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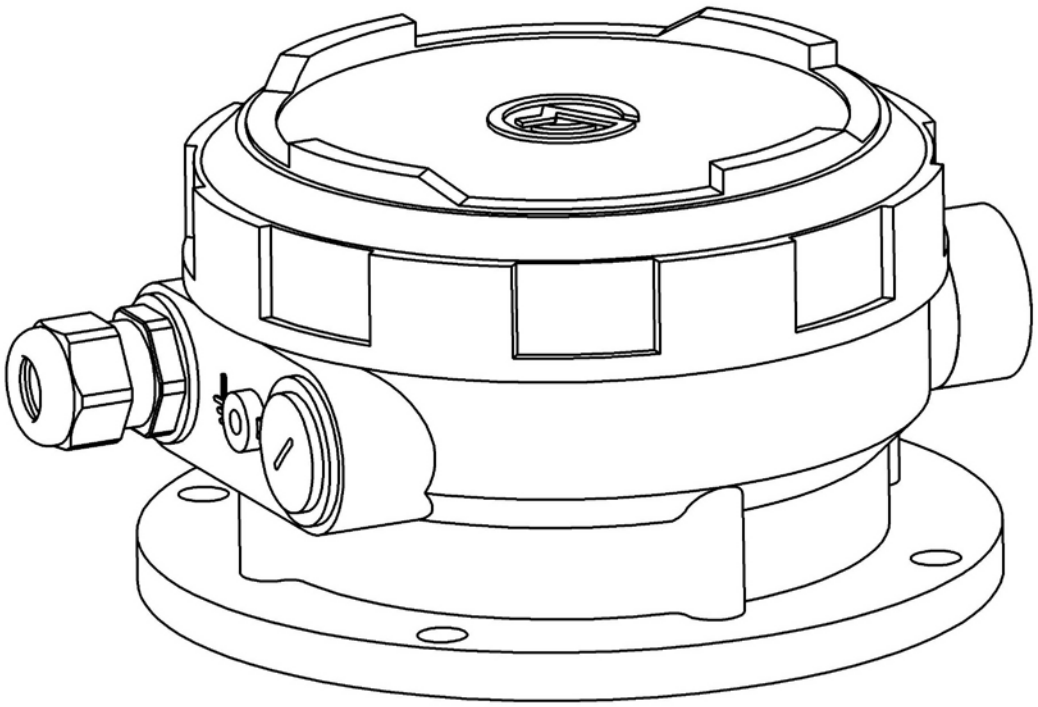
MICROWAVE CONTACTLESS

LEVEL TRANSMITTER ULM-31A1



CONTENTS

1 DOCUMENT DETAILS

1.1 Document purpose

This operation manual contains information about mechanical mounting, electrical connection, start-up and alignment of the device, along with maintaining and troubleshooting guidelines. Instructions stated in this manual should be read carefully before mounting and putting the level transmitter into operation.

1.2 Target group

This operation manual is intended for trained personnel performing mounting, putting into operation, diagnosis and maintenance of level transmitter. Personnel must follow instructions stated in this manual.

1.3 Symbols

Symbol	Symbol explanation
! ATTENTION	Non-compliance with instructions may disable the device and lead to abnormal device operation.
! WARNING	Non-compliance with instructions may harm personnel and/or lead to device damage.
NOTE	This symbol marks the useful information to be noticed.

2 BASIC SAFETY RULES

2.1 Personnel requirements

Personnel performing mounting, putting into operation, diagnosis and maintenance of level transmitter should read this manual and be allowed to work with the device. Personnel have to use individual protective in accordance with regional rules when working with the device.

2.2 Application

Level transmitter ULM-31A1 is intended for continuous contactless level measurement of liquids, viscous and bulk products. It is intended to be used in technological measurement and control systems. Level transmitter ULM-31A1 is used for close and open tank level measurement. This device can be used for measurement of wide range of products, such as acids, alkalis, water solutions, food products, cement, carbon etc.

The unintended using of the device can be source of potential hazard and lead to emergency situation for personnel or device multufunction.

2.3 Operational security

Operational Security of the device is provided by observance of instructions stated in this manual. In order to ensure operational security and implementation of warranty it is prohibited to change the construction of the device. Any operations with the device must be officially permitted by the manufacturer if they are not included in this manual.

2.4 General security guidelines

Level transmitter ULM-31A1 meets all the modern requirements and safety standards. CE-Type Examination Certificate is in progress.

Operating emission frequency of level transmitter is about 24 GHz (OPTIONAL 94GHz). Radiation power does not exceed 8 mW which is significantly below permissible values. Level transmitter is completely safe for people and animals.

Malfunctioning device exploitation is strictly prohibited to avoid emergency situations.

Level transmitter ULM-31A1 can be used only in explosion-proof area.

2.5 Environmental safety

Execution of guidelines from sections “Packaging, transportation and storage” and “Disposal” can contribute to environmental protection.

3.DEVICE DESCRIPTION

3.1 ULM-31A1 scope of delivery

The scope of delivery includes:

- Microwave level transmitter;
- Software for configuration and CD with the documentation:
  - Ulmcfg configuration program;
  - Driver software (Bluetooth, HART) is in progress;
  - Operation manual;
  - Additional documentation (certificates and permissions, other technical information if necessary).

NOTE

One copy of software and documentation in electronic format is delivered per kit in accordance with specification.

Extra equipment which may be included in order specification:

- Top level software:
  - “Limaco OPC Server”;
  - OPC client – “Reservoir Viewer” visualization of the measurement system;
- power supply;
- interface converters RS-485;
- interface converters HART;
- remote configurator PL-01;
- sealing gasket;
- adapter flange.

NOTE

Each type of extra equipment (interface adapters, flanges, sealing gaskets) may have different versions, so it must be negotiated when ordering equipment and specified in the order.

3.2 Device Design

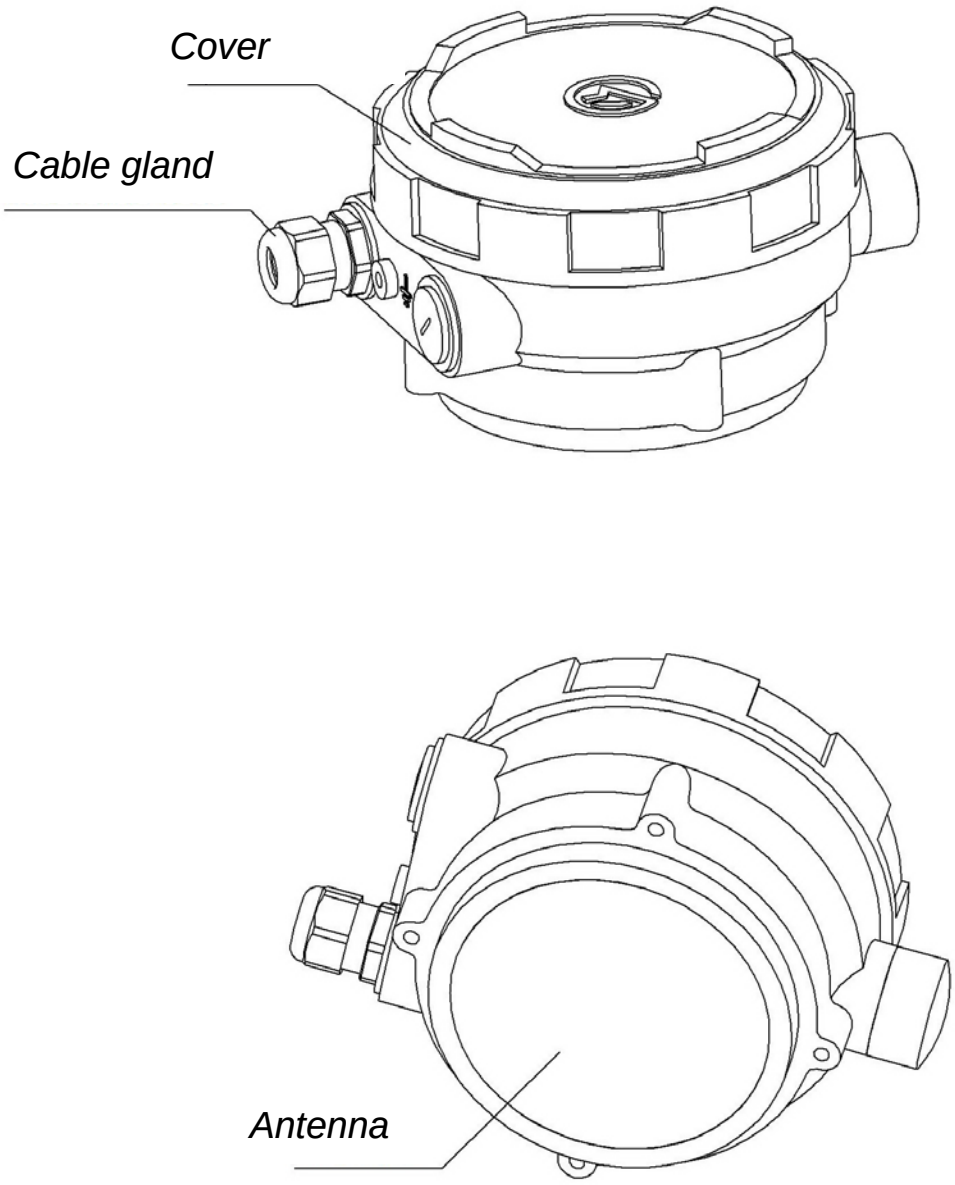


Fig. 3.1. Appearance of the device and location of basic elements

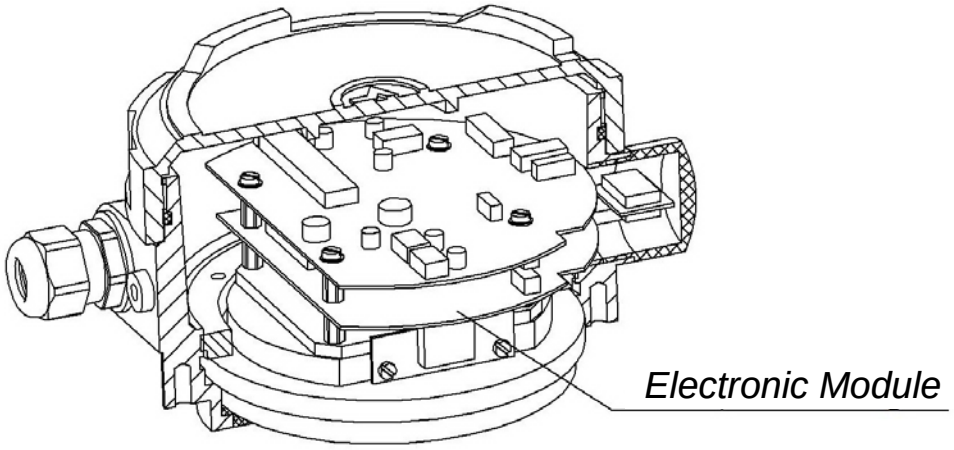


Fig. 3.2. Level sensor design. Electronic module location.

3.3 Device identification

Device Identification is carried out with the following methods:
- According to device nameplate;
- According to attached certificate of product;
- By sending the request to manufacturer with the indication of its serial number.

Standard nameplate of the level transmitter contains the following data for device identification and application of the device:
- Manufacturer's logo;
- Device type;
- Serial number;
- Year of manufacture;
- Mark of conformity;
- IP protection;
- Operatting temperature range;
- Supply voltage;
- Output signals.

Standard nameplate example, Fig. 3.3

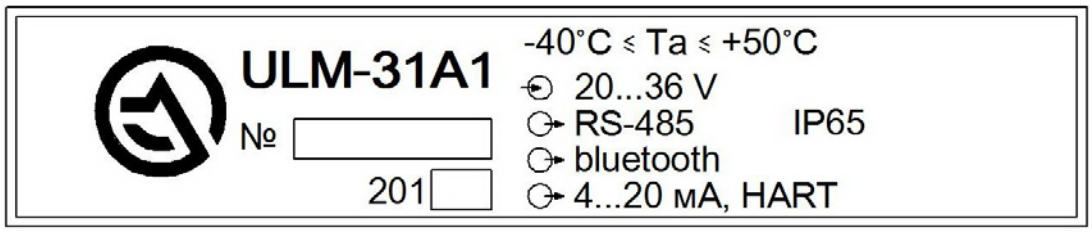


Fig. 3.3. Standard nameplate

3.4 Principle of operation

A level sensor is mounted on a tank top, on a flange of a branch pipe. At that, its parts must not be put into the tank. The device measures the distance L from an antenna screen (item 12.7) to product surface through a hole of the flange. Then the level is calculated using the following formula U=H-L, where H is a height.
Starting point of the measuring range of the level sensor is lower surface of the antenna shield.

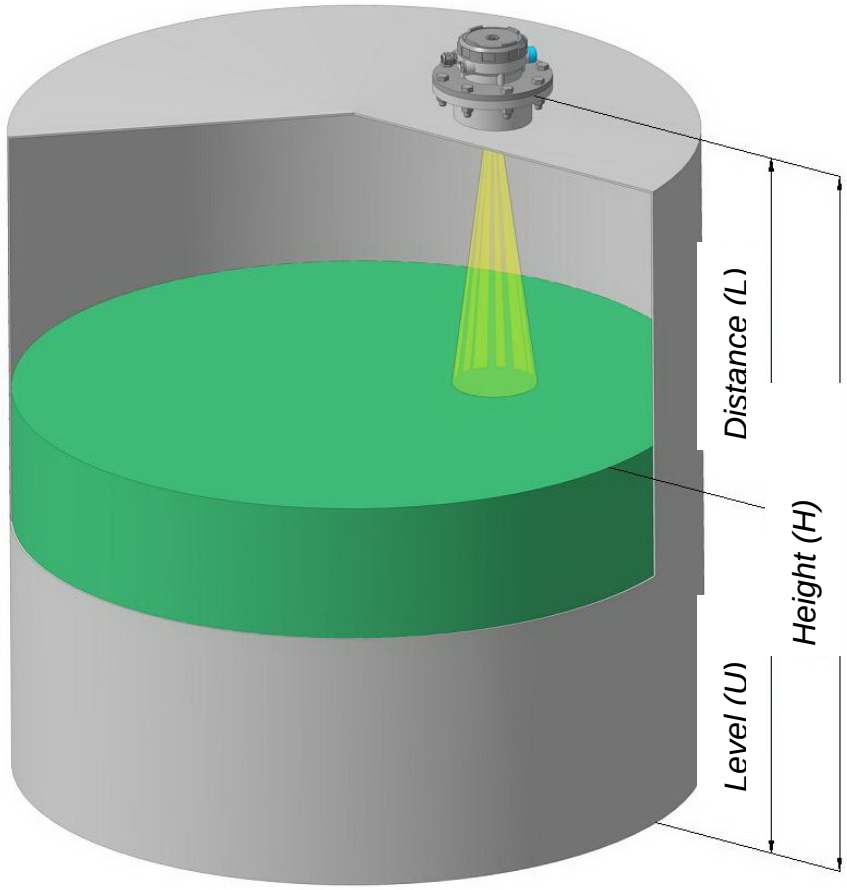


Fig. 3.4. The level sensor on the tank.

The antenna of the radar sensor emits a radio signal with a frequency of 24 GHz (OPTIONAL 94GHz) and receives an reflected signal from product surface. An electronic block processes the neflected signal by means of the MCU DSPcore and converts it into a corresponding output signal which carries information about the measured value.

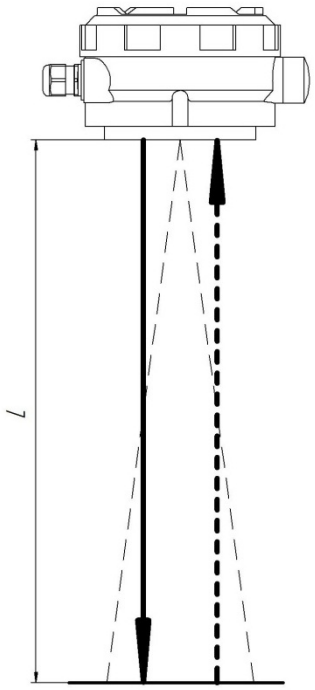


Fig. 3.5. Principle of measuring.

Level sensors operate by the principle of FMCW-radar. It is one of classical methods of non-contact distance measurement, which minimizes influence of spurious noise and noise related to surface imperfections (fluctuations) of a measured product.

The principle of operation consists in the following: a microwave low-power emitter a microwave beam, whose frequency increases linearly during the measurement period (the firm line in Fig.3.6). This signal (direct signal) is radiated by the sensor antenna in the direction of product surface. After delay time Dt the signal reflected from the surface (the dotted line in Fig. 3.6), returns to the antenna. Dt is the time required for passing the distance from the antenna to the reflecting surface and back again by a radiowave. Dt=2L/c, where c is the velocity of light. Since the speed of propagation of radiowaves is constant, distance travelled can be determined by knowing the delay time. The Figure 3.6 shows that in the time Dt the frequency of the direct signal increases by ΔF. Upon mixing of direct and reflecting signals, a low-frequency signal is extracted with difference frequency ΔF. Then this signal is digitalized and processed by a signal processor (DSP). Using the algorithm based on Fourier transform and original adaptive algorithms of processing and noise suppression, DSP process spectrum signal analysis which results in an exact value of difference frequency. Determining this frequency, we can determine the delay time, as well as a distance travelled by a radiowave. Then the measured distance is used for calculating the level and a volume.

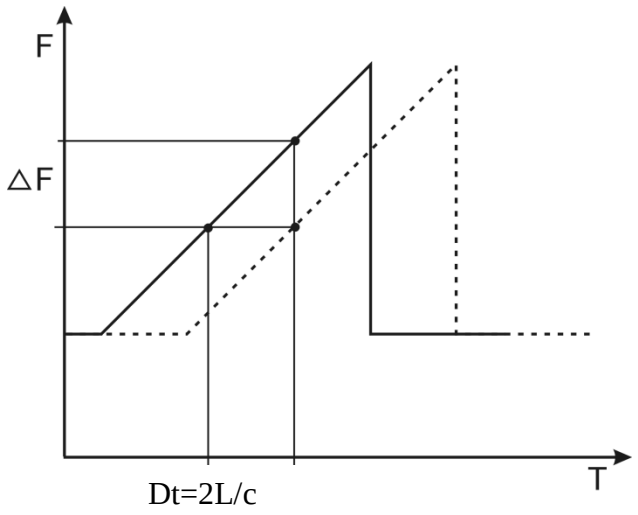


Fig. 3.6. The principle of operation of FMCW-radar

3.5 Packaging, transportation and storage

A level transmitter is protected by packaging during transportation.

The packaging is made of cardboard which is an reciclable material. In some cases it is possible to use cellular polyethylene and polyethylene film which are disposed via specialized recycling companies.

Transportation of the device must be carried out in original packaging. After transportation the device must be checked for possible transportation damage and completeness. If any transportation damage or incompleteness of equipment is founded, all shortcomings must be drawn in accordance with established procedure.

Up to the time of installation devices must be stored in original packaging which must be left closed. During the storage the following conditions are to be observed:

- Storage temperature -40…+80˚C;
- Relative humidity 20…85%;
- Storage in conditions of aggressive environment is not allowed;
- Outdoor storage is not allowed;
- Mechanical influences on the device are not allowed during storage.

4. MOUNTING

4.1 Selection of the mounting position

Stability and accuracy of obtained results depend on the correct installation of level sensor.

When selecting mounting position the following instructions must be followed:

- The device should be installed so that there are no objects or constructions which interfere with radio beam (pipes, fittings, mixers, tank walls etc., see item 4.1.7) in measurement zone (see item 4.1.4 Measurement beam operating area).

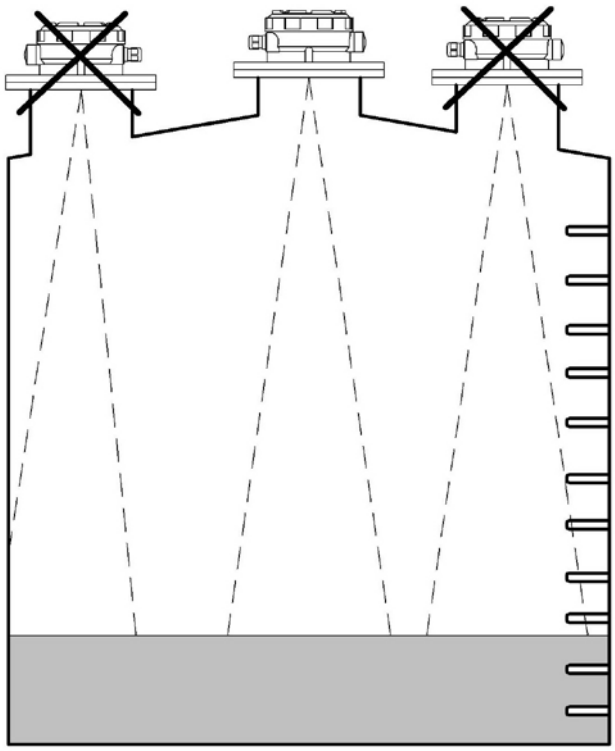


Fig. 4.1. Installation of the device on the tank. Construction elements.

- The device should not be installed so that the product stream from fillinginlet reaches the measurement beam operating area. It is better to place the device apart from the fillinginlet;

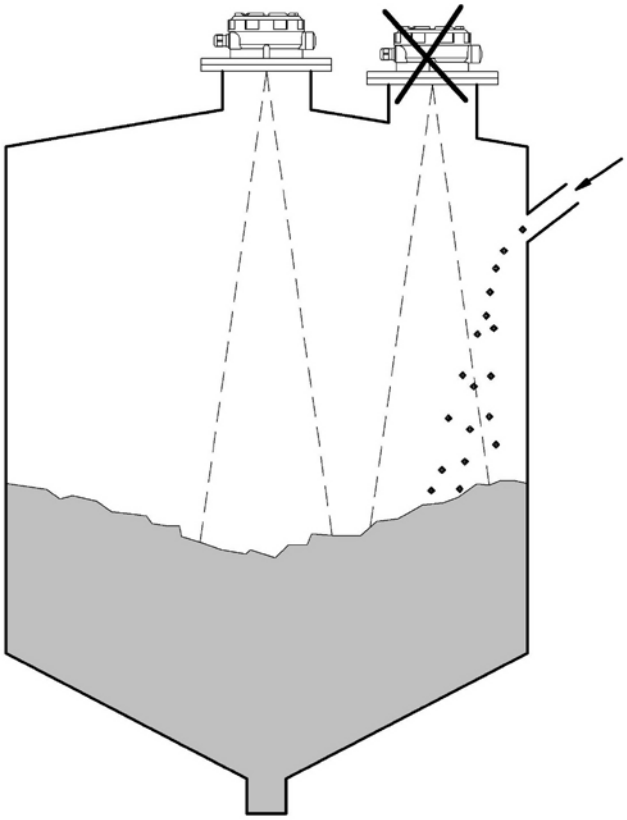


Fig. 4.2. Installation of the device on the tank. Product inlet.

- Swirl on the product surface may appear during discharging from tank. This must be considered when selecting sensor location. Level sensor must be installed above the smooth area of product surface.

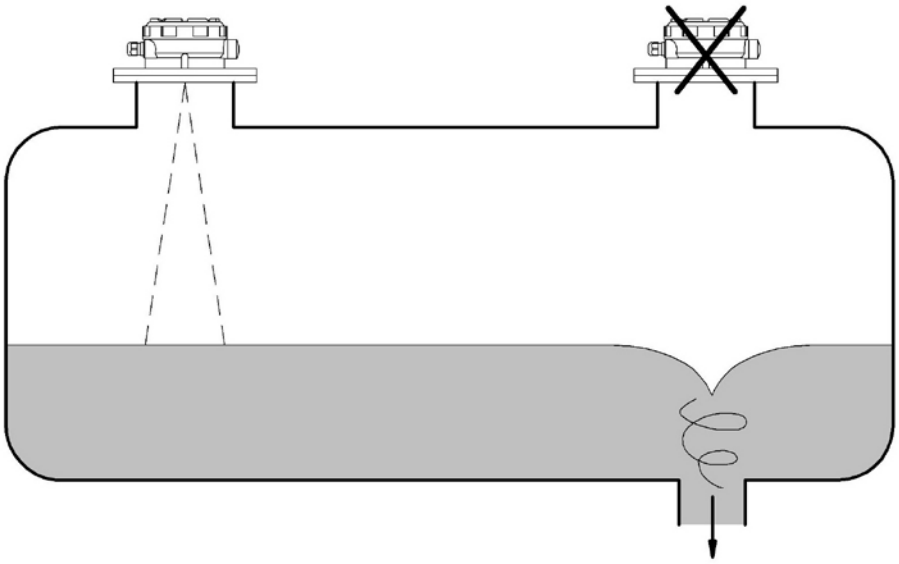


Fig. 4.3. Installation of the device on the tank. Product discharging.

- Level sensor should be installed above at the lowest point of the tank to provide level measurement throughout the entire height of the tank. For vertical cylindrical tanks with conical tank bottom this is achieved by mounting sensor in the center of the top of the tank.

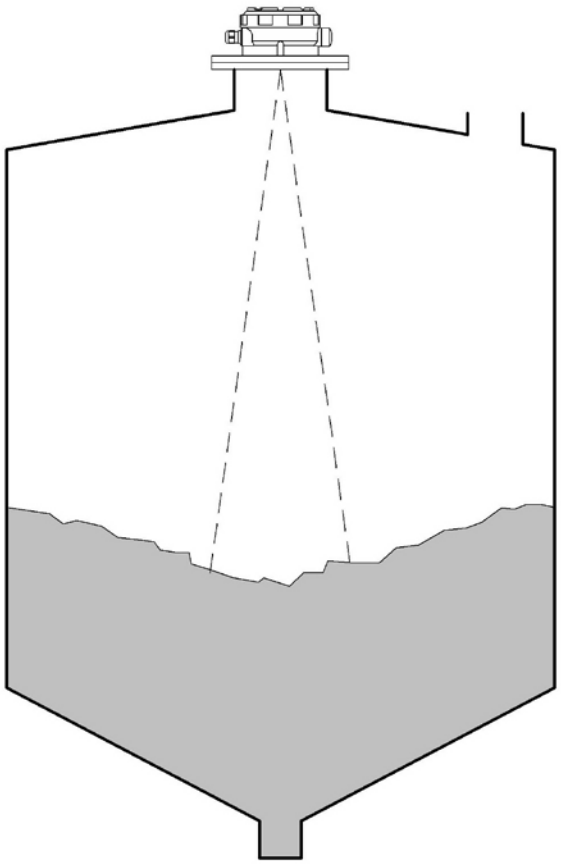


Fig. 4.4. Installation of device on the conical tank.

If this is not an option it is necessary to direct measurement beam into a center of a tank. This is achieved by tilting plane of the mounting branch pipe flange.
The required tilt angle β depends on mounting position and tank size. It can be verified by using water level or tilt angle sensor set into the level transmitter (see item 7.1 Device diagnostics).

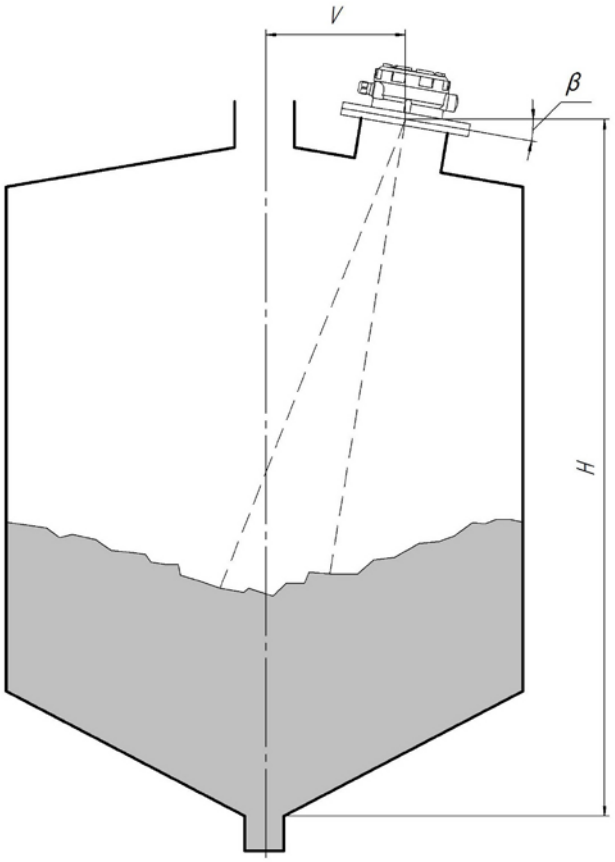


Fig. 4.5. Installation of device with the tilt angle on the conical tank.

Values of the distance between tank center and mounting location (V) are given in the table below.

Mounting height H, m	β =2˚	β =4˚	β =6˚	β =8˚	β =10˚
2	0,1	0,1	0,2	0,3	0,4
4	0,1	0,3	0,4	0,6	0,7
6	0,2	0,4	0,6	0,8	1,1
8	0,3	0,6	0,8	1,1	1,4
10	0,3	0,7	1,1	1,4	1,8
15	0,5	1,0	1,6	2,1	2,6
20	0,7	1,4	2,1	2,8	3,5
25	0,9	1,7	2,6	3,5	4,4
30	1,0	2,1	3,2	4,2	5,3
35	1,2	2,4	3,7	4,9	6,2
40	1,4	2,8	4,2	5,6	7,1
45	1,6	3,1	4,7	6,3	7,9
50	1,7	3,5	5,3	7,0	8,8

For example: Tank with the height of 15 meters, the distance between tank center and level sensor is 1,6. According to the table the required tilt angle is 6˚.

- It is necessary to use screen or shed to protect the device from direct sunlight in conditions of hot climate;

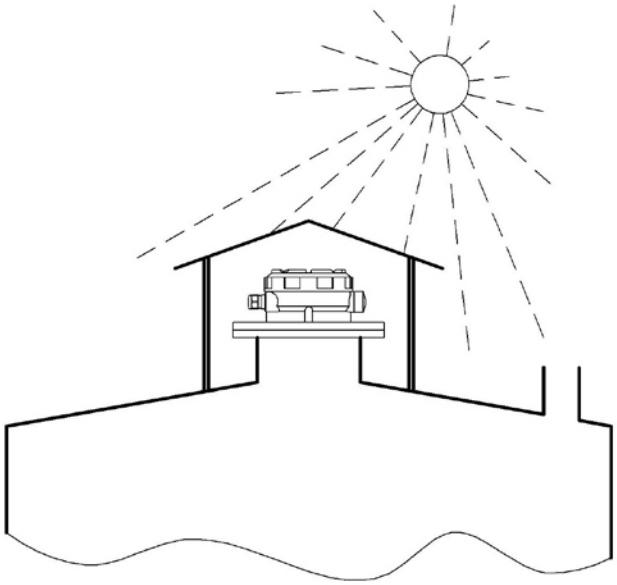


Fig. 4.6. Installation of device with the protection screen.

- The temperature in mounting location should never be more than +50°C. In case of installation on the tank with high temperature medium use radiotransparent sealing gasket (see item 12.5, 12.6).
- It is necessary to use radiotransparent sealing gasket when installing sensor on the tank with overpressure or vakuum (see item 12.5, 12.6);

NOTE

In case of using the device in tank with outlined constructions in measurement beam area, observe the following instructions:

- The distance between tank wall and central axis of level sensor must be within the range from ½ to 1/3 of the tank radius, Fig. 4.7;

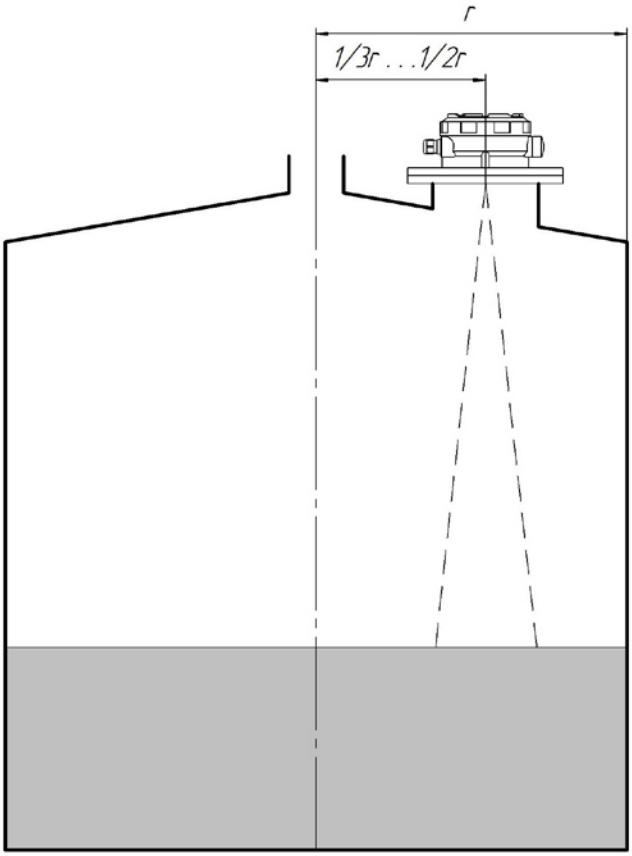


Fig. 4.7. Installation of the device

- if tank walls are not smooth (ribbed metal, weld seams, constructions) the distance from the wall must be as long as possible..

NOTE

In case of using the device on tanks made from non-conductive materials (for example, plastic) it should be taking into account when choosing mounting position that the constructions outside the tank may be located in the measurement beam area.

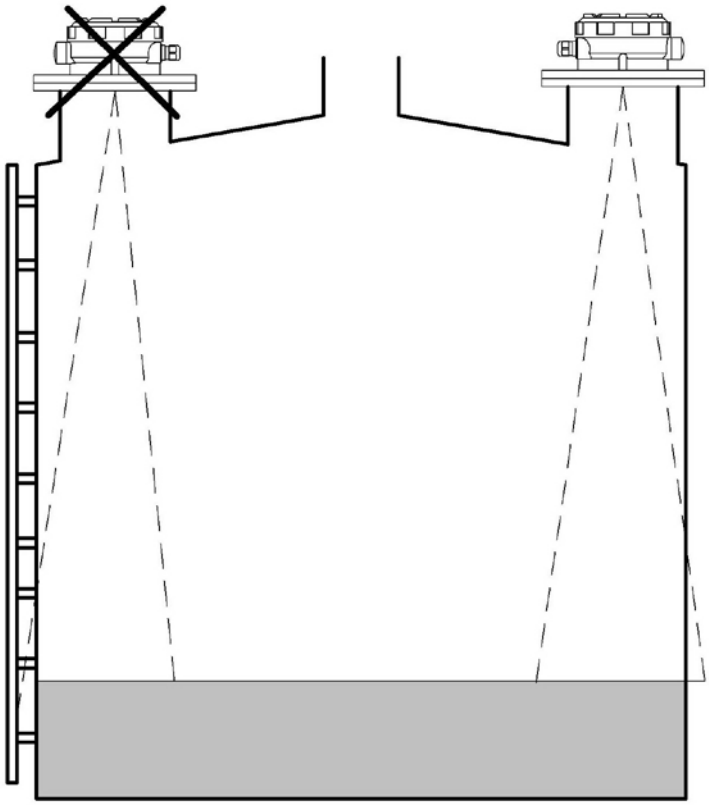


Fig. 4.8. Installation of the device. Tank made of non-conducting material.

4.2 General requirements for installation of the level transmitter on the mounting branch pipe

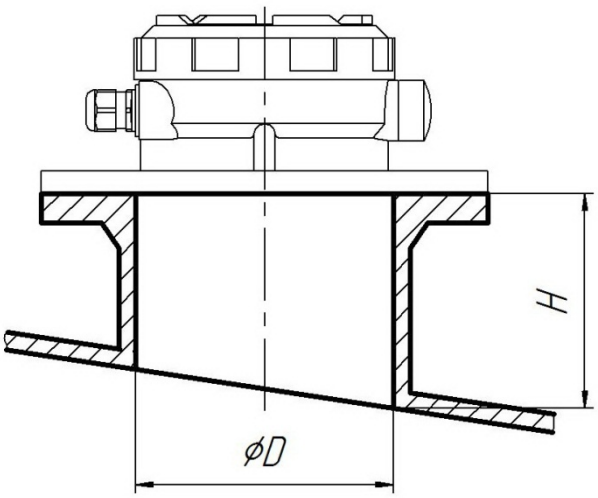


Fig. 4.9. Installation of the device on the mounting branch pipe.

The inner diameter of the branch pipe D must be at least 100 mm. Permissible branch pipe axis deviation from a vertical during level measurement of liquid products is 1°.

The branch pipe height H is measured over its inner surface from the flange to the lower edge of the hole. Maximum permitted height of the branch pipe depends on its diameter. The greater the diameter, the higher the permitted branch pipe. Formulas linking the branch pipe diameter and its height are chosen depending on using, see item 4.1.3.

Using a higher branch pipe may result in parasitic re-reflections and make difficulties for measuring. One can use a branch pipe which is longer, than a branch pipe designed for this using after coordinating construction with the manufacturer. The hole in the tank top under the branch pipe must be not less than the inner branch pipe diameter. Roughness on the branch pipe inner surface must not be larger than 3 mm. Parasitic reflections from irregularities in the branch pipe may result in reducing accuracy and measuring stability.

If branch pipes with rectangular cross section are used, the branch pipe height with roof thickness and inner constructions adjoined the roof (stiffening ribs etc.) must not be more than the height calculated according to formulas listed in item 4.1.3, where the size of the shorter rectangle side is written instead of the branch pipe diameter.

4.3 Mounting branch pipes

The requirements for branch pipes depend on type of application and fall into two ways: with weak and strong reflected signal.

Application of the first type are bulk products and foam-forming liquids (with foam >1 cm), tanks with mixers, in the cases when sensor beam falls on the conical surface with tilt angle over 6 °, arising from mixing.

All the other applications belong to the second type.

The requirements for branch pipes for application with strong reflected signal.

Allowable branch pipe height is calculated by the formula:

$$H=D*2.5;$$

Where H – maximum branch pipe height (mm), D – branch pipe diameter (mm).

Calculations for standard branch pipes are given in the table below.

Branch pipe diameter, mm	Maximum branch pipe height, mm
100	250
150	400
200	500
300	750

The requirements for branch pipe and hole in the tank top for application with weak reflected signal.
The height of mounting branch pipe may not exceed its diameter:

H=D.

For these types of appliances usage of branch pipes with height of over 250 mm is not recommended.

4.4 Measurement beam operating area

Microwave signal transmitted the device radiates in the beam form determined by a polar pattern.
The beam diameter W is determined on the basis of the function from an opening angle α and the measured distance L. The opening angle α = 9˚, to calculate the width of the polar pattern the simplified formula may be used:

W = 0.157L;

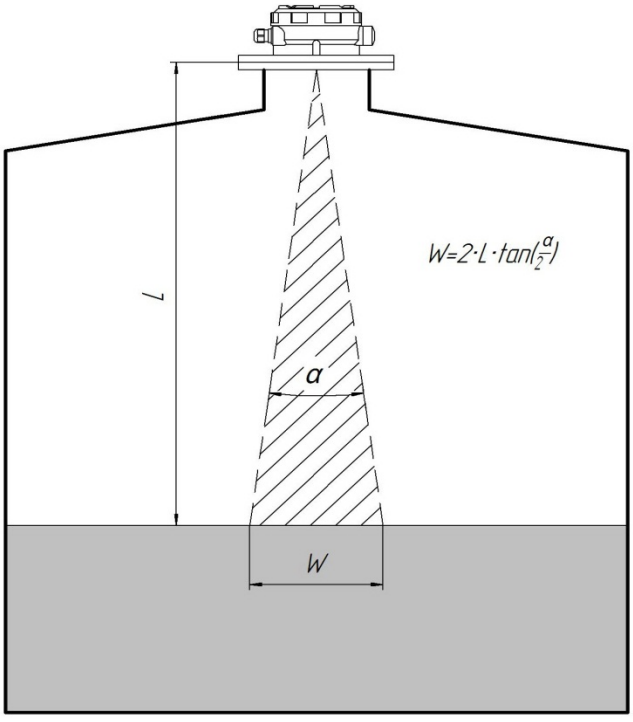


Fig. 4.10. Coverage of the measuring beam

4.5 Dead zone

Level sensors have the so-called “dead zone”. It is a zone near the sensor antenna where measuring is difficult or impossible. The “dead zone” is shown in Fig. 4.11, it can be broken down into three fields. Measuring in the nearest (left in the

Figure) field is impossible. The middle field is a field of unstable measurements; the device may determine the distance with low precision, indices may be very unsteady. Measurements in “dead zone” are unstable, and rated precision is not achieved. The size of “dead zone” depends on signal reflection level of a product, tank constructions falling in the sensor beam. Aside from the rules of installation of the sensor on the tank, the “dead zone” is not over 600 mm.

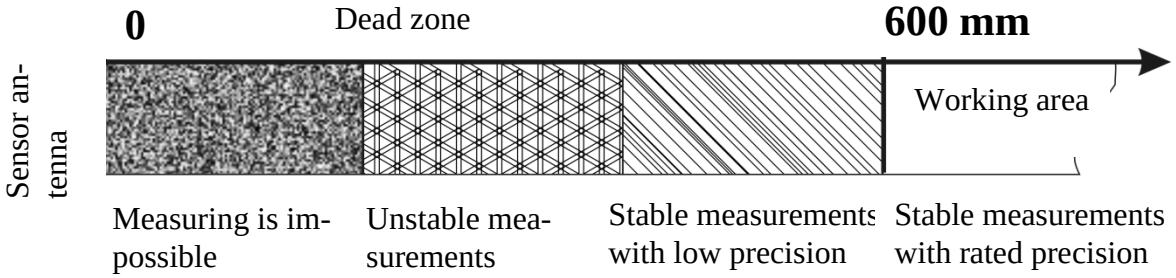


Fig. 4.11. Dead zone of the device

4.6 Mounting examples

Fig. 4.12, positions A and B show examples of mounting the level sensor carried out according to requirements. Fig. 4.12, variant A, shows the mounting of the sensor on the tank flange without the branch pipe, variant B – with branch pipe. Variants C-E show typical mounting errors which are worth observing.
Variant C – the edge of the tank top under the branch pipe steps into the branch pipe inner space, moreover, the hole in the roof is less than it is permitted.
Variant D – the lower edge of the branch pipe goes deep relative to the tank top, so the length of the branch pipe is more than it is permitted.
Variant E – the sensor is mounted with large displacement relative to the vertical axis of the branch pipe. The sensor should be mounted on the central axis of the branch pipe.

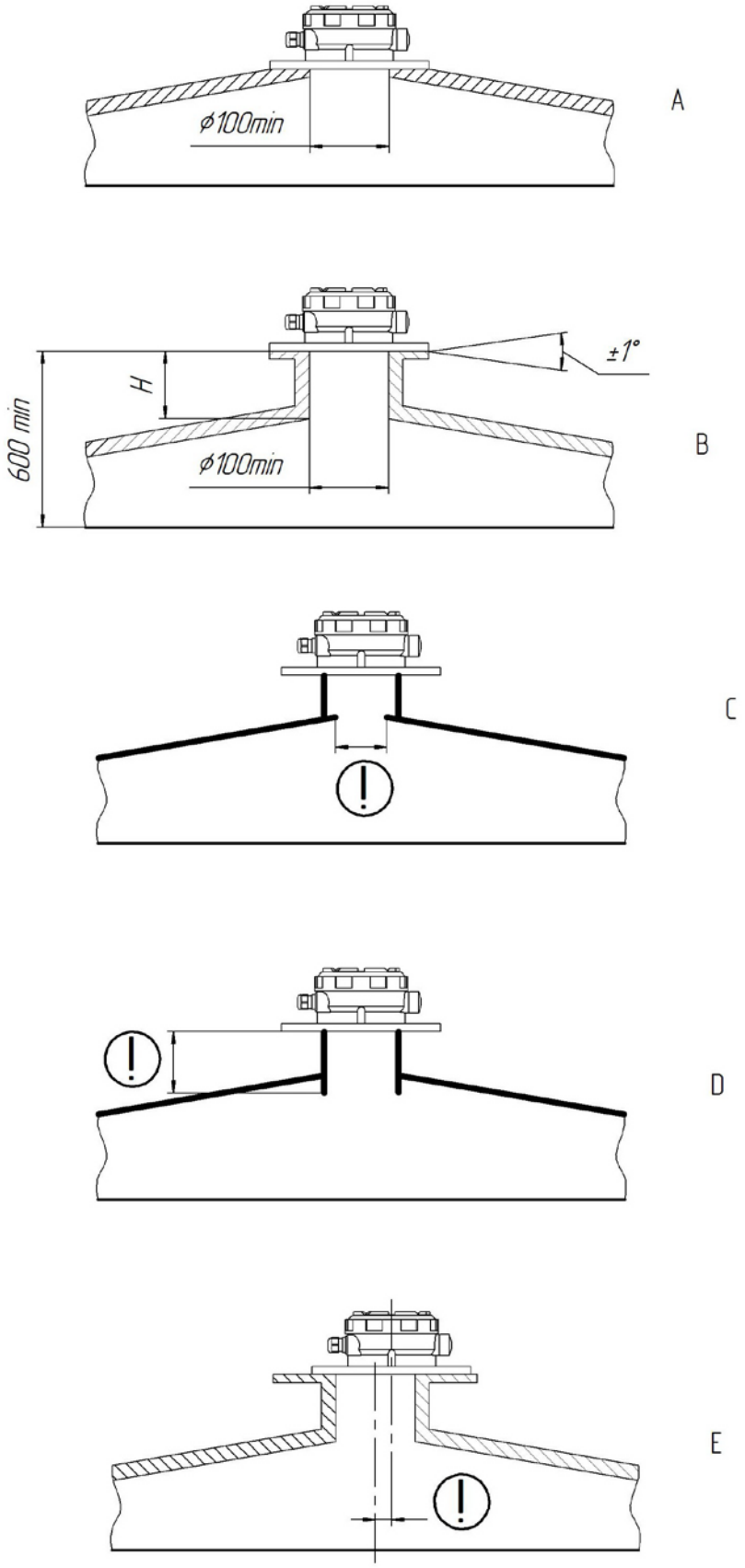


Fig. 4.12. Mounting examples

4.7. Structures inside a tank.

The structures located inside the tank (pipes, fittings, agitators, ribbed tank walls, discrete level sensors, and other objects) may be a source of parasitic signals. The level sensor mounting position should be selected so that the radio signal propagation path has no obstacles. If you can't meet this condition due to structural features of the tank, please contact the manufacturer's technical support.
The impact of structural components can be reduced by means of inclined reflectors designed to dissipate radio signals. The reflectors can be made of sheet metal.

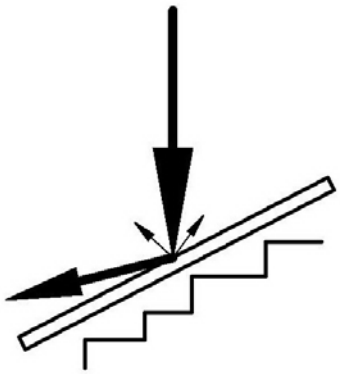


Fig. 4.13. Example of an inclined reflector above a structure inside a tank

5. ELECTRICAL CONNECTION

5.1. General instructions.

! WARNING

All electrical connections should be made with the voltage disconnected.
Electrical connection should be performed only by the qualified personnel authorized for this type of work.

The level sensor can be provided with two cable glands with NPT self-sealing threads. The housing can be fitted with one cable gland with a threaded plug when shipped from the manufacturing plant; in this case, the second cable gland is can be installed instead of threaded plug.

! ATTENTION

It is prohibited to:
- *Leave the level sensor in the mounting position without the temporary plug and connected cable;*
- *Leave the level sensor in the mounting position with the connected cable, but loose cable gland;*
- *Leave the unused cable glands unplugged; they should be replaced with the threaded plugs.*

5.2. Connecting cable.

You can use a standard unshielded cable, if only 4-20mA analog output is used.
It is recommended to use a shielded cable for RS-485 or HART digital interfaces.
The round cable should be used for this purpose. The cable with a suitable diameter should be used for the cable gland to ensure declared characteristics of dust and moisture ingress protection (IP).
For details, see item 12.1 Technical specifications. Electromechanical characteristics.

! ATTENTION

It is prohibited to insert several cables into the device through one cable gland.

NOTE

It is recommended to bend the connecting cable in close proximity to the cable gland for draining rain or condensation moisture so as to protect the device against moisture ingress.

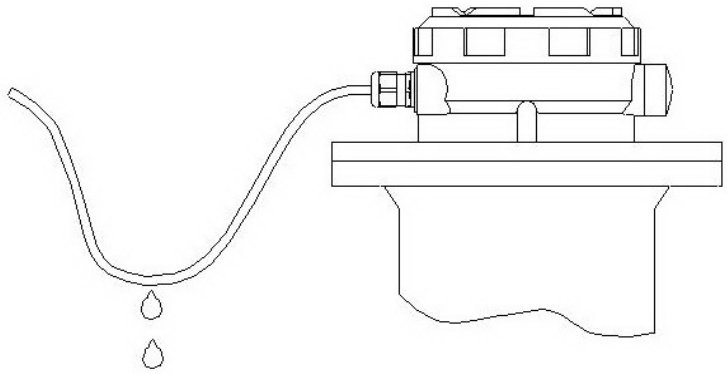


Fig. 4.14. Cable laying recommendation

5.3. Shielding and grounding.

If a shielded cable is used, it is recommended to connect the cable shield to ground potential on one side. Use a grounding terminal on the output receiver side.
The device should be grounded. The device housing is provided with an external grounding terminal to be connected to the tank ground.

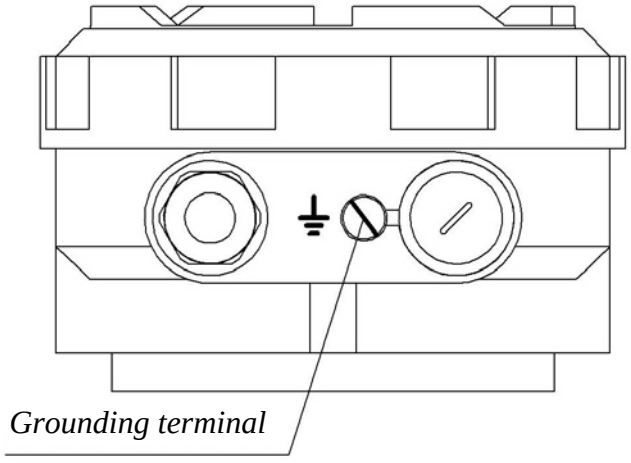


Fig. 4.15. Grounding terminal

5.4. Terminal assignment. Connection.

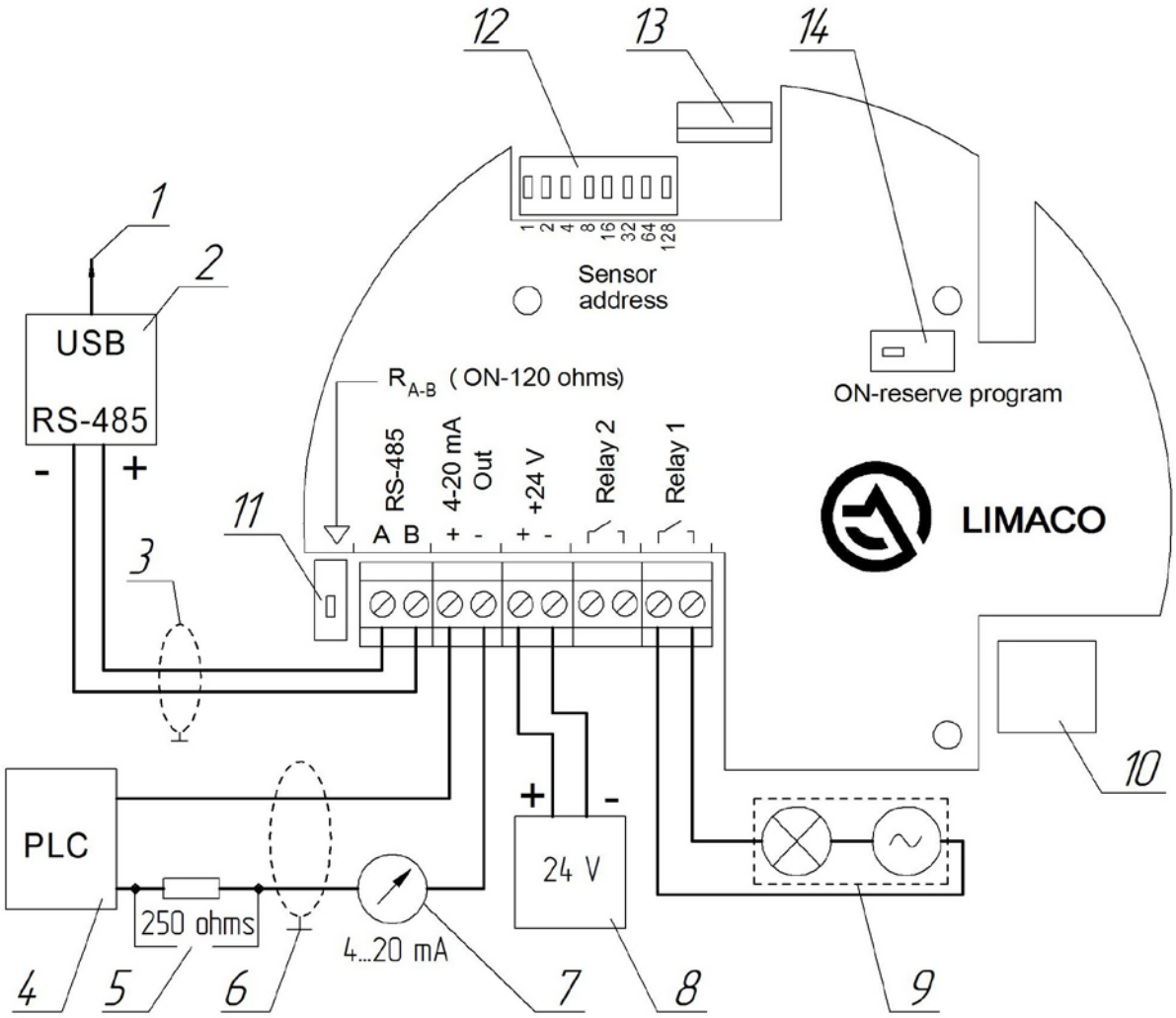


Fig. 4.16. Terminal assignment. Connection.

1 – PC connection;
2 – RS-485/USB converter;
3 – RS-485 line shield, ground connection on the converter side;
4 – Control unit, for example, PLC;
5 – HART modem connector;
6 – HART digital line shield;
7 – Analog indicating unit;
8 – 24V power supply;
9 – Relay indicating unit, lamp signaling configuration example;
10 – MicroSD card slot (under development);
11 – Switch, RS-485 line terminating resistor R_{A-B}=120Ohm;
12 – Modbus address switch;
13 – USB connector, PC connection (under development);
14 – Backup switch, factory reset.

5.5. Power supply.

It is recommended to use a stabilized DC power supply with an output voltage $U_{PS} = 24..36$V. Several level sensors can be connected to one power supply.
The power supply should provide a load current equal to 0.3A for each sensor $I_{PS} = 0.3 \cdot n$, where *n* is the number of level sensors connected to the power supply.
The power supply capacity should be not less than $P_{PS} = U_{PS} \cdot I_{PS}$.

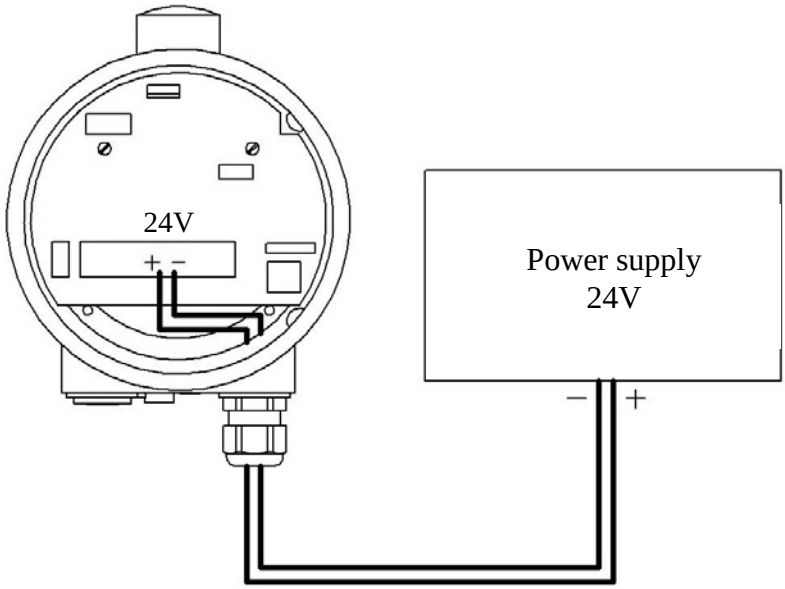


Fig. 4.17. Diagram for connecting a sensor to a PS

If a long power line is used, the voltage drop in power supply wires should be taken into account. The maximum allowable length of the lead cable (in meters) is calculated as follows

$$l_{sc} = 95.24 S_{sc} (U_{ps} - 20).$$

where S_{sc} is a power wire section in mm^2, U_{ps} is a power supply voltage.

The table shows the results of calculation of the maximum sensor power cable length for the most common wire sections and power supply output voltage of 24-28V.

Maximum allowable length of the sensor cable.

Wire section (mm^2)	24V	25V	26V	27V	28V
0.25	95m	119m	142m	166m	190m
0.35	133m	166m	200m	233m	266m
0.5	190m	238m	285m	333m	380m
0.75	285m	357m	429m	500m	571m
1	380m	476m	571m	666m	761m

If the external cable diameter exceeds the allowable value for the level sensor cable gland, it is necessary to use a terminal box connecting a sensor power supply cable of the allowable section and a larger section cable (mains cable). The described connection diagram is shown in Fig. 4.17.

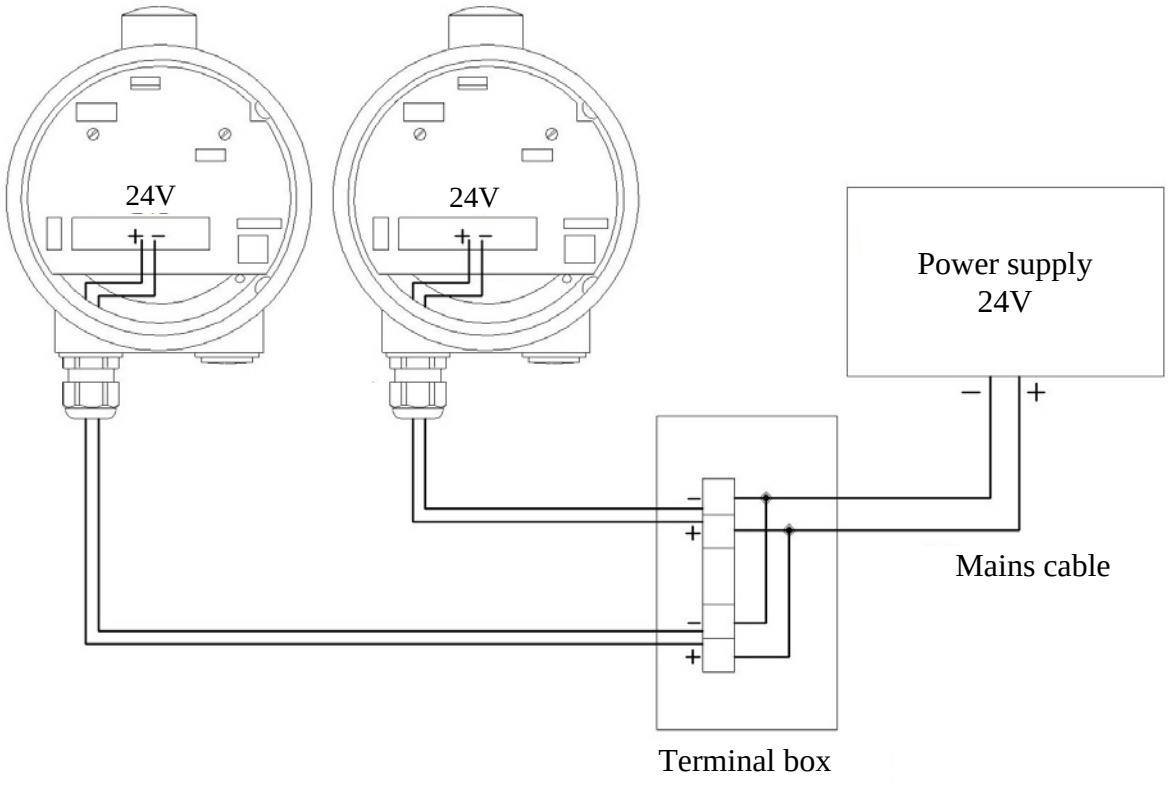


Fig. 4.18. Diagram for connecting sensors to a PS by means of a terminal box.

5.6. Device connection procedure.

! WARNING

- Safety regulations of the plant should be strictly followed;
- All work should be performed with the supply voltage disconnected;
- Input supply voltage should meet the device specifications;
- External grounding terminal of the device should be connected prior to energizing.

Required tools:
- Flat screwdriver (3mm);
- Flat screwdriver (6mm);
- Stripper or any other tool suitable for wire stripping;
- Insulated cable ends (for stranded wires).

Preparation for connection:

1. Install the required number of cable glands into the device housing. If two cable glands are used, unscrew a threaded plug using the screwdriver (6mm) and replace it with the second cable gland.
2. Remove a temporary plug from the cable gland installed at the manufacturing plant.

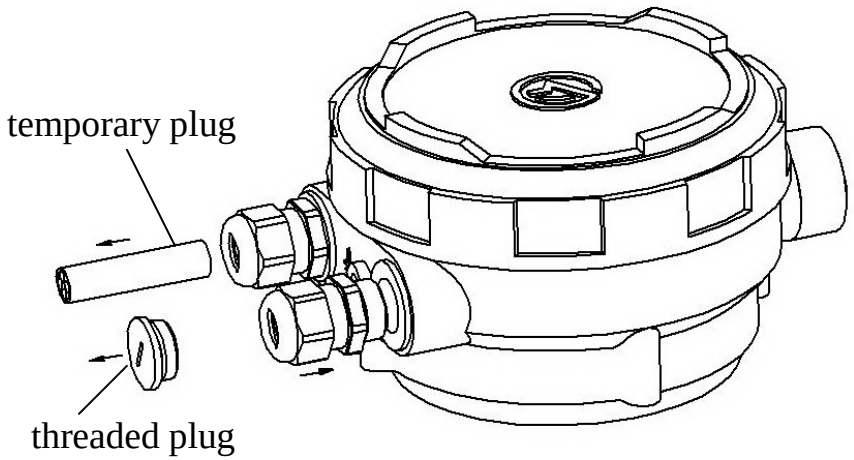


Fig. 4.19. Second cable gland installation

The device should be connected as follows:
1. Unscrew the level sensor cover.
2. Loosen the cable gland collet nut.

3. Insert the cable into the sensor through a sealing ring of the cable gland.

! ATTENTION

Absence or damage of the sealing ring affects dust and moisture ingress protection of the device and may result in its failure.

4. Remove the external cable insulation. If a shielded cable is used, remove the shield.

5. Remove the wire insulation about 4-6mm from the edge. If stranded wires are used, it is recommended to crimp stripped wire ends in the insulated cable ends.

6. Connect the cable in accordance with the pin assignment diagram. See item 5.4 and instructions on the device plate. Tighten terminal screws using the screwdriver (3mm).

! ATTENTION

Improper connection may result in the device failure.

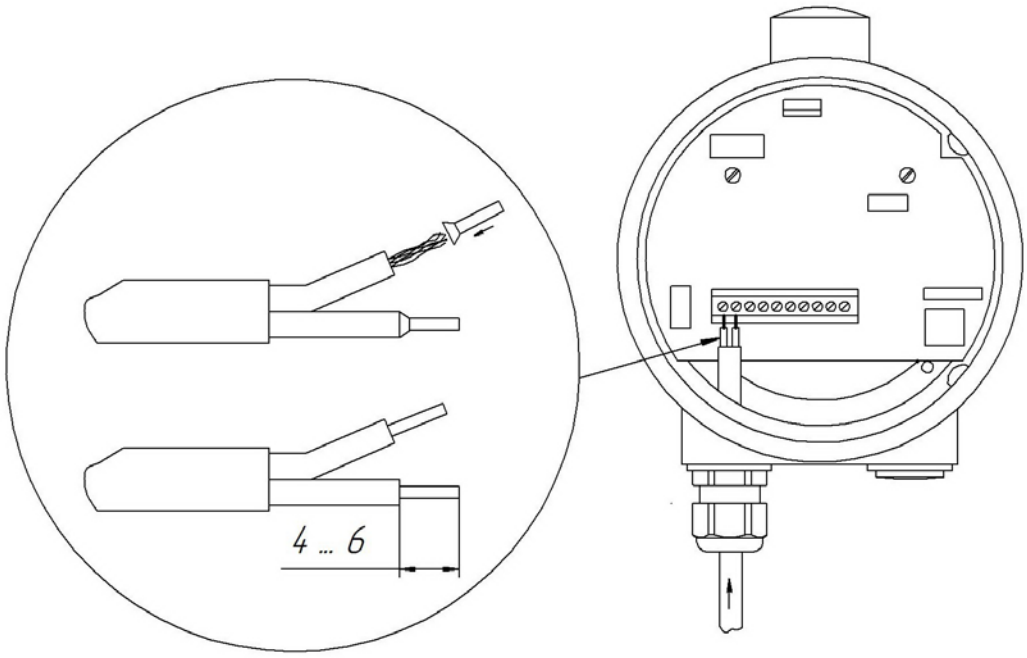


Fig. 4.20. Sensor connection

7. Pull the wires slightly to check secure fastening in the terminal block.

8. Adjust the cable length required for connection to the terminals and tighten the cable gland nut securely. The sealing ring should fit around the cable.

9. Check presence and integrity of the cover sealing ring (item 12.7, pos. 3) and tighten the level sensor cover.

10. Connect the external grounding terminal using the screwdriver (6mm) to the tank ground.

After connection it is recommended to check the quality of work performed as follows:

- Cables are free from damages;
- There is no mechanical stress resulting from cable tension;
- Cable glands are properly installed, tightened, and sealed;
- Device housing cover is installed and securely tightened.

6. INITIAL SETUP AND COMMISSIONING

The device setup before commissioning can be carried out as follows:

1) Using a PC with RS-485 interface (Modbus RTU communications protocol, see ULM Sensor Communications Protocol for details) and ULMCFG configuration software;
2) Using a PC with HART interface (under development);
3) Using a PL-01 configurator console;
4) Using a smartphone via Bluetooth (under development).

6.1. Level sensor address assignment.

According to the used communications protocol, each sensor is assigned a unique Modbus address, a number from 1 to 255. The address is defined in binary notation by means of an 8-bit DIP-switch located inside the sensor and opposite the Sensor address plate (Адрес датчика). The address is a sum of numbers specified on the plate next to the digit-raised switch positions.

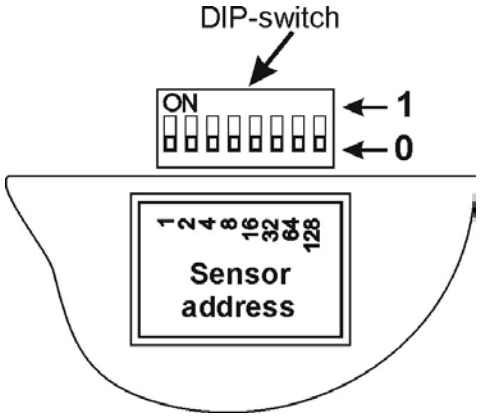


Fig. 6.1. Address switch in all-zero position

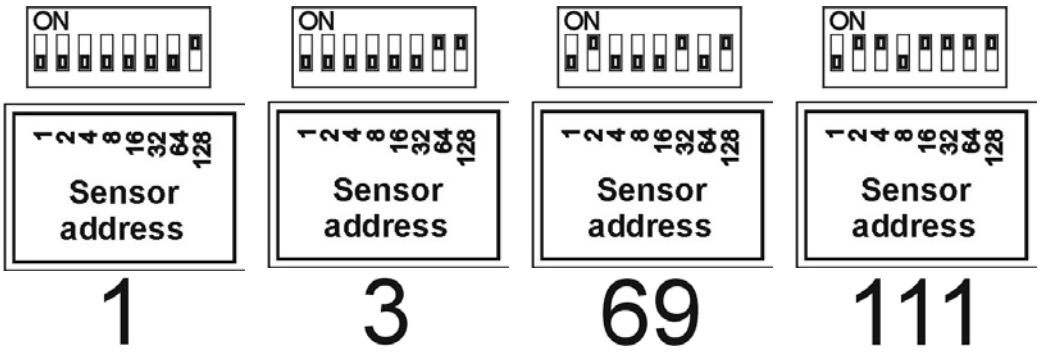


Fig. 6.2. Different address assignment examples

If all switches are in “0” position (Fig. 6.1), the sensor is assigned a default number specified in the level sensor software. The sensor address will be changed after its restart.

It is necessary to set the corresponding switch positions and cycle the device power in order to change the sensor address.

6.2. PC connection via RS-485 interface.

The digital interface provides access to the level transmitter readings and makes it possible to configure and diagnose a level transmitter. The level sensor digital interface is implemented as an RS-485 two-wire serial bus with Modbus RTU communications protocol. For details, see ULM Sensor Communications Protocol. RS-485 advantages consist in the easy network building, ability to read data from dozens of sensors via one line, without loss of accuracy, and at a distance of several kilometers, as well as ability to configure a level transmitter from the workplace or integrate it into an industrial automation system with a programmable logic controller (PLC).

“A” and “B” terminals are provided on the terminal block for connecting the sensor to the RS-485 line. Each level transmitter sensor has a unique Modbus address within one network. The address is defined by means of an 8-bit DIP-switch or determined by the sensor internal program, if the address is set as 0.

USB/RS-485 converter is used for connecting the sensor to the computer via a digital interface. “A” terminal of the sensor is connected to “+” terminal, “B” terminal is connected to “–” terminal.

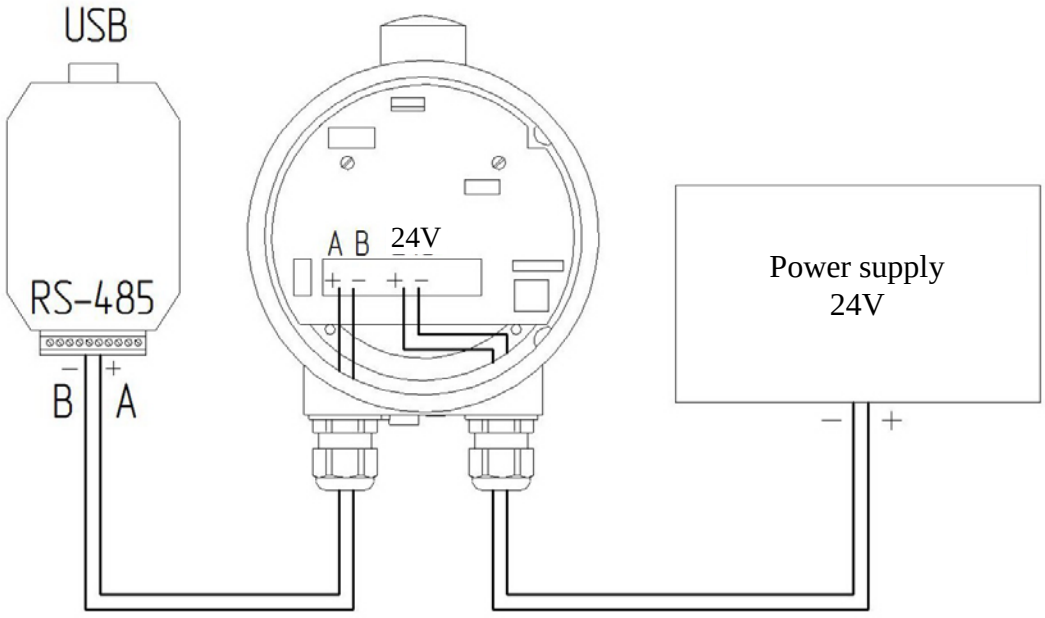


Fig. 6.3. Sensor connection using RS-485

It is necessary to use converters with automatic data flow control. There are a lot of standard devices of this type; the most widely used models include MOXA series 1100 (uPort-1150i, uPort-1130), ADAM-4561, ICP DAS series I-7561. Some converters require to set communications parameters before put into operation. In this case, you should make the following settings: Transmission speed – 9,600 bps, parity – Even, number of data bits – 8, number of stop bits – 1 or 2.

! ATTENTION

If necessary, install the device driver after connecting the interface converter to USB. Right-click My Computer icon and select Properties from the context menu. Click Device Manager button on Hardware tab in System Properties window (procedure for Win XP). Open COM and LPT Ports in the hardware list. Find the COM port corresponding to the connected device, double-click to open Properties window for the selected port and make sure the device is working properly.

RS-485 information line is organized by means of a twisted-pair cable with a characteristic impedance of 120Ohm. The external cable insulation should provide a sufficient mechanical and electrical strength for technological and environmental conditions of the customer. The total line length can be up to several kilometers.

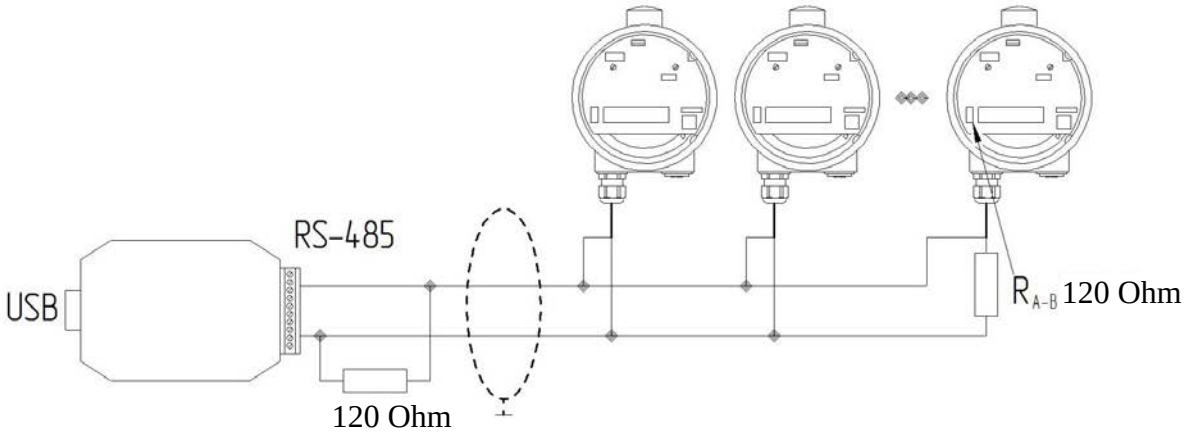


Fig. 6.4. Conventional method of RS-485 network building

The conventional network shematic diagram corresponding to the general requirements of RS-485 standard designed for high-speed data transmission under the industrial interference conditions is shown in Fig. 6.4. If the line is too long, it is recommended to install terminal resistors (120Ohm) at the line ends between “A” and “B” wires. For this purpose, the sensor is equipped with a switch connecting the resistor to the line (designated as R_{A-B} on the plate). Please note that the resistor can also be installed inside some interface converters. If the line length exceeds 800m or the number of devices on the line is more than 32 units, it is recommended to use repeaters for RS-485, for example, ADAM-4510.

! ATTENTION

Do not connect devices with a communications protocol other than Modbus RTU to the level transmitter network.
Make sure there are no sensors with the same Modbus address on one information line.

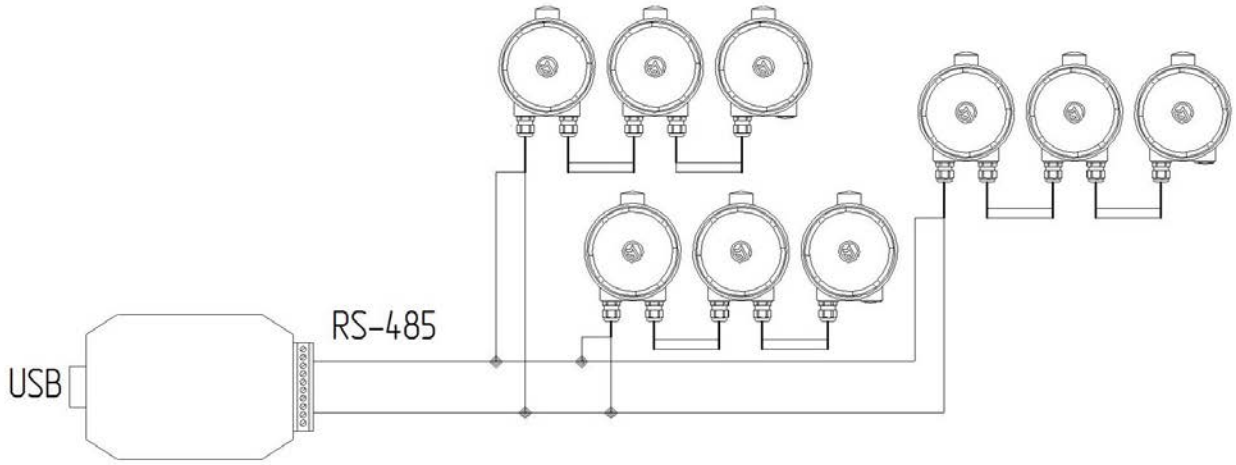


Fig. 6.5. Star method of RS-485 line laying

The low transmission speed (9,600 bps) used in the level transmitter makes it possible to provide good interference protection of the communications line and apply different interconnection options, including the so-called star topology (Fig. 6.5). The user selects the appropriate option from considerations of easy cabling and length minimization. As a rule, terminating resistors are not required for cabling of this type.
Few communications errors may occur on long and branched lines. These errors don not result in the unreliable level data, since Modbus communications protocol used in the level sensor includes the checksum calculation making it possible to determine unreliability of readings. These data will be ignored.

6.3. General sensor parameters setting by means of PC via RS-485.

Minimum PC requirements: Pentium II, 256 MB RAM, 800x600 monitor, USB or COM port, MS Windows version 95 or later.

“CONFIGURATOR” (ULMCFG) program is used for setting up the level sensors. The program enables to:
- Get and change general settings of the level sensors (hereinafter referred to as the sensors);
- Diagnose sensor operation;
- Load configuration from file to sensor;
- Write to disk and view diagnostic data (signal files);
- Update sensor program;
- Access to sensor registers.

The program does not require installation, just copy ULMCFG.EXE file to the previously created directory on the hard drive.
A detailed description of the program is given in the “Configurator. User Manual” document. The initial setup of the device requires fulfillment of the following steps.

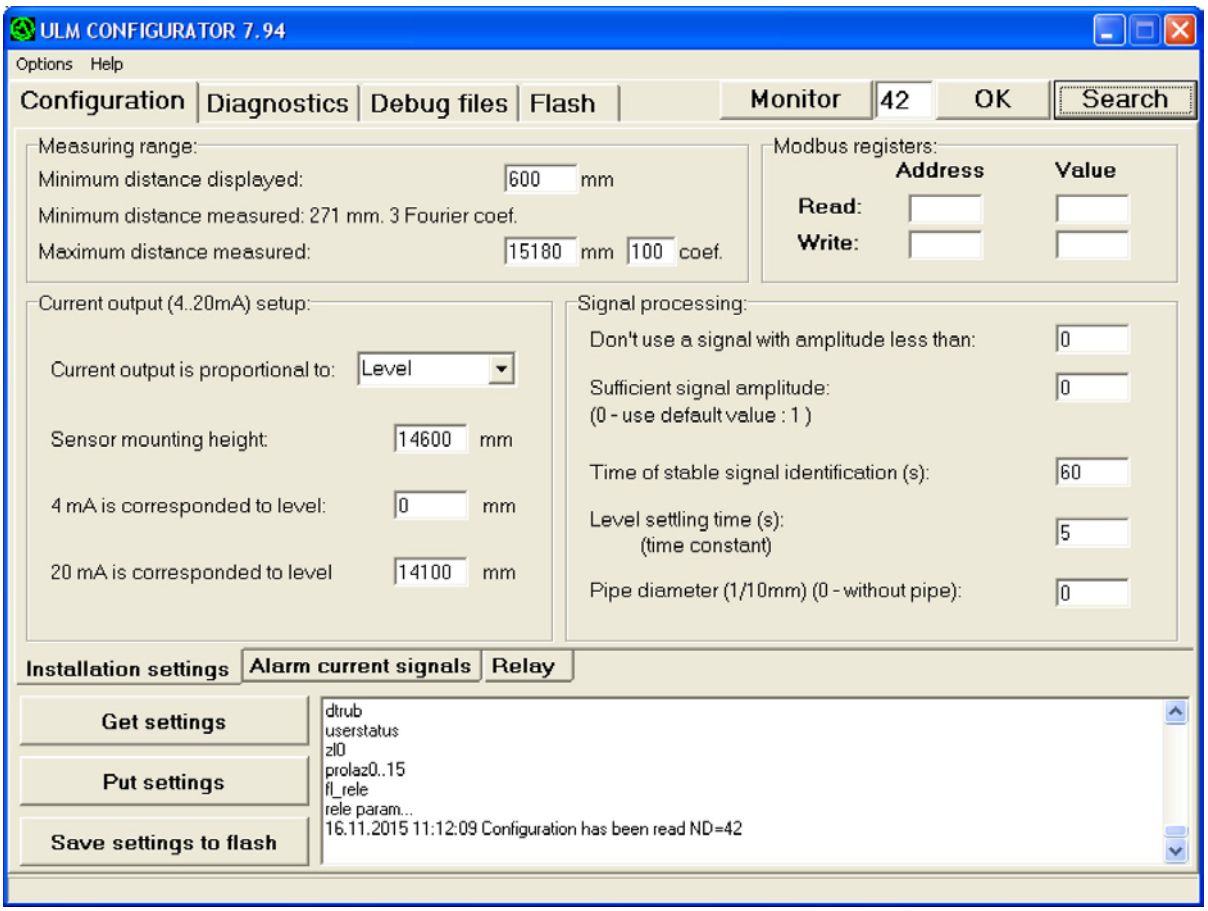


Fig. 6.6 Configurator main window

Sensor connection procedure:

1. Set the number of the COM port, which USB/RS-485 converter is connected to, in [Options] main menu

[Options]>[COM port] allows the user to select COM1-COM20 port, which the network of sensors is connected to. AUTO is selected by default for automatic search of COM ports.

2. Direct connection to the sensor can be done in two ways:

1) Enter its unique number in ModBus address field and press OK.

Fig. 6.7 Example of connection to the sensor with address 42

2) Press Search button to start the automatic scanning of sensors, generating addresses from the 1st one up to that specified in the Search up to ModBus No. field. The following window, as in Fig. 6.8, will be displayed. The program adds the detected sensors to the list. The search will stop after scanning of all ModBus numbers (if “Continuous Scanning” checkbox is not checked). To connect to one of the detected sensors for further operation, select it in the list and press ENTER key or OK button.

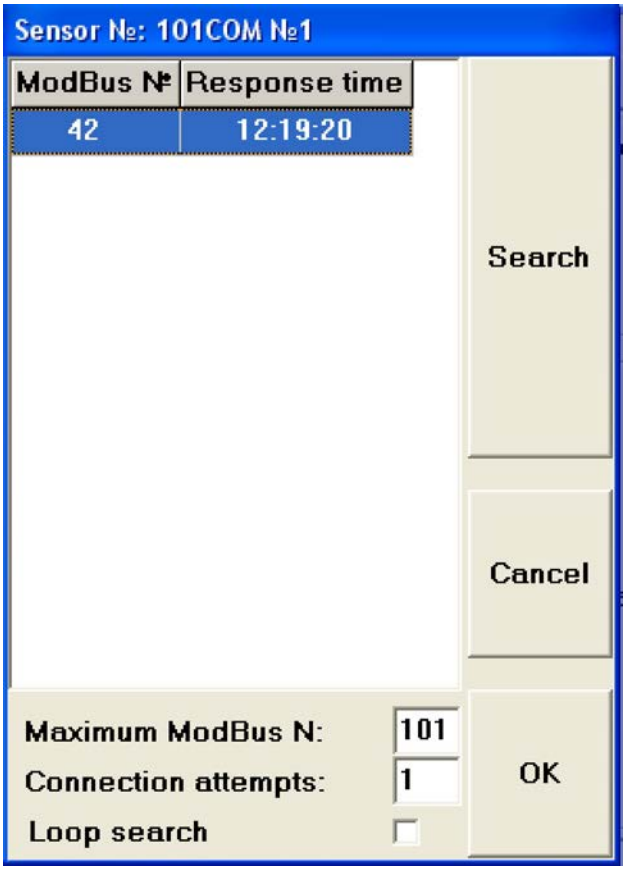


Fig. 6.8 Sensor search field

Prior to the delivery of the level sensors, their parameters are configured based on the data specified by the customer in the questionnaire available on www.limaco.ru. Settings are stored in the sensor's nonvolatile memory. These settings should be checked and changed, if necessary, during the initial sensor setup.

Measuring Range determines the range of measured and displayed distance.

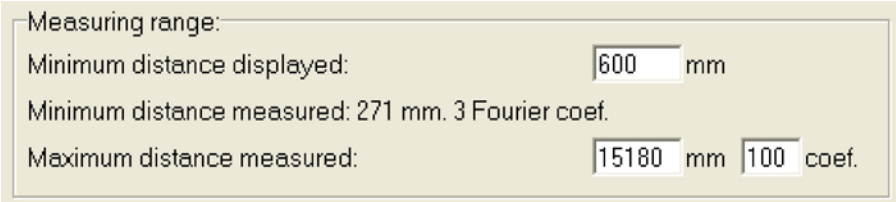


Fig. 6.9 Measuring Range setting

Minimum Distance Displayed – the device does not produce readings below this value. It is set in the area of stable measurements. It is set at the boundary of the dead zone (600 mm) by default, which is optimal for most applications. If it is necessary to measure shorter distances, this parameter can be reduced as agreed upon with ZAO LIMACO. The main thing is to keep its value within the area of stable measurements, according to item 4.5.

After this parameter value is entered, press Enter, the **Minimum Distance Measured** (the next line on the panel) will be calculated automatically. This is the left (near) boundary of the reflected signal search area (N0 - spectrum factor number, starting with which the sensor detects a useful signal).
Maximum Distance Displayed is the upper limit of the device operating range. It is usually selected equal to the sensor mounting height. It enables to eliminate the impact of occasional signal reflected from the tank bottom. After entering the value, press Enter, the right boundary of the dead zone will be calculated (Nmax - spectrum factor number, up to which (inclusively) the sensor will search and analyze the signal). The end value of the maximum displayed distance will appear in the field in millimeters after Nmax calculation.

4-20mA Current Output Configuration - Configures sensor 4-20mA output.

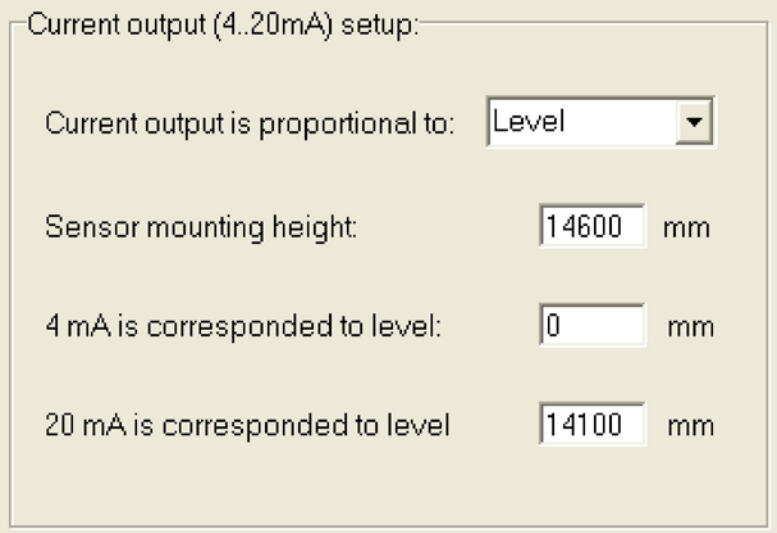


Fig. 6.9 4-20mA Output Configuration

Select whether the current signal should be proportional to the product level in the tank or to the distance to product (see Fig. 3.4.) in the **4-20mA Output is Proportional to**.
Enter the distance (H) from the sensor mounting flange to the tank bottom in millimeters in **Sensor Mounting Height**. H value is used for calculation of the tank filling level (see Fig. 3.4.).
4 mA Current Corresponds to Level (Distance), mm. It sets correlation between minimum 4 mA current and product level in the tank (distance to product).
20 mA Current Corresponds to Level (Distance), mm. It sets correlation between maximum 20 mA current and product level in the tank (distance to product).

Signal Processing – parameterization of the device on the basis of the measurement conditions.

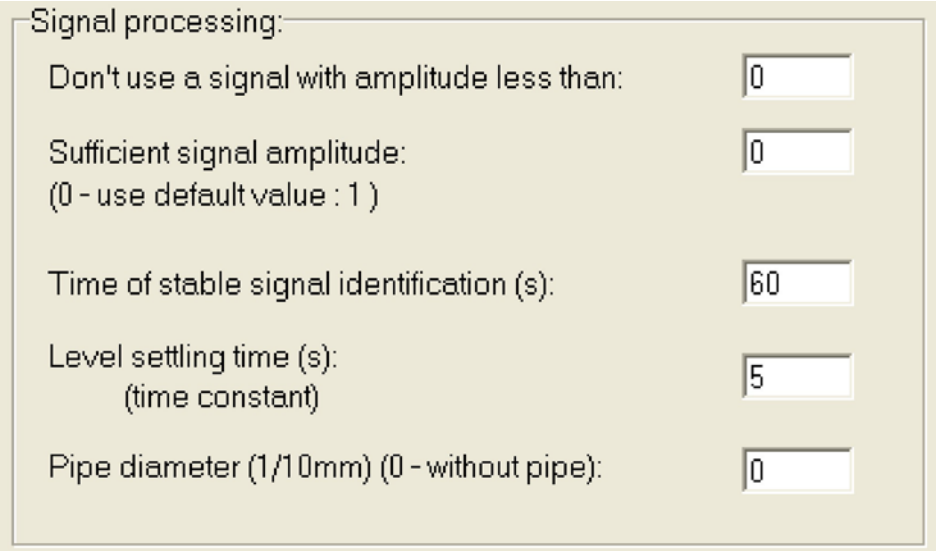


Fig. 6.10 Signal Processing parameter setting

Ignore Signals with Amplitude Lower than - the minimum signal amplitude threshold value, which may be used for calculation.
Amplitude Criterion of Signal Quality is used as a criterion for the device self-diagnostics based on the reflected signal amplitude.
Time of Stable Signal Detection - damping of spikes in readings. The device will give a new distance value after the specified time in case of a sudden and significant change in the distance to the reflecting surface. Failure of the device to respond instantly to the distance change under steady conditions is a normal case, as the product level does not change abruptly in the real tank. This behavior is caused by the algorithm of elimination of the product surface instability effect on the readings.
Time of Response is a parameter which determines the sensor dynamics. This parameter is set depending on the maximum rate of the level change in the tank.

! ATTENTION

Excessive reduction of the Time of Response parameter improves dynamics, but it also increases the readings dispersion and deteriorates the level transmitter performance if there are any waves on the product surface in the tank, for example, during product boiling or its top filling.

Pipe Diameter – is a setting used for ULM sensors of another type for product level measurement in the guide pipe (not to be confused with installation on the branch pipe). It is necessary to indicate the pipe inner diameter in tenth of millimeter (“2000” for 200 mm pipe). In all other cases (including branch pipe installation), the value of this field should be equal to zero.

Other parameters are configured if necessary, in accordance with the manufacturer's recommendations based on the provided diagnostic information, see Section 7.
A detailed description of the ways of other parameter change is given in the “Configurator – User Manual” program description.

6.4 4-20mA current output. Alarm signal setup.

The level sensor has an active 4-20 mA current output for connection of standard receivers.

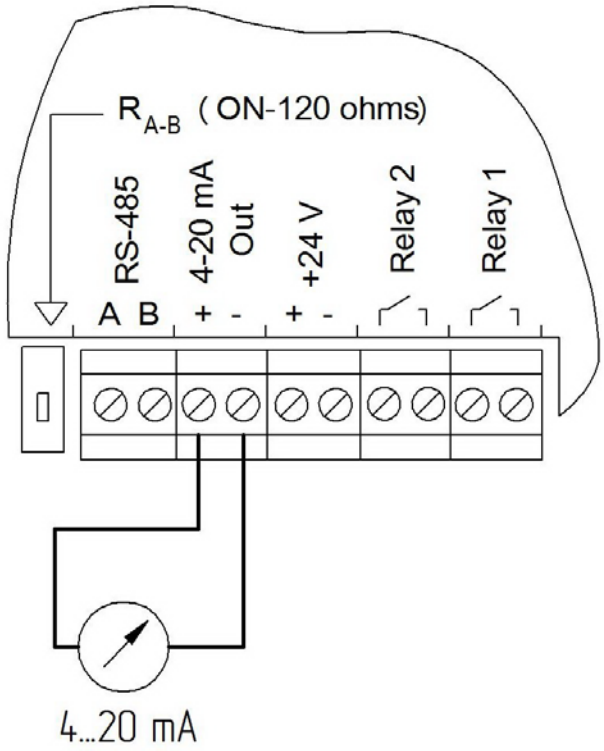


Fig. 6.11 4-20mA current output connection circuit

Readings of the product level in the tank, distance to the product surface or 3mA, 4mA or 21mA alarm current signals can be sent to it depending on its configuration.

The example of the alarm signal setup window is shown in Fig. 6.12. The right-hand part of the panel contains a list of monitored parameters with a bit number in the status register being shown in front of each parameter. More detailed information on the status register can be found in Section 7.

The left-hand part of the window has 4 columns containing 16 checkboxes each and comprising a mask to map the status register and alarm current signals. If a checkbox is checked, the corresponding mask bit is set to the logical «1», and the selected parameter being taken into account. If the checkbox is unchecked, the bit is set to logical «0». Unchecked parameters are not used set alarm current signal.

! ATTENTION

The current signals have the alarm signal reading priority: 21mA, 3mA, 4mA. If any alarm signal is formed, the level (distance) readings aren't sent to the current output. Take this fact into account while configuring the current signals.

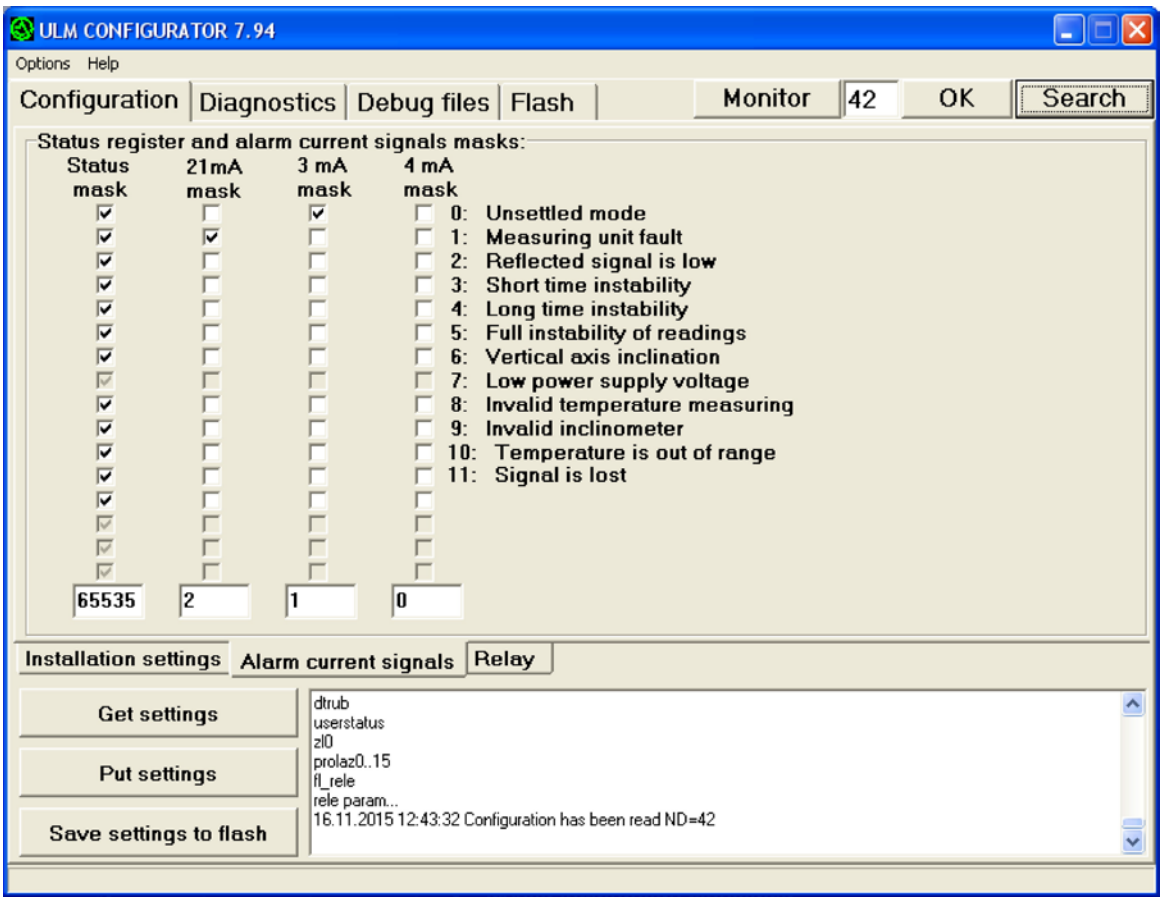


Fig. 6.12 Alarm current signal setup

The example in Fig. 6.12 shows that the current output has:

- 21mA in case of internal diagnostics of the measuring unit;

- 3mA in case of temperature rise inside the level sensor.

6.5 Relay signal setup

The sensor has two relay normally open relays with NO contacts. The tab of the Configurator program allows the user to establish the relay closing criteria. Two relay signals are formed depending on the level transmitter readings and measuring status value.

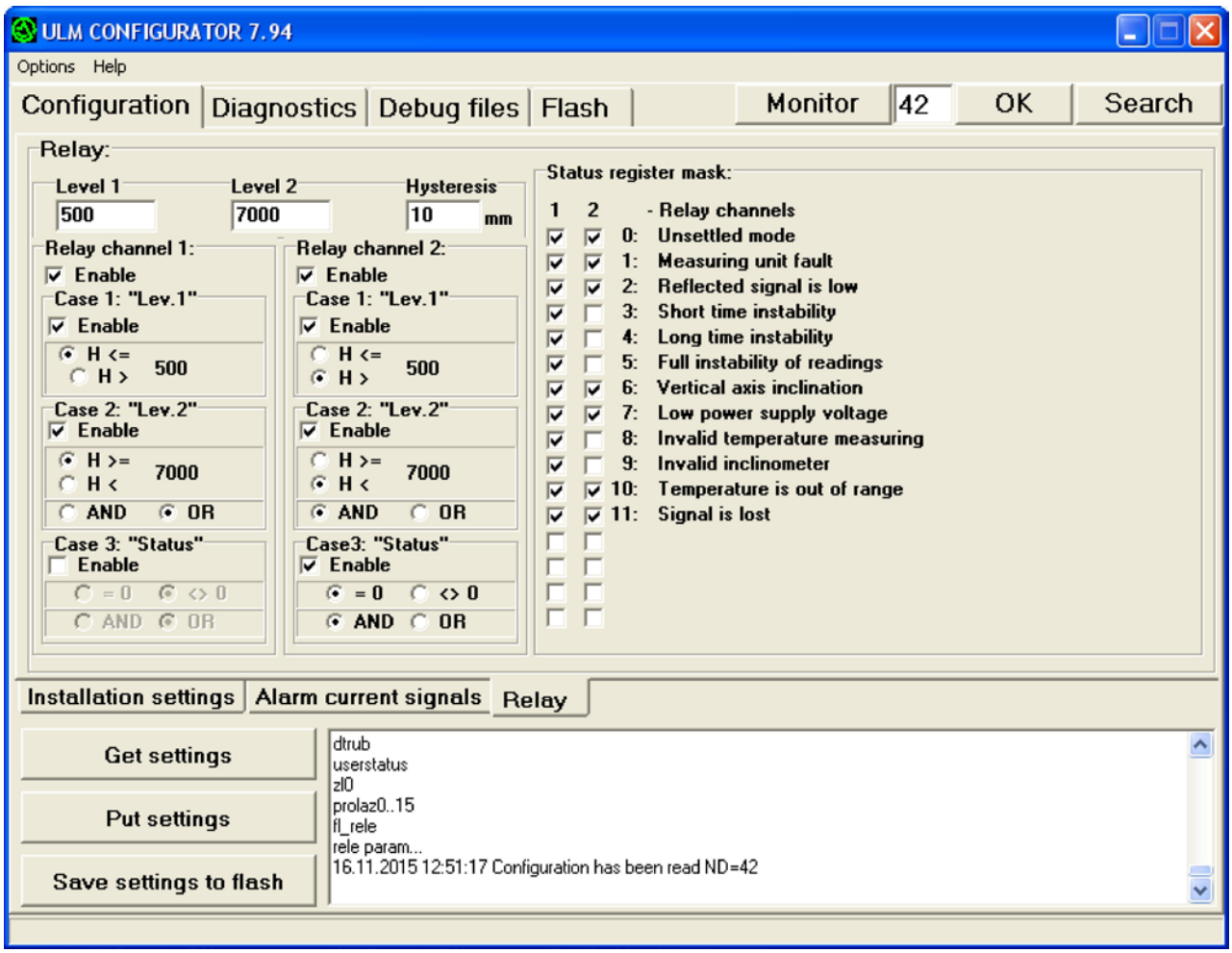


Fig. 6.13 Relay signal setup

The upper left part of the tab (Fig. contains three text fields designed for entering the values of two threshold levels (distances) (in millimeters) and hysteresis. The hysteresis is required to eliminate the relay unnecessary actuations (flutter). For example, if the hysteresis is equal to 10 mm, the relay closes when the reference level is reached and opens when the level gets back to 10 mm. Thus, readings dispersion in 10 mm observed in the threshold level area and resulted from surface oscillation in the process of loading (unloading) will not lead to frequent relay switching. The sets of chekboxes used to determine the conditions of relay signal formation are presented below in two columns, with each channel having its own set. The upper checkbox is used to activate the corresponding channel, thus making available three conditions of relay contacts closing. Two upper conditions define the relay response to the first and second threshold levels. If both conditions are enabled, it's necessary to select the logical operation to be performed between them. If AND operator is used, the relay is activated when both conditions are observed, if OR operator is used, the relay is closed when any of these conditions is observed. The third condition enables to take into account the measuring status (with mask) during a relay signal formation. If you have activated this condition, please, specify when the relay should be closed (if the status equals to zero, none of the situations speci-

fied in the status mask has occurred; if the status doesn't equal to zero, one or more situations have occurred). The status masks of both relay channels are on the right part of the panel. They are configured in the same way as the masks of the alarm current signals. If one or both conditions of threshold levels are selected along with the measuring status, the status criterion is connected to the threshold one by means of AND/OR operator as described above for the first and second limit conditions.

For example, if the system is configured as shown in Fig. 6.13, both relays are used and their actuation is performed as follows: The first relay is closed when the readings override any of the limit values (H <= 500 OR H >= 7000) without regard to the measuring status. The second relay, on the contrary, is closed when the product level is within the allowable limits (H > 500 AND H < 7000), with 0, 1, 2, 6, 7, 10, and 11^{th} status bits being equal to zero (readings are stable and valid, sensor operating conditions are normal).

7. DEVICE OPERATION INFORMATION.

7.1 Device diagnostics.

The Configurator software on the Diagnostics tab (Fig. 4.17) contains basic information about the sensor operation. Visually, it is divided into seven panels, which display the sensor operation indicators. Most of the lines are displayed in black type; the indicators that go beyond the allowable criteria or recommended state are displayed in red; the lines that have nothing to fill in, because this modification of the sensor in terms of hardware or software does not allow the relevant parameter to be controlled are displayed in grey.

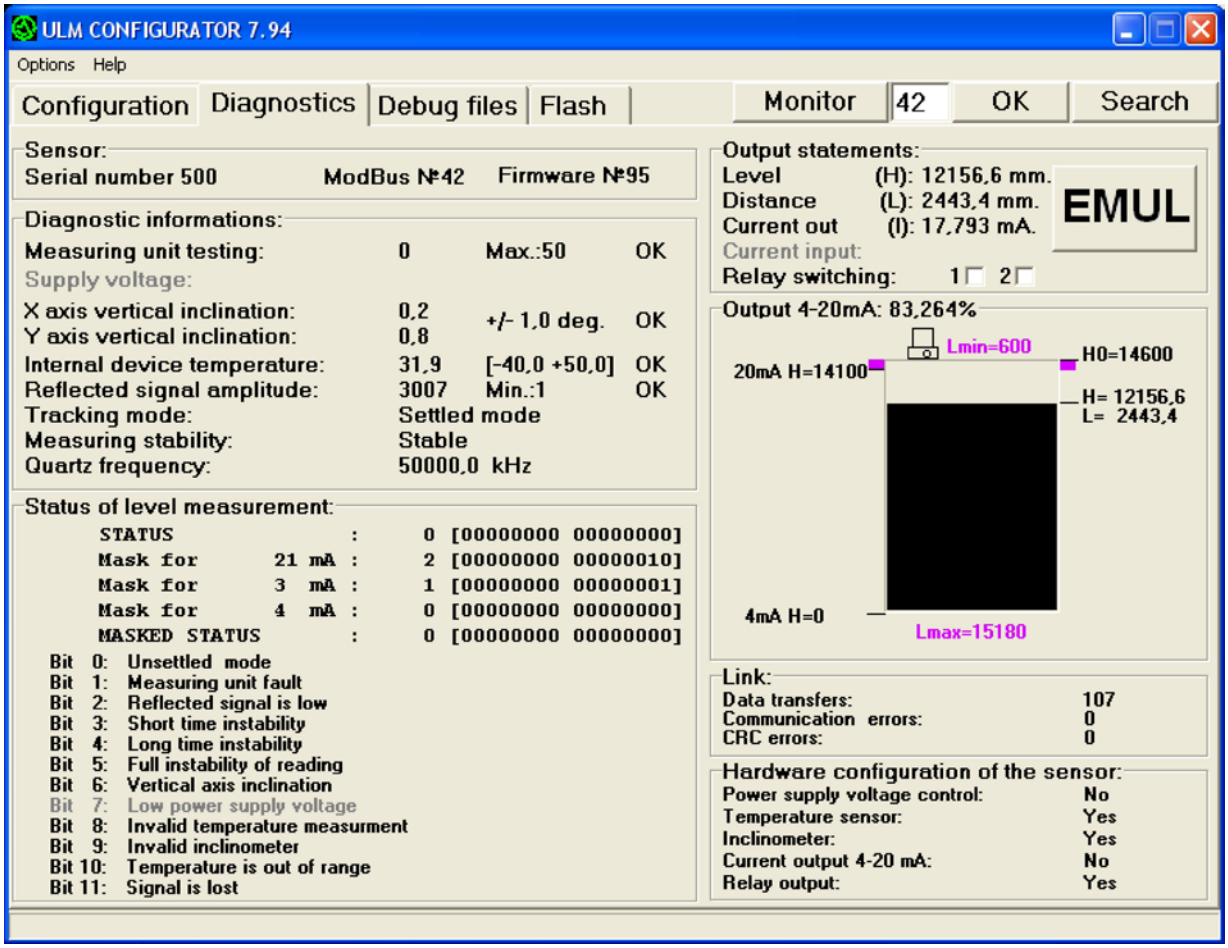


Fig. 4.17 Appearance of the Diagnostics Tab

The following parameters are displayed on the **Sensor** panel:
- A factory number of the sensor;
- The address for Modbus;
- A firmware number (the internal programs of the sensor).

The **Device Operation Information** panel shows:

- The current amplitude of the signal and on the right, next to the word "Min.:" – the amplitude threshold (Sufficient amplitude of the signal on the Configuration tab). If the amplitude is less than the threshold, the 2nd bit is set in the status register.
- «Level Meter Testing» is a measurement system operability indicator, on the right - the maximum value, in case of excess of which the 1st bit is set in the status register.

! ATTENTION

Exceeding the maximum allowable value of the "Meter Testing" parameter means the failure of the level sensor electronic module. Follow the procedure of registration of repair, according to item 11 of this guide.

- «Readings stability» – is an indicator of the overall (short-term and long-term) stability.
- «Mode» – stable if the sensor has found a steady signal, otherwise – unstable - test mode after turning-on.
- «Supply voltage» is current value and minimum allowable treshold in volts (the 7th bit of the status register). The temperature inside the sensor housing in Celsius degrees and the allowable temperature range (the 10th bit of the status).

"Deviation of the sensor axis from the vertical" in two planes in degrees and permissible deviation (the 6th bit of the status register). If permissible deviation is exceeded, the sensor must be leveled (align according to spirit level).

The **«Status of level measurment»** panel. See details in «Configurator – User's Guide».

The «**Link»** panel allows the communication line to be evaluated. When the "Diagnostics" tab is active, data continuous exchanged with the sensor. The value of the "data exchanges" field shall grow steadily (from 0 to 999 and then cleared), the values of the "communication errors" and "control sum error" fields when using a high-quality communication line, shall not increase. Isolated errors are possible on real objects with a long RS485 network.

The **«Hardware configuration on the sensor»** panel shows the presence of optional units for power supply monitoring, temperature monitoring, inclination monitoring in the device.

The «**4-20mA Output»** panel visualizes the settings of such output: base height (H0 – on the right), the levels/distance, corresponding 4 and 20 mA currents («4 mA= » «20 mA = » on the left), as well as current value of the level and distance. In addition, on the top and bottom the measurement range boundaries are indicated in purple.

The «**Readings»** panel displays level, distance, input and output currents, the position of the relay contacts.

7.2 Emulation of the Output Signal

The EMUL button turns on the emulation mode in the sensor.

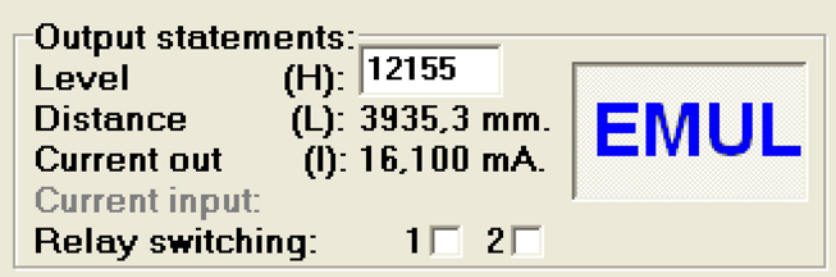


Fig. 4.18 Emulation of the Output Signal

Emulation of the output signal is a setup mode which makes it possible to check the settings and operation of such output.
After pressing the EMUL button, the sensor will be transferred to the emulation mode, it will take up to 4 seconds. The button will be fixed pressed, the inscription will be purple. Then the values of the level and the distance can be edited. When these parameters are changed the output current signal shall be changed in accordance with the data on this panel also.
To turn off the emulation click the EMUL button again, in 4 seconds the sensor will switch to the normal mode.

7.3 Debug files.

The most complete information about the device operation can be obtained from the so-called "Debug files". The debug files are files with the «FOT» extension which contain the signal records and the additional data received from the sensor. They carry extensive information about the device working conditions. Analysis of the debug files allows you to take into account the specifics of a particular application, to optimize the settings and configuration of the sensor to provide the most accurate and reliable operation of the level measurement system. See details in "Configurator - User's Guide", "Working with debug files".

8. TROUBLESHOOTING

The personnel responsible for the operation of the level transmitter shall take measures to correct the faults. Use of the defective level transmitter is prohibited.
The sources of the transmitter failure can be as follows:
- The level sensor;
- The receiving device that displays information;
- Level sensor power supply;
- The process in the tank.

In case of failure should it is necessary to locate the source of the failure whenever possible.
When an analog signal is used, check availability and correctness of formation of the output signal directly at the level sensor output, point out whether there are 3 mA, 4 mA or 21 mA alarms, check the power supply voltage.
The most extensive possibilities of troubleshooting concerning measurements can be obtained when a PC and the "Configurator" program are used.

NOTE

In most cases, this allows you to determine the cause of malfunctions and eliminate the problem of measurement.

Also, diagnosis of the device can be carried out using the PL-01 remote control (see Remote Control - Configurator PL-01. Operating Instructions), as well as via Bluetooth channel (under development).

Level sensor verification and troubleshooting operations are summarized in the following table.

Failure	Cause	Troubleshooting method
4-20mA signal is absent	The power supply voltage of the sensor is missing or is outside the acceptable value (see item 12.1 Technical Specifications)	Check the power supply source, electrical connections, when the inconsistencies are detected, they shall be eliminated.
	Electrical 4-20 mA output connection is broken or line resistance is too high (see item 12.1 Technical Specifications)	Restore the connection or eliminate the increased load on the line.
	Malfunction of the sensor electronics unit.	Send the device for repair.

Failure	Cause	Troubleshooting method
4-20 mA signal corresponds to one of the alarm values	One or more of the controlled parameters of the sensor are beyond the acceptable values:	Connect to the sensor using a PC or remote control. Check compliance the values of the alarm signal with its mask (item 6.4).
	The temperature of the sensor is beyond the range.	Eliminate the cause of the overheating, isolate the level sensor from the process with the high temperature with a radio transparent cap (see item 12.5), use air cooling of the sensor, install a sunshade.
	Deviation of the sensor from the vertical axis (for use in liquid products)	Eliminate the problem by the device leveling.
	Unreliable measurement of temperature or angle of deflection	Appropriate channels in the electronic module of the device are defective. Further operation is possible in the absence of the possibility of overheating. In other cases, send the device for repair.
	The lack of stability of indications - excitement on the surface of the product, the unstable surface	It is a reference parameter, you can continue to use.
	Unstable mode - no stable reflecting surface of the product or the sensor is initial load phase	Initial start-up mode of the sensor. After switching on the device must exit this mode in 1-2 minutes. If this does not happen, you should make records of the spectrum (see item 7.3.) and send it to manufacturer's technical support.
	Failure of the meter - failure of electronic transmitter unit	Send the device for repair.

Failure	Cause	Troubleshooting method
	- Small amplitude of the reflected signal - use on products with low dielectric constant, use in bulk solids, failure of the electronic unit	Make records of the spectrum (see item 7.3.) and send it to manufacturer's technical support. Follow further recommendations.
	Signal loss - sudden changes in the properties of the reflecting surface: foam-formation, collapses of bulk solids, overlap of measurement beam with the product stream	It is given for reference purposes. When the reflected signal is stable and the process becomes normal, the current signal should be restored. If this does not happen, you should make records of the spectrum (see item 7.3.) and send it to manufacturer's technical support.
4-20 mA signal does not correspond to the actual value of the controlled variable.	Malfunction of the level transmitter electronic unit.	Check the current loop signal through emulation (item 7.2). If there are discrepancies, send the device for repair.
4-20 mA signal does not correspond to the real value of the controlled variable, electronic unit is faultless	Incorrect initial measurement of the basic parameters of measurements (item 6.3.), the requirements of the installation are not complied (4).	Make records of the spectrum (see item 7.3.) and send it to manufacturer's technical support. Follow further recommendations.
No connection via RS-485 with presence of the 4-20mA signal	Electrical line connection is broken	Check and restore the line or correct the non compliance with requirements and the connection diagram (see item 5).

Failure	Cause	Troubleshooting method
No connection via RS-485 with presence of the 4-20mA signal, communication line is faultless	The required driver is not installed or initial settings of usb/RS-485 converter are incorrect	Check the operation of the converter in the PC operating system (Device Manager), set the necessary settings of the converter.
	Modbus sensor address is incorrect or many sensors on the line have the same address.	Set different Modbus address for sensors in one RS485 network, indicate the correct number of the sensor when searching in the "Configurator" program. (see item 6.1)
	COM port is occupied with another application.	Check whether there are applications that occupy the COM port, switch them off, restart the PC if necessary.

9. MAINTENANCE

No special maintenance is required for the level sensor. Depending on the operation conditions, only periodic cleaning of the antenna surface may be required.
Aggressive agents should not be used while cleaning the level sensor, to avoid any adverse impact on housing materials, seals, plugs and cable glands.

10. DISMANTLING

10.1. DISMANTLING PROCEDURE

The device should be dismantled in compliance with all current enterprise's standards and safety regulations; working at height and with aggressive or toxic agents is considered to be a matter of special concern.

Dismantlement is conducted in the reverse order of the procedure described in clause 5.6. Device connection procedure.

10.2 Disposal

The device housing is to be recycled.
The device can be disposed at specialized enterprises.
Disposal excludes any negative impact on the environment and allows to reuse materials.

11. REPAIR

Repairs can be performed only by the manufacturer or its authorized representatives.

If the equipment should be returned to the manufacturer for repair works, a special form "Repair order" is to be filled which is available on www.limaco.ru.

To send the device for repair, the following procedure should be done:
- complete a "Repair order";
- clean the device from dirt, to pack it to guarantee its safety during transportation;
- send the device and "Repair order" at the address indicated on the website in Contacts page.

12. APPENDICES

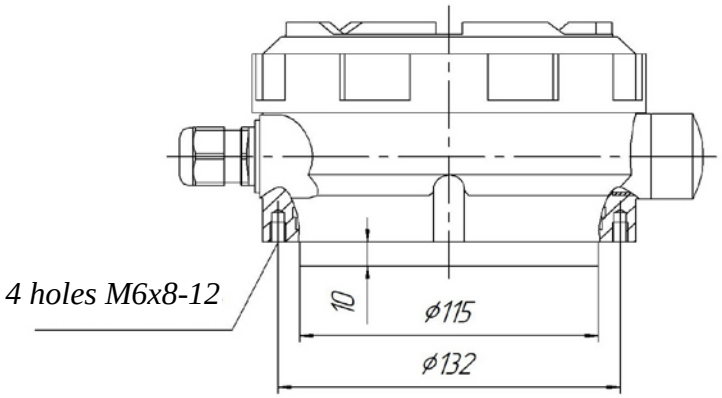
12.1 Technical specifications

Position	Value
General	
Housing material	Aluminum alloy, powder painting
Material of the sealant pad between housing and cover	Rubber compound
Antenna screen material	Teflon 4
Bluetooh cap material	Teflon 4
Cable gland material	Polyamide
Without a flange weight	2.5 kg
Dimensions	220x100x150 mm
Output signals	
Analog	
4-20mA	Active
Alarms	3 mA, 4 mA, 21 mA (adjustable)
Load	Not more than 300 ohms
Error (within -40... +50°C temperature range)	<0.5% of measuring range
Digital	
HART	Version 7.0 (under development)
RS-485	Modbus RTU
Reading presision	0.1 mm
Wireless	
Bluetooth	Version 3.0 (under development)
Relay outputs	
Number of Channels	2
Maximum switching current	3A
Maximum switching voltage, AC (DC)	250V (30V)
Mechanical durability	10000000 cycles
Electrical durability at rated load, minimum (standard)	50000 (100000) cycles

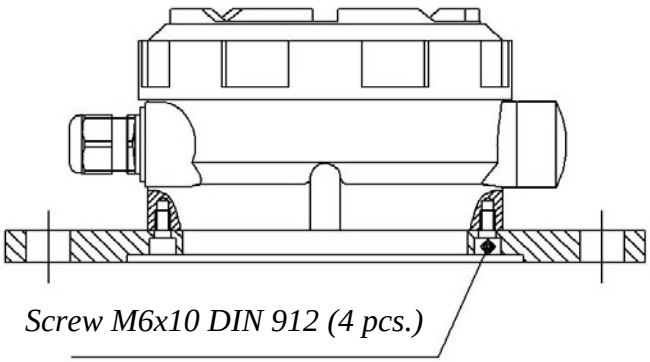
Position	Value
Device operating characteristics	
Absolute measurement error	Less than 3 mm
Measuring range	0.6 ... 50 m
Measuring range with reduced accuracy	0.3... 0.6 m
Operation principle	Radar device for level measurement, using linear frequency modulation (Frequency Modulated Continuous Wave FMCW)
Operating frequency *	24 GHz (OPTIONAL 94GHz)
Output microwave power	Not more than 8 mW
Beamwidth	9˚
Working conditions	
Ambient temperature at the sensor location	-40 ... + 50˚C
If the temperature is above 50˚C at the level sensor flange	Radiotransparent sealant pads are required to be installed. See clause 12.5
Atmospheric pressure	84.0... 106.7 kPa (630-800 mm Hg)
The relative humidity at the level sensor location	95% at 35˚C and lower, no condensation
Excessive pressure or depression in the tank	-1... 6 bar, radiotransparent sealant pad is required to be installed. See clause 12.5
Mechanical impact - Vibration amplitude - Frequency	 Not more than 0.1 mm 5... 25 Hz
The maximum sensor's axis deviation from the vertical axis	1 degree (regulated only for use with liquid products)
Protective measures	
Ingress protection grade	IP65
Target application	Industrial (non-explosion proof)
Power supply	
Supply voltage	20... 36VDC
Maximum power consumption	6W

Position	Value
Electromechanical characteristics	
Cable gland	Option 1: 1 cable gland M20x1.5 (Ø 7.8... 11.8 mm round cross section cable) 1 threaded plug M20x1,5 Option 2: 2 cable glands M20x1.5 (Ø 7.8... 11.8 mm round cross section cable)
Screw terminals for electrical cable connection permissible crossection	Not more than 2.5 mm (AWG 14)
Approvals and certificates	
This documentation can be loaded from www.limaco.ru	

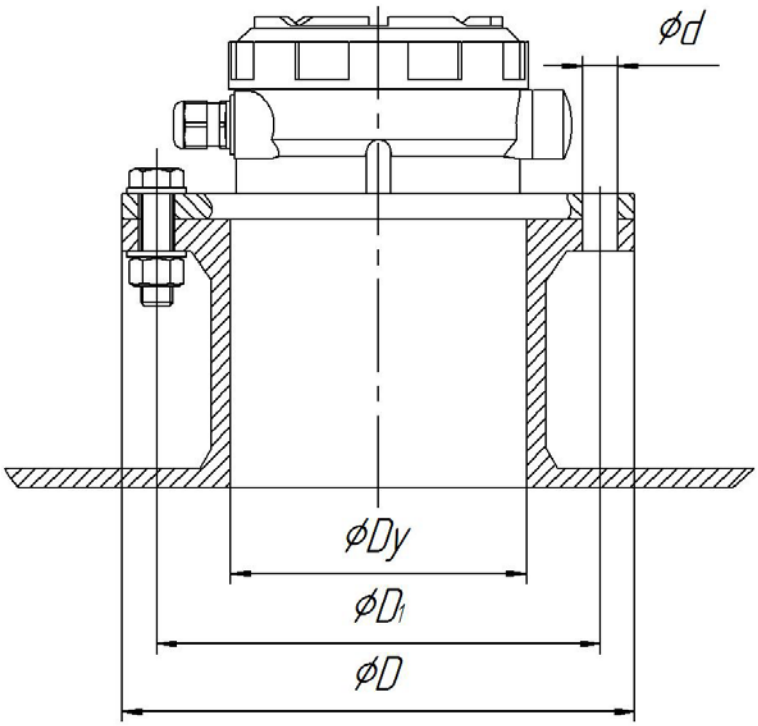
12.2. Mounting dimensions of the level sensor without mounting flange



12.3. Level sensor with the mounting flange assemble

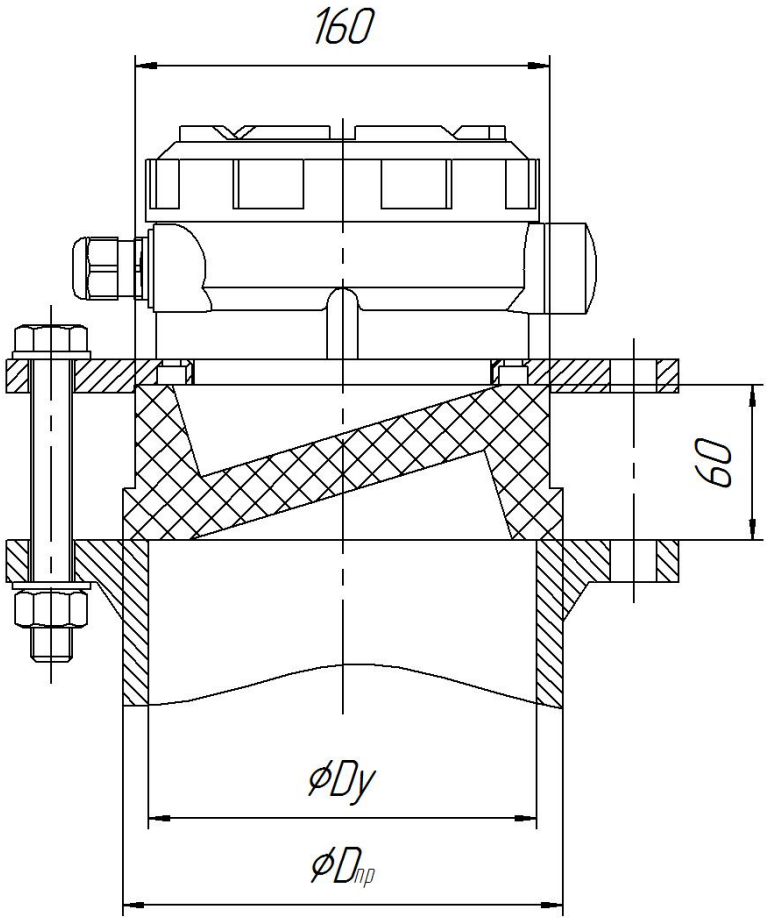


12.4 Level sensor mounting at the branch pipe



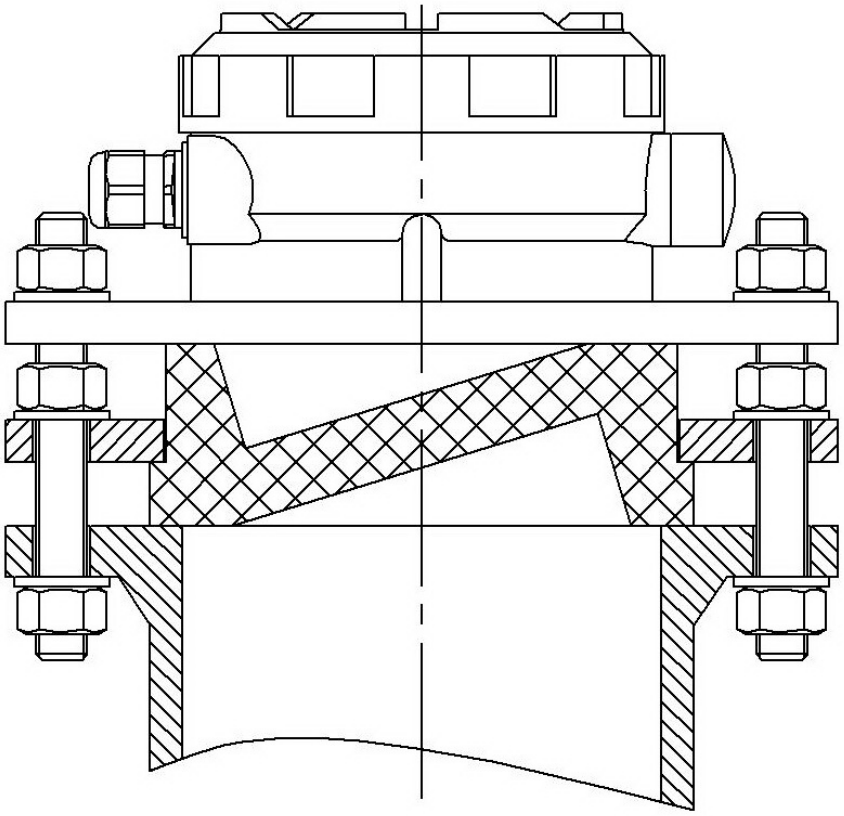
Dy, мм	D, мм	D1, мм	d, мм
100	205	170	18
150	260	225	18
200	315	280	18

12.5 Level sensor mounting at the branch pipe with a sealant pad

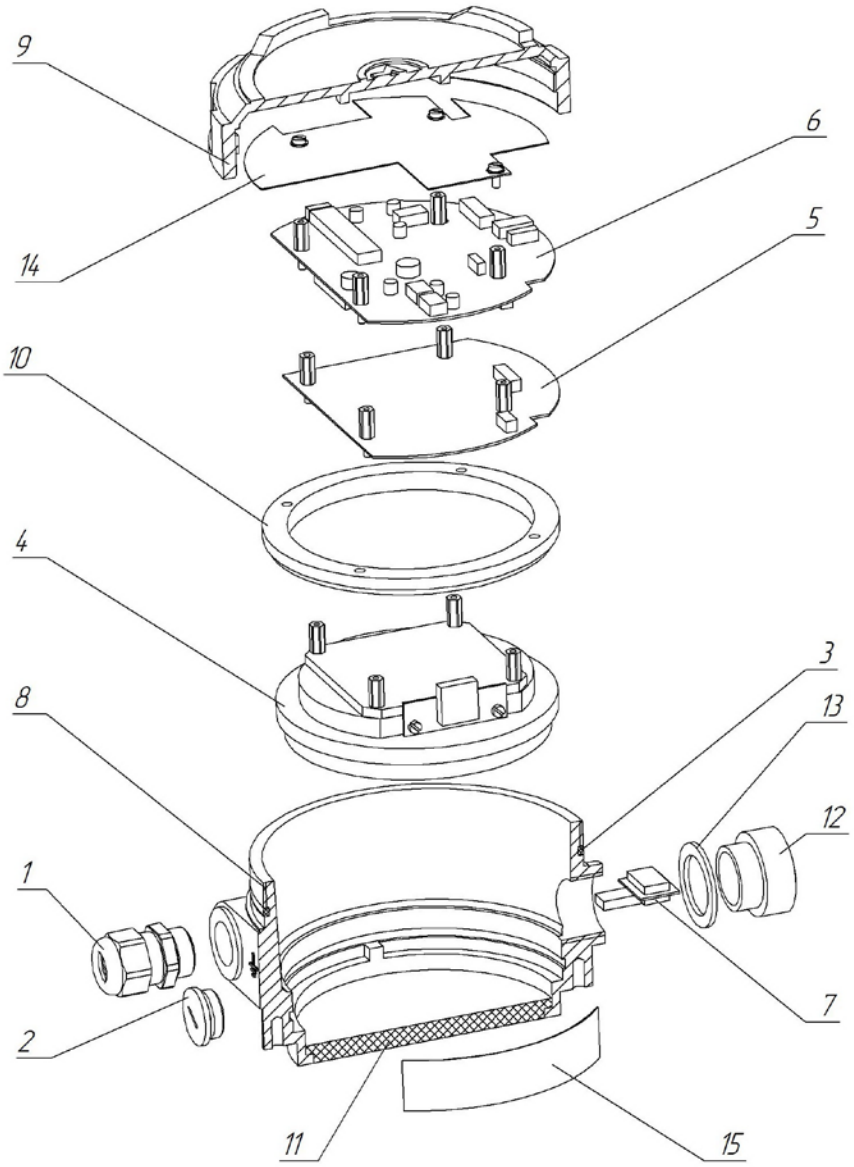


Dy, мм	$D_{пр}$, мм
100	—
150	170
200	250

12.6 Level sensor mounting at the branch pipe with a sealant pad using a clamping flange



12.7. Level sensor construction



1 – Cable gland;
2 – Treaded plug;
3 – Rubber ring;
4 – Microwave unit;
5 – Amplifier board;
6 – Interface board;
7 – Bluetooth board;
8 – Housing;
9 – Cover;
10 – Nut;
11 – Antenna shield;
12 – Radome;
13 – Gasket;
14 – Protecting plate with terminal info;
15 – Name plate.