smar - AuditFlow

USER´S MANUAL

AuditFlow
Flow Measurement System

OCT / 21

AuditFlow

VERSION 7.4

FOUNDATION

A F L O W V 7 4 M E

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GLOSSARY

Audit Trail - Compilation and storage of the information necessary to verify the custody transfer quantity, including QTR reports, configuration change reports, alarms/events reports and proving reports.

Base Conditions – Some variables refer to the base conditions, that is, to the reference temperature and pressure set by metrological body of each country.

Base Density of Gases (ρ_b) – Base density of the gas, calculated according to the equation:
$\rho_b = (P_b * Mr_{air} * G_i) / [Z_b * R * (T_b + N_5)]$ where: $Mr_{air} = 28.9625$ and $N_5 = 273.15$

Base Density of Liquids – Measured density, converted to the base conditions of temperature and pressure.

Base Flow (Q_b) – Volumetric flow calculated in the base condition, according to the equation:
$Q_b = Q_m / \rho_b$

Base Prove Volume (BPV) – Prover volume of calibrated section at base condition. The BPV is used as a reference volume in the proving process of the flow meter.

Base Static Pressure (reference) (Pb) – It is the static pressure used as reference.

Base Temperature (Tb) – It is the temperature used as reference.

Beta (β) – ratio between the diameters of the Orifice and the pipeline, to a certain temperature, according to the equation:

$$\beta = d / D$$

Coefficient of discharge (C_d) – The Coefficient of discharge of the orifice plate is the ratio between the actual flow and the theoretical flow.

Coefficient of Thermal Expansion (α) – Two coefficients are used in the calculation of the natural gas flow using the orifice plate: the Coefficient of Linear Thermal Expansion of the Pipeline Material (α_{tube}) and the Coefficient of Linear Thermal Expansion of the Orifice Plate Material (α_{plate}).

Combined Correction Factor (CCF) – It results from the multiplication of all correction factors related to temperature, pressure and calibration factor deviations.

Compressibility Factor (Z) – It corresponds to the gas compressibility, calculated in the process conditions (Z_f) and the base conditions (Z_b).

Diameter of the Plate Orifice (d) – Diameter of the orifice measured at the reference temperature.

Expansion Factor (Y) – It corrects the flow deviated by an alteration of the density in a constricted fluid through the orifice plate.

Expansion Speed Factor (E_v) – Expansion Speed Factor calculated according to the equation:
$E_v = 1 / sqrt(1 – \beta^4)$

Flow Computer – Device that supports besides the compensation calculations (correction factors), audit trail, data storage security, restricted access, etc. It also supports fiscal transfer, custody transfer and ticket.

Flow Conditions – Some variables refer to the flow conditions, that is, to the measured temperature and pressure.

Flow Corrector – Equipment/function that corrects the flow measurement compensating by the temperature and pressure, providing a more accurate measurement.

Flow of Energy – Energy flow.

Gross Standard Volume (GSV) – Volume measured by the meter, corrected to the base conditions and also by the meter performance (MF).

Heating Value (HV) – Heating value of the gas, used to calculate "Z" in the method Gross 1, and to calculate the energy flow.

Ideal Gas Relative Density (G_i) – Ideal gas relative density when comparing air density.

Indicated Mass (IM) - It is the mass measured by the meter, dividing the number of pulses by the nominal K factor.

Indicated Standard Volume (ISV) – Volume measured by the meter, corrected to the base conditions, not considering the meter performance.

Indicated Volume (IV) – It is the volume measured by the meter, dividing the number of pulses by the nominal K factor.

Internal Diameter of the Pipeline (D) – Internal diameter of the pipeline measured at the reference temperature.

Isentropic Exponent (k) – It is a thermodynamic property that establishes the relation between the expansion pressure of the fluid (gas) and the density.

K Factor (KF) – Number of pulses generated by the flow meter per unit of volume.

Mass Flow (Q_m) – Mass flow calculated according to the equation:
$Q_m = \pi/4 * C_d * E_v * Y * d^2 * \mathrm{sqrt}(2 * \rho_{t,p} * \Delta P)$

Mass Meter Reading (MMR) – Non-resettable mass totalizer.

Master meter - It is a premium meter, calibrated by a prover and used to calibrate an operational meter (indirect proving).

Measured Mass (MM) - It is the mass measured by meter and corrected by the Calibration Factor (MF). It is obtained dividing the number of pulses by the K factor and then multiplying by MF.

Meter Accuracy (MA) – It is defined as the reciprocal of the meter factor.

Meter Factor (MF) – Calibration factor of the flow meter. It corrects the inicated volume of the meter to the real volume, in flow conditions (not corrected for the base conditions). It is calculated dividing the Gross Standard Volume of Prover (GSVp) by the Indicated Standard Volume of Meter (ISVm).

Meter Reading (MR) – Non-resettable totalizer for the indicated volume.

Net Standard Volume (NSV) – Volume measured by the meter, corrected to the base conditions and the meter performance (MF) and discounting the percentage of sediments and water.

Nominal K Factor (NKF) – K Factor generated by the meter's manufacturer and used to convert the number of pulses to the indicated volume (IV).

Pressure Correction Factor (CPL) – This factor multiplies the volume measured by the flow meter to convert the volume to the base pressure conditions. This correction is related to the compressibility property of the product being measured.

Pressure Weighed Average (PWA) - The pressure measured is weighed by the volume or the mass.

$$PWA = \frac{\Sigma (Pi * Vi)}{\Sigma Vi}$$

Process Density of Gases ($\rho_{t,p}$) – Process density of the gas, calculated according to the equation:
$\rho_{t,p} = (P_f * Mr_{air} * G_i) / [Z_f * R * (T_f + N_5)]$ where: $Mr_{air} = 28.9625$ and $N_5 = 273.15$

Process Flow (Q_v) – Volumetric flow calculated in the process condition according to the equation:
$Qv = Q_m / \rho_{t,p}$

Process Static Pressure (P_f) – It is the static pressure of the process.

Process Temperature (T_f) – It is the temperature of the process.

QTR (Quantity Transaction Report) – Report including all necessary information to calculate the corrected volume/mass in the correspondent time.

Real Gas Relative Density (G_r) – Real gas relative density when comparing air density.

Restricted Access – The user must provide the password to change parameters or to execute procedures that affect the calculation of corrected volumes.

Reynolds Number (Re_D) – It is the dimensionless ratio of inertial and viscous forces in a fluid defined by the density of the fluid, the viscosity, the velocity and the pipe diameter.

Temperature Correction Factor (CTL) – This factor multiplies the volume measured by the flow meter to convert the volume to the base temperature conditions. This correction is related to the thermal expansion property of the product being measured.

Temperature Weighed Average (TWA) - The temperature measured is weighed by the volume or the mass.

$$TWA = \frac{\Sigma\ (Ti * Vi)}{\Sigma\ Vi}$$

Viscosity (μ) – It is the absolute viscosity of the gas in the process.

Chapter 1

OVERVIEW

Introduction

The AuditFlow Flow Measurement System was designed for International Standards focusing applications like custody transfer in oil and gas measurements, allocation measurement, operational measurement and/or process control.

There is a special treatment for audit trail. It allows verify the calculations taken place in the HFC302, access restriction to parameters which affect the flow calculation and configuration log, reports on occurence of process alarms and events, besides providing the QTR (Quantity Transaction Report) reports. Another important feature to attend the applications mentioned above is the data security to warrant the authenticity of presented data in the reports.

As the AuditFlow system architecture is based on SYSTEM302, many concepts and system components have detailed descriptions in specific manuals. Thus, there are some pre requirements before reading this manual, which are:

- Syscon User Manual
- Function Blocks Manual
- LogicView for FFB Manual

Note
When using Smar Foundation Fieldbus Field Device, the Firmware version must be 3.46 or higher.

SYSTEM302 Architecture

The AuditFlow - Flow Measurement System is part of the Smar SYSTEM302, as show the Figure 1.1.

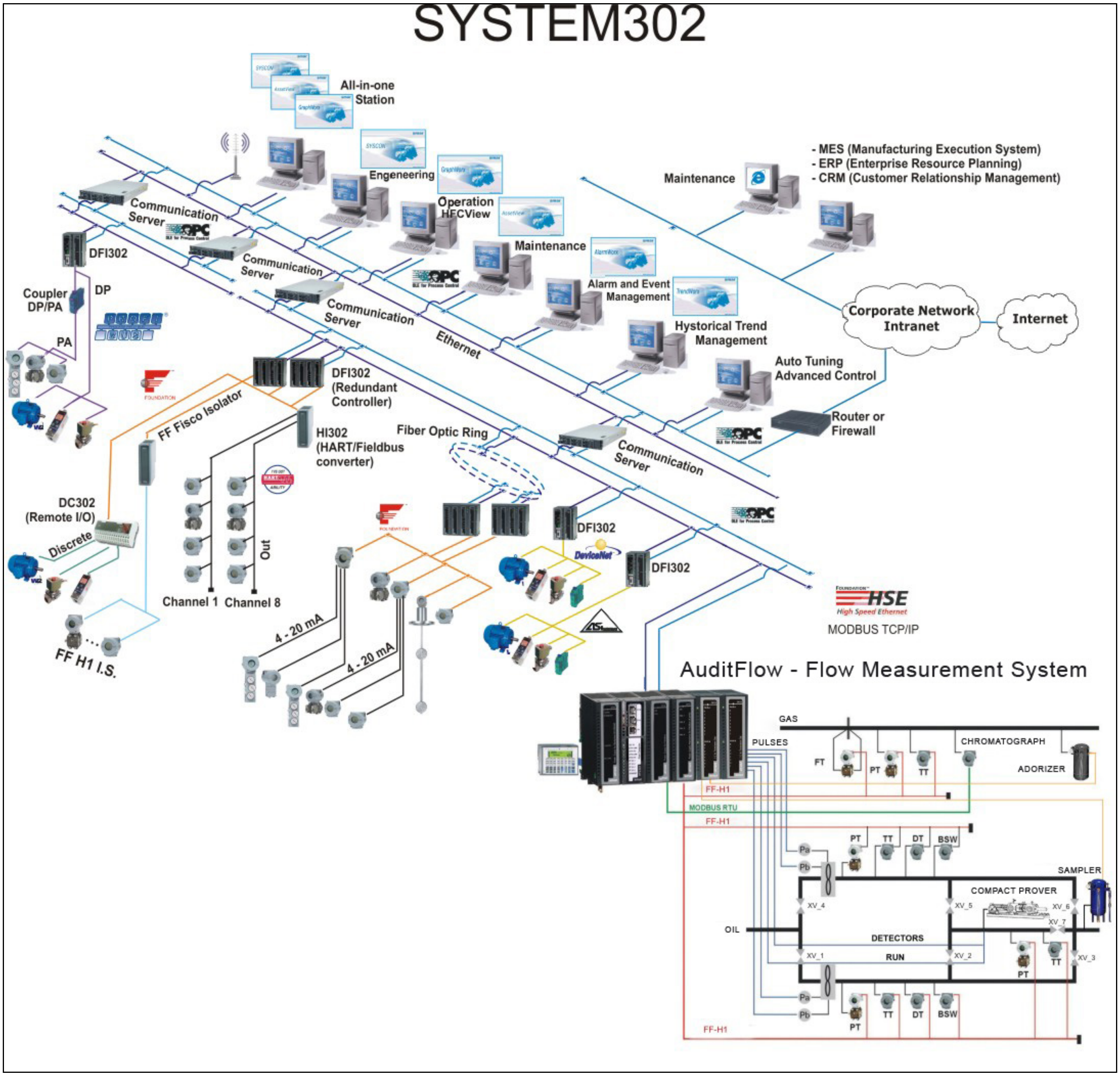


Figure 1.1 - AuditFlow System - System302

There are some characteristics of the SYSTEM302, which are:

Distributed Architecture: All system set up and maintenance can be easily done with high efficiency and interoperability.
The system supports:
- Modbus *Gateway*
- Ethernet *Gateway*
- Profibus *Gateway*
- H1 Power Supply

- H1 Barrier
- Conventional I/O

High Reliability: The distributed and embedded architecture warrants high reliability even if in industrial environments: no HDDs, and no mechanical moving parts. At software execution level, the internal processes (communication, function blocks, supervision, etc.) are controlled by a prioritized multitasking operating system guaranteeing determinism and real-time operation.

Configuration: The system is completely configurable through Foundation Fieldbus Function Blocks. Allowing the whole system (any H1 Field Device or HSE bridge/gateway of the Smar or another manufacturer) to be set up by single software, the Syscon.

Supervision: The OPC server allows the connection to any supervision package. The only requirement is to have a package compatible with OPC.

Redundancy: the system supports redundancy *hot-standby* in several levels:

- OLE Server
- LAS (*Link Active Scheduler*)
- Ethernet
- Function Blocks
- *Links* H1
- *Gateway* Modbus

AuditFlow Architecture – Flow Measurement System

The AuditFlow-V7 is the second generation of the Smar flow measurement system, representing an evolution of the system and incorporating a series of new features, to attend a higher range of the applications in lawful metrology. The Figure 1.2 shows the flexibility of the AuditFlow-V7.

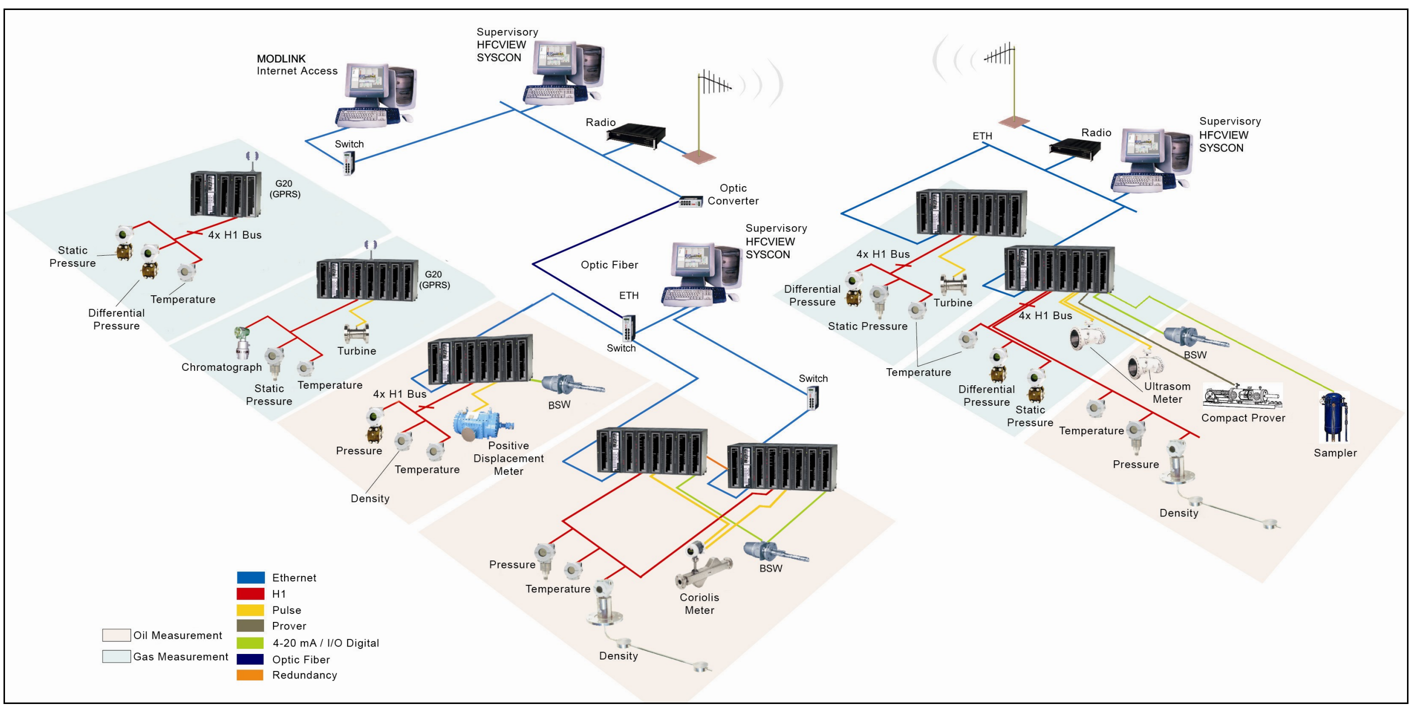


Figure 1.2 – AuditFlow System Architecture

Main Features

- In conformity with applications of custody transfer, fiscal measurement and appropriation measurement;
- Each HFC302 module supports measurement of 4 flows, selectable among gas and liquid;
- Reduced uncertainty of the measurement system obtained from digital communication with the field devices through H1 Foundation Fieldbus, where the conversions A/D and D/A are eliminated;

- Easiness of commissioning provided by digital communication via Foundation Fieldbus, that reduce drastically the cables problems;
- Supports the HSE Foundation Fieldbus for change of control data between HSE bridges and supervision through HSE OPC Server;
- Modbus (RTU and TCP/IP, master and slave) for a complete supervision and parameterization, reading of reports by HFCView and reading of the natural gas composition of the chromatograph;
- Hardware modular : expansion possibility of I/O's;
- DF77 module makes possible the fidelity A level in the transmission of the pulses, as well as propitiates a dual chronometry requested by compact provers;
- Prover Types: compact prover, ball prover, tank prover and master meter.
- Engineering unit selection for each variable;
- Up to 30 users identified by username with 4 access levels (configurable) and possibility of double password.
- Several redundancy levels : power supply and CPU, communication network and pulse input module;
- Configuration Language: function block diagram instantiate (including PID control) and ladder logic;
- Reports generated by HFC302 module are stored in non volatile memory and after read by HFCView through Modbus RTU or TCP/IP, then are stored in data base, and like this can be visualized by user through HFCView;
- Report Types: transfer report (QTR, liquid and gas), Alarms and Events, Configuration Change, Parameterization List, Flow Meter Calibration, Well Test, Historic (gas measurement, average and totalizers of 60 minutes, 24 hours, 31 days), Periodical Totalizers (liquid measurement, 24 hourly totalizers and its corresponding totalizers of 15 minutes).
- HFCView is the management tool and reports of the HFC302.
- HFCView supports network redundancy to monitor and to read the reports through Modbus, alternating automatically between Ethernets networks or between a Ethernet network and serial EIA-232;

Liquid Measurement

- Supported product Types:
    - Crude oil, refined products, MTBE and lubricating oil: API MPMS 11.1:1980/2004, ASTM D1250:1952, API MPMS 11.2.1.
    - GLP, condensed: GPA TP25, GPA TP15, API MPMS 11.2.2.
    - Ethanol (temperature correction factor): NBR5992:1980, OIML R22:1975
- Appropriation Measurement – crude oil or condensed with high water degree: API MPMS 20.1;
- Supported prover types: piston (Brooks and Calibron), ball, tank and master meter;
- Supported flow meter types : turbine, coriolis, ultra sonic, positive displacement;
- Fidelity level A in pulse transmission using the DF77 module
- Linearization of KF/NKF/MF related to the frequency/flow;

Gas Measurement

- Supported product Types:
    - Natural gas: AGA8:1992 (compressibility factor and density), AGA10 (isentropic coefficient);
    - steam: ASME IAPWS-1997
    - humid steam: Murdock equation (up to 10% in mass of the liquid phase);
    - argon, oxygen, nitrogen, carbon dioxide, ammonia: AiCHE DIPPR 801 (gaseous or liquid phase)
- Supported meter types:
    - Orifice plate: AGA3 Part 4:1992, ISO5167:2003;
    - turbine: AGA7:1996;
    - ultra sonic: AGA9:2000;
    - coriolis: AGA11:2001;
    - Vcone and WaferCone.
- Measurement with orifice plate using up to three differential pressure transmitters: avoiding problems of rangeability and obtaining redundancy of the differential pressure transmitter;
- Communication with chromatograph to obtain the composition of natural gas through Foundation Fieldbus, Modbus TCP/IP or RTU;

Application in exploration and production

- Complete report of well test: monitoring of the main variables of the crude oil measurement, natural gas produced, injected natural gas, produced water;

- Capacity for measurement of the injected product: carbon dioxide (including super critical state), steam (including super critical state), natural gas and water;
- Supports the calculations for measurement of appropriation in applications where the crude oil or condensed present high water degree;
- If used port-plate in measurement of natural gas, is possible to configure a list of plates that can be used, facilitating the operation that just selects one of the plates of the list.
- Control of sampler in the HFC302, just requesting the parameterization.

Application in transport and distribution

- SCADA architecture allowing communication with central of operation via satellite, serial radio, GSM/GPRS allowing the supervision and upload of report using the Modbus protocol;
- Batch programming for quantity (volume, mass or energy), time, interface between liquid products of different density;
- Identification of batch for tag, transporter name, date and hour;
- Access restriction to modification in configuration through double password, demanding the representatives of the supplier and customer, making possible the sharing of the measurement system for both;
- Different versions of the standard used for calculation, allowing the use of the standard selected in agreement or defined for local legislation. In liquid measurement have: ASTM D1250:1952, API MPMS 11.1:1980 and API MPMS 11.1:2004. In natural gas measurements with orifice plate have: AGA3 and ISO5167.
- Adorizer control in the HFC302, just requesting the parameterization.
- Monitoring of the weighed average and totalizations of the last 60 minutes, 60 hours and 60 days. There is also the possibility of reports generation.

Application example

Features:

- Two loops of liquid measurement (for example, gasoline) in redundancy using turbines with double pickup (dual pulse);
- Compact prover for calibration of the turbines with transmitters H1 Foundation Fieldbus from another manufacturer for the pressure, temperature of the liquid and temperature of the rod;
- Smar's transmitters H1 Foundation Fieldbus for: density (DT302), pressure (LD302), temperature (TT302) and BSW meter;
- One loop of natural gas measurement using orifice plate;
- Smar's transmitters H1 Foundation Fieldbus for: differential pressure (LD302), temperature (TT302) and static pressure (LD302);
- Communication with chromatograph through Modbus RTU;
- IHM local communicating via Modbus TCP/IP;
- Smar's Supervisory ProcessView via HSE OPC Server;
- HFCView for monitoring and reading of reports via Modbus TCP/IP;
- Sampler control for liquid and adorizer for natural gas;
- Switching control of the liquid runs using ladder logic, executed in the HFC302.

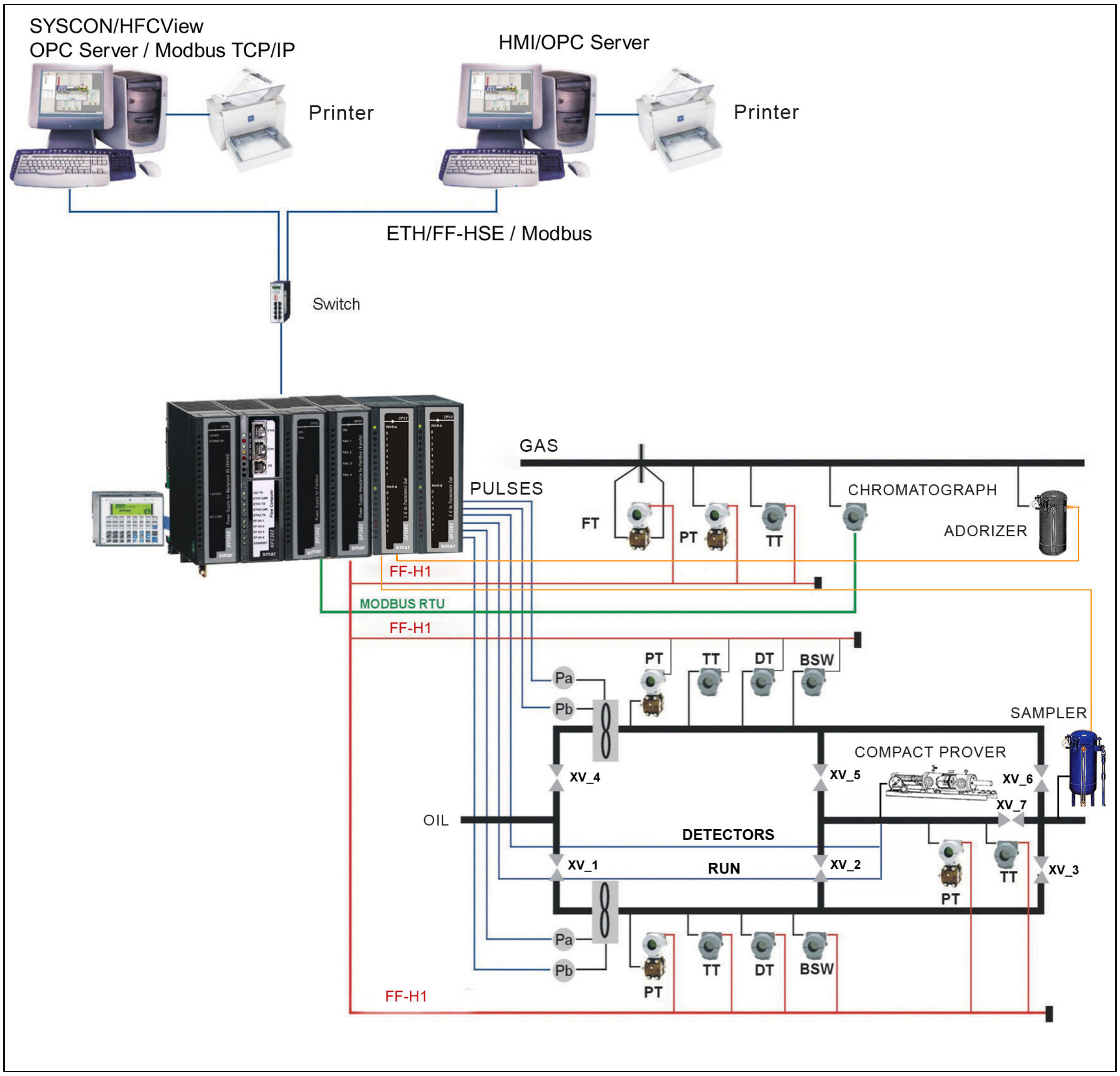


Figure 1.3 - Application Example

Operating and Blocks Diagram

The operation of the Flow Measurement System – AuditFlow has the following basic scheme:

- **Reading of the non-compensated flow** - Represented for pulses of the flow meter through an I/O module (for example DF77) or differential pressure for the DP flowmeters through differential pressure transmitter FF-H1/Hart/4-20mA protocol.
- **Reading of the secondary variables** - These variables are used to calculate the correction factors for the flow compensation in temperature and pressure. The obtaining of these variables is through FF-H1/Hart/4-20mA protocols.
- **Calculation of the compensated flow, totalization and report generation** - In this phase is the most of the standards related to the custody transfer, where the correction factors are calculated and applied to the non-compensated flow. Another process accomplished is the totalization of the compensated flow and report generation. The algorithms related to these processes are stored in Flash memory that is the denominated firmware.
- **Communication** – The communication process objectives to meet the following main features:
    - firmware download stored Flash memory (ETH1 and ETH2);
    - configuration download stored in NVRAM memory (ETH1 and ETH2);
    - supervision via HSE-OPC Server (ETH1 and ETH2) and Modbus (ETH1, ETH2 and Serial);
    - Report upload stored in NVRAM memory (ETH1, ETH2 and Serial).

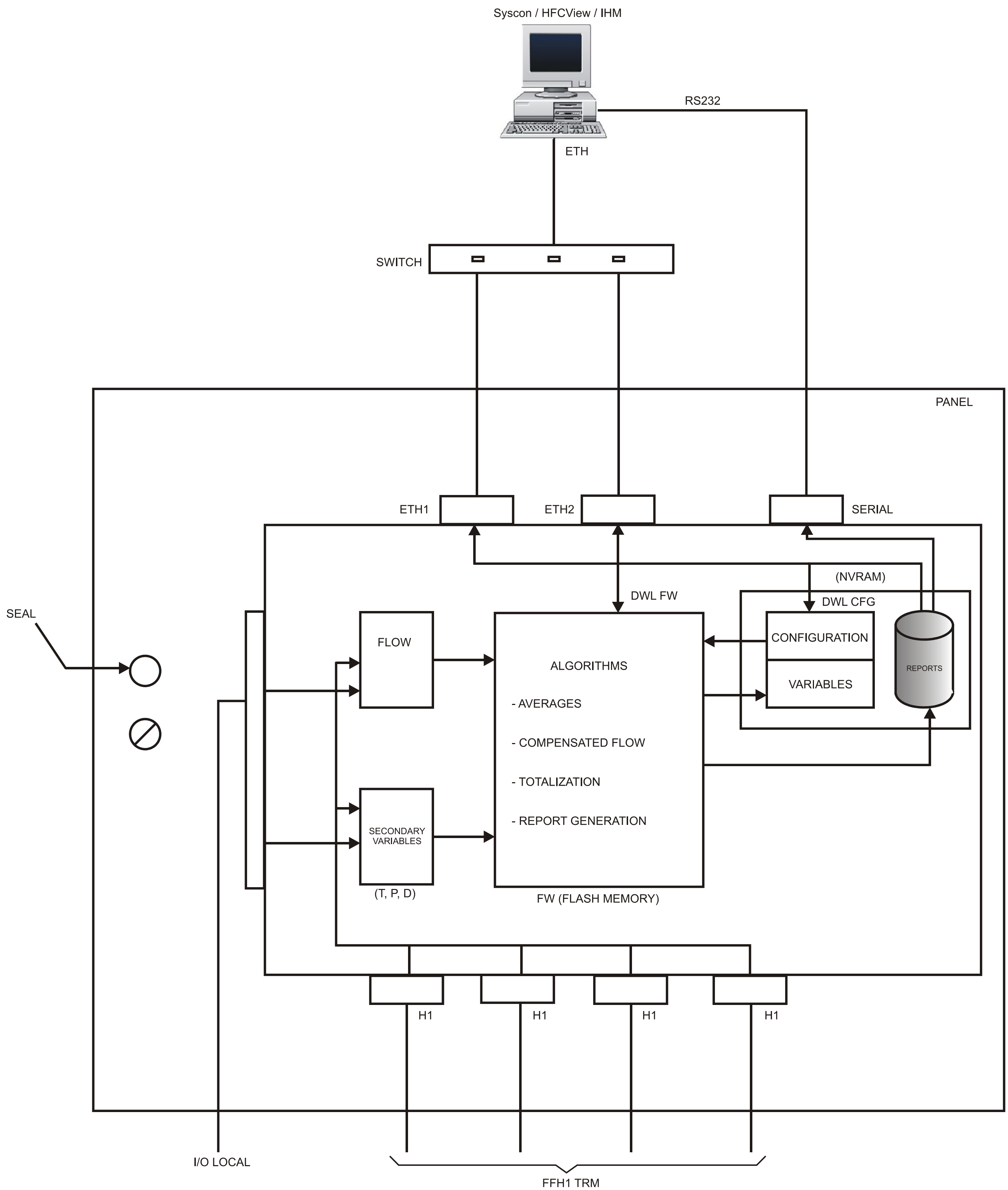


Figure 1.4 - Operating Principle

Chapter 2

THEORETICAL AND NORMATIVE DESCRIPTION

Standards used in Flow Correction and Measurement

API - American Petroleum Institute (USA)
IP - Institute of Petroleum (UK)
GPA - Gas Processors Association
AGA - American Gas Association
OIML – International Organisation of Legal Metrology
ISO - International Standard Organization
AiCHE – American Institute of Chemical Engineers

Gas Measurement

Measurement Theory using Orifice Plate

The orifice plate is the primary device that measures the flow based on the differential pressure generated.

The flow measurement based on an orifice plate uses the well-known Physics laws: the Continuity Equation and the Bernoulli Equation.

In gas measurement based on an orifice plate, the mass flow is calculated first, then dividing it by the base density and the flowing density, to obtain the volumetric flow rates at base condition and flowing condition, respectively.

The compressibility factor (Z) of the Natural Gas is a factor used to estimate the deviation of measured gas from the ideal gas law behavior. This calculation is based on the AGA8 Standard, selecting one of the three methods:

- Gross1 – The calculation is based on: CO_2 percentage, G_r relative density and Heating Value HV, and also on the pressure and temperature values.
- Gross2 – The calculation is based on: CO_2 percentage, N_2 percentage and G_r relative density, and also on the pressure and temperature values.
- Detailed – The calculation is based on the gas composition, and also on the pressure and temperature values.

The following flow calculation is based on the AGA3 Standard (1992) (It is recommended to study the AGA3 Standard - Part 4):

Beta calculation – relations between diameters to process temperature

$$\beta = \frac{d_m\left[1+\alpha_1 * (T_f - T_r)\right]}{D_m\left[1+\alpha_2 * (T_f - T_r)\right]}$$

Where:
d_m : diameter of the orifice plate at T_r temperature
D_m : diameter of the pipeline at T_r temperature
T_r : reference temperature where the measurement of d_m and D_m diameters was accomplished
T_f : flowing temperature
α_1 : linear thermal dilation coefficient of the orifice plate material
α_2 : inear thermal dilation coefficient of the pipe material

$$E_v = \frac{1}{\sqrt{1-\beta^4}}$$

$$Y = 1 - \frac{0.41 + 0.35 * \beta^4}{K} * \frac{\Delta P}{N_3 * P_f}$$

For imcompressible fluids Y = 1.0 and K = -1

Calculation of upstream static pressure from downstream static pressure

Equation 4-27 (AGA3 – Part 4)

$$P_{f1} = \frac{\Delta P}{N_3} + P_{f2}$$

Where:
P_{f1} : upstream absolute static pressure at flowing condition
P_{f2} : downstream absolute static pressure at flowing condition
ΔP : Differential pressure

Calculation of discharge coefficient (C_d) – AGA3

The calculation of discharge coefficient is based on the 4.3.2.5., 4.3.2.8. and 4.3.2.9. procedures of the AGA3 Part 4 in function of E_v, Y, d, D, β, μ, k, ΔP, $\rho_{t,p}$

Dependent factors of the type of differential pressure tap used in the calculation of the discharge coefficient:

Symbol	Description	Flange Taps	Corner Taps	D-D/2 Taps
L1	Upstream position dimensionless	$\frac{N_4}{D}$	0	1
L2	Downstream position dimensionless	$\frac{N_4}{D}$	0	0.47

Calculation of discharge coefficient (C_d) – ISO5167-2:2003

1. The calculation of discharge coefficient is based on the procedure: Initial value for the number of Reynolds: 50 000

2. Calculates the expansion factor according to ISO5167-2:2003 page 12, which is different of the definiton of AGA3.

$$\varepsilon = 1 - (0.351 + 0.256 * \beta^4 + 0.93 * \beta^8)\left[1 - \left(\frac{p2}{p1}\right)^{1/k}\right]$$

Where:
P2: downstream pressure
P1: upstream pressure

3. Calculates M2

$$M_2^{'} = \frac{2 * L_2}{1 - \beta}$$

Where:
L2 : determined according to previous table

4. Calculates the constant term A1 according to ISO5167-1:2003 table A.1

$$A_1 = \frac{\varepsilon * d^2 * \sqrt{2 * \Delta p * \rho_1}}{\mu_1 * D * \sqrt{1 - \beta^4}}$$

Where:
d, D : diameters calculated at flowing temperature
ρ_1 : fluid density at flowing condition

5. Calculates

$$A = \left(\frac{19000 * \beta}{\mathrm{Re}\,D} \right)^{0.8}$$

6. Calculates the discharge coefficient according to Reader-Harris/Gallagher (1998) – ISO5167-2:2003 page 11:

$$C = 0.5961 + 0.0261 * \beta^2 - 0.216 * \beta^8 + 0.000521 * \left(\frac{10^6 * \beta}{\mathrm{Re}\,D} \right)^{0.7} + (0.0188 + 0.0063 * A) * \beta^{3.5} * \left(\frac{10^6}{\mathrm{Re}\,D} \right)^{0.3}$$

$$+ (0.043 + 0.08 * e^{-10*L1} - 0.123 * e^{-7*L1})(1 - 0.11 * A) * \frac{\beta^4}{1 - \beta^4} - 0.031 * (M_2' - 0.8 * M_2'^{1.1}) * \beta^{1.3},$$

Se D< 71.12 mm then adds the term:

$$+ 0.011 * (0.75 - \beta) * \left(2.8 - \frac{D}{25.4} \right)$$

Where:
D : pipe diameter at flowing condition in milimeters
L1: determined according to previous table

7. Calculates a new number of Reynolds

$$\mathrm{Re}\,D = C * A_1$$

Where:
C: discharge coefficient calculated in the previous item
A1: constant term calculated in the item 4

8. Repeat the items 5, 6 and 7 until the variation of the discharge coefficient of an iteration to other to be inferior to 1E-6.

Calculation of the flows (Q_m, Q_b and Q_m)

Equation 4-1 – AGA3 – Part 4

$$Q_m = \frac{\pi}{4} * N_c * C_d * E_v * Y * d^2 * \sqrt{2 * \rho_{t,p} * \Delta P}$$

Where :
C_d : discharge coefficient
d : diameter of the orifice calculated at flowing temperature T_f
ΔP : differential pressure
E_v : velocity of the approximation factor
N_c : factor of unit conversion
Q_m : mass flow
$\rho_{t,p}$: fluid density at flowing condition (P_f, T_f)
Y : expansion factor

Qb = Q_m / ρ_b

Qv = Q_m / $\rho_{t,p}$

Energy = Qb * HV

Where:
d : diameter of the orifice at flowing temperature
D : diameter of the pipeline at flowing temperature
Ev : factor of approximation velocity
Y : expansion factor
R_{eD} : Reynolds number
Cd : coefficient of discharge
$\rho_{t,p}$: density at flowing temperature and pressure

ρ_b : density at base temperature and pressure
Qm : mass flow
Qb : volumetric flow rate calculated in base temperature and pressure
Hv : heating value

Calculation of density ($\rho_{t,p}$ and ρ_b)

The calculation of density depends on the type of measured fluid, besides the temperature and pressure:

Product Type	Standard
Natural gas	AGA8
Steam	ASME
Other fluids	Aiche/DIPPR

Calculation of Reynolds number (Re_D)

Equation 4-4 AGA3 Part 4

$$\text{Re}_D = \frac{4Q_m}{\pi \mu D}$$

Where:
Q_m : mass flow
μ : absolute viscosity of the fluid
D : internal diameter of the piping section calculated at flowing temperature (T_f)

Constants and Engineering Units Calculation

Independently of the engineering units selected by the user, the internal calculations in the AuditFlow System are always accomplished in the International System (SI).

A table with constants and engineering units used in the internal calculations from AGA3 – Part 1:1990 table 1-3 and AGA3 – Part 4:1995 table 4-5 is presented below.

Variables	SI
d_m, D_m, d_r, D_r, d, D	m
P_1, P_2, P_f, P_b	Pa
ΔP	Pa
$\rho_{t,p}$, ρ_b	kg/m^3
q_m	kg/s
q_v, Q_b	m^3/s
T_f, T_b, T_r	K
α_1, α_2	m/m-K
μ	Pa-s
R	8314.51 J/kmol-K
M_r	28.9625 kg/kmol
N_c	1.0
N_{Ic}	1.0
N_2	1.27324
N_3	1.0
N_4	0.0254
N_5	0.0
T_r	293.15 K
π	3.14159

Differences in the Flow Calculation to Vcone and WaferCone

The following equations differ the Vcone and WaferCone when compared with the AGA3.

1. Calculation of beta

$$\beta = \sqrt{1 - \left(\frac{d}{D}\right)^2}$$

Where:
d : diameter of the orifice plate at temperature T_r
D : internal diameter of the pipe at temperature T_r
T_r : reference temperature where the measurement of the d and D diameters was accomplished

2. Expansion factor

V-Cone:

$$Y = 1 - (0.649 + 0.696 * \beta^4) * \frac{\Delta P}{K * P}$$

Wafer-Cone:

$$Y = 1 - (0.755 + 6.787 * \beta^8) * \frac{\Delta P}{K * P}$$

Where ΔP and P should be in the same engineering unit.
K : isentropic coefficient

Another difference between the AGA3 and the Vcone and WaferCone for the flow calculations refers to the discharge coefficient, that in these meters this parameter is obtained at laboratory, therefore enters as configuration. While in the AGA3, the discharge coefficient is calculated.

3. Factor of thermal expansion

$$Fa = \frac{D^2 - d^2}{\left[(1 - \alpha_{pipe} * (T - Tr)) * D\right]^2 - \left[(1 - \alpha_{cone} * (T - T_r) * d\right]^2}$$

Where:
d : diameter of orifice plate at temperature T_r
D : internal diameter of the pipe at temperature T_r
α_{pipe} : coefficient of linear thermal dilation of the pipeline material
α_{cone} : coefficient of linear thermal dilation of the Vcone/WaferCone material
T : flowing temperature
T_r : reference temperature where the measurement of the d and D diameters was accomplished

4. Flow equation with adjust of the thermal expansion factor

$$Q_m = F_a * \left(\frac{\pi}{4} * N_c * C_d * E_v * Y * d^2 * \sqrt{2 * \rho_{t,p} * \Delta P} \right)$$

Theory of Measurement with Linear Devices (Pulse Input)

Volumetric Meters (METER_TYPE=Volume Pulse Input)

$$TotQ_v = \frac{n}{NKF}$$

Where:
TotQv : Volume at flowing condition accumulated at calculation period
n : number of pulses at calculation period
NKF : conversion factor of pulses for volume (nominal K-factor)

$$TotQ_b = TotQ_v * \frac{\rho_f}{\rho_b} * MF$$

Where:
TotQb : volume at base condition accumulated at calculation period
TotQv : volume at flowing condition accumulated at calculation period
ρ_f : density at flowing condition
ρ_b : density at base condition
MF : calibration factor of the flow meter (Meter Factor)

$$TotQ_m = TotQ_v * \rho_f * MF$$

Where:
TotQv : Volume at flowing condition accumulated at calculation period
ρ_f : density at flowing condition
MF : calibration factor of the flow meter (Meter Factor)

$$TotEnergy = TotQ_b * H_v$$

Where:
TotEnergy : Energy accumulated at calculation period
TotQb : volume at base condition accumulated at calculation period
Hv : heating value (Heating Value)

Mass Meters (METER_TYPE=Mass Pulse Input):

$$TotQ_m = \frac{n}{NKF}$$

Where:
TotQm : Mass accumulated at calculation period
n : number of pulses at calculation period
NKF : conversion factor of pulses for mass (nominal K-factor)

The other totalizations are obtained by the equations described for Volumetric Meters.

Compressibility Factor (Z_b, Z_f) by Detailed Method – AGA8:1992

The compressibility factor (Z) indicates the deviation of the behaviour when comparing natural and ideal gases in the gas general equation:

Equation 1 – AGA8 :

$$Z = \frac{PV}{nRT}$$

Where:
P : absolute static pressure
V : gas volume
n : moles number
Z : compressibility factor
R : general constant of the gas
T : absolute temperature

The equation of state for detailed method is below:

Equation 12 – AGA8:

$$Z = 1 + \frac{DB}{K^3} - D\sum_{n=13}^{18} C_n{}^* T^{-u_n} + \sum_{n=13}^{58} C_n{}^* T^{-u_n} (b_n - c_n k_n D^{k_n}) D^{b_n} \exp(-c_n D^{k_n})$$

Where:
B : second virial coefficient
K : mixture size parameter
D : reduced density
C_n^* : coefficients which are functions of gas composition, that is, they don't depend on pressure or temperature
T : absolute temperature
u_n, b_n, c_n, k_n : constants of the table 4 of the AGA8

1. Calculation of the reduced density

Equation 13 – AGA8:

$$D = K^3 d$$

Where:
K : mixture size parameter
d : molar density (moles per unit volume) calculated using Brent method, it will be explained later

2. Calculation of the mixture size parameter (K) using only the gas composition:

Equation 14 – AGA8:

$$K^5 = \left[\sum_{i=1}^{N} x_i K_i^{5/2} \right]^2 + 2 \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} x_i x_j (K_{ij}^{\ 5} - 1)(K_i K_j)^{5/2}$$

Where :
K_i : size parameter for ith component – table 5 of the AGA8 standard
K_j : size parameter for jth component – table 5 of the AGA8 standard
K_{ij} : binary interaction parameter for size – table 6 of the AGA8 standard
x_i : mole fraction of ith component
x_j : mole fraction of jth component
N : number of components in the gas mixture.

3. Calculation of the second virial coefficient using gas composition and temperature

Equation 15 – AGA8:

$$B = \sum a_n T^{-u_n} \sum \sum x_i x_j E_{ij}^{\ u_n} (K_i K_j)^{3/2} B_{nij}^{\ *}$$

Where B_{nij} is calculated by the following equation, which depends on the gas composition and temperature:

Equation 16 – AGA8:

$$B_{nij}^{\ *} = (G_{ij} + 1 - g_n)^{g_n} (Q_i Q_j + 1 - q_n)^{q_n} (F_i^{\ 1/2} F_j^{\ 1/2} + 1 - f_n)^{f_n} (S_i S_j + 1 - s_n)^{s_n} (W_i W_j + 1 - w_n)^{w_n}$$

Where:
B_{nij}^* : binary characterization coefficient
a_n , u_n : constants in table 4 – AGA8
g_n , q_n, f_n, s_n, w_n: constants in table 4 – AGA8
T : absolute temperature
x_i : mole fraction of component ith in the gas mixture
x_j : mole fraction of component jth in the gas mixture
G_{ij} : binary orientation parameter, according to the following equation
Q_i : quadrupole parameter for ith component (table 5 – AGA8)
Q_j : quadrupole parameter for jth component (table 5 – AGA8)
F_i : high temperature parameter for ith component (table 5 – AGA8)
F_j : high temperature parameter for jth component (table 5 – AGA8)
S_i : dipole parameter for ith component (table 5 – AGA8)
S_j : dipole parameter for jth component (table 5 – AGA8)
W_i : association parameter for ith component (table 5 – AGA8)
W_j : association parameter for jth component (table 5 – AGA8)
E_{ij} : second virial coefficient binary energy parameter, according to the following equation
K_i : size parameter for ith component (table 5 – AGA8)
K_j : size parameter for jth component (table 5 – AGA8)
N : number of components in gas mixture, the HFC302 always calculates using 21 components, so N=21.

Equation 17 – AGA8:

$$E_{ij} = E_{ij}^{\ *} (E_i E_j)^{1/2}$$

Equation 18 – AGA8:

$$G_{ij} = \frac{G_{ij}^{*}(G_i + G_j)}{2}$$

Where:
E_i : characteristic energy parameter for ith component (table 5 – AGA8)
E_j : characteristic energy parameter for jth component (table 5 – AGA8)
E_{ij}^{*} : second virial coefficient energy binary interaction parameter
G_i : orientation parameter for ith component (table 5 – AGA8)
G_j : orientation parameter for jth component (table 5 – AGA8)
G_{ij}^{*} : binary orientation parameter (table 6 – AGA8)

4. Calculation of the coefficient C_n^{*} (n=13 to 58) depending only on the gas composition

Equation 19 – AGA8:

$$C_n^{*} = a_n (G + 1 - g_n)^{g_n} (Q^2 + 1 - q_n)^{q_n} (F + 1 - f_n)^{f_n} U^{u_n}$$

Equation 20 – AGA8:

$$U^5 = \left[\sum_{i=1}^{N} x_i E_i^{5/2} \right]^2 + 2 \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} x_i x_j (U_{ij}^5 - 1)(E_i E_j)^{5/2}$$

Equation 21 – AGA8:

$$G = \sum_{i=1}^{N} x_i G_i + \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} x_i x_j (G_{ij}^{*} - 1)(G_i + G_j)$$

Equation 22 – AGA8:

$$Q = \sum_{i=1}^{N} x_i Q_i$$

Equation 23 – AGA8:

$$F = \sum_{i=1}^{N} x_i^2 F_i$$

Where:
a_n , g_n , q_n, u_n, f_n: constants in table 4 – AGA8
x_i : mole fraction for the ith component in the gas
x_j : mole fraction for the jth component in the gas
E_i : energy parameter for the ith component (table 5 – AGA8)
E_j : energy parameter for the jth component (table 5 – AGA8)
U_{ij} : binary interaction parameter for conformal energy (table 6 – AGA8)
G_i : orientation parameter for the ith component (table 5 – AGA8)
G_j : orientation parameter for the jth component (table 5 – AGA8)
G_{ij}^{*} : binary interaction parameter for orientation (table 6 – AGA8)
Q_i : quadrupole parameter for ith component (table 5 – AGA8)
Q_j : quadrupole parameter for jth component (table 5 – AGA8)
F_i : high temperature parameter for ith component (table 5 – AGA8)
F_j : high temperature parameter for jth component (table 5 – AGA8)

5. Equation of State for Pressure

The following equation is obtained using the equations 1 and 12 of AGA8 standard.

Equation 24 – AGA8:

$$P = dRT \left[1 + Bd - D \sum_{n=13}^{18} C_n^{*} T^{-u_n} + \sum_{n=13}^{58} C_n^{*} T^{-u_n} (b_n - c_n k_n D^{k_n}) D^{b_n} \exp(-c_n D^{k_n}) \right]$$

6. Algorithm for calculation of the compressibility factor (Z) by detailed method

Inputs:
T : absolute temperature
P : absolute static pressure
x_i : gas composition

Sequence of the iterative method for the calculation of the compressibility factor:

I. Calculation of the mixture size parameter (K), which depends on the gas composition.
II. Calculation of B and C_n^* coefficients, according to the items 3 and 4, respectively, which depend on the gas composition and temperature.
III. Determination of the molar density (d) using equation 24 – AGA8 and the Brent iterative method:
   - It calculates two densities (RHOL and RHOH) that are the range limits for the determination of the density using the iterative method;
   - Associated with the densities, it calculates the absolute static pressure (PRHOL and PRHOH) according to the densities using the equation 24 – AGA8;
   - The first iteration uses the inverse linear interpolation between RHOL and RHOH;
   - It calculates the absolute static pressure using the equation 24 – AGA8 with molar density (attempt), the absolute temperature (T) and the parameters K, B and C_n^*. The processing for each iteration uses the equation 24 – AGA8, because the parameters K, B and C_n^* are computed only one time;
   - There are two convergence criterions: a) deviation lower than 1E-6 between the computed pressure and the provided pressure (measured static pressure or base pressure) or; b) deviation lower than 1E-6 between the values of molar density (d) of two successive iterations;
   - If there is not convergence, it selects the most efficient option for the next iteration between: inverse quadratic interpolation, inverse linear interpolation and bisection. It is necessary to define the maximum number of iterations and the computed value for the molar density for the next iteration is delimited for the calculated range.
IV. When the molar density is solved (d), it calculates the compressibility factor using the equation 12 – AGA8.

Density Calculation (ρ) – AGA8

After determining the compressibility factor, it calculates the density at the temperature and pressure which the compressibility factor was computed by using the following equations:

Equation 3 – AGA8:

$$M_r = \sum_{i=1}^{N} x_i M_{ri}$$

Where:
M_r : molar mass of the natural gas
x_i : mole fraction of component i
M_{ri} : molar mass of ith component
N : number of components (21 components)

Equation 4 – AGA8:

$$\rho = M_r d$$

Where:
ρ: mass density (mass per unit volume) at the temperature and pressure in which Z and d were computed
d : molar density (number of moles per unit volume)
M_r : molar mass of the natural gas

Equation 6 – AGA8 (SI):

$$\rho = \frac{M_r P}{ZRT}$$

Where:
Mr : molar mass of the natural gas
P : pressure used to calculate the density in pascal
Z : compressibility factor
R : gas universal constant equal to 8314.51 J/(kmol.K)
T : temperature in kelvin

Equation 6 – AGA8 (USA):

$$\rho = \frac{M_r P}{ZR(T + 459.67)}$$

Where:
Mr : molar mass of the natural gas
P : pressure used to calculate the density in psia
Z : compressibility factor
R : gas universal constant equal to 10.7316 psia.ft^3/(lbmol.ºF)
T : temperature in Fahrenheit

The calculations for molar density (d), compressibility factor and mass density (ρ) should be performed for flowing and base conditions. Through the mass density at flowing and base conditions, and the mass flow obtained by using AGA3, it calculates the volumetric flows at flowing (Qv) and base (Qb) conditions for measurements based on differential pressure.

Calculation of Relative Density (G_r) – AGA8

The relative density (Gr) is the natural gas density divided by air density, both in the same temperature and pressure conditions.

Equation C.3-11 – AGA8:

$$\rho(\mathrm{air}, \mathrm{T_{gr}}, \mathrm{P_{gr}}) = \frac{\mathrm{M_r}(air)}{\dfrac{\mathrm{R} * \mathrm{T_{gr}}}{\mathrm{P_{gr}}} + B(air, T_{gr})}$$

Where:
T_{gr} = reference temperature for relative density
P_{gr} = reference pressure for relative density
R = gas constant equals to 8.31451 * 10^{-3} J/(Kg-mol*K)
M_r(air) = molar mass of air equals to 28.96256
B(air, T_{gr}) : air second virial coefficient at absolute temperature T_{gr}

Equation C.3-12 - AGA8:

$$\mathrm{B}(\mathrm{air}, \mathrm{T_{gr}}) = -0{,}12527 + 5{,}91 * 10^{-4} * \mathrm{T_{gr}} - 6{,}62 * 10^{-7} * \mathrm{T_{gr}}^{2}$$

Calculation of relative density (Gr)
Equation C.3-10 - AGA8:

$$\mathrm{G_r}(\mathrm{T_{gr}}, \mathrm{P_{gr}}) = \frac{\rho(\mathrm{T_{gr}}, \mathrm{P_{gr}})}{\rho(\mathrm{air}, \mathrm{T_{gr}}, \mathrm{P_{gr}})}$$

Where:
$\rho(T_{gr}, P_{gr})$: mass density of natural gas at temperature T_{gr} and pressure P_{gr}
$\rho(air, T_{gr}, P_{gr})$: mass density of air at temperature T_{gr} and pressure P_{gr}
T_{gr} e P_{gr} : base temperature and pressure

Calculation of Weighted Average

The HFC302 supports two types of average calculation suggested for API-21.1 Appendix B, those are:

1. GKD.AVERAGING_SEL = Flow-depedent time weighted linear
Gas measurement (API-21.1 – Appendix B – item B.1.1.a):

$$P_{wa} = \frac{\sum_{i=1}^{k} P_i * t_i * F_i}{\sum_{i=1}^{k} t_i * F_i}$$

Where:
Pi : input variable for i sample period
ti : interval of time for i sample period, macrocycle, that is constant in the AuditFlow and can be removed of the equation.
K : number of sample periods during the transfer
Fi : dependent factor of the flow, 1 if there is flow, 0 if there is not flow.

The equation above can be simplified for the case of AuditFlow, where the calculation is just accomplished when there is flow:

$$P_{wa} = \frac{\sum_{i=1}^{k} P_i}{k}$$

2. GKD.AVERAGING_SEL = Flow-weighted linear
Gas Measurement (API-21.1 – Appendix B – item B.1.1.c) : Flow-weighted linear average

$$P_{wa} = \frac{\sum_{i=1}^{k} P_i * t_i * W_i}{\sum_{i=1}^{k} t_i * W_i}$$

Where:
Pi : input variable for i sample period
ti : interval of time for i sample period, macrocycle, that is constant in the AuditFlow and can be removed of the equation.
K : number of sample periods during the transfer
Wi : weigh factor

The equation above can be simplified for the case of AuditFlow, where the calculation is just accomplished when there is flow:

a) Orifice Plate: square root of differential pressure $(hw)^{0.5}$

$$P_{wa} = \frac{\sum_{i=1}^{k} \left(P_i * \sqrt{DP_i}\right)}{\sum_{i=1}^{k} \sqrt{DP_i}}$$

DPi : differential pressure for period of i sample

b) Pulse : ti *Wi = number of pulses in the macrocycle or IV corresponding

$$P_{wa} = \frac{\sum_{i=1}^{k} \left(P_i * N_i\right)}{\sum_{i=1}^{k} N_i}$$

Ni : number of pulses in the macrocycle or IV corresponding (dividing for NKF)

Calculations for Gas Totalization

According to the API-21.1 standard:

$$Q_{imp} = IMV_{imp} * IV_{imp}$$

$$IMV = 7709.61 * C_d(FT) * E_v * Y * d^2 * \sqrt{\frac{Z_b}{G_r * Z_f * T_f}}$$

$$IV = \sum_{i=1}^{n} \sqrt{P_i * \Delta P_i}$$

Where:

imp : Integral Multiplier Period – frequence that IMV calculation occur. It is based on weighted averages of P, DP and T. The HFC302 module uses its macrocycle as imp, so it does the calculations frequently.

Q_{imp} : quantity accumulated during imp period.

IMV_{imp} : Integral Multiplier Value corresponding to imp period, which it is calculated using the weighted averages of P, DP and T.

IV_{imp} : integral value accumulated during the imp period.

Flow Calculation to Saturated Steam with up to 10% of Liquid Water

The flow calculation of two phases to saturated steam is accomplished using the equations presented in the book "*Flow Measurement Engineering Handbook" - 3° edition - Richard W. Miller* – page 9.68 for the following conditions:

- X >= 0.9: title equal or superior to 90%, percentage in mass of steam in relation to mixture.
- Correlation in +/- 1.5%
- Equation derived from 90 points of tests for steam-water (humid water), air-water, natural-water gas and salted natural-water gas.
- 0.25 <= β <= 0.5
- Rd > 100 000
- Y_1 >= 0.98
- Meter type orifice plate
- Murdock equation

Equation 9.85 :

$$(q_M)_{TC} = \frac{N_{Mp}.C_g.d^2.Y_1.\sqrt{\rho_{g1}}.\sqrt{h_w}}{\sqrt{1-\beta^4}.\left[X + 1.26(1-X).\sqrt{\rho_{g1}/\rho_l}\right]}$$

Equation 9.86:

$$(q_M)_g = X.(q_M)_{TC}$$

Equation 9.87:

$$F_X = \frac{1}{X + 1.26(1-X)\sqrt{\rho_{g1}/\rho_l}}$$

Equation 9.88: differential pressure of the dry gas

$$(h_w)_g = \frac{h_w}{\left\{1 + \left[1.26(1-X)/X\right]\sqrt{\rho_{g1}/\rho_l}\right\}^2}$$

Where:

$(q_M)_{TC}$: mass flow of the two components (gas and liquid water)

C_g : coefficient of discharge of the dry gas using the differential pressure of the dry gas $(h_w)_g$

d : orifice diameter at flowing temperature

Y_1 : expansion factor, calculated from differential pressure of the dry gas and measured static pressure

ρ_{g1} : upstream gas density calculated from ASME IAPWS-IF97 area 2 or AGA8 in temperature and static pressure measured
ρ_l : upstream liquid water density calculated from ASME IAPWS-IF97 area 1 in temperature and static pressure measured
h_w : differential pressure measured of the mixture
X : quality or title of the steam, percentage of steam in the mixture (steam and liquid water) in mass, supplied by user and resultant of laboratory analysis.
$(q_M)_g$: mass flow of the dry gas
F_x : quality correction factor
$(h_w)_g$: differential pressure of the dry gas, value calculated that corresponds to a value of differential pressure hypothetical corresponding only to flow of the dry gas.

Sequence of calculation:
1. Calculates ρ_{g1} (ASME IAPWS-IF97 or AGA8) and ρ_l (ASME IAPWS-IF97)
2. Calculates the differential pressure of the dry gas $(h_w)_g$
3. Calculates β and Y_1 (using the differential pressure of the dry gas)
4. Calculates the coefficient of steam discharge – C_g using the differential pressure of the dry gas $(h_w)_g$
5. Calculates $(q_M)_{TC}$ – mass flow of the two components (steam and liquid water).
6. Calculates $(q_M)_g$ – mass flow of the steam.

Calculation of Density based in the Second Virial Coefficient

The calculation of fluids density in gaseous state based in the second virial coefficient, whose equation is below, use the coefficients from the AIChE table for each type of fluid.

Procedure:
1. Calculation of the second virial coefficient (Richard W. Miller – equation 2.20)

$$B = a + \frac{b}{T_k} + \frac{c}{T_k^3} + \frac{d}{T_k^8} + \frac{e}{T_k^9}$$

Where:
B : second virial coefficient in $m^3/(kmol)$
a,b,c,d,e: coefficient from the AIChE tables for each type of fluid
Tk : flowing temperature in Kelvin

2. Calculation of molar density (Richar W. Miller – equation 2.18)

If B <0 :

$$\rho^*_{mol} = \frac{-1}{2B} - \frac{1}{2}\sqrt{\frac{1}{B^2} + \frac{4P^*_f}{BR^*_{OE}T_K}}$$

If B > 0 :

$$\rho^*_{mol} = \frac{-1}{2B} + \frac{1}{2}\sqrt{\frac{1}{B^2} + \frac{4P^*_f}{BR^*_{OE}T_K}}$$

If B = 0:

$$\rho^*_{mol} = \frac{P^*_f}{R^*_{OE}T_K}$$

Where:
ρ_{mol}^* : molar density in $kg.mol/m^3$
B : second virial coefficient in $m^3/(kg.mol)$
P_f^* :flowing pressure in Pascal
R_{OE}^* : universal constant of gases – 8 314.51 J/(kg.mol.K)
T_k : flowing temperature in Kelvin

3. Calculation of density in kg/m^3 (Richar W. Miller – equation 2.19)

$$\rho^*_f = M_w \rho^*_{mol}$$

Where:
ρ_f^* : density in kg/m^3
M_w : molar mass of the type of measured fluid
ρ_{mol}^* : molar density in kg.mol/m^3

Calculation of the Isentropic Coefficient

The calculation of isentropic coefficient (k) for fluids in gaseous state can be accomplished by two methods:
1. AIChE Fluid: based on specific heat the constant pressure for the ideal gas (Richard W. Miller – equation 2-275)

$$k_i = \left(\frac{C_p}{C_v}\right)_i = \frac{(C_p)_i}{(C_p)_i - 1.986}$$

Where:
$(C_p)_i$: specific heat the constant pressure for the ideal gas, obtained used the AIChE DIPPR 801 in Btu/(lb$_m$.mol.°R)
1.986 : universal constant of the gases in Btu/(lb$_m$.mol.°R)
2. Steam : based on sound velocity

$$k = \frac{w^2}{P_f . v}$$

Where:
w : sound velocity in m/s, obtained using ASME IAPWS-IF97
P_f : flowing static pressure in Pascal
v : specific volume in m^3/kg (inverse of density) , obtained using ASME IAPWS-IF97

Liquid Measurement

Correction Temperature Factor (CTL)

Correction hydrocarbon factors

The determination of the base density based on flowing density and temperature are related to odd tables (5, 23, 53 and 59). For the determination of CTL based on base density and temperature is related to even tables (6, 24, 54 and 60).
An algorithm overview is showed:

1. Determination of base density based on flowing density and temperature

It uses two equations. The equation derived from the equation of the coefficient of thermal expansion is showed below:

Equation 1:

$$CTL = \frac{V_b}{V} = \frac{\rho}{\rho_b} = \exp\left[-\alpha_b \Delta t\left(1 + 0.8\alpha_b \Delta t\right)\right]$$

Where:
CTL : correction factor from flowing temperature to base temperature
V_b : volume at base condition
V : volume at flowing condition
ρ : density at flowing condition
ρ_b : density at base condition
α_b : coefficient of thermal expansion at base temperature – this parameter changes with the temperature
Δt : differential temperature (flowing temperature – base temperature)

The next equation shows the relation between the base density and coefficient of thermal expansion at base conditions, whose coefficients Ko and K1 were determined using non-linear regression for the whole set of experimental points for each product type. This standard supports the liquid hydrocarbon, and separates them in four categories:
A – crude oil
B – generalized products (gasoline, diesel,...)

C – MTBE : special products which provide the coefficient of thermal expansion at base temperature instead of flowing or base density.
D – lubricating oil

Equation 2:

$$\alpha_b = \frac{K_0 + K_1 \rho_b}{\rho_b^2}$$

The parameters K_o and K_1 are determined according to the following table:

Tables	Product	K_o	K_1	Description
5/6 A, 23/24 A	Crude oil	341.0957	0	T_b=60°F and Kg/m^3
5/6 B, 23/24 B	Gasoline (650-770 kg/m^3)	192.4571	0.24380	
	Interpolation (770.5-787.5 kg/m^3) : A=-1.86840E-3 / B=1489.0670			
	Jet fuel e kerosene (787.53-838.3 kg/m^3)	330.3010	0	
	Diesel, heating oil and fuel oil (839-1075 kg/ m^3)	103.8720	0.27010	
5/6 D, 23/24 D	Lubricating oil	0	0.34878	
53/54 A	Crude oil	613.9723	0	T_b=15°C and Kg/m^3
53/54 B	Gasoline (650-770 kg/m^3)	346.4228	0.43880	
	Interpolation (770.5-787.5 kg/m^3) : A=-3.36312E-3 / B=2680.3206			
	Jet fuel and kerosene (787.53-838.3 kg/m^3)	594.5418	0	
	Diesel, heating oil and fuel oil (839-1075 kg/ m^3)	186.9696	0.48620	
53/54 D	Lubricating oil	0	0.62780	

Interpolation between the gasoline and kerosene ranges using the equation 3:

$$\alpha_b = A + \frac{B}{\rho_b^2}$$

Note that this procedure is not applied to the MTBE product, because is necessary to provide the coefficient of thermal expansion at base temperature, and then it calculates the correction factor CTL using the equation 1.

Basic procedure to determine the base density:

- Rounding the flowing density and temperature
- It checks if the value is between the range of calculation
- Iteractive process the first try for base density is the flowing density:
    1. It calculates the coefficient of thermal expansion using the equation 2 based on the base density;
    2. It calculates the new base density using the equation 1 and the coefficient of thermal expansion at base temperature determined in the previous item.
    3. It checks the convergence based on the variation of base density calculated in this and the previous iteraction, determining a maximum number of iteractions.

    It uses the base density calculated in this iteraction for the next iteraction. Repeat the sequence from the first item.
- It checks if there was not convergence, out of range, extrapolation range and inside the range.

If the calculation refers to the Table 59 (base temperature at 20°C), so the procedure modifies:

- It calculates the base density at 15°C according to the procedure above and then the coefficient of thermal expansion at 15°C.
- Using the equation 1 it calculates the factor $CTL_{20C \rightarrow 15C}$
- It calculates the base density at 20°C using the following equation

$$\rho_{20C} = \rho_{15C} * CTL_{20C \rightarrow 15C}$$

2. Determination of CTL based on base density and temperature

The procedure for the calculation of CTL based on base density and temperature is:

- Rounding of the base density and temperature
- It checks if the value is inside the calculation range
- It calculates the coefficient of thermal expansion at base temperature (equation 2), except for the MTBE;
- It calculates the CTL (equation 1).
- It checks if extrapolation region or inside the range.

If the calculation refers to the table 60 (base temperature at 20°C), so the procedure modifies:

- It calculates the base density at 15°C based on base density at 20°C.
- Using the base density at 15°C, it calculates two factors $CTL_{T\rightarrow 15C}$ and $CTL_{20C\rightarrow 15C}$
- It calculates the CTL using the following equation

$$CTL = \frac{CTL_{T\rightarrow 15C}}{CTL_{20C\rightarrow 15C}}$$

Correction factors for water

If the measured product is water, the correction factor for temperature is computed according to the following equation:

USA :

$$CTL_W = 1-(1.0312E-4+7.1568E-6*B)*\Delta t-(1.2701E-6-4.4641E-8*B)*\Delta t^2 + (1.2333E-9-2.2436E-11*B)\Delta t^3$$

Where:

$$B = (\rho_{60} - 999)/7.2$$

$$\Delta t = t - 60$$

SI :

$$CTL_W = 1-(1.8562E-4+1.2882E-5*B)*\Delta t-(4.1151E-6-1.4464E-7*B)*\Delta t^2 + (7.1926E-9-1.3085E-10*B)\Delta t^3$$

Where:

$$B = (\rho_{60} - 999)/7.2$$

$$\Delta t = t - 15$$

Correction Pressure Factor (CPL)

The compressibility factor is based on the base density, temperature, according to API-11.2.1., API-11.2.1.M standards, and it obtains the pressure correction factor (CPL).

$$F = E.\exp\left(A + Bt + \frac{C+Dt}{\rho_b{}^2}\right)$$

Where:
F: compressibility factor in psi or KPa
t : temperature in Fahrenheit or Celsius
ρ_b : base density in g/cm^3 regardless of the unit system used

Coefficients	API-11.2.1. (USA)	API-11.2.1.M (SI)
A	-1.99470	-1.62080
B	0.00013427	0.00021592
C	0.79392	0.87096
D	0.0023260	0.0042092
E	1E-5	1E-6

$$CPL = \frac{1}{1 - F(P - P_e)}$$

Where:
P : gauge pressure for the liquid
P_e :equilibrium pressure. For the four product types covered by the API-11.2.1 standard have value lower than the atmospheric pressure and by convention it considers the gauge zero pressure.

Correction factors for water
If the product is water or emulsion (crude oil and water), the correction factor for water pressure is calculated following the equation:

$CPL_w = 1 / (1 – F * P)$

Where:
P: gauge pressure which the water is submitted
F: the compressibility factor is a fixed value for water, according to the API-12.2.3 – Appendix A –

F = 3.20E-6 psi^{-1}
F = 4.64E-7 kPa^{-1}

Correction Factor for Ethanol

Using the NBR 5992-80, NBR5992-09 or OIML R22-75 standards, flowing density of the mixture and the flowing temperature, the base density and CTL factor are calculated.

There is an important difference between the standards above and the standards used for hydrocarbon, because such standards describe the behavior of the mixture ethanol and water density with the temperature, while the standards for hydrocarbon treat of substances without water. This difference is necessary because the standards for the ethanol treat of ethanol and water mixtures in a proportion of the ethanol in mass from 66% in NBR5992-80 and 0% for OIML R22-75 and NBR5992-09.

$$CTL = \frac{V_{m,b}}{V_{m,t}} = \frac{\rho_{m,t}}{\rho_{m,b}}$$

Where:
CTL : correction factor of the flowing temperature at base temperature
$V_{m,b}$: volume of the ethanol and water mixture at base condition
$V_{m,t}$: volume of the ethanol and water mixture at flowing condition
$\rho_{m,t}$: density of the ethanol and water at flowing condition
$\rho_{m,b}$: density of the ethanol and water mixture at base condition

Another variable calculated from the flowing density and flowing temperature is the percentage in mass of the ethanol in the mixture (p%), that is also denominated INPM degree in Brazil.

$$p\% = INPM = \frac{m_e}{m_m}$$

Where:
p% : percentage in mass of ethanol in the mixture
m_e : ethanol mass
m_m : mass of ethanol and water mixture.

For this product the compressibility factor will be considered null, therefore CPL=1

Thus the GSV calculation is:

$$GSV = IV * (CTL * MF)$$

The calculation of NSV presents a difference in relation to the liquid hydrocarbon, because when mixing ethanol and water happens a small shrink. Besides, BSW can be calculated by the following equations.

$$NSV = V_{e,b} = \frac{m_e}{\rho_{e,b}} = \frac{m_m * p\%}{\rho_{e,b}} = \frac{GSV * \rho_{m,b} * p\%}{\rho_{e,b}} = GSV(1 - BSW_b)$$

Where:

$V_{e,b}$: volume of ethanol at base temperature
Then the BSW is calculated using the following equation:

$$BSW_b = 1 - \frac{\rho_{m,b} * p\%}{\rho_{e,b}}$$

Where:
$\rho_{m,b}$: mixture density at base temperature
$\rho_{e,b}$: ethanol density at base temperature

	Density of pure ethanol		
Temperature	**OIML R22-75**	**NBR 5992-80**	**NBR5992-09**
15 ºC	793.51 kg/m^3	793,6 kg/m^3	793,50 kg/m^3
60 ºF	793.1 kg/m^3	793,1 kg/m^3	793,03 kg/m^3
20 ºC	789.24 kg/m^3	789,3 kg/m^3	789,23 kg/m^3

BSW_b : percentage of water in volume at base condition and considering the volumetric expansion to remove the water.

OIML R22 - 1975
All the tables of OIML R22 are based on Wagenbreth and Blake mathematical model, whose equation is:

$$\rho_{m,t} = A_1 + \sum_{k=2}^{12} A_k * p^{k-1} + \sum_{k=1}^{6} B_k * (t-20)^k + \sum_{i=1}^{n}\sum_{k=1}^{mi} C_{i,k} * p^k * (t-20)^i$$

Where:
t : temperature to calculate the density of the ethanol and water mixture in Celsius degree
p : percentage in mass of ethanol in the mixture (0 – 1.0)
$\rho_{m,t}$: density of ethanol and water mixture in kg/m^3.

The coefficients are:

k	Ak	Bk	C1,k
1	9.982012300000000E+02	-2.061851300000000E-01	1.693443461530090E-01
2	-1.929769495000000E+02	-5.268254200000000E-03	-1.046914743455170E+01
3	3.891238958000000E+02	3.613001300000000E-05	7.196353469546520E+01
4	-1.668103923000000E+03	-3.895770200000000E-07	-7.047478054272790E+02
5	1.352215441000000E+04	7.169354000000000E-09	3.924090430035050E+03
6	-8.829278388000000E+04	-9.973923100000000E-11	-1.210164659068750E+04
7	3.062874042000000E+05		2.248646550400790E+04
8	-6.138381234000000E+05		-2.605562982188160E+04
9	7.470172998000000E+05		1.852373922069470E+04
10	-5.478461354000000E+05		-7.420201433430140E+03
11	2.234460334000000E+05		1.285617841998970E+03
12	-3.903285426000000E+04		

k	C2,k	C3,k	C4,k	C5,k
1	-1.193013005057010E-02	-6.802995733503800E-04	4.075376675622030E-06	-2.788074354782410E-08
2	2.517399633803460E-01	1.876837790289660E-02	-8.763058573471110E-06	1.345612883493350E-08
3	-2.170575700536990E+00	-2.002561813734160E-01	6.515031360099360E-06	
4	1.353034988843030E+01	1.022992966719220E+00	-1.515784836987210E-06	
5	-5.029988758547010E+01	-2.895696483903640E+00		
6	1.096355666577570E+02	4.810060584300680E+00		
7	-1.422753946421160E+02	-4.672147440794680E+00		
8	1.080435942856230E+02	2.458043105903460E+00		
9	-4.414153236817390E+01	-5.411227621436810E-01		
10	7.442971530188780E+00			

NBR 5992 - 2009

The NBR 5992:2009 is based on Bettin and Spieweck (1990) mathematical model, which presents an equation to determe the density of the mixture at the operating temperature providing the alcoholic content in mass and operating temperature

$$\rho_{m,t} = A_1 + \sum_{k=2}^{12} A_k * (p - 0{,}5)^{k-1} + \sum_{k=1}^{6} B_k * (t - 20)^k + \sum_{i=1}^{n} \sum_{k=1}^{mi} C_{i,k} * (p - 0{,}5)^k * (t - 20)^i$$

Where :

t : temperature to calculate the density of the ethanol and water mixture in Celsius degree

p : percentage in mass of ethanol in the mixture (0 – 1.0)

$\rho_{m,t}$: density of ethanol and water mixture in kg/m^3.

The coefficients are:

k	Ak	Bk	C1,k
1	913.76673	-0.7943755	-0.39158709
2	-221.75948	-0.001216841	1.1518337
3	-59.61786	3.50178E-6	-5.0416999
4	146.82019	1.77094E-7	13.381608
5	-566.5175	-3.41388E-9	4.5899913
6	621.18006	-9.98802E-11	-118.21
7	3782.4439		190.5402
8	-9745.3133		339.81954
9	-9573.4653		-900.32344
10	32677.808		-349.32012
11	8763.7383		1285.9318
12	-39026.437		

k	C2,k	C3,k	C4,k	C5,k
1	-0.000120832	-3.86832E-5	-5.60249E-7	-1.44417E-8
2	-0.005746625	-0.000209114	-1.26492E-6	1.34705E-8
3	0.12030894	0.002671389	3.4864E-6	
4	-0.23519694	0.004104205	-1.51687E-6	
5	-1.0362738	-0.049364385		
6	2.1804505	-0.017952946		
7	4.2763108	0.29012506		
8	-6.8624848	0.023001712		
9	-6.9384031	-0.54150139		
10	7.4460428			

Algorithm for determination of the base density and percentage in mass of the ethanol is:

- Input data: mixture density at flowing temperature and the flowing temperature
- Iterative method for determination of the percentage in mass of the ethanol using the Wagenbreth and Blake equation or Bettin and Spieweck equation, flowing temperature and mixture density at flowing temperature.
- Calculation of the mixture density at base temperature using the Wagenbreth and Blake equation or Bettin and Spieweck equation, percentage in mass of the ethanol in the mixture (defined in the previous item) and flowing temperature.

Meter Factor (MF)

The meter factor results from the calibration process, where a reference volume is compared to the volume measured by the meter using the NKF. The MF adjusts the performance of the meter to the liquid measured in the correspondent viscosity, considering the flowing pressure and temperature, wearing and material deposition of the meter.

Flow Correction and Totalization Calculation

Indicated Volume – volume meter (IV): $IV = \frac{N}{NKF}$

Indicated Mass – mass meter (IM) : IM = N / NKF

Gross Standard Volume (GSV): GSV = IV * CCF

Net Standard Volume (NSV): NSV = GSV * (1 – SW%)

Pure product measured mass (MMpp): MMpp = NSV * Db,pp

Combined Correction Factor (CCF): CCF = CTL * CPL * MF

Pressure Correction Factor (CPL): $CPL = \frac{1}{1 - F * (P - P_E)}$

Where:

N – Number of pulses generated by the meter

NKF – Nominal K factor

SW% - Sendiments and water percentage

CTL – Temperature correction factor

CPL – Pressure correction factor

Db,pp – Base density of the pure product, oil or ethanol

Proving Process

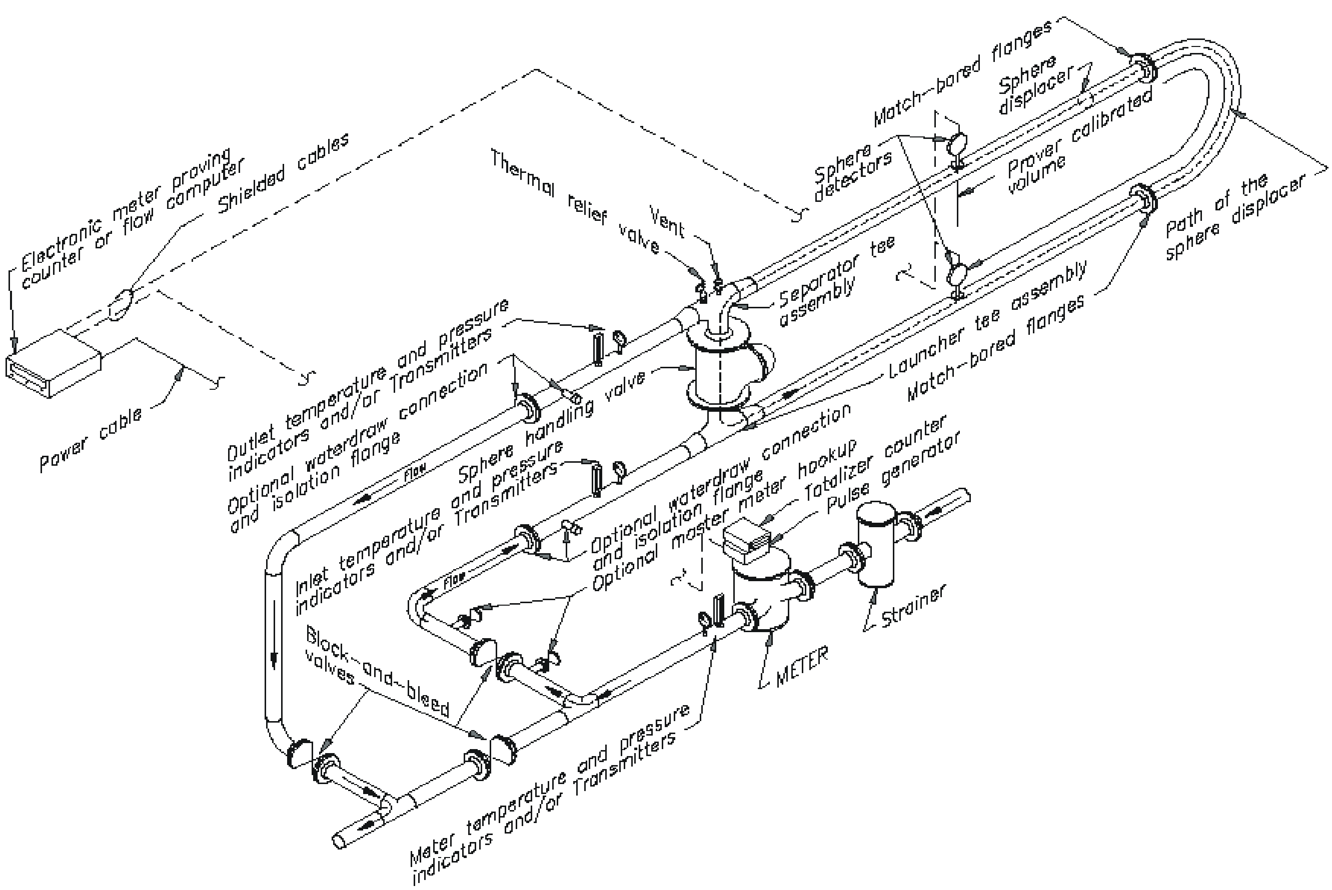
Definition

The turbine calibration process consists of flowing a known volume of liquid (similar to the liquid that will be measured in the process) through the meter and dividing it by the ISV (volume measured by the meter and corrected by the CTL and CPL factors). The result is the meter factor.

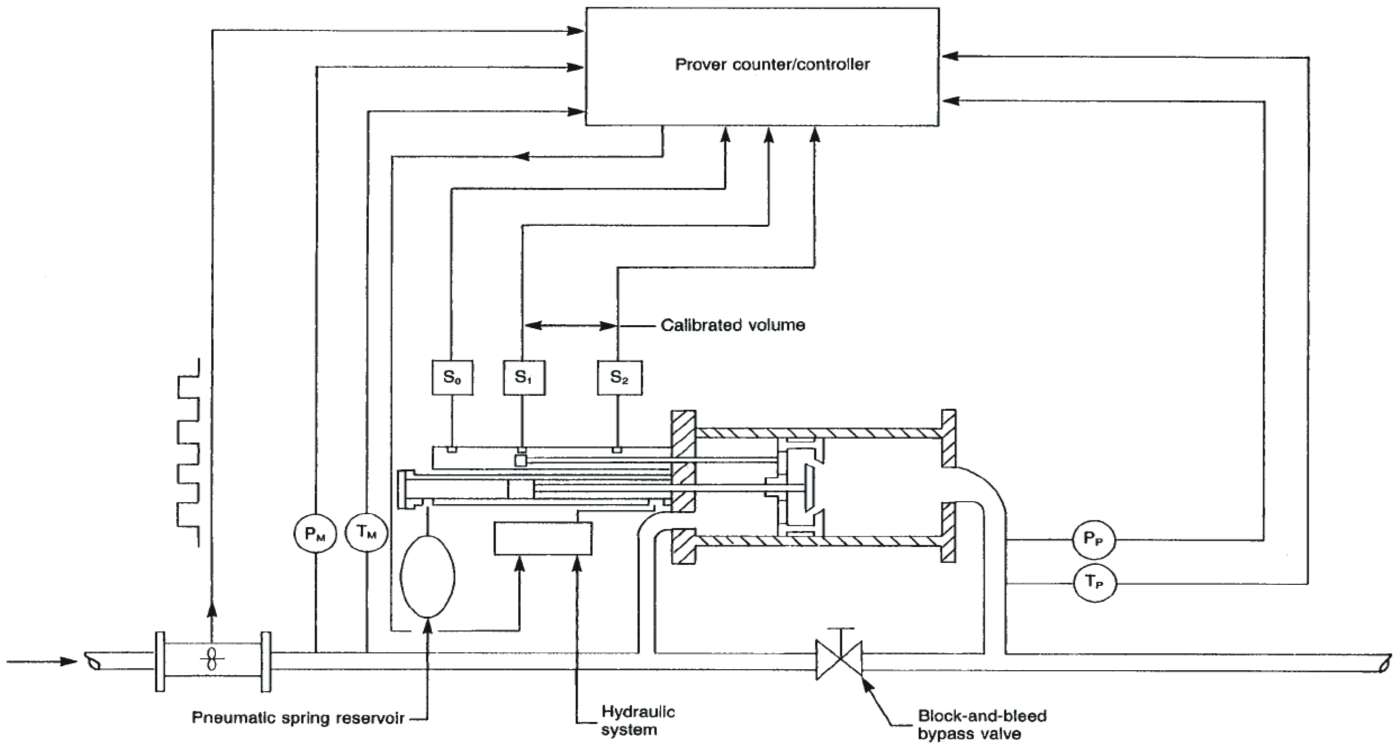
The API-12.2.3 Standard provides the background theory about the proving process. The procedures and equations specify the proving process and also provide the mandatory information for the proving process.

Prover Types

U-Type Prover – Displacement Prover, where an elastomer sphere displaces a known volume in a section of the pipeline (calibrated in specific conditions) delimited by sensors that detect the sphere motion.



Compact Prover – Displacement Prover using a piston. The volume displaced by the moving piston is not enough to generate 10.000 pulses in the meter, so it is necessary to calculate the interpolated number of pulses measured (API-4.6).



Master meter – It is a premium meter used only in the proving process. It can be permanently connected to the process or not. The master is calibrated by a prover, which calibrates the operational meter (indirect calibration method).

Tank Prover – The tank has a volume section calibrated in specific conditions and a scale of reading before and after the tank is emptied (proving batch). The difference is the reference volume that flowed through the meter.

Calculations executed in the Proving Process

Weighed averages calculation – The correction factors are calculated using the weighed averages (volume in base conditions) of density, temperature and pressure.

Gross standard volume of prover (GSVp) – The volume of the calibrated section of the prover in specific conditions is converted to the flowing conditions, considering the kind of the material used in the prover, corrected by the temperature (CTSp) and pressure (CPSp). The corrected volume corresponds to the volume of the liquid in flowing conditions that flows through the meter, and then this volume is converted to the base conditions considering the product properties, related to the temperature (CTLp) and pressure (CPLp).

- Prover :

GSVp = BPV * CCFp
Where: CCFp = CTSp * CPSp * CTLp * CPLp

- Master meter:

GSVmm= IVmm * CCFmm
Where:

$$IVmm = \frac{Nmm}{NKFmm}$$

CCFmm= CTLmm * CPLmm * MMF

MMF: master meter factor
Nmm: number of pulses measured by the master meter

Indicated Standard Volume (ISVm) Calculation – It is the volume measured by the meter considering only the NKF, and then converted to the base conditions, applying the temperature (CTLm) and pressure (CPLm) correction factors.

ISVm= IVm * CCFm

Where:
IVm= Nm / NKF
CCFm= CTLm * CPLm
Nm: number of pulses measured by the meter during one proving execution.

Meter Factor (MF) Calculation – It is the ratio of GSVp (or GSVmm) divided by ISVm.

$$MF = \frac{GSVp}{ISVm}$$

Acceptability Criteria
The proving process requires several proving batches to be executed in order to accept the process. Some criteria are:

- Any 5 of 6 consecutive proving batches: the best 5 proving batches are selected (the batches closer to the average).
- 5 consecutive batches of 10 consecutive: select 5 consecutive batches or at most 10 consecutive batches that fulfill the required repeatability.
- 5 consecutive batches.
- 3 consecutive batches.

Method
When the calibration uses a prover, there are two possibilities to determine the meter factor (MF):

- Average data: It calculates the weighed average of variables (temperature, pressure and density) for each proving batch accepted and the correction factors are calculated using the average of weighed average: GSVp, ISMm and MF.
- Average Meter factor: For each proving batch, it calculates the correction factors: GSVp, ISVm and IMF.

When the calibration uses a master meter, the only method accepted is the Average meter factor.

Repeatability
The repeatability required from the proving batches for custody transfer is 0.05%. When a master meter is submitted to a proving process, the repeatability required is 0.02%.

The repeatability is calculated as indicated below, according to the selected method:

- Average data :
  $$R\% = \frac{max\ Nm - min\ Nm}{min\ Nm}$$
  onde : Nm – number of pulses of the meter

- Average MF :
  $$R\% = \frac{max\ IMF - min\ IMF}{min\ IMF}$$

MF Calculation
If the repeatability is fulfilled, the MF will be calculated using the selected criteria, it means that some proving batches will be used, while others will be rejected.

Calculation Sequence for different proving configurations – The calculation sequence and the discrimination for intermediate variables are important to obtain the same results, regardless of the flow computer or the calculation system used. The information below is relative to the HFC302 implementation:
PV = Prover Volume
PM = Prover Mass
MM = Measured Mass

IM = Indicated Mass
Db = Base density in mass/volume in engineering units corresponding of mass and volume
Df = Flowing density in mass/volume in engineering units corresponding of mass and volume

ID	Density Type	Meter Type	Prover Type / Method	Calculation	Supported by HFC302 in Appropriation Measurement
1	Flowing density	IV pulse	- Master meter - IV pulse	- CCFmm = CTLmm * CPLmm * MFmm - IVmm = Nmm/NKFmm - GSVmm = IVmm * CCFmm - CCFm = CTLm * CPLm - IVm = Nm / NKFm - ISVm = IVm * CCFm - IMF = GSVmm / ISVm	- CCFmm = [(1-X_w)*CTLo,mm * CPLo,mm +X_w*CTLw,mm * CPLw,mm] * MFmm - IVmm = Nmm/NKFmm - GSVmm = IVmm * CCFmm - CCFm = (1-X_w)*CTLo,m * CPLo,m +X_w*CTLw,m * CPLw,m - IVm = Nm / NKFm - ISVm = IVm * CCFm - IMF = GSVmm / ISVm
2	Flowing density	IV pulse	- Master meter - IM pulse	- CCFmm = CTLmm * CPLmm * MFmm - IMmm = Nmm / NKFmm - IVmm = IMmm / Dfmm - GSVmm = IVmm * CCFmm - CCFm = CTLm * CPLm - IVm = Nm / NKFm - ISVm = IVm * CCFm - IMF = GSVmm / ISVm	No
3	Base density	IM pulse	- Master meter - IV*CTL pulse	- IVmm = Nmm/(NKFmm * CTLmm) - IMmm = IVmm * Dbmm * CTLmm - MMmm = IMmm * MFmm - IMm = Nm / NKFm - IMF = MMmm / IMm	No
4	Flowing density	IM pulse	- Master meter - IM pulse	- IMmm = Nmm/NKFmm - MMmm = IMmm * MFmm - IMm = Nm / NKFm - IMF = MMmm / IMm	- IMmm = Nmm/NKFmm - MMmm = IMmm * MFmm - IMm = Nm / NKFm - IMF = MMmm / IMm
5	Flowing density	IV*CTL pulse	- Master meter - IV pulse	- CCFmm = CTLmm * CPLmm * MFmm - IVmm = Nmm/NKFmm - GSVmm = IVmm * CCFmm - CCFm = CTLm * CPLm - IVm = Nm / (NKFm * CTLm) - ISVm = IVm * CCFm - IMF = GSVmm / ISVm	No
6	Base density	IV*CTL pulse	- Master meter - IV pulse	- CCFmm = CTLmm * CPLmm * MFmm - IVmm = Nmm/NKFmm - GSVmm = IVmm * CCFmm - CCFm = CTLm * CPLm - IVm = Nm / (NKFm * CTLm) - ISVm = IVm * CCFm - IMF = GSVmm / ISVm	No
7	Base density	IV*CTL pulse	- Master meter - IM pulse	- CCFmm = CTLmm * CPLmm * MFmm - IMmm = Nmm/NKFmm - IVmm = IMmm / (Dbmm * CTLmm) - GSVmm = IVmm * CCFmm - CCFm = CTLm * CPLm - IVm = Nm / (NKFm * CTLm) - ISVm = IVm * CCFm - IMF = GSVmm / ISVm	No
8	Flowing density	IV analog input	- Master meter - IV analog input	- CCFmm = CTLmm * CPLmm * MFmm - IVmm = ∫ (Qv,mm * Δt) - GSVmm = IVmm * CCFmm - CCFm = CTLm * CPLm - IVm = ∫ (Qv,m * Δt) - ISVm = IVm * CCFm - IMF = GSVmm / ISVm	- CCFmm = [(1-X_w)*CTLo,mm*CPLo,mm +X_w*CTLw,mm*CPLw,mm] * MFmm - IVmm = ∫ (Qv,mm * Δt) - GSVmm = IVmm * CCFmm - CCFm = (1-X_w)*CTLo,m*CPLo,m +X_w*CTLw,m*CPLw,m - IVm = ∫ (Qv,m * Δt) - ISVm = IVm * CCFm - IMF = GSVmm / ISVm
9	Flowing density	IM analog input	- Master meter - IM analog input	- IMmm = ∫ (Qm,mm * Δt) - MMmm = IMmm * MFmm - IMm = ∫ (Qm,m * Δt) - IMF = MMmm / IMm	- IMmm = ∫ (Qm,mm * Δt) - MMmm = IMmm * MFmm - IMm = ∫ (Qm,m * Δt) - IMF = MMmm / IMm
10	Flowing density	IV pulse	- Piston prover - Avg MF	- CCFp = CTSp * CPSp * CTLp * CPLp	- CCFp = CTSp * CPSp * [(1-X_w)*CTLo,p* CPLo,p +X_w*CTLw,p*CPLw,p]

ID	Density Type	Meter Type	Prover Type / Method	Calculation	Supported by HFC302 in Appropriation Measurement
				- GSVp = BPV * CCFp - CCFm = CTLm * CPLm - IVm = Ni / NKFm - ISVm = IVm * CCFm - IMF = GSVp / ISVm	- GSVp = BPV * CCFp - CCFm = (1-X_w)*CTLo,m*CPLo,m +X_w*CTLw,m*CPLw,m - IVm = Ni / NKFm - ISVm = IVm * CCFm - IMF = GSVp / ISVm
11	Flowing density	IV*CTL pulse	- Piston prover - Avg Data	- CCFp = CTSp * CPSp * CTLp * CPLp - GSVp = BPV * CCFp - CCFm = CTLm * CPLm - IVm = Ni(avg) / (NKFm * CTLm) - ISVm = IVm * CCFm - MF = GSVp / ISVm	No
12	Base density	IV pulse	- Piston prover - Avg MF	- CCFp = CTSp * CPSp * CTLp * CPLp - GSVp = BPV * CCFp - CCFm = CTLm * CPLm - IVm = Ni / NKFm - ISVm = IVm * CCFm - IMF = GSVp / ISVm	- CCFp = CTSp * CPSp * [(1-Xw)*CTLo,p*CPLo,p+Xw*CTLw,p*CPLw,p] - GSVp = BPV * CCFp - CCFm = [(1-Xw)*CTLo,m*CPLo,m+Xw*CTLw,m*CPLw,m] - IVm = Ni / NKFm - ISVm = IVm * CCFm - IMF = GSVp / ISVm
13	Base density	IV*CTL pulse	- Piston prover - Avg Data	- CCFp = CTSp * CPSp * CTLp * CPLp - GSVp = BPV * CCFp - CCFm = CTLm * CPLm - IVm = Ni(avg) / (NKFm * CTLm) - ISVm = IVm * CCFm - MF = GSVp / ISVm	No
14	Flowing density	IM pulse	- Piston prover - Avg MF	- CCFp = CTSp * CPSp - PV = BPV * CCFp - PM = PV * Dfp - IMm = Ni / NKFm - IMF = PM / IMm	No
15	Flowing density	IM pulse	- Piston prover - Avg Data	- CCFp = CTSp * CPSp - PV = BPV * CCFp - PM = PV * Dfp - IMm = Ni(avg) / NKFm - MF = PM / IMm	No
16	Base density	IM pulse	- Piston prover - Avg MF	- CCFp = CTSp * CPSp - PV = BPV * CCFp - PM = PV * Dbp * CTLp - IMm = Ni / NKFm - IMF = PM / IMm	No
17	Base density	IM pulse	- Piston prover - Avg Data	- CCFp = CTSp * CPSp - PV = BPV * CCFp - PM = PV * Dbp * CTLp - IMm = Ni(avg) / NKFm - MF = PM / IMm	No
18	Flowing density	- Master meter - IV pulse	- Piston prover - Avg Data	- CCFp = CTSp * CPSp * CTLp * CPLp - GSVp = BPV * CCFp - CCFmm = CTLmm * CPLmm - IVmm = Ni(avg) / NKFmm - ISVmm = IVm * CCFmm - MF = GSVp / ISVmm	- CCFp = CTSp * CPSp * [(1-Xw)*CTLo,p*CPLo,p +Xw*CTLw,p*CPLw,p] - GSVp = BPV * CCFp - CCFmm = (1-Xw)*CTLo,mm*CPLo,mm +Xw*CTLw,mm*CPLw,mm - IVmm = Ni(avg) / NKFmm - ISVmm = IVmm * CCFmm - MF = GSVp / ISVmm
19	Flowing density	- Master meter - IV pulse	- Ball prover bidirectional - Avg data	- CCFp = CTSp * CPSp * CTLp * CPLp - GSVp = BPV * CCFp - CCFmm = CTLmm * CPLmm - IVmm = Ni(avg) / NKFmm - ISVmm = IVm * CCFmm - MF = GSVp / ISVmm	- CCFp = CTSp * CPSp * [(1-Xw)*CTLo,p*CPLo,p +Xw*CTLw,p*CPLw,p] - GSVp = BPV * CCFp - CCFmm = (1-Xw)*CTLo,mm*CPLo,mm +Xw*CTLw,mm*CPLw,mm] - IVmm = Ni(avg) / NKFmm - ISVmm = IVmm * CCFmm - MF = GSVp / ISVmm
20	Flowing density	IV pulse	- Tank prover	- CCFp = CTSp * CTLp - GSVp = BPVa * CCFp - CCFm = CTLm * CPLm - IVm = Nm / NKFm - ISVm = IVm * CCFm - IMF = GSVp / ISVm	- CCFp = CTSp * [(1-Xw)*CTLo,p+Xw*CTLw,p] - GSVp = BPVa * CCFp - CCFm = [(1-X_w)*CTLo,m*CPLo,m +X_w*CTLw,m*CPLw,m] - IVm = Nm / NKFm - ISVm = IVm * CCFm - IMF = GSVp / ISVm

ID	Density Type	Meter Type	Prover Type / Method	Calculation	Supported by HFC302 in Appropriation Measurement
21	Flowing density	IV*CTL pulse	- Tank prover	- CCFp = CTSp * CTLp - GSVp = BPVa * CCFp - CCFm = CTLm * CPLm - IVm = Nm / (NKFm * CTLm) - ISVm = IVm * CCFm - IMF = GSVp / ISVm	No
22	Flowing density	IM pulse	- Tank prover	- CCFp = CTSp - PV = BPVa * CCFp - PM = PV * Dfp - IMm = Nm / NKFm - IMF = PM / IMm	No
23	Base density	IV*CTL pulse	- Tank prover	- CCFp = CTSp * CTLp - GSVp = BPVa * CCFp - CCFm = CTLm * CPLm - IVm = Nm / (NKFm * CTLm) - ISVm = IVm * CCFm - IMF = GSVp / ISVm	No
24	Base density	- Master meter - IV pulse	- Tank prover	- CCFp = CTSp * CTLp - GSVp = BPVa * CCFp - CCFmm = CTLmm * CPLmm - IVmm = Nmm / NKFmm - ISVmm = IVmm * CCFmm - IMF = GSVp / ISVmm	- CCFp = CTSp * [(1-Xw)*CTLo,p+Xw*CTLw,p] - GSVp = BPVa * CCFp - CCFmm = (1-X_w)*CTLo,mm*CPLo,mm +X_w*CTLw,mm*CPLw,mm - IVmm = Nmm / NKFmm - ISVmm = IVmm * CCFmm - IMF = GSVp / ISVmm

Equations used for allocation measurement

According to the API-20.1 standard page 24 for pipe prover and piston prover:

$$MF = \frac{[BPV * (1 - X_w) * CTL_p * CPL_p + BPV * X_w * CTL_w * CPL_w] * CTS_p * CPS_p}{IV_m * (1 - X_w) * CTL_m * CPL_m + IV_m * X_w * CTL_w * CPL_w}$$

For more details about the correction factors applied, it has the following equation:

Pipe prover / Piston prover :

$$MF = \frac{BPV * CTS_p * CPS_p * [(1 - X_w) * CTL_{o,p} * CPL_{o,p} + X_w * CTL_{w,p} * CPL_{w,p}]}{IV_m * [(1 - X_w) * CTL_{o,m} * CPL_{o,m} + X_w * CTL_{w,m} * CPL_{w,m}]}$$

Where:

$CTL_{o,p}$: CTL for oil in the prover
$CTL_{w,p}$: CTL for water in the prover
$CTL_{o,m}$: CTL for oil in the meter
$CTL_{w,m}$: CTL for water in the meter
$CPL_{o,p}$: CPL for oil in the prover
$CPL_{w,p}$: CPL for water in the prover
$CPL_{o,m}$: CPL for oil in the meter
$CPL_{w,m}$: CPL for water in the meter
X_w : percentage of water in volume at flowing condition

Master meter :

$$MF = \frac{IV_{mm} * [(1 - X_w) * CTL_{o,mm} * CPL_{o,mm} + X_w * CTL_{w,mm} * CPL_{w,mm}] * MMF}{IV_m * [(1 - X_w) * CTL_{o,m} * CPL_{o,m} + X_w * CTL_{w,m} * CPL_{w,m}]}$$

Where:

$CTL_{o,mm}$: CTL for oil in the master meter
$CTL_{w,mm}$: CTL for water in the master meter
$CTL_{o,m}$: CTL for oil in the meter
$CTL_{w,m}$: CTL for water in the meter
$CPL_{o,mm}$: CPL for oil in the master meter
$CPL_{w,mm}$: CPL for water in the master meter
$CPL_{o,m}$: CPL for oil in the meter
$CPL_{w,m}$: CPL for water in the meter

Chapter 3

HARDWARE

WARNING: Failing to fulfill any step described in this chapter may imply system malfunction.

Racks, cables and accessories of AuditFlow system

MODEL	DESCRIPTION
DF0	Blind module to fill empty slots
DF1A	Rack with 4 slots – support to shielded flat cable
DF2	Terminator for the last rack – right side
DF3	Flat cable to connect 2 racks – length 6.5 cm
DF4A	Flat cable to connect 2 racks – length 65 cm
DF5A	Flat cable to connect 2 racks – length 81,5 cm
DF6A	Flat cable to connect 2 racks – length 98 cm
DF7A	Flat cable to connect 2 racks – length 110 cm
DF9	Support for a single module
DF54	Twisted pair cable 100 Base-TX
DF55	Twisted pair cable 100 Base-TX – cross cable – length 2m
DF59	Cable RJ12 used to connect controllers and DF58
DF78	Rack with 4 slots – It supports Hot Swap of CPUs and redundant I/O access
DF82	Synchronism cable to connect redundant controllers – length 500 mm
DF83	Synchronism cable to connect redundant controllers – length 1800 mm
DF84	IMB Soft Starter
DF90	IMB power cable
DF91	Lateral adapter
DF92	Rack with 4 slots for redundant CPUs, hot swap and diagnostic support
DF93	Rack with 4 slots, with diagnostic
DF96	Terminator for the last rack – left side
DF101	Flat cable to connect racks by left side – length 70 cm
DF102	Flat cable to connect racks by right side – length 65 cm
DF103	Flat cable to connect racks by right side – length 81 cm
DF104	Flat cable to connect racks by right side – length 98 cm
DF105	Flat cable to connect racks by right side – length 115 cm

Installing the system's base with DF92 and DF93 racks

In the following figure is shown the DF93 rack with its components.

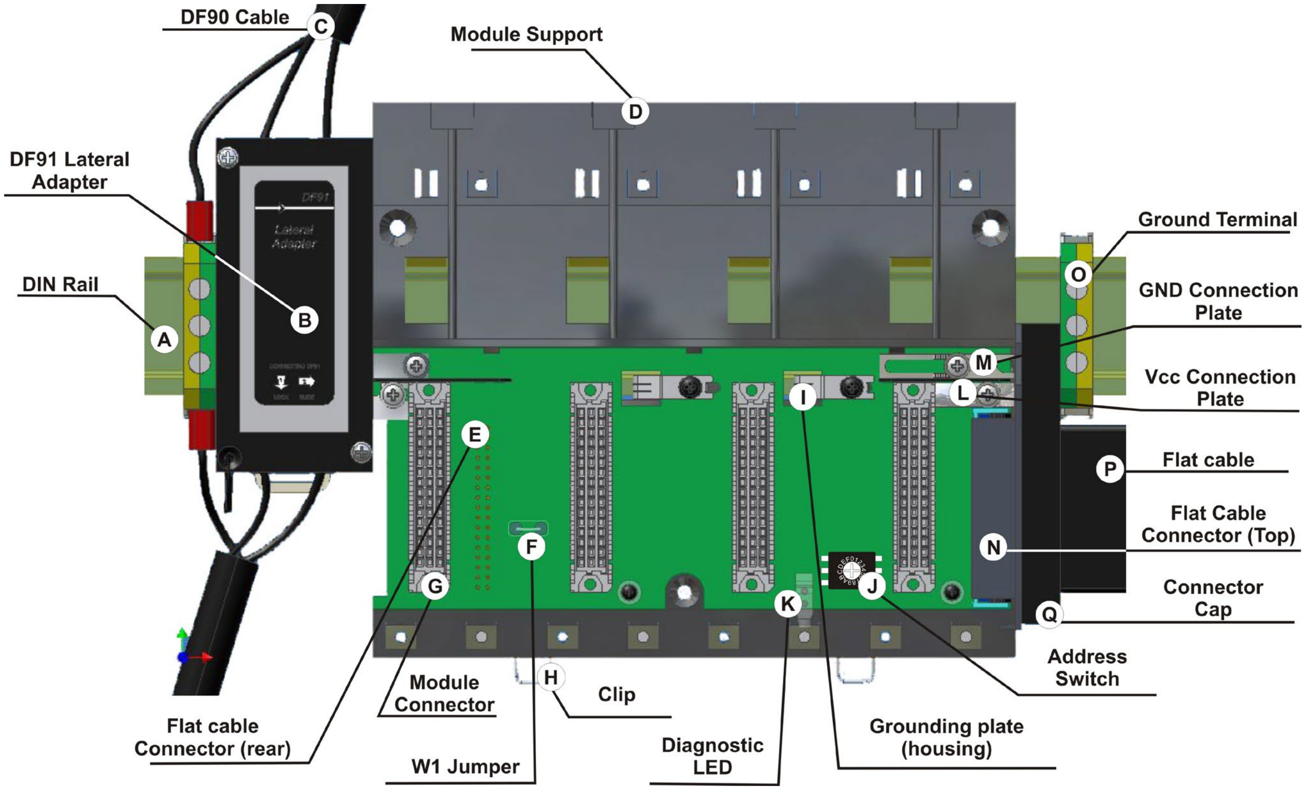


Figure 3. 1 - DF93 components

A – DIN rail- Base for rack connection. It should be tightly fixed to the place where the rack is being mounted.

B – Lateral adapter DF91 – It allows the connection of DF90 cables to rack.

C – DF90 cable– Cable for IMB power transmission. In this cable is the Vcc and GND of IMB and it has to be connected in the rack's left side.

D – Module support - Module holder located in the top of the rack.

E – Flat Cable Connector (rear) – It allows that two racks are interconnected by flat cable (P). When there is more than one rack in a same DIN rail, the user should proceed as described in the "Connection between adjacent racks" topic.

F –**W1 Jumper –** To disconnect the rack from the power of the previous rack, W1 must be cut, together with the Vcc connection plate (L) of the previous rack. This condition is necessary if a new power supply is inserted from this rack.

G – Module connector – Connector to attach the module's bottom part to the rack.

H – Clips – The metal clips, located in the rack's bottom part, allow attaching the rack to the DIN rail. They must be pulled before fitting the rack on DIN rail, and then, pushed for pieces fixation.

I – Grounding plate (housing)

J – Address switch – When there is more than one rack in same data bus, the addressing switch allows different addresses to each rack.

K – LED for diagnostic – It is used for diagnostic of the rack's voltage.

L – Vcc connection plate – Vcc terminal (for power transmission).

M – GND connection plate - GND terminal (for power transmission).

N – Flat Cable Connector (top) – It allows that two racks are interconnected by flat cable (P). When there is more than one rack in a same DIN rail, the user should proceed as described in the "Connection between adjacent racks" topic.

O – Ground terminal – It is used to ground the flat cables shield.

P – Flat Cable – Cable used to interconnect the data bus among racks.

Q – Connector cap – To meet the EMC requeriments a protector against ESD must be installed in the flat cables connections, at right.

Installing Racks - DF92 and DF93

The DF92 is used by redundant controllers, and it must be the first rack of IMB. The other racks must be DF93.

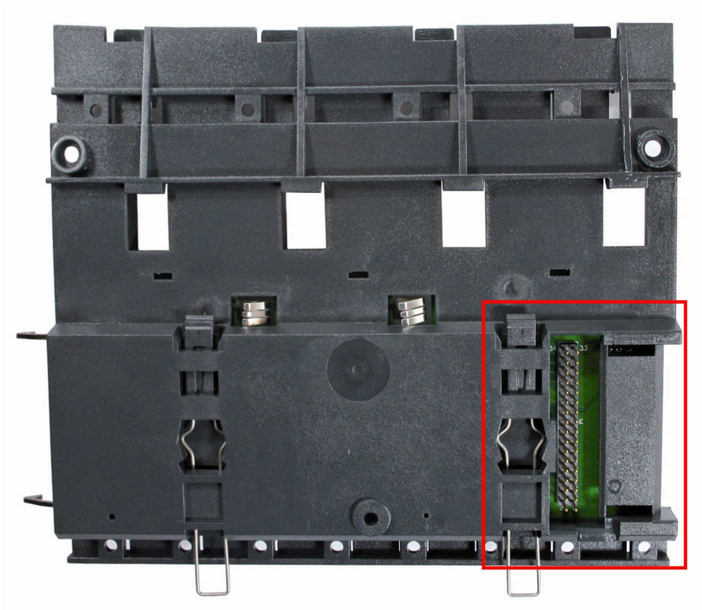


Figure 3. 2 - Rear connector of DF93 rack

IMPORTANT
Remember to leave a space in the DIN rail to install the DF91 and the grounding terminal at rack's left side.

Installing racks in the DIN rail

IMPORTANT
Before installing the rack on DIN rail, connect the flat cable to rear's connector (E) if you will connect this rack to another at left. After connected to the DIN rail is not possible place the flat cable on the rear's rack without remove it.

1. Use a screwdriver (or your fingers) to pull the clips down**.**
2. Place the back of the rack on the top of the DIN rail edge.
3. Accommodate the rack on the DIN rail and push the clips up. You will hear a click sound when they lock properly.
4. Set the correct address for the DF93 rack using its rotating switch (J). The DF92 rack does not have address switch.

Connection between adjacent racks

1. The adjacent cards to the joining part, between the racks, must be removed allowing access to this operation (racks's third slot, at left and slot 0 of rack, at right).
2. Connect the two racks using DF3 flat cable. This flat cable should already be connected to the connector on the rear's rack at right. And then, connect it to the top connector (N) of the rack at left.
3. Connect the two racks to the power connectors (L and M), moving them with a screwdriver and fixing with screws. Loose the screws only the suficient avoiding them from falling when making the connection. See the next figure.

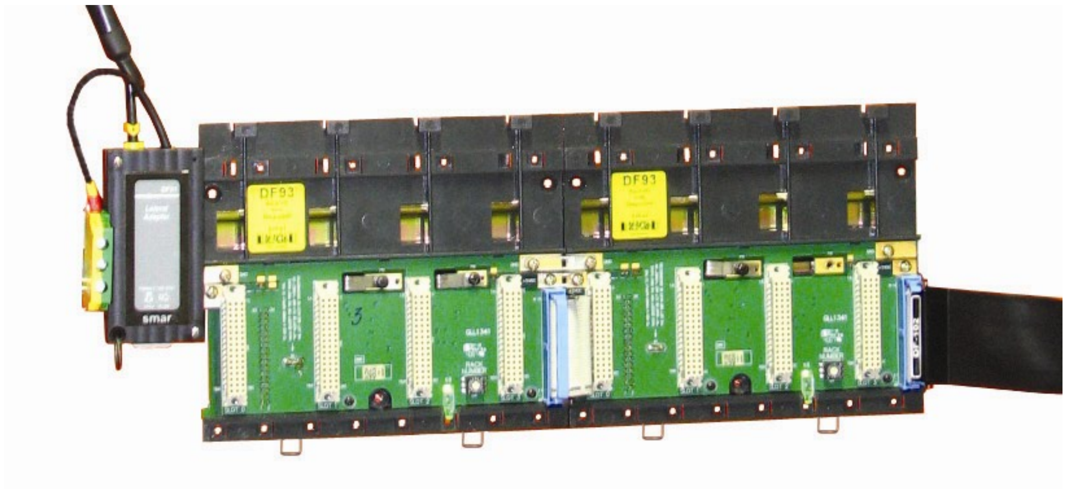


Figure 3. 3 - Connection between adjacent racks

Using the DF91

For further details about DF91 installation, refer to "Expanding the system's power supply – DF90 and DF91" topic.

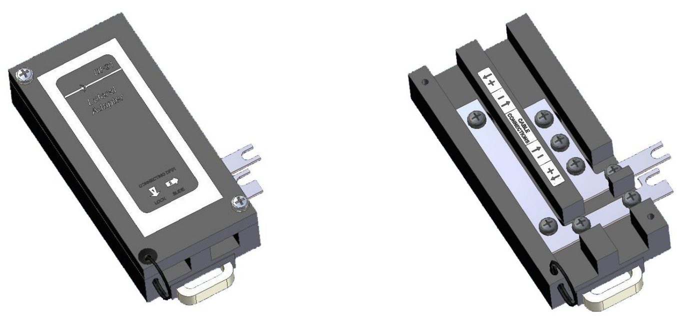


Figure 3. 4 - DF91 details

Left side ESD protection

If the power supply side connector on the left side of the rack (DF92 or DF93) is disconnected, it should be capped with the left side ESD protection for compatibility with the EMC standards. This situation can occur in the left-most rack in systems with a single row of racks or systems with individual racks.

The installation is done screwing the protection in the connection terminals on the left side of the rack. See the following figure.

Figure 3. 5 – Left side ESD protection installed on the rack

This protection is provided along with the DF2 terminator.

Disconnecting racks

1. The adjacent cards to the joining part, between the racks, must be removed allowing access to this operation.
2. Remove the flat cable of top connector (N) of the adjacent rack, at left.
3. Remove the power connections (L and M) of both sides of the rack that will be disconnected. For that, with a screwdriver, release the screws (only the sufficient) and move the connection plates to left until they are completely withdrawn, thus the rack is free to be removed.
4. If the DF91 (B) is connected to rack that will be removed, remove it until the rack to be free.
5. Remove the rear connector (E) after removing the rack from DIN rail.

Installing the expansion flat cables - DF101, DF102, DF103, DF104 and DF105.

These flat cables are used when the AuditFlow is expanded in more than one row of racks, i.e., in different DIN rail segments, one below the other.

DF101 - Flat cable to connect racks by left side

It is installed in the rack's rear connectors (E) of the left extremity of each row of racks, interconnecting the rows 2-3, 4-5 and 6-7 (if they exist).

To ground the flat cables shield, use the ground terminal (O) next to flat cables connection. The available terminal, next to each DF91 (B), can be used.

DF102, DF103, DF104 and DF105 - Flat cable to connect racks by right side

They are installed on the upper connectors (N) of the right extremity rack of each row of racks, interconnecting the rows 1-2, 3-4 and 5-6 (if they exist).

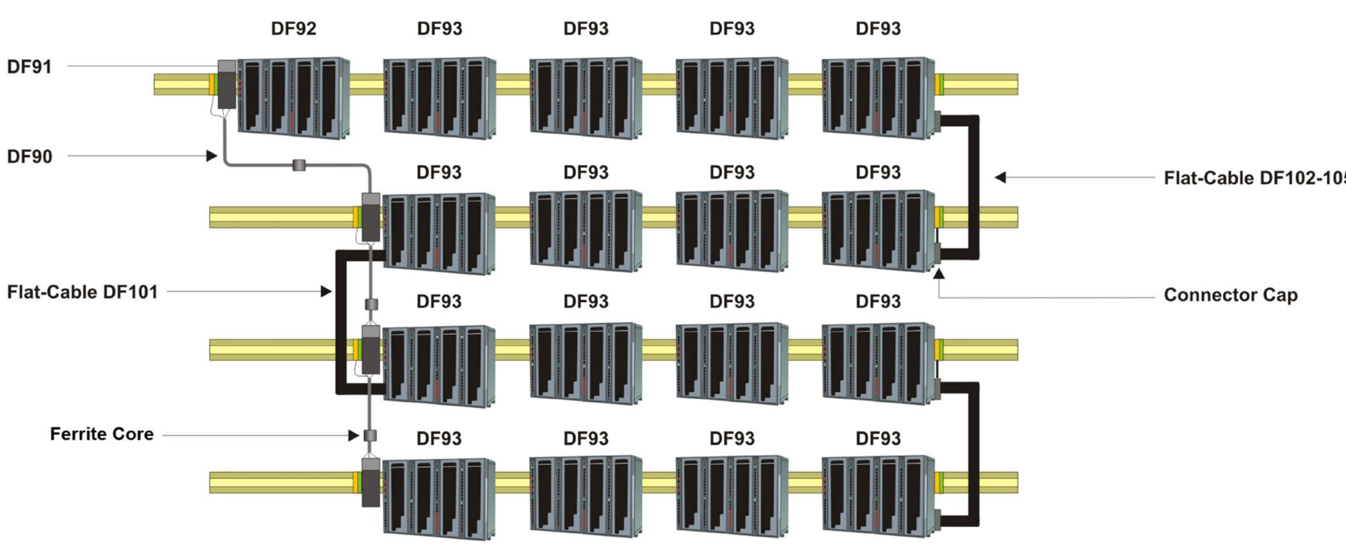


Figure 3. 6 - Illustration - DF101 and DF102-105 Flat cables

To ground the flat cables shield, use the ground terminals (O) next to flat cables connection.

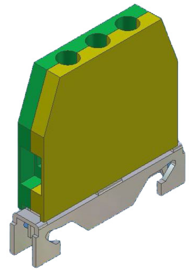


Figure 3. 7 - Ground terminal

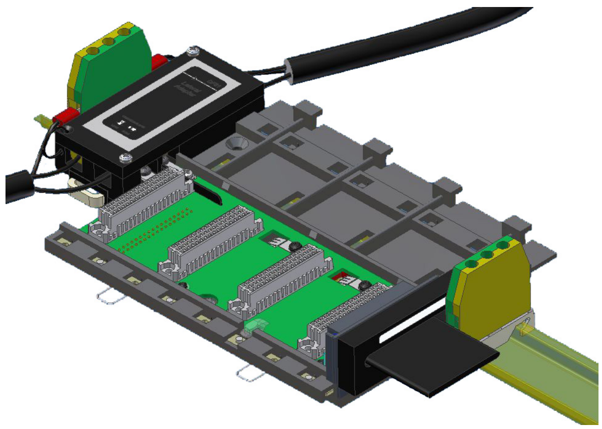


Figure 3. 8 - Ground terminal installed

Flat cables protector (connector cap)

To meet the EMC requirements a protector against ESD has to be installed on the flat cables connection, at right. In the following figure a flat cable protector is shown when it is being installed on the cable connector.

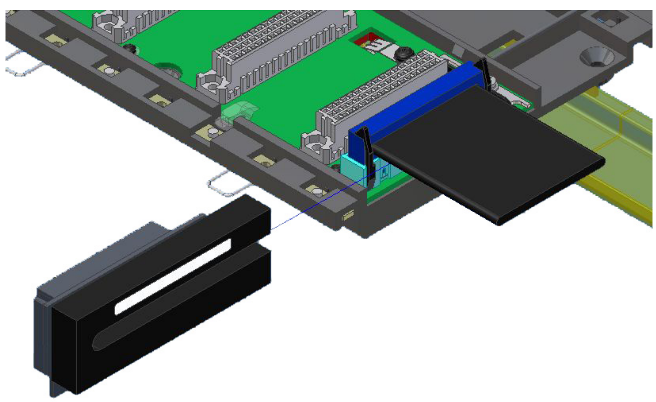


Figure 3. 9 - Installing the connector cap

In the following figure is shown a connector cap installed.

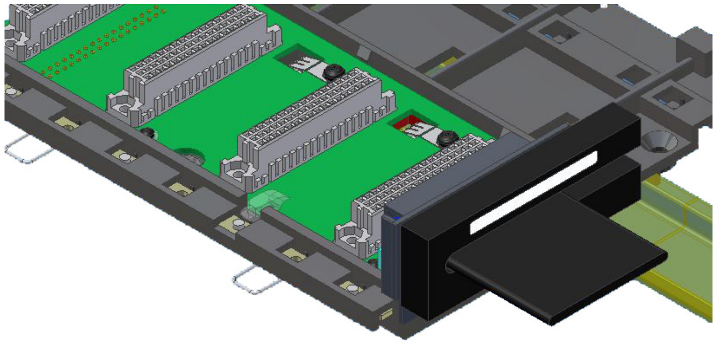


Figure 3. 10 - Connector cap installed

Installing the IMB terminator - DF2 or DF96

Only one of these two terminators types (DF2 or DF96) must to be installed at the end of IMB bus. It will depend on which side the last rack is connected to the system.

DF2 – IMB terminator for right side

It is connected to connector N of the last rack, when it is connected to the others by the left side. See the following figure.

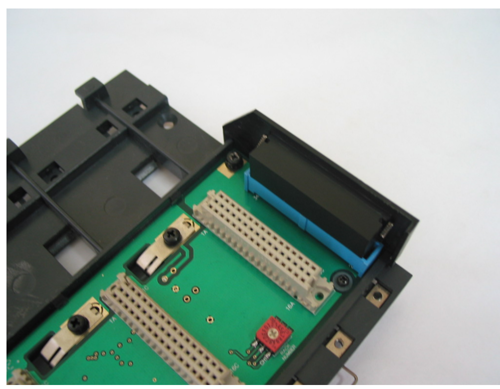


Figure 3. 11 - DF2 terminator installed

For further details about its installation refer to DF2 manual.

DF96 – IMB terminator for left side

It is connected to connector E of the last rack, when it is connected to the others by the right side. See the next figure.

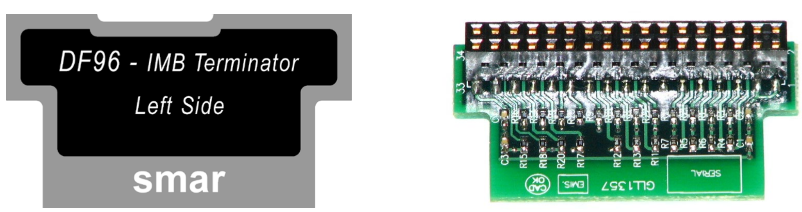


Figure 3. 12 - DF96 terminator

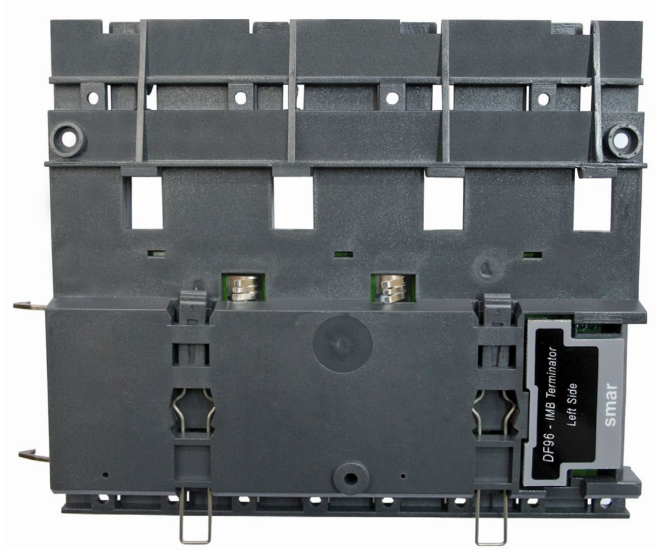


Figure 3. 13 - DF96 terminator installed in the DF93 rack

Summarizing, if the last rack has a flat cable connected by left side, use the DF2 terminator. If the last rack has a flat cable connected by right, use DF96 rack.

Both cases depend on the number of row of racks, if it is even or odd.

Expanding the system's power - DF90 and DF91.

This expansion has to be used when the Auditflow is expanded in more than one row of racks, i.e., in different DIN rail segments, one below the other.

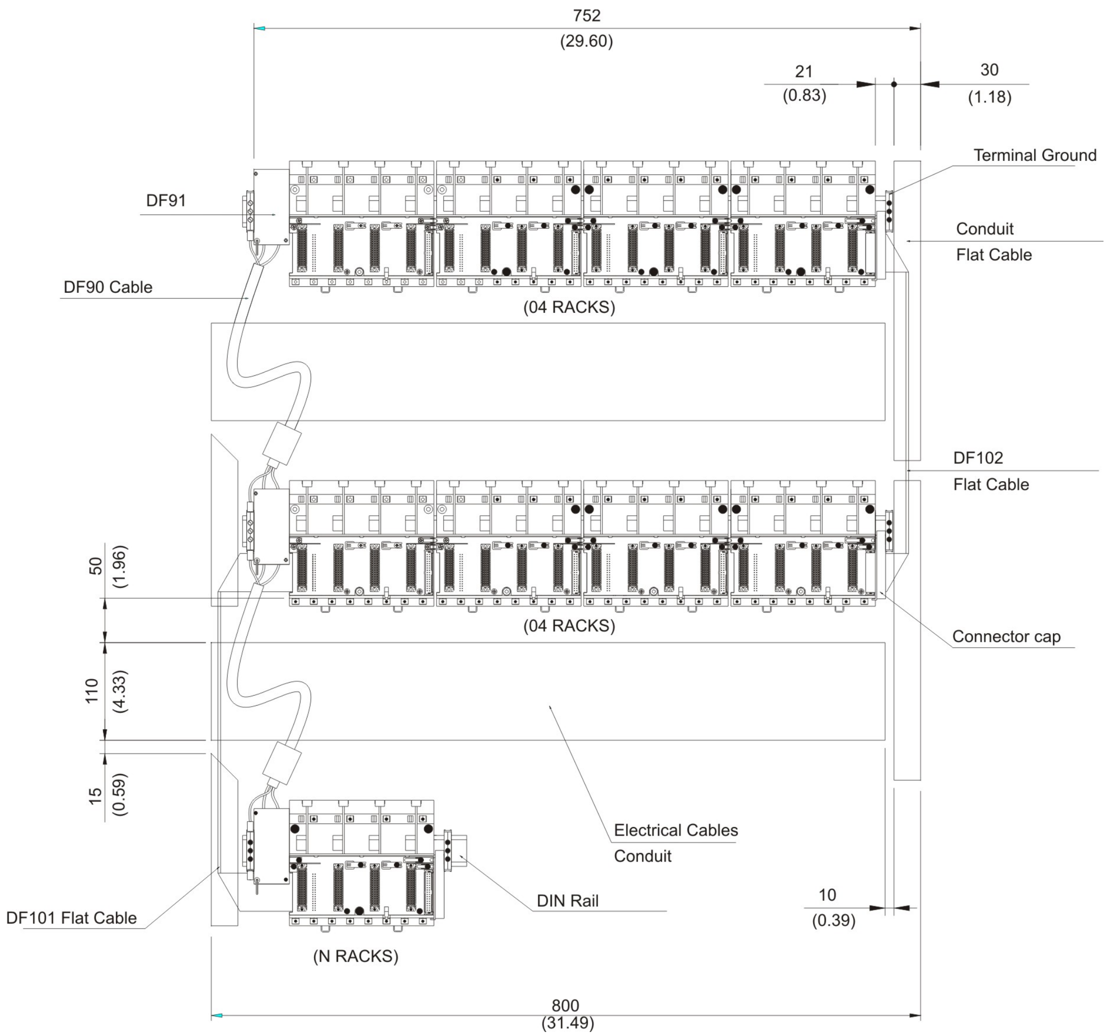


Figure 3. 14 - Example of expanded system

Installing the DF91 in the DIN rail
The DF91 is installed on the rack of the left extremity of each row of racks.

To connect the DF91 to the DIN rail, fix the DF91's rear part in the upper edge of the DIN rail, and then, accommodate the DF91 in the rail, pushing it until you hear a "click" sound.

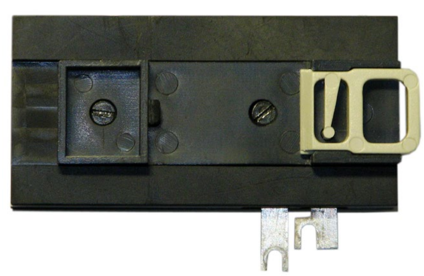


Figure 3. 15 - DF91 rear part

Connecting the DF91 to rack
The first rack's slot needs to be empty allowing access to this operation.

1. Loose the screws (only the sufficient) of the rack's power connector. See the next figure.

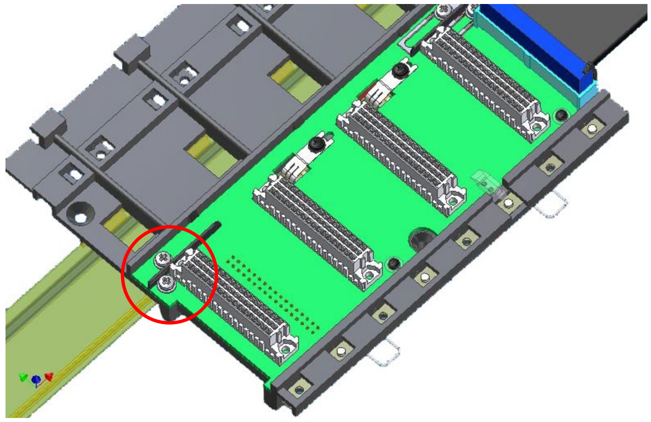


Figure 3. 16 - **Details of screws of the rack's power connector**

2. Move the DF91 to right up to fix in the screws.
3. Tighten the screws.
4. After connect the DF91 to the rack, install the terminal ground in the left side of DF91, keeping it firm to the rack. This terminal also will be used for grounding of DF90's shield.

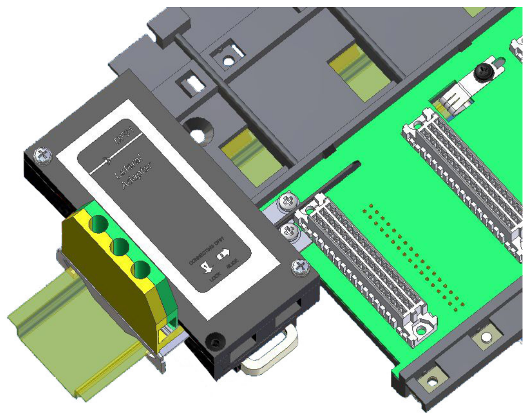


Figure 3. 17 - DF91 connected to rack

Installing DF90

Figure 3. 18 - IMB power cable (DF90)

The cable DF90 must be connected only through DF91, interconnecting two of them. Follow the next steps to execute that procedure.

1. With DF91 already connected to rack, release the cover's screws, and open it;
2. Release the DF91's screws indicated by labels (+) and (-);

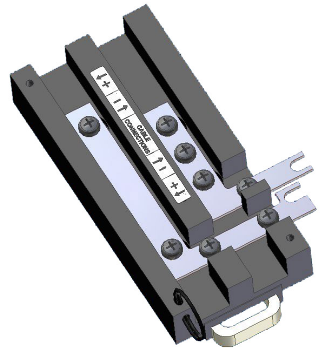


Figure 3. 19 - DF91 detail

3. Attach the DF90's terminals with the DF91's screws, obeying the polarity indications;
4. Connect the DF90's shield terminal to the ground terminal next to DF91;

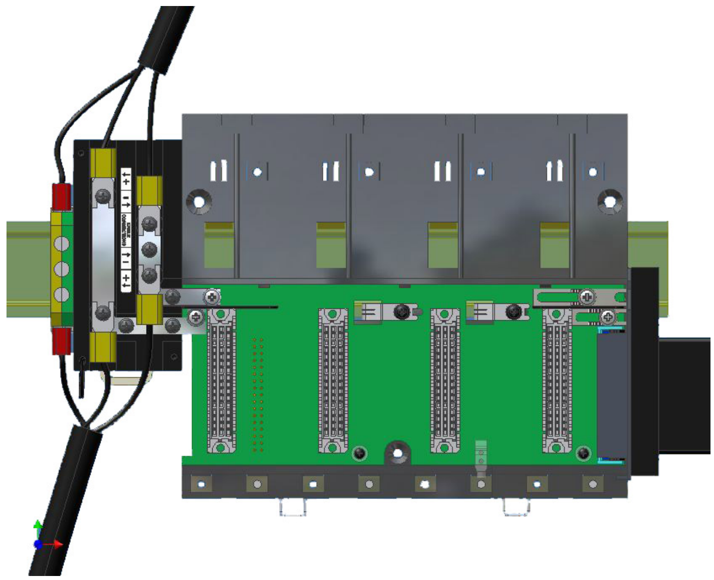


Figure 3. 20 - DF91 installed in the rack

5. Close the DF91 cover and tighten the screws.

Disconnecting DF91 from rack

1. The first card of the rack that will be disconnected must be removed allowing access to this operation;
2. Release (only the sufficient) the connector's screws of rack power, where DF91 is connected;
3. Move the DF91 to left (without separate it from rail) until the DF91's connection plates are out of rack's edge;
4. Tighten again the rack's screws if you will not connect them;
5. To remove the DF91, with a screwdriver, unlock it from DIN rail by pulling down the lock at its bottom part and removing that part from the rail.

Diagnostic resources

The DF93 rack has simple resources, but valuable, for voltage diagnostic in the bus. See the following table.

LED	Status
Off	Without voltage or voltage very low
Red	Insufficient voltage
Green	Sufficient voltage

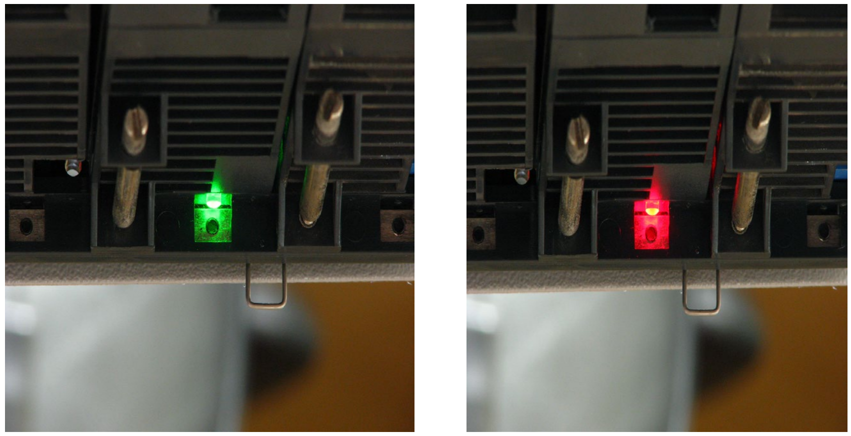


Figure 3. 21 - LEDs for diagnostic in the DF93 rack

Installing the system's base with DF1A and DF78

See below the figures and descriptions of module and rack:

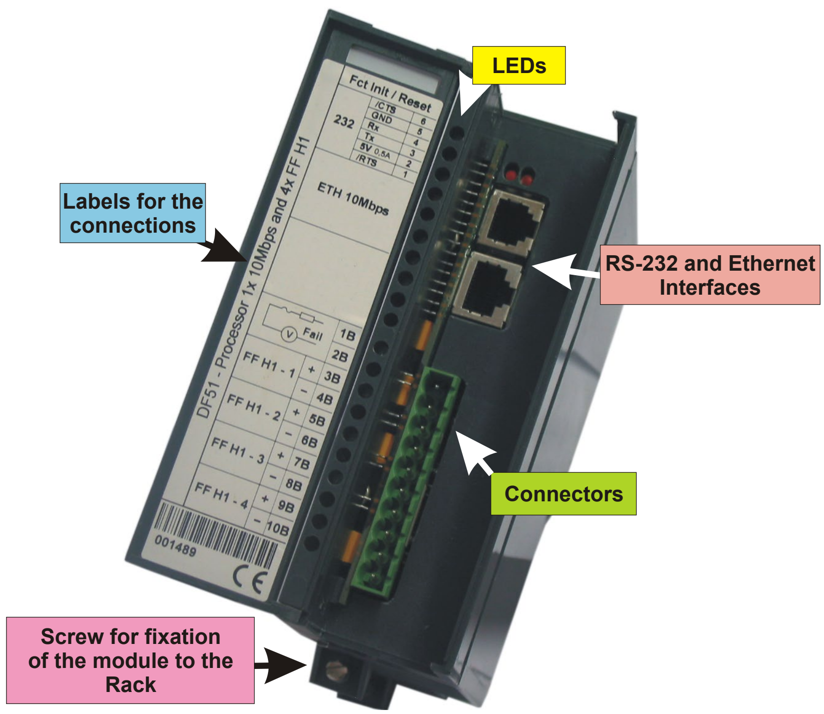


Figure 3. 22 - Module

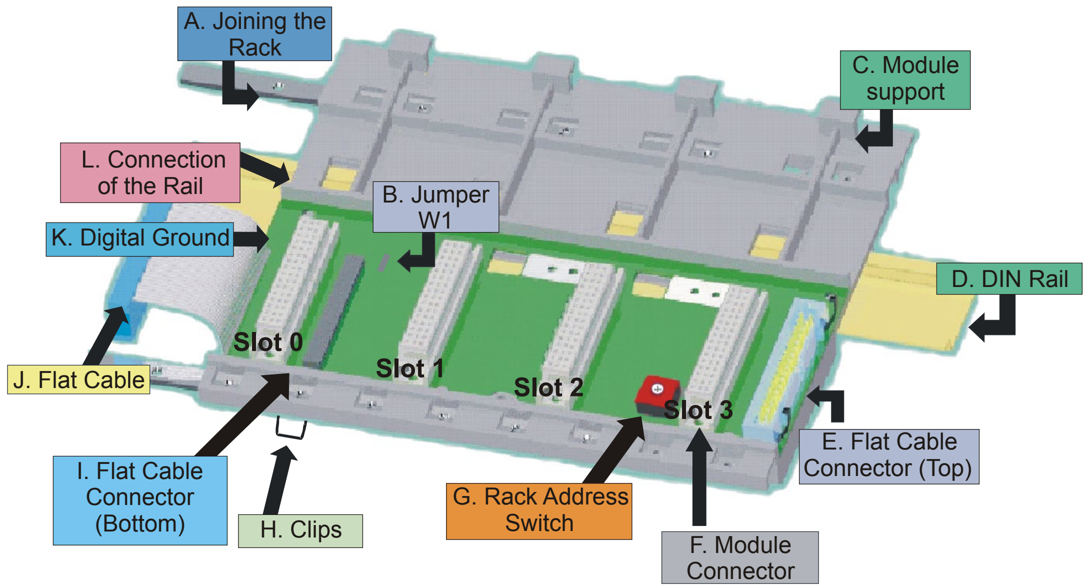


Figure 3. 23 - Rack – DF1A

A - Joining the Rack: When assembling more than one rack in the same DIN rail, use this metallic piece to interconnect the racks. This connection generates stability to the assembly and makes possible the digital ground connection (K).

B - Jumper W1: When connected, it allows the rack to be powered by the previous rack.

C - Module support: Module holder located in the top of the rack.

D - DIN Rail: base rack connection. It should be tightly fixed to the place where the rack is being mounted.

E - Flat Cable Connector (Top): When existing more than one rack in the same DIN rail, they must be hooked up by a flat cable (J) connected to the flat cable connectors (I) and (E).

F - Module Connector: Bottom connection of the module to the rack.

G - Rack Address Switch: When using more than one rack in the DIN rail, the rack address switch allows a distinct address to each rack.

H - Clips: The clips, located above of the rack, allow it to be connected in the DIN rail. It should be pushed down before inserting the rack in the DIN rail and after that pushed up to fix the pieces.

I - Flat Cable Connector (Bottom): When existing more than one rack in the same DIN rail, they must be hooked up by a flat cable (J) connected to the flat cable connectors (I) and (E).

J - Flat Cable: Cable used to connect the data bus between the racks.

K - Digital Ground – When using more than one rack in the same DIN rail, the connection between digital grounds (K) must be reinforced through appropriate metallic piece.

L - Connection of the Rail: Support that brings the connection between the rack and the DIN rail (D).

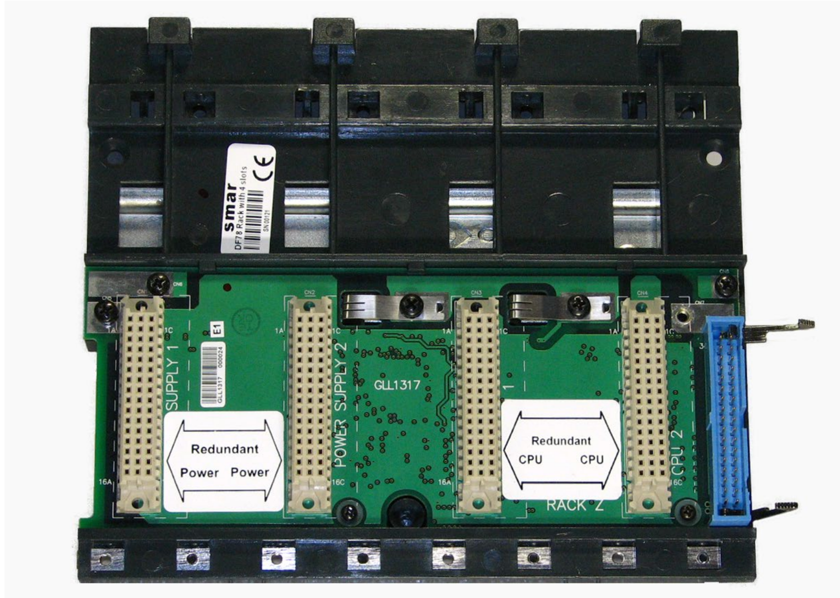


Figure 3. 24 - Rack – DF78

Installing a Rack in the DIN rail

1. In case of only one rack, this fixation can be done as the first step, even before of fixing any module to the rack.
2. Use a screwdriver (or your fingers) to pull the clips (H) down.
3. Place the back of the rack on the top of the DIN rail edge.
4. Accommodate the rack on the DIN rail and push the clips up. You will hear a click sound when they lock properly.
5. Set the correct address for the rack using the rotating switch at the rack.

Adding Racks

- In case of using more than one rack in the same DIN rail, take a look in the flat cable connections (J) in the top connector of the first rack and in the bottom connector in the second rack, before plugging the new module in the slot 3 of the first rack;
- Fix one rack to the other through the joining part of the rack (A). Pass the metal connector of one rack to the other and fix with screws;
- Connect the digital ground (K), using one metallic connection fixed by screws.
- Do not forget to place a terminator in the last rack. The terminator should be plugged in the flat cable connector (top) (E);
- Set the address for the new rack using the rotating switch.

Tips for Assembling

If there is more than one rack in the same system:

A. Do the grip in the DIN rail at the end of the assembly.
B. Keep free the slot 3 of the rack to connect the other module through the flat cable connector.
C. Check the addresses configuration (rack address switch), as well as the jumper W1 and the cable of the bus.
D. Remember that to give continuity to the DC power supply to the previous rack, it is necessary to have the jumper W1 connected.
E. Make the amendment of racks and strengthens the digital ground of the hardware.

NOTES
1 - Although any application using DF1A as the first rack can use DF84, the DF84 is only necessary when the controller (HFC302) executes local logic with discrete output cards. 2 - When using DF78 rack, DF84 is not necessary (DF78 does not have the P1 connector to install DF84).

Using the Fault Indicator

Terminals 1B and 2B of the HFC302 can be used as Fault Indicators. These terminals are NC Relays. The NC Relay supports:

0.5 A @ 125 VAC
0.25 A @ 250VAC
2 A @ 30VDC

Usually the HFC302 forces this relay to be open, but if the Processor generates a failure condition, the hardware will close the relay. This status can be used in redundant system where the backup Processor checks the relay and indicates the failure condition.

Another possibility is to use these relays to activate an alarm.

Improving the Grounding Signal in the AuditFlow (DF1A and DF78 Racks)

Although the rack 1A or DF78 of the **AuditFlow** system is connected by flat-cables that transfer the signal and power supply, it is possible that the grounding signal is degraded in applications using several modules. One solution to stabilize the grounding signal and give the system a better electrical noise immunity is to add an extra cable between the racks. These cables must follow the flat-cable path to avoid grounding loops. The wires must be strengthened and the diameter must be at least AWG18.

For adjacent racks, use the “extension connector” located on the left side of the rack. The user can mount a system with adjacent and non-adjacent racks.

IMPORTANT
Always use the Terminator Board in the last rack.

Non-Adjacent Racks

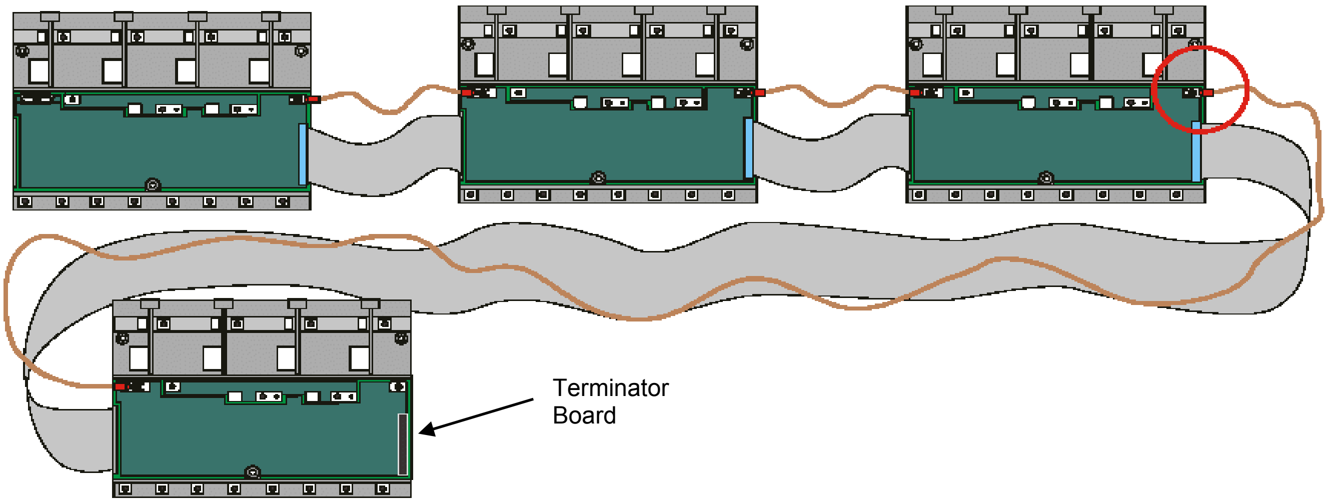


Figure 3. 25 – Improving the signal grounding

The figure below shows the connection of the grounding signal between the racks.

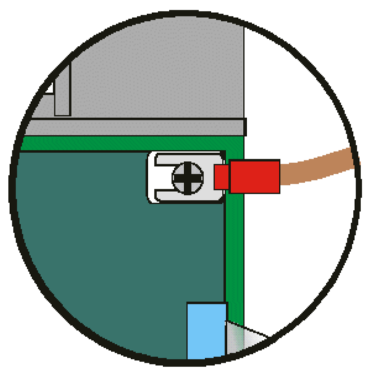


Figure 3. 26 - Connection Detail of the Grounding Signal Cable

Adjacent Racks

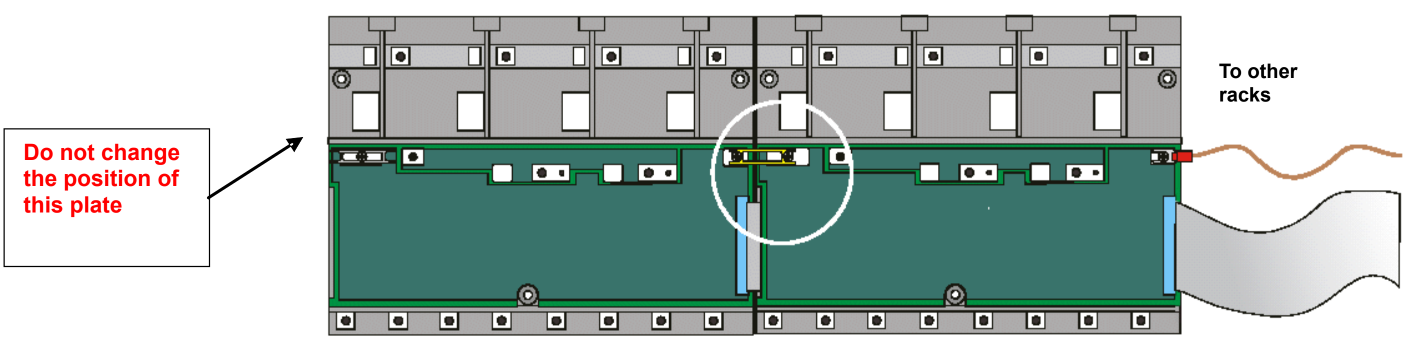


Figure 3. 27 - Connecting Adjacent Racks

Installing the Modules in the Rack

Follow the steps below to install the module in the rack.

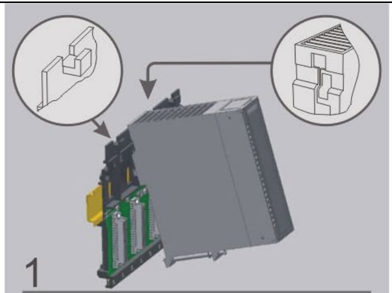
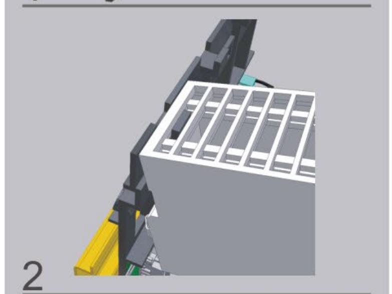
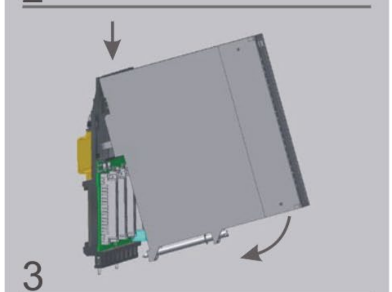
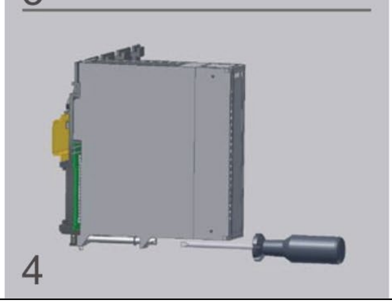
	Attach the top of the module with a 45º inclination to the module support located on the upper part of the rack.
	Mounting detail.
	Push the module fixing it to the connector.
	Next, fix the module to the rack using a screwdriver, and fasten the fixation screw at the bottom of the module.

Figure 3. 28 - Installing the module in the rack

Preventing Electrostatic Discharge

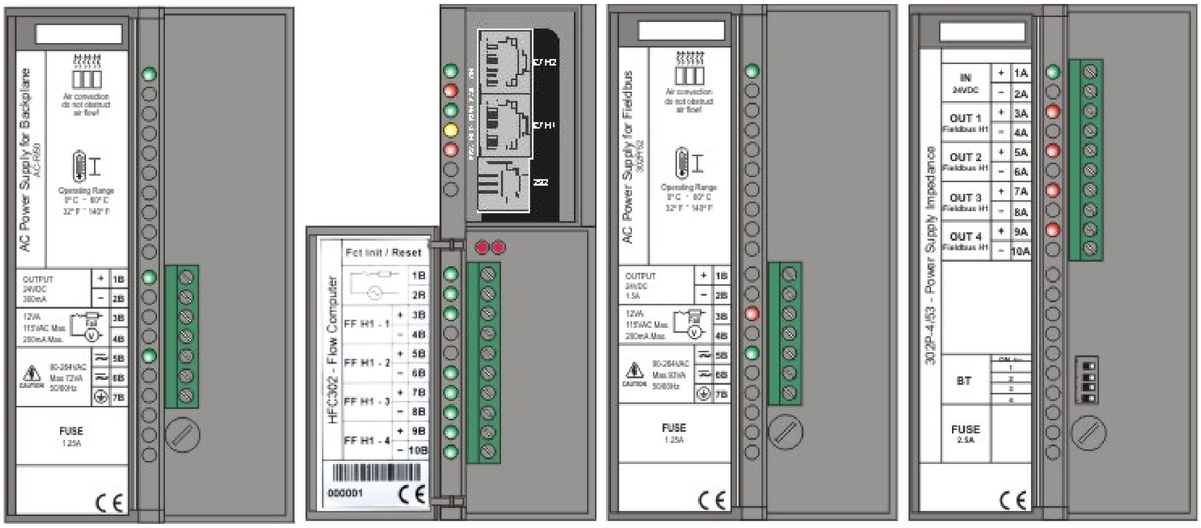
ATTENTION
Electrostatic discharges may damage semiconductor electronic components in the printed circuit boards. They usually occur when touching components or connector pins from modules and racks without wearing the appropriate equipment to prevent discharges. It is recommended to take the following precautions: - Before handling modules and racks, remove the electrostatic charge from your body by wearing a proper wristband or touching grounded devices; - Avoid touching electronic components or connector pins from racks and modules.

Installing the Hardware

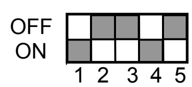
AuditFlow has LED indicators to show when the communication is active or failing. The modules can be connected and disconnected without turn them off. Using hub/switches the devices can be disconnected without interrupting the process or the control with other nodes.

Using the HFC302 Controller

A typical configuration of the system with the HFC302 controller is showed below:



Important:
The HFC302 has an internal battery that keeps the Real Time Clock (RTC) and its non volatile RAM (NVRAM) when there is lack of external supply. This battery can be either enabled or disabled, depending on the position of the switch 1, in the back part of the HFC302. To enable the battery, set the switch to 1 as shown in the following figure:



1) Battery ON
2) Keep in this position
3) Simulate
4) *Watchdog* ON
5) Keep in this position

In this configuration, when there is lack of energy, the RTC and the NVRAM will be supplied by the battery, allowing the retention of all configuration data. In case of equipment storage, it is recommended that the battery is turned off (switch 1 in position OFF).

So, before fixing the HFC302 module in the rack, be sure the switch 1, which refers to the battery, is in the enabled position.

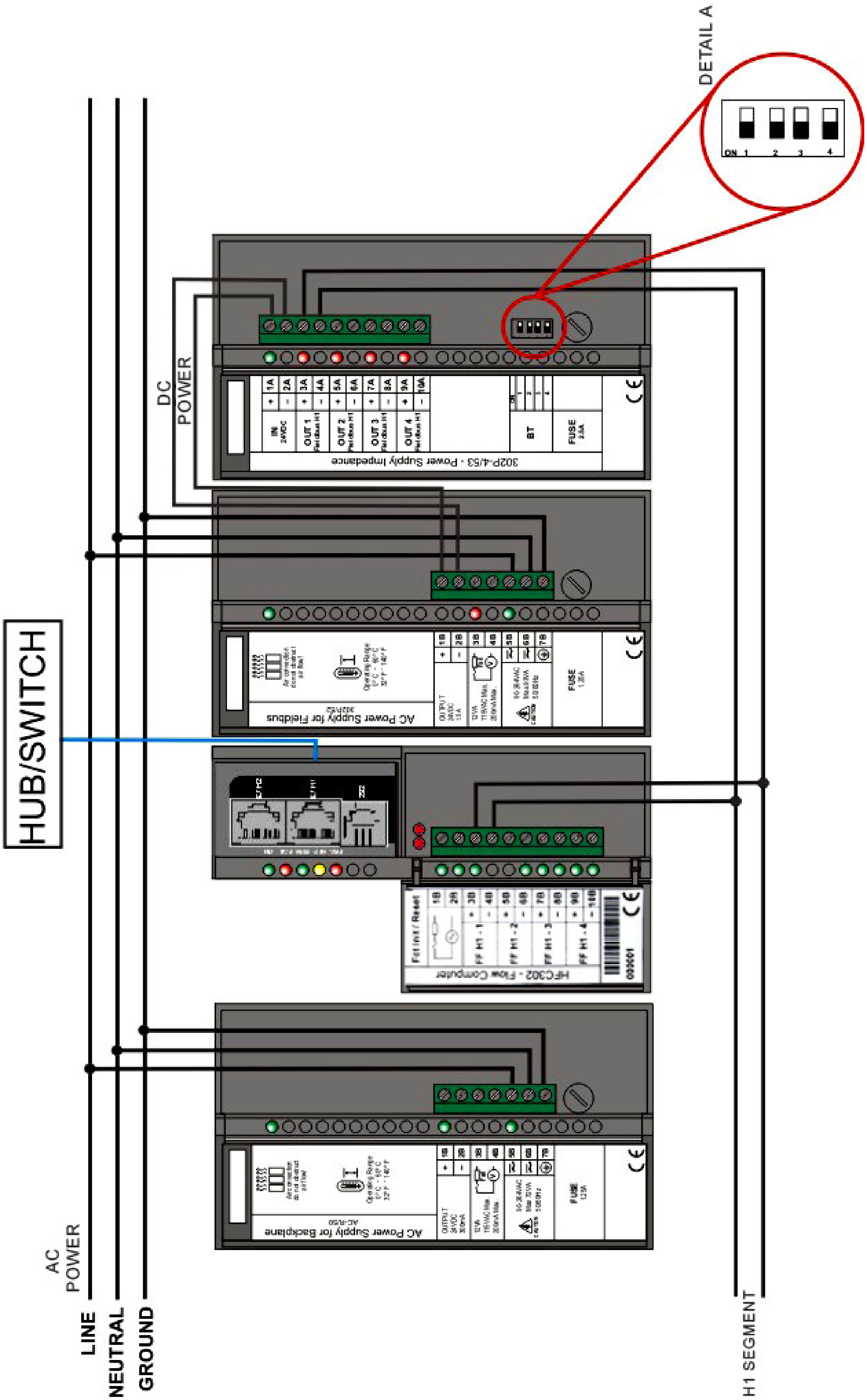
The Watchdog is a mechanism to detect if an important or high priority task stops in the controller. So, be sure the switch 4, which refers to the Watchdog, is in the ON position.

Steps for the Basic Installation

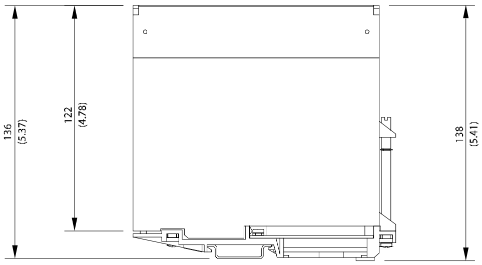
1. Connect the four modules (DF50, HFC302, DF52, DF53) plus the terminator (DF2) in the *rack* (DF1A or DF93);
2. Connect the AC voltage in the inputs of DF50 and DF52 power supply modules;
3. Connect the DF52 output to the DF53 input;
4. Plug the Ethernet twisted pair cable, connecting HFC302 to an Ethernet Hub or Switch;
5. Connect the Fieldbus H1 bus in the HFC302 FOUNDATION fieldbus H1 ports;
6. If DHCP Server is available, HFC302 IP address is automatically set up, otherwise a fixed IP will be generated. This initial fixed address IP can be changed through FBTools (see the Topic "Connecting AuditFlow in the Subnet ").

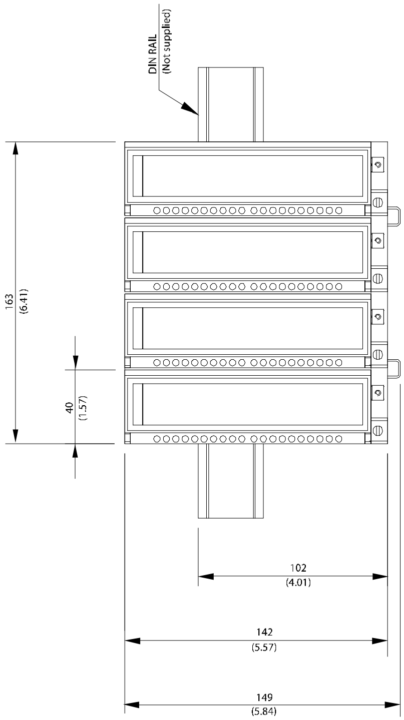
Observe in the following figure:
In the next figure, the cable diagram is showed when using the HFC302 module.

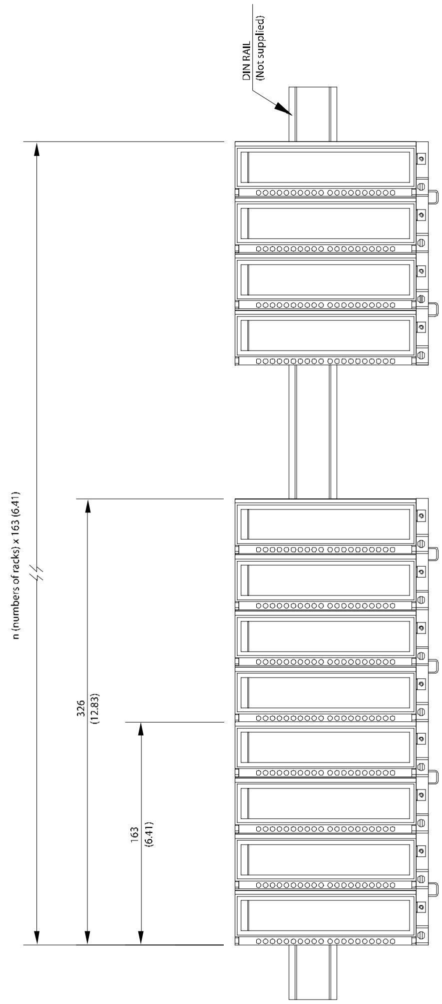
- Observe that only one H1 segment is being used.
- The DIP switches for the bus are displayed in the Detail A.

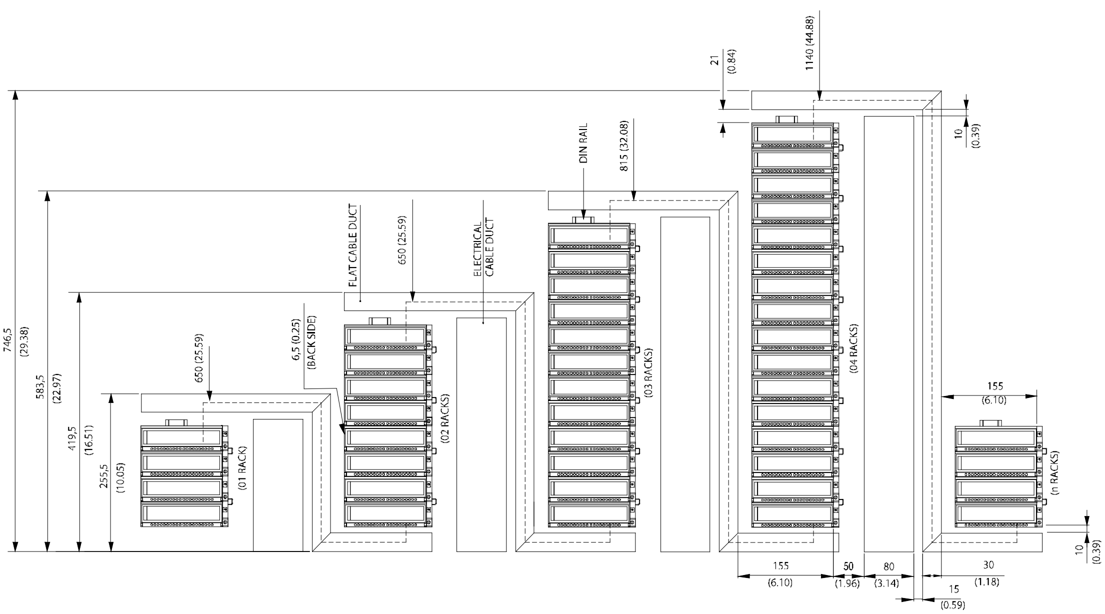

DETAIL A
HUB/SWITCH
DC POWER
AC POWER
LINE
NEUTRAL
GROUND
H1 SEGMENT
302P-4/53 - Power Supply Impedance
AC Power Supply for Fieldbus
HFC302 - Flow Computer
AC Power Supply for Backplane

Dimensional Drawings of DF1A Rack and Modules



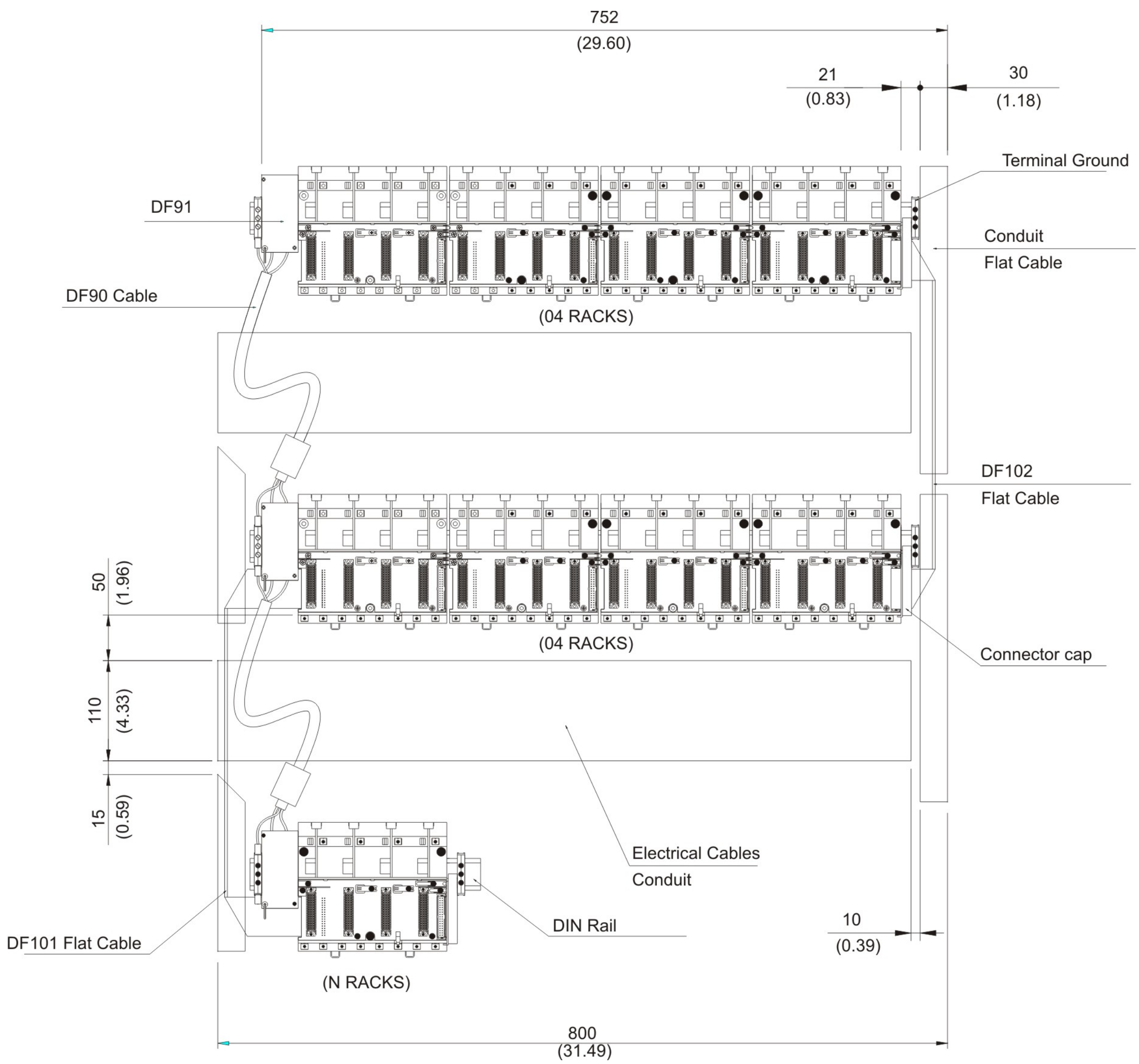


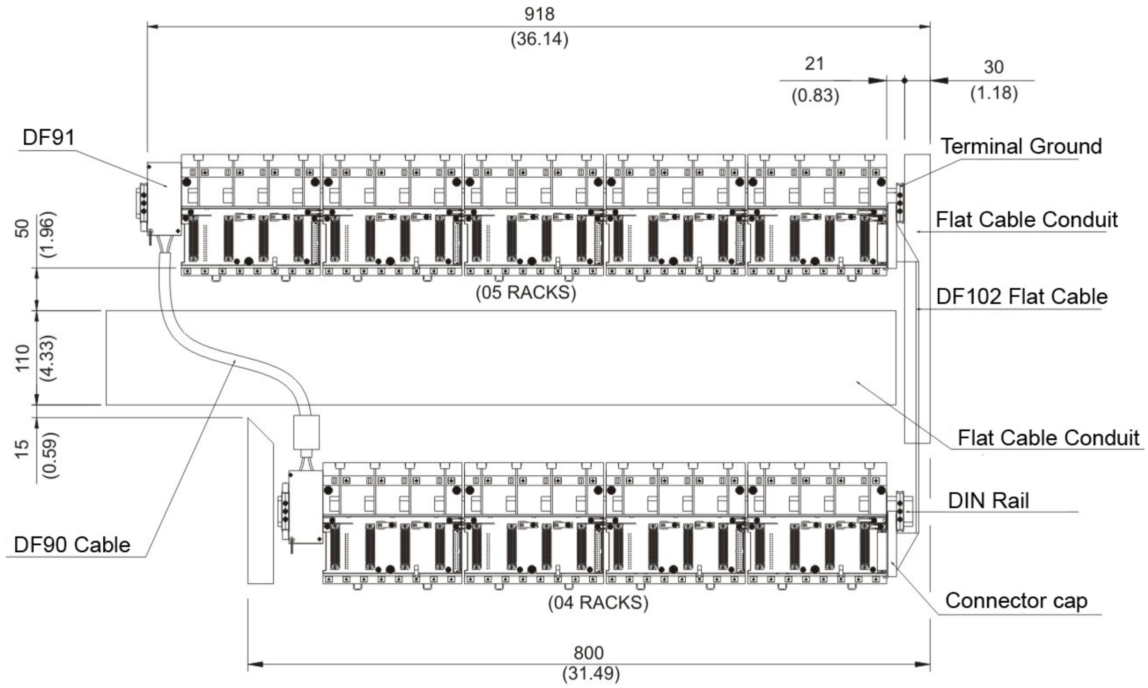




Dimensional Drawings of DF93 and Modules

The following figures show two possible combinations.




918
(36.14)
21
(0.83)
30
(1.18)
DF91
Terminal Ground
Flat Cable Conduit
50
(1.96)
(05 RACKS)
DF102 Flat Cable
110
(4.33)
Flat Cable Conduit
15
(0.59)
DIN Rail
DF90 Cable
Connector cap
(04 RACKS)
800
(31.49)

AuditFlow Panel

The AuditFlow system has a panel to cover the electronic of flow computer, which meets the most of the hardware settings and follows the principles indicated in the “Hardware Installation” chapter.

Panel Features

- Ingress Protection: IP55

- Material: carbon steel of 1.2 mm

- Painting: gray 7232

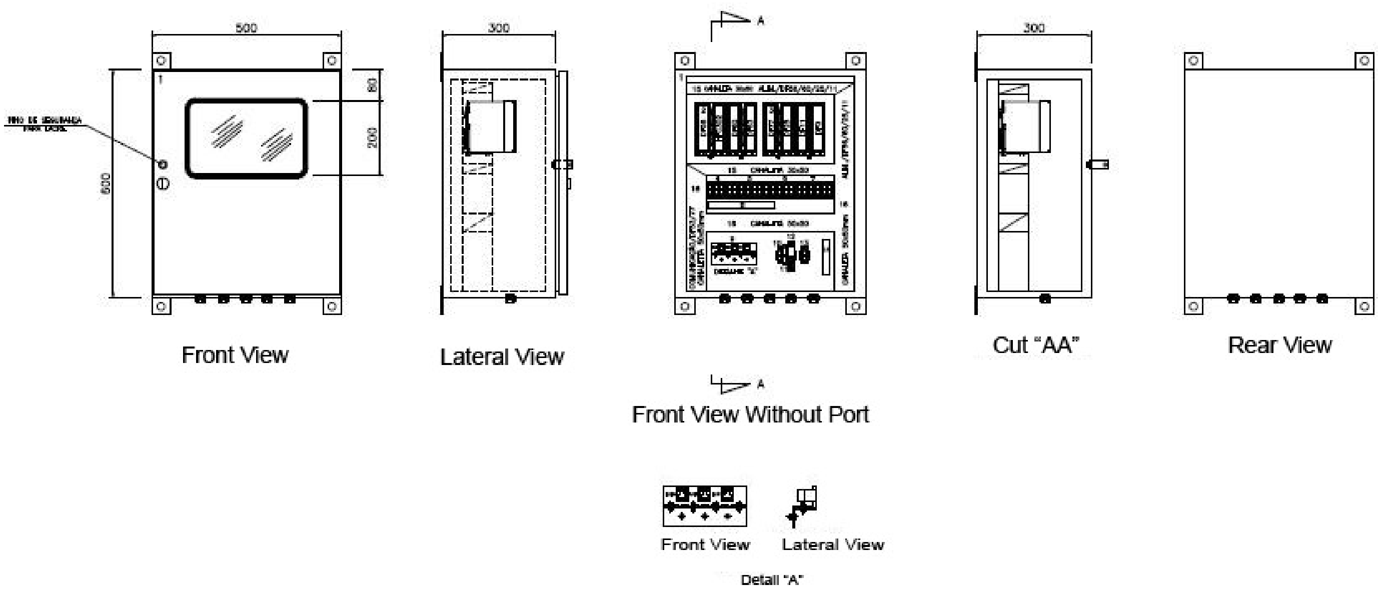
- Safety pin for seal

- Wall installation

- Acrylic window

- Cable clamp, general breaker and terminal block for field signals

Dimensional Drawing



Chapter 4

ADDING RACKS

DF1A – Rack with 4 slots

Description

A rack is basically a plastic support for the IMB circuit that carries the connectors where the modules are plugged in. These connectors that fit the modules are called slots.

New racks can be added according to the project requirements. Up to 16 Racks are allowed. Racks can be connected for Local I/O expansion using flat cables (DF3, DF4A ~ DF7A).

Remember that the distance between the first module and the last module of an AuditFlow system, expanded by flat cables cannot exceed 22.97ft (7 meters).

NOTE
Each Rack has a rotating switch to select the address. The possible addresses are **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.** Note that the "**F**" address is not allowed when I/O is being accessed by HCT function block. The address **"F"** is supported when the I/O access is done through FFB 1131, which can be configured using "LogicView for FFB" software. For further details about FFB1131 block refer to Adding Logic Using Flexible Function Blocks section.

There are restrictions related to the module location on the rack. The restrictions are as follows:

1. The first slot of rack 0 is always reserved for the power supply module.
2. The second slot of rack 0 is always reserved for the controller module.
3. All additional power Supplies need to be placed in the slot 0 of the desired Rack (jumper W1 in the rack must be cut before plugging the power supply).
4. The first rack must have a DF84 terminator when the controller (HFC302) executes local logic in discrete output cards.
5. The last rack must have a DF2 terminator installed.

Technical Specifications

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	148.5 x 25 x 163 mm ; (5.85 x 0.98 x 6.42 in)
Weight	0.216 kg

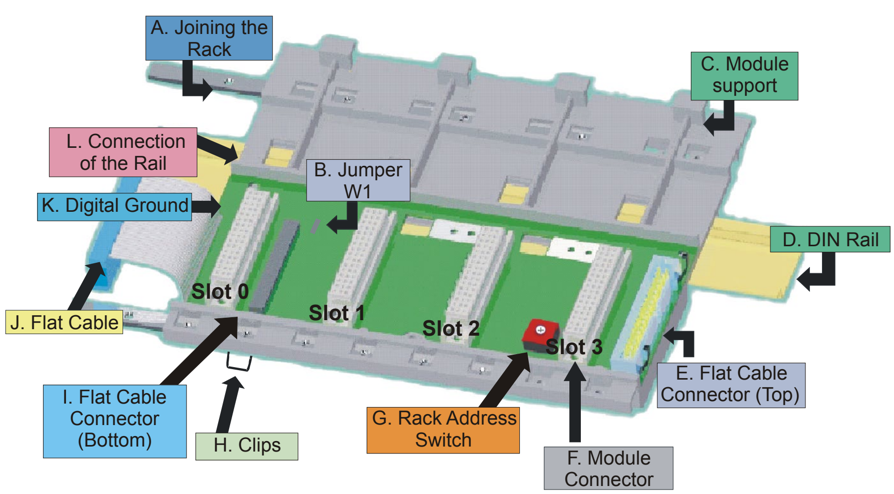


Figure 4. 1 – DF1A Rack

DF78 - Rack with 4 slots for Redundant CPUs

Description

The DF78 rack allows that two CPUs modules access the same I/O. This possibility is used when necessary redundancy and availability to the system. Up to 16 DF1A racks can be connected to DF78. Racks can be connected for Local I/O expansion using flat cables (DF3, DF4A ~ DF7A).

Remember that the distance between the first module and the last module of an AuditFlow system, expanded by flat cables cannot exceed 22.97ft (7 meters).

There are restrictions related to the power supply and controllers position on the DF78 Rack. The restrictions are as follows:

1. The first and second slots of DF78 rack are always reserved for power supply modules.
2. The third and fourth slots on DF78 rack are always reserved for controllers modules.

NOTE
Each Rack has a rotating switch to select the address. The possible addresses are **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.** Note that the "**F**" address is not allowed when I/O is being accessed by HCT function block. The address **"F"** is supported when the I/O access is done through FFB 1131, which can be configured using "LogicView for FFB" software. For further details about FFB1131 block refer to Adding Logic Using Flexible Function Blocks section.

Technical Specifications

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	148.5 x 25 x 163 mm ; (5.85 x 0.98 x 6.42 in)
Weight	0.216 kg

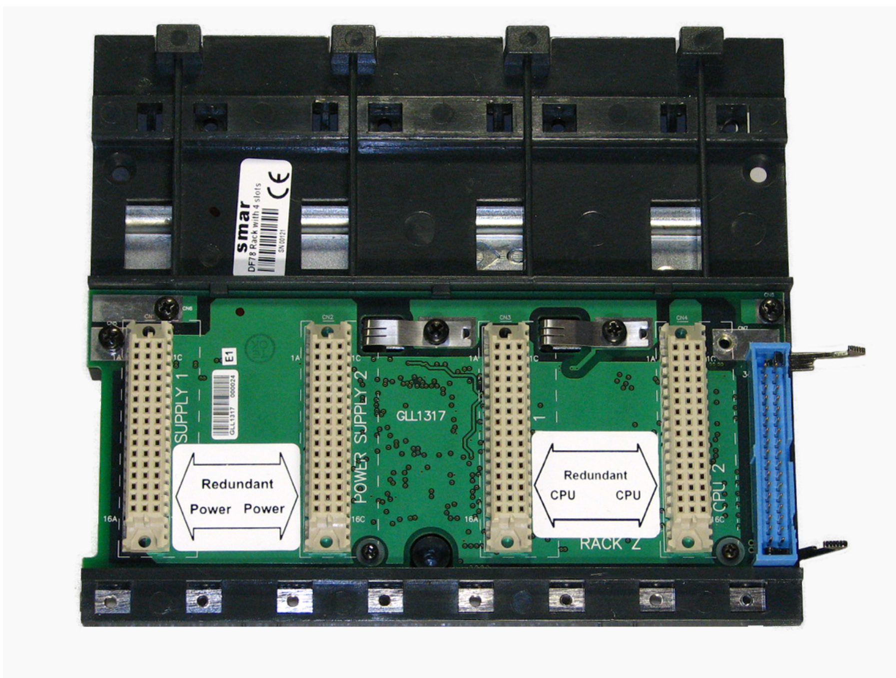


Figure 4. 2 – DF78 Rack

DF93 - Rack with 4 slots (with diagnostic)

Description

The DF93 rack is integral part of the new power system of AuditFlow. Its features provide low voltage drop through the IMB bus, so it is more efficient. Besides, the diagnostics resources of DF93 help in the problems detection minimizing the time stop and maintenance. The diagnostic can be obtained observing the diagnostics LEDs or through the status reading via controller.

The DF93 rack has Vcc and GND terminals at laterals (for power transmission). DF93's finishing avoids short circuits between the Vcc and GND connections at laterals.

As in the previous system, new racks can be added to the AuditFlow system according to the application needs. Up to 16 racks are allowed. The racks can be connected among them (expanding the bus) using flat cables (DF101 to DF107), DF90 (IMB power cable), and DF91 (lateral adapter).

Remember that the distance between the first module and the last module of an AuditFlow system, expanded by flat cables cannot exceed 22.97ft (7 meters).

NOTE
Each Rack has a rotating switch to select the address. The possible addresses are **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.** Note that the "**F**" address is not allowed when I/O is being accessed by HCT function block. The address **"F"** is supported when the I/O access is done through FFB 1131, which can be configured using "LogicView for FFB" software. For further details about FFB1131 block refer to Adding Logic Using Flexible Function Blocks section.

There are restrictions related to the module location on the rack. The restrictions are as follows:

1. The first slot of rack 0 is always reserved for the power supply module.
2. The second slot of rack 0 is always reserved for the controller module.
3. All additional power supplies need to be placed in the slot 0 of the desired rack (jumper W1 in the rack must be cut and the DF90 cable from the previous racks must be disconnected before plugging the power supply).
4. The first rack must have a DF84 terminator when the controller (HFC302) executes local logic in discrete output cards.
5. The last rack must have a terminator installed - DF2 (right side) or DF96 (left side). For further details refer to Hardware section.
6. Grounding terminals must be used.

Technical Specifications

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	148.5 x 25 x 163 mm ; (5.85 x 0.98 x 6.42 in)
Weight	0.216 kg

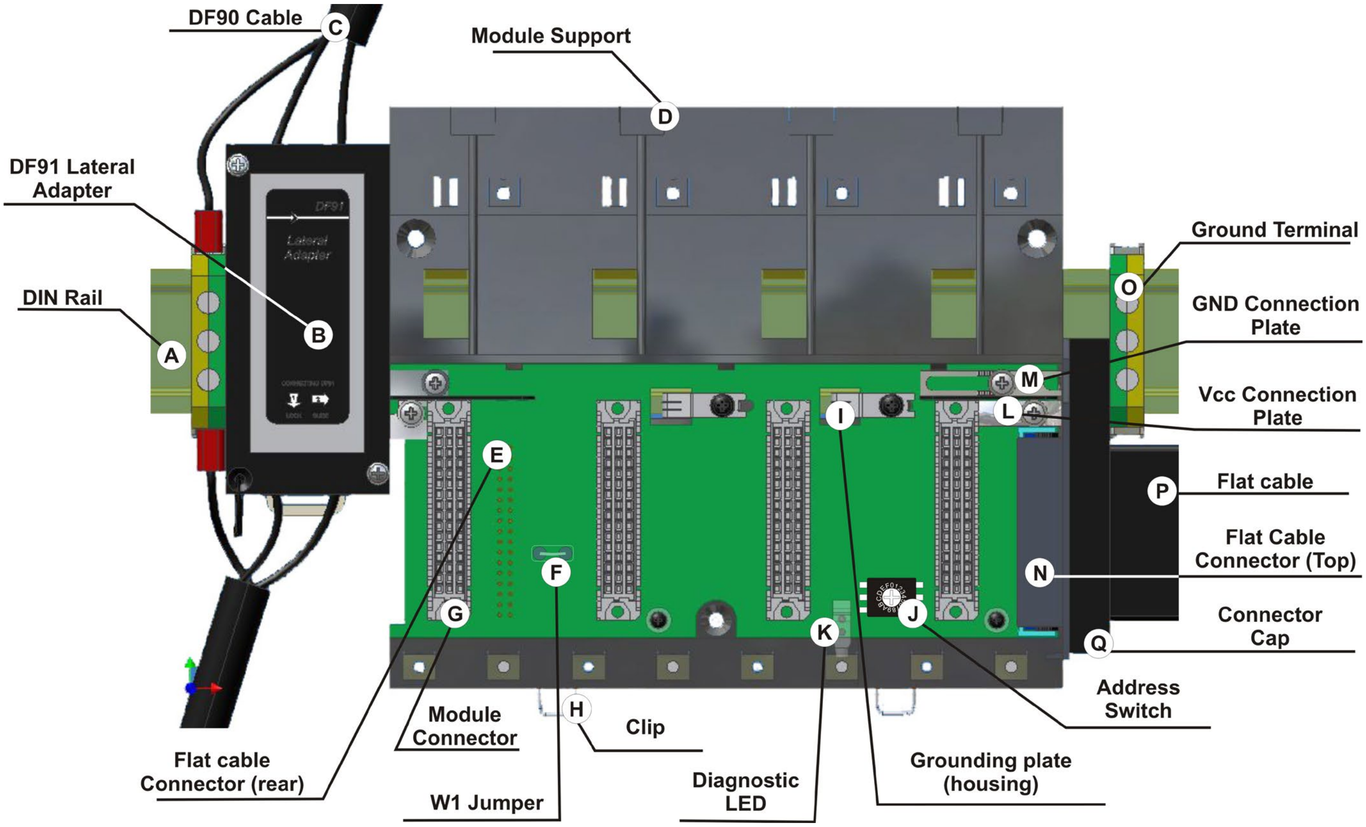


Figure 4. 3 – DF93 Rack

For compatibility with the EMC standards, if the power supply side connector on the left side of the rack is not connected, it should be capped with the left side protection according to the section Hardware, Installing racks - DF92 and DF93 topic. This protection is provided along with the terminator DF2.

DF92 - Rack with 4 slots for redundant CPUs (with diagnostic support)

Description

The DF92 is the new rack for redundant controllers in the IMB. Its function is similar to the DF78, but DF92 is optimized to reduce voltage drop in the IMB, besides it has different pins to connect, in the future, power supplies with more than 3A.

The DF92 rack has Vcc and GND terminals at laterals (for power transmission). DF92's finishing avoids short circuits between the Vcc and GND connections at laterals.

Moreover, the DF92 supports power supplies diagnostics for those that have this feature. It helps in problems detection and giving the desired confidence in the availability offered by redundancy. The diagnostic can be obtained observing the diagnostics LEDs or through the status reading via controller.

The DF92 rack can be connected up to 16 DF93 racks. The racks can be connected among them (expanding the bus) using flat cables (DF101 to DF107), DF90 (IMB power cable) and DF91 (lateral adapter).

Remember that the distance between the first module and the last module of an AuditFlow system, expanded by flat cables cannot exceed 22.97ft (7 meters).

There are restrictions related to the module location on the rack. The restrictions are as follows:

1. The first and second slots of DF92 rack are always reserved for power supply modules.
2. The third and fourth slots on DF92 rack are always reserved for controllers' modules.
3. Grounding terminals must be used.

NOTE
Each Rack has a rotating switch to select the address. The possible addresses are **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.** Note that the "**F**" address is not allowed when I/O is being accessed by HCT function block. The address **"F"** is supported when the I/O access is done through FFB 1131, which can be configured using "LogicView for FFB" software. For further details about FFB1131 block refer to Adding Logic Using Flexible Function Blocks section.

Technical Specifications

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	148.5 x 25 x 163 mm ; (5.85 x 0.98 x 6.42 in)
Weight	0.216 kg

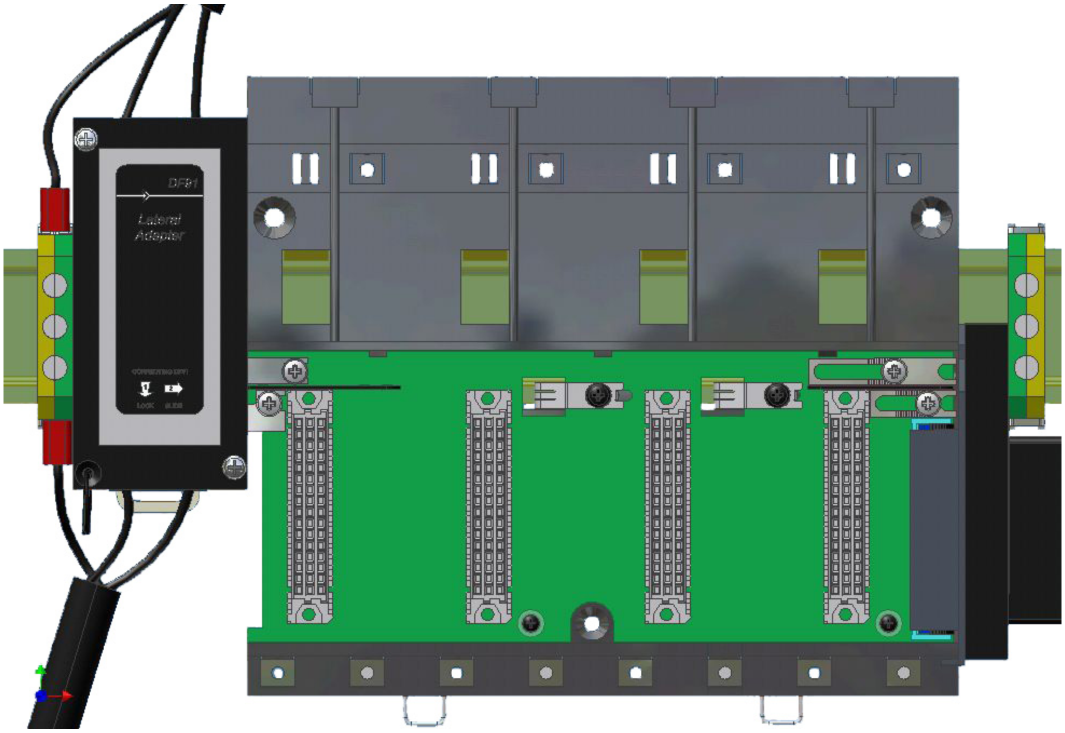


Figure 4. 4 – DF92 Rack

For compatibility with the EMC standards, if the power supply side connector on the left side of the rack is not connected, it should be capped with the left side protection according to the section Hardware, Installing racks - DF92 and DF93 topic. This protection is provided along with the terminator DF2.

Chapter 5

ADDING POWER SUPPLIES

Introduction

There are some recommendations when adding power supply modules to the system which should be considered.

First of all, an overview of the whole system is necessary at this time to better choose the modules (power supply, impedance etc.). Each controller module needs at least one power supply for backplane. The addition of I/Os modules requires new calculations to the power supply.

NOTE
Using ladder logic (FFB 1131), for a better monitoring of the functional state of each used I/O module is recommended to use the **STATUS** block in the logic. Thus the system can be advised if some I/O module have a failure. So that is easier to find a damaged module. Insert and configure this block according to the **LogicView for FFB** manual.

The following table shows the available modules used as power supply, intrinsic safety barrier and fieldbus impedances.

MODEL	DESCRIPTION
DF50	Power Supply for Backplane 90-264 Vac
DF56	Power Supply for Backplane 20-30 Vdc
DF52	Power Supply for Fieldbus 90-264 Vac
DF60	Power Supply for Fieldbus 20-30 Vdc
DF53	Power Supply Impedance for Fieldbus (4 ports)
DF47-12	Intrinsic Safety Barrier for Fieldbus
DF47-17	
DF87	Power Supply for Backplane 20-30 Vdc, 5 A, redundant, with diagnostic
DF98	High Current Power Supply Impedance for Fieldbus

DF50 – Power Supply Module for Backplane (Redundant)

Description

This redundant power supply works independently or together with another redundant power supply module to ensure a constant supply of power to the application.

When two redundant power supplies are used, if one of them fails, the backup will automatically assume the operation. A relay is provided to indicate failure on each power supply giving the user a chance to replace the faulty one.

This module provides two voltage outputs:
a) **5 Vdc @ 3 A:** distributed by Power Lines in the Inter-Module-Bus (IMB) throughout the racks to supply the module circuits;
b) **24 Vdc @ 300 mA:** for external use through the terminals 1B and 2B.

The applied AC voltage, the 5 Vdc and the 24 Vdc are all isolated between them.

Installation and Configuration

For systems based on DF92 and DF93 rack, with DF90 and DF91

Redundant mode options

- **Splitting Power concept:** In this situation, two modules will supply power to a bus segment. If one of them was turned off or fails, the other power supply must be able to supply energy, alone, to the segment.
  The **CH1** jumper (power supply) must be set in **R** position for both modules and **W1** jumper (power supply) must be opened for both modules.

- **Standby concept:** In this case, just one power supply provides energy to the system. If it was turned off or fails, the backup module will assume the operation. In both modules, the jumper **CH1** (power supply) must be set in the **R** position and **W1** jumper (power supply) must be placed only in the backup module.

Expansion of load capacity by adding power supplies or pairs of redundant power supplies
If the system consumption is greater than 3A, it can be subdivided in up to 8 groups sized for consumption of up to 3A each, and each group is individually powered by a power supply, or redundant pair of power supplies. More details on the Power supplies positioning topic.

Power supplies positions in the racks
On **DF92,** the pair of redundant power supplies must be installed in the first and second slots.

On **DF93** is recommended the placement of the redundant pair in the first and second slots, but it can be installed in any slots if necessary.

Configuration of "W1" and "CH1" jumpers
The **DF50 CH1** jumper always must be connected to the **R** position. The **W1** jumper (power supply) must be connected only in the **DF50** modules configured as "backup", in the standby concept, as above mentioned in the redundant mode options.

For systems based on DF1A and DF78 racks

Non-redundant (single module): power consumption **limited** to 3A:
There is an addressing restriction related to the power supply location. The restriction is that the first rack (address 0) must always contain a power supply module at the first slot.
In the power supply module the **CH1** jumper must be set in **E** position.

Non-redundant (more than one module): power consumption **bigger** than 3A:
Additional modules are placed in the bus in parallel, but isolated one of the other. For systems based on **DF1A rack,** the power supplies modules must always be placed at the first rack's slot. The jumper **W1** (in the rack), where is the new power supply module, must be cut. The new power supply module will only supply power to the rack where it is sitting on and to the consecutive ones (never backwards).
In all power supplies modules, the **CH1** jumper must be set in **E** position.

Redundant mode

- **Splitting Power concept:** In this case of redundancy, the user may have two power supplies modules in parallel in first and third slots of rack **DF1A** or in the first and second slots of rack **DF78**. The **CH1** jumper (power supply) must be set in **R** position for both modules and **W1** jumper (power supply) must be opened for both modules. In this situation, the two modules will supply power to the bus.

- **Standby concept:** In this case, the main module must be placed in the first slot and the backup module in the third slot of rack **DF1A** or in the first and second slots of rack **DF78**. In both modules, the **CH1** jumper (power supply) must be set in the position **R** and **W1** jumper (power supply) must be placed only in the backup module.

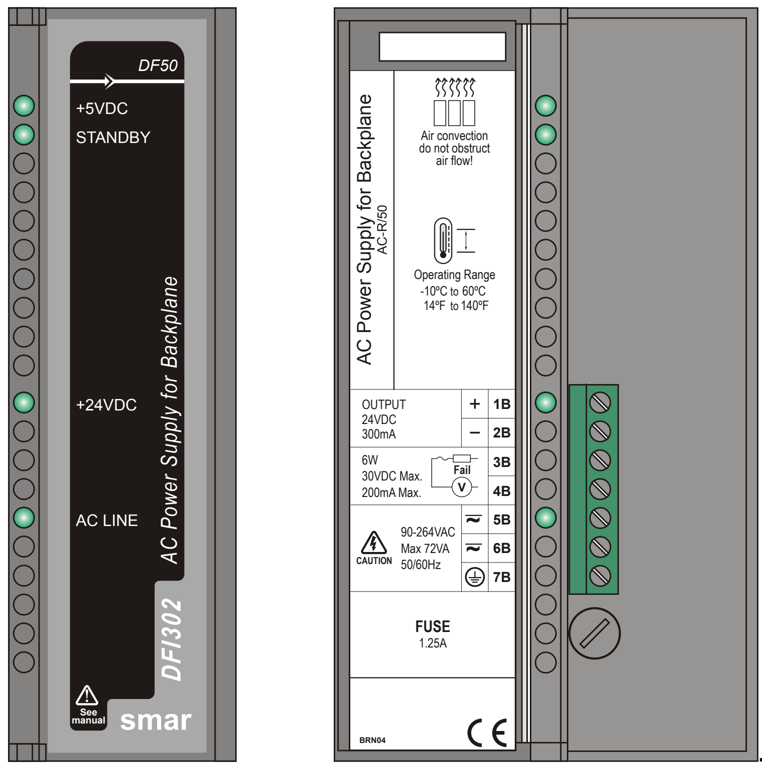


Figure 5. 1 - AC Power Supply Module: DF50

Technical Specifications

INPUTS	
DC	127 to 135 Vdc
AC	90 to 264 VAC, 50/60 Hz (nominal), 47 to 63 Hz (range)
Inrush Current	< 36 A @ 220 Vac [∆T < 740 us]
Time until Power Fail	6 ms @ 102 Vac (120 Vac – 15%) [Full Load]
Time until Shutdown	27 ms @ 102 Vac; > 200ms @ 220 Vac [Full Load]
Maximum consumption	72 VA
Indicator	AC LINE (Green LED)

OUTPUTS	
a) Output 1 (internal use)	5.2 Vdc +/- 2%
Current	3 A Maximum
Ripple:	100 mVpp Maximum
Indicator	+5 Vdc (Green LED)
Hold up Time	> 40 ms @ 120 Vac [Full Load]
b) Output 2 (external use)	24 Vdc +/- 10%
Current	300 mA Maximum
Ripple	200 mVpp Maximum
Short Circuit Current	700 mA
Indicator	+24Vdc (Green LED)

ISOLATION	
Input signal, internal outputs and the external output are isolated among them.	
Between the outputs and the ground	1000 Vrms
Between the input and output	2500 Vrms

FAILURE RELAY	
Type of Output	Solid state relay, normally closed (NC), isolated
Limits	6 W, 30 Vdc Max, 200 mA Max
Maximum Initial Contact Resistance	<13Ω
Overload Protection	Should be provided externally
Operation Time	5 ms maximum

TEMPERATURE	
Operation	-10 °C to 60 °C (14 ºF to 140 ºF)

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	39.9 x 137.0 x 141.5 mm; (1.57 x 5.39 x 5.57 in)
Weight	0.450 kg

CABLES	
One wire	14 AWG (2 mm^2)
Two wires	20 AWG (0.5 mm^2)

NOTES
1) If the power consumption exceeds the power supplied, the AuditFlow system may operate in an unpredictable manner that may causes damages to the equipment or risk of personal injury. Hence, the power consumption must be calculated correctly and install more power supplies modules, if it is necessary.
2) To increase the service life of your contacts and protect the modules from potential reverse voltage damage, connect externally a clamping diode in parallel with each inductive DC load or connect an RC snubber circuit in parallel with each inductive AC load.
3) The redundancy feature is only guaranteed for racks with GLL1270 Revision 2 or greater. For the models with their revisions less than the mentioned above, the technical support must be consulted in order to check the compatibility.
4) To meet the EMC standards requirements, the wires' length to the failure relay must be less than 30 meters. The power supply of activated load by the failure relay must not be from external network.

DF56 – Power Supply for Backplane (Redundant)

Description

This redundant power supply works independently or with another redundant power supply module to assure a constant power supply to the application. When two redundant power supply modules are used, both split the energy that is needed to supply the system. When one power supply fails, the other, automatically, will assume the operation. Each power supply has a relay to indicate failures allowing the user to replace damage modules.

This module has two voltage outputs:
a) **5 Vdc @ 3A** distributed by power lines in the Inter-Module-Bus (IMB) through racks to supply module circuits;
b) **24 Vdc @ 300 mA** for external use through terminals 1B and 2B.

The DC applied voltage and the 5Vdc and 24 Vdc are isolated.

Installation and Configuration

For systems based on DF92 and DF93 rack, with DF90 and DF91

Redundant mode
Splitting Power concept: In this situation, two modules will supply power to a bus segment. If one of them was turned off or fails, the other power supply must be able to supply energy, alone, to the segment.

Expansion of load capacity by adding power supplies or pairs of redundant power supplies
If the system consumption is greater than 3A, it can be subdivided in up to 8 groups sized for consumption of up to 3A each, and each group is individually powered by a power supply, or redundant pair of power supplies. More details on the Power supplies positioning topic.

Power supplies positions in the racks
On DF92, the pair of redundant power supplies must be installed in the first and second slots.

On DF93 is recommended the placement of the redundant pair in the first and second slots, but it can be installed in any slots if necessary.

Configuration of CH1 jumper
The DF56 **CH1** jumper always must be connected to the **R** position.

For systems based on DF1A and DF78 racks

Single Module: Less than 3 A are required.
There is an address restriction related to the location of the power supply. This restriction is the first rack (address 0) must have a power supply module in the first slot. The **CH1** jumper (power supply) must be set in the **E** position.

More Than One Module: More than 3 A are required.
For systems based on **DF1A rack** the power supplies must be placed in the first slot of the rack. Jumper **W1** on the rack that has the new power supply must be cut. Every new power supply will only supply energy to the rack in which it is located and, with the jumper cut off, it will not supply energy to the previous racks. All modules must have the **CH1** jumper (power supply) set in the **E** position.

Redundant Mode:
In redundant mode, the power supply modules must be placed in the first and third slots of rack **DF1A** or first and second slots of rack **DF78**. In both, the **CH1** jumper (power supply) must be set in the **R** position. In this condition, the power supply modules will split the power. This topology is called “split power mode”.

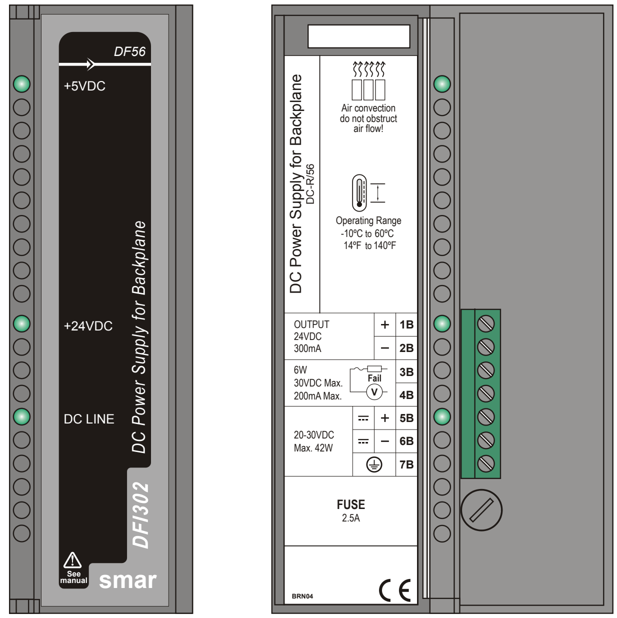


Figure 5.1 - DC Power Supply Module: DF56

Technical Specifications

INPUTS	
DC	20 to 30 Vdc
Inrush Current	< 20.6 A @ 30 Vdc [ΔT < 430 us]
Maximum Consumption	42 W
Indicator	DC LINE (Green LED)

OUTPUTS	
a) Output1 (internal use)	5.2 Vdc +/- 2%
Current	3 A Maximum
Ripple	100 mVpp Maximum
Indicator	+5 Vdc (Green LED)
Hold up Time	> 47 ms @ 24 Vdc [Full Load]
b) Output 2 (external use)	24 Vdc +/- 10%
Current	300 mA Maximum
Ripple	200 mVpp Maximum
Short Circuit Current	700 mA
Indicator	+24 Vdc (Green LED)

ISOLATION	
Input signal, internal outputs and the external output are isolated among them.	
Between outputs and ground	500 Vrms
Between input and output	1500 Vrms

FAILURE RELAY	
Type of Output	Solid state relay, normally closed (NC), isolated
Limits	6 W, 30 Vdc Max, 200 mA Max
Maximum Initial Contact Resistance	<13 Ω
Overload Protection	Should be provided externally.
Operation Time	5 ms maximum

TEMPERATURE	
Operation	-10 ºC to 60 ºC (14 ºF to 140 ºF)

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	39.9 x 137.0 x 141.5 mm ; (1.57 x 5.39 x 5.57 in)
Weight	0.450 kg

CABLES	
One wire	14 AWG (2 mm^2)
Two wires	20 AWG (0.5 mm^2)

NOTES
1. If the power consumption exceeds the power supplied, the AuditFlow system may operate in an unpredictable manner that may causes damages to the equipment or risk of personal injury. Therefore, the power consumption must be calculated correctly and a detailed analysis should be performed to define the installation of extra power supply modules. 2. The hardware revisions which are GLL1279 Rev1 and previous revisions do not support redundancy feature. 3. To meet the EMC standards requirements, the wires' length to the failure relay must be less than 30 meters. The power supply of activated load by the failure relay must not be from external network.

DF87 – Power Supply for Backplane (5 A, Redundant, with diagnostic)

Description

This redundant power supply works independently or with another redundant power supply module to assure a constant power supply to the backplane. When two redundant power supply modules are used, both split the energy that is needed to supply the system. When one power supply fails, the other, automatically, will assume the operation.

This module provides a 5 Vdc output voltage, isolated from the input, with capacity of 5 A.

The DF87 has advanced diagnostics, which are indicated by LEDs, and can be read by the DFI302 controller. It also has a relay that is activated (closed) to indicate failures.

The DF87 has three ranges to signal the diagnostics. The diagnostic signal **OK** means the DF87 is operating in correct range, ensuring that is far from the fault limits. If the DF87 is out of this range, before reaching the limits that stop its operation, warning diagnostics are flagged, allowing intervention before potential failures may occur. If the fault limits are reached, the DF87 stops the operation, disconnecting to the bus. Thus, the failure does not affect the performance of redundancy, the failure relay is activated (closed), and the possible causes of failures are indicated.

Installation and Configuration

Operation without Redundancy
Each DF87 powers one bus segment.

Redundant mode
Two modules will supply power to a bus segment. If one of them was turned off or fails, the other power supply must be able to supply energy, alone, to the segment.

For systems based on DF92 and DF93 rack, with DF90 and DF91

Expansion of load capacity by adding power supplies or pairs of redundant power supplies
If the system consumption is greater than 5A, it can be subdivided in up to 8 groups sized for consumption of up to 5A each, and each group is individually powered by a power supply, or redundant pair of power supplies. More details on the Power supplies positioning topic.

Power supplies positions in the slots
On DF92, the pair of redundant power supplies must be installed in the first and second slots.

On DF93 is recommended the placement of the redundant pair in the first and second slots, but it can be installed in any slots if necessary.

For systems based on DF1A

Expansion of load capacity by adding power supplies or pairs of redundant power supplies

With the DF1A is possible reach up to 3A per slot. If the system consumption is greater than 3A, it can be subdivided in up to 8 groups sized for consumption of up to 3A each, and each group is individually powered by a power supply, or redundant pair of power supplies. More details on the Power supplies positioning topic.

Power supplies positions in the slots

On DF1A, the pair of redundant power supplies must be installed in the first and third slots.

ATTENTION
- The power supply DF87 is not compatible with the DF78 rack. Use the DF92 rack if redundant controllers are needed together with the DF87. - Even using the power supply DF87, the DF1A rack only supports 3A per slot.

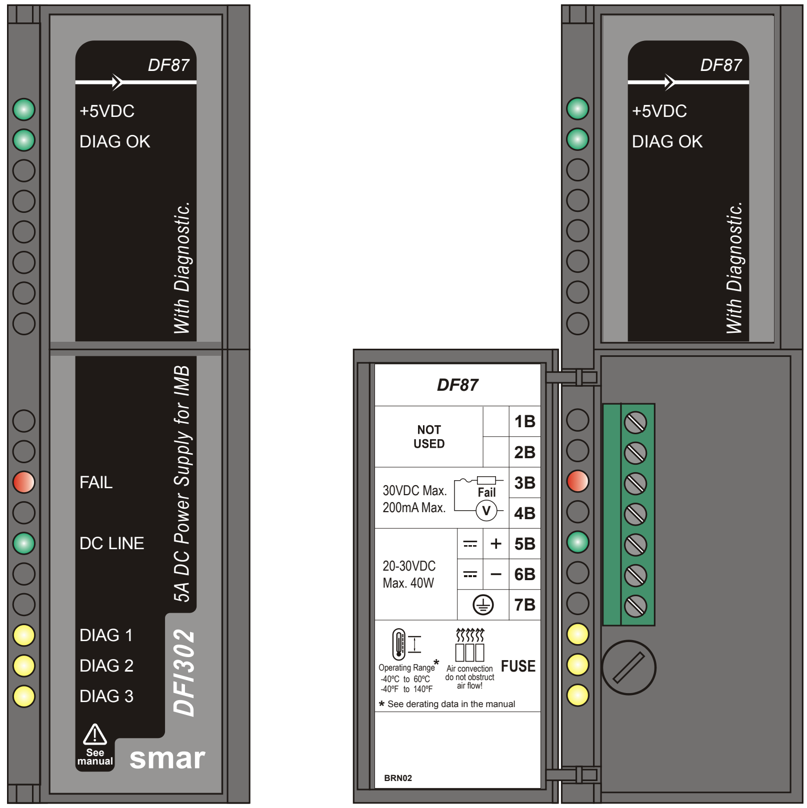


Figure 5.2 - DC Power Supply Module: DF87

Technical Specifications

INPUTS	
DC	20 to 30 Vdc 24 Vdc nominal
Maximum Consumption	40 W (@ 5A output)
Indicator	DC LINE (Green LED)

OUTPUTS	
Output (internal use)	5.2 Vdc +/- 2%
Current	5 A Maximum (See derating curve in the figure 5.6)
Ripple	100 mVpp Maximum
Indicator	+5 Vdc (Green LED)
Hold up Time	> 4.7 ms @ 24 Vdc [Full Load]

ISOLATION	
Between outputs and ground	1500 Vdc
Between input and output	1500 Vdc

FAILURE RELAY	
Type of Output	Solid state relay, normally closed (NC), isolated
Limits	6 W, 30 Vdc Max, 200 mA Max
Maximum Initial Contact Resistance	<13 Ω
Overload Protection	Should be provided externally.
Operation Time	12 ms maximum

TEMPERATURE	
Operation	-40 ºC to 60 ºC (-40 ºF to 140 ºF) (See derating curve in the figure 5.6)

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	39.9 x 137.0 x 141.5 mm ; (1.57 x 5.39 x 5.57 in)
Weight	0,453 Kg

CABLES	
One wire	14 AWG (2 mm^2)
Two wires	20 AWG (0.5 mm^2)

NOTE
To meet the EMC standards requirements, IEC 61326, the wires' length to the failure relay must be less than 30 meters. The power supply of the load activated by the failure relay must not be from external network. If the power cables of the input are greater than 3 m, install the ferrite core "FAIR-RITE V0", attached to the product packing. To install it, involve with the ferrite core all cables that are connected to the 5B, 6B and 7B contacts of the front terminal block near to DF87.

Diagnostics LEDs

The power supply DF87 has the following frontal LEDs, indicating the following situations shown in the figure below.

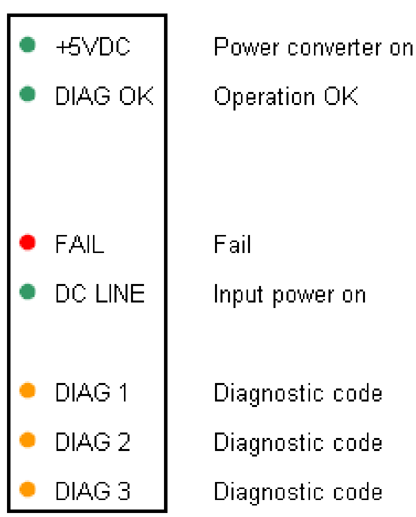


Figure 5.3 - DF87 frontal LEDs

The following is a summary of situations and the status of the LEDs for warning diagnostics, allowing intervention before potential failures may occur in the DF87 power supply.

OK	Input Voltage Low	Input Voltage High	Output Current	Internal Temperature	Unrecognized	Out Protection Acting	Internal Problem (ripple, etc)
🟢 DIAG OK	⚪ DIAG OK	⚪ DIAG OK	⚪ DIAG OK	⚪ DIAG OK	⚪ DIAG OK	⚪ DIAG OK	⚪ DIAG OK
⚪ DIAG 1	🟠 DIAG 1	⚪ DIAG 1	🟠 DIAG 1	⚪ DIAG 1	🟠 DIAG 1	⚪ DIAG 1	🟠 DIAG 1
⚪ DIAG 2	⚪ DIAG 2	🟠 DIAG 2	🟠 DIAG 2	⚪ DIAG 2	⚪ DIAG 2	🟠 DIAG 2	🟠 DIAG 2
⚪ DIAG 3	⚪ DIAG 3	⚪ DIAG 3	⚪ DIAG 3	🟠 DIAG 3	🟠 DIAG 3	🟠 DIAG 3	🟠 DIAG 3

Figure 5.4 - Diagnostics LEDs

The FAIL LED indicates failure when is ON.

The following graph shows the behavior of the output current within the operation range of the DF87 in environments without artificial ventilation.

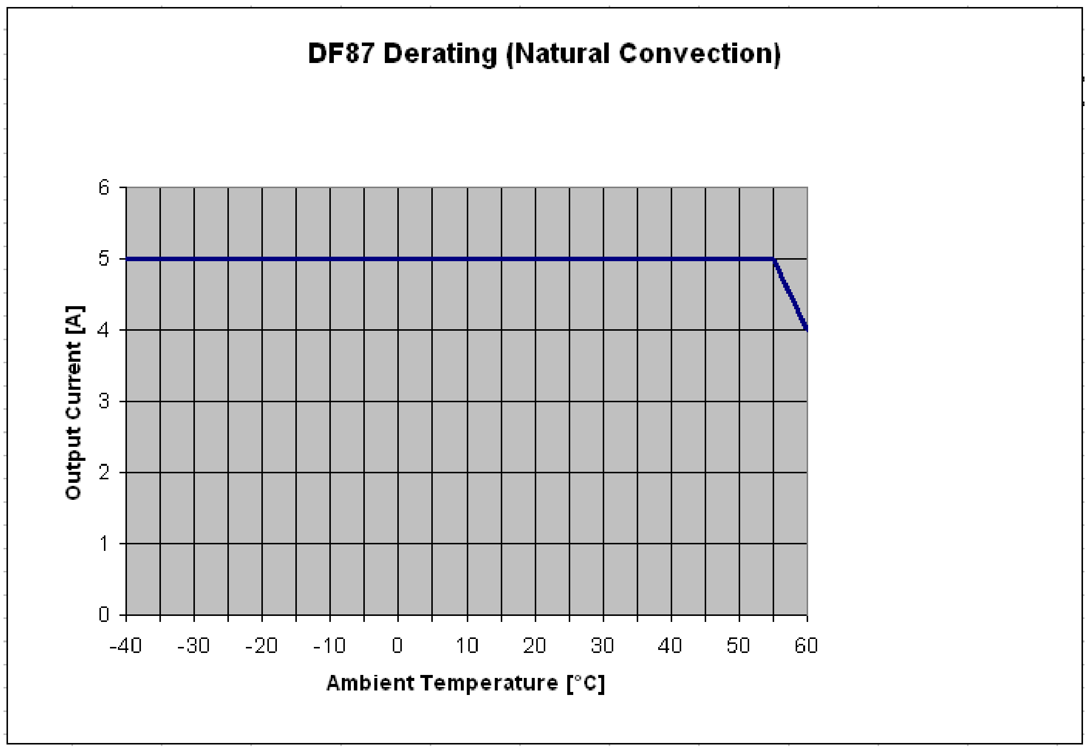


Figure 5.5 - Derating curve of the output current versus temperature, for environments without ventilation

Calculating the Power Consumption

Since the power available in the power supply is limited, it is important to calculate the power consumption of modules in use. The user can create a worksheet to summarize all supplied and required current from each module and associated equipment (such as operator interface).

Example of worksheet with the module's consumption, and some power supplies' specification.

AuditFlow Power Budget										
Module	**Description**	**Qty.**	**Consumption Unit Power (mA)**		**Total Power (mA)**		**Supply Unit Power (mA)**		**Total Power (mA)**	
			@24 V	**@5 V**	**@24 V**	**@5 V**	**@24 V**	**@5 V**	**@24 V**	**@5 V**
HFC302	Controller	1	0	550	0	0				
DF11	2*8 DI 24 Vdc		0	80	0	0				
DF12	2*8 DI 48 Vdc		0	80	0	0				
DF13	2*8 DI 60 Vdc		0	80	0	0				
DF14	2*8 DI 125 Vdc		0	80	0	0				
DF15	2*8 DI 24 Vdc (sink)		0	80	0	0				
DF16	2*4 DI 120 Vac		0	50	0	0				
DF17	2*4 DI 240 Vac		0	50	0	0				
DF18	2*8 DI 120 Vac		0	87	0	0				
DF19	2*8 DI 240 Vac	2	0	87	0	174				
DF20	8 switches		0	45	0	0				
DF44	8 AI		0	320	0	0				
DF57	8 AI		0	320	0	0				
DF45	8 Temperature inputs		0	55	0	0				
DF21	16 DO (transistor)		65	70	0	0				
DF22	2*8 DO (transistor)		65	70	0	0				
DF23	8 DO (triac)		0	70	0	0				
DF24	2*8 DO (triac)		0	115	0	0				
DF25	2*4 DO (relay)		134	20	0	0				
DF26	2*4 DO (relay)		134	20	0	0				
DF27	2*4 DO (relay)		134	20	0	0				
DF28	2*8 DO (relay)		180	30	0	0				
DF29	2*4 DO (relay)		134	20	0	0				
DF30	2*4 DO (relay)		134	20	0	0				
DF31	2*4 DO (relay)		134	20	0	0				
DF46	4 AO		180	20	0	0				
DF32	8 DI 24 Vdc, 4 DO (relay)		67	60	0	0				
DF33	8 DI 48 Vdc, 4 DO (relay)		67	60	0	0				
DF34	8 DI 60 Vdc, 4 DO (relay)		67	60	0	0				
DF35	8 DI 24 Vdc, 4 DO (relay)		67	60	0	0				
DF36	8 DI 48 Vdc, 4 DO (relay)		67	60	0	0				
DF37	8 DI 60 Vdc, 4 DO (relay)		67	60	0	0				
DF38	8 DI 24 Vdc, 4 DO (relay)		67	60	0	0				
DF39	8 DI 48 Vdc, 4 DO (relay)		67	60	0	0				
DF40	8 DI 60 Vdc, 4 DO (relay)		67	60	0	0				
DF53	4 Fieldbus Power Impedance	1	1500	0	1500	0				
TOTAL		**4**			**1500**	**1074**				
DF50		1					300	3000	300	3000
DF52		1					1500	0	1500	0
TOTAL		**6**							**1800**	**3000**

Power supplies positioning

For systems based on DF92 and DF93 racks with DF90 and DF91

A power supply connected to a rack, in a system, provides current to the racks row that are horizontally interconnected to it by their terminals of lateral connections, and vertically through DF90 cables, thus forming a group of rows of racks that use the same power supply.

The system can have only one power supply (or pair of redundant power supplies) or it can be subdivided in several of these groups[1], each one powered by a power supply (or pair of redundant power supplies).

The recommended way to distribute the power is to divide the system in groups of horizontal rows of racks. In this scheme, each power supply must be positioned on the top left of the group of rows of racks that it powers. The rack where is the power supply must be the **W1** jumper cut and the DF90 cable must not be connected to the rows powered by other power supplies (top rows). See in the following figure an example of system powered by two power supplies, each one powers a part of rows represented in green and blue.

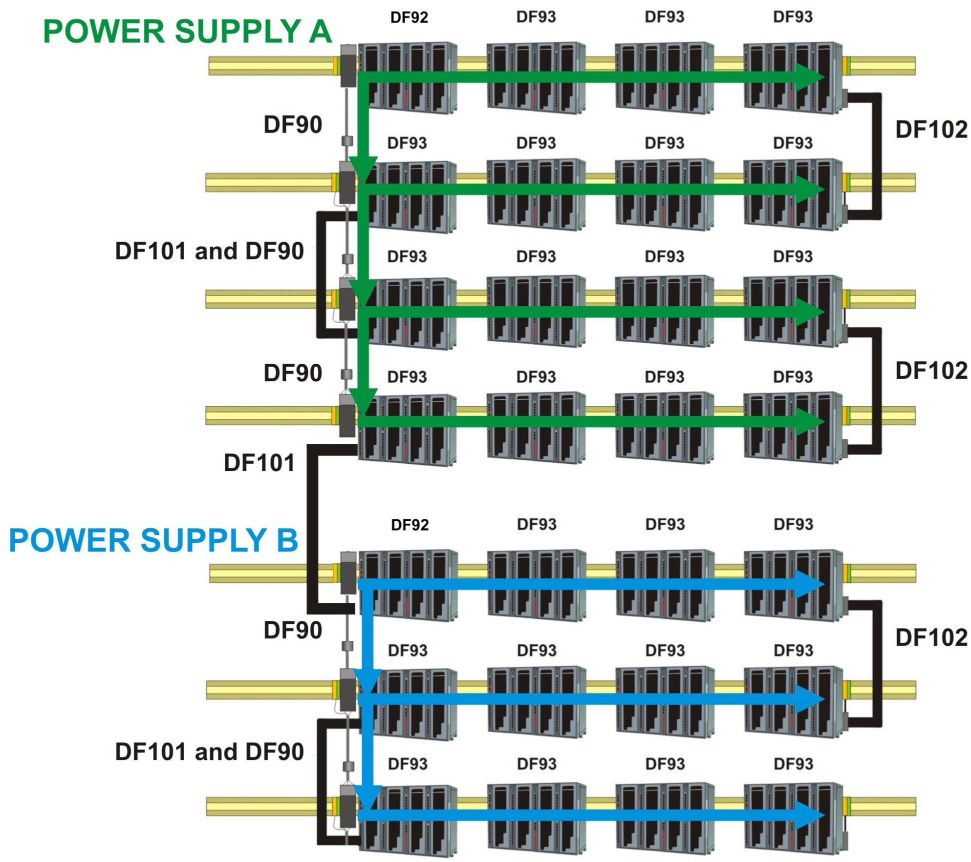


Figure 5.6 - System powered by two power supplies

Note that this system, for greater efficiency, is optimized for power distribution by groups of rows of racks. Thus, a power supply powers a whole number of rows it supports. However, in rare cases, with long rows or many modules with great consumption in the same row, there is the option to add power supplies in the middle of the row, dividing the power within this row. In this case, the power supply added powers only the modules positioned on the right in the same row, up to the end, or even where there is another power supply added. In the rack where the power supply was added, in this scheme, the **W1** jumper must be cut and left lateral connection terminal (+5 Vdc) must be disconnected (collapsed).

In this system, **DF50** and **DF56** must be their **CH1** jumper always configured in **R**, even if they are

[1] Maximum 8 groups allowed when the DF50, DF56 or DF87 power supplies are used.

not in redundant pairs.

ATTENTION
A mixture of these power supplies with the **CH1** configured in **R** and in **E** in any **AuditFlow** system, is not allowed!

On DF92, the pair of redundant power supplies must be installed in the first and second slots.

On DF93 is recommended the placement of the redundant pair in the first and second slots, but it can be installed in any slots if necessary.

The system has diagnostic for voltage level distributed to racks. It also supports modules with great power consumption in any place on the bus. Nevertheless, is recommended to place those modules close to the power supplies, to avoid unnecessary power transmission.

For systems based on DF78 and DF1A Racks

1. Observe the maximum current values from the power supply module specification. The limit for DF50 is 3 A, and for DF87 is 5 A.

2. After the connection with long cables (DF4A, DF5A, DF6A and/or DF7A) you have to put another power supply module in the first slot of the first rack.

3. Use up to 6 modules DF44/DF57 per power supply; always place consecutively the DF44/DF57 and close to the power supply. Because of the high current consumption of the modules DF44/DF57, a not desired voltage drop in the bus can occur if these modules are placed after other modules.

4. When is necessary to add interface modules, such as HI302, MB700, DF58, in the same bus which is used by output and input modules, is recommended that these modules are placed close to the power supply, because in the same way as described in the previous item, a not desired voltage drop in the bus can occur if these modules are placed after other modules.

5. Adding a new power supply module

- Determine the rack where the new power supply will be installed.
- Cut the jumper **W1** of the rack.
- Plug the new power supply at the first slot of the rack (slot 0).
- In this case, the **CH1** jumper of all modules **DF50** must be set in **E** position.

ATTENTION
- The power supply DF87 is not compatible with the DF78 rack. Use the DF92 rack if redundant controllers are needed together with the DF87. - Even using the power supply DF87, the DF1A rack only supports 3A per slot.

DF52 / DF60 – Power Supply for Fieldbus

Description

These modules were specially designed to supply the Fieldbus networks. The only difference between them is the input voltage:

DF52 (90 ~ 264 Vac)
DF60 (20 ~ 30 Vdc)

The **DF52** power supply is a non-intrinsically safe equipment with an universal AC input (90 to 264 Vac, 47 to 63 Hz or 127 to 135 Vdc), and a 24 Vdc output, isolated, with short circuit and overcurrent protection, ripple and fault indication, proper to supply fieldbus elements.

The **DF60** power supply unit is a non-intrinsically safe equipment with a DC input (20 to 30 Vdc) and a 24 Vdc output, isolated, with short circuit and overcurrent protection, ripple and fault indication, proper to supply fieldbus elements.

The interconnection of Fieldbus elements to the **DF52/DF60** is indicated in figure bellow. There is no overshoot when it is switched on or off. The **DF52/DF60** can power up to 4 fully loaded fieldbus networks.

NOTE
The length of the cables that interconnect the DF52/DF60 to the DF53/DF98 modules must not exceed 3 meters.

If any abnormal condition occurs in the output, such as overloading or short circuit, the **DF52/DF60** internal switches are automatically switched off to protect its circuit. When the outputs return to normal operation conditions, the circuit is automatically switched on.

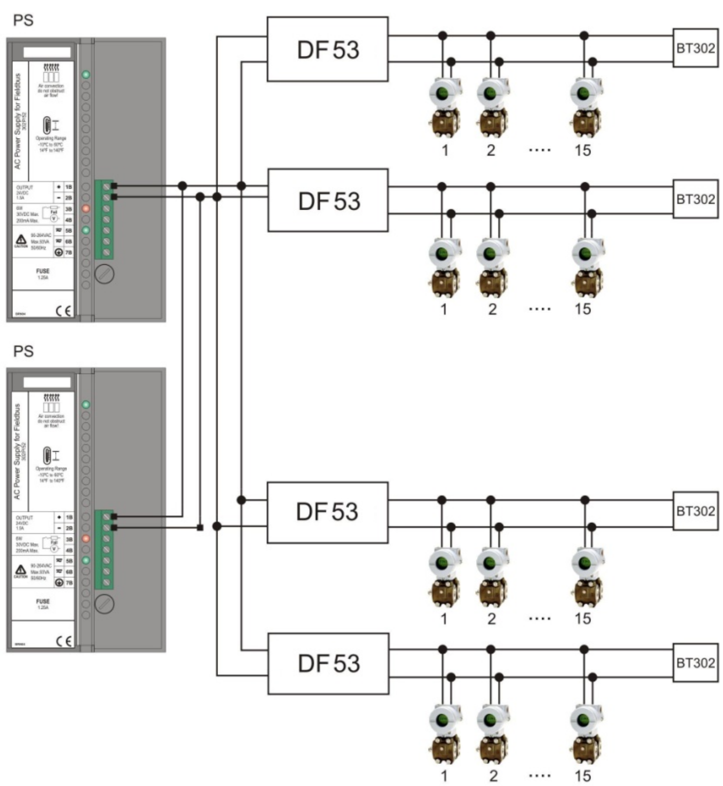


Figure 5.7- System powered by DF52

The **DF52/DF60** modules allow redundancy without any component connected to their outputs.

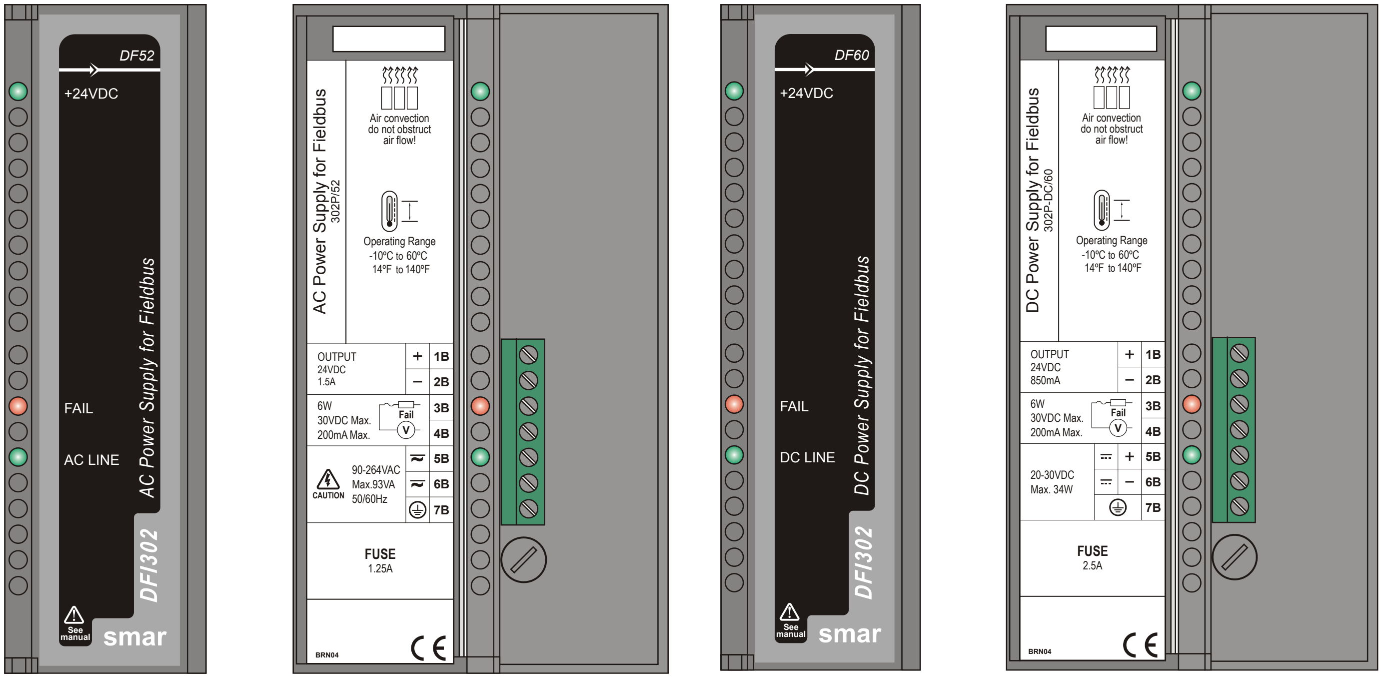


Figure 5.8 - Power Supply Module for Fieldbus: DF52/DF60

Technical Specifications

INPUTS DF52	
DC	127 to 135 Vdc
AC	90 to 264 Vac, 50/60 Hz (nominal), 47 to 63 Hz (range)
Maximum Inrush Current	< 30 A @ 220 Vac [ΔT < 640 us]
Maximum Consumption	93 VA
Indicator	AC LINE (Green LED)

INPUTS DF60	
DC	20 to 30 Vdc
Maximum Inrush Current	< 24 A @ 30 Vdc [ΔT < 400 us]
Maximum Consumption	34 W
Indicator	DC LINE (Green LED)

OUTPUTS		
Output	24 Vdc ± 1%	
Current	**DF52**	**DF60**
	1.5 A Maximum	850 mA Maximum
Ripple	20 mVpp Maximum	
Indicators	+24 Vdc (Green LED)	
	FAIL (Red LED)	

ISOLATION		
Input signal, internal outputs and the external output are isolated among them	**DF52**	**DF60**
Among outputs and ground	1000 Vrms	500 Vrms
Between input and output	2500 Vrms	1500 Vrms

FAILURE RELAY	
Type of Output	Solid state relay, normally closed (NC), isolated
Limits	6 W, 30 Vdc Max, 200 mA Max
Maximum Initial Contact Resistance	<13Ω
Overload Protection	Should be provided externally
Operation Time	5 ms maximum

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	39.9 x 137.0 x 141.5 mm ; (1.57 x 5.39 x 5.57 in)
Weight	0.450 kg

TEMPERATURE	
Operation	-10 °C to 60 °C (14 ºF to 140 ºF)
Storage	-30 °C to 70 °C

NOTE
To meet the EMC standards requirements, the wires' length to the failure relay must be less than 30 meters. The power supply of activated load by the failure relay must not be from external network.

DF53 / DF98 – Power Supply Impedance for Fieldbus

Description

These modules were specially designed to provide appropriate impedance for fieldbus networks. The only difference between them is the number of fieldbus ports supported:

DF53 (4 ports)
DF53-FC (4 ports)
DF98 (2 ports)

The purpose of this impedance is to implement an output circuit where the impedance is greater than 3 KΩ, and when assembling in parallel with two 100 Ω ±2% terminators, it results in a 50 Ω line impedance approximately. This impedance can be implemented in a passive mode (50 Ω resistance in series with a 100 mH inductance) or in an active mode, through an impedance control circuit.

The fieldbus power supply impedance is a non-isolated, active impedance control device, in compliance with IEC 61158-2 standard. This device provides an output impedance which, in parallel with the two bus terminators (a 100 Ω resistor in series with a 1 μF capacitor) required by the standard, results in a pure resistive line impedance for a broad frequency range. The **DF53/DF98** cannot be used in intrinsic safety areas.

The figure shows the device block diagram. The **DF53/DF98** can be used in redundancy, connecting its output (+ and -) in parallel. In this case, use an external bus terminator (**BT302**) to allow maintenances or replacing the **DF53/DF98** in case of failure without interrupting the fieldbus communication.

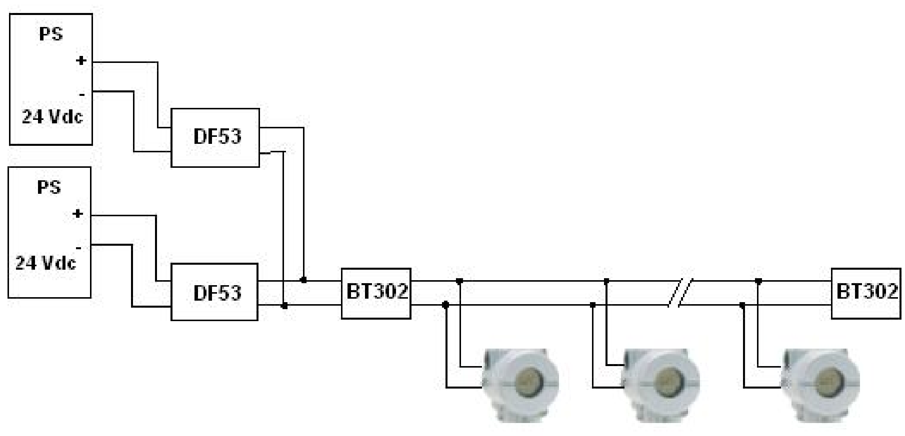


Figure 5.9 – System using the impedance DF53

The **DF53/DF98** modules have LEDs to indicate power supply and overcurrent. The input terminal block has two terminals (1A and 2A) that are connected to the external 24 Vdc. The power supply indication LED is green and it is energized while there is an external 24 Vdc power supply.

The overcurrent indication LED is red and it is energized only in case of an overcurrent caused by a short circuit in the plant or by an excessive number of devices connected. The following figure shows a **DF53/DF98** layout.

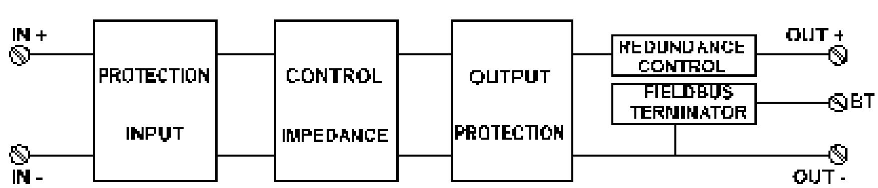


Figure 5.10 – System using the impedance DF53/DF98

DF53: Eight terminals (3A to 10A) implementing four independent Fieldbus ports, four DIP switches for activating the bus termination, one green LED for power status, and four red LEDs indicating overcurrent.

DF53-FC (PSI302P-4): It has the same characteristics of DF53 and meets the requirements for hardware tests of OIML R117-1 (Flow Measurement System of Liquids).

DF98: Four terminals (3A/4A and 9A/10A) implementing two independent Fieldbus ports, two DIP switches for activating the bus termination, one green LED for power status, and two red LEDs indicating overcurrent.

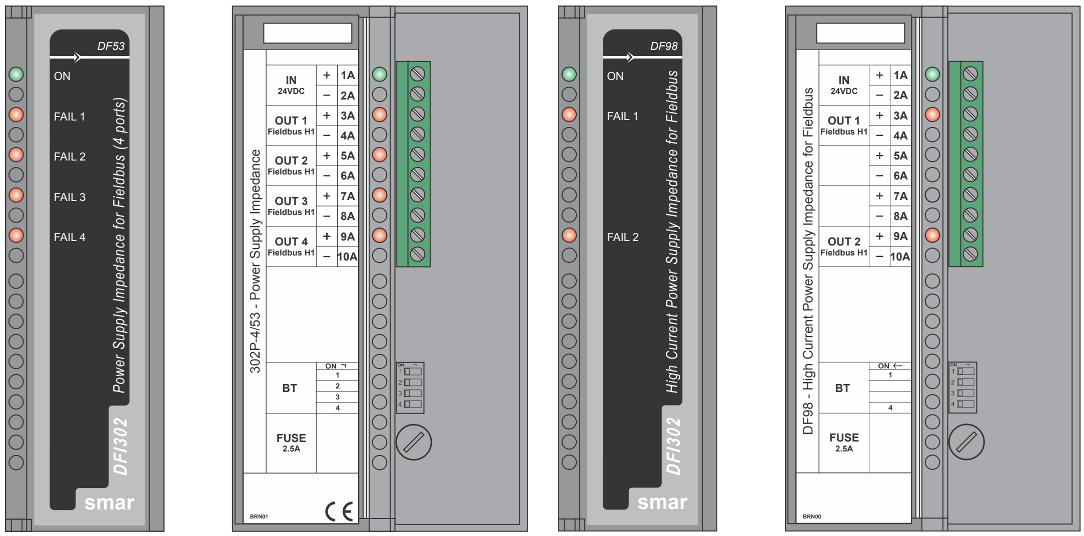


Figure 5.11 – Impedance for Fieldbus Modules: DF53/DF98

Technical Specifications

INPUT	
DC	24 to 32 Vdc +/- 10%

OUTPUT	
Current	DF53: 340 mA per channel DF98: 500 mA per channel

INPUT FILTER	
Attenuation	10 dB in the input power ripple @60 Hz

CONSUMPTION	
Maximum power dissipated	DF53: 2,26 W per channel DF98: 3,43 W per channel

DIMENSIONS AND WEIGHT	
Dimensions (W x H x D)	39.9 x 137.0 x 141.5 mm; (1.57 x 5.39 x 5.57 in)
Weight (without package)	260 g

TEMPERATURE	
Operation	0 °C to 60 °C
Storage	-30 °C to 70 °C

SAFETY	
Output Overcurrent	DF53: 450 mA DF98: 600 mA
Input Fuse	2.5 A
Atmospheric Discharges	Input and output protected by transient suppressors
Intrinsic Safety	It cannot be applied directly

MAXIMUM LENGTH OF FIELDBUS WIRING		
DF53/DF98	No redundancy	1.900 m
	Redundant	1.900 m
DF53-FC	No redundancy	1.900 m
	Redundant	1.000 m

Installation

The **DF53/DF98** is a device specially designed for panel installation and it cannot be installed in unsheltered locations, as it cannot be exposed directly to the weather. The module can be connected to the panel directly on the DIN rail or using the auxiliary support provided with the module, fixed with screws. Refer to the "Hardware" section for further details about installation and dimensional drawings of the module.

Maintenance and troubleshooting

The **DF53/DF98** is a robust device which basically requires no preventive maintenance. It is simply recommended to protect it from excessive dust accumulation and humid environments which might affect its output impedance.

The two models have LEDs which inform their operation status – one green LED which informs that the module is properly powered, and one red LED for each channel, that will be lit if any abnormal condition occurs in the field wiring.

These LEDs detect most of the problems which may occur in a Fieldbus installation. However, they might not detect other problems, such as:

- Excessive noise caused by the external power supply;
- Impedance lower than 20Ω in the communication line (note that such impedance may not be pure resistive and, therefore not detectable by the overcurrent circuit).

Such abnormal conditions may be easily detected by measurement instruments.

Because the **DF53/DF98** is a simple and compact device, it is recommended to replace faulty modules instead of electronic components during repair services.

DF47-12 and DF47-17 – Intrinsic Safety Barrier for Fieldbus

Description

The Intrinsically Safe (I.S.) technology incorporated in the DF47-12 and DF47-17 totally isolates the control network on the hazardous side of the barrier. The I.S. values of the power supply are designed for fieldbus devices, which are in compliance with the FISCO model.

The incorporation of a fieldbus repeater in compliance with IEC 61158-2 (31.25 kbits/s) essentially filters and boosts the incoming communication signal transmitting it to hazardous environment. The networks of the hazardous and safe sides of the DF47-12 and DF47-17 are completely independent from one another.

In addition the bus termination for the hazardous network is incorporated into the DF47-12 and DF47-17, which means that only a single far terminator is required.

NOTES

1. If the terminator of the DF53 module is not being used, it is necessary to install another external terminator in the safe area.
2. The model DF47 was discontinued due to the new FISCO requirements. The replacement by DF47-12 or DF47-17 models should be evaluated according to the current limits. The model DF47-17 supports up to 7 Smar devices of the 302 series. If the replacement is using the DF47-12 model, it supports up to 5 Smar devices of the 302 series.

- H1 Isolated Barrier and IS Power Supply in compliance with the FISCO Model.
- H1 Fieldbus Signal Repeater.
- In compliance with the IEC 61158-2, 31.25 kbits/s standard for fieldbus. (FOUNDATION fieldbus and PROFIBUS PA).
- IEC, FM & CENELEC Intrinsic Safety standards certified.
- In compliance with IEC 60079-27, FISCO and FNICO Power Supply.
- Dual Marking in compliance with IEC 60079-11 and IEC 60079-27.
- Bus terminator on hazardous area.

Installation

The selection and installation of the barrier should always be accomplished by competent technical personnel. Please contact Smar or our local representative if further information is required.
According to the standards for hazardous areas the barrier DF47-12 or DF47-17 must be installed out of hazardous area. The input parameters for installation in hazardous area are in the Certificates for Hazardous Areas topic.

The barrier has to be installed on DF1A, DF93 or DF9 and fixed in a DIN rail. For further details see the Hardware section.

Installation Principles
1. Ensure that there is an appropriate separation of intrinsically safe and non-intrinsically safe circuits (more than 50 mm or 1.97 inches), so the ignition energy from non-intrinsically safe circuit does not intrude into the intrinsically safe circuit.
2. Ensure that the limiting parameters of system design, for example total inductance and capacitance, upon which system approval is based are not exceeded.
3. Ensure that power system faults and ground potential differences do not generate system ignition.

Location
The barrier is normally installed in a dust-free and moisture-free enclosure located in the non-hazardous area. The enclosure should be as close as possible to the hazardous area to reduce cable runs and increased capacitance. If the barrier is installed in a hazardous area, it must be in a proper enclosure suited for the intended area. The only intrinsically safe terminals are at the barrier output.

Wiring

Intrinsically safe circuits may be wired in the same manner as conventional circuits installed for hazardous areas with two exceptions summarized as separation and identification. The intrinsically safe conductors must be separated from all other cables by placing them in separate conduits or by a separation of more than 50 mm or 1.97 inches of air. The cables, cable trays, open wiring, and terminal boxes must be labeled "Intrinsically Safe Wiring" to prevent interference with other circuits.

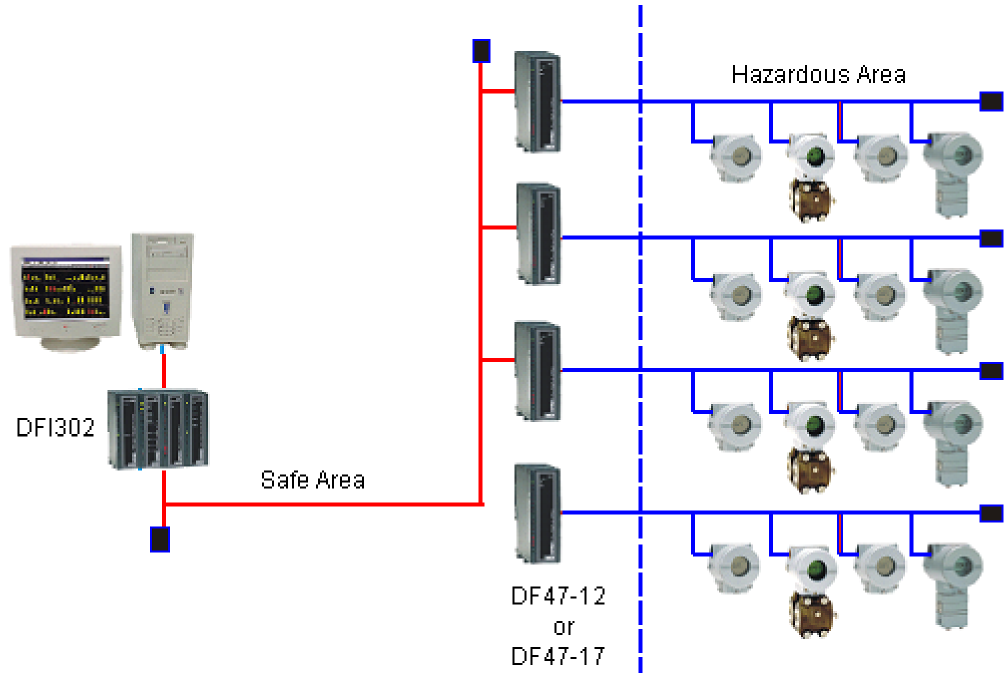


Figure 5.12 – DF47 installation

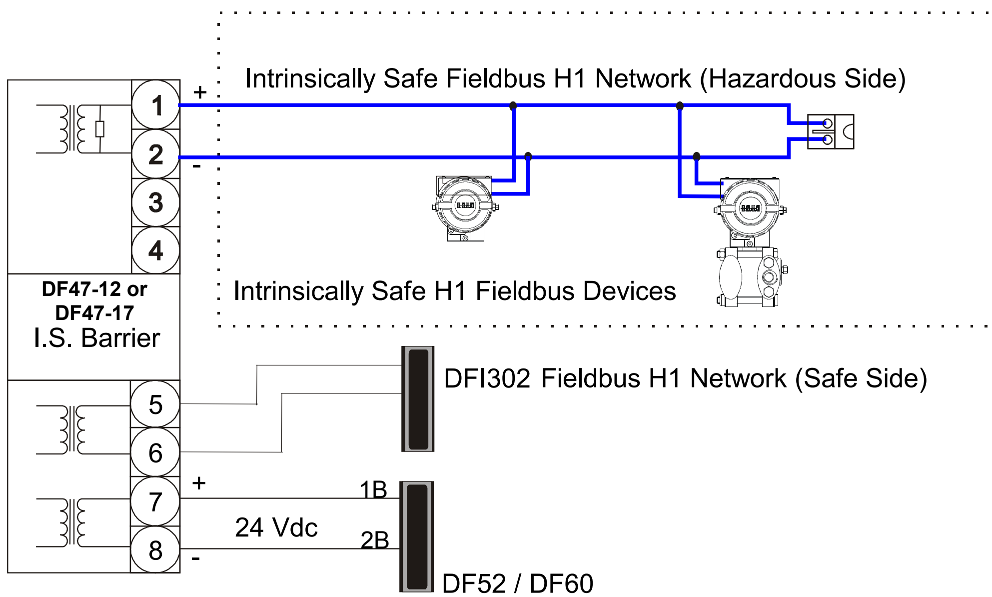


Figure 5.13 – DF47 installation

Technical Specifications

POWER	
Power Supply Input	Voltage: 24Vdc ± 5%
	Current (max.): 350mA @ 24Vdc

HAZARDOUS AREA	
Power Supply Output	Maximum voltage available at the barrier terminals: Us = 13.8 Vdc
	Maximum Current in typical operation (considering Us = 13.8 Vdc) DF47-12: Is = 65 mA DF47-17: Is = 90 mA
	Current limiting resistor (typical) DF47-12: Ri ≥ 247.5 Ω DF47-17: Ri ≥ 176.22 Ω
	Maximum output power DF47-12: Po = 1.2 W DF47-17: Po = 1.72W
Safety Parameters (Hazardous Area)	Refer to the item "Hazardous locations approvals"
Internal Dissipation	3W maximum at 24Vdc input, nominal conditions (for non-intrinsically safe circuits)
Cable Length, Number of Devices	Maximum cables lengths are determined by IS requirements, and depend on both the number of devices attached and the maximum acceptable voltage drop along the cable. Use FISCO cable.
Digital Signal Transmission	Compatible with 31.25 kbps – Fieldbus systems.
Fuse	In order to guarantee the product safe, the internal fuse change must be executed only by the manufacturer.
Terminals	Accommodate conductors up to 2.5 mm^2 (22AWG).
Isolation	2500V galvanic isolation among input, output, and power supply terminals. Tested at 1500 Vrms minimum between hazardous and safe area terminals.

PHYSICAL	
Ambient Temperature	0 to +60 ºC (operation)
	-30 ºC to 70 ºC (storage)
Humidity	5% to 95% relative humidity

IMPORTANT
By using active junction boxes you must consider their current consumption to calculate the total consumption of segment.

Certification Information

Approved Manufacturing Locations

Smar Equipamentos Industriais Ltda – Sertãozinho, São Paulo, Brazil
Smar Research Corporation – Ronkonkoma, New York, USA

European Directive Information

This product complies with following European Directives:

EMC Directive (2004/108/EC) - Electromagnetic Compatibility
The equipment is in compliance with the directive and EMC test was performed according to IEC standards: IEC61326-1:2005 and IEC61326-2-3:2006. See table 2 from IEC61326-1:2005.
To comply with the EMC directive the installation must follow these special conditions:

- Use shielded, twisted-pair cable for powering the instrument and signal wiring.
- Keep the shield insulated at the instrument side, connecting the other one to the ground.

ATEX Directive (94/9/EC) - Electrical equipment and protective system intended for use in potential explosive atmospheres
The EC-Type Examination Certificate had been released by Nemko AS (CE0470) and/or DEKRA EXAM GmbH (CE0158), according to European Standards.
The certification body for Production Quality Assurance Notification (QAN) and IECEx Quality Assessment Report (QAR) is Nemko AS (CE0470).

Consult www.smar.com for the EC declarations of conformity for all applicable European directives and certificates.

Hazardous locations general information

Ex Standards:
IEC 60079-0 General Requirements
IEC 60079-11 Intrinsic Safety "i"
IEC 60079-27 Fieldbus intrinsically safe concept (FISCO)

Customer responsibility:
IEC 60079-10 Classification of Hazardous Areas
IEC 60079-14 Electrical installation design, selection and erection
IEC 60079-17 Electrical Installations, Inspections and Maintenance

WARNING
Explosions can result in death or serious injury, besides financial damage. Installation of this instrument in an explosive environment must be in compliance with the national standards and according to the local environmental protection method. Before proceeding with the installation match the certificate parameters from the barrier, cable and device according to the environmental classification.

General Notes
Maintenance and Repair
The instrument modification or replaced parts supplied by any other supplier than authorized representative of Smar Equipamentos Industriais Ltda is prohibited and will void the Certification.

Marking Label
Once a device labeled with multiple approval types is installed, do not reinstall it using any other approval types. Scratch off or mark unused approval types on the approval label.

For Ex-i protection application

- Connect the instrument to a proper intrinsically safe barrier.
- Check the intrinsically safe parameters involving the barrier, equipment including the cable and connections.
- Associated apparatus ground bus shall be insulated from panels and mounting enclosures.
- When using shielded cable, isolate the not grounded cable end.
- Cable capacitance and inductance plus Ci and Li must be smaller than Co and Lo of the

Associated Apparatus.

For FISCO System requirements (IEC 60079-27:2008)

FISCO Power Supplies

General

The power supply shall be resistive limited or have trapezoidal output characteristic. The maximum output voltage, Uo, shall be not greater than 17.5V nor less than 14V under the conditions specified in IEC60079-11 for the respective level of protection.

The maximum unprotected internal capacitance Ci and inductance Li shall be not greater than 5nF and 10µH, respectively.

The output of the power supply may be connected to earth.

No specification of the internal capacitance Ci and Li or the maximum external parameters Lo and Co is required on the certificate or label.

The determination of power supply output parameters shall into account the possible opening, shorting and grounding of field wiring connected to the field terminals of the apparatus.

Additional requirements of “ia” and “ib” FISCO power supplies

The maximum output current Io for any “ia” or “ib” FISCO power supply shall be determined in accordance with IEC60079-11 but shall not exceed 380 mA.

Table 1 – Assessment of maximum output current for use with “ia” and “ib” FISCO power supplies

Uo	Permissible current , for IIC (includes 1.5 safety factor)	Permissible current , for IIB (includes 1.5 safety factor)
14V	183 mA	380 mA
15V	133 mA	354 mA
16V	103 mA	288 mA
17V	81 mA	240 mA
17,5V	75 mA	213 mA
Note: The two largest current values for IIB are derived from 5.32W.		

Additional requirements of “ic” FISCO power supplies

The maximum output current Io for an “ic” FISCO power supply shall be determined in accordance with IEC60079-11.

Table 2 - Assessment of maximum output current for use with “ic” FISCO power supplies

Uo	Permissible current , for IIC (includes 1.5 safety factor)	Permissible current , for IIB (includes 1.5 safety factor)
14V	274 mA	570 mA
15V	199 mA	531 mA
16V	154 mA	432 mA
17V	121 mA	360 mA
17,5V	112 mA	319 mA

GENERAL NOTES

- The intrinsically safe conductors must be of blue colored, based in the IEC standards.
- If one component of the intrinsically safe system is not FISCO comply, it is necessary to match all safety parameters among cable, device and barrier.
- Designated for connection to a Fieldbus system in compliance FISCO Model with parameters as follows:

  - Intrinsically safe apparatus interconnected to the power supply circuit (Fieldbus) shall be passive current sink (not supplying) and effective internal inductance/capacitance shall be within the following maximum values:
    $Li \leq 10\ \mu H$
    $Ci \leq 5\ nF$

  - With regard to cable-length parameters of Fieldbus interconnection-cable shall be within the following ranges:

PARAMETER	VALUE
Resistance per unit length	15 Ω/km ≤ R' ≤ 150 Ω/km
Inductance per unit length	0.4 mH/km ≤ L' ≤ 1mH/km
Capacitance per unit length (including shield)	80 nF/km ≤ C' ≤ 200 nF/km

Where:
C'=C' wire/wire + 0.5 x C' wire/shield when Fieldbus-circuit insulated.
C'=C' wire/wire + C' wire/shield when shield is connected to the output of the Fieldbus power supply.

Maximum length of each spur cable: 60m in IIC/IIB.

  - A Fieldbus-data-signal terminator, providing a capacitance less than or equal to 1.1 μF connected in series with a resistor greater than or equal to 100 Ω, is integrated in the Barrier DF47-12 and DF47-17; similar terminator may be connected to the other end of the Fieldbus circuit.

  - When meeting the parameter mentioned above, maximum permissible Fieldbus-cable length including length of all spur cables for Group IIC is 1000 m.

  - When meeting the parameter mentioned above, maximum permissible Fieldbus-cable length including length of all spur cables for Group IIB and Group I is 5000 m.

*Ci : Input's capacitance, Li : Input's inductance, Co : Output's capacitance, Lo : Output's inductance

Hazardous locations approvals

FM Approvals (Factory Mutual)

DF47-12 FISCO Power Supply
Associated Intrinsic Safety (FM 3017363)
AIS Class I, Division 1, Groups A, B, C and D
AIS Class II, Division 1, Groups E, F and G
AIS Class III, Division 1
AIS Class I, Zone 0 [AEx ia], Group IIC

Special conditions for safe use:
Entity FISCO Trapezoidal Characteristic:
Terminals 1 and 2 Groups A/B IIC:
Voc (Uo)= 15.0 V, Isc (Io)= 140 mA, Iknee (Is)= 82 mA, Po= 1.2 W, Ca (Co)= 0.23 μF, La (Lo)= 0.15 mH
Terminals 1 and 2 Groups C IIB
Voc (Uo)= 15.0 V, Isc (Io)= 140 mA, Iknee (Is)= 82 mA, Po= 1.2 W, Ca (Co)= 0.75 μF, La (Lo)= 0.5 mH
Integral Terminator: R = 100 Ω, C = 1.0 μF, Ci = 0, Li= 0

Note: The Fieldbus Isolated Barrier shall be installed in compliance with the enclosure, mounting, spacing and segregation requirements of the ultimate application, including a tool removable cover.

Ambient Temperature: -20ºC ≤ Ta ≤ + 60ºC

DF47-17 FISCO Power Supply
Associated Intrinsic Safety (FM 3017363)
AIS Class I, Division 1, Groups A, B, C and D
AIS Class II, Division 1, Groups E, F and G
AIS Class III, Division 1
AIS Class I, Zone 0 [AEx ia], Group IIC

Special conditions for safe use:
Entity FISCO Trapezoidal Characteristic:
Terminals 1 and 2 Groups A/B IIC:
Voc (Uo)= 15.0 V, Isc (Io)= 197 mA, Iknee (Is)= 115 mA, Po= 1.72 W, Ca (Co)= 0.21 μF, La (Lo)= 0.15 mH
Terminals 1 and 2 Groups C IIB
Voc (Uo)= 15.0 V, Isc (Io)= 197 mA, Iknee (Is)= 115 mA, Po= 1.72 W, Ca (Co)= 0.7 μF, La (Lo)= 0.5 mH
Integral Terminator: R = 100 Ω, C = 1.0 μF, Ci = 0, Li= 0

Note: The Fieldbus Isolated Barrier shall be installed in compliance with the enclosure, mounting, spacing and segregation requirements of the ultimate application, including a tool removable cover.

Ambient Temperature: -20ºC ≤ Ta ≤ + 60ºC

EXAM (BBG Prüf - und Zertifizier GmbH)

Non Intrinsically safe circuits Parameters:
Power Supply Un = 24 Vdc, Um = 250 Vac, Pn = 3 W
Fieldbus signal circuits Um = 250 Vac

DF47-12 FISCO Power Supply
Associated Intrinsic Safety (BVS 03ATEX E 411X)
Group II, Category (1) G, [Ex ia, EPL Ga], Groups IIB/ IIC FISCO Power Supply
Group I, Category (M2) [Ex ia, EPL Mb], Group I

Intrinsically safe fieldbus supply and signal circuit (FISCO-Model):
Safety parameters:
Uo = 15.0 Vdc, Io = 140.12 mA, Is = 80 mA, Po = 1200 mW, Ri ≥ 247.5 Ω,
Characteristics trapezoidal

Special conditions for safe use
The Fieldbus-Isolated Barrier type DF47 -** shall be installed outside the hazardous area.
Wiring in the terminal box must satisfy the conditions of clause 6.3.11 and clause 7.6.e of EN60079-11:2007
Terminals or connectors for the intrinsically safe fieldbus supply and signal circuit circuits shall be arranged

according to clause 6.21 or 6.2.2 of EN 60079-11:2007 respectively.
Local installation rules to determine Lo and Co are replaced by apparatus- and cable-parameters in clause 15.3.2.
For Group I application interconnection of fieldbus-apparatus to an intrinsically safe electrical system shall be assessed in a System Certificate, if required in local installation rules.
Ambient Temperature: -20ºC ≤ Ta ≤ + 60ºC

The Essential Health and Safety Requirements are assured by compliance with:
EN 60079-0:2009 General Requirements
EN 60079-11:2007 Intrinsic Safety "i"
EN 60079-26:2007 Equipment with equipment protection level (EPL) Ga
EN 60079-27:2008 Fieldbus intrinsically safe concept (FISCO)

DF47-17 FISCO Power Supply
Associated Intrinsic Safety (BVS 03ATEX E 411X)
Group II, Category (1) G, [Ex ia, EPL Ga], Groups IIB/ IIC FISCO Power Supply
Group I, Category (M2) [Ex ia, EPL Mb] Group I

Intrinsically safe fieldbus supply and signal circuit (FISCO-Model):
Safety parameters:
Uo = 15.0 Vdc, Io = 197 mA, Is = 115 mA, Po = 1720 mW, Ri ≥ 176.22 Ω,
Characteristics trapezoidal

Special conditions for safe use
The Fieldbus-Isolated Barrier type DF47 -** shall be installed outside the hazardous area.
Wiring in the terminal box must satisfy the conditions of clause 6.3.11 and clause 7.6.e of EN60079-11:2007
Terminals or connectors for the intrinsically safe fieldbus supply and signal circuit circuits shall be arranged according to clause 6.21 or 6.2.2 of EN 60079-11:2007 respectively.
Local installation rules to determine Lo and Co are replaced by apparatus- and cable-parameters in clause 15.3.2.
For Group I application interconnection of fieldbus-apparatus to an intrinsically safe electrical system shall be assessed in a System Certificate, if required in local installation rules.
Ambient Temperature: -20ºC ≤ Ta ≤ + 60ºC

The Essential Health and Safety Requirements are assured by compliance with:
EN 60079-0:2009 General Requirements
EN 60079-11:2007 Intrinsic Safety "i"
EN 60079-26:2007 Equipment with equipment protection level (EPL) Ga
EN 60079-27:2008 Fieldbus intrinsically safe concept (FISCO)

CEPEL (Centro de Pesquisa de Energia Elétrica)

Non Intrinsically safe circuits parameters:
Power Supply Un = 24 Vdc, Pn = 3 W

DF47-12 FISCO Power Supply
Associated Intrinsic Safety (CEPEL 06.1095 X)
[Ex ia, EPL Ga], Group IIB

Nominal values of the terminals Intrinsically safe (FISCO-Model):
Un = 14.0 V, In = 75 mA, Pn = 1200 mW

Safety parameters:
Um = 250 V, Uo = 15 V, Io = 140.12 mA, Is = 80 mA, Po = 1200 mW, Ri ≥ 247.5 Ω

Ambient Temperature: -20 to 60 ºC

Special conditions for safe use
The certificate number with "X" indicates that:
a) The equipment was projected to connect with a fieldbus system according to FISCO model, as IEC60079-27:2008. The Fieldbus intrinsic safety device connected to the fieldbus terminator must be current passive consumer (not generator) and must display Ci ≤ 5 nF and Li ≤ 10 μH;
b) Wiring in the terminal box must satisfy the conditions:
Resistance: 15 Ω/km ≤ Rc ≤ 1500/km
Capacitance (including loop): 45 nF/km ≤ Cc ≤ 200 nF/km

Inductance: 0,4 mH/km ≤ Lc ≤ 1mH/km

c) The maximum length allowed for Fieldbus cables is 1000 m for Group IIC and 5000m for Group IIB

The Essential Health and Safety Requirements are assured by compliance with:
ABNT NBR IEC 60079-0:2008 General Requirements
ABNT NBR IEC 60079-11:2009 Intrinsic Safety "i"
ABNT NBR IEC 60079-26:2008 Equipment with equipment protection level (EPL) Ga
IEC 60079-27:2008 Fieldbus intrinsically safe concept (FISCO)

DF47-17 FISCO Power Supply
Associated Intrinsic Safety (CEPEL 06.1095 X)
[Ex ia, EPL Ga], Group IIB

Nominal values of the terminals Intrinsically safe (FISCO-Model):
Un = 14.0 V, In = 110 mA, Pn = 1700 mW

Safety parameters:
Um = 250 V, Uo = 15 V, Io = 197 mA, Is = 115 mA, Po = 1720 mW, Ri ≥ 176,22 Ω

Ambient Temperature: -20 to 60 ºC

Special conditions for safe use
The certificate number with "X" indicates that:

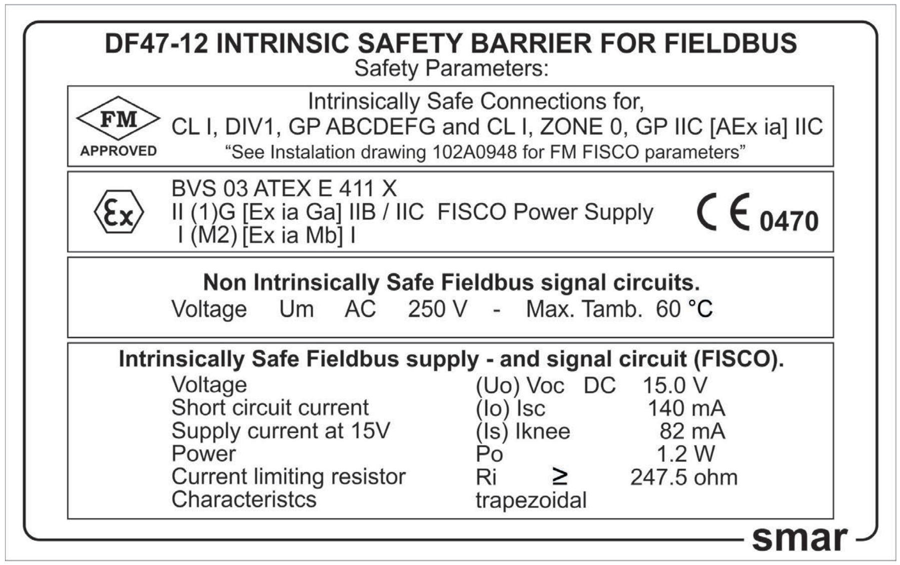
a) The equipment was projected to connect with a Fieldbus System according to FISCO model, as IEC60079-27:2008. The Fieldbus intrinsic safety device connected to the Fieldbus terminator must be current passive consumer (not generator) and must display Ci ≤ 5 nF and Li ≤ 10 µH;
b) Wiring in the terminal box must satisfy the conditions:
   Resistance: 15 Ω/km ≤ Rc ≤ 1500/km
   Capacitance (including loop): 45 nF/km ≤ Cc ≤ 200 nF/km
   Inductance: 0,4 mH/km ≤ Lc ≤ 1mH/km
c) The maximum length allowed for Fieldbus cables is 1000 m for Group IIC and 5000m for Group IIB

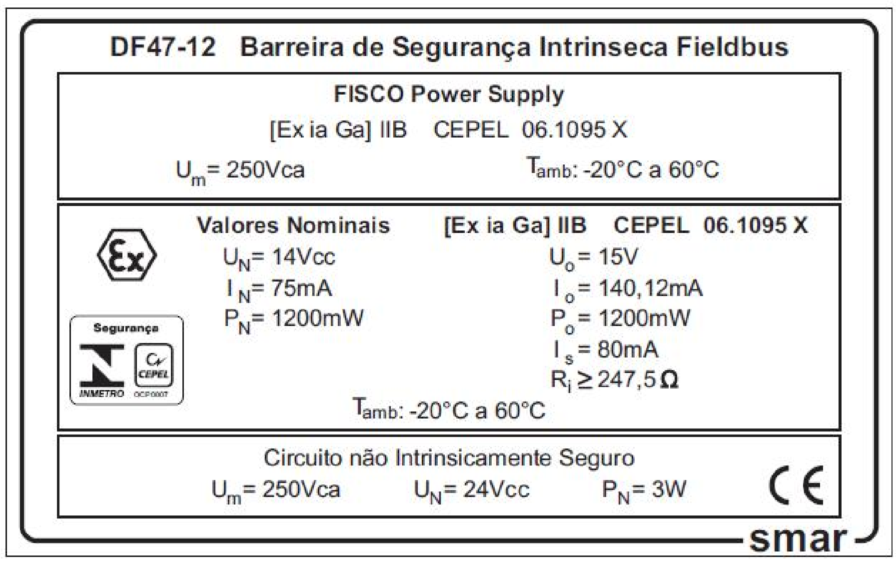
The Essential Health and Safety Requirements are assured by compliance with:
ABNT NBR IEC 60079-0:2008 General Requirements
ABNT NBR IEC 60079-11:2009 Intrinsic Safety "i"
ABNT NBR IEC 60079-26:2008 Equipment with equipment protection level (EPL) Ga
IEC 60079-27:2008 Fieldbus intrinsically safe concept (FISCO)

Identification labels and control drawings

DF47-12 – Intrinsic Safety Barrier for Fieldbus

Labels





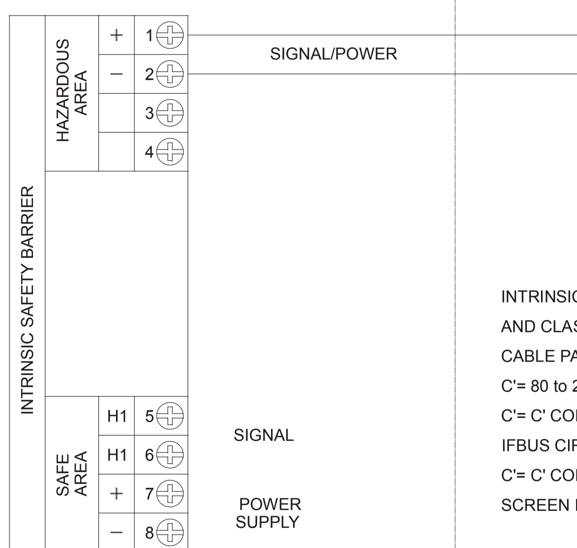
NON-HAZARDOUS LOCATION

HAZARDOUS (CLASSIFIED) LOCATION
CLASS I, II, III, GROUPS A, B, C, D, E, F, G.

REQUIREMENTS:

1- THE MAXIMUM NON-HAZARDOUS LOCATION VOLTAGE IS 250 VAC/DC.

INSTALLATION MUST BE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE (NFPA 70, ARTICLE 504 OR 505) AND ANSI/ISA-RP12.06.01.



Intrinsically safe fieldbus supply -and signal circuit (FISCO).

Voltage	(Uo) Voc	DC 15.0V
Short circuit current	(Io) Isc	140mA
Supply current at 15V	(Is) Iknee	82mA
Power	Po	1.2W
Current limiting resistor	Ri ≥	247.5ohm
Characteristcs	trapezoidal	

INTRINSICALLY SAFE OUTPUT FOR CLASS I, DIV. 1, GP A,B,C,D,E,F,G AND CLASS I, ZONE 0, [AEX ia II C];
CABLE PARAMETERS R'=15 TO 150ohms per Km, L'= 0.4 to 1mH per km,
C'= 80 to 200nF per km, INCLUDING SCREEN IF APLICABLE
C'= C' CONDUCTOR / CONDUCTOR + 0,5 C' CONDUCTOR / SCREEN,
IFBUS CIRCUIT IS POTENTIAL FREE (BALANCED).
C'= C' CONDUCTOR / CONDUCTOR + C' CONDUCTOR / SCREEN IF SCREEN IS CONNECTED WITH ONE TERMINAL OF THE BARRIER.

BARRIER INCLUDES TERMINATOR R=100ohms, C=1uF, Ci=0, Li=0

GP A,B/IIC Ca (Co) = 0.23uF, La (Lo) = 0.15mH
GP C,D/IIB,IIA Ca (Co) = 0.75uF, La (Lo) = 0.5mH

APPROVAL CONTROLLED BY C.A.R.

REV	BY	APPROVAL	DOC
	/ /	/ /	
2	MARCIAL 17/ 09/ 07	DÉLCIO 17/ 09/ 07	ALT-DE 0049/07
1	MOACIR 29/ 11/ 04	DÉLCIO 29/ 11/ 04	ALT-DE 0119/04

DRAWN	CHECKED	PROJECT	APPROVAL
MOACIR 03/ 02/ 03	SINASTRE 03/ 02/ 03	BASÍLIO 03/ 02/ 03	DÉLCIO 03/ 02/ 03

EQUIPMENT: DF47-12

CONTROL DRAWING

FM APPROVED

smar

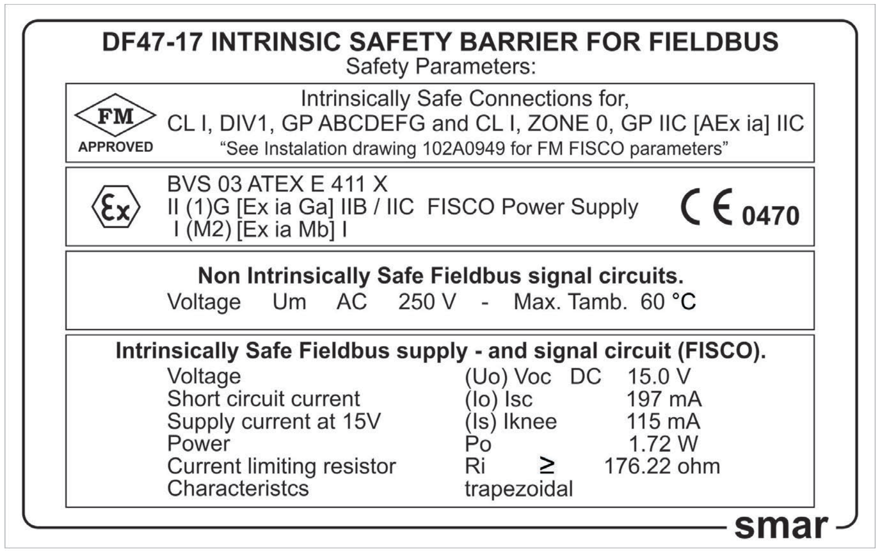
NUMBER 102A0948 REV 02

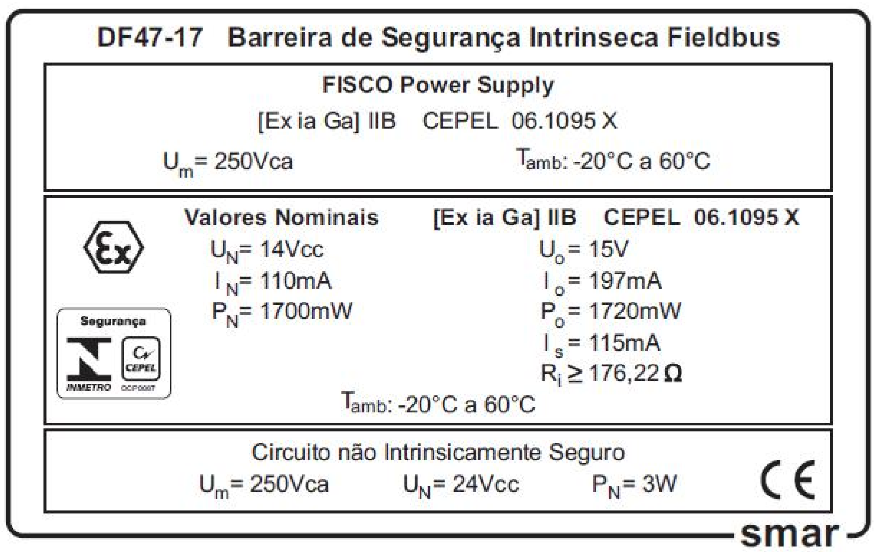
SCALE

SHEET 01/01

DF47-17 – Intrinsic Safety Barrier for Fieldbus

Labels





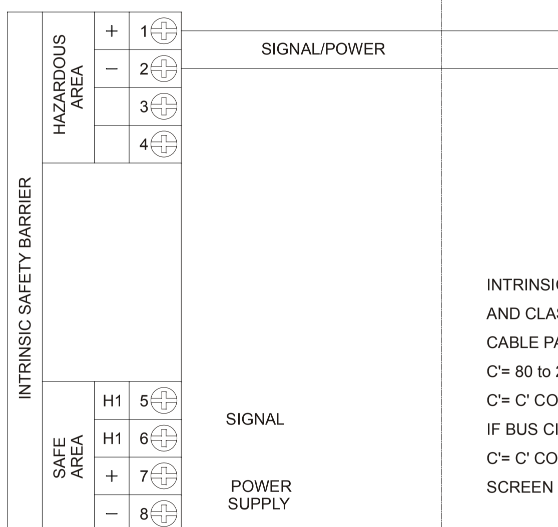
NON-HAZARDOUS LOCATION

HAZARDOUS (CLASSIFIED) LOCATION
CLASS I, II, III, GROUPS A, B, C, D, E,F,G.

REQUIREMENTS:

1- THE MAXIMUM NON-HAZARDOUS LOCATION VOLTAGE IS 250 V AC/DC.

INSTALLATION MUST BE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE (NFPA 70, ARTICLE 504 OR 505) AND ANSI/ISA-RP12.06.01.



Intrinsically safe fieldbus supply -and signal circuit (FISCO).

Voltage	(Uo)Voc	15.0V DC
Short circuit current	(Io)Isc	197mA
Supply current at 15V	(Is)Iknee	115mA
Power	Po	1.72W
Current limiting resistor	Ri ≥	176.22ohm
Characteristcs	trapezoidal	

INTRINSICALLY SAFE OUTPUT FOR CLASS I, DIV. 1, GP A,B,C,D,E,F,G AND CLASS I, ZONE 0, [AEX ia II C];

CABLE PARAMETERS R'=15 TO 150ohms per Km, L'= 0.4 to 1mH per km, C'= 80 to 200nF per km, INCLUDING SCREEN IF APLICABLE

C'= C' CONDUCTOR / CONDUCTOR + 0,5 C' CONDUCTOR / SCREEN, IF BUS CIRCUIT IS POTENTIAL FREE (BALANCED).

C'= C' CONDUCTOR / CONDUCTOR + C' CONDUCTOR / SCREEN IF SCREEN IS CONNECTED WITH ONE TERMINAL OF THE BARRIER.

BARRIER INCLUDES TERMINATOR R=100ohms, C=1uF, Ci=0, Li=0

GP A,B/IIC Ca (Co) = 0.21uF, La (Lo) = 0.15mH
GP C,D/IIB,IIA Ca (Co) = 0.7uF, La (Lo) = 0.5mH

FM APPROVED

APPROVAL CONTROLLED BY C.A.R.

REV	BY	APPROVAL	DOC
	/ /	/ /	
2	MARCIAL 17/ 09 / 07	DÉLCIO 17/ 09 / 07	ALT-DE 0049/07
1	MOACIR 29/ 11 / 04	DÉLCIO 29/ 11 / 04	ALT-DE 0119/04

DRAWN	CHECKED	PROJECT	APPROVAL
MOACIR 03 / 02 / 03	SINASTRE 03 / 02 / 03	BASÍLIO 03 / 02 / 03	DÉLCIO 03 / 02 / 03

EQUIPMENT: DF47-17

CONTROL DRAWING

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NUMBER 102A0949 REV 02

SCALE SHEET 01/01

Chapter 6

ADDING INTERFACES

Introduction

There are several interface modules available for AuditFlow that provide a wide connectivity to different media used in the Automation and Process Control Industry.

In applications that connect Modbus RTU to AuditFlow, and require more than one Modbus device in the same Modbus network, it is necessary the use of RS-232/RS-485 module interface to provide a multipoint communication.

In the cases where only one Modbus device is used, and the distance between both devices are longer than 15 meters, the RS-232/RS-485 module interface is also necessary.

Originally, the HFC302 (controller) were designed to be connected to the Ethernet 10 Mbps port. In order to connect it in an Ethernet 100 Mbps Local Area Network, add the Ethernet Switch 10/100 Mbps module.

The following table shows the available Interface module types.

INTERFACES		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF58	RS-232/RS-485 Interface	No I/O
DF61	Ethernet Switch 10/100 Mbps	No I/O

The specifications for each module are shown is the next pages.

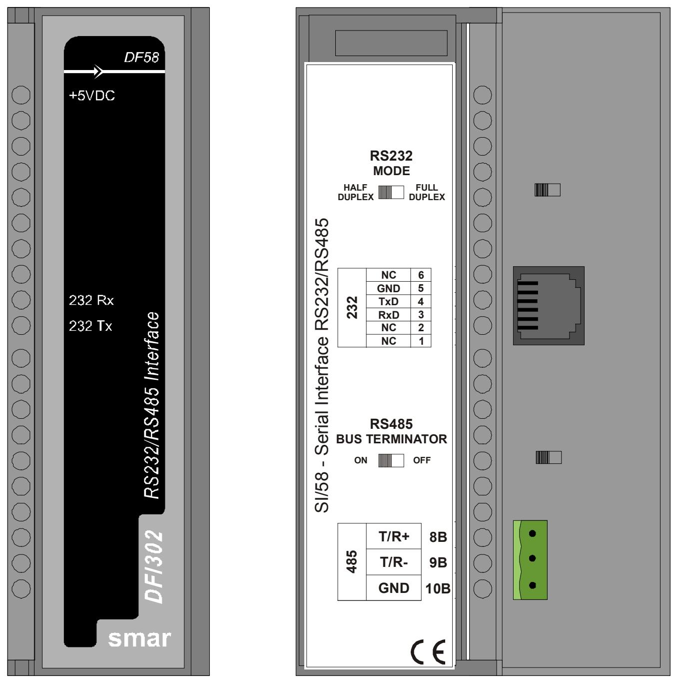
DF58 – RS-232/RS-485 Interface

Description

This module converts the electrical characteristics of the communication signal from the RS-232 to RS-485 specifications. Due to the different purposes of use between RS-232 and RS-485, where the first one is proper to peer-to-peer applications, this module was implemented to work automatically.

No control signal is necessary to control the RS-485 bus. Simply connect the transmission and reception lines on the both sides to have the interface operational.

The converter circuit isolates the signal to guarantee a safe connection between both systems. This module was designed to be use with AuditFlow/DFI302/LC700 platforms and, no power supply was embedded in the board. It uses the +5 Vdc voltage from the rack to energize the circuit.



Interface Settings

There are two interfaces settings located on the front panel to adapt the interface to the applications: RS-232 Mode and RS-485 Bus Terminator.

RS-232 Mode: Half-Duplex/Full-Duplex

The RS-232 Mode setting adapts the use of RS-232/RS-485 Interface to the communication driver RS-232. Usually, these interfaces connect unidirectional buses with bidirectional buses. The unidirectional bus can contain Full-Duplex features caused by echoes of the transmitted message.

If the driver does not support the reception/transmission simultaneously, because the reception disables or discards the reflected message, select the **Half-Duplex** option. If the reflected message does not disturb the applications, select the **Full-Duplex** option.

RS-485 Bus Terminator: On/Off

The RS-485 is a multidrop bus. The transmitter driver is set to high impedance (Hi-Z) state when there is no message to be transmitted. However, the RS-485 bus requires a bus terminator in order to avoid noise problems during the idle time of the RS-485. A perfect line impedance match is necessary to activate only one terminator by bus. The other terminators must be deactivated.

Connectors

Two connectors are available on the front panel to interconnect two communication systems: RJ-12 type connector, used in RS-232 systems; and a terminal block type connector, used in RS-485 systems.

RJ12 Pin Assignment

PIN NUMBER	DESCRIPTION
1	Connected to pin 6
2	Not used
3	RxD: RS-232 input signal - reception
4	TxD: RS-232 output signal - transmission
5	GND: RS-232 grounding signal
6	Connected to pin 1

NOTE
Pins 1 and 6 are interconnected to allow the interconnection of the modem signals requested by communication drivers, such as Clear-To-Send (CTS) with Request-To-Send (RTS).

Block Terminal Pin Assignment

PIN NUMBER	DESCRIPTION
1	+: RS-485 Non-inverting signal
2	-: RS-485 Inverting Signal
3	GND: Reference for RS-485 Communication Signal.

NOTE
The pin GND sets the voltage reference for all RS-485 nodes. The RS-485 side of the RS-232/RS-485 Interface is isolated and left on floating state. To avoid undesirable high common mode voltage, it is recommended to set all RS-485 nodes to the same reference voltage by connecting all pins GND together and grounding at the same point.

Technical Specifications

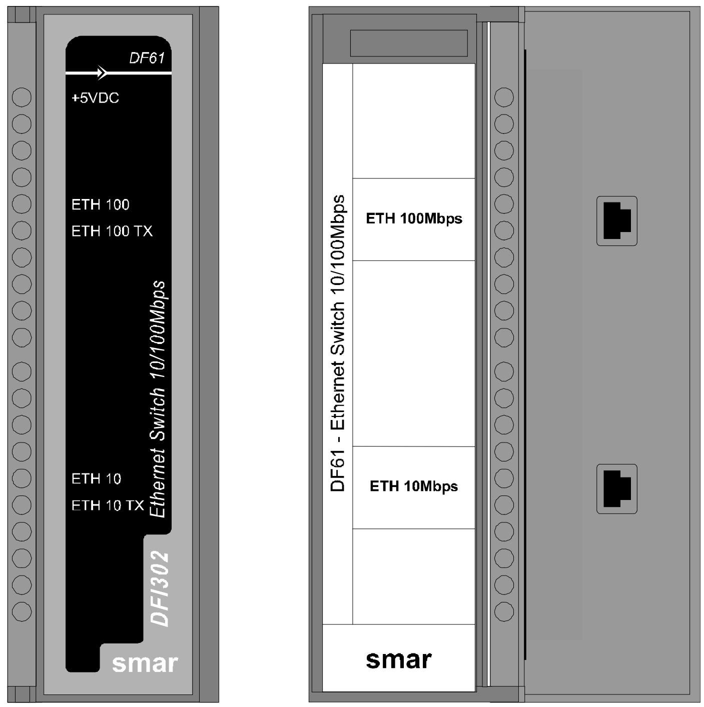
GENERAL FEATURES	
Number of Communication Channel	1
Data Communication Interface	RS-232 / RS-485
Data rate	Up to 200 Kbps
RS-232 side	Enables RS-232 Half-Duplex or Full-Duplex mode
RS-485 side	Enables Embedded Bus Terminator activation
Isolation	1600 Vrms @ 1 minute, typical
Power Supply	Provided by the IMB bus, +5 Vdc @ 60 mA Typical

DF61 – Ethernet Switch 10/100 Mbps

This module connects the HFC302 directly to an Ethernet 100 Mbps Local Area Network (LAN).

The only procedures to follow are:
1 - Fix the DF61 in a rack, and
2 - Using DF54 cable, connect DF61 to the 10 Mbps port of the HFC302. Afterwards, the 100 Mbps port will be ready to be connected to the LAN.

Make sure that the Ethernet is perfectly communicating, check if the ETH10 and ETH100 LED indicators are ON (link connected), and ETH10TX and ETH100TX are blinking in the same rate of HFC302.



Chapter 7

ADDING I/O MODULES

Introduction

The AuditFlow was specifically, and primarily, designed to operate with Fieldbus instruments. All common field instrument types are available in Fieldbus versions. Therefore, the amount of conventional I/O points required in a system is drastically reduced and will eventually be eliminated. However, since many applications require connection of old or new devices that do not have Fieldbus communication, the AuditFlow may also be fitted with conventional discrete and analogue I/O on an extended backplane. Each controller module can be fitted with an I/O-subsystem for up to 256 points or 1024 depending on the controller specification.

There are many types of modules available for the AuditFlow, designed to fit a broad range of applications in the automation and process control industry.

NOTE
The I/O modules should be accessed exclusively for Function Blocks or Ladder applications. The user is responsible for guaranteeing the consistence on the hardware configuration by Syscon and Logic View for FFB tools.

The following tables show the available I/O module types.

DISCRETE INPUTS		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF11	2 Groups of 8 Digital Inputs 24 Vdc - Sink	16-discrete input
DF12	2 Groups of 8 Digital Inputs 48 Vdc - Sink	16- discrete input
DF13	2 Groups of 8 Digital Inputs 60 Vdc - Sink	16- discrete input
DF14	2 Groups of 8 Digital Inputs 125 Vdc - Sink	16- discrete input
DF15	2 Groups of 8 Digital Inputs 24 Vdc - Source	16- discrete input
DF16	2 Groups of 4 Digital Inputs 120 Vac	8- discrete input
DF17	2 Groups of 4 Digital Inputs 240 Vac	8- discrete input
DF18	2 Groups of 8 Digital Inputs 120 Vac	16- discrete input
DF19	2 Groups of 8 Digital Inputs 240 Vac	16- discrete input
DF20	1 Group of 8 Push-Button Switches	8- discrete input

DISCRETE OUTPUTS		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF21	1 Group of 16 Digital Outputs 24 Vdc - Sink	16- discrete output
DF22	2 Groups of 8 Digital Outputs 24 Vdc - Source	16- discrete output
DF23	2 Groups of 4 Digital Outputs 120/240 Vac - Triac	8- discrete output
DF24	2 Groups of 8 Digital Outputs 120/240 Vac - Triac	16- discrete output
DF25	2 Groups of 4 NO Relay Outputs	8- discrete output
DF26	2 Groups of 4 NC Relay Outputs	8- discrete output
DF27	1 Group of 4 NO and 4 NC Relay Outputs	8- discrete output
DF28	2 Groups of 8 NO Relay Outputs without RC Protection	16- discrete output
DF29	2 Groups of 4 NO Relay Outputs without RC protection	8- discrete output
DF30	2 Groups of 4 NC Relay Outputs without RC protection	8- discrete output
DF31	1 Group of 4 NO and 4 NC Relay Outputs without RC protection	8- discrete output
DF71	2 Groups of 4 NO Relay Outputs without RC protection - Max 10 mA	8-discrete output
DF72	2 Groups of 4 NC Relay Outputs without RC protection - Max 10 mA	8-discrete output
DF69	2 Groups of 8 NO Relay Outputs	16-discrete output

COMBINED DISCRETE INPUTS AND OUTPUTS		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF32	1 Group of 8 24 Vdc Inputs and 1 Group of 4 NO Relay	8- discrete input/4-discrete output
DF33	1 Group of 8 48 Vdc Inputs and 1 Group of 4 NO Relay	8- discrete input/4-discrete output
DF34	1 Group of 8 60 Vdc Inputs and 1 Group of 4 NO Relay	8- discrete input/4-discrete output
DF35	1 Group of 8 24 Vdc Inputs and 1 Group of 4 NC Relay	8- discrete input/4-discrete output
DF36	1 Group of 8 48 Vdc Inputs and 1 Group of 4 NC Relay	8- discrete input/4-discrete output
DF37	1 Group of 8 60 Vdc Inputs and 1 Group of 4 NC Relay	8- discrete input/4-discrete output
DF38	1 Group of 8 24 Vdc Inputs and 1 Group of 2 NO and 2 NC Relay	8- discrete input/4-discrete output
DF39	1 Group of 8 48 Vdc Inputs and 1 Group of 2 NO and 2 NC Relay	8- discrete input/4-discrete output
DF40	1 Group of 8 60 Vdc Inputs and 1 Group of 2 NO and 2 NC Relay	8- discrete input/4-discrete output

PULSE INPUTS		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF41	2 Groups of 8 Low Frequency (0 - 100 Hz) 24 Vdc Pulse Inputs	16-pulse input
DF42	2 Groups of 8 High Frequency (0 - 10 KHz) 24 Vdc Pulse Inputs	16-pulse input
DF67	2 Groups of 8 High Frequency (0 - 10 KHz) AC Pulse Inputs	16-pulse input

ANALOG INPUTS		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF44	1 Group of 8 Voltage/Current Analogue Inputs with Internal Shunt Resistors	8-analog input
DF57	1 Group of 8 Voltage/Current Differential Analogue Inputs with Internal Shunt Resistors	8-analog input
DF45	1 Group of 8 Low Signal Analogue Inputs for TC, RTD, mV and Ohm	8-temperature

ANALOG OUTPUTS		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF46	1 Group of 4 Voltage/Current Analogue Outputs	4-analog output

HART MODULES		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF116	8 analog inputs with HART master interface (4-20 mA)	8 analog inputs
DF117	8 analog outputs with HART master interface (4-20 mA)	8 analog outputs

INTERFACES FOR I/O MODULES AND THEIR ACCESSORIES*	
CODE	**DESCRIPTION**
ITF - 005AC1	Interface for 16 points of 120 Vac input compatible with DF15.
ITF - 005AC2	Interface for 16 points of 240 Vac input compatible with DF15.
ITF - 001	Interface for 16 points of 24 Vdc input compatible with DF11.
ITF - 005DC	Interface for 16 points of 24 Vdc input compatible with DF15.
ITF - 101	Interface for 16 points digital output for relay with NA and NC contact compatible DF21.
ITF – 101FAC	Interface for 16 points digital output for relay with NA and NC contact with fuse for AC load compatible with DF21.
ITF – 101FDC	Interface for 16 points digital output for relay with NA and NC contact with fuse for DC load compatible with DF21.
ITF – 102	Interface for 16 points digital output for relay with NA and NC contact compatible DF22.
ITF – 102FAC	Interface for 16 points digital output for relay with NA and NC contact with fuse for AC load compatible with DF22.
ITF – 102FDC	Interface for 16 points digital output relay for relay with NA and NC contact with fuse for DC load compatible with DF22.
ITF – 120AC	Interface for 8 points digital output for AC load relay compatible with DF25.
ITF – 120DC	Interface for 8 points digital output for DC load relay compatible with DF25.
ITF – 123-7	Interface for 16 points digital output for relay with NA and NC contact compatible for AC load with DF69.
ITF – 1237FAC	Interface for 16 points digital output for relay with NA and NC contact with fuse for AC load compatible with DF28 or DF69.
ITF – 1237FDC	Interface for 16 points digital output for relay with NA and NC contact with fuse for DC load compatible with DF28 or DF69.
ITF – 304	Interface for 16 point AC pulse input compatible with DF67.
ITF – 401	Interface for 8 point analog input compatible with DF44 and DF57.
ITF – 402	Interface for 8 point analog input compatible with DF45.
ITF – 501	Interface for 8 point analog output without fuse compatible with DF46.
ITF – QDA-AC	Power distribution interface for 10 points 110/240 Vac @ 2A per point.
ITF – QDA-DC	Power distribution interface for 10 points 24 Vdc @ 2A per point.
ITF - C-10	Connection cable between modules and ITF interfaces - 1.0 m.
ITF - C-15	Connection cable between modules and ITF interfaces - 1.5 m.
ITF - C-20	Connection cable between modules and ITF interfaces - 2.0 m.
ITF - C-25	Connection cable between modules and ITF interfaces - 2.5 m.
ITF - C-30	Connection cable between modules and ITF interfaces - 3.0m.
ITF - C-35	Connection cable between modules and ITF interfaces - 3.5 m.
ITF - C-40	Connection cable between modules and ITF interfaces - 4.0 m.
ITF - C-45	Connection cable between modules and ITF interfaces - 4.5 m.
ITF - C-50	Connection cable between modules and ITF interfaces - 5.0 m.

*For further information, please refer to the Panel Interfaces manual.

ACCESSORIES		
MODEL	**DESCRIPTION**	**I/O TYPE**
DF0	Blind module to fill empty slots	No I/O
DF1A	Rack with 4 slots – support to shielded flat cable	No I/O
DF2	Terminator for last the rack – right side	No I/O
DF3, DF4A~DF7A	Flat cables to connect 2 racks	No I/O
DF9	Support for a single module	No I/O
DF54	Twisted pair cable 100 Base-TX	No I/O
DF55	Twisted pair cable 100 Base-TX – cross cable – length 2m	No I/O
DF59	Cable RJ12 used to connect controllers and DF58	No I/O
DF78	Rack with 4 slots – It supports Hot Swap of CPUs and redundant I/O access	No I/O
DF82	Synchronism cable to connect redundant controllers – length 500 mm	No I/O
DF83	Synchronism cable to connect redundant controllers – length 1800 mm	No I/O

DF84	IMB Soft Starter	No I/O
DF90	IMB power cable	No I/O
DF91	Lateral adapter	No I/O
DF92	Rack with 4 slots for redundant CPUs, hot swap and diagnostic support	No I/O
DF93	Rack with 4 slots, with diagnostic	No I/O
DF96	Terminator for the last rack – left side	No I/O
DF101	Flat cable to connect racks by left side – length 70 cm	No I/O
DF102	Flat cable to connect racks by right side – length 65 cm	No I/O
DF103	Flat cable to connect racks by right side – length 81 cm	No I/O
DF104	Flat cable to connect racks by right side – length 98 cm	No I/O
DF105	Flat cable to connect racks by right side – length 115 cm	No I/O

Steps to Set up I/O Modules

The first steps to configure HFC302 with I/O modules, need the knowledge on "How to Add a Function Block" using Syscon (the configuration tool). See the section "Adding Function Blocks", for further information.

Add one **Resource Block**, one **Hardware Configuration Transducer** (HC), one or more **Temperature Transducers** (when using temperature modules), and **TBH** Blocks (RIO HART Transducer Block), one for each HART equipment installed.

After the **Resource** and these transducers blocks, the user can add the other blocks (AI, MAI, AO, MAO, DI, MDI, DO, MDO).

NOTE
DO NOT use HCT, Temperature Transducers, AI, MAI, AO, MAO, DI, MDI, DO and MDO block, if a FFB 1131 is present in the configuration. In this case, the configuration and access of the I/O modules will be done through LogicView for FFB tool. See details in section "ADDING LOGIC BY USING FLEXIBLE FUNCTION BLOCKS (FFB 1131)"

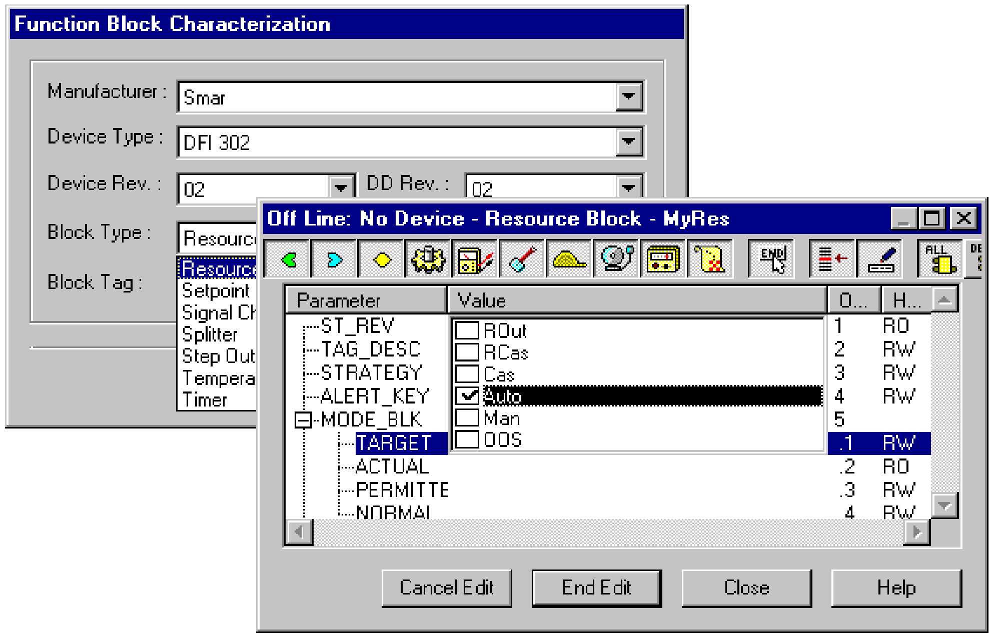
The order of the **Resource**, Transducers and block creation is very important because when **Syscon** does the configuration download, a lot of consistency checks will be done inside **HFC302**.

For instance, an **AI** block will not accept a channel configuration if the desired pointed hardware was not declared before in the Hardware Configuration Transducer.

A complete documentation about FOUNDATION fieldbus blocks and its parameters could be found under Function Blocks Manual inside the **System302** documentation folder. The following steps are more related with details about **HFC302**, and the complete description about blocks will not be found here.

RES – Resource Block

This function block has already been instantiated in the device. So, it is necessary set the **MODE_BLK.TARGET** parameter to **AUTO**.



HCT – Hardware Configuration Transducer

This transducer configures the module type for each slot in the **HFC302**.The execution method of this transducer block will write to all output modules, and it will read all input modules.

If any I/O module has failed in this scan, it will be indicated in BLOCK_ERR as well in the MODULE_STATUS_x. It makes easy to find the module or even the sensor in failure. This function block has already been instantiated in the device, so set the MODE_BLK parameter to AUTO and fill IO_TYPE_Rx parameters with its respective module that has been used.

PARAMETER	VALID RANGE/ OPTIONS	DEFAULT VALUE	DESCRIPTION
ST_REV		0	
TAG_DESC		Spaces	
STRATEGY		0	
ALERT_KEY	1 to 255	0	
MODE_BLK		O/S	See Mode Parameter
BLOCK_ERR			
REMOTE_IO		Remote I/O Master	Reserved
IO_TYPE_R0		0	Select module type for the rack 0
IO_TYPE_R1		0	Select module type for the rack 1
IO_TYPE_R2		0	Select module type for the rack 2
IO_TYPE_R3		0	Select module type for the rack 3
IO_TYPE_R4		0	Select module type for the rack 4
IO_TYPE_R5		0	Select module type for the rack 5
IO_TYPE_R6		0	Select module type for the rack 6
IO_TYPE_R7		0	Select module type for the rack 7
IO_TYPE_R8		0	Select module type for the rack 8
IO_TYPE_R9		0	Select module type for the rack 9
IO_TYPE_R10		0	Select module type for the rack 10
IO_TYPE_R11		0	Select module type for the rack 11
IO_TYPE_R12		0	Select module type for the rack 12
IO_TYPE_R13		0	Select module type for the rack 13
IO_TYPE_R14		0	Select module type for the rack 14
MODULE_STATUS_R0_3			Status of modules in rack 0-3.
MODULE_STATUS_R4_7			Status of modules in rack 4-7.
MODULE_STATUS_R8_11			Status of modules in rack 8-11.
MODULE_STATUS_R12_14			Status of modules in rack 12-14.
UPDATE_EVT			This alert is generated by any change to the static data.
BLOCK_ALM			The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

TEMP – Temperature Transducer

This is the transducer block for the module **DF45**, an eight low signal input module for RTD, TC, Ohm.

When using this module, the **TEMP** Transducer is necessary and must be added to **Syscon** Configuration, just before the Function Block, which will provide the interface with the I/O module. Therefore, create this block, set the **MODE_BLK** parameter to **AUTO** and fill parameters with range, sensor, etc, that will be used by the Temperature Module.

PARAMETER	VALID RANGE/ OPTIONS	DEFAULT VALUE	DESCRIPTION
ST_REV		0	
TAG_DESC		Spaces	
STRATEGY		0	
ALERT_KEY	1 to 255	0	
MODE_BLK		O/S	See Mode Parameter
BLOCK_ERR			
CHANNEL			The rack and slot number of the associated DF-45 module coded as RRSXX.
TEMP_0			Temperature of point 0.
TEMP_1			Temperature of point 1.
TEMP_2			Temperature of point 2.
TEMP_3			Temperature of point 3.
TEMP_4			Temperature of point 4.
TEMP_5			Temperature of point 5.
TEMP_6			Temperature of point 6.
TEMP_7			Temperature of point 7.
VALUE_RANGE_0		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_0	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 0.
SENSOR_TYPE_0	See table below	Pt 100 IEC	Type of sensor 0.
VALUE_RANGE_1		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_1	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 1.
SENSOR_TYPE_1	See table below	Pt 100 IEC	Type of sensor 1.
VALUE_RANGE_2		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_2	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 2.
SENSOR_TYPE_2	See table below	Pt 100 IEC	Type of sensor 2.
VALUE_RANGE_3		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_3	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 3.
SENSOR_TYPE_3	See table below	Pt 100 IEC	Type of sensor 3.
VALUE_RANGE_4		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_4	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 4.

PARAMETER	VALID RANGE/ OPTIONS	DEFAULT VALUE	DESCRIPTION
SENSOR_TYPE_4	See table below	Pt 100 IEC	Type of sensor 4.
VALUE_RANGE_5		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_5	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 5.
SENSOR_TYPE_5	See table below	Pt 100 IEC	Type of sensor 5.
VALUE_RANGE_6		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_6	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 6.
SENSOR_TYPE_6	See table below	Pt 100 IEC	Type of sensor 6.
VALUE_RANGE_7		0-100%	If it is connected to AI block, it is a copy of XD_SCALE. Otherwise, the user can write in this scaling parameter.
SENSOR_CONNECTION_7	1 : differential 2 : 2-wire 3 : 3-wire	3	Connection of the sensor 7.
SENSOR_TYPE_7	See table below	Pt 100 IEC	Type of sensor 7.
UPDATE_EVT			This alert is generated by any change to the static data.
BLOCK_ALM			The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

TBH – RIO HART Transducer Block

The **TBH** block (RIO HART Transducer Block) represents the HART device in the system. Through it the user can access any variable of the device. This block contains parameters for the process to be used in the control strategy and ladder logic, identification parameters, Burst and diagnosis, as well as Bypass parameters (**HART_CMD**, **HART_RESP** and **HART_COM_STAT**) that are used by the configuration and asset management tools for transmission and reception of HART messages.

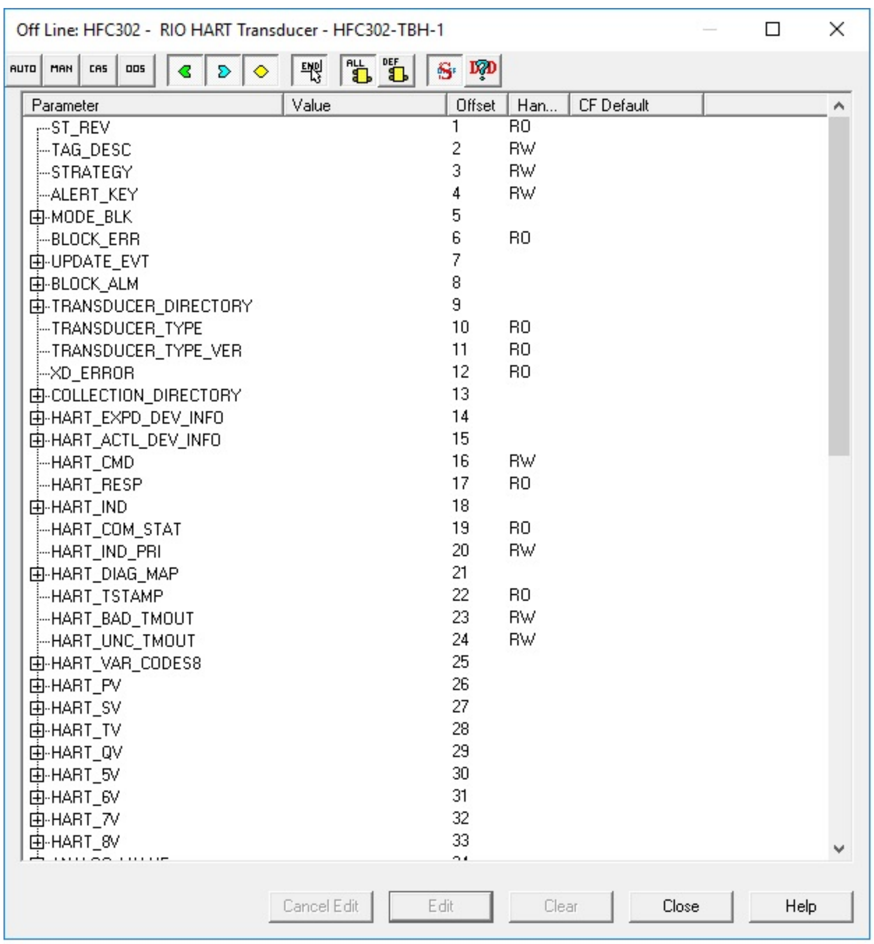
IMPORTANT
The **TBH** function block is available for **HFC302** under the following conditions: 1 – Valid for **DEV_REV 05** (see parameter 12, **Resource** block). 2 - Firmware from version **HFC302V4_0_0 build 21** supports **DEV_REV 05** (see **ALERT_KEY=21** in **FCT** block).

For each HART device installed must exist one corresponding **TBH** block on the system. The association of this block to the physical device must be done through the **RRSGP** parameter, following the rule **RRSGP** where **RR**: rack, **S**: slot, **G**: group (0 - 7) and **P**: point (9). Examples:

209 – Rack 0, Slot 2, group 0 and point 9
12319 – Rack 12, slot 3, group 1 and point 9

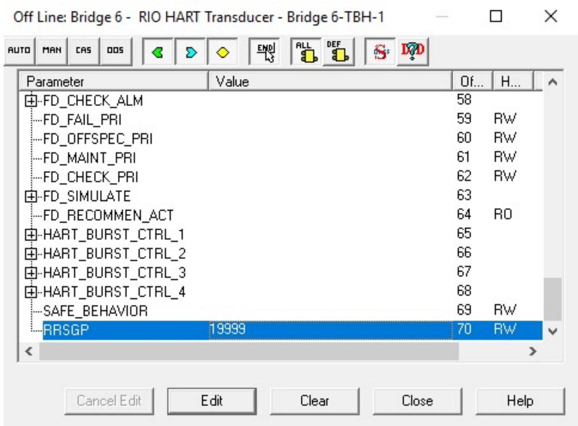
The group represents the HART device. The **DF116/DF117** modules support up to 8 HART devices. For further information about these modules, refer to Digital and Analog Input/Output Modules of DFI302 Manual.

The point must be configured with 9 because it represents the access to all available variables in the HART device: **HART_PV**, **HART_SV**, **HART_TV**, **HART_QV**, **HART_5V**, **HART_6V**, **HART_7V**, **HART_8V** and **PRIMARY_VALUE**.



TBH Block (RIO HART Transducer Block)

NOTA
The **19999** setting in the **RRSGP** parameter enables the use of the **TBH** block as multiplexer for shared access of communication DTM to all HART devices.



RRSGP parameter of TBH Block

Configuration of the dynamic variables in the TBH block

The **TBH** block is flexible and allows the user to configure up to 8 digital variables to be dynamically read from the HART device. The configuration must be done in the **HART_VAR_CODES8** parameter using indexes. The value and status of the variable for the index are shown on the corresponding parameter. See the following table.

HART_VAR_CODES8
[1] – HART_PV
[2] – HART_SV
[3] – HART_TV
[4] – HART_QV
[5] – HART_5V
[6] – HART_6V
[7] – HART_7V
[8] – HART_8V

Table – HART_VAR_CODE8S[n]

The index configured in the **HART_VAR_CODES8[n]** parameter defines which variable has to be read from the device and also the HART command used by the **DF116/DF117** module to read the variable. See the following table.

HART_VAR_CODES8[1..8] = 255	HART_VAR_CODES8[n] = (0 - 254)
Read the variable by the **HART #3** command. The **#3** command is flexible and can return information with up to 4 process variables (PV, SV, TV, and QV). The number of variables returned by this command is determined by the device manufacturer according to their functionality. If the **HART_VAR_CODE8[n]** parameter is configured with the value 255, but there is not corresponding variable on **#3** command, the default value should appear in the associated parameter.	HART command used to read the variable in question depends on the version of the HART device. HART 5: **#33** command HART 6 and 7: **#9** command Both commands return information from variables whose indexes (Device Variable Code) are defined on HART request message. These commands are flexible and accept up to 4 indexes, except the **#9** command of HART 7 which accepts up to 8 indexes. For a list of indexes supported by the device, and the associated variables, is necessary to consult the manual or the manufacturer of the device. The list of variables of Smar's devices can be obtained in the "Indexes of Smar HART devices variables" topic on the Digital and Analog Input/Output Modules of DFI302 manual. If the index configured in the **HART_VAR_CODES8[n]** parameter does not exist in the device, the corresponding parameter, and other parameters whose indexes are part of the same request message should appear with the default value.

HART commands

NOTE
HART command is a data structure used by the HART protocol to group variables and features of the device. Each command has an identification number, some commands, and therefore their IDs, are pre-defined by the HART specification. Other commands can be defined by the device manufacturer according to its functionality.

The composition/structure of HART and FOUNDATION fieldbus protocols differ in some points. Therefore, to ensure the integration of HART devices in FOUNDATION fieldbus systems in a transparent manner, some adjustments and conversions are required.

One of the necessary adjustments is related to the status of parameters associated to **HART_VAR_CODES8** (see table HART_VAR_CODES8[n]). In the HART protocol only the **#9** command returns the variable status on its response.

Thus, the parameters status whose variables are read by the **#3** or **#33** commands are obtained by interpreting the **DEVICE_STATUS** byte present in responses from all messages from the HART device. The following table shows how the **DEVICE_STATUS** bits are interpreted.

STATUS BIT	DEVICE_STATUS	HART STATUS
2	Loop Current Saturated	PoorAccuracy:NotLimited
3	Loop Current Fixed	ManualFixed:Constant
1	Non-Primary Variable Out of Limits	PoorAccuracy:NotLimited
0	Primary Variable Out of Limits	Bad:NotLimited
7	Device Malfunction	Bad:Constant
--	-- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --	Good:Constant

The HART commands **(#3, #9** and **#33**) also return the measurement unit of the variable that can be seen in the **VAR_UNITS9[n]** parameter in the same position of the **HART_VAR_CODES8** parameter where the index variable was configured.

Conversion of HART Status to FOUNDATION fieldbus

The status from the HART device is converted to the corresponding FOUNDATION fieldbus status to fill the **TBH** block parameters that have status. See the following table:

HART STATUS	FOUNDATION FIELDBUS STATUS
Good:Constant	GoodNonCascade:GoodNCNonSpecific:Constant
Good:Low Limited	GoodNonCascade:GoodNCNonSpecific:LowLimited
Good:High Limited	GoodNonCascade:GoodNCNonSpecific:HighLimited
Good:Not Limited	GoodNonCascade:GoodNCNonSpecific:NotLimited
Poor Accuracy:Constant	Uncertain:UncertainNonSpecific:Constant
Poor Accuracy:Low Limited	Uncertain:UncertainNonSpecific:LowLimited
Poor Accuracy:High Limited	Uncertain:UncertainNonSpecific:HighLimited
Poor Accuracy: Not Limited	Uncertain:UncertainNonSpecific:NotLimited
Manual Fixed:Constant	GoodNonCascade:GoodNCNonSpecific:Constant
Manual Fixed:Low Limited	GoodNonCascade:GoodNCNonSpecific:LowLimited
Manual Fixed:High Limited	GoodNonCascade:GoodNCNonSpecific:HighLimited
Manual Fixed:Not Limited	GoodNonCascade:GoodNCNonSpecific:NotLimited
Bad:Constant	Bad:BadNonSpecific:Constant
Bad:Low Limited	Bad:BadNonSpecific:LowLimited
Bad:High Limited	Bad:BadNonSpecific:HighLimited
Bad : Not Limited	Bad:BadNonSpecific:NotLimited

Access to current analog signal (4-20 mA)

Each one of the 8 channels of **DF116** and **DF117** modules has analog circuit that allows the 4-20 mA current signal to be accessed in parallel to HART communication, without disturbing the communication signal. For it is essential that the physical installation of the module is correct.

The access to the input current (**DF116**) or to the output current (**DF117**) of the channel is done in the FOUNDATION fieldbus system through the **PRIMARY_VALUE** parameter of **TBH** block. In each channel must be installed only one HART device and its address must be 0. The multidrop mode is not allowed. The **PRIMARY_VALUE** parameter is associated to the current signal of the channel where the device is installed.

The status of **PRIMARY_VALUE** parameter is in compliance with the NAMUR Standard adapted to the standard of FOUNDATION fieldbus status as in the following table.

CURRENT	FOUNDATION FIELDBUS STATUS
3.8 mA < current < 20.5 mA	GoodNonCascade:GoodNCNonSpecific:Constant
3.6 mA < current ≤ 3.8 mA	Uncertain:UncertainNonSpecific:LowLimited
20.5 mA ≤ current < 21.0 mA	Uncertain:UncertainNonSpecific:HighLimited
Current ≤ 3.6 mA	Bad:NonSpecific:Constant
Current ≥ 21.0 mA	Bad:NonSpecific:Constant

The unit of **PRIMARY_VALUE** parameter is available in the **VAR_UNITS9[9]** parameter of the **TBH** block.

The **DF117** module has a safe mode configured by the **SAFE_BEHAVIOR** parameter of the **TBH** block, with the following values: 3.6 mA and 21 mA. These values represent the current value that will be controlled by the **DF117** when, due to some fault in the controller, there is not data exchange between them.

Default value of HART parameters of TBH block

In situations where it could not read the required information from the HART device by the HART parameter of **TBH** block, this will appear with the default value. The most common conditions for this to happen are:

- HART device has not yet been identified (startup, wrong address, wrong installation);
- No HART device installed in the channel indicated by the **RRSGP** parameter of the block;
- Parameter does not exist on HART device. This depends on the HART protocol version of the device and is also mandatory implementation of the HART command that reads the parameter in question;
- Invalid index in **HART_VAR_CODES8.**

The table below shows the default value of some HART parameters of the block

PARAMETER	DEFAULT VALUE
HART_PV.VALUE	NAN (Not a number)
HART_PV.STATUS	Bad: Constant
HART_SV.VALUE	NAN (Not a number)
HART_SV.STATUS	Bad: Constant
HART_TV.VALUE	NAN (Not a number)
HART_TV.STATUS	Bad: Constant
HART_5V.VALUE	NAN (Not a number)
HART_5V.STATUS	Bad: Constant
HART_6V.VALUE	NAN (Not a number)
HART_6V.STATUS	Bad: Constant
HART_7V.VALUE	NAN (Not a number)
HART_7V.STATUS	Bad: Constant
HART_8V.VALUE	NAN (Not a number)

HART_8V.STATUS	Bad: Constant
VARUNITS9.[1]	0 (None Units)
VARUNITS9.[2]	0 (None Units)
VARUNITS9.[3]	0 (None Units)
VARUNITS9.[4]	0 (None Units)
VARUNITS9.[5]	0 (None Units)
VARUNITS9.[6]	0 (None Units)
VARUNITS9.[7]	0 (None Units)
VARUNITS9.[8]	0 (None Units)

Input/output parameters (link) of TBH block

The **TBH** block has 9 parameters that can be linked to other blocks to be used in the control strategy. The link is done through the **RRSGP** parameter according to the rule **RRSGP**.

The update time of HART parameters in the **TBH** block is indicated by **HART_TSTAMP** parameter.

Function Block Creation

The **HFC302** and Fieldbus devices use function blocks to build strategies, such as PID, AI blocks, etc. This means that **Syscon** can be used to set up every part of the system - transmitters, positioners and controller - in a same language. Once built the control strategy and chose the function blocks to be located in **HFC302**, set up the **CHANNEL** parameter for that function block, which makes the interface with I/O modules.

CHANNEL Configuration

Using **HFC302**, the user can configure the number of I/O modules as well the I/O type (input or output, discrete, analog, pulse etc). The **HFC302** is the only device classified as a configurable I/O device. All I/O modules have the I/O points arranged as follow:

Rack	0 ~ 14
Slot	0 ~ 3
Group	0 ~ 1
Point	0 ~ 7

The value in the **CHANNEL** parameter is composed by these elements in the **RRSGP** form.

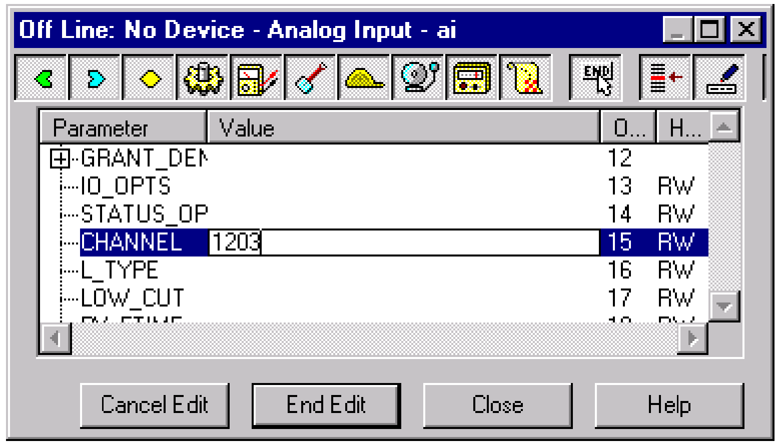
Rack (R): Each rack has four slots. The rack is numbered from 0 (first rack) till 14 (last rack). Therefore a single I/O point in the **HFC302** can be identified by specifying the rack (R), slot (S), group (G) and point (P). The **CHANNEL** parameter in the multiple I/O blocks (MIO) must specify the whole group (8 points), the point must be 9, which mean the whole group.

Slot (S): One slot supports one I/O module, and it is numbered from 0 (first slot in the rack) till 3 (last slot in the rack).

Group (G): Ordinal number of group in the specified I/O module, it is numbered from 0 (first group) till number of groups minus 1.

Point (P): Ordinal number of I/O point in a group, it is numbered from 0 (first point) to 7(last point in the group), and 9 mean the whole group of points.

For example, a **CHANNEL** parameter equals to 1203, it means rack 1, slot 2, group 0 and point 3. If the **CHANNEL** parameter of a **MAI** block is 10119, it means rack 10, slot 1, group 1 and point 9 (whole group). Before setting the **CHANNEL** parameter, it is recommended to configure the hardware in the **HC** block. Because the write check will verify if the I/O type configured in the **HC** block is suitable for block type. Therefore, setting the **CHANNEL** parameter of **AI** block to access an I/O type different of analog input will be rejected.


Off Line: No Device - Analog Input - ai
Parameter
Value
O...
H...
GRANT_DEN
12
IO_OPTS
13
RW
STATUS_OP
14
RW
CHANNEL
1203
15
RW
L_TYPE
16
RW
LOW_CUT
17
RW
Cancel Edit
End Edit
Close
Help

Module Specification Standard

The module specification is shown in a format similar to the example below. All module specifications explain functionality, field connection, and electrical characteristics, and shows a simplified schematic of the interface circuit for better understanding.

DF11/DF12/DF13/DF14 - DC Input Modules

Module Name

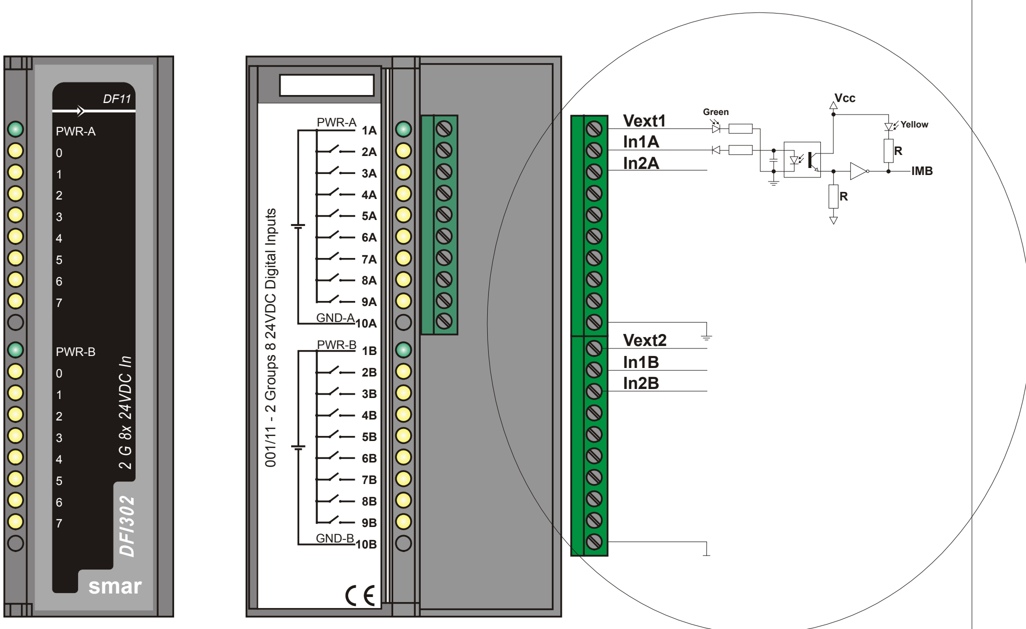
DF11 (2 groups of 8 24 Vdc inputs isolated)
DF12 (2 groups of 8 48 Vdc inputs isolated)
DF13 (2 groups of 8 60 Vdc inputs isolated)
DF14 (2 groups of 8 125 Vdc inputs isolated)

Part Number

Description

This module detects the DC input voltage and converts it in a TRUE (ON) or FALSE (OFF) logic signal . It has 2 groups isolated optically.

Brief Module Description



Simplified Internal Circuit Diagram

Technical Specifications

ARCHITECTURE	
Number of Inputs	16
Number of Groups	2
Number of Points per Group	8

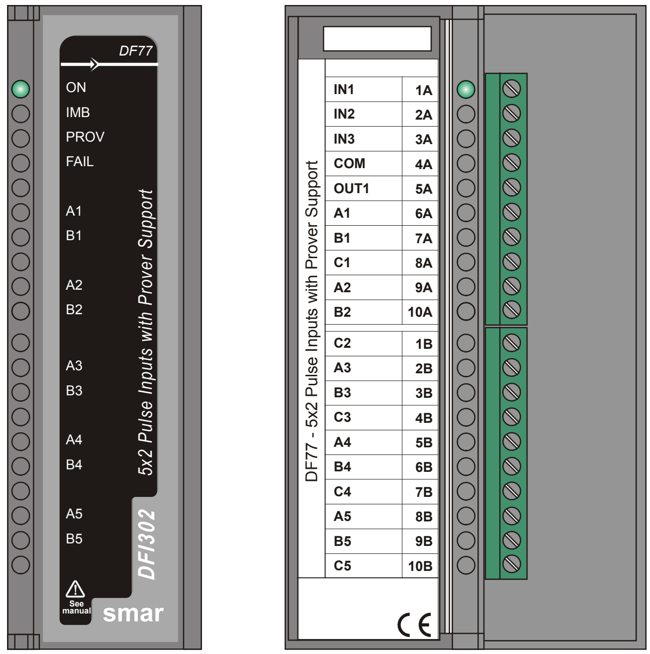
Technical Specifications

Chapter 8

DF77 – PULSE INPUTS MODULE WITH PROVER SUPPORT

Ordering Code

DF77 – 5x2 Pulse Input Module with Prover Support



Pulse Inputs Module with Prover Support: DF77

Overview

Standards Compliance

- ANP/INMETRO Regulation number 1 and number 64;
- API MPMS 4.6: Proving Systems - Pulse Interpolation;
- API MPMS 5.5: Metering - Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems;
- ISO 6551: Petroleum Liquids and Gases - Fidelity and security of dynamic measurement - Cabled transmission of electric and or electronic pulsed data;
- ISO 7278-3: Liquid hydrocarbons - Dynamic measurement - Proving systems for volumetric meters - Part 3: Pulse interpolation techniques.

Features

The DF77 is an “A level” pulse totalization module used with AuditFlow system (HFC302) in applications that transmit the mass or volume information by pulses, such as turbines or positive displacement meters. The DF77 allows the HFC302 to fulfill the international and Brazilian standards related to pulse transmission reliability and volumetric meter provings with pulsed output. It can be used with liquids and for gases.

For pulse totalization, this device provides the following features:

- Use of advanced programmable logic technology to guarantee reliable and accurate operation, with specific hardware for critical functions;
- 10 independent 16-bit totalizers operating in single pulse mode or 5 independent totalizers operating in dual pulse mode;

- The totalizers reading is done simultaneously in each CPU cycle with the counters synchronized. In the AuditFlow (HFC302) system, this feature is important for Master Meter (MM) proving where the totalization value for the meter in prove and the MM must be obtained in same instant.
- All the inputs have the following features:
  - Configurable frequency range from 5Hz to 25kHz;
  - Pulse width digital filter, adjusted by the maximum limit of the frequency configured in the transducer block;
  - Do not accept variable reluctance sensors, magnetic sensors or inductive sensors directly connected. A preamplifier must be used to provide the signal with the required amplitude;
  - Schmitt-trigger comparator with 30/60DC/VAC tolerance and logic level '0' below 1.2V and level '1' above 3.5V;
  - Active Pull-up (5V) for open-collector/drain outputs, external resistors are not necessary;
  - Average frequency measurement with of 0.01% accuracy;
  - Fault indication using the transducer block parameter and front LED's.

- On the dual pulse mode, the DF77 automatically detects and corrects the errors related to:
  - Coincident pulses;
  - Sequence error;
  - Phase difference error;
  - Missing pulses;
  - Additional pulses;
  - Coincident pulses, phase errors, sequence errors and additional pulses errors are automatically ignored in the totalization, being computed by counters that are individual for each type of error, which are available in the CPU transducer block;
  - Detected missing pulses are automatically counted;
  - If one of the signals is lost, the totalization will continue only with the remaining signal, without error detection and correction.

The prover support includes:

- Connection to any prover that detects the beginning and the end of the calibrated section (compact, U type, etc).
- Open-drain output controlled by the flow computer (HFC302) to start proving;
- Dual chronometry implementation for pulse interpolation, using counters operating at a 50 MHz providing high resolution.
- Proving doesn't interfere in the totalization, because it is executed by independent, specific hardware.

The DF77 provides the following features related to the Master Meter proving:

- The reading of pulse totalizers is executed simultaneously to guarantee that the pulse totalization in the meter being proved is the same as in the Master Meter.
- Group 5 is assigned to the Master Meter by default. All diagnostics, error detection and error correction are also applied to this group.

This equipment has Electrostatic Discharge (ESD) sensitive components. Do not open the module while it is powered or without the appropriate ESD protection. Otherwise, the circuits can be damaged permanently.

NOTE
It is important to install and configure all measurement system components correctly. It is also important to check the installation to make sure there are no noise sources. The automatic error detection and correction implemented in the DF77 helps the flow computer to reduce the measurement uncertainness only in untypical conditions. This equipment does not guarantee the system functionality in precarious installation conditions, with noise or meter problems. Frequent maintenances are extremely important.

Installation

This equipment has Electrostatic Discharge (ESD) sensitive components. Do not open the module while it is powered or without the appropriate ESD protection. Otherwise, the circuits can be damaged permanently.

The DF77 was developed using the most recent technology and must be installed and operated carefully to obtain the best results.

Things the user should never do

- Start the installation before reading and understanding this manual;
- Expose or touch the electronic circuits when the module is powered;
- Touch any internal part without ESD protection (wrist trap, ionizers, etc) and appropriate grounding. This item also applies to the front terminal;
- Insert metallic objects inside the module when it is powered;
- Connect the shield loop of the signal cables to more than one point;
- Operate the system without appropriate grounding (< 20 Ohms);
- Operate the equipment in constant noise conditions, as in the AC network or in pulse signals.
- Install signal cables in the same conduit of the power cables;
- Use signal cables without the shield loop installed correctly;
- Start the system operation without validating the installation and the pulse totalization devices, according to the recommendations in this manual;
- Start the system operation without validating the installation and the proving devices, according to the recommendations in this manual.

Things the user should always do

- Read the manuals carefully before installing and operating the system. This step prevents damages and installation delays;
- Use quality grounding (< 20 Ohms) in the installation, connecting cables with appropriate measures and isolation;
- Use shielded twisted pair cables to connect the signals from the field to the panel;
- Connect the cable loop to one single point, preferentially on the base of the mounting panel, preserving the loop in the input of the front module if the cable segment internal to the panel is superior to 50 cm. Isolate the cable terminal with a heat shrink tubing to protect the loop.

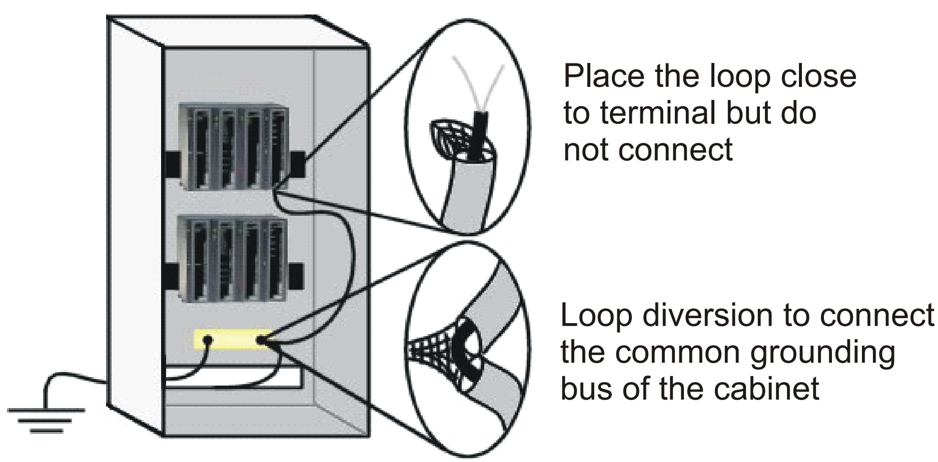


Figure 1 - Example of control panel installation

Pulse transmitters connection

The DF77 module can be used with different meter types with pulsed output. The only condition is the generated pulses to observe the module operation limits for the amplitude, frequency and active cycle:

- **Frequency**: 5Hz to 25 kHz.
- **Amplitude**: $V_{0,max}$=1V and $V_{1,min}$=4,3V, where the transition levels are: **'0' < 1,2V** and **'1' > 3,5V**.
- **Duty cycle**: 15% to 85% of the FREQ_UPPER_RANGE configured in the transducer block.

Using preamplifiers

The DF77 pulse inputs are not developed for sensors with small amplitude, such as magnetic pick-ups, inductive sensors, variable reluctance, etc. If the flow meter uses this type of sensor, a proper preamplifier must be installed between the sensor and the module, according to the following figure:

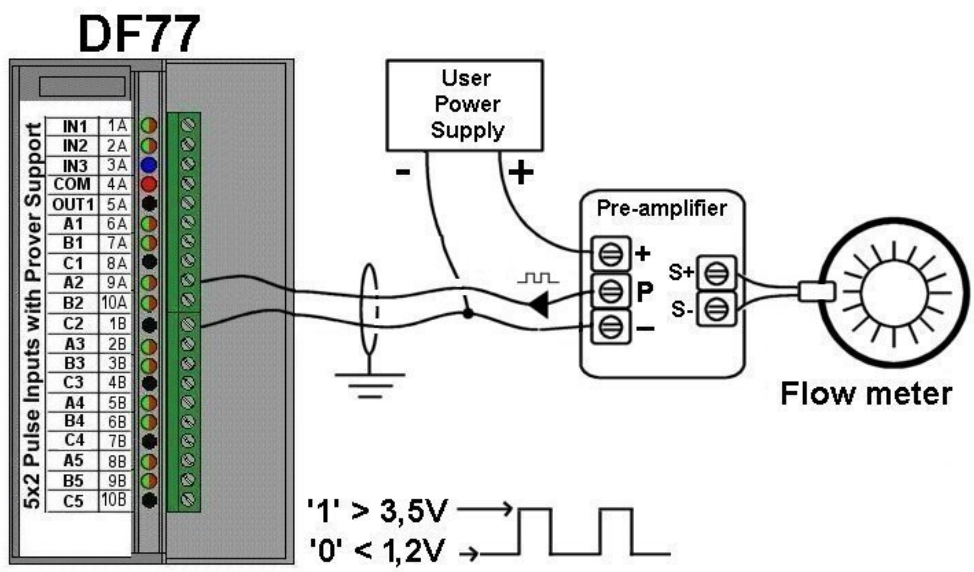


Figure 2 – Single signal connected to the A2 pulse input

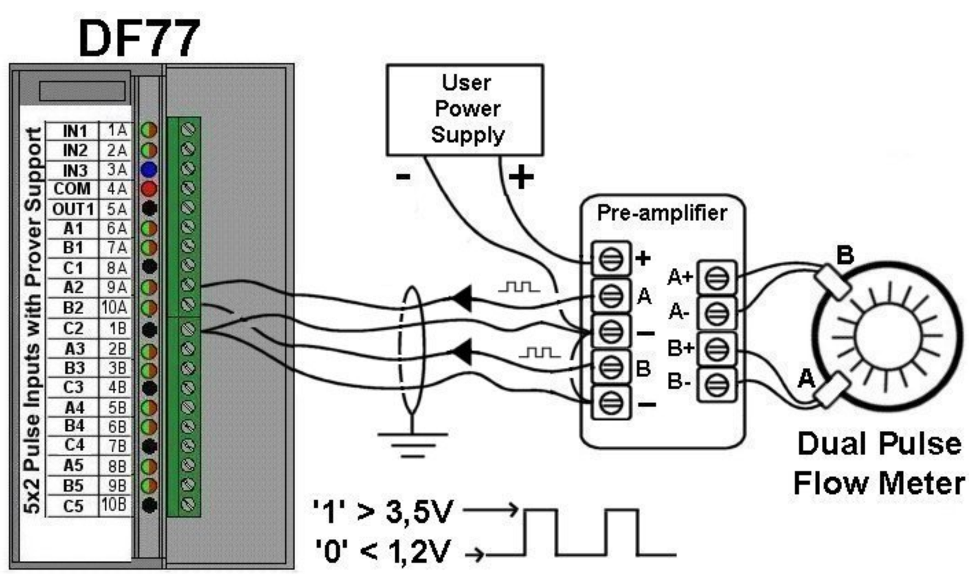


Figure 3 – Dual signal connected to group 2 (A2 and B2 inputs)

IMPORTANT
In dual pulse example above, it is extremely important to observe the pulse sequence A→B and configure the correct phase difference in the DF77 transducer block (usually 90º). The group should also be configured to operate in the dual signal check mode. If the phase difference between pulses changes, it is necessary to increase the tolerance in the phase difference in order to totalize correctly. Refer to the HFC302 manual for further details.

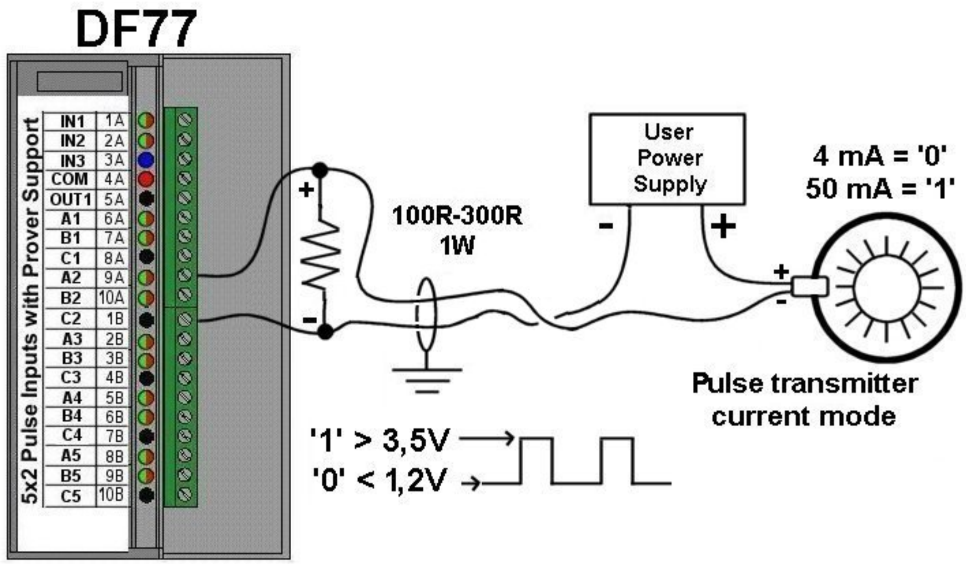


Figure 4 – Connecting the current pulse generator

Prover Connections

The DF77 allows the HFC302 to operate with a large variety of provers, from conventional provers, such as the U-type, to compact provers. The following figures show how to connect the DF77 to the most common types of provers. It is important to observe that there are no standard for provers, and therefore this figures should only be used as a reference. It is recommended to consult the specific prover documentation before the installation.

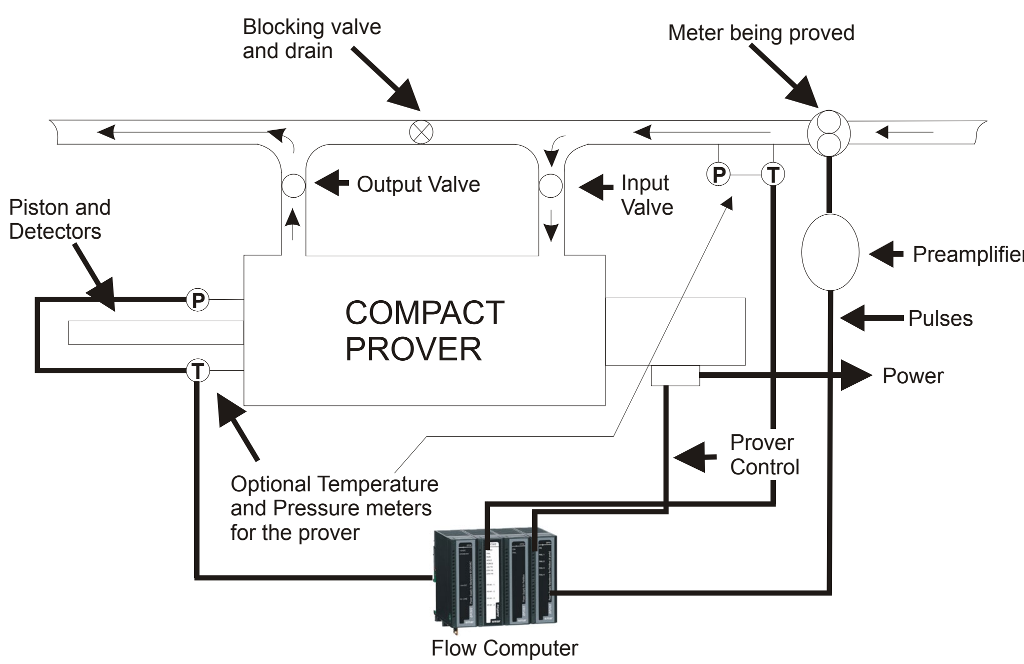


Figure 5 – Typical installation for Prover and flow computer

General connection for provers

The DF77 operates with compact provers or provers with a larger volume, such as the U-type. The figure below shows an example of a general connection. There are independent signal interfaces for each detector or a single signal for 2 detectors.

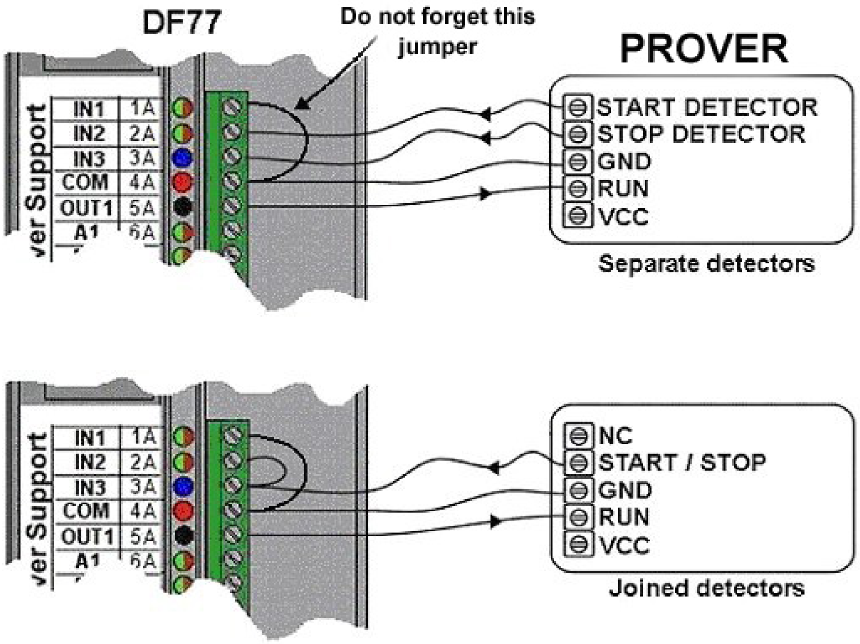


Figure 6 - General connection for provers

Connecting the Calibron Syncrotrak compact prover

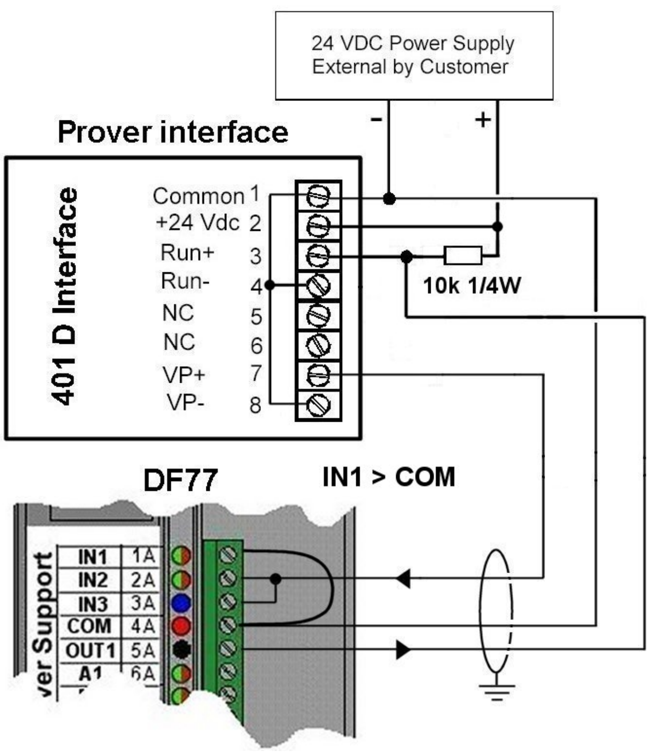
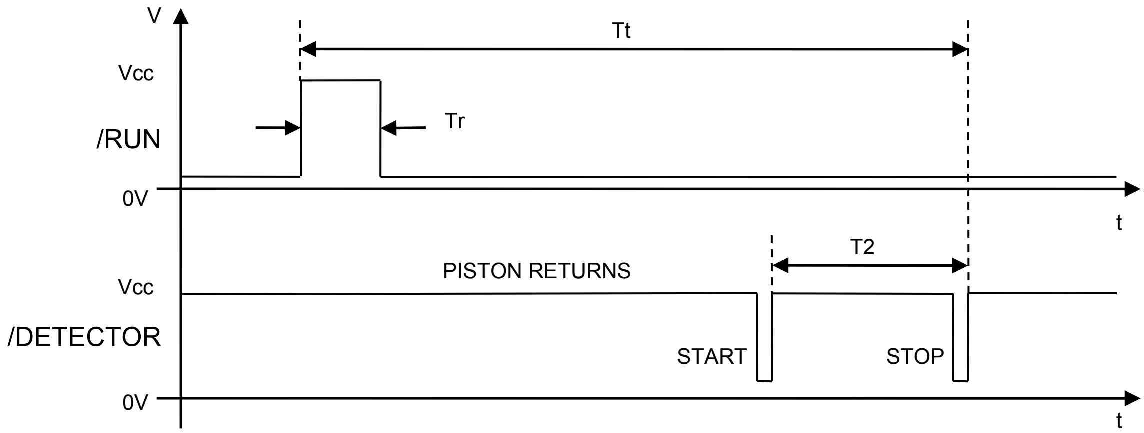


Figure 7 – Connecting the Calibron Syncrotrak compact prover

Wave form for Calibron prover (none /UPSTREAM signal):



- **Tr**: the pulse duration is configured in the OUT1_CONTROL parameter of the PIP block.
- **T2**: time used to calculate the pulses interpolation.
- **Tt**: proving total time.

Observation: The pulses of STOP and START during the piston return are not transmitted to flow computer.

Connecting the Brooks compact prover

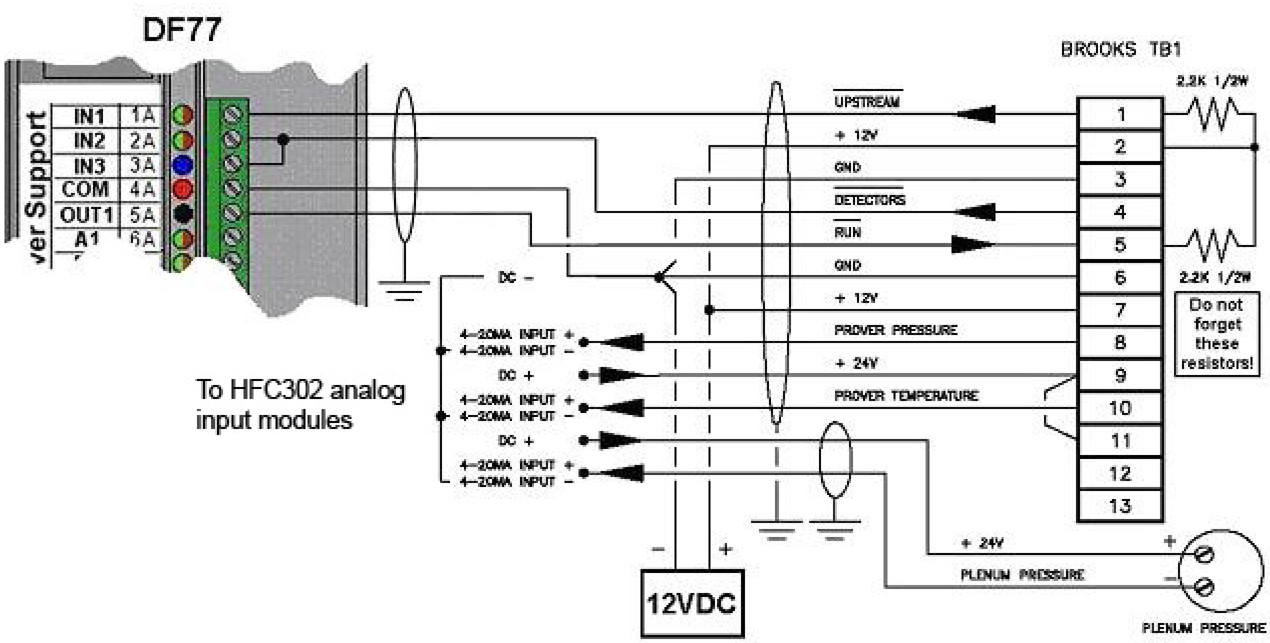
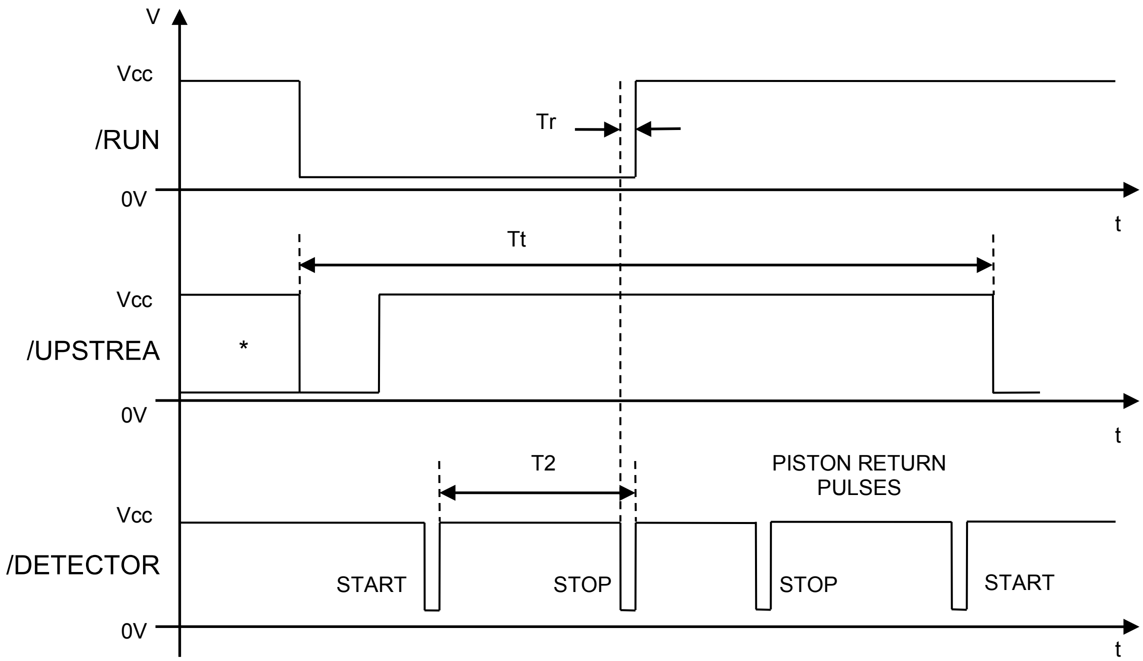


Figure 8 – Connecting the Brooks compact prover

Wave form for Brooks prover:



- *Initial level: '0' if the prover is powered and '1' if is no powered.
- **Tr**: time between the detector STOP descent and the DF77 to force the /RUN signal for logic level '1', provoking the return of the piston.
- **T1**: time used to calculate the pulses interpolation.
- **Tt**: proving total time. The proving is initiate with /UPSTREAM signal in logic level '0'. After the /UPSTREAM signal return to '0' a new proving can be initiate.

Connecting the U-type bidirectional prover

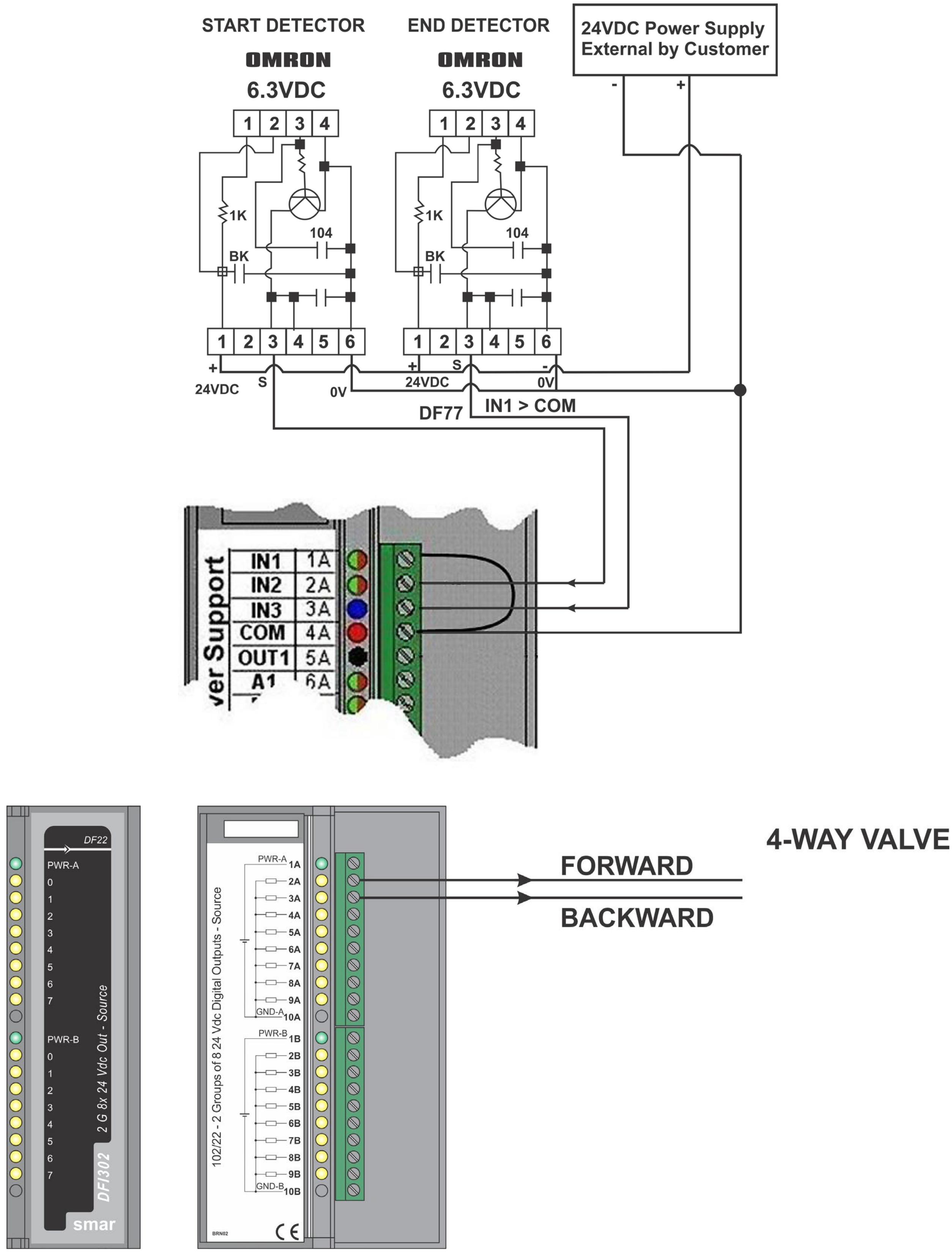
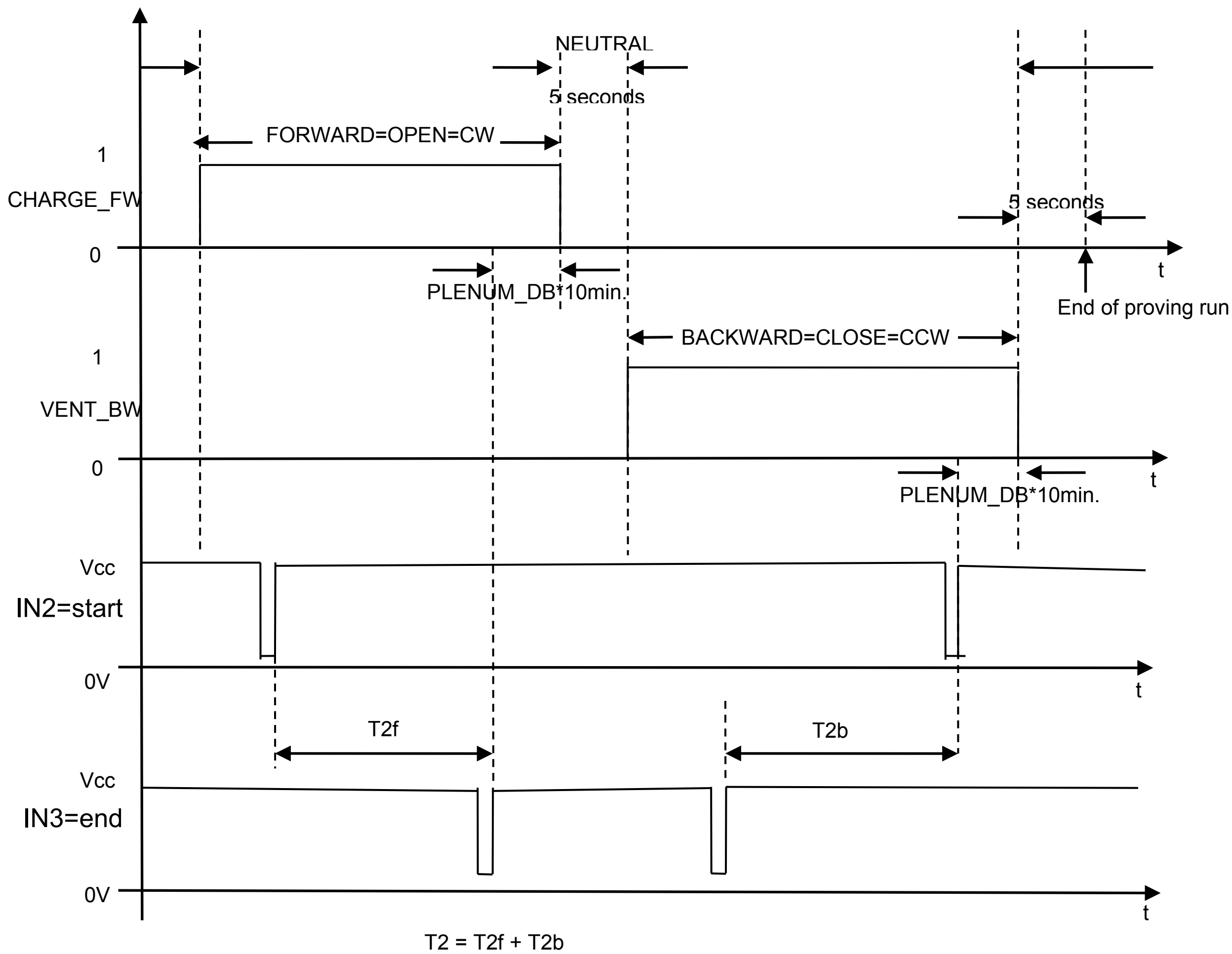


Figure 9 – Connecting the U-type bidirectional prover

Waveform for U-type bidirectional prover in the forward pass and backward pass



Connecting the Master Meter

The DF77 also supports the proving Master Meter (MM). The MM operation is the same of any other meter. This means that all filter mechanisms, error detection and correction are applied to the MM. It was defined that group 5 should be used for the MM connection. However, any input or group of inputs can be used once the HFC302 blocks were configured correctly. The MM must be carefully installed, as the production meters.

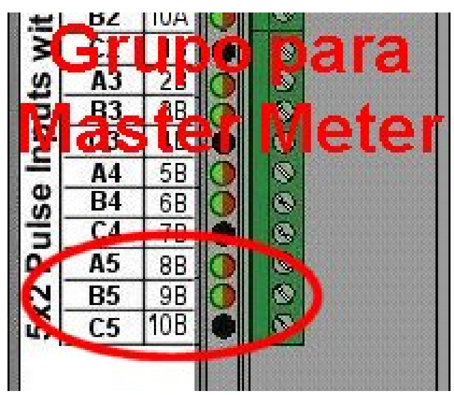


Figure 10 - Connecting the Master Meter

Installation in Hazardous Areas

The DF77 cannot be connected directly to the devices which are located in hazardous environment. One of the ways to do this kind of installation is to use intrinsic safety barriers.

Pulse signals installation

To the pulse inputs (A1, B1 ... A5, B5) should be used barriers type digital repeater. The barrier output should attend the DF77 input levels: “0” < 1.2V and “1” > 3.5V, and the barrier’s response time should be sufficient to work in the operation frequency range of the pulse transmitter (for example, rising response time plus falling response time must be less than half of period, therefore 5ms, if frequency up to 100 Hz). See the following example which is using the SENSE KD-11/Ex barrier:

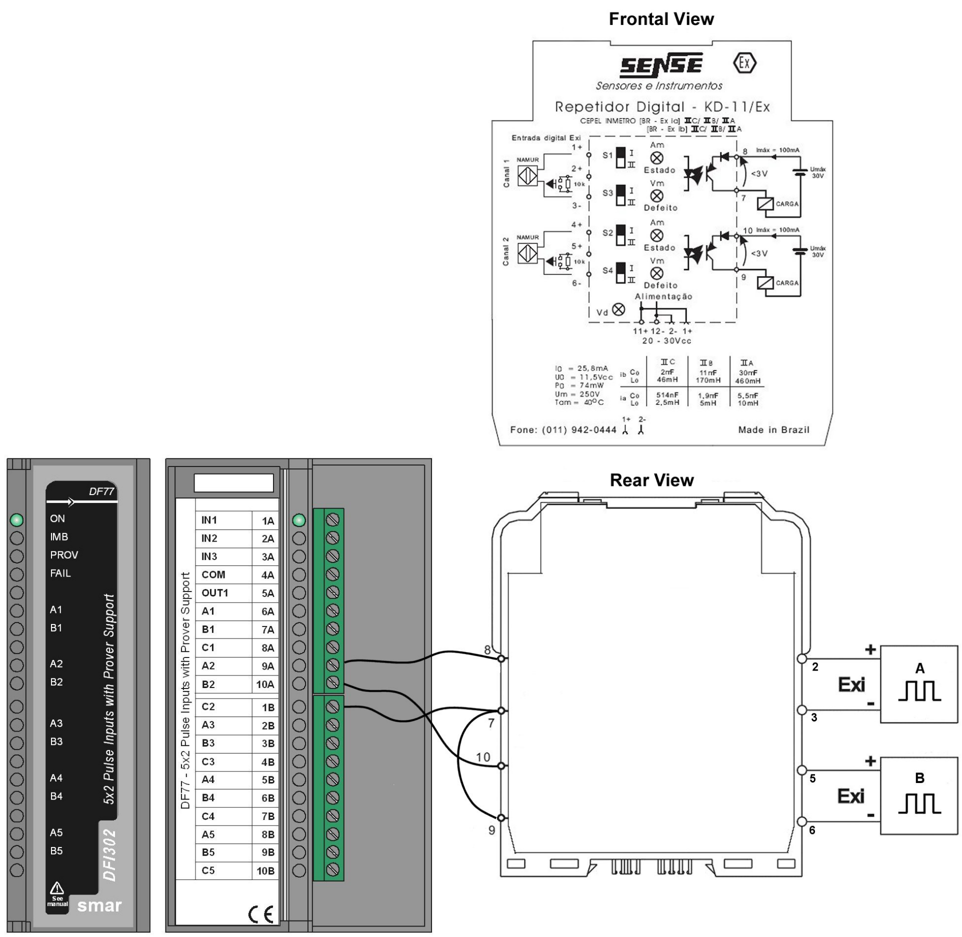


Figure 11 – Pulse input installation in Hazardous Areas

See the following example which is using the MTL5532 pulse isolator (barrier):

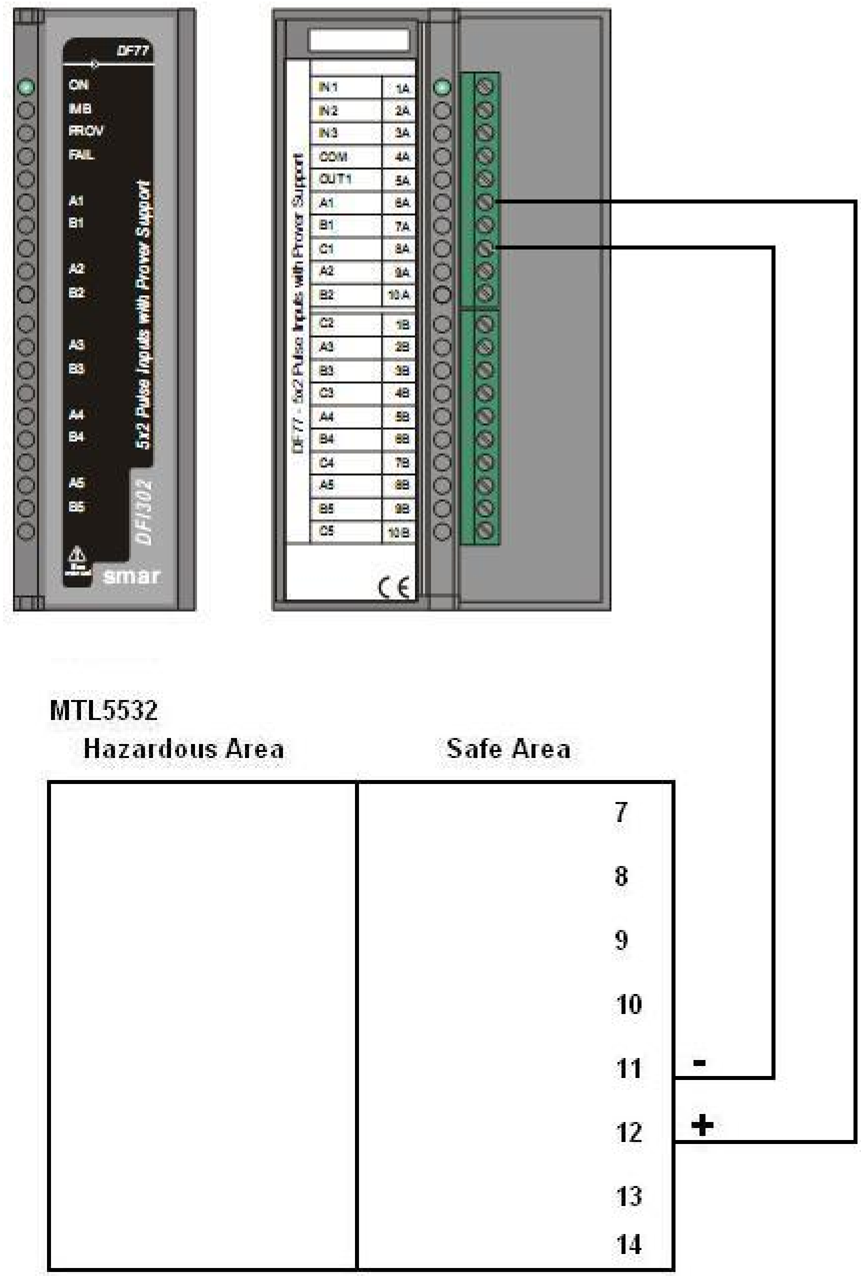


Figure 12 – Pulse input installation in Hazardous Areas

Interface with volumetric prover

To the discrete inputs (IN1, IN2, and IN3) should be used barriers type digital repeater with the same restrictions applied to the pulse inputs. To the OUT1 output should be used a barrier type digital drive. The OUT1 output is type OPEN DRAIN, which assures a voltage drop in the output less than 1V (100mA@100V maximum). To supply a barrier in 24VDC use a 10kΩ 1/4W resistor as pull-up. See the example, in the figure below, the SENSE KD-572T/Ex barrier:

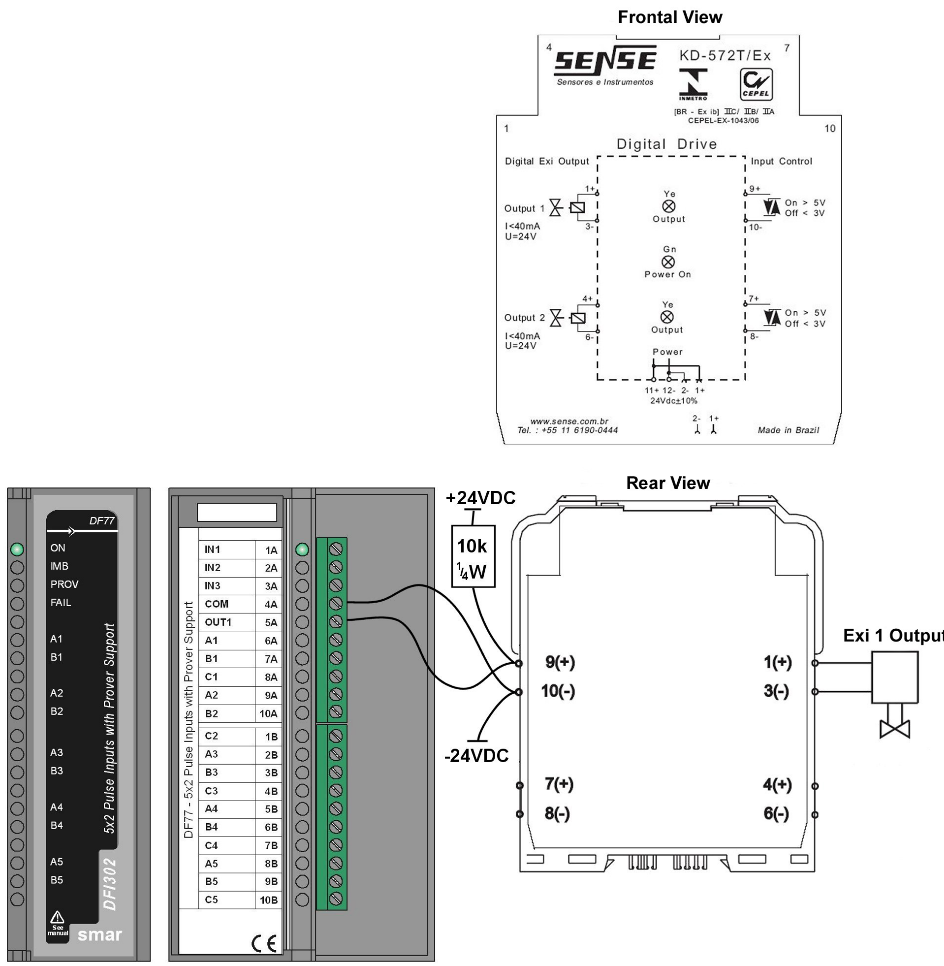


Figure 13 - Interface with Volumetric Prover in Hazardous Areas

Connection with Calibron Syncotrak prover with barriers

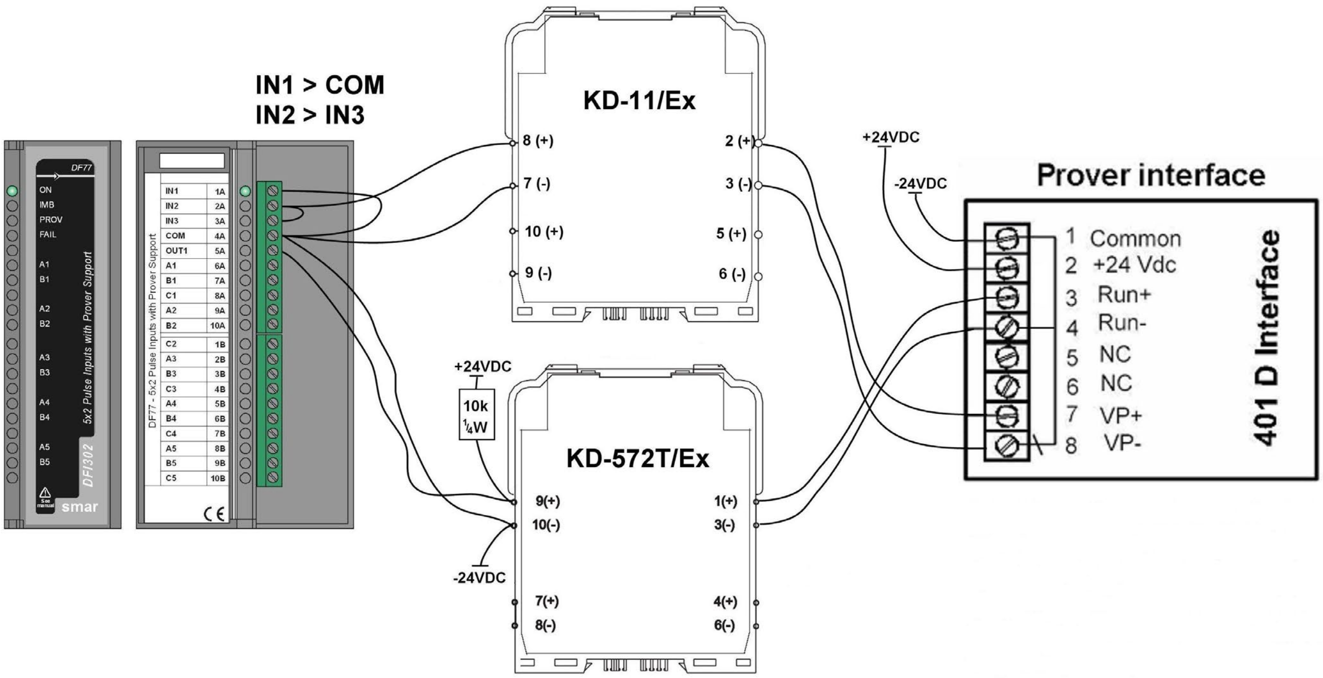


Figure 14 - Calibron Syncrotrak Prover in Hazardous Areas

IMPORTANT
The 24 VDC power supply which supplies the 401D interface have to be isolated from the barriers' power supply and from the power supply of the safe side (DF77).

DF77 Operation

Description of the Front Panel LEDs

LED	STATUS	DESCRIPTION
ON	Green ON	The module is powered; the HOT SWAP circuit is operating correctly and the FPGA initialization sequence was successful.
	Red ON	The module is powered via IMB (+5V), but the FPGA initialization sequence wasn't successful. The FPGA may not have been programmed yet, or there is an internal problem.
	OFF	There is no power on the IMB or the HOT SWAP circuit failed.
IMB	Green ON	The flow computer, HFC302, is accessing the module in the correct periodicity.
	Red ON	The HFC302 is not accessing the module.
PROV	Blue ON	Proving is being executed.
	OFF	There is no proving being executed.
FAIL	Red ON	Hardware failure, the HFC302 and/or the power supply is indicating failure in the IMB (HC block missing, power failure).
	OFF	No hardware failure.
A1…A5 B1…B5	Green ON	Input is continuously receiving the pulse train with frequency and active cycle in the configured limits in the FREQ_LOWER_RANGE and FREQ_UPPER_RANGE parameters of the PIP block.
	Green blinking	The signal frequency is between the limits: 5Hz < f < FREQ_LOWER_RANGE or FREQ_UPPER_RANGE < f < 25 kHz
	Red ON	The measured frequency is out of the maximum limits of the equipment (5Hz-25kHz) or then the duty cycle is less than 15% of the period correspondent to the value configured in FREQ_UPPER_RANGE.
	OFF	The correspondent input is disabled by the configuration in the HFC302 transducer block.

Table 1 – Front Panel LEDs

Hardware Specification

- The interface is composed by 6 isolated groups (500 Vrms), with individual grounds.
- Power provided by IMB Bus: 700 mA @ 5Vdc
- It has 10 pulse inputs divided in groups 1 to 5. Each input can be used in the single signal mode or in the dual signal mode, when combined with other input in the same group.
- Group 6 has prover interface, composed by 3 discrete inputs and 1 discrete output:
  - The OUT1 discrete output is open drain with N channel DMOS transistor, 100mA @ 100VDC, protected by reset-able polymeric fuse.
- All inputs (groups 1 to 6) have:
  - Range frequency for pulse counting : 0 Hz to 25 kHz
  - Range frequency for frequency reading: 5Hz to 25 kHz with range operation configuration.
  - Indication of average frequency in the transducer block, with 0.01 % accuracy.
  - Support for quadratic wave, pulses or sinusoidal:
    - V_0 : -30V to 1V (wave form inferior limit)
    - V_1 : 4,3V to 60V (wave form superior limit)
  - Minimum pulse width: 12.5% of period corresponding to PIP.FREQ_UPPER_RANGE.
  - 5k6 Ohm input impedance.
  - Polymeric reset-able protection fuse.
  - ESD and surges protection.
  - Pull-up active resistor for +5VDC, eliminating the external resistor.
  - Electromagnetic interference filter (ferrite bead).
  - Green/red Front LED to indicate the input status.
  - Digital debouncing circuit to eliminate the installation of external capacitors.
  - 16 bits Totalizers.
- Common features for all groups:
  - Isolated ground using individual DC-DC converter.
  - Digital signal isolation using individual opt couplers.
  - 500 Vrms Optical isolation.
- The module has Hot Swap circuit.
- It also has the MODULE_ID circuit, where the identifier is 77.
- Front LEDs indication:
  - **ON**, indicates if the module is powered and if the internal FPGA is operating correctly.
  - **IMB**, indicates if the HFC302 is accessing the DF77 correctly.
  - **PROV**, turns on if a proving is being executed.
  - **FAIL**, indicates that a serious error occurred in the equipment.
- The DF77 uses components with the most advanced semiconductors technology to improve performance.
- Using a Flash memory, all device functionalities can be updated in the field.
- Internal overload and short-circuit protections for all regulators.
- The IMB interface is protected:
  - Internal failures in the equipment won't endanger the flow computer operation or any other module in the same bus.
  - Interferences from the IMB won't compromise the module operation that continues to totalize even if the flow computer no longer access the module.

I/O Circuits

The figure below shows the block diagram of the I/O circuits to facilitate the connection of the pulse transmitters, preamplifiers and external interfaces.

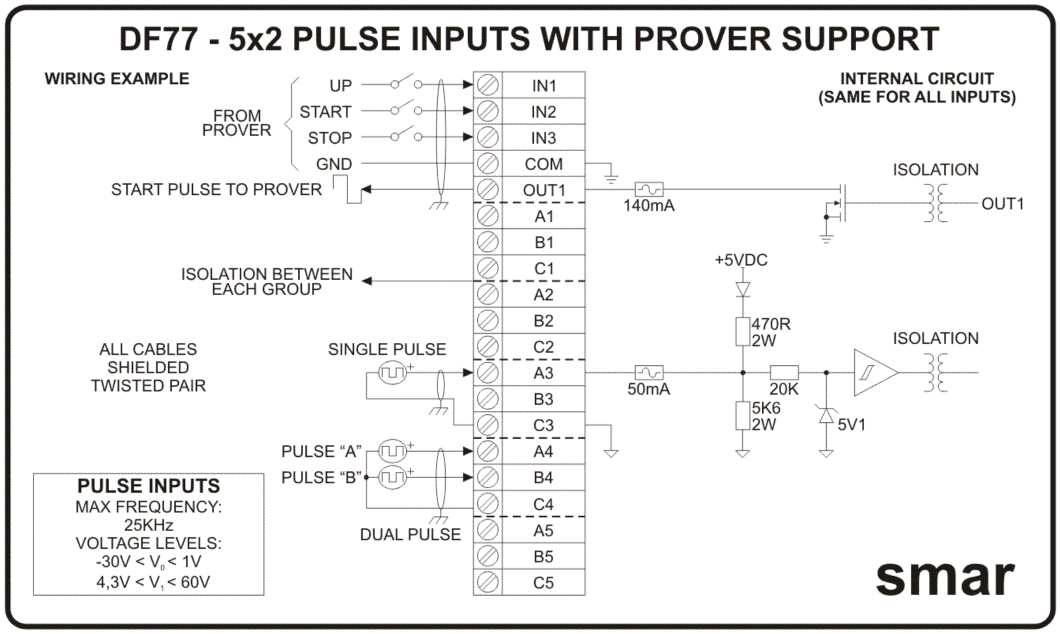


Figure 15 - I/O internal circuits

Checking the Installation

The DF77 assists the HFC302 flow computer to fulfill Brazilian and international standards related to the pulse totalization and volumetric proving. However, to get the most from the system, it is necessary to carefully check the installation before starting the measurement system operation. Some procedures are described in the standards and others originated from the experience of using this equipment. Even if the procedures described in this manual do not verify the installation, it is important to detect and correct the problems before initializing the system.

Checking the Safety Level for Pulse Totalization

Using a pulse generator with accuracy lower than 0.001% to simulate a pulse train, the installed set should have a **totalization error lower than 1 pulse for each 100.000**.

The test suggests generate 10^6 pulses in a frequency corresponding to twice the maximum flow frequency of the meter and half of the meter output amplitude. At the end of the counting, check if the totalized number differs from less than 10 pulses. Repeat this procedure using a frequency corresponding to half of the minimum working flow, with the same maximum error. In this case, the installation and the tested equipments fulfill and exceed the API MPMS 5.5 and ISO 6551 standards related to the pulse transmission and totalization. If this test is not successful, check the installation for noise sources, grounding problems, wrong connections, low quality cables, problems with the meter or the preamplifier, etc.

Note: Use the TEST_COUNTER parameter of the DF77 transducer block to check the pulse totalization.

Double Chronometry Proving

The following procedure checks the proving functionality available in the DF77, generating a simple pulse train and simulating the beginning and end detectors of the calibrated section.

The correct operation of the equipment that interpolates the pulses is extremely important for the proving accuracy, as for compact provers, as for reduced volume conventional provers (U type). A proving method for double chronometry is described below, according to the API MPMS 4.6 and

ISO 7278-3 standards. See the block diagram below with the equipments required to execute the test.

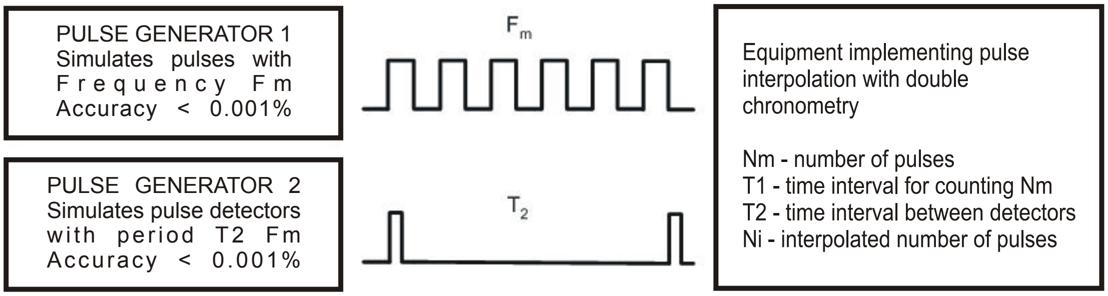


Figure 16 - Double chronometry verification

In the figure above, observe that a pulse generator is used to generate a pulse train simulating the meter output, where the frequency F_m must correspond to the maximum work flow of the meter/prover. The second signal generator simulates the beginning and end detectors of the prover calibrated section, simulating the time interval T_2. The signal generators should have accuracy ≤ 0.001%. The F_m and T_2 values must be set for the worst case, that is, the smaller number of pulses in the smallest proving time. Select the meter with the smallest ***K*** (pulses/volume), with the smallest work flow. It is extremely important that there are two conditions to guarantee a fragmented number of pulses during the test:

- Time interval T_2 is not a multiple of the frequency F_m and,
- The signal of the detectors is not synchronized with the generated pulses

The ideal number of interpolated pulses can be calculated as:

$$N_i^* = F_m \cdot T_2^*$$

The number of pulse calculated by the equipment being tested is:

$$N_i = N_m \cdot \frac{T_2}{T_1}$$

The difference between the calculated and measured values should not exceed ±0.01%, that is

$$\left| \frac{N_i^* - N_i}{N_i^*} \right| < 0.0001$$

Note: Use the LMF block to simulate the proving and to check if the calculated number of interpolated pulses is acceptable. If the error is greater than the acceptable value, check again the adjustments made in the signal generators. Also, check the wiring, grounding and noise sources.

Operation Theory

Pulse Transmission Reliability

The purpose of using a pulse dual signal to guarantee the transmission and totalization reliability is to:

1. Provide an additional signal for comparison to eliminate false errors. The comparison between two pulse trains considers:
   a. Pulse sequences, according to A→B.
   b. Phase difference, calculated cycle by cycle to validate the pulses.
   c. Instant frequency, calculated cycle by cycle.
   d. Total pulse counting for A and B.

2. Provide a basic level of redundancy: if one signal fails, the flow computer will continue totalizing using the other pulse train.
   a. In this condition, there is no error detection or correction based on the comparison between two signals, and therefore more errors may occur.

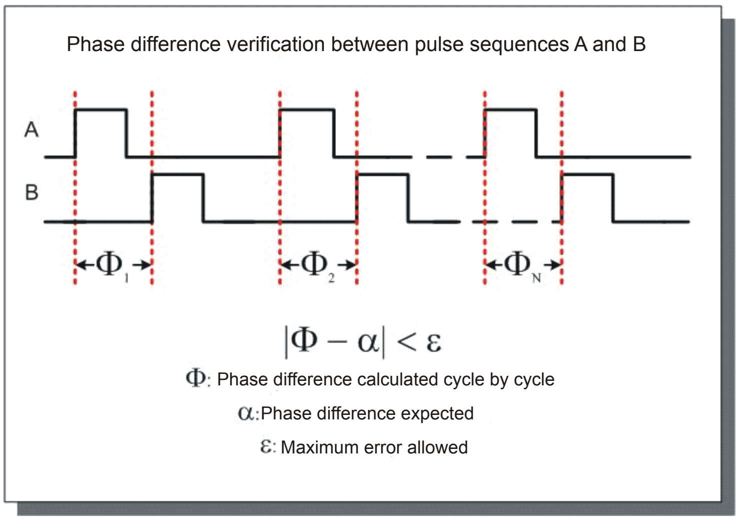


Figure 17 - Dual signal with phase difference according to the API 5.5 and ISO 6551 standards

Real-time diagnostic for the pulse train

The DF77 uses high speed dedicated hardware to analyse the pulse train and diagnose the errors, automatically correcting the totalization, when possible.

Sequence error

A sequence error occurs when a pulse arrives in B before a pulse in A, as indicated in the following figure:

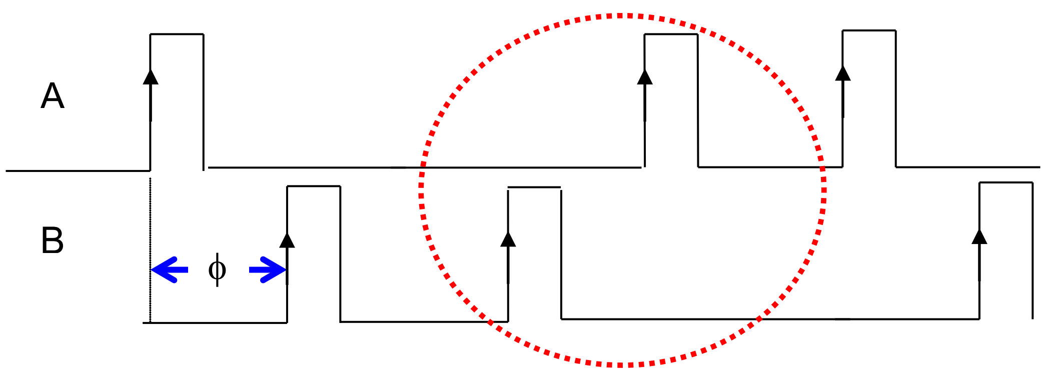


Figure 18 - Detecting a Sequence Error

In this case, these two pulses are ignored in the totalization and computed only in the sequence error counter of the PIP block, in the SEQUENCE_ERROR parameter.

Phase error and coincident pulses

These errors occur when the A→B phase difference is out of the configured range in the correspondent parameters of the PIP block (transducer).

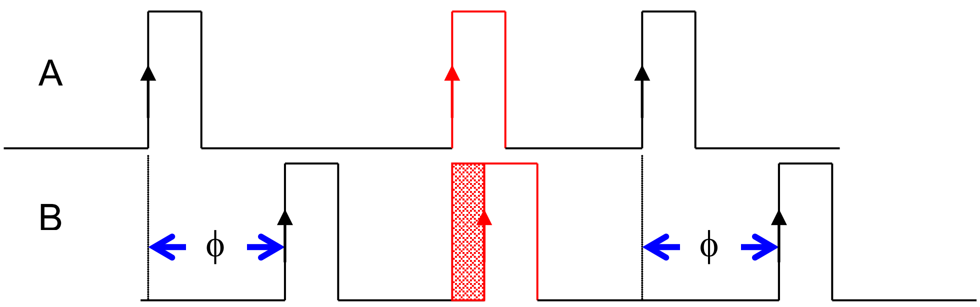


Figure 19 - Detecting Phase error and coincident pulses

The DF77 checks the following conditions in each cycle:

$$\begin{cases} (1)\phi \leq 11{,}25^o \\ (2)11{,}25^o < \phi < (\theta - \varepsilon) \\ (3)(\theta - \varepsilon) \leq \phi \leq (\theta + \varepsilon) \\ (4)\phi > (\theta + \varepsilon) \end{cases}$$

Where:
ϕ is the instantaneous phase difference measured between pulse A and pulse B (positive edges).
θ is the phase difference configured in the PIP.Gx_PHASE_DIF parameter.
ε is the maximum deviation allowed, configured in the PIP.Gx_PHASE_DEV parameter.

Notes:

- The ideal operational condition, with no errors, is represented by the equation (3). Usually, the pulses are totalized by the HFC302.
- The condition (1) represents an error of coincident pulses. The pulses are automatically rejected (they are not totalized) and the PIP.COINCIDENT_ERROR parameter is incremented, indicating the error.
- If the conditions (2) or (4) occur, that is, the error is not related to coincident pulses but to the deviation that is out of the configured limits, a phase error will be reported and the correspondent counter of the group PIP.PHASE_ERROR will be incremented. The pulses are not totalized by the flow computer.

Missing pulse error

This error indicates a missing pulse between 2 regular pulses. The error can occur with signal A or B, as indicated in the following figure:

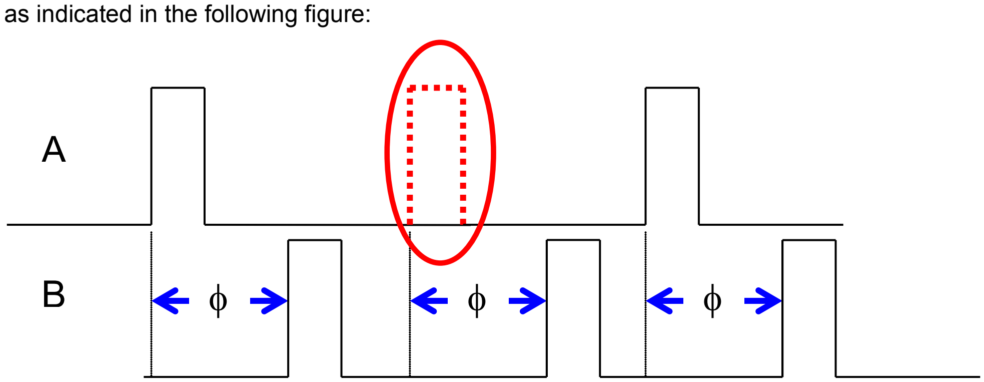


Figure 20 - Detecting missing pulses

In the example above, there is one missing pulse in signal A. The DF77 identifies the missing pulse, automatically totalizes the pulse for the flow computer and indicates this error using the PIP.MISSING_PULSES parameter.

Extra pulse error

Extra pulses conditions are extremely hard to be detected because they can be misinterpreted as an external noise. The DF77 checks if there is a false pulse between 2 regular pulses, that is, if the periods in A and in B are close to the previous periods. See the following figure:

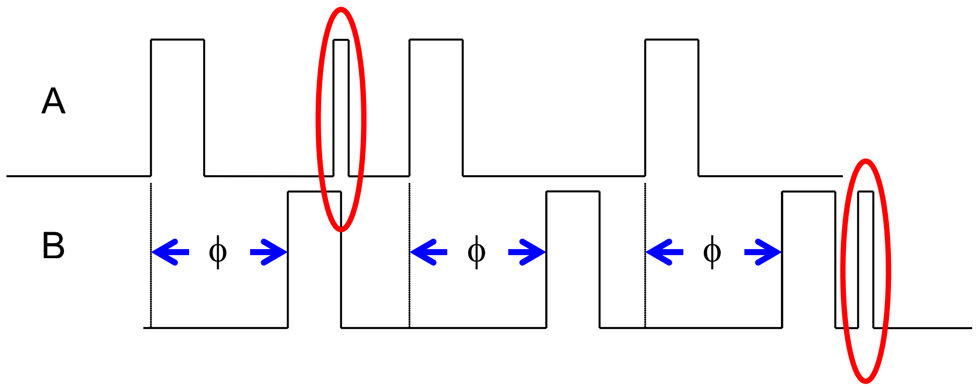


Figure 21 - Detecting extra pulses

In this example, observe an extra pulse identified in signal A and, after that, an extra pulse identified in signal B. In both events, the module automatically rejects the extra pulses, incrementing the correspondent error counters PIP.EXTRA_PULSES.

Pulse interpolation using double chronometry

The DF77 uses the double chronometry method to interpolate the pulses during the proving period. The purpose of the pulse interpolation is to calculate the fragmented part of a pulse that could not have been counted during the proving period. The result of this process, which is the interpolated number of pulses ***Ni***, is used to determine the ***MF*** with accuracy 1 in 10.000.

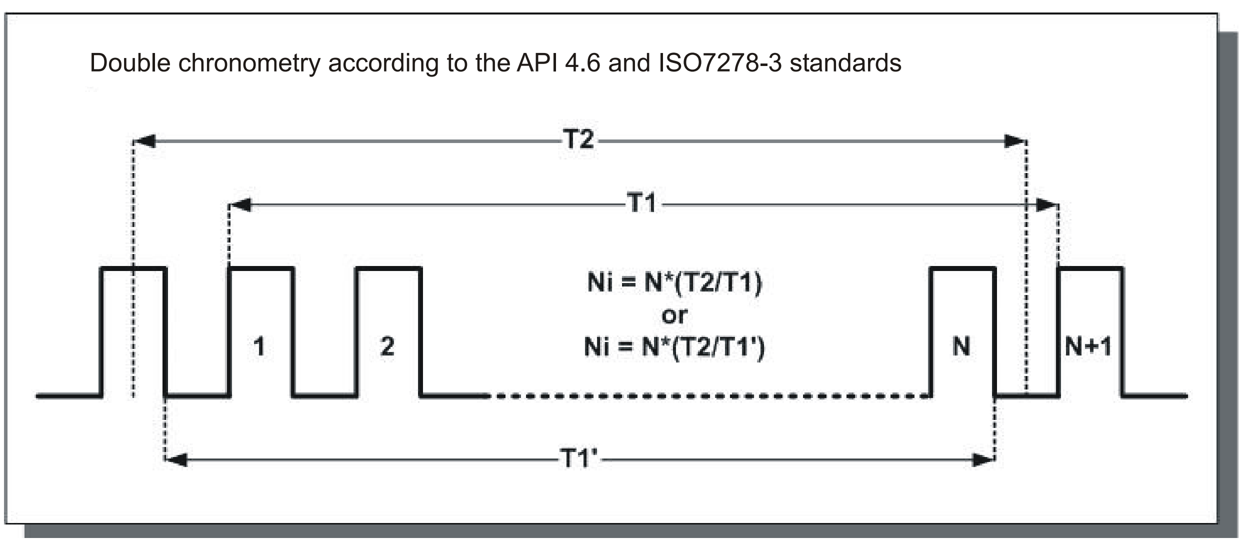


Figure 22 - Pulse interpolation according to the API 4.6 and ISO 7278-3 standards

Chapter 9

HARDWARE INSTALLATION

Purpose

This document provides general guidelines to install the AuditFlow, including I/O modules, nterfaces and communication network. Use this guideline as a tool to help to avoid Eletromagnetic Interference (EMI) that may cause malfunction or damage to the electronics.

Category of Conductors

Classify all cables following the table below and follow the recommendation to avoid coupling between cables. The basic idea is to separe noisy cables (category 1) from others (category 2) inside and outside of cabinet.

CATEGORY	CATEGORY DESCRIPTION	EXAMPLES	RECOMMENDATION
1	**Control e AC Power** Cable of high power, that are more tolerant to noise and interference than conductors of Category 2. They can generate noise in the other cables.	• AC power lines to power supply and I/O • Digital I/O lines with AC power — high power and high immunity to noise. • Digital I/O lines with DC power — high power and high immunity to noise. Typically for connection with dry contact switch, relay and solenoid valve.	• These conductors may be in the same conduit with power lines to machines up to 600Vac/100 Hp.
2	**Low level signal and Communication** Cables of low power, that are less tolerant to noise and interference than conductors of Category 1. They generate less noise to cause interference in other cables near to it.	• Analog I/O lines and DC power lines for analog devices. • AC/DC I/O lines of low power. • DC Digital I/O lines of low power to connect DC modules of I/O with low power and input circuits and constant time in order to detect pulses. Typically for connection with switches, sensors and encoders. • Cables of communication — connection between CPUs or communication interface modules, local HMI, personal computers.	• If these conductors have to cross conductors of category 1, it must be done in right angle. • Keep a distance of 1.5m, at least, from high voltage cabinet and RF/microwave sources. • If using a metallic conduit, certify that all segments have electric connections to guarantee continuity. It must connect to the grounding of cabinet too. • Use shielded cables where recommended. • If a metallic conduit, the minimum distance of conduits category 1 in the field : • 0.08m : less than 20A; • 0.15m : more than 20A, but up to 100 kVA; • 0.3m : more than 100 kVA. • Apply the double of these minimum distances, if using a non-metallic conduit or without electric continuity.
3	**Inner to cabinet** Connection between components inside of cabinet.	• Cables of DC power with low voltage, cables of power to modules in the cabinet. • Communication cables to connect devices inside the cabinet, for example, flat cable for rack interconnection.	• Route external conductors keeping separated the categories 1 and 2, observing also the minimum distance, if possible.

Table 9.1 – Category of Conductors

Mounting Racks in the Cabinet

See the instructions to mount the rack.

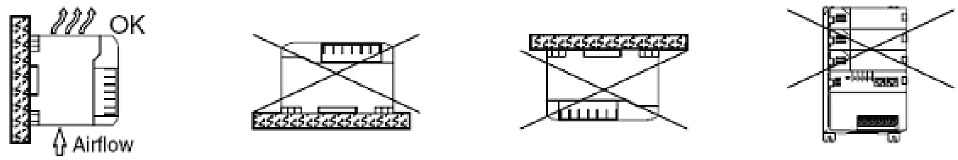


Figure 9.1 – Correct Position of Rack

Mount the racks in the vertical position in order to guarantee the airflow convection. Keep a minimum distance of modules to the wall of cabinet.

Mounting Devices and Grounding in the Cabinet

The grounding of devices chassis and shields of cable are performed to minimize electromagnetic interference (EMI) and ground noise.

Chassis Grounding Bus — Connect the chassis terminal of each device inside of cabinet to this bus, then it must be connected to the Ground Electrode System using a 8 AWG wire, at least.

The majority of AuditFlow modules do not have a chassis terminal to ground it, but they have their chassis connected to the DIN rail by a spring in the rear of module. The DIN rail must be connected to the wall of cabinet using the fixing screws, observing a good electric connection removing the paint of cabinet if necessary.

List of points that must be connected to the Chassis Grounding Bus:

- AuditFlow Power Supply Modules (DF50, DF52, DF56, DF60) : ground terminal
- AuditFlow – Modules connected to DIN rail by spring : DIN rail
- Third party devices - Panel View (HMI), fan, power supply and other : chassis ground

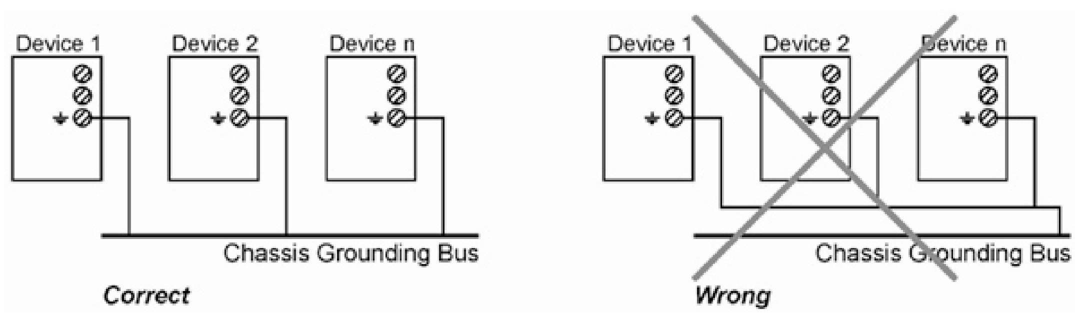


Figure 9.2 – Correct connection to Chassis Grounding Bus

Analog Grounding Bus - Some cables classified as category 2 have recommendation to use shielded cables. In this case, the shields of these cables must be connected to the Analog Grounding Bus. The negative terminal of third party power supply to I/O (4-20 mA transmitter and others) must also be connected to the Analog Grounding Bus, if the cable is classified as category 2. Then the Analog Grounding Bus must be connected to the Ground Electrode System using a 8 AWG wire, at least.

Shielded cables — It is recommended to use shielded cables for the following signals in order to minimize noise coupling:

- Foundation Fieldbus – H1 bus : shield must be grounded at both ends of H1 bus
- Pulse signal from turbine, coriolis, ultrasonic, (flow meters) : shield must be grounded at cabinet side
- 4-20 mA signals : shield must be grounded at cabinet side
- EIA-485 and EIA-232 : shield must be grounded at cabinet side
- Ethernet : shield must be grounded at both ends of the cable

Recommendations to the shields of these cables:

- The shield of each cable must be grounded to the Analog Grounding Bus at the cabinet.
- Connect each shield to Analog Grounding Bus directly, never in daisy chain, similarly as indicated in the figure 8.2.
- Don't forget to connect the shields if the shielded cable goes through a junction box. And don't remove the shield more than it is necessary to connect them.
- Don't mix different categories of cable in the same junction box.

Power Supply for flowmeters — It is recommended to use an exclusive power supply for the pulse signal flowmeter / pre-amplifier, therefore it must be separated from the other I/O signals.

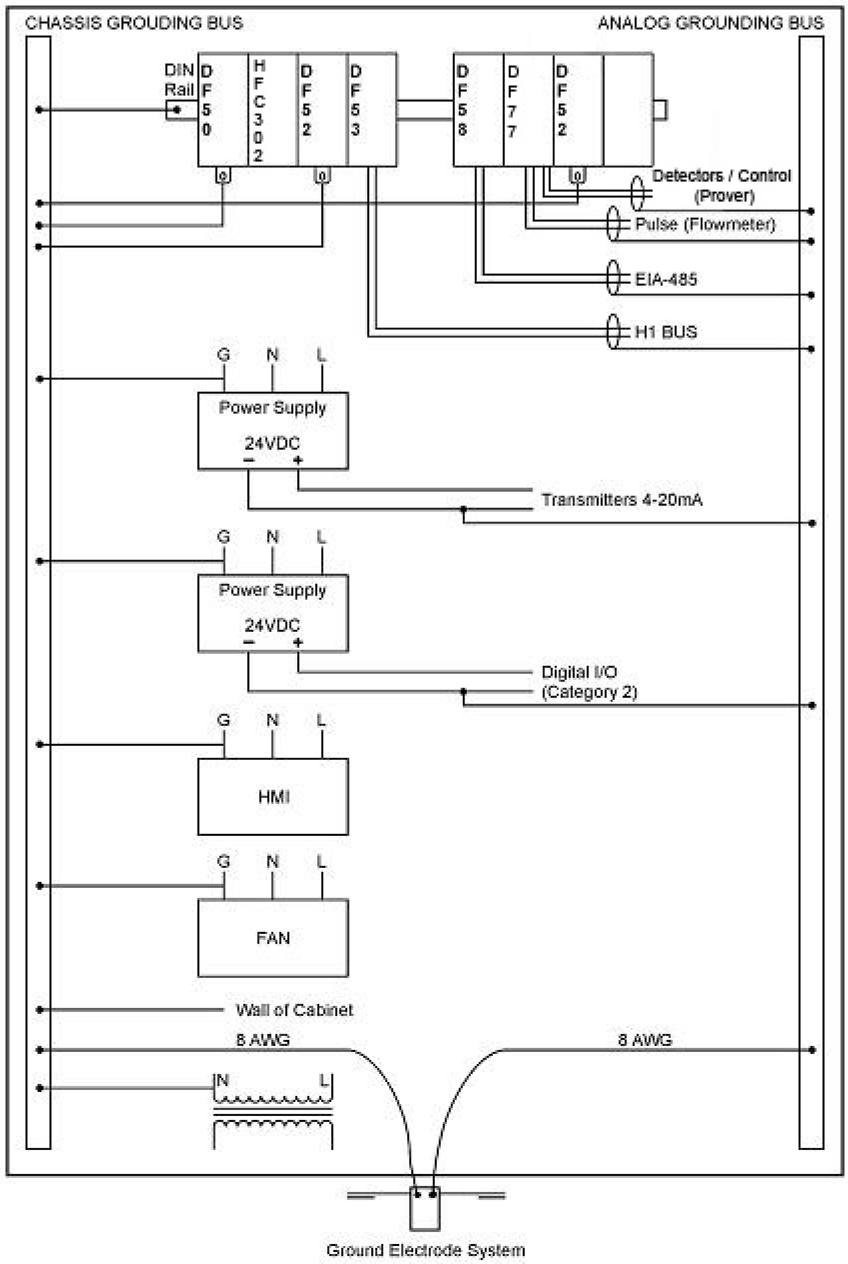


Figure 9.3 – Connection to Chassis Grounding Bus and Analog Grounding Bus

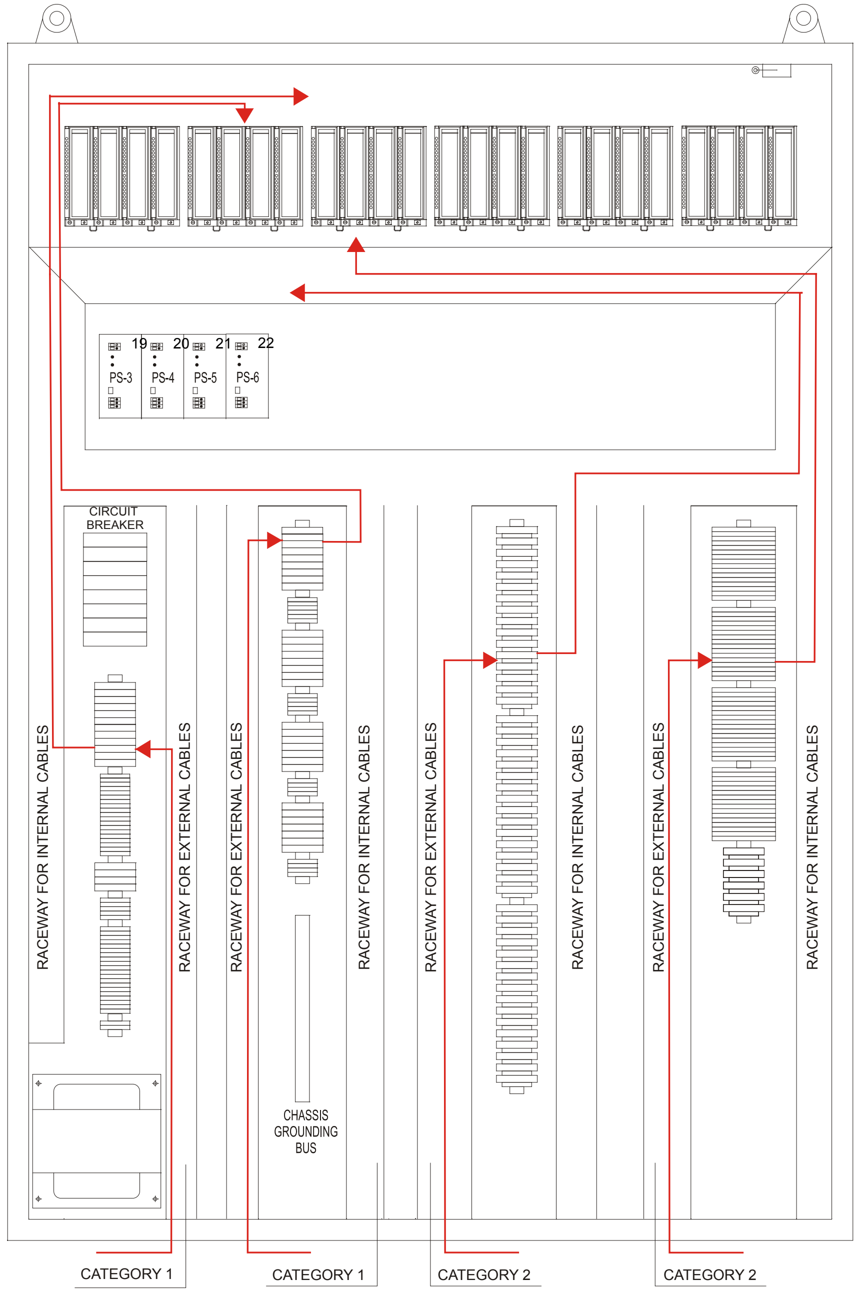


Figure 9.4 – Routing Cables of Category 1 and 2 in the Cabinet

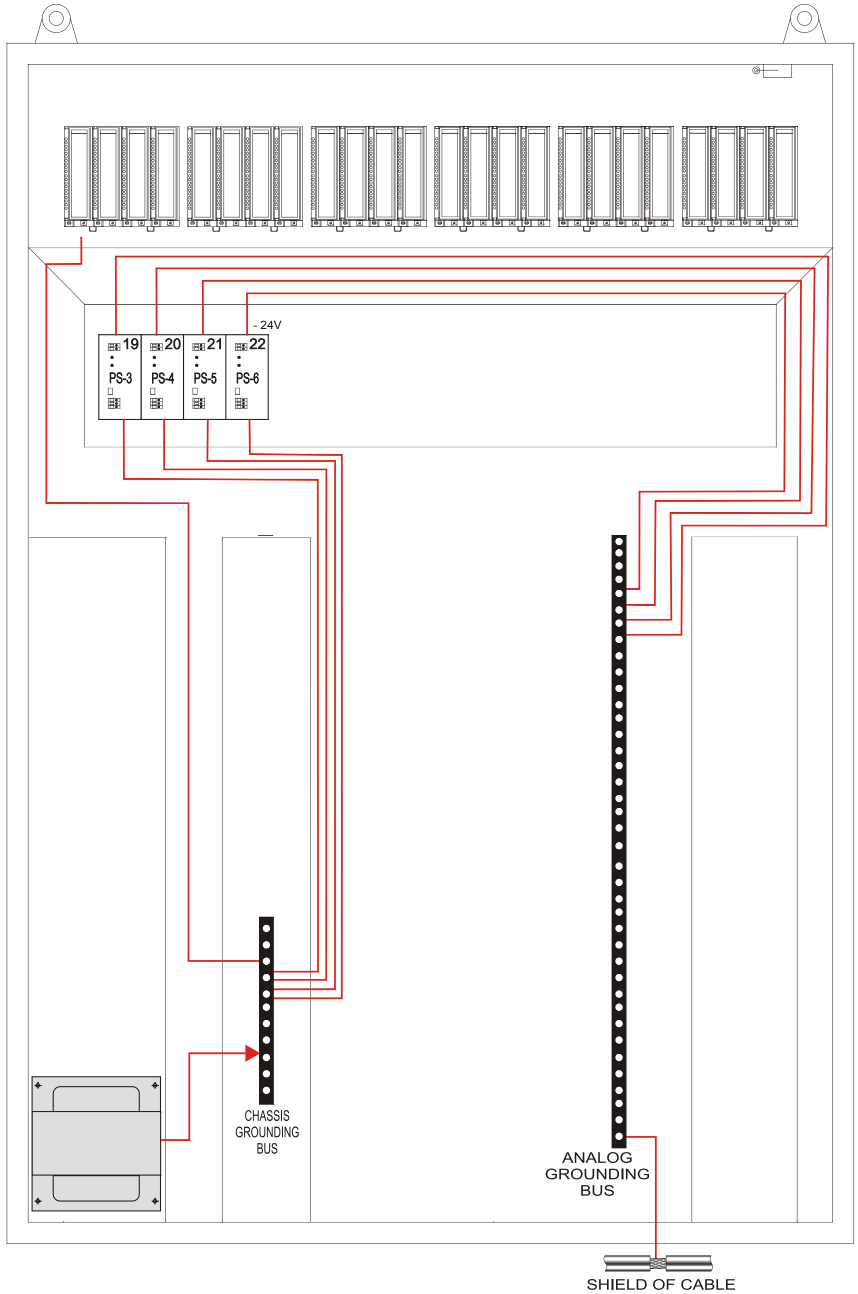


Figure 9.5 – Connection to Analog Grounding Bus and Chassis Grounding Bus

Other Recommendations

It is also necessary to follow other recommendations regarding to:

1. **Switching inductive load:** see each I/O module specification of AuditFlow regarding the clamp diode and snubber circuit.
   - Inductive DC load: Despite of the AuditFlow digital output modules for DC load have a clamping diode, it is recommended to insert another clamping diode near to the inductive load. It will avoid the noise in the cable from the inductive load till the output module that may cause interference in other cables in the same conduit.

	Clamping diode specification
Forward current	Greater than current load
Reverse voltage	Supply voltage 24 Vdc : 3-4 times greater than supply voltage (100Vdc) Supply voltage 110Vdc : 8-10 times greater than supply voltage (1000 Vdc)

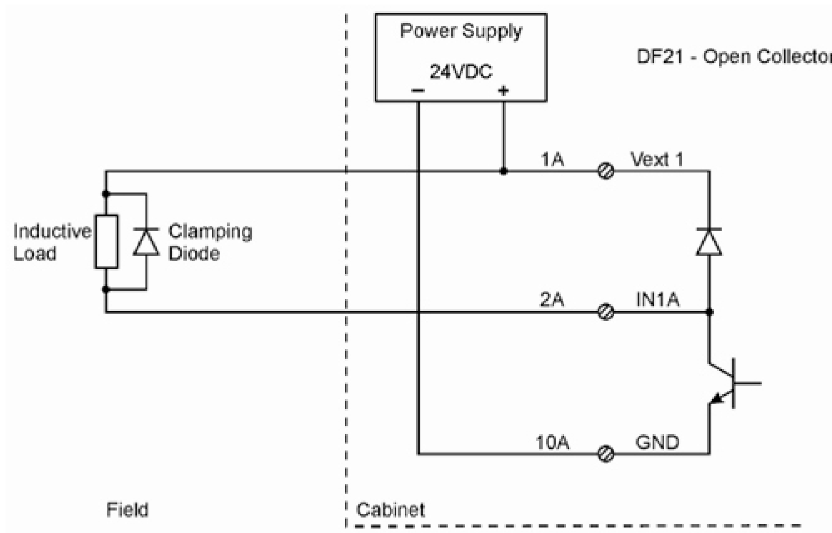


Figure 9.6 – Clamping Diode in Parallel to DC Load

- Inductive AC load: Despite of the AuditFlow digital output modules for AC load have a snubber circuit in series to the load, it is recommended to insert another snubber circuit in parallel to the load and near to i. It will avoid the noise in the cable from the inductive load till the output module that may cause interference in other cables in the same conduit.

	Snubber capacitor specification	
Load inductance	**Capacitance**	**Voltage**
25-70 milihenries	0.50 microfarads	2-3 times greater than the supply voltage
70-180 milihenries	0.250 microfarads	
180mH-10 Henries	0.10 microfarads	

	Snubber resistor specification	
Inductive load	**Resistance**	**Power**
Smaller than 100 Ω	1-3 Ω	2 W
Bigger than 100 Ω	47 Ω	½ W

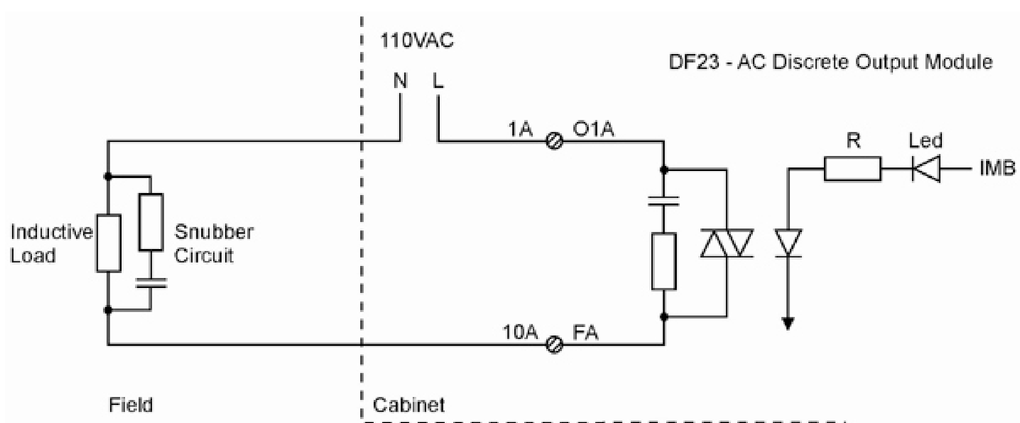


Figure 9.7 – Snubber Circuit in Parallel to AC Load

2. **EIA-485 Network:** use a suitable cable for EIA-485 network and terminators at each end, whose specification is:
    - Resistor : resistance equal to the characteristic impedance of cable (Z0), typically 100 – 120 Ω , ¼ W.

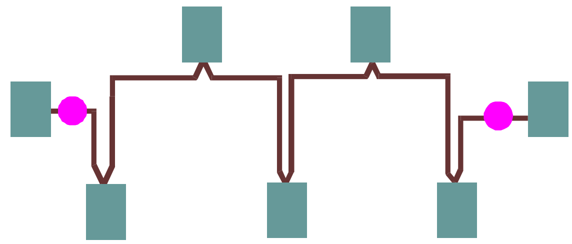


Figure 9.8 – Terminators of EIA-485 Network

    - The recommended topology is daisy chain, but backbone with stubs is acceptable.

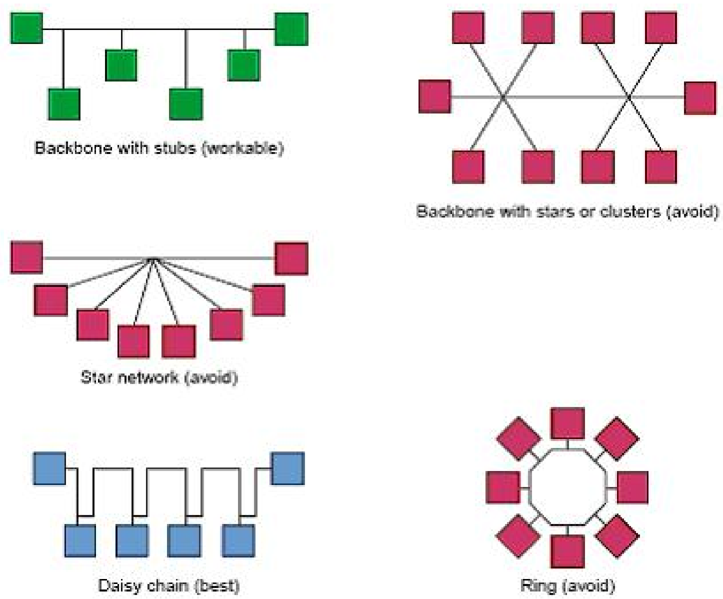


Figure 9.9 – Topology of EIA-485 Network

3. **Recommendations to avoid damage due to Electrostatic Discharge (ESD)**
    - Ground yourself before touching the electronic circuit in maintenance in order to avoid electrostatic discharge that may damage the device.
    - Keep the module lid closed when operating.
    - Maintenance of the device, when it is energized, must be performed only by a trained technician.

Chapter 10

SOFTWARE INSTALLATION

Installing the Studio302

Install the programs that compose the **SYSTEM302** using the installation media. For further details about installing the programs, refer to the **SYSTEM302** Installation Guide. The **Studio302** is the user-friendly, easy-to-use software tool that integrates all applications included in Smar's Enterprise Automation package.

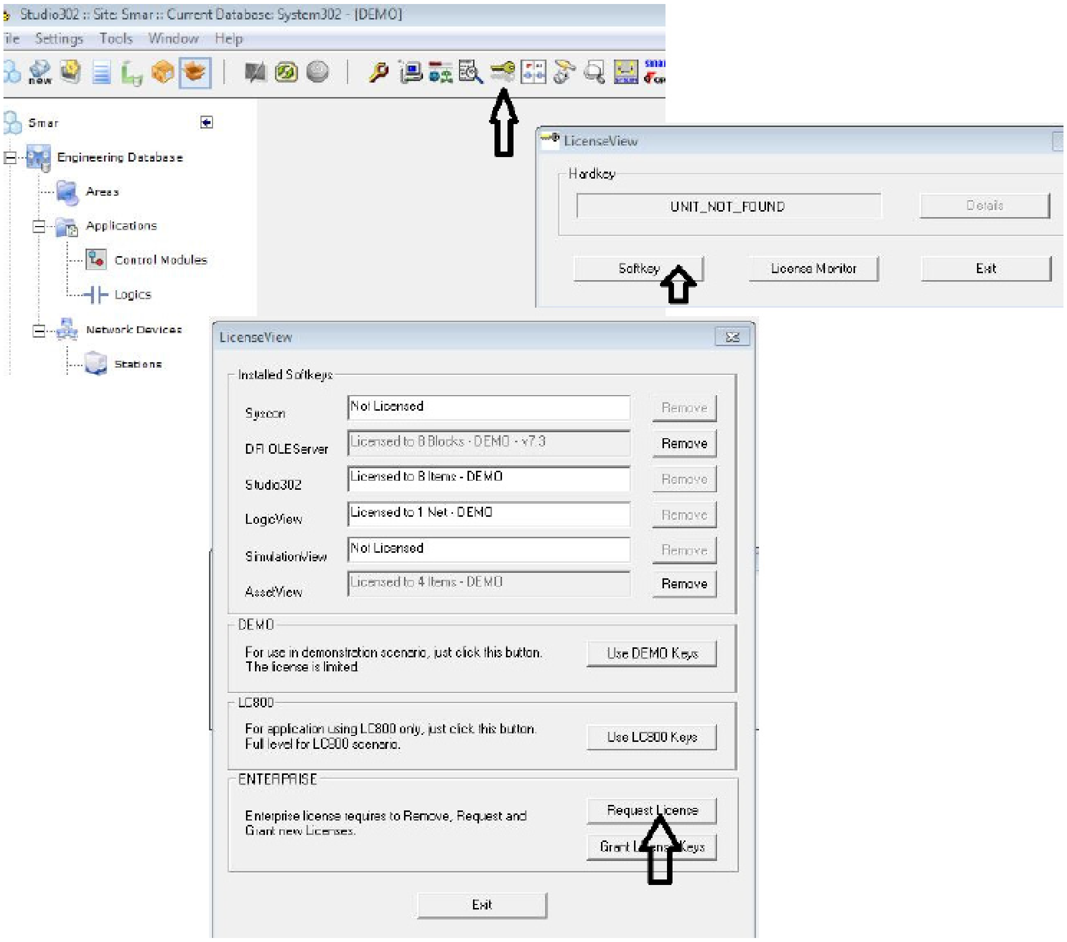
Getting License for DFI302 Servers

There are two ways to get the **DFI OLEServer** and **HSE OLEServer** license. One version is through Hard Lock protection (Hard Keys) and other through Software (Soft Key).

When using Hard Key, just connect it in the appropriated port in the computer (parallel or USB ports).

When using Soft Key, it is necessary to get a License Key through a SMAR contact. For this, use the application **LicenseView**, in the **Studio302** interface.

Click **Softkey**, and then, **Request License**.



Fill in the fields correctly, enter the **LN** (License Number) code that was received with the purchase of the product. See this code on the keyring that came with the installation media. A file (.zip) will be generated in the **\Smar\OleServers** folder for the user to send to Smar. Use the email (techsupport@smar.com.br) or access the Technical Support channel through the website (www.smar.com).

After sending the email to Smar, a key will be generated according to the corresponding **LN** level. This key will be returned via the email informed in the previous form. This generation is not automatic and, therefore, you must wait for business hours.

After receiving the email from Smar, launch the **LicenseView** application again, enter the key obtained in the **DFI OLE Server** field and click **Grant License Keys**. If everything is correct, a message will notify you that the license has been accepted.

NOTE
This license is valid for DFI OLEServer and HSE OLEServer.

At this moment, **Syscon**, **DFI OLEServer** and **HSE OLEServer** will be ready to be used.

Connecting the AuditFlow in the Subnet

AuditFlow working environment is composed of a network (subnet) where IP addresses will be necessary for each connected instrument.

ATTENTION
If the HFCView communicates with the HFC302 for ethernet ETH1 or ETH2 port, the mechanism for attribution of the IP address by DHCP should not be used. The HFCView uses fixed IP address for the HFC302's.

The automatic solution for attribution of these addresses is called DHCP (Dynamic Host Configuration Protocol) Server.

Using DHCP Server these IP addresses are generated automatically preventing any IP conflict between two distinct devices.

ATTENTION
To connect more than one **AuditFlow**, the following steps must be fully executed for each **AuditFlow**.

1- Plug the Ethernet cable (DF54) of the **HFC302** module to its respective Subnet Switch (or hub).

NOTE
For point-to-point connection (the **AuditFlow** connected directly to the computer), uses the DF55 cross cable.

2- Turn on the **HFC302** module. Ensure that ETH10 and RUN LED indicators are on.
3- Keep tight pressed the left push-button (Factory Init / Reset) and press the right push-button for three times. The FORCE LED will be blinking three times consecutively.

NOTE
If the user loses the number of times that the right push-button was pressed, just see the number of times that the FORCE LED is blinking consecutively. It will turn to blink once after the fourth touch (it is a cyclic function).

4- Release the left push-button and the system will fulfill the RESET, and subsequently will start the firmware with standard values for IP address and the Subnet Mask

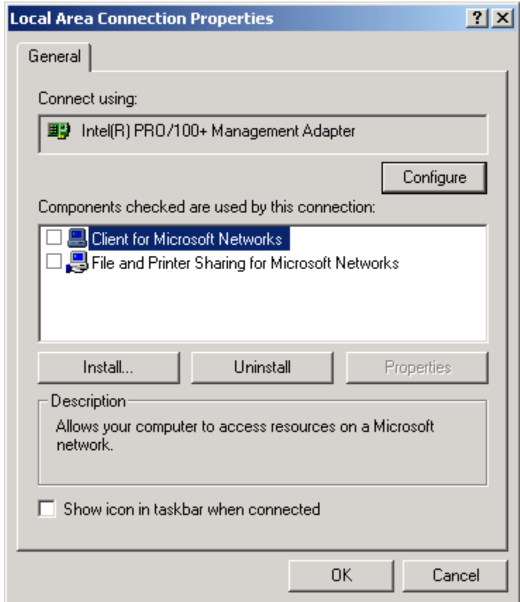
To Network without DHCP

5- If the network does not have a DHCP server, the **AuditFlow** will have the default IP address 192.168.164.100 and it will need to follow the next steps.

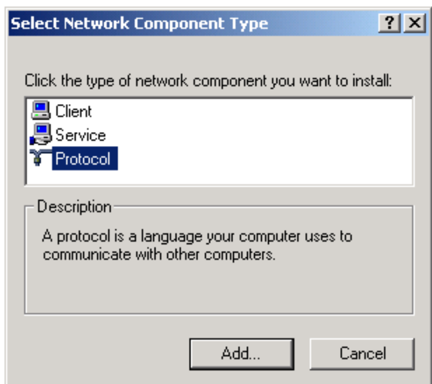
The IP address of the user's computer needs to change for a while (network management knowledge is required). The following procedures are based on Windows 2000. Choose **Start → Settings→Control Panel**. Double-click **Network and Dial-Up Connections** option or similar.

NOTE
Right-click **Local Area Connection**, choose **Properties** from the pop-up menu. Whether in the component list has TCP/IP protocol, the user should skip to step 10 or proceed the installation using the **Install** button.

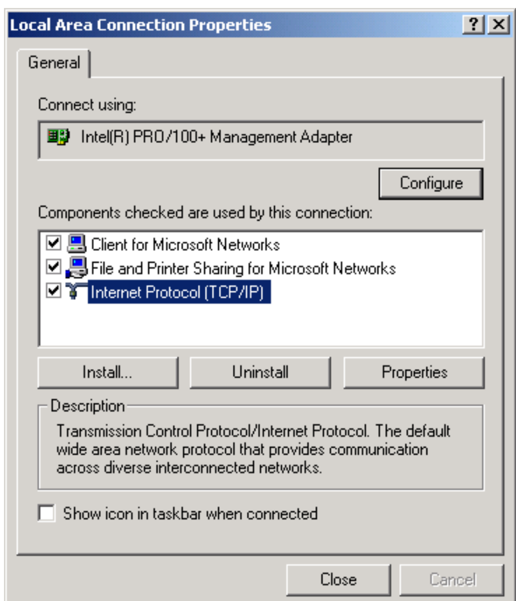
6- Click the install button;



7- Select the network type **Protocol**, and click the **Add** button:



8- Select the Internet Protocol and click the **OK** button.



9- Select **Internet Protocol (TCP/IP)**, and click the **Properties** button;

10- Take a note of the original values of IP address and Subnet Mask of the computer to restore them when the operation ends.

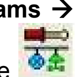
NOTE
If the IP address is already something like: 192.168.164.XXX, skip to Step 14.

11- Change IP address and the Subnet Mask of the computer. It must select the same Subnet of **AuditFlow** (164). The Network Administrator must supply the IP address.

NOTE
The values will be something like: IP Address 192.168.164.XXX and network mask (Subnet Mask) 255.255.255.0. Keep the default gateway value.

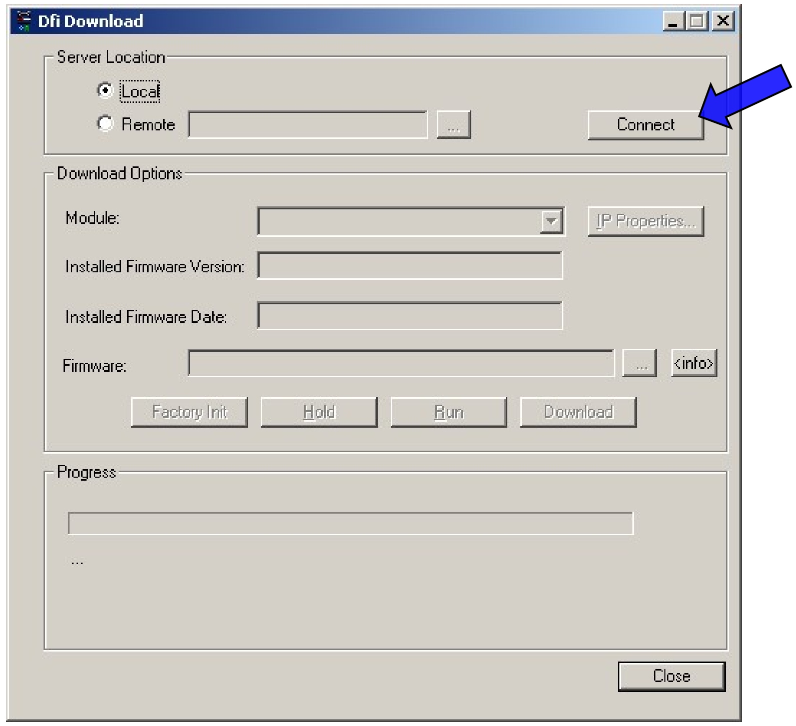
ATTENTION
Do not use the IP Address 192.168.164.100. This is already HFC302 default address

12- Click the **Apply** button.

13- Run the **FBTools Wizard**, through the **Studio302** toolbar. Click **Start menu → Programs → System302 → Studio302.** Do a login in the system. In the **Studio302** interface click the  icon in the main toolbar.

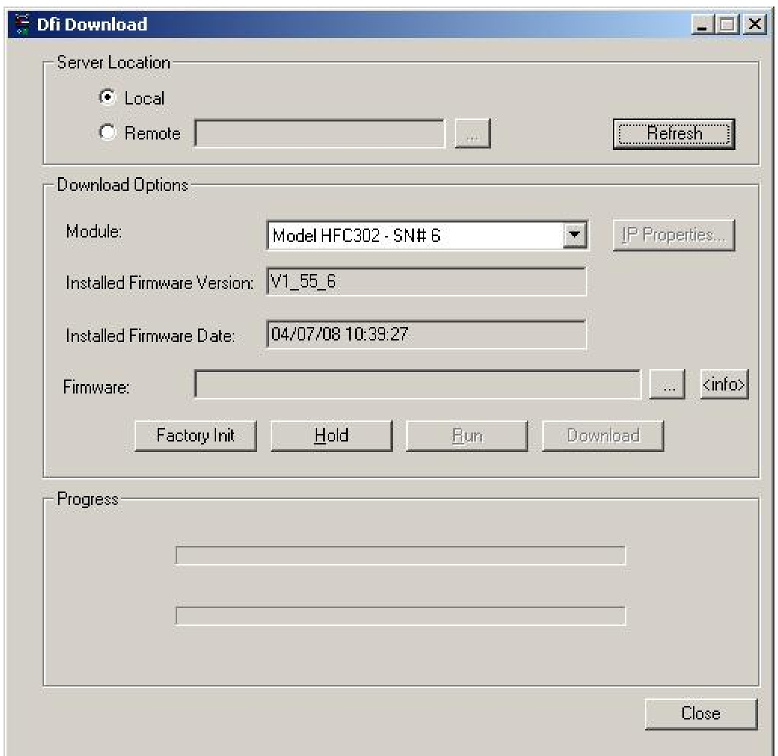
14- The following window will open. In the **Controllers** tab click the symbol ⊞ and the **DFI302** and **HI302** options will appear. Click again the symbol ⊞ in **DFI302** and select the **HFC302** controller.

15- Right-clicking the **HFC302** controller the **Dfi Download Classic** and **Batch Download** options will appear. Select **Dfi Download Classic** and the following figure will appear. Select the DFI OLEServer path to be used (Local is the default path), and click **Connect**.



16- Select the **HFC302** in the **Module** box. Use the serial number as a reference that is in the external identification label

ATTENTION
The non-observance of this step may imply in serious consequence.

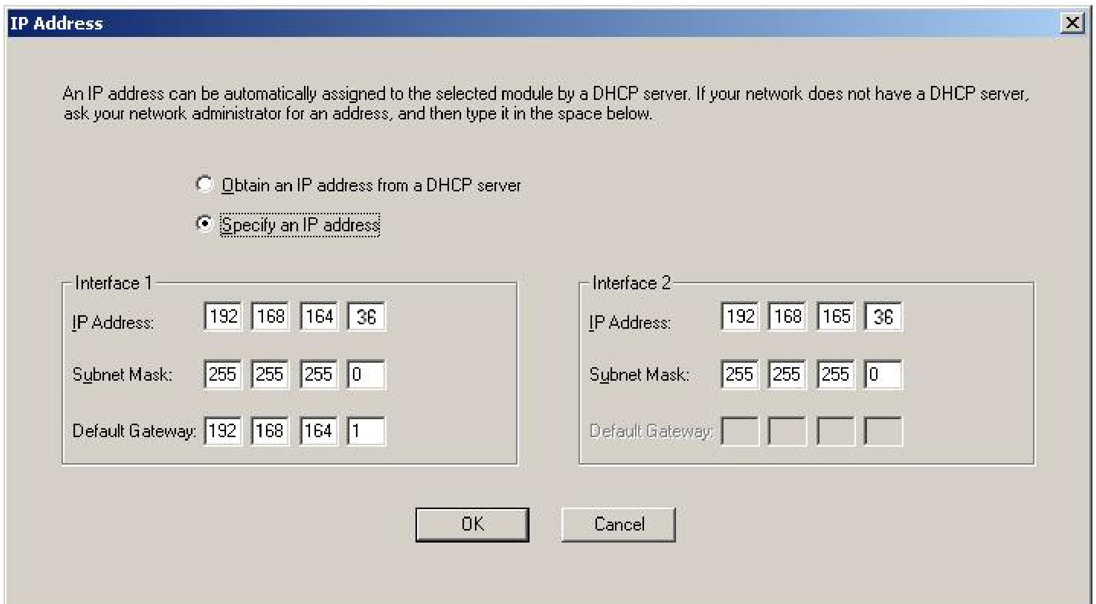


17- Click the **Hold** button to interrupt the firmware execution. When the user clicks the **Hold** button, the module will stop the firmware execution as well as all the activities in the Fieldbus line. Confirm the operation by clicking **Yes**

ATTENTION
This step will be necessary only if the **Hold** button is enabled; pointing out that the firmware is being fulfilled.

18- Check if HOLD LED is ON. Click the **IP Properties** button to configure the IP address of the module. The IP Address dialog box will open.

19- The default option is to obtain the IP address from DHCP Server. Select the option **Specify an IP address** to change to another IP address.



20- Type the IP address, the subnet mask and the default gateway. The subnet mask should be the same of the user's computer original default address (Step 11). So, the computer settings can be restored later, and the network will show **HFC302** modules

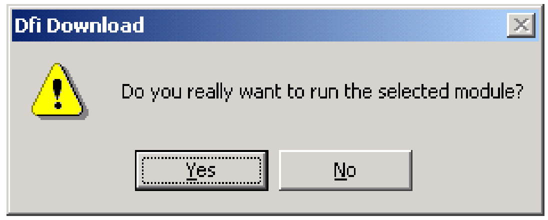
ATTENTION
Do not use the IP Address 192.168.164.100 (it is already being used by **HFC302**).

HINT
Write down the IP addresses that will be specified and the serial number of each HFC302 module. It will help in the identification and diagnostics of possible failures.

21- Click the **OK** button to end up this operation. Go back to the **Internet Protocols (TCP/IP)** properties of the computer and restore the original values of the IP address and the subnet mask.

22- Click the **Run** button to execute the **HFC302** firmware again.

23- A dialog box will open to confirm the operation. Click the **Yes** button to continue.



24- The procedure to connect the **HFC302** to the subnet is complete. Repeat these steps above for the other modules.

NOTE
In case of there is more than one AuditFlow to be set up, fulfill the following command to clear **ARP table**, before setting up the next AuditFlow. C:\>arp -d 192.168.164.100 < enter >

25- In the DOS prompt, type "C:\>arp –d 192.168.164.100 <enter>".

Visualizing and Updating the Firmware

1. Make sure that the **HFC302** is ON and has been connected to the subnet, according to the procedures in "Connecting the AuditFlow in the Subnet".
2. To continue, it will be necessary to interrupt the firmware execution in the **HFC302** module forcing it for the **Hold** mode.

   Maintain firmly pressed the *Push-Bottom* (*Factory Init/Reset*) of the left and after, click twice in *Push-Bottom* of the right. The LED FORCE will blink twice consecutive. Liberate the *Push-Bottom* (*Factory Init/Reset*) of the left, this will force the ***Hold*** mode.

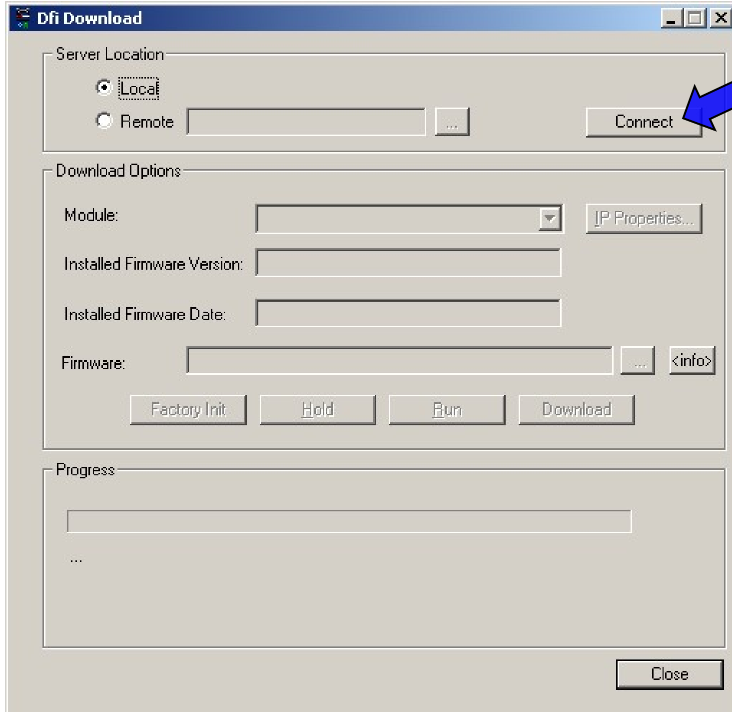
   For safety and audit trail, this is the only mode to force the **Hold** mode and then to start the firmware download process.
3. Be sure that LED *HOLD* is on.
4. Run the **FBTools Wizard**, as in step 13 of the previous topic.
5. Select the **HFC302** module and right-click it. Choose an option - **Dfi download Classic** or **Batch Download.**

The **Dfi Download Classic** option allows updating the firmware, changing the IPs of controllers and other devices.

The **Batch Download** option allows updating the firmware of up to 64 controllers simultaneously.

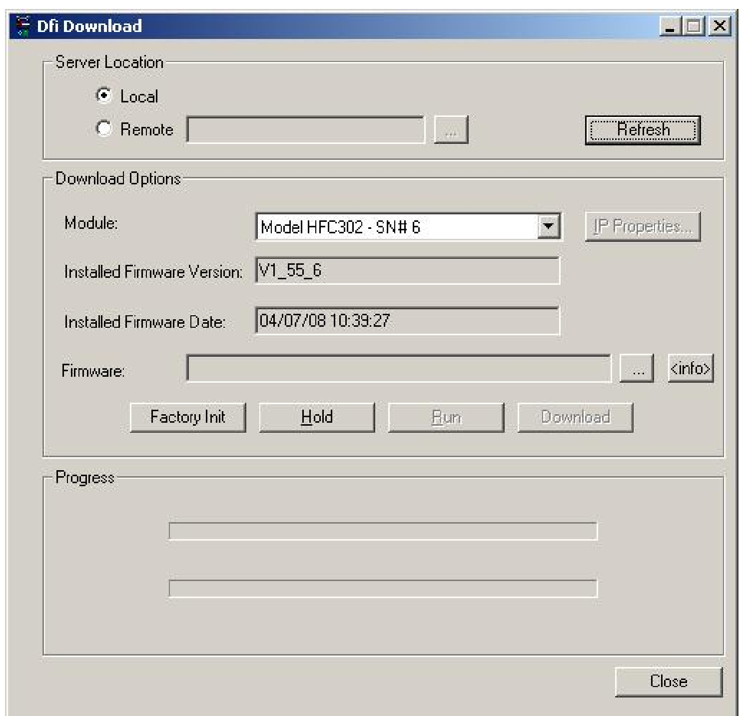
DFi Download Classic

1. By selecting the **Dfi Download Classic** the **DFi Download** window will open. Select the DFI OLEServer path to be used (Local is the default path) and click the **Connect** button.

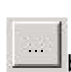


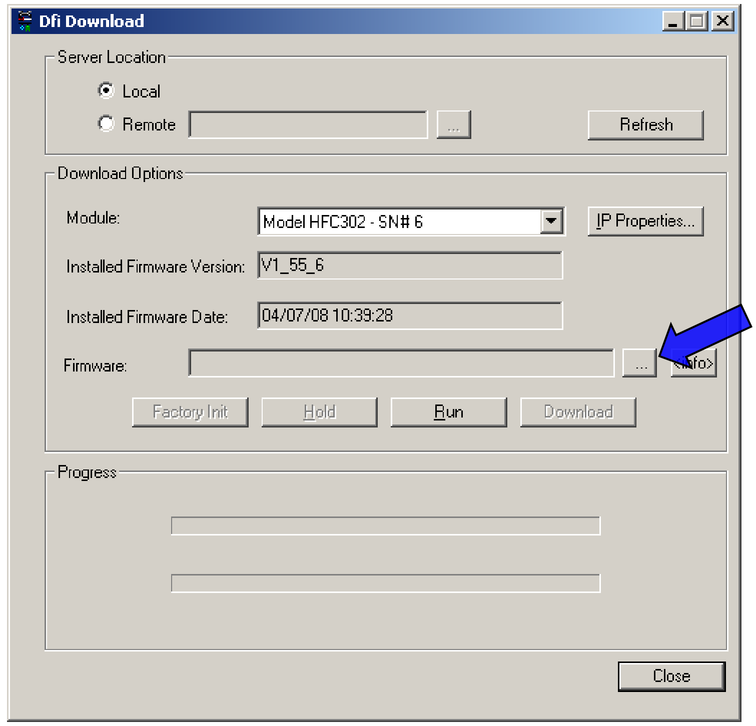
2. Select the **HFC302** module in the **Module** box. Use the serial number as a reference (see the external identification label).

ATTENTION
The non-observance of this step can imply in serious damages.

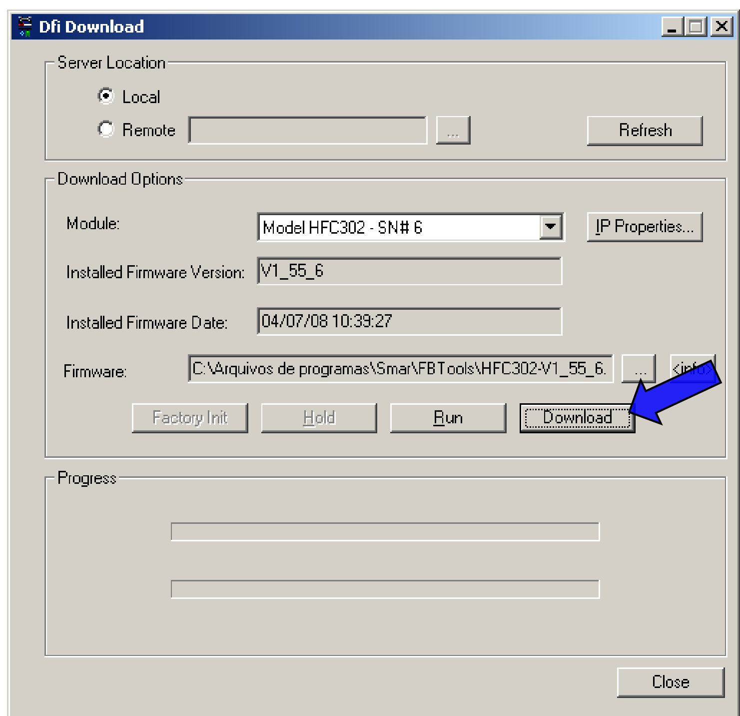


Note that the DFI Download dialog box shows the installed version and date of the current firmware loaded in the HFC302 module. This is the procedure indicated to verify the firmware version.

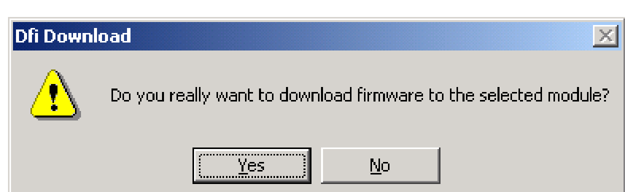
3. Click the  button to select the firmware file to be downloaded (HFC302*.ABS).



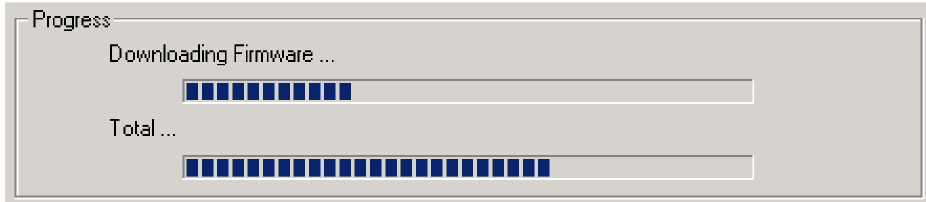
4. After selecting the firmware file, click the **Download** button to initiate the firmware download.



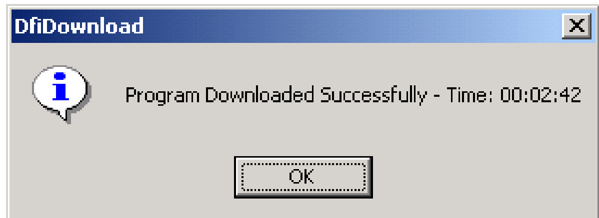
5. A message box will come up requesting a confirmation. Click **Yes** to continue.



6. The progress bar at the bottom of the dialog box will show the operation progress.



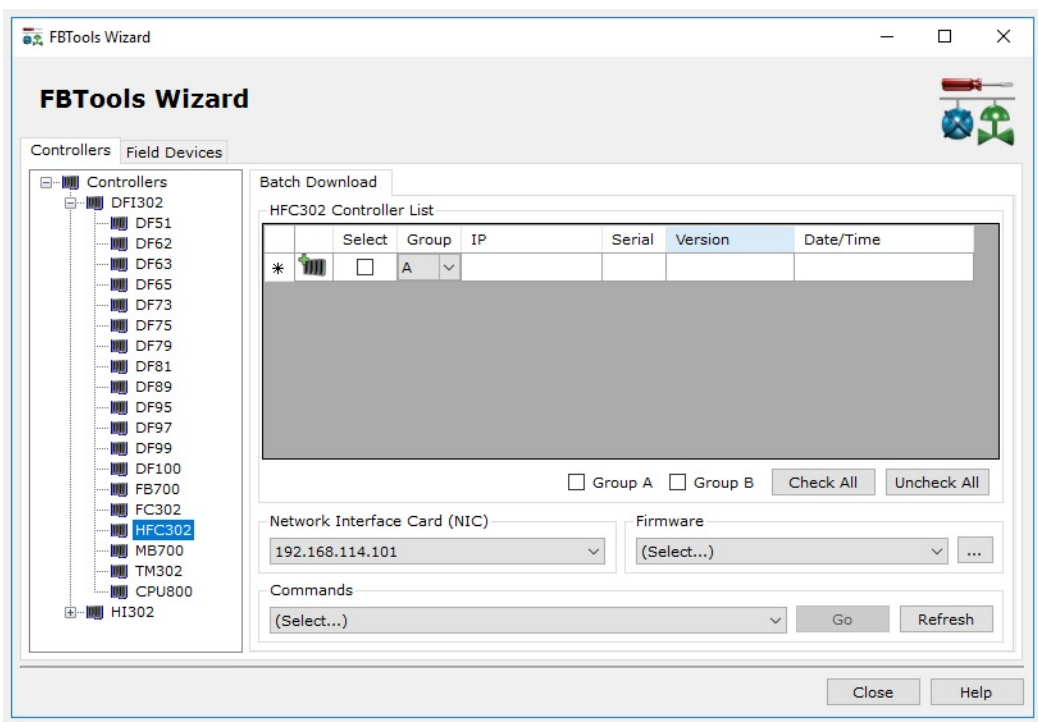
7. When the download is complete, a dialog box will appear confirming that the program was downloaded successfully. Click the **OK** button and wait a few minutes while the information is updated. The **HFC302** will be in "Run Mode". (Check if the RUN LED is ON).



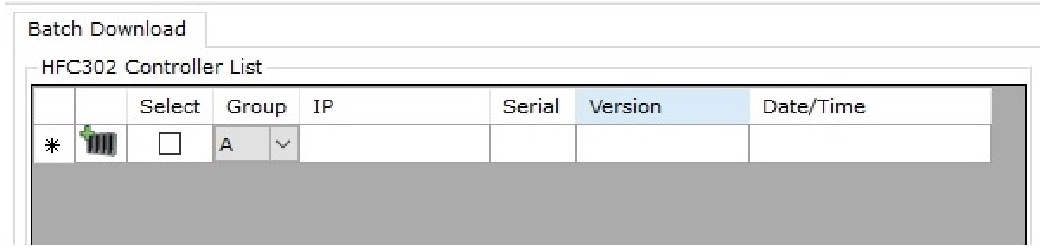
8. Click the **Close** button to exit from the **Dfi Download** dialog box.

Batch Download

By selecting the **Batch Download** option, the following window will appear:



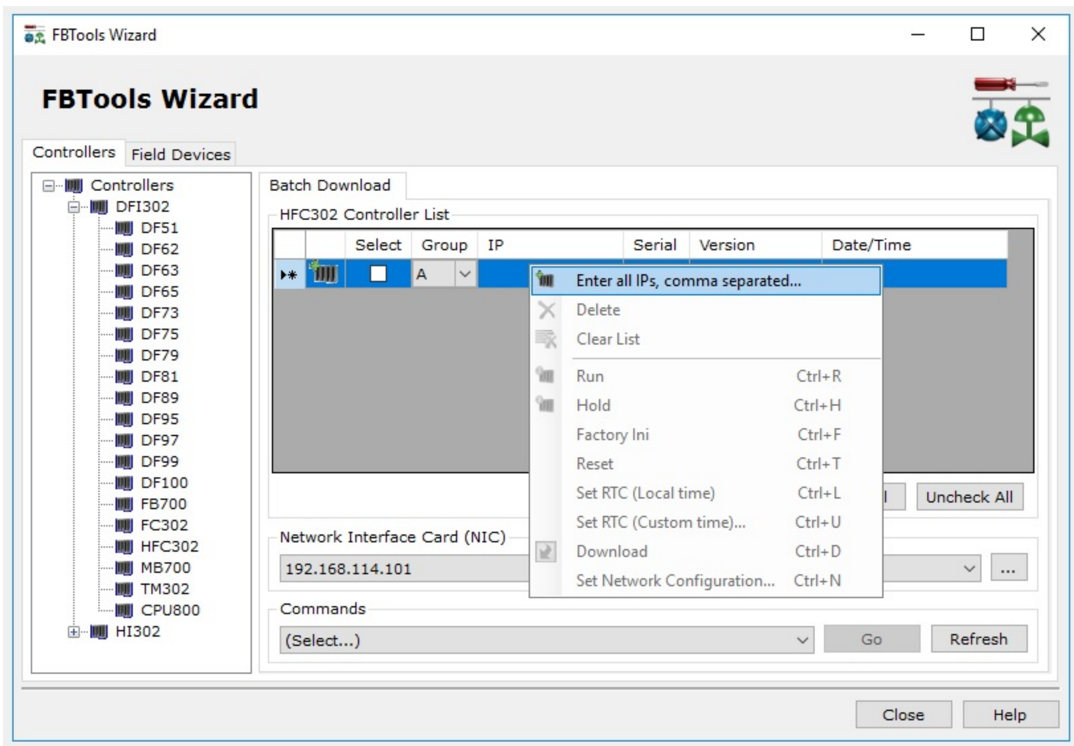
The controllers can be divided in two groups – A and B. The groups are used to classify the controllers. Typically, when redundancy is used, there is the option to change the firmware of all secondary controllers first, and then the primary ones. This procedure facilitates the hot swap maintenance of the plant without requiring stops. For this, the group A is used to classify all primary controllers, and group B the secondary controllers. See the following figure.



The symbols of the previous figure have the following meanings:

	Editing mode of a controllers list field
	Empty list item
	New controller can be inserted in this line
	Controller already registered on the list

Right-clicking the controllers list the following options will appear:

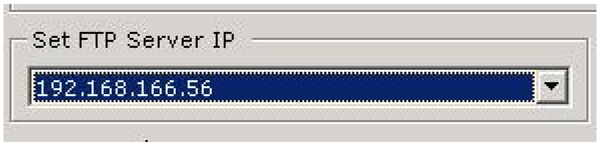


Through the **Enter all IPs, comma separated...** option the user can insert various IPs on the list simultaneously, separated by commas. After entering the IPs click **Insert** and make the association of groups A and B.

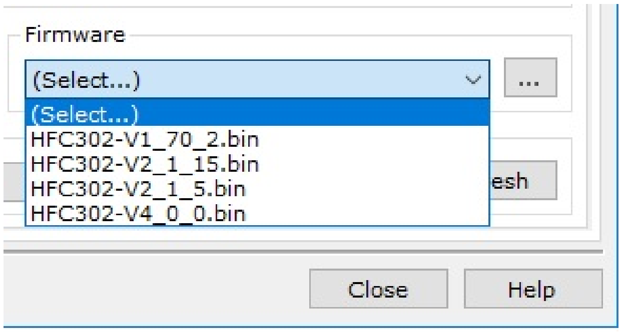
The **Delete** option deletes the selected IP and **Clear List** option clears the IPs list.

To select, or deselect, all controllers of groups A and B use the **Check All** or **Uncheck All** options, respectively. See the following figure:

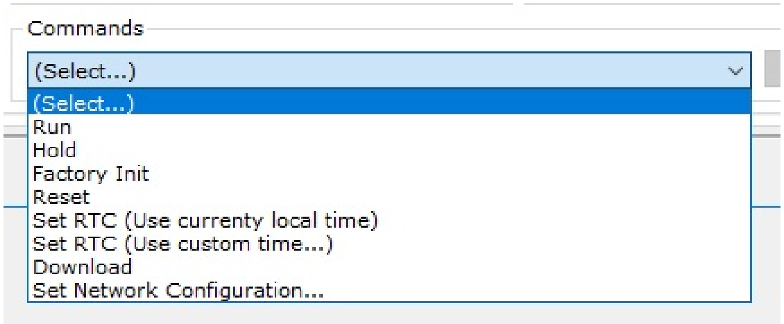
Up to 64 controllers can be updated simultaneously. The firmware file should have the **.bin** extension to be used by **Batch Download**. In the **FTP Server IP** field choose one of the options presented, because this IP chosen will be used by the controller to take the existent .**bin** file.



The available versions are in the **Firmware** field.

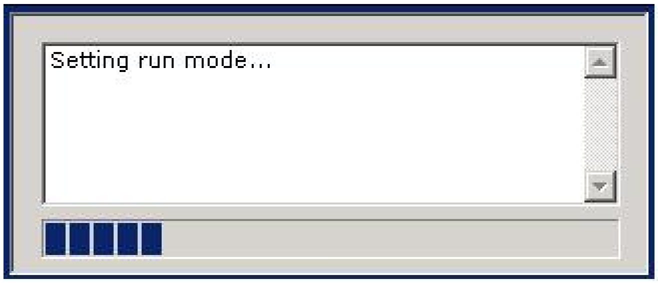


In the **Commands** field are the action options of the **Batch Download.** Select the controller, the command to be performed and click **Go**.

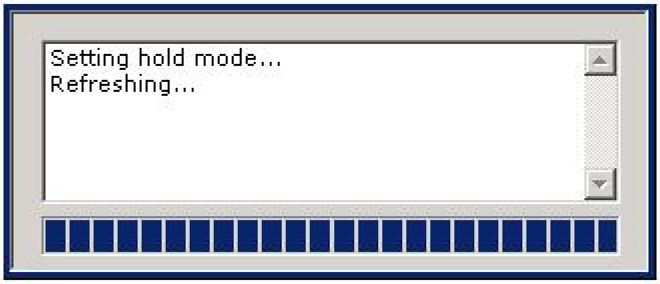


Here are the definitions of the above options:

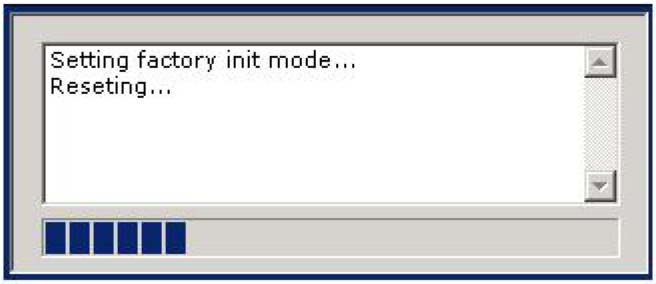
Run – Starts the firmware execution in the controller module. The following window will appear.



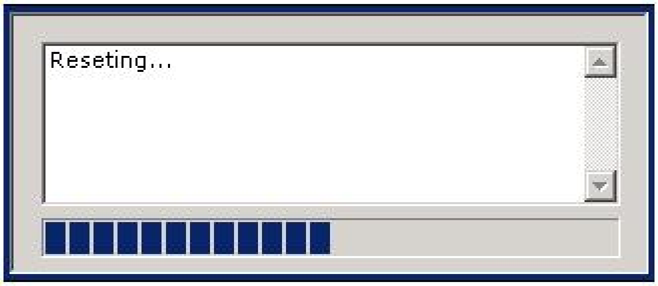
Hold - Interrupts the firmware execution in the controller. The following window will appear.



Factory Init – Erases the configurations of strategies and logics. It returns the controller to the same state it left the factory. The following window will appear:

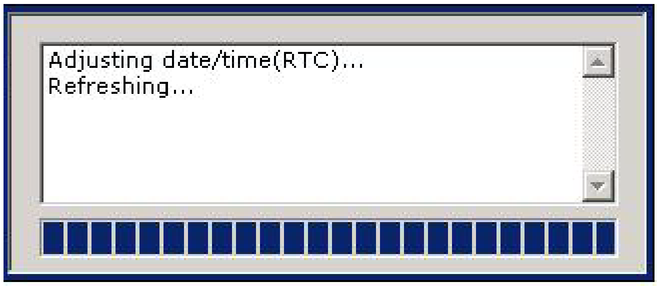


Reset – Restarts the controller, maintaining the configurations that were saved at the last download. Some dynamic parameters are erased, but not the static parameters. This is dependent on each function block. Refer to Function Blocks manual for further information. The following window will appear:

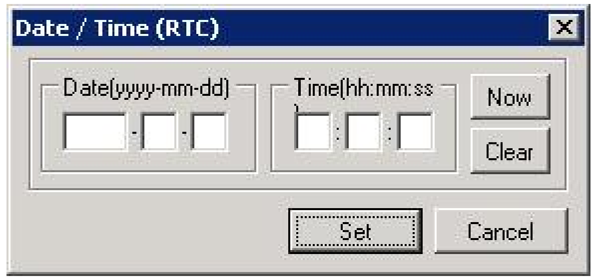


NOTE
In both cases, **Reset** and **Factory Init**, the firmware is kept. The controller's IP may be change only if is set the option to obtain it via DHCP Server. Otherwise the controller will keep the last IP assigned.

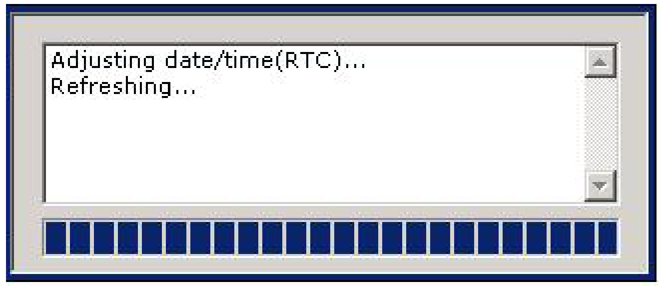
SetRTC (use currently local time) – Sends the *Localtime* to the controller. The following window will appear:



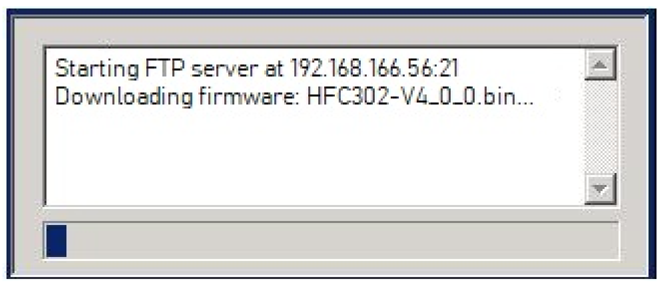
SetRTC (use custom time) – Sends the user-configured time to the controller in a properly window. See the following figure. Write the date and hour desired and click **Set**. If you want to insert the current date and hour, click **Now**. The **Clear** option clears the fields filled.



After filling the fields and click **Set** the following window will appear:

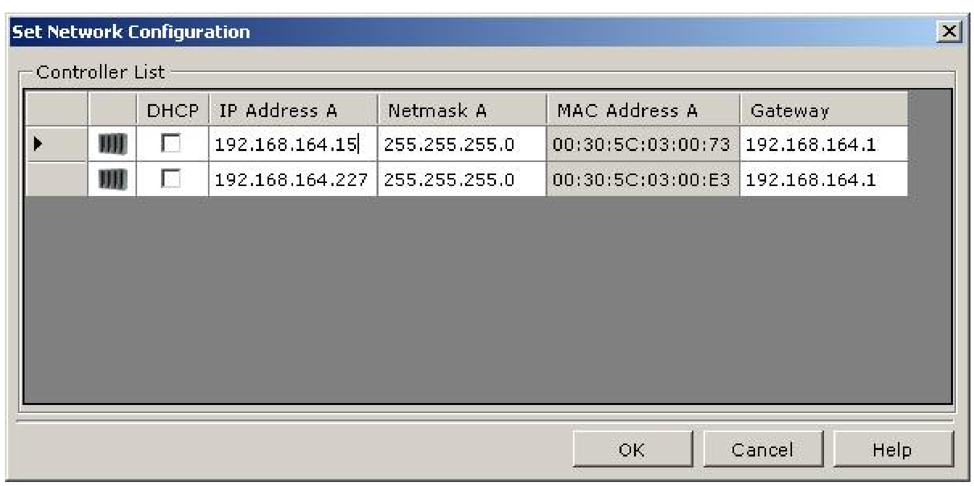


Download – Performs the firmware download. The following window will appear:

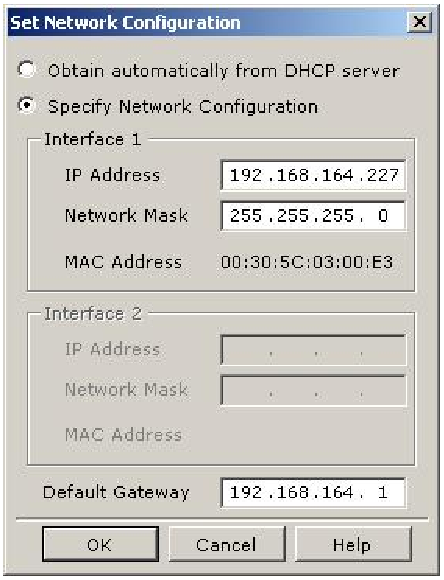


A progress bar will signal that the download is in progress. After this, confirm in the table that the information from the controller is corresponding to actions performed, for example, the firmware version.

Set Network configuration – This option allows controllers IP are changed in batch. The following figure will open:



If only one controller is selected the following figure will open:



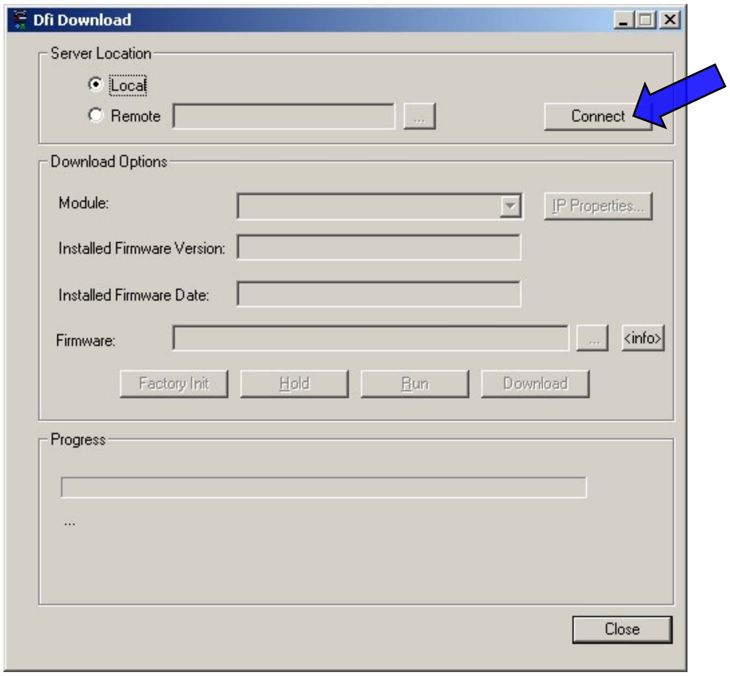
For details about changing the controller's IP see the next topic.

Changing IP Address

Changing IP HFC302

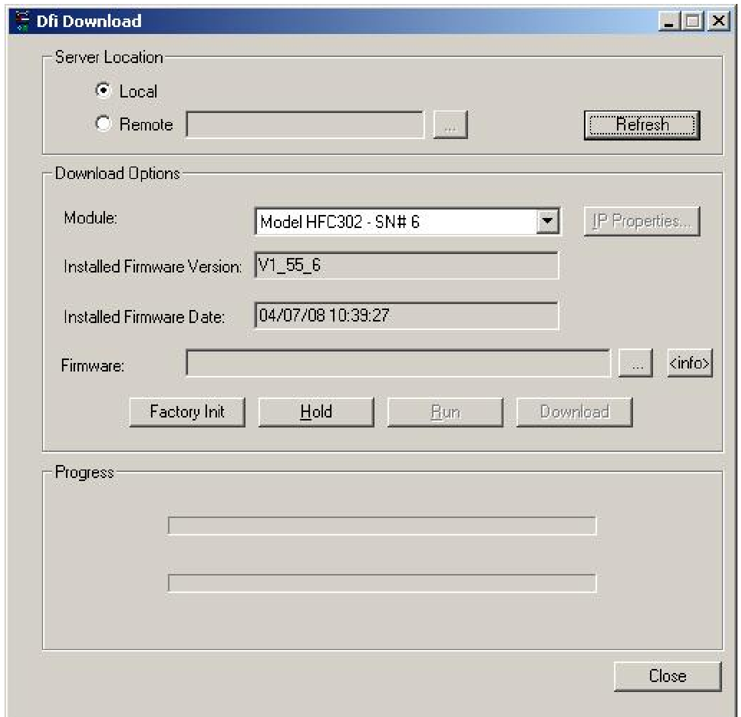
NOTE
To change the **HFC302** subnet, see the procedures in "Connecting the AuditFlow in the Subnet" (described in this section). Follow these steps to only change the IP address

1. Make sure that the **HFC302** is ON and has been connected to the subnet, according to the procedures in "Connecting the AuditFlow in the Subnet".
2. Run the **FBTools Wizard** as described in previous topics.
3. Select the **HFC302** module and click **Dfi Download Classic**.
4. The **DFi Download** dialog box will be open. Select the DFI OLEServer path to be used (Local is the default path) and click the **Connect** button.



5. Select the **HFC302** module in the **Module** box. Use the serial number as a reference (see the external identification label).

ATTENTION
The non-observance of this step can imply in serious damages.

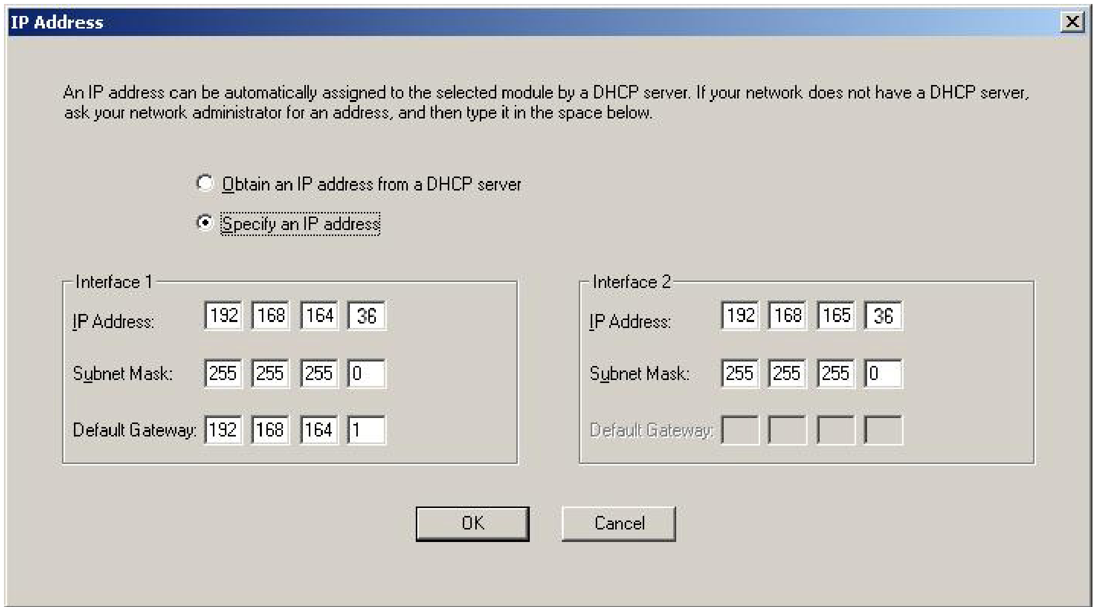


6. Click the **Hold** button to interrupt the firmware execution in the **HFC302**.

7. Afterwards all activities in the Fieldbus network will be stopped. Confirm this operation by clicking **Yes**.

ATTENTION
This step will be necessary only if the **Hold** button is enabled, indicating that the firmware is being fulfilled.

8. Check if the HOLD LED is ON.
9. Click **IP Properties** button at the **DFI Download** dialog box. The IP Address window will open.
10. The default option is Obtain the IP Address from a DHCP Server. Click the **Specify an IP address** option to change to another IP address.



11. Type the IP address, the Subnet mask and the default gateway (provided by the network administrator) to be associated to the **HFC302.**

ATTENTION
Do not use the IP Address 192.168.164.100 (it is already being used by **HFC302**). In addition, be sure that the chosen address is not in use.

HINT
Write down the IP addresses that will be specified and the serial number of each **HFC302** module. It will help in the identification and diagnostics of possible failures.

12. Click the **OK** button to conclude this operation.
13. After assigning a new IP address, the process will return to the **Dfi Download** dialog box.
14. Click the **Run** button to run the **HFC302** firmware again.
15. Click the **Close** button to exit from the **Dfi Download** dialog box.

Chapter 11

BLOCK LIBRARY

Block Types supported by HFC302

It is recommended to read the Function Blocks Manual first, included in the SYSTEM302 documentation, because it provides the information about the Foundation Fieldbus standard.

The HFC302 supports several block types, also supported by other Smar devices, and they are classified as Generic Blocks.

The Flow Measurement Blocks were developed exclusively for this device and this is the main focus of this chapter.

All the blocks supported by HFC302 and the correspondent DD revision is below:

Mnemonic	Description
FCT	Flow Computer Transducer
GKD	Gas Knowledge Database
LKD	Liquid Knowledge Database
PIP	Pulse Input & Proving
GT	Gas Transaction
GST	Gas Station Transaction
GC	Gas Composition
GMH	Gas Measurement Historic
LT	Liquid Transaction
LST	Liquid Station Transaction
LMF	Liquid Meter Factor
LCFE	Liquid Correction Factors
SBC	Sampler Batch Control
WT	Well Test
RS	Resource
HC	Hardware Configuration
TRDRED	Redundance Transducer
DIAG	Diagnostic Transducer
MBCF	Modbus Configuration
TEMP	DF-45 Temperature Transducer
AI	Analog Input
DI	Discrete Input
EPID	Enhanced PID Control
SARTH	Arithmetic
SAALM	Analog Alarm
STIME	Timer and Logic
CT	Constant
MBCS	Control Modbus Slave
MBSS	Modbus Supervision Slave
MBCM	Modbus Control Master
MBSM	Modbus Supervision Master
AO	Analog Output
MDO	Multiple Discrete Outputs
TBH	RIO HART Transducer

Generic Blocks

RESOURCE	DESCRIPTION
RS	**RESOURCE** – This block contains data specific to the hardware associated to the resource.

TRANSDUCER BLOCKS	DESCRIPTION
HC	**HARDWARE CONFIGURATION TRANSDUCER –** Configures the module type for each slot in the HFC302.
DIAG	**DIAGNOSTICS TRANSDUCER** – Provides online measurement for the block execution time, check the links between blocks and other features.
TBH	**RIO HART TRANSDUCER** – Represents the HART device in the system.

INPUT TRANSDUCER BLOCKS	DESCRIPTION
TEMP	**DF-45 TEMPERATURE TRANSDUCER** – This is the transducer block for the module DF45, an 8-low signal input module for RTD, TC, mV, Ohm.
PIP	**PULSE INPUT & PROVING –** Transducer block of the DF77 module that has 5 groups of pulse inputs with fidelity level A in pulse transmission and proving capability.

INPUT FUNCTION BLOCKS	DESCRIPTION
AI	**ANALOG INPUT** – This block reads the analog input data from the analog input signal and sends the data to other function blocks. It has scaling conversion, filtering, square root, low cut and alarm processing.
DI	**DISCRETE INPUT** – This block reads the discrete input data from the discrete input signal and sends the data to other function blocks. It has filtering and alarm processing and can invert the data.

CONTROL AND CALCULATION FUNCTION BLOCKS	DESCRIPTION
SAALM	**ANALOG ALARM** – This alarm block has dynamic or static alarm limits, hysteresis, temporary expansion of alarm limits on step setpoint changes to avoid nundesired alarms, two levels of alarm limits and delay for alarm detection.
CT	**CONSTANT –** Provides analog and discrete output parameters with constant values.
SARTH	**ARITHMETIC** – This calculation block provides pre-defined equations to be used in applications such as flow compensation, HTG, ratio control and others.
STIME	**TIMER AND LOGIC** – This block has four discrete inputs, that are processed by a combination logic. The selected timer processing type operates on the combined input signal to obtain measurement, delay, extension, pulse or debounce.

MODBUS FUNCTION BLOCKS	DESCRIPTION
MBCF	**MODBUS CONFIGURATION –** This transducer block configures general features related to the Modbus gateway.
MBCS	**MODBUS CONTROL SLAVE –** When the device is operating as a gateway between FOUNDATION Fieldbus and Modbus (slave device), this block can be used to exchange control data between both protocols.
MBSS	**MODBUS SUPERVISION SLAVE –** When the device is operating as a gateway between FOUNDATION Fieldbus and Modbus (slave device), this block can be used to convert Foundation Fieldbus parameters to Modbus variables. These variables will be available to the supervisory system with a Modbus driver.
MBCM	**MODBUS CONTROL MASTER –** When the device is operating as a gateway between FOUNDATION Fieldbus and Modbus (master device), this block can be used to exchange control data between both protocols.
MBSM	**MODBUS SUPERVISION MASTER –** When the device is operating as a gateway between FOUNDATION Fieldbus and Modbus (master device), this block can be used to convert Modbus variables to Foundation Fieldbus parameters. These parameters will be available to the supervisory system with a Foundation Fieldbus driver (OPC).

OUTPUT FUNCTION BLOCKS	DESCRIPTION
AO	**ANALOG OUTPUT** – The AO block receives an analog value and generates an analog output signal. It provides value and rate limiting, scaling conversion, fault state mechanism and other features.
MDO	**MULTIPLE DISCRETE OUTPUT** – This block can send 8 discrete variables to other modules.

Flow Measurement Blocks

Transducer Blocks

TRANSDUCER BLOCK	DESCRIPTION
FCT	**FLOW COMPUTER TRANSDUCER** – It provides the elements to configure common parameters of the gas and liquid measurements, as well that ones related to the device. The main parameters refer to access restriction, passwords and correspondent access level configurations, logger initialization, Engeneering Unit Selection, real time clock.
GKD	**GAS KNOWLEDGE DATABASE** – This block is specific for gas measurement and it has parameters to configure the base condition, the gas composition and the information about the flow meters.
LKD	**LIQUID KNOWLEDGE DATABASE** – This block is specific for liquid measurement and it has parameters to configure the base condition and the information about meters, provers and products.

Gas Measurement Blocks

FUNCTION BLOCKS	DESCRIPTION
GT	**GAS TRANSACTION** – This block calculates the weighed average of the input variables and the intermediate variables of the flow correction calculation. It also calculates the flow totalizations in flowing conditions, base conditions, totalizations in mass and energy. The totalizations are calculated for different periods and batch.
GST	**GAS STATION TRANSACTION –** The main purpose of this block is to sum and/or subtract the corrected flow rates, and it doesn't consider any references to auxiliary variables (temperature and static pressure) or calculate intermediate variables, correction factors or used sensors.
GC	**GAS COMPOSITION –** This block receives the gas composition, the heat value and the relative density as inputs. It checks the consistence and transfers the values to the correspondent product.
GMH	**GAS MEASUREMENT HISTORIC –** It indicates the average and totalizations of the last 60 minutes, the last 60 hours or the last 60 days.

Liquid Measurement Blocks

FUNCTION BLOCKS	DESCRIPTION
LT	**LIQUID TRANSACTION** – Gross flow calculation, corrected gross flow and liquid and the correspondent totalization and weighed average for continuous transaction or batch with report generation for periods: batch, hour, day and month. It accomplishes the whole processing regarding the evaluation of the usual conditions.
LST	**LIQUID STATION TRANSACTION –** The main purpose of this block is to sum and/or subtract the corrected flow rates, and it doesn't consider any references to auxiliary variables (temperature and pressure) or calculate intermediate variables, correction factors or used sensors.
LMF	**LIQUID METER FACTOR** – It provides the functionality to configure the proving process, as well support to the process, with all variables measured and calculated (average, correction factor, informations about meter, prover, product,…).
WT	**WELL TEST -** This block is used in the well test process, that is executed in parallel to the custody transfer measurement or the allocation measurement. The objective is to obtain the factors (flow test / production potential / RGO) for the production allocation in shared measurement system.
LCF	**LIQUID CORRECTION FACTOR –** This block calculates the correction factors for temperature, pressure, BSW and shrinkage factor. It includes all the correction factors used in custody transfer and allocation measurements.
SBC	**SAMPLER BATCH CONTROL** – This block is used in the batch program of gas and liquid, that can be: quantity (volume, mass, energy), time interval (start and end of batch) or detection of interface between liquid products of different density.

Classification of the HFC302 Specific Blocks

Block Type	Class	Application	Maximum Number of Instances
FCT, PIP	TRD	Both	1
GKD	TRD	Gas	1
LKD	TRD	Liquid	1
GT, GC, GMH	FB	Gas	Number of supported flow measurements
GST	FB	Gas	1
LT, LCFE	FB	Liquid	Number of supported flow measurements
LST LMF	FB	Liquid	1
WT	FB	Both	1
SBC	FB	Both	Number of supported flow measurements + 2

The table above shows the following information:

- The maximum number of instances of the sum LT+GT is the number of flow measurements (four);
- The mnemonic of specific Blocks for gas measurement starts with a "G";
- The mnemonic of specific Blocks for liquid measurement starts with a "L";

Generic Blocks

RS –Resource Block

Description
This block contains data specific to the hardware associated to the resource. All data is modeled as Contained, so there are no links to this block. The data is not processed as a function block would process the data, so there is no function schema.

The parameters have the minimum requirements of a Function Block Application associated with the resource. Some parameters, such as calibration data and ambient temperature, are included in the respective transducer blocks.

The mode controls major states of the resource. The O/S mode stops all function block execution. The actual mode of the function blocks will be changed to O/S, but the target mode will not be changed. The Auto mode allows normal operation of the resource. The IMan mode indicates that the resource is initializing or receiving the software download.

The parameters MANUFAC_ID, DEV_TYPE, DEV_REV, DD_REV, and DD_RESOURCE are required to identify and locate the correct DD to be used with the resource, selected by the Device Description Services.

The parameter HARD_TYPES is a read-only bitstring parameter that indicates the type of the hardware available to this resource. If a configured I/O block requires a type of hardware that is not available, the result will be a block alarm indicating the configuration error.

The parameter RS_STATE indicates the operational status of the Function Block Application for the resource containing this resource block.

RESTART Parameter
The parameter RESTART has different level for the initialization of the resource. They are:
1 - Run: passive state of the parameter.
2 - Restart resource: resets problems such as garbage collection.
3 - Restart with defaults: erases the configuration memory; it acts like a factory initialization.
4 - Restart processor: acts like the reset button on the processor associated to the resource.
This parameter does not appear in a view because it returns to 1 right after being written.

Non-volatile Parameters
Smar devices do not support cyclic saving of non-volatile parameters to a non-volatile memory, therefore the parameter NV_CYCLE_T will always be zero, which means that it doesn't support the feature.

On the other hand, Smar devices have a mechanism to save non-volatile parameters to a non-volatile memory while shutting down, and to recover the parameters when turning on.

Timeout for Remote Cascade Modes
SHED_RCAS and SHED_ROUT set the time limit when the communication with a remote device is lost. These constants are used by all function blocks that support a remote cascade mode. The effect of a timeout is described in Mode Calculation. Shedding from RCAS/ROUT should not occur when SHED_RCAS or SHED_ROUT is set to zero.

Alert Notification
The value of the parameter MAX_NOTIFY is the maximum number of alert reports that this resource can send without receiving a confirmation, corresponding to the amount of buffer space available for alert messages. The user can set a lower number to control the alert flow by adjusting the value of the parameter LIM_NOTIFY. If LIM_NOTIFY is set to zero, no alerts will be reported. The CONFIRM_TIME parameter is the time interval that the resource will wait for the confirmation that the report was sent before trying again. If the CONFIRM_TIME is zero, the device won't try again.

FEATURES / FEATURE_SEL parameters
The bit strings parameters FEATURES and FEATURE_SEL specify optional behaviors of the resource. The first parameter defines the available features, and it is read-only. The second parameter activates an available feature by configuration. If a bit is set in FEATURE_SEL and it is not set in FEATURES, the result will be a block alarm for a configuration error.
Smar devices support the following features: Reports, Fault State, Write-protect Software.

Fault State for the entire Resource
If the user sets the SET_FSTATE parameter, the FAULT_STATE parameter will indicate active and **all output function blocks** in the resource will change, immediately, to the condition selected by the "Fault State Type" of the IO_OPTS parameter. It can be cleared by setting the CLR_FSTATE parameter. The parameters set and clear do not appear in a view because they are transitory.

Write-Protect Software
The WRITE_LOCK parameter, when configured, will prevent any external change to the static or non-volatile database in the Function Block Application of the resource. Block connections and calculation results will proceed normally, but the configuration will be locked. The parameter is configured and cleared by writing to the WRITE_LOCK parameter. Clearing WRITE_LOCK will generate the discrete alert WRITE_ALM, with the WRITE_PRI priority. Setting WRITE_LOCK will clear the alert, if it exists.
Before setting WRITE_LOCK parameter to *Locked*, it is necessary to select the “Soft Write lock supported” option in FEATURE_SEL.

Features Being Implemented
The parameter CYCLE_TYPE is a bitstring that defines the types of cycles that this resource can execute. CYCLE_SEL allows the configurator to choose one of the types. If CYCLE_SEL contains more than one bit, or if the bit is not configured in CYCLE_TYPE, the result will be a block alarm for a configuration error. MIN_CYCLE_T is the minimum time specified by the manufacturer to execute a cycle. It sets a lower limit to the scheduling of the resource.

MEMORY_SIZE defines the size of the resource to configure the function blocks, in kilobytes.

The parameter FREE_SPACE shows the percentage of the configuration memory that is still available. FREE_TIME shows the approximate percentage of time available in the resource for processing new function blocks, should they be configured.

BLOCK_ERR
The BLOCK_ERR of the resource block will indicate the following causes:

- Device Fault State Set – When FAULT_STATE is active.
- Simulate Active – When the Simulate jumper is ON.
- Memory Failure – CRC check failure of the flash memory.
- Lost Static Data – block configuration was lost.
- Lost NV Data – low voltage battery (inferior to 2.5V), the data are preserved after the power up, but it is recommended the replacement immediate of the battery or HFC302 module.
- Out of Service – When the block is in O/S mode.

Supported Modes
O/S, IMAN and AUTO

Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5 (A2) (CL)	**MODE_BLK** Actual=3xx.xx0 Target/Normal= 4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	BitString(2)			E	D / RO	
7	RS_STATE 3xx.xx2	Unsigned8			E	D / RO	Status of the function block application state machine.
8	TEST_RW 4xx.xx5 – 4xx.x64	DS-85			None	D	Read/write test parameter - used only for conformity testing.
9	DD_RESOURCE 3xx.xx3 - 3xx.x18	VisibletString (32)		Spaces	Na	S / RO	String identifying the tag of the resource that contains the Device Description for this resource.
10	MANUFAC_ID 3xx.x19 - 3xx.x20	Unsigned32	Enumeration; controlled by FF	0x00000302	None	S / RO	Manufacturer's identification number - used by the interface device to locate the DD file for the resource.
11	DEV_TYPE 3xx.x21	Unsigned16	Set by mfgr		None	S / RO	Manufacturer's model number associated to the resource - used by the interface device to locate the DD file for the resource.
12	DEV_REV 3xx.x22	Unsigned8	Set by mfgr		None	S / RO	Manufacturer's revision number associated to the resource - used by the interface device to locate the DD file for the resource.
13	DD_REV 3xx.x23	Unsigned8	Set by mfgr		None	S / RO	Revision of the DD associated to the resource - used by the interface device to locate the DD file for the resource.
14	GRANT_DENY 4xx.x65 – 4xx.x66	DS-70	See Block Options	0	Na	D	Options for controlling the access of the host computer and local control panels to the operation, tune and alarm parameters of the block.
15	HARD_TYPES 3xx.x24	BitString(2)	Set by mfgr		Na	S / RO	The types of hardware available as channel numbers.
16	**RESTART** 4xx.x67	Unsigned8	1: Run, 2: Restart resource, 3: Restart com defaults, 4: Restart processor		E	D	Allows manual initialization. Several initialization levels are possible.
17	FEATURES 3xx.x25	BitString(2)	Set by mfgr		Na	S / RO	Display options supported by the resource block.
18	**FEATURE_SEL** 4xx.x68	BitString(2)		0	Na	S	Select the options from the resource block.
19	CYCLE_TYPE 3xx.x26	BitString(2)	Set by mfgr		Na	S / RO	Identifies the block execution methods available for this resource.
20	CYCLE_SEL 4xx.x69	BitString(2)		0	Na	S	Select the block execution method for this resource.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
21	MIN_CYCLE_T 3xx.x27 - 3xx.x28	Unsigned32	Set by mfgr		1/32 millisec	S / RO	Time interval of the shortest cycle that the resource can execute.
22	MEMORY_SIZE 3xx.x29	Unsigned16	Set by mfgr		kbytes	S / RO	Configuration memory available in an empty resource. Should be checked before executing the download.
23	NV_CYCLE_T 3xx.x30 - 3xx.x31	Unsigned32			1/32 millisec	S / RO	Time interval between writing copies of the NV parameters to the non-volatile memory. Zero means that no copy will be written.
24	FREE_SPACE 3xx.x32 - 3xx.x33	Float	0 to 100 %		%	D / RO	Percent of the memory available for further configuration. The value will be zero in a pre-configured resource.
25	FREE_TIME 3xx.x34 - 3xx.x35	Float	0 to 100%		%	D / RO	Percent of the block processing time available to process additional blocks.
26	SHED_RCAS 4xx.x70 - 4xx.x71	Unsigned32		640000	1/32 millisec	S	Time interval to write to the computer in the positions Rcas of the function block.
27	SHED_ROUT 4xx.x72 - 4xx.x73	Unsigned32		640000	1/32 millisec	S	Time interval to write to the computer in the positions ROut of the function block.
28	FAULT_STATE 3xx.x36	Unsigned8	1: Clear, 2: Active		E	D / RO	Condition set when the communication with the output block fails, caused by the output block or a physical contact. When the Fault State condition is set, the output function blocks will execute the FSAFE procedures.
29	SET_FSTATE 4xx.x74	Unsigned8	1: Off, 2: Set	1	E	D	Allows the fault state condition to be manually initiated when selecting "Set".
30	CLR_FSTATE 4xx.x75	Unsigned8	1: Off, 2: Clear	1	E	D	Selecting "Clear" for this parameter will clear the device fault state if the field condition is cleared.
31	MAX_NOTIFY 3xx.x37	Unsigned8	Set by mfgr		None	S / RO	Maximum number of alert messages unacknowledged.
32	LIM_NOTIFY 4xx.x76	Unsigned8	0 to MAX_ NOTIFY	MAX_ NOTIFY	None	S	Maximum number of alert messages unacknowledged.
33	CONFIRM_TIME 4xx.x77 - 4xx.x78	Unsigned32		640000	1/32 millisec	S	The minimum time interval before trying to send an alert report again.
34	WRITE_LOCK 4xx.x79	Unsigned8	1: Unlocked, 2: Locked	1	E	S	When configured, the user won't be able to write to the parameter, except to clear the WRITE_LOCK parameter. Block inputs will be updated.
35	UPDATE_EVT 3xx.x38 - 3xx.x44 4xx.x80	DS-73			Na	D	This alert is generated by any changes to the static data.
36	BLOCK_ALM 3xx.x45 - 3xx.x51 4xx.x81	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.
37	ALARM_SUM 3xx.x52 - 3xx.x54 4xx.x82	DS-74			Na	S	The current alert status, unacknowledged status, unreported status, and disabled status of the alarms associated to the function block.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
38	ACK_OPTION 4xx.x83	BitString (2)	0: Auto ACK Disabled 1: Auto ACK Enabled	0	Na	S	Select the alarms associated to the block that will be automatically acknowledged.
39	WRITE_PRI 4xx.x84	Unsigned8	0 to 15	0	None	S	Priority of the alarm generated by clearing the writelock.
40	WRITE_ALM 3xx.x55 - 3xx.x61 4xx.x85	DS-72			None	D	This alert is generated if the writelock parameter is cleared.
41	ITK_VER 3xx.x62	Unsigned16			Na	S/RO	This parameter indicates the ITK version of the device (only for certified devices).

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O- Output Parameter
AA- Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

HC – Hardware Configuration Transducer

Overview
This block configures the module type for each slot in the **HFC302**.

Description
The following table shows the module types available.

Code	Description	I/O Type
	Available Slot	No I/O
HFC302	HSE Flow Computer, 4xH1	No I/O
DF50	Power Supply 90-264VAC	No I/O
DF56	Power Supply for Backplane 20-30VDC	No I/O
DF52	Power Supply for Fieldbus	No I/O
DF98	2- Channel Power Supply Impedance	No I/O
DF53	4- Channel Power Supply Impedance	No I/O
DF11	2 Groups of 8 24VDC Inputs (Isolated)	16- discrete input
DF12	2 Groups of 8 48VDC Inputs (Isolated)	16- discrete input
DF13	2 Groups of 8 60VDC Inputs (Isolated)	16- discrete input
DF14	2 Groups of 8 125VDC Inputs (Isolated)	16- discrete input
DF15	2 Groups of 8 24VDC Inputs (Sink)(Isolated)	16- discrete input
DF16	2 Groups of 4 120VAC Inputs (Isolated)	8- discrete input
DF17	2 Groups of 4 240VAC Inputs (Isolated)	8- discrete input
DF18	2 Groups of 8 120VAC Inputs (Isolated)	16- discrete input
DF19	2 Groups of 8 240VAC Inputs (Isolated)	16- discrete input
DF20	1 Group of 8 On/Off Switches	8- discrete input
DF21	1 Group of 16 Open Collector Outputs	16- discrete output
DF22	2 Group of 8 Transistor Outputs (source) (Isolated)	16- discrete output
DF23	2 Groups of 4 120/240VAC Outputs	8- discrete input
DF24	2 Groups of 8 120/240VAC Outputs	16- discrete output
DF25	2 Groups of 4 NO Relays Outputs	8- discrete output
DF26	2 Groups of 4 NC Relays Outputs	8- discrete output
DF27	1 Group of 4 NO and 4 NC Relay Outputs	8- discrete output
DF28	2 Groups of 8 NO Relays Outputs	16- discrete output
DF29	2 Groups of 4 NO Relays Outputs (W/o RC)	8- discrete output
DF30	2 Groups of 4 NC Relays Outputs (W/o RC)	8- discrete output
DF31	1 Group of 4 NO and 4 NC Relay Outputs (W/o RC)	8- discrete output
DF32	1 Group of 8 24VDC Inputs and 1 Group of 4 NO Relays	8- discrete input /4- discrete output
DF33	1 Group of 8 48VDC Inputs and 1 Group of 4 NO Relays	8- discrete input /4- discrete output
DF34	1 Group of 8 60VDC Inputs and 1 Group of 4 NO Relays	8- discrete input /4- discrete output
DF35	1 Group of 8 24VDC Inputs and 1 Group of 4 NC Relays	8- discrete input /4- discrete output
DF36	1 Group of 8 48VDC Inputs and 1 Group of 4 NC Relays	8- discrete input /4- discrete output
DF37	1 Group of 8 60VDC Inputs and 1 Group of 4 NC Relays	8- discrete input /4- discrete output
DF38	1 Group of 8 24VDC Inputs,1 Group of 2 NO and 2 NC Relays	8- discrete input /4- discrete output
DF39	1 Group of 8 48VDC Inputs, 1 Group of 2 NO and 2 NC Relays	8- discrete input /4- discrete output
DF40	1 Group of 8 60VDC Inputs, 1 Group of 2 NO and 2 NC Relays	8- discrete input /4- discrete output
DF41	2 Groups of 8 pulse inputs – low frequency	16- pulse input
DF42	2 Groups of 8 pulse inputs – high frequency	16- pulse input
DF43	1 Group of 8 analog inputs	8- analog input
DF44	1 Group of 8 analog inputs with shunt resistors	8- analog input

Code	Description	I/O Type
DF57	1 Group of 8 differential analog inputs with shunt resistors	8- analog input
DF45	1 Group of 8 temperature inputs	8-temperature
DF46	1 Group of 4 analog output	4- analog output
DF77	Pulse input with prover support	Pulse input and proving
DF116	8 HART analog inputs	8- HART inputs

The execution method of this transducer block will write to all output modules and read from all input modules. If any I/O module fails this scan, it will be indicated in BLOCK_ERR as well as in the MODULE_STATUS_x. It is easy to locate the module or the sensor that failed.

All I/O modules in the previous table can be accessed directly using Input/Output Function Blocks, without a transducer block, except DF45 and DF77 that require the TEMP and PIP blocks, respectivelly.

BLOCK_ERR
The BLOCK_ERR of the HC block will indicate the following causes:

- Lost static data – Low battery voltage indication.
- Device needs maintenance now – High temperature in the CPU.
- Input Failure – a physical input point failed.
- Output Failure – a physical output point failed.
- Out of Service – When the block is in O/S mode.

Supported Modes
O/S and AUTO.

Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5(A2) (CL)	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2-4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter
6	**BLOCK_ERR** 3xx.xx1	BitString(2)			E	D / RO	
7	REMOTE_IO 4xx.xx5	Unsigned8	0 : Master 1 : I/O Remote Slave 1 2 : I/O Remote Slave 2 3 : I/O Remote Slave 3 4 I/O Remote Slave 4 5 : I/O Remote Slave 5 6 : I/O Remote Slave 6	0	E	S / O/S	Identification of the master or slave remote I/O.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
8(A2) (CL)	IO_TYPE_R0 4xx.xx6 - 4xx.xx9	4 Unsigned8	0- Available 1- No I/O 2- 8-Discrete Input 3- 16-Discrete Input 4- 8-Discrete Output 5- 16-Discrete Output 6- 8-DiscIn 4-DiscOut 7- 8-Analog Input 8- 4-Analog Output 9- 8-Temperature 10- 16-Pulse Input 11- Pulse Input and Proving Module 12- 8- HART Input	0	E	S / O/S	Select the module type for rack 0
9(A2) (CL)	IO_TYPE_R1 4xx.x10 - 4xx.x13	4 Unsigned8		0	E	S / O/S	Select the module type for rack 1
10(A2) (CL)	IO_TYPE_R2 4xx.x14 - 4xx.x17	4 Unsigned8		0	E	S / O/S	Select the module type for rack 2
11(A2) (CL)	IO_TYPE_R3 4xx.x18 - 4xx.x21	4 Unsigned8		0	E	S / O/S	Select the module type for rack 3
12(A2) (CL)	IO_TYPE_R4 4xx.x22 - 4xx.x25	4 Unsigned8		0	E	S / O/S	Select the module type for rack 4
13(A2) (CL)	IO_TYPE_R5 4xx.x26 - 4xx.x29	4 Unsigned8		0	E	S / O/S	Select the module type for rack 5
14(A2) (CL)	IO_TYPE_R6 4xx.x30 - 4xx.x33	4 Unsigned8		0	E	S / O/S	Select the module type for rack 6
15(A2) (CL)	IO_TYPE_R7 4xx.x34 - 4xx.x37	4 Unsigned8		0	E	S / O/S	Select the module type for rack 7
16(A2) (CL)	IO_TYPE_R8 4xx.x38 - 4xx.x41	4 Unsigned8		0	E	S / O/S	Select the module type for rack 8
17(A2) (CL)	IO_TYPE_R9 4xx.x42 - 4xx.x45	4 Unsigned8		0	E	S / O/S	Select the module type for rack 9
18(A2) (CL)	IO_TYPE_R10 4xx.x46 - 4xx.x49	4 Unsigned8		0	E	S / O/S	Select the module type for rack 10
19(A2) (CL)	IO_TYPE_R11 4xx.x50 - 4xx.x53	4 Unsigned8		0	E	S / O/S	Select the module type for rack 11
20(A2) (CL)	IO_TYPE_R12 4xx.x54 - 4xx.x57	4 Unsigned8		0	E	S / O/S	Select the module type for rack 12
21(A2) (CL)	IO_TYPE_R13 4xx.x58 - 4xx.x61	4 Unsigned8		0	E	S / O/S	Select the module type for rack 13
22(A2) (CL)	IO_TYPE_R14 4xx.x62 - 4xx.x65	4 Unsigned8		0	E	S / O/S	Select the module type for rack 14

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
23	MODULE_STATUS_R0_3 3xx.xx2	BitString(2)				D / RO	Status of the modules in rack 0-3.
24	MODULE_STATUS_R4_7 3xx.xx3	BitString (2)				D / RO	Status of the modules in rack 4-7.
25	MODULE_STATUS_R8_11 3xx.xx4	BitString(2)				D / RO	Status of the modules in rack 8-11.
26	MODULE_STATUS_R12_14 3xx.xx5	BitString(2)				D / RO	Status of the modules in rack 12-14.
27	UPDATE_EVT 3xx.xx6 - 3xx.x12 4xx.x66	DS-73			Na	D	This alert is generated by any changes to the static data.
28	BLOCK_ALM 3xx.x13 - 3xx.x19 4xx.x67	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O- Output Parameter
AA- Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

DIAG – Diagnostics Transducer Blocks

Description

This transducer block provides the following features:

- Online measurement of the block execution time
- Hardware revision
- Firmware revision
- Serial number of the device
- Serial number of the main board

The parameter BEHAVIOR will define which initial values for the parameters will be used after a block is instantiated. The option *Adapted* selects a more suitable initial value set, avoiding invalid values for parameters. The initial values can also be defined by selecting the option *Spec*.

Supported Modes
O/S and AUTO.

Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2-4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	BitString(2)			E	D	
7	**EXE_TIME_TAG** 4xx.xx5 - 4xx.x20	VisibletString(32)		Spaces	Na	D	Tag of the block selected to measure the execution time.
8	MIN_EXE_TIME 3xx.xx2 - 3xx.xx3	Float		+INF	ms	D / RO	Minimum execution time of the selected block.
9	**CUR_EXE_TIME** 3xx.xx4 - 3xx.xx5	Float		0	ms	D / RO	Current execution time of the selected block.
10	MAX_EXE_TIME 3xx.xx6 - 3xx.xx7	Float		0	ms	D / RO	Maximum execution time of the selected block.
11	**HW_REV** 3xx.xx8 - 3xx.x10	VisibletString (5)				S / RO	Hardware revision.
12	FIRMWARE_REV 3xx.x11 - 3xx.x13	VisibletString (5)				S / RO	Firmware revision.
13	DEV_SN 3xx.x14 - 3xx.x15	Unsigned32				S / RO	Device serial number.
14	MAIN_BOARD_SN 3xx.x16 - 3xx.x17	Unsigned32				S / RO	Main board serial number.
15	BEHAVIOR 4xx.x21	Unsigned8	0:Adapted 1:Spec	0	E	S	Select the initial values for parameters. There are two options: Adapted and Spec.
16	PUB_SUB_STATUS 3xx.x18	Unsigned8	0-good 1-bad		E	D / RO	Indicates if all external links are good or if at least one is bad.
17	LINK_SELECTION 4xx.x22	Unsigned8	0-first 1-next 2-previous	0	E	D	Select an external link.
18	LINK_NUMBER 3xx.x19	Unsigned16				D / RO	Number of the external link selected.
19	LINK_STATUS 3xx.x20	Unsigned8				D / RO	Status of the external link selected (see the table below).
20	LINK_RECOVER 4xx.x23	Unsigned8	0-no action 1-action	No action	E	D	Executes a recovery process to the external link selected.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
21	BLOCK_ALM 3xx.x21 - 3xx.x27 4xx.x24	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.
22	SAVING_CONFIG 4xx.x25	Unsigned8	0 – not saving 1 - saving	0	E	D	Indicates if the device is saving the configuration in a non-volatile memory.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA - Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

Description of the values of the LINK_STATUS parameter

Link Status	General Status	Publisher/ Subscriber	Connection Status	Sending/Receiving	Block Update
0X00	Good	Publisher			
0X40	Good	Subscriber			
0X84	Bad	Publisher	Established	Sending/Receiving	Not updating
0X88	Bad	Publisher	Established	Not sending/receiving	Updating
0X8C	Bad	Publisher	Established	Not sending/receiving	Not updating
0X98	Bad	Publisher	Not Established	Not sending/receiving	Updating
0X9C	Bad	Publisher	Not Established	Not sending/receiving	Not updating
0XA8	Bad	Publisher	Pending	Not sending/receiving	Updating
0XAC	Bad	Publisher	Pending	Not sending/receiving	Not updating
0XBC	Bad	Publisher	Not configured	Not sending/receiving	Not updating
0XC4	Bad	Subscriber	Established	Sending/Receiving	Not updating
0XCC	Bad	Subscriber	Established	Not sending/receiving	Not updating
0XDC	Bad	Subscriber	Not Established	Not sending/receiving	Not updating
0XEC	Bad	Subscriber	Pending	Not sending/receiving	Not updating
0XFC	Bad	Subscriber	Not configured	Not sending/receiving	Not updating

TBH – RIO HART Transducer Block

The **TBH** block (RIO HART Transducer Block) represents the HART device in the system. Through it the user can access any variable of the device. This block contains parameters for the process to be used in the control strategy and ladder logic, identification parameters, Burst and diagnosis, as well as Bypass parameters (**HART_CMD**, **HART_RESP** and **HART_COM_STAT**) that are used by the configuration and asset management tools for transmission and reception of HART messages.

For further information, refer to chaper 7 – Adding I/O Modules and the Digital and Analog Input/Output Modules of DFI302 manual, DF116 and DF117 modules.

TEMP – DF45 Temperature Transducer

Overview

This is the transducer block for the module DF45, an 8-low signal input module for RTD, TC, mV, Ohm.

Description

This transducer block contains the parameters to configure the eight low signal inputs, as well as the individual status and the value in engineering units for each input. Therefore, the user can configure only the TEMP block, if the purpose is to monitor variables.

If the application is a control loop or a calculation, it is also necessary to configure an AI or MAI block to address these variables. One important difference for the TEMP block, when using an AI block to access an input: writing to the VALUE_RANGE_x parameter is disabled. The user must configure the scale in the XD_SCALE parameter of the AI block, and it will be copied to the corresponding VALUE_RANGE_x parameter.

BLOCK_ERR

The BLOCK_ERR will indicate the following causes:

- Block Configuration Error - When it is not compatible to the CHANNEL parameter and the HC configuration (HFC302);
- Input Failure – At least one input failed (HFC302);
- Out of Service – When the block is in O/S mode.

Supported Modes

O/S and AUTO.

Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	Oct String(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5(A2) (CL)	MODE_BLK Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter
6	BLOCK_ERR 3xx.xx1	Bit String(2)			E	D / RO	
7(A2) (CL)	CHANNEL 4xx.xx5	Unsigned16			None	S / O/S	The rack and slot number of the associated DF-45 module, coded as RRSXX.
8	TEMP_0 3xx.xx2 - 3xx.xx4	DS-65				D / RO	Temperature of point 0.
9	TEMP_1 3xx.xx5 - 3xx.xx7	DS-65				D / RO	Temperature of point 1.
10	TEMP_2 3xx.xx8 - 3xx.x10	DS-65				D / RO	Temperature of point 2.
11	TEMP_3 3xx.x11 - 3xx.x13	DS-65				D / RO	Temperature of point 3.
12	TEMP_4 3xx.x14 - 3xx.x16	DS-65				D / RO	Temperature of point 4.
13	TEMP_5 3xx.x17 - 3xx.x19	DS-65				D / RO	Temperature of point 5.
14	TEMP_6 3xx.x20 - 3xx.x22	DS-65				D / RO	Temperature of point 6.
15	TEMP_7 3xx.x23 - 3xx.x25	DS-65				D / RO	Temperature of point 7.
16(A2) (CL)	VALUE_RANGE_0 4xx.xx6 - 4xx.x11	DS-68		0-100%	VR0	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
17(A2) (CL)	SENSOR_CONNECTION_0 4xx.x12	Unsigned8	1 : differential 2 : 2-wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 0.
18(A2) (CL)	**SENSOR_TYPE_0** 4xx.x13	Unsigned 8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 0.
19(A2) (CL)	VALUE_RANGE_1 4xx.x14 - 4xx.x19	DS-68		0-100%	VR1	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.
20(A2) (CL)	SENSOR_CONNECTION_1 4xx.x20	Unsigned 8	1 : differential 2 : 2- wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 1.
21(A2) (CL)	**SENSOR_TYPE_1** 4xx.x21	Unsigned 8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 1.
22(A2) (CL)	VALUE_RANGE_2 4xx.x22 - 4xx.x27	DS-68		0-100%	VR2	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.
23(A2) (CL)	SENSOR_CONNECTION_2 4xx.x28	Unsigned 8	1 : differential 2 : 2- wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 2.
24(A2) (CL)	**SENSOR_TYPE_2** 4xx.x29	Unsigned 8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 2.
25(A2) (CL)	VALUE_RANGE_3 4xx.x30 - 4xx.x35	DS-68		0-100%	VR3	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.
26(A2) (CL)	SENSOR_CONNECTION_3 4xx.x36	Unsigned 8	1 : differential 2 : 2- wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 3.
27(A2) (CL)	**SENSOR_TYPE_3** 4xx.x37	Unsigned 8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 3.
28(A2) (CL)	VALUE_RANGE_4 4xx.x38 - 4xx.x43	DS-68		0-100%	VR4	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.
29(A2) (CL)	SENSOR_CONNECTION_4 4xx.x44	Unsigned 8	1 : differential 2 : 2- wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 4.
30(A2) (CL)	**SENSOR_TYPE_4** 4xx.x45	Unsigned 8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 4.
31(A2) (CL)	VALUE_RANGE_5 4xx.x46 - 4xx.x51	DS-68		0-100%	VR5	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.
32(A2) (CL)	SENSOR_CONNECTION_5 4xx.x52	Unsigned 8	1 : differential 2 : 2- wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 5.
33(A2) (CL)	**SENSOR_TYPE_5** 4xx.x53	Unsigned8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 5.
34(A2) (CL)	VALUE_RANGE_6 4xx.x54 - 4xx.x59	DS-68		0-100%	VR6	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.
35(A2) (CL)	SENSOR_CONNECTION_6 4xx.x60	Unsigned 8	1 : differential 2 : 2- wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 6.
36(A2) (CL)	**SENSOR_TYPE_6** 4xx.x61	Unsigned 8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 6.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
37(A2) (CL)	VALUE_RANGE_7 4xx.x62 - 4xx.x67	DS-68		0-100%	VR7	S / O/S	If it is connected to the AI block, it is a copy of XD_SCALE. Otherwise, the user can write to the scale of the parameter.
38(A2) (CL)	SENSOR_CONNECTI ON_7 4xx.x68	Unsigned 8	1 : differential 2 : 2- wires 3 : 3- wires	3	E	S / O/S	Connection of the sensor 7.
39(A2) (CL)	**SENSOR_TYPE_7** 4xx.x69	Unsigned 8	See table below	Pt 100 IEC	E	S / O/S	Type of sensor 7.
40	UPDATE_EVT 3xx.x26 - 3xx.x32 4xx.x70	DS-73			Na	D	This alert is generated by any changes to the static data.
41	BLOCK_ALM 3xx.x33 - 3xx.x39 4xx.x71	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O- Output Parameter
AA- Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

Code	Sensor Type	Class	Sensor Range – Differential (Celsius)	Sensor Range – 2-wires (Celsius)	Sensor Range – 3-wires (Celsius)
1	Cu 10 GE	RTD	-270 to 270	-20 to 250	-20 to 250
2	Ni 120 DIN		-320 to 320	-50 to 270	-50 to 270
3	Pt 50 IEC		-1050 to 1050	-200 to 850	-200 to 850
4	Pt 100 IEC		-1050 to 1050	-200 to 850	-200 to 850
5	Pt 500 IEC		-270 to 270	-200 to 450	-200 to 450
6	Pt 50 JIS		-850 to 850	-200 to 600	-200 to 600
7	Pt 100 JIS		-800 to 800	-200 to 600	-200 to 600
51	0 to 100	Ohm		0 to 100	0 to 100
52	0 to 400			0 to 400	0 to 400
53	0 to 2000			0 to 2000	0 to 2000
151	B NBS	TC	-1600 to 1600	100 to 1800	
152	E NBS		-1100 to 1100	-100 to 1000	
153	J NBS		900 to 900	-150 to 750	
154	K NBS		-1550 to 1550	-200 to 1350	
155	N NBS		-1400 to 1400	-100 to 1300	
156	R NBS		-1750 to 1750	0 to 1750	
157	S NBS		-1750 to 1750	0 to 1750	
158	T NBS		-600 to 600	-200 to 400	
159	L DIN		-1100 to 1100	-200 to 900	
160	U DIN		-800 to 800	-200 to 600	
201	-6 to 22	MV		-6 to 22	
202	-10 to 100			-10 to 100	
203	-50 to 500			-50 to 500	

If the BEHAVIOR parameter is configured as "Adapted":
When the configuration of the sensor type has a different class, the connection is automatically changed to default (RTD and Ohm – 3-wires, TC and mV – 2-wires).

TRDRED – Redundancy Transducer

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	Oct String(32)		Spaces	Na	S	
3(A2) (CL)	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5(A2) (CL)	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 -4xx.xx4	DS-69		O/S	Na	S	See Mode Parameter
6	**BLOCK_ERR** 3xx.xx1	Bit String(2)			E	D / RO	
7	UPDATE_EVT 3xx.xx2 - 3xx.xx8 4xx.xx5	DS-73			Na	D	This alert is generated by any change to the static data.
8	BLOCK_ALM 3xx.xx9 - 3xx.x15 4xx.xx6	DS-72			Na	D	The block alarm is used for all configuration, hardware, and connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
9	TRANSDUCER_DIRECTORY 3xx.x16	Unsigned16	0 to 2^{16}			RO	A directory that specifies the number and the starting indices of the transducers in the transducer block.
10	TRANSDUCER_TYPE 3xx.x17	Unsigned16	0 to 2^{16}			RO	Identities the transducer that follows.
11	XD_ERROR 3xx.x18	Unsigned8	1 to 255			RO	Define one of the error code.
12	COLLECTION_DIRECTORY 3xx.x19 - 3xx.x20	Unsigned32	0 to 2^{32}			RO	A directory that specifies the number, the starting indices, and DD Item IDs of data collections in each transducers in the transducer block.
13	SOFTWARE_NAME 3xx.x21 - 3xx.x36	VisibileString(32)				S / RO	Name of the last software downloaded to the bridge.
14	RED_PRIMARY_SN 3xx.x37	Unsigned16	0 to 2^{16}	0	NA	D / RO	Indicates the Serial Number of the Primary controller.
15	RED_SECONDARY_SN 3xx.x38	Unsigned16	0 to 2^{16}	0	NA	D / RO	Indicates the Serial Number of the Secondary controller.
16	RED_PRIMARY_IP 3xx.x39 - 3xx.x46	VisibleString(16)		Blank	NA	D / RO	Indicates the IP of the Redundant Primary module.
17	RED_SECONDARY_IP 3xx.x47 - 3xx.x54	VisibleString(16)		Blank	NA	D / RO	Indicates the IP of the Redundant Secondary module.

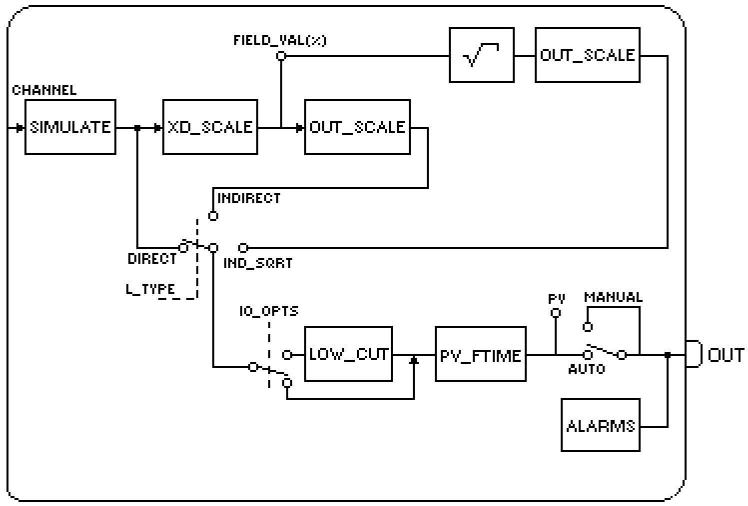
Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
18	**RED_SYNC_STATUS** 3xx.x55	Unsigned8	0 : Not defined 1 : Stand Alone 2 : Synchronizing 3 : Updating 4 : Synchronized 5 : WARNING : Role Conflict 6 : WARNING : Sync Cable Fail 7 : WARNING : Updating Secondary Fail 8 : Reserved 1 9 : Reserved 2 10 : Reserved 3 11 : Reserved 4 12 : Reserved 5	0	E	D / RO	Indicates the Synchronism status of the controller pair. 0 : Value just after start up 1 : Stand alone operation 2 : Checking configuration for synchronization. 3 : Primary transferring all the configuration to the Secondary. 4 : The modules are in perfect synchronism. The Primary continously updates the Secondary dynamic databases. 5 : The system was not able to solve autonomously the Role. (Primary / Secondary). 6 : Fail on the synchronism cable. 7 : Fail on the Updating Secondary process.
19	RED_PRIMARY_BAD_CONDITIONS 3xx.x56	Bitstring(2)	0 : Modbus 1 : H1-1 2 : H1-2 3 : H1-3 4 : H1-4 5 : Live List 6 : Ethernet cable 7 : HSE link	<None>	E	D / RO	Bad conditions for the Primary controller.
20	RED_SECONDARY_BAD_CONDITIONS 3xx.x57	Bitstring(2)	0 : Modbus 1 : H1-1 2 : H1-2 3 : H1-3 4 : H1-4 5 : Live List 6 : Ethernet cable 7 : HSE link	<None>	E	D / RO	Bad conditions for the Secondary controller.
21	RED_PRIMARY_WDG 3xx.x58	Unsigned8	0 – 255	0	NA	D / RO	Watchdog indicating OPC communication status with the Primary controller.
22	RED_SECONDARY_WDG 3xx.x59	Unsigned8	0 – 255	0	NA	D / RO	Watchdog indicating OPC communication status with the Secondary controller.
23	RED_RESERVED1 4xx.xx7	Unsigned32	0 a 2^{32}	0	NA	D	Reserved for future use.
24	RED_RESERVED2 4xx.xx9	Unsigned32	0 a 2^{32}	0	NA	D	Reserved for future use.

AI – Analog Input

Overview

The Analog Input block reads the input data from the Transducer block, selected by the channel number, and sends data to other function blocks.

Schematic



Description

The AI block is connected to the transducer block through the CHANNEL parameter, that must match the following parameter in the transducer block:

- SENSOR_TRANSDUCER_NUMBER parameter for the TT302
- TERMINAL_NUMBER parameter for the IF302

The CHANNEL parameter must be set to 1 (one) if the AI block is executing in the LD302, and no configuration is necessary in the transducer block to connect it to the AI block.

The scale of the Transducer (XD_SCALE) is applied to the value of the channel to produce the FIELD_VAL in percent. The XD_SCALE engineering units code and range should be proper to the sensor of the transducer block connected to the AI block, otherwise a block alarm indicating a configuration error will be generated.

The L_TYPE parameter determines how the values sent by the transducer block will be used by the block. The options are:

- Direct - the value from the transducer block is sent directly to the PV. OUT_SCALE will not be used.
- Indirect - the value of the PV is the value of FIELD_VAL converted to the OUT_SCALE.
- Indirect with Square Root - the value of the PV is the square root of the FIELD_VAL converted to the OUT_SCALE.

The scales of PV and OUT are always identical, based on OUT_SCALE.

The LOW_CUT parameter is an optional characteristic that can be used to eliminate noises near zero for a flow sensor. The LOW_CUT parameter has a corresponding “Low cutoff” option in the IO_OPTS bit string. If the bit is true, any output below the low cutoff value (LOW_CUT) will be changed to zero.

BLOCK_ERR

The parameter BLOCK_ERR of the AI block will indicate the following causes:

- Block Configuration Error – the configuration error is indicated when one or more of the following situations occur:
- When the parameter CHANNEL or L_TYPE has an invalid value;
- When the XD_SCALE doesn't have an engineering unit or range proper for the sensor of the transducer block.
- When the CHANNEL parameter and the HC configuration (HFC302) are not compatible;
- Simulate Active – When the Simulate is active;

- Input Failure – I/O module failed (HFC302);
- Out of Service – When the block is in O/S mode.

Supported Modes
O/S, MAN and AUTO.

Status
The AI block does not support cascade mode. The output status doesn't have a cascade sub-status.

When the OUT value exceeds the OUT_SCALE range and there isn't a bad condition configured in the block, the OUT status will be "uncertain, EU Range Violation".

The STATUS_OPTS has the following options, where Limited refers to the sensor limits: (see the Function block options for details)

- Propagate Fault Forward
- Uncertain if Limited
- BAD if Limited
- Uncertain if Man mode

Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
1	ST_REV	Unsigned6		0	None	S/RO	
2	TAG_DESC	Oct String(32)		Spaces	Na	S	
3(A2) (CL)	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5(A2) (CL)	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2-4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bit String(2)			E	D / RO	
7	**PV** 3xx.xx2 - 3xx.xx4	DS-65			PV	D / RO	Process the analog value that will be used to execute the function.
8(A2)	**OUT** 4xx.xx5-4xx.xx7	DS-65	OUT_SCALE +/- 10%		OUT	D / Man	The analog value is calculated as a result of the function execution.
9(A2)	SIMULATE 3xx.xx5 - 3xx.xx7 4xx.xx8 - 4xx.x11	DS-82	1: Disable; 2: Active; These are the Enable/Disable options.	Disable		D	Allows the input value to be manually supplied when simulate is enabled. In this case, the simulate value and status will be the PV value.
10(A2)(CL)	XD_SCALE 4xx.x12 - 4xx.x17	DS-68	Depends on the device type. See the manual for details.	Depends on the device type. See description item for details.	XD	S / Man	The high and low scale values, to transducer for a specified channel. The Default value for each Smar device is showed below: LD292/302: 0 to 5080 [mmH_2O] IF302: 4 to 20 {mA] TT302: -200 to 850 [ºC] TP302: 0 to 100 [%] DT302: 1000 to 2500 (kg/m^3] HFC302: 100,0,1342 0 to 100 [%]
11(A2) (CL)	OUT_SCALE 4xx.x18 - 4xx.x23	DS-68		0-100%	OUT	S / Man	The higher and lower scale values for the OUT parameter.
12	GRANT_DENY 4xx.x24 - 4xx.x25	DS-70		0	na	D	

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
13(A2) (CL)	IO_OPTS 4xx.x26	Bit String(2)	See Block Options	0	na	S / O/S	See Block Options.
14(A2) (CL)	STATUS_OPTS 4xx.x27	Bit String (2)	See Block Options	0	Na	S / O/S	See Block Options.
15(A2) (CL)	**CHANNEL** 4xx.x28	Unsigned16		0	None	S / O/S	The channel number of the logical hardware, for the transducer that is connected to this I/O block.
16(A2) (CL)	**L_TYPE** 4xx.x29	Unsigned 8	1: Direct 2: Indirect 3: Indirect Square Root	0	E	S / Man	Define how the values sent by the transducer block can be used: Directly (Direct); as a percentage (Indirect); or as a percentage with square root (Ind Sqr Root).
17(A2) (CL)	LOW_CUT 4xx.x30 - 4xx.x31	Float	Non-Negative	0	OUT	S	A value equals to zero percent of the scale will be used to process the block, if the transducer value is lower than this limit, in % of the scale. This feature can be used to eliminate noises near zero for a flow sensor.
18(A2) (CL)	**PV_FTIME** 4xx.x32 - 4xx.x33	Float	Non-Negative	0	Sec	S	Time constant of a single exponential filter for the PV, in seconds.
19	FIELD_VAL 3xx.xx8 - 3xx.x10	DS-65			%	D / RO	Raw value of the field device in percentage of the PV range, the status indicates the Transducer condition, before signal characterization (L_TYPE) or filtering (PV_FTIME).
20	UPDATE_EVT 3xx.x11 - 3xx.x17 4xx.x34	DS-73			Na	D	This alert is generated by any changes to the static data.
21	BLOCK_ALM 3xx.x18 - 3xx.x24 4xx.x35	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.
22	ALARM_SUM 3xx.x25 - 3xx.x27 4xx.x36	DS-74	See Block Options		Na	S	The current alert status, unacknowledged status, unreported status, and disabled status of the alarms associated to the function block.
23	ACK_OPTION 4xx.x37	Bit String(2)	0: Auto ACK Disabled 1: Auto ACK Enabled	0	Na	S	Select the alarms associated to the block that will be automatically acknowledged.
24	ALARM_HYS 4xx.x38 - 4xx.x39	Float	0 to 50 %	0.5%	%	S	Alarm hysteresis parameter. To clear the alarm, the PV should return a value within the alarm limits plus the hysteresis.
25	HI_HI_PRI 4xx.x40	Unsigned8	0 to 15			S	Priority of the high high alarm.
26	HI_HI_LIM 4xx.x41 - 4xx.x42	Float	OUT_SCALE, +INF	+INF	OUT	S	The limit for the high high alarm, in engineering units.
27	HI_PRI 4xx.x43	Unsigned8	0 to 15			S	Priority of the high alarm.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
28	HI_LIM 4xx.x44 - 4xx.x45	Float	OUT_SCALE, +INF	+INF	OUT	S	The limit for the high alarm, in engineering units.
29	LO_PRI 4xx.x46	Unsigned8	0 to 15			S	Priority of the low alarm.
30	LO_LIM 4xx.x47 - 4xx.x48	Float	OUT_SCALE, -INF	-INF	OUT	S	The limit for the low alarm, in engineering units.
31	LO_LO_PRI 4xx.x49	Unsigned8	0 to 15			S	Priority of the low low alarm.
32	LO_LO_LIM 4xx.x50 - 4xx.x51	Float	OUT_SCALE, -INF	-INF	OUT	S	The limit for the low low alarm, in engineering units.
33	HI_HI_ALM 3xx.x28 - 3xx.x35 4xx.x52	DS-71			OUT	D	The status of the high high alarm and the associated time stamp.
34	HI_ALM 3xx.x36 - 3xx.x43 4xx.x53	DS-71			OUT	D	The status of the high alarm and the associated time stamp.
35	LO_ALM 3xx.x44 - 3xx.x51 4xx.x54	DS-71			OUT	D	The status of the low alarm and the associated time stamp.
36	LO_LO_ALM 3xx.x52 - 3xx.x59 4xx.x55	DS-71			OUT	D	The status of the low low alarm and the associated time stamp.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O- Output Parameter
AA- Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL-77 bytes (include block tag and profile)

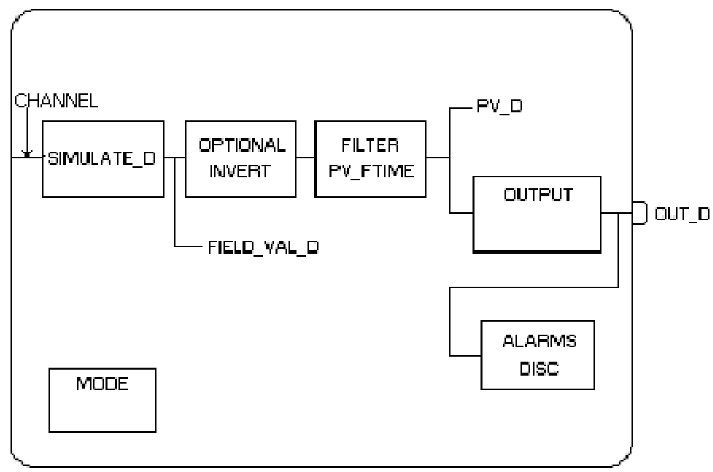
If the BEHAVIOR parameter is configured as "Adapted":
The default value of CHANNEL is the lowest number available.
The default value of L_TYPE is direct.
The required writing mode is the actual mode, regardless of the target mode: OUT.

DI – Discrete Input

Overview

The DI block reads the manufacturer's discrete input data, selected by the channel number, and sends data to other function blocks.

Schematic



Description

The FIELD_VAL_D shows the true on/off status of the hardware, using XD_STATE. The Invert I/O option can execute the Boolean function NOT between the field value and the output. A discrete value equals to zero (0) will be considered a logical zero (0) and a discrete value different from zero will be considered a logical one (1), i.e., if the bit "invert" is selected, the logical NOT of a value different from zero would result a discrete output equals to zero, and the logical NOT of zero would result a discrete output equals to one (1). PV_FTIME can be used to set the time that the hardware must be in a specific status before sending data to the PV_D. The PV_D is the value that the block will always have in OUT_D, if the mode is Auto. If the Man mode is allowed, a value can be written to OUT_D. The PV_D and the OUT_D have the same scale defined by OUT_STATE.

BLOCK_ERR

The parameter BLOCK_ERR of the DI block will indicate the following causes:

- Block Configuration Error – the configuration error is indicated when one or more of the following situations occur:
  - When the CHANNEL parameter has an invalid value;
  - When the CHANNEL parameter and the HC configuration (HFC302) are not compatible;
- Simulate Active – When the Simulate is active;
- Input Failure – I/O module failed (HFC302);
- Out of Service – When the block is in O/S mode.

Supported Modes
O/S, Man and Auto.

Status

The DI block does not support cascade mode. The output status doesn't have a cascade sub-status. The STATUS_OPTS has the following options: Propagate Fault Forward.

Parameters

Idx	Parameter	Data Type (length)	Valid Range Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	Oct String(32)		Spaces	Na	S	If this parameter is configured with the string different from spaces, this parameter will replace the block tag in the alarm and event reports.
3(A2) (CL)	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1to 255	0	None	S	
5(A2) (CL)	MODE_BLK Actual=3xx.xx0 Target/Normal=4xx .xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	BLOCK_ERR 3xx.xx1	Bit String(2)			E	D / RO	
7	PV_D 3xx.xx2 - 3xx.xx3	DS-66			PV	D / RO	The primary discrete value being used to execute the function or a process value associated to it.
8(A2)	OUT_D 4xx.xx5 – 4xx.xx6	DS-66	OUT_STATE		OUT	D / Man	The primary discrete value calculated as a result of the function execution.
9(A2)	SIMULATE_D 3xx.xx4 - 3xx.xx5 4xx.xx7 – 4xx.xx9	DS-83	1: Disable; 2: Active These are the Enable/Disable options.	Disable		D	Provides the discrete input manually when the simulation is enabled. When simulation is disabled, the value and status of the PV_D will have the Transducer value and status.
10	XD_STATE 4xx.x10	Unsigned16		0	XD	S	Index of the text that describe the status of the discrete value obtained from the transducer.
11	OUT_STATE 4xx.x11	Unsigned16		0	OUT	S	Index of the text that describe the status of a discrete output.
12	GRANT_DENY 4xx.x12 - 4xx.x13	DS-70		0	na	D	
13(A2) (CL)	IO_OPTS 4xx.x14	Bit String(2)	See Block Options	0	na	S / O/S	See Block Options.
14(A2) (CL)	STATUS_OPTS 4xx.x15	Bit String(2)	See Block Options	0	Na	S / O/S	See Block Options.
15(A2) (CL)	**CHANNEL** 4xx.x16	Unsigned16		0	None	S / O/S	The channel number of the logical hardware for the transducer that is connected to this I/O block.
16(A2) (CL)	**PV_FTIME** 4xx.x17 - 4xx.x18	Float	Non -Negative	0	Sec	S	Time constant of a single exponential filter for the PV, in seconds.
17	FIELD_VAL_D 3xx.xx6 - 3xx.xx7	DS-66			On/Off	D / RO	Raw value of the field device discrete input, the status indicates the Transducer condition.
18	UPDATE_EVT 3xx.xx8 - 3xx.x14 4xx.x19	DS-73			Na	D	This alert is generated by any changes to the static data.
19	BLOCK_ALM 3xx.x15 - 3xx.x21 4xx.x20	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Idx	Parameter	Data Type (length)	Valid Range Options	Default Value	Units	Store/ Mode	Description
20(A2) (CL)	ALARM_SUM 3xx.x22 - 3xx.x24 4xx.x21	DS-74	See Block Options		Na	S	The current alert status, unacknowledged status, unreported status, and disabled status of the alarms associated to the function block.
21	ACK_OPTION 4xx.x22	Bit String(2)	0: Auto ACK Disable 1: Auto ACK Enable	0	Na	S	Select the alarms associated to the block that will be automatically acknowledged.
22	DISC_PRI 4xx.x23	Unsigned8	0 to 15	0		S	Priority of the discrete alarm.
23(A2) (CL)	DISC_LIM 4xx.x24	Unsigned8	PV_STATE	0	PV	S	Status of the discrete input that will generate an alarm.
24	DISC_ALM 3xx.x25 - 3xx.x31 4xx.x25	DS-72			PV	D	The status and time stamp associated to the discrete alarm.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA - Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2, CL-59 bytes (include block tag and profile).

SAALM – Analog Alarm

Description

The Analog Alarm Block reportes an alarm condition to the analog output of any block. Alarm conditions include high, high-high, low and low-low alarms. These limits are based on gains and biases from a process setpoint input, providing a dynamic deviation alarm. It is possible to temporarily expand the alarm limits after changing the setpoint. Also, an alarm condition can be ignored for a specified period of time to prevent alarm reports caused by noises.

The input value, IN, is filtered according to the PV_FTIME time constant, to become the PV. PV is configured in auto mode.

Alarm limits can be dynamically calculated from the process setpoint (PSP). The operation limits (named as the parameter limits with the suffix "X") are calculated based on specified gains and biases, as indicated below:

HI_HI_LIMX = PSP * HI_GAIN + HI_HI_BIAS + EXPAND_UP (or default for HI_HI_LIM if any parameter is undefined)

HI_LIMX = PSP * HI_GAIN + HI_BIAS + EXPAND_UP (or default for HI_LIM if any parameter is undefined)

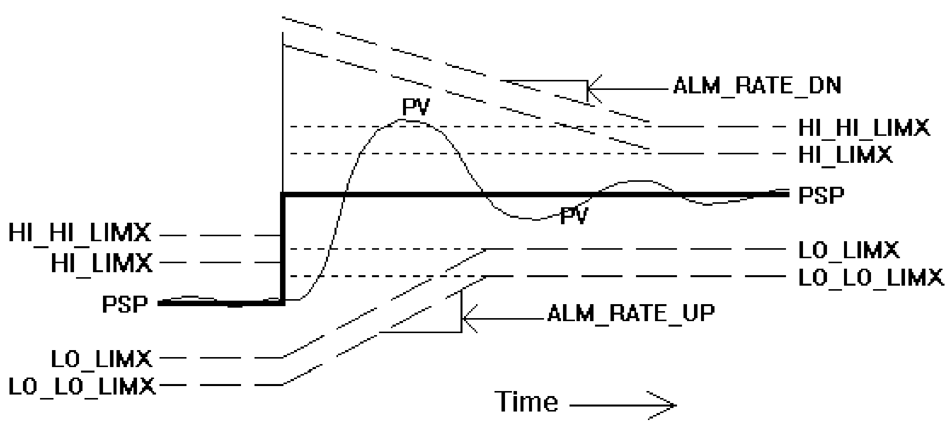
LO_LIMX = PSP * LO_GAIN - LO_BIAS - EXPAND_DN (or default for LO_LIM if any parameter is undefined)

LO_LO_LIMX = PSP * LO_GAIN - LO_LO_BIAS - EXPAND_DN (or default for LO_LO_LIM if any parameter is undefined)

Undefined means:

- HI_GAIN/HI_HI_BIAS = ± INF
- PSP_STATUS = BAD O/S

Effective alarm limits can be temporarily expanded by changing the setpoint to prevent undesired alarms. The high alarm limits (HI_HI_LIMX and HI_LMX) are increased by a calculated term, EXPAND_UP. The low alarm limits are decreased by a calculated term, EXPAND_DN. See the example in the following chart:



Both level 1 (advisory) and level 2 (critical) of the effective alarm limits are expanded after changing the setpoint with the absolute value of the alteration for the PSP. The expansions will decrease to the base limits at a rate determined by the ALM_RATE_UP and ALM_RATE_DN parameters. This parameter permits responses to the normal process with over-damped to avoid alarms on the initial change and permits under-damped process responses to avoid alarms on overshooting or ringing.

The following properties and rules apply:
- The four limits are expanded by the same value, according to the alteration of the setpoint.
- The two high limits are always expanded by the same value, EXPAND_UP, and decreased by the same rate, ALM_RATE_DN (which may differ from the low limits).
- The two low limits are always expanded by the same value, EXPAND_DN, and decreased by the same rate, ALM_RATE_UP (which may differ from the high limits).

- The expansion feature may be suppressed when increasing by setting ALM_RATE_DN to zero. The expansion feature may be suppressed when decreasing by setting ALM_RATE_UP to zero.
- Changing the setpoint before the previous expansion is complete will expand the alarm limits to both direction, to the maximum remaining value or the new expansion value.

The occurrence of a new alarm condition can be temporarily ignored by setting the IGNORE_TIME parameter to the time interval, in seconds, that the alarm will be ignored. The alarm indication and the PRE_OUT_ALM alterations will be ignored during this interval. This parameter does not delay the acknowledgement of the alarm when returning to normal operation. If the alarm condition does not persist after the IGNORE_TIME seconds, it will not be reported.

OUT_ALM parameter will assume the PRE_OUT_ALM value when the block is in Auto mode.

PRE_OUT_ALM and OUT_ALM indicate the occurrence of one or more alarm conditions selected in the specification of the OUT_ALM_SUM parameter. The table below shows the options for the OUT_ALM_SUM parameter and the alarm conditions:

OUT_ALM_SUM	INCLUDED ALARM CONDITIONS			
	HI_HI_ALM	HI_ALM	LO_ALM	LO_LO_ALM
ANY	✓	✓	✓	✓
LOWs			✓	✓
HIGHs	✓	✓		
LEVEL1		✓	✓	
LEVEL2	✓			✓
LO_LO				✓
LO			✓	
HI		✓		
HI_HI	✓			
NONE				

For example, if LOWs is selected for OUT_ALM_SUM, and LO_ALM or LO_LO_ALM is *true*, OUT_ALM will be set to *true*. If LEVEL1 is selected for OUT_ALM_SUM, and LO_ALM or HI_ALM is *true*, OUT_ALM will be set to *true*.

The OUT_ALM parameter can be used to control a lock signal, for example, besides monitoring the alarm.

Simple alarm calculation: static alarm limits, with no expansion and no delay for detection

The alarm limits will be static (HI_HI_LIM, HI_LIM, LO_LIM and LO_LO_LIM are the effective operation alarm limits) if the corresponding gain or bias is +/- INF, or the input PSP is disconnected and configured with the status Bad – O/S.

The alarm limit expansion will be disabled by setting ALM_RATE_DN and ALM_RATE_UP to zero.

There will be no delay to detect an alarm by setting IGNORE_TIME to zero.

BLOCK_ERR
The BLOCK_ERR of the Analog Alarm block will indicate the following cause:

- Out of Service – When the block is in O/S mode.

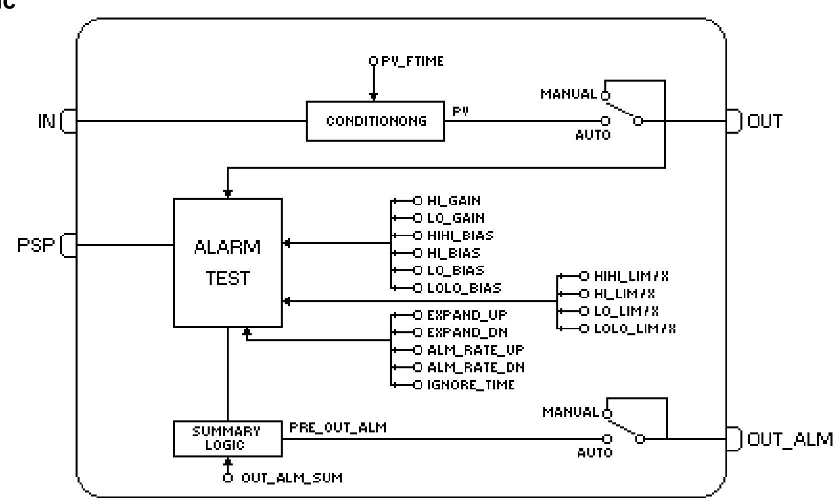
Supported Modes
O/S, MAN and AUTO.

Status
The block will not filter an IN value with a bad status or uncertain status (the option "Use Uncertain" in STATUS_OPTS is not configured), it will filter the last proper value of PV and indicate the improper status of IN instead. When the IN status returns to a proper value (good or uncertain, and the option "Use Uncertain" in STATUS_OPTS is configured), the PV value will be filtered again for the value of IN, with the IN status.

The OUT status is configured with the status of PV (and IN), when in auto mode.
If the worst status quality of PV and PSP is bad, or uncertain (and the option "Use Uncertain" in STATUS_OPTS is not configured), the alarm test will not be performed and the status of PRE_OUT_ALM will be set to bad (non-specific). Otherwise, the alarm test will be performed and the status quality of PRE_OUT_ALM will be set to the worst status quality of PV and PSP (good or uncertain). While the alarm condition is not being evaluated because of improper status, the existing alarms will not be cleared and new alarms will not be generated. Alarms from the previous conditions can be acknowledged.

In auto mode, the status of OUT_ALM will be configured with the status of PRE_OUT_ALM.

Schematic



Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3(A2) (CL)	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4(A2) (CL)	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5(A2) (CL)	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D / RO	
7	PV 3xx.xx2 - 3xx.xx4	DS-65			PV	D / RO	Process analog value. This is the IN value after passing through the PV filter.
8	**OUT** 4xx.xx5 – 4xx.xx7	DS-65	OUT_SCALE +/- 10%		OUT	N / Man	The output value resulting from the block calculation.
9	OUT_SCALE 4xx.xx8 – 4xx.x13	DS-68		0-100%	OUT	S / Man	The high and low scale values for the OUT parameter.
10	GRANT_DENY 4xx.x14 – 4xx.x15	DS-70		0	na	D	Options for controlling the access to the host computer and local control panels to the operation, tune and alarm parameters of the block.
11(A2) (CL)	STATUS_OPTS 4xx.x16	Bitstring(2)	See Block Options	0	Na	S / O/S	See Block Options.
12(A2) (CL)	PV_FTIME 4xx.x17 – 4xx.x18	Float	Non-Negative	0	Seg	S	Time constant of a single exponential filter for the PV, in seconds.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
13	**IN** 4xx.x19 – 4xx.x21	DS-65			PV	D	The primary input value of the block, or PV value.
14	PSP 4xx.x22 – 4xx.x24	DS-65			OUT	D	This is the process setpoint, that can be used to determine the alarm limit.
15(A2) (CL)	HI_GAIN 4xx.x25 – 4xx.x26	Float		1.1		S	This gain multiplies PSP before adding the bias to HI_LIM and HI_HI_LIM.
16(A2) (CL)	LO_GAIN 4xx.x27 – 4xx.x28	Float		0.9	Na	S	This gain multiplies PSP before subtracting the bias from LO_LIM and LO_LO_LIM.
17(A2) (CL)	HI_HI_BIAS 4xx.x29 – 4xx.x30	Float	Positive	1.0	Out	S	This bias is added to PSP*HI_GAIN to determine HI_HI_LIM.
18(A2) (CL)	HI_BIAS 4xx.x31 – 4xx.x32	Float	Positive	0.0	Out	S	This bias is added to PSP*HI_GAIN to determine HI_LIM.
19(A2) (CL)	LO_BIAS 4xx.x33 – 4xx.x34	Float	Positive	0.0	Out	S	This bias is subtracted from PSP*LO_GAIN to determine LO_LIM.
20(A2) (CL)	LO_LO_BIAS 4xx.x35 – 4xx.x36	Float	Positive	1.0	Out	S	This bias is subtracted from PSP*LO_GAIN to determine LO_LO_LIM.
21	PRE_OUT_ALM 4xx.x37 – 4xx.x38	DS-66			E	D	This parameter is the alarm summary variable of the analog alarm block.
22(A2)	**OUT_ALM** 4xx.x39 – 4xx.x40	DS-66			E	D	This parameter is the alarm summary variable of the analog alarm block when in *Auto* mode, and it is the value specified by the operator/engineer in *Man* mode.
23(A2) (CL)	**OUT_ALM_SUM** 4xx.x41	Unsigned8	0:NONE 1:LO_LO 2:LO 3:LOWs 4:HI 6:LEVEL1 8:HI_HI 9:LEVEL2 12:HIGHs 15:ANY	0	E	S	Specifies the alarms conditions that must be *true* to configure OUT_ALM with *true*: ANY, LOWs, HIGHs, LEVEL1, LEVEL2, LO_LO, LO, HI, or HI_HI.
24(A2) (CL)	ALM_RATE_UP 4xx.x42 – 4xx.x43	Float	Positive	0.0	OUT/seg	S	Decreasing rate (ascendent) after the alarm expansion for the lower limit caused by PSP changes. It is indicated in engineering units per second. The Lower Llimit Expansion feature will be disabled if this parameter is set to zero. (Positive).
25(A2) (CL)	ALM_RATE_DN 4xx.x44 – 4xx.x45	Float	Positive	0.0	OUT/seg	S	Decreasing rate (descendent) after the alarm expansion for the upper limit caused by PSP changes. It is indicated in engineering units per second. The Upper Limit Expansion feature will be disabled if this parameter is set to zero. (Positive).
26	EXPAND_UP 4xx.x46 – 4xx.x47	Float			OUT	D	Value, in engineering units, to expand the HI and HI_HI limits after changing the setpoint. Dynamically calculated by the block. It is initially expanded by the value of a setpoint change and decreased by the rate of ALM_RATE_UP. (Positive)

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
27	EXPAND_DN 4xx.x48 – 4xx.x49	Float			OUT	D	Value, in engineering units, to expand the LO and LO_LO limits after changing the setpoint. Dynamically calculated by the block. It is initially expanded by the value of a setpoint change and decreased by the rate of ALM_RATE_DN. (Positive)
28(A2) (CL)	IGNORE_TIME 4xx.x50 – 4xx.x51	Float	Positive	0.0	Sec	S	The time interval, in seconds, to ignore the existence of a new alarm condition. There is no delay to acknowledge the alarm and return to normal operation. If the alarm doesn't persist for IGNORE_TIME seconds, it will not be reported. It is not applied to self-clearing (transient) alarms.
29	UPDATE_EVT 3xx.xx5 - 3xx.x11 4xx.x52	DS-73			Na	D	This alert is generated by any changes to the static data.
30	BLOCK_ALM 3xx.x12 - 3xx.x18 4xx.x53	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.
31(A2) (CL)	ALARM_SUM 3xx.x19 - 3xx.x21 4xx.x54	DS-74	See Block Options		Na	S	The current alert status, unacknowledged status, unreported status, and disabled status of the alarms associated to the function block.
32	ACK_OPTION 4xx.x55	Bitstring(2)	0: Auto ACK Disable 1: Auto ACK Enable	0	Na	S	Select the alarms associated to the block that will be automatically acknowledged.
33(A2) (CL)	ALARM_HYS 4xx.x56 - 4xx.x57	Float	0 to 50 %	0.5%	%	S	Alarm hysteresis parameter. In order to clear the alarm, the value that the PV must return within the alarm limit plus the hysteresis.
34	HI_HI_PRI 4xx.x58	Unsigned8	0 to 15	0		S	Priority of the high high alarm.
35(A2) (CL)	**HI_HI_LIM** 4xx.x59 - 4xx.x60	Float	OUT_SCALE, +INF	+INF	PV	S	Settings for the high high alarm, in engineering units.
36	HI_HI_LIMX 3xx.x22 - 3xx.x23	Float	OUT_SCALE, +INF	+INF	PV	S / RO	Setting for the high high alarm, in engineering units.
37	HI_PRI 4xx.x61	Unsigned8	0 to 15	0		S	Priority of the high alarm.
38(A2) (CL)	**HI_LIM** 4xx.x62 - 4xx.x63	Float	OUT_SCALE, +INF	+INF	PV	S	Settings for the high alarm, in engineering units.
39	HI_LIMX 3xx.x24 - 3xx.x25	Float	OUT_SCALE, +INF	+INF	PV	S / RO	Settings for the high alarm, in engineering units.
40	LO_PRI 4xx.x64	Unsigned8	0 to 15	0		S	Priority of the low alarm.
41(A2) (CL)	**LO_LIM** 4xx.x65 - 4xx.x66	Float	OUT_SCALE, -INF	-INF	PV	S	Settings for the low alarm, in engineering units.
42	LO_LIMX 3xx.x26 - 3xx.x27	Float	OUT_SCALE, -INF	-INF	PV	S / RO	Settings for the low alarm, in engineering units.
43	LO_LO_PRI 4xx.x67	Unsigned8	0 to 15	0		S	Priority of the low alarm.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
44(A2)(CL)	**LO_LO_LIM** 4xx.x68 - 4xx.x69	Float	OUT_SCALE, -INF	-INF	PV	S	Settings for the low low alarm, in engineering units.
45	LO_LO_LIMX 3xx.x28 - 3xx.x29	Float	OUT_SCALE, -INF	-INF	PV	S / RO	Settings for the low low alarm, in engineering units.
46	HI_HI_ALM 3xx.x30 - 3xx.x37 4xx.x70	DS-71			PV	D	Status and associated time stamp for the high high alarm.
47	HI_ALM 3xx.x38 - 3xx.x45 4xx.x71	DS-71			PV	D	Status and associated time stamp for the high alarm.
48	LO_ALM 3xx.x46 - 3xx.x53 4xx.x72	DS-71			PV	D	Status and associated time stamp for the low alarm.
49	LO_LO_ALM 3xx.x54 - 3xx.x61 4xx.x73	DS-71			PV	D	Status and associated time stamp for the low low alarm.

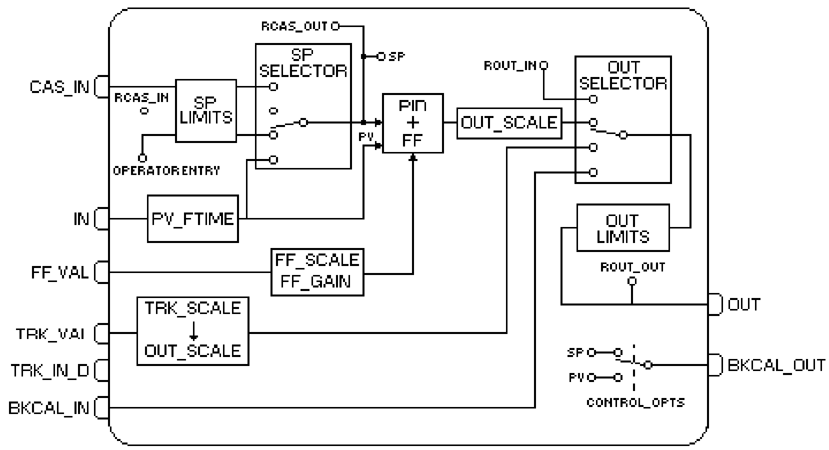
Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA - Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2, CL- 75 bytes (include block tag and profile)

If the BEHAVIOR parameter is configured as “Adapted”:
The required mode for writing is the actual mode, regardless of the target mode: OUT

EPID - Enhanced PID Control

Overview
The PID block offers a lot of control algorithms that use the Proportional, integral and derivative terms.

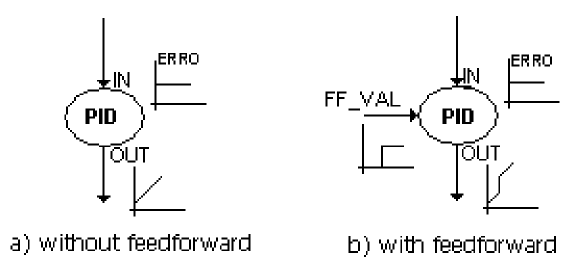
Schematic



Description
The algorithm of the PID is the non-iterative or ISA. In this algorithm, the GAIN is applied to all terms of the PID, and the Proportional and the Integral actuate over the error, and the derivative actuates over the PV value. Therefore user changes of SP will not cause bump in the output due to the derivative term when the block is in Auto.
As long as an error exists, the PID function will integrate the error, which moves the output in a direction to correct the error. PID blocks may be cascaded when the difference in process time constants of a primary and secondary process measurement makes it necessary or desirable.

See the PV calculation and SP calculation section for details.
Direct and Reverse Acting
It is possible to choose the direct or reverse action of control that is made through the "Direct Acting" bit in the CONTROL_OPTS parameter:
If the "Direct acting" bit is true then the error is obtained subtracting the SP from the PV:
Error = (PV – SP)
If the "Direct acting" bit is false (clear), the choice is "Reverse acting" then the error is obtained subtracting the PV from the SP:
Error = (SP – PV)

The Default value of the "Direct acting" bit is false, it means "reverse action".
Feedforward Control
The PID block supports the feedforward algorithm. The FF_VAL input is supplied by an external value, which is proportional to some disturbance in the control loop. The value is converted to output scale using the FF_SCALE and OUT_SCALE parameters. This value is multiplied by the FF_GAIN and added to the output of the PID algorithm.



If the status of FF_VAL is Bad, the last usable value will be used. When the status returns to good, the difference of FF_VAL values will be subtracted from BIAS_A/M in order to avoid bump in the output.

PID Constants

GAIN (Kp), RESET (Tr), and RATE (Td) are the tuning constants for the P, I and D terms, respectively. Gain is a dimensionless number. RESET and RATE are time constants expressed in seconds. There are existing controllers that are tuned by the inverse value of some or all of them, such as proportional band and repeats per minute. The human interface to these parameters should be able to display the user's preference.

Bypass

When bypass is active the SP value will be transferred to the OUT without the calculation of PID terms. Bypass is used in secondary cascade controller when the PV is bad.

Conditions to turn the Bypass on:
The "Bypass Enable" bit in the CONTROL_OPTS must be true.
BYPASS parameter is changed to ON.

The BYPASS parameter is the ON/OFF switch that activates the bypass. By default, it can be changed only when the block mode is Man or O/S. Optionally, when the "Change of Bypass in an automatic mode" bit in the FEATURES_SEL parameter in Resource block is true, then the block permits that the BYPASS switch changes in automatic modes too.

There is special treatment when the Bypass parameter changes ON/OFF in order to avoid bump in the output. When the bypass is switched to ON, the SP receives the OUT value in percent of the OUT_SCALE. And when the bypass is switched to OFF, the SP receives the PV value.

Transition in BYPASS	Action
OFF -> ON	OUT -> SP with scaling conversion
ON -> OFF	PV -> SP

Below, there is an example of the bypass in the PID block working as a PID slave in cascade control.

Step 1 – the status of IN is bad, therefore the actual mode of PID is Man
Step 2 - the target mode is changed to Man in order to write BYPASS
Step 3 – the user sets BYPASS to ON, and OUT is transferred to SP with scaling conversion
Step 4 – the user changes the target mode to Cas
Step 5 – the PID block reaches the Cas mode, despite of IN.Status.
Step 7 – the status of IN becomes good
Step 8 - the target mode is changed to Man in order to write BYPASS
Step 9 – the user sets BYPASS to OFF, and PV is transferred to SP

CONTROL_OPTS = "Bypass Enable"

Steps	1	2	3	4	5	6	7	8	9	10	11
Target	Cas	Man		Cas				Man		Cas	
Bypass	Off		On						Off		
IN	Bad	Bad	Bad	Bad	Bad	Bad	GNC 80	GNC 80	GNC 80	GNC 80	GNC 80
SP	GC 50	GC 50	GC 20	GC 20	GC 20	GC 20	GC 20	GC 20	GC 80	GC 80	GC 80
Actual	Man	Man	Man	Man	Cas	Cas	Cas	Man	Man	Man	Cas
BKCAL_OUT	NI	NI	NI	IR	GC	GC	GC	NI	NI	IR	GC
OUT	GC 20	GC 20	GC 20	GC 20	GC 20	GC 20	GC 20	GC 20	GC 20	GC 20	GC 20

Legend: GNC-Good Non Cascade status; GC-Good Cascade status

Output Tracking

The PID block supports the output track algorithm, which allows the output to be forced to a tracking value when the tracking switch is on.

In order to activate the output tracking, the block should attend the following conditions:

The "Track Enable" bit in the CONTROL_OPTS must be true.
The target mode is an "automatic" mode (Auto, Cas and Rcas) or Rout.
The TRK_VAL and TRK_IN_D status are usable, it means that the status is good or uncertain with the STATUS_OPTS."Use Uncertain as good" bit true.
The TRK_IN_D value is active.

If the target mode is Man, it is necessary besides the above conditions:
The "Track in Manual" bit in CONTROL_OPTS must be true.

When the output tracking is active, the output OUT will be replaced by the TRK_VAL converted to OUT_SCALE. The output limit status becomes constant and the actual mode goes to LO.

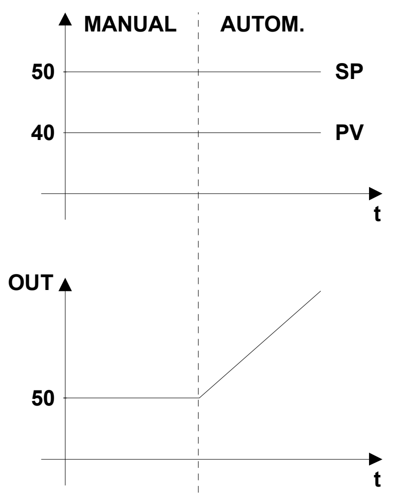
If the TRK_IN_D or TRK_VAL status is unusable, the Output tracking will be off and the PID will return to the normal operation.

Aditional features for the Enhanced PID block (EPID)

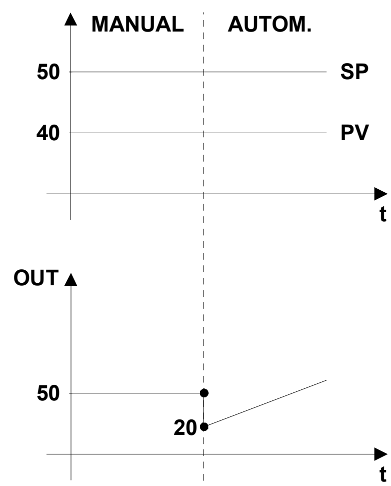
The EPID function block provides the following additional features:

1- Different type of transfer from a "manual" mode to an "automatic" mode.

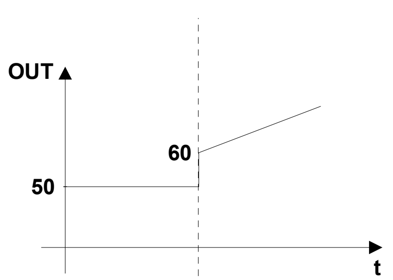
The BUMPLESS_TYPE parameter provides four types of transfer from a "manual" mode to an "automatic" mode:
a.bumpless: This is the default value and the behavior of the standard PID block. The block starts to calculate from the last value in the "manual " mode.
b.Last + proportional: The block starts to calculate from the last value in the "manual " mode plus the proportional term
c. Bias: The block starts to calculate from the BIAS parameter.
d. Bias + proportional: The block starts to calculate from the BIAS parameter plus the proportional term.



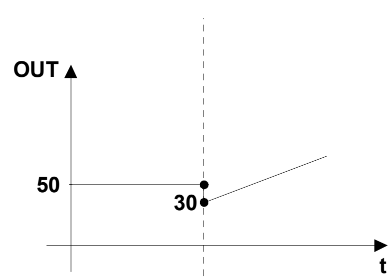
a) BUMPLESS_TYPE = "BUMPLESS"



c) BUMPLESS_TYPE = "BIAS"; BIAS = 20



b) BUMPLESS_TYPE = "LAST + PROPORCIONAL"



d) BUMPLESS_TYPE = "BIAS + PROPORCIONAL"; BIAS = 20

2-.Special treatment to Output Tracking
Special treatment is made when the output tracking is enabled:
The algorithm generates an IFS status in the output in the following situations:

When TRK_IN_D has an unusable status and the "IFS if Bad TRK_IN_D" bit in PID_OPTS is true.

When TRK_VAL has an unusable status and the "IFS if Bad TRK_VAL" bit in PID_OPTS is true.
The mode is changed to Man when the tracking inputs are not usable in the following ways:
When the TRK_IN_D is not usable and the "Man if Bad TRK_IN_D" bit in PID_OPTS is true then the mode will be Man and the OUT will be the last value. Optionally, if the "target to Man if Bad TRK_IN_D" bit in the PID_OPTS is true, then the target mode will be changed to Man too.
When the TRK_VAL is not usable and the "Man if Bad TRK_VAL" bit in PID_OPTS is true, then the mode will be Man and the OUT will be the last usable value. Optionally, if the "target to Man if Bad TRK_VAL" bit in the PID_OPTS is true, then the target mode will be changed to Man too.

The required actions are summarized in the following table:

Situation	PID_OPTS	Mode		Algorithm Action
		Target	Actual	
TRK_IN_D is not usable	0x00		"auto"	. Output tracking is not active. . The algorithm continues the normal calculation.
	IFS if Bad TRK_IN_D		"auto" -> Iman	. Output tracking is not active. . The algorithm continues the normal calculation. . OUT.Status is GoodC-IFS. . When the output block goes to fault state, the upper blocks go to Iman.
	Man if Bad TRK_IN_D		Man	. Output tracking is not active. . The algorithm stops the calculation.
	"Target to Man if Bad TRK_IN_D" ; "Man if Bad TRK_IN_D"	Man	Man	. Output tracking is not active. The target mode is changed to Man.
TRK_VAL is not usable	0x00		"auto"	. Output tracking is not active. . The algorithm continues the normal calculation.
	IFS if Bad TRK_VAL		"auto" -> Iman	. Output tracking is not active. . The algorithm continues the normal calculation. OUT.Status is GoodC-IFS. . When the output block goes to fault state, the upper blocks go to Iman.
	Man if Bad TRK_VAL		Man	. Output tracking is not active. . The algorithm stops the calculation.
	"Target to Man if Bad TRK_VAL" ; "Man if Bad TRK_VAL"	Man	Man	. Output tracking is not active. the target mode is changed to Man.
TRK_IN_D and TRK_VAL is usable, TRK_IN_D is active, output tracking is enabled			LO	Output Tracking is active.

If the additional parameters of EPID block is configured with the default values, the block works as the standard PID block.

BLOCK_ERR
The BLOCK_ERR of the PID block will reflect the following causes:
Block Configuration Error – the configuration error occurs when the BYPASS and SHED_OPT parameters have an invalid value;
Out of Service – it occurs when the block is in O/S mode.

Supported Modes
O/S, IMAN, LO, MAN, AUTO, CAS, RCAS and ROUT.
Control Algorithm

$$OUT = GAIN * \left[E + \frac{RATE * S}{1 + \alpha * RATE * S} * PV + \frac{E}{RESET * S} \right] + BIAS\_A/M + FEEDFORWARD$$

NOTE: ① BIAS_A/M: Internal BIAS calculated on changing to automatic modes (RCAS, CAS, AUTO).
- α: Pseudo - Derivative Gain Equals to 0.13

Parameters

Index	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
1	ST_REV	Unsigned16		0	None	S	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	See Mode Parameter
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D / RO	
7	**PV** 3xx.xx2 – 3xx.xx4	DS-65			PV	D / RO	Process analog value. This is the IN value after pass over the PV filter.
8	**SP** 4xx.xx5 – 4xx.xx7	DS-65	PV_SCALE +/- 10%		PV	N / Auto	The analog set point. Can be set manually, automatically through the interface device or another field device.
9	**OUT** 4xx.xx8 – 4xx.x10	DS-65	OUT_SCALE +/- 10%		OUT	N / Man	The output value result of the PID calculation.
10	PV_SCALE 4xx.x11 – 4xx.x16	DS-68		0-100%	PV	S / Man	The high and low scale values to the PV and SP parameter.
11	OUT_SCALE 4xx.x17 – 4xx.x22	DS-68		0-100%	OUT	S / Man	The high and low scale values to the OUT parameter.
12	GRANT_DENY 4xx.x23 – 4xx.x24	DS-70		0	na	D	Options for controlling access of host computer and local control panels to operating, tuning and alarm parameters of the block.
13	**CONTROL_OPTS** 4xx.x25	Bitstring(2)	See Block Options	0	na	S / O/S	See Block Options
14	**STATUS_OPTS** 4xx.x26	Bitstring(2)	See Block Options	0	Na	S / O/S	See Block Options
15	**IN** 4xx.x27 – 4xx.x29	DS-65			PV	D	The primary input value of the block, or PV value.
16	PV_FTIME 4xx.x30 – 4xx.x31	Float	Non-Negative	0	Sec	S	Time constant of a single exponential filter for the PV, in seconds.
17	BYPASS 4xx.x32	Unsigned8	1:Off 2:On	0	E	S / Man	When bypass is set, the setpoint value (in percent) will be directly transferred to the output.
18	**CAS_IN** 4xx.x33 – 4xx.x35	DS-65				D	This parameter is the remote setpoint value, which must come from another Fieldbus block, or a DCS block through a defined link.
19	SP_RATE_DN 4xx.x36 – 4xx.x37	Float	Positive	+INF	PV/Sec	S	Ramp rate at which upward setpoint changes in PV units per second. It is disable if is zero or +INF. Rate limiting will apply only in AUTO mode.
20	SP_RATE_UP 4xx.x38 – 4xx.x39	Float	Positive	+INF	PV/Sec	S	Ramp rate at which downward setpoint changes in PV units per second. It is disable if is zero or +INF. Rate limiting will apply only in AUTO mode.

Index	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
21	SP_HI_LIM 4xx.x40 – 4xx.x41	Float	PV_SCALE +/- 10%	100	PV	S	The setpoint high limit is the highest setpoint operator entry that can be used for the block.
22	SP_LO_LIM 4xx.x42 – 4xx.x43	Float	PV_SCALE +/- 10%	0	PV	S	The setpoint low limit is the lowest setpoint operator entry that can be used for the block.
23	GAIN 4xx.x44 – 4xx.x45	Float		0	None	S	Proportional term of the PID. It is the Kp value.
24	RESET 4xx.x46 – 4xx.x47	Float	Positive	+INF	sec	S	Integral term of the PID. It is the Tr value.
25	BAL_TIME 4xx.x48 – 4xx.x49	Float	Positive	0	sec	S	This specifies the time for the internal working value of bias or ratio to return to the operator set bias or ratio, in seconds. In the PID block, it may be used to specify the time constant at which the integral term will move to obtain balance when the output is limited and the mode is Auto, Cas, or Rcas.
26	RATE 4xx.x50 – 4xx.x51	Float	Positive	0	sec	S	Derivative term of the PID. It is the Td value.
27	**BKCAL_IN** 4xx.x52 – 4xx.x54	DS-65			OUT	N	The value and status from a lower block's BKCAL_OUT that is used to prevent reset windup and to initialize the control loop.
28	OUT_HI_LIM 4xx.x55 – 4xx.x56	Float	OUT_SCALE +/- 10%	100	OUT	S	Limits the maximum output value.
29	OUT_LO_LIM 4xx.x57 – 4xx.x58	Float	OUT_SCALE +/- 10%	0	OUT	S	Limits the minimum output value.
30	BKCAL_HYS 4xx.x59 – 4xx.x60	Float	0 to 50%	0.5%	%	S	The amount that the output must change away from its output limit before the limit status is turned off, expressed as a percent of the span of the output.
31	**BKCAL_OUT** 3xx.xx5 – 3xx.xx7	DS-65			PV	D / RO	The value and status required by an upper block's BKCAL_IN so that the upper block may prevent reset windup and provide bumpless transfer to closed loop control.
32	RCAS_IN 4xx.x61 – 4xx.x63	DS-65			PV	D	Target setpoint and status provided by a supervisory Host to a analog control or output block.
33	ROUT_IN 4xx.x64 – 4xx.x66	DS-65			OUT	D	Target output and status provided by a Host to the control block for use as the output (Rout mode).

Index	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
34	SHED_OPT 4xx.x67	Unsigned8	1: NormalShed, NormalReturn 2: NormalShed, NoReturn 3: ShedToAuto, NormalReturn 4: ShedToAuto, NoReturn 5: ShedToMan, NormalReturn 6: ShedToMan, NoReturn 7: ShedToRetainedTarget, NormalReturn 8: ShedToRetained Target, NoReturn	0		S	Defines action to be taken on remote control device timeout.
35	RCAS_OUT 3xx.xx8 – 3xx.x10	DS-65			PV	D / RO	Block setpoint and status after ramping - provided to a supervisory Host for back calculation and to allow action to be taken under limiting conditions or mode change.
36	ROUT_OUT 3xx.x11 – 3xx.x13	DS-65			OUT	D / RO	Block output and status - provided to a Host for back calculation in ROut mode and to allow action to be taken under limited conditions or mode change
37	TRK_SCALE 4xx.x68 - 4xx.x73	DS-68		0-100%	TRK	S / Man	The high and low scale values, engineering units code, and number of digits to the right of the decimal point, associated with TRK_VAL.
38	TRK_IN_D 4xx.x74 - 4xx.x75	DS-66			On/Off	D	This discrete input is used to initiate external tracking of the block output to the value specified by TRK_VAL.
39	TRK_VAL 4xx.x76 - 4xx.x78	DS-65			TRK	D	This input is used as the track value when external tracking is enabled by TRK_IN_D.
40	FF_VAL 4xx.x79 - 4xx.x81	DS-65			FF	D	The feed forward value and status.
41	FF_SCALE 4xx.x82 - 4xx.x87	DS-68		0-100%	FF	S	The feedforward input high and low scale values, engineering units code, and number of digits to the right of the decimal point.
42	FF_GAIN 4xx.x88 - 4xx.x89	Float		0	none	S/Man	The gain that the feed forward input is multiplied by before it is added to the calculated control output.
43	UPDATE_EVT 3xx.x14 – 3xx.x20 4xx.x90	DS-73			Na	D	This alert is generated by any change to the static data.

Index	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
44	BLOCK_ALM 3xx.x21 – 3xx.x27 4xx.x91	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
45	ALARM_SUM 3xx.x28 – 3xx.x30 4xx.x92	DS-74	See Block Options		Na	S	The current alert status, unacknowledged states, unreported states, and disabled states of the alarms associated with the function block.
46	ACK_OPTION 4xx.x93	Bitstring(2)	0: Auto ACK Disable 1: Auto ACK Enable	0	Na	S	Selection of whether alarms associated with the block will be automatically acknowledged
47	ALARM_HYS 4xx.x94 - 4xx.x95	Float	0 to 50 %	0.5%	%	S	Alarm hysteresis parameter. In order to clear the alarm the amount the PV must return within the alarm limit plus hysteresis.
48	HI_HI_PRI 4xx.x96	Unsigned8	0 to 15	0		S	Priority of the high high alarm.
49	HI_HI_LIM 4xx.x97 - 4xx.x98	Float	PV_SCALE, +INF	+INF	PV	S	The setting for high high alarm in engineering units.
50	HI_PRI 4xx.x99	Unsigned8	0 to 15	0		S	Priority of the high alarm.
51	HI_LIM 4xx.100 - 4xx.101	Float	PV_SCALE, +INF	+INF	PV	S	The setting for high alarm in engineering units.
52	LO_PRI 4xx.102	Unsigned8	0 to 15	0		S	Priority of the low alarm.
53	LO_LIM 4xx.103 - 4xx.104	Float	PV_SCALE, +INF	-INF	PV	S	The setting for low alarm in engineering units.
54	LO_LO_PRI 4xx.105	Unsigned8	0 to 15	0		S	Priority of the low low alarm.
55	LO_LO_LIM 4xx.106 - 4xx.107	Float	PV_SCALE, +INF	-INF	PV	S	The setting for low low alarm in engineering units.
56	DV_HI_PRI 4xx.108	Unsigned8	0 to 15	0		S	Priority of the deviation high alarm.
57	DV_HI_LIM 4xx.109 - 4xx.110	Float	0 to PV span, +INF	+INF	PV	S	The setting for deviation high alarm in engineering units.
58	DV_LO_PRI 4xx.111	Unsigned8	0 to 15	0		S	Priority of the deviation low alarm.
59	DV_LO_LIM 4xx.112 - 4xx.113	Float	-INF, -PV span to 0	-INF	PV	S	The setting for deviation low alarm in engineering units.

Index	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
60	HI_HI_ALM 3xx.x31 – 3xx.x38 4xx.114	DS-71			PV	D	The status for high high alarm and its associated time stamp.
61	HI_ALM 3xx.x39 – 3xx.x46 4xx.115	DS-71			PV	D	The status for high alarm and its associated time stamp.
62	LO_ALM 3xx.x47 – 3xx.x54 4xx.116	DS-71			PV	D	The status for low alarm and its associated time stamp.
63	LO_LO_ALM 3xx.x55 – 3xx.x62 4xx.117	DS-71			PV	D	The status for low low alarm and its associated time stamp.
64	DV_HI_ALM 3xx.x63 – 3xx.x70 4xx.118	DS-71			PV	D	The status for deviation high alarm and its associated time stamp.
65	DV_LO_ALM 3xx.x71 – 3xx.x78 4xx.119	DS-71			PV	D	The status for deviation low alarm and its associated time stamp.

Enhanced PID - Additional Parameters

Index	Parameter	Type	Valid Range/ Options	Default Value	Units	Mode To Change	Description
66	**BUMPLESS_TYPE** 4xx.120	Unsigned8	0: Bumpless 1: Last+Proportional 2: Bias 3: Bias+Proportiona l	0	E	S / Man	Options that defines the algorithm action to start the output when the block transfer from a “manual” to an “automatic” mode.
67	BIAS 4xx.121 - 4xx.122	Float		0	OUT	S	The bias value to use in the PID algorithm when the BUMPLESS type is “Bias” or “Bias+Proportional”.
68	PID_OPTS 4xx.123	Bitstring(2)	See block options	0		S / O/S	The options for handling the additional features of the output tracking.

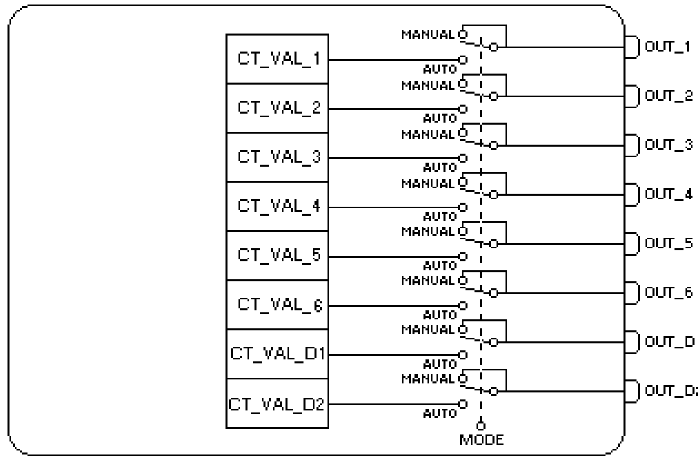
Legend: E – Enumerated parameter; na – Admensional parameter; RO – Read only; D – dynamic; N – non-volatile; S – static
AA-Nível de administrador; A1 – Nível 1; A – Nível 2
Gray Background Line: Custom Parameters

If BEHAVIOR parameter is “Adapted”:
The default value of BYPASS is OFF.
The default value of SHED_OPT is NormalShed/NormalReturn.
The required mode for writing is the actual mode, regardless the target mode: SP and OUT.

CT – Constant

Overview
The Constant function block generates constant values to be used by the inputs parameters of other blocks.

Schematic



Description
The Constant function block has 6 analog constants and 2 discrete constants to be connected to any other blocks.

If the mode is Man, all output values can be manually replaced. In Auto mode, the output values will be the respective constant values.

Supported Mode
O/S, MAN and AUTO

Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3(A2) (CL)	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5(A2) (CL)	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx .xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D/RO	
7(A2)	OUT_1 4xx.xx5 – 4xx.xx7	DS-65				N / Man	Output 1.
8(A2)	OUT_2 4xx.xx8 – 4xx.x10	DS-65				D / Man	Output 2.
9(A2)	OUT_3 4xx.x11 – 4xx.x13	DS-65				D / Man	Output 3.
10(A2)	OUT_4 4xx.x14 – 4xx.x16	DS-65				D / Man	Output 4.
11(A2)	OUT_5 4xx.x17 – 4xx.x19	DS-65				D / Man	Output 5.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
12(A2)	OUT_6 4xx.x20 – 4xx.x22	DS-65				D / Man	Output 6.
13(A2)	OUT_D1 4xx.x23 – 4xx.x24	DS-66				N / Man	Discrete output 1.
14(A2)	OUT_D2 4xx.x25 – 4xx.x26	DS-66				D / Man	Discrete output 2.
15(A2) (CL)	**CT_VAL_1** 4xx.x27 – 4xx.x28	Float		0		S	Value of the Analog constant transferred to the output OUT_1.
16(A2) (CL)	**CT_VAL_2** 4xx.x29 – 4xx.x30	Float		0		S	Value of the Analog constant transferred to the output OUT_2.
17(A2) (CL)	**CT_VAL_3** 4xx.x31 – 4xx.x32	Float		0		S	Value of the Analog constant transferred to the output OUT_3.
18(A2) (CL)	**CT_VAL_4** 4xx.x33 – 4xx.x34	Float		0		S	Value of the Analog constant transferred to the output OUT_4.
19(A2) (CL)	**CT_VAL_5** 4xx.x35 – 4xx.x36	Float		0		S	Value of the Analog constant transferred to the output OUT_5.
20(A2) (CL)	**CT_VAL_6** 4xx.x37 – 4xx.x38	Float		0		S	Value of the Analog constant transferred to the output OUT_6.
21(A2) (CL)	**CT_VAL_D1** 4xx.x39	Unsigned8		0		S	Value of the Discrete constant transferred to the output OUT_D1.
22(A2) (CL)	**CT_VAL_D2** 4xx.x40	Unsigned8		0		S	Value of the Discrete constant transferred to the output OUT_D2.
23	UPDATE_EVT 3xx.xx2 - 3xx.xx8 4xx.x41	DS-73			Na	D	This alert is generated by any change to the static data.
24	BLOCK_ALM 3xx.xx9 - 3xx.x15 4xx.x42	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O- Output Parameter
AA- Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

If the BEHAVIOR parameter is configured as “Adapted”:
The required mode for writing is the actual mode, regardless of the target mode: OUT_1, OUT_2, OUT_3, OUT_4, OUT_5, OUT_6, OUT_D1 and OUT_D2.

SARTH - Arithmetic

Description

The ARTH block was implemented to calculate measurements from combinations of the signals from the sensors. It is not to be used in the control, and for that reason it does not support the cascade mode or the back calculation mode. It doesn't convert values to percentage, or scales. It doesn't have process alarms.

The block has 5 inputs. The first two inputs are dedicated to a range extension function that results in a PV, with status reflecting the input being used. The other three inputs are combined with the PV to select four functions of terms that can be used is several measurements. The inputs that compose the PV must be read from the devices in the desired engineering units, so that the PV has the correct unit in the equation. Each one of the additional inputs has a constant bias and gain. The bias can be used to correct the absolute temperature or pressure. The gain can be used to normalize terms in the square root function. The output has also a constant gain and bias for any further required adjustment.

The function for the range extension function has a graduated transfer, controlled by two constants related to IN. An internal value, g, will be zero if the value of IN is lesser than RANGE_LO. It will be one if the value of IN is greater than RANGE_HI. It is interpolated from zero to one using the range of RANGE_LO to RANGE_HI.

The equation of the PV is:

$$PV = g * IN + (1 - g) * IN\_LO$$

if ((IN $<$ RANGE_LO) or (IN_LO < RANGE_HI) and (Status of IN is Unusable) and (Status of IN_LO is Usable))
then

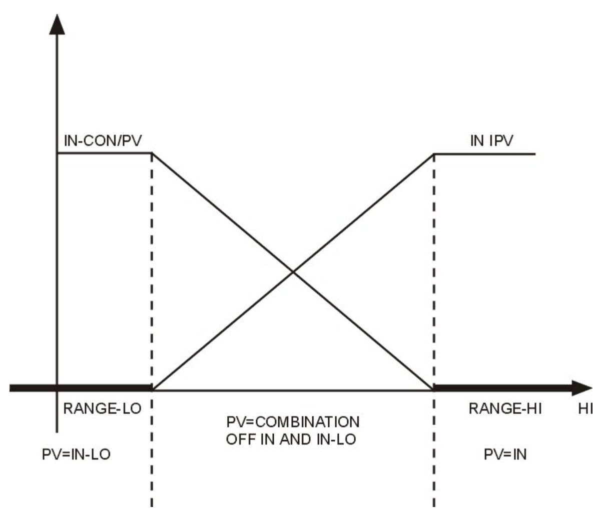
g = 0

if ((IN $>$ RANGE_HI) or (IN > RANGE_LO) and (Status of IN is Usable) and (Status of IN_LO is Unusable))
then

g = 1

if ((RANGE_LO $\leq$ IN) and (IN < RANGE_HI))
then

$$g = \frac{IN - RANGE\_LO}{RANGE\_HI - RANGE\_LO}$$



If the status of IN_LO is unusable and IN is usable and greater than RANGE_LO, then g will be set to one (1). If the status of IN is unusable, and IN_LO is usable and lesser than RANGE_HI, then g will be set to zero (0). For each case, the PV will have the status Good until the condition is no longer valid. Otherwise, the status of IN_LO will be used for the PV, if g is lesser than 0.5, while IN is used when g is greater than or equal to 0.5.

Six constants are used for the three auxiliary inputs. Each constant has a BIAS_IN_i and a GAIN_IN_i. The output has a static constant BIAS and GAIN. For the inputs, the bias is added and the gain is applied to the sum. The result is an internal value called t_i in the equations.

t_i = (IN_i + BIAS_IN_i) ∗ GAIN_IN_i

The limits of the function for the flow compensation are the value of the compensation applied to the PV, to guarantee the degradation if an auxiliary input is unstable.

The following equations have a compensation factor limited by COMP_HI_LIM and COMP_LO_LIM:

- flow compensation, linear
- flow compensation, square root
- flow compensation, approximate
- BTU flow
- Traditional multiple division

Arithmetic exceptions:
a) Division by zero will result a value equals to OUT_HI_LIM or OUT_LO_LIM, depending on the sign of PV.
b) Roots of negative numbers will result the root of the absolute value, with the negative sign.

Although the output is not scaled, it has absolute high and low limits, to keep reasonable values.

Minimum Configuration
RANGE_HI and RANGE_LO: If the range extension function is not used, these two parameters must be set to +INF and –INF, respectively. The inputs IN_1, IN_2 and IN_3 must be configured according to the equation type selected (see in the table the available equation types), or using INPUT_OPTS to disable determined input. Therefore the PV will be a copy of IN.

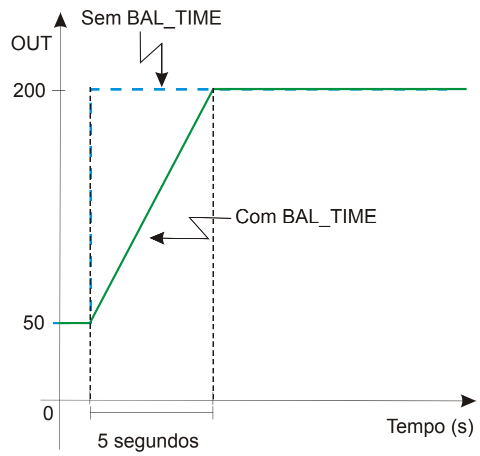
If the ARITH_TYPE is one of the first five equations, the COMP_HI_LIM and COMP_LO_LIM parameters must be set properly. The default value of the COMP_HI_LIM parameter is zero.

Since the default value of the GAIN parameter is zero, it is necessary to set a proper value.

Manual to Automatic Transition
The writing in the OUT is enabled when the block is in Man mode. During the Manual to Automatic transition, if the BAL_TIME parameter does not have configured, i.e., with the value equals to 0, the transition of the output from the written value to the calculated value will be performed with bump, such as a pulse (positive or negative). BAL_TIME parameter allows a bumpless transition for the output. It is set in seconds. See the example below:

IN_1=10
GAIN_IN_1=10
BIAS_IN_1=5
IN_2=10
GAIN_IN_2=10
BIAS_IN_2=5
ARITH_TYPE=Traditional summer
BIAS=0
GAIN=2
BAL_TIME=5 (seconds)

OUT (calculated by block)=200
OUT (written by user)=50



BLOCK_ERR
The BLOCK_ERR of the Arithmetic block will indicate the following causes:

- Block Configuration Error – the configuration error occurs when the ARITH_TYPE has an invalid value.
- Out of Service – When the block is in O/S mode.

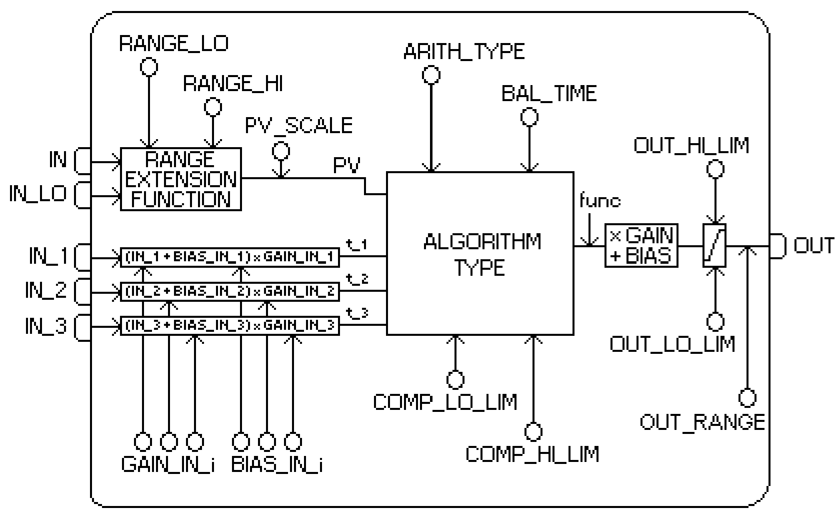
Supported Modes
O/S, Man and Auto.

Status
The status of PV depends on the factor "g", if it is less than 0.5, then the status of IN_LO will be used; otherwise, the status of IN will be used.

The INPUT_OPTS parameter can use auxiliary inputs with status lower than good. The status of the unused inputs is ignored.

The status of the output will be the same from the PV, except when the status of the PV is good and the status of an used auxiliary input is not good, and INPUT_OPTS is not configured to use the PV. In this case, the status of OUT will be Uncertain.

Schematic



Parameters

Idx	Parameters	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	Oct String(32)		Spaces	Na	S	
3 (A2)	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5 (A2) (CL)	MODE_BLK Actual=3xx.xx0 Target/Manual=4xx. xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	BLOCK_ERR 3xx.xx1	Bit String(2)			E	D / RO	
7	PV 3xx.xx2 - 3xx.xx4	DS-65			PV	D / RO	Process analog value used when executing the function.
8 (A2)	OUT 4xx.xx5 – 4xx.xx7	DS-65			OUT	D / Man	The analog value resulting from the function execution.
9	PRE_OUT 3xx.xx5 - 3xx.xx7	DS-65			OUT	D / RO	Displays the probable OUT value and status if the mode was Auto or lower.
10	PV_SCALE 4xx.xx8 – 4xx.x13	DS-68		0-100%	PV	S	The engineering units index for the display.
11	OUT_RANGE 4xx.x14 – 4xx.x19	DS-68		0-100%	OUT	S	The engineering units of the output for the display.
12	GRANT_DENY 4xx.x20 – 4xx.x21	DS-70		0	Na	D	Options for controlling the access to the host computer and local control panels to the operation, tune and alarm parameters of the block.
13 (A2) (CL)	INPUT_OPTS 4xx.x22	Bit String(2)		0	Na	S / OOS	Bitstring option for handling the status of the auxiliary inputs.
14 (A2)	IN 4xx.x23 – 4xx.x25	DS-65			PV	D	The primary input of the block.
15 (A2)	IN_LO 4xx.x26 – 4xx.x28	DS-65			PV	D	Input for the low range transmitter, in a range extension application.
16 (A2)	IN_1 4xx.x29 – 4xx.x31	DS-65			None	D	Input nº 1.
17 (A2)	IN_2 4xx.x32 – 4xx.x34	DS-65			None	D	Input nº 2.
18 (A2)	IN_3 4xx.x35 – 4xx.x37	DS-65			None	D	Input nº 3.
19 (A2) (CL)	RANGE_HI 4xx.x38 – 4xx.x39	Float		0	PV	S	Higher constant value that switches the range extension to the high range transmitter.
20 (A2) (CL)	RANGE_LO 4xx.x40 – 4xx.x41	Float		0	PV	S	Lower constant value that switches the range extension to the low range transmitter.
21 (A2) (CL)	BIAS_IN_1 4xx.x42 – 4xx.x43	Float		0	None	S	The constant added to IN_1.
22 (A2) (CL)	GAIN_IN_1 4xx.x44 – 4xx.x45	Float		0	None	S	The constant multiplied by (IN_1 + bias).
23 (A2) (CL)	BIAS_IN_2 4xx.x46 – 4xx.x47	Float		0	None	S	The constant added to IN_2.
24 (A2) (CL)	GAIN_IN_2 4xx.x48 – 4xx.x49	Float		0	None	S	The constant multiplied by (IN_2 + bias).
25 (A2) (CL)	BIAS_IN_3 4xx.x50 – 4xx.x51	Float			None	S	The constant added to IN_3.
26 (A2) (CL)	GAIN_IN_3 4xx.x52 – 4xx.x53	Float		0	None	S	The constant multiplied by (IN_3 + bias).
27 (A2) (CL)	COMP_HI_LIM 4xx.x54 – 4xx.x55	Float		0	None	S	The high limit imposed on the PV compensation term.

Idx	Parameters	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
28 (A2) (CL)	COMP_LO_LIM 4xx.x56 – 4xx.x57	Float		0	None	S	The low limit imposed on the PV compensation term.
29 (A2) (CL)	ARITH_TYPE 4xx.x58	Unsigned8	1= Flow comp. linear 2= Flow comp. square root 3= Flow comp. approx. 4= BTU flow 5= Traditional mult. div. 6= Average 7= Traditional summer 8= Fourth order polynomial 9= HTG comp. level	0	E	S	It identifies the equation that will be used.
30 (A2) (CL)	BAL_TIME 4xx.x59 – 4xx.x60	Float	Positive	0	Sec	S	This parameter specifies the time in order to have a bumpless transition in the output during the Manual to Automatic transition.
31 (A2) (CL)	BIAS 4xx.x61 – 4xx.x62	Float		0	OUT	S	The bias value used to compute the function block output, in engineering units.
32 (A2) (CL)	GAIN 4xx.x63 – 4xx.x64	Float		0	None	S	Undimensional value used by the block algorithm to calculate the block output.
33 (A2) (CL)	OUT_HI_LIM 4xx.x65 – 4xx.x66	Float		100	OUT	S	Limits the maximum output value.
34 (A2) (CL)	OUT_LO_LIM 4xx.x67 – 4xx.x68	Float		0	OUT	S	Limits the minimum output value.
35	UPDATE_EVT 3xx.xx8 - 3xx.x14 4xx.x69	DS-73			Na	D	This alert is generated by any changes to the static data.
36	BLOCK_ALM 3xx.x15 - 3xx.x21 4xx.x70	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA - Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

If the DIAG.BEHAVIOR parameter is configured as "Adapted":
The default value of ARITH_TYPE is the Gas flow compensation for linear transmitters, equation type 1.
The required mode for writing is the actual mode, regardless of the target mode: OUT

Equation Types

ARITH_TYPE	Equation
1 Flow comp. Linear	$OUT = PV * f * GAIN + BIAS$ where $f = \left[\frac{T1}{T2}\right]$ is limited
2 Flow comp. Square root	$OUT = PV * f * GAIN + BIAS$ where $f = \left[\sqrt{\frac{T1}{T2 * T3}}\right]$ is limited
3 Flow comp. Approx.	$OUT = PV * f * GAIN + BIAS$ where $f = \left[\sqrt{T1 * T2 * T3^2}\right]$ is limited
4 BTU Flow	$OUT = PV * f * GAIN + BIAS$ where $f = \left[T1 - T2\right]$ is limited
5 Traditional mult. div.	$OUT = PV * f * GAIN + BIAS$ where $f = \left[\frac{T1}{T2} + T3\right]$ is limited
6 Average	$OUT = \frac{PV + T1 + T2 + T3}{f} * GAIN + BIAS$ Where f is the number of inputs used in the calculation (unusable inputs are not used).
7 Traditional summing	$OUT = (PV + T1 + T2 + T3) * GAIN + BIAS$
8 4th order polynomial	$OUT = (PV + T1^2 + T2^3 + T3^4) * GAIN + BIAS$
9 HTG comp. Level	$OUT = \frac{PV - T1}{PV - T2} * GAIN + BIAS$

Examples

ARITH_TYPE	Example	Example Equation	Note
1	Gas flow compensation for linear transmitters (e.g. turbine)	$Q_b = Q_f * K * \frac{P}{T}$	
2	Gas flow compensation for DP transmitters.	$Q_b = Q_f * K * \sqrt{\frac{P}{T * Z}}$	Z may be a constant or an input from other block (AGA3)
3	Approx. liquid & steam flow comp.	$Q_b = Q_f * K * \sqrt{(K + K * T + K * T^2)}$ $Q_b = Q_f * K * \sqrt{(K + K * P)}$	Temperature connected to 3 and 4
4	BTU meter (heat flow)	$Q_{HEAT} = K * Q_{VOL} * (t_1 - t_2)$	
5	Simple "hard" (non-cascade) ratio	$Q_{SP} = Q_{WILD} * RATIO$	Output is the setpoint for the PID block
6	Average of four temperature measurements	$t_a = \frac{t_1 + t_2 + t_3 + t_4}{f}$	.
7	Pressure (or level) difference	$P_{bm} = P_b - P_m$	
9	Simple HTG compensated level	$h_{BT} = \frac{P_B - P_T}{P_B - P_M} * h_{BM}$	

NOTE: The square root of the third power can be calculated by selecting ARITH_TYPE = 3 and connecting the input to IN and IN_1. The square root of the fifth power can be calculated by connecting the input to IN, IN_1 and IN_3.

STIME – Timer and Logic

Description
The Timer and Logic function block provides logic combination and timing functions, including:

- Combined multiple inputs such as OR, AND, vote, or EXACT counter;
- Measuring the duration of the combined discrete input signal;
- Accumulating, until reset, the duration of the combined input signal;
- Counting the changes of the combined discrete input signal;
- Adjusting the discrete output, if the duration of the combined input signal exceeds a limit;
- Extend, Delay, Pulse, or Oscillate the combined input as an output;
- Providing outputs that indicate the elapsed time and the time remaining;
- Selectively invert any discrete input or output connected;
- Timer Reset.

Up to four inputs may be combined logically (AND, OR), voted (any 2 or more true inputs, any 3 or more true inputs), or counted (exactly 1 true input, exactly 2 true inputs, exactly 3 true inputs, odd count, or even count). The combined input value is specified by the list of combination types (COMB_TYPE). The options are indicated in the table below.

Connected inputs can be true, false, or undefined. Undefined connected inputs are interpreted as bad status (out-of-service). Unconnected inputs can be true, false, or undefined. Undefined unconnected inputs (operator) are ignored.

COMB_TYPE / List	PV_D Value
OR	true if one or more inputs are true
ANY2	true if two or more inputs are true
ANY3	true if three or more inputs are true
AND	true if all inputs are true
EXACTLY1	true if exactly 1 input is true
EXACTLY2	true if exactly 2 inputs are true
EXACTLY3	true if exactly 3 inputs are true
EVEN	true if exactly 0, 2 or 4 inputs are true
ODD	true if exactly 1 or 3 inputs are true

The processing type of the timer is specified by TIMER_TYPE. It will result the measurement, delay, extension, pulse (non-retriggerable or retriggerable) or the oscillation of the combined input signal.

TIMER_SP is the specification for the time interval of the delay, extension, pulse, oscillation filter or comparison limit. In any case, the block will be checked on each execution to verify the interval of the current delay, extension, pulse, oscillation, or to compare the time exceeding the current TIMER_SP.

OUT_D parameter will assume the PRE_OUT_D value when the block is in Auto mode.

OUT_EXP indicates the time expired in the measurement, comparison, delay, extension, oscillation, or pulse. Refer to the TIMER_TYPE for details.

QUIES_OPT allows the configurator to select the behavior of OUT_EXP and OUT_REM when the timer is quiescent, that is, it is not temporized and it is not in a triggered condition. The following table shows the definition of the quiescent state for each TIMER_TYPE option:

Definition for the beginning and end of the quiescent state as a function of the TIMER_TYPE		
TIMER_TYPE	The Quiescence state **starts** when the combined input (PV_D):	The Quiescence state **ends** when the combined input (PV_D):
MEASURE	returns to false	changes from false to true
ACCUM	[QUIES_OPT does not apply]	[QUIES_OPT does not apply]
COMPARE	returns to false	changes from false to true
DELAY	returns to false	changes from false to true
EXTEND	returns to true	changes from true to false
DEBOUNCE	has changed and the timer has expired	Changes
PULSE	has returned to false and the timer has expired	changes from false to true
RT_PULSE	has returned to false and the timer has expired	changes from false to true

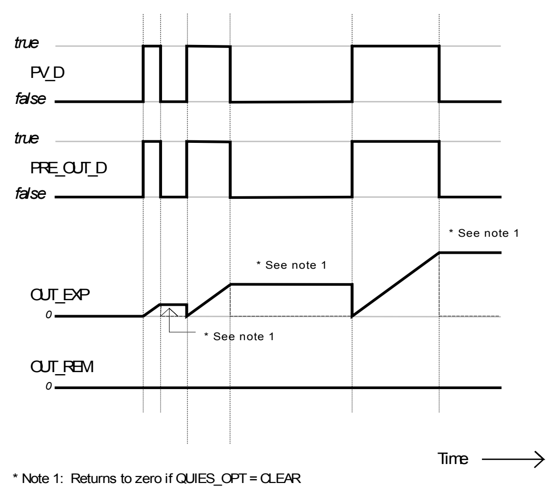
The option CLEAR of QUIES_OPT will cause both OUT_EXP and OUT_REM to be set to zero during quiescence. The option LAST of QUIES_OPT will cause both OUT_EXP and OUT_REM to keep their values when the block becomes quiescent. That is, the time expired and time remaining will be available until the quiescence ends when the next activation is started. Note that a false-to-true transition on RESET_IN will also reset OUT_EXP and OUT_REM.

N_START counts the number of false-to-true transitions of the combined input, PV_D, since the last false-to-true transition was indicated on RESET_IN.

The TIMER_TYPE, operating according to the combined input signal, can indicate:

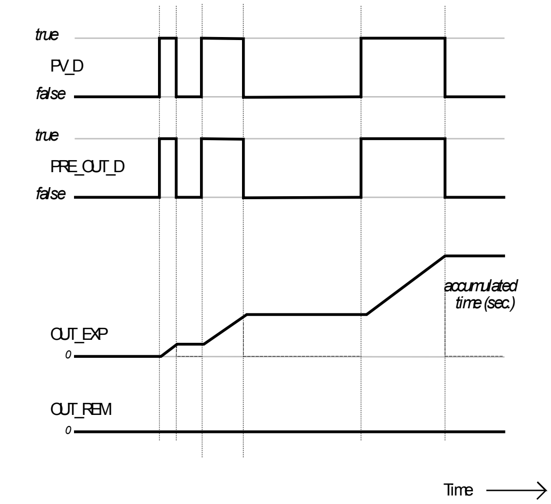
- MEASURE Indicates the duration of the most recent true signal
- ACCUM Accumulates the duration of a true signal
- COMPARE Compares the duration of a true signal with a specified duration
- DELAY Delays a false-to-true transition, eliminating it if it is short
- EXTEND Extends a true-to-false transition, eliminating it if it is short
- DEBOUNCE Delays any transition, eliminating it if it is short
- PULSE Generates a true pulse on a false-to-true transition, non-retriggerable
- RT_PULSE Generates a true pulse on a false-to-true transition, retriggerable

- If TIMER_TYPE is **MEASURE**, PRE_OUT_D will be the same as the combined input, PV_D. OUT_EXP indicates the time interval, in seconds, that the combined signal is true. OUT_REM is set to 0.



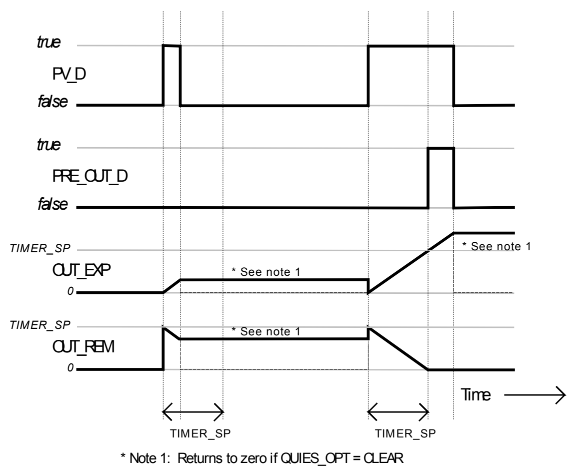
Timer Example when TIMER_TYPE = MEASURE

- If TIMER_TYPE is **ACCUM**, PRE_OUT_D will be the same as the combined input, PV_D. OUT_EXP indicates the accumulated time interval, in seconds, that the combined signal was true. Unlike TIMER_TYPE = MEAS, it will not be automatically reset by the occurrence of a false-to-true transition of PV_D. Instead, it will continue to accumulate the "on" time or "run" time until being reset to 0 by a false-to-true transition on RESET_IN. OUT_REM is unused (set to 0.0) for this type of timer.



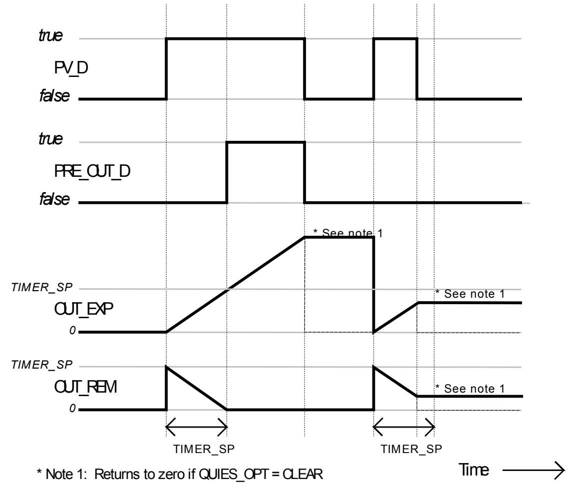
Timer Example when TIMER_TYPE = ACCUM

- If TIMER_TYPE is **COMPARE**, the block will measure the time since a false-to-true transition on the combined input, PV_D. The current duration will be indicated by OUT_EXP. OUT_REM will indicate the time remaining between the current expired duration, OUT_EXP, and the current limit, TIMER_SP. If OUT_EXP does not exceed TIMER_SP, PRE_OUT_D will be set to false. If OUT_EXP is equal to or exceeds TIMER_SP, PRE_OUT_D will be set to true and OUT_REM will be set to zero. When the combined input returns to false, whether exceeding the limits specified by TIMER_SP or not, OUT_D will be set to false. [Note that this type of behavior is the same as TIMER_TYPE = DELAY. The difference is only in the application perspective].



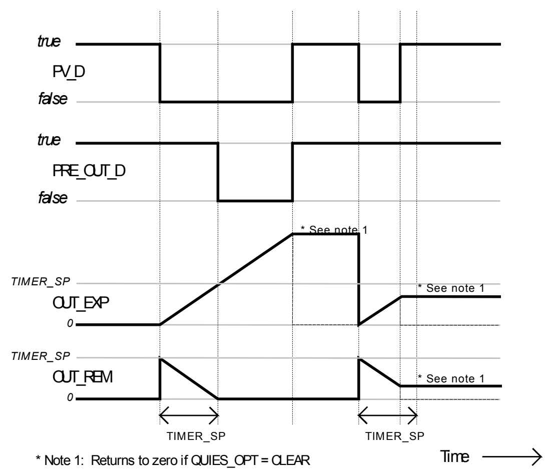
Timer Example when TIMER_TYPE = COMPARE

- If TIMER_TYPE is **DELAY**, a false-to-true transition on the combined input, PV_D, will be delayed at the output, PRE_OUT_D, until the time interval specified by TIMER_SP expires. If the combined input returns to false before the time expires, the output will remain as false, hiding the input transitions. If the PRE_OUT_D output is set to true because the time has expired, a true-to-false transition in the combined input will be indicated in PRE_OUT_D immediately. [Note that this type of behavior is the same as TIMER_TYPE = COMPARE. The difference is only in the application perspective].



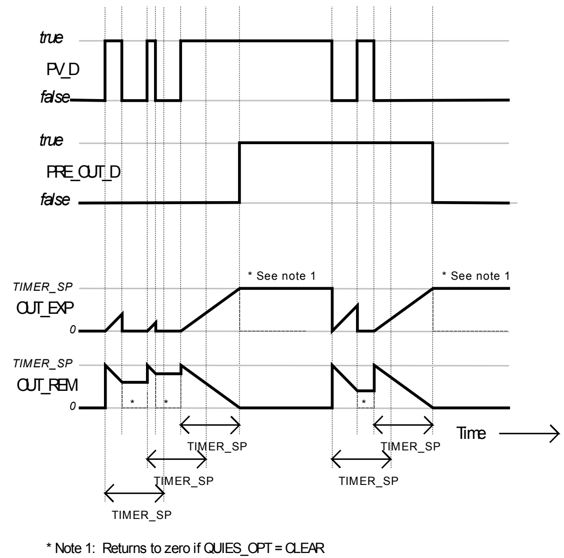
Timer Example when TIMER_TYPE = DELAY

- If TIMER_TYPE is **EXTEND**, a true-to-false transition on the combined input, PV_D, will be delayed at the output, PRE_OUT_D, until the time interval specified by TIMER_SP expires. If the combined input returns to true before the time expires, the output will remain as true, hiding the input transitions. If the PRE_OUT_D output is set to false because the time has expired, a false-to-true transition in the combined input will be indicated in PRE_OUT_D immediately.



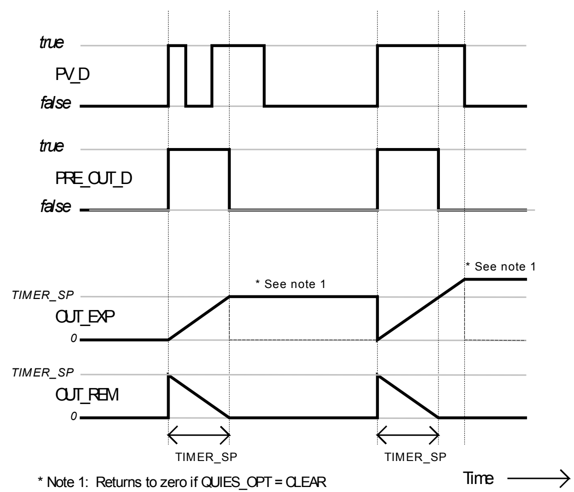
Timer Example when TIMER_TYPE = EXTEND

- If TIMER_TYPE is **DEBOUNCE**, and PRE_OUT_D is false, a false-to-true transition on the combined input, PV_D, will be delayed at the output, PRE_OUT_D, until the time interval specified by TIMER_SP expires. If the combined input returns to false before the time expires, the output will remain as false, hiding the input transitions. If PRE_OUT_D is true, a true-to-false transition on the combined input, PV_D, will be delayed at the output, PRE_OUT_D, until the time interval specified by TIMER_SP expires. If the combined input returns to true before the time expires, the output will remain as true, hiding the input transitions. In these cases, the true initializations will be delayed and the true endings will be extended, acting as a filter for intermittent state changes.



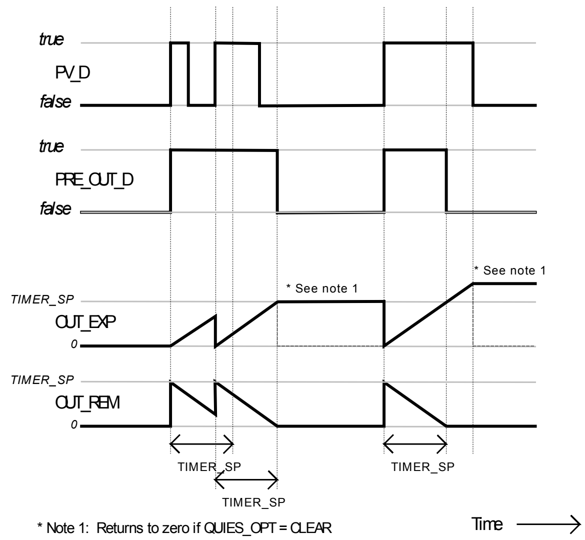
Timer Example when TIMER_TYPE = DEBOUNCE

- If TIMER_TYPE is **PULSE**, a false-to-true transition on the combined input, PV_D, will initiate a true pulse at PRE_OUT_D, and the duration is determined by the TIMER_SP value. At the end of the time interval, the output will return to false. Further false-to-true transitions of the combined input, while PRE_OUT_D is true, will be ignored.



Timer Example when TIMER_TYPE = PULSE

- If TIMER_TYPE is **RT_PULSE**, (Retriggerable pulse type) a false-to-true transition on the combined input, PV_D, will initiate a true pulse at PRE_OUT_D, and the duration is determined by the TIMER_SP value. At the end of this time interval, PRE_OUT_D will return to false. If the combined input returns to false and indicates a subsequent false-to-true transition while the timer is counted, the timer will be re-initialized and PRE_OUT_D will continue to be true.



Timer Example when TIMER_TYPE = RT_PULSE

RESET_IN is a discrete input that resets the timer on a false-to-true transition. OUT_EXP is set to 0.0, and then the timer executes the process described in "Initial Value Handling" for the values of PRE_OUT_D and OUT_REM. If RESET_IN is not connected, an operator/engineer can set it to true. In this case, the block logic will reset it to false on the next execution.

TIME_UNITS allows the user to specify the time units for the HMI where TIMER_SP, OUT_EXP and OUT_REM are displayed.

Each bit in INVERT_OPTS, when set, indicates that the corresponding input or output parameter with discrete status is inverted. That is, input values are inverted before being used by the block and outputs are inverted after the value is determined by the block.

Initialization

The following table summarizes the values of PRE_OUT_D, OUT_EXP and OUT_REM after the initial execution, as a function of TIMER_TYPE and the initial value of the combined input, PV_D:

TIMER_TYPE	PV_D	PRE_OUT_D	OUT_EXP	OUT_REM	Timer Status
MEASURE	False	False	0.0	0.0	Inactive
MEASURE	True	True	0.0	0.0	Inactive
ACCUM	False	False	0.0	0.0	Inactive
ACCUM	True	True	0.0	0.0	Inactive
COMPARE	False	False	TIMER_SP †	0.0	Inactive
COMPARE	True	False	0.0	TIMER_SP †	Active
DELAY	False	False	TIMER_SP †	0.0	Inactive
DELAY	True	False	0.0	TIMER_SP †	Active
EXTEND †	False	True	0.0	TIMER_SP †	Active
EXTEND	True	True	TIMER_SP †	0.0	Inactive
DEBOUNCE†	False	False	TIMER_SP †	0.0	Inactive
DEBOUNCE	True	True	TIMER_SP †	0.0	Inactive
PULSE I	False	False	0.0	0.0	Inactive
PULSE n	True	False	TIMER_SP †	0.0	Inactive
RT_PULSE i	False	False	0.0	0.0	Inactive
RT_PULSE c	True	False	TIMER_SP †	0.0	Inactive

† Initialize the TIMER_SP value if QUIES_OPT = LAST, initialize with 0.0 if QUIES_OPT = CLEAR.

BLOCK_ERR

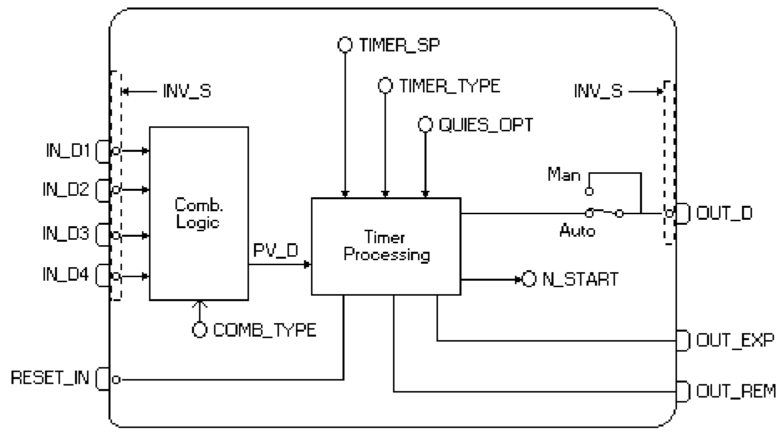
The BLOCK_ERR of the TIME block will reflect the following causes:

- Block Configuration Error – the configuration error occurs when the TIME_UNITS or QUIES_OPT parameters have an invalid value.
- Out of Service – it occurs when the block is in O/S mode.

Supported Modes

O/S, MAN and AUTO.

Schematic



Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	MODE_BLK Actual=3xx.xx0 Target/Manual=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	BLOCK_ERR 3xx.xx1	Bitstring(2)			E	D/RO	This is the timer interval used by the timer block for delay, extension, oscillation, and pulse time-processing.
7	PV_D 3xx.xx2 – 3xx.xx3	DS-66				D/RO	The primary discrete value being used to execute the function or a process value associated to it.
8	OUT_D 4xx.xx5 – 4xx.xx6	DS-66				D	The primary discrete value calculated as a result of the function execution.
9	TIMER_SP 4xx.xx7 – 4xx.x08	Float	Positive	0	Sec	S	
10	PV_STATE 4xx.x09	Unsigned16		0		S	Index of the text that describe the status of a discrete PV.
11	OUT_STATE 4xx.x10	Unsigned16		0		S	Index of the text that describe the status of a discrete output.
12	GRANT_DENY 4xx.x11 – 4xx.x12	DS-70		0	Na	D	Options for controlling the access of the host computer and local control panels to the operation, tune and alarm parameters of the block.
13	INVERT_OPTS 4xx.x13	Bitstring(2)	See Block Options.	0	Na	S / O/S	See Block Options.
14	STATUS_OPTS 4xx.x14	Bitstring(2)	See Block Options.	0	Na	S / O/S	See Block Options.
15	IN_D1 4xx.x15 - 4xx.x16	DS-66				D	Discrete input 1.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
16	IN_D2 4xx.x17 - 4xx.x18	DS-66				D	Discrete input 2.
17	IN_D3 4xx.x19 - 4xx.x20	DS-66				D	Discrete input 3.
18	IN_D4 4xx.x21 - 4xx.x22	DS-66				D	Discrete input 4.
19	COMB_TYPE 4xx.x23	Unsigned8	0=AND 1=OR 2=ANY2 3=ANY3 21=EXACTLY1 22=EXACTLY2 23=EXACTLY3 40=EVEN 41=ODD	1	E	S	Determine how the multiple values of IN_D[i] are combined.
20	TIMER_TYPE 4xx.x24	Unsigned8	0=MEASURE 1=ACCUM 2=COMPARE 3=DELAY 4=EXTEND 5=DEBOUNCE 6=PULSE 7=RT_PULSE	0	E	S	Type of the time-processing applied to PV_D to determine the PRE_OUT_D.
21	PRE_OUT_D 4xx.x25 - 4xx.x26	DS-66				D	This parameter is the combined output and the time processed by the timer block.
22	N_START 4xx.x27	Unsigned16			None	D	Counts *false*-to-*true* transitions in the combined input, PV_D. Reset by the *false*-to-*true* transition of RESET_IN.
23	OUT_EXP 3xx.xx4 - 3xx.xx6	DS-65			Sec	N / RO	This is the time expired. Stops when TIMER_SP is reached. Reset to zero (1) by RESET_IN, (2) in the next timer event if QUIES_OPT = LAST, or (3) when the block becomes quiescent if QUIES_OPT = CLEAR.
24	OUT_REM 3xx.xx7 - 3xx.xx9	DS-65			Sec	N / RO	This is the time remaining if the timer is active. Stops when event ends (block becomes quiescent). Reset to 0.0 if QUIES_OPT = CLEAR, and the timer is inactive.
25	RESET_IN 4xx.x28 - 4xx.x29	DS-66	0=Off 1=Reset				Resets the timer.
26	QUIES_OPT 4xx.x30	Unsigned8	1=CLEAR 2=LAST	0	E	S / O/S	Mode of OUT_EXP and OUT_REM during quiescence. CLEAR resets the parameters to zero. LAST keeps the last values of the parameters.
27	TIME_UNITS 4xx.x31	Unsigned8	1=seconds 2=minutes 3=hours 4=days 5=[day-[hr:[min[:sec]]]]	0	E	S	Displays the Time Units for TIMER_SP, OUT_EXP, and OUT_REM:
28	UPDATE_EVT 3xx.x10 - 3xx.x16 4xx.x32	DS-73			na	D	This alert is generated by any changes to the static data.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
29	BLOCK_ALM 3xx.x17 - 3xx.x23 4xx.x33	DS-72			na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O- Output Parameter
AA- Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

If the BEHAVIOR parameter is configured as “Adapted”:
The default value of TIME_UNITS is “Seconds”.
The default value of QUIES_OPT is “CLEAR”.

MBCF – ModBus Configuration

Overview
This block configures the communication parameters of the Modbus protocol.

Description
This block configures the communication parameters between the HFC302 and the Modbus slave devices through the Ethernet and serial ports (EIA-232). The user defines the data transference rate of the serial ports, the parity, timeout and the number of re-transmissions.

NOTE
Every time a MODBUS parameter is changed, it is necessary to set the ON_APPLY parameter of the MBCF block to "Apply". Otherwise, these changes won't be applied.

The user must set ONLY one MBCF block for each device.

MODBUS Addresses
The user must attribute a Modbus address to the HFC302. However, this address cannot be the same of any other device connected to the Modbus network through the serial or Ethernet ports. In this case, the user must set the parameter DEVICE_ADDRESS. The default value of this parameter is 247.

In applications where the HFC302 operates as a master TCP/IP, the user should also inform the IP address of the devices in the parameter SLAVE_ADRESSES.

Parameters MASTER_SLAVE and MEDIA
These parameters set the mode and the communication of the HFC302. The MASTER_SLAVE parameter defines if the HFC302 will operate as a slave or master MODBUS device. The MEDIA parameter can be serial or TCP/IP. It is necessary that the DEVICE_ADDRESS is unique in the MODBUS network.

Transference Rate of the serial ports
It is possible to select the baud rate of the serial ports. The baud rate is configured by the parameter BAUD_RATE. The following values are available:

- 0:100 bps
- 1:300 bps
- 2:600 bps
- 3:1200 bps
- 4:2400 bps
- 5:4800 bps
- 6:9600 bps(Default)
- 7:19200 bps

Parity
The PARITY parameter defines the type or the parity of the serial ports.
- 0: Even Parity (Default)
- 1: Odd parity
- 2: No parity

Timeout and number of re-transmissions
Timeout is the time interval that the controller will wait for an answer from a slave after a message is sent to the serial port or Ethernet. The default value is 1000 ms. This parameter is directly connected to the parameter NUMBER_RETRANSMISSIONS.

The number of re-transmissions is the number of times that the HFC302 will retry to establish the communication with the slave device when a reply is not obtained. The time interval to wait for this answer is set by the TIME_OUT parameter. The number of re-transmissions is configured by the NUMBER OF RETRANSMISSIONS parameter. The user can select a value from 0 to 255 for this parameter. The default value is 1.

Parameters

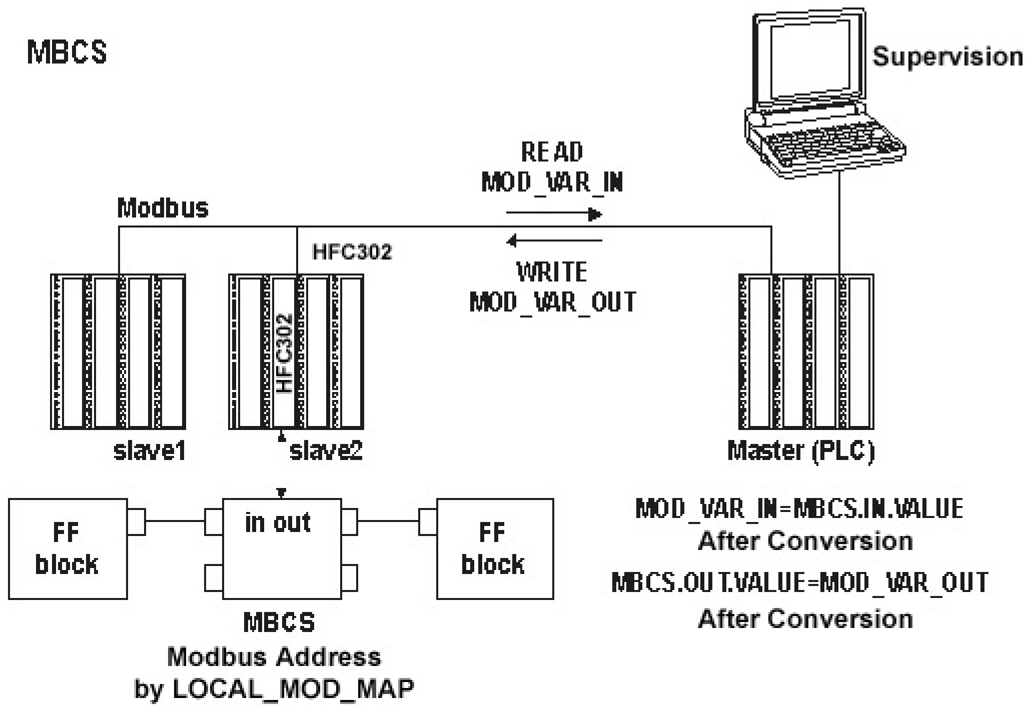
Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Manual=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	BItString(2)			E	D / RO	
7	**MEDIA** 4xx.xx5	Unsigned8	0:Serial	Serial	E	S / RO	Defines the type of Modbus channel.
8	**MASTER_SLAVE** 4xx.xx6	Unsigned8	0:Master, 1:Slave	Slave	E	S	Defines if the HFC302 is a master or slave.
9	**DEVICE_ADDRESS** 4xx.xx7	Unsigned8	1-247	1	E	S	Defines the HFC302 Modbus address (only for the HFC302 slave).
10	**BAUD_RATE** 4xx.xx8	Unsigned8	0:110, 1:300, 2:600, 3:1200, 4:2400, 5:4800, 6:9600, 7:19200	9600	E	S	Defines the baud rate (only for serial communication).
11	**STOP_BITS** 4xx.xx9	Unsigned8	0:1, 1:2	1	E	S	Defines the number of stop bits (only for serial communication).
12	**PARITY** 4xx.x10	Unsigned8	0: even, 1: odd, 2: none.	Even	E	S	Defines the parity (only for serial communication).
13	**TIMEOUT** 4xx.x11	Unsigned16	0-65535	1000	ms	S	Time interval that the HFC302 master will wait for an answer from a slave or the time interval that the HFC302 slave will wait until the OUTs are updated.
14	NUMBER_RETRANSMISSIONS 4xx.x12	Unsigned8	0-255	1		S	Number of re-transmissions if the HFC302 doesn't receive an answer from the slave.
15	SLAVE_ADDRESSES 4xx.x13 - 4xx.x66	DS-263				S	IP number and modbus addresses of the slaves (only for HFC302 master in the TCP/IP communication).
16	RESTART_MODBUS 4xx.x67	Boolean		FALSE		S	Indicates if there will be a new transmission after the communication with the slave fails, after the time defined in TIME_TO_RESTART (only for HFC302 master).
17	TIME_TO_RESTART 4xx.x68	Unsigned16	1-65535	1	s	S	When the device is operating as a master, it is the time interval between the periodic scan of the commands.
18	RTS_CTS 4xx.x69	Boolean	0=False 0xff =True	FALSE		S	Enables (True) or disables (False) the inversion of registers for variables such as Integer32 and Float types. This feature is applied to all blocks MBSS, MBSM.FVALUE and MBSM.IVALUE and all blocks of HFC302.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
19	**ON_APPLY** 4xx.x70	Unsigned16	0:None, 1: Apply	None	E	S	Apply the changes made in the modbus blocks.
20	CHECK_COMM_STAN DBY 4xx.x71	Unsigned8	0-255	0	Na	S/RW	This parameter is configured to Standby if the communcation test was performed between slave equipment in the TCP. 0: Disables the test. 1 – 255: Enables the test setting the time between each test. (s).

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

MBCS – Modbus Control Slave

Overview



Description
The MBCS block generates a communication strategy between a MODBUS master and a FOUNDATION FIELDBUS slave. In this case, the Smar's linking device HFC302 operates as the slave of the MODBUS network. It allows MODBUS variables to be associated with FIELDBUS variables, and data will be exchanged between these two protocols through the HFC302.

NOTE
Every time a MODBUS parameter is changed, it is necessary to set the ON_APPLY parameter of the MBCF block to "Apply". Otherwise, these changes won't be applied.

Inputs and Outputs
This block has 4 digital inputs, 4 analog inputs, 4 digital outputs and 4 analog outputs, that can be connected to other FIELDBUS function blocks or to the MODBUS protocol.

- IN1, IN2, IN3 and IN4 are analog inputs.
- IN_D1, IN_D2, IN_D3 and IN_D4 are digital inputs.
- OUT1, OUT2, OUT3 and OUT4 are analog outputs.
- OUT_D1, OUT_D2, OUT_D3 and OUT_D4 are digital outputs.

Digital outputs and inputs are DS-66 data type. Both inputs and outputs have a Status and a value (both Unsigned 8). The analog outputs and inputs are DS-65 data type, and also have status and value. The type of the values is Float.

Parameter LOCAL_MOD_MAP
This parameter defines the address range of the MODBUS addresses attributed to the input and output FIELDBUS variables of the MBCS block. Check the table below to configure this parameter properly:

LOCAL_MOD_MAP (MBCS)		
PARAMETER	LOCAL_MOD_MAP = x OFFSET = 40 * x x = 0 ~ 15	e.g. LOCAL_MOD_MAP =1
IN1-Value	40001+ OFFSET 40002+ OFFSET	40041 40042
IN2-Value	40003+ OFFSET 40004+ OFFSET	40043 40044
IN3-Value	40005+ OFFSET 40006+ OFFSET	40045 40046
IN4-Value	40007+ OFFSET 40008+ OFFSET	40047 40048
OUT1-Value	40009+ OFFSET 40010+ OFFSET	40049 40050
OUT2-Value	40011+ OFFSET 40012+ OFFSET	40051 40052
OUT3-Value	40013+ OFFSET 40014+ OFFSET	40053 40054
OUT4-Value	40015+ OFFSET 40016+ OFFSET	40055 40056
IN1-Status	40017+ OFFSET	40057
IN2-Status	40018+ OFFSET	40058
IN3-Status	40019+ OFFSET	40059
IN4-Status	40020+ OFFSET	40060
OUT1-Status	40021+ OFFSET	40061
OUT2-Status	40022+ OFFSET	40062
OUT3-Status	40023+ OFFSET	40063
OUT4-Status	40024+ OFFSET	40064
IN_D1-Status	40025+ OFFSET	40065
IN_D2-Status	40026+ OFFSET	40066
IN_D3-Status	40027+ OFFSET	40067
IN_D4-Status	40028+ OFFSET	40068
OUT_D1-Status	40029+ OFFSET	40069
OUT_D2-Status	40030+ OFFSET	40070
OUT_D3-Status	40031+ OFFSET	40071
OUT_D4-Status	40032+ OFFSET	40072
IN_D1-Value	1+ OFFSET	41
IN_D2-Value	2+ OFFSET	42
IN_D2-Value	3+ OFFSET	43
IN_D2-Value	4+ OFFSET	44
OUT_D1-Value	5+ OFFSET	45
OUT_D2-Value	6+ OFFSET	46
OUT_D3-Value	7+ OFFSET	47
OUT_D4-Value	8+ OFFSET	48

In this table, note that:
LOCAL_MOD_MAP= X
OFFSET = 40*X

The second column of the table above shows the values attributed to the Inputs and Outputs of the MBCS block, according to the value set to LOCAL_MOD_MAP. For example, if LOCAL_MOD_MAP is equal to 1, the MODBUS range of addresses will be the result showed in the third column. It is important to note that when this parameter is configured, a whole range is selected, not only a specific address.

INn and OUTn values use two MODBUS registers (for example IN1 = 40041 and 40042 for LOC_MOD_MAP=1) because the data type is float. IN_Dn and OUT_Dn values use one MODBUS register (for example IN_D1, 41). Status values also use only one register.

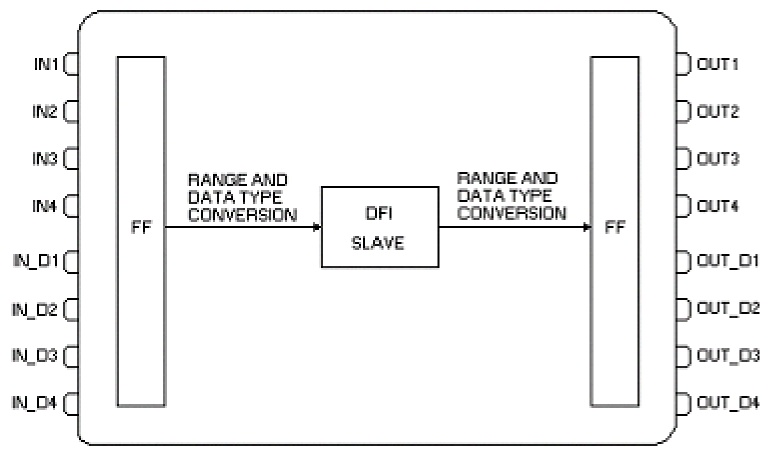
Once this MODBUS range is defined, it is possible to configure how the MODBUS master will read the data.

This block has Modbus Scale Conversion, to execute the conversion procedure, refer to the item "View 1 – MBCS" in the chapter 13 for further details.

Output Status

If the OUTs are not updated by the Modbus Master in a time interval specified by the user (parameter TIMEOUT in MBCF), a "bad status" will be generated. If TIMEOUT < Macrocycle, TIMEOUT = Macrocycle. Once all parameters are configured as mentioned above, it will be possible to use the parameters in the control strategy. The MODBUS master will be able to read all the MBCS inputs and outputs, connected by the user, reading the values from the DF I/O modules and sending to the MODBUS master, or configuring the values in the MODBUS master and sending them to the DF I/O modules. Each input and output are associated to the MODBUS addresses and the MODBUS master is able to read their values from the address DEVICE_ADDRESS (configured by the MBCF block) and from the specific MODBUS address (configured by this block).

Schematic



BLOCK_ERR

The BLOCK_ERR of the MBCS block will indicate the following causes:

- Other: occurs when the conversion from Y to DATA_TYPE_IN results in a value out of range for this data type;
- Out of Service: when the block is in O/S mode.

Parameters

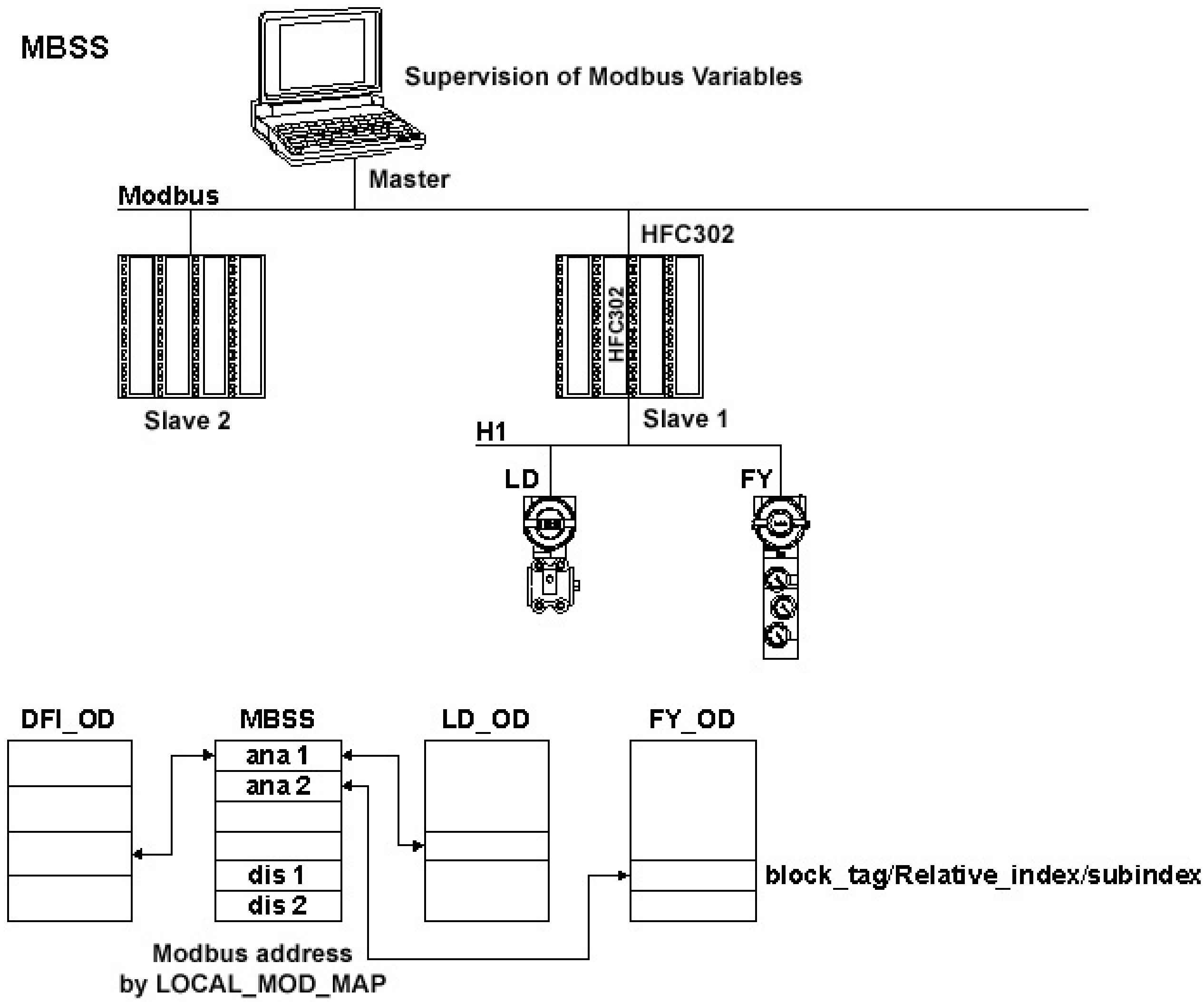
Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D / RO	
7	**LOCAL_MOD_MAP** 4xx.xx5	Unsigned8	0 to 15	0		S / O/S	Defines the modbus addresses.
8	IN1 4xx.xx6 - 4xx.xx8	DS-65				N	Analog input 1.
9	SCALE_CONV_IN1 4xx.xx9 - 4xx.x17	DS-256				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B.
10	IN2 4xx.x18 - 4xx.x20	DS-65				N	Analog input 2.
11	SCALE_CONV_IN2 4xx.x21 - 4xx.x29	DS-256				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B.
12	IN3 4xx.x30 - 4xx.x32	DS-65				N	Analog input 3.
13	SCALE_CONV_IN3 4xx.x33 - 4xx.x41	DS-256				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B.
14	IN4 4xx.x42 - 4xx.x44	DS-65				N	Analog input 4.
15	SCALE_CONV_IN4 4xx.x45 - 4xx.x53	DS-256				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B.
16	IN_D1 4xx.x54 - 4xx.x55	DS-66				N	Discrete input 1.
17	IN_D2 4xx.x56 - 4xx.x57	DS-66				N	Discrete input 2.
18	IN_D3 4xx.x58 - 4xx.x59	DS-66				N	Discrete input 3.
19	IN_D4 4xx.x60 - 4xx.x61	DS-66				N	Discrete input 4.
20	OUT1 4xx.x62 - 4xx.x64	DS-65				N / Man	Analog output 1.
21	SCALE_CONV_OUT1 4xx.x65 - 4xx.x74	DS-257				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B and the output status.
22	OUT2 4xx.x75 - 4xx.x77	DS-65				N / Man	Analog output 2.
23	SCALE_CONV_OUT2 4xx.x78 - 4xx.x87	DS-257				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B and the output status.
24	OUT3 4xx.x88 - 4xx.x90	DS-65				N / Man	Analog output 3.
25	SCALE_CONV_OUT3 4xx.x91 - 4xx.100	DS-257				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B and the output status.
26	OUT4 4xx.101 - 4xx.103	DS-65				N / Man	Analog output 4.
27	SCALE_CONV_OUT4 4xx.104 - 4xx.113	DS-257				S / O/S	Information to generate the constants A and B in the equation Y=A*X+B and the output status.
28	OUT_D1 4xx.114 - 4xx.115	DS-66				N / Man	Discrete output 1.
29	STATUS_OUT_D1 4xx.116	Unsigned8				S / O/S	Status of OUT_D1 if the master is not updated.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
30	OUT_D2 4xx.117 - 4xx.118	DS-66				N / Man	Discrete output 2.
31	STATUS_OUT_D2 4xx.119	Unsigned8				S / O/S	Status of OUT_D2 if the master is not updated.
32	OUT_D3 4xx.120 - 4xx.121	DS-66				N / Man	Discrete output 3
33	STATUS_OUT_D3 4xx.122	Unsigned8				S / O/S	Status of OUT_D3 if the master is not updated.
34	OUT_D4 4xx.123 - 4xx.124	DS-66				N / Man	Discrete output 4.
35	STATUS_OUT_D4 4xx.125	Unsigned8				S / O/S	Status of OUT_D4 if the master is not updated.
36	UPDATE_EVT 3xx.xx2 - 3xx.xx8 4xx.126	DS-73			Na	D	This alert is generated by any changes to the static data.
37	BLOCK_ALM 3xx.xx9 - 3xx.x15 4xx.127	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

MBSS – Modbus Supervision Slave

Overview



Description
The MBSS block generates a communication strategy between a MODBUS master and a FOUNDATION FIELDBUS slave. In this case, the Smar's linking device HFC302 operates as the slave of the MODBUS network. The MBSS block allows the FIELDBUS variables to be monitored. Unlike the MBCS block, the MBSS doesn't have inputs or outputs to be connected. In other words, links to other function blocks can not be created. This block only allows the MODBUS master to monitor specific configured variables. For example, suppose that there is a PID function block in a FIELDBUS control strategy and it is necessary to display this value in the MODBUS master. The MBSS block will monitor this value.

NOTE
Every time a MODBUS parameter is changed, it is necessary to set the ON_APPLY parameter of the MBCF block to "Apply". Otherwise, these changes won't be applied.

I_IDn, F_IDn, B_IDn Parameters
I_IDn are integer variables, F_IDn are float variables and D_IBn refers to boolean variables. These parameters are DS-262 data type. This data type has 3 elements:

√ Block Tag: Indicates the Tag of the block that contains the variable to be displayed. For example, if the user needs to monitor the gain of the PID block, include the Tag of the PID block containing the "gain" parameter to be displayed in the MODBUS master.

√ Relative Index: Every parameter of a function block has this index. The relative index is indicated in the first column of all parameter tables for function blocks. Include the number of the relative index in the parameter to be monitored. In the example above, the relative index to monitor the gain parameter of the PID function block is 23.

√ Sub Index: The sub index is used for parameters that have a structure. In this case, it is necessary to indicate which element of the structure is being referred.

LOCAL_MOD_MAP Parameter
This parameter will attribute the MODBUS address to the variables to be monitored. See the table below:

LOCAL_MOD_MAP (MBSS)		
PARAMETER	LOCAL_MOD_MAP = x OFFSET = 40 * x x = 0 ~ 15	e.g. LOCAL_MOD_MAP =1
FVALUE1	42601+ OFFSET 42602+ OFFSET	42641 42642
FVALUE2	42603+ OFFSET 42604+ OFFSET	42643 42644
FVALUE3	42605+ OFFSET 42606+ OFFSET	42645 42646
FVALUE4	42607+ OFFSET 42608+ OFFSET	42647 42648
FVALUE5	42609+ OFFSET 42610+ OFFSET	42649 42650
FVALUE6	42611+ OFFSET 42612+ OFFSET	42651 42652
FVALUE7	42613+ OFFSET 42614+ OFFSET	42653 42654
FVALUE8	42615+ OFFSET 42616+ OFFSET	42655 42656
IVALUE1	42617+ OFFSET 42618+ OFFSET	42657 42658
IVALUE2	42619+ OFFSET 42620+ OFFSET	42659 42660
IVALUE3	42621+ OFFSET 42622+ OFFSET	42661 42662
IVALUE4	42623+ OFFSET 42624+ OFFSET	42663 42664
BVALUE1	2601+ OFFSET	2641
BVALUE2	2602+ OFFSET	2642
BVALUE3	2603+ OFFSET	2643
BVALUE4	2604+ OFFSET	2644
BAD_STATUS	42625+OFFSET	42665

LOCAL_MOD_MAP= X
OFFSET = 40*X

Once the values for LOCAL_MOD_MAP are set, the MODBUS ADDRESSES are assigned to the variables that will be monitored. Each integer, float or Boolean variable will have an associated MODBUS address.

For example, suppose that LOCAL_MOD_MAP = 1 and a float value will be monitored. Selecting F_ID1 and configuring the parameters, the user will have:

F_ID1.Tag = Tag of the block to be monitored.
F_ID1.Index= Index of the parameter to be monitored.

F_ID1.subindex = The subindex is used by the parameters that have a structure. In this case, it is necessary to indicate which element of the structure is being referred.

See the table above. The MODBUS addresses assigned to this parameter (remember that float values use two MODBUS registers) are 42641 and 42642.

BAD_STATUS Parameter
It indicates if the Fieldbus communication is OK. If the corresponding bit is in the logic level 1, so there was an errror during the reading/writing of the parameter. The table below shows the status values.

Relation between the BAD_STATUS bits and Modbus addresses

BIT	VARIABLE
0	FVALUE1
1	FVALUE2
2	FVALUE3
3	FVALUE4
4	FVALUE5
5	FVALUE6
6	FVALUE7
7	FVALUE8
8	IVALUE1
9	IVALUE2
10	IVALUE3
11	BVALUE4
12	BVALUE1
13	BVALUE2
14	BVALUE3
15	BVALUE4

BLOCK_ERR
The BLOCK_ERR of the MBSS block will indicate the following causes:

- Block Configuration Error: If the tag requested has a data type that is not permitted, or it is invalid, or the block tag was not found;
- Out of Service: when the block is in O/S mode.

Remarks
The BVALUEx parameters can address FF block parameters for the following data types: boolean, integer8 and unsigned8. These data types are automatically converted to a bit (0 or 1) and vice versa, for Modbus supervision and, also, they can be converted to a boolean parameter (BVALUEx).

The IVALUEx parameters can address FF block parameters for the following data types: Integer8, Integer16, Integer32, Unsigned8, Unsigned16 and Unsigned32.

Each analog parameter (IVALUEx) is mapped as two Modbus analog registers, that is, four bytes. When addressing a FF block parameter with one or two bytes, this parameter will change to Unsigned32 or Integer32.

If the Relative Index is 5 (MODE_BLK) e the Sub Index is 0, a writing will be execute in Sub Index 1 and a reading in Sub Index 2.

Parameters

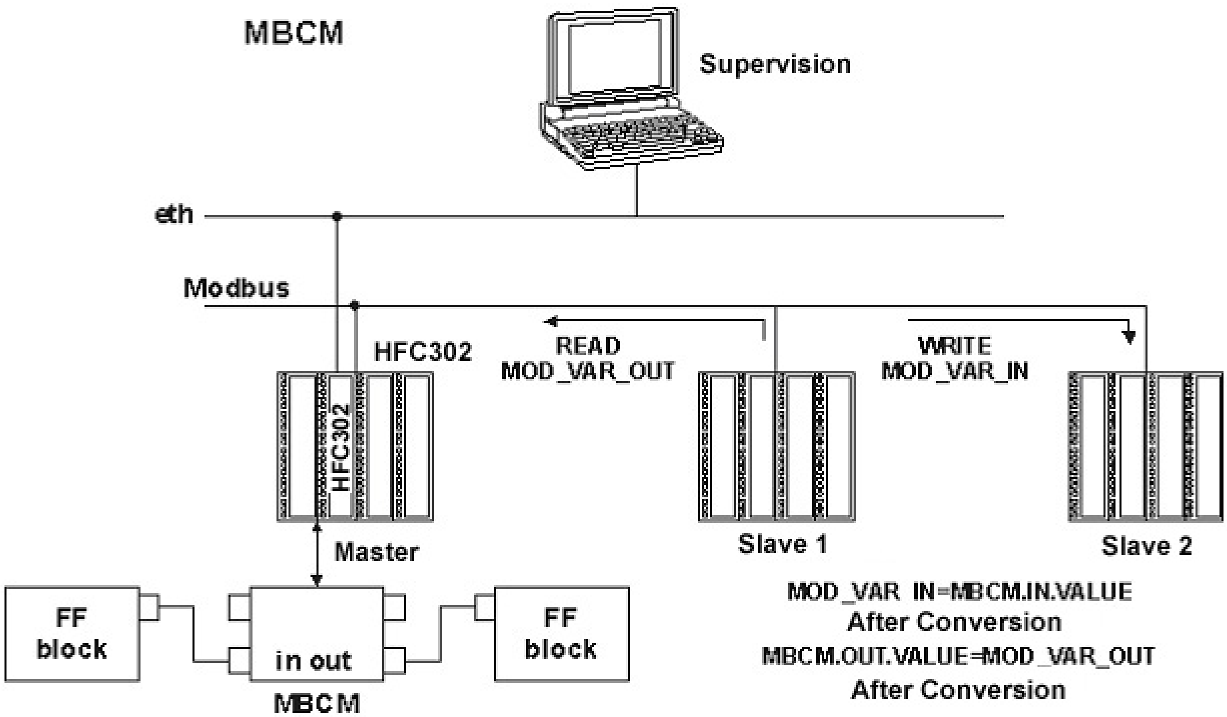
Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D / RO	
7	**LOCAL_MOD_MAP** 4xx.xx5	Unsigned8	0 to 15	0		S / O/S	Defines the modbus addresses.
8	F_ID1 4xx.xx6 - 4xx.x23	DS-262				S / O/S	Information to locate the float parameter (FVALUE1).
9	**FVALUE1** 4xx.x24 - 4xx.x25	Float		0		N	Value of the requested float parameter.
10	F_ID2 4xx.x26 - 4xx.x43	DS-262				S / O/S	Information to locate the float parameter (FVALUE2).
11	**FVALUE2** 4xx.x44 - 4xx.x45	Float		0		N	Value of the requested float parameter.
12	F_ID3 4xx.x46 - 4xx.x63	DS-262				S / O/S	Information to locate the float parameter (FVALUE3).
13	**FVALUE3** 4xx.x64 - 4xx.x65	Float		0		N	Value of the requested float parameter.
14	F_ID4 4xx.x66 - 4xx.x83	DS-262				S / O/S	Information to locate the float parameter (FVALUE4).
15	**FVALUE4** 4xx.x84 - 4xx.x85	Float		0		N	Value of the requested float parameter.
16	F_ID5 4xx.x86 - 4xx.103	DS-262				S / O/S	Information to locate the float parameter (FVALUE5).
17	FVALUE5 4xx.104 - 4xx.105	Float		0		N	Value of the requested float parameter.
18	F_ID6 4xx.106 - 4xx.123	DS-262				S / O/S	Information to locate the float parameter (FVALUE6).
19	FVALUE6 4xx.124 - 4xx.125	Float		0		N	Value of the requested float parameter.
20	F_ID7 4xx.126 - 4xx.143	DS-262				S / O/S	Information to locate the float parameter (FVALUE7).
21	FVALUE7 4xx.144 - 4xx.145	Float		0		N	Value of the requested float parameter
22	F_ID8 4xx.146 - 4xx.163	DS-262				S / O/S	Information to locate the float parameter (FVALUE8).
23	FVALUE8 4xx.164 - 4xx.165	Float		0		N	Value of the requested float parameter.
24	I_ID1 4xx.166 - 4xx.183	DS-262				S / O/S	Information to locate the integer parameter (IVALUE1).

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
25	**IVALUE1** 4xx.184 - 4xx.185	Integer32		0		N	Value of the requested integer parameter.
26	I_ID2 4xx.186 - 4xx.203	DS-262				S / O/S	Information to locate the integer parameter (IVALUE2).
27	**IVALUE2** 4xx.204 - 4xx.205	Integer32		0		N	Value of the requested integer parameter.
38	I_ID3 4xx.206 - 4xx.223	DS-262				S / O/S	Information to locate the integer parameter (IVALUE3).
29	**IVALUE3** 4xx.224 - 4xx.225	Integer32		0		N	Value of the requested integer parameter.
30	I_ID4 4xx.226 - 4xx.243	DS-262				S / O/S	Information to locate the integer parameter (IVALUE4).
31	**IVALUE4** 4xx.244 - 4xx.245	Integer32		0		N	Value of the requested integer parameter.
32	B_ID1 4xx.246 - 4xx.263	DS-262				S / O/S	Information to locate the boolean parameter (BVALUE1).
33	**BVALUE1** 4xx.264	Boolean		TRUE		N	Value of the requested boolean parameter.
34	B_ID2 4xx.265 - 4xx.282	DS-262				S / O/S	Information to locate the boolean parameter (BVALUE2).
35	**BVALUE2** 4xx.283	Boolean		TRUE		N	Value of the requested boolean parameter.
36	B_ID3 4xx.284 - 4xx.301	DS-262				S / O/S	Information to locate the boolean parameter (BVALUE3).
37	**BVALUE3** 4xx.302	Boolean		TRUE		N	Value of the requested boolean parameter.
38	B_ID4 4xx.303 - 4xx.320	DS-262				S / O/S	Information to locate the boolean parameter (BVALUE4).
39	**BVALUE4** 4xx.321	Boolean		TRUE		N	Value of the requested boolean parameter.
40	UPDATE_EVT 3xx.xx2 - 3xx.xx8 4xx.322	DS-73			Na	D	This alert is generated by any changes to the static data.
41	BLOCK_ALM 3xx.xx9 - 3xx.x15 4xx.323	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.
42	BAD_STATUS 3xx.x16	BitString			E	D/RO	This parameter indicates the status of the corresponding variable.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

MBCM – Modbus Control Master

Overview



Description
This block controls the communication in a strategy where the HFC302 is a MODBUS master and the slaves can exchange data among them and with the HFC302. With this block, it is not only possible to read the MODBUS variables, but also to write to the variables in the MODBUS protocol, exchange data and communicate with the FOUNDATION fieldbus control strategy.

NOTE
Every time a MODBUS parameter is changed, it is necessary to set the ON_APPLY parameter of the MBCF block to “Apply”. Otherwise, these changes won't be applied.

LOCAL_MOD_MAP Parameter
All MBCM blocks added to the strategy must have different values in the LOCAL_MOD_MAP parameter. Otherwise, the block will not operate properly.

Inputs and Outputs
This block has 4 digital inputs, 4 digital outputs, 4 analog inputs and 4 analog outputs. These inputs and outputs can be connected to other FIELDBUS function blocks and then connected to the MODBUS I/O modules or registers.

- INn: Analog input. DS-65 Data type. Value and Status. In this parameter, the value of the parameter configured for this input and its status will be displayed.
- IN_Dn: Digital input. DS-66 Data type. Value and Status. In this parameter, the value of the parameter configured for this input and its status will be displayed.
- OUTn: Analog output. DS-65 Data type. Value and Status. In this parameter, the value of the parameter configured for this output and its status will be displayed.
- OUT_Dn: Digital output. DS-66 Data type. Value and Status.In this parameter, the value of the parameter configured for this output and its status will be displayed.

SCALE_LOC_INn and SCALE_LOC_OUTn
These parameters are DS-259 data type. The INn and OUTn inputs and outputs are associated to the SCALE_LOC_INn and SCALE_LOC_OUTn parameters. It is necessary to configure these parameters to monitor and exchange data properly.

Each of these parameters consist of the following elements:
√ From EU 100%;
√ From EU 0%;
√ To EU 100%;
√ To EU 0%;
√ Data Type;
√ Slave Address;
√ MODBUS Address Of Value;
√ Modbus Address of Status;

This block allows Modbus scale conversion. To execute the conversion procedure, refer to the item "View 3 - MBCM" in the chapter 13 for further details.

The following table shows the input/output treatment:

Input/Output	Configured Status (MODBUS_A.DDRESS_OF_STATUS ≠ 0)	Non-Configured Status (MODBUS_ADDRESS_OF_STATUS = 0)
Inputs (IN_n , IN_Dn)	The block sends to the device the status corresponding to the input of the Modbus slave. (The status follows the FF standard format).	No status information is sent to the slave device.
Outputs (OUT_n, OUT_Dn)	The block reads the corresponding status from the slave device. (The block assumes that the Modbus variable follows the same format of the FF Status).	The block updates the status to "Good Non Cascade" when the communication with the Modbus slave device is ok. - The block updates the status to "Bad No Communication with last value" when the communication with the Modbus slave device is not ok.

Float values use two MODBUS registers, but it is necessary to inform only the first one.

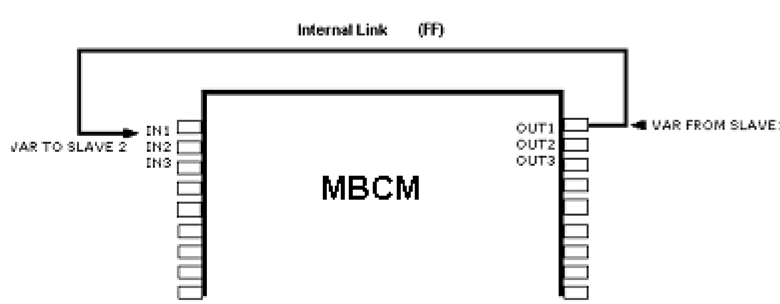
Setting inputs and outputs of the MBCM block
To read a MODBUS variable, connect the variable to an output of the MBCM function block. To write to a MODBUS register connect the register to an input of the MBCM block.

Usually, MODBUS address are:
The Modbus protocol standards specifies the division of the address range for the variables.

- 0001 to 9999 => Digital Outputs;
- 10001 to 19999 => Digital Inputs;
- 30001 to 39999 => Analog Inputs;
- 40001 to 49999 => Analog Outputs.

Once the variables that need to be mapped are defined and referenced in the MBCM block, the user can configure the strategy.

Connect the variables to other FIELDBUS function blocks (Connect the block output or input to other blocks in the strategy), to write to the MODBUS registers (Connect the MBCM block input to a MODBUS register). To exchange data between two slaves, configure the input of the MBCM block with the slave address and specify the MODBUS address where the value will be written; configure the output of the MBCM block with the slave address and the MODBUS address of the variable where the value will be read. See the application below:



BAD_STATUS Parameter
This parameter indicates if the communication between the slaves was established properly. If the corresponding bit is at logic level 1, it indicates that there was an error during the writing/reading of the respective parameter. The table below shows the values for these status.

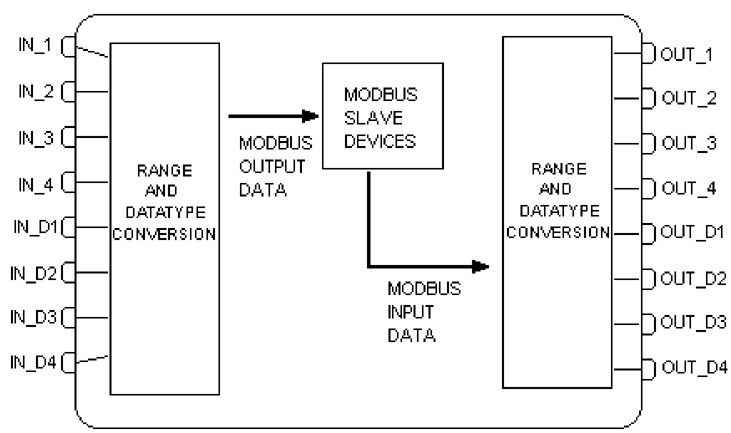
Relation between bits in BAD_STATUS and Modbus addresses

BIT	VARIABLE
0	N1
1	IN2
2	IN3
3	IN4
4	IN_D1
5	IN_D2
6	IN_D3
7	IN_D4
8	OUT1
9	OUT2
10	OUT3
11	OUT4
12	OUT_D1
13	OUT_D2
14	OUT_D3
15	OUT_D4

Notes
Each bit corresponds to an OR between the value and the status, indicating whether the communication with the slave is good or bad.

- If only the value is used, the status will be considered zero.
- If only the status is used, the value will be considered zero.

Schematic



BLOCK_ERR
The BLOCK_ERR of the MBCM block will indicate the following cause:

- Other: occurs when the conversion from Y to DATA_TYPE_IN results in a value out of range for this data type;
- Out of Service: occurs when the block is in O/S mode.

Parameters

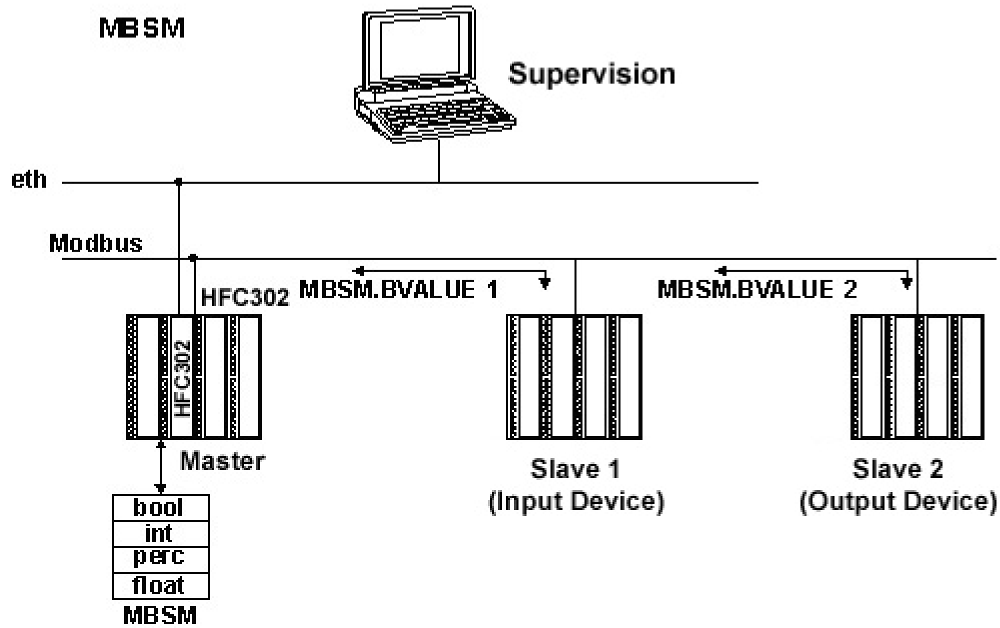
Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D / RO	
7	**LOCAL_MOD_MAP** 4xx.xx5	Unsigned8	0 to 15	0		S / O/S	Defines the modbus addresses.
8	**BAD_STATUS** 3xx.xx2	Bitstring(2)		0	E	D / RO	Indicates whether the communication with the slave is good or not (each bit corresponds to a Modbus variable).
9	**IN1** 4xx.xx6 – 4xx.xx8	DS-65				N	Analog input 1.
10	SCALE_LOC_IN1 4xx.xx9 – 4xx.x20	DS-259				S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
11	**IN2** 4xx.x21 – 4xx.x23	DS-65				N	Analog input 2.
12	SCALE_ LOC_IN2 4xx.x24 – 4xx.x35	DS-259				S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
13	**IN3** 4xx.x36 – 4xx.x38	DS-65				N	Analog input 3.
14	SCALE_ LOC_IN3 4xx.x39 – 4xx.x50	DS-259				S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
15	**IN4** 4xx.x51 – 4xx.x53	DS-65				N	Analog input 4.
16	SCALE_ LOC_IN4 4xx.x54 – 4xx.x65	DS-259				S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
17	**IN_D1** 4xx.x66 – 4xx.x67	DS-66				N	Discrete input 1.
18	LOCATOR_IN_D1 4xx.x68 – 4xx.x70	DS-261				S / O/S	Addresses in a slave device.
19	**IN_D2** 4xx.x71 – 4xx.x72	DS-66				N	Discrete input 2.
20	LOCATOR_IN_D2 4xx.x73 – 4xx.x75	DS-261				S / O/S	Addresses in a slave device.
21	**IN_D3** 4xx.x76 – 4xx.x77	DS-66				N	Discrete input 3.
22	LOCATOR_IN_D3 4xx.x78 – 4xx.x80	DS-261				S / O/S	Addresses in a slave device.
23	**IN_D4** 4xx.x81 – 4xx.x82	DS-66				N	Discrete input 4.
24	LOCATOR_IN_D4 4xx.x83 – 4xx.x85	DS-261				S / O/S	Addresses in a slave device.
25	**OUT1** 4xx.x86 – 4xx.x88	DS-65				N / Man	Analog output 1.

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
26	SCALE_ LOC_OUT1 4xx.x89 – 4xx.100	DS-259				S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
27	**OUT2** 4xx.101 – 4xx.103	DS-65				N / Man	Analog output 2.
28	SCALE_ LOC_OUT2 4xx.104 – 4xx.115	DS-259				S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
29	**OUT3** 4xx.116 – 4xx.118	DS-65				N / Man	Analog output 3.
30	SCALE_ LOC_OUT3 4xx.119 – 4xx.130	DS-259	.			S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
31	**OUT4** 4xx.131 – 4xx.133	DS-65				N / Man	Analog output 4.
32	SCALE_ LOC_OUT4 4xx.134 – 4xx.145	DS-259				S / M	Information to generate the constants A and B in the equation Y=A*X+B, plus the addresses in the slave device.
33	**OUT_D1** 4xx.146 – 4xx.147	DS-66				N / Man	Discrete output 1.
34	LOCATOR_OUT_D1 4xx.148 – 4xx.150	DS-261				S / O/S	Addresses in a slave device.
35	**OUT_D2** 4xx.151 – 4xx.152	DS-66				N / Man	Discrete output 2.
36	LOCATOR_OUT_D2 4xx.153 – 4xx.155	DS-261				S / O/S	Addresses in a slave device.
37	**OUT_D3** 4xx.156 – 4xx.157	DS-66				N / Man	Discrete output 3.
38	LOCATOR_OUT_D3 4xx.158 – 4xx.160	DS-261				S / O/S	Addresses in a slave device.
39	**OUT_D4** 4xx.161 – 4xx.162	DS-66				N / Man	Discrete output 4.
40	LOCATOR_OUT_D4 4xx.163 – 4xx.165	DS-261				S / O/S	Addresses in a slave device.
41	UPDATE_EVT 3xx.xx3 - 3xx.xx9 4xx.166	DS-73			Na	D	This alert is generated by any changes to the static data.
42	BLOCK_ALM 3xx.x10 - 3xx.x16 4xx.167	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

MBSM – Modbus Supervision Master

Overview



Description
This block enables the HFC302 to monitor MODBUS variables. The HFC302 is the master for the slaves that contain the MODBUS variables to be read. Unlike the MBCM block, this block does not have inputs and outputs that can be connected.

NOTE
Every time a MODBUS parameter is changed, it is necessary to set the ON_APPLY parameter of the MBCF block to "Apply". Otherwise, these changes won't be applied.

LOCAL_MODE_MAP
All MBSM blocks added to the strategy must have different values in the LOCAL_MOD_MAP parameter. Otherwise, the block will not operate properly.

FVALUEn, PVALUEn, IVALUEn and BVALUEn Parameters
These parameters are selected when needed. If the variable being monitored is float, a FVALUE parameter will be necessary. If the variable is in percentage, the PVALUEn parameter will be used. The IVALUE parameter refers to Integer values and the BVALUE parameter refers to boolean values.

For each one of these parameters, there are other parameters associated to address them in the MODBUS network so the MBSM block will know the location.

FLOCATORn Parameter
This parameter refers to the FVALUEn parameter.
This parameter is a DS-260 data type, so it is necessary to configure two elements for this parameter:

- Slave Address: Type the slave address where the variable being monitored is located. For example, if a LC700 has the Device Address equals to 1, the Slave Address should be equal to 1.
- Modbus Address Of Value: Type the MODBUS address of the variable being monitored in the MBSM block. Suppose that the user will monitor the variable in the MODBUS address 40001, located in the Slave I/O module with the Device Address equals to 1. The Modbus Address Of Value must be equal to 40001.

The FVALUEn parameters will display the values of the variables configured in FLOCATORn.
Float values use two MODBUS registers, but it is necessary to inform only the first one.

MODBUS Addresses

- 0001 to 9999 => Digital Outputs.
- 10001 to 19999 => Digital Inoputs.
- 30001 to 39999 => Analog Inputs.
- 40001 to 49999 => Analog Outputs.

PLOCATORn Parameter
This parameter refers to the PVALUEn parameter.
These parameters are DS-258 data type. Each parameter consists of the following elements:
- From EU 100%;
- From EU 0%;
- To EU 100%;
- To EU 0%;
- Data Type;
- Slave Address;
- MODBUS Address Of Value.

This block allows Modbus scale conversion. To execute the conversion procedure, refer to the item “View 4 - MBSM” in the chapter 13 for further details.

ILOCATORn Parameter
This parameter refers to the IVALUEn parameter:
- Slave Address;
- Modbus Address of Value.

The IVALUEn parameters will display the values of the variables configured in the ILOCATORn parameter.

BLOCATORn Parameter
This parameter refers to the BVALUEn parameter.
This parameter is a DS-260 data type, so the user will have to configure two elements for this parameter:
- Slave Address;
- Modbus Address of Value.

The BVALUEn parameters will display the values of the variables configured in BLOCATORn.

BAD_STATUS Parameter
This parameter indicates if the communication between the slaves was established properly. If the corresponding bit is at logic level 1, it indicates that there was an error during the writing/reading of the respective parameter. The table below shows the values for these status.

Relation between bits in COMM_STATUS and Modbus addresses

Bit	Variable
0	BAD COMM B1
1	BAD COMM B2
2	BAD COMM B3
3	BAD COMM B4
4	BAD COMM B5
5	BAD COMM B6
6	BAD COMM B7
7	BAD COMM B8
8	BAD COMM I1
9	BAD COMM I2
10	BAD COMM P1
11	BAD COMM P2
12	BAD COMM F1
13	BAD COMM F2

Parameters

Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D / RO	
7	**LOCAL_MOD_MAP** 4xx.xx5	**Unsigned8**	0 to 15	0		S / O/S	Defines the modbus addresses.
8	**BAD_STATUS** 3xx.xx2	Bitstring(2)		0	E	D / RO	Indicates whether the communication with the slave is good or not (each bit corresponds to a Modbus variable).
9	FLOCATOR1 4xx.xx6 - 4xx.xx7	DS-260				S / O/S	Information to locate the float parameter (FVALUE1).
10	**FVALUE1** 4xx.xx8 - 4xx.xx9	Float		0		N	Value of the requested address.
11	FLOCATOR2 4xx.x10 - 4xx.x11	DS-260				S / O/S	Information to locate the float parameter (FVALUE2).
12	**FVALUE2** 4xx.x12 - 4xx.x13	Float		0		N	Value of the requested address.
13	PLOCATOR1 4xx.x14 - 4xx.x24	DS-258				S / O/S	Information to locate the percentage parameter (PVALUE1).
14	**PVALUE1** 4xx.x25 - 4xx.x26	Float		0		N	Value of the requested address.
15	PLOCATOR2 4xx.x27 - 4xx.x37	DS-258				S / O/S	Information to locate the percentage parameter (PVALUE2).
16	**PVALUE2** 4xx.x38 - 4xx.x39	Float		0		N	Value of the requested address.
17	ILOCATOR1 4xx.x40 - 4xx.x41	DS-260				S / O/S	Information to locate the integer parameter (IVALUE1).
18	ILENGTH1 4xx.x42	Integer8	1,2,4	2		S / O/S	Data length.
19	**IVALUE1** 4xx.x43 - 4xx.x44	Integer32		0		N	Value of the requested address.
20	ILOCATOR2 4xx.x45 - 4xx.x46	DS-260				S / O/S	Information to locate the integer parameter.
21	ILENGTH2 4xx.x47	Integer8	1,2,4	2		S / O/S	Data length.
22	**IVALUE2** 4xx.x48 - 4xx.x49	Integer32		0		N	Value of the requested address.
23	BLOCATOR1 4xx.x50 - 4xx.x51	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE1).
24	**BVALUE1** 4xx.x52	Boolean		TRUE		N	Value of the requested address.
25	BLOCATOR2 4xx.x53 - 4xx.x54	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE2).
26	**BVALUE2** 4xx.x55	Boolean		TRUE		N	Value of the requested address.
27	BLOCATOR3 4xx.x56 - 4xx.x57	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE3).
28	**BVALUE3** 4xx.x58	Boolean		TRUE		N	Value of the requested address.

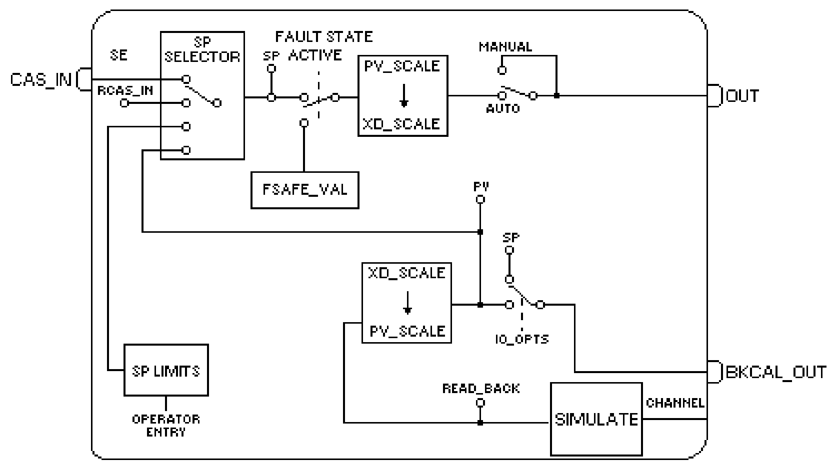
Idx	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
29	BLOCATOR4 4xx.x59 - 4xx.x60	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE4).
30	**BVALUE4** 4xx.x61	Boolean		TRUE		N	Value of the requested address.
31	BLOCATOR5 4xx.x62 - 4xx.x63	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE5).
32	**BVALUE5** 4xx.x64	Boolean		TRUE		N	Value of the requested address.
33	BLOCATOR6 4xx.x65 - 4xx.x66	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE6).
34	**BVALUE6** 4xx.x67	Boolean		TRUE		N	Value of the requested address.
35	BLOCATOR7 4xx.x68 - 4xx.x69	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE7).
36	**BVALUE7** 4xx.x70	Boolean		TRUE		N	Value of the requested address.
37	BLOCATOR8 4xx.x71 - 4xx.x72	DS-260				S / O/S	Information to locate the boolean parameter (BVALUE8).
38	**BVALUE8** 4xx.x73	Boolean		TRUE		N	Value of the requested address.
39	UPDATE_EVT 3xx.xx3 - 3xx.xx9 4xx.x74	DS-73			Na	D	This alert is generated by any changes to the static data.
40	BLOCK_ALM 3xx.x10 - 3xx.x16 4xx.x75	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

AO – Analog Output

Overview
The Analog Output Block is a function block used by the devices operating as an output element in a control loop, such as valves, actuators, positioners, etc. The AO block receives a signal from another function block and sends the results to an output transducer block through the internal reference channel.

Schematic



Description
The AO block is connected to the transducer block through the CHANNEL parameter that must match the following parameter in the transducer block:
TERMINAL_NUMBER parameter for the FI302.

The CHANNEL parameter must be set to 1 (one) if the AO block is running in the FY302 or FP302, and no configuration is necessary in the transducer block to connect it to the AO block.

Handling Input Values
The SP value can be automatically controlled through a cascade control, a remote cascade control or controlled manually by the operator. The PV_SCALE and XD_SCALE are used in the SP scale conversion.

Handling Output Values
The transducer scale parameter (XD_SCALE) converts span percentage to a number used by the transducer. The SP span can cause a full span movement for the output.

OUT = SP% * (EU_100% - EU_0%) + EU_0% [XD_SCALE]

The bit "Increase to Close" in the IO_OPTS parameter allows the output to be inverted according to the span of the input value. For example, if the SP is 100. (PV_SCALE=0-100%; XD_SCALE = 3-15Psi):
If the bit "Increase to Close" in IO_OPTS is zero, the SP converted to OUT_SCALE will be15 psi. Therefore, the actuator type will be "air to open".

If the bit "Increase to Close" in IO_OPTS is true, the SP converted to OUT_SCALE will be 3 psi. Therefore, the actuator type will be "air to close".

Simulate
The SIMULATE parameter is used for the diagnostics and checkout. When it is active, the transducer value and status will be overridden by the simulate value and status. The SIMULATE parameter can be disabled by the software in the SIMULATE parameter or the hardware, using a jumper.

The SIMULATE structure is composed by the following attributes:

- Simulate Value and Status
- Transducer Value and Status
- Simulate Enable/Disable

The Transducer Value/Status attributes of the SIMULATE parameter always show the value that the AO block receives from the corresponding transducer block.

There is a hardware jumper to disable the SIMULATE parameter. If this jumper is set to Off, the simulation will be disabled. In this case, the user cannot change the ENABLE/DISABLE attribute. This jumper avoids the simulation from being accidentally enabled during the plant operations. When the jumper is set to ON, the “Simulate Active” attribute in the BLOCK_ERR of Resource block will be true.

The simulation will be active if the following conditions exist:

- The jumper of the simulation hardware is not set to Off;
- The SIMULATE.ENABLE/DISABLE parameter is “Active”.

When simulation is active, the READBACK and PV parameters are calculated based on the attribute Simulate Value/Status of the SIMULATE parameter. Otherwise, they will be provided by the transducer block in the Transducer Value/Status attribute of the SIMULATE parameter.

Readback Parameter

If the hardware supports a readback value, such as valve position, then the value will be read by the transducer block and will be sent to the corresponding AO block through the Transducer Value/Status attribute of the SIMULATE parameter. If the hardware does not support the readback value, the Transducer Value/Status attribute of the SIMULATE parameter will be generated from the AO.OUT by the transducer block.

The READBACK parameter is a copy from the Transducer Value/Status attribute of the SIMULATE parameter when the simulation is disabled; otherwise, it will be a copy of the Simulate Value/Status attribute of the SIMULATE parameter.

The PV is the READBACK parameter converted to the PV_SCALE, therefore the PV can be simulated through the SIMULATE parameter.

In addition, the block admits the safe condition as described previously in the fault state processing. The AO block supports the mode-shedding feature as described previously in the mode parameter.

BLOCK_ERR

The BLOCK_ERR of the AO block will indicate the following causes:

- Block Configuration Error – the configuration error is indicated when one or more of the following situations occur:
    - When the CHANNEL or SHED_OPT parameters have an invalid value;
    - When the XD_SCALE doesn't have a engineering unit and/or a range proper for the respective transducer block;
    - When the transducer block is in O/S mode;
    - When it is not compatible to the CHANNEL parameter and the HC configuration (HFC302).
- Simulate Active – When the Simulate is active.
- Local Override – When the block is in LO mode because the fault state is active.
- Output Failure – I/O module failure (HFC302)
- Out of Service – When the block is in O/S mode.

Supported Modes

O/S, IMAN, LO, MAN, AUTO, CAS and RCAS.

Parameters

Idx	Parameter	Data Type (length)	Valid Range Options	Default Value	Units	Store / Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx.xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D/RO	
7	PV 3xx.xx2 - 3xx.xx4	DS-65			PV	D / RO	Process the analog value.
8	**SP** 4xx.xx5 – 4xx.xx7	DS-65	PV_SCALE +/- 10%		PV	N / Auto	Analog setpoint. It can be configured manually, automatically through the device interface or by another field device.
9	OUT 4xx.xx8 – 4xx.x10	DS-65	XD_SCALE		OUT	N / Man	The output value resulting from the transducer block.
10	SIMULATE 3xx.xx5 - 3xx.xx7 4xx.x11 – 4xx.x14	DS-82	1: Disable; 2: Active These are the Enable/Disable options.	Disable		D	Allows the readback value to be manually supplied when simulate is enabled. In this case, the simulate value and status will be the PV value.
11	PV_SCALE 4xx.x15 – 4xx.x20	DS-68		0-100%	PV	S / Man	The higher and lower scale values for the SP parameter.
12	XD_SCALE 4xx.x21 – 4xx.x26	DS-68	Depends on the device type. See the corresponding manual for details.	Depends on the Device type. See description for details.	XD	S / Man	The higher and lower scale values for the transducer of a specific channel. The Default value for each Smar device is showed below: FY302: 0 to 100 [%] FP302: 3 to 15 [psi] FI302: 4 to 20 [mA] HFC302: 0 to 100 [%]
13	GRANT_DENY 4xx.x27 – 4xx.x28	DS-70		0	Na	D	
14	**IO_OPTS** 4xx.x29	Bitstring(2)	See Block Options.	0	Na	S / O/S	See Block Options.
15	STATUS_OPTS 4xx.x30	Bitstring(2)	See Block Options.	0	Na	S / O/S	See Block Options.
16	READBACK 3xx.xx8 - 3xx.x10	DS-65			XD	D / RO	Indicate the readback of the current position of the transducer, in transducer units.
17	**CAS_IN** 4xx.x31 – 4xx.x33	DS-65				D	This parameter is the value of the remote setpoint, received from another Fieldbus block, or from a DCS block through a defined link.
18	SP_RATE_DN 4xx.x34 – 4xx.x35	Float	Positive	+INF	PV/Sec	S	Ramp rate to increase the setpoint, in PV units per second. It will be disabled if it is zero or +INF. Rate limiting will be applied in AUTO, CAS and RCAS modes.
19	SP_RATE_UP 4xx.x36 – 4xx.x37	Float	Positive	+INF	PV/Sec	S	Ramp rate to decrease the setpoint, in PV units per second. It will be disable if it is zero or +INF. Rate limiting will be applied in AUTO, CAS and RCAS modes.
20	SP_HI_LIM 4xx.x38 – 4xx.x39	Float	PV_SCALE +/- 10%	100	PV	S	The setpoint high limit is the highest executed setpoint that can be used for the block.

Idx	Parameter	Data Type (length)	Valid Range Options	Default Value	Units	Store / Mode	Description
21	SP_LO_LIM 4xx.x40 – 4xx.x41	Float	PV_SCALE +/- 10%	0	PV	S	The setpoint low limit is the lowest executed setpoint that can be used for the block.
22	CHANNEL 4xx.x42	Unsigned16		0	None	S / O/S	The channel number of the logical hardware, for the transducer that is connected to this I/O block.
23	FSTATE_TIME 4xx.x43 – 4xx.x44	Float	Positive	0	Sec	S	The time interval, in seconds, to ignore the existence of a new fault state condition. If the fault state condition doesn't persist during FSTATE_TIME seconds, and while this time interval doesn't expires, the block will execute in the last current mode.
24	FSTATE_VAL 4xx.x45 – 4xx.x46	Float	PV_SCALE +/- 10%	0	PV	S	The preset analog value of the PV to be used when a failure occurs. This value will be used if the I/O option of the fault state is selected.
25	BKCAL_OUT 3xx.x11 - 3xx.x13	DS-65			PV	D / RO	The value and status required by an block before BKCAL_IN. The previous block can prevent a final reset and provide bumpless transfer to end the control loop.
26	RCAS_IN 4xx.x47 – 4xx.x49	DS-65			PV	D	Target setpoint and status provided by a supervisory Host for an analog control or an output block.
27	SHED_OPT 4xx.x50	Unsigned8	1: NormalShed, NormalReturn 2: NormalShed, NoReturn 3: ShedToAuto, NormalReturn 4: ShedToAuto, NoReturn 5: ShedToMan, NormalReturn 6: ShedToMan, NoReturn 7: ShedToRetained Target, NormalReturn 8: ShedToRetained Target, NoReturn	0		S	Defines the action to be taken on a remote control device timeout.
28	RCAS_OUT 3xx.x14 - 3xx.x16	DS-65			PV	D / RO	Block setpoint and status after ramping – provided to a supervisory Host for back calculation and to allow define the action to be taken under limiting on limit conditions or mode change alterations.
29	UPDATE_EVT 3xx.x17 - 3xx.x23 4xx.x51	DS-73			Na	D	
30	BLOCK_ALM 3xx.x24 - 3xx.x30 4xx.x52	DS-72			Na	D	

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

If the BEHAVIOR parameter is configured as "Adapted":

The default value of CHANNEL is the lowest number available.
The default value of SHED_OPT is NormalShed/NormalReturn.
The required writing mode is the actual mode, regardless of the target mode: SP and OUT

MDO – Multiple Discrete Output

Description
The MDO block enables 8 input parameters, IN_D1 to IN_D8, to the I/O subsystem.

This function block has the same fault state characteristics of the DO block, including an option to store the last value or change to a preset value when the fault state is active, individually preset values for each point, and a delay time to before changing to the fault state.

The current mode will be LO because of the resource block, otherwise the bad status in the input parameter and the configuration of MO_OPTS will not affect the mode calculation. However, the functionality of the fault state will be applied only for that input parameter.

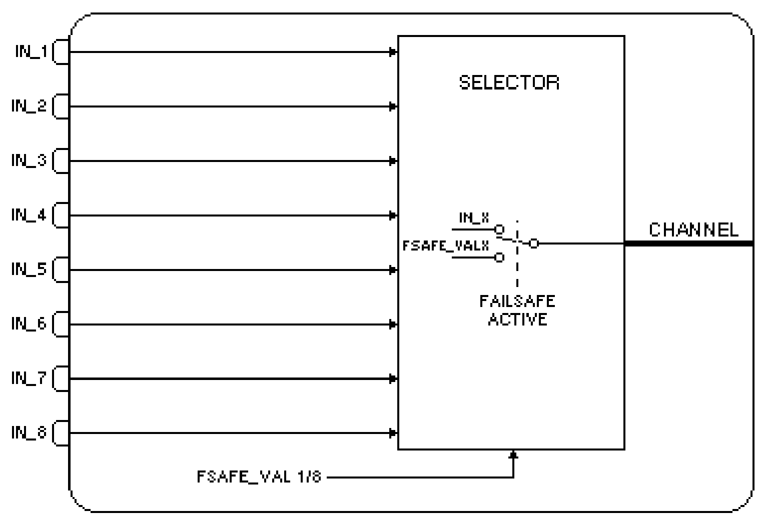
The parameter FSTATE_STATUS shows for which points the fault state is active.

BLOCK_ERR
The BLOCK_ERR of the MDO block will indicate the following causes:

- Block Configuration Error – the configuration error is indicated when OCCURRENCE / CHANNEL has an invalid value;
- Out of Service – When the block is in O/S mode.

Supported Modes
O/S, LO and AUTO.

Schematic



Parameters

Idx	Parameter	Data Type (length)	Valid Range Options	Default Value	Units	Store/ Mode	Description
1	ST_REV	Unsigned16		0	None	S/RO	
2	TAG_DESC	OctString(32)		Spaces	Na	S	
3	STRATEGY 4xx.xx0	Unsigned16		0	None	S	
4	ALERT_KEY 4xx.xx1	Unsigned8	1to 255	0	None	S	
5	**MODE_BLK** Actual=3xx.xx0 Target/Normal=4xx .xx2 – 4xx.xx4	DS-69		O/S	Na	S	Refer to the Mode Parameter.
6	**BLOCK_ERR** 3xx.xx1	Bitstring(2)			E	D/RO	
7	**OCCURRENCE / CHANNEL** 4xx.xx5	Unsigned16		0	None	S / O/S	The OCCURRENCE/CHANNEL number of the logical hardware connected to this multiple I/O block. It defines the transducer block. It addresses a group of eight points.
8	**IN_D1** 4xx.xx6 – 4xx.xx7	DS-66				D	Discrete input 1.
9	**IN_D2** 4xx.xx8 – 4xx.xx9	DS-66				D	Discrete input 2.
10	**IN_D3** 4xx.x10 – 4xx.x11	DS-66				D	Discrete input 3.
11	**IN_D4** 4xx.x12 – 4xx.x13	DS-66				D	Discrete input 4.
12	**IN_D5** 4xx.x14 – 4xx.x15	DS-66				D	Discrete input 5.
13	**IN_D6** 4xx.x16 – 4xx.x17	DS-66				D	Discrete input 6.
14	**IN_D7** 4xx.x18 – 4xx.x19	DS-66				D	Discrete input 7.
15	**IN_D8** 4xx.x20 – 4xx.x21	DS-66				D	Discrete input 8.
16	MO_OPTS (different bit description in profile revision 1) 4xx.x22	Bitstring(2)	See Block Options	0	Na	S / O/S	See Block Options.
17	FSTATE_TIME 4xx.x23 - 4xx.x24	Float	Positive	0	Sec	S	The time interval, in seconds, to ignore the existence of a new fault state condition. If the fault state condition doesn't persist during FSTATE_TIME seconds, and while this time interval doesn't expires, the block will execute in the last current mode.
18	FSTATE_VAL_D1 4xx.x25	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D1. It will be ignored if “Fault state to value 1” in the MO_OPTS parameter is false.
19	FSTATE_VAL_D2 4xx.x26	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D2. It will be ignored if “Fault state to value 2” in the MO_OPTS parameter is false.
20	FSTATE_VAL_D3 4xx.x27	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D3. It will be ignored if “Fault state to value 3” in the MO_OPTS parameter is false.
21	FSTATE_VAL_D4 4xx.x28	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D4. It will be ignored if “Fault state to value 4” in the MO_OPTS parameter is false.

Idx	Parameter	Data Type (length)	Valid Range Options	Default Value	Units	Store/ Mode	Description
22	FSTATE_VAL_D5 4xx.x29	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D5. It will be ignored if "Fault state to value 5" in the MO_OPTS parameter is false.
23	FSTATE_VAL_D6 4xx.x30	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D6. It will be ignored if "Fault state to value 6" in the MO_OPTS parameter is false.
24	FSTATE_VAL_D7 4xx.x31	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D7. It will be ignored if "Fault state to value 7" in the MO_OPTS parameter is false.
25	FSTATE_VAL_D8 4xx.x32	Unsigned8		0		S	The preset discrete value to be used when a failure occurs in IN_D8. It will be ignored if "Fault state to value 8" in the MO_OPTS parameter is false.
26	FSTATE_STATUS 3xx.xx2	Unsigned8			None	D / RO	Shows for which points the fault state is active.
27	UPDATE_EVT 3xx.xx3 - 3xx.xx9 4xx.x33	DS-73			Na	D	This alert is generated by any changes to the static data.
28	BLOCK_ALM 3xx.x10 - 3xx.x16 4xx.x34	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2

If the BEHAVIOR parameter is configured as "Adapted":
The default value of OCCURRENCE is the number of MDO blocks instantiated to the block.

Device Type	Description
FB700	The block has the OCCURRENCE parameter.
HFC302 and DC302	The block has the CHANNEL parameter. MO_OPTS has a different bit description MO_STATUS_OPTS is not availabe in profile revision 1.

Transducer Blocks

FCT – Flow Computer Transducer

Description

This block contains general information, that is, non specific to a measured stream neither related to the gas and liquids measurements only.

The main features of this block are related to access restriction, Engineering Unit System Selection, logger initialization and date/hour.

This block has parameters which refer to the Initial Setup, identified on column "Idx" ny "(Init)" , with the following features:

- Functionalities: Engineering units, users configuration and report quantities to liquid and gas
- Initial Setup must be done prior to download procedures by Syscon and parameter settings.
- The values of these Initial Setup parameters are preserved even in case of firmware download (if compatible) and configuration.

COMPANY_NAME, LOCAL_NAME, RESPONSIBLE_NAME and MANAGER_NAME Parameters
These parameters are strings used in all report types to identify the company, local and the responsible for the reports.

Configuration of the enabled users to modify the configuration
The HFC302 supports up to 30 users and for each must be configured: access level (LOGIN_LEVEL), user_name (USER_NAME_x, string to user identification that might be used on configuration log report) and configuration of the second password, if double password is required.

The access level indicates the allowed modifications in configuration, according to the table below:

Access Level (*)	Operations allowed
AP – Authorized Person	This is the only access level that allows changing the parameter SEALED_CONDITION to "sealed", specifically reserved for the Notified Body responsible for the validation of the measurement system. Another exclusive attribution of this access level is the firmware download. Besides, this level allows unrestricted access to the configuration, including configuration download. It is allowed only one login configured for Authorized Person and only this level of access can configure the corresponding password. The only way to create a user with this access level is through "factory init". This procedure will configure the login 1 with the Authorized Person level, if it is the first memory initialization or if none LOGIN_LEVEL configured as Authorized Person was found.
AA – Administrator	This level allows the user to have complete access to change the configuration, including password configuration, logger initialization and configuration download. The exception is the configuration of password for login with access level Authorized Person.
A1 – Level 1	It allows configuration download, and writing into all parameters including critical ones.
A2 – Level 2	It allows written into regular parameters.

(*) The required access level for the configuration of each parameter is indicated in the Index column in the function block tables.

The majority of the operations with access restriction by password are registered as configuration logs. However, in some cases, access restriction is done only, that is, unregistered in the HFC302 memory, for example, passwords configuration of each login/ user name.

The access restriction (only) is indicated in the function block table by classification: RA – administrator level restriction; R1 – restriction requiring level 1; R2 – restriction requiring level 2;

User Logon Process in the HFC302
To a user be registered and perform changes the configuration, the HFC302 must have been configured previously as described above. Therefore, the user needs to inform the login (LOGIN) or

User name (USER_NAME), enter the password (PASSWORD_CODE) and in case of a double password, the other user must provide the second password by PASSWORD_CODE_2 parameter.

The double password is an important feature for applications, in where the measurement system is shared by provider and customer during the custody transfer, since the passwords of the representatives of each part are required in each configuration intervention.

When a double password is configured for a specific login/user name, the PASSWORD_CODE and PASSWORD_CODE_2 parameters inform whether the first or second password is entered. The password entry sequence is not considered, however it must be executed in a shorter period of time than specified on LOGON_TIMEOUT parameter.

Even if the user has selected the login and correctly entered the password, the logon process may fail. This may occur when LOG_MODE = User acknowledge and LOG_FULL= ATV are configured. In this case, the user must at first recognize by writing in LOG_FULL=ATV, then execute again the logon process.

Logoff Process
The logon is done by writing zero (logoff) on PASSWORD_CODE or PASSWORD_CODE_2. Once the logon process is accomplished successfully, the user will be able to change the configuration and at each change, the HFC302 starts a timeout which is restarted at each new successful configuration change. However, if this timeout exceeds the configured value in LOGON_TIMEOUT, the HFC302 automatically will logoff.

This feature, which can be disabled writing zero in the LOGON_TIMEOUT, avoids that the user which has forgotten the logoff, has its login / user name used improperly.

Firmware download
The firmware download operation requires the HFC302 in the Hold mode.
The transition from Run mode to Hold mode through a software tool for firmware download (FBTools, DFBatch, web page) is accepted only if the user is logged on with Authorized Person level.
On the other hand, the transition from Run mode to Hold mode through the push-buttons in the front panel of HFC302 is always accepted, however it requires to break the physical seal of the cabinet, besides that, the corresponding event will be registered. See Chapter 18 – Audit Trail and Diagnosis for details about this event.

HFC real time clock
The HFC302 real time clock can be monitored and set through RTC parameter with DATE format (see definition in the end of this chapter), or use the RTC_RD, RTC_WR e RTC_CMD parameter, when man machine interface has problems in handling this type of data.

The RTC_RD e RTC_WR parameters should be interpreted as follows:

Element	Description	Range / Interpretation
1	Second	0 - 59
2	Minute	0 - 59
3	Hour	0 - 23
4	Week day	1=Monday,.... 7=Sunday
5	Month day	1 - 31
6	Month	1=January,.... 12=December
7	Year	00 - 99

In order to synchronize the clock automatically, refer to the HFCView chapter.

Registers and reports in the HFC302 memory initialization

The registers and reports in the HFC302 memory are initialized in the following situations:

Event	Register type / Initialized report
Register diagnosis / reports detects inconsistence	All type of registers / reports
Writing into GAS_QTR or LIQ_QTR, that is accepted if there is no QTR with status not-stored.	Only the QTR reports

The total quantity of QTR reports for gas and liquid is defined by the HFC302 hardware, which specification is in the “Registers/reports Quantity supported by HFC302” item. Therefore, configuring the GAS_QTR parameter, automatically involves changing the LIQ_QTR parameter, always keeping the HFC302 whole specification quantity.

Registers / reports Storage in only one

By configuring the FCVIEW_VSN parameter with the volume serial number of the hard disk, which the HFCView designed to read the HFC 302 registers / reports is executing, only this computer will be able to do this operation. This procedure avoids the registers and reports of a certain HFC302 to be downloaded by different computers, which would cause a scattered database.

If the FCVIEW_VSN parameter is not configured, its default value is null. It means that any computer executing the HFCView will be able to download the registers and reports.

Engineering Unit Selection for each variable

There are two ways to select the Engineering Units:
a) Selection of the whole set of Engineering Units through the SYSTEM_UNITS parameter (metric or USA units);
b) Choosing the Engineering Unit for each kind of variable (custom).

See next table, the engineering units which can be selected by user in the FCT block, classified as selectable engineering units.

The derived engineering units are selected by an indirect way, for example, the compressibility factor has the Engineering Unit as the inverse of the selected unit for pressure (P_UNITS).

FCT Parameter	Unit(*)	Description	Engineering Units for USA system	Engineering Unit for metric system
UNITS SELECTED				
T_UNITS	T	Temperature	°F	°C
P_UNITS	P	Pressure	psia	kPa
DP_UNITS	DP	Differential pressure	psig	kPa
GD_UNITS	GD	Gas density	lb/ft^3	kg/m^3
LD_UNITS (**)	LD	Liquid density	°API	kg/m^3
GV_UNITS	GV	Gas volume	MCF	m^3
LV_UNITS	LV	Liquid volume	Bbl	m^3
M_UNITS	M	Mass	klb	ton
VISC_UNITS	Visc	Viscosity	cP	Pa.s
EN_UNITS	EN	Energy	MMBTU	GJ
HV_UNITS	HV	Heating value	BTU/ft^3	MJ/m^3
L_UNITS	L	Length	inch	mm
DERIVED UNITS				
	F	Compressibility Factor - F	1/[P]	
	Elas	Elasticity Module - E	[P]	
	G	Coefficient of Thermal Expansion: Gl, Ga and Gc	1/[T]	
	TV	Volume totalization	[V]	
	TM	Mass totalization	[M]	
	QV	Volume Flow Rate	[V]/h	
	QM	Mass Flow Rate	[M]/h	
	K	K Factor	pulsos/ [V] ou pulsos /[M]	
	ER	Energy Flow	[EN]/h	

(*) This column provides the engineering units symbology used for each parameter in the function block table.
(**) The selected Engineering Unit will also indicate the selection of standards to be used:

- SG → API-11.1 tables 23 & 24 and API-11.2.1.;
- API → API-11.1 tables 5 & 6 and API-11.2.1.;
- g/ m^3 → API-11.1 tables 53 & 54 (temperature of 15°C) or tables 59 & 60 (base temperature of 20°C) and API-11.2.1.M

The default values of some configuration parameters depend on the selected unit system during the initial setup. These cases are shown on the parameters table of each block type on "Default "column.

NOTE
It is recommended to download all reports/registers from HFC302 and save in database before changing the Engineering unit configuration for each variable, because the Engineering Unit indicated in the reports is the one configured in HFC302 at the moment the reports are downloaded by HFCView. Therefore this procedure addresses the information consistence in the reports.

Day-light saving Time

The day and the month to start (DS_START_DAY and DS_START_MONTH parameters) and to stop (DS_END_DAY and DS_END_MONTH parameters) can be configured for the daylight-saving time. Thus, the HFC302 changes automatically the date/hour of the real time clock according to the configuration. These events are registered in the HFC302 memory (showed by the AEV block) and are also detected at the beginning or the ending while the daylight-saving time occurs when the HFC302 is turned off.

In the table below, an example of QTR reports generated during the transition of the end of the daylight-saving time:
DS_END_DAY = 8
DS_END_MONTH = May
ENABLE_REPORT = Hourly & Daily

Item	QTR Type	Report Period			Comment
		Date/hour to start	Date/hour to end	Flow Time	
1	Hourly	May 7 - 23:00	May 8 - 0:00	1 hour	Hourly report that antecedes the end of the daylight-saving time.
2	Daily	May 07- 0:00	May 8 - 0:00	1 day	Daily report that antecedes the end of the daylight-saving time.
3	Hourly	May 7 - 23:00	May 8 - 0:00	1 hour	Second hourly report from May 7 - 23:00 to May 8 – 0:00. This report will have the same beginning and closing date/time of the item 1, however the report number will be different.
4	Daily	May 7 - 23:00	May 8 - 0:00	1 day	Second daily report of May 7, however the flow time is one hour only.

Start of period: Day and month
The definition for accounting periods, regarding to QTR reports, can be different in comparison with the calendar when configuring the following parameters:
• START_HOUR: hour which starts the accounting day;
• START_DAY_MONTH: first day of month.

Foundation Fieldbus Transmitters Audit trail
The writing in the CONFIG_LOG_TRM parameter must be done always in the whole structure, never partially, since the partial writing will be rejected.

Some structure elements will be ignored during the writing operation, as shown in the table below:

E	Element Name	Data type	Size	Modbus Register Numbers	Writing Ignored (S/N)
1	Meter run (0=master meter; 1-4=meter run number, 253=Gas Station, 254=Liquid Station, 255=Not Specific)	Unsigned8	1	1	S
2	Block tag	Visiblestring[32]	32	16	
3	Relative index	Unsigned16	2	1	
4	Subindex	Unsigned16	2	1	
5	Data type	Unsigned16	2	1	

E	Element Name	Data type	Size	Modbus Register Numbers	Writing Ignored (S/N)
6	Login number (0 to 29,100=HFCView)	Unsigned8	1	1	S
7	Date and time	Date	7	6	S
8	As found	Octetstring[16]	16	8	
9	As left	Octetstring[16]	16	8	
10	Storage state	Unsigned8	1	1	S
11	Log counter (0 to 65000)	Unsigned16	2	1	S
12	Username	Visiblestring[8]	8	4	S

Total structure size: 90bytes / 49 Modbus registers

Procedure to overwrite in logger.

Diagnosis and Troubleshooting

1. Failure in writing the LOGIN and USER_NAME parameters: verify if another user is already logon, thus the writing is allowed only in logoff;
2. Failure in writing the USER_NAME_x parameter: verify if another user has already the desired user name;
3. Failure in the logon process: verify if it the selected LOGIN/USER_NAME and the LOGIN_LEVEL or LOG_MODE = User acknowledge e LOG_FULL= ATV configured level;
4. BLOCK_ERR. Out of Service : block in Out of service mode;
5. BLOCK_ERR. Block configuration: it indicates if there are blocks for gas measurement, however no one QTR was reserved for gas measurement, similarly for liquid measurement.

Supported Modes

O/S and AUTO.

Parameters

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3	4	STRATEGY 3xx.xx0	Unsigned16	255	255	None	S / RO	
4 (CL)	4	ALERT_KEY 4xx.xx0	Unsigned8	1 to 255	0	None	S	
5	1,3 CF	MODE_BLK Target/Normal=4xx.xx1-4xx.xx3 Actual=3xx.xx1	DS-69		Auto	Na	S	Refer to Mode Parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7 (A1) (CL) (Init)	2 IS	SYSTEM_UNITS 4xx.xx4	Unsigned8	0=SI 1=USA units 2=Custom	0	E	S	International System (cubic meter, meter, Celsius, kPa). American System (barrel, inches, Fahrenheit, psi). The custom option indicates the free choosing of the Engineering Unit for each kind of variable.
8 (A1) (CL)(Init)	2 IS	T_UNITS 4xx.xx5	Unsigned16	1000=Kelvin 1001=Celsius 1002=Fahrenheit	Celsius	E	S	Engineering Unit for Temperature.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
9 (A1) (CL) (Init)	2 IS	P_UNITS 4xx.xx6	Unsigned16	1130=Pa 1132=Mpa 1133=kPa 1137=bar 1138=mbar 1139=torr 1140=atm 1141=psi 1144=g/cm^2 1145=kgf/cm^2 1147=inH2O 4°C 1148=inH2O 68 °F 1150=mmH2O 4°C 1151= mmH2O 68 °F 1154=ftH2O 68 °F	KPa	E	S	Engineering Unit for Static Pressure.
10 (A1) (CL) (Init)	2 IS	DP_UNITS 4xx.xx7	Unsigned16	1130=Pa 1132=Mpa 1133=kPa 1137=bar 1138=mbar 1139=torr 1140=atm 1141=psi 1144=g/cm^2 1145=kgf/cm^2 1147=inH2O 4°C 1148=inH2O 68 °F 1150=mmH2O 4°C 1151= mmH2O 68 °F 1154=ftH2O 68 °F	KPa	E	S	Engineering Unit for Differential Pressure.
11 (A1) (CL) (Init)	2 IS	GD_UNITS 4xx.xx8	Unsigned16	1097= Kg/m^3 1107=lb/ft^3	Kg/m^3	E	S	Engineering Unit for Gas Density.
12 (A1) (CL) (Init)	2 IS	LD_UNITS 4xx.xx9	Unsigned16	1097= Kg/m^3 1113=API 1599 = relative density/SG	Kg/m^3	E	S	Engineering Unit for liquid density. The selection of this unit indicates which table should be used for correction factor calculations. (CTL and CPL).
13 (A1) (CL) (Init)	2 IS	GV_UNITS 4xx.x10	Unsigned16	1034=cubic meter 1038=liter 1048=US gallon 1051=barrel 1600=MCF 1610=MMCF	m^3	E	S	Engineering Unit for Gas Volume.
14 (A1) (CL) (Init)	2 IS	LV_UNITS 4xx.x11	Unsigned16	1034=cubic meter 1038=liter 1048=US gallon 1051=barrel 1600=MCF	m^3	E	S	Engineering Unit for Liquid Volume.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
15 (A1) (CL) (Init)	2 IS	M_UNITS 4xx.x12	Unsigned16	1088=kilogram 1092=ton 1094=pound 1601=kilo pound	ton	E	S	Engineering Unit for mass.
16 (A1) (CL) (Init)	2 IS	EN_UNITS 4xx.x13	Unsigned16	1171=Gigajoules1172 =MJ 1179=KWh 1602=MMBtu 1603=MBtu	GJ	E	S	Engineering Unit for Energy.
17 (A1) (CL) (Init)	2 IS	HV_UNITS 4xx.x14	Unsigned16	1604=MJ/ m^3 1605=KJ/m^3 1606=KJ/dm^3 1607=Kcal/m^3 1608=BTU/in^3 1609=BTU/ft^3 =KWh/m^3	MJ/m^3	E	S	Engineering Unit for Heating value.
18 (A1) (CL) (Init)	2 IS	VISC_UNITS 4xx.x15	Unsigned16	1159=Pascal second 1162=centipoises	Pa.s	E	S	Engineering Unit for Viscosity.
19 (A1) (CL) (Init)	2 IS	L_UNITS 4xx.x16	Unsigned16	1013=mm 1019=in	mm	E	S	Engineering Unit for Length.
20 (A2) (Init)	2 IS	USER_NAME_1 4xx.x17 - 4xx.x20	Visiblestring[8]		User 1		S	User name related to login 1.
21 (A2) (Init)	2 IS	USER_NAME_2 4xx.x21 - 4xx.x24	Visiblestring[8]		User 2		S	User name related to login 2.
22 (A2) (Init)	4 IS	USER_NAME_3 4xx.x25 - 4xx.x28	Visiblestring[8]		User 3		S	User name related to login 3.
23 (A2) (Init)	4 IS	USER_NAME_4 4xx. x29 - 4xx. x32	Visiblestring[8]		User 4		S	User name related to login 4.
24 (A2) (Init)	4 IS	USER_NAME_5 4xx..x33 - 4xx.x36	Visiblestring[8]		User 5		S	User name related to login 5.
25 (A2) (Init)	4 IS	USER_NAME_6 4xx.x37 - 4xx.x40	Visiblestring[8]		User 6		S	User name related to login 6.
26 (A2) (Init)	4 IS	USER_NAME_7 4xx.x41 - 4xx.x44	Visiblestring[8]		User 7		S	User name related to login 7.
27 (A2) (Init)	4 IS	USER_NAME_8 4xx.x45 - 4xx.x48	Visiblestring[8]		User 8		S	User name related to login 8.
28 (A2) (Init)	4 IS	USER_NAME_9 4xx.x49 - 4xx.x52	Visiblestring[8]		User 9		S	User name related to login 9.
29 (A2) (Init)	4 IS	USER_NAME_10 4xx.x53 - 4xx.x56	Visiblestring[8]		User 10		S	User name related to login 10.
30 (A2) (Init)	4 IS	USER_NAME_11 4xx.x57 - 4xx.x60	Visiblestring[8]		User 11		S	User name related to login 11.
31 (A2) (Init)	4 IS	USER_NAME_12 4xx.x61 - 4xx.x64	Visiblestring[8]		User 12		S	User name related to login 12.
32 (A2) (Init)	4 IS	USER_NAME_13 4xx.x65 - 4xx.x68	Visiblestring[8]		User 13		S	User name related to login 13.
33 (A2) (Init)	4 IS	USER_NAME_14 4xx.x69 - 4xx.x72	Visiblestring[8]		User 14		S	User name related to login 14.
34 (A2) (Init)	IS	USER_NAME_15 4xx.x73 - 4xx.x76	Visiblestring[8]		User 15		S	User name related to login 15.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
35 (A2) (Init)	IS	USER_NAME_16 4xx.x77 - 4xx.x80	Visiblestring[8]		User 16		S	User name related to login 16.
36 (A2) (Init)	IS	USER_NAME_17 4xx.x81 - 4xx.x84	Visiblestring[8]		User 17		S	User name related to login 17.
37 (A2) (Init)	IS	USER_NAME_18 4xx.x85 - 4xx.x88	Visiblestring[8]		User 18		S	User name related to login 18.
38 (A2) (Init)	IS	USER_NAME_19 4xx.x89 - 4xx.x92	Visiblestring[8]		User 19		S	User name related to login 19.
39 (A2) (Init)	IS	USER_NAME_20 4xx.x93 - 4xx.x96	Visiblestring[8]		User 20		S	User name related to login 20.
40 (A2) (Init)	IS	USER_NAME_21 4xx.x97 - 4xx.100	Visiblestring[8]		User 21		S	User name related to login 21.
41 (A2) (Init)	IS	USER_NAME_22 4xx.101 - 4xx.104	Visiblestring[8]		User 22		S	User name related to login 22.
42 (A2) (Init)	IS	USER_NAME_23 4xx.105 - 4xx.108	Visiblestring[8]		User 23		S	User name related to login 23.
43 (A2) (Init)	IS	USER_NAME_24 4xx.109 - 4xx.112	Visiblestring[8]		User 24		S	User name related to login 24.
44 (A2) (Init)	IS	USER_NAME_25 4xx.113 - 4xx.116	Visiblestring[8]		User 25		S	User name related to login 25.
45 (A2) (Init)	IS	USER_NAME_26 4xx.117 - 4xx.120	Visiblestring[8]		User 26		S	User name related to login 26.
46 (A2) (Init)	IS	USER_NAME_27 4xx.121 - 4xx.124	Visiblestring[8]		User 27		S	User name related to login 27.
47 (A2) (Init)	IS	USER_NAME_28 4xx.125 - 4xx.128	Visiblestring[8]		User 28		S	User name related to login 28.
48 (A2) (Init)	IS	USER_NAME_29 4xx.129 - 4xx.132	Visiblestring[8]		User 29		S	User name related to login 29.
49 (A2) (Init)	IS	USER_NAME_30 4xx.133 - 4xx.136	Visiblestring[8]		User 30		S	User name related to login 30.
50 (RA) (Init)	2 IS	LOGIN_LEVEL 4xx.137 - 4xx.166	Unsigned8[30]	0=Authorized person 1=Administrator 2=Level 1 3=Level 2 255=Not allowed	First=Administrator Others=Not allowed	E	S	By writing into this parameter, it is possible to attribute a change level of an adequate configuration for each of the 30 logins. It is necessary to logon with Administration Level to write into this parameter.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
51(RA) (Init)	IS	PASSWORD 4xx.167 - 4xx.196	Unsigned16 [30]	4 to 65535	4	Na	S	In order to configure the password for each Login, it is necessary to type in this parameter. The reading/writing in this parameter is allowed when the operator has Administrator level or Authorized person. Only when the user was Registered as Administrator, the password will return, except if the access level is Authorized person. Otherwise, it will indicate zero.
52 (RA) (Init)	IS	PASSWORD_2 4xx.197 - 4xx.226	Unsigned16[30]	0 = double password disabled 4 to 65535	0	Na	S	It is possible to configure the password for each associated Login by writing in this parameter. The reading/writing in this parameter is allowed when the user has Administrator level or was registered with correspondent Login. The real value of the parameter is only read via communication when the user has Administrator level. Otherwise, it will indicate zero.
53(A1) (CL)	2 CF	LOGON_TIMEOUT 4xx.227	Unsigned16	0 = never expire	0	Min	S	The Logon ends automatically after this time interval, if there is no changing in any parameter under Audit Trail.
54 (AA) (CL) (Init)	2 IS	GAS_QTR 4xx.228	Unsigned16	0 to 1000	-	Na	S	Number of QTR for gas. The difference between the maximum number associated to QTR supported by HFC302 module and this parameter will be the number of QTR reserved for liquid. Writing into this parameter is accepted only if there is no report with not-stored status.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
55 (AA) (CL) (Init)	2 IS	LIQ_QTR 4xx.229	Unsigned16	0 to 1000	-	Na	S	Number of QTR for liquid. The difference between the maximum number associated to QTR supported by HFC302 module and this parameter will be the number of QTR reserved for gas. Writing into this parameter is accepted only if there is no report with not-stored status.
56 (AA) (CL)	2 CF	HFCVIEW_VSN 4xx.230-4xx.234	Visiblestring[10]		Blank		S	Serial number of the hard disk where the HFCView is installed. Only the HFCView executed in this computer will communicate with the HFC302.
57	1	CLEAR_LOG 4xx.235	Unsigned8	0 = None 1 = Clear all loggers 2=ATV-config log 3=AEV-alarm and event 4=LMFV-proving 5=WTV-well test 6=GTV-gas 7=LTV-liquid 8=HV 9=PTV	0	Na	D / RO	Parameter without functionality.
58(CL)	CF	COMPANY_NAME 4xx.236- 4xx.251	Visiblestring[32]		Blank		S	Company identification. It is used to generate reports.
59(CL)	CF	LOCAL_NAME 4xx.252 - 4xx.267	Visiblestring[32]		Blank		S	Identification of the place where the measurement is being done. It is used to generate reports.
60(CL)	CF	RESPONSIBLE_NAME 4xx.268 - 4xx.283	Visiblestring[32]		Blank		S	Identification of the responsible for the reports.
61(CL)	CF	MANAGER_NAME 4xx.284 - 4xx.299	Visiblestring[32]		Blank		S	Identification of the responsible manager for the reports.
62	1 OP	LOGIN 4xx.300	Unsigned8	1 to 30=Login 1 / 30	0	E	D	Login for configuration changes with access restriction.
63	1 OP	USER_NAME 4xx.301-4xx.304	Visiblestring[8]		Blank		D	Selection of the User name selection to change the configuration.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
64	1 OP	PASSWORD_CODE 4xx.305	Unsigned16	Read : 0=Logoff 1=Logon 2=WaitingPW1 3=WaitingPW2 Write: 0=Logoff 4 to 65535, =password	0	Na	D	This parameter has double functionality. When in reading, the value 1 indicates Logon, and thus it is possible to change the configuration with access restriction. When writing value 0, it means the operator wants to logoff. When writing values between 4 and 65535, the user is trying to logon.
65	1 OP	PASSWORD_CODE_2 4xx.306	Unsigned16	Read : 0=Logoff 1=Logon 2=WaitingPW1 3=WaitingPW2 Write: 0=Logoff 4 to 65535=password	0	Na	D	When working with double password, the second password must be written in this parameter. This parameter has double functionality. When in reading, the value 1 indicates Logon, and thus it is possible to change the configuration with access restriction. When writing value 0, it means the operator wants to logoff. When writing values between 4 and 65535, the user is trying to logon.
66 (A2)	1 OP, MN	RTC 4xx.307 - 4xx.312	Date				N	Date and time in real time.
67	1 OP, MN	RTC_RD 3xx.xx3 - 3xx.xx9	Unsigned8[7]				D / RO	Date and time, in numeric format, read from the HFC302 in real time.
68	1 MN	RTC_WR 4xx.313 - 4xx.319	Unsigned8[7]				D	Date and time to be typed in the real time clock HFC302 of the in numeric format.
69 (A2)	1 MN	RTC_CMD 4xx.320	Unsigned8	0=None 1=Copy from HFC302 to RTC_WR 2=Copy from RTC_WR to HFC302 3=Failed	0	E	D	Command to read or write in the real time clock of the HFC302.
70 (A2) (CL)	2 CF	DS_START_DAY 4xx.321	Unsigned8	0 to 31 0=disabled	0	NA	S	Daylight saving time starting day.
71 (A2) (CL)	2 CF	DS_START_MONTH 4xx.322	Unsigned8	0 to 12 0=disabled 1=January 2=February .. 12=December	0	E	S	Daylight saving time starting month.
72 (A2) (CL)	2 CF	DS_END_DAY 4xx.323	Unsigned8	0 to 31 0=disabled	0	NA	S	Daylight saving time ending day.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
73 (A2) (CL)	2 CF	DS_END_MONTH 4xx.324	Unsigned8	0 to 12 0=disabled 1=January 2=February .. 12=December	0	E	S	Daylight saving time ending month.
74 (CL)	2 CF	START_HOUR 4xx.325	Unsigned8	0 to 23	0	Hour	S	Hour that starts the counting period of the day.
75 (CL)	2 CF	START_DAY_MONTH 4xx.326	Unsigned8	1 to 28	1	Day of month	S	Day that starts the counting period of the month.
76	1 OP	WARNING 3xx.x10	Bitstring[2]	See Block Options	0	Na	D / R0	When the report is in not-stored status among the five first reports (the oldest reports), the report type correspondent will be indicated in this parameter.
77	1 OP	OVERFLOW 4xx.327	Bitstring[2]	See Block Options	0	Na	D	If a report is upon others and with not-stored status, therefore the correspondent report type will be indicated in this parameter. Only when the user writes the value 1 in this parameter on the bit correspondent, the event is considered recognized and the correspondent bit for this parameter will be zero.
78	1	UPDATE_EVT 3xx.x11 – 3xx.x17 4xx.328	DS-73			Na	D	This alert is generated by any change to the static data.
79	1	BLOCK_ALM 3xx.x18 – 3xx.x24 4xx.329	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is displayed in the sub code field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported, without clearing the Active status, if the sub code has changed.
80	CF	CONFIG_LOG_TRM 4xx.330 – 4xx.378	DS-273				D	FF Transmitters Configuration audit trail.

Idx	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
81 (AP)	MN	SEALED_CONDITION 4xx.379	Unsigned8	0=Not sealed 1=Sealed	0	E	S	Identification in case the system is on "sealed condition" or not. Only the user with "Authorized person-AP" access is able to write the value "Sealed" in this parameter. Writing in any parameter with audit trail leads this parameter to "Not sealed" value.
82	MN	LEGAL_SW_VERSION 3xx.x25	Unsigned32	> 0	-	Na	S / RO	Software module version under legal metrological control.
83	OP	LOG_FULL 4xx.380	Bitstring[2]	See Block Options	0	Na	D	If a log type has full memory, thus the correspondent report type will be indicated in this parameter. Only when the user write the value 1 in this parameter in the correspondent bit, thus the oldest report is cleared and a new measurement can be done. Meanwhile, the blocks would be on O/S mode.
84 (A1) (CL)	CF	LOG_MODE 4xx.381	Unsigned8	0=Automatic overwrite 1=User acknowledge	0	Na	S	This indicates if the log mechanism operates with automatic overwriting mechanism or requires user manual operation.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – dynamic; N – non-volatile;
S – Static; I – Input Parameter; O-Output Parameter
AP-Authorized person, AA-Administrator Level; A1 – Level 1; A2 – Level 2
RA –Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL=209 bytes (includes block tag and profile); V1-75 bytes; V2-95 bytes; V3-8 bytes; V4-99 bytes
HFCView: OP (Operation), IS (Initial Setup), CF (Configuration), MN (Maintenance)

GKD – Gas Knowledge Database

Description
This is a specific transducer block for gas measurement; however it is not specific for a measured stream, the configuration of the base conditions for this block affect the calculation for all instances of the GT block.

Base conditions for gas measurement
The temperature and base pressure definitions (BASE_TEMPERATURE and BASE_PRESSURE parameters, respectively) for gas measurement are used at flowing calculation in the base condition (Qb), related to the flow calculated at flowing conditions (Qv).

Composition and information for each product
The HFC302 supports up to twenty products for natural gas, it means different compositions, heating value, relative density, mode to get the composition (manual input or via chromatograph) and if the HFC302 calculates heating value, relative density and isentropic coefficient. The same product can be referred by more than one gas measurement in the same HFC302. The typical application is using the chromatograph measuring the gas composition before splitting in two measurement stations using the same HFC302.
The twenty products for natural gas are configured and visualized through the PRODUCT1 to PRODUCT20 parameters.

There are the following parameters for each product:

- COMPOSITION_Px: it selects the mode to get the gas composition which can be through chromatograph or by the user ("user enter") or typical compositions as referenced by international standards (Gulf Coast, Amarillo, Ekofisk, High N_2, High CO_2-N_2);
- CALC_Px: it selects if the HFC302 must calculate the heating value (Hv), relative density (Gr) and/or isentropic coefficient. For example, if this parameter is selected in order to the HFC302 calculates only the heating value, the input manual for this variable will be ignored and the relative density must be provided. If the composition comes from a chromatograph, thus the GC_HV input will be ignored and the GC_REL_DENSITY input must be connected in the GC block.
- PRODUCTx: it indicates the composition, heating value and the relative density utilized in the flow calculation. There is a consistency check for this information, regardless of the selected way to obtain the composition, heating value and relative density.

Composition provided by user

When the gas composition is provided by laboratory analysis, the user must write the composition into the TEMPORARY_PRODUCT parameter and then requests the transfer for the desired product through the command (GKD_CMD). The available options for written in the GKD_CMD parameter are indicated in the parameter table in the column "Valid range" by the suffix "(Wr)". These writing options are basically for transference of the temporary product to a specific product or the reverse.

Before accomplishing the transference to the product, the HFC302 checks the consistence of the data provided related to the range for each component and sum of the percents. If there is inconsistence it will be indicated with details in the GKD_CMD parameter.

The transference for the selected product will include the heating value and relative density values if the HFC302 was not configured to calculate these variables.

Another way to entry the gas composition is writing the whole gas composition, instead of component by component, then it will be checked. If it is consistent, the writing wil be performed.

The table below indicates the component associated to the element in the array for the gas composition (PRODUCTx and TEMPORARY_PRODUCT).

	Offset Modbus Parameter	Description
1	xxx.xx0 - xxx.xx1	Mol % - Methane
2	xxx.xx2 - xxx.xx3	Mol % -Nitrogen
3	xxx.xx4 - xxx.xx5	Mol % - Carbon Dioxide
4	xxx.xx6 - xxx.xx7	Mol % - Ethane
5	xxx.xx8 - xxx.xx9	Mol % - Propane

	Offset Modbus Parameter	Description
6	xxx.x10 - xxx.x11	Mol % - Water
7	xxx.x12 - xxx.x13	Mol % - Hydrogen Sulphide
8	xxx.x14 - xxx.x15	Mol % - Hydrogen
9	xxx.x16 - xxx.x17	Mol % - Carbon Monoxide
10	xxx.x18 - xxx.x19	Mol % - Oxygen
11	xxx.x20 - xxx.x21	Mol % - i-Butane
12	xxx.x22 - xxx.x23	Mol % - n-Butane
13	xxx.x24 - xxx.x25	Mol % - i-Pentane
14	xxx.x26 - xxx.x27	Mol % - n-Pentane
15	xxx.x28 - xxx.x29	Mol % - n-Hexane
16	xxx.x30 - xxx.x31	Mol % - n-Heptane
17	xxx.x32 - xxx.x33	Mol % - n-Octane
18	xxx.x34 - xxx.x35	Mol % - n-Nonane
19	xxx.x36 - xxx.x37	Mol % - n-Decane
20	xxx.x38 - xxx.x39	Mol % - Helium
21	xxx.x40 - xxx.x41	Mol % - Argon
22	xxx.x42 - xxx.x43	Reserved
23	xxx.x44 - xxx.x45	Reserved
24	xxx.x46 - xxx.x47	Heating Value [HV]
25	xxx.x48 - xxx.x49	Relative density (specific gravity)
26	xxx.x50 - xxx.x51	Reserved
27	xxx.x52 - xxx.x53	Reserved
28	xxx.x54 - xxx.x55	Reserved/Total Mol % (*)

(*) For the TEMPORARY_PRODUCT parameter, this element indicates the total percentage.

Configuration log for the composition provided by user
When writing into PRODUCTx parameters indirectly through TEMPORARY_ PRODUCT and GKD_CMD parameters, a comparison between the last and the new values will be executed for each element and only when they are different, it will be registered as configuration change, so it will minimize the register quantity.

Information about the pulse signal flow meter (METERx_INFO)
The NKF is the main feature for the meter and must be configured in the METERx_INFO parameter. This factor is used to convert from pulses to volume/mass. Other information are strings to identify the meter manufacturer, serial number, model, size and meter number.

This information about the meter are associated to the measured stream, for example, the METER1_INFO refers to the meter used for the measured stream 1 and the METER2_INFO refers to the meter used for the measured stream 2, and so on. It means the GT block, which has the STRATEGY parameter equals to 3 and using a pulse signal flow sensor, will utilize the NKF of the METER3_INFO parameter.

If the sensor selected for the flow measurement does not use a pulse signal, this parameter can be ignored.

Meter Factor history for each meter
The MFx_HISTORY parameters store the last eight meter factor for the meter, thus the user can write only in the first element of the structure, and this will shift the last seven changes of the meter factor and the corresponding date/time to enter the new value. The MF1_HISTORY parameter is associated to the measured stream 1 and the MF2_HISTORY parameter is associated to the measured stream 2, and so on.

Local Atmospheric Pressure
The local atmospheric pressure must be configured in the ATMOSPHERE_PRESSURE parameter where the measurement system is installed. This information will be used to convert the gauge pressure into absolute pressure (value used in the flow calculations), and must be configured in the GFC.PRESSURE_TYPE block for gauge pressure. Thus, for each flow calculation block (GT), it has the configuration if the static pressure provided is absolute or gauge (and in this case, the sum will be with the local atmospheric pressure).

Diagnosis and Troubleshooting
1. BLOCK_ERR. Out of Service: the block is in the Out of service mode;

2. Failure during the transference of the composition from the TEMPORARY_PRODUCT to the desired product, according to the indication in the GKD_CMD parameter. If one of the substances was indicated, verify the range according to the following table:

Substance	Normal Range	Expanded Range	Extrapolated Range
Relative density	0.554 to 0.87	0.07 to 1.52	0,07 to 1,52
Heating Value	18.7 to 45.1 MJ/ m^3	0 to 66 MJ/m^3	0 to 66 MJ/m^3
Mol % - Methane	45 to 100	0 to 100	0 to 100
Mol % - Nitrogen	0 to 50	0 to 100	0 to 100
Mol % - Carbon Dioxide	0 to 30	0 to 100	0 to 100
Mol % - Ethane	0 to 10	0 to 100	0 to 100
Mol % - Propane	0 to 4	0 to 12	0 to 100
Mol % - Total of butanes	0 to 1	0 to 6	0 to 100
Mol % - Total of pentanes	0 to 0.3	0 to 4	0 to 100
Mol % - Total of hexanes +	0 to 0.2	0 to Dew Point	0 to 100
Mol % - Helium	0 to 0.2	0 to 3	0 to 3
Mol % - Hydrogen	0 to 10	0 to 100	0 to 100
Mol % - Carbon Monoxide	0 to 3	0 to 3	0 to 3
Mol % - Argon	0	0 to 1	0 to 1
Mol % - Oxygen	0	0 to 21	0 to 21
Mol % - Water	0 to 0.05	0 to Dew Point	0 to Dew Point
Mol % - Hydrogen Sulphide	0.02	0 to 100	0 to 100

Supported Modes
O/S and AUTO.

Parameters

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3	4	STRATEGY 3xx.xx0	Unsigned16	255	255	None	S / RO	
4	4	ALERT_KEY 4xx.xx0	Unsigned8		1	None	S	
5	1,3 CF	MODE_BLK Target/Normal=4xx.xx1-4xx.xx3 Actual=3xx.xx1	DS-69		Auto	Na	S	Refer to Mode Parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7 (A1) (CL)	2 CF	BASE_TEMPERATURE 4xx.xx4 - 4xx.xx5	Float	-130 to 400 ºC	SI=15.00 USA=60	T	S	Base temperature for gas in the Engineering Unit selected in T_UNITS parameter in the FCT block.
8 (A1) (CL)	2 CF	BASE_PRESSURE 4xx.xx6 - 4xx.xx7	Float	1E-13 to 280 MPa	SI=101.325 USA=14.73	P	S	Base pressure for gas in the Engineering Unit selected in P_UNITS parameter in the FCT block.
9 (A2) (CL)	2 CF	ATMOSPHERE_PRESSURE 4xx.xx8-4xx.xx9	Float	> 0.0	SI=101.325 USA=14.73	P	S	Local Atmospheric Pressure. It is used when the gauge pressure is selected in the GFC.PRESSURE_TYPE block.
10 (A2) (CL)	2 CF	AVERAGING_SEL 4xx.x10	Unsigned8	0=Flow-dependent time-weighted 1=flow-weighted	1	E	S	Average calculation method for gas measurement.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
11 (A2) (CL)	2 CF	COMPOSITION_P1 4xx.x11	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 1. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition.
12 (A2) (CL)	2 CF	CALC_P1 4xx.x12	Bitstring[2]	See description of CALC_Px	3	E	S	This selects the variables referring to PRODUCT1 that must be calculated by HFC302 as heating value (HV), relative density (Gr), isentropic coefficient (K).
13 (A2) (CL)	2 CF	COMPOSITION_P2 4xx.x13	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 2. If the option "Chromatograph" was selected, it is not allowed the manual input of the gas composition.
14 (A2) (CL)	2 CF	CALC_P2 4xx.x14	Bitstring[2]	See description of CALC_Px	3	E	S	This selects the variables referring to PRODUCT2 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
15 (A2) (CL)	2 CF	COMPOSITION_P3 4xx.x15	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 3. If the option "Chromatograph" was selected, it is not allowed manual input for the gas composition.
16 (A2) (CL)	2 CF	CALC_P3 4xx.x16	Bitstring[2]	See description of CALC_Px	3	E	S	This selects the variables referring to PRODUCT3 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
17 (A2) (CL)	2 CF	COMPOSITION_P4 4xx.x17	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 4. If the option "Chromatograph" was selected, it is not allowed manual input for the gas composition.
18(A2) (CL)	2 CF	CALC_P4 4xx.x18	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) or relative density (Gr) from PRODUCT4 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
19 (A2) (CL)	3 OP	PRODUCT1 4xx.x19 - 4xx.x74	Float[28]				N / Wr whole prm	Information about the product 1 (including gas composition, heating value, relative density).

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
20 (A2) (CL)	OP	PRODUCT2 4xx.x75 – 4xx.130	Float[28]				N / Wr whole prm	Information about the product 2 (including gas composition, heating value, relative density).
21 (A2) (CL)	OP	PRODUCT3 4xx.131 – 4xx.186	Float[28]				N / Wr whole prm	Information about the product 3 (including gas composition, heating value, relative density).
22 (A2) (CL)	OP	PRODUCT4 4xx.187 – 4xx.242	Float[28]				N / Wr whole prm	Information about the product 4 (including gas composition, heating value, relative density).
23	1 OP	TEMPORARY_PRODUCT 4xx.243 – 4xx.298	Float[28]	0 to 100% Gr: 0.07 to 1.52 Hv : > 0		%	D	Gas temporary composition while is being edited, after that, it must be transferred to the PRODUCTx desired through the GKD_CMD parameter.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
24 (R)	1 OP	GKD_CMD 4xx.299	Unsigned8	0=None 1=Transfer to PRODUCT1(Wr) 2=Transfer to PRODUCT2(Wr) 3=Transfer to PRODUCT3(Wr) 4=Transfer to PRODUCT4(Wr) 11=Methane 12=Nitrogen 13=Carbon Dioxide 14=Ethane 15=Propane 16=Water 17=Hydrogen sulfide 18=Hydrogen 19=Carbon monoxide 20=Oxygen 21=I-Butane 22=n-Butane 23=I-Pentane 24=n-Pentane 25=n-Hexane 26=n-Heptane 27=n-Octane 28=n-Nonane 29=n-Decane 30=Helium 31=Argon 32=Total butanes 33=Total Pentanes 34=HV 35=Gr 101…120=Copy from PRODUCT1…120(Wr) 201=Total greater than 100% 202=Total less than 100% 203=Inconsistent composition 205…220= Transfer to PRODUCT5...20(Wr) 253=Successful transfer, but in expanded range 254=Successful transfer, but in extrapolated range 255=Successful transfer	0	Na	D	Basically, it is possible to execute two types of operation: to transfer the gas composition from the TEMPORARY_PRODUCT parameter to the desired product or to copy from the PRODUCTx to the TEMPORARY_ PRODUCT. The second type of operation isrecommended when it intends to adjust just some components. After the command, it will return the result of the consistence check.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
25 (A2) (CL)	4 CF	METER1_INFO 4xx.300 – 4xx.336	DS-268				S	Information for the meter 1 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 1.
26 (A2) (CL)	CF	METER2_INFO 4xx.337 – 4xx.373	DS-268				S	Information for the meter 2 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 2.
27 (A2) (CL)	CF	METER3_INFO 4xx.374 – 4xx.410	DS-268				S	Information for the meter 3 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 3.
28 (A2) (CL)	CF	METER4_INFO 4xx.411 – 4xx.447	DS-268				S	Information for the meter 4 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 4.
29 (A2)	MN	MF1_HISTORY 3xx.xx3 – 3xx.x64 4xx.448 – 4xx.449	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and their correspondent date/time for the meter 1. The first element of the array is the MF used and it is the only one that can be written by user.
30 (A2)	MN	MF2_HISTORY 3xx.x65 – 3xx.126 4xx.450 – 4xx.451	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and their correspondent date/time for the meter 2. The first element of the array is the MF used and it is the only one that can be written by user.
31 (A2)	MN	MF3_HISTORY 3xx.127 – 3xx.188 4xx.452 – 4xx.453	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and their correspondent date/time for the meter 3. The first element of the array is the MF used and it is the only one that can be written by user
32 (A2)	MN	MF4_HISTORY 3xx.189 – 3xx.250 4xx.454 – 4xx.455	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and their correspondent date/time for the meter 4. The first element of the array is the MF used and it is the only one that can be written by user.
33		UPDATE_EVT 3xx.251 – 3xx.257 4xx.456	DS-73			Na	D	This alert is generated by any change to the static data.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
34		BLOCK_ALM 3xx.258 – 3xx.264 4xx.457	DS-72			Na	D	The block alarm is used for all configuration, hardware, and connection failure or system problems in the block. The cause of the alert is displayed in the sub code field. The first alert that becomes active Will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported, without clearing the Active status, if the sub code has changed.
35 (A2) (CL)	2 CF	COMPOSITION_P5 4xx.458	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 5. If the option “Chromatograph” was selected, it is not allowed manual input of the gas composition.
36 (A2) (CL)	2 CF	CALC_P5 4xx.459	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT5 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
37 (A2) (CL)	2 CF	COMPOSITION_P6 4xx.460	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 6. If the option “Chromatograph” was selected, it is not allowed manual input of the gas composition
38 (A2) (CL)	2 CF	CALC_P6 4xx.461	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT6 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
39 (A2) (CL)	2 CF	COMPOSITION_P7 4xx.462	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	. It defines the source of the gas composition for the product 7. If the option “Chromatograph” was selected, it is not allowed manual input of the gas composition
40 (A2) (CL)	2 CF	CALC_P7 4xx.463	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT7 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
41 (A2) (CL)	2 CF	COMPOSITION_P8 4xx.464	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 8. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
42 (A2) (CL)	2 CF	CALC_P8 4xx.465	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT8 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
43 (A2) (CL)	2 CF	COMPOSITION_P9 4xx.466	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 9. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
44 (A2) (CL)	2 CF	CALC_P9 4xx.467	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT9 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
45 (A2) (CL)	2 CF	COMPOSITION_P10 4xx.468	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 10. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
46 (A2) (CL)	2 CF	CALC_P10 4xx.469	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT10 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
47 (A2) (CL)	2 CF	COMPOSITION_P11 4xx.470	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 11. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
48 (A2) (CL)	2 CF	CALC_P11 4xx.471	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT11 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
49 (A2) (CL)	2 CF	COMPOSITION_P12 4xx.472	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 12. If the option “Chromatograph” was selected, it is not allowed manual input of the gas composition
50 (A2) (CL)	2 CF	CALC_P12 4xx.473	Bitstring[2]	See description of CALC_Px	3	E	S	isentrópico (K).. This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT12 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
51 (A2) (CL)	2 CF	COMPOSITION_P13 4xx.474	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 13. If the option “Chromatograph” was selected, it is not allowed manual input of the gas composition
52 (A2) (CL)	2 CF	CALC_P13 4xx.475	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT13 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
53 (A2) (CL)	2 CF	COMPOSITION_P14 4xx.476	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 14. If the option “Chromatograph” was selected, it is not allowed manual input of the gas composition
54 (A2) (CL)	2 CF	CALC_P14 4xx.477	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT14 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
55 (A2) (CL)	2 CF	COMPOSITION_P15 4xx.478	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 15. If the option “Chromatograph” was selected, it is not allowed manual input of the gas composition
56 (A2) (CL)	2 CF	CALC_P15 4xx.479	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT15 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
57 (A2) (CL)	2 CF	COMPOSITION_P16 4xx.480	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 16. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
58 (A2) (CL)	2 CF	CALC_P16 4xx.481	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT16 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
59 (A2) (CL)	2 CF	COMPOSITION_P17 4xx.482	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 17. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
60 (A2) (CL)	2 CF	CALC_P17 4xx.483	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT17 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
61 (A2) (CL)	2 CF	COMPOSITION_P18 4xx.484	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 18. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
62 (A2) (CL)	2 CF	CALC_P18 4xx.485	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT18 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
63 (A2) (CL)	2 CF	COMPOSITION_P19 4xx.486	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 19. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
64 (A2) (CL)	2 CF	CALC_P19 4xx.487	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT19 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
65 (A2) (CL)	2 CF	COMPOSITION_P20 4xx.488	Unsigned8	0 - User Enter 1 - Chromatograph 2 - Gulf Coast 3 - Amarillo 4 - Ekofisk 5 - High N_2 6 - High CO_2-N_2	3	E	S	It defines the source of the gas composition for the product 20. If the option "Chromatograph" was selected, it is not allowed manual input of the gas composition
66 (A2) (CL)	2 CF	CALC_P20 4xx.489	Bitstring[2]	See description of CALC_Px	3	E	S	This selects if the heating value (Hv) and/or relative density (Gr) from PRODUCT20 that must be calculated by HFC302 as heating value (Hv), relative density (Gr), isentropic coefficient (K).
67 (A2) (CL)	OP	PRODUCT5 4xx.490 – 3xx.545	Float[28]				N / Wr whole prm	Information about the product 5 (including gas composition,heating value, relative density).
68 (A2) (CL)	OP	PRODUCT6 4xx.546 – 4xx.601	Float[28]				N / Wr whole prm	Information about the product 6 (including gas composition,heating value, relative density).
69 (A2) (CL)	OP	PRODUCT7 4xx.602 – 4xx.657	Float[28]				N / Wr whole prm	Information about the product 7 (including gas composition,heating value, relative density).
70 (A2) (CL)	OP	PRODUCT8 4xx.658 – 4xx.713	Float[28]				N / Wr whole prm	Information about the product 8 (including gas composition,heating value, relative density).
71 (A2) (CL)	OP	PRODUCT9 4xx.714 – 4xx.769	Float[28]				N / Wr whole prm	Information about the product 9 (including gas composition,heating value, relative density).
72 (A2) (CL)	OP	PRODUCT10 4xx.770 – 4xx.825	Float[28]				N / Wr whole prm	Information about the product 10 (including gas composition,heating value, relative density).
73 (A2) (CL)	OP	PRODUCT11 4xx.826 – 4xx.881	Float[28]				N / Wr whole prm	Information about the product 11 (including gas composition,heating value, relative density).
74 (A2) (CL)	OP	PRODUCT12 4xx.882 – 4xx.937	Float[28]				N / Wr whole prm	Information about the product 12 (including gas composition,heating value, relative density).
75 (A2) (CL)	OP	PRODUCT13 4xx.938 – 4xx.993	Float[28]				N / Wr whole prm	Information about the product 13 (including gas composition,heating value, relative density).
76 (A2) (CL)	OP	PRODUCT14 4xx.994 – 4x1.049	Float[28]				N / Wr whole prm	Information about the product 14 (including gas composition,heating value, relative density).
77 (A2) (CL)	OP	PRODUCT15 4x1.050 – 4x1.105	Float[28]				N / Wr whole prm	Information about the product 15 (including gas composition,heating value, relative density).
78 (A2) (CL)	OP	PRODUCT16 4x1.106 – 4x1.161	Float[28]				N / Wr whole prm	Information about the product 16 (including gas composition,heating value, relative density).
79 (A2) (CL)	OP	PRODUCT17 4x1.162 – 4x1.217	Float[28]				N / Wr whole prm	Information about the product 17 (including gas composition,heating value, relative density).

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
80 (A2) (CL)	OP	PRODUCT18 4x1.218 – 4x1.273	Float[28]				N / Wr whole prm	Information about the product 18 (including gas composition,heating value, relative density).
81 (A2) (CL)	OP	PRODUCT19 4x1.274 – 4x1.329	Float[28]				N / Wr whole prm	Information about the product 19 (including gas composition,heating value, relative density).
82 (A2) (CL)	OP	PRODUCT20 4x1.330 – 4x1.385	Float[28]				N / Wr whole prm	Information about the product 20 (including gas composition,heating value, relative density).

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – Dynamic; N – non-volatile; S – Static; I – Input Parameter; O-Output Parameter; AA-Administrator Level; A1 – Level 1; A2 – Level 2; RA –Restriction to Administration; R1 – Restriction level 1; R – Restriction level 2; CL=791 bytes (includes block tag and profile); V1-121 bytes; V2-55 bytes; V3-120 bytes; V4-77 bytes
HFCView: OP (Operation), CF (Configuration), MN (Maintenance)

LKD – Liquid Knowledge Database

Description
This is a specific transducer block for liquid measurement; therefore it is not specific for a run number. The configuration of the base conditions for this block affects the calculations for all instances of the blocks for liquid measurement, that calculate the flow corrector, except the LCF block which has self-configuration for base condition.

Base Conditions for liquid measurement
The base temperature (BASE_TEMPERATURE) and equilibrium pressure define the base conditions for liquid measurement. They are used in the flow/totalization calculation at base conditions (GSV) related to the flow/totalization at flowing conditions (IV). For the products which have the equilibrium pressure equals or less than 101.325 Kpa (abs) / 14.696 psia, the equilibrium pressure used is this value.

Information about the signal flow meter in pulse (METERx_INFO)
The NKF is the main feature for the meter and must be configured in the METERx_INFO parameter, this factor is used in the conversion from pulses to volume.

Information as strings identifies the meter manufacturer, serial number, model, and size and meter number.

This information about the meter are associated to the run number, for example, the METER1_INFO refers to the meter used for the run number 1 and the METER2_INFO refers to the meter used for the run number 2, and so on. It means the LT block, which has the STRATEGY parameter equals to 3 and is using a pulse signal flow sensor, will utilize the NKF of the METER3_INFO parameter.

If the sensor selected for the flow measurement does not use a pulse signal, this parameter can be ignored.

Linearization of the pulse meter (LINx_TYPE, METERx_FREQ and METERx_LIN)
Rules for the linearization curve related to the frequency for meters with pulse signal input:
• Crescent values of frequency in the METERx_FREQ parameter;
• The first value zero in the METERx_FREQ parameter indicates the end of the curve, except for the first element;
• The value of the factor for each one of the configured frequencies must be higher than zero;
• If there is inconsistence in the configuration of the linearization curve, it will be indicated as configuration error and the measurement block will execute in Out of Service mode.
• Curve with 12 points.

If the operation frequency is out of range of the linearization curve in any moment, the value of the factor related to the limit of the configured frequency (upper or lower) will be used. This linearization curve allows three different operation ways according to the LINx_TYPE parameter:
1. K-factor linearization (K-factor = NKF/MF): the calibration value is included in the curve and the MF value for the calculations will be obtained through the division of NKF factor by the average weighted of K-factor. The proving process consists of executing the proving for different flows, this must be impossible due to project (proving in different flows) or time.
2. NKF linearization: the linearization curve, in fact, indicates NKF related to the frequency, that is, the curve obtained in the laboratory, after the meter manufacturing, is kept unchanged. The proving process must be executed using the usual flow (frequency), where the MF must be unique for the whole operation range.
3. MF linearization: the linearization curve indicates MF related to the frequency. It is obtained in large time intervals, while the last proving (low periodicity) executed for the flow closest to the usual provides to the linearization curve an adjusting.

The indicated values for k-factor, NKF and MF in the QTR reports or proving, if they are result of linearization process, are obtained through weighted average calculations, according to the API-21.2 item 10.3.4 standard.

LINx_TYPE	METERx_INFO.NKF	MF_METER_PRODUCT.Meter Factor(n) – Last Proving	Factor that changes according to the frequency/flow	Specific consistence check
K-factor	Must be configured by user.	Ignored, calculates the MF=NKF/KF_{lin}.	MF, it is included in the K-factor.	NKF divided by each one of the K-factor values, This result must be between the range from 0.8 to 1.2
NKF	Ignored.	Used for the calculations.	NKF	
MF	Must be configured by user	Used for adjusting the linearization curve of MF.	MF	MF value in the range from 0.8 to 1.2

Note: Each meter has only one linearization curve, it is obtained from a determined condition, and also includes the product type. The user must keep the consistence between:
- Linearization curve obtained for the product type;
- MF obtained for proving using the same product of the obtained curve (NKF or MF linearization);
- The measured product must be the same of the product used for the curve obtainment.

Special procedures when selecting the MF linearization:
- It configures the linearization curve for the desired meter;
- It configures the linearization curve between the established ranges from 0.8 to 1.2 for METERx_LIN;
- It accomplishes the proving with the new configuration or writing the MF and also the flow that the proving was executed.

Information about provers
When the master meter for proving is used, the MASTER_METER_INFO parameter must be configured properly. It needs to be emphasized that the master meter must be the same type as the operational meter, that is, both must provide pulse, both measuring volume (IV), or both measuring volume correctly in temperature (IV*CTL), or both measuring mass (IM).

Observe that the Base Prover Volume, Outside diameter and Wall thickness parameters must be provided at base temperature defined for this block at base TEMPERATURE parameter.

The default prover configuration using SI Unit System is shown below:

PROVER1_INFO:

E	Element Name	Data type
1	Prover type	Small volume prover, unidirectional
2	Base Prover Volume (not used if tank prover)	0.120350 m^3
3	Outside diameter	469.90 mm
4	Wall thickness	31.75 mm
5	Pipe Gl	0.0000112 1/Celsius
6	Modulus of elasticity [Elas]	206 800 000 KPa
7	Single-walled (0=No; 1=Yes)	Yes
8	External shaft – Gl (0.0=internal detectors)	0.0000014 1/Celsius
9	Serial number	9501-1754
10	Manufacturer name	SK Instruments

PROVER2_INFO:

E	Element Name	Data type
1	Prover type	U type, unidirectional
2	Base Prover Volume (not used if tank prover)	0.905060 m^3
3	Outside diameter	396.88 mm
4	Wall thickness	9.53 mm
5	Pipe Gl	0.0000159 1/Celsius
6	Modulus of elasticity [Elas]	193 100 000 KPa
7	Single-walled (0=No; 1=Yes)	Yes

E	Element Name	Data type
8	External shaft – Gl (0.0=internal detectors)	0 1/Celsius
9	Serial number	SPA-430
10	Manufacturer name	PP Industries

PROVER3_INFO:

E	Element Name	Data type
1	Prover type	U type, bidirectional
2	Base Prover Volume (round trip if bidirectional prover)	1.81974 m^3
3	Outside diameter	396.88 mm
4	Wall thickness	9.53 mm
5	Pipe Gl	0.0000159 1/Celsius
6	Modulus of elasticity [Elas]	193 100 000 KPa
7	Single-walled (0=No; 1=Yes)	Yes
8	External shaft – Gl (0.0=internal detectors)	0 1/Celsius
9	Serial number	SPB-430
10	Manufacturer name	PP Industries

PROVER4_INFO:

E	Element Name	Data type
1	Prover type	Tank prover
2	Base Prover Volume (not used if tank prover)	5.00000 m^3
3	Outside diameter	0 mm
4	Wall thickness	0 mm
5	Pipe Gl	0 0000159 /Celsius
6	Modulus of elasticity [Elas]	0 KPa
7	Single-walled (0=No; 1=Yes)	No
8	External shaft – Gl (0.0=internal detectors)	0 1/Celsius
9	Serial number	023
10	Manufacturer name	BR 102/5255

Information about the measured products (PRODUCTx_INFO)

The products measured by HFC302 are showed in the graphs below and also the correspondent valid ranges for density and temperature for calculation of the correction factors.

The selection of emulsion product type (mix of crude oil/light hydrocarbon and water) means an allocation measurement and the API-MPMS 20.1 Allocation Measurement Standard will be used for the correction factor calculations.

The allocation measurement (mix of crude oil/light hydrocarbon and water) has some restrictions when compared to the custody transfer measurement:

• Meter or master meter are not supported with pulse or analog signal IV*CTL.

• The density type for hydrocarbon (crude oil or light hydrocarbon) must be at base condition, resulting from laboratory analysis.

• Meter Proving in field using emulsion is only allowed on the following configurations:

1. Volume meter of the IV pulse input and prover type (piston prover, ball prover and tank prover).

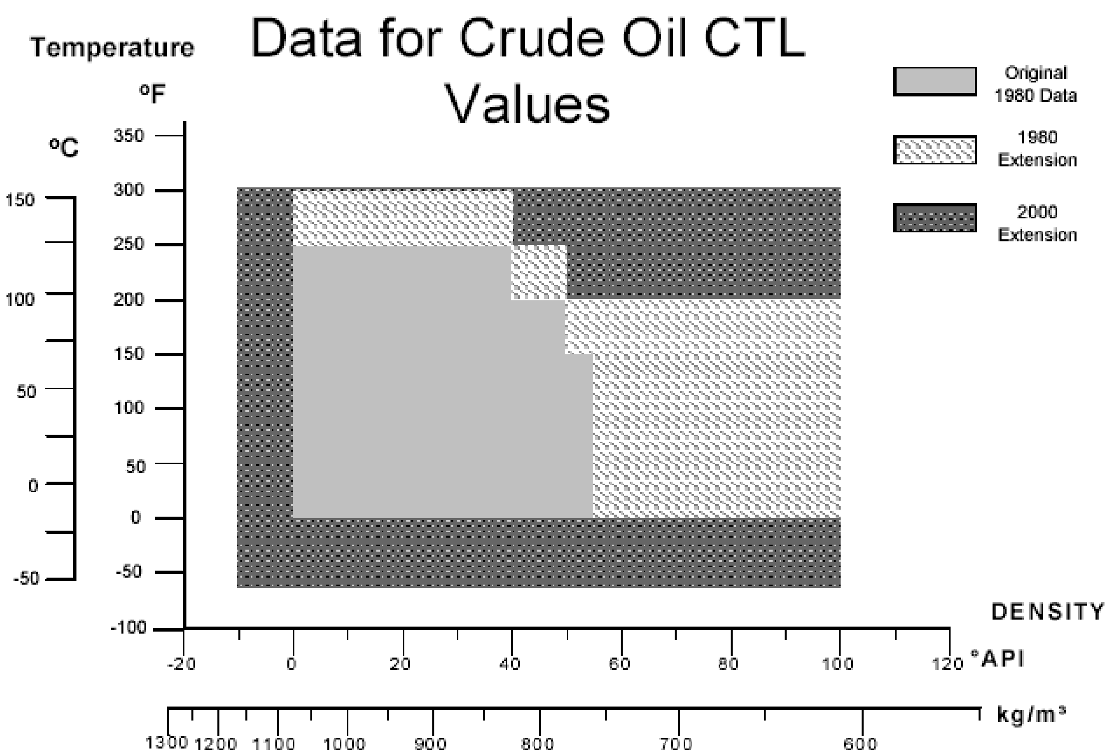
2. Master meter: meter and master meter should be of the same type and one of the following types: IV pulse input, IV analog input, IM pulse input or IM analog input.

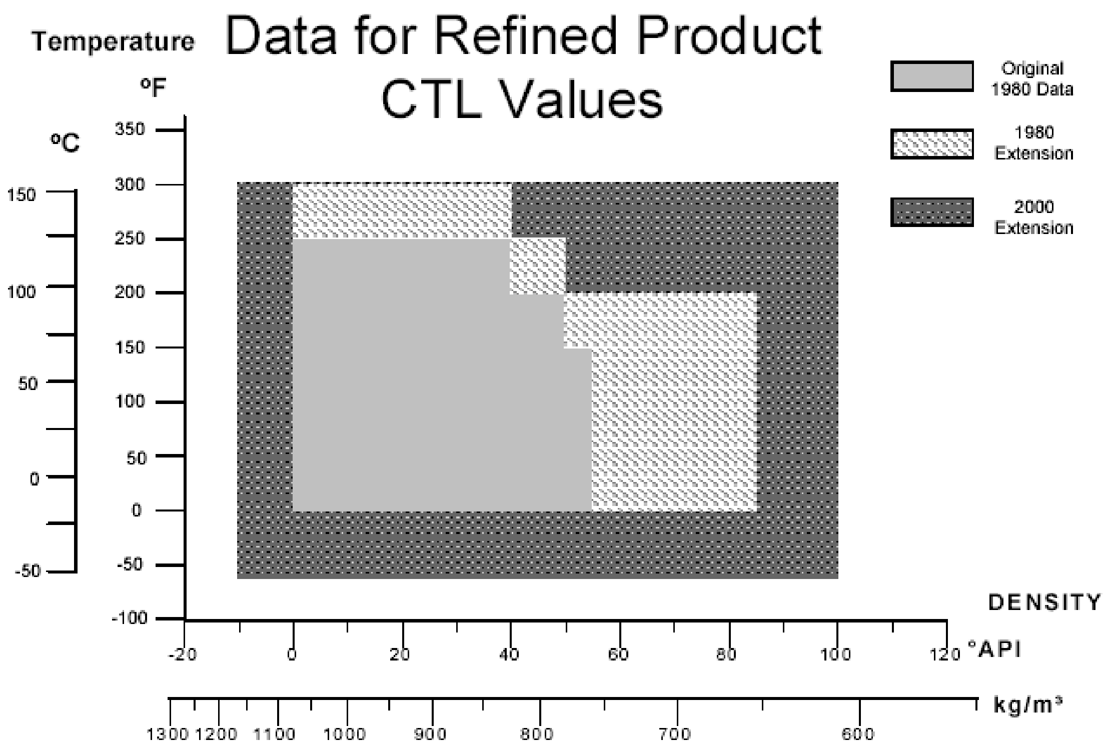
To calculate the temperature (CTL) and pressure (CPL) correction factors, if the density or temperature were out of the established range by the standard, these factors will assume the value 1. This event will be registered in the logger and accessed via AEV block and also it will be showed in the summarized status of the QTR report for the correspondent period.

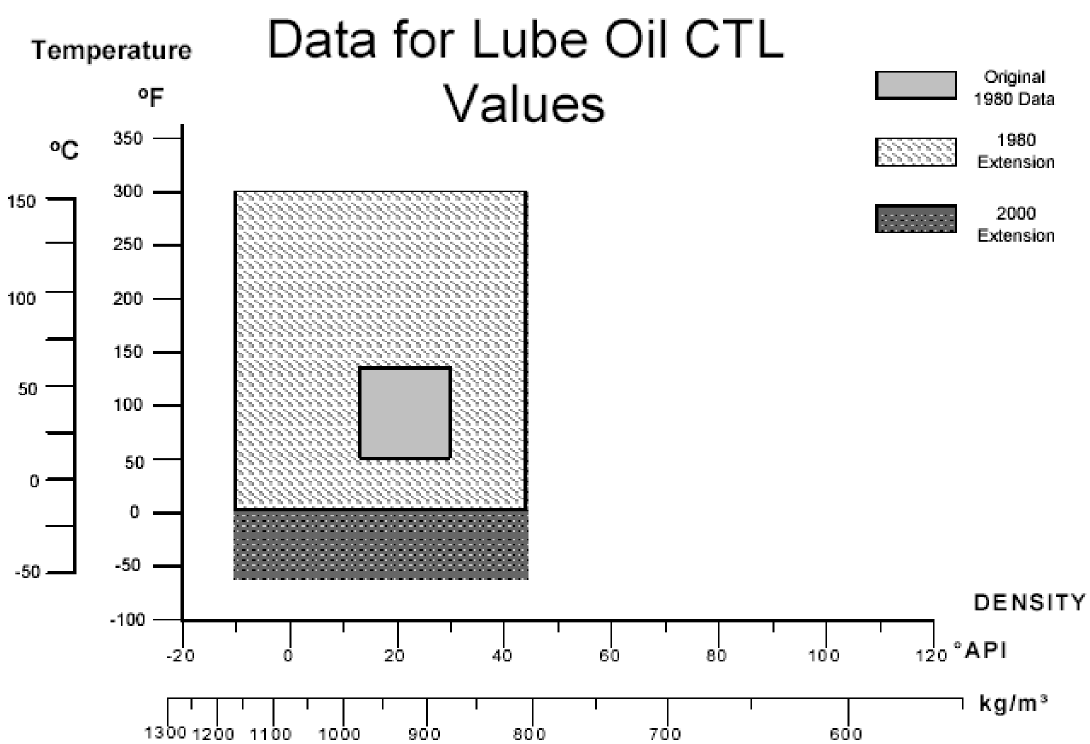
This rule is applied to average values (period of one batch, time, day, week or month) or instantaneous values (used to calculate flow).

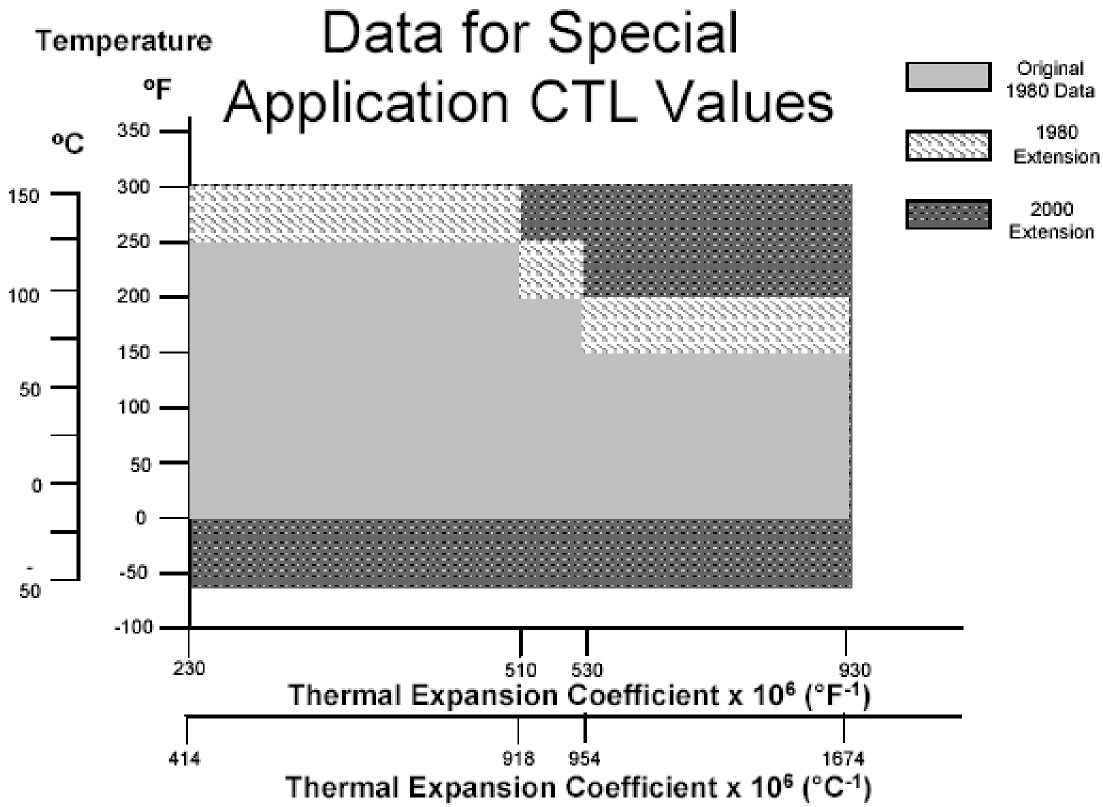
The variable ranges used in the correction factor calculations are presented below, which the density and temperature ranges indicated for the CTL calculation does not indicate a square area for API-11.1:1980. However, the calculation ranges for 2004 version are always a square area.

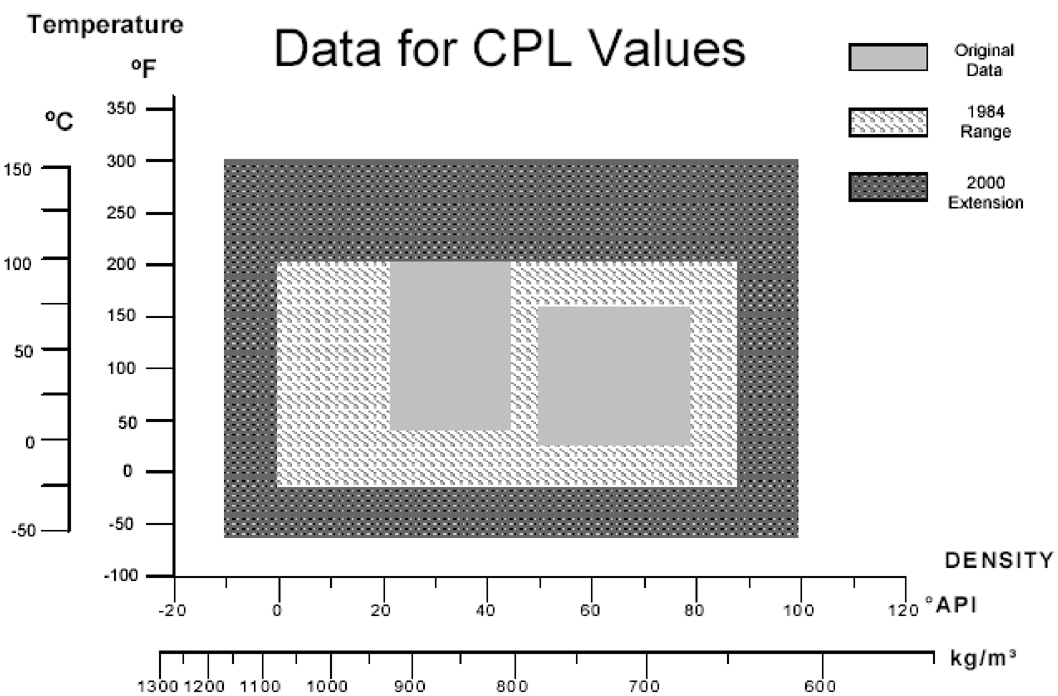
	Crude Oil	Refined Products	Lubricating Oil
Density, kg/m^3@60°F	610.6 to 1163.5		800.9 to 1163.5
Relative Density@60°F	0.61120 to 1.16464		0.80168 to 1.1646
API @60°F	100 to -10		45.0 to -10.0
kg/m^3@15°C	611.16 to 1163.79	611.16 to 1163.86	801.25 to 1163.85
kg/m^3@20°C	606.12 to 1161.15	606.12 to 1160.62	798.11 to 1160.71
Temperature, °C	-50.00 to 150.00		
°F	-58.00 to 302.0		
Pressure, psig	0 to 1500		
Kpa (gauge)	0 to 1.034E4		
α_{60} , 1/°F	230.0E-6 to 930.0E-6		
1/°C	414.0E-6 to 1674.0E-6		




Data for Refined Product CTL Values
Temperature
°F
°C
Original 1980 Data
1980 Extension
2000 Extension
DENSITY
°API
kg/m³
350
300
250
200
150
100
50
0
-50
-100
150
100
50
0
-50
-20
0
20
40
60
80
100
120
1300
1200
1100
1000
900
800
700
600


Data for Lube Oil CTL Values
Temperature
°F
°C
Original 1980 Data
1980 Extension
2000 Extension
DENSITY
°API
kg/m³
350
300
250
200
150
100
50
0
-50
-100
150
100
50
0
-50
-20
0
20
40
60
80
100
120
1300
1200
1100
1000
900
800
700
600





For the CTL calculation of the MTBE product (Methyl Tert-butyl Ether), it is used the coefficient of thermal expansion instead of the density. This coefficient must be configured in the PRODUCTx_INFO parameter.

For MTBE product type, observe the specific following features:

- Must be configured the thermal expansion coefficient in PRODUCTx_INFO. Thermal expansion coefficient in base temperature (MTBE), as following table.

API-11.1:1980		API-11.1:2004	
SI **T_{base} = 15ºC or 20ºC**	**USA** **T_{base} = 60ºF**	**SI** **T_{base} = 15ºC or 20ºC**	**USA** **T_{base} = 60ºF**
α @ 15ºC α @ 20ºC In the temperature unit selected at T_UNITS	α @ 60ºF In the temperature unit selected at T_UNITS	α @ 60ºF In the temperature unit selected at T_UNITS	

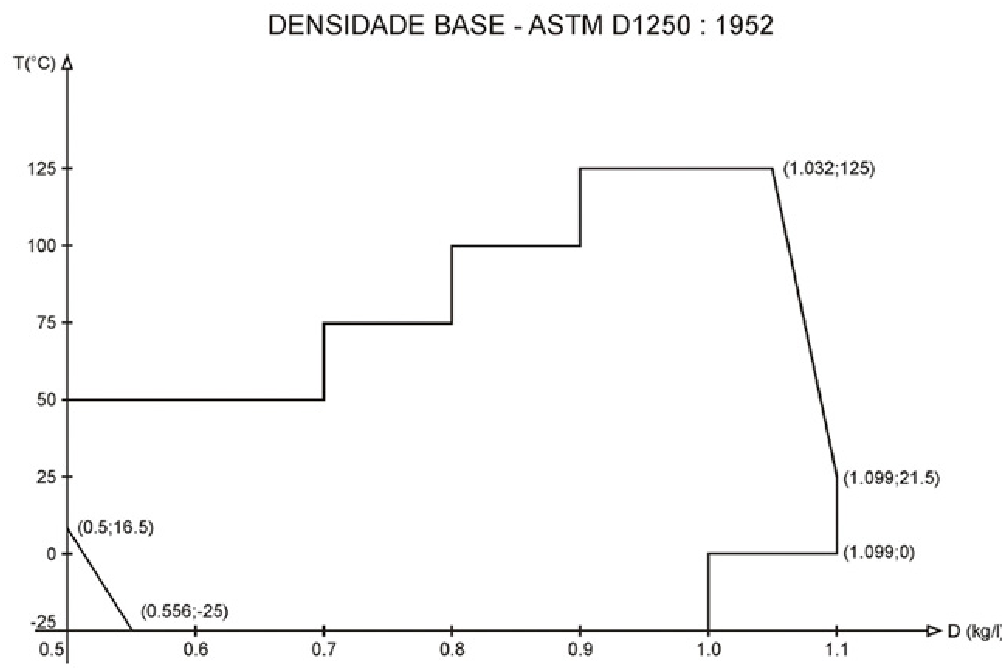
The conversion equation of engineering unit is given by:

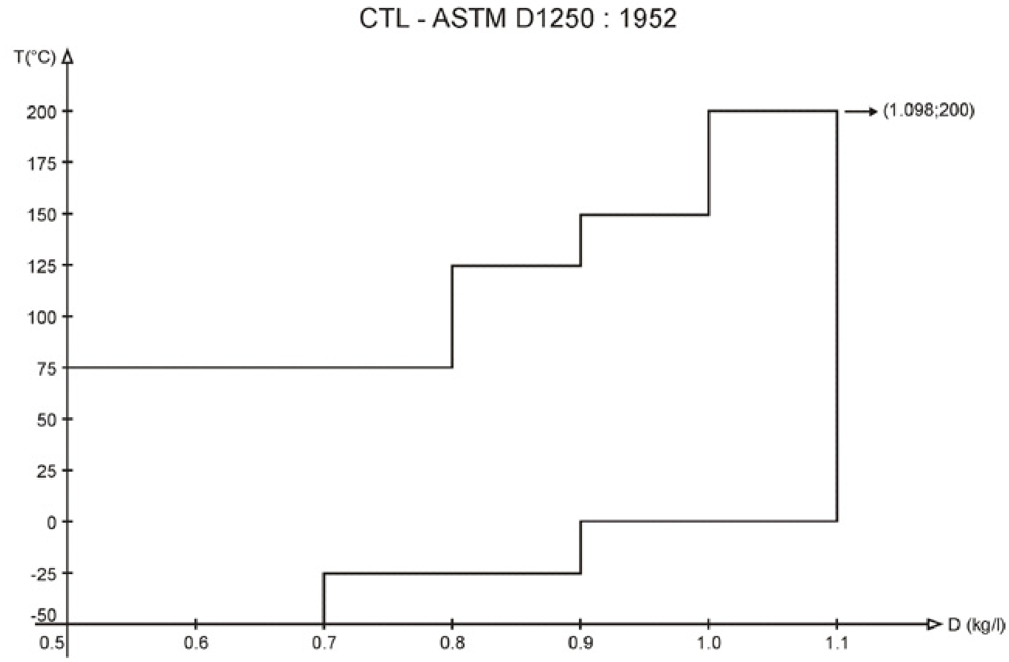
$$\alpha_{60^\circ F,^\circ F} = \frac{\alpha_{60^\circ F,^\circ C}}{1.8}$$

Where:

$\alpha_{60ºF,ºC}$: Coefficient of thermal expansion at 60 °F expressed in °C
$\alpha_{60ºF,ºF}$: Coefficient of thermal expansion at 60 °F expressed in ºF

Calculation of base density and CTL by using ASTM D 1250:1952 (*)




CTL - ASTM D1250 : 1952
T(°C)
200
175
150
125
100
75
50
25
0
-25
-50
0.5
0.6
0.7
0.8
0.9
1.0
1.1
D (kg/l)
(1.098;200)

NOTE
The density value provided in the DENSITY_METER parameter of the LBT/LCT blocks is used for calculating the compressibility factor calculation for MTBE.

Standards used in the CPL calculation

Standard	Base Density Range	Temperature Range	Product type
API-11.2.1	0-90 API @ 60 °F	-20 to 200 °F	Crude Oil Generalized Products MTBE Lubricant Oil Light Hydrocarbon Emulsion of Crude Oil and Water Emulsion of Light Hydrocarbon and Water ASTM D1250:1952
API-11.2.1.M	638-1074 Kg/m^3 @15° C	-30 to 90 °C	Crude Oil Generalized Products MTBE Lubricant Oil Light Hydrocarbon Emulsion of Crude Oil and Water Emulsion of Light Hydrocarbon and Water ASTM D1250:1952
API-11.2.2 (*)	0.350-0.637 RD (60°F/60°F)	-50°F to 140°F	Light Hydrocarbon Emulsion of Light Hydrocarbon and Water
API-11.2.2.M (*)	350-637 Kg/m^3 @15° C	-46°C to 60°C	Light Hydrocarbon Emulsion of Light Hydrocarbon and Water

(*)The GPA TP 15 standard is used for calculating the equilibrium pressure.

Standard	Base Density Range (RD (60°F/60°F))	Temperature Range (°F)
GPA-TP-15	0.490 to 0.676	-50°F to 140°F

The GPA TP 15 standard establishes two calculation formulas:

- New Correlation – Related to base density and temperature → mix of propane, mix of butane and NGL (mainly pentane and hexane). Must be configured in PRODUCTx_INFO.Absolute equilibrium pressure @100F = 0.

- Modified Correlation – Related to base density, temperature and equilibrium absolute pressure at 100 °F = 37.8 °C → proper for NGL measurement that the variation of the equilibrium pressure at 100 °F is more significant for the same density

Besides five products mentioned (crude oil, generalized products, MTBE, lubricant oil and LPG/NGL), there is an option to select water and emulsion of water and oil. For these two products, the water is compensated in temperature using the base density and flow temperature. The ranges for water base density and correction factor temperature are indicated in the table below:

Product	Base Density Range	Temperature Range
Water	999 to 1100 kg/m^3	60°F/15°C to 280°F/138°C

The CPL calculation for water utilizes the following factors for compressibility, according to the API-12.2.3 appendix A4:

F	Engineering Unit
3.20E-6	Psi^{-1}
4.64E-7	kPa^{-1}

Light Hydrocarbon Measurement – NGL / LPG
The light hydrocarbon measurement shows a particularity, because there is no international standard for temperature correction factor (CTL) for the base temperatures of 15°C or 20°C in the International System of Units.

The previous standards GPA TP16 and GPA TP 16M are discontinued. The GPA TP 16 M was applied to the International System of Units.

The new standard GPA TP 25, which defines the tables 23E and 24E, utilizes the relative density(SG) as input and the temperature in Fahrenheit to obtain the base density at 60°F and the CTL.

The following calculations are developed for HFC302 in order to fill this standard table:
1. International System of Units and base temperature of 15°C
- The process density is converted from Kg/m3 to SG
- The process temperature is converted from Celsius to Fahrenheit
- It calculates the relative density at the base temperature of 60°F using the table 23E
- The temperature correction factor is calculating following the equation below:

$$CTL_{T,15°C} = \frac{CTL_{T,60°F}}{CTL_{15°C,60°F}}$$

Where:
$CTL_{T,15°C}$: temperature correction factor of the process at 15°C
$CTL_{T,60°F}$: temperature correction factor of the process at 60°F using table 24E.
$CTL_{15°C,60°F}$:correction factor from 15°C to 60°F using the table 24E.

- It calculates the equilibrium pressure using the GPA TP 15 standard providing the relative density in the base temperature of 60°F and the process temperature.
- It calculates the compressibility factor using the API-11.2.2 standard providing the relative density in the base temperature of 60°F, the process temperature and the pressure higher than the equilibrium pressure.

2. International System of Units and base temperature of 20°C
- The process density is converted from Kg/m3 to SG
- The process temperature is converted from Celsius to Fahrenheit
- It calculates the relative density at base temperature of 60°F using the table 23E
- It calculates the temperature correction factor following the equation below:

$$CTL_{T,20°C} = \frac{CTL_{T,60°F}}{CTL_{20°C,60°F}}$$

Where:
$CTL_{T,20°C}$: temperature correction factor of the process for 20°C
$CTL_{T,60°F}$: temperature correction factor of the process for 60°F using the table 24E..
$CTL_{20°C,60°F}$: correction factor from 20°C to 60°F using the table 24E.

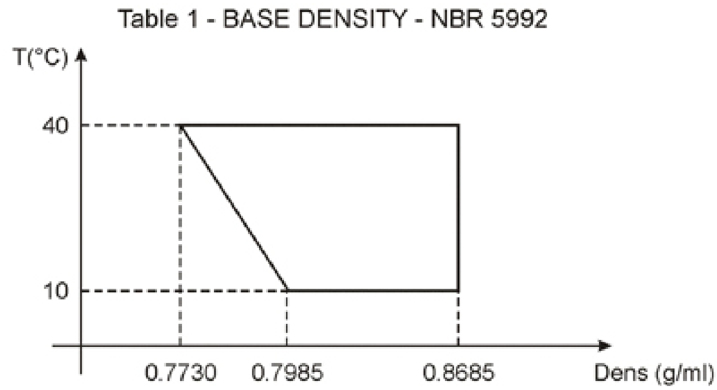
- It calculates the equilibrium pressure using the GPA TP 15 standard providing the relative density at base temperature at 60°F and the process temperature.
- It calculates the compressibility factor using the API-11.2.2.M standard, providing the relative density at base temperature at 60°F, process temperature and the pressure higher than the equilibrium pressure. The API-11.2.2.M standard determines the base temperature conversion at 15°C to the relative density at the base temperature of 60°F, thus it is not necessary to calculate the density in kg/m3 at 15°C.

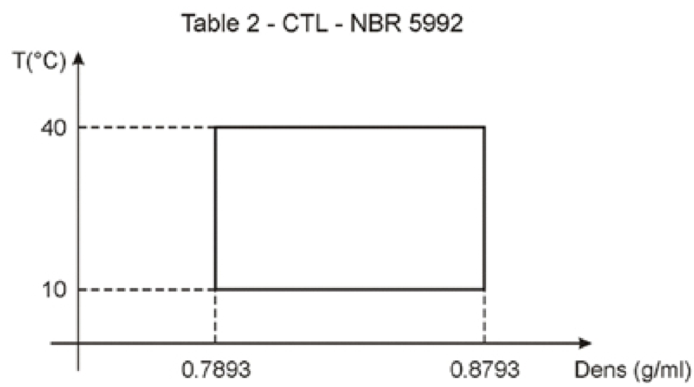
The temperature and pressure correction factors are calculated using three standards: GPA TP 15, GPA TP 25 and API-11.2.2/API-11.2.2.M or API-11.2.1/API-11.2.1.M. Each standard has the density and temperature ranges proper, so the intersection among them provides the range which allows the whole calculation, as showed below:

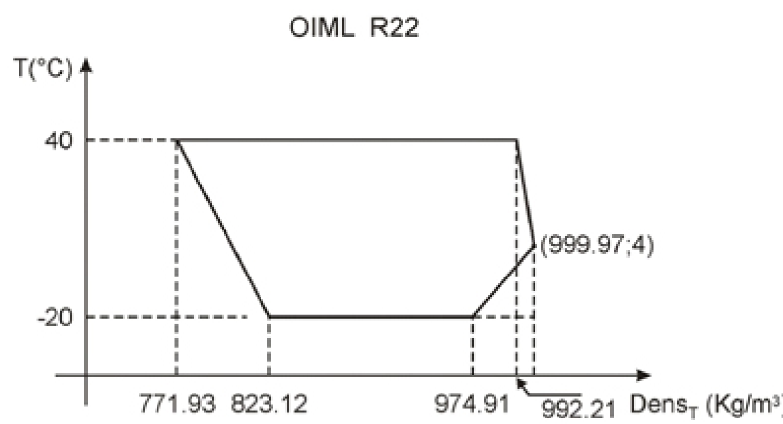
Base Density Range (RD (60°F/60°F)	Temperature Range
0.490 to 0. 676	- 46°C/-50°F to 60°C/140°F

Ethanol Measurement – NBR 5992-80, NBR 5992-09 or OIML R22-75

- Must necessarily be in liquid phase.
- It is a mix of water and ethanol.
- It is considered Considera-se fluido incompressible.
- NBR 5992-80 : alcoholic content (percentage in mass in mix) from 66% to 100% and temperature range between 10ºC and 40ºC.
- OIML R22 and NBR 5992-09 : alcoholic content (percentage in mass in mix) from 0% to 100% and temperature range between -20ºC and 40ºC.







Selected product type

The standards used for the selected product follow the table below:

Product Type	Products	CTL Standard	CPL Standard	Pe Standard	Appropriation Measurement
Crude Oil	Crude Oils Natural Gasolines Drip Gasolines JP4	• API-11.1-A:1980 • API-11.1-A:2004	• API-11.2.1:1984 • API-11.2.1:2004	Pe=0 (gauge)	No
Generalized	Gasoline	• API-11.1-B:1980	• API-11.2.1:1984	Pe=0 (gauge)	No

Product Type	Products	CTL Standard	CPL Standard	Pe Standard	Appropriation Measurement
Products	Naphthenes Jet Fuels Aviation Fuels Kerosine Diesel Heating Oils Fuel Oils Furnace Oils	• API-11.1-B:2004	• API-11.2.1:2004		
MTBE		• API-11.1-C:1980 • API-11.1-C:2004	• API-11.2.1:1984 • API-11.2.1:2004	Pe=0 (gauge)	No
Lubricant Oil	Lube Oils	• API-11.1-D:1980 • API-11.1-D:2004	• API-11.2.1:1984 • API-11.2.1:2004	Pe=0 (gauge)	No
Water	Water with salinity up to 14%	API-20.1	F=4.64E-7 Kpa^{-1} or 3.2E-6 psi^{-1}	Pe=0 (gauge)	No
Light Hydrocarbon	Liquefied Petroleum Gas (LPG) Natural Gas Liquid (NGL)	GPA TP 25	API-11.2.1:1984 / API-11.2.2:1986	GPA TP 15	No
Emulsion of Crude Oil and Water	Emulsion of crude oil	• API-11.1-A:1980 • API-11.1-A:2004	• API-11.2.1:1984 • API-11.2.1:2004	Pe=0 (gauge)	CTLw: API-20.1 CPLw: F=4.64E-7 Kpa^{-1} or 3.2E-6 psi^{-1}
Emulsion of light hydrocarbon and water	Emulsion of natural gasoline	GPA TP 25	API-11.2.1:1984 / API-11.2.2:1986	GPA TP 15	CTLw: API-20.1 CPLw: F=4.64E-7 Kpa^{-1} or 3.2E-6 psi^{-1}
ASTM D 1250:1952	Crude Oils Refined products	ASTM D 1250:1952	API-11.2.1:1984	Pe=0 (gauge)	No
Etanol-OIML R22 Etanol-NBR 5992	Anhydrous (absolute) ethanol Hydrous ethanol	• OIML R22 • NBR 5992	F=0	-	No

Information for the proving historic

The historic information about the last provings is stored in the HFC302 memory and can be visualized in the MF_METERx and CONDITIONS_METERx parameters.

Each operational and master meters has: historic (MF and date/time) of the last provings in the MF_METERx parameter and the conditions in which the last and the last but two provings were accomplished in the CONDITIONS_METERx parameter.

Meter factor changes (MF)

In some situations, it is desired to change directly the MF, because the meter was calibrated by a prover with calculation capacity and MF determination or the meter was calibrated in laboratory, then the user must proceed:

1. Write the volume flow rate (IV) into the CONDITIONS_METERx.Current flow rate IV parameter.

   This information is very important if the meter factor linearization is selected.

2. Writing the new value for MF in the first element of the MF_METERx parameter in a time interval lower than 30 seconds after writing the flow rate. Writing it, HFC302 will provide the correspondent date/time of change.

The CONDITIONS_METERx.Current flow rate IV parameter will return to the previous value if the time interval of 30 seconds expires.

Therefore the writing into the flow rate is confirmed through the writing into the correspondent meter factor.

Diagnosis and troubleshooting

- BLOCK_ERR. Out of Service: the block is in the Out of service mode.
- BLOCK_ERR. Block configuration: this indication may occur due to the following problem:
  - Any inconsistency in the linearization curve;

Supported modes

O/S and AUTO.

Parameters

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3	4	STRATEGY 3xx.xx0	Unsigned16	255	255	None	S / RO	
4	4	ALERT_KEY 4xx.xx0	Unsigned8	1 to 255	0	None	S	
5	1,3 CF	MODE_BLK Target/Normal=4xx.xx1-4xx.xx3 Actual=3xx.xx1	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7 (A1) (CL)	CF	BASE_TEMPERATURE 4xx.xx4 - 4xx.xx5	Float SI-DD2 US-DD1	15.0 °C or 20.0 °C (Kg/m^3) or 60.0 °F (API or SG)	SI=15.0 USA=60.0	T	S	Base pressure for the fluid according to the SYSTEM_UNITS selected in the FCT block.
8 (A2) (CL)	2 CF	METER1_INFO 4xx.xx6 - 4xx.x42	DS-268				S	Information of meter 1 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 1.
9 (A2) (CL)	4 CF	METER2_INFO 4xx.x43 - 4xx.x79	DS-268				S	Information of meter 2 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 2.
10 (A2) (CL)	CF	METER3_INFO 4xx.x80 - 4xx.116	DS-268				S	Information of meter 3 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 3.
11 (A2) (CL)	CF	METER4_INFO 4xx.117 - 4xx.153	DS-268				S	Information of meter 4 provided by the manufacturer. This parameter should be configured when a pulse signal sensor is selected for the run number 4.
12 (A2) (CL)	CF	MASTER_METER_INFO 4xx.154 - 4xx.190	DS-268				S	Information of the Master meter information provided by the manufacturer.
13 (A2) (CL)	2 CF	MM_TYPE 4xx.191	Unsigned8	0 = IV pulse input 1=IV*CTL pulse input 2=IM pulse input 3=Flow IV analog input 4=Flow IV*CTL analog input 5=Flow IM analog input	0	E	S	When the option pulse input is selected, it is necessary to configure the CHANNEL_MM parameter to address the physical point of the pulse input. When the option analog input is selected, it is necessary to link the FLOW_MM input. IV: indicated volume without any correction IV*CTL: indicated volume corrected by temperature IM: indicated mass.
14 (A2) (CL)	CF	PROVER1_INFO 4xx.192 - 4xx.221	DS-269				S	Information for Prover 1 provided by manufacturer.
15 (A2) (CL)	CF	PROVER2_INFO 4xx.222 - 4xx.251	DS-269				S	Information for Prover 2 provided by manufacturer.
16 (A2) (CL)	CF	PROVER3_INFO 4xx.252 - 4xx.281	DS-269				S	Information for Prover 3 provided by manufacturer
17 (A2) (CL)	CF	PROVER4_INFO 4xx.282 - 4xx.311	DS-269				S	Information for Prover 4 provided by manufacturer.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
18 (A2) (CL)	2 CF	PRODUCT1_INFO 4xx.312 - 4xx.330	DS-270		Crude Oil		S	Information for Product 1.
19 (A2) (CL)	4 CF	PRODUCT2_INFO 4xx.331 - 4xx.349	DS-270		Generalized Products		S	Information for Product 2.
20 (A2) (CL)	CF	PRODUCT3_INFO 4xx.350 - 4xx.368	DS-270		MTBE		S	Information for Product 3.
21 (A2) (CL)	CF	PRODUCT4_INFO 4xx.369 - 4xx.387	DS-270		Lubricating Oil		S	Information for Product 4.
22 (A2) (CL)	CF	PRODUCT5_INFO 4xx.388 - 4xx.406	DS-270		Light hydrocarbon		S	Information for Product 5.
23 (A2) (CL)	CF	PRODUCT6_INFO 4xx.407 - 4xx.425	DS-270		Emulsion Crude Oil and Water/base density		S	Information for Product 6.
24 (A2) (CL)	CF	PRODUCT7_INFO 4xx.426 - 4xx.444	DS-270		Emulsion Light hydrocarbon and Water/base density		S	Information for Product 7.
25 (A2) (CL)	CF	PRODUCT8_INFO 4xx.445 - 4xx.463	DS-270		ASTM D1250:1952		S	Information for Product 8.
26 (A2) (CL)	CF	PRODUCT9_INFO 4xx.464 - 4xx.482	DS-270		Ethanol-OIML R22		S	Information for Product 9.
27 (A2) (CL)	CF	PRODUCT10_INFO 4xx.483 - 4xx.501	DS-270		Ethanol-NBR 5992-80		S	Information for Product 10.
28 (A2) (CL)	CF	METER1_FREQ 4xx.502 - 4xx.525	Float[12]	>= 0.0	0.0	Hz	S	Frequencies for the linearization curve of the NKF factor related to the frequency applied to the meter 1.
29 (A2) (CL)	CF	METER1_LIN 4xx.526 - 4xx.549	Float[12]	>= 0.0	0.0	K	S	Linearization curve factor of K-factor/NKF/MF related to the frequency applied to the meter 1, if LIN1_TYPE is different from none.
30 (A2) (CL)	CF	METER2_FREQ 4xx.550 - 4xx.573	Float[12]	>= 0.0	0.0	Hz	S	Frequencies for the linearization curve of the NKF factor related to the frequency applied to the meter 2.
31 (A2) (CL)	CF	METER2_LIN 4xx.574 - 4xx.597	Float[12]	>= 0.0	0.0	K	S	NKF's of the linearization curve for the K-factor/NKF/MF related to the frequency applied to the meter 2, if METER2_INFO.NKF is different from none.
32 (A2) (CL)	CF	METER3_FREQ 4xx.598 - 4xx.621	Float[12]	>= 0.0	0.0	Hz	S	Frequencies for the linearization curve of the NKF factor related to the frequency applied to the meter 3..
33 (A2) (CL)	CF	METER3_LIN 4xx.622 - 4xx.645	Float[12]	>= 0.0	0.0	K	S	Factor of the linearization curve for the K-factor/NKF/MF related to the frequency applied to the meter 3, if LIN3_TYPE is different from none.
34 (A2) (CL)	CF	METER4_FREQ 4xx.646- 4xx.669	Float[12]	>= 0.0	0.0	Hz	S	Frequencies for the linearization curve of the NKF factor related to the frequency applied to the meter 4.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
35 (A2) (CL)	CF	METER4_LIN 4xx.670 - 4xx.693	Float[12]	>= 0.0	0.0	K	S	Factor of the linearization curve for the K-factor/NKF/MF related to the frequency applied to the meter 4, if LIN4_TYPE is different from none.
36 (A2) (CL)	CF	MASTER_METER_FREQ 4xx.694 - 4xx.717	Float[12]	>= 0.0	0.0	Hz	S	Frequencies for the linearization curve of the NKF factor related to the frequency applied to the master meter.
37 (A2) (CL)	CF	MASTER_METER_LIN 4xx.718 - 4xx.741	Float[12]	>= 0.0	0.0	K	S	Factor of the linearization curve for the NKF factor related to the frequency applied to the master meter, if LIN_MASTER_TYPE is different from none.
38 (A2) (CL)	CF	LIN1_TYPE 4xx.742	Unsigned8	0=none 1=K-factor 2=NKF 3=MF	0	Na	S	It indicates the linearization type to be used for the meter 1.
39 (A2) (CL)	CF	LIN2_TYPE 4xx.743	Unsigned8	0=none 1=K-factor 2=NKF 3=MF	0	Na	S	It indicates the linearization type to be used for the meter 2.
40 (A2) (CL)	CF	LIN3_TYPE 4xx.744	Unsigned8	0=none 1=K-factor 2=NKF 3=MF	0	Na	S	It indicates the linearization type to be used for the meter 3.
41 (A2) (CL)	CF	LIN4_TYPE 4xx.745	Unsigned8	0=none 1=K-factor 2=NKF 3=MF	0	Na	S	It indicates the linearization type to be used for the meter 4.
42 (A2) (CL)	CF	LIN_MASTER_TYPE 4xx.746	Unsigned8	0=none 1=K-factor 2=NKF 3=MF	0	Na	S	It indicates the linearization type for the master meter.
43	1	SELECT_METER 4xx.747	Unsigned8	0=Master Meter 1=Meter 1 2=Meter 2 3=Meter 3 4=Meter 4	1	E	N	Parameter without functionality.
44	1	SELECT_PRODUCT 4xx.748	Unsigned8	1-10 = Product 1-10	1	E	N	Parameter without functionality.
45 (A2) (CL)	MN	MF_MASTER 3xx.xx3 – 3xx.x64 4xx.749 - 4xx.750	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and date/time for the master meter. The first element of the array is the actual and the only one can be written by user.
46	MN	CONDITIONS_MASTER 3xx.x65 – 3xx.x88 4xx.751 - 4xx.752	DS-272				S	Previous conditions and the last proving session for the master meter.
47		UPDATE_EVT 3xx.x89 – 3xx.x95 4xx.753	DS-73			Na	D	This alert is generated by any change to the static data.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store / Mode	Description
48		BLOCK_ALM 3xx.x96 – 3xx.102 4xx.754	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is displayed in the sub code field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported, without clearing the Active status, if the sub code has changed.
49 (A2) (CL)	MN	MF_METER1 3xx.103 – 3xx.164 4xx.755 - 4xx.756	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and date/time for the meter 1. The first element of the array is the actual and the only one can be written by user.
50 (CL)	MN	CONDITIONS_METER1 3xx.165 – 3xx.188 4xx.757 - 4xx.758	DS-272				S	Previous conditions and the last proving session for the meter 1.
51 (A2) (CL)	MN	MF_METER2 3xx.189 – 3xx.250 4xx.759 - 4xx.760	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and date/time for the meter 2. The first element of the array is the actual and the only one can be written by user.
52 (CL)	MN	CONDITIONS_METER2 3xx.251 – 3xx.274 4xx.761 - 4xx.762	DS-272				S	Previous conditions and the last proving session for the meter 2.
53 (A2) (CL)	MN	MF_METER3 3xx.275 – 3xx.336 4xx.763 - 4xx.764	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and date/time for the meter 3. The first element of the array is the actual and the only one can be written by user.
54 (CL)	MN	CONDITIONS_METER3 3xx.337 – 3xx.360 4xx.765 - 4xx.766	DS-272				S	Previous conditions and the last proving session for the meter 3.
55 (A2) (CL)	MN	MF_METER4 3xx.361 – 3xx.422 4xx.767 - 4xx.768	DS-271	0.8 to 1.2	1.0000		S	The last 8 meter factors and date/time for the meter 4. The first element of the array is the actual and the only one can be written by user.
56 (CL)	MN	CONDITIONS_METER4 3xx.423 – 3xx.446 4xx.769 - 4xx.770	DS-272				S	Previous conditions and the last proving session for the meter 4.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – dynamic; N – non-volatile;
S – Static; I – Input Parameter; O-Output Parameter
AA-Administrator Level; A1 – Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL= 1466 bytes (includes block tag and profile); V1-10 bytes; V2-110 bytes; V3-8 bytes; V4-112 bytes
HFCView: OP (Operation), CF (Configuration), MN (Maintenance)

PIP – Pulse Input & Proving

Description
This transducer block of the DF77 module allows whole configuration for the module, as well as the correct reading of the data and status related to pulse reading. For further details, refer to the specific chapter for this module.

Notice that, this block must always be associated to the DF77; and also it must be set previously in the HC transducer block (Hardware Configuration).

Monitoring of 5 groups of pulse input
The 5 groups of pulse inputs are composed, each one, by two pulse inputs, which can act as:
- single pulse: two independent pulse inputs
- dual pulse: two inputs related to only one meter that has two pulse inputs out of phase.

Each pulse input has: status monitoring, pulse quantity of the last macro cycle and the average frequency during the last macro cycle.

The table with the description of the input status is showed below:

Bit	Meaning	Interpretation
0	Pulses have been lost	Overflow of the input pulse counters (24 bits = 16.777.216)
1	Frequency out of range	The frequency set in FREQ_UPPER_RANGE and FREQ_LOWER_RANGE is out of range.
2	Noise detected	The occurred pulses have width larger than the value specified by the input filter (1/8 of the corresponding period of FREQ_UPPER_RANGE).
3	Pulse failure	It is impossible to read the module: incorrect module ID or there is no module
4	Running proving	
5	Reserved5	
6	Dual pulse not active	Dual pulse is set, however one of the signals is not received.
7	Unack pulse error	Occurrence of one of the following types of errors in dual-pulse and unacknowledged: • Coincident pulses • Phase error • Sequence error
8	Current pulse error	Occurrence of one of the following types of errors in dual-pulse in the current macrocycle: • Coincident pulses • Phase error • Sequence error
9	Reserved9	
10	Reserved10	
11	Reserved11	
12	Reserved12	
13	Reserved13	
14	Reserved14	
15	Reserved15	

Detection, correction and indication of the error quantity during the pulse transmission
This block provides, through MISSING_PULSES and EXTRA_PULSES parameters, the monitoring of the error quantity due to missing or extra pulses, respectively, in single pulse or dual pulse modes.

The analysis is based on the instantaneous frequency does not change abruptly to a determined value and then returns to the previous condition and also in the behavior of another phase if dual pulse.

When it is configured for dual pulse, it also has the following consistency checks between A and B pulses that have the correspondent error counters:

- COINCIDENT_ERROR: error counter in which there is a coincidence on the active edges of the phases A and B, with tolerance.
- SEQUENCE_ERROR: the expected behavior is the occurrence of the active edge of the signal A and then the active edge of the signal B, thus they should occur interpolated.
- PHASE_ERROR: besides the expected sequence between the pulses A and B, the phase difference between them must be close to the configured in the Gx_PHASE_DIF parameter with a maximum deviation configured in the Gx_PHASE_DEV parameter.
- COUNT_ERROR: indicates the difference in the counting of the pulses A and B.

The counters mentioned above are increased at each occurrence, it is possible to reset each one or together using the RESET_ERROR_COUNTER parameter.

Error type	Pulse signal	Detection Algorithm	Algorithm	Referring to the Standard	Increased error totalizer	Totalizer(s) of the stage(s)
Coincident Pulses	Dual pulse	Stage difference lower than 11.25º	Φ <= 11.25 or Φ >= 348.75	Must be rejected according to the API-5.5:1992 item 5.5.4.5	COINCIDENT_ERROR	Rejected in both phases
Sequence error	Dual pulse	Sequence inversion : active edge in A stage→ active edge B stage	Only for Gx_PHASE_DIF= 45º or 90º. 180º <= Φ < 348.75º	-	SEQUENCE_ERROR	Rejected in both phases
Phase difference error	Dual pulse	Stage difference between A and B signals compared to the expected stage difference higher to the tolerance (Gx_PHASE_DEV)	(Gx_PHASE_DIF + Gx_PHASE_DEV) < Φ < 180º or 11.25º < Φ < (Gx_PHASE_DIF - Gx_PHASE_DEV)	-	PHASE_ERROR	Rejected in both phases
Extra Pulses	Single and dual pulse	Transitory variation and abrupt in the immediate frequency		Continually check and **correct** problems by methods of comparison according to API-5.5:1992 item 5.5.4.5	EXTRA_PULSES	Rejected in the phase in which was detected.
Missing pulse	Single and dual pulse	Transitory variation and abrupt in the immediate frequency.		Continually check and **correct** problems by methods of comparison according to API-5.5:1992 item 5.5.4.5	MISSING_PULSES	Automatically added to the phase in which was detected

Logic state of inputs and outputs - LOGIC_STATE_PINS parameter
The LOGIC_STATE_PINS parameters shows, at the moment of the reading, the logic state for each one of the ten pulse inputs, the three detector inputs (IN1, IN2 and IN3) and the OUT1 output.

Configuration for the CHANNEL parameter
The CHANNEL parameter indicates where placing the DF77 module associated to this block by rack number, slot, group and point.

The rules to configure the CHANNEL parameter for this block are a slightly different for the other blocks, so it is necessary to follow the steps below:

- The CHANNEL format is RRSGP, where RR indicates the rack number, S indicates the slot number, G indicates the group number and P indicates the point number.
- Point (P): ordinal number of the group input and numerated from 0 (first point) to 7 (last group point) and 9 (the whole group).

- Group (G): ordinal number of the module group and numerated from 0 (first group), 1 (second group) and 9 (all module groups). The DF77 module has 7 groups, groups from 0 to 4 corresponds to pulse inputs while group 5 refers to the detector inputs and group 6 refers to output for prover.
- Slot (S): ordinal number of the slot for a determined rack and numerated from 0 (first slot) to 3 (last slot).
- Rack (R): Each rack has 4 slots and the racks are numerated from 0 (first rack) to 14 (last rack). The physical address of the racks is executed by a rotary key from 0 to F (located between the slots 2 and 3), where the last position (F) must not be used.

Example:
CHANNEL parameter is 1099: it means rack 1, slot 0, the whole group and all the points.
Before configuring the CHANNEL parameter, it is recommended to configure previously the HC block that indicates the module types are being used and the positions (rack/slot). This is important when writing in the CHANNEL parameter, the PIP block will check the addressed module and also the availability (no other block is already using this block).

Pulse simulation – FREQ_SIMULATE parameter
This parameter can simulate the pulse signal in the pulse inputs. The frequency simulated is the value of this parameter given in hertz. The same simulation frequency will be used for all inputs and regardless the malfunction or the DF77 module existence in the rack and configured slot.

Pulse Input Configuration – Gx_CONF, Gx_PHASE_DIF and Gx_PHASE_DEV
For each of the five pulse input groups, there is the following configuration:

- Gx_CONF Parameter:
    - Dual pulse check enable: indicates the pulses A and B are signals out of phase of the same meter, and then the consistency check is possible for pulse transmission related to: coincident pulses, sequence of the phases A and B, phase difference between A and B, and counting difference between A and B.
    - Falling edge Ax and Falling edge Bx: when the operation is selected, this indicates the active edge is the falling one.
    - Ax pulse filter disable and Bx pulse filter disable: the pulse signals go through the low pass filter before any consistency check. When this option is selected, the filter is disabled.
    - Input Ax disabled and Input Bx disabled: A and B signals can be disabled while selecting these options.
- Gx_PHASE_DIF and Gx_PHASE_DEV Parameter: these parameters are used when the dual pulse option is selected. In this situation, these parameters define the phase difference expected between the pulses A and B (Gx_PHASE_DIF) and also the maximum deviation between the measured and expected phase (Gx_PHASE_DEV).

Pulse inputs frequency range
The FREQ_UPPER_RANGE and FREQ_LOWER_RANGE parameters define the frequency operation range for ten pulse inputs. FREQ_UPPER_RANGE defines the cut frequency for the pass low filter applied to the pulse signals, before the consistency check processing. The pulse signals should have maximum width defined by 25% of the correspondent period configured in FREQ_UPPER_RANGE.

If the average frequency for the macro cycle is out of the determined range, the corresponding LED related to the pulse input, Green LED, will be blinking.

Output Control OUT1 – OUT1_CONTROL parameter
The configured value for this parameter defines the pulse width for the OUT1 output, which reflects the difference among the prover types as showed in the following table:

	Brooks	Calibron	Digital Output
Piston resting position	Upstream	Downstream	-
OUT1_CONTROL	1	2 to 254 (Defines the pulse width, OUT1_CONTROL multiplied by 10ms. It is recommended to use 10, that is, 100ms)	0 or 255 (DO Block or MDO controls the OUT1 output)
Active OUT1	Low	High (associated to the DF77 module as suggested)	Depends on the application
When OUT1 is activated (when a run is required)	When /UPSTREAM becomes active.	When the previous run is finished	Depends on the application

When OUT1 is inactivated	When the second detector signals occurs	The OUT1 pulse width is defined by UT1_CONTROL multiplied by 10ms	Depends on the application
Supposed OUT1 signal use in the prover	While OUT1 is active, the hydraulic valve is open, enabling piston downstream position.	Starts the motor which brings the piston for upstream position. The prover automatically decouple the motor, when the piston gets the upstream position.	-

Maintenance and diagnosis for this module

- GENERAL_CONTROL parameter: allows forcing the manufacturer initialization, resetting the module and do the manufacturer auto test.
- TEST_COUNTER and TEST_COUNTER_CONTROL parameter: Enable/disable the pulse counting for the inputs without any processing and it is indicated in TEST_COUNTER. This counting is accomplished in parallel to the usual module processing in which the pulse are checked in order to attend the reliability level A.
- Direct access to the IMB bus:
  - IMB_REQUEST: defines the required operation type
  - IMB_START_ADDR: initial physical address
  - IMB_SIZE: quantity of bytes to be written or read
  - IMB_DATA: reading or writing data in the initial address specified in IMB_START_ADDR in the quantity of specified bytes in IMB_SIZE.

Diagnosis and Troubleshooting

1. BLOCK_ERR. Block configuration: this indication may occur due to the following problems:
   - CHANNEL parameter not configured não foi configurado (value is zero);
   - When the CHANNEL parameter addresses a module type in HC block which is incompatible with this transducer block.
2. BLOCK_ERR.Input failure: any input failures;
3. BLOCK_ERR.Device needs maintenance now: the input configured to dual pulse is failing;
4. BLOCK_ERR. Simulate Active – all pulse inputs are in simulation when the FREQ_SIMULATE parameter is different from zero.

Supported Modes

O/S and AUTO.

Parameters

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3	4	STRATEGY 3xx.xx0	Unsigned16	255	255	None	S / RO	
4	4	ALERT_KEY 4xx.xx0	Unsigned8	1 to 255	0	None	S	
5 (A2) (CL)	1,3 CF	MODE_BLK Target/Normal=4xx.xx1-4xx.xx3 Actual=3xx.xx1	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7	1 MN	GENERAL_STATUS 3xx.xx3	Bitstring(2)	See GENERAL_STATUS		E	D / RO	Module status.
8	1 OP	PROVING_STATUS 3xx.xx4	Bitstring(2)	See PROVING_STATUS		E	D / RO	Status indication related to proving.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/Mode	Description
9	1 MN	A1_STATUS 3xx.xx5	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input A1.
10	1 OP	A1_PULSES 3xx.xx6 - 3xx.xx7	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input A1.
11	1 OP	A1_FREQ 3xx.xx8 - 3xx.xx9	Float			Hz	D / RO	Average- frequency in the last macro cycle – pulse input A1.
12	1 MN	B1_STATUS 3xx.x10	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input B1.
13	1 OP	B1_PULSES 3xx.x11 - 3xx.x12	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input B1.
14	1 OP	B1_FREQ 3xx.x13 - 3xx.x14	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input B1.
15	1 MN	A2_STATUS 3xx.x15	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input A2.
16	1 OP	A2_ PULSES 3xx.x16 - 3xx.x17	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input A2.
17	1 OP	A2_ FREQ 3xx.x18 - 3xx.x19	Float			Hz	D / RO	Average frequency of the last macro cycle – pulse input A2.
18	1 MN	B2_STATUS 3xx.x20	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input B2.
19	1 OP	B2_ PULSES 3xx.x21 - 3xx.x22	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input B2.
20	1 OP	B2_ FREQ 3xx.x23 - 3xx.x24	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input B2.
21	1 MN	A3_STATUS 3xx.x25	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input A3.
22	1 OP	A3_ PULSES 3xx.x26 - 3xx.x27	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input A3.
23	1 OP	A3_ FREQ 3xx.x28 - 3xx.x29	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input A3.
24	1 MN	B3_STATUS 3xx.x30	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input B3.
25	1 OP	B3_ PULSES 3xx.x31 – 3xx.x32	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input B3.
26	1 OP	B3_ FREQ 3xx.x33 – 3xx.x34	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input B3.
27	1 MN	A4_STATUS 3xx.x35	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input A4.
28	1 OP	A4_ PULSES 3xx.x36 – 3xx.x37	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input A4.
29	1 OP	A4_ FREQ 3xx.x38 – 3xx.x39	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input A4.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/Mode	Description
30	1 MN	B4_STATUS 3xx.x40	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input B4.
31	1 OP	B4_ PULSES 3xx.x41 - 3xx.x42	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input B4.
32	1 OP	B4_ FREQ 3xx.x43 - 3xx.x44	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input B4.
33	1 MN	A5_STATUS 3xx.x45	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input A5.
34	1 OP	A5_ PULSES 3xx.x46 - 3xx.x47	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input A5.
35	1 OP	A5_ FREQ 3xx.x48 - 3xx.x49	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input A5.
36	1 MN	B5_STATUS 3xx.x50	Bitstring(2)	See PULSE_STATUS		E	D / RO	Actual status of the pulse input B5.
37	1 OP	B5_ PULSES 3xx.x51 - 3xx.x52	Unsigned32		0		D / RO	Number of pulses in the last macro cycle – pulse input B5.
38	1 OP	B5_ FREQ 3xx.x53 – 3xx.x54	Float			Hz	D / RO	Average frequency in the last macro cycle – pulse input B5.
39	MN	COINCIDENT_ERROR 3xx.x55 – 3xx.x64	Unsigned32[5]		0		D / RO	Array that contains the accumulated number of coincident pulses (common mode error) for each input.
40	MN	SEQUENCE_ERROR 3xx.x65 – 3xx.x74	Unsigned32[5]		0		D / RO	Array that contains the accumulated number of sequence errors (A -> B) for each input.
41	MN	PHASE_ERROR 3xx.x75 – 3xx.x84	Unsigned32[5]		0		D / RO	Array that contains the accumulated number of phase errors for each input.
42	3 MN	COUNT_ERROR 3xx.x85 – 3xx.x94	Unsigned32[5]		0		D / RO	Array that contains the accumulated number of counting errors for each input, that is, the difference between the A and B inputs.
43	3 MN	MISSING_PULSES 3xx.x95 – 3xx.114	Unsigned32[10]		0		D / RO	Array that contains the accumulated number of missing pulses for each input. Only for diagnostics purposes.
44	3 MN	EXTRA_PULSES 3xx.115 – 3xx.134	Unsigned32[10]		0		D / RO	Array that contains the accumulated number of extra pulses (noise) for each input. Only for diagnostics purposes.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/Mode	Description
45(A1)	1 MN	RESET_ERROR_COUNTER 4xx.xx4	Bitstring(2)	Bit 0="Coincident Error" Bit 1="Sequence Error" Bit2="Phase Error" Bit3="Count Error" Bit 4= "Missing Pulses" Bit 5= "Extra Pulses" Bit 6..Bit 14 = "Reserved" Bit 15="All Error Counters"	All bits zero		D	Reset the error counters.
46	1 MN	LOGIC_STATE_PINS 3xx.135	Bitstring(2)	See PINS_STATE		E	D / RO	Logic state of each pin in the last macrocycle.
47(A2) (CL)	4 CF	CHANNEL 4xx.xx5	Unsigned16		0	Na	S	Number for the hardware channel of the pulse input module.
48(A1) (CL)	4 CF	FREQ_SIMULATE 4xx.xx6 - 4xx.xx7	Float	0=DISABLED 0 to 10000	0	Hz	S	When this parameter is different from zero, the module acts in the simulation mode on the specified frequency for all inputs, regardless of the module status.
49(A2) (CL)	4 CF	G1_CONF 4xx.xx8	Bitstring(2)	See Gx_CONF	All bits zero	E	S	Group 1 configuration.
50(A2) (CL)	4 CF	G1_PHASE_DIF 4xx.xx9	Unsigned16	1: 180 degrees 2: 90 degrees 3: 45 degrees.	2	E	S	Phase difference expected between A1 and B1, if the dual pulse option is configured.
51(A2) (CL)	4 CF	G1_PHASE_DEV 4xx.x10	Unsigned8	3: +-45 degrees 4: +-22.,5 5:+- 11.25 degrees 6: +- 5.625 degrees.	5	E	S	Allowed deviation on the phase difference between A1 and B1 related to the expected value, if the dual pulse option is configured.
52(A2) (CL)	4 CF	G2_CONF 4xx.x11	Bitstring(2)	See Gx_CONF	All bits zero	E	S	Group 2 configuration.
53(A2) (CL)	4 CF	G2_PHASE_DIF 4xx.x12	Unsigned16	1: 180 degrees 2: 90 degrees 3: 45 degrees.	2	E	S	Phase difference expected between A2 and B2, if the dual pulse option is configured.
54(A2) (CL)	4 CF	G2_PHASE_DEV 4xx.x13	Unsigned8	3: +-45 degrees 4: +-22.5 5:+- 11.25 degrees 6: +- 5.625 degrees.	5	E	S	Allowed deviation on the phase difference between A2 and B2 related to the expected value, if the dual pulse option is configured.
55(A2) (CL)	4 CF	G3_CONF 4xx.x14	Bitstring(2)	See Gx_CONF	All bits zero	E	S	Group 3 configuration.
56(A2) (CL)	4 CF	G3_PHASE_DIF 4xx.x15	Unsigned16	1: 180 degrees 2: 90 degrees 3: 45 degrees.	2	E	S	Phase difference expected between A3 and B3, if the dual pulse option is configured.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/Mode	Description
57(A2) (CL)	4 CF	G3_ PHASE_DEV 4xx.x16	Unsigned8	3: +-45 degrees 4: +-22.5 5:+- 11.25 degrees 6: +- 5.,625 degrees.	5	E	S	Allowed deviation on the phase difference between A3 and B3 related to the expected value, if the dual pulse option is configured.
58(A2) (CL)	4 CF	G4_CONF 4xx.x17	Bitstring(2)	See Gx_CONF	All bits zero	E	S	Group 4 configuration.
59(A2) (CL)	4 CF	G4_ PHASE_DIF 4xx.x18	Unsigned16	1: 180 degrees 2: 90 degrees 3: 45 degrees.	2	E	S	Phase difference expected between A4 and B4, if the dual pulse option is configured.
60(A2) (CL)	4 CF	G4_ PHASE_DEV 4xx.x19	Unsigned8	3: +-45 degrees 4: +-22.5 5:+- 11.25 degrees 6: +- 5.625 degrees.	5	E	S	Allowed deviation on the phase difference between A4 and B4 related to the expected value, if the dual pulse option is configured.
61(A2) (CL)	4 CF	G5_CONF 4xx.x20	Bitstring(2)	See Gx_CONF	All bits zero	E	S	Group 5 configuration.
62(A2) (CL)	4 CF	G5_ PHASE_DIF 4xx.x21	Unsigned16	1: 180 degrees 2: 90 degrees 3: 45 degrees.	2	E	S	Phase difference expected between A5 and B5, if the dual pulse option is configured.
63(A2) (CL)	4 CF	G5_ PHASE_DEV 4xx.x22	Unsigned8	3: +-45 degrees 4: +-22.5 5:+- 11.25 degrees 6: +- 5.625 degrees.	5	E	S	Allowed deviation on the phase difference between A5 and B5 related to the expected value, if the dual pulse option is configured.
64(A2) (CL)	4 CF	FREQ_UPPER_RANGE 4xx.x23 - 4xx.x32	Unsigned16[10]	5 to 25k	10k	Hz	S	Upper limit of the frequency range used to check the pulse range and dynamic filter.
65 (A2) (CL)	4 CF	FREQ_LOWER_RANGE 4xx.x33 - 4xx.x42	Unsigned16[10]	5 to 25k	50	Hz	S	Lower limit of the frequency range used to check the pulse range and dynamic filter.
66(A2)	1 MN	GENERAL_ CONTROL 4xx.x43	Bitstring(2)	See GENERAL_CONTROL	0	E	D	Module control.
67(A2) (CL)	1 CF	OUT1_CONTROL 4xx.x44	Unsigned8	0 to 255	10		D	Discrete output control. By writing "0" the OUT1 output is controlled by the DO/MDO block. And, writing values between 1 and 255, the control is executed automatically by the proving process, generating one pulse with width equals to the value typed and multiplied by 10ms, when the run begins. When the module is in manufacturer test mode is generated one standard for test.
68	MN	TEST_COUNTER 3xx.136 - 3xx.155	Unsigned32[10]		0		D / RO	Number of accumulated pulses for each input controlled by TEST_COUNTER_CONTROL parameter. This parameter is used only for test and maintenance.
69	MN	TEST_COUNTER_CONTROL 4xx.x45	Unsigned8	0= DISABLE 1=ENABLE	0	E	D	Enables/disables the pulse counting in the TEST_COUNTER parameter.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/Mode	Description
70	MN	PULSE_INPUT_SEL 4xx.x46	Unsigned8	0 to 10	0		D	Pulse input under analysis. Zero means disabled.
71	CF	MAX_INTER_PULSE 3xx.156	Unsigned8	0 to100	0	%	D / RO	Maximum space between pulses, in average percent.
72	MN	IMB_REQUEST 4xx.x47	Unsigned8	0:OK 1: WRITE 2: READ 3: ERROR	0	E	D	Requisition to reading/writing directly from/to the IMB.
73	MN	IMB_START_ADDR 4xx.x48	Unsigned16	0 to 511	0		D	Initial address for reading/writing
74	MN	IMB_SIZE 4xx.x49	Unsigned8	0 to 32	0		D	Size in bytes for reading/writing.
75	MN	IMB_DATA 4xx.x50 - 4xx.x65	Octetstring(32)		0		D	Data to be writing or reading.
76		UPDATE_EVT 3xx.157 - 3xx.163 4xx.x66	DS-73			Na	D	This alert is generated by any change to the static data.
77		BLOCK_ALM 3xx.164 - 3xx.170 4xx.x67	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the sub code field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the sub code has changed.
78	MN	FPGA_VERSION 3xx.171	Unsigned8			Na	S / RO	FPGA Configuration Version.

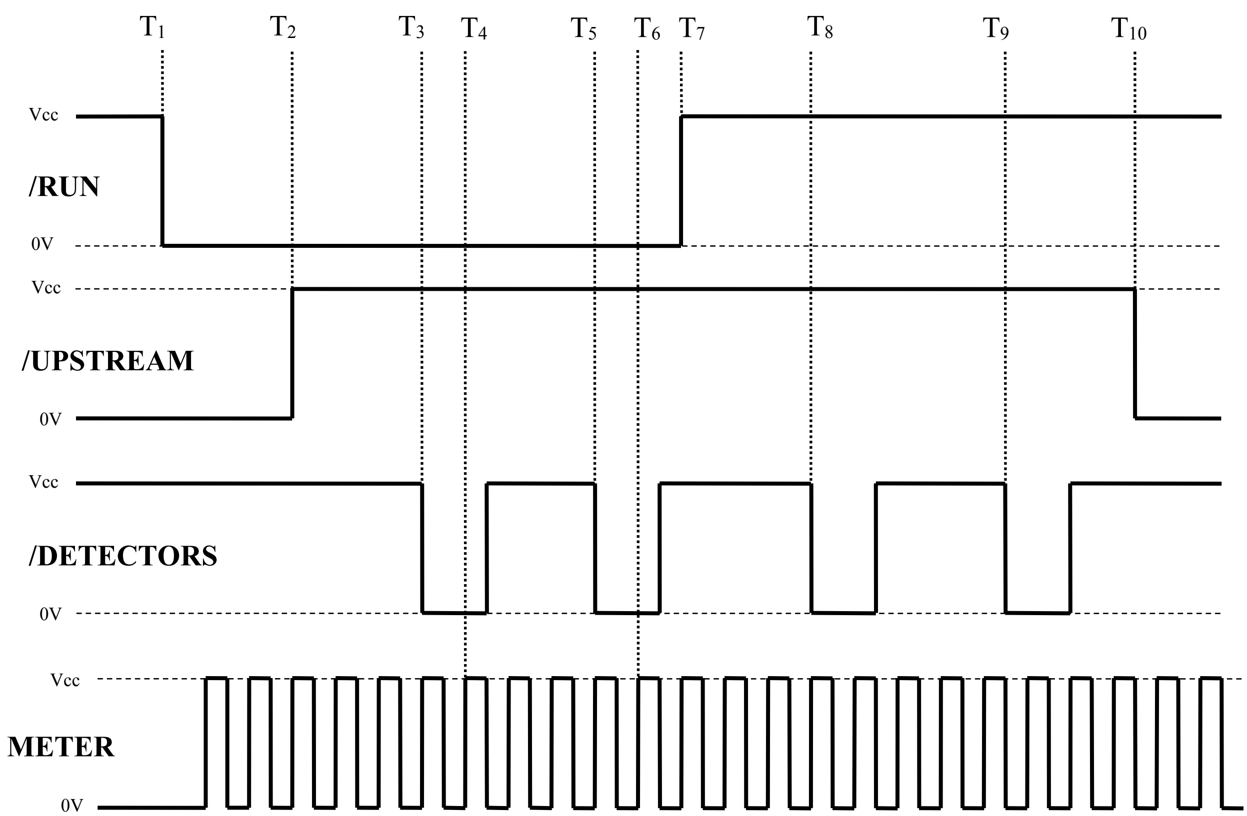
Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – dynamic; N – non-volatile;
S – Static; I – Input Parameter; O-Ouput Parameter
AA-Administrator Level; A1 – Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction level 1; R – Restriction level 2
CL=109 bytes; V1-117 bytes; V2-2 bytes; V3-108 bytes; V4-76 bytes
HFCView: OP (Operation), CF (Configuration), MN (Maintenance)

Troubleshooting

Situation	Possible solutions
There is no pulse totalization	• Check if the CHANNEL parameter in the PIP block is set properly. Check if the CHANNEL parameter of the (LCT, GT etc.) block is set properly. • Check the electrical connections with the meter. • See the front LEDs of DF77 module: o Turned off: it indicates input disabled in the configuration. o Red: it indicates without proper signal. o Green blinking: it indicates there is signal, but it is out of the range set (FREQ_UPPER_RANGE and FREQ_LOWER_RANGE). o Green ON: it indicates there is signal without errors. • Check with an oscilloscope or frequencimeter if there is pulse signal in the DF77 input with proper amplitude and frequency. • If using DUAL_PULSE mode, check the corresponding status of the input (AX_STATUS, BX_STATUS) in the PIP block. If it is indicating “Dual pulse not active” check the coincident error, sequence and phase counters. If one or more counters are being increased, check if the signal A and signal B are not inverted.

Situation	Possible solutions
	Check if the phase difference corresponds to the meter difference set (usually 90 degrees). Another check is to increase the allowed phase deviation in the GX_PHASE_DIF parameter.
Not doing provings	• Check the electrical connections with the prover. • Check if the OUT1_CONTROL parameter is set properly. • Check if the PROV_STATUS parameter in the PIP block shows a • timeout, check the prover electrical connections and hardware.

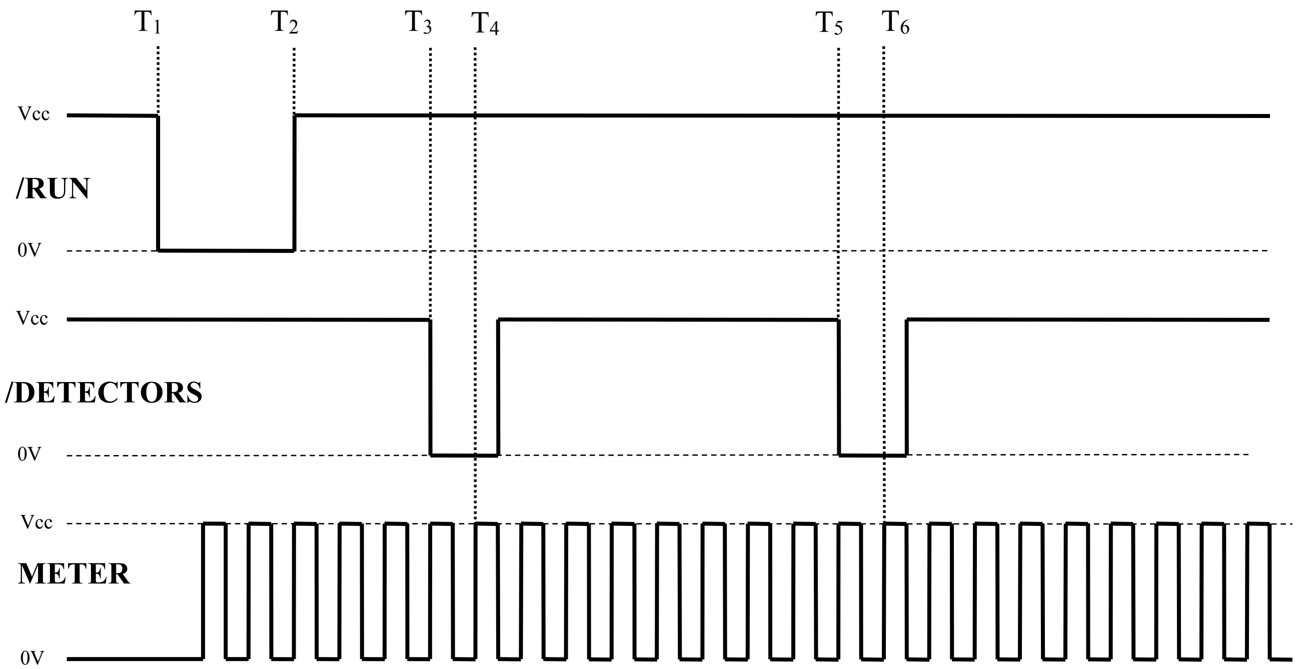
Wave form of the proving with pulse interpolation using double chronometry (API 4.6 and ISO 7278-3) for Brooks/Daniel compact prover



T1: the flow computer transmits the command for the DF77 to start the proving. So, the DF77 forces the /RUN (OUT1) signal to the logic level '0'.
T2: the prover should indicate by the signal /UPSTREAM that it is in the standby position. When it receives the /RUN signal, prover starts the movement to execute the proving.
T3: when the prover shaft passes by the START detector, the prover transmits one pulse to the DF77 in the /DETECTORS (IN2,IN3)) input to start the timer T2 counting.
T4: as following, DF77 waits for the next rise edge of the pulse signal generated by the meter. This rise edge starts timer T1 counting.
T5: when the prover shaft passes by the STOP detector, DF77 receives another pulse, ending the timer T2 counting.
T6: the DF77 waits, for the next rise edge of the meter signal. When this rise edge is detected, the T1 counter stops. At this moment the proving ends.
T7: when the flow computer reads the proving result (T1, T2 and Nm), DF77 forces the /RUN (OUT1) output for the logic level '1'. It indicates to the prover to pull the piston for the standby position, so it will be ready for the next proving.
T8: during the return of the piston for the standby position (UPSTREAM), the shaft passes by the STOP detector, transmitting one pulse that the DF77 ignores.
T9: during the return of the piston for the standby position (UPSTREAM), the shaft passes by the START detector, transmitting one pulse that the DF77 ignores.

T10: when reaching the standby position, the /UPSTREAM signal goes to the logic level ‘0’, indicating that the proving is ready for the next run.

Wave form of the proving with pulse interpolation using double chronometry (API 4.6 and ISO 7278-3) for Calibron Syncrotak compact prover

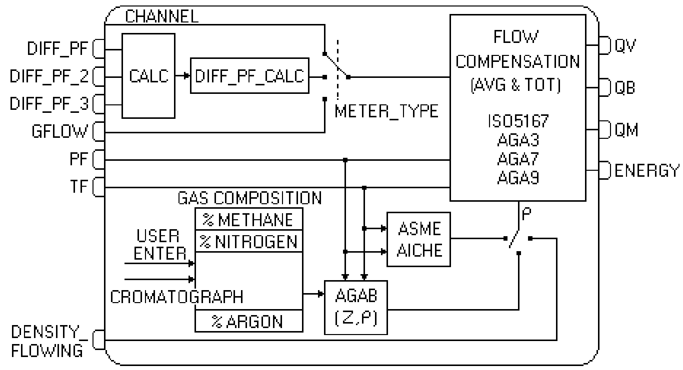


T1: the flow computer transmits the command for the DF77 to start the proving. So, the DF77 forces the /RUN (OUT1) signal to the logic level ‘0’ during the time set in the OUT1_CONTROL parameter of the PIP block. When receiving the /RUN = ‘0’, the prover starts the piston pulling for the upstream position.
T2: after the time set in the OUT1_CONTROL parameter of the PIP block, the /RUN (OUT1) signal returns to the logic level ‘1’.
T3: during the piston pulling, the shaft passes by the STOP and START detectors. However, the Syncrotrak prover does not transmit these pulses for the DF77. When reaching the upstream position, the prover unfastens the piston that starts to move pushed by the flux. With the piston movement, the shaft passes by the start detector of the calibrated section (T2 START).
T4: as following, the DF77 waits for the next rise edge of the pulse signal generated by the meter. This rise edge starts the timer T1 counting.
T5: when the prover shaft passes by the STOP detector (end of the calibrated section), the DF77 receives other pulse, ending the timer T2 counting.
T6: the DF77 waits for the next rise edge of the meter signal. When this rise edge is detected, the T1 counter stops. At this moment the proving ends, the flow computer can read the DF77 results (T1, T2 and Nm) and execute a new proving if is necessary.

Blocks for Gas Measurement

GT – Gas Transition

Schematic



Description
This block was developed to accomplish the flow compensation calculation in the natural gas measurement using orifice plate, turbine, ultra sonic or any other meter which provides volume measurement in pulse signal or analog signal.

The natural gas composition can be obtained by manual input or through the chromatograph communicating via Modbus or Foundation Fieldbus.

This block executes the totalization, weighed average calculation, status analysis and QTR reports for the following periods: batch, time, day and month. Other features include the usual conditions assessments, batch configuration and active process events indication and non recognized related to this measurement.

Run number identification – STRATEGY
This parameter identifies the control loop number and is automatically configured by HFC302 during the configuration download, following the block orders in the Syscon.

This parameter also associates the information of the operational meter in the GKD block (METERx_INFO - NKF and MFx_HISTORY – meter factor), if the meter type is "pulse input".

Block inputs
The block inputs are used according to the configuration, as showed in the table below.

Input	When used	Description
PF	Always	Flowing static pressure
TF	Always	Flowing temperature
DIFF_PF	Always if METER_TYPE = differential pressure	Flowing static pressure
DIFF_PF_2	Optional if METER_TYPE = differential pressure	Flowing static pressure
DIFF_PF_3	Optional if METER_TYPE = differential pressure	Flowing static pressure
DENSITY_FLOWING	Optional if PRODUCT_SEL = Density measurement	Density in flowing
GFLOW	Optional if METER_TYPE = analog input	Volume flow rate input. The input value has a limitation value lower than zero.

Block Outputs
The block outputs are flow rates resulting of the calculation and they are available to be connected to other blocks:
QV – volume flow rate at flowing conditions
QB – volume flow rate at base conditions
QM – mass flow rate
ENERGY – energy flow rate

Selection of the product to be measured – PRODUCT_SEL parameter
The PRODUCT_SEL parameter selects the product of the GKD block that is being used for the calculation. Thus, the same composition can be used in the calculations for different flow measurements. This situation can occur when the chromatograph is measuring before a splitting the stream.

Product Type (PRODUCT_SEL)	State of the fluid	Standard for Density Calculation	Viscosity	K (Isentropic Coefficient – Gas Phase)	Comments
Natural gas (Product 1...20)	Gas Phase	AGA8	Laboratory Analysis	AGA10 or laboratory analysis	Volume totalization in flowing, base, mass and energy condition.
Wet natural gas Product 1...20)	Double-phase. Natural gas with up to 10% in mass of water in liquid state.	AGA8 and ASME IAPWS-IF97 (water density in liquid phase)	Laboratory Analysis	AGA10 or laboratory analysis	Volume totalization in flowing and base condition, mass and energy of the natural gas, i.e., without water. Flow calculation using Murdock equation for double-phase fluid. Supported only for Orifice Plate (AGA3 and ISO5167).
(*) Steam/water	Liquid (Area 1) Gas Phase (Area 2, 4 and 5) Supercritical (Area 3) Does not include metastable steam	ASME IAPWS-IF97	ASME IAPWS-IF97 Appendix B	ASME IAPWS-IF97 – Speed of sound	Mass and energy totalization. The energy totalization can be extracted of the steam up to condensation to 101.42 KPa and 100ºC.. It will be indicated zero if the enthalpy is inferior to the value of this condition (419.1 kJ/kg).
Wet steam	Double-phase. Steam up to 10% in liquid mass	ASME IAPWS-IF97 (density of liquid and gas phases in the saturation point)	ASME IAPWS-IF97 Appendix B (gas phase)	ASME IAPWS-IF97 – Speed of sound	Mass totalization of the two energy and phases. Flow calculation using Murdock equation for biphasic fluid. Supported only for Orifice Plate(AGA3 e ISO5167).
Density measurement		Density in flowing conditions measured by instrument and base density provided by user in the DENSITY_BASE parameter..	Laboratory Analysis	Laboratory Analysis	Volume totalization in flowing, base and mass condition.
(*) Argon, Oxygen, Nitrogen, Carbon Dioxide, Ammonia	Liquid and Gas phase (between triple and critical points)	AIChE DIPPR 801 (liquid phase density and second coefficient virial for gas).	AIChE DIPPR 801	AIChE DIPPR 801 – Heat capacity, Ideal gas	Volume totalization in flowing, base and mass condition

(*) Automatic determination of the fluid state from flowing temperature and pressure.

Fluid type compensated by AGA8

The user must select the method of AGA8 using the AGA8_METH parameter:

0 – Detailed method

1 – Gross 1 : data used in the calculation - HV, Gr, mol% CO_2, mol% CO, e mol% H_2.

2 – Gross 2 : data used in the calculation - Gr, mol% CO_2, mol% N_2, mol% CO, e mol% H_2.

Despite of methods Gross 1 and 2 not using all components in the calculation, it is recommended to provide the complete gas composition to the flow computer manually (based on the laboratory analysis) or automatically through a gas analyzer. Because the check consistency applied to the gas composition is always the same, regardless the selected AGA8 method.

Range :

Static pressure : 0 to 40 000 psi (280 Mpa)

Temperature : -200 ºF to 760 ºF (-130ºC to 400ºC)

Fluid type compensated by AICHE-DIPPR 801

For fluid calculated by using AiCHE – DIPPR 801 the variable calculation range are:

Variable	Argon	Oxygen	Nytrogen	Carbon Dioxide	Amnonia
Temperature range for calculation via HFC302 [ºC]	-189.37 to 1226.85	-218.789 to 499.75	-210.00 to 1126.85	-56.57 to 1247.85	-77.74 to 426.85
Molecular Weight [kg/kmol]	39.948	31.9988	28.0134	44.0095	17.0305
Critical point	-122.29 ºC / -188.12ºF 4 898 Kpa / 710.39 psi	-118.57 ºC / -181.43ºF 5 043 Kpa / 731.43 psi	-146.95 ºC / -232.51ºF 3 400 Kpa / 493.13 psi	31.06 ºC / 87.91ºF 7 383 Kpa / 1070.81 psi	132.5 ºC / 270.5ºF 11280 Kpa / 1636.03 psi
Triple point	-189.37 ºC / -308.87ºF 68.7 Kpa / 9.96 psi	-218.789 ºC / -361.82ºF 0.15 Kpa / 0.022 psi	-210.00 ºC / -346ºF 12.52 Kpa / 1.82 psi	-56.57 ºC / -69.83ºF 518.67 Kpa / 75.23 psi	-77.74 ºC / -107.93ºF 6.11 Kpa / 0.886 psi
Temp.Range- second coefficient virial[ºC]	-223.15 to 1226.85	-195.86 to 499.75	-173.15 to 1126.85	-121.05 to 1247.85	-73.15 to 426.85
Temp. Range –liquid density [ºC]	-189.37 to -122.29	-218.8 to -118.57	-210 to -146.95	-56.57 to 31.06	--77.74 to132.50
Temp. Range-specific heating, ideal gas [ºC]	-173.15 to 1226.85	-223.15 to 1226.85	-223.15 to 1226.85	-223.15 to 4726.85	-173.15 to 1226.85

Ttemp.Range - vapor viscosity[ºC]	-189.37 to 2999.95	-218.8 to 1226.85	-210 to 1696.85	-78.48 to 1226.85	-77.74 to 726.85
Temp. Range-liquid viscosity[ºC]	-189.37 to -123.15	-218.79 to -123.15	-210 to -149.15	-56.57 to 30	-77.74 to 120.00

It has been considered as calculation range the temperature range between the triple point and maximum temperature by the second virial, by exceeding the associated variable calculation, if necessary.

Condition	Status Indication (BATCH_STATUS_GAS)	Used Value
T_{triple} <= T_f <= $T_{critical}$	OK	IT is considered the fluid phase (gas or liquid) and calculates the corresponding density.
$T_{critical}$ <= T_f <= $T_{max,2nd.virial}$	OK : P_f <= $P_{critical}$	Calculates density by using the second virial
	OOR : P_f > $P_{critical}$ FLUID_STATE=Invalid	Uses critical pressure and the second virial
If temperature of flowing is out of calculation range.	OOR FLUID_STATE=Invalid	Reaps the temperature to the closest limit and calculates.
Density calculation in gas phase using the second virial can be inconsistent, despite being in range calculation, since the square root is done of a negative value.	Inconsistent data	Uses density considering zero the square root value.

Where :
T_f : flowing temperature
T_{triple} : triple point temperature
$T_{critical}$: critical point temperature
P_f : flowing pressure
P_{triple} : triple point pressure
OOR : out of range

The following pictures show the phase diagram for carbon dioxide. For others, the curve format is similar by setting the triple and critical point.

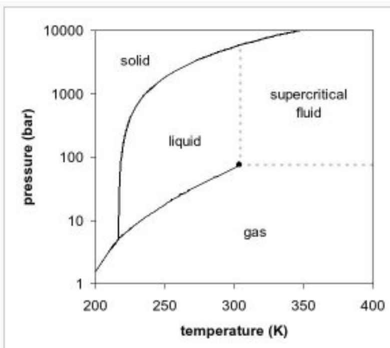


Figure 1. Carbon dioxide pressure-temperature phase diagram

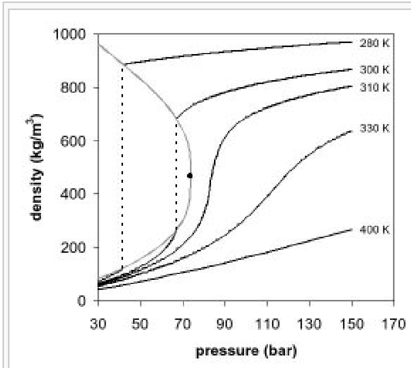


Figure 2. Carbon dioxide density-pressure phase diagram

Override handling for the inputs
There is an override handling for the temperature, static pressure or differential pressure inputs when it has bad status, which can be considered a sensor has any problem, for example, an open thermocouple. There are the following options to choose the override value through the OVER_TEMP_USAGE / OVER_PRES_USAGE / OVER_DPRES_USAGE parameters:

- Override value when bad: when the input status is bad, it utilizes the value of the override parameter (OVERRIDE_TEMPERATURE, OVERRIDE_PRESSURE and OVERRIDE_DIFF_PRESSURE);
- Last good when bad: when the input status is bad, it utilizes the last good value of the input;
- Hourly average when bad: when the input status is bad, it utilizes the hourly weighted average;
- Force override value: it utilizes the value of the override parameter (OVER_TEMP_USAGE / OVER_PRES_USAGE / OVER_DPRES_USAGE) regardless the input status. This option is useful to check the block calculation;
- Never use: when the input status is bad, it interrupts the flow calculation and considers null. In this situation, one event is registered ("Stop totalization – override never use").

The input and output transition events of the override use condition are registered as "Override temperature used" and "Override temperature cleared", for example, besides the indication in the summarized status of the correspondent period.

Configurations for the static pressure
There are two important parameters to be configured related to the static pressure:
• PRESSURE_DOWNSTREAM_SECTION: this parameter is configured if the measurement of the static pressure is upstream or downstream related to the orifice plate. This parameter is used only

when the meter is differential pressure type (METER_TYPE = differential pressure, Vcone and Wafer Cone);

• PRESSURE_TYPE: this parameter is configured if the static pressure is "gauge" or "absolute". If it is using the gauge option, then the PF input value (or the resulting value of the override handling) will be added to the local atmosphere pressure that is configured in the GKD.ATMOSPHERE_PRESSURE. The result of this sum is used in the flow calculations, as well as in the weighted average calculation.

Meter type selection (METER_TYPE parameter)

The METER_TYPE parameter allows selecting the flow meter type and this parameter has the following options:

• Differential pressure: orifice plate;
• Pulse Input : typically turbine, ultra sonic;
• Analog Input: meter which provides volume flow rate;
• V-Cone;
• Wafer-Cone.

Differential Pressure Meters

Specifications of orifice plate and piping section

The orifice plate and piping section manufacturers must provide the orifice plate bore diameter and the meter tube internal diameter at given temperature, respectively. The temperature for this measurement must be configured in the TEMP_DIAMETER parameter and the respective diameters in the ORIFICE_DIAMETER and TUBE_DIAMETER parameters.

There are two ways to provide the linear coefficient of thermal expansion of the material used for the orifice plate:

• The value of the linear coefficient of thermal expansion: ALPHA_1 parameter must be configured with the linear coefficient of thermal expansion for the orifice plate. The configuration of this parameter automatically changes the STEEL_TYPE1 parameter to the "custom" option;

• Selection of the material type: STEEL_TYPE1 parameter defines the type of the material used in the orifice plate and, consequently, its linear coefficient of thermal expansion. When configuring this parameter, automatically the ALPHA_1 parameter is updated with the correspondent value to the selected material type.

Similarly, the configuration for the linear coefficient of thermal expansion of the meter tube (ALPHA_2) or the material selection (STEEL_TYPE2) must be accomplished.

Differential pressure calculation

The flow calculations accomplished in the GFC block are according to the "flange tap" connection type, following the AGA 3:1992 description.

To improve the rangeability and maintaining the accuracy of the differential pressure, there is the option to configure up to three differential pressure transmitters in different ranges.

To utilize the multiple range feature (more than one differential pressure transmitter), it is necessary to connect the inputs DIFF_PF, DIFF_PF_2 and DIFF_PF_3 and also configure the following parameters obeying the rule: RANGE_LO_3 < RANGE_HI_3 < RANGE_LO_2 < RANGE_HI_2.
The differential pressure used in the flow calculation will follow the rules below:

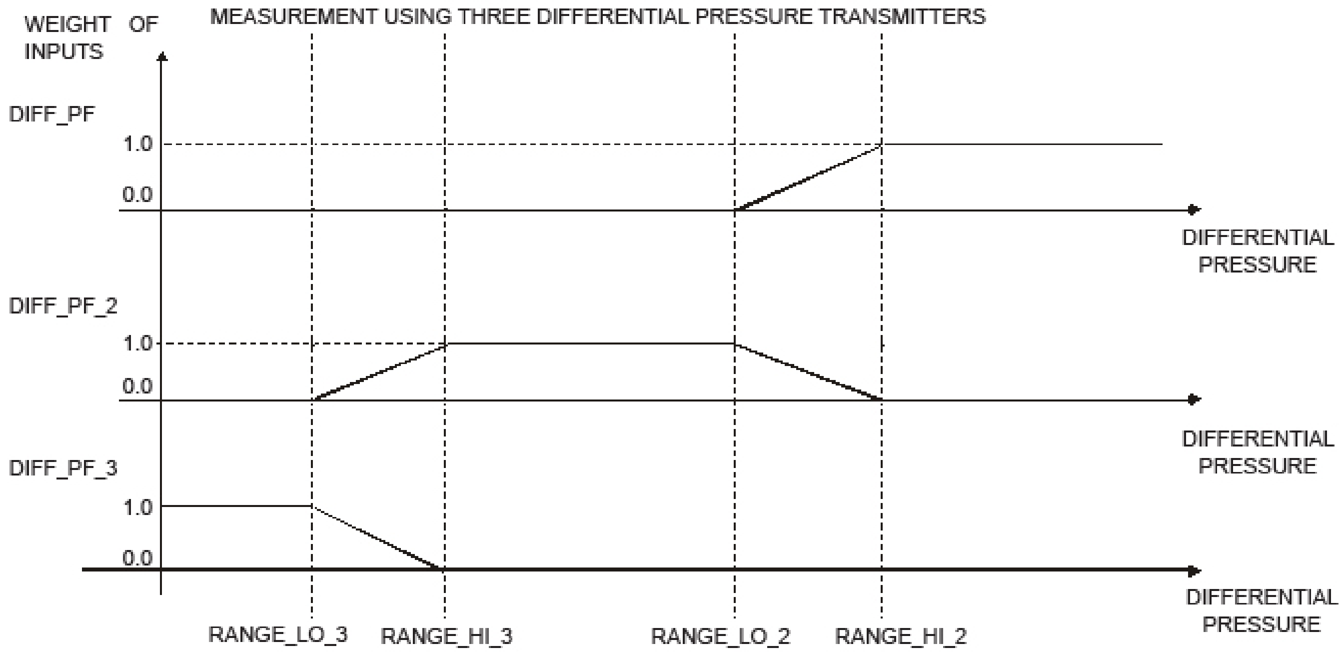
- Only the inputs with good status will be considered, the others will be ignored;
- When the multiple range option is used, there is a transition band (RANGE_LOx and ANGE_HIx) from an input (transmitter) to another;
- When the differential pressure is in the transition band, a weighted average is calculated between the lower and upper inputs (transmitters);
- The differential pressure is closer to the upper limit of the transition band, the weighted factor for the upper input is bigger (near to one), and Consequently the weighted factor of the lower input will be the complement of 1.0. The equation for the transition between the inputs DIFF_PF_2 and DIFF_PF is showed below:

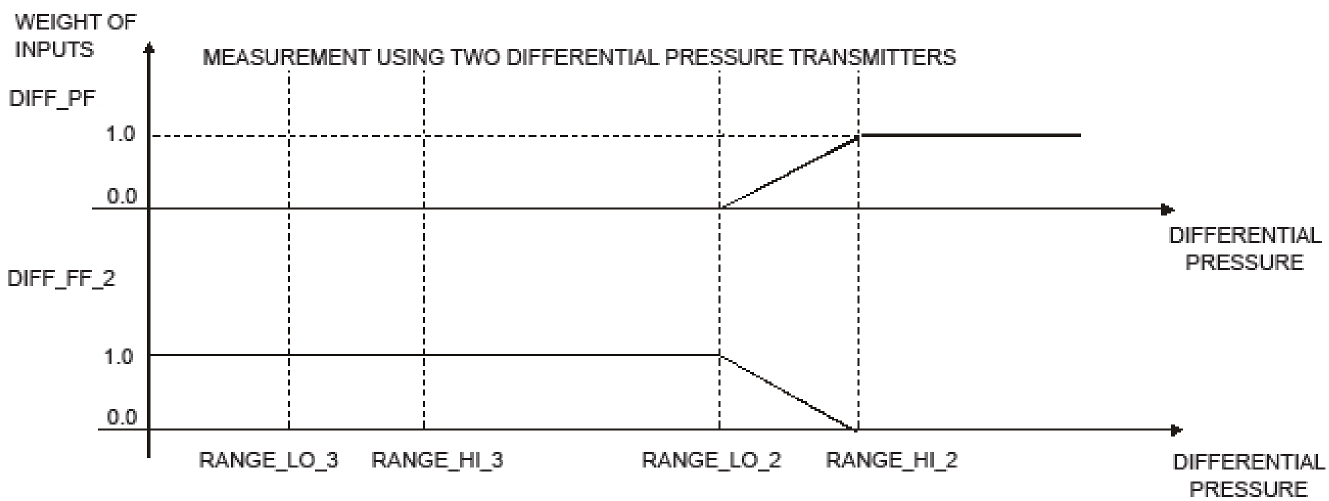
$$G = \frac{DIFF\_PF - RANGE\_LO\_2}{RANGE\_HI\_2 - RANGE\_LO\_2}$$

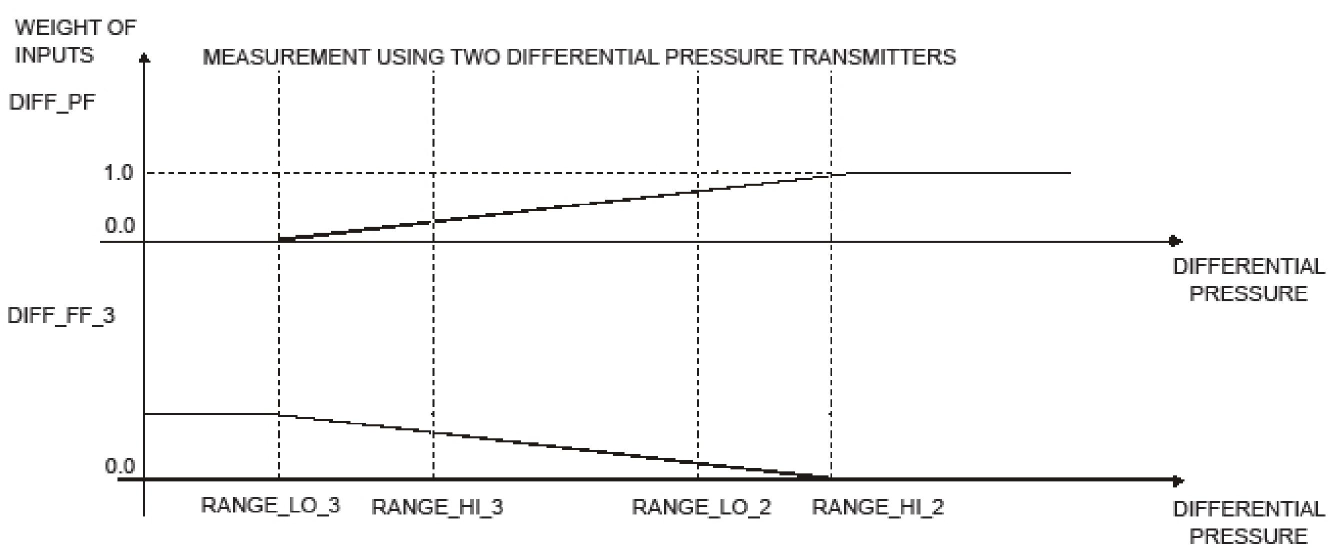
$$DIFF\_PF\_CALC = G * DIFF\_PF + (1 - G) * DIFF\_PF\_2$$

- Above the upper limit of this transition band (RANGE_HIx), it is used only the upper input value (transmitter);
- Under the lower limit of this transition band (RANGE_LOx), it is used the lower input value (transmitter).
- The next picture shows a situation that three inputs (transmitters) are used and two situations that two inputs (transmitters) are used. Observe the features below:

- The multiple range feature can be used as redundancy for the differential pressure transmitter, that is, if one of the transmitters fails, the GFC block uses automatically only the other transmitter which keeps working in good conditions;
- If a certain configuration utilizes three differential pressure transmitters, and there is necessity of maintenance in one of them, the GFC block considers only the other two transmitters adjusting automatically for this situation. However there will be an indication in the BLOCK_ERR. Input failure parameter;
- The indication of the override value in the summarized status and the event register for differential pressure occurs only when the three inputs have bad status.
- The input used for the range comparison (defined by RANGE_LO_3, RANGE_HI_3, RANGE_LO_2 e RANGE_HI_2) in order to find out which input to be used or which inputs in case the transition range will be lower than those connected with good status. For example, it is considered DIFF_PF input, if the three inputs are connected and with good status.


WEIGHT OF INPUTS
MEASUREMENT USING THREE DIFFERENTIAL PRESSURE TRANSMITTERS
DIFF_PF
1.0
0.0
DIFFERENTIAL PRESSURE
DIFF_PF_2
1.0
0.0
DIFFERENTIAL PRESSURE
DIFF_PF_3
1.0
0.0
DIFFERENTIAL PRESSURE
RANGE_LO_3
RANGE_HI_3
RANGE_LO_2
RANGE_HI_2


WEIGHT OF INPUTS
MEASUREMENT USING TWO DIFFERENTIAL PRESSURE TRANSMITTERS
DIFF_PF
1.0
0.0
DIFFERENTIAL PRESSURE
DIFF_FF_2
1.0
0.0
RANGE_LO_3
RANGE_HI_3
RANGE_LO_2
RANGE_HI_2
DIFFERENTIAL PRESSURE


WEIGHT OF INPUTS
MEASUREMENT USING TWO DIFFERENTIAL PRESSURE TRANSMITTERS
DIFF_PF
1.0
0.0
DIFFERENTIAL PRESSURE
DIFF_FF_3
0.0
RANGE_LO_3
RANGE_HI_3
RANGE_LO_2
RANGE_HI_2
DIFFERENTIAL PRESSURE

The differential pressure used in the flow calculations is indicated in the DIFF_PF_CALC parameter that is a result of the multiple ranges processing (if it is the case) and the override handling.

Intermediate variables for calculation
Some intermediate variables of the flow calculation at flowing conditions are indicated in the parameters:
- RE: Reynolds number
- BETA: Ratio between the diameters of the Orifice and the pipeline at flowing conditions
- CD: Coefficient of Discharge
- EV: Expansion speed factor
- Y: Expansion factor

Meters with Pulse Signal

Configuration of CHANNEL parameter
The CHANNEL parameter associates to the pulse input via rack number, slot, group and point.

The rules to configure the CHANNEL parameter are the following:
- The format of the CHANNEL parameter is RRSGP, where RR indicates the rack number, S indicates the slot number, G indicates the group number and P indicates the point number;
- Point (P): ordinal number of point numbered from 0 (first point) to 7 (last point of the group). When accessing the DF77 module, point equals to 2 (P=2) means dual-pulse selection. In this case, the PIP.Gx_CONF parameter. Dual pulse check enable option must be enabled previously;
- Group (G): ordinal number for the group numbered from 0 (first group) to 1 (second group);
- Slot (S): ordinal number for the slot numbered from 0 (first slot) to 3 (last slot);
- Rack (R): Each rack has 4 slots and the racks are numbered from 0 (first rack) to 14 (last rack). The physical address of the racks is configured through a rotary key from 0 to F (located between the slots 2 and 3). The last position (F) must not be used.

Example:
CHANNEL parameter equals 1203 means: rack 1, slot 2, group 0 and point 3.
Before configuring the CHANNEL parameter, it is recommended to configure previously the HC block that indicates which module types are being used and the positions (rack/slot). This is important when writing in the CHANNEL parameter, the GT block will check the compatible type, pulse input and the availability of the addressed input (no other block may address it).

Meter factor (MF)
The meter factor used in the calculations is indicated in the MF parameter. It is a copy of the last meter factor in the MFx_HISTORY parameter of the GKD block. The value of the STRATEGY parameter indicates the run number and, consequently, indicates which MFx_HISTORY parameter is associated to.

QV/QM Output Calculation
The QV/QM output is calculated by multiplying the number of pulses by the correspondent meter factor, then dividing by the correspondent time and NKF. This procedure is applied to calculate QV, if METER_TYPE is configured to “Volume Pulse Input”. On the other hand, if METER_TYPE is configured to “Mass Pulse Input”, then it is calculated the output QM.

Flow Meters with Analog Signal

QV/QM Output Calculation
The GFLOW input must provide a volume flow rate at flowing or mass conditions in engineering units by multiplying to meter factor and it will be obtained the QV/QM output.

QB, QM and ENERGY Outputs Calculation

Selection of the calculation method for the compressibility factor
The AGA8_METH parameter selects the calculation algorithm for the compressibility factor which has the following options:
- Detailed: uses the whole gas composition for the calculation;
- Gross 1: uses only the Hv, Gr and CO2 values and other components are ignored;
- Gross 2: uses only the Gr, CO2, N2 values and other components are ignored.

Calculation for QB, QM and ENERGY outputs
Using the gas universal equation and the compressibility factors at base and flowing conditions, it calculates the density at base and flowing conditions. Through these densities, it calculates the flow rate at base conditions (QB) and the mass flow rate (QM).

If any of the flow rates (QV, QB, QM and ENERGY) is higher than the rollover value (10.000.000.000), it will be considered null and an event will be generated in order to indicate that the totalization stopped.

QTR Report Generation
There are several events that generate a QTR report in the HFC memory for a later reading and a database saving by HFCView.

The situations are as follows:

Event	Report type (GTV.QTR_TYPE)	Condition
Correspondent accounting period transition	"Continous & period"	All periods enabled in ENABLE_REPORT
Configuration download	"Reset & period"	All periods enabled in ENABLE_REPORT and batch
Writing in CT_CMD parameter requesting operational report	"Operational & period"	Report of the requested period
Writing in CT_CMD parameter requesting snapshot	"Snapshot"	-
Batch end	"Batch"	-

Note that the generation of a report in HFC302 memory, when the volume totalization in base condition is null, it can be disabled while configuring the parameter REPORT_NO_FLOW = no (default condition).

The snapshot purpose is check the calculation by showing the immediate values of the inputs and correction factor, gross flowrate and standard gross flowrate.

Actual conditions evaluation
The usual conditions refer to the weighted average value of the temperature, pressure and flow rate at base conditions in a certain period. They are reference when executing a proving, and a well test, since it is desirable that these procedures are executed at conditions close to the operation.

Through START_USUAL_CONDITIONS parameter it is configured which variables must be calculated by HFC302, since there is a possibility the user provides directly these usual values in USUAL_TEMPERATURE, USUAL_PRESSURE and USUAL_FLOW parameters.

Besides the usual conditions calculation or manual input of the value for each one of the variables (temperature, pressure and flow rate in base conditions), the GT block monitories frequently the immediate value deviation of these variables related to the usual conditions.

The maximum acceptable deviations are configurated in USUAL_TEMP_DEV, USUAL_PRESS_DEV and USUAL_FLOW_DEV parameter. Note in the parameter table that the deviation for temperature is in engineering unit while the deviation for pressure and flow are percentage values.

The indication of the deviation upper than specified in the valuation period of the usual conditions is executed in GAS_WARN parameter.

Date/time of the start of the valuation in usual conditions is registered in OPEN_USUAL_CONDITIONS and occurs in the following situations:

- By writing in the START_USUAL_CONDITIONS parameter Start all;
- When a well test is requested while writing WT.TEST_STATE = Start usual conditions (Wr) parameter.

Calculation done by period (batch, time, day and month)
For each period are calculated the flow totalizations: volume at flowing condition (Qv), volume at base condition (Qb), mass (Qm) and energy.

The totalizer for Qv is different from the totalizers for Qb, Qm and Energy.

There is just one totalizer for Qv for a specific period and it increments when operating at normal and abnormal conditions. See the abnormal conditions described in the BATCH_STATUS_GAS.

While there are two totalizers for Qb, Qm and Energy for a specific period, one totalizer when operating at normal conditions and another totalizer for abnormal conditions.

If the differential pressure calculated by GT block for DP flowmeters is lower than specified in the NO_GAS_FLOW parameter, all flow rates will be considered nulls for totalization matters, working as a cutoff.

The weighted average calculation of inputs variable are done (temperature, pressure and differential pressure) and calculation intermediate variables (Gr, Cd, Ev e Y1).

Indication of events in summarized status of the period as:

- Override temperature used;
- Override pressure used;
- Override differential pressure used;
- Bad pulse input / flow input;
- Inconsistent secondary variables;
- Out of range;
- Bad chromatograph;
- Process alarm;
- Dual pulse not active
- NRL_TOT_ACC_QB rollover
- Stop totalization / Block in O/S
- Inconsistent data;
- Not sealed

The summarized status provide only one indication that in any moment of the considered period occurred any relevant event. And this does not indicate the current status (information provided by CURRENT_STATUS parameter) or more details, which must be obtained from the event registers.

Flow time calculation is the time counting while the flow occurred in the considered period. If the QTR report is generated, this will have the number of the mentioned report in the COUNTER_BATCH, COUNTER_HOUR, COUNTER_DAY or COUNTER_MONTH parameter.

Non resettable totalizer
The NRL_TOT_ACC_QB totalizer does not reset when the accounting period or batch finishes. This occurs only when the download of a new configuration is done.

These non resettable totalizer increase until 10.000.000.000,from where return to zero. This event of returning to zero is registered as Rollover accum. totalizer Qv" / "Rollover accum. totalizer Qb" / "Rollover accum. totalizer Qm" / "Rollover accum. totalizer energy".

This totalizer non resettable back turn is independent, therefore NRL_TOT_ACC_QB may return to zero, however this probably will not occur simultaneously with NRL_TOT_ACC_QM.

Previous period totalizer
The PREV_TOT_QV, PREV_NRL_TOT_QB, PREV_ABN_TOT_QB, PREV_NRL_TOT_QM , PREV_ABN_TOT_QM, PREV_NRL_TOT_ENERGY and PREV_ABN_TOT_ENERGY totalizers indicate the totalizations of the previous accounting period to the current one. Besides that, it is indicated the flow time in PREV_FTIME.

These information of the previous period consider possible resets in the totalizations of a certain period, therefore these totalizers and flow time indicate a totalization sum / flow times in case of reset occurrence.

The previous period information are consistent even in a power break situation. While energized, the HFC302 verifies if the totalizers are really related to the previous accounting period to the actual.

Alarm events: active (ACTIVE_ALARM1 and ACTIVE_ALARM2) and unacknowledged (UNACK_ALARM1 and UNACK_ALARM2).
The alarm events (high, high high, low and low low) of variables related to measurement as temperature, static pressure, differential pressure, flow rate and mass flow rate are executed by AALM block. In GT block there is only one summarized indication of active alarms and unacknowledged alarms. For more information it is necessary to check the AALM block or the alarm events.

Diagnosis and Troubleshooting

1. BLOCK_ERR. Block configuration: this indication may occur due to the following problems:
- If the selected meter in differential pressure and orifice plate bore diameter is bigger than meter tube diameter;
- Inconsistency in the transition range limits configuration that must follow the following rule: RANGE_LO_3 <= RANGE_HI_3 <= RANGE_LO_2 <= RANGE_HI_2.

- If the selected meter is "pulse input" type and the CHANNEL parameter is addressing a rack and slot where one module that does not read pulse is configured (in the HC block);
- If selected wet steam or wet natural gas and different plate orifice meter type;

2. BLOCK_ERR. Input failure: this indication occurs due to the following problems:
- If the selected meter is "differential pressure" type and one of the differential pressure inputs is connected, however with bad status;
- If the selected meter is "pulse input" type and the pulse reading is impossible for the addressed module using the CHANNEL parameter;
- If the selected module is "analog input" type and with bad status in the GFLOW input.

3. BLOCK_ERR. Out of Service : the GT block can continue in the Out of service mode although the target mode is Auto due to the following causes:
- Configuration error of the GT block;
- Resource block is in O/S.

4. The consistence checks are executed and indicated as the table below, according to the meter type:

Bit	Description	Cause	Logged event	Firmware action
0	Override temperature used (LSB)	TF.Status bad	"Override temperature used"	Defined by OVER_TEMP_USAGE
1	Override pressure used	PF.Status bad	"Override pressure used"	Defined by OVER_PRES_USAGE
2	Override differential pressure used	DIFF_PFx.Status bad	"Override Diff. pressure used"	Defined by OVER_DPRES_USAGE
3	Bad pulse input / flow input	- signal type of flowmeter is analog input and the corresponding status is bad - signal type of flowmeter is pulse input and it happened a problem to access the pulse input module or error in dual-pulse mode (coincident pulse, phase error, sequence error, missing pulse or extra pulse).	"Bad pulse input occ" "Bad analog input occ"	Set flow rate to zero.
4	Inconsistent secondary variables	Upstream static pressure and static pressure is less than differential pressure.	"Inconsistent 2nd Vars occurred"	Set differential pressure to zero.
5	Out of range	Temperature or static pressure is out of range defined by the specification to calculate the density.	"Flowing out range corr.fact. occ"	Clamp the temperature/static pressure to the limit.
6	Bad chromatograph	Block GC detected a inconsistency in the gas composition.	"Bad chromatograph occurred"	Keep the previous gas composition.
7	Process alarm	It happened a process alarm in any variable associated to the stream	TAG_DESC or block tag of AALM.	-
8	Dual pulse not active	Dual-pulse is enabled, but one phase is inactive (without pulses).	-	-
9	TOT_ACC_QB rollover	Non-resettable totalizer rolled over the maximum value.	-	-
10	Stop totalization / Block in O/S	- Input status is bad and OVER_X_USAGE=never use - GT.MODE_BLK.Actual=OS	"Stop totalization – override never use"	Set flow rate to zero.
11	Inconsistent data	- Y<= 0 or - inconsistency in the density calculation using second virial in the gas phase	-	- Force Y=1 - Force to square root of zero
12	Not sealed	Configuration was changed and it was sealed through	-	-

		FCT.SEALED_CONDITION parameter.		
13	Extrapolated range of composition	Gás composition is out of range defined by AGA8.	-	It accepts the provided gas composition, but it registers a indication in the status.
14	Inconsistent flow rate	QM,QB,QV or ENERGY : it is greater thatn the rollover value or invalid floating point number (+INF/-INF/NAN)	"Inconsistent flow rate occ"	Set flow rate to zero.
15	Reserved15			
		Differential pressure is negative or greater than the upper limit of static pressure defined by the specification used to calculate the density.	-	Set differential pressure to zero.

Supported Modes
O/S and AUTO.

Parameters

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2	CF	TAG_DESC 4xx.x00 – 4xx.x15	OctString(32)		Spaces	Na	S	If this parameter is configured with different space strings, so this parameter will replace the block tag in the QTR report.
3	4 OP	STRATEGY 3xx.xx0	Unsigned16	1 to 4		None	S / RO	This parameter indicates the run number.
4	4	ALERT_KEY 4xx.x16	Unsigned8	1 to 255	0	None	S	
5 (A2) (CL)	1,3 CF	MODE_BLK Target/Normal - 4xx.x17 – 4xx.x19 Actual – 3xx.xx1	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7 (A2)	**I**,1,VL (value) OPx	PF 4xx.x20 - 4xx.x22	DS_65			PRESSURE_TYPE: P (gauge) or P (abs)	N	Flowing static pressure.
8 (A2)	**I**,1,VL (value) OPx	TF 4xx.x23 - 4xx.x25	DS_65			T	N	Flowing temperature.
9	**I**,1 OPx	DIFF_PF 3xx.xx3 - 3xx.xx5	DS_65			DP	N / RO	Differential pressure.
10	**I**,1 OPx	DIFF_PF_2 3xx.xx6 - 3xx.xx8	DS_65			DP	N / RO	Differential pressure to low range.
11	**I**,1 OPx	DIFF_PF_3 3xx.xx9 - 3xx.x11	DS_65			DP	N / RO	Differential pressure to low low range.
12 (A2)	**I** OPx	DENSITY_FLOWING 4xx.x26 - 4xx.x28	DS_65			GD	N	Fluid density at flowing conditions, if selected "Density Measurement" product.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
13	**I,1** OPx	GFLOW 3xx.x12 - 3xx.x14	DS-65			QV or QM	N / RO	Volume flow rate or mass flow rate. This input is ignored if a different option of analog input is selected for METER_TYPE parameter .
14	**O**,1 VL(value) OPx	QM 3xx.x15 - 3xx.x17	DS-65			QM	N/RO	Mass flow rate.
15	**O**,1, VL(value) OPx	QB 3xx.x18 - 3xx.x20	DS-65			QV	N/RO	Volume flow rate at base conditions (reference), Pb and Tb.
16	**O**,1 VL(value)OPx	QV 3xx.x21 - 3xx.x23	DS-65			QV	N/RO	Volume flow rate at flowing conditions (Pf, Tf).
17	**O**,1 OPx	ENERGY 3xx.x24 - 3xx.x26	DS-65			ER	N/RO	Energy flow rate.
18 (A2) (CL)	2 CF	PRODUCT_SEL 4xx.x29	Unsigned8	1..4=Product 1 ..4(AGA8) 5=Steam(ASME) 6=Density measurement 7=Argon(Aiche) 8=Oxygen(Aiche) 9=Nitrogen(Aiche) 10=Carbon Dioxide(Aiche) 11=Ammonia(Aiche) 205…220=Product 5…20(AGA8)	1	E	S	Selection of the product from the list provided in the GKD block.
19(A2) (CL)	CF	PRODUCT_NAME 4xx.x30 - 4xx.x37	Visiblestring[16]		Blank		S	Measuring product name.
20 (A2)(CL)	CF	X 4xx.x38 - 4xx.x39	Float	0.9 to 1.0 1 = Single phase	1.0	Na	S	If “Stream” measurement is selected and this parameter value is among 0.9 and 1, so this is related to stream measurement in two phases. Otherwise, monophase fluid is considered, which phase is indicated in FLUID_STATE.
21(A2) (CL)	2 CF	OVER_PRES_USAGE 4xx.x40	Unsigned8	0=override value when bad 1=last good when bad 2= hourly average when bad 3=force override value 4=never use	0	E	S	It specifies when and what value must be utilized as override value for the pressure.
22 (A2) (CL)	2 CF	OVERRIDE_PRESSURE 4xx.x41 - 4xx.x42	Float	> 0.0	SI=101.325 USA=14.73	PRESSURE_TYPE: P (gauge) or P (abs)	S	Override value for the pressure input when with bad status.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
23 (A2) (CL)	2 CF	OVER_TEMP_ USAGE 4xx.x43	Unsigned8	0=override value when bad 1=last good when bad 2= hourly average when bad 3=force override value 4=never use	0	E	S	It specifies when and what value must be utilized as override value for the temperature.
24(A 2) (CL)	2 CF	OVERRIDE_TE MPERATURE 4xx.x44 - 4xx.x45	Float		SI=15 USA=60	T	S	Override value for the temperature input when was in bad status.
25 (A2) (CL)	2 CF	OVER_DPRES _USAGE 4xx.x46	Unsigned8	0=override value when bad 1=last good when bad 2= hourly average when bad 3=force override value 4=never use	0	E	S	It specifies when and what value must be utilized as override value for the differential pressure.
26 (A2)(CL)	2 CF	OVERRIDE_DI FF_PRESSUR E 4xx.x47 - 4xx.x48	Float	>= 0	0.0	DP	S	Override value for the differential pressure when with bad status.
27 (A2)(CL)	2 CF	PRESS_DOWN STREAM_SEC TION 4xx.x49	Boolean	FALSE and TRUE	TRUE		S	It determines if the static pressure is upstream (TRUE) or downstream (FALSE).
28 (A2) (CL)	2 CF	PRESSURE_T YPE 4xx.x50	Unsigned8	0=gauge 1=absolute	0	E	S	It defines if the static pressure is gauge or absolute.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
29 (A2) (CL)	2 CF	IMP 4xx.x51	Unsigned16	0=1s 1=2s 2=3s 3=4s 4=5s 5=6s 6=10s 7=12s 8=15s 9=20s 10=30s 11=1min 12=2min 13=3min 14=4min 15=5min 16=6min 17=10min 18=12min 19=15min 20=20min 21=30min 22=1hour	0	E	S	IMP Calculation period for meters based in differential pressure. Corresponds to the bmp period for linear meters.
30 (A2) (CL)	2 CF	METER_TYPE 4xx.x52	Unsigned8	1=Orifice Plate-AGA3 2=Volume Pulse Input 3=Mass Pulse Input 4=Volume Analog Input 5=Mass Analog Input 6=V-Cone 7=Wafer-Cone 8=Orifice Plate-ISO5167	1	E	S	Signal type indicates flow meter and flow calculation method.
31 (A2) (CL)	2 CF	TAPS_TYPE 4xx.x53	Unsigned8	0=Flange taps 1=Corner taps 2=D-D/2 taps	0	E	S	Taps position type of differential pressure for orifice plate.
32 (A2) (CL)	2 CF	TEMP_DIAMETER 4xx.x54 - 4xx.x55	Float		SI=20 USA=68	T	S	Temperature for Diameter measurements.
33 (A2) (CL)	2 CF	ORIFICE_DIAMETER_LIST 4xx.x56 - 4xx.x71	Float[8]	> 0	SI=50.80 USA=2.00	L	S	Diâmetro dos orifícios das placas na temperatura TEMP_DIAMETER.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
34 (A2) (CL)	2 CF	ORIFICE_PLATE_SEL 4xx.x72	Unsigned8	0=Manual entry 1=First plate 2=Second plate 3=Third plate 4=Fourth plate 5=Fifth plate 6=Sixth plate 7=Seventh plate 8=Eighth plate	0	E	S	Orifice plate selection among those configured on ORIFICE_DIAMETER_LIST. The writing in ORIFICE_DIAMETER is only possible if selected the Manual entry" option.
35 (A2) (CL)	2 CF	ORIFICE_ DIAMETER 4xx.x73 - 4xx.x74	Float	> 0	SI=50.80 USA=2.00	L	S	Orifice plate bore diameter at temperature TEMP_DIAMETER. The writing in this parameter is possible if ORIFICE_PLATE_SEL=Manual entry.
36 (A2) (CL)	2 CF	TUBE_DIAMETER 4xx.x75 - 4xx.x76	Float	> 0	SI=102.24 USA=4.025	L	S	Meter tube internal diameter at temperature TEMP_DIAMETER.
37 (A2) (CL)	2 CF	STEEL_TYPE_ PLATE 4xx.x77	Unsigned8	0=custom 1=Mild carbon 2=304 Stainless 3=316 Stainless	3	E	S	Material type of orifice plate.
38 (A2) (CL)	2 CF	ALPHA_PLATE 4xx.x78 – 4xx.x79	Float	> 0	SI=1.67E-5 USA=9.25 E-6	G	S	Thermal expansion linear coefficient of the orifice plate material.
39 (A2) (CL)	2 CF	STEEL_TYPE_ TUBE 4xx.x80	Unsigned8	0=custom 1=Mild carbon 2=304 Stainless 3=316 Stainless	1	E	S	Pipeline material type.
40 (A2) (CL)	2 CF	ALPHA_TUBE 4xx.x81 - 4xx.x82	Float	> 0	SI=1.12E-5 USA=6.20 E--6	G	S	Thermal expansion linear coefficient of the meter pipeline material.
41 (A2) (CL)	2 CF	RANGE_HI_2 4xx.x83 - 4xx.x84	Float	>= 0.0	0	DP	S	Upper limit of the transition band between DIFF_PF and DIFF_PF_2.
42 (A2) (CL)	2 CF	RANGE_LO_2 4xx.x85 - 4xx.x86	Float	>= 0.0	0	DP	S	Lower limit of the transition band between DIFF_PF and DIFF_PF_2.
43 (A2) (CL)	2 CF	RANGE_HI_3 4xx.x87 - 4xx.x88	Float	>= 0.0	0	DP	S	Upper limit of the transition band between DIFF_PF_2 and DIFF_PF_3.
44 (A2) (CL)	2 CF	RANGE_LO_3 4xx.x89 - 4xx.x90	Float	>= 0.0	0	DP	S	Limite inferior da faixa de transição entre DIFF_PF_2 e DIFF_PF_3.
45 (A2) (CL)	CF	K 4xx.x91 - 4xx.x92	Float	> 0 -1 = incompressible fluid	1.3	Na	N	Isentropic exponent.
46 (A2) (CL)	CF	ABS_VISCOSITY 4xx.x93 - 4xx.x94	Float	> 0	SI=1.0268 E-5 USA=1.0268E-2	Visc	N	Absolute viscosity of fluid.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
47 (A2) (CL)	2 CF	AGA8_METH 4xx.x95	Unsigned8	0 = Detailed 1 = Gross 1 (HV, Gr, CO_2, CO and H_2) 2 = Gross 2 (Gr, CO_2, N_2, CO and H_2)	0	Na	S	It determines the calculation method to be used: 0 – Detailed 1 – Gross Method 1 (HV, Gr, CO_2, CO and H_2) 2 – Gross Method 2 (Gr, CO_2, N_2, CO and H_2)
48 (A2) (CL)	CF	DENSITY_BASE 4xx.x96 - 4xx.x97	Float	> 0	SI=700 USA=43.69957	GD	S	Fluid density at base condition for product type "Density measurement".
49 (A2) (CL)	2 CF	CHANNEL 4xx.x98	Unsigned16		0	Na	S	The number for the logic hardware channel for Pulse Input module. This parameter is ignored if a different option of Pulse Input is selected.
50 (A2) (CL)	CF	PV_FTIME 4xx.x99 - 4xx.100	Float	>= 0	0	Sec	S	Time constant of the first order filter applicable to the flow calculation, however only when the flow meter provides a pulse signal.
51 (A2) (CL)	2 CF	NO_GAS_FLOW 4xx.101 - 4xx.102	Float	>= 0.0 0.0=disabled	0.0	DP	S	Lower limit for differential pressure, which will be considered null.
52 (A2) (CL)	2 CF	REPORT_NO_FLOW 4xx.103	Unsigned8	0=No 1=Yes	0	E	S	QTR report will not be created if the QB totalizer is zero and this parameter is configured as "No".
53 (A2) (CL)	2 CF	ENABLE_REPORT 4xx.104	Bitstring[2]		Daily		S	Enables the report generation for time, day or month periods.
54	1 OPx	MF 3xx.x27 - 3xx.x28	Float		1.0		N / RO	Flow meter calibration factor selected for all types of meters except those based in differential pressure.
55	1, VL MN	DIFF_PF_CALC 3xx.x29 - 3xx.x30	Float		0.0	DP	N / RO	Differential pressure resulting from the multiple range processing and the override handling.
56	1 MN	P1F_CALC 3xx.x31 - 3xx.x32	Float		0	P (abs)	N / RO	Upstream absolute static pressure.
57	1, VL MN	CURRENT_STATUS 3xx.x33	Bitstring[2]	See Block Options	0	Na	N/ RO	Status in current imp/bmp period. Similar to BATCH_STATUS_GAS.
58	1 MN	CURRENT_PF_AVG 3xx.x34 - 3xx.x35	Float			P (abs)	N/ RO	Absolute static pressure average value in imp/bmp current period.
59	1 MN	CURRENT_TF_AVG 3xx.x36 - 3xx.x37	Float			T	N/ RO	Temperature average value in imp/bmp current period.
60	1 MN	CURRENT_DIFF_PF_AVG 3xx.x38 - 3xx.x39	Float			DP	N/ RO	Differential pressure average value in imp/bmp current period.
61	1 MN	CURRENT_GR_AVG 3xx.x40 - 3xx.x41	Float			Na	N/ RO	Gr average value imp/bmp current period.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
62	1 MN	CURRENT_IV_IMP 3xx.x42 - 3xx.x43	Float			Diferencial: Pa.s Linear: m^3	N/ RO	Integral Value over the imp/bmp current period based in differential pressure. Corresponds to Actual Volumetric Quantity (AVQ) of bmp period for linear meters.
63	1 MN	CURRENT_IMP_ELAPSED 3xx.x44 - 3xx.x46	Time difference				N/ RO	Elapsing time over the imp calculation period for meters in differential pressure. Corresponds to the bmp period for linear meters.
64	1 MN	PREVIOUS_PF_AVG 3xx.x47 - 3xx.x48	Float			P (abs)	N/ RO	Absolute static pressure average value in imp/bmp previous period.
65	1 MN	PREVIOUS_TF_AVG 3xx.x49 - 3xx.x50	Float			T	N/ RO	Temperature average value in imp/bmp previous period.
66	1 MN	PREVIOUS_DIFF_PF_AVG 3xx.x51 - 3xx.x52	Float			DP	N/ RO	Differential pressure average value in imp/bmp previous period.
67	1 MN	PREVIOUS_GR_AVG 3xx.x53 - 3xx.x54	Float			Na	N/ RO	Gr average value in imp/bmp previous period.
68	1 MN	PREVIOUS_RE 3xx.x55 - 3xx.x56	Float		50000		N/RO	Reynolds number of previous imp/bmp.
69	1 MN	PREVIOUS_BETA 3xx.x57 - 3xx.x58	Float				D/RO	Orifice plate rate at Reynolds flowing conditions of previous imp/bmp.
70	MN	PREVIOUS_CD 4xx.105 - 4xx.106	Float				D	Discharge coefficient of imp/bmp previous period. Configurated value by user and if the meter is V-Cone or Wafer-Cone.
71	MN	PREVIOUS_DENSITY_FLOWING 3xx.x59 - 3xx.x60	Float			GD	D / RO	Fluid density at flowing conditions of imp/bmp previous period.
72	MN	PREVIOUS_DLIQ_FLOWING 3xx.x61 - 3xx.x62	Float			GD	D / RO	Liquid phase density at flowing conditions in imp/bmp previous period for two-phase measurement.
73	MN	PREVIOUS_DENSITY_BASE 3xx.x63 - 3xx.x64	Float			GD	D / RO	Fluid density at base conditions in imp/bmp previous period.
74	MN	PREVIOUS_ZB 3xx.x65 - 3xx.x66	Float			Na	D/RO	Compressibility factor at base conditions in imp/bmp previous period.
75	MN	PREVIOUS_ZF 3xx.x67 - 3xx.x68	Float			Na	D/RO	Compressibility factor at flowing conditions in imp/bmp previous period.
76	MN	PREVIOUS_C 3xx.x69 – 3xx.x70	Float			Na	D/RO	Volume conversion factor from flowing condition to base condition.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
77	MN	PREVIOUS_IV_IMP 3xx.x71 - 3xx.x72	Float			Differential: Pa.s Linear: m^3	N/ RO	Integral value over imp previous period for meters based in differential pressure. Corresponds to Actual Volumetric Quantity (AVQ) from bmp period for linear meters.
78	MN	PREVIOUS_IMV_IMP 3xx.x73 - 3xx.x74	Float			Differential: m^4.s/kg Linear: Dimensionless	N/ RO	Integral Multiplier Value (IMV) calculated for imp previous period for meters based in differential pressure. Corresponds to Base Mutiliplier Value (BMV) for linear meters.
79	MN	PREVIOUS_TOT_QB_IMP 3xx.x75 - 3xx.x76	Float			TV	N/ RO	Volume at base condition of imp/bmp previous period.
80	MN	PREVIOUS_TOT_QM_IMP 3xx.x77 - 3xx.x78	Float			TM	N/ RO	Mass of imp/bmp previous period.
81	MN	PREVIOUS_FTIME_IMP 3xx.x79 - 3xx.x81	Time difference				N/ RO	Period in which flowing occurred in imp/bmp previous calculation period. Corresponds to bmp period for linear meters.
82	3 OP	FLUID_STATE 4xx.107	Unsigned8	0=Invalid 1=Liquid 2=Gas 3=Supercritical fluid 5=Superheated gas 6=Two phase (Murdock)		E	N	Fluid state from temperature and pressure on. Writing is allowed if PRODUCT_SEL is configured to “Density measurement”.
83 (A2)	3 OPx	CT_CMD 4xx.108	Unsigned8	0=None 2=Operational batch 3=Operational hour report 4=Operational day report 5=Operational month report 6=Snapshot 7=Previous batch 8=Previous hour 9=Previous day 10=Previous month	Previous day	E	N	This parameter allows to request operational and snapshot report. After executing a requisition action, the value will return automatically to the state which indicates the type of the previous visualized period.
84	3 OPx	NRL_TOT_ACC_QB 3xx.x82 - 3xx.x85	Double		0	TV	N / RO	Non resettable volume at base conditions totalizer , when operating at normal conditions.
85		FNRL_TOT_ACC_QB 3xx.x86 - 3xx.x87	Float		0	TV	N / RO	Non resettable volume at base conditions totalizer , when operating at normal conditions.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
86	OPx	NRL_TOT_ACC_QM 3xx.x88 – 3xx.x91	Double		0	TM	N / RO	Non resettable mass totalizer , when operating at normal conditions.
87		FNRL_TOT_ACC_QM 3xx.x92 - 3xx.x93	Float		0	TM	N / RO	Non resettable mass totalizer , when operating at normal conditions.
88	OP1	TOT_QV_BATCH 3xx.x94 - 3xx.x97	Double		0	TV	N / RO	Volume at flowing conditions totalizer of the current batch, when operating at normal and abnormal conditions.
89		FTOT_QV_BATCH 3xx.x98 - 3xx.x99	Float		0	TV	N / RO	Volume at flowing conditions totalizer of the current batch, when operating at normal and abnormal conditions.
90	3 OP1	NRL_TOT_QB_BATCH 3xx.100 - 3xx.103	Double		0	TV	N / RO	Volume at base conditions totalizer of the current batch, when operating at normal conditions.
91		FNRL_TOT_QB_ BATCH 3xx.104 - 3xx.105	Float		0	TV	N / RO	Volume at base conditions totalizer of the current batch, when operating at normal conditions.
92	3 OP1	NRL_TOT_QM_ BATCH 3xx.106 - 3xx.109	Double		0	TM	N / RO	Mass totalizer of current batch, when operating at normal conditions.
93		FNRL_TOT_QM_ BATCH 3xx.110 - 3xx.111	Float		0	TM	N / RO	Mass totalizer of current batch, when operating at normal conditions.
94	OP1	NRL_TOT_ENERGY_ BATCH 3xx.112 - 3xx.115	Double		0	EN	N / RO	Energy totalizer of current batch, when operating at normal conditions.
95		FNRL_TOT_ENERGY_ BATCH 3xx.116 - 3xx.117	Float		0	EN	N / RO	Energy totalizer of current batch, when operating at normal conditions.
96	OP1	TWA_ BATCH 3xx.118 - 3xx.119	Float			T	N / RO	Temperature weighted average of current batch.
97	OP1	PWA_ BATCH 3xx.120 - 3xx.121	Float			P (abs)	N / RO	Absolute static pressure weighted average of current batch.
98	OP1	DPWA_ BATCH 3xx.122 - 3xx.123	Float			DP	N / RO	Differential pressure weighted average of current batch. Used only for differential pressure meters.
99	OP1	GRWA_BATCH 3xx.124 - 3xx.125	Float			Na	N / RO	Relative density weighted average of current batch. Used only for differential pressure meters.
100	OP1	FTIME_BATCH 3xx.126 - 3xx.128	Time difference				N / RO	Flowing time of current batch.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
101	OP1	STATUS_BATCH 3xx.129	Bitstring[2]	See Block Options	0	Na	N/ RO	Current batch status. Similar to BATCH_STATUS.
102	OP1	COUNTER_BATCH 3xx.130 - 3xx.131	Unsigned32		1	Na	N / RO	Batch report counter.
103	OP2	TOT_QV_HOUR 3xx.132 - 3xx.135	Double		0	TV	N / RO	Volume at flowing conditions totalizer of the current hour, when operating at normal and abnormal conditions.
104		FTOT_QV_HOUR 3xx.136 - 3xx.137	Float		0	TV	N / RO	Volume at flowing conditions totalizer of the current hour, when operating at normal and abnormal conditions.
105	3 OP2	NRL_TOT_QB_HOUR 3xx.138 - 3xx.141	Double		0	TV	N / RO	Volume at base conditions totalizer of the current hour, when operating at normal conditions.
106		FNRL_TOT_QB_HOUR 3xx.142 - 3xx.143	Float		0	TV	N / RO	Volume at base conditions totalizer of the current hour, when operating at normal conditions.
107	3 OP2	NRL_TOT_QM_HOUR 3xx.144 - 3xx.147	Double		0	TM	N / RO	Mass totalizer of current hour, when operating at normal conditions.
108		FNRL_TOT_QM_HOUR 3xx.148 - 3xx.149	Float		0	TM	N / RO	Mass totalizer of current hour, when operating at normal conditions.
109	OP2	NRL_TOT_ENERGY_HOUR 3xx.150 - 3xx.153	Double		0	EN	N / RO	Energy totalizer of current hour, when operating at normal conditions.
110		FNRL_TOT_ENERGY_HOUR 3xx.154 - 3xx.155	Float		0	EN	N / RO	Energy totalizer of current hour, when operating at normal conditions.
111	OP2	TWA_HOUR 3xx.156 - 3xx.157	Float			T	N / RO	Temperature weighted average of current hour.
112	OP2	PWA_HOUR 3xx.158 - 3xx.159	Float			P (abs)	N / RO	Absolute static pressure weighted average of current hour.
113	OP2	DPWA_HOUR 3xx.160 - 3xx.161	Float			DP	N / RO	Differential pressure weighted average of current hour. Used only for differential pressure meters.
114	OP2	GRWA_HOUR 3xx.162 - 3xx.163	Float			Na	N / RO	Relative density weighted of current hour. Used only for differential pressure meters.
115	OP2	FTIME_HOUR 3xx.164 - 3xx.166	Time difference				N / RO	Flowing time of current hour.
116	OP2	STATUS_HOUR 3xx.167	Bitstring[2]	See Block Options	0	Na	N/ RO	Current hour status. Similar to BATCH_STATUS

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
117	OP2	COUNTER_HOUR 3xx.168 - 3xx.169	Unsigned32		1	Na	N / RO	Hourly report counter.
118	OP3	TOT_QV_DAY 3xx.170 - 3xx.173	Double		0	TV	N / RO	Volume at flowing conditions totalizer of current day, when operating at normal and abnormal conditions.
119	VL	FTOT_QV_DAY 3xx.174 - 3xx.175	Float		0	TV	N / RO	Volume at flowing conditions totalizer of current day, when operating at normal and abnormal conditions.
120	3 OP3	NRL_TOT_QB_DAY 3xx.176 - 3xx.179	Double		0	TV	N / RO	Volume at base conditions totalizer of current day, when operating at normal conditions.
121	VL	FNRL_TOT_QB_ DAY 3xx.180 - 3xx.181	Float		0	TV	N / RO	Volume at base conditions totalizer of current day, when operating at normal conditions.
122	3 OP3	NRL_TOT_QM_ DAY 3xx.182 - 3xx.185	Double		0	TM	N / RO	Mass totalizer of current day, when operating at normal conditions.
123		FNRL_TOT_QM_ DAY 3xx.186 - 3xx.187	Float		0	TM	N / RO	Mass totalizer of current day, when operating at normal conditions.
124	OP3	NRL_TOT_ENERGY_ DAY 3xx.188 - 3xx.191	Double		0	EN	N / RO	Energy totalizer of current day, when operating at normal conditions.
125		FNRL_TOT_ENERGY_ DAY 3xx.192 - 3xx.193	Float		0	EN	N / RO	Energy totalizer of current day, when operating at normal conditions.
126	OP3	TWA_ DAY 3xx.194 - 3xx.195	Float			T	N / RO	Temperature weighted average of current day.
127	OP3	PWA_ DAY 3xx.196 - 3xx.197	Float			P (abs)	N / RO	Absolute static pressure weighted average of current day.
128	OP3	DPWA_ DAY 3xx.198 - 3xx.199	Float			DP	N / RO	Differential pressure weighted average of current day. Used only for differential pressure meters.
129	OP3	GRWA_DAY 3xx.200 - 3xx.201	Float			Na	N / RO	Relative density weighted average of current day. Used only for differential pressure meters.
130	OP3	FTIME_DAY 3xx.202 - 3xx.204	Time difference				N / RO	Flowing time of current day.
131	OP3	STATUS_DAY 3xx.205	Bitstring[2]	See Block Options	0	Na	N/ RO	Current day status. Similar to BATCH_STATUS.
132	OP3	COUNTER_DAY 3xx.206 - 3xx.207	Unsigned32		1	Na	N / RO	Daily report counter.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
133	OP4	TOT_QV_MONTH 3xx.208 - 3xx.211	Double		0	TV	N / RO	Volume at flowing conditions totalizer of current month, when operating at normal and abnormal conditions.
134		FTOT_QV_MONTH 3xx.212 - 3xx.213	Float		0	TV	N / RO	Volume at flowing conditions totalizer of current month, when operating at normal and abnormal conditions.
135	3 OP4	NRL_TOT_QB_MONTH 3xx.214 - 3xx.217	Double		0	TV	N / RO	Volume at base conditions totalizer of current month, when operating at normal conditions.
136		FNRL_TOT_QB_ MONTH 3xx.218 - 3xx.219	Float		0	TV	N / RO	Volume at base conditions totalizer of current month, when operating at normal conditions.
137	3 OP4	NRL_TOT_QM_ MONTH 3xx.220 - 3xx.223	Double		0	TM	N / RO	Mass totalizer of current month, when operating at normal conditions.
138		FNRL_TOT_QM_ MONTH 3xx.224 - 3xx.225	Float		0	TM	N / RO	Mass totalizer of current month, when operating at normal conditions.
139	OP4	NRL_TOT_ENERGY_ MONTH 3xx.226 - 3xx.229	Double		0	EN	N / RO	Energy totalizer of current month, when operating at normal conditions.
140		FNRL_TOT_ENERGY_ MONTH 3xx.230 - 3xx.231	Float		0	EN	N / RO	Energy totalizer of current month, when operating at normal conditions.
141	OP4	TWA_ MONTH 3xx.232 - 3xx.233	Float			T	N / RO	Temperature weighted average of current month.
142	OP4	PWA_ MONTH 3xx.234 - 3xx.235	Float			P (abs)	N / RO	Absolute static pressure weighted average of current month.
143	OP4	DPWA_ MONTH 3xx.236 - 3xx.237	Float			DP	N / RO	Differential pressure weighted average of current month. Used only for differential pressure meters.
144	OP4	GRWA_MONTH 3xx.238 - 3xx.239	Float			Na	N / RO	Relative density weighted average of current month. Used only for differential pressure meters.
145	OP4	FTIME_MONTH 3xx.240 - 3xx.242	Time difference				N / RO	Flowing time of current month.
146	OP4	STATUS_ MONTH 3xx.243	Bitstring[2]	See Block Options	0	Na	N/ RO	Current month status. Similar to BATCH_STATUS.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
147	OP4	COUNTER_ MONTH 3xx.244- 3xx.245	Unsigned32		1	Na	N / RO	Monthy report counter.
148	OPx	ACTIVE_ALAR M1 3xx.246	Bitstring[2]				N / RO	Indicates which alarms related to this flow is active.
149	OPx	ACTIVE_ALAR M2 3xx.247	Bitstring[2]				N / RO	Indicates which alarms related to this flow is active.
150	OPx	UNACK_ALAR M1 4xx.109	Bitstring[2]				N	Indicates which alarms related to this flow have not been recognized by the operator.
151	OPx	UNACK_ALAR M2 4xx.110	Bitstring[2]				N	Indicates which alarms related to this flow have not been recognized by the operator.
152	OP1	PREV_BATCH _ID 3xx.248 - 3xx.251	Visiblestring[8]				N / RO	Previous batch description.
153	3 OPx	PREV_TOT_Q V 3xx.252 - 3xx.255	Double		0	TV	N / RO	Volume at flowing conditions totalizer of the previous period, when operating at normal and abnormal conditions.
154	VL	FPREV_TOT_ QV 3xx.256 - 3xx.257	Float		0	TV	N / RO	Volume at flowing conditions totalizer of the previous period, when operating at normal and abnormal conditions.
155	3 OPx	PREV_NRL_T OT_QB 3xx.258 - 3xx.261	Double		0	TV	N / RO	Volume at base conditions totalizer of the previous period, when operating at normal conditions.
156	VL	FPREV_NRL_T OT_QB 3xx.262 - 3xx.263	Float		0	TV	N / RO	Volume at base conditions totalizer of the previous period, when operating at normal conditions.
157	3 OPx	PREV_NRL_T OT_QM 3xx.264 - 3xx.267	Double		0	TM	N / RO	Mass totalizer of the previous period, when operating at normal conditions.
158		FPREV_NRL_T OT_QM 3xx.268 - 3xx.269	Float		0	TM	N / RO	Mass totalizer of the previous period, when operating at normal conditions.
159	3 OPx	PREV_NRL_T OT_ENERGY 3xx.270 - 3xx.273	Double		0	EN	N / RO	Energy totalizer of the previous period, when operating at normal conditions.
160		FPREV_NRL_T OT_ENERGY 3xx.274 - 3xx.275	Float		0	EN	N / RO	Energy totalizer of the previous period, when operating at normal conditions.
161	VL OPx	PREV_FTIME 3xx.276 - 3xx.278	Time difference				N / RO	Flowing time of the previous period.
162	4 CF	USUAL_TEMP _DEV 4xx.111 - 4xx.112	Float	0.0=disabled 0.0 to 100.0	0	T	S	Maximum deviation for temperature during the usual conditions valuation and well test execution.

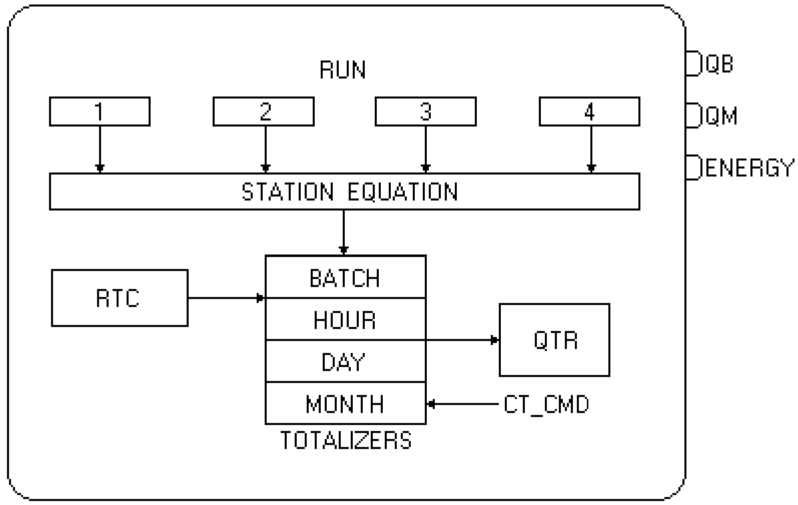
Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
163	4 CF	USUAL_PRES S_DEV 4xx.113 - 4xx.114	Float	0.0=disabled 0.0 to 100	0	%	S	Maximum deviation for pressure during the usual conditions valuation and well test execution.
164	4 CF	USUAL_FLOW _DEV 4xx.115 - 4xx.116	Float	0.0=disabled 0.0 to 100	0	%	S	Maximum deviation for flow rate during the base conditions valuation and well test execution.
165	4 MN	START_USUAL _CONDITIONS 4xx.117	Bitstring[2]	See the specific description	0	E	S	A new valuation of usual conditions for enabled variables at this parameter is started when a proving is executed successfully or when required during a well test or writing in this parameter.
166	MN	OPEN_USUAL _CONDITIONS 3xx.279 – 3xx.284	Date				N / RO	Date/time of valuation start of the usual conditions.
167	MN	GAS_WARN 3xx.285	Bitstring[2]	See the specific description	0	E	N / RO	Warning events occurred during the usual conditions valuation.
168 (A2)	MN	USUAL_TEMP ERATURE 4xx.118 - 4xx.119	Float		0	T	N	If the usual temperature is not configured to be calculated by HFC302 in no START_USUAL_CONDITIONS, it is possible to write in this parameter.
169 (A2)	MN	USUAL_PRES SURE 4xx.120 - 4xx.121	Float	>= 0.0	0	PRESSUR E_TYPE: P (gauge) or P (abs)	N	If the usual static pressure is not configured to be calculated by HFC302 in no START_USUAL_CONDITIONS, it is possible to write in this parameter.
170 (A2)	MN	USUAL_FLOW 4xx.122 - 4xx.123	Float	>= 0.0	0	QV	N	If the usual flow rate is not configured to be calculated by HFC302 in no START_USUAL_CONDITIONS, it is possible to write in this parameter.
171		UPDATE_EVT 3xx.286 – 3xx.292 4xx.124	DS-73			Na	D	This alert is generated by any changes in static data.
172		BLOCK_ALM 3xx.293 – 3xx.299 4xx.125	DS-72			Na	D	The block alarm is used for all configuration, hardware, and connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
173	OP1	ABN_TOT_QB_ BATCH 3xx.300 - 3xx.303	Double		0	TV	N / RO	Volume at base conditions totalizer of the current batch, when operating at abnormal condition.
174	OP1	ABN_TOT_QM _BATCH 3xx.304 - 3xx.307	Double		0	TM	N / RO	Mass totalizer of the current batch, when operating at abnormal condition.
175	OP1	ABN_TOT_EN ERGY_BATCH 3xx.308 - 3xx.311	Double		0	EN	N / RO	Energy totalizer of the current batch, when operating at abnormal condition.

Idx	Type/View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
176	OP2	ABN_TOT_QB_HOUR 3xx.312 - 3xx.315	Double		0	TV	N / RO	Volume at base conditions totalizer of the current hour, when operating at abnormal condition.
177	OP2	ABN_TOT_QM_HOUR 3xx.316 - 3xx.319	Double		0	TM	N / RO	Mass totalizer of the current hour, when operating at abnormal condition.
178	OP2	ABN_TOT_ENERGY_HOUR 3xx.320 - 3xx.323	Double		0	EN	N / RO	Energy totalizer of the current hour, when operating at abnormal condition.
179	OP3 VL	ABN_TOT_QB_DAY 3xx.324 - 3xx.327	Double		0	TV	N / RO	Volume at base conditions totalizer of the current day, when operating at abnormal condition.
180	OP3	ABN_TOT_QM_DAY 3xx.328 - 3xx.331	Double		0	TM	N / RO	Mass totalizer of the current day, when operating at abnormal condition.
181	OP3	ABN_TOT_ENERGY_DAY 3xx.332 - 3xx.335	Double		0	EN	N / RO	Energy totalizer of the current day, when operating at abnormal condition.
182	OP4	ABN_TOT_QB_MONTH 3xx.336 - 3xx.339	Double		0	TV	N / RO	Volume at base conditions totalizer of the current month, when operating at abnormal condition.
183	OP4	ABN_TOT_QM_MONTH 3xx.340 - 3xx.343	Double		0	TM	N / RO	Mass totalizer of the current month, when operating at abnormal condition.
184	OP4	ABN_TOT_ENERGY_MONTH 3xx.344 - 3xx.347	Double		0	EN	N / RO	Energy totalizer of the current month, when operating at abnormal condition.
185	OPx VL	PREV_ABN_TOT_QB 3xx.348 - 3xx.351	Double		0	TV	N / RO	Volume at base conditions totalizer of previous period, when operating at abnormal condition.
186	OPx	PREV_ABN_TOT_QM 3xx.352 - 3xx.355	Double		0	TM	N / RO	Mass totalizer of previous period, when operating at abnormal condition.
187	OPx	PREV_ABN_TOT_ENERGY 3xx.356 - 3xx.359	Double		0	EN	N / RO	Energy totalizer of previous period, when operating at abnormal condition.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – Dinamic; N – non-volatile;
S – Static; I – Input Parameter; O-Output Parameter
AA-Administrator Level; A1 – Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL = 177 bytes (includes block tag and profile); V1-112 bytes; V2-105 bytes; V3-114 bytes; V4-19 bytes, VL-60 bytes.
HFCView: OPx (OP1, OP2, OP3, OP4), OP1 (Operation - Batch), OP2 (Operation - Hour), OP3 (Operation - Day), OP4 (Operation - Month), CF (Configuration), MN (Maintenance)

GST – Gas Station Transaction

Schematic



Description
This block is used for gas measurement calculations, the corrected flows of the meters are combined (sum and/or subtract) according to the user configuration and one QTR report can be generated.

The main purpose of this block is to add/subtract the corrected flows, therefore this block does not refer to secondary variables (temperature and pressure), intermediate variables for calculation, correction factors or sensors. And these flows may have been measured using different types of sensors.

Other features include batch programming and indication of active and unacknowledged process alarms related to the station.

Block outputs
The block inputs are calculation resultanting flows and therefore, available to be connected to other blocks:
QB – corrected flow rate at base conditions
QM – mass flow rate
ENERGY – energy flow rate

Configuration of the station equation – STATION_EQUATION parameter
The STATION_EQUATION parameter defines the operations to be accomplished among the streams, obeying the following rules:
- Allowed operations: sum (+) and subtract (-);
- Interspersed sequence of the run number with the arithmetic operator without spaces;
- If the first character is blank, no operation will be accomplished;
- There is a writing check for the STATION_EQUATION parameter regarding to consistency: valid run number and operation;
- During the block execution, the equation consistence will be checked and any problem will be indicated in the BLOCK_ERR.Block Configuration Error parameter;
- Run number of a gas measurement;
- Streams measuring same type of product;
- Configuration example:
  - o 1+2+3-4
  - o 2-1
  - o 1+1-2

QTR report generation
There are several events which cause the QTR report generation in the HFC302 memory for later reading and save it in database by the HFCView.
The situations are showed below:

Event	Report type (GTV.QTR_TYPE)	Condition
Transition of correspondent account period	"Continous & period"	All the periods enabled in the ENABLE_REPORT
Configuration download	"Reset & period"	All the periods enabled in the ENABLE_REPORT and the period of the batch
Writing in the CT_CMD parameter requesting operational report.	"Operational & period"	Report of the requested period
-	"Snapshot"	Not supported
Batch end	"Batch"	-

When the volume totalizer at base conditions is null, the report generation in the HFC302 memory will be disabled when configuring REPORT_NO_FLOW = no (default condition) parameter.

Calculations executed by period (batch, hour, day, week and month)
The flow calculations are done for volume at base conditions (Qb), mass (Qm) and energy (energy) for each period.

Indication of events in the summarized status of period:
- Override temperature used;
- Override pressure used;
- Block in O/S;
- Override differential pressure used;
- Bad status of chromatograph;
- Out of range correction factor;
- Process alarm;
- Bad status of flow input;
- Inconsistent secondary variables;
- Abnormal condition;
- Stop totalization.

This summarized status provides only indication that an important event occurred at one moment in any of the measured flows, which is in the station equation. And it does not indicate more details, which must be obtained from the event register.

The flow time calculation is the time counting when there was flow rate at the considered period.

If the QTR report is generated, it will have the report number indicated in the COUNTER_BATCH, COUNTER_HOUR, COUNTER_DAY, COUNTER_BATCH or COUNTER_MONTH parameter.

Totalizers of the previous period
The PREV_NRL_TOT_QB, PREV_ABN_TOT_QB, PREV_NRL_TOT_QM, PREV_ABN_TOT_QM, PREV_NRL_TOT_ENERGY and PREV_ABN_TOT_ENERGY totalizers indicate the totalizations of the previous accounting period. Besides it, the flow time is indicated in PREV_FTIME parameter.

This information of the previous period considers possible resets in the totalizations during this period, thus these totalizers and the flow time indicate a sum of totalizers/flow times if a reset occurred.

The information of the previous period is consistent even in a power failure situation, thus when energizing, the HFC302 checks if the totalizers are related to the previous or current accounting day.

Process alarm: active (ACTIVE_ALARM1 and ACTIVE_ALARM2) and unacknowledged (UNACK_ALARM1 and UNACK_ALARM2).
The process alarms (high, high high, low and low low) of variables related to the measurement systems such as volume flow rate, mass flow rate, temperature and pressure, which are used in the station equation, are processed by the AALM block. In the GST block there is only one summarized status indication of active and unacknowledged alarms. For further details, refer to the AALM block or the event register.

Diagnosis and Troubleshooting

- BLOCK_ERR. Block configuration: this indication occurs when the control loop does not measure the same product.;
- BLOCK_ERR. Out of Service: the GST block may continue in the Out of service mode, although the target mode is Auto, because the Resource block is in O/S

Supported Modes
O/S and AUTO.

Parameters

Idx	Type/View	Parameter	Data type (length)	Valid range / Options	Default Value	Units	Store / Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2	CF	TAG_DESC 4xx.x00 – 4xx.x15	OctString(32)		Spaces	Na	S	If this parameter is configured with a string different of spaces, this parameter will replace the block tag in the QTR report.
3	4	STRATEGY 3xx.xx0	Unsigned16	253	253	None	S / RO	
4	4	ALERT_KEY 4xx.x16	Unsigned8	1 to 255	0	None	S	
5 (A2) (CL)	1,3 CF	MODE_BLK Target/Normal - 4xx.x17 – 4xx.x19 Actual - 3xx.xx1	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7	O,1 OPx	QB 3xx.xx3 – 3xx.xx5	DS-65			QV	N / RO	Volume flow rate at base conditions.
8	O,1 OPx	QM 3xx.xx6 – 3xx.xx8	DS-65			QM	N / RO	Mass flow rate.
9	O,1 OPx	ENERGY 3xx.xx9 – 3xx.x11	DS-65			ER	N / RO	Energy flow rate.
10 (A2) (CL)	2 CF	STATION_EQUATION 4xx.x20 – 4xx.x27	Visiblestring[16]		Blank		S	Station equation for gas. If the first is blank, it means no processing.
11 (A2) (CL)	2 CF	ENABLE_REPORT 4xx.x28	Bitstring[2]		Daily		S	This parameter enables the report generation for the periods: time, day, week or month.
12 (A2) (CL)	2 CF	REPORT_NO_FLOW 4xx.x29	Unsigned8	0=No 1=Yes	0	E	S	QTR report will not be generated if the BA totalizer is zero and this parameter is configured as "No".

13 (A2)	1 OP	CT_CMD 4xx.x30	Unsigned8	0=None 2=Operational batch 3=Operational hour report 4=Operational day report 5=Operational month report 6=Snapshot 7=Previous batch 8=Previous hour 9=Previous day 10=Previous month	Previous day	E	N	This parameter allows to request operational and snapshot report. Through this parameter is also possible to select the type of previous period to be visualized. After executing a request action, the value will return automatically to the state that shows the type of previous period visualized.
14	1 OPx	PREV_NRL_TOT_QB 3xx.x12 – 3xx.x15	Double		0	TV	N / RO	Volume at base conditions totalizer of the previous period, when operating at normal conditions.
15		FPREV_NRL_TOT_QB 3xx.x16 – 3xx.x17	Float		0	TV	N / RO	Volume at base conditions totalizer of the previous period, when operating at normal conditions.
16	1 OPx	PREV_NRL_TOT_QM 3xx.x18 – 3xx.x21	Double		0	TM	N / RO	Mass totalizer of the previous period, when operating at normal conditions.
17		FPREV_NRL_TOT_QM 3xx.x22 – 3xx.x23	Float		0	TM	N / RO	Mass totalizer of the previous period, when operating at normal conditions.
18	1 OPx	PREV_NRL_TOT_ENERGY 3xx.x24 – 3xx.x27	Double		0	EN	N / RO	Energy totalizer of the previous period, when operating at normal conditions.
19		FPREV_NRL_TOT_ENERGY 3xx.x28 – 3xx.x29	Float		0	EN	N / RO	Energy totalizer of the previous period, when operating at normal conditions.
20	1 OPx	PREV_FTIME 3xx.x30 – 3xx.x32	Time difference				N / RO	Flow time for the previous period.
21	1 MN	CURRENT_STATUS 3xx.x33	Bitstring[2]	See Block Options	0	Na	N/ RO	Current status. Similar to BATCH_STATUS.
22	1 OP1	NRL_TOT_QB_BATCH 3xx.x34 – 3xx.x37	Double		0	TV	N / RO	Volume totalizer at base conditions for the current batch, when operating at normal conditions.
23		FNRL_TOT_QB_ BATCH 3xx.x38 – 3xx.x39	Float		0	TV	N / RO	Volume totalizer at base conditions for the current batch, when operating at normal conditions.
24	1 OP1	NRL_TOT_QM_ BATCH 3xx.x40 – 3xx.x43	Double		0	TM	N / RO	Mass totalizer for the current batch, when operating at normal conditions.

25		FNRL_TOT_QM_ BATCH 3xx.x44 – 3xx.x45	Float		0	TM	N / RO	Mass totalizer for the current batch, when operating at normal conditions.
26	3 OP1	NRL_TOT_ENERGY_ BATCH 3xx.x46 – 3xx.x49	Double		0	EN	N / RO	Energy totalizer for the current batch, when operating at normal conditions.
27		FNRL_TOT_ENERGY_ BATCH 3xx.x50 – 3xx.x51	Float		0	EN	N / RO	Energy totalizer for the current batch, when operating at normal conditions.
28	3 OP1	FTIME_BATCH 3xx.x52 – 3xx.x54	Time difference				N / RO	Flow time for the current batch.
29	3 OP1	STATUS_BATCH 3xx.x55	Bitstring[2]	See Block Options	0	Na	N/ RO	Current batch status. Similar to the BATCH_STATUS.
30	3 OP1	COUNTER_BATCH 3xx.x56 – 3xx.x57	Unsigned32		1	Na	N / RO	Batch report counter.
31	1 OP2	NRL_TOT_QB_HOUR 3xx.x58 – 3xx.x61	Double		0	TV	N / RO	Volume totalizer at base conditions for the current hour, when operating at normal conditions.
32		FNRL_TOT_QB_HOUR 3xx.x62 – 3xx.x63	Float		0	TV	N / RO	Volume totalizer at base conditions for the current hour, when operating at normal conditions.
33	1 OP2	NRL_TOT_QM_HOUR 3xx.x64 – 3xx.x67	Double		0	TM	N / RO	Mass totalizer of the current hour, when operating at normal conditions.
34		FNRL_TOT_QM_HOUR 3xx.x68 – 3xx.x69	Float		0	TM	N / RO	Mass totalizer of the current hour, when operating at normal conditions.
35	3 OP2	NRL_TOT_ENERGY_HOUR 3xx.x70 – 3xx.x73	Double		0	EN	N / RO	Energy totalizer of the current hour, when operating at normal conditions.
36		FNRL_TOT_ENERGY_HOUR 3xx.x74 – 3xx.x75	Float		0	EN	N / RO	Energy totalizer of the current hour, when operating at normal conditions.
37	3 OP2	FTIME_HOUR 3xx.x76 – 3xx.x78	Time difference				N / RO	Flow time of the current hour.
38	3 OP2	STATUS_HOUR 3xx.x79	Bitstring[2]	See Block Options	0	Na	N/ RO	Current hour status. Similar to BATCH_STATUS
39	3 OP2	COUNTER_HOUR 3xx.x80 – 3xx.x81	Unsigned32		1	Na	N / RO	Hourly report counter.

40	1 OP3	NRL_TOT_QB_DAY 3xx.x82 – 3xx.x85	Double		0	TV	N / RO	Volume totalizer at base conditions of the current day, when operating at normal conditions.
41		FNRL_TOT_QB_ DAY 3xx.x86 – 3xx.x87	Float		0	TV	N / RO	Volume totalizer at base conditions of the current day, when operating at normal conditions.
42	1 OP3	NRL_TOT_QM_ DAY 3xx.x88 – 3xx.x91	Double		0	TM	N / RO	Mass totalizer of the current day, when operating at normal conditions.
43		FNRL_TOT_QM_ DAY 3xx.x92 – 3xx.x93	Float		0	TM	N / RO	Mass totalizer of the current day, when operating at normal conditions.
44	3 OP3	NRL_TOT_ENERGY_ DAY 3xx.x94 – 3xx.x97	Double		0	EN	N / RO	Energy totalizer of the current day, when operating at normal conditions.
45		FNRL_TOT_ENERGY_ DAY 3xx.x98 – 3xx.x99	Float		0	EN	N / RO	Energy totalizer of the current day, when operating at normal conditions.
46	3 OP3	FTIME_DAY 3xx.100 – 3xx.102	Time difference				N / RO	Flow time of the current day.
47	3 OP3	STATUS_DAY 3xx.103	Bitstring[2]	See Block Options	0	Na	N/ RO	Current day status. Similar to BATCH_STATUS.
48	3 OP3	COUNTER_DAY 3xx.104 – 3xx.105	Unsigned32		1	Na	N / RO	Daily report counter.
49	1 OP4	NRL_TOT_QB_MONTH 3xx.106 – 3xx.109	Double		0	TV	N / RO	Volumetric totalizer of the current month at base conditions, when operating at normal conditions.
50		FNRL_TOT_QB_ MONTH 3xx.110 – 3xx.111	Float		0	TV	N / RO	Volumetric totalizer of the current month at base conditions, when operating at normal conditions.
51	1 OP4	NRL_TOT_QM_ MONTH 3xx.112 – 3xx.115	Double		0	TM	N / RO	Mass totalizer of the current month, when operating at normal conditions.
52		FNRL_TOT_QM_ MONTH 3xx.116 – 3xx.117	Float		0	TM	N / RO	Mass totalizer of the current month, when operating at normal conditions.
53	3 OP4	NRL_TOT_ENERGY_ MONTH 3xx.118 – 3xx.121	Double		0	EN	N / RO	Energy totalizer of the current month, when operating at normal conditions.
54		FNRL_TOT_ENERGY_ MONTH 3xx.122 – 3xx.123	Float		0	EN	N / RO	Energy totalizer of the current month, when operating at normal conditions.

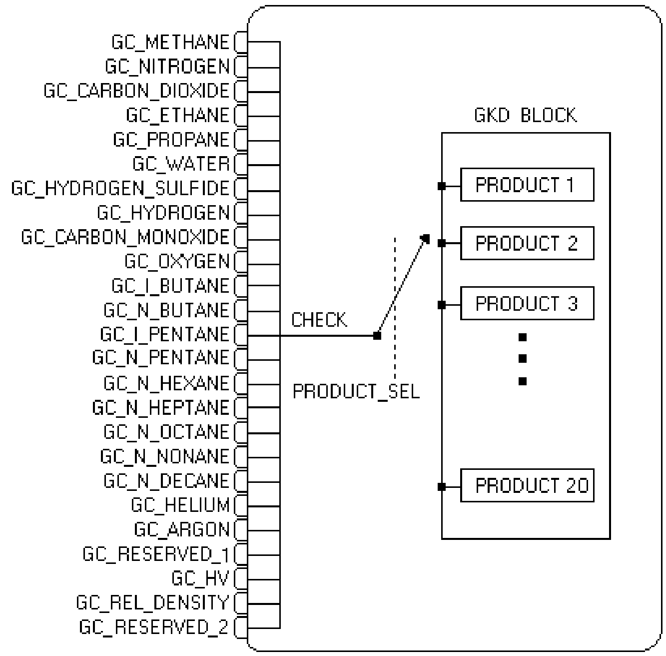
55	3 OP4	FTIME_MONTH 3xx.124 – 3xx.126	Time difference				N / RO	Flow time of the current month.
56	3 OP4	STATUS_ MONTH 3xx.127	Bitstring[2]	See Block Options	0	Na	N/ RO	Current month status. Similar to BATCH_STATUS.
57	3 OP4	COUNTER_ MONTH 3xx.128 – 3xx.129	Unsigned32		1	Na	N / RO	Monthly report counter.
58	3 OPx	ACTIVE_ALARM1 3xx.130	Bitstring[2]				N / RO	Indicates which alarms related to the station are active.
59	3 OPx	ACTIVE_ALARM2 3xx.131	Bitstring[2]				N / RO	Indicates which alarms related to the station are active.
60	3 OPx	UNACK_ALARM1 4xx.x31	Bitstring[2]				N	Indicate the alarms related to the station are unacknowledged by the operator.
61	3 OPx	UNACK_ALARM2 4xx.x32	Bitstring[2]				N	Indicate the alarms related to the station are unacknowledged by the operator.
62		UPDATE_EVT 3xx.132 – 3xx.138 4xx.x33	DS-73			Na	D	This alert is generated by any changes to the static data.
63		BLOCK_ALM 3xx.139 – 3xx.145 4xx.x34	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
64	OP1	ABN_TOT_QB_ BATCH 3xx.146 – 3xx.149	Double		0	TV	N / RO	Volume at base conditions totalizer of the current batch, when operating at abnormal condition.
65	OP1	ABN_TOT_QM_ BATCH 3xx.150 – 3xx.153	Double		0	TM	N / RO	Mass totalizer of the current batch, when operating at abnormal condition.
66	OP1	ABN_TOT_ENERGY_ BATCH 3xx.154 – 3xx.157	Double		0	EN	N / RO	Energy totalizer of the current batch, when operating at abnormal condition.
67	OP2	ABN_TOT_QB_ HOUR 3xx.158 – 3xx.161	Double		0	TV	N / RO	Volume at base conditions totalizer of the current hour, when operating at abnormal condition.
68	OP2	ABN_TOT_QM_ HOUR 3xx.162 – 3xx.165	Double		0	TM	N / RO	Mass totalizer of the current hour, when operating at abnormal condition.

69	OP2	ABN_TOT_EN ERGY_ HOUR 3xx.166 – 3xx.169	Double		0	EN	N / RO	Energy totalizer of the current hour, when operating at abnormal condition.
70	OP3	ABN_TOT_QB_ DAY 3xx.170 – 3xx.173	Double		0	TV	N / RO	Volume at base conditions totalizer of the current day, when operating at abnormal condition.
71	OP3	ABN_TOT_QM _ DAY 3xx.174 – 3xx.177	Double		0	TM	N / RO	Mass totalizer of the current day, when operating at abnormal condition.
72	OP3	ABN_TOT_EN ERGY_ DAY 3xx.178 – 3xx.181	Double		0	EN	N / RO	Energy totalizer of the current day, when operating at abnormal condition.
73	OP4	ABN_TOT_QB_ MONTH 3xx.182 – 3xx.185	Double		0	TV	N / RO	Volume at base conditions totalizer of the current month, when operating at abnormal condition.
74	OP4	ABN_TOT_QM _ MONTH 3xx.186 – 3xx.189	Double		0	TM	N / RO	Mass totalizer of the current month, when operating at abnormal condition.
75	OP4	ABN_TOT_EN ERGY_ MONTH 3xx.190 – 3xx.193	Double		0	EN	N / RO	Energy totalizer of the current month, when operating at abnormal condition.
76	OPx	PREV_ABN_T OT_QB 3xx.194 – 3xx.197	Double		0	TV	N / RO	Volume at base conditions totalizer of previous period, when operating at abnormal condition.
77	OPx	PREV_ABN_T OT_QM 3xx.198 – 3xx.201	Double		0	TM	N / RO	Mass totalizer of previous period, when operating at abnormal condition.
78	OPx	PREV_ABN_T OT_ENERGY 3xx.202 – 3xx.205	Double		0	EN	N / RO	Energy totalizer of previous period, when operating at abnormal condition.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – Dynamic; N – non-volatile;
S – Static; I – Input Parameter; O-Output Parameter
AA-Administrator Level; A1 – Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL = 57 bytes (includes block tag and profile); V1-120 bytes; V2-21 bytes; V3-96 bytes; V4-5 bytes
HFCView: OPx (OP1, OP2, OP3, OP4), OP1 (Operation - Batch), OP2 (Operation - Hour), OP3 (Operation - Day), OP4 (Operation - Month), CF (Configuration), MN (Maintenance)

GC –Gas Composition

Schematic



Description

This block receives the gas composition from other blocks, which can be Modbus blocks (MBCM) or blocks from the chromatograph via Foundation Fieldbus.

Block Inputs

The block inputs refer to 21 gas components plus heating value and relative density. Only the linked inputs will be analyzed considering consistency and also they can be transferred to the GKD block in the specified product in the PRODUCT_SEL parameter.

Configuration of the PRODUCT_SEL parameter

This parameter indicates which product in the GKD block will receive the composition provided by the input parameters of this block, after the consistency check.

Block processing

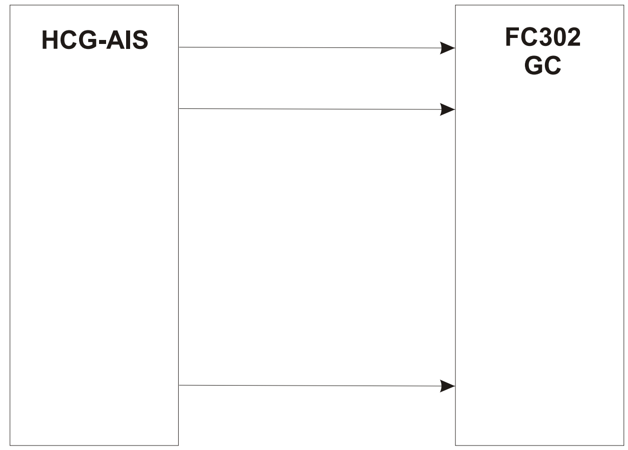
For each linked input, the status and the range will be analyzed (refer to the component range in the GKD block), in case of problem, the CHROMA_STATUS parameter will show it.
Besides this, the following analyses are accomplished:

- Total of the percentages equals to 100%;
- If the HFC302 is not configured to calculate the heating value or relative density (GKD.HV_GR_CALC_Px), the correspondent inputs of this block must be linked with good status and within the range;
- The GKD.COMPOSITION_Px block must be configured to “chromatograph”.

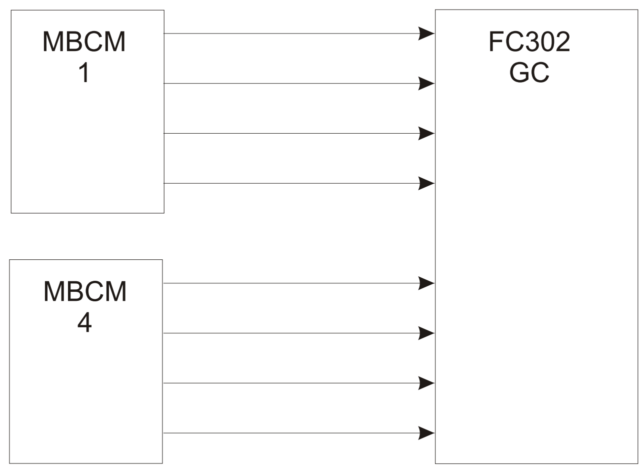
The TIME_LAST_UPDATE parameter indicates the elapsed time since the last transference of the composition to the GKD block, if any value changed. Thus, after transferring the composition to the GKD block, if an inconsistency is detected or all linked inputs of this block remains unchanged, the TIME_LAST_UPDATE parameter will keep counting the time and will be resettled when transferring a different composition.

Application with Foundation Fieldbus chromatograph

The HGC-AIS block of the chromatograph provides the composition and must be linked to the GC block in the HFC302.



Application with Modbus chromatograph
The HFC302 must be configured as Master Modbus and can communicate with the chromatograph using Modbus RTU or Modbus TCP/IP. The MBCM block brings the gas composition from the chromatograph and its output parameters must be linked to the GC block.



Diagnosis and Troubleshooting
1. BLOCK_ERR. Out of Service: GC block may remain in the Out of service mode, although the target mode is Auto because the Resource block is in O/S;
2. The CHROMA_STATUS parameter shows problems occurred in consistency checks, as:

CHROMA_STATUS	Corrective Action
Mode O/S	
Total greater than 100% Total less than 100%	Check the percentage sum for the 21 components.
Inconsistent composition	
User enter	GKD.COMPOSITION_Px Parameter must be configured to "chromatograph"
Methane Nitrogen Carbon Dioxide Ethane Propane Water Hydrogen sulfide Hydrogen Carbon monoxide Oxygen I-Butane n-Butane I-Pentane	Check the linked input status, verify the component range (refer to the GKD block description)

CHROMA_STATUS	Corrective Action
n-Pentane n-Hexane n-Heptane n-Octane n-Nonane n-Decane Helium Argon Total butanes Total Pentanes	
HV Gr	Verify the GKD.HV_GR_CALC_Px block configuration. Check the range according to the table in the GKD block.

Supported Modes
O/S and AUTO.

Parameters

Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3	4	STRATEGY 3xx.xx0	Unsigned16	255	255	None	S / RO	
4	4	ALERT_KEY 4xx.xx0	Unsigned8	1 to 255	0	None	S	
5 (A2)(CL)	1,3 CF	MODE_BLK Actual=3xx.xx1 Target/Normal=4xx.xx1 – 4xx.xx3	DS-69		Auto	Na	S	See Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7	I,1 OP	GC_METHANE 3xx.xx3 - 3xx.xx5	DS-65			%	N/RO	Methane percentage in the composition.
8	I,1 OP	GC_NITROGEN 3xx.xx6 - 3xx.xx8	DS-65			%	N/RO	Nitrogen percentage in the composition.
9	I,1 OP	GC_CARBON_DIOXIDE 3xx.xx9 - 3xx.x11	DS-65			%	N/RO	Carbon dioxide percentage in the composition.
10	I,1 OP	GC_ETHANE 3xx.x12 - 3xx.x14	DS-65			%	N/RO	Ethane percentage in the composition.
11	I,1 OP	GC_PROPANE 3xx.x15 - 3xx.x17	DS-65			%	N/RO	Propane percentage in the composition
12	I,1 OP	GC_WATER 3xx.x18 - 3xx.x20	DS-65			%	N/RO	Water percentage in the composition.
13	I,1 OP	GC_HYDROGEN SULFIDE 3xx.x21 - 3xx.x23	DS-65			%	N/RO	Hydrogen sulfide percentage in the composition.
14	I,1 OP	GC_HYDROGEN 3xx.x24 - 3xx.x26	DS-65			%	N/RO	Hydrogen percentage in the composition.
15	I,1 OP	GC_CARBON_MONOXIDE 3xx.x27 - 3xx.x29	DS-65			%	N/RO	Carbon monoxide percentage in the composition.

Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
16	I,1 OP	GC_OXYGEN 3xx.x30 - 3xx.x32	DS-65			%	N/RO	Oxygen percentage in the composition.
17	I,1 OP	GC_I_BUTANE 3xx.x33 - 3xx.x35	DS-65			%	N/RO	I-butane percentage in the composition.
18	I,1 OP	GC_N_BUTANE 3xx.x36 - 3xx.x38	DS-65			%	N/RO	N-butane percentage in the composition.
19	I,1 OP	GC_I_PENTANE 3xx.x39 - 3xx.x41	DS-65			%	N/RO	I-pentane percentage in the composition.
20	I,1 OP	GC_N_PENTANE 3xx.x42 - 3xx.x44	DS-65			%	N/RO	N-pentane percentage in the composition.
21	I,1 OP	GC_N_HEXANE 3xx.x45 - 3xx.x47	DS-65			%	N/RO	N-hexane percentage in the composition.
22	I,1 OP	GC_N_HEPTANE 3xx.x48 - 3xx.x50	DS-65			%	N/RO	N-heptane percentage in the composition.
23	I,1 OP	GC_N_OCTANE 3xx.x51 - 3xx.x53	DS-65			%	N/RO	N-octane percentage in the composition.
24	I,1 OP	GC_N_NONANE 3xx.x54 - 3xx.x56	DS-65			%	N/RO	N-nonane percentage in the composition.
25	I,1 OP	GC_N_DECANE 3xx.x57 - 3xx.x59	DS-65			%	N/RO	N-decane percentage in the composition
26	I,1 OP	GC_HELIUM 3xx.x60 - 3xx.x62	DS-65			%	N/RO	Helium percentage in the composition.
27	I,1 OP	GC_ARGON 3xx.x63 - 3xx.x65	DS-65			%	N/RO	Argon percentage in the composition.
28	I	GC_RESERVED1 3xx.x66 - 3xx.x68	DS-65			Na	N / RO	Reserved1.
29	I,3 OP	GC_HV 3xx.x69 - 3xx.x71	DS-65			HV	N/RO	Composition Heating value.
30	I,3 OP	GC_REL_DENSITY 3xx.x72 - 3xx.x74	DS-65			Na	N/RO	Composition Relative density.
31	I	GC_RESERVED2 3xx.x75 - 3xx.x77	DS-65			Na	N / RO	Reserved2.
32 (A2)(CL)	4 CF	CHROMA_TYPE 4xx.xx4	Unsigned8	0 - None 1 – Yamatake HGC303 FF 2 – Yamatake HGC303 Modbus	1	E	S	Chromatograph type selection
33 (A2)(CL)	4 CF	PRODUCT_SEL 4xx.xx5	Unsigned8	1-4-20 = Product 1-4-20(AGA8)	1	E	S	Product selection of list provided in the GKD block.

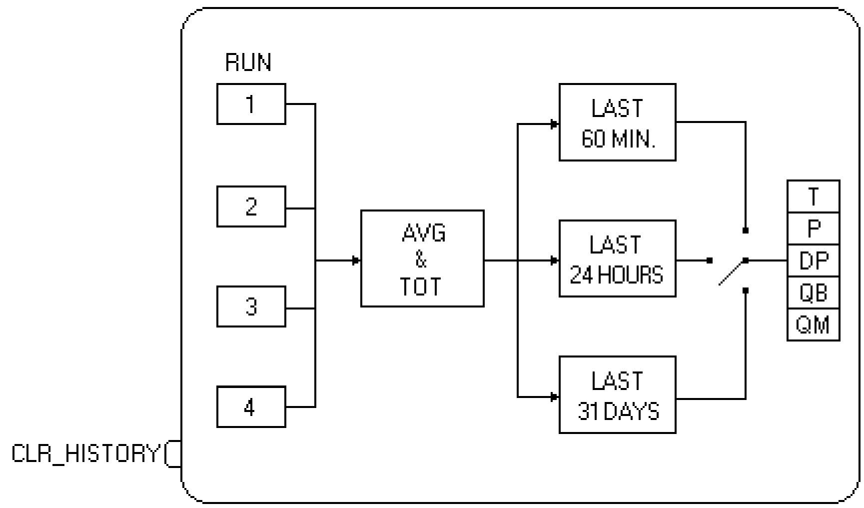
Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
34	3 OP	CHROMA_STATUS 3xx.x78 – 3xx.x79	Unsigned32	0=normal 1=Mode O/S 2=Total greater than 100% 3=Total less than 100% 4=Inconsistent composition 5=User enter 11=Methane 12=Nitrogen 13=Carbon Dioxide 14=Ethane 15=Propane 16=Water 17=Hydrogen sulfide 18=Hydrogen 19=Carbon monoxide 20=Oxygen 21=I-Butane 22=n-Butane 23=I-Pentane 24=n-Pentane 25=n-Hexane 26=n-Heptane 27=n-Octane 28=n-Nonane 29=n-Decane 30=Helium 31=Argon 32=Total butanes 33=Total Pentanes 34=HV 35=Gr		E	N / RO	Status information for the gas analyzer device.
35	3 OP	TIME_LAST_UPDATE 3xx.x80 – 3xx.x82	Time difference				N / RO	Elapsed time since last composition update.
36	3	UPDATE_EVT 3xx.x83 – 3xx.x89 4xx.xx6	DS-73			Na	D	This alert is generated by any change to the static data.

Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store/ Mode	Description
37	3	BLOCK_ALM 3xx.x90 – 3xx.x96 4xx.xx7	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter NA – Dimensionless Parameter; RO – Read only; D – Dynamic; N – non-volatile;
S – Static; I – Input Parameter O-Output Parameter
AA-Administrator Level; A1 – Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL = 40 bytes (includes block tag and profile); V1-113 bytes; V2-2 bytes; V3-55 bytes; V4-5 bytes;
HFCView: OP (Operation), CF (Configuration), MN (Maintenance)

GMH – Gas Measurement Historic

Schematic



Description

This block stores the last 60 minutes totalizations, the last 24 hourly totalization and the last 28/29/30/31 daily totalizations for gas measurement of QB and ENERGY, as well as the weight weighted correspondent to temperature, static pressure and differential pressure.

The proper function will only be possible if GT block is configured for a calculation period (IMP) lower or equal to 1 minute.

The array elements provide the average value and totalizations according to the following rules:

- The arrays are used as circular buffers, in where the element correspondent to the current average (in operation) is updated in each IMP.
- The array elements used in the circular buffer depend on the HISTORY_CMD selection. If selected Monitor minutes, all the elements are used, however if selected Monitor hours, only the 24 first elements are used.
- The array position indicates the correspondent second, minute, hour and day. For example, the average temperature for minutes monitoring (HISTORY_CMD = Monitor minutes) for 11:32:10 time will be indicated in TEMP_21 parameter, element 12.
- The arrays first elements TEMP_1, PRES_1, DP_1, QB_1 and MASS_1 indicate the second 0, the minute 0, hour 0 or day 1.

The HISTORY_CMD parameter offers the following functionality:

- Average visualization and window totalization, in which the user selects the last 60 minutes visualization or the last 24 hours or the last 28/29/30/31 days. At any moment the user can select the period type, the only restriction would be the simultaneous values visualization in different periods. For example, monitoring simultaneously the last 60 minutes or the last 60 hours.
- The indicated value by HISTORY_CMD parameter is the selected period type.
- The operational report requisition, that is, the report type generation of the requested period and related to the requested moment.

The generated reports follow the rules below:

- Hourly report shows averages and totalizations of 60 minutes
- Daily report shows averages and totalizations of 24 hours
- Monthly report shows averages and totalizations with up to 31 days
- The generated continual report types are those selected in the ENABLE_REPORT at the hour start, day or month, according to the configuration in the FCT block.
- Operational report is generated according to the user request through HISTORY_CMD parameter

Consistence check related to STRATEGY:

- Only one GMH instance by control loop: avoid the repetition in the writing.

- Check the configured value in STRATEGY refers to a gas measurement. If not, indicate in BLOCK_ERR parameter.

Historic constancy of HFC302 memory measurement
The measurement historic (period totalizations) is started (cleared) in the following conditions:
- Configuration download
- Firmware download

The measurement historic keeps in memory in the following situations:
- On and off the equipment: when gaps indication occurs, that is, no information gathering done.
- Control loop change (STRATEGY);
- GT Block correspondent in O/S;

Diagnosis and Troubleshooting
BLOCK_ERR. Block configuration:
- Configured value in STRATEGY parameter does not refer to a gas measurement.
- IMP period configurated in GT block correspondent is upper than 1 minute.

Index	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Unit	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3 (A2) (CL)	4 CF	STRATEGY 4xx.xx0	Unsigned16	1 to 4		None	S	This parameter is used to identify the measured flow number.
4	4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5 (A2) (CL)	1,3 CF	MODE_BLK Target/Normal – 4xx.xx2 – 4xx.xx4 Actual – 3xx.xx0	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx1	Bitstring(2)			E	D / RO	
7	I,1 OP	CLR_HISTORY 3xx.xx2 - 3xx.xx3	DS-66				D / RO	While this input is activated, the average and totalizations will be cleaned/reset.
8 (A2) (CL)	2 CF	ENABLE_REPORT 4xx.xx5	Bitstring[2]		Daily		S	Enables the report generation for hour, day or month periods.
9 (A2)	1 OP	HISTORY_CMD 4xx.xx6	Unsigned8	1=Monitor minutes 2= Monitor hours 3=Monitor days 4=Operational minutes 5=Operational hours 6=Operational days	2	E	D	Command for operational report generation of minutes, hour and days historic.
10	OP	TEMP_1 3xx.xx4 - 3xx.x43	Float[20]			T	N / RO	Temperature weighted average in minutes/hours/days 0 to 19.

Index	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Unit	Store/ Mode	Description
11	OP	PRES_ 1 3xx.x44 - 3xx.x83	Float[20]			P (abs)	N / RO	Absolute static pressure weighted average in minutes/hours/days 0 to 19.
12	OP	DP_ 1 3xx.x84 - 3xx.123	Float[20]			DP	N / RO	Differential pressure weighted average in minutes/hours/days 0 to 19.
13	1 OP	QB _1 3xx.124 - 3xx.163	Float [20]			GV	N / RO	QB totalizers of minutes / hours / days 0 to 19, when operating at normal and abnormal conditions.
14	OP	MASS _ 1 3xx.164 - 3xx.203	Float [20]			EN	N / RO	Mass totalizers of minutes / hours / days 0 to 19, when operating at normal and abnormal conditions.
15	OP	TEMP_21 3xx.204 - 3xx.243	Float[20]			T	N / RO	Temperature weighted average in minutes / hours / days 20 to 39.
16	OP	PRES_ 21 3xx.244 - 3xx.283	Float[20]			P (abs)	N / RO	Absolute static pressure weighted average in minutes / hours / days 20 to 39.
17	OP	DP_ 21 3xx.284 - 3xx.323	Float[20]			DP	N / RO	Differential pressure weighted average in minutes / hours / days 20 to 39.
18	3 OP	QB _21 3xx.324 - 3xx.363	Float [20]			GV	N / RO	QB totalizers of minutes / hours / days 20 to 39, when operating at normal and abnormal conditions.
19	OP	MASS _ 21 3xx.364 - 3xx.403	Float [20]			EN	N / RO	Mass totalizers of minutes / hours / days 20 to 39, when operating at normal and abnormal conditions.
20	OP	TEMP_41 3xx.404 - 3xx.443	Float[20]			T	N / RO	Temperature weighted average in minutes / hours / days 40 to 59.
21	OP	PRES_ 41 3xx.444 - 3xx.483	Float[20]			P (abs)	N / RO	Absolute static pressure weighted average in minutes / hours / days 40 to 59.
22	OP	DP_ 41 3xx.484 - 3xx.523	Float[20]			DP	N / RO	Differential pressure weighted average in minutes / hours / days 40 to 59.
23	OP	QB _41 3xx.524 - 3xx.563	Float [20]			GV	N / RO	QB totalizers of minutes / hours / days 40 to 59, when operating at normal and abnormal conditions.
24	OP	MASS _ 41 3xx.564 - 3xx.603	Float [20]			EN	N / RO	Mass totalizers of minutes / hours / days 40 to 59, when operating at normal and abnormal conditions.
25		UPDATE_EVT 3xx.604 – 3xx.610 4xx.xx7	DS-73			Na	D	This alert is generated by any change to the static data.

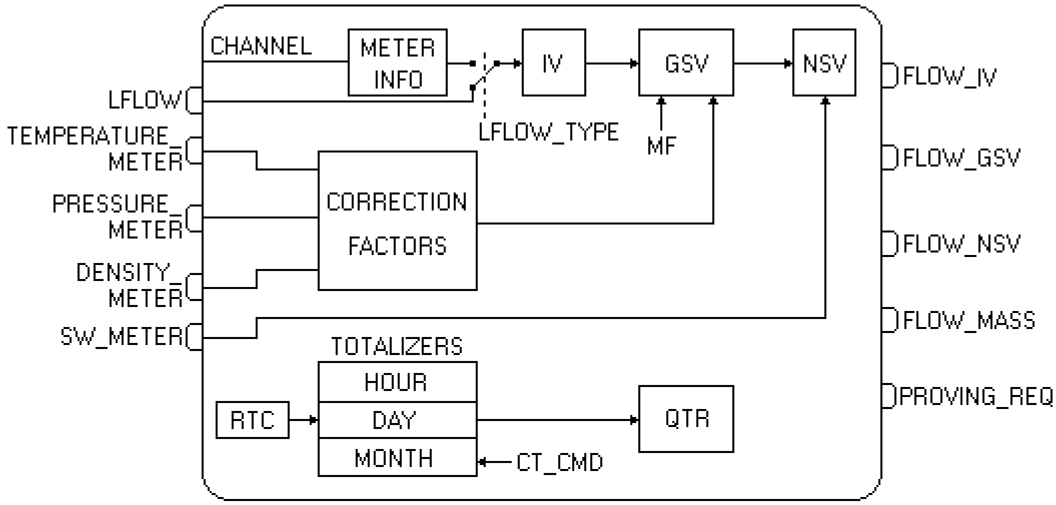
Index	Type/View	Parameter	Data type (length)	Valid range/ Options	Default Value	Unit	Store/ Mode	Description
26		BLOCK_ALM 3xx.611 – 3xx.617 4xx.xx8	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

CL= 42 BYTES (includes block tag and profile); V1-91 bytes; V2-4 bytes; V3-88 bytes; V4-5 bytes;
HFCView: OP (Operation), CF (Configuration), MN (Maintenance)

Blocks for Liquid Measurement

LT –Liquid Transaction

Schematic



Description
This block executes the correction factor calculation (CTL and CPL), totalizations, weight weighted average, status analysis and QTR report generation for the following periods: hour, day and month. Other features include the usual condition valuation, active process and unacknowledged alarm indications and checking/indication of proving needs of the operational meter.

Run number identification - STRATEGY
This parameter identifies the control loop number and is automatically configured by HFC302 during the configuration download by following the block order at Syscon.

This parameter also associates with the information from the operational meter in LKD (METERx_INFO - NKF e MF_METER_PRODUCT – meter factor) block, if the meter type is "pulse input".

Blocks input
These block inputs are used according to the configuration, as showed in the table below:

Input	Link needs	Description
TEMPERATURE_METER	Mandatory	Flowing Temperature
PRESSURE_METER	Mandatory if custody measurement and operational if allocation measurement.	Flowing gauge Pressure
DENSITY_METER	Mandatory	Density of the measured product, which can be at flowing or base conditions depending on the configuration of LKD.PRODUCTx_INFO.Density type. If an online density meter is measuring in temperature and pressure conditions (it requires instruments to read the variables) different from that found in the meter, it is recommended to use the LCF block to convert the density flowing conditions to base conditions, and also it must be connected to the DENSITY_METER input. For water measurement, the density must always be at base temperature.

Input	Link needs	Description
SW_METER	Mandatory if not ethanol. In case of ethanol, must not be connected	Percentage of water and sediments
LFLOW	Mandatory, if analog input" meter type	This input must indicate the flow rate type configured in the LFLOW_TYPE parameter. The input value has a limitation of a value lower than zero.

Block Outputs
The flow rates resulting from calculations are indicated in the outputs below (regardless of the meter type selected in LFLOW_TYPE), and thus they are available to be linked to other blocks:

- FLOW_IV – volume flow rate at flowing conditions;
- FLOW_GSV – corrected volume flow rate at base conditions, it is not calculated for allocation
- FLOW_NSV – corrected volume flow rate at base conditions, discounting the percentage of water and sediments;
- FLOW_MASS – mass flow (IM).

The REPORT_DONE output indicates only for one macrocycle, that a QTR report, regardless of the type, was generated and stored in the HFC302 memory.

The PROV_REQ output indicates the necessity of a new proving, due to the elapsed time or by measured volume since the last proving.

Selection of the meter type (LFLOW_TYPE parameter)
The LFLOW_TYPE selects the flow meter type, which has the following options:

LFLOW_TYPE	Volume / Mass	Corrected in Temperature	Pulse Input / Analog Input
IV pulse input	volume	No	pulse input
IV*CTL pulse input	volume	Yes	pulse input
IM pulse input	mass	-	pulse input
Flow IV analog input	volume	No	analog input - LFLOW
Flow IV*CTL analog input	volume	Yes	analog input - LFLOW
Flow IM analog input	mass	-	analog input - LFLOW

For IV*CTL meter type, there is the CTL=1.0000 value and the MR and IV values are calculated by dividing the pulse number by NKF (pulse input) or LFLOW*macrocycle, according to API MPMS 12.2.2 item 2.11.

CHANNEL parameter configuration – pulse input
The CHANNEL parameter addresses the pulse input via the rack number, slot, group and point.

The rules to configure CHANNEL parameter are as follows:
- The CHANNEL parameter format is RRSGP, where RR indicates the rack number, S indicates the slot number, G indicates the group number and P indicates the point number;
- Point (P): input ordinal number and numerated from 0 (first point) to 7 (last point of the group). When accessing the DF77 module, point equals to 2 means dual-pulse selection, in this case the configuration for the PIP.Gx_CONF.Dual pulse check enable must be enabled previously;
- Group (G): ordinal number of a module group and numerated from 0 (first group) to 1 (second group);
- Slot (S): ordinal number of the slot for a certainrack and numerated from 0 (first slot) to 3 (last slot);
- Rack (R): Each rack has 4 slots and the racks are numerated from 0 (first rack) to 14 (last rack). The rack physical addressing is accomplished through the rotary key from 0 to E (located between the slots 2 and 3). The last position (F) must not be used.

Example:
The CHANNEL parameter equals to 1203 means rack 1, slot 2, group 0 and point 3.
Before configuring the CHANNEL parameter, it is recommended to configure previously the HC block, since it indicates which module types are being used and their position (rack/slot). This is important when writing in the CHANNEL parameter, the LT block will check whether the addressed module is compatible, that is, if there is availability of pulse input (no other block is already using).

Selection of the product to be measured – PRODUCT_SELECTION parameter
The PRODUCT_SELECTION parameter selects which product of the LKD block is being used for calculation.

Override handling for the inputs
For temperature, pressure, density and BSW inputs there is an override processing of which value to be used when the input has bad status, which may mean the sensor has problems. For this situation there are the following options to choose the override value through the parameters: OVER_TEMP_USAGE / OVER_PRES_USAGE / OVER_DENS_USAGE / OVER_SW_USAGE:

- Override value when bad: when the input has bad status, it use the value of the override parameter (OVERRIDE_TEMPERATURE, OVERRIDE_PRESSURE, OVERRIDE_DENSITY and OVERRIDE_SW);
- Last good when bad: when the input has bad status, it uses the last good value of input;
- Hourly average when bad: when the input has bad status, it uses the hourly weighted average;
- Force override value: it uses the value of the override parameter (OVER_TEMP_USAGE / OVER_PRES_USAGE / OVER_DENS_USAGE / OVER_SW_USAGE) regardless the input status. This option is useful to verify the block calculation;
- Never use: when the input has bad status, the flow calculation is interrupted and considered null. An event is registered in this situation ("Stop totalization – override never use").

The events of the input and output transition of the override use condition are registered as "Override temperature used" and "Override temperature cleared", for example, besides the indication in the summarized status of the correspondent period.

Parameters only for visualization – reflect the configuration of other blocks
The START_HOUR, START_DAY_WEEK and START_DAY_MONTH parameters indicate the configuration on the FCT block.

QTR report generation
There are several events which cause the QTR report generation in the HFC302 memory, for later reading and save it in database by the HFCView. The situations are described below:

Event	Report Type (LTV.QTR_TYPE)	Condition
Transition of the correspondent accounting period	"Continous & period"	All the enabled periods in the ENABLE_REPORT
Configuration Download	"Reset & period"	All the enabled periods in the ENABLE_REPORT
Writing in the CT_CMD parameter requesting an operational report.	"Operational & period"	Requested period report
Writing in the CT_CMD parameter requesting an immediate report. (snapshot)	"Snapshot"	-
Batch end	"Batch"	-

Note that the report generation in the HFC302 memory, when the net volume totalizer at base condition (NSV) is null, can be disabled when configuring the REPORT_NO_FLOW = no (default condition) report.

The snapshot purpose is a calculation check to show immediate values of inputs and correction factors, gross flow rate, standard gross flow rate.

Indication for the proving necessity
The block can indicate the necessity of a new meter proving through the PROV_REQ output parameter, based on two rules:

- Volume measured at flowing conditions since the last proving: the MAX_IV_PROVING parameter specifies the maximum volume, from which there will have the indication in PROV_REQ parameter;
- Time elapsed since the last successful proving: there are two ways to specify the maximum time since the last proving, from which the PROV_REQ parameter will indicate. By writing a value between 1 and 12 in the MAX_TIME_PROVING parameter, so the indication will occur in multiple

number of months, always in the same day of the month. If the value is between 13 and 120, thus it is considered the number of days.

After a successful proving and the new meter factor is acknowledged by user (if it is configured), the PROV_REQ output automatically returns to zero.

Evaluation of the usual conditions
Usual conditions refer to the weighted average value of the temperature, pressure, density, BSW and volume flow rate at base conditions of a certain period. The usual conditions can be referred to the proving execution and also well test, because it is expected that these procedures are performed at conditions close to the usual operation.

The START_USUAL_CONDITIONS parameter configures the variables to be calculated by the HFC302, since the user can also provide these values directly in the USUAL_TEMPERATURE, USUAL_PRESSURE, USUAL_DENSITY, USUAL_SW and USUAL_FLOW parameters.

Besides the usual conditions calculation or manual input of the value for each of the variables (temperature, pressure, density, BSW and net volume flow at base conditions), The LT block always checks the deviation of instantaneous values of the variables related to the usual conditions.

The maximum acceptable deviation is configured in the USUAL_TEMP_DEV, USUAL_PRESS_DEV, USUAL_DENS_DEV, USUAL_SW_DEV and USUAL_FLOW_DEV parameters. In the parameter table, the deviation for the temperature is in Engineering Unit and the deviation for pressure, density, BSW and flow rate are in percentage.

The LIQ_WARN parameter indicates the occurrence of a higher deviation than the specified in the period of usual condition evaluation.

The OPEN_USUAL_CONDITIONS registers the date/time for the beginning of the usual condition Evaluation and occurs in the following situations:

- Writing in the parameter START_USUAL_CONDITIONS Start all;
- When requested by writing into the WT.TEST_STATE = Start usual conditions (Wr) parameter during a well test.

Nonresettable totalizer - MR
The MR totalizer does not reset when the accounting period or batch finishes. Only a new configuration download resets this totalizer.

This nonresettable totalizer increases while reaching the maximum value of 10.000.000.000 from which returns to zero. This event is registered as “Rollover Totalizer MR”.

This value is also used as upper limit for the maximum flow rate (FLOW_IV), if the flow rate is higher than this value, it will be considered null and an event will be generated in order to indicate that the totalization stopped.

Calculations performed by period (hour, day, week and month)
In the beginning of the new accounting period, the MR non-resettable totalizer value is sampled and stored in the MRO_HOUR / MRO_DAY / MRO_WEEK / MRO_MONTH parameters.

The calculations for the weighted averages of the input variables (temperature, pressure, density and BSW) use as weight factor the volume at base conditions.

The correspondent correction factors are indicated for each period:

- CTL: temperature correction factor is calculated based on average temperature, average density and product type;
- CPL: pressure correction factor is calculated based on average temperature, average density, average pressure and product type;
- MF: meter factor utilized, which is associated to the combination between the meter number/run number and product number.

For each period, the volume flow rate are calculated: volumetric without any correction (IV), volumetric at base condition (GSV), volumetric at base condition discounting water and sediments (NSV) and pure product mass without water (MASS).

If the net volume flow rate at base condition (FLOW_NSV) is less than the specified in the NO_LIQ_FLOW parameter, all the flow rates will be considered null for the totalization working as cutoff.

This summarized status provides only one indication at the moment of the considered period when an important event occurred. This does not indicate the current status (information provided by STATUS_CURRENT parameter) nor has more details, which must be obtained from the event register.

The flow time calculation is the time counting during the considered period that the flow occurred. If the QTR report is generated, it will have the report number indicated in the COUNTER_HOUR, COUNTER_DAY or COUNTER_MONTH parameter.

Totalizers of the previous period
The PREV_IV, PREV_GSV, PREV_NSV and PREV_ totalizers indicate the totalizations of the previous and current accounting period. Besides that, the flow time is indicated in PREV_FTIME. The selection and indication of the period visualized in the corresponding parameters are done through the CT_CMD parameter.

These information of the previous period consider possible resets in the totalizations in this period, thus these totalizers and flow time indicate a sum of totalizers/flow times if a reset occurred.

The information of the previous period is consistent even when a power failure occurs, therefore, when energizing, the HFC302 checks if the totalizers are pertinent to the previous or current period.

Allocation Measurement
In order to select the allocation measurement, the LKD.PRODUCTx_INFO.Product type = Emulsion crude oil and water/ Emulsion light hydrocarbon and water parameter must be configured, which shows simplified features related to equipment for oil treatment when compared to custody transfer. They are showed below:

- MF Variation: from 2% to 7%: set and reproved
- Higher than 7%: repaired and reproved
- Proving and Sample Frequency: semestral
- Well test frequency: annual
- Percentage of water between 0 and 100%

The shrinkage factor is configured in the SF parameter and it must be different from 1 only for emulsion of crude oil, at first. If the LCF block is used with the CALC_BSW parameter set to “Lab analysis” for BSW calculation, the shrinkage factor will be updated automatically in the LCF block, and vice-versa.

CTL calculation used in measurement
The crude oil density is used, which must be provided to the block through DENSITY_METER input at base condition.

NSV calculation
$NSV = IV * MF * (1 – X_{w,m}) * CTL_{o,m} * CPL_{o,m} * SF$
$SWV = IV * MF * X_{w,m} * CTL_{w,m} * CPL_{w,m}$

Where:
NSV : net volume of oil at standard condition
SWV: volume of water at standard condition
$X_{w,m}$: percent of water in the emulsion at measuring condition
$CTL_{o,m}$: temperature correction factor for oil at measuring condition
$CPL_{o,m}$: pressure correction factor for oil at measuring condition. The standard does not consider this factor; this block will behave by not linking the PRESSURE_METER input.
$CTL_{w,m}$: temperature correction factor for water at measuring condition
$CPL_{w,m}$: pressure correction factor for water at measuring condition

Process alarms: active (ACTIVE_ALARM1 and ACTIVE_ALARM2) and unacknowledged (UNACK_ALARM1 and UNACK_ALARM2).

The process alarms (high, high high, low and low low) from variables related to temperature, pressure, density, BSW, volume flow rate and mass flow rate are processed by the AALM block. In this block, there is only a summarized indication of active and unacknowledged alarms, for further details, refer to the AALM block or the event register.

15 minutes totalizer reports

If the user enables the report generation with 15 minutes totalizer (ENABLE_REPORT.Quarter report), therefore there will be generated a daily report of PTV type with the following features:

- The stored totalizer will be related to NSV if the meter is volumetric (depend on LFLOW_TYPE) or MASS in case of mass meter. This flow rate is considered as input flows.
- There are totalizers in each 15 minutes, hourly totalizers and daily totalizers on PTV report type.
- If RETURN_STREAM parameter is configured different from zero, the correspondent stream will be considered as return stream that is, deducting from input flows. In this case, there will be also generated, a 15 minutes totalizer report referring to consume, which is the difference between input flows and return stream.
- If the return stream is upper than input flows, the 15 minutes totalizer consume will be negative.
- The LT block related to return stream must be executed before input flows block on macrocycle, so that the consume calculation can be done with the related data to the same period.

Diagnosis and Troubleshooting

1. BLOCK_ERR. Block configuration: this indication may happen due to the following problems:

- If the selected meter is "pulse input" type and the CHANNEL parameter is addressed in a rack and slot with a module unable to read pulses (in the HC block), or it is addressing no module (equals to zero);
- Linearization curve inconsistence related to frequency, if this option has been selected;
- If the selected product is emulsion (allocation measurement) and the meter is IV*CTL pulse input or analog input type (LFLOW_TYPE).
- If return stream is configured in RETURN_STREAM and the variable type (volume or mass) indicated by return stream meter is different of LFLOW_TYPE in relation to variable type – volume or mass).
- The RETURN_STREAM parameter indicates another liquid measurement control loop (LT block).

2. BLOCK_ERR. Input failure: this indication may happen due to the following problems:

- If the selected meter is "pulse input" type and it is impossible to read the pulses from the module addressed by the CHANNEL parameter;
- If the selected meter is "analog input" type and the LFLOW input has bad status.

3. BLOCK_ERR. Out of Service: LT block can continue in Out of service mode, although the target mode is Auto due to the following causes:

- Configuration error of the LT block;
- Resource block in O/S.
- Error in the meter linearization configuration on the LKD block
- QTR logger is full and FCT.LOG_MODE is configured "User acknowledge".

Supported modes

O/S and AUTO.

Status

When the TEMPERATURE_METER, PRESSURE_METER, DENSITY_METER or SW_METER parameter has bad status, the correspondent override value will be used. The BATCH_STATUS parameter will indicate and register as an event.

Bit	Description	Cause	Logged event	Firmware action
0	Override temperature used (LSB)	TEMPERATURE_METER.Status bad or TEMPERATURE_METER.Value= {+INF, -INF, NAN}	"Override temperature used"	Defined by OVER_TEMP_USAGE
1	Override pressure used	PRESSURE_METER.Status bad or PRESSURE _METER.Value= {+INF, -INF, NAN}	"Override pressure used"	Defined by OVER_PRES_USAGE
2	Override density used	DENSITY_METER.Status bad or DENSITY_METER.Value= {+INF, -INF, NAN}	"Override density used"	Defined by OVER_DPRES_USAGE

3	Override SW used	SW_METER.Status bad or SW_METER.Value= {+INF, -INF, NAN}	"Override SW used"	Defined by OVER_SW_USAGE
4	Bad pulse input / flow input	- signal type of flowmeter is analog input and the corresponding status is bad - signal type of flowmeter is pulse input and it happened a problem to access the pulse input module or error in dual-pulse mode (coincident pulse, phase error, sequence error, missing pulse or extra pulse).	"Bad pulse input occ" "Bad analog input occ"	Set flow rate to zero.
5	Extrapolated CTL	Extrapolation range for CTL calculation	-	-
6	Out of range CTL	Out of range for CTL calculation	"Period Out of range correction factor occurred"	API MPMS11.1:2004-Calculate the correction factor using the limit of range.
7	Out of range CPL	Out of range for CPL calculation	"Period Out of range correction factor occurred"	-
8	Stop totalization / Block in O/S	- Input status is bad and OVER_X_USAGE=never use - LT.MODE_BLK.Actual=OS	"Stop totalization / Block in O/S"	Set flow rate to zero.
9	IV rollover	Non-resettable totalizer rolled over the maximum value.	-	-
10	Process alarm	It happened a process alarm in any variable associated to the stream	TAG_DESC or block tag of AALM.	-
11	Dual pulse not active	Dual-pulse is enabled, but one phase is inactive (without pulses).	-	-
12	Not sealed	Configuration was changed and it was sealed through FCT.SEALED_CONDITION parameter.	-	-
13	Reserved13	-	-	-
14	Inconsistent flow rate	Invalid value of flow rate (Pulses/NKF/macrocycle) or LFLOW : it is greater than ROLLOVER or equal to +INF/-INF/NAN.	"Inconsistent flow rate"	Set flow rate to zero.
15	Reserved15	-	-	-

Parameters

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2	CF	TAG_DESC 4xx.x00 – 4xx.x15	OctString(32)		Spaces	Na	S	If this parameter is configured with string different of spaces, this parameter will replace the block tag in the QTR report and proving.
3	4 OP	STRATEGY 3xx.xx0	Unsigned16	1 to 4		None	S / RO	This parameter identifies the run number.
4	4	ALERT_KEY 4xx.x16	Unsigned8	1 to 255	0	None	S	
5 (A2)(CL)	1,3 CF	MODE_BLK Target/Normal - 4xx.x17 – 4xx.x19 Actual – 3xx.xx1	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7 (A2)	I,1, VL(value) OPx	TEMPERATURE_METER 4xx.x20 - 4xx.x22	DS-65			T	N	Temperature used for correction factor calculation for liquid thermal expansion.
8 (A2)	I,1, VL(value) OPx	PRESSURE_METER 4xx.x23 - 4xx.x25	DS-65			P	N	Gauge pressure used for correction factor calculation for the liquid compressibility.
9 (A2)	I,1, VL(value) OPx	DENSITY_METER 4xx.x26 - 4xx.x28	DS-65			LD	N	Density used for calculations of CPLm and CTLm factors.
10 (A2)	I,1, VL(value) OPx	SW_METER 4xx.x29 - 4xx.x31	DS-65			%	N	Percentage of land and water mixed in the oil. Percentage calculated in water volume mixed at base conditions, in case of ethanol.
11	I,1 OPx	LFLOW 3xx.xx3 - 3xx.xx5	DS-65			QV or QM	N / RO	Mass or volume flow according to the selection in LFLOW_TYPE. This input is unconsidered if the option pulse input is selected.
12	O,1, VL(value) OPx	FLOW_IV 3xx.xx6 - 3xx.xx8	DS-65		0	QV	N / RO	Volume flow at flowing conditions.
13	O,1 OPx	FLOW_GSV 3xx.x09 - 3xx.x11	DS-65		0	QV	N / RO	Volume flow corrected by CCF. It is not calculated for allocation measurement.
14	O,1 OPx	FLOW_NSV 3xx.x12 - 3xx.x14	DS-65		0	QV	N / RO	Volume flow corrected by CCF and percentage of SW.
15	O,1 OPx	FLOW_MASS 3xx.x15 - 3xx.x17	DS-65		0	QM	N / RO	Mass flow (IM).

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
16	O,1 OPx	PROVING_REQ 3xx.x18 - 3xx.x19	DS-66				N / RO	This output indicates the calculated volume indicated since the last proving is larger than the MAX_IV_PROVING or the elapsed time is higher than the MAX_TIME_PROVING.
17 (A2)(CL)	2 CF	LFLOW_TYPE 4xx.x32	Unsigned8	0 = IV pulse input 1=IV*CTL pulse input 2=IM pulse input 3=Flow IV analog input 4=Flow IV*CTL analog input 5=Flow IM analog input	0	E	S	When the option pulse input is selected, it is necessary to configure the CHANNEL parameter to address the physical point of the pulse input. When the option analog input is selected, it is necessary to link the LFLOW input. IV: indicated volume without any correction. IV*CTL: indicated volume corrected by the temperature. IM : indicated mass.
18 (A2)(CL)	2 CF	CHANNEL 4xx.x33	Unsigned16		0	Na	S	Channel number of the logic hardware for the pulse input module.
19 (A2) (CL)	CF	PV_FTIME 4xx.x34 – 4xx.x35	Float	>= 0	0	Sec	S	Time constant of a first order filter used for flow rate calculation, however only when the flow meter provides a pulse signal.
20 (A2)(CL)	CF	PRODUCT_SELECTION 4xx.x36	Unsigned8	1-10 = Product 1-10	1	E	N	Selection of one among ten products in the LKD block. In case of a SBC block associated to this one, so the measured product type is defined by the batch block, if a batch of different products.
21 (A2)(CL)	2 CF	OVER_TEMP_USAGE 4xx.x37	Unsigned8	0=override value when bad 1=last good when bad 2= hourly average when bad 3=force override value 4=never use	0	E	S	Specify when and which value uses as override value for temperature.
22 (A2)(CL)	2 CF	OVERRIDE_TEMPERATURE 4xx.x38 - 4xx.x39	Float		SI=15 USA=60	T	S	Override value for the temperature input, when in bad status.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
23 (A2)(CL)	2 CF	OVER_PRES_USAGE 4xx.x40	Unsigned8	0=override value when bad 1=last good when bad 2= hourly average when bad 3=force override value 4=never use	0	E	S	Specify when and which value uses as override value for pressure.
24 (A2)(CL)	2 CF	OVERRIDE_PRESSURE 4xx.x41 - 4xx.x42	Float	> 0.0	SI=101.325 USA=14.696	P	S	Override value for the pressure input, when in bad status.
25 (A2)(CL)	2 CF	OVER_DENS_USAGE 4xx.x43	Unsigned8	0=override value when bad 1=last good when bad 2= hourly average when bad 3=force override value 4=never use	0	E	S	Specify when and which value uses as override value for density.
26 (A2)(CL)	2 CF	OVERRIDE_DENSITY 4xx.x44 - 4xx.x45	Float	> 0.0	SI=900.0 USA=25.6	LD	S	Override value for density input, when in bad status.
27 (A2)(CL)	2 CF	OVER_SW_USAGE 4xx.x46	Unsigned8	0=override value when bad 1=last good when bad 2= hourly average when bad 3=force override value 4=never use	0	E	S	Specify when and which value uses as override value for BSW.
28 (A2)(CL)	2 CF	OVERRIDE_SW 4xx.x47 - 4xx.x48	Float	0.0 to 100.0	0.0	%	S	Override value for SW input, when in bad status.
29 (A2)(CL)	2 CF	SF 4xx.x49 - 4xx.x50	Float	1=disabled 0< SF <= 1	1	Na	S	Shrinkage factor obtained in laboratory analysis.
30 (A2)(CL)	2 CF	NO_LIQ_FLOW 4xx.x51 - 4xx.x52	Float	>= 0.0 0.0=disabled	0.0	QV	S	Lower limit for net volume flow at base condition. If this value is less than this limit, it is considered null.
31 (A2)(CL)	2 CF	ENABLE_REPORT 4xx.x53	Bitstring[2]		Daily		S	Enable report generation for the periods: hour, day or month.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
32 (A2)(CL)	2 CF	REPORT_NO_FLOW 4xx.x54	Unsigned8	0=No 1=Yes	0	E	S	If the NSV totalizer is zero and is configured as “No”, the QTR report will not be generated.
33 (A2)(CL)	2 CF	MAX_IV_PROVING 4xx.x55 – 4xx.x56	Float	0 to 1E10 0 = disabled	0	TV	S	IV maximum totalization since the last proving, from which will be indicated in PROV_REQ.
34 (A2)(CL)	2 CF	MAX_TIME_PROVING 4xx.x57	Unsigned16	0 = disabled 1 to 12 = number of months 13 to 120 = number of days	0	Months/Days	S	Maximum time elapsed since the last successful proving, from which will be indicated in PROV_REQ parameter.
35 (A2)	1 OPx	CT_CMD 4xx.x58	Unsigned8	0=None 2=Operational batch 3=Operational hour report 4=Operational day report 5=Operational month report 6=Snapshot 7=Previous batch 8=Previous hour 9=Previous day 10=Previous month	Previous day	E	N	This parameter allows to request operational and snapshot report. By writing “Operational Report” into this parameter, the correspondent report type will be generated. Through this parameter is also possible to select the type of previous period to be visualized. After executing a request action, the value will return automatically to the state that shows the previous period report type visualized.
36	1 OPx	MR 3xx.x20 - 3xx.x23	Double		0	TV	N / RO	Meter reading. Indicated volume counter (without any correction).
37		FMR 3xx.x24 - 3xx.x25	Float		0	TV	N / RO	Meter reading. Indicated volume counter (without any correction).
38	1, VL MN	CURRENT_STATUS 3xx.x26	Bitstring[2]	See Block Options	0	Na	N/ RO	Current Status. Similar to BATCH_STATUS.
39	1 MN	CTL_W 3xx.x27 - 3xx.x28	Float	0=Custody transfer > 0.0 : Allocation measurement	0		N / RO	Correction factor of the pressure effect in volume of water, calculated based on water base density, that must be configured in PRODUCTxINFO and flowing temperature.
40	1 MN	CPL_W 3xx.x29 - 3xx.x30	Float	0=Custody transfer > 0.0 : Allocation measurement	0		N / RO	Correction factor of the pressure effect in volume of water that is calculated using the flowing pressure.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
41	1 OP1	MRO_BATCH 3xx.x31 - 3xx.x34	Double		0	TV	N / RO	Totalizer starting value nonresettable of the current batch.
42		FMRO_BATCH 3xx.x35 - 3xx.x36	Float		0	TV	N / RO	Totalizer starting value nonresettable of the current batch.
43	1 OP1	TWA_ BATCH 3xx.x37 - 3xx.x38	Float			T	N / RO	Temperature weighted average of the current batch.
44	1 OP1	PWA_ BATCH 3xx.x39 - 3xx.x40	Float			P	N / RO	Pressure weighted average of the current batch.
45	1 OP1	DWA_ BATCH 3xx.x41 - 3xx.x42	Float			LD	N / RO	Flowing density weighted average of the current batch.
46	1 OP1	SWWA_ BATCH 3xx.x43 - 3xx.x44	Float			%	N / RO	SW weighted average of the current batch.
47	1 OP1	MF_ BATCH 3xx.x45 - 3xx.x46	Float		1.0		N / RO	This parameter is the MF used according to the product and selected meter from the LKD block.
48	1 OP1	CTL_ BATCH 3xx.x47 - 3xx.x48	Float		1.0		N / RO	Temperature correction factor based on weighted average of the input parameters.
49	1 OP1	CPL_ BATCH 3xx.x49 - 3xx.x50	Float		1.0		N / RO	Pressure correction factor based on weighted average of the input parameters.
50	OP1	IV_ BATCH 3xx.x51 - 3xx.x54	Double			TV	N/ RO	Indicated volume of the current batch.
51		FIV_ BATCH 3xx.x55 - 3xx.x56	Float			TV	N/ RO	Indicated volume of the current batch.
52	3 OP1	GSV_ BATCH 3xx.x57 - 3xx.x60	Double			TV	N/ RO	Corrected gross volume of the current batch. Not calculated in allocation measurement.
53		FGSV_ BATCH 3xx.x61 - 3xx.x62	Float			TV	N/ RO	Corrected gross volume of the current batch. Not calculated in allocation measurement.
54	3 OP1	NSV_ BATCH 3xx.x63 - 3xx.x66	Double			TV	N/ RO	Corrected net volume of the current batch.
55		FNSV_ BATCH 3xx.x67 - 3xx.x68	Float			TV	N/ RO	Corrected net volume of the current batch.
56	OP1	MASS_BATCH 3xx.x69 - 3xx.x72	Double			TM	N/ RO	Current batch totalized pure product measured mass (MMpp).
57		FMASS_BATCH 3xx.x73 - 3xx.x74	Float			TM	N/ RO	Current batch totalized pure product measured mass (MMpp).

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
58	OP1	FTIME_ BATCH 3xx.x75 - 3xx.x77	Time difference				N / RO	Current batch flowing time.
59	OP1	STATUS_ BATCH 3xx.x78	Bitstring[2]	See Block Options	0	Na	N/ RO	Current batch status. Similar to BATCH_STATUS.
60	OP1	COUNTER_ BATCH 3xx.x79 - 3xx.x80	Unsigned32		1	Na	N / RO	Batch report counter.
61	OP2	MRO_HOUR 3xx.x81 - 3xx.x84	Double		0	TV	N / RO	Current time starting value of the nonresettable totalizer.
62		FMRO_HOUR 3xx.x85 - 3xx.x86	Float		0	TV	N / RO	Current time starting value of the nonresettable totalizer.
63	OP2	TWA_HOUR 3xx.x87 - 3xx.x88	Float			T	N / RO	Temperature weighted average of the current time.
64	OP2	PWA_HOUR 3xx.x89 - 3xx.x90	Float			P	N / RO	Pressure weighted average of the current time.
65	OP2	DWA_HOUR 3xx.x91 - 3xx.x92	Float			LD	N / RO	Flowing density weighted average of the current time.
66	OP2	SWWA_HOUR 3xx.x93 - 3xx.x94	Float			%	N / RO	SW weighted average of the current time.
67	OP2	MF_HOUR 3xx.x95 - 3xx.x96	Float		1.0		N / RO	This parameter is the MF used according to the product and selected meter from the LKD block.
68	OP2	CTL_HOUR 3xx.x97 - 3xx.x98	Float		1.0		N / RO	Temperature correction factor based on the weighted average of the input parameters.
69	OP2	CPL_HOUR 3xx.099 - 3xx.100	Float		1.0		N / RO	Pressure correction factor based on the weighted average of the input parameters.
70	OP2	IV_HOUR 3xx.101 - 3xx.104	Double			TV	N/ RO	Current time indicated volume.
71		FIV_HOUR 3xx.105 - 3xx.106	Float			TV	N/ RO	Current time indicated volume.
72	3 OP2	GSV_HOUR 3xx.107 - 3xx.110	Double			TV	N/ RO	Corrected gross volume for the current hour. Not calculated in allocation measurement.
73		FGSV_HOUR 3xx.111 - 3xx.112	Float			TV	N/ RO	Corrected gross volume for the current hour. Not calculated in allocation measurement.
74	3 OP2	NSV_HOUR 3xx.113 - 3xx.116	Double			TV	N/ RO	Corrected net volume for the current hour.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
75	VL	FNSV_HOUR 3xx.117 - 3xx.118	Float			TV	N/ RO	Corrected net volume for the current hour.
76	OP2	MASS_HOUR 3xx.119 - 3xx.122	Double			TM	N/ RO	Pure product measured mass (MMpp) totalization for the current hour.
77		FMASS_HOUR 3xx.123 - 3xx.124	Float			TM	N/ RO	Pure product measured mass (MMpp) totalization for the current hour.
78	OP2	FTIME_HOUR 3xx.125 - 3xx.127	Time difference				N / RO	Current hour flowing time.
79	OP2	STATUS_HOUR 3xx.128	Bitstring[2]	See Block Options	0	Na	N/ RO	Current time status. Similar to BATCH_STATUS.
80	OP2	COUNTER_HOUR 3xx.129 - 3xx.130	Unsigned32		1	Na	N / RO	Time report counter.
81	OP3	MRO_DAY 3xx.131 - 3xx.134	Double		0	TV	N / RO	Starting value for the current day of the nonresettable totalizer.
82		FMRO_DAY 3xx.135 - 3xx.136	Float		0	TV	N / RO	Starting value for the current day of the nonresettable totalizer.
83	OP3	TWA_DAY 3xx.137 - 3xx.138	Float			T	N / RO	Temperature weighted average of the current day.
84	3 OP3	PWA_DAY 3xx.139 - 3xx.140	Float			P	N / RO	Pressure weighted average of the current day.
85	3 OP3	DWA_DAY 3xx.141 - 3xx.142	Float			LD	N / RO	Flowing density weighted average of the current day.
86	3 OP3	SWWA_DAY 3xx.143 - 3xx.144	Float			%	N / RO	SW weighted average of the current day.
87	3 OP3	MF_DAY 3xx.145 - 3xx.146	Float		1.0		N / RO	This parameter is the MF used according to the product and selected meter from the LKD block.
88	3 OP3	CTL_DAY 3xx.147 - 3xx.148	Float		1.0		N / RO	Temperature correction factor based on the weighted average of the input parameters.
89	3 OP3	CPL_DAY 3xx.149 - 3xx.150	Float		1.0		N / RO	Pressure correction factor based on the weighted average of the input parameters.
90	3 OP3	IV_DAY 3xx.151 - 3xx.154	Double			TV	N/ RO	Current day indicated volume.
91		FIV_DAY 3xx.155 - 3xx.156	Float			TV	N/ RO	Current day indicated volume.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
92	3 OP3	GSV_DAY 3xx.157 - 3xx.160	Double			TV	N/ RO	Corrected gross volume for the current day. Not calculated in allocation measurement.
93		FGSV_DAY 3xx.161 - 3xx.162	Float			TV	N/ RO	Corrected gross volume for the current day. Not calculated in allocation measurement.
94	3 OP3	NSV_DAY 3xx.163 - 3xx.166	Double			TV	N/ RO	Corrected net volume of the current day.
95	VL	FNSV_DAY 3xx.167 - 3xx.168	Float			TV	N/ RO	Corrected net volume of the current day.
96	OP3	MASS_DAY 3xx.169 - 3xx.172	Double			TM	N/ RO	Current day totalized pure product measured mass (MMpp).
97		FMASS_DAY 3xx.173 - 3xx.174	Float			TM	N/ RO	Current day totalized pure product measured mass (MMpp).
98	OP3	FTIME_DAY 3xx.175 - 3xx.177	Time difference				N / RO	Current day flowing time.
99	OP3	STATUS_DAY 3xx.178	Bitstring[2]	See Block Options	0	Na	N/ RO	Current day status. Similar to BATCH_STATUS.
100	OP3	COUNTER_DAY 3xx.179 - 3xx.180	Unsigned32		1	Na	N / RO	Daily report counter.
101	OP4	MRO_MONTH 3xx.181 - 3xx.184	Double		0	TV	N / RO	Current month starting value of the nonresettable totalizer.
102		FMRO_MONTH 3xx.185 - 3xx.186	Float		0	TV	N / RO	Current month starting value of the nonresettable totalizer.
103	OP4	TWA_MONTH 3xx.187 - 3xx.188	Float			T	N / RO	Temperature weighted average of the current month.
104	OP4	PWA_MONTH 3xx.189 - 3xx.190	Float			P	N / RO	Pressure weighted average of the current month.
105	OP4	DWA_MONTH 3xx.191 - 3xx.192	Float			LD	N / RO	Flowing density weighted average of the current month.
106	OP4	SWWA_MONTH 3xx.193 - 3xx.194	Float			%	N / RO	SW weighted average of the current month.
107	OP4	MF_MONTH 3xx.195 - 3xx.196	Float		1.0		N / RO	This parameter is the MF used according to the product and selected meter from the LKD block.
108	OP4	CTL_MONTH 3xx.197 - 3xx.198	Float		1.0		N / RO	Temperature correction factor based on the weighted average of the input parameters.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
109	OP4	CPL_MONTH 3xx.199 - 3xx.200	Float		1.0		N / RO	Pressure correction factor based on the weighted average of the input parameters.
110	OP4	IV_MONTH 3xx.201 - 3xx.204	Double			TV	N/ RO	Current month indicated volume.
111		FIV_MONTH 3xx.205 - 3xx.206	Float			TV	N/ RO	Current month indicated volume.
112	3 OP4	GSV_MONTH 3xx.207 - 3xx.210	Double			TV	N/ RO	Corrected gross volume for the current month. Not calculated in allocation measurement.
113		FGSV_MONTH 3xx.211 - 3xx.212	Float			TV	N/ RO	Corrected gross volume for the current month. Not calculated in allocation measurement.
114	3 OP4	NSV_MONTH 3xx.213 - 3xx.216	Double			TV	N/ RO	Corrected net volume of the current month.
115		FNSV_MONTH 3xx.217 - 3xx.218	Float			TV	N/ RO	Corrected net volume of the current month
116	OP4	MASS_MONTH 3xx.219 - 3xx.222	Double			TM	N/ RO	Current month totalized pure product measured mass (MMpp).
117		FMASS_MONTH 3xx.223 - 3xx.224	Float			TM	N/ RO	Current month totalized pure product measured mass (MMpp).
118	OP4	FTIME_MONTH 3xx.225 - 3xx.227	Time difference				N / RO	Current month flowing time.
119	OP4	STATUS_MONTH 3xx.228	Bitstring[2]	See Block Options	0	Na	N/ RO	Current month status. Similar to BATCH_STATUS
120	OP4	COUNTER_MONTH 3xx.229 - 3xx.230	Unsigned32		1	Na	N / RO	Monthly report counter.
121	OPx	ACTIVE_ALARM1 3xx.231	Bitstring[2]				N / RO	Indicate active alarms related to the flow.
122	OPx	ACTIVE_ALARM2 3xx.232	Bitstring[2]				N / RO	Indicate active alarms related to the flow.
123	OPx	UNACK_ALARM1 4xx.x59	Bitstring[2]				N	Indicate the alarms related to this flow unacknowledged by the operator.
124	OPx	UNACK_ALARM2 4xx.x60	Bitstring[2]				N	Indicate the alarms related to this flow unacknowledged by the operator.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
125	OP1	PREV_BATCH _ID 3xx.233 - 3xx.236	Visiblestring[8]				N / RO	Previous batch description.
126	OPx	PREV_IV 3xx.237 - 3xx.240	Double			TV	N / RO	Previous period indicated volume.
127		FPREV_IV 3xx.241 - 3xx.242	Float			TV	N / RO	Previous period indicated volume.
128	3 OPx	PREV_GSV 3xx.243 - 3xx.246	Double			TV	N / RO	Corrected gross volume for the previous period. Not calculated in allocation measurement.
129		FPREV_GSV 3xx.247 - 3xx.248	Float			TV	N / RO	Corrected gross volume for the previous period. Not calculated in allocation measurement.
130	3 OPx	PREV_NSV 3xx.249 - 3xx.252	Double			TV	N / RO	Corrected net volume of the previous period.
131	VL	FPREV_NSV 3xx.253 - 3xx.254	Float			TV	N / RO	Corrected net volume of the previous period.
132	OPx	PREV_MASS 3xx.255 - 3xx.258	Double			TM	N/ RO	Previous period totalized pure product measured mass (MMpp).
133		FPREV_MASS 3xx.259 - 3xx.260	Float			TM	N/ RO	Previous period totalized pure product measured mass (MMpp).
134	VL OPx	PREV_FTIME 3xx.261 - 3xx.263	Time difference				N / RO	Previous period flowing time.
135	2 CF	USUAL_TEMP _DEV 4xx.x61 - 4xx.x62	Float	0.0=disable d 0.0 to 100.0	0	T	S	Maximum deviation allowed for temperature during the usual conditions evaluation and well test execution.
136	2 CF	USUAL_PRES S_DEV 4xx.x63 - 4xx.x64	Float	0.0=disable d 0.0 to 100	0	%	S	Maximum deviation allowed for pressure during the usual conditions evaluation and well test execution.
137	2 CF	USUAL_DENS _DEV 4xx.x65 - 4xx.x66	Float	0.0=disable d 0.0 to 100	0	%	S	Maximum deviation allowed for density during the usual conditions evaluation and well test execution.
138	2 CF	USUAL_SW_D EV 4xx.x67 - 4xx.x68	Float	0.0=disable d 0.0 to 100	0	%	S	Maximum deviation allowed for temperature during the usual conditions evaluation and well test execution.
139	2 CF	USUAL_FLOW _DEV 4xx.x69 - 4xx.x70	Float	0.0=disable d 0.0 to 100	0	%	S	Maximum deviation allowed for net volume flow at base condition during the usual conditions evaluation and well test execution.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
140	2 MN	START_USUAL_CONDITIONS 4xx.x71	Bitstring[2]	See the specific description	0	E	S	A new evaluation of the usual conditions for the enabled variables is initialized when a proving is successfully done or requested during the well test or writing into this parameter.
141	MN	OPEN_USUAL_CONDITIONS 3xx.264 – 3xx.269	Date				N / RO	Date/time of beginning of the usual condition evaluation.
142	MN	LIQ_WARN 3xx.270	Bitstring[2]	See the specific description	0	E	N / RO	Warning events occurred.
143 (A2)	MN	USUAL_TEMPERATURE 4xx.x72 - 4xx.x73	Float		0	T	N	If HFC302 is not configured to calculate the usual temperature in the START_USUAL_CONDITIONS parameter, the writing is allowed in this parameter.
144 (A2)	MN	USUAL_PRESSURE 4xx.x74 - 4xx.x75	Float	>= 0.0	0	P	N	If HFC302 is not configured to calculate the usual pressure in the START_USUAL_CONDITIONS parameter, the writing is allowed in this parameter.
145 (A2)	MN	USUAL_DENSITY 4xx.x76 - 4xx.x77	Float		0	LD	N	If HFC302 is not configured to calculate the usual density in the START_USUAL_CONDITIONS parameter, the writing is allowed in this parameter.
146 (A2)	MN	USUAL_SW 4xx.x78 - 4xx.x79	Float	0.0 to 100	0	%	N	If HFC302 is not configured to calculate the usual BSW in the START_USUAL_CONDITIONS parameter, the writing is allowed in this parameter.
147 (A2)	MN	USUAL_FLOW 4xx.x80 - 4xx.x81	Float	>= 0.0	0	QV	N	If HFC302 is not configured to calculate the usual net volume flow at base condition in the START_USUAL_CONDITIONS parameter, the writing is allowed in this parameter.
148	OPx	P_FLOWING 3xx.271 – 3xx.272	Float	0.0 to 100.0	0	%	D / RO	Ethanol percentage in mass over the mixture.
149	OPx	RHO_B 3xx.273 - 3xx.274	Float			LD	N / RO	Current base density calculated by using density inputs, flowing temperature and flowing pressure.
150	OPx	CTL 3xx.275 - 3xx.276	Float				N / RO	Temperature correction factor for input instantaneous values.
151	OPx	CPL 3xx.277 - 3xx.278	Float				N / RO	Pressure correction factor for input instantaneous values.
152		UPDATE_EVT 3xx.279 – 3xx.285 4xx.x82	DS-73			Na	D	This event is generated by any change in static data.

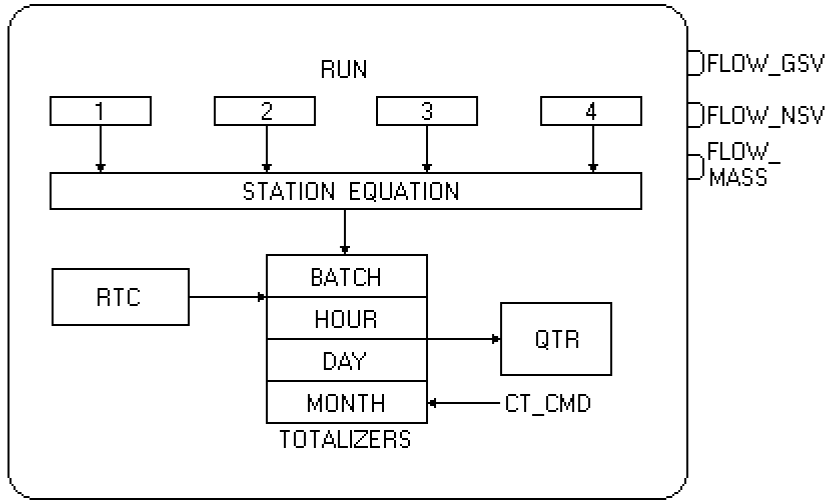
Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
153		BLOCK_ALM 3xx.286 – 3xx.292 4xx.x83	DS-72			Na	D	The block alarm is used for all configuration, hardware, and connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
154	OPx	MMR 3xx.293 - 3xx.296	Double		0	TM	N / RO	Nonresettable indicated mass (IM) totalizer.
155		FMMR 3xx.297 - 3xx.298	Float		0	TM	N / RO	Nonresettable indicated mass (IM) totalizer.
156	OP1	MMRO_BATCH 3xx.299 - 3xx.302	Double		0	TM	N / RO	Current batch starting value of nonresettable indicated mass (IM) totalizer.
157		FMMRO_ BATCH 3xx.303 - 3xx.304	Float		0	TM	N / RO	Current batch starting value of nonresettable indicated mass (IM) totalizer.
158	OP2	MMRO_HOUR 3xx.305 - 3xx.308	Double		0	TM	N / RO	Current time starting value of nonresettable indicated mass (IM) totalizer.
159		FMMRO_HOU R 3xx.309 - 3xx.310	Float		0	TM	N / RO	Current time starting value of nonresettable indicated mass (IM) totalizer.
160	OP3	MMRO_DAY 3xx.311 - 3xx.314	Double		0	TM	N / RO	Current day starting value of nonresettable indicated mass (IM) totalizer.
161		FMMRO_DAY 3xx.315 - 3xx.316	Float		0	TM	N / RO	Current day starting value of nonresettable indicated mass (IM) totalizer.
162	OP4	MMRO_MONT H 3xx.317 - 3xx.320	Double		0	TM	N / RO	Current month starting value of nonresettable indicated mass (IM) totalizer.
163		FMMRO_MON TH 3xx.321 - 3xx.322	Float		0	TM	N / RO	Current month starting value of nonresettable indicated mass (IM) totalizer.
164	CF	RETURN_STR EAM 4xx.x84	Unsigned 16	0 to 4	0	Na	S	Return stream measurement number, which will be deducted from input flow to compose the “Quarter” report.
165	OP1	DWA_B_ BATCH 3xx.323 - 3xx.324	Float			LD	N / RO	Base density weighted average of the current batch.

Idx	Type/View	Parameter	Data type (length)	Valid Range	Default Value	Unit	Store/ Mode	Description
166	OP2	DWA_B_HOUR 3xx.325 - 3xx.326	Float			LD	N / RO	Base density weighted average of the current hour.
167	OP3	DWA_B_DAY 3xx.327 - 3xx.328	Float			LD	N / RO	Base density weighted average of the current day.
168	OP4	DWA_B_MONTH 3xx.329 - 3xx.330	Float			LD	N / RO	Base density weighted average of the current month.
169	OP1	CTPL_ BATCH 3xx.331 - 3xx.332	Float		1.0		N / RO	Temperature and pressure correction factor of the current batch based on the weighted average of the input parameters.
170	OP2	CTPL_ HOUR 3xx.333 - 3xx.334	Float		1.0		N / RO	Temperature and pressure correction factor of the current hour based on the weighted average of the input parameters.
171	OP3	CTPL_ DAY 3xx.335 - 3xx.336	Float		1.0		N / RO	Temperature and pressure correction factor of the current day based on the weighted average of the input parameters.
172	OP4	CTPL_ MONTH 3xx.337 - 3xx.338	Float		1.0		N / RO	Temperature and pressure correction factor of the current month based on the weighted average of the input parameters.
173	OPx	RHO 3xx.339 - 3xx.340	Float			LD	N / RO	Current flowing density calculated by using density input, flowing temperature and flowing pressure.
174	OPx	CTPL 3xx.341 - 3xx.342	Float		1.0		N / RO	Temperature and pressure correction factor for input instantaneous values.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – non-volatile;
S – Static; I – Input Parameter; O-Output Parameter
AA-Administrator Level; A1 –Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction level 1; R – Restriction level 2
CL = 86 bytes (includes block tag and profile)
V1-110 bytes; V2-61 bytes; V3-120 bytes; V4-5 bytes; VL- 40 bytes.
HFCView: OPx (OP1, OP2, OP3, OP4), OP1 (Operation - Batch), OP2 (Operation - Hour), OP3 (Operation - Day), OP4 (Operação - Month), CF (Configuration), MN (Maintenance)

LST – Liquid Station Transaction

Schematic



Description

This block is used in liquid measurements referred to the station. According to the user configuration, the corrected flows of the meters are combined (summed and/or subtracted) and a QTR report can be generated and visualized through the LTV block.

The main purpose of this block is adding/subtracting the corrected flows, so this block does not refer to secondary variables (density, temperature and pressure), intermediate variables for calculation, correction factors or utilized sensors. These streams may have been measured using different types of sensors.

Other features include batch programming and indication of active and unacknowledged process alarms related to the station.

Block Output

These block outputs are resultanting stream of calculation and therefore are available to be connected to other blocks:

- FLOW_GSV – corrected gross volume flow rate at base conditions, not calculated for allocation measurement;
- FLOW_NSV – corrected net volume flow rate at base conditions;
- FLOW_MASS – mass flow rate.

Configuration for the Station Equation – STATION_EQUATION parameter

The STATION_EQUATION parameter defines the operations to be accomplished between the measured streams, following the rules below:

- Allowed operations: sum (+) and subtract (-);
- Interspersed sequence of run number with an arithmetic operator without spaces.
- If the first character is blank, no operation will be accomplished;
- The STATION_EQUATION parameter writing will be checked related to consistency of valid run number and operation.
- During the block execution, the equation consistence will be checked and any problem will be indicated in the BLOCK_ERR.Block Configuration Error;
- Run number for the liquid measurement and all runs measuring the same product type or the combination of crude oil/light hydrocarbon and its correspondent emulsion:
- Configuration example:
    - 1+2+3-4
    - 2-1
    - 1+1-2

QTR report generation

There are several events that cause the QTR report generation in the HFC302 memory for later reading and save it in database by the HFCView.
The situations are showed below:

Event	Report Type (LTV.QTR_TYPE)	Condition
Transition of the corresponding account period	"Continuous & period"	All the enabled periods in the ENABLE_REPORT
Configuration download	"Reset & period"	All the enabled periods in the ENABLE_REPORT and batch
Writing into CT_CMD parameter requesting operational report.	"Operational & period"	Request period report.
-	"Snapshot"	Not supported
Batch end	"Batch"	-

When the net volume totalizer at base conditions is null, the report generation in the HFC302 memory will be disabled when configuring REPORT_NO_FLOW = no (default condition) parameter.

The product name and the viscosity indicated in the QTR report are related to that product measured in the first flow of the equation in the STATION_EQUATION parameter. If the operation involves emulsion (allocation) measurement, then the GSV totalizers will show zero.

Calculations executed for each period (time, day and month)
The flow totalizers are calculated for each period: gross volume at base conditions (FLOW_GSV), net volume at base conditions (FLOW_NSV) and mass (FLOW_MASS) for each period.

The following events are indicated in the summarized status of the period:

- Override temperature used;
- Override pressure used;
- Override density used;
- Override SW used;
- Bad status of pulse input;
- Block in O/S;
- Extrapolated correction factor;
- Out of range correction factor;
- Process alarm;
- Bad status of flow input;
- Stop totalization.

This summarized status provides only indication that an important event occurred at one moment in any of the measured streams participating in the station equation. And it does not indicate more details, which must be obtained from the event register.

The flow time calculation is the time counting during the considered period if the flow occurred. If a QTR report is generated at end, it will have the report number indicated in the COUNTER_BATCH, COUNTER_HOUR, COUNTER_DAY or COUNTER_MONTH parameter.

Totalizers of the previous period
The PREV_GSV, PREV_NSV and PREV_MASS totalizers indicate the previous to the current accounting period totalizers. Besides that, the flow time is indicated in PREV_FTIME.

These information about the previous period consider possible resets in the totalizations during such period, thus these totalizers and flow time indicate a sum of totalizers/flow time if a reset occurred.

The information about the previous period is consistent, even when a power failure occurs, thus when the HFC302 is powered up, it checks if the totalizers are pertinent from the previous to current accounting period.

Process alarms: active (ACTIVE_ALARM1 and ACTIVE_ALARM2) and unacknowledged (UNACK_ALARM1 and UNACK_ALARM2).
The process alarms (high, high high, low and low low) of the variables as volume flow rate, mass flow rate, temperature, pressure, density and SW (if shared by measurements) related to the streams participating of the station equation are processed by the AALM block. The LST block has only a summarized indication of active and unacknowledged alarms. For further details, refer to the AALM block or the event register.

Diagnosis and Troubleshooting

1. BLOCK_ERR. Block configuration: this indication occurs when there is any problem in the station equation, for example, any stream participating of the equation is not measuring liquid or it is not the same product. Note it is allowed the operation between crude oil/light hydrocarbon and its correspondent emulsion;

2. BLOCK_ERR. Out of Service: the LST block can continue in the Out of service mode, although the target mode is Auto because the Resource block is in O/S.

Supported Modes

O/S and AUTO.

Parameters

Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store / Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2	CF	TAG_DESC 4xx.x00 – 4xx.x15	OctString(32)		Spaces	Na	S	If this parameter is configured with string different of spaces, this parameter will substitute the block tag in the QTR report.
3	4	STRATEGY 3xx.xx0	Unsigned16	254	254	None	S / RO	
4	4	ALERT_KEY 4xx.x16	Unsigned8	1 to 255	0	None	S	
5 (A2)(CL)	1,3 CF	MODE_BLK Target/Normal - 4xx.x17 – 4xx.x19 Actual - 3xx.xx1	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF,MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7	O,1 OPx	FLOW_GSV 3xx.xx3 – 3xx.xx5	DS-65		0	QV	N / RO	Volume flow corrected by the CCF. It is not calculated in allocation measurement.
8	O,1 OPx	FLOW_NSV 3xx.xx6 – 3xx.xx8	DS-65		0	QV	N / RO	Volume flow corrected by the CCF and discounted the SW percentage.
9	O,1 OPx	FLOW_MASS 3xx.xx9 – 3xx.x11	DS-65		0	QM	N / RO	Mass flow (IM).
10 (A2)(CL)	2 CF	STATION_EQUATION 4xx.x20 – 4xx.x27	Visiblestring[16]		Blank		S	Station equation for liquid. First element blank means no processing.
11 (A2)(CL)	2 CF	ENABLE_REPORT 4xx.x28	Bitstring[2]		Daily		S	This parameter enables the report generation for the periods: time, day or month.
12(A2) (CL)	2 CF	REPORT_NO_FLOW 4xx.x29	Unsigned8	0=No 1=Yes	0	E	S	If the NSV totalizer is zero and is configure as “No”, it will not generate the QTR report.

Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store / Mode	Description
13 (A2)	1 OPx	CT_CMD 4xx.x30	Unsigned8	0=None 2=Operational batch 3=Operational hour report 4=Operational day report 5=Operational month report 6=Snapshot 7=Previous batch 8=Previous hour 9=Previous day 10=Previous month	Previous day	E	N	This parameter allows to request operational and snapshot report. By this parameter is also possible select the previous period type to be visualized. After executing a request action, the value will return automatically to the state that shows the type of previous period visualized.
14	1 OPx	PREV_GSV 3xx.x12 – 3xx.x15	Double			TV	N/ RO	Corrected gross volume of previous period. Not calculated in allocation measurement.
15		FPREV_GSV 3xx.x16 – 3xx.x17	Float			TV	N/ RO	Corrected gross volume of previous period. Not calculated in allocation measurement.
16	1 OPx	PREV_NSV 3xx.x18 – 3xx.x21	Double			TV	N/ RO	Corrected net volume of previous period.
17		FPREV_NSV 3xx.x22 – 3xx.x23	Float			TV	N/ RO	Corrected net volume of previous period.
18	3 OPx	PREV_MASS 3xx.x24 – 3xx.x27	Double			TM	N/ RO	Previous period pure product measured mass (MMpp).
19		FPREV_MASS 3xx.x28 – 3xx.x29	Float			TM	N/ RO	Previous period totalized pure product measured mass (MMpp).
20	1 OPx	PREV_FTIME 3xx.x30 – 3xx.x32	Time difference				N / RO	Flow rate time of the previous period.
21	1 MN	CURRENT_STATUS 3xx.x33	Bitstring[2]	See Block Options	0	Na	N/ RO	Current status Similar to BATCH_STATUS.
22	1 OP1	GSV_BATCH 3xx.x34 – 3xx.x37	Double			TV	N/ RO	Gross volume totalizer at base conditions of current batch. Not calculated in allocation measurement.
23		FGSV_BATCH 3xx.x38 - 3xx.x39	Float			TV	N/ RO	Gross volume totalizer at base conditions of current batch. Not calculated in allocation measurement.
24	1 OP1	NSV_BATCH 3xx.x40 – 3xx.x43	Double			TV	N/ RO	Net volume totalizer at base conditions of current batch.
25		FNSV_BATCH 3xx.x44 - 3xx.x45	Float			TV	N/ RO	Net volume totalizer at base conditions of current batch.

Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store / Mode	Description
26	3 OP1	MASS_BATCH 3xx.x46 – 3xx.x49	Double			TM	N/ RO	Current batch totalized pure product measured mass (MMpp).
27		FMASS_BATCH 3xx.x50 - 3xx.x51	Float			TM	N/ RO	Current batch totalized pure product measured mass (MMpp).
28	3 OP1	FTIME_BATCH 3xx.x52 - 3xx.x54	Time difference				N / RO	Current batch flow time
29	3 OP1	STATUS_BATCH 3xx.x55	Bitstring[2]	See Block Options	0	Na	N/ RO	Current batch status. Similar to BATCH_STATUS.
30	3 OP1	COUNTER_BATCH 3xx.x56 - 3xx.x57	Unsigned32		1	Na	N / RO	Batch report counter.
31	1 OP2	GSV_HOUR 3xx.x58 – 3xx.x61	Double			TV	N/ RO	Gross Volume totalizer at base conditoins of current time. Not calculated in allocation measurement.
32		FGSV_HOUR 3xx.x62 - 3xx.x63	Float			TV	N/ RO	Gross Volume totalizer at base conditions of current time. Not calculated in allocation measurement.
33	1 OP2	NSV_HOUR 3xx.x64 – 3xx.x67	Double			TV	N/ RO	Net volume totalizer at base conditions of current time.
34		FNSV_HOUR 3xx.x68 - 3xx.x69	Float			TV	N/ RO	Net volume totalizer at base conditions of current time.
35	3 OP2	MASS_HOUR 3xx.x70 – 3xx.x73	Double			TM	N/ RO	Current time totalized pure product measured mass (MMpp).
36		FMASS_HOUR 3xx.x74 - 3xx.x75	Float			TM	N/ RO	Current time totalized pure product measured mass (MMpp).
37	3 OP2	FTIME_HOUR 3xx.x76 - 3xx.x78	Time difference				N / RO	Flow time of current time.
38	3 OP2	STATUS_HOUR 3xx.x79	Bitstring[2]	See Block Options	0	Na	N/ RO	Current time status. Similar to BATCH_STATUS.
39	3 OP2	COUNTER_HOUR 3xx.x80 - 3xx.x81	Unsigned32		1	Na	N / RO	Time report counter.
40	1 OP3	GSV_DAY 3xx.x82 – 3xx.x85	Double			TV	N/ RO	Gross volume totalizer at base conditions of current day. Not calculated in allocation measurement.
41		FGSV_DAY 3xx.x86 - 3xx.x87	Float			TV	N/ RO	Gross volume totalizer at base conditions of current day. Not calculated in allocation measurement.

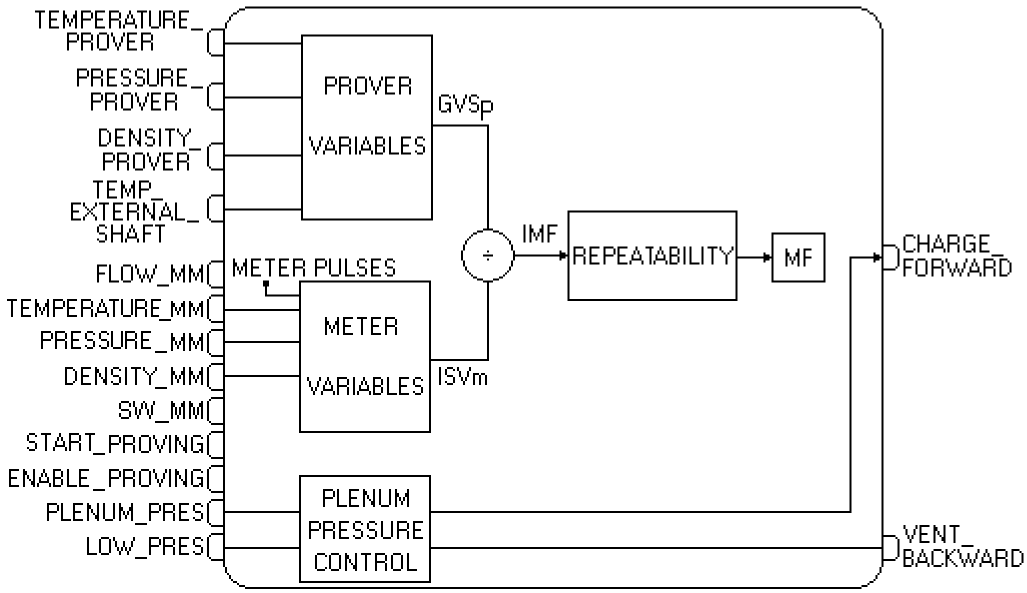
Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store / Mode	Description
42	1 OP3	NSV_DAY 3xx.x88 – 3xx.x91	Double			TV	N/ RO	Net volume totalizer at base conditions of current day.
43		FNSV_DAY 3xx.x92 - 3xx.x93	Float			TV	N/ RO	Net volume totalizer at base conditions of current day.
44	3 OP3	MASS_DAY 3xx.x94 – 3xx.x97	Double			TM	N/ RO	Current day totalized pure product measured mass (MMpp).
45		FMASS_DAY 3xx.x98 - 3xx.x99	Float			TM	N/ RO	Current day totalized pure product measured mass (MMpp).
46	3 OP3	FTIME_DAY 3xx.100 - 3xx.102	Time difference				N / RO	Current day flow time.
47	3 OP3	STATUS_DAY 3xx.103	Bitstring[2]	See Block Options	0	Na	N/ RO	Current day status. Similar to BATCH_STATUS
48	3 OP3	COUNTER_DAY 3xx.104 - 3xx.105	Unsigned32		1	Na	N / RO	Daily report counter.
49	1 OP4	GSV_MONTH 3xx.106 – 3xx.109	Double			TV	N/ RO	Gross volume totalizer at base conditions of current month. Not calculated in allocation measurement.
50		FGSV_MONTH 3xx.110 - 3xx.111	Float			TV	N/ RO	Gross volume totalizer at base conditions of current month. Not calculated in allocation measurement.
51	1 OP4	NSV_MONTH 3xx.112 – 3xx.115	Double			TV	N/ RO	Net volume totalizer at base conditions of current month.
52		FNSV_MONTH 3xx.116 - 3xx.117	Float			TV	N/ RO	Net volume totalizer at base conditions of current month.
53	3 OP4	MASS_MONTH 3xx.118 – 3xx.121	Double			TM	N/ RO	Current batch totalized pure product measured mass (MMpp).
54		FMASS_MONTH 3xx.122 - 3xx.123	Float			TM	N/ RO	Current batch totalized pure product measured mass (MMpp).
55	3 OP4	FTIME_MONTH 3xx.124 - 3xx.126	Time difference				N / RO	Current month flow time.
56	3 OP4	STATUS_MONTH 3xx.127	Bitstring[2]	See Block Options	0	Na	N/ RO	Current month status. Similar to BATCH_STATUS.
57	3 OP4	COUNTER_MONTH 3xx.128 - 3xx.129	Unsigned32		1	Na	N / RO	Montly report counter.

Idx	Type/ View	Parameter	Data type (length)	Valid range/ Options	Default Value	Units	Store / Mode	Description
58	3 OPx	ACTIVE_ALARM1 3xx.130	Bitstring[2]				N / RO	Indicates which alarms related to the station are active.
59	3 OPx	ACTIVE_ALARM2 3xx.131	Bitstring[2]				N / RO	Indicates which alarms related to the station are active.
60	3 OPx	UNACK_ALARM1 4xx.x31	Bitstring[2]				N	Indicates which alarms related to the station have not been recognized by the operator.
61	3 OPx	UNACK_ALARM2 4xx.x32	Bitstring[2]				N	Indicates which alarms related to the station have not been recognized by the operator.
62		UPDATE_EVT 3xx.132 – 3xx.138 4xx.x33	DS-73			Na	D	This alert is generated by any static data change.
63		BLOCK_ALM 3xx.139 – 3xx.145 4xx.x34	DS-72			Na	D	The block alarm is used for all configuration, hardware, and connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – Dynamic; N – non-volatile;
S – Static; I – Input Parameter; O-Output Parameter
AA-Administrator Level; A1 – Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction level 1; R – Restriction level 2
CL = 57 bytes (includes block tag and profile); V1-111 bytes; V2-21 bytes; V3-104 bytes; V4-5 bytes;
HFCView: OPx (OP1, OP2, OP3, OP4), OP1 (Operation - Batch), OP2 (Operation - Hour), OP3 (Operation - Day), OP4 (Operation - Month), CF (Configuration), MN (Maintenance)

LMF – Liquid Meter Factor

Schematic



Description

This block main functionality is provide support for the proving using a prover, which can be of the following types: Ball Prover (conventional prover, U-type), Small Volume Prover (piston prover), Tank Prover and Master Meter.

The indirect proving, in which the Master Meter calibrates the operational meter, can be through DF77 or any other available pulse module in Audit Flow using LMF block.

The direct proving that would be through a Ball Prover, Small Volume Prover or Tank Prover calibration the operational meter or Master Meter, requires the DF77 module use, since this module has been projected specifically to consider the API-Chapter 4 and ISO7278 standards.

This block receives from field devices all the needed variables for proving process related to the prover and meter in calibration: flow meter pulses, temperature, pressure, density and BSW in case of allocation measurement.

The following paragraph shows a general idea of events sequence that occurs during a proving run, where:

- IN1: DF77 module input, in which the prover is ready for executing another proving run;
- IN2: DF77 module input in which the prover signals the calibrated section starting of the prover;
- IN3: DF77 module input in which the prover signals the end of the prover calibration section;
- OUT1: DF77 module output for indicating the prover to start a proving run, which may mean a command for launching the Ball Prover sphere or piston launching, in case of Small Volume Prover;
- Ball Prover – Unidirectional: 1 proving run corresponds to 1 proving pass. Alignment (IN1), start run (OUT1), start pass, start detector (IN2), end detector (IN3), end pass, end run.
- Ball Prover – Bidirectional: 1 proving run corresponds to 2 proving running (one whole running). Alignment (IN1), start run (OUT1), start pass, start detector (IN2), end detector (IN3), end pass, way change (IN1), start run (OUT1), start pass, end detector (IN3), start detector (IN2), end pass, end run.
- Small Volume Prover – Unidirectional: 1 proving run corresponds to 1 proving pass. Check the piston in waiting position (IN1), start run (OUT1), start pass, start detector (IN2), end detector (IN3), piston return (OUT1), waiting position (IN1), end pass, end run.
- Tank Prover: O user informs the HFC302 the proving run start and end, through PROVING_STATE parameter of this block.
- Master Meter: 1 proving run corresponds to a batch, in which the totalized pulse numbers for meter and master meter are higher than the specified value in PULSES_PROVING_RUN or SIZE_PROVING_RUN, according to the meter signal, pulses or analog value, respectively.

Block input
These block inputs are used according to the configuration, as showed below:

Input	Link necessity	Description
TEMPERATURE_PROVER	mandatory	Prover flowing temperature.
PRESSURE_PROVER	Mandatory if custody measurement and optional if allocation measurement	Prover flowing gauge pressure
DENSITY_PROVER	Mandatory	Product density measured by prover, which may be at flowing conditons or base conditions depending on LKD.PRODUCTx_INFO.Density type configuration. Therefore, the meter density type and prover must be the same as configurated in the mentioned parameter.
TEMP_EXTERNAL_SHAFT	Mandatory for Small Volume Prover	Shaft temperature in where the prover calibrated section holders are.
PLENUM_PRES	Mandatory for Brooks prover	Indicates the plenum pressure, which woks as a pneumatic spring for poppet valve closing.
LOW_PRES	Mandatory for Brooks prover	Indicates if the nitrogen cylinder pressure is low, therefore requires this replacement.
TEMPERATURE_MM	Mandatory for master meter proving and indirect proving.	Master meter flowing temperature.
PRESSURE_MM	Mandatory for master meter proving and indirect proving; optional for allocation measurement	Master meter gauge flowing pressure.
DENSITY_MM	Mandatory for master meter proving and indirect proving	Measured product density in master meter, which can be at flowing conditions or base conditions depending on the LKD.PRODUCTx_INFO.Density type configuration.
SW_MM	Mandatory for master meter proving, if allocation measurement	Emulson BSW (cruide oil/light hydrocarbon and water) used **only** for mater meter calibration.
FLOW_MM	Mandatory if Master Meter prover is analog type	Indicates the Master Meter stream, when indirect proving is done.
START_PROVING_SESSION	Depends on the application	This input can be selected when an detected event by other block starts automatically a proving. For example, the alignment end for a prover or a necessity indication of a block proving LT.PROV_REQ must start automatically a proving session.
ENABLE_PROVING	Depends on the application	If this input is connected, therefore the status and value must be adequete so that the proving section can be started. If the proving have already started and the status changes to bad or value for zero, the proving will be aborted.

Block Output
The PROVING_DONE output indicates, only by one macrocycle, that a proving was accomplished successfully, that is, obtained the expected repeatability and the MF percentage variation is within the maximum acceptable value and it also was acknowledged/ accepted by the user, which generates the proving report.

If used the Brooks prover, which requires the plenum pressure control, therefore both discrete outputs CHARGE_FORWARD and VENT_BACKWARD must be used while operating solenoid valves for setting the pressure.

Status bad treatment in block input
1. In case of an indirect proving, the override treatment for TEMPERATURE_MM, PRESSURE_MM and DENSITY_MM inputs consists of using values correspondents to the operational meter (after this override treatment) when bad status.
2. For other situations is requested that all inputs are in good status. In case of bad status, proving will be aborted.

Prover selection (PROVER_SELECTION)
The device for reference to calibrate the meter can be:

- Some of the four provers configured in the LKD block;
- The master meter, that has only this functionality, i.e., can not work as an operational meter;
- Some of the four operational meters, which would be working also as master meter in this moment;

So, the four operational meters can have also the functionality of master meter and its secondary variables (temperature, pressure, density and BSW) are obtained from the respective LT blocks.

Configuration for Master Meter calibration

1. CHANNEL_MM parameter: address the pulse physical input associated to master meter.
2. Configure METER_SELECTION parameter to zero (master meter).
3. Configure in LKD block data related to master meter as: MASTER_METER_INFO, MM_TYPE,
4. Generate links for TEMPERATURE_MM, PRESSURE_MM e DENSITY_MM inputs.
5. Set REQ_REPEATABILITY parameter for 0.02%.

Configuration for pulse input meter type e Master Meter
If the operational meter is pulse input type, mandatorily the master meter must be from the same type. In this case, it is necessary to configure the CHANNEL_MM parameter to address the pulse physical input associated to master meter

In order to read the pulses from the operational and master meter in the same time frame (synchronous pulse reading), the pulse input of both must be addressing the same rack, slot and group. For example, CHANNEL = 2100 and CHANNEL_MM = 2107, that is, both addressing the rack 2, slot 1 and group 0.

The PULSES_PROVING_RUN parameter specifies another configuration for meters of the pulse input type; this parameter sets the minimum quantity of pulses for the operational and master meter for each proving run. The specific standards for proving determine that the minimum pulse quantity is 10,000, which is the lower limit of configuration for the PULSES_PROVING_RUN parameter.

Configuration for analog input meter type and Master Meter
If the master meter type is analog input, thus it is necessary to link the FLOW_MM input, which must provide the measured stream by master meter.

The criteria to end a proving run will be the indicated volume specified in SIZE_PROVING_RUN parameter, therefore, when the operational and master meter had measured the volume upper the parameter value, the proving run will be concluded.

The proving process for volume meters
When the meter in matter is volumetric, the proving process compares the measured volumes corrected by the prover and meter submitted to the proving in the same time frame.

Direct proving:

$$MF = \frac{GSVp}{ISVm} = \frac{BPV * (CTSp * CPSp * CTLp * CPLp)}{(Ni/NKFm) * (CTLm * CPLm)}$$

If a tank prover is used, then CPSp = CPLp = 1 and BPV corresponds to the difference between starting and final volumes in tank prover.

Indirect Proving – Volumetric Master Meter:

$$MF = \frac{GSVmm}{ISVm} = \frac{IVmm * CTLmm * CPLmm * MFmm}{IVm * CTLm * CPLm}$$

Indirect Proving – Mass Master Meter:

$$MF = \frac{GSVmm}{ISVm} = \frac{(IMmm/Dfmm) * CTLmm * CPLmm * MFmm}{IVm * CTLm * CPLm}$$

The sequence phases of these processes are:

- Check temperature, pressure and density stability of the meter and prover by the specified time STABILITY_TIME before starting the first proving run. The stability is analyzed by comparing the variable values to the values determined at usual conditions evaluation. This stability checking includes all the proving process and is indicated in each proving run status;
- For each proving run, which total number depends on RUN_CRITERIA, it is started the weighted average calculation, correction factor, corrected flow totalizers and the intermediate meter factor (IMF). If "Average MF" method;

- For all prover types Small Volume Prover and Ball Prover, the event sequence for each proving run is basically the following:
  - The indication in IN1 input from DF77 module that the prover is ready for executing a run;
  - Under the user command the run is started, in where the prover is informed through OUT1 output from DF77;
  - The measurement of T1 e T2 time, as well as the pulses counting is started when the indication in IN2 input occurs from DF77 module and ends when indicates in IN3 input from DF77 module;
- For Tank Prover, the operation is totally manual, that is, the command to start the run as well as to start and end indication is provided directly by user.
- For Master Meter prover type, each proving batch ends when the pulse numbers counted for master meter and meter in calibration is upper than specified in PULSES_PROVING_RUN for pulse input or measured volume by both are upper than SIZE_PROVING_RUN for analog input;
- While ends the proving runs, the final calculation is done, which includes the MF calculation, the repeatability using the criteria configured in RUN_CRITERIA and the MF variation obtained in relation to the current value. If the repeatability is considered (REQ_REPEATABILITY), it is verified the percentual variation of meter factor obtained in relation to the current value compared to the ALLOWED_DEV_MF parameter;
- By considering the above criterias, it is verified the configuration in REQ_ACK parameter, which allows two options: use the MF obtained in calibration process automatically or await the user knowledge, that if not occurs, the proving process will be ignored;
- If the proving process is accepted (automatically or user knowledge), there are the following options:
  - ❑ Use immediately the new MF, that is, the running batches that uses this new factor;
  - ❑ The new MF would be used only in previous batches to current;
- A proving report is generated.

Proving process for mass meters

In case of mass meter, then the comparison is between the measured mass by the prover and the meter submitted to the proving.

Therefore the proving method for mass meters with mass output (LFLOW_TYPE=IM Pulse input) used in AuditFlow is inferred mass according to API-5.6 item 9.1.7.2.

If mass meter, however in volumetric output, the proving process will be accomplished as if a volume meter.

Direct Proving:

$$MF = \frac{\text{Prover Mass}}{IMm} = \frac{BPV * CTSp * CPSp * Dens\ f,p}{Ni / NKFm}$$

Where:
BPV: prover volume at base conditions
CTSp: BPV correction factor due to temperature effect
CPSp: BPV correction factor due to pressure effect
Dens f,p: density at proving condition measured in the prover

Indirect Proving – Volumetric Master Meter:

$$MF = \frac{MMmm}{IMm} = \frac{IVmm * Dens\ f,mm * MFmm}{IMm}$$

Indirect Proving – Mass Master Meter:

$$MF = \frac{MMmm}{IMm} = \frac{IMmm * MFmm}{IMm}$$

Meter type and direct prover type combinations:

Operational or Master Meter	Prover type	Variable compared in Proving	Comments
0 = IV pulse input 1=IV*CTL pulse input	0 = U type, unidirectional 1 = U type, bidirectional 2 = Small volume prover, unidirectional 3 = Small volume prover, two-directional 4 = Tank prover	Corrected volume in temperature and pressure	Any combination in volume meter in pulse or any prover type
2=IM pulse input	0 = U type, unidirectional 1 = U type, bi-directional 2 = Small volume prover, unidirectional 3 = Small volume prover, two-directional 4 = Tank prover	Mass	Mass meter in pulse and any prover type

Operational and master meter combinations:

Operational Meter LFLOW_TYPE	Master Meter LKD.MM_TYPE	Variable compared in Proving	Comments
0 = IV pulse input 1=IV*CTL pulse input 3=Flow IV analog input 4=Flow IV*CTL analog input	0 = IV pulse input 1=IV*CTL pulse input 3=Flow IV analog input 4=Flow IV*CTL analog input	Corrected volume in temperature and pressure	Any combination of volume meters.
2=IM pulse input 5=Flow IM analog input	2=IM pulse input 5=Flow IM analog input	Mass	Any combination of mass meters.
0 = IV pulse input 1=IV*CTL pulse input 3=Flow IV analog input 4=Flow IV*CTL analog input	2=IM pulse input 5=Flow IM analog input	Corrected volume in temperature and pressure	Any combination of volume operational meter with mass master meter.
2=IM pulse input 5=Flow IM analog input	0 = IV pulse input 1=IV*CTL pulse input 3=Flow IV analog input 4=Flow IV*CTL analog input	Mass	Any combination of mass operational meter and volume master meter.

Proving configuration

Stability check at the beginning of the proving process– STABILITY_TIME parameter
The input variables stability analysis is performed during the time configured in this parameter, before starting the first proving run.

Rule to be used – RUN_CRITERIA parameter
The RUN_CRITERIA parameter defines the rule to be used for the repeatability calculation, which options are:

- Any 5 of 6 consecutive: six proving runs must be processed in sequence and select the better five (any, they do not need to be in sequence) and, the repeatability is calculated using these five proving runs. The selection of the better five consists of rejecting the proving run which IMF value is the furthest from the average of the six IMF's.
- 5 consecutive of 10 consecutive: after processing ten proving runs in sequence, select any 5 proving runs, in sequence, which attend the repeatability.
- 3 sets of 5: 3 groups of 5 consecutive proving runs are executed; an average value of IMF is calculated as well as the number of interpolate pulses. The repeatability is calculated using these three averages of IMF

- 5 consecutive: it processes five proving runs in sequence and the repeatability of them is calculated.
- 3 consecutive: it processes 3 proving runs in sequence and the repeatability of them is calculated.
- 2 consecutive: it processes 2 proving runs in sequence and the repeatability of them is calculated.

Required repeatability - REQ_REPEATABILITY parameter
The calculated repeatability is compared to the maximum value allowed that is configured in REQ_REPEATABILITY parameter. The repeatability is calculated following the form:

$$\text{Repeatability (\%)} = \frac{\text{max IMF} - \text{min IMF}}{\text{Min IMF}}$$

“Average Data“ Method:

$$\text{Repeatability (\%)} = \frac{\text{max Ni} - \text{min Ni}}{\text{min Ni}}$$

The maximum and minimum values are determined between proving run selected after application of RUN_CRITERIA.

Maximum allowed percentage variation of the meter factor– ALLOWED_DEV_MF parameter
When the required repeatability is attended, the percentage variation of the meter factor obtained in the proving compared to the actual value is calculated. If the percentage variation calculated is upper than the specified in the ALLOWED_DEV_MF parameter, the proving is rejected.

By configuring the value in the ALLOWED_DEV_MF parameter to zero, it means that this verification is disabled.

Acknowledgement by user before using the new meter factor – REQ_ACK and PROVING_RUN_TIMEOUT parameter
By considering all the proving requested criteria, the meter factor (MF) obtained will automatically be accepted if REQ_ACK = Use new MF parameter, otherwise (REQ_ACK = Ack to new MF), it is needed to wait the acknowledgement by user so that the meter can be accepted.

The PROVING_RUN_TIMEOUT parameter specifies the maximum time after ends the proving and repeatability calculation, so that the user knowledge the new calculated meter and uses it. If this does not occur, the PROVING_STATE goes to “Acknowledgment timeout”, that means the proving is rejected.

The user acknowledges the new meter factor by writing in PROVING_STATE = Using new MF (Wr).

This parameter specifies the maximum time between the ending of a proving run and starting of the next proving run, when the proving is executed interactively.

When using the new meter factor – APPLY_RETROACTIVELY parameter
The parameter allows defining two ways to use the new meter factor:
• “No”: the totalizations in operation continue using the previous meter factor and start to use the new meter factor only in the beginning of a new accounting period.
• “Yes”: the totalizations in operation start to use the new meter factor immediately the new meter factor is applied to the indicated volume measured since the beginning of each period (hour, day, and month).

Calculations accomplished during the Proving

During the execution of the proving run, the following calculations are accomplished:
• Direct Proving: T1 and T2 time measurement correspondent to each proving run and interpolate pulse counting meter;
- Indirect Proving: Pulse counting of operational and master meter, if pulse input or volume totalization of both if is analog input type;
- Weighted average calculation of the variables associated to the meter (operational and master meter) and to the prover;
- Status evaluation during proving run;

At the end of each proving run the following operations are accomplished for volume meters:
• Correction factor calculations (CTLm and CPLm) associated to the meter;

• Correction factor calculations (CTLp and CPLp), if direct prover also the CTSp and CPSp factores associated to the meter;
• Calculation of prover gross volume volume (GSVp or GSVmm) and indicated volume at base condition of the meter(ISVm);
• Calculation of intermediate meter factor (IMF), if "Average MF" method.

At the end of each proving run the following operations are accomplished for mass meters:

- Indicated mass calculation by the meter (IMm = Ni / NKF);
- Mass calculation in prover;
- Meter factor intermediate value calculation (IMF), if "Average MF" method.

After finishing all required proving runs, according to the selected criteria, the following procedure is performed:

- MF is calculated by using the arithmetic average of weighted average and interpolate pulse numbers, if "Average Data" method selected;
- Application of selected criteria;
- Repeatability calculation.
- Calculation of the MF, CMF, MA, KF and CKF parameters
- Repeatability check and percentage variation of the meter factor;
- If the specifications and user acknowledgement were attended (if required), the new meter factor is transferred to the LKD.MF_METER_PRODUCT block;
- A proving report is automatically generated when transferring the new meter factor to the LKD block. The user may request a report generation even when a proving failed by writing PROVING_STATE = Save report of failed proving (Wr);
- If one failure occurred during the proving, the cause is indicated in PROV_FAIL_CAUSE and the state in PROVING_STATE will be one of the following options:
    - Repeatability not satisfied – repeatability not reached;
    - Acknowledgement timeout – the user did not acknowledge the new meter factor;
    - Unacceptable conditions – problems in the pulse reading or the pulse input module.
    - Proving run timeout – time among proving runs exceeded.

Operation during the proving process
There are two possible ways of execution:
• Automatic and sequential execution of the proving runs: all the proving runs are executed sequentially up to the required number to attend the selected criteria (RUN_CRITERIA).
• Interactive execution under user request for each proving run writing PROVINVG_STATE = One proving run: since the first proving run or after a failure, even when it occurred after an automatic and sequential execution of the proving runs.

Plenum pressure control

The AuditFlow integration with the compact Brooks prover requires the plenum pressure control, which is used in the poppet valve closing, causing the piston displacement. In order to enable the plenum pressure control there is needed to configure the PLENUM_DB parameter different from zero.

The expected value for plenum pressure is given by the below equation, in where the pressure setting accomplished inside a dead band configured in PLENUM_DB parameter.

$$Plenum\,\mathrm{Pr}\,essure\_SP = \frac{Line\,\mathrm{Pr}\,essure}{PlenumCons\,\tan t} + 60\,psi$$

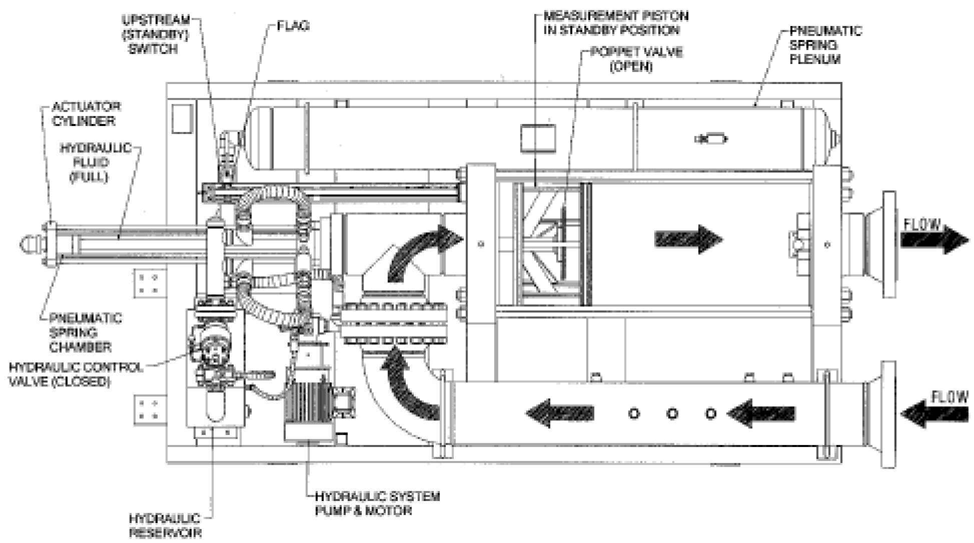
If the prover is in vertical position to 60 psi, must be replaced by 40psi.

The plenum constant is selected according to the following table and must be configured in PLENUM_CT parameter.

Prover size – Diameter (inches)	R
8	3.5
12 Mini	3.2
12	3.2
18	5
24	5.88
34	3.92
40	4.45

The event sequence during a proving run is the following:

1. Resting position: piston in upstream position, active upstream signal, open poppet valve, since the hydraulic control valve is closed avoiding the actuator piston movement.
2. Piston movement start: the flow computer sends the command from RUN to prover, the hydraulic control valve is open, then the pneumatic pressure overcomes the pressure in line and dislocate the actuator piston down the hydraulic control valve is stream by closing the poppet valve.
3. Proving end: the measurement piston dislocate downstream with the closed poppet valve, flag in calibrated session start and at the end of the calibrated session, this last event causes the closing at the hydraulic control valve by holding the actuator piston, the measurement flow pushes the ring in the measurement piston perimeter and the poppet valve is open.
4. Piston return: the bomb injects in the actuator piston overcoming the pneumatic pressure making the actuator and measurement piston dislocate upstream with the open poppet valve.



Standby position

Plenum pressure control algorithm

When a proving session is started, that is, start a proving run and PROVING_RUN=0, then occurs the checking and if necessary the plenum pressure setting according to the following algorithm:

1. If LOW_PRES input is active, this indicates to the user the needs of replacing the nitrogen cylinder for having a low load.
2. It is checked if the plenum pressure is in range between: PlenumPressure_SP and PlenumPressure_SP*(1+PLENUM_DB).
3. If is below the range, activate the CHARGE_FORWARD output until reaches the upper limit. If the plenum pressure exceeds the upper limit, then activates the VENT_BACKWARD output until the pressure is slightly lower.

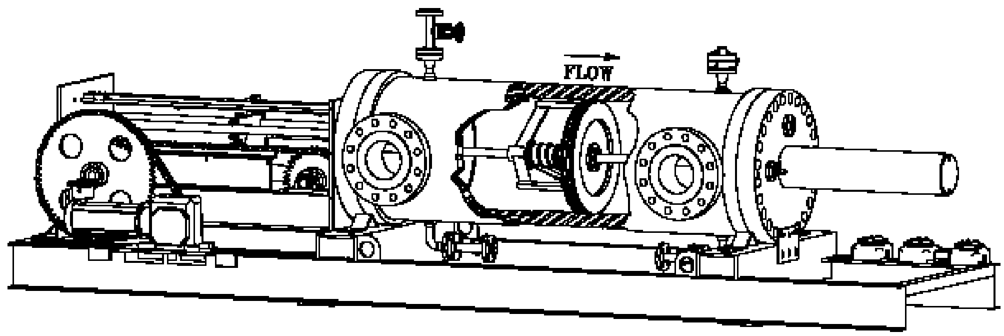
Therefore when the plenum pressure is set, it is always set to upper limit. There is a timeout for operation the valves CHARGE_FORWARD and VENT_BACKWARD, that is, they can keep active by a maximum time of 1 minute each one. If the setting is not possible at this moment, the process is aborted and is indicated in PROV_FAIL_CAUSE=bad plenum pressure.

The following situations also cause the proving failure and indicate PROV_FAIL_CAUSE=bad plenum pressure:

- Bad status of PLENUM_PRES input
- Bad status LOW_PRES input
- LOW_PRESS input settled by indicating the needs of nitrogen cylinder exchange

Prover Syncrotrak

O Syncrotrak from Calibron does not use the pneumatic/hydraulic system for opening and closing the poppet valve, but uses the mechanics spring, according to the drawing below.



U-type bidirectional

Despite the U-type bidirectional prover does not require pulse interpolation, the AuditFlow does it . This type of prover has a 4-way valve to control flow through the prover in both directions (forward and backward).
The block LMF has the outputs CHARGE_FORWARD and VENT_BACKWARD to control the 4-way valve as indicated in the following table.

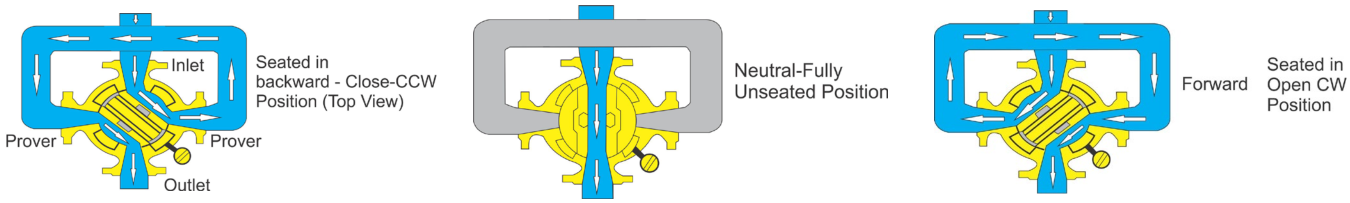
4 way valve position	CHARGE_FORWARD	VENT_BACKWARD	Description
Forward-Open-CW (top view)	1	0	Flow through prover in Forward=Open=ClockWise direction.
Backward-Close-CCW (top view)	0	1	Flow through prover in Backward=Close=CounterClockWise direction.
Neutral-Fully	0	0	Bypass prover
-	1	1	The block LMF will never generate this condition.

Warning: The outputs CHARGE_FORWARD and VENT_BACKWARD must be associated to physical discrete output points in the same group and in the same I/O module.

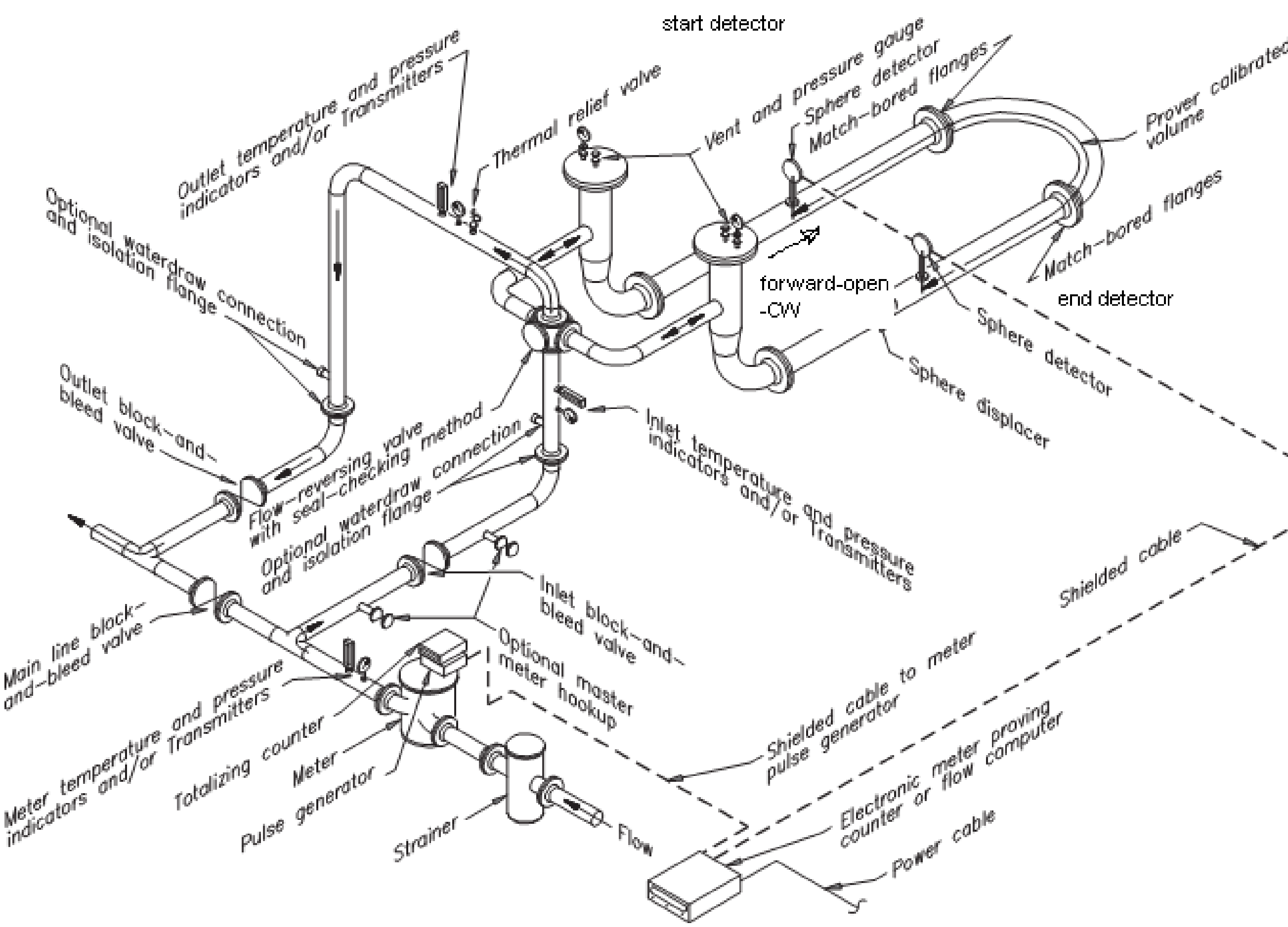
It was adopted the below convention for valve positions and detector names. It is highly recommend following it in the application too.

	Name	Description
4-way valve	Forward-Open-CW	Adopting the top view of 4-way valve as reference, this valve position corresponds to the flow through the prover in the clockwise direction and it is also named as forward direction or open position by the U-type prover manufacturers.
	Backward-Close-CCW	Adopting the top view of 4-way valve as reference, this valve position corresponds to the flow through the prover in the counterclockwise direction and it is also named as backward direction or close position by the U-type prover manufacturers.
	Neutral-Fully	When the 4-way valve is in this position, the U-type prover is bypassed.
detectors	Start detector	The start detector is the first detector when 4-way valve is in the Forward-Open-CW position
	End detector	The end detector is the first detector when 4-way valve is in the Backward-Close-CCW position

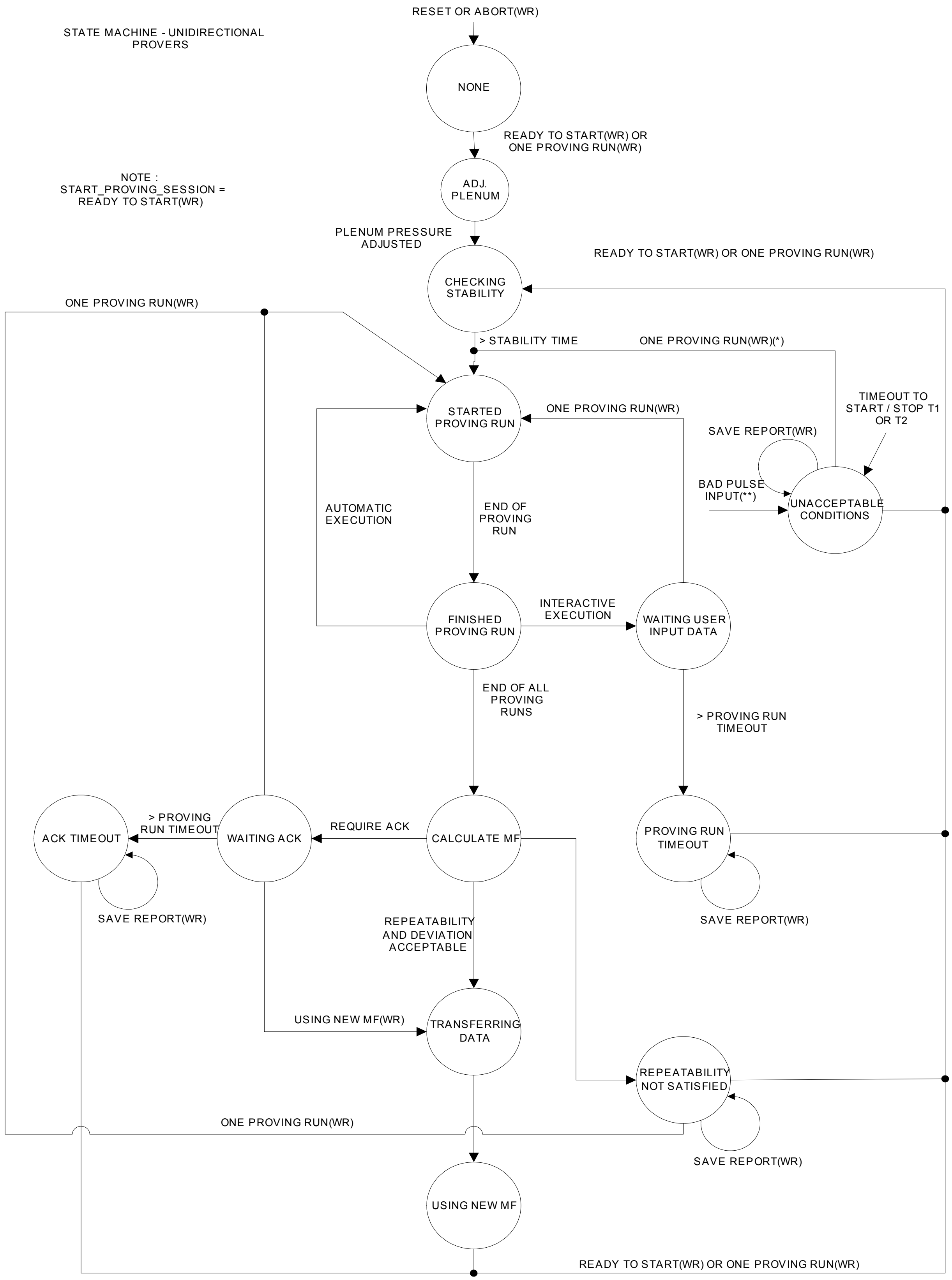
The 4-way valve position naming convention.



The U-type bidirectional prover and detector naming convention.

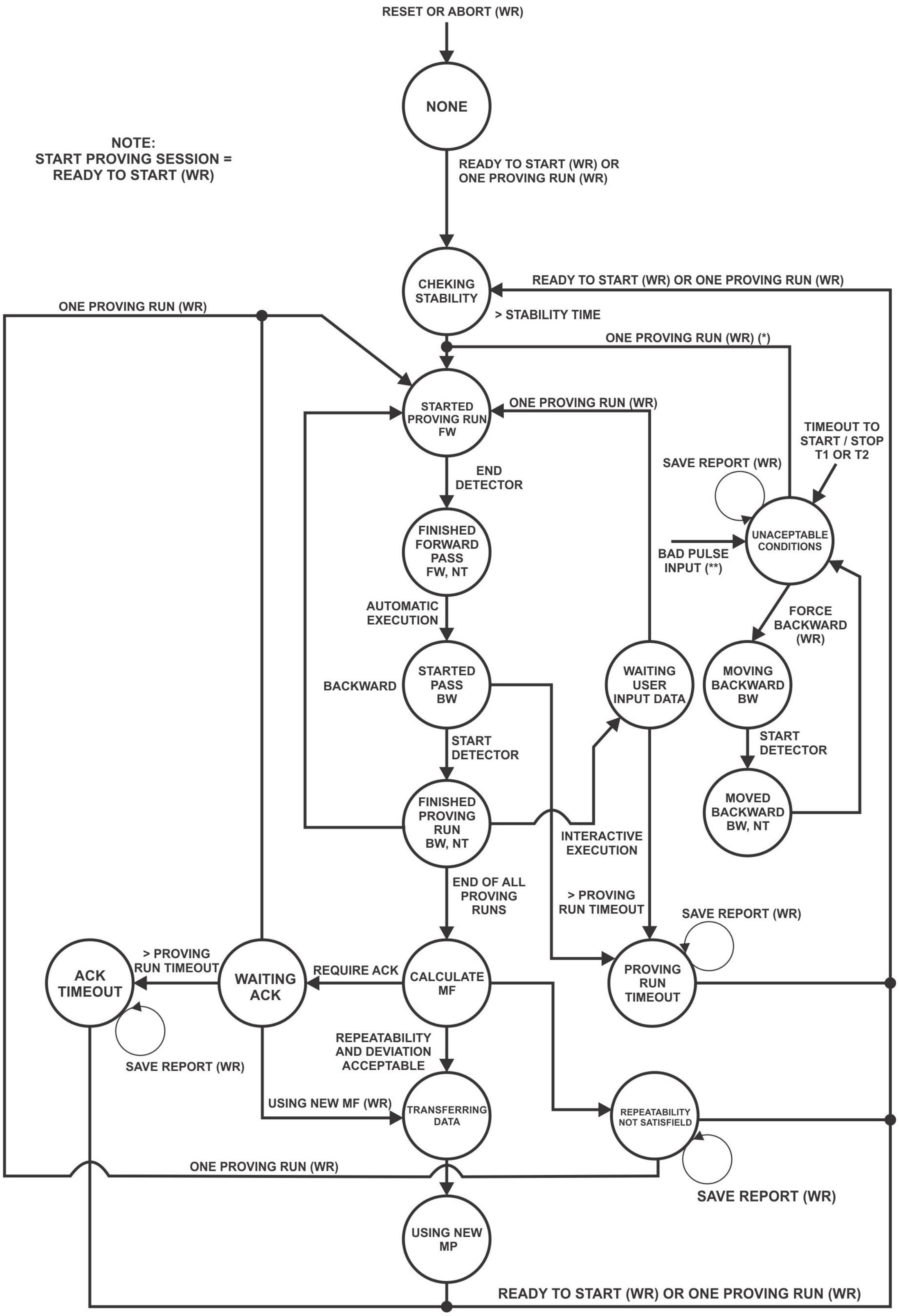


State Machine for Small Volume Prover, U type unidirectional and Master Meter



Status	Possible Commands	Comments
None	Ready to start(Wr) One proving run(Wr) Abort(Wr)	
Checking stability	Abort(Wr)	Awaiting the manufacturing stability of well test.
Started proving run	Abort(Wr)	
Finished proving run	Abort(Wr)	
Waiting user input data	One proving run(Wr) Abort(Wr)	Accomplishment of each run under user request.
Calculate MF	Abort(Wr)	
Transferring data		At this phase, it is not possible to abort the proving.
Using new MF	Ready to start(Wr) One proving run(Wr) Abort(Wr)	
Waiting ack	One proving run(Wr) Abort(Wr)	
Ack timeout	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Proving run timeout	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Repeatability not satisfied	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Unacceptable conditions	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	

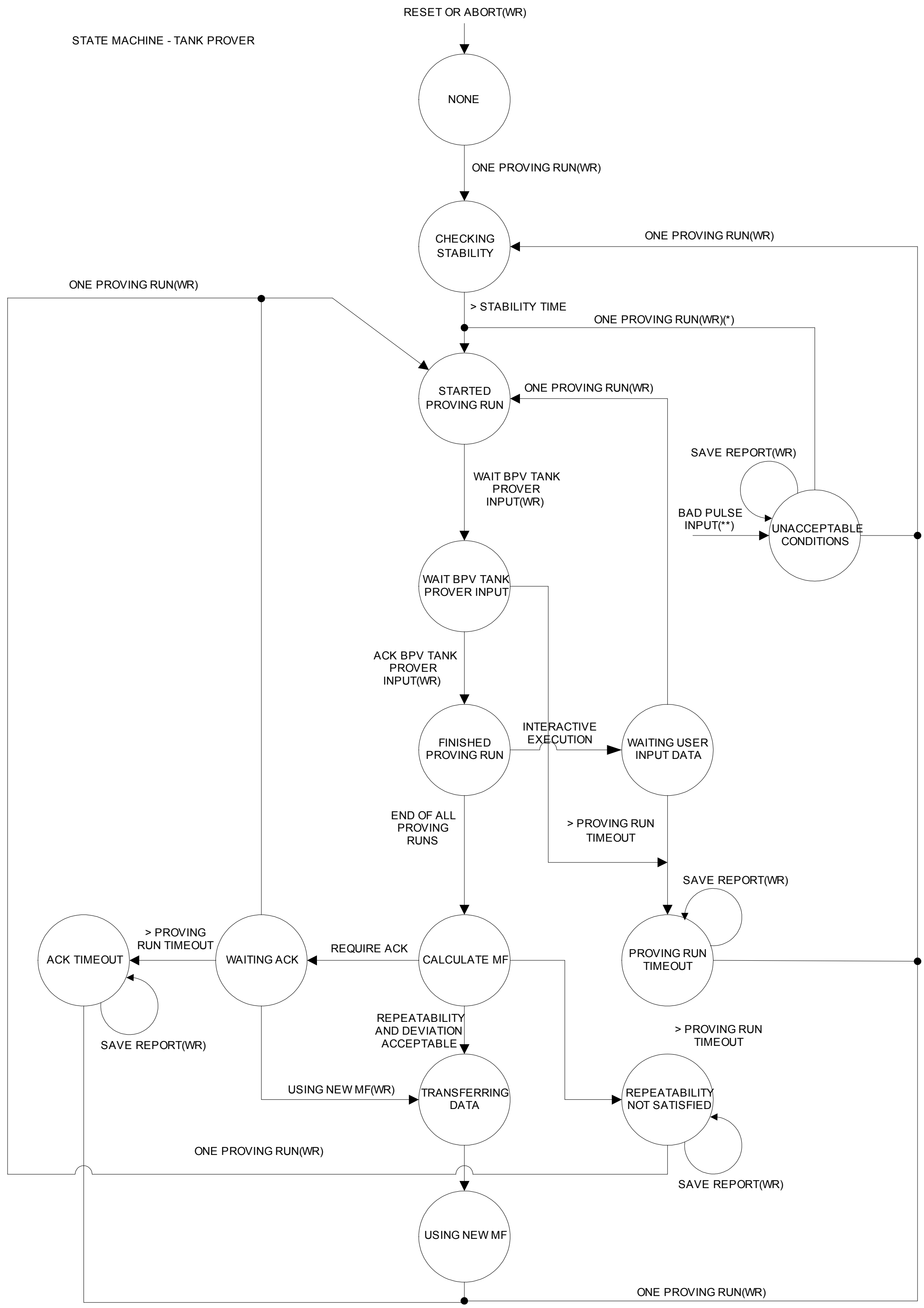
State Machine for prover U type bidirectional



4-Way valve position:
FW = Forward
BW = Backward
NT = Neutral (when not indicated in state)

Status	Possible Commands	Comments
None	Ready to start(Wr) One proving run(Wr) Abort(Wr)	
Checking stability	Abort(Wr)	Awaiting the manufacturing stability of well test.
Started proving run	Abort(Wr)	
Finished forward pass	Abort(Wr)	It keeps the 4-way valve position at Forward=Open=CW for the time corresponding to PLENUM_DB*10minutes. Then it changes to Neutral-Fully position and it stays for 4 seconds.
Started backward pass	Abort(Wr)	
Finished proving run	Abort(Wr)	It keeps the 4-way valve position at Backward=Close=CCW for the time corresponding to PLENUM_DB*10minutes. Then it changes to Neutral-Fully position and it stays for 4 seconds.
Waiting user input data	One proving run(Wr) Abort(Wr)	Waiting for user request to start another proving run
Calculate MF	Abort(Wr)	
Transferring data		At this phase, it is not possible to abort the proving.
Using new MF	Ready to start(Wr) One proving run(Wr) Abort(Wr)	
Waiting ack	One proving run(Wr) Abort(Wr)	
Ack timeout	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Proving run timeout	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Repeatability not satisfied	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Unacceptable conditions	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr) Force backward (Wr)	Force backward (Wr) allows to place the displacer (sphere) at the expected initial position (near to the start detector).
Moving backward	Abort(Wr)	
Moved backward	Abort(Wr)	It keeps the 4-way valve position at Backward=Close=CCW for the time corresponding to PLENUM_DB*10minutes. Then it changes to Neutral-Fully position and it stays for 4 seconds.

State Machine for tank prover



Status	Possible Commands	Comments
None	Ready to start(Wr) One proving run(Wr) Abort(Wr)	
Checking stability	Abort(Wr)	Awaiting the manufacturing stability of well test.
Started proving run	Abort(Wr)	
Wait BPV tank prover input	Abort(Wr)	Awaiting the user provides the volume transferred by tank prover making the reading difference before and after the run.
Finished proving run	Abort(Wr)	
Waiting user input data	One proving run(Wr) Abort(Wr)	Accomplishment of each run under user.
Calculate MF	Abort(Wr)	
Transferring data		At this phase, it is not possible to abort the proving.
Using new MF	Ready to start(Wr) One proving run(Wr) Abort(Wr)	
Waiting ack	One proving run(Wr) Abort(Wr)	
Ack timeout	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Proving run timeout	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Repeatability not satisfied	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	
Unacceptable conditions	Ready to start(Wr) One proving run(Wr) Save report(Wr) Abort(Wr)	

Diagnosis and Troubleshooting

1. BLOCK_ERR. Block configuration: this indication can occur due to the following problems:

- Inconsistence in the linearization curve meter, if this option was selected.
- No operational meter associated to METER_SELECTION
- Product type to be proved as "Water".
- Meter configuration submitted to proving: LKD.METERx_INFO.NKF or LKD.MASTER_METER_INFO.NKF equals to zero
- Operational meter proving: CHANNEL parameter is not properly configured.

Checking of specific configuration to indirect prover (PROVER_SELECTION = "Master meter")

- CHANELL_MM parameter or LT.CHANNEL of the operational meter selected to work as master meter is not properly configured;
- Meter and Master meter (or meter selected to work as master meter) of "pulse input" type and not address to the same module. If used a module different from DF77, the pulse inputs must belong also to the same group.
- "Pulse input" meter type and Master Meter is "analog input" type.
- "Analog input" meter type and Master Meter is "pulse input" type.
- Not supported "average data" option in METER_FACTOR_METHOD parameter.
- METER_SELECTION configured to "Master meter"
- If operational meter selected to work as master meter is configured for measuring a product different of the configured in the meter to be calibrated.

Check of specific configuration to direct prover (PROVER_SELECTION different from "Master meter"):

- LKD.PROVERx_INFO prover configuration (where, x = [1..4]) is incorrect.
- Meter signal type to be proved different from "IV Pulse input" and "CTL*IV Pulse input" and "IM Pulse input".
- If"Tank Prover" prover type and calculation method of meter factor is different from "Average MF".
- Meter submitted to proving using pulse inputs of a module different from DF77.
- Meter submitted to proving different from "IV Pulse input" in allocation measurement.
- Selected Tank Prover and the product used are Light hydrocarbon" or "Emulsion light hydrocarbon and water".

2. BLOCK_ERR. Input failure: this indication may occur due to the following problems:

- If the selected meter is "pulse input" type and it is not being possible to read the pulses from the operational meter LT. CHANNEL) or master meter (LMF.CHANNEL_MM);
- If the selected meter or Master Meter is "analog input" type and the LFLOW or FLOW_MM input has bad status, respectively.

3. BLOCK_ERR. Out of Service: LMF block may continue in Out of service mode although the target mode is Auto due to the following causes:

- If METER_SELECTION parameter is equal to zero, that is, master meter proving and CHANNEL_MM parameter equals to zero for Master Meter "pulse input" type or FLOW_MM input not connected to Master Meter "analog input" type.
- If METER_SELECTION parameter is different from zero, that is, the operational meter proving and no LT block for selected run number;
- Resource block is in O/S.
- If any indication of BLOCK_ERR.Block configuration.

4. If a proving failure occurs due to repeatability not satisfied (PROVING_STATE = Repeatability not satisfied), the user can check the following options:

- The obtained repeatability compared to the requested (REQ_REPEATABILITY);
- High variation in interpolate pulse number among proving runs;
- The stream during proving run must have variation less +/- 2% of average stream according to ISO7278-3:1998 item 5.1.c;
- Check the meter flow meter pulse waves regarding to levels, frequency and duty cycle on pulse module terminal block;
- Check if the devices or same cabling between flow meter and pulse module (pre-amplifier, intrinsic safety barrier) are not filtrating the pulse signal;
- Meter variable instability submitted to proving (temperature, pressure and density).

5. If a proving failure occurs due to unacceptable conditions (PROVING_STATE = Unacceptable conditions):

- Pulse reading failure: module with problem or pulse transmission from the meter to the module.
- Verify if the variables (density and temperature) of the operational and master meters are in the calculation ranges of the correction factors. Refer to the tables in the LKD block description.
- Percentage variation of the meter factor was larger than the specified in the LLOWED_DEV_MF parameter.
- Meter factor is out of the range 0.8 to 1.2.

6. Write failure in writing proving configuration parameter: writing is allowed only if no proving is being performed.

7. Indication interpretation in PROV_FAIL_CAUSE:
   a. Abnormal proving.

8. Adopting a different convention of this manual for U-type bidirectional prover may cause the following behavior.

#	Detectors	Initial position of displacer	Digital outputs for 4-way valve	Behavior
1	Correct	Correct	Correct	Correct functionality
2	Exchanged	Correct	Correct	Timeout to stop T2 in the forward direction
3	Correct	Exchanged	Correct	Timeout to start T2 in the forward direction. Use the option Force Backward(Wr) to position the displacer at the expected initial position.
4	Exchanged	Exchanged	Correct	Timeout to start T2 in the forward direction
5	Correct	Correct	Exchanged	Timeout to start T2 in the forward direction
6	Exchanged	Correct	Exchanged	Timeout to start T2 in the forward direction
7	Correct	Exchanged	Exchanged	Timeout to stop T2 in the forward direction
8	Exchanged	Exchanged	Exchanged	Correct functionality despite of exchanging all references.

Supported Modes
O/S and AUTO.

Parameters

Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	Tag of the master meter in proving report, when the same is submitted to proving.
3	4	STRATEGY 3xx.xx0	Unsigned16	255	255	None	S / RO	
4	4	ALERT_KEY 4xx.xx0	Unsigned8	1 to 255	0	None	S	
5 (A2)(CL)	1,3 CF	MODE_BLK Target/Normal - 4xx.xx1 – 4xx.xx3 Actual - 3xx.xx1	DS-69		Auto	Na	S	Refer to Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7 (A2)	I,1 OP1	TEMPERATURE_PROVER 4xx.xx4 - 4xx.xx6	DS-65			T	N	Product temperature in prover, used to calculate the CTSp and CTLp correction factors.
8 (A2)	I,1 OP1	PRESSURE_PROVER 4xx.xx7 - 4xx.xx9	DS-65			P	N	Pressure in prover, used to calculate CTSp and CTLp correction factors.
9 (A2)	I,1 OP1	DENSITY_PROVER 4xx.x10 - 4xx.x12	DS-65			LD	N	Product density in prover, used to calculate the CTSp and CTLp correction factors.
10 (A2)	I,1 OP1	TEMP_EXTERNAL_SHAFT 4xx.x13 - 4xx.x15	DS-65			T	N	External shaft temperature with starting and ending detectors of calibrated section.
11	I,1 OP1	PLENUM_PRES 3xx.xx3 - 3xx.xx5	DS-65			P	N / RO	Plenum pressure, used for closing the poppet valve.

Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
12	I,1 OP1	LOW_PRES 3xx.xx6 - 3xx.xx7	DS-66				N / RO	Indicates if nitrogen cylinder pressure is low and must be replaced.
13 (A2)	I,1 OP2	TEMPERATURE_MM 4xx.x16 - 4xx.x18	DS-65			T	N	Master meter product temperature.
14 (A2)	I,1 OP2	PRESSURE_MM 4xx.x19 - 4xx.x21	DS-65			P	N	Master meter pressure.
15 (A2)	I,1 OP2	DENSITY_MM 4xx.x22 - 4xx.x24	DS-65			LD	N	Master meter liquid density.
16 (A2)	I,1 OP2	SW_MM 4xx.x25 - 4xx.x27	DS-65			%	N	Emulsion BSW used in mater meter proving. Used only if product type is emulsion (allocation measurement) and mater meter calibration.
17	I,1 OPx	FLOW_MM 3xx.xx8 - 3xx.x10	DS-65			LKD.MM_TYPE: QV or QM	N / RO	If the MM_TYPE parameter defines master meter as "analog input", thus this input must be connected. Otherwise ("pulse input"), this input must not be connected and the defined flow type will be indicated in LKD.MM_TYPE, which is calculated from pulse frequency.
18	I,1 OPx	START_PROVING 3xx.x11 - 3xx.x12	DS-66				N/RO	When this input is TRUE, it will force one session of automatic proving.
19	I,1 OPx	ENABLE_PROVING 3xx.x13 - 3xx.x14	DS-66				N /RO	This input must be TRUE during all proving session. It will be ignored if not connected.
20	O,1 OP1	CHARGE_FORWARD 3xx.x15 - 3xx.x16	DS-66				N / RO	Output for solenoid valve control of plenum tube charging. When it is a U-type bidirectional prover, this output is used to control the 4-way valve. This output is activated to seat in "Forward=Open=CW" position.
21	O,1 OP1	VENT_BACKWARD 3xx.x17 - 3xx.x18	DS-66				N / RO	Output for solenoid valve control of plenum tube ventilation. When it is a U-type bidirectional prover, this output is used to control the 4-way valve. This output is activated to seat in "Backward=Close=CCW" position.
22(A2)(CL)	2 OPx	CHANNEL_MM 4xx.x28	Unsigned16		0	Na	S / NW	Hardware channel number for pulse input module of the master meter.
23(A2)(CL)	2 CF	PROVER_SELECTION 4xx.x29	Unsigned8	0=Master 1-4 = Prover 1-4 5 = Meter 1 6 = Meter 2 7 = Meter 3 8 = Meter 4	1	E	S / NW	Prover selection among the four products configured in LKD block. It is allowed writing since the proving session is not in operation.
24 (A2)(CL)	2 CF	PULSES_PROVING_RUN 4xx.x30	Unsigned16	10000 to 65535	10000	Na	S / NW	Minimum number of pulses for proving run, when the master meter is used. And applied to the operational meter and also to the master meter. It is allowed to write since a proving is not occurring.
25 (A2)(CL)	2 CF	SIZE_PROVING_RUN 4xx.x31 - 4xx.x32	Float	> 0.0	100	LV	S / NW	Minimum size of proving run. Based always in the indicated volume, regardless the LFLOW_TYPE parameter.

Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
26 (A2)(CL)	1 CF	METER_SELECTION 4xx.x33	Unsigned8	0=Master Meter 1=Meter 1 2=Meter 2 3=Meter 3 4=Meter 4	1	E	N / NW	Selects the meter to submit the proving.
27(A2)(CL)	CF	PRODUCT_SELECTION 4xx.x34	Unsigned8	1-10 = Product 1-10	1	E	S / NW	Product selection among the10 products configured in LKD block. It is allowed writing since the proving session is not in operation. It is necessary to configure this parameter only if executing the master meter proving.
28(A2)(CL)	2 CF	METER_FACTOR_METHOD 4xx.x35	Unsigned8	0 = Average MF 1 = Average data	0	E	S / NW	Method used to calculate MF. It is allowed writing since proving session is not in operation.
29 (A2)(CL)	2 CF	STABILITY_TIME 4xx.x36	Unsigned16	0 to 65535	60	Sec	S / NW	Minimum time expected of stable temperature, pressure and density to start the proving. It is allowed writing since a proving is not occurring.
30 (A2)(CL)	2 CF	RUN_CRITERIA 4xx.x37	Unsigned8	0=any 5 of 6 consecutive 1= 5 consecutive of 10 consecutive 2=3 sets of 5 3=5 consecutive 4=3 consecutive 5=2 consecutives	0	E	S / NW	Rule used to analyze the repeatability. The writing is allowed since there is no executing a proving process.
31 (A2)(CL)	2 CF	REQ_ACK 4xx.x38	Unsigned8	0=Use new MF 1=Ack to new MF	0	E	S / NW	The MF calculated recently and that attends the repeatability, can be used immediately or need the operator acknowledge. It is allowed to write since a proving is not occurring.
32(A2)(CL)	2 CF	APPLY_RETROACTIVELY 4xx.x39	Unsigned8	0=No 1=Yes	0	E	S / NW	This parameter allows the user applies the new MF to the totalizations in operation. It is allowed to write since a proving is not occurring.
33 (A2)(CL)	2 CF	REQ_REPEATABILITY 4xx.x40 - 4xx.x41	Float	0.01 to 2.00	0.05	%	S / NW	Repeatability requested by proving session to be accepted. Applied to the IMF parameter or N_INTERPOLATED, according to the selected method.
34 (A2)(CL)	2 CF	ALLOWED_DEV_MF 4xx.x42 - 4xx.x43	Float	0.0=No restriction > 0.0	0.0	%	S / NW	Define the maximum deviation allowed for the MF when it is compared to the current value.
35 (A2)(CL)	2 CF	PROVING_RUN_TIMEOUT 4xx.x44	Unsigned8	0=disabled 1 to 255	5	Min	S / NW	Maximum time between proving runs when executing the proving using interactive form. Maximum time for the acknowledgement of the new MF.
36 (A2) (CL)	2 CF	PLENUM_CONTROL 4xx.x45	Unsigned8	0=Disabled 1=Horizontal 2=Vertical	1	E	S / NW	Enable/Disable the plenum pressure control and if the prover is in horizontal or vertical position.
37 (A2)(CL)	CF	PLENUM_CT 4xx.x46 - 4xx.x47	Float	1.1 to 20	3.2		S / NW	Plenum constant to determine the set point of plenum pressure.
38(A2)(CL)	CF	PLENUM_DB 4xx.x48 - 4xx.x49	Float	0 to 30% 0=disabled	5	%	S / NW	Band for setting the plenum pressure if it is a Brooks prover. When using U-type bidirectional prover, it defines the time to keep the 4-way valve position after the second detector. It is a percentage of 10minutes.

Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
39	1 OPx	REPORT_COUNTER 3xx.x19 - 3xx.x20	Unsigned32		0	Na	N / RO	Report counter for report type and measured flow number.
40 (A2)	1 OPx	PROVING_STATE 4xx.x50	Unsigned8	0=None 1=Ready to start(Wr) -> Not applicable for tank prover 2=Checking stability 3=Started proving run 4=Finished proving run 5=Waiting user input data 6=Calculate MF 7=Repeatability accepted and waiting acknowledgement 8=Transferring data 9=Using new MF(Wr) 10=Repeatability not satisfied 11=Acknowledgment timeout 12=Unacceptable conditions 13=Save report of failed proving(Wr) 14=Abort(Wr) 15=One proving run(Wr) 16=Proving run timeout 17=Finished forward pass 18=Started backward pass 19 = Waiting BPV tank prover input(Wr) 20 = Ack BPV tank prover input(Wr) 21=Adjusting plenum pressure 22=Force backward (Wr) 23=Moving backward 24=Moved backward	0	E	D	Indicate the proving situation. When the state is Waiting user input data, it means any data supplied by the user must be supplied to calculate the MF. If the REQ_ACK was configured to Ack to new MF and the state is "Repeatability accepted and waiting acknowledgement", the operator must type Using new MF to initiate the use of the new MF. This acknowledgement must occur before timeout. When the repeatability is not satisfied, the user has the option to execute a new proving run and reject the last. The option "One proving run" also can be used for executing the proving in an interactive form.
41	1 OPx	PROVING_RUN 3xx.x21	Unsigned8		0	Na	D / RO	Show the proving run number in execution. For unidirectional provers indicate one running. For bidirectional provers indicate one whole running (start and back).

Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
42 (A2)	OP2	BPV_TANK_PROVER 4xx.x51 - 4xx.x82	Float[16]	> 0.0	0.0	LV	D	This parameter is used only when the selected prover is Tank Prover type. The user must calculate the difference between the reading for upper scale (Sru – volume before running) and lower scale (volume at the end of running) and must be written when the PROVING_STATE is “Waiting user input data”.
43	1 MN	LIQ_WARN 3xx.x22	Bitstring[2]	See WARN description	0	E	N / RO	Warning events occurred.
44	MN	T1 3xx.x23 - 3xx.x52	Float[15]			Sec	N / RO	T1 corresponding to each running.
45	MN	T2 3xx.x53 - 3xx.x82	Float[15]			Sec	N / RO	T2 corresponding to each running (time within detectors)
46	OPx	NM 3xx.x83 - 3xx.112	Float[15]				N / RO	Pulse number corresponding to each running for meter submitted to proving (operational or master meter).
47	MN	N_INTERPOLATED 3xx.113 - 3xx.150	Float[19]	> 0.0	0.0		D / RO	Interpolate pulse numbers corresponding to each running for meter submitted to proving (operational or master meter).
48	MN	AVERAGE_FREQ 3xx.151 - 3xx.180	Float[15]			Hz	N / RO	Average frequency corresponding to each running for meter submitted to proving (operational or master meter).
49	OPx	TWA_PROVER 3xx.181 - 3xx.212	Float[16]		0.0	T	D / RO	Weighted average temperature of the prover liquid or master meter (indirect proving) corresponding to each running.
50	OPx	PWA_PROVER 3xx.213 - 3xx.244	Float[16]	> 0.0	0.0	P	D / RO	Weighted average pressure of prover liquid or master meter (indirect proving) corresponding to each running.
51	OPx	DWA_PROVER 3xx.245 - 3xx.276	Float[16]	> 0.0	0.0	LD	D / RO	Weighted average flowing density of prover liquid or master meter (indirect proving) corresponding to each running.
52	OP1	TWA_EXTERNAL_SHAFT 3xx.277 - 3xx.308	Float[16]		0.0	T	D / RO	Weighted average temperature of the shaft in where are the detectors corresponding to each running.
53	OP2	N_MM 3xx.309 - 3xx.340	Float[16]	> 0.0	0.0		D / RO	Master meter pulse number in the indirect proving.
54	OPx	TWA_METER 3xx.341 - 3xx.372	Float[16]		0.0	T	D / RO	Weighted average temperature of meter liquid submitted to the proving (operational or master meter) corresponding to each running.
55	OPx	PWA_METER 3xx.373 - 3xx.404	Float[16]	> 0.0	0.0	P	D / RO	Weighted average pressure of meter liquid submitted to the proving (operational or master meter) corresponding to each running.
56	OPx	DWA_METER 3xx.405 - 3xx.436	Float[16]	> 0.0	0.0	LD	D / RO	Weighted average flowing density of meter liquid submitted to the proving (operational or master meter) corresponding to each running.
57	OP2	IVMM 3xx.437 - 3xx.468	Float[16]	> 0.0	0.0	LFLOW_TYPE of selected meter: LV or M	D / RO	Volume indicated of the master meter in indirect proving, if the meter is volume. Mass Indicated (IMmm) in master meter, if the meter is mass.

Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
58	OP1	CTSP 3xx.469 - 3xx.500	Float[16]	> 0.0	0.00000		D / RO	Correction in temperature effect in steel in the prover. When "average data" is selected, only the last array element is used.
59	OP1	CPSP 3xx.501 - 3xx.532	Float[16]	> 0.0	0.00000		D / RO	Correction in pressure in steel in the prover. When selected "average data" only the last array element is used.
60	OPx	CTLP 3xx.533 - 3xx.564	Float[16]	> 0.0	0.00000		D / RO	Correction in liquid hydrocarbon temperature in prover or master meter (indirect proving). When selected "average data" only the last array element is used.
61	OPx	CPLP 3xx.565 - 3xx.596	Float[16]	> 0.0	0.00000		D / RO	Correction in liquid hydrocarbon compressibility in prover or master meter (indirect proving). When selected "average data" only the last array element is used.
62	OPx	CTL_W_P 3xx.597 - 3xx.628	Float[16]	0=Custody transfer > 0.0 : Allocation measurement	0		N / RO	Temperature correction factor in water volume for prover or master meter (indirect proving). This parameter is calculated based on the water base density that should be configured in the PRODUCTxINFO parameter.
63	OPx	CPL_W_P 3xx.629 - 3xx.660	Float[16]	0=Custody transfer > 0.0 : Allocation measurement	0		N / RO	Correction factor of the pressure effect in volume of water for prover or master meter (indirect proving) that is calculated using the average pressure for each proving run.
64	OPx	GSVP 3xx.661 - 3xx.692	Float[16]	> 0.0	0.0	LFLOW _TYPE of selected meter: LV or M	D / RO	Gross volume compensated for prover or master meter (indirect proving). When selected "average data" only the last array element is used. Indicates mass in prover if mass meter.
65	MN	NKF_METER 3xx.693 - 3xx.724	Float[16]	> 0.0	0.0	LFLOW _TYPE of selected meter: LV or M	D / RO	Meter NKF submitted to the proving (operational or master meter) in each proving run for linearization related to the frequency. When selected "average data", the last element is the average.
66	OPx	IVM 3xx.725 - 3xx.756	Float[16]	> 0.0	0.0	LFLOW _TYPE of selected meter: LV or M	D / RO	Meter indicated volume submitted to the proving (operational or master meter). Indicates mass in meter if mass meter.
67	OPx	CTLM 3xx.757 - 3xx.788	Float[16]	> 0.0	0.00000		D / RO	Effect temperature correction of the temperature for meter submitted to the proving (operational or master meter). When the "average data" is selected, only the first matrix element is used.
68	OPx	CPLM 3xx.789 - 3xx.820	Float[16]	> 0.0	0.00000		D / RO	Compressibility correction factor of the liquid hydrocarbon for meter submitted to the proving (operational or master meter). When the "average data" is selected, only the last array element is used.

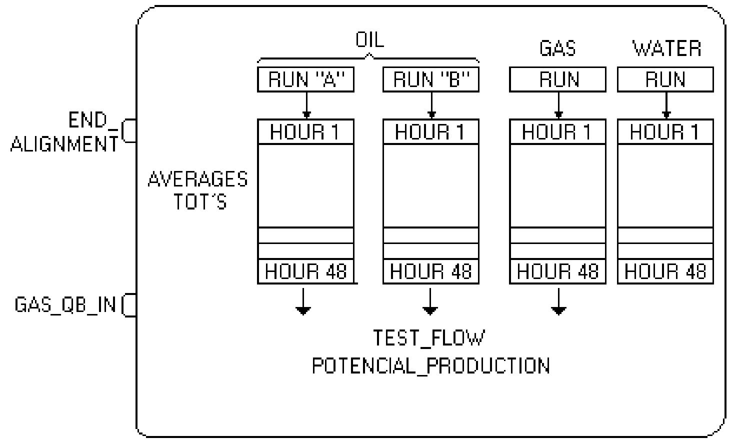
Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
69	OPx	CTL_W_M 3xx.821 - 3xx.852	Float[16]	0=Custody transfer > 0.0 : Allocation measurement	0		N / RO	Temperature correction factor in water volume for meter submitted to the proving (operational or master meter). It is calculated based on the water base density that must be configured in the PRODUCTxINFO parameter.
70	OPx	CPL_W_M 3xx.853 - 3xx.884	Float[16]	0=Custody transfer > 0.0 : Allocation measurement	0		N / RO	Correction factor of the pressure effect in volume of water for meter submitted to the proving (operational or master meter), that is calculated using the average pressure for each proving run.
71	OPx	ISVM 3xx.885 - 3xx.916	Float[16]	> 0.0	0.0	LV	D / RO	Standard volume indicated for proving in volume operations for meter submitted to the proving (operational or master meter). When the "average data" option is selected, only last array element is used.
72	3 OPx	IMF 3xx.917 - 3xx.954	Float[19]	> 0.0	0.0		D / RO	Intermediate MF obtained in each proving run. When the METER_FACTOR_METHOD is "average MF".
73	1 OPx	MF 3xx.955 - 3xx.956	Float	0.8 to 1.2	1.0		D / RO	Meter factor. If the MF calculated is accepted, the proving basic information will be stored in the LKD block.
74	1 OPx	CMF 3xx.957 - 3xx.958	Float	> 0.0	0.0		D / RO	Composite meter factor (MF * CPL)
75	1 OPx	MA 3xx.959 - 3xx.960	Float	> 0.0	0.0		D / RO	Meter accuracy (1 / MF).
76	1 OPx	KF 3xx.961 - 3xx.962	Float	> 0.0	0.0	LFLOW _TYPE of selected meter: p/LV or p/M	D / RO	K calculated factor, pulses by volume unit (NKF/MF).
77	1 OPx	CKF 3xx.963 - 3xx.964	Float	> 0.0	0.0	LFLOW _TYPE of selected meter: p/LV or p/M	D / RO	Composed K factor, given in pulses by volume or mass unit (KF/CPL)
78	1 OPx	REPEATABILITY 3xx.965 - 3xx.966	Float		0.0	%	D / RO	Repeatability of the proving session.

Idx	Type/ View	Parameter	Data type (length)	Valid Range/ Options	Default Value	Units	Store/ Mode	Description
79	1 OPx, MN	PROV_FAIL_CAUSE 3xx.967 - 3xx.968	Unsigned32	0= OK 1= bad flow sensor 2 = repeatability not achieved 3 = out-of-range correction factor 4=too large variation of MF 5= abnormal proving 6=proving run timeout 7= T2 start timeout 8= T1 start timeout 9= T2 stop timeout 10= T1 stop timeout 11= invalid pulse input selected 12= pulse input error 13= bad plenum pressure	0	E	D / RO	Proving failure cause.
80		UPDATE_EVT 3xx.969 – 3xx.975 4xx.x83	DS-73			Na	D	This alert associated to this parameter is generated by any change to the data static.
81		BLOCK_ALM 3xx.976 – 3xx.982 4xx.x84	DS-72			Na	D	The block alarm is used for all configuration, hardware, and connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.
82	CF	METER_ALIGN_DATE_TIME 4xx.85 – 4xx90	Date				N	Date and time of alignment to the meter to be proved.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read only; D – Dynamic; N – non-volatile;
S – Static; I – Input Parameter; O-Output Parameter
AA-Administrator Level A1 – Level 1; A2 – Level 2
RA –Restriction to Administration; R1 – Restriction Level 1; R – Restriction level 2
CL = 73 bytes (includes block tag and profile); V1-97 bytes; V2-27 bytes; V3-72 bytes; V4-5 bytes;
HFCView: OPx (OP1, OP2), OP1 (Operation - Prover), OP2 (Operation – Master Meter), CF (Configuration), MN (Maintenance)

WT – Well Test

Schematic



Description

This block is used in the well test and it is executed in parallel to custody transfer or allocation measurement. The purpose is the evaluation of a well production by calculating the well test flow rate, potential of production and RGO (gas/oil ratio) for allocation of production to the wells in shared measurement system.

The calculation for oil and natural gas correction factors and the totalizations and QTR reports generation are executed by specific blocks.

Through this block, the well test begins and ends, so it generates a well test report, whose final results are the well test flow rates corresponding to oil, gas and water.

If the duration of the well test is longer than 48 hours, only the last 48 hours will be registered and considered in the test flow rate calculations.

Block input

The block input is used according to the configuration, as showed below:

Input	Link Necessity	Description
END_ALIGNMENT	Depends on the application	This input can inform that the well alignment process was concluded.

There are two ways to indicate the ending for the well alignment:
• Through the END_ALIGNMENT input or
• The user provides the date/time in the ALIGN_DATE_TIME parameter.

Field and well identifications

The field and well identifications are accomplished through the FIELD_NAME and WELL_ID parameters, these parameters are also used in the well test report generation.

Runs associated to the well test

OIL_STATION_EQUATION parameter: this block is prepared for up to two oil/emulsion measurements, the sum of runs associated to the well must be written in this parameter. Or simply, the run number.

The equation that defines the operation to be accomplished between the runs must obey the following rules:

- Allowed operations: sum (+) and subtract (-).
- Only one operation is allowed.
- If the first character is blank, no operation will be accomplished.
- The writing in the STATION_EQUATION parameter will be checked about consistency.
- Blank equation means disabled crude oil measurement in the well test.

  - Run number of liquid measurement.
  - The block used in the measurement must be the LT;
  - The measured product in each run is a combination of:
    - Crude oil and/or emulsion of crude oil and water.
    - Light hydrocarbon and/or emulsion of light hydrocarbon and water.
- During the block execution also will be checked the equation consistency, and any problem will be indicated in BLOCK_ERR.Block Configuration Error;
- Example :
  - 1+2
  - 3 -1
  - 1+1

GAS_RUN_NUMBER parameter: indicates the run number of gas measurement. If this parameter has value 0, the gas measurement will be ignored in the well test.

WATER_RUN_NUMBER parameter: indicates the run number of water measurement. If this parameter has value 0, the water measurement will be ignored in the well test.

Open and close date/time of the well test
The date/time indication of the start and end of the well test is through the OPEN_DATE_TIME and CLOSE_DATE_TIME parameters. The NUM_HOURS parameter shows the duration in number of hours.

Crude oil/light hydrocarbon/emulsion measurement
The first oil/emulsion measurement indicated in the OIL_STATION_EQUATION parameter (the first number from left to right) will be processed and indicated in this block as OIL1. If there is the second oil/emulsion measurement, this will be indicated as OIL2. For each one of the oil/emulsion measurement, the following calculations are accomplished:

- Temperature, pressure, density and BSW: instantaneous values when openning and closing the well test, weighted averages for each hour.
- Hourly totalizers of the indicated volume, gross standard volume and net standard volume.

At the end of well test, there are the totalizers in gross corrected volume (GSV) and net corrected volume (NSV) correspondent to the equation described in OIL_STATION_EQUATION parameter; it is the sum of the hourly totalizers for each stream and then the sum with the other stream, if it is the case.

During the well test is accomplished a status processing, as indicated below:
• LIQ_WARN parameter: status during the usual conditions evaluation, that is, indicates if any problem occurred in any moment during the usual conditions evaluation.
• LIQ_CURRENT_WARN parameter: current status of the crude oil measurements.
• LIQ_TEST_WARN parameter: status during the well test, it does not consider the phases of the well alignment, warm up period, usual conditions evaluation period.

This status word provides the following information:

- Override temperature meter;
- Override pressure meter;
- Override density meter;
- Bad temperature master meter;
- Bad pressure master meter;
- Bad density master meter;
- Unstable temperature meter;
- Unstable pressure meter;
- Unstable density meter;
- Unstable temperature master meter;
- Unstable pressure master meter;
- Unstable density master meter;
- Unstable SW;
- Unstable volume flow at base.

The standards applied to the crude oil measurement calculation are indicated in LIQ_SPEC_1 and LIQ_SPEC_2 parameters.

Gas measurement

For the gas measurement produced, the following calculations are accomplished:

- Temperature and absolute static pressure: instantaneous values at the beginning and ending of the well test, weighted averages for each hour.
- Hourly totalizers of the volume flow rate at flowing conditions (Qv), volume flow rate at base conditions (Qb) and mass flow rate (Qm).

At the end of the well test, there are volume totalizers at flowing conditions (TOT_QV) and at base conditions (TOT_QB), and also mass totalization (TOT_QM) correspondent to the measured flow indicated in GAS_RUN_NUMBER parameter; they are the sum of the hourly totalizers during the well test.

During the well test, a status processing is accomplished, as indicated below:

- GAS_WARN parameter : status during the usual conditions evaluation, that is, indicates if any problem occurred in any moment during the usual condition evaluation.
- GAS_CURRENT_WARN parameter : current status of the gas measurement.
- GAS_TEST_WARN parameter : status during the well test, it does not consider the well test alignment, warm up period, usual conditions evaluation phases.

The information contained in these status words are:

- Override temperature meter;
- Override pressure meter;
- Unstable temperature meter;
- Unstable pressure meter;
- Unstable volume flow at base;
- Bad GAS_QB_IN.

The gas composition produced used for the calculations is indicated in the GAS_PRODUCT parameter. The standards applied to the gas measurement are indicated in GAS_SPEC_1 parameter.

This block also offers the option to execute the operation with another gas measurement (before calculating the RGO, well test flow rate and potential of production) in the following situations:

  - GAS_OPERATION=None: this option is used when there is no necessity of subtracting or adding another gas flow (GAS_RUN_NUMBER);
  - GAS_OPERATION= Subtract GAS_QB_IN: the injected gas is subtracted from the produced gas, calculating the net produced gas;
  - GAS_OPERATION= Add GAS_QB_IN: if another gas measurement is required due to the rangeability, it is possible to execute the sum with the volume flow rate at base condition indicated in GAS_QB_IN input.

The hourly totalizers of gas, after the operation indicated in GAS_OPERATION parameter, are showed in NET_QB_HOUR1 and NET_QB_HOUR2 parameters, as well as the total during the test (NET_TOT_QB). These values can be negative, when the “Subtract GAS_QB_IN” option is selected, so they indicate that the injected volume of gas is higher than the produced.

Water measurement

For water measurement, the hourly totalizers of the volume flow rate at base conditions are corrected in temperature and pressure.

At the end of the well test, there is the totalizer in volume at base condition (WATER_GSV) correspondent to the measured flow indicated in WATER_RUN_NUMBER parameter; it is the sum of the hourly totalizers during the well test, added the water of the emulsion.

During the well test a status processing is accomplished, as showed below:

- WATER_WARN parameter: status during the usual conditions evaluation, that is, indicates if any problem occurred in any moment during the usual conditions evaluation.
- WATER_CURRENT_WARN parameter: current status of the water measurement.
- WATER_TEST_WARN parameter: status during the well test, it does not consider the phases of well alignment, warm up period, usual conditions evaluation period.

The information contained in these status words are:

- Override temperature meter;
- Override pressure meter;
- Override density meter;

- Unstable temperature meter;
- Unstable pressure meter;
- Unstable density meter;
- Unstable volume flow at base.

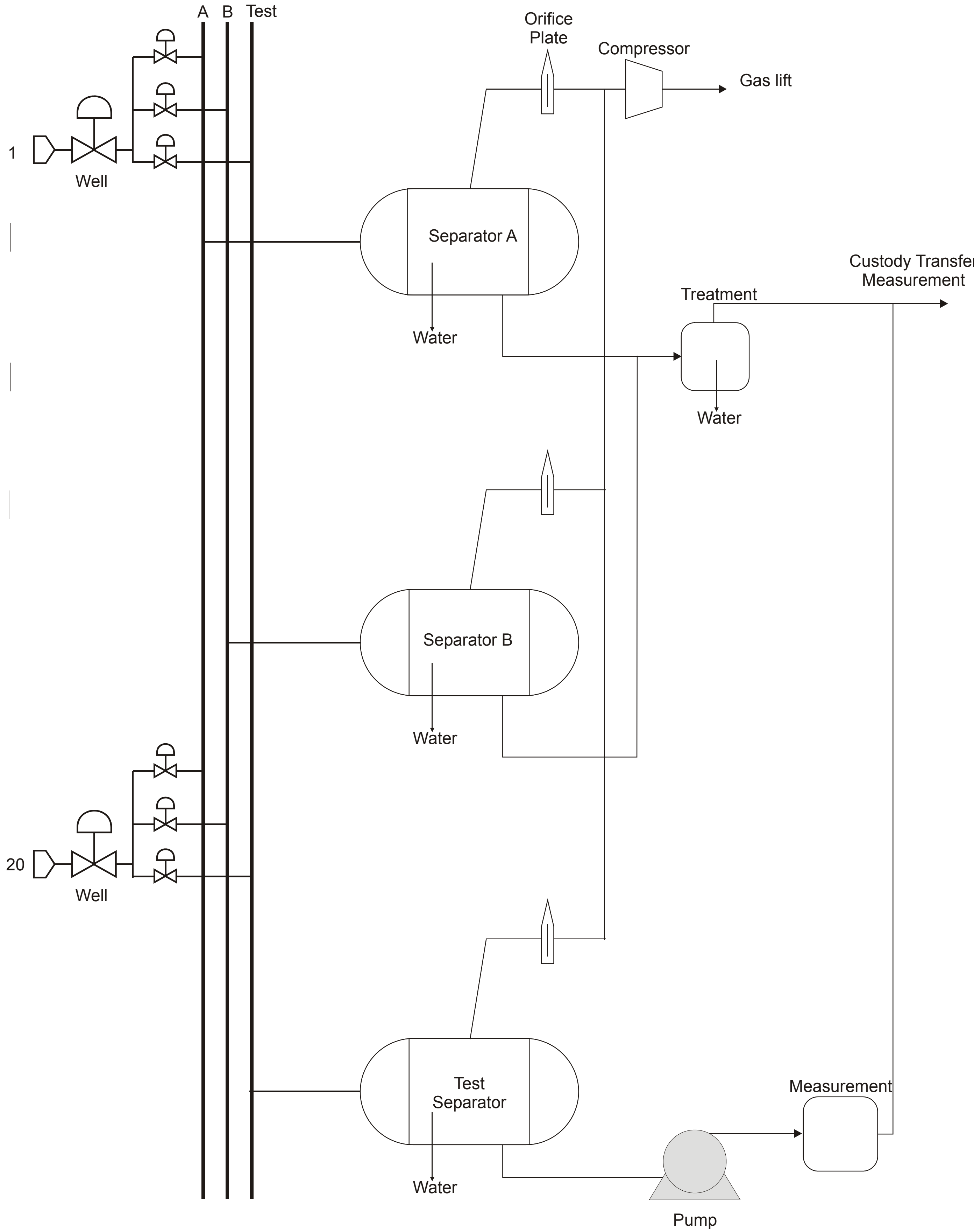
Duration the well test phases
The WELL_TEST_TIME parameter indicates the current phase of the well test:
• When WELL_STATE = Waiting start of usual conditions: indicates the warm up period, that is, after the well alignment and before the usual conditions evaluation.
• When WELL_STATE = Evaluating usual conditions: indicates the usual conditions evaluation period, that is, after the warm up and before the well test.
• When WELL_STATE = Calculating: indicates the well test period, that is, after the usual conditions evaluation.

The time computed during the "Calculating" phase, the duration of the well test, is used in the crude oil, gas and water test flow rate calculation.

Final results
The final results of well are:
• OIL_TEST_FLOW parameter: It is the net standard volume flow rate at base conditions (per hour), corresponds to the oil totalizer (NSV parameter) divided by the well test duration in hours.
• GAS_ TEST_FLOW parameter: It is the standard volume flow rate at base conditions (per hour), it corresponds to the gas totalizer (NET_TOT_QB parameter) divided by the well test duration in hours.
• WATER_ TEST_FLOW parameter: It is the volume flow rate at base condition (per hour), it corresponds to the water totalizer (WATER_GSV parameter) divided by the well test duration in hours.

Other calculated variables are:
• OIL_POTENTIAL_PRODUCTION: It is the net standard volume flow rate at base conditions per day.
• GAS_POTENTIAL_PRODUCTION: It is the standard volume flow rate at base condition per day.
• WATER_POTENTIAL_PRODUCTION : It is water volume flow at base condition per day.
• TOTAL_POTENTIAL_PRODUCTION : It is volume flow at base condition of oil plus water per day.
• RGO: It is the ratio between the gas volume at base conditions and the oil volume at base conditions during the test; it corresponds to the division of the TOT_QB parameter by NSV.
• AVG_BSW : Medium BSW of the test considering the two oil flow.

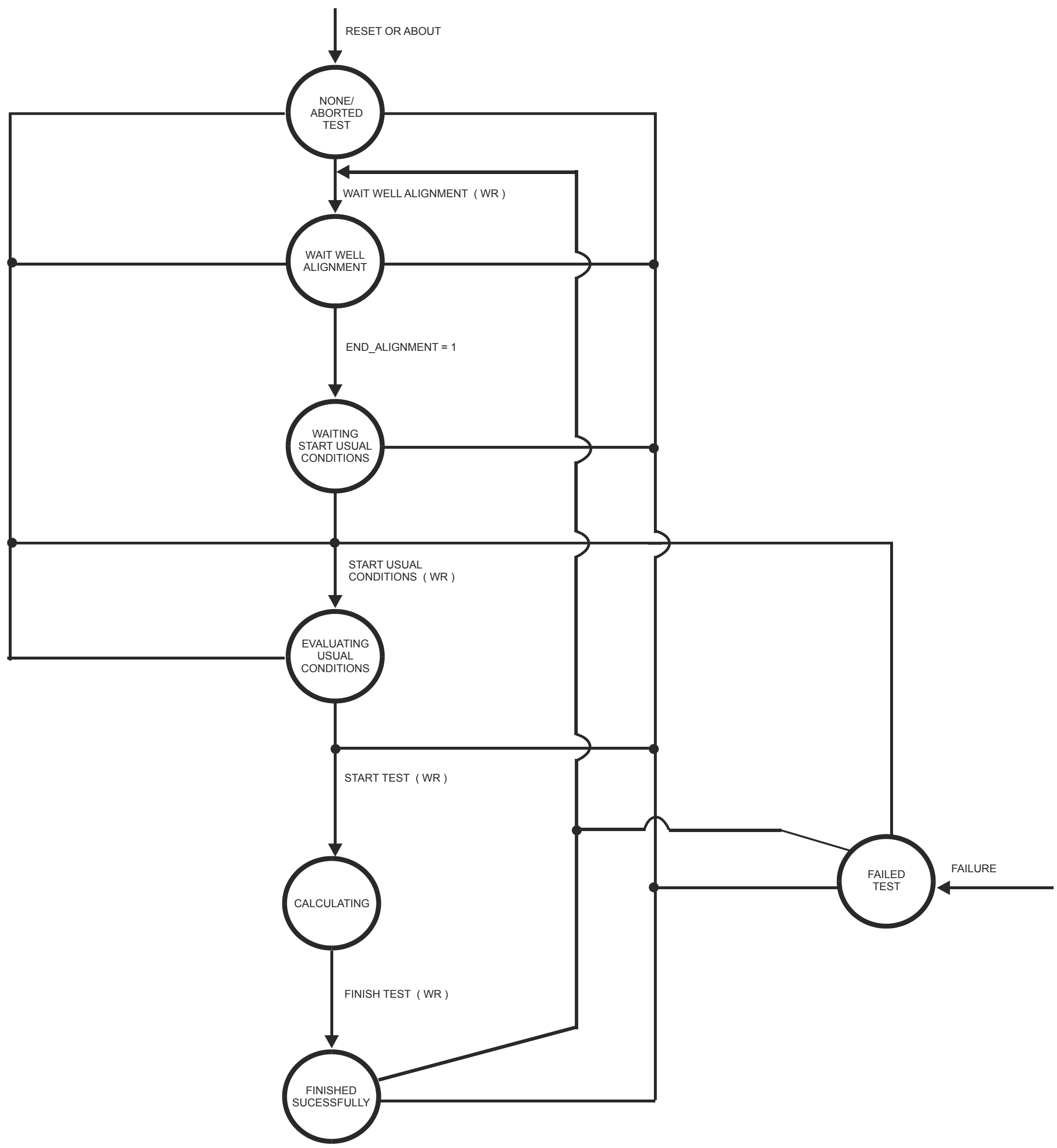
Block application
The below example shows a typical application of this block with the following features:
• Shared measurement: measurement system measuring oil/gas of different wells.
• Well test flow rate used as factor to allocate the production in shared measurement.
• Two production separators (A and B): it separates the water, oil and gas of the production (mixed of many wells).
• Test separator: It separates the water, oil and gas of the well which is aligned to the well test.


A
B
Test
Orifice
Plate
Compressor
Gas lift
1
Well
Separator A
Water
Custody Transfer
Measurement
Treatment
Water
Separator B
Water
20
Well
Test
Separator
Water
Measurement
Pump

Operation during the well test

The well test state diagram shows the following features:

- The well test process is composed of the following sequential phases: well alignment, warm up, usual condition evaluation and well test.
- The beginning of the well test phase can occur at any moment, except if a well test is already executing.
- The test begins when writing in the TEST_STATE parameter:
  - Start Test (Wr) : the beginning of hourly variables occurs at the beginning of each hour of the real time clock (RTC);
  - Start Test 60 minutes (Wr) : the hourly variables are related to the 60 minutes in sequence, therefore except for the last hour, the others have 60 minutes of duration.
- The finish of well test will be when writing "Finish Test (Wr)" by user.



Diagnosis and Troubleshooting

1. BLOCK_ERR. Block configuration: this indication occurs when there are the following problems and causes the change of state for "Aborted test":

• A run number indicated in OIL_STATION_EQUATION parameter is not associated to the crude oil/light hydrocarbon /emulsion measurement by the LT block or the LT block is in O/S.

• There is no gas measurement in the run number indicated by GAS_RUN_NUMBER parameter or the GT block is in O/S;

• The run number indicated in WATER_RUN_NUMBER parameter is not associated to the water measurement by the LT block or the LT block is in O/S.
2. BLOCK_ERR. Out of Service: the WT block can continue in the Out of service mode, although the target mode is Auto because the Resource block is in O/S.

Supported Modes
O/S and AUTO.

Parameters

Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3	4	STRATEGY 3xx.xx0	Unsigned16	255	255	None	S / RO	
4	4	ALERT_KEY 4xx.xx0	Unsigned8	1 to 255	0	None	S	
5 (A2)(CL)	1,3 CF	MODE_BLK Target/Normal - 4xx.xx1-4xx.xx3 Actual - 3xx.xx1	DS-69		Auto	Na	S	Refer to the Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx2	Bitstring(2)			E	D / RO	
7	I,1 OPx	END_ALIGNMENT 4xx.xx4 - 4xx.xx5	DS-66				N	When it is TRUE, this input indicates the alignment ending for the well to be tested.
8	I,1 OP3	GAS_QB_IN 3xx.xx3 -3xx.xx5	DS-65			QV	N / RO	Volume flow in base condition to be additioned or subtracted of the gas flow indicated in GAS_RUN_NUMBER parameter.
9 (CL)	2 CF	FIELD_NAME 4xx.xx6 - 4xx.x21	Visiblestring[32]		Blank		S	String to identify the field well. It is used in report generation.
10 (CL)	2 CF	WELL_ID 4xx.x22 - 4xx.x37	Visiblestring[32]		Blank		S	String to identify the well that will be tested. It will be used in report generation.
11 (A2)(CL)	2 CF	OIL_STATION_EQUATION 4xx.x38 - 4xx.x45	Visiblestring[16]		Blank		S	Liquid station equation. When it is initialized by a blank character, it will not accomplish any operation. It supports an equation with up to two flow measurements. The writing is allowed in this parameter since the well test is not in operation.
12(A2) (CL)	2 CF	GAS_RUN_NUMBER 4xx.x46	Unsigned16	0 to 4	0	Na	S	Number of the gas flow. If it was zero, the gas measurement will be ignored in this well test. The writing is allowed since the well test is not in operation.
13 (A2) (CL)	2 CF	GAS_OPERATION 4xx.x47	Unsigned8	0=None 1=Subtract GAS_QB_IN 2=Add GAS_QB_IN	0	E	S	Indicates the operation to be performed between the measured gas (GAS_RUN_NUMBER) and the input GAS_QB_IN.
14 (A2)(CL)	2 CF	WATER_RUN_NUMBER 4xx.x48	Unsigned16	0 to 4	0	Na	S	Number of the water flow. I was zero; the water measurement will be ignored in this well test. The writing is allowed since the well test is not in operation.

Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
15	1 OPx	TEST_STATE 4xx.x49	Unsigned8	0=none 1=Wait well alignment (Wr) 2=Waiting start of usual conditions 3=Start usual conditions (Wr) 4=Evaluating usual conditions 5=Start test (Wr) 6=Calculating 7=Finish test (Wr) 8=Finished successfully 9=Abort (Wr) 10=Aborted test 11=Failed test 12=Start test 60minutes (Wr)	0	E	D	This parameter is used to start and abort the well test, and also to indicate the test state or failure.
16	1 OPx	ALIGN_DATE_TIME 4xx.x50 – 4xx.x55	Date				N	Date/hour of the alignment for the well in test.
17	1 OPx	OPEN_DATE_TIME 3xx.xx6 – 3xx.x11	Date				N / RO	Date/hour of the beginning of the actual test. After the warm up period.
18	1 OPx	CLOSE_DATE_TIME 3xx.x12 – 3xx.x17	Date				N / RO	Date/hour of the ending of the actual test.
19	1 OPx	NUM_HOURS 3xx.x18	Unsigned16		0	Na	N / RO	Number of hourly periods of information collect.
20	1 MN	LIQ_WARN 3xx.x19	Bitstring[2]	See WARN description	0	E	N / RO	Events occurred during the usual condition evaluation.
21	1 MN	LIQ_CURRENT_WARN 3xx.x20	Bitstring[2]	See WARN description	0	E	N / RO	Events at the moment.
22	1 MN	LIQ_TEST_WARN 3xx.x21	Bitstring[2]	See WARN description	0	E	N / RO	Events occurred during the well test.
23	1 MN	GAS_WARN 3xx.x22	Bitstring[2]	See WARN description	0	E	N / RO	Events occurred during the usual condition evaluation.
24	1 MN	GAS_CURRENT_WARN 3xx.x23	Bitstring[2]	See WARN description	0	E	N / RO	Events at the moment.
25	1 MN	GAS_TEST_WARN 3xx.x24	Bitstring[2]	See WARN description	0	E	N / RO	Events occurred during the well test.
26	1 MN	WATER_WARN 3xx.x25	Bitstring[2]	See WARN description	0	E	N / RO	Events occurred during the usual condition evaluation.
27	1 MN	WATER_CURRENT_ WARN 3xx.x26	Bitstring[2]	See WARN description	0	E	N / RO	Events at the moment.
28	1 MN	WATER_TEST_WARN 3xx.x27	Bitstring[2]	See WARN description	0	E	N / RO	Events occurred during the well test.

Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
29	3 OP1	OPEN_OIL1_TEMP 3xx.x28 - 3xx.x29	Float		0	T	N / RO	Temperature of the first oil flow at the beginning of the well test.
30	OP1	OIL1_TWA_HOUR1 3xx.x30 - 3xx.x77	Float[24]		0.0's	T	N / RO	Temperature weighted average of the first oil flow for each hour of test during the first day (the first 24 hours).
31	OP1	OIL1_TWA_HOUR25 3xx.x78 - 3xx.125	Float[24]		0.0's	T	N / RO	Temperature weighted average of the first oil flow for each hour of test during the second day (the next 24 hours).
32	3 OP1	CLOSE_OIL1_TEMP 3xx.126 - 3xx.127	Float		0	T	N / RO	Temperature of the first oil flow at the end of the well test.
33	3 OP1	OPEN_OIL1_PRESS 3xx.128 - 3xx.129	Float		0	P	N / RO	Pressure of the first oil flow at the beginning of the well test.
34	OP1	OIL1_PWA_HOUR1 3xx.130 - 3xx.177	Float[24]		0.0's	P	N / RO	Pressure weighted average of the first oil flow for each hour of test during the first day (the first 24 hours).
35	OP1	OIL1_PWA_HOUR25 3xx.178 - 3xx.225	Float[24]		0.0's	P	N / RO	Pressure weighted average of the first oil flow for each hour of test during the second day (the next 24 hours).
36	3 OP1	CLOSE_OIL1_ PRESS 3xx.226 - 3xx.227	Float		0	P	N / RO	Pressure of the first oil flow at the end of the well test.
37	3 OP1	OPEN_OIL1_DENS 3xx.228 - 3xx.229	Float		0	LD	N / RO	Flowing density of the first oil flow at the beginning of the well test.
38	OP1	OIL1_DWA_HOUR1 3xx.230 - 3xx.277	Float[24]		0.0's	LD	N / RO	Flowing density weighted average of the first oil flow for each hour of test during the first day (the first 24 hours).
39	OP1	OIL1_DWA_HOUR25 3xx.278 - 3xx.325	Float[24]		0.0's	LD	N / RO	Flowing density weighted average of the first oil flow for each hour of test during the second day (the next 24 hours).
40	3 OP1	CLOSE_OIL1_DENS 3xx.326 - 3xx.327	Float		0	LD	N / RO	Flowing density of the first oil flow at the end of the well test.
41	3 OP1	OPEN_OIL1_SW 3xx.328 - 3xx.329	Float		0	%	N / RO	SW of the first oil flow at the beginning of the well test.
42	OP1	OIL1_SWWA_HOUR1 3xx.330 - 3xx.377	Float[24]		0.0's	%	N / RO	SW weighted average of the first oil flow for each hour of test during the first day (the first 24 hours).
43	OP1	OIL1_SWWA_HOUR25 3xx.378 - 3xx.425	Float[24]		0.0's	%	N / RO	SW weighted average of the first oil flow for each hour of test during the second day (the next 24 hours).
44	3 OP1	CLOSE_OIL1_SW 3xx.426 - 3xx.427	Float		0	%	N / RO	SW of the first oil flow at the ending of the well test.
45	OP1	OIL1_IV_HOUR1 3xx.428 - 3xx.475	Float[24]		0	TV	N / RO	IV of the first oil flow for each hour of test during the first day (the first 24 hours).
46	OP1	OIL1_IV_HOUR25 3xx.476 - 3xx.523	Float [24]		0	TV	N / RO	IV of the first oil flow for each hour of test during the second day (the next 24 hours).
47	3 OP2	OPEN_OIL2_TEMP 3xx.524 - 3xx.525	Float		0	T	N / RO	Temperature of the second oil flow at the beginning of the well test.

Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
48	OP2	OIL2_TWA_HOUR1 3xx.526 - 3xx.573	Float[24]		0.0's	T	N / RO	Temperature weighted average of the second oil flow for each hour of test during the first day (the first 24 hours).
49	OP2	OIL2_TWA_HOUR25 3xx.574 - 3xx.621	Float[24]		0.0's	T	N / RO	Temperature weighted average of the second oil flow for each hour of test during the second day (the next 24 hours).
50	3 OP2	CLOSE_OIL2_TEMP 3xx.622 - 3xx.623	Float		0	T	N / RO	Temperature of the second oil flow at the ending of the well test.
51	3 OP2	OPEN_OIL2_PRESS 3xx.624 - 3xx.625	Float		0	P	N / RO	Pressure of the second oil flow at the beginning of the well test.
52	OP2	OIL2_PWA_HOUR1 3xx.626 - 3xx.673	Float[24]		0.0's	P	N / RO	Weighted average of the pressure of the second oil flow for each hour of test during the first day (the first 24 hours).
53	OP2	OIL2_PWA_HOUR25 3xx.674 - 3xx.721	Float[24]		0.0's	P	N / RO	Pressure weighted average of the pressure of the second oil flow for each hour of test during the second day (the next 24 hours).
54	3 OP2	CLOSE_OIL2_ PRESS 3xx.722 - 3xx.723	Float		0	P	N / RO	Pressure of the second oil flow at the end of the well test.
55	3 OP2	OPEN_OIL2_DENS 3xx.724 - 3xx.725	Float		0	LD	N / RO	Flowing density of the second oil flow at the beginning of the well test.
56	OP2	OIL2_DWA_HOUR1 3xx.726 - 3xx.773	Float[24]		0.0's	LD	N / RO	Flowing density weighted average of the second oil flow for each hour of test during the first day (the first 24 hours).
57	OP2	OIL2_DWA_HOUR25 3xx.774 - 3xx.821	Float[24]		0.0's	LD	N / RO	Flowing density weighted average of the second oil flow for each hour of test during the second day (the next 24 hours).
58	3 OP2	CLOSE_OIL2_DENS 3xx.822 - 3xx.823	Float		0	LD	N / RO	Flowing density of the second oil flow at the end of the well test.
59	3 OP2	OPEN_OIL2_SW 3xx.824 - 3xx.825	Float		0	%	N / RO	SW of the second oil flow at the beginning of the well test.
60	OP2	OIL2_SWWA_HOUR1 3xx.826 - 3xx.873	Float[24]		0.0's	%	N / RO	SW weighted average of the second oil flow for each hour of test during the first day (the first 24 hours).
61	OP2	OIL2_SWWA_HOUR25 3xx.874 - 3xx.921	Float[24]		0.0's	%	N / RO	SW weighted average of the second oil flow for each hour of test during the second day (the next 24 hours).
62	3 OP2	CLOSE_OIL2_SW 3xx.922 - 3xx.923	Float		0	%	N / RO	SW of the second oil flow at the ending of the well test.
63	OP2	OIL2_IV_HOUR1 3xx.924 - 3xx.971	Float [24]		0	TV	N / RO	IV of the second oil flow for each hour of test during the first day (the first 24 hours).
64	OP2	OIL2_IV_HOUR25 3xx.972 - 3x1.019	Float [24]		0	TV	N / RO	IV of the second oil flow for each hour of test during the second day (the next 24 hours).
65	OP1, OP2	OIL_TWA 3x1.020 – 3x1.023	Float [2]		0.0	T	N / RO	Temperature weighted average of the oil flow test.
66	OP1, OP2	OIL_PWA 3x1.024 – 3x1.027	Float [2]		0.0	P	N / RO	Pressure weighted average of the oil flow test.

Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
67	OP1, OP2	OIL_DWA 3x1.028 – 3x1.031	Float [2]		0.0	LD	N / RO	Flowing density weighted average of the oil flow test.
68	OP1, OP2	OIL_SWWA 3x1.032 – 3x1.035	Float [2]		0.0	%	N / RO	SW weighted average of the oil flow test.
69	OP1, OP2	VISCOSITY 3x1.036 – 3x1.039	Float[2]		0.0	Visc	N / RO	Viscosity of the measured oil.
70	OP1, OP2	OIL_BASE_DENSIT Y 3x1.040 – 3x1.043	Float [2]		0.0	LD	N / RO	Base density of the oil flow test.
71	OP1, OP2	OIL_CTL 3x1.044 – 3x1.047	Float [2]		0.0	Na	N / RO	Temperature correction factor with base in weighted average of the oil flow input parameters.
72	OP1, OP2	OIL_CPL 3x1.048 – 3x1.051	Float [2]		0.0	Na	N / RO	Pressure correction factor with base in weighted average of the oil flow input parameters.
73	OP1, OP2	OIL_MF 3x1.052 – 3x1.055	Float [2]		1.0	Na	N / RO	MF of the oil flow.
74	OP1, OP2	OIL_SF 3x1.056 – 3x1.059	Float [2]		1.0	Na	N / RO	Shrinkage factor of the oil flow.
75	OP1, OP2	WATER_BASE_DE NSITY 3x1.060 – 3x1.063	Float [2]		0.0	LD	N / RO	Water base density emulsioned to the oil flow.
76	OP1, OP2	OIL_CTLW 3x1.064 – 3x1.067	Float [2]		0.0	Na	N / RO	Water temperature correction factor with base in weighted average of the input parameters.
77	OP1, OP2	OIL_CPLW 3x1.068 – 3x1.071	Float [2]		0.0	Na	N / RO	Water pressure correction factor with base in weighted average of the input parameters.
78	OP1, OP2	OIL_IV 3x1.072 – 3x1.075	Float [2]		0.0	TV	N / RO	Gross volume of the oil flow.
79	OP1, OP2	OIL_GSV 3x1.076 – 3x1.079	Float [2]		0.0	TV	N / RO	Gross standard volume of the oil flow.
80	OP1, OP2	OIL_NSV 3x1.080 – 3x1.083	Float [2]		0.0	TV	N / RO	Net standard volume of the oil flow.
81	OP1, OP2	OIL_SWV 3x1.084 – 3x1.087	Float [2]		0.0	TV	N / RO	Standard emulsioned water volume of the oil flow.
82	OP1, OP2	IV_ 3x1.088 - 3x1.089	Float			TV	N / RO	Gross volume of this test.
83	1 OP1,OP2	GSV_ 3x1.090 - 3x1.091	Float			TV	N/ RO	Corrected gross volume of this test.
84	1 OP1,OP2	NSV_ 3x1.092 - 3x1.093	Float			TV	N/ RO	Corrected net volume of this test.
85	3 OP3	OPEN_GAS_TEMP 3x1.094 - 3x1.095	Float		0	T	N / RO	Gas temperature at the beginning of the well test.
86	OP3	GAS_TWA_HOUR1 3x1.096 - 3x1.143	Float[24]			T	N / RO	Gas temperature weighted average for each hour of test during the first day (the first 24 hours).
87	OP3	GAS_TWA_HOUR2 5 3x1.144 - 3x1.191	Float[24]			T	N / RO	Gas temperature weighted average for each hour of test during the second day (the next 24 hours).
88	3 OP3	CLOSE_GAS_TEM P 3x1.192 - 3x1.193	Float		0	T	N / RO	Gas temperature at the ending of the well test.

Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
89	3 OP3	OPEN_GAS_PRESS 3x1.194 - 3x1.195	Float		0	P (abs)	N / RO	Gas absolute static pressure at the beginning of the well test.
90	OP3	GAS_PWA_HOUR1 3x1.196 - 3x1.243	Float[24]			P (abs)	N / RO	Gas absolute static pressure weighted average for each hour of test during the first day (the first 24 hours).
91	OP3	GAS_PWA_HOUR25 3x1.244 - 3x1.291	Float[24]			P (abs)	N / RO	Gas absolute static pressure weighted average for each hour of test.
92	3 OP3	CLOSE_GAS_PRESS 3x1.292 - 3x1.293	Float		0	P (abs)	N / RO	Gas absolute static pressure at the ending of the well test.
93	OP3	TOT_QV_HOUR1 3x1.294 - 3x1.341	Float [24]		0	TV	N / RO	Gas volume at flowing conditions totalizers for each hour of test during the first day (the first 24 hours), while operating at normal and abnormal conditions.
94	OP3	TOT_QV_HOUR25 3x1.342 - 3x1.389	Float [24]		0	TV	N / RO	Gas volume at flowing conditions totalizers for each hour of test during the second day (the next 24 hours), while operating at normal and abnormal conditions.
95	OP3	TOT_QB_HOUR1 3x1.390 - 3x1.437	Float [24]		0	TV	N / RO	Gas volume at base conditions totalizers for each hour of test during the first day (the first 24 hours), while operating at normal and abnormal conditions.
96	OP3	TOT_QB_HOUR25 3x1.438- 3x1.485	Float [24]		0	TV	N / RO	Gas volume at base conditions totalizers for each hour of test during the second day (the next 24 hours), while operating at normal and abnormal conditions.
97	OP3	TOT_QM_HOUR1 3x1.486 - 3x1.533	Float [24]		0	TV	N / RO	Gas mass totalizers for each hour of test during the first day (the first 24 hours), while operating at normal and abnormal conditions.
98	OP3	TOT_QM_HOUR25 3x1.534 - 3x1.581	Float [24]		0	TV	N / RO	Gas mass totalizers for each hour of test during the second day (the next 24 hours), while operating at normal and abnormal conditions.
99	1 OP3	TOT_QV_ 3x1.582 - 3x1.583	Float		0	TV	N / RO	Gas volume at flowing conditions totalizers, while operating at normal and abnormal conditions.
100	1 OP3	TOT_QB_ 3x1.584 - 3x1.585	Float		0	TV	N / RO	Gas volume at base conditions totalizers, while operating at normal and abnormal conditions.
101	1 OP3	TOT_QM_ 3x1.586 - 3x1.587	Float		0	TV	N / RO	Gas mass totalizers, while operating at normal and abnormal conditions.
102	OP4	WATER_GSV_HOUR1 3x1.588 - 3x1.635	Float [24]		0	TV	N / RO	Water GSV for each hour of test during the first day (the first 24 hours), related to the flow indicated in WATER_RUN_NUMBER.
103	OP4	WATER _GSV_HOUR25 3x1.636 - 3x1.683	Float [24]		0	TV	N / RO	Water GSV for each hour of test during the second day (the next 24 hours), related to the flow indicated in WATER_RUN_NUMBER parameter.

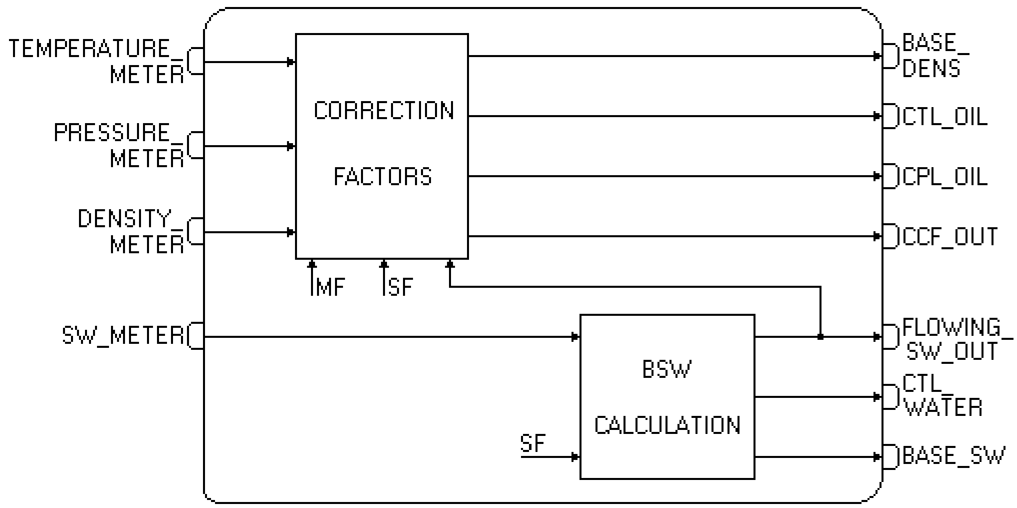
Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
104	1 OP4	WATER_GSV 3x1.684 – 3x1.685	Float			TV	N / RO	Water GSV during the test related to the flow indicated by WATER_RUN_NUMBER parameter summed to the water emulsioned to the oil.
105	1 OPx	WELL_TEST_TIME 3x1.686 – 3x1.688	Time difference				N / RO	Actual state time. When the state is “waiting start of usual conditions”, this parameter indicates the warm up time. When in the state “evaluating usual conditions”, this parameter indicates the usual condition evaluation. When in the state “calculating”, this parameter indicates the well test time.
106	1 OP1,OP2	OIL_TEST_ FLOW 3x1.689 – 3x1.690	Float			QV	N / RO	Oil net volume at base condition flow rate during the well test.
107	1 OP3	GAS_TEST_ FLOW 3x1.691 – 3x1.692	Float			QV	N / RO	Gas volume at base condition flow rate during the well test, while operating at normal and abnormal conditions.
108	1 OP4	WATER_TEST_ FLOW 3x1.693 – 3x1.694	Float			QV	N / RO	Water volume flow rate during the well test.
109	1 OP1,OP2 OP3	RGO 3x1.695 – 3x1.696	Float			Na	N / RO	Gas/oil ratio.
110	1 OP1,OP2	OIL_POTENTIAL_P RODUCTION 3x1.697 – 3x1.698	Float		0.0	LV	N / RO	Oil daily production potential in liquid volume at base condition.
111	1 OP3	GAS_POTENTIAL_ PRODUCTION 3x1.699 – 3x1.700	Float		0.0	GV	N / RO	Gas daily production potential in volume at base condition, while operating at normal and abnormal conditions.
112	3 OP4	WATER_POTENTIA L_PRODUCTION 3x1.701 – 3x1.702	Float		0.0	LV	N / RO	Water daily production potential in volume in base condition.
113	3 OP1,OP2 OP4	TOTAL_POTENTIA L_PRODUCTION 3x1.703 – 3x1.704	Float		0.0	LV	N / RO	Oil and water daily production potential in volume in base condition.
114	OP3	GAS_PRODUCT 3x1.705 – 3x1.760	Float[28]				N / RO	Information about gas (including composition, heat value, relative density).
115	3 OP1,OP2 OP4	AVG_BSW 3x1.761 – 3x1.762	Float			%	N / RO	Medium BSW during the well test.
116	3 MN	LIQ_SPEC_1 3x1.763	Bitstring[2]				N / RO	Show the standards used in the calculation.
117	3 MN	LIQ_SPEC_2 3x1.764	Bitstring[2]				N / RO	Show the standards used in the calculation.
118	3 MN	GAS_SPEC_1 3x1.765	Bitstring[2]				N / RO	Show the standards used in the calculation.
119	OP3	NET_QB_HOUR1 3x1.766 – 3x1.813	Float [24]		0	TV	N / RO	Totalization of the gas volume at base condition for each hour of test during the first day (the first 24 hours), while operating at normal and abnormal conditions, after the operation indicated in GAS_OPERATION.

Idx	Type /View	Parameter	Data Type (length)	Valid Range / Options	Default Value	Unit	Store/ Mode	Description
120	OP3	NET_QB_HOUR25 3x1.814 – 3x1.851	Float [24]		0	TV	N / RO	Totalization of the gas volume at base condition for each hour of test during the second day (the next 24 hours), while operating at normal and abnormal conditions, after the operation indicated in GAS_OPERATION.
121	1 OP3	NET_TOT_QB 3x1.862 – 3x1.863	Float		0	TV	N / RO	Totalization of the gas volume at base condition for gas, while operating at normal and abnormal conditions, after the operation indicated in GAS_OPERATION.
122		UPDATE_EVT 3x1.864 – 3x1.870 4xx.x56	DS-73			Na	D	This alert is generated by any change to the static data.
123		BLOCK_ALM 3x1.871 – 3x1.877 4xx.x57	DS-72			Na	D	The block alarm is used for configuration failures, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute. When the Unreported status is cleared by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non-volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL = 123 bytes; V1-115 bytes; V2-87 bytes; V3-106 bytes; V4-5 bytes;
HFCView: OPx (OP1, OP2, OP3, OP4), OP1 (Operation – Oil 1), OP2 (Operation – Oil 2), OP3 (Operation - Gas), OP4 (Operation - Water), CF (Configuration), MN (Maintenance)

LCFE – Liquid Correction Factors

Schematic



Description

This block calculates the BSW at operating temperature using:

- density of dry oil at base condition or other temperature defined by configuration
- density of water at base condition or other temperature defined by configuration
- density of oil emulsion at operating condition measured online

Besides that, it calculates correction factors (CTL, CPL) for the liquid measurement.

Identification for the run number – STRATEGY parameter

The configuration for the STRATEGY parameter is mandatory, because this identifies the run number.

The quantity of the block instances is **not** limited to the maximum number of streams.

Product Configuration

Using the PRODUCT_TYPE parameter is possible to select the product type to be used in the calculation. There is also the selection of the density type in the DENSITY_TYPE parameter, the application of the glass hydrometer correction (HYDROMETER_CORRECTION parameter) and the coefficient of thermal expansion at base temperature or absolute pressure of equilibrium.

Application of this block

This block meets requirements for multiple scenarios of application as indicated below:

1- Custody transfer: It performs the calculation of temperature correction factor (CTL_OIL), pressure correction factor (CPL_OIL) and base density of oil (BASE_DENS) using the density provided in the DENSITY_METER input. It is supposed that this input provides the density of hydrocarbon liquid with up to 1% of water.
One important application is the calculation of oil base density, when the online density measurement is performed at temperature and/or pressure different from temperature and/or pressure at the flowmeter. Therefore this block converts the measured density to base condition, that will be used by the measurement block LT. The block LT is prepared only for density at the operational condition of flowmeter or density at base condition.

2- Allocation measurement: The main application is the BSW calculation for allocation measurement and supply base density of dry oil for the measurement block in two possible ways:

a) CALC_BSW=Dual range

It allows to apply a density meter instead of a BSW analyzer or a combination of a BSW analyzer device for low range, for example up to 10% of water, with a calculation of BSW for higher range based on the density of dry oil, density of water and density of emulsion. The goal is a cheaper option than the full range BSW device (0-100%).

b) CALC_BSW=Lab analysis
It allows the BSW calculation based on the BSW value provided by the laboratory analysis performing just the volume conversion (oil and water) from laboratory temperature to operational temperature. Therefore it is a simpler application than the previous one, but it is still specified in the API MPMS 20.1 for allocation measurement.

The calculation of temperature correction factor for oil (CTL_OIL) and pressure correction factor for oil (CPL_OIL) is based on the density provided by the configuration parameter LAB_DENS_OIL (density of dry oil) in these applications for allocation measurement. This density is provided by the laboratory analysis based on the sample of emulsion after separation of oil from water, that may have up to 100% of water. Besides that, it allows to apply the shrinkage factor (SF).

This table shows some details for each type of application.

Application	Configuration	Density used in the calculation of CTL_OIL, CPL_OIL and BASE_DENS	Value of FLOWING_SW_OUT	Meaning of DENSITY_METER input
Custody transfer	CALC_BSW configured as None.	DENSITY_METER	SW_METER	Density of (dry) oil at operation condition or base condition depending on the parameter DENSITY_TYPE.
Allocation measurement	CALC_BSW configured as Dual range and LO_SW is 100%.	LAB_DENS_OIL	SW_METER	DENSITY_METER is not used
Allocation measurement	CALC_BSW configured as Dual range and LO_SW is between 0% and 100%.	LAB_DENS_OIL	If SW_METER is lower than LO_SW, then FLOWING_SW_OUT follows the SW_METER. Otherwise it is calculated based on LAB_DENS_OIL, DENSITY_METER and LAB_DENS_WATER. However if the DENSITY_METER input has a bad status, then the SW_METER input is used as override value.	Density of emulsion at operational condition (not suitable for calculation of CTL_OIL), that is used for BSW calculation at operational condition. The DENSITY_TYPE parameter does not apply in this case.
Allocation measurement	CALC_BSW configured as Dual range and LO_SW is 0%.	LAB_DENS_OIL	It is calculated based on LAB_DENS_OIL, DENSITY_METER and LAB_DENS_WATER.	Density of emulsion at operational condition (not suitable for calculation of CTL_OIL), that is used for BSW calculation at operational condition. The DENSITY_TYPE parameter does not apply in this case.
Allocation measurement	CALC_BSW configured as Lab analysis.	LAB_DENS_OIL	Value of LAB_SW is converted from laboratory temperature (LAB_TEMP) to the operational temperature (TEMPERATURE_METER)	DENSITY_METER is not used

This table shows details about status handling and override value.

CALC_BSW	If bad status of DENSITY_METER	If bad status of TEMPERATURE_METER or PRESSURE_METER	If bad status of SW_METER	Calculated BSW is out of range 0-100%
None	CTL_OIL, CPL_OIL={1, Good} BASE_DENS.Status={last, Bad}	CTL_OIL, CPL_OIL={1, Good} BASE_DENS.Status={last, Bad} if DENSITY_TYPE is “measured density” BASE_DENS.Status=DENSITY_METERif DENSITY_TYPE is “Density at base”	FLOWING_SW_OUT= SW_METER	-
Dual range and LO_SW is 100%.	This input is not used	CTL_OIL, CPL_OIL={1, Good} BASE_DENS.Status={LAB_DENS_OIL, Good}	FLOWING_SW_OUT=SW_METER	-
Dual range and LO_SW is between 0% and 100%	FLOWING_SW_OUT=SW_METER	CTL_OIL, CPL_OIL={1, Good} FLOWING_SW_OUT=SW_METER	FLOWING_SW_OUT={calculated, Good}	-
Dual range and LO_SW is 0%.	FLOWING_SW_OUT={LAB_SW(t), Good}	CTL_OIL, CPL_OIL={1, Good} FLOWING_SW_OUT={last, Bad}	This input is not used	FLOWING_SW_OUT={LAB_SW(t), Good}
Lab analysis	This input is not used	CTL_OIL, CPL_OIL={1, Good} FLOWING_SW_OUT={last, Bad}	This input is not used	-

LAB_SW(t) : LAB_SW converted from LAB_TEMP to the operational temperature

CCF Calculation

If the FLOWING_TEMP and DENSITY_METER input are connected, the CTL_OUT factor will be calculated. And if the FLOWING_PRES input is also connected, the CPL_OUT factor will be calculated.

If the CALC_BSW parameter is configured to accomplish the BSW calculation, thus:
$CCF = CTL * CPL * MF * (1 - X_{w,m}) * SF$

Block Inputs

Input	Link Necessity	Description
TEMPERATURE_METER	Mandatory	Flowing temperature. If the system has an online density meter, the temperature which the density measurement is being accomplished must be lower than the variation of the acceptable limits related to the flow temperature in the flow meter.
PRESSURE_METER	Optional	Flowing gauge pressure. If this input is not connected, CPL = 1.
DENSITY_METER	It depends on the configuration	Density of the product (oil or emulsion), which can be at flowing conditions or base conditions, it depends on the DENSITY_TYPE configuration.

Block Outputs

This block provides four outputs described below. In the applications which the CPL factor is not calculated and the PRESSURE_METERS input is not connected, thus the CPL_OUT output will indicate 1.

Output	Description	Value in the Exception Condition (*)
BASE_DENS	Density of dry oil at base condition.	
CTL_OUT	Temperature correction factor.	1.0000
CPL_OUT	Pressure correction factor.	1.0000
CCF_OUT	Combined correction factor.	1.0000

(*) When it is impossible to calculate due to the input status or it is out of range specified by the standard.

TEMPERATURE_METER and DENSITY_METER	PRESSURE_METER	CALC_BSW	CCF
No connected	-	-	1
Connected	No connected	None	CTL * MF
Connected	Connected	None	CTL * CPL * MF
Connected	No connected	Dual range / Lab analysis	MF * (1 - $X_{w,m}$) * CTL * SF
Connected	Connected	Dual range / Lab analysis	MF * (1 - $X_{w,m}$) * CTL * CPL * SF

The CCF_OUT output is the result of three correction factors multiplication (CTL, CPL and MF), if the calculation of any factor is impossible, thus the value in the exception condition must be used.

Temperature Correction Factor for Liquid Hydrocarbon (CTL_OIL parameter)
The density used in the CTL calculation depends on the configuration, as indicated in the table in the section "Application of this block":

For the measurement of crude oil, general products, MTBE and lubrificating oil is used the API-11.1 standard. For the measurement of light liquid hydrocarbon are used GPA-TP25 and GPA-TP15 standards.

Compressibility Factor – F
The Compressibility Factor for the measured liquid is calculated using the base density and flow temperature. If it is impossible to calculate the compressibility factor, the F parameter will be zero.

The CPL factor is calculated using compressibility factor, flowing gauge pressure and equilibrium pressure. If the selected product is water, the compressibility factor will be zero and the CPL factor is 1.

The standards used for the compressibility factor calculation are API-11.2.1 and API-11.2.1.M for crude oil, general products, MTBE and lubrificant oil. For the measurement of light hydrocarbon liquid are used API-11.2.2 and API-11.2.2.M standards.

Meter Factor – MF
If the meter is submitted to the proving, thus the meter factor value obtained must be written in the MF parameter. Otherwise, the default value of the MF parameter must be kept, that is 1.

BSW Calculation – None

The CALC_BSW parameter must be configured as "None", when it is desired the calculation of temperature correction factor for oil (CTL_OIL), pressure correction factor for oil (CPL_OIL) and base density of oil (BASE_DENS) for custody transfer application.
The FLOWING_SW_OUT just follows the SW_METER input in this case.

BSW Calculation – Dual Range

If the CALC_BSW parameter is set to "Dual range", the FLOWING_SW_OUT parameter is the SW_METER input, if this input is lower than LO_SW. Otherwise, the BSW will be calculated using the result of laboratory analysis and emulsion density at flow condition.

If LO_SW = 0.0, thus BSW will be always calculated
If LO_SW = 100.0, thus the FLOW_SW_METER input will be always used.

Block Inputs
The inputs used are indicated below:

Input	Link Necessity	Description
TEMPERATURE_METER	Mandatory	Flowing temperature.
DENSITY_METER	Mandatory	Density of the measured product which must be at flowing condition for the Dual range option.
SW_METER	Optional	If the measured online BSW is lower than the configured value in LO_SW parameter, this input will be used. Otherwise the calculated value of BSW will be used.

		If this input is not connected, it will be ignored, thus the BSW will be always calculated.

Block Outputs

Outputs	Description
FLOWING_SW_ OUT	If the value of the SW_METER input is lower than the LO_SW parameter, this output will follow the SW_METER input. Otherwise, it will be the calculated value.
CTL_WATER	Temperature correction factor for water.
BASE SW	BSW calculated at base temperature condition.

BSW Calculation– LAB_DENS_OIL and LAB_DENS_WATER
The BSW is calculated using the dry oil and water densities at laboratory analysis condition, the density at flowing condition and the flowing temperature. These last two variables measured are online.

These calculations suppose constant properties (base density) of the produced oil and water.

FLOWING_SW_OUT Calculation:

- It calculates: $DENS_{oil,T} = f(DENS_{oil,Tlab}, T)$

Where:
$DENS_{oil,T}$: dry oil density at flowing temperature
$DENS_{oil,Tlab}$ = LAB_DENS_OIL : dry oil density at laboratory analysis temperature.
T : flowing temperature

- It calculates: $DENS_{water,T} = f(DENS_{water,15/60}, T)$

Where:
$DENS_{water,T}$: water density at flow temperature
$DENS_{water,lab}$ = LAB_DENS_WATER: water density at laboratory analysis temperature.
T : flowing temperature

- It calculates BSW_T (FLOWING_SW_OUT parameter).

Where:
BSW_T : BSW at flowing temperature

$$BSW_T = \frac{DENS_{emulsion,T} - DENS_{oil,T}}{DENS_{water,T} - DENS_{oil,T}}$$

BASE_SW Calculation :

- $CTL_A = f(DENS_{water,15/60}, Tb)$ is the CTL_WATER parameter, which converts the volume at flowing temperature to base temperature.
- $CTL_o = f(DENS_{oil,Tlab}, Tlab, Tb)$, which converts the volume at laboratory analysis temperature to flowing temperature.
- It calculates BSW_{Tb} (BASE_SW parameter).

$$BSW_{Tb} = \frac{BSW_T * CTL_A}{BSW_T * CTL_A + (1 - BSW_T) * CTL_o}$$

BSW Calculation – Lab Analysis

If the CALC_BSW parameter is set to “Lab analysis”, the value of the FLOWING_SW_OUT output will be calculated using only the laboratory analysis results. It is supposed a stability/regularity of fluid properties as oil base density and BSW (correction factors are applied to the temperature and the difference of the water and oil coefficients of thermal expansion).
This equation is calculated as indicated in the API-201 standard. – Allocation measurement, located in the B Appendix

Block Inputs
The input is:

Input	Link Necessity	Description
TEMPERATURE_METER	Mandatory	Flowing Temperature.

Block Outputs

Outputs	Description
FLOWING_SW_OUT	Value calculated for the BSW parameter at flowing condition.
CTL_WATER	Temperature correction factor for water.
BASE SW	BSW calculated at base temperature

BSW – LAB_DENS_OIL, LAB_DENS_WATER and XWS Calculations
The BSW at flowing condition is calculated using the laboratory analysis results: dry oil density, water density and BSW at laboratory analysis temperature. These calculations assume constant properties (base density) for oil and water.

FLOWING_SW_OUT Calculation:
It calculates:

$$X_{w,m} = \frac{X_{w,lab} * (CTL_{w,lab} / CTL_{w,m})}{X_{w,lab} * (CTL_{w,lab} / CTL_{w,m}) + (1 - X_{w,lab}) * (CTL_{o,lab} / (CTL_{o,m} * SF))}$$

Where:
$X_{w,m}$: BSW at flowing condition
$X_{w,lab}$: BSW in laboratory analysis condition
$CTL_{w,lab}$: Temperature correction factor for water, from the temperature of the laboratory analysis to BASE_TEMPERATURE.
$CTL_{w,m}$: Temperature correction factor for water, from flowing temperature to BASE_TEMPERATURE.
$CTL_{o,lab}$: Temperature correction factor for oil, from the temperature of laboratory analysis to BASE_TEMPERATURE.
$CTL_{o,m}$: Temperature correction factor for oil, from flowing temperature to BASE_TEMPERATURE.
SF : oil shrinkage factor.

Diagnosing and Troubleshooting
1. BLOCK_ERR. Block configuration:
   - The Temperature or Density Inputs are not connected.
2. BLOCK_ERR. Out of Service: LCF block can continue in Out of service mode, although the target mode is Auto, because the Resource block is in O/S.

Special Indications for CURRENT_STATUS
"Override SW used" – Problems in the BSW calculation. SW input values is out of range 0-100 % (caso CALC_BSW ="Dual Range").

Supported Modes
O/S and AUTO.

Parameters

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
1	1,2,3,4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	If this parameter is configured with a string other than blank spaces, then this parameter will replace the block tag in the QTR report.
3 (A2)(CL)	4 CF	STRATEGY 4xx.xx0	Unsigned16	0 to 4	0	None	S	This parameter identifies the run number.
4	4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
5 (A2)(CL)	1,3 CF	MODE_BLK Actual=3xx.xx0 Target/Normal= 4xx.xx2 – 4xx.xx4	DS-69		Auto	Na	S	Refer to the Mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx1	Bitstring(2)			E	D / RO	
7	I,1,3 OP	TEMPERATURE_METER 3xx.xx2 - 3xx.xx4	DS-65			T_UNITS	N / RO	Temperature used for the correction factor calculation for the thermal expansion of a liquid.
8	I,1,3 OP	PRESSURE_METER 3xx.xx5 - 3xx.xx7	DS-65			P_UNITS	N / RO	Gauge pressure used for the correction factor calculation for the liquid compressibility.
9	I,1,3 OP	DENSITY_METER 3xx.xx8 - 3xx.x10	DS-65			LD_UNITS	N / RO	Density of oil or emulsion depending on the configuration.
10	I,1,3 OP	SW_METER 3xx.x11 - 3xx.x13	DS-65			%	N / RO	Percentage of sand and water mixed in the oil.
11	O,1,3 OP	BASE_DENS 3xx.x14 - 3xx.x16	DS-65			LD_UNITS	N / RO	Base density of the dry oil. This parameter is calculated.
12	O,1,3 OP	CTL_OIL 3xx.x17 - 3xx.x19	DS-65				N / RO	Temperature Correction Factor.
13	O,1,3 OP	CPL_OIL 3xx.x20 - 3xx.x22	DS-65				N / RO	Pressure Correction Factor.
14	O,1,3 OP	CCF_OUT 3xx.x23 - 3xx.x25	DS-65				N / RO	Combined Correction Factor.
15	O,1,3 OP	FLOWING_SW_OUT 3xx.x26 - 3xx.x28	DS-65			%	N / RO	Percentage calculated of sand and water mixed in the oil.
16	O,1,3 OP	CTL_WATER 3xx.x29 - 3xx.x31	DS-65				N / RO	Temperature Correction Factor.
17	O,1,3 OP	BASE_SW 3xx.x32 - 3xx.x34	DS-65			%	N / RO	Percentage of sand and water mixed in the oil calculated in base conditions. If is ethanol, it indicates the percentage of water in volume in the ethanol and water mixture in base condition.
18	4 CF	BASE_PRESSURE 3xx.x35 - 3xx.x36	Float	101.325 kPa or 14.696 psi	101.325 kPa	P_UNITS	S / RO	Parameter not used.
19 (A1)(CL)	4 CF	BASE_TEMPERATURE 4xx.xx5 – 4xx.xx6	Float	15.0 °C or 20.0 °C or 60.0 °F	15.0 °C	T_UNITS	S	Base temperature for the fluid according to the selected unit in the T_UNITS parameter.

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
20 (A1)(CL)	4 CF	T_UNITS 4xx.xx7	Unsigned16	1000=Kelvin 1001=Celsius 1002=Fahrenheit 1003=Rankine	Celsius	E	S	Engineering Unit for temperature.
21 (A1)(CL)	4 CF	P_UNITS 4xx.xx8	Unsigned16	1130=Pa 1132=Mpa 1133=kPa 1137=bar 1138=mbar 1139=torr 1140=atm 1141=psi 1144=g/cm^2 1145=kgf/cm^2 1147=inH2O 4°C 1148=inH2O 68 °F 1150=mmH2O 4°C 1151= mmH2O 68 °F 1154=ftH2O 68 °F	KPa	E	S	Engineering Unit for static pressure.
22 (A1)(CL)	4 CF	LD_UNITS 4xx.xx9	Unsigned16	1097= Kg/m^3 1113=API 1599 = relative density/SG	Kg/m^3	E	S	Engineering Unit for liquid density. The selection of this unit indicates which table uses for the correction factor calculations (CTL and CPL).
23 (A2)(CL)	4 CF	PRODUCT_TYPE 4xx.x10	Unsigned8	0=Crude oil(1980) 1=Generalized products (1980) 2=MTBE (1980) 3=Lubricating oil (1980) 4=Water 5=Light hydrocarbon (NGL&LPG) 6=ASTM D 1250 (1952) 7=Ethanol-OIML R22 8=Ethanol-NBR 5992-80 9=Crude oil(2004) 10=Generalized products (2004) 11=MTBE (2004) 12=Lubricating oil (2004) 13=Ethanol-NBR 5992-09	0	E	S	Product type.
24 (A2)(CL)	4 CF	DENSITY_TYPE 4xx.x11	Unsigned8	1=Density at base 2=Measured density	1	E	S	Density type.

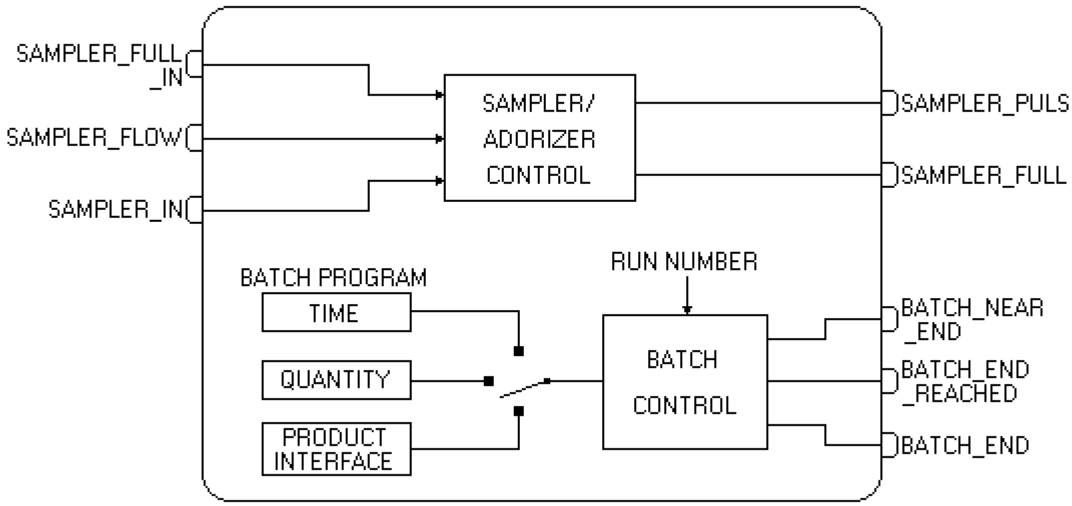
Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
25 (A2)(CL)	4 CF	HYDROMETER_CORRECTION 4xx.x12	Unsigned8	0=No correction 1=Correction is done	0	E	S	Hydrometer correction.
26 (A2)(CL)	4 CF	COEF_OF_THERMAL_EXP 4xx.x13 - 4xx.x14	Float	>= 0.0	0.0	MTBE-1/T_UNITS Light-P_UNITS	S	If the selected product is MTBE, the coefficient of thermal expansion at base temperature must be provided. If the selected product is Light hydrocarbon, the absolute equilibrium pressure is at 100 °F.
27 (A2)(CL)	2 CF	MF 4xx.x15 - 4xx.x16	Float	0.8 to 1.2	1.0	Na	S	MF used for the combined correction factor (CCF).
28 (A2)(CL)	4 CF	CALC_BSW 4xx.x17	Unsigned8	0=None 1=Dual range 2=Lab analysis	0	Na	S	It selects one of possible modes to calculate the BSW. If the selected product is ethanol, the BSWb is always calculated independently on the configuration of this parameter.
29 (A2)(CL)	2 CF	LO_SW 4xx.x18 - 4xx.x19	Float	0.0 to 100.0 0.0 = Always calculated 100.0 = Never calculated	0.0	%	S	Lower limit to calculate the BSW, if the “Dual range” option is selected in CALC_BSW.
30(A2)(CL)	2 CF	LAB_TEMP 4xx.x20 - 4xx.x21	Float		15	T_UNITS	S	Temperature of the laboratory analysis is accomplished to obtain the XWS.
31 (A2)(CL)	2 CF	LAB_DENS_WATER 4xx.x22 - 4xx.x23	Float	>= 0.0	1000	LD_UNITS	S	Water density in laboratory analysis condition (LAB_TEMP).
32 (A2)(CL)	2 CF	LAB_DENS_OIL 4xx.x24 - 4xx.x25	Float	>= 0.0	900	LD_UNITS	S	Oil density in laboratory analysis condition (LAB_TEMP).
33 (A2)(CL)	2 CF	LAB_SW 4xx.x26 - 4xx.x27	Float	0 to 100	0	%	S	BSW value obtained in laboratory analysis condition (LAB_TEMP).
34 (A2)(CL)	2 CF	SF 4xx.x28 - 4xx.x29	Float	1=disabled 0< SF <= 1	1	Na	S	Shrinkage factor obtained in laboratory analysis.
35	3 OP	F 3xx.x37 - 3xx.x38	Float			1/P_UNITS	N / RO	Compressibility factor.
36	3 MN	CURRENT_STATUS 3xx.x39	Bitstring[2]	See Block Options	0	Na	N/ RO	Current status. Similar to BATCH_STATUS.
37	OP	PE_TF 3xx.x40 - 3xx.x41	Float			P_UNITS	N / RO	Equilibrium pressure in flow temperature.
38		UPDATE_EVT 3xx.x42 - 3xx.x48 4xx.x30	DS-73			Na	D	This alert is generated by any change to the static data.

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
39		BLOCK_ALM 3xx.x49 - 3xx.x55 4xx.x31	DS-72			Na	D	The block alarm is used for all configuration, hardware and connection failure, or system problems in the block. The cause of the alert is indicated in the subcode field. The first active alert will set the Active status in the Status attribute. When the Unreported status is removed by the alert reporting task, another block alert can be reported without clearing the Active status, if the subcode has been changed.

Legend: E – Enumerated Parameter; NA – Dimensionless Parameter; RO – Read Only; D – Dynamic; N – Non volatile;
S – Static; I – Input Parameter; O - Output Parameter
AA – Administrator Level; A1 – Level 1; A2 – Level 2
RA – Restriction to the Administration; R1 – Restriction Level 1; R – Restriction Level 2
CL = 86 bytes (include block tag and profile); V1-73 bytes; V2-52 bytes; V3-8 bytes; V4-5 bytes;
HFCView: OP (Operation), CF (Configuration), MN (Maintenance)

SBC – Sampler Batch Control

Schematic



Description

This block has the following functions:

1. Sampler control for liquid and gas, and adorizer.
2. Batch control for liquid and gas, whose program can be in terms of:
   - volume/mass,
   - pre-defined time,
   - interface detection of different liquid products.

Sampler/Adorizer Control

The SAMPLE_PULSE output can be used to request to the sampler the collection of a sample of the measured product and at the end of a period the collected volume would be for analysis in laboratory (proportional sampler).

This output will be actioned every time that the totalization to accumulate the volume specified in VOLUME_PULSE and for a time specified in SAMPLE_PULSE_WIDTH.
To calculate the configuration value of VOLUME_PULSE to use the following equation:

$$VOLUME\_PULSE = \frac{Q * T * SAMPLE\_GRAB\_VOL}{SAMPLER\_TVOL}$$

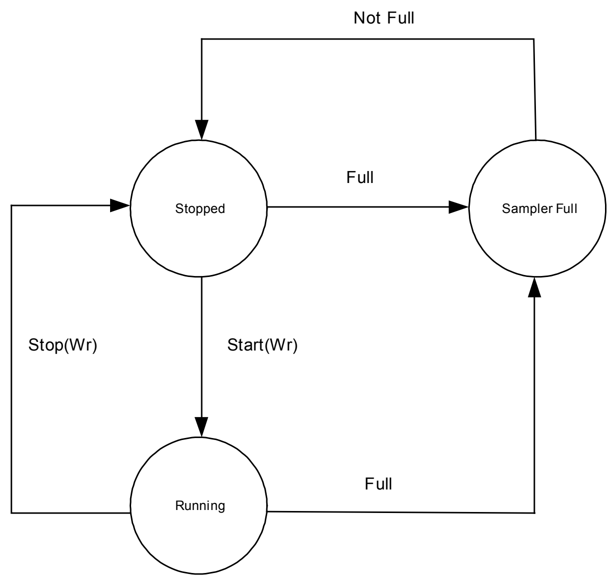
Where:
Q: operation average flow
T: time to collect the samples
SAMPLER_TVOL: sample total volume (limited for the sampler capacity)
SAMPLE_GRAB_VOL: volume of each sample

Example: The average flow of operation is 160m3/h and it is wanted that in a period of 12 hours the sampler has collected 5 liters being each sample of volume 4 cm3.
Q=160 m3/h
T=12 hours
SAMPLER_TVOL = 5 liters = 5E-3 m3
SAMPLE_GRAB_VOL= 4 cm3 = 4E-6 m3

$$VOLUME\_PULSE = \frac{160 * 12 * 4E\text{-}6}{5E\text{-}3} = 1.536 \text{ m3}$$

Where the interval of time between pulses is calculated of the following form:
160 m3 ----------- 3600 s
1.536 m3 ---------- t

$$t = \frac{1.536 * 3600}{160} = 34.5 \text{ seconds.}$$



Batch Program

This block allows different types of batch as described in the following item, as well as products gaseous or liquid.

The STRATEGY parameter has the important function to define which the measurement loop will be submitted the programming and control of batch of this block. Therefore the possible types of blocks of the loop are: GT, GST, LT and LST.

Defined the measurement loop a series of information will be changed between the blocks, for example:

- monitoring of the flow to detect the end of the transfer;
- ID of the product measured: concluded the last batch, the measurement continues using the ID of the product of this last batch.
- It indicates of the beginning and end of the batch.

Type of Batch

The type of batch is selected through the BATCH_TYPE parameter that can only be configured if the state is "Not transfer". A description for each supported types, as well as configuration/program parameters are shown below.

Volume/Mass Batch (BATCH_TYPE=Quantity)

In this batch type a volume/mass is programmed to be transferred and will determine the end of the batch. The batch refer to the product type selected in the measurement block (GT or LT), therefore in the programming of the batch it is just configured the quantity.

Input / Output	Mnemonic	Interpretation	Comments
Output	BATCH_NEAR_END	It indicates that is near of end/value programmed for batch.	This output is activated when the quantity transferred reaches the percentage configured in NEAR_END of the value programmed. This output can be used to command valve of high flow.
Output	BATCH_END_REACHED	It indicates the end programmed for batch.	This output is activated, when the quantity programmed for the batch is reached. Used to command valve.
Output	BATCH_END	It indicates the end of transfer.	This output is activated, when the quantity programmed for the batch is reached and product transfer is stopped and after a time specified in TIME_DELAY. This output is activated until the beginning of a new batch.

Parameters used in the batch program:

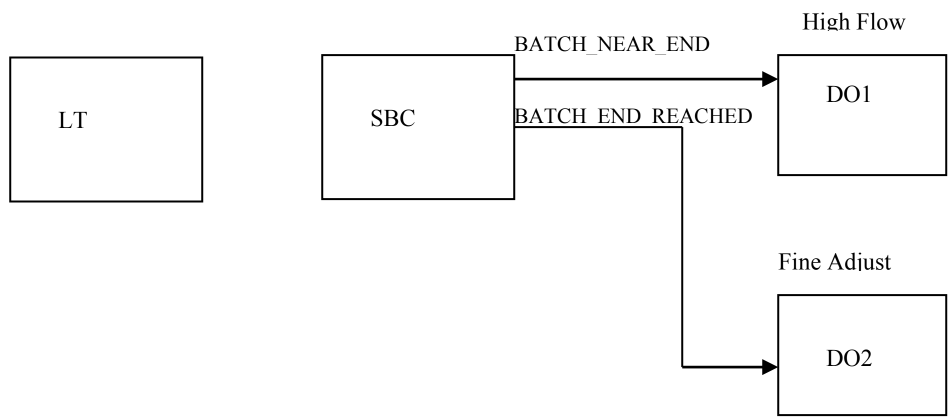
- TOT_TYPE: it selects the variable type to be compared with the value programmed by user. This parameter can only be configured in the state "Not transfer ".
- BATCH_SIZE: quantity programmed for the next 10 batches. It is not allowed to alter the configuration of the first element if the batch was already initiate, being recommended the "Cancel" command to conclude the batch in execution. It is not also allowed to start a batch if

the value programmed in the first element is zero. The programmed value refers to the sum of totalizers at normal and at abnormal conditions.

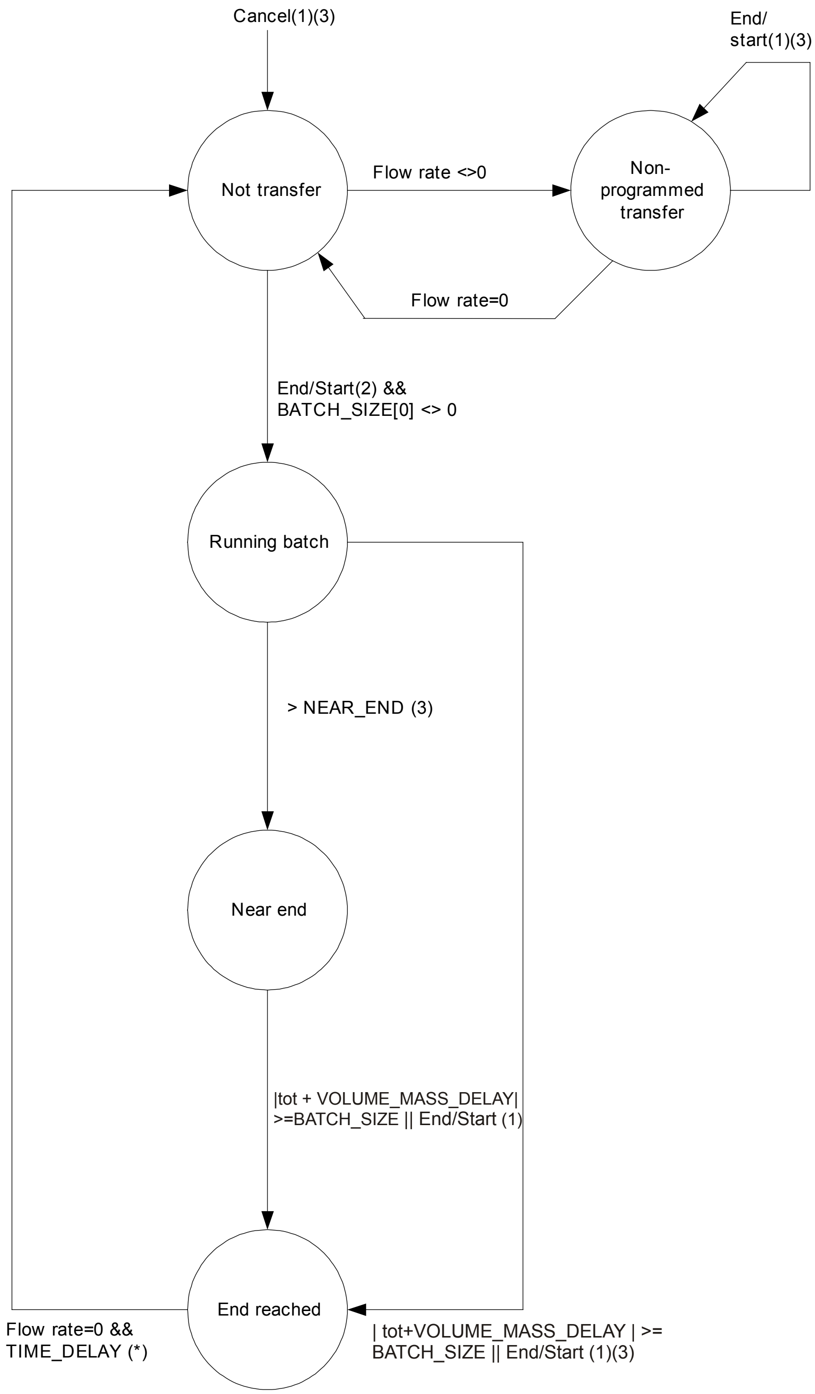
- NEAR_END: percentage to indicate the end near of the batch that can be used to close valve of high flow.
- TIME_DELAY: after reaching the quantity programmed for the batch and the flow is zero, the time configured in this parameter is awaited to end the batch.
- VOLUME_MASS_DELAY: The output BATCH_END_REACHED will be activated to command valve closing, because the volume in the pipe will still be transferred and measured.
- BATCH_IDx: batch identification.
- CARRIER_IDx: carrier identification.

Typical application
Measurement of liquid product always of the same type where the batch is programmed by gross volume at base condition. There are two valves ON/OFF for transfer control, one of high flow and other for fine adjustment.

When reaching the value programmed the valves are closed and the end of the batch happens only after the flow is zero and after the time configured in TIME_DELAY.



State Diagram



(*) the report is generated
(1) Activate BATCH_END_REACHED
(2) Deactivate BATCH_END_REACHED and BATCH_NEAR_END
(3) Activate BATCH_NEAR_END

Time Batch (BATCH_TYPE=Time)
In the time batch, the programming, beginning and end of the batch are defined for date and hour and refer to the product selected in the measurement block (GT or LT).

Input / Output	Mnemonic	Interpretation	Comments
Output	BATCH_END_REACHED	It indicates the end programmed for the batch.	This output is activated, when the date and programmed hour for the end of the batch is reached. Used to command valve closing.
Output	BATCH_END	It indicates the end of the transfer.	This output is activated, when the date and hour programmed for the end of the batch is reached and the product transfer is stopped and after a time specified in TIME_DELAY. This output is activated until the beginning of a new batch.

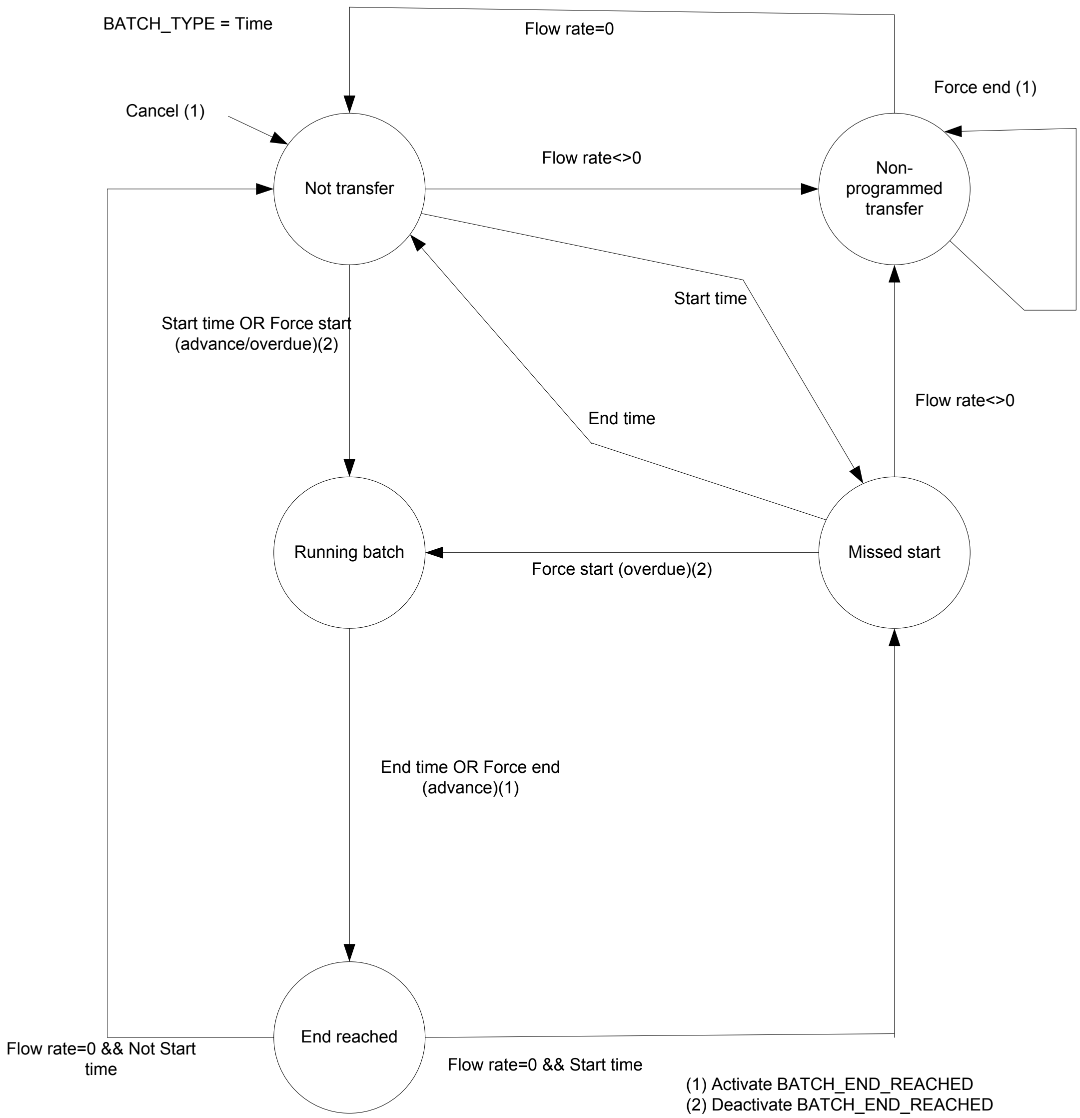
Parameters used in the batch program:
- BATCHx_START_TIME and BATCHx_END_TIME: date and hour programmed for the beginning and end of the next 10 batches. The programming is supplied in the TEMP_START_TIME and TEMP_END_TIME parameters and when requesting the inclusion of this programming, the same will be verified in its consistence (TEMP_END_TIME posterior to TEMP_START_TIME, both posterior to current date/hour and without intersection with the existent programming) and inserted in the chronological order of the existent programming. It is not allowed to delete the programming of the first element if the batch was initiate, being recommended the "Cancel" command to end the batch in execution.

The format for date and hour is the following:

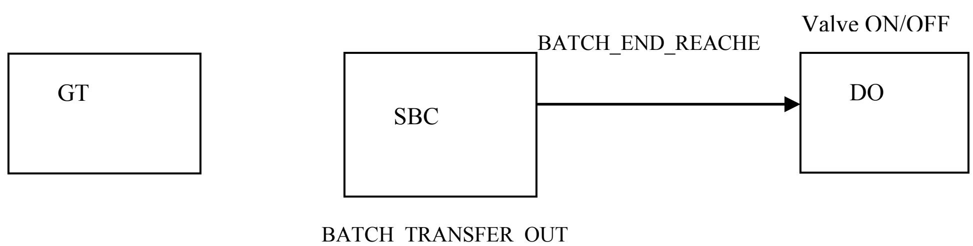
Element	Description	Range / Interpretation
1	Second	0 - 59
2	Minute	0 - 59
3	Hour	0 - 23
4	Week day	1=Monday,.... 7=Sunday
5	Month day	1 - 31
6	Month	1=January,.... 12=December
7	Year	00 - 99

- BATCH_IDx: batch identification
- CARRIER_IDx: carrier identification

Power up procedure
- It verifies if the BATCHx_END_TIME is previous the current date/hour, then batch programmed is removed. It continues to verify for the posterior batches. If the beginning of the next batch was not reached, then the state will be "Not Transfer ".
- It verifies if only the BATCHx_START_TIME is previous to the current date/hour. If the state before the power down was "Running batch", "End reached", "Missed start" or "Non-programmed transfer", then will be in the previous state. But if the state before the power down was "Not transfer ", then the state will be "Missed start ".



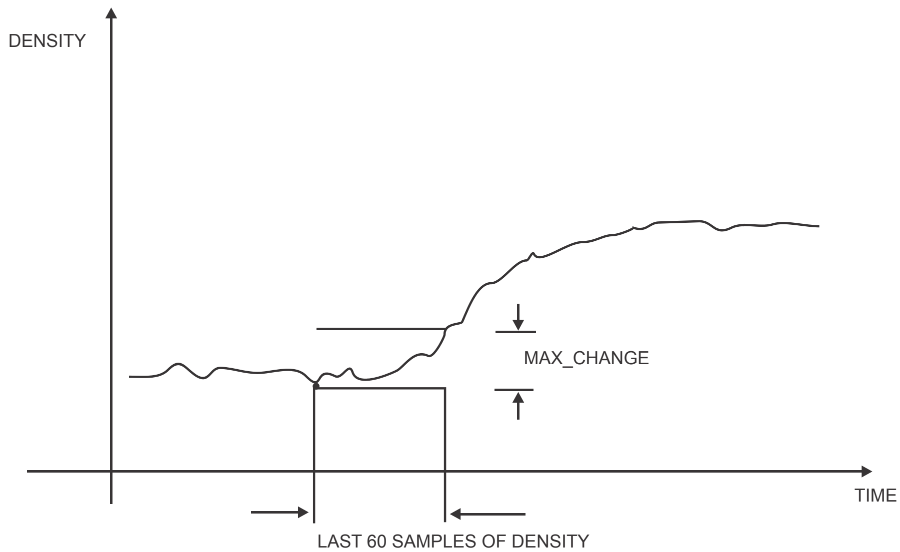
Typical application
Natural gas measurement where the batch is programmed for date and hour of the beginning and end.



Batch of Products Interface (BATCH_TYPE=Product interface)

In this batch type, the transfer of liquid products is accomplished in sequence, typically products of different density to avoid a mixture. A maximum variation of a variable to be monitored is defined (typically the density), if the variation is superior to the specified, it is considered the batch end and the start of a new batch. The product type of each batch is programmed in BATCH_PRODUCT_ID and the correspondent measurement block (LT block) generates the value of the current batch.

The batch is automatically concluded by detection in the variation of the density, when this variation is superior to the specified in MAX_CHANGE. There is also a form of specifying the volume in the pipe (VOLUME_MASS_DELAY) between the density meter and the valve that classify the product, therefore after the detection of the interface between the products of different density.

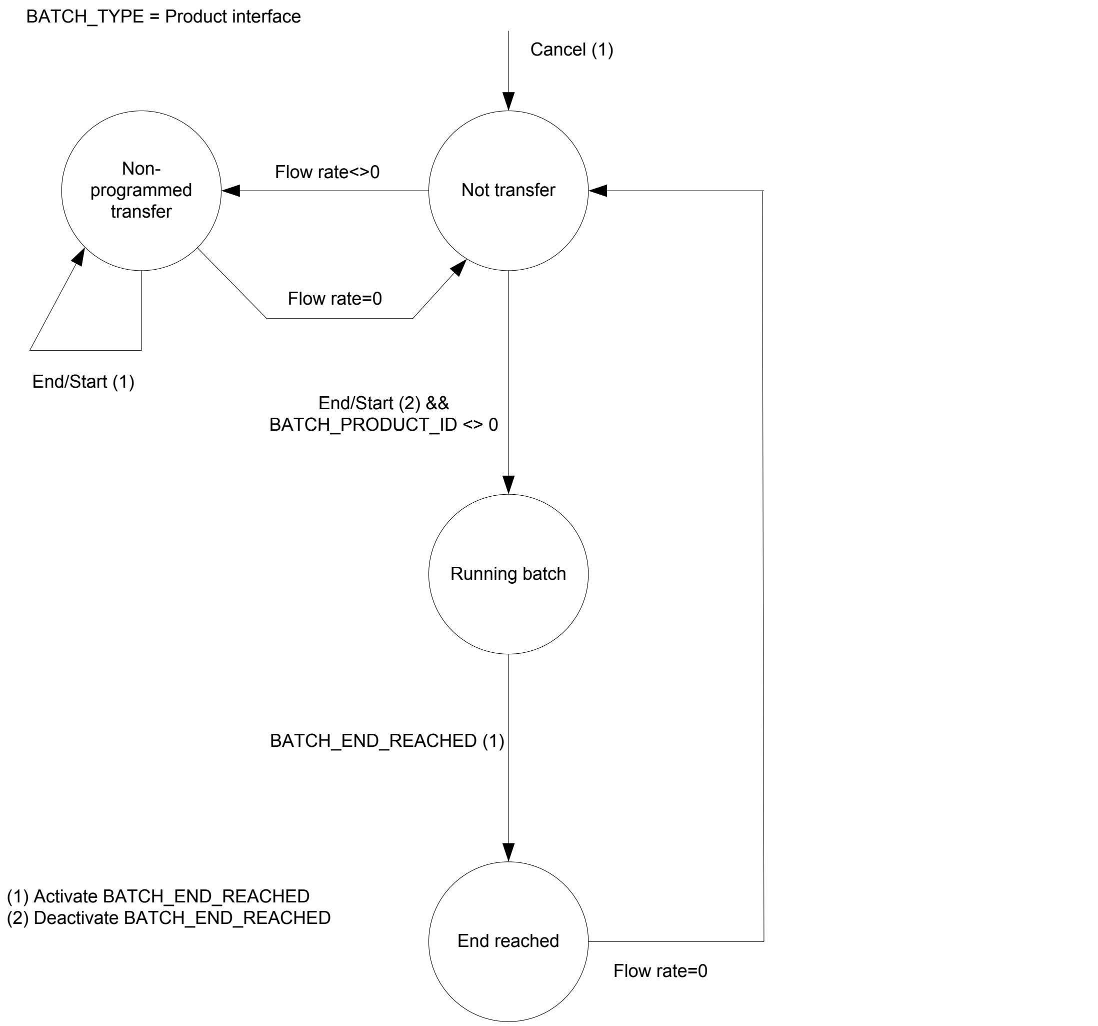


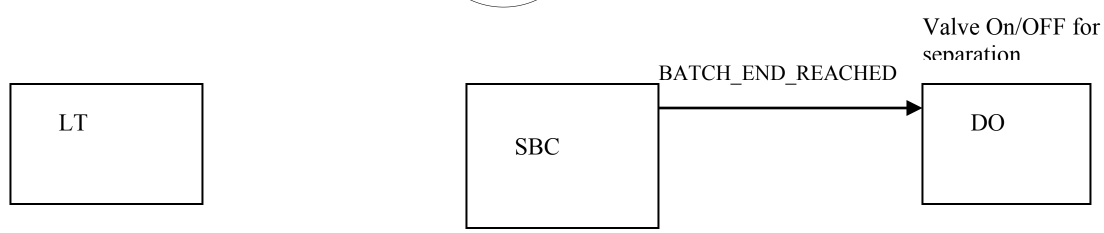
Input / Output	Mnemonic	Interpretation	Comments
Output	BATCH_END_REACHED	After the interface detection and measured the volume corresponding to VOLUME_MASS_DELAY	This output is activated when the interface between different products is detected and transferred the volume at flowing condition corresponding to VOLUME_MASS_DELAY.
Output	BATCH_END	It indicates the end of transfer.	This output is activated, when the interface is reached (BATCH_END_REACHED) the product transfer stopped and TIME_DELAY elapsed. This output is activated until the beginning of a new batch.

Parameters used in the batch program:

1. MAX_CHANGE: Maximum variation of the density to be considered the same product type and therefore the same batch.

- VOLUME_MASS_DELAY: volume in the pipe between density meter (interface detection) and the valve activated by BATCH_END_REACHED output. Value equal to zero disable this function.
- TIME_DELAY: when the flow is zero, the time configured in this parameter is awaited before changing for the "Not transfer" state.
- BATCH_PRODUCT_ID: This parameter should contain the types of products transferred in sequence. It is not allowed to change the configuration of the first element if the batch was already initiate, being recommended the "Cancel" command to end the batch in execution.
- BATCH_IDx: batch identification.
- CARRIER_IDx: carrier identification.
- The flow is monitored to determine the beginning and end of the sequence batch.





Some restrictions for batch type “Product Interface”:

- Not supported if the block SBC is associated to loop of gas measurement, liquid or gas station.
- If the block SBC is associated to loop of liquid measurement and configured for batch type "Product Interface", the block LT correspondent will accomplish only the calculations relative to the batch. The other periods (hour, day and month) will continue with default values.

Diagnosis and Troubleshooting

1. BLOCK_ERR. Block configuration: this indication can occur due to the following problems:
- If BATCH_TYPE=Product interface and selected a loop of gas measurement;
- If SAMPLER_FLOW*SAMPLE_PULSE_WIDTH > VOLUME_PULSE
- If BATCH_TYPE = Quantity, TOT_TYPE = Qv / IV and the measurement loop is Station.
- If there is not a measurement loop corresponding to the value of the STRATEGY parameter.

Parameters

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
1	1,2,3, 4	ST_REV	Unsigned16		0	None	S / RO	
2		TAG_DESC	OctString(32)		Spaces	Na	S	
3 (A2)(CL)	4 CF	STRATEGY 4xx.xx0	Unsigned16	1 to 4, 253-GST, 254-LST	0	None	S	This parameter is used to identify the run number.
4	4	ALERT_KEY 4xx.xx1	Unsigned8	1 to 255	0	None	S	
5(A2)(CL)	1,3 CF	MODE_BLK Target/Normal - 4xx.xx2 – 4xx.xx4 Actual – 3xx.xx0	DS-69		Auto	Na	S	Refer to the mode parameter.
6	1,3 CF, MN	BLOCK_ERR 3xx.xx1	Bitstring(2)			E	D / RO	
7	I,1 OP	SAMPLER_FULL_IN 4xx.xx5 - 4xx.xx6	DS-66				N	This input indicates if the sampler is full, what stops the generation of pulses for the sampler (SAMPLE_PULSE).
8	I,1 OP	SAMPLER_FLOW 4xx.xx7 - 4xx.xx9	DS-65				N	Variable where the pulses for the sampler are generated.
9	I,1 OP	SAMPLER_IN 4xx.x10 - 4xx.x12	DS-65				N	Variable used to determine if the sampler is full.
10	O,1 OP	BATCH_NEAR_END 3xx.xx2 - 3xx.xx3	DS-66				N / RO	It indicates that the current batch is near of the end. This output will be in TRUE until the end of the batch.
11	O,1 OP	BATCH_END_REACHED 3xx.xx4 - 3xx.xx5	DS-66				N / RO	It indicates that the programmed value for the batch was reached. Closing of the batch can depend on the user according to configuration.
12	O,1 OP	BATCH_END 3xx.xx6 - 3xx.xx7	DS-66				N / RO	It indicates the end of a batch to begin a new batch.
13	O,1 OP	SAMPLE_PULSE 3xx.xx8 - 3xx.x09	DS-66				N/ RO	Output to obtain a sample.
14	O,1 OP	SAMPLER_FULL 3xx.x10 - 3xx.x11	DS-66				N/ RO	It indicates that the collected total volume reached the value configured in SAMPLER_TVOL.

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
15 (A2)(CL)	2 CF	VOLUME_PULSE 4xx.x13 - 4xx.x14	Float	0.0=disabled >= 0.0	0.0	LV	S	Volume at flowing condition regarding a pulse for the sampler.
16(A2)(CL)	2 CF	SAMPLE_PULSE_WIDTH 4xx.x15	Unsigned8	1 to 10	1	Sec	S	Pulse width for the sampler.
17(A2)(CL)	2 CF	SAMPLE_GRAB_VOL 4xx.x16 - 4xx.x17	Float	0.0=disabled >= 0.0	0.0	LV	S	Volume collected to each capture (grab).
18(A2)(CL)	2 CF	SAMPLER_TVOL 4xx.x18 - 4xx.x19	Float	>= 0 0=endless	0	LV	S	Total volume to be collected by sampler.
19(A2)(CL)	2 CF	SAMPLER_IN_HI 4xx.x20 - 4xx.x21	Float	0.0=disabled >= 0	0		S	Sampler will be considered full if the input SAMPLER_IN is superior to this parameter for 2 seconds, at least.
20	1 OP	SAMPLER_CMD 4xx.x22	Unsigned8	0=Stopped 1=Start(Wr) 2=Running 3=Stop(Wr) 4=Sampler full	0	E	D	Command to begin the collection of the sample
21	2 CF	BATCH_TYPE 4xx.x23	Unsigned8	0=Quantity 1=Time 2=Product interface	0	E	S	It defines the criterion for beginning and end of the batch.
22	2 CF	TOT_TYPE 4xx.x24	Unsigned8	0=Qv / IV 1=Qb / GSV 2=Qm / NSV 3=Energy / Mass	1	E	S	Variable type to be totalized and compared to BATCH_SIZE.
23	2 PG1	BATCH_SIZE 4xx.x25 - 4xx.x44	Float[10]		0	V/M/EN	N	Programming of the batch considering the size of each one. The first element is the current batch to be started or in execution.
24	2 CF	NEAR_END 4xx.x45 - 4xx.x46	Float	50 to 100	95	%	S	It specifies a percentage of the batch size to be reached to activate the output BATCH_NEAR_END.
25	2 CF	TIME_DELAY 4xx.x47	Unsigned16	0 to 65535	10	S	S	Time to end the batch and to activate the output BATCH_END.
26	3 PG2	BATCH_TIME_CMD 4xx.x48	Unsigned8	0 = None 1 to 10 = Delete entry 1... 10 (Wr) 254 = Inconsistent entry 255 = Insert (Wr)	0	E	D	Command to delete certain batch of the type time or to insert a new batch whose beginning and end are configured in TEMP_START_TIME and TEMP_END_TIME. The new batch will be inserted automatically in the position of the chronological order.
27	3 PG2	TEMP_START_TIME 4xx.x49 - 4xx.x55	Unsigned8[7]				N	Date and hour of the batch start to be programmed.

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
28	3 PG2	TEMP_END_TIME 4xx.x56 - 4xx.x62	Unsigned8[7]				N	Date and hour of the batch end to be programmed.
29	1 PG2	BATCH1_START_TIME 3xx.x12 - 3xx.x18	Unsigned8[7]				N / RO	Date and hour of the batch1 start.
30	1 PG2	BATCH1_END_TIME 3xx.x19 - 3xx.x25	Unsigned8[7]				N / RO	Date and hour of the batch1 end.
31	1 PG2	BATCH2_START_TIME 3xx.x26 - 3xx.x32	Unsigned8[7]				N / RO	Date and hour of the batch2 start.
32	1 PG2	BATCH2_END_TIME 3xx.x33 - 3xx.x39	Unsigned8[7]				N / RO	Date and hour of the batch2 end.
33	1 PG2	BATCH3_START_TIME 3xx.x40 - 3xx.x46	Unsigned8[7]				N / RO	Date and hour of the batch3 start.
34	1 PG2	BATCH3_END_TIME 3xx.x47 - 3xx.x53	Unsigned8[7]				N / RO	Date and hour of the batch3 end.
35	1 PG2	BATCH4_START_TIME 3xx.x54 - 3xx.x60	Unsigned8[7]				N / RO	Date and hour of the batch4 start.
36	1 PG2	BATCH4_END_TIME 3xx.x61 - 3xx.x67	Unsigned8[7]				N / RO	Date and hour of the batch4 end.
37	1 PG2	BATCH5_START_TIME 3xx.x68 - 3xx.x74	Unsigned8[7]				N / RO	Date and hour of the batch5 start.
38	1 PG2	BATCH5_END_TIME 3xx.x75 - 3xx.x81	Unsigned8[7]				N / RO	Date and hour of the batch5 end.
39	3 PG2	BATCH6_START_TIME 3xx.x82 - 3xx.x88	Unsigned8[7]				N / RO	Date and hour of the batch6 start.
40	3 PG2	BATCH6_END_TIME 3xx.x89- 3xx.x95	Unsigned8[7]				N / RO	Date and hour of the batch6 end.
41	3 PG2	BATCH7_START_TIME 3xx.x96 - 3xx.102	Unsigned8[7]				N / RO	Date and hour of the batch7 start.

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
42	3 PG2	BATCH7_END_TIME 3xx.103 - 3xx.109	Unsigned8[7]				N / RO	Date and hour of the batch7 end.
43	3 PG2	BATCH8_START_TIME 3xx.110 - 3xx.116	Unsigned8[7]				N / RO	Date and hour of the batch8 start.
44	3 PG2	BATCH8_END_TIME 3xx.117 - 3xx.123	Unsigned8[7]				N / RO	Date and hour of the batch8 end.
45	3 PG2	BATCH9_START_TIME 3xx.124 - 3xx.130	Unsigned8[7]				N / RO	Date and hour of the batch9 start.
46	3 PG2	BATCH9_END_TIME 3xx.131 - 3xx.137	Unsigned8[7]				N / RO	Date and hour of the batch9 end.
47	3 PG2	BATCH10_START_TIME 3xx.138 - 3xx.144	Unsigned8[7]				N / RO	Date and hour of the batch10 start.
48	3 PG2	BATCH10_END_TIME 3xx.145 - 3xx.151	Unsigned8[7]				N / RO	Date and hour of the batch10 end.
49	PG3	BATCH_PRODUCT_ID 4xx.x63 - 4xx.x72	Unsigned8[10]	1 to 10	0	Na	N	Define the ID of the product for each batch of type "Product interface".
50	2 CF	MAX_CHANGE 4xx.x73 - 4xx.x74	Float	> 0.0	10.0	LD	S	This parameter specifies the necessary change of density to consider the end of a batch and beginning of a new batch.
51	2 CF	VOLUME_MASS_DELAY 4xx.x75 - 4xx.x76	Float	> 0.0	2.0	V / M	S	It indicates the volume/mass of the fluid in the pipe between the density meter and the separation valve of the products.
52	4 PGx	BATCH_ID1 4xx.x77 - 4xx.x80	Visiblestring[8]		Blank	Na	N	Tag of batch1 description (current)
53	4 PGx	BATCH_ID2 4xx.x81 - 4xx.x84	Visiblestring[8]		Blank	Na	N	Tag of batch2 description
54	4 PGx	BATCH_ID3 4xx.x85 - 4xx.x88	Visiblestring[8]		Blank	Na	N	Tag of batch3 description
55	4 PGx	BATCH_ID4 4xx.x89 - 4xx.x92	Visiblestring[8]		Blank	Na	N	Tag of batch4 description
56	4 PGx	BATCH_ID5 4xx.x93 - 4xx.x96	Visiblestring[8]		Blank	Na	N	Tag of batch5 description

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
57	4 PGx	BATCH_ID6 4xx.x97 - 4xx.100	Visiblestring[8]		Blank	Na	N	Tag of batch6 description
58	4 PGx	BATCH_ID7 4xx.101 - 4xx.104	Visiblestring[8]		Blank	Na	N	Tag of batch7 description
59	4 PGx	BATCH_ID8 4xx.105 - 4xx.108	Visiblestring[8]		Blank	Na	N	Tag of batch8 description
60	4 PGx	BATCH_ID9 4xx.109 - 4xx.112	Visiblestring[8]		Blank	Na	N	Tag of batch9 description
61	4 PGx	BATCH_ID10 4xx.113 - 4xx.116	Visiblestring[8]		Blank	Na	N	Tag of batch10 description
62	PGx	CARRIER_ID1 4xx.117 - 4xx.124	Visiblestring[16]		Blank	Na	N	Batch carrier 1 (current)
63	PGx	CARRIER_ID2 4xx.125 - 4xx.132	Visiblestring[16]		Blank	Na	N	Batch carrier 2
64	PGx	CARRIER_ID3 4xx.133 - 4xx.140	Visiblestring[16]		Blank	Na	N	Batch carrier 3
65	PGx	CARRIER_ID4 4xx.141 - 4xx.148	Visiblestring[16]		Blank	Na	N	Batch carrier 4
66	PGx	CARRIER_ID5 4xx.149 - 4xx.156	Visiblestring[16]		Blank	Na	N	Batch carrier 5
67	PGx	CARRIER_ID6 4xx.157 - 4xx.164	Visiblestring[16]		Blank	Na	N	Batch carrier 6
68	PGx	CARRIER_ID7 4xx.165 - 4xx.172	Visiblestring[16]		Blank	Na	N	Batch carrier 7
69	PGx	CARRIER_ID8 4xx.173 - 4xx.180	Visiblestring[16]		Blank	Na	N	Batch carrier 8
70	PGx	CARRIER_ID9 4xx.181 - 4xx.188	Visiblestring[16]		Blank	Na	N	Batch carrier 9
71	PGx	CARRIER_ID10 4xx.189 - 4xx.196	Visiblestring[16]		Blank	Na	N	Batch carrier 10

Idx	Type/ View	Parameter	Data Type (length)	Valid Range/ Options	Default Value	Unit	Store/ Mode	Description
72	1 OP	BATCH_STATE 4xx.197	Unisnged8	0=Not Transfer 1=Running batch 2=Near end 3=End reached 4=End/Start (Wr) 5=Missed start 6=Non-programmed transfer 7=Force start (Wr) 8=Force end (Wr) 9=Cancel (Wr)	0	E	N	It indicates the state of batch and allows to the user to interrupt the batch.
73		UPDATE_EVT 3xx.152 – 3xx.158 4xx.198	DS-73			Na	D	This alert is generated by any change to the static data.
74	3	BLOCK_ALM 3xx.159 – 3xx.165 4xx.199	DS-72			Na	D	The block alarm is used for all configuration, hardware, connection failure or system problems in the block. The cause of the alert is entered in the subcode field. The first alert to become active will set the Active status in the Status attribute. As soon as the Unreported status is cleared by the alert reporting task, another block alert may be reported without clearing the Active status, if the subcode has changed.

CL = 57 bytes (include block tag and profile); V1-105 bytes; V2-85 bytes; V3-106 bytes; V4-85 bytes.
HFCView: OP (Operation), CF (Configuration), PGx (PG1, PG2, PG3), PG1 (Batch Programming - Quantity), PG2 (Batch Programming - Time), PG3 (Batch Programming - Interface), MN (Maintenance)

Data Discrimination and Format

The proposed discrimination below refers to liquid measurement only and follow API-12.2.2 and API-12.2.3 standards. Regarding to gas measurement, this must be kept the discrimination/format from version 3.

In the following table, the digit number showed as (X) prior to decimal point has illustrative purpose only with higher or lower value than the showed number (X).

The digit numbers showed as (x) after decimal point are specifics, since they define the discrimination level required for each described value.

Tables 8 and 9 show letters, such as ABCD.xx, from left side of decimal point, in this case the letters show the current size of the previous value from decimal point and are intended to be specific and not illustrative.

In cases the value is showed with number 5 in the last decimal place, such as XX.x5, that means the value from last decimal place must be changed to 0 or 5, no other value is allowed [API 12.2.3 – page 15].

Class	Format	Comments	Ref.
1-DD1	XX.X	One decimal place	API 12.2.3 – Tab. 3 – page 15
2-DD2	X.XX	Two decimal places	API 12.2.3 – Tab. 9 – page 18
3-DD3	X.XXX	Three decimal places	API 12.2.3 – Tab. 9 – page 18
4-DD4	X.XXXX	Four decimal places	API 12.2.3 – Tab. 8 – page 17
5-DD5	X.XXXXX	Five decimal places	API 12.2.3 – Tab. 8 – page 17
7-DD7	0.00000XX 0.0000XXX 0.000XXXX 0.00XXXXX	Seven decimal places	API 12.2.3 – Tab. 5 – page 16
8-DD8	0.000000XX 0.00000XXX 0.0000XXXX 0.000XXXXX	Eight decimal places	API 12.2.3 – Tab. 5 – page 16
9-DD9	0.000000XXX 0.00000XXXX 0.0000XXXXX	Nine decimal places	API 12.2.3 – Tab. 5 – page 16
10-DD10	XX.0	One decimal place equals to zero	API 12.2.3 – Tab. 4 – page 16
15-DD15	XXXX.5	One decimal place always equals to 0 or 5	API 12.2.2 – Tab. 2 – page 6
25-DD25	XX.X5	Two decimal places in which the last is always 0 or 5	API 12.2.3 – Tab. 3 – page 15
45-DD45	X.XXX5	Four decimal places in which the last is always 0 or 5	API 12.2.2 – Tab. 2 – page 6
50-SD5	AB.XXX ABC.XX ABCD.X ABCDE.0	Five significative digits	API 12.2.3 – Tab. 8 – page 17
60-SD6	AB.XXXX ABC.XXX ABCD.XX ABCDE.X	Six significative digits	API 12.2.3 – Tab. 9– page 18
65-SD65T	ABCDE.x ABCD.xx ABC.xxx AB.xxx	Five or six (ten) significative digits	API 5.6. – Tab.E-2
67-SD67T	AB.XXXXX A.XXXXX 0.XXXXXX 0.0XXXXXX	Six or seven (ten) significative digits	API 12.2.3 – Tab. 9 – page 18
68-SD67H	ABC.XXXX AB.XXXX A.XXXXX 0.XXXXXX	Six or seven (ten) significative digits	API 12.2.3 – Tab. 9 – page 18
79-DD79	0.0000XXX 0.00000XXXX	Seven decimal place if higher or equal to 1E-5 Nine decimal places if lower than 1E-5	API 12.2.2. – Tab. 5 – page 16
102-ISD2	AB,CDE,FGH	Integer32 with 2 significative digits	API 12.2.3 – Tab. 7 – page 17
104-ISD4	ABC,DEF,GHI	Integer32 with 4 significative digits	API 12.2.3 – Tab. 7 – page 17

(*)The discrimination type DD1 to DD45 also applies, regardless the digits at left of decimal point and the digits zero at right of decimal point.

Standard Data Structure

Date

E	Element Name	Data type	Size	Range
1	Milli-seconds xxx xx0	Unsigned16	2	0…59999
2	Minutes xxx xx1	Unsigned8	1	0…59
3	Hours xxx xx2	Unsigned8	1	0…23
4	Day of week (bit 5-7)& Day of month (bits 0-4) xxx xx3	Unsigned8	1	1…7 1…31
5	Month xxx xx4	Unsigned8	1	1…12
6	Year xxx xx5	Unsigned8	1	0…99

Time Difference

E	Element Name	Data type	Size	Range
1	Number of milli-seconds xxx xx0 - xxx xx1	Unsigned32	4	0…134,217,727
2	Number of days xxx xx2	Unsigned16	2	0…65535

Block Structure – DS-64

This data structure has the attributes of a block.

E	Element Name	Data Type	Size
1	Block Tag	VisibleString	32
2	DD MemberId	Unsigned32	4
3	DD ItemId	Unsigned32	4
4	DD Revision	Unsigned16	2
5	Profile	Unsigned16	2
6	Profile Revision	Unsigned16	2
7	Execution Time	Unsigned32	4
8	Period of Execution	Unsigned32	4
9	Number of Parameters	Unsigned16	2
10	Next FB to Execute	Unsigned16	2
11	Starting Index of Views	Unsigned16	2
12	NumberofVIEW_3	Unsigned8	1
13	NumberofVIEW_4	Unsigned8	1

Value & Status – Float Structure – DS-65

This structure data has the values and status parameters from float parameters which are Inputs or Outputs.

E	Element Nam	Data type	Size
1	Status xxx xx0	Unsigned8	1
2	Value xxx xx1 - xxx xx2	Float	4

Value & Status – Discrete Structure – DS-66

This structure has parameter value and status of discrete values.

E	Element Name	Data type	Size
1	Status xxx xx0	Unsigned8	1
2	Value xxx xx1	Unsigned8	1

Scaling Structure – DS-68

This data structure has information of scale for analog variables.

E	Element Name	Data Type	Size
1	EU at 100% 4xx xx0 - 4xx xx1	Float	4
2	EU at 100% 4xx xx2 - 4xx xx3	Float	4
3	Units Index 4xx xx4	Unsigned16	2
4	Decimal Point 4xx xx5	Integer8	1

Mode Structure – DS-69

This data structure has information about the block operation mode.

E	Element Name	Data Type	Size
1	Target 4xx xx0	Bitstring	1
2	Actual 3xx xx0	Bitstring	1
3	Permitted 4xx xx1	Bitstring	1
4	Normal 4xx xx2	Bitstring	1

Access Permissions – DS-70

This data structure has control flags for block parameters access.

E	Element Name	Data Type	Size
1	Grant 4xx xx0	Bit String	1
2	Deny 4xx xx1	Bit String	1

Alarm Float Structure – DS-71

This data structure has information about analog variable alarms.

E	Element Name	Data Type	Size
1	Unacknowledged 4xx xx0	Unsigned8	1
2	Alarm State 3xx xx0	Unsigned8	1
3	Time Stamp 3xx xx1 - 3xx xx4	Time Value	8
4	Subcode 3xx xx5	Unsigned16	2
5	Value 3xx xx6 - 3xx xx7	Float	4

Alarm Discrete Structure – DS-72

This data structure has information about discrete variable alarms.

E	Element Name	Data Type	Size
1	Unacknowledged 4xx .xx0	Unsigned8	1
2	Alarm State 3xx xx0	Unsigned8	1
3	Time Stamp 3xx xx1 - 3xx xx4	Time Value	8
4	Subcode 3xx xx5	Unsigned16	2
5	Value 3xx xx6	Unsigned8	1

Event Update Structure – DS-73

This data structure has information about events which indicates writing in static parameters.

E	Element Name	Data Type	Size
1	Unacknowledged 4xx xx0	Unsigned8	1
2	Update State 3xx xx0	Unsigned8	1
3	Time Stamp 3xx xx1 - 3xx xx4	Time Value	8
4	Static Revision 3xx xx5	Unsigned16	2

E	Element Name	Data Type	Size
5	Relative Index6 3xx xx6	Unsigned16	2

Alarm Summary Structure – DS-74

This data structure has alarms summarized information.

E	Element Name	Data Type	Size
1	Current 3xx xx0	Bit String	2
2	Unacknowledged 3xx xx1	Bit String	2
3	Unreported 3xx xx2	Bit String	2
4	Disabled 4xx xx0	Bit String	2

Simulate - Floating Point Structure – DS-82

This data structure has information about analog variable simulation.

E	Element Name	Data Type	Size
1	Simulate Status 4xx xx0	Unsigned8	1
2	Simulate Value 4xx xx1 - 4xx xx2	Float	4
3	Transducer Status 3xx xx0	Unsigned8	1
4	Transducer Value 3xx xx1 - 3xx xx2	Float	4
5	Simulate En/Disable 4xx xx3	Unsigned8	1

Simulate - Discrete Structure – DS-83

This data structure has information about discrete variable simulation.

E	Element Name	Data Type	Size
1	Simulate Status 4xx xx0	Unsigned8	1
2	Simulate Value 4xx xx1	Unsigned8	4
3	Transducer Status 3xx xx0	Unsigned8	1
4	Transducer Value 3xx xx1	Unsigned8	4
5	Simulate En/Disable 4xx xx2	Unsigned8	1

Test Structure – DS-85

This data structure has information for writing and reading test in variable of different types.

E	Element Name	Data Type	Size
1	Value1 4xx xx0	Boolean	1
2	Value2 4xx xx1	Integer8	1
3	Value3 4xx xx2	Integer16	2
4	Value4 4xx xx3 - 4xx xx4	Integer32	4
5	Value5 4xx xx5	Unsigned8	1
6	Value6 4xx xx6	Unsigned16	2
7	Value7 4xx xx7 - 4xx xx8	Unsigned32	4
8	Value8 4xx xx9 - 4xx x10	FloatingPoint	4
9	Value9 4xx x11 - 4xx x26	VisibleString	32
10	Value10 4xx x27 - 4xx x42	Octetstring	32
11	Value11 4xx x43 - 4xx x48	Date	7
12	Value12 4xx x49 - 4xx x51	Time of Day	6
13	Value13 4xx x52 - 4xx x54	Time Difference	6
14	Value14 4xx x55	Bitstring	2
15	Value15 4xx x56 - 4xx x59	Time Value	8

Special Data Structure

Scale Conversion Structure - DS-256

This data structure has data used to generate the A and B constants in the equation Y= A*X + B.

E	Element Name	Data type	Size
1	From EU 0% 4xx xx0 - 4xx xx1	Float	4
2	From EU 100% 4xx xx2 - 4xx xx3	Float	4
3	To EU 0% 4xx xx4 - 4xx xx5	Float	4
4	To EU 100% 4xx xx6 - 4xx xx7	Float	4
5	Data Type 4xx xx8	Unsigned8	1

Scale Conversion Structure with Status - DS-257

This data structure has data used to generate the A and B constants in the equation Y= A*X + B, plus the output status.

E	Element Name	Data type	Size
1	From EU 0% 4xx xx0 - 4xx xx1	Float	4
2	From EU 100% 4xx xx2 - 4xx xx3	Float	4
3	To EU 0% 4xx xx4 - 4xx xx5	Float	4
4	To EU 100% 4xx xx6 - 4xx xx7	Float	4
5	Data Type 4xx xx8	Unsigned8	1
6	Output Status 4xx xx9	Unsigned8	1

Locator Scale Structure - DS-258

This data structure has data used to generate the A and B constants in the equation Y= A*X plus the slave device addresses.

E	Element Name	Data type	Size
1	From EU 0% 4xx xx0 - 4xx xx1	Float	4
2	From EU 100% 4xx xx2 - 4xx xx3	Float	4
3	To EU 0% 4xx xx4 - 4xx xx5	Float	4
4	To EU 100% 4xx xx6 - 4xx xx7	Float	4
5	Data Type 4xx xx8	Unsigned8	1
6	Slave Address 4xx xx9	Unsigned8	1
7	Modbus Address of Value 4xx x10	Unsigned16	2

Locator and Status Scale Structure - DS-259

This data structure has data used to generate the A and B constants in the equation Y= A*X + B, plus the slave device address.

E	Element Name	Data type	Size
1	From EU 0% 4xx xx0 - 4xx xx1	Float	4
2	From EU 100% 4xx xx2 - 4xx xx3	Float	4
3	To EU 0% 4xx xx4 - 4xx xx5	Float	4
4	To EU 100% 4xx xx6 - 4xx xx7	Float	4
5	Data Type 4xx xx8	Unsigned8	1
6	Slave Address 4xx xx9	Unsigned8	1
7	Modbus Address of Value 4xx x10	Unsigned16	2
8	Modbus Address of Status 4xx x11	Unsigned16	2

Modbus Variable Locator Structure - DS-260

This structure has data which indicate the slave device addresses.

E	Element Name	Data type	Size
1	Slave Address 4xx xx0	Unsigned8	1
2	Modbus Address of Value 4xx xx1	Unsigned16	2

Modbus Variable Locator Structure with Status- DS-261

This data structure has data which indicates addresses in a slave device.

E	Element Name	Data type	Size
1	Slave Address 4xx xx0	Unsigned8	1
2	Modbus Address of Value 4xx xx1	Unsigned16	2
3	Modbus Address of Status 4xx xx2	Unsigned16	2

FF Parameter ID Structure - DS-262

This structure has data which informs the requested FF parameter position.

E	Element Name	Data type	Size
1	Block Tag 4xx xx0 - 4xx x15	VisibleString(32)	32
2	Relative Index 4xx x16	Unsigned16	2
3	Sub Index 4xx x17	Unsigned8	1

Slave Address Structure - DS-263

This data structure has data which informs the Slave IP and Modbus Addresses.

E	Element Name	Data type	Size
1	IP Slave1 4xx xx0 - 4xx xx7	VisibleString(16)	16
2	IP Slave2 4xx xx8 - 4xx x15	VisibleString(16)	16
3	IP Slave3 4xx x16 - 4xx x23	VisibleString(16)	16
4	IP Slave4 4xx x24 - 4xx x31	VisibleString(16)	16
5	IP Slave5 4xx x32 - 4xx x39	VisibleString(16)	16
6	IP Slave6 4xx x40 - 4xx x47	VisibleString(16)	16
7	Slave Address1 4xx x48	Unsigned8	1
8	Slave Address2 4xx x49	Unsigned8	1
9	Slave Address3 4xx x50	Unsigned8	1
10	Slave Address4 4xx x51	Unsigned8	1
11	Slave Address5 4xx x52	Unsigned8	1
12	Slave Address6 4xx x53	Unsigned8	1

Meter Information Data Structure - DS-268

E	Element Name	Data type	Size
1	Factor type (0=MF) 4xx xx0	Unsigned8	1
2	Reserved 4xx xx1	Unsigned8	1
3	Nominal K factor [K] 4xx xx2-4xx xx3	Float	4
4	Meter num 4xx xx4	Unsigned16	2
5	Manufacturer name 4xx xx5-4xx x12	Visiblestring[16]	16
6	Size [L] 4xx x13-4xx x20	Visiblestring[16]	16
7	Serial number 4xx x21-4xx x28	Visiblestring[16]	16
8	Model number 4xx x29-4xx x36	Visiblestring[16]	16

Length = 72 bytes

Prover Information Data Structure - DS-269

E	Element Name	Data type	Size
1	Prover type 4xx xx0	Unsigned8	1
2	Base Prover Volume (not used if tank prover) [V] 4xx xx1-4xx xx2	Float SI-SD67T US-SD67H Liter-SD6 Gallon-SD6	4
3	Outside diameter [L] 4xx xx3-4xx xx4	Float SI-DD2 US-DD3	4
4	Wall thickness [L] 4xx xx5-4xx xx6	Float SI-DD2 US-DD3	4
5	Pipe Gl [G] 4xx xx7-4xx xx8	Float SI-DD7 US-DD8	4
6	Modulus of elasticity [Elas] 4xx xx9-4xx x10	Float SI- ISD4 US-ISD2 Bar-ISD4	4
7	Single-walled (0=No; 1=Yes) 4xx x11	Unsigned8	1
8	External shaft – Gl (0.0=internal detectors) 4xx x12-4xx x13	Float SI-DD7 US-DD8	4
9	Serial number 4xx x14-4xx x21	Visiblestring[16]	16
10	Manufacturer name 4xx x22-4xx x29	Visiblestring[16]	16

Length=58 bytes

Prover type:
0 = U type, unidirectional;
1 = U type, bi-directional;
2 = Small volume prover, unidirectional;
3 = Small volume prover, bi- directional;
4 = Tank prover;
5 = Master meter.

Base Prover Volume:
Prover volume of calibrated section at base conditions defined in the block LKD.
If it is a U-type bidirectional prover, then it must be provided the BPV in the forward direction added to the BPV in the backward direction.

Outside diameter:
Outside diameter of prover at base temperature defined in the block LKD.

Wall thickness:
Wall thickness of prover at base temperature defined in the block LKD.

Pipe GI:
Coefficient of linear thermal expansion of steel type used in the prover.

Modulus of elasticity:
Modulus of elasticity of steel type used in the prover.

Single-walled:
Some piston provers are double-walled. It does not apply to pipe provers.

External shaft:
Coefficient of linear thermal expansion of the external shaft, whose material is usually different from the prover.

Serial number:
Serial number of prover that is used to provide such information in the proving report.

Manufacturer name:
Manufacturer name of prover that is used to provide such information in the proving report.

Product Information Data Structure - DS-270

E	Element Name	Data type	Size
1	Product 4xx xx0-4xx xx7	Visiblestring[16]	16
2	Viscosity [Visc] 4xx xx8-4xx x09	Float	4
3	Product type 4xx x10	Unsigned8	1
4	Density type 4xx x11	Unsigned8	1
5	Coefficient of thermal expansion (MTBE) [1/T] 4xx x12-4xx x13	Float	4
6	Standard version 4xx x14	Unsigned8	1
7	Absolute equilibrium pressure @ 100 °F [P] 4xx x15-4xx x16	Float SI-DD10 US-DD10 Bar-DD1	4
8	Base density of water [LD] 4xx x17-4xx x18	Float SI-DD1 US-DD1 SG-DD4	4

Length=35 bytes

Product type
0=Crude Oil (Table Suffix A);
1=Generalized Products (Table Suffix B);
2=MTBE (Table Suffix C);
3=Lubrificating Oil (Table Suffix D);
4=Water
5=Light hydrocarbon (Table Suffix E)
6=Crude oil and water emulsion
7= Emulsion of light hydrocarbon and water
8=ASTM D 1250:1952 (**)
9=Ethanol-OIML R22-75 (*)
10=Ethanol-NBR 5992-80 (*)
11=Ethanol-NBR 5992-09 (*)
(*) By selecting this product type, the elements from 4 to 8 of this structure do not have activity, that is, they are ignored always considering the flowing temperature density.
(**) Correction is always done due to density measurement by glass densimeter.

Inputs and basis
- API -> 60 °F (table 5 & 6);
- Rel.Dens -> 60 °F (table 23 & 24);
- Dens + 15 °C -> (table 53 & 54);
- Dens + 20 °C -> (table 59 & 60).

Note:
The LD_UNITS, in FCT blocks and BASE_TEMPERATURE, in LKD block, is sufficient to select the correct table.

Density type
1= base temperature density (this density type is mandatory for water measurement;
2= flowing temperature density.

Thermal expansion coefficient in base temperature
In order to calculate the CTL factor for MTBE measurement it is necessary to provide the thermal expansion coefficient in base temperature.

Standard version
0 = API-11.1:1980 – No correction for glass densimeter (default);
1= API-11.1:1980 - Correction for glass densimeter.
2= API-11.1:2004

Equilibrium pressure at 100°F
If the measured meter is Light Hydrocarbon (NGL&LPG), the equilibrium pressure is calculated according to the GPA TP 15 standard that shows two possible ways to calculate it. One is using the equilibrium pressure at 100°F. Thus, this structure element is important only for the referred product.

Water base density
Water density measured in the temperature LKD.BASE_TEMPERATURE with maximum salinity degree of 14%, if the product is emulsion type; otherwise, this parameter is ignored. In allocation measurement applications for crude oil/light hydrocarbon, the base density of water is used for calculating the BSW conversion from base condition to flow condition, if it is static sample, as well as the water volume compensated in temperature.

Proving Information Data Structure - DS-271

E	Element Name	Data type	Size
1	Meter factor (n) – last proving 4xx xx0-4xx xx1	Float DD4	4
2	Date and time of proving (n) – last proving 3xx xx0-3xx xx5	Date (11)	7
3	Meter factor (n-1) 3xx xx6-3xx xx7	Float DD4	4
4	Date and time of proving (n-1) 3xx xx8-3xx xx13	Date (11)	7
5	Meter factor (n-2) 3xx x14-3xx x15	Float DD4	4
6	Date and time of proving (n-2) 3xx x16-3xx x21	Date (11)	7
7	Meter factor (n-3) 3xx x22-3xx x23	Float DD4	4
8	Date and time of proving (n-3) 3xx x24-3xx x29	Date (11)	7
9	Meter factor (n-4) 3xx x30-3xx x31	Float DD4	4
10	Date and time of proving (n-4) 3xx x32-3xx x37	Date (11)	7
11	Meter factor (n-5) 3xx x38-3xx x39	Float DD4	4
12	Date and time of proving (n-5) 3xx x40-3xx x45	Date (11)	7
13	Meter factor (n-6) 3xx x46-3xx x47	Float DD4	4
14	Date and time of proving (n-6) 3xx x48-3xx x53	Date (11)	7
15	Meter factor (n-7) – oldest proving 3xx x54-3xx x55	Float DD4	4
16	Date and time of proving (n-7) – oldest proving 3xx x56-3xx x61	Date (11)	7

If the user needs to record MF, this must be done in the first element. If the type was accepted, the list is changed and the oldest is removed. All the other elements of this data structure are read only.

Proving Conditions Data Structure - DS-272

E	Element Name	Data type	Size
1	Current request type : 0=Auto; 1=Demand 3xx xx0	Unsigned8	1
2	Current flowrate IV [QV] 4xx xx0-4xx xx1	Float	4
3	Current MR [LV] 3xx xx1-3xx xx2	Float SI-DD3 US-DD2 Liter-DD10 Gallon-DD2	4
4	Current density at base [LD] 3xx xx3-3xx xx4	Float SI-DD1 US-DD1 SG-DD4	4
5	Current viscosity [Visc] 3xx xx5-3xx xx6	Float	4
6	Current temperature of prover [T] 3xx xx7-3xx x08	Float SI-DD25 US-DD1	4
7	Current repeatability (%) 3xx x09-3xx x10	Float DD3	4
8	Previous request type : 0=Auto; 1=Demand; 2= User entry 3xx x11	Unsigned8	1
9	Previous flowrate IV [QV] 3xx x12-3xx x13	Float	4
10	Previous MR [LV] 3xx x14-3xx x15	Float SI-DD3 US-DD2 Liter-DD10 Gallon-DD2	4
11	Previous density at base [LD] 3xx x16-3xx x17	Float SI-DD1 US-DD1 SG-DD4	4
12	Previous viscosity [Visc] 3xx x18-3xx x19	Float	4
13	Previous temperature of prover [T] 3xx x20-3xx x21	Float SI-DD25 US-DD1	4
14	Previous repeatability (%) 3xx x22-3xx x23	Float DD3	4

Configuration Log Data Structure - DS-273

E	Element Name	Data type	Size
1	Meter run (0=master meter; 1-4=meter run number, 253=Gas Station, 254=Liquid Station, 255=Not Specific)	Unsigned8	1
2	Block tag	Visiblestring[32]	32
3	Relative index	Unsigned16	2
4	Subindex	Unsigned16	2
5	Data type	Unsigned16	2
6	Login number (0 to 29,100=HFCView)	Unsigned8	1
7	Date and time	Date	7
8	As found	Octetstring[16]	16
9	As left	Octetstring[16]	16
10	Storage state	Unsigned8	1

E	Element Name	Data type	Size
11	Log counter (0 to 65000)	Unsigned16	2
12	Username	Visiblestring[8]	8

Notes:
If Subindex=253 (internal wr), consider as 255 (whole structure). By deleting HF block, GT.CHANNEL writing is done with internal wr so that the writing is done independently the block mode.

Structure total size: 90bytes / 49 Modbus records

Data Structure Alarm/Event of the Log Data Structure - DS-274

E	Element Name	Data type	Size
1	Meter run (0=master meter or prover ; 1-4=meter run number, 253=Gas Station, 254=Liquid Station, 255=Not Specific)	Unsigned8	1
2	Block tag or Event description	Visiblestring[32]	32
3	Alert key	Unsigned8	1
4	Type	Unsigned16	2
5	Date and time	Date	7
6	Value (only for alarm)	Float	4
7	Priority	Unsigned8	1
8	Storage state	Unsigned8	1
9	Log counter (0 to 65000)	Unsigned16	2

Notes

- Structure total size : 51 bytes;
- The element meaning "Type" is the following:

1=Low (occurred);
2=High (occurred);
3=Low Low (occurred);
4=High high (occurred);
7=Discrete (occurred);
8=Alarm Block/Event (occurred).

30001=Low (cleared);
30002=High (cleared);
30003=Low Low (cleared);
30004=High high (cleared);
30007=Discrete (cleared);
30008= Alarm Block/Event (cleared).

- Priority:

0-7: non critical;
8-15: critical.

- The correspondent Alert key element to the ALERT_KEY from the AALM block must be configured to identify the variable type:

0 = None;
1 = Temperature;
2 = Pressure;
3 = Differential pressure;
4 = Density;
5 = SW;
6 = Flow in volume;
7 = Flow in mass.

Bits Enumeration Description

BATCH_STATUS_LIQ

Bit	Meaning
0	Override temperature used (LSB)
1	Override pressure used (*)
2	Override density used
3	Override SW used
4	Bad pulse input / flow input (**)
5	Extrapolated CTL
6	Out of range CTL
7	Out of range CPL
8	Stop totalization / Block in O/S
9	IV rollover
10	Process alarm
11	Dual pulse not active
12	Not sealed
13	Reserved13
14	Inconsistent flow rate
15	Reserved15

(*) The status is not suggested if allocation measurement and pressure input not connected. In this situation, neither the event is registered.

(**) This indication occurs when:

a. Flow signal type is an analog input and the status is bad.
b. Signal type is pulse and problems occurred on pulse input module access to the pulse input module or errors operation in dual pulse mode (coincident pulses, phase error, sequence error, missing pulse or extra pulse.

BATCH_STATUS_GAS

Bit	Meaning	Abnormal Condition (***)
0	Override temperature used (LSB)	X
1	Override pressure used	X
2	Override differential pressure used	X
3	Bad pulse input / flow input (**)	X
4	Inconsistent secondary variables	X
5	Out of range	X
6	Bad chromatograph	X
7	Process alarm	
8	Dual pulse not active	
9	NRL_TOT_QB rollover	
10	Stop totalization / Block in O/S	X
11	Inconsistent data (*)	X
12	Not sealed	
13	Extrapolated range of composition	
14	Inconsistent flow rate	
15	Reserved15	

(*) This indication occurs when Y<= 0 or in density calculation by second virial in gas phase with inconsistency.

(**) This indication occurs when:

a. Flow signal type is an analog input and the status is bad.
b. Signal type is pulse and problems occurred on pulse input module access to the pulse input module or errors operation in dual pulse mode (coincident pulses, phase error, sequence error, missing pulse or extra pulse.

(***) Abnormal condition of operation will cause the increment of specific totalizers (Qb, Qm and Energy) for this conditions and the totalizers for normal conditions will stop incrementing. There is only one totalizer for Qv and it will increment when operating at normal and abnormal conditions.

ACTIVE_ALARM1 and UNACK_ALARM1

Bit	Meaning	LCT	GT
0	Temperature - lo (LSB)	X	X
1	Temperature - hi	X	X
2	Temperature – lo lo	X	X
3	Temperature – hi hi	X	X
4	Pressure - lo	X	X
5	Pressure - hi	X	X
6	Pressure – lo lo	X	X
7	Pressure – hi hi	X	X
8	Diff. Pressure - lo		X
9	Diff. Pressure - hi		X
10	Diff. Pressure – lo lo		X
11	Diff. Pressure – hi hi		X
12	Density - lo	X	
13	Density - hi	X	
14	Density – lo lo	X	
15	Density – hi hi	X	

ACTIVE_ALARM2 and UNACK_ALARM2

Bit	Meaning	LT	GT
0	SW - lo	X	
1	SW - hi	X	
2	SW – lo lo	X	
3	SW – hi hi	X	
4	Flow Volume - lo	X	X
5	Flow Volume - hi	X	X
6	Flow Volume – lo lo	X	X
7	Flow Volume – hi hi	X	X
8	Flow Mass - lo	X	X
9	Flow Mass - hi	X	X
10	Flow Mass – lo lo	X	X
11	Flow Mass – hi hi	X	X
12	Reserved12		
13	Reserved13		
14	Reserved14		
15	Reserved15		

ENABLE_REPORT

(*) Available option for LT block only.

Bit	Meaning
0	Hourly report (LSB)
1	Daily report
2	Monthly report
3	Quarter report (*)
4	Reserved4
5	Reserved5
6	Reserved6
7	Reserved7
8	Reserved8
9	Reserved9
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

LIQ_SPEC1

Bit	Meaning
0	API-11.1-Tables 5A & 6A (LSB)
1	API-11.1-Tables 5B & 6B
2	API-11.1-Table 6C
3	API-11.1-Tables 5D & 6D
4	API-11.1-Tables 23A & 24A
5	API-11.1-Tables 23B & 24B
6	API-11.1-Table 24C
7	API-11.1-Tables 23D & 24D
8	API-11.1-Tables 53A & 54A
9	API-11.1-Tables 53B & 54B
10	API-11.1-Table 54C
11	API-11.1-Tables 53D & 54D
12	API-11.1-Tables 59A & 60A
13	API-11.1-Tables 59B & 60B
14	API-11.1-Table 60C
15	API-11.1-Tables 59D & 60D

LIQ_SPEC2

Bit	Meaning
0	API-11.2.1 (LSB)
1	API-11.2.1 M
2	API-11.2.2
3	API-11.2.2 M
4	GPA-TP25-Tables 23E & 24E
5	GPA-TP15
6	API-20.1-Allocation measurement
7	API-11.1:2004
8	ASTM D1250:1952
9	OIML R22:75
10	NBR 5992:80
11	API-11.1:1980
12	NBR 5992:09
13	Reserved13
14	Reserved14
15	Reserved15

WARN

Bit	Meaning
0	Override temperature meter (LSB)
1	Override pressure meter
2	Override density meter
3	Bad temperature master meter or prover
4	Bad pressure master meter or prover
5	Bad density master meter or prover
6	Unstable temperature meter
7	Unstable pressure meter
8	Unstable density meter
9	Unstable temperature master meter or prover
10	Unstable pressure master meter or prover
11	Unstable density master meter or prover
12	Unstable SW
13	Unstable volume flow at base
14	Bad temperature of external shaft / Bad GAS_QB_IN
15	Reserved 15

GAS_SPEC1

Bit	Meaning
0	AGA3 (LSB)
1	AGA5
2	AGA7 / AGA9
3	VCONE
4	WAFER CONE
5	ISO5167
6	AGA8 - Detailed
7	AGA8 – Gross 1
8	AGA8 – Gross 2
9	Aiche DIPPR801
10	ASME IAPWS-IF97
11	AGA11
12	AGA10
13	Reserved 13
14	Reserved 14
15	Reserved 15

USED_PROV_RUN_1 and USED_PROV_RUN_2

Bit	Meaning
0	Proving run 1
1	Proving run 2
2	Proving run 3
3	Proving run 4
4	Proving run 5
5	Proving run 6
6	Proving run 7
7	Proving run 8
8	Proving run 9
9	Proving run 10
10	Proving run 11
11	Proving run 12
12	Proving run 13
13	Proving run 14
14	Proving run 15
15	Proving run 16

Bit	Meaning
0	Proving run 17
1	Proving run 18
2	Proving run 19
3	Proving run 20
4	Proving run 21
5	Reserved 5
6	Reserved 6
7	Reserved 7
8	Reserved 8
9	Reserved 9
10	Reserved 10

Bit	Meaning
11	Reserved 11
12	Reserved 12
13	Reserved 13
14	Reserved 14
15	Reserved 15

START_USUAL_CONDITIONS

Bit	Meaning	LT	GT
0	Temperature (LSB)	X	X
1	Pressure	X	X
2	Density	X	
3	SW	X	
4	Flow	X	X
5	Reserved 5		
6	Reserved 6		
7	Reserved 7		
8	Reserved 8		
9	Reserved 9		
10	Reserved 10		
11	Reserved 11		
12	Reserved 12		
13	Reserved 13		
14	Reserved 14		
15	Start all	X	X

PULSE_STATUS

Bit	Meaning
0	Pulses have been lost
1	Frequency out of range
2	Noise detected
3	Frequency out of specification
4	Running proving
5	Reserved5
6	Dual pulse not active
7	Unack pulse error (*)
8	Current pulse error
9	Reserved9
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

(*) It indicates that one of the following types of errors was detected: coincident error, phase error or sequence error. This indication is retained and it will be cleared only when writing into PIP.RESET_ERROR_COUNTER in Error Counters.

GENERAL_STATUS

Bit	Meaning
0	Ready to scan
1	IMB failure
2	Saving configuration
3	Configuration saving error
4	General failure
5	Factory init jumper ON
6	Factory test running
7	Reserved7
8	Reserved8
9	Reserved9
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

Gx_CONF

Bit	Meaning
0	Dual pulse check enable
1	Falling edge Ax
2	Ax pulse filter disable
3	Falling edge Bx
4	Bx pulse filter disable
5	Use error pulses (*)
6	Input Ax disabled
7	Input Bx disabled
8	Reserved8
9	Reserved9
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

(*) Counts as valid pulses: COINCIDENT_ERROR, PHASE_ERROR and SEQUENCE_ERROR.

GENERAL_CONTROL

Bit	Meaning
0	Start factory init
1	Reset module
2	Start factory test
3	Start factory test 2
4	Reserved4
5	Reserved5
6	Reserved6
7	Reserved7
8	Reserved8
9	Reserved9
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

PINS_STATE

Bit	Meaning
0	Input A1 active
1	Input B1 active
2	Input A2 active
3	Input B2 active
4	Input A3 active
5	Input B3 active
6	Input A4 active
7	Input B4 active
8	Input A5 active
9	Input B5 active
10	IN1 active
11	IN2 active
12	IN3 active
13	OUT1 active
14	Reserved14
15	Reserved15

PROVING_STATUS

Bit	Meaning
0	Proving cycle is running
1	Time out to start T2 counter
2	Time out to start T1 counter
3	Time out to stop T2 counter
4	Time out to stop T1 counter
5	Selected input invalid or disabled
6	Pulse signal failure
7	Reverse flow direction
8	T2 started
9	Proving aborted
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

WARNING / OVERFLOW / LOG_FULL

Bit	Meaning
0	GTV (LSB)
1	LTV
2	LMFV
3	WTV
4	AEV (not applied to LOG_FULL)
5	ATV
6	HV
7	PTV
8	Reserved8
9	Reserved9
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

CALC_Px

Bit	Meaning
0	Hv (LSB)
1	Gr
2	K
3	Reserved3
4	Reserved4
5	Reserved5
6	Reserved6
7	Reserved7
8	Reserved8
9	Reserved9
10	Reserved10
11	Reserved11
12	Reserved12
13	Reserved13
14	Reserved14
15	Reserved15

Chapter 12

FUNCTION BLOCKS CONFIGURATION

Introduction

This section describes how to configure a Foundation Fieldbus strategy using a HFC302 as a bridge. This example is a natural gas measurement application using orifice plate, where the differential pressure, static pressure and temperature are measured using Foundation Fieldbus transmitters.

GasMeasurementDemo

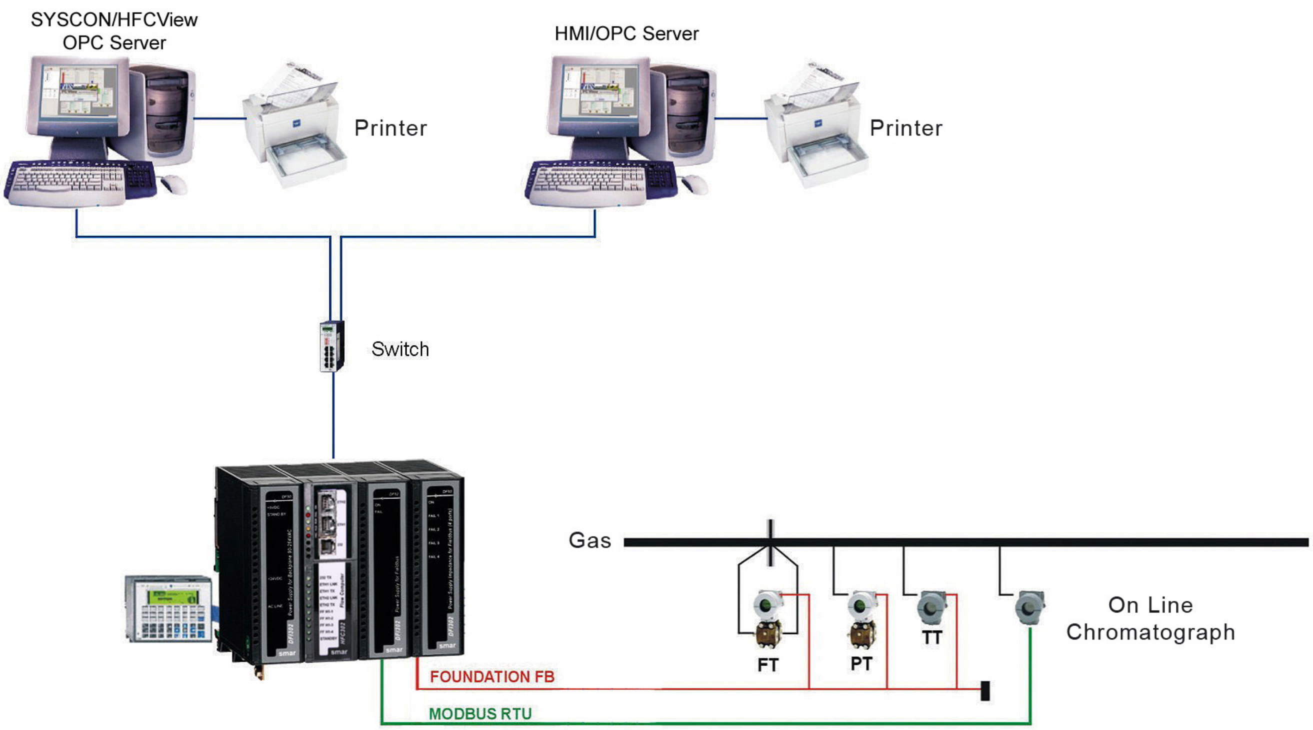
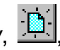


Figure 12.1 – Gas Measurement Application

Step by Step Configuration

Starting the Project

To create a new Project, go to the *File* menu and click *New*. Or click *New*, , on the *General Operation* toolbar.

The *Document Type* dialog box will open. Select the option *HSE Project* as the type of the project:

Figure 12.2 - Select the File Type

The *Setup New Project* dialog box will open. Select the folder where the project will be saved:

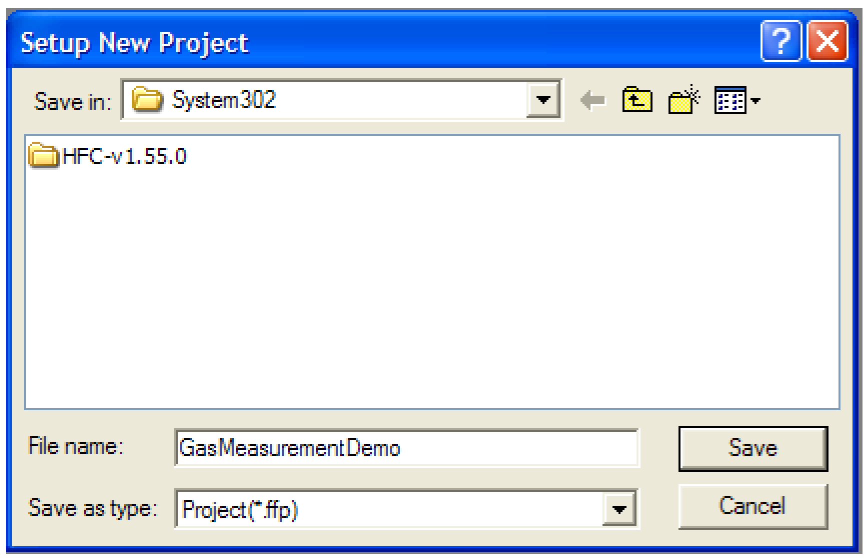


Figure 12.3 – Saving the Project

Type the name of the project on the *File Name* box and click *Save*. A new folder will be created with the name of the project and the extension *FFP*. In this example, the name of the project will be **GasMeasurementDemo**.

A new window will open. This window has the following icons:

- **Application** (default "Area 1") – In this section, the control strategies are created.
- **Fieldbus Networks** – In this section, the equipments and function blocks are added.

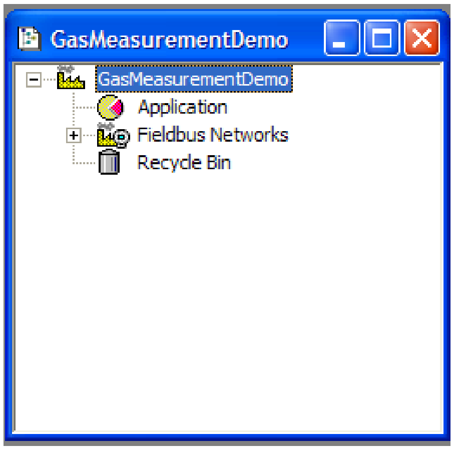


Figure 12.4 – Project Window

Physical Plant Project

In the project window, named **GasMeasurementDemo**, right-click the icon *Fieldbus Networks*, , and select the option *Communication Settings*. Or go to the *Communication* menu and click *Settings*. The dialog box will open to set the communication parameters.

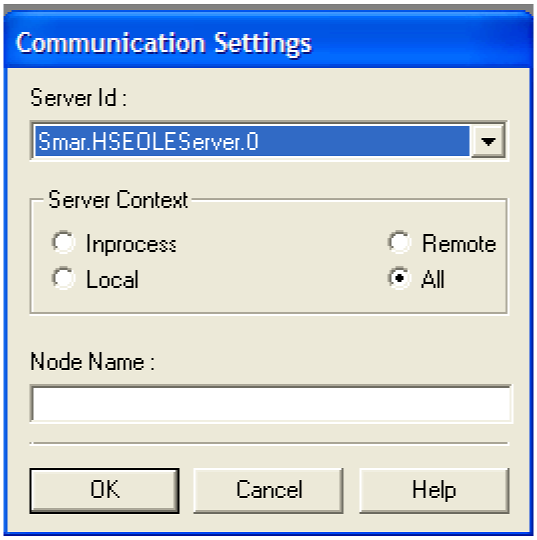


Figure 12.5 – Selecting the Server

Select the option *Smar.HSEOLEServer.0* and click *OK*. With this procedure a HSE network was created.

Adding the HFC302 (bridge HSE) to HSE Network

In the project window, right-click the icon *HSE Network* and click in *Expand*. A new window will open showing the HSE network.

Right click in the HSE network and select *New* and *Bridge*. In the box *Device type*, select the HFC302 and complete the HFC302 module tag, for example, *HFC302 1*.

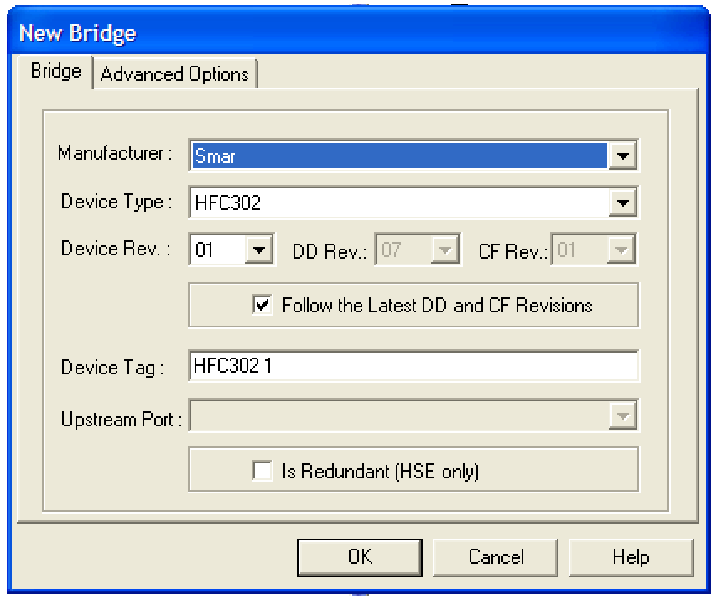


Figure 12.6 – Configuring the Bridge for the Project

On the *Manufacturer* box, select *SMAR* and from the *drop down* menu, select *HFC302* as the *Device Type*. On the *Device Tag* box, type *FQI-100* or other related tag and click *OK*.

IMPORTANT
Remember that there are some characters that cannot be used in the tag. The valid characters are: A-Z a-z 0-9 # { } [ ] ( )+ - The invalid characters are: ~ ` ! @ # $ % ^ & * = | : ; , . < > ? / ' " \

HINT
To better identify the equipments used in the project, it is recommended to use the equipment's serial number as the device tag. In this example, use *HFC302_101*, where 101 is the serial number of the HFC302 used in the project. This hint also applies to field devices added to the project.

Adding a H1 Network to the HFC302

In the project window, right-click the HFC302 and click in *New Fieldbus*. The dialog box *New Fieldbus* will open. Select the communication port for the fieldbus, *Fieldbus 1* tag type and click OK.

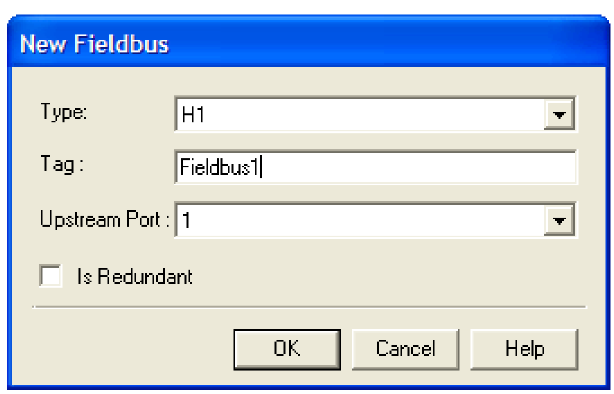


Figure 12.7 – Creating a H1 Network

Adding Fieldbus Devices

Right click in the *Fieldbus 1* and select the option *Expand...*. Add the field devices that will be used in this project (differential pressure, static pressure and temperature) to the H1 network.

First, add the *Smar Temperature Transmitter - TT302*.

In the *Fieldbus 1* window, right-click the *Fieldbus1* icon. Click the item *New* > *Device*. The *Device* dialog box will open:

1. Select the device *TT302* in the *"Device Type"* box. The default option in the *Manufacturer* box is "*Smar*".
2. Type the tag of Temperature to the device, in the "*Device Tag"* box.
3. Click *OK*.

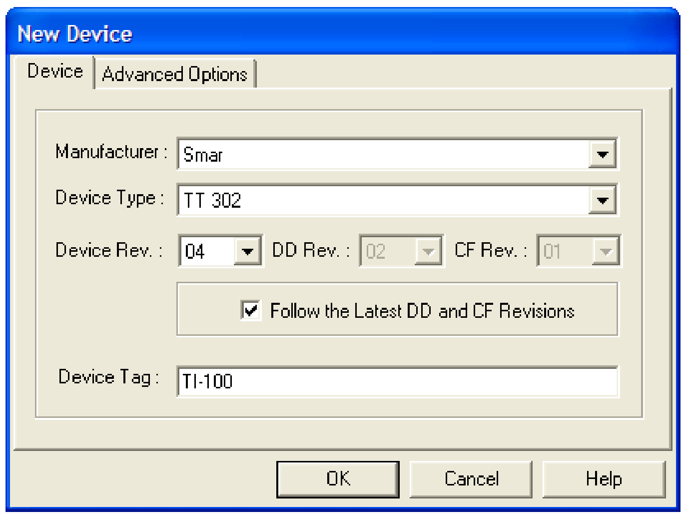


Figure 12.8 – Selecting the Transmitter

Follow the same procedure to add the Smar *Pressure Transmitter – LD302* with the tag *Differential Pressure*, and the Smar *Pressure Transmitter – LD302* with the tag *Static Pressure*.

After finishing this process, the *Fieldbus 1* window should look like the following figure:

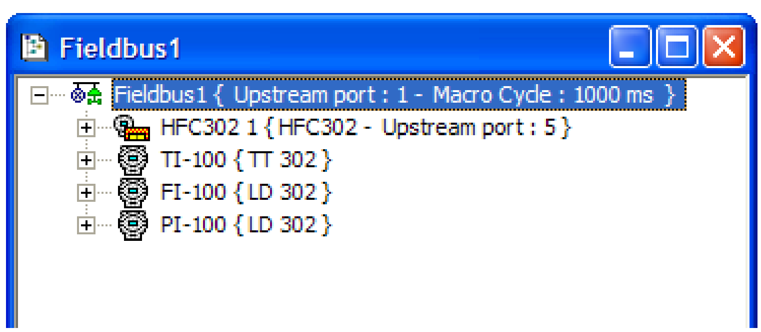


Figure 12.9 – Transmitters in the Fieldbus 1

Adding Function Blocks

Now the user can add the function blocks to HFC302 and field devices.

The *MIB* is responsible for data management.
Click the expansion sign ⊞ of the device icon, right-click the *FB VFD* icon (*Virtual Field Device*) and select the option *New Block*.

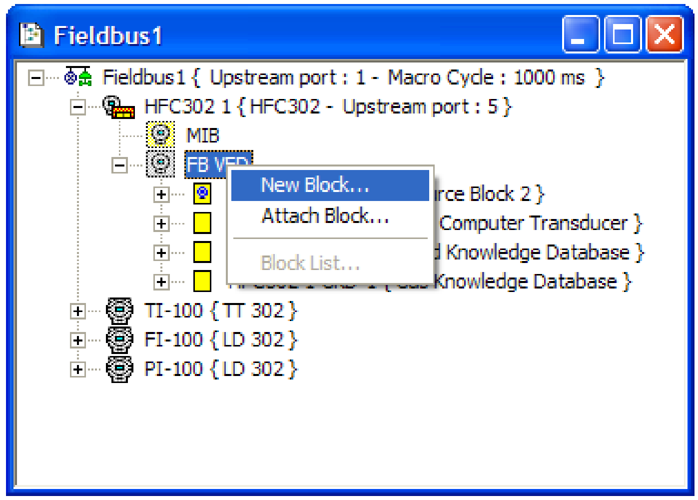


Figure 12.10 – Adding a New Block to HFC302

The *New Block* dialog box will open. In the *Block Type* box, select the type of block from the list of blocks available in the device. On the *Block Tag* box, type the tag for the new block. The figure below shows the *Gas Transaction* block:

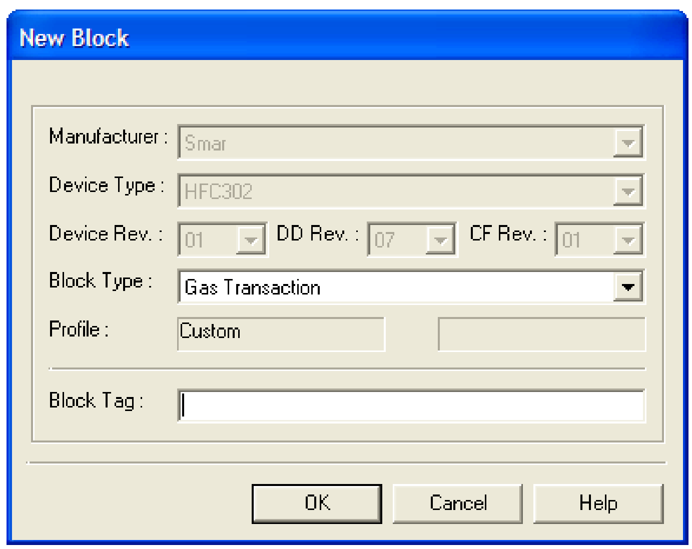


Figure 12.11 – Selecting a GT Block

Not typing the block tag, the Syscon automatically set a tag default connecting the tag of the device with the mnemonic of the block type selected and an ordinal number of the instance.

Repeat the procedure from above to add the Analog Input blocks to the transmitters:

Device	***Block Type***	***Block Tag***
TI-100	Analog Input	TI-100-AI-1
FI-100	Analog Input	FI-100-AI-1
PI-100	Analog Input	PI-100-AI-1

The channel configuration with all devices and blocks is represented in the figure below.

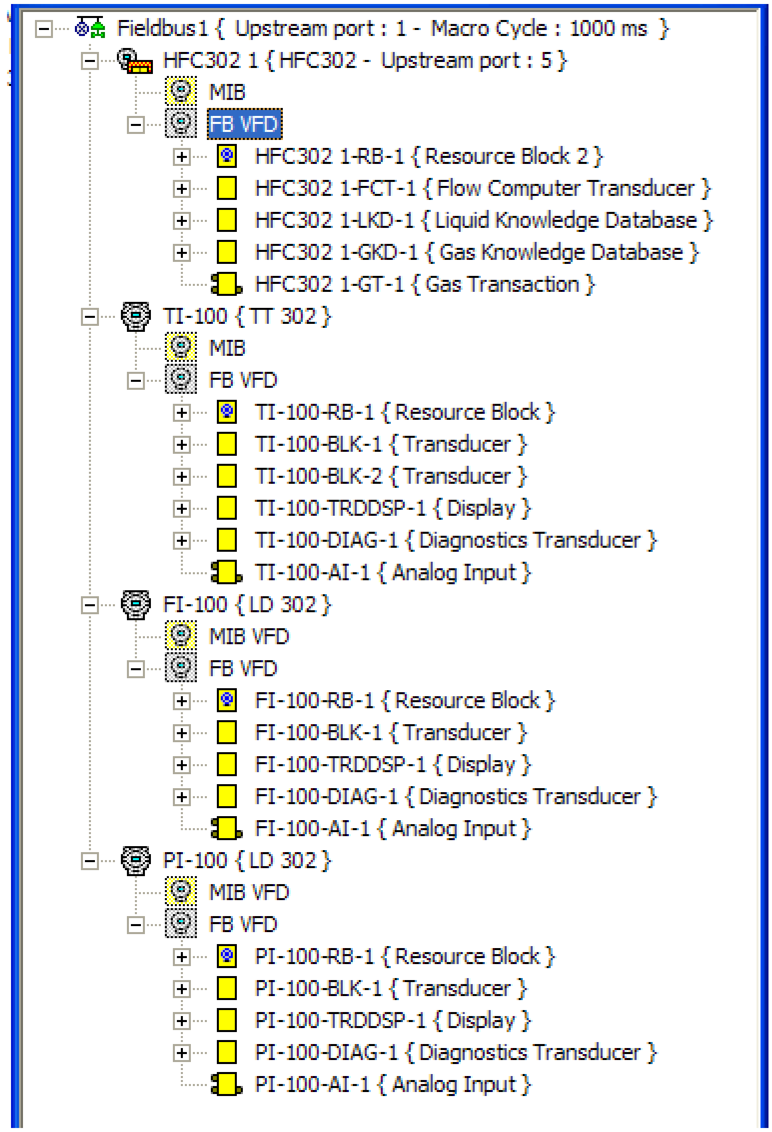


Figure 12.12 – Fieldbus Channel Configuration

Now, the user can create the strategy control.

Creating New Areas

To create a new *process cell*, right-click in the *Application* icon and select the option *New Process Cell.*

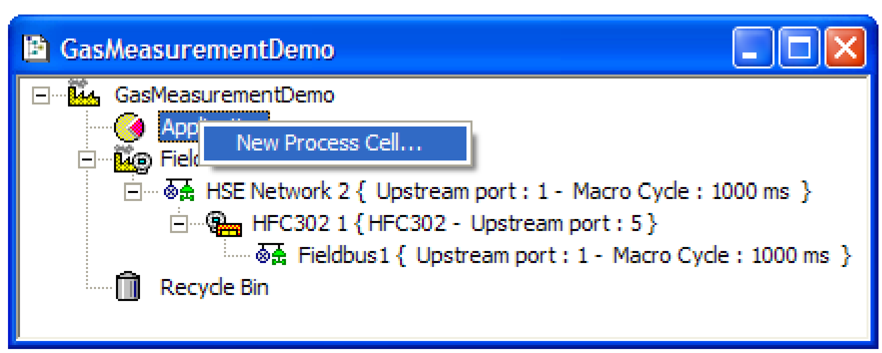


Figure 12.13 - Adding a Process Cell

The *Process Cell* dialog box will open:

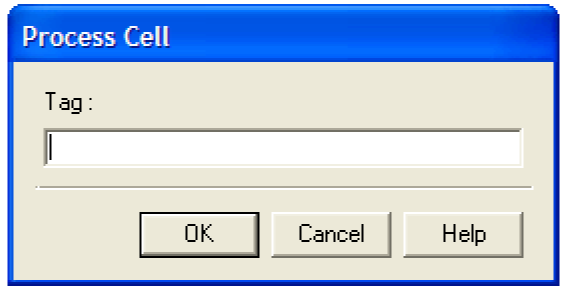


Figure 12.14 – Typing a tag for the Process Cell

Type the tag for the process cell and click *OK*. Repeat this procedure to create other process cells. The project window will be similar to the following figure.

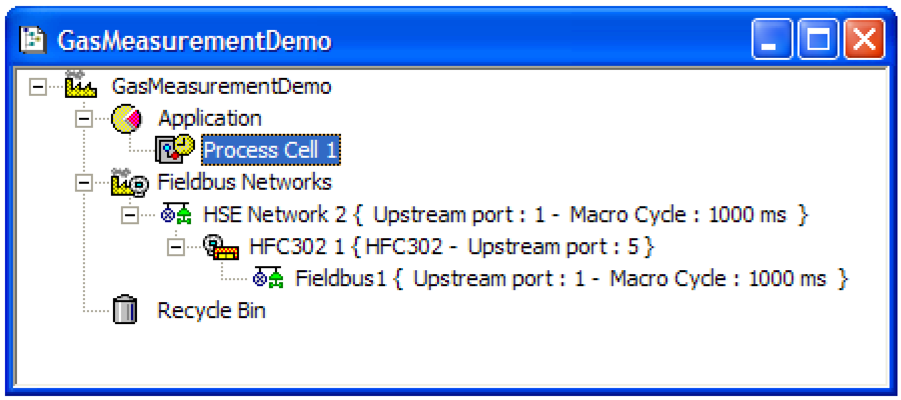


Figure 12.15 - Project Window

Creating a Control Module

Proceeding with the project, now the user must create a *Function Block Application* in the *Application*.

Right click in the *Process Cell* and select *Expand*.

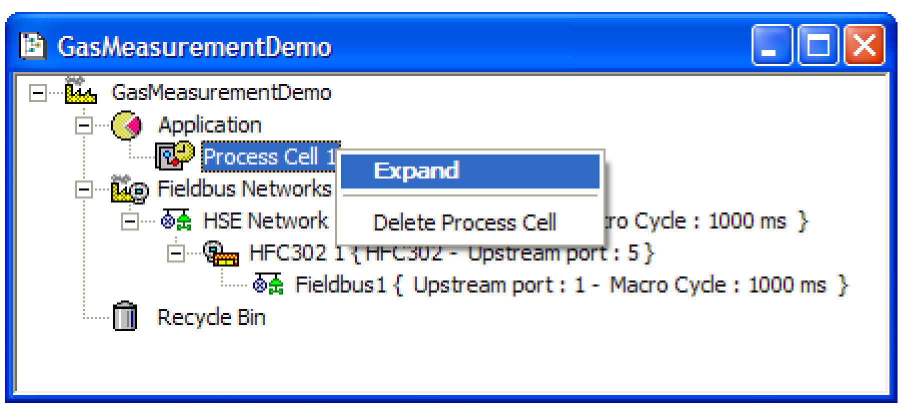


Figure 12.16 – Opening the Process Cell Window

On the *Process Cell 1* window, right-click the *FBAP_01* icon and select *New Control Module*.

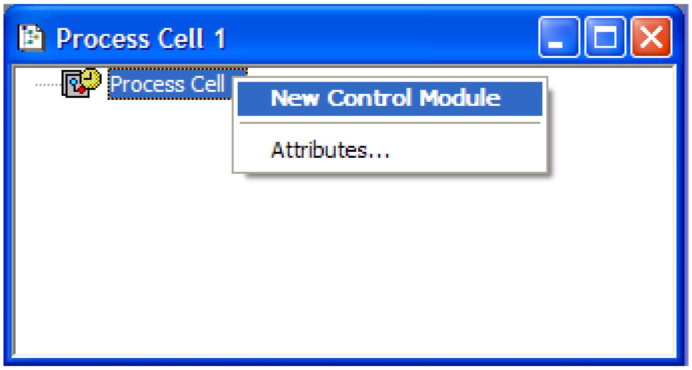


Figure 12.17 – Creating a Control Module

The *New Control Module* dialog box will open. Type the tag for the control module and click *OK*.

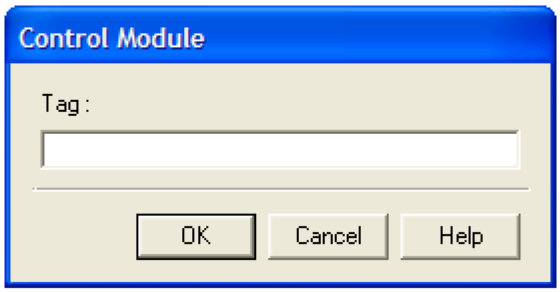


Figure 12.18 – Editing the tag of the Control Module

IMPORTANT
Remember that there are characters that cannot be used as in the tag.

Attaching the Blocks to the Control Module

Now you can attach the blocks from the devices to the control module. Right click the *FBAP_01* icon and select the option *Attach Block*.

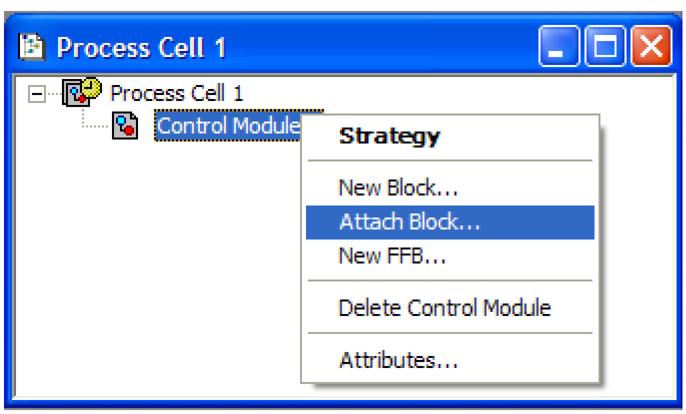


Figure 12.19 – Attaching Blocks to the Control Module

The *Attach Block* dialog box will open:

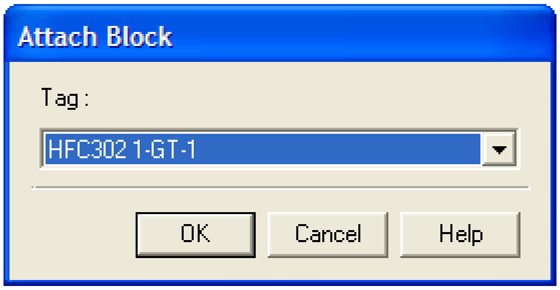


Figure 12.20 – Selecting Blocks

The blocks that can be attached to the control module are listed in this dialog box. Select also de AI block of TT302 and click *OK*. Repeat the procedure for both LD302.

The *process cell* window will be similar to the figure below

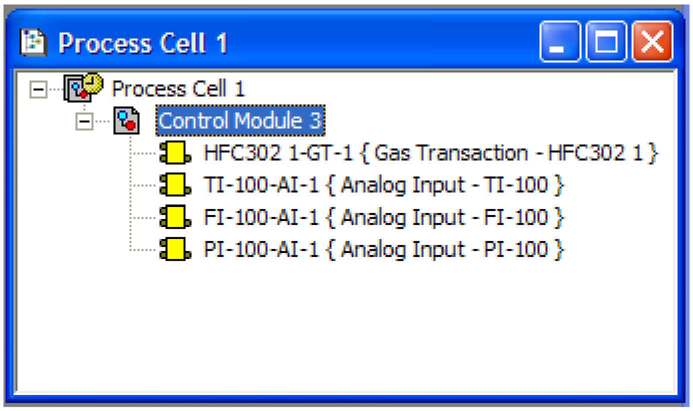


Figure 12.21 – Blocks Added to the Control Module

Another easy way to attach the blocks to the *control module* is to click the block icon in the fieldbus window and drag it to the process cell window.

Configuring the Control Strategy

Now the user is ready to develop the control strategy.

First, right click the *Control Module 3* icon and select the option *Strategy*. The strategy window will open:

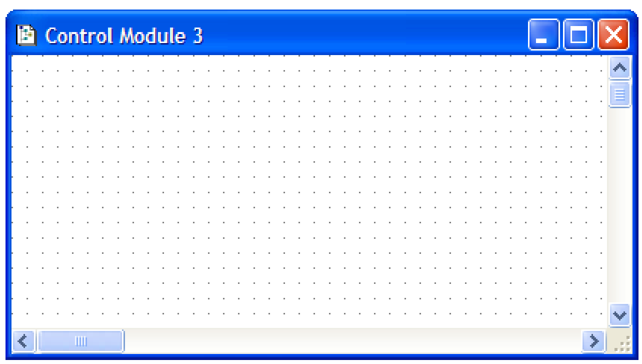


Figure 12.22 – Strategy Window

At this moment, there might be 3 or 4 windows opened in SYSCON. Minimize the *H1_1* window. Go to the *Window* menu and click the option *Tile*.

If the monitor is not bigger than 17", it is recommended to maximize the strategy window to visualize the entire project.

The strategy window offers several drawing tools. For details, refer to the SYSCON Online Help.

Adding Blocks to the Strategy Window

The blocks can be added to the strategy window *Control Module 3*.

Click the first block HFC302 1-GT-1, and drag it to the strategy window. The block will be created automatically. See the following figure:

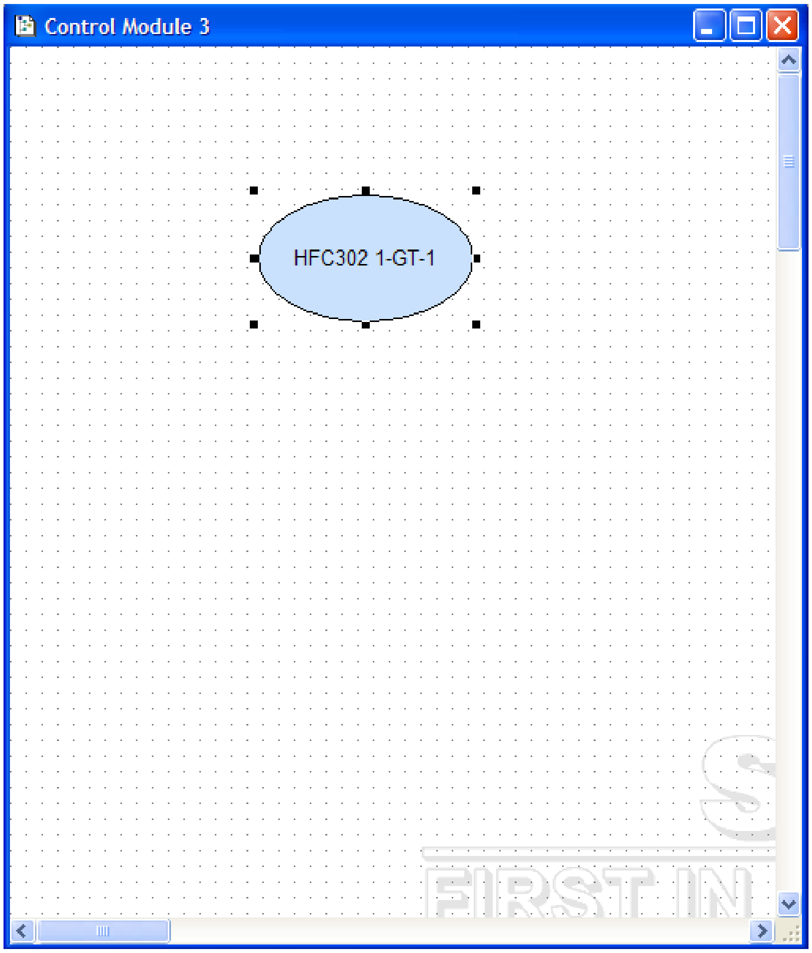


Figure 12.23 – Block Added to the Strategy Window

Repeat this procedure to drag the blocks *TI-100-AI-1*, *FI-100-AI-1* and *PI-100-AI-1* to the strategy window.

Linking Blocks

Click the *Link* button, , in the *Strategy* toolbar, to connect the blocks.

Click the *Link* button and click the block *TI-100-AI-1*. A dialog box to select the output parameter will open. Select the parameter *Out* and click *OK*.

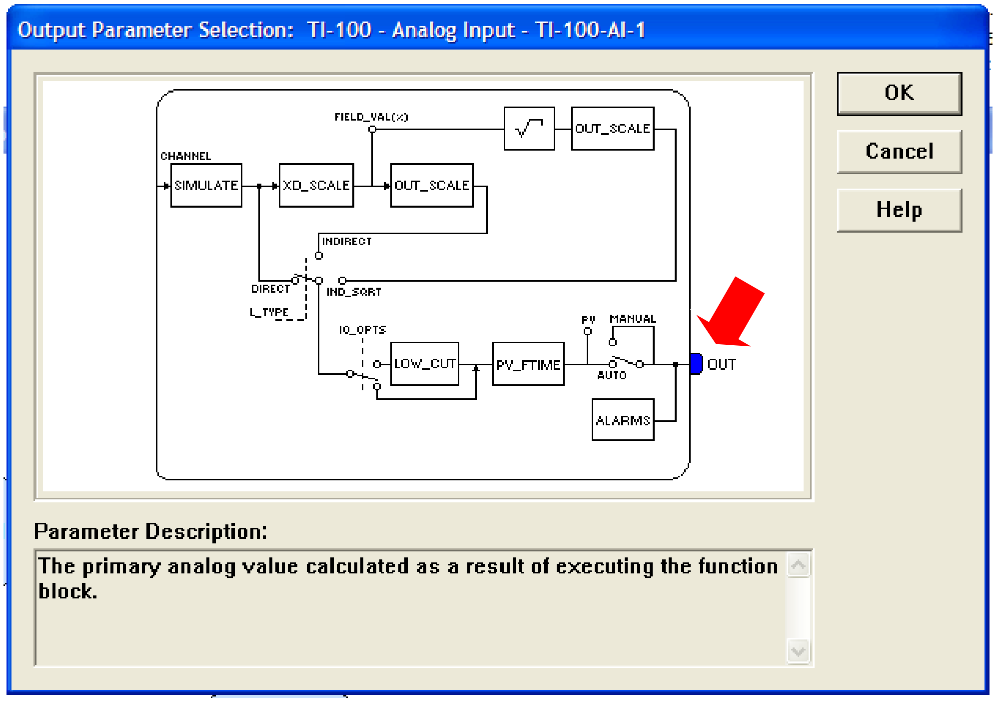


Figure 12.24 – Linking Blocks

Move the mouse cursor over the second block that will be linked to the first one (*HFC302 1-GT-1*), click on it, then click on the input of block (TF).

A faster way to create the link is right-clicking the *TI-100-AI-1* block, select OUT right-clicking the *HFC302 1-GT-1 block and select TF*.

Create the following links for this strategy:

- OUT(TI-100-AI-1) ➔ TF(*HFC302 1-GT-1*)
- OUT(FI-100-AI-1) ➔ DIFF_PF(*HFC302 1-GT-1*)
- OUT(PI-100-AI-1) ➔ PF(*HFC302 1-GT-1*)

The figure below shows the strategy window after connecting the parameters listed above.

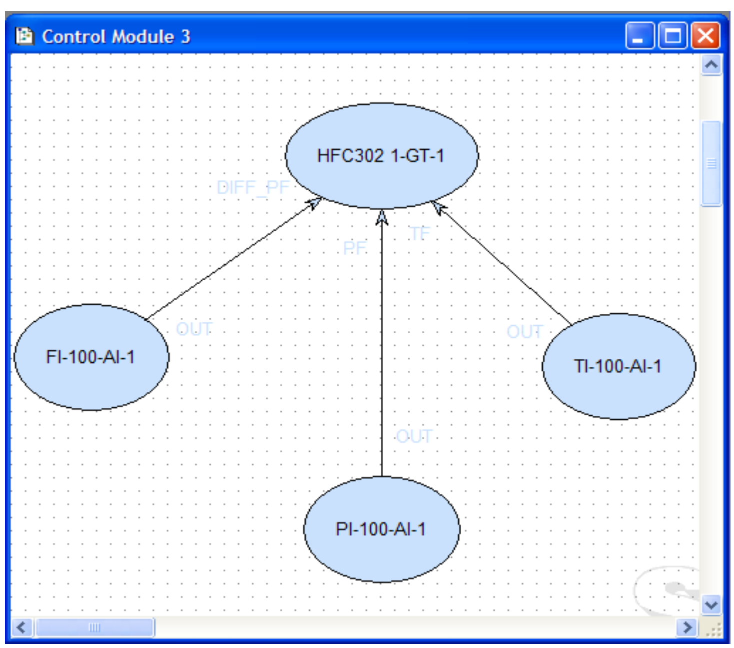


Figure 12.25 – Strategy Window

Block Characterization

The blocks added to the project must be parameterized according to the application.

The characterization can be performed in *offline* or *online* mode. In the *offline* mode, the parameters are configured before initializing the communication with the devices. In the *online* mode, the parameters are configured in the devices when the plant is already communicating with the system.

To configure the block parameters, follow these steps:

1. In the Strategy Window

Select the block to be configured. Right-click the block and select the option *Off Line Characterization,* or double-click the block. Observe the following figure:

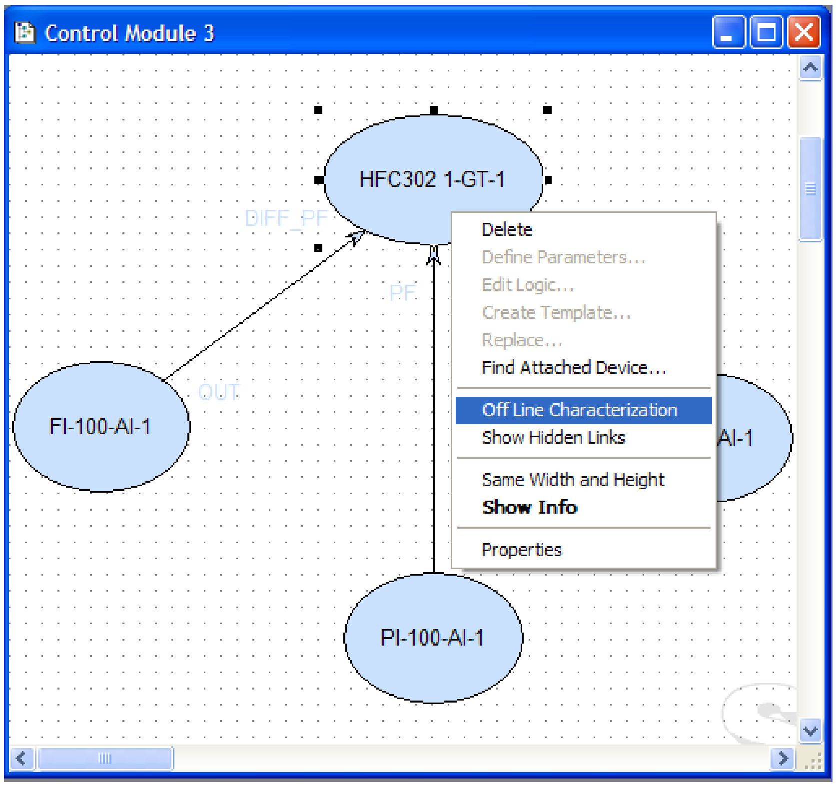


Figure 12.26 – Block Offline Characterization in the Strategy Window

2. In the H1_1 Window

Another way to parameterize the block is right-clicking the block in the fieldbus window and selecting the option *Off line Characterization*, as indicated below:

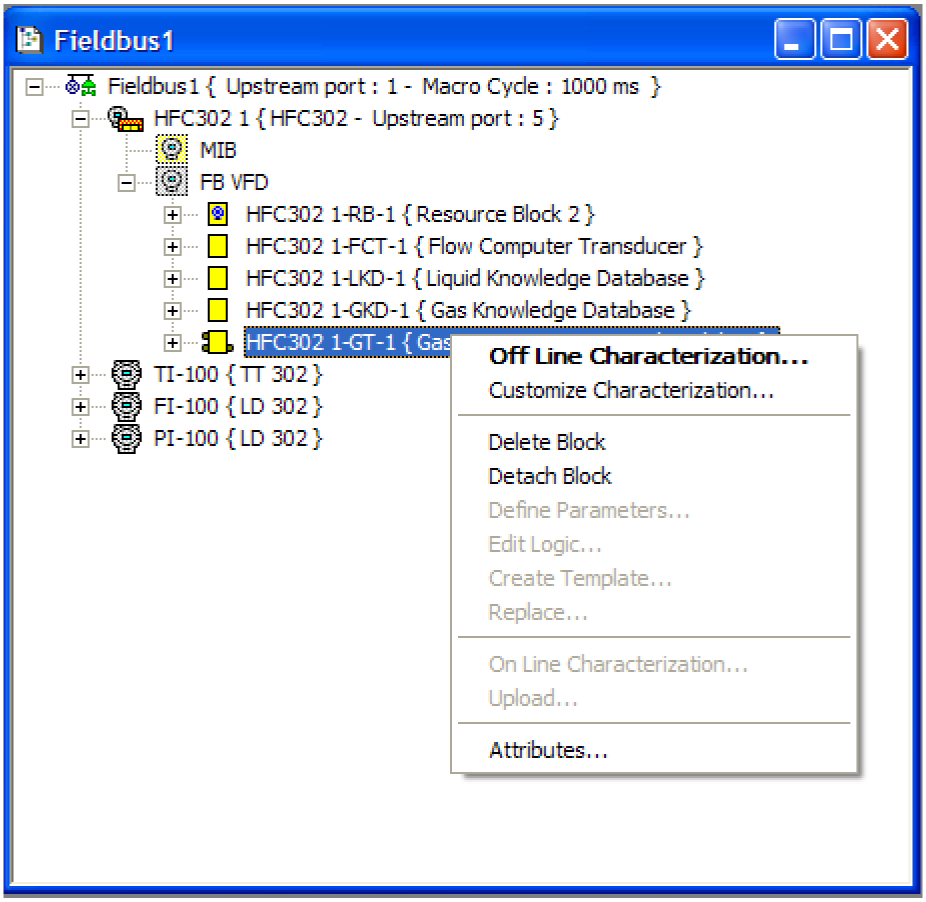


Figure 12.27 – Block Offline Characterization in the Fieldbus Window

In both cases, the *Block Characterization* dialog box will open:

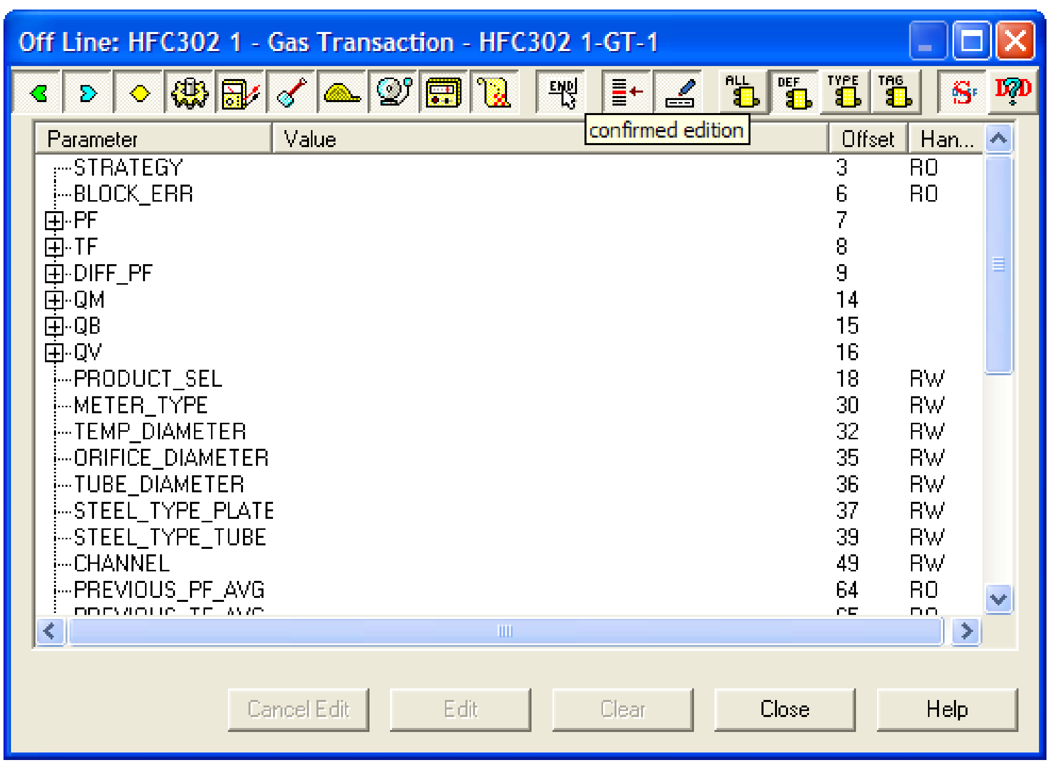


Figure 12.28 – Block Characterization Dialog Box

Double-click the *Value* column in front of the parameter that will be modified. Or click the parameter and click the button *Edit* to edit the parameter value. Click *End Edit* to conclude the alteration.

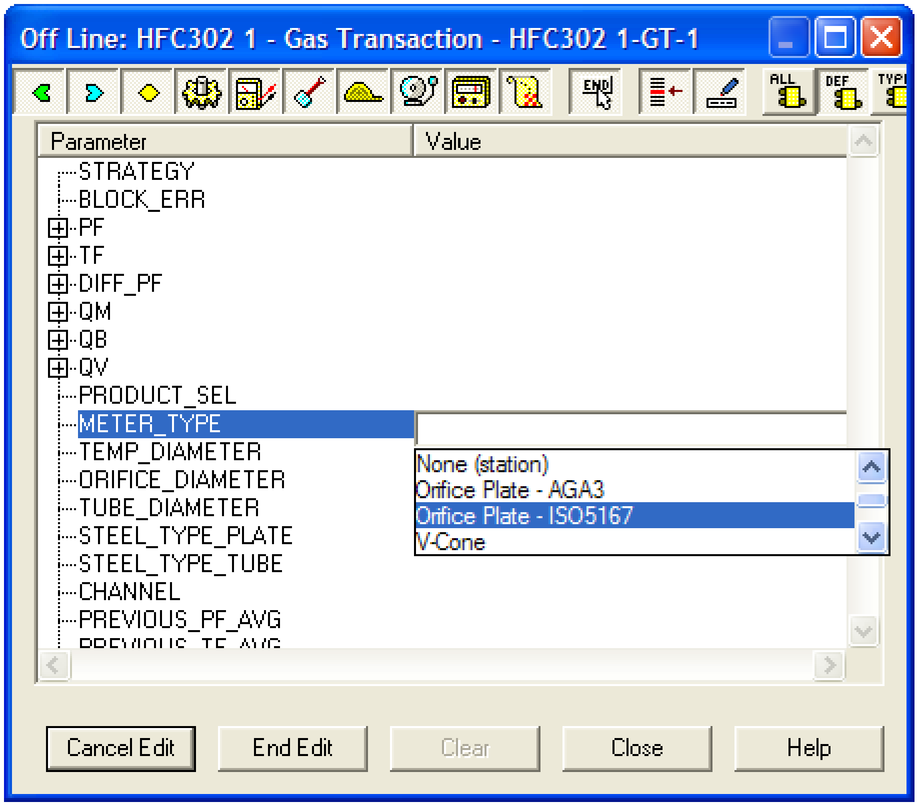


Figure 12.29 – Editing the Parameters

Initializing the Communication

Click the *On-line Mode* button, , on the *General Operation* toolbar, to initialize the communication.

The video clip below should appear for a couple of seconds. During this time, SYSCON will identify and attach any bridges installed in the computer and added to the configuration.

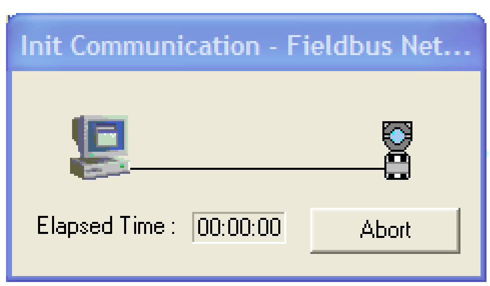


Figure 12.30 – Initializing the Communication

Commissioning the Bridge

Note that at this point, if all the procedures were completed successfully, a red symbol will be displayed in the top-left side of each device and bridge icon ( ). This means that the Device IDs were not commissioned yet. On the fieldbus window, right-click the HSE Host icon and click the option *Comission...*.

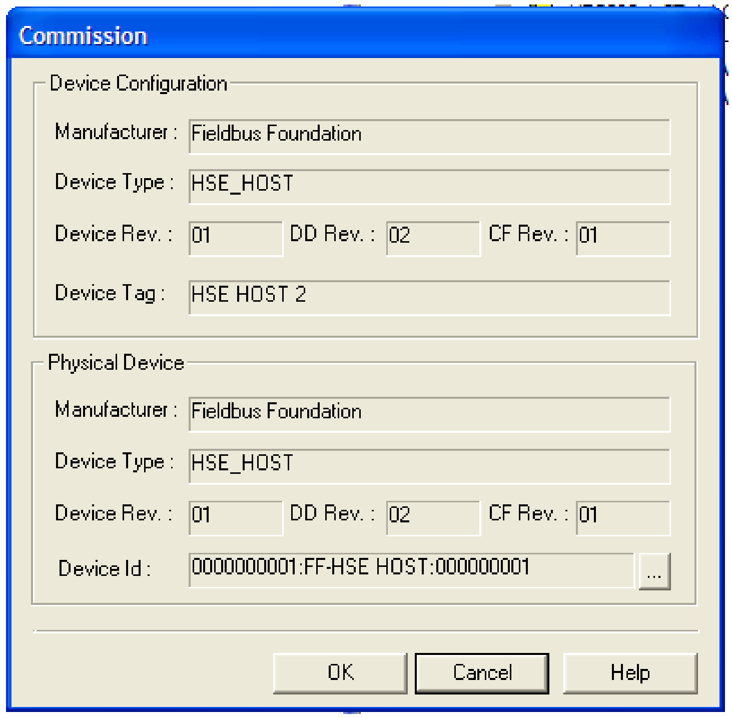


Figure 12.31– Attributes Dialog Box of the Host

On the fieldbus window, right-click the bridge icon and click the option *Comission...*.The following dialog box will open:

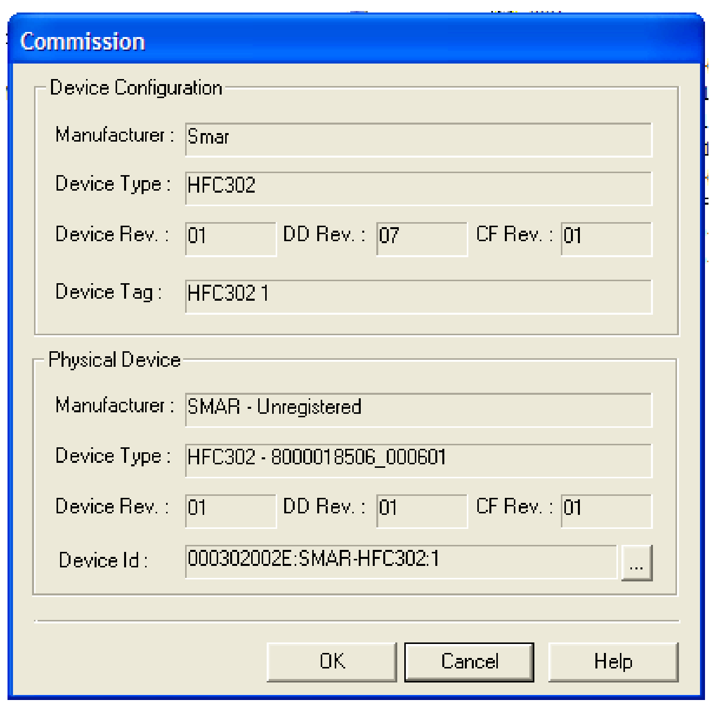


Figure 12.32 – Attributes Dialog Box of the Bridge

Select the bridge and click *OK*. The following dialog box will open while the device is being commissioned.

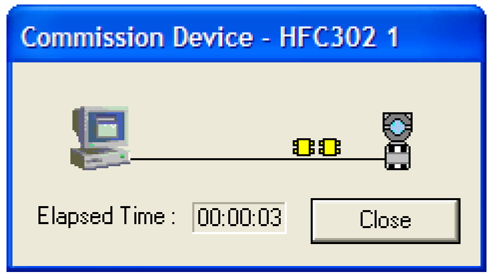


Figure 12.33 – Commissioning the Bridge

Now the red symbol in the bridge icon disappears.

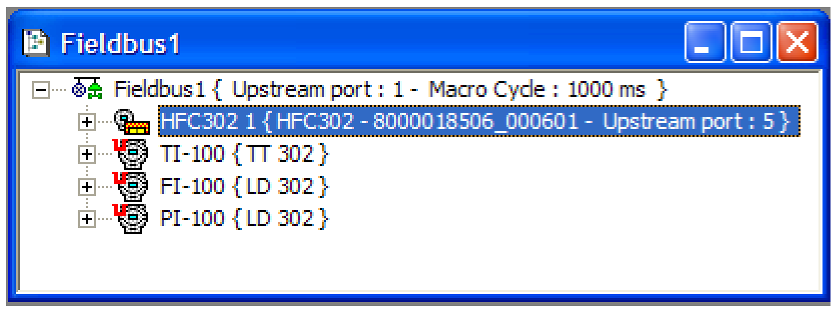


Figure 12.34 – H1 Channel after Commissioning the HFC302

Commissioning Devices

Each device must be commissioned using the procedure described for the bridge. Right-click the device icon, click the option *Comission...* and select the proper Device ID to each device.

IMPORTANT
If there are differences between the device configuration in the SYSCON file and the physical device, SYSCON will execute the *Exchange* procedure for the device, which means that the information in the configuration should be compatible to the information in the physical equipment.

Don't forget to save the project configuration by clicking *Save Entire Configuration* button.

Checking the Commissioning

Open the fieldbus 1 window, right-click the *fieldbus* icon and select the option *Live List*:

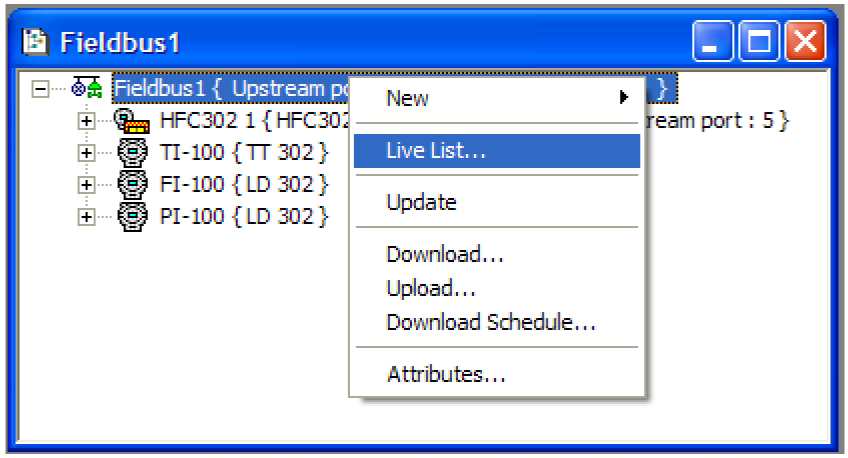


Figure 12.35 - Live List

Another window will list all devices connected to this segment, as in the example below:

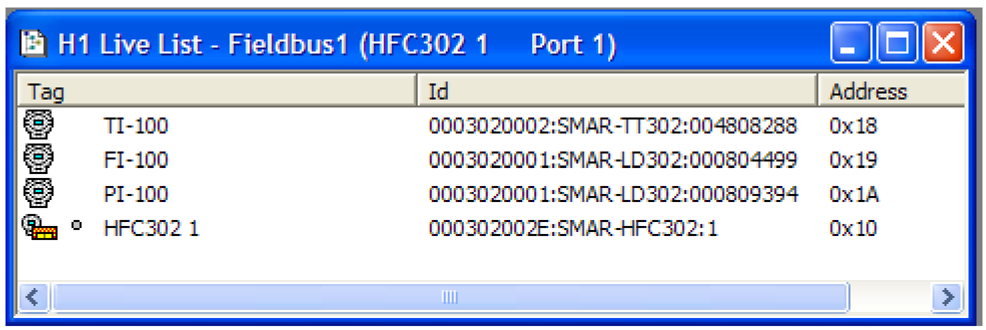


Figure 12.36 - Checking the Live List

Erasing the Error Log Registry

It is important to clear the *Error Log Registry* before downloading the configuration, because any eventual error that might occur during the download process will be easily detected as the *Error Log* window pops up automatically when the first error occurs.

Click the button , on the *General Operations* toolbar. The *Error Log* window will open. (If the button is not enabled, this step won't be necessary).

Right-click inside this window and select the option *Clear Log*, as indicated:

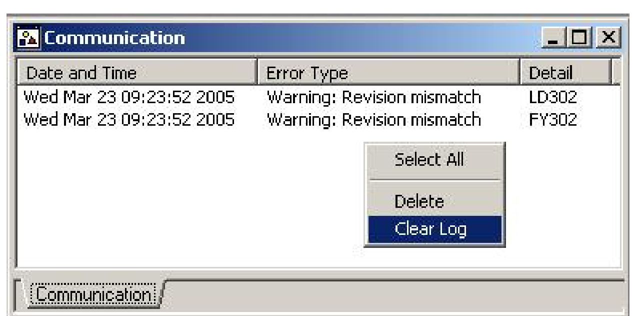


Figure 12.37 – Erasing the Error Log Registry

Plant Configuration Download

In the project window, click the *Fieldbus Networks* icon, go to the *Communication* menu and click the item *Download*. Or right-click the *Fieldbus Networks* icon and select the item *Download*.

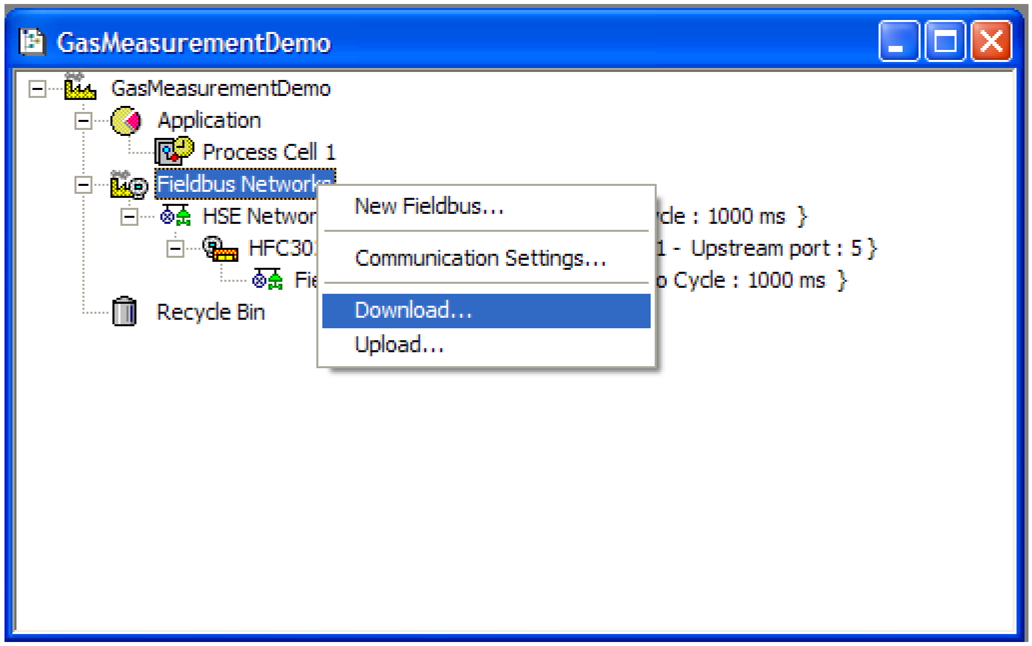


Figure 12.38 – Fieldbus Configuration Download

The *Download* dialog box will open. To download the entire configuration to the plant and click *Start*.

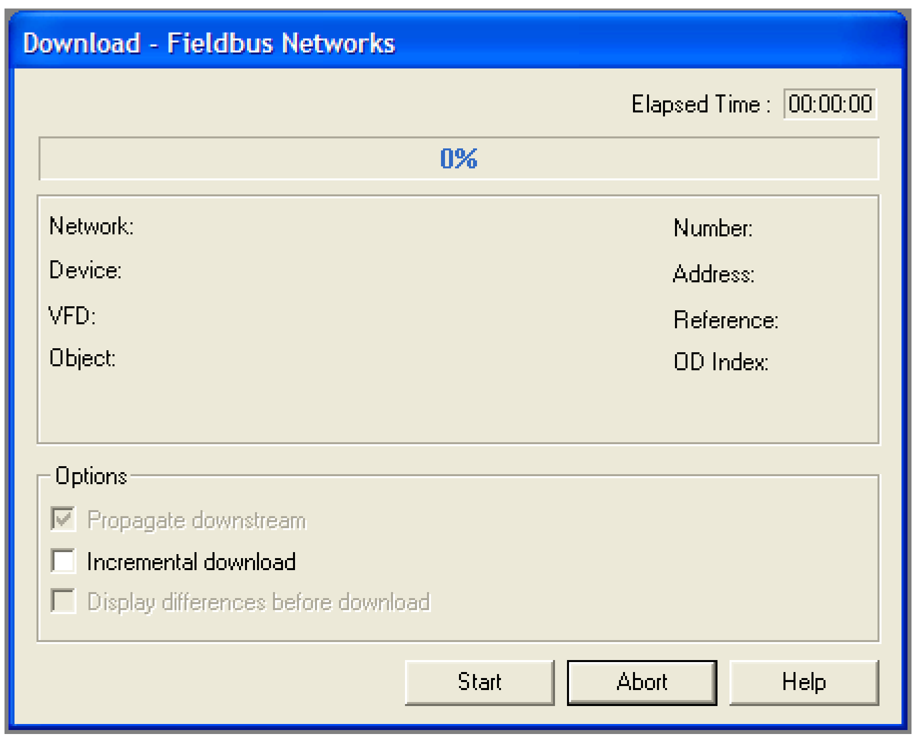


Figure 12.39 – Complete Download

Exporting Tags

Preferences

Before executing the *Export Tags* procedure, select the operation mode and the path to the *Taginfo.ini* file.

On the *Project File* menu, click *Preferences*. The *Preferences* window will open. Select the *Export Tag* tab.

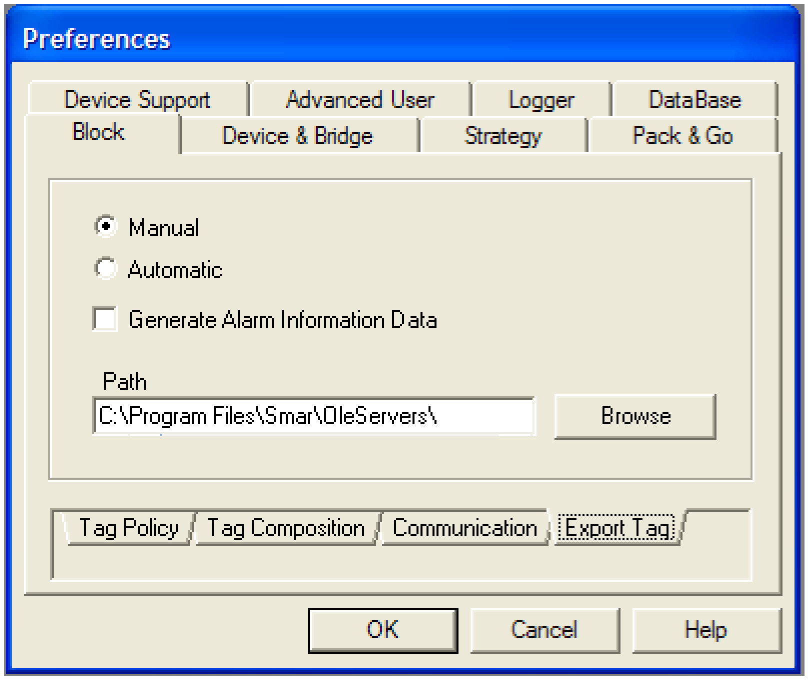


Figure 12.40 – Setting the Export Tag Preferences

Select the *Manual* or *Automatic* mode and type the path to the *Taginfo.ini* file. In this example, the path to the file is *C:\Program Files\ Smar\OleServers.*

Exporting Tags

In the project window, right-click the project icon and select *Export Tags*, as indicated below.

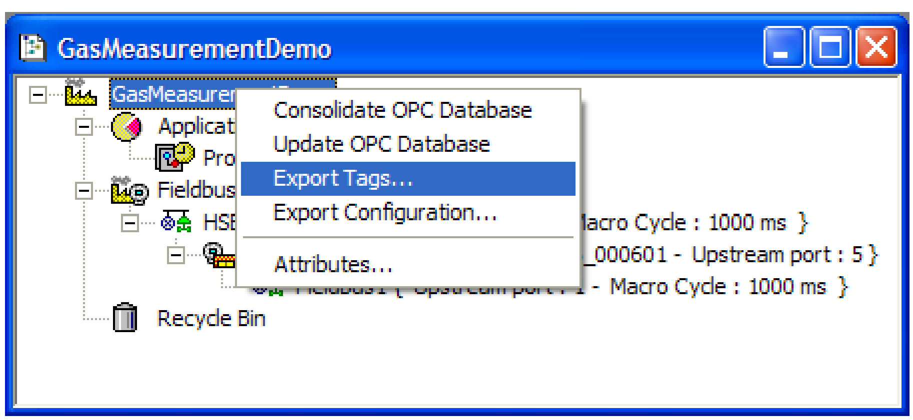


Figure 12.41 - Exporting Tags

The *Browse for Folder* dialog box will open.

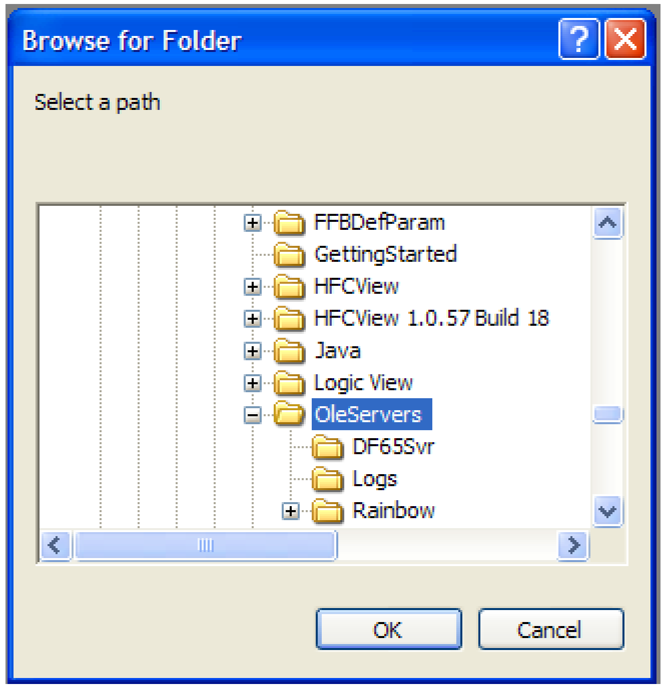


Figure 12.42 – Selecting the Folder to Export the tags

If the path to save the *Taginfo.ini* file was configured in the *Preferences* window, the dialog box will show the correct folder to this file. Otherwise, select the folder *C:\Program Files\Smar\OleServers* and click *OK*.

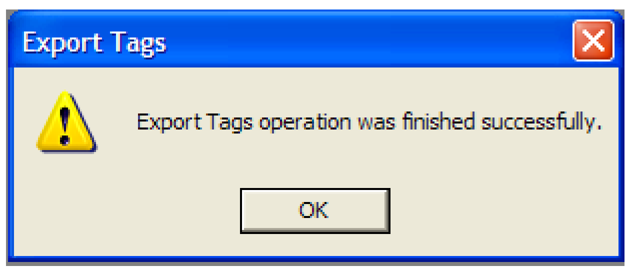


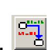
Figure 12.43 – Exporting the Tags

Click *OK* to conclude.

NOTE
The *Export Tags* procedure must be executed only once, unless the tags in the project configuration are changed. In this case, execute again the procedure to update the file.

On-Line Supervision

It is possible to monitor the control strategy when SYSCON is operating in On-Line Mode.

Open the Strategy window, click the *On Line Monitoring* button, , in the *Strategy* toolbar. Click on the strategy window again. The figure below shows the process values being monitored.

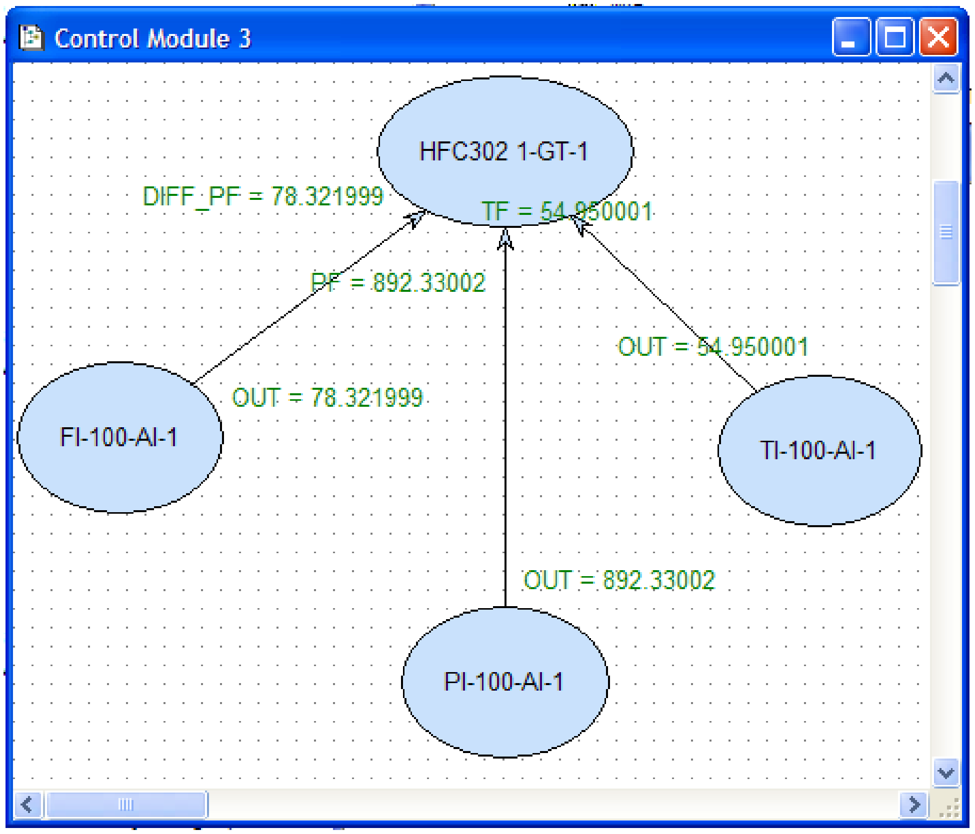


Figure 12.44 – On-Line Supervision

The green links indicate that there are no communication failures. When a failure occurs, the link color changes to red. See the example in the figure below that simulates a failure in the temperature sensor *PT100*.

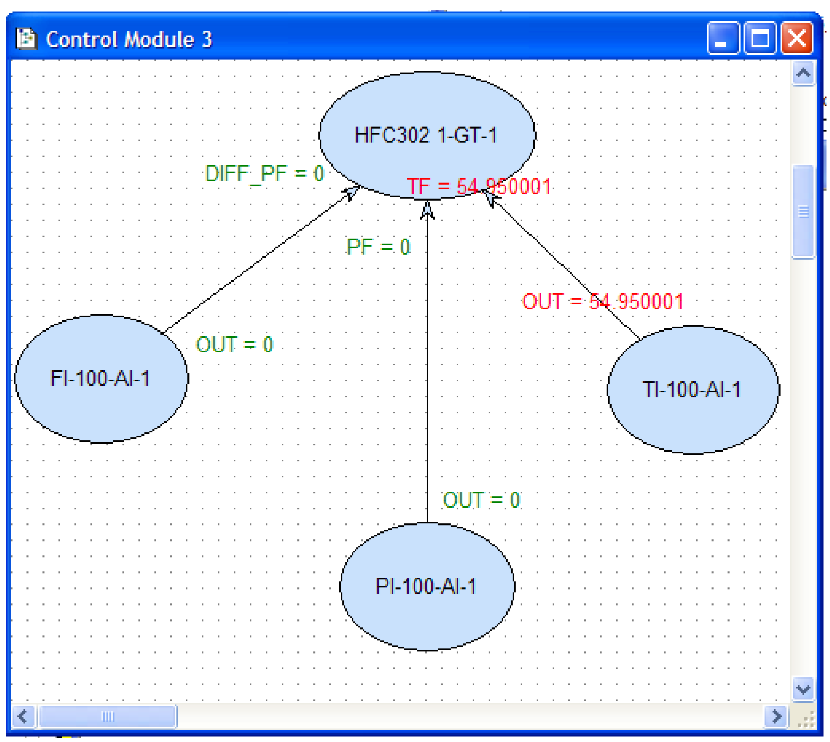


Figure 12.45 – Failure Simulation in the Strategy Window

On-Line Characterization

It is possible to monitor the block parameters when SYSCON is operating in On-Line Mode by right clicking in the block in the *Fieldbus 1* window.

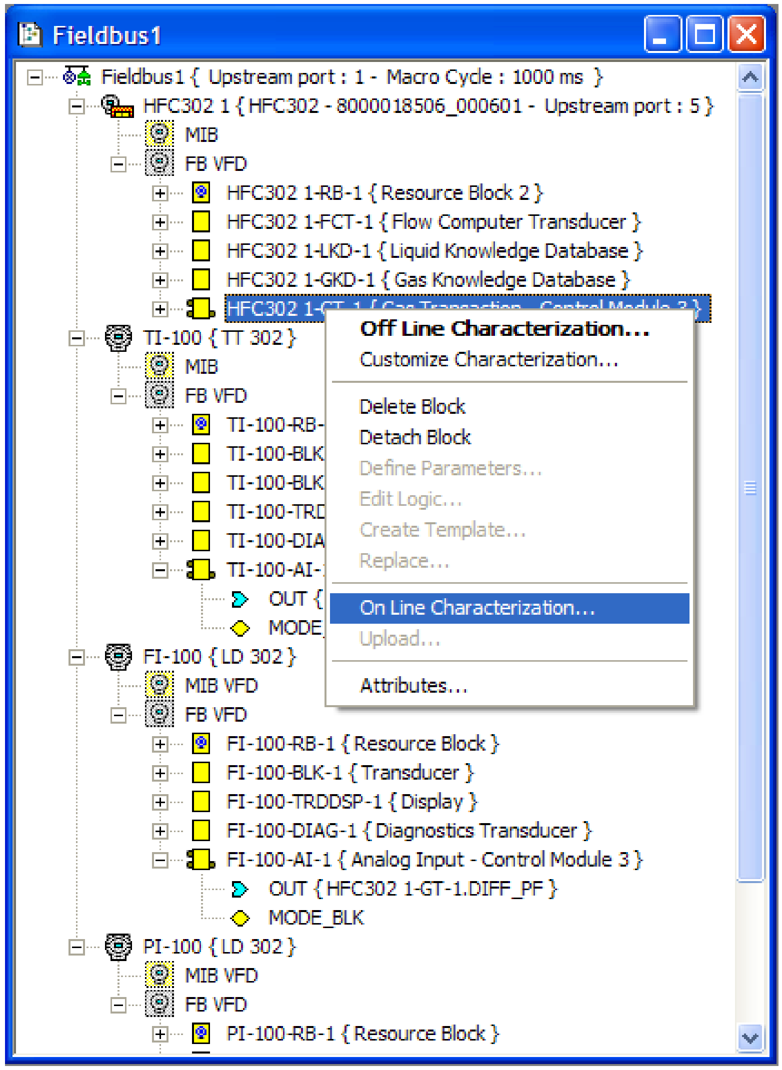


Figure 12.46 – Online Characterization

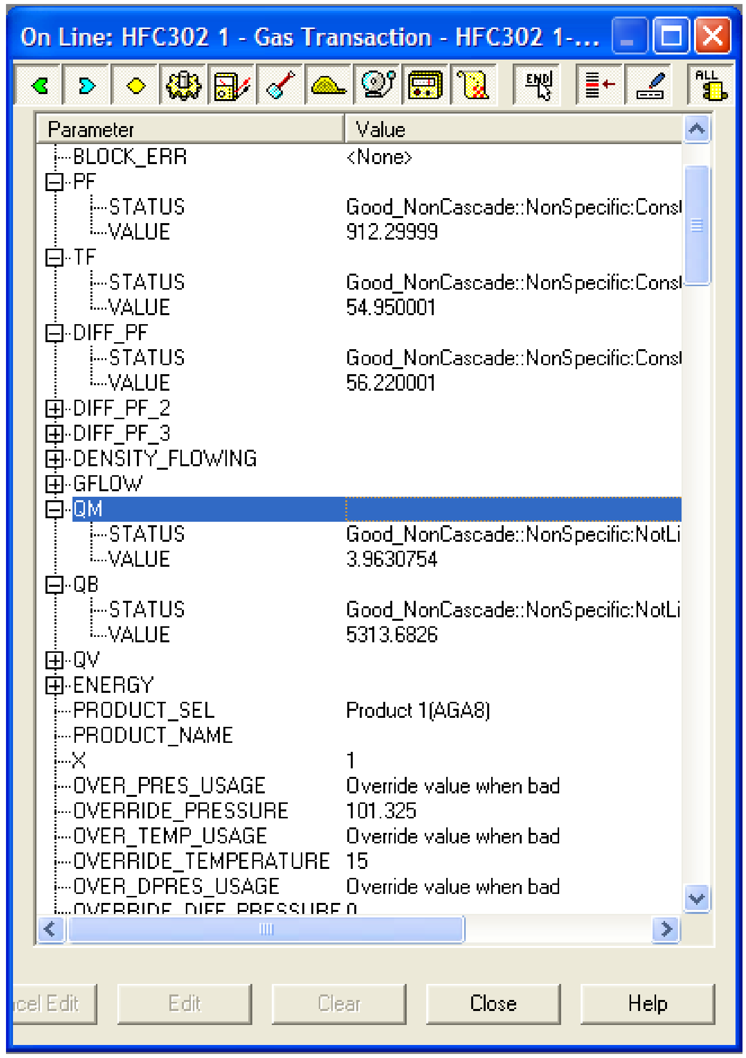


Figure 12.47 – Online Characterization

CHANNEL and STRATEGY Allocation (number of the measured flow)

CHANNEL Configuration

The **CHANNEL** parameter identifies the physical input or output point associated to the function block.

The AuditFlow system is classified as configurable hardware equipment, where the user configures the number of I/O modules and the type (input or output, discrete or analog, pulse, etc). The rules to configure the **CHANNEL** parameter in the AuditFlow system are listed below:

- **Point (P):** ordinal number of I/O points in a group, numbered from 0 (first point) to 7 (last point), where 9 indicates the whole group of points. The whole group can have 4 or 8 I/O points. When accessing the DF77 module, point 2 (P=2) means dual-pulse option for configuring the PIP.Gx_CONF parameter. The option Dual pulse check enable must be enabled previously;

- **Group (G):** ordinal number of the group in the selected I/O module, numbered from 0 (first group) to the number of groups minus 1;

In the AuditFlow System, the input and output modules are classified according to the hierarchy.

- **Slot (S):** a slot supports the I/O module and it is numbered from 0 (first slot in the rack) to 3 (last slot in the rack);

- **Rack (R):** each rack has four slots. The rack is numbered from 0 (first rack) to 14 (last rack). A single I/O point in the HFC302 can be identified by the rack (R), slot (S), group (G) and point (P). Since the **CHANNEL** parameter for multiple I/O blocks (MIO) must specify the whole group (8 points), the point value will be 9.

The value of the **CHANNEL** parameter is represented by these elements in the format **RRSGP**.

For example, if the value of the **CHANNEL** parameter is 1203, the block will be in rack 1, slot 2, group 0 and point 3. If the **CHANNEL** parameter of the **MAI** block is 10119, the block will be in rack 10, slot 1, group 1 and point 9 (whole group).

Before setting the **CHANNEL** parameter, it is recommended to configure the hardware in the **HC** block. The HFC302 checks if the I/O type configured in the **HC** block corresponds to the block type when writing the value to the block. If the **CHANNEL** parameter configures the **AI** block to access an I/O type that is not an analog input, the settings will be discarded.

Block Type	Configuration of CHANNEL parameter	Module Type	Notes
TEMP	RRS09	8 - temperature	Number of groups: 1 (G: 0) Points/group: 8 (P: 0 to 7, 9-whole points)
PIP	RRS99	Pulse input and proving	Number of groups: 7 (G: 0 to 6, 9-whole groups) Number of points: variable, depending of the group, 9-whole groups
DI	RRS0P	8 - discrete inputs	Number of groups: 1 (G: 0) Points/group: 8 (P: 0 to 7)
	RRSGP	16 - discrete inputs	Number of groups: 2 (G: 0 to 1) Points/group: 8 (P: 0 to 7)
	RRS0P	8 - discrete inputs/4-discrete outputs	Number of groups: 2 (G: 0-inputs to 1-outputs) Points/group: Group#0: 8 (P: 0 to 7) Group#1: 4 (P: 0 to 3) – Not accessible to the DI block
	RRS5P	Pulse input and proving	Number of groups: 7 (G: 0 to 6, but only the group 5 is accessible to DI block for IN1, IN2 and IN3 inputs of DF77) Points/group: 3 (P: 0-IN1, 1-IN2, 2-IN3) Note: The access to IN1, IN2 and IN3 inputs of DF77 via DI block is required only if these inputs are used as common discrete inputs. If such inputs are used as prover detectors, there is no need to use the DI block to map these points.
AI	RRS0P	8 – analog inputs	Number of groups: 1 (G: 0)

			Points/group: 8 (P: 0 to 7)
	RRSGP	8 – HART inputs	Number of groups: 8 (G: 0 to 7) Each HART device or only 4-20 mA is associated to a group. Points/group: 5 (P: 0 to 4) P: 0 (4-20mA signal) P: 1 to 4 (respectively, primary, secondary, tertiary and quaternary variables obtained by the command 3 - HART)
	RRSGP	Pulse input and proving	Number of groups: 7 (G: 0 to 6, but only the groups 0 to 4 are accessible to AI block to read the corresponding pulse input frequency) Group#0 to Group#4: single or dual pulse input P: 0 – single pulse, phase A (terminal Ax) P: 1 - single pulse, phase B (terminal Bx) P: 2 – dual pulse, phase A (terminal Ax) and phase B (terminal Bx)
GT,LT	RRSGP	16 - pulse inputs	Number of groups: 2 (G: 0 to 1) Points/group: 8 (P: 0 to 7)
	RRSGP	Pulse input and proving	Number of groups: 7 (G: 0 to 6, but only the groups 0 to 4 are accessible to GT and LT blocks to read the pulses of corresponding input) Group#0 to Group#4: single or dual pulse input P: 0 – single pulse, phase A (terminal Ax) P: 1 - single pulse, phase B (terminal Bx) P: 2 – dual pulse, phase A (terminal Ax) and phase B (terminal Bx)
LMF	RRSGP	16 - pulse inputs	Number of groups: 2 (G: 0 a 1) Points/group: 8 (P: 0 a 7)
	RRSGP	Pulse input and proving	Number of groups: 7 (G: 0 to 6, but only the groups 0 to 4 are accessible to LMF block to read the pulses of master input) Group#0 to Group#4: single or dual pulse input P: 0 – single pulse, phase A (terminal Ax) P: 1 - single pulse, phase B (terminal Bx) P: 2 – dual pulse, phase A (terminal Ax) and phase B (terminal Bx)
AO	RRS0P	4 – analog outputs	Number of groups: 1 (G: 0) Points/group: 4 (P: 0 to 3)
MDO	RRS09	8 – discrete outputs	Number of groups: 1 (G: 0) Points/group: 8 (P: 9-whole points)
	RRSG9	16 – discrete outputs	Number of groups: 2 (G: 0 to 1) Points/group: 8 (P: 9-whole points)
	RRS19	8 – discrete inputs/4 – discrete outputs	Number of groups: 2 (G: 0-inputs to 1-outputs) Points/group: Group#0: 8 (P: 0 to 7) – Not accessible to the MDO block Group#1: 4 (P: 9-whole points)
	RRS69	Pulse input and proving	Number of groups: 7 (G: 0 to 6, but only the group 6 is accessible to the MDO block for OUT1 output of DF77) Group#0 to Group#4: single or dual pulse input Points/group: 1 (P: 9-whole points)

CHANNEL Allocation

Parameter	Check Type
LT.CHANNEL GT.CHANNEL	The consistence check should not allow two blocks to use the same CHANNEL.
LMF.CHANNEL_MM	Checks if the addressed module is the pulse input, which indicates that more than one block may have the same CHANNEL.

STRATEGY Configuration

The STRATEGY parameter of some blocks in the HFC302 identifies the run number, such as:

- Change in the configuration (AI, GT, LT,...) are registered to indicate the affected run number.
- Process alarms (AALM block) are registered to indicate which run number uses the variable that caused the alarm condition.
- QTR reports identify the run number using the STRATEGY parameter of the GT and LT blocks (no user's configuration is required, the HFC302 configures automatically);

STRATEGY Allocation (run number)

Value range to configure the STRATEGY parameter in the HFC302 specific blocks:

STRATEGY	Block Types
255 (read only)	FCT, LKD, GKD, WT, PIP, LMF
254 (read only)	LST
253 (read only)	GST
255 (read only)	GC
1-4 (Auto1) (read only)	LT, GT
1-4, 253, 254	SBC
1-4	LCFE, GMH

Rules of the STRATEGY automatic configuration:

1. Auto1: The automatic configuration occurs only to instance the block (configuration download). The value configured in the STRATEGY parameter is the minor number of flow available in the group of the block type corresponding. Therefore it is possible to predict the value to be configured for STRATEGY during the offline phase through the block sequence from the Syscon block list.

Recommendations to Configure the HFC302

1. Create the HFC302 blocks in this order: RS, FCT, LKD, GKD, HC, PIP, MBCF, etc. These transducer blocks should be at the top of list of the Syscon blocks, that is, before the function blocks;

2. After the firmware download or reset mode 1, the HFC302 module will be in the logon mode with Administrator level and LOGON_TIMEOUT disabled (equal to zero):
   a) The user will be able to perform any change in the configuration and it will be registered. It is recommended to keep these settings during the configuration, test and startup. When the measurement system starts operating, the user should logoff and write a proper value to the LOGON_TIMEOUT parameter.
   b) Set the passwords and the correspondent access levels.

3. During the commissioning in the startup, the FCT.LOGON_TIMEOUT parameter can be set at zero, but during the operation, it is recommended to write a proper value (for example, between 5 and 10 minutes) to this parameter, avoiding problems if the operator forgets to logoff;

- To download the complete configuration of the HFC302 and its H1 Foundation Fieldbus device, execute the download in the Fieldbus Networks (project window, right-click in the Fieldbus Networks icon and select the option Download).

- It is recommended to update the Real Time clock in the FCT block when the device is first initialized, and then periodically.

- Before starting the firmware download or the configuration download, interrupt the supervision through the HSE OPC Server or the Modbus protocol.

Note
When using Smar Field Devices, the Firmware version must be 3.46 or higher.

What Happens during Configuration Download

The configuration download has the following sequence:
1. Syscon starts to clear the whole configuration in the bridge (HFC302), then it clears the configuration in the field devices (transmitters).
2. It starts to download the application (block instantiation, parameter write, function block schedule) in the HFC302, then it downloads the transmitters.
3. Then it downloads the network schedule (external links between blocks).

What happens during configuration download:
1. As the configuration download starts by HFC302, the flow calculation stops as soon as the download starts.
2. As the block execution in the HFC302 starts before the external links are operating, the calculation of flow measurement executes using the override value for a while (till the download of network schedule).

If a message of failure is shown during the configuration download:
1. Check if all devices are in the live list, as well commissioned.
2. Check if you are logged on with Level 1, at least.
3. Repeat the configuration download
4. Read the Syscon – Installation and Operation Manual for more details.

Process Alarm Configuration

The date and time of entering or leaving the process alarm condition is registered in the alarm and event log.

The block developed to process the alarm of analog variables is the AALM block, which is described in the FF Function Blocks Manual. This block has several characteristics, such as:

- Dynamic alarm limits calculated according to the PSP input multiplyed by a gain, plus a bias or a static limits configured by the parameters HI_LIM, HI_HI_LIM, LO_LIM and LO_LO_LIM.
- Active alarm type selection (hihi, hi, lo, lolo) using the OUT_ALM_SUM parameter and indicated in the OUT_ALM output.
- Hysteresis: prevent frequent alarm condition indications caused by the process variable oscillating near the alarm limits.
- Temporization: the system enters the active alarm condition after a minimum configurable interval has elapsed.
- Alarm priority.

The AALM block has also tracking functionality, that is, the block registers the alterations when entering or leaving the alarm condition.

Configure the following parameters to make the necessary information available to generate alarm and events reports:

- STRATEGY: run number associated to the variable submitted to the alarm processing.
- TAG_DESC: if this parameter is different from spaces, this string is utilized for the event description in the report, instead of the AALM block tag
- ALERT_KEY: identifies the type of the variable submitted to the alarm processing:

  1 = Temperature
  2 = Pressure
  3 = Differential pressure
  4 = Density
  5 = SW
  6 = Volume flow rate
  7 = Mass flow rate

- HI_HI_PRI, HI_PRI, LO_LO_PRI, LO_PRI: the alarm priority is a block standard feature; it is also used in the reports and as filter criteria in HFCView.

The following characteristics will be available after configuring the system as indicated:

- Identification of run number affected by the alarm.
- Identification of the Variable type in the alarm condition.
- Status indication of the corresponding period in the transaction blocks (GT, GST, LT, LST).

Discrete Alarm Configuration (Electronic Seal)

The inlet and outlet of the discrete alarm condition are registered in the alarm and event log.

The DI block is developed for the alarm processing of discrete variables. For further details about this block, refer to the Foundation Fieldbus Function Blocks Manual. This block has the following available features:

- STRATEGY: run number associated to the variable submitted to the alarm process, and it will be also used for the report;
- TAG_DESC: configuring this parameter different from spaces, this string will be used in the event description for the report instead of the DI block tag;
- DISC_LIM parameter: condition of the discrete alarm which the alarm will be generated;
- DISC_PRI parameter: alarm priority.

Application

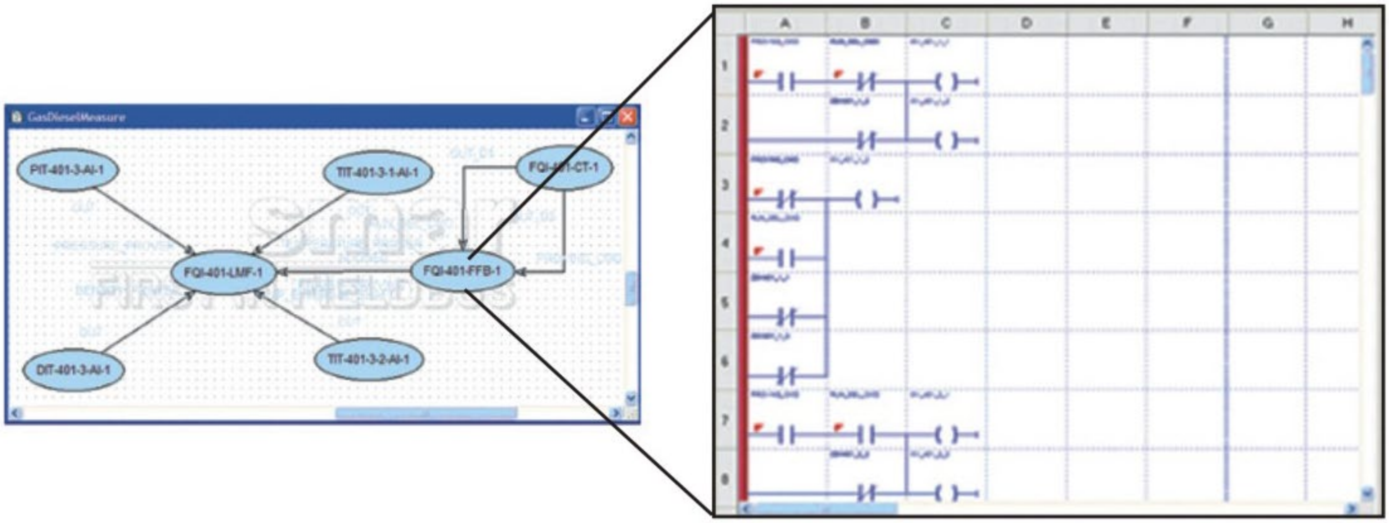
- The special feature regarding audit trail in the DI block is available only for physical discrete inputs.
- To detect and register events identified by description (TAG_DESC), and also the date and time of occurrence:
    - Opening/closing of cabinet and housing where the equipment for measurement station are stored (Electronic Seal).
    - Opening/closing valves that indicate the alignment of the operation or master meter.
    - Opening/closing the valves that indicate the start and the end of custody transfer.
- The information above improve the system audit trail, allowing the comparison and/or association with other events, configuration changes, maintenance or operation procedures, etc.

Chapter 13

ADDING LOGIC BY USING FLEXIBLE FUNCTION BLOCKS (FFB 1131)

Introduction

The AuditFlow has an advanced configuration resource by using Flexible Function Block (FFB 1131). Its purpose is to provide the connection between the ladder logic (usually used for discrete control strategies) and the continuous control strategies, configured through function blocks.

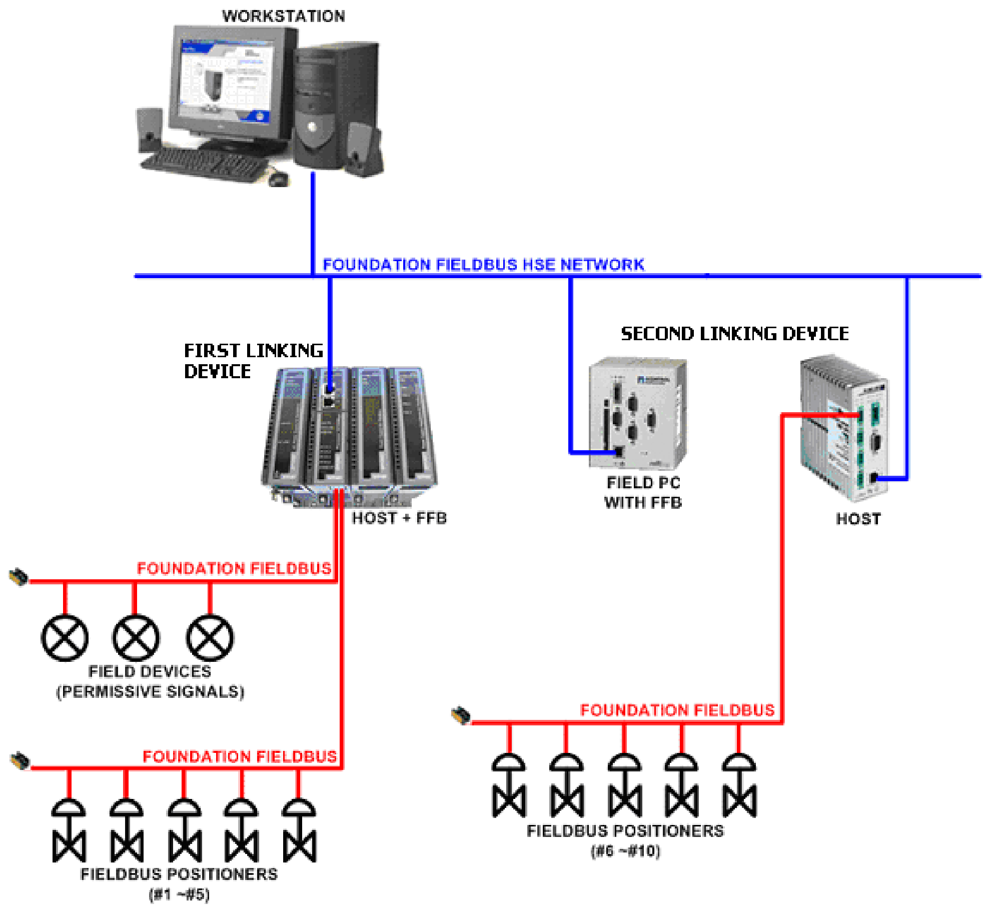


NOTE
The example that will be showed is applied to HFC302.

Area with FFB

For the application below, there is integration between 2 linking devices and also:

- 3 FOUNDATION™ fieldbus transmitters;
- 10 FOUNDATION fieldbus valve positioners.



To create the control strategy using the FFB, it is necessary to open the **Syscon**. Choose **File** option and then choose **New**. Choose **Predefined Area** item, as shown in the next figure:

Figure 13.1 – Area Options

The window with the options of area templates will be showed next. The user should select one of the template types with FFB. The following figure shows the dialog box with one of the options selected.

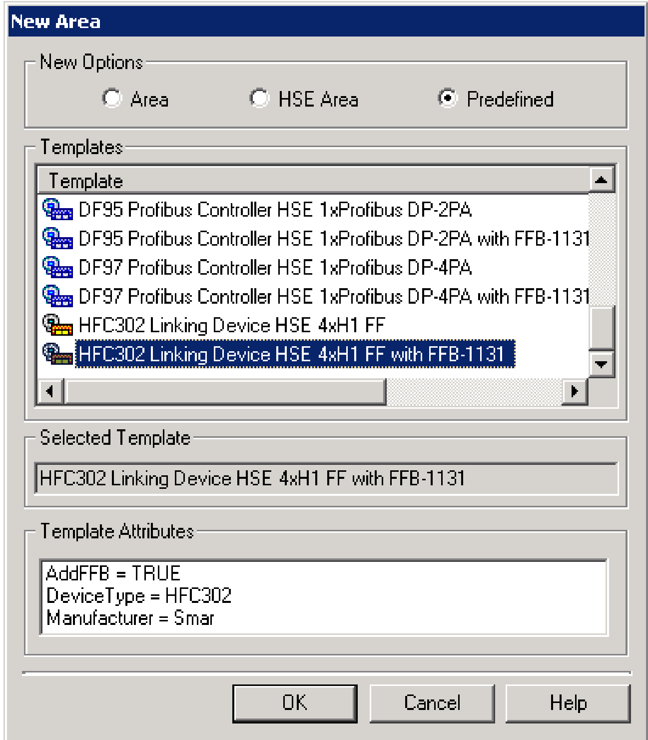


Figure 13.2 – Choosing the template using HFC302

Clicking **OK**, the dialog box to name the area will open. The user should assign a name to the area and click **OK**.

Figure 13.3 – New area name

Arranging the Syscon Windows

When clicking **Ok**, two new windows will open in the **Syscon** automatically. For better view of the area, choose **Window** option on the **Syscon** toolbar, and then **Tile**. The next figure shows the available windows for the area:

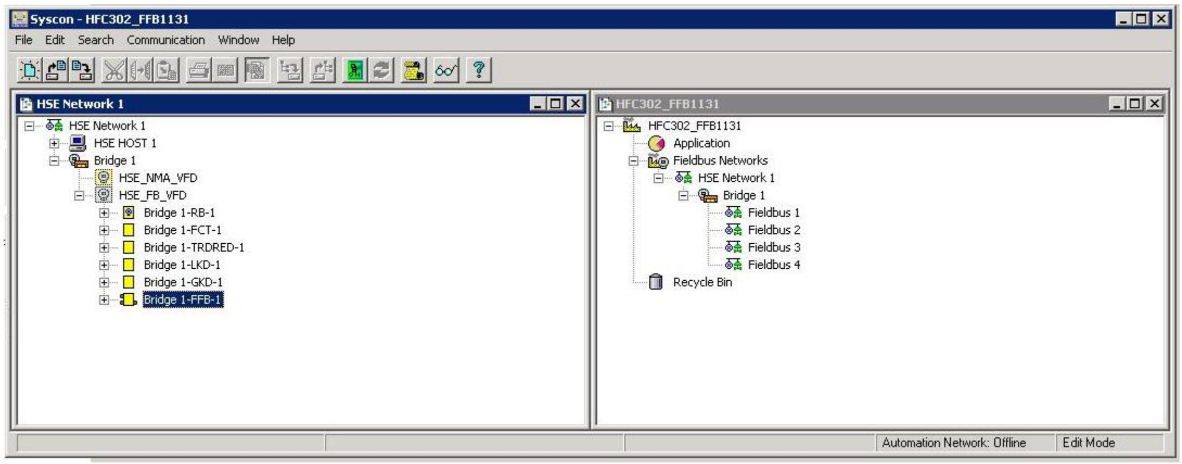


Figure 13.4 – Arranging the windows for the FFB area

Defining the FFB Parameters

To see the area's elements, such as blocks that were added, click the **Details** button on the toolbar, . So, a description will appear just after the tag of each element. In the figure below, click the **HSE Network 1**[1] window, and then right-click the FFB block. The dialog box for the parameter definition will open:

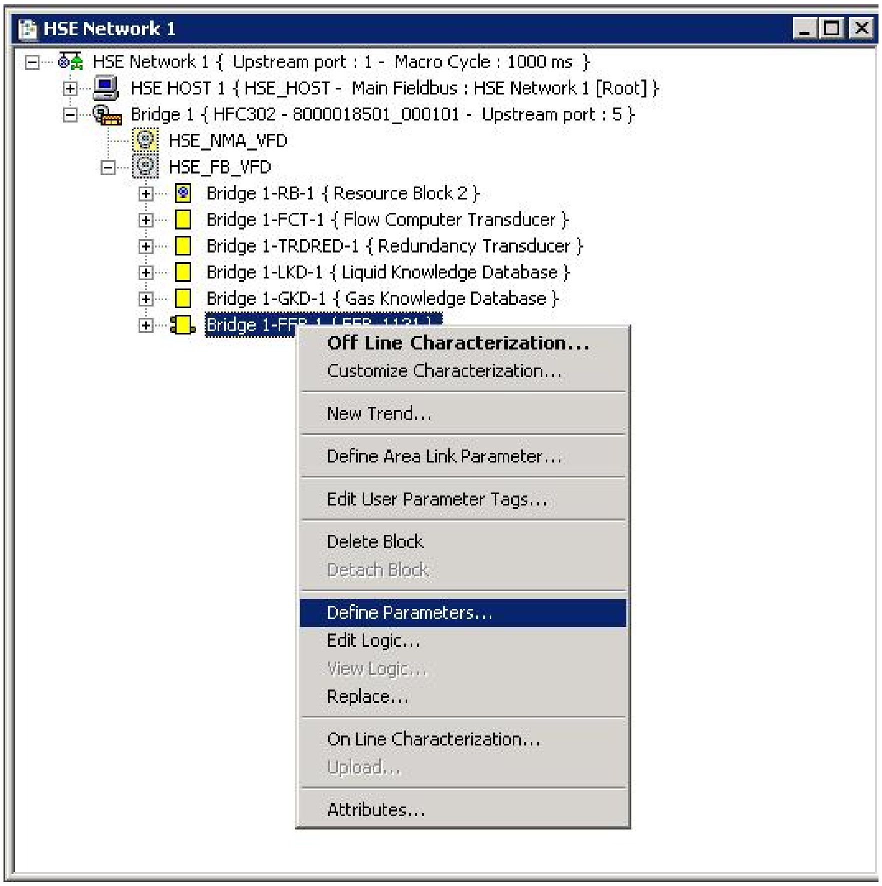


Figure 13.5 – Defining the FFB parameters

[1] This number changes if another area was created before. When a new HSE area is created, this number increases.

To define which I/O types will be exchanged between the discrete and continuous logic, select **Define Parameters** option from the popup menu. The **FFB Parameters Definition** window will open as shown in the next figure:

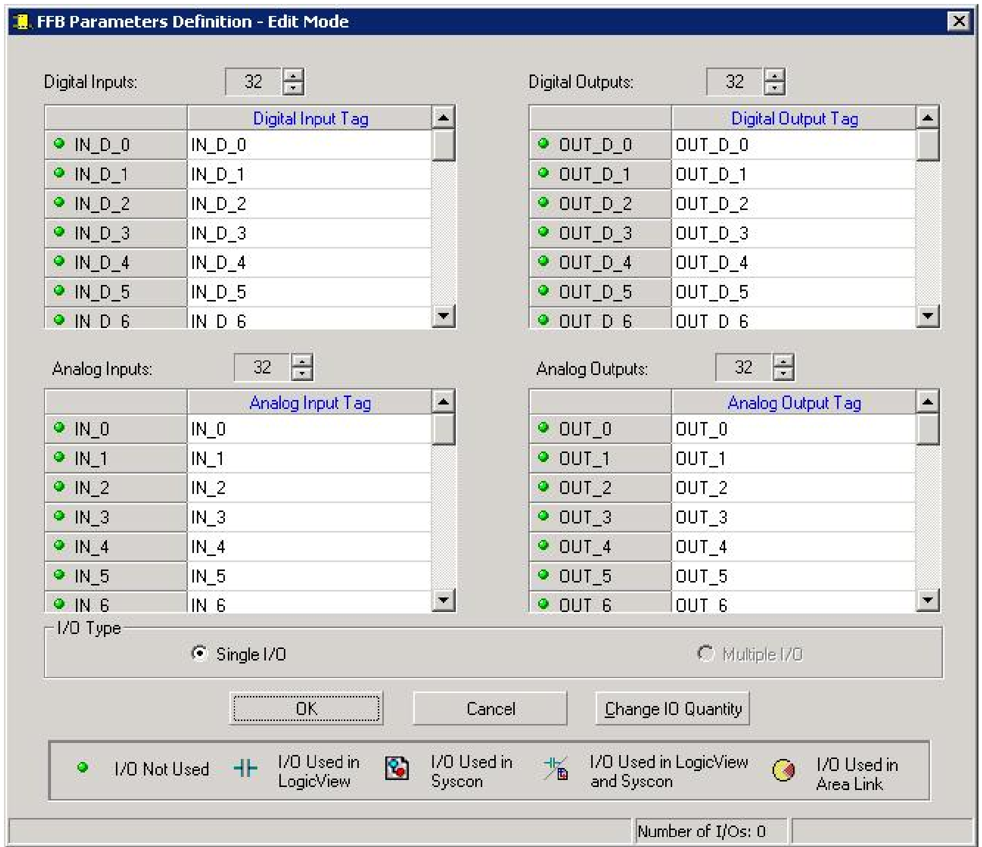


Figure 13.6 – Defining I/O types

NOTE
From the 7.3 version of **SYSTEM302**, the FFB is automatically created, with the following number of parameters: 32 DO, 32 DI, 32 AO, and 32 AI.

In the window above, the user can configure the number of analog and digital inputs and outputs: Analog Inputs, Analog Outputs, Digital Inputs, and Digital Outputs. After the user clicks **OK** the points DI, DO, AI, and AO are generated. In **I/O Type, Single I/O** is the unique option available for HFC302, the DI, DO, AI, and AO are configured. For further details about **FFB Parameters Definition** refer to the **Syscon** manual.

To change the tags right-click the FFB block icon on **Syscon** (in the Process Cell, Fieldbus or Strategy window) and click **Edit User Parameter Tags**. The **User Parameter Tag** dialog box will open. For further information refer to **Syscon** manual.

If neither all I/O points are known at this moment, new I/O points may be defined later.

IMPORTANT
When a FFB block is used in a control strategy it is recommended to reserve extra parameters for future usage avoiding an impact of stopping the control during an incremental download. It will be necessary when a new strategy with new parameters were included. When new FFB parameters are added, as well as a change of parameter's name, the devices' DDs will be redefined, and this will demand a wider download, resulting in deleted links and deleted blocks, and the re-establishment of them. The utilization of extra parameters, which were previously defined, will not redefine new DDs and will demand only the establishment of new links which will use the reserved parameters. However, from the 7.3 version of SYSTEM302 when creating a new parameter, four other reserve parameters are automatically created for that same type.

Right-click the **FFB block** again. The dialog box to edit the logic will open. Now the user can select **Edit Logic** option to edit the internal logic of the function block.

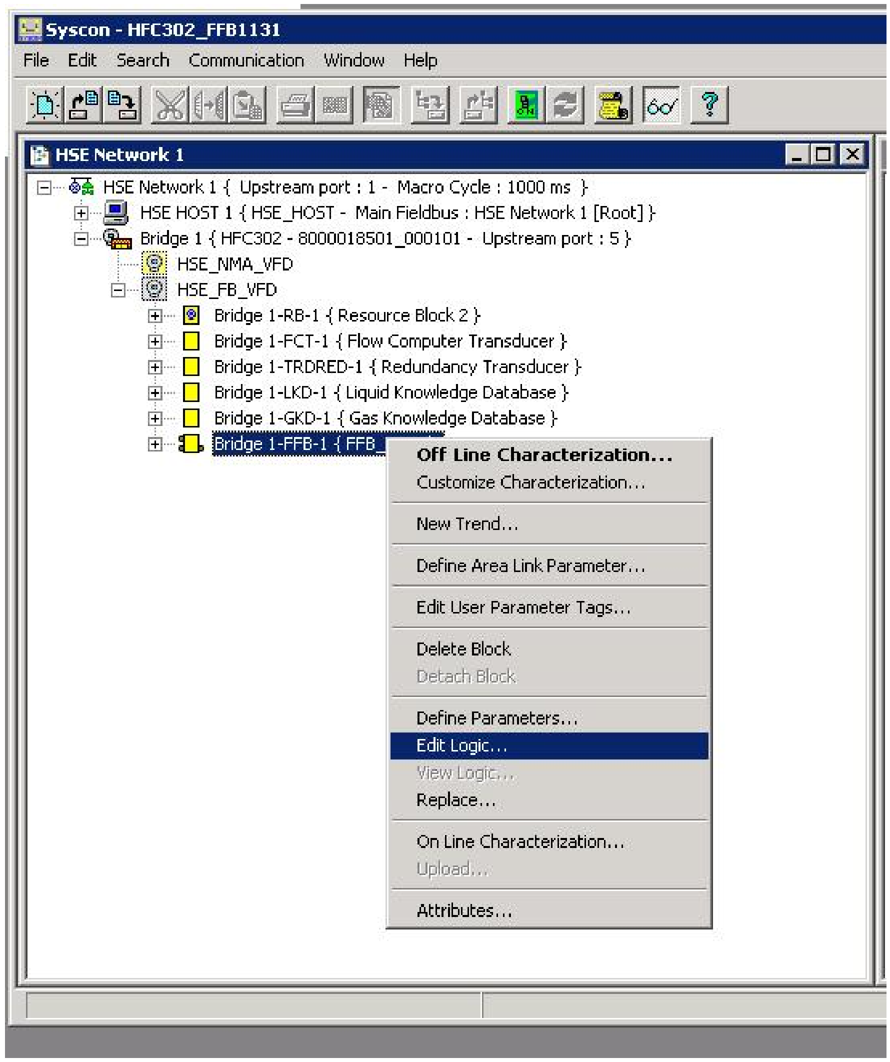


Figure 13.7 – Selecting the option to edit the logic

Just clicking this option, a new window will open. The configuration tool specialized in ladder logic will allow the user to build the discrete control. For further details about the ladder logic edition, refer to the **LogicView for FFB** manual.

Chapter 14

ADDING REDUNDANCY

Introduction

To meet with requirements for fault tolerance, system availability and safety of the industrial process, the HFC302 HSE controller work with a Hot Standby redundancy strategy. In this strategy, the Primary controller executes all tasks, and the Secondary controller is the one that, continuously synchronized with the Primary, keeps ready to assume the process in case the Primary controller fails. This event, where the Secondary assumes the process by changing its function to Primary, occurs in a bumpless and autonomous way.

In this controller the redundancy is Device D-3 type, in compliance with the specification "High Speed Ethernet (HSE) Redundancy Specification FF-953" of Fieldbus Foundation. By this capacity (Device D-3), during the entire operation time, the controller pair is seen as a single device by the configurator. Thus, actions as commissioning, decommissioning, configuration download, and parameterizations affect both controllers (Primary and Secondary).

The different failure types, such as failures in the interfaces, are indicated even if occur in the Secondary, this allows proactive maintenance and thus ensure the own redundancy availability.

This new generation of Hot Standby redundancy of the HFC302 controller brings better diagnostic and failure detection capacities, autonomy during startup and transparency for the configuration tools.

IMPORTANT
The characteristics described in this section are valid for the HFC302 controller. It is assumed that the user is familiar with Studio302 and Syscon. For further information, refer to the respective manuals.

Hot Standby Redundancy

With the Hot Standby redundancy full redundancy is achieved, heavily improving the fault tolerance, plant availability and safety. All the controller functionalities and databases have redundancy:

- Device Redundancy;
- Network redundancy (or LAN redundancy, for controllers with two Ethernet ports – HFC302);
- *Gateway* Ethernet ↔ 4 ports FOUNDATION fieldbus™ H1;
- *Link Active Scheduler* (LAS) in the FOUNDATION fieldbus™ H1 channels;
- Controller (running function blocks, including FFB/Ladder Logic);
- Supervision;
- *Gateway* Modbus ↔ 4 ports FOUNDATION fieldbus™ H1;
- Synchronism channel redundancy.

The procedures for configuration and maintenance are as simple as for a non-redundant system, saving time to get the system running. Only one configuration download is necessary to configure the redundant pair. And in case of replacement of a failed controller no configuration download or user intervention is necessary. The new module inserted is automatically recognized, receiving the whole configuration from the controller in operation.

Preparing a Redundant System

In order to have a true redundant system, not just all the equipments must be redundant but also the entire system architecture must be designed as redundant. The more elements with redundancy ability the system have, better reliability and availability can be achieved. A typical redundant architecture based on HFC302 controller can be seen in the next figure.

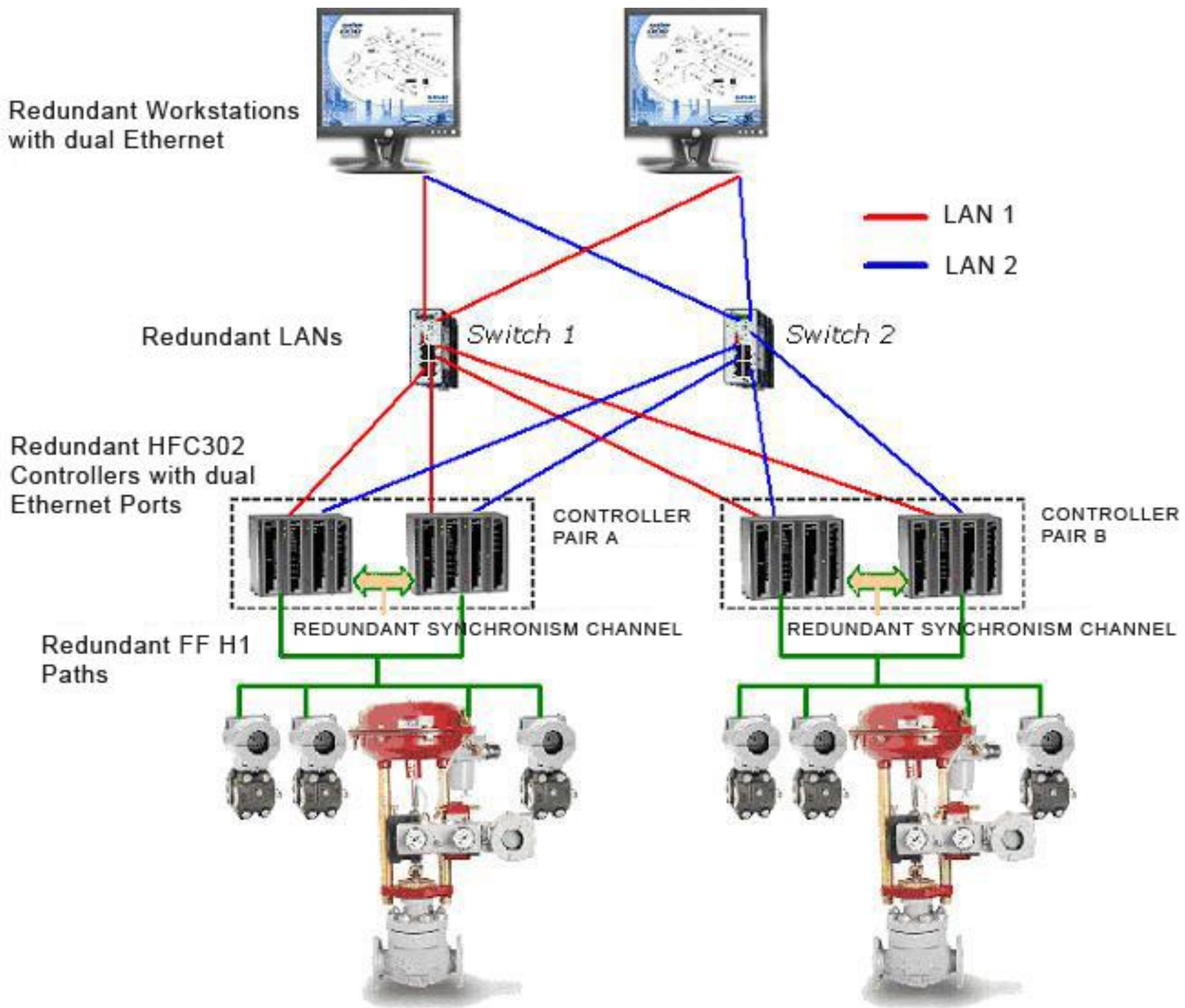


Figure 14.1 – Redundant System Architecture

Ethernet Network

- The Ethernet network IP addresses, used by the controller, have to be Class C (mask 255.255.255.0).
- For controllers with two Ethernet interfaces, the networks' nodes have to be equal. For the ETH1 interface must be used one subnet, and for the ETH2 interface must be used another subnet. Example: the first HFC302 interface (ETH1) = 192.168.164.34, the second HFC302 interface (ETH2) = 192.168.165.34. The node (34) in this example will be used as controller's "node address" in the Syscon configuration file. This way, there will be two subnets: 192.168.164.X and 192.168.165.X, the first serves all ETH1 interfaces and the second serves all ETH2 interfaces of all the controllers. These two subnets must be designed physically separated and using different network elements.

- The workstations must have two network cards and each card must have the IP configured in one of the designed subnets as explained previously.

Configuring the System302 ServerManager and Syscon

At the **Studio302** toolbar, click the button  and the **System302 ServerManager** dialog box will open.

Figure 14.2 – System302 ServerManager

Click the **Network** option and the next window will open.

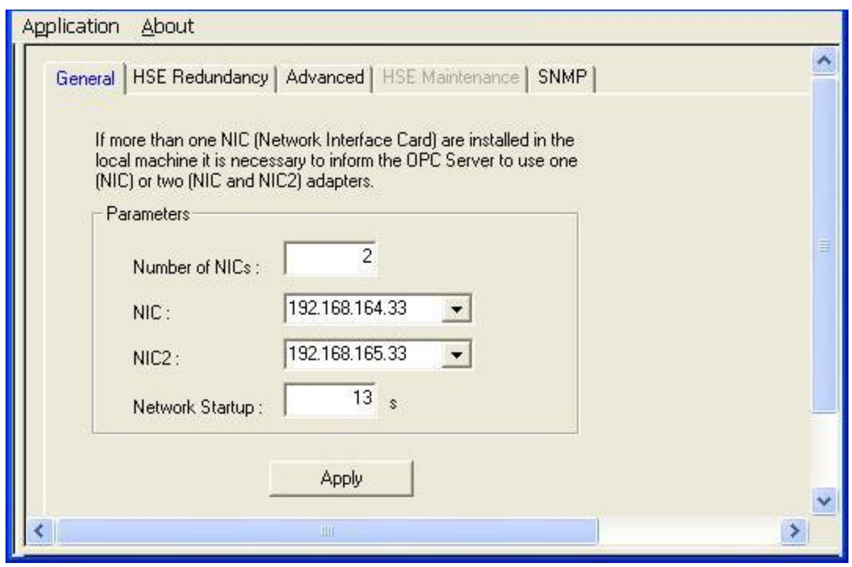


Figure 14.3 – System302 ServerManager: General Tab

At the **General** tab insert the number of NICs (network cards) used in the machine, in this case is **2** (redundant system).

Select the IP address of the NICs used by the Server Manager. At the **HSE Redundancy** tab, configure the fields as in the following figure.

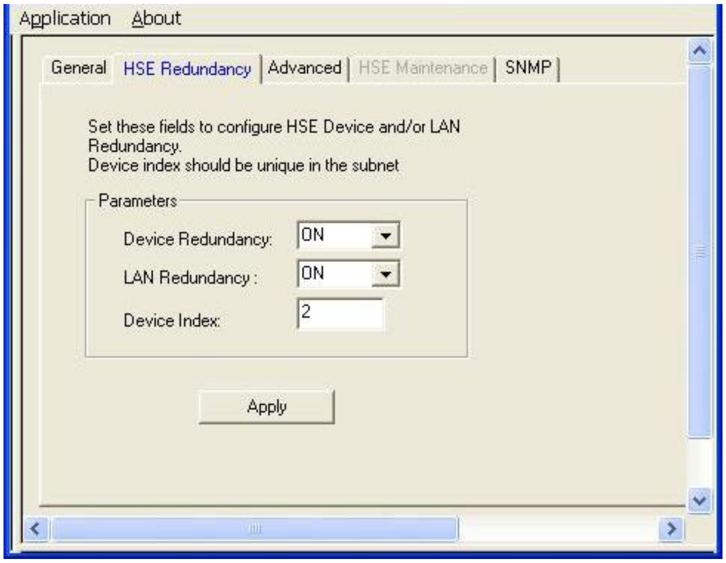


Figure 14.4 – System302 ServerManager: HSE Redundancy Tab

Select ON for Device Redundancy and LAN Redundancy.

At the Device Index text box, type a value between 1 and 9 for each machine, and every machine must have a unique number. In the HSE network, the Device Index represents the network address for each equipment for routing purposes, because of this it needs to be unique.

At the Syscon, the only care to be taken in the control strategy configuration related to redundancy is:
- Right-click each controller which will be redundant and choose **Attributes** option;
- Configure the item "**Is Redundant (HSE Only)"** as enabled.

Synchronism Channels

A RS232 serial port is dedicated to synchronism between the Primary and Secondary controllers using the DF82 (0.5 m) or DF83 (1.8 m) cables. See the next figures.

Thus, the distance between controllers is limited in 1.8 m. Therefore, they have to be installed preferentially in the same panel, but with different power supplies and independent no-breaks.

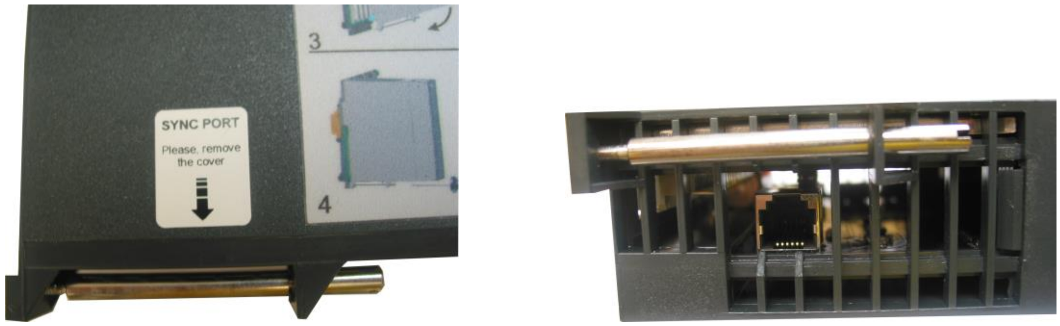


Figure 14.5 – Label to identify the serial synchronism connector (Left) and the serial synchronism connector in the bottom part of the module (Right)

The synchronism between the controllers is done through the serial port mainly during the startup.

After controllers' startup the synchronism is done through the Ethernet interfaces, ensuring a greater transfer rate for synchronism. If there is a communication failure in an Ethernet interface, the synchronism is reestablished by another one. If there is a communication failure in both Ethernet interfaces, the synchronism will be done through the serial synchronism port.

DIFFERENTIAL
The HFC302 controller has redundancy of synchronism channel as a differential. Thus ensure a greater availability of the own device's redundancy. Three failures of synchronism channels are necessary for controllers with two Ethernet interfaces (HFC302).

IMPORTANT
The synchronism serial cable (DF82/DF83) must remain connected all the time. This peer-to-peer connection is what determines the formation of a redundant controller pair during the plant startup, and also, during re-startup, after scheduled stops.

Foundation Fieldbus^{TM} H1 Channels

Foundation Fieldbus^{TM} H1 redundant segments: For each Foundation Fieldbus^{TM} H1channel, from a common point in the panel, a segment can be ramified up to the Primary controller, and another one up to the Secondary controller offering failure tolerance in these segments.

To make the redundancy possible in the H1 fieldbus network, the HFC302 controller uses the flat address 0x05 in the publication moment. As third-party devices typically do not support flat address, they may not support links with blocks which are in those controllers.

Accessing the I/O bus

To allow the access to the I/O modules in a redundant way, a proper hardware topology must be used. Thus, it is necessary to use the DF78 or DF92 rack, where in the first two slots (Power Supply 1 and Power Supply 2) the power supplies DF50 (AC/DC) or DF56 (DC/DC) must be inserted, thus the power supply redundancy is provided. The controllers must be installed side by side in the CPU 1 and CPU 2 slots. See the next figures.

DF78 or DF92 rack allows direct access to the I/O modules in a safe and transparent way when redundant controllers are used. Also is possible hot swap (insertion/extraction) of the controllers for maintenance purposes.

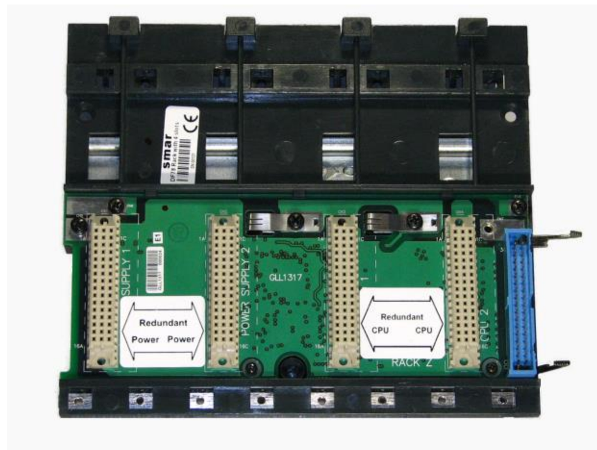


Figure 14.6 –DF78 Rack

Figure 14.7 – Example of modules arrangement in the DF78 rack (DF50-DF50-CPU1-CPU2)

Hot Standby Redundancy Working

Starting up the redundancy

The controller which starts up first becomes the Primary. In case of both controllers which form a pair are started up at the same time, both will assume the same role that they were operating previously (nonvolatile information).

In the absence of nonvolatile information (startup immediately after firmware updating or Factory Init mode) and in case of both controllers are started up at the same time, the controller which has a bigger serial number will be elected as Primary, and its partner will be the Secondary.

IMPORTANT
The controllers have conditions to define their role (Primary or Secondary) autonomously during the startup; and no user action is necessary.

Besides the information above mentioned, during the entire operating time of the controller pair and in conditions free of failures, we have the following:

- There is not physical difference between Primary and Secondary controllers;
- There is not preference for a controller rather than another, or for a rack position rather than another, to determine which controller will be the Primary.

Switch over Condition

The different failures that may occur in such system, lead it to a switch over, when the Secondary becomes Primary, and vice-versa in a bumpless way. The possible reasons for a switch over, divided in two types, are as follows:

General Failures
When the whole controller fails, this comprises:
- Hardware failure
- Power off
- Removal of the controller from the rack.

Bad Condition Failures
When one of the Primary controller's interfaces fails:
- Failure in all Ethernet cables directly connected to the Primary.
- Failure in an H1 channel (hardware or cables) of the Primary.
- Failure in the Modbus communication (hardware or cables; in case of operating as master).
- Failure in all HSE links of the Primary.

The system can check which controller has the best conditions, electing it as the Primary. It is assured the recovery of one failure at a time. That is, once a failure has occurred, a second failure will be recovered by redundancy only if the first failure has been fixed. While the failure is not fixed, the system has the redundancy not fully available (in case of **Bad Condition Failures**) or even not available (in case of **General Failures**).

For the case of **General Failures**, as soon as the failed controller recovers a healthy state or is replaced, the controllers automatically become a redundant pair again. That is, the system automatically recognizes a new inserted controller.

In order to monitoring the redundancy state, some parameters available in the Redundancy Transducer function block (TRDRED) should be used. See the following table. For further details see the Function Blocks manual.

<table>
<tr><th>PARAMETER</th><th>VALID RANGE/OPTIONS</th><th>DESCRIPTION</th></tr>
<tr><td>RED_PRIMARY_SN</td><td>0 ~ 65535</td><td>Indicates the Serial Number of the Primary controller.</td></tr>
<tr><td>RED_SECONDARY_SN</td><td>0 ~ 65535</td><td>Indicates the Serial Number of the Secondary controller.</td></tr>
<tr><td>RED_SYNC_STATUS</td><td>0: Not defined
1: Stand Alone
2: Synchronizing
3: Updating Secondary
4: Synchronized
5: WARNING: Role Conflict
6: WARNING: Sync Cable Fail
7: WARNING: Updating Secondary Fail</td><td>Indicates the Synchronism status of the controller pair.
0: Default just after startup.
1: Stand alone operation (no redundancy).
2: Checking configuration for synchronization.
3: Primary transferring configuration to the Secondary.
4: The Primary continuously updates the Secondary dynamic databases.
5: It was not possible to solve autonomously the Role. (Primary / Secondary).
6: Fail on all the synchronism channels (redundancy unavailable).
7: Primary fails before synchronism be completed (redundancy unavailable).</td></tr>
<tr><td>RED_PRIMARY_BAD_CONDITIONS</td><td rowspan="2">Bit
0: Modbus
1: H1-1
2: H1-2
3: H1-3
4: H1-4
5: Live List
6: Eth1
7: HSE link
8: Eth2
9: Serial Sync Cable
10: Unable to Sync</td><td rowspan="2">Bad conditions for the Primary / Secondary controllers.</td></tr>
<tr><td>RED_SECONDARY_BAD_CONDITIONS</td></tr>
</table>

Table 14.1 – Description of main parameters of Redundancy Transducer function block

BIT	VARIABLE	DESCRIPTION
0	Modbus	When working as master and if no Modbus slave device answers, it means that Modbus communication is in bad conditions. Failures on the communication path or even a failure on the slave can cause it.
1	H1-1	Failure on an H1 channel, specifying each channel had the failure.
2	H1-2	
3	H1-3	
4	H1-4	
5	LiveList	H1 Live List was not completed on Secondary controller.
6	Eth1	Synchronism failure on Eth1 interface.
7	HSE link	Failure on HSE link.
8	Eth2	Synchronism failure on Eth2 interface.
9	Serial Sync Cable	Failure on serial synchronism cable.
10	Unable to Sync	Firmware versions with incompatible synchronism.

Table 14.2 – Description of RED_PRIMARY_BAD_CONDITIONS and RED_SECONDARY_BAD_CONDITIONS parameters bits

IMPORTANT
To know how to proceed when warnings appear in **RED_SYNC_STATUS** parameter and the indications of **BAD_CONDITIONS** parameters refer to Troubleshooting topic.

Standby LED Behavior

The available blinking patterns for the Standby LED are summarized below. The next figure shows a graphic representation for these patterns.

a. PRIMARY IN STAND ALONE: Standby LED turned off all the time. It indicates that there is no partner connected.

b. SECONDARY SYNCHRONIZED: Standby LED turned on all the time. It indicates that the Secondary controller is totally synchronized with the Primary controller and the redundancy is available.

c. PRIMARY WITH PARTNER: Each three seconds, Primary's Standby LED blinks briefly. It indicates that the Primary controller has a partner.

d. SECONDARY SYNCHRONIZED: Standby LED blinking slowly turned off about one second and turned on about one second. It indicates that the configuration synchronism is on progress.

e. ROLE CONFLICT: Standby LED blinking fast. It indicates the controller did not define its role during the startup. The Primary will pause for two seconds the blinking each ten times. The Secondary will blink permanently.

f. PRIMARY – CABLE FAILURE: Standby LED blinking twice in the Primary, quickly at each two seconds. It indicates failure in the synchronism serial cable.

g. SECONDARY – CABLE FAILURE: Standby LED blinking four times in the Secondary, quickly, at each two seconds. It indicates failure in the synchronism serial cable.

h. PRIMARY FAILS DURING SECONDARY UPDATING: Standby LED blinking three times in the Secondary, quickly, at each two seconds. It indicates that there has been a general failure on Primary before reaching the **Synchronized** status.

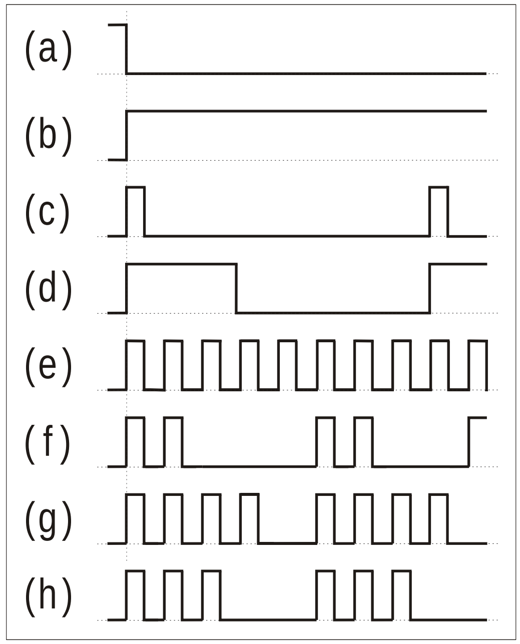


Figure 14.8 – LED Standby Behavior

Procedures for Hot Standby Redundancy

The next steps are for configuration and maintenance when using the Hot Standby redundancy. It is recommended that the steps be all read and understood before they are executed.

IMPORTANT
Before executing any of the following procedures, make sure you have followed the guidelines of the topic Preparing a redundant system. At this section, the following expressions and their respective definitions are used: - Hold Mode: stops the firmware execution in the controller as well as all tasks in the process. - Run Mode: executes the firmware again. - Factory Init Mode: restores the factory configuration, erasing the user's configuration. For further information about those expressions and how to update the firmware refer to sections Setting Up or Troubleshooting in this manual.

Configuring for the first time a redundant system

This is the procedure to configure the system with Hot Standby redundancy for the first time, at the plant startup.

1 – With the rack not powered, connect the synchronism serial cable to each controller.

2 – Connect both controllers through the H1 channels (1 to 4), in case of HFC302. Connect the Ethernet cables to the corresponding controllers' interfaces.

3 – Power the rack where the controllers are installed. The controllers will decide autonomously which one will be Primary and Secondary. Wait until the Standby LED of one controller turns on permanently, what means the roles have been defined and the controller pair is synchronized.

4 - At the Studio302 click **Areas** , choose the desired configuration. It will be open at Syscon, and then click **On-line Mode** option . Execute the commissioning of controllers and field devices. Download the configuration right-clicking **Fieldbus Networks** . For further information refer to Syscon's manual, section Creating a FOUNDATION fieldbus configuration.

5 – The controller pair will synchronize the configuration (Standby LED will blink). When the

controller pair is synchronized (Standby LED turned on permanently in Secondary), the Primary will constantly update the Secondary with the process dynamic variables.

As soon the controller pair get the **Synchronized** status and <**none**> in the **BAD_CONDITIONS** parameters, the redundancy will be fully available and failure simulations can be performed.

Changing the configuration

Download the new configuration to the device commissioned in the Syscon. The controller pair will re-synchronize automatically.

Replacing a controller with failure

To ensure a high safety process when replacing a controller, make sure of following the steps below:

1 - With the new controller disconnected from the rack, turn off the battery switch, at least, for 30 seconds. Set the **BATTERY** position to **OFF**, wait for 30 seconds and return to the **ON** position.

2 - You must connect the synchronism cable (DF82/DF83) just before inserting the new controller. This will avoid role conflict between controllers.

3 - If possible, connect all cables: besides the synchronism cable, H1 channels (1 to 4) in case of HFC302 and the Ethernet ports.

4 - Insert the new controller in the rack.

5 - In case all cables have been connected before the insertion of new controller, the synchronism will automatically start (the Standby LED should blink in the new controller). When the system is synchronized (Standby LED turned on permanently), the Primary controller will constantly update the Secondary with the process dynamic variables.

6 - In case only the synchronism cable has been connected before the insertion, a hot insertion of the H1 cables (in HFC302) may be necessary. In this case, set the new controller to **Hold** (none executing), connect the H1 cables, and the Ethernet cables. Then, return the controller to **Run** mode (execution).

7 - As soon the system gets the **Synchronized** status and <**none**> in the **BAD _CONDITIONS** parameters, the redundancy will be fully available and failure simulations can be performed.

8 – For any situation different from **Synchronized** status, refer to section Standby LED Behavior to make a better diagnosis.

Adding redundant controllers in a non-redundant system

Even a non-redundant controller supports redundant operation, working as Primary in Stand Alone state.

Thus, a non-redundant system, in operation, may have redundant controllers added later without process interruption. Only is necessary that the non-redundant system has foreseen some cares according to the section Preparing a Redundant System. The procedure is the same of the previous section (Replacing a controller with failure).

Firmware update without process interruption

It is possible updating the controllers' firmware to new versions, which have new features or improvements, without process interruption.

For reference purpose in the following procedure, we designate one of the controllers as **A** and another as **B**. Suppose the controller A is the one which was Primary at the beginning of the procedure execution. That is, the references A and B are static, and the user can even associate the controller A as the one in the rack's left side and controller B as the one in the rack's right side.

Follow the next steps:

1 – Be sure the system is in the **Synchronized** status, and it has <**none**> in the **BAD _CONDITIONS** parameters. So, using FBTools update the firmware of the controller A *(*current Primary*)*. At this moment, the other controller (B) will take over becoming the current Primary.

2 – After finishing the firmware's update of controller A, the controller pair will synchronize with the current Primary (B) transferring the entire configuration to the other one (A). Wait for the system get the **Synchronized** status and it has <**none**> in the **BAD _CONDITIONS** parameters.

3 – Using FBTools update the firmware of the current Primary controller (B). At this moment, the other controller (A) will take over becoming the current Primary.

4 – After finishing the firmware's update, the controller pair will synchronize with the current Primary (A) transferring the entire configuration to the other one (B). As soon the system get the **Synchronized** status and it has <**none**> in the **BAD_CONDITIONS** parameters, the redundancy is fully available again and failure simulations can be performed.

After finishing this procedure both controllers will have updated firmware and the original configuration will be preserved without need of process interruption.

Troubleshooting

Role Conflict
This exceptional situation occurs when some procedure was not followed. It is signaled by the **RED_SYNC_STATUS** parameter (value **5**: **WARNING: Role Conflict**) and by the Standby LED (see Standby LED behavior topic).

There is a chance of occurs role conflict only when a controller has already had a partner operating in redundancy when one of the controllers is exchanged without doing a Factory Init in the new controller inserted. In such situation the redundancy does not define the function of the new controller because of security reasons. The user is responsible to decide which controller has the right configuration.

Solution: the user has to do a Factory Init in the controller which will be the Secondary (the entire configuration of this controller will be erased, and it will receive the configuration from another controller).

Correction of synchronism cable failure
Once there is a failure in some of the synchronism media (Serial, Eth1, Eth2) it is signaled by the **BAD_CONDITIONS** parameters, respectively with: **Serial Sync Cable**, **Eth1** and **Eth2** (see Table 13.2). Even the synchronism channel is redundant (with up to three paths); it is recommended that as soon as a failure is signaled in some of the paths, it has to be fixed.

The cables' failures caused by human intervention are very common. For example, if the Ethernet cables were exchanged in the Secondary (Eth1 cable in the Eth2 interface, Eth2 cable in the Eth1 interface) the LEDs ETH1 LNK and ETH2 LNK of the Secondary will indicate that there is a media (link) normally. However, the synchronism communication through the Ethernet ports will not be established since the subnets 1 and 2 are physically separated. This type of error will be realized by the **BAD_CONDITIONS** parameters and will be diagnosed through user's analysis.

Solution:
- Check if the connectors are properly fitted;
- Check the synchronism cables with failure indication as well the network elements in case of a failure in the Ethernet interfaces.

Primary fails before completing the synchronism
This exceptional situation occurs when some procedure was not followed. It is signaled by the **RED_SYNC_STATUS** parameter (value **7***:* **WARNING: Updating Secondary Fail**) and by the Standby LED (see Standby LED behavior topic).

There is a chance to occur this failure only when a redundant pair is not yet with **Synchronized** in the **RED_SYNC_STATUS** parameter and then the current Primary is turned off. In such situation, when the redundancy is not available yet, the Secondary does not have conditions to take over the plant in a safe way. In this situation the Secondary keeps the same function and indicates this state as a safety condition.
Solution:

- In case the user knows that the Primary, which was turned off recently, has the complete configuration, set the Secondary to Hold, and then, turn on the Primary. Some seconds after that, remove the Secondary from Hold. The controller pair will synchronize, and only after they get **Synchronized** status and <**none**> in the **BAD CONDITIONS** parameters, failure simulations can be performed.
- In case the user does not trust the Primary configuration, follow the same procedure above mentioned, however download the configuration again.

Correction of an H1 cable failure

Cables failures in H1 segments which affect only one controller (Primary or Secondary) are signaled in the **BAD CONDITIONS** parameters allowing an immediate maintenance.

In case the failure occurs in an H1 cable segment which affects only the Primary controller, the redundancy will cover this failure, performing a switch-over. In case the failure affects only the Secondary, it will not affect the process but even so it will be signaled by the **RED_SECONDARY_BAD_CONDITIONS** parameter allowing proactive maintenance.

During the maintenance, in case the H1 cable is reconnected at once, the noise inserted in the line will cause communication problems for some time, what is undesirable. To avoid this, the next procedure has to be followed.

1 – Set the controller, which was affected by the H1 cable failure, to Hold mode.

2 – Fix the H1 cable connection.

3 – Remove the controller from Hold mode. The controller will be automatically recognized by the Primary controller. As soon as the controller pair has **Synchronized** status and <**none**> in the **BAD_CONDITIONS** parameters, the redundancy will be fully available again.

Correction of bad conditions – Modbus

Check:
- If there are any cables failures in the paths related to the Modbus communication topology.
- The parameterization of the Modbus function blocks.
- If the converters/devices used in the Modbus communication topology are working properly.
- If the Modbus slave device is correctly configured and working.

Correction of bad conditions – Live List

Check:
- If the H1 cables have some connection problem or noise;
- Problems with line terminators (BT302): bad contact, missing or excess of BT302;
- Bad grounding;
- Water in the junction boxes or inside the devices;
- Transmitters with poor isolation;
- Transmitter digital card with some problem;

In case a deeper investigation is necessary, it is recommended to use the FBView software which is integral part of System302. The FBView manual, in the Signal Quality and Live List topics, brings the necessary procedures.

Correction of bad conditions – Synchronism incompatibility

When executing the procedure Firmware update without process interruption in general will occur momentarily a situation where a controller has a firmware version and the other controller has another one. The following momentary situations may happen:

a) Secondary has a newer firmware version than the Primary (Upgrade): the synchronism is compatible, and the controller pair synchronizes normally. That is, this scenario is perfectly supported.

b) Secondary with an older firmware version than the Primary (Downgrade): the synchronism is not compatible, and the controller pair does not synchronize indicating this situation as "**Unable to Sync**" in the **BAD_CONDITIONS** parameters. That is, this scenario is not supported in the redundancy context.

Solution for case b:

This scenario (downgrade) must be avoided. Once a plant is operating with a firmware version in the controllers, and for some reason the user desires to operate the plant with a previous firmware version the option is: with the plant stopped, change the firmware of all controllers (Primaries and Secondaries) and then follow the procedure in the Configuring for the first time a redundant system topic.

Chapter 15

MODBUS

Introduction to Modbus Protocol

The Modbus protocol is a digital communication protocol created by Modicon in 1970 decade and became public domain.

There are documents that present details of this protocol in the internet and we recommended the reading, if you are a beginner in this topic or there is the necessity to implement or to configure this protocol. In this document we will just present the implementation of this protocol in AuditFlow.

Supported features:

- Serial Port 1: physical level EIA-232, Modbus RTU, only one master in each network, characteristics configured in the MBCF block
    - BAUD_RATE : up to 19.2 Kbps
    - STOP_BITS: 1 or 2
    - PARITY : even, odd or none
    - MASTER_SLAVE : Master or Slave
- Ports ETH1 and ETH2: Ethernet physical level TCP/IP, Modbus TCP/IP
    - Modbus TCP/IP : multimaster protocol
    - ETH1 : HFC302 can be master and slave simultaneously and not request configuration
    - ETH2 : HFC302 can be only slave
- Bypass: Bridge functionality, physical layer conversion. When the Serial Port 1 is configured as Master, Modbus commands of a HFC302 are sent via TCP/IP for IP Address, but whose ID is different from this HFC302, the command is retransmitted in the Serial Port 1 and the answer from this port will be retransmitted in the Ethernet.
- Depending on physical layer used, extra interfaces can be necessary:
    - EIA-485 :DF58 - interface of conversion EIA-232/EIA-485, whose layer physical has the multidrop feature and distance up to 1.3 Km
    - GPRS : G20 Modem – module used with Modlink software
    - Radio EIA-232/EIA-485, Ethernet radio, optic fiber
- The address of HFC302 in Modbus networks is configured in the MBCF block DEVICE_ADDRESS parameter. This identifier (ID) of the device is the same for the three ports (Serial 1, ETH1 and ETH2).
- It is possible to configure the swap of the registers by MBCF block, RTS_CTS parameter, and the same is applied all the ports (Serial 1, ETH1 and ETH2). This configuration applies to the Native mapping and MBSS block. Other scenarios of application using MBCS, MBCM and MBSM already have a way to select the swap for each variable through the data type.

  Exemplifying the functionality of the registers swap, the sequence of the bytes in the Modbus message:

	Floating point in IEEE754 format			
Floating point	**B1 (MSB)**	**B2**	**B3**	**B4 (LSB)**
101.325	0x42	0xCA	0xA6	0x66

If a Modbus variable with value 101.325 is mapped into holding registers 402.601 and 402.602:

RTS_CTS	False				True			
Register 402.601	B3		B4		B1		B2	
	0xA6		0x66		0x42		0xCA	
Register 402.602	B1		B2		B3		B4	
	0x42		0xCA		0xA6		0x66	
Modbus message	B3	B4	B1	B2	B1	B2	B3	B4
	0xA6	0x66	0x42	0xCA	0x42	0xCA	0xA6	0x66

- Types of standard commands supported as master and slave:

Function Code	Description
03	Range reading of Holding Registers (reading and writing variables)
04	Range reading of Input Registers (reading variables)
06	Writing in an only Holding Register
16	Range writing of Multiple Registers

- Native Mapping: Variables mapped in Modbus independently on configuration. All the parameters of all the blocks executed in HFC302 are mapped as Modbus variables in Input Register (reading only) or Holding Register (reading and writing). See the "Native Mapping" item for details.
- Configured Mapping: Through the configuration of the MBSS and MBCS Modbus blocks, some parameters of the Foundation Fieldbus transmitters blocks and of the HFC302 can be mapped (for an addresses sequence and like this to use the reading or written commands in registers range) as Holding Register.
- Address reserved for MBCS and MBSS blocks:

Block Type	Modbus Address
MBCS (16 instances)	400.001 – 400.632
MBSS (16 instances)	402.601 – 403.225

- The HFC302 supports some special commands used exclusively by HFCView to read reports, reading the configuration from HFC302 and more efficient monitoring.

Description of Supported Standard Commands

The following standard commands are supported as master and slave:

Read Holding Register

Read Holding Register – Request – Fixed Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8 x03	Function code: Read Holding Register = 0x03
2	Starting address	U16	Address Modbus of the register
4	Quantity of registers	U16	Registers quantity
5	CRC	U16	

Read Holding Register – Response – Variable Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8	Function code: Read Holding Register = 0x03
2	Byte count	U8	Bytes number from de next up to CRC, exclusive.
4	Holding register 1	U16	Register 1 value
6	Holding register 2	U16	Register 2 value
	….		
	CRC	U16	

Read Input Register

Read Input Register – Request – Fixed Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8 = x04	Function code: Read Input Register = 0x04
2	Starting address	U16	Address Modbus of the register
4	Quantity of registers	U16	Registers quantity
6	CRC	U16	

Read Input Register – Response – Variable Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8 = x04	Function code: Read Input Register = 0x04
2	Byte count	U8	Bytes number from de next up to CRC, exclusive.
3	Input register 1	U16	Value of input 1 register
5	Input register 2	U16	Value of input 2 register
	….		
	CRC	U16	

Write Single Register

Write Single Register – Request – Fixed Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8 = x06	Function code: Write Single Register = 0x06
2	Register Address	U16	Modbus address of the register to be written
4	Register value	U16	Value to be written in the register
6	CRC	U16	

Write Single Register – Response – Fixed Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8 = x06	Function code: Write Single Register = 0x06
2	Register Address	U16	Modbus address of the written register
4	Register value	U16	Value written in the register
6	CRC	U16	

Write Multiple Registers

Write Multiple Register – Request – Variable Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8 = x10	Function code: Write Multiple Register = 0x10
2	Starting Address	U16	Modbus address of the register to be written
4	Quantity of registers	U16	Registers quantity to be written
6	Byte count	U8	Bytes number from de next up to CRC, exclusive
7	Register value	U16	Value to be written in the register
	Register value	U16	Value to be written in the register
	…..		
	CRC	U16	

Write Multiple Register – Response – Fixed Size			
Offset	Field Name	Data Type	Description
0	Device ID	U8	HFC302 address in the Modbus network
1	Function code	U8 = x10	Function code: Write Single Register = 0x10
2	Starting Address	U16	Modbus address of the register to be written
4	Quantity of registers	U16	Registers quantity to be written
6	CRC	U16	

Native Mapping

Rules used for the parameters mapping of the HFC302 blocks to the Modbus address, independently of configuration:

- All the parameters of all the blocks are mapped in the addresses 3xx.xxx and 4xx.xxx, that is, Input Register address of 300.001 to 365.535 and Holding Register of 400.001 to 465.535.

- The Modbus address of an instance parameter of block type is the sum of Base Address with Offset, and both can be configured offline.
- The Base Address is determined through the following table, the block type and the number of instance sequence that is the sequence of the blocks in Syscon.
- The following table shows the Base Address for Input Register and Holding Register of each block type and corresponding block instance.

Block Type	Maximum number of instances	Used/ Reserved	Input register base(R)	Holding register base(R/W)
FCT	1	IR=26 / 30 HR=382 / 400	300.001	404.001
LKD	1	IR= 447 / 600 HR=771 / 900	300.031	404.401
GKD	1	IR=265 / 340 HR=1.386 / 1.500	300.631	405.301
GST	1	IR=206 / 240 HR=35 / 50	300.971	406.801
LST	1	IR=146 / 160 HR=35 / 40	301.211	406.851
LMF	1	IR= 983 / 1000 HR= 91 / 100	301.371	406.891
WT	1	IR= 1.878 / 2.100 HR= 58 / 80	302.371	406.991
RS	1	IR = 63 / 70 HR = 86 / 90	304.471	407.071
HC	1	IR = 20 / 30 HR = 68 / 80	304.541	407.161
PIP	1	IR=172 / 200 HR=68 / 80	304.571	407.241
TEMP	1	IR = 40 / 50 HR = 72 / 80	304.771	407.321
MBCF	1	IR = 2 / 10 HR = 72 / 90	304.821	407.401
TRDRED	1	IR = 60 / 70 HR = 10 /20	304.831	407.491
GT	4	IR=360 / 430 HR=126 / 140	304.901 305.331 305.761 306.191	407.511 407.651 407.791 407.931
LT	4	IR= 343 / 430 HR=85 / 140	304.901 305.331 305.761 306.191	407.511 407.651 407.791 407.931
SBC	6	IR= 166 / 180 HR= 200 / 220	306.621 306.801 306.981 307.161 307.341 (#253) 307.521 (#254)	408.071 408.291 408.511 408.731 408.951 409.171
GMH	4	IR = 618 / 630 HR = 9 / 20	307.701 308.331 308.961 309.591	409.391 409.411 409.431 409.451
GC	4	IR = 97 / 110 HR = 8 / 20	310.221 310.331 310.441 310.551	409.471 409.491 409.511 409.531
LCFE	4	IR = 56 / 70 HR = 32 / 50	310.661 310.731 310.801 310.871	409.551 409.601 409.651 409.701
AI	20	IR = 60 / 70 HR = 56 / 60	310.941	409.751

DI	24	IR = 32 / 40 HR = 26 / 30	312.341	410.951
AALM	20	IR = 62 / 70 HR = 74 /90	313.301	411.671
EPID	4	IR = 79 / 90 HR = 124 / 130	314.701	413.471
CT	4	IR = 16 / 20 HR = 43 / 50	315.061	413.991
ARTH	4	IR = 22 / 30 HR = 71 / 80	315.141	414.191
TIME	4	IR = 24 / 30 HR = 34 / 40	315.261	414.511
MBCS	16	IR = 16 / 20 HR = 128 / 130	315.381	414.671
MBSS	16	IR = 17 / 20 HR = 324 / 330	315.701	416.751
MBCM	16	IR = 17 / 20 HR = 168 / 170	316.021	422.031
MBSM	16	IR = 17 / 20 HR = 76 / 80	316.341	424.751
AO	4	IR = 31 / 40 HR = 53 / 60	316.661	426.031
MDO	2	IR = 17 / 20 HR = 35 / 40	316.821	426.271
DIAG	1	IR = 28 / 40 HR = 26 / 30	316.861	426.351

- The Offset is determined through parameters table of each block type.
- Example of native address: Measurement block of loop 2 (second measurement block from the list of Syscon blocks) is a LT block, parameter FIV_HOUR. In this case the Base Address is 304.891 and Offset is 3xx.105 and 3xx.106, therefore would be the 304.996 and 304.997 registers.
- If the register solicitation in commands of Read Holding Register or Read Input Register requires (exclusively or not) gap addresses or block non instanced, the HFC302 will answer with zero value for such registers. For example, a command of Input Register reading of 300.001 initial address and quantity 30. The registers 300.027 to 300.030 although be not associated to any parameter, this registers will have value zero attributed to it.

Combined View Modbus

The HFC302 supports Combined View Modbus, where can be master and slave simultaneously via Modbus TCP/IP independently of any configuration.

The selection between master and slave would just be applied to serial port that could be communicating simultaneously to Modbus TCP/IP in the ETH1 and ETH2 ports.
An application is showed below where:

- Serial 1, slave: communication with IHM local.
- ETH1, master: obtains the natural gas composition.
- ETH1, slave: data change with a PLC being master Modbus and supervision e reports reading by HFCView.

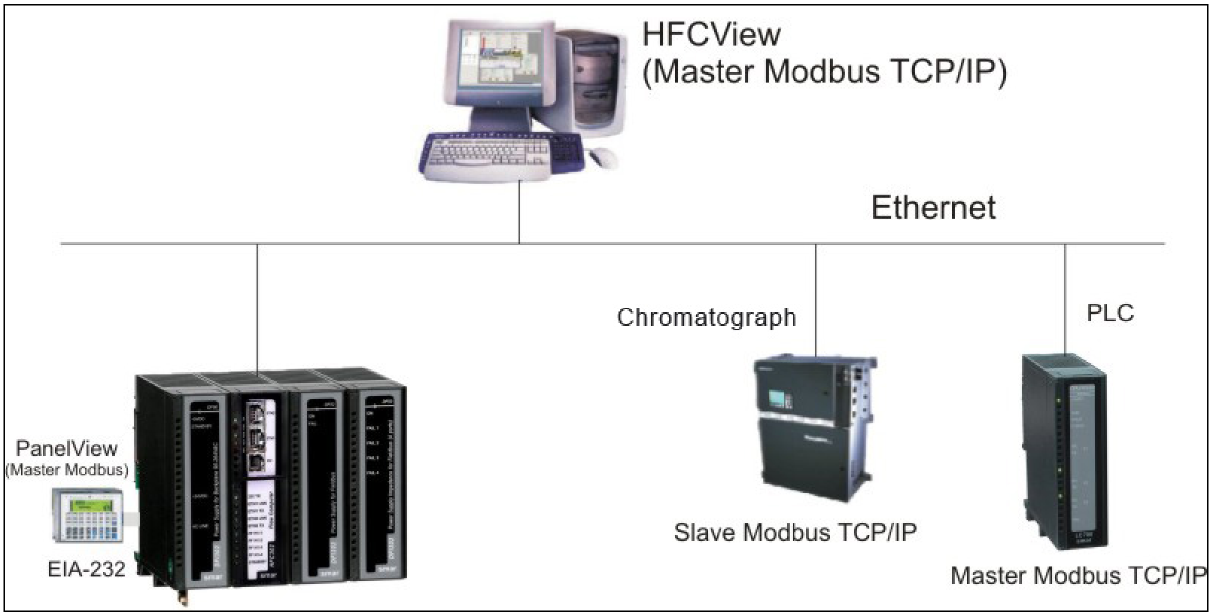


Figure 15.1 – Combined View Modbus

Where:
PanelView: it can be via a radio modem or G20 modem (GPRS)

Modbus Architecture

Two types of system architecture using the Modbus are presented below.

1. Concentrate system: local communication via Ethernet, Modbus TCP/IP and HSE OPCServer.

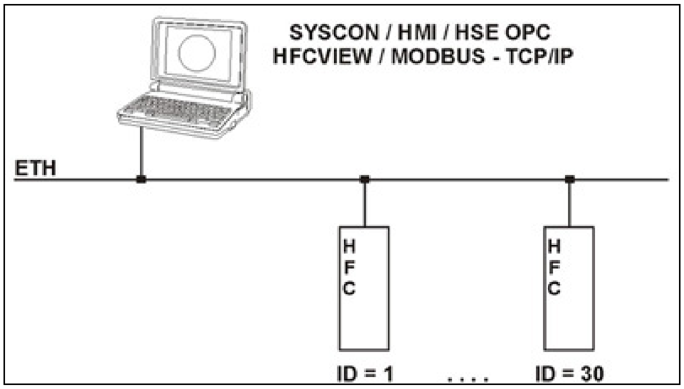


Figure 15.2 – Architecture with Ethernet Network

2. SCADA System: remote communication via radio/GPRS, Modbus.

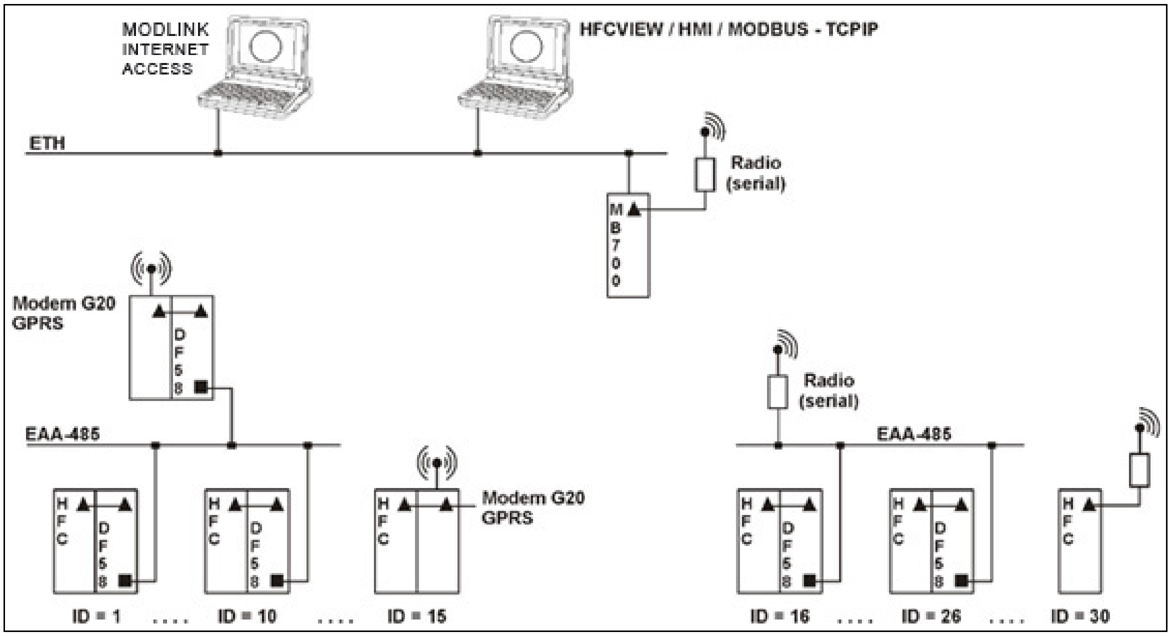


Figure 15.3 – Architecture with Wireless/GPRS Network

The Modbus master device in the central network access the HFC302's through following IP address.

ID of the HFC302	IP Address	Observations
1 to 15	From equipment that execute the Modlink	Modlink sets table of IP floating Address correlation of HFC302's in the GPRS network to ID's of each equipment. Fixation in the GPRS network happens for transferred Kbyte.
16 to 30	From MB700	

Modbus Blocks (MBSS, MBCS, MBSM, MBCM)

The Modbus blocks allow the integration of equipment with Modbus protocol to the AuditFlow System. Basically the functionalities are:

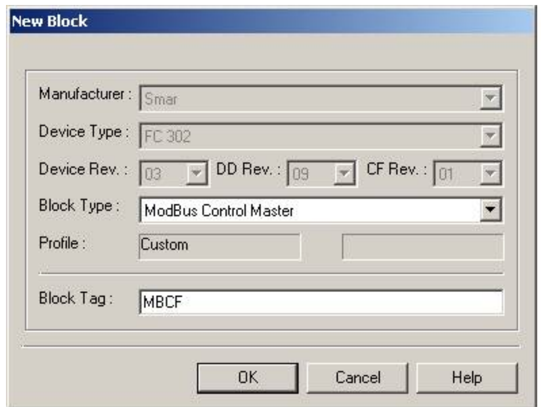
BLOCK	HFC302 FUNCTIONALITY	APPLICATION
MBSS	slave and data for supervision	- To create an address Modbus sequential of the variables used, resulting in a more efficient communication - To map blocks parameters of the FF transmitters in Modbus
MBCS	slave and data for control	
MBSM	master and data for supervision	- To map variables of equipment just Modbus in parameters of Modbus blocks (MBSM), using an only driver (HSE OPC Server) and cables for supervision.
MBCM	master and data for control	- Control data change between just equipment Modbus and HFC302, for example, the composition of the natural gas.

Configuring the Modbus

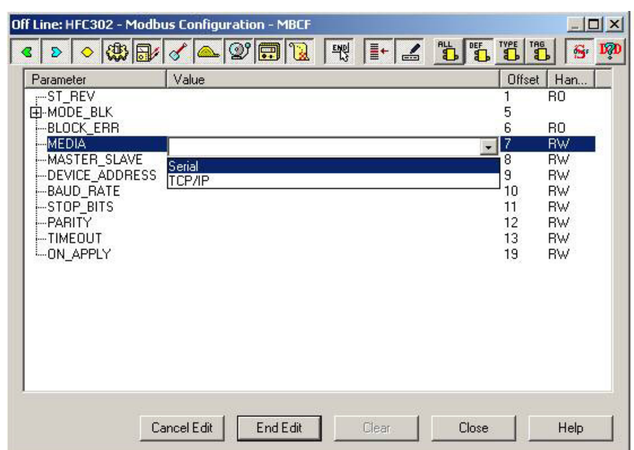
The HFC302 uses Syscon to configure all the necessary functions, including Modbus. Refer to the chapter "Adding Blocks" for further information on how to add Function Blocks to the Syscon configuration. Remember that MODBUS function blocks are available in different DD Revisions.

1) To include the Modbus functions in the HFC302, first of all, create a MBCF block (Modbus Configuration Block).

NOTE
Remember that, as for all Fieldbus devices, the Resource block must have been already created and configured as Auto.



2) Adjust the parameters according to the desired media, transmission rate, addresses, etc.

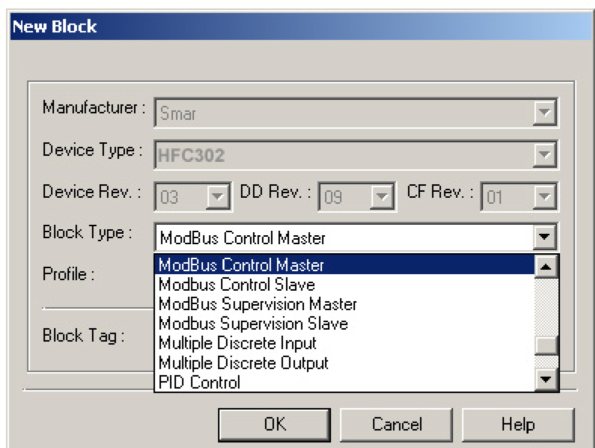


Parameter	Valid Range/ Options	Default Value	Description
ST_REV		0	
TAG_DESC		Spaces	
STRATEGY		0	
ALERT_KEY	1 to 255	0	
MODE_BLK		O/S	
BLOCK_ERR			
MEDIA	0:Serial, 1:TCP/IP	Serial	Define the Modbus channel type.
MASTER_SLAVE	0:Master, 1:Slave	Slave	Define if the HFC302 is master or slave.
DEVICE_ADDRESS	1-247	1	Define the HFC302 Modbus address (only for a HFC302 slave).
BAUD_RATE	0:110, 1:300, 2:600, 3:1200, 4:2400, 5:4800, 6:9600, 7:19200	19200	Define the transmission rate (only for serial channel).

Parameter	Valid Range/ Options	Default Value	Description
STOP_BITS	0:1, 1:2	1	Define the number of stop bits (only for serial channel).
PARITY	0:None, 1:Even, 2:Odd.	Even	Define the parity (only for serial media).
TIMEOUT	0-65535	1000	Waiting time for a slave response (for a HFC302 Master) or waiting time to update the outputs (for a HFC302 Slave). It is disable when the value is 0.
NUMBER_RETRANSMISSIONS	0-255	1	Number of re-transmission, if the HFC302 doesn't receive an answer from the slave.
SLAVE_ADDRESSES			IP Number and Modbus address of the slaves (only for a HFC302 Master in TCP/IP channel).
RESTART_MODBUS		FALSE	Parameter not used.
TIME_TO_RESTART	1-65535	1	Time to restart the communication with the slave.
RTS_CTS		FALSE	Enable or disable handshaking.
ON_APPLY	0:None, 1:Apply	None	Apply the changes from the Modbus blocks.
UPDATE_EVT			This alert is generated by any changes to the static data.
BLOCK_ALM			The block alarm is used for configuration fails, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute.

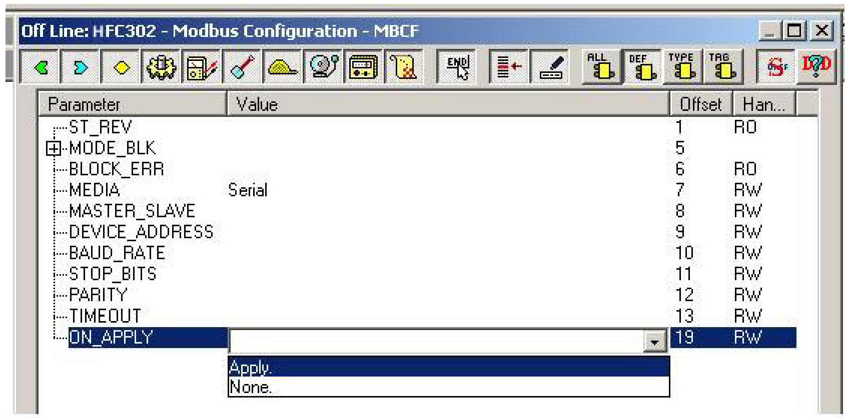
When using the RS-232, install the DF58 module (RS232/RS485 Interface Module) if it is necessary to communicate with more than one Modbus instrument, that is, in a Multipoint Network. Refer to chapter “Adding Interfaces”.

3) Now, create the necessary blocks. The blocks available are MBSS (Modbus Supervision Slave), MBSM (Modbus Supervision Master), MBCS (Modbus Control Slave), MBCM (Modbus Control Master).



To create these blocks, adjust the MODE_BLK.TARGET parameter to AUTO.

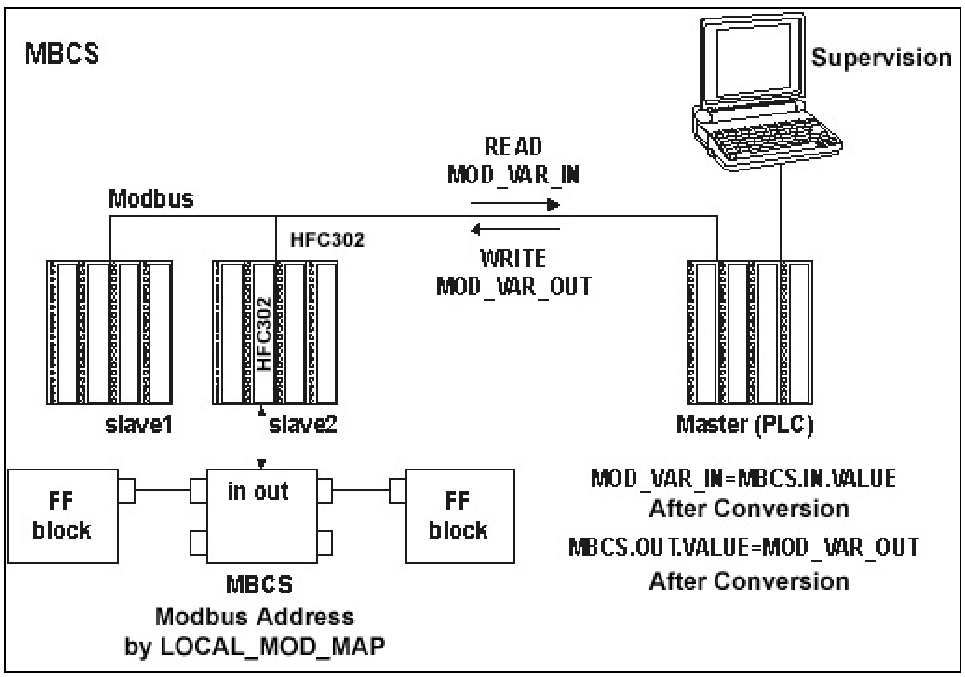
IMPORTANT
After downloading the configuration to the HFC302, all Modbus blocks will set the MODE_BLK.ACTUAL parameter at Out of Service. This protection allows the user to create all the necessary blocks, adjusting the parameters even in the online mode. Only at the end of the configuration process the user changes all blocks to AUTO simultaneously, configuring the parameter ON_APPLY of the MBCF block. Other important parameter that should be defined for all blocks is LOCAL_MOD_MAP (0 ~ 15). Sixteen blocks are accepted for functionality and this variable identifies each function. For MBSS and MBCS blocks, the LOCAL_MOD_MAP parameter specifies the Modbus Slave address. A value 255 (default) does not permit the block runs.



The following views (1 to 4) summarize some of the applications that can be implemented using the HFC302 Modbus Functions.

View 1 - MBCS

A Modbus Master Instrument wants to read and/or write to the Modbus registers of the HFC302, mapped as Input and Output parameters in the Fieldbus network. Using Syscon, create a MBCF block and 1 to 16 MBCS blocks. In the Strategy window, link these blocks with FF blocks.



When creating these parameters, define the LOCAL_MOD_MAP (0 ~ 15) parameter, and the Input and Output parameters will indicate the Modbus pre-defined addresses. Refer to the sub-section LOCAL_MOD_MAP for further information.

Parameter Description

Refer to the FOUNDATION Fieldbus Function Blocks Manual for details.

Parameter	Valid Range/ Options	Default Value	Description
ST_REV		0	
TAG_DESC		Spaces	
STRATEGY		0	
ALERT_KEY	1 to 255	0	
MODE_BLK		O/S	Refer to the Mode Parameter.
BLOCK_ERR			
LOCAL_MOD_MAP	0 to 15	0	Define the Modbus Addresses.
IN1			Analog Input 1.
SCALE_CONV_IN1			Information to generate the constants A and B in the equation Y=A*X+B.
IN2			Analog Input 2.
SCALE_CONV_IN2			Information to generate the constants A and B in the equation Y=A*X+B.
IN3			Analog Input 3.
SCALE_CONV_IN3			Information to generate the constants A and B in the equation Y=A*X+B.
IN4			Analog Input 4.
SCALE_CONV_IN4			Information to generate the constants A and B in the equation Y=A*X+B.
IN_D1			Discrete Input 1.
IN_D2			Discrete Input 2.
IN_D3			Discrete Input 3.
IN_D4			Discrete Input 4.
OUT1			Analog Output 1.
SCALE_CONV_OUT1			Information to generate the constants A and B in the equation Y=A*X+B and the output status.
OUT2			Analog Output 2.
SCALE_CONV_OUT2			Information to generate the constants A and B in the equation Y=A*X+B and the output status.
OUT3			Analog Output 3.
SCALE_CONV_OUT3			Information to generate the constants A and B in the equation Y=A*X+B and the output status.
OUT4			Analog Output 4.
SCALE_CONV_OUT4			Information to generate the constants A and B in the equation Y=A*X+B and the output status.
OUT_D1			Discrete Output 1.
STATUS_OUT_D1			Status of OUT_D1 if the Master is not updated.
OUT_D2			Discrete Output 2.
STATUS_OUT_D2			Status of OUT_D2 if the Master is not updated.
OUT_D3			Discrete Output 3.
STATUS_OUT_D3			Status of OUT_D3 if the Master is not updated.
OUT_D4			Discrete Output 4.
STATUS_OUT_D4			Status of OUT_D4 if the Master is not updated.
UPDATE_EVT			This alert is generated by any changes to the static data.
BLOCK_ALM			The block alarm is used for configuration fails, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute.

NOTE
The STATUS_OUT_Dx and STATUS_OUTPUT members, used in the output parameters, define the following rules for the OUTPUT STATUS parameters: - Once the user defines this member as "Set by master", the output status will behave exactly as Fieldbus protocol works. In other words, the status will reflects the value, which the master is writing, but if after the TIMEOUT (defined in MBCF block) the status is not be updated, this status will be forced to BAD COMMUNICATION. - Once the user defines this member with anything different from "Set by master", this value will be reflected in output status, while communication is good. Otherwise, status goes to BAD COMMUNICATION.

Inputs and Outputs
This block has 4 digital inputs, 4 analog inputs, 4 digital outputs and 4 analog outputs that can be connected to other FIELDBUS or MODBUS function blocks.

- IN1, IN2, IN3 and IN4 are analog inputs;
- IN_D1, IN_D2, IN_D3 and IN_D4 are digital inputs;
- OUT1, OUT2, OUT3 and OUT4 are analog outputs;
- OUT_D1, OUT_D2, OUT_D3 and OUT_D4 are digital outputs.

The digital outputs and inputs are DS-66, containing value and status (both Unsigned 8). The analog outputs and inputs are DS-65 and also contain status and value, in FLOAT type.

Scale Conversion Parameters
Each analog input and output has an extra parameter that should be adjusted using the SCALE_CONV_INn and SCALE_CONV_OUTn parameters, so the MBCS block executes properly. These parameters are represented by the data structures DS-256 and DS-257.

The DS-256 data structure has 5 elements to be configured:
- From EU 100%
- From EU 0%
- To EU 100%
- To EU 0%
- Data Type

The DS-257 data structure has 6 elements to be configured:
- From EU 100%
- From EU 0%
- To EU 100%
- To EU 0%
- Tipo do Dado
- Output Status

Data Type
It is necessary to configure the Data Type because MODBUS variables have different formats. This parameter indicates only the number that refers to a specific format.

Data Type Number	Data Type Format
1	Float
2	Unsigned 8
3	Unsigned 16
4	Unsigned 32
5	Integer8
6	Integer16
7	Integer32
8	Swapped Float
9	Swapped Unsigned 8
10	Swapped Unsigned 16
11	Swapped Unsigned 32
12	Swapped Integer 8
13	Swapped Integer 16
14	Swapped Integer 32

The swapped data types were created in order to support the communication between Modbus devices. Normally, it has the following options:

4 Bytes (2 Registers – Word)
Normal *Datatype*: Inside Register – Motorola
Between Registers – Intel
Swapped Datatype: Inside Register – Motorola
Between Registers – Motorola

2 Bytes
Swapped Datatype: *Status* information is in the most significant byte (MSB).

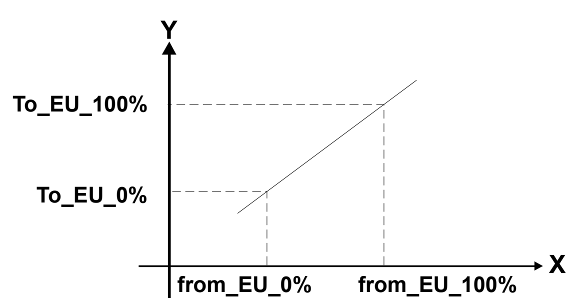
1 Byte
Swapped Data type: Value (MSB) and *Status* (LSB – less significant byte) are in the same register.

In case of the Swapped Integer 16 data type no change is done.

Procedure to convert FF parameter to MODBUS variable:

Load IINn_ VALUE.
Calculate Y = A * Inn_VALUE + B.
Convert Y to DATA_TYPE_IN, generating MOD_VAR_IN.
Save MOD_VAR_IN.

Procedure to convert MODBUS variable to FF parameter:
Load MOD_VAR_OUT.
Convert MOD_VAR_OUT to float, generating Y.
Calculate OUTn_VALUE = (A*Y + B).
Save OUTn_VALUE.



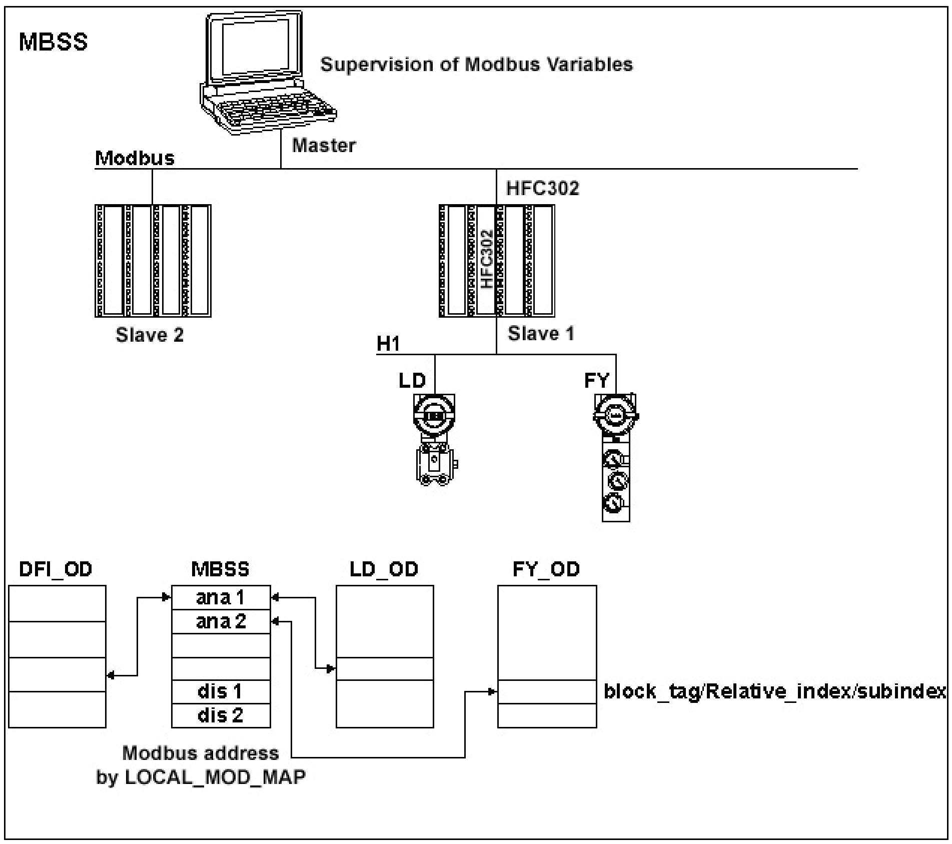
A= (TO_EU_100% - TO_EU_0%) / (FROM_EU_100% - FROM_EU_0%)
B = TO_EU_0% - A* FROM_EU_0%

Inn_VALUE, OUTx_VALUE: FF parameter.
MOD_VAR_IN, MOD_VAR_OUT: MODBUS variable.
Y: auxiliary float variable

Output Status
If the outputs are not updated by the Modbus Master during the period of time specified by the user (parameter TIMEOUT in MBCF), a "BAD STATUS" will be generated. If TIMEOUT < Macrocycle, TIMEOUT = Macrocycle.

View 2 – MBSS

A Modbus Master Instrument wants to read and/or write to the Modbus registers of the HFC302, mapped as any parameter in the Fieldbus network. Using Syscon, create a MBCF block and 1 to 16 MBSS blocks. In the characterization window, configure these blocks setting the parameters TAG, Relative Index and Sub-Index with the value of the parameters in the FF blocks.



To adjust these parameters, define the LOCAL_MOD_MAP (0 ~ 15) parameter, and the Input and Output parameters will indicate the Modbus pre-defined addresses. Refer to the sub-section LOCAL_MOD_MAP for further information.

Parameter Description

Refer to the FOUNDATION Fieldbus Function Blocks Manual for details

Parameter	Valid Range/ Options	Default Value	Description
ST_REV		0	
TAG_DESC		Spaces	
STRATEGY		0	
ALERT_KEY	1to 255	0	
MODE_BLK		O/S	Refer to the Mode Parameter.
BLOCK_ERR			
LOCAL_MOD_MAP	0 to 15	0	Define the modbus addresses.
F_ID1			Information to locate the float parameter.
FVALUE1		0	Value of the requested float parameter.
F_ID2			Information to locate the float parameter.
FVALUE2		0	Value of the requested float parameter.
F_ID3			Information to locate the float parameter.
FVALUE3		0	Value of the requested float parameter.
F_ID4			Information to locate the float parameter.
FVALUE4		0	Value of the requested float parameter.
F_ID5			Information to locate the float parameter.
FVALUE5		0	Value of the requested float parameter.
F_ID6			Information to locate the float parameter.
FVALUE6		0	Value of the requested float parameter.
F_ID7			Information to locate the float parameter.
FVALUE7		0	Value of the requested float parameter.
F_ID8			Information to locate the float parameter.
FVALUE8		0	Value of the requested float parameter.
I_ID1			Information to locate the integer parameter.
IVALUE1		0	Value of the requested integer parameter.
I_ID2			Information to locate the integer parameter.
IVALUE2		0	Value of the requested integer parameter.
I_ID3			Information to locate the integer parameter.
IVALUE3		0	Value of the requested integer parameter.
I_ID4			Information to locate the integer parameter.
IVALUE4		0	Value of the requested integer parameter.
B_ID1			Information to locate the Boolean parameter.
BVALUE1		TRUE	Value of the requested Boolean parameter.
B_ID2			Information to locate the Boolean parameter.
BVALUE2		TRUE	Value of the requested Boolean parameter.
B_ID3			Information to locate the Boolean parameter.
BVALUE3		TRUE	Value of the requested Boolean parameter.
B_ID4			Information to locate the Boolean parameter.
BVALUE4		TRUE	Value of the requested Boolean parameter.
UPDATE_EVT			This alert is generated by any changes to the static data.
BLOCK_ALM			The block alarm is used for configuration fails, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute.
BAD_STATUS			This parameter indicates whether the status of the correspondent value is bad or no.

NOTE
Every time a MODBUS parameter changes, it is necessary to set the ON_APPLY parameter of the MBCF block at “Apply”. Otherwise, these alterations will not be applied.

I_IDn, F_IDn, B_Idn Parameters

The I_IDn parameters are "integer" variables; F_IDn are "float" variables and B_IDn are "boolean" variables.

These parameters are DS-262. This data type has 3 elements.

- **Block Tag:** Indicates the Tag of the block that contains the variable to be displayed. For example, if the user needs to monitor the gain of the PID block, include the Tag of the PID block containing the "gain" parameter to be displayed in the MODBUS master.

- **Relative Index:** Every parameter of a function block has this index. The relative index is indicated in the first column of all parameter tables for function blocks. Include the number of the relative index in the parameter to be monitored. In the example above, the relative index to monitor the gain parameter of the PID functions 23.

- **Sub index:** The sub index is used for parameters that have a structure. In this case, it is necessary to indicate which element of the structure is being referred.

BVALUEx and IVALUEx Parameters

The BVALUEx parameters can address the FF parameters for the following data types: boolean, integer8 and unsigned8. These data type are automatically converted to bit (0 or1), and vice versa, for MODBUS supervision and, also, they can be converted to a boolean parameter (BVALUEx).

The IVALUEx parameters can address FF parameters for the following data types: Integer8, Integer16, Integer 32, Unsigned 8, Unsigned 16 and Unsigned 32.

Each analog parameter (IVALUEx) is mapped as two MODBUS analog registers, that is, four bytes. When addressing a FF parameter with one or two bytes, this parameter will change to Unsigned 32 or Integer 32.

If the Relative Index is 5 (MODE_BLK) and the Sub Index is "zero", a writing will be execute in Sub Index 1 and a reading in Sub Index 2.

BAD_STATUS Parameter

This parameter indicates if the communication with Master device is working properly. If the correspondent bit is in logic level 1 means that an error occurred during writing/reading in this respective parameter. The table below shows the values for this status parameter. If the communication with the specific parameter is good, there is no indication in BAD_STATUS. However, if the communication is bad, BAD_STATUS will indicate which parameter failed in the communication.

Relation between the bits in BAD_STATUS and Modbus addresses

BIT	VARIABLE
0	FVALUE1
1	FVALUE2
2	FVALUE3
3	FVALUE4
4	FVALUE5
5	FVALUE6
6	FVALUE7
7	FVALUE8
8	IVALUE1
9	IVALUE2
10	IVALUE3
11	IVALUE4
12	BVALUE1
13	BVALUE2
14	BVALUE3
15	BVALUE4

NOTE
Each bit corresponds to an OR function between the Value and Status, indicating if the communication with Master is good or bad.

Data Type and supported structures by MBSS
The Modbus supervision blocks (MBSS) used in the controllers configured as slave, have some restrictions about data types and structures that they support when supervising the block parameters tags. In such case, the next table shows the data types and structures which can be monitored by the MBSS block.

DATA TYPE *
Booleano
Float
Unsigned 8
Unsigned 16
Unsigned 32
Integer8
Integer16
Integer32

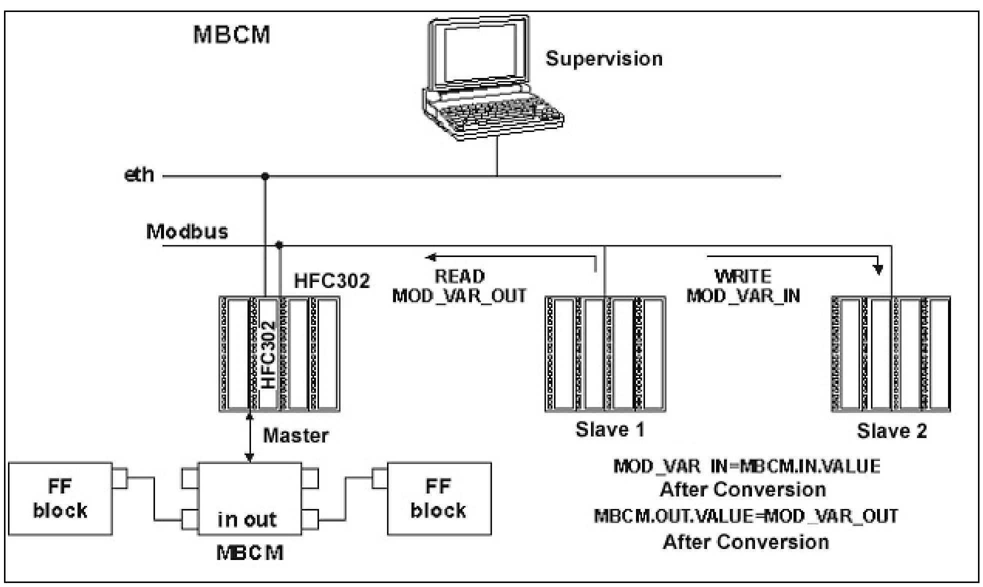
STRUCTURE TYPES
DS-65
DS-66
DS-68
DS-69
DS-71
DS-72
DS-74
DS-159 (DC302)
DS-160 (DC302)

*For the HFC302 controller the data types Swapped Float and Swapped Integer can be obtained by setting the RTS_CTS parameter to TRUE value in the MBSS block.

For further information about the blocks parameters and their data and structures types, as mentioned in the previous table, please see the Function blocks manual and in the DataType field of each table presented in the manual.

View 3 – MBCM

A Modbus Slave Instrument needs to sent and/or receive Modbus registers from the HFC302, mapped as Input and Output parameters in the Fieldbus network. Using Syscon, create a MBCF block and 1 to 16 MBCM blocks. In the Strategy window, link these blocks to FF blocks. This application is also useful for display instruments installed in the plant.



Adjust the option Master in the MASTER_SLAVE parameter, below the MBCF block. Define the LOCAL_MOD_MAP (0 ~ 15) parameter.

Parameters Description
Refer to the FOUNDATION Fieldbus Function Blocks Manual for details.

Parameter	Valid Range/ Options	Default Value	Description
ST_REV		0	
TAG_DESC		Spaces	
STRATEGY		0	
ALERT_KEY	1to 255	0	
MODE_BLK		O/S	Refer to the Mode Parameter.
BLOCK_ERR			
BAD_STATUS		0	Indicate whether the communication with the slave is good or not (each bit corresponds to a Modbus variable).
IN1			Analog Input 1.
SCALE_LOC_IN1			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
IN2			Analog Input 2.
SCALE_ LOC_IN2			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
IN3			Analog Input 3.
SCALE_ LOC_IN3			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
IN4			Analog Input 4.
SCALE_ LOC_IN4			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
IN_D1			Discrete Input 1.
LOCATOR_IN_D1			Addresses in a slave instrument.
IN_D2			Discrete Input 2.
LOCATOR_IN_D2			Addresses in a slave instrument.
IN_D3			Discrete Input 3.
LOCATOR_IN_D3			Addresses in a slave instrument.
IN_D4			Discrete Input 4.
LOCATOR_IN_D4			Addresses in a slave instrument.
OUT1			Analog Output 1.
SCALE_ LOC_OUT1			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
OUT2			Analog Output 2.
SCALE_ LOC_OUT2			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
OUT3			Analog Output 3.
SCALE_ LOC_OUT3			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
OUT4			Analog Output 4.
SCALE_ LOC_OUT4			Information to generate the constants A and B in the equation Y=A*X+B plus the addresses in the slave device.
OUT_D1			Discrete Output 1.
LOCATOR_OUT_D1			Addresses in a slave instrument.
OUT2_D2			Discrete Output 2.
LOCATOR_OUT_D2			Addresses in a slave instrument.
OUT_D3			Discrete Output 3.
LOCATOR_OUT_D3			Addresses in a slave instrument.
OUT_D4			Discrete Output 4.
LOCATOR_OUT_D4			Addresses in a slave instrument.
UPDATE_EVT			This alert is generated by any changes to the static data.
BLOCK_ALM			The block alarm is used for configuration fails, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute.

IMPORTANT
Every time a MODBUS parameter is changed, it is necessary to set the ON_APPLY parameter of the MBCF block to “Apply”. Otherwise, these changes won't take effect.

NOTE
The MODBUS_ADDRESS_OF_STATUS members define the following rules for the OUTPUT STATUS parameters: - When the user defines this member with a value different from Zero, the output status will behave as an output protocol, that is, the status will reflect the value read by the master, but if the status is not updated after the TIMEOUT (defined in the MBCF block), it will be set as BAD COMMUNICATION; - When the user defines this member with value equals to Zero, the output status will automatically display GOOD and accept the Syscon characterization (such as GOOD CASCADE, etc). But, if the communication with the Modbus Device is not Ok after the TIMEOUT (defined in the MBCF block), the status will be forced to BAD COMMUNICATION.

LOCAL_MOD_MAP Parameter
All MBCM blocks added to the strategy must have different values in the LOCAL_MOD_MAP parameter. Otherwise, the block will not operate properly.

Inputs and Outputs
This block has 4 digital inputs and outputs and 4 analog inputs and outputs. These inputs and outputs can be connected to other FIELDBUS function blocks, connecting to MODBUS I/O modules or registers.

INn: Analog input. DS-65 Data type (Value and Status). In this parameter, the value of the parameter configured for this input and its status will be displayed.

IN_Dn: Digital input. DS-66 Data type (Value and Status). In this parameter, the value of the parameter configured for this input and its status will be displayed.

OUTn: Analog output. DS-65 Data type (Value and Status). In this parameter, the value of the parameter configured for this output and its status will be displayed.

OUT_Dn: Digital output. DS-66 Data type (Value and Status). In this parameter, the value of the parameter configured for this output and its status will be displayed.

SCALE_LOC_INn and SCALE_LOC_OUTn
These parameters are DS-259 data type. They convert the value to Engineering Units and address the variable in the MODBUS network. The INn and OUTn inputs and outputs are associated to the SCALE_LOC_INn and SCALE_LOC_OUTn parameters. It is necessary to configure these parameters to monitor and change data correctly.

Each parameter consists of the following elements:

- From Eu 100 %
- From Eu 0 %
- To Eu 100 %
- To Eu 0 %

To configure these elements:

Data Type: It is necessary to inform the data type of the variable. This parameter only displays the number that refers to a specific format.

Data Type Number	Data Type Format
1	Float
2	Unsigned 8
3	Unsigned 16
4	Unsigned 32
5	Integer8
6	Integer16
7	Integer32
8	Swapped Float
9	Swapped Unsigned 8
10	Swapped Unsigned 16
11	Swapped Unsigned 32
12	Swapped Integer 8
13	Swapped Integer 16
14	Swapped Integer 32

The swapped data types were created in order to support the communication between Modbus devices. Normally we have the following cases:

4 Bytes (2 Registers – Word)
Normal *Datatype*: Inside Register – Motorola
Between Registers – Intel
Swapped Datatype: Inside Register – Motorola
Between Registers – Motorola

2 Bytes
Swapped Datatype: Status information is in the Most Significant Byte (MSB)

1 Byte
Swapped Data type: Value (MSB) and Status (LSB – Less Significant Byte) are in the same register.

In case of the Swapped Integer 16 data type no change is done.

Slave Address: Indicate the address of the slave required in the IN input. For example, suppose a LC700 has the Device Address equals to 3 and it is necessary to connect one of its inputs or outputs. The Slave Address should be equal to 3.

MODBUS Address of Value: Indicate the MODBUS address of the variable being referenced as the input or output. In the example of the previous element, suppose the MODBUS address is 40032. Therefore, this element should have the same address.

MODBUS Address of Status: In this parameter, the user indicates the Modbus address where the status will be read or written. Each input or output has a corresponding status. The interpretation of the status follows the FOUNDATION Fieldbus Standard.

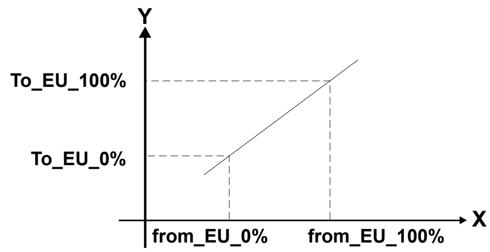
The inputs and outputs are supervised as described in the table below:

Input/Output	Configured Status (Modbus_Address_Of_Status ≠ 0)	Non-Configured Status (Modbus_Address_Of_Status = 0)
Input (IN_n, IN_Dn)	The block sends to the device the status corresponding to the input of the Modbus slave (the status follows the FF standard format).	No status information is sent to the slave device.
Output (OUT_n, OUT_Dn)	The block reads the corresponding status from the slave device. (The block assumes that the Modbus variable follows the format of the FF Status.).	- The block updates the status to "Good Non Cascade" when the communication with the Modbus slave device is ok. - The block updates the status to "Bad No Communication with last value" when the communication with the Modbus slave device is not ok.

Float values use two MODBUS registers, but it is necessary to inform only the first one.

Procedure to convert FF parameter to MODBUS variable:
Load INx_VALUE
Calculate Y = (A * Inx_VALUE + B)
Convert Y to DATA_TYPE_IN, generating MOD_VAR_IN
Write MOD_VAR_IN

Procedure to convert MODBUS variable to FF parameter:
Read MOD_VAR_OUT
Convert MOD_VAR_OUT to float, generating Y
Calculate OUTx_VALUE = (A * Y + B)
Save OUTx_VALUE
A = (TO_EU_100% - TO_EU_0%) / (FROM_EU_100% - FROM_EU_O%)
B = TO_EU_0% - A * FROM_EU_0%;



IN_VALUE, OUT_VALUE: FF parameters
MOD_VAR_IN, MOD_VAR_OUT: MODBUS variables
Y = auxiliary float variable

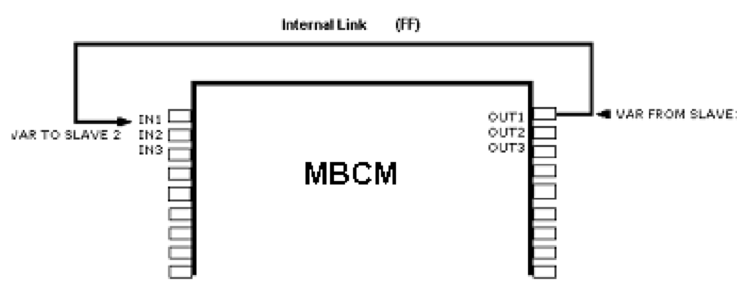
Setting the inputs and outputs of the MBCM block
To read a MODBUS variable, connect the variable to an output of the MBCM function block. To write to a MODBUS register, connect the register to an input of the MBCM block.

Usually, MODBUS addresses are:

00001 to 9999 – Digital Outputs
10001 to 19999 – Digital Inputs
30001 to 39999 – Analog Inputs
40001 to 49999 – Analog Outputs

Once the variables that need to be mapped are defined and referenced in the MBCM block, the user can configure the strategy.

Connect the variables to other Fieldbus blocks (connect the block input or output to other blocks in the strategy) to write to the MODBUS registers (connect the MBCM block input to the MODBUS register). To exchange data between the slaves, configure the MBCM block input with the slave address, specify the MODBUS address where the value will be written, configure the MBCM block output with the slave address and the MODBUS variable where the value will be read. See the application below:



BAD_STATUS Parameter
This parameter indicates if the communication between the slaves was established properly. If the corresponding bit is at logic level 1, it indicates that there was an error during the reading/writing of the respective parameter. The table below shows the values for these status. If the communication with the specific parameter is good, there won't be any indication in BAD_STATUS. However, if the communication is bad, the BAD_STATUS parameter will indicate which parameter failed in the communication.

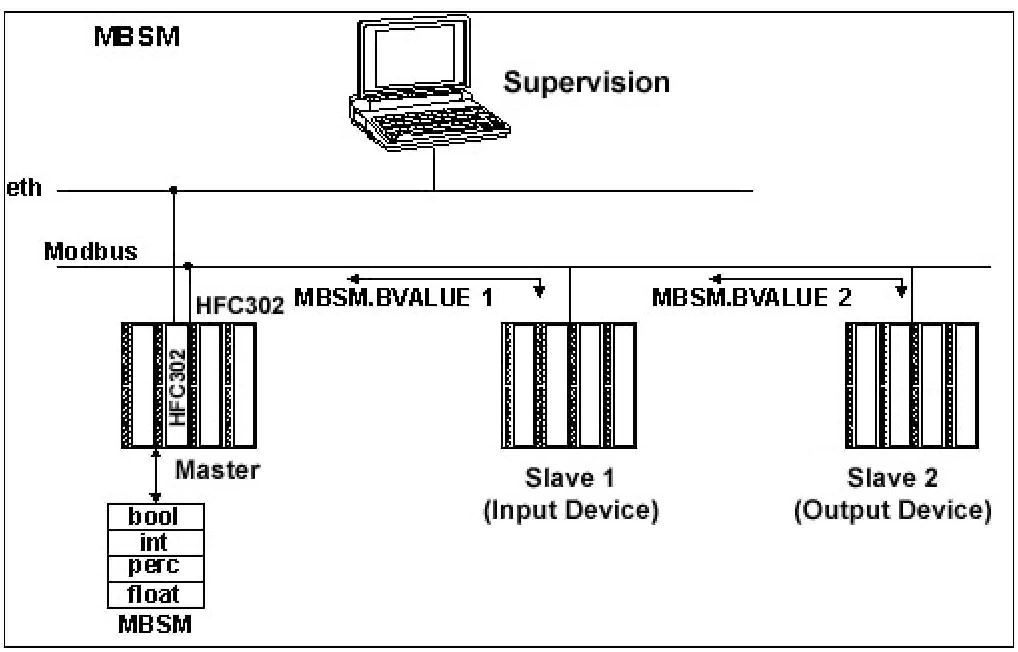
Relation between bits in BAD_STATUS and MODBUS addresses.

Bit	Variable
0	IN1
1	IN2
2	IN3
3	IN4
4	IN_D1
5	IN_D2
6	IN_D3
7	IN_D4
8	OUT1
9	OUT2
10	OUT3
11	OUT4
12	OUT_D1
13	OUT_D2
14	OUT_D3
15	OUT_D4

NOTE
Each bit corresponds to an OR between the value and the status, indicating whether the communication with the slave is good or bad. If only the value is used, the status is considered zero. If only the status is used, the value is considered zero.

View 4 – MBSM

A Supervisory System connected to the HFC302, via OPC Server, needs to read and/or write some parameters, mapped as Modbus registers. Using Syscon, create a MBCF block and 1 to 16 MBSM blocks. In the Characterization window, configure these blocks setting the parameters with the Slave Address and Parameter Address.



Adjust the option Master in the MASTER_SLAVE parameter below the MBCF block. Define the LOCAL_MOD_MAP (0 ~ 15) parameter.

Parameters Description
Refer to the FOUNDATION Fieldbus Function Blocks Manual for details.

Parameter	Valid Range/ Options	Default Value	Description
ST_REV		0	
TAG_DESC		Spaces	
STRATEGY		0	
ALERT_KEY	1 to 255	0	
MODE_BLK		O/S	Refer to the Mode Parameter.
BLOCK_ERR			
LOC_MOD_MAP			
BAD_STATUS		0	Indicate whether the communication with the slave is good or not (each bit corresponds to a Modbus variable).
FLOCATOR1			Information to locate the float parameter.
FVALUE1		0	Value of the requested address.
			Information to locate the float parameter.
FVALUE2		0	Value of the requested address.
PLOCATOR1			Information to locate the percentage parameter.
PVALUE1		0	Value of the requested address.
PLOCATOR2			Information to locate the percentage parameter.
PVALUE2		0	Value of the requested address.
ILOCATOR1			Information to locate the integer parameter.
ILENGTH1	1,2,4	2	Data length.
IVALUE1		0	Value of the requested address.
ILOCATOR2			Information to locate the integer parameter.
ILENGTH2	1,2,4	2	Data length.
IVALUE2		0	Value of the requested address.
BLOCATOR1			Information to locate the boolean parameter.
BVALUE1		TRUE	Value of the requested address.
BLOCATOR2			Information to locate the boolean parameter.
BVALUE2		TRUE	Value of the requested address.
BLOCATOR3			Information to locate the boolean parameter.
BVALUE3		TRUE	Value of the requested address.
BLOCATOR4			Information to locate the boolean parameter.
BVALUE4		TRUE	
BLOCATOR5			Information to locate the boolean parameter.
BVALUE5		TRUE	Value of the requested address.
BLOCATOR6			Information to locate the boolean parameter.
BVALUE6		TRUE	Value of the requested address.
BLOCATOR7			Information to locate the boolean parameter.
BVALUE7		TRUE	Value of the requested address.
BLOCATOR8			Information to locate the boolean parameter.
BVALUE8		TRUE	Value of the requested address.
UPDATE_EVT			This alert is generated by any changes to the static data.
BLOCK_ALM			The block alarm is used for configuration fails, hardware and connection failures or system problems. The cause of the alert is displayed in the subcode field. The first alert that becomes active will set the Active status in the Status attribute.

LOCAL_MODE_MAP
All MBSM blocks added to you're the strategy should have different values in the LOCAL_MODE_MAP parameter. Otherwise, the block will not operate properly.

FVALUEn, PVALUEn, IVALUEn and BVALUEn Parameters
These parameters are selected when needed. If the variable being monitored is "FLOAT", a FVALUE parameter will be necessary. If the variable is in percentage, the PVALUE parameter will be used. The IVALUE parameter refers to "Integer" values and BVALUE parameter refers to boolean values.

For each one of these parameters, there are other parameters associated to address them in the MODBUS network, and the MBSM blocks will know the location.

FLOCATORn Parameter
This parameter refers to the FVALUE parameter. This parameter is a DS-260 data type, so it is necessary to configure two elements:

Slave Address: Type the slave address where the variable being monitored is located. For example, if a LC700 has the Device Address equals to 1, the Slave Address should be equal to 1.

MODBUS Address of Value: Type the MODBUS address of the variable being monitored in the MBSM block. Suppose the user will monitor the variable in the MODBUS address 40001, located in the slave I/O module with the Device Address equals to 1. The MODBUS Address of Value must be equal to 1.

The FVALUEn parameters will display the values of the variables configured in FLOCATORn. FLOAT values use two MODBUS registers, but it is necessary to inform only the first one.

MODBUS Addresses

00001 to 9999 – Digital Outputs
10001 to 19999 – Digital Inputs
30001 to 39999 – Analog Inputs
40001 to 49999 – Analog Outputs

PLOCATORn Parameter
This is a DS-258 data type parameter and refers to PVALUEn parameters. They convert the values to Engineering Units and address the variable in the MODBUS network.

It is necessary to configure these parameters to monitor that data properly. Each parameter consists of the following elements:

- From Eu 100 %
- From Eu 0 %
- To Eu 100 %
- To Eu 0 %
- Data Type

To configure these parameters:

Data type: It is necessary to inform the data type of the variable. This parameter only displays the number that refers to a specific format.

Data Type Number	Data Type Format
1	Float
2	Unsigned 8
3	Unsigned 16
4	Unsigned 32
5	Integer8
6	Integer16
7	Integer32
8	Swapped Float
9	Swapped Unsigned 8

Data Type Number	Data Type Format
10	Swapped Unsigned 16
11	Swapped Unsigned 32
12	Swapped Integer 8
13	Swapped Integer 16
14	Swapped Integer 32

The swapped data types were created in order to support the communication between Modbus devices. Normally, there are the following cases:

4 Bytes (2 Registers – Word)
Normal *Datatype*: Inside Register – Motorola
Between Registers – Intel
Swapped Datatype: Inside Register – Motorola
Between Registers – Motorola

2 Bytes
Swapped Datatype: Status information is in the Most Significant Byte (MSB)

1 Byte
Swapped Data type: Value (MSB) and Status (LSB – Less Significant Byte) are in the same register.

In case of the Swapped Integer 16 data type no change is done.

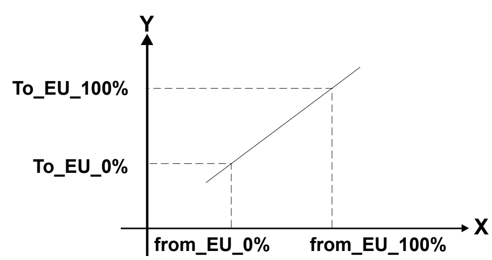
Slave Address: Indicate the slave address to the PVALUEn parameter. For example, suppose a LC700 has the Device Address equals to 3 and it is necessary to monitor a specific variable. The Slave Address should be equal to 3.

MODBUS Address of Value: Indicate the MODBUS address of the variable being monitored. In the example of the element above, suppose the MODBUS address is 40032. Therefore, this element should have the same address.

Procedure to convert FF parameter to MODBUS variable:
Load VALUEn
Calculate y = (A*VALUEn + B)
Convert Y to DATA_TYPE_IN, generating MOD_VAR_IN
Write MOD_VAR_IN

Procedure to convert MODBUS variable to FF parameter:
Read MOD_VAR_OUT
Convert MOD_VAR_OUT (from DATA TYPE) to Float, generating Y
Calculate PVALUE = (A*Y + B)
Save OUTx_VALUE

A = (TO_EU_100% - TO_EU_0%) / (FROM_EU_100% - FROM_EU_0%)
B = (TO_EU_0% - A*FROM_EU_0%);



PVALUEn: FF Parameter
MOD_VAR_IN, MOD_VAR_OUT: MODBUS Variables
Y: Auxiliary FLOAT Variable

ILOCATORn Parameter
Refer to the IVALUEn parameter.

Slave Address: Type the slave address where the variable being monitored is located. For example, if a LC700 has the Device Address equals to 1, the Slave Address should be equal to 1.

MODBUS Address of Value: Type the MODBUS address of the variable being monitored in the MBSM block. Suppose the user will monitor the variable in the MODBUS address 40001, located in the I/O module of the Slave with the Device Address equals to 1.The Modbus Address Of Value should be 40001.

The IVALUEn parameters will display the variable values configured in the ILOCATORn parameter.

BLOCATORn Parameter
Refer to the BVALUEn parameter.

This parameter is a DS-260 data type, the user will have to configure two elements for this parameter.

Slave Address: Type the slave address where the variable being monitored is located. For example, if a LC700 has the Device Address equals to 1, the Slave Address should be equal to 1.

MODBUS Address of Value: Type the MODBUS address of the variable being monitored in the MBSM block. Suppose the user will monitor the variable in the MODBUS address 40001, located in the Input/Output module with the Device Address equals to 1. The MODBUS Address of Value should be 40001.

The BVALUEn parameters will show the variable values configured in BLOCATORn.

BAD_STATUS Parameter
This parameter indicates if the communication between the slaves was established properly. If the corresponding bit is at logic level 1, it indicates that there was an error during the reading/writing of the respective parameter. The table below shows the values for these status:

Relation between bits in BAD_STATUS and MODBUS Addresses

Bit	Variable
0	B1
1	B2
2	B3
3	B4
4	B5
5	B6
6	B7
7	B8
8	I1
9	I2
10	P1
11	P2
12	F1
13	F2

Modbus Slave Addresses

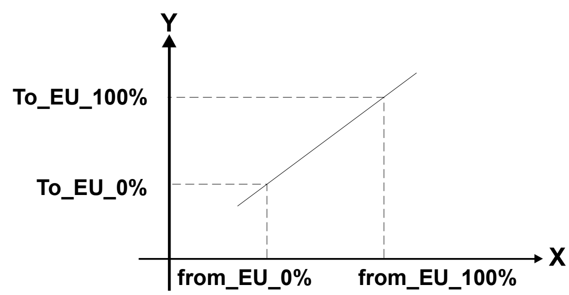
MBCS		
PARAMETER	LOCAL_MOD_MAP = x OFFSET = 40 * x x = 0 ~ 15	e.g. LOCAL_MOD_MAP =1
IN1-Value	40001+ OFFSET 40002+ OFFSET	40041 40042
IN2-Value	40003+ OFFSET 40004+ OFFSET	40043 40044
IN3-Value	40005+ OFFSET 40006+ OFFSET	40045 40046
IN4-Value	40007+ OFFSET 40008+ OFFSET	40047 40048
OUT1-Value	40009+ OFFSET 40010+ OFFSET	40049 40050
OUT2-Value	40011+ OFFSET 40012+ OFFSET	40051 40052
OUT3-Value	40013+ OFFSET 40014+ OFFSET	40053 40054
OUT4-Value	40015+ OFFSET 40016+ OFFSET	40055 40056
IN1-Status	40017+ OFFSET	40057
IN2-Status	40018+ OFFSET	40058
IN3-Status	40019+ OFFSET	40059
IN4-Status	40020+ OFFSET	40060
OUT1-Status	40021+ OFFSET	40061
OUT2-Status	40022+ OFFSET	40062
OUT3-Status	40023+ OFFSET	40063
OUT4-Status	40024+ OFFSET	40064
IN_D1-Status	40025+ OFFSET	40065
IN_D2-Status	40026+ OFFSET	40066
IN_D3-Status	40027+ OFFSET	40067
IN_D4-Status	40028+ OFFSET	40068
OUT_D1-Status	40029+ OFFSET	40069
OUT_D2-Status	40030+ OFFSET	40070
OUT_D3-Status	40031+ OFFSET	40071
OUT_D4-Status	40032+ OFFSET	40072
IN_D1-Value	1+ OFFSET	41
IN_D2-Value	2+ OFFSET	42
IN_D2-Value	3+ OFFSET	43
IN_D2-Value	4+ OFFSET	44
OUT_D1-Value	5+ OFFSET	45
OUT_D2-Value	6+ OFFSET	46
OUT_D3-Value	7+ OFFSET	47
OUT_D4-Value	8+ OFFSET	48

MBSS		
PARAMETER	LOCAL_MOD_MAP = x OFFSET = 40 * x x = 0 ~ 15	e.g. LOCAL_MOD_MAP =1
F_ID1	42601+ OFFSET 42602+ OFFSET	42641 42642
F_ID2	42603+ OFFSET 42604+ OFFSET	42643 42644
F_ID3	42605+ OFFSET 42606+ OFFSET	42645 42646
F_ID4	42607+ OFFSET 42608+ OFFSET	42647 42648
F_ID5	42609+ OFFSET 42610+ OFFSET	42649 42650
F_ID6	42611+ OFFSET 42612+ OFFSET	42651 42652
F_ID7	42613+ OFFSET 42614+ OFFSET	42653 42654
F_ID8	42615+ OFFSET 42616+ OFFSET	42655 42656
I_ID1	42617+ OFFSET 42618+ OFFSET	42657 42658
I_ID2	42619+ OFFSET 42620+ OFFSET	42659 42660
I_ID3	42621+ OFFSET 42622+ OFFSET	42661 42662
I_ID4	42623+ OFFSET 42624+ OFFSET	42663 42664
B_ID1	2601+ OFFSET	2641
B_ID2	2602+ OFFSET	2642
B_ID3	2603+ OFFSET	2643
B_ID4	2604+ OFFSET	2644
BAD_STATUS	42625+OFFSET	42665

NOTE
MBCS The second column in the table above shows the values applied to the inputs and outputs of the MBCS block, according to the value configured for the LOCAL_MODE_MAP. For example, if the LOCAL_MODE_MAP is equal to 1, the result of the MODBUS address range will be the values displayed in the third column. Observe that, when this parameter is configured, the entire range will be selected. The INn and OUTn values use two MODBUS registers (for example, IN1: 40041 and 40042) because the data type is float. The IN_Dn and OUT_Dn values use one MODBUS register (for example, IN_D1, 41). The values of the status also use only one register. Once the MODBUS range is defined, the user can configure the MODBUS master to read these values. **MBSS** When configuring the values for LOCAL_MODE_MAP, MODBUS addresses are applied to the variables to be monitored. Each variable - Integer, Float or Boolean - will have a MODBUS address. For example, suppose LOCAL_MODE_MAP = 1 and the float variable being monitored. Configuring the F_ID1 parameters, use: F_ID1.Tag = Tag of the float parameter being monitored. F_ID1.Index = Index of the first column of the parameter being monitored. F_ID1.Subindex = The sub index is used for parameters with a structure. In this case, it is necessary to indicate which element of the structure is being referenced. Refer to the table above. The MODBUS addresses applied to this parameter (Float values use two MODBUS registers) are 42641 and 42642.

Scale Conversion

This data structure consists of data used to generate the constants A and B in the equation Y= A*X+B



E	Element	Data Type	Size
1	From EU 100%	Float	4
2	From EU 0%	Float	4
3	To EU 100%	Float	4
4	To EU 0%	Float	4
5	Data Type (Use this parameter to convert Fieldbus to Modbus or Modbus to Fieldbus, where Modbus should be...) Float = 1 Unsigned8 = 2 Unsigned16 = 3 Unsigned32 = 4 Integer8 = 5 Integer16 = 6 Integer32 = 7 Swapped Float = 8 Swapped Unsigned8 = 9 Swapped Unsigned16 = 10 Swapped Unsigned32 = 11 Swapped Integer8 = 12 Swapped Integer16 = 13 Swapped Integer32 = 14	Unsigned8	1

Chapter 16

GAS MEASUREMENT

The following examples show gas measurement applications.

Application 1 – Natural Gas Measurement – Production Area

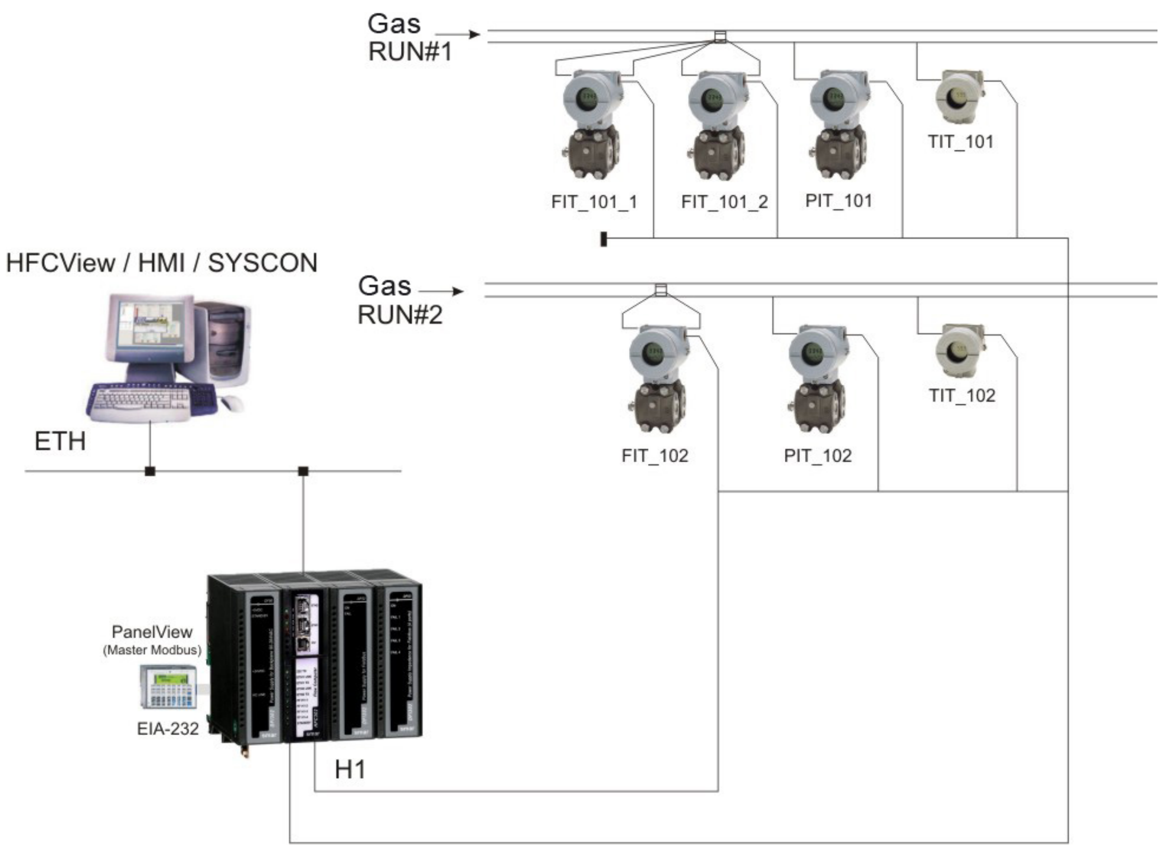


Figure 16.1 – Application 1 Architecture

- Unit system: SI
- Base temperature = 15 ºC
- Base pressure = 101.325 KPa
- 2 flow measurement of natural gas;
- Flow measurement 1 - H1 Foundation Fieldbus transmitters: 2 differential pressure transmitters of different ranges, static pressure and temperature
- Flow measurement 2 - H1 Foundation Fieldbus transmitters : differential pressure, static pressure and temperature;
- Sensor: orifice plate;
- Standard used: ISO5167
- Input for composition of the natural gas: manual;
- Transfer reports: daily (continuous transfer)
- Serial 1: local panel communicating via Modbus RTU + EIA-232, ID=2, BR=19200, par, 1 stop.
- ETH1: Syscon/Supervisory communicating via HSE OPC Server.
- ETH1: HFCView communicating via Modbus TCP/IP;
- This configuration is installed in \Smar\Syscon\Samples\HFC302\GasProduction

Application configuration:

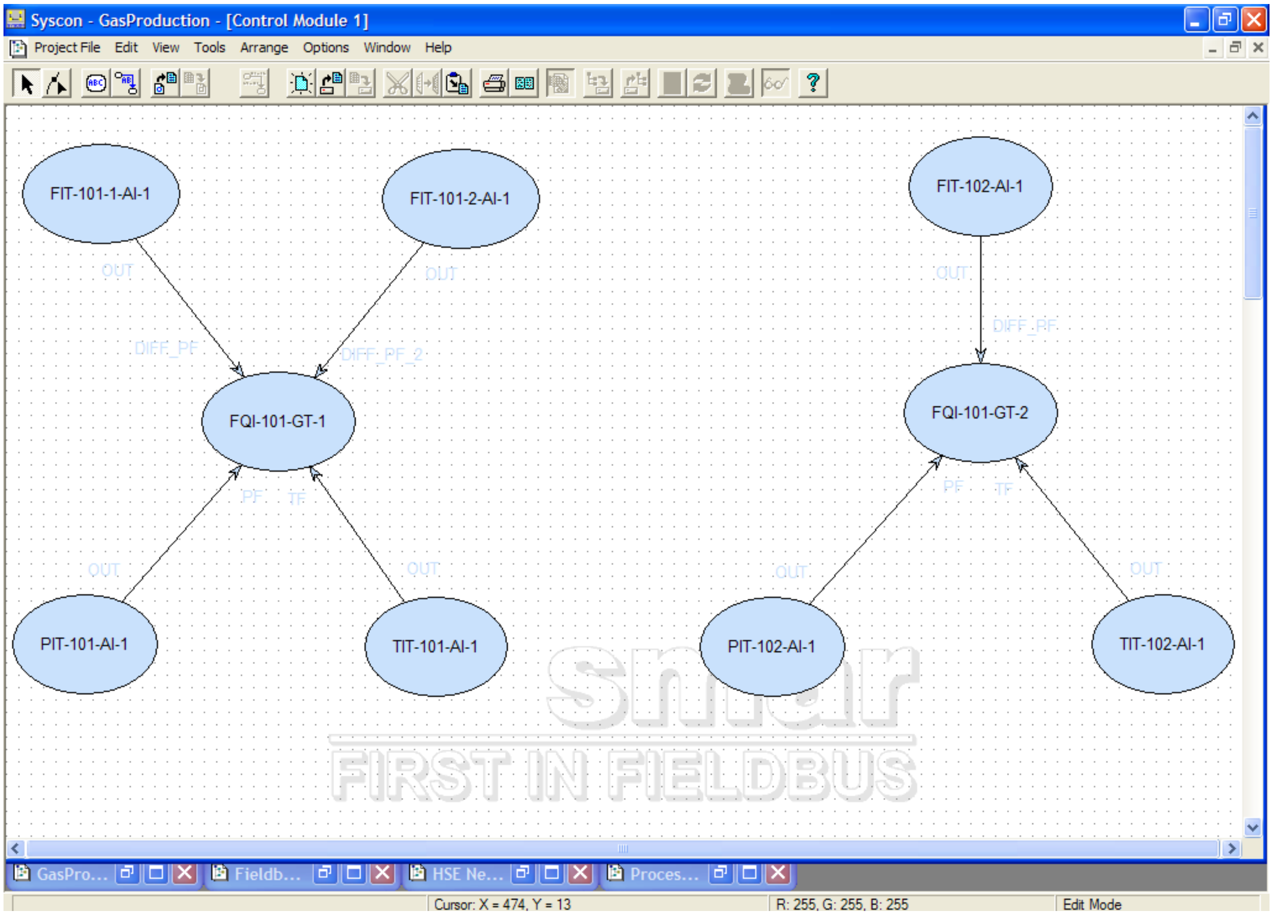


Figure 16.2 – Configuration of the Application 1

Parameterization:
The parameters to be configured are shown below. The parameters that are not listed below, is because its default value meet the application.

1) Block FQI-101-MBCF-1:
DEVICE_ADDRESS = 2
BAUD_RATE = 19200

2) Block FQI-101-GT-1:
RANGE_LO_2 = 60 KPa
RANGE_HI_2 = 50 Kpa
METER_TYPE = Orifice Plate-ISO5167

3) Block FQI-101-GT-2:
METER_TYPE = Orifice Plate-ISO5167

4) Block FIT-101-1-AI-1:
XD_SCALE.UNITS_INDEX = KPa

5) Block FIT-101-2-AI-1:
XD_SCALE.UNITS_INDEX = KPa

6) Block PIT-101-AI-1:
XD_SCALE.UNITS_INDEX = KPa
7) Bloco FIT-102-AI-1:
XD_SCALE.UNITS_INDEX = KPa

8) Block FIT-102-AI-1:
XD_SCALE.UNITS_INDEX = KPa

9) Block PIT-102-AI-1:
XD_SCALE.UNITS_INDEX = KPa

Variables monitored via Modbus in the Serial 1:

The parameters to be monitored are shown below:

Block Tag	Address – Input Register	Address – Holding Register
FQI-101-GT-1	304.521	406.161
FQI-101-GT-2	304.891	406.301

Block Tag	Parameter	Description	Modbus Address
FQI-101-GT-1 (Loop 1)	PF	Static pressure	406.182 - 406.183
	TF	Flowing temperature	406.185 – 406.186
	DIFF_PF	Differential pressure – low range	304.525 – 304.526
	DIFF_PF_2	Differential pressure – high range	304.528 – 304.529
	DIFF_PF_CALC	Differential pressure – value used in calculations	304.550 – 304.551
	QB	Volumetric flow at base condition	304.540 – 304.541
	QM	Mass flow	304.537 – 304.538
	FTOT_QB_DAY	Totalizer Qb of the current day	304.701 – 304.702
	FTOT_QM_DAY	Totalizer Qm of the current day	304.707 – 304.708
	FPREV_TOT_QB	Totalizer Qb of the previous day	304.783 – 304.784
	FPREV_TOT_QM	Totalizer Qm of the previous day	304.789 – 304.790
FQI-101-GT-2 (Loop 2)	PF	Static pressure	406.322 – 406.323
	TF	Flowing temperature	406.325 – 406.326
	DIFF_PF	Differential pressure	304.895 – 304.896
	QB	Volumetric flow at base condition	304.910 – 304.911
	QM	Mass flow	304.907 – 304.908
	FTOT_QB_DAY	Totalizer Qb of the current day	305.071 – 305.072
	FTOT_QM_DAY	Totalizer Qm of the current day	305.077 – 305.078
	FPREV_TOT_QB	Totalizer Qb of the previous day	305.153 – 305.154
	FPREV_TOT_QM	Totalizer Qm of the previous day	305.159 – 305.160

Application 2 – Natural Gas Measurement – Distribution Area

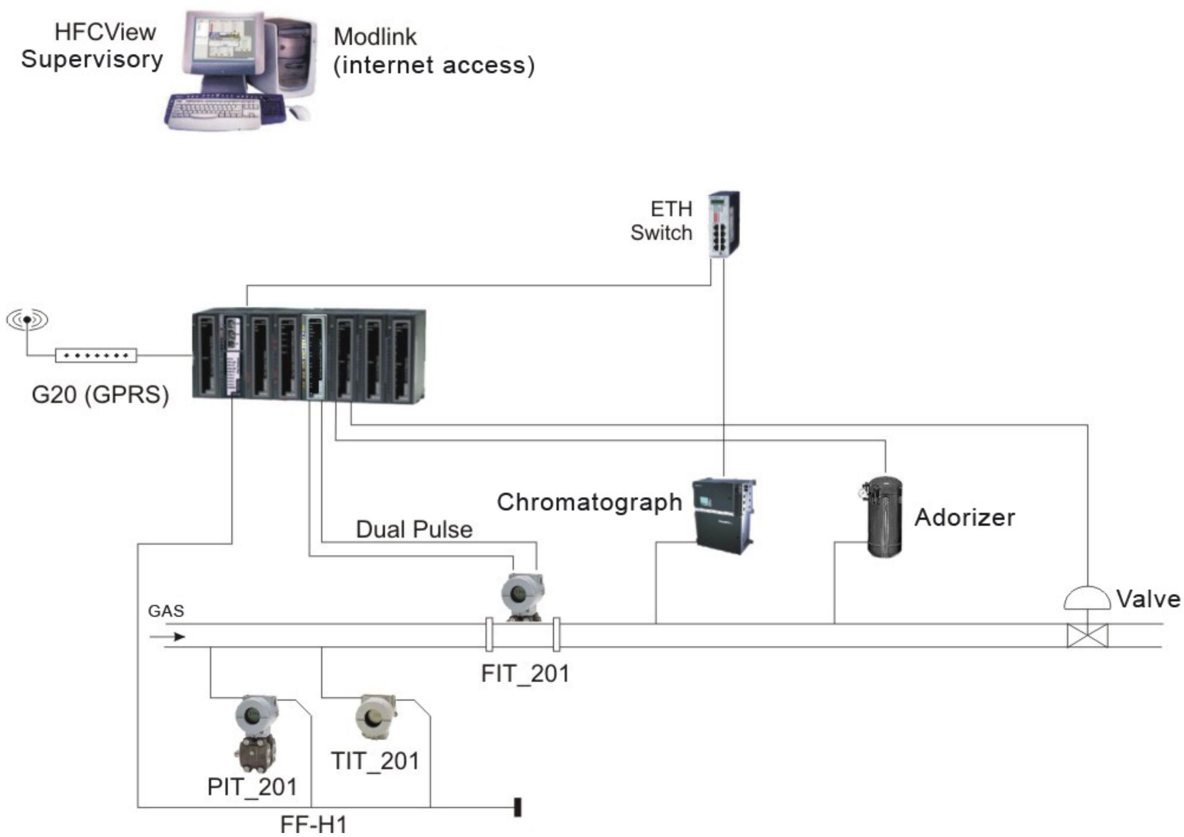


Figure 16.3 – Application 2 Architecture

- Unit system: SI
- Base temperature = 20 ºC
- Base pressure = 101.325 KPa
- 1 flow measurement of natural gas;
- Sensor : Turbine or ultrasonic (Volume Pulse Input), K-factor = 100 pulses/m^3;
- Pulse input: dual-pulse, phase difference 90º, deviation +/- 11.25º, positive edges;
- 2 H1 Foundation Fieldbus transmitters: static pressure and temperature;
- Input for composition of the natural gas: chromatograph;
- Modbus address of the chromatograph:

Component	Modbus Address
Methane	40001 - 40002
Ethane	40003 – 40004
Prophane	40005 – 40006
n-Butane	40007 - 40008
i-Butane	40009 - 40010
n-Pentane	40011 – 40012
i-Pentane	40013 - 40014
Hexane	40015 – 40016
Nitrogen	40017 - 40018
Carbonic gas	40019 - 40020

- Batch control for quantity (volume at base condition).
- Adorizer / sampler control: each $10m^3$ of natural gas put in 5 cm^3 of mercaptan (injected volume for pulse in the adorizer) through pulse with 1 second of width.
- Transfer profile in the last 24 hours and the last 30 days.
- Transfer report: batch.
- Historic report (averages and totalizations): daily (24 hours)

- ETH1 : Modbus TCP/IP, reading of the composition, chromatograph (ID=3, IP=192.168.164.10);
- Serial 1 + Modem G20: Supervisory and HFCView communicating via Modbus + GPRS, ID=2, BR=9600, par, 1 stop;
- This configuration is installed in \Smar\Syscon\Samples\HFC302\GasMeasure

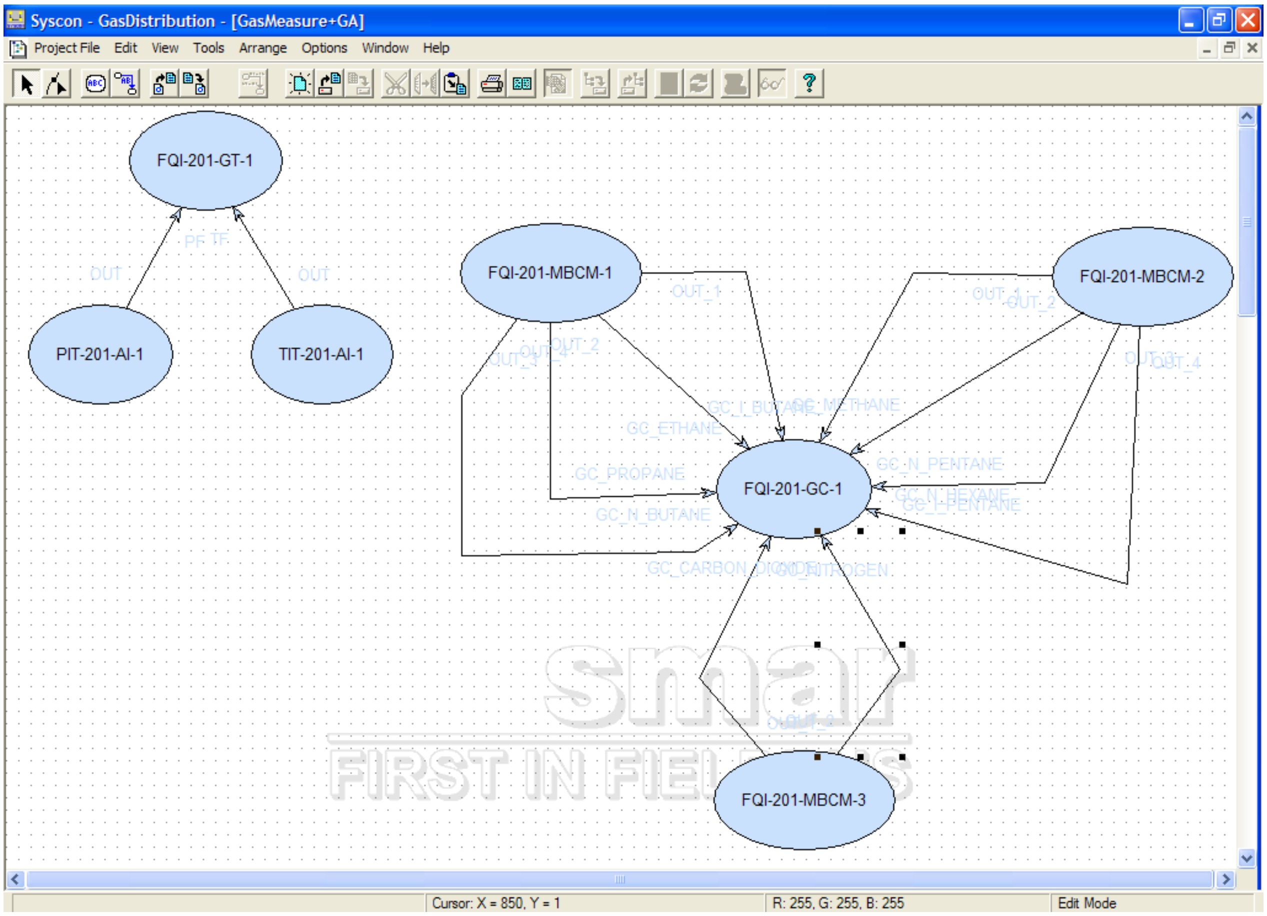


Figure 16.4 – Configuration of the Application 2 – Measurement and Chromatograph

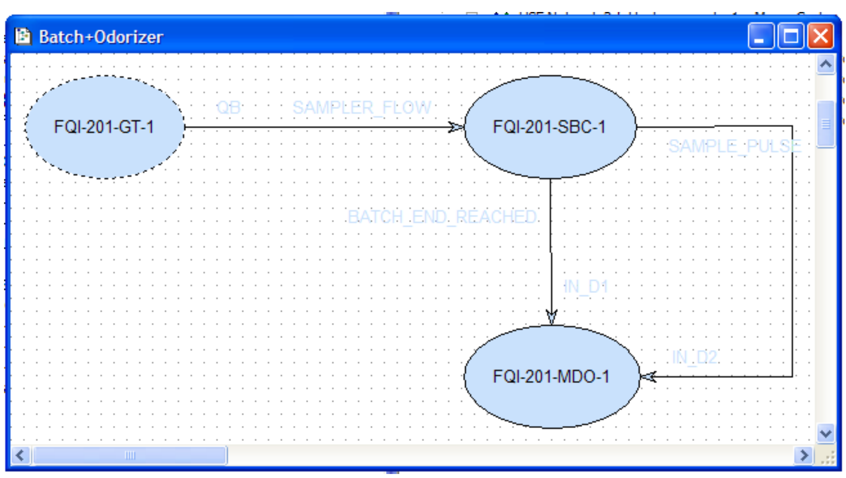


Figure 16.5 – Configuration of the Application 2 – Batch and Adorizer

Parameterization:
The parameters to be configured are shown below. The parameters that are not listed below, is because its default value meet the application.

1) Block FQI-102-MBCF-1:
DEVICE_ADDRESS = 2
SLAVE_ADDRESSES.IP_SLAVE_1 =192.168.164.10
MODBUS_ADDRESS_SLAVE_1 = 3
ON_APPLY = Apply

2) Block FQI-201-HC-1:
MODE_BLK.Target = Auto
IO_TYPE_R1.SLOT_0 = Pulse Input and Proving Module
IO_TYPE_R1.SLOT_1 = 16-Discrete Output

3) Block FQI-201-PIP-1:
CHANNEL = 1099
G1_CONF = Dual pulse check enable

4) Block FQI-201-GKD:
BASE_TEMPERATURE = 20 ºC
COMPOSITION_P1 = Chromatograph
METER1_INFO.NOMINAL_K_FACTOR = 100 pulses/m^3

5) Block FQI-101-GT-1:
METER_TYPE = Volume Pulse Input
CHANNEL = 1002

6) Block FQI-201-SBC-1:
STRATEGY = 1
VOLUME_PULSE = 10 m^3
SAMPLER_CMD = Start/Stop

BATCH_SIZE = batch programming, volumes to be transferred
BATCH_STATE = Start (to start the batch), End (to end the batch before the programmed volume)

7) Block FQI-201-GMH-1:
STRATEGY =1
HISTORY_CMD = 2 (monitoring the averages and hourly totalizations)

8) Block FQI-201-MBCM-1:
MODE_BLK.Target = Auto
LOCAL_MOD_MAP = 0
SCALE_LOC_OUT1.DATA_TYPE = Float
SCALE_LOC_OUT1.SLAVE_ADDRESS = 3
SCALE_LOC_OUT1.MODBUS_ADDRESS_OF_VALUE = 40001

SCALE_LOC_OUT2.DATA_TYPE = Float
SCALE_LOC_OUT2.SLAVE_ADDRESS = 3
SCALE_LOC_OUT2.MODBUS_ADDRESS_OF_VALUE = 40003

SCALE_LOC_OUT3.DATA_TYPE = Float
SCALE_LOC_OUT3.SLAVE_ADDRESS = 3
SCALE_LOC_OUT3.MODBUS_ADDRESS_OF_VALUE = 40005

SCALE_LOC_OUT4.DATA_TYPE = Float
SCALE_LOC_OUT4.SLAVE_ADDRESS = 3
SCALE_LOC_OUT4.MODBUS_ADDRESS_OF_VALUE = 40007

9) Block FQI-201-MBCM-2:
MODE_BLK.Target = Auto
LOCAL_MOD_MAP = 1
SCALE_LOC_OUT1.DATA_TYPE = Float
SCALE_LOC_OUT1.SLAVE_ADDRESS = 3
SCALE_LOC_OUT1.MODBUS_ADDRESS_OF_VALUE = 40009

SCALE_LOC_OUT2.DATA_TYPE = Float
SCALE_LOC_OUT2.SLAVE_ADDRESS = 3
SCALE_LOC_OUT2.MODBUS_ADDRESS_OF_VALUE = 40011

SCALE_LOC_OUT3.DATA_TYPE = Float
SCALE_LOC_OUT3.SLAVE_ADDRESS = 3
SCALE_LOC_OUT3.MODBUS_ADDRESS_OF_VALUE = 40013

SCALE_LOC_OUT4.DATA_TYPE = Float
SCALE_LOC_OUT4.SLAVE_ADDRESS = 3
SCALE_LOC_OUT4.MODBUS_ADDRESS_OF_VALUE = 40015

10) Block FQI-201-MBCM-3:
MODE_BLK.Target = Auto
LOCAL_MOD_MAP = 2
SCALE_LOC_OUT1.DATA_TYPE = Float
SCALE_LOC_OUT1.SLAVE_ADDRESS = 3
SCALE_LOC_OUT1.MODBUS_ADDRESS_OF_VALUE = 40017

SCALE_LOC_OUT2.DATA_TYPE = Float
SCALE_LOC_OUT2.SLAVE_ADDRESS = 3
SCALE_LOC_OUT2.MODBUS_ADDRESS_OF_VALUE = 40019

11) Block FQI-201-MDO-1:
MODE_BLK.Target = Auto
CHANNEL = 1109

Chapter 17

LIQUID MEASUREMENT

Application 1 – Well Test

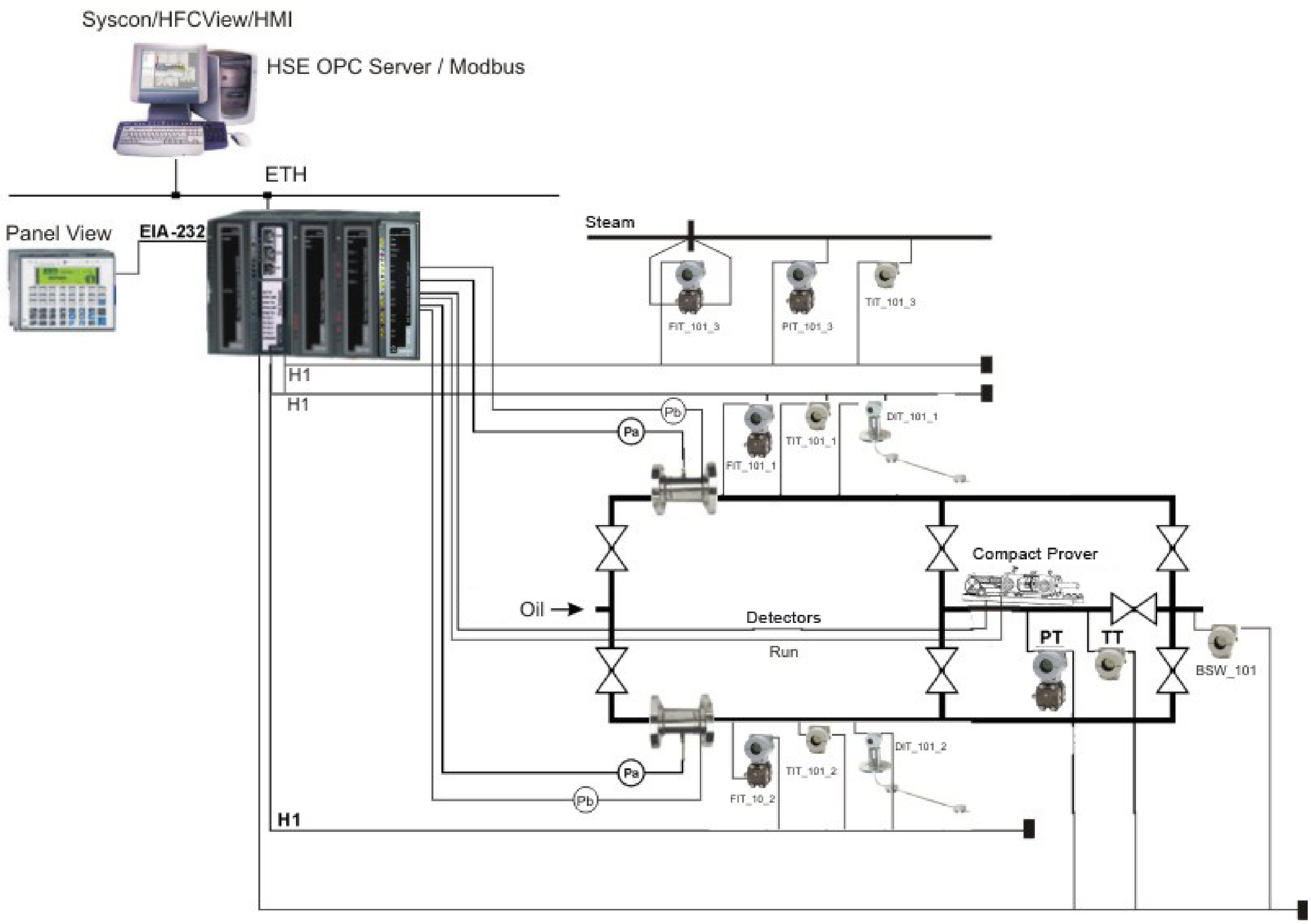


Figure 17.1 – Well Test Application

Measurement Features

- Application: well test with production of crude oil, steam injection;
- Unit system: SI
- Base temperature = 20 ºC
- Base pressure = 101.325 KPa
- 2 flow measurement of crude oil, in redundant way for maintenance without interruption of production;
- Pulse Input: dual-pulse, phase difference 90º, deviation +/- 11.25º, positive edges.
- K-factor : meter 1 = 1010 p/m^3, meter 2 = 1020 p/m^3;
- Allocation measurement of crude oil (emulsion of crude oil and water, high degree of water) using turbine or other sensor with pulse signal (Volume Pulse Input);
- Base density of water = 1001 kg/m^3
- Shrinkage factor for both measurements: 0.94
- Calibron Compact prover: BPV=0.060123 m^3, OD = 330.63 mm, WT=31.75 mm, Pipe Gl=0.0000112 1/ºC, elasticity module = 206 800 000 1/Kpa, external shaft-Gl = 0.0000014 1/Celsius
- For each flow measurement has: pulse input, density, gauge pressure, temperature;
- BSW measurement: common to the two ways, full range;
- 1 measurement of steam for injection using orifice plate – AGA3

- Bus H1: channel 1 and 2 have instruments associated to each one of the operational turbines, channel 3 has the instruments of the meter prover of BSW (IF302 to convert the 4-20 mA signal in Foundation Fieldbus), channel 4 has the instruments of the steam measurement;
- Syscon/HFCView/Supervisory communicating via OPC Server+Ethernet.
- The configuration below was installed in: \Smar\Syscon\Samples\HFC302\CrudeOilMeasure.

Application Configuration

The configuration strategy below show two crude oil measurements.

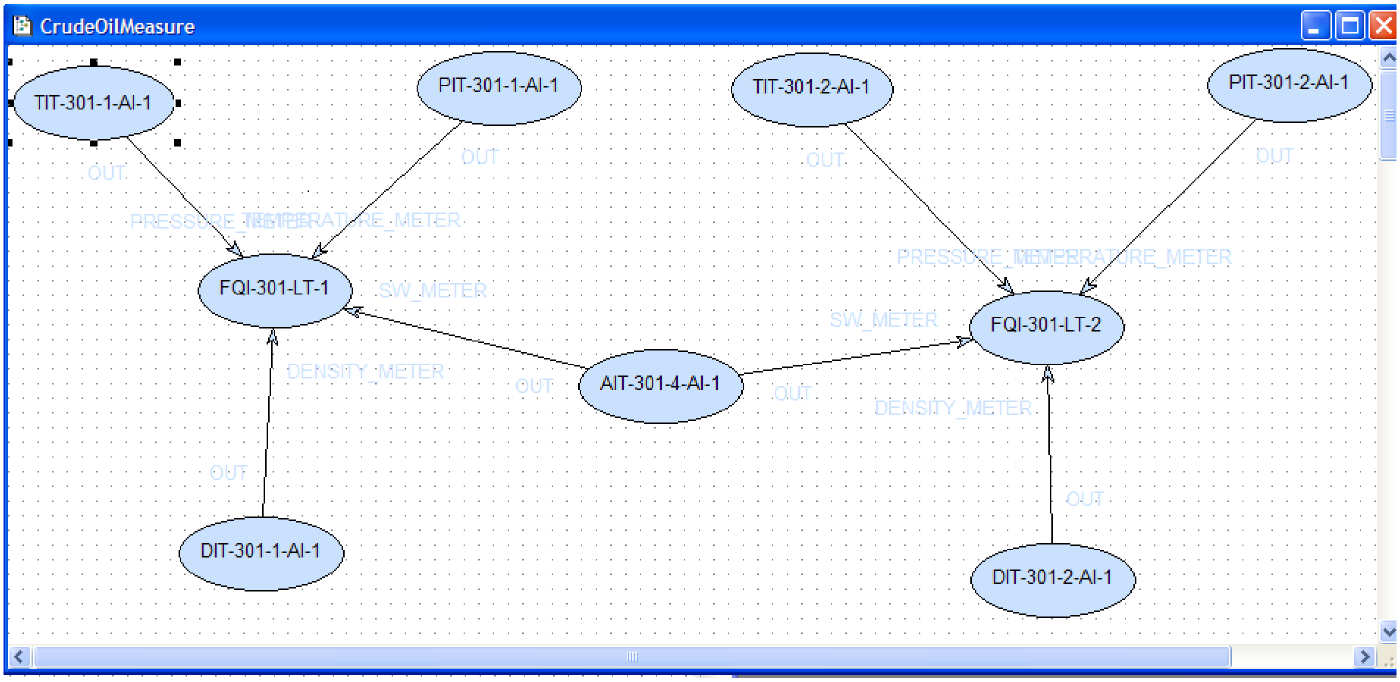


Figure 17.2 – Configuration of the Application in Well Test – Crude Oil Measurement

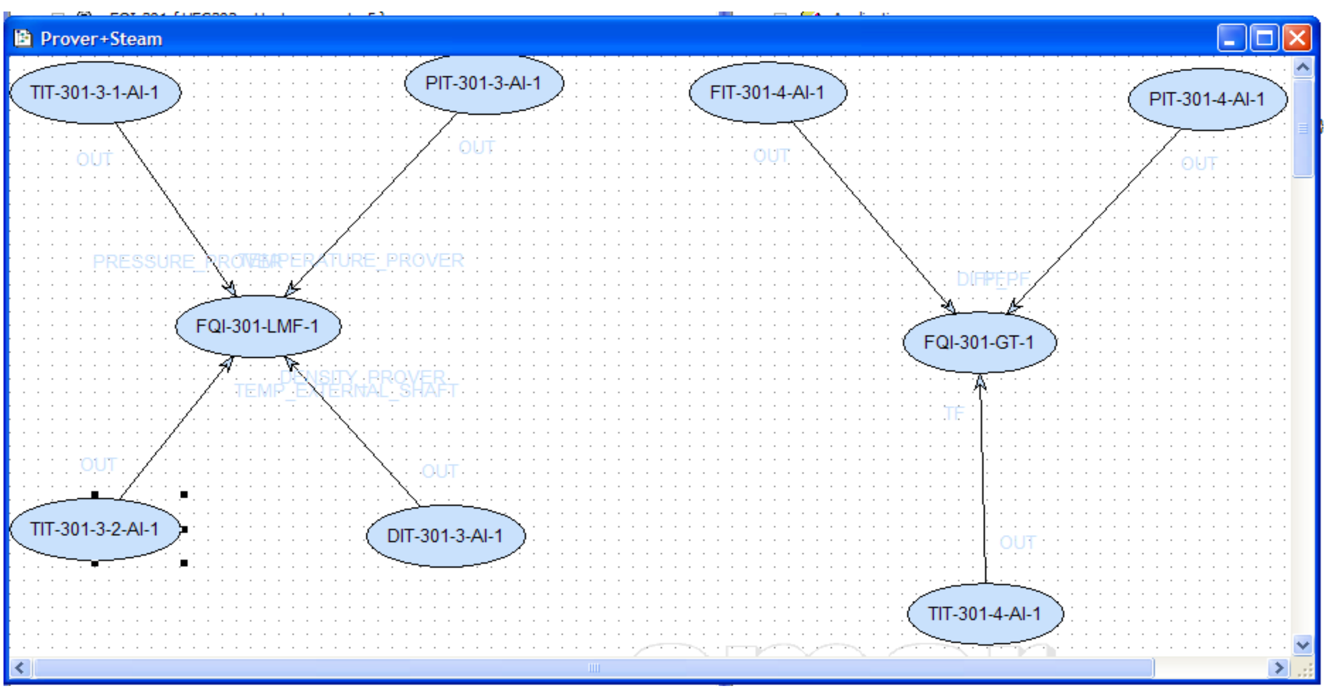


Figure 17.3 – Configuration of the Application in Well Test – Prover and Steam

Parameterization

The parameters to be configured are shown below. The parameters that are not listed below, is because its default value meet the application.

1) Block FQI-102-MBCF-1:
DEVICE_ADDRESS = 2
BAUD_RATE =19200
ON_APPLY = Apply

2) Block FQI-201-HC-1:
MODE_BLK.Target = Auto
IO_TYPE_R1.SLOT_0 = Pulse Input and Proving Module
IO_TYPE_R1.SLOT_1 = 16-Discrete Output
IO_TYPE_R1.SLOT_2 = 16-Discrete Input

3) Block FQI-201-PIP-1:
OUT1_CONTROL = 10
CHANNEL = 1099
G1_CONF = Dual pulse check enable
G2_CONF = Dual pulse check enable

4) Block FQI-201-GKD-1:
BASE_TEMPERATURE = 20 ºC

5) Block FQI-201-LKD-1:
BASE_TEMPERATURE = 20 ºC
METER1_INFO. NOMINAL_K_FACTOR = 1010 pulses/m^3
METER2_INFO. NOMINAL_K_FACTOR = 1020 pulses/m^3
PROVER1_INFO.BASE_PROVER_VOLUME=0.060123 m^3
PROVER1_INFO.OUTSIDE_DIAMETER = 330.63 mm
PROVER1_INFO.WALL_THICKNESS=31.75 mm
PROVER1_INFO.PIPE_GL=0.0000112 1/ºC
PROVER1_INFO.MODULUS_ELASTICITY = 206 800 000 1/Kpa,
PROVER1_INFO.EXTERNAL_SHAFT_GL = 0.0000014 1/Celsius
PRODUCT6_INFO.BASE_DENSITY_OF_WATER =1001 kg/m3

6) Block FQI-201-LT-1:
CHANNEL = 1002
PRODUCT_SELECTION = Product 6
SF = 0.94

7) Block FQI-201-LT-2:
CHANNEL = 1012
PRODUCT_SELECTION = Product 6
SF = 0.94

8) Block FQI-201-LMF-1:

9) Block FQI-201-GT-1:
PRODUCT_SEL = Steam (ASME)

10) Block FQI_201-WT-1:
OIL_STATION_EQUATION = 1+2
GAS_RUN_NUMBER = 3

Application 2 – Gasoline and Diesel Distribution

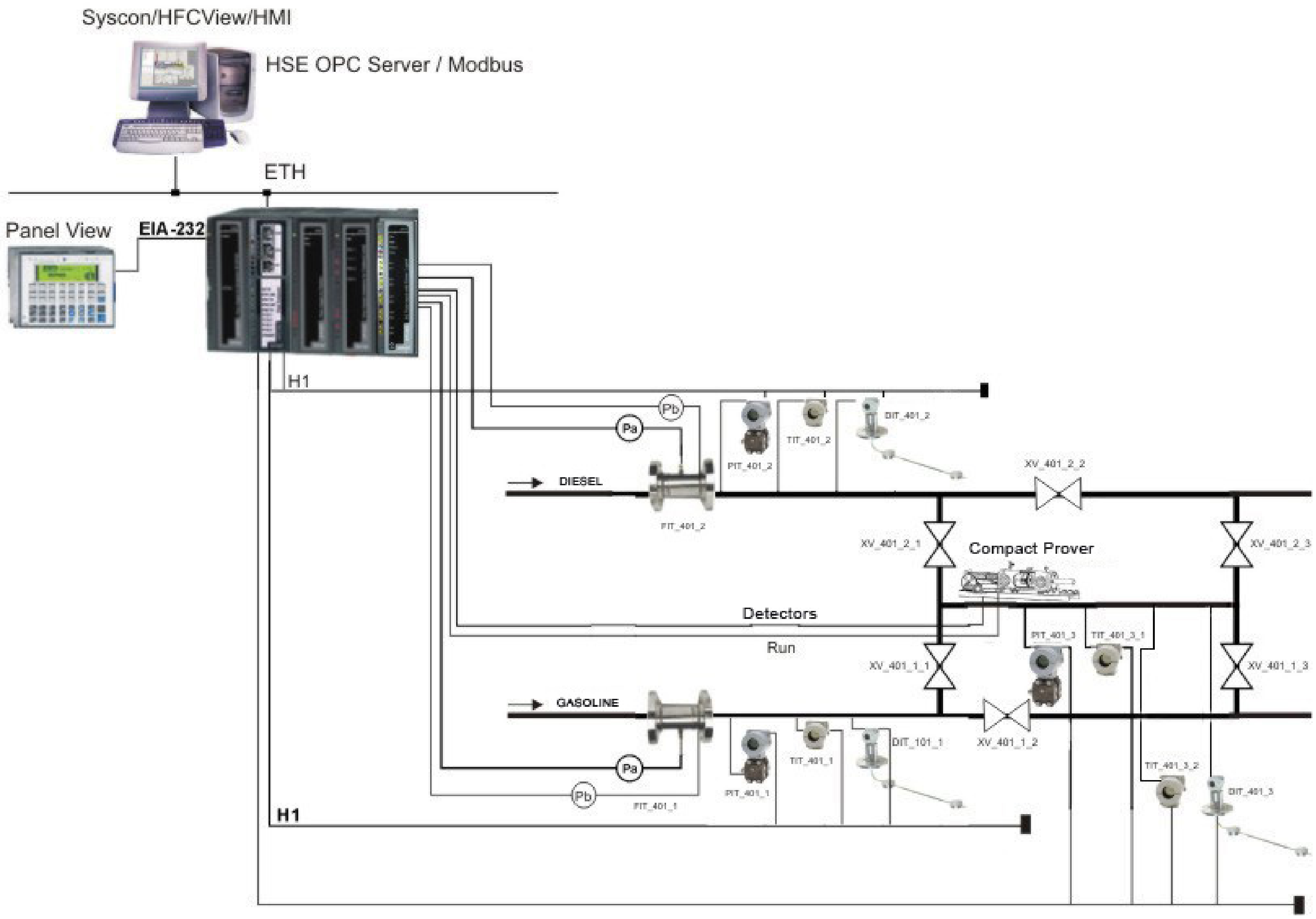


Figure 17.4 – Gasoline and Diesel Distribution

Measurement Features

- Application: gasoline and diesel distribution;
- Unit system: SI
- Base temperature = 20 ºC
- Base pressure = 101.325 KPa
- 2 flow measurement – custody transfer: gasoline and diesel (API MPMS-11.1:2004 Refined Products);
- Flow meters: ultrasonic (Volume Pulse Input)
- Pulse input: dual-pulse, phase difference 90º, deviation +/- 11.25º, positive edge.
- K-factor : meter 1 = 1000.1 p/m^3,   meter 2 = 1000.2 p/m^3;
- Calibration of the flow meters using compact prover, shared for two measurements;
- Calibron compact prover: BPV=0.018909 m^3, OD = 321.31 mm, WT=30.48 mm, Pipe Gl=0.00001728 1/ºC, elasticity module = 4 061 060 1/Kpa, external shaft-Gl = 0.00001728 1/Celsius
- For each flow measurement has: pulse input, density, gauge pressure, temperature;
- Bus H1: channel 1 and 2 have the instruments associated to each one of the operational meters, channel 3 has the instrument of the prover;
- Control of the ways alignment by ladder logic (FFB);
- Syscon/HFCView/Supervisory communicating via OPC Server+Ethernet.
- The configuration below was installed in: \Smar\Syscon\Samples\HFC302\CrudeOilMeasure.

Application Configuration
The configuration strategy below show two crude oil measurements.

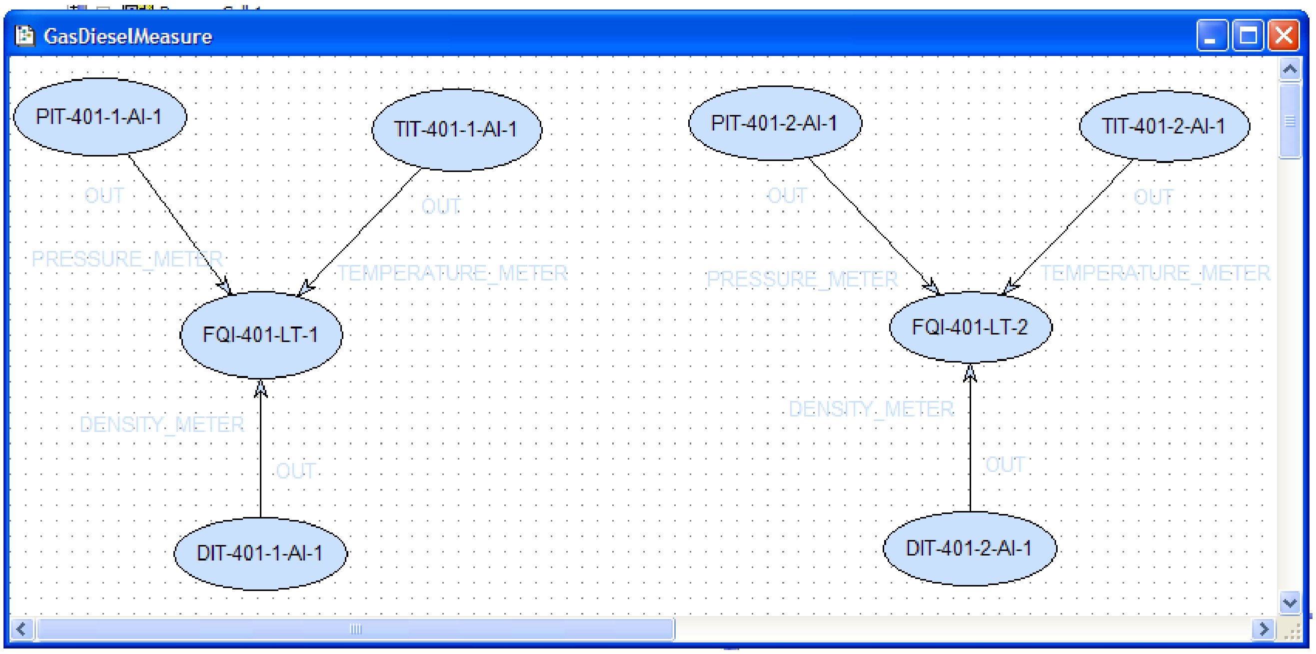


Figure 17.5 – Configuration of the Gasoline and Diesel Distribution - Measurement

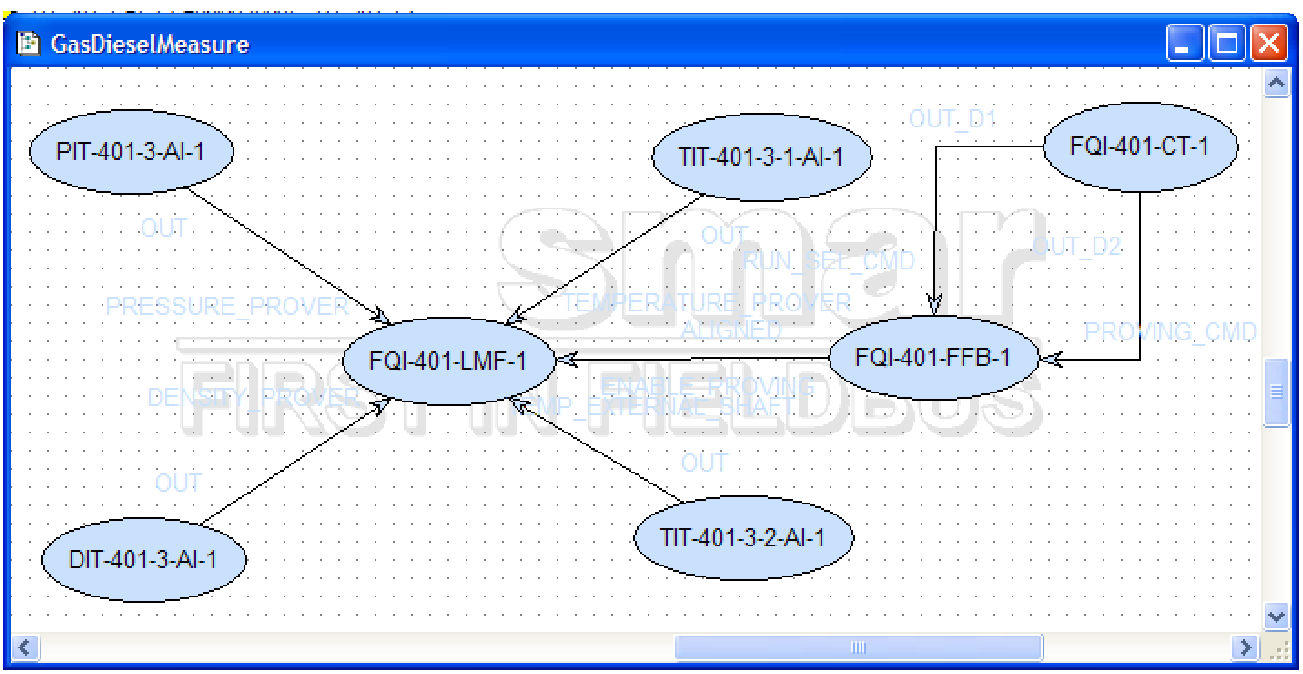


Figure 17.6 – Configuration of the Gasoline and Diesel Distribution - Proving

Parameterization

The parameters to be configured are shown below. The parameters that are not listed below, is because its default value meet the application.

1) Block FQI-102-MBCF-1:
DEVICE_ADDRESS = 2
BAUD_RATE =19200
ON_APPLY = Apply

2) Block FQI-201-HC-1:
MODE_BLK.Target = Auto
IO_TYPE_R1.SLOT_0 = Pulse Input and Proving Module

3) Block FQI-201-PIP-1:
OUT1_CONTROL = 10
CHANNEL = 1099
G1_CONF = Dual pulse check enable
G2_CONF = Dual pulse check enable

4) Block FQI-201-LKD-1:
BASE_TEMPERATURE = 20 ºC
PRODUCT2_INFO.STANDARD_VERSION = API-11.1:2004/GPA TP 25
METER1_INFO. NOMINAL_K_FACTOR = 1000.1 pulses/m^3
METER2_INFO. NOMINAL_K_FACTOR = 1000.2 pulses/m^3
PROVER1_INFO.BASE_PROVER_VOLUME=0.018909 m^3
PROVER1_INFO.OUTSIDE_DIAMETER = 321.31 mm
PROVER1_INFO.WALL_THICKNESS=30.48 mm
PROVER1_INFO.PIPE_GL=0.00001728 1/ºC
PROVER1_INFO.MODULUS_ELASTICITY = 4 061 060 1/Kpa,
PROVER1_INFO.EXTERNAL_SHAFT_GL = 0.00001728 1/Celsius

5) Block FQI-201-LT-1:
CHANNEL = 1002
PRODUCT_SELECTION = Product 2

6) Block FQI-201-LT-2:
CHANNEL = 1012
PRODUCT_SELECTION = Product 2

7) Block FQI-201-LMF-1:

8) Block FQI-201-CT-1:
MODE_BLK.Target = Auto
CT_VAL_D1 = 0 (way 1 selection), 1(way 2 selection)
CT_VAL_D2 = 0 (not to align the prover), 1 (to align the prover)

Ladder Logic – Alignment of the Ways to Prover

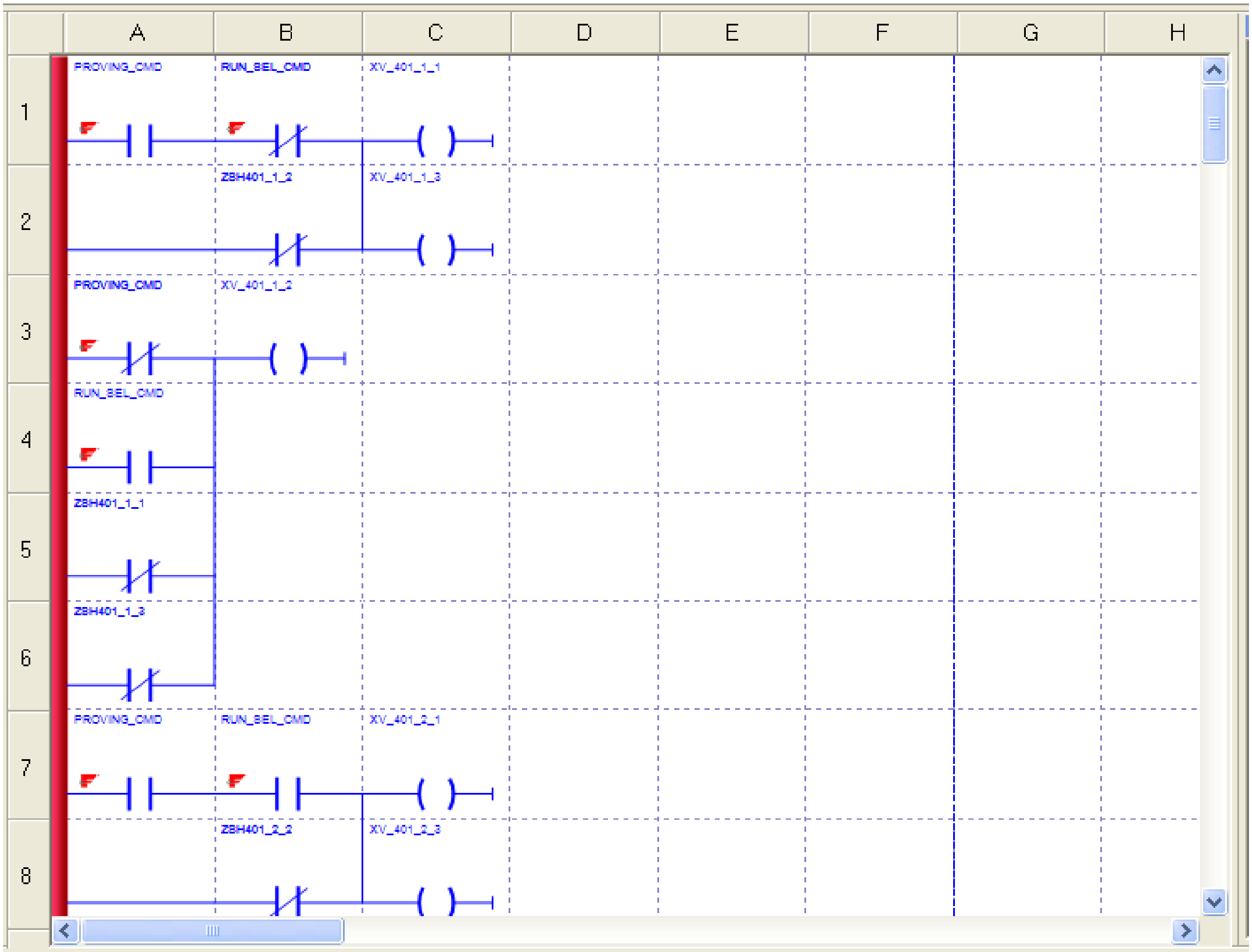


Figure 17.7 – Configuration of the Gasoline and Diesel Distribution – Ladder Logic

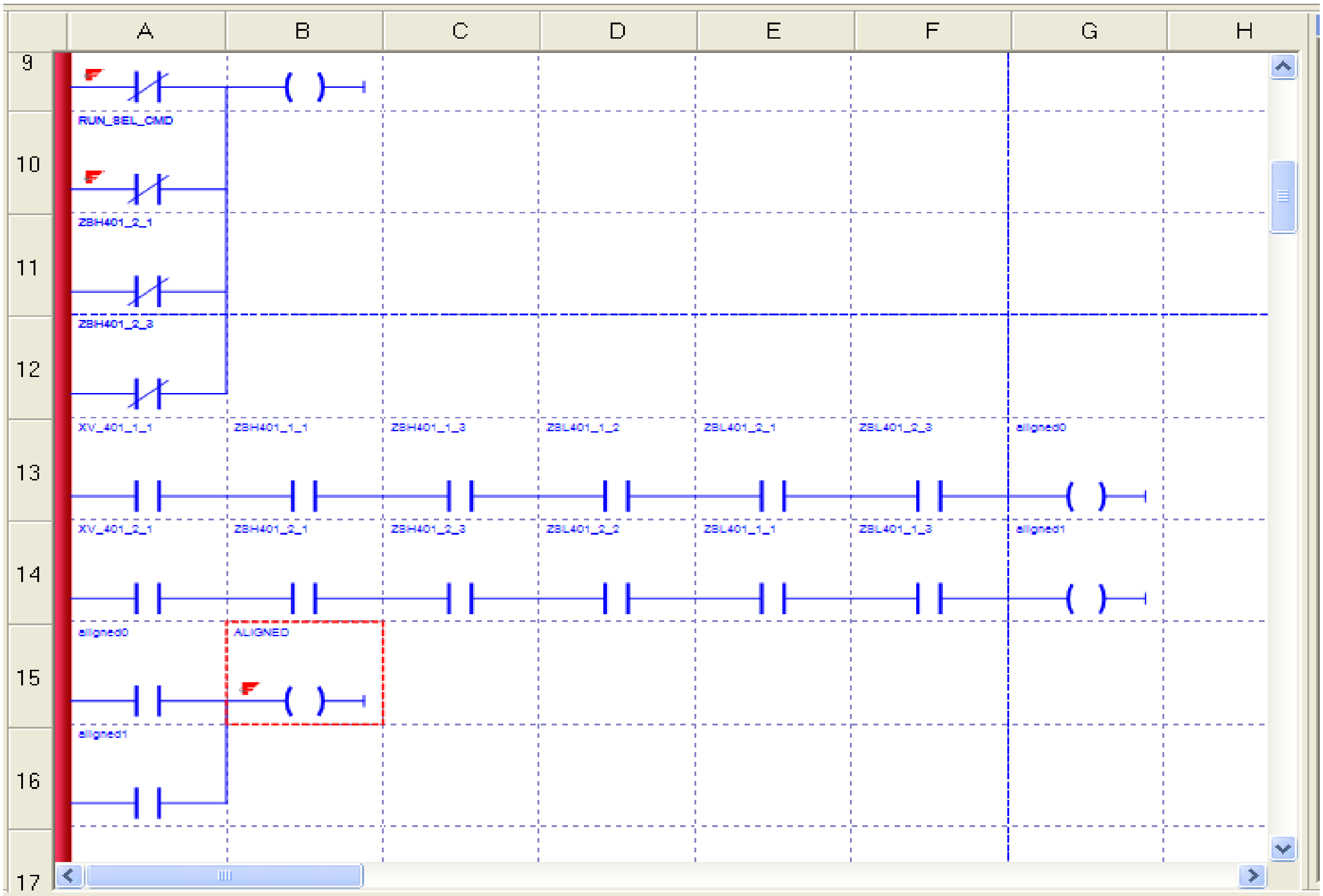


Figure 17.8 – Configuration of the Gasoline and Diesel Distribution – Ladder Logic

Variables changed with the Function Blocks Application:
FFB Inputs:

- PROVING_CMD : command of the user to align the prover
- RUN_SEL_CMD : command of the user selecting the meter to be calibrated

FFB Output:

- ALIGNED : indication that the meter selected for proving it is aligned

The following carefuls were considered:
a) To align the prover: first the valves are open for fluid to circulate by the prover (XV401-1-1 / XV401-1-3 and XV401-2-1 / XV401-2-3), after the limit switch of these valves indicate that the same are open, then the bypass valve of the prover is closed (XV401-1-2 and XV401-2-2).
b) For normal operation: first the bypass valves of the prover are open (XV401-1-2 and XV401-2-2), after the alignment valves of the prover are closed (XV401-1-1 / XV401-1-3 and XV401-2-1 / XV401-2-3).

Activate of the ON/OFF valves:
XV-401-1-1 = XV-401-1-3 = (PROVING_CMD * /RUN_SEL_CMD) + /ZSH401-1-2
XV-401-1-2 = /PROVING_CMD + RUN_SEL_CMD + /ZSH401-1-1 + /ZSH401-1-3
XV-401-2-1 = XV-401-2-3 = (PROVING_CMD * RUN_SEL_CMD) + /ZSH401-2-2
XV-401-2-2 = /PROVING_CMD + /RUN_SEL_CMD + /ZSH401-2-1 + /ZSH401-2-3

Alignment indication for concluded proving:
Aligned_0 = XV-401-1-1 * ZSH401-1-1 * ZSH401-1-3 * ZSL401-1-2 * ZSL401-2-1 * ZSL401-2-3
Aligned_1 = XV-401-2-1 * ZSH401-2-1 * ZSH401-2-3 * ZSL401-2-2 * ZSL401-1-1 * ZSL401-1-3
ALIGNED = Aligned_0 + Aligned_1

Chapter 18

AUDIT TRAIL AND DIAGNOSIS

Access Restriction

The change in the configuration with audit trail and access restriction uses access level and Password in the FCT block, represented as:

- **Authorized Person Level (AP)**: This is the only access level that allows changing the parameter SEALED_CONDITION to "sealed", specifically reserved for the Notified Body responsible for the validation of the measurement system. Another exclusive attribution of this access level is the firmware download. Besides, this level allows unrestricted access to the configuration, including configuration download. It is allowed only one login configured for Authorized Person and only this level of access can configure the corresponding password.
- **Administrator Level (AA):** This level allows the user to have complete access to change the configuration, including password configuration, logger initialization and configuration download. The exception is the configuration of password for login with access level Authorized Person.
- **Level 1 (A1):** It allows the download of the configuration and writing to all parameters, including critical ones.
- **Level 2 (A2):** It allows writing to regular parameters.

Some changes in the configuration have access restriction, but they are not trackable, such as the passwords and login configuration. These parameters are indicated by RA, R1 and R, according to the level required.

Before writing to the parameters being tracked, it is necessary to write to the parameter LOGIN or USER_NAME, and then to the parameter PASSWORD_CODE. If the Logon is executed with success, the user will have the time interval configured in the FCT.LOGON_TIMEOUT parameter to write to these parameters. Each time a parameter being tracked is written, this timeout is retriggered. After that, it will be necessary to write to the PASSWORD_CODE parameter again.

Password-Restricted Operations

The operator must be logged in the system to perform the following operations:

- Configuration Download: requires an Administrator level logon.
- Writing to specified parameters with access restriction: in this case, the access level required is defined in the block description (chapter 11), at the Index column in the parameters table.

Communication Restriction

The user must logon to the system to change the AuditFlow configuration using:

- Syscon;
- HFCView;
- Supervisory application through OPC Server, Modbus TCP/IP or Modbus RTU;
- Local Panel: Modbus TCP/IP or RTU.

The audit trail is warranted by any one of the applications listed above, because the AuditFlow system saves the configuration log in the device's NVRAM memory.

Logger Mechanism

The AuditFlow mechanism for audit trail has the following features:

- The HFC302 module saves the information in the NVRAM memory to generate the reports in HFCView, classified by the following types:
    - QTR: custody transfer reports (ticket);
    - Configuration log;
    - Parameterization;
    - Process alarme and event reports;
    - Proving reports;
    - Well Test reports;

- Average historic and totalizers.

- The logger uses the HFC302 NVRAM memory where the memory area is pre-allocated and has fixed size, independent from the configuration.

- The logger uses the FIFO logic (First In First Out). The reports are stored in a chronological sequence and the oldest report is discarded when a new report is generated in memory.

- Report storage in the NVRAM: all the parameters of the report are stored, after each one of the saved parameters are verified, writing-reading cycle (OIML R117:e07 - B.4.3.3.1). If there is discrepancy, the report is invalidated and it proceeds for the next area of memory, where are accomplished at the most more two attempts.

- When the new report is generated, it receives the "Not-stored" status. When HFCView reads and saves it in the database, this status changes to "Stored". Therefore the status indicates if the report has alredy been copied from the HFC302 memory to the database.

- During the process of reports upload the verification of report CRC is accomplished by HFC302 before sending it, confirming the integrity of the stored data. This same CRC for each report is verified also by HFCView received via Modbus, besides the verification mechanisms of each frame in the communication via Modbus TCP/IP or Modbus RTU.

- HFC302 can automatically print a report/register while saving in the database (this option is configured in HFCView).

- The report storage in the database by HFCView has also the feature of recording verification using the writing-reading cycle and the "hash code" method is used to verify the data integrity. The verification of "hash code" is accomplished also when the user is visualizing the report. When occur an error in the hash code when saving in the database or reading, the HFCView registers an event.

- Even after changing the report/register status to "Stored" in the logger (after saving to the database), the report/register continues in the HFC302 memory until being replaced by the FIFO algorithm. Meanwhile, it is possible to force a new reading and storage in the database, if it hasn't been registered yet, through the Restore operation in HFCView. Refer to the HFCView chapter for further information.

- There are two alarm levels related to the status of each type of logger: warning and overflow.

    - Warning: there is a report/register in the logger that hasn't been stored in the database yet and there is a risk of being overlaid by a new one. The warning alarm indication of the logger occurs when one of the five oldest registers/reports has the "Not-stored" status.
    - Overflow: The overflow alarm indication occurs when a report/register overflows another report/register with the "Not-stored" status, and in this case the user must acknowledge the alarm, writing to the LOG_STATUS parameter.
    - These alarms are indicated by the parameters WARNING and OVERFLOW of the FCT block.

- The HFC302 has a feature selectable by FCT.LOG_MODE=User acknowledge parameter, where the reports are overwrite in the memory only with the previous user's identification through the FCT.LOG_FULL parameter. This feature objectives to meet the OIMLR117:07 item 3.5.4. Other mode is the automatic mode (Automatic overwrite) of overwrite to generate a new report without the user's interference, but always maintaining indications of Warning and Overwrite, if there is it.

- There is a mechanism that allows only one specific computer running HFCView to transfer the reports/registers from the HFC302 to the database. While HFCView is storing the information from a specific HFC302, the value of the parameter FCT.HFCVIEW_VSN is confronted with the Volume Serial Number of the computer HD running HFCView.

Report Persistence in the HFC302 Memory

The persistence of the information in the logger follows the rules:

- When operating in normal conditions, a report/register of the logger is lost only when an overflow occurs, caused by a new report/register generation following the FIFO mechanism.
- Even after transferring the register/report from the NVRAM memory to the database using HFCView, and consequently changing the status to Stored, the register/report remains in the NVRAM memory.
- The HFC302 configuration download doesn't affect the registers/reports stored in the NVRAM memory.
- When downloading a compatible version of the firmware, regarding the logger, the registers/reports are preserved in the memory.
- In the “factory initialization” condition (after the firmware download or reset mode 1) or reset (when powering the equipment), the control variables of the logger, including the version of the logger, are checked and if any abnormality is detected, the variables will be initialized. This abnormality would imply in losing registers/reports in the memory.
- Writing successfully to the parameters FCT.GAS_QTR or FCT.LIQ_QTR initializes the QTR’s logger.

Report Type	Initialization
QTR (GTV,LTV)	• Configuring the QTR quantity for gas and liquid (FCT.GAS_QTR and FCT.LIQ_QTR), that is accepted if there is no QTR with status not-stored. • Abnormality in the control variables of the logger
Configuration Change (ATV) Alarms and Events (AEV) Proving Reports (LMFV) Well Test Reports (WTV) Average Historic and totalizers (HV) Periodic Totalizer (PTV)	• Abnormality in the control variables of the logger.

Configuration log of Foundation Fieldbus Transmitters

Observe the following items when configuring H1 Foundation Fieldbus devices to certify that the logger for configuration change will work properly:

- Use only RS, TRD, AI and DSP blocks in field devices, regarding the sensor data processing. Concentrate the calculation and processing in the HFC302.
- Disable the local tuning, removing the jumper from the Smar transmitters.
- AuditFlow system provides restricted access and stores the configuration change of all Smar Foundation Fieldbus transmistters.

Events Registered by AuditFlow

The following events are registered in the logger:

Registered event	Interpretation of the event and action executed by firmware	Possible causes and user's actions
Power down Power up	The HFC302 module was powered/ no powered or occurred reset of the CPU, caused by the own user or due to problem found by the firmware.	To verify the basic conditions of operation: mainly power, operation temperature, excessive electromagnetic noise, grounding of the system, etc. For problem in the firmware, to contact the Smar's technical support.
Override temperature used Override temperature cleared	Status of the temperature input in the block is "Bad" or "Uncertain".	Possible causes: - There is not link for the temperature input and the status is "Bad" or "Uncertain" - There was a break of the link for the temperature input. - Temperature transmitter was removed. - Temperature sensor (RTD or thermocouples) broken.
Override pressure used Override pressure cleared	Status of the pressure input in the block is "Bad" or "Uncertain".	Possible causes: - There is not link for the pressure input and the status is "Bad" or "Uncertain" - There was a break of the link for the pressure input. - Pressure transmitter was removed. - Pressure sensor with problem.
Override density used Override density cleared	Status of the density input in the block is "Bad" or "Uncertain".	Possible causes: - There is not link for the density input and the status is "Bad" or "Uncertain" - There was a break of the link for the density input. - Density transmitter was removed. - Density sensor with problem.
Override SW used Override SW cleared	Status of the BSW input in the block is "Bad" or "Uncertain".	Possible causes: - There is not link for the BSW input and the status is "Bad" or "Uncertain" - There was a break of the link for the BSW input. - BSW transmitter was removed.
Override Diff. pressure used Override Diff. pressure cleared	Status of the differential pressure input in the block is "Bad" or "Uncertain".	Possible causes: - There is not link for the differential pressure input and the status is "Bad" or "Uncertain" - There was a break of the link for the differential pressure input. - Differential pressure transmitter was removed. - Differential pressure sensor with problem.
Stop totalization / Block in O/S	Status of the input in the block is "Bad" or "Uncertain" and it was configured the option of override "Never use". Block in O/S caused by a configuration error.	Possible causes: - There is not link for the input and the status is "Bad" or "Uncertain" - There was a break of the link for the input. - Transmitter was removed. - Sensor with problem. - Configuration error
Bad pulse input occurred Bad pulse input cleared	It was not possible to read the module pulses.	Possible causes: - Error in the hardware configuration or CHANNEL parameter. - Module of pulse input with problem.
Bad analog input – flow	"Bad" Status in the flow analog input.	Possible causes: - There is not link for the flow input and the status is "Bad" or "Uncertain" - There was a break of the link for the flow input. - Flow meter was removed.
Inconsistent 2nd Vars occurred Inconsistent 2nd Vars cleared	Upstream static pressure and pressure smaller than differential pressure.	Possible causes: - Configuration error: to verify if absolute static pressure or gage, engineering unit for the static and differential pressures, etc. - Sensor with problem
Bad chromatograph occurred Bad chromatograph cleared	GC block detected problem in the natural gas composition.	

Registered event	Interpretation of the event and action executed by firmware	Possible causes and user's actions
Flowing Out of range correction factor occurred Flowing Out of range correction factor cleared	Instantaneous variable (temperature, pressure or density) out of range of applicability of the standard used to calculate the compensated flow.	Possible causes: - Configuration error to select the product to be measured.
Hourly Out of range correction factor occurred (if enabled in ENABLE_REPORT) Hourly Out of range correction factor cleared (if enabled in ENABLE_REPORT)	Weighted average of the hour variable (temperature, pressure or density) out of range of applicability of the standard used to calculate the compensated flow.	Possible causes: - Configuration error to select the product to be measured.
Daily Out of range correction factor occurred (if enabled in ENABLE_REPORT) Daily Out of range correction factor cleared (if enabled in ENABLE_REPORT)	Weighted average of the day variable (temperature, pressure or density) out of range of applicability of the standard used to calculate the compensated flow.	Possible causes: - Configuration error to select the product to be measured.
Monthly Out of range correction factor occurred (if enabled in ENABLE_REPORT); Monthly Out of range correction factor cleared (if enabled in ENABLE_REPORT)	Weighted average of the month variable (temperature, pressure or density) out of range of applicability of the standard used to calculate the compensated flow.	Possible causes: - Configuration error to select the product to be measured.
Batch Out of range correction factor occurred Batch Out of range correction factor cleared	Weighted average of the batch variable (temperature, pressure or density) out of range of applicability of the standard used to calculate the compensated flow.	Possible causes: - Configuration error to select the product to be measured.
Configuration download	The configuration download of the application was accomplished via Syscon.	Informative.
Rollover Hourly NRL_TOT_QB Rollover Daily NRL_TOT_QB Rollover Monthly NRL_TOT_QB Rollover Batch NRL_TOT_QB	The NRL_TOT_QB totalizer of the indicated period reached value superior to 10.000.000.000, returning automatically to zero.	Possible causes: - NKF configuration error of the flow meter - Configuration error of the engineering unit (FCT.GV_UNITS).
Initialization of loggers	All the reports in the HFC302 memory were deleted.	Informative.
Start of daylight saving End of daylight saving	Start and end of daylight saving, according to accomplished programming.	Informative.
Primary CPU - SNxxx	Indicates that CPU of indicated serial number assumed the control. This event is registered even in non redundant system during the power up.	If the system is redundant, to investigate possible problems in the hardware of CPU.
Restore of loggers	All the reports in the HFC302 memory were for not-stored state, therefore will be accomplished the upload of the same.	Informative.
HFC302 - low voltage battery – occurred HFC302 - low voltage battery – cleared	Low voltage of the battery (less than 2.5 V) that is used to preserve the configuration and HFC302 reports. This condition is indicated also in the RS block, BLOCK_ERR parameter, bit Lost NV Data.	To contact the Smar's technical support to replace the battery or HFC302 module.
GTV : Inconsistency fixed LTV : Inconsistency fixed LMFV : Inconsistency fixed	It was found inconsistency in the report type indicated. The consistence check is	Possible causes: - Low voltage of the NVRAM battery - NVRAM with problem

Registered event	Interpretation of the event and action executed by firmware	Possible causes and user's actions
WTV : Inconsistency fixed ATV : Inconsistency fixed AEV : Inconsistency fixed HV : Inconsistency fixed PTV : Inconsistency fixed	accomplished in the following situations: - power up of HFC302 - doing report upload If possible, the correction is accomplished, otherwise the report is disabled.	- Basic conditions of operation: operation temperature, power, excessive electromagnetic noise, etc. Possible actions: - factory init - HFC302 replacement
Rollover Hourly IV Rollover Daily IV Rollover Monthly IV Rollover Batch IV	The IV totalizer of the indicated period reached value superior to 10.000.000.000, returning automatically for zero.	Possible causes: - NKF configuration error of the flow meter - Configuration error of the engineering unit (FCT.LV_UNITS).
Bad GAS_QB_IN	Input status of GAS_QB_IN of the GT block is "Bad" or "Uncertain".	Possible causes: - There is not link for the input and the status is "Bad" or "Uncertain" - There was a break of the link for the input. - Transmitter was removed. - Sensor with problem.
Rollover Totalizer MR	The IV totalizer non-resettable reached value superior to 10.000.000.000, returning automatically for zero.	At first, it is a normal operation. The message is informative.
Rollover totalizer MMR	The mass totalizer non-resettable reached value superior to 10.000.000.000, returning automatically for zero.	At first, it is a normal operation. The message is informative.
Bad flash memory occurred Bad flash memory cleared	Flash memory where is stored the HFC302 firmware is with problem. This condition is indicated also in the RS block, BLOCK_ERR parameter, bit Memory failure. Block RS in O/S.	To do a firmware download. If the problem persist, to replace the HFC302 module.
Bad NVRAM-configuration occurred Bad NVRAM-configuration cleared Field "Value" indicates the Modbus base address to Holding Register.	NVRAM area used to store configuration is with problem. This condition is indicated also in the RS block, BLOCK_ERR parameter, bit Lost Static Data. Only the function block which was with problem of configuration will execute in O/S mode.	Possibles causes: - Low voltage of the NVRAM battery - NVRAM with problem - Basic conditions of operation: operation temperature, power, excessive electromagnetic noise, etc. Possible actions: - factory init - HFC302 replacement
GTV : bad cluster skipped LTV : bad cluster skipped LMFV : bad cluster skipped WTV : bad cluster skipped ATV : bad cluster skipped HV : bad cluster skipped PTV : bad cluster skipped Field "Value" indicates the report index.	When storing the report type indicated a problem in the memory was detected. Occurring this situation more two other different positions of memory are tried. This condition is indicated also in the RS block, BLOCK_ERR parameter, bit Memory failure. Block RS in O/S. This same event is generated also during the report upload if there was CRC error. Occurring this situation the report is deleted. It is not possible to register AEV problems, because there would be recursion.	Possible causes: - Low voltage of the NVRAM battery - NVRAM with problem - Basic conditions of operation: operation temperature, power, excessive electromagnetic noise, etc. Possible actions: - factory init - HFC302 replacement
Start of firmware download	Attempt of firmware download.	Informative.
New FW-Vx.xx.xx-Legal Vxxxxx	Firmware download accomplished successfully, indication of the new firmware version and new software	Informative.

Registered event	Interpretation of the event and action executed by firmware	Possible causes and user's actions
	version at legal control.	
Firmware download failure	Firmware download failure. The firmware installed was deleted.	Possible causes: - Ethernet communication failure - Firmware download failure A new firmware download must be accomplished. Persisting the failure: - To try the firmware download in an isolated ethernet network - Replacement of the HFC302 module - To verify the authenticity of the firmware file
Inconsistent flow rate	Invalid value in the flow rate: Flow rate (Pulses/NKF/macrocycle) or LFLOW/GFLOW : it is greater than ROLLOVER or equal to +INF/-INF/NAN. Firmware action : set flow rate to zero	Possible causes : - Configuration error in the NKF - Invalid value linked to LFLOW/GFLOW input.

Procedure before the Configuration Download and/or Firmware Download

The reports in the HFC302 memory are preserved during the configuration download, but it depends on the compatibility of logger version for firmware download.
It is recommended in both situations the following procedure before executing the download:

- Stop the product transferring;
- Finish the batches through reset command, it will cause report generation with the transferred quantities;
- Let HFCView read all reports and store them in database;
- Execute the firmware and/or configuration download.

Blocks in Transmitters with Configuration Log

The parameter list of each block type below refers to the tracking (A2), when running in a field device.

Parameter List:

RS Block :

Rindex	Mnemonic
5	MODE_BLOCK

AI BlocK:

Rindex	Mnemonic
3	STRATEGY
5	MODE_BLOCK
8	OUT
9	SIMULATE
10	XD_SCALE
11	OUT_SCALE
13	IO_OPTS
14	STATUS_OPTS
15	CHANNEL
16	L_TYPE
17	LOW_CUT
18	PV_FTIME

TRD-LD:

Rindex	Mnemonic
3	STRATEGY
5	MODE_BLK
16	CAL_POINT_HI
17	CAL_POINT_LO
22	SENSOR_SN
34	DEAD_BAND_BYPASS
40	BACKUP_RESTORE
41	SENSOR_RANGE_CODE
42	COEFF_POL0
43	COEFF_POL1
44	COEFF_POL2
45	COEFF_POL3
46	COEFF_POL4
47	COEFF_POL5
48	COEFF_POL6
49	COEFF_POL7
50	COEFF_POL8
51	COEFF_POL9
52	COEFF_POL10
53	COEFF_POL11
54	POLYNOMIAL_VERSION
55	CHARACTERIZATION_TYPE
56	CURVE_BYPASS_LD
57	CURVE_LENGTH
58	CURVE_X
59	CURVE_Y
64	CAL_TEMPERATURE
69	ACTUAL_OFFSET
70	ACTUAL_SPAN

TRD-TT:

Rindex	Mnemonic
3	STRATEGY
5	MODE_BLK
13	PRIMARY_VALUE_TYPE
16	CAL_POINT_HI
17	CAL_POINT_LO
20	SENSOR_TYPE
27	SENSOR_CONNECTION
31	SECONDARY_VALUE_ACTION
32	BACKUP_RESTORE
38	TWO_WIRES_COMPENSATION
39	SENSOR_TRANSDUCER_NUMBER
41	FACTORY_GAIN_REFERENCE
42	FACTORY_BORNE_REFERENCE

TRD-DT:

Rindex	Mnemonic
3	STRATEGY
5	MODE_BLK
10	TRANSDUCER_TYPE
16	CAL_POINT_HI
17	CAL_POINT_LO
22	SENSOR_SN
34	ERROTMVIEW
40	BACKUP_RESTORE
41	SENSOR_RANGE_CODE
42	COEFF_POL0
43	COEFF_POL1

Rindex	Mnemonic
44	COEFF_POL2
45	COEFF_POL3
46	COEFF_POL4
47	COEFF_POL5
48	COEFF_POL6
49	COEFF_POL7
50	COEFF_POL8
51	COEFF_POL9
52	COEFF_POL10
53	COEFF_POL11
54	POLYNOMIAL_VERSION
55	CHARACTERIZATION_TYPE
56	CURVE_BYPASS_LD
57	CURVE_LENGTH
58	CURVE_X
59	CURVE_Y
64	CAL_TEMPERATURE
69	ACTUAL_OFFSET
70	ACTUAL_SPAN
75	GRAVITY
76	HEIGHT
77	MEASURED_TYPE
78	LIN_DILATATION_COEF
79	PRESS_COEF
82	ZERO_ADJUST_TEMP
83	HEIGHT_MEAS_TEMP
84	AUTO_CAL_POINT_LO
85	AUTO_CAL_POINT_HI
86	SOLID_POL_COEFF_0
87	SOLID_POL_COEFF_1
88	SOLID_POL_COEFF_2
89	SOLID_POL_COEFF_3
90	SOLID_POL_COEFF_4
91	SOLID_POL_COEFF_5
92	SOLID_LIMIT_LO
93	SOLID_LIMIT_HI
95	SIMULATED_PRESS_ENABLE
96	SIMULATED_PRESS_VALUE
97	SIMULATED_DENSITY_VALUE
101	DT_RANGE_CODE

TRD-IF:

Rindex	Mnemonic
3	STRATEGY
5	MODE_BLK
16	CAL_POINT_HI
17	CAL_POINT_LO
25	TERMINAL_NUMBER
26	BACKUP_RESTORE
31	FACTORY_GAIN_REFERENCE

Data Structure Types with Configuration log

Besides the simple data types defined by Fieldbus Foundation (FF-890 item 5.3.1. data type from 1 to 14, and 21) for the function blocks, as well as the data type arrays, the following structures are also available for tracking:

DS-65: Value & Status – Floating Point Structure
DS-66: Value & Status – Discrete Structure
DS-68: Scaling Structure
DS-69: Mode Structure
DS-82: Simulate – Floating Point Structure
DS-83: Simulate – Discrete Structure

Note
All elements from the structures above appear as one single register in HFC302 and, consequently, in the configuration change report printed by HFCView. For the others structure types, each structure element is a register.

Reports/Registers Provided by HFC302

The HFC302 NVRAM memory provides the following number of registers/reports:

Type	Description	Quantity
GTV,LTV	QTR (operational, hourly, daily, weekly, monthly) (*)	1000
AEV	Alarms and events	300
ATV	Configuration changes	400
-	Parameterization	Use only database
LMFV	Proving report	10
WTV	Well Test report	2
HV	Average Historic and totalizers	10
PTV	Periodic totalizers	210

(*) The quantity of reports specified for QTR is related to the total available for the module. The user configures the quantity used for liquid measurement (FCT.LIQ_QTR) and for gas measurement (FCT.GAS_QTR). So, the quantity specified for liquid measurement in FCT.LIQ_QTR parameter indicates the total quantity available for all liquid measurements, including station, for this HFC302, and for all report types (batch, hourly, daily, weekly, monthly, operational and reset, except summary reports). Similarly, the rules for liquid measurements are applied to gas measurements.

Diagnosis of the HFC302 Memory

The HFC302 flow computer module has online and periodical diagnosis of the memories meeting to OIML R117:e07 - B.4.3.3.1 for:

Memory Type	Content	When is accomplished: periodicity/event	Diagnosis accomplished	Indication/action in case of failure
Flash	Firmware (algorithm)	• Power up • Every 5 minutes	CRC calculation of whole memory.	RS block, BLOCK_ERR parameter, bit Memory failure. RS block in O/S and consequently all the other blocks.
NVRAM	Configuration of the specific blocks of measurement	1 block/macrocycle	CRC calculation of the configuration parameters.	• RS block, BLOCK_ERR parameter, bit Lost Static Data • Event “Bad NVRAM-configuration occurred” • Block executes in O/S mode.
NVRAM	Logger (reports)	When storing and report upload	CRC calculation of the report when storing and verifying all the report elements after the storing. In upload, verify the CRC. HFCView verify also this CRC in report upload.	• Indicates the event “xxV : bad cluster skipped” • Occurring failure when storing, other positions of memory are tried up to twice. • Occurring failure in report upload, the report is unconsidered.

Safety Mechanism of the HFC302 Firmware Download

The HFC302 has many safety mechanisms for firmware download, shown below:

- Use the FBTools to identify the software version according to procedure described in “Software Installation” chapter in “Visualizing and Updating the Firmware” section.
- The software version at metrological control is indicated in the LEGAL_SW_VERSION parameter FCT block.
- Indication of events for audit trail meeting Welmec-7.2 requirement D4: a) start of firmware download; b) firmware version and software version at metrological control which was installed; c) indication of download failure, if it occurs;
- To protect that the firmware download be accomplished of intentional mode, but inadmissible, the HFC302 only change for Hold (mode for firmware download) through frontal switches of the module. Therefore only breaking the seal panel will be possible to accomplish the firmware change, when the measurement system was approved by the legal metrological body. Unlike HFC302, other CPUs of the System302 allow the change for Hold via software for command. (Welmec-7.2 requirement P6).
- The integrity of firmware download in the HFC302 is guaranteed by the intrinsic mechanisms to Ethernet and for the mechanisms especially developed for verification and validation after the transfer of the whole firmware and before to start the firmware download (Welmec-7.2 requirement D3).
- The integrity of firmware recorded in Flash memory is verified after the firmware download, in the power-up process and periodically every 5 minutes.

Chapter 19

HFCVIEW

Overview

The HFCView is the software tool used during the operational phase, that is, after the installation, configuration and startup of the measurement system using the AuditFlow.

The main functionalities provided by HFCView are:
• Monitoring of the main measurement variables simultaneously.
• Supervision and parameterization of the main HFC302s function blocks through Modbus standard commands.
• Transfer, schedule and automatic printer of the reports from the HFC302 memory to the database, through task executed in background.
• Modbus mapping file generation of the HFC302 for other applications.
• Configuration Log generation: to keep the information of HFC302 configuration.
• Portuguese and English language.
• Multiple printers.
• Redundant HFC302's.
• Automatic update of the HFC302 internal clock.
• Personalized reports.
• Data recovery from database through HFC302 memory in case of failure.
• SQL Server compatibility.
• Database navigation for visualization and report print.
• Use protection through hardkey.
• Access restriction in the database to guarantee the inviolability.
• Exports data in XML.

NOTE
Only one instance of the HFCView should be enabled to do report upload for each HFC302, avoiding that the reports are in different database.

Figure 19.1

Starting HFCView

The HFCView can be started from Start menu, because it is installed inside the System302 menu.

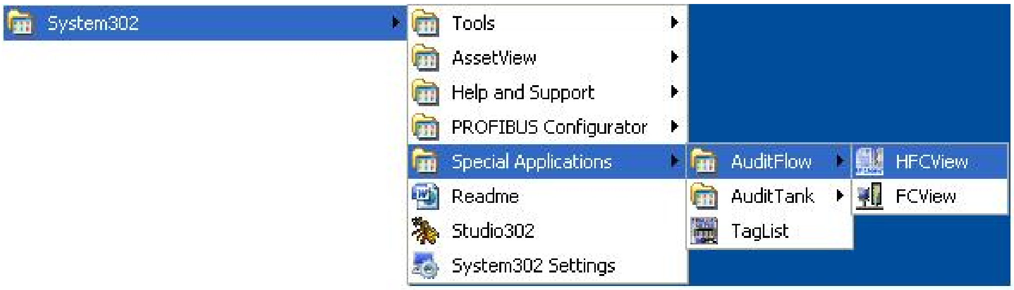


Figure 19.2

The HFCView receives the user with the welcome window. Uncheck the confirmation box and the message will not be shown again.

Figure 19.3

When starting the HFCView at the first time, it is necessary to provide a list of HFC302 flow computers that will be monitored, that is, to provide the IP address and the ID Modbus of each device. As when the user to request the "Connect" process, the HFCView will read the configurations from HFC302's, then it will be capable to accomplish the supervision of the measurement loops and the reports reading.

List of Flow Computers

The configuration of the Flow Computers List is the first procedure to be executed in HFCView after the installation. In this process, HFCView will have all necessary information to establish the communication with the devices, besides in case of network redundancy and HFC302 module redundancy.

The user can associate a specific printer for each HFC302 registered. If the printer is not selected or if the printer is deleted later, the HFCView will use the system default printer.

After opening HFCView, to start the configuration process of the Flow Computers List, click **Process → Flow Computers → Flow Computer List...**

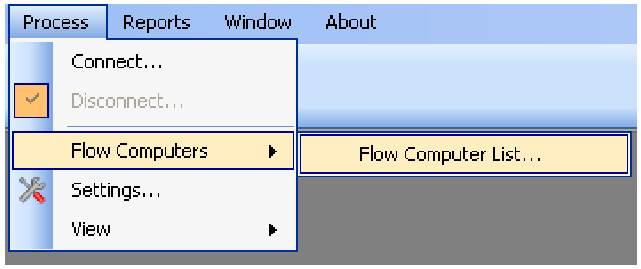


Figure 19.4

Enter with the IP information, Modbus address and printer and click **Add** to add in the main list. The user can change and remove the IP's settings.

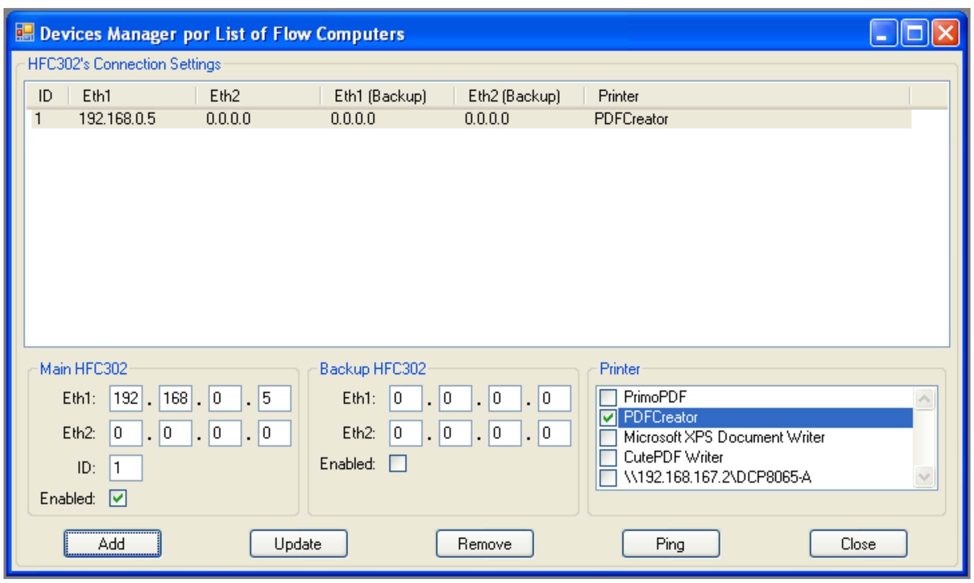


Figure 19.5

The HFC302 can be “Stand-alone” or redundant type. The redundancy can be of network, of HFC302 or both. The user should provide the redundancy data according to screen during the IPs register.

The HFC302s IPs can be tested through the **Ping** option.

NOTE
It is **mandatory** that at least one printer is installed in Windows, because the HFCView uses the printer settings for the navigation of the reports on screen.

Connection

The Connection process establishes the communication with the devices from the List of Flow Computers and obtains the following information of each equipment:

- **Topology Data**: tag, serial number, firmware version, redundancy state
- **HFC302 Block List**: blocks instantiated in each HFC302
- **Engineering Units**: the parameters that describe the units in the FCT block;
- **Safety Data**: parameters as the HFCVIEW_VSN of the FCT block.

This process is executed when the communication connection is requested.

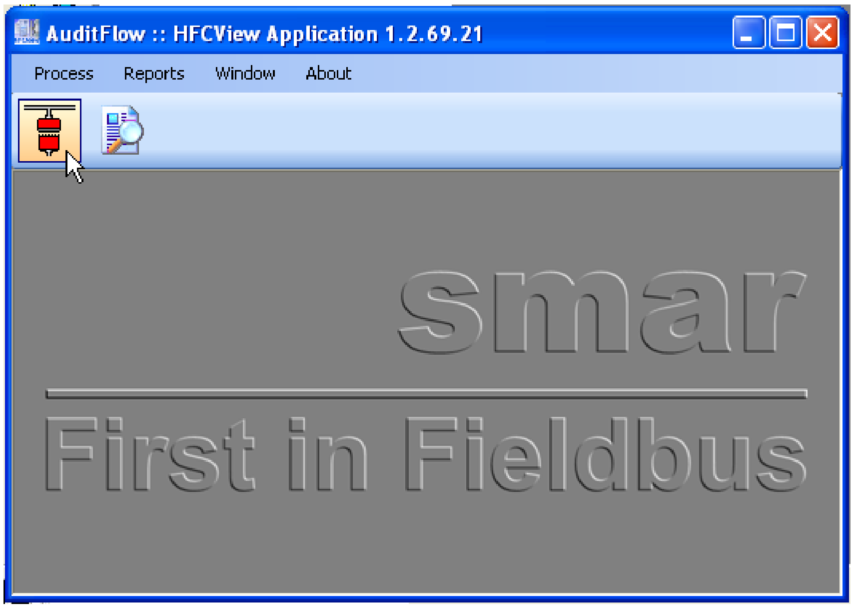


Figure 19.6

If the connection process was accomplished with success, HFCView begins the reports extraction from the HFC302 memory (Process of Background) and it allows to the user to open the operation/supervision screens.

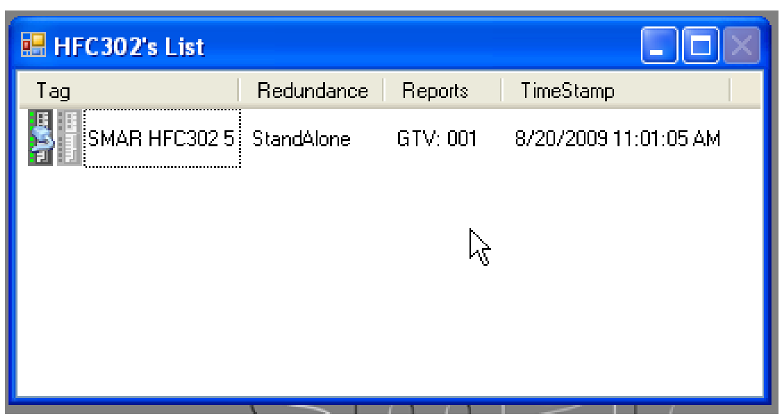


Figure 19.7

All tasks associated to HFC302 can be done through main popup menu. To activate this menu, right-click the HFC302 desired.

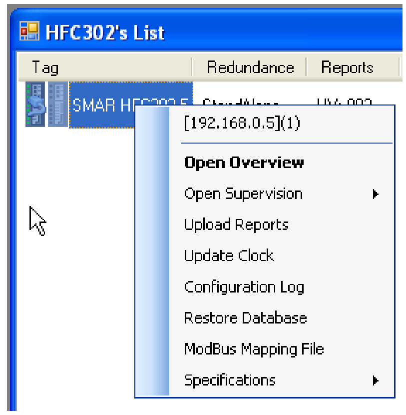


Figure 19.8

NOTE
Depending on the communication status, some functions of the main menu can be disabled.

In case of communication failure, the HFC302 main icon shows an error signal informing to the user that something is not correct.

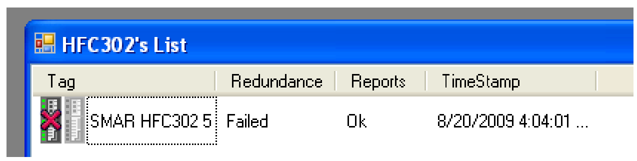


Figure 19.9

Reports

Report Extraction

When establishing the connection with the flow computers, the HFCView is responsible for extract the reports. The HFCView extracts all pending reports in an only attempt, but when ending the task or in cases of communication failure, the HFCView will try again in the interval defined through the events configuration screen (Schedule).

The current status of the reports extraction is showed in the following figure.

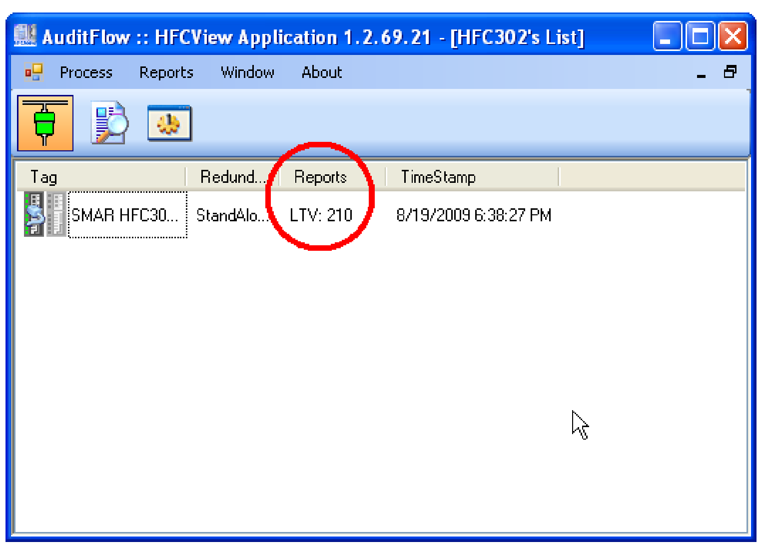


Figure 19.10

The HFCView, for each extracted report, accomplishes one calculation of CRC to verify the data integrity. In case of CRC errors the HFCView will be blocked of transferring the invalidated report.

Besides the check of CRC during the reading of the reports, HFCView generates a new calculation of CRC when storing the data of a report. This new code is used during the reports search and to guarantee that the data were not changed after the extraction phase from HFC302 memory. If some report was corrupted, a red stripe will indicate that the report is invalid.

If the HFCVIEW_VSN configuration parameter of the FCT block is configured with a different number of the serial number of the installation partition, the HFCView will be blocked of transferring reports. Like this, if to appear a padlock in the HFC302 main icon that indicates the parameter is enabled and the reports will be just transferred through another HFCView, which the serial number of the partition coincides with the number recorded in the parameter. This mechanism avoids that two HFCViews transfer reports at the same time, may cause an inconsistency of the data. Another option is to clean the parameter, disabling the mechanism.

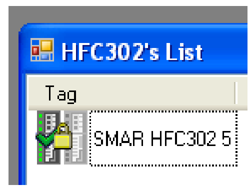


Figure 19.11

The frequency of reports checking is configurable through the events configuration screen (Schedule). It is possible to choose the checking by seconds, days or by hour and minute selected.

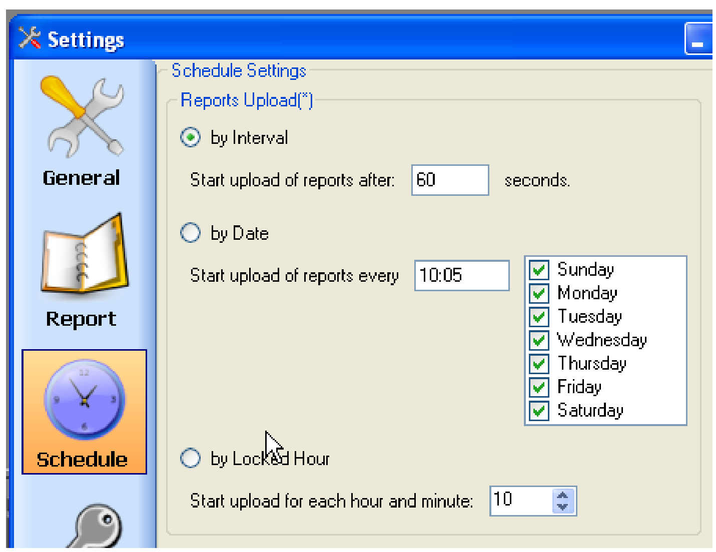


Figure 19.12

Report Visualization

The extracted reports from the HFC302 memory can be visualized from HFCView through a consultation interface. This interface can be opened in the menu **Reports -> Search**... or by icon in the toolbar.

Figure 19.13

The search is done for each report type and HFC302 Tag. The user can enter further data for filtering, but are optional. If there are not reports of the selected type in the database, the **Device Tag** field will not have any option to select. But when this field is blank, it will search in more than one HFC302.

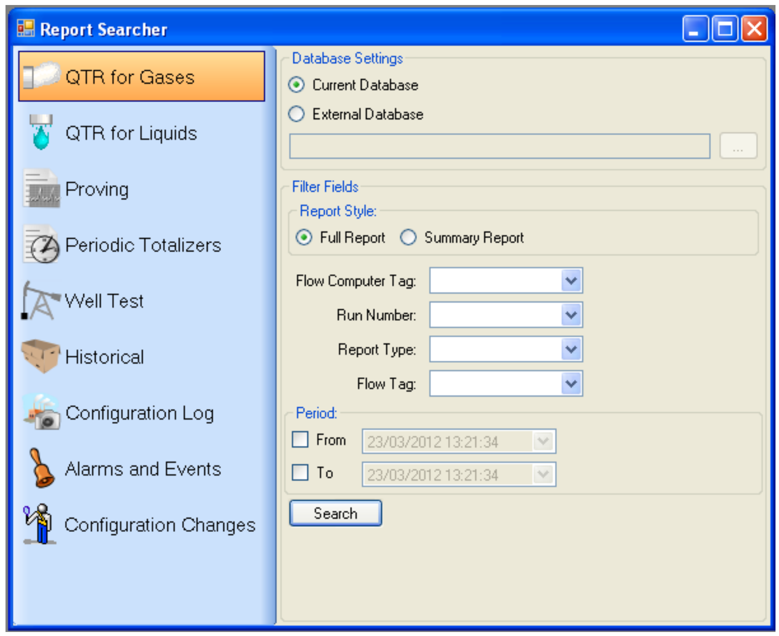


Figure 19.14

The search result is a navigation screen of reports where for each new search, a new result screen will be shown.

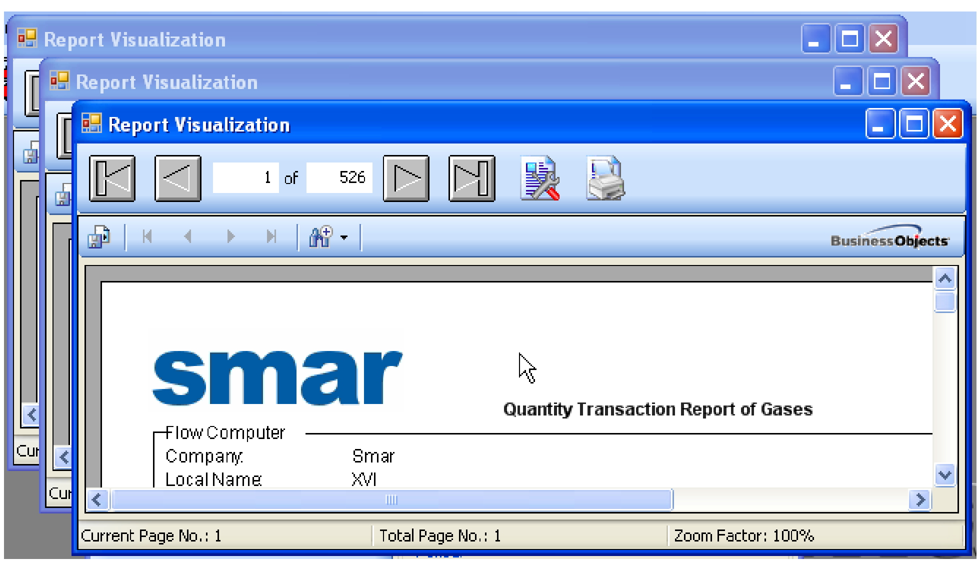


Figure 19.15

HFCView becomes available the report search from the current database or from any external file (Backup), which this was generated by the HFCView.

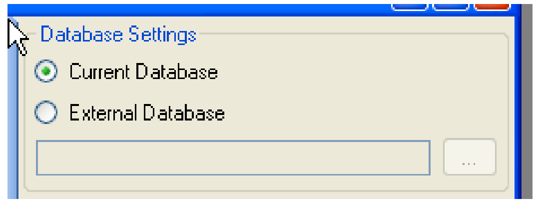


Figure 19.16

All reports searched from database include information on the top right informing that the report is a copy.

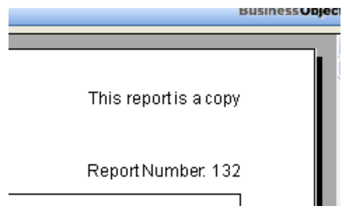


Figure 19.17

Registers Navigation (Reports)

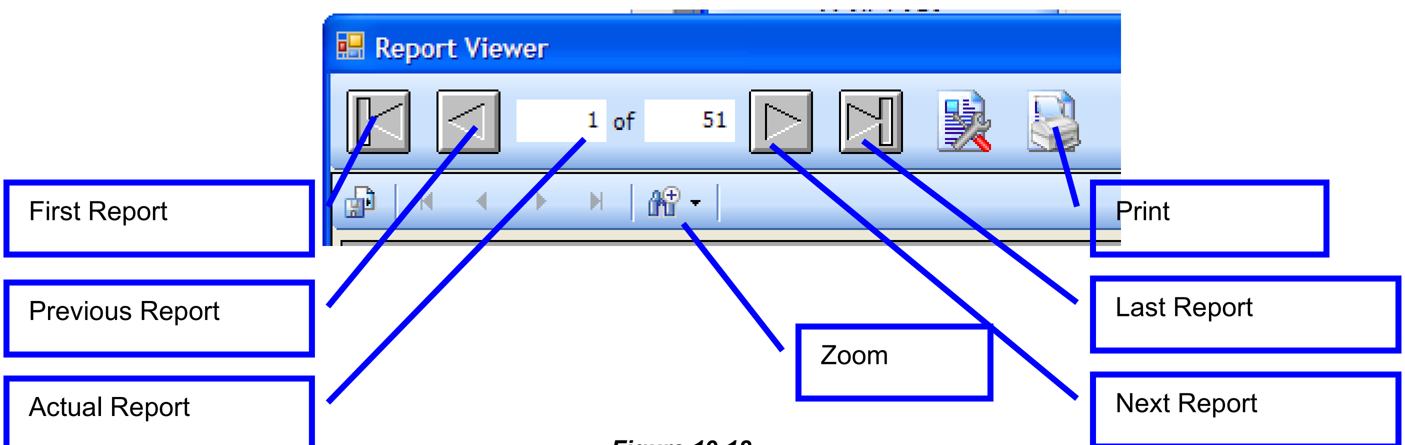


Figure 19.18

Selected report navigation page

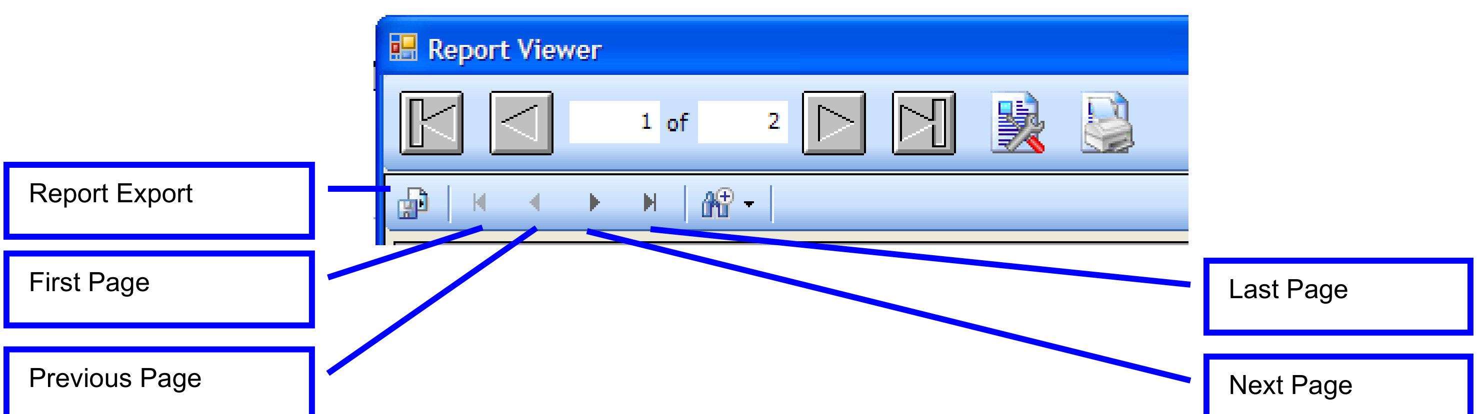


Figure 19.19

Printing Reports Displayed

The HFCView allows the stored reports in the database were printed after consulting them, by clicking the print menu.

Figure 19.20

The user can change the print configuration by the following button:

Figure 19.21

The changes include paper size, orientation, margins and printer configuration.

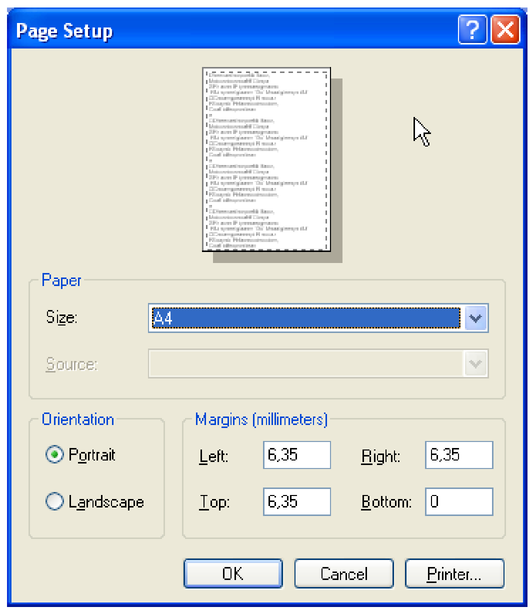


Figure 19.22

Automatic Print of Reports Extracted from the HFCView Memory

The report automatic print occurs when a report is extracted from the HFC302 memory. This is optional and by default is disabled.

In the printed report through the automatic print, the label which indicates the report is a copy disappears, because this process collects data directly from the HFC302 memory.

To configure the automatic print, menu **Process** → **Settings...** → **Report**.

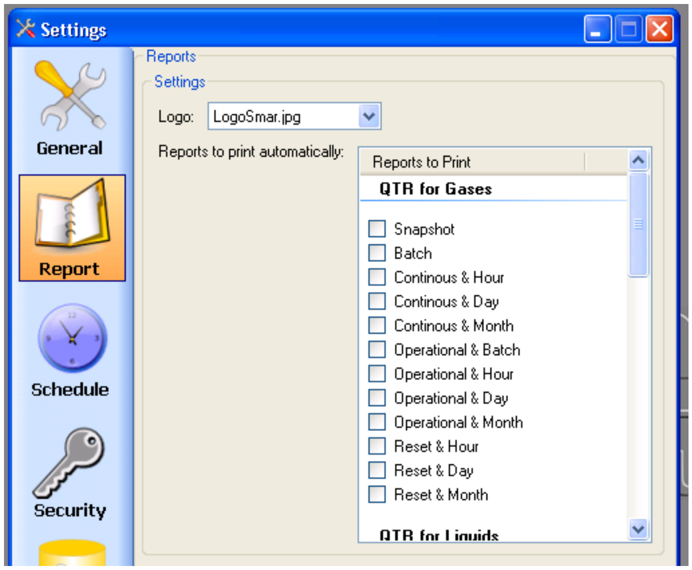


Figure 19.23

The user can activate the automatic print by report type selecting the option desired.

Configuration Log Report

The Configuration Log report allows the user to read the parameterization of the HFC302 blocks on the report format, and many reports can be generated along the time. So the operator can reconfigure the device if it is replaced or when the data is lost and also to compare differences in the parameterization in different times.

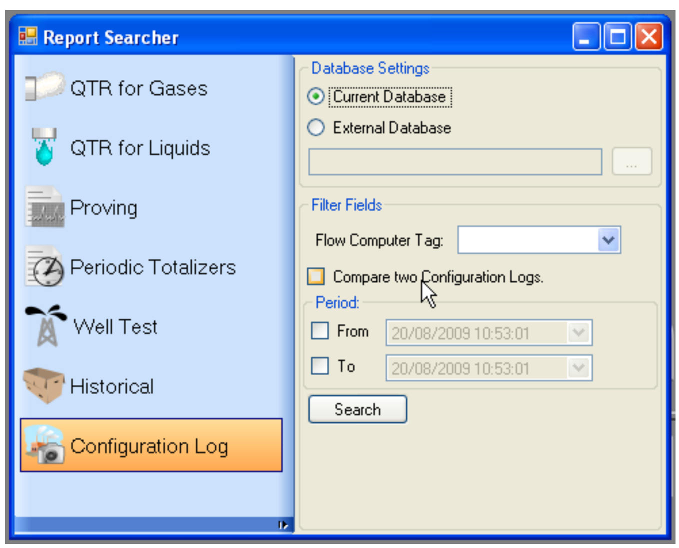


Figure 19.24

To generate a new report of Configuration Log, the user should request the task through popup menu on HFC302.

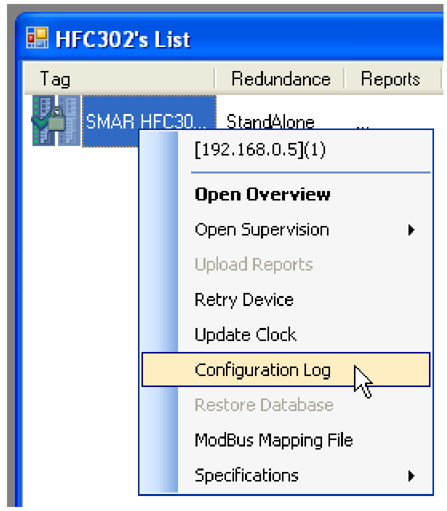


Figure 19.25

Operational and Supervision Screens

The operation and supervision mode of the HFCView is divided in two forms: **Graphical Overview** and **Detailed Supervision.**

Graphical Overview: a way to provide a visualization of the main measuring variables: inputs measured by the transmitters, weighted average, correction factors, corrected flow (gross and net), status simplified of the period and summary information about process alarm of the measured flow.

To open the overview screens, activate the popup menu of the HFC302 and click **Open Overview**.

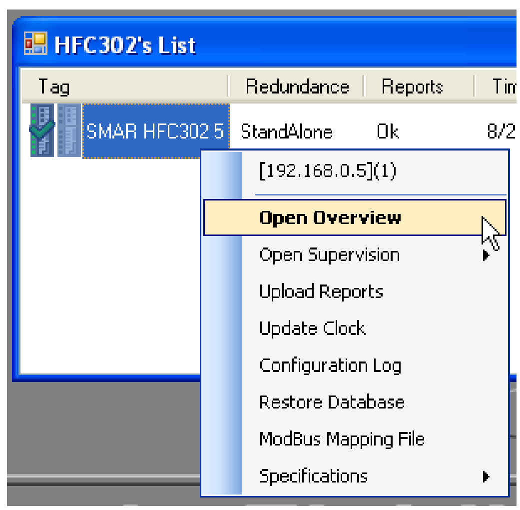


Figure 19.26

If the measurement runs are set, then until Graphical Overview screens will be available. The measurement loops are divided between the GT and LT blocks.

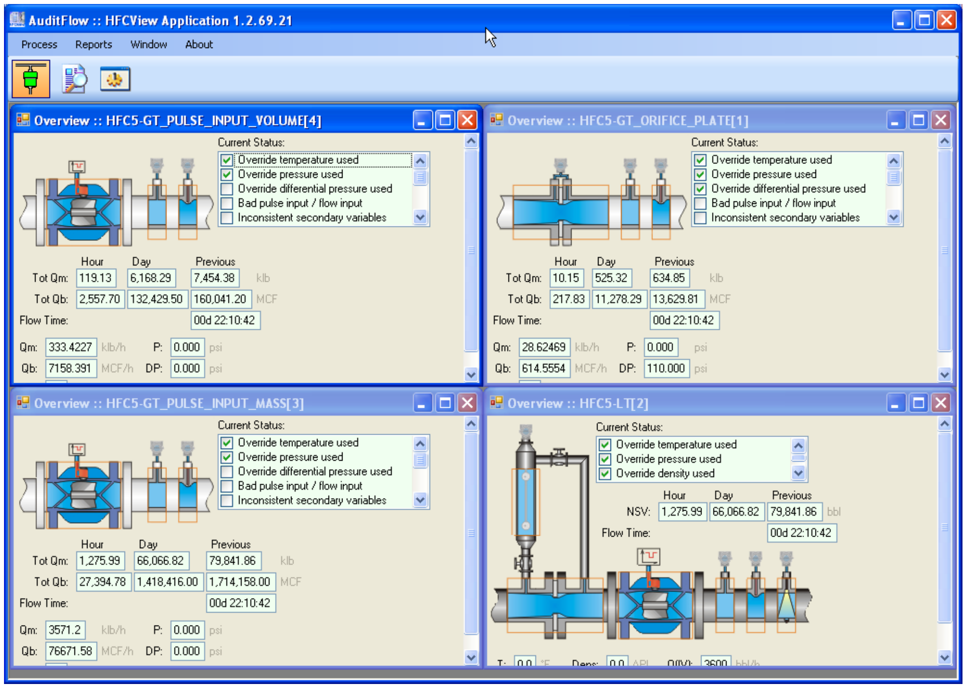


Figure 19.27

NOTE
The Graphical Overview task is finished when all the overview screens are closed. If one of the screens was closed accidentally it is necessary that the other screens are closed and the Graphical Overview is activated again.

Detailed Supervision: through Modbus standard commands, the HFCView monitors and interacts with the main function blocks of the HFC302, allowing the total parameterization and eliminating the use of configurator and other supervisory systems.

The Detailed Supervision screens are grouped in: Operation, Configuration, Maintenance, Startup Settings and Batch Schedule. Each one can have one or more blocks and subgroups.

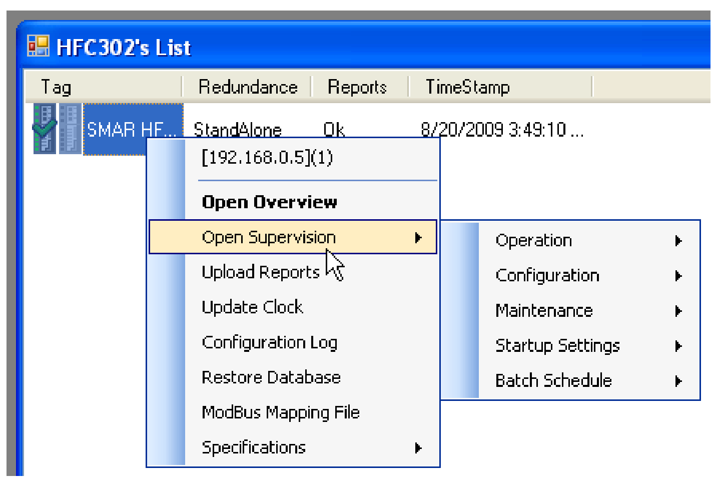


Figure 19.28

To access one of the Detailed Supervision screens, activate the popup menu on HFC302 and click in the block of the group desired.

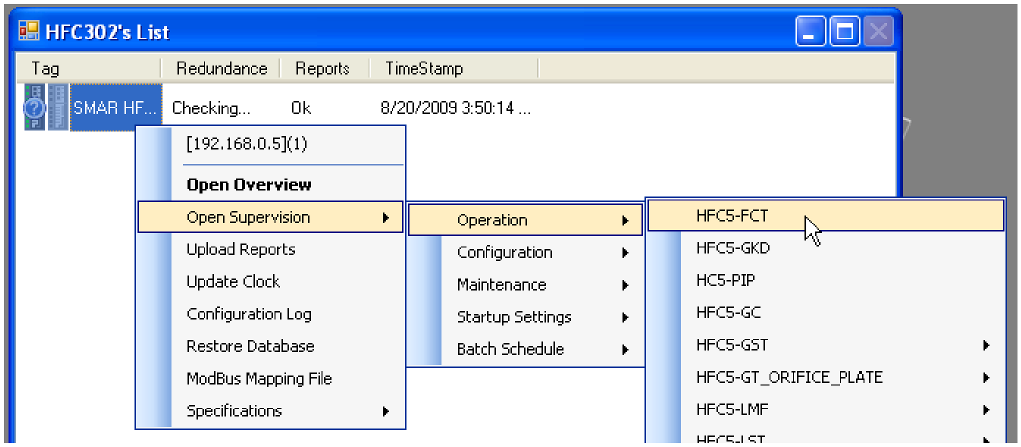


Figure 19.29

For limitation of the Modbus commands, it is allowed only one Detailed Supervision screen per time, i.e., when trying to open other screen, the oldest screen will be closed automatically. The limitation is applied only to a same HFC302, i.e., if exist 2 HFC302s configured, then it is possible to open a Detailed Supervision screen for each one.

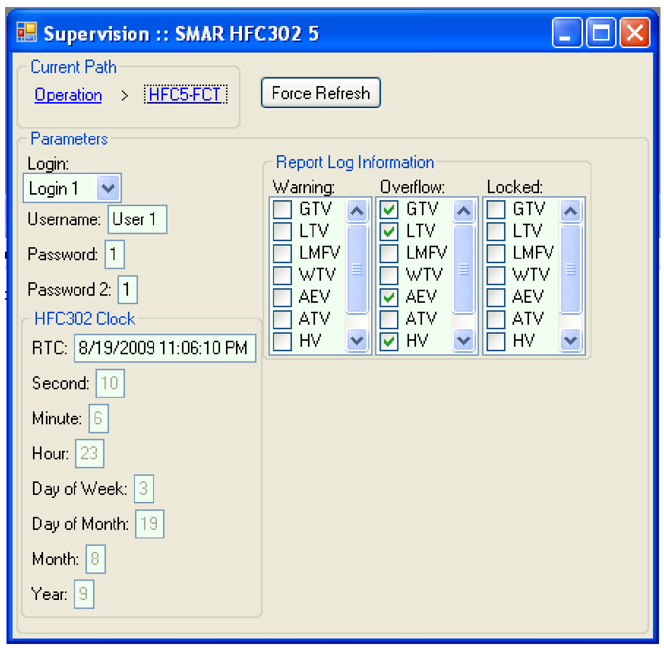


Figure 19.30

The Detailed Supervision screens allow the parameters writing. Just type or click the field with access of Read/Write to edit the value, changing the color of the field for YELLOW until to press ENTER to confirm the written.

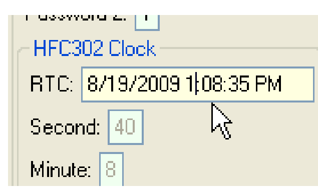


Figure 19.31

Database Restore

The HFCView allows recovering the database from the HFC302 memory. Once this recovery is requested, all reports are checked to be extracted again.

During the process, the HFCView verifies if the report which is being recovered is already in the database, thus preventing duplicity.

To execute this recovery, right-click on the HFC302 selected and selects the **Request Restore Database** option.

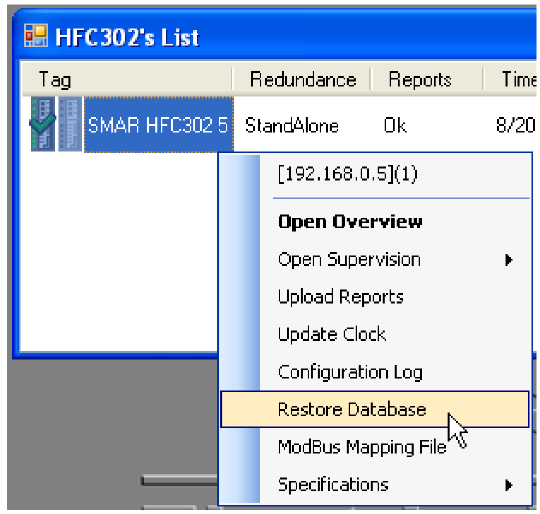


Figure 19.32

Configuring the HFCView

The HFCView has some important configurations. To open the configuration screen, click **Process → Settings**.

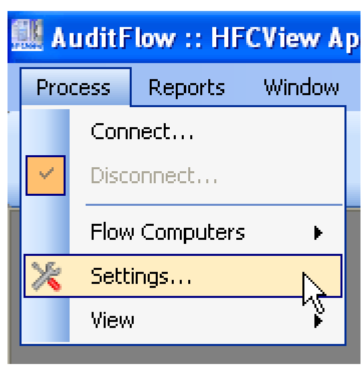


Figure 19.33

Scheduling

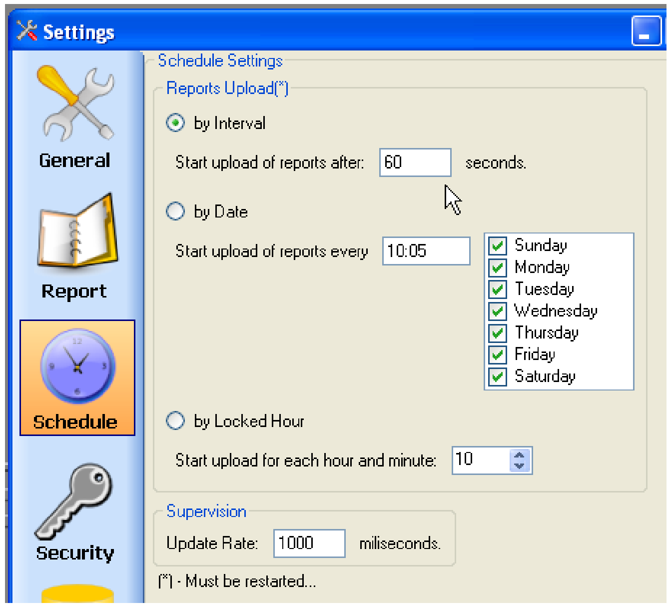


Figure 19.34

Scheduling Settings: For the scheduling of reports extraction there are three options to optimize the communication with the flow computers, mainly in SCADA system:

- Interval: It defines the periodicity that HFCView will verify the existence of a new report in the memory of the flow computers.
- Date: It defines the week days and the hour that the verification of the new reports will be accomplished.
- Locked Hour: the periodicity to verify the existence of new reports is hourly and the user can configure the minutes in that it will be accomplished.

Supervision: Configuration of the update periodicity of supervision variables.

Report

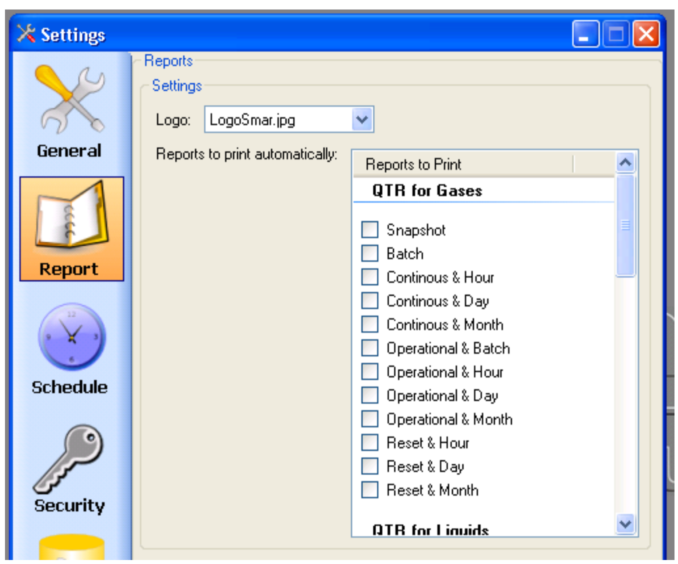


Figure 19.35

It allows the configuration:

- Logo to be inserted in the reports
- Report type to be printed automatically when extracted from the HFC302 memory.

NOTE
The language of the reports, as well as their format, will be the same used by user interface.

General

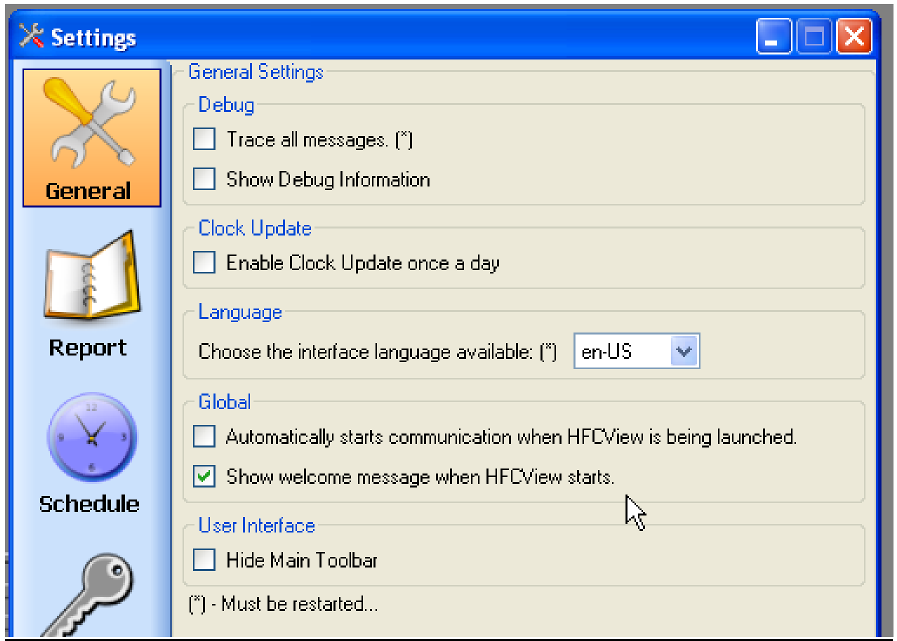


Figure 19.36

Debug: During a support can be necessary to enable these options to supply information more exact about the tool. Maintain the options disabled to optimize the performance and to minimize the space in hard disk.

Clock Update: It allows enable synchronism of the real time clock of the flow computers based on the real time clock of the computer that is executing the HFCView. The adjustment is done automatically once a day, but such adjustments will be implemented successfully if the difference is less than five minutes, i.e., this mechanism should just be used to correct deviation problems that accumulate along the time.

Language: It allows changing the language of the interface, the format of the number data and report dates and operation screens.

Global: It allows enabling the automatic start of the connection with the HFC302 and to show or not the welcome screen when starting the HFCView.

User Interface: It allows hiding the task main bar, allowing more space in the screen.

Security

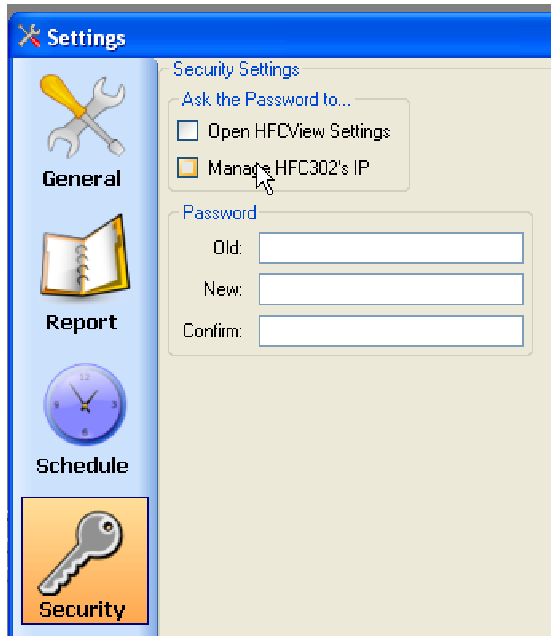


Figure 19.37

The HFCView allows blocking the access to the configuration menu and to the HFC302s IPs register. Just enable the options and register a new password. Initially HFCView does not have configured password, it can be blank.

Database

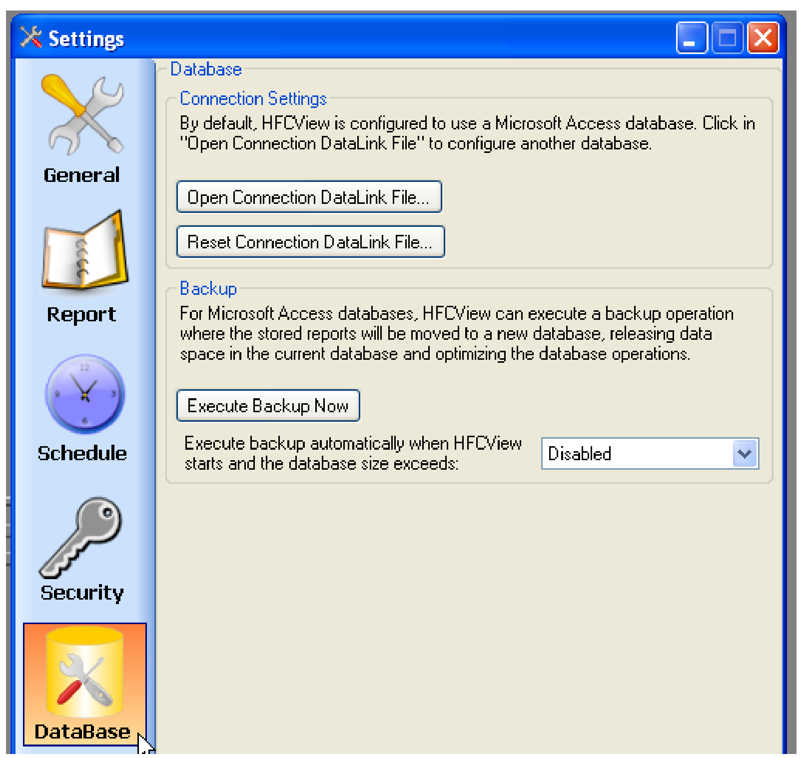


Figure 19.38

The configuration of the HFCView database can be changed by this screen, but another possible way is to edit the file "connection.udl" which is in "Database" folder in the installation directory of HFCView.

As the database used is standard, i.e., MS Access, HFCView can accomplish backup routines during its initialization, cleaning the database and storing the report data in the backup directory, in the HFCView installation folder. The verification of the database size is disabled by default.

The HFCView also supports SQL Server and maintains in the \Database\SQL2005 folder a ZIP file, a MDF compressed file, named HFCVIEW_DATABASE.ZIP. To use the SQL Server as database, the user has to extract the MDF file and make the operation "Attach Database" through a manager. It is recommended that the user has the guidance of a DBA during this operation.

NOTE
For specification, the MS Access database supports up to 2 GB, however it is not recommended to reach this size due to performance and data integrity.

Hardkey

To execute HFCView it is necessary to install the hardkey. This hardkey is obtained with the System302 license.

If appear an error message as the figure below, the user should contact the Smar to request a new license of HFCView.

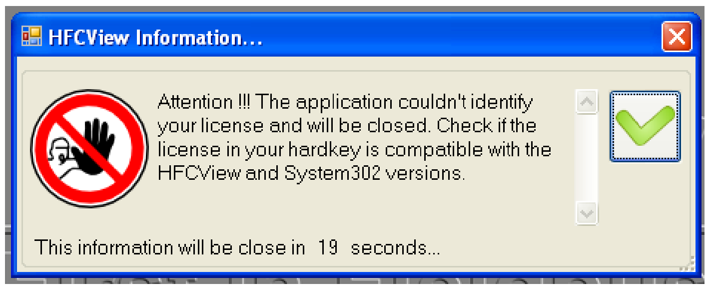


Figure 19.39

If the error persists, verify the hardkey operation through the licenses administration tool of the Studio302.

Automatic Export of Reports in XML

The reports export in XML meets a requirement of ANP on how HFCView must to provide part of their data to the ANP system.

The HFCView transfer the reports from the HFC302 memory to the database and an export service from time to time exports them in XML files in the format specified by the ANP. For each XML file generated is also created a TXT file with a 512-bit hashcode as required by ANP. Both files are compressed into a ZIP file and are available in a folder for the system to transfer it.

The HFCView ensures the integrity of files exported using a proprietary mechanism to check the hashcode, as well as checking the consistency of the reports in the database.

The operation of the exporting server of data in XML depends on the implementation and configuration of the following items:
- At least one Configuration Report for each HFC302 to be exported;
- The configuration report must be updated, because part of the information of the last report will be used to generate the XML report;
- Selection of HFC302s that will be part of service;
- Selection of runs for each HFC302;
- Provision of manual input fields for each run;
- Totalization reports corresponding to the HFC302 and to the selected runs and not exported;
- Wait for the service run automatically or execute it manually.

NOTE
The data export in XML is focused on reports of Fiscal Measurement, i.e., only the daily totals reports and their runs with their alarms/events and information of AuditTrail will be exported in this format.

Generating the Configuration Report

Initially for data export in XML, the data of HFC302 configuration report are used to determine units, quantity, and types of runs available.

Before configuring the export of reports in XML is necessary that the user to generate a configuration report for each HFC302 desired.

To request a new configuration report, just start the HFCView communication, and through the popup menu request for their generation.

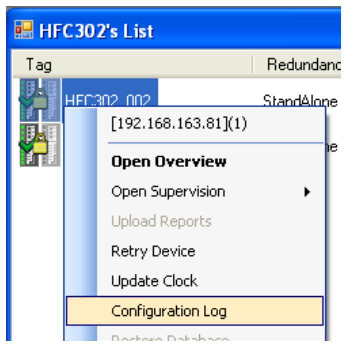


Figure 19.40

The user can monitor the progress of this report generation by the status window.

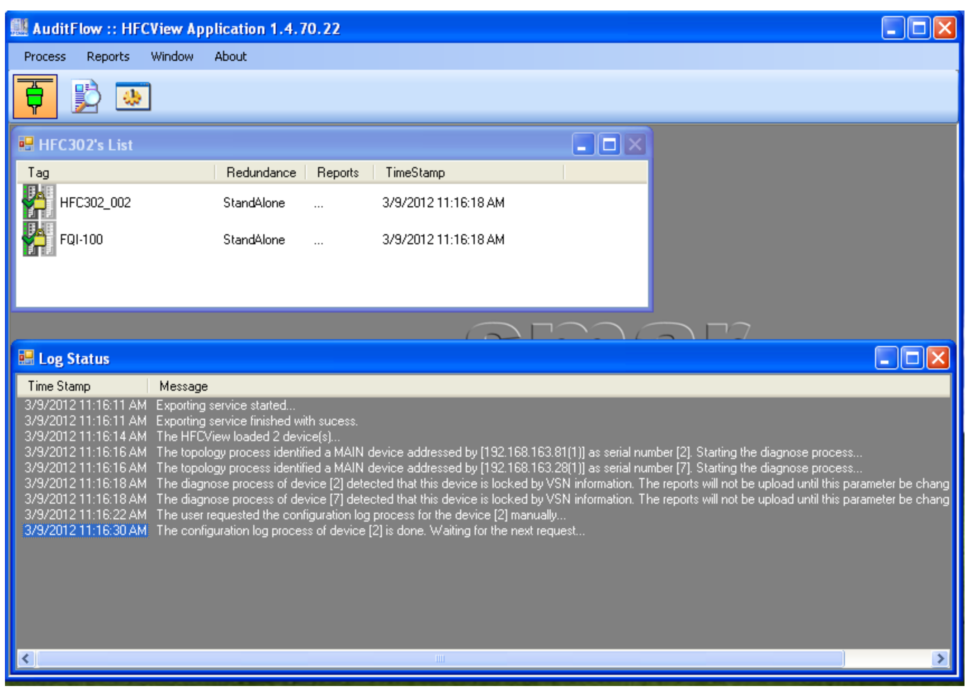


Figure 19.41

Configurator of Data Export in XML

The configurator is responsible for:
- determine which runs and HFC302s will have their reports exported;
- provide fields of manual input (data that are not available directly through the HFC302);
- provide the CNPJ;
- enable or disable the export service;
- provide the destination folder of the XML files exported;
- specify which XML version will be used as template;
- define the checking interval of the reports available for export

The access to the configurator is in the menu **Reports -> Exporting Service -> Configurator**:

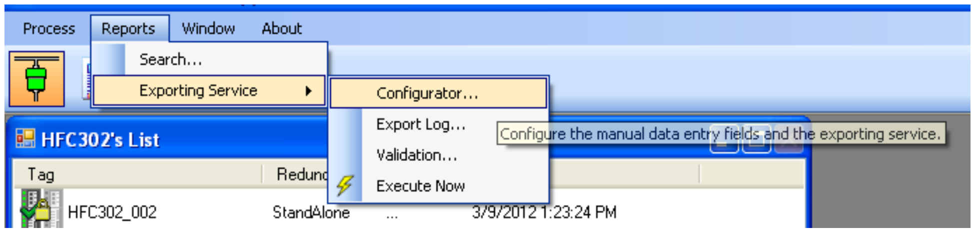


Figure 19.42

The configurator home page:

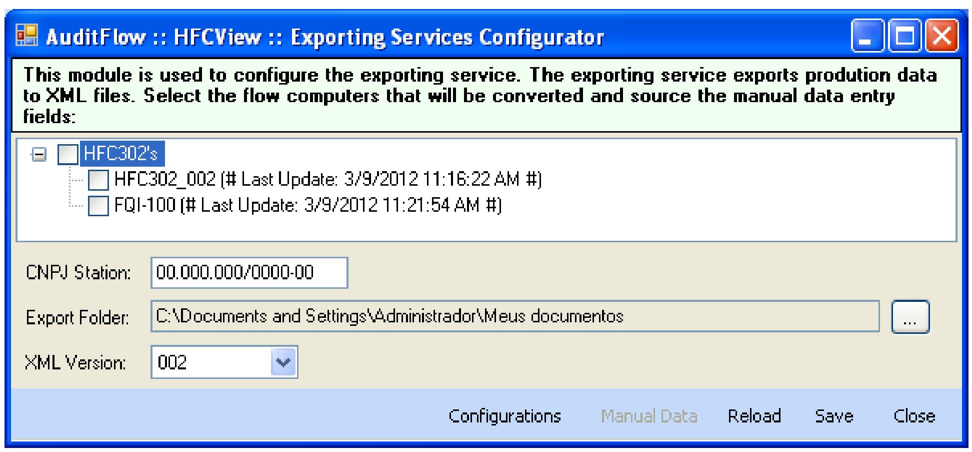


Figure 19.43

The user has to select which HFC302s will have their reports exported checking the corresponding selection boxes:

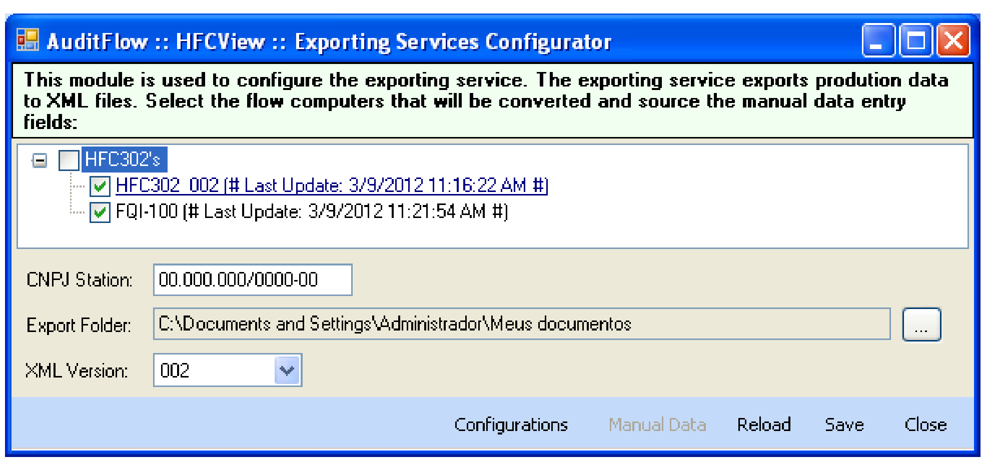


Figure 19.44

In this window the fields CNPJ, destination folder of XML files exported, and template version are also configured.

Use the **Configurations** option to select the frequency that the data export service will run from the date/time of the HFCView startup and if the service will be enabled or not.

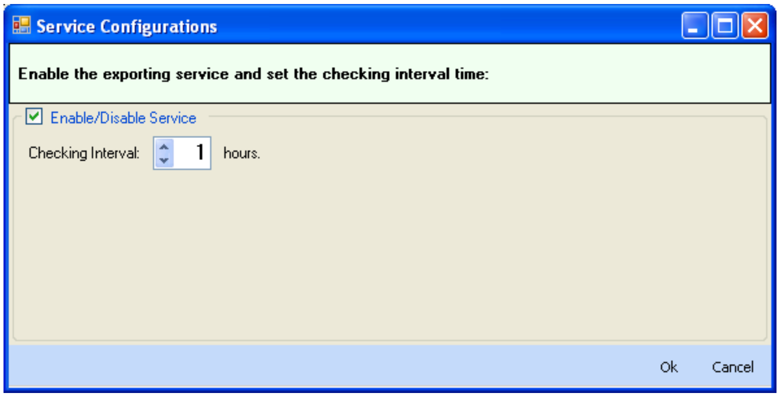


Figure 19.45

For each HFC302 selected, the user has to give the focus, and then click **Manual Data** to open the manual data entry window:

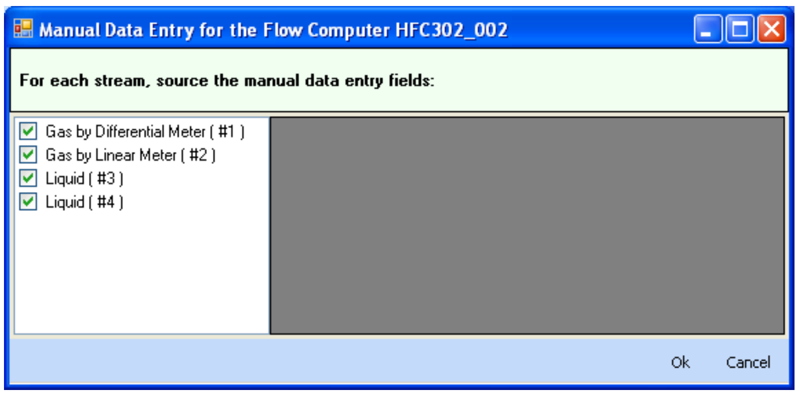


Figure 19.46

In this window, the number and types of runs are variable according to the information of the corresponding HFC302 configuration report.

By default, all runs are selected, but the user can filter some runs just deselecting the corresponding selection boxes. This procedure can be interesting for example in case of runs for products measurement that are not important for the system that will use those data.

By clicking the runs, the user must fill the fields of manual input. These fields are required, because they contain information that is not available in the HFC302 memory. If the fields are left blank, the same will happen when exporting data.

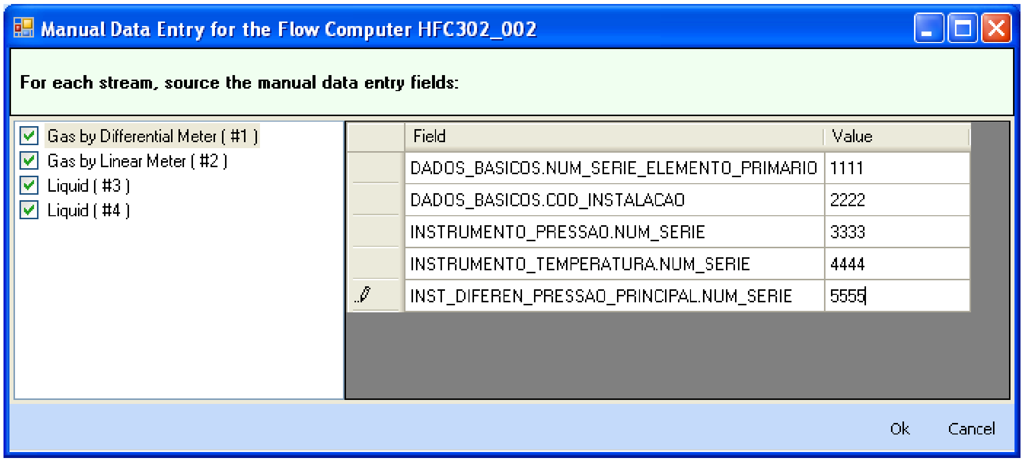


Figure 19.47

To finish the configuration, the user must confirm all screens, and at the end of the operation has to save the data by clicking the button **Save**.

Validation of Exported Reports

The reports validation consists in to generate a validation report where HFCView makes a comparison between what was exported, the database and content of the TXT file with the hashcode of the generated XML.

The user who receives the XML files in another location has the option to validate them from just the TXT file.

The access to the window for generating validation reports through the menu **Reports->Exporting Service-> Validation**:

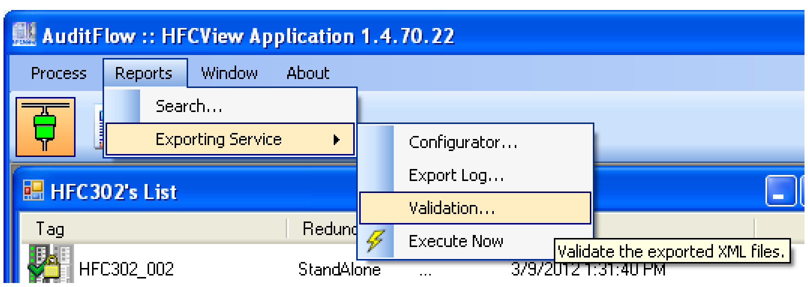


Figure 19.48

In the validation window, the user selects the validation method and the directory where are the ZIP files with the XML and TXT compressed files.

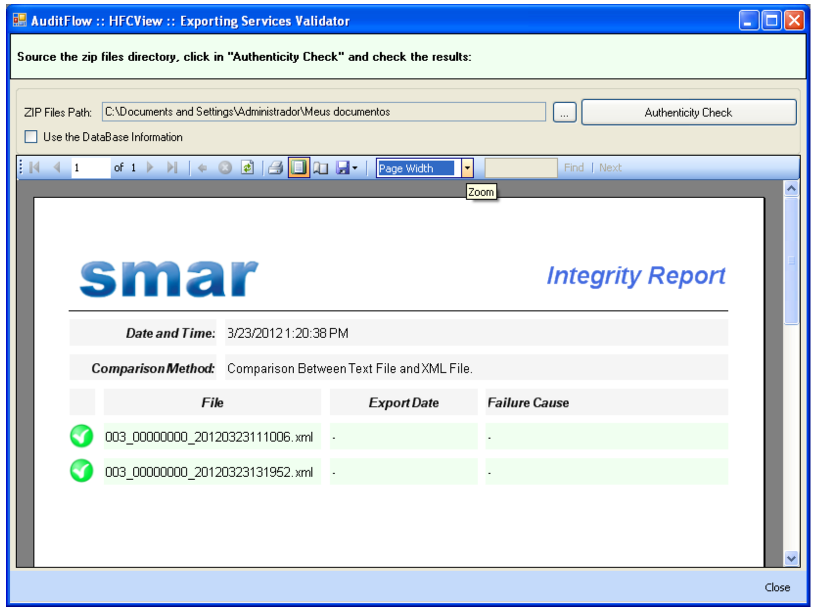


Figure 19.49

By clicking **Authenticity Check**, the HFCView extract the XML and TXT files from the ZIP files and compare them according to the chosen method. The result is presented in a report.

Exporting Report

The exporting report guides the user about the history of exports. In this report the user specifies the search period, which corresponds to the date/time to export reports.

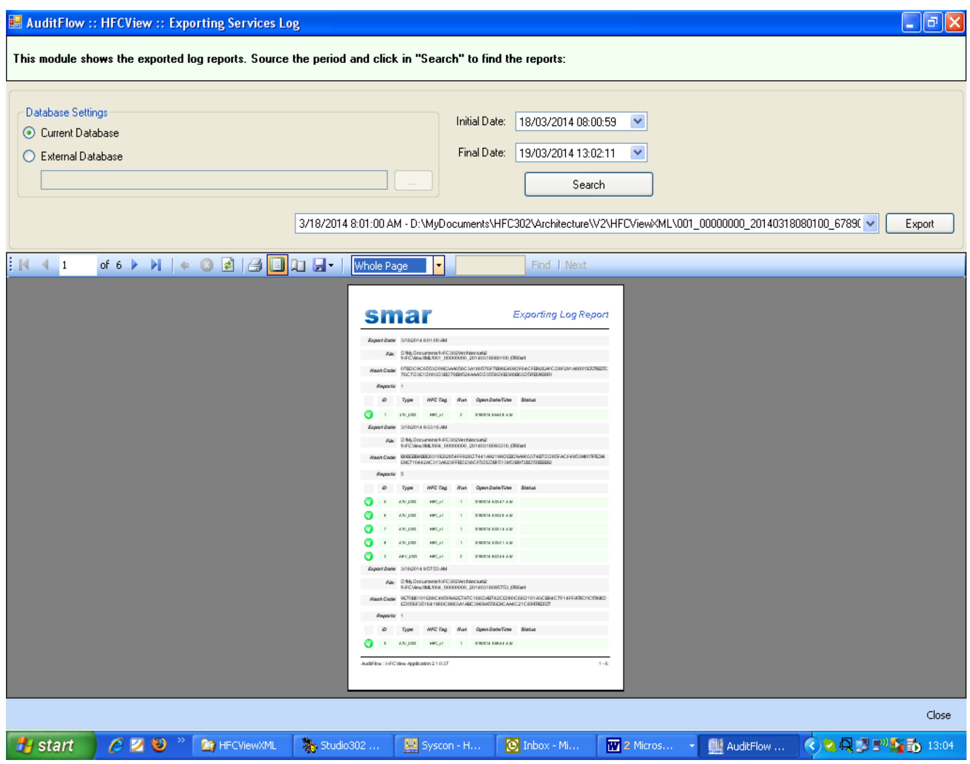


Figure 19.50

The access to the window for generating exporting reports through the menu **Reports->Exporting Service-> Export Log**:

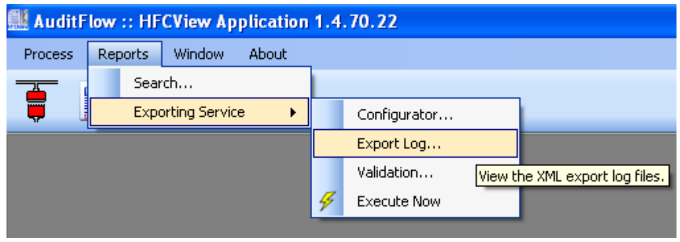


Figure 19.51

In the report, each session in gray corresponds to an XML file generated, providing information on quantity, time/date generation, hashcode generated and the location of the generated file.

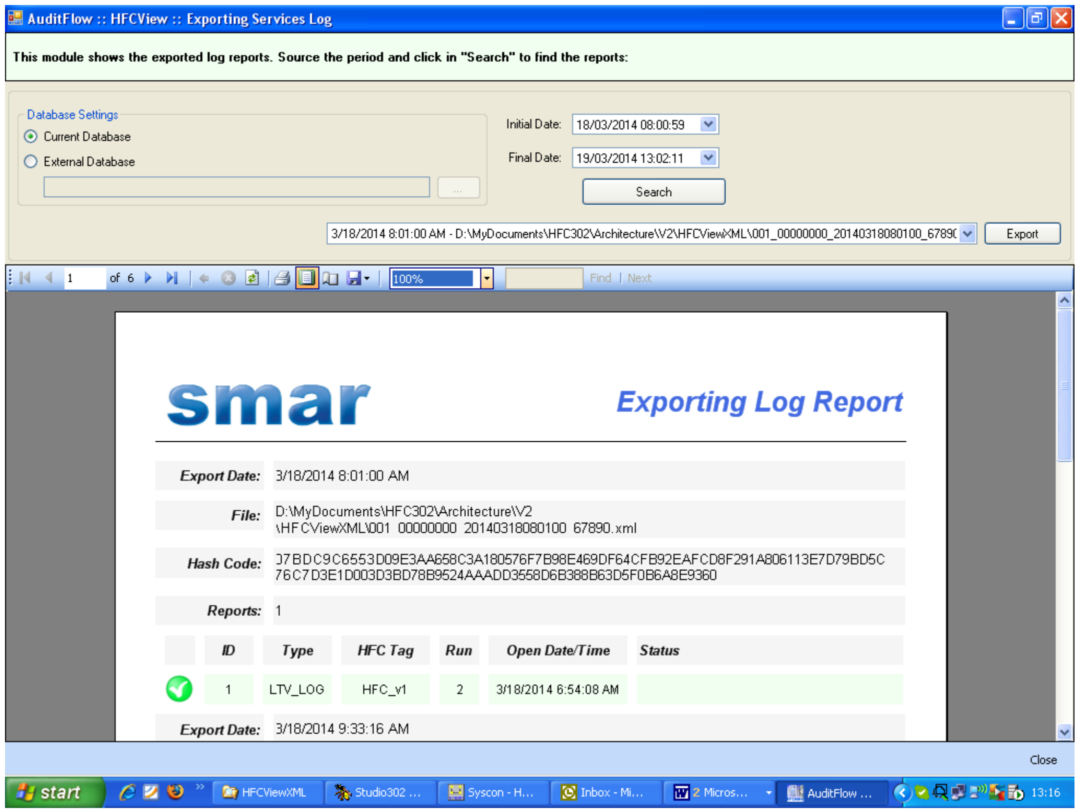


Figure 19.52

Each exported report corresponds to a line shifted to right. When the export is correct, the line will be green. If a problem occurs, for example wrong units, report corrupt, etc. the line appears in red indicating the error cause. The data exported will be converted to units in the International System, if necessary.

Generating the copy of XML Report

It is possible to generate a copy of XML report. Just select the report, and click **Export**. See the next figure.

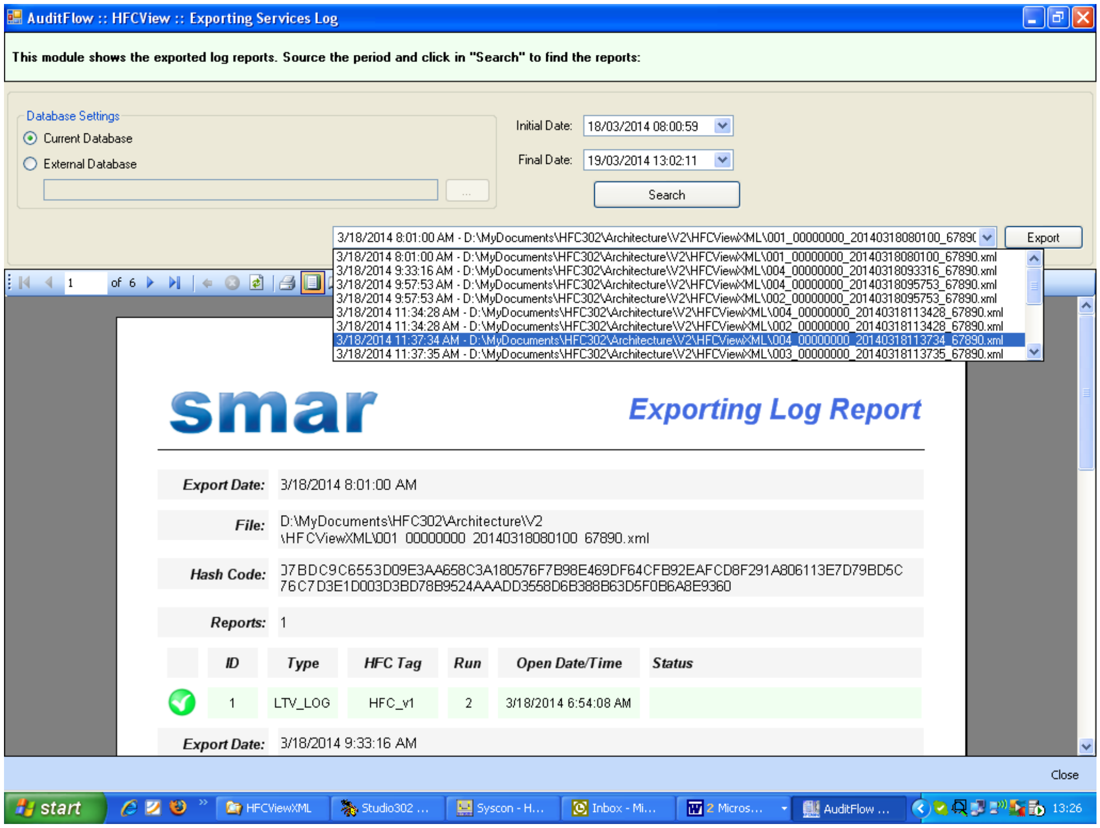


Figure 19.53

Performing the Exporting Report

The exporting data service is always performed when the HFCView starts and, automatically, at each hour by default. This period can be changed through the configuration menu.

Once the service is configured, it will always try to export data when find daily totalization reports available in the database. The types of report to be exported depend on the configuration.

To launch manually the exporting service, just access the menu **Reports->Exporting Service-> Export Now:**

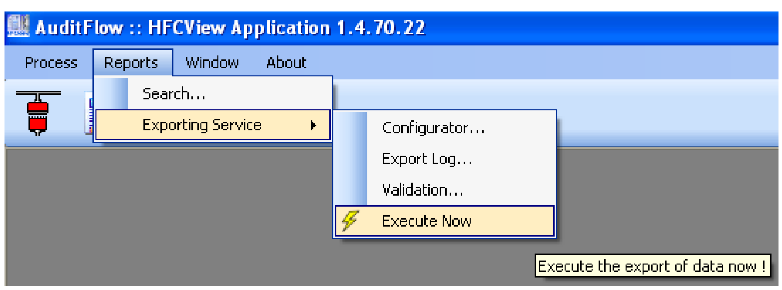


Figure 19.54

To monitor the progress of the export process, simply open the status window or view the report export.

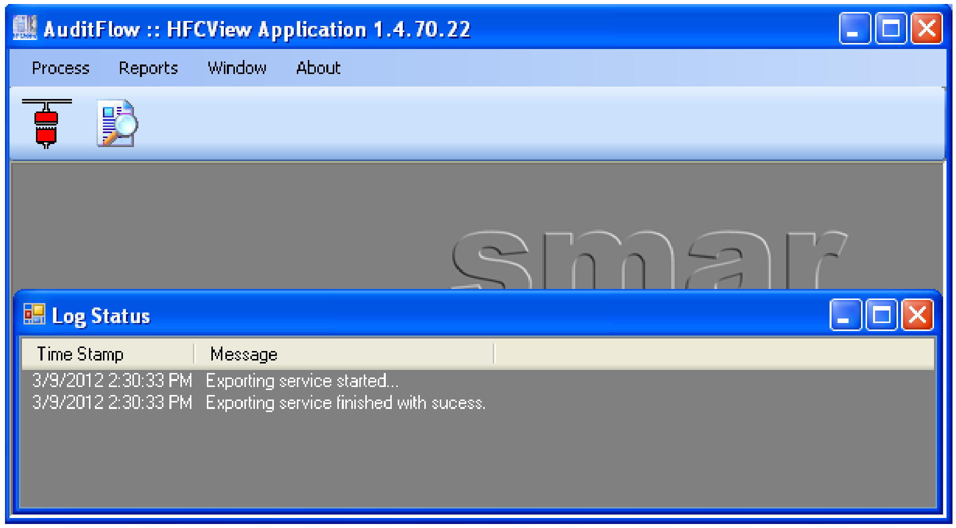


Figure 19.55

Reports will be generated in the destination folder specified by the user in the service configuration window.

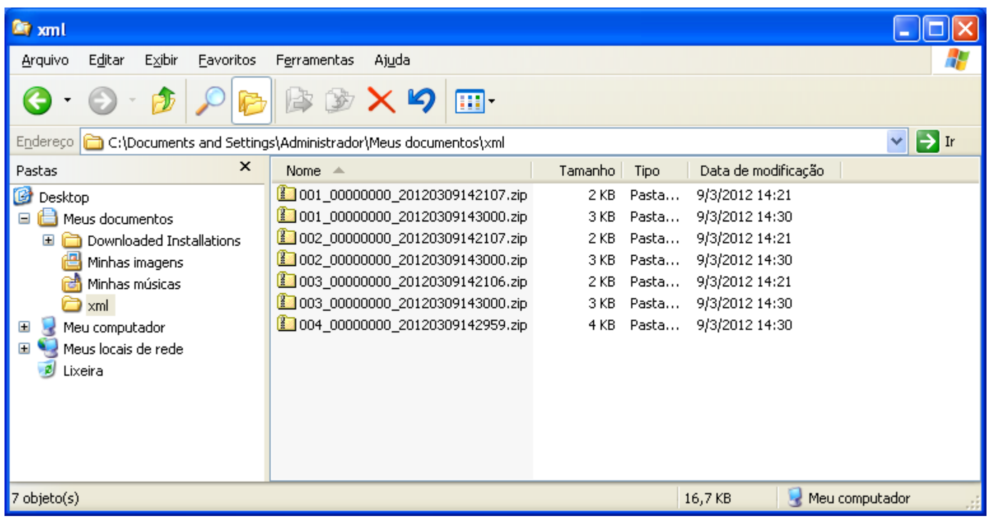
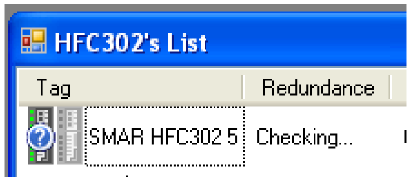
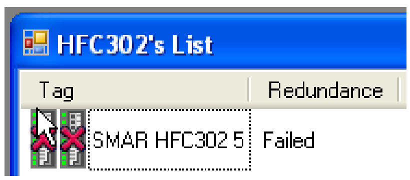
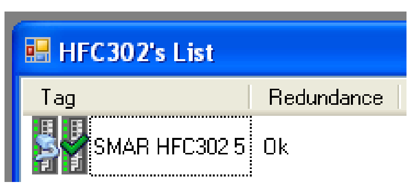


Figure 19.56

Status Dictionary

The table below describes the main status of the communication with the HFC302.

Status	Description
	- HFC302 primary OK, does not have secondary.
	- HFC302 primary and secondary OK.

Status	Description
	- Checking primary HFC302, does not have secondary.
	- Checking primary and secondary HFC302.
	- Failure in the primary HFC302.
	- Failure in the primary and secondary HFC302.
	- HFC302 primary transferring reports.
	- HFC302 primary transferring reports and secondary waiting. (The HFC302 secondary will never transfer reports, unless it becomes the primary).
	- HFC302 primary OK and secondary failed.
	- HFCVIEW_VSN does not confer (it can indicate that HFC302 is reserved to transfer reports to other HFCView).

Specifications

Hardware:

- Processor and RAM: Suitable for the operating system used
- Free Space in Hard Disk: 100MB for installation
- Display: 1024 x 768 pixels
- Enabled Hardkey

Software:

- Windows 7 SP1 Professional or above 64-bit
- Windows 10 Professional
- Windows Server 2008 R2 64-bit
- Windows Server 2012 R2
- Windows Server 2016 Standard.

Chapter 20

TECHNICAL SPECIFICATIONS

AuditFlow Hardware Specifications

ENVIRONMENT CONDITIONS	
Operation Temperature	-10°C to 60 °C, 20~90% RH non condensing.(*)
Storage Temperature	-20°C to 80 °C, 20~90% RH non condensing. (To achieve ten years of battery life, without excessive battery discharge).
Environmental Protection	IP55 (**) 5 – Ingress of solid : dust protected 5 – Ingress of liquid : water jets.
Supply	See power supply module specifications. It is not allows motor car's battery supply.
Vibration	10 to 150 Hz 10 m/s^2
Installation	Indoor, no humidity control.

(*) This temperature range applies to the DF56, HFC302, DF60, DF53, DF25, DF11, DF77. All others modules have operating temperature range 0°C to 60 °C, unless it has a different explicit specification.
(**) Ingress Protection of the standard panel for the AuditFlow System.

HFC302 Specifications

Ordering Code

HFC302 – HSE/FF Flow Computer with 2 ports Ethernet 100 Mbps and 4 channels H1

Description

HFC302 module is the second generation of Smar flow computer. Using 4 H1 channels (FOUNDATION™ fieldbus), two ports 10/100 Mbps Ethernet and capacity for execution of blocks and logic ladder, HFC302 can operate as a bridge H1-H1 or as a gateway H1-HSE, allowing a large communication between field devices and high flexibility in the strategies projects in continuous controls. Through I/O modules, it is possible to execute discrete control via logic ladder, allowing an only and integrated system. The module HFC302 can also work as Modbus gateway, interconnecting modules that are not FOUNDATION™ fieldbus or HSE, and also supports redundancy, supplying to the process high level of safety.

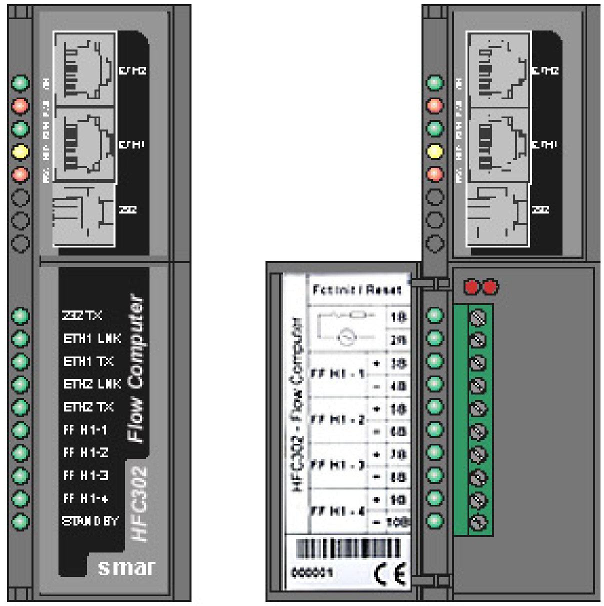
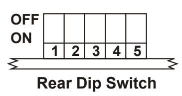


Figure 20.1 - HFC302 – Flow Computer Module



	STORAGING	OPERATION
1 BATTERY	OFF	ON
2	OFF	OFF
3 SIMULATE	OFF	OFF
4 WATCHDOG	ON	ON
5	OFF	OFF

Characteristics and Module Limits

- Up to 4 flow measurement loop in any combination of liquid and gas;
- Support for integration with compact prover, sampler/adorizer, chromatograph, IHM and other;
- Liquid products types: crude oil and emulsion, refined products, MTBE, lubricant oil, GLP/condensed and emulsion, water, ethanol;
- Types of gaseous products: natural gas, argon, oxygen, nitrogen, dioxide of carbon, ammonia, steam and humid steam;
- Dynamic Instantiation of blocks;
- Maximum of 100 function blocks;
- Support for Flexible Function Block with 256 parameters that can be linked by interface between the discrete and continuous control;
- LAS Function (*Link Active Scheduler*);
- 4 H1 channels (FOUNDATION™ fieldbus);
- Up to 32 field devices (8 devices for channel H1);
- Limit of 48 links H1 external (16 VCRs *publishers* and 32 VCRs *subscribers*);
- Limit of 32 links HSE (publisher or subscriber, configurable).

Continuous Control with FOUNDATION™ Fieldbus

The HFC302 module act as a *bridge* for the HSE main bus. This accomplishes four functions:

- Messages forwarding using the model Client/Server.
- Publication of data using the model *Publisher/subscriber*.
- Reports forwarding using the model *Report source/sink*.
- Distribution of the time between the applications.

Discrete Control

The module HFC302 also has capacity to access I/O cards through IMB (Inter-Module Bus), existent in the backplane where HFC302 is mounted. Through IMB, up to 15 racks can be interconnected, each one containing up to 4 cards. For the case of a redundant processor, the use of rack DF78 is possible to connect up to 16 racks. Additional power supplies in others racks can be necessary depending on the load of the cards.

DISCRETE CONTROL CHARACTERISTICS	
I/O* Points	Maximum 64 discrete or analog points
Auxiliary Points	Maximum 1024 points
Ladder Function Block	Maximum 300 blocks
Supervision of Analog Points	Maximum 2400 analog points
Configuration File	Maximum 5 kbytes
Program Execution Cycle for 1000 boolean operations (without redundancy)	50 ms (minimum)** 90 ms (typical)***
Program Execution Cycle with redundancy	Increment of 10ms (typical)**** up to 50 ms (maximum) to execution cycle
Execution Average Time	5.8 ms/Kbyte of program (minimum) 10.5 ms/Kbyte of program (typical)

* The whole number of points includes inputs and outputs, analog or digitals.
** 1131 Flexible Function Block adjusted to One (High Priority). Each 1000 boolean operations allocate 8.6 Kbytes.
*** Total execution time will change depending on the adjusted priority of 1131 FFB. The adjustment should be compatible with the quantity of function blocks and HSE links.
**** The whole execution time may change depending on the configuration file size.

Technical Specifications

Memory

TYPE	SIZE
Volatile Memory	16 Mbytes
Non Volatile Memory	4 Mbytes
EEPROM	1 kbytes
Flash to program	8 Mbytes
Flash to monitor	2 Mbytes

Battery

Type of battery	Battery Panasonic BR-2/3AE2SP - Lithium
Capability	1200 mAh
Devices maintained by the battery	RTC and NVRAM
Minimum life span	8 years (typical charge of 17uA)
Maximum life span	49 years (typical charge of 2.8uA)

Communication Ports and Channels

ETHERNET PORT	
Number of ports	2
Communication Rate	10/100Mbits
Standard	IEEE 802.3u
Isolation	150Vrms
Operation Mode	*Full-duplex*
Connector	RJ45 with shield*

* Grounded to the rail used for fixing the rack in which the HFC302 is installed.

H1 CHANNELS	
Number of Channels	4
Communication Rate	31.25 kbps
Standard	EN 61158 EN 50170
Physical Layer	ISA-S50.02-1992
H1 Modem	FB3050P (3.3V)
MAU Type	Passive (bus not powered)
Isolation	500 Vac
Bus Current	40mA

MODBUS PORT	
Communication Rate (Maximum)	19200 bps
Cable Length (Maximum)	15 m
Standard	EIA-232
Connector	RJ12 with shield *
Maximum Current **	0.5A @ 3.3V

* Grounded to the rail used for fixing the rack in which the HFC302 is installed.
** Internally protected by solid state fuse.

REDUNDANT PORT	
Communication Rate (Maximum)	115200 bps
Cable for CPUs connection	Its uses DF82 (length 0.5 m) or DF83 (length 1.8 m) only.
Standard	EIA-232
Connector	RJ12 with shield *
Maximum Current **	0.5A @ 3.3V

* Grounded to the rail used for fixing the rack in which the HFC302 is installed.
** Internally protected by solid state fuse.

FAILURE RELAY	
Output Type	Solid state relay, normally closed (NC), isolated
Maximum Voltage	30 VDC
Maximum Current	200 mA
Overload Protection	Not available. It must be provided externally
Normal Operation	Opened contacts
Failure Condition	Closed contacts
Cable length (maximum) connected to the relay	30m

Failure indication relay must not be connected to a specific load which is connected to an external power supply (outside the panel).

IMB BUS	
Voltage	5 VDC
Maximum Current	200 mA
Bus	8 bits
Access time to read and write	450 ns
Failure Signal	Yes
Hot Swap	Yes
Redundancy in the buss access	Yes, but only use the *rack* DF78

Module Features

CONTROLLER	
CPU	Family ARM7TDMI
Bus	32bits
Architecture	RISC
Performance	40 MIPS
Cache CPU	8kbytes
Clock	40 MHz
DMA	10 channels
Ethernet	MAC 10/100 integrated
Watchdog	Yes (200ms of cycle)
Operation Voltage	3.3V for I/O

MODULE	
Operation Voltage	5V (± 5% of tolerance)
Typical Current	550 mA
Real Consumption	2.75 W
Environment Air Temperature	-10 - 60º C (IEC 1131)
Storage Temperature	-20 - 80º C (IEC 1131)
Relative Air Humidity (Operation)	5% - 95% (non condensing)
Cooling Mode	Air convection
Dimensions (H x W x D) in mm	149 x 40 x 138 (without package)

LED Indicators

The LED names, colors, descriptions and behaviors are showed in the table below.

LED	COLOR	DESCRIPTION	BEHAVIOR
+5V DC (ON)	Green	It indicates when the module is ON.	Solid green LED when power is on.
FAIL (FAIL)	Red	It indicates hardware failure.	Solid red LED when FAIL.
RUN (RUN)	Green	It indicates when the processor is running in normal mode.	Solid green LED in RUN.
HOLD (HLD)	Yellow	It indicates when the processor is not executing only the firmware, but it is executing the monitor. (flash update, or default settings, or factory is being requested).	Solid yellow LED when firmware download and/or service routine is being executed.
FORCE (FRC)	Red	It indicates different modes FACT INIT, HOLD and IP Address. These modes are activated by using push-buttons. It also indicates when the operation voltage decays down the value of 4.8V (low line). The module will reset if the voltage reaches 4.6V.	Depending on the number of times that the right push-button is pressed, the LED blinks at a given rate for a limited time. It also remains solid during FACT INIT operation. It can also indicate when an I/O Module has its input and/or output locked, for example in Logic programming applications.
232 TX	Green	It indicates RS 232 activity (transmission).	Solid green LED when RS 232 is connected and blinking green when there is communication activity.
ETH1 LNK	Green	It indicates when the Ethernet connection is active.	Solid green when the Ethernet connection is established.
ETH1 TX	Green	It indicates Ethernet communication activity (transmission).	Blinking green LED when there is Ethernet/IP activity.
ETH2 LNK	Green	It indicates when the Ethernet connection is active.	Solid green when the Ethernet connection is established.
ETH2 TX	Green	It indicates Ethernet communication activity (transmission).	Blinking green LED when there is Ethernet/IP activity.
FF H1-1, FF H1-2, FF H1-3, FF H1-4	4 x Green	It indicates H1 channel activity.	Blinking green LED when H1 link activity is normal and network is loaded.
STANDBY	Green	It indicates if module is operating as Primary or Secondary redundant Master CPU. This LED blinks during the redundancy synchronism.	Solid green LED when CPU is the Secondary redundant Master CPU and blinking green LED when swap between Primary to Secondary or Secondary to Primary is underway.

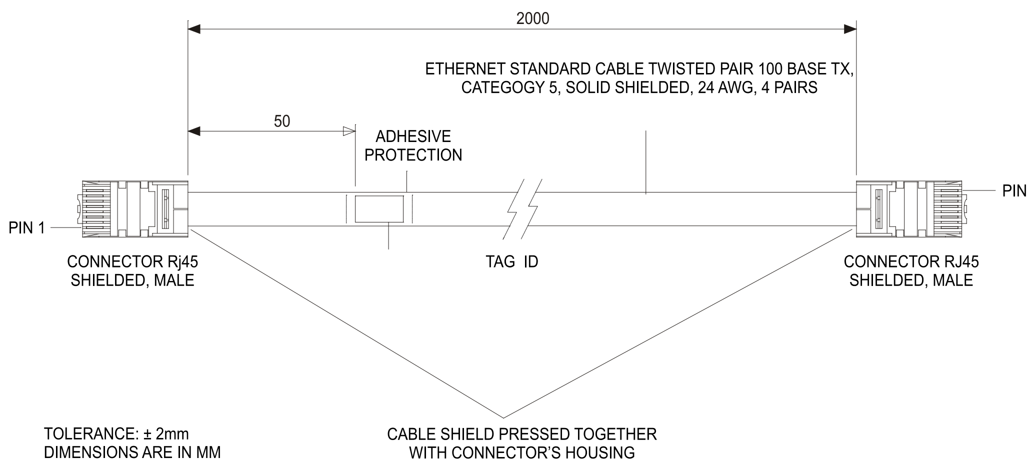
Ethernet Cable Specifications

To assembly a new Ethernet cable, the user should follow the specifications of the twisted cable pair, according to the part number DF54 or DF55.

DF54/DF55

DF54 – Standard cable. To be used in network communication between controllers and Switch/HUB.

DF55 – Cross cable. To be used in a point-to-point communication between PC and HFC302.



CABLE CONNECTION DIAGRAM

DF54

1	WHITE GREEN	1
2	GREEN	2
3	WHITE ORANGE	3
4	BLUE	4
5	WHITE BLUE	5
6	ORANGE	6
7	WHITE BROWN	7
8	BROWN	8

DF55 CROSS

1	WHITE GREEN	3
2	GREEN	6
3	WHITE ORANGE	1
4	BLUE	4
5	WHITE BLUE	5
6	ORANGE	2
7	WHITE BROWN	7
8	BROWN	8

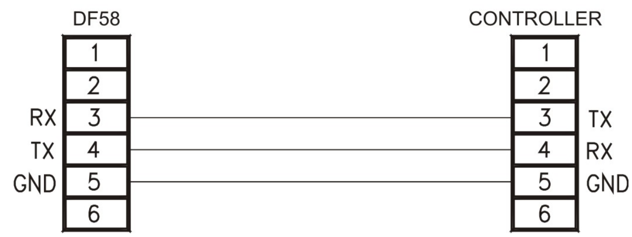
OBS: COLORS ARE MERELY A SUGGESTION.
IS IMPORTANT TO OBEY THE COLORS PAIRS AS THE CABLE CONNECTION DIAGRAM.

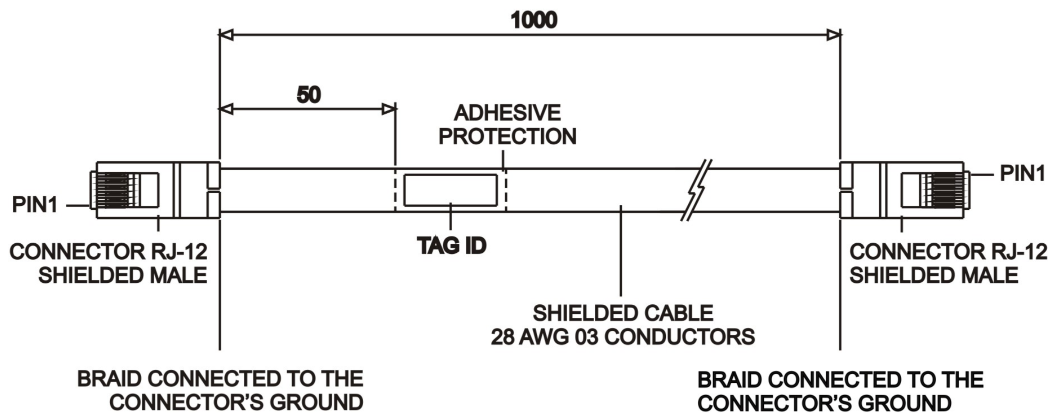
Serial Cable Specifications

DF59

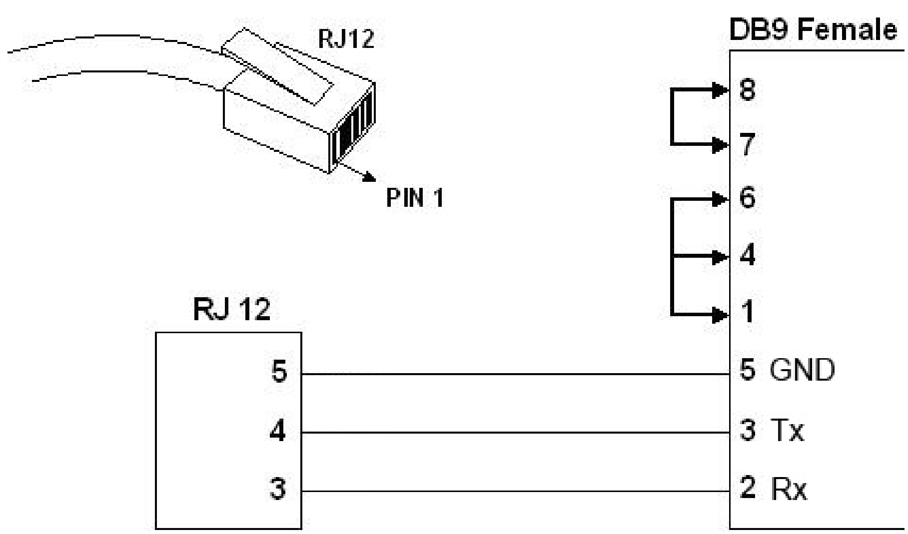
To assembly a serial cable between ***controller and DF58 (RS232/RS485 Interface)***, the user has to follow the specifications of the part number **DF59**.

CABLE CONNECTION DIAGRAM





To assembly a serial cable between ***Controller and PC computer***, see the following instructions that show a connection between RJ12 (used in the controller) and a female-DB9 connector:

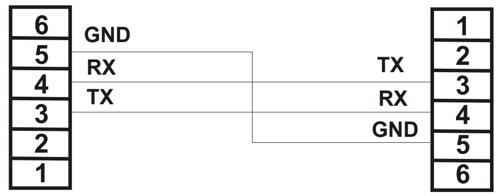


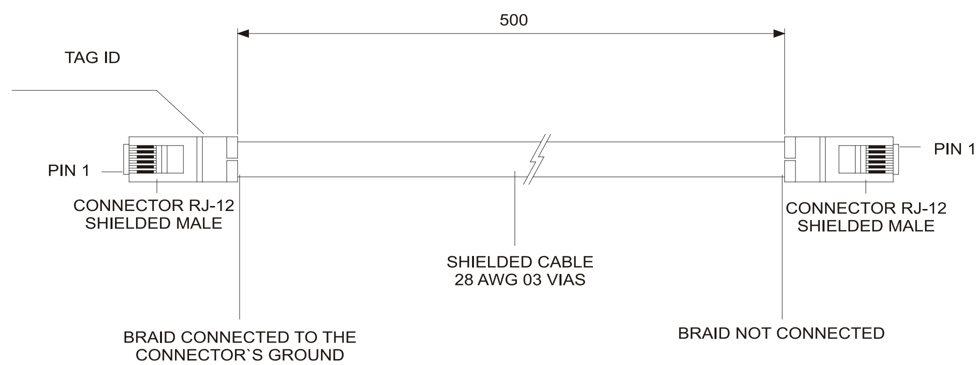
The jumpers under DB9 side are recommended but not necessary. It depends on the application running in the PC.

DF82

DF82 cable interconnects redundant controllers. The figure below shows the cable connection diagram.

CABLE CONNECTION DIAGRAM

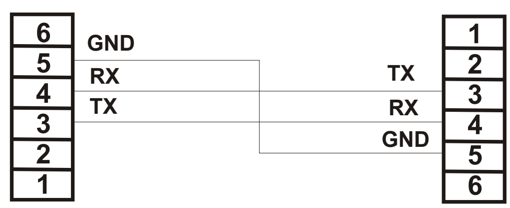


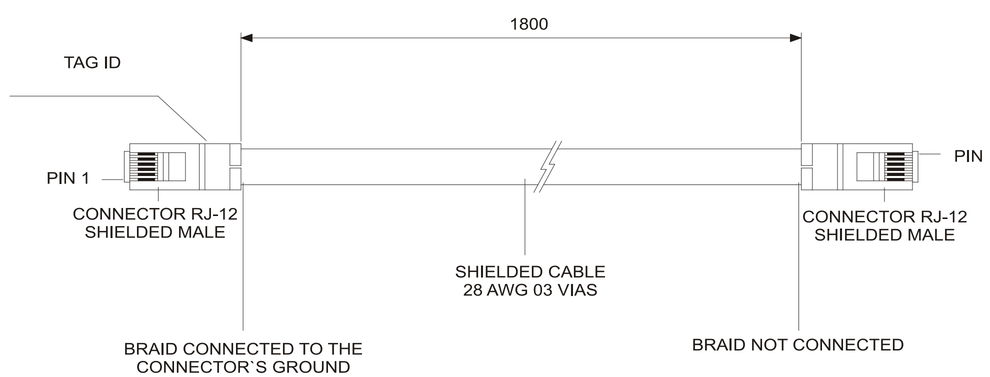


DF83

DF83 cable interconnects redundant controllers. The picture below shows the cable connection diagram

CABLE CONNECTION DIAGRAM





Cables for Racks Interconnection and Power Distribution

Depending on the rack model different types of cables are necessary to interconnect racks and for power distribution throughout the IMB bus. In the following table are the available cable types.

Code	Description
System based on DF1A and DF78	
DF3	AuditFlow flat cable to connect two racks – length 6.5 cm
DF4A	AuditFlow flat cable to connect two racks – length 65 cm
DF5A	AuditFlow flat cable to connect two racks – length 81.5 cm
DF6A	AuditFlow flat cable to connect two racks – length 98 cm
DF7A	AuditFlow flat cable to connect two racks – length 110 cm
System based on DF92 and DF93	
DF90	IMB power cable
DF101	Shielded flat cable to connect racks by left side – length 70 cm
DF102	Shielded flat cable to connect racks by right side – length 65 cm
DF103	Shielded flat cable to connect racks by right side – length 81 cm
DF104	Shielded flat cable to connect racks by right side – length 98 cm
DF105	Shielded flat cable to connect racks by right side – length 115 cm

For further details about the correct cable installation, please, refer to Hardware section.

Expansion flat cables for systems based on DF92 and DF93

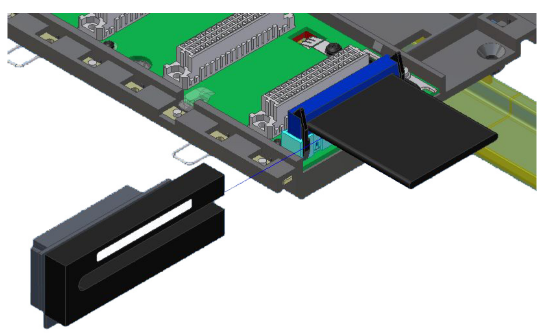
These flat cables are used when the Auditflow is expanded in more than one row of racks (DF92 or DF93), i.e., in different DIN rail segments, one below the other. To ground the flat cables' shield, use ground terminals next to the connections among flat cables and racks.

- **DF101 - Flat cable to connect racks by left side**
  The DF101 is installed on the rear connectors of the left extremity rack of each row of racks, interconnecting the rows 2-3, 4-5 and 6-7 (if they exist). The available terminal next to each DF91 can be used for grounding. See the Hardware section.

- **DF102, DF103, DF104 and DF105 - Flat cable to connect racks by right side**
  They are installed on the upper connectors of the right extremity rack of each row of racks, interconnecting the rows 1-2, 3-4 and 5-6 (if they exist). See the Hardware section.

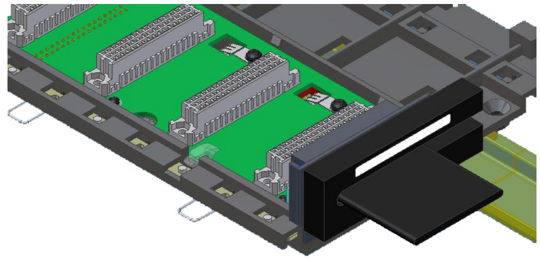
Flat cables protector (connector cap)

To meet the EMC requirements an ESD protector has to be installed on the flat cables connection, at right. In the following figure a flat cable protector is shown when it is being installed on the cable connector.



Installing the flat cables protector

The following figure shows the flat cable protector installed.



Flat cable protector installed

DF90 cable

The power expansion has to be used when the Auditflow is expanded in more than one row of racks, i.e., in different DIN rail segments, one below the other. The DF90 is the IMB power transmission cable. Its features provide low voltage drop and protection against electromagnetic interference.

The cable DF90 must be connected only through DF91. It cannot be directly installed in the racks, because it can damage the racks. For further details, see the Hardware section.

IMB power cable (DF90)

Maximum Flow (Liquid and Gas)

The time totalizers (hour, day, month and batch) and the Non resetable totalizers for liquid and gas measurements have rollover value of 10.000.000.000.

Rollover value	Maximum average flow (LV/h, M/h, EN/h)	Instantaneous flow (LV/h) (*)
10 000 000 000	13 440 860	10 000 000 000

(*) If instantaneous flow is superior to the specified in the table above, the totalization will be interrupted and showed in the status as “Stop totalization”.

Chapter 21

TROUBLESHOOTING

The **HFC302** module has some initialization resources to solve certain kind of troubles. These resources are two small push buttons available to permit the user to choose a specific controller action (see details in the following figure that shows two small buttons located in the controllers).

ATTENTION
Be aware that any of these procedures will cause a reset in the system.

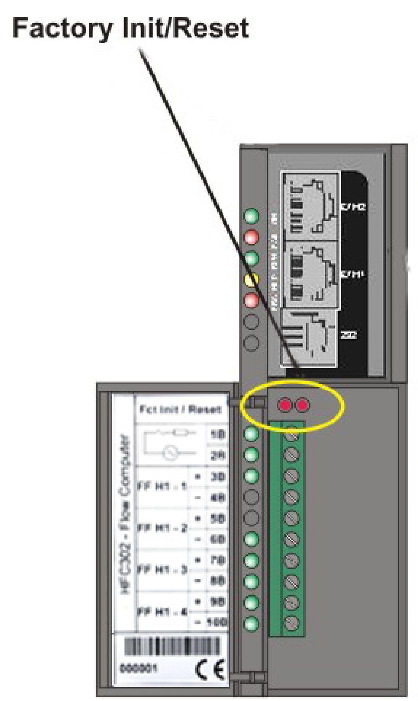


Figure 21.1 – Reset Push Button

The next table summarizes the possible actions for the HFC302 module.

Name	Push Buttons Procedure	Controller Action
Reset	Press the right *Push-Button*	Controller will reset, taking some seconds for correct system initialization. A new IP will be attributed automatically (when DHCP Server is available) or the last fixed configured IP will be kept, depending on the last setting via FBTools and/or Mode 3. Controller should go to Run or HOLD Mode depending on the last state before the Reset.
Mode 1 – Factory Init	Keep the left Push-button pressed. Click the right Push-button ensuring that the FORCE LED is blinking once a second. Release the left push-button and the system will execute the Reset, clearing previous configuration.	Controller will fulfill a factory initialization erasing the previous configurations downloaded via Syscon. A new IP will be attributed automatically (when DHCP Server is available) or the last fixed configured IP will be kept, depending on the last setting via FBTools and/or Mode 3. Controller should go to Run or HOLD Mode depending on the last state before the Reset.
Mode 2 – Hold	Keep pressed the left push-button and double click the right Push-button ensuring that the FORCE LED is blinking twice a second. Release the left Push-button. The system will execute the Reset and change the mode. The LED indicators will be HOLD or RUN depending on the mode.	With the controller in HOLD mode, you can use the FBTools Wizard to download the firmware or change IP address value and settings. If you want to go back to the execution mode (Run), use the mode 2 again.
Mode 3 – IP Automatic Assign	Keep pressed the left push-button and double click the right Push-button ensuring that the FORCE LED is blinking three times per second. Release the left Push-button.	A new IP will be attributed automatically (when DHCP Server is available) or the default IP address (192.168.164.100 to port 0 and 192.168.165.100 to port 1) will be set. Controller should go to Run or Hold Mode depending on the last state before the Reset.

HINTS
- Once started any mode (Factory Init or Hold Mode) can be prevented. Remain the right push-button pressed, and release the left push-button first. - If the user loses how many times have pressed the right Push-button, just verify the number of times that the FORCE LED is blinking per second. After the fourth touch it will come to blink once a second (this function is cyclic). - To press these push-buttons use some pointed instrument (for example a ballpoint pen).

When to use the procedures of Factory Init/Reset

1. **How to reset the HFC302 without disconnecting it?**
   Use the Reset Procedure.

2. **HOLD LED remains ON, even after a Mode 2 or when setting the HFC302 to RUN through FBTools.**
   The probable cause is the firmware execution of the HFC302 in other hardware platform. If this is the case, contact the Smar's technical support.

3. **ETH1 LNK or ETH2 LNK LED does not turn on, how to proceed?**
   Check if the cable is connected correctly, or if it is not damaged. Check the specification of the cables:
   DF54 – Standard Cable. To be used in network communications between HFC302 and Switch/Hub.
   DF55 – Crossed Cable. To be used in point-to-point communications between computer and HFC302.

4. **The FORCE LED is blinking, how to proceed?**
   Use the RESET procedure. If the problem persists, the power supply module should be changed to check if the problem is solved.

5. The FBTools does not show all the HFC302's that are in the Subnet, how to proceed?
Probably there is an IP address conflict in this Subnet. Disconnect all the HFC302s from the Subnet and follow the procedures on "Connecting the HFC302 to its Subnet" for each module, ensuring that the addresses to be used are not associated with another device in the network.

6. The FBTools does not find the HFC302. How to proceed?

- Make sure that the initial connection procedure was followed, the default IP address was assigned via Reset Mode 3, and the computer has the IP 192.168.164.101.
- The Ethernet cable used must be the DF54 when using Hub or Switch. For point-to-point connection (module HFC302 linked directly to the computer) use crossed cable (DF55).
- Check if the network adapter is OK, fulfilling the ***ping*** command to its own IP, via DOS Prompt.
- Check if the Ethernet connection is OK, fulfilling the ***ping*** command to the HFC302.

7. The license is not accepted by the Get License program. How to proceed?
Follow the procedure described below:

1. Try to register the DEMO license. In the **Get License** window there is a **Use a DEMO keys** button. If it works, the problem must be a mistake while typing the key.
2. If it still does not work, check the existence of **SmarOlePath** in System variables. Right click on **My Computer / Properties / Advanced Tab / Environment Variables**. In case of the non-existence of SmarOlePath variable, execute "Interface Setup" from Smar folder to create it.

NOTE
Use only numbers and dashes "-".Do not use space or symbols such as: "! @ # $ % ^ & * ( ) _ + ~ < > , . / ? \ | { } [ ] :;"

3. Fulfill the server register again. In the SMAR shortcut folder **(Program Files\Smar\OleServers**) run **Register.Bat** program.
4. If any previous option fails, the License file can be generated manually.
   - Use an "ASC" text editor (notepad, for instance) because the file can not contain format characters. The file name and its contents are shown below:

   File: Syscon.dat
   SMAR-MaxBlocks-**55873-03243-22123-04737-10406**

   File: OleServer.dat
   #PCI OLE Server
   SMAR-OPC_NBLOCKS**8-23105-23216-11827-2196**

   File: DfiOleServer.dat
   #DFI OLE Server
   SMAR-DFIOPC_NBLOCKS**8-19137-32990-37787-24881-12787**

The keys presented are for DEMO license, the user can use its own keys.

8. I can not switch the Modbus Blocks to "AUTO", even setting the Mode Block target to "AUTO", the actual mode block keeps on "O/S".
In order to set the Modbus Blocks to "**AUTO**", it is necessary that the Mode Block of the HFC302 Resource Block has been set to "**AUTO**" and the LOCAL_MOD_MAP of each Modbus Block must be different from 255.

9. I define a value different from 255 to the LOCAL_MOD_MAP of a Modbus Block but it remains 255.
Within the same type of Modbus Block (MBCM, MBCS, MBSS, MBSM), it is not possible to contain two blocks with the same LOCAL_MOD_MAP, whereas the value must be from 0 to 15.

10. I tried to change the static value of a Modbus Block, but the value does not update.
In order to update the static value of a Modbus Block, it is necessary to set the Block to "O/S", so that the static values can be changed.

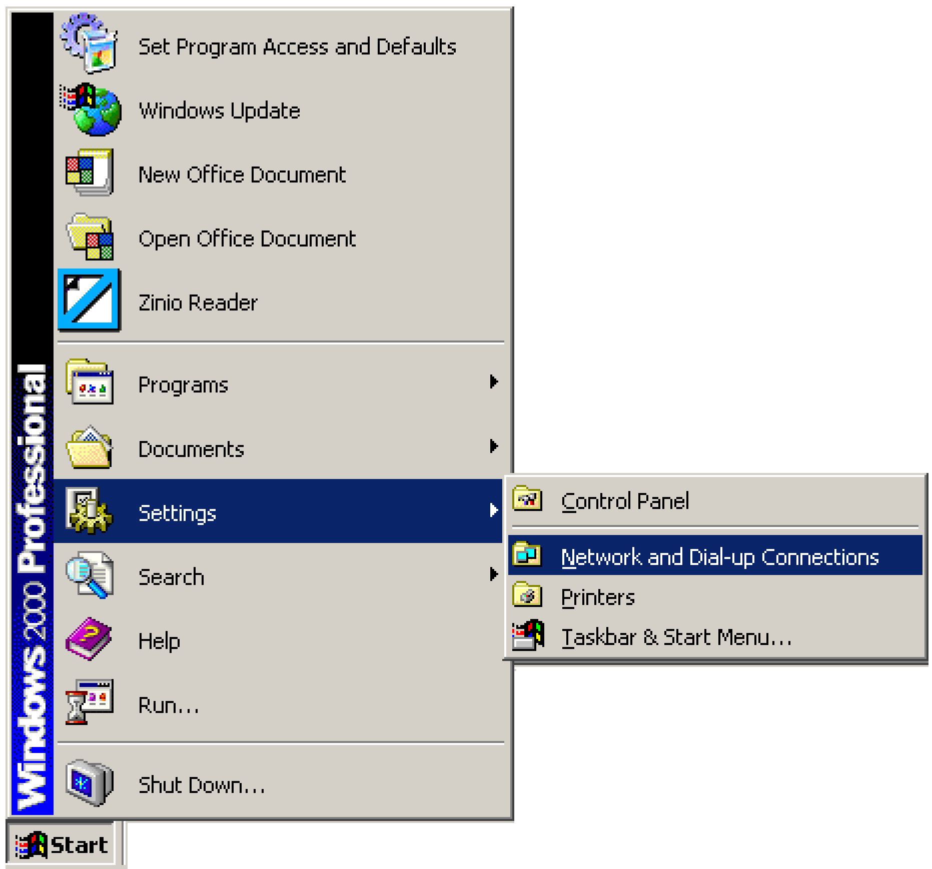
11. After changing a static value of a block, and set the Mode Block target to "AUTO", the actual one does not change into "AUTO".
If any static parameter of a Modbus Block has been changed, the Block only will be set to "**AUTO**" after accomplishing the "**On_Apply**" in the Block MBCF.

12. **HOLD Led is ON and the FAIL led is blinking (similar to the factory init) after the power up of the HFC302**.
The configuration and report data can not be preserved when there is lack of energy due to two possible causes: a) dip switch 1 in the rear part of the HFC302 is OFF position, in this case change to ON position; b) The battery load is very low, in this case to change the battery or module.

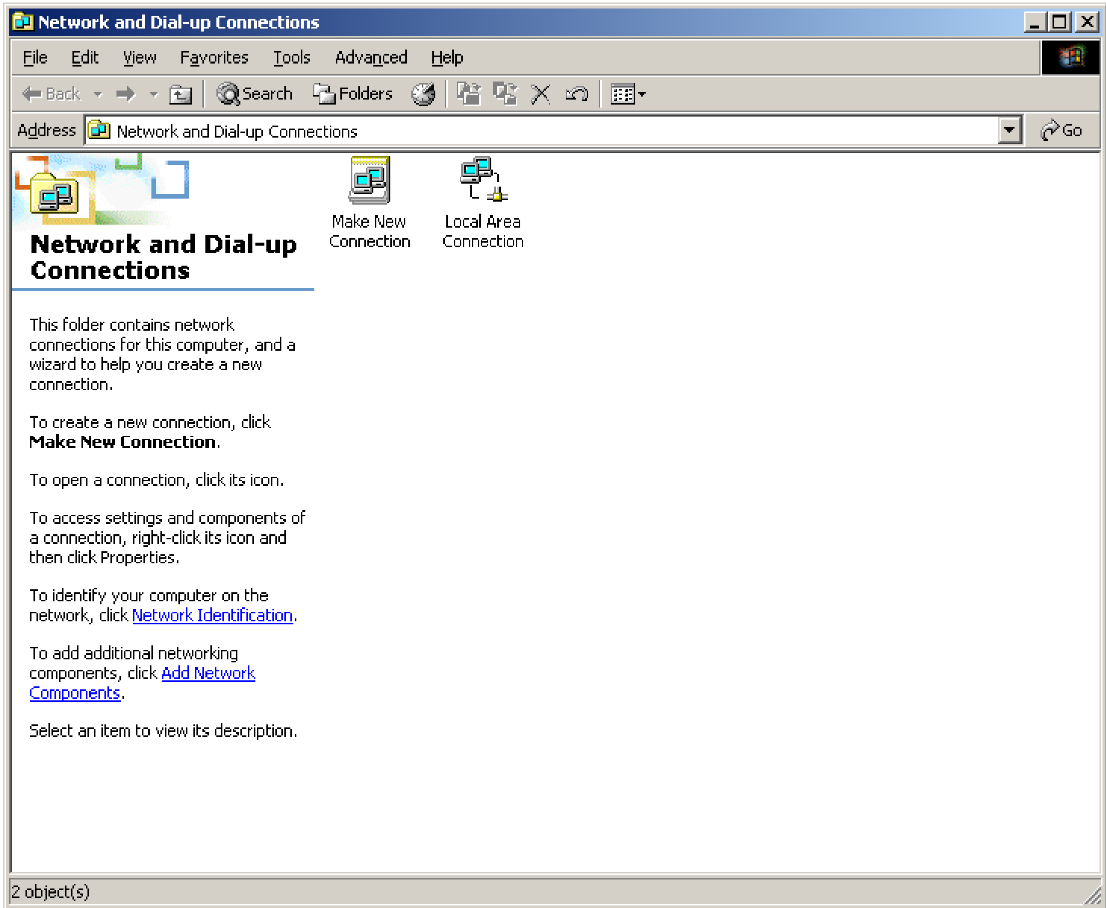
Incompatibility in the Communication between Computer and Module HFC302 when using DF55

A failure can occur in the communication between the HFC302 flow computer and the computer when using the DF55 cable (cross cable) with the 3COM EtherLink XL10/100 PCI TX NIC (3C905B-TX) Adapter. For this situation, the autonegotiation will fail and the link will not be established. To resolve this problem, the adapter must be set to the fixed rate of 10 Mbps. To configure the adapter with this rate, follow the next steps:

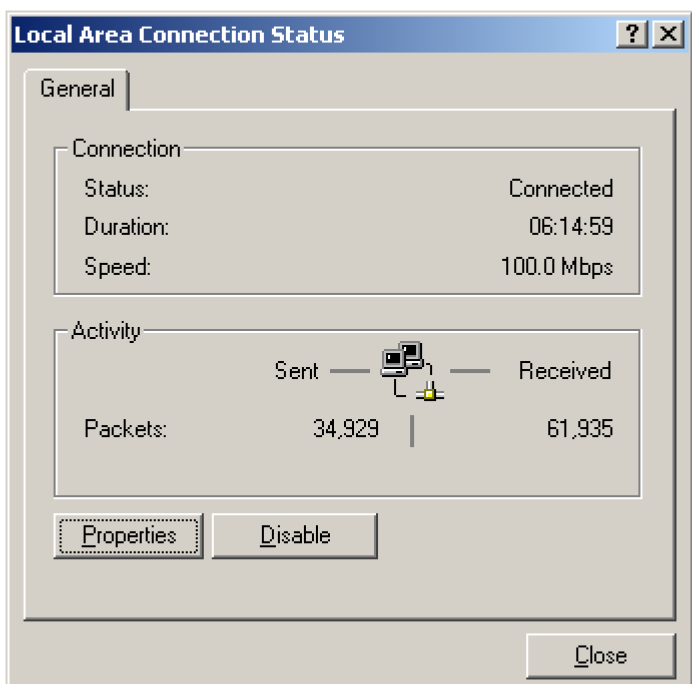
1. Choose **Start→Settings→Network and Dial-up Connections**. See the figure below:



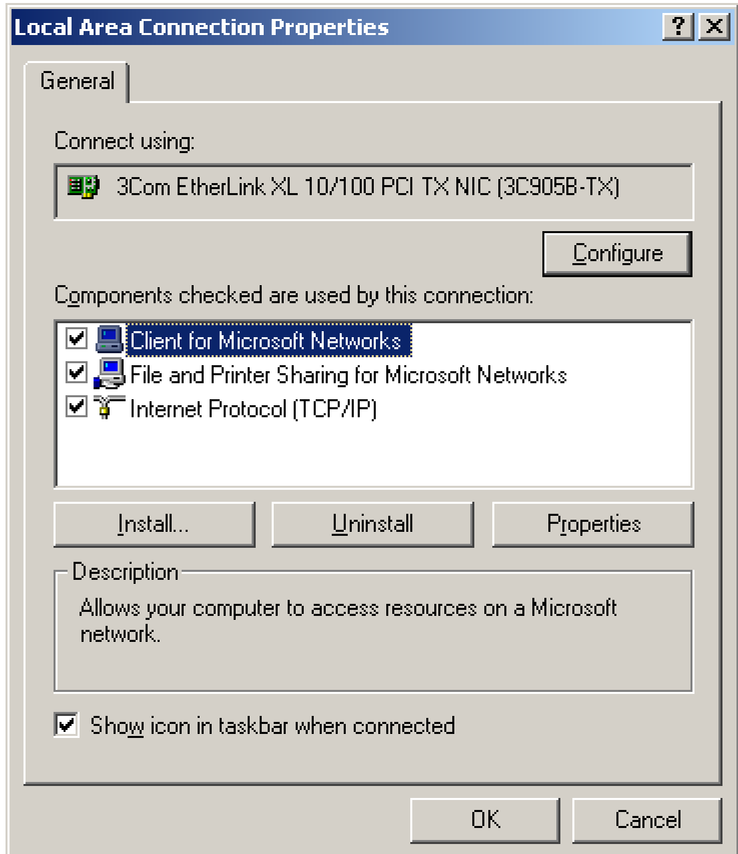
2. The next window will open:



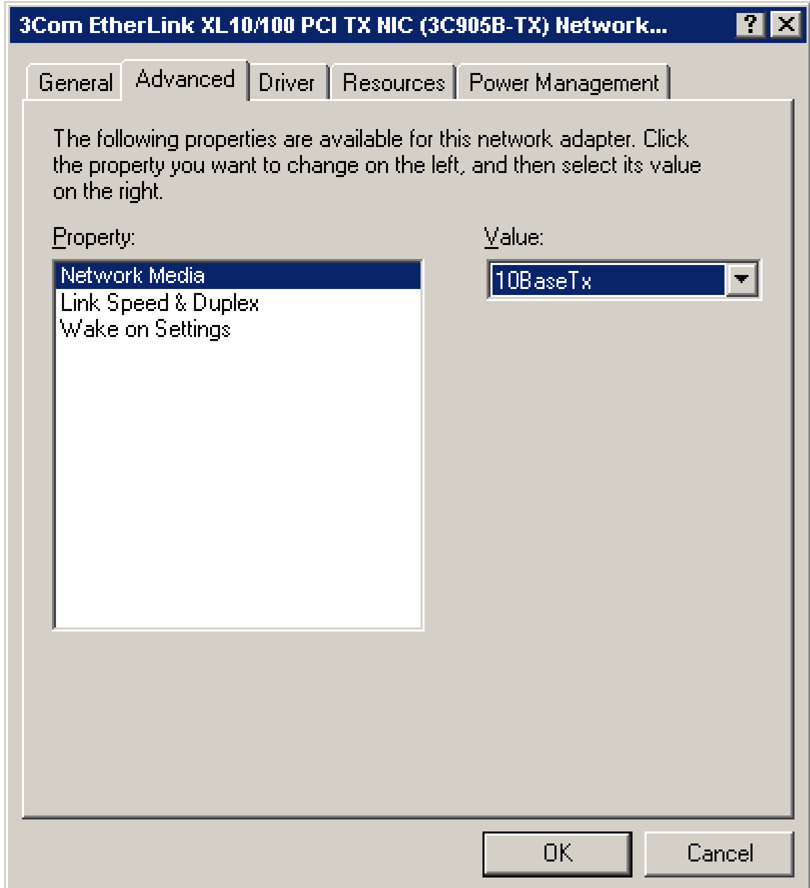
3. Double-click the *Local Area Connection item*. The following window will appear:



4. By clicking the *Properties* button, it opens the window to configure the adapter. Then, click the *Configure* button, placed under the field with the adapter, to configure the adapter rate. See the next picture:



5. The adapter properties window will open. Select the *Advanced* tab. In the field at left select *Network Media*. Select *10 BaseT* or *10 BaseT Full Duplex,* if this option is available, in the field at right. Then click *OK* to conclude the configuration.



Specific Problems in the Measurement

1. Problem in the function block showed in the BLOCK_ERR parameter.
All the measurement blocks have a Troubleshoot section before the Parameters table, where some causes are listed.

2. General problems with audit trail and access restriction.
Read the section “Audit Trail and Access Restriction” on the Chapter 17.

3. Indications of “Override temperature/pressure/density/SW/differential pressure used” in the alarm/event reports.
The user must check:

- Configuration: the corresponding input is linked
- If the device responsible to measure the secondary variable is turned on and set properly.
- If there is problem in the measurement block input (GT or LT) is related to the communication (Bad: No Communication), so try the partial download in the corresponding FF transmitter.
- If there is problem in the measurement block input (GT or LT), it can be diagnosis information detected by the transmitter. This problem can be related to: the sensor (for example: range or open sensor) or the configuration (for example: scale, physical connection, etc.).

4. Indications of “Flow Computer power down/up” in the alarm/event reports.
Check the following items:

- Voltage level and the quality of the voltage for the HFC302 power supply.
- Load connected in the same power network: motor startup, inductive load switching.
- New firmware versions can correct reset problems in the CPU module.

5. Problems related to the HFCView.
Check the section **Troubleshoot** in the chapter HFCView.

6. Failure during the configuration download.

Check:

- If the logon was with Administrator access level.
- If during the configuration download occurred any event, such as: glitch in the powering network, reset in the device of the Foundation Fieldbus network, failure in the Etehrnet network communication.
- Repeat the download if any error appears.

7. Indications of "Bad pulse input occurred" in the alarm/event reports.

Check the following items:

- If the pulse input module is installed in the rack and the slot is addressed in the CHANNEL parameter.
- Check the module configuration related to rack number and slot. Also check the module status of the HC block through the parameters MODULE_STATUS_Rx_y.
- LED shows the Power supply status.
- If using the module DF77, check the status of the scan through the IMB LED, as well as the pulse input.
- Check problems of noise in cables;

8. Problems related to the pulse transmission or proving.

Check the Troubleshooting section in the chapter of the DF77 module and the PIP and LMF block.

9. Indications of "HFC302 – low voltage battery – occurred" in the alarm/event reports.

Run the HFCView to read all reports from the HFC302 memory and then replace the module.

10. The correction factor is out of range.

For liquid or gas measurement, any standard used there is always a range proper to calculate correction factor. Consult the ranges in the blocks GKD (gaseous products) and LKD (liquid products).

11. Events registered in the logger.

Consult the "Audit trail and Diagnosis" chapter for more details.

Appendix A

CERTIFICATION INFORMATION

The **AuditFlow-V.7.4** system has Model Approval by Inmetro for legal metrology according to the following information:

Item	Description
Notified Body	Inmetro
Country	Brazil
Type of Instrument	Flow Computer
Mark	AuditFlow
Model	HFC302–V1
Accuracy class	Class 0.3 for liquids and Class A for gases
Mechanical environment class	M2 (places with significant or high levels of vibration and shock transmitted from machines or trucks, conveyors, etc.)
Electromagnetic environment class	E2 (industrial environment)
Climatic environment class	H2 (indoors without humidity control in industrial process plants)
Approval document provides the tested hardware configuration as well the test conditions	N.º 499 of October 02 2015
Gas measurement – fluid type	Natural gas
Gas measurement – flow meter	Orifice plate, turbine, coriolis and ultrasonic
Liquid measurement – fluid type	Crude oil and derivatives, ethanol (anhydrous and hydrated) fuel
Liquid measurement – measurement type	Fiscal measurement and allocation measurement

The **AuditFlow-V.7** has other certificates according to the following information:

Document	Description
TUV Rheinland 016-07-46761730000106-309	Certificate of Brazilian content for the HFC302 module.
Smar CE Label declaration for AuditFlow-V7 provides the tested hardware configuration as well the test conditions	European Conformity

smar

SRF – Service Request Form

AUDITFLOW

Proposal Nº:

COMPANY INFORMATION

Company: ______________________________

Unit/Department:___________ ______________________________

Invoice:______________ ______________________________

COMMERCIAL CONTACT

Full Name:______ ______________________________

Phone:___ _________ ________________________ _________ ________________________ **Fax:** ______________________

Email: ______________________________

TECHNICAL CONTACT

Full Name: ______________________________

Phone: _________ ________________________ _________ ________________________ **Extension:** ______________________

Email: ______________________________

EQUIPMENT DATA

Model: ______________________________

Serial Number: ______________________________

PROCESS DATA

Process Type (E.g. boiler control)**:** ______________________________

Operation Time: ______________________________

Failure Date: ______________________________

FAILURE DESCRIPTION

(Please, describe the failure. Can the error be reproduced? Is it repetitive?)

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____

OBSERVATIONS

____

____

____

USER INFORMATION

Company: ______________________________

Contact: ______________________________

Title: ______________________________

Section:___________ ______________________________

Phone: _________ ________________________ _________ ________________________ **Extension:** ___________________

E-mail: ______________________________ **Date:** ______/ ______/ _________

For warranty or non-warranty repair, please contact your representative.
Further information about address and contacts can be found on **www.smar.com/contactus.asp**.