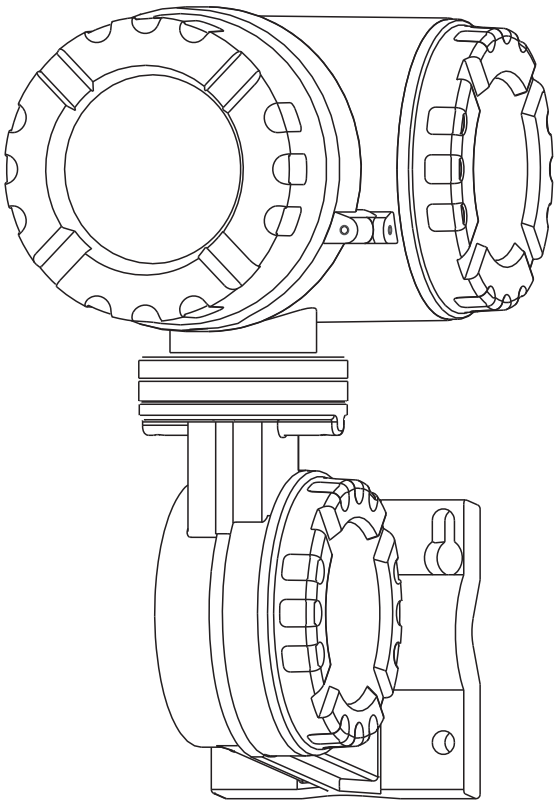
BA00256F/00/EN/15.15
71307017

Valid as of software version:
V02.04.zz

Operating Instructions
Tank Side Monitor NRF590

Inventory Control
Software Version 02.04.zz



Endress+Hauser
People for Process Automation

Notes on Software Version SW 02.xx

Key operation

From Software Version SW 02.01 onwards, the operation of the optical keys of the Tank Side Monitor NRF590 is based on the distinction between **"pressing"** and **"holding"** of the keys.

Pressing a key means to touch the optical key and to release it after a short time (< 2 seconds). The key operation "press" is required for most menue operations.

Holding a key means to touch the optical key for more than 2 seconds.
The key operation "hold" is required for scrolling in lists or changing of values.

The **change of the display contrast** is based on pressing the optical keys. When pressing the according key combination, the contrast change screen appears, where the contrast may be changed by continuously holding the respective keys.

Automatic HART scan

From Software Version 02.01 onwards, the HART scan is performed automatically by the NRF590 HART Master and needs not to be started from the operating menue.

Modbus termination

From Software Version 02.01 onwards, the Modbus termination is activated via menu operation, not by a hardware jumper.

Table of contents

1 Safety instructions

1.1 Designated use

The Tank Side Monitor is a monitoring unit for use with the Endress+Hauser Micropilot M and Micropilot S-series radars and other HART compatible devices. Mounted at the tank side, the NRF590 provides indication of measured data, allows configuration and supplies intrinsically safe (i.s.) power to the connected sensors on the tank. Various industry standard digital gauging communication protocols support integration into open architecture tank gauging and inventory systems.

1.2 Installation, commissioning, operation

- Mounting, electrical installation, start-up and maintenance of the device may only be carried out by trained personnel authorized by the operator of the facility.
- Personnel must absolutely and without fail read and understand this Operating Manual before carrying out its instructions.
- The device may only be operated by personnel who are authorized and trained by the operator of the facility. All instructions in this Manual are to be observed without fail.
- The installer has to make sure that the measuring system is correctly wired according to the wiring diagrams. The measuring system is to be grounded.
- Please observe all provisions valid for your country and pertaining to the opening and repairing of electrical devices.

1.3 Operational safety and process safety

Alternative monitoring measures must be taken to ensure operational safety and process safety during configuration, testing and maintenance work on the device.

1.3.1 Hazardous areas

Measuring systems for use in hazardous environments are accompanied by separate "Ex documentation", which is an integral part of this Operating Manual. Strict compliance with the installation instructions and ratings as stated in this supplementary documentation is mandatory.

- Ensure that all personnel are suitably qualified.
- Observe the specifications in the certificate as well as national and local standards and regulations.

1.3.2 FCC approval

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

Caution!
Changes or modifications not expressly approved by the part responsible for compliance could void the user's authority to operate the equipment.

1.4 Return

The following procedures must be carried out before a transmitter is sent to Endress+Hauser for repair:

- Always enclose a duly completed "Declaration of Contamination" form.
  Only then can Endress +Hauser transport, examine and repair a returned device.
- Enclose special handling instructions if necessary, for example a safety data sheet as per EN 91/155/EEC.
- Remove all residue which may be present. Pay special attention to the gasket grooves and crevices where fluid may be present. This is especially important if the fluid is dangerous to health, e.g. corrosive, poisonous, carcinogenic, radioactive, etc.

Note!

A copy of the "**Declaration of Contamination**" is included at the end of this operating manual.

Caution!

- No device should be sent back for repair without all dangerous material being completely removed first, e.g. in scratches or diffused through plastic.
- Incomplete cleaning of the device may result in waste disposal or cause harm to personnel (burns, etc.). Any costs arising from this will be charged to the operator of the device.

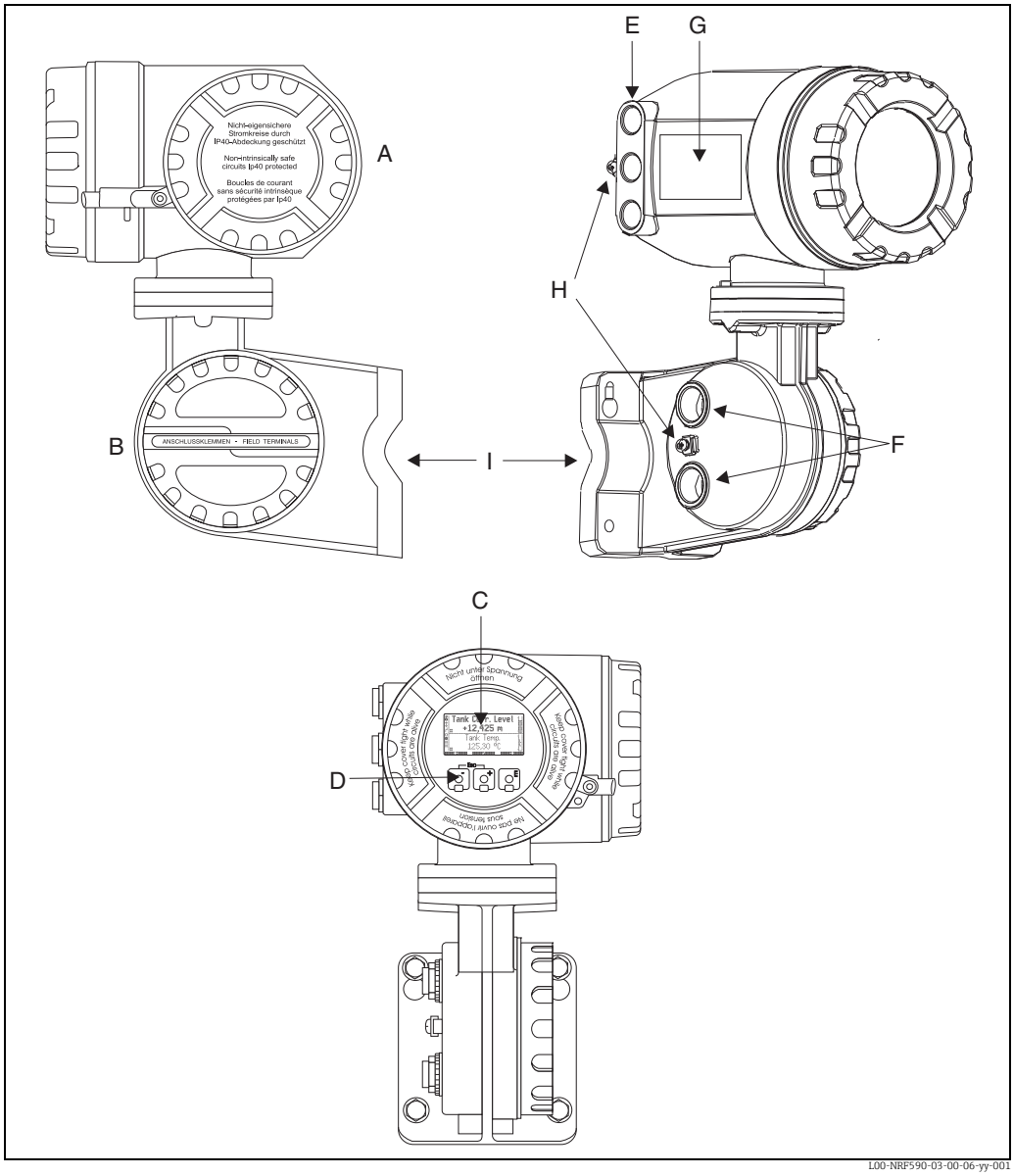
1.5 Notes on safety conventions and symbols

In order to highlight safety-relevant or alternative operating procedures in the manual, the following conventions have been used, each indicated by a corresponding symbol in the margin.

Safety conventions	
	**Warning!** A warning highlights actions or procedures which, if not performed correctly, will lead to personal injury, a safety hazard or destruction of the device.
	**Caution!** Caution highlights actions or procedures which, if not performed correctly, may lead to personal injury or incorrect functioning of the device.
	**Note!** A note highlights actions or procedures which, if not performed correctly, may indirectly affect operation or may lead to an device response which is not planned.
Explosion protection	
	**Device certified for use in explosion hazardous area** If the device has this symbol embossed on its name plate it can be installed in an explosion hazardous area.
	**Explosion hazardous area** Symbol used in drawings to indicate explosion hazardous areas. Devices located in and wiring entering areas with the designation “explosion hazardous areas” must conform with the stated type of protection.
	**Safe area (non-explosion hazardous area)** Symbol used in drawings to indicate, if necessary, non-explosion hazardous areas. Devices located in safe areas still require a certificate if their outputs run into explosion hazardous areas.
Electrical symbols	
	**Direct voltage** A terminal to which or from which a direct current or voltage may be applied or supplied.
	Alternating voltage A terminal to which or from which an alternating (sine-wave) current or voltage may be applied or supplied.
	**Grounded terminal** A grounded terminal, which as far as the operator is concerned, is already grounded by means of an earth grounding system.
	**Protective grounding (earth) terminal** A terminal which must be connected to earth ground prior to making any other connection to the equipment.
	**Equipotential connection (earth bonding)** A connection made to the plant grounding system which may be of type e.g. neutral star or equipotential line according to national or company practice.
	**Temperature resistance of the connection cables** States, that the connection cables must be resistant to a temperature of at least +85 °C (+185 °F).

2 Identification

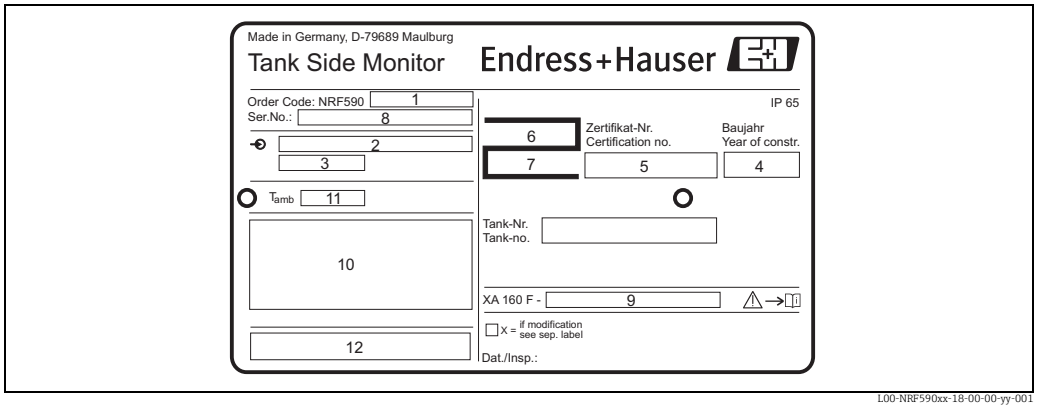
2.1 Parts of the Tank Side Monitor



L00-NRF590-03-00-06-yy-001

***A**: Non-i.s. terminal compartment; **B**: i.s. terminal compartment; **C**: graphical display; **D**: optical keys;*
***E**: cable entries for non-i.s. connection (with glands according to product structure);*
***F**: cable entries for i.s. connection (with glands according to product structure); **G**: nameplate; **H**: grounding terminals;*
***I**: mounting plate*

2.2 Nameplate



***1**: complete product designation; **2/3**: power supply specifications; **4**: year of construction; **5**: NMi certification number; **6/7**: PTB certification number; **8**: serial number; **9**: reference to installation drawing or safety instructions (for Ex-certified device versions only); **10**: type of protection (for Ex-certified device versions only); **11:** admissible ambient temperature; **12:** certification symbols*

2.3 Product structure

This overview does not mark options which are mutually exclusive.

10	Certificates
	A Non-hazardous areas
	B NEPSI Ex d(ia) IIC T6
	6 ATEX II 2 (1) EEx d (ia) IIC T6
	U CSA XP Cl. I, Div 1, Gr. A-D, zone 1, 2
	S FM XP Cl. I, Div 1, Gr. A-D, zone 1, 2
	K TIIS EEx d (ia) IIC T6
	Y Special version, TSP-No. to be spec.

20		Field communication protocol Ex d/XP
	E	ENRAF BPM, 4-20mA input, 4-20mA HART output
	G	GPE, -20mA output, 4-20mA HART output
	1	Whessoe WM550 (dual output), 4-20mA output, 4-20mA HART output
	3	Mark/Space, 4-20mA input, 4-20mA HART output
	4	Modbus EIA 485
	5	Modbus, 4-20mA input, 4-20mA HART output
	7	L&J, 4-20mA input, 4-20mA HART output
	8	Sakura V1, 4-20mA output, 4-20mA HART output, Relais output
	9	Special version, TSP-No. to be spec.

30		Power supply
	A	18-55 VAC/DC
	B	55-264V AC
	Y	Special version, TSP-No. to be spec.

40		Spot RTD option
	0	Not selected
	1	Intrinsically safe input
	9	Special version, TSP-No. to be spec.

50		Digital Module A
	A	Not selected
	B	Input 90-140V AC
	C	Input 3-32V DC
	D	Input 180-264V AC
	E	Input 35-60V AC/DC
	G	Output 24-250V AC
	H	Output 3-60V DC
	J	Output 24-140V AC
	K	Output 4-200V DC
	R	Relay 0-100 VDC, 0-120VAC
	Y	Special version, TSP-No. to be spec.

60		Digital Module B
	A	Not selected
	B	Input 90-140V AC
	C	Input 3-32V DC
	D	Input 180-264V AC
	E	Input 35-60V AC/DC
	G	Output 24-250V AC
	H	Output 3-60V DC
	J	Output 24-140V AC
	K	Output 4-200V DC
	R	Relay 0-100 VDC, 0-120VAC
	Y	Special version, TSP-No. to be spec.

70		Additional intrinsically safe module
	2	Input 4-20mA + 2x input digital
	9	Special version, TSP-No. to be spec.

80								**Cable entry (Non-IS)**						
								F	2 x Ex d gland G1/2					
								B	2 x Ex d gland M20 (EEx d > thread M20)					
								C	2 x Ex d thread G1/2					
								D	2 x Ex d thread NPT1/2					
								E	2 x Ex d thread NPT3/4					
								H	3 x Ex d gland M20 (EEx d > thread M20)					
								K	3 x Ex d thread G1/2					
								L	3 x Ex d thread NPT1/2					
								G	3 x Ex d thread NPT3/4 (in preparation)					
								Y	Special version, TSP-No. to be spec.					
90									**Entry - IS Compartment**					
									2	2x gland M25, 13-18mm				
									3	2x thread G1/2				
									4	2x thread NPT1/2				
									5	2x thread NPT3/4				
									9	Special version, TSP-No. to be spec.				
100										**Weight + Measure Approval**				
										N	Not selected			
										A	NMi type approval			
										G	PTB type approval			
										Y	Special version, TSP-No. to be spec.			
110											**Additional Option**			
											0	Basic version		
											9	Special version, TSP-No. to be spec.		
110												**Marking**		
												1	Tagging (TAG), see additional spec.	
NRF590 -														Complete product designation

2.4 Scope of delivery

- Device according to the version ordered
- FieldCare (CD-ROM)
- Accessories (as ordered)

2.5 Supplied documentation

Document	Designation	Content/Remarks
BA00256F/00/EN (this manual)	Operating Instructions	Describes installation and commissioning of the Tank Side Monitor. Only those functions of the operating menu are included, which are used for a standard measuring task. Any additional functions are **not** included.
BA00257F/00/EN	Description of Instrument Functions	Contains a detailed description of **all** the functions of the Tank Side Monitor.
XA00160F/00/A3	Safety Instructions	Only for device versions approved for use in explosion hazardous areas; the nameplate specifies, which of these documents is relevant for your device version.
ZD00084F/00/EN ZD00103F/00/EN	Installation Drawings	
ZE00253F/00/EN	NMi Certificate	Only for device versions with the respective custody transfer approval
ZE00255F/00/DE	PTB Certificate	

2.6 CE mark, declaration of conformity

The device is designed to meet state-of-the-art safety requirements, has been tested and left the factory in a condition in which it is safe to operate. The device complies with the applicable standards and regulations in accordance with EN 61010 "Protection Measures for Electrical Equipment for Measurement, Control, Regulation and Laboratory Procedures". The device described in this manual thus complies with the statutory requirements of the EG directives. Endress+Hauser confirms the successful testing of the device by affixing to it the CE mark.

2.7 Registered trademarks

HART®
Registered trademark of HART Communication Foundation, Austin, USA

ToF®
Registered trademark of the company Endress+Hauser GmbH+Co.KG, Maulburg, Germany

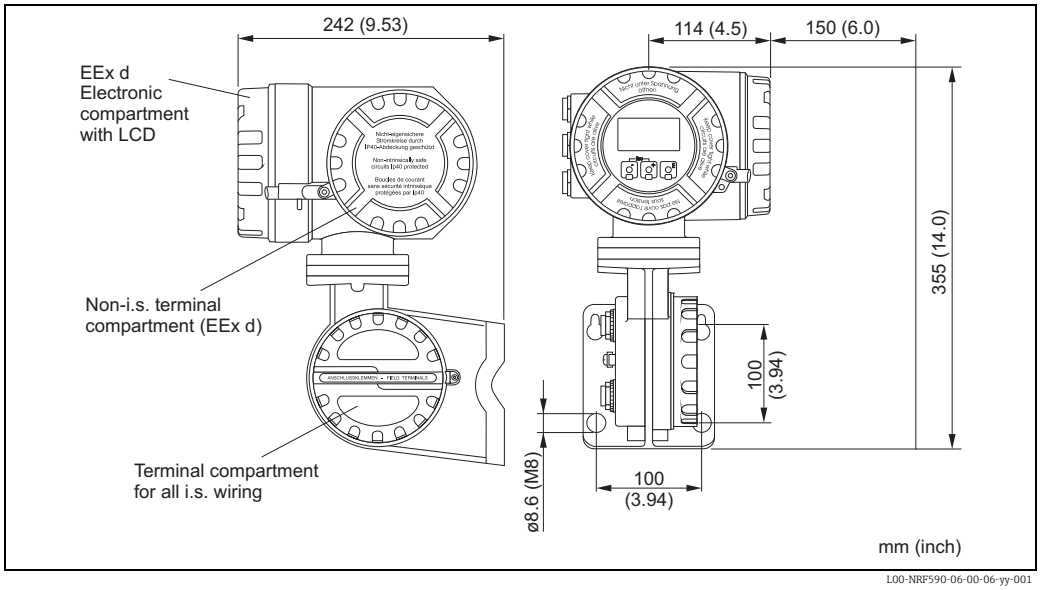
MODBUS®
Registered trademark of the MODBUS-IDA, Hopkinton, MA, USA

Enraf®
Registered trademark of the Enraf B.V, Delft, The Netherlands

FieldCare®
Registered trademark of the Endress+Hauser Process Solutions AG, Reinach, Switzerland

3 Installation

3.1 Design, dimensions



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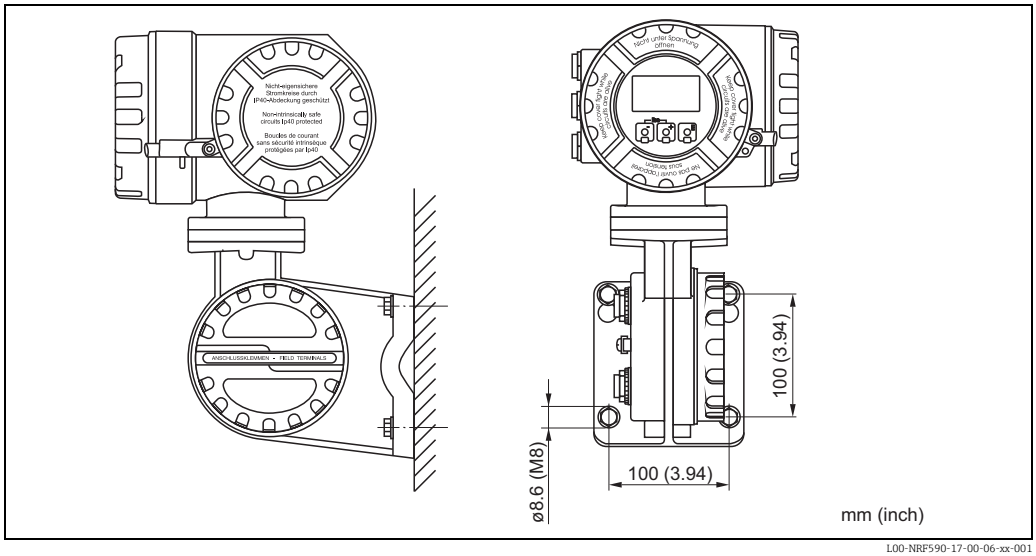
3.2 Installation variants

3.2.1 Wall mounting



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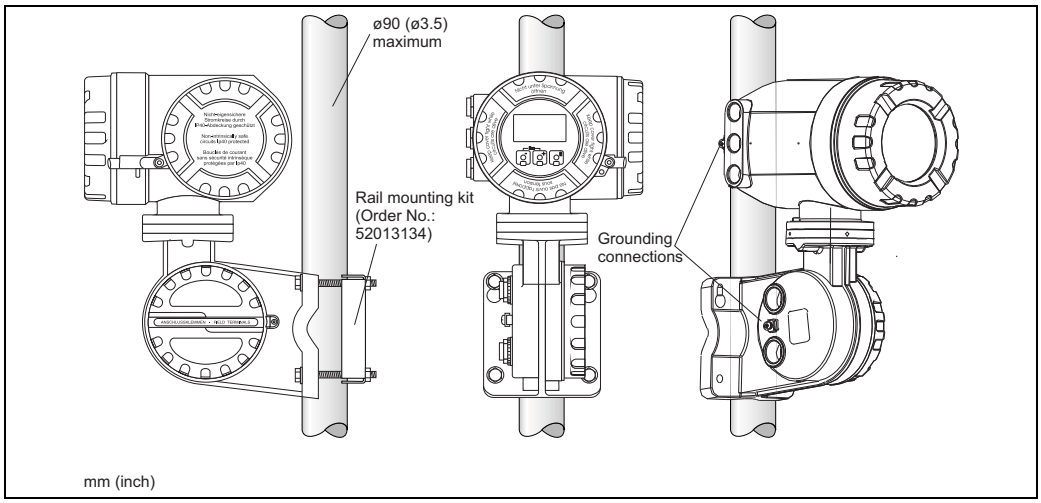
3.2.2 Mounting on vertical rail



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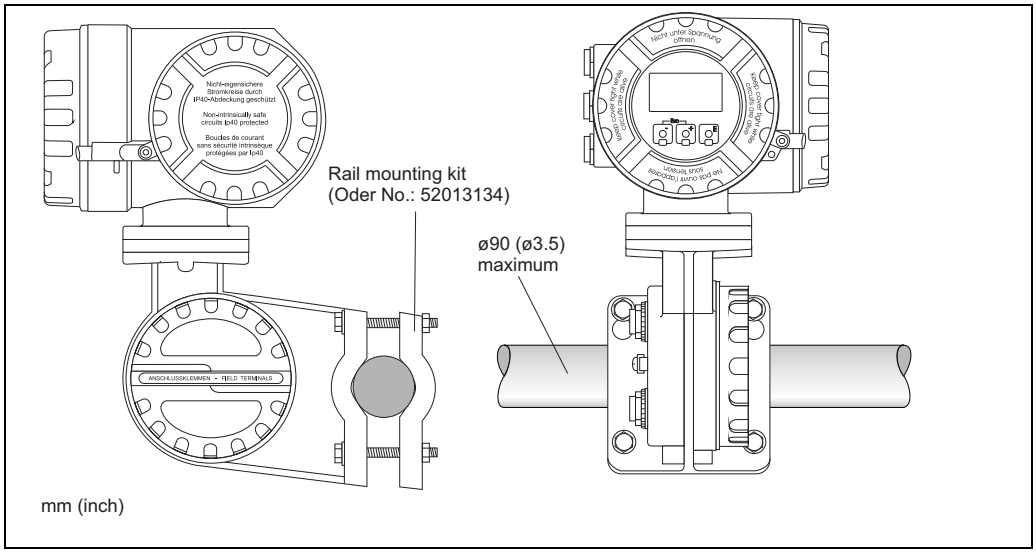
3.2.3 Mounting on horizontal rail



L00-NRF590-17-00-06-en-003

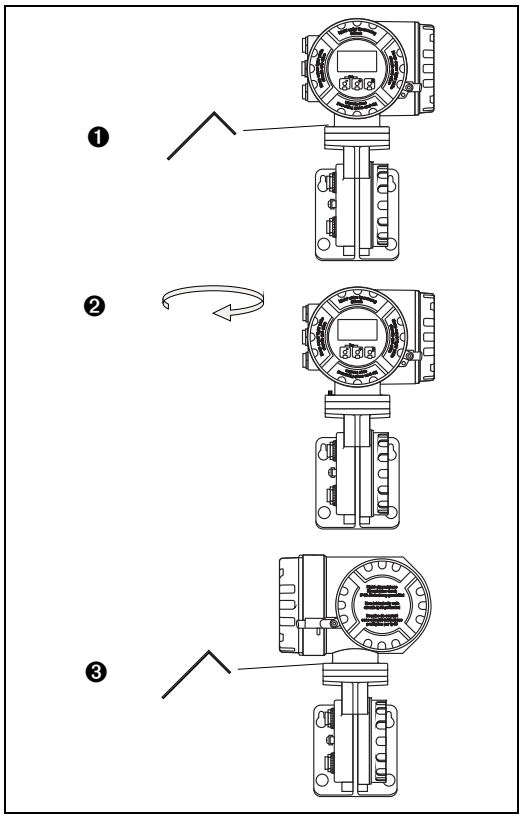
Note!

The rail mounting kit is available as an accessory("Accessories", → 59).

3.3 Rotating the housing

For easy access to the display or the terminal compartment, the upper part of the housing can be rotated into an arbitrary position. In order to do this, perform the following steps:

1. Loosen the alignment pin using a 4 mm Allen key (approx. 5 turns).
2. Rotate the upper part of the housing to the desired position.
3. Tighten the pin securely.



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3.4 Rotating the display module

In order to facilitate operation and reading of the measuring value, the display module can be rotated in the following way:

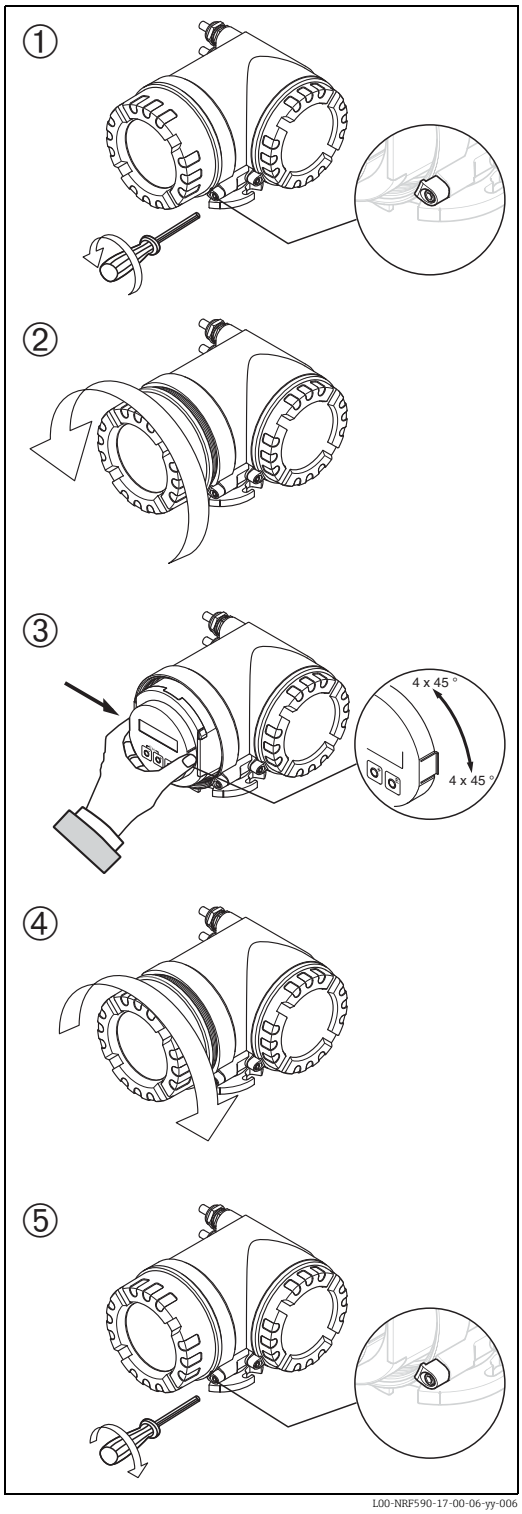
⚠ Warning!
Danger from elctrical schock! Switch off power supply before opening the housing.

1. Using a 3 mm /7/64") Allen wrench, losen the safety pin for the display lid.
2. Unscrew the display lid.

   Note!
   If the display is difficult to unscrew, unplug one of the cables from the cable gland to allow air to enter the housing. Then, attempt once again to unscrew the display lid.
3. Push in the two flat areas on each side of the display module. Remove the Module from the holder, rotate it into the desired position and put it back onto the holder. Snap-in positions are located at an angle of 45° from each other.

   ⚠ Warning!
   The maximum angle of rotation is 180° in both directions (measured from the initial position).
4. Replace the display lid on the Tank Side Monitor housing.

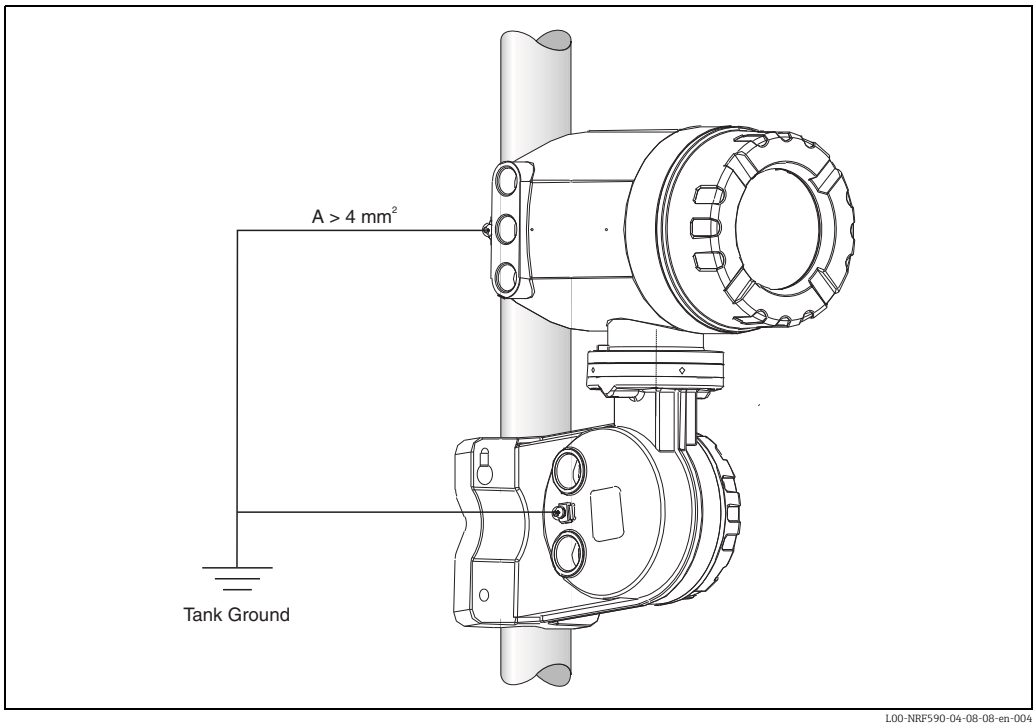
   Note!
   Make sure to clean the threads of the lid to remove any dust or paritcles. Check that O-ring is in place and reapply anti-seize grease.
5. Adjust the safety pin so it is set over the display lid and tighten.



L00-NRF590-17-00-06-yy-006

3.5 Grounding

The NRF590 must be grounded to the tank potential before communication and power connections are made. The connections (A ≥ 4mm^2) from each outer ground plug of the NRF590 to the tank ground must be made before any other wiring connections are made. All grounding must be compliant with local and company regulations and checked before the equipment is commissioned.



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It is recommended to connect the cable shields of the tank instrumentation centrally to the NRF590 ("Connection of HART devices", → 27).

3.6 Post-installation check

After the Tank Side Monitor has been installed, perform the following checks:
- Is the measuring device damaged (visual check)?
- Have the mounting bolts been tightend securely?
- Are both grounding terminals connected to tank ground?

4 Wiring

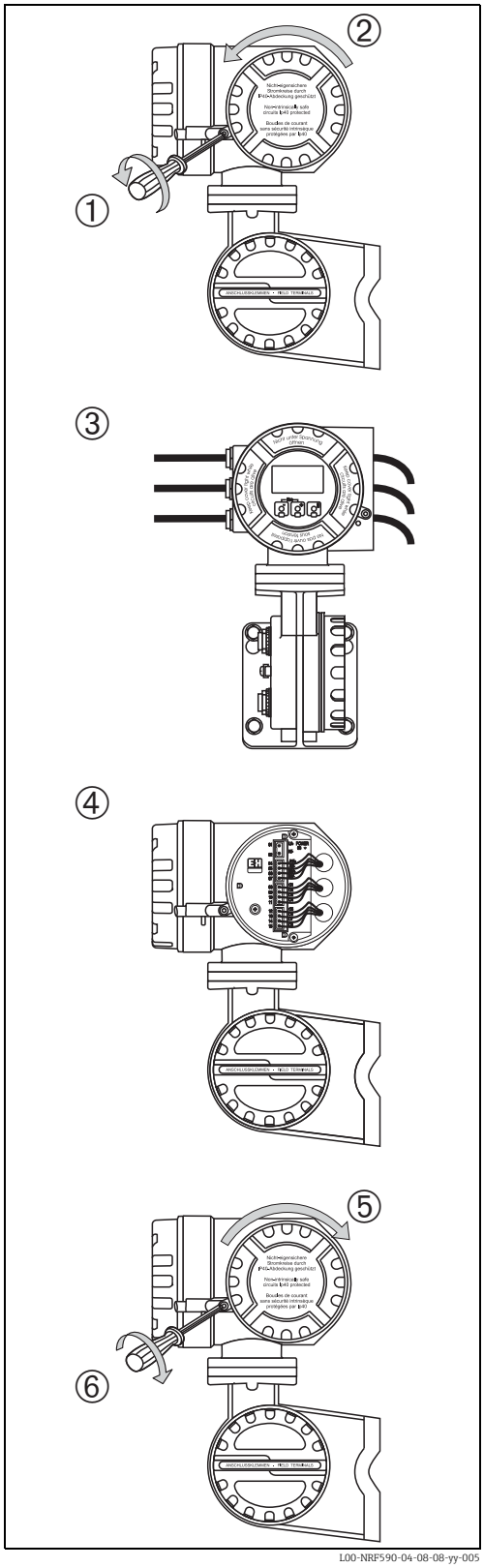
4.1 Wiring the Non-IS (Ex d) connections

4.1.1 The procedure

Note!
Before starting the wiring procedure, make sure that the supply voltage is switched off.

1. Using a 3 mm (7/64") Allen wrench, losen the safety pin for the lid.
2. Unscrew the lid of the terminal compartment.
3. Push the power and signal cables through the appropriate cable glands.
4. Wire up according to the terminal assignment diagram ("Terminal assignment of the field protocol/host side", → 18).
5. Screw the lid of the terminal compartment securely back onto the transmitter housing.

   Note!
   Make sure to clean the threads of the lid to remove any dust or particles. Check that O-ring is in place and reapply anti-seize grease.
6. Adjust the safety pin so it is set over the display lid and tighten.



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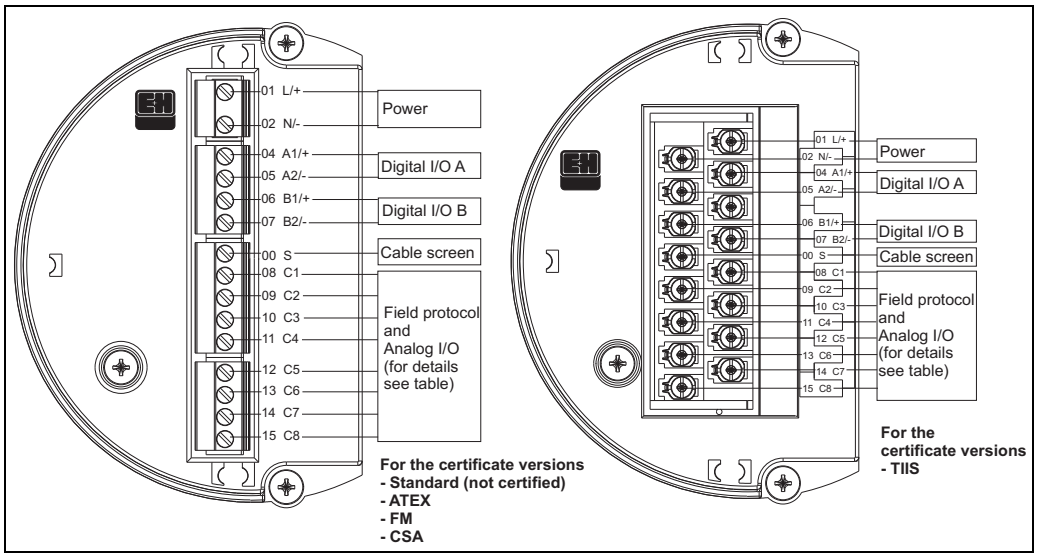
4.1.2 Terminal assignment of the field protocol/host side



Terminal	01 L/+	02 N/-	04 A1/+	05 A2/-	06 B1/+	07 B2/-	00 S
	Power supply		Discrete I/O A +	Discrete I/O A -	Discrete I/O B +	Discrete I/O B -	Cable screen

	08 C1	09 C2	10 C3	11 C4	12 C5	13 C6	14 C7	15 C8
V1	4 to 20 mA output[1] #2	V1A	V1B	0 V[1]	0 V	4 to 20 mA output #1 + HART	discrete output 1C	discrete output 2C
EIA-485 Modbus	not used[2]	485-B	485-A	0 V	0 V[1]	4 to 20 mA output[3] +HART	4 to 20 mA input[3]	+24 V[1]
Whessoe WM550	4 to 20 mA output[1] #2	Loop 1-	Loop 1+	0 V[1]	0 V	4 to 20 mA output #1 +HART	Loop 2-	Loop 2+
BPM	not used[2]	T	T	0 V	0 V[1]	4 to 20 mA output + HART	4 to 20 mA input	+24 V[1]
Mark/Space	V+	Space	Mark	0 V (V-)	0 V[1]	4 to 20 mA output + HART	4 to 20 mA input	+24 V[1]
L&J Tankway	Power	Encoder	Computer	Ground	0 V[1]	4 to 20 mA output + HART	4 to 20 mA input	+24 V[1]
GPE	4 to 20 mA output[1] #2	Loop 1-	Loop 1+	0 V[1]	0 V	4 to 20 mA output #1 + HART	do not connect	do not connect

1) In case an "Ex d" rated 4-wire level gauge version is used, the power supply can be obtained from these terminals (21V ±10%).

2) The internal voltage at this terminal is 0 V, however, shielding and signal common should be connected to terminal 11 or 12.

3) Option, s. pos. 20 of the product structure

4.1.3 Connection of the field protocols

Sakura V1

The V1 protocol provides 2 wire communication allowing up to 10 devices to operate on a loop.
V1 connects to terminals 9-10. Max. distance: 6000 m

EIA-485 Modbus

The NRF590 protocol uses a shielded 3-wire EIA-485 hardware interface to communicate with the modbus master. EIA-485 is a high speed, differential communications network that allows up to 32 devices to operate on one network.

- Using one shielded twisted pair of 18 AWG wire, connect the EIA-485 at terminal 9 and 10.
- Termination of the EIA-485 bus at the NRF590 can be set in the operating menu (only enable on end device in a loop)
- Connect the 3rd wire from the control system signal common (0V) to terminal 11 or 12.
- Max distance: 1.300 m (4.000 ft).

Whessoematic WM550

The WM550 protocol provides 2 wire, current loop communication and allows up to 16 devices per loop. For redundancy (safety function) two wire pairs are used. They always transmit the same values. The WM550-loops connect to terminals 9 - 10 and 14 - 15. Max. distance: 7000 m (22967 ft).

BPM

The BPM protocol provides 2 wire communication allowing up to 10 devices to operate on a loop. BPM connects to terminals 9-10. Max. distance: 1000 m (3281 ft)

Mark/Space

For a NRF590 using the Mark/Space field communications option, the following additional wiring connections must be made:

- Run 2 twisted pairs (one power, one communication) of 18 AWG wire (Mark/Space wires) into the upper terminal compartment through one of the conduit entries along with the 48 Vdc power wiring.
- Connect the Mark line to terminal 10 and the Space line to terminal 9.
- Connect to power supply at terminals 8 and 11.

L&J Tankway

Including power and ground, L&J is a 4-wire system, allowing 50+ devices to be connected on the communication bus. L&J connects to terminals 8 through 11.

GPE

The GPE protocol provides 2 wire current loop communication. GPE connects to terminal 9-10.

4.1.4 Grounding of the fieldbus screen

The screen of the fieldbus cable should be connected to ground at both ends. If this is not possible due to signal disruption by potential equalisation currents, it is advisable to connect the screen of the fieldbus cable to terminal "00 S" at the NRF590 and to ground at the other end. The "00S" terminal provides a 500 V capacitor between the cable screen and tank ground potential.

4.1.5 Connection of the auxiliary energy

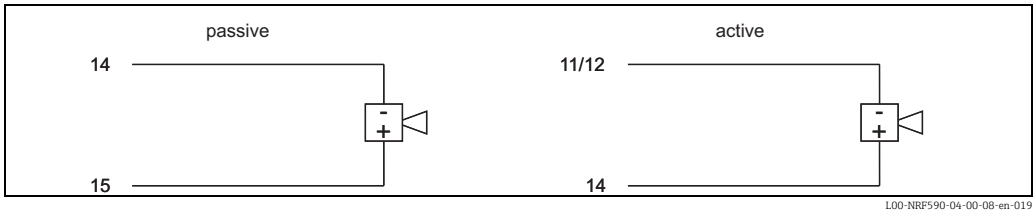
The Tank Side Monitor can be AC or DC supplied, depending on the installed power supply board. The AC supply needs to be connected to the terminals marked "L/+" (Line) and "N/-" (Neutral), corresponding with the phase/line and neutral wire. DC supply can be connected to the same terminals, for which it is necessary to connect the positive (+) to the terminal marked "L/+", and the negative to the terminal marked "N/-".

Note!

When using the public power supply, install an easy accessible power switch in the proximity of the instrument. Mark the power supply as a disconnector for the instrument (IEC/EN 61010).

4.1.6 Connection of the non-i.s. 4 to 20 mA analogue input

Depending on the selected fieldbus communication board, a non-i.s. self-powered or loop powered analogue transmitter can be connected. The analogue signal for the loop powered transmitter can be connected to the terminals 14 (-) and 15 (+24 Vdc). The maximum supply current for the analogue transmitter is limited to 24 mA. The analog signal for a self powered transmitter should be connected to terminals 11 or 12 and 14.

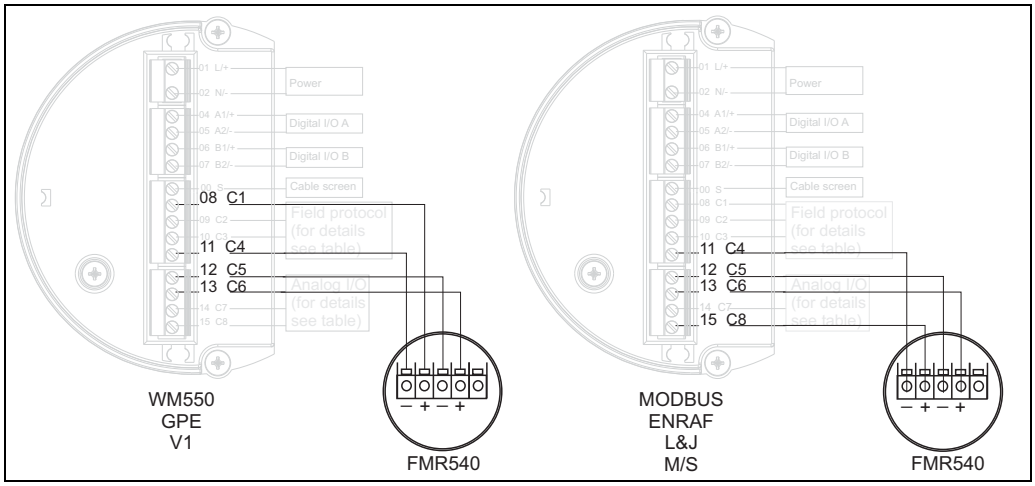


4.1.7 Connection of the non-i.s. 4 to 20 mA analogue output

For all field communication boards except the Modbus Option without analog in/output, a non-i.s. 4 to 20mA output is available. Via Software settings, this analogue output can be connected to any parameter in the Tank Side Monitor.
The analogue output is available between terminals 13 (+) and 12 (-). From SW 02.01.zz onwards, an additional HART signal is available at terminal 13.

4.1.8 Connection of the secondary non-i.s. 4 to 20 mA analogue output

For the V1, WM550 and GPE field protocol, a secondary analogue output is available at the terminals 8 (+) and 11 (0V). This output can also be used to power a FMR540 radar, see figure below.



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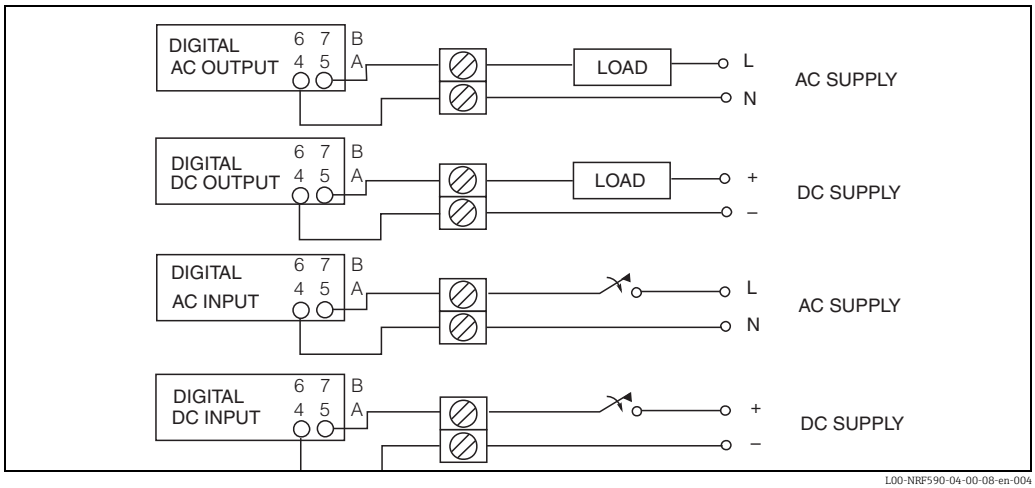
4.1.9 Connection of the discrete in and output

The Tank Side Monitor can be equipped with up to 2 discrete I/O modules. These modules can be used for interfacing to non-i.s. discrete in- or outputs. Input and output voltage and current ranges depend on the type of selected module installed in the relevant I/O slot. Terminals 4 and 5 correspond to discrete I/O slot A, terminals 6 and 7 correspond to discrete I/O slot B. For details on available I/O modules, → 59.



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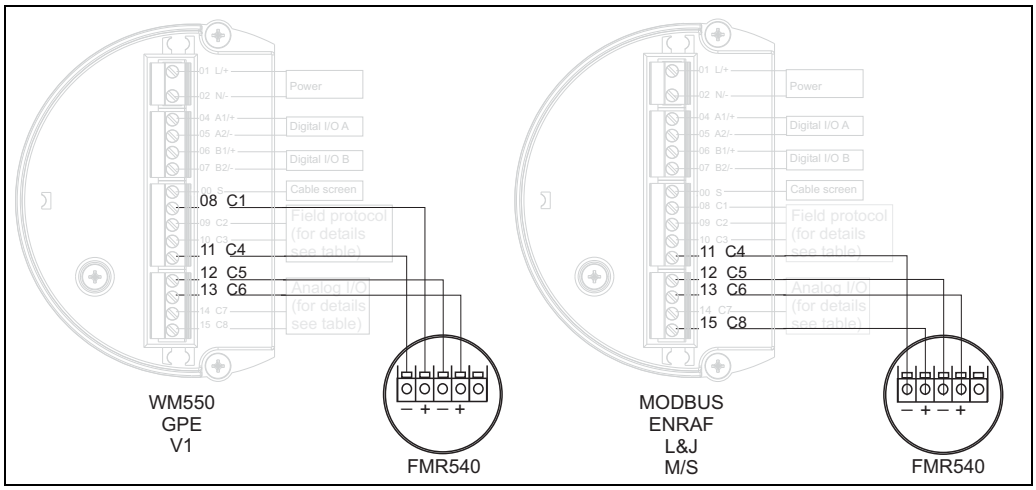
Note!

250 V AC is the maximum load that can be connected.

4.1.10 Connection of a 4-wire Radar gauge to the non-i.s. / field protocol side



Depending on the selected field communication board, a 4-wire non i.s. Radar can be connected to the HART input and power supply as follows:

- For all versions, use clamps l3 (+) and 12 (0V) to connect the HART communication line to the Tank Side Monitor.
- For the Modbus, BPM, L&J and M/S field protocols:
  Use the clamps 11 (0V) and 15 (24V) to power the radar gauge.
- For the Vi, WM550 and GPE field protocols: U
  se the terminals 8 (+) and 11 (0V) to power the radar gauge.

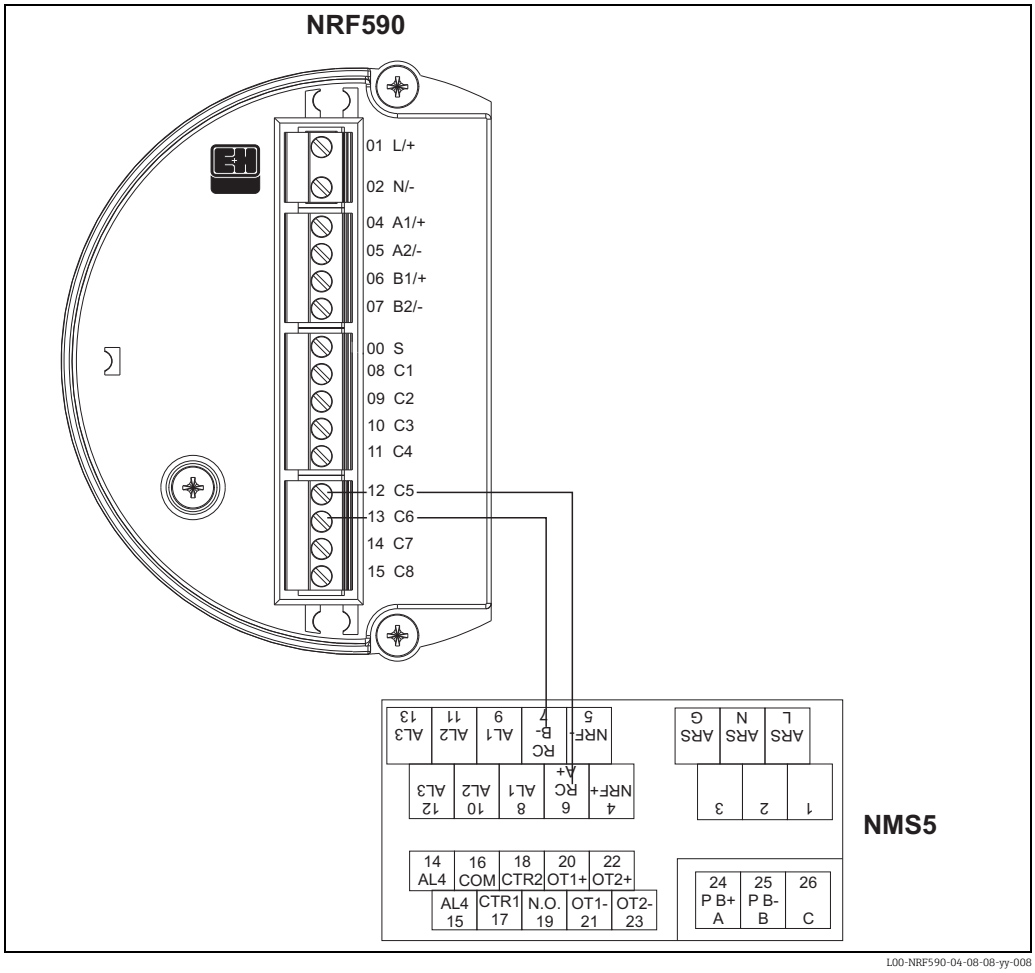
4.1.11 Connection of a Proservo NMS5 to the non-i.s. HART input

It is possible to connect Proservo NMS5 to the Tank Side Monitor NRF590 using the non-i.s. HART input available in the Exd terminal compartment.

Note!

- This is only possible if the NMS5 is equipped with a HART digital output (passive). The relevant order code must be: NMS5 - ***H********. ("H" meaning "HART passive")
- The Software Version must be: 04.24 or later.
- The Hardware Version must be: 4.00 or later
- The Tank Side Monitor NRF590 software version must be V02.04 or later

The communication is "read only". This type of connection does not provide any parametrization or commanding capability from the Tank Side Monitor NRF590 to the Proservo NMS5.



Terminal at Tank Side Monitor NRF590	Terminal at Proservo NMS5
12 / C5	6 / RC / A+
13 / C6	7/ RC / B-

Note!

Optionally, a Prothermo NMT539 can be connected to the Proservo NMS5 at terminal 24 (+) and terminal 25 (-) (for reading temperature and water bottom).

The read-only parameters of the Proservo NMS5

Proservo NMS5		Tank Side Monitor NRF590	
Parameter name	**Parameter number**	**Parameter name**	**Parameter number (n: HART bus address)**
OperatinStatus	021	Op. Status	8n32
OperatingCommand	020	Op. Command	8n33
CustodyTransfer	271	Custody Mode	8n35
SoftwareVersion	029	Software Ver.	8n42
AccessCode	039	Access Code	8n31
DeviceStatus	036	Error Code	8n41
MatrixSelect	030	Matrix Select	8n45
New NMS Status	272	New NMS Status	8n36
WMTimeout	NA	W&M Timeout	8n46
Balancing	022	Balancing	8n34
MeasuredLevel	000	Displacer Pos	8n21
WaterBottom	014	Water Level	8n24
UpperDensity	005	Upper Density	8n23
LiquidTemperature	010	Liquid Temp	8n22
GasTemperature	013	Vapour Temp	8n26
SWVersion	275	Software Id	8n43
HWVersion	276	Hardware Id	8n44
LevelData	008	Liquid Level	8n27
BottomLevel	004	Bottom Level	8n25

Tank Side Monitor NRF590 settings

NRF590 settings to start communication with NMS5

1. Go to the "Analog I/O" (7xxx) menu.
2. Go to "Analog Out" (73xx).
3. Go to the "HART Master" (735x) submenu.
4. Go to "Fixed current" (7351).
5. Set the fixed current to 26 mA (default setting).

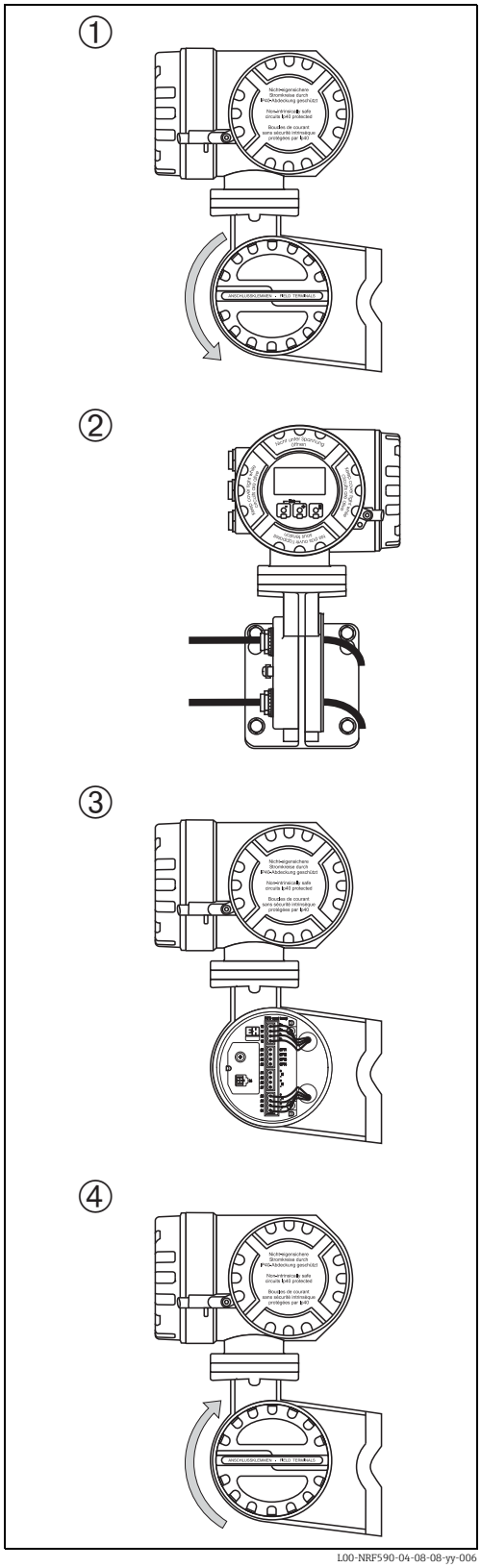
4.2 Wiring the IS (Ex ia) connection

4.2.1 The procedure

Caution!
The diameter of the signal cable should allow tight closing of the cable glands.
Example:
– Tank Side Monitor: M25x1,5
– Micropilot S: M20x1,5
→ suitable cable diameter: 10 to 13 mm

1. Unscrew the lid of the terminal compartment.
2. Push the signal cables through the appropriate cable glands.
3. Wire up according to the terminal assignment diagram ("Terminal assignment", → 26).
4. Screw the lid of the terminal compartment securely back onto the transmitter housing.

   Note!
   Make sure to clean the threads of the lid to remove any dust or particles. Check that O-ring is in place and reapply anti-seize grease.



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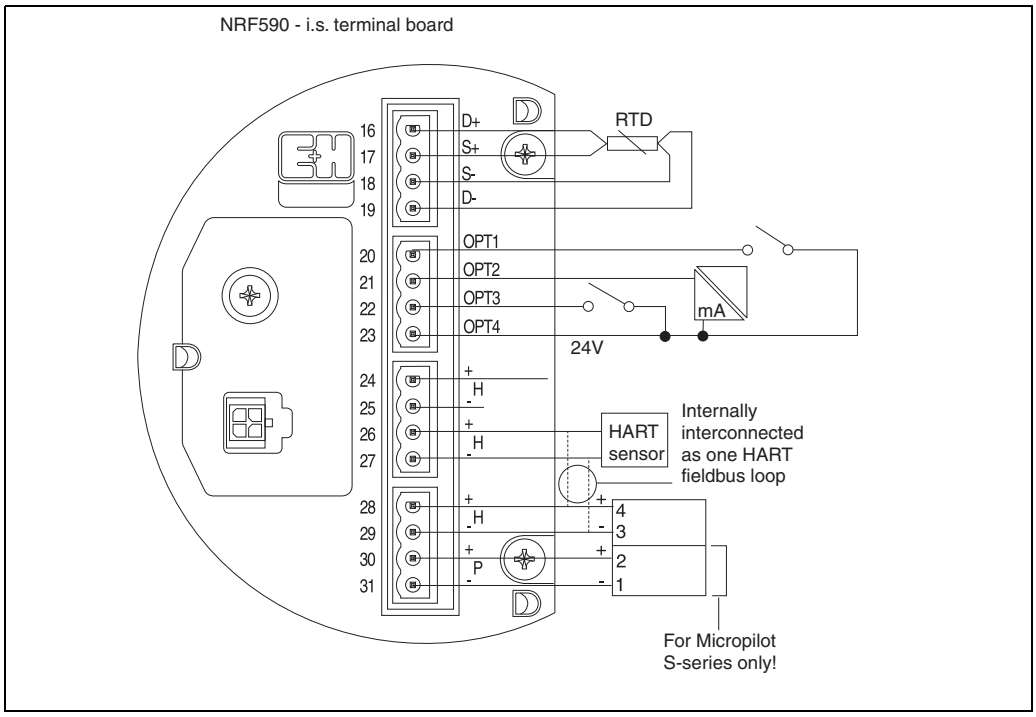
4.2.2 Terminal assignment



Terminal	Designation	Meaning
16	D+	+ RTD drive[1)]
17	S+	+ RTD sense[1)]
18	S-	- RTD sense[1) ,2)]
19	D-	- RTD drive[1) ,2)]
20	OPT1	Discrete Input 1
21	OPT2	Analog Input 1 (4 ... 20 mA)
22	OPT3	Discrete Input 2
23	OPT4	Option +24 V
24	H+	+HART comm.[3)]
25	H-	-HART comm.[4)]
26	H+	+HART comm.[3)]
27	H-	-HART comm.[4)]
28	H+	+HART comm.[3)]
29	H-	-HART comm.[4)]
30	P+	+ i.s. power for FMR S-series (terminal 2 of FMR)[3)]
31	P-	- i.s. power for FMR S-series (terminal 1 of FMR)[4)]

1) These terminals should be left unconnected if RTD has not been selected in feature 40 of the product structure.

2) For a 3-wire RTD, terminals 18 and 19 should be connected together.

3) These terminals share the same HART signal.

4) These terminals share the same i.s. 0 V signal.

4.2.3 Connection of HART devices

Tank sensors

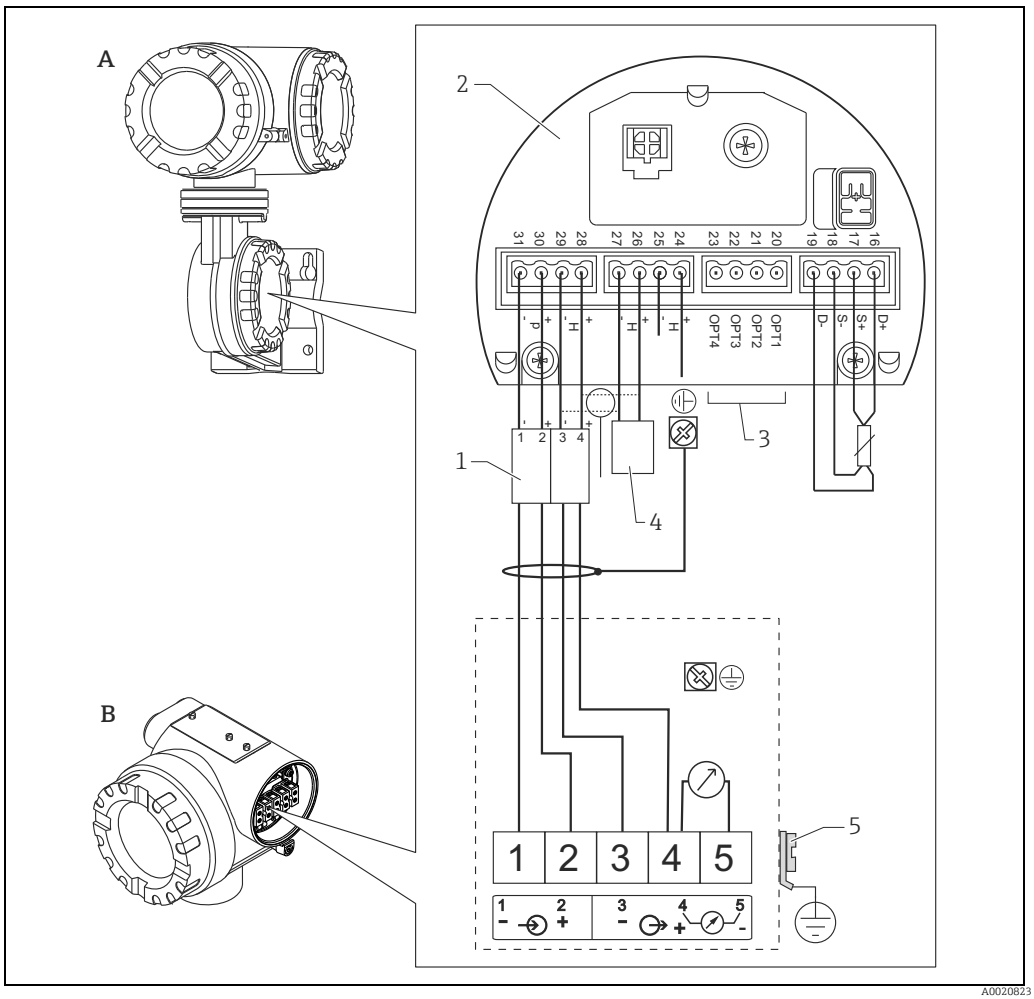
The Tank Side Monitor can interface to a maximum of 6 i.s. HART sensors.
All HART sensors are connected to one HART multi-drop communication loop. In order to keep wiring simple, 3 interconnected terminal pairs are available. The terminal pairs are marked respectively "H+" and "H-".

Power supply for Micropilot S

For supplying extra i.s. power to the FMR S-series radar, additional power terminals are available, marked as "P+" and "P-". Although it is possible to use only 3 wires between the S-series radar and the NRF590, by combining the "P-" and "H-" wires, it is recommended to use a double pair of screened and twisted cable.

Grounding of the cable screen (for Micropilot S)

The screen of the cable connecting the Micropilot S to the Tank Side Monitor should be grounded at the Tank Side Monitor, **not** at the Micropilot S.

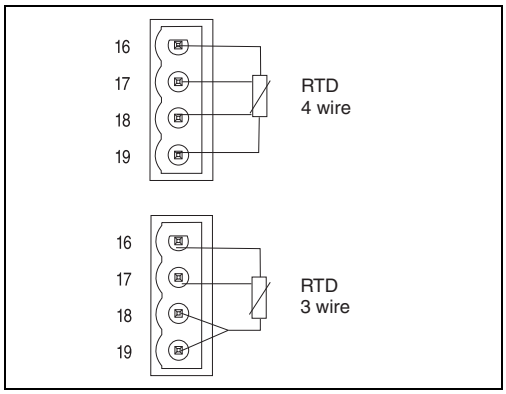


A Tank Side Monitor NRF590
B Micropilot S
1 Only for Micropilot S
2 Intrinsically safe terminal board
3 Grounding single sided on Tank Side Monitor NRF590
4 HART Sensor
5 Shield ground
6 PML (potential equalization line)

If there is no way to set a ground cable between NRF590 and Micropilot S it is possible to ground single side (grounding on side NRF590). In this case it's imperative to ground the shield (on Micropilot S side) via a ceramic capacitor with a maximum capacitance of 10 nF and a minimum insulating voltage of 1500 V.

The Micropilot S is - possibly in combination with other devices - connected to a tank side monitor in a hazardous area. In this case, it is recommended that you ground the cable screen centrally at the Tank Side Monitor and connect all devices to the same potential matching line (PML). If, for functional reasons, a capacitive coupling is required between local earth and screen (multiple grounding), ceramic condensers with a dielectric strength of min. 1500 Veff must be used, whereby the total capacitance of 10 nF must not be exceeded. Notes on grounding interconnected intrinsically safe devices are provided by the FISCO model.

4.2.4 Spot RTD



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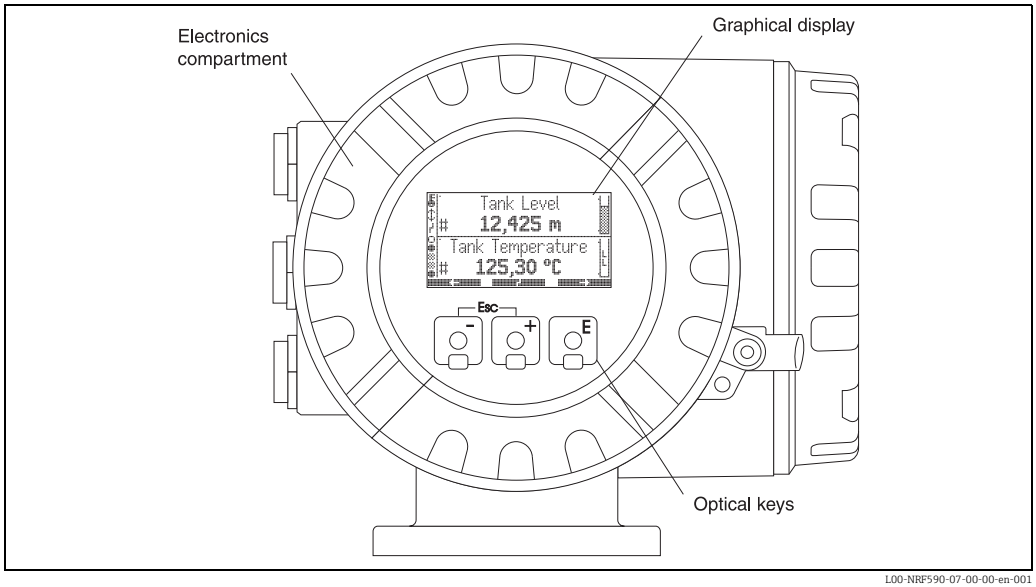
A spot RTD can be connected to the NRF590 if the option is installed. For 4-wire connection, the RTD must be connected to the 4 available terminals marked D+, S+, S- and D-. For 3-wire connection, the RTD should be connected to the same 4 terminals. The terminals D- and S- should be connected together directly at the NRF590 terminals.

Temperature setup should be performed after all external devices are connected to the NRF590.

5 Operation

5.1 Display and operating elements

The Tank Side Monitor is operated via the display module and the three optical keys. The keys can be operated through the cover glass. Therefore, the Tank Side Monitor needs not to be opened for operation. The backlight of the display is activated during operation for user defined time (always off, 10 sec, 30 sec, 1 min, always on).



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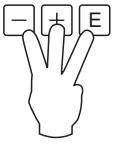
5.1.1 Format of decimal numbers

The number of decimal places displayed can be selected from three resolution presets (high, normal, low)

VAlue	resolution preset		
	low	normal	high
level units			
mm	xxxxx	xxxxx	xxxxx.x
cm	xxxx.x	xxxx.x	xxxx.x
m	xx.xxx	xx.xxx	xx.xxxx
in	xxxx.x	xxxx.x	xxxx.xx
ft	xxx.xxx	xxx.xxx	xxx.xxxx
ft-in-8	xx'xx"x/8	xx'xx"x/8	xx'xx"x/8
ft-in-16	xx'xx"xx/16	xx'xx"xx/16	xx'xx"xx/16
16ths	xxxxx	xxxxx	xxxxx.x
temperature units			
°C	xxx	xxx.x	xxx.xx
°F	xxx	xxx.x	xxx.xx
pressure units			
Pa	xxxxxxx	xxxxxxx	xxxxxxx
kPa	xxxx.x	xxxx.xx	xxxx.xxx
MPa	x.xxxx	x.xxxxx	x.xxxxxx
mbar	xxxxx	xxxxx	xxxxx.x
bar	xx.xxx	xx.xxx	xx.xxxx
psi	xxx	xxx.x	xxx.xx
inH_20	xxxxx	xxxxx.x	xxxxx.x
density units			
kg/m^3	xxxx.x	xxxx.xx	xxxx.xx
g/ml	x.xxxx	x.xxxx	x.xxxxx
lb/ft^3	xx.xx	xx.xxx	xx.xxxx
°API	xxx.xx	xxx.xx	xxx.xxx
current units			
mA	xx.xxx	xx.xxx	xx.xxxx

5.2 Key assignment

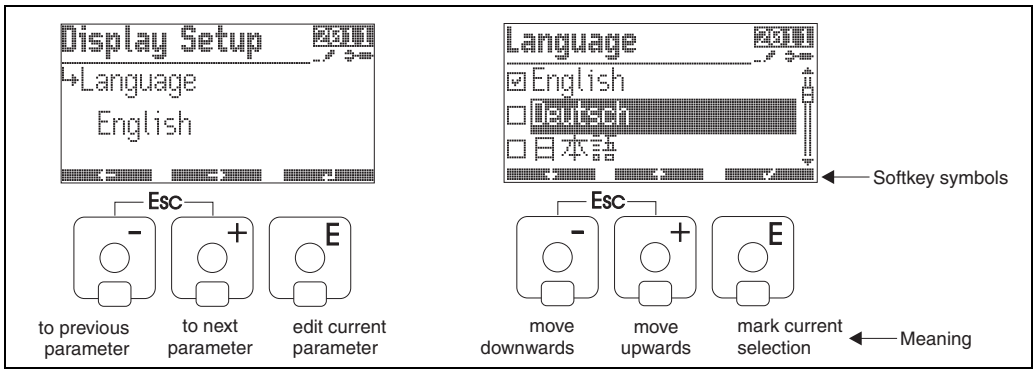
5.2.1 General key combinations

Key combination	Meaning
	**Escape** Escape from the current editing opration. If the currently edited value has not been stored, then the parameter will retain its original value.
	**Display contrast** Opens the menu for the setting of the display contrast.
	
	**In the operating menu: Quick Exit** Return to the measured value display **In the measured value display: Software-locking** Sets "Access Code" = 0 (device locked) Sets "Service English" = off (display language as selected by the user)

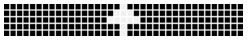
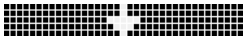
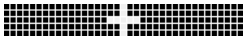
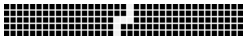
5.2.2 Softkeys

Except for the aforementioned key combinations, the keys operate as softkeys, i.e. their meaning varies depending on the current position within the operating menu. The meaning is indicated by softkey symbols in the bottom line of the display.

Example

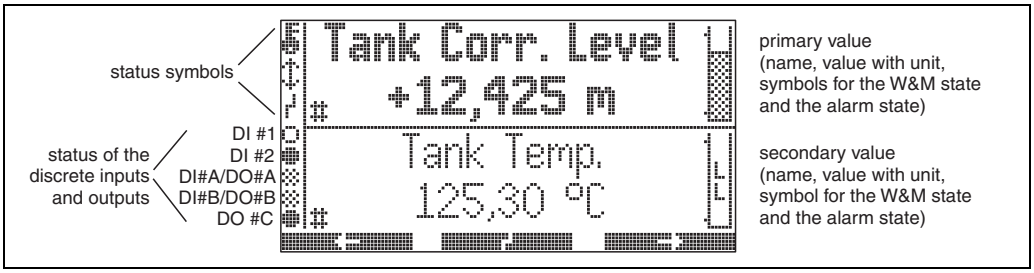


List of the softkey symbols

Softkey symbol	Meaning
	Move to the previous parameter in the list.
	Move to the next parameter in the list.
	Return to the group selection.
	Enter the current parameter for editing.
	Move the selection in a list up to the previous one.
	Move the selection in a list down to the next one.
	– Select the currently highlighted option. – "Yes" for yes/no questions.
	– Unselect the current option. – "No" for yes/no questions.
	Increment a numerical or alphanumerical value by one.
	Decrement a numerical or alphanumerical value by one.
	Display device status.

5.3 Measured value display

The appearance and meaning of the measured value display depends on the configuration of the Tank Side Monitor. The following picture gives a typical example. The table summarises all display symbols.



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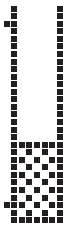
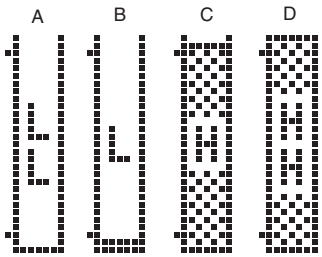
The primary measurement value is constantly displayed in user configured units an format; the secondary value can display up to four alternately measurement values, in a scroll rate choosen by the user.

Symbol	Meaning
Status of the Tank Side Monitor	
	**W&M locking** is displayed, if the W&M parameters of the Tank Side Monitor have been locked by the hardware locking switch.
	**Communication** is displayed if the Tank Side Monitor is currently communicating on the Fieldbus.
	**Error** is displayed if the Tank Side Monitor detects an error.
Status of the displayed measuring values	
	**W&M status** is displayed, if the suitability for custody transfer measurement of the measured value can currently not be ensured (e.g. if the W&M locking of the respective sensor is not ensured).
Status of the discrete inputs and outputs	
	**Active** is displayed if the respective discrete input or output currently is in the "active" state.
	**Inactive** is displayed, if the respective discrete input or output currently is in the "inactive" state.
	**"Value unknown" or "Not fitted"** is displayed ▪ if "discrete" has been disabled in the operating menu ▪ before the first value has been read ▪ if the optional module is not installed.
Access code	
	**User** is displayed, if the "user" access code ("100") has been entered.
	**Service** is displayed, if the "service" access code has been entered.
	**Diagnostic** is displayed, if the "diagnostic" access code has been entered.

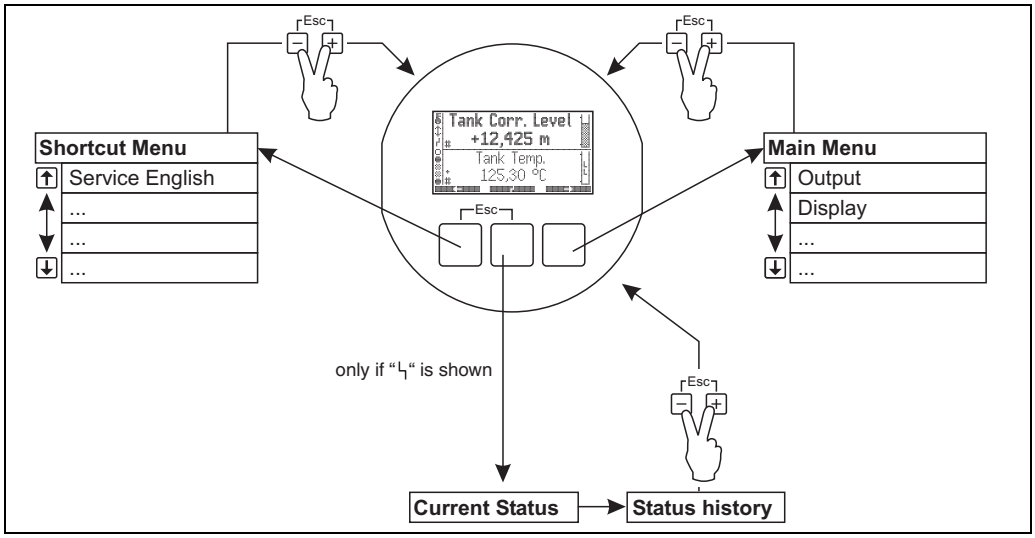
Symbol	Meaning
Parameter type	
	**Read only** indicates a measured or calculated value
	**Editable** indicates a configuration parameter
	**W&M locked** indicates the current parameter is locked by the W&M switch
	Cyclic update (flashing left of the parameter name) indicates that the parameter is cyclically updated
	**DD** These parameters are linked to an external Hart device. There is no internal copy of these parameters and their value is not automatically scanned by the system. When one of these parameters is selected on the display it is immediatly read from the connected device and displayed, changes are written directly back to the device (which may reject these changes, depending on device configuration e.g. access code or local W&M lock activated).

Symbol	Meaning
Alarm state	
	**Alarm inactive** is displayed, if the measured value displayed in the same section of the display is within the allowed range (i.e. between the L and H limits). The bar within this symbol represents the current value scaled between the L and H limit. If no alarm has been defined for the measured value, this symbol is not displayed.
	**Alarm active (flashing symbols)** – A: measured value is below the LL limit – B: measured value is between the LL and L limits – C: measured value is between the H and HH limits – D: measured value is above the HH limit If no alarm has been defined for the measured value, these symbols are not displayed.

5.4 Operating menu

5.4.1 Entering the menu

The navigation in the operating menu always starts from the main screen (measured value display). From there, the following three menus can be entered by the keys:



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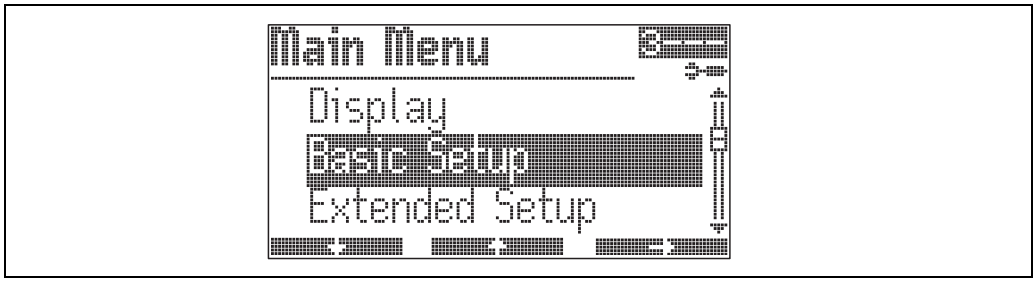
- **Shortcut menu**
  The shortcut menu allows to change the display language to "English", if any other language has been choosen by the customer. By activating the option "Service English", all parameters are displayed in english language. Using the "Quick exit" ("General key combinations", → 31) twice, the system is reset to the language and the Software lock is activated.
- **Main menu**
  The main menu contains all readable and editable parameters of the Tank Side Monitor. The parameters are distributed among statical and dynamical submenus. Dynamical submenus adapt themselves to the current installation environment of the Tank Side Monitor. The main menu should be used if one wants to read or edit parameters which are not accessible via the shortcut menu.
- **Device Status**
  The "Device Status" comprises the most important parameters describing the current state of the Tank Side Monitor (error indication, alarm states etc.). Functions only, if a status is active (indicated by the error symbol on the display).

5.4.2 Navigation within the menu

Selecting a submenu



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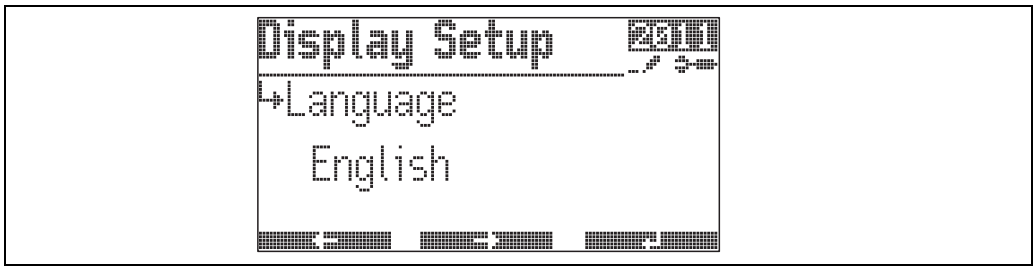
- Select the submenu by [redacted] and [redacted].
- Go to the first function of the submenu by [redacted].

Selecting a parameter within the submenu

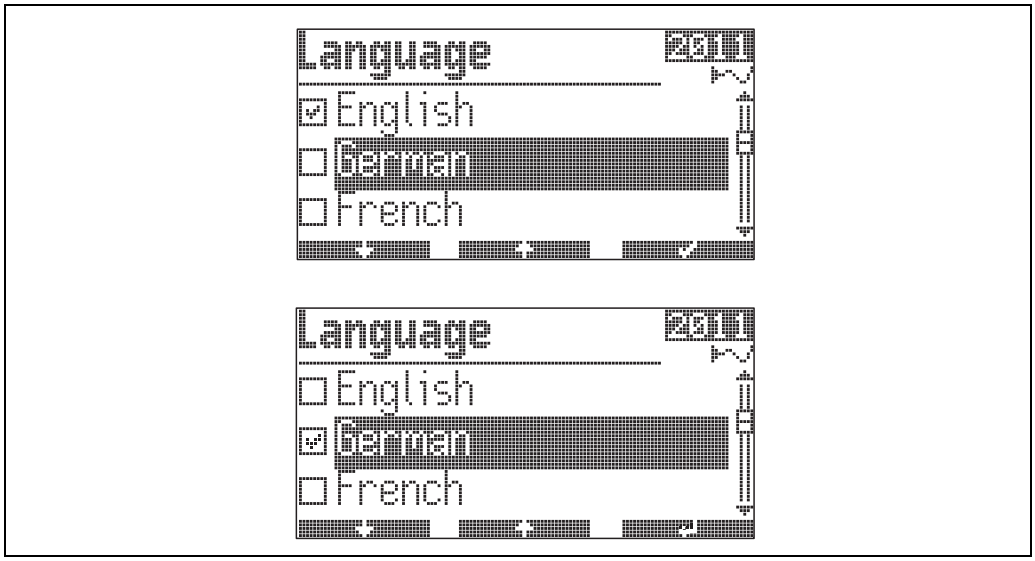


L00-NRF590-07-00-00-en-051

- Go to the previous parameter by [redacted].
- Go to the next parameter by [redacted].
- Open the current parameter for editing by [redacted].

5.4.3 Editing parameters

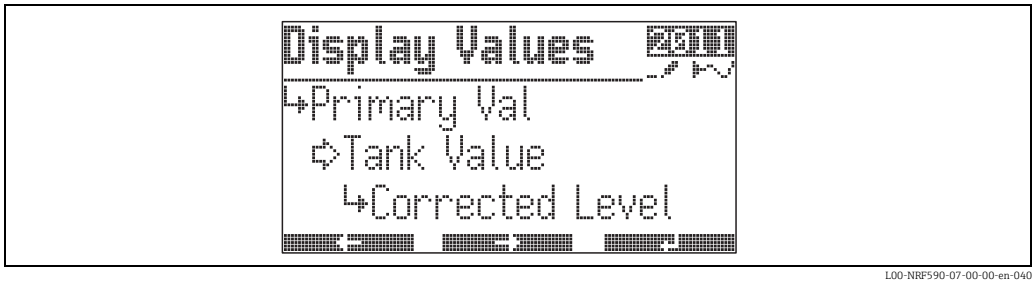
Parameters with selection list



L00-NRF590-07-00-00-en-052

- Select the parameter value by [▒▒] and [▒▒].
- Mark the selected value by [▒▒].
- Confirm the marked value by [▒▒].

Reference parameters



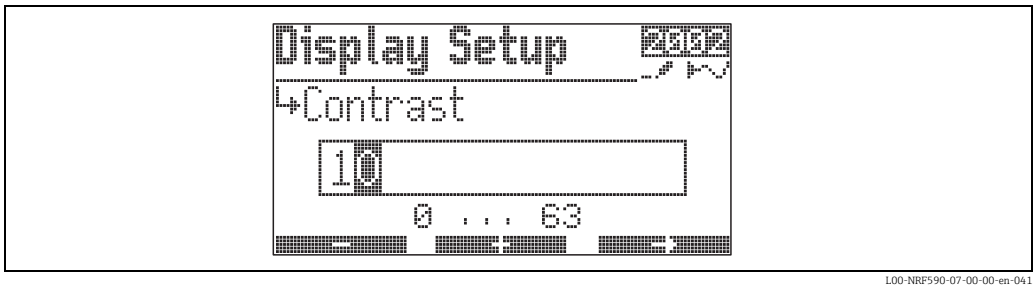
L00-NRF590-07-00-00-en-040

Reference parameters describe where a numerical or logical value (here: Primary Value) is obtained from. The selection consists of two steps:

1. Select the function group, from which the value is to be obtained (here: Tank Value).
2. Select the value within this group (here: Corrected Level).

There is a separate selection list for each of these steps.

Alphanumeric parameters



L00-NRF590-07-00-00-en-041

- Set the activated digit by [redacted] and [redacted].
- Go to the next digit by [redacted].
- If ↵ appears at the active digit, the currently displayed value can be accepted by [redacted].
- If ← appears at the active digit, return to the previous digit by [redacted].

5.4.4 Quitting the menu

Return to the measured value display by pressing all keys simultaneously.

5.5 Locking/unlocking parameters

5.5.1 Software locking

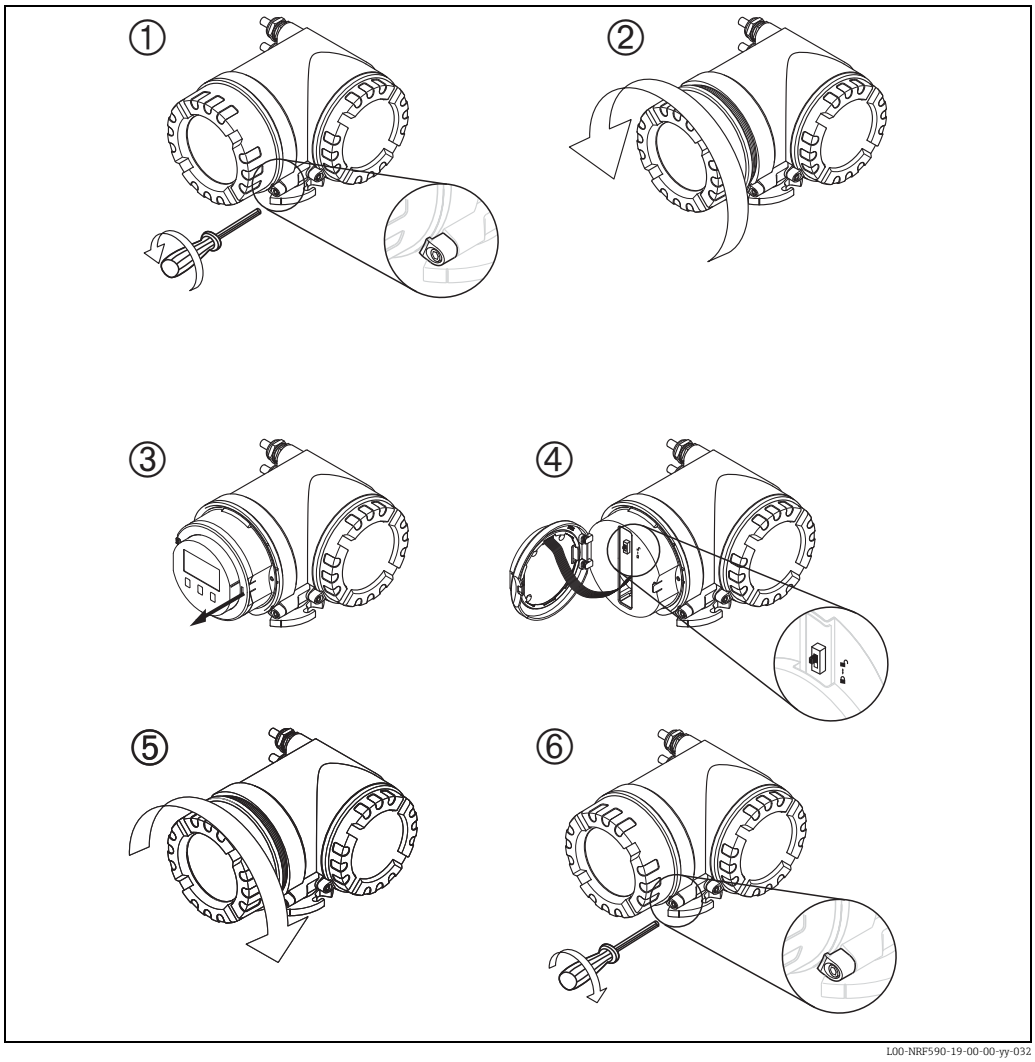
If the device is in the measured value display, it can be locked by pressing all keys simultaneously.
In doing so, "Access Code" is set to "0" (i.e. parameters can no longer be changed) and "Service English" is set to "off" (i.e. the display is returned in the language selected by the customer).

5.5.2 Software unlocking

If you try to edit a parameter, the device goes to the "Access Code" function.
Enter "100". Parameters can be changed again.

5.5.3 W&M hardware locking switch

A hardware locking switch for W&M sealing is located behind the display module.
All W&M parameters can be set to definite values and locked by this switch. In this state, the Tank Side Monitor can be used for W&M applications.
In order to operate the hardware locking switch, procede as follows:



L00-NRF590-19-00-00-yy-032

Warning!
Danger of electrical shock! Before opening the housing, completely switch off the power supply.

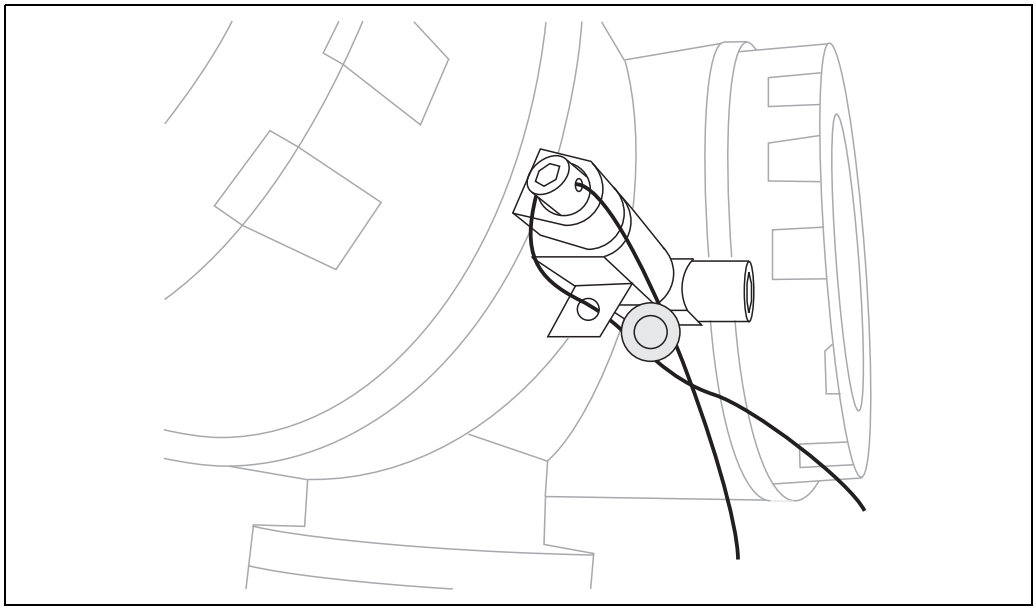
1. Using a 3 mm (7/64") Allen wrench, losen the safety pin for the display lid.
2. Unscrew the display lid.

   Note!
   If the display lid is difficult to unscrew, unplug one of the cables from the cable gland to allow air to enter the housing. Then, attempt once again to unscrew the display lid.
3. Turn the display module sideways.
4. Place the locking shift into the desired position:
   – :W&M parameters are **free**.
   – :W&M parameters are **locked**.
5. Replace the display lid on the Tank Side Monitor housing.

   Note!
   Make sure to clean threads on lid to remove any dust or particles. Check that O-ring is in place and reapply anti-seize-grease.
6. Adjust the safety pin so it is set over the display lid and tighten. The safety pin can now be secured by a sealing thread and a sealing ring.

5.5.4 Sealing of the Tank Side Monitor

When the tests according to the applicable regulatory standards have been completed, it is required to secure the housing cover with a sealing wire and a sealing ring.



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6 Commissioning

6.1 Theoretical background

6.1.1 Function blocks and data flow

The internal architecture of the Tank Side Monitor is organized as function blocks. During commissioning one can link the outputs and inputs of different function blocks in order to define a data flow through the Tank Side Monitor. Generally one can distinguish three parts of the data flow:

1. Data enter into the Tank Side Monitor via the input blocks. There is a block for each connected HART device (e.g. FMR, NMT, PMD). Depending on the device version, there are additional Analog (AI) and Digital (DI) Input blocks.
2. Data are processed in the TANK function block (tank calculations and corrections) and in the Alarm (AL) function blocks.
3. Data are output to
   - the display
   - the fieldbus via the fieldbus function blocks (e.g. MODBUS, ENRAF, ...)
   - the analog or digital outputs via the Analog (AO) and Digital (DO) output blocks.

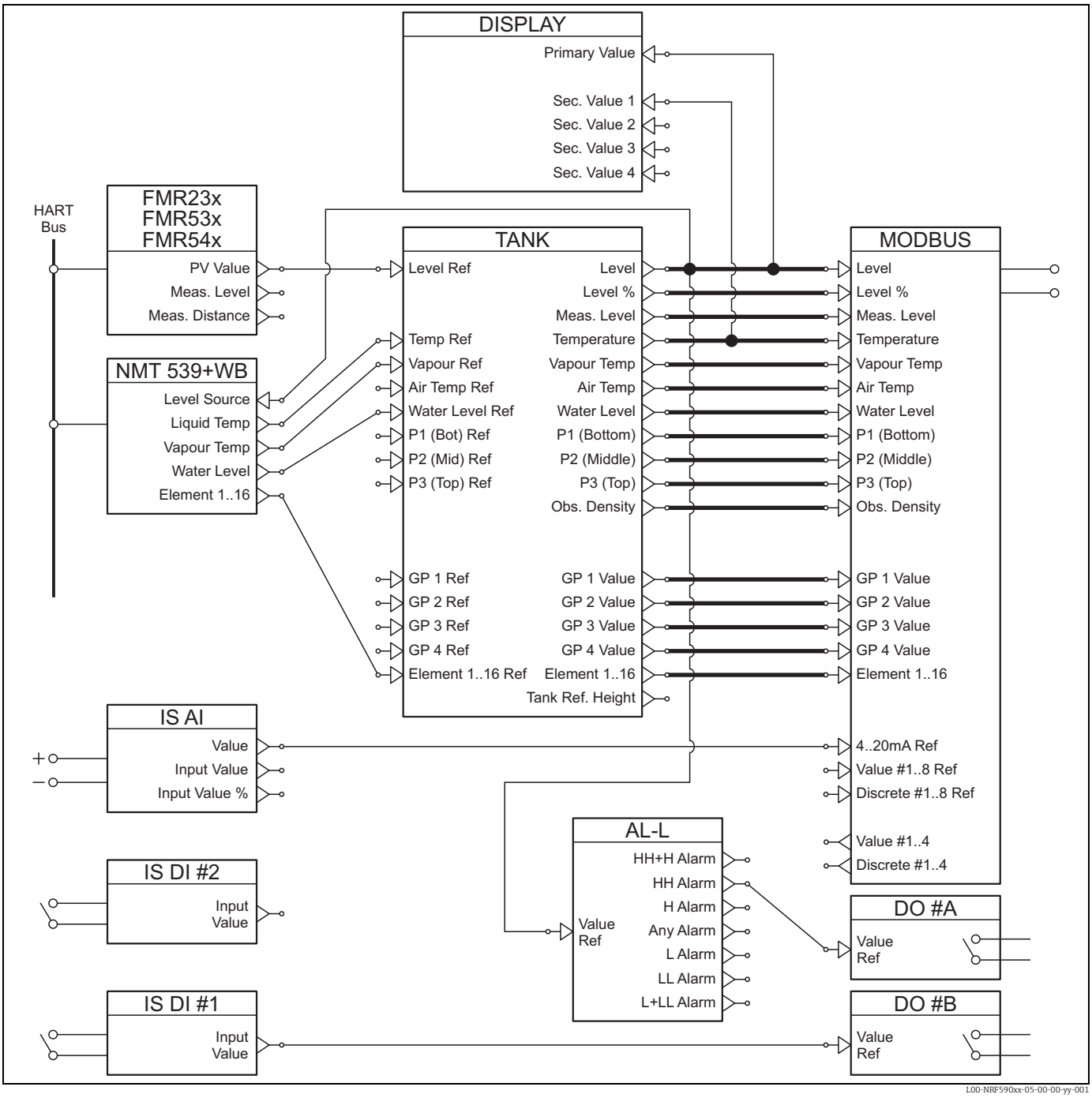
6.1.2 Linking sensors to function blocks

To commission the NRF590, it is necessary to connect all Tank HART sensor blocks to one of the internal function blocks, either the "tank functions" block or the "alarm function" block. The outputs of these function blocks can then be mapped to the display, the fieldbus function block and the AO or DO blocks.
By default, these mappings are set to the most common default values. Some of these default mappings are unbreakable system links, others can be modified by the user.
The linking is performed by reference parameters (marked by the ending "REF" in the parameter name). For each of these reference parameters the desired source can be selected from a list.

6.1.3 Linking Digital Inputs

An additional Digital Input can either be linked to the field protocol inputs or directly to an Digital output. This latter case is usually used for overspill protection.

6.1.4 Example of block linking



The level value as given by the FMR level radar via the HART protocol is read into the FMR function block. The FMR function block sends the value to the TANK function block, to be stored in the "Level Ref" data point. From here, it is displayed in the primary display as well as communicated to the Modbus protocol function block, which maps the value to the adequate Modbus register.
In parallel, the level value is sent to the NMT function block, from where it is sent to the NMT Prothermo gauge in order to assign the product level for the product temperature respectiveley the product vapour temperature.
Additionally, a digital input value is directly transferred from the Digital Input block (IS DI#1) to a Digital Output block (DO#B) as well as an analog value from the Analog Input Block (IS AI) to the MODBUS Block.

Furthermore, the level is evaluated in the Alarm block (AL-L). If the HH limit is overshot, an alarm signal will be transmitted via the Digital Output Block (DO #A).

6.1.5 Validation of Weight & Measure approved measurements

The weight & measure status is evaluated by the Tank Side Monitor on two stages:
- On a first stage, the measurement device value coming into the Tank Side Monitor is evaluated
- On a second stage, the TANK function block is evaluated.

Status of a measurement device

The weight & measure status of a measurement device is o.k. if:

- the custody transfer switch (or the related software setting) of the device is closed
- no alarm status is received from the measurement device
- for the Micropilot S level radar: the custody transfer status is "active positive"
- for a RTD transmitter: the sensor's custody transfer switch is locked, the sensor position is defined and situated between the defined min and max alarm values.

If any of these conditions are not met, then the devices measured values will be shown with the "**#**" symbol in the HART device menu.

Status of the TANK function block

The weight & measure status of the TANK function block is o.k. if:

- the custody transfer switch of the Tank Side Monitor is closed
- the referenced measured value has a validated weight & measure status
- additionally for the level measurement: no tank calculations (CTSh, HyTD, HTMS, HTG) are activated

If any of these conditions are not met, then the "**#**" symbol is displayed along with the displayed tank function group value in the display.

The tank values are transmitted via the field protocol to the control room along with the current weight & measure status.

6.2 Configuration of the HART Interface

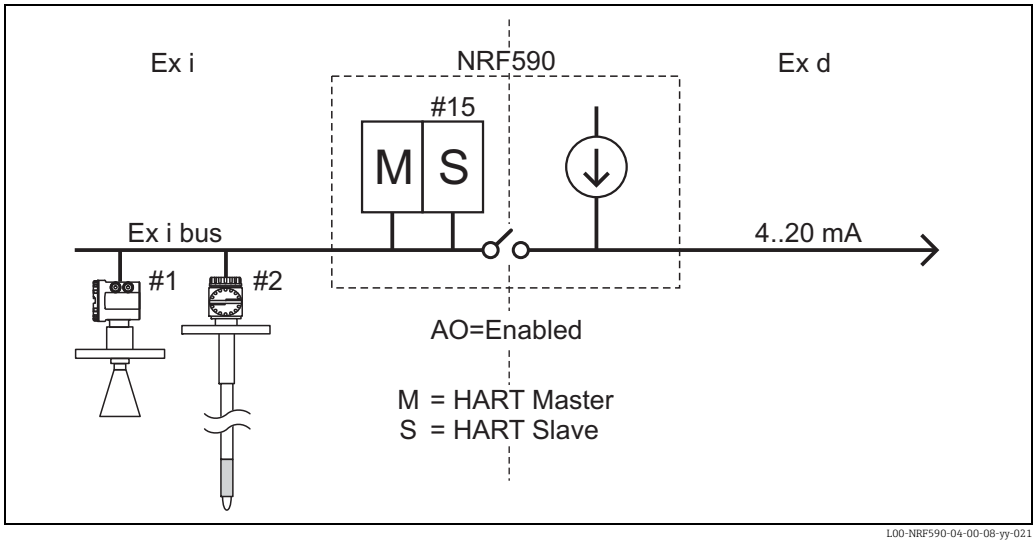
The NRF590 comes with two HART interfaces; the Ex i interface and the Ex d interface[1)].

- On the **Ex i** side the Tank Side Monitor is always operating as **HART Master** polling the devices connected. It can also temporarily operate as **HART Slave** in order to communicate with the FieldCare.
- On the **Ex d** side the HART interfaced is controlled by the "Analog IO/AO" function group. The following modes can be selected:
  - **Enabled**
    In this mode no HART signal is used on the Ex d side. There is only a 4-20 mA signal present at the analog output.
  - **HART Slave**
    In this mode data can be transmitted from the analog output to a primary or secondary HART Master (e.g. FieldCare).
  - **HART Master**
    In this mode the Tank Side Monitor can poll HART devices which are connected to the Ex d HART bus.

The following sections describe these modes in more detail.

6.2.1 Ex i Interface Only (Default Mode)

This mode becomes effective if the Analog Output is set to "Enabled".



In this mode the **HART Master** scans the measuring devices on the Ex i bus to obtain the measured values.

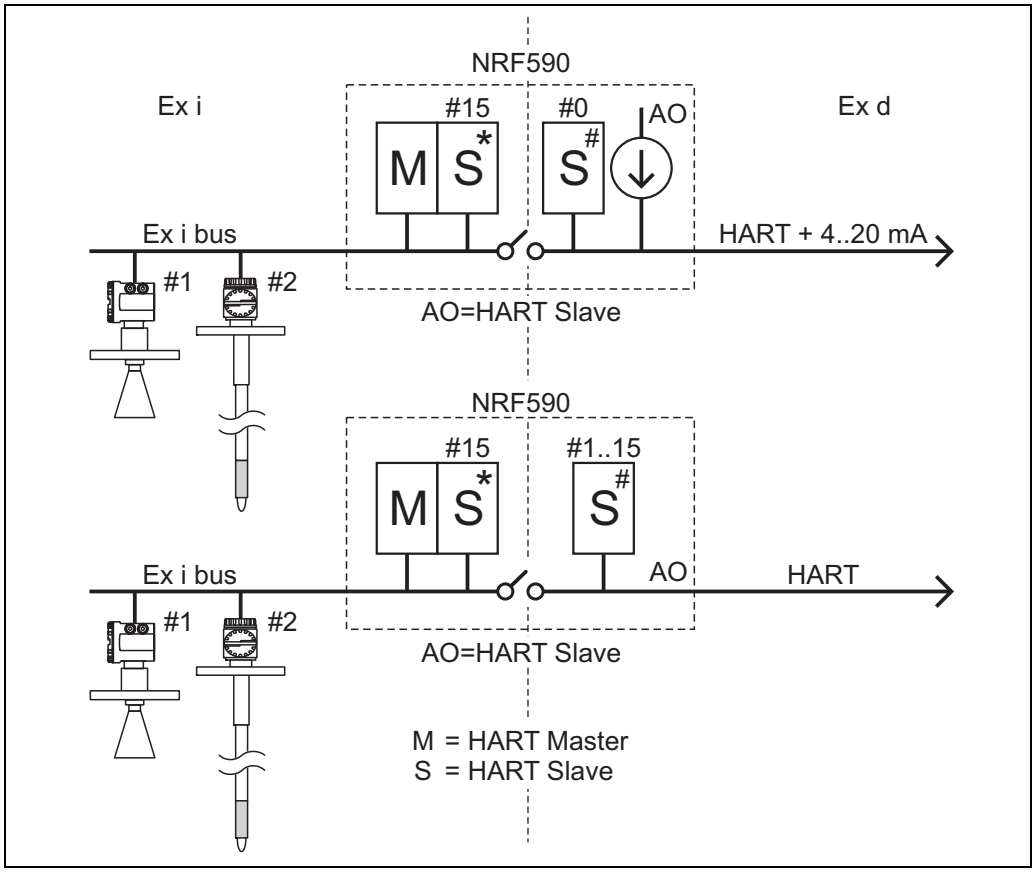
The **HART Slave** is normally inactive, used to communicate with a FieldCare when connected to the Ex i bus. The HART Slave address of the Tank Side Monitor is controlled by the parameter "NRF Output/HART Slave/Slave Setup/Comm. address"(9121). By default this address is set to "15".

On the **Ex d side**, no HART signal is available. Only the 4-20mA current signal can be used.

1) The Ex d HART bus is not available on a Modbus NRF590 with order code *4********* (without 4..20mA Input or Output).

6.2.2 Ex i Interface with Ex d Slave Interface

This mode becomes effective if the Analog Output is set to "HART Slave".



In this mode the **HART Master** scans the measuring devices on the Ex I bus to obtain the measured values.

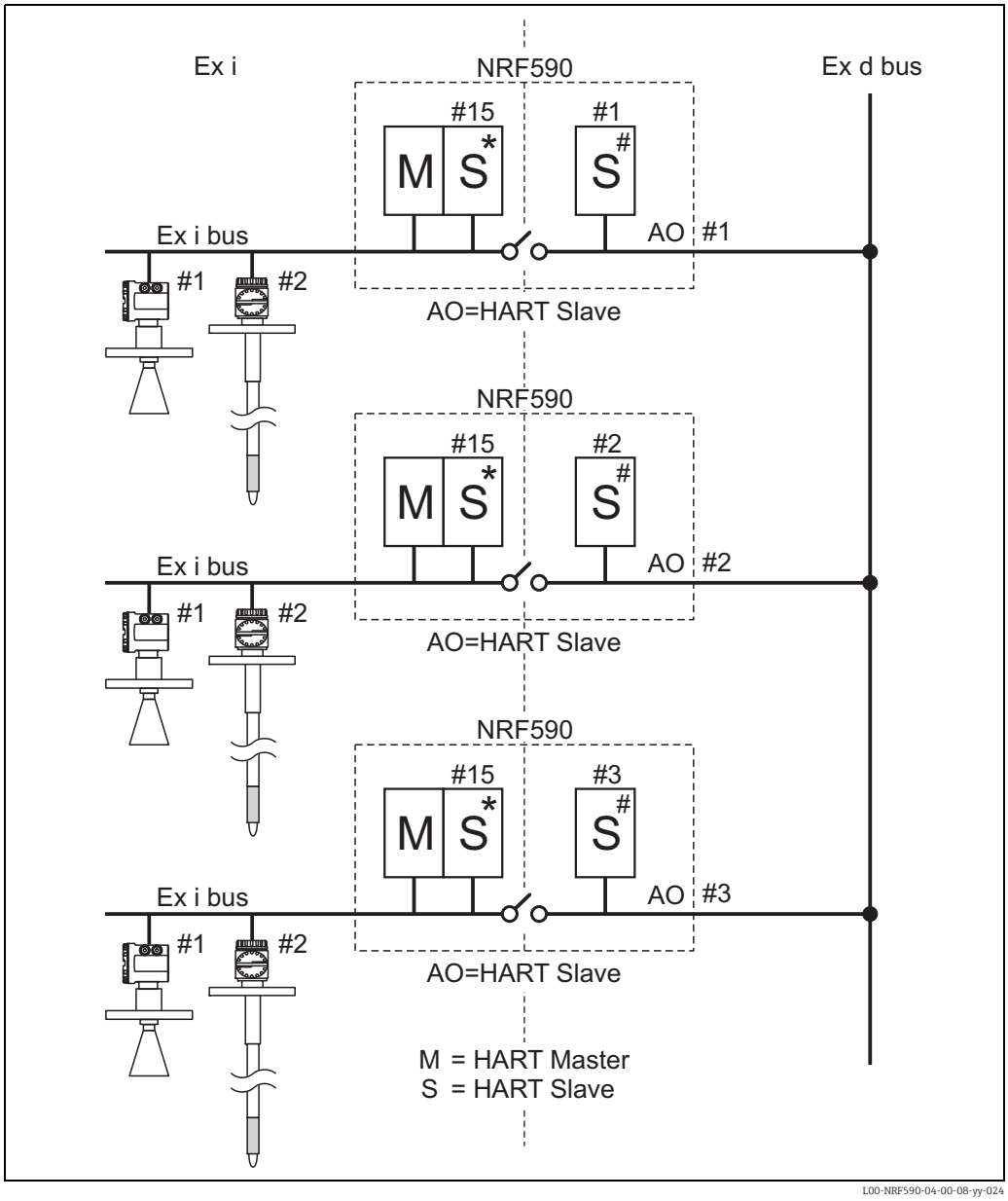
The **HART Slave** on the Ex I bus is normally inactive, used to communicate with a FieldCare when connected to the Ex I bus. The HART Slave address of the Ex i interface of the Tank Side Monitor is controlled by the parameter "NRF Output/HART Slave/Slave Setup/Comm. address"(9121).
By default this address is set to "15".

The **HART Slave on the Ex d bus** provides data to an external Primary or Secondary master. The HART Slave address of the Ex d interface of the Tank Side Monitor is controlled by the parameter "Analog IO/AO/HART Slave/Comm. Address"(7341). By default this address is set to "0", which means that the HART signal and a 4-20mA signal are output.

The HART slave values are the same for both HART Slaves (except for the HART address). They can be configured through the “NRF Output/HART Slave/Slave Values” menu.

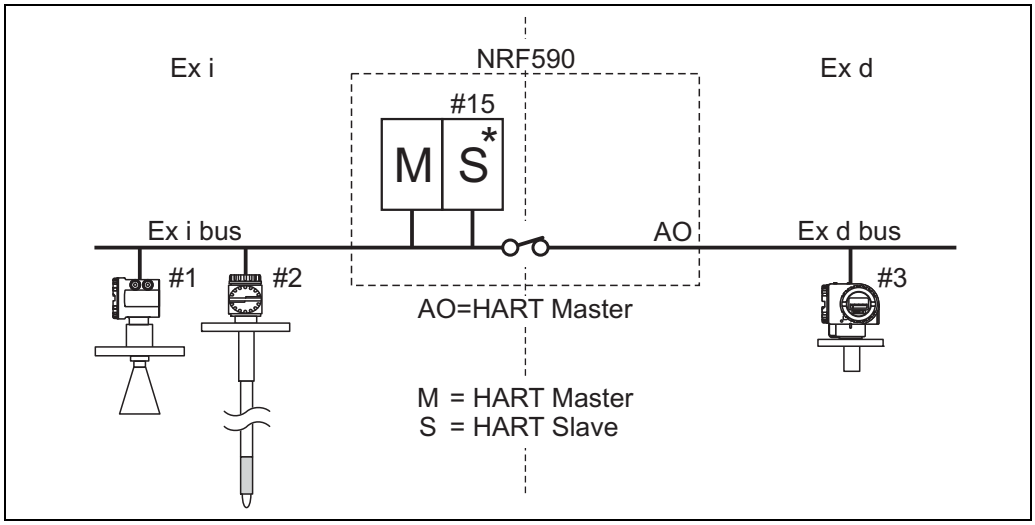
6.2.3 Ex i Interface with Ex d Interface in Multidrop Mode

If addresses from "1" to "15" are selected on the Ex d bus, the HART signal is superimposed over a fixed current and the devices can be used in multidrop mode:



6.2.4 Ex i Interface with Ex d Master Interface

This mode becomes effective if the Analog Output is set to "HART Master".



In this mode the **HART Master** scans the measuring devices on both the Ex I & Ex d buses to obtain the measured values.

The **HART Slave** is normally inactive, used to communicate with a FieldCare when connected to either the Ex I or Ex d bus.

There is only one **HART Slave address**, which is valid for both the Ex d and the Ex i interface. It is controlled by the parameter "NRF Output/HART Slave/Slave Setup/Comm. address"(9121). By default this address is set to "15".

In this mode all HART devices no matter where they are connected must have unique HART polling addresses.

6.3 Addressing of the HART devices

If possible, the addresses of the HART devices should be set before connection to the Tank Side Monitor. The default block configurations require usage of the following addresses:

Tank calculation[1)]	Addresses of the individual HART devices				
	Level	Temperature[2)]	Pressure 1 (bottom)	Pressure 2 (middle)	Pressure 3 (top)
level only	1	-	-	-	-
level + temp.	1	2	-	-	-
HTMS + P1	1	2	3	-	-
HTMS + P1,3	1	2	3	-	5
HTG P1	-	2	3	-	-
HTG P1,3	-	2	3	-	5
HTG P1,2	-	2	3	4	-
HTG P1,2,3	-	2	3	4	5

1) The types of tank calculations are described in the Appendix, → 77

2) If the RTD interface of the Tank Side Monitor is used for spot temperature measurement, no HART temperature sensor is required. In this case address "2" should remain unassigned.

Caution!
Do not connect a device with address "0". Such a device has an active 4 to 20 mA output which may overload the HART bus, disrupting all HART communication.

Note!
The HART interface on the non-IS side of the Tank Side Monitor can be operated in different modes. If the "slave" mode has been selected, the HART loops on the IS an the non-IS sides will operate independently of each other. Therefore, it would be possible to use devices with the same HART address on the IS and on the non-IS loop. In order to prevent confusion, we strongly recommend to avoid this kind of double usage of addresses.

6.4 Steps of the Commissioning Procedure

1. **Automatic check of the HART addresses of the connected devices**[2)]
   After connection of the HART devices, the Tank Side Monitor will check if all HART addresses are unique and unequal to "0". If this is not the case, then an alarm message will be displayed. In parallel, the actual HART addresses of the connected gauges can be checked in the "HART devices"(8---) function group.
2. **Define the display values of the Tank Side Monitor**
   In the "Display"(2---) function group, the information to be displayed and their format (such as language, timing, scroll rate) is defined.
   a. **Primary Value**
      The primary value will be continuously displayed in the upper part of the main display screen.
   b. **Secondary Values**
      Up to four secondary values will be displayed, which will be displayed cyclically in the lower part of the main display screen.
3. **Select the display units**
   The following unit presets are selectable in the "units preset"(2031) function:

Selection	Level	Pressure	Temperature	Density	Level Flow	Volume	Volume Flow
mm, bar, °C	mm	bar	°C	kg/m³	m/h	m³	m³/h
m, bar, °C	m	bar	°C	kg/m³	m/h	m³	m³/h
mm, PSI, °C	mm	PSI	°C	kg/m³	m/h	m³	m³/h
ft, PSI, °F	ft	PSI	°F	°API	ft/h	us gal	us gal/h
ft-in-16, PSI, °F	ft-in-16	PSI	°F	°API	ft/h	us gal	us gal/h
ft-in-8, PSI, °F	ft-in-16	PSI	°F	°API	ft/h	us gal	us gal/h

Note!
Only Tank values will be diesplayed in NRF590 units, values directly form HART devices will be displayed in the HART devices units.

2) In the Software Version SW 02.01, the HART buses on the IS and on the non-IS side are continuously monitored by the Tank Side Monitor. This means, that in contrast to SW 01.xx, an initial HART scanning of the bus has not to be performed. As soon as a new HART device is found, it is displayed with its HART communication address in the "HART devices" (8---) group.

4. **Configure the connected HART devices**
   After connecting all HART devices to the HART multidrop line of the NRF590, these gauges can be configured via the NRF590 Tank Side Monitor display. In the "HART devices"**(8---)** function group, all connected devices are displayed with their respective HART address in brackets (e.g. FMR53x[01]).
   a. **Devices known to the Tank Side Monitor**
      Endress+Hauser devices "known" to the Tank Side Monitor will be represented by their product code, e.g. "FMR53x" for Micropilot S, "NMS" for Proservo, "NMTxxx" for the Prothermo line etc. If more than one device of a specific type is connected, each individual device will be represented in the Tank Side Monitor by a separate function block.

   b. **Devices not known to the Tank Side Monitor**
      Devices not known to the Tank Side Monitor will be presented as "generic HART device". For these, the universal HART commands and variables (such as communication address, TAG, message, PV, SV, etc.) are supported.

5. **Link the gauges to the tank functions**
   a. **Level and temperature functions**
      In the "Basic Configuration"(32--) function group, the connected HART devices are linked to the Tank functions simply by choosing the appropriate references.
      For instance, a Micropilot S FMR53x level gauge will appear as a selectable choice in the "level reference"(3201) function, and by checking the box, the PV of this gauge will be taken by the Tank Side Monitor as the measured level. In the same manner, a connected Prothermo NMT53x average temperature transmitter can be chosen as "temperature reference"(3202) by checking its procuct code in the selection list.

   b. **Other typical Tank Gauging functions**
      For other typical Tank Gauging sensors, the appropriate links are found in either the "Extended Configuration"(33--) or the "Pressure Setup"(34--) function groups.

   c. **General Purpose Functions**
      Devices which offer functionality not provided for in the standard function groups (e.g. pH meters) can be connected to the "General Purpose"(35--) functions. Here, the user can define a function name for the indication on the Tank Side Monitor display. The units of the device will not be processed in the tank function group. Instead, the values are transmitted directly to the output field protocols[3)].

6. **Define the tank calculations and the tank corrections**
   In case any typical tank calculations (as the hydrostatic level measurement or the hybrid tank measurement) or tank corrections (as the "hydrostatic tank shell compensation" or the "correction of the thermal expansion") shall be performed, these functions can be easily set up in the "Calculations"(36--) function group.
   If any level corrections are defined in the calculation functions, then the corrected level is automatially sent to the HOST system via the field protocol. Further Informations can be found in the "Description of Instrument Functions" Manual BA00257F/00/EN.

3) For a list of values which can be transmitted by the individual protocols refer to the chapter "Technical Data".

7. **Define Alarm Functions**
   a. **Alarm type and limits**
      For all input variables, alarm limits can be defined. In the "Alarm"(5---) function group, the alarm type (level, temperature, various) and the alarm behaviour can be selected.
   b. **Alarm behaviour**
      To have the alarm disappear when the value is back in normal state, the "enabled" selection has to be made. To wait for alarm acknowledgement, the "latching" selection is appropriate. In both cases, the alarm limits have to be defined in the following steps. Either one or all values may be defined.
   c. **Extended alarm setup**
      In the extended alarm setup, additional default values (such as damping factor, hysteresis etc.) may be changed.
8. **Define Discrete Inputs and Outputs**
   In the "Discrete I/O"(6---) function group, both, the intrinsically safe (IS) in- and outputs as well as the explosion proof (non-IS) in- and outputs may be configured.
9. **Configure the field protocol**
   For each protocol listed below these parameters should be configured. Additional parameters may in some cases require changes from the default values, a description of these parameters can be found in the "Description of Instrument Function", BA00257F/00/EN and the protocol specific KA document.

   Sakura V1 (see KA00246F/00/EN)
   – **"Type"(9211)**
     defines the primary V1 communication type to be compatible with your control room system.
   – **"Id"(9212)**
     must be set to a unique number on this V1 loop.

   EIA-485 Modbus (KA00245F/00/EN)
   – **"Id"(9211)**
     must be set to a unique number on this Modbus loop.
   – **"Baud Rate"(9212) and "Type"(9213)**
     must be the same as the control room system setting.
   – **Floating Values**
     – **"FP Mode"(9214)**
       must match the control room system floating point type.
     – **"V01 Map. Mode(9223)**
       must be set to **"Float Vals"** if access to software V01 compatible register map is required.
   – **"Word Type"(9221)**
     must be configured to match the control room integer type.
   – **Integer Values**
     – **"Word Type"(9221)**
       must be configured to match the control room integer type.
     – **"V01 Map. Mode"(9223)**
       must be set to **"Integer Vals."** if access to software V01 compatible register map is required.
     – **"0% Value" and "100% Value" (in the "Integer Scaling" menu)**
       must be configured to obtain correct integer values ("Configuring the Modbus Integer Scaling", → 53)

Whessoematic WM550 (KA00247F/00/EN)

– **"Id"**(9211)
  must be set to a unique number on both of the WM550 loops.
– **"Baud Rate"**(9212)
  must match the control room equipment settings.
– **"Software Id"**(9213)
  may need to be changed for some control room systems to enable the required functionality.
– If the second loop has a different baud rate, the **"Loop 2"**(9231) parameter must be set to "Different" and the **"Baud Rate (2)"**(9232) can be configured.

BPM (KA00248F/00/EN)

– **"Id length" (9211) and "Baud Rate"**(9213)
  must be configured to match the control room settings.
– **"Id"**(9212)
  must be set to a unique number on the BPM loop.
– **"TOI"**(9214)**, "Device No [dn]"**(9215) **and "Dev. Type [dt]"**(9216)
  must be configured to achieve the correct Enraf gauge emulation.

Mark/Space (KA00249F/00/EN)

– **"Id"**(9211)
  must be set to a unique number on both of the Mark/Space loops.
– **"Baud Rate"**(9212)**, "Type"**(9213) **an "Data Mode"**(9214)
  must match the control romm equipment settings.

GPE (KA00251F/00/EN)

– **"Id"**(9211)
  must be set to a unique number on both of the Mark/Space loops.
– **"Bad Rate"**(9212)**, "Type"**(9213) **and "Loop Mode"**(9214)
  must match the control room equipment settings.

6.5 Configuring the Modbus Integer Scaling

Note!
This chapter applies only to the Modbus version of the Tank Side Monitor.

In order for the NRF590 to send correct integer values to the control room, the scaling factors must be configured; these are used to convert the floating-point measured/ calculated values into suitable integer values.

6.5.1 Integer Scaling

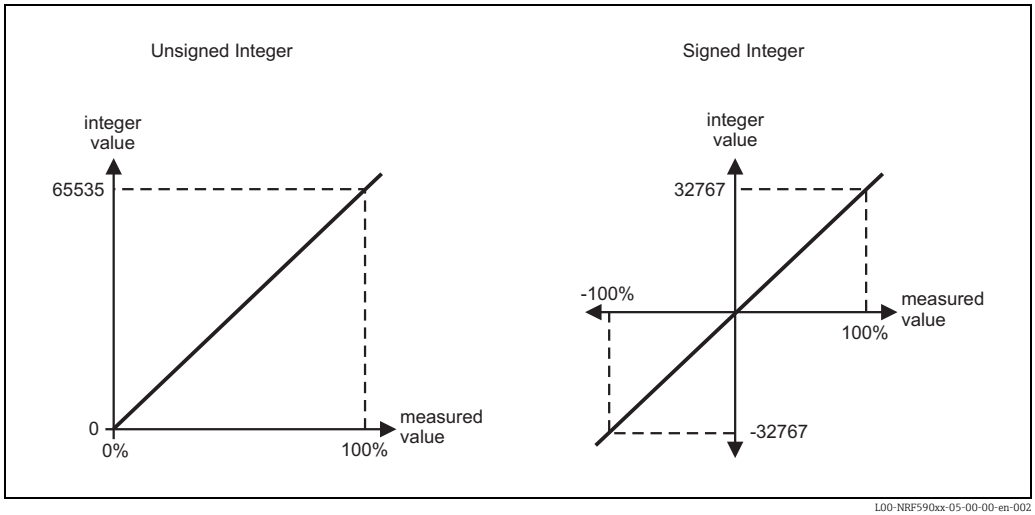
Scaling of a value is handled by a pair of parameters ("0% Value" and "100% Value"). Each type of measured value (Level, Temperature, Density, Pressure, etc.) has its own set of scaling parameters due to the different value ranges each data type uses.
In most cases 0% will have a value 0; here the integer value is simply calculated as follows:

$$\text{Integer} = \frac{\text{“Maximum Integer Value”}}{\text{“100\% Value”}} \text{ Value}$$

In the cases where 0% is not 0, the integer value is calculated as follows:

$$\text{Integer} = \frac{\text{“Maximum Integer Value”}}{\text{(“100\% Value” - “0\% Value”)}} \text{ (Value - “0\% Value”)}$$

Where "Maximum Integer Value" is
- for unsigned integers: 65535
- for signed integers: 32767



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6.5.2 Examples of integer scaling for maximum accuracy

For maximum accuracy of the integer value, simply set the "100% Value" to the maximum possible value you require, this maximum value will then be transmitted to the control room as the integer value 65535 (for unsigned values) and 32767 (for signed values). The control room system must then scale the value back into the original value using the same scaling factors.

Example 1

- Level = 23665 mm
- 0% Value = 0 mm
- 100% Value = 35000 mm (Maximum level value)

→ Unsigned Integer value = (65535 / 35000) × level = 44351

Example 2

- Level = 7.886 ft
- 0% Value = 0 ft
- 100% Value = 32.000 ft (Maximum level value)

→ Signed Integer value = (32767 / 32) × level = +8075

6.5.3 Examples of integer scaling for human readable values

To obtain an integer value which is immediately accessible to the operator it is advisable to scale the measured value by a power of 10 (i.e. 1, 10, 100, 1000, ...).
For example the level "23.45 ft" might be represented by the integer "23450" (factor 1000).

In order to obtain this type of values, the scaling factors must be calculated as follows:
- 0% value = 0
- 100% value =
  - for unsigned integers: 65535 divided by a suitable factor of 10.
  - for signed integers: 32767 divided by a suitable factor of 10.

This yields the following common configuration values, which can be directly used for most applications:

Requirement		100% value for unsigned integers[1)]	100% value for signed integers[1)]
Measured value	**Integer value**		
12.345	12	65535.000	32767.000
	123	6553.500	3276.700
	1235[2)]	655.350	327.670
	12345	65.535	32.767
12' 10'' $3_{/8}$ (12.615 ft)	12615	65' 6'' $3_{/8}$ (65.535 ft)	32' 9'' $2_{/8}$
23' 10'' $7_{/16}$ (23.870 ft)	23870	65' 6'' $7_{/16}$ (65.535 ft)	32' 9'' $3_{/16}$ (32.767 ft)

1) The 0% and 100% values are always specified in the current NRF590 units.

2) This value is a result of rounding of fractional values.

Example 1

- Level = 23655 mm
- 0% value = 0 mm
- 100% value = 65535 mm (according to the table above)

→ Unsigned integer value = 23655

Example 2

- Level = 7.886 ft
- 0% value = 0 ft
- 100% value = 32.767 ft (according to the table above)

→Signed integer value = +7886

Example 3

- Level = 14' 8'' $3_{/16}$ (= 14.682 ft)
- 0% value = 0' 0'' $0_{/16}$
- 100% value = 65' 6'' $7_{/16}$ (according to the table above)

→ Unsigned integer value = 14682

7 Maintenance and repairs

7.1 Exterior cleaning

When cleaning the exterior, always use cleaning agents that do not attack the surface of the housing and the seals.

7.2 Replacing seals

The seals of the sensors must be replaced periodically, particularly if molded seals (aseptic construction) are used. The period between changes depends on the frequency of cleaning and on the temperature of the measured substance and the cleaning temperature.

7.3 Repairs

The Endress+Hauser repair concept assumes that the measuring devices have a modular design and that customers are able to undertake repairs themselves ("Spare parts", → 56). For more information on service and spare parts, contact the Service Department at Endress+Hauser.

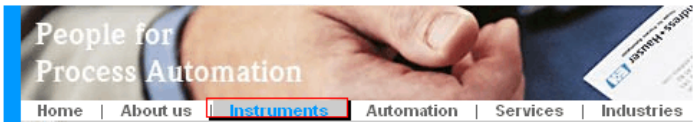
7.4 Repairs to Ex-approved devices

When carrying out repairs to Ex-approved devices, please note the following:
- Repairs to Ex-approved devices may only be carried out by trained personnel or by the Endress+Hauser Service.
- Comply with the prevailing standards, national Ex-area regulations, safety instructions (XA) and certificates.
- Only use original spare parts from Endress+Hauser.
- When ordering a spare part, please note the device designation on the nameplate. Only replace parts with identical parts.
- Carry out repairs according to the instructions. On completion of repairs, carry our the specified routine test on the device.
- Only Endress+Hauser Service may convert a certified device into a different certified variant.
- Document all repair work and conversions.

7.5 Spare parts

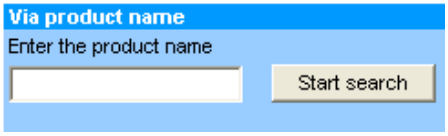
An overview of the spare parts for your device is available in the internet at www.endress.com.
To obtain information on the spare parts, proceed as follows:

1. Go to "www.endress.com" and select your country.
2. Click "Instruments".

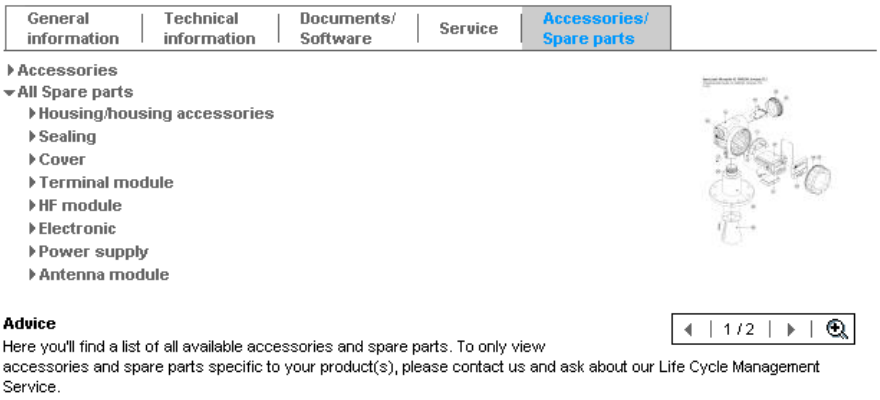


3. Enter the product name into the "product name" field.

Endress+Hauser product search



4. Select the device.
5. Click the "Accessories/Spare parts" tab.



6. Select the required spare parts (You may also use the overview drawing on the right side of the screen.)

When ordering spare parts, always quote the serial number indicated on the nameplate. As far as necessary, the spare parts also include replacement instructions.

7.6 Return

The following procedures must be carried out before a transmitter is sent to Endress+Hauser e.g. for repair or calibration:

- Remove all residue which may be present. Pay special attention to the gasket grooves and crevices where fluid may be present. This is especially important if the fluid is dangerous to health, e.g. corrosive, poisonous, carcinogenic, radioactive, etc.
- Always enclose a duly completed "Declaration of contamination" form (a copy of the “Declaration of contamination” is included at the end of this operating manual).
  Only then can Endress +Hauser transport, examine and repair a returned device.
- Enclose special handling instructions if necessary, for example a safety data sheet as per EN 91/155/EEC.

Additionally specify:

- An exact description of the application.
- The chemical and physical characteristics of the product.
- A short description of the error that occurred (specify error code if possible)
- Operating time of the device.

7.7 Disposal

In case of disposal please seperate the different components according to their material consistence.

7.8 Software history

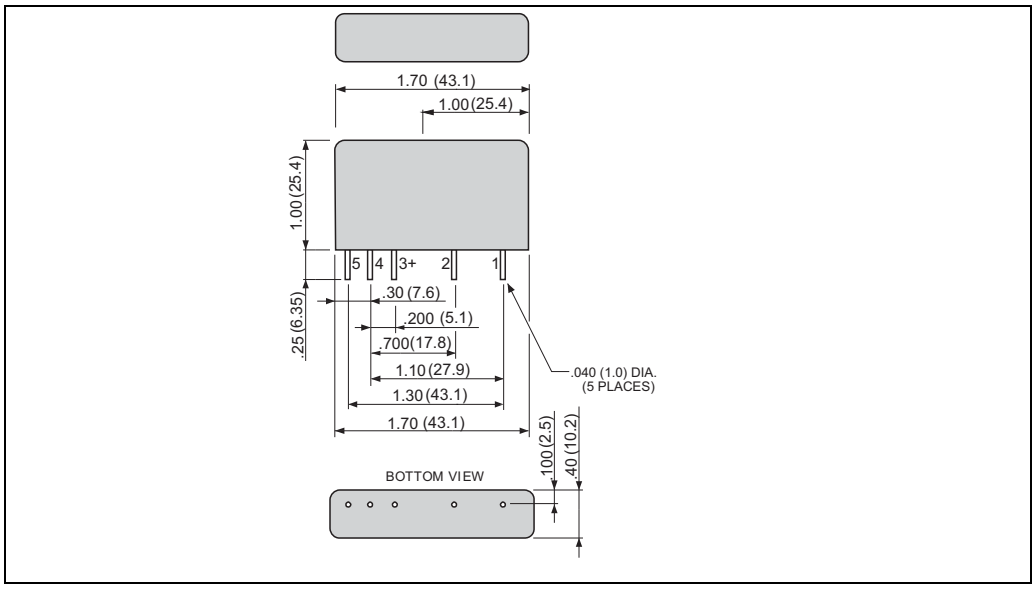
Software version[1)]	Changes to software	Associated documentation
V 01.00 V 01.01 V 01.02		– BA039G (Operating Instructions) – BA042G (Description of Instrument Functions
V 01.03	can be operated via ToF Tool V3.0/3.1	– BA256F/00/ae/02.02 (Operating Instructions) – BA257F/00/ae/02.02 (Description of Instrument Functions)
V 01.04	can be operated via ToF Tool V3.0/3.1 (additional Device Descriptions required)	– BA256F/00/en/09.02 (Operating Instructions) – BA257F/00/en/09.02 (Description of Instrument Functions)
V 01.04.06	GPE and V1 protocol introduced; can be operated via ToF Tool V 3.0/3.1 (additional Device Descriptions available)	– BA256F/00/en/02.03 (Operating Instructions) – BA257F/00/en/03.03 (Description of Instrument Functions)
V 02.01.zz	Operating concept completely revised; Enraf protocol introduced;	– BA256F/00/en/12.04 (Operating Instructions)
V 02.02.zz	Priorisation of level update rate	– BA256F/00/en/06.05 (Operating Instructions – BA257F/00/en/06.05 (Description of Instrument Functions)
V 02.03.zz	▪ user calibration of AO, AO#2, AI, IS AI and IS RTD ▪ Status system with error codes ▪ value entering in ft-in-16 and ft-in-8	– BA256F/00/en/07.06 (Operating Instructions – BA257F/00/en/07.06 (Description of Instrument Functions)
V02.04.zz	▪ Integration of Proservo NMS5 ▪ Support of remote configuration via MODBUS and V1 ▪ Enhancement of functionality of the optical keys	– BA256F/00/en/10.08 (Operating Instructions) – BA257F/00/en/10.08 (Decription of Instrument Functions) – BA00256F/00/EN/13.10 (Operating Instructions) – BA00256F/00/EN/15.15 (Operating Instructions)

1) The software version of the device is displayed immediately after switch-on of the supply voltage.

8 Accessories

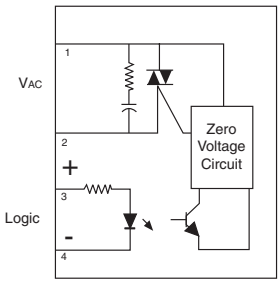
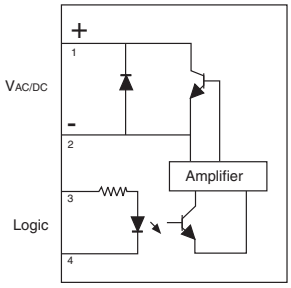
8.1 Discrete I/O modules

8.1.1 Standard mechanical diagram for all I/O modules



L00-NRF590-00-00-08-en-001

8.1.2 Output modules

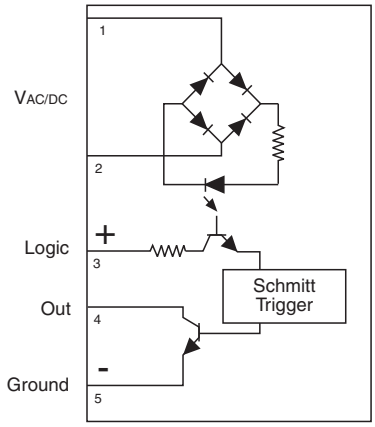
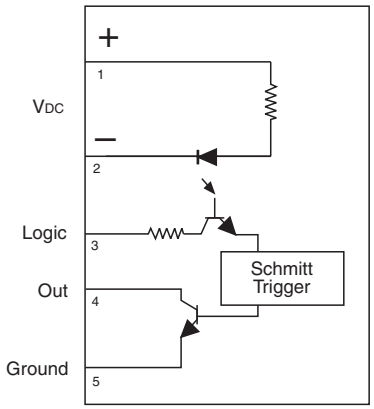
	AC voltage		DC voltage	
				
NRF590 order code[1)] module A	NRF590 - ****J******	NRF590 - ****G******	NRF590 - ****H******	NRF590 - ****K******
NRF590 order code[1] module B	NRF590 - *****J*****	NRF590 - *****G*****	NRF590 - *****H*****	NRF590 - *****K*****
Order Code[2)]	52012959	52012960	52012961	52012962
Colour of housing	black	black	red	red
Load voltage	24 to 140 V AC	24 to 250 V AC	3 to 60 V DC	4 to 200 V DC
Load current	30 to 500 mA eff.[3)]		20 to 500 mA eff.[1]	
Typ. power dissipation	1 W/A		1 to 1.5 W/A	
Transient protection	Meets IEEE472		Meets IEEE472	
Type of contact	SPST normally open Zero crossing turn-on		SPST normally open	
Optical isolation	yes		yes	
Isolation voltage	4000 V eff.		4000 V eff.	
Approvals	UL, CSA, CE, TÜV		UL, CSA, CE, TÜV	

1) This order code is valid if the module is preinstalled in the Tank Side Monitor as module A or module B

2) This order code is valid if the module is ordered as an accessory.

3) This upper limit of the load current is determined by the Tank Side Monitor.

8.1.3 Input modules

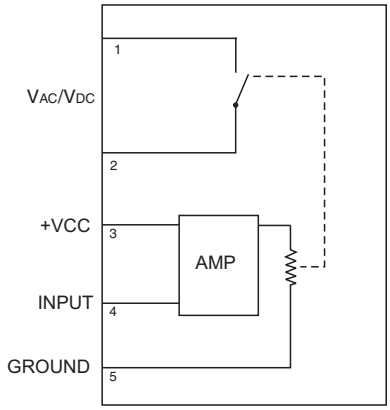
	AC voltage		DC voltage	
				
NRF590 order code[1)] module A	NRF590 - ****B******	NRF590 - ****D******	NRF590 - ****C******	NRF590 - ****E******
NRF590 order code[1] module B	NRF590 - *****B*****	NRF590 - *****D*****	NRF590 - *****C*****	NRF590 - *****E*****
Order code[2)]	52012955	52012956	52012957	52012958
Colour of housing	yellow	yellow	white	white
Input voltage	90 to 140 V AC	180 to 264 V AC[3)]	3 to 32 V DC	35 to 60 V DC
Nominal input resistance	22 kΩ	60 kΩ	22 kΩ	60 kΩ
Max. pick-up voltage	90 V AC	180 V AC	3 V DC	35 V DC
Min. drop-out voltage	25 V AC	50 VAC	1 V DC	9 V DC
Input current @ max. voltage	8 mA rms		8 mA rms	
Typ. power dissipation	1 to 1.5 W/A		1 to 1.5 W/A	
Transient protection	Meets IEEE472		Meets IEEE472	
Optical isolation	yes		yes	
Isolation voltage	4000 V rms		4000 V rms	
Approvals	UL, CSA, CE, TÜV		UL, CSA, CE, TÜV	

1) This order code is valid if the module is preinstalled in the Tank Side Monitor as module A or module B.

2) This order code is valid if the module is ordered as an accessory.

3) This upper limit of the input voltage is determined by the Tank Side Monitor.

8.1.4 Relay output module

	
NRF590 order code[1)] module A	NRF590 - ****R******
NRF590 order code[1] module B	NRF590 - *****R*****
Order code[2)]	52026945
Colour of housing	red
Load voltage	0 to 100 VDC / 0 to 120 VAC
Load current	0 to 500 mA[3)]
Max. contact resistance	250 mΩ
Max. turn on/off time[4)]	1 ms
Min. life expectancy	500000 cycles
Type of contact	SPST normally open; mechanical relay
Isolation voltage	1500 V_{eff}
Approvals	UL, CSA, CE, TÜV

1) This order code is valid if the module is preinstalled in the Tank Side Monitor as module A or module B.

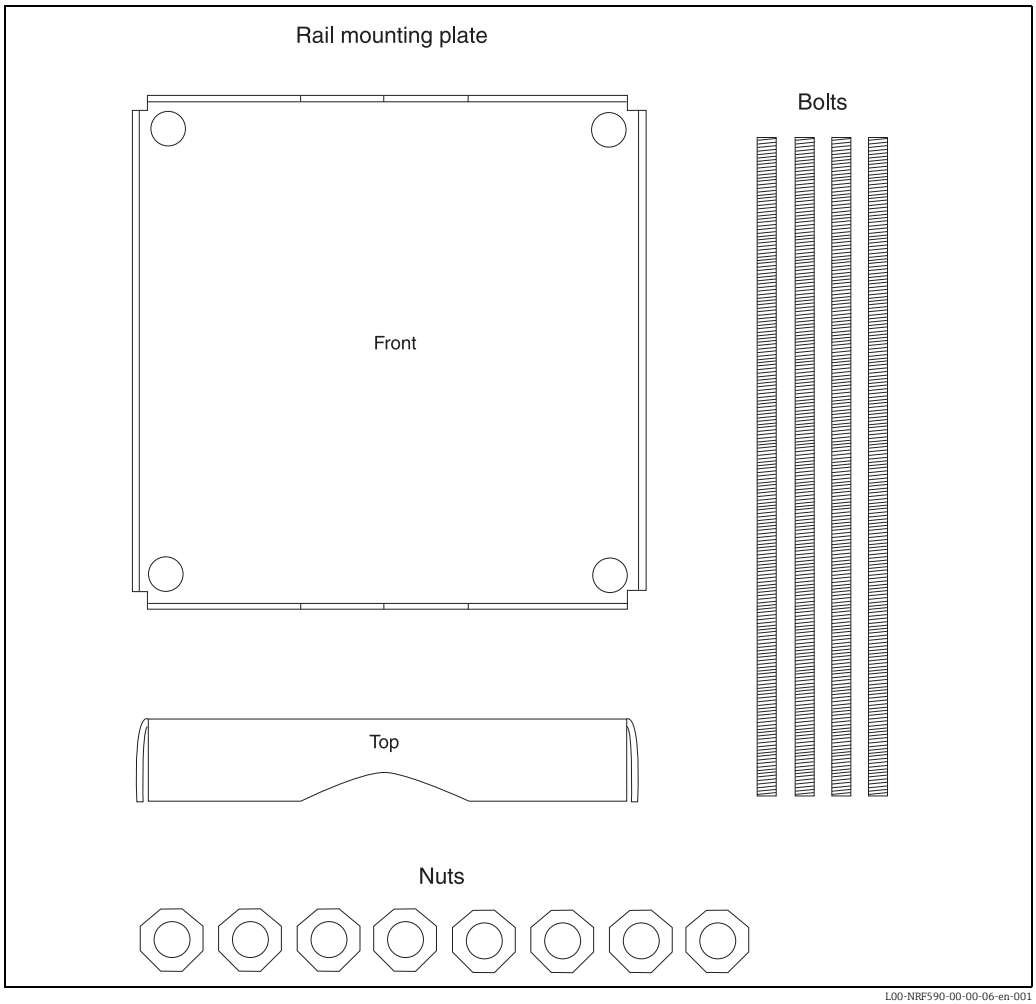
2) This order code is valid if the module is ordered as an accessory.

3) For inductive loads, use diode suppression or RC network to improve contact life.

4) including debounce

8.2 Rail mounting kit

For rail mounting the Tank Side Monitor to vertical or horizontal pipe.
Order-Number: 52013134



9 Trouble Shooting

9.1 System error messages

Code	Display text	Description	Action
F101	Open Circuit	The input signal to the analogue input circuit is no longer detected, probably due to a broken or disconnected cable	Check installation and cabling.
F102	Overloaded Input	The input signal to the analogue input circuit is > 28 mA	Check installation and cabling.
F103	Device Offline	Indicates the connected HART device is no longer responding to communication	Check device. Check cabling.
M104	Check Device	The connected HART device is indicating through its diagnostic value that a problem exists (not available for Generic HART devices).	Check device diagnostic code and rectify device problem (see the documentation for the specific HART device for details).
S105	IS HART Overload	Indicates the Ex i HART Bus voltage is below 14 V, therefore HART device operation may be abnormal.	Caused due to overloading the HART Bus, check no device has address 0 (active 4...20 mA output) and/or reduce the number of connected devices (see Technical specifications for limits).
F106	IS HART Short	Indicates a short circuit has been detected (voltage below 2 V) on the Ex i HART Bus.	Check installation and cabling.
F107	IS FMR Short	Indicates a short circuit has been detected (voltage below 2 V) on the Ex i Power Circuit for the FMR53x Radar device.	Check installation and cabling.
F108	IS Ext Short	Indicates a short circuit has been detected (voltage below 2 V) on the Ex i External Power output used for IS AI, IS DI#1 and IS DI#2.	Check installation and cabling.
C281	Initialization	Hardware Initialization (e.g. after Power On)	None, for historical information only
F301	Flash Contents	System initialisation error indicating the data stored on the board's Flash Memory chip is corrupt.	Device requires re-flashing or returning to supplier for repair.
F302	No Order Code	System initialisation error indicating the factory order code has not been found.	System must be returned to supplier.
F303	App Failure	System initialsation error indicating the Application Microcontroller is indicating a failure during initialisation	If spare parts have been fitted, make sure both boards are from the same set (do not mix old/ new boards) If device has been re-flashed, try again. Otherwiese the system must be returned to the supplier.
F304	Com Failure	System initialisation error indicating the Communication Microcontroller is indicating a failure during initialsation.	If device has been re-flashed, try again. Otherwiese the system must be returned to the supplier.

Code	Display text	Description	Action
F305	App Error	System initialisation error indicating the Application Microcontroller is not communicating with the Main Microcontroller in the system.	If spare parts have been fitted, make sure both boards are from the same set (do not mix old/ new boards). If device has been re-flashed, try again. Otherwise the system must be returned to the supplier.
F306	Comm Error	System initialisation error indicating the Communication Microcontroller is not communicating with the Main Microcontroller in the system.	If device has been re-flashed, try again. Otherwise the system must be returned to the supplier.
F307	DD Failure	System initialisation error indicating what a problem occurred when loading one of the device DDs from the Flash Memory.	If device has been re-flashed, try again. Otherwise the sytem must be returned to the supplier.
C312	Initialization	Hardware initialisation (e.g. after Internal System Reset)	None, for historical information only.
C401	Factory RESET	Indicates the system (or the group) has been reset back to factory settings by the user.	None, for historical information only.
C402	Initialization	Configuration Initialisation (e.g. after Soft Reset from Menu)	None, for historical information only.
S432	Calibration	The user and/or factory calibration of this function has failed, and circuit is currently operating without any calibration.	Re-calibrate using User calibration or Return to supplier for repair.
S434	Scaling	The 0% and/or 100% scaling values for the function are invalid, as a result the function cannot operate properly.	Check configuration.
C482	Simulated Output	The output function is currently operating in simulation mode, therefore the output value no longer relates to the process values.	Exit simulation mode.
C483	Simulated Input	The input function is currently operrating in simulation mode, therefore the input value no longer relates to the connected process value.	Exit simulation mode.
F501	Value Ref	The value reference used as the input value for this function is no longer valid, therefore the output value is no longer related to the process.	Check configuration.
F502	Device 0 found	Indicates that this device has polling address 0. By definition of the HART standard that also means the device has an active 4...20 mA output signal, as this load can vary such a device can overload the HART bus and is therefore not allowed by the NRF590 system.	Change the device HART address or remove device from system.
F503	Level Ref	The level Reference value is no longer valid (e.g. the value it was linked to is no longer available in the system).	Check configuration.

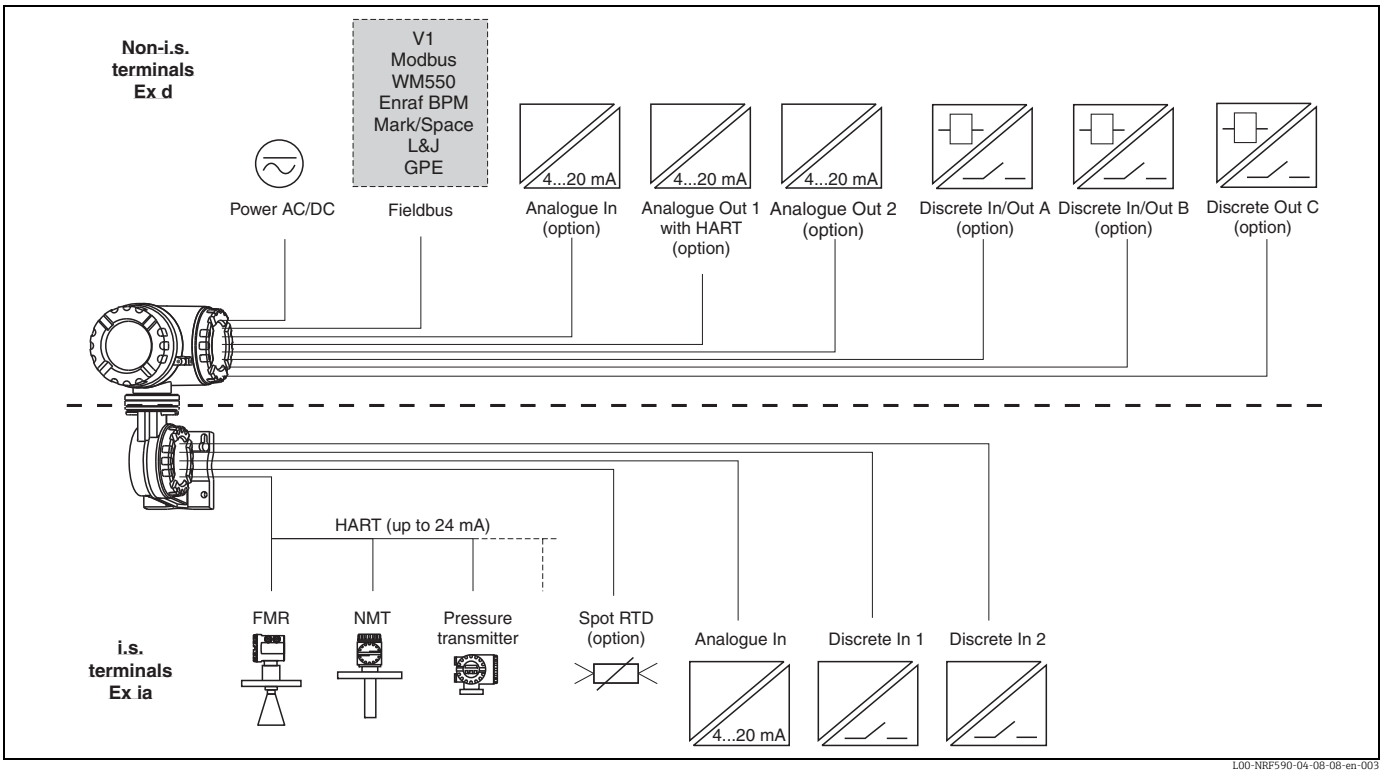
Code	Display text	Description	Action
F504	Water Level Ref	The Water Level Reference value is no longer valid (e.g. the value it was linked to is no longer available in the system).	Check configuration.
F505	Temp. Ref	The Temperature Reference value is no longer valid (e.g. the value it was linked to is no longer available in the system).	Check configuration.
F506	Vapor Temp. Ref	The Vapor Temperature Reference value is no longer valid (e.g. the value it was linked to is no longer available in the system).	Check configuration.
F507	Air Temp. Ref	The Air Temperature Reference value is no longer valid (e.g. the value it ws linked to is no longer available in the system).	Check configuration.
F508	P1 Ref	The P1 (Bottom) Pressure Reference value is no longer valid (e.g. the value it was linked to is no longer available in the system).	Check configuration.
F509	P2 Ref	The P2 (Middle) Pressure Reference value is no longer valid (e.g. the value it was linked to is no longer available in the system).	Check configuration.
F510	P3 Ref	The P3 (Top) Pressure Reference value is no longer valid (e.g. the value it was linked to is no longer available in the system).	Check configuration.
C511	CS Restored	The user performed a Customer Settings restore operation on the whole system or on this group.	None, for historical information only.
C512	Device Removed	The indicated HART device was removed from the system by the user.	None, for historical information only.
C513	Restart	The software restart operation was selected by the user.	None, for historical information only.
F514	CS Saved	Indicates the user has saved the current configuration of the system as the "Customer Settings".	None, for historical information only.
C515	User Access	The user access code 100 was entered.	None, for historical information only.
C516	Service Access	The service engineer access code was entered.	None, for historical information only.
C517	Diag. Access	The Endress+Hauser diagnostic code was entered.	None, for historical information only.
C518	Unknown Access	An invalid access code was entered.	None, for historical information only.
C519	Access Locked	Indicates the access code was locked, either by changing it to 0 manually or by using the three button method.	None, for historical information only.
C520	Access Timeout	Indicates the access code was removed by the system as the menu had not been used for the timeout period.	None, for historical information only.
S901	Level Held	The tank level value is being held at an old value and no longer being updated (e.g. during Dip Freeze).	This may be normal operation (e.g. during Dip Freeze), otherwise check configuration.

Code	Display text	Description	Action
S902	Temp. Held	The tank temperature value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
S903	Vap. Temp. Held	The tank vapor temperature value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
S904	Air Temp. Held	The tank air temperature value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
S905	Water Level Held	The Tank water level value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
S906	P1 Held	The tank P1 (bottom) pressure value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
S907	P2 Held	The tank P2 (middle) pressure value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
S908	P3 Held	The tank P3 (top) pressure value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
S909	Obs. Density Held	The tank observed density value is being held at an old value and no longer being updated (e.g. during HTG mode when level is below pressure sensors).	This may be normal operation (e.g. when in HTG mode and the level is below the pressure sensors), otherwise check configuration.
S910	Flow Held	The tank flow rate value is being held at an old value and no longer being updated.	This may be normal operation, otherwise check configuration.
F911	Level Fault	The tank level value has failed.	Check configuration, manual values, reference.
F912	Temp. Fault	The tank temperature value has failed.	Check configuration, manual values, reference.
F913	Vap. Temp. Fault	The tank vapor temperature value has failed.	Check configuration, manual values, reference.
F914	Air Temp. Fault	The tank air temperature value has failed.	Check configuration, manual values, reference.
F915	Water Level Fault	The tank water level value has failed.	Check configuration, manual values, reference.
F916	P1 Fault	The tank P1 (bottom) pressure value has failed.	Check configuration, manual values, reference.
F917	P2 Fault	The tank P2 (middle) pressure value has failed.	Check configuration, manual values, reference.
F918	P3 Fault	The tank P3 (top) pressure value has failed.	Check configuration, manual values, reference.
F919	Obs. Density Fault	The tank observed density value has failed.	Check configuration, manual values, reference.
F920	Flow Fault	The tank flow rate value has failed.	Check configuration, manual values, reference.

10 Technical Data

10.1 Technical Data at a Glance

10.1.1 Inputs and Outputs



Values transmitted by the Field Protocols

The following values can be transmitted by the communication protocols:

Tank Value	Symbol	V1 - old	V1 - new	Modbus	WM550	BPM	Mark/ Space	L&J Tankway Basic	L&J Tankway Servo	GPE
Level	L	yes	yes	yes	yes	yes	yes	yes	yes	yes
Temperature (Product)	T_P	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observed Density	D_{obs}	-	yes	yes	yes	yes	-	-	yes	-
Water Level	L_W	-	yes	yes	yes	yes	-	-	yes	-
Pressure 1 (Bottom)	P_1	-	yes	yes	yes[1)]	yes	-	-	-	-
Pressure 2 (Middle)	P_2	-	yes	yes	yes[1)]	-	-	-	-	-
Pressure 3 (Top)	P_3	-	yes	yes	yes	yes	-	-	-	-
Measured Level	L_M	-	-	yes	yes[1)]	-	-	-	-	-
Level Correction	L_C	-	-	yes	-	-	-	-	-	-
Percentage Level	$L_{\%}$	-	-	yes	yes	-	-	-	-	-
Vapour Temperature	T_V	-	yes	yes	yes[1)]	yes	-	-	-	-
Air Temperature	T_A	-	-	yes	yes[1)]	yes	-	-	-	-
General Purpose Value 1	GP_1	-	yes[2)]	yes	-	-	-	-	-	-
General Purpose Value 2	GP_2	-	yes[3)]	yes	-	-	-	-	-	-
General Purpose Value 3	GP_3	-	-	yes	-	-	-	-	-	-
General Purpose Value 4	GP_4	-	-	yes	-	-	-	-	-	-
Multi-Element Temperatures	$T_{(1)}$ to $T_{(16)}$	-	yes	yes	$T_{(1)}$ to $T_{(15)}$	-	-	-	-	-
Alarm/Discrete Values		yes[4)]	yes[4)]	yes	yes	yes[5)]	yes[6)]	yes[7)]	yes[7)]	-
Discrete Output Control		-	-	yes	-	-	-	-	-	1
Additional		-	4-20mA[8)]	yes	Level %	-	-	Temp[9)]	-	4-20mA[8)]
Protocol Documentation		KA00246F	KA00246F	KA00245F	KA00247F	KA00248F	KA00249F	KA00250F	KA00250F	KA00251F

1) Only accessible through WM550 extended tasks (51&52); not available on older control room systems.

2) In new V1 - HART Device 1

3) In new V1 - HART Device 2

4) The protocol allows 2 alarm and 4 general purpose flags which can be connected to any alarm or discrete input.

5) Level L & H alarm, 4 alarms and 2 general purpose flags which can be connected to any alarm or discrete input.

6) The protocol allows 2 digital alarm values which can be connected to any alarm or discrete input.

7) The protocol allows 2 digital values which can be connected to any alarm or discrete input.

8) One additional value "4-20mA" which can be connected to any value, however range of value sent is limited (see KA00246F/00/EN).

9) One additional value "Temp2" which can be connected to any value, however the range of value sent is limited (see KA00250F/00/EN).

Non IS inputs and outputs

		V1	Modbus	WM550	BPM	Mark/ Space	L&J Tankway	GPE
Analogue In	AI	-	option[1)]	-	standard	standard	standard	-
Analogue Out 1	AO	standard +HART	option[1)] +HART	standard +HART	standard +HART	standard +HART	standard +HART	standard +HART
Analogue Out 2	AO#2	standard	-	standard	-	-	-	standard
Discrete In/Out A	DI#A DO#A	option, s. pos. 50 of the product structure						
Discrete In/Out B	DI#B DO#B	option, s. pos. 60 of the product structure						
Discrete Out C	DO#C	standard	-	-	-	-	-	-

1) see pos. 20 option 4 of the product structure; Modbus without in- or output does **not** provide an Ex d HART bus!

Technical data of the non-IS inputs and outputs

Analogue 4 to 20 mA input (option, s. pos. 20 of the product structure)

Internal load (to ground)	110 Ω
Measuring range	0 ... 26 mA
Accuracy	±15 µA (after linearisation and calibration)

Analogue 4 to 20 mA outputs

Output current	3 to 24 mA
Output voltage	U = 24 V - I_{LOAD} 400 Ω
Output load	max. 500 Ω
Accuracy	±15 µA (after linearisation and calibration)
HART options[1)]	▪ Slave, address # 0: 4 to 20 mA active ▪ Slave, address #1 - #15: fixed current (user selectable) ▪ Master: max. current (≤ 24 mA) selectable by user; typically 6 HART devices (each 4 mA) can be connected[2)]

1) The second analogue output (available for V1, WM550 and GPE) has no HART option.

2) Start-up current of the HART devices has to be taken into account

Discrete inputs/outputs A and B

The Tank Side Monitor can be equipped with 1 or 2 discrete I/O modules.
Available types: see position 50 and 60 of Product Structure or chapter "Accessories".

Discrete output C (for V1 protocol)

Load voltage	3 to 100 V
Load current	max. 500 mA
Type of contact	mechanical latching relay
Isolation voltage	1500 V
Approvals	UL, CSA

IS inputs and outputs

		V1	Modbus	WM550	BPM	Mark/ Space	L&J Tankway	GPE
HART		standard	standard	standard	standard	standard	standard	standard
IS RTD		option, s. pos. 40 of the product structure						
IS Discrete In 1	IS DI#1	standard	standard	standard	standard	standard	standard	standard
IS Discrete In 2	IS DI#2	standard	standard	standard	standard	standard	standard	standard
IS Analogue In	IS AI	standard	standard	standard	standard	standard	standard	standard

Technical Data of the IS inputs and outputs

HART input loop

Source voltage	U = 25 V - I_{Load} x 333 Ω (typically)
total I_{max}	Start-up currents of all connected HART devices may not exceed a total of 27 mA
connectable sensors	depending on current consumption (including start-up current)

Spot RTD input (option, s. pos. 40 of the product structure)

Measuring range	10 to 600 Ω
Excitation current	typ. 400 µA, max. 2000 µA

Accuracy	3-wire-type: ±2.0 °C (± 4 °F)
	4-wire-type: ±0.15 °C (≈ ± 0.2 °F)

Accuracy Prothermo averaging temperature probe

Type of Sensor	Nominal value	$Temp_{min}$	$Temp_{max}$	Accuracy[1)]
Pt100 (385) IEC751 Pt100 (389) Pt100 (392) IPTS-68	100 Ω at 0 °C (≈ 32 °F)	-200 °C (≈ -330 °F)	+600 °C (≈ +1110 °F)	±0.1 °C (≈ ± 0.2 °F)
Cu90 (4274)	100 Ω at 25 °C (≈ 77 °F) [90 Ω at 0 °C (≈ 32 °F)]	-100 °C (≈ -150 °F)	+250 °C (≈ +480 °F)	±0.1 °C (≈ ± 0.2 °F)
Ni120 (672)	120 Ω at 0 °C (≈ 32 °F)	-60 °C (≈ -75 °F)	+180 °C (≈ +350 °F)	±0.1 °C (≈ ± 0.2 °F)
Ni100 (618) DIN 43760	100 Ω at 0 °C (≈ 32 °F)	-60 °C (≈ -75 °F)	+180 °C (≈ +350 °F)	±0.1 °C (≈ ± 0.2 °F)

1) Accuracy of converter, may be influenced by element accuracy

IS Analogue 4 to 20 mA input (option, s. pos. 70 of the product structure)

Source voltage	U = 25 V - I_{Load} x 333 Ω (typically)
Internal load (to ground)	100 Ω
Measuring range	0 to 26 mA
Accuracy	±15 µA (after linearisation and calibration)
Usage	▪ Source for Discrete Inputs ▪ Source for 4 to 20 mA loop device

Discrete inputs (option, s. pos. 70 of the product structure)

Active voltage ("closed circuit")	min. 9 V (default)
In-active voltage ("open circuit")	max. 7 V (default)
Active high current	4 mA
Switching hysteresis	2 V

10.1.2 Auxiliary energy

AC supply

55 to 264 V AC; insensitive to polarity / CSA approved: 55 to 250 V AC

DC supply

18 to 55 V AC/DC

Inrush current

30 A, duration 0.6 ms

Power consumption

- 370 mA at 24 V DC
- 200 mA at 48 V DC
- 75 mA at 125V AC
- 45 mA at 220 V AC

Fuse

Internal (on primary power)

10.1.3 Performance characteristics

Accuracy

HART sensors

Accuracy of all data from connected HART sensors depends on the type and installation of devices. The use of the digital HART protocol prevents accuracy data degradation, as would be the case with analogue (4 to 20 mA) sensors.

Spot RTD input, analogue inputs, analogue outputs

See "Technical data of the IS inputs and outputs".

Resolution

Resolution of all measured data depends on sensor and communication settings. The following settings are recommended for inventory and custody transfer applications:

Data type	Units	Inventory control	Custody transfer
Level	millimeters	1 mm	1 or 0.1 mm
	meters	10 mm	1 or 0.1 mm
	feet	0.01 ft	0.01 ft
	inches	1" or 0.1"	0.01" or 0.001"
	ft-in-16	1/16"	1/16"
Temperature	°C	0.1 °C	0.1 °C
	°F	0.1 °F	0.1 °F

For purpose of consistency all internal calculations are performed in SI units.

Scan time

HART sensors

The data of connected HART sensors is constantly scanned and updated in the internal data base. The scanning sequence is based on the priorities of the measurements (level - prio 1, temperature - prio 2, pressure - prio 3,...). Typically, a value change on the HART multidrop loop is displayed after a 2 seconds delay (for priority 1 values).

Spot RTD input

RTD resistance is measured and recalculated at least every second.

10.1.4 Ambient conditions

Ambient temperature

-40 °C to +60 °C (-40 °F to +140 °F)

Storage temperature

-55 °C to +85 °C (-67 °F to +185 °F)

Ingress protection

IP65, Nema 4X

Electromagnetic compatibility (EMC)

- Interference emission to EN 61326, Equipment class A
- Interference immunity to EN 61326

Use shielded signal lines for installation.

Overvoltage protection

Both interfaces of the NRF590 - the Ex ia and the Ex d side - are protected by internal 600 Vrms surge arresters which have been tested against 10 kA transient discharges.

10.1.5 Mechanical construction

Design, dimensions

"Installation", → 12.

Material

- Remote field housing: powder coated die-cast aluminium
- Wall-mount housing: powder coated die-cast aluminium
- Window material: glass

Construction

The NRF590 housing has three separate compartments, one containing all electronics and two for electrical connections. The enclosure is die-cast aluminum with an polyester coating and IP65 (NEMA 4) rating. The upper terminal compartment and electronics compartment are designated for non-i.s. connections and electronics and are rated EEx d.The lower terminal compartment is designated for i.s. wiring connections and wiring only.

Weight

approx. 8 kg (17.64 lbs)

Cable entries

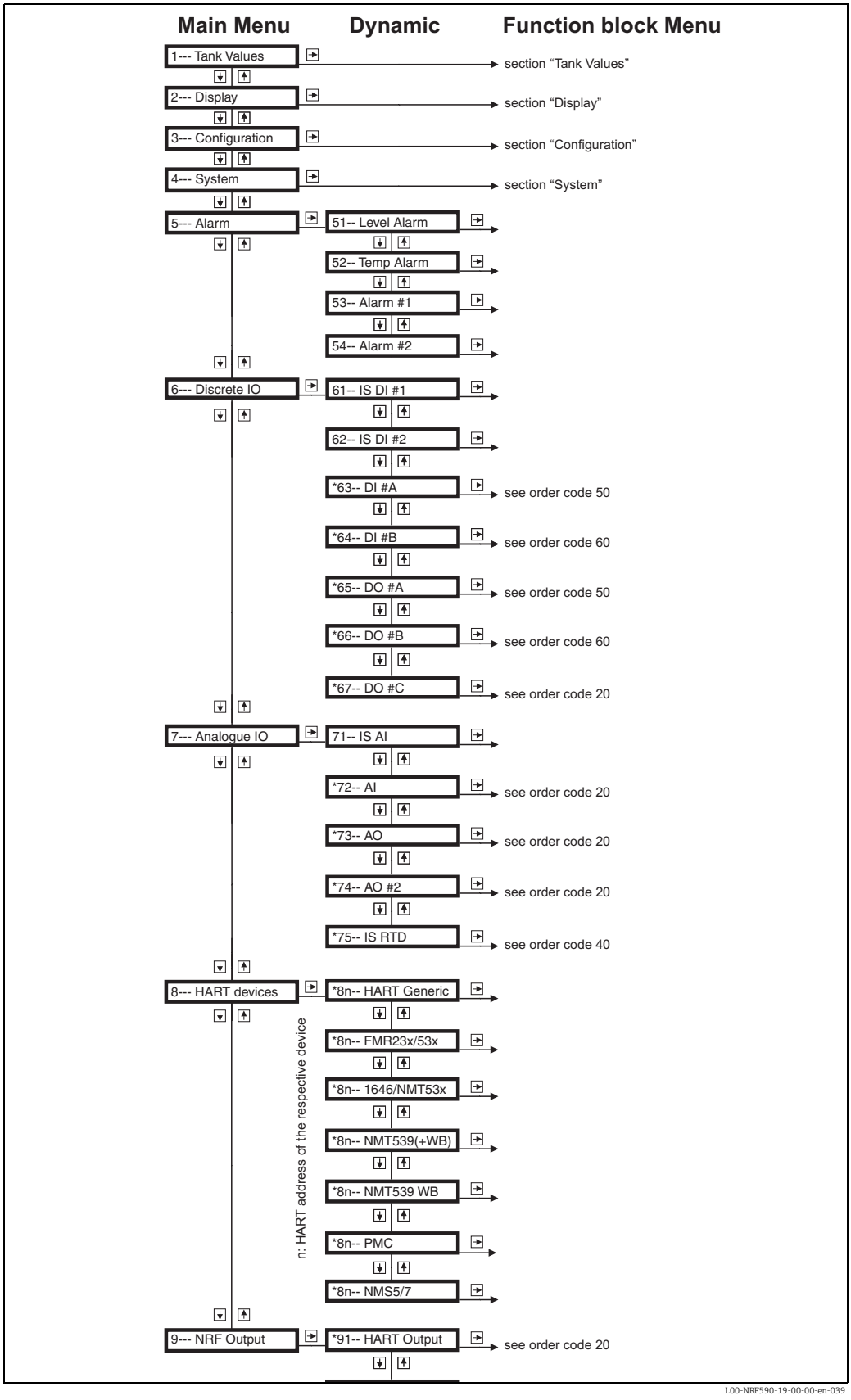
The non-i.s. terminal compartment has 3 cable entries. The threading in this terminal compartment enclosure is M20x1.5. All intrinsically designated wiring has to be terminated in the i.s. terminal compartment. For the i.s. wiring, two M25x1.5 cable entries are available. The internal diameter of the cable entry is 16 mm. For accommodating various types of cable glands or cable conduit (rigid or flexible), the following sizes of cable gland adapters are optionally available:

- M20x1.5
- G½
- ½" NPT
- ¾" NPT (max. 2 cable entries)

All adapters are rated EEx d and can be used for either cable connection. When installing, properly seal all ports to prevent moisture or other contamination from entering the wiring compartments.

11 Operating Menu

11.1 Overview



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12 Appendix

12.1 Function and system design

12.1.1 Application

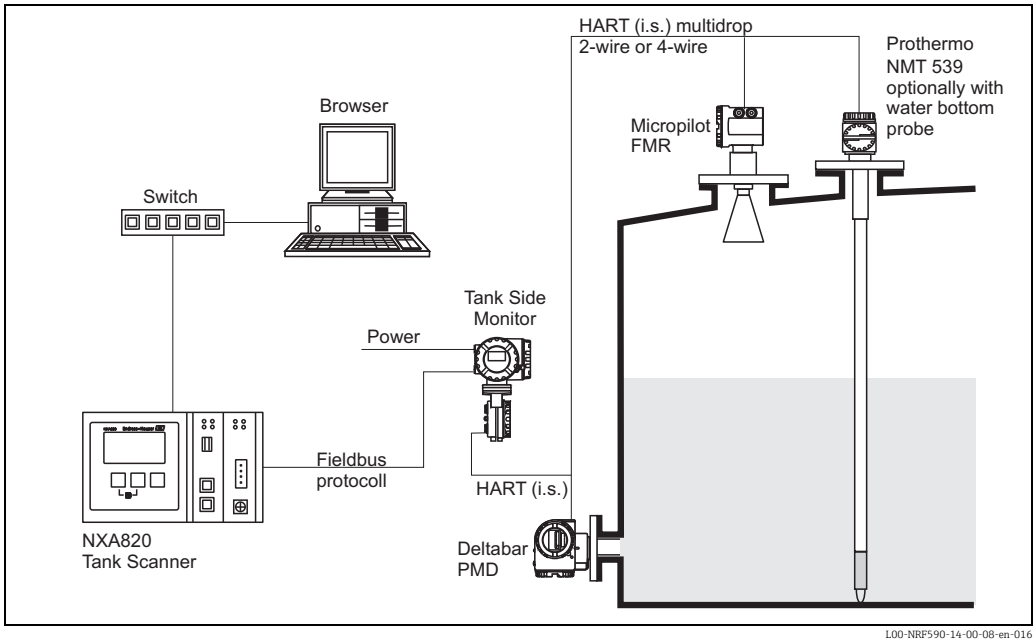
The Tank Side Monitor NRF590 is a field device for the integration of tank sensors into tank inventory systems. It is used in tank farms, terminals and refineries.
Especially, it can be used in connection with Micropilot M level radars (for inventory control) and Micropilot S high accuracy level radars (for custody transfer applications).

12.1.2 Operating principle

The Tank Side Monitor is typically installed at the bottom of the tank and allows to access all connected tank sensors. Typical process values measured by the sensors are:
- level
- temperature (point and/or average)
- water level (measured by capacitive probe)
- hydrostatic pressure (for hydrostatic tank gauging, "HTG", or hybrid tank measurements, "HTMS")
- secondary level value (for critical applications)

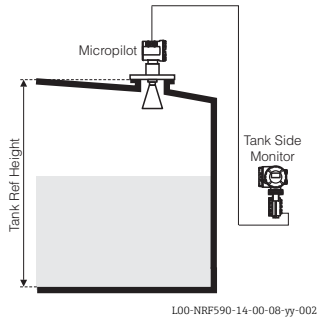
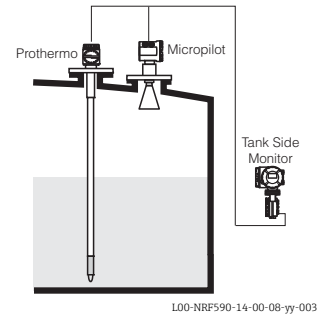
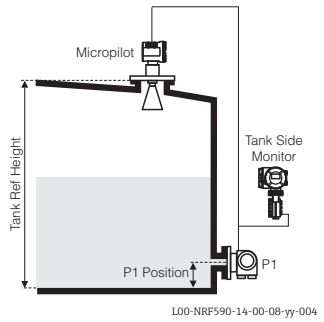
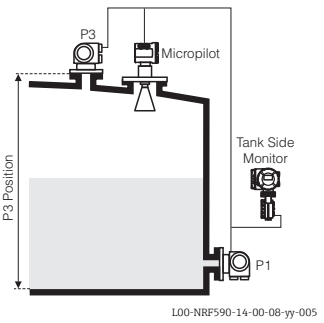
The Tank Side Monitor collects the measured values and performs several configurable tank calculations. All measured and calculated values can be displayed at the on-site display. Via a field communication protocol, the Tank Side Monitor can transfer the values to an inventory control system.

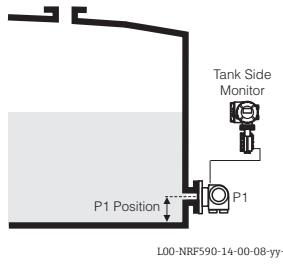
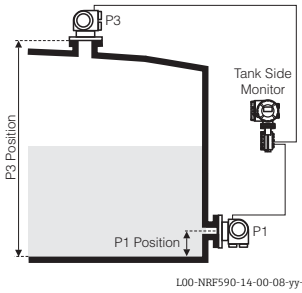
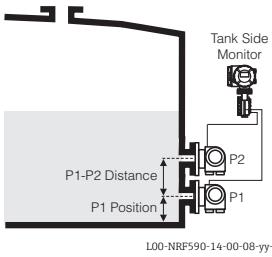
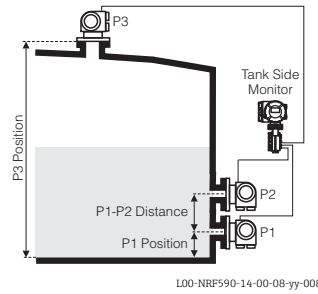
12.1.3 System Integration (typical example)



12.2 Tank calculations

Depending on the connected sensors the Tank Side Monitor can perform different tank calculations in order to determine the tank content. The type of tank calculation is selected during the configuration with the setup wizard in the parameter "setup preset". The possible settings are summarised in the following table:

Setup preset	Installation example	Sensors	measured/ calculated values	required parameters
Direct level measurement				
Level only		▪ Level sensor	▪ level	▪ Tank Ref Height
Level + Temperature		▪ Level sensor ▪ Temperature sensor (RTD or HART device; optionally with bottm water probe)	▪ level ▪ temperature	
Hybrid Tank Measuring System (HTMS)				
HTMS + P1		▪ Level sensor ▪ Pressure sensor (P1, bottom)	▪ level ▪ density of the measured medium (calculated)	▪ Tank Ref Height ▪ P1 Position ▪ Min HTMS (minimum level at which HTMS measurement is possible; should be slightly above the position of the P1 sensor) ▪ local gravity ▪ vapour density ▪ air density ▪ P3 Position (only for the "HTMS + P1,3" mode)
HTMS + P1,3 Note! This mode should be used in non-atmospheric tanks (e.g. pressurised tanks)		▪ Level sensor ▪ Pressure sensor (P1, bottom) ▪ Pressure sensor (P3, top)		

Setup preset	Installation example	Sensors	measured/ calculated values	required parameters
Hydrostatic Tank Gauging (HTG)				
HTG P1		▪ Pressure sensor (P1, bottom)	▪ level (calculated)	▪ Tank Ref Height ▪ local gravity ▪ density of the measured medium ▪ Min HTG Level (minimum level at which HTG measurement is possible; should be slightly above the position of the P1 sensor) ▪ P1 Position ▪ P3 Position (only for the "HTG P1,3" mode)
HTG P1,3 Note! This mode should be used in non-atmospheric tanks (e.g. pressurised tanks)		▪ Pressure sensor (P1, bottom) ▪ Pressure sensor (P3, top)		
HTG P1,2		▪ Pressure sensor (P1, bottom) ▪ Pressure sensor (P2, middle)	▪ level (calculated) ▪ density of the measured medium (calculated)	▪ Tank Ref Height ▪ local gravity ▪ Min HTG Level (minimum level at which HTG measurement is possible; should be slightly above the position of the P2 sensor) ▪ P1 Position ▪ P1-P2-Distance ▪ P3 Position (only for the "HTG P1,2,3" mode)
HTG P1,2,3 Note! This mode should be used in non-atmospheric tanks (e.g. pressurised tanks)		▪ Pressure sensor (P1, bottom) ▪ Pressure sensor (P2, middle) ▪ Pressure sensor (P3, top)		

12.3 The block model of the Tank Side Monitor

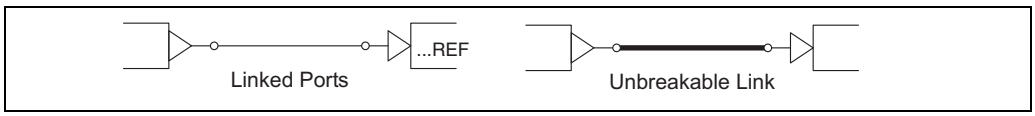
12.3.1 Function blocks and data transfer

The concept

In order to facilitate the overview of numerous parameters, the Tank Side Monitor has been subdivided into function blocks. Each function block contains a group of parameters and has one or more inputs and outputs. The measuring data are processed within the function blocks. During commissioning one can link the outputs of individual function blocks to input of other function blocks. In this way one defines a specific path of the data through the Tank Side Monitor.

Connecting blocks, reference parameters

Blocks can be interconnected via so called reference parameters (marked by "REF" within the parameter name). There is a reference parameter for each configurable block input. The reference parameter is used to define the source of the input value. Moreover, there are some fixed links between function blocks, these links haven't got a reference parameter and can not be changed.
In a block diagram, the links between blocks are depicted in the following way:



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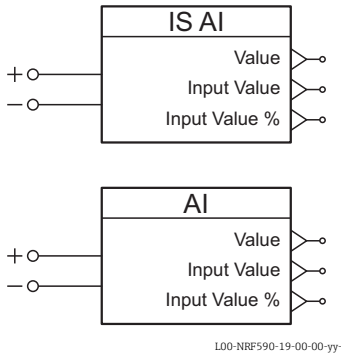
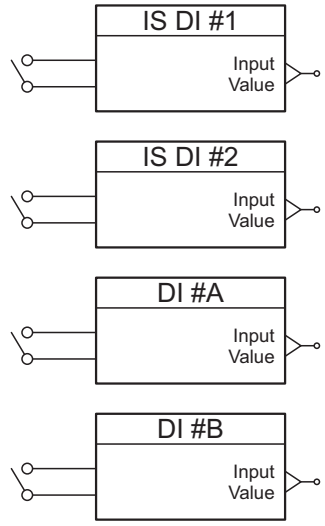
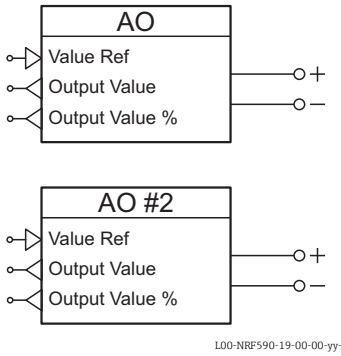
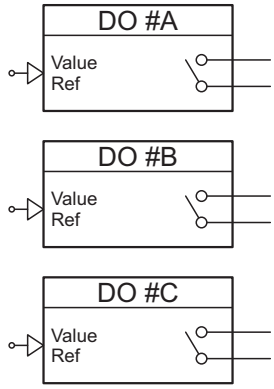
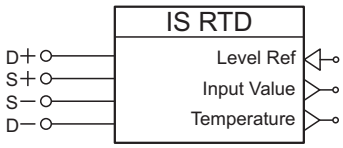
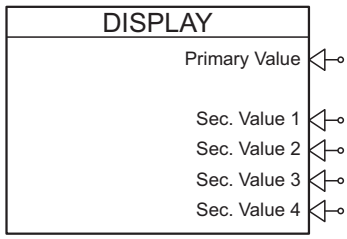
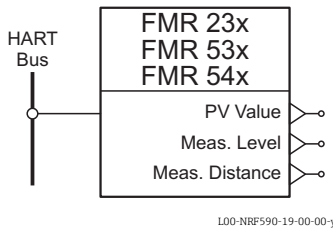
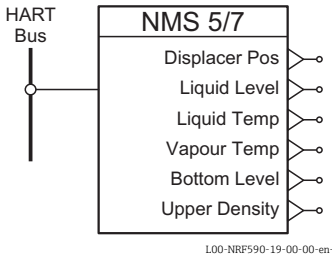
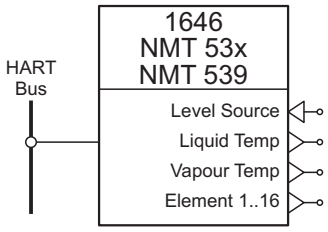
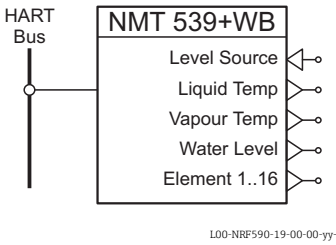
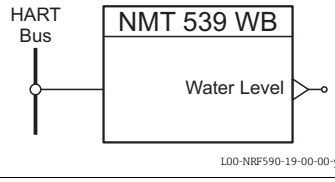
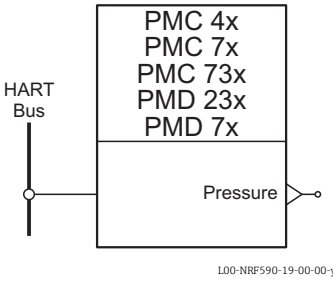
12.3.2 The function blocks of the Tank Side Monitor

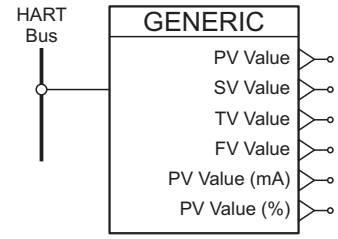
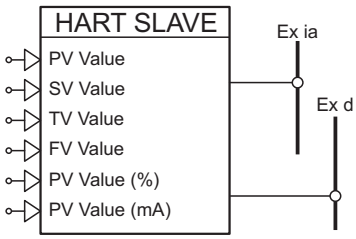
Input and output blocks

Name	Symbol	Function
AI Analog Input IS AI Intrinsically Safe Analog Input		receives an 4 to 20 mA signal, from which it calculates an absolute measured value and a percentage Note! Each analogue input of the Tank Side Monitor has got its own AI block.
DI #A DI #B Discrete Input IS DI #1 IS DI #2 Intrinsically Safe Discrete Input		receives a switching signal, from which it calculates a binary signal; can be operated in two modes: – normally open – normally closed Note! Each discrete input of the Tank Side Monitor has got its own DI block.
AO/AO#2 Analog Output		recieves an analogue signal, from which it calculates an 4 to 20 mA analogue signal Note! Each analogue output of the Tank Side Monitor has got its own AO block.

Name	Symbol	Function
DO#A DO #B DO #C Discrete Output	 L00-NRF590-19-00-00-yy-013	receives a binary signal, from which it calculates a switching signal; can be operated in two modes: – normally open – normally closed Note! Each discrete output of the Tank Side Monitor has got its own DO block.
RTD	 L00-NRF590-19-00-00-yy-014	receives the resistance signal of a RTD and an analogue level signal; calculates the temperature; the temperature output contains a status bit which indicates if the temperature sensor is currently above or below the level surface. Note! this block is only present in the following device version: NRF590 - ***1*******
Display	 L00-NRF590-19-00-00-en-079	receives one primary value and up to four secondary values and transfers them to the display module

HART blocks

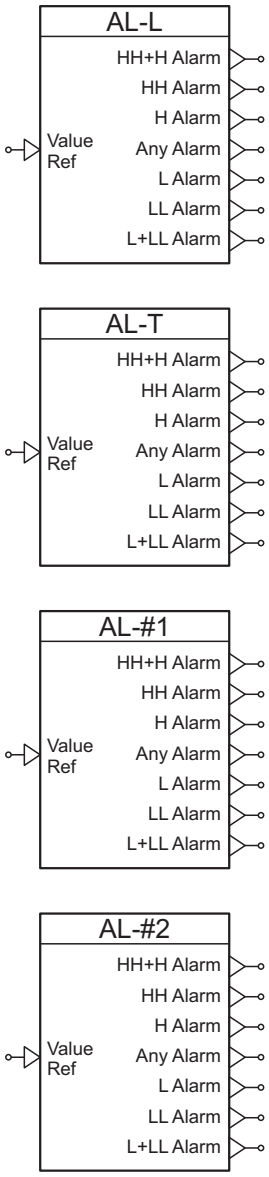
Name	Symbol	Function
FMR Micropilot		receives the HART signal of the Micropilot; outputs the following values: – (corrected) level – measured level – measured distance
NMS5/7 Proservo		receives the HART signal of the Proservo; outputs the following values: – Displacer Position – Liquid Level – Liquid Temperature – Vapour Temperature – Bottom Level – Upper Density
1646 NMT53x NMT539 Prothermo		receives the HART signal of the Prothermo and an analogue level signal; outputs the following values: – the medium liquid temperature – the medium gas temperature – the individual temperatures of the elements 1 ... 16
NMT539+WB Prothermo with water bottom probe		receives the HART signal of the Prothermo and an analogue level signal; outputs the following values: – the medium liquid temperature – the medium gas temperature – the water level – the individual temperatures of the elements 1 ... 16
NMT539 WB water bottom probe		receives the HART signal of the water bottom probe; outputs an analog water level signal
PMC4x PMC7x PMC73x PMD23x PMD7x DeltabarS/ Cerabar S		receives the HART signal of the Deltabar S or Cerabar S; outputs an analogue pressure signal

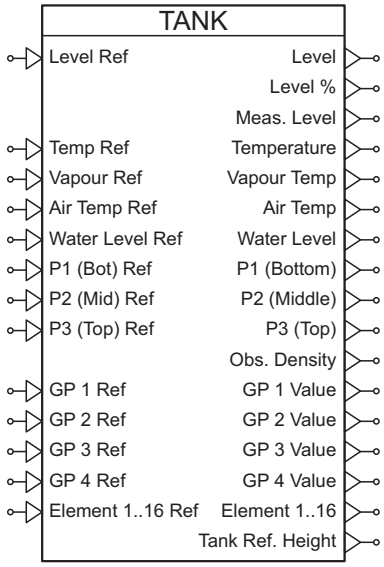
Name	Symbol	Function
GEN Generic HART device	 L00-NRF590-19-00-00-yy-016	receives the HART signal of an arbitrary HART device: outputs the following values: – up to four measured values – the current (mA) belonging to the primary value – the percentage of the primary value
HART Slave	 L00-NRF590-19-00-00-en-071	is active if the NRF590 is operating as a HART slave; receives up to four analogue signals and outputs them to the HART communication line

Note!

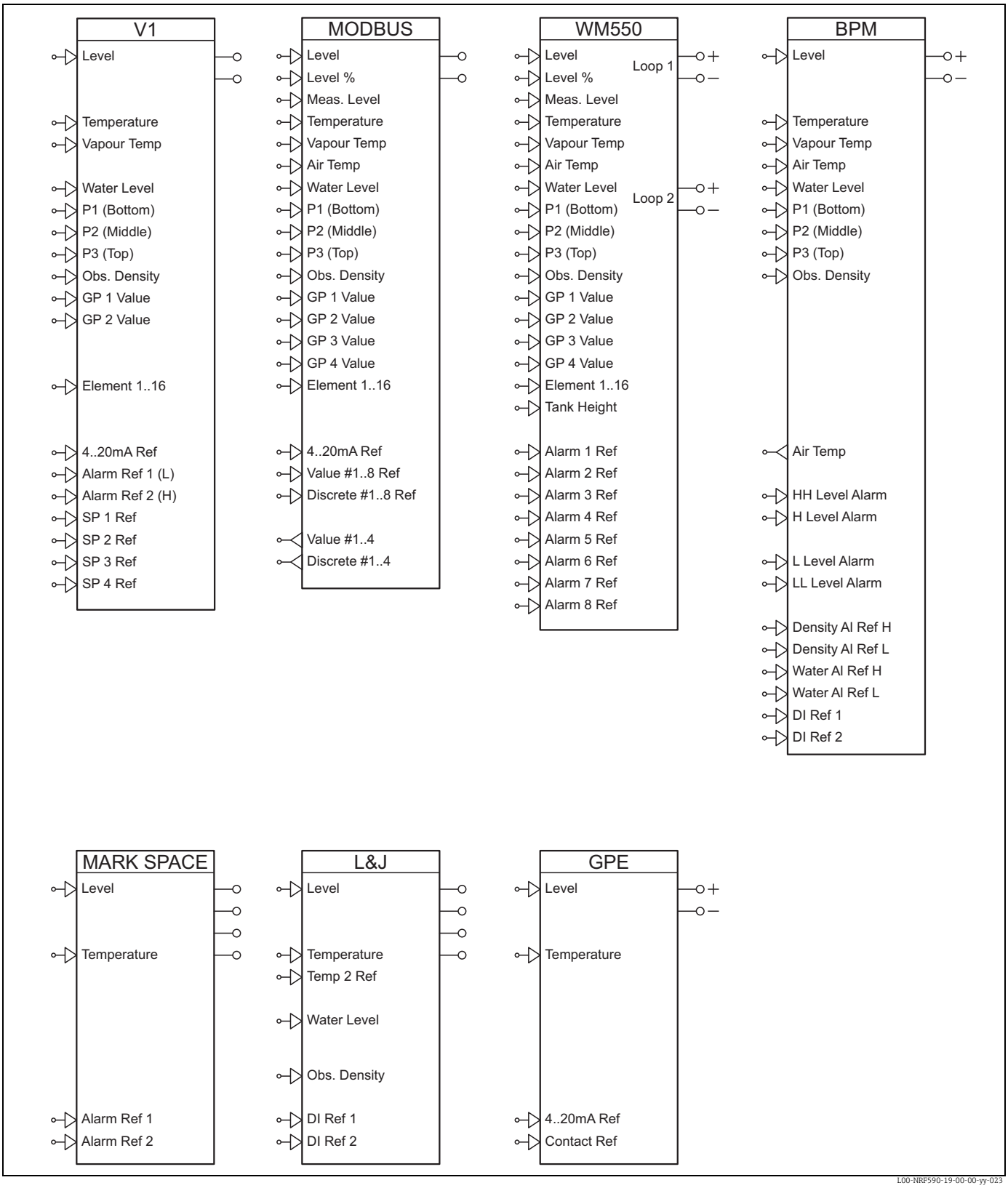
The HART blocks are dynamical. That means, they are only present, if the respective HART device is connected to the Tank Side Monitor. As soon as the Tank Side Monitor recognizes a new device on the HART loop, it creates the corresponding block.

Internal function blocks

Name	Symbol	Function
AL-L Level Alarm AL-T Temperature Alarm AL #1/AL #2 Alarm		receives an analogue signal; calculates 5 binary values according to the alarm points Note! The Tank Side Monitor contains 4 alarm blocks with the following designations: – Level Alarm – Temperature Alarm – Alarm 1 – Alarm 2

Name	Symbol	Function
TANK Tank functions		receives the measured values from the HART and the input blocks; performs the tank calulations and corrections; outputs the calculated tank values

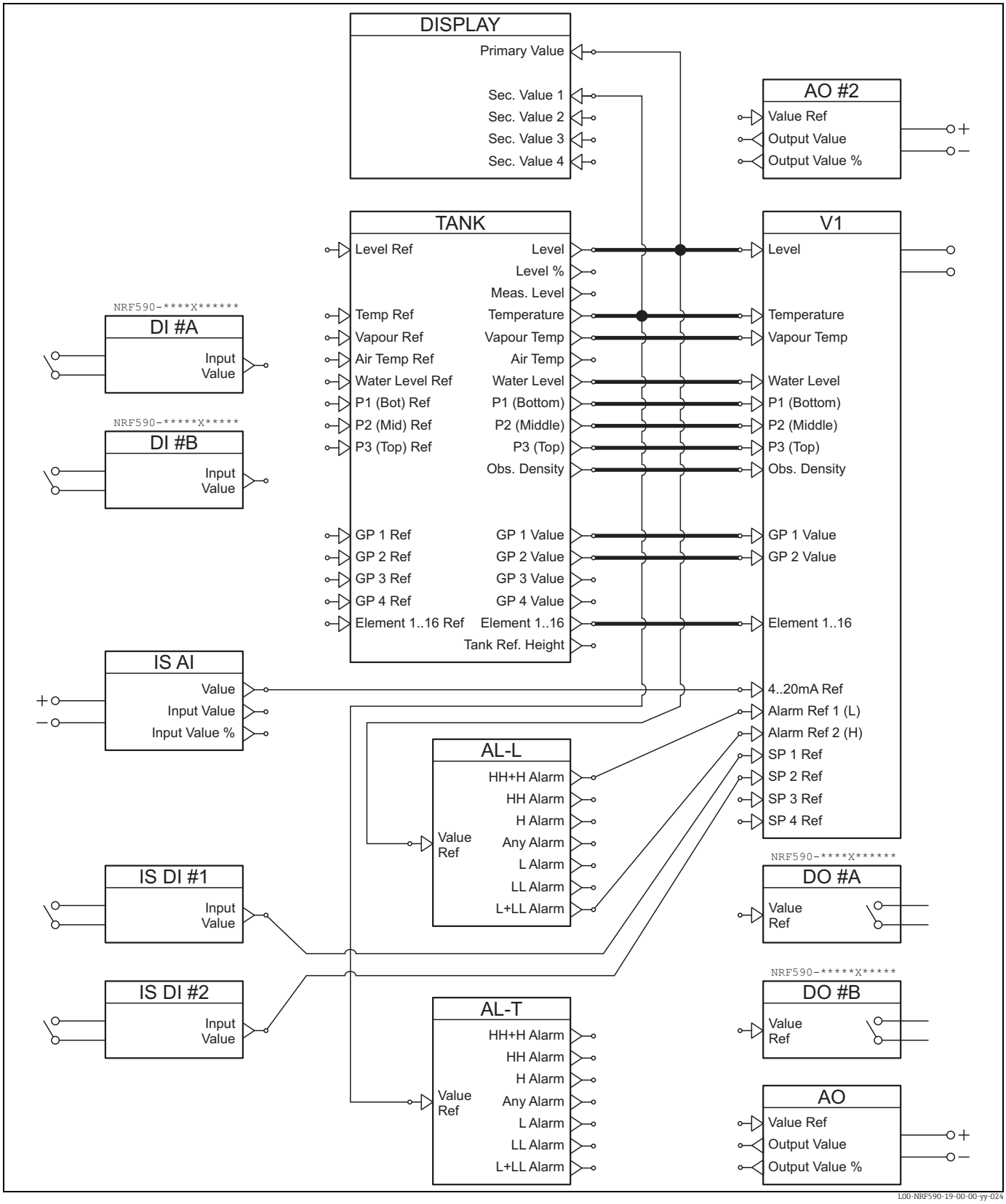
Field protocol blocks



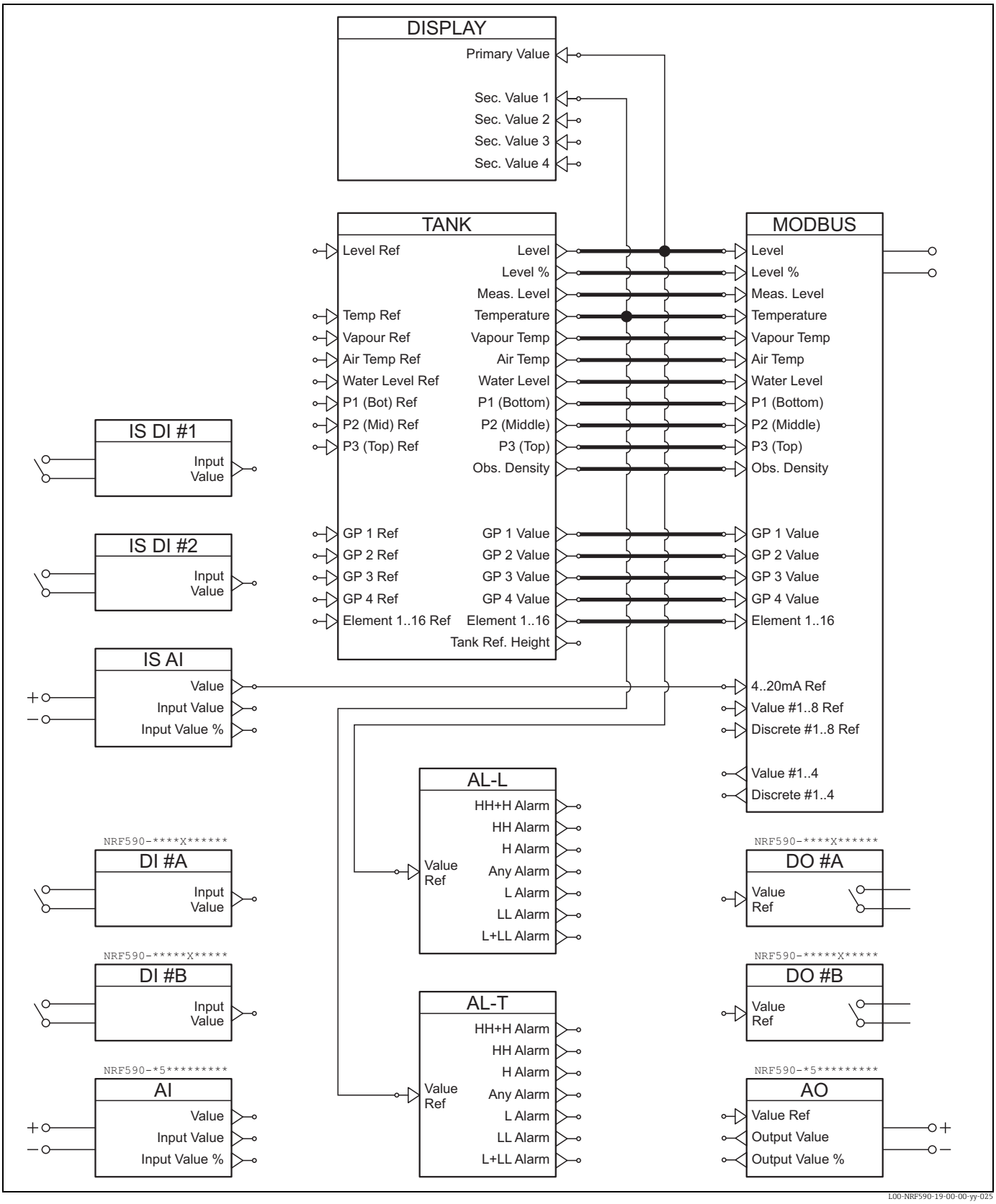
Every Tank Side Monitor contains one of these block - corresponding to its field protocol. The field protocol block receives values from other blocks and outputs them to the fieldbus.

12.3.3 Default Block-Configuration

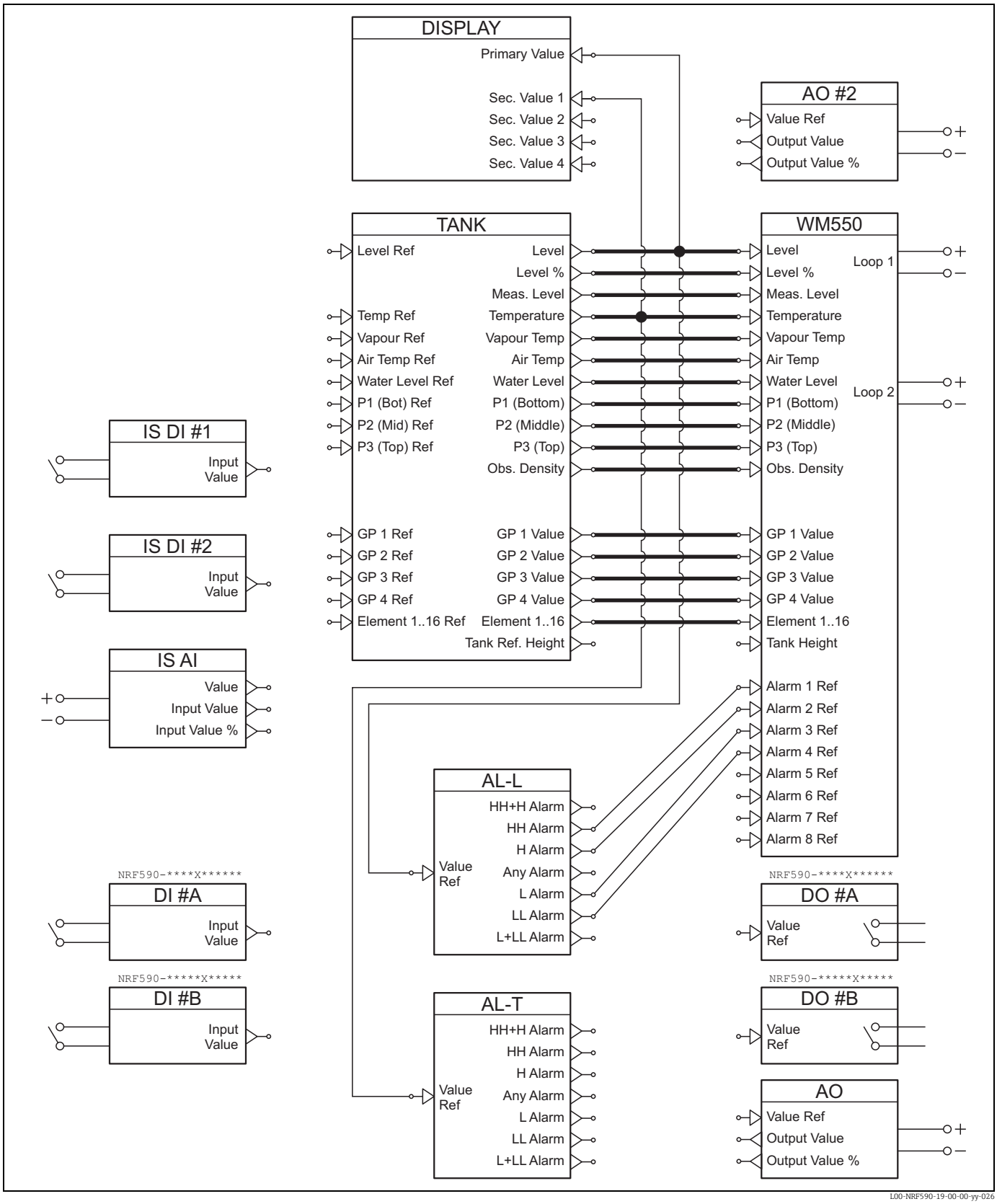
Default Configuration for Sakura V1 (NRF590 - *8*******)**



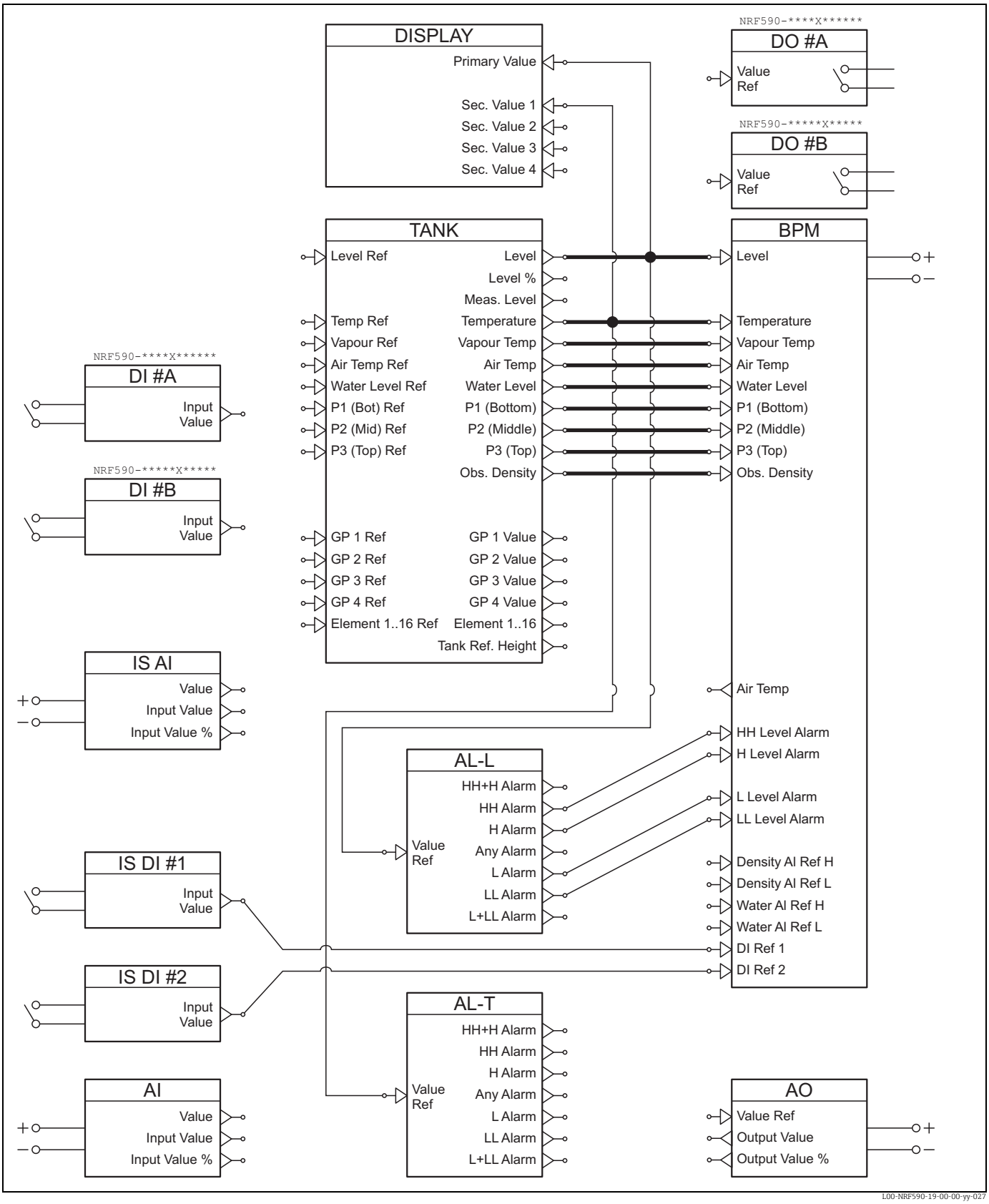
Default Configuration for EIA-485 Modbus (NRF590 - *4/5*********)



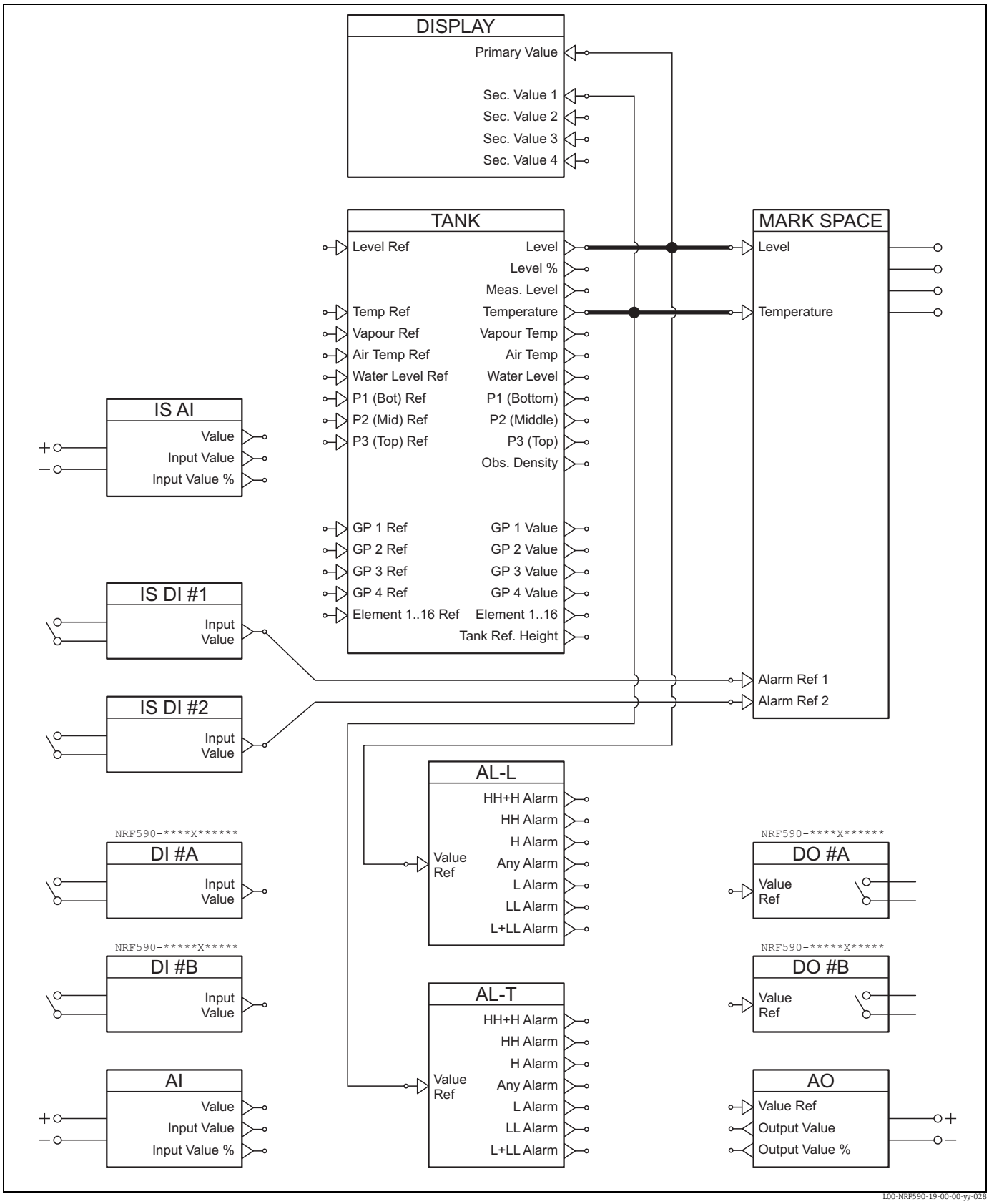
Default Configuration for Whessoematic WM550 (NRF590 - *1*********)



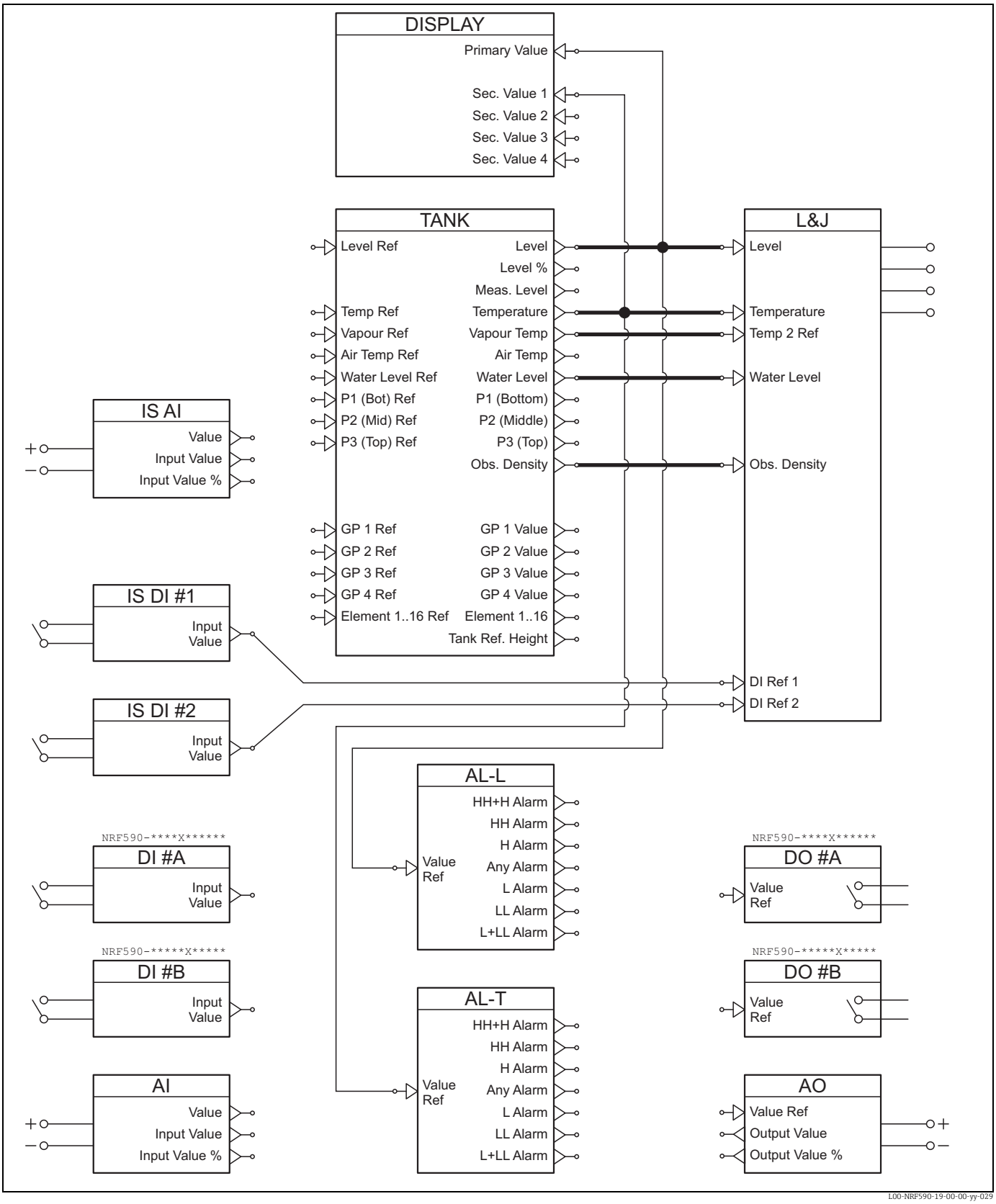
Default Configuration for BPM (NRF590 - *E*********)



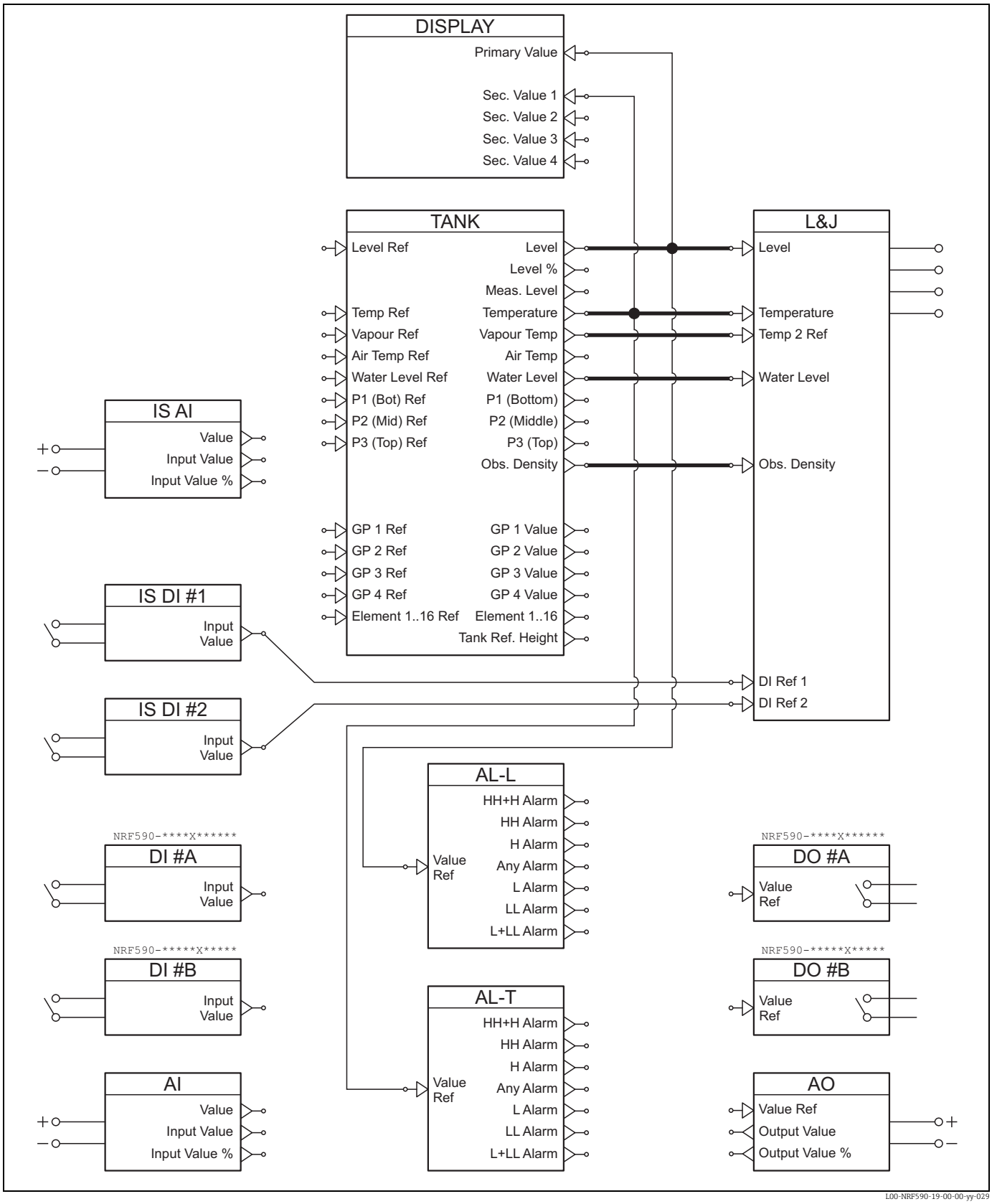
Default Configuration for Mark/Space (NRF590 - *2/3*********)



Default Configuration for L&J Tankway (NRF590 - *7*********)



Default Configuration for GPE (NRF590 - *G*********)



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