MANUAL

INSTRUCTIONS | OPERATION | MAINTENANCE

GENERAL 302

FOUNDATION


FY302


LD302


FP302


IF302


TT302


FI302


LD292


DT302


TP302

SEP/10 - VERSION 3

smar
Technology Company

GENERAL 302

Consult our subsidiary

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INTRODUCTION

FOUNDATION™ fieldbus (FF) is an open architecture to integrate information, whose main objective is to interconnect control devices and industrial automation, distributing the control functions for the network and supplying information to all the layers of the system.

The FOUNDATION™ fieldbus technology substitutes with advantages the 4-20mA + HART traditional, technology making possible the bi-directional communication among the devices in a more efficient way.

This technology is much more than a protocol of digital communication or a local network to field instruments. It includes several technologies, such as distributed processing, advanced diagnosis and redundancy. A FOUNDATION™ fieldbus system is heterogeneous and distributed, composed by field devices, configuration and supervision software, communication interfaces, power supply and by its own physical network that interconnects them.

One of the functions of the field devices is to execute the user application of control and supervision distributed by the network. This is the big difference between FOUNDATION™ fieldbus and other technologies that depend on a central controller to execute the algorithms.

Compared to other systems, FOUNDATION™ fieldbus allows the access to many variables, not only related to the process, but also diagnostics of sensor and actuator, electronic components, performance degradation, among others. Besides, there are other outstanding characteristics:

- Intrinsic safety for use in hazardous areas, with power supply and communication on the same wire pair;
- Topology in bus or tree, with support to multiple masters in the communication bus;
- Deterministic (foreseeable) behavior, even with redundancy in several levels;
- Distribution of the control functions among the devices (distributed control);
- Standardized interfaces among the devices that facilitate interoperability;
- Application modeling using functional blocks language.

This manual presents details of fieldbus installation, besides common configuration points of Smar. series 302 FOUNDATION™ fieldbus devices.

Whenever possible, consult standards, physical regulations, as well as the safety practices of each area.

Act with safety in the measurements, avoiding contact with terminals and wiring, because high voltage can be present and cause electric discharge. Remember that each plant and system has their own safety details. To find out about them before beginning the work is very important.

To minimize the risk of potential problems related to safety, follow the safety standards applicable to the local classified areas regulating the installation and operation of the devices. These standards vary area by area and are constantly updated. It is the user's responsibility to determine which standards should be followed in your applications and to guarantee that each equipment is installed accordingly.

Inadequate installation or use of a device on non-recommended applications can harm the system performance and consequently the process, besides being a source of danger and accidents. Due to this, it is recommended using only trained and qualified professionals for installation, operation and maintenance.

NOTE
Damages caused to the devices by inadequate installations or use in the wrong applications are not covered by warranty.

Get the best results from the Foundation™ fieldbus Series 302 by carefully reading these instructions.

ATENTION
This Manual is compatible with version 3.XX, where 3 denote software version and XX software release. The indication 3.XX means that this manual is compatible with any release of Series 302 field devices with software version 3.

TABLE OF CONTENTS

Section 1

INSTALLATION

Network Wiring

Access the wiring block by removing the Electrical Connection Cover. This cover can be locked closed by the cover locking screw; to release the cover, rotate the locking screw clockwise. (See Figure 1.1).

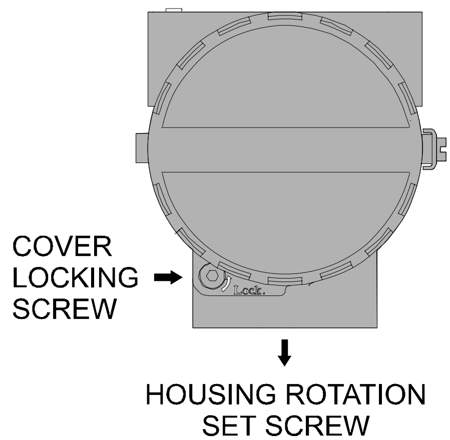


Figure 1.1 - Housing Adjusting Screw and Cover Lock

NOTE
The covers should be closed by hand completely, until the O'Ring is tight. For more safety, do not use tools in this operation.

Cable access to wiring connections is obtained by two outlets. Conduit threads should be sealed by means of code-approved sealing methods. The unused outlet connection should be plugged accordingly.

The wiring block has screws on which fork or ring-type terminals can be fastened. See Figure 1.2.

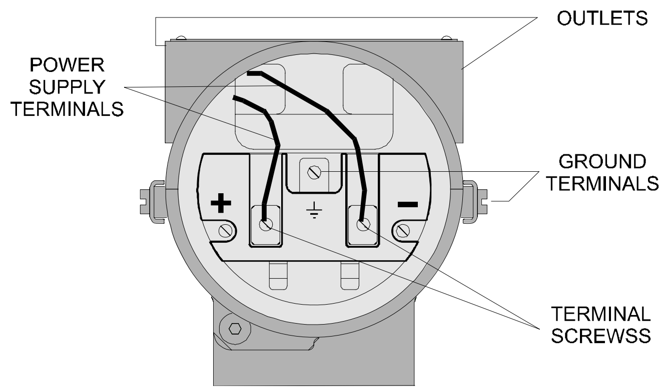


Figure 1.2 - Wiring Block

NOTE
Due to each device particularity, check the electric connection block in the specific equipment manual. The LD302 was used above as example.

For convenience there are two ground terminals: one inside the cover and one external, located close to the conduit entries. More details are described in Shield and Grounding item.

Avoid routing signal wiring close to power cables or switching equipment.

The **Series 302** devices are protected against reverse polarity, and can withstand up to 35 VDC without damage.

The Figure 1.3 show as to connect a device in a fieldbus network.

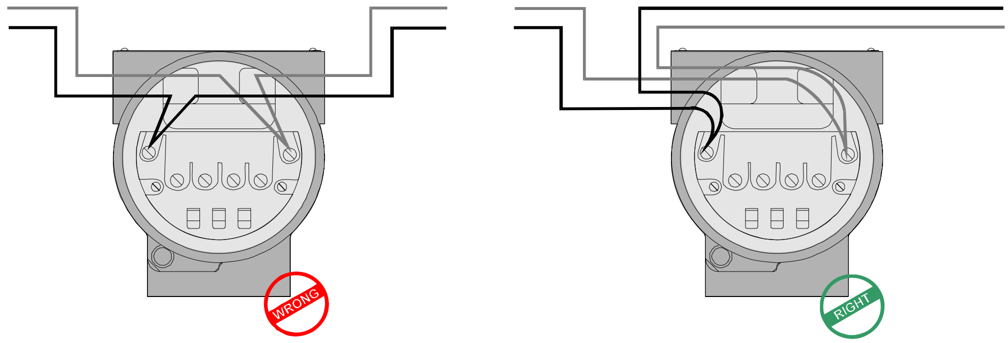


Figure 1.3 – Connecting a device to the Fieldbus network

Foundation Fieldbus Physical Medium, Cabling and Installation

The standard first versions specify two options for the physical layer: H1 and H2. The H1, with rate of 31.25 Kbits/s is oriented basically to field device (transmitters, valve positioners, etc), and it can be used in areas requiring intrinsic safety (explosive atmospheres). The H2, with rate from 1 to 2.5 Mbps, would be used to integrate controllers and more complex devices.

Due to the fast technological evolution, the H2 was substituted by the HSE that uses Ethernet at 100 Mbps. Therefore, for field devices connection there is the FOUNDATION fieldbus H1, with physical layer based on ISAS50.02-1992 or IEC61158-2:2000. For connection among PLCs, Linking Devices, Gateways and PCs, there is the FOUNDATION fieldbus HSE, based on Ethernet (IEEE802.3-2000, ISO/IEC8802.3-2000).

Foundation Fieldbus H1 Network

A Fieldbus network is composed by several H1 buses, connected to each other by bridges or Foundation Fieldbus Linking Devices that connect the H1 networks to the HSE backbone.

According to definitions, each H1bus can hold, theoretically, up to 32 devices not powered by the bus. In practice, there may be up to 12 field devices powered by the bus and other 20 devices not powered by the bus, each one with a single logical address in the network (1 Byte). This limit is due mainly to the electric characteristics of the power supply and the current consumption of the devices. In practical terms, it is recommended that the total number of devices doesn't surpass 10, because the network traffic tends to become very high and there may be performance degradation. In classified areas, it is recommended to analyze the output of the intrinsic safety barrier to define the number of devices. With the FISCO concept, there may be a larger amount of devices per segment.

The wiring length can reach 1900 m, and up to 4 repeaters can be used.

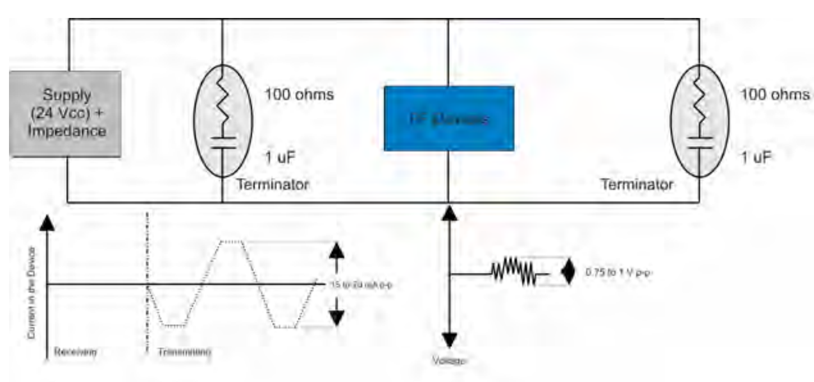


Figure 1.4 –Simplicity of the Foundation Fieldbus H1 Physical Layer (IEC61158-2)

The physical medium is a shielded twisted pair cable. The power supply and the communication are done by the same pair, needing at least 9 V in the terminal of the device to energize it. It is recommended that this tension be larger than 10 V, enough to keep a complete communication signal (0.75 Vpp to 1 Vpp), taking into account the cable tension loss, the bus total consumption, etc.

A modified Manchester code is used, producing a signal with null average value, that is, without DC components. That code brings other advantages: *frame* formation (special characters for *start delimiter* and *end delimiter*), formations of different physical topologies (bus and stars) and the warranty that the data and the *clock* arrive at the same time (synchronous serial signal).

The signal modulation is done by the variation of a current of 10 mA to 31.25 Kbit/s in an equivalent load of 50 Ω, resulting in a modulated voltage of 0.75 Vpp to 1 Vpp overlapping the bus voltage (9 – 32 Vdc).

Both the current and the operation minimum voltage can vary according to the manufacturer or device model (consult the respective manual). For Smar devices, each fieldbus device consumes about 12 mA.

Foundation Fieldbus HSE Network

This network is based on the same Ethernet physical layer. Several manufacturers offer specific equipments for industrial applications, be it with adequate temperature range (-40 to 85 ºC), be with specific functions for real time data communication.

The communication and synchronism characteristics among the devices are basically the same as the H1, and the main differences are in determinism. Through the use of the Ethernet network in the Foundation Fieldbus HSE network it is possible to build an industrial control network with shelf components, independently of the manufacturer.

The HSE standard uses 100 Mbps, but nothing opposes the devices from communicating at higher rates, like 1 Gbps or even the new 10 Gbps standard.

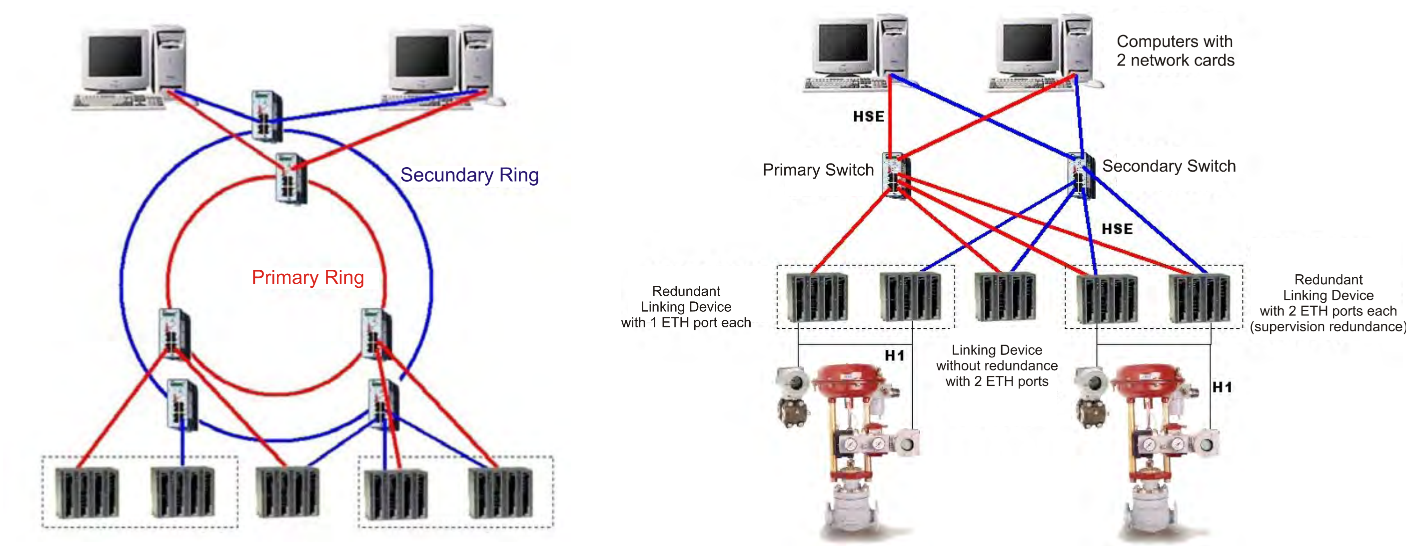


Figure 1.5 –Usual Topologies of the Foundation Fieldbus HSE Network: Ring and Stars, both Redundant

Summary of characteristics H1 and HSE Networks

The Table 1.1 show a summary of characteristics presents in H1 and HSE networks.

	H1	HSE
Baud Rate	31.25 Kbits/s	10 Mbit/s or 100 Mbit/s
Distance (segment)	1.900 m	100 m
Two wires	Yes	Não
Multidrop	Yes	No (UTP)
Bus-power	Yes	No
Intrinsically Safe	Yes	No
Redundance	No	Yes
Deterministic	Yes	Yes (with *switches*)

Table 1.1 - Summay of the Characteristics of the Physical Layer FF

General Notions of Installation for the H1 Network

The H1 network represents a great digital communication solution for the factory ground, both in safe as classified areas. It accepts topologies in bus, ring, star or tree, and even distances up to 1900 m without repeater.

Using up to 4 repeaters it is possible to cover a radius of approximately 10 km. The maximum amount of devices in each H1 segment depends on the type of application, the length of the cables and even the performance wanted for the network.

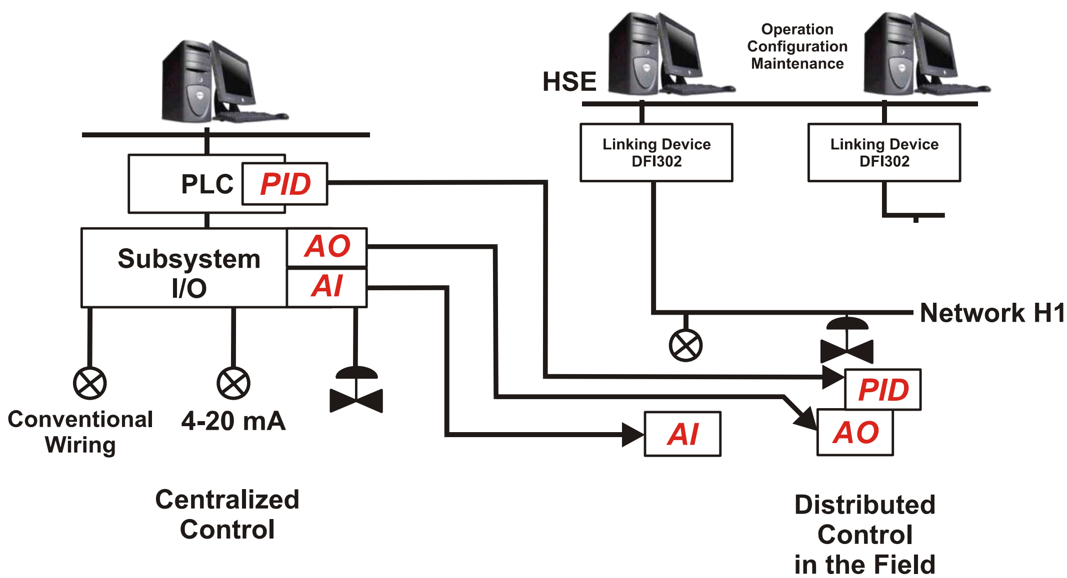


Figure 1.6 - Comparison of Wiring and Distribution of Control over the Network Devices

Main elements of the Foundation Fieldbus H1 Network

Cabling

The IEC61158-2 determines that the physical medium of the Foundation Fieldbus H1 network should be a twisted pair cable. The properties of a field bus are determined by the electric conditions of the cable used.

Although the IEC61158-2 doesn't specify the cable technically, the type A cable is highly recommended, in order to guarantee the best communication conditions and distances involved.

Table 1.2 presents in detail the specifications of the several cables at 25 ºC. It is worth to remind that most of the cable manufacturers recommend the operation temperature between -40 ºC and +60 ºC. It is necessary to verify the critical points of temperature through where the cabling passes and if the cable supports it. The type A cable resistance of 22 O/Km is valid at 25 ºC. For example, the resistance of the type A cable to 50 ºC is 24.58 Ω/Km. That should be taken into account in hot countries as Brazil.

	Type A	Type B	Type C	Type D
Cable Description	Twisted Pair with *Shield*	One or more total twisted pair with *Shield*	Several twisted pair without *Shield*	Several non-twisted pair without *Shield*
Nominal Driver Section Area (of the)	0.8 mm^2 (AWG 18)	0.32 mm^2 (AWG 22)	0.13 mm^2 (AWG 26)	0.25 mm^2 (AWG 16)
(Resistance DC Maximum) Maximum DC Loop Resistance (*loop*)	44 Ω/Km	112 Ω/Km	264 Ω/Km	40 Ω/Km
Characteristic impedance (to) at 31.25 KHz	100 Ω ± 20%	100 Ω ± 30%	**	**
Maxim Attenuation to 39 KHz	3 dB/Km	5 dB/Km	8 dB/Km	8 dB/Km
Maximum Unbalanced Capacitance	2 nF/Km	2 nF/Km	**	**
Group Delay Distortion (7.9 to 39 KHz)	1.7 µsec/Km	**	**	**
Surface Covered by the *Shield*	90%	**	-	-
Recommendation for Network Extension (including *spurs*)	1900 m	1200 m	400 m	200 m

Table 1.2 – Characteristics of the Several Cables Used in Foundation Fieldbus H1

Total Cable Length and Distribution and Installation Rules
The total length of the H1 cable should be considered from the exit of the point of PSI (*power supply impedance* – power supply with active impedance) until the most distant point of the segment, considering the derivations. Remember that spurs smaller than 1 m don't enter in this total.

The cabling total length is the sum of the main bus trunk size plus all the spurs (branches larger than 1 m), and with type A cable, the length is a maximum 1900 m in non-safety areas. In safe areas with type A cable, it is a maximum 1000 m, considering that the spurs cannot exceed 30 m.

In installation and distributions terms avoid splices, in other words, any part of the network with a specified conductive medium and a discontinuous length smaller than 1 m, for example: shielding removal, wire diameter changes, connection to bare terminals, etc. In networks with total length larger than 400 m, the sum of the lengths of all the splices should not surpass 2% of the total length and also, in lengths smaller than 400 m, should not exceed 8 m.

A H1 segment maximum length, when using different cable types is limited by the following formula:

$$\left(\frac{LA}{LA\max}\right)+\left(\frac{LB}{LB\max}\right)+\left(\frac{LC}{LC\max}\right)+\left(\frac{LD}{LD\max}\right)\langle=1$$

Where:

LA : Length to the cable A ;
LB : Length to the cable B ;
LC : Length to the cable C ;
LD : Length to the cable D ;
$LA\max$: Maximum length allowed with the cable A (1900 m);
$LB\max$: Maximum length allowed with the cable B (1200 m);
$LC\max$: Maximum length allowed with the cable C (400 m);
$LD\max$: Maximum length allowed with the cable D (200 m).

In relation to the spurs be attentive to the lengths of the same. The amount of devices, < including repeaters, if any, should comply with the Table 1.3. In classified areas the maximum spur is 30 m.

Total H1 devices per segment	*Spur* length with 1 device	*Spur* length with 2 devices	*Spur* length with 3 devices	*Spur* length with 4 devices	Length Considering the Maximum Amount of Spurs (m)
1-12	120	90	60	30	12 x 120 =1440
13-14	90	60	30	1	14 x 90 = 1260
15-18	60	30	1	1	18 x 60 = 1080
19-24	30	1	1	1	24 x 30 = 720
25-32	1	1	1	1	1 x 32 = 32

Table 1.3 - Spur x Number of H1 Devices

Note: The cable capacitance limit should be considered when the effect in the spur signal is smaller than 300 m and resembles capacitor. In the absence of the cable manufacturer´s data, a value of 0.15 nF/m can be used for fieldbus cables.

$$Ct = (Ls * Cs) + Cd$$

Where:

Ct : Total capacitance in nF;

LS : *Spur* length in m;

Cs: Wire capacitance per segment in nF (Standard – 0.15);

Cd : Foundation fieldbus device capacitance;

The attenuation associated to this capacitance is 0.035 dB/nF. Therefore, the total attenuation is:

$$A = Ct * Ls * 0.035\, dB / nF \, \langle 14\, dB$$

Then, 14 dB will allow the minimum necessary signal to detect it with integrity.

There are some rules to follow in terms of cabling and separation from other cables, be it for signals or potency. Use preferably trays or metal ducts, observing the distances according to Table 1.4. Never pass the fieldbus H1cable beside high voltage lines because the induction is a noise source and it can affect the communication signal. Furthermore, the fieldbus signal should be isolated from noise sources, as power cables, motors and frequency. It is recommended to put in separated channels and ducts. The ideal is to use aluminum ducts, with internal and external eletromagnetic shield. The *Foucault* currents are practically immune, due to the aluminum good electric conductivity. Remember that the crossing of cables should be at 90º angle.

	Fielbbus Communication Cables	Cables with and without shield: 60 Vdc or 25 Vac and < 400 Vac	Cables with and without shield: > 400 Vac	Any cable subject to the (exhibition of rays) exposition to lightning
Cabo de comunicação Fieldbus		10 cm	20 cm	50 cm
Cabos com e sem *shield*: 60Vdc ou 25Vac e < 400Vac	10 cm		10 cm	50 cm
Cabos com e sem *shield:* > 400Vac	20 cm	10 cm		50 cm
Qualquer cabo sujeito à exposição de raios	50 cm	50 cm	50 cm	

Table 1.4 –Minimum separation distances between Cables

H1 Network Terminators

Two bus terminators should be connected to the H1 network, being one in the PSI output and the other in the last device (usually the most distant from the PSI), depending on the adopted topology.

If in the cabling distribution there is a junction box in the end of the main trunk with several spurs, the field terminator should be placed in this point, to facilitate the maintenance when removing devices.

Check the correct connection of the terminator, reminding that the lack of terminators allows communication intermittency, once there is no impedance match and there is reflection signal increase.

The lack of a terminator or its connection in the incorrect point also degrades the signal, once it will also be part of the cabling as an antenna. Its lack can increase the signal in more than 70% and an additional terminator can increase the sign up to 30%. The attenuation and intermittency can generate communication failure.

The H1 network terminator is formed by a resistor of 100 ± 2% and a capacitor of 1 µF ± 20% in series.

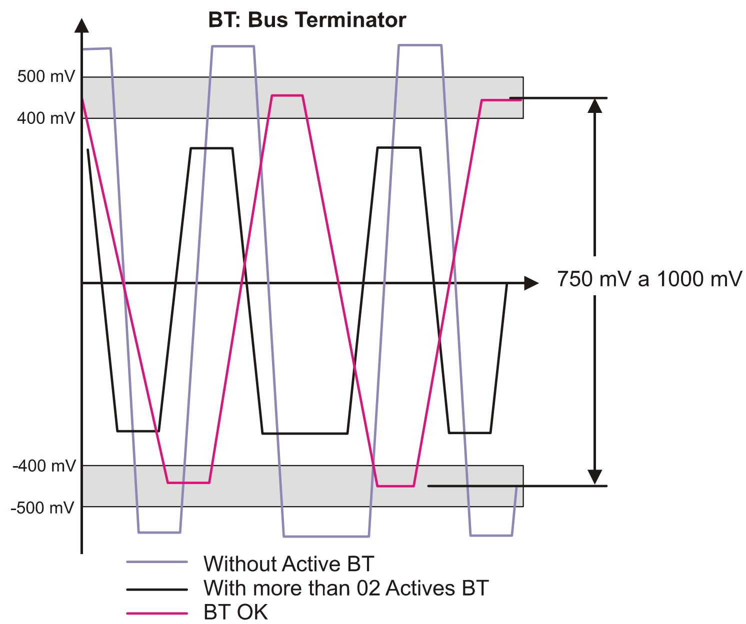


Figure 1.7 –Typical H1 Wave Forms According to the Termination

Following, the real waves forms related to the three cases mentioned on Figure 1.7.

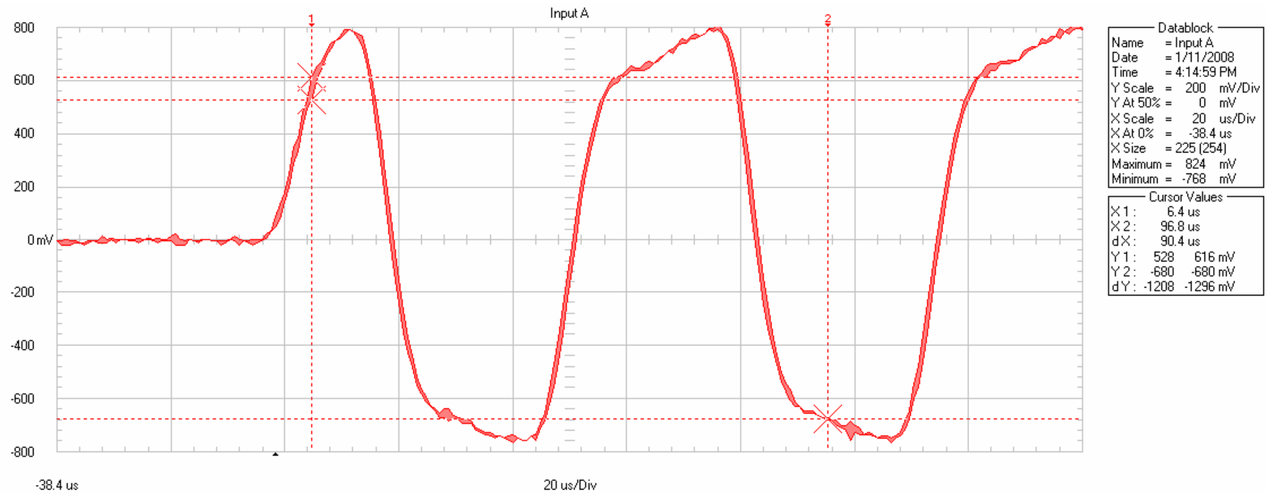


Figure 1.8 –Wave form without Active BT

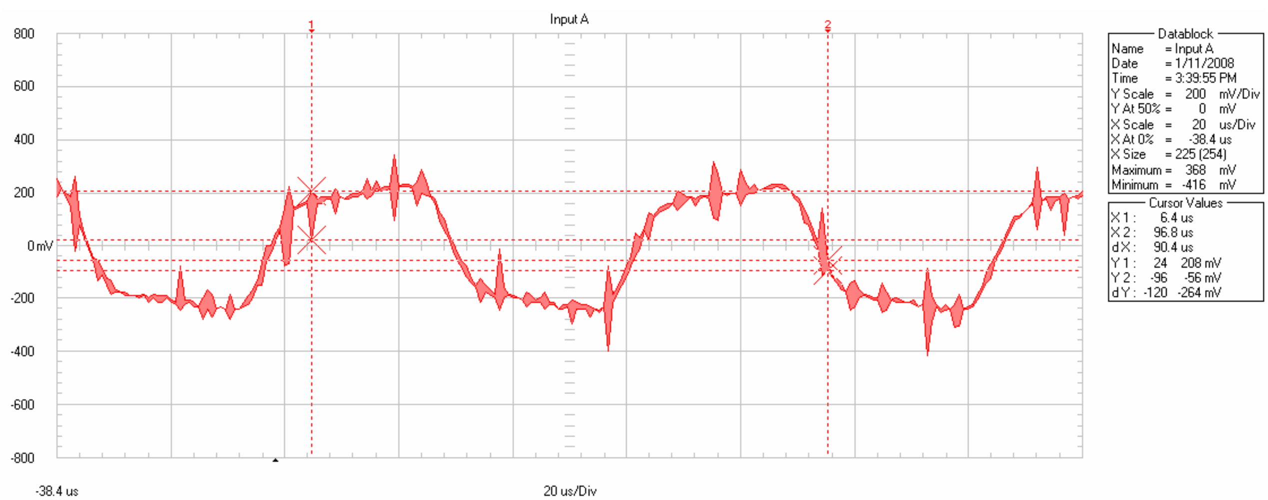


Figure 1.9 –Wave form with more than 2 Active BTs

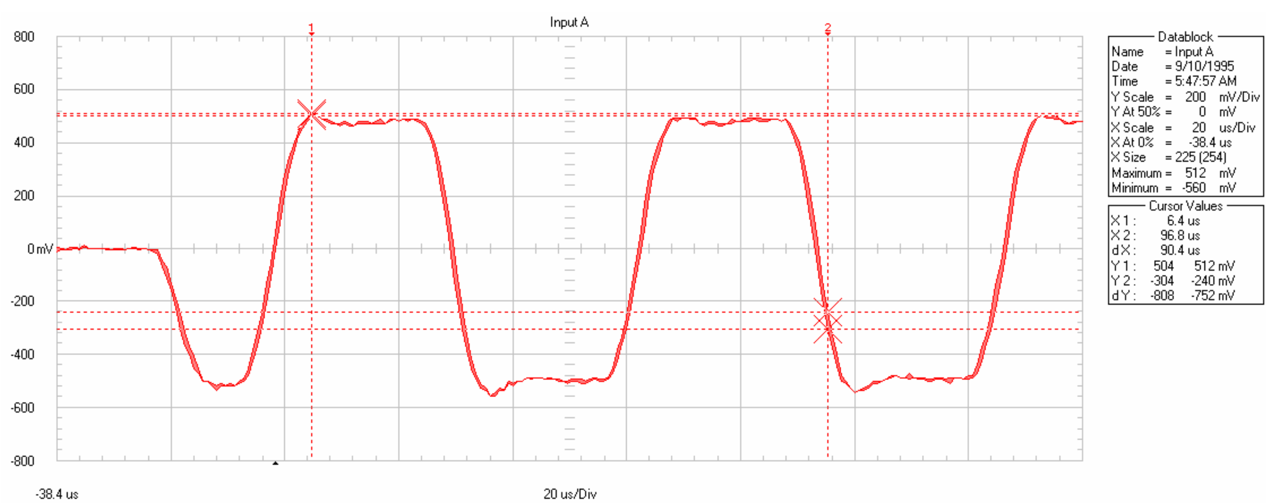


Figure 1.10 –Wave form with Correct BT

Check the position of the terminators in the following topologies.

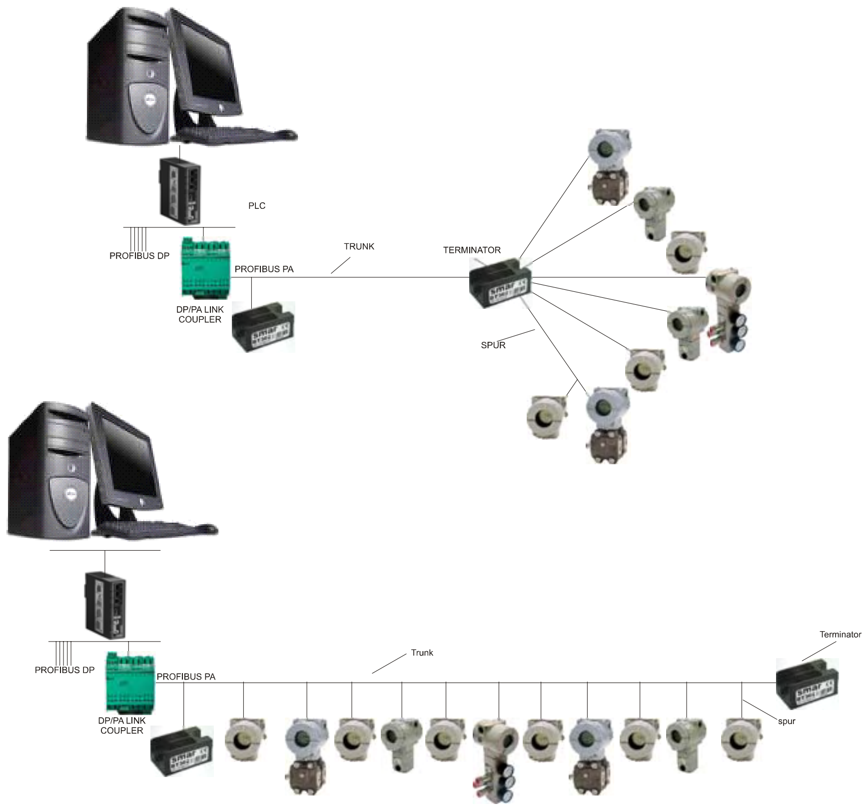


Figure 1.11 - Position of Terminators in Tree or Star Topologies and on the Bus

Power Supply
The power supply usually has an output of 24 Vdc with capacity of a few ampéres. The power supply can operate in redundant mode and it should failure indication and protection against surges, transients and short circuits. Smar makes the DF52 power supply that meets these characteristics.

In terms of power supply signal, consider as acceptable values in practice:

- 12 to 32 Vdc in the PSI output (Active Impedance)
- Ripple (mV):
  < 25: excelent;
  25 < r< 50: ok;
  50 < r < 100: acceptable;
  > 100: unacceptable.

In terms of communication signal, consider as acceptable values in practice:

- 750 to 1000 mVpp: ok;
  > 1000 mVpp: Very high. A terminator may be lacking.
  Some barriers and segment protectors, like spur guards, have high impedance in series and can produce signals up to 2000 mV and even allow the appropriate operation.
- < 250 mVpp: Very low. It is necessary to verify if there is more than 2 active terminators, power supply, etc.

Some devices have polarity, others not, so it is very important to assure the correct polarity of the devices. All the devices are connected in parallel, that is, all the negative terminals together and all the positive terminals together. The use of colored wires codified is recommended to distinguish the positive from the negative.

Active Impedance
The active impedance avoids that the power supply low impedance lessens the communication signal of the bus, allowing the feeding to be supplied in the same wire pair.

It works as low impedance for DC and high impedance for AC communication signal and may have an additional internal terminator activated by a frontal key. The active impedance is fundamental for the network correct operation.

The Foundation Fieldbus impedance is on a device of non-isolated, active impedance control, complying with the IEC61158-2 standard. This device has an output impedance that works in parallel with the two bus terminators (a resistor of 100 Ω in series with a capacitor of 1 μF) assisting to the pattern and results in purely resistive line impedance for a wide frequency range. The Smar DF49 module has two channels and the DF53 module four channels.

Repeaters H1

The passive repeater increases the H1 segment range of 1900 m by amplifying its signal. Up to 4 repeaters may be used with 8-bit preamble or a maximum of 8 repeaters with 16-bit preamble. A maximum of 4 repeaters. It is usually allowed.

As the repeater isolates the communication signal and the power supply, it is possible to connect devices that drain more current from the bus or even to create new segments starting from the same main bus (Figure 1.12). Smar offers the RP302 repeater, as well as the DF47 model that works both as repeater and intrinsic safety barrier.

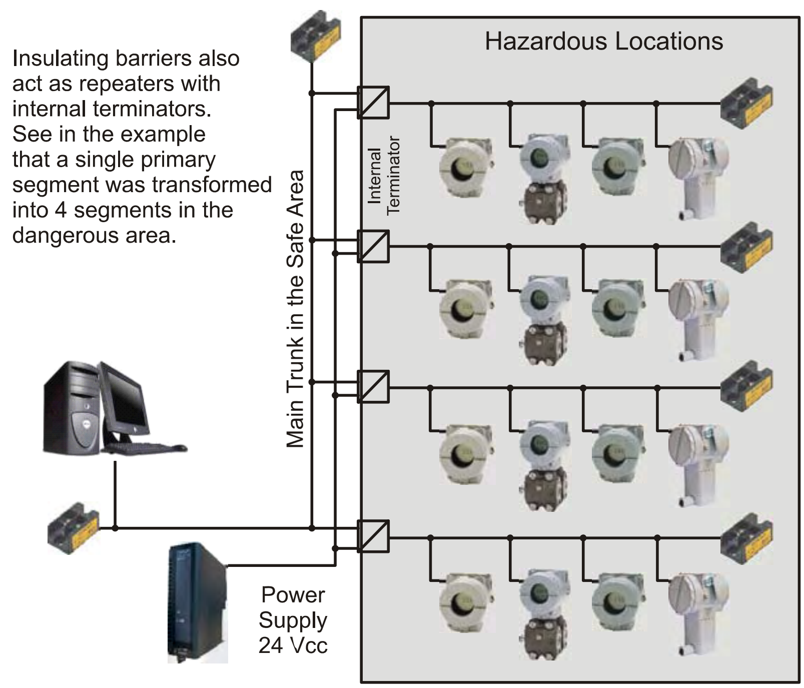


Figure 1.12 - Isolation Provided by the Barrier

Intrinsic Safety Barrier

The intrinsic safety barrier has the primary function to limit the energy available in the bus that circulates for the classified areas.

A classified area is that whose atmosphere is potentially explosive. The barrier usually isolates and repeats the FF signal, allowing several segments on the dangerous side to be connected to the safe side. See Figure 1.12. The Smar offers the model DF47, which works as repeater and intrinsic safety barrier, as well as the SB302 model, which is an isolated barrier.

Derivation Box

It allows the connection and disconnection of devices without interrupting the continuity of the bus, increasing the plant availability and simplifying maintenance. It reduces start-up time, stoppage time and cabling costs.

In the Smar JM400 model, the weather-proof and explosion-proof housing prevents water, oil or dirt from reaching the electric connections (IP66/68). Its cover lock mechanism doesn't require specific support. See Figure 1.13 and 1.14.

Figure 1.13 - Field Network with Derivation Box

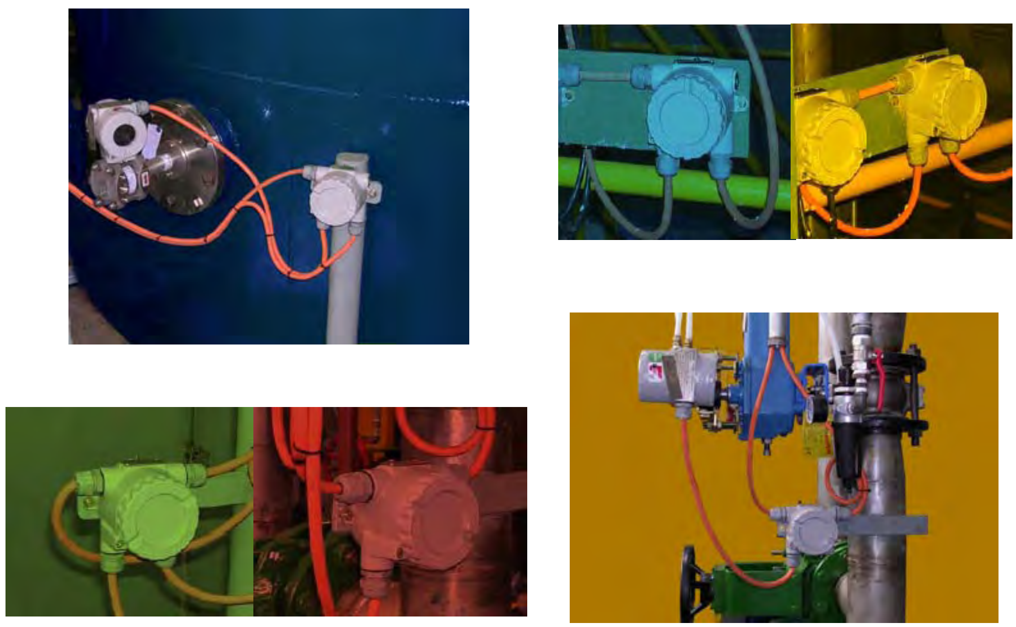


Figure 1.14 –Field Network with Derivation Box

The FISCO Concept Intallation
The FISCO model (*Fieldbus Intrinsically Safe Concept*) has the following characteristics:

a) There is only one active element - the power supply - in the field bus, located in the non-classified area;
b) The other devices in the classified area are passive;
c) Each field device should have a minimum consumption of 10 mA;
d) In *Ex ia* areas the maximum bus length should be 1000 m and in *Ex ib*, 5000 m;
e) Concerning cables observe the following parameters:

- R´:15 to 150 Ω/km;
- L´: 0.4 to 1 mH/km;
- C´: 80 to 200 nF/km.

Type A cable: 0.8 mm² (AWG 18)

a) Concerning termination:

- R = 90 to 100 Ω;
- C = 0 to 2.2 µF.

The FISCO concept was optimized so that a larger number of field devices is allowed according to the bus length, taking into account the cable variation characteristics (R', L',C ') and terminators that assist categories and groups of gases with a simple evaluation of the installation involving intrinsic safety. Thus, it increased the current capacity per segment and facilitated the evaluation for the user. Besides, when acquiring certified products, the user doesn't need to worry with calculations, even in substitution of an operation.

The FISCO model represents a fast and easy way to project, install and operate H1 networks in installations on classified areas. The main idea is to supply more current to the H1 segment, enabling among other advantages the connection of a greater number of equipments, when compared to a conventional intrinsically safe installation. In summary, just follow the requirements below:

- Use certified and approved devices for FISCO applications;
- Check the parameters of each device (U_i, I_i, P_i): $U_0<U_i$, $I_0<I_i$, $P_0<P_{i;}$
- Observe the parameters of the used cables carefully (R, L, C). Use type A cable
- To observe the correct use of the terminators;
- Do not exceed the maximum length allowed for the cabling.

The main advantages when using a FISCO installation are:

- Plug&Play actions in hazardous areas;
- The system certification is not mandatory, but is up to user discretion;
- The expansion of the application is very simple;
- It is possible to connect the maximum number of devices in the classified area;
- The installation costs are reduced;
- There is no need for parameter recalculation when changing the devices.

FNICO

A new concept that also appears on the scene is FNICO (*Fieldbus Nonincendive Concept*), which is similar to the FISCO, but limited for use in Zone 2. Both concepts, FISCO and FNICO, are turning the fieldbus more attractive for use in hazardous areas.

FNICO is allowed in North America countries or those based on standards of this region. This concept considers:

- Input capacitance/inductance;
- Maximum cabling and spurs;

And the following:

- Vmax of each field device > Voc of the Repeater;
- Imax of each field device > Ioc of the Repeater;
- Pmax of each field device > Poc of the Repeater.

Repeaters with 215 mA of capacity are common.

Transient Supressor

Whenever having an effective distance larger than 100 m on the horizontal or 10 m on the vertical position between two grounded points, the use of transient protectors is recommended, on the distance initial and final points. On the horizontal, its use is recommended between 50 and 100 m.

The transient protector should be installed immediately after the PSI, before each device and also in the junction box. In classified areas, the use of certified protectors is recommended. See Figure 1.15.

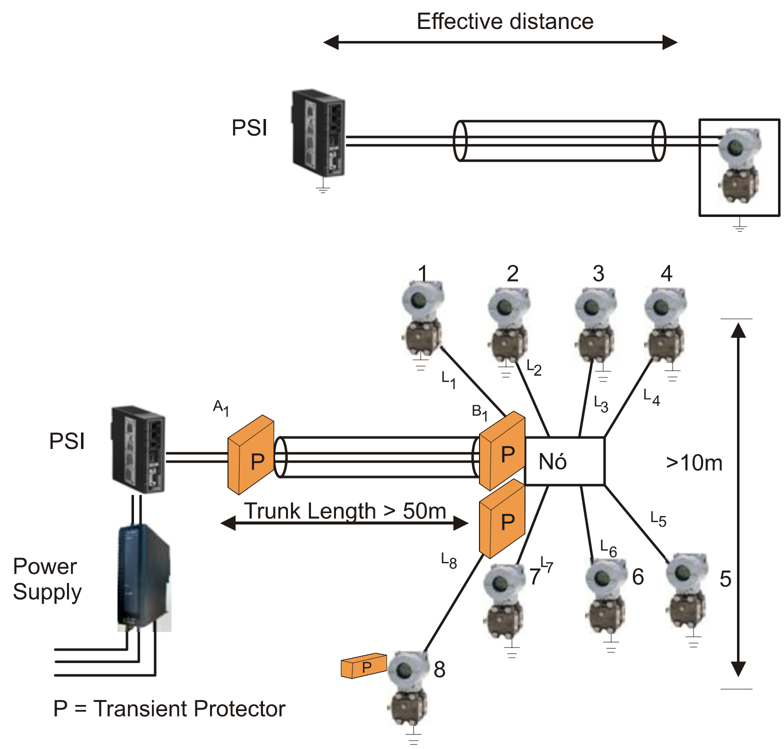


Figure 1.15 – Effective Distance in a Cable Distribution

Topologies

In relation to topology, there are the following models: Star or Tree, Bus and Point-to-point (Figure 1.16). In practice, there is usually a mixed topology.

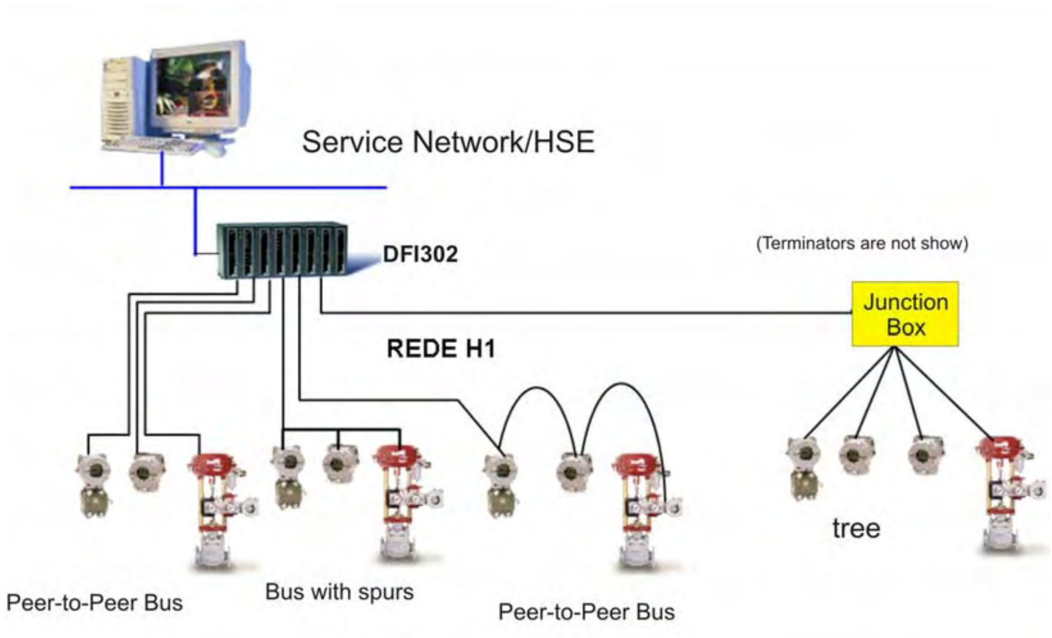


Figure 1.16 – Examples to the Fieldbus Topology

Shield and Grounding

When considering shielding and grounding in field bus, the following should be taken into account:

- Electromagnetic compatibility;
- Protection against explosion;
- Protection of people.

According to the IEC61158-2, to ground means to be permanently connected to the ground through sufficiently low impedance and with enough conduction capacity to prevent any voltage to cause damages to equipments or people.

Voltage lines with 0 V should be connected to the ground and be galvanically isolated from the bus. The purpose of grounding the shield is to avoid high frequency noises.

Preferably, the shield should be grounded in two points, in the beginning and the end of the bus, as long as there is no potential difference between these points, allowing the existence of loop current and access to it. In practice, when this difference exists, the shield should be grounded in a single point, in other words, at the power supply or the intrinsic safety barrier. The continuity of the cable shield must be kept in more than 90% of the cable total length. See the Figure 1.17.

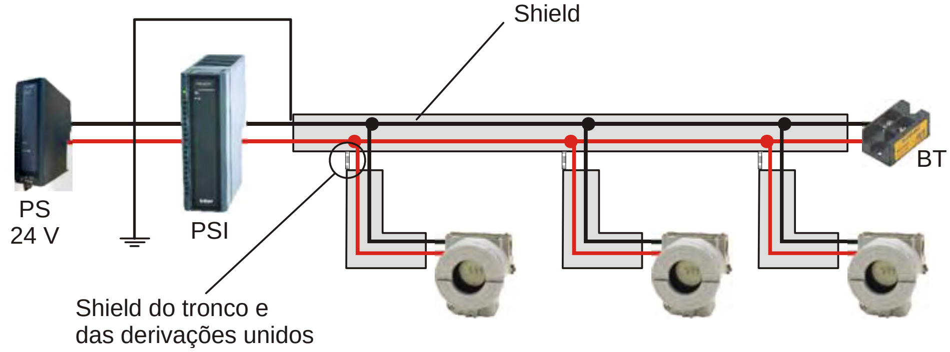


Figure 1.17 – Shield Grounding

The shield should cover the electric circuits completely through the connectors, couplers, splices and distribution and junction boxes.

The shield should never be used as a signal driver. The shield continuity should be checked until the last fieldbus device on the segment, and the connection and finishing inspected, because the shield should not be grounded to the equipment housing.

In classified areas, if a potential equalization between the safe area and the hazardous area would not be possible, the shield should be connected directly to the ground (Equipotencial Bonding System) only on the dangerous area side. In the safe area, the shield should be connected preferably through a ceramic capacitive coupler, like a solid dielectric capacitor, C =10 nF, isolation voltage ≥ 1.5 kV). See Figures 1.18 and 1.19.

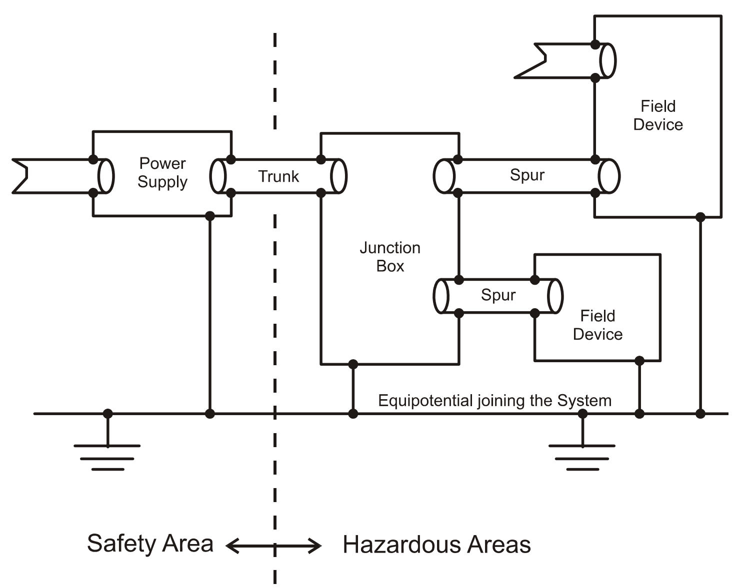


Figure 1.18 – Ideal Combination of Shield and Grounding

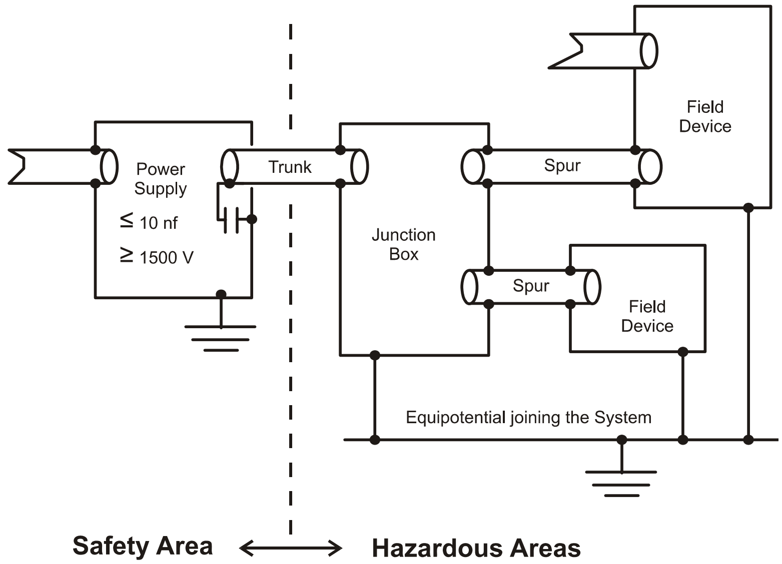


Figure 1.19 – Capacitive Grounding

IEC61158-2 recommends the complete isolation. This method is used mainly in the United States and in England. In this case, the shield is isolated from all the grounds, except the negative ground of the power supply or of the intrinsic safety barrier on the safe side. The shield has continuity from the PSI output, through the junction and distribution boxes and reaches the equipments. The equipment housings are grounded individually on the non-safety side. This method has the disadvantage of not entirely protecting the signals from the high frequency signals and, depending on the cable topology and length; in some cases it can generate communication intermittency. Metal ducts are recommended in these cases.

Another complementary form would be to ground the junction boxes and the equipment housings in an equipotencial ground line on the non-safety side. The grounds on the non-safety side and on the safe side are separate.

The multiple grounding conditions are also common, with more effective protection from high frequency and electromagnetic noises. This method is preferentially adopted in Germany and some countries in Europe. In this method, the shield is grounded on the negative ground point of the power supply or the intrinsic safety barrier on the safe side, in addition to the junction boxes ground and in the equipment housings and these are also grounded on the non-safety side. Another complementary condition would be the grounds being connected together in an equipontencial ground line, uniting the non-safety side to the safe side.

For more details, always consult the local safety standards. Use the IEC60079-14 as reference for applications in classified areas. See some ground and shield ways on Figure 1.20.

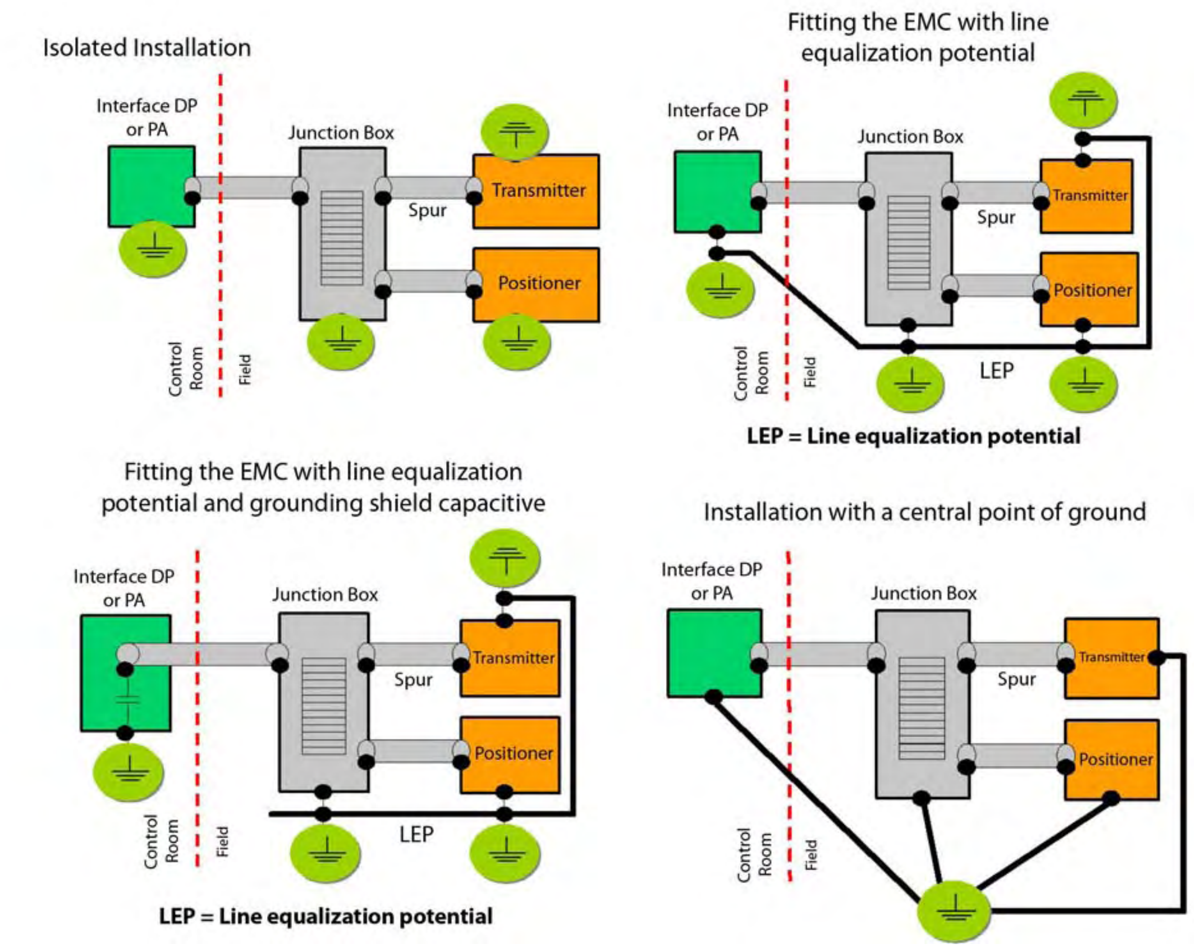


Figure 1.20 – Several Grounding and Shield Ways

Quantity of Foundation Fieldbus Equipments in a H1 Segment
The amount of equipments (N) for segment is a function of the quiescent consumption of each H1 equipment, the involved distances (type A cable loop resistance: 44 O/km), the drained current, of the area classification, besides the FDE current (usually 0 mA, depending on the manufacturer). The total segment current should be smaller than the one drained by the power supply. Smar devices consume 12 mA.

$$I_{Seg} = \sum I_{BN} + I_{FDE} + I_{FREE}$$

Because:

$$I_{Seg} \langle I_C$$

Where:

I_{Seg} : H1 segment current;

$\sum I_{BN}$: Sum of the quiescent currents of all the devices in the H1 segment;

I_{FDE} : Additional current in case of failure, usually negligible;

I_{FREE} : Recommended: 20 mA, rest current useful in case of expansion or change of manufacturer

I_C : Drained current.

Besides, it is recommended more than 9.0 V in the terminal block of the H1 device most distant from the PSI to guarantee its powering and correct communication:

$$V_{BN} = V_C - (R * L)$$

Where:

V_C : Power supply output voltage;

R : Loop resistance (Type A cable, R = 44 Ω/km);

L : H1 Bus total length;

V_{BN} : Voltage in the terminal block of the H1 devices most distant from the PSI.

Being $V_{BN} \rangle 9.0V$. This guarantees the powering of the last H1 device. Remember that the communication signal should range from 750 to 1000 mV.

Some junction boxes or short circuit protectors for segments, called spur guards, are active and can be powered through the H1 bus; hence, it should be included in the calculation of the total current. Besides, each spur guard output has an allowed current limit that should be respected.

In classified areas follow the established limits.

Foundation Fieldbus in Hazardous Areas
According to the standards, the Foundation Fieldbus technology can be applied in hazardous areas with the following characteristics:

- Ex d: In this case choose the power supply Ex and conduits with Ex d approval;

Ex i: There are three options. The first involves the Ex-i concepts and the second a combination of Ex and Ex i. The third option is the FISCO.

Summary of Classified Areas

Zone/ Explosion Group	Identification	Observation
Zone 0	(Ex ia) IIx	Devices installed in Zone 0 should operate in a segment with “Ex ia” protection.
Zone 1	(Ex ia) IIx (Ex ib) IIx	Devices installed in Zone 1 should operate in a segment with “Ex ia” or “Ex ib” protection. All the circuits connected to this segment should be certified for “Ex ia” or “Ex ib” protection.
Explosion Group IIC	IIC (Ex ia) IIC	If the measures are taken in an IIC explosion group, the devices and components should be certified for the IIC.explosion group
Explosion Group IIB	(Ex ia) IIC (Ex ib) IIB	For the IIB medium explosion group, both devices and components can be certified for the IIC or IIB groups.
Non -Ex	Non-Ex	Devices that are operating in a no-Ex segment should not be installed in explosion-risk areas.

Table 1.5 - Summary of Classified Areas

Intrinsic Safety Definition
Intrinsic safety limits the equipment circuit energy, so that they do not cause the ignition of potentially explosive atmospheres even in the occurrence of failures that may produce sparks or warm surfaces in contact.

As it deals with energy limitation, this is an adequate technique for electronic equipments, typically used in control and process instrumentation.

Foundation Fieldbus Technology and Intrinsic Safety
According to standards, 1 to 4 devices may be connected together in the hazardous areas, after the Intrinsic Safety Barrier, and two more devices in the safe areas in the same bus.

With the energy limitations for each device in the hazardous area, some instruments will need to be run through other power supplies. Therefore, devices such as, process analyzers, of I/O subsystems, magnetic or Coriolis effect meters can combine intrinsic safety with other installation or contention techniques for protection against possible explosions.

It should be considered as intrinsic safety barrier the quantity of devices, the amount of cables and the capacitance and inductance limit values for the Ex I installation.

Table 1.6 presents a brief comparison between the FISCO and FNICO models and the entity model.

	FISCO	Entity Model	FNICO
Cable Length	1000 m - ia (*) 5000 m - ib (*)	1900 m	1000 m
Maximum *Spur* Length	30 m(*)	120 m	30 m(*)
Cable and Length Reactance	Non-considered	Considered	Non considered

(*)Maximum analyzed length. It is possible (the) to use (of) a larger length.

Table 1.6 –FISCO vs. Entity Model

There is a set of rules for applications in hazardous areas that uses intrinsic safety methods. The fieldbus technology refers to the lengths of the segments, limits of currents in the power supply and parameters as capacitance and inductance, as well as parameters of equipment failures. The FISCO method provides an easy implementation for applications intrinsically safe in fieldbus, giving flexibility, operational safety to the applications and reducing installation costs, since one can handle up to 10 devices in an Ex network. Besides, the possibility of online handling simplifies commissioning, startup and maintenance. More power means more devices and less cables, hence less barriers.

Equipments compliant to FISCO can be directly connected to IS networks based on the entity model. The reverse condition needs to be evaluated.

Following are described some key points that should be considered during the implementation, involving classified areas and fieldbus:

- Which is the hazardous area. Remember that non-incendive is only allowed in Division 2 areas and intrinsic safety equipment only in Division Div 1 and Division Div 2 areas);
- Which size and scalability required ;
- Will there be short circuit protection for the main trunk and the spurs?
- Which are the acceptable safety level and risks? (Projects involving intrinsic safety take into account the components failure and allow maintenance while being powered, although without heat. Conversely, non-incendive equipment doesn't allow maintenance being performed during powering or even heat exchange.
- Are there limitations to shutdowns?
- Do the engineering and the maintenance teams have proven experience with hazardous and classified areas?
- Do all the devices have certification compatible with the application?
- Are the facilities compliant to the area and country safety standards?

For more details consult IEC60079-27, "*Fieldbus Intrinsically Safe Concept* (FISCO)" and "*Fieldbus Non-Incendive Concept* (FNICO)".

Increasing the Reliability

There are several ways to increase the fieldbus network reliability. They are the following:

a) Power supply redundancy, according to Figure 1.21.

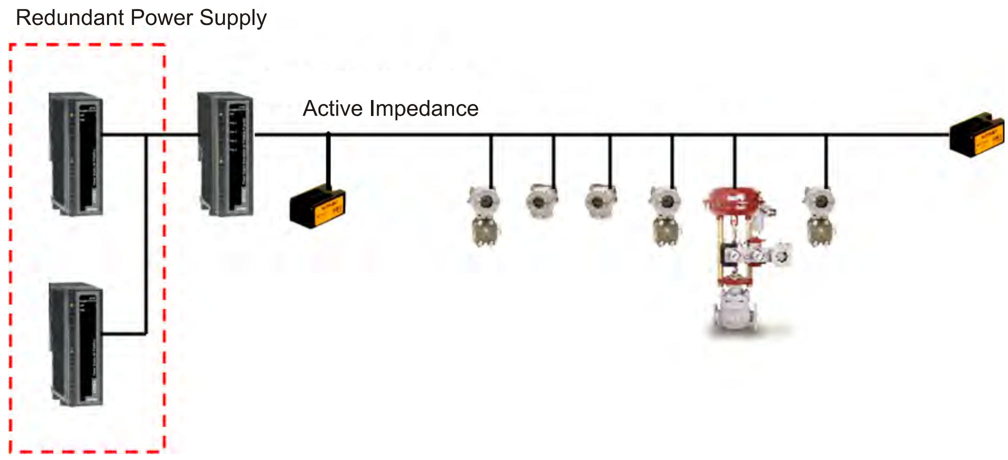


Figure 1.21 –Power Supply Redundancy

b) Double active power supplies and impedance, in case of a cabling break for: See Figure 1.22

- Guaranteed power supply;
- Non-guaranteed Integral communication;
- Guaranteed failure position.

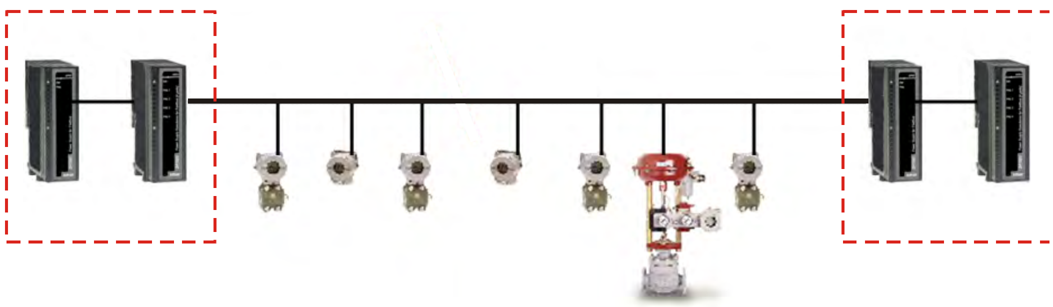


Figure 1.22 – Double power supplies and PSI

OPERATION

The Series 302 devices have an optional digital LCD display that works as a local operator interface for basic factory pre-programmed functions or for personalized user functions through the host system remote tool in the engineering and/or maintenance station. To accomplish these configurations through local adjustment, use the SD-1 magnetic tool for local adjustment.

In a more complete and friendly way, all configuration, operation and diagnosis can be accomplished remotely, by using, for example, a configurador, an engineering or maintenance console. For more details consult the Syscon network manual configurator or the AssetView asset manager.

The configuration is composed of the automatic association of addresses for the H1 network device, the tag attribution and the selection or instantiation of function blocks that will be executed inside the device. And based on these, build the control strategies that it is made by selecting the blocks, inter-connecting and adjusting the internal parameters in order to get the required operation.

The local and remote operation interfaces also enable monitoring the performance of the variables, such as process variables and setpoint. These variables depend on their use and can be accessed in a single communication.

The management of acyclic events is performed automatically. When alarms and other critical events occur, the function block informs the user directly, without the need for the interface to execute a scan periodically to determine if there is an alarm condition. It takes some time for the recognition to be received. This will happen even if the alert condition disappeared and it will be reported by the device. If it is not recognized in a given period, the event report will be issued.

Similarly, the communication informs automatically the configuration changes involving statistical data. An event is generated by an internal mechanism when a change occurs, so the host won't need to constantly check for a possible system overload.

Through the scheduled communication, the transfer of connection parameters between function blocks can be synchronized with the block execution. Thus, the block that uses an input parameter can receive this data before running the algorithm block.

Due to the configuration and alarm mechanism, the so-called "non-operational traffic", has been minimal, with more time for operational traffic and control improvement.

After being configured, the system saves the parameter tags and names to allow for an optimized communication.

Using the device function blocks, the speed can increasingly be improved. For example, using the PID block for control, there is one communication less , unlike the control done by another device. This decreases the duration of the control application and therefore the network macro-cycle.

LCD Indicator

The LCD indicator displays each function block parameter that is user-selectable. Some of them can be changed by local action, according to the user configuration and the parameter properties.

When the user chooses a variable, the display shows the parameter mnemonic, its value and status when it is different from "*good*". The field and status indicators are explained in Figure 2.1.

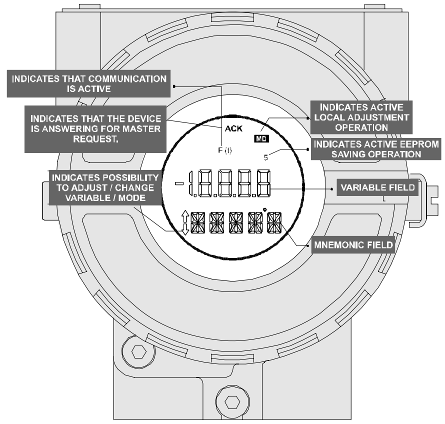


Figure 2.1 - Indicator

Indication Operation

During the indication operation, the Series 302 equipment stays in the monitoring mode. In this mode, it shows a variable indicated by the user configuration. Figure 2.2 shows the indicator displaying a "position". Whenever the displayed value exceeds "19999, it will appear with a two-digit mantissa and an exponent.

The indication mode is interrupted when the user performs an action with the local adjustment.

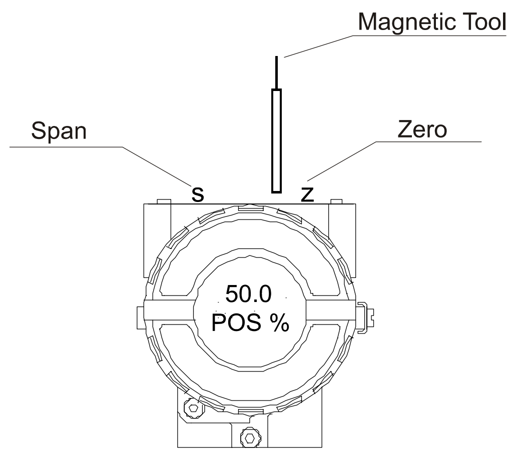


Figure 2.2 - Typical Normal Display Showing PV, in this case 50.0 %

The display is also displays errors and other messages. See Table 2.1 – Displayed Messages.

Display	Description
INIT	The device is in initializing mode after power on.
BOUT	The sensor is open or not connected properly (when it is applicable).
FAIL	The device presents some fail or malfunctioning
FACT	The device is recovering default configuration to non-volatile memory.

Table 2.1 – Displayed Messages

Basic details of the Syscon Use

Introduction

Syscon is the software tool that configures, maintains and operates the newest SMAR product line and communicates with the comprehensive new series of controllers. These controllers are all connected to the High Speed Ethernet providing field network connections to well-known FOUNDATION fieldbus™ protocol. For more details, please, consult the Syscon Manual.

Communication

The friendly Man-Machine Interface (MMI) provides an efficient and productive interaction with the user, without previous knowledge of the software. A large library of pre-configured and tested templates for devices, control strategies and graphic symbols makes the engineering system as efficient and as fast as it can be. Only a minimum of data needs to be entered when defining I/Os, networking, and control strategies.

Support Tool

The plant control configuration is now managed by a unique tool, the Studio302, which integrates all applications included in the Smar's SYSTEM302 Enterprise Automation System and incorporates Windows-based Users and Groups to provide a multi-user environment. Now the Syscon project files have controlled access defined for each professional operating the plant and a precise register of the history of modifications to guarantee the integrity of the project configuration data.

Live List

The Live List function is available in the support tools and provides a list of all equipment in the fieldbus network after communication startup.

On the Fieldbus window, select the fieldbus icon, search the View menu and click on Live List or click on the fieldbus icon with the right button to open the menu and select the Live List item. Figure 2.3.

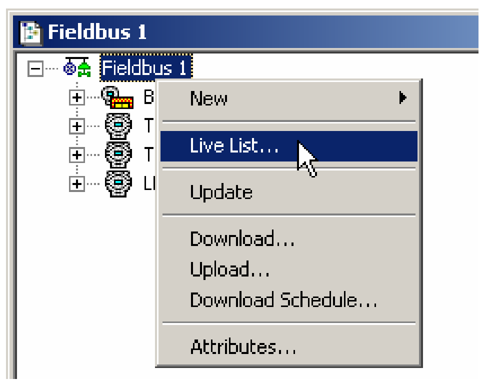


Figure 2.3 - Live List

The Live List window appears, as shown in Figure 2.4.

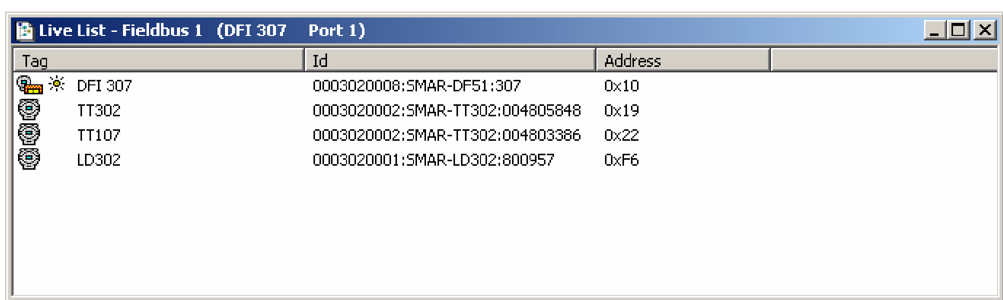


Figure 2.4 - Live List Window

The Live List window shows the devices and bridges identified by the device tag, ID and address, and also the device configured as Active LAS (Link Active Schedule). The active LAS is indicated by a different icon on the Live List.

Table 2.1 below describes the icons that identify the instruments and bridges in the window of the Live List.

	Active LAS Bridge.
	Bridge set to assume the LAS function when the active LAS stop communicating.
	Active LAS field device.
	Field device set to assume the LAS function when the active LAS stop communicating.
	Bridge H1 or HSE.
	Field device H1 or HSE.
	Information reading from the field equipment in process.
	HSE Host.
	Third-party gateway or I/O modules.
	Bridge or field device that has no supporting files (DD, CF or FFB blocks file (Flexible Function Block)). This situation can occur when there is some FFB block with ladder logic in the configuration.

Table 2.1 - Icons that identify instruments and bridges in the Live List

Block List

The list of blocks instantiated in an instrument may be visualized through the Block List, after the communication was initialized.

In the Fieldbus window, select the FB VFD icon, search the View menu on the Block List or click in the FB VFD icon with the right button to open the menu and select the Block List item.

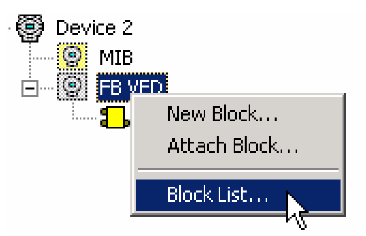
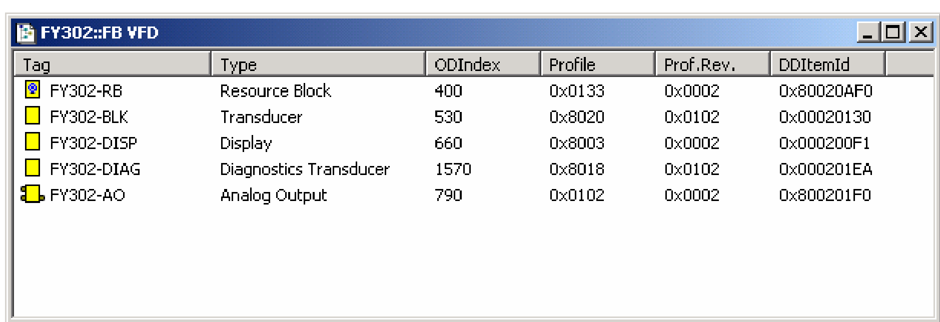


Figure 2.5 – Block List

The Block List window is displayed:



FY302::FB VFD

Tag	Type	ODIndex	Profile	Prof.Rev.	DDItemId
FY302-RB	Resource Block	400	0x0133	0x0002	0x80020AF0
FY302-BLK	Transducer	530	0x8020	0x0102	0x00020130
FY302-DISP	Display	660	0x8003	0x0002	0x000200F1
FY302-DIAG	Diagnostics Transducer	1570	0x8018	0x0102	0x000201EA
FY302-AO	Analog Output	790	0x0102	0x0002	0x800201F0

Figure 2.6 - Block List Windows

Using the AssetView Asset Manager

The Smar AssetView is a software system for online network-enabled asset management. The primary objective is to unleash the powerful diagnostics capabilities found in Fieldbus devices in general and in Smar devices particularly, providing several maintenances schemes and a user-friendlier interface

AssetView deals only with devices and is used for the long-term maintenance and device operation. AssetView is not restricted to just displaying device error messages, but it can analyze devices through test sequences, recorded data and plot charts providing a much more sophisticated failure analysis.

Another important characteristic of the AssetView is the web-based architecture technology. The user interface is the Internet Explorer web browser and it can be used on any Windows platform.

For more information see AssetView Manual.

Visualizing the Device Page

Each device has a standard Web page layout. Each device installed in the plant has a page where the user can calibrate, configure, detect, diagnose or reconcile the device configuration.

Navigate the topology tree and click on a device icon to view its page. Figure 2.7 shows the FY302 page with the **FY-302-AV01** tag.

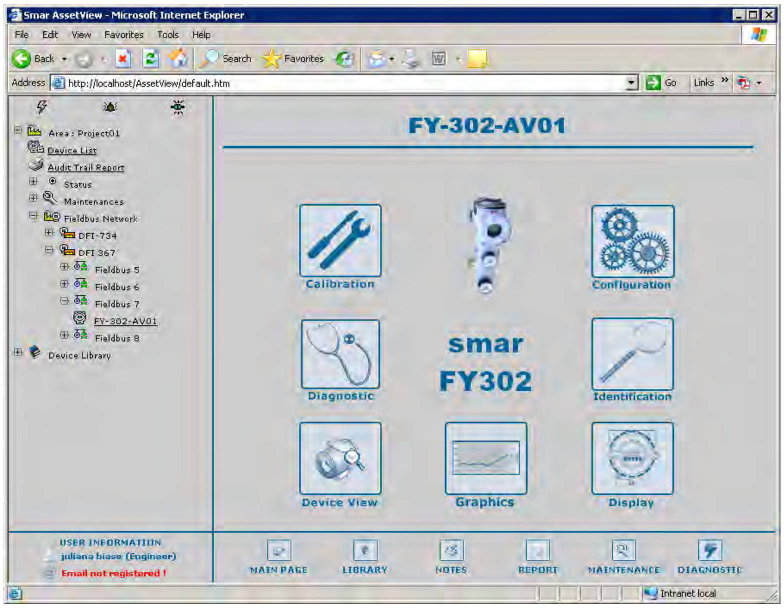


Figure 2.7 - Initial Page of an AssetView 4.3 Device

For each type of device, the main page can have the following links:

Calibration

Calibration is the correction of sensor readings and physical outputs. During this process, messages are displayed to the user indicating the status of this condition. There are specific calibration methods for each device based on scripts defined by the manufacturers.

Configuration

In the Configuration page, the user can read and write the parameter values of the devices. From this page, the user can also access the Reconciliation page and compare the current configurations to previous device configurations stored in the database. Refer to subsection ***Reconciliation***.

Diagnostics

Simple diagnostics are displayed to the user. Comprehensive tests can be done from time to time using several charts to check the condition of the field device. Because of the diagnostic it is possible to first remotely check the device if there really is a failure before going into the field. And yet, because of the detailed information about the Network and device operation provided by the diagnostics, the user knows exactly where the problem is.

Identification

The Identification page provides all the information relevant to the maintenance of the device, such as its manufacturer, device type, tag, serial number, and its versions. Construction materials for wetted parts are also indicated.

Device View

The Device View page monitors the instrument data, such as temperature or pressure values read from the instrument.

Display

In the Display page, the user can configure the device’s display, viewing and modifying parameters such as device mnemonics.

Reconciliation

Reconciliation allows comparison of current device settings with past configurations stored in the database. The **Time** menu on the left side of the page lists the modifications made in the device, including the last modification that is also called the “current device parameterization”. The Time menu on the right side also lists the modifications made in the device, except date and time for the current device parameterization.

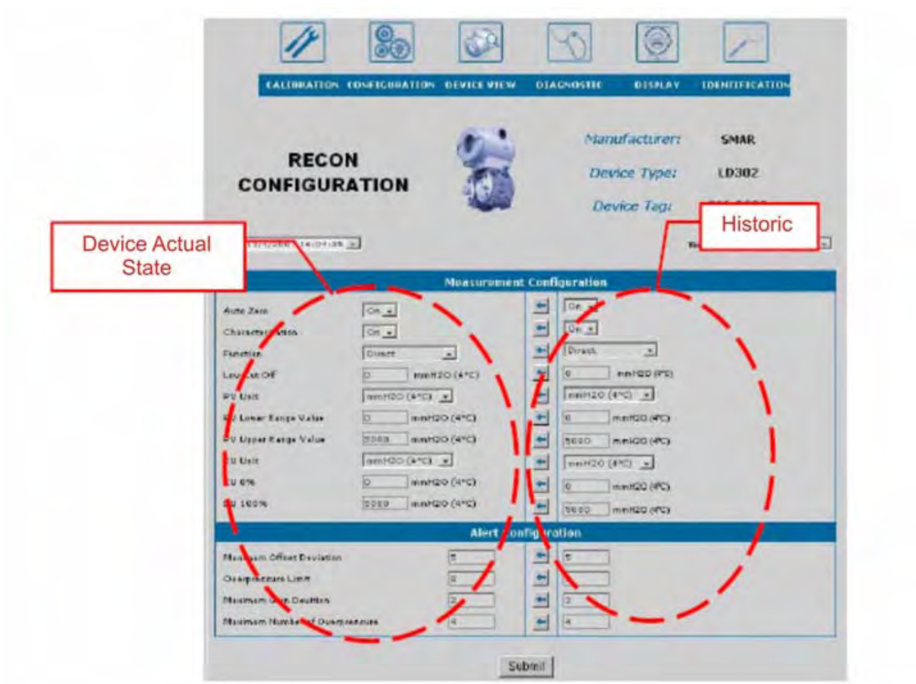


Figure 2.8 - Device Reconciliation Page (Instrument)

Section 3

LOCAL ADJUSTMENT SETTING

To configure the function blocks and communication in the Series 302 equipment use the configuration system called Host. The heavier and difficult task is automated and the risk of configuration error is reduced. In the case of the Smar SYSTEM302 (Smar), an automatic guide directs the user to commission the device properly. In this system, the equipment addressing is made with the same physical tag.

The steps described below are based on the Smar – Syscon system configurator 6.1 Version. Importantly, these settings may vary with each manufacturer.

Creating Devices

On the *Fieldbus* window, right-click the fieldbus icon and click **New > Device**. The **New Device** dialog box will open.

Select the *Device Manufacturer* from the list and the *Device Type* provided by the selected manufacturer.

Select the *Device Revision*, then select the *DD Revision* and the *CF Revision*, or check the option **Follow the Latest DD/CF Revision** to apply the latest revision for the selected device.

NOTE
If the option **Follow the Latest DD/CF Revision** is selected, ***Syscon*** will update the device with the latest revision of the *DD* and *CF* every time the configuration file is opened. To disable the automatic update, right-click the device icon, click **Exchange** and unmark that option on the **Exchange** dialog box.

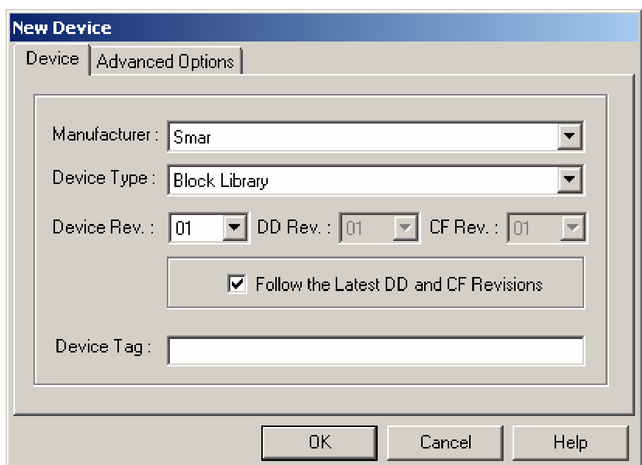


Figure 3.1 - Device Dialog Box

Type a related tag for the device. If you do not define the tag, **Device n** will be the default tag, where **n** is a sequential number for devices.

At the *Advanced Options* tab, select the options to automatically create and configure blocks and parameters, according to the *Capabilities File*:

Creation Based on Default Template: creates the device based on the *Default Template* file for the selected *Device Revision*, located in the corresponding *Device Support* folder.

Create Resource Block: automatically creates the *Resource Block* of the selected device. You can set the initial value for the *Mode Block* parameter.

Create Transducer Blocks: automatically creates the *Transducer Blocks* of the selected device. You can set the initial value for the *Mode Block* parameter.

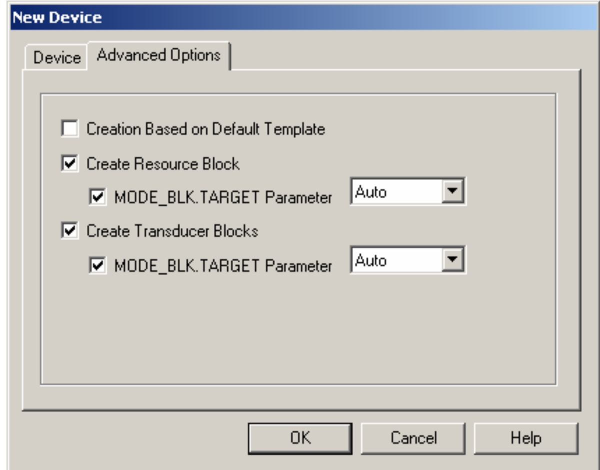


Figure 3.2 - Advanced Options

Click **Ok** to add the device to the configuration.

OBSERVATION
If the *Default Template* file is not found, ***Syscon*** will automatically create the *Resource* and *Transducer Blocks* for the selected device. If the tag is not entered, Device *n* will be the default tag, where *n* is a sequential number for the instruments.

The Fieldbus window will be similar to the Figure 3.3 bellow:

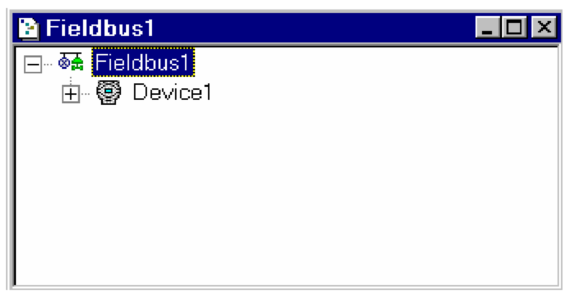


Figure 3.3 – Fieldbus Window

IMPORTANT
The *HSE Device* can only be added to the *HSE Fieldbus*. Likewise, the *H1 Device* can only be added to the *H1 Fieldbus*.

Creating a Device from a Template

Para criar um instrumento baseado em um arquivo modelo, selecione o ícone do fieldbus*,* vá ao menu *Edit* e clique em *Import Device Template*. Também é possível criar um instrumento através do menu do fieldbus, clicando sobre o ícone com o botão direito e selecionando o item *New* > *Device from Template*.

On the *Fieldbus* window, right-click the fieldbus icon and click **New > Device from Template**.

Select the directory where the template file is located, select the device template file and click **Open**. A message box will open to confirm the operation. Click **Ok** to proceed.

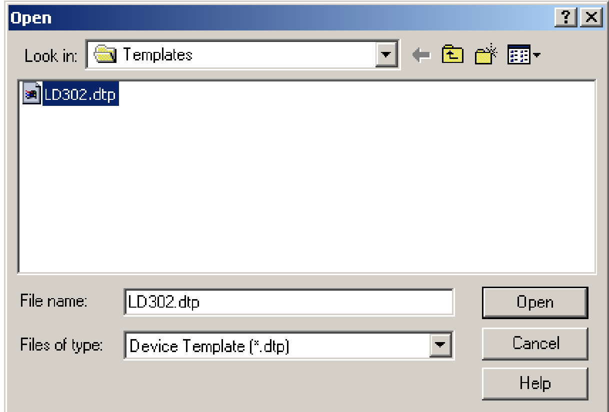


Figure 3.4 - Selecting a Model Instrument

The **Tag Table** will open, showing the list with block and device tags based on the preferences settings and the old tags used in the template file. To edit a tag, right-click the block or device icon at the **New Tag** column and click **Rename**. Type the new tag and click **Enter** on the keyboard.

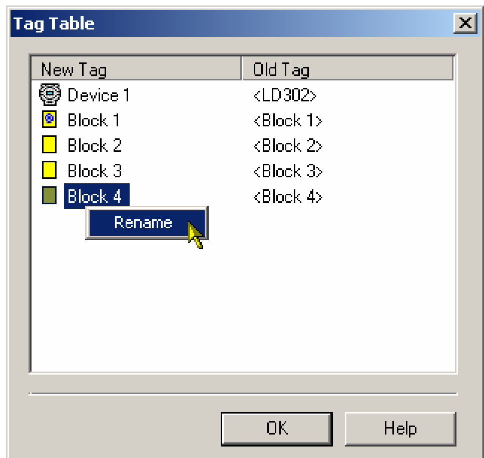


Figure 3.5 - Tag Table Dialog Box

Click **Ok** to close the **Tag Table** dialog box and add the device to the configuration.

Changing the Device Attributes

Right-click the device icon and click **Attributes**. The **Device Attributes** dialog box will open.

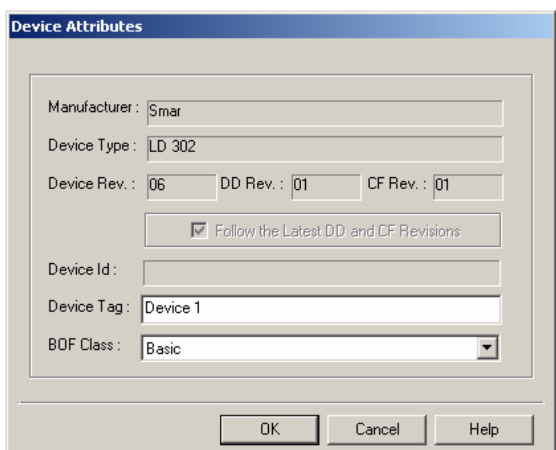


Figure 3.6 - Device Attributes Dialog Box

NOTE
When the Syscon is in on-line mode, the **Device Selection** dialog box displays the devices that have not been instantiated in the project. If the user selects **Unspecified** in the **Device Tag** list and apply this tag to the instrument, the Syscon will automatically generate a new tag for the standard instrument, based on the preferences settings.

When operating in the **Advanced User** mode, the tab **Advanced Options** will be available in the **Device Attributes** dialog box. Type the new physical address for the device.

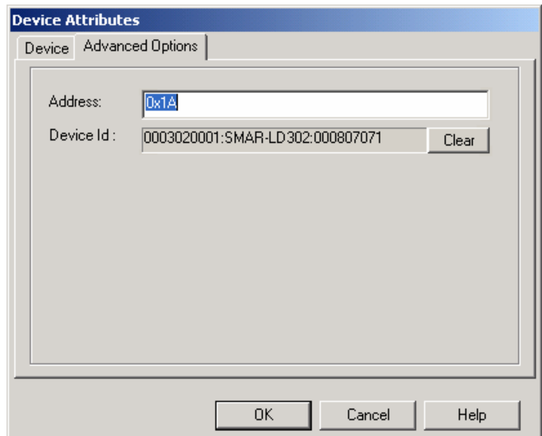


Figure 3.7 - Advanced Options

Enter the physical address in the Address field of the instrument.

The normal commissioning operation should use the options **Commission** and **Decommission**. Only for some engineering and test scenarios, with the ***Syscon*** in **Advanced Mode** options, it is possible to delete the *Device Id* from the instrument without using the decommissioning procedure.

Click **Clear** to delete the *Device Id*. This procedure do not replace the **Decommission** option, it only disassociates the physical device from the instrument on the configuration.

Click **Ok** to apply the alterations and conclude.

Master Backup Device

To configure the device to operate as a *Master Backup*, a *Link Master* should be selected.

Right-click the device icon and click **Attributes**. Click the down arrow on the **BOF Class** box and select the Link **Master** option.

Click **Ok** to conclude.

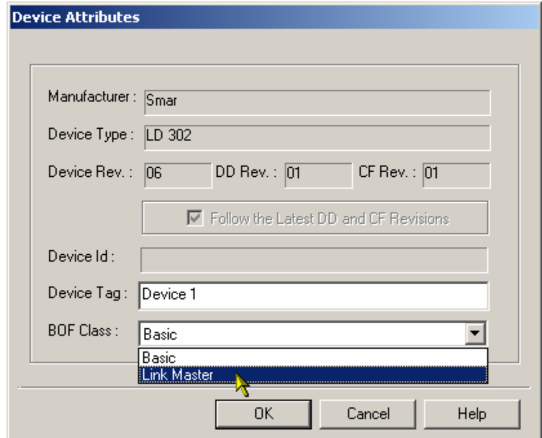


Figure 3.8 - Configuring the Link Master Device

When the Syscon is working **online**, open the device menu and select **Change Class BOF**. Click **Yes** to confirm the change and Syscon will display a message requesting that the instrument is rebooted.

A message box will inform that it is necessary to reinitialize the device. Reset the device and execute the **Download Schedule** in the channel where the device is configured: right-click the fieldbus icon and select **Download Schedule**.

After the download, the device will operate as a *Link Master*.

OBSERVATION
During the download, all **Master Backups** in the **Fieldbus Network** will be configured with the **Traffic Schedule**.

Deleting Devices

To remove a device from the *Fieldbus* window, right-click its icon and click **Delete**, or press **Delete** on your keyboard.

The warning dialog box will appear. Click **Yes** to confirm the operation.

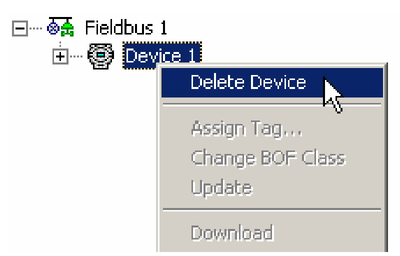


Figure 3.9 - Deleting Devices

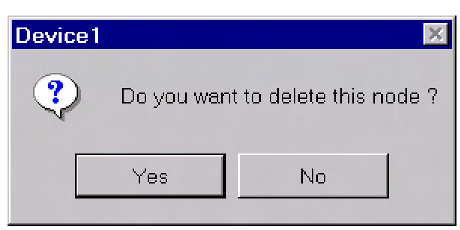


Figure 3.10 - Confirming Operation

Ordering Devices

Select a device icon and drag it over the other device icon. The selected device will be placed above the other device in the configuration tree.

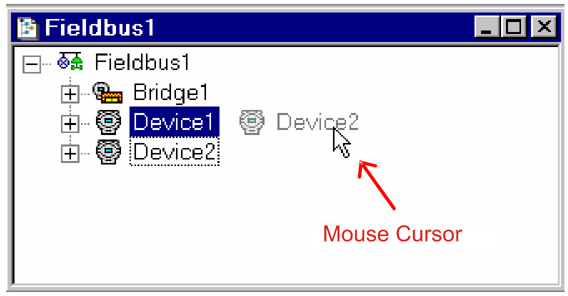


Figure 3.11 - Fixing the window Fieldbus Instruments

The window **Fieldbus** will be as in the Figure 3.12:

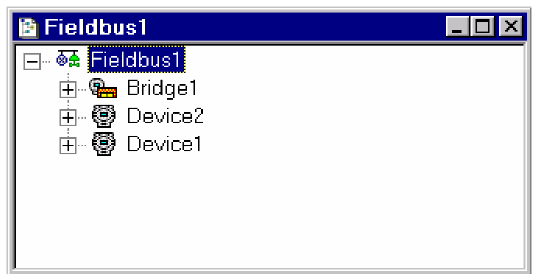


Figure 3.12 – Fieldbus Window

Moving Devices

To move a device from one fieldbus to another, click to select the device icon in the *Fieldbus* window and drag the device over the other *Fieldbus* window.

If there are any block links connecting the device to its original *Fieldbus* window, these links may no longer be available for the communication, because no valid path would be found in the topology. The **incomplete** links will be identified by a **dotted line** in the *Strategy* window.

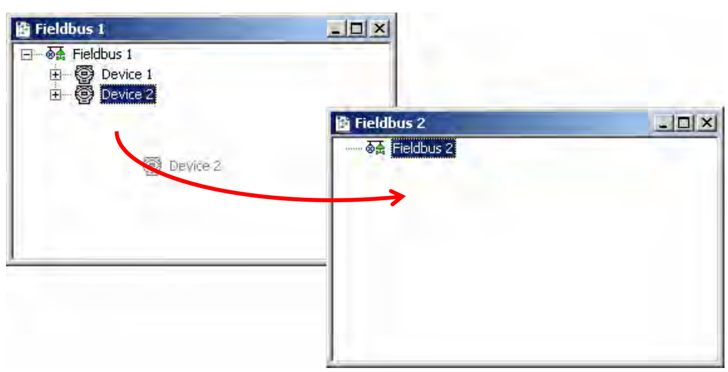


Figure 3.13 - Moving a Device

Device Exchange

When a defective device must be replaced by a new device with a newer or different *Device Revision*, it is possible to exchange these devices easily without modifying the existing configuration. You can also use the **Exchange** procedure to change the *Device Revision*.

The *Device Exchange* checks the inconsistencies, incompatibilities and interchangeability problems, and generates a report about the changes that will affect the configuration.

To exchange a device, right-click its icon and click **Exchange**. The **Exchange** dialog box will open:

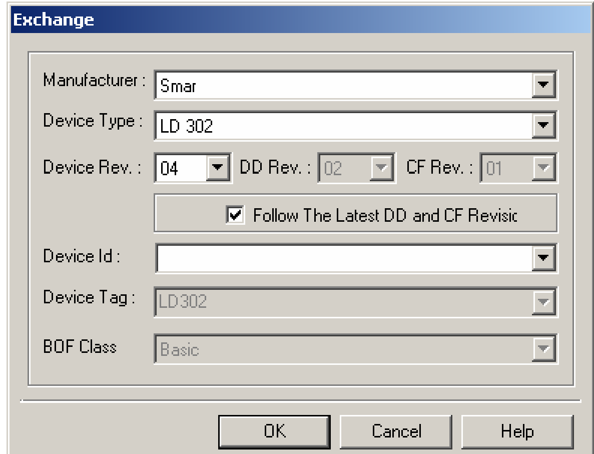


Figure 3.14 - Device Exchange Dialog Box

You can change the *Manufacturer*, the *Device Type* and the *Device Revision* attributes. Edit the attributes and click **Ok**.

Syscon will compare the new device capabilities with the previous device capabilities and display the incompatibilities at the **Device Exchange Deviations** dialog box.

The **Deviations** dialog box shows detailed information about the device, blocks and parameters, indicating to the user the functionalities that can be lost when exchanging the device. See the example below:

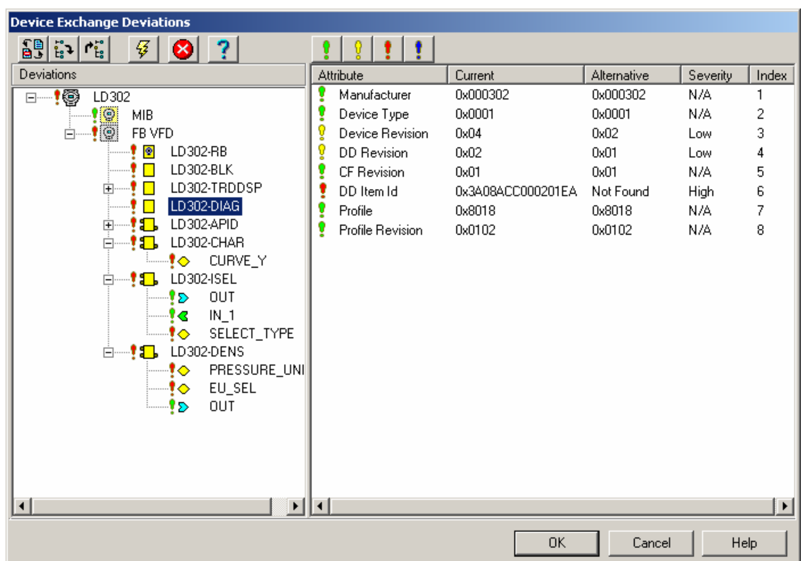
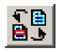
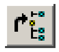


Figure 3.15 - Device Deviations Dialog Box

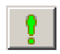
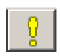
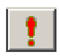
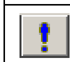
The panel on the left shows the blocks and parameters configured in the original device and indicates the new device compatibilities.

The panel on the right compares the original device attributes to the new equipment selected. Click the column headers (*Attribute*, *Current*, *Alternative*, *Severity* or *Index*) to sort the list of parameters. Clicking the column header will also toggle between ascendant and descendent sorting.

The **Deviations** dialog box has its own toolbar. The following table describes the functionalities of the buttons:

	Click this button to refresh the information on the dialog box.
	Click this button to expand all nodes.
	Click this button to collapse all nodes.
	Click this button to accept the changes and close the **Deviations** dialog box.
	Click this button to cancel the **Exchange** procedure and close the **Deviations** dialog box.
	Click this button to open the **Syscon Online Help**.

The **Deviations** dialog box has four filter levels that classify all of the blocks and parameters attributes for the device:

	The attributes classified by this filter are compliant with the device.
	The *Low Severity* filter indicates that the attributes are not compliant but the information won't be lost.
	The *High Severity* filter indicates that the attributes are not compliant and the information can be lost or converted.
	This filter will display all attributes.

Click **Ok** to confirm the **Exchange** procedure. ***Syscon*** will verify the compatibility of the blocks. If a block is not available in the target device, a dialog box will open alerting the user that inconsistencies were detected and some functionalities will be lost if the device is exchanged.

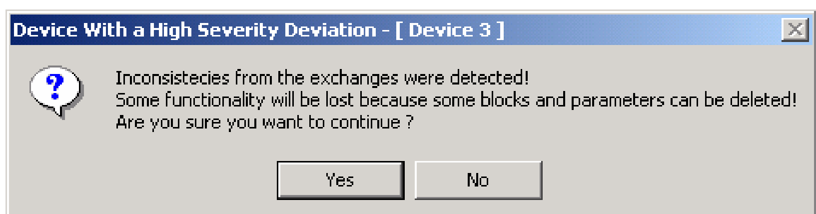


Figure 3.16 - Detecting Inconsistencies

Click **Yes** to confirm the exchange or click **No** to cancel the procedure and discard the device alterations.

If you confirm the **Exchange** procedure, the **Compatibility** dialog box will open. The **Compatibility** dialog box allows you to replace the blocks from the previous device that are not compatible with the new device. See the example below:

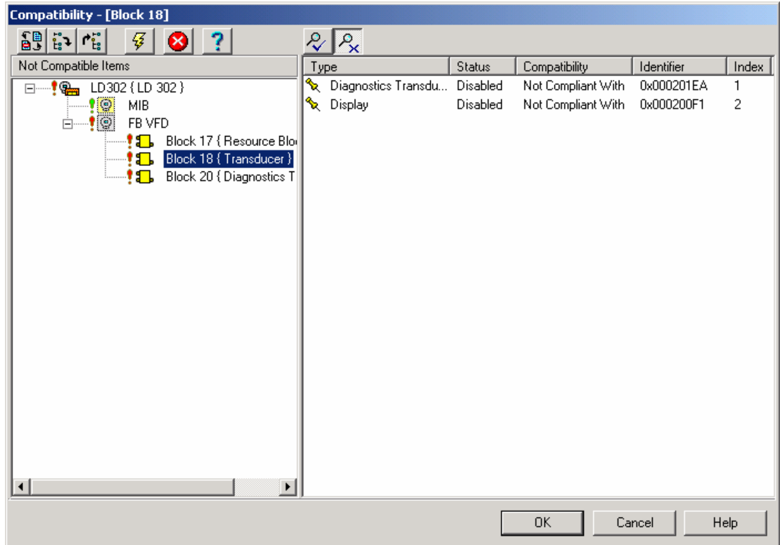


Figure 3.17 - Compatibility Dialog Box

The panel on the left indicates the blocks that are not compatible with the new device. For each block not compatible, click its icon and the panel on the right will show the types of the compatible blocks.

Use the buttons in the toolbar to filter the blocks:

	This filter shows the list of blocks from the new device, which is compatible to the blocks from the previous device.
	This filter shows the list of blocks from the new device, which is **not** compatible to the blocks from the previous device.

Right-click the icon of the compatible block and click **Enable** to replace the old block in the device.

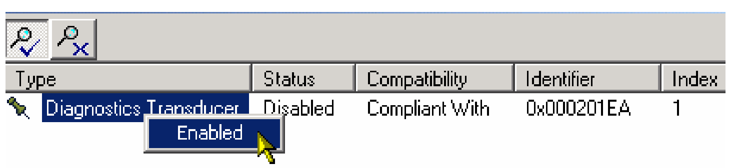


Figure 3.18 - Selecting a Compliant Block

Repeat this procedure for each block that is not compatible with the new device. Click **Ok** to confirm the alterations and close the **Compatibility** dialog box.

Blocks that cannot be converted will be removed from the configuration and sent to the **Recycle Bin**. Parameters cannot be converted. If there is no identical parameter in the new device, the parameter will be deleted and will **not** be sent to the **Recycle Bin**.

For more details see Configurator Software Manual.

NOTE
The local adjustment can be used for basic operations and some configuration tasks. This eliminates the need for a high performance configurator system, but requires more knowledge. See the section Local Adjustment Methodology how to use the local adjustment.

Function Blocks

For function block configuration details see the Function Blocks Instruction Manual.

Display Transducer

The 302 series devices can be equipped with an LCD display. In the normal monitoring mode, the system may show a variable.

The display transducer block can be configured by the Syscon. In the example below, the LD302 has four blocks instantiated: analog input block, display and Transducer and Resource blocks.

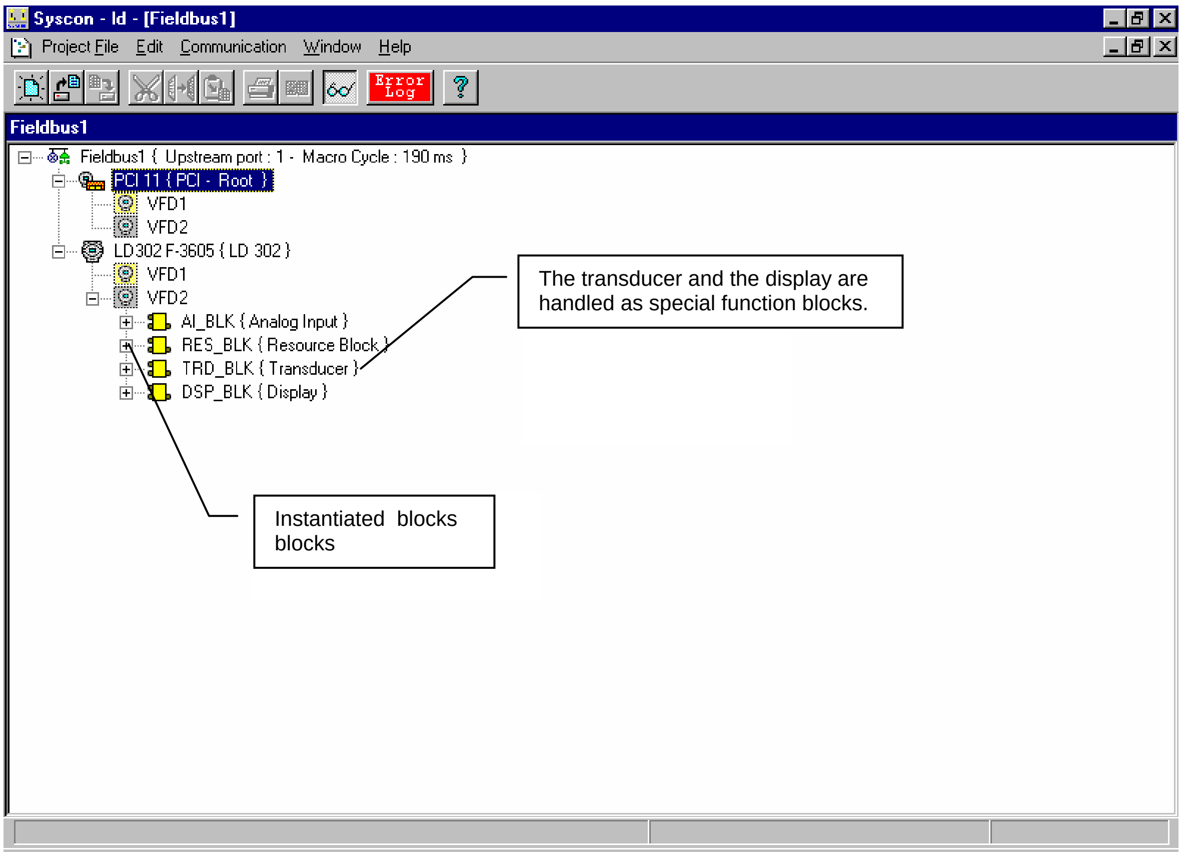


Figure 3.19 – Function Blocks and Transducers

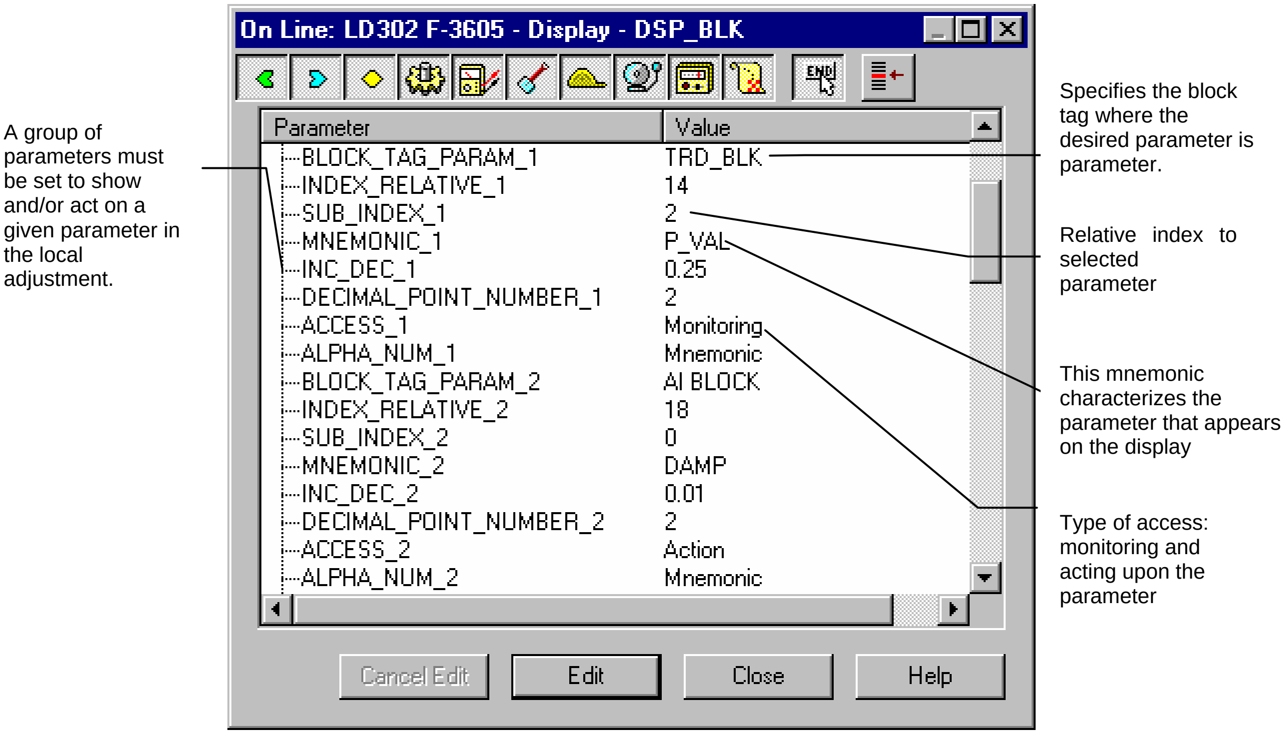


Figure 3.20 – Display of the Transducer – Configuration

The display block is handled as a common function block. This means that this block can be configured by Syscon, setting parameters and choosing values according to the user's needs. The LCD display can be used for parameter monitoring or performance

Local Programming Tree

The programming tree is a menu system that allows the configuration of the most important items. The menu is configured through the display block.

Each field device is supplied with a factory default setting.

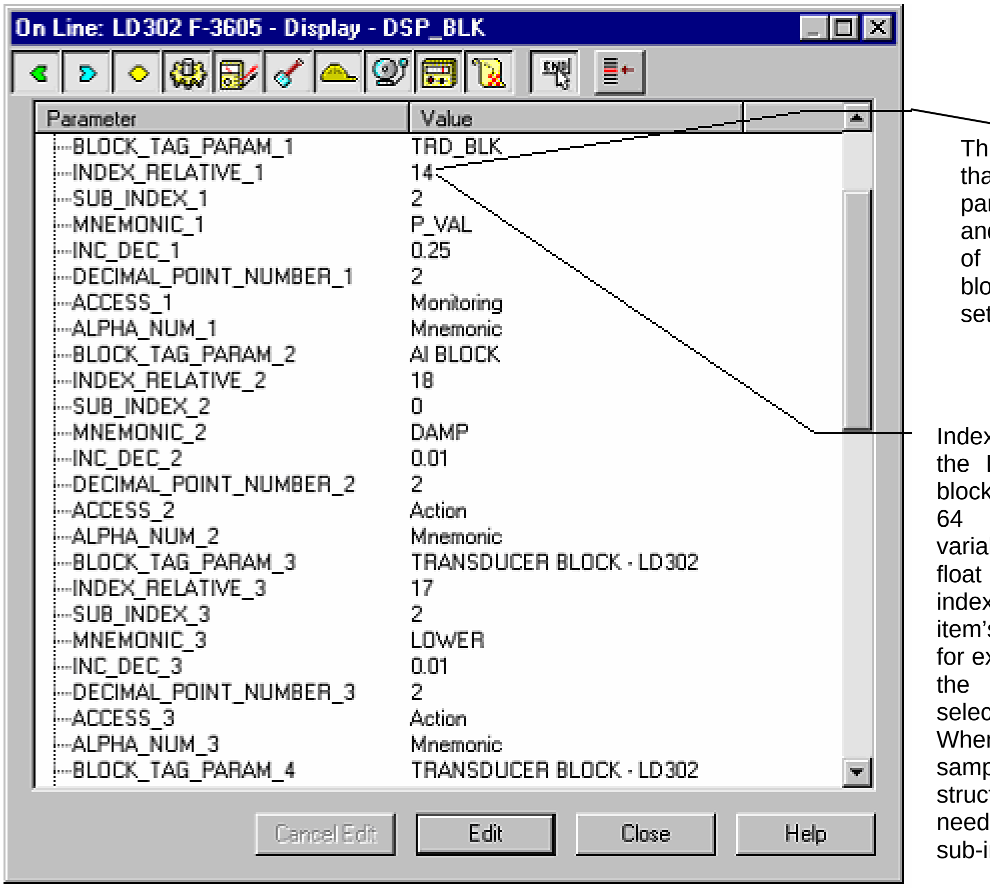
There is a default setting for each type of field equipment, but usually it includes the tag, the output or input of the transducer block as a monitoring parameter and calibration parameters as shown on Table 3.1:

Parameter	Function	Class
Tag	Monitoring	Read
Primary Value	Monitoring	Read
Lower	Calibration	Read/Write
Upper	Calibration	Read/Write

Table 3.1 - Configuration Indicator Example

Display Configuration Using Syscon

The user must determine and set up the values described in the table below, for each selected parameter.



This value indicates that a default parameter index 14 and the sub-index 2 of the transducer block – LD302 are set as monitoring

Index 14 represents the LD302 transducer block output. It is a DS-64 type (DS-64) variable, i.e., status – float value. The sub-index indicates the item's data structure, for example, 1 selected the status and 2 selected the value. When the parameter is sample, i.e., not a data structure, there is no need to configure the sub-index.

Figure 3.21 – Display Block Parameter Adjustments

Block Tag	Tag assigned to the function block.
Relative Index	Relative index of the specified block parameter.
Sub-Index	Logical member sub-index.
Mnemonic	Mnemonic assigned to the parameter.
Float Inc_Dec	Step to increase or decrease for a float or integer type.
Decimal Point	Number of decimal places after the mantissa.
Acces	Permission to Read and/or Write.
Alpha_Num	Select the mnemonic or value in the display when the value is greater than 10,000.
Refresh	Flag to indicate new configuration.

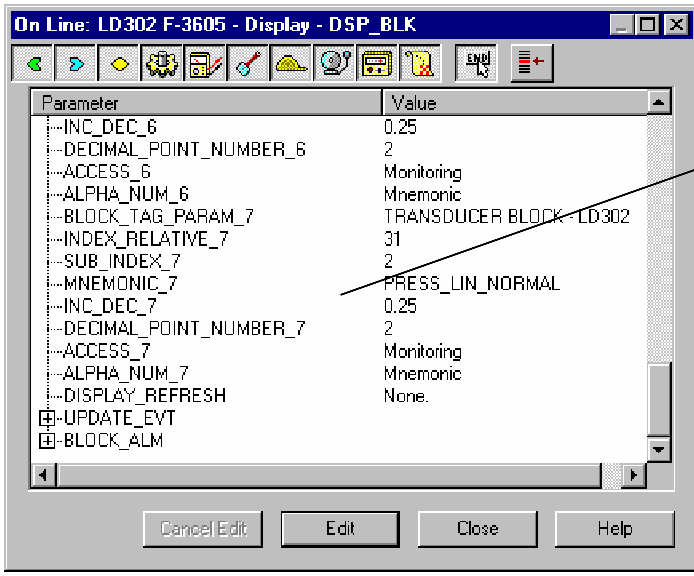
Table 3.2 – Display Block Parameters

Local Adjustment can be fully configured by Syscon. The user can set the parameters to be adjusted or monitored locally. Usually, these parameters are inputs and outputs of control function blocks. It can also change the parameter mode and tuning.

Almost all function block parameters configured by Syscon, can be adjusted locally.

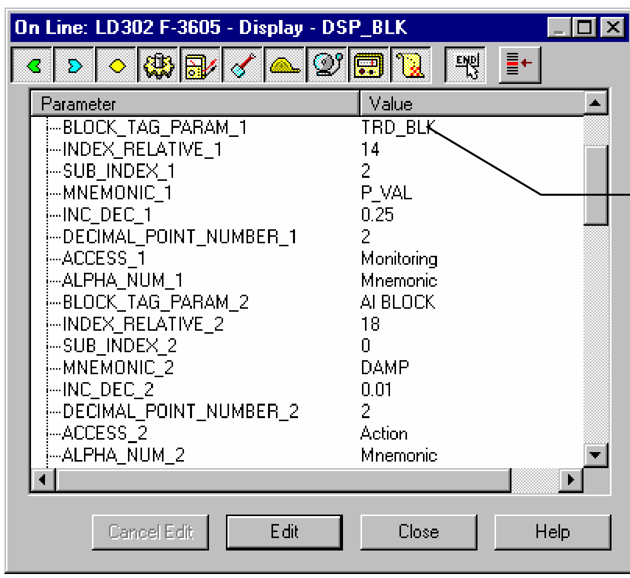
The user can select them using the following data types:

- Integer
- Float
- Status + Float
- Mode
- Tag (read – only)



These settings are required to set a parameter on the LCD display.

Figure 3.22 – Display Block Parameter Adjustment



After the first firmware download, the display block will adjust the tags of functional blocks with default values.

Figure 3.23 – Display Block Parameter Adjustment

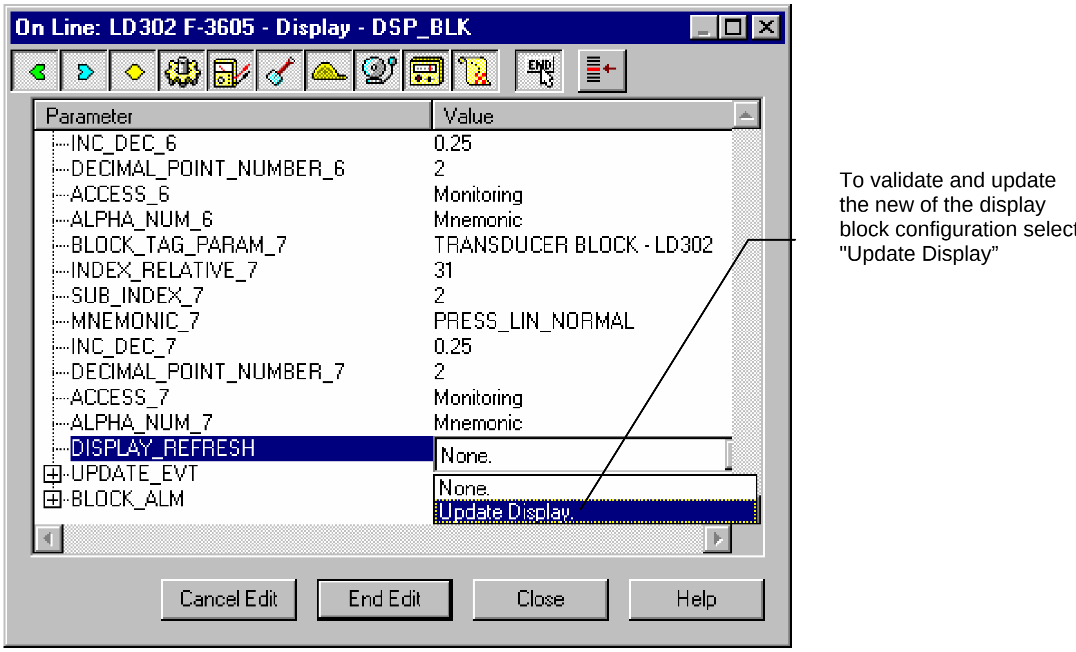


Figure 3.24 – Display Block Parameter Adjustment

Using Local Adjustment

To enable this function, the equipment must have the digital display.

The equipment has two holes located under the identification tag, and the magnetic sensors are activated via magnetic tool. See Figure 3.25.

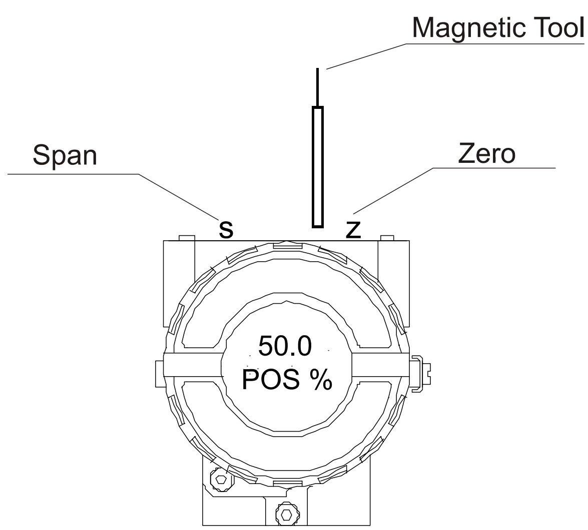


Figure 3.25 – Local Adjustment

The magnetic tool enables adjustment and monitoring of the parameters configured on the local adjustment tree.

The "**LOC. ADJ**" at the top of the main board must be in position **ON**.

Local Adjustment Methodology

Enter the local adjustment by inserting the magnetic tool in the **ZERO** hole. Wait until the **"MD"** flag appears on the LCD. Then insert the magnetic tool twice in the **SPAN** hole The message **"LOC ADJ"** will appear. Next, insert the magnetic tool in the **ZERO** hole. Leaving the tool in the **ZERO** hole, browse through the items in the menu. The **ZERO** hole is used for browsing. By moving the tool to the **SPAN** hole, the parameter can be set on another value.

NOTE
SUMMARY:
Zero (z) Browses
Span (s) Selects / Actions.

To browse the available parameter options, move the tool to the **ZERO** hole to go to the specific menu option. See Figure 3.12. Then make a selection by moving the tool to **SPAN** when the choice is displayed. If the options are on/off, or enumerated, the option will appear in the value field. The mnemonic of each parameter will be displayed on the alphanumeric field. This is for viewing only, as changes are not to be made on the tag configured for the block. If the Functional Block tag is longer than five characters, it will move to the left.

If the magnetic tool is kept in the **SPAN** hole, the action will be continuous when the parameter is numeric. By temporarily removing the tool from the **SPAN** hole and then reinserting it, the working speed is reduced.

When the user inserts in and removes the magnetic tool from the **SPAN** hole, the increment or decrement will be done in steps.

Remove the tool when the desired value is reached.

When incrementing a variable beyond the value desired, move the tool to **ZERO** and wait until the decrement option of the same variable appears. By moving the tool to **SPAN**, it is reduced to the desired value. For "undershoot", the opposite applies.

To exit from any menu, remove the tool from any hole for a break, and an escape sequence will return to normal display.

The arrows inside each mnemonic indicate that the user can change the value by writing if the parameter has reading and writing access.

Whenever the user decrements the value of a parameter, he is given an option to “increment this value” when the magnetic tool is inserted into the **ZERO** hole.
Then the user enters the local adjustment, the last parameter used before is shown.

To monitor a parameter in normal operation, the user just needs to browse at the desired parameter and remove the magnetic tool. Then this parameter will be shown continuously on the LCD.

NOTE
Every action should be done critically because no confirmation is required to change the parameter value. After writing the value, it is automatically stored in the E2PROM memory.

Almost all Function block parameters can be configured by local adjustment. The user should select them from the following classes:

- Integer
- Float
- Status + Float
- Mode
- Tag (read-only)

All of them can be set or monitored by using the magnetic tool.

The default values for the local adjustment are trim parameters, transducer block output or input and Tag identifying the block.

How to Configure a Transducer Block

Each time you select a field device on the configuration tool, automatically you can see the transducer block as it appears on screen.

The transducer block has an algorithm, a set of contained parameters and a channel connecting it to a function block.

The algorithm describes the behavior of the transducer as a data transfer function between the I/O hardware and other function block. There are several parameters in the Function Block. They can be divided into Standard and Manufacturer Specific.

The standard parameters are available for such class of instruments as pressure, temperature actuator devices, etc., whatever the manufacturer. Oppositely, the manufacturer specific ones are defined only by their manufacturer. Common manufacturer specific parameters are calibration settings, materials information, linearization curve, etc.

When you perform a standard routine as a calibration, you are guided step by step by a method. The method is generally defined as guideline to help the user to make common tasks. The configuration tool, for example the Simatic PDM, identifies each method associated to the parameters and enables the interface to it.

Channels

Identifies the channel interface between the transducer block and the function block according to the manufacturer. This number starts from the value 1.

Calibration

This is a specific method to make the calibration operation. It is necessary to match the source of reference applied to or connected to the device with the required value. Some parameters should be used to configure this process: CAL_POINT_HI, CAL_POINT_LO, CAL_MIN_SPAN e CAL_UNIT. Those parameters define the highest and lowest calibrated values for each device, the minimum allowable span value for calibration (if necessary) and the engineering unit selected for calibration purposes, when differentiated by SENSOR_RANGE or FINAL_VALUE_RANGE.

Section 4

MAINTENANCE

General

SMAR Series 302 devices are extensively tested and inspected before delivery to the end user. Nevertheless, during their design and development, consideration was given to the possibility of repairs being made by the end user, if necessary.

In general, it is recommended that end users do not try to repair printed circuit boards. Spare circuit boards may be ordered from **SMAR** whenever necessary. Refer to the item "Returning Materials" at the end of this Section.

TROUBLESHOOTING

Basic *Troubleshooting:* The communication errors are detected automatically and indicated depending on the engineering tools. Troubleshooting is a useful way to remove the parts, one by one, until the failure is detected by elimination. It is also recommended to test the faulty device in your own work bench. Check the following parameters:

- If the polarity is correct;
- If the addresssis correct;
- If the network is secure;
- If the power supply voltage is adequate, always with a minimum 9V current during the communication, plus the course of the Manchester sign.

If there is not any communication, there is a problem with your configuration or installation.

Advanced Troubleshooting: In order to find serious problems, bus analyzers can be used to study the communication messages;

An oscilloscope (balanced/isolated - for example, operated by battery) can also be a useful tool in severe cases.

TROUBLESHOOTING	
SYMPTOM	**PROBABLE SOURCE OF PROBLEM**
NO COMMUNICATION	***Device Connections*** • Check wiring polarity and continuity; • Check for shorts or ground loops; • Check if the power supply connector is connected; • Check if the shield is not used as a conductor. It should be grounded at only one end; • Check the coupler/link connections.
	Power Supply • Check power supply output. The voltage must be between 9 - 32 VDC at the Series 303 device terminals.
	Network Connection • Check that the topology is correct and all devices are connected in parallel; • Check that two bus terminators are OK and correctly positioned; • Check that the bus terminators are according to the specifications; • Check length of trunk and spurs; • Check the connections of the coupler are correct and correctly positioned; • Check the *baud rate*; • Check low isolation.
	Network Configuration • Make sure the Device Tag is configured if system configuration is desired; • Make sure that device address, master connection, and the address.
	Electronic Circuit Failure • Check the main board for defect by replacing it with a spare one.

Table 4.1 - Diagnostic of the Field Devices

COMMUNICATION ERRORS
Installation problems, non-configuration or other main causes of communication errors:

- Loose connections
- Badly installed terminator, without endpoint.
- Very low or unstable power supply;
- Very long spurs or excessive spurs;
- Wrong grounding or no grounding;
- Water leak due to poor electric connections and cable clamp.

Factory Init

The Factory Init should be tried as a last option to recover the equipment control when the equipment presents some problem related to the function blocks or the communication. **This operation must only be carried out by authorized technical personnel and with the process offline, since the equipment will be configured with standard and factory data.**

This procedure resets all the configurations run on the equipment, after which a partial download should be performed. With exception to the equipment physical address and the GSD identifier number selector parameter. After doing this, all configurations must be remade according to their application.

Two magnetic tools should be used to this effect, on the equipment, withdraw the nut that fixes the identification tag on the top of the housing, so that access is gained to the "S" and "Z" holes.

The operations to follow are:

1) Switch off the equipment, insert the magnetic tools and keep them in the holes (the magnetic end in the holes);

2) Power up the equipment;

3) As soon as Factory Init is shown on the display, take off the tools and wait for the "5" symbol on the right upper corner of the display to unlit, thus indicating the end of the operation.

This procedure makes effective the entire factory configuration and will eliminate eventual problems with the function blocks or with the equipment communication.

Note that this procedure must be performed by authorized personal only and with the process switched off, since the equipment will be configured with standard and factory data.

Symptoms	Probable Causes	Recommendations
Excessive noise or spiking in the bus or very high signal.	Humidity in the terminal block and/or connectors causing low signal isolation, low isolation or bad operation power supply and/or devices and/or terminators etc inadequate shield grounding, excessive log or spur, inadequate amount of terminators or noise source near the Profibus cabling.	Check every device connector and terminal block, and make sure that no humidity got in; detect bad contact, if the shield cables are well ended and grounded properly, the ripple level in the power supply and in the bus are within acceptable values, the terminator number and cable lengths and are within the recommended values and also the cabling is distant from noise sources. Check if the grounding is adequate. If damaged devices generate noises, disconnect one at a time and monitor the noise.
Excessive transmissions or intermittent communication.	Inadequate cabling or spur length; power supply voltage in the wrong device terminal block; bad device operation; improper terminals, inadequate shielding or grounding, the amount of devices for spur in the network etc.	Check the cabling lengths, if the power supply voltage of the devices is between 9 to 32 Vdc, if there are no noise sources close to the Profibus bus. In some situations, if damaged devices generate noises or intermittence, disconnect one at a time and monitor the status of the communication. Check the communication AC signal course (750mV to 1000mV). Check the shielding and grounding distribution. Check the number of devices in the network and per spur.
Communication fails with some devices.	Repeated address in the bus, feeding tension insufficient (<9.0 Vdc), position of the terminators, cable excess, amount of devices besides allowed in the segment, etc.	Make sure all the devices have different addresses, and note that when placing a device in the bus with address 126, place it according to the configuration, and only then include another device with address 126 in the bus. Check the cabling lengths and amount of devices, as well as their power supply and terminators positioning.
Intermittent powering of some or all the equipments.	Short circuit between the bus shielding and the terminals, defective power supply, excessive equipment or improper amount of devices.	Check the shield isolation, the amount of devices and their consumption, etc.

Table 4.2 – Symptoms, Probable Causes and Useful Maintenance Recommendations

Returning SMAR Products and/or Materials

Should it become necessary to return the transmitter and/or configurator to **SMAR**, simply contact our office, informing the defective instrument serial number, and return it to our factory.

If it becomes necessary to return the transmitter and/or configurator to Smar, simply contact our office, informing the defective instrument's serial number, and return it to our factory. In order to speed up analysis and solution of the problem, the defective item should be returned with the Service Request Form properly filled with a description of the failure observed and with as much details as possible. Other information concerning to the instrument operation, such as service and process conditions, is also helpful.

Instruments returned or to be revised outside the warranty term should be accompanied by a purchase order or a quote request.

UNITS CODES

Value	Unit	Description	Equivalence
1000	K	Kelvin	SI
1001	°C	degree Celsius	ΔT = 1°C is equal to ΔT = 1K
1002	°F	degree Fahrenheit	
1003	°R	degree Rankine	
1004	r	radian	1 r = 1 m/m = 1
1005	°	degree	1 ° = (π/180)rad
1006	'	minute	1 ‘ = (1°/60)
1007	"	second	1 ” = (1‘/60)
1008	gon	gon (or grade)	1 gon = (π/200)rad
1009	rev	revolution	
1010	m	meter	SI
1011	km	kilometer	
1012	cm	centimeter	
1013	mm	millimeter	
1014	µm	micrometer	
1015	nm	nanometer	
1016	pm	picometer	
1017	Å	angstrom	1 Å = 10^{-10}m
1018	ft	feet	
1019	in	inch	
1020	yd	yard	
1021	mile	mile	
1022	nautical mile	nautical mile	1 nautical mile = 1852 meters
1023	m^2	square meter	
1024	km^2	square kilometer	
1025	cm^2	square centimeter	
1026	dm^2	square decimeter	
1027	mm^2	square millimeter	
1028	a	are	1 a = 10^2 m^2
1029	ha	hectare	1 ha = 10^4 m^2
1030	in^2	square inch	
1031	ft^2	square feet	
1032	yd^2	square yard	
1033	$mile^2$	square mile	
1034	m^3	cubic meter	
1035	dm^3	cubic decimeter	
1036	cm^3	cubic centimeter	
1037	mm^3	cubic millimeter	
1038	L	liter	1 L = 10^{-3} m^3
1039	cl	centiliter	
1040	ml	milliliter	
1041	hl	hectoliter	
1042	in^3	cubic inch	
1043	ft^3	cubic feet	
1044	yd^3	cubic yard	
1045	$mile^3$	cubic mile	
1046	pint	pint	

Value	Unit	Description	Equivalence
1047	quart	quart	
1048	gallon	US gallon	
1049	ImpGal	Imperial gallon	
1050	bushel	bushel	
1051	bbl	barrel	1 bbl = 42 US gallons
1052	bbl (liq)	barrel liquid	1 liquid bbl = 31.5 US gallons
1053	SCF	standard cubic foot	
1054	s	second	SI
1055	ks	kilosecond	
1056	ms	millisecond	
1057	µs	microsecond	
1058	min	minute	1 min = 60 s
1059	h	hour	1 h = 60 min
1060	d	day	1 d = 24 h
1061	m/s	meter per second	
1062	mm/s	millimeter per second	
1063	m/h	meter per hour	
1064	km/h	kilometer per hour	
1065	knot	knot	1 knot = 1.852 km/h
1066	in/s	inch per second	
1067	ft/s	feet per second	
1068	yd/s	yard per second	
1069	in/min	inch per minute	
1070	ft/min	feet per minute	
1071	yd/min	yard per minute	
1072	in/h	inch per hour	
1073	ft/h	feet per hour	
1074	yd/h	yard per hour	
1075	MPH	miles per hour	
1076	m/s^2	meter per second per second	
1077	Hz	hertz	1 Hz = 1 s^{-1}
1078	THz	terahertz	
1079	GHz	gigahertz	
1080	MHz	megahertz	
1081	kHz	kilohertz	
1082	1/s	per second	
1083	1/min	per minute	
1084	rev/s	revolutions per second	
1085	RPM	revolutions per minute	
1086	r/s	radian per second	
1087	$1/s^2$	per second per second	
1088	kg	kilogram	SI
1089	g	gram	
1090	mg	milligram	
1091	Mg	megagram	
1092	t	metric ton	1 t = 10^3kg
1093	oz	ounce	
1094	lb	pound (mass)	
1095	STon	short ton	1 short ton = 2000 pounds
1096	LTon	long ton	1 long ton = 2240 pounds
1097	kg/m^3	kilograms per cubic meter	

Value	Unit	Description	Equivalence
1098	Mg/m^3	megagrams per cubic meter	
1099	kg/dm^3	kilograms per decimeter	
1100	g/cm^3	grams per cubic centimeter	
1101	g/m^3	grams per cubic meter	
1102	t/m^3	metric tons per cubic meter	
1103	kg/L	kilograms per liter	
1104	g/ml	grams per milliliter	
1105	g/L	grams per liter	
1106	lb/in^3	pounds per cubic inch	
1107	lb/ft^3	pounds per cubic foot	
1108	lb/gal	pounds per US gallon	
1109	$STon/yd^3$	short tons per cubic yard	1 STon = 2000 pounds
1110	degTwad	degrees Twaddell	
1111	degBaum hv	degrees Baume heavy	
1112	degBaum lt	degrees Baume light	
1113	degAPI	degrees API	
1114	SGU	specific gravity units	
1115	kg/m	kilograms per meter	
1116	mg/m	milligrams per meter	
1117	tex	tex	1 tex = 10^{-6}kg/m = 1 g/km
1118	$kg\text{-}m^2$	kilogram square meter	
1119	kg-m/s	kilogram meter per second	
1120	N	newton	1 N = 1 $kg\text{-}m/s^2$
1121	MN	meganewton	
1122	kN	kilonewton	
1123	mN	millinewton	
1124	µN	micronewton	
1125	$kg\text{-}m^2/s$	kilogram square meter per second	
1126	N-m	newton meter	
1127	MN-m	meganewton meter	
1128	kN-m	kilonewton meter	
1129	mN-m	millinewton meter	
1130	Pa	pascal	1 Pa = 1 N/m^2
1131	GPa	gigapascal	
1132	MPa	megapascal	
1133	kPa	kilopascal	
1134	mPa	millipascal	
1135	µPa	micropascal	
1136	hPa	hectopascal	
1137	bar	bar	1 bar = 100 kPa
1138	mbar	millibar	1 mbar = 1 hPa
1139	torr	torr	
1140	atm	atmospheres	
1141	psi	pounds per square inch	unreferenced or differential pressure
1142	psia	ponds per square inch absolute	referenced to a vacuum
1143	psig	pounds per square inch guage	referenced to atmosphere
1144	g/cm^2	gram per square centimeter	
1145	kg/cm^2	kilogram per square centimeter	
1146	inH2O	inches of water	
1147	inH2O (4°C)	inches of water at 4°C	
1148	inH2O (68°F)	inches of water at 68°F	

Value	Unit	Description	Equivalence
1149	mmH2O	millimeters of water	
1150	mmH2O (4°C)	millimeters of water at 4°C	
1151	mmH2O (68°F)	millimeters of water at 68°F	
1152	ftH2O	feet of water	
1153	ftH2O (4°C)	feet of water at 4°C	
1154	ftH2O (68°F)	feet of water at 68°F	
1155	inHg	inches of mercury	
1156	inHg (0°C)	inches of mercury at 0°C	
1157	mmHg	millimeters of mercury	
1158	mmHg (0°C)	millimeters of mercury at 0°C	
1159	Pa-s	Pascal second	
1160	m^2/s	square meter per second	
1161	P	poise	
1162	cP	centipoise	1 cP = 1 mPa-s
1163	St	stokes	
1164	cSt	centistokes	1 cSt = 1 mm^2/s
1165	N/m	newton per meter	
1166	mN/m	millinewton per meter	
1167	J	joule	1 J = 1 N-m
1168	EJ	exajoules	
1169	PJ	petajoules	
1170	TJ	terajoules	
1171	GJ	gigajoules	
1172	MJ	megajoules	
1173	kJ	kilojoules	
1174	mJ	millijoules	
1175	WH	watt hour	1 W-h = 3.6 kJ
1176	TWH	terawatt hour	
1177	GWH	gigawatt hour	
1178	MWH	megawatt hour	
1179	KWH	kilowatt hour	
1180	cal	calorie	1 cal = 4.184 J
1181	kcal	kilocalorie	
1182	Mcal	megacalorie	
1183	Btu	British thermal unit	1 Btu = 0.2519958 kcal
1184	decatherm	decatherm	
1185	ft-lb	foot-pound	
1186	W	watt	1 W = 1 J/s
1187	TW	terawatt	
1188	GW	gigawatt	
1189	MW	megawatt	
1190	KW	kilowatt	
1191	mW	milliwatt	
1192	μW	microwatt	
1193	nW	nanowatt	
1194	pW	picowatt	
1195	Mcal/h	megacalorie per hour	
1196	MJ/h	megajoule per hour	
1197	Btu/h	British thermal unit per hour	
1198	hp	horsepower	
1199	W/(m-K)	watt per meter kelvin	

Value	Unit	Description	Equivalence
1200	$W/(m^2\text{-}K)$	watt per square meter kelvin	
1201	$m^2\text{-}K/W$	square meter kelvin per watt	
1202	J/K	joule per kelvin	
1203	kJ/K	kilojoule per kelvin	
1204	J/(kg-K)	joule per kilogram kelvin	
1205	kJ/(kg-K)	kilojoule per kilogram kelvin	
1206	J/kg	joule per kilogram	
1207	MJ/kg	megajoule per kilogram	
1208	kJ/kg	kilojoule per kilogram	
1209	A	ampere	SI
1210	kA	kiloampere	
1211	mA	milliampere	
1212	μA	microampere	
1213	nA	nanoampere	
1214	pA	picoampere	
1215	C	coulomb	1 C = 1 A-s
1216	MC	megacoulomb	
1217	kC	kilocoulomb	
1218	μC	microcoulomb	
1219	nC	nanocoulomb	
1220	pC	picocoulomb	
1221	A-h	ampere hour	1 A-h = 3.6 kC
1222	C/m^3	coulomb per cubic meter	
1223	C/mm^3	coulomb per cubic millimeter	
1224	C/cm^3	coulomb per cubic centimeter	
1225	kC/m^3	kilocoulomb per cubic meter	
1226	mC/m^3	millicoulomb per cubic meter	
1227	$\mu C/m^3$	microcoulomb per cubic meter	
1228	C/m^2	coulomb per square meter	
1229	C/mm^2	coulomb per square millimeter	
1230	C/cm^2	coulomb per square centimeter	
1231	kC/m^2	kilocoulomb per square meter	
1232	mC/m^2	millicoulomb per square meter	
1233	$\mu C/m^2$	microcoulomb per square meter	
1234	V/m	volt per meter	
1235	MV/m	megavolt per meter	
1236	kV/m	kilovolt per meter	
1237	V/cm	volt per centimeter	
1238	mV/m	millivolt per meter	
1239	μV/m	microvolt per meter	
1240	V	volt	1 V = 1 W/A
1241	MV	megavolt	
1242	KV	kilovolt	
1243	mV	millivolt	
1244	μV	microvolt	
1245	F	farad	1 F = 1 C/V
1246	mF	millifarad	
1247	μF	microfarad	
1248	nF	nanofarad	
1249	pF	picofarad	
1250	F/m	farad per meter	

Value	Unit	Description	Equivalence
1251	μF/m	microfarad per meter	
1252	nF/m	nanofarad per meter	
1253	pF/m	picofarad per meter	
1254	C-m	coulomb meter	
1255	A/m^2	ampere per square meter	
1256	MA/m^2	megampere per square meter	
1257	A/cm^2	ampere per square centimeter	
1258	kA/m^2	kiloampere per square meter	
1259	A/m	ampere per meter	
1260	kA/m	kiloampere per meter	
1261	A/cm	ampere per centimeter	
1262	T	tesla	$1 T = 1 Wb/m^2$
1263	mT	millitesla	
1264	μT	microtesla	
1265	nT	nanotesla	
1266	Wb	weber	1 Wb = 1 V-s
1267	mWb	milliweber	
1268	Wb/m	weber per meter	
1269	kWb/m	kiloweber per meter	
1270	H	henry	1 H = 1 Wb/A
1271	mH	millihenry	
1272	μH	microhenry	
1273	nH	nanohenry	
1274	pH	picohenry	
1275	H/m	henry per meter	
1276	μH/m	microhenry per meter	
1277	nH/m	nanohenry per meter	
1278	$A\text{-}m^2$	ampere square meter	
1279	$N\text{-}m^2/A$	newton square meter per ampere	
1280	Wb-m	weber meter	
1281	Ohm	Ohm	1 Ω = 1 V/A
1282	GOhm	gigaOhm	
1283	MOhm	megaOhm	
1284	kOhm	kiloOhm	
1285	mOhm	milliOhm	
1286	μOhm	microOhm	
1287	S	siemens	$1 S = 1 \Omega^{-1}$
1288	kS	kilosiemens	
1289	mS	millisiemens	
1290	μS	microsiemens	
1291	Ohm-m	Ohm meter	
1292	GOhm-m	gigaOhm meter	
1293	MOhm-m	megaOhm meter	
1294	kOhm-m	kiloOhm meter	
1295	Ohm-cm	Ohm centimeter	
1296	mOhm-m	milliOhm meter	
1297	μOhm-m	microOhm meter	
1298	nOhm-m	nanoOhm meter	
1299	S/m	siemens per meter	
1300	MS/m	megasiemens per meter	
1301	kS/m	kilosiemens per meter	

Value	Unit	Description	Equivalence
1302	mS/cm	millisiemens per centimeter	
1303	μS/mm	micorsiemens per millimeter	
1304	1/H	per henry	
1305	sr	steradian	1 sr = 1 m^2/m^2 = 1
1306	W/sr	watt per steradian	
1307	W/(sr-m^2)	watt per steradian square meter	
1308	W/(m^2)	watt per square meter	
1309	lm	lumen	1 lm = 1 cd-sr
1310	lm-s	lumen second	
1311	lm-h	lumen hour	1 lm-h = 3600 lm-s
1312	lm/m^2	lumen per square meter	
1313	lm/W	lumen per watt	
1314	lx	lux	1 lx = 1 lm/m^2
1315	lx-s	lux second	
1316	cd	candela	SI
1317	cd/m^2	candela per square meter	
1318	g/s	gram per second	
1319	g/min	gram per minute	
1320	g/h	gram per hour	
1321	g/d	gram per day	
1322	kg/s	kilogram per second	
1323	kg/min	kilogram per minute	
1324	kg/h	kilogram per hour	
1325	kg/d	kilogram per day	
1326	t/s	metric ton per second	1 t = 10^3 kg
1327	t/min	metric ton per minute	
1328	t/h	metric ton per hour	
1329	t/d	metric ton per day	
1330	lb/s	pound per second	
1331	lb/min	pound per minute	
1332	lb/h	pound per hour	
1333	lb/d	pound per day	
1334	STon/s	short ton per second	1 STon = 2000 pounds
1335	STon/min	short ton per minute	
1336	STon/h	short ton per hour	
1337	STon/d	short ton per day	
1338	LTon/s	long ton per second	1 LTon = 2240 pounds
1339	LTon/min	long ton per minute	
1340	LTon/h	long ton per hour	
1341	LTon/d	long ton per day	
1342	%	percent	
1343	% sol/wt	percent solids per weight	
1344	% sol/vol	percent solids per volume	
1345	% stm qual	percent steam quality	
1346	% plato	percent plato	
1347	m^3/s	cubic meter per second	
1348	m^3/min	cubic meter per minute	
1349	m^3/h	cubic meter per hour	
1350	m^3/d	cubic meter per day	
1351	L/s	liter per second	
1352	L/min	liter per minute	

Value	Unit	Description	Equivalence
1353	L/h	liter per hour	
1354	L/d	liter per day	
1355	ML/d	megaliter per day	
1356	CFS	cubic feet per second	
1357	CFM	cubic feet per minute	
1358	CFH	cubic feet per hour	
1359	ft^3/d	cubic feet per day	
1360	SCFM	standard cubic feet per minute	
1361	SCFH	standard cubic feet per hour	
1362	gal/s	US gallon per second	
1363	GPM	US gallon per minute	
1364	gal/h	US gallon per hour	
1365	gal/d	US gallon per day	
1366	Mgal/d	mega US gallon per day	
1367	ImpGal/s	Imperial gallon per second	
1368	ImpGal/min	Imperial gallon per minute	
1369	ImpGal/h	Imperial gallon per hour	
1370	ImpGal/d	Imperial gallon per day	
1371	bbl/s	barrel per second	1 bbl = 42 US gallons
1372	bbl/min	barrel per minute	
1373	bbl/h	barrel per hour	
1374	bbl/d	barrel per day	
1375	W/m^2	watt per square meter	
1376	mW/m^2	milliwatt per square meter	
1377	$\mu W/m^2$	microwatt per square meter	
1378	pW/m^2	picowatt per square meter	
1379	$Pa\text{-}s/m^3$	pascal second per cubic meter	
1380	N-s/m	newton second per meter	
1381	Pa-s/m	pascal second per meter	
1382	B	bel	
1383	dB	decibel	1 dB = 10^{-1}B
1384	mol	mole	SI
1385	kmol	kilomole	
1386	mmol	millimole	
1387	μmol	micromole	
1388	kg/mol	kilogram per mole	
1389	g/mol	gram per mole	
1390	m^3/mol	cubic meter per mole	
1391	dm^3/mol	cubic decimeter per mole	
1392	cm^3/mol	cubic centimeter per mole	
1393	L/mol	liters per mole	
1394	J/mol	joule per mole	
1395	kJ/mol	kilojoule per mole	
1396	J/(mol-K)	joule per mole kelvin	
1397	mol/m^3	mole per cubic meter	
1398	mol/dm^3	mole per cubic decimeter	
1399	mol/L	mole per liter	
1400	mol/kg	mole per kilogram	
1401	mmol/kg	millimole per kilogram	
1402	Bq	becquerel	1 Bq = $1\text{-}s^{-1}$
1403	MBq	megabecquerel	

Value	Unit	Description	Equivalence
1404	kBq	kilobequerel	
1405	Bq/kg	becquerel per kilogram	
1406	kBq/kg	kilobecquerel per kilogram	
1407	MBq/kg	megabecquerel per kilogram	
1408	Gy	gray	1 Gy = 1 J/kg
1409	mGy	milligray	
1410	rad	rad	1 rad = 10^{-2} Gy
1411	Sv	sievert	1 Sv = 1 J/kg
1412	mSv	millisievert	
1413	rem	rem	1 rem = 10^{-2} Sv
1414	C/kg	coulomb per kilogram	
1415	mC/kg	millicoulomb per kilogram	
1416	R	röntgen	1 R = 2.58 x 10^{-4} C/kg
1417	1/J-m^3		
1418	e/V-m^3		
1419	m^3/C	cubic meter per coulomb	
1420	V/K	volt per kelvin	
1421	mV/K	millivolt per kelvin	
1422	pH	pH	
1423	ppm	parts per million	
1424	ppb	parts per billion	
1425	ppt	parts per thousand	
1426	degBrix	degrees Brix	
1427	degBall	degrees Balling	
1428	proof/vol	proof per volume	
1429	proof/mass	proof per mass	
1430	lb/ImpGal	pound per Imperial gallon	
1431	kcal/s	kilocalorie per second	
1432	kcal/min	kilocalorie per minute	
1433	kcal/h	kilocalorie per hour	
1434	kcal/d	kilocalorie per day	
1435	Mcal/s	megacalorie per second	
1436	Mcal/min	megacalorie per minute	
1437	Mcal/d	megacalorie per day	
1438	kJ/s	kilojoules per second	
1439	kJ/min	kilojoules per minute	
1440	kJ/h	kilojoules per hour	
1441	kJ/d	kilojoules per day	
1442	MJ/s	megajoules per second	
1443	MJ/min	megajoules per minute	
1444	MJ/d	megajoules per day	
1445	Btu/s	British thermal units per seoncd	
1446	Btu/min	British thermal units per minute	
1447	Btu/day	British thermal units per day	
1448	μgal/s	micro US gallon per second	
1449	mgal/s	milli US gallon per second	
1450	kgal/s	kilo US gallon per second	
1451	Mgal/s	mega US gallon per second	
1452	μgal/min	micro US gallon per minute	
1453	mgal/min	milli US gallon per second	
1454	kgal/min	kilo US gallon per minute	

Value	Unit	Description	Equivalence
1455	Mgal/min	mega US gallon per minute	
1456	μgal/h	micro US gallon per hour	
1457	mgal/h	milli US gallon per hour	
1458	kgal/h	kilo US gallon per hour	
1459	Mgal/h	mega US gallon per hour	
1460	μgal/d	micro US gallon per day	
1461	mgal/d	milli US gallon per day	
1462	kgal/d	kilo US gallon per day	
1463	μImpGal/s	micro imperial gallon per second	
1464	mImpGal/s	milli imerial gallon per second	
1465	kImpGal/s	kilo imperial gallon per second	
1466	MImpGal/s	mega imperial gallon per second	
1467	μImpGal/min	micro imperial gallon per minute	
1468	mImpGal/min	milli imerial gallon per minute	
1469	kImpGal/min	kilo imperial gallon per minute	
1470	MImpGal/min	mega imperial gallon per minute	
1471	μImpGal/h	micro imperial gallon per hour	
1472	mImpGal/h	milli imerial gallon per hour	
1473	kImpGal/h	kilo imperial gallon per hour	
1474	MImpGal/h	mega imperial gallon per hour	
1475	μImpGal/d	micro imperial gallon per day	
1476	mImpGal/d	milli imerial gallon per day	
1477	kImpGal/d	kilo imperial gallon per day	
1478	MImpGal/d	mega imperial gallon per day	
1479	μbbl/s	microbarrel per second	
1480	mbbl/s	millibarrel per second	
1481	kbbl/s	kilobarrel per second	
1482	Mbbl/s	megabarrel per second	
1483	μbbl/min	microbarrel per minute	
1484	mbbl/min	millibarrel per minute	
1485	kbbl/min	kilobarrel per minute	
1486	Mbbl/min	megabarrel per minute	
1487	μbbl/h	microbarrel per hour	
1488	mbbl/h	millibarrel per hour	
1489	kbbl/h	kilobarrel per hour	
1490	Mbbl/h	megabarrel per hour	
1491	μbbl/d	microbarrel per day	
1492	mbbl/d	millibarrel per day	
1493	kbbl/d	kilobarrel per day	
1494	Mbbl/d	megabarrel per day	
1495	$\mu m^3/s$	cubic micrometer per second	
1496	mm^3/s	cubic millimeter per second	
1497	km^3/s	cubic kilometer per second	
1498	Mm^3/s	cubic megameter per second	
1499	$\mu m^3/min$	cubic micrometer per minute	
1500	mm^3/min	cubic millimeter per minute	
1501	km^3/min	cubic kilometer per minute	
1502	Mm^3/min	cubic megameter per minute	
1503	$\mu m^3/h$	cubic micrometer per hour	
1504	mm^3/h	cubic millimeter per hour	
1505	km^3/h	cubic kilometer per hour	

Value	Unit	Description	Equivalence
1506	Mm^3/h	cubic megameter per hour	
1507	$\mu m^3/d$	cubic micrometer per day	
1508	mm^3/d	cubic millimeter per day	
1509	km^3/d	cubic kilometer per day	
1510	Mm^3/d	cubic megameter per day	
1511	cm^3/s	cubic centimeter per second	
1512	cm^3/min	cubic centimeter per minute	
1513	cm^3/h	cubic centimeter per hour	
1514	cm^3/d	cubic centimeter per day	
1515	kcal/kg	kilocalorie per kilogram	
1516	Btu/lb	British thermal unit per pound	
1517	kL	kiloliter	
1518	kL/min	kiloliter per mnute	
1519	kL/h	kiloliter per hour	
1520	kL/d	kiloliter per day	
1521	vendor-specific 1521		
1522	vendor-specific 1522		
1523	vendor-specific 1523		
1524	vendor-specific 1524		
1525	vendor-specific 1525		
1526	vendor-specific 1526		
1527	vendor-specific 1527		
1528	vendor-specific 1528		
1529	vendor-specific 1529		
1530	vendor-specific 1530		
1531	vendor-specific 1531		
1532	vendor-specific 1532		
1533	vendor-specific 1533		
1534	vendor-specific 1534		
1535	vendor-specific 1535		
1536	vendor-specific 1536		
1537	vendor-specific 1537		
1538	vendor-specific 1538		
1539	vendor-specific 1539		
1540	vendor-specific 1540		
1541	vendor-specific 1541		
1542	vendor-specific 1542		
1543	vendor-specific 1543		
1544	vendor-specific 1544		
1545	vendor-specific 1545		
1546	vendor-specific 1546		
1547	vendor-specific 1547		
1548	vendor-specific 1548		
1549	vendor-specific 1549		
1550	vendor-specific1550		
1551	S/cm	Siemens per centimeter	
1552	µS/cm	Micro Siemens per centimeter	
1553	mS/m	Milli Siemens per meter	
1554	µS/m	Micro Siemens per meter	
1555	MOHM*cm	Mega Ohm times centimeter	
1556	KOHM*cm	Kilo Ohm times centimeter	

Value	Unit	Description	Equivalence
1557	Gew%		
1558	mg/l	Milli gramm per liter	
1559	µg/l	Micro gramm per Liter	
1560	%Sät		
1561	vpm		
1562	%vol	Volume percent	
1563	ml/min	Milli liter per minute	
1564	mg/dm^3	Milli gramm per cubic deci meter	
1565	mg/l	Milli gramm per Liter	
1566	mg/m^3	Milli gramm per cubic meter	
1567	Reserved		
...	...		
1994	Reserved		
1995	Textual unit definition		
1996	Not used		
1997	None		
1998	unknown		
1999	special		

Table 5.1 - Unit Codes