smar - TT400 SIS

OPERATION & MAINTENANCE
INSTRUCTIONS MANUAL

Smart Temperature Transmitter for Safety Instrumented Systems (SIS)

Safety tested
Production monitored
TÜV SÜD
Functional Safety

HART COMMUNICATION PROTOCOL

AUG / 14

TT400SIS

VERSION 1

TT400SI SME

INTRODUCTION

WARNING
TT400 HART® SIS has the housing cover in red to distinguish them from the other line 400 models.

The **TT400 HART® SIS** is a Smart Temperature Transmitter with 4-20 mA analog output and HART® protocol, developed for SIS (Safety Instrumented Systems) applications. It uses a HCS12 based platform, a 16-bit microcontroller which allows a complete diagnostic of possible failures in the 4-20 mA output generations. **TT400 HART® SIS** is certified by TÜV for use in SIL 2 (not redundant) and SIL 3 (redundant) for safety requirement.

The **TT400 HART® SIS** is a transmitter mainly intended for measurement of temperature using RTDs or thermocouples, but can also accept other sensors with resistance or mV output such as: pyrometers, load cells, resistance position indicators, etc. The digital technology used in the **TT400 HART® SIS** enables the choice of several output functions, an easy interface between the field and the control room and several interesting features that reduce considerably the installation, operation and maintenance costs.

The **TT400 HART® SIS**, besides the normal functions offered by other smart transmitters, offers the following functions:

BACKUP SENSOR: the process measurement is made by two sensors, but only one supplies the temperature. If it fails the other takes its place.

INPUT SELECTOR: the selection between two sensors to obtain the output value is configured by user based in the conditions of maximum, minimum or average temperature of the sensor.

CALLENDER VAN DUSEN: allows a precise linearization of a RTD sensor based on the constants A, B, C and R0.

PASSWORD: three configurable levels for different functions.

PARAMETER CHANGE: indicates the number of changes in each function.

LOGGED EVENT: indicates when the changes were done.

DIAGNOSES: inform the instrument status.

Get the best results of the TT400 HART® SIS by carefully reading these instructions.

Acronyms and abbreviations

Acronym / Abbreviation	Designation	Description
HFT	Hardware Fault Tolerance	The hardware fault tolerance of the device. This is the capability of a functional unit to continue the execution of the demanded function in case of faults or deviations.
MTBF	Mean Time Between Failures	This is the mean time period between two failures.
MTTR	Mean Time To Repair	This is the mean time period between the occurrence of a failure in a device or system and its repair.
PFD	Probability of Failure on Demand	This is the likelihood of dangerous safety function failures occurring on demand.
PFDAVG	Average Probability of Failure	This is the average likelihood of dangerous safety function failures occurring on demand.
SIL	Safety Integrity Level	The International Standard IEC 61508 specifies four discrete safety integrity levels (SIL 1 to SIL 4). Each level corresponds to a specific probability range regarding the failure of a safety function. The higher the safety integrity level of the safety-related systems, the lower likelihood of non-execution of the demanded safety functions.
SFF	Safe Failure Fraction	The fraction of non-hazardous failures, e.g., the fraction of failures without the potential to set the safety-related system to a dangerous undetected state.
Low Demand Mode	Low Demand Mode of Operation	Measuring mode with low demand rate, in which the demand rate for the safety-related system is not more than once a year and is not greater than double the frequency of the periodic test.
DTM	Device Type Manager	The DTM is a software module which provides functions for accessing device parameters, configuring and operating the devices and diagnosing problems. By itself, a DTM is not executable software.
LRV	Device Configuration	Lower Range Value of the measurement range.
URV	Device Configuration	Upper Range Value of the measurement range.
Multidrop	Multdrop Mode	In multidrop mode, up to 15 field devices are connected in parallel to a single wire pair. The analog current signal serves just to energize the two-wire devices providing a fixed current of 4 mA.

NOTE
This Manual is compatible with version 1.XX, where 1 is the firmware Version and XX firmware "RELEASE". The indication 1.XX means that this manual is compatible with any release of firmware version 1.

Waiver of responsibility

The contents of this manual abides by the hardware and software used on the current equipment version. Eventually there may occur divergencies between this manual and the equipment. The information from this document are periodically reviewed and the necessary or identified corrections will be included in the following editions. Suggestions for their improvement are welcome.

Warning

For more objectivity and clarity, this manual does not contain all the detailed information on the product and, in addition, it does not cover every possible mounting, operation or maintenance cases.

Before installing and utilizing the equipment, check if the model of the acquired equipment complies with the technical requirements for the application. This checking is the user's responsibility.

If the user needs more information, or on the event of specific problems not specified or treated in this manual, the information should be sought from Smar. Furthermore, the user recognizes that the contents of this manual by no means modify past or present agreements, confirmation or judicial relationship, in whole or in part.

All of Smar's obligation result from the purchasing agreement signed between the parties, which includes the complete and sole valid warranty term. Contractual clauses related to the warranty are not limited nor extended by virtue of the technical information contained in this manual.

Only qualified personnel are allowed to participate in the activities of mounting, electrical connection, startup and maintenance of the equipment. Qualified personnel are understood to be the persons familiar with the mounting, electrical connection, startup and operation of the equipment or other similar apparatus that are technically fit for their work. Smar provides specific training to instruct and qualify such professionals. However, each country must comply with the local safety procedures, legal provisions and regulations for the mounting and operation of electrical installations, as well as with the laws and regulations on classified areas, such as intrinsic safety, explosion proof, increased safety and instrumented safety systems, among others.

The user is responsible for the incorrect or inadequate handling of equipments run with pneumatic or hydraulic pressure or, still, subject to corrosive, aggressive or combustible products, since their utilization may cause severe bodily harm and/or material damages.

The field equipment referred to in this manual, when acquired for classified or hazardous areas, has its certification void when having its parts replaced or interchanged without functional and approval tests by Smar or any of Smar authorized dealers, which are the competent companies for certifying that the equipment in its entirety meets the applicable standards and regulations. The same is true when converting the equipment of a communication protocol to another. In this case, it is necessary sending the equipment to Smar or any of its authorized dealer. Moreover, the certificates are different and the user is responsible for their correct use.

Always respect the instructions provided in the Manual. Smar is not responsible for any losses and/or damages resulting from the inadequate use of its equipments. It is the user's responsibility to know and apply the safety practices in his country.

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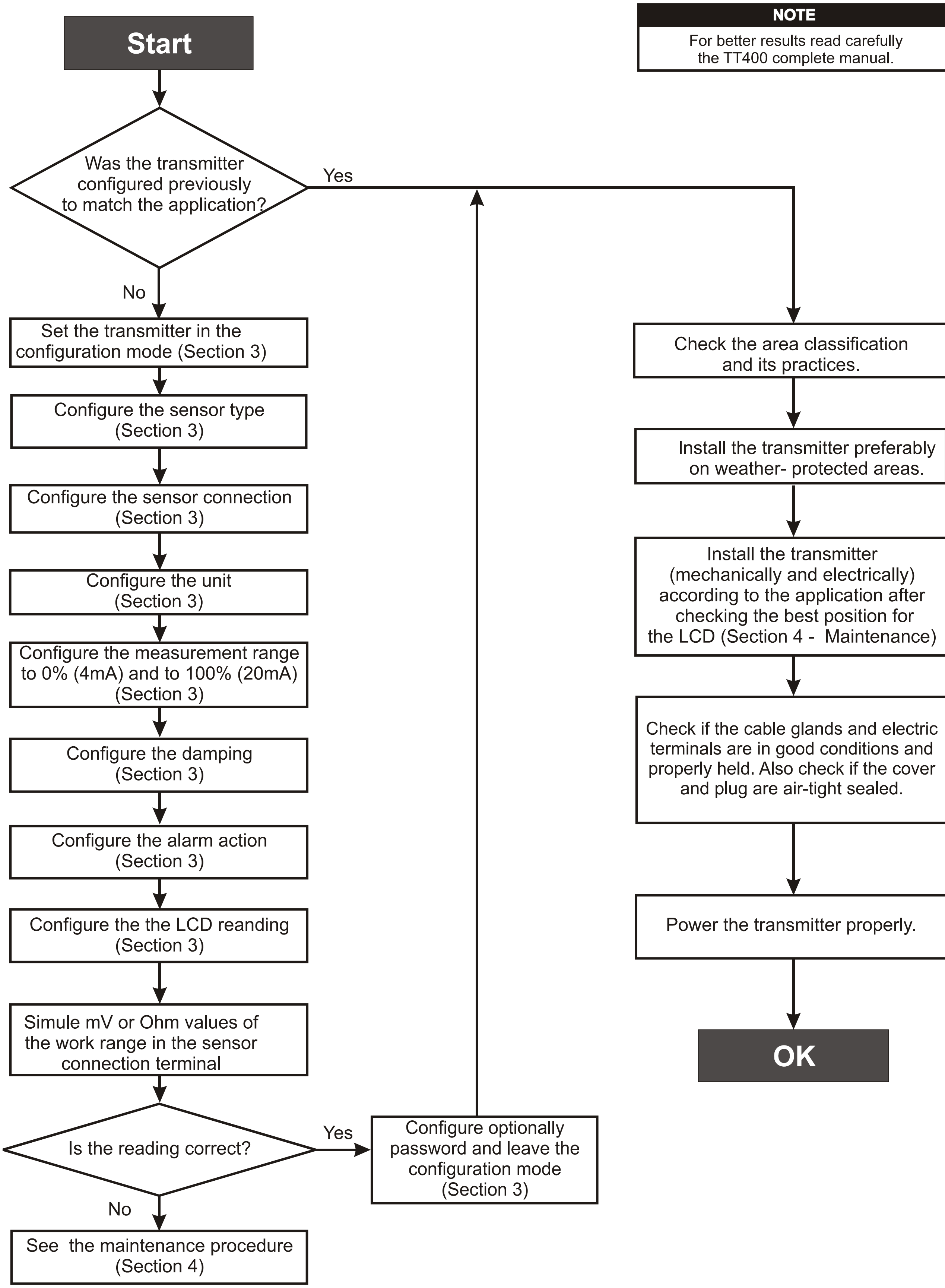
NOTE

For better results read carefully the TT400 complete manual.



Section 1

INSTALLATION

General

The overall accuracy of temperature and other measurements depends on several variables. Although the transmitter has an outstanding performance, proper installation is essential, in order to maximize its performance.

Among all factors, which may affect transmitter accuracy, environmental conditions are the most difficult to control. There are, however, ways of reducing the effects of temperature, humidity and vibration.

Temperature fluctuation effects can be minimized by locating the transmitter in areas protected from extreme environmental changes.

In warm environments, the transmitter should be installed to avoid, as much as possible, direct exposure to the sun. Installation close to lines and vessels subjected to high temperatures should also be avoided. For temperature measurements, sensors with cooling-neck can be used or the sensor can be mounted separated from the transmitter housing.

Use of sunshades or heat shields to protect the transmitter from external heat sources should be considered, if necessary.

Humidity is fatal to electronic circuits. In areas subjected to high relative humidity, the O'Rings for the electronics cover must be correctly placed. Removal of the electronics cover in the field must be reduced to the minimum necessary, since each time it is removed the circuits are exposed to the humidity. The electronic circuit is protected by a humidity proof coating, but frequent exposures to humidity may affect the protection provided. It is also important to keep the covers tightened in place. Every time they are removed, the threads are exposed to corrosion, since these parts can not be protected by painting. Code-approved sealing methods on conduit entering the transmitter should be employed.

Measurement error can be decreased by connecting the sensor as close to the transmitter as possible and using proper wires (see Section 2, Operation).

WARNING

Do not remove the graphite grease from the covers, or they may jam.

WARNING

The SIS project must be carried through by a professional duly authorized from Smar and qualified for this type of work.

WARNING

Random, frequent or common cause failures must not damage the equipment´s work or result in death or serious injure, must not harm to the environment or equipment, and must not loss of equipment or production.

WARNING

Electrical shock can result in serious injury.

WARNING

For a better reading performance, the installation should not present degradation problems of the signal 4 to 20 mA. For the detection of this problem, the operator should always certify that the current emitted by the transmitter it is the same read by PLC.

Mounting

The transmitter may be mounted in two basic ways, as follows:

- Separated from the sensor, using optional mounting brackets;
- Mounted on the sensor assembly.

Using the brackets, the mounting may be done in several positions, as shown on Figure 1.1.

One of the conduit inlets for electrical connection is used to mount the sensor integral to the temperature transmitter (see Figure 1.1).

For better visibility, the digital indicator may be rotated in steps of 90^o (see Section IV, Maintenance).

Reach the display and main board by removing the cover with window. This cover can be locked closed by the cover locking screw. To release the cover, rotate the locking screw clockwise. See Figure 1.2.

Electric Wiring

Access the wiring block by removing the Electrical Connection Cover. This cover can be locked closed by the cover locking screw (Figure 1.3). To release the cover, rotate the locking screw clockwise.

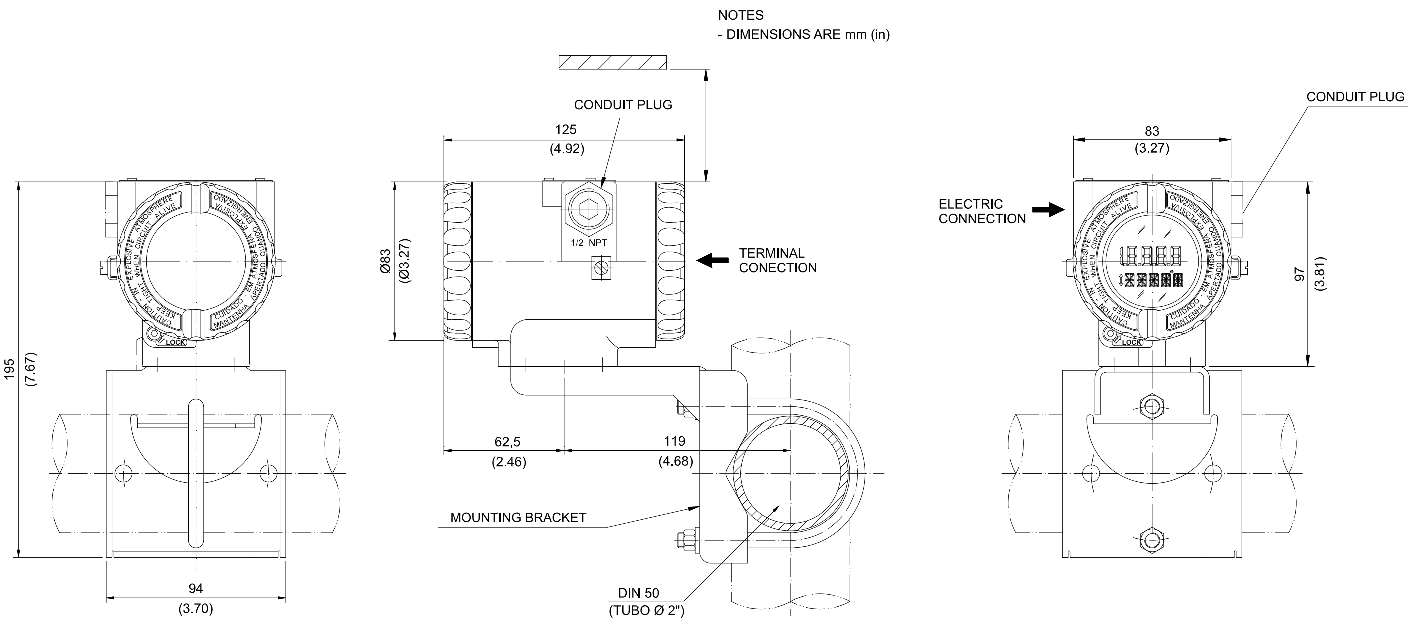


Figure 1.1 - Dimensional Drawing and Mounting Positions

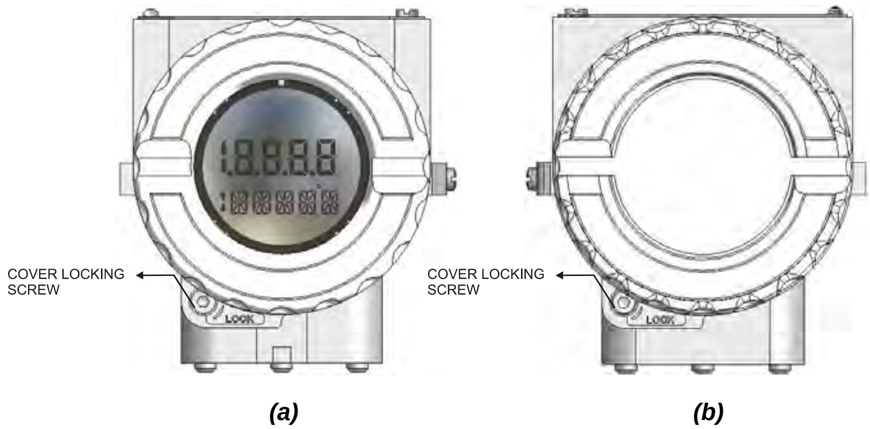


Figure 1.2 – (a) Cover Locking with Display   (b) Cover Locking of the Terminals

The Figure 1.3 shows the correct installation of the conduit, in order to avoid entrance of water, or other substance, which may cause malfunctioning of the equipment.

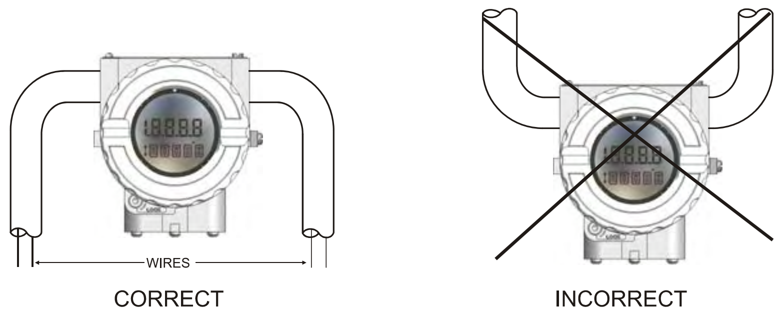


Figure 1.3 - Conduit Installation Diagram

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

The terminals in the upper part marked with (**+**) and (−) are able to receivefrom 12 to 55 Vdc. The bottom terminals marked with the numbers from 1 to 4 allow connections to several types of sensor.

The wiring block has screws on which terminals type fork or ring can be fastened, see Figure 1.5.

For convenience there are three ground terminals: one inside the cover and two external, located close to the conduit entries.

Test and Communication terminals allow, respectively, to measure the current in the 4-20 mA loop, without opening it, and to communicate with the transmitter. To measure it, connect a multimeter in the mA scale in the "**–** " and "**+**" **TEST** terminals. To communicate with it, use a HART configurator between "**+**" and "**–** " **COMM** terminals. See Figure 1.4.

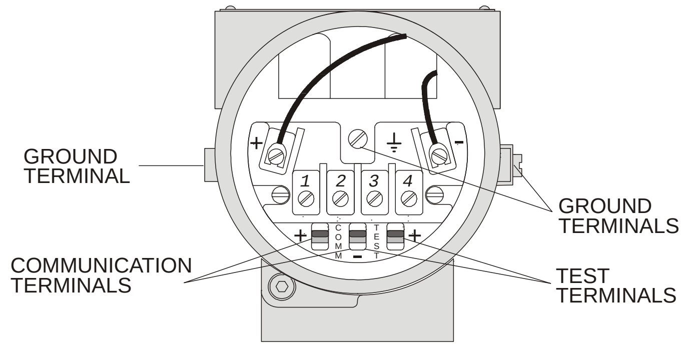


Figure 1.4 - Ground Terminal

Use of twisted pair (22 AWG) cables is recommended.

WARNING
Do not connect the Power Supply to the sensor terminals (Terminals 1, 2, 3 and 4).

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

Connection of the **TT400 HART® SIS** should be performed as in Figure 1.5.

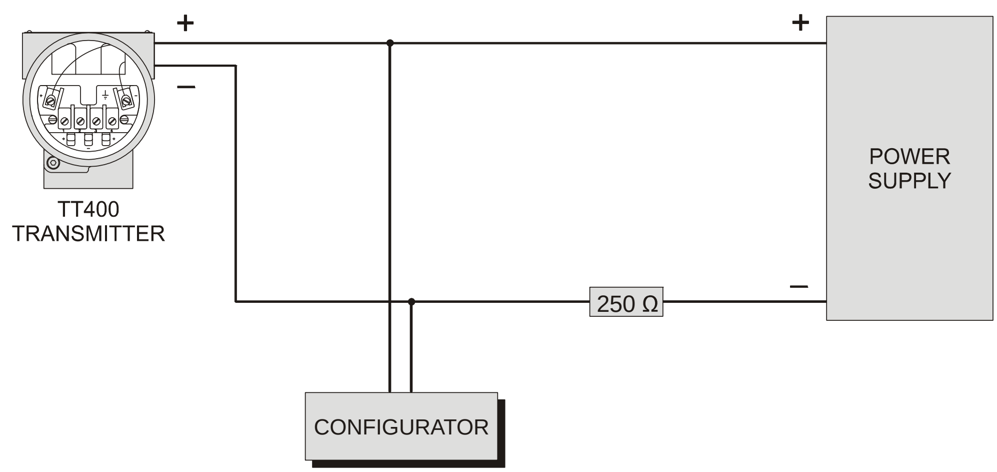


Figure 1.5 – Wiring Diagram for the TT400 HART® SIS

WARNING
For proper operation, the configurator requires a minimum load of 250 Ohm between it and the power supply.

The configurator can be connected to the communication terminals of the transmitter or at any point of the signal line by using the interface with connection terminals.

It is also recommended to ground the shield of the cable at only one extreme. Ungrounded parts must be carefully isolated.

NOTE
Make sure that the transmitter is operating within the operating area as shown on the load diagram (Figure 1.6). Communication requires a minimum load of 250 Ohm.

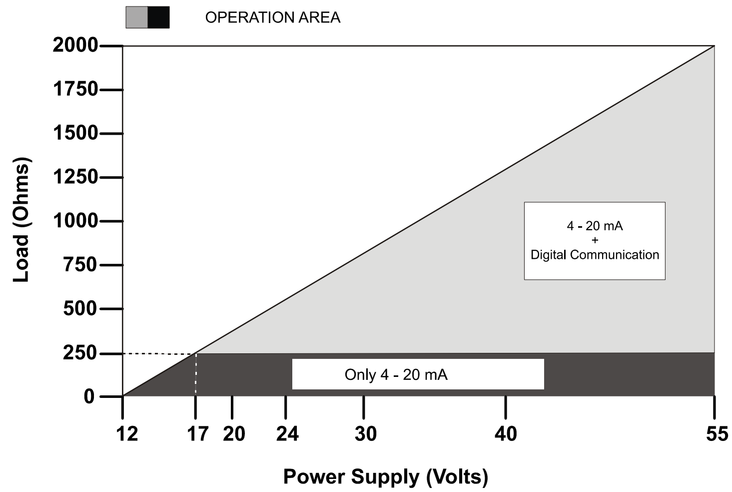


Figure 1.6 – Load Curve

The sensor should be connected as per Figure 1.7.

WARNING
When operating with two sensors, the sensors can not be both grounded. At least one has to be not grounded for proper operation of **TT400 HART® SIS**.

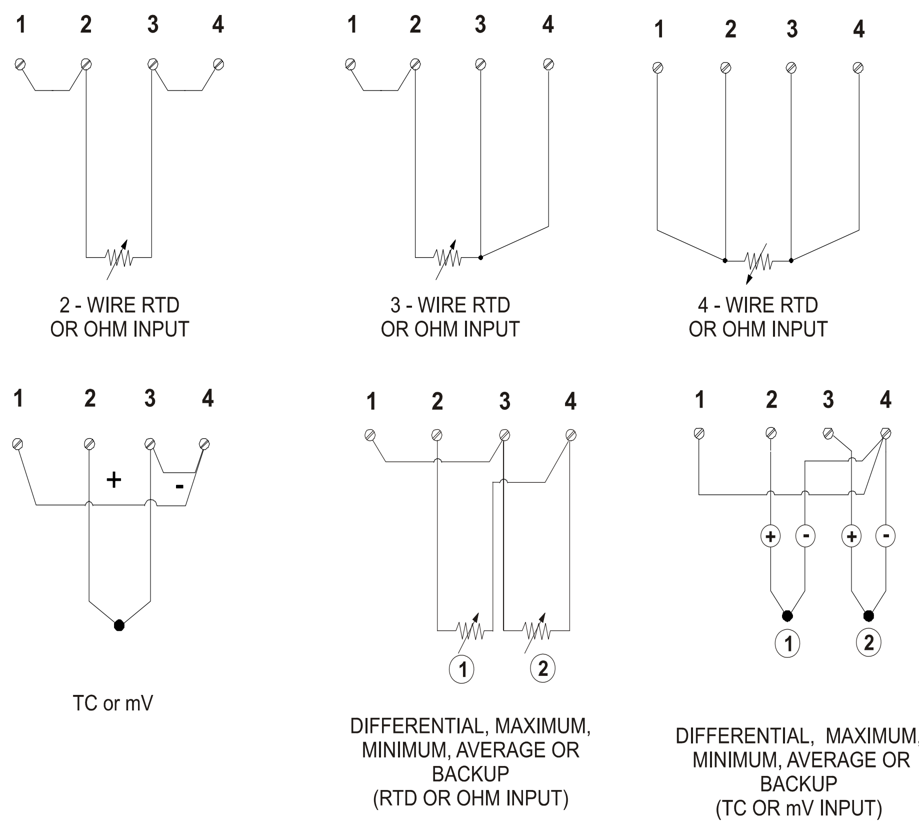


Figure 1.7 – Sensor Wiring

OPERATION

The **TT400 HART® SIS** accepts signals from mV generators such as thermocouples or resistive sensors such as RTDs. The criterium is that the signal is within the range of the input. For mV, the range is -50 to 500 mV and for resistance, 0 to 2000 Ohm.

Functional Description-Hardware

Refer to the block diagram (Figure 2.1). The function of each block is described below.

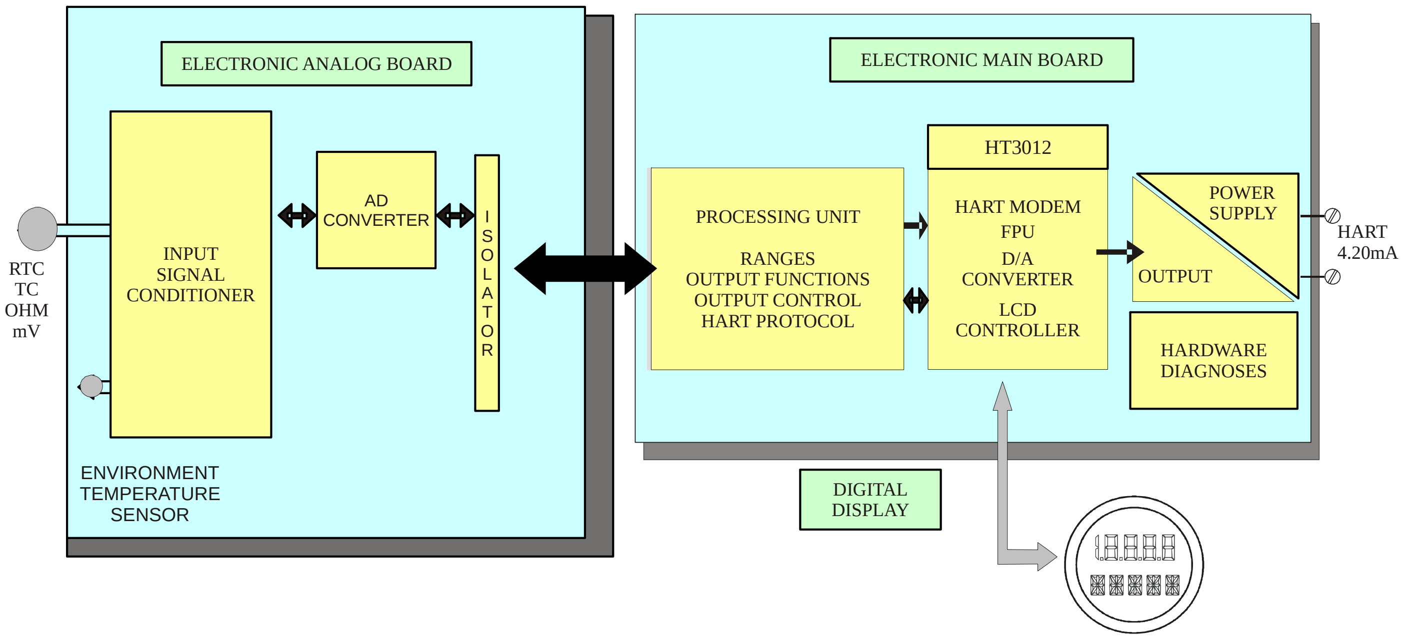


Figure 2.1 – TT400 SIS Block Diagram

Input Signal Conditioner
A function to apply the correct gain to the input signals to make them suit the A/D converter.

A/D Converter
The A/D converts the input signal to a digital format for the CPU.

Isolator
A function to isolate the control and data signal between the input and the CPU.

CPU - Central Processing Unit & PROM
The CPU is the intelligent portion of the transmitter, being responsible for the management and operation of all other blocks: linearization, cold junction compensation and communication.

Output
Controls the current in the line feeding the transmitter. It acts as a variable resistive load whose value depends on the voltage from the D/A converter.

Modem
Modulates a communication signal on the current line. A number "1" is represented by 1200 Hz and a "0", by 2200 Hz. These signals are symmetric and do not affect the DC level of the 4-20 mA signal.

Power Supply
Power shall be supplied to the transmitter circuit using the signal line (2-wire system). The transmitter quiescent consumption is 3.6 mA; during operation, consumption may be as high as 21 mA, depending on the measurement and sensor status.

The **TT400 HART® SIS** shows failure indication at 3.6 mA if configured for low signal failure or 21 mA if configured for high signal failure; 3.8 mA in the case of low saturation or 20.5 mA in the case of high saturation and measurements proportional to the applied temperature in the range between 3.8 and 20.5 mA. 4 mA corresponds to 0% of the working range and 20 mA to100% of the working range.

Display Digital
Receives data from the CPU informing which segments of the Liquid Crystal Display, should be turned on.

Temperature Sensors

The **TT400 HART® SIS**, as previously explained, accepts several types of sensors. The **TT400 HART® SIS** is specially designed for temperature measurement using thermocouples or thermoresistances (RTDs).

Some basic concepts about these sensors are presented below.

THERMOCOUPLES

Thermocouples are the most widely used sensors in industrial temperature measurements.

Thermocouples consist of two wires made from different metals or alloys joined at one end, called measuring junction. The measuring junction should be placed at the point of measurement. The other end of the thermocouple is open and connected to the temperature transmitter. This point is called reference junction or cold junction.

For most applications, the Seebeck effect is sufficient to explain thermocouple behavior:

How the Thermocouple Works
When there is a temperature difference along a metal wire, a small electric potential, unique to every alloy, will occur. This phenomenon is called Seebeck effect.

When two wires of different metals are joined in one end, and left open in the other, a temperature difference between the two ends will result in a voltage since the potentials generated by the different materials are not the same and does not cancel each other out. Two important things must be noted. First: the voltage generated by the thermocouple is proportional to the difference between the measuring-junction and the cold junction temperatures. Therefore the temperature at the reference junction must be added to the temperature derived from the thermocouple output, in order to find the temperature measured. This is called cold junction compensation, and is done automatically by the **TT400 HART® SIS**, which has a temperature sensor at the sensor terminals for this purpose. Secondly, if the thermocouple wires are not used all the way to the terminals of the transmitter (e.g. copper wire is used from sensor-head or marshalling box), new junctions with additional Seebeck effects will be created and ruin the measurement in most cases, since the cold-junction compensation will be done in the wrong point.

The relation between the measuring junction temperature and the generated millivoltage is tabulated in thermocouple calibration tables for standardized thermocouple types, the reference temperature being 0 ^{o}C.

Standardized thermocouples which are commercially used, whose tables are stored in the memory of the **TT400 HART® SIS**, are the following:

- ✓ **NBS (B, E, J, K, N, R, S, T)**
- ✓ **DIN (L, U)**

THERMORESISTANCES (RTDs)

Resistance Temperature Detectors, most commonly known as RTD's, are based on the principle that the resistance of a metal increases as its temperature increases.

Standardized RTDs, whose tables are stored in the memory of the **TT400 HART® SIS**, are the following:

- ✓ **JIS [1604-81] (Pt50 & Pt100)**
- ✓ **IEC, DIN, JIS [1604-89] (Pt50, Pt100, Pt500, Pt1000)**
- ✓ **GE (Cu 10)**
- ✓ **DIN (Ni 120)**

For a correct measurement of RTD temperature, it is necessary to eliminate the effect of the resistance of the wires connecting the sensor to the measuring circuit. In some industrial applications, these wires may be hundreds of meters long. This is particularly important at locations where the ambient temperature changes a lot.

A 2-wire connection may cause measuring errors. It will depend on the length of connections wires and on the temperature to which they are exposed (see Figure 2.2).

In a 2-wire connection, the voltage V2 is proportional to the RTD resistance plus the resistance of the wires.

V2 = [RTD + 2x R] x I

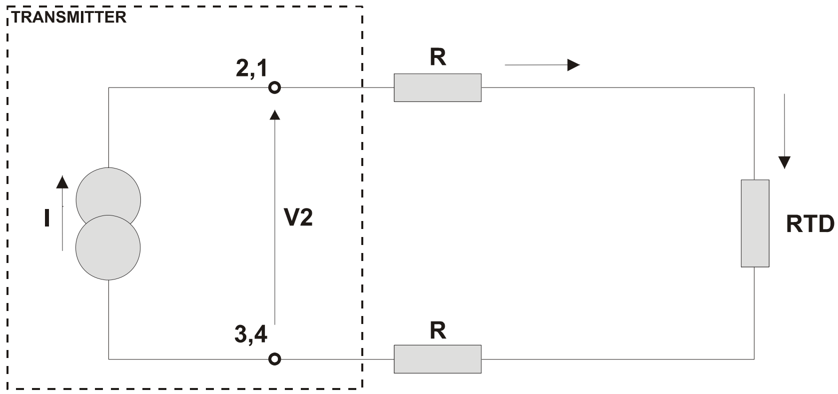


Figure 2.2 – Two-Wire Connection

In order to avoid the resistance effect of the connection wires, it is recommended to use a 3-wire connection (see Figure 2.3) or a 4-wire connection (see Figure 2.4).

In a 3-wire connection, terminal 3 is a high impedance input. Thus, no current flows through that wire and no voltage drop is caused. The voltage V2-V1 is independent of the wire resistances since they will be canceled out, and is directly proportional to the RTD resistance alone.

V2-V1 = [RTD + R] x I – R x I = RTD x I

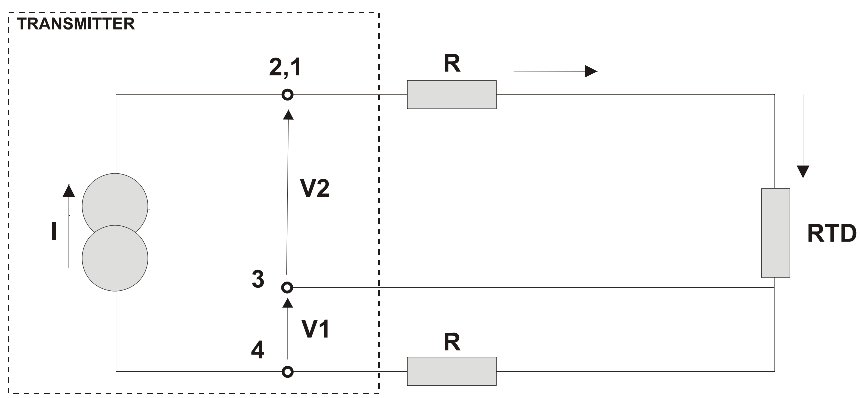


Figure 2.3 – Tree-Wire Connection

In a 4-wire connection, terminals 2 and 3 are high impedance inputs. Thus, no current flows through those wires and no voltage drop is caused. The resistances of the other two wires are not interesting since no measurement is done on them. Hence the voltage V2 is directly proportional to the RTD resistance. (V2 = RTD x I).

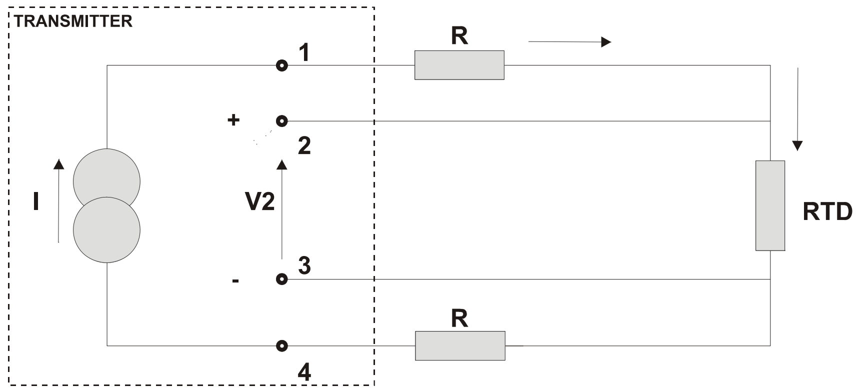


Figure 2.4 – Four-Wire Connection

A differential connection is similar to the two-wire connection and gives the same problem (see Figure 2.5). The resistance of the other two wires will be measured and does not cancel each other out in a temperature measurement, since linearization will affect them differently.

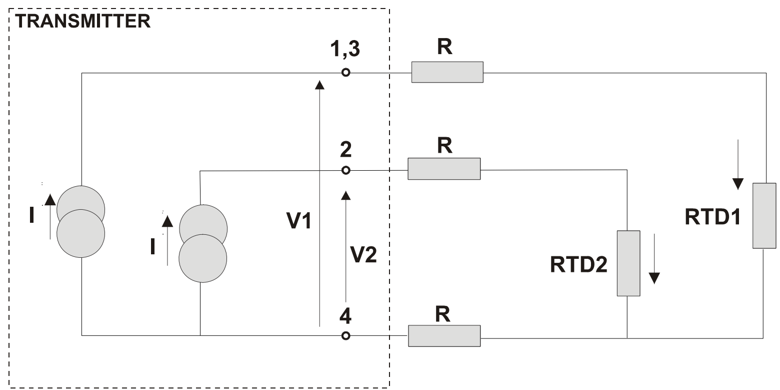


Figure 2.5 – Two Sensor Connection

NOTE
The material the gauge and the length should be the same connections of 3 or 4 threads.

The Display

The digital indicator is able to display one or two variables which are user selectable. When two variables are chosen, the display will alternate between the two with an interval of 3 seconds.

The display indicates engineering units, values and parameters simultaneously with most status indicators. The monitoring mode indication is interrupted in case of an alarm been activated.

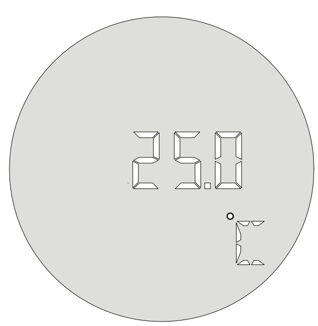


Figure 2.6 – Display

NOTE
The Display is only for monitoring and should not consider for safety proposals.

The different fields and status indicators are shown in the picture bellow.

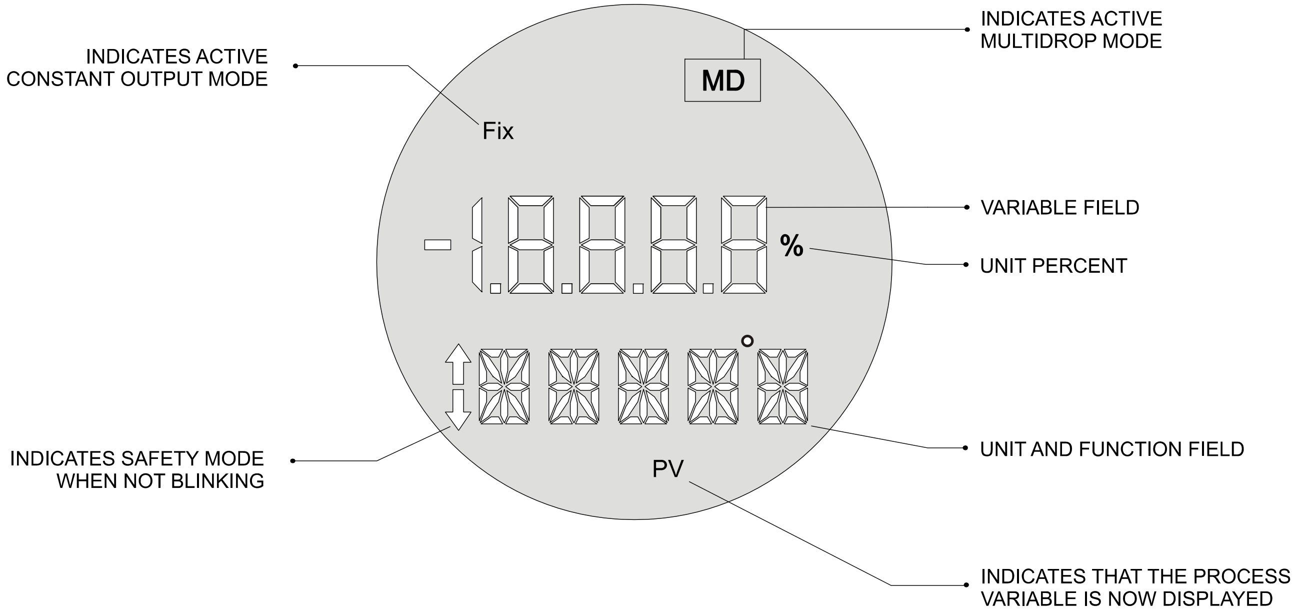


Figure 2.7 – Typical Monitoring Mode Display

CONFIGURATION

The Smart Temperature Transmitter **TT400 HART® SIS** is a digital device bearing the most advanced features that measurement equipment can offer. A HART® digital communication protocol permits the device to be connected to an external computer for a simple and complete configuration. These computers, connected to the transmitters, are called HOST computers and may be a Primary or Secondary Master type. Although HART® may be a master/slave protocol, it may coexist with up to two masters in a field bus. Generally, the Primary HOST stands for a Supervisory and the Secondary HOST is used as a Configurator.

Transmitters, on the other hand, must be connected to a point-to-point. In a point-to-point network, the equipment should have its address set at “0”, so that the output current is modulated from 4 to 20 mA, according to the measurement performed. The multidrop network can be used but the current will never be fixed in 4 mA for SIS purpose.

The **TT400 HART® SIS** Smart Temperature Transmitter presents a comprehensive set of HART® Commands that permit accessing any implemented functionality. These commands comply with the HART® protocol specifications and are grouped in Universal Commands, Common Practice Commands and Specific Commands.

Smar developed the **CONF401** configuration tools, that works in Windows platform (95, 98, 2000, XP, NT and 7). They bring easy configuration and monitoring of field devices, capacity to analyze data and to modify the action of these devices. **The operation characteristics and use of each one of the configurators are stated on their respective manuals.**

Figures 3.1 show the appearance of **CONF401** with the active configuration.

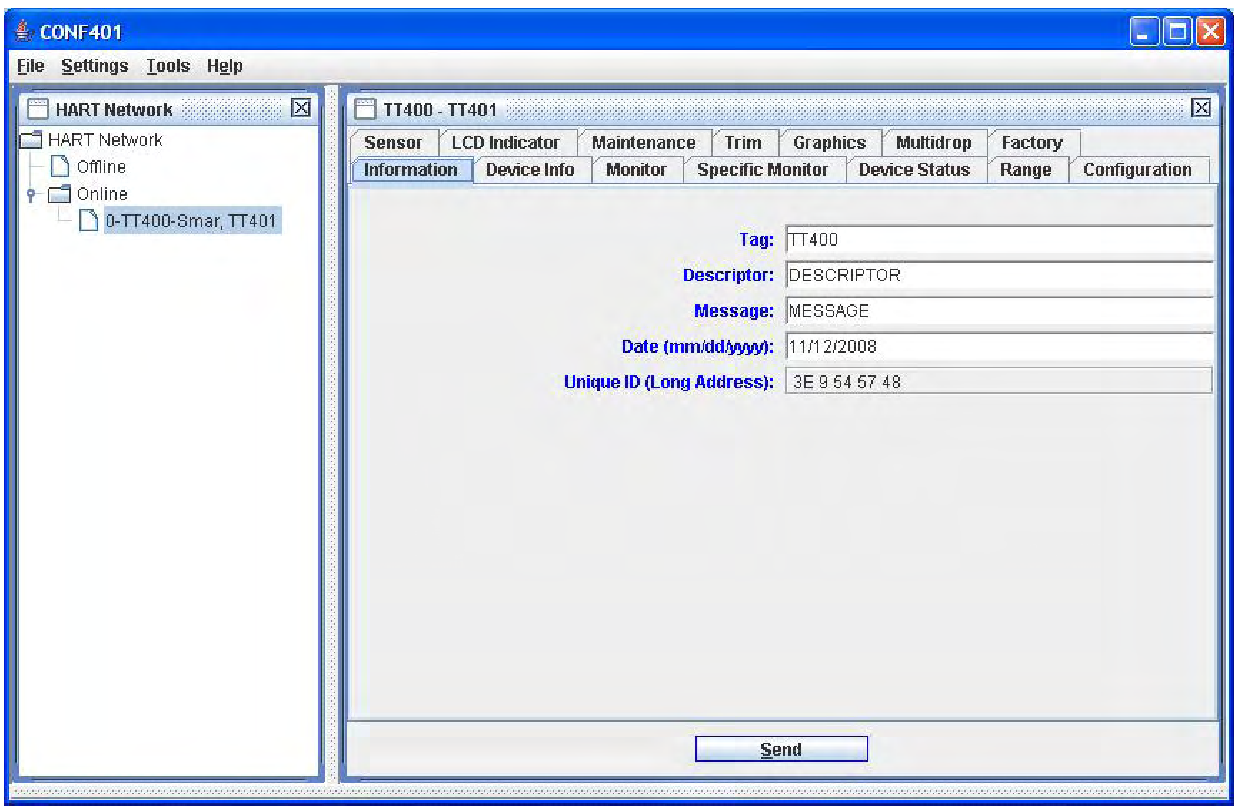


Figure 3.1 – CONF401 Configurator

Configuring the TT400 HART® SIS

Operation Modes

- **Configuration Mode**

Used transmitter's configuration. To access this mode, the user must follow the SIS Mode Disabling procedure explained bellow. It is highly recommended to not used the transmitter for SIS application while it is in the Configuration Mode.

By using the configuration services provided by HART Protocol it is possible to change the transmitter configuration parameters such as: sensor trimming, work range setting, output current calibration, measure damping setting, engineering unit setting, output transfer function selection and display information configuration. These services are important to set the transmitter to appropriated operation according to application requirements.

- **SIS Mode**

In the SIS Mode the **TT400 HART® SIS** is enabled to work only as measurement equipment. In this mode no changes on configuration are allowed and not even the hardware jumpers can be able to change transmitter parameters. Only HART® read commands are permitted.

In this way, before selecting to SIS Mode, it is necessary to make a parameter configuration in Configuration mode to adequate the transmitter to target application.

NOTE
When the transmitter is operating in the SIS mode all the functions are disable impeding the writing and the change in the configuration parameters.

To use this transmitter in the SIS application it is necessary to adjust the measurement to the local reference and setting the parameters to its adequate use (damping setting, units setting, range calibration, etc). To do it, the transmitter must be in Configuration Mode where all configuration functionalities are enabled. After completed the setup, the transmitter must be put on SIS mode. The mode can be noticed by looking the icon on the display (⇔). If it is blinking it means the configuration mode is enabled.

- **SIS Mode Disabling Procedure**

This procedure describes the action that the user will have to do to change the transmitter to the configuration mode. The Write Protect switch must be put in the position OFF (to allow changes in the transmitter), the Local Adjust Switch must be put int the SIMPLE or COMPLETE position and the transmitter must be turned OFF and then turned ON again. If only one of these conditions is being satisfied the the transmitter will stay in the SIS mode. This guarantees that random failures will not change the transmitter mode while in operation.

NOTE
Necessary steps to leave SIS mode and enter in the Configuration Mode: • Write Protect Switch OFF; • Local Adjustment Switch COMPLETE or SIMPLE; • RESET and POWER UP.

To be back to the SIS mode it is only necessary to change the switch position and turn the device off and then on.

Configuration Resources

Through the HART® configurators, the **TT400 HART® SIS** allows the following configuration resources to be accessed:

- ✓ Transmitter Identification and Manufacturer Data;
- ✓ Equipment Calibration;
- ✓ Equipment Configuration;
- ✓ Equipment Maintenance.

The digital communication between the configurator and the transmitter do not interrupt the temperature measuring and do not disturb the output signal. The configurator may be connected on the same 4 to 20 mA signal cable to a maximum 2000 m distance from the transmitter.

Programming Tree

The programming tree is a structure resembling a tree, with all the resources available in the software, as shown on Figure 3.2.

WARNING
All transmitters are factory-configured without passwords. To avoid bad operation on a few critical levels on the programming tree, the configuration is recommended of all passwords before operating. See option “PASSWORD”, on the maintenance section.

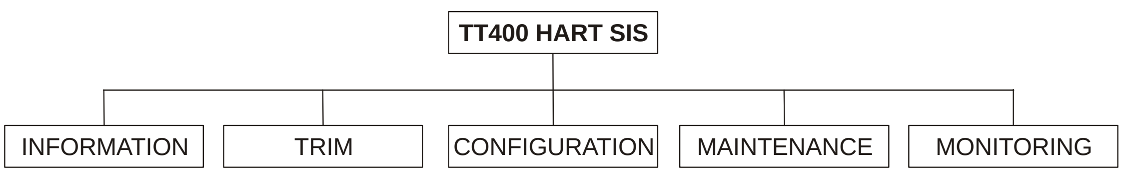


Figure 3.2 – Configuration Tree

INFORMATION – The main information on the transmitter may be accessed here. They include: Tag, Description, Message, Date, Sensor Information and Device Information.

TRIM – Adjusts the transmitter displaying to a current or an Ohm/mV standard. Also allows the terminal temperature sensors trim.

CONFIGURATION – This option allows configuring LCD, Range, Unit, Damping, Burnout and Sensor Type.

MAINTENANCE – Current loop test, equipment's operations reset, operations counter checking, password configuration and ordering code displaying.

MONITORING – The user may monitor 4 of the transmitter dynamic variables and the current output and also check the health of the device through status.

Information

The main information on the transmitter may be obtained here. They are: Tag, Description, Message, Date, Sensor Information, and Device Information.

The following information is available for the **TT400 HART® SIS** transmitter identification and manufacturer data:

- ✓ **TAG** – Field with 8 alphanumerical characters for transmitter identification;
- ✓ **DESCRIPTION** – Field with 16 alphanumerical characters for additional transmitter identification;
- ✓ **MESSAGE** – Field with 32 alphanumerical characters for any other information, such as the name of the last person to calibrate, some special caution to be observed or if a ladder is needed to access the transmitter, for example.

- ✓ **MODIFICATION DATE** – The date may be used to identify a relevant date, as the last calibration, the next calibration or installation. The date is stored in the form of bytes, where DD = [1...31], MM = [1..12], AA = [0..255] and the effective year is calculated by [year = 1900 + AA];
- ✓ **SENSOR INFO** – Informs the sensor type, its connection and the configurated range
- ✓ **DEVICE INFO** – Shows general information about the transmitter such as: Manufacturer, Device Type, Serial Number and Transmitter Firmware Version, HART protocol Version and Hardware Revision.

Trim

The Trim function is used to adjust resistance, voltage and current reading to user standard.

In order to perform the Trim, the control loop must be on MANUAL to avoid interferences in the process.

CURRENT TRIM (4-20 mA output)
When the microprocessor generates a 0 percent signal, the Digital-to-Analogic converter and related electronic circuits must emit a 4 mA output. If the signal is 100 percent, the output must be 20 mA. Differences may occur between the SMAR standard current and the plant standard. In this case, the current Trim adjustment should be used. The Configurator will adjust the output signal and then it will ask again if the current is correct or not.

PRIMARY VARIABLE TRIM
There may be differences between the SMAR resistance standard and mV and the plant standards. In this event, the user Trim adjustment may be used. The Trim available are: Cal Point Low and Cal Point High.

Cal Point Low – Calibrates the resistance or millivoltage lower value.
Cal Point High – Calibrates the resistance or milivoltage upper value.

For low or high adjustment point, a resistance or mV standard should be connected with a better than 0.02% accuracy.

If the transmitter is configured as differential, backup, average, maximum or minimum, only the low trim is available. To perform low, it is needed to short circuit each sensors in the field and to enter with the value 0 (zero). After perform the Trim, remove the short circuit for the transmitter to read the sensors resistance without the influence of the lines. The line maximum resistance should be less than 32 Ω for that zero trim would be possible.

SECONDARY VARIABLE TRIM
Although it is not necessary to perform the temperature trim for the sensor in the terminal block, it is possible a little adjustment in the temperature measure through this menu.

FACTORY
Allow to return the factory calibration to the primary and secondary variables.

Configuration

LCD

This function allows configuring the LCD to shows two variables simultaneously. The variables that can be monitored are:

VARIABLE	DESCRIPTION
CURRENT	Analog Output Current.
PV	Primary Variable on the selected engineering unit.
TEMP	Secondary Variable on the selected primary engineering unit.
PV%	Primary Variable in Percent of the calibrated range.

Burnout

The burnout may occur when the sensor reading is out of range or the sensor is open. In this case, the transmitter may be adjusted for maximum output limit at 21.0 mA, by configuring it on the upper value, or the minimum limit at 3.6 mA configured on the lower value.

Damping

The **DAMPING** option on the **RANGE** function enables electronic damping adjustment. The damping may be adjusted between 0 and 128 seconds.

Calibration Range without Reference

The **TT400 SIS** may be configured to supply 4 to 20 mA, the equivalent to the temperature limits on the user's application, without the need to connecting a reference calibrating generator on its terminals. This is possible because the **TT400 HART® SIS** has linearization curves for several standard temperature sensors in its memory.

Let us suppose the transmitter range is calibrated from 0 to 100 °C. The transmitter will generate a signal varying from 4 to 20 mA when the temperature oscillates between 0 and 100 °C.

Watch that both the LOWER and UPPER values are entirely independent. Adjusting one does not affect the other. However, the following rule must be observed:

a) Both values should not be less than the lower limit or in excess of the upper calibration limit.

b) The Upper value less Lower value (span) must be bigger than the MINIMUM SPAN.

Calibration Range with Reference

This is the most convenient way to calibrate a transmitter. Apply the signal for adjusting the 4 mA point (PV=0 %). The Lower Value is changed but the span remains the same.

The same procedure is applied for the Upper Value.

Single Sensor

It configures the **TT400 HART® SIS** input for the type of sensor in use and its connecting mode. The types covered in this manual are:

RTD: Temperature Resistant Detector
Cu10 (GE)
Ni120 (DIN)
Pt50, 100, 500, 1000 (IEC)
Pt50, 100 (JIS)
Configurable for 2, 3 or 4 wires

TC: Thermocouples
B, E, J, K, N, R, S e T (NBS)
L e U (DIN), K e S (IEC584)
Configurable for 2 wires

Ohm: Resistance Measuring
0 a 100 Ohm
0 a 400 Ohm
0 a 2000 Ohm
Configurable for 2, 3 or 4 wires

mV: Voltage Measuring
-6 a 22 mV
-10 a 100 mV
-50 a 500 mV
Configurable for 2 wires

Dual Sensor

The available options are: differential, backup, average, maximum and minimum.

Differential: In this mode, the **TT400 HART® SIS** will provide the difference between two sensors.

Maximum and minimum: the process variable will be supplied by sensor that has the maximum or minimum reading, respectively. If one of them ruptures, the burnout indication will be showed.

Backup: TT400 HART® SIS works with the reading of the first sensor (between 2 and 4 terminals). If the first sensor brokes, the second sensor (between 3 and 4 terminals) will replace it. In this case, the reading of the first sensor will be ignored, even if this sensor returns to operate again. The first sensor will back to operate again if either gives it the equipmnent is reseted via software or manually.

If the difference between the two sensors is higher than a programmed value, the burnout indication will be showed.

Average: the final reading will be the average of the signals from two sensors. If one of them ruptures, the other continues performing the process variable reading. If the difference between them is higher than a programmed value, the burnout indication will be showed.

Cold Junction

This option enables the cold junction compensation for thermocouple sensor.

Unit

The Engineering Unit showed on the transmitter and the configurator displays can be changed. The units are linked to a selected process variable.
The following units are available:
For **mV** input: always **mV**.
For **Ohm** input: always **Ohm**.
For **Thermocouple** and **RTD: Celsius, Fahrenheit, Rankine and Kelvin degrees.**

Maintenance

The maintenance menu provide some options to check his loop functionality, such as: restart the equipment, test the current loop, verify the number of configurations changing, configure passwords and verify the equipment ordering code. Below is a brief description of the commands performed by the equipment in Maintenance function:

Device Reset - The equipment is switched off and then on. The restarting option should be carried out as the last option, as it may destabilize the process control.

Self Test – The **TT400 HART® SIS** runs an internal algorithm in order to verify its performance.

Loop Test - The current output may be adjusted to any desired value between 3.8 and 21.0 mA regardless of the input value. Also there are a few fixed current values for the loop test. The values available are: 4, 8, 16 or 20 mA.

Operation Counter - The operation number counting is useful to indicate if somebody changed any configuration on the equipment. Every time one of the parameters below is changed, the respective counter is incremented. The monitored parameters are:

- Range configuration (Lower/Upper);
- Change to Constant Current;
- 4 mA Trim;
- 20 mA Trim;
- Sensor Trim;
- Burnout configuration;
- Sensor configuration etc.

Logged Events - Shows the time when a configuration was changed.

Over Temperature - Shows the maximum and minimum primary variable value.

Passwords - The options for password configuration and access level.

Monitoring - MONIT

Device Variables - This function monitors the transmitter 4 dynamic variables and the output current on the configurator display simultaneously.

VARIABLE	DESCRIPTION
CURRENT	mA output
PV	Process variable on the selected engineering unit
TEMP	°C Room temperature
PV%	Process variable percent

Table 3.3 - Monitored Variables

Device Status – Shows additional status information.

MAINTENANCE PROCEDURES

General

TT400 HART® SIS is extensively tested and inspected before delivery to the end user.

A special care must be taken with your transmitter. All maintenance services must be done by qualified people and component exchanges must be done by replacing for certified ones that are supplied by Smar.

Diagnoses with Smar Configurator

If any problem with the transmitter's output occurs, it can be investigated by using a configurator, as long as power is supplied and communication and the processing unit are operating normally.

The configurator should be connected to the transmitter in accordance with the wiring diagram shown on Section 1 - Figure 1.6.

Error Messages

When communicating using the Configurator, the user will be informed about any problem found by the transmitters self diagnosis.

As an example, the Configurator of the display may show in the output saturation.

The messages are always alternated with the information on the top line. The table below lists the error messages. Refer to troubleshooting for more details on corrective action.

Diagnostics with the Configurator

DIAGNOSTIC MESSAGES	POTENTIAL SOURCE OF PROBLEM
PARITY ERROR	• Excessive noise or ripple.
OVERRUN ERROR	• Excessive noise or ripple.
CHECK SUM ERROR	• Excessive noise or ripple.
FRAMING ERROR	• Excessive noise or ripple.
NO RESPONSE	• The line resistance is not in accordance with load curve. • Transmitter not powered. • Interface not connected. • Transmitter configured in Multidrop mode being accessed by ONLINE SINGLE UNIT. • Transmitter reversely powered (polarity is reversed). • Interface damaged. • Power supply or battery voltage of the Configurator.
CMD NOT IMPLEMENTED	• Software version not compatible between Configurator and transmitter. • Configurator is trying to carry out a **TT400 HART® SIS** specific command in a transmitter from another manufacturer.
TRANSMITTER BUSY	• Transmitter carrying out on important task.
COLD START	• Start-up or Reset due to power supply failure.
OUTPUT FIXED	• Output in Constant Mode. • Transmitter in Multi-drop mode.
OUTPUT SATURATED	• Primary variable out of calibrated Span (Output current in 3.8 or 20.5 mA).
SV OUT OF LIMITS	• Terminal Temperature Sensor out of operating limits or damaged.
PV OUT OF LIMITS	• Input signal out of operating limits. • Sensor damaged. • Transmitter with false configuration. • PV out of range limits.

Table 4.1 - Diagnostics with the Configurator

Diagnostics with the Display

The display can also shows fail messages in the alphanumeric segment. When these messages are shown the transmitter goes automatically to fail safe state. These messages are show in the Table 4.2:

DIAGNOSTIC MESSAGES	POTENTIAL SOURCE OF PROBLEM
F MLK	Memory leak
F ROM	PROM fail
F FRM	FRAM fail
F RAM	RAM fail
F FPU	CPU fail
F mA	Output current fail
F 1V2	AD reference fail
F FLW	Program sequence fail
AD HD	AD fail
AD Pt	Environment temperature sensor fail
AD 23	Terminal 2 acquisition fail
AD 34	Terminal 3 acquisition fail
ADREF	AD internal reference fail
PVbad	Sensor is broken or its signal is out of range
SVbad	Temperature sensor in the terminal is broken or its signal is out of range
PVsat	Primary variable out of calibrated range

Table 4.2 - Diagnostics with the Display

Disassembly Procedure

Refer to Figure 4.1 - " **TT400 HART® SIS** Exploded View". Make sure to disconnect power supply before disassembling the transmitter.

Sensor
If the sensor is mounted on the transmitter, first disconnect the wires in order to prevent them from breaking. To access the terminal block, first loose the cover locking screw on the side marked "Field Terminals", then unscrew the cover.

Electronic Circuits
The main board (**6**) and input board (**8**) are matched pairs and must be changed together and not mixed with others.

To remove the circuit boards (**6** and **8**) and display (**4**), first loose the cover locking (**17**) on the side not marked "Field Terminals" then unscrew the cover (**1**).

WARNING
The board has CMOS components which may be damaged by electrostatic discharges. Observe correct procedures for handling CMOS components. It is also recommended to store the circuit boards in electrostatic-proof cases.

Loosen the two screws (**5**) that anchor the main circuit board. Gently pull out the main board (**6**). To remove the input board (**8**), first unscrew the two screws (**7**) that anchors it to the housing (**18**), gently pull out the board.

Reassembly Procedure

- Put input board (**8**) into housing (**18**);
- Tighten input board with its screws (**7**);
- Put main board (**6**) into the housing, ensuring all interconnecting pins are connected;
- Anchor main board with their screws (**5**);
- Put display (**4**) into the housing, observing the four mounting positions (see Figure 4.2) "▲" symbol should point in the direction desired as UP;
- Anchor display with their screws (**3**);
- Fit the cover (**1**) and lock it using the locking screw (**17**).

Interchangeability

Calibration data is stored in the EEPROM of the main board; hence READING TRIM must be done if main board or input board has been changed.

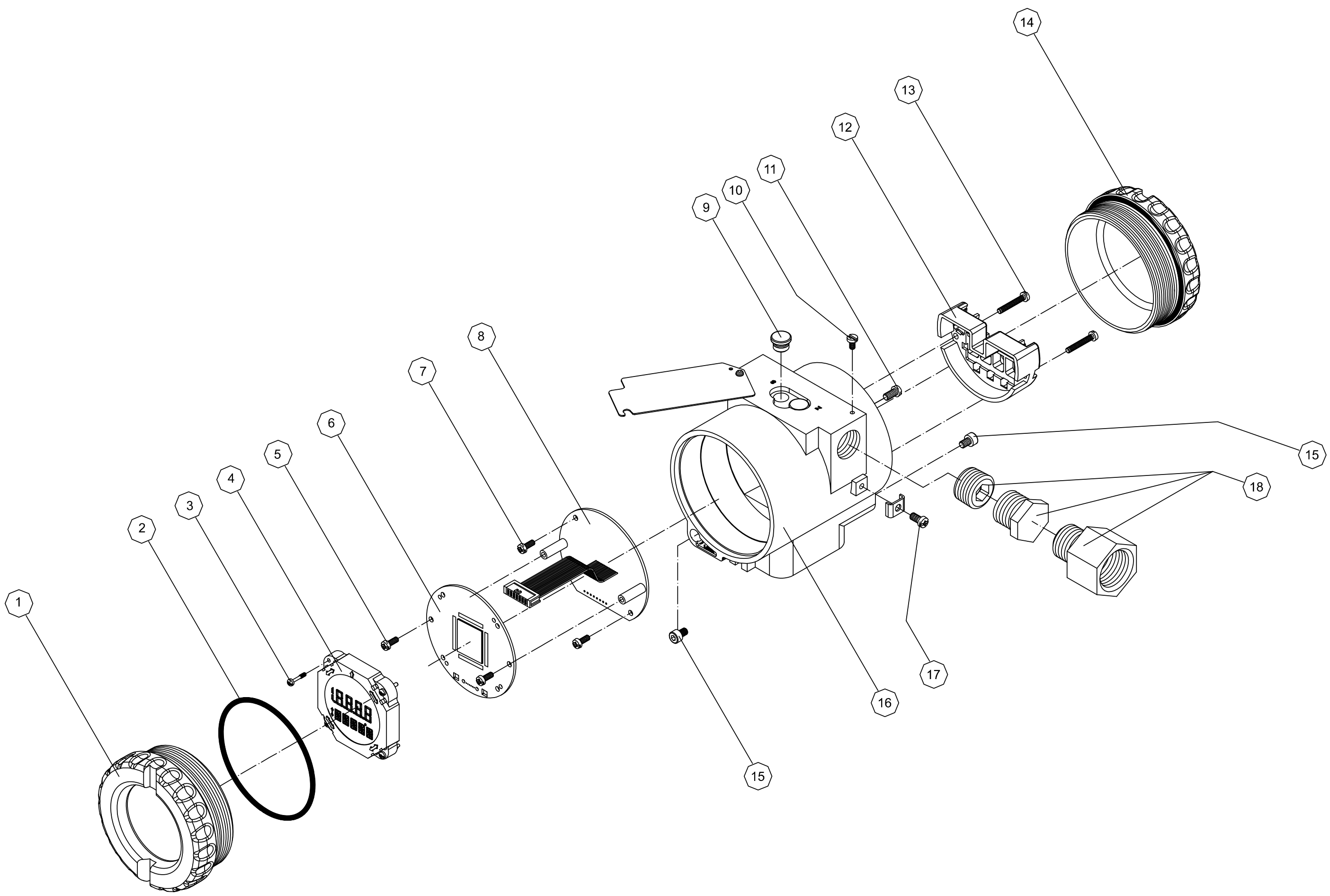


Figure 4.1 – Exploded View

SPARE PARTS LIST FOR TRANSMITTER				
DESCRIPTION OF PARTS		POSITION	CODE	CATEGORY (NOTE1)
HOUSING, Aluminum (NOTE 2)				
. 1/2 - 14 NPT		15	214-0200	
. M20 x 1.5		15	214-0201	
. PG 13.5 DIN		15	214-0202	
HOUSING, 316 SS (NOTE 2)				
. 1/2 - 14 NPT		15	214-0203	
. M20 x 1.5		15	214-0204	
. PG 13.5 DIN		15	214-0205	
HOUSING, COOPER FREE (NOTA 2)				
. 1/2 - 14 NPT		15		
. M20 x 1,5		15		
. PG 13,5 DIN		15		
COVER				
. ALUMINUM		1 and 13	400-0822	
. 316 SS		1 and 13	400-0823	
COVER WITH WINDOW FOR INDICATION				
. ALUMINUM		1	400-0824	
. 316 SS		1	400-0825	
DESCRIPTION OF PARTS				
COVER LOCKING SCREW		14	204-0120	
EXTERNAL GROUND SCREW	. 316 SST HOUSING . ALUNIMIUM HOUSING	11 11	400-0826 400-0904	
IDENTIFICATION PLATE FIXING SCREW		10	204-0116	
DIGITAL INDICATOR		4	400-0828	
TERMINAL BLOCK		11	214-0220	
BOARD GROUP GLL1351 AND GLL1353 (DISPLAY AND ASSEMBLY KIT INCLUDED); TT400 SIS.		6 and 8	400-1136	A
BOARD GROUP GLL1351 AND GLL1353 (DISPLAY AND ASSEMBLY KIT NOT INCLUDED); TT400 SIS.		6 and 8	400-1137	A
BOARD GROUP GLL1351 AND GLL1353 (WITHOUT DISPLAY AND WITH ASSEMBLY KIT INCLUDED); TT400 SIS.		6 and 8	400-1138	A
BOARD GROUP GLL1351 AND GLL1353 (INCLUDED DISPLAY AND WITHOUT ASSEMBLY KIT); TT400 SIS.		6 and 8	400-1139	A
0-RINGS Cover, BUNA-N (**NOTE 3**)		2	204-0122	B
TERMINAL BLOCK SCREW		12	204-0119	
CONDUIT PLUG				
1/2 NPT INTERNAL SOCKET SET PLUG IN BICHROMATIZED CARBON STEEL		17	400-0808	
1/2 NPT INTERNAL SOCKET SET PLUG IN 304 SST		17	400-0809	
M20 X 1.5 EXTERNAL SOCKET SET PLUG IN 316 SST		17	400-0810	
PG 13.5 EXTERNAL SOCKET SET PLUG IN 316 SST		17	400-0811	
PLUG		17		
MAIN BOARD SCREW				
INPUT BOARD SCREWS (FOR ALUMINIUM HOUSING)		7	400-0905	
INPUT BOARD SCREWS (FOR INOX HOUSING)		7	400-0832	
ANALOG BOARD SCREW				
MAIN BOARD SCREWS		5	400-0832	
MOUNTING BRACKET FOR 2" PIPE MOUNTING (NOTE 4)				
. CARBON STEEL (ACCESSORIES IN CARBON STEEL)		-	214-0801	
. STAINLESS STEEL 316 (ACCESSORIES IN STAINLESS STEEL 316)		-	214-0802	
. CARBON STEEL (ACCESSORIES IN STAINLESS STEEL 316)		-	214-0803	
LOCAL ADJUSTMENT PROTECTION CAP		9	204-0114	

NOTE
1 - For category A, it is recommended to keep, in stock, 25 parts installed for each set, and for category B, 50.
2 - It includes terminal holder insulator, bolts (cover lock, grounding and terminal holder insulator) and identification plate without certification.
3 - O'Rings are packaged in packs of 12 units.
4 - Including U-clamp, nuts, bolts and washers.

ACCESSORY	
ODERING CODE	**DESCRIPTION**
SD-1	Magnetic tool for local adjustment.
Palm*	16 Mbytes Palm Handheld, Including HPC401 initialization and installation software.
HPC401*	HART® interface (HPI311) for Palm, including the configuration package for Smar transmitters and generic transmitters.
HPI311*	HART® interface.

* For equipment updates and HPC401 software, access our website: **http://www.smarresearch.com**.

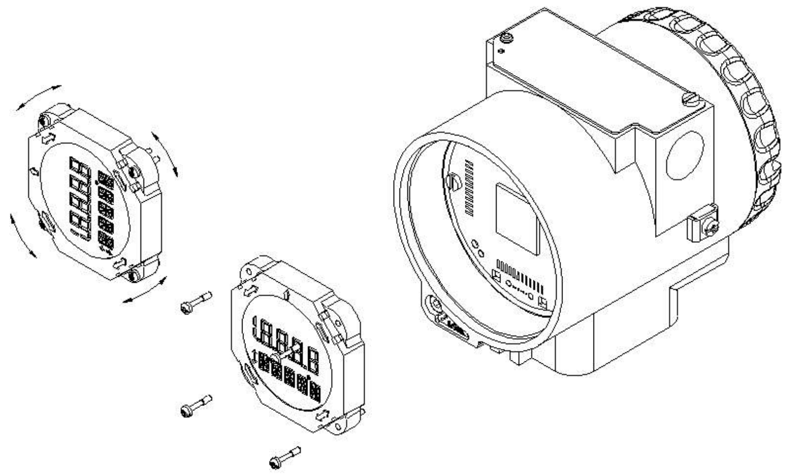


Figure 4.2 – Four Possible Positions of the Display

WARNING
The firmware download should not be made in field.

Lifetime Transmitter

The excepted lifetime of the **TT400 HART® SIS** is 50 years. The reliability data listed the FMEDA report is only valid for this period. The failure rates of the **TT400 HART® SIS** may increase sometime after this period. Reliability calculations based on the data listed in the FMEDA report for **TT400 HART® SIS** lifetimes beyond 50 years may yield results that are too optimistic, i.e., the calculated Safety Integrity Level will not be achieved.

Section 5

TECHNICAL CHARACTERISTICS

Functional Specifications	
Inputs	See table 5.1, 5.2 and 5.3;
Output Signal	Two-wire, 4-20 mA with superimposed digital communication (HART Protocol Version 5.1/Transmitter/Poll-Response mode/Common 4-20 mA).
Power Supply	12 - 55 Vdc; Input with polarization; Input with transient suppressor.
Display	Liquid crystal display, rotative, with 4 ½ numeric digits, 5 alphanumeric digits and icons of function and status; Display indication for both sensor failure and sensor saturation;
Communication Protocol	HART Protocol Version 5, with the **TT400 HART® SIS** commands set; The HART Transmitter Specific Revision must be managed in accordance to **TT400 HART® SIS** transmitter; HART® is a trademark of HART Communication Foundation.
Failure Alarm	In case of dangerous failure detection, the output goes to failure state according to NAMUR NE-43 and the detected failure is indicated in the display; The Low or High failure state is configured by the user; The failure detection by hardware results in high failure state.
Measured Type	Temperature with one sensor; Differential Temperature between two sensors; Temperature with two sensors considering the highest; Temperature with two sensors considering the lowest; Average temperature with two sensors; Backup temperature with two sensors; Temperature generated by Callendar Van Dusen equation.
Configuration	Remote configuration with the external programmer via HART protocol, using the resources of the DDL/EDDL; Persistent data stored in the FRAM.

Performance Specifications	
Accuracy	See tables 5.1, 5.2 and 5.3.
Ambient Temperature Effect For 10°C Variation	**mV (- 6 to 22 mV), TC (NBS: B, R, S,T):** ± 0.03% of the input milivoltage or 0.002 mV whichever is greater; **mV (- 10 to 100 mV), TC (NBS: E, J, K, N; DIN: L, U):** ± 0.03% of the input milivoltage or 0.01 mV whichever is greater; **mV (-50 to 500 mV):** ± 0.03% of the input milivoltage or 0.05 mV whichever is greater; **Ohms (0 to 100 Ω), RTD (GE: Cu10):** ± 0.03% of the input resistance or 0.01 Ω whichever is greater; **Ohms (0 to 400 Ω), RTD (DIN: Ni120; IEC: Pt50, Pt100; JIS: Pt50, Pt100):** ± 0.03% of the input resistance or 0.04 Ω whichever is greater; **Ohms (0 to 2000 Ω), RTD (IEC: Pt500), RTD (IEC: Pt1000):** ± 0.03% of the input resistance or 0.2 Ω whichever is greater; **TC:** cold-junction compensation rejection 60:1 (Reference: 25.0 ± 0.3 °C).
Power Supply Effect	± 0.005% of calibrated span per volt.
Response Time	300 ms.
Output Current	Output current resolution: 15 bits; Output current accuracy: ±0.01% of the span.
Sensor Reading	A/D converter accuracy: ±0.02% of full span.
Stabilization Time after the Power up – hot start up	Less than 15 seconds.

Physical Specifications	
Electrical Connections	1/2 - 14 NPT, PG 13.5 DIN, and M20 X 1.5 conduit; Electrical inlet finished in plan face to allow connection sealing by compressing the O'Ring.
Terminal Block	2 terminals for power supply connection; 4 terminals for sensor connection.
Mounting Bracket	In carbon steel SAE 1020 with electrostatic polyester painting or 316 SST; Accessories (bolts, nuts, washers and U-clamps) in carbon steel or 316 SST.
Weight	Up to 0.93 Kg (2.067 lb) without any optional part.
Identification Plate	316 SST plate with bounded special plastic label.

Transmitter Specifications	
Sensor input treatment	AD with 50 and 60 Hz input noise rejection, programmed gain, input multiplex and 16-bits resolution; Input Sensor trim in two points; Environment Temperature trim in two point.
Primary variable treatment	Damping of 0 to 128 seconds; Engineering unit conversion; Cold junction compensation; Input Sensor characterization (Callendar Van Dusen); Measured Type (single, differential, maximum, minimum, average).
Output treatment	Analog current trim in two points.

Protected Operation Specifications	
Configuration operation counter	Counting of the configuration change operations.
Configuration Protection	Configurations blocked by password; Write Protection via hardware;
Certification / Compliance to the standards	Intrinsic Safety, Explosion Proof, Weather Proof.

Human Machine Interface Specifications

Indication of the state in the display

Item	Icon	Definition
1	MD	Multidrop Mode
2	FIX	Fixed Output Current
3	PV	Primary Variable Indication
4	⇳	SIS Mode

	2, 3 or 4 wires					
SENSOR	**TYPE**		**RANGE °C**	**RANGE °F**	**MINIMUM SPAN °C**	**°C DIGITAL ACCURACY***
RTD	Cu10	GE	-20 to 250	-4 to 482	150	± 1.0
	Ni120	DIN	-50 to 270	-58 to 518	20	± 0.1
	Pt50	IEC	-200 to 850	-328 to 1562	40	± 0.2
	Pt100	IEC	-200 to 850	-328 to 1562	40	± 0.2
	Pt500	IEC	-200 to 450	-328 to 842	40	± 0.2
	Pt1000	IEC	-200 to 300	-328 to 572	40	± 0.2
	Pt50	JIS	-200 to 600	-328 to 1112	40	± 0.25
	Pt100	JIS	-200 to 600	-328 to 1112	40	± 0.25
THERMOCOUPLE	B	NBS	100 to 1800	212 to 3272	50	± 0.5*
	E	NBS	-100 to 1000	-148 to 1832	20	± 0.2
	J	NBS	-150 to 750	-238 to 1382	30	± 0.3
	K	NBS	-200 to 1350	-328 to 2462	60	± 0.6
	N	NBS	-100 to 1300	-148 to 2372	50	± 0.5
	R	NBS	0 to 1750	32 to 3182	40	± 0.4
	S	NBS	0 to 1750	32 to 3182	40	± 0.4
	T	NBS	-200 to 400	-328 to 752	15	± 0.15
	L	DIN	-200 to 900	-328 to 1652	35	± 0.35
	U	DIN	-200 to 600	-328 to 1112	50	± 0.5

Table 5.1 - 2, 3 or 4 wires Sensor Characteristics

* Not applicable for the first 20% of the range (up to 440 °C).

SENSOR	**RANGE mV**	**MINIMUM SPAN mV**	**DIGITAL ACCURACY %**
mV	-6 to 22	0.40	± 0.02% or ± 2 µV
	-10 to 100	2.00	± 0.02% or ± 10 µV
	-50 to 500	10.00	± 0.02% or ± 50 µV

Table 5.2 - mV Sensor Characteristics

SENSOR	**RANGE Ohm**	**MINIMUM SPAN Ohm**	***DIGITAL ACCURACY %**
Ohm	0 to 100	3	± 0.02% or ± 0.01 Ohm
	0 to 400	12	± 0.02% or ± 0.04 Ohm
	0 to 2000	60	± 0.02% or ± 0.20 Ohm

Table 5.3 - Ohm Sensor Characteristics

Ordering Code

MODEL	
TT400	SMART TEMPERATURE TRANSMITTER

COD.	Communication Protocol
H	HART and 4 to 20 mA

COD.	Security Option
1	SIS – Safety Instrumented Systems

COD.	Local Indicator (1)
0	Without Indicator
1	With Digital Indicator

COD.	Electrical Connections	COD.	
0	1/2 – 14 NPT	A	M20 X 1.5 **(5)**
1	3/4 – 14 NPT (with 316 SST adapter for 1/2 - 14 NPT) **(5)**	B	PG13.5 DIN **(6)**
2	3/4 – 14 BPS (with 316 SST adapter for 1/2 - 14 NPT) **(2)**	Z	User's specification
3	1/2 – 14 BPS (with 316 SST adapter for 1/2 - 14 NPT) **(2)**		

COD.	Blanket Plug
I	316 SST
C	Carbon Steel **(3) (7)**

COD.	Mounting Bracket	COD.	
0	Without Bracket	2	316 SST Bracket with 316 SST Fasteners
1	Carbon Steel Bracket with Carbon Steel Fasteners	7	Carbon Steel Bracket with 316 SST Fasteners

COD.	Housing Material	COD.	
A	Aluminium (default) (IP/TYPE)	B	Aluminum – saline atmospheres **(4)** (IPW/TYPEX)
I	316 SST – CF8M (ASTM – A351) (IP/TYPE)	H	Aluminium Copper Free (IPW/TYPEX)
J	316 SST – saline atmospheres **(4)** (IPW/TYPEX)		

COD.	Painting
0	Gray Munsell N 6.5 Polyester (Default)
8	Without Painting **(8)**
9	Safety Blue Epoxy – Electrostatic Painting
C	Safety Blue Polyester – Electrostatic Painting
Z	Special Painting

COD.	Certification Type (10)
N	Without Certification
I	Intrinsic Safety
D	Explosion Proof
F	Non-incendive + Intrinsic Safety
K	Intrinsic Safety + Explosion Proof + Non-incendive
J	Non-incendive + Intrinsic Safety + Dust

COD.	Organ Certifier (10)
0	Without Organ Certified
3	CSA (pending)
5	CEPEL
8	SIRA (pending)

COD.	Tag Plate (11)	COD.	
0	With TAG, when specified	2	According to user's notes
1	Blanket		

COD.	Sensor Type	COD.	
1	RTD Cu10 – GE	F	Thermocouple type S - NBS
2	RTD Ni120 – Edison Curve #7	G	Thermocouple type T - NBS
3	RTD Pt50 – IEC	K	Thermocouple type L – DIN
4	RTD Pt100 – IEC	P	Thermocouple type U – DIN
5	RTD Pt500 – IEC	M	22 mV
6	RTD Pt1000 – IEC	N	100 mV
7	RTD Pt50 – JIS	O	500 mV
8	RTD Pt100 – JIS	R	100 Ohm
9	Thermocouple type B - NBS	S	400 Ohm
A	Thermocouple type E - NBS	U	2K Ohm
B	Thermocouple type J - NBS	Z	Other
C	Thermocouple type K - NBS		
D	Thermocouple type N - NBS		
E	Thermocouple type R - NBS		

COD.	Sensor Connection	COD.	
2	2-wire	4	4-wire
3	3-wire	F	2-wire (two sensors) **(9)**

TT400 - H 1 1 - 0 C 1 - A 0 N 0 0 - 4 3

NOTES	
(1) Values limited to 4 ½ digits; units limited to 5 characters.	**(7)** Not applicable for saline atmosphere.
(2) Explosion proof approvals do not apply to these adapters, only to transmitters.	**(8)** Not available for aluminum housing.
(3) Only available for electrical connections 1/2".	**(9)** For the choice of the sensor, consult HART table, Measurement Mode item in the page 5.5.
(4) IP66/68W tested for 200h to according with standard NBR 8094 / ASTM B 117.	**(10)** For hazardous locations.
(5) Certificate for use in Explosion Proof (CEPEL and FM).	**(11)** Rectangular plate in 316 SST.
(6) Certificate for use in Explosion Proof (CEPEL).	

****HART OPTIONAL CONFIGURATION (1)**

TT400	MAIN CODE OF HART TRANSMITTER (CONTINUATION)
COD.	**Burn-out**
BD	Start Scale (According NAMUR NE43 specifications) (Default)
BU	End Scale (According NAMUR NE43 specifications)
COD.	**LCD1 Indication**
Y0	LCD1: Percentage (Default)
Y1	LCD1: Current - I (mA)
Y2	LCD1: Temperature (Engineering Unit)
COD.	**LCD2 Indication**
Y0	LCD2: Percentage (Default)
Y1	LCD2: Current (mA)
Y2	LCD2: Temperature (Engineering Unit)
COD.	**PID Avaliability**
P0	PID not available
COD.	**Special Measurement Type (2)**
F3	Callendar Van Dusen
F4	Special Sensor
COD.	**Measurement Mode (3)**
T0	Differential
T1	Backup
T2	Average
T3	Maximum
T4	Minimum
T5	Not Applicable
COD	**Special Features**
ZZ	User´s specifications

TT400-H11-0C1-A0N00-43	BD	Y2	Y1	P0	F3	T0	*	**TYPICAL MODEL NUMBER**

*Leave it blank for item no options.

NOTES
(1) Fill out with optional codes only if different from default.
(2) Callendar Van Dusen defines user-specific linearization of resistance temperature sensor.
(3) When working with two sensors connected to the terminal block.

SAFETY INSTRUMENTED SYSTEMS (SIS)

Safety Instrumented Systems are designed and used to prevent or mitigate hazardous events to protected people, the environment or prevent damage to process equipment. The SIS project is based on the damage that a failure can cause.

WARNING

The SIS project must be carried by a professional duly qualified for this type of work.

Safety Standard

TT400 HART® SIS satisfies the requirements of the standards shown in the Table 6.1.

Standard	Description
IEC 61508 – Part 1 to 7	Functional safety of electrical/electronic/programmable electronic safety-related systems.
IEC 61326	Electrical equipment for measurement, control and laboratory use - EMC requirements.
IEC 61326-3-2	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety related functions (functional safety) - Industrial applications with specified EM environment.
IEC 61298	Process measurement and control devices - General Methods and procedures for evaluating performance.
IEC 60770	Transmitters for use in industrial-process control systems - Methods for performance evaluation and for inspection and routine testing.
IEC 61010	Safety requirements for electrical equipment for measurement, control and laboratory use.
ANSI/NEMA-250	Enclosures for Electrical Equipment.

Table 6.1 – Safety Standards

Application Standards

Standard	Description
EN50014	Electrical apparatus for potentially explosive atmospheres - General requirements.
EN50018	Electrical apparatus for potentially explosive atmospheres - Flameproof enclosure ‘d’.
EN50019	Electrical apparatus for potentially explosive atmospheres - Increased safety ‘e’.
EN50020	Electrical apparatus for potentially explosive atmospheres - Intrinsic safety ‘i’.
FMRC-3600	Electrical Equipment for use in Hazardous (Classified) Locations - General Requirements.
FMRC-3610	Intrinsically Safe Apparatus and Associated Apparatus for use in Class I, II and III, Division 1 Hazardous Location.
FMRC-3611	Electrical Equipment for use in Class I, Division 2; Class II, Division 2; and Class III, Division 1 and 2 Hazardous Location.
FMRC-3615	Explosion proof Electrical Equipment.
FMRC-3810	Electrical and Electronic Test - Measuring and Process Control Equipment.
ANSI/ISA-12.27.01	Requirements for Process Sealing between Electrical Systems and Flammable or Combustible Process Fluid.
IEC 61511	Functional safety - Safety instrumented systems for the process industry sector.
ISA84	Application of Safety Instrumented Systems for the process industries (USA).

Table 6.2 – Application Standards

Safety Function

The **TT400 HART® SIS** transmitter measures the temperature within the safety accuracy and converts it in a 4-20 mA analog output using the selected output transfer function and the output current is treated according to NAMUR NE-43 specification. In case of sensor or circuit failure, the implemented self-diagnoses (software or hardware) drive the output to below 3.6 or above 21 mA that are the device safe states defined to this equipment.

In the normal circumstance it takes about 180 ms to read the temperature within the specified resolution (response time).

In order to judge the failure behavior of the **TT400 HART® SIS**, the following definitions for the product were considered:

Failure	Description
Safe State	It is considered the state when the output current is out of the valid range, therefore lower than 3.8 mA or higher than 20.5 mA;
Safe Failure	Failure that leads the system to a safe state, without a process demand;
Dangerous Failure	Failure that leads the system to a dangerous condition, in other words, the transmitter will output a current out of the safety specification;
Undetected Failure	Failure that cannot be detected by the online diagnostics
Detected Failure	Failure that can be detected by the online diagnostics

Table 6.3 – Failure Modes

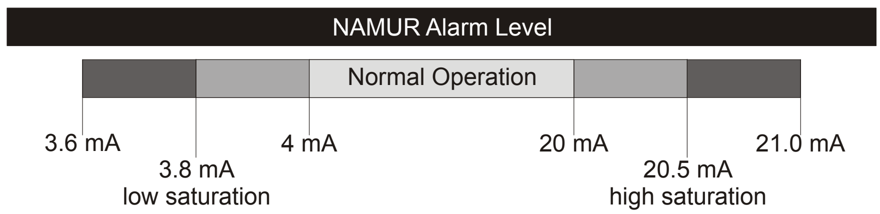


Figure 6.1 – Alarm Levels

Functional Safety Properties

The Table 4 shows the Functional Safety Values obtained for **TT400 HART® SIS**.

OPERATION MODE	LOW DEMAND
TYPE	B
SFF	96%
LAMBDA SD (FITS)	23
LAMBDA SU (FITS)	39.2
LAMBDA DD (FITS)	103
LAMBDA DU (FITS)	5.8
PFD AVG FOR 20 YEARS	5.16E-4
% SIL 2 (PFD AVG)	10,32%
TRANSMITTER LIFETIME	20 YEARS
FIT FOR USE IN SIL	2
FIT FOR USE IN STL	5

Table 6.4 – Functional Safety Values

Returning Materials

If it is necessary to return the transmitter and/or Configurator to **SMAR**, simply contact your local agent or **SMAR** office, informing this equipment serial number, and return it to our factory.

In order to expedite analysis and solution of the problem, the defective item should be returned with a description of the failure observed, with as much details as possible. Other information concerning to the instrument operation, such as service and process conditions, is also helpful.

CERTIFICATION INFORMATION

Hazardous Locations Certifications

NOTE
The IP68 sealing test (immersion) was performed at 1 bar for 24 hours. For any other situation, please consult Smar.

South America Certification

INMETRO approvals

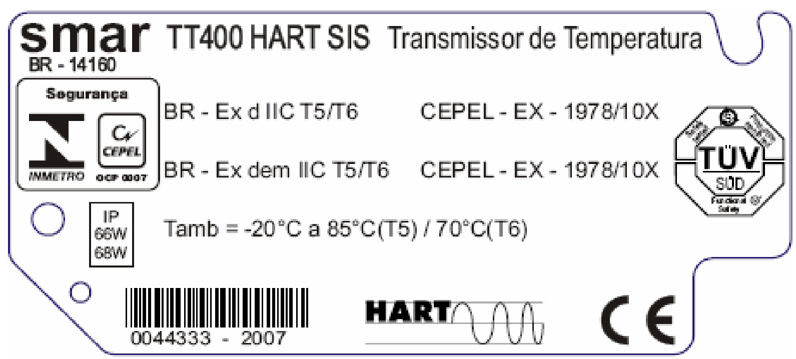
Certificate No: CEPEL- Ex-1979/10X
Intrinsically safe - **Ex-ia IIC T4/T5/T6**
Entity Parameters: U_i = 30 Vdc I_i = 100 mA C_i =6.4nF L_i = neg P_i=0.7 W
Ambient Temperature: 85 ºC for T4
60 ºC for T5
50 ºC for T6

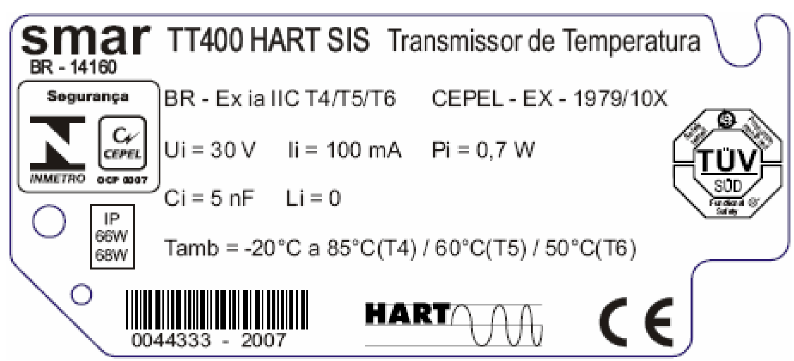
Certificate No: CEPEL- Ex-1978/10X
Flameproof - **Ex-d IIC T5/T6**
Ambient Temperature: 70 ºC for T6
85 ºC for T5

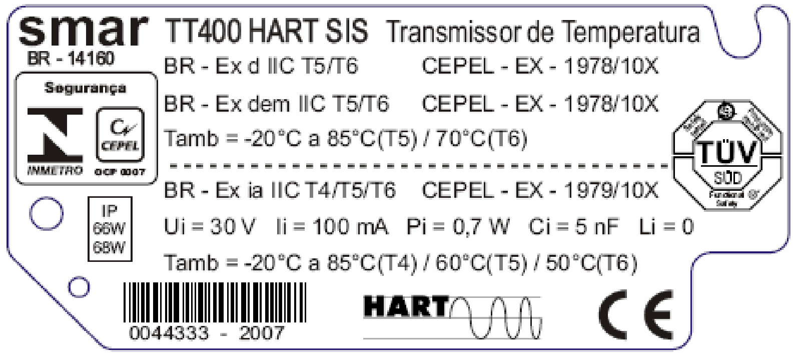
Increased Safety - **Ex-dme IIC T5/T6**
Ambient Temperature : 85 ºC for T5
70 ºC for T6
Enclosure IP66/68 W or IP66/68.

Identification Plate

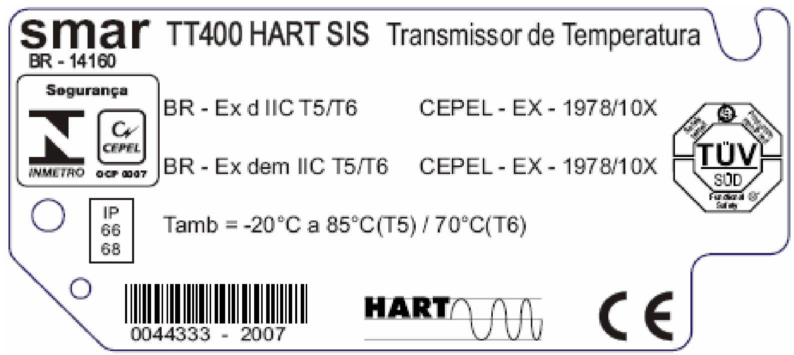
- Identification of Intrinsically Safe and Explosion Proof for saline atmospheres:

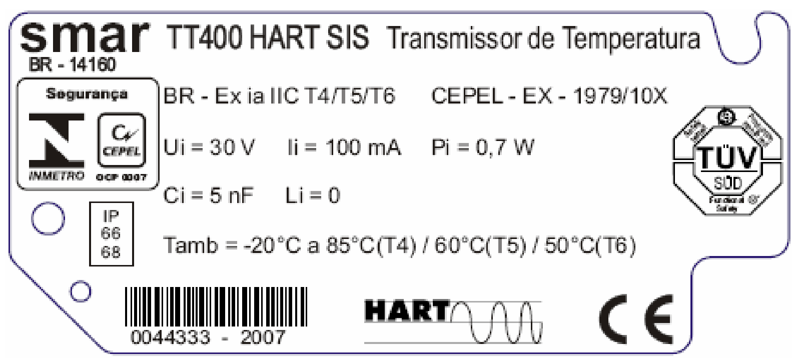


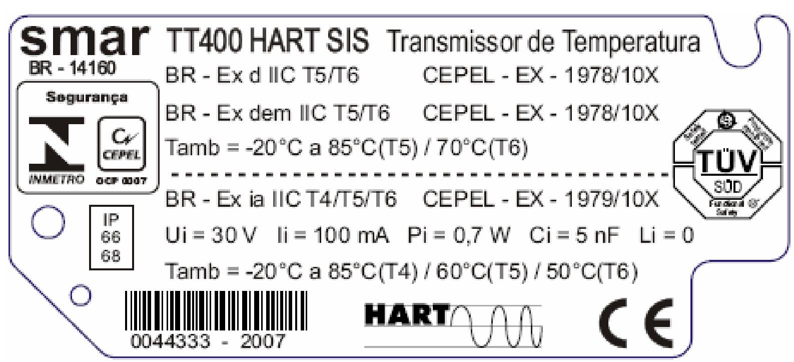




- Identification of Intrinsically Safe and Explosion Proof for gas and steam:







Apêndice B

smar	SRF – Service Request Form for Temperature Transmitter	Proposta No.: (1)
Company:	**Unit:**	**Receipt of Remittance:**

COMMERCIAL CONTACT	CUSTUMER CONTACT
Full name:	**Full name:**
Position:	**Position:**
Phone: **Extension:**	**Phone:** **Extension:**
Fax:	**Fax:**
Email:	**Email:**

EQUIPMENT DATA		
Model:	**Serial Number:**	**Firmware Version:**

Technology:
( ) 4-20 mA ( ) HART® ( ) HART® SIS ( ) WIRELESS HART® ( ) ISP ( ) FOUNDATION fieldbus™ ( ) PROFIBUS PA

PROCESS DATA					
Ambient Temperature (ºC)		**Work Temperature (ºC)**		**Calibration Range**	
Min:	**Max:**	**Min:**	**Max:**	**Min:**	**Max:**
Operation Time:			**Failure Date:**		
Sensor Type:					

Measurement type:
( ) Double Sensor ( ) Average between Sensors ( ) Differential ( ) Backup ( ) Single

Application: (3)
( ) Transmitter ( ) Repeater

FAILURE DESCRIPTION
(Please, describe the behavior of the fail, if it is repetitive, how it exactly happens, and so on.)

Did device detect the fail? (2) Yes ( ) No ( )	**What is the final value of the current? (2)** ___________ (mA)	**Message showed in the display: (2)**

MAINTENANCE INFORMATION

Did you allow the upgrade in the firmware? Yes ( ) No ( )	**Certification Plate: Will it maintained the certification?** Yes ( ) No ( )

Main Board Configuration
( ) Original Factory Configuration ( ) Default Configuration
( ) Special Configuration (Should be informed by the client. Please, use the space below)

OBSERVATIONS

SUBMITTER INFORMATION

Company:

Submitted by: Title: Section:

Phone: Extension: E-mail:

Date: Signature:

For warranty or non-warranty repair, please contact your representative.
Further information about address and contacts can be found on **www.smar.com/contactus.asp**.

NOTA

(1) This field should be filled out by the Smar.
(2) Required for SIS devices.
(3) Required for Wireless HART® devices.

Appendix C

SMAR WARRANTY CERTIFICATE

1. SMAR guarantees its products for a period of 24 (twenty four) months, starting on the day of issuance of the invoice. The guarantee is valid regardless of the day that the product was installed.

2. SMAR products are guaranteed against any defect originating from manufacturing, mounting, whether of a material or manpower nature, provided that the technical analysis reveals the existence of a quality failure liable to be classified under the meaning of the word, duly verified by the technical team within the warranty terms.

3. Exceptions are proven cases of inappropriate use, wrong handling or lack of basic maintenance compliant to the equipment manual provisions. SMAR does not guarantee any defect or damage caused by an uncontrolled situation, including but not limited to negligence, user imprudence or negligence, natural forces, wars or civil unrest, accidents, inadequate transportation or packaging due to the user's responsibility, defects caused by fire, theft or stray shipment, improper electric voltage or power source connection, electric surges, violations, modifications not described on the instructions manual, and/or if the serial number was altered or removed, substitution of parts, adjustments or repairs carried out by non-authorized personnel; inappropriate product use and/or application that cause corrosion, risks or deformation on the product, damages on parts or components, inadequate cleaning with incompatible chemical products, solvent and abrasive products incompatible with construction materials, chemical or electrolytic influences, parts and components susceptible to decay from regular use, use of equipment beyond operational limits (temperature, humidity, etc.) according to the instructions manual. In addition, this Warranty Certificate excludes expenses with transportation, freight, insurance, all of which are the customer's responsibility.

4. For warranty or non-warranty repair, please contact your representative.

   Further information about address and contacts can be found on www.smar.com/contactus.asp

5. In cases needing technical assistance at the customer's facilities during the warranty period, the hours effectively worked will not be billed, although SMAR shall be reimbursed from the service technician's transportation, meals and lodging expenses, as well dismounting/mounting costs, if any.

6. The repair and/or substitution of defective parts do not extend, under any circumstance, the original warranty term, unless this extension is granted and communicated in writing by SMAR.

7. No Collaborator, Representative or any third party has the right, on SMAR's behalf, to grant warranty or assume some responsibility for SMAR products. If any warranty would be granted or assumed without SMAR's written consent, it will be declared void beforehand.

8. Cases of Extended Warranty acquisition must be negotiated with and documented by SMAR.

9. If necessary to return the equipment or product for repair or analysis, contact us.
   See item 4.

10. In cases of repair or analysis, the customer must fill out the Revision Requisition Form (FSR) included in the instructions manual, which contains details on the failure observed on the field, the circumstances it occurred, in addition to information on the installation site and process conditions. Equipments and products excluded from the warranty clauses must be approved by the client prior to the service execution.

11. In cases of repairs, the client shall be responsible for the proper product packaging and SMAR will not cover any damage occurred in shipment.

12. Responsibility: Except for the above-mentioned general warranty conditions for SMAR products, SMAR will not assume any responsibility before the customer, without limitation, for damages, consequences, indemnity claims, loss of earnings, service expenses and other costs caused by the non-observation of the installation, operation and maintenance instructions included in SMAR manuals. Furthermore, the buyer also agrees to exempt the supplier for indemnity of damages (with exception to costs for repairs or the reposition of defective products above described) directly or indirectly caused by inadequate tests, application, operation or repair of SMAR products.

13. It is the customer's responsibility to clean and decontaminate products and accessories prior to shipping them for repair, and SMAR and its dealer reserve themselves the right to refuse the service in cases not compliant to those conditions. It is the customer's responsibility to tell SMAR and its dealer when the product was utilized in applications that contaminate the equipment with harmful products during its handling and repair. Any other damages, consequences, indemnity claims, expenses and other costs caused by the lack of decontamination will be attributed to the client. Kindly, fill out the Declaration of Decontamination prior to shipping products to SMAR or its dealers, which can be accessed at www.smar.com/doc/declarationofcontamination.pdf and include in the packaging.

14. This warranty certificate is valid only when accompanying the purchase invoice.