AFLOWT

ULTRASONIC LEVEL GAUGE
AFLOWT LV

VERSION
LV-2xx

OPERATION MANUAL
PART I

9001:2008

Saint-Petersburg, Russia

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VZLJOT JSC quality management system is certified to ISO 9001:2008

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Vzljot JSC
Postal address: Masterskaya Str., 9,
190121, Saint-Petersburg, RUSSIA
Tel.: +7 (812) 714-81-62
Fax: +7 (812) 714-71-38
E-mail: im@vzljot.ru
URL: http://www.aflowt.com

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TABLE OF CONTENTS

This document covers "AFLOWT LV" ultrasonic level gauges (hereinafter referred to as "the Level gauge", “LV", or “the Device”) of "LV-2xx" versions and contains the information about their design and operation. Part I is devoted to Level gauge's technical description. Part II describes its operation.

Due to continuous improvement of product policy actual Level gauge's specifications may differ from the data specified in this manual. However, this will not affect the metrological characteristics and functionality.

LIST OF ABBREVIATIONS

AS - Acoustic system
BMD - Digital measuring block
CB - Communication block
SPS - Secondary power source
LCD - Liquid crystal display
ER - Error
PC - Personal computer
PEP - Piezoelectric converter
RTD - Resistance temperature detector (temperature sensor)
UW - Ultrasonic waves
USS - Ultrasonic signal
LV - Ultrasonic level gauge.

NOTE: Words in the text marked in bold, for example, “**Activity level”** correspond to the items displayed on the Level gauge's screen.

1. DESCRIPTION AND OPERATION

1.1. Application

1.1.1. Practical purpose of AFLOWT LV ultrasonic level gauge of LV-2xx versions is to automatically and contactlessly measure level of liquids with wide range of properties (including aggressive ones) located in containers, storage tanks, reservoirs, open channels etc. Two-channel design makes it possible to carry out simultaneous monitoring of two objects. The Level gauge can also be applied as a multilevel alarm device.

The LVs of explosion-proof type are designed for use in explosion hazard areas.

The Level gauge is designed for a wide range of applications including integration into meter reading systems and automatic process control systems.

1.1.2. "AFLOWT LV" Ultrasonic level gauge provides the functions to:

- Measure the distance to an interface between media
- For two-channel design versions: determine the current level of liquid and differential in levels
- Determine the percentage of filling the tank with liquid
- Determine liquid volume along with the percentage of filled volume under condition that the volume/level characteristic is entered into the Device
- Display measurement, calculation, configuration, and history (logged) data along with the current date and time on the built-in LCD
- Automatically monitor changes in ultrasound velocity upon changes in the gas medium composition or parameters using reference reflector or temperature sensor (RTD)
- Output measurement results to current, pulse or logical output
- transfer measurement, diagnostic, configuration, and history (log) data via RS-232, RS-485, or Ethernet interfaces
- Log measurement results in the hourly log, daily log, interval log (with the preset logging interval), and register alarm and fault situations in the special-purpose logs
- Record configuration settings into the Device's non-volatile memory
- Programmatically configure the measuring system according to on-site specific requirements
- Automatically monitor and indicate alarm and fault conditions
- Protect logged data and configuration settings from unauthorized access.

1.2 Specifications

1.2.1. General Specifications are listed in Table 1.

Table 1

Parameter	Value of the parameter	Notes
1. Number of measuring channels	1/2	Optional
2. Level measuring range, mm: - Standard design - Explosion-proof design	 From 0 to 13600 From 0 to 14200 From 0 to 10600 From 0 to 11200	 Note 2 Note 1 Note 2 Note 1
3. Max. measuring distance, mm: - Standard design - Explosion-proof design	 *15000* 12000	
4. Min. measuring distance, mm:	*800* 1400	Note 2 Note 1
5. Power supply voltage	*DC 24 V*	see section 1.2.5
6. Power consumption, maximum, W	20	
7. Mean time to failure, h	75 000	
8. Mean life time, years	12	

NOTES:

1. For AS with reference reflector.
2. For AS with RTD.

1.2.2. Number of displayed digits is specified in Table 1 of Appendix C.

1.2.3. The Level gauge provides that the results of measurements can be outputted to:

- Universal outputs – from 1 to 9 (optional)
- Current outputs - up to 2 (optional)
- RS-232 (RS-485) interface
- Ethernet interface (optional).

1.2.4. Number of records in logs and special-purpose logs:

- Hourly log – 1440 records/hours (log capacity is 60 days)
- Daily log – 60 records (log capacity is 2 months)
- Interval log – up to 6000 records
- User log – up to 1000 records
- Measuring channels alarm logs – up to 512 records per a channel
- Universal outputs alarm log – up to 512 records
- Fault log – up to 60 records
- Mode log – up to 512 records.

When powered off, the Level gauge stores data for no less than 1 year.

1.2.5. The Level gauge is powered from a stabilized 22 … 29 V DC voltage source with pulse level of no more than ± 1.0 %. The Level gauge can

be powered from mains AC (154-264) V (50±2) Hz via Secondary Power Source ADN-3024 (ADN).

1.2.6. Operation conditions according and protection provided by the enclosure according for Level gauge's components are specified in Table 2.

Table 2

Level meter's version	Ambient temperature, °C	Relative humidity, %	Class of resistance		Code of protection
			sinusoidal vibration, Hz	atmospheric pressure	
1. Digital Measuring Block (BMD)	From +5 to +50	no more than 80 at + 35 °C (without condensation)	10…55	66.0…106.7	IP54
2. Communication Block (CB) BK-201	From - 20 to +70	no more than 100 at a temperature of up to + 40 °C, with condensation	10…55		IP65
3. Piezoelectric Converter (PEP)	From - 20 to +50 From +1 to +100		10…150		IP67
4. Resistance temperature detector (RTD)	From - 50 to +100	no more than 95 at + 35 °C (without condensation)	5…80		IP65

NOTE. Within (+ 1 to + 100 °C) temperature range, piezoelectric converter (PEP) should only be used in AS without a sound guide.

1.2.7. View, overall dimensions and weight of Level gauge's components are given in Appendix A.

1.3. Metrological specifications

1.3.1. Limits of permissible relative error for level measurements Δ are derived from an empirical formula:

$$\Delta = \pm 4 + k \cdot G \cdot (D - DR)^2, \text{ mm} \quad (1)$$

where G – absolute value of temperature gradient of gas medium in a gas tank in the direction of ultrasonic propagation, °C/m;

$k = 10^{-3}$ °C^{-1} – linear factor;

D – measured value of the distance to the interface between media, m;

DR – distance to the reference reflector, m. If the acoustic system is equipped with RTD, DR=0.

Temperature gradient G is calculated by the formula:

$$G = \frac{t_1 - t_2}{D}, \quad (2)$$

where t_1 – temperature of gas medium near the piezoelectric converter, °C;

t_2 – temperature of gas medium near the interface between media, °C.

1.3.2. Limits of permissible relative errors for calculation of time intervals do not exceed ± 0.1 %.

1.4. Contents of the delivery package

Items of the delivery package are specified in Table 3.

Table 3

Item	Qty	Notes
1. Digital Measuring Block	1	Note 1
2. Acoustic system	1-2	Note 2
3. Communication block	1-2	
4. Secondary power source AC 220/DC 24 V	1	Optional
5. Installation kit	1	Note 3
6. Equipment Certificate	1	
7. Operating documentation: - Operation manual, Part I and Part II - Instruction on installation	 1 1	Note 4

NOTES:

1. Number of measuring channels as well as number and type of external communication modules are specified in the order sheet.
2. Quantity and type are specified in the order sheet.

   The standard supply implies that AS-6xx-xx0 and AS-7xx-xx0 acoustic systems are equipped with "VZLJOT TPS", the AS-11x-xx3 are equipped with sensitive element fore resistance temperature detectors Pt 500 sensor curve, $\alpha = 0.00385°C^{-1}$.

   The corresponding mounting kit depends on the acoustic system type and contents of the order sheet.
3. In standard supply configuration, CB-BMD cable length is 10 m. Cables of up to 250 m are available on customer's request.

4. Required items of the delivery package are specified in the order sheet.

1.5. Design and operation

1.5.1. Operation principle

1.5.1.1. The Level gauge's operation principle is based on the method of gas medium acoustic sounding (see Fig.1).

PEP generates ultrasonic signal (USS) in the direction of media interface, and then receives the reflected signal.

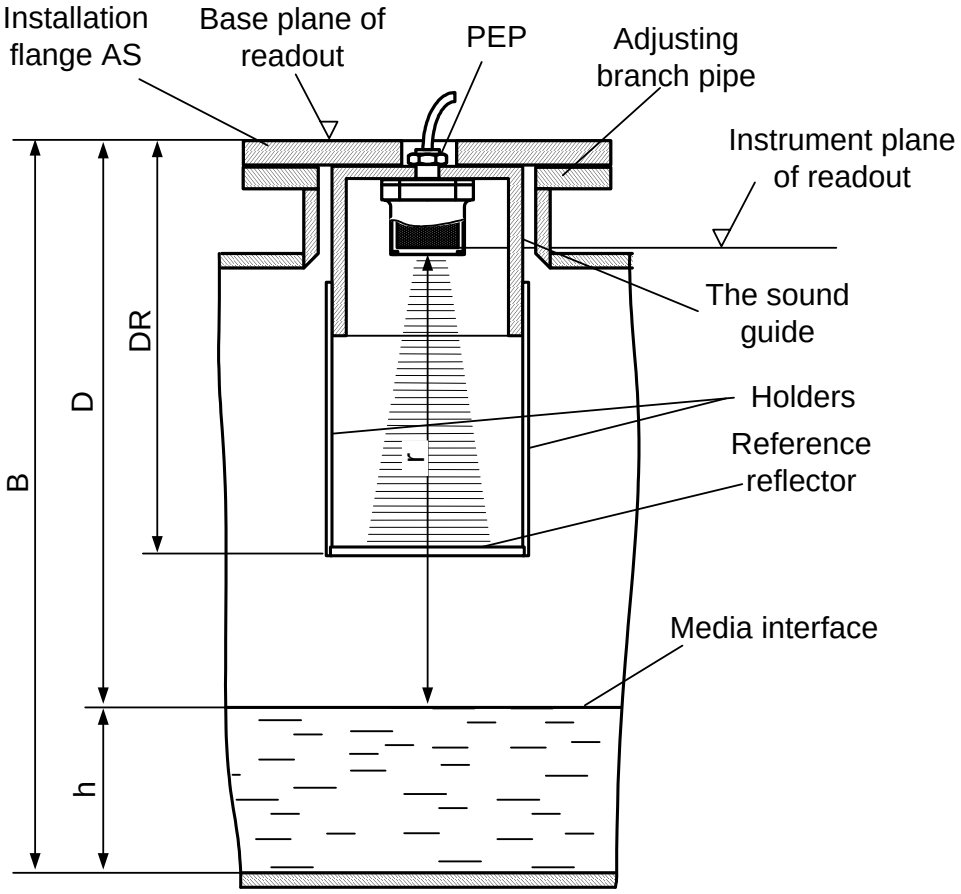


Fig. 1. Level measurement diagram

The time it takes for USS to travel in the forward and reverse direction T and the velocity of propagation of ultrasonic waves (UW) in gas medium C are measured, and the distance r from the emitting surface to the media interface is calculated on this basis using the following formula:

$$r = \frac{CT}{2}, \text{ m} \qquad (3)$$

1.5.1.2. For convenience of measurement data analysis, the base plane, from which the distance readings are taken, is fixed to the top plane of the whole structure where PEP is installed. The measured distance D is the distance from the base plane to the media interface:

$$D = r + dD, \text{ m} \qquad (4)$$

where dD is zero offset.

1.5.1.3. Taking into consideration the known value of base level B, the current level value H is calculated by the formula:

$$H = B - D, \text{ m} \quad (5)$$

where B (base level) is the distance from the base plane to the bottom of the tank or to a conventional plane which is taken as the reference for level measurements.

1.5.1.4. To measure the level of filling a tank under control, the user should specify the maximum level value Hmax. The current level of liquid in the tank being filled is determined as a percentage of Hmax.

1.5.1.5. To determine the current value of liquid volume in a tank under control **V**, the user should specify the dependence of volume on the liquid level for this tank (tank volume/level characteristic). The volume/level function either calculated on the basis of the tank parameters or found experimentally is recorded into the non-volatile memory of the Device. The Level gauge may store 32 pairs of volume/level values.

1.5.1.6. Provided that the tank volume/level characteristic is specified, the Device can determine the current value of filled volume as a percentage of maximum volume of liquid under control.

1.5.1.7. USS propagation velocity depends on the parameters of gas medium (temperature, composition, humidity, and pressure). Thus, to provide required measurement accuracy, the Level gauge supports various methods for measuring USS velocity, which may be applied in acoustic systems (AS) of different types.

a) For acoustic systems with reference reflector (a cylinder-type reflector placed on the way of acoustic beam (AS-40x-xx0, -50x-xx0), the actual velocity of ultrasound in the gas is derived from the known distance between the base plane and the reference reflector:

$$C = \frac{2(DR - dD)}{T_R}, \text{ m/s} \quad (6)$$

where T_R – time of USS travel to the reference reflector and back, sec.;

DR – distance between the reference reflector and base plane, m;

dD – zero offset, m.

NOTE: Values of DR and dD are determined during post-manufacture calibration and specified in the Equipment Certificate.

b) For acoustic systems with temperature sensor RTD (AS-61x-xx0, AS-62x-xx0, AS-71x-xx0, AS-72x-xx0) or the sensitive element RTD (AS-11x-xx3), the actual value of USS velocity is calculated with the empirical formula that takes into account the dependence of the USS velocity on gas medium temperature:

$$C = C_0 + 0.59\ t, \text{ m/s} \quad (7)$$

where C_0 – velocity of ultrasound wave at a temperature of 0 °C, m/s;

0.59 – correction factor, m/s,°C;

t – actual value of gas medium temperature measured by the Level gauge, °C.

NOTE: The value of C_0 for the air is determined in post-manufacture calibration. If on-site gas composition (inside the tank un-

der control) differs from air composition, and AS-11x-xx3, AS-61x-xx0, AS-62x-xx0, AS-71x-xx0 or AS-72x-xx0 acoustic systems are installed, to ensure correct calculation of UW velocity value, C_0 parameter must be adjusted according to the procedure specified in section 5.3 of "Ultrasonic level gauge AFLOWT LV". LV-2xx version. Instruction on installation" document.

1.5.1.8. Automatic and manual echo search modes are used to enhance interference protection of the measuring path. Interferences may result from repetitive reflections of echo signal or appear due to the inside components acting as reflectors (e.g., stirring blades).

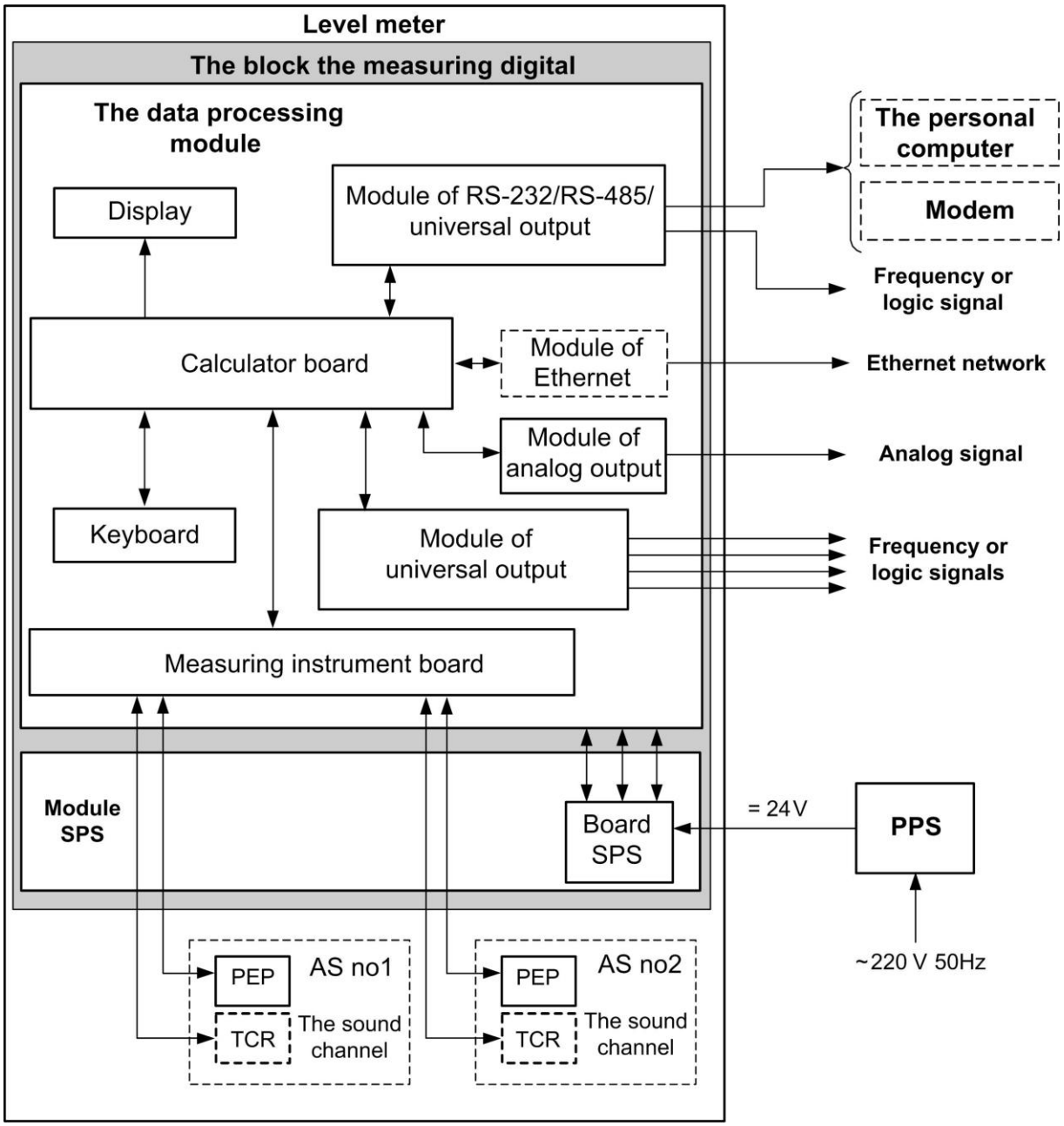
In the automatic search mode, the desired echo signal reflected from the media interface is detected according to one of 4 criteria.

The procedure for configuring echo signal search modes is specified in "Ultrasonic level gauge "AFLOWT LV. LV-2xx version. Installation manual" document.

On detecting the desired echo signal, a signal tracking window is created. Signals falling outside the tracking interval are not considered by the Device. Echo signal detection criteria are given in Table C.2, Appendix C.

1.5.2. Design

The Device's block diagram is shown in Fig.2.



SPS – secondary power source; RTD – resistance temperature detector; PEP – piezoelectric converter; PPS – primary power source; AS – acoustic system

Fig. 2. Two-channel Level gauge's block diagram

The Level gauge comprises one or two acoustic systems (AS) and Digital Measuring Block (BMD).

AS includes BK-201 unit, sound guide, and piezoelectric converter (PEP). The PEP transmits and receives ultrasound waves. AS-40x-xx0 or -50x-xx0 sound guides are equipped with a reference reflector. AS-61x (-62x),-71x,-72x) sound guides are delivered with one or two RTDs.

Simplistically designed AS-1xx-xxx acoustic systems are equipped with one RTD and supplied without a sound guide. AS-10x-xxx systems come without RTDs, level gauges equipped with such systems are used as level indicators.

Number of acoustic systems in an ultrasonic level gauge depends on the design version.

BMD consists of two basic components: measuring and calculation boards.

The measuring board is responsible for sounding liquid surface (it generates sounding pulses coming to PEP, receives and amplifies signals coming from PEP), measuring forward and reverse USS travel time, and communicating with the calculation board.

The calculation board calculates measurement results, communicates with the measuring board and external devices, records data into logs, controls external communication modules, LCD, and keyboard work.

To provide data exchange with external devices, the calculation board is equipped with the Combined module consisting of universal, RS-232 and RS-485 output circuits.

You may opt for installation of up to 2 additional communication modules:

- One or two 4-channel universal output modules
- Module of current output
- Ethernet module.

Level gauge's operation is controlled from the keyboard. The graphic Liquid Crystal Display (LCD) makes visible measurement, diagnostic, configuration, and history (logged) data. On-screen data update period is 1 s.

1.5.3. Operating modes

1.5.3.1. The Level gauge operates in three modes:

- SETUP – adjustment and calibration
- SERVICE – start-up procedures
- OPERATION – user mode.

The operating modes differ by level at which the user can access certain data (displayed and/or transferred via external communication modules) and modify Level gauge's configuration settings.

Maximum rights are granted in SETUP mode. The mode allows the user to view all of the parameters and to modify all of the configuration settings. Minimum rights are given in OPERATION mode.

Level gauge's operation is controlled from the keyboard via the menu designed on the model of nested menus and windows. Operation procedures, indication principles, menu structure, and tables of displayed parameters are specified in Appendices A and B of the present manual.

In addition, the Level gauge can be controlled from a PC connected via RS-232 (RS-485) interfaces or Ethernet.

1.5.3.2. Level gauge's operating modes are set by placing (removing) jumpers on J3 and J4 terminals, which are located on the Combined module ("RS-232 / RS-485 / Universal output 0").

Combinations of jumpers with regard to operating modes are specified in Table 4 ("+" means that the terminal contacts are closed by a jumper, and "-" means that the terminal contacts are opened).

Table 4

Mode	Terminal		Mode description
	J3	J4	
OPERATION	-	-	Work
SERVICE	-	+	Start-up procedures
SETUP	+	-	Adjustment

CAUTION! Do not place or remove jumpers when the Level gauge is powered up.

1.5.3.3. OPERATION mode – Level gauge's on-site operation.

In OPERATION mode, the user can view the following parameters:

a) Measurement values of: level, distance, volume, filled level, filled volume, USS velocity, temperature, difference of level and average level (averaged over two points, only for two-channel versions).

b) Measurement data and event logs (excluding "User" log);

c) Configuration settings: automatic winter/summer time clock setting, types of additional external communication modules installed, and specifications of outputs;

d) Operation settings:

- Reading of built-in real time clock
- RS-232 (RS-485) and Ethernet settings;
- Start time and duration of error situations (ER)
- Error messages related to measuring channels and outputs.

In OPERATION mode, the following parameters are configured via RS-232 (RS-485) interfaces: Device's network address, data transfer rate, delay duration, transfer gaps etc.

1.5.3.4. SERVICE mode – start-up procedures.

In SERVICE mode, in addition to the above, available in OPERATION mode, the operator can do the following:

a) View the values of service settings;

b) View and modify the values of:

- Object (tank under control) settings
- Settings of adjustment profiles
- Object's volume/level characteristic
- Indication settings
- Measuring results processing settings
- Volume measurement units (m^3; l)
- Type and settings of communication modules
- Interval log settings
- Reading of built-in real time clock
- Automatic winter/summer time clock setting.

c) Clear measurement data and event logs (excluding the "Mode" log).

1.5.3.5. SETUP mode allows the user to view and modify all of the settings.

In SETUP mode, in addition to the above, available in OPERATION and SERVICE modes, the operator can do the following:

- Calibrate the Level gauge
- Enter Device's serial number into the memory.

1.5.4. External connections

1.5.4.1. Serial interfaces

Serial interfaces and Ethernet interface are used to control the Level gauge, read measurement results, data logs, configuration settings, and diagnostic data as well as to modify Level gauge's configuration. The RS-232 and RS-485 interfaces support ModBus (RTU ModBus and ASCII ModBus), which is a standard protocol for VZLJOT instruments.

The RS-232 interface may be used for connection to a PC via:

- Cable (maximal cable length is 15 m)
- Phone line (telephone modem)
- Wireless channel (wireless modem)
- 900/1800 MHz GSM line via "VZLJOT AS" mobile communications adaptor, ASSV-030 version.

Communication distance via phone, wireless or mobile communications channel is determined by characteristics of the channel.

RS-485 interface supports cable communications among a group of several end users, one of which can be a PC, at a distance of up to 1200 m.

Connection of ASSV-030 Mobile Communications adapter either to a group or to a single device allows for data transfer via wireless communications channel including the Internet.

Single devices or groups of devices can be networked together and administered from a control center with "VZLJOT SP" Software Solution.

Data transfer rate via RS-232 and RS-485 interfaces (from 1200 to 115200 baud) as well as communication properties are set from a PC.

CAUTION! You must not use RS-232 and RS-485 interfaces at one time.

Ethernet interface is used for connecting the devices via local network or for data exchange among the LAN devices and a remote PC via the Internet. Data exchange is performed via a LAN gateway having its own (global) IP address. Transferred data is packaged using Ethernet / IP / UDP / TFTP / ModBus stack of protocols. ARP (Ethernet / ARP) protocol is also supported. It is used to define MAC-address of the node by IP address of a request.

1.5.4.2. Universal outputs

Depending on the number of service modules installed (see section 1.6.1.2), the Level gauge can have from 1 to 9 galvanically isolated universal outputs.

Functions, working modes, specifications of output signals and disconnection of the outputs are specified programmatically. Options available are specified in Table C.4, Appendix C, Part II.

Diagram showing an output stage of universal outputs and description of its operation are given in Appendix B.

In the frequency mode, measurement results are outputted in the form of square pulse sequence with period-to-pulse duration ratio of 2 and pulse repetition rate proportional to the current value of level. The frequency output can be scaled programmatically. This is done via **FREQUENCY OUTPUT x** menu by setting the following parameters: maximum value of operating output frequency **Fmax**, scale factor **KC**, as well as lower **Param. lt** and upper **Param. ut** threshold values of level related to 0 Hz and **Fmax** output frequencies. Maximum value of **Fmax** is 3000 Hz.

To provide correct work of the universal outputs, in the frequency mode the scale factor **KC** (pulses/m) is calculated automatically.

KC calculation is made on the basis of user-specified lower **Param. lt** and upper **Param. ut** threshold levels and maximum frequency **Fmax**.

In the logical mode, one signal level corresponds to “event” (or its state) and the other level corresponds to “no event” (or another state).

Programmatically this means: **Activity level**, i.e. **high** or **low**) signal level is set when the event is present. Electrical parameters of corresponding signal levels are specified in Appendix B.

Function of the logical output is set in **LOGIC OUTPUT x / Param.** window where ten options are available (see Table C.5, Appendix C, Part II). The logical output is locked, if **no** value is selected.

While in the logic mode, the operator is allowed to programmatically specify 4 conditions (standard settings) per a measuring channel and 1 "Acoustic signal presence" condition. The values are set in **CONSTRAINTS Chan. X** window. When the standard settings are activated, the actual value of level is checked against these 4 preset values considering the conditions specified in Table C.5, Appendix C, Part II.

On meeting a preset condition, the corresponding logical signal appears at the output.

1.5.4.3. Current outputs

Current signal is provided by the corresponding service module. The Level gauge can be equipped with one or two current output modules. Function and operational parameters of the current output modules are set programmatically. Options available are specified in Table C.4 and Table C.5, Appendix C, Part II.

Galvanically isolated current output realized on the base of the service module works in one of three ranges: 0-5 mA, 0-20 mA or 4-20 mA.

The standard curve of a current output is calculated as follows:

$$P_V = P_{lt} + (P_{ut} - P_{lt}) \frac{I_{out} - I_{min}}{I_{max} - I_{min}}, \quad (8)$$

where P_V – actual value of the parameter being measured, m;

P_{ut} – upper threshold value of the measured parameter preset for the current output that corresponds to I_{max}, m;

P_{lt} – lower threshold value of the measured parameter preset for the current output that corresponds to I_{min}, m;

I_{out} – value of current at the output that corresponds to the actual value of the parameter being measured, mA;

I_{max} – maximal operating range for the current output (5 or 20), mA;

I_{min} – minimal operating range for the current output (0 or 4), mA.

The set of measured parameters taken from the current output is the same as for the frequency output.

The current output can be connected to an external load of up to 1 kOhm in (0-20) mA or (4-20) mA operating ranges or up to 2.5 kOhm in (0-5) mA operating range.

Permissible length of a signal cable connected to the current output depends on the impedance of the corresponding signal circuit and impedance of a connected input. The condition is that the sum of impedances shall not exceed the specified external load resistance.

1.5.5. Logging

1.5.5.1. Measurement and calculation results per each channel are recorded into Device's internal logs: hourly, daily and interval logs.

Each channel is assigned to a corresponding log. Log capacity:

- Hourly log – 1440 records
- Daily log – 60 records
- Interval log – 6000 records.

For the interval log, interval duration can be selected from 5 s to 24 hours.

1.5.5.2. Format of each channel record is as follows

- **Tdw** – dead time, min – in the hourly log, hour:min – in the daily log, hour:min:sec – in the interval log
- **Hmean** – arithmetic average value of level averaged over logging interval, m
- **Hmin** – minimum value of level determined for the logging interval, m
- **Hmax** – maximum value of level determined for the logging interval, m
- Status words indicating faults end error situations.

In addition to the above, the interval log contains:

- **Vmean** – arithmetic average value of volume averaged over logging interval, m^3 (l)
- **Vmin**– minimum value of level determined for the logging interval, m^3 (l)
- **Vmax**– maximum value of level determined for the logging interval, m^3 (l)
- **Cmean** – arithmetic average value of ultrasound velocity averaged over logging interval, m/s
- **Cmin**– minimum value of ultrasound velocity determined for the logging interval, m/s
- **Cmax**– maximum value of ultrasound velocity determined for the logging interval, m/s.

Data are logged along with logging interval indication:

- Date and hour – for hourly logs
- Date – for daily logs

- Date and stop time of the logging interval – for interval logs.

1.5.5.3. Modifications made on configuration settings are logged in the User log with a capacity of 1000 records. User log format is as follows:

- Modification date and time
- Name of the modified parameter
- Parameter's value prior to modification
- Parameter's value after modification
- Order number of the record.

1.5.5.4. Modifications made on the operation mode are logged in the Mode log with a capacity of 512 records.

Mode log format is as follows:

- Order number of the record
- Name of the active operation mode
- Date and time of activation.

1.5.5.5. Alarm conditions and faults are recorded into the Measuring Channels alarm log, Outputs alarm log (universal and current outputs) and Fault log. The Alarm logs can contain up to 512 records, the Fault log has a capacity of 60 records.

Alarm log format:

- Order number of the record
- Alarm (error) name
- Date and start time of ER
- ER duration (hours, minutes, seconds);
- Date and stop time of the alarm (error) situation (ER).

Fault log format is as follows:

- Order number of the record
- Fault name
- Date and time of fault detection.

List of faults and alarm conditions that may be detected is given in Table D 4, see Part II of the present manual.

1.5.6. Design versions

Depending on application and operating conditions, the Level gauge comes in various design versions.

1.5.6.1. Design versions intended for various applications differ in number of measuring channels and measurement method. The design versions available are listed in Table 5.

Table 5

Design version	Number of measuring channels	Measurement method	Number of objects under control
UL-211	1	One-channel measurement of level	1
UL-221	2	Two-channel measurement of levels	2
		Two-channel measurement and calculation of average level	1-2
		Two-channel measurement and calculation of level difference	1-2

Depending on operating conditions and design of tanks (objects) under control, the Level gauge is equipped with acoustic systems of different types. Description of acoustic systems available is given in section 1.6.2, and their types are described in the Installation Instruction.

1.5.6.2. Explosion-proof design version

The Level gauge of explosion-proof type intended for operation in explosive areas is equipped with an intrinsically safe PEP, spark protector and BC-201 communication block coming in explosion proof version.

Degree of explosion protection – "Highly explosion-proof".

Type of explosion protection - "Intrinsically-safe electrical circuit".

Marking of explosion protection:

- PEP – "0ExiaIIBT6 X"
- Spark protector – "[Exia]IIB"
- BC-201 – "0ExiaIIBT6".

1.6. Device's components

1.6.1. Digital Measuring Block

1.6.1.1. Functions

BMD is a microprocessor-based measurement/calculation Data Processing Block designed on modular principle. Its functions are as follows:

- Generating of sounding pulses as well as generating of pulses for clearing PEP from condensate
- Conversion and processing of data received from PEP
- Calculation of measured values
- Logging and storing of measurement results, calculated parameters, configuration settings etc. in Level gauge's non-volatile memory
- Processing of commands coming from the keyboard
- Transferring of measurement, history (logged), diagnostic, and configuration data to LCD display via RS-232 (RS-485) or Ethernet interfaces
- Transfer of measuring data via the current and/or universal outputs
- Automatic monitoring and indication of Level gauge's alarm conditions and faults.

1.6.1.2. BMD design

BMD view is shown in Fig.A.1, Appendix A.

BMD consists of three parts (modules) enclosed in aluminum alloy cast housings: front part – Measuring Module, center part – SPS (Secondary Power Source) module, and base part - Mount module.

Measuring module comprises measurement and calculation boards. LCD graphic display and keyboard are both mounted on the module's front panel. LCD displays data in four lines (20 characters per line).

Depending on the number of measuring channels (PEPs), Measurement board includes the corresponding number of transmitting/receiving communication modules: from 1 to 2.

Calculation board bears the following electronic modules:

- Combined output module containing “Universal 0”, RS-232, and RS-485 outputs. The combined module is equipped with the terminals (used to set operation modes for BMD and output stage of the universal output) and connectors (used for external cable connections)
- Temperature module with connectors used for connection of up to 3 RTDs.

Calculation board is equipped with two expansion slots (connectors) intended for connection of one or two optional external communication (service) modules.

Service modules are equipped with the connectors used to connect signal cables from signal receivers, and, besides the above, universal output modules bear the terminals for setting operating modes of the output stages.

Table 6 shows possible combinations of external communication modules and numbering of outputs relative to module (expansion slot) location.

Table 6

Module name	N of the slot	N of the output	Possible combinations of modules						
			1	2	3	4	5	6	7
Combined module RS-232 / RS-485 / Universal output	–	0	×	×	×	×	×	×	×
Module of current output	1	1	–	–	×	–	–	–	–
	2	2	–	×	×	–	–	×	–
Module of universal outputs	1	1-4	–	–	–	–	×	×	–
	2	5-8	–	–	–	×	×	–	–
Ethernet module	1	1	–	×	–	×	–	–	×

CAUTION! It is permissible to use two current outputs at one time only if there is no difference in potentials between "ground" wires of the input devices connected to them.

SPS module includes the board of internal power source. Grounding terminal and service connector is located on the SPS bottom panel.

SPS and Measurement modules are electrically (by a multiple-wire flexible flat cable) and mechanically (by screws installed from SPS side) connected and built up Measurement Subblock.

Terminals and connectors of the external communication modules used to connect signal cables from PEP, RTD and external devices are accessed from the rear side of the Measurement Subblock (Fig.A.2).

Measurement Subblock is in turn screwed with Mount module from the front panel side, and together they build up Digital Measuring Block. The rear panel bears fixing holes for the brackets, which are used to mount BMD on DIN rail. (Fig.A.3).

Bottom panel of the Mount module contains: RS-232 connectors, entry holes with membrane plugs for power cable, PEP signal cables and external signal cables.

External RS-232 port located on the Mount module is connected to 8-pin RS-232 port of the Combined Module by a flexible flat cable.

View of ADN-3024 power source is represented in Fig.A.5.

1.6.2. Acoustic systems

1.6.2.1. Purpose of an acoustic system is to generate an ultrasonic signal, transmit it in the direction of media interface, and receive the reflected signal.

Designation of design versions of acoustic systems is shown in Table 7. Types of acoustic systems are specified in the Installation instruction.

Table 7

		AS- X X X -1 X X
1. Type of sound guide		
- without sound guide	1	
- flanged, with reference reflector	4	
- suspended, with reference reflector	5	
- flanged, with RTD	6	
- suspended, with RTD	7	
2. Number of RTDs in a measuring channel		
- without RTD	0	
- with one RTD	1	
- with two RTDs	2	
3. Resistance to aggressive media		
- waste water, spirit, acid, acetone, and ammonia fumes	1	
- petrochemical fumes	2	
- acid or alkali fumes of up to 20% concentration	3	
4. Maximal measurable distance		
- up to 15 m	1	
5. Operating temperature range		
- from - 20 °C to +50 °C	1	
- from +1 °C to + 100 °C	2	
6. AS design		
- AS with sound guide	0	
- AS without sound guide, fastening disc mount	3	

Two RTDs can only be installed in the first channel. In this case, the second RTD is installed on the object under control considering its operation parameters.

1.6.2.2. As part of AS, PEP (Fig.A.4, Appendix A) is intended to transmit and receive ultrasound waves. In the transmission mode, AC voltage applied to the electrodes of PEP's piezoelectric cell is transduced into acoustic waves (inverse piezoelectric effect) that are transmitted in the media interface direction. In the receiving mode, the acoustic waves reflected

from the media interface act on the piezoelectric cell that transduces the waves into AC voltage (direct piezoelectric effect). Self-cleaning (PEP surface cleaning) electrical signal is applied to PEP at specified intervals.

There is a special transmitting plate used to ensure stable operation of the piezoelectric cell in gas medium. The plate is protected from environmental conditions by fluoroplastic coating. Piezoelectric cell and plate assembly is housed in a sealed stainless steel case. Signal cable is connected to PEP via a cable through.

PEP cable that is 5 m in length and rigidly fixed to the case is equipped with leads used for connection with BMD via the switchgear module (Communication Block - CB).

In case that CB is rigidly fixed to AS near PEP, the cable is rolled in a coil or cut.

1.6.3. Communication block

BK-201 communication (switchgear) block is housed in aluminum alloy case with sealed cover and grounding terminal. Inside there is a PCB with terminal blocks for connecting wires. CB cable entry holes provide for connection of cables from PEP, RTD and spark protectors. CB view is shown in Fig.A.6, Appendix A.

1.7. Marking and sealing

1.7.1. BMD front panel bears the following information:

- Level gauge's name and designation
- Manufacturer’s trademark
- Sign of the Type Approval Certificate
- Serial number (indicated on the nameplate located on BMD case).

1.7.2. Serial numbers of other units are either indicated on the nameplate or stenciled on the corresponding case.

1.7.3. After calibration, a terminal used to enable modification of calibration settings is sealed along with one of the screws fixing Measurement Subblock.

The terminal used to enable modification of operation settings is sealed after start-up procedure and checking the compliance of the operation settings with the values specified either in the Equipment Certificate for the Level gauge and/or in the Reports on mounting and start-up procedures. Forms for the Reports on mounting and start-up procedures are given in the Installation Manual.

Characteristics of acoustic systems are determined after manufacture and entered in the Device's Equipment Certificate.

1.7.4. To protect the device from unauthorized access, seals may be hung on two fixing screws located on the front panels of BMD and CB.

2. OPERATION

2.1. Operating restrictions

2.1.1. Environmental restrictions with regard to the factors affecting the Device's performance and characteristics of the gas medium shall comply with the requirements specified in the operating documentation.

To mount the Level gauge on site, the following free areas should be available:

- Channel (tank, pipeline) section for mounting an acoustic system
- An area suitable for positioning BMD, SPS and CB.

2.1.2. Medium in the tank under control shall not affect the performance and characteristics of piezoelectric converter and resistance temperature detectors.

Device's on-site resistance to aggressive media is conditioned by the properties of materials used in the acoustic system.

2.1.3. The need for protective grounding is determined by power supply and environment conditions under which the Level gauge is operated.

Grounding terminal must not be connected to the lightning protection system.

2.1.4. Lightning protection system for the site where the Device is located protects the device against failures caused by lightning strokes.

2.1.5. Mounting considerations and mounting (dismounting) instructions are given in the "Ultrasonic level gauge "AFLOWT LV". LV-2xx version. Installation manual" document. Intensity of external electromagnetic field (commercial frequency) should not exceed 40 A/m.

2.1.6. Mounting location and operating conditions requirements specified in this operating documentation are based on the most typical factors affecting Device's performance.

The external factors that cannot be foreseen, evaluated or tested by the manufacturer during designing may exist or appear on site.

In this case, it is necessary to eliminate these factors or place the Level gauge in other location.

2.2. Safety instructions

2.2.1. The Level gauge should only be used by technical staff authorized to work with electrical installations up to 1000 V and familiar with all operating documentation for the product and equipment in use.

2.2.2. When working with the Level gauge, the dangerous factors are as follows:

- AC voltage (RMS value up to 264 V, frequency 50 Hz)
- Other site-specific factors.

2.2.3. When in operation, the Device's modules shall be connected to a separate ground bus.

2.2.4. In the course of mounting, start-up or repair works you must not:

- Make connections to the Device, switch over modes and replace electronic components, when the Level gauge is powered up

- Use electronic devices and electric tools unless their cases are connected to the protective earthing trunk line. Also, you must not use the defective devices and tools.

2.3 Preparing for operation

2.3.1. On-site mounting and adjustment of the Device shall be performed according to "Ultrasonic level gauge AFLOWT LV. LV-2xx version. Installation manual" document.

The works shall be performed by authorized dealers or by the manufacturer.

2.3.2. When putting the Device into operation, check the following:

- The Device and related equipment are connected in accordance with the wiring diagram;
- Serial numbers of modules in use correspond to the specification, and each signal cable is connected to the assigned measuring channel
- Power supply voltage corresponds to the specification
- Outputs operate in the preset modes.

Besides the above, it is necessary to make sure that actual operation settings in the Device comply with the values specified in the Device's Equipment Certificate or in the Reports on mounting and start-up procedures.

2.3.3. The Device becomes operational in 30 minutes after applying power.

3. MAINTENANCE

3.1. After putting the Level gauge into operation, it should undergo regular visual inspection and examination. During the procedure you need to make sure that:

- Device's performance corresponds to the technical specification
- Operating conditions are met
- Power supply characteristics are within the required ranges
- No external defects are detected
- Electrical and mechanical parts are reliably connected.

Check periods depend on operating conditions but should not exceed two weeks.

3.2. If the operating conditions specified in the present manual are not observed, this may lead to the Device's fault, or the permissible limits of relative measurement error may be impaired.

External defects may also lead to deterioration in measurement accuracy. Therefore, when the above-specified external defects are detected, contact the Service Center or regional dealer for the information about the device’s operability.

3.3. The presence of display indication means that power is applied to the Level gauge; the indicated information gives an idea of the Device's performance. The list of possible faults indicated by the Level gauge is given in Appendix D of this operation manual.

Alarm (ER) situations are also indicated by status words.

3.4. Regarding the design and operating conditions, the Level gauge refers to the devices that should be repaired by authorized dealers or by the manufacturer.

The error is localized on the site to an accuracy of a block: BMD, PEP, CB, and sound guide.

3.5. When the device is dispatched to the manufacturer for repair or replacement, it should be sent together with AS or BMD considering that subsequent calibration will be performed upon both units.

In case that BMD or AS are replaced or in case that cables are replaced or changed in length, the Device must be calibrated by the manufacturer.

3.6. When the Level gauge is sent for service, the Equipment Certificate must be enclosed. Please specify post details, phone/fax numbers along with the way and address for redispatching.

When the device is dispatched for calibration or repair complete with AS, the acoustic systems should be cleaned off sediments, residue, scale etc.

4. PACKING, STORAGE AND TRANSPORTATION

4.1. The Level gauge is packed into a separate container (corrugated carton or wooden box) along with the operational documentation.

The sound guide and fittings are transported in separate boxes.

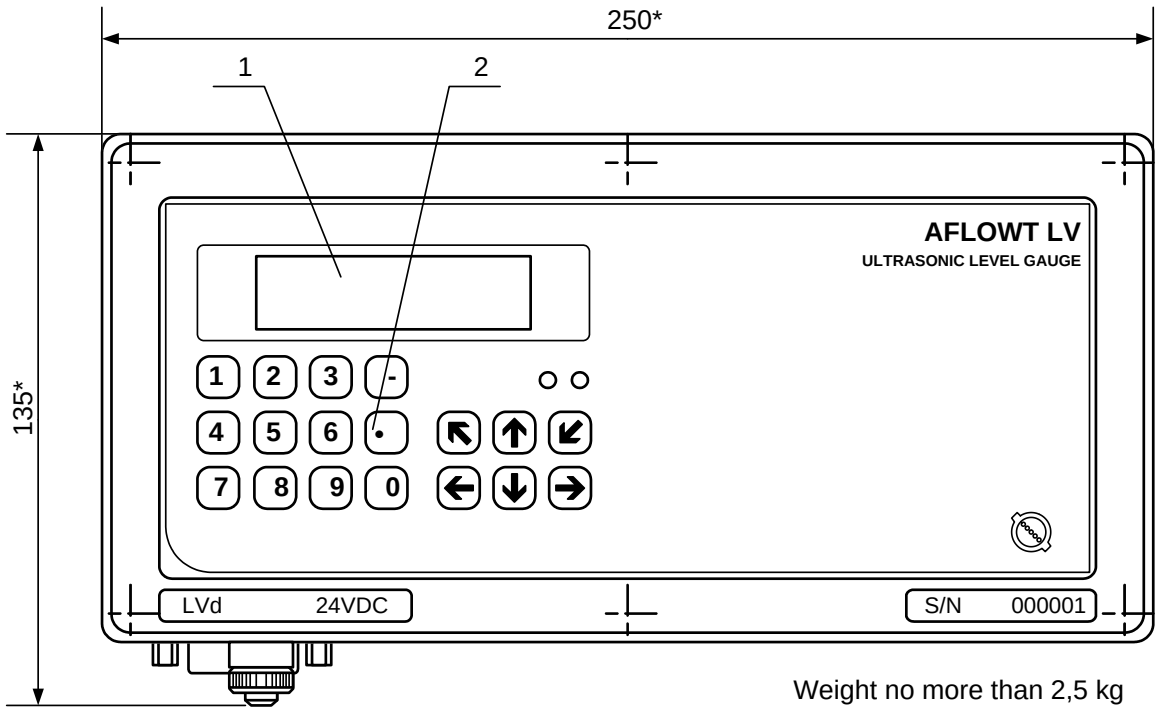
4.2. The Level gauge should be kept in manufacturer's box in a dry heated storeroom. The storeroom should be free from current-conductive dust, acid or alkali fumes and aggressive gases that may damage insulation.

During storage the Level gauge does not require any special maintenance.

4.3. The devices can be transported by road, rail, sea, or air provided that the following requirements are met:

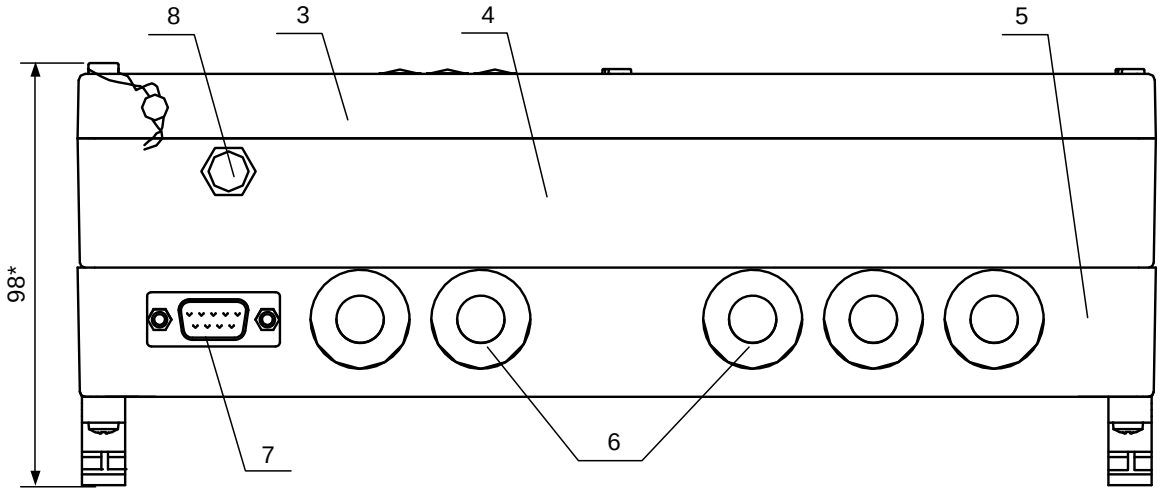
- Level gauge is transported packed in the manufacturer’s box
- Protection against moisture is provided
- Temperature is within the range of -30 to + 50°C
- Humidity does not exceed 98 % at + 35 °C
- Vibration is within the range of 10-500 Hz with maximum 0.35 mm amplitude or up to 49 m/s^2 acceleration
- Impact acceleration does not exceed 98 m/s^2
- Level gauges are fixed to prevent damages.

APPENDIX A. View of components



Weight no more than 2,5 kg

a) front view



b) bottom view

1 – indicator; 2 – keyboard; 3 – data processing module; 4 – SPS module; 5 – mount module; 6 – membrane plug; 7 – RS-232 port; 8 – grounding terminal.

* - reference dimension

Fig. A.1. Digital Measuring Block

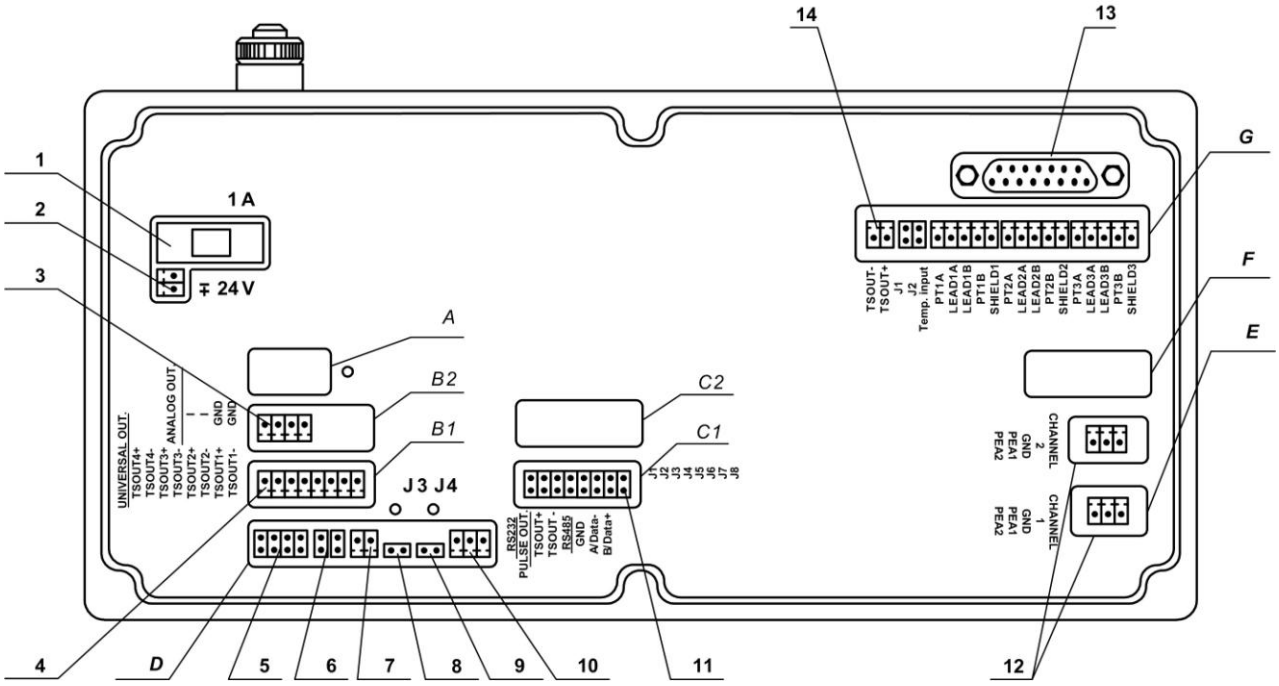


Fig. A.2. Measurement Subblock BMD-221 (rear view) comprising:

- "RS-232 / RS-485 / universal output 0" combined module
- 2 transmitting/receiving modules
- temperature module
- universal output (service) module 1-4 (installed in slot 1)
- current output (service) module 2 (installed in slot 2).

A, F – reserve windows;

B1, C1 – windows for connectors of additional external communication module mounted into slot 1;

B2, C2 – windows for connectors of additional external communication module mounted into slot 2;

D – window for connectors of "RS-232 / RS-485 / Universal output 0" Combined Module;

E – window for connectors of transmitting/receiving modules;

G – window for temperature output module;

1 – Fuse terminal block (1 A, DC 24V);

2 – DC 24 V power supply connector;

3 – Current output connector, output 2, Service module;

4 – Universal outputs connector, outputs 1-4, Service module;

5 – RS-232 interface connector, Combined module;

6 – J2, J1 terminals used to set operation modes for “Universal output 0”, Combined module;

7 – "Universal output 0" connector, Combined module;

8, 9 – J3, J4 terminals used to set level gauge's operation modes on the Combined module;

10 – RS-485 interface connector, Combined module;

11 – terminals used to set operation mode for Universal outputs 1-4, Service module;

12 – connectors of Transmitting/Receiving modules for connection of PEP communication cables to the 1st and 2nd channels respectively;

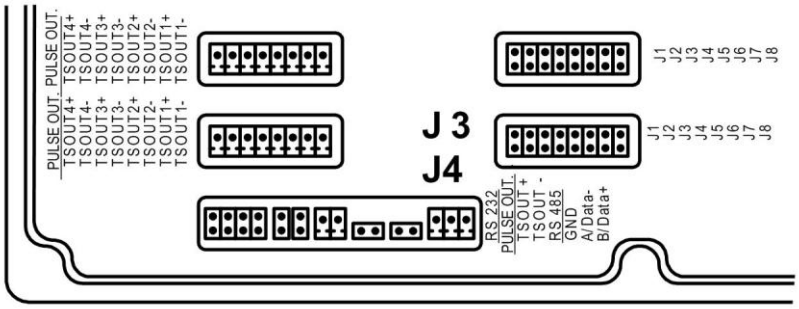
13 – service connector;

14 – connectors for temperature module outputs.

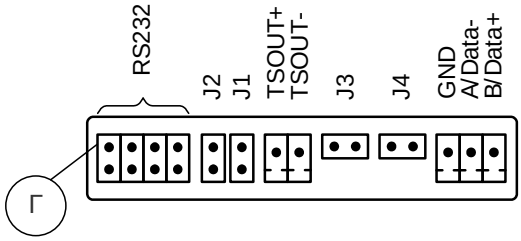
Marking of service module connectors

Output	Number of the slot where the module is installed	Output signals		Terminals	
		How the window is marked in Fig.A.2	Signals	How the window is marked in Fig.A.2	Terminals
Universal 1	1	B1	TSOUT1 +/-	C1	J1, J2
Universal 2			TSOUT2 +/-		J3, J4
Universal 3			TSOUT3 +/-		J5, J6
Universal 4			TSOUT4 +/-		J7, J8
Universal 5	2	B2	TSOUT1 +/-	C2	J1, J2
Universal 6			TSOUT2 +/-		J3, J4
Universal 7			TSOUT3 +/-		J5, J6
Universal 8			TSOUT4 +/-		J7, J8
Current 1	1	B1	I / GND		-
Current 2	2	B2	I / GND		-
Ethernet	1	B1	TX+,TX-, RX+, RX-		-

Example of marking the connection elements of combined module and two modules of universal outputs



Identification of signals and connectors on "RS-232 / RS-485/Universal output 0" combined module, D window

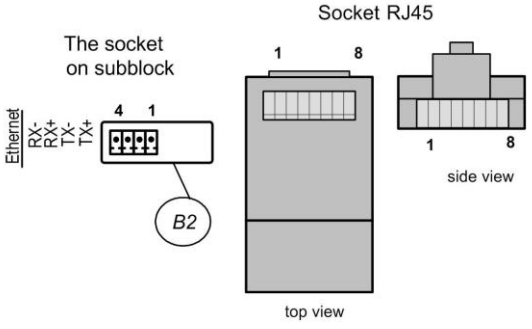


NOTE: The cable from an external RS-232 connector is connected to the RS-232 connector located on the Mount module (see Fig.A.1).

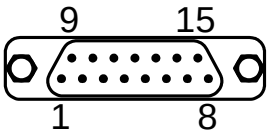
Ethernet connector in B2 window

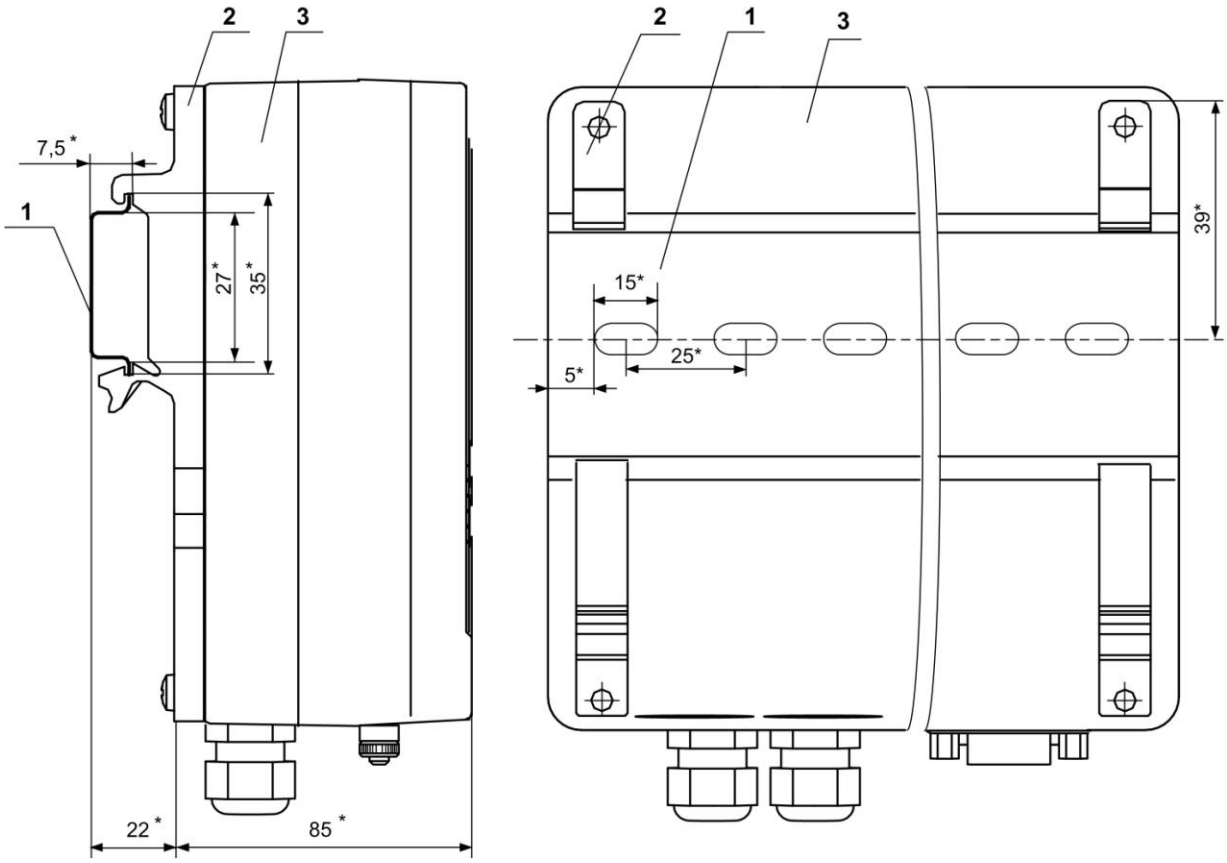
The socket soldering

circuit	No contact on subblock	No contact on RJ45	
		for connection to a network	for connection to a PC
TX+	1	1	3
TX-	2	2	6
RX+	3	3	1
RX-	4	6	2



Service connector (exterior view)

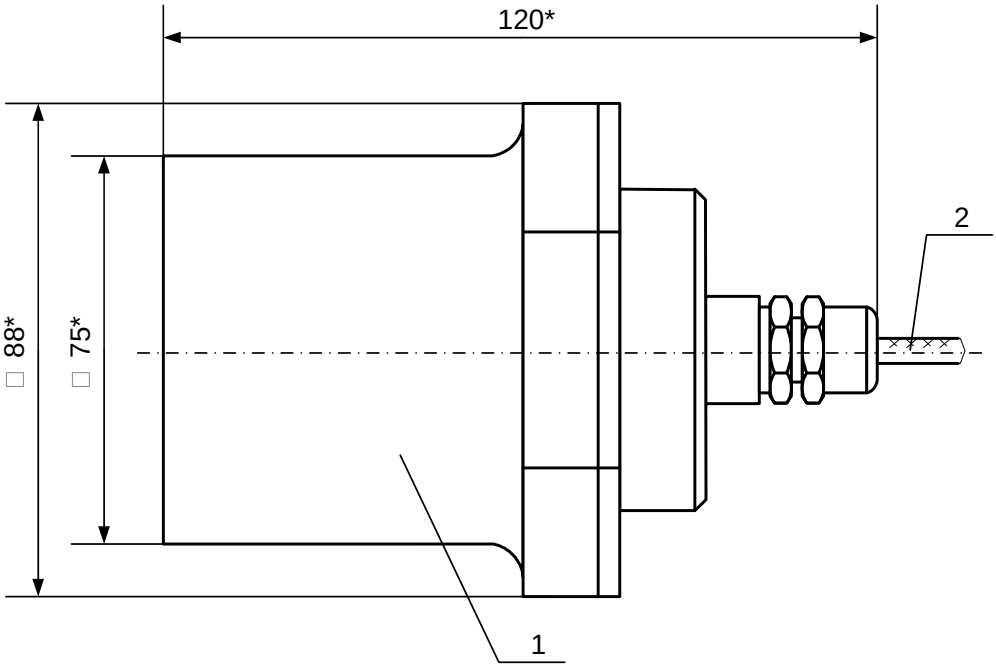




1 – DIN-rail; 2 – bracket; 3 – mount module.

* - reference dimension

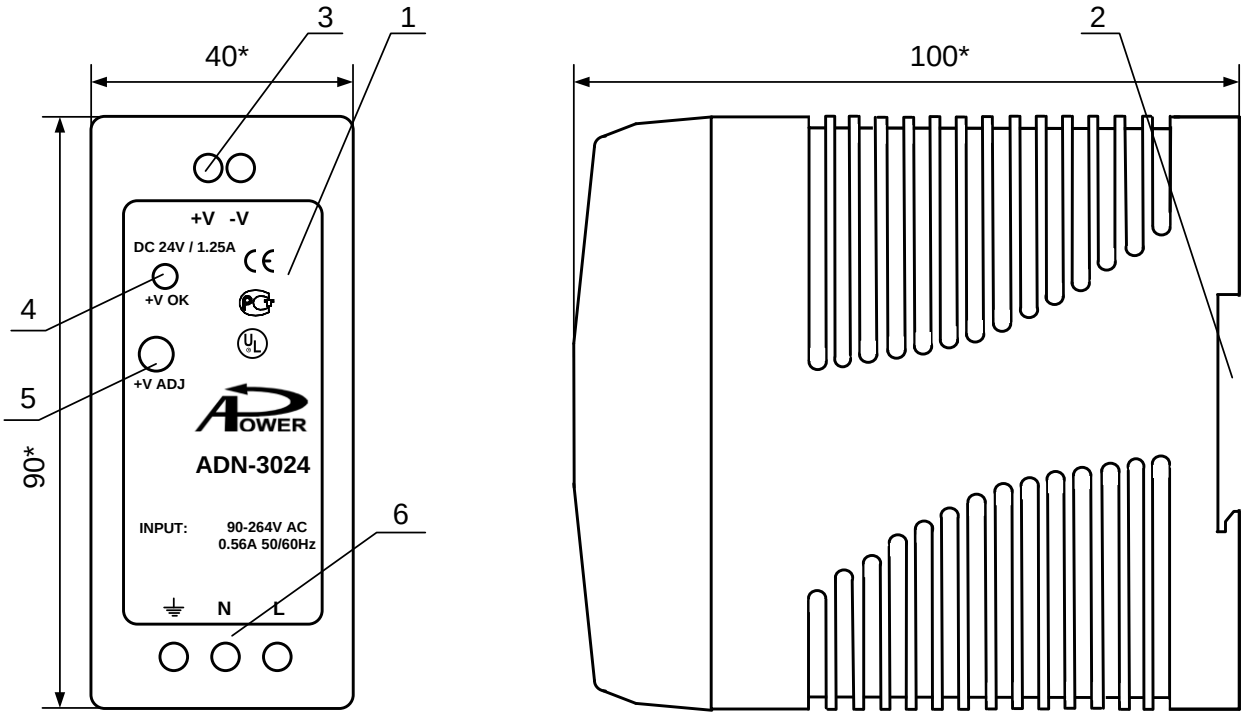
Fig. A.3. Mounting BMD on DIN-rail



1 – sensor case; 2 – cable for connecting to BMD

* - reference dimension

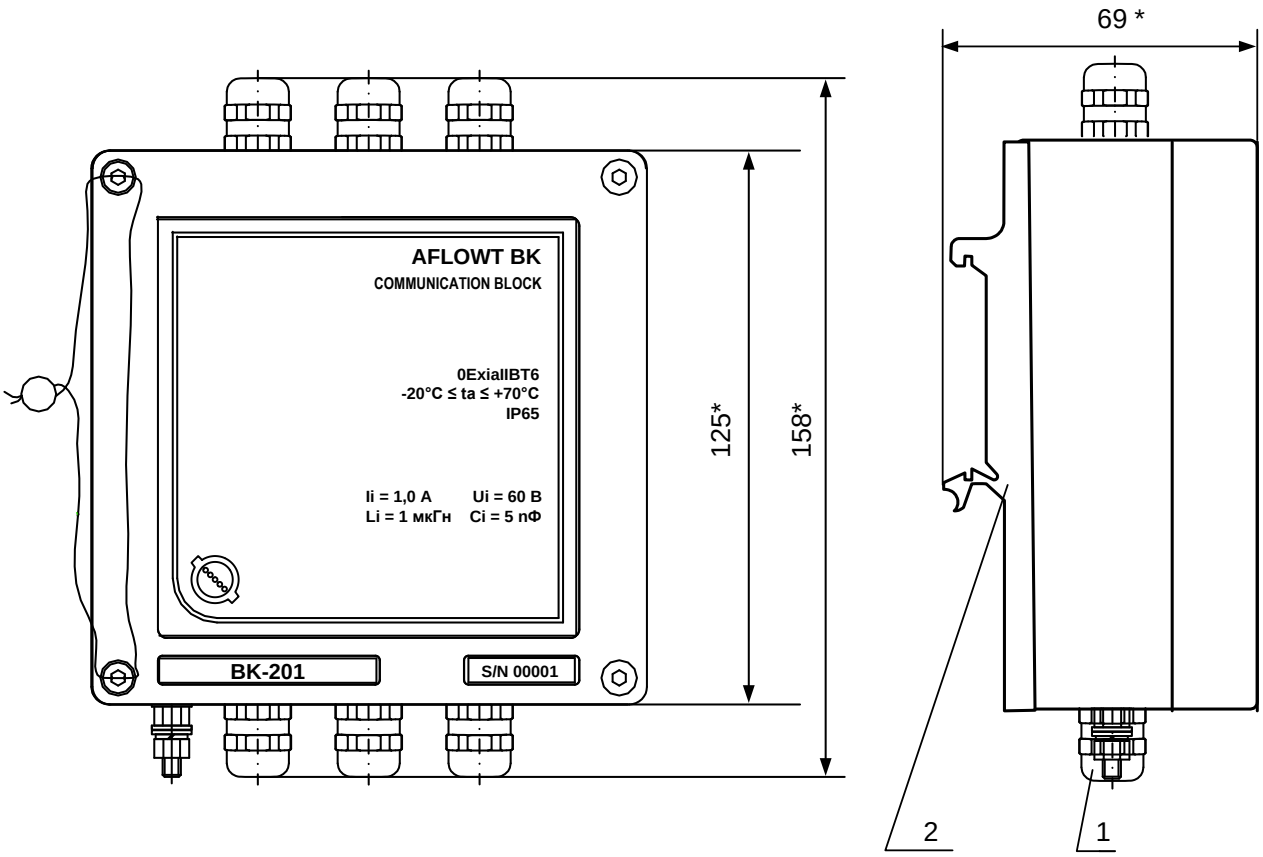
Fig. A.4. Piezoelectric converter



1 – power source; 2 – bracket for 35/7.5 DIN rack mounting; 3 – terminal block for DC 24V output voltage; 4 – Secondary Power Source indicator; 5 – contact hole for adjustment of output voltage; 6 – terminal block for connection to mains (AC 220V, 50Hz).

** - reference dimension*

Fig. A.5. Secondary Power Source ADN-3024



a) front view b) side view

1 – cable through; 2 – bracket

* - reference dimension

Fig. A.6. BK-201 Communication Block

APPENDIX B. Wiring diagram of Level gauge's output stage

The output stage of universal outputs (Fig.B.1) can be powered either from an external power source (passive mode) or internal power source (active mode).

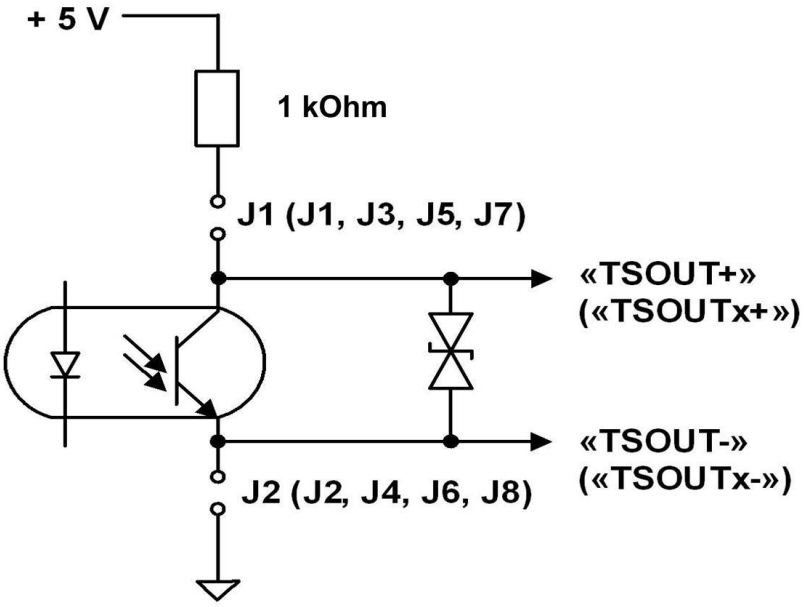


Fig. B.1. Universal outputs, circuit diagram of output stages

To match output stages to inputs of different types, the output stages are designed to work with either the internal galvanically isolated power source (active mode) or an external power source (passive mode). In standard supply configuration the output stages are in the passive mode.

Identifiers for the universal outputs are given in brackets.

In the active mode and in case that **Activity level** is set to <**high**>, output voltage in the logic mode and pulse amplitude in the pulse mode is within 2.4 to 5.0 V. In case of no pulse or at logic <**low**> the output voltage is less than 0.4 V. External load resistance shall be 1 kOhm as a minimum.

In the passive mode, power from an external power source with output DC voltage from 5 to10 V can be applied. Permissible value of external load current is no more than 10 mA. The output stages can be powered from an external power source with DC up 24 V. Amplitude of output pulses is limited by supressor's triggering voltage at 15 V level.

Connection of the output stage to the internal power source +5 V is made by placing jumpers between the corresponding terminals.

For the universal outputs, length of signal cables should be up to 300 m.