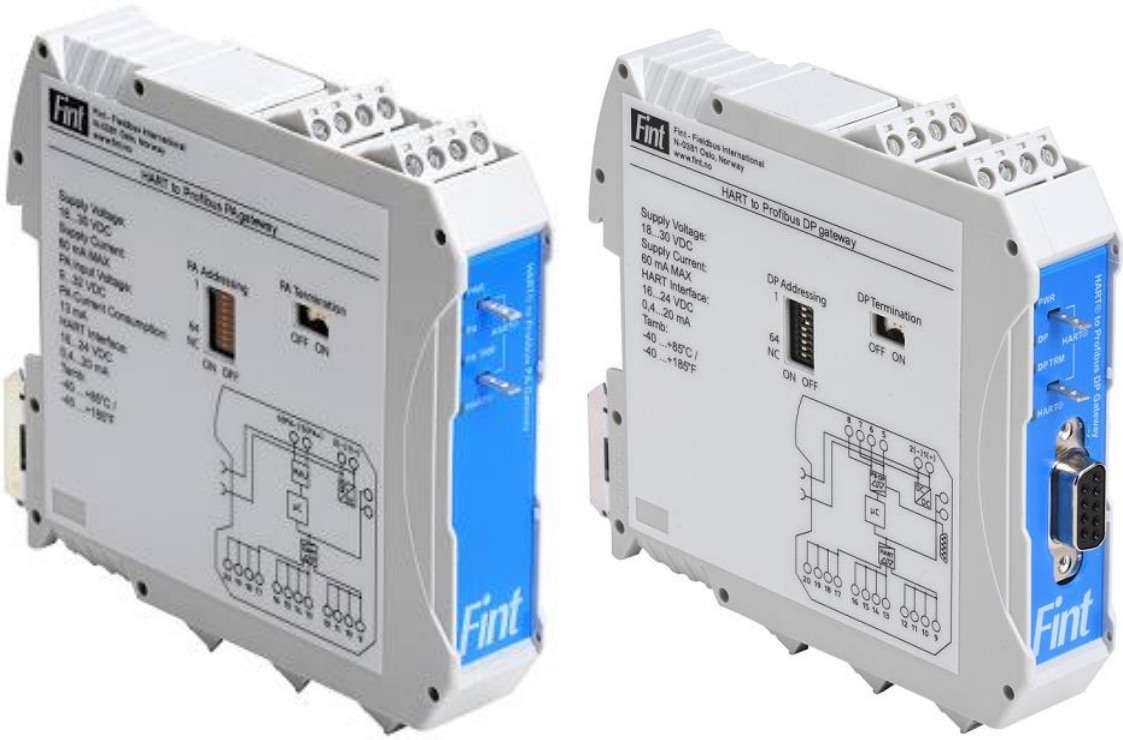
The HART to Profibus gateways, the T501 and T500

Reference Manual



Fieldbus International AS

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

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About this document

The Reference Manual gives an overview of the capabilities and the use of the T50x DIN rail mounted generic Profibus DP gateway. Furthermore it explains how to configure the device.

The following abbreviations are used in this document:

DPV1	Extended functions in Profibus DP that allow acyclic communication for parameter configuration. DP is traditionally only suited for transfer of measured variables.
MSAC1	Acyclic communication services from a Master Class 1 (PLC).
MSAC2	Acyclic communication services from a Master Class 2 (configurations station)
PV	Primary dynamic variable in the transmitter
SV	Secondary dynamic variable in the transmitter
TV	Third dynamic variable in the transmitter
FV	Fourth dynamic variable in the transmitter
gsd file	Datasheet that describes the behavior of the device on Profibus, like data-rates, dynamic variables etc. A Master Class 1 uses the gsd file to start cyclic communication with the instrument.
IDENT_NO	A type number for a Profibus device. The gsd file describes the communication capabilities of a device type and is the description of the capabilities that are related to a particular IDENT_NO. The allocation of IDENT_NO is administered by PI.
PI	Profibus International
DD	Device description
TB	Transducer Block
PB	Physical Block
FB	Function Block
RB	Resource Block
PA	Profibus PA
PDM	Simatic Configuration tool
NAMUR NE107	Standard for Field Diagnostics
PLC	Control or monitoring system

Summary

The T501 capabilities can be summarized as follows:

- Interfaces up to four HART devices to Profibus DP (DP)
- Standard Profibus PA 3.02 profile
- Supports reading of an Additional Device in each HART instrument
- Two connections are supported for acyclic configuration traffic
- Powered from 18V – 30 V instrument power
- Support for NAMUR NE107 Diagnostics

The instrument interface:

Protocol:

- HART

Physical interfaces:

- HART sinking or sourcing devices

1. HART TO PROFIBUS DP – THE T501

1.1. Functional Description

The T501 is a Profibus DP compliant DIN rail mountable gateway for connecting HART instruments to DP. Applying the T501 enables legacy instruments with a HART interface to connect to a Profibus DP network.

Figure 1. The T501

Up to four HART instruments can be connected through one T501 module.

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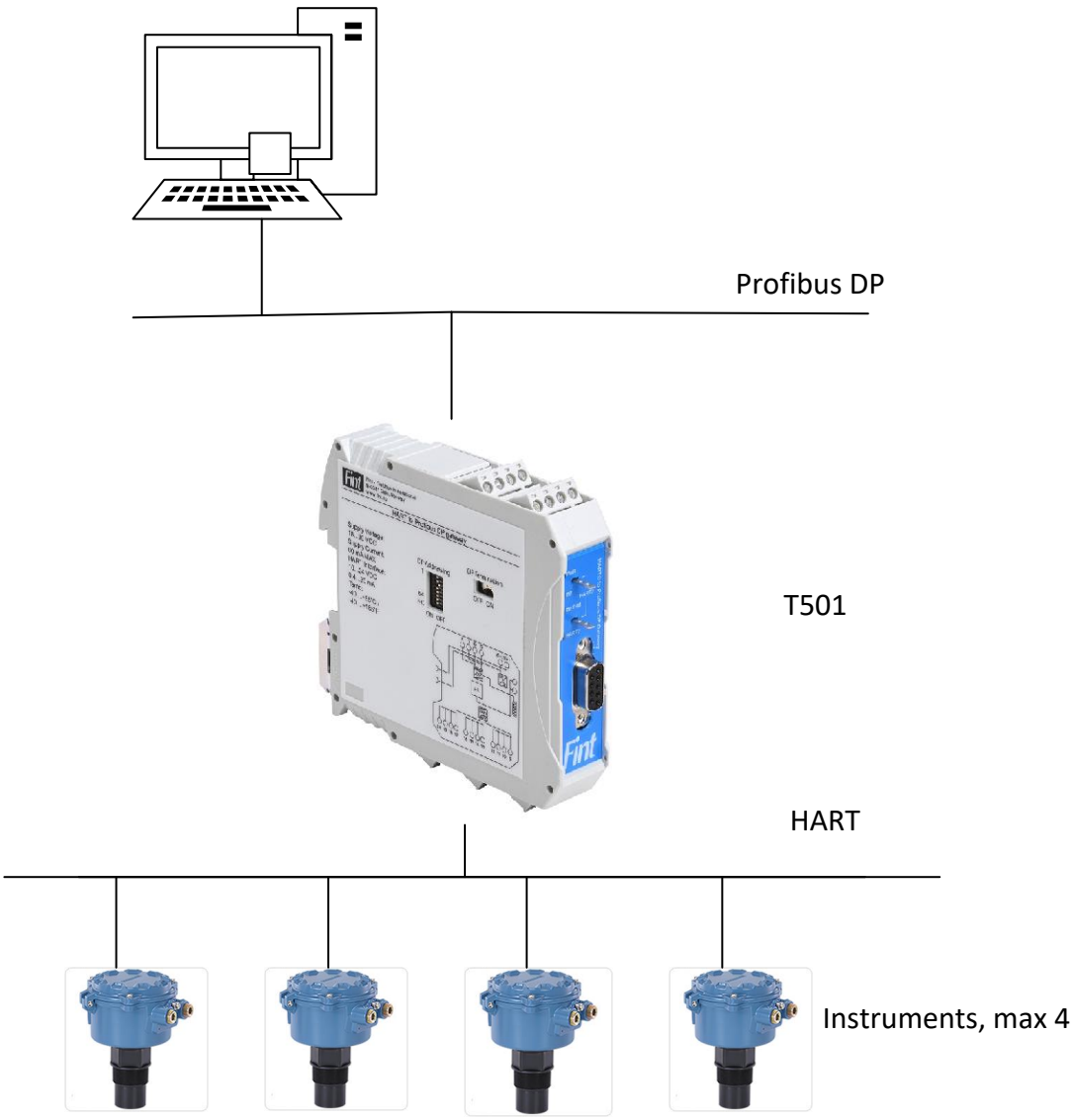

Figure 2: The T501 device in a typical application

The T501 is intended for installation on a DIN rail and within a cabinet. It is powered from an 18 – 30 VDC supply

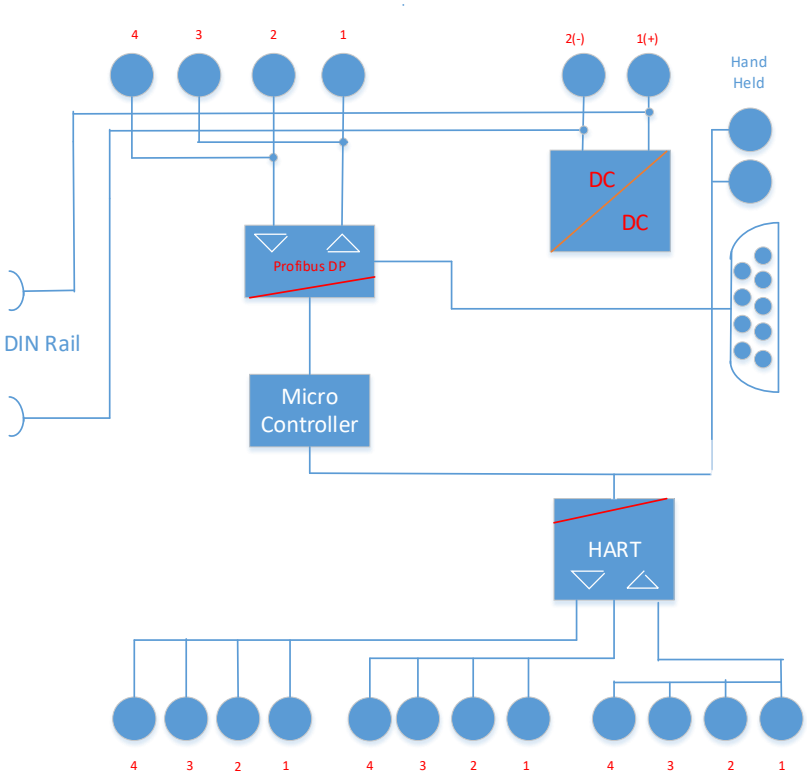

Figure 3. Functional Diagram

1.2. Mechanical Dimensions

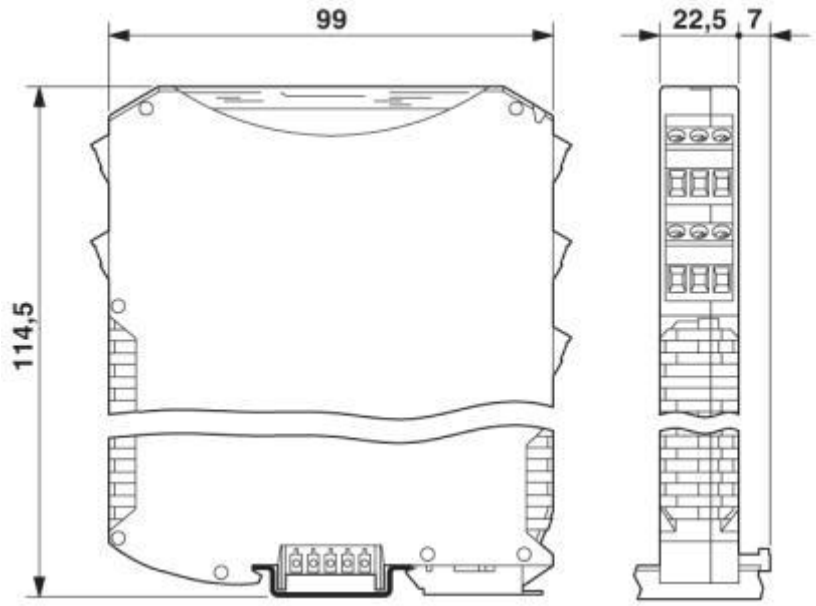

Figure 4. ME MAX Dimensions

1.3. Installation

The T501 is designed for being mounted in a cabinet on a DIN rail.

1.3.1. Electrical Connections

The T501 contains 5 pluggable screw terminals.

The T501 shall use the screw terminal pinout as shown in Table 1:

Profibus can either be connected on the screw terminals or from the DSUB connector. These are electrically equivalent. There are connectors that allow the bus to be daisy-chained to the next instrument.

Connector	Pin	Comment
PWR	1	Positive supply to T501
	2	Negative supply to T501
	3	No Connection
	4	No Connection
DP	1	Profibus B - In
	2	Profibus A In
	3	Profibus B Out
	4	Profibus A Out
HART Sourcing Instruments	1	Channel 1 -
	2	Channel 2 -
	3	Channel 3 -
	4	Channel 4 -
HART Common	1	Channel 1 Common
	2	Channel 2 Common
	3	Channel 3 Common
	4	Channel 4 Common
HART Sinking Instrument	1	Channel 1 +
	2	Channel 2 +
	3	Channel 3 +
	4	Channel 4 +
DIN clip	-	PE connection for EMC (see Figure 6)

Table 1: Connector Arrangement Table

T501 supports a Profibus DSUB connector with the following pin-out

Connection	Pin No	Signal Type	Description
	1	NC	
	2	NC	
Profibus B	3	RS485	Signal connection
	4	NC	
	5	GND	Profibus Termination GND
	6	VCC	
	7	NC	
Profibus A	8	RS485	Signal Connection
	9	NC	

Table 2: Profibus DSUB Connector Arrangement Table

The detachable plugs are coded to avoid misconnection.

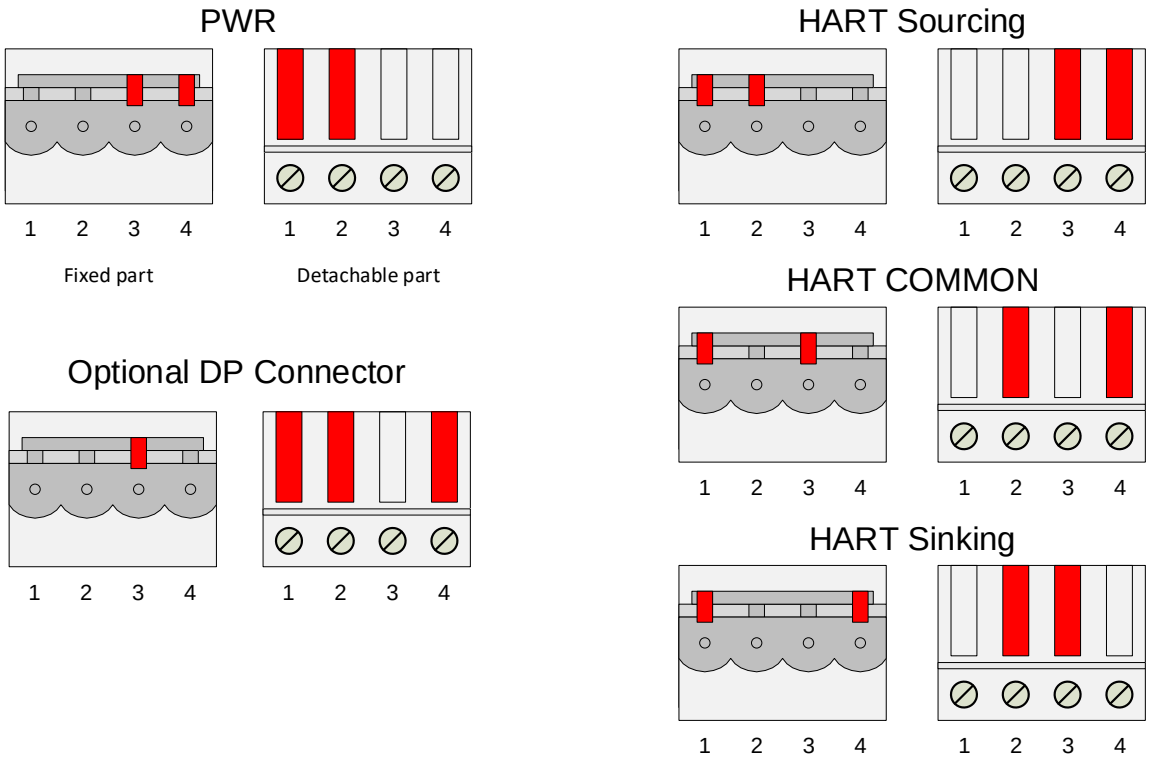

Figure 5. Coding of the plugs

1.3.2. Slide switches and DIP switches

1.3.2.1. DP termination

The Profibus lines may be terminated in the T501. Whether to terminate is selected by a slide switch as indicated in Figure 6.

1.3.2.2. DIP switches

The Profibus address can be set using DIP switches as indicated in Figure 6 and Figure 15. The address is binary coded.

1.3.2.3. Programming utility

Behind the panel on top of the device there is a USB connector for updating software in the field. See Figure 6.

1.3.2.4. Configuration utility

On the front panel there is a connector for a Handheld configurator.

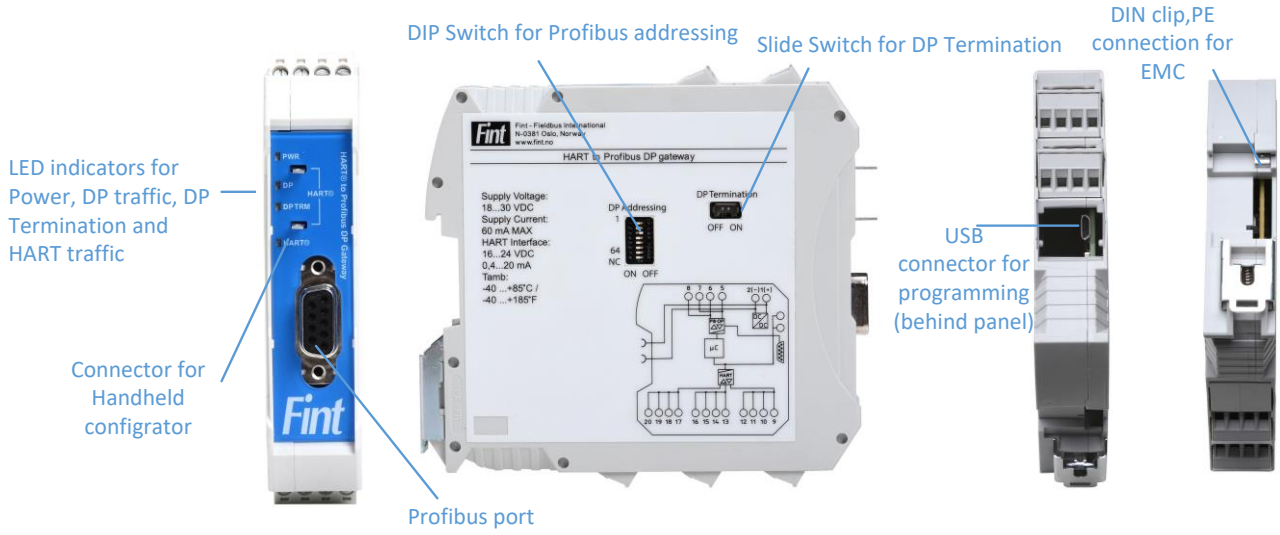

Figure 6. Front and Side Label mounted on T501, showing the functions

1.3.2.5. Scan HART network using DIP switches

It is possible to scan the HART network using the DIP switches. The connected HART instruments will then be detected and read into the directory of the T501. They will be arranged in the order of the lower short address and upwards. So the lower address will be located on the lower slot in T501 and be the first value in the PLC.

Scanning is done as a consequence of the following procedure:

1) All the switches shall be in the ON position (address 126).
2) The switch named NC shall be switched to position OFF
3) When the switch NC is switched back to position ON, a scan is executed.

1.3.3. Power, Termination and Diagnostic LEDs

There are four LEDs on the front. One for Power ON, one for DP Termination ON/OFF, one for the HART communication and one for the DP communication. The communication LEDs are bicolor. One color is blinking on request telegrams and the other on responding telegrams. A slow blink in one of the HART LED indicates that there is no HART communication.

1.4.gsd file for T501

The T501 supports a manufacturer and a profile Ident No

	Ident No	Gsd file
Profile	9703	pa139703.gsd
Manufacturer	A001	FINa001.gsd

The manufacturer gsd file supports the following configurations:

Configurations	Format	No Of bytes	Device	Comment
PV channel 1	Float + status	Five bytes	HART 1	Lowest HART address
PV channel 2	Float + status	Five bytes	HART 2	
PV channel 3	Float + status	Five bytes	HART 3	
PV channel 4	Float + status	Five bytes	HART 4	Highest HART address

Table 3: gsd file

2. HART TO PROFIBUS PA - THE T500

2.1. Functional Description

The T500 is a Profibus PA compliant DIN rail mountable gateway for connecting HART instruments to DP. Applying the T500 enables legacy instruments with a HART interface to connect to a Profibus PA network.

Figure 7. The T500

Up to four HART instruments can be connected through one T500 module.

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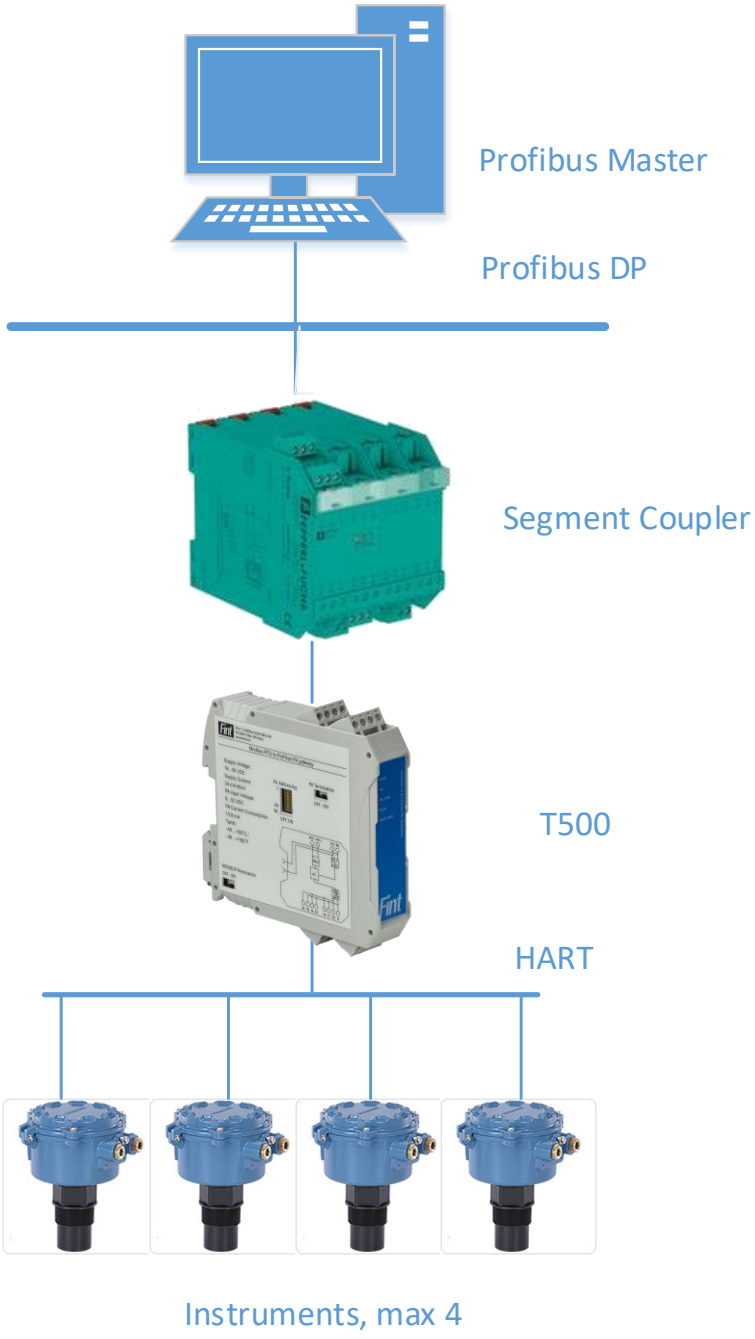


Figure 8. The T500 device in a typical application

The T500 is intended for installation on a DIN rail and within a cabinet. It is powered from an 18 – 30 VDC supply

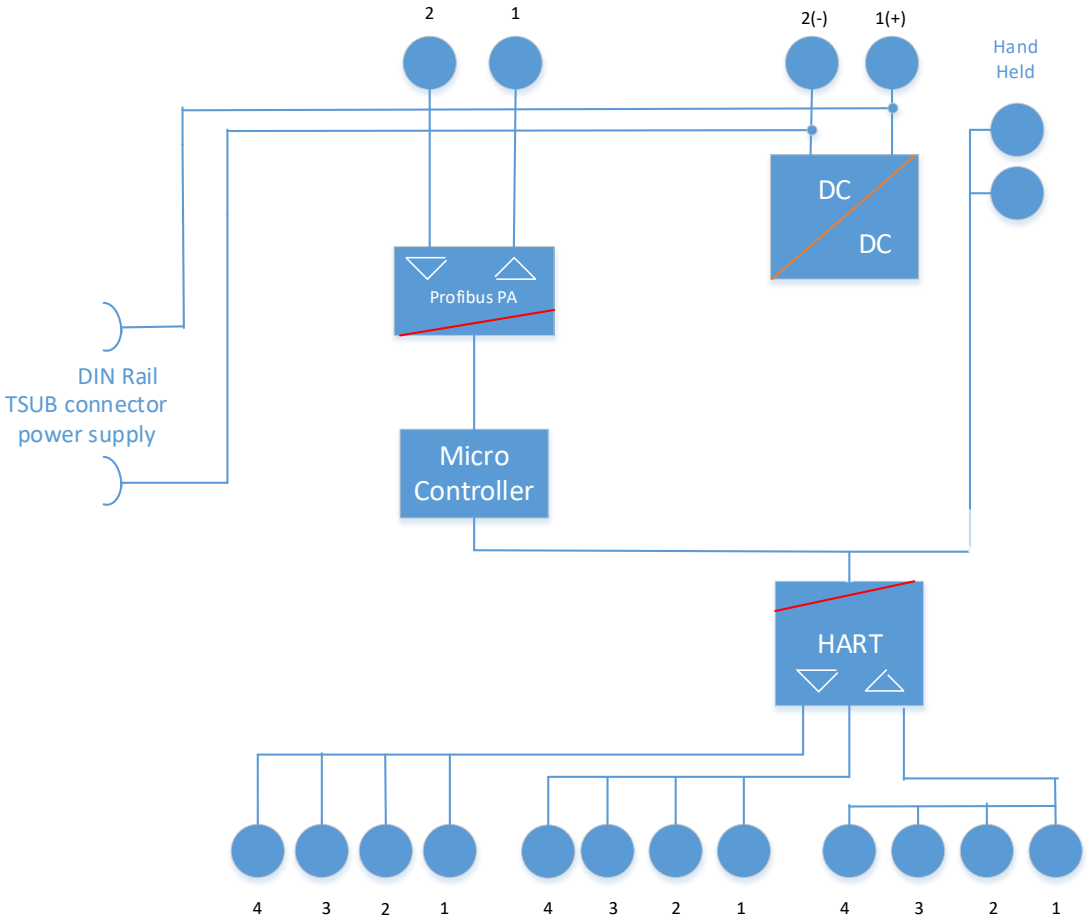


Figure 9. Functional Diagram

2.2. Mechanical Dimensions

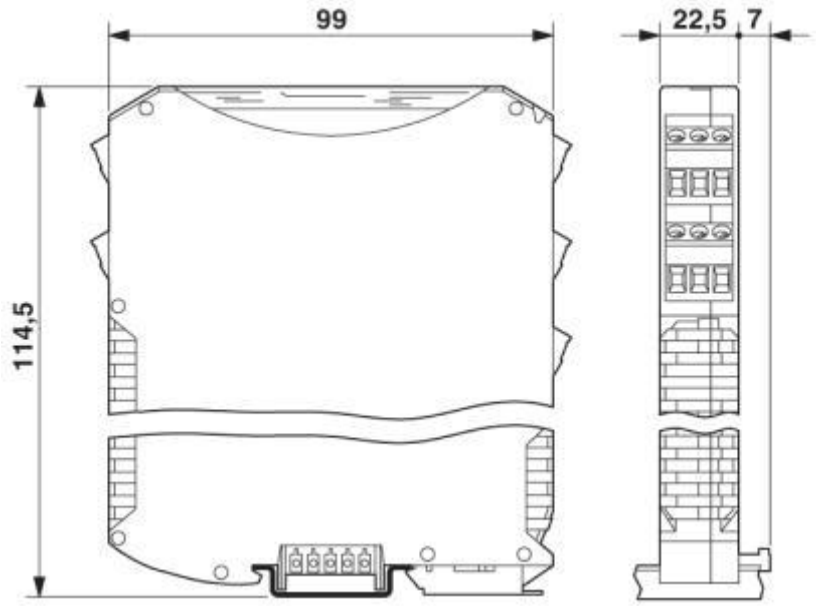


Figure 10. ME MAX Dimensions

2.3. Installation

The T500 is designed for being mounted in a cabinet on a DIN rail.

2.3.1. Electrical Connections

The T500 contains 5 pluggable screw terminals.

The T500 shall use the screw terminal pinout as shown in Table 4:

Connector	Pin	Comment
PWR	1	Positive supply to T500
	2	Negative supply to T500
	3	No Connection
	4	No Connection
PA	1	Profibus +
	2	Profibus -
	3	No Connection
	4	No Connection
HART Sourcing Instruments	1	Channel 1 -
	2	Channel 2 -
	3	Channel 3 -
	4	Channel 4 -
HART Common	1	Channel 1 Common
	2	Channel 2 Common
	3	Channel 3 Common
	4	Channel 4 Common
HART Sinking Instrument	1	Channel 1 +
	2	Channel 2 +
	3	Channel 3 +
	4	Channel 4 +
DIN clip	-	PE connection for EMC (see Figure 3. Functional DiagramFigure 3)

Table 4: Connector Arrangement Table

The detachable plugs are coded to avoid misconnection.

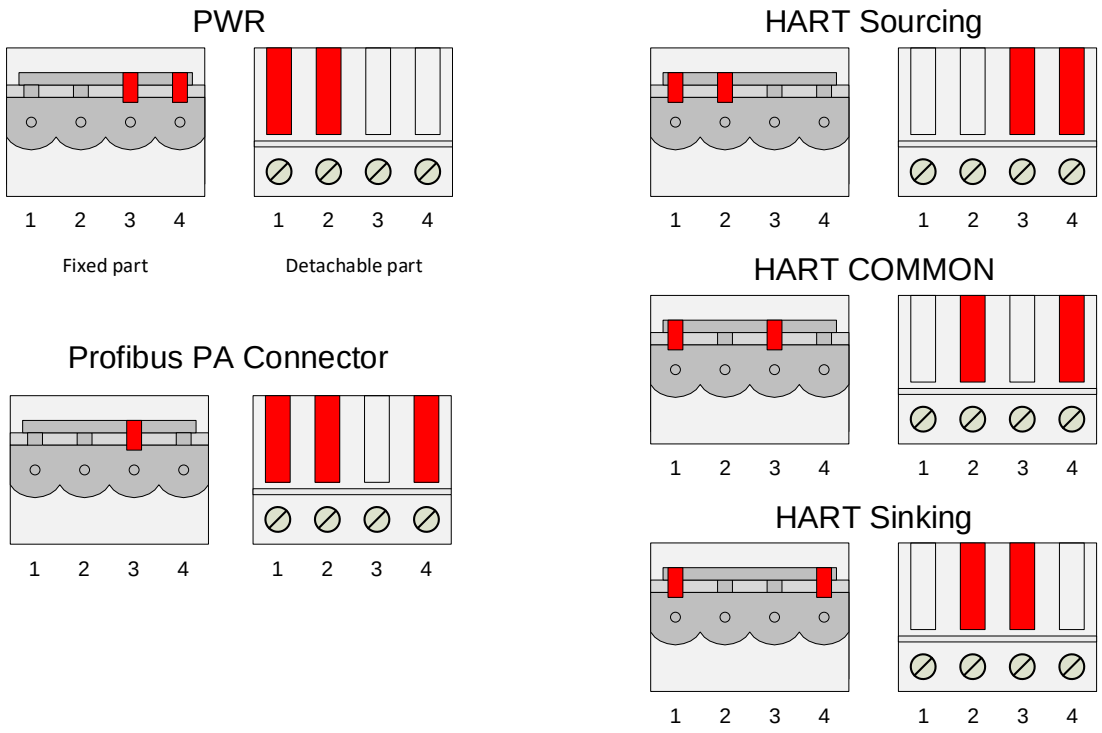


Figure 11. Coding of the plugs

2.3.2. Slide switches and DIP switches

2.3.2.1. PA termination

The Profibus lines may be terminated in the T500. Whether to terminate is selected by a slide switch as indicated in Figure 12.

2.3.2.2. DIP switches

The Profibus address can be set using DIP switches as indicated in Figure 12 and Figure 15. The address is binary coded.

2.3.2.3. Programming utility

Behind the panel on top of the device there is a USB connector for updating software in the field. See Figure 12.

2.3.2.4. Configuration utility

On the front panel there is a connector for a Handheld configurator.

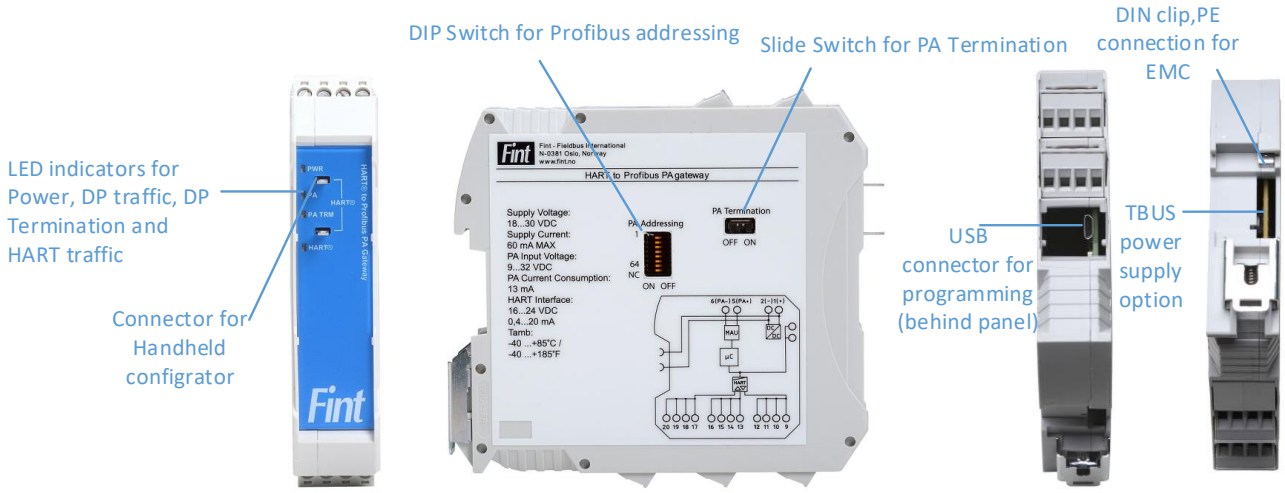


Figure 12. Front and Side Label mounted on T500, showing the functions

2.3.2.5. Scan HART network using DIP switches

It is possible to scan the HART network using the DIP switches. The connected HART instruments will then be detected and read into the directory of the T500. They will be arranged in the order of the lower short address and upwards. So the lower address will be located on the lower slot in T500 and be the first value in the PLC.

Scanning is done as a consequence of the following procedure:

4) All the switches shall be in the ON position (address 126).
5) The switch named NC shall be switched to position OFF
6) When the switch NC is switched back to position ON, a scan is executed.

2.3.3. Power, Termination and Diagnostic LEDs

There are four LEDs on the front. One for Power ON, one for PA Termination ON/OFF, one for the HART communication and one for the PA communication. The communication LEDs are bicolor.

One color is blinking on request telegrams and the other on responding telegrams. A slow blink in one of the HART LED indicates that there is no HART communication.

2.4. gsd file for T500

The T500 supports a manufacturer and a profile Ident No

	Ident No	Gsd file
Profile	9703	pa139703.gsd
Manufacturer	A005	FINa005.gsd

The manufacturer gsd file supports the following configurations:

Configurations	Format	No Of bytes	Device	Comment
PV channel 1	Float + status	Five bytes	HART 1	Lowest HART address
PV channel 2	Float + status	Five bytes	HART 2	
PV channel 3	Float + status	Five bytes	HART 3	
PV channel 4	Float + status	Five bytes	HART 4	Highest HART address

Table 5: gsd file

3. CONNECTING A HART TRANSMITTER TO T50X

Current sinking and sourcing HART devices can be connected, but needs to be connected in different ways. Current sinking and sourcing devices can be combined on the same T50x.

3.1. Current Sourcing devices

Current sourcing instruments shall be connected to T50x in following manner:

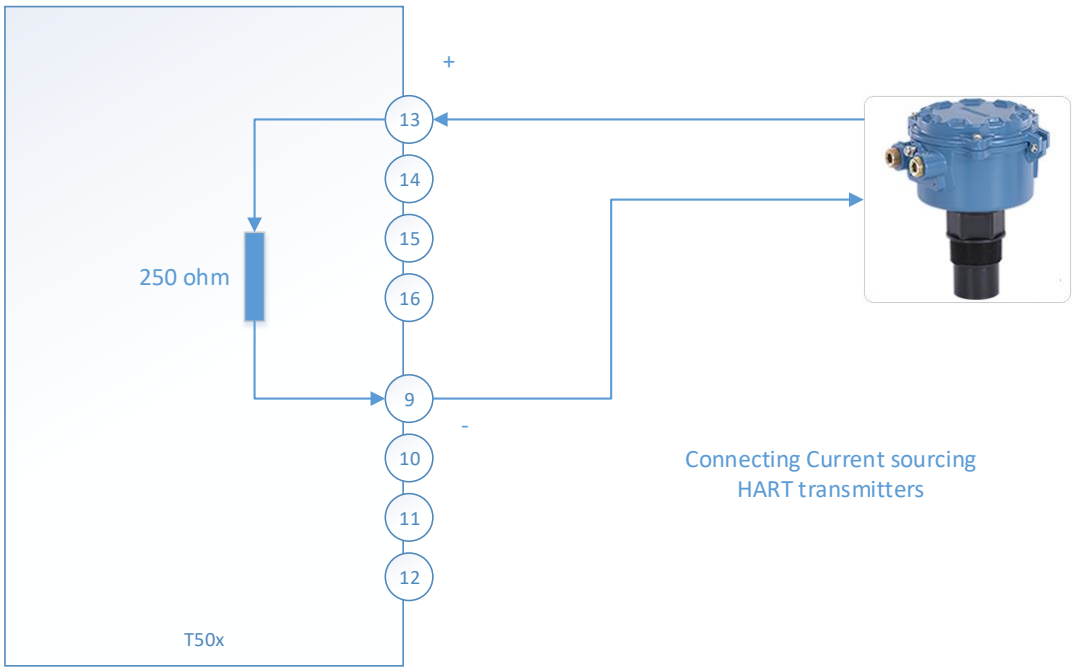


Figure 13. Connecting Current Sourcing HART Transmitters

NOTE!

The direction of the 4-20 mA loop current is important. Protecting diodes will block the loop current if connected in the opposite direction.

NOTE!

Don't use external resistors in the HART loop. A HART resistor is built into the T50x
.

3.2. Current sinking devices

Current sinking devices takes their loop current from the T50x.

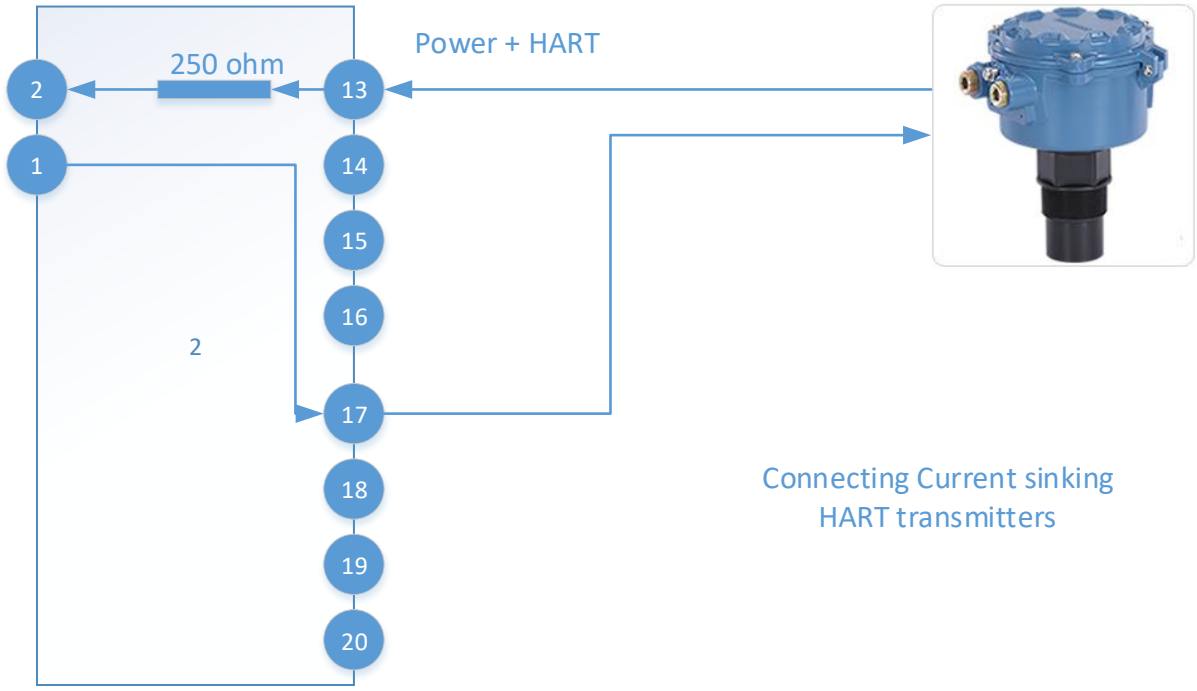


Figure 14. Connecting Current Sinking HART Transmitters

NOTE!

The direction of the 4-20 mA loop current is important. Protecting diodes will block the loop current if connected in the opposite direction.

NOTE!

Don’t use external resistors in the HART loop. A HART resistor is built into the T50x

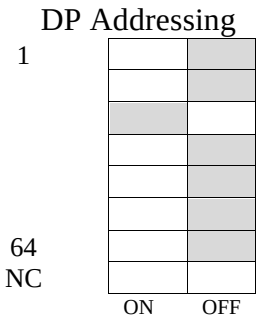
3.3.Setting Profibus address

The T50x is delivered from factory with address 126. To set the device in operation, the address has to be moved to the operational range 1-125.

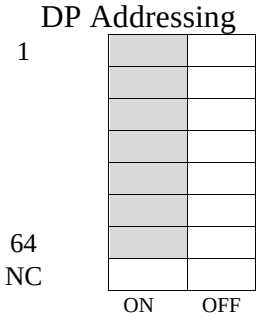
The address can be set using the DIP switches or through Profibus using the Set_Address service.

If a legal address is set by the DIP switches, the DIP switches determine the address. The coding on the switches is binary.

If the switches are set to address 126, address setting can be performed using the Profibus command, (Set_Address).



Example: DIP switch coding for Profibus Address = 4



Example: DIP switch coding when Profibus Address is set using Set_Address

Figure 15. Address setting

4. OPERATION PRINCIPLE

4.1. Connecting HART devices

The T50x is a protocol converter, to allow legacy HART devices to communicate on a Profibus DP network.

Up to four channels are supported. Each device sourcing channel is defined by a HART short Address. Up to four HART devices may be connected. This implies four different HART addresses. The HART instruments are electrically interconnected within T50x.

Connecting procedure:

Set the HART instruments to a HART multi-drop address, 1- 16. This should preferably be done before connecting to the T50x.

NOTE ! *The output from T50x is limited to 20 mA. If the loop current because the sinking HART transmitters draw more, the HART signals will be clipped and no communication will be possible*.

Arrange the addresses so that the output to the PLC is in the order wanted, with the lower HART address first.

On single HART devices with single-drop address 0 can be connected. It will be detected in the same manner as multi-drop HART devices. No special setting of the T50x will be required.

NOTE! *Single-drop and multi-drop devices cannot be mixed*.

Current sourcing HART devices shall be connected as in Figure 5

Current sinking HART devices shall be connected as in Figure 6

When the all HART devices are connected, run a scan. This can be done using the DIP switches (See Ch. 2.3.2) or from a configuration program like the PDM configuration tool from Siemens.

The result of the scanning is reported as ok or fault in Profibus status. See Figure 18.
See appendix A for possible scanning errors.

4.2. Variables

The T50x can support up to 4 HART transmitters. The Primary Value (PV) from each of these transmitters will be calculated in four channels through a Transducer Block (TB) and a Function Block (FB). The TBs and the FBs are according to the Profibus PA Profile. In the FBs there are

Scaling, Damping and Alarm setting functions. These functions can be configured from the PDM configuration tool.

The PVs are copied to the output buffer. The user selects which of the four dynamic variables to read based on the gsd file.

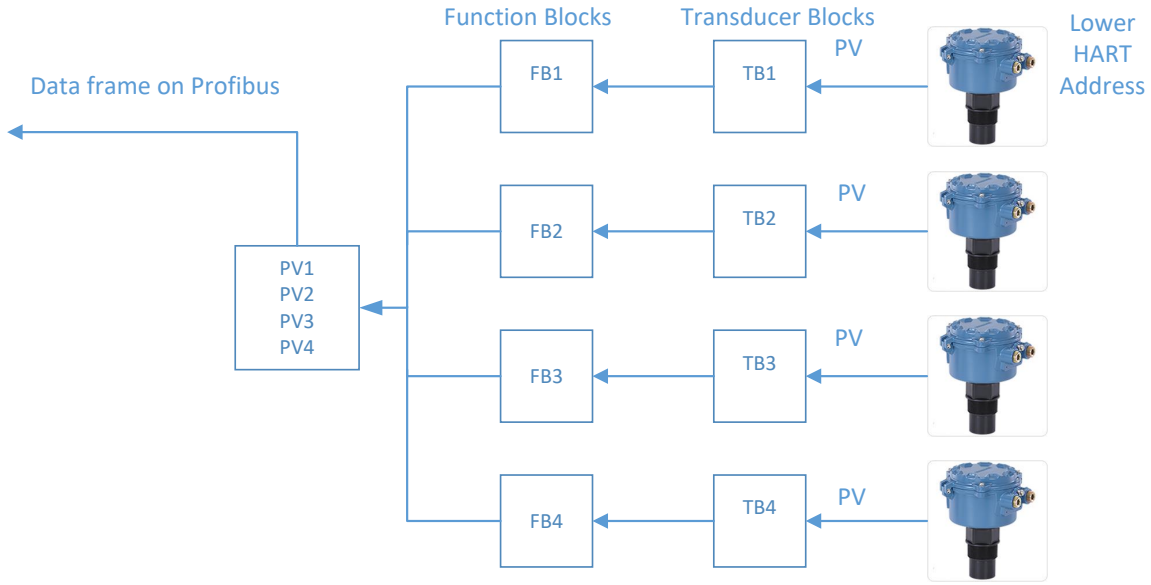


Figure 16. Four HART transmitters connected to T50x

Using the PDM configurator, it is possible to read all dynamic variables from one HART transmitter instead of the PV from four different transmitters. See Figure 17.

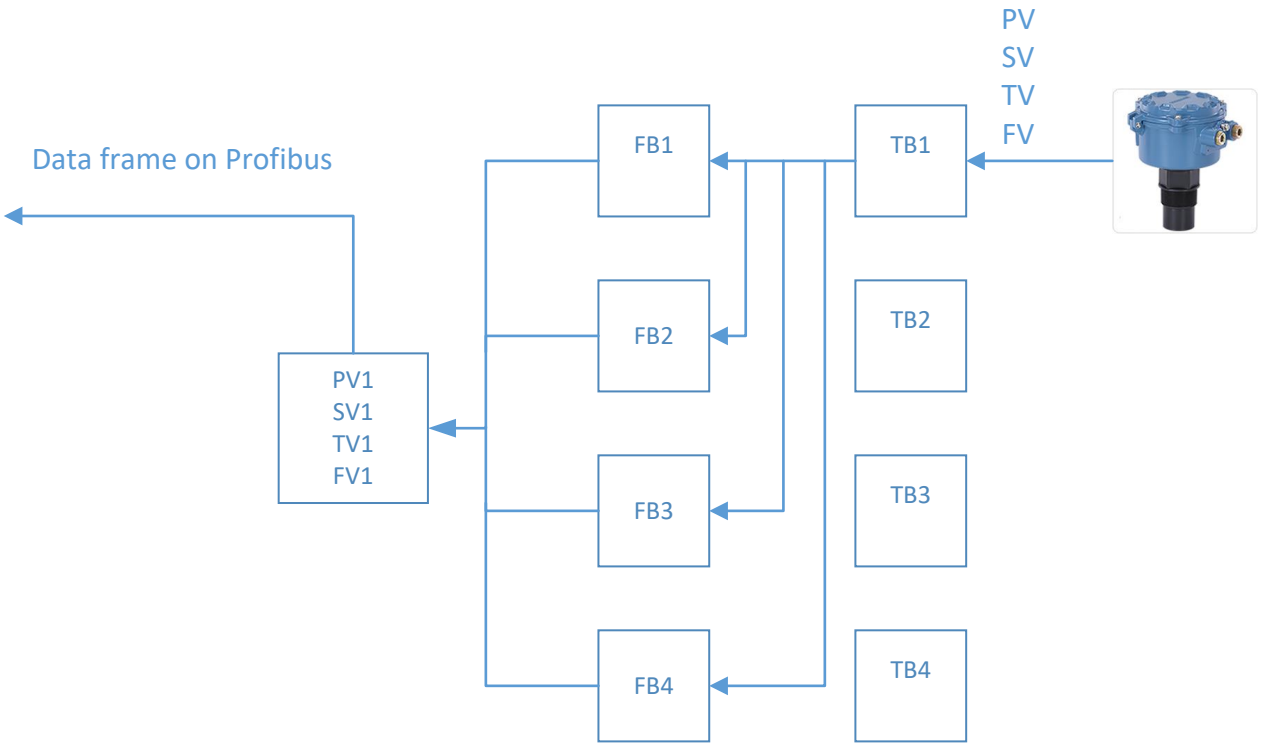


Figure 17. One HART transmitter connected to T50x

4.3. Coding of the variables

Each variable is coded according the Profibus PA profile. It consists of a four byte IEE785 float value and a one-byte status.

MSB							LSB	Profibus meaning	Comment
0	0	0	0	1	0	x	x	BAD Not connected	The device is powered up without connection to a HART transmitter on this channel
0	0	0	0	1	1	x	x	BAD Device failure	T50x HW failure
0	0	0	1	0	0	1	1	BAD No data	No HART reading- for the last xx s –
0	0	0	1	1	1	1	1	BAD Out of service	Operator initiated
0	1	0	0	0	1	1	1	Uncertain – Last usable Value	No HART reading- for the last xx s –
1	0	0	0	0	0	x	x	Good - Non cascade	value OK
								Alarm Flagging	
x	x	x	x	x	x	0	0	Ok No alarm	
1	0	0	0	1	0	0	1	Good Lo	
1	0	0	0	1	0	1	0	Good Hi	
1	0	0	0	1	1	0	1	Good Lo-Lo	
1	0	0	0	1	1	1	0	Good Hi-Hi	
x	x	x	x	x	x	1	1	Constant output	

Table 6: Coding of Status

4.4.Diagnosis

4.4.1. Diagnosis information from the HART Instrument

The Diagnosis is gather in a 32 bit structure containing Diagnosis information from each instrument, status on the HART communication and whether the Scanning of HART instruments were successful or not.

The NAMUR NE107 Diagnosis structure contains:

- HART device NAMUR NE 107 diag flags
- HART Communication Errors
- HART Communication Warning
- Internal Fault in T50x
- Scan error
- HART Additional Status

Using four 32 bit masks the user can select which of these flags shall be mapped to four NAMUR NE107 flags:

- Failure
- Out of Spec
- Function Check
- Maintenance required.

A PDM configuration tool will be required for this operation.

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Mask parameters determine how these flags shall be NAMUR flags, Fault, Function Check Maintenance required and Out of spec. The flags that are hooked will be mapped to the aggregated Diag flag

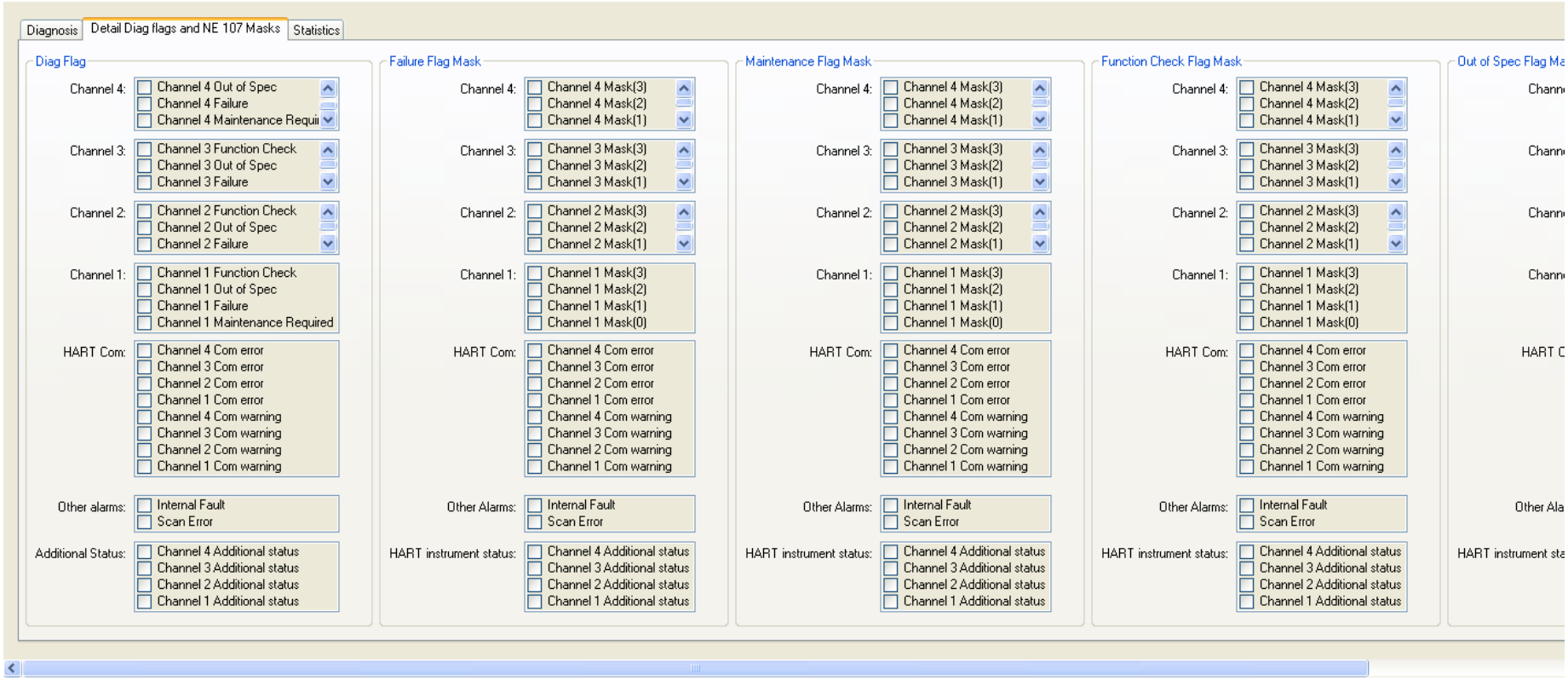

Figure 18. Diagnosis flags and NAMUR masks

The aggregated Diagnosis is shown in Figure 19:

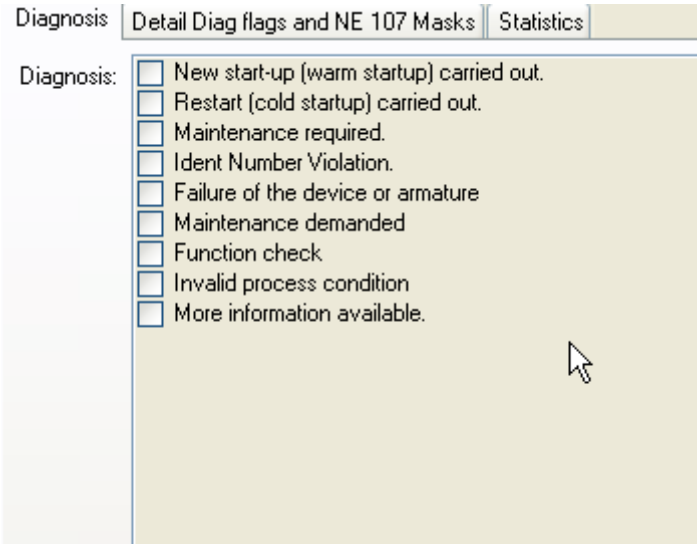

Figure 19. Aggregated Diagnosis according to NAMUR NE107

4.5.HART communication statistic

For each channel the HART communication is supervised. This information can help debug difficulties on a HART line. The HART Statistic window is shown in Figure 20

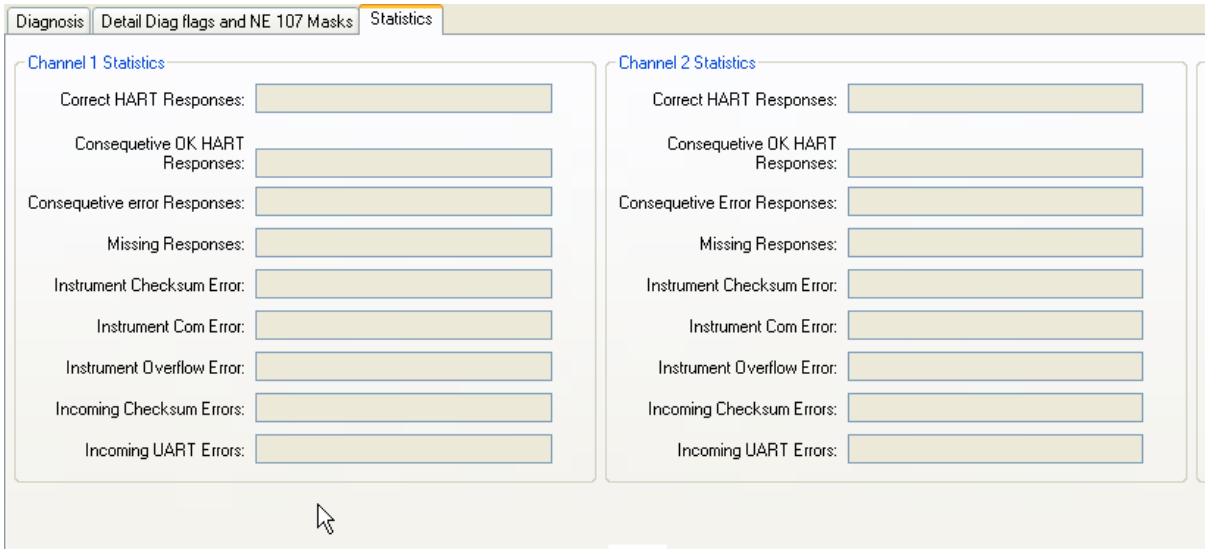

Figure 20. HART statistics

5. CONFIGURATION

The following configuration needs to be done:

1. Set Profibus address
2. Scan HART network
3. Select channels

Profibus Address is set by DIP switches or from a Profibus configurator

Scan HART network can be done using the utility T50x Configurator provided by Fint or from Simatic PDM. Scan HART network is also possible using the DIP switches, see Ch. 1.3.2.5

Select channels can be done using the utility T50x Configurator provided by Fint or from Simatic PDM. Default the PV from four separate HART transmitters channels are routed to the Cyclic-Data exchange frame. If more data shall be read from one transmitter, the channels has to be reconfigured.

T50x Configurator runs on a Windows 7 or Windows 10 PC. It connects to the T50x using a USB cable with a microUSB to the T50x. The USB plug on the T50x is hidden beneath a blind plug, see Figure 6 or Figure 12. The blind plug is easily opened using a small screw driver.

6. TECHNICAL SPECIFICATIONS

6.1. Technical specification T501

Mechanical:

Size	114,5 * 99 mm
Mounting	DIN rail
Module width	23,2 mm
Weight	192 gram
Housing	Plastic, IP-20 protection
DIP Switch	Profibus address (1-125)
Slide Switch	DP Terminator

Electrical:

Supply voltage	18....30 VDC
Supply current	60 mA MAX
HART Interface	16..24 VDC, 0,4..20mA

Environmental:

Operating temperature range	-40 °C to + 85 °C
Shock	IEC 600068-2-27
Vibration resistance	IEC 600068-2-6

Protocols and Ports:

Profibus protocol	DP-V0 / DP-V1, Slave
Profibus connector	DB9 Female
Profibus connector	Screw terminal
Profibus baud rates supported	9.6 kbit/s – 12 Mbits/s

Update rate / latency:

One HART instrument connected	max 1 sec latency
Four HART instruments connected	max 2,5 sec latency

6.1. Technical specification T500

Mechanical:

Size	114,5 * 99 mm
Mounting	DIN rail
Module width	23,2 mm
Weight	192 gram
Housing	Plastic Polyamid, IP-20 protection
DIP Switch	Profibus address (1-125)
Slide Switch	PA Terminator

Electrical:

Supply voltage	18....30 VDC
Supply current	60 mA MAX
PA input voltage	9.....32 VDC
HART Interface	16..24 VDC, 0,4..20mA

Environmental:

Operating temperature range	-40 °C to + 85 °C
Shock	IEC 600068-2-27
Vibration resistance	IEC 600068-2-6

Protocols and Ports:

Profibus protocol	DP-V0 / DP-V1, Slave
Profibus connector	Screw terminal
Profibus baud rate (PA)	31.25 kbits/s

Update rate / latency:

One HART instrument connected	max 1 sec latency
Four HART instruments connected	max 2,5 sec latency

7. APPENDIX A: SCANNING FAULTS

If a Scan Error is reported, check the following:

- All HART instruments are connected properly, ref 2.2.
- If there are more than one instrument when the first one has address 0.
- More than 4 instruments are connected
- One or more instrument has the malfunction bit set in device status.

If an instrument is not detected and no Scan Error is reported, check that each connected instrument has a unique short address.