AFLOWT

TECHNOLOGICAL MAGNETIC FLOW METER

AFLOWT MFT

OPERATION MANUAL PART I

ISO 9001:2015

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Manufacturer quality management system is certified to ISO 9001:2015

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This document covers "AFLOWT MFT" Technological Magnetic Flowmeter hereinafter referred to as the flowmeter or the Device and contains information about its operation and design.

Part I is devoted to technical description, preparing for operation and maintenance. Part II describes how to use the flowmeter.

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

LIST OF ABBREVIATIONS

BE	- Electronic block
DN	- Nominal diameter
EMF	- Electromotive force
EPMC	- Primary measuring converter electromagnetic
LCD	- Liquid crystal display
MFT	- Technological Magnetic flowmeter
PFC	- Flow sensor (Primary flow converter)
SPS	- Secondary power source

NOTE. Words in the text marked in bold, for example, **FLOW DATA** correspond to the items displayed on the flowmeter's screen.

DESIGN VERSIONS

Flowmeter's design versions differ in the materials used to line the inner surface of the flow pipe and electrodes (considering the type of the medium under control).

The design versions available are identified as follows:

I F - xxx, I W - xxx	- General industrial version – **I**
A F - xxx, **A W - xxx**	- Aggressive version – **A** (for handling aggressive liquids)
F T - xxx	- Food industry design – **F**

Identification includes:

Connection type:

- **F** – Flanged
- **W** – Wafer
- **T** – Threaded
- **xxx** – Flowmeter's standard size (DN).

1. DESCRIPTION AND OPERATION

1.1. Purpose of the flowmeter

1.1.1. The flowmeter is designed to measure average volumetric flow rate and volume of the following liquid media (e.g., in pressure pipelines) depending on the design version:

- Mains water
- Solutions of food and technical acids, alkalis, salts, and other strongly aggressive media
- Liquid food products (juice, vine, beer, milk, sour cream, mayonnaise and etc)
- Abrasive media (pulp, slurry, waste water etc)
- Poorly conductive liquids (spirits, syrups, chemical-organic liquids etc).

The flowmeter is designed for use either in metal or plastic (metal-plastic) pipelines.

1.1.2. "AFLOWT MFT" Technological Magnetic Flowmeter provides the functions to:

- Measure average volumetric flow rate in either forward or reverse flow directions
- Totalize volume of forward and reverse flows independently and calculate their algebraic sum with regard to flow direction
- Record the time of operation
- Monitor filling of the pipeline with liquid
- Batching of preset liquid volume or batching in the "start-stop"
- Display measurement results
- Output measurement results to current, pulse or logical outputs
- Automatically monitor and display alarm conditions and faults
- Transfer measurement, diagnostic, configuration, and other data via RS-485 interface (using a cable, phone cable or radio channel) as well as via Ethernet, Profibus or HART interfaces
- Protect configuration settings from unauthorized access.

The flow meter also provides the calculation of the values of the mass flow and mass when introduced into the unit density values of the controlled fluid. The error in determining the mass flow and the mass is not normalized.

The flow meter also can control the filling of the pipeline with fluid.

1.2. Specifications

1.2.1. Specifications are listed in Table 1.

Table 1

Name of the parameter	Value												
1. Nominal diameter, DN	10	15	20	25	32	40	50	65	80	100	150	200	300
2. Maximal velocity of flow in the pipeline, v, m/s	10												
3. Maximal measurable volumetric flow rate, Qmax, m^3/h	2.5	6.3	10.0	16.0	25.0	40.0	63.0	100	160	250	630	1000	2500
4. Flowmeter's sensitivity to flow velocity, no less than, m/s	0.01												
5. Maximal pressure in the pipeline, MPa	1.6/2.5/4.0 depending on the flow sensor (PFC) design version												
6. Minimal specific conductivity of medium, S/m	10^{-4}												
7. Power supply	DC (24 ± 2.0) V (see section 1.2.2)												
8. Ambient temperature range, °C	see section 1.2.3												
9. Temperature of medium, °C	see section 1.2.3												
10. Power consumption, W	no more than 15												
11. Mean time to failure, h	75 000												
12. Mean life time, years	12												

NOTE:

1. Range of nominal diameters depend on the flowmeter's the design version.
2. Maximal permissible pressure in the pipeline is selected by the customer.

1.2.2. The flowmeter is powered from a stabilized (24 ± 2.0) V DC voltage. The flowmeter can be powered from mains AC 220 V 50 Hz via Secondary Power Source.

1.2.3. Operating conditions:

1.2.3.1. Environmental:

- Ambient temperature range from - 25 °C to + 70 °C, relative humidity up to 100 % at + 40 °C or below with moisture condensation
- Atmospheric pressure from 66.0 to 106.7 kPa
- Vibration: within 10 ... 55 Hz range, with up to 0.35 mm amplitude.

1.2.3.2. Temperature of the medium under control:

- From - 10 to + 150°C (PFC covered with fluoroplastic lining)
- From - 5 to + 70°C (PFC covered with polyurethane).

1.2.3.3. Maximal excessive operating pressure of the medium under control:

- For the flanged flowmeters (DN200, DN300) and flowmeters of "wafer pipe" type: 2.5 MPa; for the flanged flowmeters (DN20-DN150): 2.5 MPa or 4.0 MPa (optional)
- For the threaded (pipe connection) flowmeters: 1.6 MPa.

1.2.3.4. Protection provided by the enclosure: IP67 code.

1.2.4. View, overall dimensions and weight are given in Appendix A.

1.3. Metrological specifications

1.3.1. Limits of permissible relative error for measuring, displaying, logging, storing and transferring of volume and average volumetric flow rate measurement data for various liquids regardless of flow direction within $0.03 \cdot Q_{max}$ to Q_{max} range are as follows ± 0.35 %.

1.3.2. Limits of the supposed basic resulted error for measuring, displaying, logging, storing and transferring of volume and average volumetric flow rate measurement data for various liquids regardless of flow direction within $0.001 \cdot Q_{max}$ to $0.03 \cdot Q_{max}$ range are as follows ± 0.35 %.

1.3.3. Limits of permissible relative error for recording the time of operation are no more than ± 0.1 %.

1.4. Contents of the delivery package

Items of the delivery package are specified in Table 2.

Table 2

Name	Qty	Notes
"AFLOWT MFT" Technological Magnetic Flowmeter	1	Note 1
Installation kit	1	Note 2
Operating documentation: Passport	1	
Operation manual Installation manual	1 1	Note 3

NOTES:

1. Flowmeter's nominal diameter and design type (see section DESIGN VERSIONS) are specified in the purchase order.
2. The Installation kit includes: gaskets, power supply and interface connection cables, cable leads, seals, seal wire, and fittings.

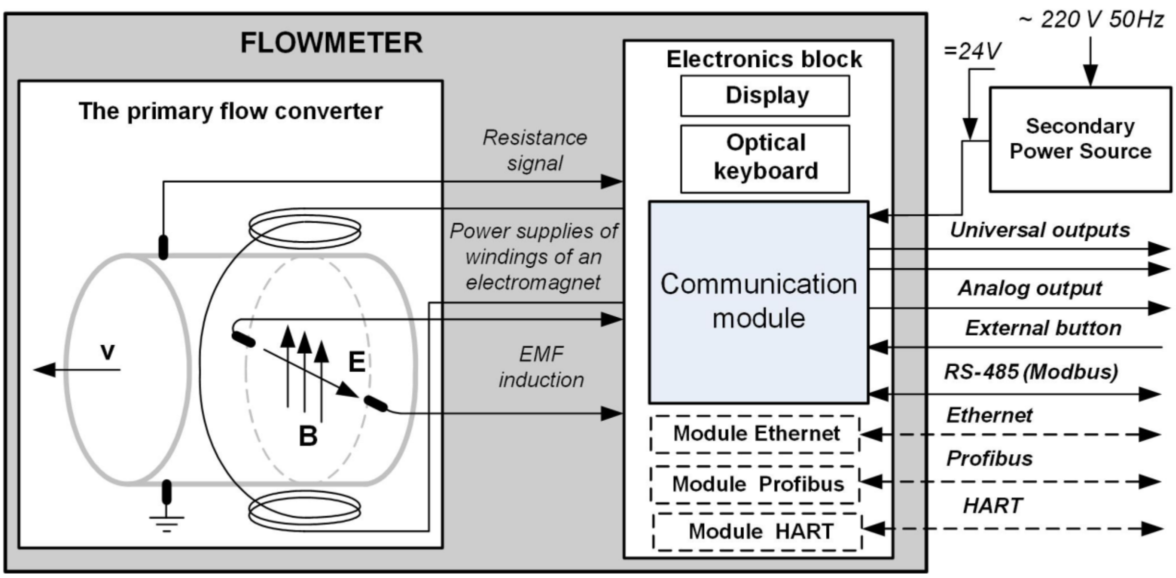
   The fittings for mounting on-site the flowmeters of flanged and "wafer pipe" types are provided on customer's request. The set of fittings may include: flanges, PFC dimension simulator, fasteners, and additional gaskets. The PFC dimension simulator is included in the delivery package for mounting the flowmeter of thread mount type.

   The fittings provided are rated at a pressure of 2.5 MPa or 4.0 MPa (optional).
3. Operating documentation for this product and other products are available on **www.aflowt.com**.
4. In the scope of delivery (if specified in the purchase order) may be included a secondary power source to power the flowmeter from mains AC 220 V, 50 Hz.

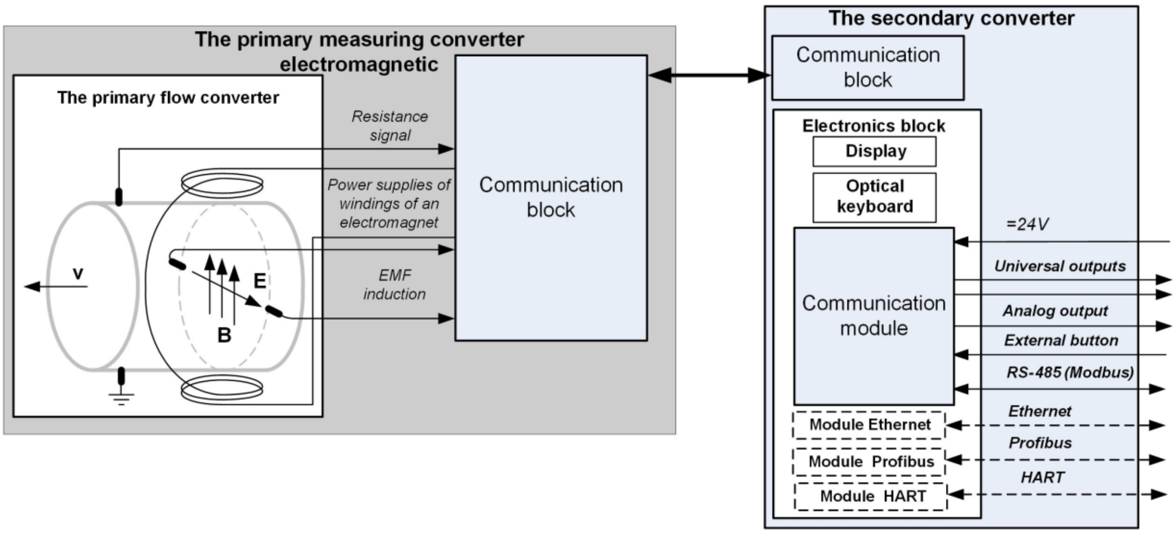
1.5. Design and operation

1.5.1. Operation principle

MFT operation principle is based on measuring electromotive force (EMF) induced in electrically conductive liquid when it moves in magnetic field. The magnetic field is furnished in the flow sensor's inner channel by a special electromagnetic system (see Fig.1).



a) Structure of the flowmeter combined version



b) Structure of the flowmeter remote version

Fig.1. Flowmeter's block diagram

The Flow Sensor (PFS) is designed as a hollow cylinder made of non-magnetic material with solenoid coils located outside. The inside of the cylinder is covered with an electrically insulating material (lining). The induced signal is picked up by two electrodes, which are in conductive contact with the liquid under control.

To measure electrical resistance of medium in the flow sensor's vertical plane, there are two additional electrodes located at diametrically opposite points, one of which (a lower one) is connected to the Device's case.

1.5.2. Device structure

1.5.2.1. The flowmeter combined version consists of the primary transducer (electromagnetic flow sensor) and secondary converter which is a microprocessor-based electronic block (BE). The flowmeter remote version consists:

- Primary measuring converter electromagnetic (EPMC), consisting of a primary flow sensor and communication block
- Remote Secondary Converter, consisting of a communication block and microprocessor-based electronic block, connected by a cable pumping and measuring cable.

Communication block (CB) provides connection of the Secondary Converter and EPMC.

BE includes the power supply module, Communication board, primary measuring converter, and additional interface output module.

1.5.2.2. The purpose of BE is to:

- Provide power supply for solenoids (through Communication block in the remote version)
- Receive and process induced EMF signals and determine average volumetric flow rate
- Determination of volume and mass of fluid progressive total separately for forward and reverse direction of flow, and total values of volume and mass with or without regard to flow direction
- Receive and process medium resistance measurement signals
- Convert the measurement values of average volumetric flow rate into output signals represented as a pulse sequence or signal of current
- Determine flow direction and generate flow direction signals in the form of logic signals
- Provide data exchange via RS-485 interface
- Totalize volume and time of operation
- Perform MFT diagnostics
- Store configuration settings and collected data.

The type of an optional interface output module (Ethernet, Profibus or HART) is specified in the purchase order.

1.5.3. Access levels

1.5.3.1. The flowmeter has three levels of access to setting and calibration parameters:

- “**CALIBR**" – adjustment and calibration
- “**SERVICE**" – start-up procedures
- “**WORK**" – operation (user) mode.

To change a mode activated in the device, it is necessary to place a jumper on J1 terminal and SK4 switch located on the Communication board (see Fig.A.5, Appendix A). If no jumpers are placed, the flowmeter operates in "**WORK**" mode.

Names and description of operation modes along with the corresponding terminals to be closed with the jumpers are given in Table 3.

Table 3

Mode	Terminal		Mode description
	J1	SK4	
CALIBR	+	off	Adjustment and calibration
SERVICE	-	on	Start-up procedures
WORK	-	off	Operation

1.5.3.2. The operating modes differ by level at which the user can access certain data (displayed and/or transferred via RS-485, Ethernet, or Profibus interfaces) and modify flowmeter's configuration settings.

Maximum rights are granted in "**CALIBR**" 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 "**WORK**" mode.

1.5.3.3. "**WORK**" – flowmeter's on-site operation. In "**WORK**" mode, the user can view the following parameters:

a) Values being measured

b) Time of operation.

"**WORK**" mode gives the possibility to control the User counter in the "start-stop" mode.

1.5.3.4. "**SERVICE**" – start-up procedures. In this mode, access to configuration settings is protected by a password. The protection can only be removed in the "AFLOWT MFT" program.

In "**SERVICE**" mode, in addition to the above, available in "**WORK**" mode, the operator can do the following:

a) Without entering a password – view all values of the configuration settings

b) After entering a password – view and modify the following configuration settings:

- Settings related to RS-485, Ethernet, Profibus, HART operation
- Settings for the control input and universal outputs
- Constant for the Flow rate signal filter and settings for the Automatic flow rate setup module
- "Pipeline filling" settings
- Flow rate measurement units [(m^3/h, l/min), (t/h, kg/min)] and volume measurement units [(m^3, l), (t, kg)]
- Password to access modification of configuration settings.

1.5.3.5. "**SERVICE**" mode allows the user to view and modify all of the settings.

Adjustment during manufacture and after-calibration adjustment are made in this mode.

1.5.3.6. Configuring the settings in "**SERVICE**" mode does not affect flowmeter’s metrological characteristics and can be performed on-site, if necessary.

In "**SERVICE**" and "**WORK**" modes, adjustment and calibration settings are inaccessible.

1.5.4. External connections

1.5.4.1. Output interfaces

RS-485 serial interface and Ethernet interface are used to control the flowmeter, read measurement results, configuration settings, and diagnostic data as well as to modify configuration settings. The RS-485 interface supports ModBus (RTU ModBus and ASCII ModBus).

The 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.

Data transfer rate via RS-485 interface (from 2400 to 115200 baud) as well as communication properties are set from a PC.

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 on request.

Profibus interface is used to connect the flowmeter to an industrial network and to read measurement, configuration and diagnostics data.

The HART interface is used to read the measuring information and control the device in SCADA systems. HART protocol is based on Frequency Shift Keying (FSK) method of data transmission in accordance with Bell 202 communication standard. Digital information is transmitted at frequencies of 1200 Hz (logical 1) and 2200 Hz (logical 0), which are superimposed on the analogue current signal.

The frequency-modulated signal is bipolar and does not affect the main analogue signal of 4-20 mA if the appropriate filtering is used. The baud rate for HART is 1.2 kbps. The HART protocol implements levels 1, 2 and 7 of the ISO/OSI standard reference model. In addition, the protocol provides an add-on to level 7 in the form of a HART Device Description Language.

The flowmeter with HART-interface can be connected to the registering device in different ways:

- Via a remote communication device with the object, for example, SIMATIC ET200M with HART modules
- Via a HART-modem, which establishes a point-to-point connection between the PC or workstation and the flowmeter
- Via HART multiplexers

Ethernet, Profibus and HART connection diagrams are shown in Fig.A.12-A.14 (Appendix A).

1.5.4.2. Control input (button)

The control input is used to start batching a pre-defined liquid volume (mass) or to start and stop batching in the "start/stop" mode based on the control signal. Control input circuit diagram and control signal characteristics are given in Appendix B.

1.5.4.3. Universal outputs

MFT has two galvanically isolated outputs: N1 and N2. The outputs are universal both regarding the operation modes (frequency, pulse or logical) and function (flow rate in absolute value, forward flow rate and reverse flow rate). For how to set functions of the outputs see Table 4.

When working in the pulse and frequency mode, the outputs can be used to transfer measurement results in the form of square pulse sequence with period-to-pulse duration ratio of 2 and standardized pulse weight. The maximum pulse repetition rate is 2000 Hz.

Output scaling constant **KP** (p/l) or **KPm** (p/kg) that determines the pulse weight may be set within the range from 0.0001 to 9999 with 0.0001 increment. To calculate **KP** (**KPm**) having regard to the maximal flow rate in the pipeline where the flowmeter is installed and frequency characteristics of the input receiving the pulse signal, the following formula may be used:

$$KP(p/l) \leqslant \frac{3{,}6 \times F}{Q_{max}} = \frac{1{,}8 \times 10^3}{Q_{max} \times \tau_p}$$

Where: Q_{max} – maximal flow rate in the pipeline under operating conditions, m^3/h (t/h)

F – maximal flowmeter's pulse repetition rate permissible for a receiving input, Hz

$\tau_p = \frac{T_p}{2}$ – minimal flowmeter's pulse duration permissible for a receiving input, ms

T_p – pulse repetition period for the pulses at the MFT output, ms.

Table 4. Functions of the universal outputs

Operation mode	Displayed symbol	Condition for generating signal / changing state on the output
1	2	3
Frequency	**Q– (Qm–)**	Flow rate for reverse flow (negative flow direction)
	Q+ (Qm+)	Flow rate for direct flow (positive flow direction)
	│Q│(│Qm│)	Flow rate for any flow direction
Pulse	**V– (M–)**	Volume (mass) for reverse flow
	V+ (M+)	Volume (mass) for direct flow
	│V│(│M│)	Volume (mass) for any flow direction
	batch. stop im	Pulse stop of the batching
Logic	**Reverse flow**	Flow direction is changed
	Q > Qmax	Q_{max} value is exceeded
	Error	Any error detected by the flowmeter
	Batch. sign.	Start / Stop batching
	Power	Interruption of power supply
	R out range	Measured value of resistance exceeds the specified value
	Empty pipe	Value of resistance exceeds the threshold specified for the empty pipe
	Q out range	Value of flow rate falls outside the specified range
	Q < Qlow	Current value of flow rate is low than low rate value
	Q > Qhigh	Current value of flow rate is more than high rate value

The default mode for N1 output is the frequency mode; the default KP value is specified in Table 5 and corresponds to a frequency of approximately 1500 Hz at Q_{max} flow rate.

Table 5

DN, mm	10	15	20	25	32	40	50	65	80	100	150	200	300
KP, p/l	1600	700	400	250	160	100	65	40	25	15	7	4	1,7

♦ In the frequency mode, frequency is proportional to average volumetric flow rate measured over previous 80 ms.

For the frequency mode, the values of **KP** and **Active level**, as well as maximal frequency (**Fmax**), emergency frequency (**Femeg**) and flow rate cutoff value (**Q up thresh.**) should be selected.

Active level is the signal level (**high** or **low**) related to the presence of a pulse. Electrical parameters of the corresponding signal levels are specified in Appendix B.

Maximal frequency is the frequency of output signal corresponding to the maximal flow rate in the pipeline. If the maximal frequency value is exceeded, this is identified by the flowmeter as an alarm condition, i.e. the value of KP set for this output is incorrect.

Emergency frequency is the pulse repetition rate of a pulse sequence (no more than 2000 Hz) generated on the output if the measured flow rate exceeds Q_{max} for a given DN. The value set for the emergency frequency must be no less than the maximal frequency value specified for this output. To disable the emergency frequency function, it is necessary to set 0 for **Femeg** parameter.

Flow rate cutoff is the value of maximal flow rate that is less than or equal to Q_{max} under change of which the value of **KP** is recalculated automatically to maintain **Fmax** in the frequency mode or **Tpulse** in the pulse mode.

For how to set functions of the outputs in the frequency mode see Table 4.

Flow rate in absolute value **|Q|(|Qm|)** corresponds to a pulse sequence with pulse repetition rate proportional to the measured flow rate generated on the output regardless of flow direction. Forward flow rate **Q+ (Qm+)** corresponds to the pulse sequence generated only for forward flow. **Q- (Qm-)** implies that the pulse sequence is only generated for reverse flow.

♦In the pulse mode, a burst of pulses is generated on the output within a second, in which the number of pulses (considering pulse weight) corresponds to the flow volume measured over a previous second.

For the pulse mode, you should specify **KP, Active level**, pulse period **Tpulse**, and flow rate cutoff value (**Q up thresh.**).

Pulse period **Tpulse** is the pulse repetition period in a burst that may be set from1 to 1000 ms.

For how to set functions of the outputs in the pulse mode see Table 4. Volume in absolute value **|V|(|M|)** corresponds to a pulse sequence with the number of pulses proportional to the measured volume, the sequence is generated on the output regardless of flow direction. Forward volume **V+ (M+)** corresponds to a pulse sequence generated only for direct flow. Reverse volume **V- (M-)** means that the pulse sequence is generated only for reverse flow.

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

For the logic mode, you should specify **Active level** parameter. For how to set functions of the outputs in the logic mode see Table 4.

- **Direction** – Signal level on the output is changed without lag on changing flow direction
- **Q > Qmax** – Signal level on the output is changed if the actual value of flow rate exceeds Q_{max} for a given DN
- **Error** – Signal level on the output is changed in case of any alarm situation detected by the flowmeter
- **Power** – High signal level is generated if power is applied to the Device; in case of power supply failure output signal is absent
- **R out range** – Signal level on the output is changed if the measured value of resistance exceeds a specified value
- **Empty pipe** – Signal level on the output is changed if the value of resistance exceeds the threshold specified for the empty pipe
- **Q out range** – Signal level on the output is changed if the value of flow rate falls outside the specified range.

Software for all modes sets the value of the **Active level**, i.e. the signal level (**high** or **low**) corresponding to the occurrence of an event.

Diagram showing an output stage of universal outputs is given in Appendix B.

1.5.4.4. Analogue output

Analogue output can operate in one of three ranges: 0-5 mA, 0-20 mA or 4-20 mA.

The standard curve of the analogue output is calculated as follows:

$$Q_v = Q_{lt} + (Q_{ut} - Q_{lt})\frac{I_{out} - I_{min}}{I_{max} - I_{out}},$$

$$Q_m = Q_{mlt} + (Q_{mut} - Q_{mlt})\frac{I_{out} - I_{min}}{I_{max} - I_{out}}$$

Where Q_V (Q_m) – measured flow rate value, m^3/h, l/min (t/h, kg/min);

Q_{lt} (Q_{mlt}) – specified value of lower threshold for the analogue output corresponding to I_{min}, m^3/h, l/min (t/h, kg/min)

Q_{ut} (Q_{mut}) – specified value of upper threshold for the analogue output corresponding to I_{max}, m^3/h, l/min (t/h, kg/min)

I_{out} – value of output current signal corresponding to the measured flow rate, mA

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

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

The analogue output is configured by setting the operating range, setpoints and function. If **Flow** value is activated for **Param.** option, current proportional to the measured flow rate is generated on the output regardless of flow direction.

Analogue output filter is configured by setting the value for "**Kfilter**" factor which is selected from 0 to 39 range. The approximate time for establishing the filter response in relation to Kfilter factor values are given in Table 6.

Table 6

Kfilter factor value	0	10	20	30	35	39
Approximate period for establishing filter response, s	1	3	4	11	22	117

NOTE. The filter response establishing periods are given for reference.

Current output in ranges 0-20 мА or 4-20 мА can work on load resistance up to 1 kOhm, in range 0-5 мА – to 2,5 kOhm.

Permissible length of a signal cable connected to the analogue output depends on resistance of the corresponding signal circuit. The condition is that the sum of input resistance of a connected analogue input and signal circuit resistance must not exceed the above-specified external load resistance.

1.5.5. Design

1.5.5.1. The design of the flowmeter's flow pipe depends on the pipe connection type and may be as follows:

- Wafer connection type (DN10, DN15): PFC is fixed by studs between the flanges welded to the pipeline ends
- Flanged type (DN20-DN300): PFC flanges are bolted to the mating pipeline flanges
- Threaded coupling connection type (DN15, DN32, DN40, DN50, and DN80).

View, overall dimensions and weight of the flowmeters of different design types are given in Fig.A.1-A.8, Appendix A.

Inner surface of the Flow Sensor is covered by fluoroplastic or polyurethane.

To protect fluoroplastic lining during mounting and operation, PFC is equipped with protection rings that are installed on its end faces. The protection rings used with the flanges provide alignment of PFC inner channel with the mating flanges.

Electrodes in contact with the controlled fluid, depending on the purpose of the flowmeter (controlled fluid) are made of different materials. Marking with the designation of the electrode material (H – stainless steel, Ta – tantalum or Ti – titan) is applied to the cylindrical surface of the projection of the flow part of the flowmeter for the connection of type "wafer" or flange of the flowmeter.

In the combined version of the flowmeter electronics is mounted on the flow sensor. In the remote version on the flow sensor is mounted in the communication block to be connected to the communication line from the Secondary Converter's communication block.

1.5.5.2. The Electronic Block includes the Communication board, LCD and optical keyboard.

BE is housed in a metal cylindrical case with covers screwed on two sides. The front cover has a transparent front panel. LCD and optical keyboard are placed beneath the front panel. The keyboard keys are activated by placing a finger (or an object) over a photosensitive cell.

PFC case and hollow BE fixing stand (or CB in the remote version) are made of metal. It is possible to turn BE about the stand axis by 90° (in both directions) or maximum by 180° (factory-installed or installed on start-up upon customer's request).

If necessary (for convenience of display reading), the display may be set on the Electronic block at an angle of 90° clockwise (factory-installed upon customer's request).

The top of BE case is thickened in the shape of quadrangular prism with the holes located on opposite sides. The holes are used to enter power cable and signal cables.

The screw on BE (CB) case is used as a grounding terminal. The wire for connection with the earthing trunk line is fastened to the screw.

1.6. Marking and sealing

1.6.1. The BE front panel bears:

- Name and identification
- Manufacturer's trademark
- Mark of conformity with EU Directives.

On top of the case located nameplate, with indicated (see Fig.A.10, Appendix A):

- Design version
- The serial number of the flow meter
- Characteristics of the flow meter (power supply voltage, the maximum pressure and temperature of the controlled fluid, the code protection).

1.6.2. To avoid misconnection, there is a sticker on the Device's rear cover where all connection elements are appropriately marked (see Fig.A.11).

1.6.3. After calibration, the terminal used to enable modification of calibration settings is sealed.

1.6.4. To protect the device from unauthorized access during transportation, seals may be hung on the BE case cover.

2. OPERATION

2.1. Operating restrictions

2.1.1. Environmental restrictions are specified in section 1.2.3 of this manual.

2.1.2. MFT may be mounted into the pipeline installed horizontally, vertically or obliquely. Special filters or dirt traps are not needed.

2.1.3. For precision and reliable operation, when choosing PFC mounting location, the following conditions must be met:

- No air collection in the mounting location
- Liquid pressure in the pipeline must not be of values that may facilitate gas release
- Straight pipe runs of appropriate length and DN equal to flow sensor’s (PFC) DN must be provided upstream and downstream the flow sensor. The runs must not include devices or components that may disturb flow structure
- When the Device is operated, PFC inner channel must be fully filled with liquid
- Intensity of external magnetic field (commercial frequency) should not exceed 400 A/m.

CAUTION! DO NOT touch the electrodes in the PFC inner channel at any step of working with the flowmeter.

Mounting considerations and mounting (dismounting) instructions are given in "Technological Magnetic Flowmeter "AFLOWT MFT". Installation manual" document.

2.1.4. Type and composition of medium (suspensions and their concentration, impurity substances, etc.), operating mode and pipeline conditions must not lead to sediments affecting performance and metrological characteristics of the flowmeter.

To provide proper operation of the flowmeter in pipelines equipped with carbon filters, it is necessary to keep the filters in good condition.

2.1.5. Grounding system is arranged according depending on power supply value and environment conditions.

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

2.1.7. 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 flowmeter in other location.

2.2. Selecting standard size

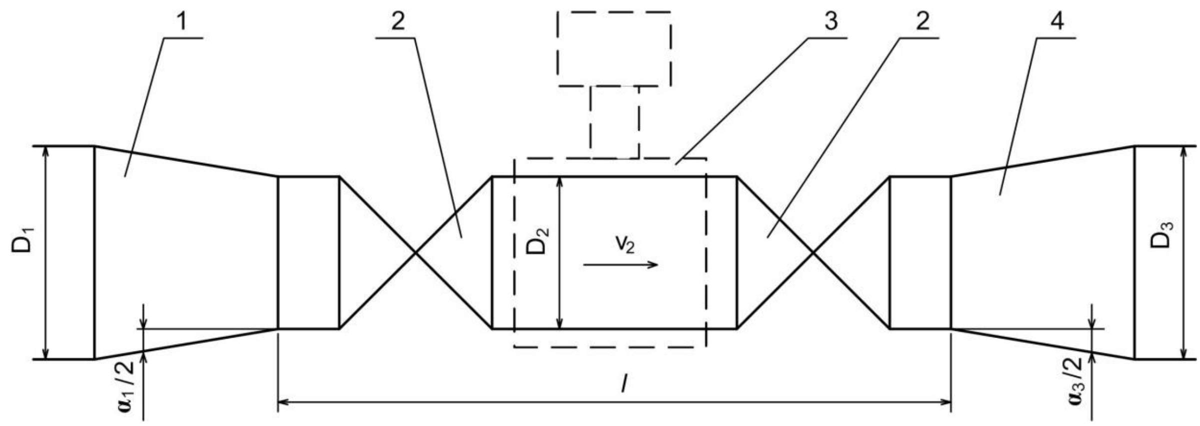
2.2.1. Flowmeter’s standard size is selected on the basis of flow rate range in the pipeline where PFC is installed. If several sizes are suitable, the standard size is selected from the specified limit of pressure losses.

2.2.2. If the selected DN is less than DN of the pipeline where PFC is expected to be installed, you may use pipe reducers (confusor and diffusor).

2.2.3. To evaluate hydraulic losses in the <confusor-PFC-diffusor> system, you may use the method represented in Fig.2.

2.2.3.1. Initial values for evaluation of the hydraulic losses:

- Liquid volumetric flow rate in the pipeline	- Q (m^3/h)
- DN of the inlet pipeline	- D_1 (mm)
- DN (standard size) of PFC	- D_2 (mm)
- DN of the outlet pipeline	- D_3 (mm)
- Confusor taper angle	- α_1 (deg.)
- Diffusor taper angle	- α_3 (deg.)
- Length of the straight pipe run	- l (mm).



1 – confusor; 2 – full bore spherical valve; 3 – PFC; 4 – diffusor.

Fig.2. Pipeline at PFC mounting location

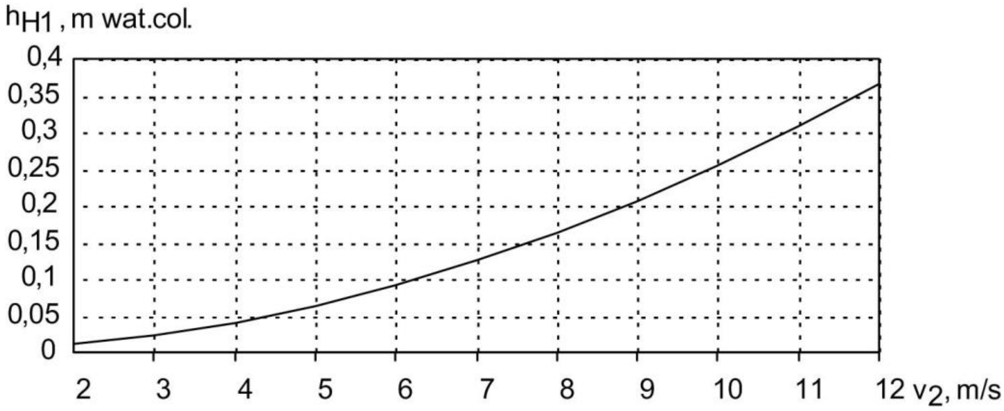
2.2.3.2. According to superposition principle, pressure losses in the <confusor-PFC-diffusor> system $\mathbf{h_H}$ are the sum of pressure losses in the confusor $\mathbf{h_{H1}}$, losses in the straight pipe run (having length l) $\mathbf{h_{H2}}$ and losses in the diffusor $\mathbf{h_{H3}}$:

Hydraulic losses in the confusor are determined according to Graph 3a, where $\mathbf{v_2}$ is flow velocity in the straight pipe run. The Graph of hydraulic losses as a function of flow velocity is calculated for confusor taper angle $\alpha_1 = 20°$. To determine flow velocity by volumetric flow rate Q, you may use Graph 4 or the formula:

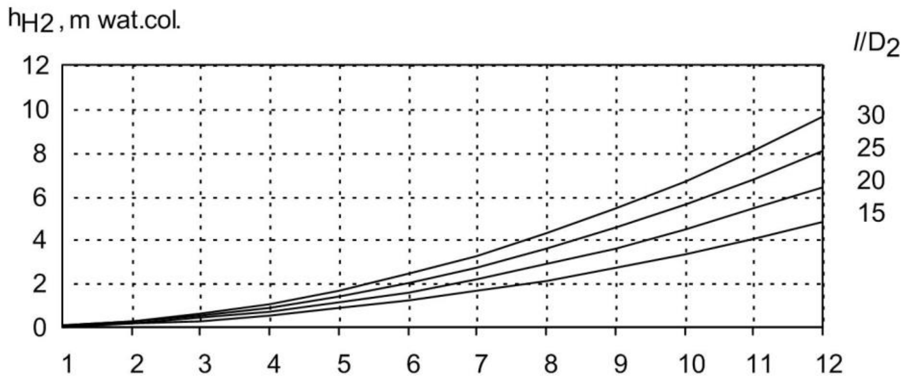
$$v\,(m/s) = \frac{Q\,(m^3/h)}{0{,}9\pi \times DN^2 (mm)} \times 10^3 .$$

Hydraulic losses in the straight pipe run are determined according to Graph 3b. The Graph of hydraulic losses as a function of flow velocity corresponds to straight pipe run length-to-diameter ratio 15, 20, 25, and 30.

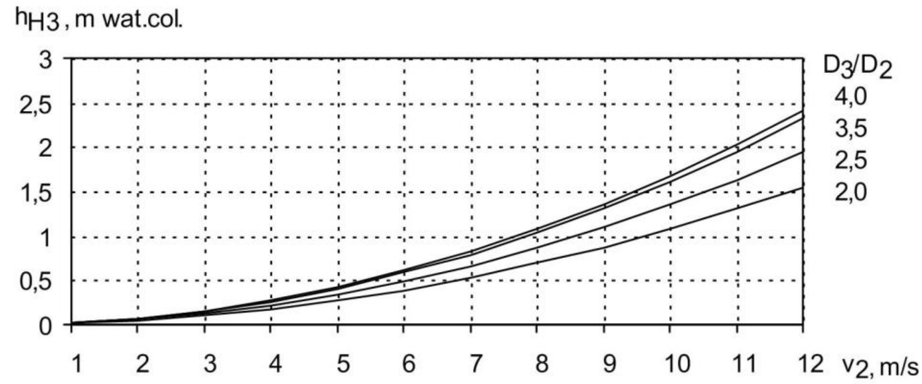
Hydraulic losses in the diffusor are determined according to Graph 3c. The Graph of hydraulic losses as a function of flow velocity is calculated for diffusor taper angle α_3 = 20° and corresponds to diffusor's maximal-to-minimal diameter 2.0, 2.5, 3.5, and 4.0.



a)



b)



c)

Fig.3. Graphs of hydraulic losses in confusor (a), straight pipe run (b) and diffusor (c)

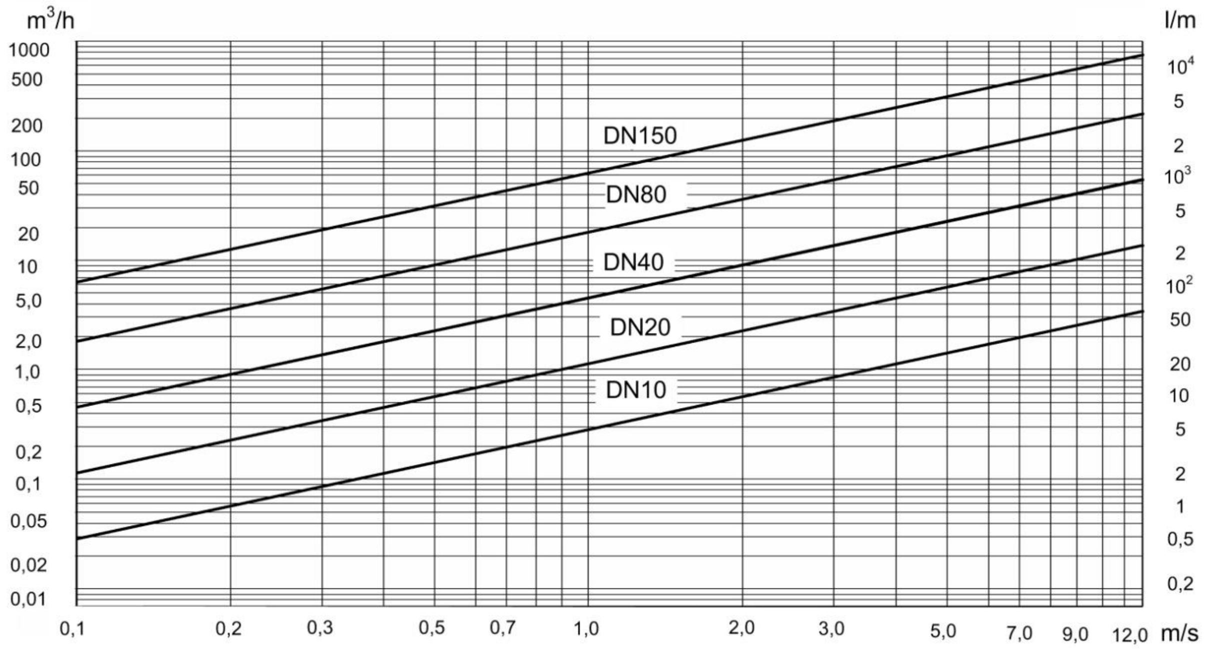


Fig.4. Graph of flow rate vs flow velocity for various DNs

2.3 Preparing for operation

2.3.1. Safety instructions

2.3.1.1. The flowmeter should only be used by personnel familiar with all operational documentation for the product.

2.3.1.2. When working with the flowmeter, the dangerous factors are as follows:

- AC voltage with RMS up to 264 V when the Device is powered from SPS
- Pipeline pressure (up to 4.0 MPa)
- Temperature of medium (up to 150 °C)
- Other installation site-specific factors.

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

- Connect to the flowmeter, switch over modes and replace electronic components, if the flowmeter is powered up
- Remove the flowmeter from the pipeline until pressure in the pipeline section worked on is fully released
- Use defective electronic devices and electric tools or use them without proper grounding.

2.3.2. The flowmeter is put into operation in accordance with the instructions given in section 5 of the installation manual.

3. MAINTENANCE

3.1. Maintenance check

3.1.1. It is recommended to check on regular basis that:

- Device's performance corresponds to the technical specification
- Operating conditions are met
- Power supply voltage is present
- No external defects are detected
- Electrical and mechanical parts are reliably connected.

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

3.1.2. If operating conditions specified in sections 1.2.3 and 2.1 are not observed, this may lead to the flowmeter’s fault, or the permissible limits of relative measurement error may be impaired.

External defects on the flowmeter or power cable can also lead to the flowmeter's fault or growth of the permissible limits of relative measurement error. Therefore, when the above-specified external defects of the product or power supply cables are detected, contact the manufacturer's representative office for the information about the device’s operability.

3.1.3. During device’s lifecycle, it is necessary to check the PFC inner channel for dirt or/and sediment no less than once a year. Slight layer of sediment that can be removed with a soft damp cloth is permissible.

If dirt and/or sediment of other type or in considerable amount are detected, it is necessary to clean the surface of PFC and send the flowmeter for unscheduled calibration.

In this case, it is recommended to clean the flow sensor immediately after removing it from the pipeline with a clean cloth moistured in water and non-abrasive detergent.

3.1.4. Before dispatching the flowmeter for calibration or repair, clean the PFC inner channel from sediment and liquid residues after dismounting. **Rests of aggressive liquid must be neutralized**.

Mounting and dismounting of the flowmeter is regulated by the installation manual.

When the flowmeter is sent for service, the Passport must be enclosed. Please specify post details, phone/fax numbers along with the way and address for redispatching.

3.2. Calibration

"AFLOWT MFT" flowmeter shall undergo primary post-manufacture calibration and calibration after each repair, and then regular calibration shall be performed during operation.

Calibration interval is 4 years.

4. PACKING, STORAGE AND TRANSPORTATION

4.1. "AFLOWT MFT" Flowmeter is packed into a separate container (corrugated carton or wooden box) along with the operational documentation (on request).

The set of fittings is delivered as an assembly or in bulk in a separate box.

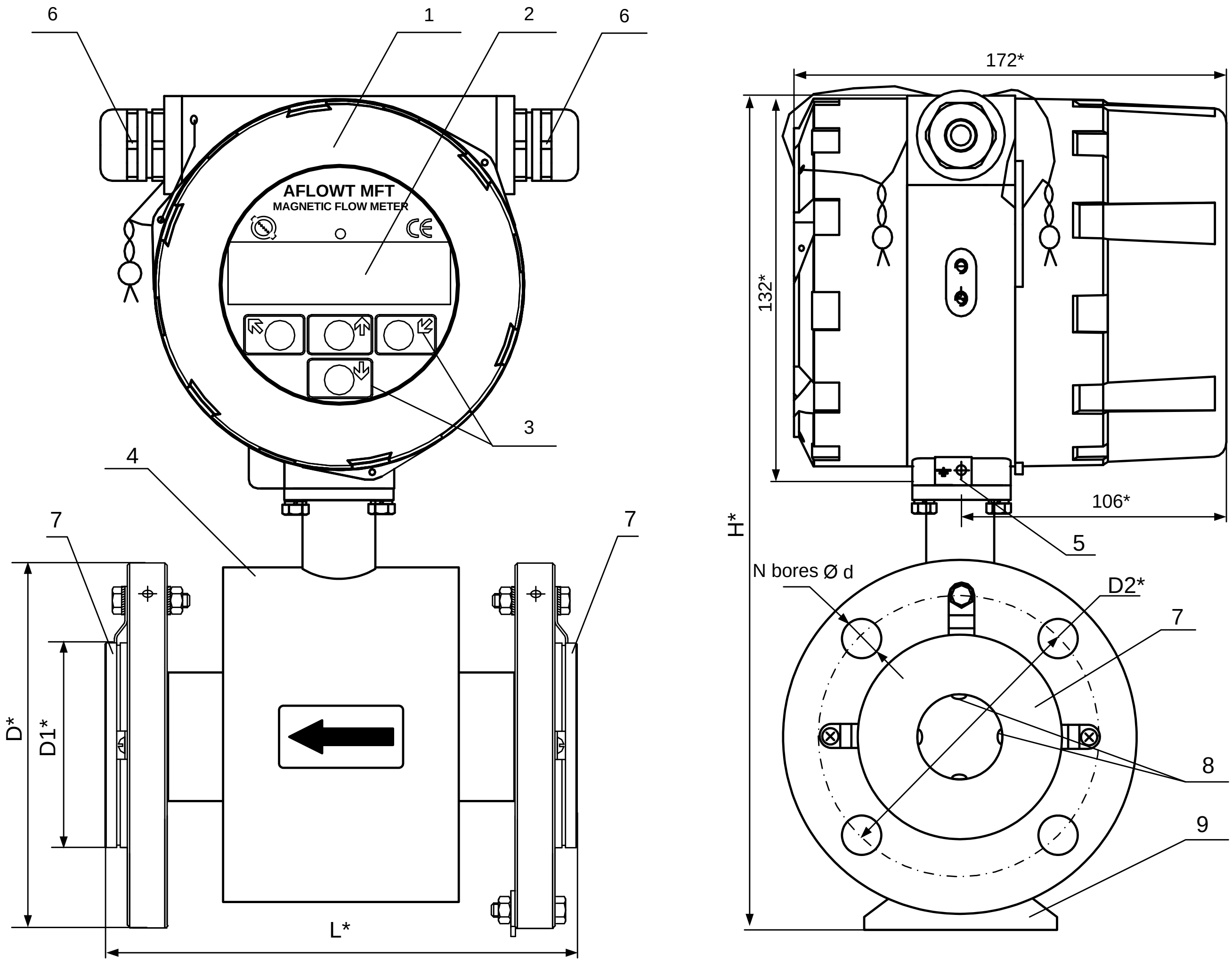
4.2. The flowmeter should be kept in the manufacturer's box in a dry heated storeroom. The storeroom should be free from current-conductive dust, acid or alkali fumes and aggressive gases that may damage insulation.

During storage the flowmeter does not require any special maintenance.

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

- Flowmeter is transported packed in the manufacturer’s box
- Protection against moisture is provided
- Temperature is within the range of - 40 to + 50 °C
- Humidity does not exceed 95 % at + 35 °C
- Vibration is within the range of 10-500 Hz with maximum 0.35 mm amplitude and 49 m/s^2 acceleration
- Impact acceleration does not exceed 98 m/s^2
- Flowmeters are fixed to prevent damages.

APPENDIX A. View of components



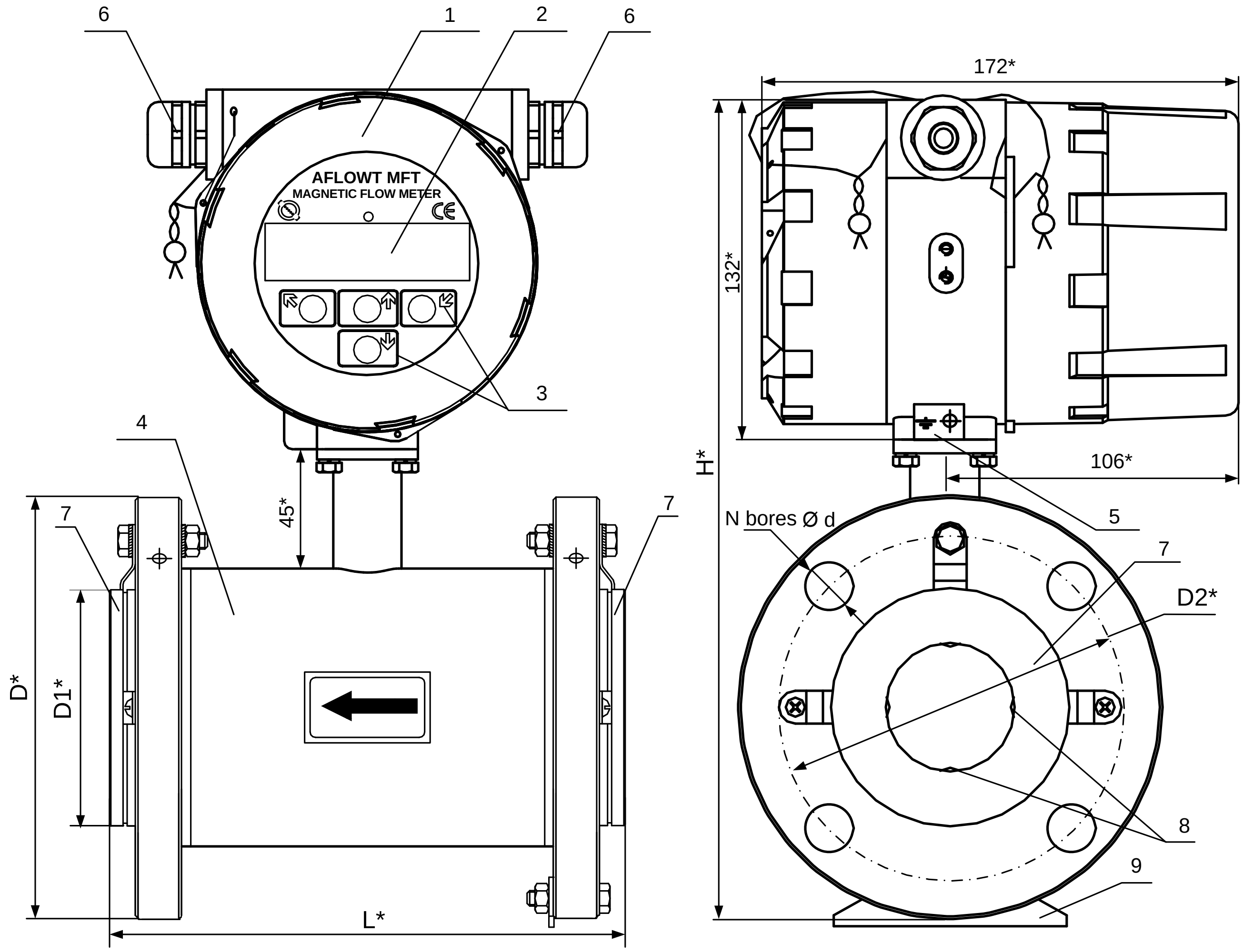
* - reference dimension

1 – electronic block; 2 – display; 3 – optical keyboard buttons; 4 – flow sensor (PFC); 5 – screw fixing the grounding wire; 6 – cable glands; 7 – protection rings; 8 – electrodes; 9 – support

Flowmeter's DN	D, mm	D1, mm	D2, mm	d, mm	N	L, mm	H, mm	Weight, kg
20	100	50	75	14	4	150	270	5.6
25	110	58	85	14	4	200	280	6.2
32	130	65	100	18	4	200	290	7.7
40	140	75	110	18	4	200	300	8.6

Fig.A.1. View of flanged flowmeter combined version, DN20 – DN40, with protection rings

NOTE. The total length “L”, mm, of flow meter, lined with polyurethane without protection rings reduced to 8 mm.



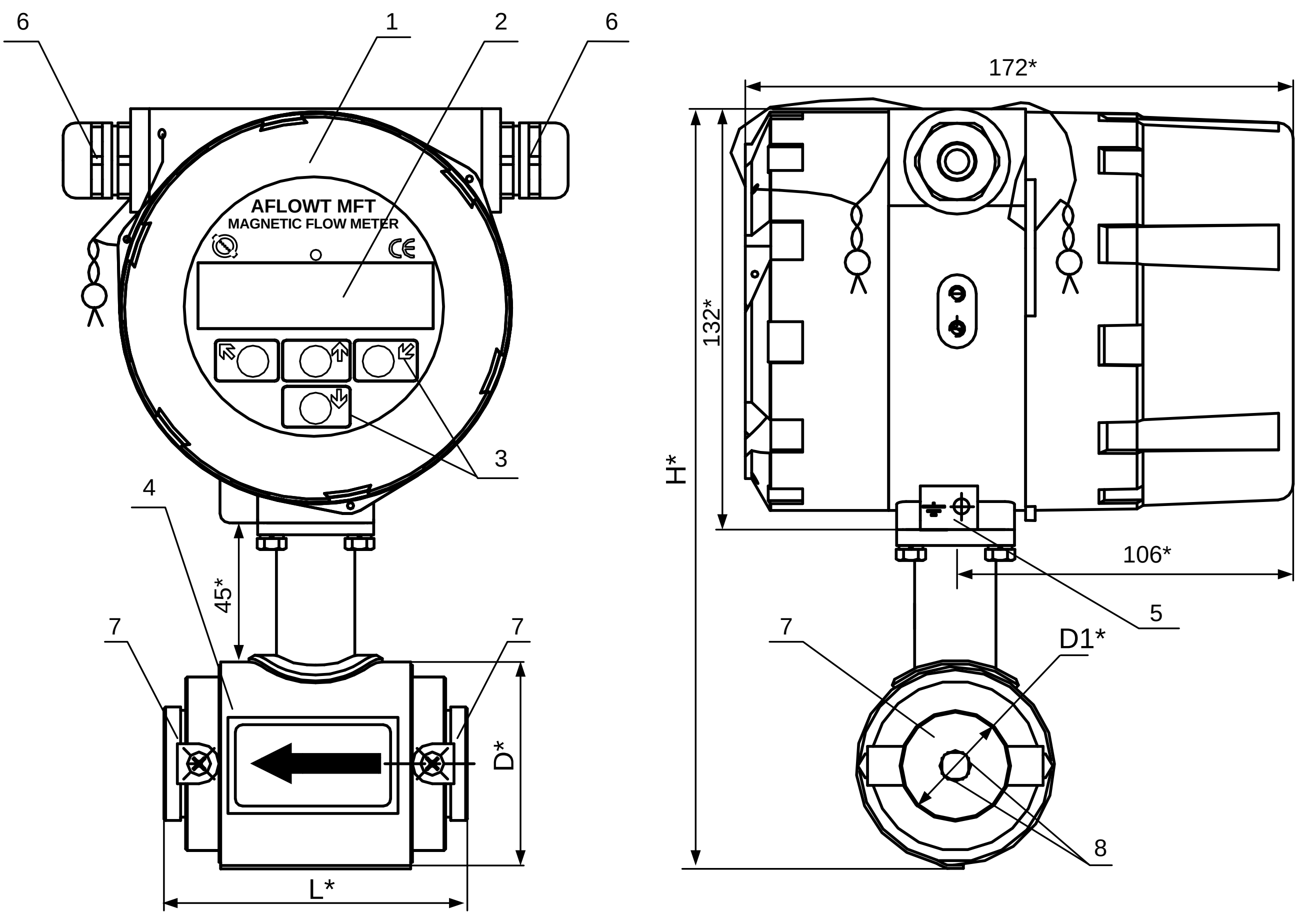
* - reference dimension

1 – electronic block; 2 – display; 3 – optical keyboard buttons; 4 – flow sensor (PFC); 5 – screw fixing the grounding wire; 6 – cable glands; 7 – protection rings; 8 – electrodes; 9 – support

Flowmeter's DN	D, mm	D1, mm	D2, mm	d, mm	N	L, mm	H, mm	Weight, kg
50	155	87	125	18	4	200	315	10.1
65	175	109	145	18	8	200	325	11.5
80	190	120	160	18	8	200	340	13.6
100	225	149	190	22	8	250	370	19.7
150	290	202	250	26	8	270	430	33.2
200	358	258	310	26	12	340	493	52.0
300	475	362	430	30	16	500	607	98.0

Fig.A.2. View of flanged flowmeter combined version, DN50 – DN300, with protection rings

NOTE. The total length “L”, mm, of flow meter, lined with polyurethane without protection rings reduced to 8 mm.

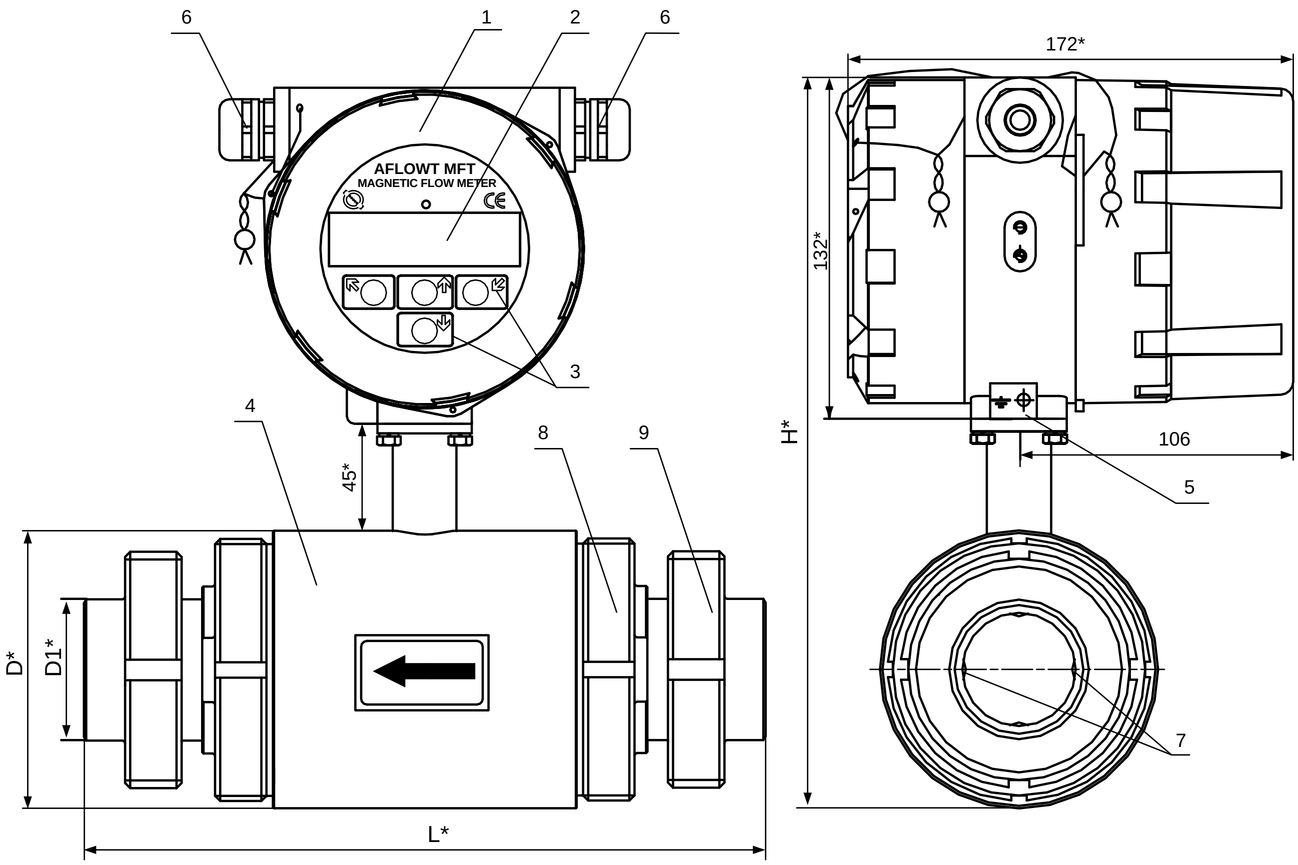


* - reference dimension

1 – electronic block; 2 – display; 3 – optical keyboard buttons; 4 – flow sensor (PFC); 5 – screw fixing the grounding wire; 6 – cable glands; 7 – protection rings; 8 – electrodes

Flowmeter's DN	D, mm	D1, mm	L, mm	H, mm	Weight, kg
10	61	34	93	240	3.4
15	61	39	93	240	3.5

Fig.A.3. View of "wafer pipe" flowmeter combined version, with protection rings

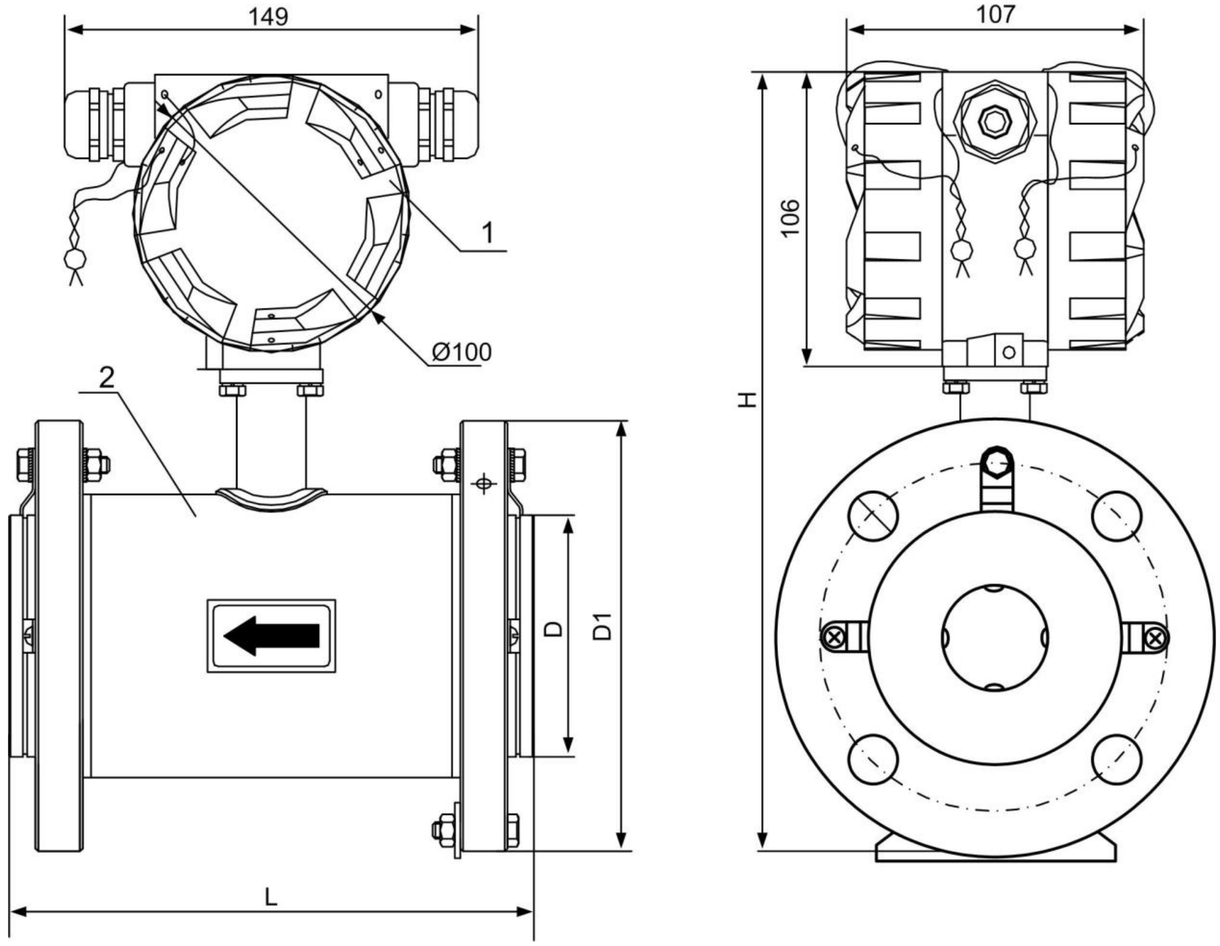


* - reference dimension

1 – electronic block; 2 – display; 3 – optical keyboard buttons; 4 – flow sensor (PFC); 5 – screw fixing the grounding wire; 6 – cable glands; 7 – electrodes; 8 – coupling nut; 9 – grooved nut

Flowmeter's DN	D, mm	D1, mm	L, mm	H, mm	Weight, kg
15	65	21	141	245	3.8
32	95	37	186	275	7.6
40	101	43	188	283	8.1
50	108	55	222	285	11.0
80	140	87	262	320	14.5

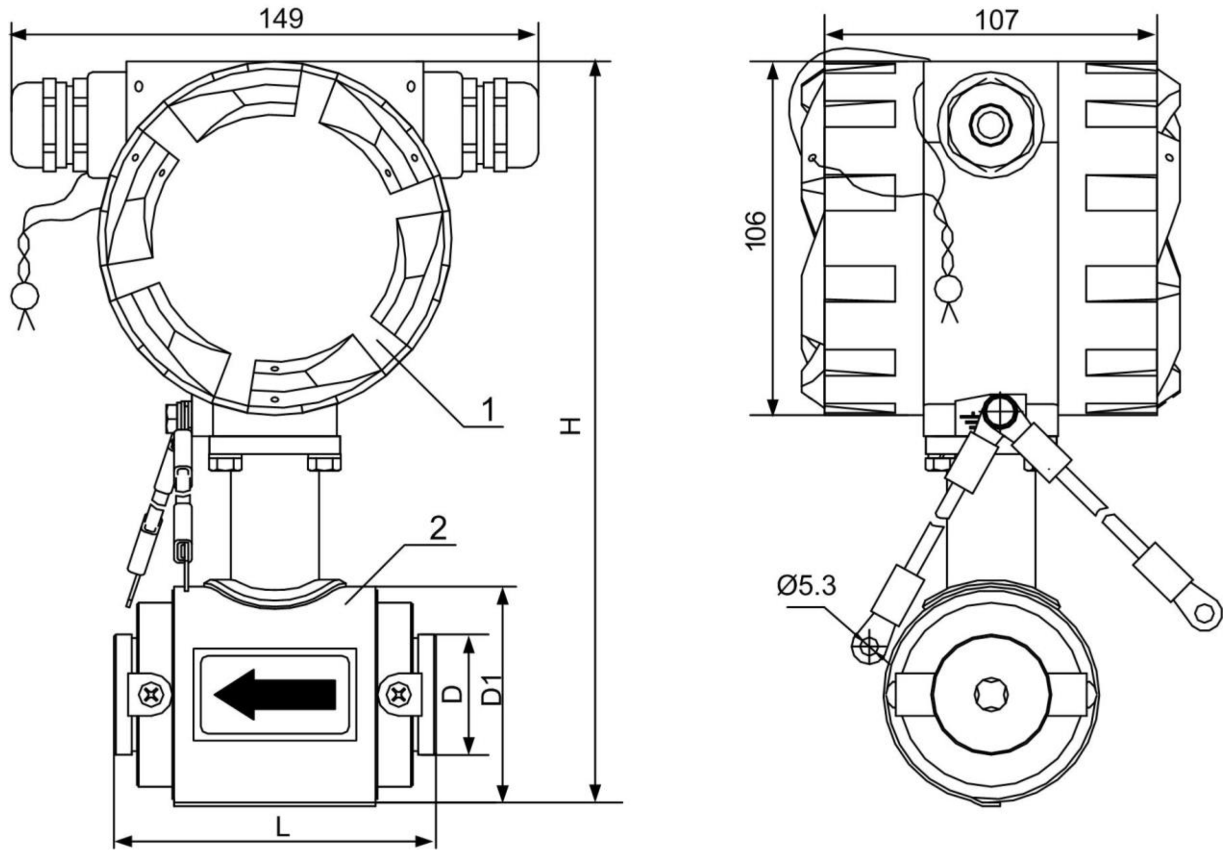
Fig.A.4. View of flowmeters combined version with threaded coupling



1 – communication block; 2 – electromagnetic primary flow converter

Flowmeter's DN	D, mm	D1, mm	L, mm	H, mm	Weight, kg
20	50	100	150	244	4.8
25	58	110	200	254	5.4
32	65	130	200	264	6.9
40	75	140	200	274	7.8
50	87	155	200	289	9.3
65	109	175	200	299	10.7
80	120	190	200	314	12.8
100	149	225	250	344	18.9
150	202	290	270	404	32.4
200	258	358	340	467	51.2
300	362	475	500	581	97.2

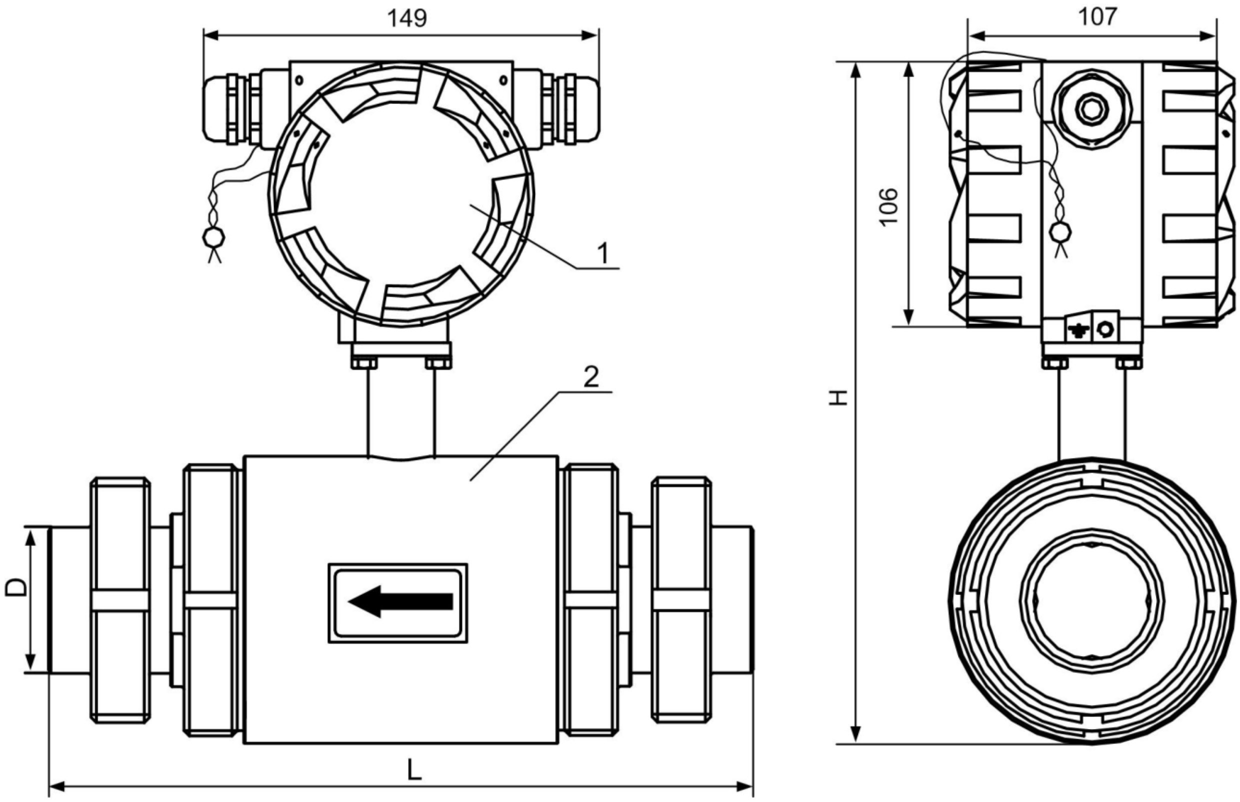
Fig.A.5. View of EPMC remote version flanged type, with protection rings.



1 – communication block; 2 – electromagnetic primary flow converter

Flowmeter's DN	D, mm	D1, mm	L, mm	H, mm	Weight, kg
10	34	61	93	214	2.6
15	39	61	93	214	2.7

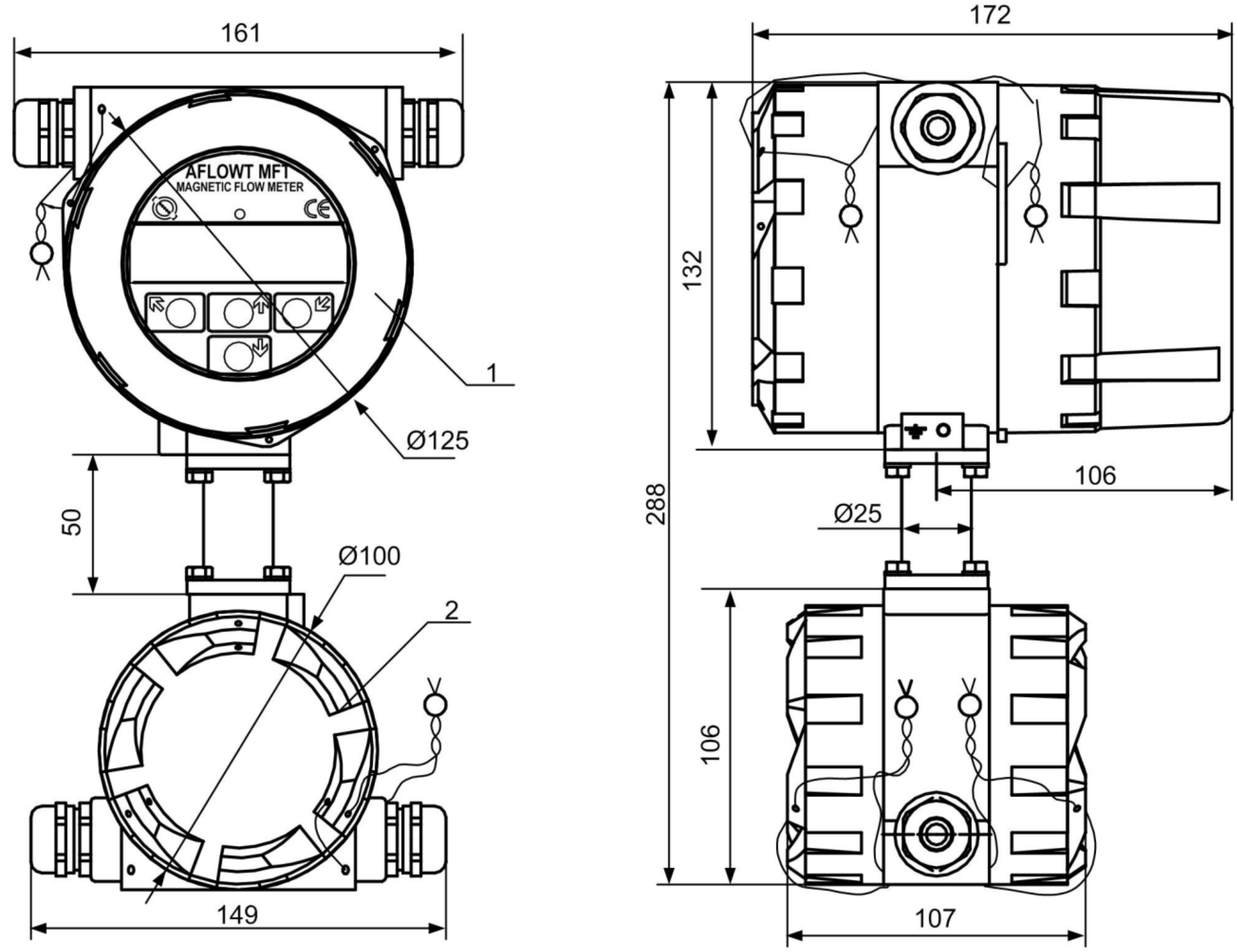
Fig.A.6. View of "wafer pipe" EPMC remote version with protection rings



1 – communication block; 2 – electromagnetic primary flow converter

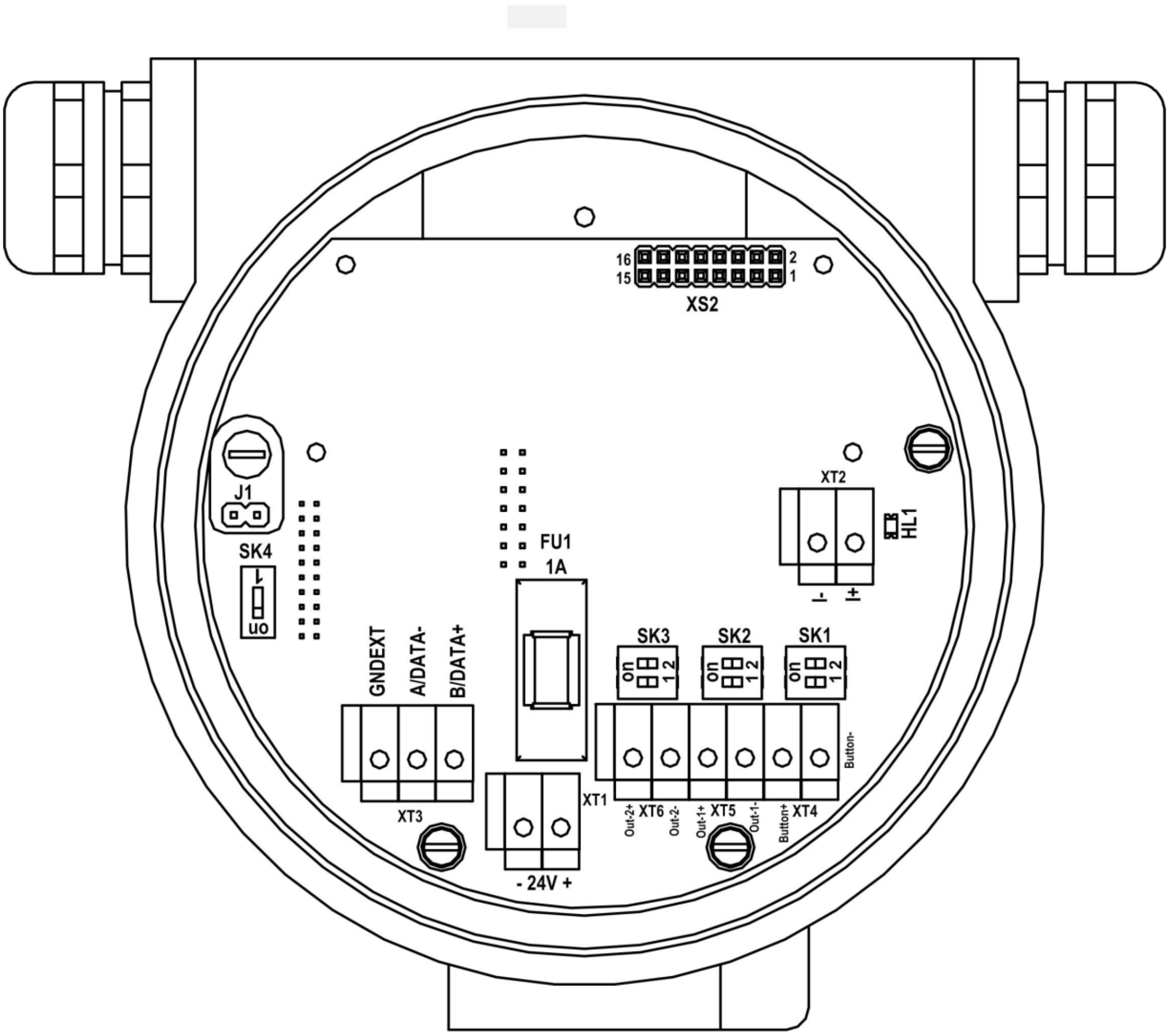
Flowmeter's DN	D, mm	L, mm	H, mm	Weight, kg
15	65	171	219	3.0
32	95	224	249	6.8
40	101	228	257	7.3
50	108	266	259	10.2
80	140	322	294	13.7

Fig.A.7. View of EPMC remote version with threaded coupling



1 – electronics block; 2 – communication block

Fig.A.8. View of Secondary Converter flowmeter remote version



XT1 – 24V power supply connector
XT2 – analogue output connector
XT3 – RS-485 connector
XT4 – connector for connecting external button
XT5 – universal output N1 connector
XT6 – universal output N2 connector
SK1 – switch of button modes
SK2 – switch of output modes, universal output N1
SK3 – switch of output modes, universal output N2
SK4 – switch of "Service" modes
*HL1 – LED for error detection on the current output (normal condition – **LED is OFF**)*
XS2 – connector for connecting an additional module
J1 – "Calibr." connector beneath sealing cup

Fig.A.9. Rear view of Electronic Block with cover removed (view of Communication module)

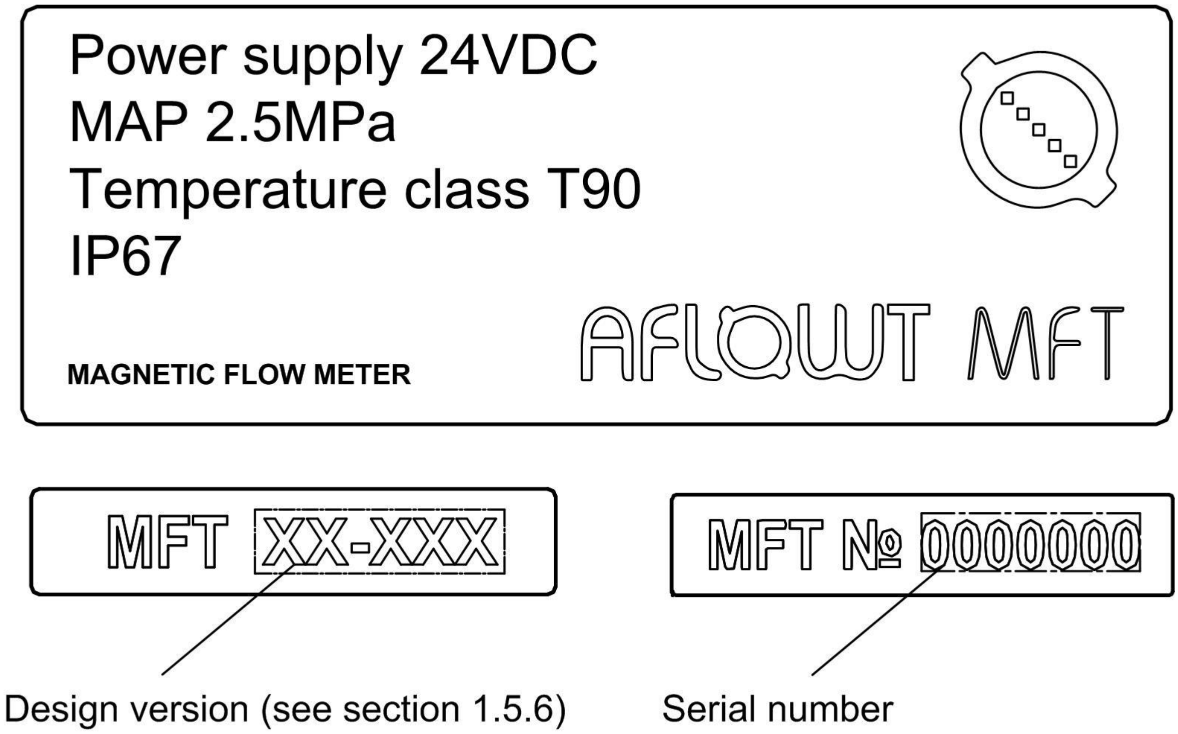
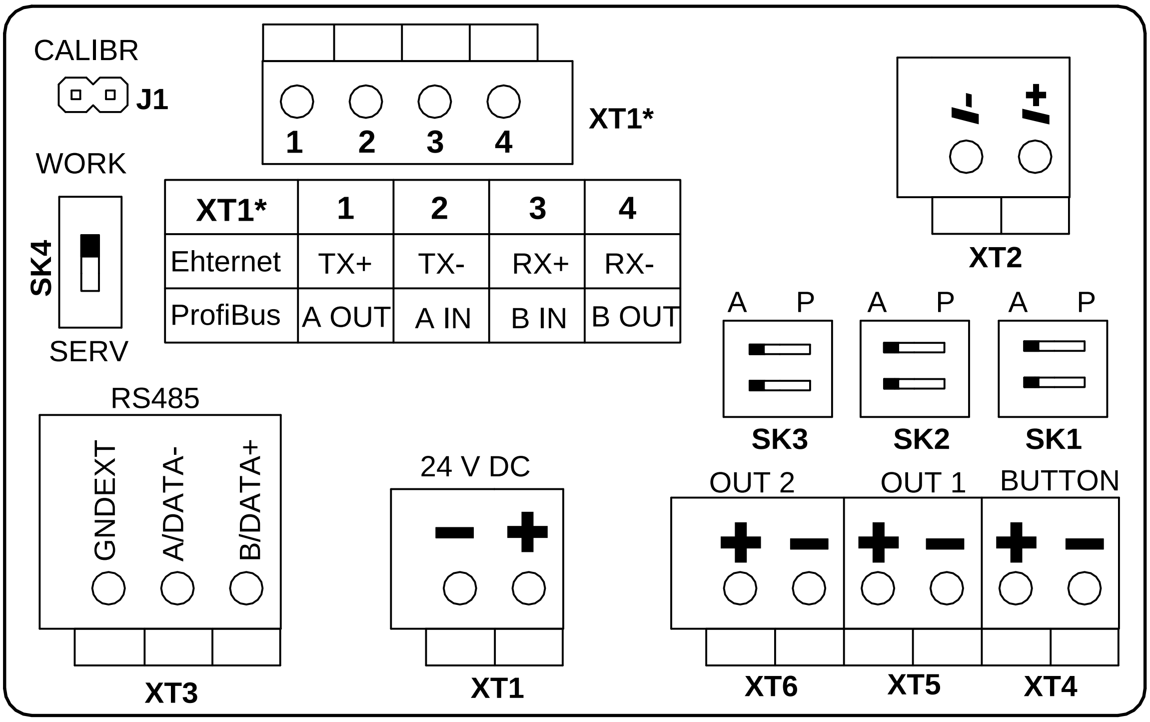
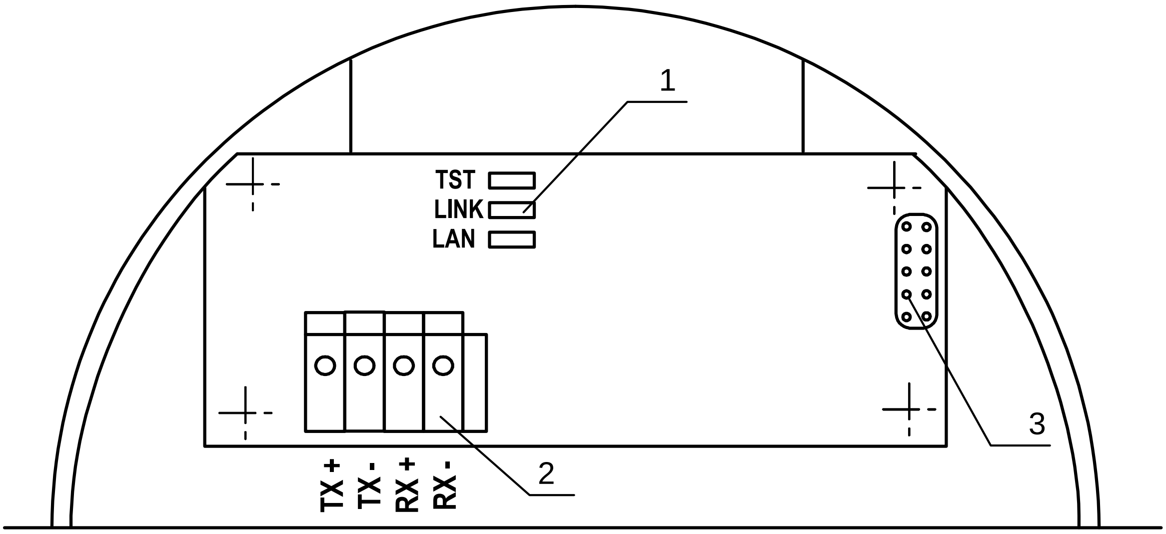


Fig.A.10. Nameplate, located on top of the case



* - pins of XT1 connector are marked in accordance with the type of the module installed (Ethernet or Profibus).

Fig.A.11. Sticker on the flowmeter's rear cover with marking of connection elements



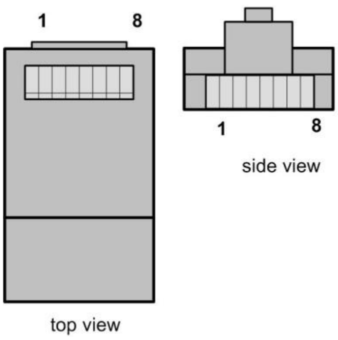
1 – LEDs; 2 – Ethernet terminal block; 3 – service connector

Fig.A.12. View of Ethernet module (installed on the Communication board).

Ethernet cable may be equipped with RJ45 connector for connection to a PC or network.

a) View of RJ45 connector

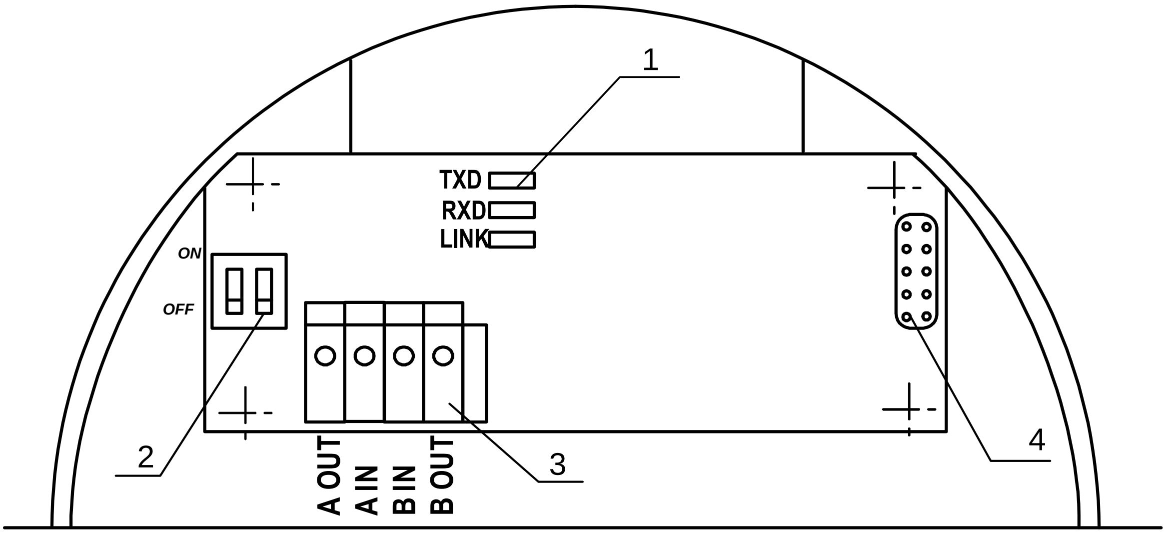
Socket RJ45



b) Ethernet connector pins for PC or network connection

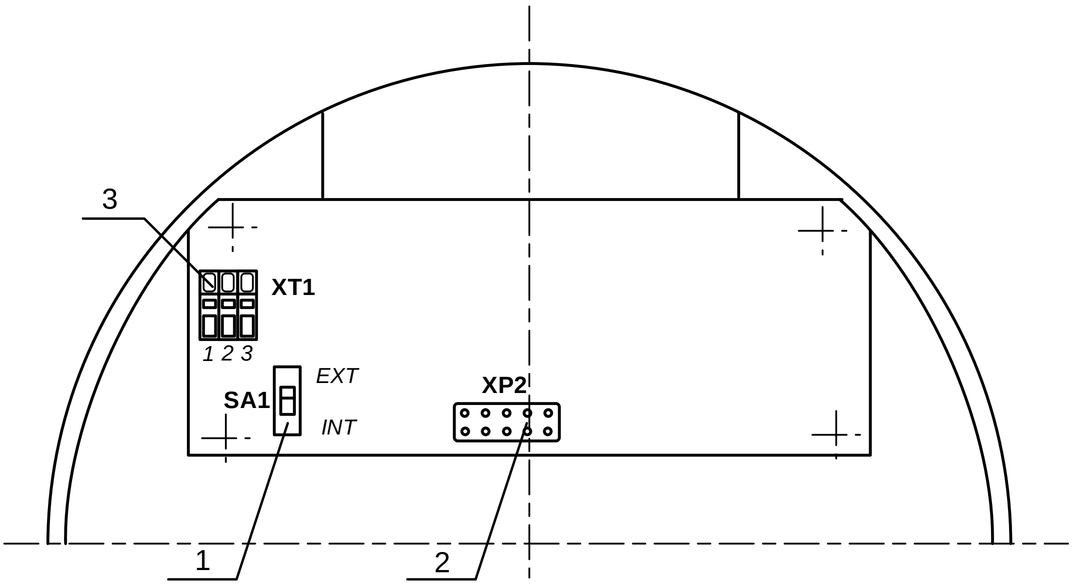
The socket soldering

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



1 – LEDs; 2 – Terminator switch; 3 – Profibus terminal block; 4 – service connector

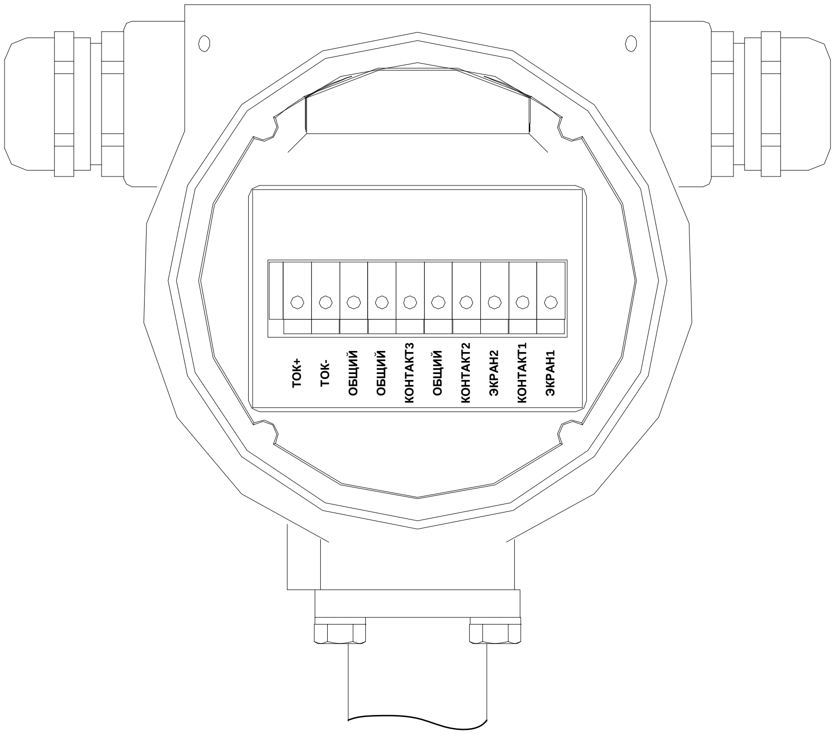
Fig.A.13. View of Profibus module (installed on the Communication board).



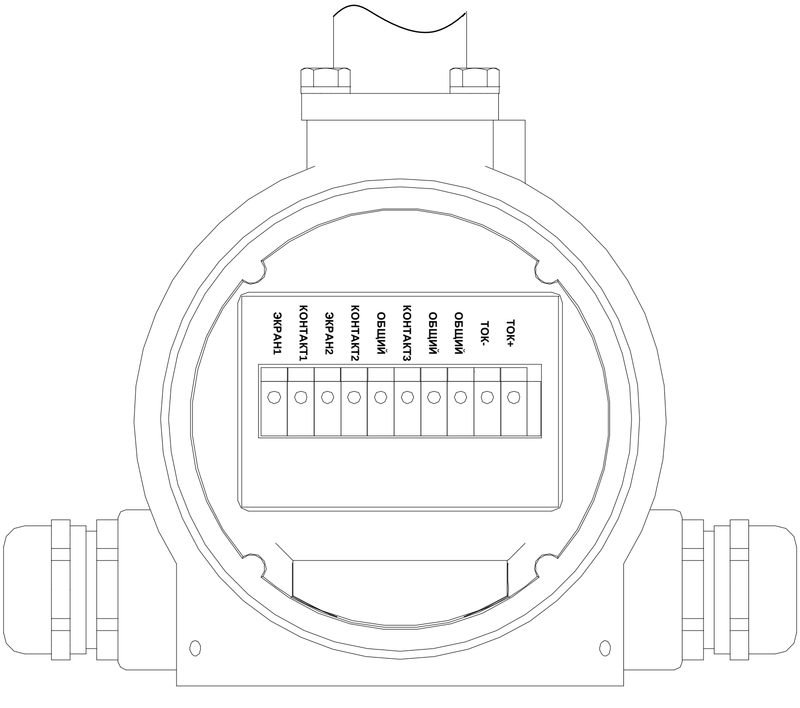
1 – HART module power supply switch; 2 – technological connector; 3 – terminal block for connection of interface cable.

Fig.A.14. View of HART module (installed on the Communication board)**.**

SA1	XT1		
	1	*2*	*3*
EXTERNAL *(1-2)*	LOOP PWR	PREF	NC
INTERNAL *(3-2)*	NC	PREF	LOOP GND



a) Communication Block of PFC (cover removed).



b) Communication Block of BE (cover removed).

Рис.А.15. View of Communication Blocks flowmeter remote version.

APPENDIX B. Schematics of input and outputs

1. Universal outputs

To match output stages to inputs of different types, the output stages (Fig.B.1) 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.

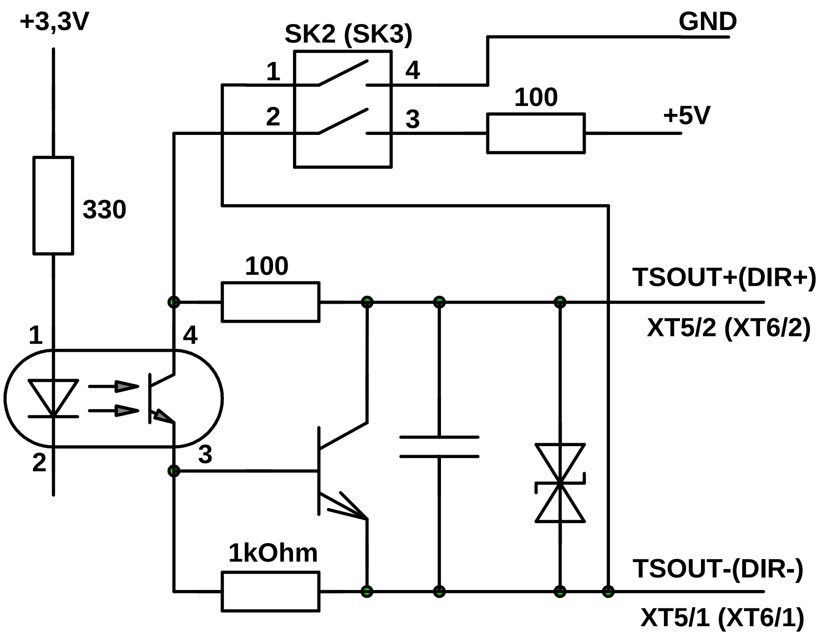


Fig.B.1. Universal outputs, circuit diagram of output stages

In the active mode, in case of no pulse or at logic **high**, output voltage is from 4.5 to 5.0 V. In the presence of pulse or at logic **low**, output voltage is maximum 0.5 V. External load resistance shall be of 1 kOhm as a minimum.

N1 (N2) output stage is connected to +5 V internal power source with SK2 (SK3) switch located on the Communication board.

In the passive mode, power from an external power source with output DC voltage of up to 30 V can be applied. Permissible value of external load current is no more than 200 mA.

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

Identifiers for output N2 are given in brackets.

2. Analogue output

The analogue 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 analogue output depends on resistance of the corresponding signal circuit. The condition is that the sum of input resistance of a connected analogue input and signal circuit resistance must not exceed the above-specified external load resistance.

The analogue output is powered from the flowmeter's galvanically isolated secondary power source.

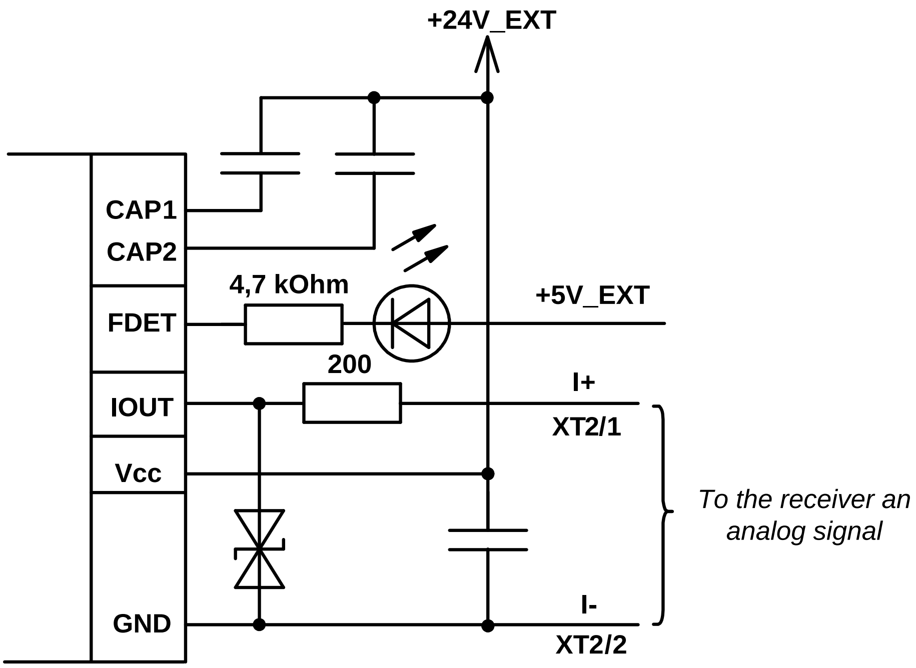


Fig.B.2. Analogue output

3. Control input

Circuit diagram for the control input is represented in Fig.B.3.

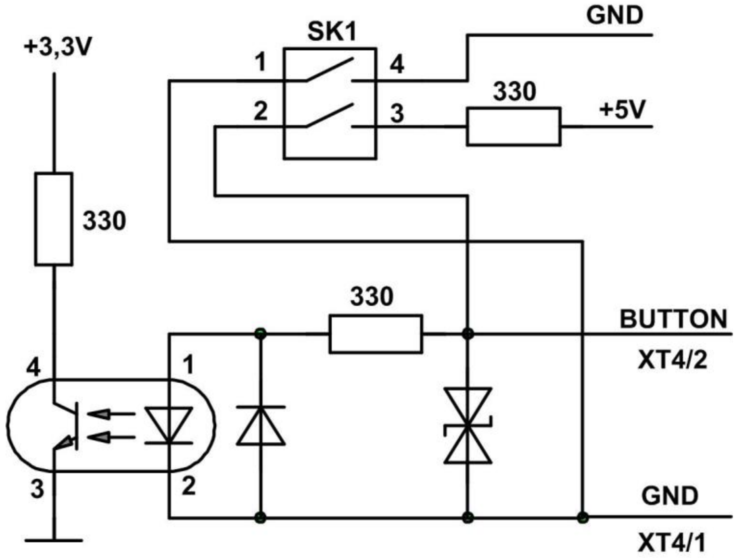


Fig.B.3. Circuit diagram for MFT input stage

When SK1 is in "OFF" position (passive mode), the control signal applied to the input of BUTTON-GND circuit is represented as pulses of current (5.0-20) mA.

In the active mode of the input (SK1 is in "ON" position), the control signal can be generated by closing BUTTON-GND contacts (e.g., using a button) provided that resistance of the external circuit is no more than 50 Ohm.