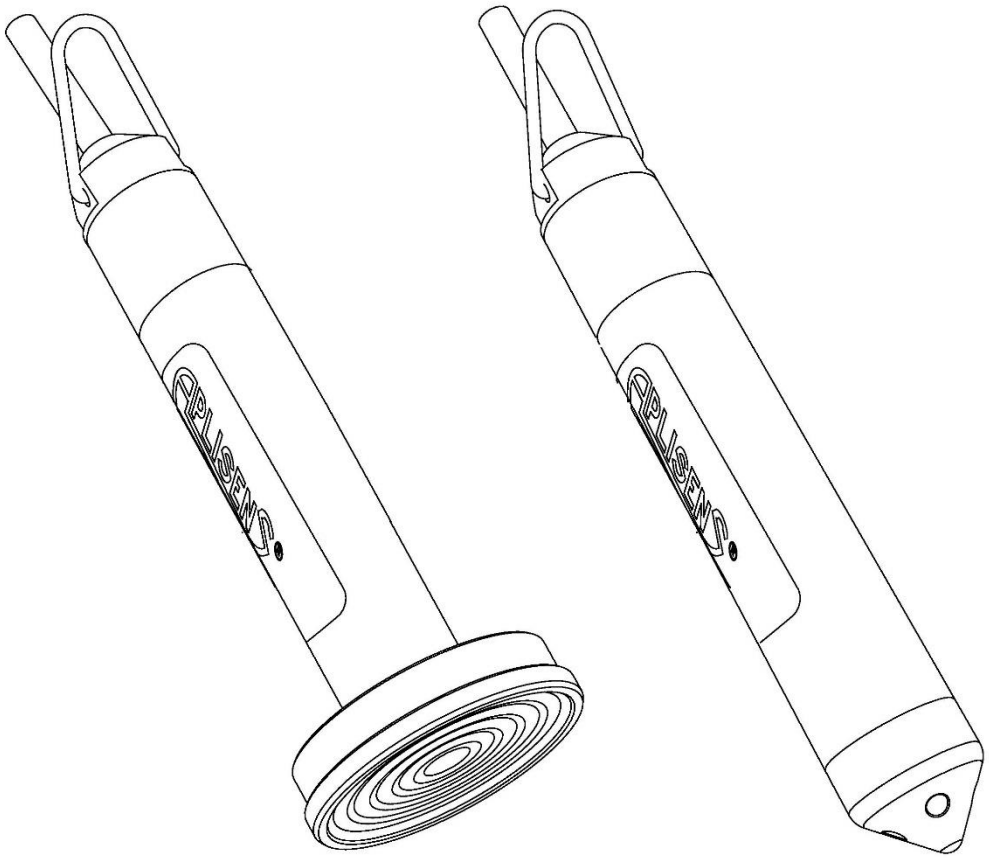
USER'S MANUAL

SMART LEVEL PROBES

SGE-25.Modbus and SGE-25S.Modbus



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tel. +48 22 814 07 77; fax +48 22 814 07 78
www.aplisens.com, e-mail: export@aplisens.com

PRODUCT CODE – see: (➔ Probe identification).
The QR code or ID number identifies the probe and provides quick access to the following documentation on the manufacturer's website: User's Manual, Explosion Proof Device Manual, Modbus Manual, declarations of conformity and copies of certificates.

SGE-25.Modbus

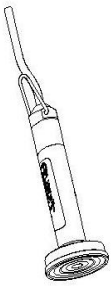
ID: 0044 0001 0001 0000 0000 0000 0001 77
https://www.aplisens.pl/ID/004400010001000000000000000177/

SGE-25.Modbus (Exi)

ID: 0044 0002 0001 0000 0000 0001 0001 94
https://www.aplisens.pl/ID/004400020001000000000001000194/

SGE-25S.Modbus

ID: 0045 0001 0001 0000 0000 0000 0001 74
https://www.aplisens.pl/ID/004500010001000000000000000174/



SGE-25S.Modbus (Exi)

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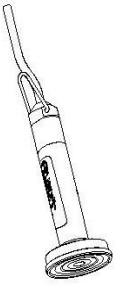

Symbols used

Symbol	Description
	Warning to proceed strictly in accordance with the information contained in the documentation in order to ensure the safety and full functionality of the device
	Information particularly useful during installation and operation of the device.
	Information particularly useful during installation and operation of an Ex type device.
	Information on disposal of used equipment.

BASIC REQUIREMENTS AND SAFE USE

The manufacturer will not be liable for damage resulting from incorrect installation, failure to maintain a suitable technical condition of the device or use of the device other than for its intended purpose.

Installation should be carried out by qualified staff having the required authorizations to install electrical and I&C equipment. The installer is responsible for performing the installation in accordance with manual as well as with the electromagnetic compatibility and safety regulations and standards applicable to the type of installation.

In systems with I&C equipment, in case of leakage, there is a danger to staff due to the medium under pressure. All safety and protection requirements must be observed during installation, operation and inspections.

If a malfunction occurs, the device should be disconnected and handed over to the manufacturer for repair.

In order to minimize the risk of malfunction and associated risks to staff, the device is not to be installed or used in particularly unfavorable conditions, where the following hazards occur:

- possible mechanical impacts, excessive shocks and vibration;
- excessive temperature fluctuation;
- water vapor condensation, dusting, icing.

Installations for intrinsically safe executions should be carried out with particular care in accordance with the standards and regulations applicable to this type of installation.

Changes made to the manufacturing of products may be introduced before the paper version of the manual is updated. The up-to-date manuals are available on the manufacturer's website: www.aplisens.com.

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1. INTRODUCTION

1.1. Purpose of the document

The subject of manual are smart level probes: **SGE-25**.**Modbus** and **SGE-25S.Modbus** hereinafter referred to as probes in the manual. The manual applies to the following versions: standard and intrinsically safe Exi.
The manual contains data, guidelines and general recommendations for the safe installation and operation of the probes, as well as procedures in the event of a possible failure.

It is forbidden to use devices in hazardous areas without appropriate permits.

Data on the hydrostatic level probes **SGE-25.Modbus**, **SGE-25S.Modbus** and **SGE-25C.Modbus** in intrinsically safe version according to ATEX are included in the **Explosion-proof Device Manual** marked as EN.IX.SGE.25.MODBUS.

2. SAFETY

- The installation and start-up of the device and any activities related to operation shall be carried out after thorough examination of the contents of user's manual and the instructions related thereto;
- installation and maintenance should be carried out by qualified staff having the required authorizations to install electrical and measuring devices;
- the device shall be used according to its intended purpose in line with the permissible parameters specified on the nameplate (➔ Probe identification);
- the protection elements used by the manufacturer to ensure probes safety may be less effective if the device is operated in a manner not consistent with its intended purpose;
- before installing or disassembling the device, it is absolutely necessary to disconnect; it from the power source;
- no repairs or alterations to the probes electronic system are permitted. Assessment of damages and possible repair may only be performed by the manufacturer or authorized representative;
- do not use instruments if damaged. In case of malfunction, the device must be put out of operation.

3. TRANSPORT AND STORAGE

3.1. Delivery check

After receiving the delivery, please refer to the general terms and conditions of contracts available on the manufacturer website:
https://aplisens.com/ogolne_warunki_umow.html.

3.2. Transport

Transport of probes shall be carried out with the use of covered means of transport, in original packages with diaphragm provided with protection. The packaging shall be protected against movement and direct impact of atmospheric factors.

3.3. Storage and use

Probes shall be stored in a factory packaging, in a room without vapours and aggressive substances, protected against mechanical impact. The cable should be coiled into a circle with a diameter of ≥ 30 cm, the coils of the coil should be fixed in relation to each other and the whole should be fixed in the package. Avoid kinking the cable at the point where it exits the gland.

Permissible medium temperature range according to the data sheet.

The medium must not be allowed to freeze in the immediate vicinity of the probe.

4. GUARANTEE

General terms and conditions of guarantee are available on the manufacturer's website:
www.aplisens.com/ogolne_warunki_gwarancji.

The guarantee shall be repealed if the device is used against its intended use, failure to comply with user's manual or interference with the structure of the device.

5. IDENTIFICATION

5.1. Manufacturer address

APLISENS S.A.
03-192 Warsaw
Morelowa 7 St.
Poland

5.2. Probe identification

Depending on the version of the probe, the nameplates may differ in the amount of information and parameters.

Table 1 Symbols appearing on the probe's nameplate

APLISENS S.A.	Logo and name of manufacturer
CE	CE mark
CE 1453	CE mark with number notified body
03-192 WARSZAWA Morelowa 7 Poland tel.: +48 22 814 07 77	Manufacturer address
	QR code
TYPE:	Probe type
ID	Probe model ID
# S/N	Probe serial number
P	Measuring range
U	Power supply voltage
	Output signal
Tamb	Permissible range of ambient temperature
IP	IP protection rating
Year of production	Year of production
	Note about the obligation of read the manual
//Lower part of the nameplate//	Special versions

5.3. CE mark, declaration of conformity

The device has been designed to meet the highest safety standards, has been tested and has left the factory in a condition that is safe for operation. The device complies with the applicable standards and regulations listed in the EU Declaration of Conformity and has CE marking on nameplate.

6. INSTALLATION

6.1. General recommendation

The probe can be hung on the power cable, e.g. by using from the Aplisens SG cable hanger (item 1 in fig. 1). In the event of frequent removal of the probe or when there is a risk of catching on protruding elements during pulling up, it is recommended to hang the probe on a steel cord using the carrying eye (item 2 in Fig. 1.). The probes are immersed in the medium to be measured. A special cable extends above the level of the medium and can be connected directly to probe or to a junction box. If the probe is to be placed in the current or in an area of turbulence, it should be installed in a protective tube.

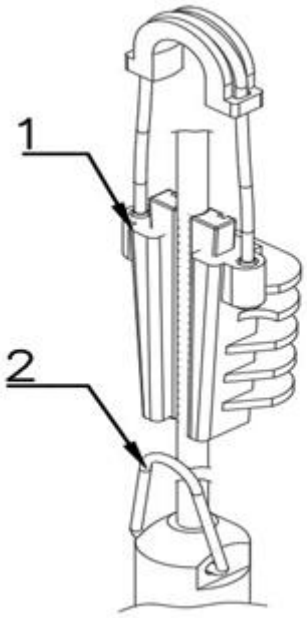


Figure 1 Mounting brackets for probes

Do not clean or touch the diaphragm with hard or sharp objects. Hang the probe with the additional Teflon coating on the cable on the suspension cable or on the inner cable (do not grab the Teflon).

Remove the protective cap from the probe's separator immediately before the SGE-25S.Modbus type probe is inserted into the medium to be measured.

During installation protect the probe from mechanical impacts

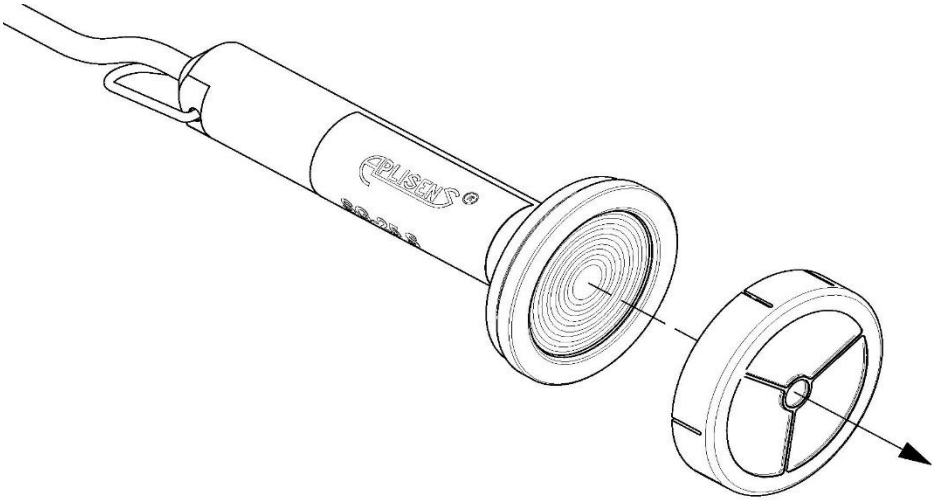


Figure 2 Diaphragm cover for SGE-25S.Modbus probe

7. ELECTRICAL CONNECTION

7.1. Connection, signal output

All connection and installation operations shall be performed with disconnected supply voltage and other external voltages, if used.

I Failure to provide proper connection of the transmitter may result in danger.
Risk of electric shock and/or ignition in potentially explosive atmospheres.

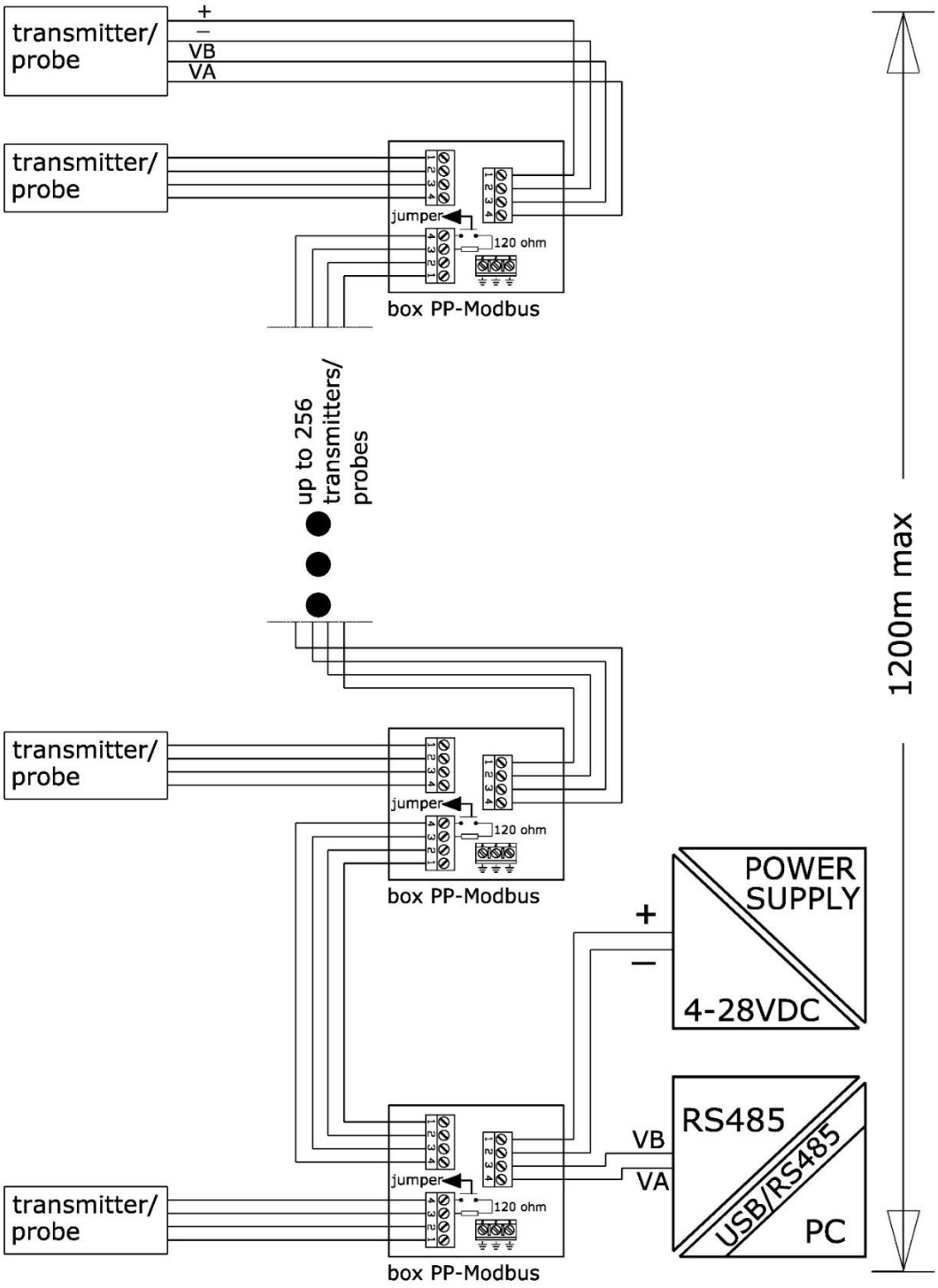


Figure 3 Connection in Modbus network

The electrical connection should be made according to Table. 2. It is recommended to install the PP-Modbus connection box manufactured by Aplisens S.A. to connect the probe cable with the rest of the transmission line. The PP-Modbus junction box is non-hermetic (pressure inside is equal to atmospheric pressure) due to the use of an air filter, which is required for the probe to operate correctly. Do not allow the capillary outlet to become contaminated or any liquid to enter the capillary.

Table 2 Probe connection

Signal output	
Type of connector	**Wire colour**
SHIELD	Green
+	Red
- (GND)	Black
RS-485 A +	Blue
RS-485 B -	Yellow

7.2. Power supply

7.2.1. Power supply voltage

Supply cables may be live.

There is a risk of electric shock and/or explosion.

Installation in potentially explosive atmospheres must comply with local standards and regulations.

Table 3 Permissible power supply voltage for probes

Mode	**Output signal**	**MIN. Power supply voltage**	**MAX Power supply voltage**
Modbus mode - standard version*	Modbus RTU	4 V DC	28 V DC
Modbus mode Exi version	Modbus RTU	4 V DC	10 V DC
Configuration mode – standard version	4…20 mA	5 V DC	28 V DC
*- power consumption in Modbus mode <3,6 mA.			

7.2.2. Resistance load in power supply line

The power line resistance, power source resistance and other additional serial resistances increase the voltage drops between the power source and the transmitter. The maximum current is 0,022 A. The maximum resistance value in the power circuit (along with the power cables resistance) is defined by the formula:

$$R_{Lmax} = \frac{(U_{zas} - U_{min})}{0{,}022\ A}$$

where:

U_{zas} – voltage at the supply terminals of 4…20 mA current loop [V],

U_{min} – minimum supply voltage of probes **Table 3** Permissible power supply voltage for probes,

RL_MAX – maximum power supply line resistance [Ω].

7.3. Equipment bonding

The cable shield (green wire) is led out from the probe's power supply and measurement cable. The manufacturer recommends connecting the probe cable shield at one end to the probe's power supply point.

7.4. Overvoltage protection

Probes may be exposed to the effect of switching overvoltage's or those resulting from lightning discharges. Protection against overvoltage's between the wires of the transmission line is provided by TVS diodes. For protection against surges between the transmission line and earth or housing (which are not protected by diodes connected between the line conductors), the probes are equipped with additional protection in the form of surge arrestors. Additionally, an external protective device can be used, e.g. the UZ-2 system by APLISENS or others.

7.5. Final inspection of cabling

After completing the electrical installation of the probe, check the following:
- that the supply voltage measured at the power supply terminals of the cable connection at the maximum current is in accordance with the supply voltage range specified on the nameplate;
- that the probe is connected in accordance with the information given in section ➔7.1 Connection, signal output;
- if a junction box is used, that the glands are tightened.

8. OPERATION

8.1. Physical layer for RS485 data transfer

8.1.1. Introduction

The probe is connected to the system via RS485 serial interface. It guarantees high resistance to interferences and flexible bus structure, e.g. multiple "Slave" devices can be managed via a single "Master" device. An RS485 half-duplex mode has been implemented to reduce the number of necessary communication cables. This means that 2 communication cables are required.

8.1.2. Description

To ensure correct operation of multiple devices on one serial communication bus, appropriate leads (RS485A, RS485B, GND and +Vcc) should be connected in parallel to the bus. Before connecting to the bus, a unique address must be defined for each device.
A network of up to 1,200 meters with max 247 Modbus devices can be set up. Each cable junction from the bus can be up to 15 m long.
The cables should conform to EIA RS485.

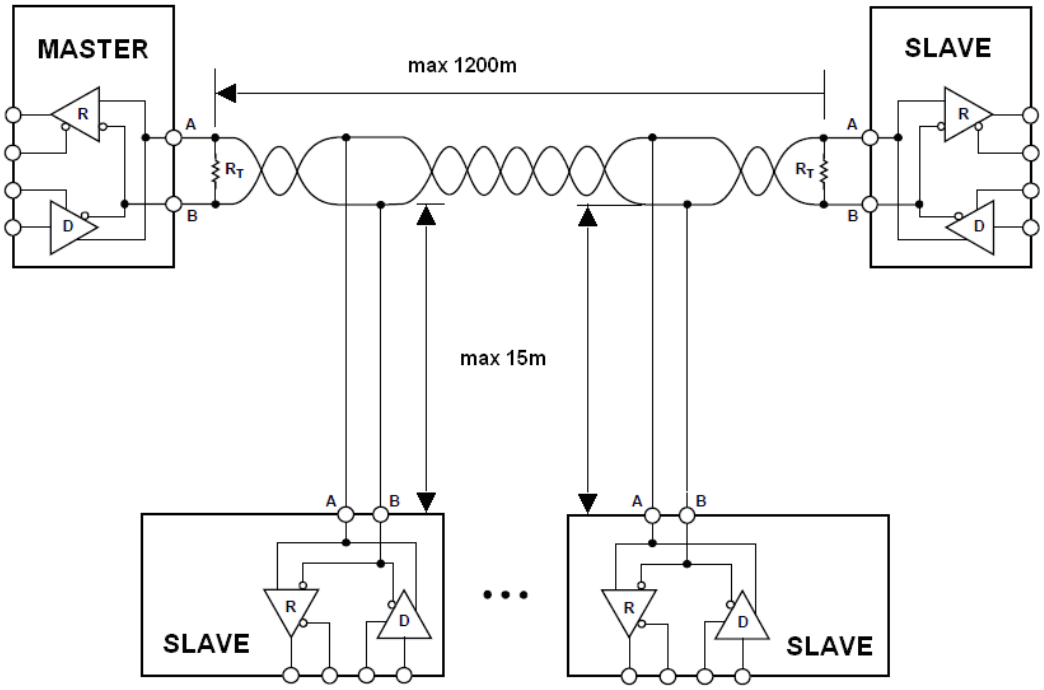


Figure 4 Example of Modbus network configuration

8.1.3. Details of RS485 “half duplex”

To ensure the best possible efficiency in industrial environment, the probes from Aplisens S.A. are provided with RS485 transceivers with appropriately customized operating parameters. To provide compatibility and the best possible working conditions, the “Master” transceiver should conform to the specifications below.

8.1.3.1. Limited digital signal incremental rate

To eliminate oscillations and interferences, the output voltage slew rate of the signals from the probes is limited by the use of appropriate RS485 transceivers. This makes it possible to use standard cable-based connections and/or customized topologies (e.g. branches up to 15 m long).

8.1.3.2. “Fail safe” mode

The “fail-safe” mode means a strictly defined level of received signals – both in open bus connection and **closed bus** connection modes. It is very important in half-duplex mode when all the devices connected to the bus are in receiving mode. This approach eliminates the need to use external polarization resistors. Power losses in RS485 transceivers caused by e.g. bus short-circuit, are limited by the use of thermal safety features in transmitting and receiving circuits.

8.1.3.3. 1/16 of bus load

Input impedance in RS485 transceivers used in the transmitters from Aplisens S.A., in receiving mode, is higher than the standard impedance to enable connecting up to 256 devices to the bus.

8.1.3.4. Line transmission

The terminating resistors on the RS485 bus should be connected between the points A and B at the beginning and at the end of the communication bus. When working with long transmission lines at the highest transfer rates, resistor value should correspond to cable impedance which typically is 120 Ω. With shorter bus segments and lower transfer rates, resister with higher values, e.g. 1 kΩ, can be used to reduce current fluctuations in the transmission line (with 2 resistors of 120 Ω, the amplitude can be as high as ca 50 mA). At least one resistor should be used to ensure stable communication.
If a “fail-safe” device is connected to the “Master” bus, the electromagnetic environment in which the communication bus is located is free of interferences and the transmission line is relatively short (several meters) and terminations resistors are not required.
The Aplisens S.A. devices described in this document are NOT provided with terminations resistors.

8.1.3.5. Polarizing resistors

Polarizing resistors can be used for ensuring permanently defined voltage levels in relation to power supply on the communication bus. The resistors are connected respectively:
- between point A on the bus and +Vcc point;
- between point B on the bus and GND point.

They are necessary if any of the transceivers of the devices connected to the bus is not a fail-safe transceiver. The resistance of such resistors depends on the power supply connected to the bus, input current in the connected devices operated in receiving mode, and it should be calculated or determined experimentally. It usually ranges from 450 to 650 Ω. If the “Master” device is in fail-safe mode and only works with Modbus transmitters from Aplisens S.A. polarizing resistors are not required.
The APLISENS S.A. devices described in this document are NOT integrated with polarizing resistors.

8.1.3.6. Common mode voltage on RS485 bus

The probes do not have galvanic isolation so the common voltage level should be equalized to the common potential by connecting the negative poles of the power supply of the probes together (e.g. GND).

Transmission line definitions:

Signal	Designation by APLISENS and transceiver manufacturers	Designation acc. to EIA
Inverted (-)	B	A
Simple (+)	A	B

8.2. Data link layer

This subsection describes data transfer on the bus. Data and their control structures are divided into groups and make up a message. A message means the smallest communication unit and only such units can be transferred between devices. “Half-duplex” mode means that at a given point in time only one device can be in transmitting mode while the other devices must be in receiving mode. A PC or a controller is a “Master” device and the connected measuring or execution devices are “Slave” devices. Messages are transferred at all times under the control of the “Master” device. All messages contain a “Slave” address. As a result two options of data transfer are available:

- **Broadcast mode**

This communication mode of the “Master” allows the “Slave” devices to receive and perform functions simultaneously, regardless of the “Slave” network address. In the APLISENS probes covered by this manual, the broadcast mode is used to make entries to the transmitters using the 101, 102, 103, 104, 105 functions. In the broadcast mode, the transmitters does not send back a telegram to acknowledge its receipt and that the function has been completed.

- **Unicast data transfer mode**

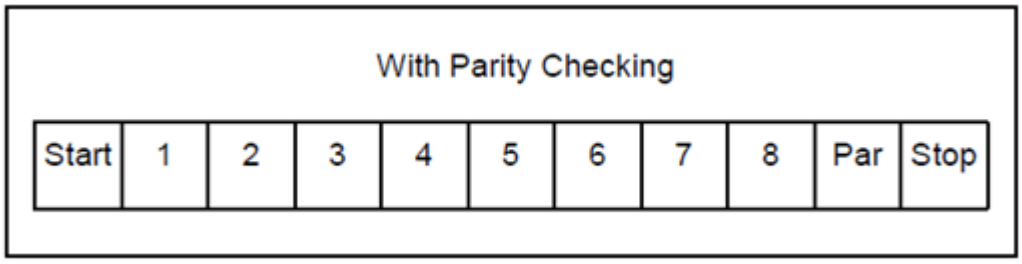
This mode enables communication between the “Master” device and a selected “Slave” device. The communication process involves sending a request message from the “Master” device and a response message from an appropriate “Slave” device. Only the “Master” device can send request messages. The request is received by all “Slave” devices connected to the bus, however, only a device with an address specified in the message sends a response. A “Slave” device must respond to a correctly received request message within the defined maximum time interval, otherwise the “Master” device recognizes that the request failed and will retry sending the message in accordance with the programmed algorithm.

8.2.1. Modbus RTU serial transmission mode

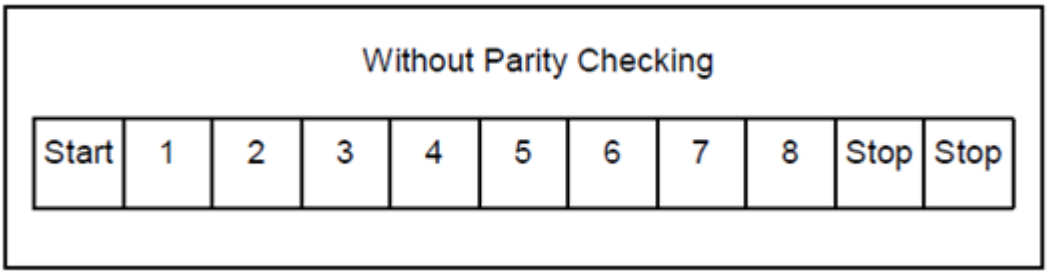
Data in the RS485 bus are transmitted serially. As described in the Modbus RTU standard (Modbus over Serial Line Specification and Implementation Guide v1.02), the following formats can be used:

- 1 start bit
- 8 data bits (binary coding, least significant is bit sent first)
- bits for parity checking:
  1 bit Even (default), or
  1 bit Odd, or
  0 bits None (no bits for parity control)
- 1 stop bit for Even or Odd parity mode, or
- 2 stop bits for None parity mode

Characters are always sent using 11 bits. The number of stop bits (1 or 2) is selected by the transmitter depending on whether an Even, Odd or None parity mode is set.



Bit sequence with parity checking.



Bit sequence without parity checking.

8.2.2. Modbus RTU message format

All Modbus RTU messages are sent in the following format:

Slave Address	Function Code	Data	CRC
1 byte	1 byte	0 up to 252 byte(s)	2 bytes CRC Low, CRC Hi

Slave Address – network address of the “Slave” device. The address 0 is reserved for the broadcast in the query mode of the “Master” device. “Slave” devices, irrespective of their network address, should be able to perform the function of a write operation without sending back a response telegram in this mode.

The individual “Slave” devices are assigned addresses in the range of 1…247. In one network cannot be more than one device with the same address in this range. Addresses in the range of 248 – 255 are reserved for future use.

0	From 1 to 247	From 248 to 255
Broadcast address	Slave individual addresses	Reserved

Function Code – A code to tell the “Slave” to which a request is addressed what functions are to be performed. Function codes use 7 bits (0...127). The oldest 8th bit is always zero when a message is sent by the “Master”. The same function code is returned in this field in the “Slave” response message. If the oldest 8th bit is zero, it means that the function was performed correctly and the data returned in the message are also correct. If the oldest 8th bit is one, it means that a function error or a device error was detected.

Data – The “Function Code” can be followed by the field “Data” containing control data (“Master” request) or read data (“Slave” response), depending on the function number. This field can contain up to 252 bytes of data. If the oldest 8th bit of the “Function code” in the “Slave” response is one, the data read are not entered in the field “Data” in the response message, but one byte of the field is used for sending an error code.

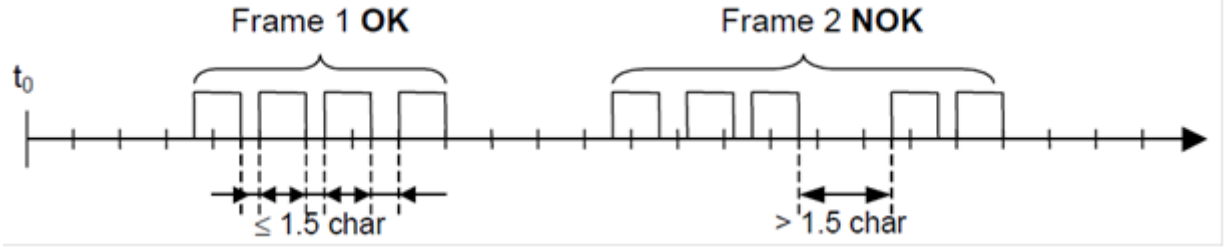
CRC – At the end of a message, there is always a field for the 2-byte control sum CRC16 sent according to the sequence “CRC Low | CRC High”. The control sum is calculated as defined in Supplement B to “Modbus over Serial Line Specification and Implementation Guide v1.02” available at http://www.modbus.org/.

8.2.3. Modbus RTU message transfer rules

8.2.3.1. Primary rules

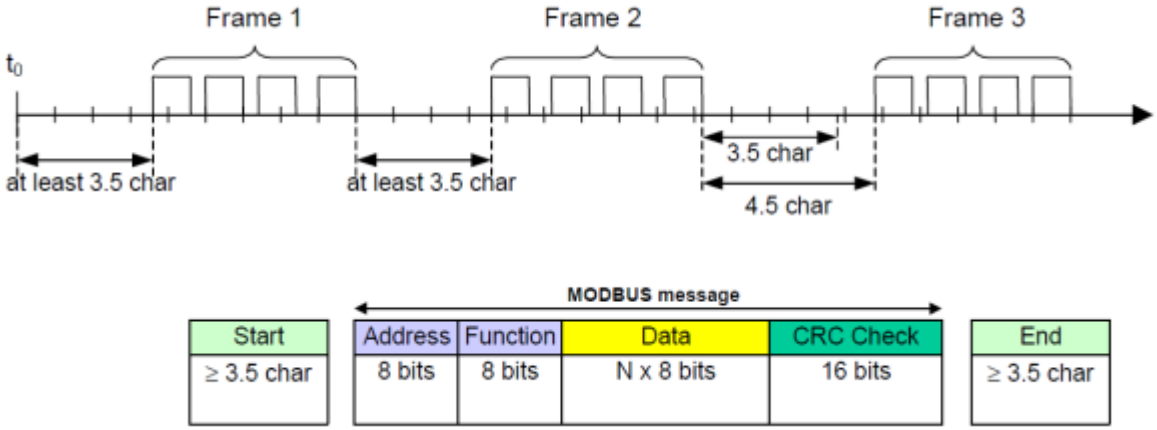
- An address in the range 1...247 can only be assigned to one “Slave” device connected to the bus. If more devices connected to the bus are assigned the same address, they will send a response telegram, causing a conflict on the bus.
- Data transfer operations via messages are initiated at all times by the “Master”. This means that “Slave” devices can only send data-containing messages after receiving a properly addressed request message from the “Master”.
- A message is made up of a number of bytes. These bytes should be sent without any in-between intervals.

The maximum permissible silent interval between two successive characters must not exceed 1.5T, where T is the time it takes to transmit one character (11 bits). If the silent interval between two successive characters exceeds 1.5T, the message can be considered invalid and rejected by the device.



- The addressed “Slave” must respond within a defined silent interval, otherwise the response message will be considered invalid and rejected by the “Master”.

The silent interval between the request message sent by the “Master” and the response message sent by the “Slave” must not be shorter than 3.5T, where T is the time it takes to transmit one character (11 bits). The maximum silent interval after which a “Slave” device responds to the “Master” request message depends on the function code in the request and the data load. The response time in the APLISENS S.A. transmitters described in this document should be less than 5 ms, including the most disadvantageous conditions (data load, transfer rate).



8.2.3.2. Error handling

When messages are transferred between “Master” and “Slave” devices, two main types of errors may arise: transmission errors and “Slave” device errors.

Transmission errors, causes:

- The message received is too short due to e.g. an excessively long interval between bytes contained in the message.
- The message received is longer than allowed by the device’s reception buffer due to e.g. message frame syntax improperly programmed in the controller.
- The maximum character transmission time is exceeded due to an inappropriate transfer rate.
- The control sum calculated based on the message received does not correspond to the value sent in the message in the CRC field.

“Slave” devices do not respond to messages for which a transmission error is detected, the “Master” device can retry sending a request message if an invalid message receipt is detected. The respective algorithm is programmed in the “Master” device.

- Illegal function code.
- Illegal data address.
- Illegal data load.

Errors in functioning of the slave device, causes:

- Damage to the ADC transmitter, damage to the pressure sensor.
- Damage to the local oscillator of the microcontroller.
- Damage to RAM, FLASH, EEPROM.

Error codes conform to “Modbus over Serial Line Specification and Implementation Guide v1.02”.

8.3. Application layer, description of implemented functions

8.3.1. System functions

8.3.1.1. 0x03 (3) “Read Holding Register”

This function used to read the continuous address space of a data block. The master sets the log start address (2 bytes) and the number of 2-byte read logs. The logs are addressed starting from zero, for this reason, e.g. the log 1 has an address 0x0000, the log 3 has an address 0x0004, log 17 has an address 0x0020, i.e. 32.

The data read from each log is transmitted by the slave as 2 bytes per log, where the first byte in the sequence is a byte older than the next one. When reading data from more than one log, the data from the slave is transmitted according to the log numbering.

The logs contain data related to process variable measurements, temperatures as well as other probe settings.

8.3.1.2. 0x2B (43) ”Read Device Identification”

Function used to read, in streaming mode, the basic transmitter identification data, including the manufacturer name, product code, software revision.
Read Device Identification | 7 bytes request, 46 bytes response |
Req: [ADD][FC][0x0E][0x01][0x00][CRC_H][CRC_L]
Resp: according to **Modbus Application Protocol Specification V1.1**

8.3.2. Manufacturer/user functions

8.3.2.1. 0x64 (100) „Read coefficients”

Function used to read 4 bytes of coefficients.
Read Coefficients | 5 bytes request, 9 bytes response |
Req: [ADD][FC][COEFF_NUMBER][CRC_H][CRC_L]
Resp: [ADD][FC][COEFF_NUMBER][DATA0] [DATA1] [DATA2] [DATA3] [CRC_H][CRC_L]

COEFFICIENT NUMBER	**NAME**	**DESCRIPTION OF DATA0 … DATA3**
0x00	Dumping Time "s"	float IEE754 referred to PVU - Primary Variable Unit
0x01	Upper sensor limit	float IEE754 referred to PVU - Primary Variable Unit
0x02	Lower sensor limit	float IEE754 referred to PVU - Primary Variable Unit
0x03	Minimum span	float IEE754 referred to PVU - Primary Variable Unit
0x04	Upper range value	float IEE754 referred to PVU - Primary Variable Unit
0x05	Lower range value	float IEE754 referred to PVU - Primary Variable Unit
0x06	Max work temperature	float IEE754 referred to °C
0x07	Min work temperature	float IEE754 referred to °C
0x80	Auxiliary Coefficients_0	**[FIR] [ALM] [TRF] [PVU]** [FIR] – ADC integration time Filter Register 0x00 18,6 ms 0x01 22,0 ms 0x02 62,0 ms 0x03 102,0 ms 0x04 122,4 ms 0x05 121,7 ms 0x06 152,4 ms 0x07 212,6 ms [ALM] – Alarm Mode (current output) BIT0 0 = no alarm, 1 = alarm on ADC converter failures BIT1 0 = no alarm, 1 = alarm on pressure sensor failures BIT2 0 = no alarm, 1 = alarm on memory failures BIT3 0 = no alarm, 1 = alarm on oscillator failures BIT6 0 = Alarm 22,0 mA, 1=Alarm 3,6 mA BIT7 0 = 3,9 … 20,5 mA operation 1 = 3,8 … 20,5 mA operation [TRF] - Transfer Function Code 0x00 Linear (y=x) 0x01 Square root ($y=x^{½}$) 0x04 Special (piecewise linear) 0x05 Square ($y=x^2$) [PVU] - Primary Variable Unit 0x01 InH2O inches of water at 68 °F / 20 °C 0x02 InHg inches of mercury at 0 °C 0x03 FtH2O feet of water at 68 °F / 20 °C 0x04 mmH2O millimeters of water at 68 °F / 20 °C 0x05 mmHg millimeters of mercury at 0 °C 0x06 psi pounds per square inch 0x07 bar bars 0x08 mbar millibars 0x09 g/cm^2 grams per square centimeter 0x0A kg/cm^2 kilograms per square centimeter 0x0B Pa pascals

COEFFICIENT NUMBER	NAME	DESCRIPTION OF DATA0 … DATA3
		0x0C kPa kilopascals 0x0D Torr torr 0x0E ATM atmospheres 0xAB mH2O4 °C meters of water at 4 °C 0xED MPa megapascals 0xEE inH2O4 °C inches of water at 4 °C 0xEF mmH2O4 °C millimeters of water at 4 °C
0x81	Auxiliary Coefficients_1	**[ADD][RS_mode_1][RS_mode_2][RS_mode_3]** [ADD] Modbus Address [RS_mode_1] BIT0 - 9600 bps BIT1 - 19200 bps BIT2 - 28800 bps BIT3 - 38400 bps BIT4 - 57600 bps BIT5 - 115200 bps BIT6 - n.u. BIT7 - n.u. [RS_mode_2] BIT0 - n.u. BIT2,BIT1 - 01 - NONE, 2STOP BIT2,BIT1 - 10 - ODD, 1STOP BIT2,BIT1 - 00 - EVEN, 1STOP BIT3 - n.u. BIT4 - n.u. BIT5 - 1200 bps0 BIT6 - 2400 bps BIT7 - 4800 bps [RS_mode_3] n.u. **Remarks:** Only one bit from BIT0 to BIT5 in RS_mode_1 and bits from BIT5 to BIT7 in RS_mode_2 can be in “ON” state. [n.u.] Bit not used (can be set as zero – “OFF” state)
0x82	Auxiliary Coefficients_2	**[-][-][-][WP]** [-][-][-] Not used, data negligible [WP] 0x00 Not write protected 0x01 Write protected
0x83	Auxiliary Coefficients_3	**[-][-][-][-]** Not used, data negligible
0x88	Auxiliary Coefficients_4	**[SLDC_1_H][SLDC_1_L][SLDC2_H][SLDC_2_L]** [SLDC_1_H] Most significant byte of Bus Communication Error Counter [SLDC_1_L] Least significant byte of Bus Communication Error Counter [SLDC_2_H] Most significant byte of Slave Exception Error Counter [SLDC_2_L] Least significant byte of Slave Exception Error Counter
0x89	Auxiliary Coefficients_5	**[SLDC_3_H][SLDC_3_L][SLDC_4_H][SLDC_4_L]** [SLDC_3_H] Most significant byte of Broadcast RX Mode Counter [SLDC_3_L] Least significant byte of Broadcast RX Mode Counter [SLDC_4_H] Most significant byte of CRC RX Error Counter [SLDC_4_L] Least significant byte of CRC RX Error Counter

COEFFICIENT NUMBER	NAME	DESCRIPTION OF DATA0 … DATA3
Legend:		
FIR	Filter Register	
ALM	Alarm Mode Code	
TRF	Transfer Function Code	
PVU	Primary Variable Unit	
WP	Write Protection	
RS_mode_1	Communication settings 1	
RS_mode_2	Communication settings 2	
RS_mode_3	Communication settings 3	
SLDC_1_H,L	Bus Communication Error Counter, a 16-bit binary counter, reset after overflow or POR	
SLDC_2_H,L	Slave Exception Error Counter, a 16-bit binary counter, reset after overflow or POR	
SLDC_3_H,L	Broadcast RX Mode Counter, a 16-bit binary counter, reset after overflow or POR	

8.3.2.2. 0x65 (101) „Write coefficients”

Function used to store 4 bytes of coefficients.
Write Coefficients | 9 bytes request, 9 bytes response |
Req: [ADD][FC][COEFF_NUMBER][DATA0][DATA1][DATA2][DATA3][CRC_H][CRC_L]
Resp: [ADD][FC][COEFF_NUMBER][DATA0][DATA1][DATA2][DATA3][CRC_H][CRC_L]

COEFFICIENT NUMBER	NAME	DESCRIPTION OF DATA0 … DATA3
0x00	Dumping Time "s"	float IEE754
0x80	Auxiliary Coefficients_0	4 bytes [-][-][-][PVU]
Remarks: Unicast / Broadcast mode available, no response with Broadcast Mode. **Legend:**		
PVU	Primary Variable Unit	
[-]	Data in byte negligible, not currently used	

8.3.2.3. 0x66 (102) „Set Modbus Device Address (FLASH)”

Function used to store the Modbus address in non-volatile FLASH memory.
Caution! Using the broadcast mode for this function, for more than one device connected in the network, will set them to the same address and block further communication.
Set Modbus Device Address (FLASH) | 5 bytes request, 5 bytes response |
Req: [ADD][FC][new_ADD][CRC_H][CRC_L]
Resp: [ADD][FC][old_ADD]][CRC_H][CRC_L]

COEFFICIENT NAME	DESCRIPTION
new_ADD	New Modbus device address from the range 1…127 to be store in the FLASH memory.
old_ADD	Previous Modbus device address.
Remarks: Unicast / Broadcast mode available, no response with Broadcast Mode. Automatically performs a HOT RESET after execution.	

8.3.2.4. 0x67 (103) „Set Speed, Parity, Stop”

Function used to configure the 3 coefficients that define the Modbus communication parameters.
Set Speed, Parity, Stop | 7 bytes request, 7 bytes response |
Req: [ADD][FC][RS_mode_1][RS_mode_2][RS_mode_3][CRC_H][CRC_L]
Resp: [ADD][FC][RS_mode_1][RS_mode_2][RS_mode_3][CRC_H][CRC_L]

COEFFICIENT NAME	DESCRIPTION OF COEFFICIENTS
RS_mode_1	[RS_mode_1] BIT0 - 9600 bps BIT1 - 19200 bps BIT2 - 28800 bps BIT3 - 38400 bps

	BIT4 - 57600 bps BIT5 - 115200 bps BIT6 - n.u. BIT7 - n.u.
RS_mode_2	[RS_mode_2] BIT0 - n.u. BIT2,BIT1 - 01 - NONE, 2STOP BIT2,BIT1 - 10 - ODD, 1STOP BIT2,BIT1 - 00 - EVEN, 1STOP BIT3 - n.u. BIT4 - n.u. BIT5 - 1200 bps0 BIT6 - 2400 bps BIT7 - 4800 bps
RS_mode_3	[RS_mode_3] Data in byte negligible, currently not used for configuration
Remarks: Unicast / Broadcast mode available, no response in broadcast mode. Only one bit from BIT0 to BIT5 in RS_mode_1 and bits from BIT5 to BIT7 in RS_mode_2 can be in “ON” state. [n.u.] Bit not used (can be set as zero – “OFF” state)	

8.3.2.5. 0x68 (104) „Perform Action”

Function used to perform specific transmitter actions.
Req: [ADD][FC][DATA] [CRC_H][CRC_L]
Resp: [ADD][FC][DATA] [CRC_H][CRC_L]

COEFFICIENT NAME	DESCRIPTION OF ACTION
DATA	[DATA] 0x00 – Zeroing Pressure 0xFD - Set Write Protection 0xFE - Remove Write Protection 0xFF - Hot Reset
Remarks: Unicast / Broadcast mode available, no response in broadcast mode. The reset function 0xFF may take about 2 seconds to complete.	

8.3.2.6. 0x69 (105) „Set Modbus Device Address (RAM)”

Function used to store the Modbus address in volatile RAM.
0x69 | 105 | Set Modbus Device Address (RAM) | 5 bytes request, 5 bytes response |
Req: [ADD][FC][new_ADD][CRC_H][CRC_L]
Resp: [ADD][FC][old_ADD]][CRC_H][CRC_L]

COEFFICIENT NAME	DESCRIPTION
new_ADD	New device address from the range 1…127 to be store in the RAM memory.
old_ADD	Previous device address.
Remarks: Unicast / Broadcast mode available, no response in broadcast mode. The new device address is valid until POWER ON RESET or HOT RESET, after their execution it returns to the address saved in the FLASH memory.	

8.3.3. Modbus register layout

Register	Address (hex)	Purpose	Notes	Format	Bytes (2 bytes per register)
1	0x0000	**User specific**	% of the controlled set range	IEEE754	4 bytes (2 registers)
3	0x0002	**Pressure of sensor 1**	Pressure or level process variable	IEEE754	4 bytes (2 registers)
5	0x0004	**Pressure of sensor 2**	Constant 0	IEEE754	4 bytes (2 registers)
7	0x0006	**Temperature of sensor 1**	Sensor 1 temperature process variable at ºC	IEEE754	4 bytes (2 registers)
9	0x0008	**CPU temperature**	CPU temperature process variable at ºC	IEEE754	4 bytes (2 registers)
11	0x000A	**Temperature of sensor 2**	Constant 0 ºC	IEEE754	4 bytes (2 registers)
13	0x000C	----------	----------	----------	4 bytes (2 registers)
15	0x000E	----------	----------	----------	4 bytes (2 registers)
17	0x0010	**User specific**	1/100% of the controlled set range	Signed 16-bit int	2 bytes (1 register)
18	0x0011	**Pressure of sensor 1**	Integer, 1/100 of the pressure or level unit	Signed 16-bit int	2 bytes (1 register)
19	0x0012	**Pressure of sensor 2**	Value 0 1/100 of the selected unit	Signed 16-bit int	2 bytes (1 register)
20	0x0013	**Temperature of sensor 1**	Integer, 1/100ºC	Signed 16-bit int	2 bytes (1 register)
21	0x0014	**CPU temperature**	Integer, 1/100ºC	Signed 16-bit int	2 bytes (1 register)
22	0x0015	**Temperature of sensor 2**	Value 0 1/100 at ºC	Signed 16-bit int	2 bytes (1 register)
23	0x0016	**Pressure unit**	Pressure or level unit	Unsigned 16-bit int	2 bytes (1 register)
24	0x0017	----------	----------	----------	2 bytes (1 register)
25	0x0018	**Upper sensor limit**	Upper limit of the standard range	IEEE754	4 bytes (2 registers)
27	0x001A	**Lower sensor limit**	Lower limit of the standard range	IEEE754	4 bytes (2 registers)
29	0x001C	**Damping value**	Seconds (s)	IEEE754	4 bytes (2 registers)
31	0x001E	**Response delay value**	Milliseconds (ms)	Unsigned 16-bit int	2 bytes (1 register)
32	0x001F	**Modbus address**	1…247	Unsigned 8-bit int	2 bytes (1 register)
33	0x0020	**Identity register**		Unsigned 8-bit int	6 bytes (3 registers)
36	0x0023	**Status register**		8-bit flags	2 bytes (1 register)

* Fields shaded in gray are not active in the specified models .

8.3.3.1. Request message with the function 0x03 (Example 1)

Master request and slave response, sensor 1 pressure read value.

Request message							
Slave address	Function	Parameters				CRC(L)	CRC(H)
		Starting address in register (H)	Starting address in register (L)	Number of registers to be read (H)	Number of registers to be read (L)		
0x01	**0x03**	**0x00**	**0x02**	**0x00**	**0x02**	**0x65**	**0xCB**
Response message							
Slave address	Function	Parameters				CRC(L)	CRC(H)
		Number of data bytes	Data value (sensor 1 pressure in IEEE754 format), hexadecimal numbers				
0x01	**0x03**	**0x04**	**40 5F D1 BC**			**0x82**	**0x00**

8.3.3.2. Request message (Example 2)

Master request and slave response, read total accessible address space.

Request message							
Slave address	Function	Parameters				CRC(L)	CRC(H)
		Starting address in register (H)	Starting address in register (L)	Number of registers to be read (H)	Number of registers to be read (L)		
0x01	**0x03**	**0x00**	**0x00**	**0x00**	**0x24**	**0x45**	**0xD1**
Response message							
Slave address	Function	Parameters				CRC(L)	CRC(H)
		Number of data bytes	Memory content in registers read, hexadecimal numbers				
0x01	**0x03**	**0x48**	**00 00 00 00 40 5F F8 DD 00 00 00 00 41 C8 00 00 41 C8 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 5E 00 00 09 C4 09 C4 00 00 00 0C 00 00 42 C8 00 01 00 00 00 00 00 00 00 00 00 00 00 01 00 BC 7D 00 00 01 00 00**			**0x97**	**0xCE**

8.3.3.3. Received data based on example 2, assigned to the relevant registers.

1	0x0000	**User specific**	IEEE754	40 5F F8 DD	4 bytes (2 registers)
3	0x0002	**Pressure of sensor 1**	IEEE754	**40 5F F8 DD**	4 bytes (2 registers)
5	0x0004	**Pressure of sensor 2**	IEEE754	**00 00 00 00**	4 bytes (2 registers)
7	0x0006	**Temperature of sensor 1**	IEEE754	**41 C8 00 00**	4 bytes (2 registers)
9	0x0008	**CPU temperature**	IEEE754	**41 C8 00 00**	4 bytes (2 registers)
11	0x000A	**Temperature of sensor 2**	IEEE754	**00 00 00 00**	4 bytes (2 registers)
13	0x000C	----------	----------	**00 00 00 00**	4 bytes (2 registers)
15	0x000E	----------	----------	**00 00 00 00**	4 bytes (2 registers)
17	0x0010	**User specific**	Signed 16-bit int	**01 5E**	2 bytes (1 register)
18	0x0011	**Pressure of sensor 1**	Signed 16-bit int	**01 5E**	2 bytes (1 register)
19	0x0012	**Pressure of sensor 2**	Signed 16-bit int	**00 00**	2 bytes (1 register)
20	0x0013	**Temperature of sensor 1**	Signed 16-bit int	**09 C4**	2 bytes (1 register)
21	0x0014	**CPU temperature**	Signed 16-bit int	**09 C4**	2 bytes (1 register)
22	0x0015	**Temperature of sensor 2**	Signed 16-bit int	**00 00**	2 bytes (1 register)
23	0x0016	**Pressure unit**	Unsigned 16-bit int	**00 0C**	2 bytes (1 register)
24	0x0017	----------	----------	**00 00**	2 bytes (1 register)
25	0x0018	**Upper sensor limit**	IEEE754	**42 C8 00 01**	4 bytes (2 registers)
27	0x001A	**Lower sensor limit**	IEEE754	**00 00 00 00**	4 bytes (2 registers)
29	0x001C	**Damping value**	IEEE754	**00 00 00 00**	4 bytes (2 registers)
31	0x001E	**Response delay value**	Unsigned 16-bit int	**00 06**	2 bytes (1 register)
32	0x001F	**Modbus address**	Unsigned 8-bit int	**00 01**	2 bytes (1 register)
33	0x0020	**Identity register**	Unsigned 8-bit int	**00 BC 7D 00 00 01**	6 bytes (3 registers)
36	0x0023	**Status register**	8-bit flags	**00 00**	2 bytes (1 register)
* Fields shaded in gray are not active in the specified models					

8.3.4. Data from registers readable using function 03

8.3.4.1. Register 1, user value, % control of the set range

1	0x0000	**User specific**	% of the controlled set range	IEEE754	4 bytes (2 registers)

This is the percentage control value of the set range. For example: if the set range is 0...100 kPa, and the currently read pressure value is 50 kPa, the control value is 50%. The advantage of the set range is that the user can define its span by setting the start and end values contained within the basic pressure range. You can then perform mathematical operations on a part of the measuring range or use that part of the measuring range to display your custom units/values. This value can be used to perform additional mathematical operations on it in the controller working with the transmitter. It can also be converted by the transmitter by means of a quadratic, cubic, root or linear multi-section function and read from the log in this form using the **0x03 (3) Read Holding Register** function. For the SGE-25.Modbus, SGE-25S.Modbus probes, the set range is also related to the internal 4-20 mA current controller, where the start of the set range is assigned the value of 4 mA and it ends at 20 mA.

8.3.4.2. Register 3, pressure of sensor 1

3	0x0002	**Pressure of sensor 1**	Pressure or level process variable	IEEE754	4 bytes (2 registers)

Basic process variable (pressure or level) standardized for the selected physical unit. This value is sent in 4-byte floating point format conforming to IEEE754. The maximum readable pressure or level range lies between:
[Lower sensor limit – 0.5 x (Upper sensor limit – Lower sensor limit)], and

[0.5 x (Upper sensor limit – Lower sensor limit) + Upper sensor limit].
If the lower sensor limit is designated Pd and the upper sensor limit is designated Pg, then the transmitter's maximum possible processing range can be described as:
P= [Pd -0,5x(Pg-Pd) … Pg+0,5x(Pg-Pd)]
example:
A level probes for which Pd=0 kPa, Pg=100 kPa will process pressure in the range of -50 kPa to +150 kPa. If the pressure continues to increase beyond the permissible range, the read value will not change.

8.3.4.3. Register 5, pressure of sensor 2

5	0x0004	**Pressure of sensor 2**	Constant 0	IEEE754	4 bytes (2 registers)

Standby register. Data variables to be read are always zero.

8.3.4.4. Register 7, temperature of sensor 1

7	0x0006	**Temperature of sensor 1**	Sensor 1 temperature process variable at ºC	IEEE754	4 bytes (2 registers)

Value of the temperature process variable in ºC read from the probe's measuring head. This value reflects the temperature of the measuring sensor and an approximate temperature of the medium (depending on the application).

8.3.4.5. Register 9, CPU temperature

9	0x0008	**CPU temperature**	CPU temperature process variable at ºC	IEEE754	4 bytes (2 registers)

Value of the temperature process variable in ºC read from the microcontroller temperature sensor. This value reflects the approximate temperature of the probe electronics board.

8.3.4.6. Register 11, temperature of sensor 2

11	0x000A	**Temperature of sensor 2**	Constant 0 ºC	IEEE754	4 bytes (2 registers)

Standby register. Data variables to be read are always zero.

8.3.4.7. Register 13, standby

13	0x000C	----------	----------	----------	4 bytes (2 registers)

Standby register. Data variables to be read are always zero.

8.3.4.8. Register 15, standby

15	0x000E	----------	----------	----------	4 bytes (2 registers)

Standby register. Data variables to be read are always zero.

8.3.4.9. Register 17, user value

17	0x0010	**User specific**	1/100% of the controlled set range	Signed 16-bit int	2 bytes (1 register)

A given value has been described in Register 1. Outside this index, it also occurs in a 16-bit integer version with a sign.

8.3.4.10. Register 18, pressure of sensor 1 – binary format, integer and sign

18	0x0011	**Pressure of sensor 1**	Integer, 1/100 of the pressure or level unit	Signed 16-bit int	2 bytes (1 register)

Value of the primary process variable (pressure) standardized for the selected physical unit of pressure (or level). This value is an integer sent in scalable binary format as a value 100 times greater than the value of the sensor 1 pressure process variable.

Caution! The measuring range for a scalable integer, including its sign, is in the range of -32767 to 32767 units. If this range is exceeded, a false value will be read. In case of pressure reading in binary format “Signed 16-bit int”, the basic unit should be selected so that 100 times the pressure value does not exceed the above range.

8.3.4.11. Register 19, pressure of sensor 2

19	0x0012	**Pressure of sensor 2**	Value 01/100 of the selected unit.	Signed 16-bit int	2 bytes (1 register)

Standby register. Data variables to be read are always zero.

8.3.4.12. Register 20, temperature of sensor 2 – binary format, integer and sign

20	0x0013	**Temperature of sensor 2**	Integer,1/100ºC	Signed 16-bit int	2 bytes (1 register)

Value of the temperature process variable in ºC read from the probe’s measuring head. This value is an integer sent in scalable binary format as a value 100 times greater than the value of the sensor 1 temperature process variable. This value reflects the temperature of the measuring sensor and an approximate temperature of the medium (depending on the application).

8.3.4.13. Register 21, CPU temperature – binary format, integer and sign

21	0x0014	**CPU temperature**	Integer,1/100ºC	Signed 16-bit int	2 bytes (1 register)

Value of the temperature process variable in ºC read from the probe’s CPU. This value is an integer sent in scalable binary format as a value 100 times greater than the value of the CPU temperature process variable. This value reflects the temperature of the probe’s electronic circuits.

8.3.4.14. Register 22, temperature of sensor 2

22	0x0015	**Temperature of sensor 2**	Signed 16-bit int	**00 00**	2 bytes (1 register)

Standby register. Data variables to be read are always zero.

8.3.4.15. Register 23, pressure unit

23	0x0016	**Pressure unit**		Unsigned 16-bit int	**00 0C**	2 bytes (1 register)

Binary value corresponding to the pressure unit. The table below shows the units used.

Unit	Value (decimal number)	Unit	Value (decimal number)
atm	14	mbar	8
bar	7	mmH2O in 4°C	239
FtH2O	3	mmH2O	4
g/cm²	9	mH2O in 4°C	171
InH2O in 4°C	238	mmHg	5
InHg	1	MPa	237
kg/cm²	2	Pa	11
kPa	10	psi	6
mbar	12	torr	13

8.3.4.16. Register 24, standby

24	0x0017	----------	----------	----------	2 bytes (1 register)

Standby register. Data variables to be read are always zero.

8.3.4.17. Register 25, standby

25	0x0018	**Upper sensor limit**	Upper limit of the basic range	IEEE754	4 bytes (2 registers)

An upper value of the probe's basic range expressed in the probe's pressure units. This value is sent in 4-byte floating point format conforming to IEEE754.

8.3.4.18. Register 27, standby

27	0x001A	**Lower sensor limit**	Lower limit of the basic range	IEEE754	4 bytes (2 registers)

A lower value of the probe's basic range expressed in the probe's pressure units. This value is sent in 4-byte floating point format conforming to IEEE754.

8.3.4.19. Register 29, standby

29	0x001C	**Damping value**	The seconds [s]	IEEE754	4 bytes (2 registers)

A damping block time constant in the transmitter in seconds. This value is sent in 4-byte floating point format conforming to IEEE754.

8.3.4.20. Register 31, response dalay value

31	0x001E	**Response delay value**	Milliseconds [ms]	Unsigned 16-bit int	2 bytes (1 register)

It is a value of response delay subsequent to the "Master" request. It describes the time between the end of a bit stop byte of the message checksum and a bit start byte of the response message address. This time depends on the speed of transmission and always exceeds 3.5T. This time may be useful in designing the time of a measurement cycle in a Modbus network.

8.3.4.21. Register 32, Modbus address

32	0x001F	**Modbus Address**	1 … 247	Unsigned 8-bit int	2 bytes (1 register)

Values of the transmitter's network address register. The address is sent using 2 bytes. The first older byte is always zero. The second lower byte is used for the address. The address can be set in the range of 1 to 247. Each device connected to the network must have a unique network address. If the same address is assigned to more than one transmitter, the "Master" will not be able to communicate with all present transmitters on the bus.

8.3.4.22. Register 33, identity register

33	0x0020	**Identity register**		Unsigned 8-bit int	6 bytes (3 registers)

An identifier of the manufacturer, type and serial number of the level probe. A unique identifier, different for each transmitter.
Identification of bytes according to the transmission sequence:

- 1st byte – insignificant, always 0;
- 2nd byte – manufacturer's number acc. to HCF, APLISENS number: 188 dec (BC hex);
- 3rd byte – device type number, number for the probes described in this document: 125 dec (7D hex);
- 4th-6th byte – 24-bit binary identification number of the device. This number identifies the date of manufacture and serial number.

8.3.4.23. Register 36, status register

36	0x0023	**Status register**		8-bit flags	2 bytes (1 register)

A 2-byte register monitoring the functioning of the transmitter's subsystems. Events and the probe's irregularities modify bits contained in the Modbus register below:

15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	0	0	0	0	0	0	SV,TV,FV out of limit	PV out of limit	0	0	0	0	0

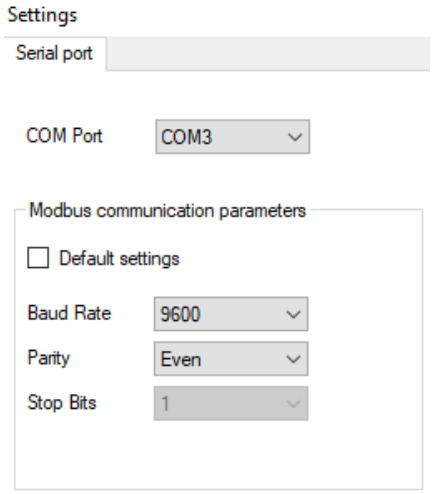
These irregularities can be identified in detail in configuration mode with the use of programmes such as e.g. Raport 2 from APLISENS S.A.

8.4. Configuration mode

8.4.1. "Modbus Configurator" software. Serial port configuration, Modbus network scanning, single transmitter search

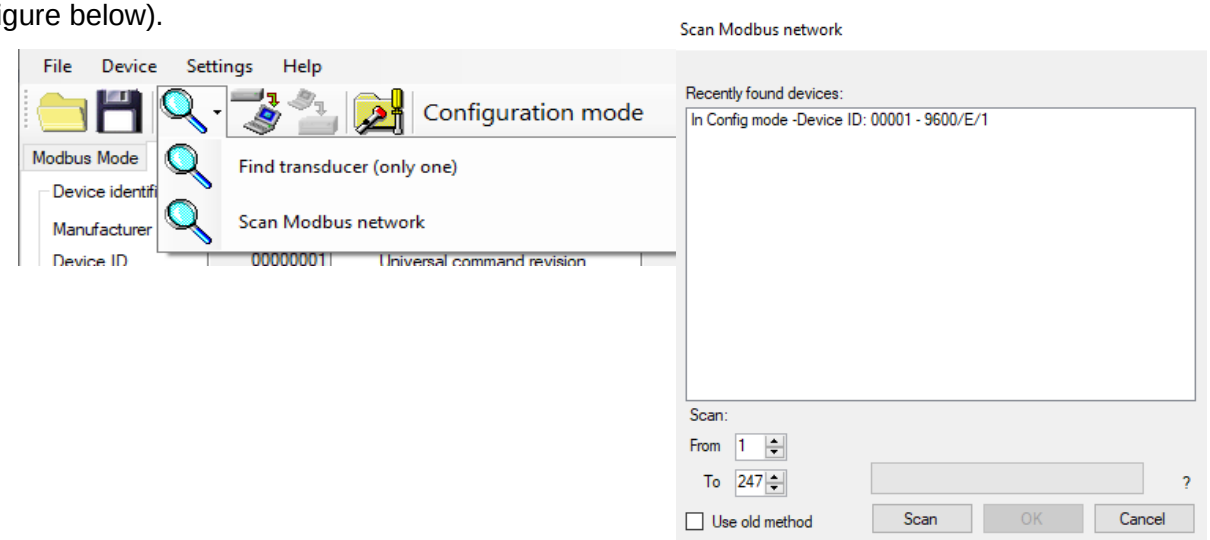
The probe software version 17 and above allows you to perform basic actions or parameter changes via Modbus functions as described in section ➔8.3 Application layer, description of implemented functions. However, to make out specific settings or calibration operations, the probe must be adjusted using the APLISENS S.A. software. (link to software):
https://aplisens.pl/download/pliki_do_pobrania/Modbus%20Configurator%20Setup.exe.
Modbus Configurator to the configuration mode by pressing the respective program key. For operation in the configuration mode, it is recommended to disconnect the probe to be configured from the Modbus network and connect it directly to an RS485 converter coupled to a PC/Windows computer with the Modbus Configurator software installed.
Proceeding when a change of parameters of one of the Modbus network devices is required:
To change settings or perform calibration operations on the device in the configuration mode, disconnect it from the Modbus network. If this is not possible, stop the master process controller that supports the Modbus network and plug in an additional PC-based master with the Modbus Configurator software to proceed with the configuration.

After launching the Configurator, open the tab Serial port settings  and set the number of COM port to which the RS485 converter is connected, Modbus baud rate, parity mode and stop bits for the transmitters in the network.

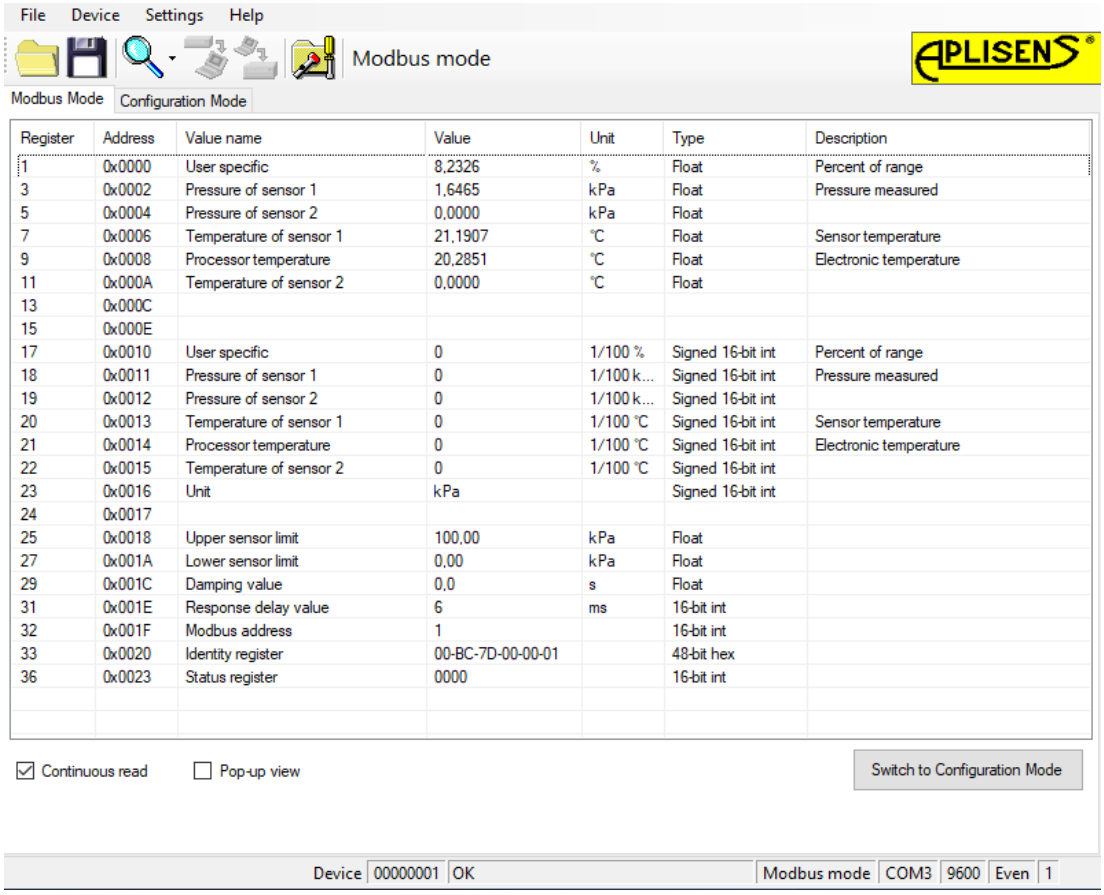


Serial port settings (example).

Next, search for Modbus devices according to address by clicking on "Scan Modbus network" (see figure below).

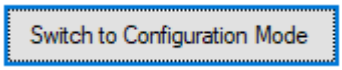


When searching the network, a list of Modbus devices from Aplisens S.A., connected to the network, will be displayed. If you know the network address of the device to be set up, click on the appropriate device in the scanned list. A list of registers will appear with read-out parameters from Modbus registers.



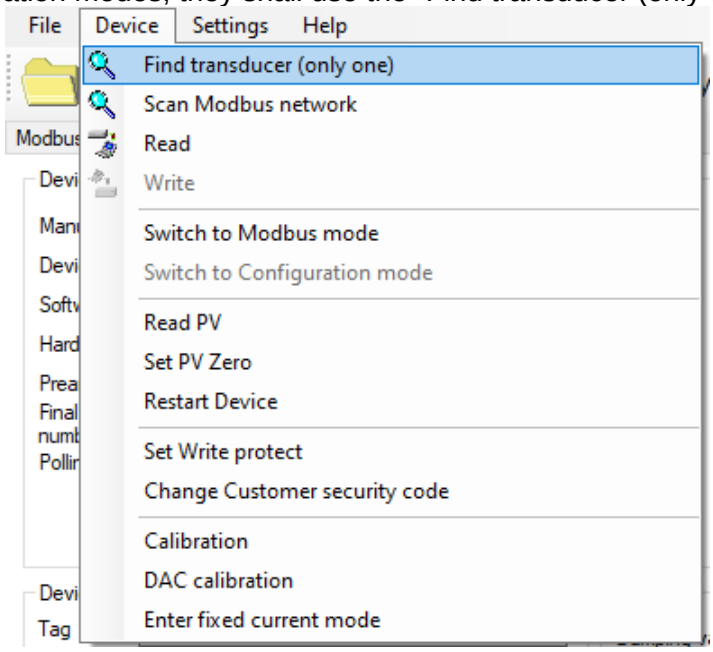
Register	Address	Value name	Value	Unit	Type	Description
1	0x0000	User specific	8,2326	%	Float	Percent of range
3	0x0002	Pressure of sensor 1	1,6465	kPa	Float	Pressure measured
5	0x0004	Pressure of sensor 2	0,0000	kPa	Float	
7	0x0006	Temperature of sensor 1	21,1907	°C	Float	Sensor temperature
9	0x0008	Processor temperature	20,2851	°C	Float	Electronic temperature
11	0x000A	Temperature of sensor 2	0,0000	°C	Float	
13	0x000C					
15	0x000E					
17	0x0010	User specific	0	1/100 %	Signed 16-bit int	Percent of range
18	0x0011	Pressure of sensor 1	0	1/100 k...	Signed 16-bit int	Pressure measured
19	0x0012	Pressure of sensor 2	0	1/100 k...	Signed 16-bit int	
20	0x0013	Temperature of sensor 1	0	1/100 °C	Signed 16-bit int	Sensor temperature
21	0x0014	Processor temperature	0	1/100 °C	Signed 16-bit int	Electronic temperature
22	0x0015	Temperature of sensor 2	0	1/100 °C	Signed 16-bit int	
23	0x0016	Unit	kPa		Signed 16-bit int	
24	0x0017					
25	0x0018	Upper sensor limit	100,00	kPa	Float	
27	0x001A	Lower sensor limit	0,00	kPa	Float	
29	0x001C	Damping value	0,0	s	Float	
31	0x001E	Response delay value	6	ms	16-bit int	
32	0x001F	Modbus address	1		16-bit int	
33	0x0020	Identity register	00-BC-7D-00-00-01		48-bit hex	
36	0x0023	Status register	0000		16-bit int	

Switch the transmitter from Modbus into configuration mode working with Hart communication protocol.

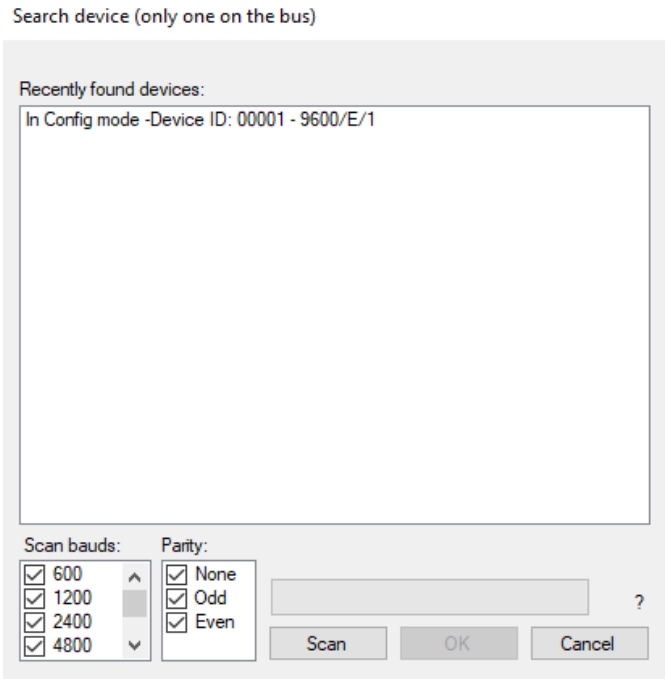


The procedure to be followed, if it is required to reconfigure parameter or identify an individual transmitter not connected via the Modbus network with other devices:

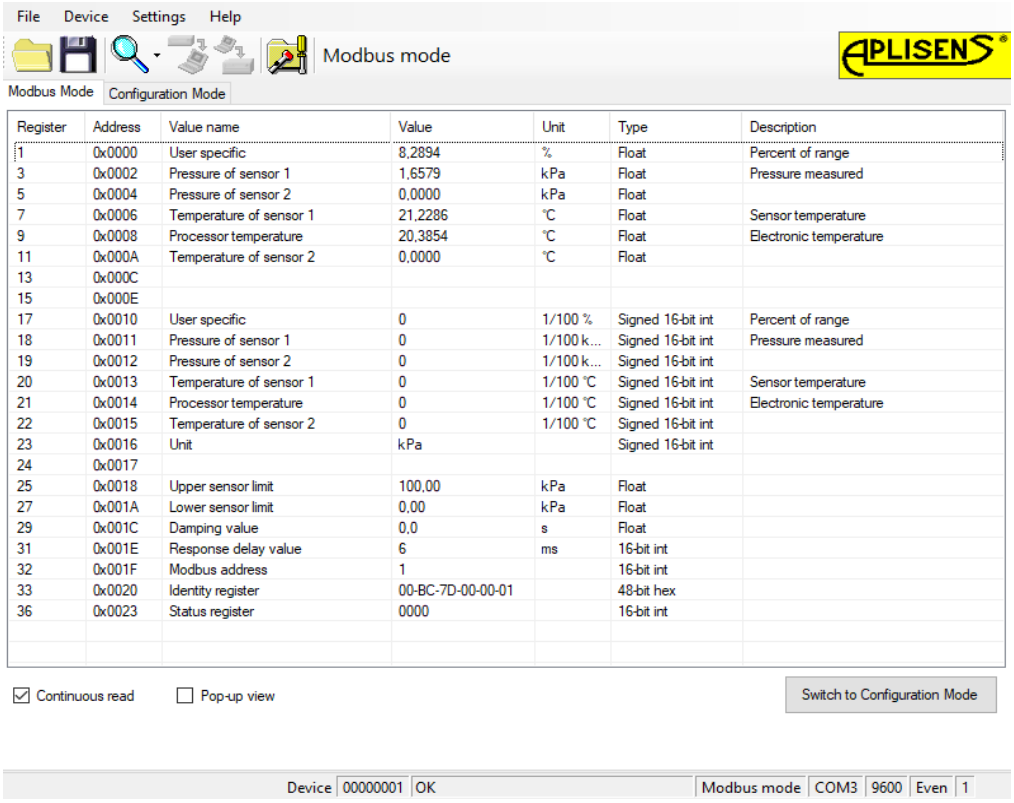
If the user wishes to identify an individual transmitter and they are not sure whether it is operating in the Modbus or Configuration modes, they shall use the "Find transducer (only one)" option.



Transmitter search parameters related to potential transmission settings must be configured in the opened window. When in doubt, as to the range of settings, the best solution is to tick all the options. Clicking the "Scan" button prompts the programme to start searching for a transmitter, in a sequence, starting from the Configuration mode, and then it will go through an indicated range of transmission speeds and parity in the Modbus mode.
Searching for a device in the Modbus mode is carried out with a broadcast = 0. Therefore, only one transmitter may be connected, when scanning through a communication bus. Where there are a larger number of transmitters operating in the Modbus mode connected to the bus and set to the same transmission parameters - sending a broadcast address will make transmitters respond to a request message at the same time, causing data corruption and an unreadable answer.

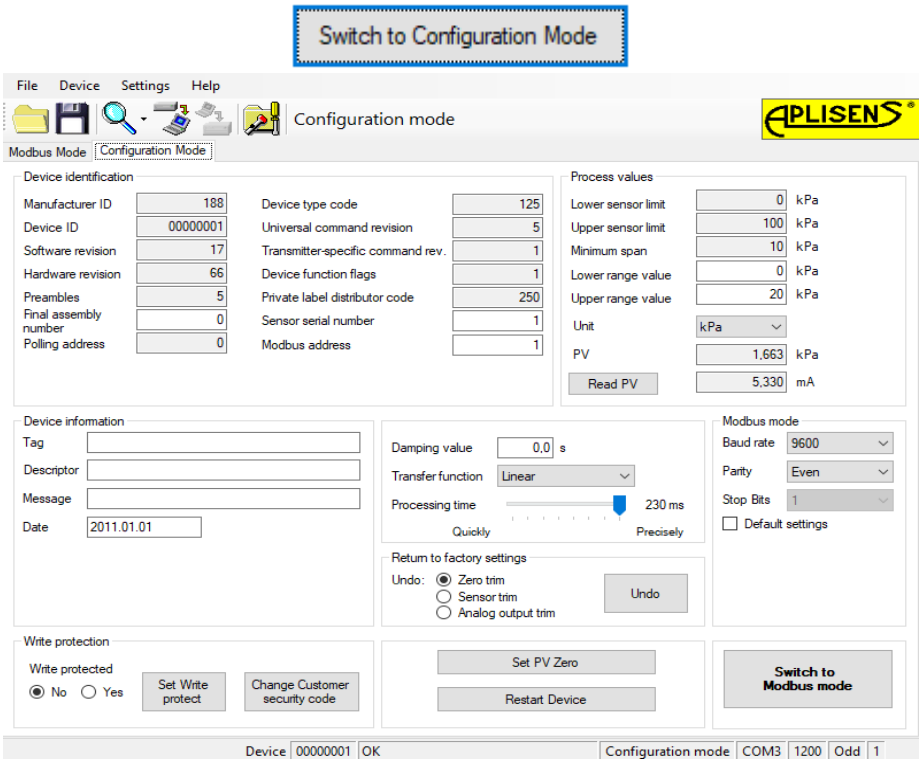


Click on the detected transmitter... A list of registers will appear with parameters read out from Modbus registers.



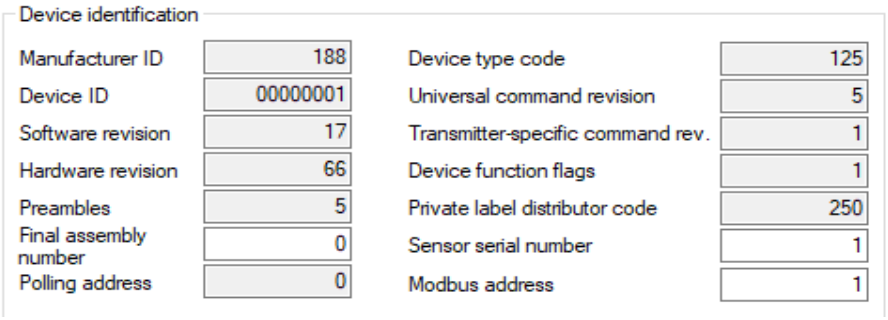
Register	Address	Value name	Value	Unit	Type	Description
1	0x0000	User specific	8,2894	%	Float	Percent of range
3	0x0002	Pressure of sensor 1	1,6579	kPa	Float	Pressure measured
5	0x0004	Pressure of sensor 2	0,0000	kPa	Float	
7	0x0006	Temperature of sensor 1	21,2286	°C	Float	Sensor temperature
9	0x0008	Processor temperature	20,3854	°C	Float	Electronic temperature
11	0x000A	Temperature of sensor 2	0,0000	°C	Float	
13	0x000C					
15	0x000E					
17	0x0010	User specific	0	1/100 %	Signed 16-bit int	Percent of range
18	0x0011	Pressure of sensor 1	0	1/100 k...	Signed 16-bit int	Pressure measured
19	0x0012	Pressure of sensor 2	0	1/100 k...	Signed 16-bit int	
20	0x0013	Temperature of sensor 1	0	1/100 °C	Signed 16-bit int	Sensor temperature
21	0x0014	Processor temperature	0	1/100 °C	Signed 16-bit int	Electronic temperature
22	0x0015	Temperature of sensor 2	0	1/100 °C	Signed 16-bit int	
23	0x0016	Unit	kPa		Signed 16-bit int	
24	0x0017					
25	0x0018	Upper sensor limit	100,00	kPa	Float	
27	0x001A	Lower sensor limit	0,00	kPa	Float	
29	0x001C	Damping value	0,0	s	Float	
31	0x001E	Response delay value	6	ms	16-bit int	
32	0x001F	Modbus address	1		16-bit int	
33	0x0020	Identity register	00-BC-7D-00-00-01		48-bit hex	
36	0x0023	Status register	0000		16-bit int	

Then, switch the transmitter from the Modbus mode to the Configuration mode.



Configuration mode view

8.4.2. Device identification data



Identification data frames (example). Read-only values are shaded.

Read-only information fields:

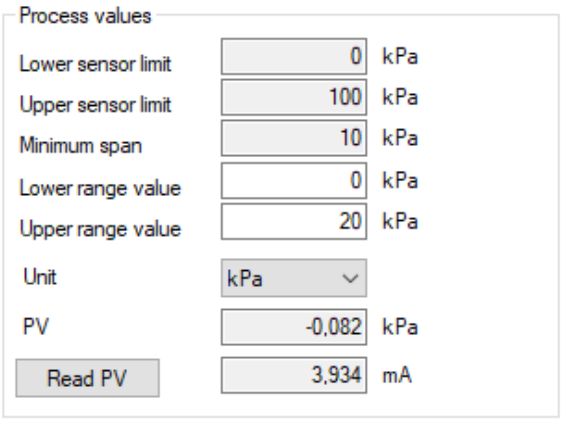
- **Manufacturer ID** - manufacturer's code according to HCF (HART) specifications.
- **Device ID** - transmitter's serial number.
- **Software revision** - CPU software version.
- **Hardware revision** - transmitter's PCB version.
- **Preambles** - number of preambles used for communication in configuration mode.
- **Pooling address** - address used for communication in configuration mode.
- **Device type code** – code indicating the transmitter type.
- **Universal command revision** - number in configuration mode.
- **Transmitter-specific command revision** – number in configuration mode.
- **Device function flags** – related to record handling type.
- **Private label distributor code**.

Editable information fields:

- **Final assembly number** of the device, recorded in binary format using 3 bytes, an integer in the range of 0...16777215 used for identification (modifiable by user).
- **Sensor serial number**, recorded in binary format using 3 bytes, an integer in the range of 0...16777215 used for identification (modifiable by user).
- **Modbus address**, an integer in the range of 1...247 (modifiable by user).

The field "**Modbus address**" used for defining the transmitter's network address is highly significant.

8.4.3. Reading the transmitter's limit values process variables

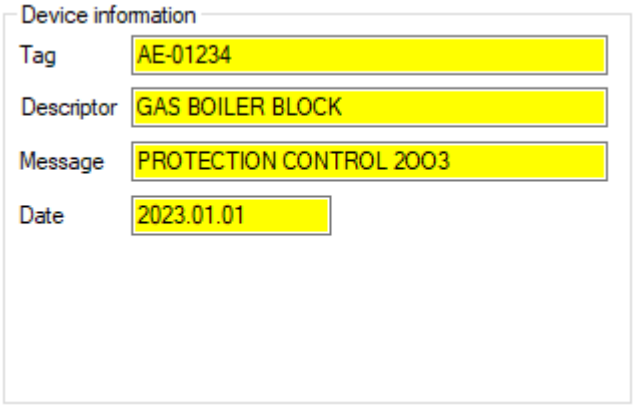


Frame containing process variables and limit values (example)

- **Lower sensor limit** A read-only value. If exceeded, accuracy of measurements using the transmitter cannot be guaranteed. However, the transmitter will continue to process measuring signals up to 50% of the basic range below this point.
- **Upper sensor limit** A read-only value. If exceeded, accuracy of measurements using the transmitter cannot be guaranteed. However, the transmitter will continue to process measuring signals up to 50% of the basic range above this point.
- **Minimum span** A read-only value that defines the minimum width of the set range, modifiable by user by changing the start and/or the end points of the range. This parameter is also important when calibrating pressure or level. If intervals between calibration points are insufficient, the transmitter cannot be calibrated.
- **Lower range value** Value related to the current loop mode: 4-20 mA. Specific pressure or level is assigned to the current of 4 mA.
- **Upper range value** Value related to the current loop mode: 4-20 mA. Specific pressure or level is assigned to the current of 20 mA.
- Standard **Unit** is the physical unit used for standardizing measurements performed with the transmitter (definable by user).
- **PV** is the value of the pressure or level process variable, standardized basic unit as defined. Additionally, the current process variable is displayed.

To refresh the value, click on the button "**Read PV**".

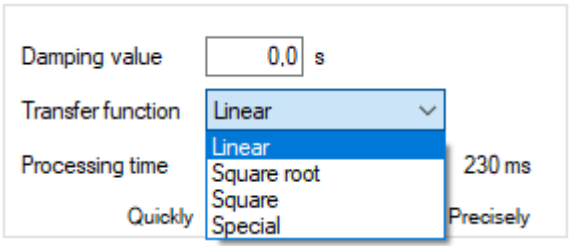
8.4.4. Reading alphanumeric identification data



Alphanumeric identification data frame (example).

User can read or modify the transmitter's alphanumeric identification data.
Tag is an 8-character alphanumeric field where you can enter e.g. an identification number of the transmitter in the system. This field can contain digits and capital letters without diacritics.
Descriptor is a 16-character alphanumeric field where you can enter a short description of e.g. an installation site. This field can contain digits and capital letters without diacritics.
Message is a 32-character alphanumeric field where you can enter a longer description. This field can contain digits and capital letters without diacritics.

8.4.5. Damping and transfer function

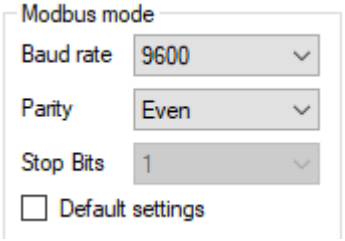


User can read or modify the measurement damping value and transfer function type.
Damping value is expressed in seconds and describes the duration of a non-determined status after which the process variable will achieve 63.2% of the total value change. The process variable value will be nearly fully changed with an accuracy of below 1% after ca 5 time constants.
The transfer function determines the method of transforming a process variable related to pressure measurement / pressure differences into a control value of a process output (current or a percentage value of the set range). The following functions are available from a drop-down list:

- linear;
- root;
- quadratic;
- user.

The control value of a process output transformed with a transfer function is available in Modbus 1 and 17 registers.

8.4.6. Modbus mode



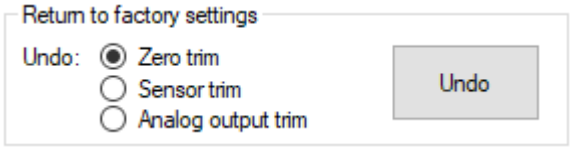
User can read or edit and save Modbus RTU baud rate and parity control mode or restore default settings.

8.4.7. Restore default settings

User can restore default settings for the following parameters:

- Zero-point calibration.
- Pressure sensor calibration.
- Analogue output calibration.

You can restore default settings if you changed some settings accidentally and you are not able to perform calibration to your own settings. Please remember that this operation will restore calibration settings defined by the manufacturer. If you have already calibrated the transmitter to your own settings, all your calibration settings will be lost as a result of this operation.



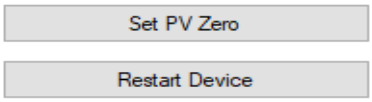
8.4.8. Write lock

You can set a lock that prevents from modification of the transmitter parameters and change the security code to remove the lock. The lock code has a format of 8 hexadecimal characters, i.e. in the range 0...9, A-F, **the default value is 00000000**.
It is not possible to change the transmitter settings when the lock is activated.

8.4.9. Additional operation

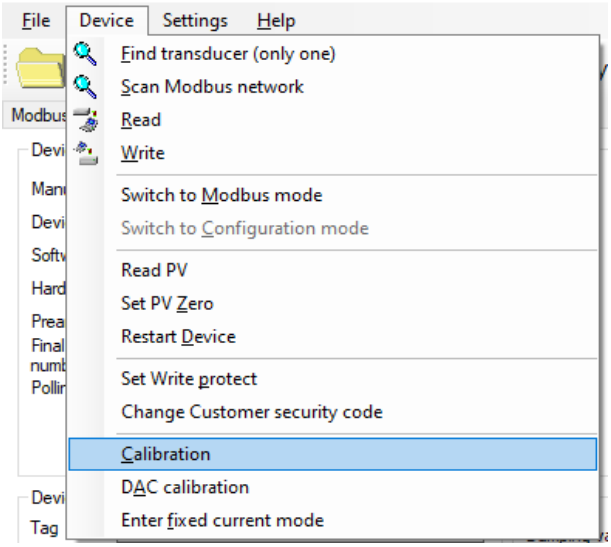
User can perform additional operations on the transmitter:

- Set PV Zero enables resetting pressure in a non-pressurized transmitter. The resetting option is used for eliminating any deviations of the zero point caused by installation (position or stress). The operation cannot be performed if deviation of the zero point exceeds the permissible limit or if the transmitter measures absolute pressure.
- Restart Device enables sending a command to hot restart the transmitter without the need to disconnect the power supply.



8.4.10. Calbrations

User can perform 2-point pressure calibration, DAC (analogue) calibration and, in addition to that, enter fixed current mode.



8.4.10.1. Level calibration.

To open the level calibration tab, select Device → Calibration on the top bar of the programme screen. Calibration of the lower and upper pressure limits should be best performed for the transmitter's standard measuring range. For metrological reasons, if the used range is only an insignificant section of the standard range, the transmitter should be calibrated based on the lower and upper limits of the used range. The calibration procedure involves supplying reference pressure to the transmitter for the lower calibration point. The reference level value should be entered into the set value field. As soon as the read value is stable, press "Calibrate". If calibration is successful, an appropriate message will appear. Repeat the above steps for the upper pressure limit.
If the difference between the reference pressure and the actual pressure read by the transmitter exceeds the permissible limit, calibration will not be performed and an appropriate message will be displayed. A similar situation arises if the selected calibration point lies outside the transmitter's lower or upper limit.

8.4.10.2. Calibrating the analogue output

Select the "Device → DAC calibration" option in the top bar to access the analogue output calibration tab. With the calibration wizard, you can perform a two-point calibration of the low (4 mA) or high (20 mA) current.

8.4.10.3. Setting the fixed current mode

To enter fixed current mode tab, select "Device → Enter fixed current mode," in the top bar. In this mode, on transmitters equipped with a current controller, you can set the controller current between 3.600 and 23.000 mA for testing purposes, e.g. 4.000 mA and 20.000 mA.

8.4.10.4. Configuration write

Once the parameters have been configured save the changes to the transmitter. To do this, select the "Device → Write" on the top bar of the program or press the save configuration icon.

8.5. Current loop 4-20 mA operation

The set range is a parameter linked to the “user value” or “% control of the set range” process variable (log 1 and 17). The LRV point of the set range corresponds to the controller current of 4.000 mA, and the URV point to 20.000 mA. The LRV and URV points can be assigned different pressure values from the transmitter's basic range, subject to the minimum range span condition of the MSV setting. It is also possible to set a reverse curve, where the LRV point is assigned a higher pressure than the URV, subject to the minimum range span condition of the MSV setting.

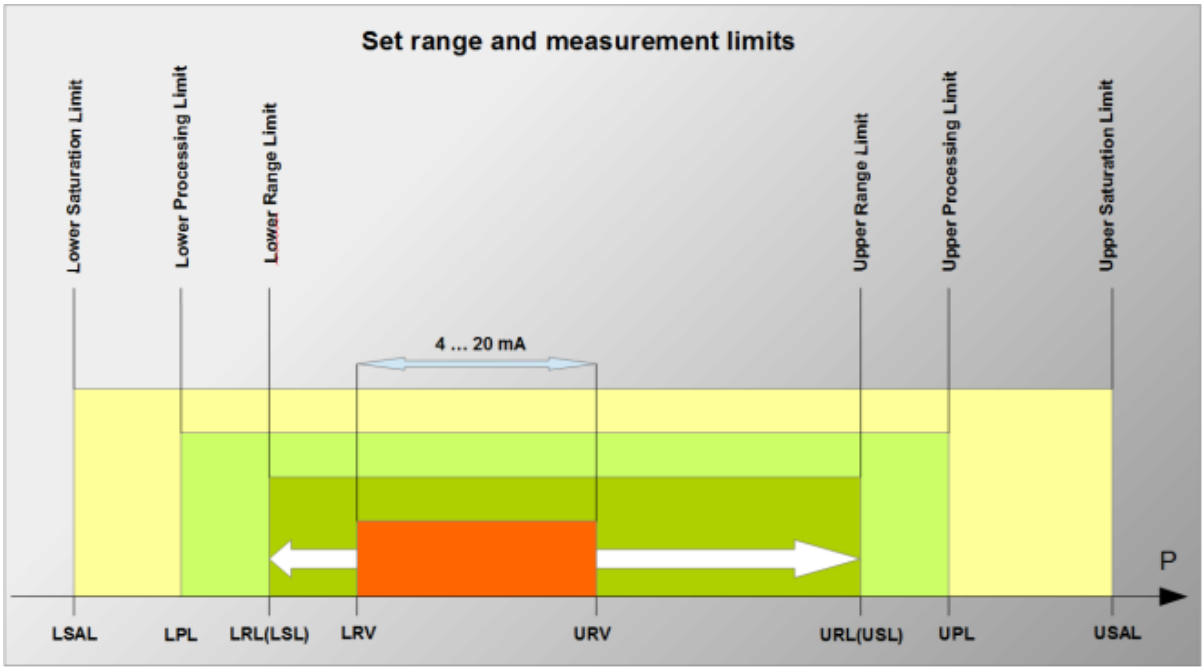


Figure 5 Set range and measurement limits

Table 4 Set range and measurement limits

Set range and measurement limits		
Item no.	**Abbr.**	**Meaning**
1	**LRV**	"Lower Range Value" – the value of the set range expressed in physical units corresponding to the current of 4,000 mA, i.e. 0% of the output setpoint. The set range cannot exceed the set range limits. The minimum width of the set range **|(URV-LRV)|** is limited to 10% of the base range **(URL-LRL)**.
2	**URV**	"Upper Range Value" – the value of the set range expressed in physical units corresponding to the current of 20,000 mA, i.e. 100% of the output setpoint. The set range cannot exceed the set range limits. The minimum width of the set range **|(URV-LRV)|** is limited to 10% of the base range **(URL-LRL)**.
3	**LRL LSL**	"Lower Range Limit" or "Lower Sensor Limit" - lower limit of set range expressed in physical units. Value **(URL-LRL)** or **(USL-LSL)** is referred to as the base transmitter range.
4	**URL USL**	"Upper Range Limit" or "Upper Sensor Limit" – upper limit of set range expressed in physical units. Value **(URL-LRL)** or **(USL-LSL)** is referred to as the base transmitter range.
5	**LPL**	"Lower Processing Limit" – lower limit of digital processing of measured value. The transmitter processes a digital measurement up to 50% of the base range width below the lower limit of set range **LRL (LSL)**. After reaching the **LPL** and when below this value up to **LSAL,** the transmitter freezes the refreshing of digital value of the measurement.
6	**UPL**	"Upper Processing Limit" – upper limit of digital processing of measured value. The transmitter processes a digital measurement up to 50% of the base range width above the upper limit of set range **URL (USL)**. After reaching the **UPL** and when above this value up to **USAL**, the transmitter freezes the refreshing of digital value of the measurement.
7	**LSAL**	"Lower Saturation Limit" - lower limit of the ADC transmitter processing range. The lower limit of the ADC transmitter saturation is on the pressure/differential pressure scale below the **LPL** point and is associated with the minimum pressure, at which the analogue-digital pressure measurement transmitter reaches the lower limit of the processing capacity. Exact determination of this pressure is not possible, but it exceeds the pressure corresponding to 30 times the span of the (URL-LRL) basic range below the lower limit of digital processing of the UPL measured value. After reaching **LSAL** and when below this value diagnostic alarm mode will be activated depending on the settings I_AL<3,650 mA or I_AL>21,500 mA.
8	**USAL**	"Upper Saturation Limit" - upper limit of the A/D transmitter processing range. The upper limit saturation point of A/D transmitter is on the pressure/differential pressure scale above the **UPL** point and is associated with the maximum pressure at which the analogue-digital pressure measurement transmitter reaches the upper limit of the processing capacity. Exact determination of this pressure is not possible, but it exceeds the pressure corresponding to 30 times the span of the (URL-LRL) basic range above the upper limit of digital processing of the UPL measured value. After reaching **LSAL** and when above this value diagnostic alarm mode will be activated depending on the settings I_AL<3,650 mA or I_AL>21,500 mA.
9	**AL_L**	Low current alarm.
10	**AL_H**	High current alarm.
11	**MSV**	"Minimum Span Value" – the value of the minimum span of the |URV - LRV| range setting possible to set in the transmitter. This value is written into the transmitter at the manufacturing stage and cannot be changed by the user.

8.5.1. Alarm signal levels

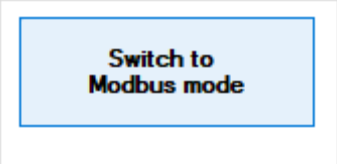
In level probes Modbus transmitters, where the controller current signal is routed outside, alarm signals can be detected with an external controller.
The nominal value of the AL_L low alarm current is 3.600 mA.
The nominal value of the AL_H high alarm current is 22.000 mA.

The alarm mode is activated in the following cases:

- ADC converter fault;
- local quartz oscillator fault;
- dynamic RAM fault;
- coefficient memory or the FLASH program memory fault.

8.6. Modbus mode

After configuring the transmitter as necessary to restore Modbus mode, you must save new settings. Click on the button Switch to Modbus mode to save new settings and switch the transmitter into Modbus communication mode.



9. MAINTENANCE

9.1. Periodic inspections

Periodic inspections should be carried out in accordance with the standards applicable to the user. Check the processing characteristics by following the steps appropriate to the calibration and configuration procedure described in the EN.IM.PCE.PRE.SGE.MODBUS document available on the manufacturer's website.

9.1.1. External overview

During the inspection, check the condition of the separating membranes (tarnish, corrosion) and the electrical connection (check the condition of the cable), as well as the stability of the handle (if used). Check for signs of mechanical damage in the form of impact marks or dents.

9.1.2. „Zero” check

Every 2 years or in accordance with the user's standards, check the probe's "zero" by pulling the probe above the liquid mirror and reading the output signal. Make any adjustments using the "Modbus Configurator" software”.

9.2. Non periodic inspections

If the probe has been subjected to mechanical damage, pressure overload, hydraulic impulses, electrical surges, deposits, crystallization of the medium, etching of the diaphragm, or if the probe is found to be working incorrectly, the device should be inspected. Check the condition of the diaphragm, clean it, check the electrical functionality and processing characteristics.

If the signal is missing in the transmission line or its value is incorrect, check the power supply line, the state of connections on terminal strips, connections, etc. Check the correct value of the supply voltage and the resistance of the load.

9.3. Cleaning/Washing

To remove impurities from the external surfaces of the probe wipe it with a cloth dampened in water.

9.4. Diaphragm cleaning

The only possible method of cleaning the probe diaphragms is to dissolve the sludge produced.

Do not remove deposits and impurities from the probe diaphragms, which are formed during operation, mechanically using tools, since the diaphragms and the probes can be damaged.

9.5. Spare parts

Parts of the probe that may be worn or damaged and must be replaced: cable and gland seals. The cable and seals can only be replaced by the manufacturer.

9.6. Repair

Faulty or non-operational probe shall be provided to the manufacturer or an authorized representative.

9.7. Return

In the following cases the, probe should be returned directly to the manufacturer:

- Need for repair;
- Need for factory calibration;
- Replacement of improperly selected/shipped probe.

10. SCRAPPING, DISPOSAL

Worn or damaged devices shall be scrapped in accordance with WEEE Directive (2012/19/EU) on waste electrical and electronic equipment or returned to the manufacturer.

11. HISTORY OF REVISIONS

Revision No.	Document revision	Description of changes
1	D1/2018.12	The electrical parameters in point 2.3 of Part 1 have been completed.
2	D2/2019.05	The content of the comment in point 1 of Part 1 has been changed.
3	01.D.011/2020.06	The figure in point 5 and figure 1.5 in appendix Ex.04 has been changed.
4	01.A.001/2021.09	New version of the document. Replaces the revision 01_01.D.011_2020-01. Change of software, power supply, figures. Editorial changes. Prepared by DBFD.
5	02.A.001/2022.12	Revisions due to the introduction of version 17 of the transmitter firmware, editorial changes. Prepared by the DBFD.

11.1. PCB and software versions

01-09-2022 – Introduction of version 17 of the transmitter firmware.

Version 17 of the software introduced the following changes:

- Modbus function 0x2B (43) Read Device Identification added.
- Modbus function 0x64 (100) Read coefficients added.
- Modbus function 0x65 (101) Write coefficients added.
- Modbus function 0x66 (102) Set Modbus Device Address (FLASH) added.
- Modbus function 0x67 (103) Set Speed, Parity, Stop added.
- Modbus function 0x68 (104) Perform Action added.
- Modbus function 0x69 (105) Set Modbus Device Address (RAM) added.
- Application layer management layout changed.
- Register addresses changed (doubled address value).

***05-10-2017* - Implementation of version 16 of the transmitter firmware.**

- Eliminating of damping time maximum limit.
- Introduction of new version of Modbus Configuration software numbered 2.2.0.204, from which there is the possibility of enter the maximum damping time without limit.

***01-09-2015* – Supply voltage details for the 4-20 mA mode added.**

24-06-2015 - Correction of pressure units for the codes 1, 2, 10, 12.

01-03-2015 - Implementation of version 15 of the transmitter firmware.

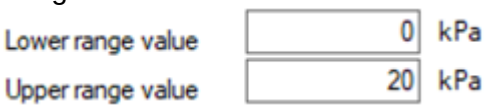
- The management of the data connection layer in the transmitter software has been improved. Under certain conditions, a transmitter may have failed to send a response to a correctly sent request message. The implemented patch has removed this fault.
- The option of reading a percentage value of the controlled set range from the transmitters in the Modbus mode has been added. A variable of the IEEE754 float type with a header is sent on 4 bytes:

Register	Address (hex)	Intended use	Notes	Format	Number of bytes (2 bytes per register)
1	0x0000	**User value**	% of the set range control	IEEE754	4 bytes (2 register)

A variable of the 16-bit integer type with a header is sent on 2 bytes:

17	0x0010	**User value**	1/100% of the set range control	Signed 16-bit int	2 bytes (1 register)

The set range is defined in the Configuration mode:



The set range may be equal to or lower than the basic range. It is defined mostly to configure a transmitter to operate in the 4-20 mA current loop mode.
In this mode, the start of the set range corresponds to the current of 4mA and the control percentage of 0%, whereas the end of the set range corresponds to the current of 20mA and the control percentage of 100%. Both the value of current in a current loop in the 4-20mA mode and the percentage of the set range control may be converted with the transfer function defined in the Configuration mode.
In the Modbus operating mode, the percentage of the set range control (0-100) may be used by the user to convert this value into any other value, by performing a mathematical operation in a resolver. At the same time, when a root function is set in the transmitter, it may be used to read out flows through orifices or reducers.

- The information entered by a transmitter to register 31 in version 15 of the firmware describes the actual time between the end of a bit stop of the last byte of the CRC checksum in a request message and a bit start of the byte of the transmitter answer message (response time). This time depends on the set speed of transmitter transmission within the range from 3ms to 20ms.
- Small corrections increasing the comfort of use have been introduced to the Modbus Configurator software dedicated to transmitters, at the same time incrementing it to version 2.1.0.195.

01-07-2014 - Implementation of PCB version 48.

The 48 version of PCB introduced following changes:

- Miniaturized printed circuit board with reduced dimensions.
- Frequency of the CPU clock frequency changed from 14.74 to 3.68 MHz, reduced power consumption.
- Additional D/A transmitter and current source circuits to enable control in current loop mode (4 20 mA).
- Change in the way signals are connected to the M12 electrical connection.
- Greater resistance to EMI interferences.

01-07-2014 - Implementation of version 14 of the transmitter firmware.

The new version 14 of the firmware was designed in parallel with the introduction of version 48 of the electronic system, and it introduced the following changes:

- Eliminated option of a 10-bit word in serial transmission. Starting from the software version 14, in accordance with the Modbus RTU standard (“Modbus over Serial Line Specification and Implementation Guide v1.02”) one character always consists of 11 bits. If there is no parity bit, 2 stop bits are used to achieve 11 bits in the character frame. The following formats are used: 8E1 (default), 8O1, 8N2.
- Eliminated option of modifying the transmitter’s response delay. In the version 14 this time interval is set to 0 and depends on such factors as the number of data read using function 03, defined transfer rate and coincidence of the request with the transmitter’s automated programme. This time interval should not be greater than 5 ms.
- Eliminated Modbus transfer rate of 600 b/s.
- Reduced consumption and optimized input energy management.
- Optimized time-critical procedures.
- Implemented functions related to operation of the transmitters in current loop mode.
- Implemented functions related to configuration of the transmitters in current loop mode.

Appendix 1. Explosion-proof Device Manual EN.IX.SGE.25.MODBUS

LEVEL PROBES:
SGE-25.Modbus, SGE-25C.Modbus, SGE-25S.Modbus
INTRINSICALLY SAFE acc. to ATEX

1. Introduction

Explosion-proof Device Manual EN.IX.SGE.25.MODBUS only applies to probes SGE-25.Modbus, SGE–25S.Modbus, SGE–25C.Modbus in intrinsically safe version acc. to ATEX marked as in point 2 and the Ex information in the Product Certificate. During installation and use of Ex probes it is necessary to use User's Manual EN.IO.SGE.25.MODBUS with „Explosion-proof Device Manual EN.IX.SGE.25.MODBUS".

2. Using probes in hazardous area.

The probes are produced in accordance with the requirements of the following standards:
EN 60079-0:2018-09, EN 60079-11:2012, EN 50303:2004
The probes may operate in areas where there is a risk of explosion, in accordance with the rating of the explosion protection design:

I M1 Ex ia I Ma
II 1G Ex ia IIB T4/T5/T6 Ga
FTZÚ 18 ATEX 0077X

3. Permissible input parameters (based on data from the FTZÚ 18 ATEX 0077X)

For the connection of the power supply line and the RS485 data transmission signal line, use devices that have the relevant intrinsic safety certificates, whose parameters must not exceed the permissible input-output parameters given in points a) and b).

The probes should be powered from devices with galvanically separated power supply.
Minimum probe supply voltage 4 V DC.
The probe is an intrinsically safe device with protection level "ia" when the power supply circuit has protection level "ia"

a) Permissible input parameters for power supply (red "+", black "-")
- for power supply with linear characteristics:

$$U_i \leq 10\ V,\ I_i \leq 0.4\ A,$$

- for power supply with rectangular and trapezoidal characteristics:

$$U_i \leq 5\ V,\ I_i \leq 0.4\ A$$

b) Permissible input and output parameters for RS485 transmission (blue VA, yellow VB):

$$U_i \leq 10\ V,\ I_i \leq 0.2\ A,\quad U_o \leq 10V^*,\ I_o \leq 0.4\ A^*$$

* the output parameters of the probes Uo, Io are equal to the output parameters Uo, Io of the power supply used.
Dependence of temperature class of probes on ambient temperature (including temperature of measured medium) Ta [°C] and sum of power Pi [W] in power supply circuit and in RS485 transmission circuit is given in **Table Z1**.
Min. ambient temperature Ta = -40°C (special version from -50°C).
c) The internal capacitance and inductance of the probe in the power supply circuit and in the RS485 transmission circuit is:

$$L_i = 0\ \mu H,\ C_i \approx 2.5\ \mu F\ **$$

d) The maximum capacitance and inductance that can be connected to the probe in the transmission circuit is for the subgroup:
- IIC Lo= 0.2 mH, Co = 0.5 µF;
- IIB Lo= 0.7 mH, Co = 15 µF;
- IIA and group I Lo= 1.7 mH, Co = 80 µF.

** Consider the cable capacitance and inductance, which for a permanently connected cable are:

$$C_k = 0{,}2\ nF/m \text{ i } L_k = 1\ \mu H/m$$

Table Z1. Temperature class dependence on ambient temperature Ta and total amount of input power Pi.

Pi [W] Total input power of 485 power and transmission circuits	Ta [ºC]	Class temp.	Pi [W] Total input power of 485 power and transmission circuits	Ta [ºC]	Class temp.	Pi [W] Total input power of 485 power and transmission circuits	Ta [ºC]	Class temp.
0.25	65	T6	0.75	55	T6	1.5	65	T5
	80	T5		80	T5		80	T4
0.5	60	T6	1.2	70	T5	1.75	60	T5
	80	T5		80	T4		80	T4

4. Connection of probes in Ex version

Connections of the probe and devices in the probe measuring loop must be made in accordance with intrinsic safety and explosion protection standards and conditions of use in hazardous areas. Failure to observe the intrinsic safety rules may result in an explosion and resultant danger to people.

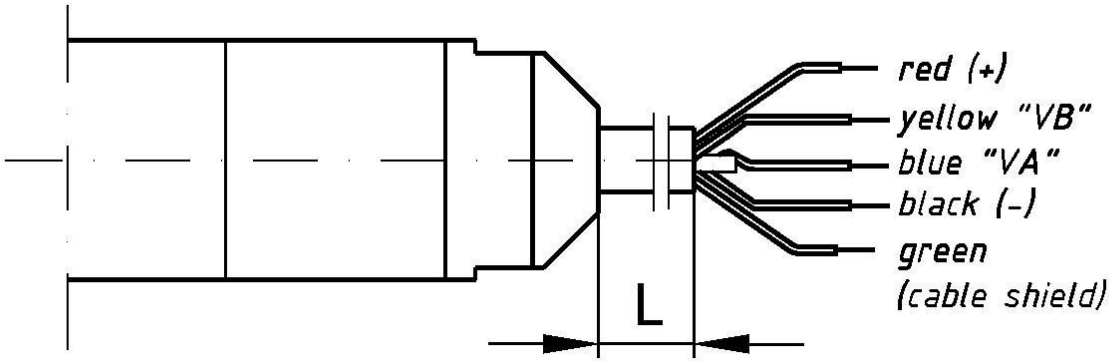


Fig. I.1

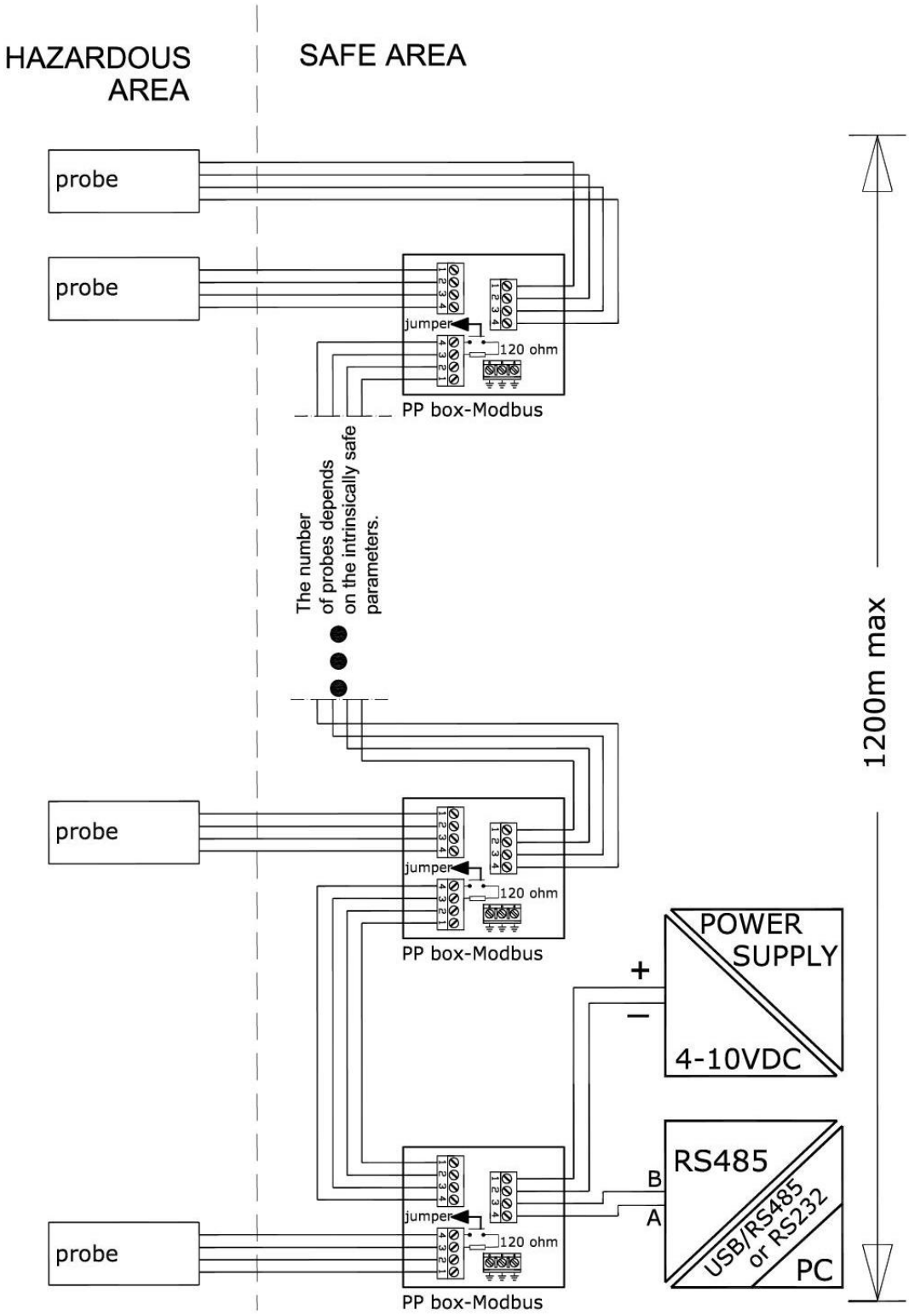


Fig. I.2

5. Special conditions for safe use

1. The probes do not meet the insulation test (500 V rms) required by EN 60079 11:2012. This must be taken into account during installation of the device.
2. For the ambient temperature range – see Table Z1 as well as the information on the probe's rating plate.
3. The process (medium) temperature at the diaphragm must be within the ambient temperature range.