7.6.2.5 Alarm Loop Checking

Normally, level alarms can be verified when the level reaches the low-level or high-level alarm set point. The level alarms and, if applicable, the hard alarm contact coupled to one of the level alarms can be checked by a “loop check” command. This check is independent from the actual level value.

The level alarm signaling can be checked in several ways:

- via the communication line to the host
- via the hard alarm output contact

Engauge
SmartView

☛ To perform the alarm test, set [Alarm test enable] to <Enable> and set [Alarm test] to the required alarm (<High High alarm>, <High Alarm>, <Low Alarm>, or <Low Low alarm>). [Alarm test] is a parameter command, and the command will be executed when the parameter is sent to the gauge. When the command is given, the corresponding alarm will be set for 1 minute.

7.6.2.6 Compensations

7.6.2.6.1 Filtering

The gauge contains an output filter for both radar innage and radar ullage. The higher the [Filter averaging constant], the more damping on the radar innage and radar ullage values. The filter also introduces a lag between actual ullage/innage and filtered ullage/innage when the product level is changing. The higher the [Filter averaging constant], the larger the lag. The minimum [Filter averaging constant] value is 0 (no filtering), the maximum [Filter averaging constant] value is 99. For the general filter behavior, see FIGURE 7-12.

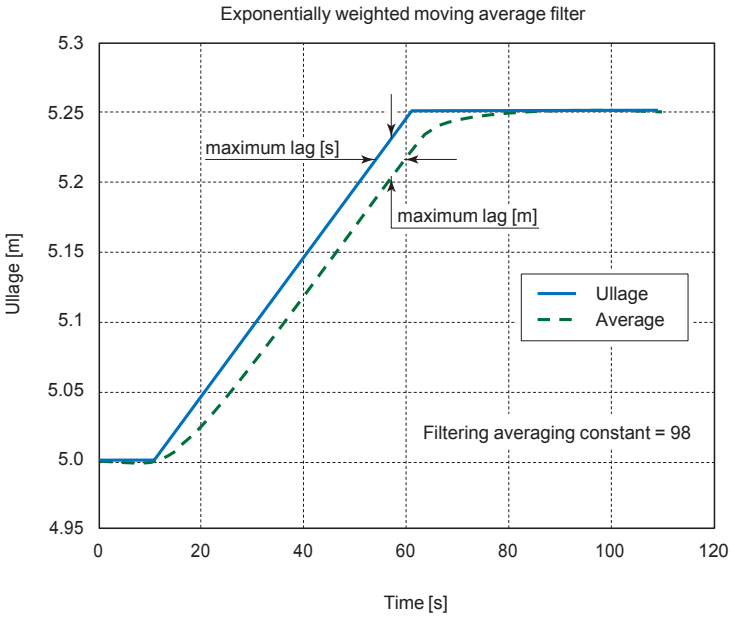


FIGURE 7-12 Filtering characteristic example (level change = 5 mm/s)

In the table below some filtering figures are given.

[Filter averaging constant]	Approximate noise reduction factor	Maximum lag [s]	Maximum lag [distance]
50	1.4	0.1	0.1 * dL/s
70	1.8	0.25	0.25 * dL/s
90	3	1	1 * dL/s
95	4.5	2	2 * dL/s
98	7	5.5	5.5 * dL/s
99	10	11	11 * dL/s

7.6.2.6.2 Verification Pins

When a radar level gauge is installed on a pressurized tank, both ISO and API suggest to use so-called verification pins to verify the radar level measurement. Prime reason to use said verification pins is the impossibility of doing a manual reference dip. With verification pins it is possible to verify the correct reading of the radar measurement at specific heights while the tank is in operation.

The SmartRadar FlexLine can be switched to measure the pin positions. The reading can then be compared with the known position of the pins. It is advised to have three verification pins:

- Pin 1 at approximately 80 - 90 % of tank height
- Pin 2 at approximately 50 % of tank height
- Pin 3 at approximately 10 - 20 % of tank height

Pin 1 should be above maximum safe fill (so, it can always be measured), however there must be at least 0.6 m (2') free space from pin 1 to cone end. All pin positions should be measured with 1 mm (1/32”) uncertainty with reference to the ball valve.

The SmartRadar FlexLine can measure the position of the three pins when the housing is rotated 90°. The verification pins are then ‘visible’ to the SmartRadar FlexLine.
This can be done without closing the 1" (or 4") ball valve, as the FlexLine housing is located above the tank separator.
After the command “Measure verification pins” is given, the measured positions of the three pins can be requested. The “real” position of the pins (from tank drawing) and the “measured” position of the pins are compared and a correction is applied.
After the SmartRadar FlexLine is placed in the normal (product measuring) mode, the measurement is automatically corrected for the found verification pin positions.

FIGURE 7-13 illustrates the correction method for verification pins.
Once the position of the verification pins is determined, the FlexLine can be switched into verification mode to verify the measured (and corrected) distances with the real pin positions.

If the correction is properly made, both values of each of the three pins should be equal to each other.

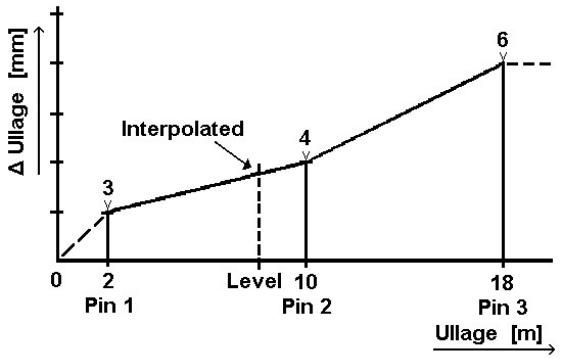


FIGURE 7-13 Ullage correction using the verification pins

If the product level in the tank is above pin position 1 or below pin position 3, the correction is extended by the following estimation:

- above pin1: there is an interpolation from the radar zero point (no correction) to the position of pin 1 (with its correction).
- below pin 3: the correction found at pin 3 is valid for the range below pin position 3.

At installation of the verification pins, the distances of the pins towards the flange of the stilling well (L1, L2, and L3) are noted.

The FlexLine measures ullage from the radar zero point.

NOTE: The radar zero point from the FlexLine with an H04 Antenna is located at the flange of the tank separator. See FIGURE 7-14.

In case the 1" ball valve is used (that is with antenna models H04/N1 and H04/N4), an offset must be added to the distances of the verification pins.

Engauge
SmartView

☛ The above found verification pin distances must be entered in the following entities:

Entity name	Explanation
Verification pin physical position 1	Physical ullage of verification pin 1 with respect to radar zero
Verification pin physical position 2	Physical ullage of verification pin 2 with respect to radar zero
Verification pin physical position 3	Physical ullage of verification pin 3 with respect to radar zero

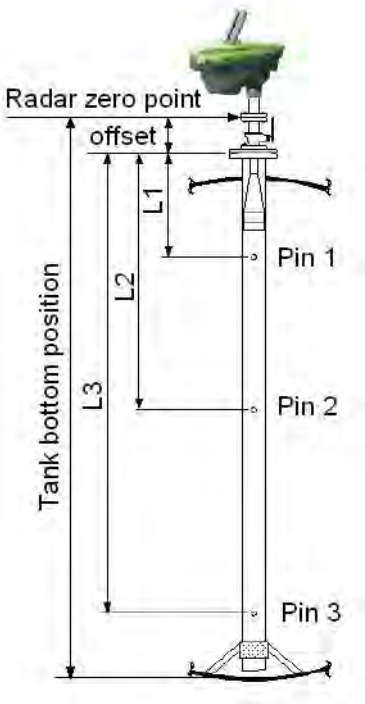


FIGURE 7-14 Radar zero point and verification pins positions

In normal (product measuring) position (see FIGURE 7-15), the E-field (electrical field of the microwave) is located perpendicular to the direction of the verification pins. In this position, the verification pins are less visible to the SmartRadar FlexLine.

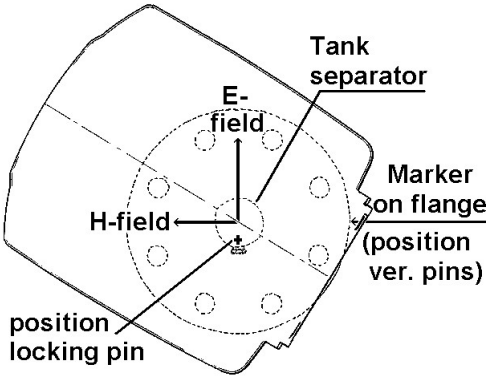


FIGURE 7-15 Product measuring position

In verification pin measuring position (see FIGURE 7-16), the E-field should be in parallel with the verification pin direction. Then the

reflections from the verification pins are stronger and recognized by the SmartRadar FlexLine.

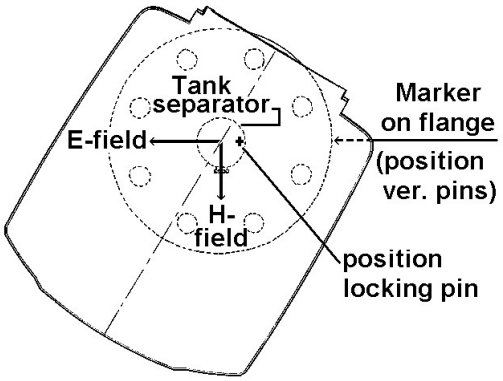


FIGURE 7-16 Verification pin measuring position

To measure the position of the verification pins, the SmartRadar FlexLine must be turned 90 degrees as follows:

- Release the coupling nut of the SmartRadar FlexLine housing.
- Lift the SmartRadar FlexLine housing from tank separator.
- Rotate the SmartRadar FlexLine for 90°. This can only be done in one direction because of the locking pin.
- Place SmartRadar FlexLine on tank separator; mind locking pin.
- Secure the coupling nut of the SmartRadar FlexLine housing.

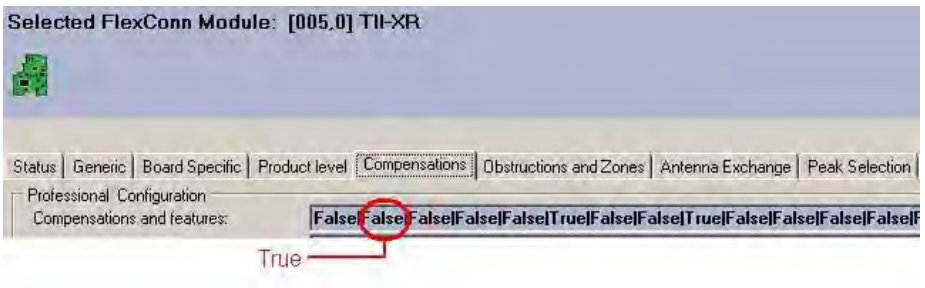
Then issue the command: [Measure verification pins] (on *SmartView*: Calibrate v-pins).

When the verification pin measurement is completed, the SmartRadar FlexLine housing must be turned back 90° (follow above procedure in reverse order).

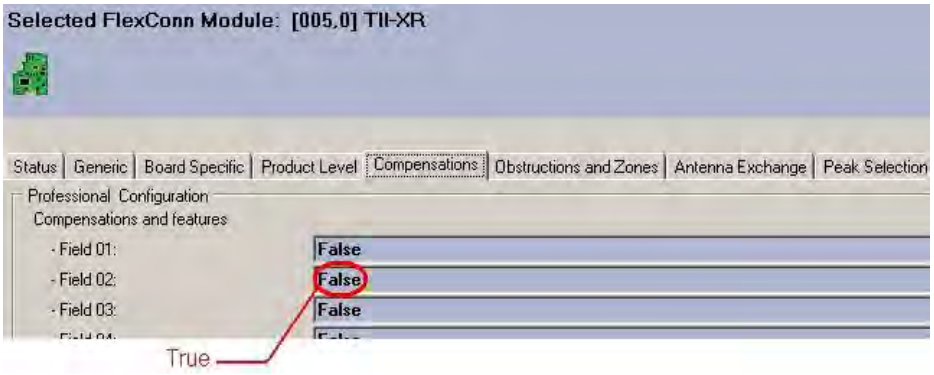
Engauge
SmartView

The verification-pin compensation must be **enabled** by the appropriate switch. In Engauge, that is (depending on installed TII-XR firmware and board descriptor):

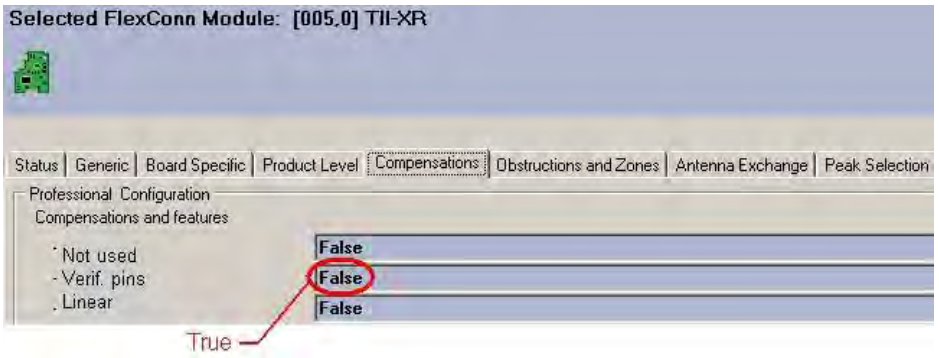
″ the second position of correction field:
(up to TII-XR firmware version A1130 and board descriptor V4)



″ or, Field02:
(with TII-XR firmware version A1131 and board descriptor V5)



″ or, Verification pins:
(from TII-XR firmware version A1140 and board descriptor V6)



Engauge
SmartView

For the *SmartView* the command is implemented from TII-XR firmware version A1142, and resides under the Command menu as follows:

☛ From the menu select:

- [Commands]
- board [TII-XR] and
- [Product level].

☛ Then scroll through the list of commands, and select the command [Enable v-pins].

To **disable** the verification pin compensation, proceed as follows:

Engauge
SmartView

- By *Engauge*:

☛ Set the appropriate field in the Compensation TAB to <False>.

- By *SmartView*:

☛ From the menu select:

- [Commands]
- board [TII-XR] and

- [Product level].

☛ Then scroll through the list of commands, and select the command [Disable v-pins].

Below an example of two *reflection diagrams* from product measuring mode and verification-pin measuring mode, and an example of the *compensation sheet*.

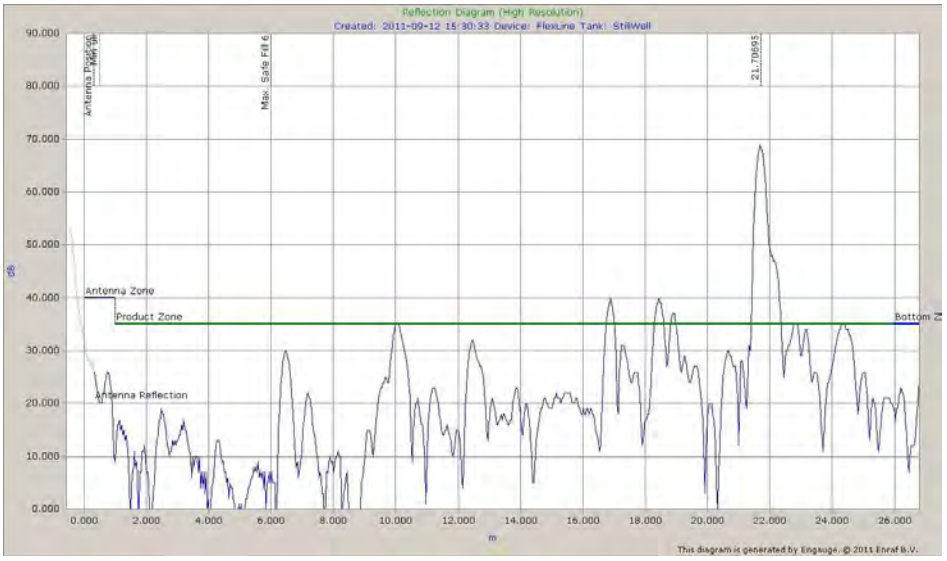


FIGURE 7-17 Product measuring mode, reflection diagram example

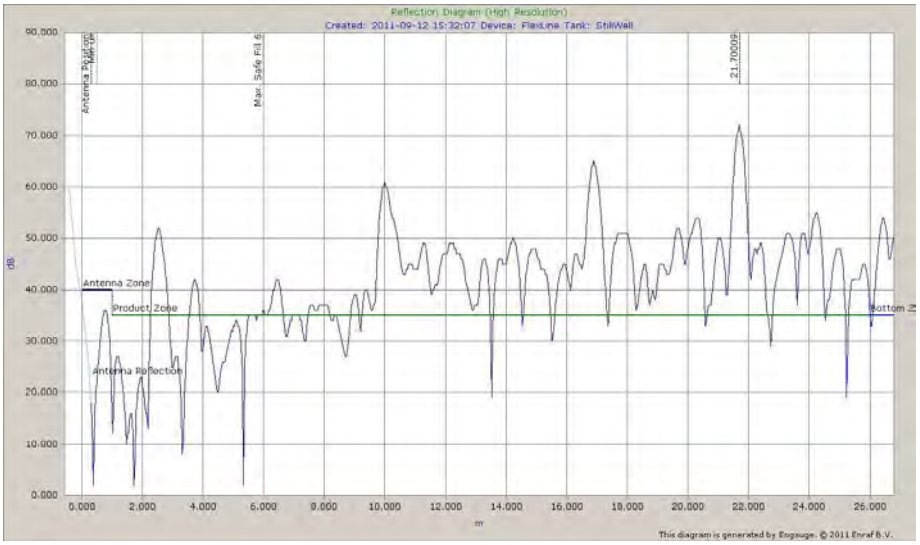


FIGURE 7-18 Verification pin measuring mode, reflection diagram example

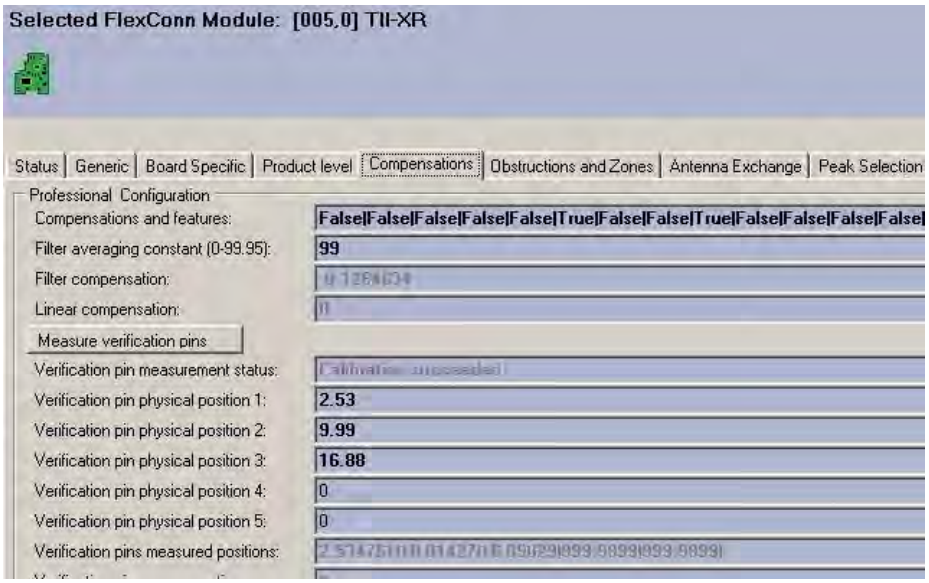


FIGURE 7-19 Verification pin compensation, example

7.6.2.7 Errors and Warnings

The status code of the [Primary value] or the [Secondary value] can display an error (status = <BAD>) or a warning (status = <UNCERTAIN>).

Most common error messages are:

Message	Cause
Radar max safe fill not set error	[Maximum safe fill] still set to 0 (zero)
Radar max safe fill out of range	[Maximum safe fill] value too high

7.6.2.8 Additional Information

Following information can be extracted from the TII-XR system:

Entity	Description
[DSP firmware version]	Besides a generic processor, the TII-XR has a Digital Signal Processor for algorithm calculations. See also FIGURE 7-7.
[Production date]	Production date of the complete SmartRadar FlexConn system.
[ART2A serial number]	The serial number of the high-frequency module. This module does all measurements.
[Device serial number]	Serial number of the complete SmartRadar FlexConn system.
[Antenna serial number]	Serial number of the measuring antenna.

7.6.2.9 Overfill Protection Application

For the configuration of the TII-XR within an Overfill protection application, see 7.7.11.

7.7 Relay Contacts (FII-DO)

7.7.1 Introduction

The Field Interface Instrument - Digital Output (FII-DO) board has 4 software-controlled, electromechanical relays; see FIGURE 7-20.

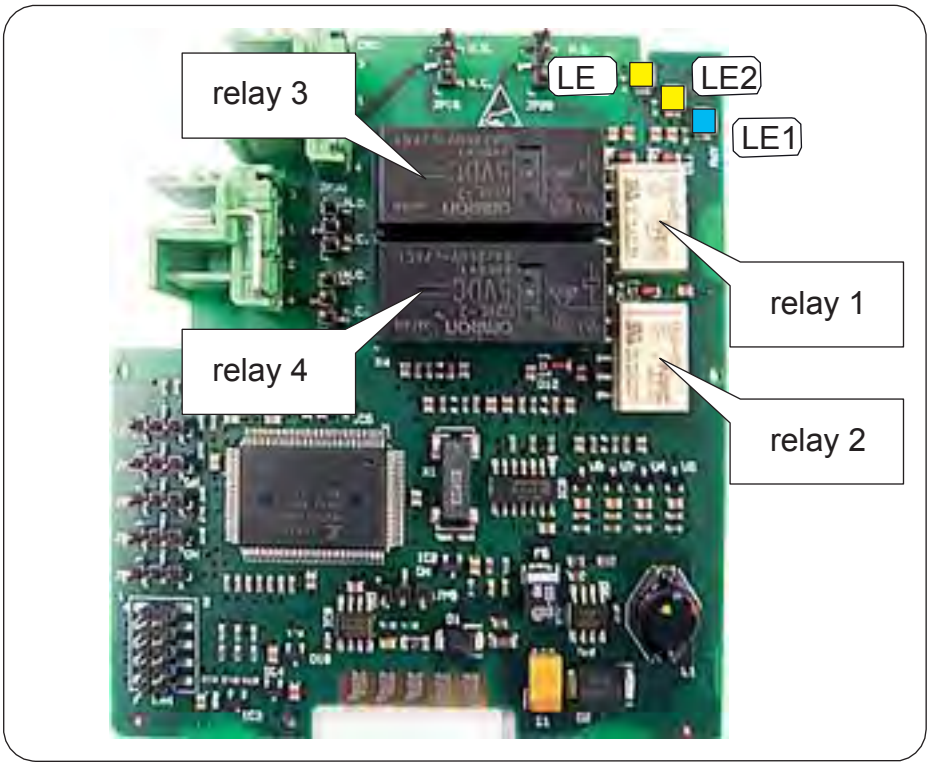


FIGURE 7-20 The relays and LEDs on the FII-DO board

These relays are allocated to FlexConn functions as shown below:

Function Number	Function
1	Relay 1
2	Relay 2
3	Relay 3
4	Relay 4

The relays have output status read-back lines.

With jumpers, the relays can individually be set to Normally Open (NO) or Normally Closed (NC).

In addition to the board's [Health] LED LE1, the LEDs LE2 and LE3 are available (see FIGURE 7-20). They can be associated to a relay, by setting the [LED Association] entity.

☛ For a *fail-safe level application*, continue with section 7.7.10.

7.7.2 Operation Mode

The FII-DO can operate in one of two modes: [Alarm Mode] and [Fallback Mode]. This is controlled by the [Operation Mode] entity.

Fallback Mode is *not* implemented yet.

☛ Set the [Operation Mode] entity to [Alarm Mode].

7.7.3 Relay Configuration

7.7.3.1 Jumper Settings

At installation, each individual relay contact was configured as required with the hardware jumpers JPx0, where x = Relay 1 to 4 respectively. See FIGURE 7-21.

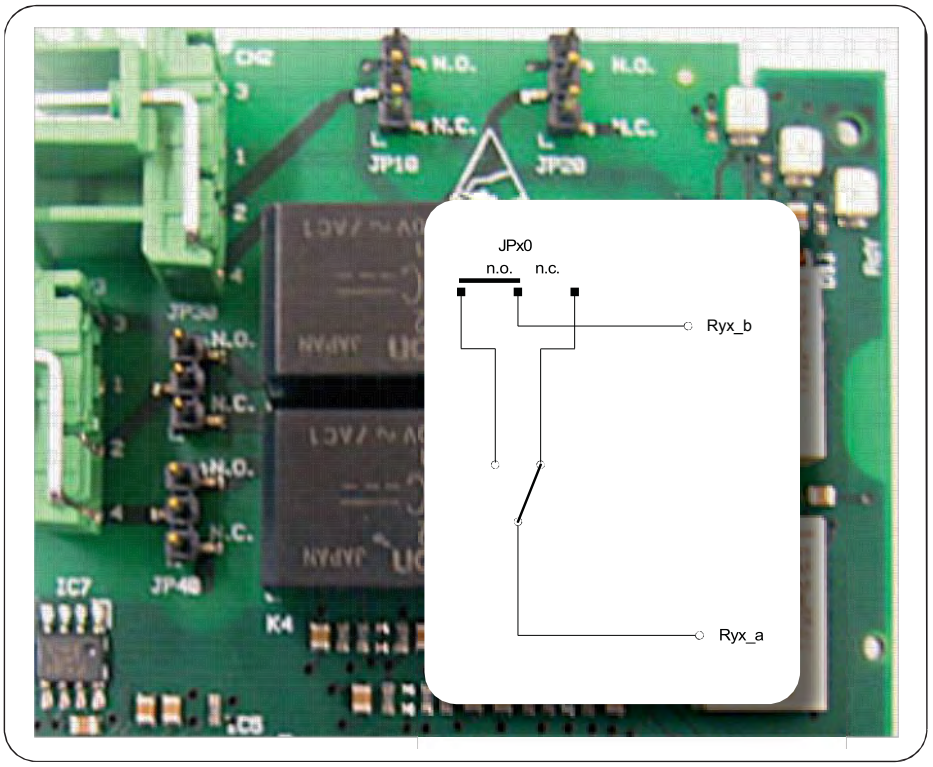


FIGURE 7-21 The relays' hardware jumpers

NOTE: In the Commissioning stage, no jumper setting can be changed without breaking the compartment screw sealing.

7.7.3.2 Relay Mode

Each individual relay can be set to be *energized* or *de-energized* during operation, by setting the [Relay Mode] entity to <Energized> or <De-energized> respectively.

If the [Relay Mode] entity is set to <Energized>, the relay coil will be energized when the relay state is <Deactivated>, and the relay coil will be de-energized when the relay state is <Activated>.

If the [Relay Mode] entity is set to <De-Energized>, the relay coil will be de-energized when the relay state is <Deactivated>, and the relay coil will be energized when the relay state is <Activated>.

The <Energized> option is used for *fail-safe* operation whereas the <De-Energized> option is used for *non-fail-safe* operation.

Engauge SmartView

☛ Set each individual relay to the required configuration, by selecting the proper entities. See also next overview (fail-safe configuration is colored).

Physically Configured	Relay Mode	Relay State	Physical Result
Normally Open (NO)	De-Energized	Activated	Closed
		Deactivated	Open
	Energized	Activated	Open
		Deactivated	Closed
Normally Closed (NC)	De-Energized	Activated	Open
		Deactivated	Closed
	Energized	Activated	Closed
		Deactivated	Open

7.7.4 Alarm Mode

Each individual relay can operate in one out of three modes, by setting the [Alarm Mode] entity to either [PV Monitor], [Remote Control], or [Not In Use].

7.7.4.1 PV Monitor

In [PV Monitor] mode, each individual FII-DO-relay unit can monitor the Primary Value (PV) or Secondary Value (SV) of another board connected to the CAN bus, and either activate or deactivate the associated relay if a certain condition is <True> or <False>.

☛ If [Remote Control] or [Not In Use] mode must be selected, skip to section 7.7.4.2 or 7.7.4.3 respectively.

Engauge SmartView

☛ From the [Alarm Mode] menu, select [PV Monitor].

☛ Select [Monitor Board ID], set proper value.

☛ Select [Monitor Board Instance], set proper value.

☛ Select [Monitor Function Instance], set proper value.

☛ Select [Monitor Source], select either <PV> or <SV>, as desired.

The [Monitor Board ID], [Monitor Board Instance], and [Monitor Function Instance] entities determine the *location* of the entity to be scanned.

The [Monitor Source] entity determines if either the Primary Value <PV> or Secondary Value <SV> entity shall be scanned.

The behavior of each individual relay in PV Monitor mode is further controlled by the [Monitor Mode] and the [Status Behavior] entities; see next.

7.7.4.1.1 Monitor Mode

The [Monitor Mode] entity can either be set to [Remote] or [Local].

- If the [Monitor Mode] is set to [Remote], the *alarm status* of the scanned PV or SV is monitored. The alarm status is compared against the value set in the [Remote Threshold Source] entity. The [Remote Threshold Source] entity can be set to <HH>, <HA>, <LA>, or <LL>.

Example: If the [Remote Threshold Source] is set to <HH> and a High High Alarm occurs, the relay will be activated. It will not be activated by any other alarms.

☛ If [Local] [Monitor Mode] is to be set, skip to next bullet (■).

☛ From the [Monitor Mode], select [Remote].

☛ Select [Remote Threshold Source], set desired value.

- If the [Monitor Mode] is set to [Local], the scanned PV or SV value is compared against the value set in the [Threshold] entity. The behavior is modified by the [Threshold Mode] and the [Hysteresis] entities. The [Threshold Mode] entity can be set to either <Treat as HA> or <Treat as LA>.

If the [Threshold Mode] entity is set to <Treat as HA>, the relay is activated if the scanned PV or SV is greater than or equal to the [Threshold] entity value, and the relay is deactivated if the scanned PV or SV is less than the [Threshold] entity value minus the [Hysteresis] entity value.

If the [Threshold Mode] entity is set to <Treat as LA>, the relay is activated if the scanned PV or SV is greater than or equal to the [Threshold] entity value, and the relay is deactivated if the scanned PV or SV is less than the [Threshold] entity value plus the [Hysteresis] entity value.

☛ From the [Monitor Mode], select [Local].

☛ Select [Threshold Mode], and choose either <Treat as HA> or <Treat as LA>.

☛ Select [Hysteresis], set desired value.

7.7.4.1.2 Status Behavior

The Status Behavior entity determines what happens to the relay if the health of the scanned PV or SV differs from Good. The [Status Behavior] should be set to one of the following options: <BAD>, <BAD-UNCERTAIN>, or <Not Used>.

- If the [Status Behavior] is set to <BAD>, and the scanned PV or SV health is Bad, the respective relay will be activated.

- If the [Status Behavior] is set to <BAD-UNCERTAIN>, and the scanned PV or SV health is Bad or Uncertain, the respective relay will be activated.
- If the [Status Behavior] is set to <Not Used>, the respective relay will *not* be activated if the scanned PV or SV health is Bad or Uncertain.

Engauge SmartView

☛ Set the [Status Behavior] entity either to <BAD>, <BAD-UNCERTAIN>, or <Not Used>.

NOTE: This behavior takes priority over the [Remote] *or* [Local] *monitoring. For example: If the* [Status Behavior] *is set to* <BAD>*, and the scanned PV or SV health is Bad, the respective relay will be activated regardless of the* [Monitor Mode] *entity settings. The* [Remote] *or* [Local] *option PV or SV checks will then not affect the relay status.*

7.7.4.2 Remote Control

In [Remote Control] mode, each individual relay can directly be activated or deactivated, by sending an !Activate! respectively a !Deactivate! command via the CAN bus.

The behavior of each individual relay is further controlled by the [Remote Control] mode entity, which can be set to either <Restricted> or <Not Restricted>.

- If the [Remote Control] mode entity is set to <Not Restricted>, any source can be used to control the relay with an !Activate! or a !Deactivate! command.
- If the [Remote Control] mode entity is set to <Restricted>, the relay can only be controlled by the source that matches the values set in the [Control Board ID], the [Control Board Instance], and the [Control Function Instance].

Engauge SmartView

☛ From the [Remote Control] mode menu, select either <Restricted> or <Not Restricted>.

☛ If Not Restricted was selected, skip to 7.7.4.3.

☛ Select [Control Board ID], set proper value.

☛ Select [Control Board Instance], set proper value.

☛ Select [Control Function Instance], set proper value.

7.7.4.3 Not in Use

If an individual relay is not required in a particular application, the [Alarm Mode] entity must be set to <Not In Use>.

Example: If a particular application requires only two relays to be used, say relay 1 and 2, then for relay 3 and 4 the [Alarm Mode] entities must be set to <Not In Use>.

☛ For the FII-DO relays not used within the application, set the [Alarm Mode] entities to <Not In Use>.

7.7.5 Commands

The following commands can be given to the FII-DO:

- Activate
- Deactivate
- Acknowledge

7.7.5.1 Activate

The !Activate! command will cause the specified relay to become <Activated>. This command is only available in [Remote Control] mode; see 7.7.4.2.

The !Activate! command behavior is modified by the [Time Setting] entity. If the [Time Setting] entity is set to zero, the relay will stay permanently activated until a !Deactivate! command is given.

If the [Time Setting] entity is set to a value other than zero, the relay will be activated for a time in seconds equal to the value set in the [Time Setting] entity, then deactivated. During the period the relay is activated, the relay state will be !Time Setting Active!. This is useful for site commissioning.

☛ For each relay, set the [Time Setting] entity to the desired value.

7.7.5.2 Deactivate

The !Deactivate! command will cause the specified relay to become <Deactivated>. This command is only available in [Remote Control] mode; see 7.7.4.2.

7.7.5.3 Acknowledge

The !Acknowledge! command will cause the specified relay to be physically deactivated, but the relay status will be set to !Acknowledged!. This command is only available in [PV Monitor] mode; see 7.7.4.1. This

command can only be given when the concerned relay has already been activated.

For example, this command is useful if the relay is connected to an alarm system. The alarm can be silenced by the command, but it is still possible to determine if an alarm has occurred. When the alarm condition is then removed, the relay state will become deactivated, and normal operation will resume.

7.7.6 LED Association

Depending on the value set in the [LED Association] entity, the 4 individual relays on the FII-DO board can be associated with one out of 2 LEDs, LE2 or LE3 (see FIGURE 7-20).

The associated LED will be ON when the relay state is <Activated>, and the LED will be OFF when the relay state is <Deactivated>.

*NOTE: The LEDs do **not** indicate the **physical** relay state (coil state or contacts state), as this depends on the software settings and the physical settings (jumper), see 7.7.3.*

☛ Set the value of the [LED Association] entity as desired (optional). For an example, see table below.

LED Association	LED Number	Relay Number
1 + 2	LE2	1
	LE3	2
3 + 4	LE2	3
	LE3	4

7.7.7 Terminal Allocation

Terminal Number	Name	Function
14	Ry1_a	Relay 1 Common
15	Ry1_b	Relay 1 NO or NC*
16	Ry2_a	Relay 2 Common
17	Ry2_b	Relay 2 NO or NC*
18	Ry3_a	Relay 3 Common
19	Ry3_b	Relay 3 NO or NC*
20	Ry4_a	Relay 4 Common
21	Ry4_b	Relay 4 NO or NC*

*) See jumper settings, section 7.7.3.1.

7.7.8 Commissioned Entities

☛ By using the table below, make sure all entities are commissioned.

The [Commissioned] entity will display either <True> if the function is commissioned or <False> if the function is not commissioned. To commission the function, the entities must be set in accordance with the table below.

Operation Mode	Alarm Mode	Remote Control Mode	Parameters	Commissioned
Alarm Mode	Remote Control	Restricted	[Control Board ID] >=1 and <=255 [Control Board Instance] >=0 and <=7 [Control Function Instance] >=1 and <=15 [Time Setting] = 0	<True>
			[Control Board ID] <1 or >255 [Control Board Instance] <0 and >7 [Control Function Instance] <1 and >15 [Time Setting] ≠ 0	<False>
		Not Restricted	[Time Setting] = 0	<True>
			[Time Setting] ≠ 0	<False>
	PV Monitor	Remote	[Monitor Board ID] >=1 and <=255 [Monitor Board Instance] >=0 and <=7 [Monitor Function Instance] >=1 and <=15 [Time Setting] = 0	<True>
			[Monitor Board ID] <1 or >255 [Monitor Board Instance] <0 and >7 [Monitor Function Instance] <1 and >15 [Time Setting] ≠ 0	<False>
		Local	[Monitor Board ID] >=1 and <=255 [Monitor Board Instance] >=0 and <=7 [Monitor Function Instance] >=1 and <=15 [Time Setting] = 0 [Threshold] = value entered [Hysteresis] = value entered	<True>
			[Monitor Board ID] <1 or >255 [Monitor Board Instance] <0 and >7 [Monitor Function Instance] <1 and >15 [Time Setting] ≠ 0 [Threshold] = value entered [Hysteresis] = value entered	<False>
	Not In Use	N/A	N/A	<True>
Fallback Mode	N/A	N/A	N/A	<False>

7.7.9 Board Commissioned Entity

The [Board Commissioned] entity will display either <True> if all functions are commissioned or <False> if any of the functions are not commissioned.

Engauge
SmartView

☛ If the [Board Commissioned] entity displays <False>, check each function parameter again. Use the table from 7.7.8.

7.7.10 Fail-safe Level Application

Following steps include all commissioning-aspects settings for the Fail-safe level application.

☛ The corresponding jumper of the concerned relay must be in the Normally Open (NO) state (= *default* setting).

NOTE: In the Commissioning stage, no jumper setting can be changed without breaking the compartment screw sealing. See also section 7.7.3.1.

Engauge
SmartView

☛ Set [Operation Mode] to [Alarm Mode].

☛ Set [Relay Mode] to <Energized>.

☛ Set [Alarm Mode] to [PV Monitor].

☛ Set [Monitor Board ID] to <board id> of product-level board.

☛ Set [Monitor Board Instance]to <board instance>of related product-level board.

☛ Set [Monitor Function Instance] to <function instance> of related product-level board.

☛ Set [Monitor Source] to <PV>.

☛ Set [Monitor Mode] to [Remote].

☛ Set [Remote Threshold Source] to <HH>, <HA>, <LA>, or <LL>.

☛ Set corresponding alarm setting of the related product-level board.

☛ Set [Status Behavior] to <BAD-UNCERTAIN>

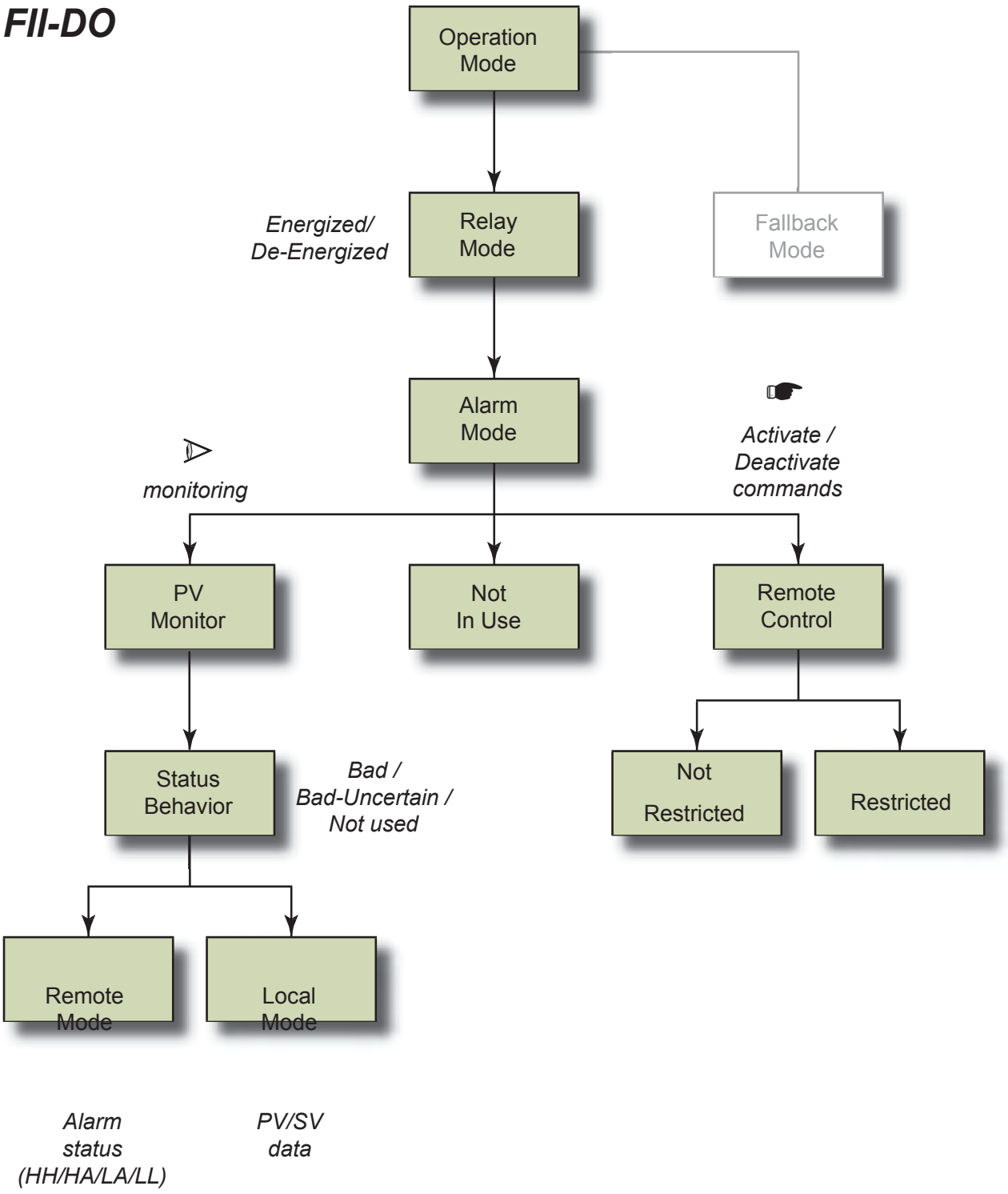


FIGURE 7-22 FII-DO operation mode survey

7.7.11 Overfill Protection Application

7.7.11.1 Introduction

Because of some tank storage overfill accidents in the past, there is an increased need for a qualified overfill-protected level measuring system.

The SmartRadar FlexLine can be configured such that an adequate overfill protection level is achieved. As such it is qualified as a Safety Instrumented Function (SIF) for overfill protection of storage tanks in the oil and gas industry, to a SIL[1] 2 level.

The safety parameters are within the range of SIL 2 if the following conditions are met:

- **The SmartRadar FlexLine uses the Overfill Protection Application with the dual redundant configuration of the FII-DO as described in this manual, and**
- **All relevant entities are commissioned as described in this manual.**

7.7.11.2 Essential FlexConn Boards

The essential FlexConn boards for an overfill protection application are:

- FII-DO (1)
- FII-DO (2)
- TII-XR
- Power Supply (PSx)

7.7.11.3 Application Principle

- In order to achieve the correct SIL, **2 SmartRadar FII-DO modules are combined into a special safety configuration**.
- For this special configuration, **only relay 3 and relay 4 are used**. For their locations, see FIGURE 7-23.

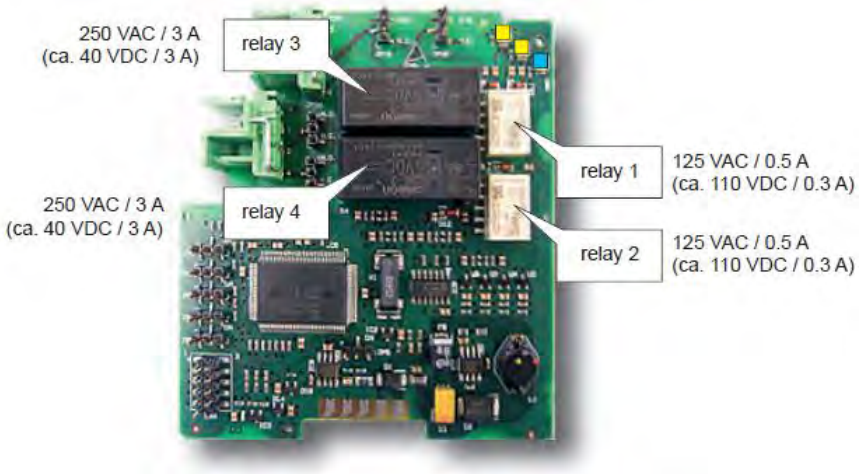


FIGURE 7-23 Locations and ratings of the Electro Mechanical Relays on the FII-DO board

1. SIL = Safety Integrity Level.

- The relays must be set to **Normally Open** (jumper, see 7.7.3.1) and **Normally Energized** (configuration parameter, see 7.7.3.2).
- In a normal situation, the relay contacts are closed.
- Relays 4 are used to increase the availability: if a problem is detected with the other relays, the redundancy takes care that the overfill protection function will work (see also FIGURE 7-24).
- The relays typically can stop a pump or close a valve that is used filling a storage tank. See FIGURE 7-24.
- Overfill safety analysis, including diagnostic tests is done every second.
- The 2 FII-DO boards are continuously checking each other for a correct functioning. This is done every second. In case of malfunction, 2 retries are executed before the status is definitely determined.
- The radar scans the overfill protection status every second and will react accordingly.

7.7.11.4 Overfill Protection Board Actions

The following table shows the important parameters for overfill protection.

Output = Function PV	
1	= relay contact closed
0	= relay contact opened (safe situation)
Diagnostics = Function health + Board health	
1	= status = GOOD, healthy
0	= status = BAD, UNCERTAIN, not healthy (force safe situation)
Level = product level analysis	
1	= product level < threshold
0	= product level >= threshold (force safe situation)
0	= product level status = BAD, UNCERTAIN, not healthy
0	= no communication with the TII-XR
Voltage = all FlexConn monitored voltages	
1	= voltage within specifications (OK)
0	= voltage too high (one or more) (force safe situation)
Counter part communication = communication with other relay board	
1	= valid communication
0	= no communication (force safe situation)

- **Both board contacts are always opened** if **one** out of the following events occurs:
  - **Level = 0** (product level >= threshold, product level TV = BAD/ UNCERTAIN, TII-XR board does not respond)
  - **Voltage = 0** (one of more board voltages out of range)
  - **Board diagnostic = 0** (board status = BAD / UNCERTAIN)
  - **Board diagnostic of counter part (redundant board) = 0** (board status = BAD / UNCERTAIN)
  - **Counter part (redundant board) communication = 0** (other relay board does not respond)

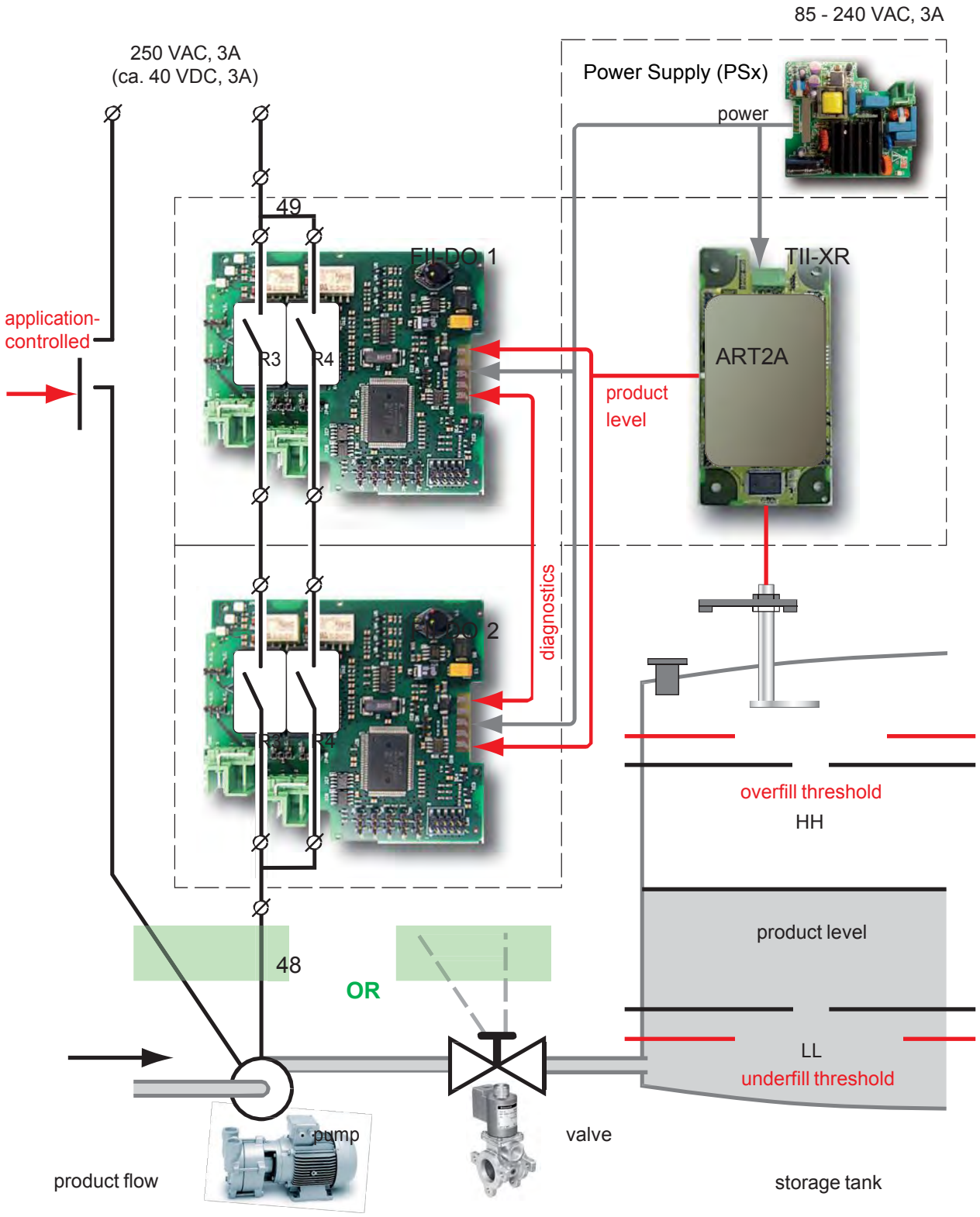

85 - 240 VAC, 3A
250 VAC, 3A
(ca. 40 VDC, 3A)
Power Supply (PSx)
power
49
FII-DO 1
TII-XR
application-
controlled
R3
R4
ART2A
product
level
diagnostics
2
overfill threshold
HH
product level
48
OR
LL
underfill threshold
pump
valve
product flow
storage tank

FIGURE 7-24 Overfill protection application using 2 FII-DO boards

- **An individual board relay contact is closed** if **all** following conditions are met:
  - **Level = 1** (product level < threshold, product level TV = GOOD, valid communication with TII-XR)
  - **Voltage = 1** (board voltages within ranges)
  - **Board diagnostic = 1** (board status = GOOD)
  - **Board diagnostic counter part = 1** (board status = GOOD)
  - **Counter part = 1** (other relay board responds)
  - **Relay (Rn) diagnostic = 1** (function status = GOOD)
  - **Relay (Rn) diagnostic counter part = 1** (function status = GOOD)

*NOTE: Both boards needs to be configured **identically** for relay behavior, threshold, and hysteresis.*

The following matrix gives an overview of the relations between the status and resulting events:

SD = Shut Down | **O = Overfill alarm** | **N = No**

NO = Normal Operation | **W = Gauge alarm (warning)** | **Y = Yes**

H = Healthy

	1	2	3	4	5				6	7	8	9	10	11	12	13	14
Own board status																	
Level (incl. TII-XR comms + TV Health + status check)	0	X	X	X	X				1	1	1	1	1	1	1	1	1
Voltage	X	0	X	X	X				1	1	1	1	1	1	1	1	1
Diag board	X	X	0	X	X				1	1	1	1	1	1	1	1	1
Diag R3	X	X	X	X	X				0	0	0	1	1	1	1	1	1
Diag R4	X	X	X	X	X				1	1	1	0	0	0	1	1	1
Counter part (redundant board) communication	X	X	X	0	X				1	1	1	1	1	1	1	1	1
Other board status																	
Diag board (incl. Voltage)	X	X	X	X	0				1	1	1	1	1	1	1	1	1
Diag R3	X	X	X	X	X				0	1	1	0	1	1	0	1	1
Diag R4	X	X	X	X	X				1	0	1	1	0	1	1	0	1
Board action																	
Output R3	0	0	0	0	0				0	0	0	0	1	1	0	1	1
Output R4	0	0	0	0	0				1	0	1	0	0	0	1	0	1
Application status	SD	SD	SD	SD	SD				NO	SD	NO	SD	NO	NO	NO	NO	NO
Overfill Protection Status	O	W	W	W	W				W	W	W	W	W	W	W	W	H
Start safety timer	N	N	N	N	N				Y	N	Y	N	Y	Y	Y	Y	N

7.7.11.5 Merging the Status to GPU-level status

The TII-XR firmware implements an alarm for the operator by merging the output status of each board with the GPU level status, in order to communicate shut down information to the control room. See following matrix.

NOTE: For field installations upgraded with the Overfill Protection functionality, the TII-XR firmware must be upgraded.

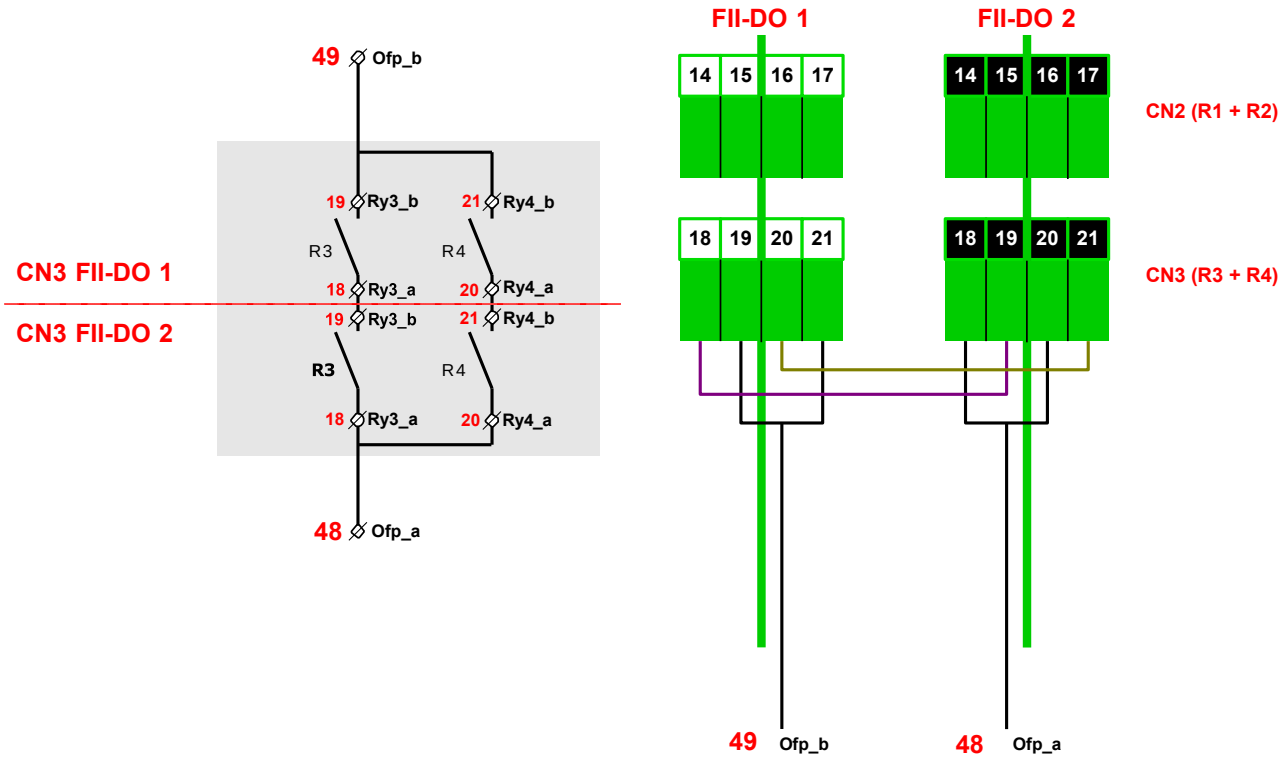
F = Fail
? = Warning, reduced accuracy
- = valid

FII-DO 1	FII-DO 2	TII-XR
Overfill Protection status	Overfill Protection status	level status GPU protocol
O	O	F
O	H	F
O	W	F
W	O	F
W	H	?
W	W	?
H	O	F
H	H	-
H	W	?
no comms	X	F
X	no comms	F

7.7.11.6 Overfill Protection Application Wiring

☛ Connect the external wiring (see illustrations below):

- Connect terminal 48 to the pump or to the valve.
- Connect terminal 49 to the mains.



7.7.11.7 Commissioning the Overfill Protection Application

To configure the Overfill Protection Application all essential boards needs to be configured.

7.7.11.7.1 FII-DO (redundant)

☛ Make sure all jumpers are set to **Normally Open** (N.O.). See 7.7.3.1.

Engauge
SmartView

☛ Set the [Board Instance] entity of each FII-DO board to a different value (e.g. 0 and 1).
The boards are redundant and share the same board ID, so to be able to address the board uniquely by the internal (CAN-Bus) or external FlexConn protocol, the board instance must be different to distinguish the boards from each other.

☛ Set the [Counterpart Board Instance] entity of each FII-DO board to the [Board instance] of the *counterpart* FII-DO board (redundant board).

☛ Set the [Relay Mode] entity of R3 and R4 relay to <Normally Energized> for both FII-DO boards.

☛ Set the [Alarm Mode] entity of R3 and R4 relay to <PV Monitoring> for both FII-DO boards.

☛ Set the [Monitor Mode] entity of R3 and R4 relay to <Local> for both FII-DO boards.

☛ Set the [Threshold] entity and [Hysteresis] entity of R3 and R4 relay to the application-specific desired values, for both FII-DO boards **identically**.

☛ For *overfill* protection, configure the [Threshold] entity above the HA and HH setting of the TII-XR board. Entities [High alarm] and [High high alarm].

☛ For *underfill* protection, configure the [Threshold] entity below the LA and LL setting of the TII-XR board. Entities [Low alarm] and [Low low alarm].

☛ For *overfill* protection, configure the [Threshold Mode] entity of R3 and R4 relay to <Treat as HA> for both FII-DO boards.
The threshold will now be approached as high alarm above [High alarm] and [High high alarm], with the relevant hystresis behavior.

☛ For *underfil*l protection, configure the [Threshold Mode] entity of R3 and R4 relay to <Treat as LA> for both FII-DO boards.
The threshold will now be approached as low alarm below [Low alarm] and [Low low alarm], with the relevant hysteresis behavior.

☛ Set the other relevant entities:

The [Overfill Protection Status] entity shows the Overfill Protection Status of each FII-DO board.

<H> = Healthy

<W> = Gauge alarm (Warning)

<O> = Overfill alarm

With the [Safety shut down timer] entity, the user can set the time that a safe shutdown will be forced when only an error or failure in one relay chain is detected. Default value: <0>: Safety Shutdown Timer DISABLED.

NOTE: This is an enhanced safety function.

When one potential fail situation is detected in one chain, the other chain will be forced to fail safe (contacts opened) after the safety shut down time.

Philosophy: the first detected fail will not result in a shut down directly *but should be solved within a certain time*.

7.7.11.7.1.1 If the Safety shut down timer is *enabled*, so value ≠ <0>, then operation can continue with one branch till second fault is detected.

In other words, this means: In case an anomaly is detected by the internal gauge diagnostics, the gauge needs service within the time set by this timer.
Typical value: <72> hours.

7.7.11.7.1.2 If the Safety shut down time is *disabled*, so value = <0>, then the customer wants to continue permanently with the other branch.

NOTE: When the "Safety shut down timer" is active or running, the remaining time until shutdown can be inspected by reading the [Safety shut down timer left] entity.

7.7.11.7.2 TII-XR

Engauge
SmartView

☛ Set the [Overfill Protection Function] entity to <Enabled>.

☛ Set the [First Relay Board Instance] entity of the [Board Instance] entity to the first FII-DO board.

☛ Set the [Second Relay Board Instance] entity of the [Board Instance] entity to the second FII-DO board.

The "Maximum Safe Fill" mechanism of the TII-XR should be ignored for the SmartRadar FlexLine overfill protection application.

When the "Maximum Safe Fill" level is configured lower than the Over fill Threshold, the PV status becomes BAD much earlier, and the FII-DO will open the contacts.

☛ Set the [Maximum safe fill level] entity above the [Threshold] values of the FII-DO boards when used for overfill protection.

OR

☛ Set the 9th switch [Compensations and features] entity to <FALSE>.

7.7.11.7.3 Power Supply (PSx)

CAUTION

CAUTION! The Overfill Protection Application may ONLY be powered by AC mains. Only 85VAC - 240 VAC can be used for mains connected to the SmartRadar FlexLine having the Overfill Protection Application option.

7.7.11.8 Proof Testing

- By activating the command [Start Proof test] entity, the FII-DO simulates an overfill or underfill. The remainder of the SIF should work as expected (e.g. close a valve, stop a pump, generate an alarm) this should be validated.

NOTE: This test must only be performed in a healthy situation when the product level in the tank is below the overfill threshold or above the underfill threshold.

During the proof test - when the level is simulated above or below the threshold - the "Overfill protection status" will indicate "O" in order to enable checking the "Proof test" results in the control room as well.

Each FII-DO of the overfill protection application implements the proof test functionality, so the proof test has to be performed *successively for both modules*.

- By activating the command [Stop Proof test] entity, the FII-DO returns to normal overfill analysis mode again.

NOTE: The FII-DO module of the SmartRadar FlexLine overfill protection safety application implements an automatic termination of the "Proof test" function in case the user forgets the command [Stop Proof test].

☛ Set the [Proof test termination time out] entity to the most desired value in *minutes*:

- <0> (auto termination off)
- <5> (default)
- <10>
- <20>
- <30>

7.8 SmartView Display Interface (FII-SMV)

7.8.1 Introduction

The Field Interface Instrument - SmartView (FII-SMV) board is a module that communicates with *SmartView*.

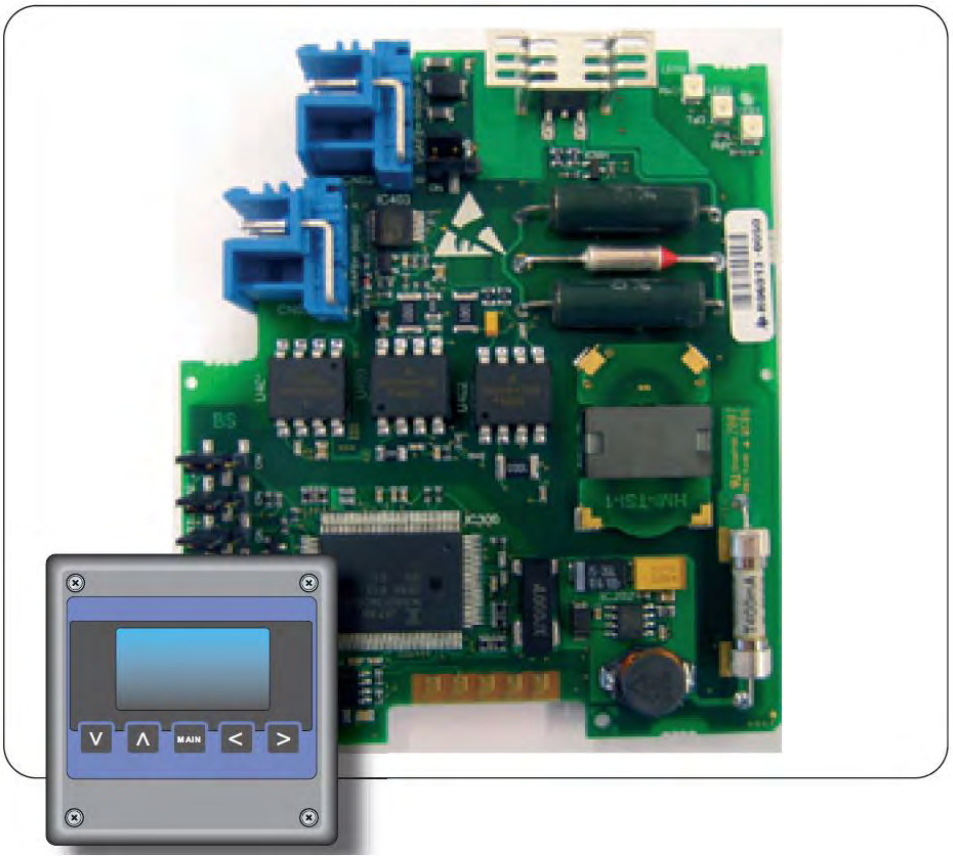


FIGURE 7-25 The FII-SMV board with the *SmartView* display

At request from *SmartView* the FII-SMV board prepares data sets for it. The requests from *SmartView* depend on the actual screen at the time. The communication between the FII-SMV and *SmartView* uses an own protocol on an RS-485 physical layer.

The *SmartView* display can be delivered in 3 versions, each version having its own specific address:

- Portable *SmartView* (address 1)
- *SmartView* fixed on the instrument (address 2)
- *SmartView* as a tank-side indicator (address 3)

The FII-SMV board continuously scans all addresses, and only the one with the lowest address will be served.

So, for example, if a stand-alone SmartView (address 3) and an integrated SmartView (address 2) are connected, the stand-alone SmartView (address 3) will be served as soon as the integrated SmartView (address 2) is closed (set to idle).

7.8.2 Commissioning the FII-SMV

For a correct functioning of the FII-SMV module in an instrument the following entities can be set by using either *Engauge* or *SmartView*.

☛ By using the following table, check each entity for correctness.

Name	Value Range	Default Value	Explanation
[Decimal separator]	<point> <comma>	<point>	The decimal separator in which entities are shown on the *SmartView* display.
[Tenth millimeter selection]	<enable> <disable>	<enable>	Determines whether the tenth millimeter is shown on the display in the [PV screen] in case a level entity is shown.
[Identification]	8 characters e.g. <TANK1234>	<-------->	Name of a tank or instrument. This string is visible within a [PV screen].
[Password]	<.....> 6 characters	<ENRAF2>	The password *SmartView* uses for entering the protected level. Note: Some settings reside under the protected level.
[Function identification] 	<.....> 13 characters	<SmartView mst>	The name of the current function of this module. This name is visible on the *SmartView* display.
[Extra information switch]	<level temperature> <Info Switch>	<Info Switch>	Determines whether the [extra information] screen on the *SmartView* will display level and temperature or extra information from a specific function.
[Extra info board ID]	<01.....XX> 2 digits	<01>	Board ID of the board that has the [extra information] to display. In case of OneWireless, the ID = 12.
[Extra info board instance]	<00.....XX> 2 digits	<00>	Board instance of the board that has the [extra information] to display.
[Extra info function instance]	<01.....XX> 2 digits	<01>	Function instance that has extra information to display. In case of OneWireless, this = 01.

7.8.3 Reading the SmartRadar FlexLine field device information from the SmartView

To read the SmartRadar FlexLine field device information from the SmartView

1. On SmartView, press the UP ARROW and DOWN ARROW simultaneously (MENU push buttons) to view the menu items on the display.
2. On the display, scroll to the **commands** item using the **MENU** buttons.
3. Press the LEFT ARROW and RIGHT ARROW (**SELECT** push buttons) simultaneously. You are prompted to enter the password. The default password for SmartView is AAAAAA.
4. Use the **MENU** push buttons to enter the password and then press the SELECT push buttons. The list of **commands** appears.
5. Scroll to select the CAN-1WL FlexConn board name and then press the SELECT push buttons.
6. Scroll to select **board** and then press the **SELECT** push buttons.
7. Scroll to select **Read Dev Param** then press the **SELECT** push buttons.
8. On the display, scroll to the **commissioning** item using the **MENU** buttons.
9. Scroll to select the CAN-1WL FlexConn board name and then press the **SELECT** push buttons.

   The details available on the SmartView are as follows:

   - Board Serial No
   - Network Address
   - Device revision
   - CAN-1WL Build
   - Tx Power Level
   - Radio Mode
   - SD Card Status
   - Key Tx Status
   - Radio Diag1
   - Radio Diag2
   - Device Diag1
   - Device Diag2

7.9 Pressure & Density Measurement and Other HART Inputs (FCI-HT)

7.9.1 Introduction

The Field Communication Instrument - HART (FCI-HT) board is a HART®[1] master module that enables hybrid-signal (both analog + digital) communication between the FlexConn instrument and a HART sensor.

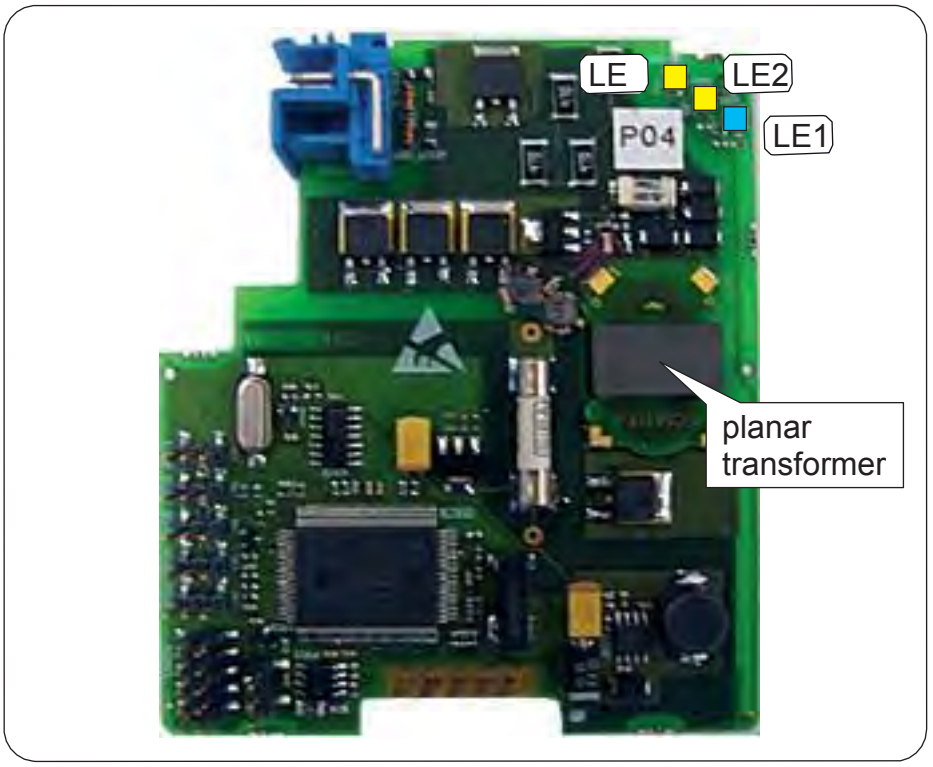


FIGURE 7-26 The FCI-HT board

The HART protocol is a bi-directional master-slave communication protocol, which is used to communicate between intelligent field instruments and host systems.

The FCI-HT board has a planar transformer for galvanic isolation from the HART bus. See FIGURE 7-26.

LED LE1 is the board's [Health] LED. LEDs LE2 and LE3 will be flashing to indicate activity on the HART bus. LE2 indicates data is being transmitted (Tx), LE3 indicates data is being received (Rx).

With the HART protocol, an analog 4-20 mA signal can be combined with a digital Frequency Shift Keying (FSK) signal. See FIGURE 7-27.

1. Highway Addressable Remote Transducer.

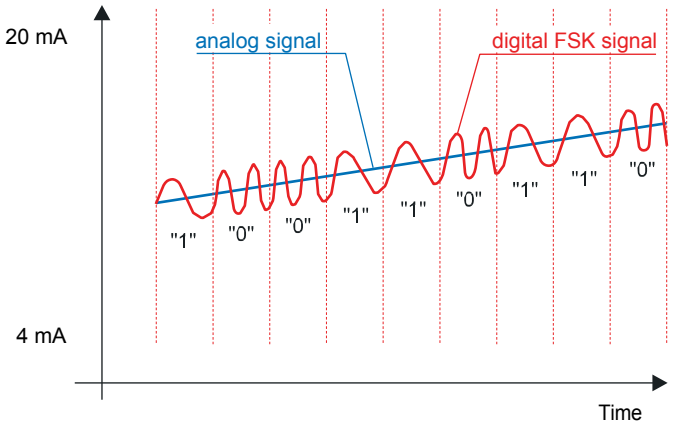


FIGURE 7-27 The analog and digital signals within the HART® communication

7.9.2 Software Description

The FCI-HT board, being a functional module of the SmartRadar FlexLine, contains embedded software which enables it to collect data input from sensors via both the HART bus and the FlexConn CAN bus.

Moreover, the FCI-HT module can calculate the HIMS[1] product density.

The *main* function of the FCI-HT software is to measure HIMS product density, by connecting the FCI-HT board via the HART bus to 1 or 2 pressure sensors, and via the FlexConn bus to a product level and a water level sensor.

To measure product density, the needed standard system configuration is:

- HART pressure sensor P1 (product pressure)
- HART pressure sensor P3 (Vapor pressure)
- Product level scanned from a FlexConn board (e.g. TII-XR)
- Water level scanned from a FlexConn board (e.g. FII-VT)

For tanks that are free venting to the atmosphere or floating-roof tanks, P3 pressure is not required. The water level sensor is also optional.

1. Hybrid Inventory Measurement System.

For HIMS density measurement system diagrams, see FIGURE 7-28 and FIGURE 7-29.

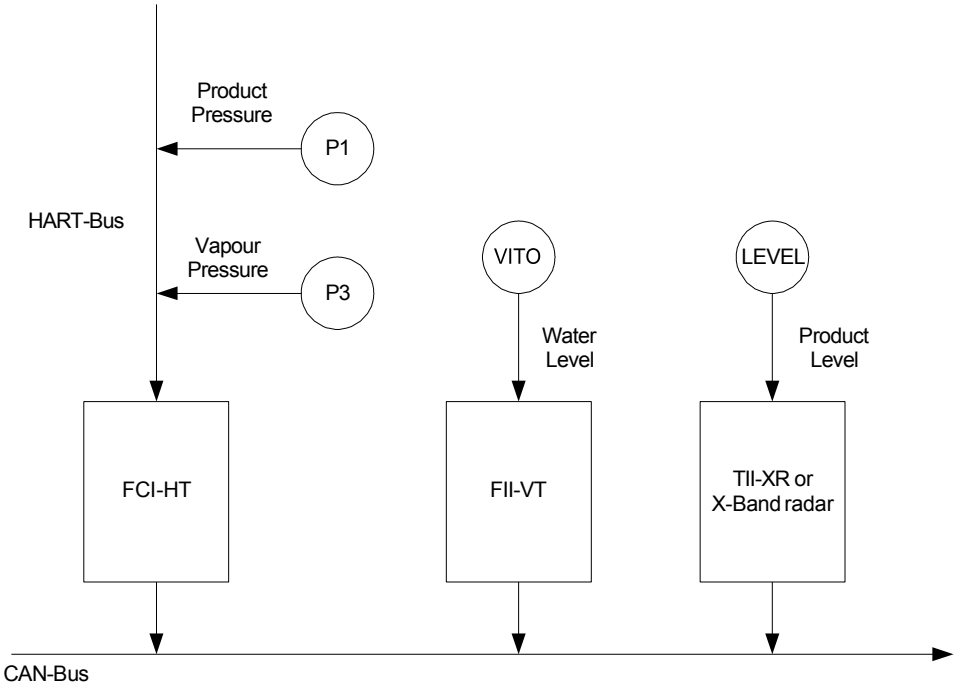


FIGURE 7-28 Standard HIMS density measurement system diagram

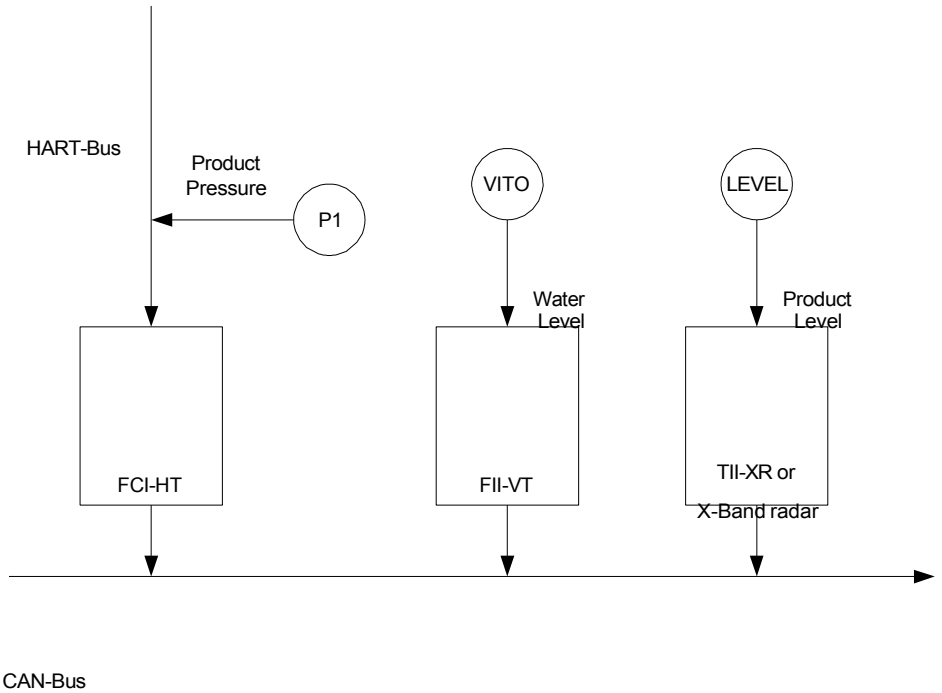


FIGURE 7-29 Floating-roof or free-venting tank HIMS density measurement system diagram

As an *alternative* function, the FCI-HT board also allows the connection of up to 5 generic HART sensors operating in *multi-drop digital* mode or one generic HART sensor operating in *analog* mode.

In the multi-drop digital mode situation, one or two of the generic HART sensors can be [P1 Pressure] or [P3 Pressure], providing product pressure and Vapor pressure respectively, but no HIMS density calculation will be available.

The HART sensors and HIMS density measurement are allocated to a function number in the FCI-HT software. See table below.

FlexConn Function	Device Type
Function 1	[P1 Pressure]
Function 2	[P3 Pressure]
Function 3	[Distance]
Function 4	[Temperature]
Function 5	[Pressure]
Function 6	[Density]
Function 7	[Other]
Function 8	[HIMS Density]

TABLE 7-1 FlexConn function allocation

Function 1 is exclusively reserved for P1 pressure, Function 2 is exclusively reserved for P3 pressure, and Function 8 is exclusively reserved for HIMS density calculation.

Only one of each type of HART device can be allocated to a function. Therefore, this limits the number of HART devices of each type that can be fitted.

Example 1

4 HART pressure devices and 1 temperature device can be connected.

- P1 pressure device allocated to Function 1
- P3 pressure device allocated to Function 2
- one pressure device allocated to Function 5
- one pressure device allocated to Function 7
- the temperature device allocated to Function 4

Example 2

2 HART density devices and 1 distance device can be connected.

- density device 1 allocated to Function 6
- density device 2 allocated to Function 7
- the distance device allocated to Function 3

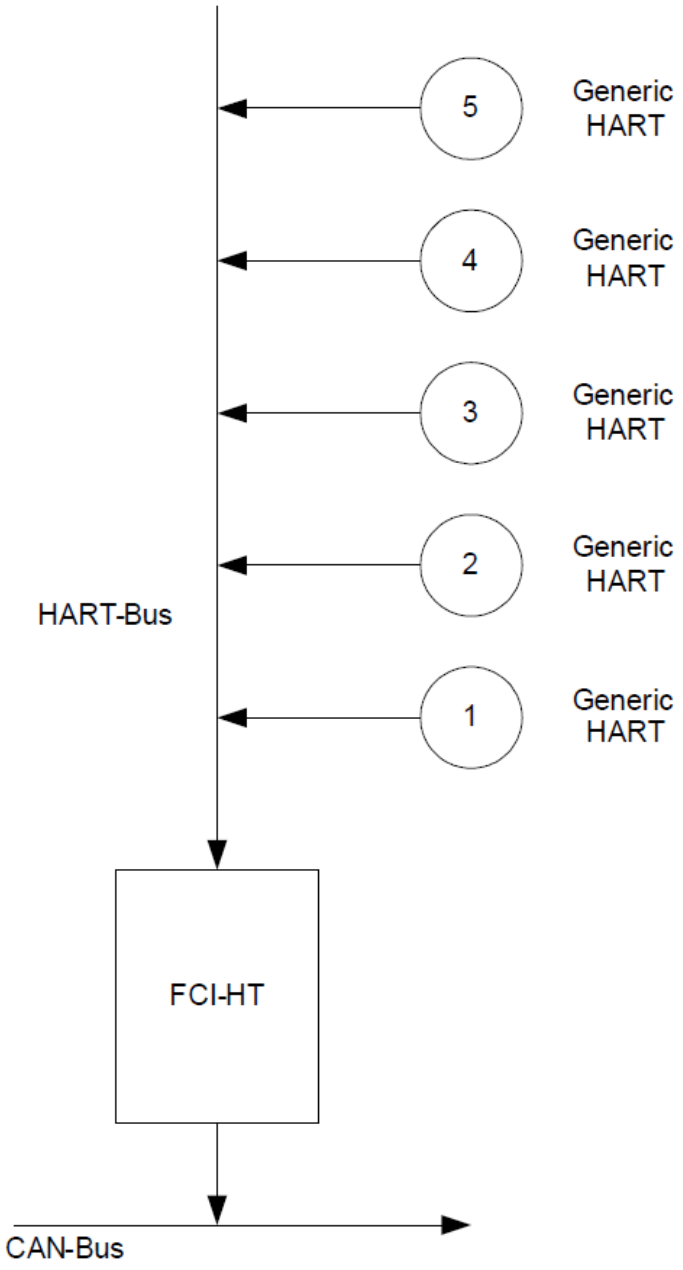


FIGURE 7-30 Alternate system diagram multi-drop digital mode

In analog mode, the connected HART device will be allocated to Function 1 through 7, depending on the type of HART device connected.

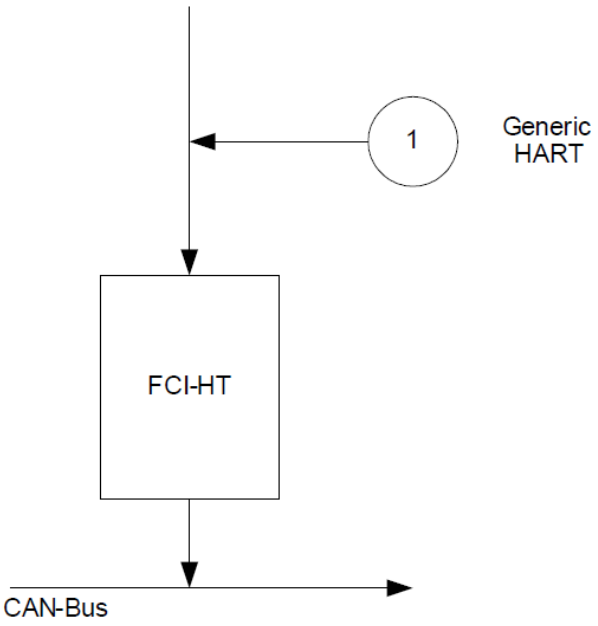


FIGURE 7-31 Analog mode system diagram

7.9.3 Software Specifications

7.9.3.1 General

The *main* function of the FCI-HT software is to measure HIMS product density, by connecting the FCI-HT board via the HART bus to 2 pressure sensors (P1 and P3), and via the FlexConn bus to a product level sensor and an optional water level sensor.

The *alternative* function is to connect up to 5 generic HART devices operating in multi-drop digital mode, or 1 generic HART device operating in analog mode.

The FCI-HT software only supports HART devices with the following addresses.

HART Address	Function
00	Reserved for HART device in analog mode
01	Reserved for P1 pressure sensor
02	N/A Reserved for future use
03	Reserved for P3 pressure sensor
04	HART generic sensor

HART Address	Function
05	HART generic sensor
06	HART generic sensor
07	HART generic sensor
08	HART generic sensor
09	HART generic sensor
10	HART generic sensor
11	HART generic sensor
12	HART generic sensor
13	HART generic sensor
14	HART generic sensor
15	HART generic sensor

TABLE 7-2 Accepted HART addresses

☛ Before proceeding with commissioning, first check the maximum start-up current of all connected HART devices.

☛ Make sure the HART address of the installed device(s) are in accordance with TABLE 7-2.

7.9.3.2 P1 Pressure

The FCI-HT software only accepts the Primary Value of a P1 pressure HART device in SI units kilo Pascals (kPa).

☛ Make sure the P1 pressure HART device is configured to output data in kilo Pascals (kPa). If not, correctly configure as yet, by using an appropriate HART configuration tool.

Sensor Type	Accepted HART PV Unit	Abbreviation	HART PV Unit Code
P1 Pressure	Kilo Pascal	kPa	12

TABLE 7-3 Accepted PV unit for a P1 HART device

NOTE: The Secondary and Tertiary values of a P1 pressure HART device may be any units.

The PV of the P1 pressure HART device is read and converted into SI Units Pascals (Pa) within the FlexConn function PV.

The value is filtered, and the filtering factor depends on the value set in the entity [P1 Integration time]. A higher value gives more filtering, and a lower value gives less filtering.

The correction factor stored in the [P1 PV offset] entity is then subtracted from the filtered value. If the [P1 PV offset] entity = 0 no offset is applied.

P1 is a default relative pressure.

If an absolute pressure is needed, set the entity “Standard ambient air pressure” to 0.

Pressure PV	Pressure Type	Standard Ambient Air Pressure
Pressure	Absolute	0
	Relative	Any value

TABLE 7-4 Pressure Types

If Relative pressure is selected, the value stored in the [Ambient Air Pressure] entity is added to the measured pressure. If Absolute pressure is selected, no factor is added. The final result is available in the [Primary Value] entity.

NOTE: Absolute pressure is used in the density calculation; the relative pressure is only displayed in P1 [Primary Value].

For the FCI-HT software to differentiate between a HART device malfunction and a HART device not actually installed, P1 pressure has the entity [P1 Installed] which must be set to either <Installed> if a P1 pressure HART device is actually fitted or <Not Installed> if a P1 pressure HART device is *not* actually fitted.

The Secondary and Tertiary values of a P1 pressure HART device are not converted, and they are simply translated from the HART device to the FlexConn environment.

7.9.3.3 P3 Pressure

The FCI-HT software only accepts the Primary Value of a P3 pressure HART device in SI units kilo Pascals (kPa).

☛ Make sure the P3 pressure HART device is configured to output data in kilo Pascals (kPa). If not, correctly configure as yet, by using an appropriate HART configuration tool.

Sensor Type	Accepted HART PV Unit	Abbreviation	HART PV Unit Code
P3 Pressure	Kilo Pascal	kPa	12

TABLE 7-5 Accepted PV unit for a P3 HART device

NOTE: The Secondary and Tertiary values of a P3 pressure HART device may be any units.

The PV of the P3 pressure HART device is read and converted into SI Units Pascals (Pa) within the FlexConn function PV.

The value is filtered, and the filtering factor depends on the value set in the entity [P3 Integration time]. A higher value gives more filtering, and a lower value gives less filtering.

The correction factor stored in the [P3 PV offset] entity is then subtracted from the filtered value. If the [P3 PV offset] entity = 0 no offset is applied.

P3 is a default relative pressure.

If an absolute pressure is needed, set the entity “Standard ambient air pressure” to 0.

Pressure PV	Pressure Type	Standard Ambient Air Pressure
Pressure	Absolute	0
	Relative	Any value

TABLE 7-6 P3 pressure displayed unit types

If Relative pressure is selected, the value stored in the [Ambient Air Pressure] entity is added to the measured pressure. If Absolute pressure is selected, no factor is added. The final result is available in the [Primary Value] entity.

NOTE: Absolute pressure is used in the density calculation; the relative pressure is only displayed in P3 [Primary Value].

For the FCI-HT software to differentiate between a HART device malfunction and a HART device not actually installed, P3 pressure has the entity [P3 Installed] which must be set to either <Installed> if a P3 pressure HART device is actually fitted or <Not Installed> if a P3 pressure HART device is *not* actually fitted. For example, in the case of free-venting tanks, P3 would usually not be installed.

If the P3 pressure status is <Good Actual>, the P3 pressure value is also stored in memory in the [Last Valid P3] entity, to allow recovery from a power-down situation when a P3 pressure is not available.

If the measured P3 pressure is *invalid* (e.g. HART scan error), the software will check the [P3 Installed] entity to determine if P3 is actually fitted. If P3 is fitted, the software will check for a [Manual P3 Pressure] entity value to be entered. If no manual P3 pressure value is entered, the [Last Valid P3] is used in the density calculation. If no [Last Valid P3] is available, an error will be reported.

If P3 pressure is *not* installed - in the case of free-venting tanks - a default value of 0.0 for P3 pressure is used for density calculations.

The Secondary and Tertiary values of a P3 pressure HART device are not converted, and they are simply translated from the HART device to the FlexConn environment.

7.9.3.4 HIMS Density

To make HIMS density calculation possible, the relevant entity values must be available. See also FIGURE 7-32.

☛ Read also the *Instruction Manual HIMS pressure measurement*.

Engauge SmartView

☛ Enter the appropriate values into the following entities:

- [Distance P1 to Zero Level]
- [Distance P3 to Zero Level]
- [Hydrostatic Deformation Level]
- [Hydrostatic Deformation Factor]
- [Local Gravity]
- [Minimum HIMS Level]
- [HIMS Level Hysteresis]
- [Ambient Air Density]
- [Tank Vapor Density]

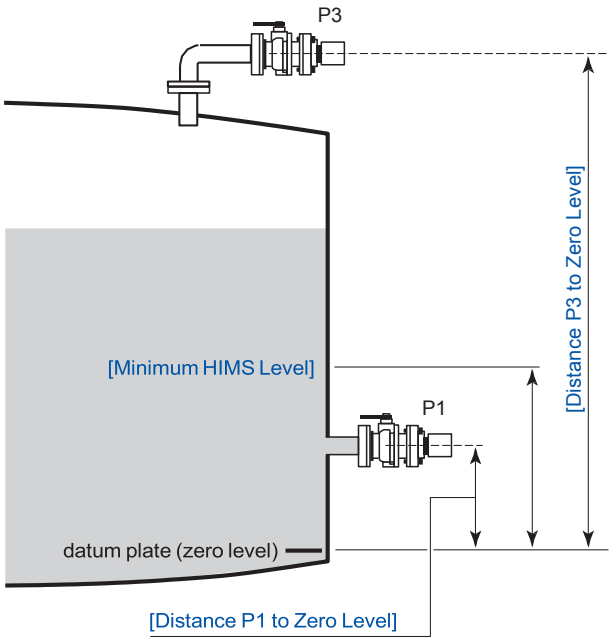


FIGURE 7-32 HIMS configuration principle

To calculate HIMS density, the following valid data must be available:

- P1 pressure
- P3 pressure
- Product level
- Water level (optional)

The software analyses the status of these 4 (3) inputs, to determine the value and status of the [HIMS Density PV].

If the HIMS Density PV status is <Good Actual>, the HIMS Density PV value is also stored in memory in the [Last Valid Density] entity, to allow recovery from a power-down situation when a HIMS Density PV value is not available.

If any of the 4 input statuses are bad, the software will check for a [Manual Product Density] entity value to be entered. If a [Manual Product Density] entity value is entered, this value will be used for the HIMS Density PV. If no [Manual Product Density] entity value is entered, the software will check if a [Last Valid Product Density] entity value was stored. If a [Last Valid Product Density] entity value was stored, this value will be used for the HIMS Density PV. If no [Manual Product Density] or [Last Valid Product Density] entity value is found, an error will be reported.

When calculating HIMS Density, the software will check for a negative density value. If the value is negative, the same manual or last-valid mechanism is used as described before. If the value is positive, HIMS Density is calculated.

When calculating HIMS Density, in order to achieve a valid result, the software will also check if the product level is above the [Minimum HIMS Level] entity value. If this condition is <True>, HIMS Density is calculated. If the product level is below the [Minimum HIMS Level] entity value, the same manual or last valid mechanism is used as described before.

When calculating HIMS Density, if the [Water Level Correction] entity is <Enabled>, the software will check if the scanned water level <= [Distance P1 to Zero Level]. If this is <True>, the HIMS Density is calculated. If the water level > [Distance P1 to Zero Level], the same manual or last valid mechanism is used as described before. If [Water Level Correction] entity is <Disabled>, the software will not check the scanned water level.

7.9.3.5 Generic HART Devices

The FCI-HT software only accepts Generic HART devices at addresses 0 and 4 through 15 with the required sensor type configured.

The generic HART devices are scanned sequentially from address 0 and then address 4 through 15. When a device is detected, initially the HART PV unit code is checked against TABLE 7-7 in the following order: Distance, Temperature, Pressure, and Density.

Sensor Type	Accepted HART Units	Abbreviation	HART Unit Code
Pressure	Pounds per square inch	psi	6
	Pascal	Pa	11
	Kilo Pascal	kPa	12

Sensor Type	Accepted HART Units	Abbreviation	HART Unit Code
Temperature	Degrees Celsius	°C	32
	Degrees Fahrenheit	°F	33
Distance	Feet	ft	44
	Meters	m	45
	Inches	in	47
Density	Kilograms per cubic meter	kg/m^3	92
	Pounds per cubic foot	lb/ft^3	94
	Degrees API	API	104

TABLE 7-7 Accepted units for generic HART devices

- If an accepted HART PV unit code is found, the HART device is allocated to the relevant FlexConn function as detailed in TABLE 7-8.
- If the HART PV unit code is *not* accepted, the HART SV unit code is checked against TABLE 7-7 in the following order: Distance, Temperature, Pressure, and Density. If an accepted HART SV unit code is found, the HART device is allocated to the relevant FlexConn function as detailed in TABLE 7-8.
- The process is repeated for the HART TV unit code.
- If none of the unit codes are accepted, the device is allocated to Function 7.

Engauge
SmartView

☛ If a generic HART device output is *not* in the accepted units, configure it to accepted units output data, by using the HART configuration tool.

FlexConn Function	Device Type
Function 1	[P1 Pressure]
Function 2	[P3 Pressure]
Function 3	[Distance]
Function 4	[Temperature]
Function 5	[Pressure]
Function 6	[Density]
Function 7	[Other]
Function 8	[HIMS Density]

TABLE 7-8 FlexConn function allocation

Once a device has been allocated to a function, the HART PV, SV, and TV are translated into the FlexConn function's PV, SV, and TV.

The required sensor value of the generic HART device may not be in the HART PV but it is translated into the FlexConn PV.

Example:

A HART temperature sensor may have a PV unit code Ohms, and a SV unit code Celsius. The required sensor value is temperature in Celsius, and this is translated into the FlexConn PV, and the Ohms value is translated into the FlexConn SV.

Translation is performed in the order: PV (Distance, Temperature, Pressure, and Density), SV (Distance, Temperature, Pressure, and Density), TV (Distance, Temperature, Pressure, and Density).

The required sensor value read from the generic HART devices will be converted into SI Units within the FlexConn PV as shown in TABLE 7-9.

The other sensor values of a generic HART device are not converted, and they are simply translated from the HART device environment into the FlexConn environment SV and TV.

Accepted HART Units	Abbreviation	FlexConn PV Unit Translation	Abbreviation
Pounds per square inch	psi	Pascal	Pa
Pascal	Pa		
Kilo Pascal	kPa		
Degrees Celsius	°C	Celsius	°C
Degrees Fahrenheit	°F		
Feet	ft	Meters	m
Meters	m		
Inches	in		
Kilograms per cubic meter	kg/m^3	Kilograms per cubic meter	kg/m^3
Pounds per cubic foot	lb/ft^3		
Degrees API	API		

TABLE 7-9 Generic HART device units into FlexConn PV unit translation

7.9.3.6 Function Identification

Functions 1 through 8 are identified by the entities: [Function Category], [Function Type], and [Function Sub-type].

Their default identification information is detailed in TABLE 7-10.

Function	Allocation	Function Category	Function Type	Function Sub-type
Function 1	P1 Pressure	Sensor (1)	Product pressure (5)	(6)
Function 2	P3 Pressure	Sensor (1)	Vapor pressure (13)	(7)
Function 3	Distance	Sensor (1)	HART transmitter (12)	(16)

Function	Allocation	Function Category	Function Type	Function Sub-type
Function 4	Temperature	Sensor (1)	HART transmitter (12)	(16)
Function 5	Pressure	Sensor (1)	HART transmitter (12)	(16)
Function 6	Density	Sensor (1)	HART transmitter (12)	(16)
Function 7	Other	Sensor (1)	HART transmitter (12)	(16)
Function 8	HIMS Density	Sensor (1)	Product density (6)	(8)

TABLE 7-10 Default function category, type, and sub-type

The function type entity for Functions 3 through 7 can be changed from the default value <HART transmitter> to provide more information about the sensor, by setting the [User function type] entity and then resetting the FCI-HT board.

The possible values are detailed in TABLE 7-11.

Function	Allocation	User Function Type	Value
Function 3	Distance	User function type product level	4
		User function type water level	9
Function 4	Temperature	User function type product temperature	8
		User function type Vapor temperature	7
Function 5	Pressure	User function type product pressure	5
		User function type Vapor pressure	13
Function 6	Density	User function type product density	6
Function 7	Other	User function type product level	4
		User function type water level	9
		User function type product temperature	8
		User function type Vapor temperature	7
		User function type product pressure	5
		User function type Vapor pressure	13
		User function type product density	6

TABLE 7-11 Generic HART user function types

Functions 1 through 8 have fixed values for [PV Unit Type] and [Function Identification] entities, as detailed in TABLE 7-12.

Function	Allocation	PV Unit Type	Function Identification
Function 1	P1 Pressure	UNIT_TYPE_PRESSURE	<P1 Pressure>
Function 2	P3 Pressure	UNIT_TYPE_PRESSURE	<P3 Pressure>
Function 3	Distance	UNIT_TYPE_LENGTH	<Distance>
Function 4	Temperature	UNIT_TYPE_TEMPERATURE	<Temperature>
Function 5	Pressure	UNIT_TYPE_PRESSURE	<Pressure>
Function 6	Density	UNIT_TYPE_DENSITY	<Density>
Function 7	Other	UNIT_TYPE_UNDEFINED	<Other Units>
Function 8	HIMS Density	UNIT_TYPE_DENSITY	<HIMS Density>

TABLE 7-12 PV unit type and function identification

7.9.3.7 SmartView Display

Although the Primary Values (PV) of functions 1 through 8 are *calculated* in SI units, the *SmartView display* supports the following units for local calibration, commissioning etc. The displayed unit depends on the value of the [PV selected unit] entity.

PV Unit Type	Display Unit Type	Displayed Units	PV Selected Unit	Range
Pressure	Pascal	<pas>	1	max. 0.99 MPa
	Kilo Pascal	<kpas>	2	max. 9.9 MPa
	Pounds per square inch (small)	<psi s>	3	max. 99 psi
	Pounds per square inch (large)	<psi l>	4	max. 999 psi
Temperature	Degrees Celsius	<°C>	1	-
	Degrees Fahrenheit	<°F>	2	-
Distance	Meters	<m>	1	-
	Feet	<ft>	2	-
	Inches	<in>	3	-
	Fractions (feet, inches, 1/16th inch)	<f.i.s.>	4	-
Density	Kilograms per cubic meter	<kg/m3>	1	-
	Pounds per cubic foot	<lb/f3>	2	-
	Degrees API	<a.p.i>	3	-

PV Unit Type	Display Unit Type	Displayed Units	PV Selected Unit	Range
Other	Milli	<m ...>	1	-
	(none)	<->	2	-
	Kilo	<k ...>	3	-
	Mega	<M ...>	4	-

TABLE 7-13 *SmartView* displayed unit types

The following PV types are supported on the *SmartView* display for P1 pressure and P3 pressure only.

P1 and P3 are default relative pressures.

If an absolute pressure is needed, set the entity “Standard ambient air pressure” to 0.

Pressure PV	Pressure Type	Standard Ambient Air Pressure
Pressure	Absolute	0
	Relative	Any value

TABLE 7-14 P1 and P3 pressure displayed unit types

7.9.4 Board Commissioning

The commissioning entity for each *function* is initially default to <False>. The commissioning entity for each function will only be <True> when the associated entities of each function have been set *within normal operating range*.

The *board-level* commissioned entity default is also <False>. It will only be <True> when all the function-level commissioned entities are <True>.

7.9.4.1 Function 1 Commissioning

Engauge SmartView

☛ Set all Function 1 entities according to TABLE 7-15 requirements, to commission P1.

HIMS Density	P1 Pressure Sensor Detected	P1 Ambient Air Pressure and P1 Installed	Commissioned
<Enabled>	N/A	[P1 ambient air pressure] ≠ <default> AND [P1 installed] = <enable>	<True>
		[P1 ambient air pressure] = <default> OR [P1 installed]= <disable>	<False>

HIMS Density	P1 Pressure Sensor Detected	P1 Ambient Air Pressure and P1 Installed	Commissioned
<Disabled>	Yes	[P1 ambient air pressure] ≠ <default> AND [P1 installed] = <enable>	<True>
		[P1 ambient air pressure] = <default> OR [P1 installed] = <disable>	<False>
	No	N/A	<True>

TABLE 7-15 Function 1 commissioning entities

7.9.4.2 Function 2 Commissioning

Engauge SmartView

☛ Set all Function 2 entities according to TABLE 7-16 requirements, to commission P3.

HIMS Density	P3 Pressure Sensor Detected	P3 Installed	P3 Ambient Air Pressure	Commissioned
<Enabled>	Yes	<Enable>	[P3 ambient air pressure] ≠ <default>	<True>
			[P3 ambient air pressure] = <default>	<False>
		<Disable>	N/A	<False>
	No	<Enable>	N/A	<False>
		<Disable>		<True>
<Disabled>	Yes	<Enable>	[P3 ambient air pressure] ≠ <default>	<True>
		<Disable>	[P3 ambient air pressure] ≠ <default>	<False>
		N/A	[P3 ambient air pressure] = <default>	<False>
	No	N/A	N/A	<True>

TABLE 7-16 Function 2 commissioning entities

7.9.4.3 Function 3 through 7 Commissioning

Engauge SmartView

☛ Set all Function 3 through 7 entities according to TABLE 7-17 requirements, to commission all generic HART sensors.

Function	HART Sensor Detected	User Function Type	Commissioned
3	Yes	= <Product level> OR <Water level>	<True>
		≠ <Product level> OR <Water level>	<False>
	No	N/A	<True>
4	Yes	= <Product temp.> OR <Vapor temp.>	<True>
		≠ <Product temp.> OR <Vapor temp.>	<False>
	No	N/A	<True>
5	N/A	N/A	<True>
6	N/A	N/A	<True>
7	N/A	N/A	<True>

TABLE 7-17 Function 3 through 7 commissioning entities

7.9.4.4 Function 8 Commissioning

☛ Set Function 8 entities according to TABLE 7-18 requirements, to commission the HIMS density function.

HIMS Density	Function 8 Commissioning Entities	Commissioned
Enabled	<Hydrostatic deformation level> ≠ <Default> AND <Hydrostatic deformation factor> ≠ <Default> AND <Local gravity> ≠ <Default> AND <Minimum HIMS level> ≠ <Default> AND <Ambient air density> ≠ <Default> AND <Tank Vapor density> ≠ <Default> AND <Distance P1 to zero level> ≠ <Default> AND <Distance P3 to zero level> ≠ <Default>	<True>
	<Hydrostatic deformation level> = <Default> OR <Hydrostatic deformation factor> = <Default> OR <Local gravity> = <Default> OR <Minimum HIMS level> = <Default> OR <Ambient air density> = <Default> OR <Tank Vapor density> = <Default> OR <Distance P1 to zero level> = <Default> OR <Distance P3 to zero level> = <Default>	<False>
Disabled	N/A	<True>

TABLE 7-18 Function 8 commissioning entities

7.9.5 Hardware Configuration

7.9.5.1 Terminal Allocation

Terminal Number	Name	Function
24	V_Loop	HART Bus power
25	GND_Loop	HART Bus ground

7.9.5.2 LED Allocation

LED Number	Function
LE2	HART data Transmit
LE3	HART data Receive

7.10 HART Analog Outputs (HCI-HAO)

7.10.1 Introduction

The Host Communication Interface – HART Analog Output (HCI-HAO) is a HART® slave module which communicates with the associated HART master over the HART bus.

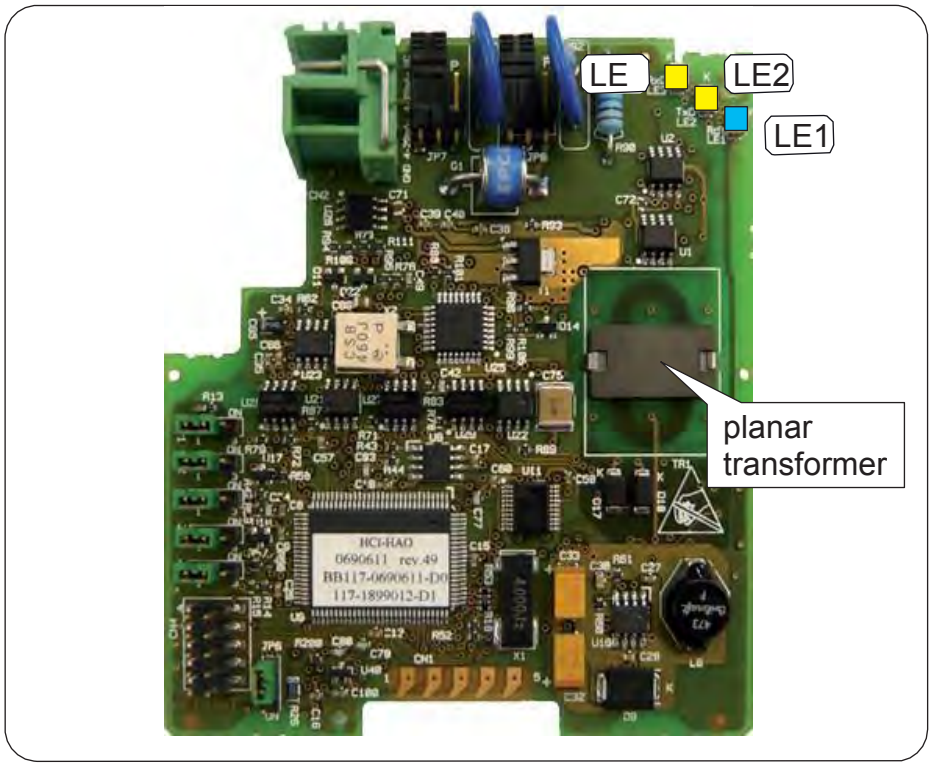


FIGURE 7-33 The HCI-HAO board

The HART protocol is a bi-directional master-slave communication protocol, which is used to communicate between intelligent field instruments and host systems.

The HCI-HAO board has a planar transformer for galvanic isolation from the HART bus. See FIGURE 7-33.

LED LE1 is the board's [Health] LED. LEDs LE2 and LE3 will be flashing to indicate activity on the HART bus. LE2 indicates data is being transmitted (Tx), LE3 indicates data is being received (Rx).

7.10.2 Functional Description

HCI-HAO is a HART slave module, which uses standard HART communication to communicate with HART-devices. This module makes use of the Bell 202 Frequency Shift Keying (FSK) standard to superimpose digital signals at a low level on the 4–20 mA analog signal.

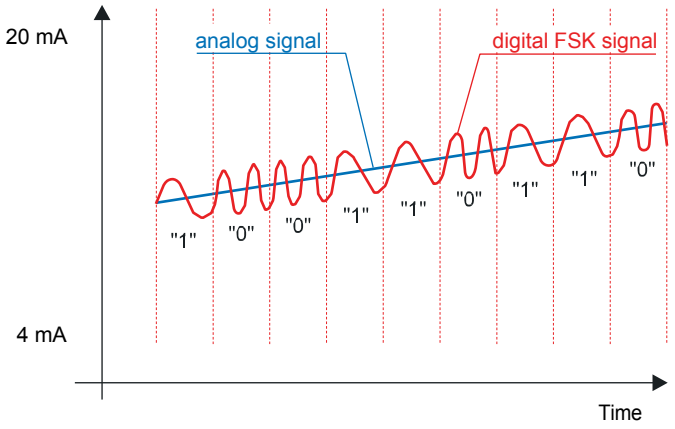


FIGURE 7-34 The analog and digital signals within the HART® communication

The HCI-HAO works as an interface board between FlexConn boards and a HART master, and it makes the data available on the HART bus.

The user needs *to set the required linked variable details*.

The linked primary variable is mapped between 4–20 mA on the analog output depending on the range values set. The linked variables are scanned every 1 second and so is the analog output refresh rate.

The HCI-HAO is configurable by:

- a HART communicator
- a local SmartView
- Engauge

The HCI-HAO (board ID = 11) has following two functions:

Function	Category	Type	Sub-type
1 - HART communication	Communication	Instrument slave	HART
2 - Analog output	Sensor	Analog output	4 - 20 mA

All the HART *universal commands* and some *common practice commands* are supported by HCI-HAO. These are listed in the below tables.

HART Universal Commands	
Command no.	**Description**
0	Read Unique Identifier
1	Read Primary Variable
2	Read Loop Current and Percentage of Range
3	Read Dynamic variables and Loop Current
4	Reserved
5	Reserved
6	Write Polling Address
7	Read Loop Configuration
8	Read Dynamic Variable Classifications
9	Read Device Variable with Status
10	Reserved
11	Read Unique Identifier Associated with Tag
12	Read Message
13	Read Tag, Descriptor, Date
14	Read PV Sensor Information
15	Read Device Information
16	Read Final Assembly Number
17	Write Message
18	Write Tag, Descriptor, Date
19	Write Final Assembly Number
20	Read Long Tag
21	Read Unique Identifier Associated with Long Tag
22	Write Long Tag

HART Common Practice Commands	
Command no.	**Description**
34	Write Primary Variable Damping Value
35	Write Primary Variable Range Values
36	Set Primary Variable Upper Range Value
37	Set Primary Variable Lower Range Value
38	Reset Configuration Changed Flags
40	Enter / Exit Fixed Current Mode
41	Perform Self Test
42	Perform Device Reset
44	Write Primary Variable Units
48	Read Additional Device Status
50	Read Dynamic Variable Assignments
51	Write Dynamic Variable Assignments
53	Write Device Variable Units
54	Read Device Variable Information
55	Write Device Variable Damping Value
59	Write Number of Response Preambles
72	Squawk
79	Write Device Variable
113	Catch Device Variable

7.10.3 Other HCI-HAO features

- *Planar transformer* for galvanic isolation from HART bus.
- *Malfunctioning* of the HCI-HAO card (or any linked cards) is revealed on the HART bus by means of the *device status*.
- If any *fatal errors* occur during operation - which will run the program into an undesired situation - then a software reset (Warm Reset) is given to the HCI-HAO software. During this situation, the output of the module remains at the desired level till the software starts normal working. Handling of a fatal error is a general FlexConn function. This will update the appropriate entity as well.
- *Unit conversions* for the linked variables are possible. All the linked variables available through linking (data read from other FlexConn boards) are in SI units. Accepted units are listed in the table below.

Sensor Type	Accepted HART Units	Abbreviation	HART Unit Code
Temperature	Degrees Celsius	°C	32
	Degrees Fahrenheit	°F	33
Pressure	Pounds per square inch	psi	6
	Pascal	Pa	11
	Kilo Pascal	kPa	12
Level	Feet	ft	44
	Meters	m	45
	Inches	in	47
Density	Kilograms per cubic meter	kg/m^3	92
	Pounds per cubic foot	lb/ft^3	94
	Degrees API	API	104

- *Analog output read back* mechanism, which is used to indicate any errors in the analog output section. An error can be indicated using the control relay on the FII-DO module over the CAN bus. If some error is found in the DAC read back, then the same is updated in function 2 (sensor) health, as per following details in status and status codes:

Status	<BAD>
Status Category	<GENERAL_HARDWARE_FAIL>
Status Code	<DAC_READ-BACK_FAIL>

- *Active and Passive mode* of operation for Loop current.
- *Multi-drop mode* supported to connect more than one HART-compatible device on HART bus. For operating the device in Multi-Drop mode, user needs to select the polling address to a non-zero value. Making the polling address to a non-zero value makes the output current mode to Fixed_4_20_MA (4 mA fixed). Non-zero polling address will automatically make the output current mode to Fixed_4_20_MA.

All the HART-compatible devices connected over the HART bus must have different polling addresses. *Multi-drop mode is supported only in Passive mode of loop configuration*. When the output current mode is set to Standard_4_20_MA, the polling address of the device must be made zero.

- When the device is *not* in multi-drop mode (STANDARD_4_20_MA mode selected) then the output current follows the changes in linked PV value.
- *Scanning of each linked available PV, SV, TV and QV on the CAN-bus with frequency of 1 Hz.* That means all the available linked variables are scanned every 1 second.
- The *analog output is refreshed every 1 second*, even if there is no change in the scanned variables. So, the watchdog for analog output is automatically implemented. If the output is not refreshed within 45 seconds, then a watchdog to analog output is generated and the output is forced to 0 mA.
- *During startup, the analog output* of the HCI-HAO module is *kept low (< 0.5 mA)*. This value will be there till initialization takes place. Once the normal operation starts the output will follow the linked PV depending upon the output mode setting.
- *Manual overwrite mechanism*. This is a standard FlexConn functionality. Separate configuration and command entities are defined for this. See 7.10.5 - Board Commissioning.

7.10.4 Calibration of the HCI-HAO

A calibration provision is given, which is used to accurately map the analog output between 4-20 mA using the two range values entered for Primary Variable.

Following table lists all entities required for calibration.

Entity	Data Type	Type
[Analog Output at 4 mA]	Float	non-volatile R/W
[Analog Output at 18 mA]	Float	non-volatile R/W
[Calibrate at 4 mA]	Undefined	command
[Calibrate at 18 mA]	Undefined	command
[Enter Calibration Mode]	Undefined	command
[Exit Calibration Mode]	Undefined	command

NOTE: Commands used in the following calibration procedure can be executed either by using the CAN tool, the SmartView, or Engauge.

Calibrate the analog output of the HCI-HAO as follows:

☛ Connect loop resistor at connector CN2

☛ Power up HCI-HAO board

☛ Give command [Enter Calibration Mode]

☛ Give command [Calibrate Analog Output at 4mA]

☛ Measure actual output current through the loop resistor, using a current meter

☛ Enter this value in the [Analog Output at 4mA] entity

☛ Give command [Calibrate Analog Output at 18mA]

☛ Measure actual output current through the loop resistor, using a current meter

☛ Enter this value in the [Analog Output at 18mA] entity

☛ Give command [Exit Calibration Mode], to exit the calibration mode

These calibration data are used to calculate the analog output current for the Primary Value (PV).

Until calibration has been carried out, the Health status of the PV and the analog output function will be:

Status	<BAD>
Status Category	<STATUS_CATEGORY_BAD_GENERAL_CALIBRATION_FAIL>
Status Code	<CALIBRATION_SET_POINTS_NOT_CALIBRATED>

7.10.5 Board Commissioning

7.10.5.1 Basic Configurable Entities Overview

Basic configuration entities of the HCI-HAO board, which are configurable by using *SmartView*, are listed in the following table.

Entity	SmartView Display	Data Type	Type	Default	Function
[PV Link board ID]	PV linked Brd ID	Unsigned int 8 bits	Non-Volatile	<0>	Board Specific
[PV Link board instance]	PV linked Brd IN	Unsigned int 8 bits	Non-Volatile	<0>	
[PV Link function instance]	PV linked Brd FI	Unsigned int 8 bits	Non-Volatile	<0>	
[PV Link Board Sensor Value]	PV link Brd SVAL	Enumeration	Non-Volatile	<PV_LINK>	
[SV Link board ID]	SV linked Brd ID	Unsigned int 8 bits	Non-Volatile	<0>	
[SV Link board instance]	SV linked Brd IN	Unsigned int 8 bits	Non-Volatile	<0>	
[SV Link function instance]	SV linked Brd FI	Unsigned int 8 bits	Non-Volatile	<0>	
[Polling Address]	Polling Address	Unsigned int 8 bits	Non-Volatile	<0>	Communication
[HART PV unit code]	PV Unit Code	Enumeration	Non-Volatile	<UNKNOWN>	
[Upper Transducer Limit]	Upper Tran Limit	Float	Non-Volatile	<0>	
[Lower Transducer Limit]	Lower Tran Limit	Float	Non-Volatile	<0>	
[Transducer Serial Number]	Transducer Sr No	Unsigned int 32 bits	Non-Volatile	<123>	

Entity	SmartView Display	Data Type	Type	Default	Function
[PV Lower range value]	Lw Range Value	Float	Non-Volatile	<0>	Sensor (Analog Output)
[PV Upper range value]	Up Range Value	Float	Non-Volatile	<0>	
[Analog Output mode]	HART Mode	Enumeration <Fixed 4-20mA> <Standard 4-20mA>	Non-Volatile	<Standard 4-20mA>	
[Burnout Value]	Burnout Value	Float	Non-Volatile	<3.6>	
[Burnout Behavior]	Burnout Behavior	Enumeration <BAD> <UNCERTAIN> <BAD + UNCERTAIN>	Non-Volatile	<BAD>	
[Enter Calibration Mode]	Enter Cal Mode	Undefined	Command		
[Cal Value at 4 mA]	Cal Value at 4 mA	Float	Non-Volatile	<0>	
[Cal Value at 18 mA]	Cal Value at 18 mA	Float	Non-Volatile	<0>	
[Calibrate at 4 mA]	Calibrate at 4 mA	Undefined	Command		
[Calibrate at 18 mA]	Calibrate at 18 mA	Undefined	Command		
[Exit Calibration Mode]	Exit Cal Mode	Undefined	Command		

7.10.5.2 Commissioning

☛ The following entities ***must*** be set by *Engauge* or *SmartView* for a correct functioning of the HCI-HAO module in an instrument.

Name	Explanation	Default Value	Function Part	Function
[PV Link board ID]	Board ID of Other FlexConn to be linked as PV to HCI-HAO	<0>	Board	Board Specific
[PV Link board instance]	Board Instance of the linked PV board	<0>		
[PV Link function instance]	Function Instance of the linked PV board	<0>		
[PV Link Sensor Value]*	Primary or secondary variable of linked card can be assigned to this	<PV_LINK>		

Name	Explanation	Default Value	Function Part	Function
[HART PV unit code]	Unit code for linked PV	<UNIT_CODE_UNKNOWN>	Function 1	Communication (HART communication)
[HART Upper Transducer Limit]	Upper transducer limit for connected sensor of linked PV board	<0>		
[HART Lower Transducer Limit]	Lower transducer limit for connected sensor of linked PV board	<0>		
[Polling Address]	Polling address of the device, which is used for poll-based addressing	<0>		
[Transducer Serial Number]	Transducer serial number of connected sensor of linked PV board	<123>		
[Upper Range Value]	Upper range value for PV. This value is used to calculate the analog output current.	<0>	Function 2	Sensor (Analog Output)
[Analog Output at 4mA]	Calibration reading when [Calibrate at 4 mA] command is given	<0>		
[Analog Output at 18 mA]	Calibration reading when [Calibrate at 18 mA] command is given	<0>		
[Lower Range Value]	Lower range value for PV. This value is used to calculate the analog output current.	<0>		
[Analog Burnout Value]	Analog burnout value in case of malfunctioning device	<3.6mA>		

*) Default values for entities marked in GREEN in the above table could be considered as proper values for making the health for respective Function or Board <GOOD>. However, the user is free to choose these values as per the requirement along with the rest of the entities.

All the entities in the above table would be initialized to their *default* values after [init novram] command is given. All the entities should have their proper values so as to make the respective Function and Board health to <GOOD> status.

The [Analog Output at 4 mA] and [Analog Output at 18 mA] fields should be entered after giving proper calibration commands (for more details, see 7.10.4).

☛ The following entities ***can*** be set by *Engauge* or *SmartView* for a correct functioning of the HCI-HAO module in an instrument.

If one needs to assign SV, TV, QV to HCI-HAO then the corresponding unit codes also needs to be set properly so that the value read from other FlexConn board will be proper.

Name	Explanation	Default Value	Function Part	Function
[SV Link board ID]	Board ID of Other FlexConn which is linked as SV to HCI-HAO	<0>	Board	Board Specific
[SV Link board instance]	Board Instance of the linked SV board	<0>		
[SV Link function instance]	Function Instance of the linked SV board	<0>		
[TV Link board ID]	Board ID of Other FlexConn which is linked as TV to HCI-HAO	<0>		
[TV Link board instance]	Board Instance of the linked TV board	<0>		
[TV Link function instance]	Function Instance of the linked TV board	<0>		
[QV Link board ID]	Board ID of Other FlexConn which is linked as QV to HCI-HAO	<0>		
[QV Link board instance]	Board Instance of the linked QV board	<0>		
[QV Link function instance]	Function Instance of the linked QV board	<0>		
[Linked Primary Value]	PV / SV value of linked PV board in the set unit code	<0>		
[Linked Secondary Value]	PV value of linked SV board in the set unit code	<0>		
[Linked Tertiary Value]	PV value of linked TV board in the set unit code	<0>		
[Linked Quarternary Value]	PV value of linked QV board in the set unit code	<0>		

Name	Explanation	Default Value	Function Part	Function
[HART SV unit code]	Unit code for linked SV	<UNIT_CODE_UNKNOWN>	Function 1	Communication (HART communication)
[HART TV unit code]	Unit code for linked TV	<UNIT_CODE_UNKNOWN>		
[HART QV unit code]	Unit code for linked QV	<UNIT_CODE_UNKNOWN>		
[Configuration changed Counter]	Increments every time the configuration is changed	<0>		
[Device ID]	Same as Enraf Serial number. This is a unique number to every board.			
[Device Type]	Device type registered with the HART Communication Foundation	<127>		
[Manufacturer ID Number]	Manufacturer ID registered with the HART Communication Foundation	<148>		
[Number of Preambles]	Number of preambles required for a request from the HART master	<7>		
[Number of Response Preambles]	Number of preambles in the HCI-HAO response stream	<7>		
[Fixed Current Value]	Fixed analog output current set by HART command 40	<0>	Function 2	Sensor (Analog Output)
[Loop Current Mode]	If HART mode selected is <Standard 4-20mA>, then it is enabled. If HART mode selected is <Fixed 4-20mA>, then it is disabled.	<Enabled>		
[Percentage of Range]	Percentage of current PV with respect to the limits set	<0>		

7.10.6 Hardware Configuration

7.10.6.1 Jumper Allocation

The following are typical jumper settings done on the HCI-HAO board.

Jumper Number	Position	Connection Details	Description	Default Position	Default Connections
JP1	ON	Short 2 & 3	W&M Entity Protection	OFF	Short 1 & 2
JP2	ON	Short 2 & 3	Password Read Protection	OFF	Short 1 & 2
JP3	ON	Short 2 & 3	Write Protection All Entities	OFF	Short 1 & 2
JP4	ON	Short 2 & 3	Free	OFF	Short 1 & 2
JP5	ON	Short 2 & 3	Free	OFF	Short 1 & 2
JP6	ON	Short 2 & 3	CAN termination 120E resistor	OFF	Short 1 & 2
JP7 & JP8	A	Short 1 & 2	Active mode for Analog Output	A	Short 1 & 2
JP7 & JP8	P	Short 2 & 3	Passive mode for Analog Output		

7.10.6.2 Terminal Allocation

t.b.d.

7.10.6.3 LAD Allocation

LED Number	Function
LE2	HART data Transmit
LE3	HART data Receive

7.11 Average Temperature & Water Level Measurement (FII-VT)

7.11.1 Introduction

The Field Interface Instrument - VITO[1] (FII-VT) board is a VITO-data processor module, which calculates average product- and Vapor temperatures, and optionally a water level.

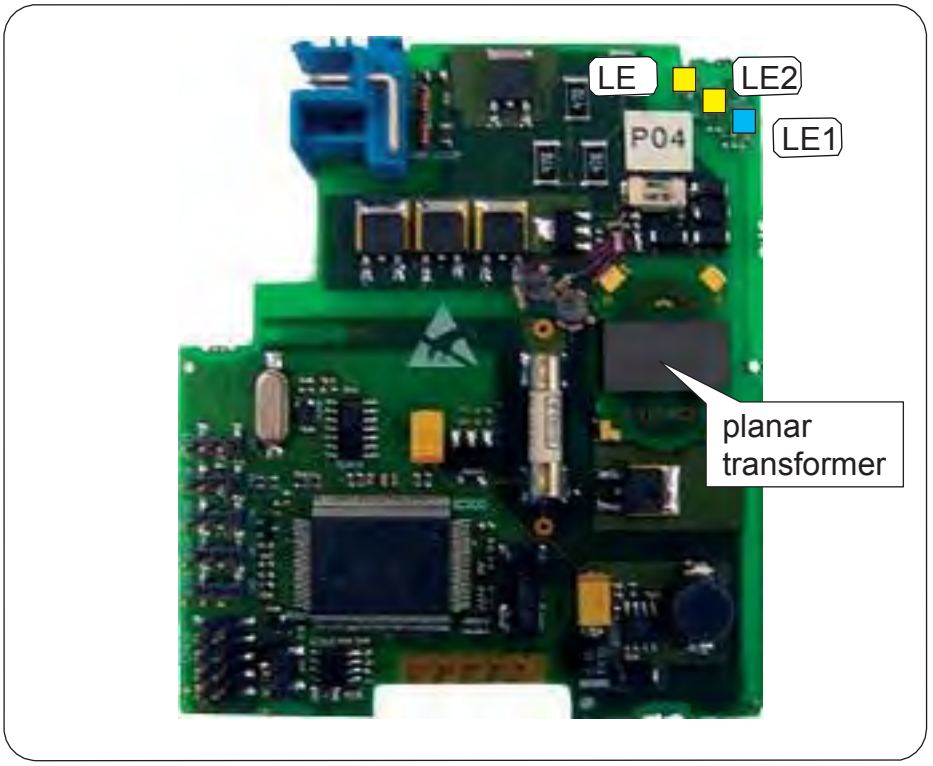


FIGURE 7-35 The FII-VT board with its planar transformer

By using the HART® protocol (see also 7.9.1), the FII-VT module can be connected to one VITO-interface which in turn is connected to a probe for *product temperature*, *Vapor temperature*, *water level*, or a combination of these.

The FII-VT board has a planar transformer for galvanic isolation from the HART bus. See FIGURE 7-35.

LED LE1 is the board's [Health] LED. LEDs LE2 and LE3 will be flashing to indicate activity on the HART bus. LE2 indicates data is being transmitted (Tx), LE3 indicates data is being received (Rx).

1. Versatile In-Tank Observer

7.11.2 VITO Interface Types

For temperature and/or water level measurement, a proper VITO probe must be connected to the FII-VT module, using a VITO interface.

There are 3 VITO interface types:

- 762 VITO MTT interface for 16-spot temperature measurement (*thermocouple principle*) and optionally a water bottom measurement
- 762 VITO LT interface for 9-spot temperature measurement (*thermocouple principle*) and optionally a water bottom measurement
- 762 VITO MRT interface for Multiple Resistance Thermometer and multi-spot (*resistance variation principle*) measurement

7.11.3 Commissioning

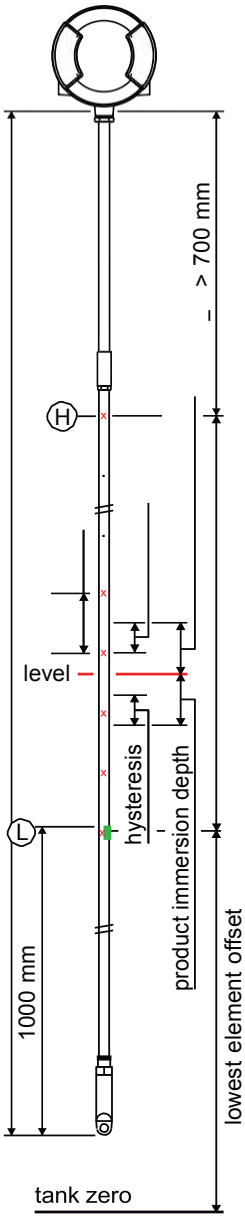
7.11.3.1 Commissioning Parameters for MTT/LT Probes

The following 9 configurations are possible:

Enraf Model	VITO Type	Description
764C	MTT Temperature probe	lowest spot next to Pt100, no water probe
764D		lowest spot below Pt100, no water probe
766C	MTT Combi probe	lowest spot next to Pt100, combined with water probe
766D		lowest spot below Pt100, combined with water probe
767C	LT Temperature probe	lowest spot next to Pt100, no water probe
767D		lowest spot below Pt100, no water probe
768C	LT Combi probe	lowest spot next to Pt100, combined with water probe
768D		lowest spot below Pt100, combined with water probe
765	Water probe	water probe only

These models are depicted in FIGURE 7-36 and FIGURE 7-37.

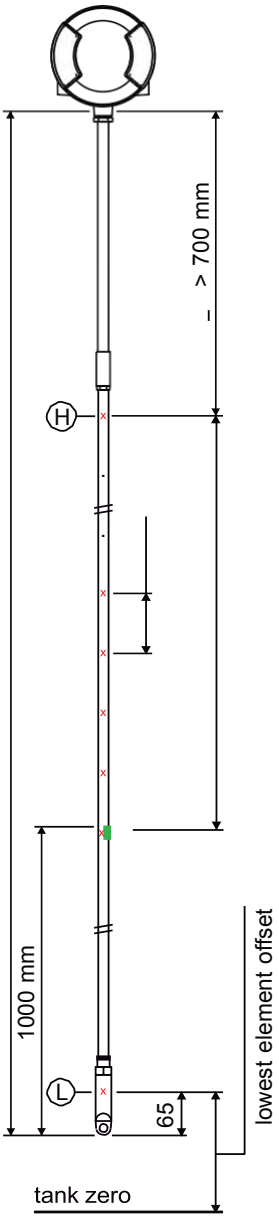
762 VITO MTT interface



Model

. . . . 764 C
<he>

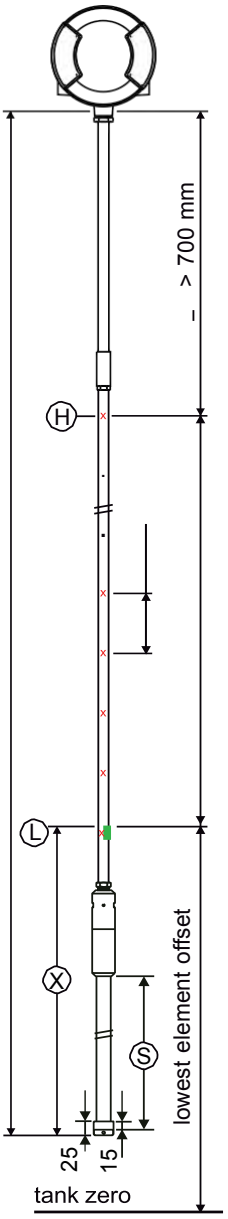
762 VITO MTT interface



Model

. . . . 764 D
<he>

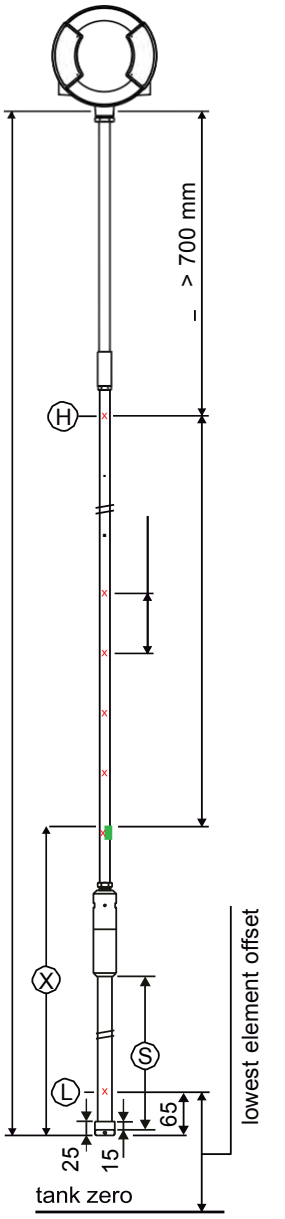
762 VITO MTT interface



Model

.A . . 766 C
<he>

762 VITO MTT interface



Model

.A . . 766 D
<he>

Pt 100 reference resistor

X Thermocouple (spot)

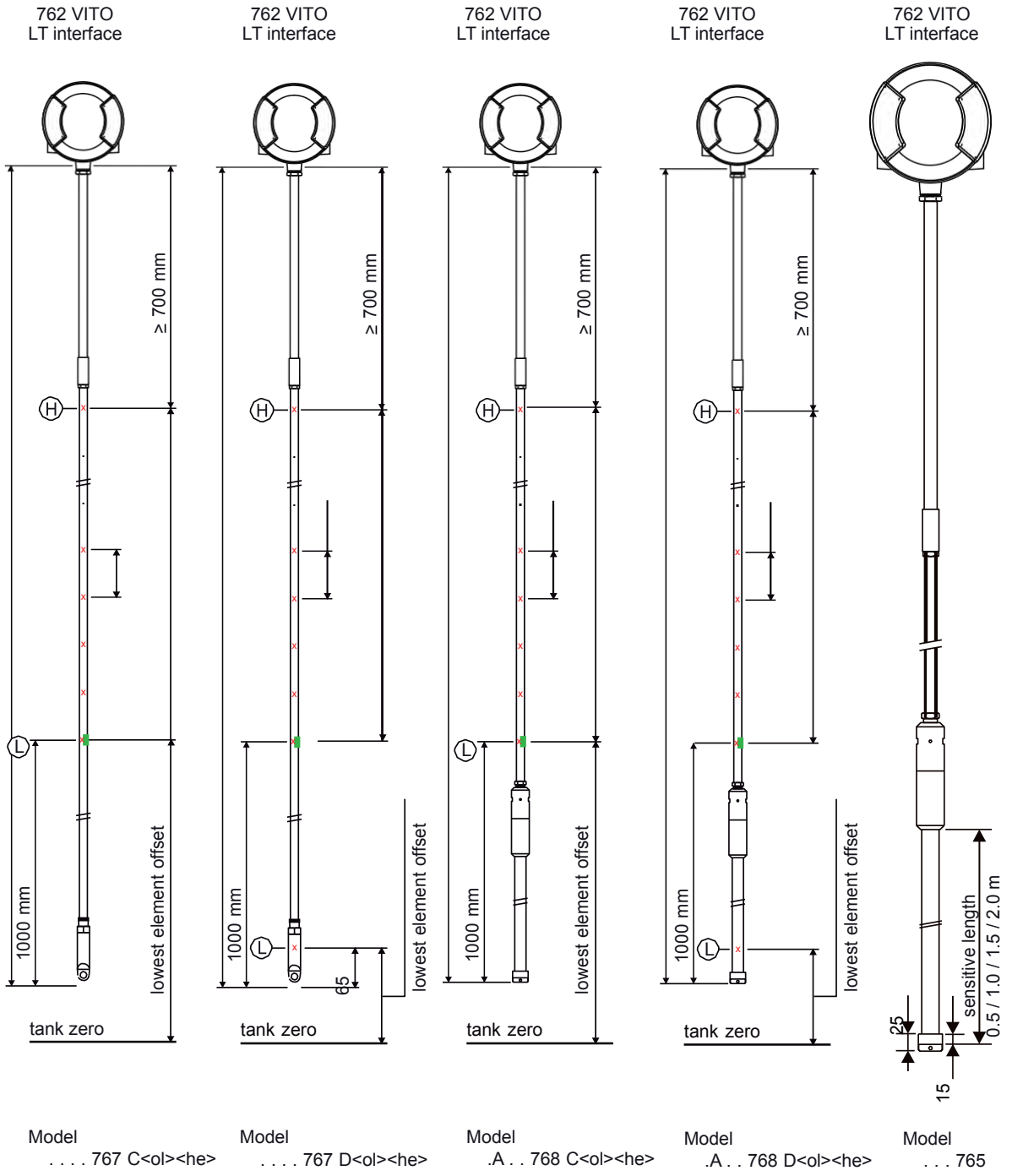
Ⓗ Highest spot

L Lowest spot

Ⓢ Sensitive length = 0.5 / 1.0 / 1.5 / 2.0 m

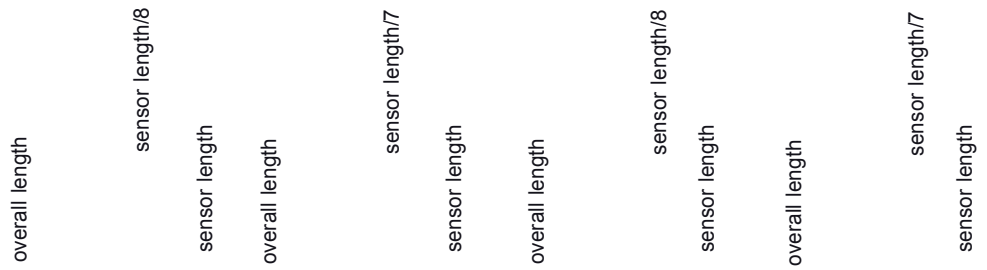
Ⓧ Depending on actual Sensitive length, this length = 1.0 / 1.5 / 2.0 / 2.5 m

FIGURE 7-36 Tank and temperature probe data (1)



Pt 100 reference resistor
X Thermocouple (spot)
H Highest spot
L Lowest spot

FIGURE 7-37 Tank and temperature probe data (2)



7.11.3.1.1 Product Temperature

☛ The following entities ***must*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

*NOTE: Using Engauge, following entities are set within the Engauge **Product temperature** tab.*

Name	Explanation	Value Range	Default
[Lowest element offset]	The distance from tank zero till the lowest element position in the temperature probe	floating point number: <-x.x .. +x.x>	<80.0>
[Sensor length]	The distance from the Pt100 position till the highest element position	floating point number: <-x.x .. +x.x>	<80.0>

The following entities ***can*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Product immersion depth]	The minimum required distance of the product level above an element before it is taken into account in the average product temperature calculation	floating point number: <-x.x .. +x.x>	<0.5>
[Hysteresis]	The distance for a hysteresis mechanism around the switching point of the elements that are taken into account in the calculation	floating point number: <-x.x .. +x.x>	<0.1>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value	floating point number: <-x.x .. +x.x>	<+1.0E22>

Name	Explanation	Value Range	Default
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Element wiring]	Used for excluding an element from the average product temperature calculation.	16 characters A non-zero (≠ 0) character at position **x** results in element **x** being excluded from calculation.	<0000000000000000>
[Function identification] 	The current module's function name. This function is visible on the *SmartView* display.	13 characters	<Product temp.>

7.11.3.1.2 Vapor Temperature

*NOTE: Using Engauge, following entities are set within the Engauge **Vapor temperature** tab.*
Some Vapor temperature settings are shared with Product temperature settings.

The following entities ***can*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Gas immersion depth]	The minimum required distance below an element before it is taken into account in the average Vapor temperature calculation	floating point number: <-x.x .. +x.x>	<0.5>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value	floating point number: <-x.x .. +x.x>	<+1.0E22>

Name	Explanation	Value Range	Default
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the *SmartView* display.	13 characters	<Vapor temp.>

7.11.3.1.3 Water Level (for 766/768 Combi probes and 765 Water probe only)

☛ The following entities must be set by Engauge or SmartView for a correct functioning of the FII-VT module in an instrument.

Name	Explanation	Value Range	Default
[Maximum water capacity]	The maximum capacity when the probe is fully submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Minimum water capacity]	The minimum capacity when the probe is not submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Water probe bottom position]	The offset to the water probe zero point in relation with the tank zero point	floating point number: <-x.x .. +x.x>	<80>
[Upper reference level]	The distance from tank zero point to upper reference point; is used for water ullage calculation	floating point number: <-x.x .. +x.x>	<80>

☛ The following entities ***can*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

Name	Explanation	Value Range	Default
[Water probe length]	The length of a water probe	floating point number: <-x.x .. +x.x>	<0.5>

Name	Explanation	Value Range	Default
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the *SmartView* display.	13 characters	<Water level>

7.11.3.2 Commissioning Parameters for MRT or RTD

Enraf Model	VITO Type	Description
MRT	Multiple Resistance Thermometer	MRT with up to 13 temperature elements with one spot element
RTD	3-spot Resistance Temperature Detector	1..3 RTD spots in a 3-wire connection
	multi-spot Resistance Temperature Detector	1..14 RTD spots in a 2-wire connection

See FIGURE 7-38 and FIGURE 7-39.

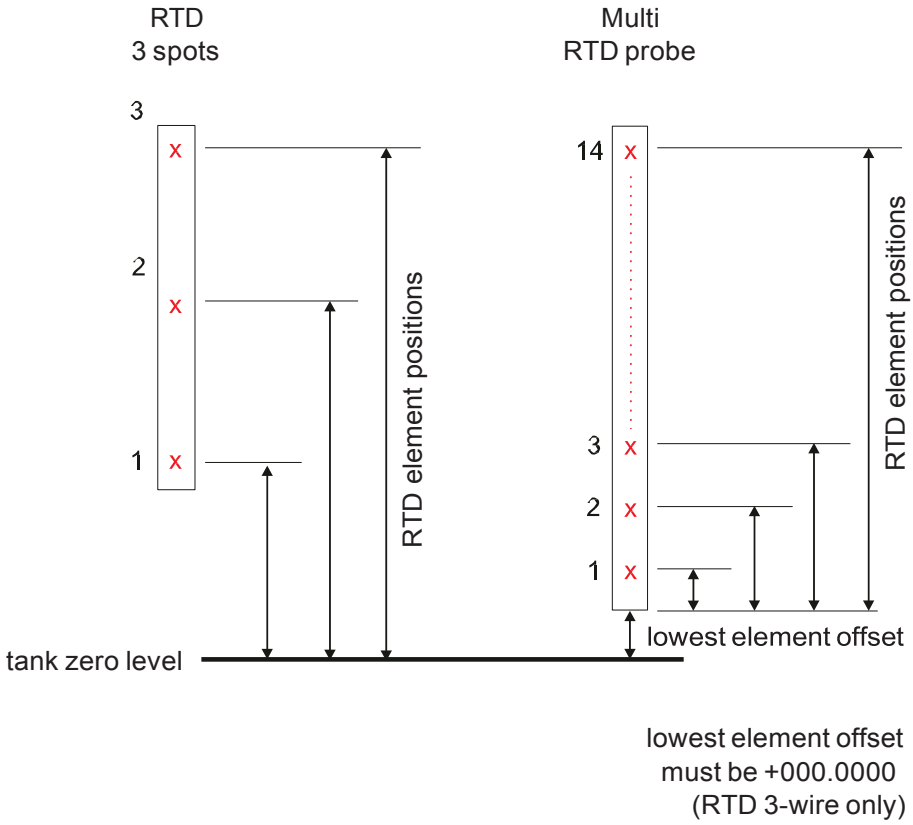


FIGURE 7-38 Resistance Temperature Detector (RTD) elements positions

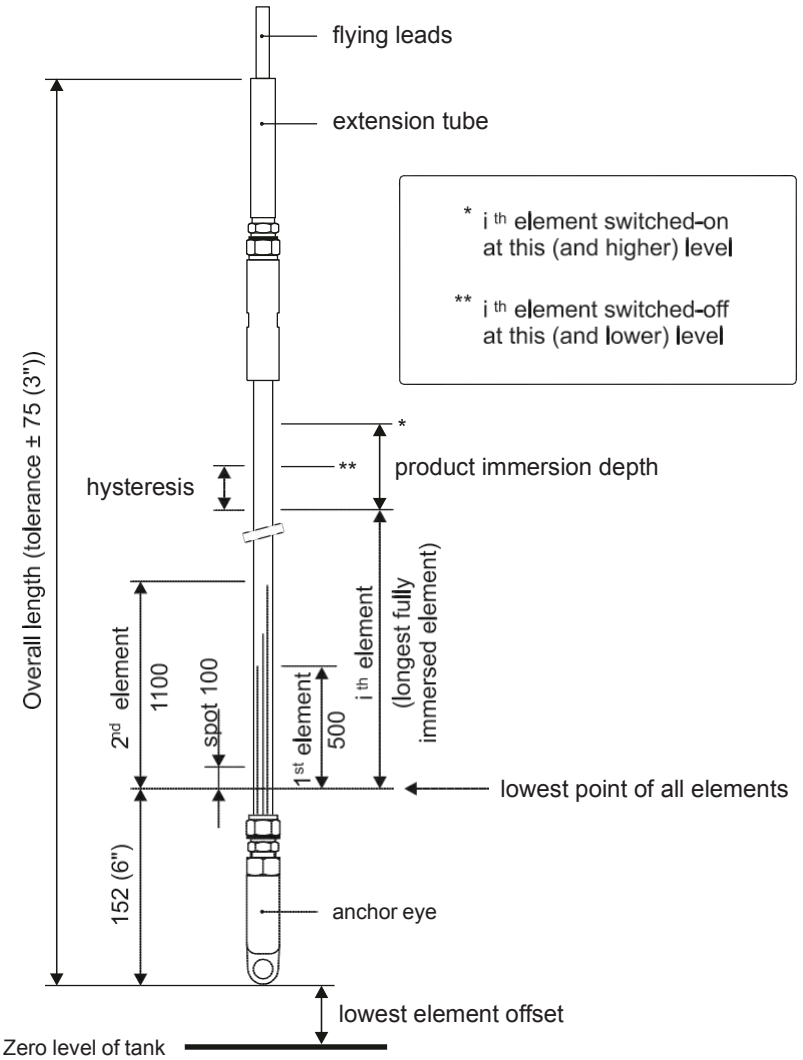


FIGURE 7-39 Multiple Resistance Thermometer (MRT) parameters

7.11.3.2.1 Product Temperature

Engauge
SmartView

☛ The following entities **must** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

*NOTE: Using Engauge, following entities are set within the Engauge **Product temperature** tab.*

- RTD 3 spots (see FIGURE 7-38 *left* side)

Name	Explanation	Value Range	Default
[Element type]	The supported element type is: SPL	3 characters <SPL>	<--->
[Number of elements]	The number of elements a RTD probe has	<1 .. 3>	<0>
[Lowest element offset]	The distance from tank zero till the lowest position of the multi-RTD probe. So **not** used for the 3-wire version and it must be 0.	floating point number: <-x.x .. +x.x> MUST BE <0.0>	<80.0>
[RTD element positions] 	The positions of the RTDs from tank zero level	3 floating point numbers: <-x.x .. +x.x> Note: Only *actually used* elements to be entered.	<0,0,0>

- Multi RTD probe (see FIGURE 7-38 *right* side)

Name	Explanation	Value Range	Default
[Element type]	The supported element type is: SPL	3 characters <SPL>	<--->
[Number of elements]	The number of elements a RTD probe has	<1 .. 14>	<0>
[Lowest element offset]	The distance from tank zero till the lowest position of the multi-RTD probe	floating point number: <-x.x .. +x.x>	<80.0>
[RTD element positions] 	The positions of the RTDs from the lowest position of the probe. So **not** tank zero level!	14 floating point numbers: <-x.x .. +x.x> Note: Only *actually used* elements to be entered.	<0,0,0,0,0,0,0,0,0,0,0,0,0,0>

- MRT (see FIGURE 7-39)

Name	Explanation	Value Range	Default
[Element type]	See Table TABLE 7-19 below.	3 characters <RCB> <RCN> <RCS> <QCB> <QCN> <QCS>	<--->
[Number of elements]	The number of elements (resistors) an MRT probe has	<1 .. 14>	<0>
[Lowest element offset]	The distance from tank zero till the lowest position of the MRT probe	floating point number: <-x.x .. +x.x>	<80.0>
[MRT element length] if MRT length table = <T> 	The lengths of the MRTs including anchor eye	14 floating point numbers: <-x.x .. +x.x>	<0,0,0,0,0,0,0,0,0,0,0,0,0,0>
[MRT length table] 	Specifies whether a fixed range of MRT resistors is used (= <F>) or user-configured lengths (= <T>). Fixed lengths are: 0.25 / 0.65 / 1.25 / 1.95 / 2.85 / 4.15 / 5.65 / 7.35 / 9.25 / 11.65 / 14.65 / 18.45 / 22.95 / 29.65	1 character <F> <T>	<F>

R..	= an MRT *without* spot element
Q..	= an MRT *with* spot element
.CB	Rth = 90.2935 + T x 0.38826 (- 100 through + 280 °C)
.CN	Rth = 90.4778 + T x 0.38090 (- 100 through + 280 °C)
.CS	Rth = 90.5000 + T x 0.38730 (- 100 through + 280 °C)

TABLE 7-19 Element type definitions

The following entities ***can*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Product immersion depth]	The minimum required product level distance above an element before this element is taken into account in the average product temperature calculation.	floating point number: <-x.x .. +x.x>	<0.5>
[Hysteresis]	This is a hysteresis mechanism distance around the switching points of the elements that are taken into account in the calculation.	floating point number: <-x.x .. +x.x>	<0.1>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the *SmartView* display.	13 characters	<Product temp.>

7.11.3.2.2 Vapor Temperature

*NOTE: Using Engauge, following entities are set within the Engauge **Vapor temperature** tab.*
Some Vapor temperature settings are shared with Product temperature settings.

The following entities ***can*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Gas immersion depth]	The minimum required distance below an element before it is taken into account in the average Vapor temperature calculation.	floating point number: <-x.x .. +x.x>	<0.5>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the *SmartView* display.	13 characters	<Vapor temp.>

7.11.3.3 Commissioning Parameters for the 765 VITO Water Probe

For the entities to be set for the stand-alone 765 VITO water probe (see FIGURE 7-40), see 7.11.3.3.1.

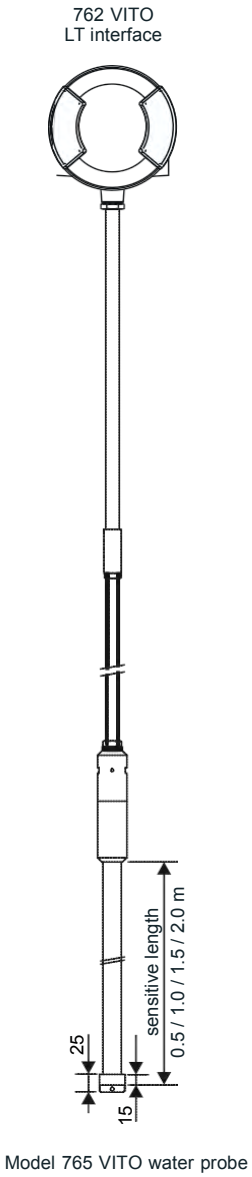


FIGURE 7-40 The model 765 VITO water probe

7.11.3.3.1 Water Level

☛ The following entities ***must*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

Name	Explanation	Value Range	Default
[Maximum water capacity]	The maximum capacity when the probe is fully submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Minimum water capacity]	The minimum capacity when the probe is not submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Water probe bottom position]	The offset to the water probe zero point in relation with the tank zero point	floating point number: <-x.x .. +x.x>	<80>
[Upper reference level]	The distance from tank zero point to upper reference point; is used for water ullage calculation	floating point number: <-x.x .. +x.x>	<80>

☛ The following entities ***can*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-VT module in an instrument.

Name	Explanation	Value Range	Default
[Water probe length]	The length of the 765 VITO water probe.	floating point number: <-x.x .. +x.x>	<0.5>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>

Name	Explanation	Value Range	Default
[Alarm test]	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification]	The current module's function name. This function is visible on the *SmartView* display.	13 characters	<Water level>

7.11.4 Commissioning Check

☛ After having checked/set all before listed entities, make sure

- the [Board Commissioned], the [Product temperature Commissioned], the [Vapor temperature Commissioned], and - if applicable - the [Water level Commissioned] entities are <True>;
- the [Board Health], the [Product temperature Health], the [Vapor temperature Health], and - if applicable - the [Water level Health] entities are <GOOD>.

7.12 Average Temperature Measurement (FII-RTD)

7.12.1 Introduction

The Field Interface Instrument - Resistance Temperature Detector (FII-RTD) board is a sensor module for the instrument (gauge) and calculates average product- , Vapor- and ambient temperatures.

For accomplishing this, RTDs or MRTs must be directly connected to the FII-RTD module.

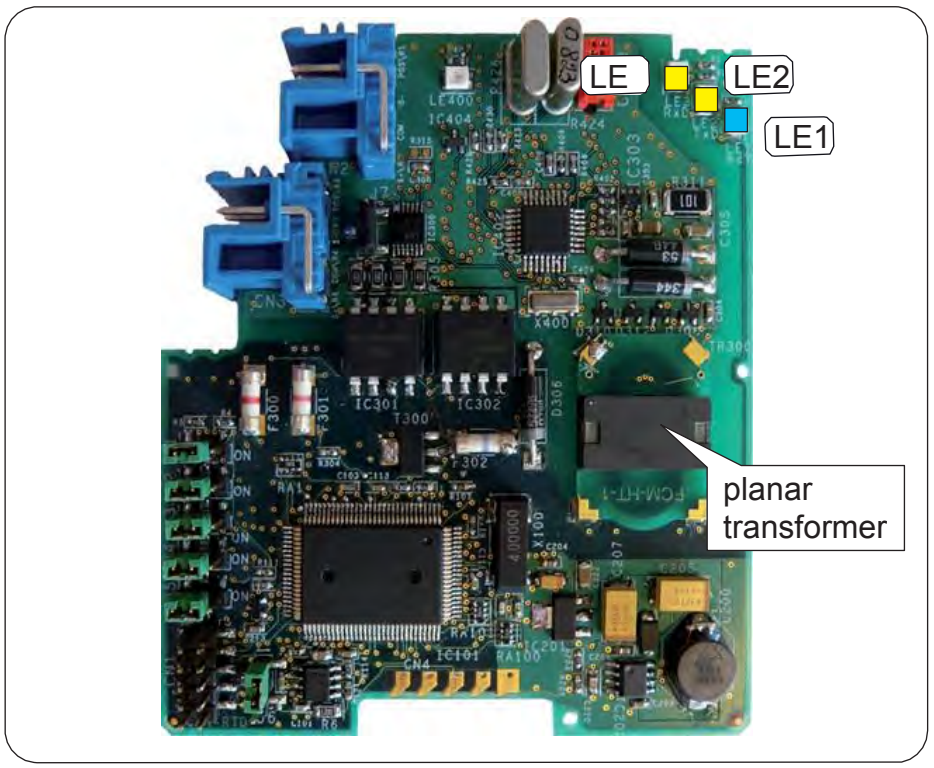


FIGURE 7-41 The FII-RTD board

There are four possible configurations to calculate the average product, Vapor, and ambient temperatures using the FII-RTD board.

- 1 or 2 RTDs in a 3-wire configuration.
- 1 or 2 RTDs in a 4-wire configuration.
- 2 through 6 RTDs as a probe called MPT. It should contain 1 wire per RTD + 2 common wires for all RTDs.
- 2 through 6 MRTs as a probe. It should contain 1 wire per MRT + 2 common wires for all MRTs.

NOTE: Only in RTD 3-wire or 4-wire configurations ambient temperature calculation is possible.

7.12.2 Some Important Settings

The FII-RTD can be tailored to the need of the customer by a lot of settings. See 7.12.4 - Commissioning.

Some important settings of the FII-RTD in Board Specific tab are listed below.

Setting	Remarks
[Measurement type]	″ MPT ″ MRT ″ Mtt ″ No measurement type ″ RTD 3-wire ″ RTD 4-wire
[Element type]	″ Cu100 ″ Cu90 Beacon ″ Cu90 Enraf ″ Cu90 Nulectrohms ″ Ni191 ″ No element type ″ Pt100 large ″ Pt100 small ″ PtCu100 ″ Sangamo MRT ″ Sangamo spot ″ Thermocouple
[RTD configuration]	• RTD1 in tank • RTD1 + RTD2 in tank • RTD1 in tank + RTD2 ambient • RTD1 ambient ″ No RTD configuration ″ RTD1 in tank ″ RTD1 in tank + RTD2 ambient
[Gauge temperature scale]	Can be: • IPTS-68 • ITS-90
[Lowest element offset]	This is the distance from tank bottom till lowest element position
[Number of elements]	Can be 1..6
[MPT sensor length]	-

7.12.3 Some Important Features

- Temperature calculations can be:
  - ″ *Standard* (just simple averaging the spot temperatures).
  - ″ *Enhanced* (averaging the spot temperatures and taking into account the contribution of each spot in respect to its immersion).
  - ″ *Custom* (as *standard* but then giving it a weighing factor).

- A *temperature-range check* can be turned on. In this case, if spot elements are out of range, a fail state results (if not skipped), see FIGURE 7-42.

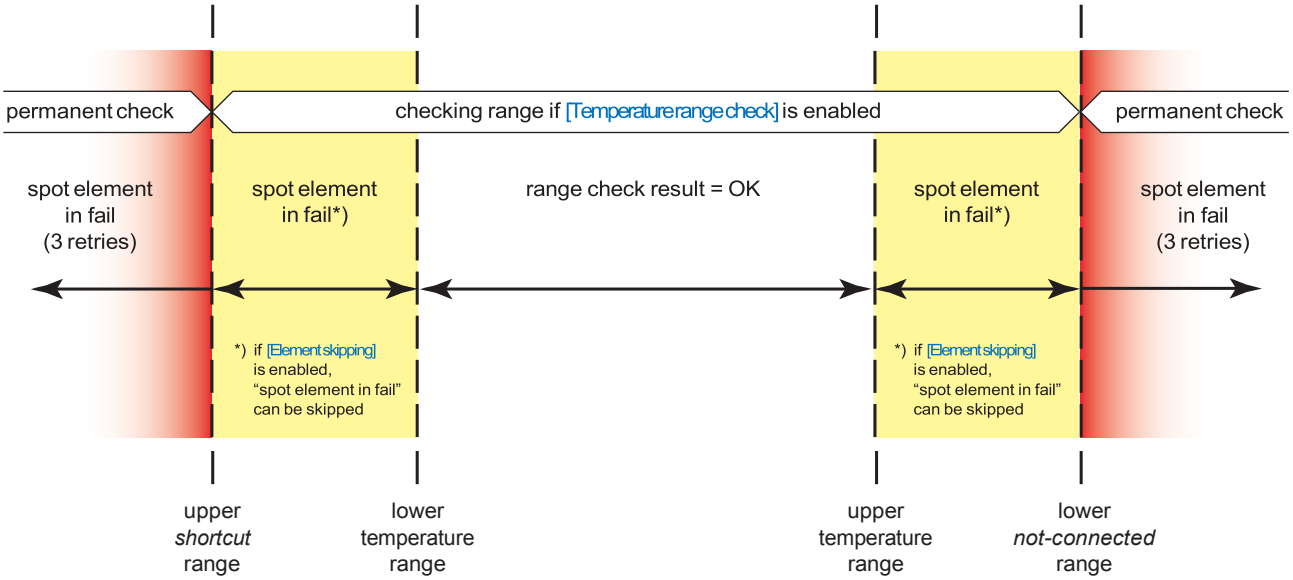


FIGURE 7-42 Temperature range check feature

- *A median filter can be turn on or off, which eliminates spikes of each individual calculated spot temperature.*
- An *averaging constant filter* can be turned on or off, which takes a certain part of the previous calculated average temperature and a certain part of the new calculated temperature into account.
- *Low element usage* with following possible sub-settings can be applied:
  - No exclusion
  - Static exclusion
  - Dynamic exclusion
    These settings are then to be refined further with:
  - Exclude zone
  - Smoothing level
  - Low element behavior

See FIGURE 7-43 on next page.

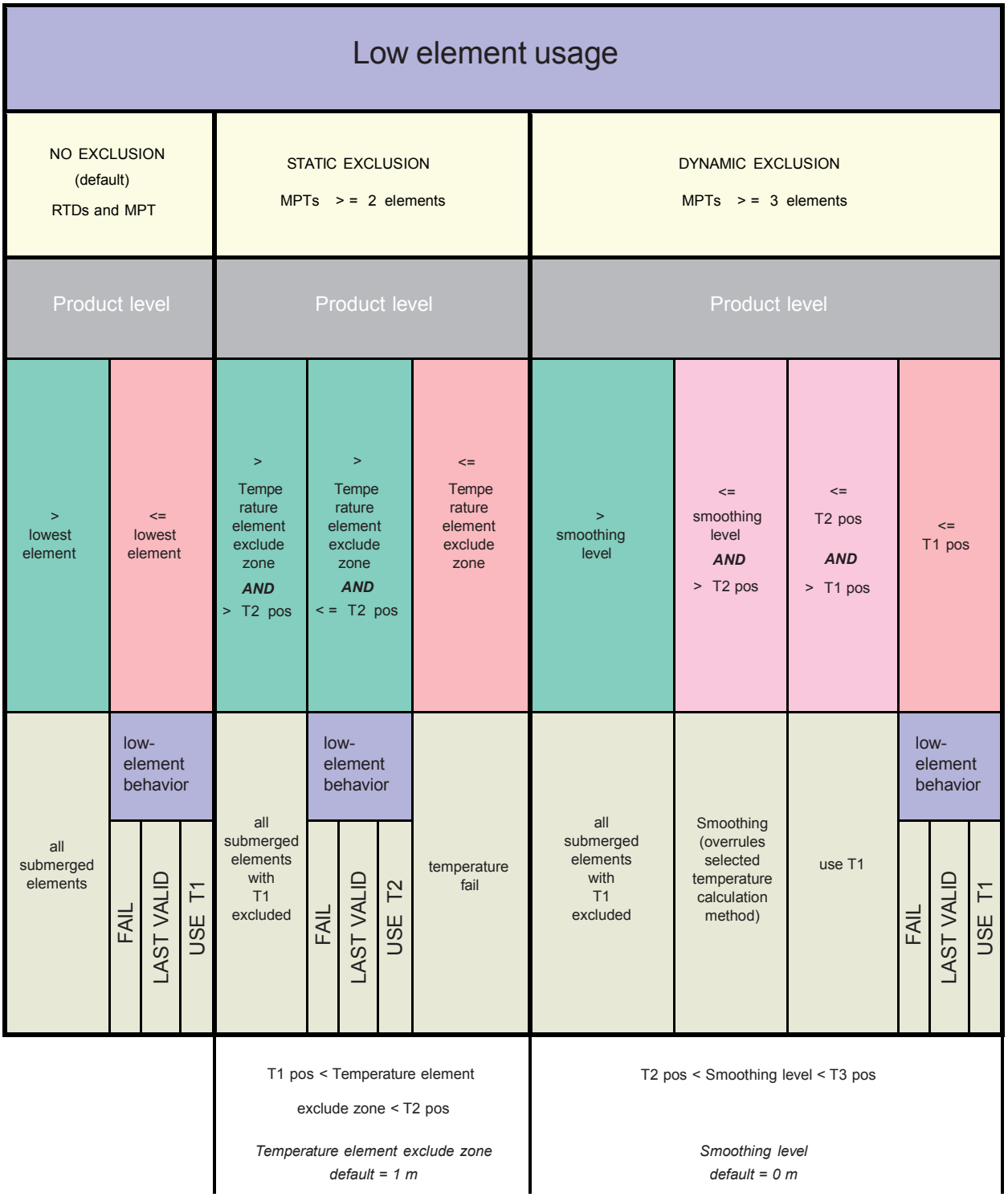


FIGURE 7-43 Low element usage settings overview

- *W&M Sealing*[1]: This board can be electronically sealed via the software. A Notified Body can set his password via [W&M notified body seal password]. He can apply the seal by setting [W&M seal]. Here some data logging is filled in and the related password. This requires a W&M module for Engauge.
  If the primary value of the product temperature is completely valid, then a W&M indication will be set (e.g. visible in SmartView).

  Unsealing: give the [W&M unseal level 1] and [W&M unseal the level 2] commands successively.

  History can be made visible via [W&M seal history].

7.12.4 Commissioning

7.12.4.1 Commissioning Parameters for 1 or 2 RTDs (3- and 4-wire) Temperature Calculations

NOTE: Make sure the RTD/MPT jumper is set to RTD.

☛ The following entities ***must*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-RTD module in an instrument. The default values are available after initialization of the non-volatile memory.

Name	Explanation	Value Range	Default
[Lowest element offset]	The distance from tank zero till the first RTD	floating point number: <-x.x .. +x.x>	<80.0>
[Second element offset] if applicable	The distance from tank zero till the second RTD	floating point number: <-x.x .. +x.x>	<0.0>
[Number of elements]	The number of RTDs used	<1..2>	<0>
[Element type]	The type (material) of the used RTDs	<Pt100 large + small> <Ni191> <PtCu100> <Cu100> <Cu90 enraf + beacon + weston/ solartron/nulectrohms> <Sangamo MRT> <Sangamo spot>	<No type>
[Measurement type]	Selects **RTD**s, MPT, or MRT.	<RTD 3wire> <RTD 4wire> <MPT> <MRT>	<No type>
[RTD configuration]	Selects how the RTDs are positioned.	<RTD1 in tank> <RTD1 and RTD2 in tank> <RTD1 in tank and RTD2 ambient> <RTD1 ambient>	<No configuration>

1. Weights & Measures Sealing.

7.12.4.2 Commissioning Parameters for MPT Temperature Calculations

NOTE: Make sure the RTD/MPT jumper is set to MPT.

☛ The following entities ***must*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-RTD module in an instrument. The default values are available after initialization of the non-volatile memory.

Name	Explanation	Value Range	Default
[Lowest element offset]	The distance from tank zero till the bottom of the probe	floating point number: <-x.x .. +x.x>	<80.0>
[Number of elements]	The number of elements used	<1..6>	<0>
[Element type]	The type (material) of the used RTDs	<Pt100 large + small> <Ni191> <PtCu100> <Cu100> <Cu90 enraf + beacon + weston/ solartron/nulectrohms> <Sangamo MRT> <Sangamo spot>	<No type>
[Measurement type]	Selects RTDs, **MPT**, or MRT.	<RTD 3wire> <RTD 4wire> <MPT> <MRT>	<No type>
[MPT sensor length]	The length of the MPT probe	floating point number: <-x.x .. +x.x>	<80.0>

7.12.4.3 Commissioning Parameters for MRT Temperature Calculations

NOTE: Make sure the RTD/MPT jumper is set to MRT (= MPT position).

☛ The following entities ***must*** be set by *Engauge* or *SmartView* for a correct functioning of the FII-RTD module in an instrument. The default values are available after initialization of the non-volatile memory.

Name	Explanation	Value Range	Default
[Lowest element offset]	The distance from tank zero till the bottom of the probe	floating point number: <-x.x .. +x.x>	<80.0>
[Number of elements]	The number of elements used	<1..6>	<0>

Name	Explanation	Value Range	Default
[Element type]	The type (material) of the used RTDs	<Pt100 large + small> <Ni191> <PtCu100> <Cu100> <Cu90 enraf + beacon + weston/ solartron/nulectrohms> <Sangamo MRT> <Sangamo spot>	<No type>
[Measurement type]	Selects RTDs, MPT, or **MRT**.	<RTD 3wire> <RTD 4wire> <MPT> <MRT>	<No type>

7.12.4.4 Commissioning Parameters for All Types of Probes

*7.12.4.4.1 Engauge *Product temperature* Tab*

☛ The following entities ***can*** be set by *Engauge* or *SmartView* for a specific functioning of the FII-RTD module in an instrument. The default values are available after initialization of the non-volatile memory; so check each entity for its correctness.

Name	Explanation	Value Range	Default
[Product immersion depth]	The minimum required product level distance above an element before this element is taken into account in the average product temperature calculation.	floating point number: <-x.x .. +x.x>	<0.5>
[Hysteresis]	This is a hysteresis mechanism distance around the switching points of the elements that are taken into account in the calculation.	floating point number: <-x.x .. +x.x>	<0.1>
[High high alarm] [High alarm] [Low alarm] [Low low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<1.0E22>

Name	Explanation	Value Range	Default
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is slightly below or above the alarm threshold.	<Enable> <Disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	<No Alarm> <High-high alarm> <High alarm> <Low alarm> <Low-low alarm>	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the *SmartView* display.	13 characters	<Product temp.>
[Element offset] 	Each element can individually be given an offset.	floating point numbers: <-x.x .. +x.x>	<0.0>
[Element weighing factor] 	Each element can individually be given a weighing factor, which is applicable if the calculation method is CUSTOM.	floating point numbers: <-x.x .. +x.x>	<1.0>
[Gauge temperature scale] 	Determines whether the IPTS-68 or ITS-90 scale is used.	<IPTS-68> <ITS-90>	<ITS-90>
[Low element usage] 	See FIGURE 7-43	<No Exclusion> <Static Exclusion> <Dynamic Exclusion>	<No Exclusion>
[Low element behavior] 	See FIGURE 7-43	<Temp To Fail> <Temp To Last Valid> <Temp Use First Element> <Temp Use Second Element>	<Temp To Fail>
[Temperature element exclude zone] 	See FIGURE 7-43	floating point number: <-x.x .. +x.x>	<1.0>
[Smoothing level] 	See FIGURE 7-43	floating point numbers: <-x.x .. +x.x>	<0.0>

Name	Explanation	Value Range	Default
[MPT element position mode] *[Only for MPT]*	Determines whether the element positions are automatically calculated (based on sensor length) or manually entered.	<Automatically> <Manually>	<Automatically>
[RTD element positions] *[Only for MPT]*	If MPT element position mode is MANUALLY then here the positions can be filled in.	floating point numbers: <-x.x .. +x.x>	<0.0>
[Averaging constant filter]	Enables or disables a averaging constant filter.	<enable> <disable>	<enable>
[Averaging constant]	Value of how much of the old calculated value is used with respect to the new calculated value.	<0.0 .. 1.0>	<0.9>
[Temperature range check]	Enables or disables the fact that an element which is outside a temperature range will lead to temperature fail. (See also FIGURE 7-42.)	<enable> <disable>	<disable>
[Element skipping]	Enables or disables the fact that elements can be skipped if an element is outside a temperature range.	<enable> <disable>	<disable>
[Maximum skipped elements]	The number of elements that can be skipped.	<1,2>	<1>
[Median filter]	Enables or disables a median filter of 5 levels deep (spike filtering).	<enable> <disable>	<enable>
[Temperature calculation method]	The way the average temperature is calculated (see also features above).	<Standard> <Custom> <Enhanced>	<Enhanced>
[MRT length table] *[Only for MRT]*	Specifies whether a fixed range of MRT resistors is used (= <F>) or user configured lengths (= <T>). Fixed lengths are: 0.65, 1.25, 1.95, 2.85, 4.15, 5.65	1 character <F> <T>	<F>

Name	Explanation	Value Range	Default
[MRT element length used if MRT length table is 'T'] *[Only for MRT]* 	The lengths of the MRTs including anchor eye.	floating point numbers: <-x.x .. +x.x>	<0.0>

*7.12.4.4.2 Engauge * Vapor temperature * Tab*

NOTE: Some settings for Vapor temperature calculations are shared via the product temperature settings.

☛ The following entities ***can*** be set by *Engauge* or *SmartView* for a specific functioning of the FII-RTD module in an instrument. The default values are available after initialization of the non volatile memory; so check each entity for its correctness.

Name	Explanation	Value Range	Default
[Gas immersion depth]	The minimum required distance below an element before it is taken into account in the average Vapor temperature calculation.	floating point number: <-x.x .. +x.x>	<0.5>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 Thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The name of the current function of this module. This name is visible on the SmartView.	13 characters	<Vapor temp.>

7.12.4.4.3 *Engauge * Ambient temperature * Tab*

NOTE: Some settings for ambient temperature calculations are shared via the product temperature settings.

☛ The following entities ***can*** be set by *Engauge* or *SmartView* for a specific functioning of the FII-RTD module in an instrument. The default values are available after initialization of the non volatile memory; so check each entity for its correctness.

Name	Explanation	Value Range	Default
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 Thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The name of the current function of this module. This name is visible on the SmartView.	13 characters	<Ambient temp.>

7.12.5 Commissioning Check

☛ After having checked/set all before listed entities, make sure

- the [Board Commissioned], the [Product temperature Commissioned], the [Vapor temperature Commissioned], and the [Ambient Temperature Commissioned] entities are <True>;
- the [Board Health], the [Product temperature Health], the [Vapor temperature Health], and the [Ambient Temperature Health] entities are <GOOD>.

For viewing the *software version,* the Engauge *Generic tab* can be viewed; also a *Reset board command* can be issued here.

NOTE: In the SmartView situation, the Commissioning flag must be 'G' and the Health flag must be 'Y'.

7.13 FCI-HRT

7.13.1 Introduction

The Field Communication Instrument - HART (FCI-HRT) board is a module that communicates with HART *SmartView*.

The FCI-HRT board is a HART®[1] master module that enables hybrid-signal (both analog + digital) communication between the FlexConn instrument and a HART sensor and VITO-data processor module, which calculates average product- and Vapor temperatures, and optionally a water level.

.

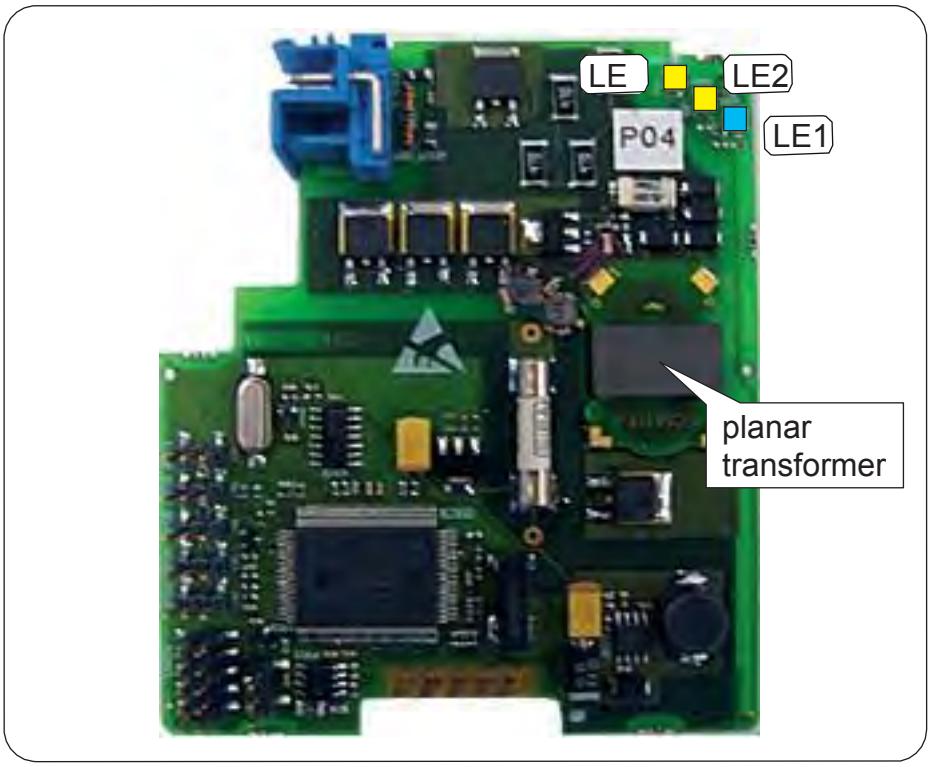


FIGURE 7-44 The FCI-HRT board

The HART protocol is a bi-directional master-slave communication protocol, which is used to communicate between intelligent field instruments and host systems.

The FCI-HRT board has a planar transformer for galvanic isolation from the HART bus. See FIGURE 7-26.

1. Highway Addressable Remote Transducer.

LED LE1 is the board's [Health] LED. LEDs LE2 and LE3 will be flashing to indicate activity on the HART bus. LE2 indicates data is being transmitted (Tx), LE3 indicates data is being received (Rx).

With the HART protocol, an analog 4-20 mA signal can be combined with a digital Frequency Shift Keying (FSK) signal. See FIGURE 7-45.

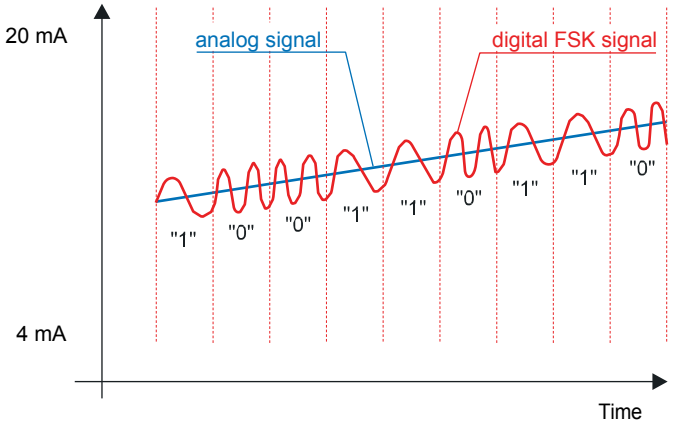


FIGURE 7-45 The analog and digital signals within the HART® communication

By using the HART® protocol (see also 7.9.1), the HRT module can be connected to one VITO-interface which in turn is connected to a probe for *product temperature*, *Vapor temperature*, *water level*, or a combination of these.

The HRT board has a planar transformer for galvanic isolation from the HART bus. See FIGURE 7-35.

LED LE1 is the board's [Health] LED. LEDs LE2 and LE3 will be flashing to indicate activity on the HART bus. LE2 indicates data is being transmitted (Tx), LE3 indicates data is being received (Rx).

7.13.2 HART SmartView Display Interface

At request from HART *SmartView* the FCI-HRT board prepares data sets for it. The requests from HART *SmartView* depend on the actual screen at the time. The communication between the FCI-HRT board and HART *SmartView* uses an own protocol on HART.

For a correct functioning of the HRT module in an instrument the following entities can be set by using either *Engauge* or *SmartView*.

☛ By using the following table, check each entity for correctness.

Name	Value Range	Default Value	Explanation
[Decimal separator]	<point> <comma>	<point>	The decimal separator in which entities are shown on the *SmartView* display.
[Tenth millimeter selection]	<enable> <disable>	<enable>	Determines whether the tenth millimeter is shown on the display in the [PV screen] in case a level entity is shown.
[Identification]	8 characters e.g. <TANK1234>	<-------->	Name of a tank or instrument. This string is visible within a [PV screen].
[Password]	<.....> 6 characters	<ENRAF2>	The password *SmartView* uses for entering the protected level. Note: Some settings reside under the protected level.
[Function identification] 	<.....> 13 characters	<SmartView mst>	The name of the current function of this module. This name is visible on the *SmartView* display.
[Extra information switch]	<level temperature> <Info Switch>	<Info Switch>	Determines whether the [extra information] screen on the *SmartView* will display level and temperature or extra information from a specific function.
[Extra info board ID]	<01.....XX> 2 digits	<01>	Board ID of the board that has the [extra information] to display. In case of OneWireless, the ID = 12.
[Extra info board instance]	<00.....XX> 2 digits	<00>	Board instance of the board that has the [extra information] to display.
[Extra info function instance]	<01.....XX> 2 digits	<01>	Function instance that has extra information to display. In case of OneWireless, this = 01.

7.13.3 Pressure & Density Measurement and Other HART Inputs (FCI-HRT)

7.13.3.1 Software Description

The FCI-HRT board, being a functional module of the SmartRadar FlexLine, contains embedded software which enables it to collect data input from sensors via both the HART bus and the FlexConn CAN bus.

Moreover, the FCI-HRT module can calculate the HIMS[1] product density.

The *main* function of the FCI-HRT software is to measure HIMS product density, by connecting the FCI-HRT board via the HART bus to 1 or 2 pressure sensors, and via the FlexConn bus to a product level and a water level sensor.

To measure product density, the needed standard system configuration is:

- HART pressure sensor P1 (product pressure)
- HART pressure sensor P3 (Vapor pressure)
- Product level scanned from a FlexConn board (e.g. TII-XR)
- Water level scanned from a FlexConn board (e.g. HRT)

For tanks that are free venting to the atmosphere or floating-roof tanks, P3 pressure is not required. The water level sensor is also optional.

1. Hybrid Inventory Measurement System.

For HIMS density measurement system diagrams, see FIGURE 7-28 and FIGURE 7-29.

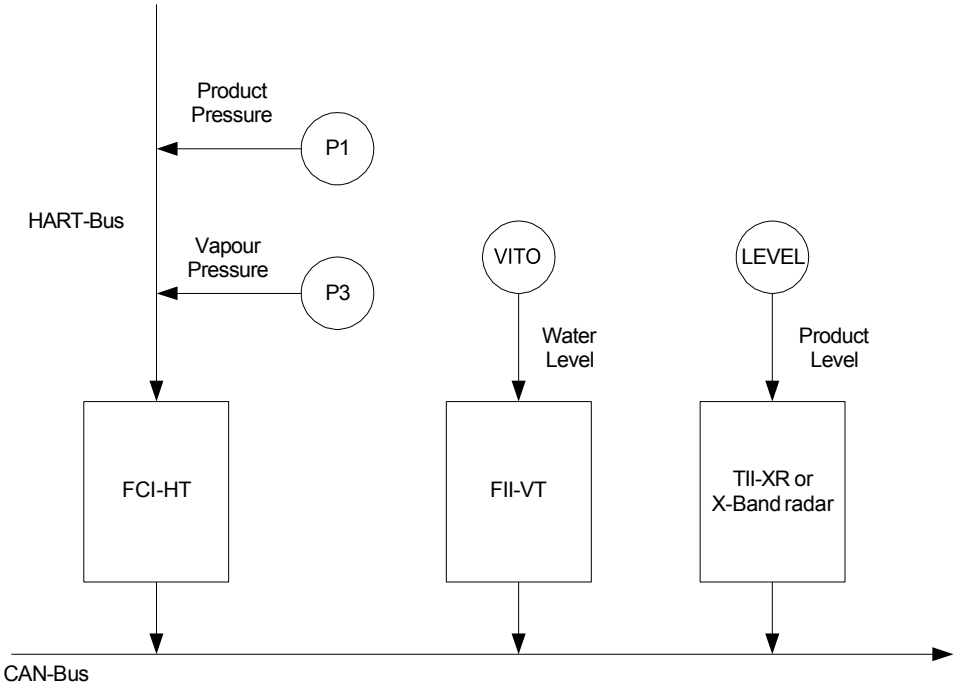


FIGURE 7-46 Standard HIMS density measurement system diagram

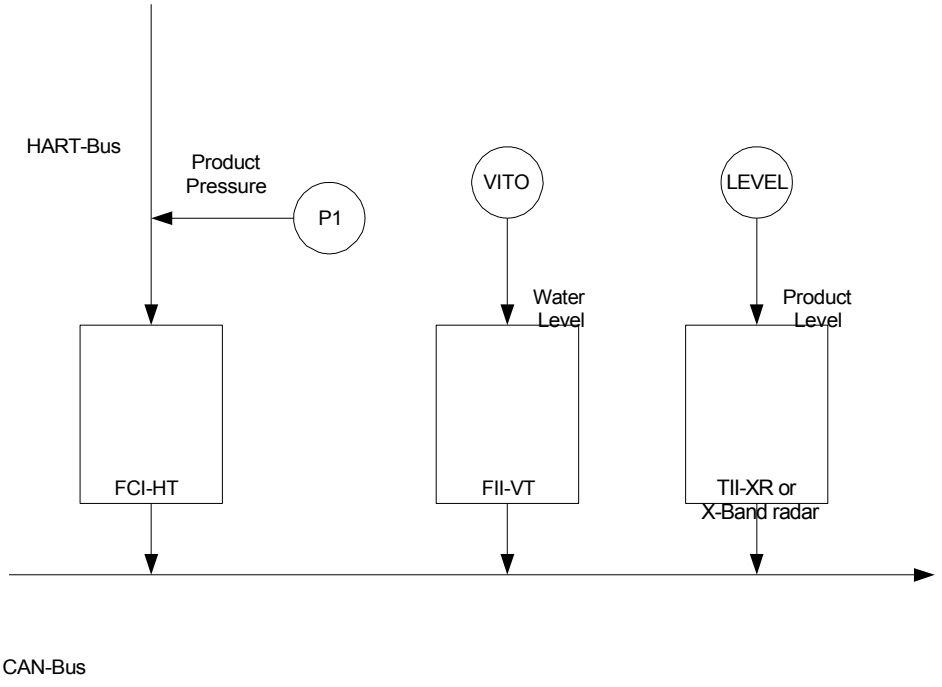


FIGURE 7-47 Floating-roof or free-venting tank HIMS density measurement system diagram

As an *alternative* function, the FCI-HRT board also allows the connection of up to 5 generic HART sensors operating in *multi-drop digital* mode or one generic HART sensor operating in *analog* mode.

In the multi-drop digital mode situation, one or two of the generic HART sensors can be [P1 Pressure] or [P3 Pressure], providing product pressure and Vapor pressure respectively, but no HIMS density calculation will be available.

The HART sensors and HIMS density measurement are allocated to a function number in the FCI-HRT software. See table below.

FlexConn Function	Device Type
Function 1	[P1 Pressure]
Function 2	[P3 Pressure]
Function 3	[Distance]
Function 4	[Temperature]
Function 5	[Pressure]
Function 6	[Density]
Function 7	[Other]
Function 8	[HIMS Density]

TABLE 7-20 FlexConn function allocation

Function 1 is exclusively reserved for P1 pressure, Function 2 is exclusively reserved for P3 pressure, and Function 8 is exclusively reserved for HIMS density calculation.

Only one of each type of HART device can be allocated to a function. Therefore, this limits the number of HART devices of each type that can be fitted.

Example 1

4 HART pressure devices and 1 temperature device can be connected.

- P1 pressure device allocated to Function 1
- P3 pressure device allocated to Function 2
- one pressure device allocated to Function 5
- one pressure device allocated to Function 7
- the temperature device allocated to Function 4

Example 2

2 HART density devices and 1 distance device can be connected.

- density device 1 allocated to Function 6
- density device 2 allocated to Function 7
- the distance device allocated to Function 3

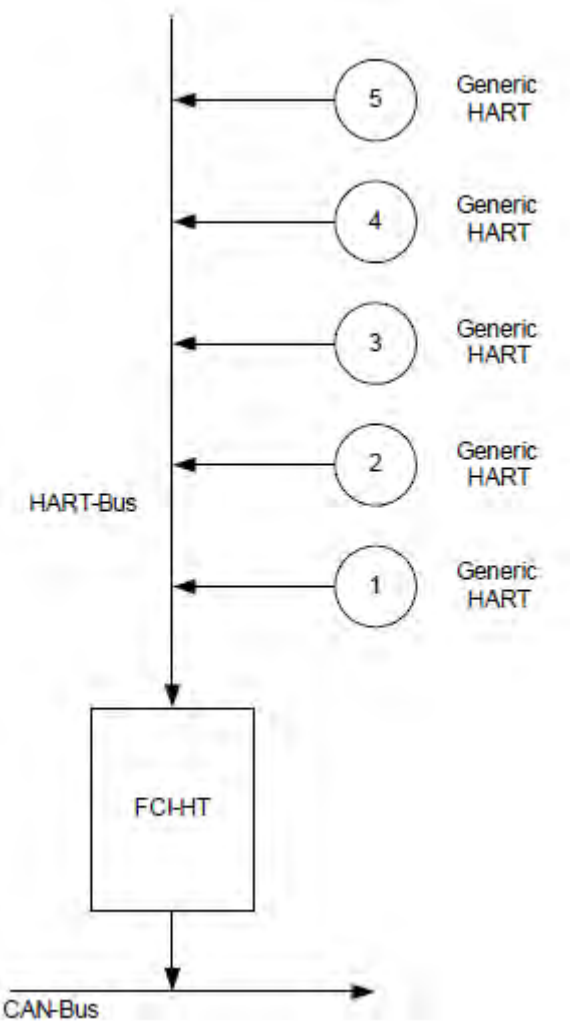


FIGURE 7-48 Alternate system diagram multi-drop digital mode

In analog mode, the connected HART device will be allocated to Function 1 through 7, depending on the type of HART device connected.

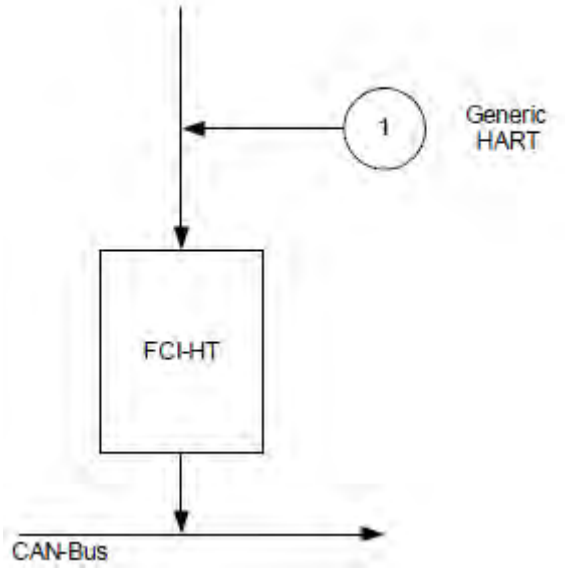


FIGURE 7-49 Analog mode system diagram

7.13.3.2 Software Specifications

7.13.3.2.1 General

The *main* function of the FCI-HRT software is to measure HIMS product density, by connecting the FCI-HRT board via the HART bus to 2 pressure sensors (P1 and P3), and via the FlexConn bus to a product level sensor and an optional water level sensor.

The *alternative* function is to connect up to 5 generic HART devices operating in multi-drop digital mode, or 1 generic HART device operating in analog mode.

The FCI-HRT software only supports HART devices with the following addresses.

HART Address	Function
00	Reserved for HART device in analog mode
01	Reserved for P1 pressure sensor
02	N/A Reserved for future use
03	Reserved for P3 pressure sensor
04	HART generic sensor

HART Address	Function
05	HART generic sensor
06	HART generic sensor
07	HART generic sensor
08	HART generic sensor
09	HART generic sensor
10	HART generic sensor
11	HART generic sensor
12	HART generic sensor
13	HART generic sensor
14	HART generic sensor
15	HART generic sensor

TABLE 7-21 Accepted HART addresses

☛ Before proceeding with commissioning, first check the maximum start-up current of all connected HART devices.

☛ Make sure the HART address of the installed device(s) are in accordance with TABLE 7-2.

7.13.3.2.2 P1 Pressure

The FCI-HRT software only accepts the Primary Value of a P1 pressure HART device in SI units kilo Pascals (kPa).

☛ Make sure the P1 pressure HART device is configured to output data in kilo Pascals (kPa). If not, correctly configure as yet, by using an appropriate HART configuration tool.

Sensor Type	Accepted HART PV Unit	Abbreviation	HART PV Unit Code
P1 Pressure	Kilo Pascal	kPa	12

TABLE 7-22 Accepted PV unit for a P1 HART device

NOTE: The Secondary and Tertiary values of a P1 pressure HART device may be any units.

The PV of the P1 pressure HART device is read and converted into SI Units Pascals (Pa) within the FlexConn function PV.

The value is filtered, and the filtering factor depends on the value set in the entity [P1 Integration time]. A higher value gives more filtering, and a lower value gives less filtering.

The correction factor stored in the [P1 PV offset] entity is then subtracted from the filtered value. If the [P1 PV offset] entity = 0 no offset is applied.

P1 is a default relative pressure.

If an absolute pressure is needed, set the entity “Standard ambient air pressure” to 0.

Pressure PV	Pressure Type	Standard Ambient Air Pressure
Pressure	Absolute	0
	Relative	Any value

TABLE 7-23 P1 pressure displayed unit types

If Relative pressure is selected, the value stored in the [Ambient Air Pressure] entity is added to the measured pressure. If Absolute pressure is selected, no factor is added. The final result is available in the [Primary Value] entity.

NOTE: Absolute pressure is used in the density calculation; the relative pressure is only displayed in P1 [Primary Value].

For the FCI-HRT software to differentiate between a HART device malfunction and a HART device not actually installed, P1 pressure has the entity [P1 Installed] which must be set to either <Installed> if a P1 pressure HART device is actually fitted or <Not Installed> if a P1 pressure HART device is *not* actually fitted.

The Secondary and Tertiary values of a P1 pressure HART device are not converted, and they are simply translated from the HART device to the FlexConn environment.

7.13.3.2.3 P3 Pressure

The FCI-HRT software only accepts the Primary Value of a P3 pressure HART device in SI units kilo Pascals (kPa).

☛ Make sure the P3 pressure HART device is configured to output data in kilo Pascals (kPa). If not, correctly configure as yet, by using an appropriate HART configuration tool.

Sensor Type	Accepted HART PV Unit	Abbreviation	HART PV Unit Code
P3 Pressure	Kilo Pascal	kPa	12

TABLE 7-24 Accepted PV unit for a P3 HART device

NOTE: The Secondary and Tertiary values of a P3 pressure HART device may be any units.

The PV of the P3 pressure HART device is read and converted into SI Units Pascals (Pa) within the FlexConn function PV.

The value is filtered, and the filtering factor depends on the value set in the entity [P3 Integration time]. A higher value gives more filtering, and a lower value gives less filtering.

The correction factor stored in the [P3 PV offset] entity is then subtracted from the filtered value. If the [P3 PV offset] entity = 0 no offset is applied.

P3 is a default relative pressure.

If an absolute pressure is needed, set the entity “Standard ambient air pressure” to 0.

Pressure PV	Pressure Type	Standard Ambient Air Pressure
Pressure	Absolute	0
	Relative	Any value

TABLE 7-25 P3 pressure displayed unit types

If Relative pressure is selected, the value stored in the [Ambient Air Pressure] entity is added to the measured pressure. If Absolute pressure is selected, no factor is added. The final result is available in the [Primary Value] entity.

NOTE: Absolute pressure is used in the density calculation; the relative pressure is only displayed in P3 [Primary Value].

For the FCI-HRT software to differentiate between a HART device malfunction and a HART device not actually installed, P3 pressure has the entity [P3 Installed] which must be set to either <Installed> if a P3 pressure HART device is actually fitted or <Not Installed> if a P3 pressure HART device is *not* actually fitted. For example, in the case of free-venting tanks, P3 would usually not be installed.

If the P3 pressure status is <Good Actual>, the P3 pressure value is also stored in memory in the [Last Valid P3] entity, to allow recovery from a power-down situation when a P3 pressure is not available.

If the measured P3 pressure is *invalid* (e.g. HART scan error), the software will check the [P3 Installed] entity to determine if P3 is actually fitted. If P3 is fitted, the software will check for a [Manual P3 Pressure] entity value to be entered. If no manual P3 pressure value is entered, the [Last Valid P3] is used in the density calculation. If no [Last Valid P3] is available, an error will be reported.

If P3 pressure is *not* installed - in the case of free-venting tanks - a default value of 0.0 for P3 pressure is used for density calculations.

The Secondary and Tertiary values of a P3 pressure HART device are not converted, and they are simply translated from the HART device to the FlexConn environment.

7.13.3.2.4 *HIMS Density*

To make HIMS density calculation possible, the relevant entity values must be available. See also FIGURE 7-32.

☛ Read also the *Instruction Manual HIMS pressure measurement*.

Engauge
HART SmartView

☛ Enter the appropriate values into the following entities:

- [Distance P1 to Zero Level]
- [Distance P3 to Zero Level]
- [Hydrostatic Deformation Level]
- [Hydrostatic Deformation Factor]
- [Local Gravity]
- [Minimum HIMS Level]
- [HIMS Level Hysteresis]
- [Ambient Air Density]
- [Tank Vapor Density]

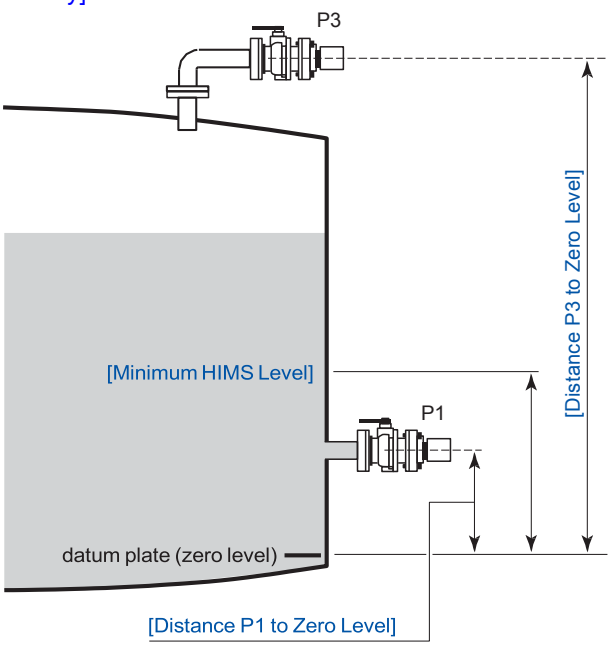


FIGURE 7-50 HIMS configuration principle

To calculate HIMS density, the following valid data must be available:

- P1 pressure
- P3 pressure
- Product level
- Water level (optional)

The software analyses the status of these 4 (3) inputs, to determine the value and status of the [HIMS Density PV].

If the HIMS Density PV status is <Good Actual>, the HIMS Density PV value is also stored in memory in the [Last Valid Density] entity, to allow recovery from a power-down situation when a HIMS Density PV value is not available.

If any of the 4 input statuses are bad, the software will check for a [Manual Product Density] entity value to be entered. If a [Manual Product Density] entity value is entered, this value will be used for the HIMS Density PV. If no [Manual Product Density] entity value is entered, the software will check if a [Last Valid Product Density] entity value was stored. If a [Last Valid Product Density] entity value was stored, this value will be used for the HIMS Density PV. If no [Manual Product Density] or [Last Valid Product Density] entity value is found, an error will be reported.

When calculating HIMS Density, the software will check for a negative density value. If the value is negative, the same manual or last-valid mechanism is used as described before. If the value is positive, HIMS Density is calculated.

When calculating HIMS Density, in order to achieve a valid result, the software will also check if the product level is above the [Minimum HIMS Level] entity value. If this condition is <True>, HIMS Density is calculated. If the product level is below the [Minimum HIMS Level] entity value, the same manual or last valid mechanism is used as described before.

When calculating HIMS Density, if the [Water Level Correction] entity is <Enabled>, the software will check if the scanned water level <= [Distance P1 to Zero Level]. If this is <True>, the HIMS Density is calculated. If the water level > [Distance P1 to Zero Level], the same manual or last valid mechanism is used as described before. If [Water Level Correction] entity is <Disabled>, the software will not check the scanned water level.

7.13.3.2.5 Generic HART Devices

The FCI-HRT software only accepts Generic HART devices at addresses 0 and 4 through 15 with the required sensor type configured.

The generic HART devices are scanned sequentially from address 0 and then address 4 through 15. When a device is detected, initially the HART PV unit code is checked against TABLE 7-7 in the following order: Distance, Temperature, Pressure, and Density.

Sensor Type	Accepted HART Units	Abbreviation	HART Unit Code
Pressure	Pounds per square inch	psi	6
	Pascal	Pa	11
	Kilo Pascal	kPa	12

Sensor Type	Accepted HART Units	Abbreviation	HART Unit Code
Temperature	Degrees Celsius	°C	32
	Degrees Fahrenheit	°F	33
Distance	Feet	ft	44
	Meters	m	45
	Inches	in	47
Density	Kilograms per cubic meter	kg/m^3	92
	Pounds per cubic foot	lb/ft^3	94
	Degrees API	API	104

TABLE 7-26 Accepted units for generic HART devices

- If an accepted HART PV unit code is found, the HART device is allocated to the relevant FlexConn function as detailed in TABLE 7-8.
- If the HART PV unit code is *not* accepted, the HART SV unit code is checked against TABLE 7-7 in the following order: Distance, Temperature, Pressure, and Density. If an accepted HART SV unit code is found, the HART device is allocated to the relevant FlexConn function as detailed in TABLE 7-8.
- The process is repeated for the HART TV unit code.
- If none of the unit codes are accepted, the device is allocated to Function 7.

Engauge
HART SmartView

☛ If a generic HART device output is *not* in the accepted units, configure it to accepted units output data, by using the HART configuration tool.

FlexConn Function	Device Type
Function 1	[P1 Pressure]
Function 2	[P3 Pressure]
Function 3	[Distance]
Function 4	[Temperature]
Function 5	[Pressure]
Function 6	[Density]
Function 7	[Other]
Function 8	[HIMS Density]

TABLE 7-27 FlexConn function allocation

Once a device has been allocated to a function, the HART PV, SV, and TV are translated into the FlexConn function's PV, SV, and TV.

The required sensor value of the generic HART device may not be in the HART PV but it is translated into the FlexConn PV.

Example:

A HART temperature sensor may have a PV unit code Ohms, and a SV unit code Celsius. The required sensor value is temperature in Celsius, and this is translated into the FlexConn PV, and the Ohms value is translated into the FlexConn SV.

Translation is performed in the order: PV (Distance, Temperature, Pressure, and Density), SV (Distance, Temperature, Pressure, and Density), TV (Distance, Temperature, Pressure, and Density).

The required sensor value read from the generic HART devices will be converted into SI Units within the FlexConn PV as shown in TABLE 7-9.

The other sensor values of a generic HART device are not converted, and they are simply translated from the HART device environment into the FlexConn environment SV and TV.

Accepted HART Units	Abbreviation	FlexConn PV Unit Translation	Abbreviation
Pounds per square inch	psi	Pascal	Pa
Pascal	Pa		
Kilo Pascal	kPa		
Degrees Celsius	°C	Celsius	°C
Degrees Fahrenheit	°F		
Feet	ft	Meters	m
Meters	m		
Inches	in		
Kilograms per cubic meter	kg/m^3	Kilograms per cubic meter	kg/m^3
Pounds per cubic foot	lb/ft^3		
Degrees API	API		

TABLE 7-28 Generic HART device units into FlexConn PV unit translation

7.13.3.2.6 Function Identification

Functions 1 through 8 are identified by the entities: [Function Category], [Function Type], and [Function Sub-type].

Their default identification information is detailed in TABLE 7-10.

Function	Allocation	Function Category	Function Type	Function Sub-type
Function 1	P1 Pressure	Sensor (1)	Product pressure (5)	(6)
Function 2	P3 Pressure	Sensor (1)	Vapor pressure (13)	(7)
Function 3	Distance	Sensor (1)	HART transmitter (12)	(16)
Function 4	Temperature	Sensor (1)	HART transmitter (12)	(16)

Function	Allocation	Function Category	Function Type	Function Sub-type
Function 5	Pressure	Sensor (1)	HART transmitter (12)	(16)
Function 6	Density	Sensor (1)	HART transmitter (12)	(16)
Function 7	Other	Sensor (1)	HART transmitter (12)	(16)
Function 8	HIMS Density	Sensor (1)	Product density (6)	(8)

TABLE 7-29 Default function category, type, and sub-type

The function type entity for Functions 3 through 7 can be changed from the default value <HART transmitter> to provide more information about the sensor, by setting the [User function type] entity and then resetting the FCI-HRT board.

The possible values are detailed in TABLE 7-11.

Function	Allocation	User Function Type	Value
Function 3	Distance	User function type product level	4
		User function type water level	9
Function 4	Temperature	User function type product temperature	8
		User function type Vapor temperature	7
Function 5	Pressure	User function type product pressure	5
		User function type Vapor pressure	13
Function 6	Density	User function type product density	6
Function 7	Other	User function type product level	4
		User function type water level	9
		User function type product temperature	8
		User function type Vapor temperature	7
		User function type product pressure	5
		User function type Vapor pressure	13
		User function type product density	6

TABLE 7-30 Generic HART user function types

Functions 1 through 8 have fixed values for [PV Unit Type] and [Function Identification] entities, as detailed in TABLE 7-12.

Function	Allocation	PV Unit Type	Function Identification
Function 1	P1 Pressure	UNIT_TYPE_PRESSURE	<P1 Pressure>

Function	Allocation	PV Unit Type	Function Identification
Function 2	P3 Pressure	UNIT_TYPE_PRESSURE	<P3 Pressure>
Function 3	Distance	UNIT_TYPE_LENGTH	<Distance>
Function 4	Temperature	UNIT_TYPE_TEMPERATURE	<Temperature>
Function 5	Pressure	UNIT_TYPE_PRESSURE	<Pressure>
Function 6	Density	UNIT_TYPE_DENSITY	<Density>
Function 7	Other	UNIT_TYPE_UNDEFINED	<Other Units>
Function 8	HIMS Density	UNIT_TYPE_DENSITY	<HIMS Density>

TABLE 7-31 PV unit type and function identification

7.13.3.2.7 HART SmartView Display

Although the Primary Values (PV) of functions 1 through 8 are *calculated* in SI units, the *HART SmartView display* supports the following units for local calibration, commissioning etc. The displayed unit depends on the value of the [PV selected unit] entity.

PV Unit Type	Display Unit Type	Displayed Units	PV Selected Unit	Range
Pressure	Pascal	<pas>	1	max. 0.99 MPa
	Kilo Pascal	<kpas>	2	max. 9.9 MPa
	Pounds per square inch (small)	<psi s>	3	max. 99 psi
	Pounds per square inch (large)	<psi l>	4	max. 999 psi
Temperature	Degrees Celsius	<°C>	1	-
	Degrees Fahrenheit	<°F>	2	-
Distance	Meters	<m>	1	-
	Feet	<ft>	2	-
	Inches	<in>	3	-
	Fractions (feet, inches, $1/16^{th}$ inch)	<f.i.s.>	4	-
Density	Kilograms per cubic meter	<kg/m3>	1	-
	Pounds per cubic foot	<lb/f3>	2	-
	Degrees API	<a.p.i>	3	-
Other	Milli	<m ...>	1	-
	(none)	<->	2	-
	Kilo	<k ...>	3	-
	Mega	<M ...>	4	-

TABLE 7-32 HART SmartView displayed unit types

The following PV types are supported on the HART SmartView display for P1 pressure and P3 pressure only.

P1 and P3 are default relative pressures.

If an absolute pressure is needed, set the entity “Standard ambient air pressure” to 0.

Pressure PV	Pressure Type	Standard Ambient Air Pressure
Pressure	Absolute	0
	Relative	Any value

TABLE 7-33 P1 and P3 pressure displayed unit types

7.13.3.3 Board Commissioning

The commissioning entity for each *function* is initially default to <False>. The commissioning entity for each function will only be <True> when the associated entities of each function have been set *within normal operating range*.

The *board-level* commissioned entity default is also <False>. It will only be <True> when all the function-level commissioned entities are <True>.

7.13.3.3.1 Function 1 Commissioning

☛ Set all Function 1 entities according to TABLE 7-15 requirements, to commission P1.

HIMS Density	P1 Pressure Sensor Detected	P1 Ambient Air Pressure and P1 Installed	Commissioned
<Enabled>	N/A	[P1 ambient air pressure] ≠ <default> AND [P1 installed] = <enable>	<True>
		[P1 ambient air pressure] = <default> OR [P1 installed]= <disable>	<False>
<Disabled>	Yes	[P1 ambient air pressure] ≠ <default> AND [P1 installed] = <enable>	<True>
		[P1 ambient air pressure] = <default> OR [P1 installed] = <disable>	<False>
	No	N/A	<True>

TABLE 7-34 Function 1 commissioning entities

7.13.3.3.2 Function 2 Commissioning

☛ Set all Function 2 entities according to TABLE 7-16 requirements, to commission P3.

HIMS Density	P3 Pressure Sensor Detected	P3 Installed	P3 Ambient Air Pressure	Commissioned
<Enabled>	Yes	<Enable>	[P3 ambient air pressure] ≠ <default>	<True>
			[P3 ambient air pressure] = <default>	<False>
		<Disable>	N/A	<False>
	No	<Enable>	N/A	<False>
		<Disable>		<True>
<Disabled>	Yes	<Enable>	[P3 ambient air pressure] ≠ <default>	<True>
		<Disable>	[P3 ambient air pressure] ≠ <default>	<False>
		N/A	[P3 ambient air pressure] = <default>	<False>
	No	N/A	N/A	<True>

TABLE 7-35 Function 2 commissioning entities

7.13.3.3.3 Function 3 through 7 Commissioning

☛ Set all Function 3 through 7 entities according to TABLE 7-17 requirements, to commission all generic HART sensors.

Function	HART Sensor Detected	User Function Type	Commissioned
3	Yes	= <Product level> OR <Water level>	<True>
		≠ <Product level> OR <Water level>	<False>
	No	N/A	<True>
4	Yes	= <Product temp.> OR <Vapor temp.>	<True>
		≠ <Product temp.> OR <Vapor temp.>	<False>
	No	N/A	<True>
5	N/A	N/A	<True>
6	N/A	N/A	<True>
7	N/A	N/A	<True>

TABLE 7-36 Function 3 through 7 commissioning entities

7.13.3.3.4 Function 8 Commissioning

☛ Set Function 8 entities according to TABLE 7-18 requirements, to commission the HIMS density function.

HIMS Density	Function 8 Commissioning Entities	Commissioned
Enabled	<Hydrostatic deformation level> ≠ <Default> AND <Hydrostatic deformation factor> ≠ <Default> AND <Local gravity> ≠ <Default> AND <Minimum HIMS level> ≠ <Default> AND <Ambient air density> ≠ <Default> AND <Tank Vapor density> ≠ <Default> AND <Distance P1 to zero level> ≠ <Default> AND <Distance P3 to zero level> ≠ <Default>	<True>
	<Hydrostatic deformation level> = <Default> OR <Hydrostatic deformation factor> = <Default> OR <Local gravity> = <Default> OR <Minimum HIMS level> = <Default> OR <Ambient air density> = <Default> OR <Tank Vapor density> = <Default> OR <Distance P1 to zero level> = <Default> OR <Distance P3 to zero level> = <Default>	<False>
Disabled	N/A	<True>

TABLE 7-37 Function 8 commissioning entities

7.13.3.4 Hardware Configuration

7.13.3.4.1 Terminal Allocation

Terminal Number	Name	Function
24	V_Loop	HART Bus power
25	GND_Loop	HART Bus ground

7.13.3.4.2 LED Allocation

LED Number	Function
LE2	HART data Transmit
LE3	HART data Receive

7.13.4 Average Temperature & Water Level Measurement (HRT)

7.13.4.1 VITO Interface Types

For temperature and/or water level measurement, a proper VITO probe must be connected to the HRT module, using a VITO interface.

There are 3 VITO interface types:

- 762 VITO MTT interface for 16-spot temperature measurement (*thermocouple principle*) and optionally a water bottom measurement
- 762 VITO LT interface for 9-spot temperature measurement (*thermocouple principle*) and optionally a water bottom measurement
- 762 VITO MRT interface for Multiple Resistance Thermometer and multi-spot (*resistance variation principle*) measurement

7.13.4.2 Commissioning

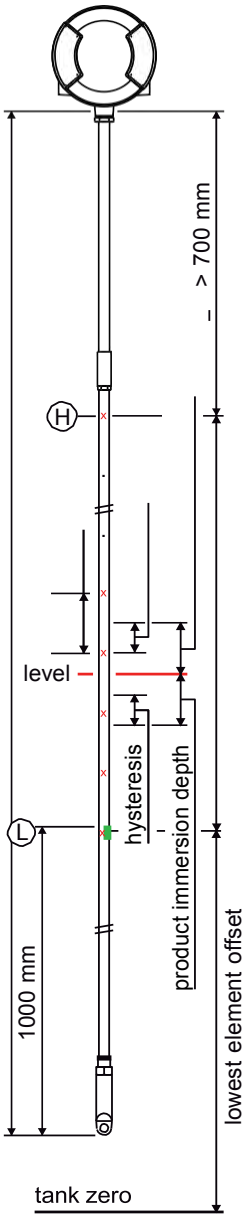
7.13.4.2.1 Commissioning Parameters for MTT/LT Probes

The following 9 configurations are possible:

Enraf Model	VITO Type	Description
764C	MTT Temperature probe	lowest spot next to Pt100, no water probe
764D		lowest spot below Pt100, no water probe
766C	MTT Combi probe	lowest spot next to Pt100, combined with water probe
766D		lowest spot below Pt100, combined with water probe
767C	LT Temperature probe	lowest spot next to Pt100, no water probe
767D		lowest spot below Pt100, no water probe
768C	LT Combi probe	lowest spot next to Pt100, combined with water probe
768D		lowest spot below Pt100, combined with water probe
765	Water probe	water probe only

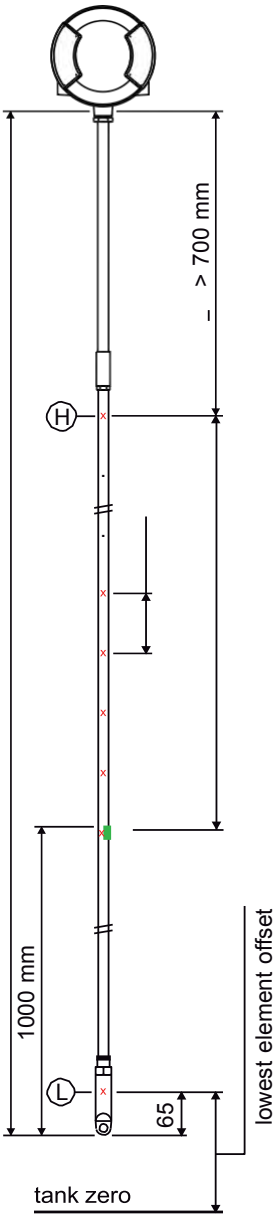
These models are depicted in FIGURE 7-36 and FIGURE 7-37.

762 VITO MTT interface



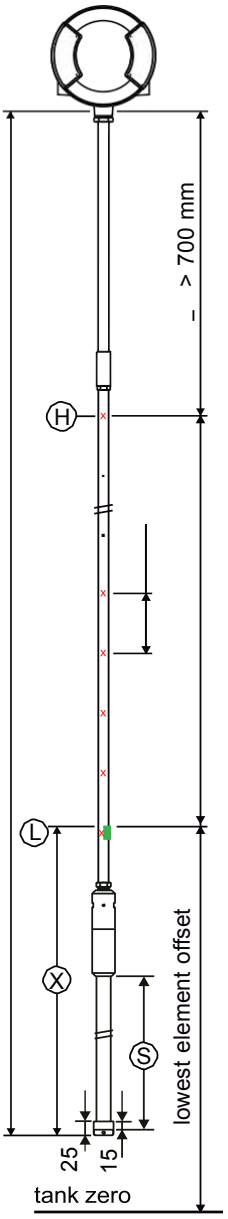
Model
. . . . 764 C
<he>

762 VITO MTT interface



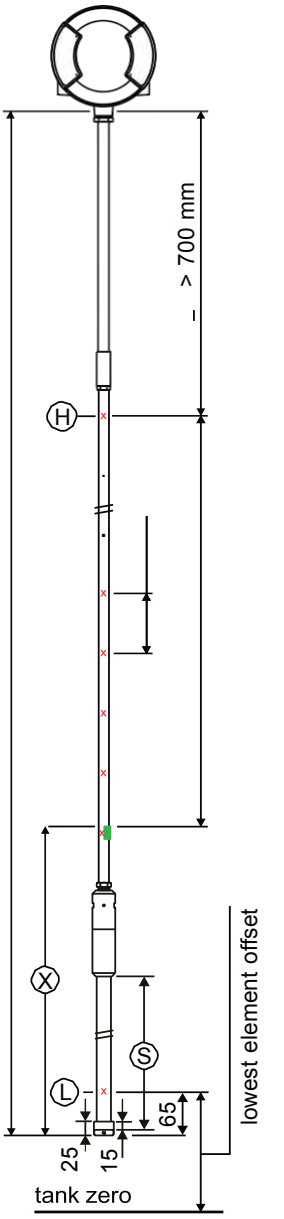
Model
. . . . 764 D
<he>

762 VITO MTT interface



Model
.A . . 766 C
<he>

762 VITO MTT interface



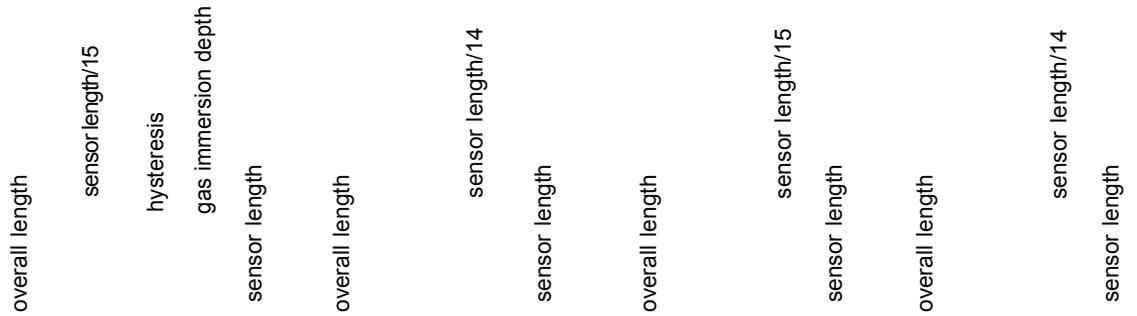
Model
.A . . 766 D
<he>

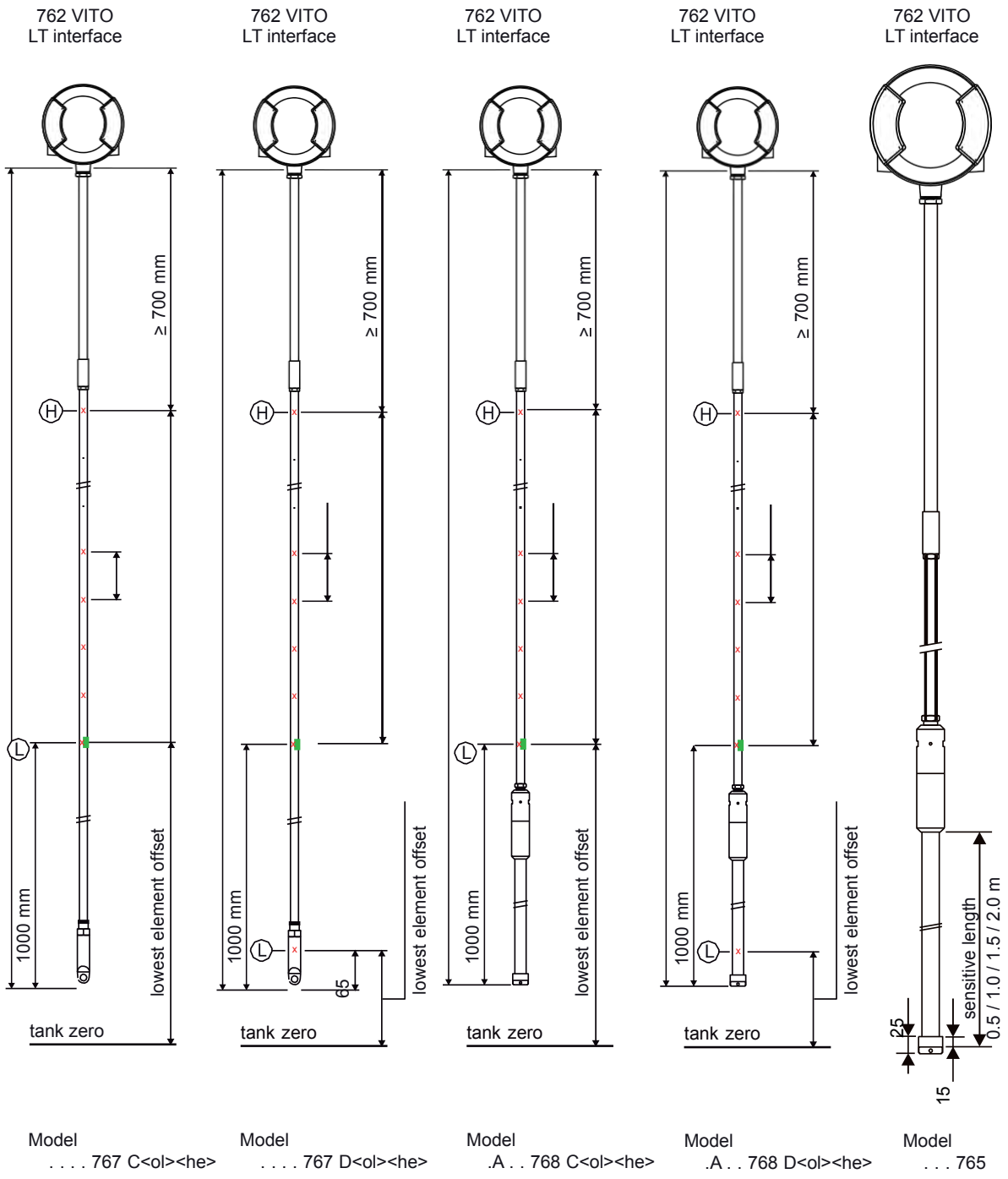
Pt 100 reference resistor
X Thermocouple (spot)

Ⓗ Highest spot
L Lowest spot

Ⓢ Sensitive length = 0.5 / 1.0 / 1.5 / 2.0 m
Ⓧ Depending on actual Sensitive length, this length = 1.0 / 1.5 / 2.0 / 2.5 m

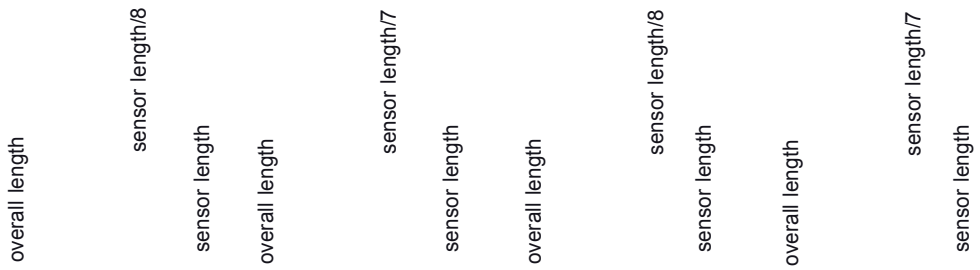
FIGURE 7-51 Tank and temperature probe data (1)





Pt 100 reference resistor
X Thermocouple (spot)
H Highest spot
L Lowest spot

FIGURE 7-52 Tank and temperature probe data (2)



7.13.4.2.1.1 Product Temperature

☛ The following entities ***must*** be set by *Engauge* or *HART SmartView* for a correct functioning of the HRT module in an instrument.

*NOTE: Using Engauge, following entities are set within the Engauge **Product temperature** tab.*

Name	Explanation	Value Range	Default
[Lowest element offset]	The distance from tank zero till the lowest element position in the temperature probe	floating point number: <-x.x .. +x.x>	<80.0>
[Sensor length]	The distance from the Pt100 position till the highest element position	floating point number: <-x.x .. +x.x>	<80.0>

The following entities ***can*** be set by *Engauge* or HART SmartView for a correct functioning of the HRT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Product immersion depth]	The minimum required distance of the product level above an element before it is taken into account in the average product temperature calculation	floating point number: <-x.x .. +x.x>	<0.5>
[Hysteresis]	The distance for a hysteresis mechanism around the switching point of the elements that are taken into account in the calculation	floating point number: <-x.x .. +x.x>	<0.1>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value	floating point number: <-x.x .. +x.x>	<+1.0E22>

Name	Explanation	Value Range	Default
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Element wiring]	Used for excluding an element from the average product temperature calculation.	16 characters A non-zero (≠ 0) character at position **x** results in element **x** being excluded from calculation.	<0000000000000000>
[Function identification] 	The current module's function name. This function is visible on the HART SmartView display.	13 characters	<Product temp.>

7.13.4.2.1.2 Vapor Temperature

*NOTE: Using Engauge, following entities are set within the Engauge **Vapor temperature** tab.*
Some Vapor temperature settings are shared with Product temperature settings.

The following entities ***can*** be set by *Engauge* or HART SmartView for a correct functioning of the HRT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Gas immersion depth]	The minimum required distance below an element before it is taken into account in the average Vapor temperature calculation	floating point number: <-x.x .. +x.x>	<0.5>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value	floating point number: <-x.x .. +x.x>	<+1.0E22>

Name	Explanation	Value Range	Default
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the HART SmartView display.	13 characters	<Vapor temp.>

7.13.4.2.1.3 Water Level (for 766/768 Combi probes and 765 Water probe only)

Engauge / HART SmartView

☛ The following entities ***must*** be set by *Engauge* or *HART SmartView* for a correct functioning of the HRT module in an instrument.

Name	Explanation	Value Range	Default
[Maximum water capacity]	The maximum capacity when the probe is fully submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Minimum water capacity]	The minimum capacity when the probe is not submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Water probe bottom position]	The offset to the water probe zero point in relation with the tank zero point	floating point number: <-x.x .. +x.x>	<80>
[Upper reference level]	The distance from tank zero point to upper reference point; is used for water ullage calculation	floating point number: <-x.x .. +x.x>	<80>

Engauge / HART SmartView

☛ The following entities ***can*** be set by *Engauge* or *HART SmartView* for a correct functioning of the HRT module in an instrument.

Name	Explanation	Value Range	Default
[Water probe length]	The length of a water probe	floating point number: <-x.x .. +x.x>	<0.5>

Name	Explanation	Value Range	Default
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the HART SmartView display.	13 characters	<Water level>

7.13.4.2.2 Commissioning Parameters for MRT or RTD

Enraf Model	VITO Type	Description
MRT	Multiple Resistance Thermometer	MRT with up to 13 temperature elements with one spot element
RTD	3-spot Resistance Temperature Detector	1..3 RTD spots in a 3-wire connection
	multi-spot Resistance Temperature Detector	1..14 RTD spots in a 2-wire connection

See FIGURE 7-38 and FIGURE 7-39.

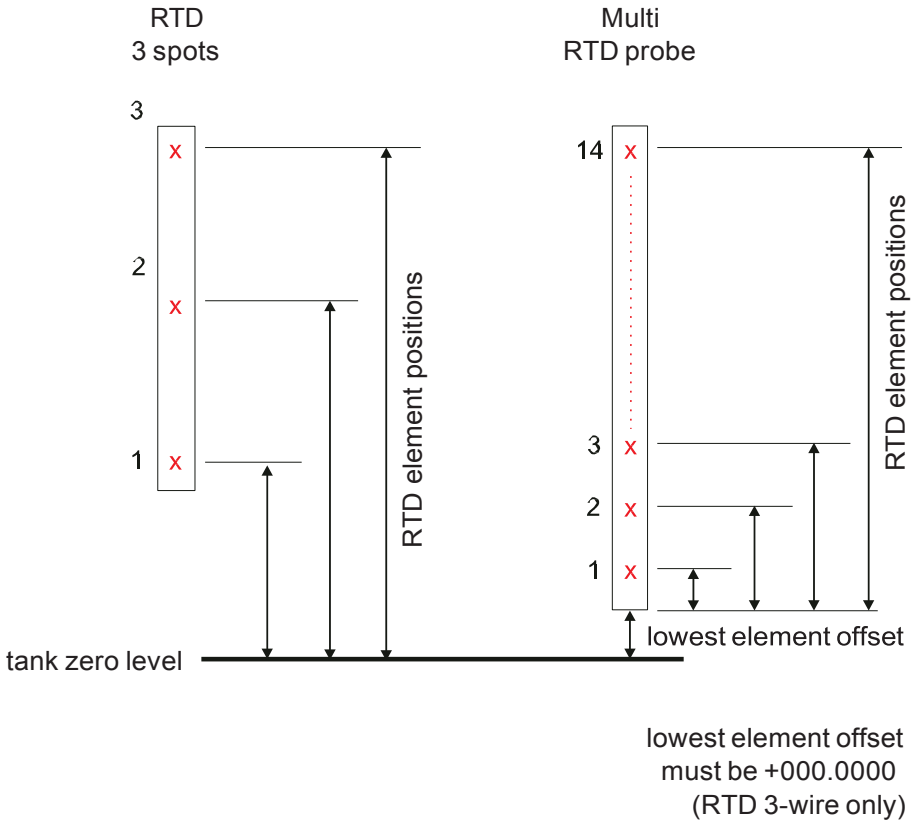


FIGURE 7-53 Resistance Temperature Detector (RTD) elements positions

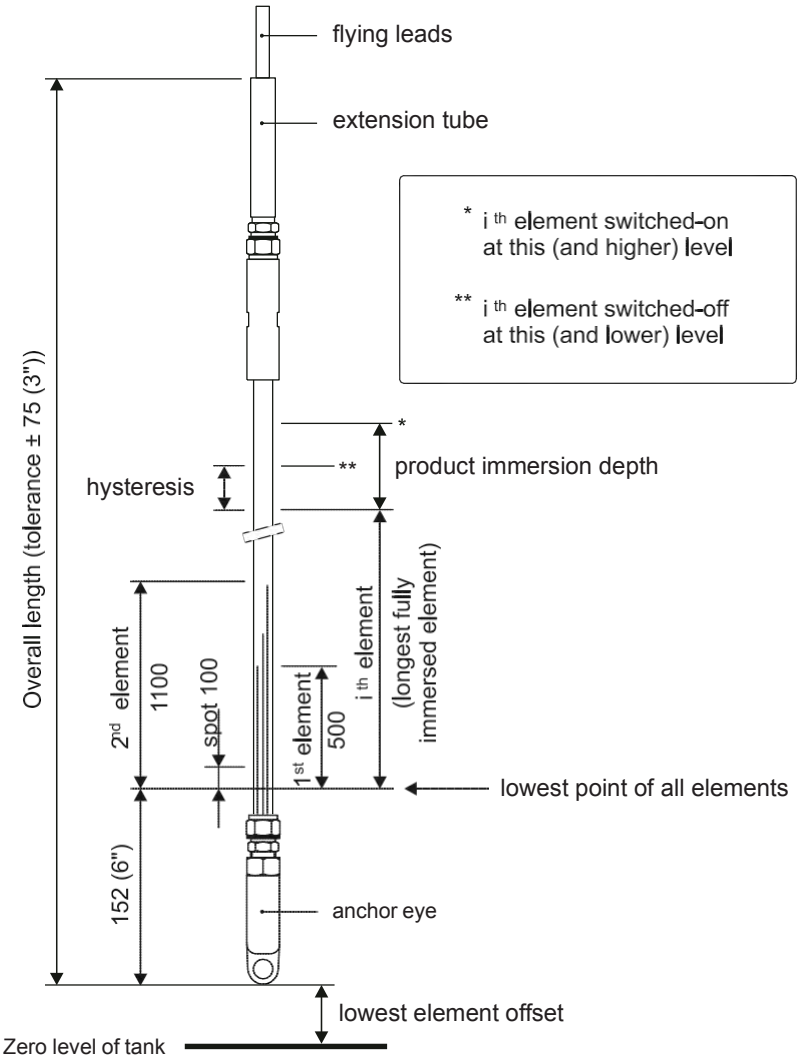


FIGURE 7-54 Multiple Resistance Thermometer (MRT) parameters

7.13.4.2.2.1 Product Temperature

Engauge
HART SmartView

☛ The following entities ***must*** be set by *Engauge* or *HART SmartView* a correct functioning of the HRT module in an instrument.

*NOTE: Using Engauge, following entities are set within the Engauge **Product temperature** tab.*

- RTD 3 spots (see FIGURE 7-38 *left* side)

Name	Explanation	Value Range	Default
[Element type]	The supported element type is: SPL	3 characters <SPL>	<--->
[Number of elements]	The number of elements a RTD probe has	<1 .. 3>	<0>
[Lowest element offset]	The distance from tank zero till the lowest position of the multi-RTD probe. So **not** used for the 3-wire version and it must be 0.	floating point number: <-x.x .. +x.x> MUST BE <0.0>	<80.0>
[RTD element positions] 	The positions of the RTDs from tank zero level	3 floating point numbers: <-x.x .. +x.x> Note: Only *actually used* elements to be entered.	<0,0,0>

- Multi RTD probe (see FIGURE 7-38 *right* side)

Name	Explanation	Value Range	Default
[Element type]	The supported element type is: SPL	3 characters <SPL>	<--->
[Number of elements]	The number of elements a RTD probe has	<1 .. 14>	<0>
[Lowest element offset]	The distance from tank zero till the lowest position of the multi-RTD probe	floating point number: <-x.x .. +x.x>	<80.0>
[RTD element positions] 	The positions of the RTDs from the lowest position of the probe. So **not** tank zero level!	14 floating point numbers: <-x.x .. +x.x> Note: Only *actually used* elements to be entered.	<0,0,0,0,0,0,0,0,0,0,0,0,0,0>

- MRT (see FIGURE 7-39)

Name	Explanation	Value Range	Default
[Element type]	See Table TABLE 7-19 below.	3 characters <RCB> <RCN> <RCS> <QCB> <QCN> <QCS>	<--->
[Number of elements]	The number of elements (resistors) an MRT probe has.	<1 .. 14>	<0>
[Lowest element offset]	The distance from tank zero till the lowest position of the MRT probe.	floating point number: <-x.x .. +x.x>	<80.0>
[MRT element length] if MRT length table = <T> 	The lengths of the MRTs including anchor eye.	14 floating point numbers: <-x.x .. +x.x>	<0,0,0,0,0,0,0,0,0,0,0,0,0,0>
[MRT length table] 	Specifies whether a fixed range of MRT resistors is used (= <F>) or user-configured lengths (= <T>). Fixed lengths are: 0.25 / 0.65 / 1.25 / 1.95 / 2.85 / 4.15 / 5.65 / 7.35 / 9.25 / 11.65 / 14.65 / 18.45 / 22.95 / 29.65	1 character <F> <T>	<F>

R..	= an MRT *without* spot element
Q..	= an MRT *with* spot element
.CB	Rth = 90.2935 + T x 0.38826 (- 100 through + 280 °C)
.CN	Rth = 90.4778 + T x 0.38090 (- 100 through + 280 °C)
.CS	Rth = 90.5000 + T x 0.38730 (- 100 through + 280 °C)

TABLE 6-38 Element type definitions

NOTE: When after commissioning of an MRT/RTD the right temperature is not directly visible (but eg. status = over range and the temp value is slowly heading to its final temp value) a board reset is advised. After startup the right temp is then directly visible.

The following entities ***can*** be set by *Engauge* or HART SmartView for a correct functioning of the HRT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Product immersion depth]	The minimum required product level distance above an element before this element is taken into account in the average product temperature calculation.	floating point number: <-x.x .. +x.x>	<0.5>
[Hysteresis]	This is a hysteresis mechanism distance around the switching points of the elements that are taken into account in the calculation.	floating point number: <-x.x .. +x.x>	<0.1>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the HART SmartView display.	13 characters	<Product temp.>

7.13.4.2.2.2 Vapor Temperature

*NOTE: Using Engauge, following entities are set within the Engauge **Vapor temperature** tab.*
Some Vapor temperature settings are shared with Product temperature settings.

The following entities ***can*** be set by *Engauge* or HART SmartView for a correct functioning of the HRT module in an instrument.

☛ Check each entity for its correctness.

Name	Explanation	Value Range	Default
[Gas immersion depth]	The minimum required distance below an element before it is taken into account in the average Vapor temperature calculation.	floating point number: <-x.x .. +x.x>	<0.5>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High alarm] [High Alarm] [Low Alarm] [Low Low alarm]	<No Alarm>
[Function identification] 	The current module's function name. This function is visible on the HART SmartView display.	13 characters	<Vapor temp.>

7.13.4.2.3 Commissioning Parameters for the 765 VITO Water Probe

For the entities to be set for the stand-alone 765 VITO water probe (see FIGURE 7-40), see 7.11.3.3.1.

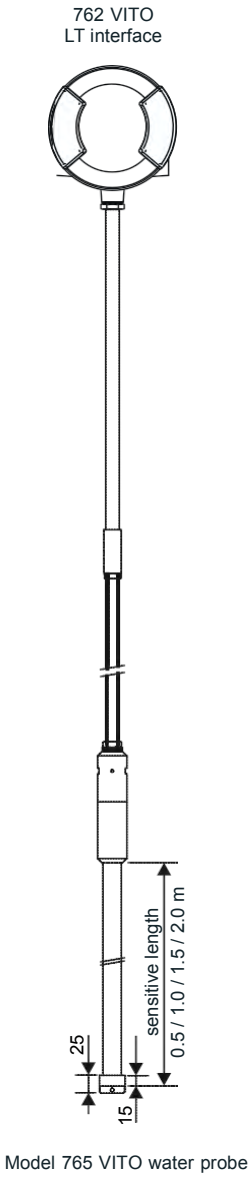


FIGURE 7-55 The model 765 VITO water probe

7.13.4.2.3.1 Water Level

Engauge
HART SmartView

☛ The following entities ***must*** be set by *Engauge* or *HART SmartView* for a correct functioning of the HRT module in an instrument.

Name	Explanation	Value Range	Default
[Maximum water capacity]	The maximum capacity when the probe is fully submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Minimum water capacity]	The minimum capacity when the probe is not submerged in water (in pF)	floating point number: <-x.x .. +x.x>	<20000>
[Water probe bottom position]	The offset to the water probe zero point in relation with the tank zero point	floating point number: <-x.x .. +x.x>	<80>
[Upper reference level]	The distance from tank zero point to upper reference point; is used for water ullage calculation	floating point number: <-x.x .. +x.x>	<80>

☛ The following entities ***can*** be set by *Engauge* or *HART SmartView* for a correct functioning of the HRT module in an instrument.

Name	Explanation	Value Range	Default
[Water probe length]	The length of the 765 VITO water probe.	floating point number: <-x.x .. +x.x>	<0.5>
[High High alarm] [High Alarm] [Low Alarm] [Low Low alarm] 	4 thresholds for activating a related alarm status in the Primary Value.	floating point numbers: <-x.x .. +x.x>	<+1.0E22>
[Alarm test enable] 	Enables (*if* activated, see next listed entity) the simulation of one of the 4 alarms for a minute, by simulating the actual measured Primary Value is below or above the alarm threshold.	<enable> <disable>	<disable>
[Alarm test] 	Activates and selects at the same time the Alarm test (if enabled with the [Alarm test enable] listed before, and the 4 alarm thresholds are properly set).	[No Alarm] [High High Alarm] [High Alarm] [Low Alarm] [Low Low Alarm]	<No Alarm>

Name	Explanation	Value Range	Default
[Function identification] 	The current module's function name. This function is visible on the HART SmartView display.	13 characters	<Water level>

7.13.4.3 Commissioning Check

☛ After having checked/set all before listed entities, make sure

- the [Board Commissioned], the [Product temperature Commissioned], the [Vapor temperature Commissioned], and - if applicable - the [Water level Commissioned] entities are <True>;
- the [Board Health], the [Product temperature Health], the [Vapor temperature Health], and - if applicable - the [Water level Health] entities are <GOOD>.

7.14 TRL/2

7.14.1 Introduction

The FlexLine 990 radar gauge is an inventory and custody transfer level gauge for storage tanks. It is a state of art technology design with highest reliability components and tested for the industrial level performance across global locations. This is designed to fit into existing Emerson gauging system as an attractive replacement with very minimal changes. The replacement of FlexLine 990 gauge with the existing gauge is a very smooth process and can be quickly done. There will be no change in the existing measurement system network as the replacement is designed to replicate the existing gauging system with no changes in terms of measured parameters, number of sensors, number of inputs/outputs, and relays.

Emulation is open interface design concept covering electrical interface, communication protocol interface and utilizing existing power and cabling resources. This interface makes it easy to incorporate reliable, stable, state of the art precision FlexLine gauges in the existing field bus system from other systems like Emerson.

Key benefits of FlexLine 990 gauge with CAN-TRL/2 communication card:

- Replaces Rex, Rex with DAU, and Rex with RDU
- Directly connects to Enraf® FCU 2160/65/75 or FBM 2180
- TRL/2 Field bus compatible
- Supports level, temperature, pressure, relay, Analog I/O, HART inputs
- Integrates with Taskmaster Win OPI
- Supports configuration directly / via Emerson FCU over TRL/2 Field bus through Smart Link
- High reliability – Maintenance free
- Utilizes the existing power & cabling infra structure

7.14.2 System Description

The FlexLine 990 radar gauges act as Rex gauges with the help of CAN-TRL/2 card. The CAN-TRL/2 communication card for FlexLine gauge is added to integrate to the Emerson system. The Rex Gauge and Rosemount Tankmaster (Emerson tank inventory) communicates over TRL/2 network and uses Modbus protocol. When Rex gauge is replaced in field with FlexLine gauge, the Rosemount TankMaster gets the data (for example: product level, temperature) from FlexLine gauge same as Rex gauge.

The FlexLine gauge 990 has the capability to connect directly to Emerson TRL/2 field bus. The Rex or TRL/2 RTG gauges can be replaced with FlexLine gauge with great ease, minimum modifications,

and quick turnaround time. The FlexLine gauge communicates with TRL/2 FSK protocol over Modbus RTU and can interface with Enraf® FCU 2160/65/75 or tank hub 2410 or FBM 2180.

The system integrates with Rosemount TankMaster Win OPI and provides level, temperature, and other inputs to the system. Replace the Rex gauge (with or without DAU) with FlexLine gauge and RDU with SmartLine display.

The figure 7-56 shows the Emerson system with Rex gauges, and one of its gauge is replaced by FlexLine 990 gauge.

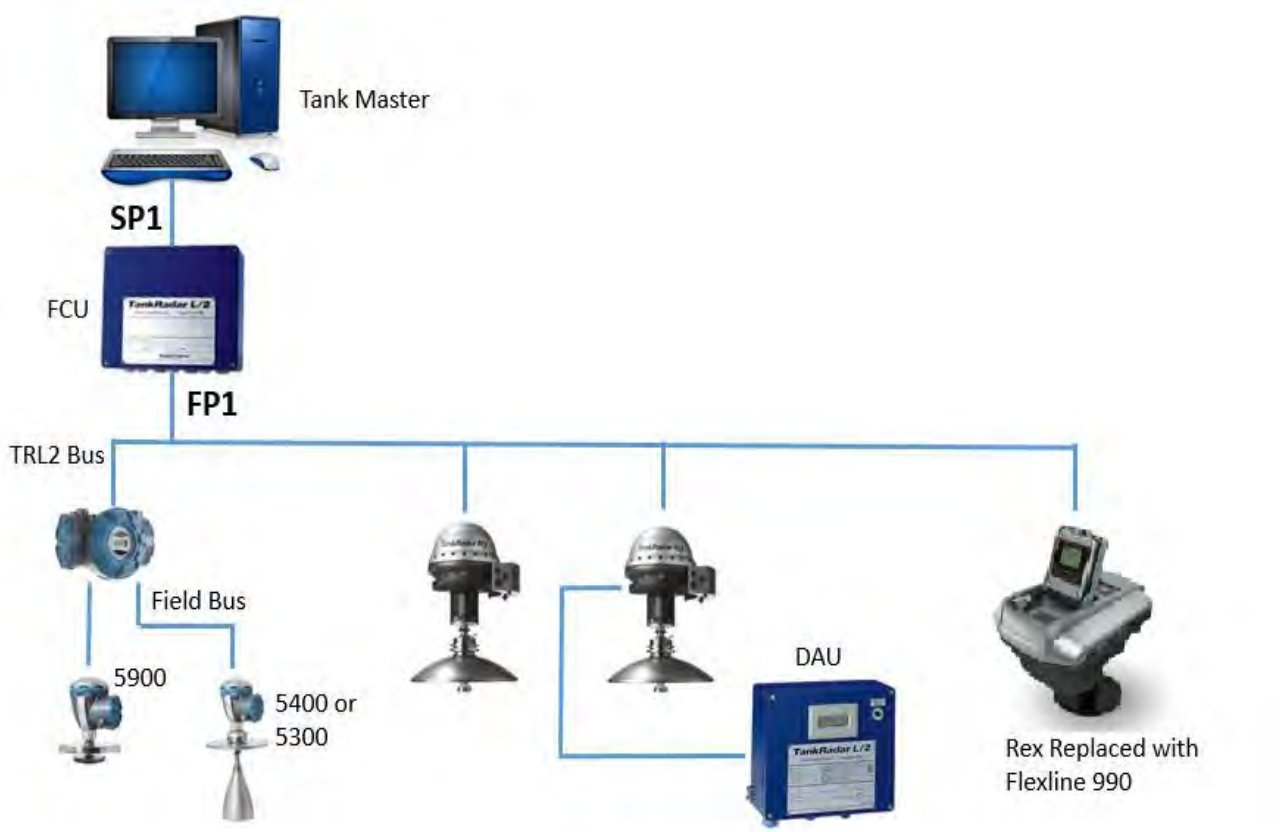


FIGURE 7-56 System Architecture - Rex Replaced with FlexLine 990

NOTE: Ensure that the following devices/network/Hosts should be physically protected in a controlled area:

- Gauge and the SmartLink devices
- Networks in which the Gauge and the SmartLink nodes operate
- Hosts that connect to the Gauge and the SmartLink nodes operate

7.14.3 Before You Begin Migration

7.14.3.1 Device Mapping

Before mapping the device:

- Enraf® FCU checklist: Note the FCU unit ID and FCU Modbus address. Cross verify the data base about these entries.
- Communication overview: Note the field port that FlexLine will replace and its corresponding group port, if Rex is connected to Enraf® FCU. Confirm with saved database.
- RTG general information: Note the RTG unit ID and Modbus address This is required for configuring TRL/2.
- Data Acquisition Unit: Note the unit ID and Modbus address (Required for configuring TRL/2).
- Operator Software: Verify the data base, the unit ID and Modbus, address of Rex/RTG, Data Acquisition Unit and Enraf® FCU and the number of field ports to which Rex/RTG is attached and the number of group ports to which the system with Rosemount Tankmaster is attached. Also, note whether the other group port is connected or free.

The following table describes the possible combination of cards:

Rex	AI	HART	AO	Relay	Temp	Possible combinations of cards in FlexLine Gauge
Option 1	2	0	0	1 or 2	6 or 14	Option1: HRT-1 (AI1 & AI2 as HART input), FII-DO (Relay) and FII-RTD/ HRT-1. (**3 cards**). Option2: HRT-1 (AI1), HART-2 (AI2), FII-DO (Relay) and FII-RTD/ HRT-3. (**4 cards**). SMV card (Display) NOT possible for option 2.
Option 2	1	1	0	1 or 2	6 or 14	Option1: HRT-1(HART, AI as HART & Temp), FII-DO (Relay) - (**2 cards**) Option2: HRT-1(HART & Temp), HART-2 (AI), FII-DO (Relay) - (**3 cards**) Option3: HRT-1(HART), HART-2 (AI), FII-DO (Relay) & FII-RTD - (**4 cards**) SMV card (Display) NOT possible for option 3.

Rex	AI	HART	AO	Relay	Temp	Possible combinations of cards in FlexLine Gauge
Option 3	1	1	1	1	6 or 14	Option1: HRT-1(HART, Temp & AI as HART input), HCI-HAO (AO), FII-DO (Relay) - (**3 cards**) Option2: HRT-1(HART, & AI as HART input), FII-RTD (Temp), HCI-HAO (AO) & FII-DO (Relay) - (**4 cards**) Option3: HRT-1(HART & Temp), HRT-2 (AI), HCI-HAO (AO), FII-DO (Relay) - (**4 cards**) SMV card (Display) NOT possible for option 2 & 3. FII-RTD not possible for option 3.
Option 4	2	0	1	1	6 or 14	Option1: HRT-1 (AI1 & AI2 as HART inputs and Temp), HCI-HAO (AO), FII-DO (Relay) - (**3 cards**) Option2: HRT-1 (AI1 & AI2 as HART inputs), HCI-HAO (AO), FII-DO (Relay), FII-RTD (Temp) - (**4 cards**) SMV card (Display) NOT possible for option 2. Analog Input NOT possible with this combination.
Option 5	1	0	0	1 or 2	6 or 14	Option1: HRT-1 (Temp & AI1 as HART input),FII-DO (Relay) - (**2 cards**) Option2: HRT-1 (AI1),FII-DO (Relay) FII-RTD (Temp) - (**3 cards**)
Option 6	0	1	0	1 or 2	6 or 14	Option1: HRT-1 (HART & Temp), FII-DO (Relay) - (**2 cards)** Option2: HRT-1 (HART), FII-DO (Relay), FII-RTD (Temp) - (**3 cards**)
Option 7	1	0	1	1	6 or 14	Option1: HRT-1 (Temp & AI1 as HART input),FII-DO (Relay) & HAO (AO) - (**3 cards**) Option2: HRT-1 (AI1),FII-DO (Relay) FII-RTD (Temp) & HAO (AO) - (**4 cards**) SMV card (Display) NOT possible for option 2.
Option 8	0	1	1	1	6 or 14	Option1: HRT-1 (Temp & HART input),FII-DO (Relay) & HAO (AO) - (**3 cards**) Option2: HRT-1 (HART),FII-DO (Relay), FII-RTD (Temp) & HAO (AO) - (**4 cards**) SMV card (Display) NOT possible for option 2.

Rex	AI	HART	AO	Relay	Temp	Possible combinations of cards in FlexLine Gauge
Option 9	1	1	1	0	6 or 14	Option1: HRT-1(HART, Temp & AI as HART input), HCI-HAO (AO) - (**2 cards**) Option2: HRT-1(HART, Temp & AI as HART input), HCI-HAO (AO), FII-RTD (Temp) - (**3 cards**) Option3: HRT-1(AI1), HRT-2(AI2),HCI-HAO (AO), FII-RTD (Temp) - (**4 cards**) SMV card (Display) NOT possible for option 3.
Option 10	1	0	1	0	6 or 14	Option1: HRT-1 (Temp & AI1 as HART input), HAO (AO) - (**2 cards**) Option2: HRT-1 (AI1), HAO (AO), FII-RTD (Temp) - (**3 cards**)
Option 11	0	1	1	0	6 or 14	Option1: HRT-1 (HART & Temp), HAO (AO) - (**2 cards**) Option1: HRT-1 (HART), HAO (AO) , FII-RTD (Temp) - (**3 cards**)

7.14.3.2 Saving configuration in database

Save the configuration settings in the database to upload the same configuration after inserting TRL/2 card in the gauge.

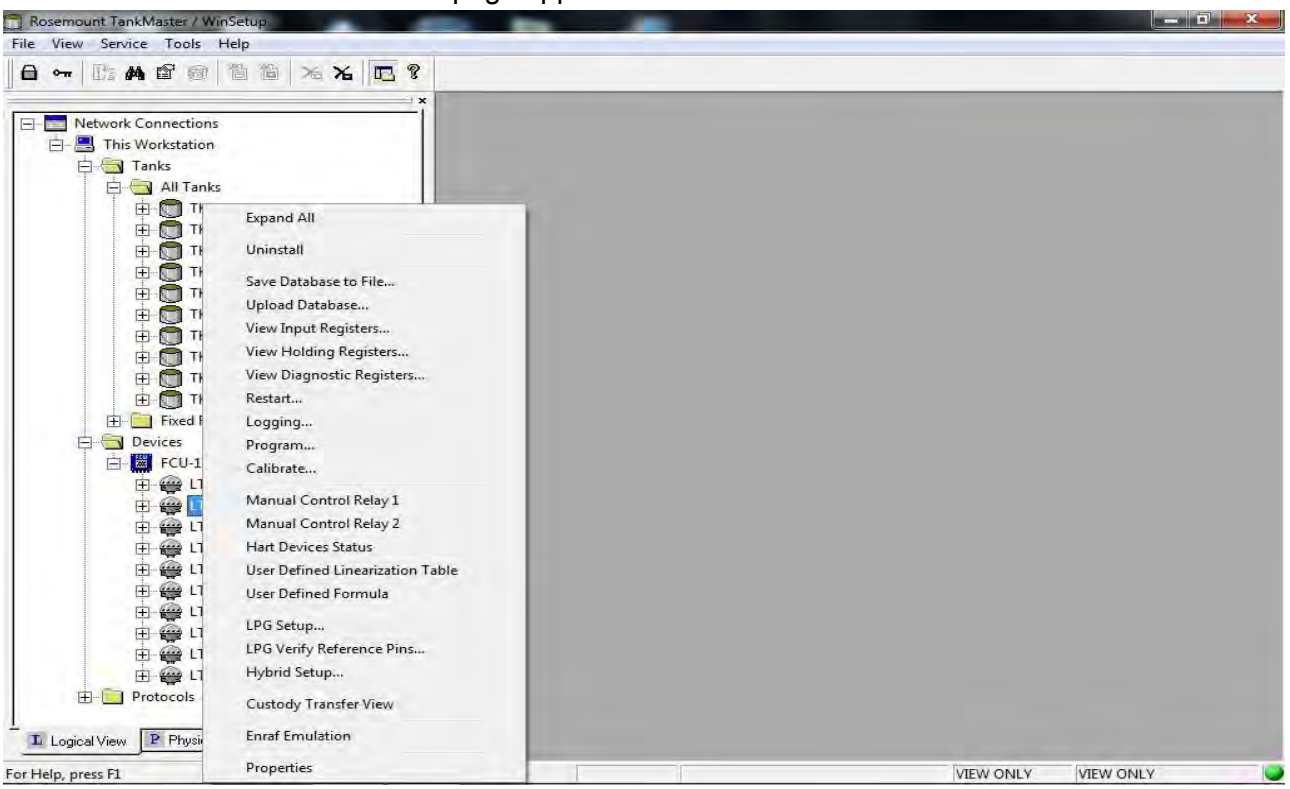
To save the configuration settings in the database:

1. On the Rosemount TankMaster page, select the device (for which data has to be saved) on the left pane.

   For Example: Select LT-52

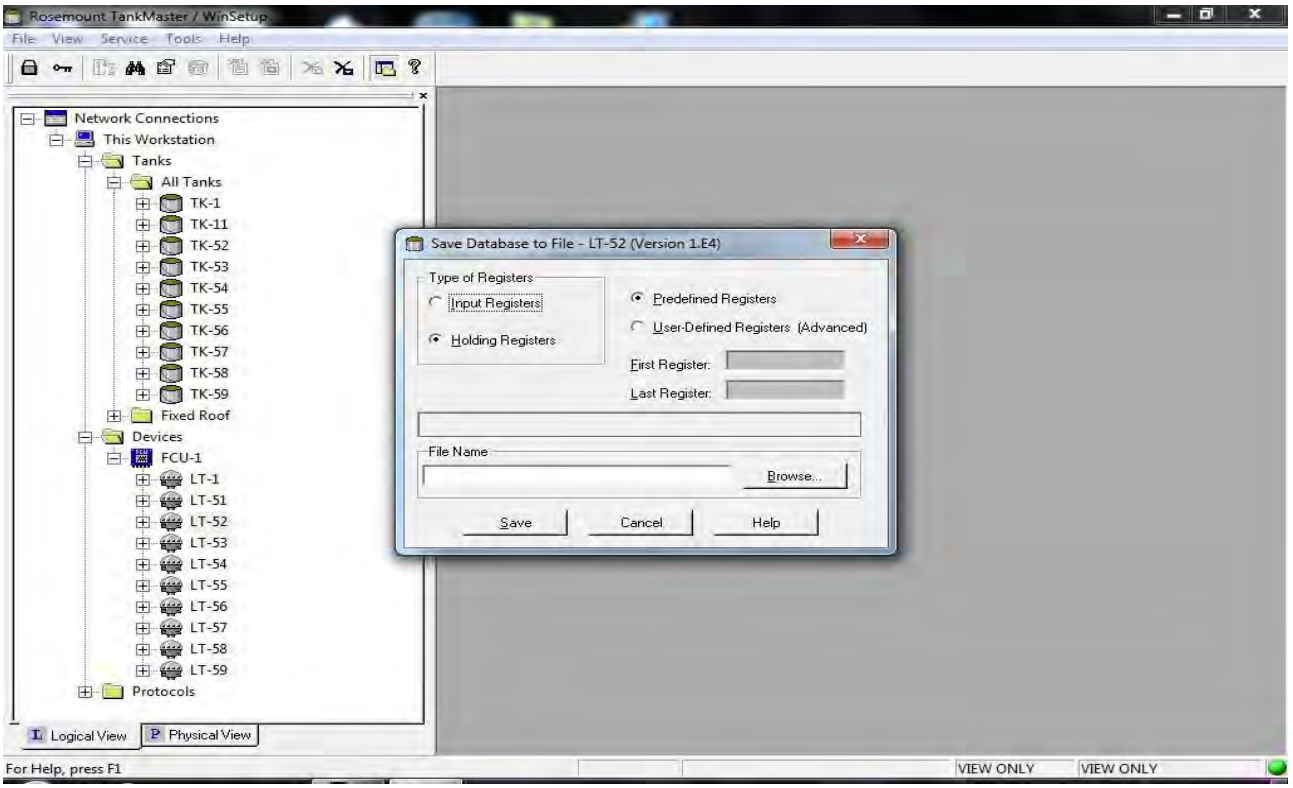
2. Right click the selected device.

The page appears as follow:

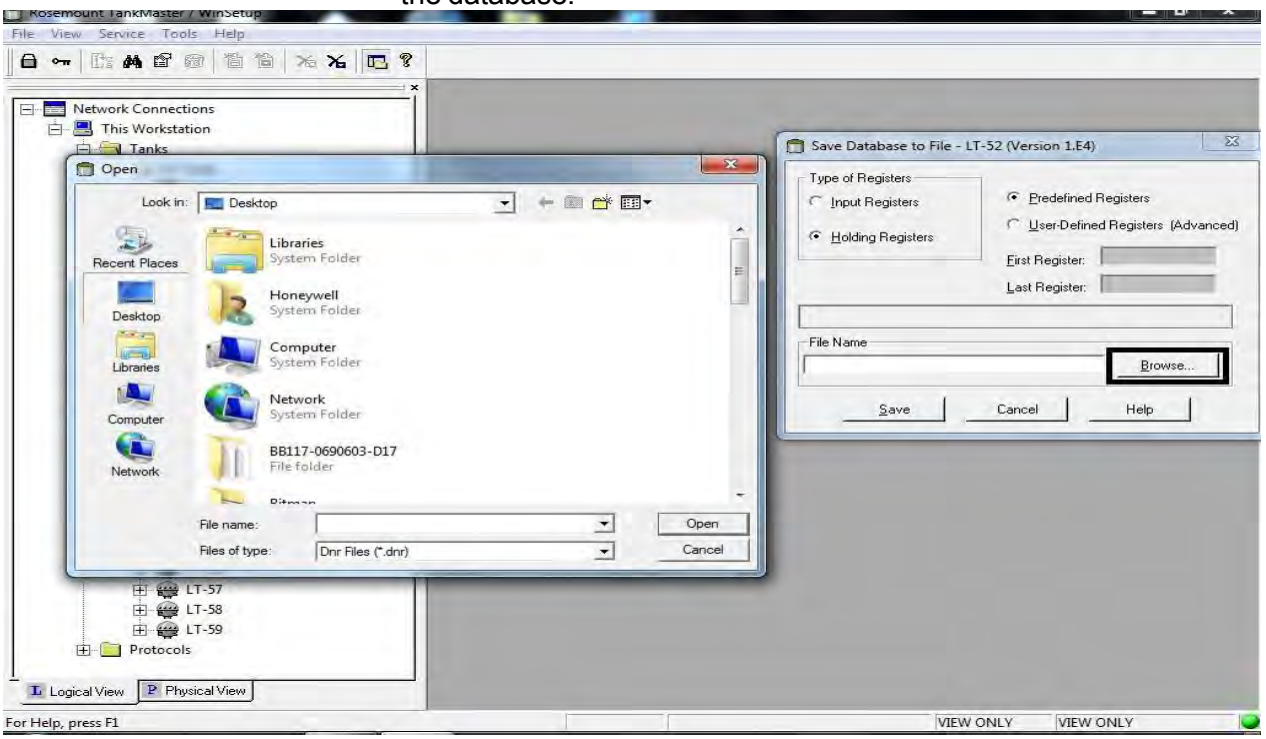


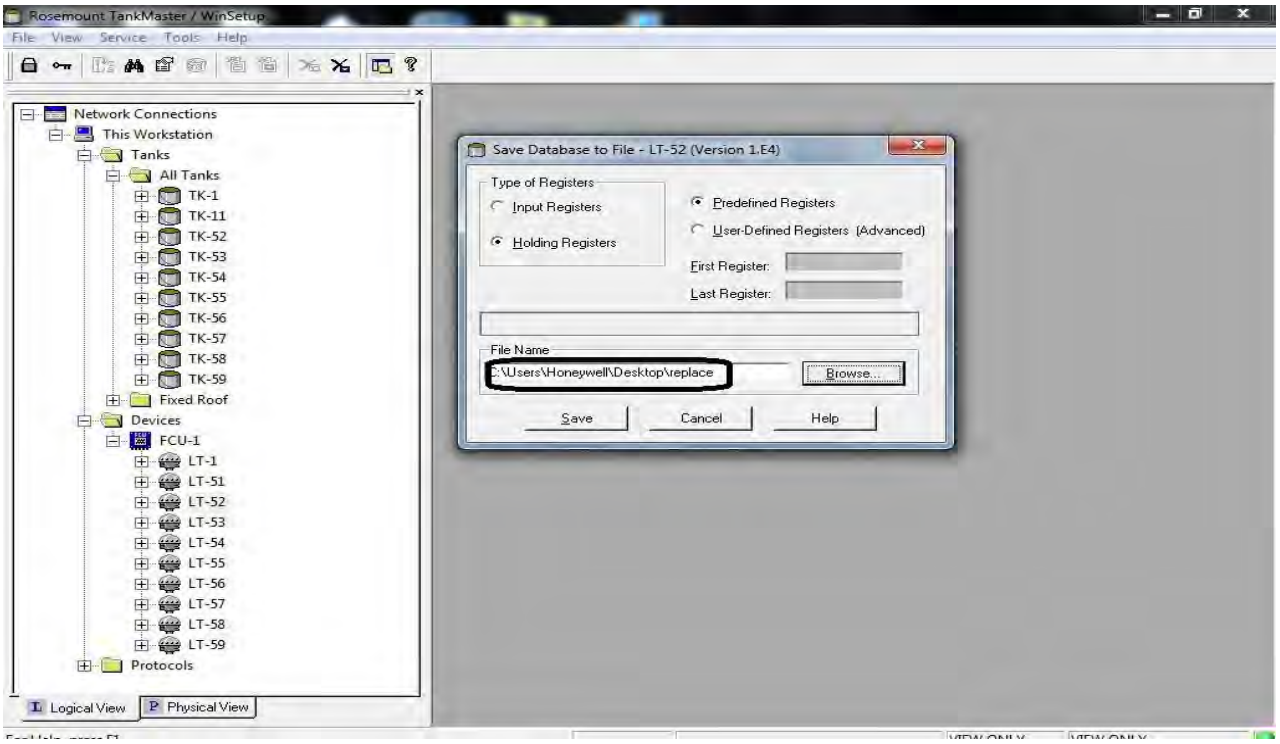
3. Select **Save Database to File**.

The **Save Database to File-LT-52 (Version 1.E4)** dialogue box appears:



4. **Browse** and specify a folder to save the configuration settings from the database.





5. Click **Save** to save the configuration settings of the database.

7.14.4 Configuration of Gauge Using SmartLink and Engauge

7.14.4.1 Configuration of SmartLink with TRL/2 Card

The SmartLink system requires Engauge service tool for configuration.

The Engauge service tool (version 2.2 and higher) is required for SmartLink modules delivered from September 2007 with software versions:

- HCM -GPU A1005 (and higher)
- FCM-TRL/2

7.14.4.2 Configuration of the SmartLink system

7.14.4.2.1 The Connection between the PC and the SmartLink

Before you can start to configure the SmartLink you have to connect the SmartLink to PC with the service tool Engauge installed. The communication between the PC and the SmartLink takes place by means of a serial connection. The user must select a free serial port on the PC. The chosen port must be set in Engauge, the maximum com-port number is COM24. On the SmartLink side the communication takes place by using the Non-Isolated RS232 interface on the HCM-GPU module.

7.14.4.2.2 Making new site in Engauge

NOTE: Navigate to C:\Users\Public\Documents\Honeywell\ConfigFiles BoardDescriptor" and paste board descriptor files for FCM-TRL/2 and HCI-TRl/2.

Refer **Installation and Operation Manual Enguage 2.6 - Professional.**

7.14.4.2.3 HCM - GPU Module

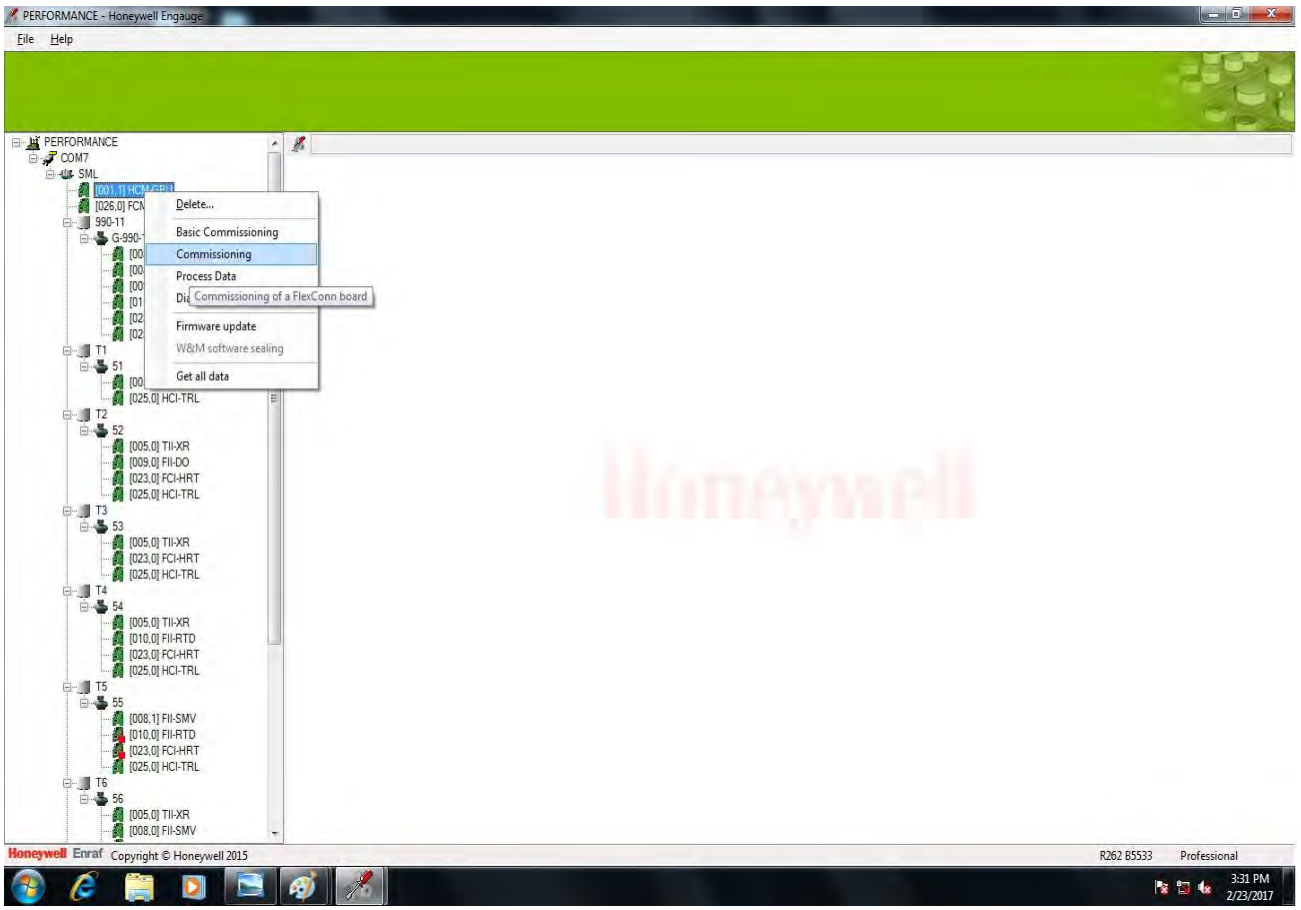


FIGURE 7-57 HCM-GPU Screen

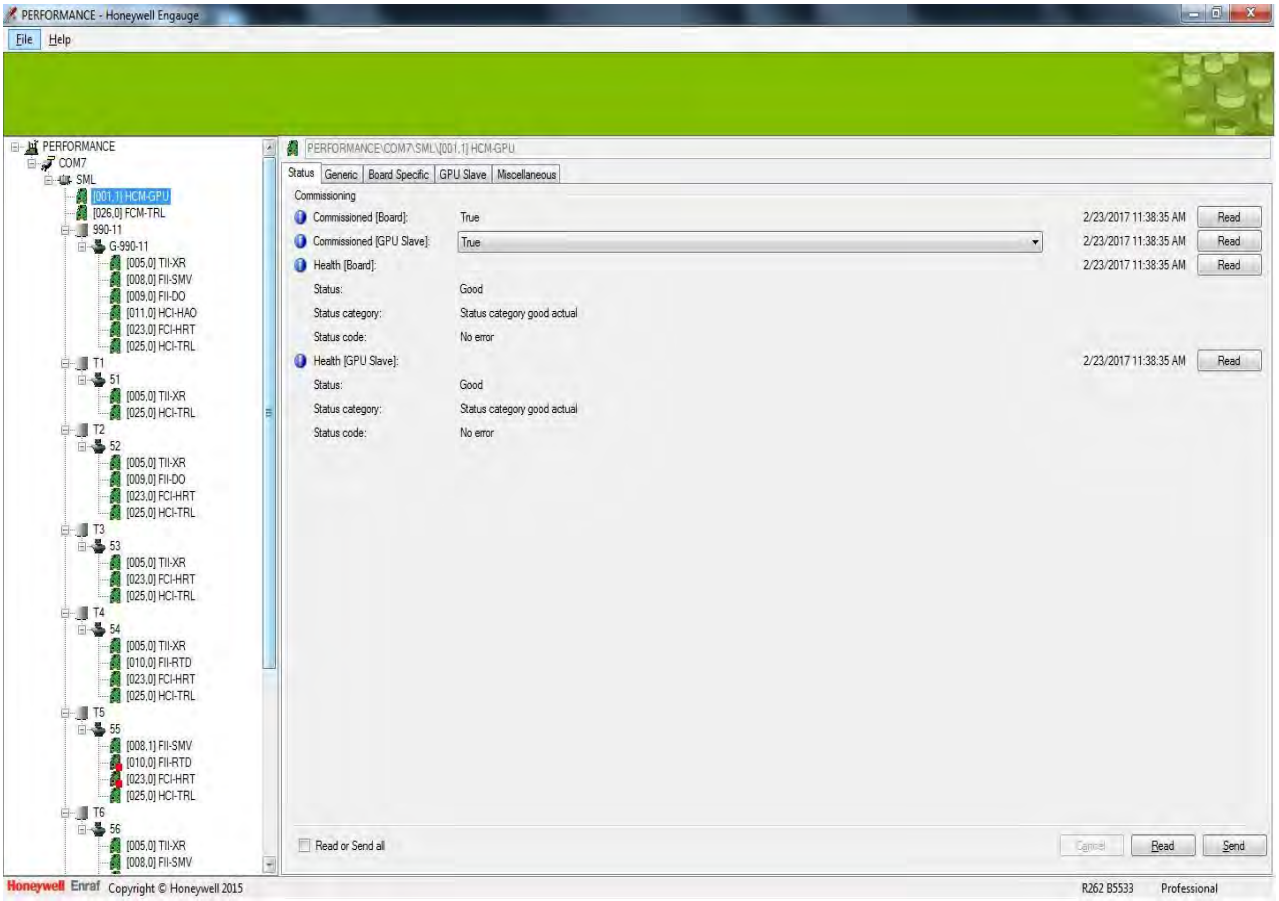


FIGURE 7-58 HCM-GPU Status

Open the Enguage tool from the PC where enguage is installed. Right click on **HCM-GPU** card. Select **Commissioning**.

To read the current data of this TAB sheet, press the Read button. Instead, you can also select to press the Read All button available when extending the read function by the arrow at the right side of the read button). Then the current data of all TAB sheets are read.

The **TAB** sheet Status gives information about the health of the HCM-GPU module (Refer to "HCM-GPU Status").

The TAB sheet **Generic** gives information on the installed software version and from there two commands can be given (Refer to Figure "HCM-GPU Generic").

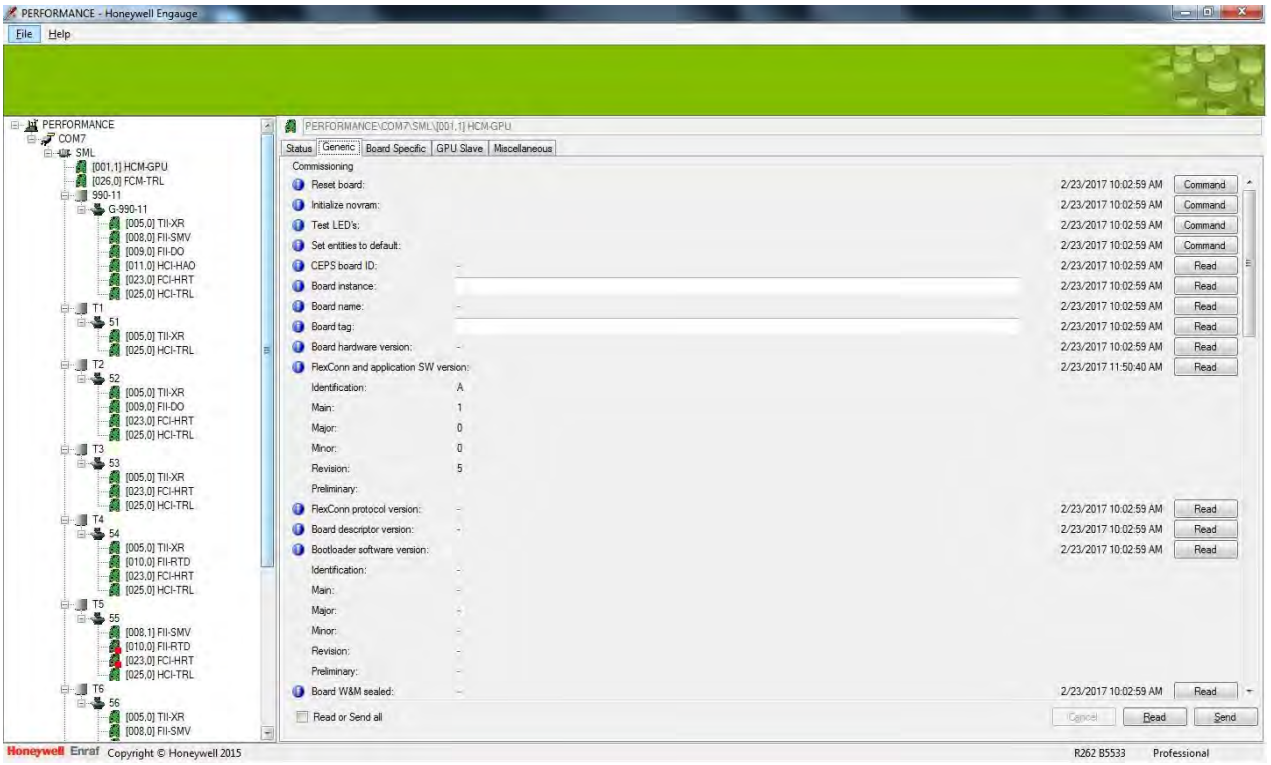


FIGURE 7-59 HCM-GPU Generic

Reset device button: All modules of the SmartLink are reset

Reset board button: Only the HCM-GPU module is reset

Software version: Current installed software version for the HCM-GPU module.

The TAB sheet **Board Specific** provides host communication information as baud rate and turn around delay time (Refer to Figure "HCM-GPU Board Specific").

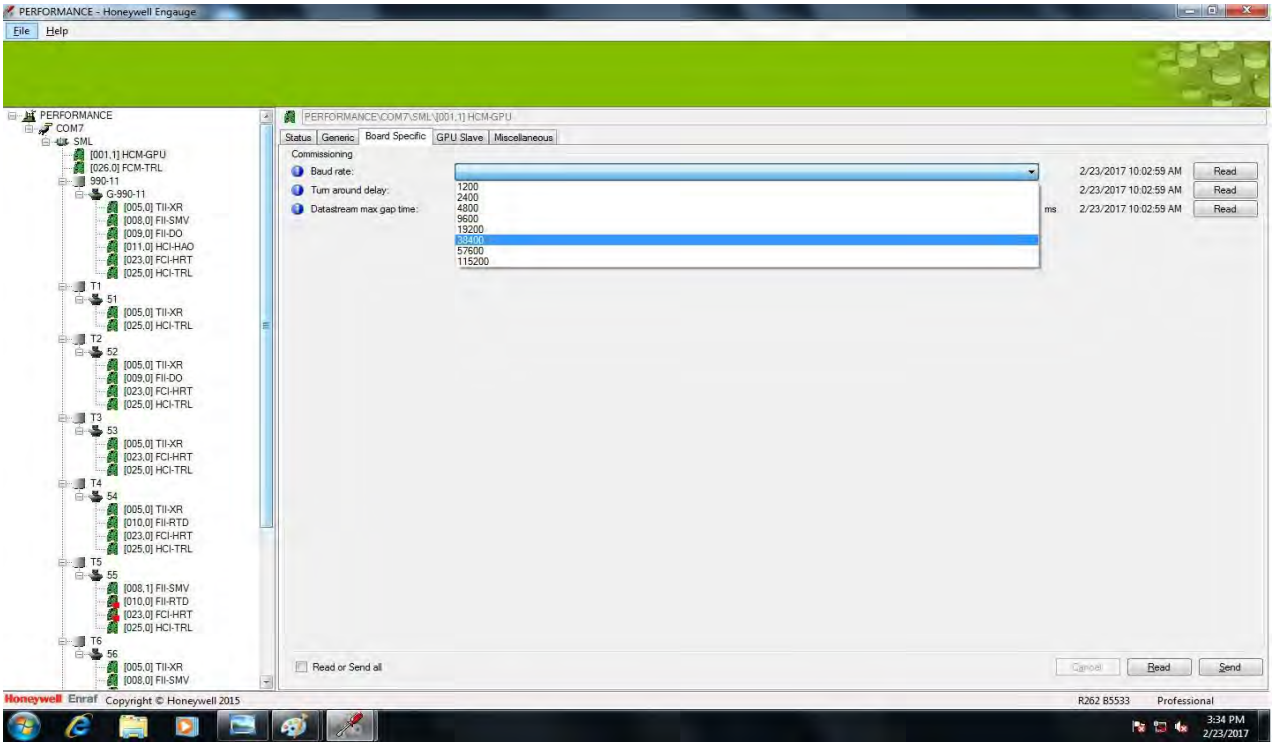


FIGURE 7-60 HCM-GPU Board Specific

Baud rate

Host communication baud rate of the SmartLink. The default setting is 38400. When required, the baud rate can be changed. The following settings are possible:

- 115200
- 57600
- 38400
- 19200
- 9600
- 4800
- 2400
- 1200

To make the change effective, press the Send button. When the baud rate is changed, also change the baud rate at the COM port icon (two levels higher).

Turn around delay

This setting is used for host systems that cannot switch directly from sending to receiving. The delay time can be set between 0 and 2000 msec.

On the TAB sheet **GPU-slave** communication parameters can be set such as: GPU and FlexConn interface addresses, parity and modem control type (Refer to Figure "HCM-GPU Slave").

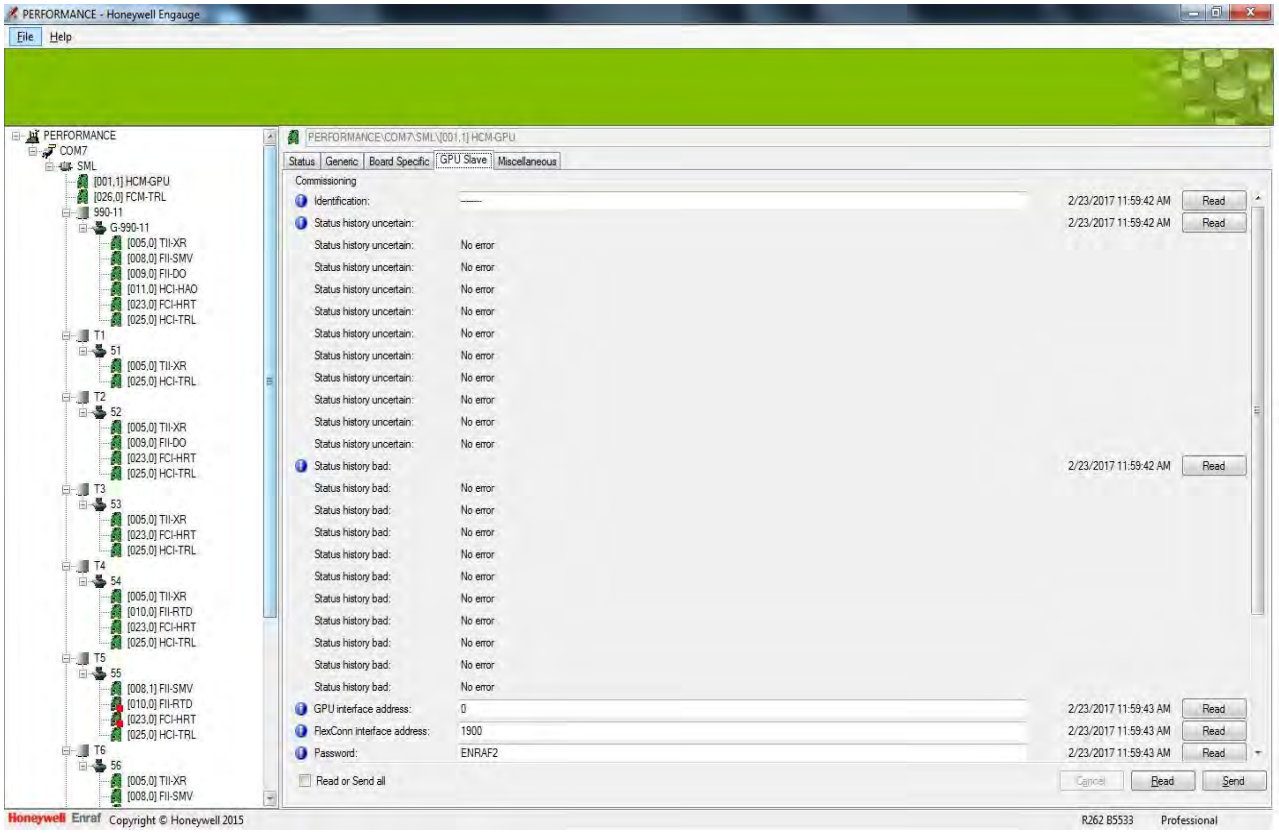


FIGURE 7-61 HCM-GPU Slave

Identification:

An 8 character long name for the HCM-GPU board.

GPU interface address:

The address of the SmartLink, ranging from 0 till 9 (similar as the CIU address). Each SmartLink, connected to the same PC ComPort, must have a unique address. If the GPU interface address is changed from default, and the new address has been sent to the HCM-GPU module, then also change the address at the SmartLink icon Properties TAB sheet (one level higher).

FlexConn interface address:

The address for FlexConn communication, ranging from 1900 till 1999. Each SmartLink, connected to the same PC ComPort, must have a unique address. Similar as with the GPU interface address, if changed from default, also alter this FlexConn address at the SmartLink icon (one level higher).

Password:

6 alpha-numerical characters. ChTRanging of some entities requires a password. Default, ENRAF2 (or with newer software versions: AAAAAA) is used as password. Unless it is changed in this entity; then is requested for the password.

Parity:

Can be set to: Odd, Even or None. Standard Enraf GPU protocol (and FlexConn protocol) uses Odd parity.

Modem control type:

The modern control type Can be:

- Isolated RS232 (uses connector CN2, marked 1 to 4)
- Isolated RS485 (uses connector CN3, marked 5 to 8)
- Non-isolated RS232 (uses 9 pin D-type connector)
- Non-isolated RS422 (uses 9 pin D-type connector)
- Non-isolated RS232 (handshake) (uses 9 pin D-type connector)

When changed from default, make sure to adapt the communication line according to the new setting.

ACK mechanism:

Can be set to Enable or Disable. When enabled, the SmartLink transmits ACK characters about every 50 msec. after a host request is received and the reply message is not yet ready.

Function identification:

In the SmartLink, the HCM-GPU module has the function of: GPU-slave (the host is the GPU-master).

7.14.4.3 FCM-TRL/2 Module

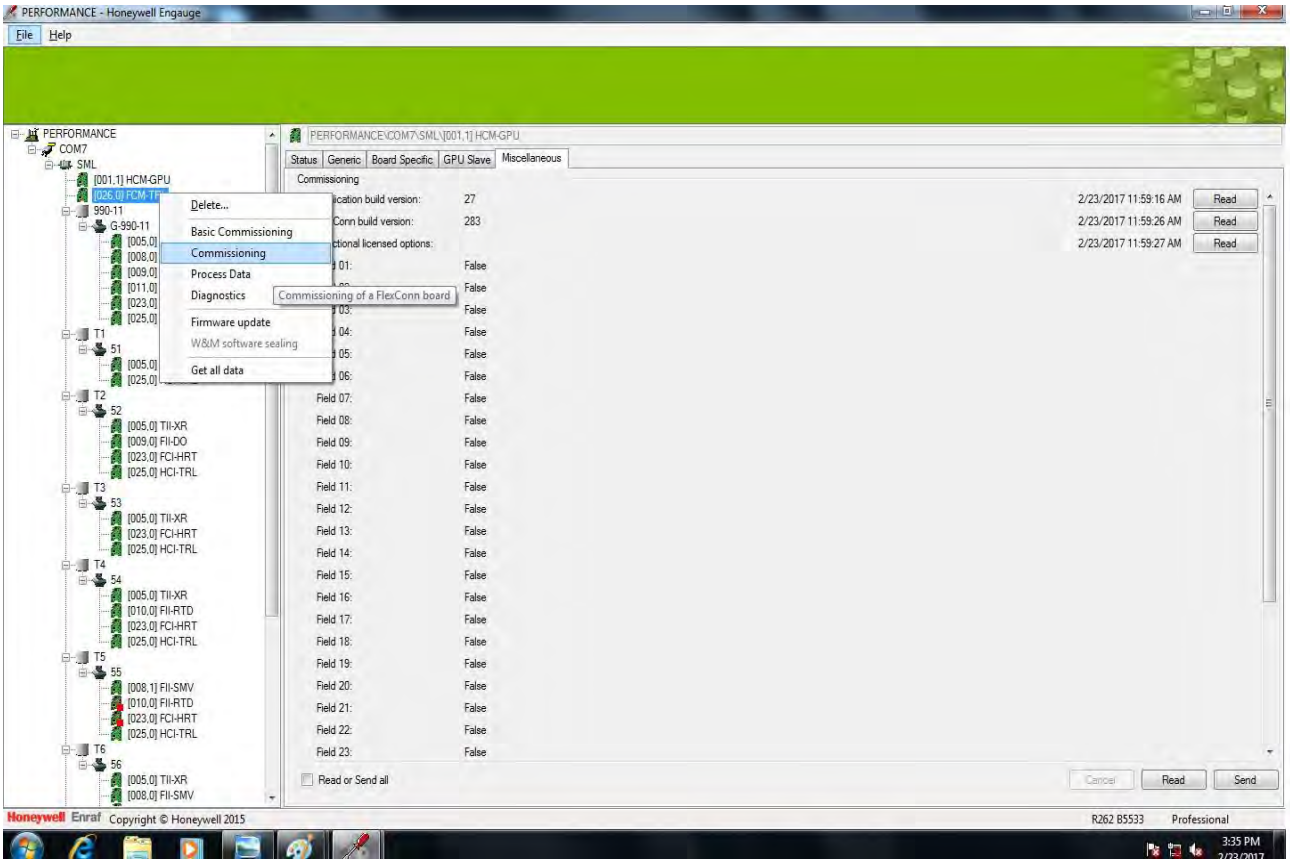


FIGURE 7-62 FCM-TRL/2 Screen

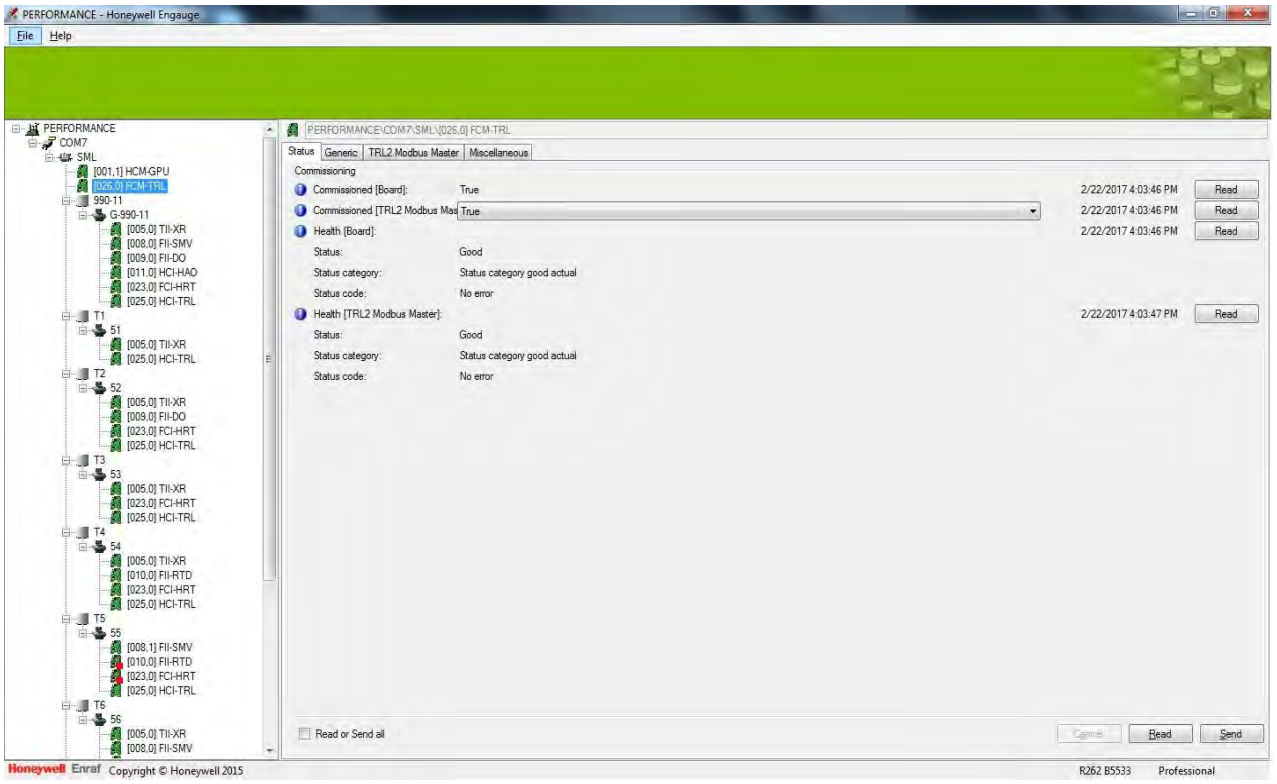


FIGURE 7-63 FCM-TRL/2 Status

Right click on **FCM-TRL** card. Select **Commissioning**. The TAB sheet **Status** gives information about the health of the TRL/2 module master (Refer to "FCM-TRL/2 Status").

The TAB sheet **Generic** gives information on the installed software version, the board instance number and from there three commands can be given (Refer to Figure "FCM-TRL/2 Specific").

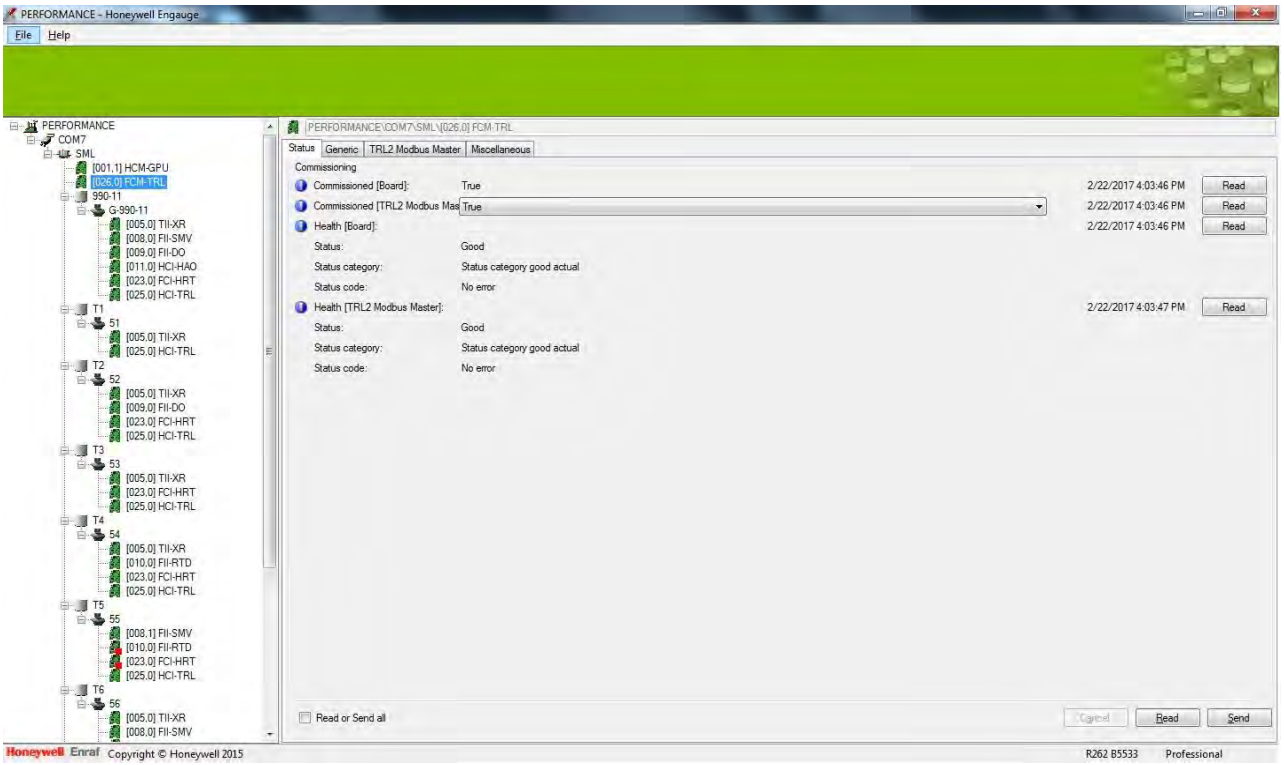


FIGURE 7-64 FCM-TRL/2 Specific

Reset device button: All modules of the SmartLink are reset

Reset board button: Only the FCM-TRL/2 module is reset

Test LED's button: The TxD and RxD led's are switched on for 10 seconds. The selected FCM-TRL/2 Module is identified. This is useful incase more than one FCM- TRL/2 Module is present.

Board Instance: If more than one FCM-TRL/2 Module is present in the SmartLink, each FCM-TRL/2 Module needs to have a unique board instance number. Range: 0 till 9.

Software version: Current installed software version for the FCM-TRL/2 module.

On the TAB sheet **TRL/2 Modbus Master** gauges Modbus address can be set (Refer to Figure "FCM-TRL/2 Modbus Master").

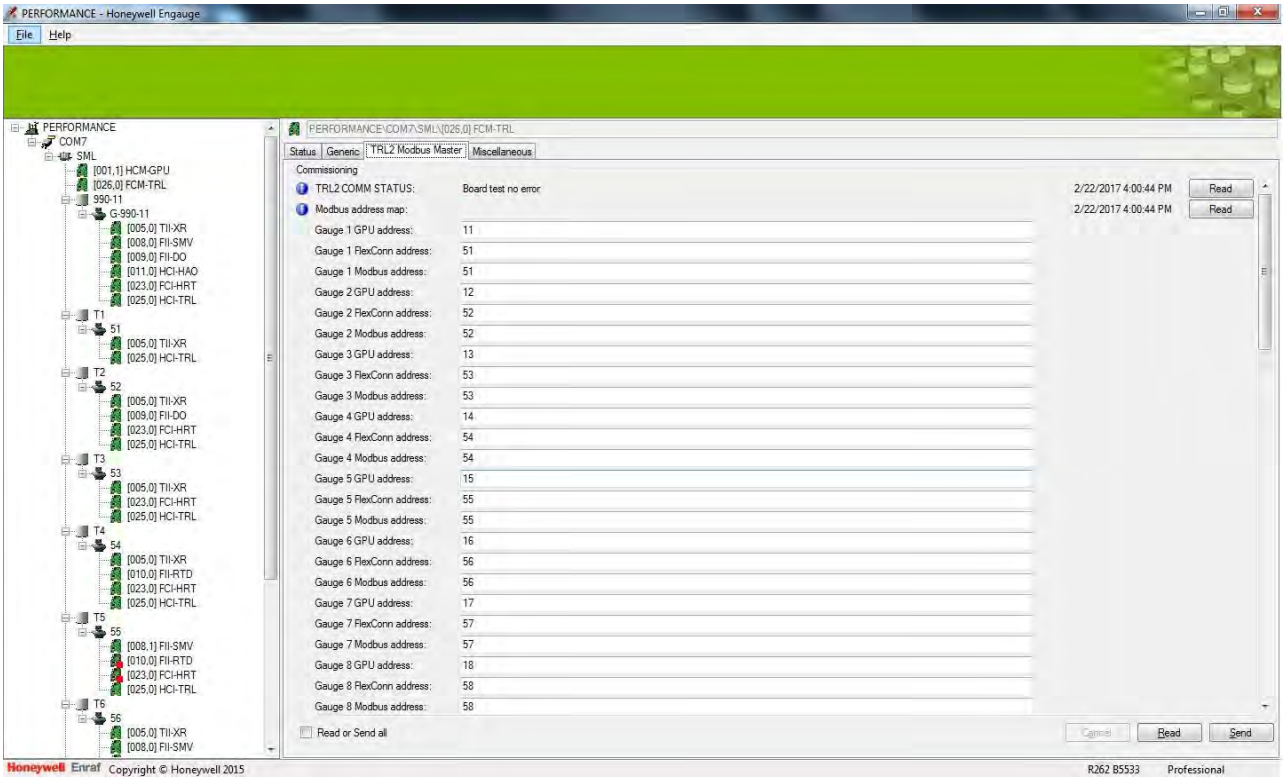


FIGURE 7-65 FCM-TRL/2 Modbus Master

NOTE: You can enter maximum 20 gauges Modbus address for commissioning at a time. If you want to commission more gauges, delete the first 20 modbus address on the TRL2 Modbus page after commisioning them and add next 20 gauges address and commission them. All the gauges will be listed on the left pane after every commissioning.

Identification:

An 8 character long name for the FCM- TRL/2 board.

GPU instrument start address:

GPU instrument stop address:

When one FCM-TRL/2 Module is used in the SmartLink, the default start and stop addresses (0 and 99) can be used.

When two or three FCM-TRL/2 Modules are used in the SmartLink, a division must be made of the full range; for instance:

l 99 for the second FCM-TRL/2 Module or

0 till 29 for the first FCM-TRL/2 Module

30 till 59 for the second FCM-TRL/2 Module

60 till 99 for the third FCM-TRL/2 Module

FlexConn instrument start address:

FlexConn instrument stop address:

When one FCM-TRL/2 Module is used in the SmartLink, the default start and stop addresses can be used.

When two or three FCM-TRL/2 Modules are used in the SmartLink, a division must be made, like described above.

NOTE: This is only required when FlexConn gauges are connected (like the SmartRadar FlexLine).

Time-out GPU instrument reply:

A time-out can be specified on the instrument's reply record. The time-out can be set between 10 and 2000 msec.

Password:

Refer to the password description of the HCM-GPU module.

Function identification:

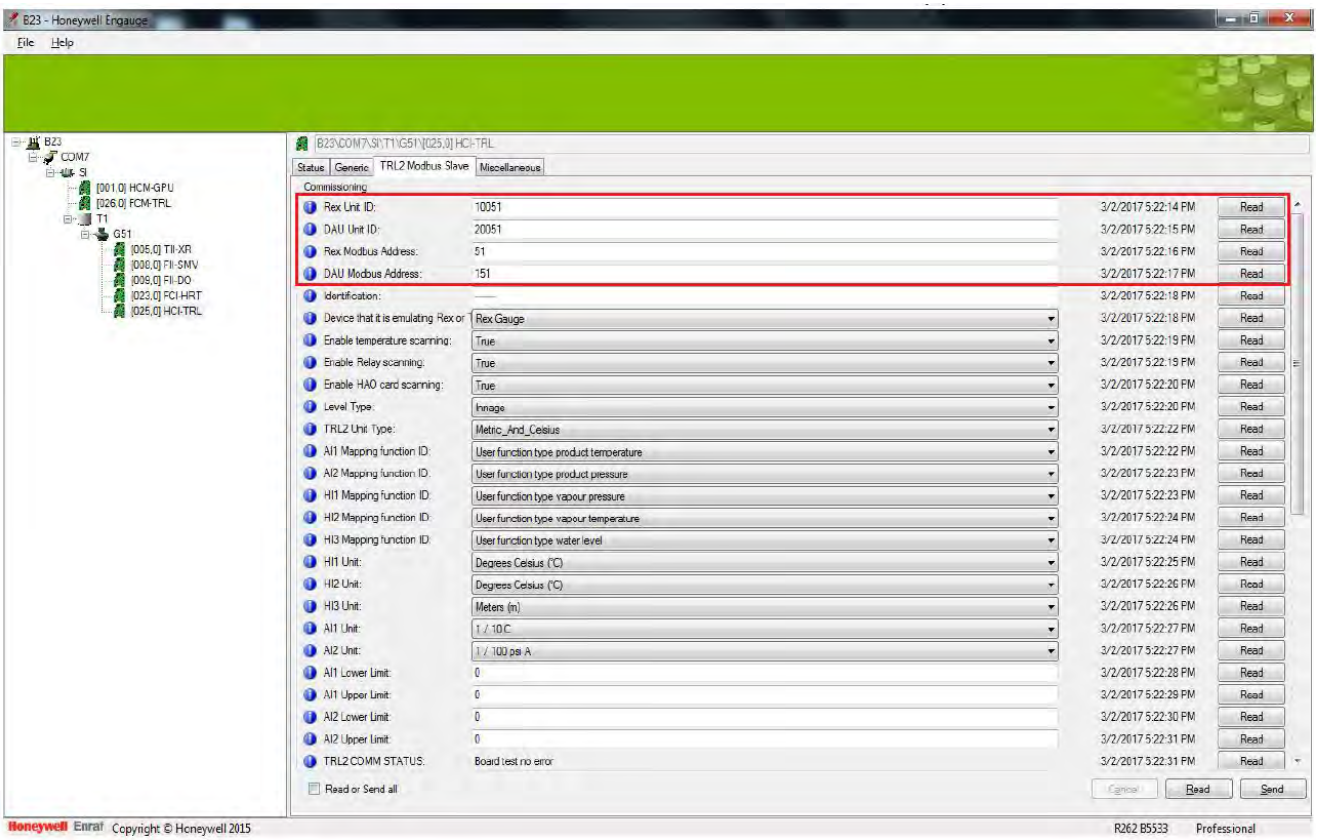
In the SmartLink, the FCM-TRL/2 module has the function of: TRL/2-master (the instrument is the TRL/2-slave).

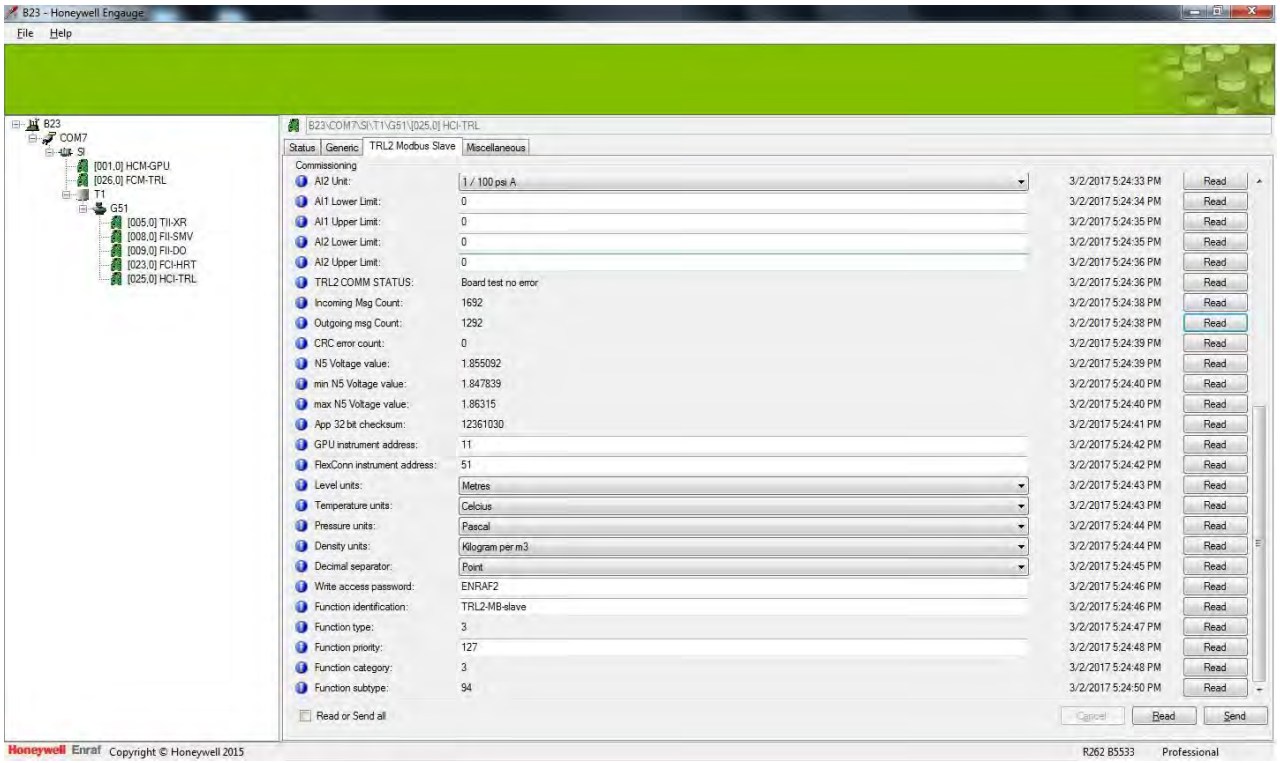
7.14.5 Configuration of Gauge TRL/2 through Engauge

You must configure the gauge TRL/2 through engauge.

Follow the steps to configure the gauge TRL/2:

1. Connect the HCI TRL/2 card in FlexLine 990 gauge.
2. Scan the gauge through SmartLink.
3. In the Enguage tool, right click on HCI-TRL board. Click on **Commissioning**
4. The TAB sheet **TRL2 Modbus Slave** appears:





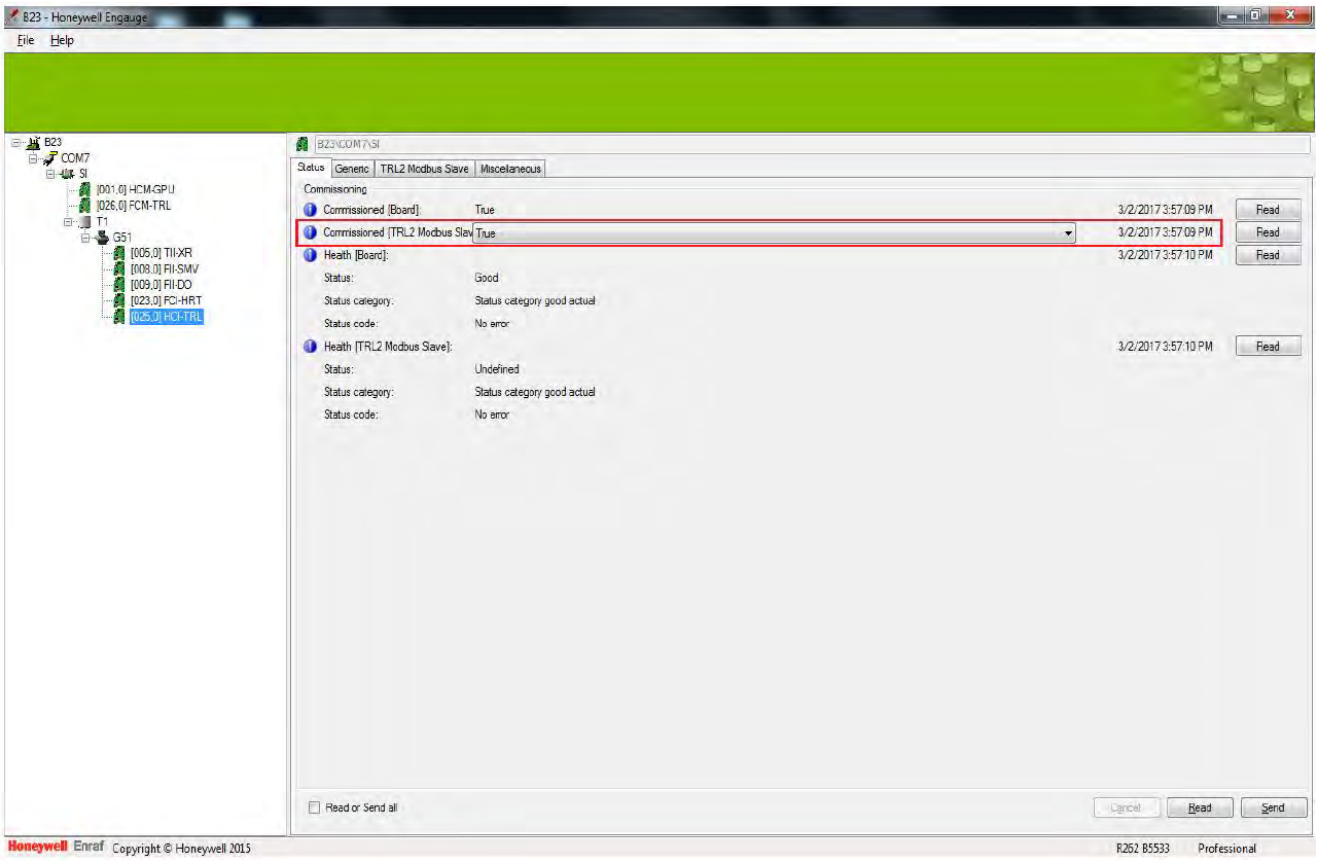
5. Under commissioning do the configuration as follows:
   a) Enter the Rex Unit ID, DAU Unit ID, Rex Modbus Address, DAU Modbus Address, GPU instrument address, FlexConn instrument address.

NOTE: The basic configuration (Rex Unit ID, DAU Unit ID, Rex Modbus Address, DAU Modbus Address, GPU instrument address, FlexConn instrument address) of Gauge TRL/2 card must be done using Enguage tool through SmartLink..

NOTE: The parameter for Rex Unit ID, DAU Unit ID, Rex Modbus Address, DAU Modbus Address should be entered as per Emerson system, as in saved database (Refer Figure "Saving configuration in database").

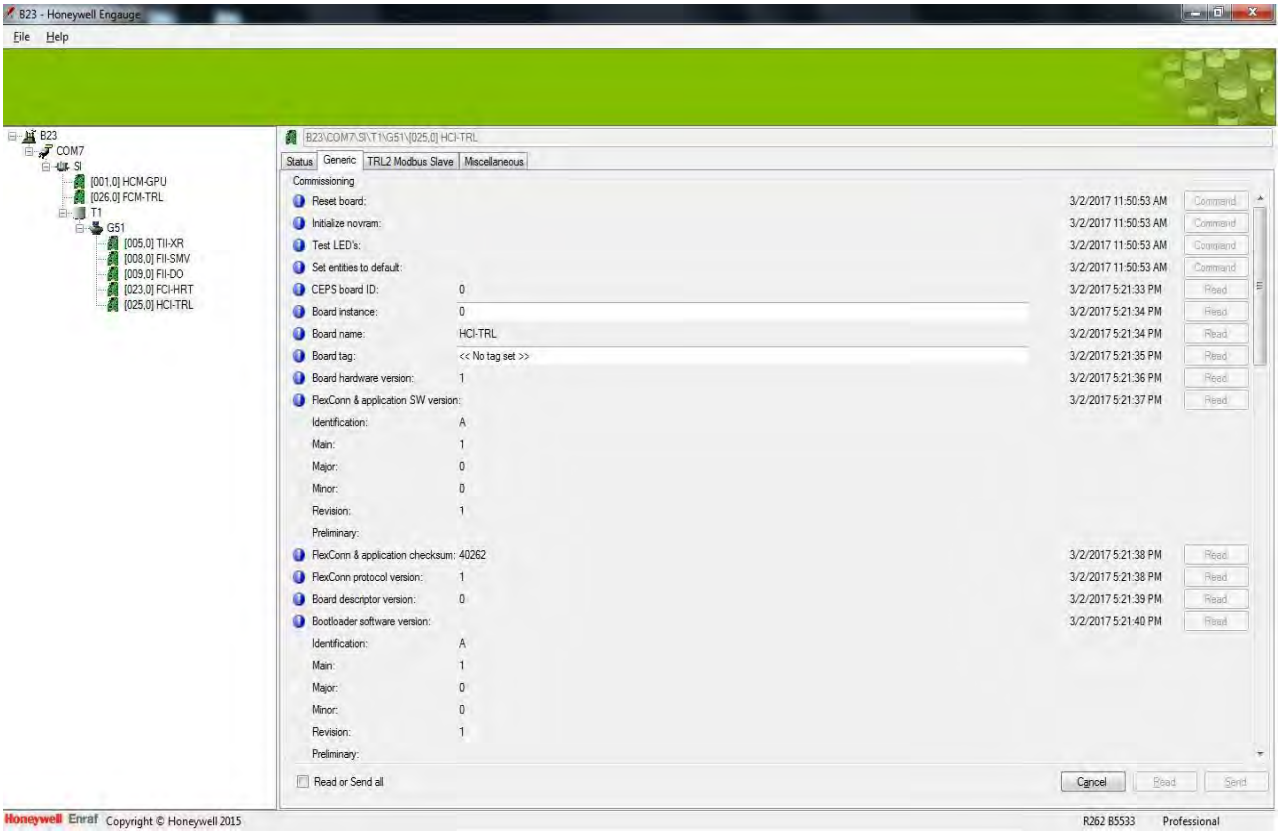
   b) Click Read.
   c) Click Send.
6. Click on Status tab.

The page appears as follow:



7. Select **True** from the Commissioned [TRL/2 Modbus Slave] drop down menu.
8. Click Read.
9. Click Send.
10. Click on **Generic** tab.

The page appears as follow:



11. Check the Firmware version is correct, and if you want to reset board and Novram you can reset using this tab.
12. Open the machine where Engauge tool is installed.
13. Create new site. Refer **Installation and Operation Manual Enguage 2.6 - Professional**.
14. Add device. Refer **Installation and Operation Manual Enguage 2.6-Professional.**
15. Add field connector. See **Installation and Operation Manual Enguage 2.6 - Professional**.
16. Add Tank. **See Installation and Operation Manual Enguage 2.6 - Professional.**
17. Add gauge. See **Installation and Operation Manual Enguage 2.6 - Professional**.
18. Scan the field for connected instruments and field connectors (interfaces).
19. Add the GPU and FlexConn address in the Engauge tool.

7.14.6 Firmware Upgrade

7.14.6.1 General

The Firmware Upgrade can be done for two boards:

1. SmartLink TRL/2 (FCM-TRL)
2. Gauge TRL/2 (HCI-TRL)

7.14.6.2 Firmware Upgrade through Engauge

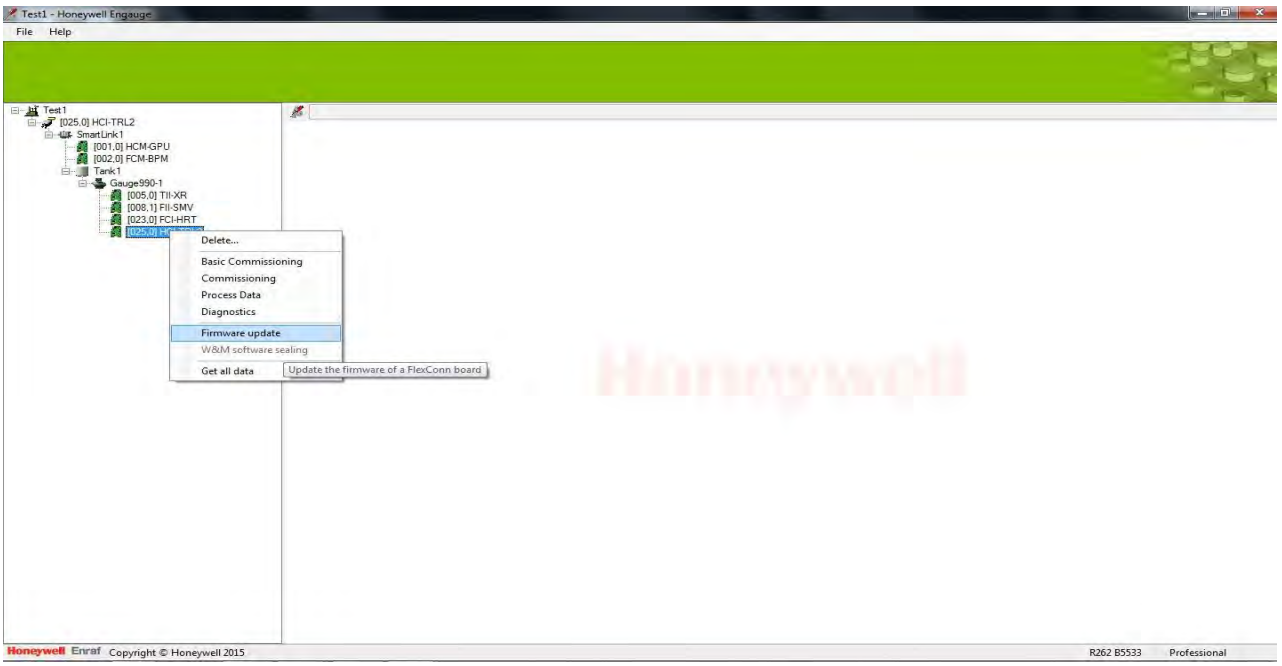
NOTE: The Firmware upgrade process is same for both SmartLink TRL/2 and Gauge TRL/2 boards.
When SmartLink based direct upgrade is not possible, upgrade of gauge TRL2 firmware should be done through CAN-SD Card and not through FCU.

Follow the steps to upgrade the firmware:

1. Scan the FlexConn Board.

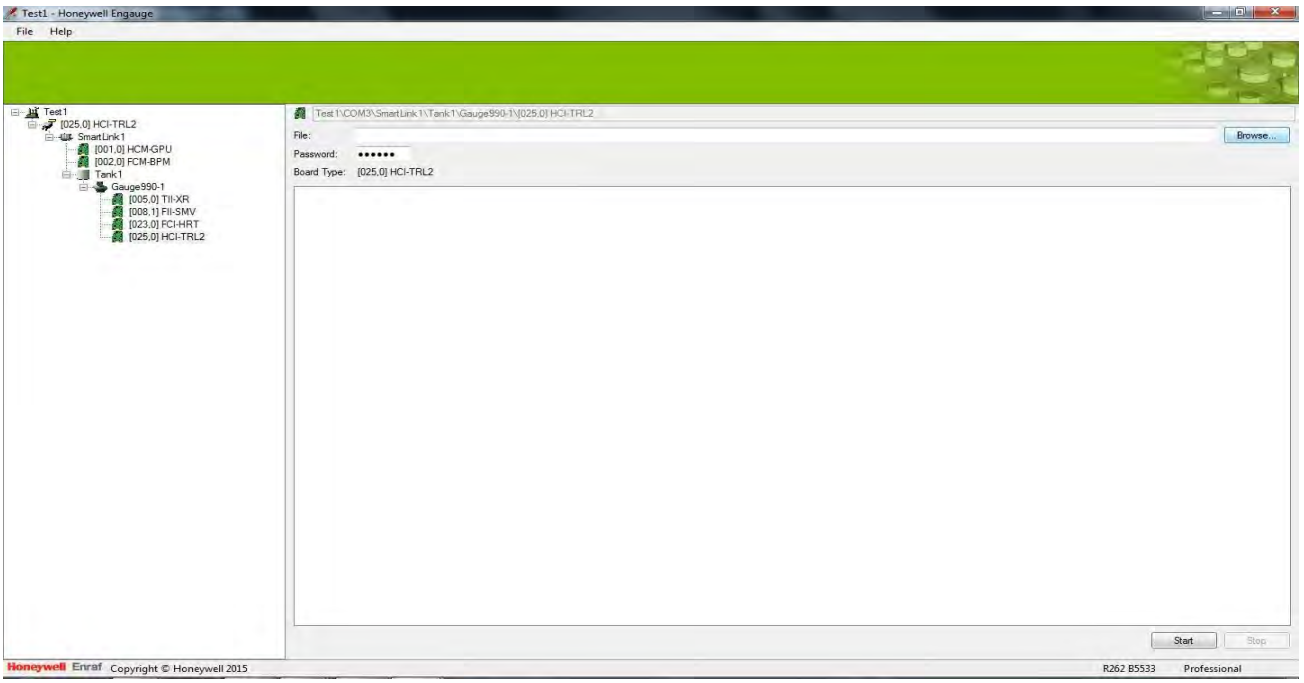
NOTE: After scanning if communication is proper, the connected devices on CAN drive will be automatically displayed.

2. Select **Device** and right click for options.

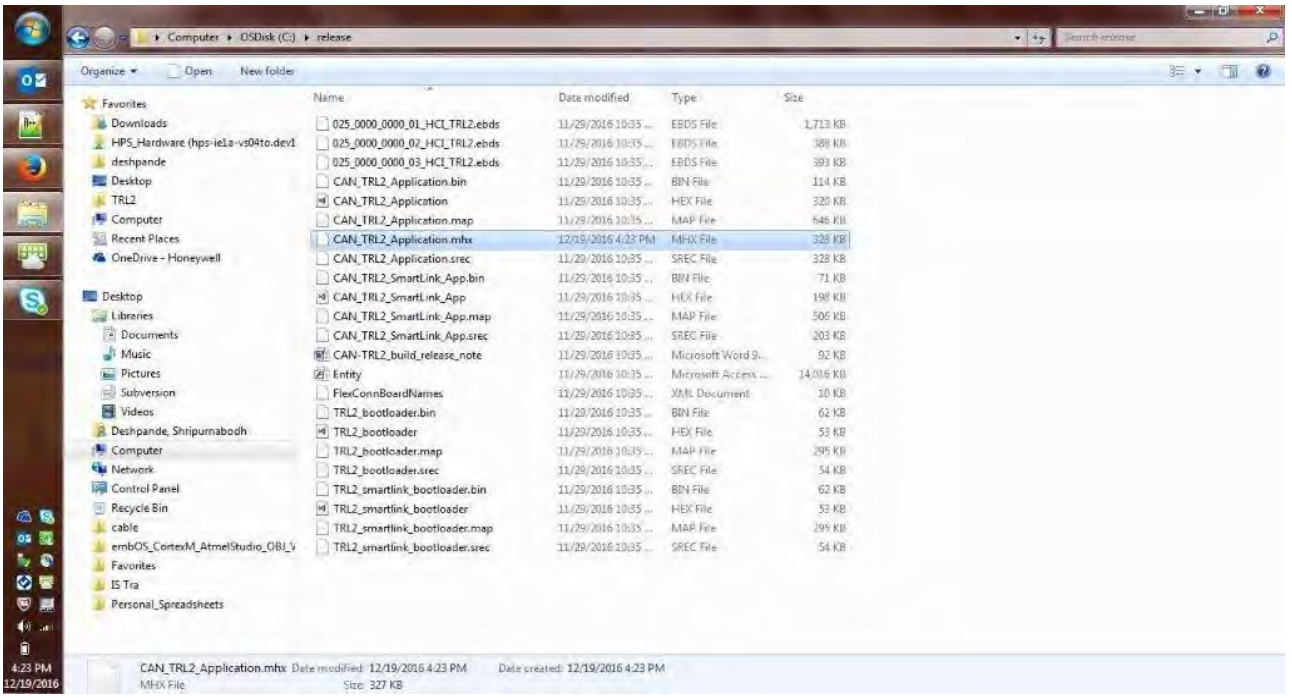


3. Select **Firmware upgrade**.

The window appears as follow:



4. Click on **Browse** to select the file.



5. Select .**MHX file** from the folder and click OK.
6. Click on **Start**.

   The Firmware is upgraded for SmartLink TRL/2.

7.14.6.3 Firmware Upgrade of HCI-TRL/2 or FCM-TRL/2 through CAN-SD Card

Follow the steps to upgrade firmware for HCI-TRL/2 or FCM-TRL/2 through CAN-SD card.

1. Insert the card in a card reader and connect it to PC.
2. Create a folder in the card and name it as "**Firmware**".
3. Add/Copy the bin format file to the card inside the **Firmware** folder.

   For Example: 0_A1001.025
4. Remove the card from the PC and insert in CAN-SD (TII-SD) card.
5. Connect the card to the gauge.
6. During Firmware upgrade the following process occurs:

   The health LED blinks indicating the health status. After few seconds Amber light (LED 2) blinks indicating the firmware upgrade process.

   Once the upgrade starts the card will go to bootloader state.

   After upgrade is completed, the card gets back to normal state.
7. The Firmware is upgraded for HCI-TRL/2 or FCM-TRL/2 through CAN- SD card.

Step 1

Step 2

7.14.7 Replacement Scenario

7.14.7.1 Replacing Rex Gauge

The Rex gauges are replaced with CAN TRL/2 FlexLine 990 gauges. Follow the steps to replace Rex gauge:

1. Save backup of Rex configuration from Rosemount TankMaster. Refer to Section "Saving configuration in database" on page 3.
2. Set the device to manual mode.

Configure the CAN TRL/2 FlexLine gauge from Enguage. Refer to Section "Configuration of Gauge TRL/2 through Engauge" on page 13.

3. Replace the Rex gauges with FlexLine gauge.
4. Connect all the transmitters and sensors to FlexLine and connect FlexLine gauge in TRL/2 network.
5. Connect Engauge to Enraf® FCU or FBM based on install base. The converter required for connecting Engauge to FBM/FCU.
6. Configure/Calibrate all the measurement cards to match Rex configuration (Offset, threshold, calibration etc.) using Engauge.
7. Configure Analog input and HART input entities from Engauge.

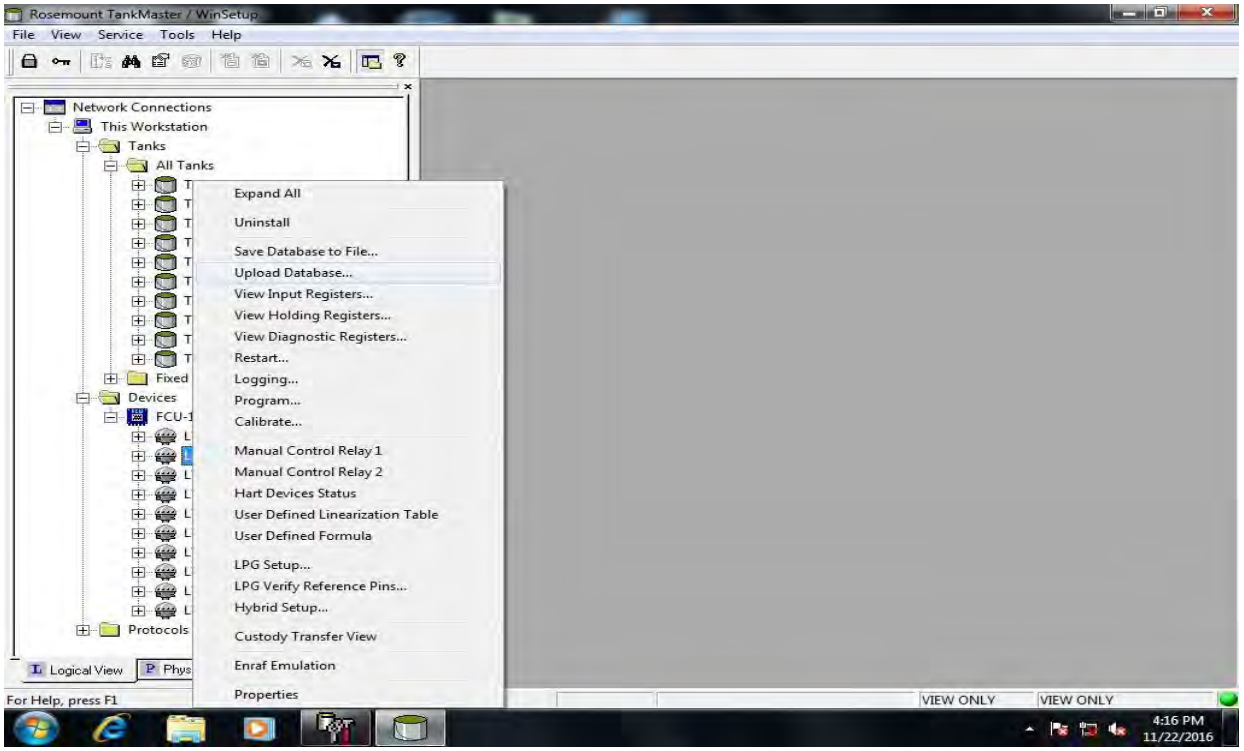
   Example: Functionalities supported by these cards in Rex like Product Pressure, vapor temperature etc.
8. Disconnect Engauge and connect to Rosemount TankMaster (If FBM or if the second group port of FCU connected to DCS).
9. Restore all the saved Rexgauge configuration to FlexLine from Rosemount TankMaster.

   To restore the saved Rexgauge configuration:

   a) On the Rosemount TankMaster page, select the device (for which data has to be uploaded) on the left pane.

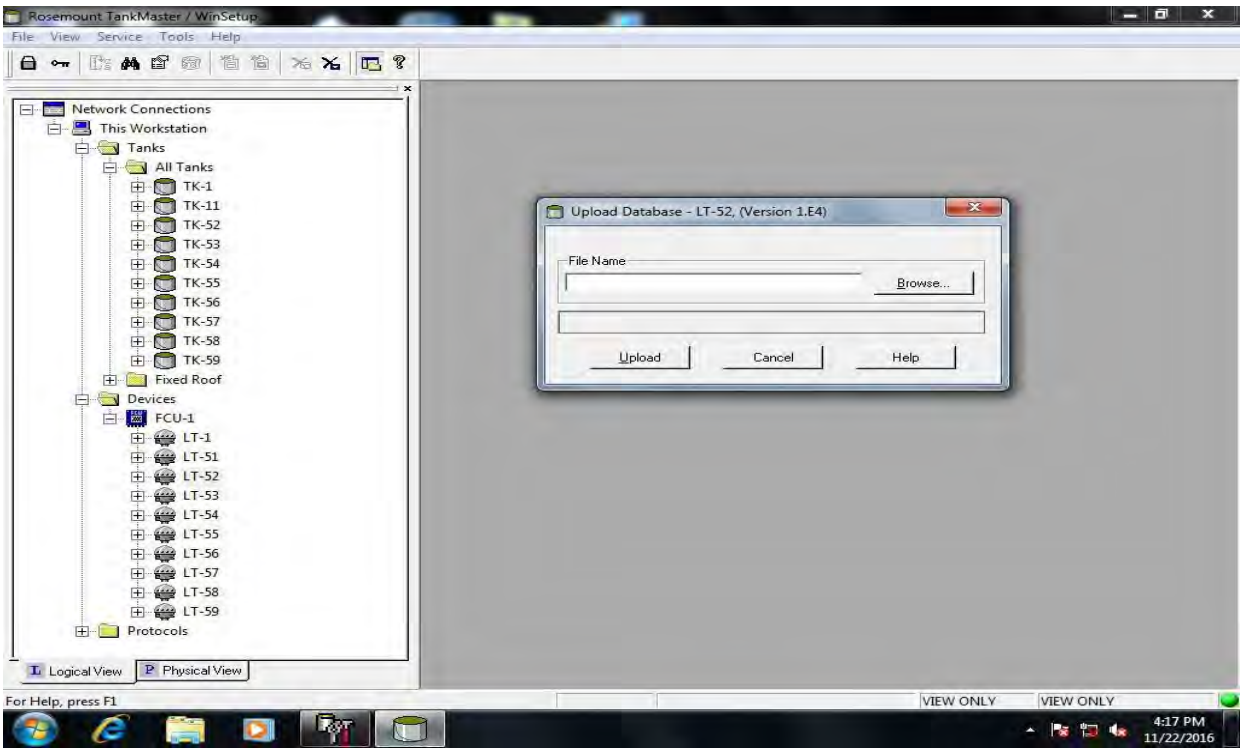
   b) Right click on the selected device.

The page appears as follow:

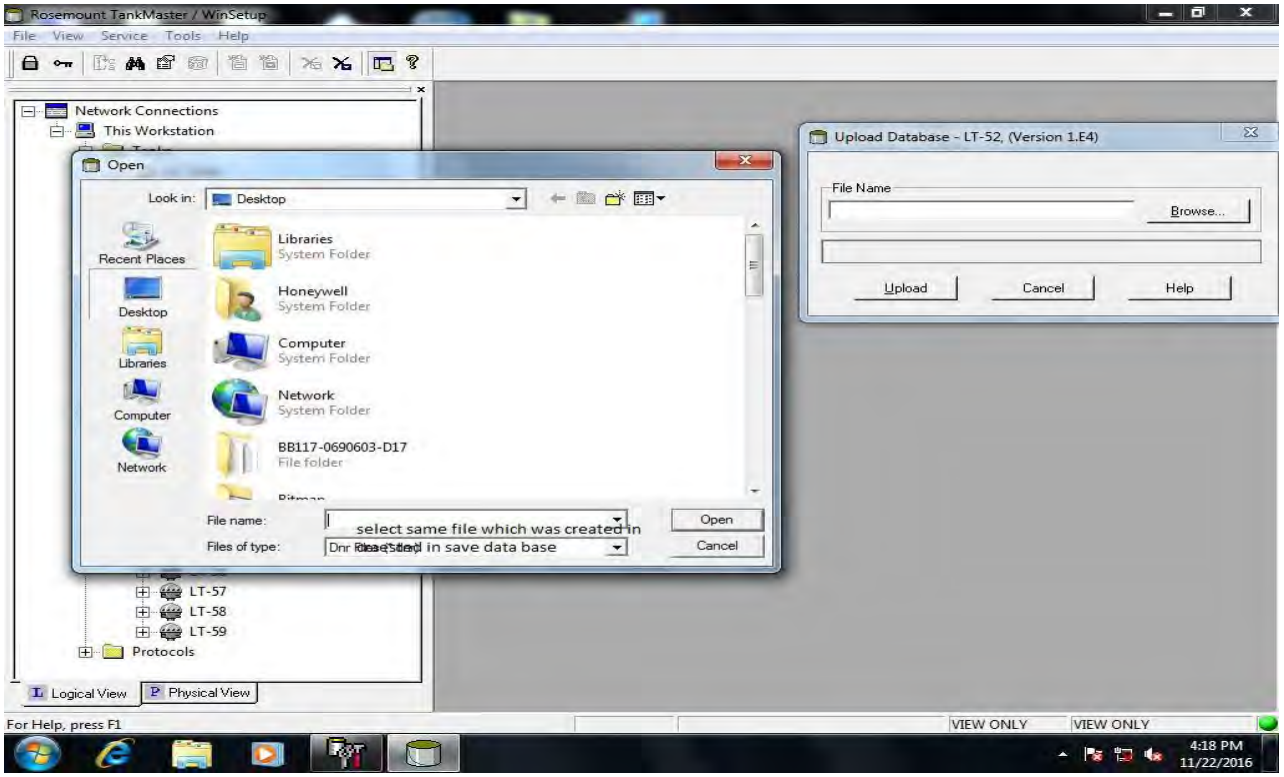


c) Select **Upload Database.**

The dialogue box appears as follow:



d) Click on **Browse**.
Use the path where you saved the database.



e) Select the file.

f) Click on Upload.
The configuration files are uploaded.

10. FlexLine reports data similar to Rex gauge which is replaced.

7.14.7.2 Possible Configuration Scenarios - FlexLine 990 Gauge

The following schematics represents the possible configuration scenarios for connecting the 990 gauge interfacing to Rosemount TankMaster and Enraf Engauge tool with all possible intermediate devices.

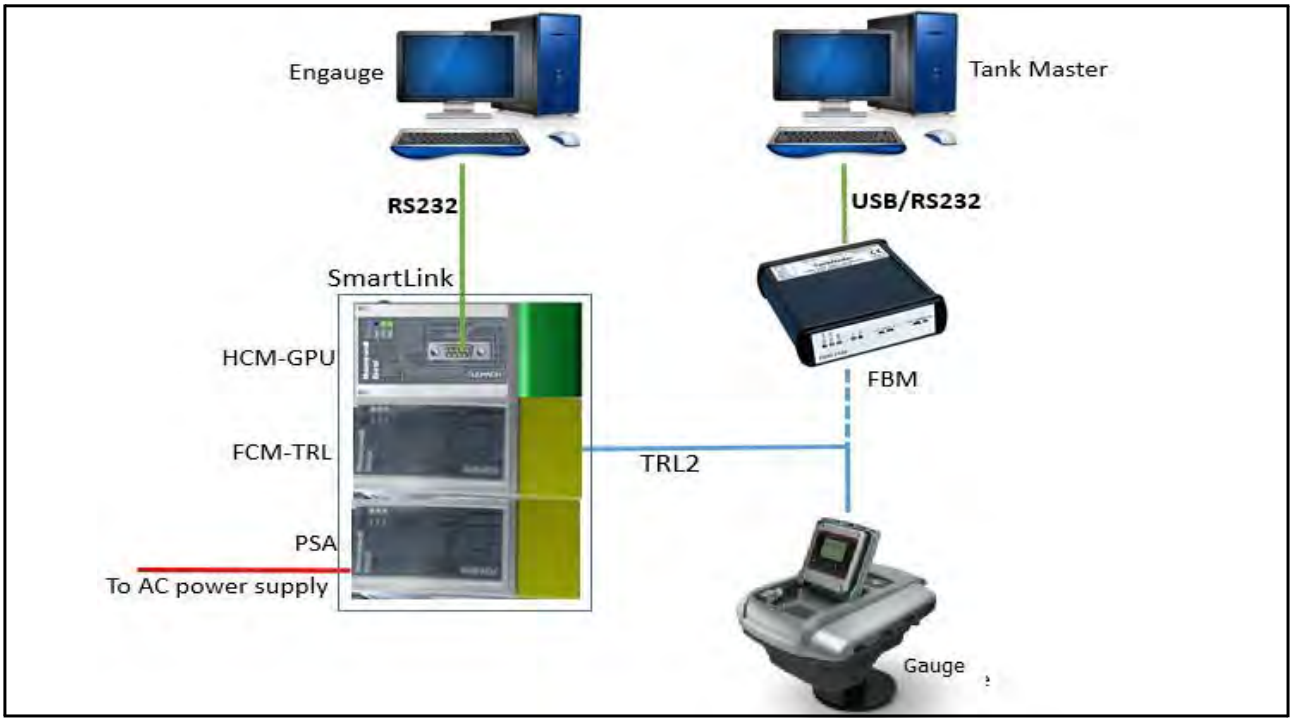


FIGURE 7-66 Configuration Scenario 1

NOTE: Configuration path: Engauge **>** *SmartLink* **>** *Gauge*

Communication path: TankMaster **>** *FBM* **>** *Gauge*

FIGURE 7-67 Configuration Scenario 2

NOTE: Configuration path: Engauge **>** *SmartLink* **>** *FCU* **>** *Gauge*

Communication path: TankMaster **>** *FCU* **>** *Gauge*

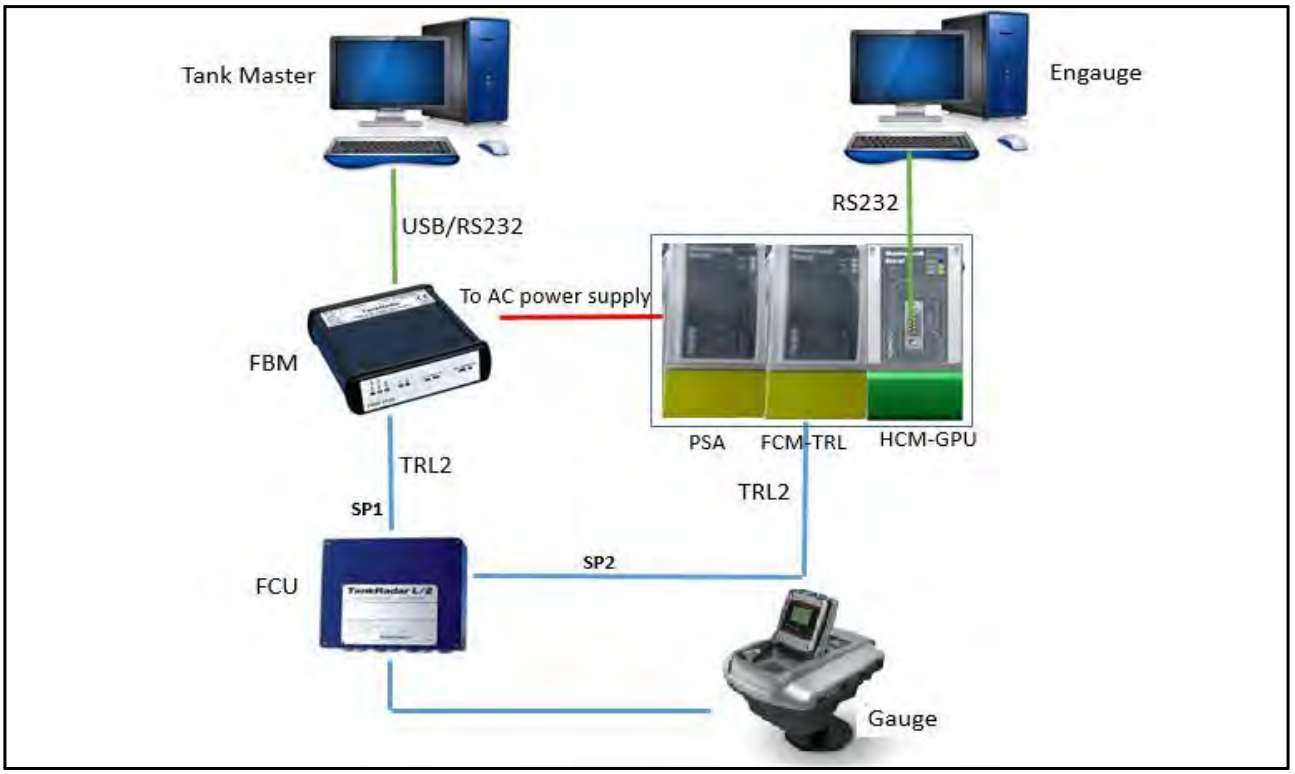


FIGURE 7-68 Configuration Scenario 3

NOTE: Configuration path: Engauge **>** *SmartLink* **>** *FCU* **>** *Gauge*

Communication path: TankMaster **>** *FBM* **>** *FCU* **>** *Gauge*

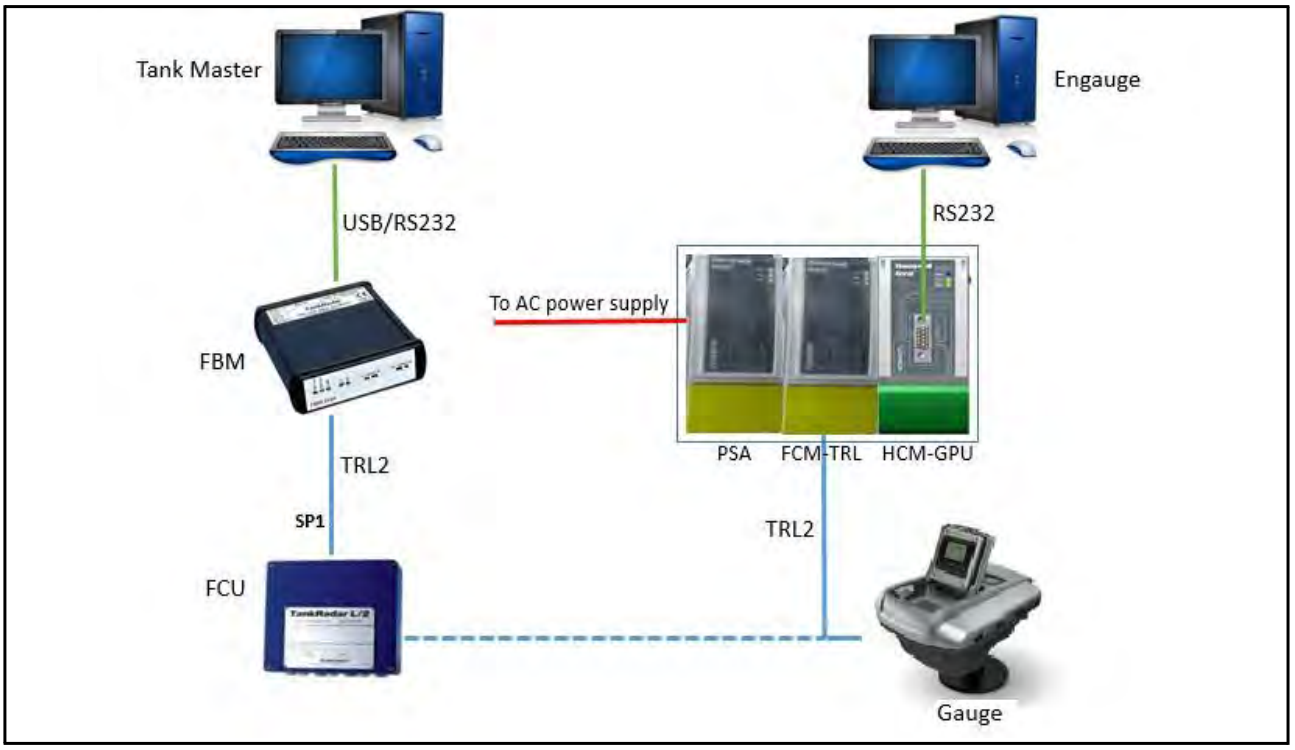


FIGURE 7-69 Configuration Scenario 4

NOTE: Configuration path: Engauge **>** *SmartLink* **>** *Gauge*

Communication path: TankMaster **>** *FBM* **>** *FCU* **>** *Gauge*

7.14.8 Troubleshooting

7.14.8.1 Gauge Scan Issue

1. Scan the SmartLink and check for the gauge address mentioned in FCM-TRL/2 card.
2. If gauge address is not entered, enter the gauge address and GPU address and read all the board parameters.
3. Reset FCM-TRL/2 card after reading all the parameters.
4. Make Commissioned option as “True” and press send.
5. Scan the gauge with proper FlexConn and GPU address provided in FCM-TRL/2 card (Recheck gauge and GPU of gauge is same as entered in the FCM-TRL/2 card before scanning the gauge).

7.14.8.2 TII-XR card Detection Issue

1. Scan the SmartLink and provide respective gauge address to the cards before you scan the cards.
2. Check if all cards are scanned which are present in the gauge.
3. If TII-XR card is not detecting, check all other FlexConn boards for which the level parameter is linked are blinking with healthy (Blue LED light comes on for every 5 seconds) status (Particularly HCI-HAO card).
4. If any of the FlexConn board for which level parameter is linked and is not healthy then switch off the gauge and remove the unhealthy FlexConn board from the gauge.
5. Scan the gauge and observe TII-XR card is appeared in scanning.

   If the TII-XR card is appeared in scanning:

   - Re-insert affected FlexConn board into gauge (Gauge should be switched off).
   - Restart gauge and scan all boards once again.

   If the TII-XR card is not appeared in scanning:

   - Hardset the gauge and repeat all the steps from step 1.

7.14.8.3 HCI-TRL/2 detection issue

1. Reset HCI-TRL/2 card every time after firmware upgrade of TRL/2 card is performed.
2. If HCI-TRL/2 card appears more than one time when gauge scan is performed, reset NOVROM of HCI-TRL/2 gauge then provide all gauge addresses and rescan the gauge.
3. If gauge scan Time out error appears then restart smart link and try to scan again (check gauge address mentioned in FCM-TRL/2).

7.14.8.4 Firmware Upgrade of HCI-TRL2 using CAN-SD card

1. Store Binary format firmware of HCI-TRL/2 card in SD card (0_A1000B.026)
2. Switch off the gauge and insert CAN-SD card with suitable firmware inside gauge.
3. Switch on the gauge observe LED pattern of SD card and HCI-TRL/2 card.
4. Remove SD card from CAN rail or from gauge after firmware upgrade completed.

NOTE: If CAN-SD card remains inside the gauge after firmware upgrade, it will upgrade firmware whenever gauge is restarted for some other purpose and may lead to miscellaneous causes.

7.14.8.5 Firmware Upgrade issue/Gauge scan issue when smart link connected to FCU host port

1. Check Time out, Retries options in Engauge. if Timeout is less than 8000ms then Firmware upgrade will fail when it's done via FCU.
2. Keep Time out as 8000ms and set Retries as 3 in Engauge COM setting option.
3. Scan gauge and Upgrade Firmware of any FlexConn boards.

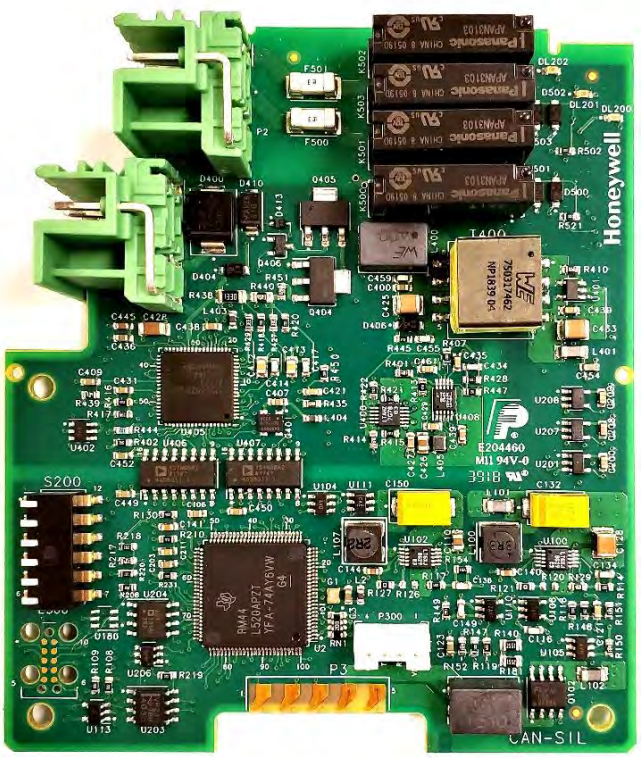
7.14.8.6 Smart link scan issue

4. Scan smart link if it shows network connection error.
5. Open "services" option in Engauge PC.
6. Select Honeywell Engauge Data service option, Right click and select Restart.
7. Scan Smart link from Engauge Tool.

7.14.8.7 Gauge scan after Novram reset

8. Do Novram reset of HCI-TRL card.
9. Scan the gauge. The error message appears giving information about gauge scan fail.
10. Click on FCM-TRL card in SmartLink and set GPU and FlexConn address of particular gauge as "0".
11. Scan the gauge again

7.15 SIL overfill and underfill protection (FII-SIL)



7.15.1 Introduction

Field Interface Instrument - Safety Integrity Level (FII-SIL) is an optional FlexConn board. The FII-SIL module provides overfill and underfill protection functionality certified and suitable for use in Safety Instrumented Systems at SIL 2 with systematic capability at SIL 3. It is used with the 990 SmartRadar FlexLine tank gauge system.

FII-SIL provides two relay contacts for signaling a safety shutdown or safe state, and one 4-20 mA analog output both for monitoring the product level and signaling a safe state. The presence of two relay contacts provides configuration flexibility, such as separate signaling of overfill and underfill conditions, or the capability of an overfill early warning to allow corrective action before an overfill condition prompts a safety shutdown.

The physical contacts of each relay are closed or energized during normal operation. When a relay is in a safe state, the physical contacts

are open or de-energized. This allows loss of power to also signal a safe state.

In compliance with NAMUR NE 43, the analog output signals a safe state when the current at or above 21 mA, or is at or below 3.6 mA.

The following safety categories are monitored continuously to determine whether a safe state should be activated, in the order listed, at a rate of at least once per second.

Monitored Safety Categories
Contact and analog output physical health
Physical module health
Contact and analog output functional health
Product level health
Product level overfill or underfill

7.15.2 Errors

7.15.2.1 Safety Function Status

The Safety Function Status define possible reasons for activation of the safe state for each output. Each is a condition monitored as part of the safety categories outlined in section 7.15.1, above.

When the condition causing activation is no longer present, the output may be configured to remain in the safe state (latched) until power is cycled or a reset is initiated. This latching behavior can be enabled or disabled for each of the possible reasons for activation.

The safe state of the analog output can be configured to be a high or low burnout current level. High or low burnout action can also be assigned for each of the possible reasons for activation of a safe state.

Board and function failures are hardware failures which are considered to impact the integrity of the analog output current level. To assure a safe state will always be signaled, these failures always result in a latched burnout current level of 0 mA.

The safety function status error codes, user actions, and the default latching behavior and burnout action for each are defined below:

Safety Function Status Code	User Action	Latching Default	Burnout Default
PRODUCT LEVEL DATA CORRUPTED The product level value received from the tank gauge is corrupted.	Service the CAN-SERVO board	Disabled	High
PRODUCT LEVEL DATA TOO OLD The product level value received from the tank gauge is more than 5 seconds old.	Service the CAN-SERVO board	Disabled	High
PRODUCT LEVEL DATA FROM WRONG SOURCE The product level value was received from a source that is not a 954 SmartServo tank gauge.	Remove the incompatible board	Disabled	High
PRODUCT LEVEL NOT GOOD The product level value received from the tank gauge has a bad status.	Service the CAN-SERVO board	Disabled	High
PRODUCT LEVEL SCAN TIMEOUT No product level value has been received for more than 5 seconds.	Service the CAN-SERVO board	Disabled	High
DISPLACER NOT ON PRODUCT LEVEL The Servo tank gauge displacer is not positioned on the product level.	Deploy displacer to measure product level	Disabled	High
PRODUCT LEVEL OVERFILL The product level value is above the threshold value.	Correct the product level	Disabled	High
PRODUCT LEVEL UNDERFILL The product level value is below the threshold value.	Correct the product level	Disabled	High
FIXED FREQUENCY ABOVE SETPOINT The Servo tank gauge displacer is at the high motor limit.	Calibrate the servo level measurement	Disabled	High
FIXED FREQUENCY BELOW SETPOINT The Servo tank gauge displacer is at the low motor limit.	Calibrate the servo level measurement	Disabled	High
BOARD TEMPERATURE FAILURE The temperature of the FII-SIL module is excessive.	Replace the CAN-SIL board	Disabled	High

Safety Function Status Code	User Action	Latching Default	Burnout Default
DATA MEMORY FAILURE A failure of the FII-SIL data memory has occurred.	Replace the CAN-SIL board	Enabled	High
CODE CHECKSUM FAILURE The FII-SIL module code memory has become corrupted.	Replace the CAN-SIL board	Enabled	High
OUTPUT READBACK FAILURE The contact state or analog output level cannot be verified.	Replace the CAN-SIL board	Enabled	High
BOARD FAILURE A failure of the FII-SIL module electronics has occurred.	Replace the CAN-SIL board	Enabled	High
FUNCTION FAILURE A failure of the FII-SIL module software has occurred.	Replace the CAN-SIL board	Disabled	High

7.15.2.2 Safety Shutdown Reason Codes

The Safety Function Status Codes listed below have detail error information in the output's Safety Shutdown Reason entity.

Safety Function Status Code	Safety Shutdown Reason Codes
BOARD FAILURE	VOLTAGE MON ADC ERROR Communication with the FII-SIL voltage monitor failed VOLTAGE MON POWER SUPPLY LO LIM_EXCEEDED The power supply voltage is below the lower limit. VOLTAGE MON POWER SUPPLY HI_LIM_EXCEEDED The power supply voltage is above the upper limit. VOLTAGE MON LOGIC LO LIM EXCEEDED The internal voltage VDD1 is below the lower limit. VOLTAGE MON LOGIC HI LIM EXCEEDED The internal voltage VDD1 is above the upper limit. VOLTAGE MON CAN TRANSMITTER LO LIM EXCEEDED The internal voltage VDD3 is below the lower limit. VOLTAGE MON CAN TRANSMITTER HI LIM EXCEEDED The internal voltage VDD3 is above the upper limit. HARDWARE VERSION VOLTAGE OUT OF RANGE The FII-SIL hardware version is invalid

Safety Function Status Code	Safety Shutdown Reason Codes
FUNCTION FAILURE	SIL OUTPUT SELF-TEST FAILURE The output function health diagnostics have failed.
CODE CHECKSUM FAILURE	ROM ERROR The FII-SIL firmware is corrupted.
BOARD TEMPERATURE FAILURE	TEMPERATURE MON LO LIM EXCEEDED The FII-SIL module temperature is below the lower limit TEMPERATURE MON HI LIM EXCEEDED The FII-SIL module temperature is above the upper limit TEMPSENS SPI COMMUNICATION ERROR Communication with the FII-SIL module temperature sensor failed.
DATA MEMORY FAILURE	NOVRAM ENTITY BCC ERROR The data read from non-volatile memory is corrupted. NOVRAM READ BACK ERROR The data written to non-volatile memory did not read back correctly. NOVRAM CORRUPT The non-volatile memory is corrupted. NOVRAM ADMINISTRATION BCC ERROR The data facilitating access to non-volatile memory is corrupted.

7.15.2.3 Other Errors

There are also other Safety Function Status codes can also cause the outputs to go to a safe state. These errors are not latchable and the AO current is fixed.

Safety Function Status Code	Safety Shutdown Reason Codes
Safety Function Not Used	This Safety Function selection is available on all three outputs. When selected, the output is not functional. For the analog output, the output current becomes fixed at 21 mA.
Analog Output Mode Disabled	The analog output is not functional, and the output current is fixed at 0 mA.

7.15.2.4 Uncertain Conditions

These are not errors but are considered to be uncertain conditions, since the requested current level cannot be produced.

Safety Function Status Code	Safety Shutdown Reason Codes
Analog Output Over Range	An analog output current level above 20.5 mA is being requested. The actual current level stays at the upper limit of 20.5 mA and the SIL function health status becomes Uncertain.
Analog Output Under Range	An analog output current level below 3.8 mA is requested. The actual current level stays at the lower limit of 3.8 mA and the SIL function health status becomes Uncertain.
Analog Output Zero Span	The Upper Range Value and Lower Range Value are equal, preventing a product level percent of range from being calculated. The output current stays at the upper limit of 20.5 mA and the SIL function health status becomes Uncertain.
Analog Output Not Calibrated	The analog output has not been calibrated. The output current which corresponds to the product level may not be accurate.

7.15.3 Commissioning

The FII-SIL module does not require the configuration of any entities for commissioning. By default, the board and all three output functions are already in the commissioned state. However, all outputs are in safe state, so configuration is necessary for the FII-SIL module to be useful.

7.15.4 Proof Testing

The FII-SIL module requires periodic user operations to maintain its SIL certification, which are described in the Safety Manual. One of these activities is to perform proof tests on each of the outputs to assure the safe state functionality will perform properly when necessary. A proof test activates the safe state on each of the contacts and analog output by simulating an overfill or underfill condition and exercising the detection logic. A maximum interval can be configured for each output to warn the user if the time from the last proof test (or from the factory default state) has exceeded the interval time. A configurable timeout assures that proof tests will not remain active.

7.15.5 Entities

The following entities are mostly specific to the FII-SIL module and are readable or configurable using the Engauge and SmartView tools.

Contact 1 Health, Contact 2 Health and Analog Output Health are generic function entities but use the status codes specific to FII-SIL, as defined in Section 7.15.1, above.

(RO) = read only

Contact 1			
Name	**Value Range**	**Default Value**	**Description**
[Contact 1 Health] (RO)	*Status* GOOD UNCERTAIN BAD *Status Category* GOOD, ACTUAL VALUE GOOD, STORED VALUE UNCERTAIN, INSTRUMENT BAD, HARDWARE FAILURE BAD, OPERATIONAL FAILURE *Status Code* See section 7.15.2.1 "Safety Function Status" for definitions.		Functional health of contact 1. Any status other than GOOD will result in a safe state activation for contact 1.
[Contact 1 safety function]	< Not Used > < Overfill > < Underfill >	< Overfill >	The condition of product level relative to the threshold which will determine the activation of a contact 1 safe state, as an underfill or overfill condition. Overfill: activation occurs when the product level is above the Overfill Threshold. Underfill: activation occurs when the product level is below the Underfill Threshold. Not Used: contact 1 is activated in a constant safe state and does not perform any function.
[Contact 1 threshold]	< 0 – 3.402823×10^{38} > (meters)	< 0 >	The product level limit value for determining an overfill or underfill condition for contact 1.

Name	Value Range	Default Value	Description
[Contact 1 hysteresis]	< 0 – 3.402823 × 10^{38} > (meters)	< 0.010 >	A value relative to the threshold that will determine the point at which deactivation of a contact 1 safe state occurs after activation by an overfill or underfill condition. For an underfill, deactivation occurs when the product level is above (threshold + hysteresis). For an overfill, deactivation occurs when the product level is below (threshold – hysteresis).
[Contact 1 safety function status] (RO)	Status: < H >, < O >, < U >, < W > Status Code: Defined in Section 7.15.2.1	Status: < H > Status Code: NO ERROR	H: Healthy O: Overfill condition U: Underfill condition W: Warning condition, safe state is active, or proof test is overdue (status code is NO ERROR)
[Contact 1 safety shutdown counter] (RO)	< 0 – 3.402823 × 10^{38} >	< 0 >	The number of contact 1 safe state activations that have occurred since commissioning.
[Contact 1 safety shutdown reason] (RO)	Safety Function Status Code	NO ERROR	The safety function status code identifies the reason for the last time a contact 1 safe state activation occurred.
[Contact 1 switch count] (RO)	< 0 – 3.402823 × 10^{38} >	< 0 >	The number of contact 1 closures, or transitions from safe state to normal state, since commissioning.
[Contact 1 Start proof test]	Command		Initiates a contact 1 proof test if an actual contact 1 safe state is not currently active. Upon activation, contact 1 will open to simulate a safe state. An active poof test will terminate if an actual contact 1 safe state is activated, or if the contact 1 proof test timeout value is exceeded.

Name	Value Range	Default Value	Description
[Contact 1 Stop proof test]	Command		Terminates an active contact 1 proof test. Upon termination, the normal process will resume and contact 1 will close.
[Contact 1 proof test interval]	< 1 – 3650 > (days)	< 1825 >	The maximum time interval permitted between contact 1 proof tests. If exceed and when a contact 1 safe state is not active, the contact 1 safety function status will change to W to signal a warning that a proof test is overdue. The status code will remain as NO ERROR.
[Contact 1 proof test timeout]	< Auto timeout off > < 5 minutes > < 10 minutes > < 20 minutes > < 30 minutes >	< 5 minutes >	If not < Auto timeout off >, the maximum time duration a contact 1 proof test will remain active. If exceeded the proof test will automatically stop.
[Contact 1 proof test elapsed time] (RO)	< 0 – 4,294,967,295 > (days)	< 0 >	The elapsed time since the last contact 1 proof test or since commissioning if no contact 2 output proof test has been executed.

Contact 2			
Name	**Permitted Values**	**Default Value**	**Description**
[Contact 2 health] (RO)	Status GOOD UNCERTAIN BAD Status Category GOOD, ACTUAL VALUE GOOD, STORED VALUE UNCERTAIN, INSTRUMENT BAD, HARDWARE FAILURE BAD, OPERATIONAL FAILURE Status Code See section 7.15.2.1 “Safety Function Status” for definitions.		Functional health of contact 2. Any status other than GOOD will result in a safe state activation for contact 2.
[Contact 2 safety function]	< Not Used > < Underfill > < Overfill >	< Overfill >	The condition of product level relative to the threshold which will determine the activation of a contact 2 safe state, as an underfill or overfill condition. Overfill: activation occurs when the product level is above the Overfill Threshold. Underfill: activation occurs when the product level is below the Underfill Threshold. Not Used: contact 2 is activated in a constant safe state and does not perform any function.
[Contact 2 threshold]	< 0 – 3.402823×10^{38} > (meters)	< 0 >	The product level limit value for determining an overfill or underfill condition for contact 2.

Name	Value Range	Default Value	Description
[Contact 2 hysteresis]	< 0 – 3.402823 × 10^{38} > (meters)	< 0.010 >	A value relative to the threshold that will determine the point at which deactivation of a contact 2 safe state occurs after activation by an overfill or underfill condition. For an underfill, deactivation occurs when the product level is above (threshold + hysteresis). For an overfill, deactivation occurs when the product level is below (threshold – hysteresis).
[Contact 2 safety function status] (RO)	Status: < H >, < O >, < U >, < W > Status Code: Defined in Section 7.15.2	Status: < H > Status Code: NO ERROR	H: Healthy O: Overfill condition U: Underfill condition W: Warning condition, safe state is active or proof test is overdue
[Contact 2 safety shutdown counter] (RO)	< 0 – 3.402823 × 10^{38} >	< 0 >	The number of contact 2 safe state activations that have occurred since commissioning.
[Contact 2 safety shutdown reason] (RO)	Safety Function Status Code	NO ERROR	The safety function status code identifying the reason for the last time a contact 2 safe state activation occurred.
[Contact 2 switch count] (RO)	< 0 – 3.402823 × 10^{38} >	< 0 >	The total number of contact 2 closures, or transitions from safe state to normal state.

Name	Value Range	Default Value	Description
[Contact 2 start proof test]	Command		Initiates a contact 2 proof test if an actual contact 2 safe state is not currently active. Upon activation, contact 2 will open to simulate a safe state. An active proof test will terminate if an actual contact 2 safe state is activated, or if the contact 2 proof test timeout value is exceeded.
[Contact 2 stop proof test]	Command		Terminates an active contact 2 proof test. Upon termination, the normal process will resume and contact 2 will close.
[Contact 2 proof test interval]	< 1 – 3650 > (days)	< 1825 >	The maximum time interval permitted between contact 2 proof tests. If exceed and when a contact 2 safe state is not active, the contact 2 safety function status will change to W to signal a warning that a proof test is overdue. The status code will remain as NO ERROR.
[Contact 2 proof test elapsed time] (RO)	< 0 – 4,294,967,295 > (days)	< 0 >	The elapsed time since the last contact 2 proof test or since commissioning if no contact 2 output proof test has been executed.
[Contact 2 proof test timeout]	< Auto timeout off > < 5 minutes > < 10 minutes > < 20 minutes > < 30 minutes >	< 5 minutes >	If not < Auto timeout off >, the maximum time duration a contact 2 proof test will remain active. If exceeded the proof test will automatically stop.

Analog Output			
Name	**Permitted Values**	**Default Value**	**Description**
[Analog output health] (RO)	*Status* GOOD UNCERTAIN BAD *Status Category* GOOD, ACTUAL VALUE GOOD, STORED VALUE UNCERTAIN, INSTRUMENT BAD, HARDWARE FAILURE BAD, OPERATIONAL FAILURE *Status Code* See section 7.15.2.1 “Safety Function Status” for definitions.		Functional health of the analog output. Any status other than GOOD will result in a safe state activation for the analog output.
[Analog output mode]	< Disabled > < Enabled >	< Disabled >	Disabled: the analog output does not function and remains at 0 mA current value. 4-20 mA: The analog output is in normal 4-20 mA mode.

Name	Value Range	Default Value	Description
[Analog output safety function]	< Not used > < Overfill > < Underfill > < Overfill and underfill >	< Overfill and underfill >	The condition of product level relative to the threshold which will determine the activation of an analog output safe state, as an underfill or overfill condition. Overfill: activation occurs when the product level is above the Overfill Threshold. Underfill: activation occurs when the product level is below the Underfill Threshold. Overfill and underfill: activation occurs when the product level is above the Overfill Threshold or below the Underfill Threshold. Not used: the analog output remains in high burnout safe state of 21 mA and does not perform any function.
[Analog output overfill threshold]	< 0 – 3.402823 × 10^{38} > (meters)	< 0 >	The product level limit value for determining an overfill condition for the analog output.
[Analog output underfill threshold]	< 0 – 3.402823 × 10^{38} > (meters)	< 0 >	The product level limit value for determining an underfill condition for the analog output.

Name	Value Range	Default Value	Description
[Analog output hysteresis]	< 0 – 3.402823 × 10^{38} > (meters)	< 0.010 >	A value relative to the threshold that will determine the point at which deactivation of an analog output safe state occurs after activation by an overfill or underfill condition. For an underfill condition, deactivation occurs when the product level is above (threshold + hysteresis). For an overfill condition, deactivation occurs when the product level is below (threshold – hysteresis).
[Analog output burnout action	< High >, < Low >	< High >	The burnout action or safe state of the analog output for each of the possible reasons for activating a safe state.
[Analog output high burnout value]	< 21 – 25 > (mA)	< 21	The safe state current level of the analog output for a condition configured for high burnout.
[Analog output low burnout value]	< 0.5 – 3.6 > (mA)	< 3.6 >	The safe state current level of the analog output for a condition configured for low burnout.
[Analog output upper range value]	< 0 – 3.402823 × 10^{38} > (meters)	< 0 >	Product level value corresponding to a 20 mA or 100% current level.
[Analog output lower range value]	< 0 – 3.402823 × 10^{38} > (meters)	< 0 >	Product level value corresponding to a 4 mA or 0% current level.

Name	Value Range	Default Value	Description
[Analog output safety function status] (RO)	Status: < H >, < O >, < U >, < W > Status Code: Defined in Section 7.15.2	Status: < H > Status Code: NO ERROR	H: Healthy O: Overfill condition U: Underfill condition W: Warning condition, safe state is active, or proof test is overdue (status is NO ERROR).
[Analog output safety shutdown counter] (RO)	< 0 – 3.402823 × 10^{38} >	< 0 >	The number of safe state activations that have occurred for the analog output.
[Analog output safety shutdown reason] (RO)	Safety Function Status Code	NO ERROR	The safety function status code identifying the reason for the last time an analog output safe state activation occurred.
[Analog output start overfill proof test]	Command		Initiates an analog output overfill proof test if an actual analog output safe state is not currently active. Upon activation, a simulated overfill condition will occur. An active poof test will terminate if an actual analog output safe state is activated, or if the analog output proof test timeout value is exceeded.
[Analog output start underfill proof test]	Command		Initiates an analog output underfill proof test if an actual analog output safe state is not currently active. Upon activation, a simulated underfill condition will occur. An active poof test will terminate if an actual analog output safe state is activated, or if the analog output proof test timeout value is exceeded.

Name	Value Range	Default Value	Description
[Analog output stop proof test]	Command		Terminates an active analog output proof test. Upon termination, the normal process will resume and contact 2 will close.
[Analog output proof test interval]	< 1 – 3650 > (days)	< 1825 >	The maximum time interval permitted between analog output proof tests. If exceed and when an analog output safe state is not active, the analog output safety function status will change to W to signal a warning that a proof test is overdue. The status code will remain as NO ERROR.
[Analog output proof test timeout]	< Auto timeout off > < 5 minutes > < 10 minutes > < 20 minutes > < 30 minutes >	< 5 minutes >	If not < Auto timeout off >, the maximum time duration an analog output proof test will remain active. If exceeded the proof test will automatically stop.
[Analog output proof test elapsed time] (RO)	< 0 – 4,294,967,295 > (days)	< 0 >	The elapsed time since the last analog output proof test or since commissioning if no analog output proof test has been executed.

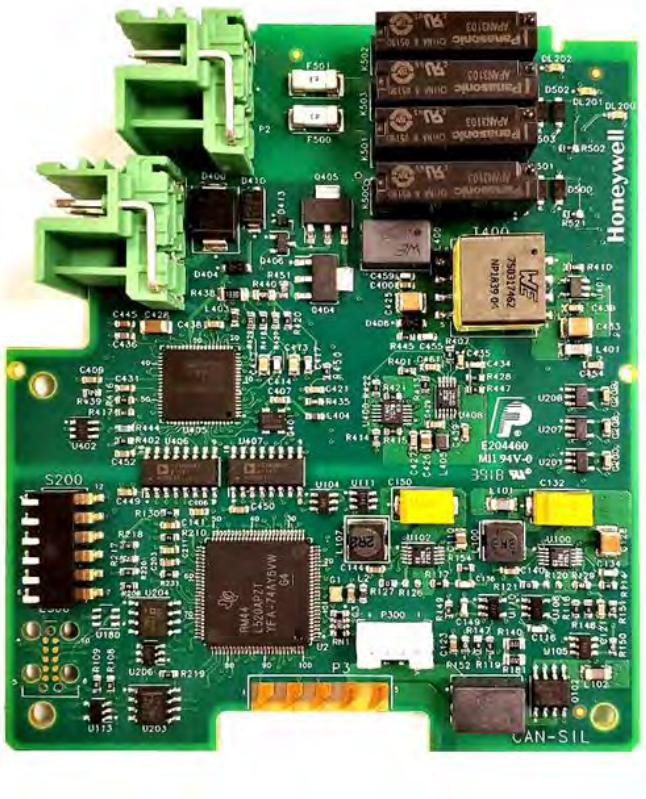
All Outputs			
[Safe state latching behavior]	< Enabled > < Disabled >	Defined in section 7.15.2.1 “Safety Function Status”.	Behavior of a safe state when the reason for activation no longer applies, to either deactivate when Disabled, or to remain active (latch) until power is cycled when Enabled.

7.16 Non SIL Digital Relay Output Alarms (FII-ALM)

7.16.1 Introduction

Field Interface Instrument - Alarm (FII-ALM) is an optional FlexLine module using the CAN-SIL board which is compatible with both the 954 SmartServo and 990 SmartRadar FlexLine tank gauge systems. The FII-ALM can independently control two digital outputs (DO) using relay contacts for alarming applications, which can be activated by monitoring measured variables for exceeded threshold levels, or on demand by command.

Each DO uses two relays in series. If one relay fails from overloading and welding of the contacts, the other relay will still allow the DO to function. Each DO is current rated at 2A and is fuse protected at 3A against contact welding.



These DO contacts are associated with the FlexConn functions and LEDs shown below:

Function Number	Function	LED
1	DO 1	LE2
2	DO 2	LE3

For failsafe level applications, continue with Failsafe Level Application section 7.16.9.

7.16.2 DO Configuration

7.16.2.1 Relay Mode

Each DO can be set to be energized or de-energized during operation, by setting the [Relay Mode] entity to <Energized> or <De-energized> respectively. The relay contacts are physically closed when energized, and physically open when de-energized.

If the [Relay Mode] entity is set to <Energized>, the relay coil will be energized when the relay state is <Deactivated>, and the relay coil will be de-energized when the relay state is <Activated>.

If the [Relay Mode] entity is set to <De-energized>, the relay coil will be de-energized when the relay state is <Deactivated>, and the relay coil will be energized when the relay state is <Activated>.

The <Energized> option is used for failsafe operation whereas the <De-energized> option is used for non-failsafe operation.

Engauge
SmartView

- Set each DO function to the required configuration, by selecting the proper entities. The failsafe configuration is highlighted.

Relay Mode	Relay State	Physical Result
De-energized	Activated	Closed
	Deactivated	Open
Energized	Activated	Open
	Deactivated	Closed

7.16.3. Alarm Mode

Each DO can operate in one of three modes, by setting the [Alarm Mode] entity to either <PV Monitor>, <Remote Control> or <Not in Use>.

7.16.3.1 PV Monitor

In [PV Monitor] mode, each DO function can monitor the Primary Value (PV), Secondary Value (SV) or Tertiary Value (TV) of another board connected to the CAN bus, and either activate or deactivate the associated DO if a certain condition is <True> or <False>.

- If <Remote Control> or <Not in Use> mode is selected, skip to Remote Control section 7.16.3.4 or Not in Use section 7.16.3.5.

Set [Alarm Mode] to <PV Monitor>.

- Select <Monitor Board Id>, set proper value.
- Select <Monitor Board Instance>, set proper value.
- Select <Monitor Function Instance], set proper value.
- Set [Monitor Source] to <PV>, <SV> or <TV>.

The [Monitor Board Id], [Monitor Board Instance] and [Monitor Function Instance] entities determine the location of the entity to be scanned.

The behavior of each DO in PV Monitor mode is further controlled by the [Monitor Mode] and [Status Behavior] entities; see next.

7.16.3.2 Monitor Mode

The [Monitor Mode] entity can set to <Remote> or <Local>.

If the [Monitor Mode] is set to <Remote>, the alarm status of the scanned PV, SV or TV is monitored. The alarm status is compared against the value set in the [Remote Threshold Source] entity. The [Remote Threshold Source] entity can be set to <HH>, <HA>, <LA> or <LL>.

Example: If the [Remote Threshold Source] is set to <HH> and a High-High alarm occurs, the relay will be activated. It will not be activated by any other alarms.

- Set [Monitor Mode] to <Remote>.
- Select [Remote Threshold Source], set desired value.

If [Monitor Mode] is set to <Local>, the scanned PV, SV or TV value is compared against the value set in the [Threshold] entity. The behavior is modified by the [Threshold Mode] and the [Hysteresis] entities. The [Threshold Mode] entity can be set to either <Treat as HA> or <Treat as LA>.

If the [Threshold Mode] entity is set to <Treat as HA>, the relay is activated if the scanned PV, SV or TV is greater than or equal to the [Threshold] entity value, and the relay is deactivated if the scanned PV or SV is less than the [Threshold] entity value minus the [Hysteresis] entity value.

If the [Threshold Mode] entity is set to <Treat as LA>, the DO is activated if the scanned PV, SV or TV is greater than or equal to the [Threshold] entity value,

and the relay is deactivated if the scanned PV, SV or TV is less than the [Threshold] entity value plus the [Hysteresis] entity value.

- Set [Monitor Mode] to <Local>.
- Set [Threshold Mode] to <Treat as HA> or <Treat as LA>.
- Select [Hysteresis], set desired value.

7.16.3.3 Status Behavior

The [Status Behavior] entity determines the DO activate state if the health of the scanned PV or SV differs from Good. The [Status Behavior] entity should be set to one of the following options: <BAD>, <BAD-UNCERTAIN> or <Not Used>.

If [Status Behavior] is set to <BAD>, and the scanned PV, SV or TV health is Bad, the respective DO will be activated.

If [Status Behavior] is set to <BAD-UNCERTAIN>, and the scanned PV, SV or TV health is Bad or Uncertain, the respective DO will be activated.

If [Status Behavior] is set to <Not Used>, the respective DO will not be activated if the scanned PV, SV or TV health is Bad or Uncertain.

- Set [Status Behavior] to <BAD>, <BAD-UNCERTAIN> or <Not Used>.

NOTE: This behavior takes priority over Remote or Local monitoring. For example: If [Status Behavior] is set to <BAD> and the scanned PV, SV or TV health is Bad, the respective DO will be activated, regardless of the [Monitor Mode] entity setting. Neither <Remote> nor <Local> PV, SV or TV monitor checks will affect the DO state.

7.16.3.4 Remote Control

With [Alarm Mode] set to <Remote Control>, each individual relay can directly be activated or deactivated, by sending an Activate or Deactivate command via the CAN bus.

The behavior of each individual relay is further controlled by the [Remote Control] mode entity, which can be set to either <Restricted> or <Not Restricted>.

If [Remote Control] is set to <Not Restricted>, any source can be used to control the relay with an Activate or Deactivate command.

If the [Remote Control] mode entity is set to <Restricted>, the relay can only be controlled by the source that matches the values set in entities [Control Board Id], [Control Board Instance] and [Control Function Instance].

Engauge SmartView

- From the [Remote Control] mode menu, select either <Restricted> or <Not Restricted>.
- If <Restricted> is selected, the following entities must also be set:
  - Select [Control Board Id], set proper value.
  - Select [Control Board Instance], set proper value.
  - Select [Control Function Instance], set proper value.

7.16.3.5 Not in Use

If an individual DO function is not required in the application, the [Alarm Mode] entity must be set to <Not in Use>.

7.16.4. Commands

The following commands are available:

- !Activate!
- !Deactivate!
- !Acknowledge!

7.16.4.1 Activate

The !Activate! command will cause the associated DO to become activated. This command is only available in [Remote Control] mode. See Remote Control section 7.16.3.5.

The !Activate! command behavior is modified by the [Activate Time] entity. If [Activate Time] is set to zero, the DO will stay permanently activated until a !Deactivate! command is issued, or a reset or power cycle occurs.

If the [Activate Time] entity is set to a value other than zero, the DO will be activated for a time duration of that value in seconds, and then deactivated. During activation, [Relay State] will be set to <Time Setting Activated>. This is useful for site commissioning.

Engauge SmartView

- Set [Activate Time] to the desired value.

7.16.4.2 Deactivate

The !Deactivate! command will cause the associated DO to become deactivated. This command is only available in <Remote Control> mode. See Remote Control section 7.16.3.4.

7.16.4.3 Acknowledge

The !Acknowledge! command will cause the associated DO to become deactivated, but [Relay State] will be set to <Acknowledged>. This command is only available in <PV Monitor> mode, section 7.16.3.1. This command can only be accepted when the associated DO has already been activated.

This command is useful when the DO is connected to an alarm system. When an active alarm is silenced by this command, [Relay State] will still indicate that an alarm has occurred. When the alarm condition is removed, <Relay State> will change to <Deactivated> and normal operation will resume.

7.16.5. Function LEDs

Each function LED will be on when the associated DO is activated, and the LED will be off when the DO is deactivated.

NOTE: The LEDs indicate the active state of each DO, not the energized state, which is determined by the DO function's [Relay Mode] setting. See Relay Mode section 7.16.2.1.

7.16.6. Terminal Allocation

Terminal Number	Name	Function
54	DO1_a	Digital Output 1
55	DO1_b	Digital Output 1
56	DO2_a	Digital Output 2
57	DO2_b	Digital Output 2

7.16.7. Function Commissioned

Engauge SmartView

By using the table below, make sure both DO functions are commissioned.

The [Commissioned] entity will display either <True> if the function is commissioned or <False> if the function is not commissioned. To commission a function, the entities must be set according to the table below.

Alarm Mode	Remote Control Mode	Entities
Remote Control	Restricted	[Control Board Id] = 1 - 255 [Control Board Instance] = 0 - 7 [Control Function Instance] = 1 -15 [Activate Time] = 0
	Not Restricted	[Activate Time] = 0
PV Monitor	Remote	[Monitor Board Id] = 1 - 255 [Monitor Board Instance] = 0 - 7 [Monitor Function Instance] = 1 - 15 [Activate Time] = 0
	Local	[Monitor Board Id] = 1 – 255 [Monitor Board Instance] = 0 - 7 [Monitor Function Instance] = 1 - 15 [Activate Time] = 0 [Threshold] = -1000000 - 1000000 [Hysteresis] = -1000000 - 1000000
Not in Use	N/A	N/A

7.16.8. Board Commissioned

The [Board Commissioned] entity will display <True> only if both functions are commissioned and at least one of the functions has it's [Alarm Mode] set to <Remote Control> or <PV Monitor>.

If the [Board Commissioned] entity displays <False>, check each function parameter again. Use the table in Function Commissioned section 7.16.7 and make sure at least one of the DO functions is set to be in use.

7.16.9. Failsafe Level Application

The following steps include all commissioning requirements for failsafe level applications.

- Set [Relay Mode] to <Energized>.
- Set [Alarm Mode] to <PV Monitor>.
- Set [Monitor Board Id] to board id of product level board.
- Set [Monitor Board Instance] to board instance of related product level board.
- Set [Monitor Function Instance] to function instance of related product level board.
- Set [Monitor Source] to <PV>.
- Set [Monitor Mode] to <Remote>.

- Set [Remote Threshold Source] to <HH>, <HA>, <LA> or <LL>.
- Set corresponding alarm setting of the related product level board.
- Set [Status Behavior] to <BAD-UNCERTAIN>.

For service-related questions, contact:

Technical Assistance Centre
Phone:
+1 800 423 9883 or +1 215 641 3610
E-mail:
HFS-TAC-SUPPORT@honeywell.com

For More Information
To learn more about Honeywell Enraf's solutions, contact your Honeywell Enraf account manager or visit www.honeywellenraf.com.

Americas
Honeywell Enraf Americas, Inc.
1250 West Sam Houston Pkwy S.
Houston, TX 77042
USA
Phone: +1 (480) 293-2042
Email: enraf-us@honeywell.com

Europe, Middle East and Africa
Honeywell Enraf
Delftechpark 39
2628 XJ Delft
The Netherlands
Phone: +31 (0) 15 2701 100
Email: enraf-nl@honeywell.com

Asia Pacific
Honeywell Pte Ltd.
17 Changi Business Park Central 1
Singapore 486073
Phone: +65 6355 2828
Email: enraf-sg@honeywell.com

Honeywell

4417762 Rev .11