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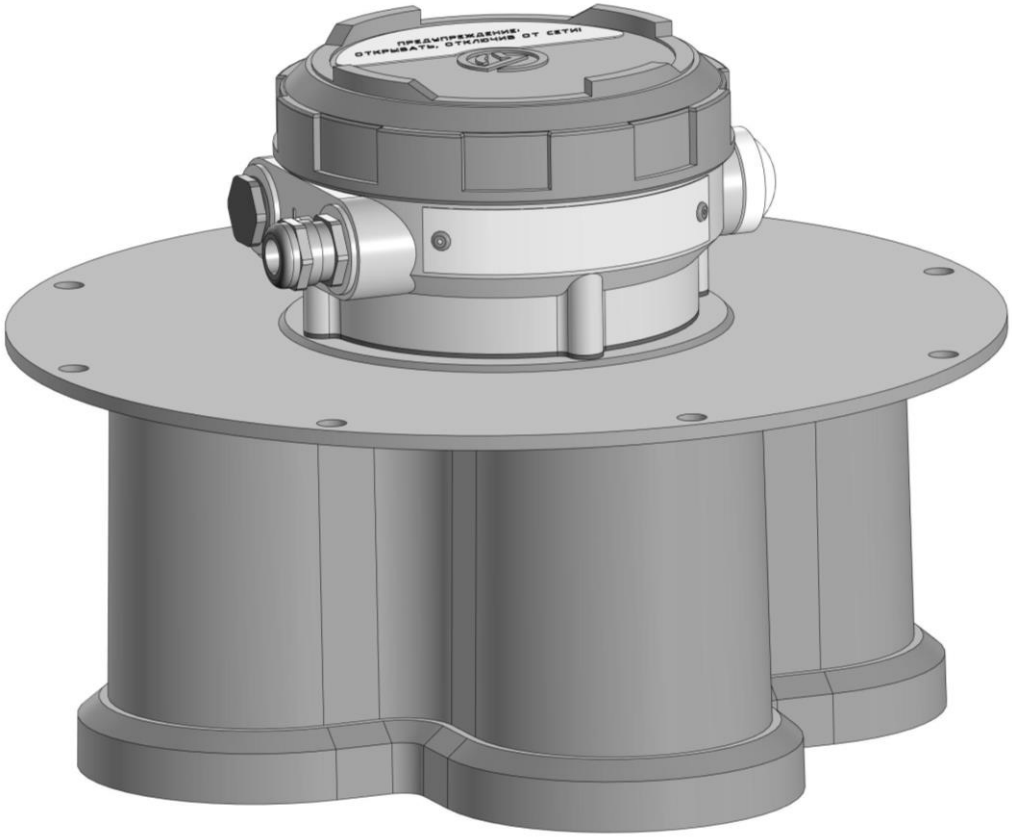
ULM-3D RADAR LEVEL TRANSMITTER

FOR BULK MATERIALS

Operating and Installation Manual



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1 DOCUMENT INFO

1.1 Purpose

This operating manual contains information necessary for installation, connection, commissioning, and configuration, as well as instructions for maintenance and Troubleshooting. Please read the instructions provided here before the installation and commissioning of the level transmitter.

1.2 Target group

This operating manual is intended for trained personnel who perform installation, commissioning, diagnostics, and maintenance of the level transmitter. The personnel shall know and follow the instructions provided in this document.

1.3 Symbols

Symbol	Description
! ATTENTION	Failure to follow the instructions may disable the device or cause its malfunction.
! WARNING	Failure to follow the instructions may cause damage to personnel and/or to the device.
NOTE	The symbol indicates useful information that needs attention.

2 SAFETY BASICS

2.1 Personnel requirements

Personnel who perform installation, commissioning, diagnostics, and maintenance of the level transmitter shall read this manual and be admitted to work with the device. When working with equipment, personnel shall use the required personal protective equipment in accordance with the company's regulations.

2.2 Purpose

ULM-3D level transmitter is designed for continuous non-contact measurement of the level of any bulk materials and is intended for use in process flow metering systems and product inventory management. ULM-3D level transmitter can be used to measure the level and volume in tanks and open storage facilities. A system of multiple level transmitters can be used for large tanks and storage facilities. The software package can display a three-dimensional picture of the measured material on a remote computer.

The level transmitter marked Ex tb IIIC T85°C Db is intended for use in explosive dust environments for conductive dust for installation in zones of class 21, 22 as per ATEX - Directive 2014/34/EU, EN 60079-0, EN 60079-31.

Before using level transmitters in an explosion hazardous zone, make sure that the version indicated on the nameplate corresponds to the one acceptable for use in this zone.

Climatic category is O1 as per GOST 15150-69.

The level transmitter belongs to D3 group as per GOST R 52931-2008 in terms of resistance to the influence of temperature and ambient air humidity.

Undue device application can result in occupational accident or device failure and is a source of potential danger.

2.3 Operational safety

The operational safety of device is ensured only subject to the observation of instructions provided herein.

The level transmitter corresponds to safety integrity level 3 (SIL 3) as per IEC 61508-1:2010, IEC 61511-1:2003.

Due to operational safety and warranty reasons, any modifications to the device design are prohibited. Any actions with the device other than those described in this manual can only be performed with the official permission of the manufacturer. The service life of level transmitters is 20 years.

2.4 General safety guidelines

ULM-3D level transmitter meets all modern requirements and safety standards.
The operating frequency of level transmitter is about 125±5 GHz. The radiation power does not exceed 8 MW, which is significantly lower than the maximum permissible values. The level transmitter is completely safe for humans and animals.
The device may be operated only in good working order to avoid occupational accidents.
ULM-3D level transmitter without an explosion protection label may be used only in an explosion-proof zone.

2.5 Environmental safety

Compliance with the recommendations provided in sections "Packaging, transportation, and storage" and "Disposal" contributes to environmental protection.

3. PRODUCT DESCRIPTION

3.1 ULM-3D scope of supply

The scope of supply includes:
- Radar level transmitter
- Documentation and software on electronic media:
    - Ulmcfg setup and configuration software;
    - Software for setup via Bluetooth for Android mobile operating system;
    - Limaco OPC-server software;
    - Multi Beam Radar Surface Plotter software;
    - Operating and Installation Manual;
    - Supplementary documentation (certificates and permits, if necessary, other technical information).

NOTE

1 piece of software and documentation on electronic media can be supplied for the entire order as per the specification.

Optional equipment that can be included in the order specification:
- power supply;
- RS-485 interface converters;
- mounting kit.

NOTE

The specific type of optional equipment (interface adapters, mounting products) may have different versions. This is to be agreed when ordering the equipment and stated in the order specification.

3.2 Product design

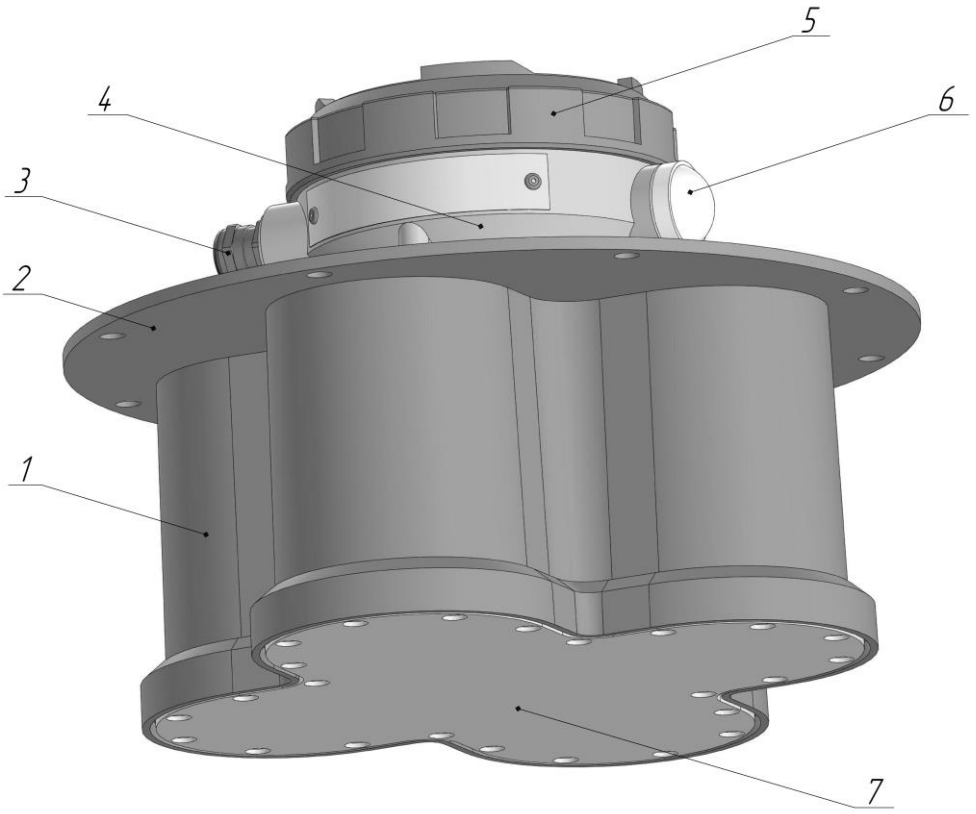


Fig. 3.1. Appearance and location of key ULM-3D-5 components

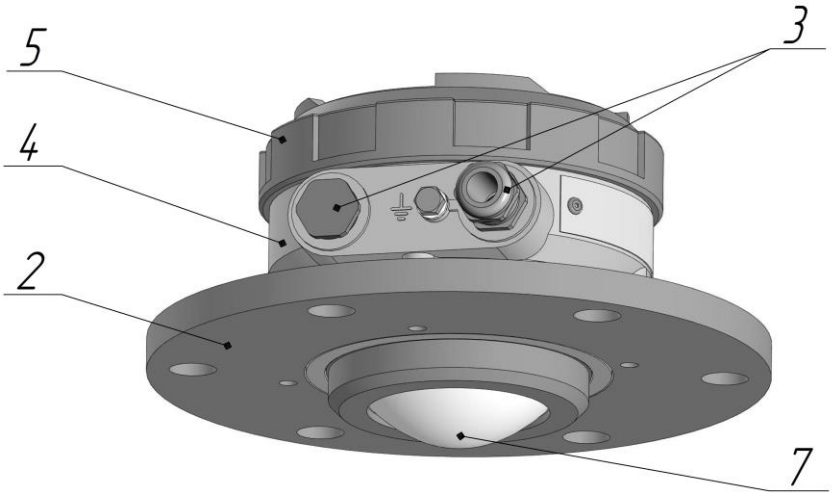


Fig. 3.2. Appearance and location of key ULM-3D-1 components

1 – aerial unit housing;
2 – mounting flange;
3 – cable gland or cable gland plug;
4 – electronic module housing;
5 – electronic module cover;
6 – Bluetooth module plug;
7 – aerial unit shield.

3.3 Product identification

The device is identified in one of the possible ways:
- as per the data specified on the device nameplate;
- as per the attached product data sheet;
- upon request to the manufacturer with the indication of level transmitter serial numbers.

A standard level transmitter nameplate contains the following data for device identification and application:
- manufacturer's logo;
- device type;
- serial number;
- year of manufacture;
- IP rating;
- explosion protection marking;
- name of the certification body and number of the certificate of conformity;
- permissible ambient temperature;
- supply voltage;
- output signals.

An example of a standard nameplate is shown in Fig. 3.3

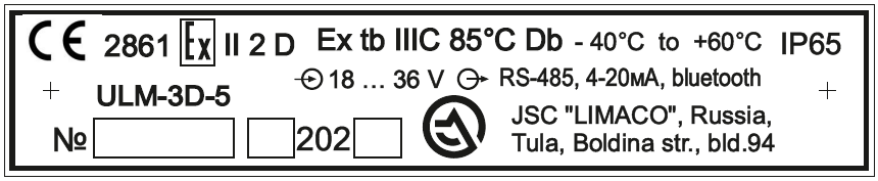


Fig. 3.3. Standard nameplate

Level transmitter designation system has the following form:
ULM-3D-X, where
X – level transmitter version: 1 – one measuring channel, 5 – measuring channels.

3.4 Operation concept

The level transmitter is installed above the measured surface of material. The device is mounted in an opening on the tank roof using a flange in a closed tank (Fig. 3.4), and using a special bracket in open tanks and storage facilities. The device measures the distance L_i from the bottom surface of mounting flange to the product surface for each of the measuring channels. Then the level is calculated using the formula $U_i=H-L_i*\cos(a_i)$, where H is the installation height, a_i is the tilt angle of i-channel. The base plane of the measuring range of level transmitter is the lower surface of mounting flange (Fig. 3.1 item 2).

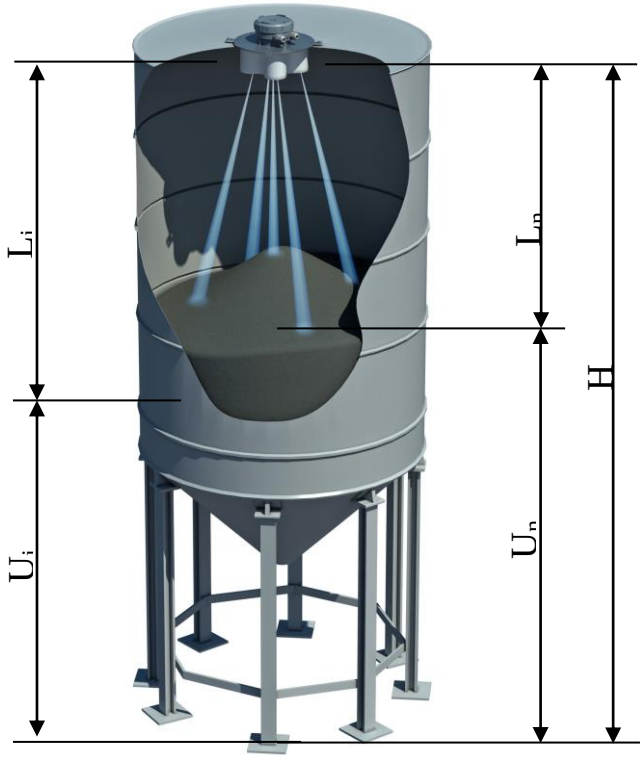
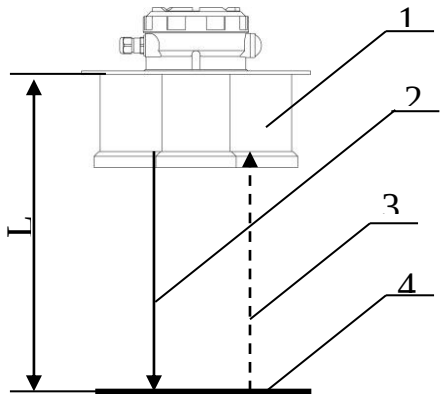


Fig. 3.4. ULM-3D-5 level transmitter on the tank

Radar level transmitter aerial system emits a radio signal with a frequency of about 125±5 GHz and receives an echo signal reflected from the product surface. The electronic unit processes the echo signal by means of a software and hardware complex and converts it into a corresponding output signal that carries information about the measured value.



1 – level transmitter;
2 – emitted signal;
3 – reflected signal;
4 – the surface of measured product.

Fig. 3.5. Measurement method

The level transmitter operates as a FMCW (Frequency Modulated Continuous Wave) radar. This is one of conventional methods of non-contact distance measurement, which minimizes the influence of spurious interference and interference associated with irregularities (disturbances) of the surface of measured product.

The operation concept is as follows: a low-power microwave generator generates a probing radio signal with linearly increasing frequency during the measurement period (solid line in Fig.3.5). This signal (let's call it direct) is emitted by the level transmitter aerial in the direction of product surface. After the delay time Td, the signal reflected from the surface (the dotted line in Fig. 3.5) returns to the aerial Td – the time a radio wave requires to travel the distance from the aerial to the reflecting surface and back. Td=2L/s, where s is the speed of light. Since the speed of radio wave propagation is constant, if you know the delay time, you can derive the distance traveled. Fig. 3.6 shows that during Td, the frequency of direct signal will increase by ΔF. When mixing the direct and reflected signals, a low-frequency difference frequency signal ΔF is released. This signal is then digitized and processed by a signal processor (DSP). Using a Fourier transform algorithm and original adaptive processing and noise reduction algorithms, the DSP performs a spectral analysis of the signal that results in an accurate difference frequency value. By determining this frequency, we will derive the delay time of the signal, and therefore the distance traveled by the radio wave. Then the measured distance is used to calculate the level.

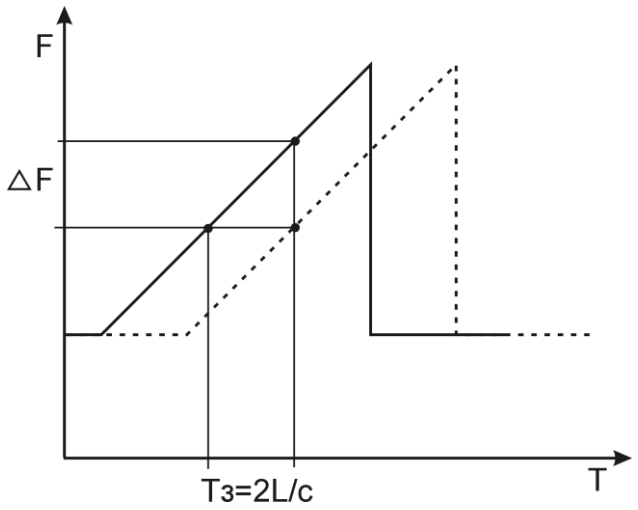


Fig. 3.6. Operating concept of FMCW-radar

ULM-3D-5 level transmitter has 5 measuring channels. Each channel can be oriented to a specific area on the product surface. Thus, the level transmitter has information on the level of measured product at 5 different points in the tank or storage facility.

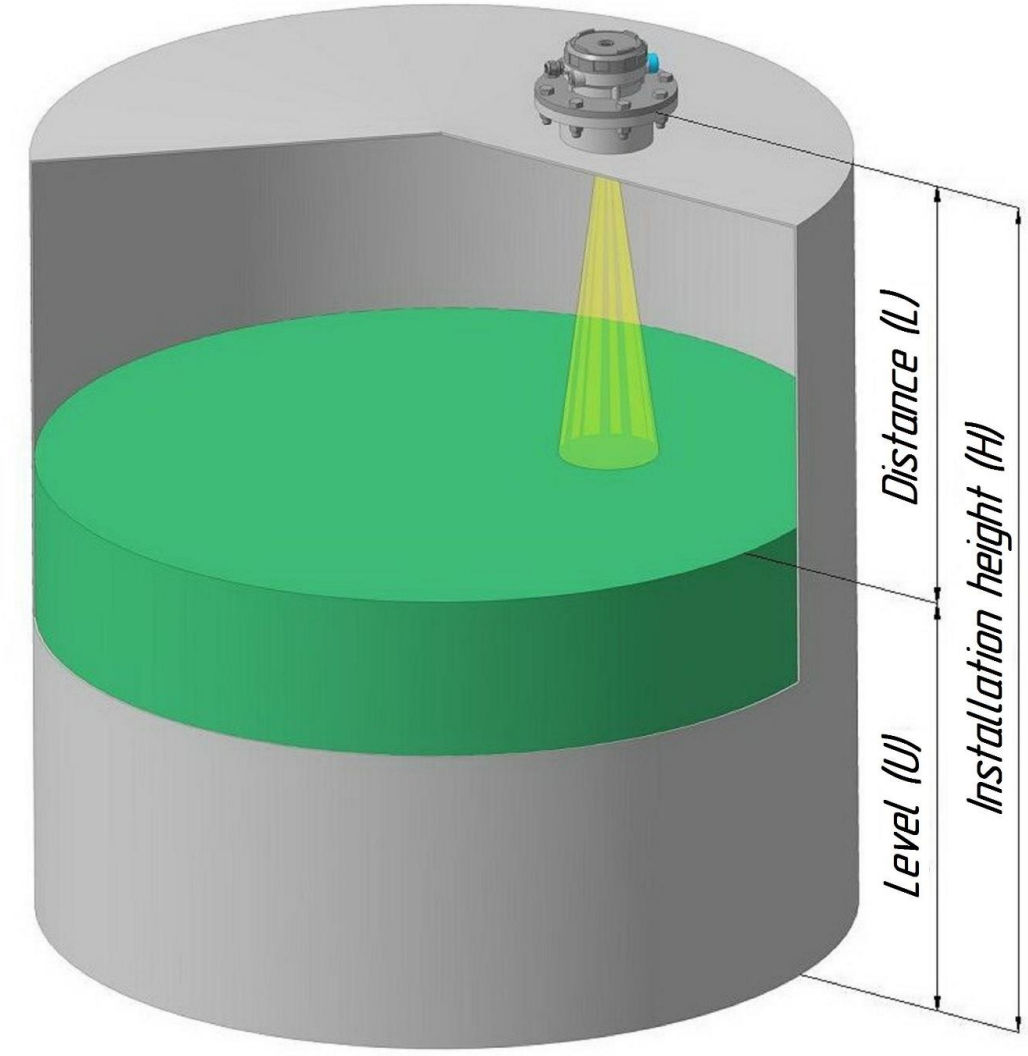


Fig. 3.7. ULM-3D-1 level transmitter on the tank.

ULM-3D-1 level transmitter has one measuring channel, which is always oriented strictly along the vertical axis of level transmitter.

3.5 ULM-3D-3.5 operation specifics

The measuring channels of ULM-3D-5 level transmitter work in turn. The information from each channel is processed by a microprocessor system that calculates the distance to the product surface from each channel.
Each measuring channel has its own serial number; the numbering of channels is shown in Fig. 3.8. Information from each measuring channel of the level transmitter can be transmitted to the Multi Beam Radar Surface Plotter software, which builds a model of the product surface profile and calculates the volume of measured material taking into account the shape and dimensions of the tank.

Detailed description of the use of level transmitter channel numbering in the product volume measurement system is given in cl. 9 of this description.

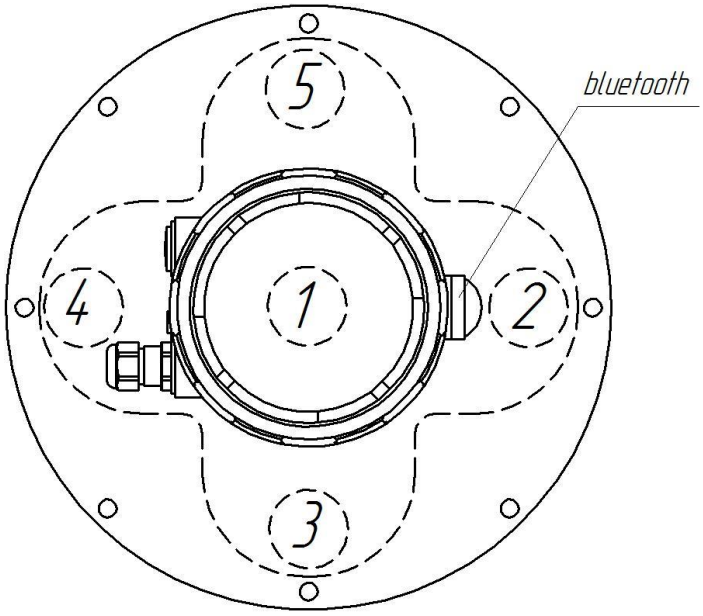


Fig. 3.8. Numbering of transmitter channels

The measuring beam of each channel is oriented to a specific area of the product surface in the storage facility. Channel number 1 (central) is always oriented strictly along the vertical axis of the level transmitter. Other channels are oriented based on the specific application, see cl. 4.2 for more details.

Tilt angle relative to the vertical axis of the level transmitter for each measurement channel is specified in the level transmitter data sheet. The direction of the measuring beams of channels is shown in Fig. 3.9.

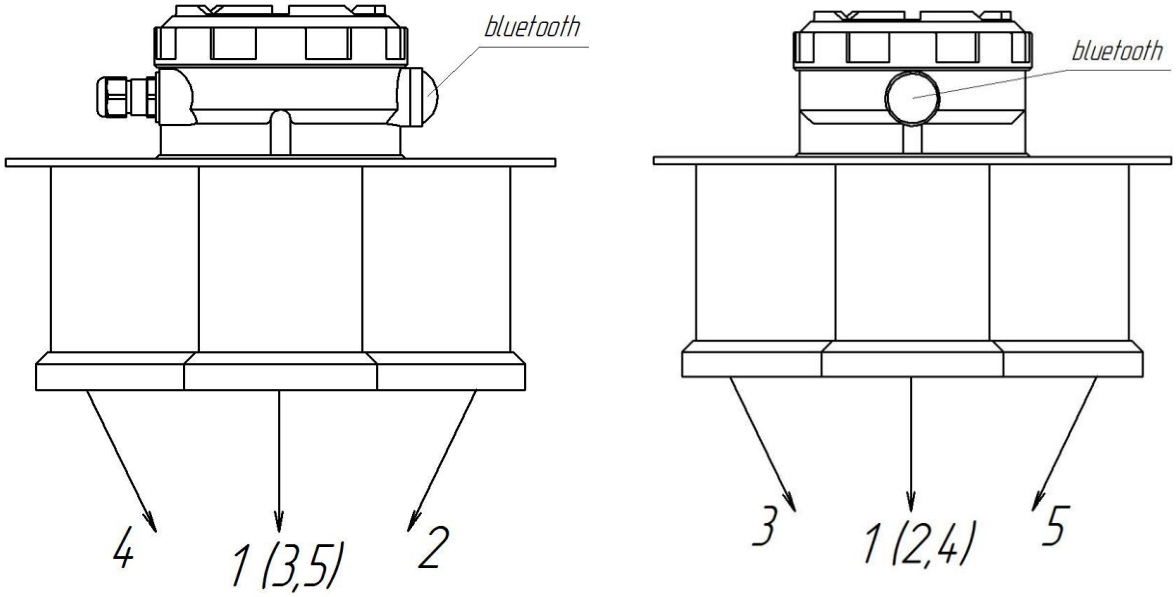


Fig. 3.9. The direction of the measuring beams of level transmitter channels relative to the vertical axis of the level transmitter.

3.6 Acceptance, packaging, transportation, and storage rules

During the acceptance of equipment, compliance with the following requirements is determined:
- the completeness of level transmitter corresponds to the one specified in the data sheet;
- the level transmitter is free from mechanical damages that prevent its use;
- the ID of level transmitter corresponds to the one specified in the device data sheet;
- labels and symbols on the level transmitter are clear and meet the requirements of operating manual;
- the data sheet contains a QC stamp and the stamp of state verification officer in case of verification.

The level transmitter that has not passed visual inspection is not admitted to operation.
The level transmitter is supplied in a package that protects it during transportation.
The packaging is made of cardboard, which is a recyclable material. In some cases, PE foam and PE film may be used, which are recycled at special processing plants.
The level transmitter may be placed in its original packaging in wooden or plywood boxes during transportation.
The storage of level transmitter in the warehouses of the manufacturer and the consumer shall meet storage conditions 3 as per GOST 15150-69. The shelf life in the original packaging is 20 years.
Unpacked level transmitter shall be kept on racks.
When kept in warehouses at railway stations, the level transmitter shall not be exposed to precipitation.
The level transmitter shall be transported only in a package in covered railway cars, containers, and covered vehicles in accordance with storage conditions 5 as per GOST 15150-69, as per the rules of cargo transportation of the relevant transport ministries.
The placement and fastening of boxes with packed level transmitters during loading and transportation shall ensure a stable position of boxes, to prevent them from shifting and hitting each other.
During loading and unloading, the level transmitter shall not be exposed to impacts or precipitation.
The requirements of handling marks on the container shall be strictly observed during loading and transportation.
The level transmitter shall be preserved as per the temporary anti-corrosion protection option VZ-15 as per GOST 9.014-78.

4. INSTALLATION

4.1 General notes on the placement of level transmitter

The correct installation of level transmitter determines the stability of readings and the accuracy of level measurement. Incorrect positioning of the level transmitter can lead to measurement errors or incorrect operation.

The following recommendations shall be met when selecting the mounting position of the device:

- install the device in such a way that the measuring area (see cl. 4.4 for details) is free from objects or structures that interfere with the propagation of radio beam (pipes, fittings, agitators, tank walls, etc.);

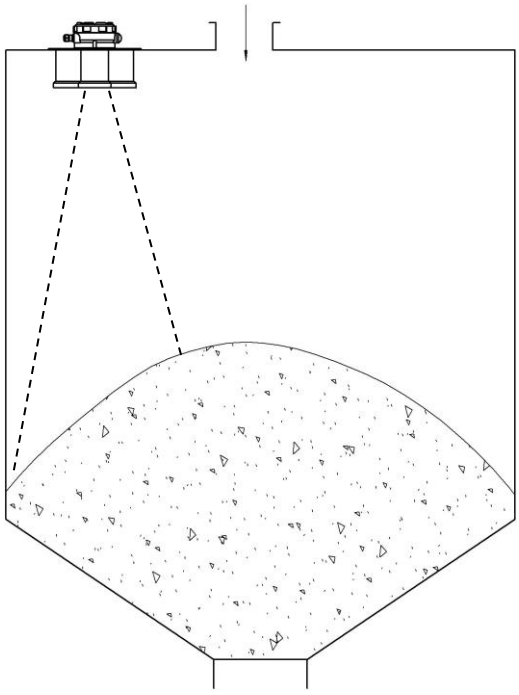


Fig. 4.1. Device installation on the tank

- do not install the device in such a way that the flow of product filling the vessel falls within the range of beam, the best location for the device is away from the loading site;

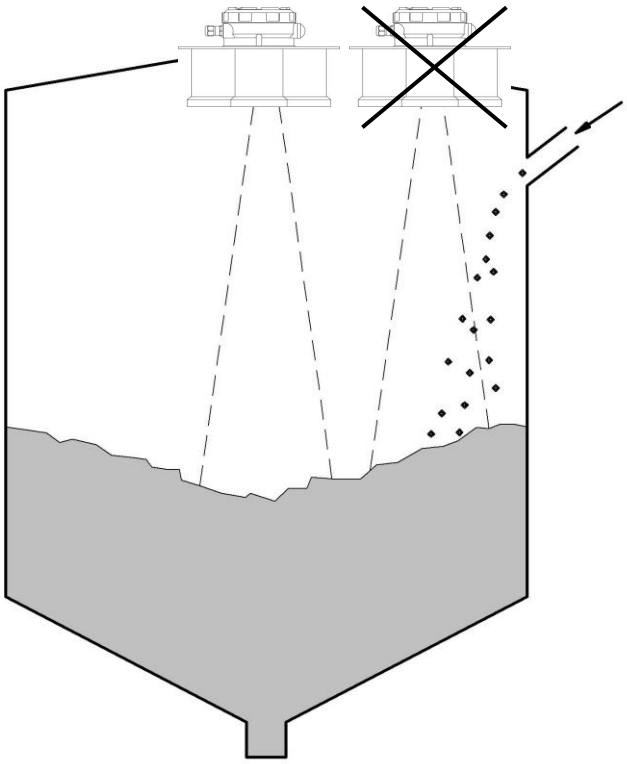


Fig. 4.2. Device installation on the tank. Product supply.

- orient the level transmitter towards the lowest vessel point to ensure level measurement over the entire vessel depth;
- in hot climates, use a visor or canopy to protect the device from direct sunlight;

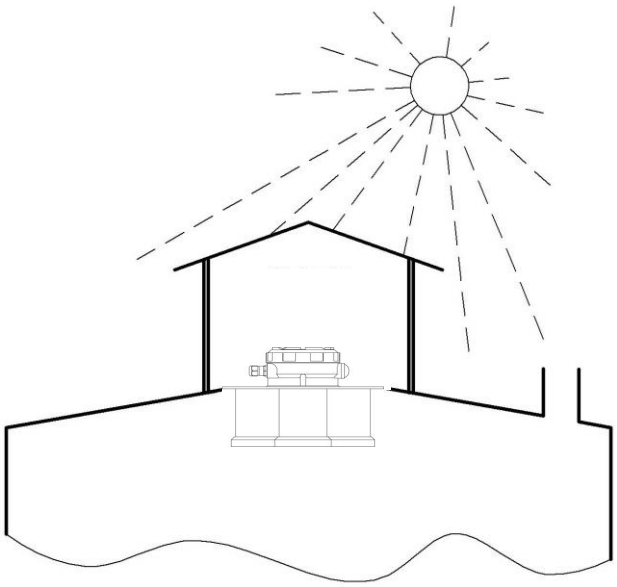


Fig. 4.3. Installation of device with a visor

- the temperature at the location of level transmitter installation shall not exceed +50 °C;

NOTE

If the device is used in a tank, when it is impossible to stick to installation requirements for the absence of structures and the flow of incoming product in the measuring beam, observe the following recommendations:

- choose the distance from the vessel wall to the central axis of the level transmitter within 1/2...1/3 of the tank radius, Fig. 4.4;

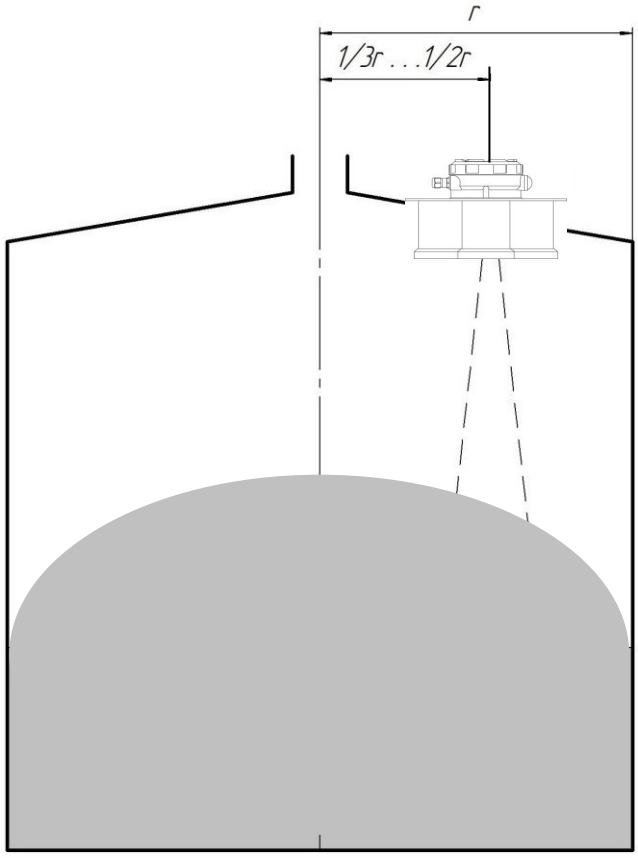


Fig. 4.4. Device installation

- if the tank walls are not smooth (for example, corrugated metal, welds, structures), the distance from the wall shall be as far as possible.

NOTE

If the device is used on tanks made of non-conductive material (for example, plastic), it should be taken into account that structures outside the tank may fall into the measuring beam. Therefore, choose the installation position with this fact in mind.

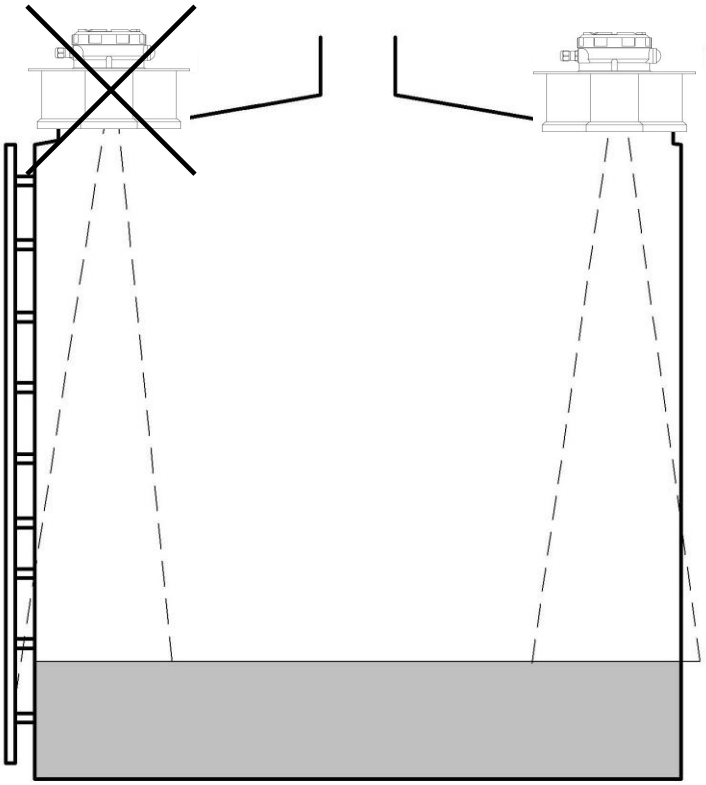


Fig. 4.5. Device installation. Tank made of non-conductive material.

4.2 Position for installation

The best location and orientation of level transmitters in the space depends on the dimensions and structure of the tank, the number and location of product filling and unloading points. Before ordering level transmitters, the number of transmitters installed on each tank, installation location and the orientation of transmitters in space (sensor rotation about its axis and tilt) shall be agreed.
For the best choice of installation location, provide the following data on the intended use:
1. The name of measured product;
2. Product density;
3. Tank shape (cylindrical bin, rectangular bin, open dump, a dome-shaped tank, etc.);
4. The dimensions of tank and its components (for example, in a cylindrical tank, the dimensions of cylindrical and conical parts.). Provide drawings or sketches with dimensions;
5. Presence of internal structures. Specify the location of internal structures, if any, indicating the dimensions;
6. Possible installation locations. Roof thickness and roof material.
7. Specify all existing filling and discharge points of the tank. Provide drawings or sketches with dimensions;

8. Specify all existing discharge points of the tank. Provide drawings or sketches with dimensions.

4.3 Requirements for the installation on mounting nozzle for ULM-3D-5

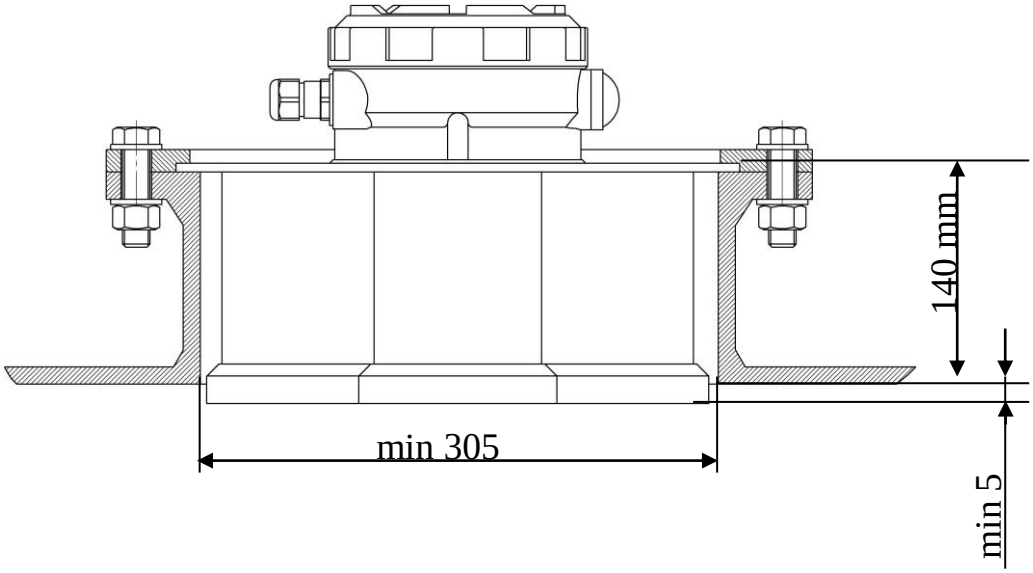


Fig. 4.7. Device installation on the mounting nozzle

Internal nozzle diameter D shall be 305 mm min. The permissible nozzle axis deviation from the vertical is 1°.

4.4 Requirements for the installation on mounting nozzle for ULM-3D-1

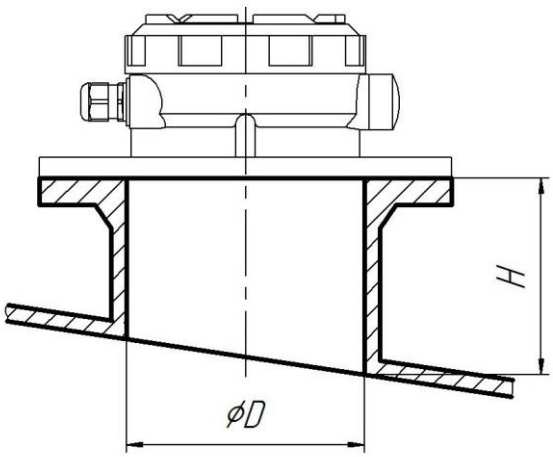


Fig. 4.8. Device installation on the mounting nozzle.

Internal nozzle diameter *D* shall be 100 mm min. The permissible deviation of nozzle axis from the vertical when measuring the level of liquid products is 1°.

Nozzle height H is measured along its inner surface from the flange to the lower edge of the hole. The maximum permissible nozzle height depends on its diameter. The larger the diameter, the higher the permissible nozzle.
Using a nozzle exceeding recommended size may cause spurious re-reflections and hinder the measurement process. The opening in the roof under the nozzle shall be not less than the inner nozzle diameter. The inner nozzle surface shall not contain irregularities larger than 3 mm. Spurious reflections from irregularities inside the nozzle can lead to poor measurement accuracy and stability.
In case of rectangular nozzles, the height of nozzle including roof thickness together with internal structures adjacent to the roof (stiffeners, etc.) shall not exceed the values given below, where the size of narrow rectangle side is recorded instead of nozzle diameter.
The height of mounting nozzle shall not exceed its diameter:

$$H = D.$$

Do not use nozzles higher than 250 mm for the measurement of bulk products.

4.5 Measurement beam coverage

ULM-3D-5 device has five measuring channels Fig. 3.9. We have five independent measuring beams on the product surface. The width of beam pattern is 2 degrees.
The coverage of measuring beams is determined independently in two mutually perpendicular planes. The value of angular sector for each plane is equal to the sum of beam tilt angles of two channels lying in this plane. For each device, for each measuring channel, the value of beam tilt angle is given in the device data sheet. The maximum beam tilt angle is 25 degrees. Tilt angles are established during manufacturing in accordance with the pre-order.

4.6 Blind spot

The level transmitter has a so-called "blind spot". This is the area near the level transmitter aerial, where measurement is difficult or impossible. The "blind spot" is shown in Fig. 4.9, it can be divided into three regions. The nearest region (left in the figure) is where the measurement is impossible. Intermediate region of unstable measurements, the device can determine the distance with low accuracy, there may be spikes in readings. The far region of the "blind spot" is where the measurements are stable, but rated accuracy is not achieved. The size of the "blind spot" regions depends on the product's reflectivity and the presence of tank structures that fall into the beam of level transmitter. The "blind spot" does not exceed 600 mm subject to the observation of rules for device installation on the tank.

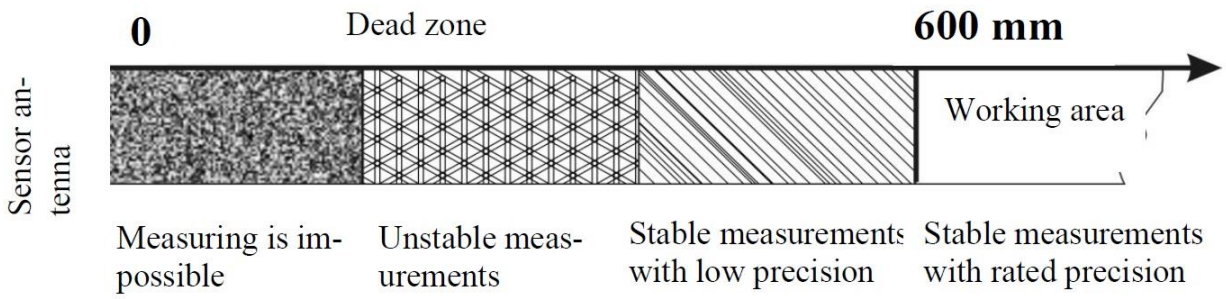


Fig. 4.9. Blind spot of the device

4.7 Installation examples for ULM-3D-5

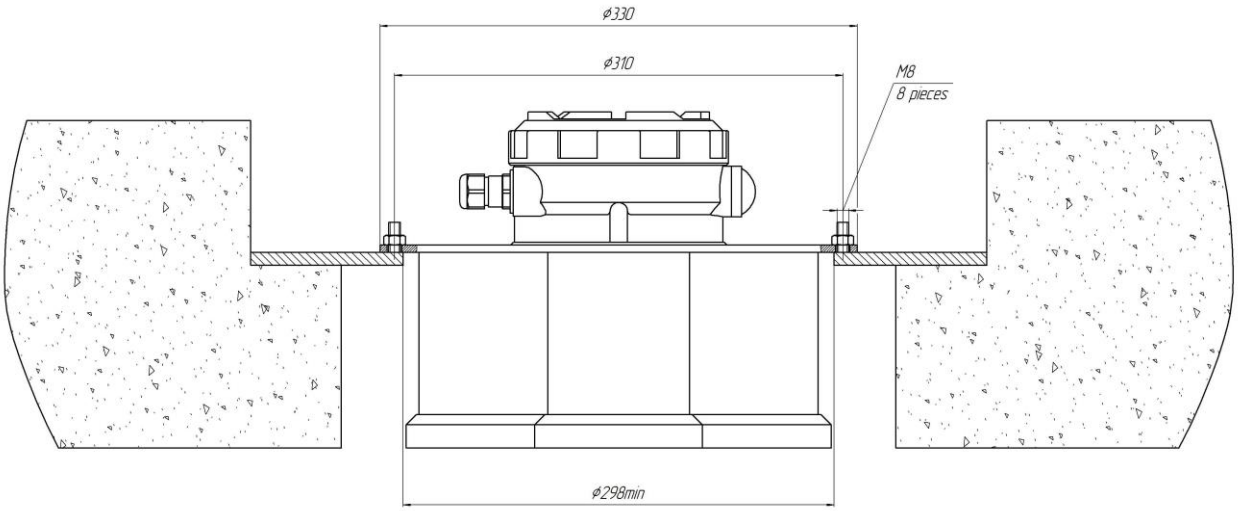


Fig. 4.10. Installation on the concrete tank roof

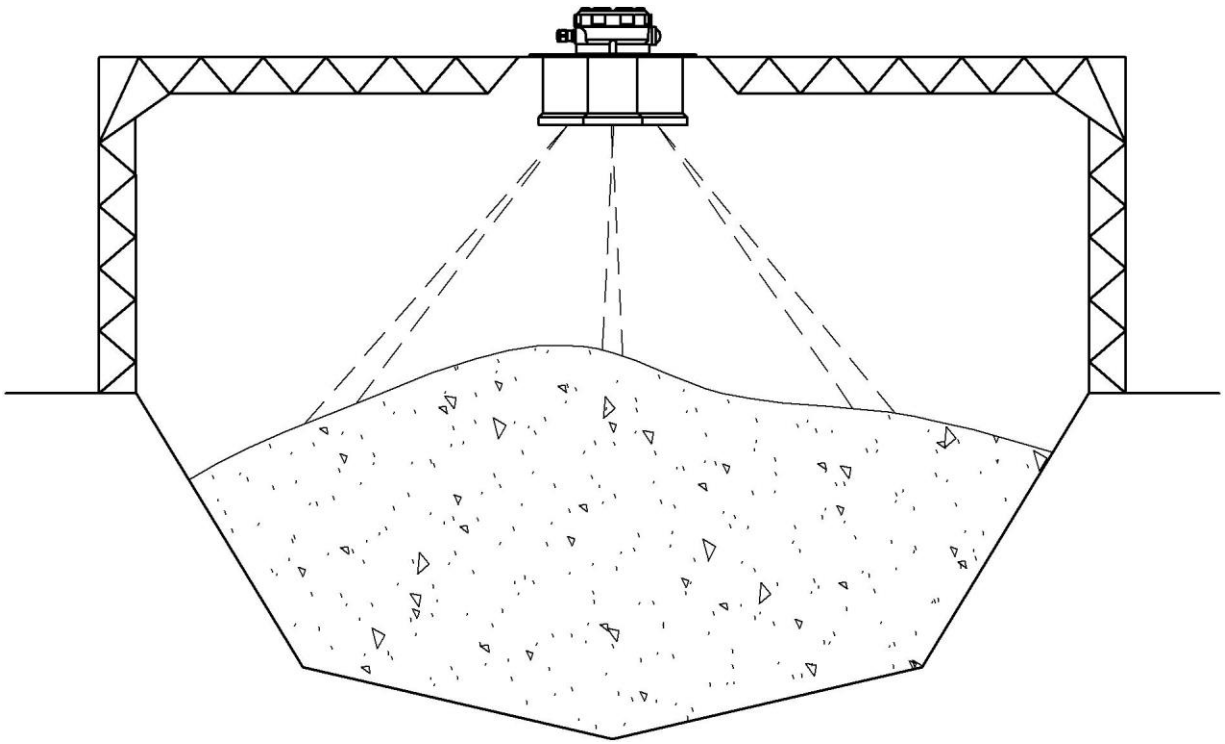


Fig. 4.11. Installation in the open storage facility

4.8 Installation examples for ULM-3D-1

Fig. 4.13, items A and B show examples of level transmitter installation in accordance with the requirements of this manual. Fig. 4.13 option A shows the installation of level transmitter on the tank flange without a nozzle, option B shows installation with a nozzle. Options C-E show typical installation errors that should be noted.
Option C – the edge of the roof under the nozzle protrudes into the nozzle, besides, the opening in the roof is less than the minimum permissible one.
Option D – the lower edge of the nozzle is buried relative to the roof, so the nozzle length is more than permissible one.
Option E – level transmitter is installed with a large offset relative to the vertical nozzle axis. The device should be installed on the central nozzle axis.

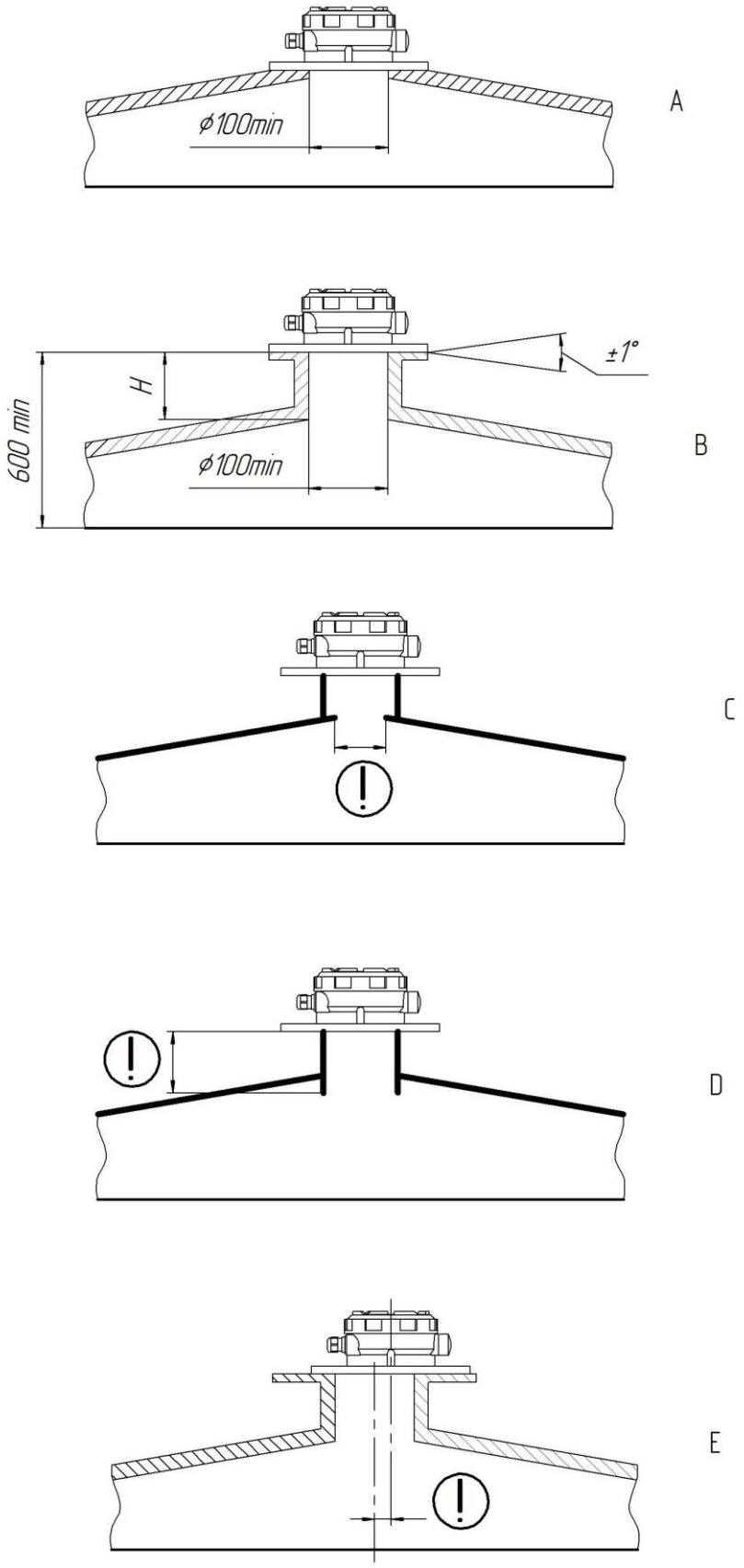


Fig. 4.13. Installation examples

5. ELECTRICAL CONNECTION

5.1 General instructions

! WARNING

All connections shall be made when the voltage is off.
Electrical connection shall be performed by qualified personnel who have a permit for this type of work.

Two cable glands with self-sealing NPT threads may be installed in the level transmitter. When delivered from the manufacturer, one cable gland with a process plug can be installed in the transmitter housing. In this case, a certified plug is installed in place of the second cable gland.

! ATTENTION

Do not:
- leave the device in the mounting position without a process plug, without a connected cable;
- leave the level transmitter in the mounting position with the cable connected, but the cable gland not tightened;
- leave unused cable glands unplugged, a certified plug shall be installed in their place.

5.2 Connection cable

To connect the 4-20 mA analog output, use a standard pair of conductors in a separate shield.
To connect the RS-485 digital interface, it is necessary to use a pair of conductors in the shield, it is allowed to use a cable with a common shield. The use of round section cable is required. In order to ensure stated IP grade with regard to dust and moisture protection, the use of cable with diameter suitable for particular cable gland is required.
See further information in cl. 12.1 of Technical specifications. Electromechanical data.

! ATTENTION

Do not insert multiple cables into the device via a single cable gland.

NOTE

To protect the device from moisture, bent down the connection cable in the immediate vicinity of the cable gland to drain moisture from rain or condensate.

5.3 Shielding and earthing

It is recommended to connect a cable shield to earth potential on one side. Use grounding terminal on the output signal receiver side.
The device must be grounded. There is external grounding terminal on the device casing, which is connected to tank grounding.

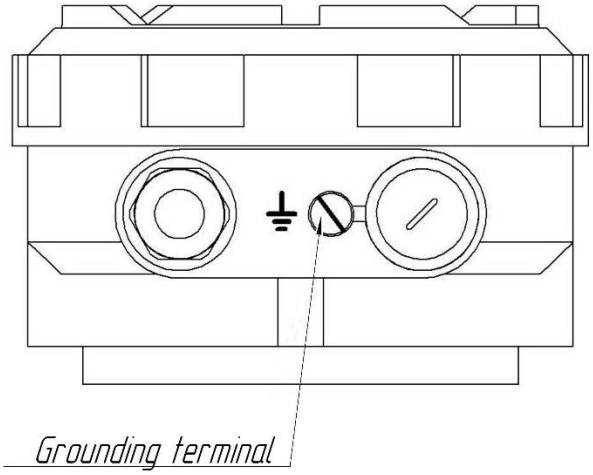


Fig. 5.1 Ground terminal

5.4 Pin assignment. Connection.

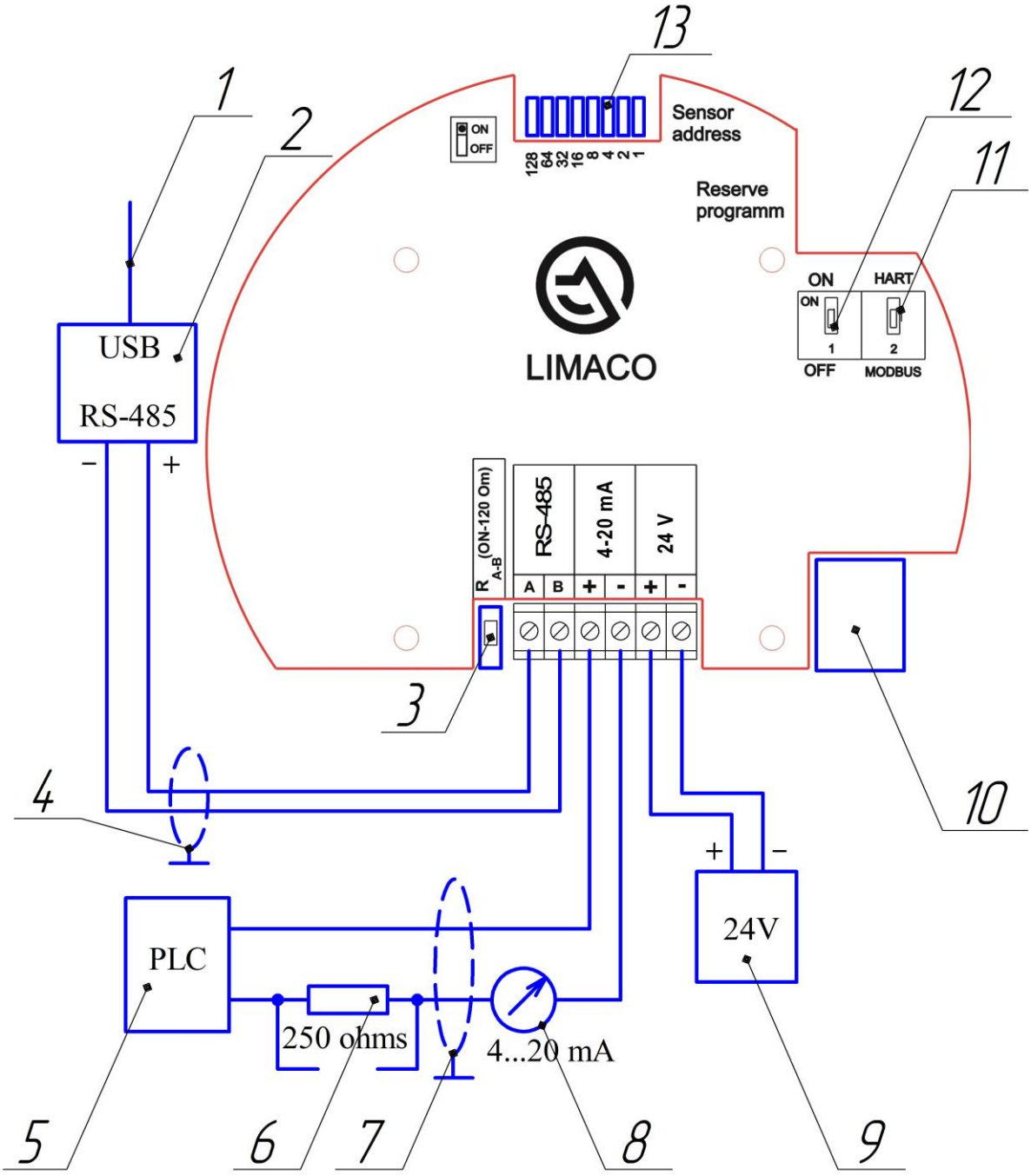


Fig. 5.2 ULM-3D-5. Pin assignment. Connection. Option 1.

1 – Connecting to a PC; 2 – RS-485/USB converter; 3 – Switch, matching load of RS-485 line R_{A-B}=120 Ohm; 4 – RS-485 line shield, connection to the "ground" on the side of converter; 5 – Control unit, e.g. PLC; 6 – Terminal for HART-modem connection*;	7 – HART digital line shield*; 8 – Analog display unit; 9 – 24V power supply; 10 – microSD slot; 11 – Switch for selecting the interface in use; 12 – "Backup program" switch, return to factory settings; 13 – Modbus address switch.

* depending on the type of equipment used.

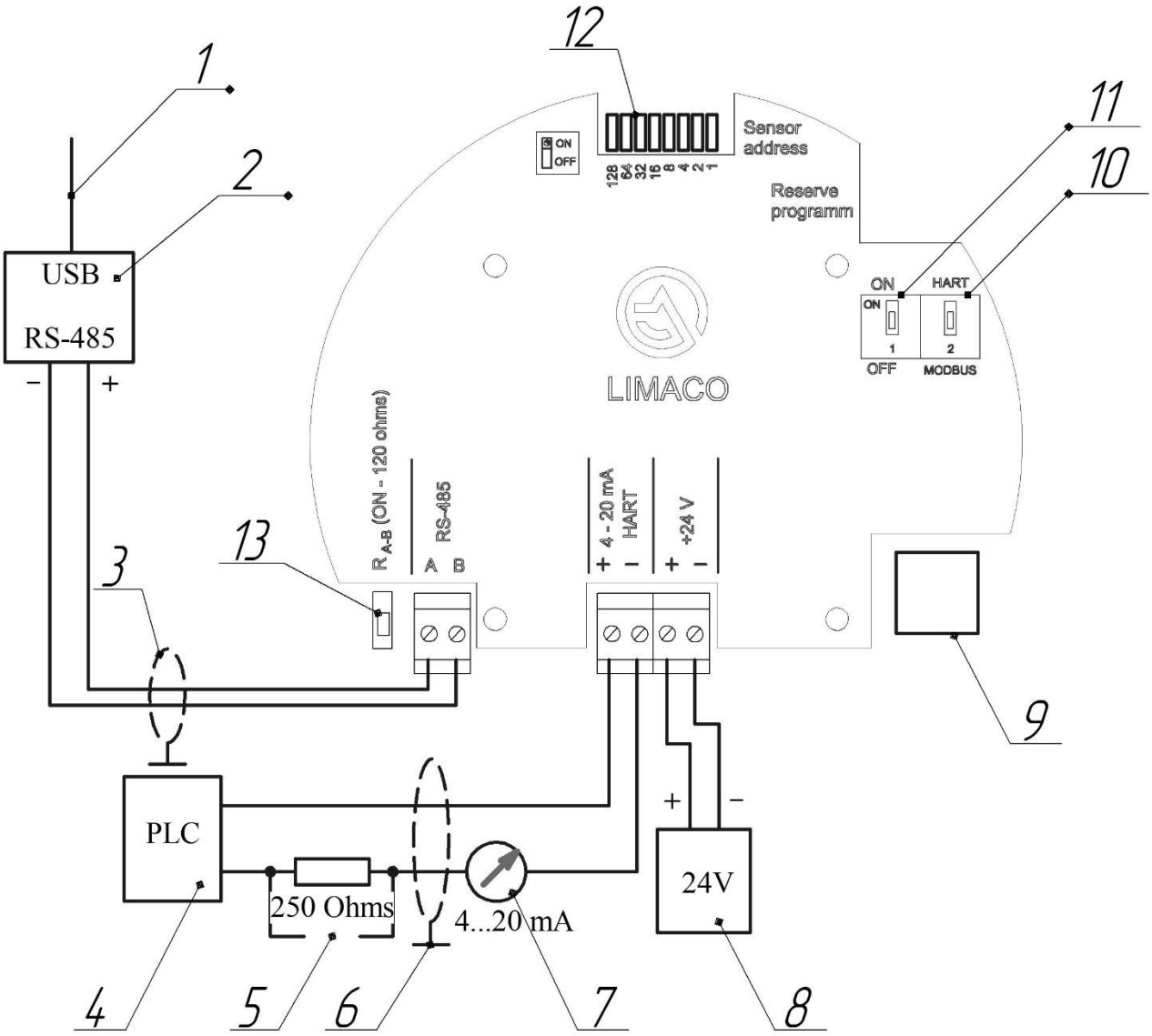


Fig. 5.3 ULM-3D-5. Pin assignment. Connection. Option 2.

1 – Connecting to a PC; 2 – RS-485/USB converter; 3 – RS-485 line shield, connection to the "ground" on the side of converter; 4 – Control unit, e.g. PLC; 5 – Terminal for HART-modem connection*; 6 – HART digital line shield*; 7 – Analog display unit;	8 – 24V power supply; 9 – microSD slot; 10 – Switch for selecting the interface in use; 11 – "Backup program" switch, return to factory settings; 12 – Modbus address switch; 13 – Switch, matching load of RS-485 line R_{A-B}=120 Ohm;

* depending on the type of equipment used.

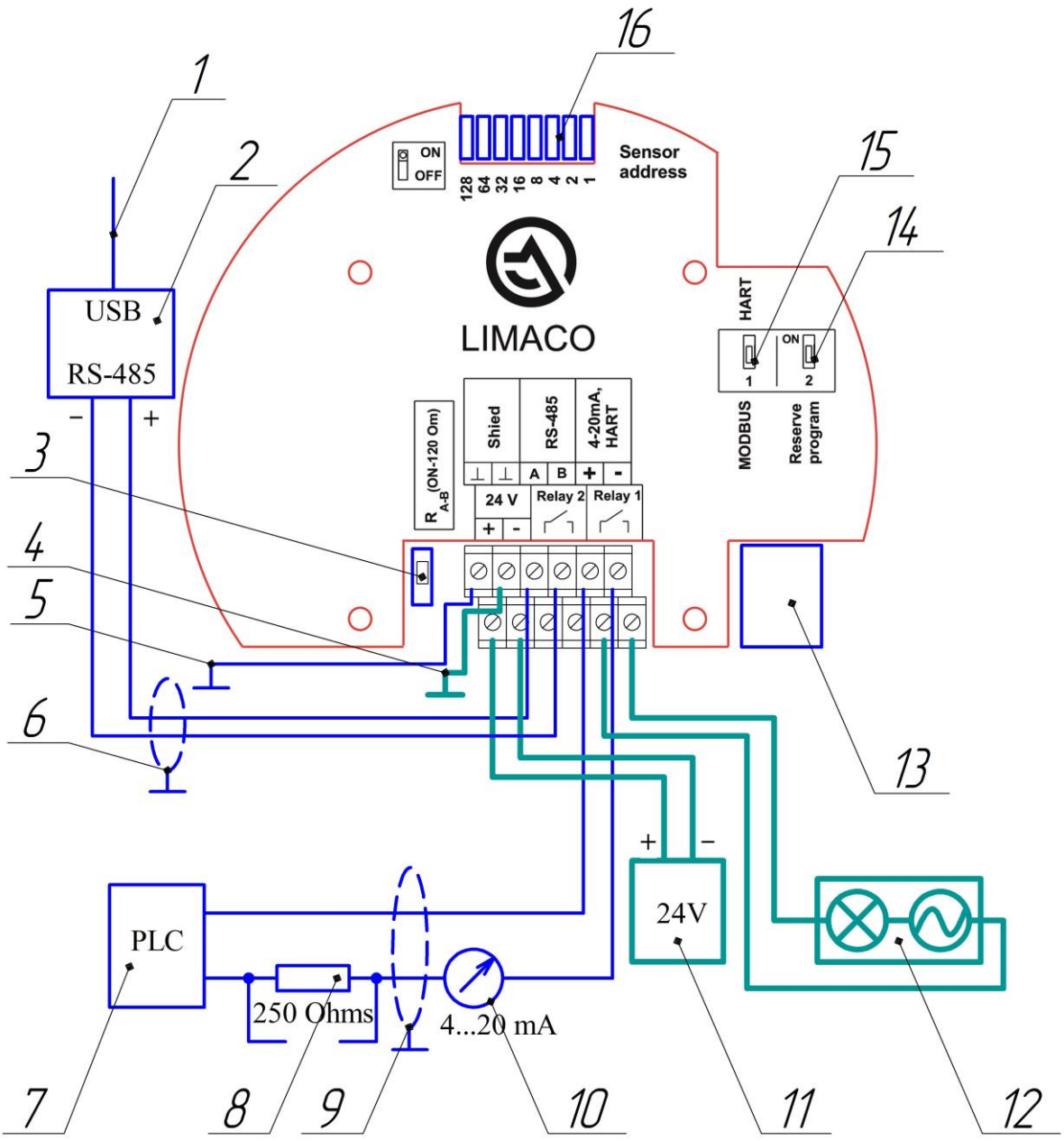


Fig. 5.4 ULM-3D-1. Pin assignment. Connection. Option 1.

1 – Connecting to a PC; 2 – RS-485/USB converter; 3 – Switch, matching load of RS-485 line R_{A-B}=120 Ohm; 4, 5, 6, 9 – Connecting the shields interface lines; 7 – Control unit, e.g. PLC; 8 – Terminal for HART-modem connection*; 10 – Analog display unit;	11 – 24V power supply; 12 – Relay display unit, example of light alarm structure; 13 – microSD slot; 14 – "Backup program" switch, return to factory settings; 15 – Switch for selecting the interface in use. 16 – Modbus address switch;

* depending on the type of equipment used.

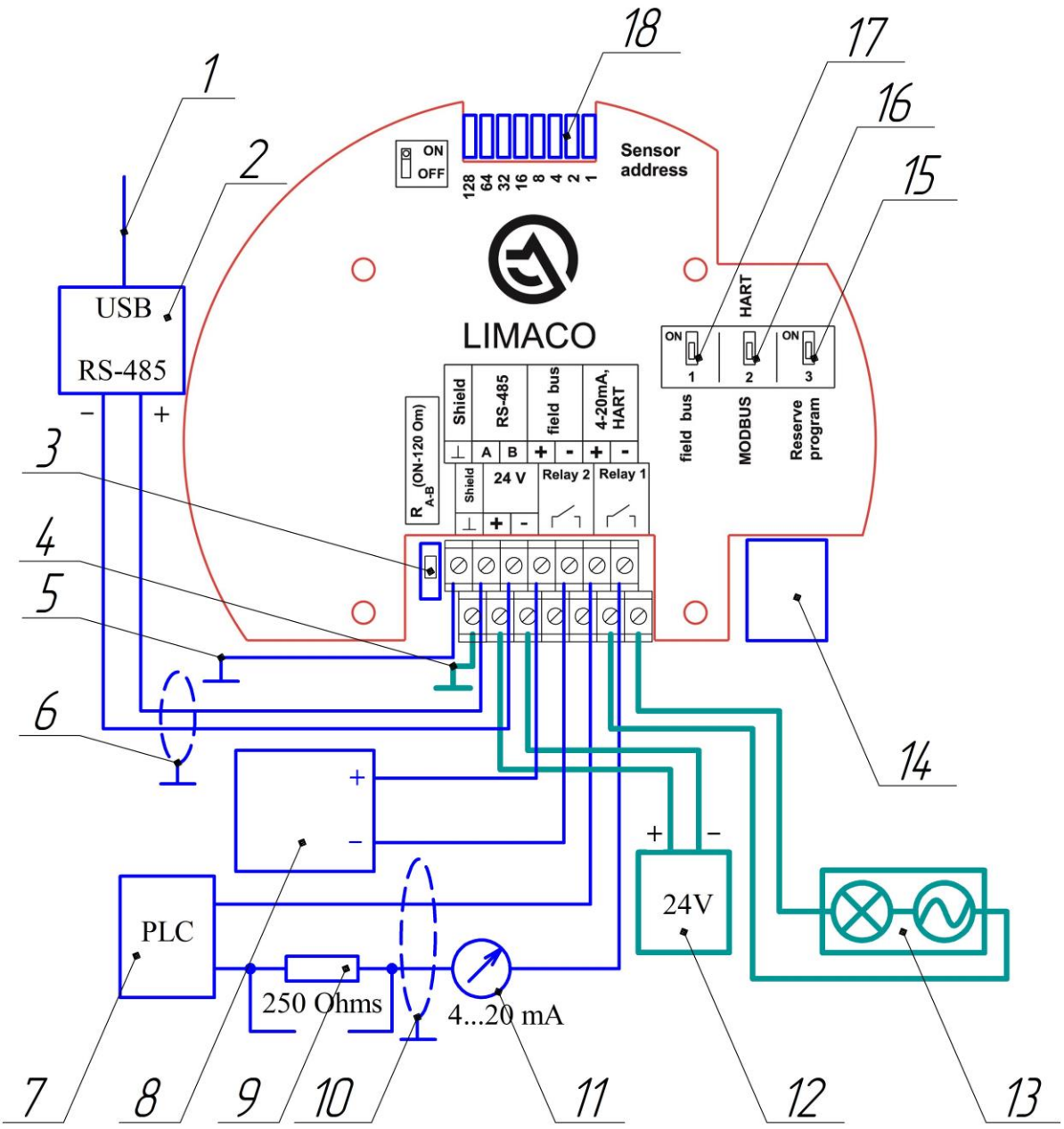


Fig. 5.5 ULM-3D-1. Pin assignment. Connection. Option 2.

1 – Connecting to a PC; 2 – RS-485/USB converter; 3 – Switch, matching load of RS-485 line R_{A-B}=120 Ohm; 4, 5, 6, 10 – Connecting the shields interface lines; 7 – Control unit, e.g. PLC; 8 – Connection to the field bus interface module*; 9 – Terminal for HART-modem connection*;	11 – Analog display unit; 12 – 24V power supply; 13 – Relay display unit, example of light alarm structure; 14 – microSD slot; 15 – "Backup program" switch, return to factory settings; 16 – Switch for selecting the interface in use; 17 – field bus switch; 18 – Modbus address switch.

* depending on the type of equipment used.

5.5 Power supply

Use a stabilized DC power supply with an output voltage of $U_{ИП}$ = (24..36) V. Several level transmitters can be connected to the same power source.
The power supply shall ensure a load current of at least 1A per level transmitter $I_{ИП} = n$,
where n is the number of level transmitters connected to the source.
The power of source shall be at least $P_{ИП} = U_{ИП} \cdot I_{ИП}$.

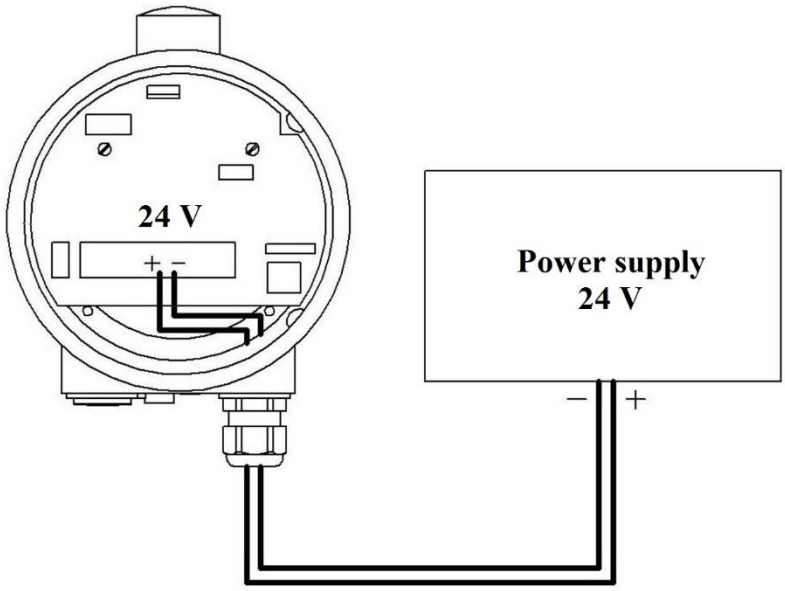


Fig. 5.6 Diagram of level transmitter connection to power source

If the power supply line is extended, take into account the voltage drop on the supply wires.
If the external diameter of cable will be more than permissible one for the transmitter cable gland, use the terminal box connecting the supply transmitter cable of permissible sections and cables of larger section (trunk cable). The above connection diagram is shown in Fig. 5.7.

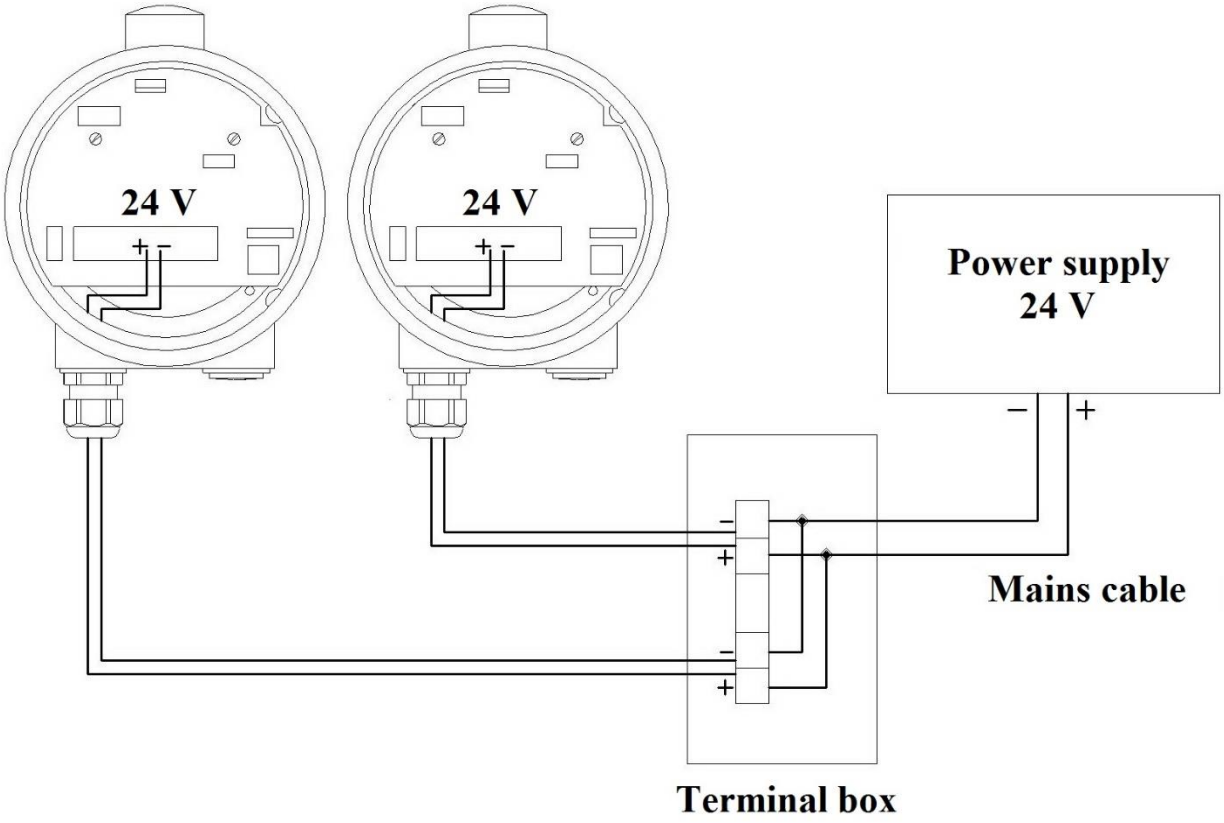


Fig. 5.7 Diagram of level transmitter connection to the power source using a terminal box.

5.6 How to connect the device

! WARNING

- strictly comply with the company's safety regulations;
- perform all works with deactivated voltage;
- the supply voltage shall match the technical characteristics of the device;
- before the supply of power, connect the external ground terminal of the device.

Required tools:
- flat screwdriver 3 mm;
- flat screwdriver 6 mm;
- stripper or any suitable wire stripping tool;
- use tips in case of multi-conductor wires.

Getting ready for connection:

1. Install the required number of cable glands in the device housing. When using two cable glands, remove the plug with a 6 mm screwdriver and install the second cable gland in its place.

2. Remove the process plug from the cable gland installed at the factory.

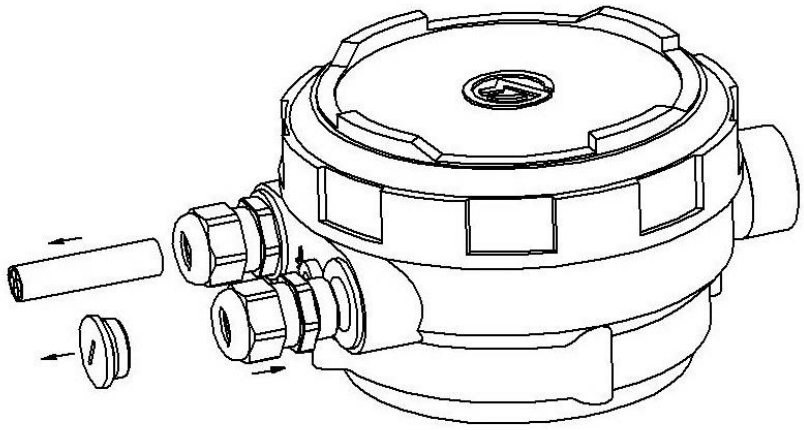


Fig. 5.8 Installing the second cable gland

Proceed as follows to connect the device:

1. Unscrew the level transmitter cover.
2. Loosen the collet nut of the cable gland.
3. Insert the cable into the device through the rubber seal of the cable gland.

! ATTENTION

The absence or damage to O-ring affects the device's dust protection and may cause it to fail.

4. Remove the external insulation of the cable. In case of shielded cable, remove the shield.
5. Remove 4-6 mm of the insulation from the wire edge. When using multi-conductor wires, compress the stripped ends into tips.
6. Connect the cable as per the pin assignment diagram. As per cl. 5.4 and following the instructions on the device nameplate. Use a 3 mm screwdriver to tighten the screw terminals.

! ATTENTION

Incorrect connection may cause the device to fail.

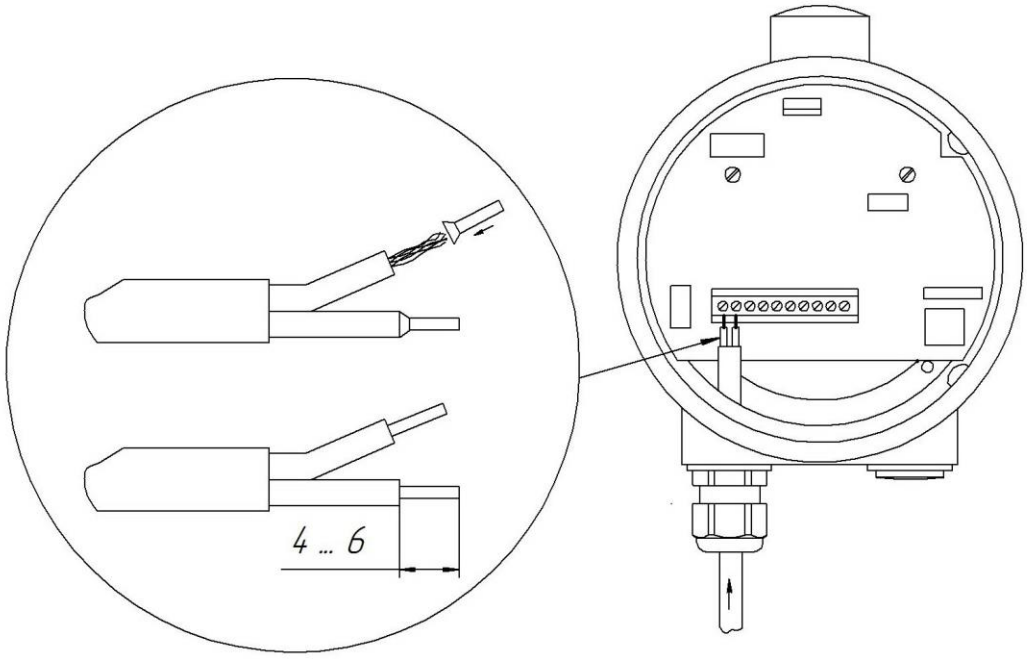


Fig. 5.9 Connecting the level transmitter

7. Pull the wires slightly to make sure they are securely fixed in the terminal box terminals.
8. Adjust the cable length required for connection to the terminals and tighten the cable gland nut firmly. O-ring shall completely cover the cable.
9. Check the presence and integrity of the cover O-ring (cl. 12.7 item 3) and tighten the device cover.
10. Connect the external ground terminal to the tank ground using a 6 mm screwdriver.

When the connection is over, check the quality of works performed as to the following:
- no cable damage;
- no mechanical stress due to cable tension;
- cable glands are installed, twisted, and sealed properly;
- the cover of device housing is installed and tightly screwed.

6. INITIAL SETUP AND COMMISSIONING

The device can be configured as follows before commissioning:

1) using a PC with RS-485 interface (Modbus RTU exchange protocol, see "Exchange protocol for ULM sensors" for more details) and the ulmcfg configuration utility;
2) using a PC using NRT interface (under development);
3) using PL-01 configurator console;
4) using a smartphone via Bluetooth.

6.1 Level transmitter address setup

In accordance with the applicable exchange protocol, each level transmitter is assigned a unique Modbus address - a number from 1 to 255. The address is set in binary mode using an 8-bit DIP-switch located inside the device, opposite "Sensor Address" inscription on the nameplate. The address is obtained as the sum of digits indicated on the nameplate, opposite switch category raised to the unit digit power.

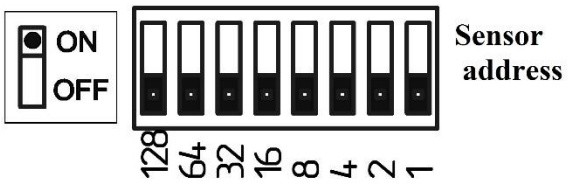


Fig. 6.1 Switch position “0”

When all the switches are in "0" position (Fig.6.1), the level transmitter will be assigned the "default number" specified in the software. The device address will be changed after the device reset.
Set the appropriate position of switches, turn off and then turn on the device to change the address of level transmitter.

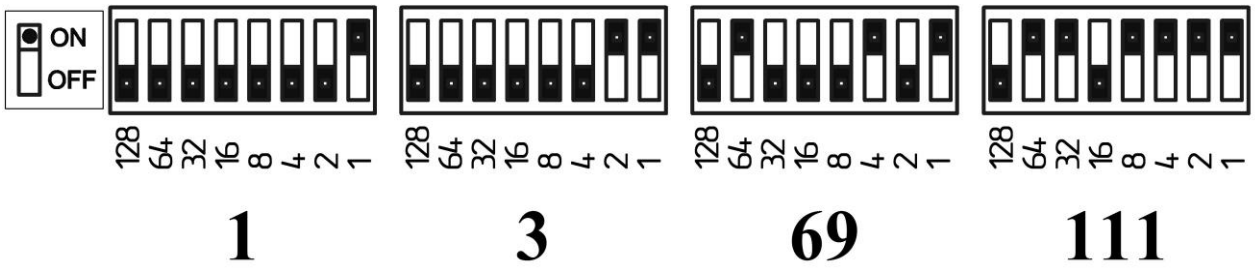


Fig. 6.2 Examples of address setup using a switch

6.2 PC connection via RS-6.2

The digital interface provides the user with access to the level transmitter readings and allows the user to configure and diagnose the level transmitter. The digital interface of level transmitter is implemented as a two-wire, serial RS-485 line. Modbus RTU data exchange protocol. See protocol description in “Exchange protocol for ULM sensors”. The advantages of using RS-485 include simple information network building; the ability to transmit the readings of dozens of different sensors over a single line, without loss of accuracy, over a distance of up to several kilometers; the ability to configure the level transmitter from the workplace or integrate it into a PLC-controlled industrial automation system (programmable logic controller, PLC).

To connect the level transmitter to RS-485 line, terminals "A" and "B" are provided on its terminal box. Each level transmitter has a unique Modbus address. The address is set by an 8-bit DIP-switch, or determined by the internal device program, if 0-address is set.

A USB/RS-485 converter is used to connect the level transmitter to a computer via a digital interface. Terminal "A" of the level transmitter is connected to terminal "+", terminal "B" to terminal "–".

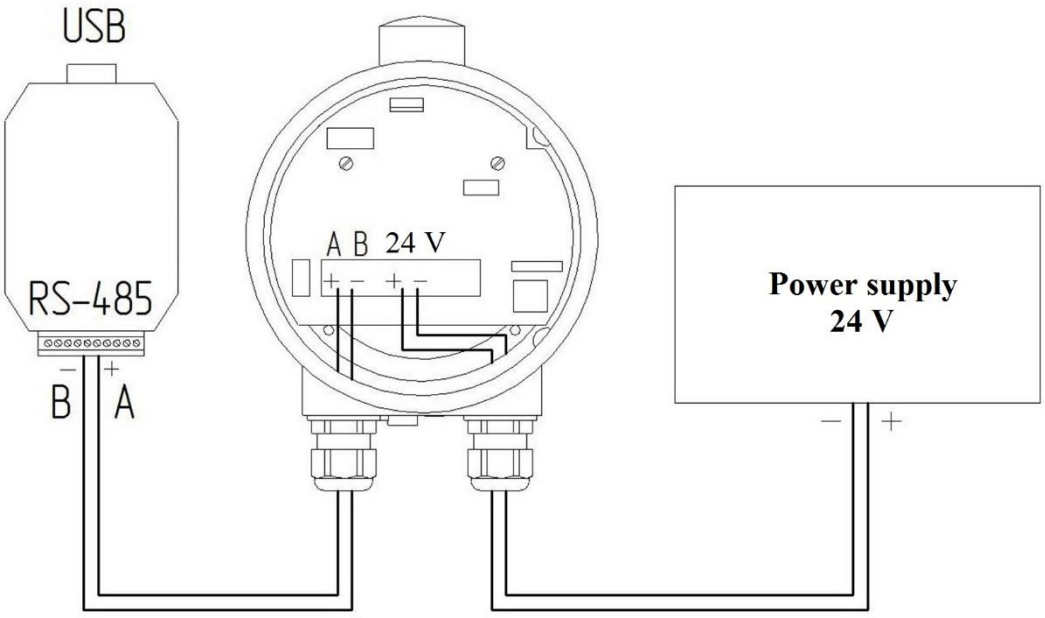


Fig. 6.3 Connecting the level transmitter using RS-485

Use transducers with auto-detected transmission direction. A lot of standard devices of this type are available, the most commonly used include: MOXA 1100 series (uPort-1150i, uPort-1130), ADAM-4561, ICP DAS I-7561 series. Some converters require setting data exchange parameters before the start. In this case install: transmission rate – 9,600 bps, parity – even, data bits – 8, number of stop bits – 1 or 2.

! ATTENTION

After connecting the interface converter to USB, install the device driver, if necessary. Right-click "My Computer" shortcut and select "Properties" from the context menu. In "System Properties" window that opens, in "Hardware" tab, click "Device Manager" button (the procedure for Win XP). In the hardware list, open "COM and LPT Ports" section. Find the COM-port corresponding to the connected device, double-click "Properties" window of the selected port, and make sure that the device is working properly.

RS485 information line is arranged using a twisted pair cable with a wave resistance of 120 Ohm. The external cable insulation shall provide sufficient mechanical and electrical strength for the customer's process and climatic conditions. The total length of line can reach several kilometers.

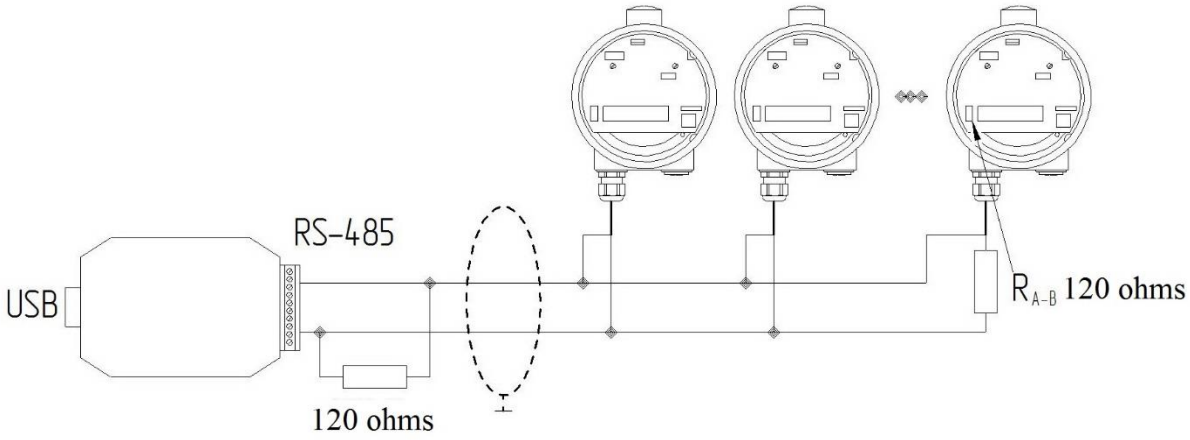


Fig. 6.4 Conventional method of RS-485 line laying

The diagram of the conventional method of line laying that meets the general requirements of RS-485 standard, designed for high-speed data transmission in man-made noise is shown in Fig. 6.4. If the line is long, install 120 Ohm matching resistors at the ends of the line between "A" and "B" wires. For this purpose, a switch that connects this resistor to the line, designated as R_{A-B} on the nameplate, is provided in the level transmitter. Note that this resistor is also installed inside some interface converters. If the line length is more than 800 m or the number of devices on the line is more than 32 pieces, use standard repeaters for RS-485, for example, ADAM-4510.

! ATTENTION

Do not connect devices with a data exchange protocol other than Modbus RTU to the information line of level transmitter.
The same information line shall not have sensors with the same Modbus addresses.

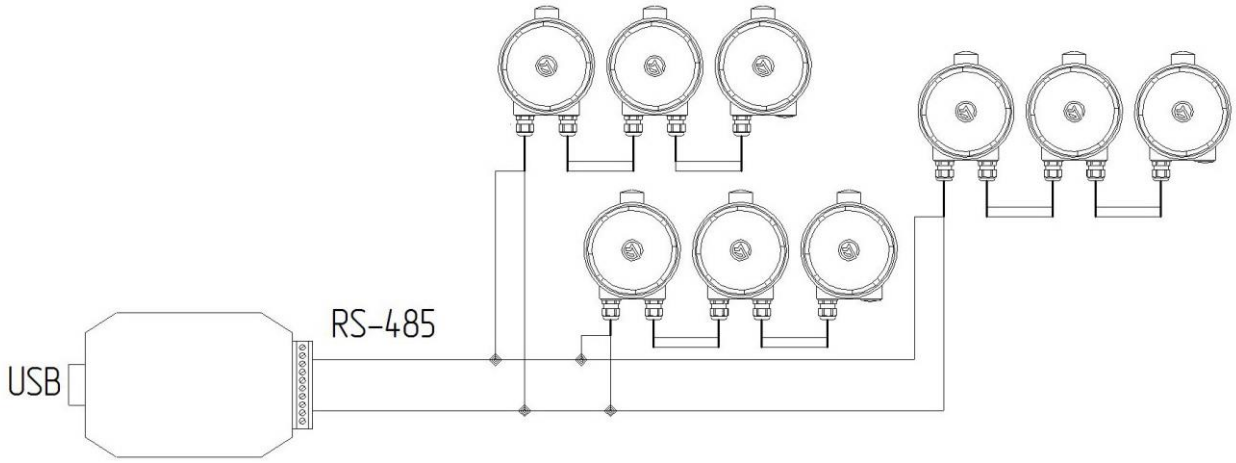


Fig. 6.5 "Star" method of laying RS-485 line

The low transmission rate of 9,600 bps used in the level transmitter ensures good noise immunity of the communication line and allows using various options for laying cables, including "star" method, Fig. 6.5. The user chooses the appropriate option for the convenience of laying cables and minimizing their length. There is usually no need to install matching resistors for a line like this.
Few communication errors may occur on long and branched lines. Such communication errors do not result in unreliable data about the level, since the Modbus exchange protocol used in the level transmitter contains a control computation to determine the unreliability of readings. Such data will be ignored.

6.3 Setting key parameters of level transmitter using PC via RS-485.

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

CONFIGURATOR software (ULMCFG) is used to configure level transmitters.
The software helps:
- obtain and change key settings of level transmitters;
- diagnose the operation;
- upload the configuration from a file to the level transmitter;
- save on disk and view debug information (photos of signals);
- update level transmitter software;
- access the registers of level transmitter.

The program does not require installation, just copy the ULMCFG file.EXE to a pre-created folder on your hard disk.

A detailed software description is given in "Configurator. User Manual".

7. TROUBLESHOOTING

The personnel responsible for the operation of level transmitter shall take steps to correct any arising problems. Do not use a faulty level transmitter.
The sources of the failure of level transmitter-based measuring system can include:
- level transmitter itself;
- receiving device that displays information;
- level transmitter power supply;
- process in the tank.

In case of failure, the source of fault shall be localized to the maximum extent possible.
When using analog signal, check that the output signal is present and correctly generated directly at the level transmitter output, pay attention to the presence of 3 mA, 4 mA or 21 mA alarms, and check the power supply voltage.
You can get the most extensive opportunities to find and fix measurement problems using a PC and Configurator software.

NOTE

In most cases, this can help you determine the cause of failures and fix the measurement problem.
You can also diagnose the device using the Bluetooth channel.

Checking and Troubleshooting operations for the level transmitter are summarized in the table below.

Failure	Cause	Troubleshooting method
No 4-20mA signal	The supply voltage is absent or outside the acceptable values (see cl. 12.1 of Technical specifications)	Check the power supply, the electrical connection, and eliminate the non-compliance, if any.
	The electrical connection of the 4-20mA output is damaged or the line resistance is too high (see cl. 12.1 of Technical specifications)	Restore the connection or eliminate the increased load in the line.
	Malfunction of the level transmitter electronic unit.	Send the device for repair.

Failure	Cause	Troubleshooting method
4-20mA signal corresponds to one of the alarm values	One or more monitored parameters of the level transmitter are outside tolerance:	Connect to the level transmitter using a PC or a console. Check the match of alarm value and its mask (cl. 6.4).
	- temperature in the level transmitter is outside the range	Eliminate the overheating cause, isolate the device from the process with high temperature, provide sensor cooling, install a sun visor.
	- deviation of the level transmitter from the vertical axis	Align the device to the horizon.
	- incorrect measurement of temperature or tilt angle	The corresponding channels in the electronic module of the device are faulty. Further operation is possible in the absence of overheating. In other cases, send the device for repair.
	- lack of stability of readings - agitation on the product surface, unstable surface.	A reference parameter, operation can be continued.
	- unstable mode - no stable reflecting product surface or the level transmitter is in the initial loading stage	The mode of initial activation, the device should leave this mode 1-2 minutes after it is activated. If this does not happen, contact the technical support.
	- meter malfunction – the failure of level transmitter electronic unit	Send the device for repair.

Failure	Cause	Troubleshooting method
	- a small amplitude of reflected signal – application on products with low dielectric conductivity, application on bulk products, electronic unit failure	Make spectrum recordings (see cl. 7.3.), send it to the technical support. Follow further recommendations.
	- signal loss - sudden changes in the properties of reflecting surface: foaming, bulk product collapses, overlapping of the measuring beam with the product flow	Provided for reference, when a stable reflected signal appears and the process normalizes, the current signal should restore. If this does not happen, make spectrum recordings (see cl. 7.3.) and send it to the technical support.
4-20 mA signal does not correspond to the actual value of the monitored variable.	The malfunction of level transmitter electronic unit	Check the current signal performance by emulation (cl. 7.2). In case of non-conformance, send the device for repair.
4-20 mA signal does not correspond to the actual value of the monitored variable, the electronic unit is in good working order	Incorrect initial settings of key measurement parameters (cl. 6.3.), violated installation requirements (cl. 4).	Make spectrum recordings (see cl. 7.3.), send it to the technical support. Follow further recommendations.
No RS-485 connection in the presence of 4-20 mA signal	The electrical connection of the line is damaged.	Check and restore the line or eliminate non-compliance with the requirements and connection diagram (see cl. 5).

Failure	Cause	Troubleshooting method
No RS-485 connection in the presence of 4-20 mA signal, the communication line is in good working order	The required driver is not installed or the initial settings of USB/RS-485 converter are incorrect	Check the operation of converter in the PC operating system (Device Manager), make required settings for the converter.
	The Modbus address of one or more level transmitters on a line with the same address is set incorrectly.	Set different Modbus addresses of sensors in the line, specify the correct number of the level transmitter when searching in Configurator software (see cl. 6.1)
	COM-port is occupied by another application.	Check for applications that occupy the COM-port, turn them off, and restart the PC, if necessary.

The list of possible critical failures

The list of possible critical failures, possible human (user) errors that lead to emergency equipment modes, and actions that prevent these errors are given in the table below:

Fault name	Possible cause	Troubleshooting method
Mechanical damage to the housing (dents, cracks, damage to threaded connections)	Damage during installation	Products with damaged explosion protection (cl. 3.5) are subject to replacement.
Mechanical damage to the cable gland (dents, cracks, damage to threaded connections)	Damage during installation	Products that cannot be restored are subject to replacement
No output signals	Damage to the cable network	Check and restore the electrical connection
	Electronic unit failure	Dismantle the device and send it to the manufacturer for repair

8. THE STRUCTURE OF VOLUME MEASUREMENT SYSTEM

The volume measurement system consists of level transmitters, a personal computer, the Limaco OPC server software, and the Multi Beam Radar Surface Plotter software. The system can include both ULM-3D level transmitters (with multiple measuring beams) and ULM level transmitters (with a single measuring beam). The system also includes optional equipment, such as interface converters and repeaters. Data may be transferred to Multi Beam Radar Surface Plotter software and SCADA systems running on remote computers connected to the network.

The structure of the volume measurement system is shown in Figure 7. ULM 3D and ULM level transmitters are connected to the main computer via the RS-485 interface. The Limaco OPC server software queries level transmitters. In this case, data about the measured distances is transmitted from the sensors to the OPC-server.

This data is then transmitted to the Multi Beam Radar Surface Plotter software via the WCF data exchange interface. The Multi Beam Radar Surface Plotter software processes data received from the OPC-server for all level transmitters, calculates levels using data about the angles of each beam stored in the configuration of this software. The Multi Beam Radar Surface Plotter software provides three-dimensional visualization of the product surface and displays data on the measured levels, volume, minimum, maximum, and average levels. This software records the above data to the Limaco OPC-server.

Thus, Limaco OPC Server and Multi Beam Radar Surface Plotter have to work continuously for the volume measurement system to work properly.

WCF data exchange interface helps use multiple instances of such software, including those that run on remote computers connected to the host via Ethernet network. Data can also be transmitted to computers connected via Internet.

In this case, only one instance of such software should be selected as a master program. Only the master program records the measured data to the OPC-server. OPC-server helps access data for industrial automation programs that support OPC Data Access 1.0 a/2.0 interface. Such programs are so-called SCADA systems.

Limaco OPC server software records the volume received from the Multi Beam Radar Surface Plotter to the memory of the level transmitters, so that each of them can deliver the volume to the current output subject to appropriate settings of the level transmitter. (Set the volume delivery to the current output). To transfer data to a SCADA system located on a remote computer, install a remote version of Limaco OPC server on this computer and connect the SCADA system to this server in accordance with the connection standards via the OPC-interface. In this case **the presence of Limaco OPC server master program running on the host computer is mandatory!**

Follow software operating manuals to configure Limaco OPC server, Multi Beam Radar Surface Plotter. Use ULMCFG software to configure level transmitters and follow the operating manual for this software.

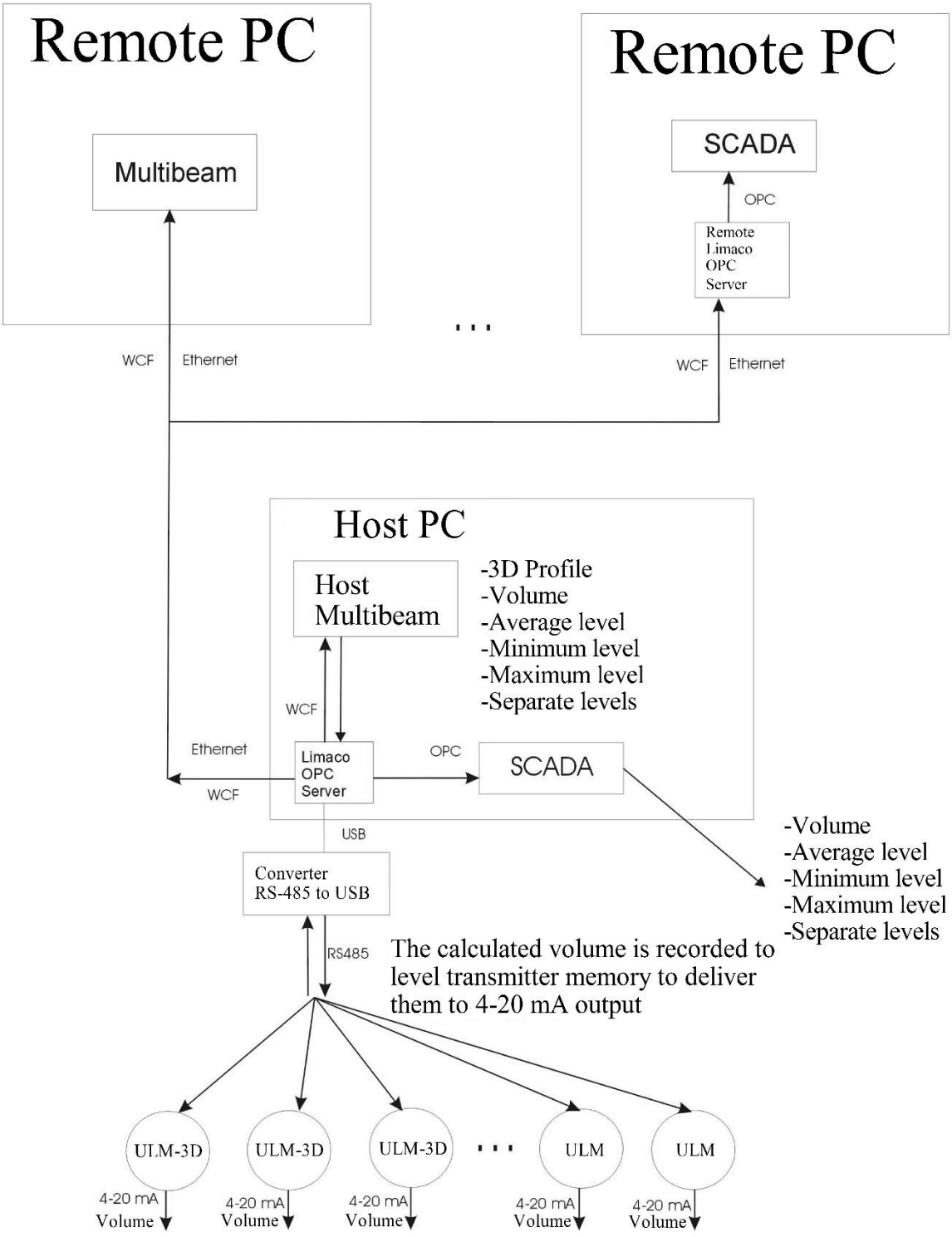


Figure 8.1. The structure of volume measurement system.

9. MAINTENANCE

The level transmitter does not require special maintenance. Depending on the operating conditions, only periodic cleaning of the aerial shield surface may be required. When cleaning the level transmitter, do not use agents that can have an aggressive effect on the materials of housing, seals, plugs, and cable glands.
When using the level transmitter in explosive dust atmosphere, clean the surface of level transmitters. Provide a sufficient level of maintenance in accordance with GOST IEC 60079-10-2-2011.

9.1 Preventive inspection, preventive maintenance

Inspect the level transmitter, remove dirt and dust, and check the tightening of bolts and level transmitter fastening nuts to the tank and the fastening of supply lines to the cable input of level transmitter. Check level transmitter housing for mechanical damage and damage to the explosion protection marking.
Make visual inspection of the cable gland for the absence of mechanical damage and the tightness of cable gland nut.

9.2 Preventive inspection with the removal of level transmitter, preventive maintenance

Perform work in accordance with cl. 10.1.
De-energize the level transmitter. Carefully remove the level transmitter. Examine the state of aerial lens. If necessary, gently wipe the aerial or aerial shield with an alcohol-impregnated swab. Check the integrity of sealing and the state of threaded connections of cable glands. Position the level transmitter in compliance with safety requirements and installation rules. Check the tightening of fasteners.

10. DISMANTLING AND DISPOSAL

10.1 Dismantling procedure

The device shall be disassembled in compliance with all applicable safety standards and regulations. Pay special attention to works at height and on tanks with aggressive or poisonous products.

Dismantling is performed in the reverse order of actions described in paragraph. 5.6. How to connect the device.

10.2 Disposal

At the end of specified service life, level transmitters shall be disposed of in accordance with the regulations in force at the facility that operates the product.

The device housing is recyclable. Housing can be recycled in specialized organizations.
Recycling eliminates the negative impact on the environment and allows reusing materials.

11. REPAIRS

Repair can only be performed at the site of manufacturer or its authorized representative offices.

In case of return of the equipment to the manufacturer for repair, fill out a special form "Repair Application" posted on the website www.limaco.ru

Procedure for sending the device for repair:
- fill out the "Repair Application" form;
- clean the device and pack it in a container that ensures its safety during transportation;
- send the equipment and "Repair Application" to the address specified in Contacts section on the website.

Repair can be made by replacing the level transmitter with a serviceable one.

12. APPENDICES

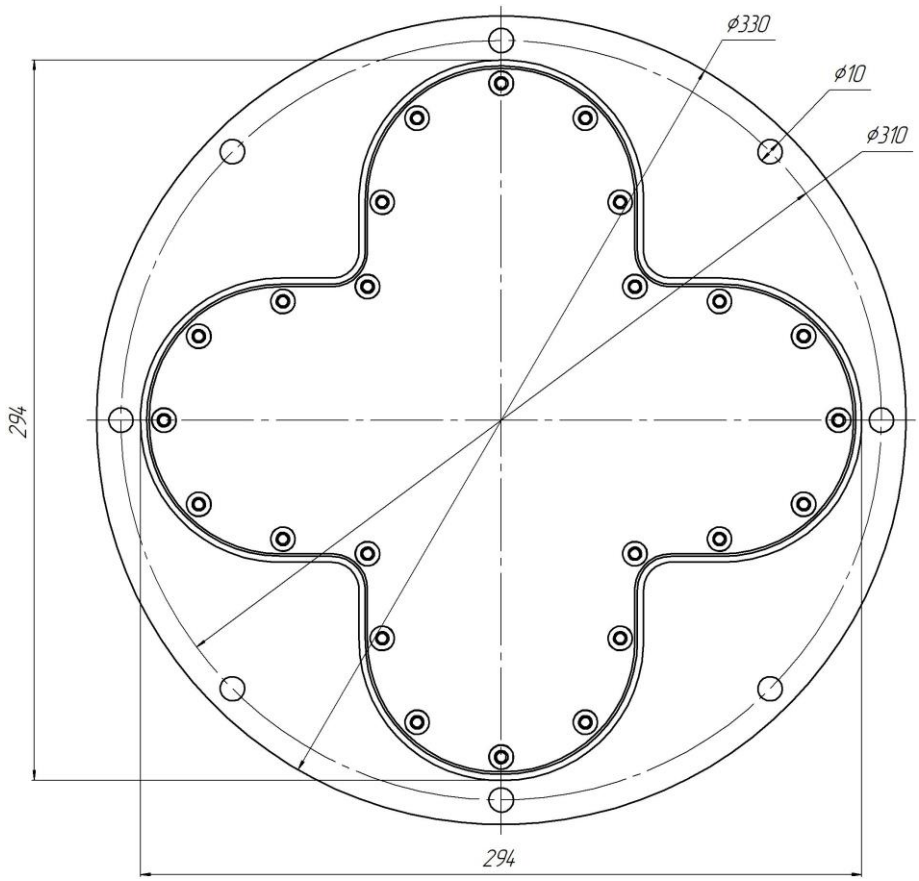
12.1 Technical specifications

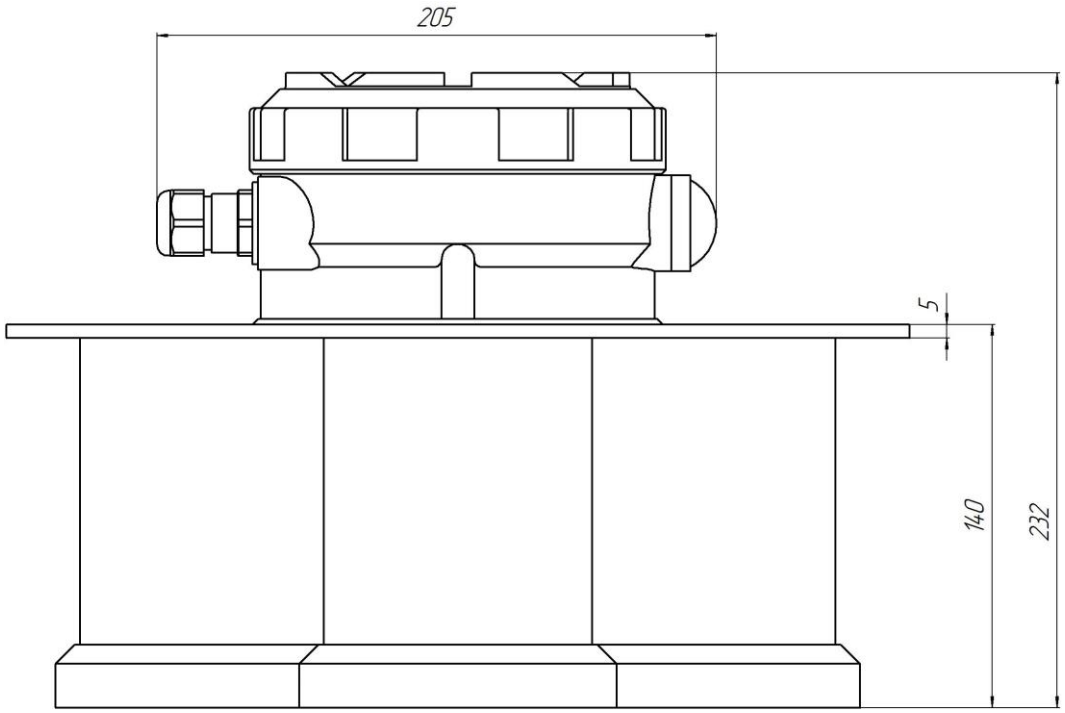
Name	Description
General information	
Housing material	Aluminum casting alloy, anodized, powder coating
Sealing material between the housing and the cover	Rubber compound
Aerial shield material	Polyethylene, fluoroplastic
Bluetooth module plug material	Fluoroplastic
Cable gland material	Nickel-plated brass
Weight, kg, max ULM-3D-5 ULM-3D-1	 11 3
Overall dimensions, mm, max ULM-3D-5 ULM-3D-1	 330x330x235 205x170x135
Type of installation on the process	flange
Output signals	
Analog	
4-20 mA	Active
Alarms	3 ma, 21 mA (installable)
Load	300 Ohm max
Error (in the temperature range -40...+60°C)	0.25% of the measurement range max
Digital	
RS-485	Modbus RTU
Resolution	0.1 mm
Wireless	
Bluetooth	Version 4.0 or higher
Relay outputs only ULM-3D-1	
Number of channels	2
Maximum switching current	3 A
Maximum switching voltage, alternate (direct)	250V (30V)

Name	Description
Device performance data	
Absolute level measurement error (on a flat surface*)	±5 mm max
Range of measurement	0.6…40 m
Low-accuracy measurement range	0.3…0.6 m
Operation concept	Radar level measurement device implementing linear frequency modulation (FMCW)
Operating frequency	125±5 GHz
Output power of each channel	8 MW max
Number of measuring channels ULM-3D-5 ULM-3D-1	 5 1
Channels operating mode	Alternate
Beam pattern width of each channel	2˚
Operating conditions	
Ambient temperature at the level transmitter installation location	-40 … +60˚ C
At a temperature on the level transmitter flange above 60 ˚C	The installation of radar-transparent insulating gasket is required
Atmospheric pressure	84.0…106.7 kPa (630-800 mmHg)
Relative humidity at the level transmitter installation location	Not more than 95% @ 35 ˚C or lower temperatures, without moisture condensation
Mechanical impacts - vibration amplitude - vibration frequency	 0.1 mm max 5…25 Hz
Maximum deviation of the vertical axis from the recommended mounting position	±1 degree max
Protective measures	
Protection rating per GOST 14254-2015 (IEC 60539-0:2013)	IP65
Explosion protection marking	Ex tb IIIC T85°C Db
Safety integrity level GOST R IEC 61508-2012, GOST R IEC 61511-1-2018	SIL 3

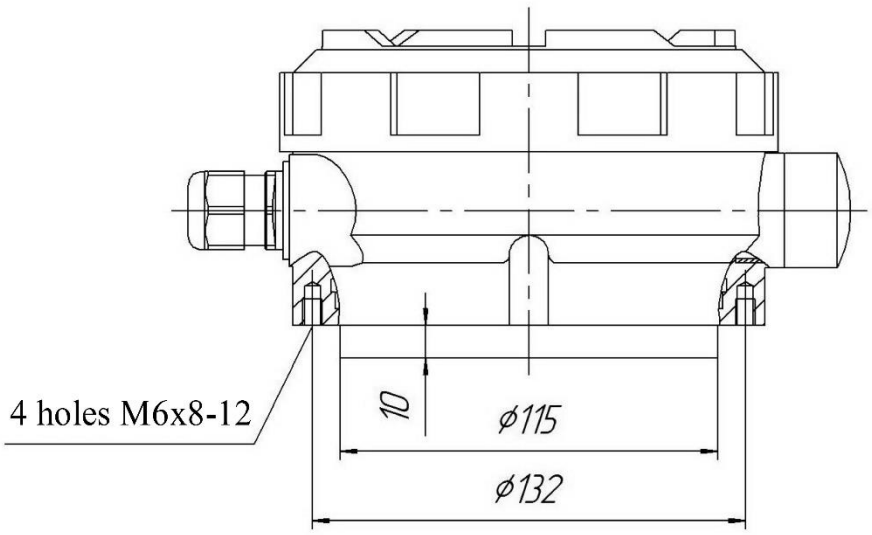
Name	Description
Power supply	
Supply voltage	18…36 V DC
Maximum power consumption, W, max ULM-3D-5 ULM-3D-1	 15 6
Electromechanical data	
Cable gland	Option 1: 1 x cable gland M20x1.5 (round cable Ø 7...12 mm) 1 x plug M20x1.5 Option 2: 2 x cable glands M20x1.5 (round cable Ø 7...12 mm)
Screw terminals for electrical connection of wires of	2.5 m (AWG 14) max
Permits and certificates	
You can download this documents from the website www.limaco.ru	

12.2 Level transmitter connection to the mount flange and overall dimensions of ULM-3D-5

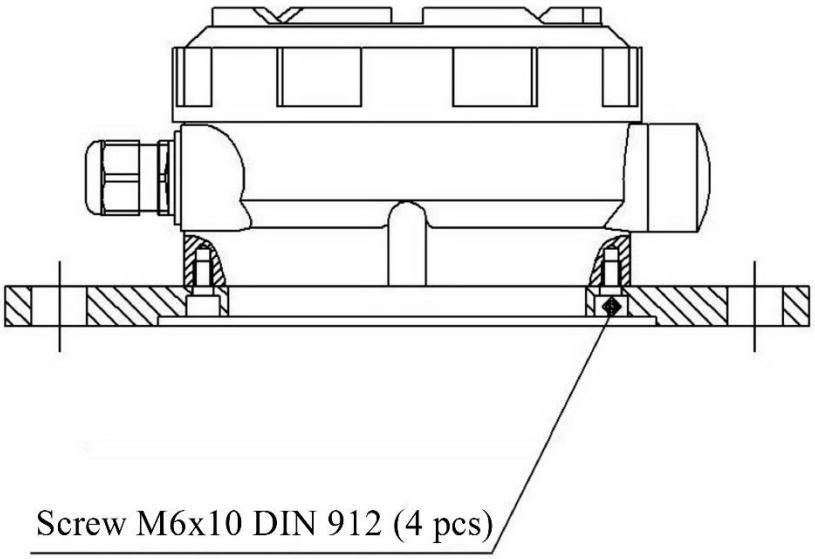




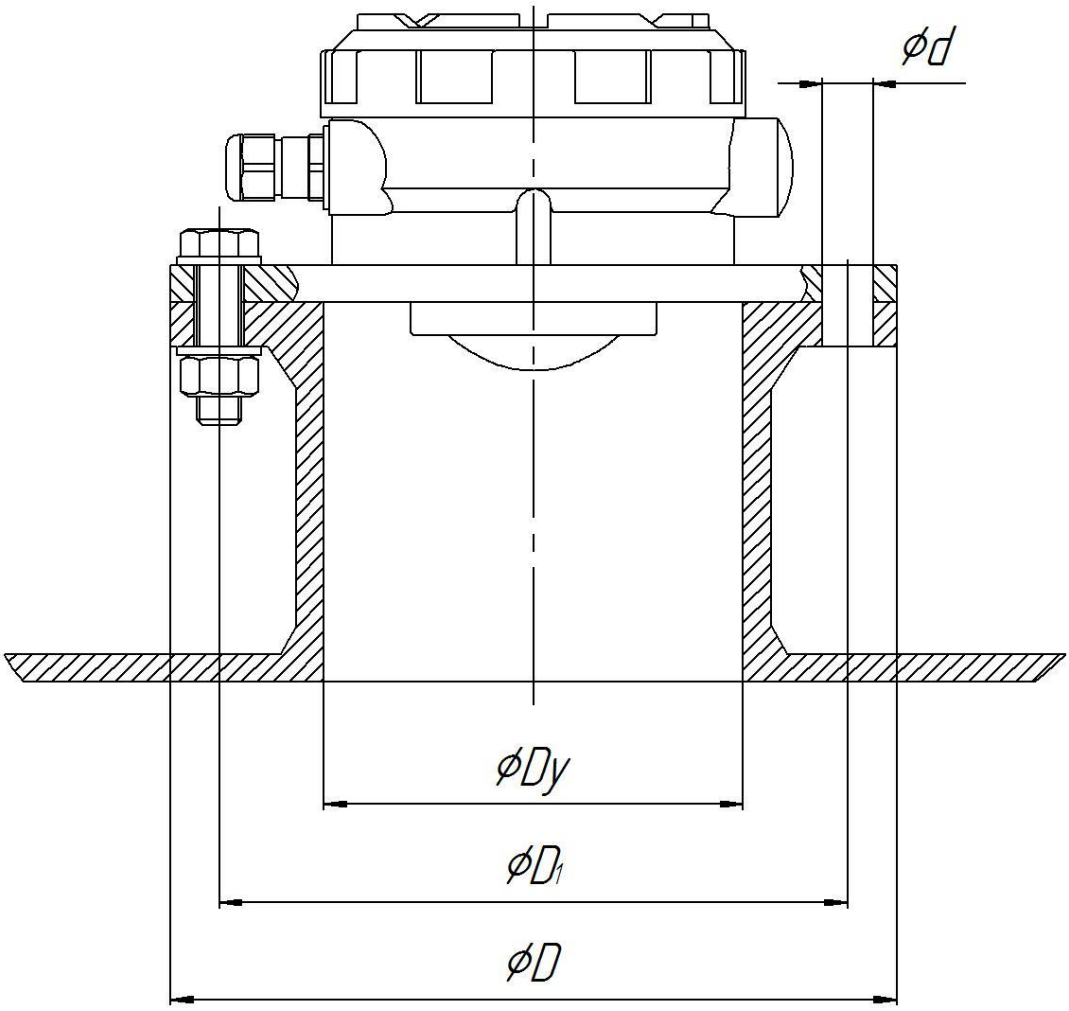
12.3 Level transmitter connection to the mount flange and overall dimensions of ULM-3D-1



Mounting dimensions of ULM-3D-1 level transmitter without a mounting flange



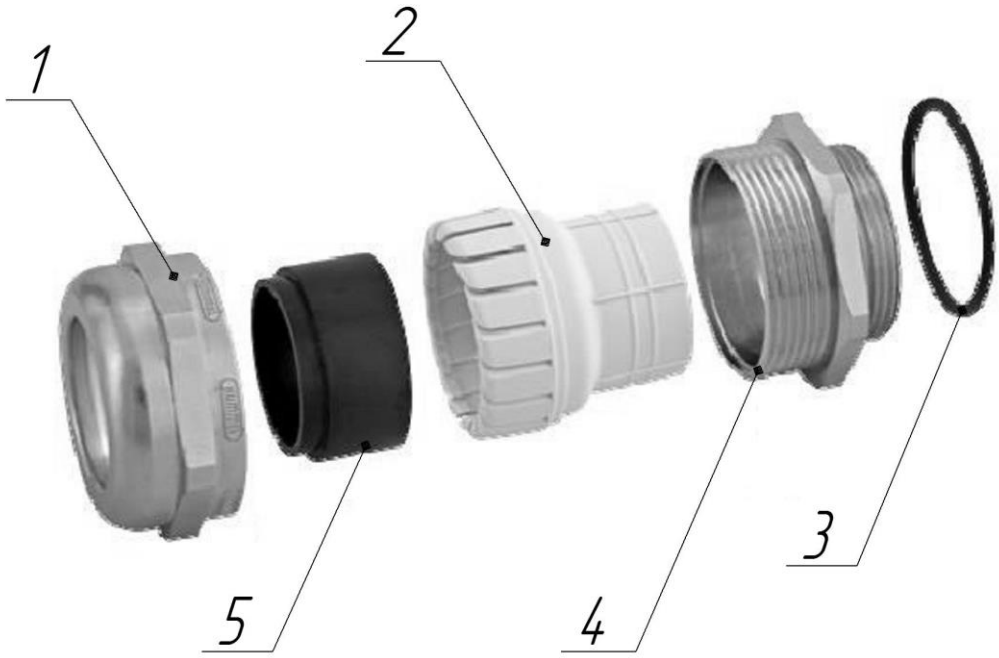
Connecting ULM-3D-1 level transmitter to a mounting flange



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

Installation of ULM-3D-1 level transmitter on a nozzle

12.4 Handling of cable gland



Cable gland design

1	Clamp nut
2	Clamping sleeve
3	Ring
4	Housing
5	Cross-sectional sealing

IP rating:

IP 68 - 10 bar / IP 69K within the specified cable diameter ranges and only with an additional round O-ring

External thread:

M 20 x 1.5

Cable diameter, (mm):

7 - 12

Wrench size:

22

Material:

Nickel-plated brass

Procedure for connecting the cable to the level transmitter

1. Screw the cable gland into the level transmitter housing (Fig. 3.1, 3.2)
2. Loosen the clamp nut.
3. Run a cable of the appropriate diameter through the cable gland.
4. Tighten the clamp nut.

Special conditions for operation and installation. Cable entries are only applicable for permanently laid cables. The person installing the cable gland shall ensure that the cable tension does not exceed permissible values.