Fieldbus International AS

The Modbus to Foundation Fieldbus gateway, the T710

Reference Manual

Fieldbus International AS

TABLE OF CONTENTS

About this document

The Reference Manual gives an overview of the capabilities and the use of the T710 DIN rail mounted generic Foundation Fieldbus gateway. Furthermore it explains how to configure the device.

The following abbreviations are used in this document:

FF	Foundation Fieldbus
PV	Primary Variable, dynamic variable in the transmitter
AI FB	Analog Input Function Block, measurement application object.
RB	Resource Block, device application object
TB	Transducer Block, Modbus application object
DD	Device Description, Electronic description of device application capability.
NI	National Instrument

Summary

The T710 capabilities can be summarized as follows:

- Interfaces up to four Modbus RTU devices to Foundation Fieldbus (FF)
- Supports Diagnostics Flags according to NAMUR NE107
- Supports transparent Read/Write services for configuration of Modbus devices
- Set-up services of T710 through the FF interface.
- Powered from 18V – 30 V instrument power
- The bus load is 13,8 mA

The instrument interface:

Protocol:
- Modbus RTU

Physical interfaces:
- RS 485

1. INTRODUCTION

1.1. Functional Description

The T710 is an FF compliant DIN rail mountable gateway for connecting Modbus RTU instruments (Modbus slaves) to FF.

Figure 1. the T710

Up to four Modbus instruments can be connected through one T710 module.

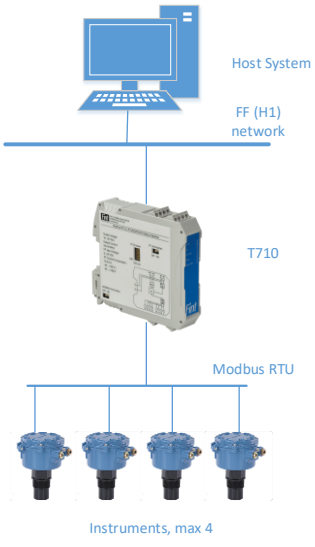

Figure 2. T710 used in an FF application

T710 has communication routines for communicating with a Modbus instrument (Modbus slave). Applying the T710 enables an existing Modbus instrument to become an FF compliant device.

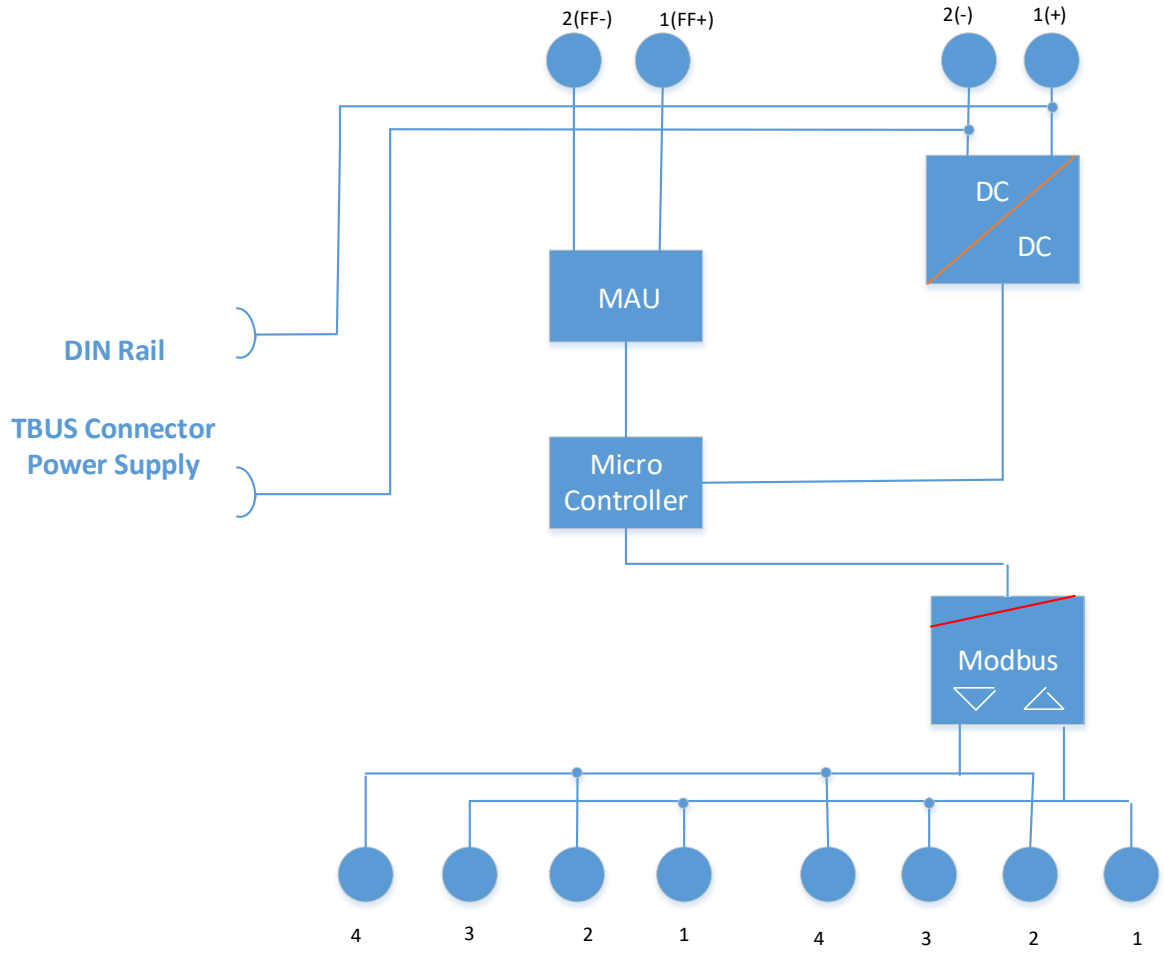

Figure 3 Functional Diagram

1.2. Mechanical Dimensions

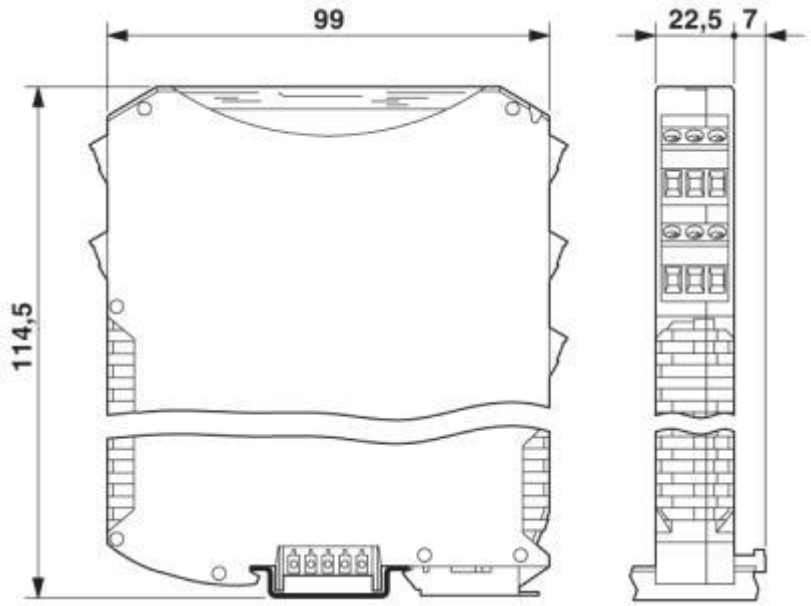

Figure 4 – ME MAX Dimensions

2. INSTALLATION

The T710 is designed for being mounted in a cabinet on a DIN rail.

2.1. Electrical Connections

The T710 contains 4 pluggable screw terminals.

The T710 shall use the connector pinout as shown in Table 1

Table 1 Connector Arrangement Table

Connector	Pin	Comment
Top connectors		
PWR	1	Positive supply to FGW
	2	Negative supply to FGW
	3	No Connection
	4	No Connection
FF	1	FF +
	2	FF -
	3	No Connection
	4	No Connection
Bottom connectors		
Modbus Con1	1	MODBUS Device 1 – Signal A
	2	MODBUS Device 1 – Signal B
	3	MODBUS Device 2 – Signal A
	4	MODBUS Device 2 – Signal B
Modbus Con2	1	MODBUS Device 3 – Signal A
	2	MODBUS Device 3 – Signal B
	3	MODBUS Device 4 – Signal A
	4	MODBUS Device 4 – Signal B
Other		
DIN clip	-	PE connection for EMC, see Figure 5
TBUS	1	Positive supply to T710 (pin 1 is at top of the TBUS connector
	2	Negative supply to T710

Figure 5 The TBUS connector

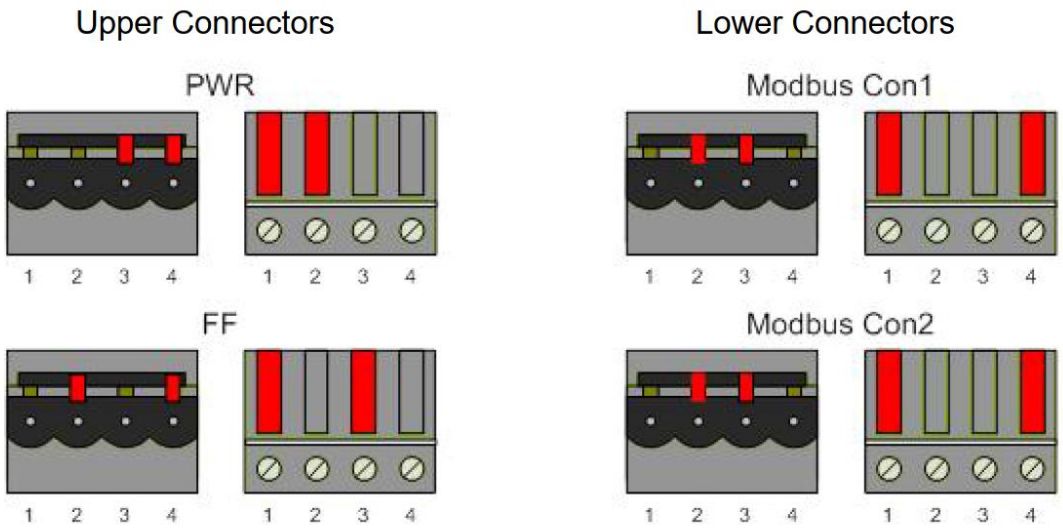

Figure 6 Connector Keying

2.2. Slide switches and DIP switch

2.2.1. Modbus termination

The RS485 Modbus line may be terminated in the T710. Whether to terminate is selected by a slide switch as indicated in Figure 5. There is one terminator serving all the four Modbus instruments. Internally they are connected together. The terminator terminates all four instruments.

2.2.2. FF termination

The Fieldbus lines may be terminated in the T710. Whether to terminate is selected by a slide switch as indicated in Figure 5.

2.2.3. DIP switches

One DIP switch is used for Simulation Mode, ON/OFF. The other switches are not in use.

2.2.4. Programming utility

Behind the panel on top of the device, there is an USB connector, see Figure 7, for software download.

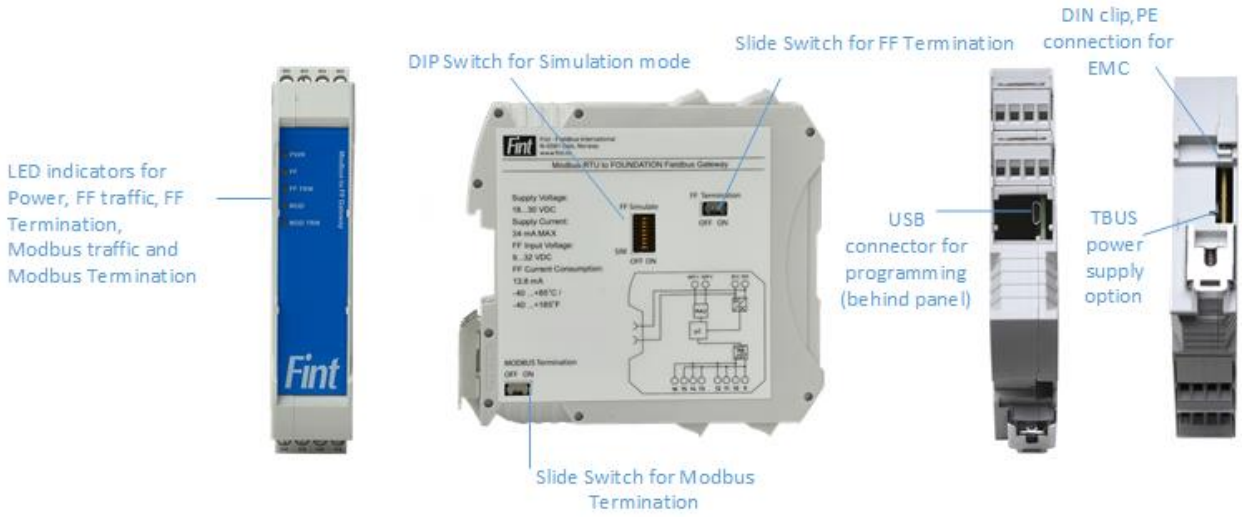

Figure 7 ***Front and Side Label mounted on T710, showing the functions***

2.3. Power, Termination and Diagnostic LEDs

There are five LEDs on the front. One for Power ON, One for Modbus Termination ON/OFF, one for FF Termination ON/OFF, one for the Modbus communication and one for the FF 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 Modbus LED indicates that there is no Modbus communication. The blinking frequency is determined by the configured time-out time on Modbus

3. OPERATION PRINCIPLE

3.1. Connecting Modbus devices

The T710 is a protocol converter, to allow legacy Modbus devices to communicate on an FF network.

Four channels are supported. The source of each channel is defined by a Modbus Device Address. Up to four Modbus devices may be connected. This implies four different Modbus addresses. The instruments are electrically interconnected.

The channels may be assigned to the same Modbus address. This will allow more information to be interchanged with one Modbus instrument.

NOTE: *Set-up can only be performed when the Channels are in Out of Service mode*.

Each Channel supports three types of traffic, transfer of measurements (PV), transfer of status/diagnostic information and Modbus instrument read/write services. The principle diagram for the communication is shown in Figure 6.

The PV, the status information and the configuration data can be located anywhere within the Modbus Register map. In order for the T710 to find the data, it must be configured. The configuration is done through the FF interface.

The FF read and write services are used to set-up the Modbus channels. These services should be writable for the OEM user and Read-only for the end-user.

The device parameters are organized in a Block structure consisting of a Resource Block (RB), Function Blocks (FBs) and a Transducer Block (TB). There are standard parameters defined for all these three Block categories.

The RB is used to describe the device's identity in the field, such as name, manufacturer, and serial number. There are no input or output parameters in the RB. T710 supports one RB.

The TB contains the setup parameters required to establish the Modbus communication for each channel. T710 supports one TB.

The Modbus communication is configured independently for each channel. The setup is performed using read and write services, by reading and writing to indexes in the TBs. Fint is providing a DD package that allows the configuration to be done from a DD based Host, like an NI Configurator.

3.1. Setting up the Modbus

The Modbus setup is generic for the four channels. The parameters for set-up is located in the RB.

Table 2 The Modbus setup parameters

Modbus baud rate	9 600, 19 200, 38 400, 57 600, 115 200 kbit/s
# stop bits	1 or 2 (1 is default)
Modbus Parity	0 = Odd parity 1= Even parity 2= No parity (default)
CRC byte order	0 = Normal byte order (default) 1 = Reverse byte order
Modbus Timeout	In ms (100ms default)

3.2. Channel communication services

For each of the four channels there is a set-up record.

The Modbus address is configured per channel. This implies that the PVs may reside in four different instruments (four different Modbus addresses). They may also be located in the same instrument.

.

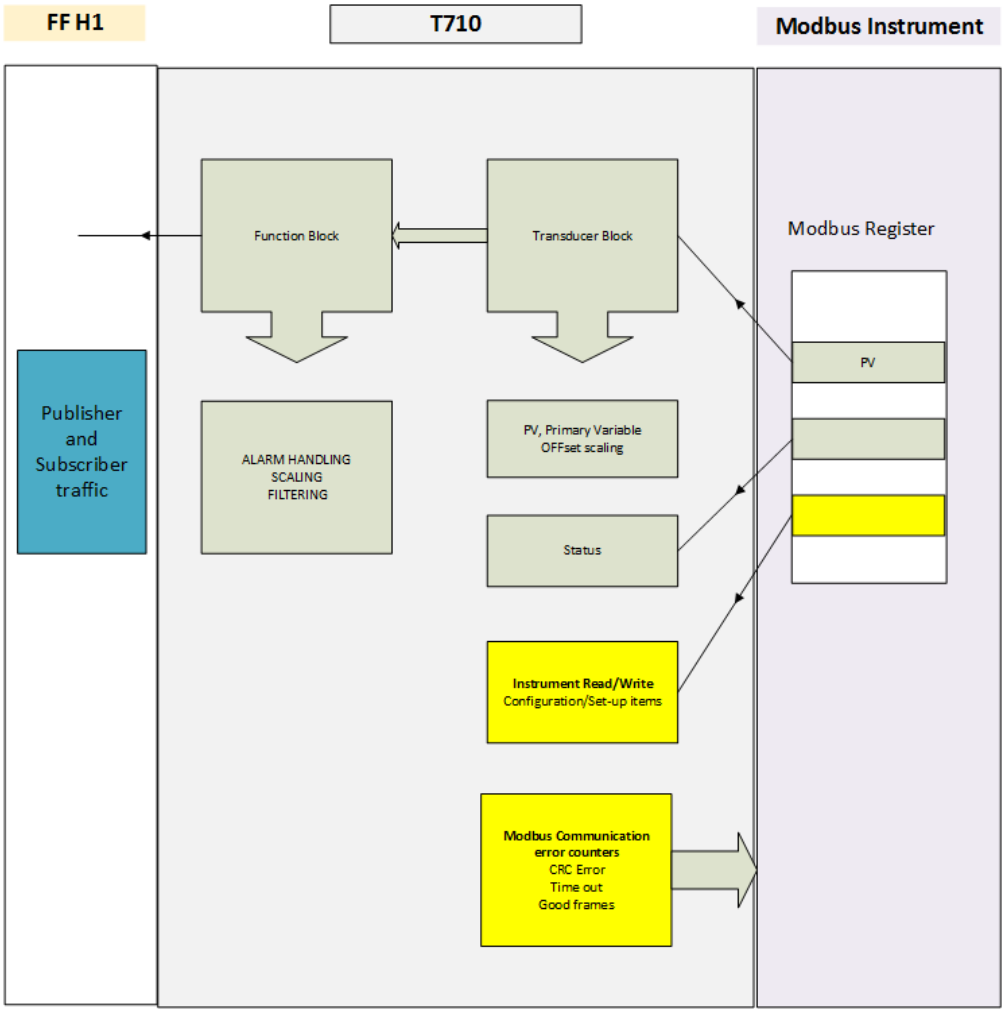

Figure 8 Channel communication services

3.2.1. Set-up of PV

The T710 can support up to 4 channels.

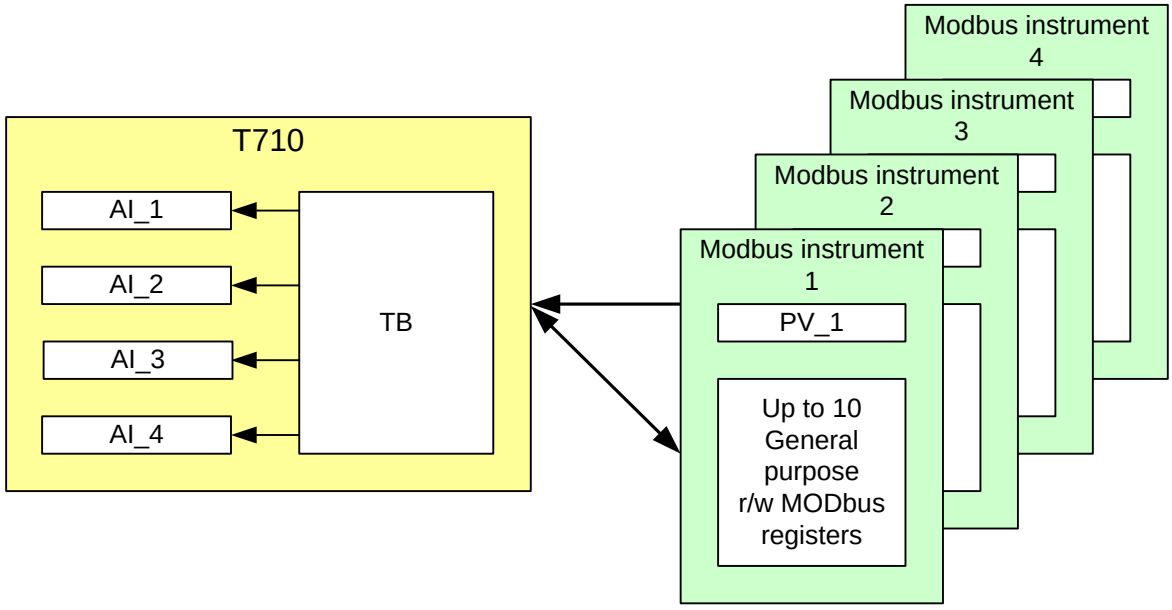

Figure 9 Four channels

Each channel supports one PV (Primary Variable). The PV is processed through an Analog Input Function Block (AI FB).

The PV is read from a Holding or Read register in the Modbus instrument. The register address and the Function code to be used shall be set-up by the user. It is possible to enter the Register address or the address that is sent on the bus. Hence if it is entered 30001, the address sent on the bus is 0 or if the entered value is 40001, the value in the data frame sent on the bus is 0. However, it will also be possible to enter 0 and the value sent on the bus will be 0.

The T710 supports a variety of data types and related byte ordering. The variable needs to be converted into the IEEE 785 float format in order to be processed through an AI FB. The data type parameter allows the user to select the right data type and byte ordering.

The PV type defines the data type and the byte ordering of the dynamic variable stored in the Modbus device. T710 needs this information in order to convert the variable to an IEEE format float used by Foundation Fieldbus. The PV may be defined as float, integer or unsigned integer in the Modbus instrument. T710 assumes that there are two bytes per register, so a float will be located in two adjacent registers. An integer will be located in one register.

The byte ordering is defined in the type. The byte is numbered so the Most Significant byte has the higher number.

Table 3. Byte order for PV

Data Type Modbus	Byte order	PV Type code
Float	4 3 2 1	0 (normal)
Float	2 1 4 3	1
Float	3 4 1 2	2
Float	1 2 3 4	3
Short Integer	2 1	4 (normal)
Short Integer	1 2	5
Unsigned short	2 1	6 (normal)
Unsigned short	1 2	7
Long Integer	4 3 2 1	8 (normal)
Long Integer	2 1 4 3	9
Long Integer	3 4 1 2	10
Long Integer	1 2 3 4	11
Long unsigned	4 3 2 1	12 (normal)
Long unsigned	2 1 4 3	13
Long unsigned	3 4 1 2	14
Long unsigned	1 2 3 4	15

If the PV is stored as a float or long in the Modbus device, T710 assumes that two consecutive registers are used. The Register address pointer in T710 will point to the lower address.

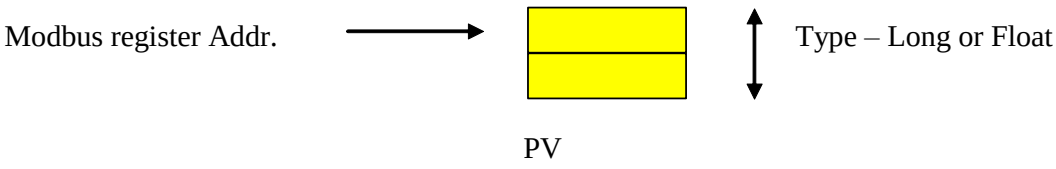

Figure 10 Storage when the PV is a float or Long

The scaling factors allow offset and gain to be adjusted before the variables are processed further.
If an Integer value is stored in a fixed format with one decimal, the scaling factor (gain) must be specified to “0.1” to allow T710 to interpret the value correctly.

The PV unit shall be specified by the user. There is no unit conversion in the T710 module. The PV unit is just for information purposes, but it is important that they are the same as the units in the AI_i, i=1,2,3,4, blocks XD_SCALE parameter, else it will be a block configuration error in the AI-i, i=1,2,3,4, block.

T710 adds a status byte to the PV. The status provides quality information about the measurement.

3.2.2. Diagnosis

For each channel the user can fetch four flags from the Modbus device. The flag must be located in one Modbus register which is denoted the Status register.

The operation on the Status register is defined by its Modbus register address and Function Code. Status register can either be Read or Holding registers. The four flags to be used in the register are selected using a Status Mask. The status mask is configured by the user.

Set-up is only allowed when the channel is in Out of Service mode.

The four selected flags are transferred to the NAMUR NE107 structure in the same order as stored in the status register. Do as follows,

1) Set-up the communication for reading a Status register from the Modbus instrument. It is possible to read one register from each instrument connected. The set-up is by Modbus Register address, Byte order and Function Code.
2) Select up to four bit-flags from the Status. This is done by using the Mask. The selected four bits will then be available for the Field Diagnostic structure. Regardless of their placement in the Status register, the bits will be renumbered 1-4 but with the same priority as in the Status register.
3) These bits can now be mapped into the Field Diagnostic structure. There is one structure for each of the four NAMUR flags, The NAMUR flag MAP parameter determines which bit-flag shall be mapped to each NAMUR flag. The NAMUR flag MASK determines if some of the bits shall not contribute anyway.
4) The Priority parameter must be set in order for the setting to be taken into consideration.

The Modbus communication is supervised. If the communication on one channel is unstable, a warning flag is set, if it stops working, an error flag is set. This is mapped to the Field Diagnostics in the same manner as described above.

If the Modbus registers are erroneously set, Modbus device is returning Error Codes and the Configuration Error Flag is set.

The NAMUR NE107 Diagnosis structure contains:

- Modbus Device Status Flags
- Modbus Device Communication Errors
- Modbus Device Communication Warning
- Modbus Device Configuration Error.

Map and mask parameters determine how these flags shall be NAMUR flags, Fault, Function Check Maintenance required and Out of spec.

3.2.3. Transparent Read/Write services.

For each channel there is a block of up to ten consecutive Modbus Read/Write Holding registers, MODBUS_RW_REGS_x. They can be reached from the FF control system. This block of up to ten registers is characterized with a start address (The lower address of the block) and number of registers. They start at Modbus register MODBUS_RW_REGS_START_ADDRESS. MODBUS_RW_REGS_NUM_OF defines how many of the ten registers that is used. It is possible to swap the byte ordering of the registers if required by writing 0 (byte order 1-0, default) or 1 (byte order 0-1) to the parameter MODBUS_RW_REGS_BYTE_ORDER.

The content of these registers will be written to the Modbus device when the user is writing to the corresponding indexes of the T710.

Read back of Modbus rw registers:

The Modbus rw registers are read back at request the from the Host:

In each MODBUS_RW_REGS_x record, x=1,2,3 or 4, there is one subindex (1) UP_DATE_RW_REGS which function as follows:

i.) To trigger a read back of a rw-register a value of 1 (enumerated as Update_RW_regs) is written into the MODBUS_RW_REGS_x.UPDATE_RW_REGS.

ii.) As long as a new register value is NOT ready, T710 sets the value of 2 (enumerated as Update in progress) MODBUS_RW_REGS_x.UPDATE_RW_REGS.

iii). When the value of the MODBUS_RW_REGS_x.UPDATE_RW_REGS is set to 3 (Enumerated as Updated RW regs ready) the updated values of MODBUS_RW_REGS_x can be read by the Host.

iv). At start-up all configured rw-registers are read out from each Modbus slave.

v) A Host is only allowed to write the values 0 and 1 to the MODBUS_RW_REGS_x.UPDATE_RW_REGS. In fact it must terminate the read sequense of rw-registers by writing a 0 (No update) to MODBUS_RW_REGS_x.UPDATE_RW_REGS after the updated rw-registers has been read out. Or in the unlikely event that the MODBUS_RW_REGS_x.UPDATE_RW_REGS is stuck at the value 2.

vi). Writing to a Modbus rw-register or to MODBUS_RW_REGS_x.UPDATE_RW_REGS is only allowed when the transducer block is in OoS mode.

vii). When the transducer block mode is changed from Auto to OoS all the configured rw-registers are re-read. This will be indicated by the value 3(Updated RW regs ready) in the MODBUS_RW_REGS_x.UPDATE_RW_REGS parameter. This parameter can be left in this state after the transducer block is changed to Auto, but it is not recommended. After a mode change to OoS the MODBUS_RW_REGS_x.UPDATE_RW_REGS always goes through the sequence 0 (3) -> 1 -> 2 -> 3 (data ready)

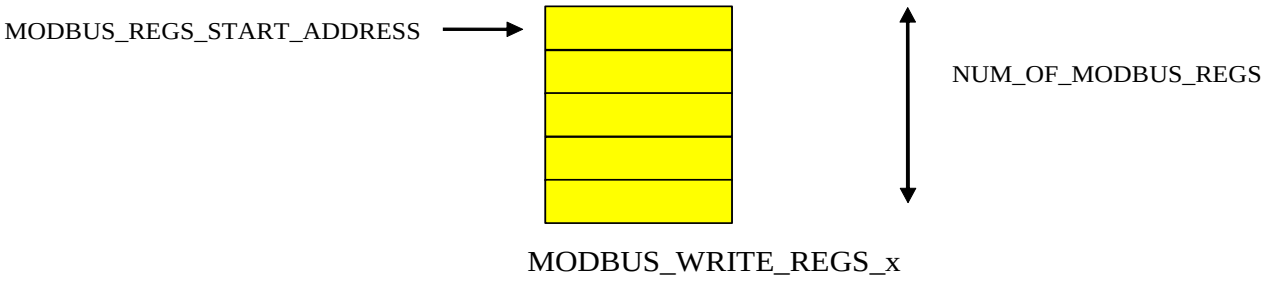

Figure 11 Read/Write registers

3.2.4. Configuration windows in the NI configurator

How they appear under configuration is shown below.

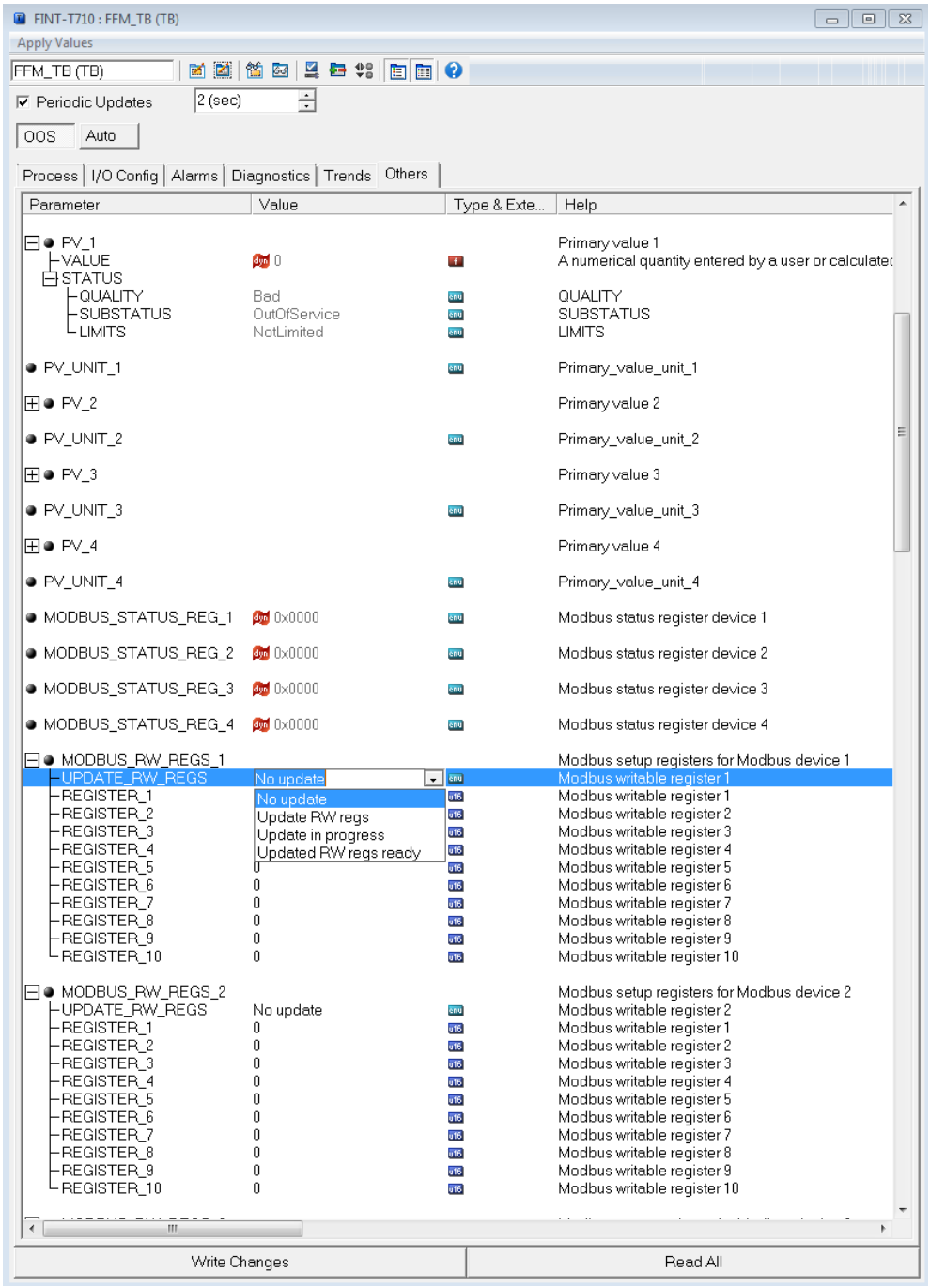

Figure 12 Transducer Block with R/W registers – ten per channel

The picture is a NI configurator picture of the Transducer Block parameters. There is one dynamic variable (PRIMARY_VALUE) per channel. The MODBUS_SETUP contains the communication settings for the Modbus. Each channel is set-up individually and the related configuration parameters are in MODBUS_REG_SETUP_x. The communication statistics per channel is shown in MODBUS_STATISTICS_x.

The picture below shows the MODBUS_COM_SETUP parameters and the set-up parameters for each channel, MODBUS_REG_SETUP_x. The variables can be located in four different Modbus devices; hence the Modbus device address is part of the set-up for each channel.

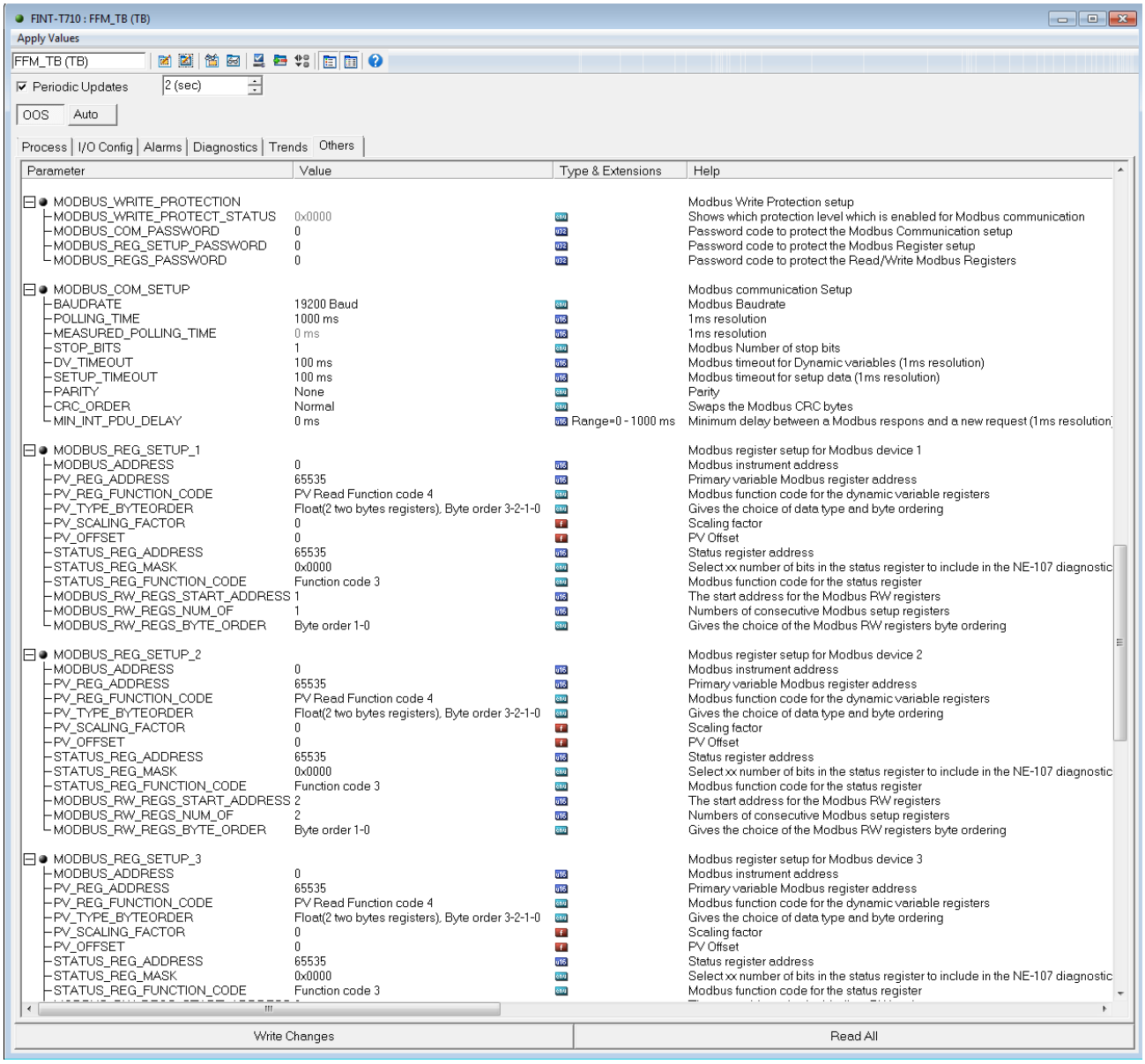

Figure 13 Modbus set-up and configuration of the four channels

3.2.5. Write protection of Modbus set-up

T710 has three levels of write protection of the Modbus registers. Each level has its individual passcode according to the table below:

Parameter(s)	Passcode	Description
MODBUS_COM_SETUP	1014	Protection of the Modbus Communication setup
MODBUS_REG_SETUP_i,i=1,2,3,4	2037	Protection of the Modbus register setup
MODBUS_RW_REGS_i, i=1,2,3,4	4084	Protection of the Modbus read/write registers

Table 4 Write protect Pass codes

Each protection level is implemented as a toggle function:
Entering the correct passcode turns the protection ON if OFF, and vice versa.

The enabled protection level is stored in EEProm and thus remembered through power cycling.
When a correct passcode is entered the Protection status is shown in the Modbus write protection status parameter. (See below).
The passcode is set to zero by the device immediately after it is entered so that it not viewable if you re-open the Transducer Block

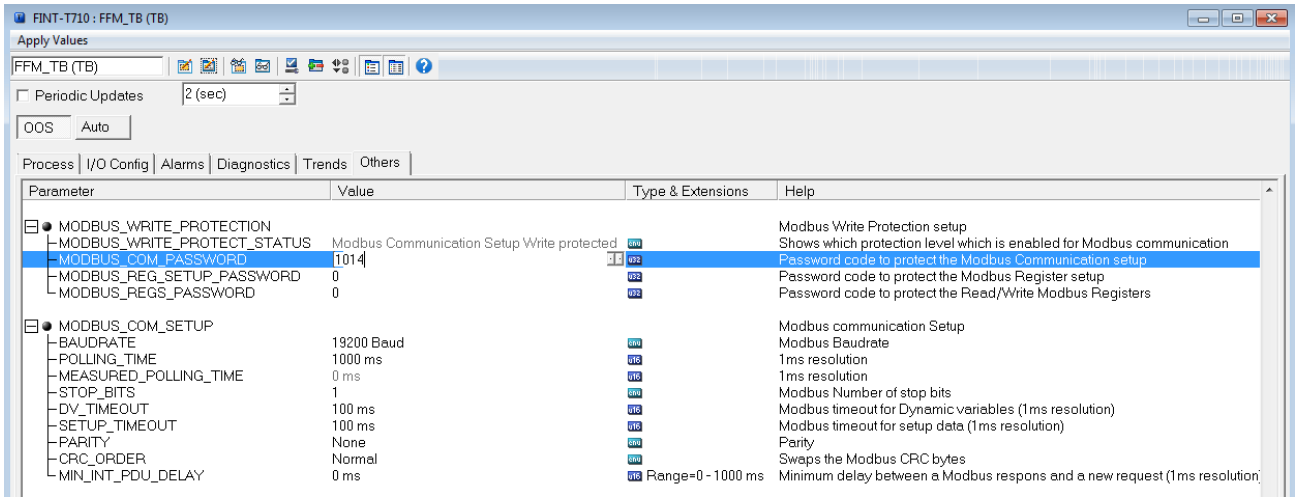

Figure 14 Pass codes

4. TECHNICAL SPECIFICATIONS

Mechanical:

Size	114,5 * 99 mm
Mounting	DIN rail
Module width	23,2 mm
Weight	126 gram
Housing	Plastic Polyamid, IP-20 protection
DIP Switch	Simulation on/off
Slide Switch	FF Terminator
Slide Switch	Modbus Terminator

Electrical:

Supply voltage	18....30 VDC
Supply current	34 mA MAX
FF input voltage	9.....32 VDC
Current draw	13,8 mA

Environmental:

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

Protocols and Ports:

Number of FF ports	1
Number of Modbus ports	4
FF protocol	H1, Slave
Modbus protocol	Modbus RTU, Master
Modbus serial standard	RS-485

5. OPERATIONAL BEHAVIOR

5.1. RUN-TIME

The T710 controls the reading of variables from the Modbus instruments. The PV and the Modbus data string will be read periodically if their register address is different from 0xFFFF.

If the instrument module has failed to respond to ten requests for data, it is defined as failing. This is flagged in the status for PV and will show “Status bad. Device failure”

When a variable (PV) is read on Modbus, it will be stored in the related Transducer Block and calculated through the Analog Function Block connected to this Transducer Block

5.2. Modbus

The Modbus RTU protocol is used. There is no length field in the frame. The frame is supposed to be transmitted without gaps between bytes. The frame is by definition completed when there has been silence for 3.5 characters.

If an instrument does not respond within the specified time-out time, the T710 Modbus protocol will time out and continue with other requests.

Function Code 3 (Read Holding registers) or Function Code 4 (Read Input registers) is used to read the dynamic variables.

The Function code is selected in the set-up and is selected individually per variable.

.