Terwin models
µ400P, µ500PT, µ600P & µ700PT
Process Indicators/Alarm Controllers

Modbus Communications Manual

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1. INTRODUCTION

Read this chapter before powering the unit.

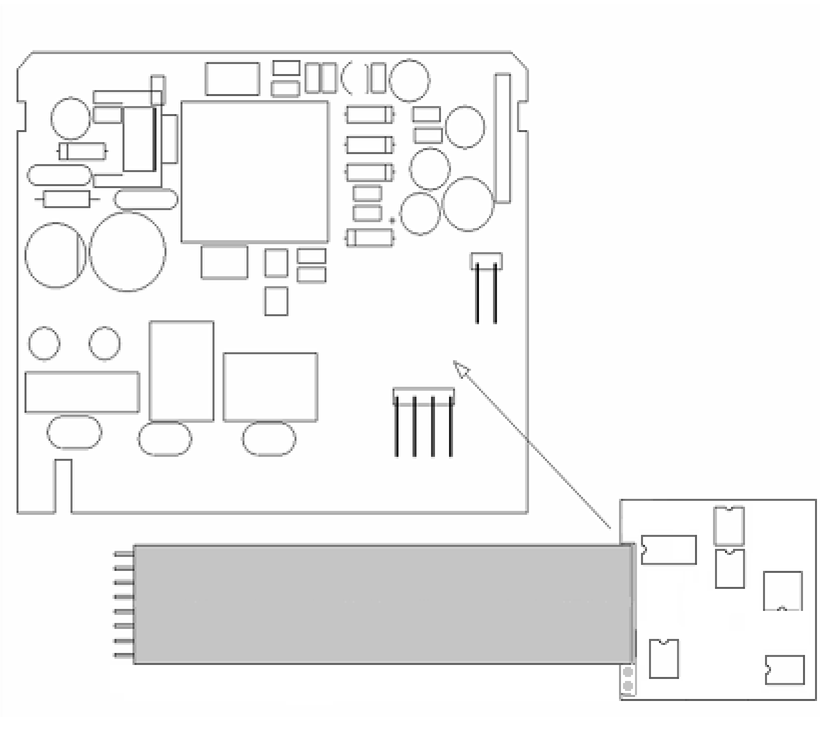
This manual is intended for users requiring digital communications with the MODBUS protocol for supervision, control and configuration of processes via the models µ400P or µ500PT indicators from TERWIN.

It is considered that the user has basic familiarity with communications protocols, and with operation of these series indicators (see the instructions manuals for operation of these indicators).

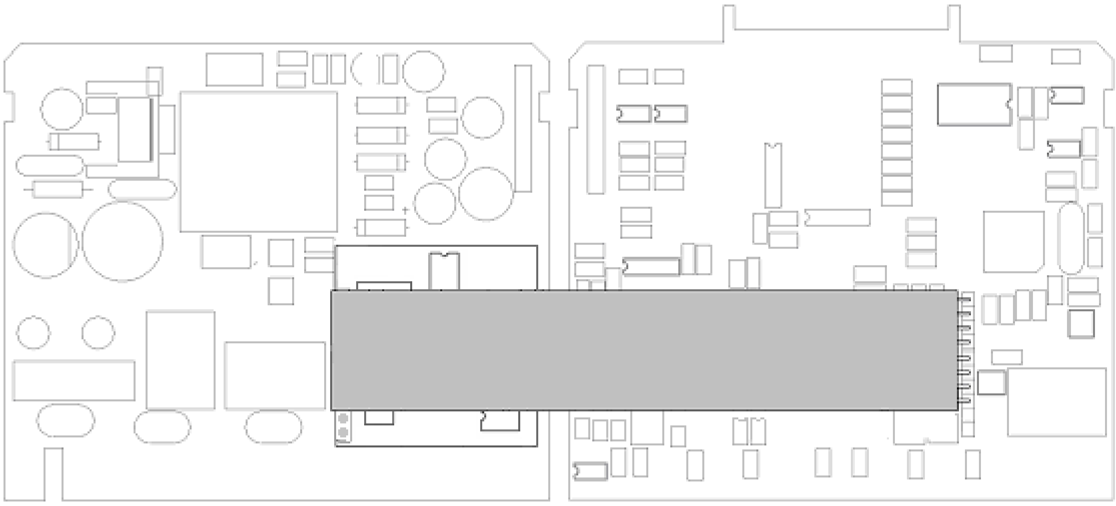
1.1. Installing the communications card

Before installing the Modbus module, the indicator must be extracted from its enclosure and the board with output connectors must be identified.

Install Modbus module carefully, in a way that all terminals from µ400P/µ500PT power supply circuit fit into Modbus module connectors placed on the bottom side.



Plug the other Modbus module connector to the µ400P/µ500PT CPU board as shown in the figure below.



Once the Modbus module is installed, the communications are accessible from terminals 11,12 and 13 (see section 2.2).
Power up the instrument and set the menu option OPT to 1 to activate the communications module (see section 4. for more parameters)

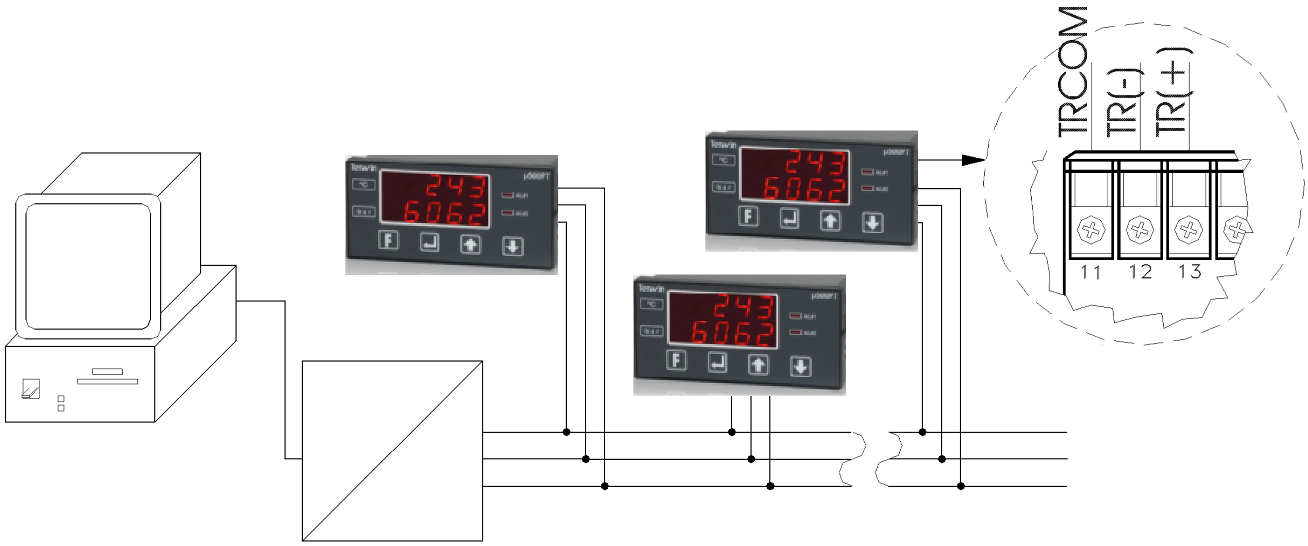
2. RS485 COMMUNICATIONS

2.1. RS485 Standard

The RS485 communications standard enables connection of one or more instruments via two conductors with a maximum length of 1200 m. In addition, it is advisable to connect a ground/shield wire as a common, in order to provide the line with additional noise protection.

2.2. Connections

The µ400P and µ500PT models admit connections to RS485 buses via two conductors plus one additional earth one. To use an RS485 connection from a PC, an RS-3232/RS485 converter needs to be inserted. If the converter provides RS485 communications to 4 conductors, the terminals marked as TX- should be connected to RX- and, in turn, the terminals marked TX+ to RX+. In this way, two lines will be obtained, which we will identify as TR+ and TR-.



In addition, just after the last instrument in the line, a 220-Ohm termination resistance should be connected in the line between TR+ and TR-.

Run the communications cables along different paths from the power leads.

The communications leads can be run next to signal leads if these are not exposed to interference source. We recommend using twisted pair cables, with a capacity between conductors of less than 60pF, rated characteristic impedance at 100 kHz of 100 Ohm, and a rated resistance of less than 100/Ohm/km (minimum 24 AWG conductors).

3. MODBUS PROTOCOL

3.1. Introduction

The MODBUS protocol defines a message structure that can be recognised by different units, regardless of the type of communications network used. The protocol describes the process for accessing information from a unit, how this should respond, and how error situations are notified.
The MODBUS protocol defines a digital communications network with a single master and one or more slave units.

3.2. Transmission mode

The transmission mode is the structure of the units of information contained in a message. The MODBUS protocol defines two transmission modes: ASCII (American Standard Code for Information Interchange) and RTU (Remote Terminal Unit). In a network of units connected by the MODBUS protocol, units **CANNOT** be shared by using different transmission modes.
The µ400P and µ500PT communicate in RTU mode.

3.3. Message structure

A message consists of a sequence of characters that can be interpreted by the receiver. This sequence of characters defines the frame.
To synchronize the frame, the receiver units monitor the time interval elapsing between characters received. If an interval greater than three and a half times the time required to transmit a character is detected, the receiver unit ignores the frame and assumes that the following character it receives will be an address.

3.5T	**ADDRESS**	**FUNCTION**	**DATA**	**CRC**	**3.5T**
3.5 bytes	1 byte	1 byte	N bytes	2 bytes	3.5 Bytes

3.3.1 Address

The address field is the first of the frame after the synchronization time. It indicates the unit the message is addressed to. Each unit in the network must have a unique address assigned, other than zero.
Likewise, when a unit responds to a message, it must first send its address so that the master recognises the source of the message.
MODBUS enables messages to be sent to all the units at the same time, using the zero address to do this. However, to prevent conflicts with other units in the network, the µ400P and µ500PT do not accept this type of message.

3.3.2 Function

The function field tells the unit addressed what type of function it is to perform.
The µ400P and µ500PT models accept the following functions:

Code	Function
01 or 02	Read N bits (max. 255)
03 or 04	Read N registers (max 127)
05	Write 1 bit
06	Write 1 register
07	Read instrument status byte

See section 3.4 for a description of the functions

3.3.3 Data

The data field contains the information needed for the units to be able to perform the functions requested, or the information sent by the units to the master in response to a function.

3.3.4 CRC

The CRC field is the last in the frame and enables the master and the units to detect transmission errors. Occasionally, due to electric noise or interference of any other kind, certain modifications may occur to the message while it is being transmitted. The error control by CRC ensures that the receiver units or the master will not perform wrong actions due to accidental modification of a message.
The units **DO NOT** send any response when they detect a CRC error in the frame received.
For CRC calculation, neither the stop nor parity bits are considered, just the data.
The sequence for CRC calculation is described as follows:

1. Load a 16-bit register to 1's.
2. Perform an exclusive OR of the first 8 bits received with the high register byte, saving the result in the register.
3. Shift the register one bit to the right.
4. a) If the overflow bit is 1, perform an exclusive OR of the value 1010 0000 0000 0001 with the content of the register and save it in the register.
4. b) If the overflow bit is 0, go back to step 3.
5. Repeat steps 3 and 4 until 8 bit shifts have been made.
6. Perform an exclusive OR of the following byte of the frame with the 16-bit register.
7. Repeat steps 3 to 6 until all the bytes in the frame have been processed.
8. The content of the 16-bit register is the CRC, which is added to the message with the most significant bit first.

3.4. Description of the functions

3.4.1 Read N bits (Function Code 01 or 02)

This function enables the user to obtain the logical values (ON/OFF) of the bits of the unit addressed. The response data are packaged in bytes so that the first bit requested occupies the least significant bit of the first data byte. The next ones follow on so that, if they are not a multiple of 8, the remaining bits of the last byte are set to zero.

Master-unit frame:

Address of unit	**Function Code (01 or 02)**	**Address of first bit**		**Number of bits to be read (max. 255)**		**CRC**	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Unit-master frame:

Address of unit	**Function Code**	**Number of bytes read**	**First data byte**	**............**	**Last data byte**	**CRC**	
1 byte	1 byte	1 byte	1 byte	....	1 byte	MSB	LSB

For example: Read 2 bits from bit with address 4, of indicator with address 2.

Master-unit:

Address of unit	**Function Code**	**Address of first bit**		**Number of bits to be read**		**CRC**	
02	01	00	04	00	02	FC	39

Unit-master:

Address of unit	**Function Code**	**Number of bytes read**	**First data byte**	**CRC**	
02	01	01	03	11	CD

The response tells us that the bits of address 4 (AL1) and 5 (AL2) are set to 1. So, alarms AL1 and AL2 are activated. The response has assigned zeros to the addresses which have not been asked for from the master, which does not mean that their real value is zero.

3.4.2 Read N Registers (Function Code 03 or 04)

This function enables the user to obtain the registers value of the unit addressed. These registers store the numerical values of the indicator's parameters and variables. The range of the data goes from 0 to 65536 (see section 4.2). The data corresponding to addresses of registers going over the last valid address of parameters are returned as zero (00 00).

Master-unit frame:

Address of unit	**Function Code (03 or 04)**	**Address of first register**		**Number of registers to be read (Max. 127)**		**CRC**	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Unit-master frame:

Address of unit	**Function Code**	**Number of bytes read**	**Value of first register**		**......**	**Value of last register**		**CRC**	
1 byte	1 byte	1 byte	MSB	LSB	......	MSB	LSB	MSB	LSB

For example: Read 3 registers as from the register with address 2, of the indicator with address 2.

Master-unit:

Address of unit	**Function Code**	**Address of first register**		**Number of registers to be read**		**CRC**	
02	03	00	02	00	02	A4	38

Unit-master:

Address of unit	**Function Code**	**Number of bytes read**	**Value of first register**		**Value of second register**		**Value of last register**		**CRC**	
02	03	06	00	00	00	C8	00	01	80	A6

The response tells us that the registers of address 2 and 3 (SP.A2) and 4 (C.A1) have, respectively, the hexadecimal value of 000000C8 and 0001. So, the corresponding decimal values are: SP.A2=200 and C.A1=1.

3.4.3 write a bit (Function Code 05)

This function enables the user to set the logical values (ON/OFF) of the bits of the unit addressed. To set a bit value of 0, 00h must be sent and to set a bit value of 1t, 01h or FFh. This value should be written in the **most significant byte**.

Master-unit frame:

Address of unit	**Function Code (05)**	**Address of bit**		**Value of bit**		**CRC**	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Unit-master frame:

Address of unit	**Function Code (05)**	**Address of bit**		**Value of bit**		**CRC**	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

For example: Set a value 1 to the bit of address 8, of the indicator with address 2.

Master-unit:

Address of unit	**Function Code**	**Address of bit**		**Value of bit**		**CRC**	
02	05	00	08	01	00	4D	AB

Unit-master:

Address of unit	**Function Code**	**Address of bit**		**Value of bit**		**CRC**	
02	05	00	08	01	00	4D	AB

The response tells us that bit 8 (Alarm 1 mask) has been set, thus the Alarm 1 is masked.

3.4.4 Write a register (Function code 06)

This function enables the user to modify the content of the parameters of the unit addressed. The values are sent scaled in accordance with the scale factor corresponding to each parameter, in a range between 0000h and FFFFh (see section 4.2).

Master-unit frame:

Address of unit	Function Code (06)	Address of register		Value of register		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Unit-master frame

Address of unit	Function Code (06)	Address of register		Value of register		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

For example: Assign the value 4 (0004h) to the register of address 04, of the indicator with address 2.

Master-unit:

Address of unit	Function Code	Address of register		Value of register		CRC	
02	06	00	05	00	04	98	3B

Unit-master:

Address of unit	Function Code	Address of register		Value of register		CRC	
02	06	00	05	00	04	98	3B

The response tells us that register 5 (Alarm 2 configuration) has received the value of 4 (Alarm 2 is Low, Reverse action).

Some parameters use two registers (Set points, bias, etc...) to store their values. To set values greater than 65535 o below 0 to these parameters, both registers must be set correctly. e.g. setting "Bias channel 1" to -200 (ffffff38h) should be done by writing ffffh to register 28 and ff38h to register 29. It's recommended to write the HIGH WORD first.

3.5. Error codes

Generally, errors appearing during operations to access and program units relate to invalid data in the frame. When a unit detects an error of this type, the response to the master consists of the unit's address, the function code, the error code and the CRC. To indicate that the response is an error notification, the most significant bit of the function code is set to 1.

The µ400P and µ500PT models use the following error codes:

Error code	Description
01	Invalid function
02	Invalid data address field
03	Invalid data field
06	Busy: Accessing the EEPROM.

With reference to these models, the following cases should be considered:

If a unit receives a request for reading of N bits and goes over the last accessible address, the indicator sends the value 00 in response for non-existent addresses.
If a unit receives a request for reading of N registers and goes over the last accessible address, the indicator sends the value 00 00 in response for non-existent addresses.
If a unit receives a request for writing a register defined as "read only", the instrument sends error code 02 in response.
If a unit receives a request for writing a register and a user is modifying a parameter from the keyboard at this moment, the indicator sends error code 06 in response.
If the address of the first register is greater than the last valid address, the indicator sends error code 02 in response.
If a unit receives a request with an invalid function, the indicator sends error code 01 in response.
If a unit receives a request for writing of a register or bit corresponding to an option not installed in the instrument, the indicator sends error code 03 in response.

4. OPERATION OF THE INDICATORS

Models µ400P and µ500PT equipped with an RS485 interface for Modbus connection must have the **OPT** parameter set to 1.
The communications are made with a format of 1 start bit, 8 data bits and 1 stop bit. In addition, four parameters can be configured.

Addr	**Address of the indicator in the Modbus network**	
	Minimum value	0(Modbus disabled)
	Maximum value	255
Speed	**Baud Rate**	
	Value	Baud Rate
	0	2400 bps
	1	4800 bps
	2	9600 bps
	3	19200 bps
Prty	**Parity**	
	Value	Parity
	0	None
	1	Even
	2	Odd
dLAy	**Delay Time**	
	Minimum value	0
	Maximum value	10

The **dLAY** value is the indicator's waiting time before answering a frame sent by the master. The time is the result of multiplying the **dLAY** value by 10 ms. This parameter is required when delays occur in the switching of the receive/send modes in the RS232/RS485 conversion units. In this way, a wait time is created, enabling the communications to be synchronized and conflicts prevented.

4.1. Modbus table of addresses

There follows a list of all the parameters available via communications in the µ400P and µ500PT models. All the keyboard-accessible parameters are available via the communications. However, due to the fact that the µ400P and µ500PT models can be configured for a great variety of applications, if read or write of a parameter relating to an option not configured in the instrument is accessed, the instrument responds with a code 03 error message (see section 3.5).

4.1.1 Modbus bit addresses

MODBUS bit address	Parameter
0	1= over range channel 1*
1	1=under range channel 1*
2	1= over range channel 2*
3	1=under range channel 2*
4	1=AL1 Activated *
5	1=AL2 Activated *
6	0= Channel 1 AL1 / 1= Channel 2 AL1 *
7	0= Channel 1 AL2 / 1= Channel 2 AL2 *
8	1 = AL1 mask activated
9	1 = AL2 mask activated
10	0 = °C / 1 = °F
11	0 = µ400P / 1= µ500PT*
12	Security level
13	1= Tare activated *
14	1= Menu is accessed by user *

*Read only

4.1.2 Modbus registers addresses

Add	Parameter	Display Reading	Position	µ400P	µ500PT	Low Limit	High Limit	Notes
0	Alarm 1 Set Point*	**SP.A1**	HIGH WORD	RW	RW	Probe	Probe	
1			LOW WORD					
2	Alarm 2 Set Point*	**SP.A2**	HIGH WORD	RW	RW	Probe	Probe	
3			LOW WORD					
5	Alarm 1 Configuration	**C.A1**		RW	RW	0	7	
7	Alarm 2 Configuration	**C.A2**		RW	RW	0	7	
8	Alarm 1 Hysteresis*	**Hy.A1**	HIGH WORD	RW	RW	Probe-SP.A1	0	
9			LOW WORD					
10	Alarm 2 Hysteresis*	**HY.A2**	HIGH WORD	RW	RW	Probe-SP.A2	0	
11			LOW WORD					
13	Channel Alarm 1	**CH.A1**		NP	RW	2	1	
15	Channel Alarm 2	**CH.A2**		NP	RW	2	1	
17	Alarm 1 Mask	**NAS.A1**		RW	RW	1	0	Activate/ No activate
19	Alarm 2 Mask	**NAS.A2**		RW	RW	1	0	Activate/ No activate
21	Alarm 1 activation delay	**dLY.A1**		RW	RW	300	0	Seconds
23	Alarm 2 activation delay	**dLY.A2**		RW	RW	300	0	Seconds
25	Alarm 1 Manual Deactivation	**Lch.A1**		RW	RW	1	0	Manual/Auto
27	Alarm 2 Manual Deactivation	**Lch.A2**		RW	RW	1	0	Manual/Auto
28	Bias channel 1*	**BIAs.1**	HIGH WORD	RW	RW	99999	-9999	
29			LOW WORD					
30	Bias channel 2*	**BIAS.2**	HIGH WORD	NP	RW	99999	-9999	
31			LOW WORD					

Add	Parameter	Display Reading	Position	µ400P	µ500PT	Low Limit	High Limit	Notes
33	Input probe	**Inp**		RW	RW	(µ400P) 14 (µ500PT) 12	0	0:J 1:L 2:K 3:N 4:T 5:R 6:S 7:RTD -200 a 600 8:RTD -99.9 a 200.0 9:Linear 0-5V 10:Linear 0-10V 11:Linear 0-20mA 12:Linear 4-20mA 13:Pressure 14:Gauge
35	Units	**Unit**		RW	RW	1	0	0: °C, 1: °F
37	Decimal point (linear input)	**dP**		RW	RW	3	0	
38 39	Start Linear Scale*	**In.L**	HIGH WORD LOW WORD	RW	RW	End	-9999	
40 41	End Linear Scale*	**In.H**	HIGH WORD LOW WORD	RW	RW	99999	Start	
43	Decimal point (pressure)	**dP**		RW	NP	3	0	
44 45	FSV pressure*	**FSU**	HIGH WORD LOW WORD	RW	RW	99999	0	
47	Display Filter (pressure)	**FILtr**		RW	RW	99	0	% Filtered
51	Decimal Point (gauge)	**dP**		RW	NP	3	0	
52 53	FSV gauge	**FSU**	HIGH WORD LOW WORD	RW	NP	99999	0	
69	Modbus Address	**Addr**		RW	RW	240	0	

Add	Parameter	Display Reading	Position	µ400P	µ500PT	Low Limit	High Limit	Notes
71	Baud Rate	**Speed**		RW	RW	4	0	0: 2,400 1: 4,800 2: 9,600 3: 19,200
73	Parity	**Prty**		RW	RW	2	0	0: None 1: Even 2: Odd
75	Modbus Delay	**dLAy**		RW	RW	10	0	
76 77	Password	**PASS**	HIGH WORD LOW WORD	RW	RW	99999	0	
79	Protection Level	**LEUEL**		RW	RW	1	0	
81	Pressure Zero Calibration Value	Internal		RW	RW	65535	Span Value	**0** stands for the voltage value corresponding to the start of the pressure scale. **65535** stands for the voltage value corresponding to the end of the pressure scale.
83	Tare	Internal		R	NP	65535	0	
85	Pressure Span Calibration Value	Internal		RW	RW	Zero Value	0	
87	Gauge Zero (mV) * 100	**ZErO.r**		RW	NP	Gauge Span	-300	
89	Gauge Span (mV) * 100	**SPAN.r**		RW	NP	3700	Gauge Zero	
90 91	Channel 1 Reading*	Channel 1 Display Value	HIGH WORD LOW WORD	R	R	Probe	Probe	
92 93	Channel 1 High Res Reading	Internal	HIGH WORD LOW WORD	R	R	----	----	

Add	Parameter	Display Reading	Position	µ400P	µ500PT	Low Limit	High Limit	Notes
94	Channel 2 Reading *	Channel 2 display Value	HIGH WORD	NP	R	Probe	Probe	
95			LOW WORD					
96	Channel 2 High Res Reading	Internal	HIGH WORD	NP	R	----	----	
97			LOW WORD					
99	Number of Channels	Internal		R	R	2	1	
143	Pressure Calibration	Internal		RW	RW	7	0	**Write 0**: Activates the automatic calibration of the pressure transducer. **Read**: Shows the last state after a transducer calibration: **0**: The calibration couldn't start or the instrument has never been calibrated through Modbus before. **1**: Waiting for Zero calibration **2**: Zero calibration **3**: Waiting for Span calibration **4**: Span calibration **5**: Calibration Failed **6**: Waiting for SAVE (ONLY if the calibration started from the instrument keypad) **7**: Calibration finished successfully

- **R**: Read Only Register, W: Write enabled Register **NP**: Not valid register.

- All the parameters are two's complement Integers.

-Some parameters can have a value greater than 65535 or below 0. For that reason they are stored in 2 Modbus registers. To write a negative value in any of these registers, note that the High Word has to be filled with ones according to their two's complement nature. It's recommended to write the High Word first.

-High Res values are stored in 4 bytes. To get the actual value of these registers, they should be divided by 65535.

*If the input probe (**inP**) is number 8 (RTD /-99.9...200.0), this registers should be divided by 10. If the input probe is linear (**inP** = 9,10,11 or 12), or pressure or gauge (**inP** = 13 o 14) in line with the value of **dP** (0, 1 or 2), they should be divided by 1, 10 or 100 respectively.