

GAS-VOLUME CONVERSION DEVICE

MacBAT 5

Manual

Specifications

Technical description

Mounting instructions

Configuration



Single-channel gas conversion device

Approved for installation in potentially explosive atmospheres

September 2022



Safety measures

This measurement device can be operated only by an operator trained in compliance with the technical terms, safety regulations, and standards. It is necessary to consider any other legal and safety regulations stipulated for special applications. Similar measures also apply for special applications. Similar measures also apply for using the accessories.

The information in this manual does not have the power of a legal obligation from the manufacturer's side. The manufacturer reserves the right to implement changes. Any changes in the manual or in the product itself can be performed at any time without any previous alert, with the goal of improving the device or fixing any typographical or technical mistakes.



Atex safety and health

This device is an equipment protected by intrinsic safety "i" intended for use in potentially explosive atmospheres according to certificate FTZU 17 ATEX 0047X. Read carefully the whole documentation.



Radio equipment safety and health

This device in some versions becomes a radio equipment according to RED.

MID - Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of measuring instruments

ATEX - DIRECTIVE 2014/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres

RED - Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC

According to Directive WEEE 2012/19/UE:

Purchased product is designed and made of materials of highest quality. The product meets the requirements of the Directive 2012/19/EU of 4 July 2012 on waste electrical and electronic equipment (WEEE), according to which it is marked by the symbol of crossed-out wheeled bin (like below), meaning that product is subjected to separate collection.



Responsibilities after finishing a period of using product:

- dispose of the packaging and product at the end of their period of use in an appropriate recycling facility,
- do not dispose of the product with other unsorted waste,
- do not burn the product.

By adhering obligations of waste electrical and electronic equipment controlled disposal mentioned above, you avoid harmful effects on the environment and human health.

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1 Introduction

1.1 Device description

Gas volume conversion device MacBAT 5 is a device used for measurements of gas volume at base conditions and energy. It is designed to be used at gas measuring stations and pressure reduction-measuring stations. It can cooperate with rotor and turbine gas meters.



MacBAT 5 according to standard EN 12405-1:2018 is a gas volume conversion device type 1.

In fully equipped device a configuration of MacBAT 5 offers:

- analogue input (pressure P1 – metrological channel)
- analogue input (temperature T – metrological channel)
- up to 5 configurable potential-free contact inputs (DI1 to DI5):
 - o Measuring inputs LF1, LF2 (inputs DI3, DI4) – frequency up to 2Hz (optionally up to 60 Hz) with the possibility of cooperation with Wiegand transmitters, detection of flow direction (when using two LF inputs with phase shifted pulses)
 - o TS input – default tamper switch, normally closed (input DI5),
 - o Up to 5 digital inputs (inputs DI1, DI2, DI3, DI4, DI5)¹
- up to 2 configurable NAMUR inputs (inputs DI6, DI7):
 - o 2 HF pulse inputs, frequency 0÷5000 Hz, detection of flow direction (when using two HF inputs with phase shifted pulses)
 - o HF2 (DI7) input can work with NAMUR encoder,
 - o Up to 2 NAMUR digital inputs¹
- SCR input for SCR encoder (optionally, interchangeable with DI8 potential-free digital input, depends on hardware configuration)
- up to 4 outputs of „open collector” type:
 - o DO1, DO3, DO4: binary
 - o DO2: configurable – binary or frequency (1÷5000 Hz),
- communications:
 - o COM1 (optional) - standard RS-485, active with external power supply,
 - o COM2 - standard RS-485, galvanic insulated, typically active with external power supply, active on battery power when the casing is opened,
 - o COM3 – optical interface, standard IEC 62056-21,
 - o GSM 2G/3G/4G modem (optional),
 - o NFC – radio interface (optional).
- input of external power supply,
- additional absolute pressure or overpressure p2 sensor (optional)

¹ – Number of digital inputs depends on the configuration of the counting inputs

The device can be configured using the supplied *ConfIT!* software for PC. This software also allows the readout, display and archive of both the immediate measured values as well as the contents of the internal device archives.

1.2 Function principle

1.2.1 General characteristics

- The measurement is based on counting of the volume at measurement conditions, based on amount of pulses from reed contact LF or high frequency HF sensor mounted in the head of the gas meter or from direct readout of gas meter counter with use of its built-in encoder.
- With built-in sensors device measures pressure and temperature of gas.
- Device converts the counted gas volume at measurement conditions into volume at base conditions (EN 12405-1:2018) and using pre-set gas parameters it computes value of energy (EN 12405-2:2012).
- Beside measurements and computation of current parameters, device also archives chosen parameters and information about registered alarm states – available for later readout.
- The incorporated display and keyboard enable to monitor current measurement data, peak values and alarms as well as to adjust the basic operating parameters, such as time and date, measurement input limits, transmission parameters, and the like. Any modification of parameters both via transmission and with use of the keyboard requires user authorization.
- MacBAT 5 is a device powered by internal battery, but it also can be powered by external power supply. In standard version, at typical operating conditions (1-2 readout per month) 1 piece of battery allows up to five years of lifetime.
- Device has functions, which allow to use it in control and telemetry systems. During use of these features it is necessary to connect applicable type of AC power adapter, which provides separation of intrinsically safe circuits and allows to power by external supply of device. AC power adapter is an optional accessory.



Some parameters of the device (e.g. V_b , V_m , dV_b , dV_m , $dV_b.ph$, $dV_m.ph$) are particularly important for billing process. Correct work of these parameters has been confirmed during proper approval tests. The parameters can be marked as “**VERIFIED**” by adding the symbol of paragraph **§** on the display, the symbol precedes the parameter name e.g. **§ V_b** .

1.2.2 Measurement – calculation cycles

MacBAT 5 device operates by default in measurement-calculation cycle:

- Every 30 seconds – when running in BATT mode (powered from internal battery),
- Every 1 second – when running in FULL mode (powered from external power source),
- Every 1 second – when display is turned on (in all power modes),
- Frequency of mentioned cycles in BATT mode could be set in range of 6..30s (up to 60s when device is non-MID version);
- In every cycle, at first step device performs read of information about values of all measuring inputs and calculates increments from chosen counting input. Basing on this input data MacBAT 5 calculates increment of volume at measurement conditions **dV_m** , adds it up to counter **V_m** and computes value of flow at measurement conditions **Q_m** . At the same time, device checks, whether new alarms have occurred or earlier alarm situations have been closed.
- In next step, basing on the current values of pressure **p_1** , temperature **t** and programmed gas parameters, unit calculates conversion factor **C** and then increment of volume at base conditions **dV_b** and flow **Q_b** . Simultaneously there are calculated values of: **dE , dM , QE , QM** .

1.2.3 Emergency state

During typical usage of the device, depending on the appearance of alarm situation, it can operate either in normal state or in emergency state. All parameters listed before are active in both states of device operation (calculation of temporary values of flows and counters increments).

If the unit operates in normal state, all calculated increments are added up to main counters („n” - new value of parameter, „p” - value from previous calculation cycle):

$$V_{m_n} = V_{m_p} + dV_m$$

$$V_{b_n} = V_{b_p} + dV_b$$

$$E_n = E_p + dE$$

$$M_n = M_p + dM$$



During normal state, emergency counters are stopped.

If the unit operates in emergency state, all calculated increments are added up to emergency counters:

$$V_{me_n} = V_{me_p} + dV_m$$

$$V_{be_n} = V_{be_p} + dV_b$$

$$E_{e_n} = E_{e_p} + dE$$

$$M_{e_n} = M_{e_p} + dM$$



During emergency state, the main counters V_b , E and M are stopped. V_m counter is always active.

Emergency state of MacBAT 5 is active as long as an alarm from a system group is active.

1.2.4 Calculation of conversion factor C

The main objective of the gas volume conversion device is to calculate conversion factor to base conditions C , which is later used to convert values obtained at the measurement conditions into values at the base conditions.

To calculate coefficient C , following values are used:

- pressure p_1 and temperature t , coming from modules at the left side of Figure 1.
- compressibility factors: at measurement conditions Z and at base conditions Z_b – computed basing on measured values of gas pressure, temperature and current gas composition.

If values of pressure or temperature will exceed the ranges determined for currently used calculation method of compressibility factor, an alarm will be generated, and further results will be saved into emergency counters. Calculation of compressibility factors is possible even if values of p_1 and t will be out of ranges (however, keep in mind, that uncertainty of performed calculations in this conditions will be increased). If chosen calculation method is unable to perform further computation, then last calculated values of Z and Z_b are used.

- base pressure ***pb*** and base temperature ***Tb***.

Both of those values are describing the base conditions, on which values obtained at measurement conditions are going to be converted. Additionally, combustion temperature for computation of the superior calorific value ***Hs*** (***T1***).

Basing on parameters presented before, a Conversion factor to base conditions ***C*** is calculated:

$$C = \frac{Tb [K]}{pb [kPa]} \times \frac{p1 [kPa]}{t [K]} \times \frac{1}{K1} \quad (1a)$$

$$K1 = \frac{Z}{Zb} \quad (1b)$$

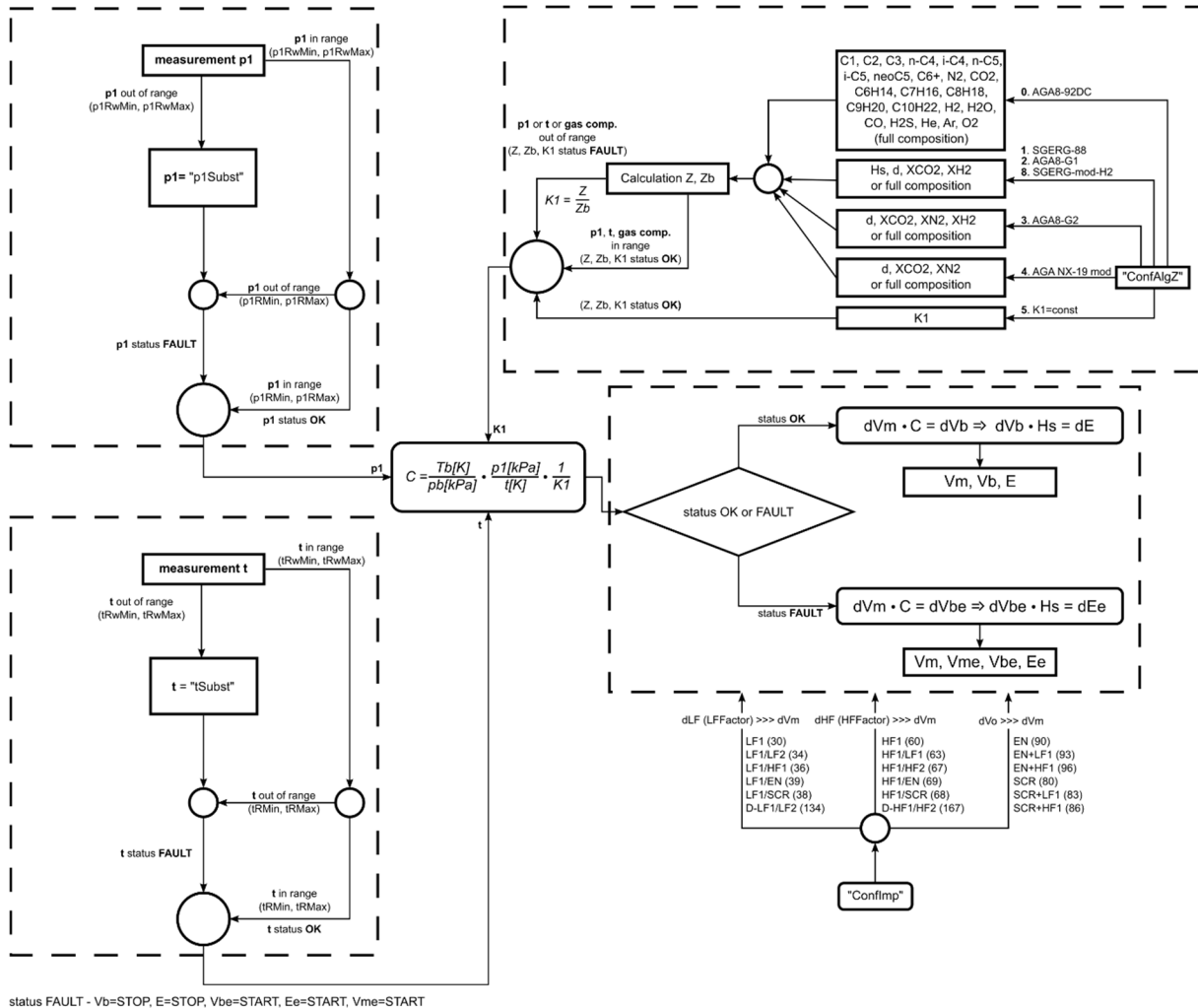


Figure 1. Diagram of calculation methods operation

WARNING! In methods SGERG-88, SGERG-mod-H2, AGA8-G1, AGA8-G2, AGA NX-19-mod and K1-const device requires to program values of superior calorific value ***Hs*** and relative density ***d*** specified for used base conditions ***Tb*** and ***pb*** and combustion process ***T1*** and ***P1*** (always $P1=pb$). If given values of ***Hs*** and ***d*** are known for different base conditions than ones used in the device, they must be recalculated for those base conditions before programming. Methods for recalculations of ***Hs*** and ***d*** between different base conditions are described in standard EN ISO 6976:2005, annex J and in standard EN ISO 12213-3:2010, annex D. When programming full gas composition, no further recalculations are necessary.

1.2.5 Increment of volume at measurement conditions

Device's configuration allows to choose method of obtaining volume at measurement conditions basing on data from pulse inputs LF and HF, additionally from digital input of encoder.

In configurations with LF as main counting input (configurations: LF1, LF1/LF2, LF1/HF1, LF1/SCR, LF1/EN) increment of volume at measurement conditions **dVm** is calculated with formula:

$$dVm = \frac{dLF}{LF \text{ factor}} \quad (2a)$$

where:

dLF – increment of pulses on LF input during measurement-calculation cycle

LF factor – LF input pulse rate

In configurations with HF as main counting input (configurations: HF1, HF1/LF1, HF1/HF2, HF1/SCR, HF1/EN) increment of volume at measurement conditions **dVm** is calculated with formula:

$$dVm = \frac{dHF}{HF \text{ factor}} \quad (1b)$$

where:

dHF – increment of pulses on HF input during measurement-calculation cycle

HF factor – HF input pulse rate

In configurations with EN and SCR as main counting input (configurations: EN, EN/LF1, EN/HF1, SCR, SCR/LF1, SCR/HF1) increase of volume at measurement conditions **dVm** is calculated with formula:

$$dVm = dVo \quad (2c)$$

where:

dVo – increment of auxiliary counter **Vo**, derived from direct reading of encoder.

Increments **dVm** are summed in **Vm** counter during normal and emergency mode. During emergency mode, additional auxiliary emergency counter of volume at measurement conditions **Vme** is driven.

1.2.6 Averaged conversion factor

A value of arithmetic average of conversion factor **C** is calculated in the device. By default, averaged value is equal to momentary value from current measurement-calculation cycle. Averaging of conversion factor covers the period in which flow of gas has been observed (flow rate **Qm**>0), but in following measurement-calculation cycles increment of volume at measurement conditions counter value **dVm** was not detected. When finally increment of that counter is detected – period of averaging value of **C** ends.

E.g. measurement-calculations cycle period is 30 seconds and increment of volume at measurement conditions **dVm** occurs e.g. every 180 seconds (it could be correct period of incoming low frequency pulses LF or readouts of encoder's counter state). Counting from 0 second – every 30 seconds device calculates momentary value of conversion factor **C** and its averaged value. In 180th second, increment of **dVm** counter will be detected and calculation of increased volume at base conditions will be carried with use of averaged **C**. This allows to take into account of following calculations possible dynamic changes of pressure or temperature or gas composition during period of volume increment.

1.2.7 Increment of volume at base conditions

$$dVb = dVm \times C \quad (3)$$

where:

dVm – increment of volume at measurement conditions

C – conversion factor to base conditions averaged for increment period of **dVm**.

Increments **dVb** are summed up to **Vb** counter during normal operation and to **Vbe** during emergency mode.

1.2.8 Increment of energy

$$dVb \times Hs = dE \quad (4)$$

where:

dVb – increment of volume at base conditions

Hs – superior calorific value.

Increments **dE** are summed up to **E** counter during normal operation and to **Ee** during emergency mode.

1.2.9 Increment of mass

$$dVb \times rob = dM \quad (5)$$

where:

dVb – increment of volume at base conditions

rob – gas density at base conditions

Increments **dM** are summed up to **M** counter during normal operation and to **Me** during emergency mode.

1.2.10 Flow of volume at measurement conditions

Flow of gas volume at measurement conditions **Qm** (without enabled correction) is calculated using formula:

- based on **HF** pulses measurement:

$$QmHF = \frac{fHF}{HFFactor} \times 3600 \quad (6a)$$

typically:

$$Qm = QmN = QmHF \quad (6b)$$

where:

QmN – uncorrected flow of volume at measurement conditions,

fHF – frequency of pulses on HF input,

HFFactor – gas meter HF pulse rate (number of pulses per 1m³).

- based on **LF** pulses measurement:

$$QmLF = \frac{\frac{1}{LFtm}}{LFFactor} \times 3600 \quad (7a)$$

typically:

$$Qm = QmN = QmLF \quad (7b)$$

where:

QmN – uncorrected flow of volume at measurement conditions,
 $LFtm$ – time between successive pulses at the LF input [s],
 $LFfactor$ – gas meter LF pulse rate (number of pulses per 1m³).

- based on readouts of encoder:

Value of flow is calculated based on the data read from the encoder.

1.2.11 Flow of volume at base conditions

$$Qb = Qm \times C \quad (8)$$

where:

Qm – flow of volume at measurement conditions (may be corrected by gas meter correction error curve),

C – averaged conversion factor to base conditions

1.2.12 Flow of energy

$$QE = \frac{Qb \times Hs}{3,6} \quad (9)$$

where:

Qb – gas volume flow at base conditions

Hs – superior calorific value

1.2.13 Flow of mass

$$QM = Qb \times rob \quad (10)$$

where:

Qb – gas volume flow at base conditions

rob – gas density at base conditions

1.2.14 Correction of flow from error curve of the gas meter (flowmeter)

Switching of correction function is controlled by parameter ***CurveCorr***, where

Value **0** – correction function disabled;

Value **1** – correction function enabled.

Switching of correction function generates event “*Configuration changed*” which saves status of function before and after modification.

Corrected flow **Qm** from error curve of the gas meter is calculated with formula:

$$Qm = QmN \times FQ \quad (11)$$

$$FQ = 1 - \frac{f'(Q)}{100\%} \quad (12)$$

$$f'(Q) = \frac{fP_{i+1} - fP_i}{QP_{i+1} - QP_i} \times (QmN - QP_i) + fP_i \quad (13)$$

where:

QmN – uncorrected flow of volume at measurement conditions,

FQ – correction function, calculated basing on points **$FP1 \div FP10$** and **$QP1 \div QP10$**

fP_{i+1}, fP_i – values of gas meter errors at specific points,

QP_{i+1}, QP_i – values of flow for which error value was determined

WARNING: In accordance with standard EN 12405-1:2018 correction function can be used only when gas meter at Q_{min} generates at least 10 pulses per second, this means that correction function can be used in configurations of pulse inputs with HF signal as main.

Below value of Q_{min} , correction function is not used, while above Q_{max} , value of correction function is the same as for the one obtained for Q_{max} .

Correction is also used to calculate volume, energy and mass, parameters after correction are: **V_c , V_b , E , M .**

2 Technical description

2.1 Device construction

Device consists of two boards:

- main board in bottom part of the casing, containing processor, input/output connectors (including pulse inputs, temperature sensor input, signaling inputs, digital outputs, communication ports, power supply terminal), terminal for internal pressure sensor, batteries (main and backup), sim tray for optional modem. Connectors related to metrological functions are protected by special covers, which are secured with metrological seals.
- display board in the upper cover of the device, with LCD display and 6 (18) button keyboard, optical communication interface and NFC. It also contains switches for metrological and configuration locks.

Optionally device may be equipped with 4G/3G/2G modem.

2.2 Main parts of the device

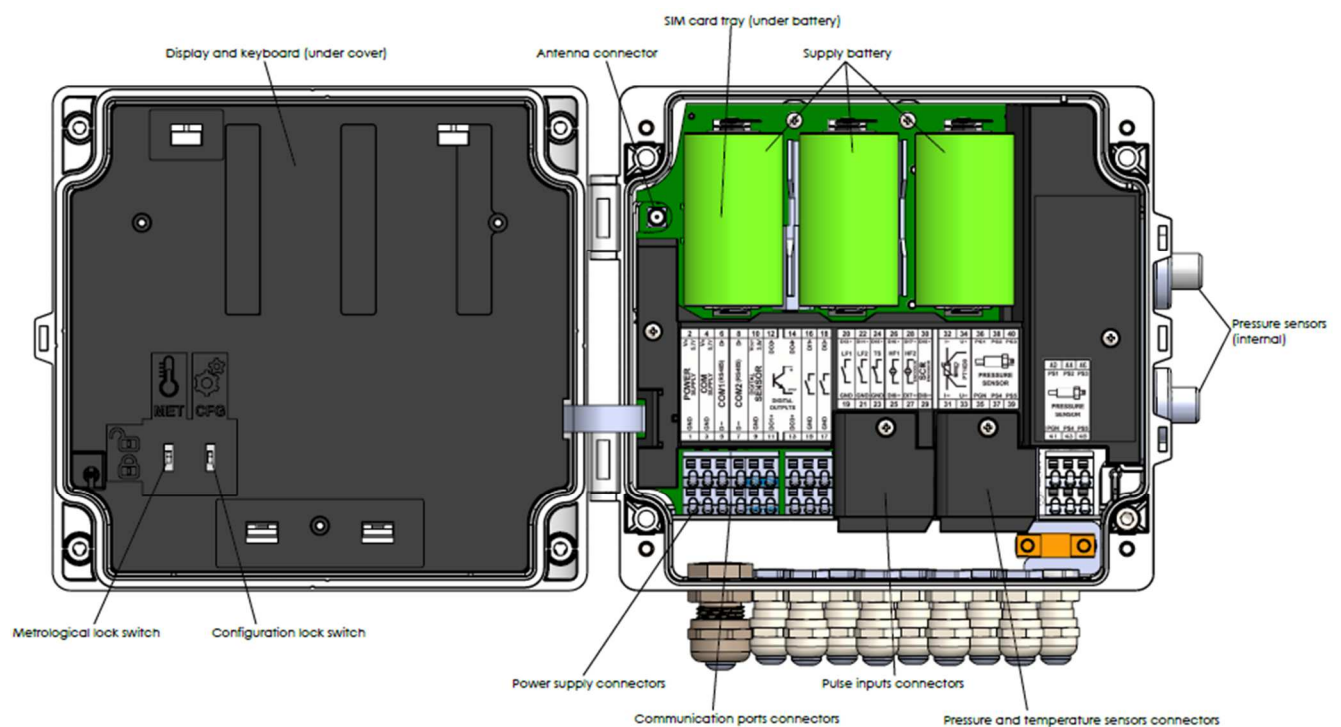


Figure 2. General view (example for plastic housing).

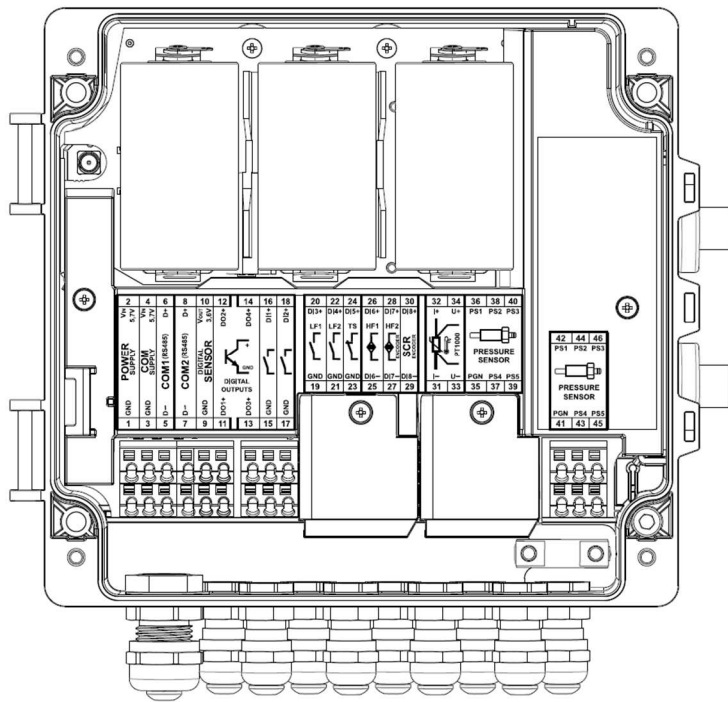


Figure 3. Connection scheme (view after opening of terminals chamber cover, internal view in plastic housing of fully equipped device).

- 1, 2** - input of external power supply
- 3, 4** - input of external power supply for transmission ports,
- 5..8** - transmission ports COM1 and COM2,
- 9..10** - power output for external reserve transducers,
- 11..14** - controlling outputs, “open-collector” type,
- 15..18** - digital inputs DI1 and DI2,
- 19..22** - pulse inputs LF1 and LF2 from gas meter (optional digital inputs DI3 and DI4),
- 23, 24** - tamper switch input from gas meter (optional digital input DI5),
- 25, 26** - pulse input HF1 from gas meter (optional digital input DI6 in NAMUR standard),
- 27, 28** - pulse input HF2 from gas meter (shared with encoder input and with digital input DI7 in NAMUR standard),
- 29, 30** - input of SCR encoder or DI8 digital input,
- 31..34** - Pt1000 temperature sensor terminals
- 35..40** - terminals for connection of external pressure sensor P1 or P2 (with sealing)
- 41..46** - terminals for connection of external pressure sensor P1 or P2 (without sealing, terminals available only in plastic housing)

2.3 Power supply

2.3.1 Main battery

The device is powered from 1 up to 3, lithium 3,6V size D internal batteries.

Batteries – depending on Customer order – can be designed to supply:

- complete device, without built-in GSM modem (1 ÷ 3 batteries);
- built-in GSM modem (optional) (1 ÷ 2 batteries);

Life time of device equipped with 1 battery is over 5 years, assuming:

- Registration period set on 60 min.
- All of outputs, signalization inputs and transmission ports (wire without terminators) are inactive;
- LCD display is constantly switched off, keyboard not used;
- Operating temperature equals minimum of ambience temperature, -25° C;
- Provided maximum pulses frequency on LF input (2 Hz);
- Measured gas pressure $p_1 = p_{1max}$;
- Measured gas temperature $t = t_{min}$;

The operating time of the GSM modem powered by batteries is dependent on the modem usage.

When battery charge reaches 10% of its remaining capacity, an alarm will be generated (**Battery low**), it's recommended then to perform battery replacement procedure.

2.3.2 Battery replacement

The battery replacement procedure must be carried out in accordance with the instructions given in this chapter.



MacBAT 5 is the intrinsically safe equipment. The housing of the device should be sealed – replacement of the battery can only be carried out by an authorized person, i.e. a factory or authorized service representative or other persons authorized by the manufacturer.



It is permissible to replace the batteries in the explosion hazard zone.



For power supply of MacBAT 5 only batteries of the types: LS33600 (Saft), SL2780 (Tadiran) or ER34615 (EVE), may be used. When using batteries type EVE ER34615 range of ambient temperature is limited to $(-25 \div +50)$ °C.



It is prohibited to combine different types of batteries in one device.



Opening of device's housing is forbidden under conditions that allow ingress of water (for example rain, snow) or dirt inside the unit.



Always replace the battery with a new, full charge batteries.

Battery replacement causes break in measurements of pressure and temperature but allows working of real time clock. Settings and registered data are not affected.

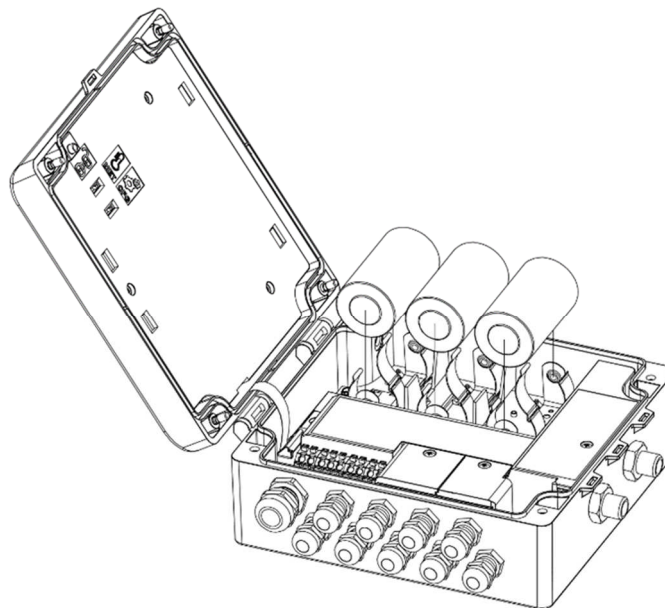


Figure 4. Insertion of batteries



Inserting of „old”, partly discharged batteries will cause incorrect readouts of charge level and may lead to unexpected device operation (such as restarting, errors in counting, errors in archives and in current values).



Discharged batteries are in the hazardous waste category, therefore they must not be disposed together with common waste.



Declared by manufacturer IP class of housing protection will be maintained when the gasket is properly seated and the housing cover is tightened.

2.3.3 Backup battery

The battery maintains backup of device's crucial functions in case of discharge or replacement of main battery. It allows to keep counting of LF pulses and working of real time clock while battery replacement procedure is in place. The backup battery may be replaced by authorized service after metrological seal is broken.



Only type 1/2AA LS14250 (Saft) or ER14250H (Fanso) backup batteries may be used.

2.3.4 External power supply

External power supply is required when using:

- HF inputs

External power supply is recommended for cases of high power usage:

- frequent communications
- frequent screen usage
- NAMUR/SCR encoder

Power supply is intrinsically safe type circuit, with intrinsic safety parameters given in paragraph 13.

External power supply of device should be connected to terminals 1, 2 – according to indications on wiring diagram. Parameters of power supply are described in paragraph 13.

The cables used must meet requirements for type B cables in accordance with standard EN 60079-14 – in particular, wire insulation should withstand the test voltage 500V AC and cannot be thinner than 0.1 mm (for insulation of polyethylene 0.2 mm).

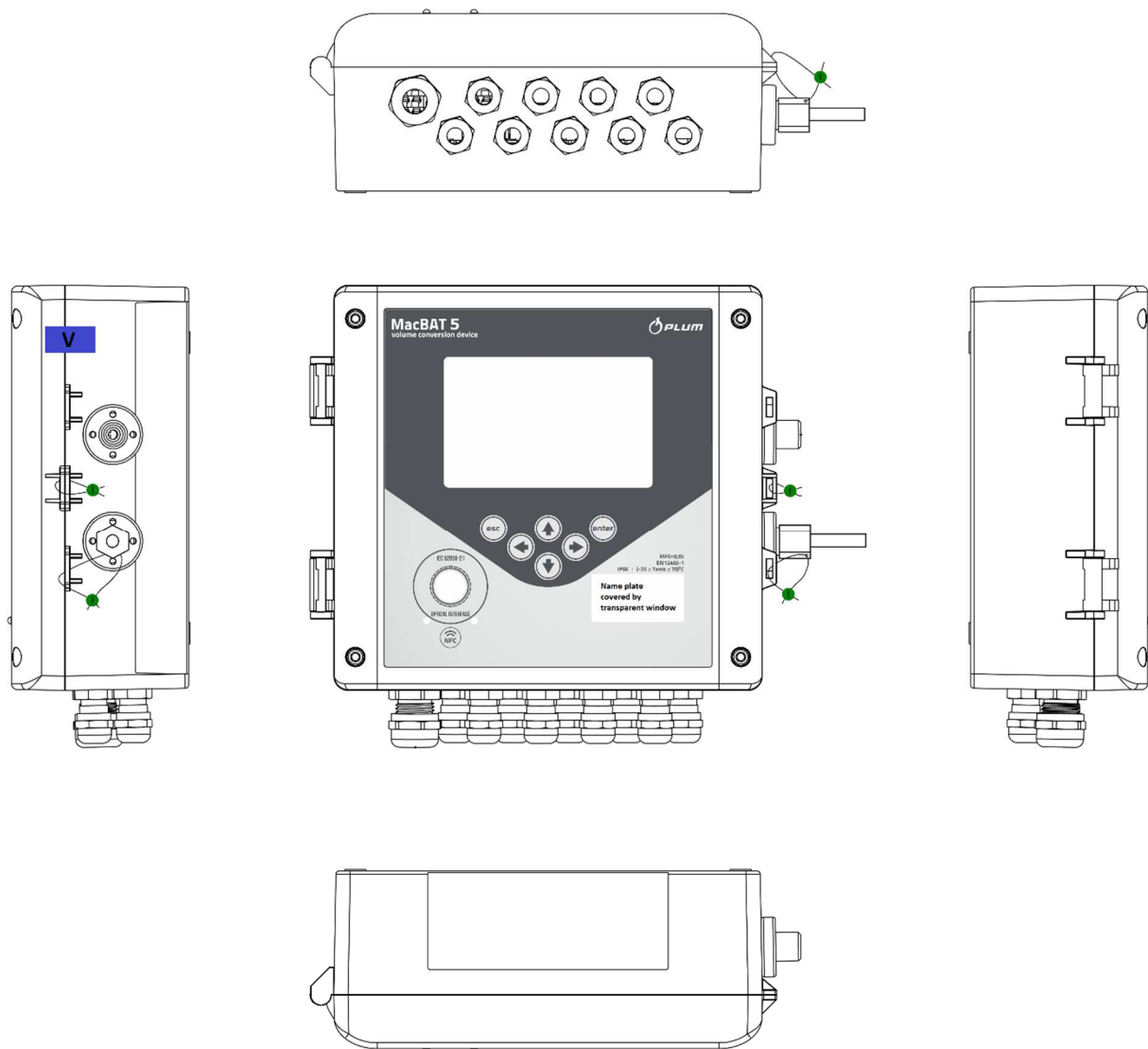
2.4 Sealing of the unit

MacBAT 5 as a device for billing, should be protected against unauthorized access. To do this, unit housing is secured with seals like presented on figure below and access to the menu is protected by a password system. Damage of any sealing marks causes loss of confirmation of device's metrological features and certifications. Avoid damaging of seals during installation and operation of the device.

Installation staff is obligated to verify condition of seals before mounting of device. If the seals are damaged, the proper functioning of device must be checked by the manufacturer authorized service.

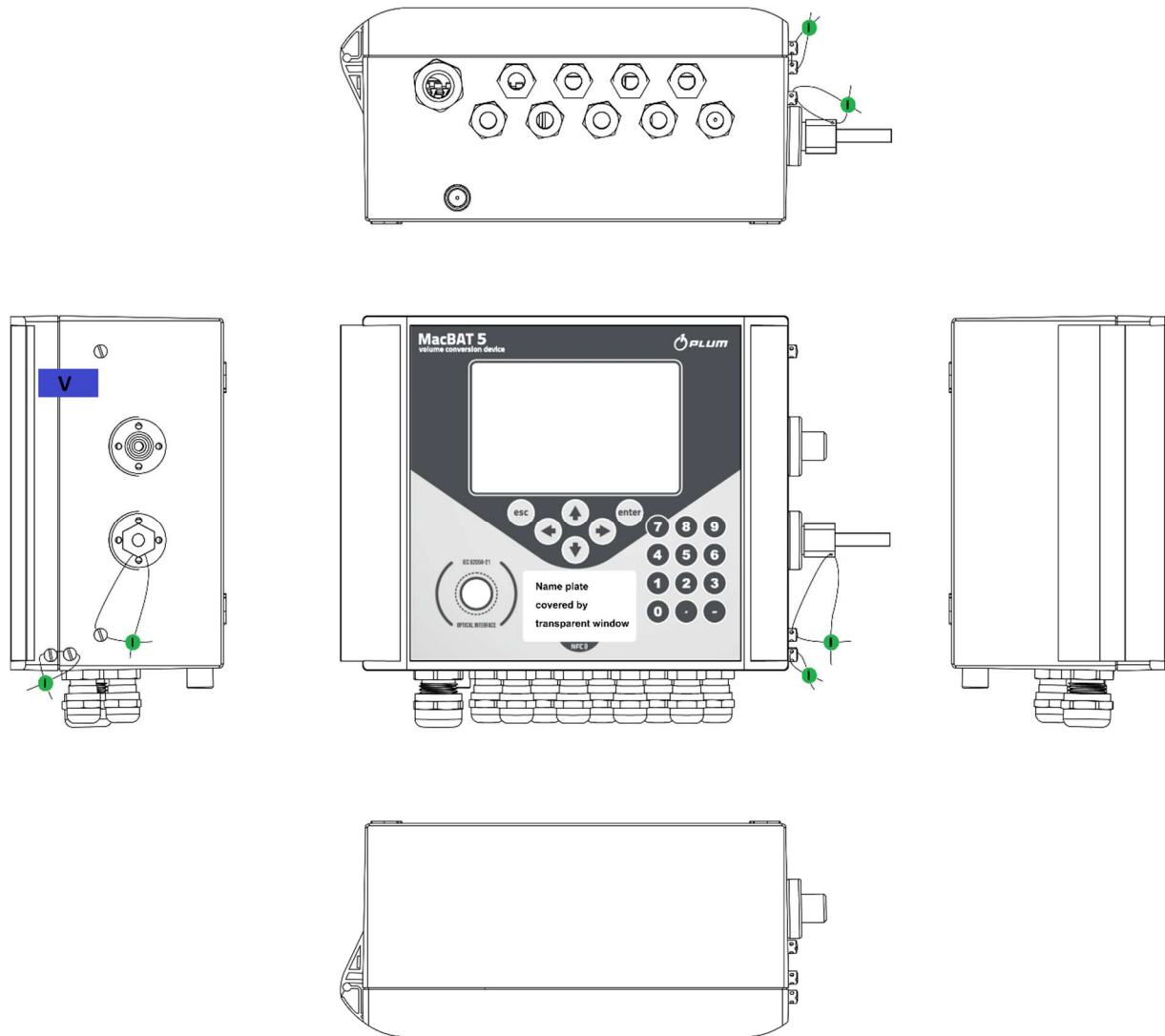


Unauthorized opening of the device, mounting inconsistent with this documentation or any changes to construction of the device can lead to loss of intrinsically-safe features and/or metrological characteristics and/or radio equipment characteristics. Damage of any sealing marks causes loss of confirmation of: metrological, intrinsically-safe, radio equipment features of the device.



I – installer seal, **V** – temporary seal (for the time of transport).

Figure 5. External sealing of the device (plastic housing).



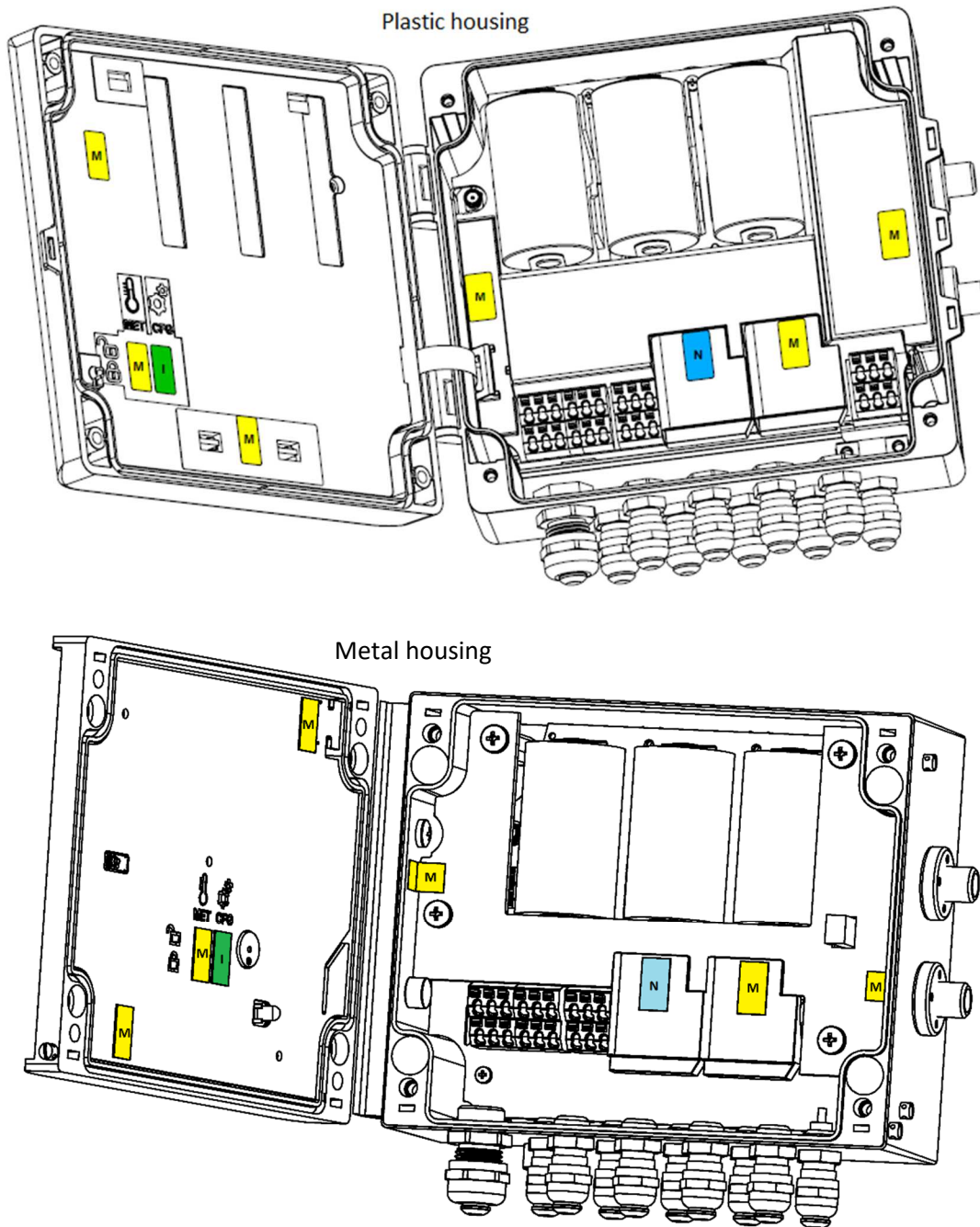
I – installer seal, **V** – temporary seal (for the time of transport).

Figure 6. External sealing of the device (metal housing).

After mounting of device, installation staff is obligated to place own wire protection seals accordingly to scheme on Figure 5 or Figure 6. During transportation, terminals chamber is protected with temporary seal. Installation staff after checking its condition may remove it.



In accordance with the directive RoHS 2011/65/UE, where applicable, it is unacceptable to use lead seals.



M – MID sealing mark, **I** – installer seal, **N** – seal according to national regulations,

Figure 7. Internal sealing of the device



Figure 8. Example of MID sealing mark void sticker

3 Nameplates

Some important information is imprinted directly on the solid elements of the device housing. The specific, additional information contain the plates below.

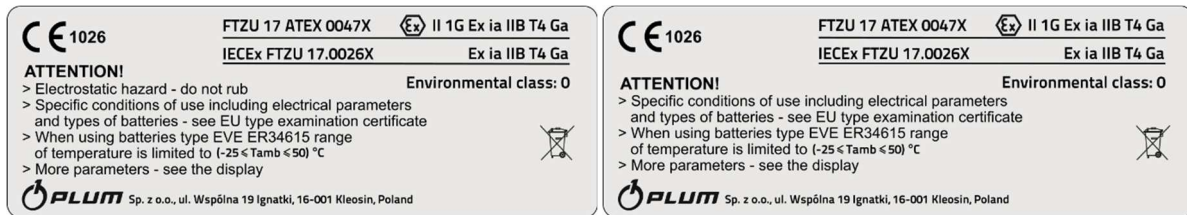


Figure 9. Label placed on top of the device (left – plastic housing, right – metal housing)



Load recorder (optional)



MID plastic housing



MID metal housing

Figure 10. Nameplates placed on front door of the device (examples)

4 Safety

4.1 General



The MacBAT 5 is intrinsically-safe device. It should be used in accordance with the requirements of this documentation and the conditions specified in the ATEX certificate.



The manufacturer's declaration of the IP66 housing tightness class will be valid only if cables with appropriate diameters for the cable bushings are used, the bushings are properly tightened, and ensuring proper placement of gasket and tightening of the housing cover to the device casing.



For the connection of external circuits is required to use cables with circular cross-section and an external diameter adequate to the internal diameter of used cable gland.



Version of devices equipped with metal housing. The metal housing is made of light metal alloys. If the product is used in the Z0 zone of explosion hazard, the enclosure must be protected against knocks and abrasions.



Internal intrinsically safe circuits, including pressure and temperature sensors internal circuits, do not stand 500V test given in EN60079-11 to earthed or isolated metal parts of its enclosure. The type of protection does not depend on the separation. Metal bushings of product and metal parts of its pressure sensors are galvanically connected. It can be installed as fully floating or bonded. It must be taken into account during installation.



The person installing the device is responsible for checking the continuity of protective connections.



Version of devices equipped with plastic housing. Under certain extreme circumstances, the plastic enclosure or plastic parts of enclosure may store an ignition-capable level of electrostatic charge. The product shall not be installed in a location where the external conditions are conducive to the build-up of electrostatic charge. The product shall only be cleaned with a damp cloth.



The function and parameters of some inputs/outputs depend on version of product, detailed information is written herein.



The unit should not be installed in the vicinity of strong electromagnetic fields.



Unauthorized opening of the device, installation inconsistent with this documentation or any changes in the device design may lead to the loss of intrinsically safe features and / or metrological characteristics and / or characteristics of radio devices. Damage to any seal means loss of confirmation of: metrological features, intrinsic safety, compliance with the requirements for radio devices.

Under no circumstances the construction of the device must not be modified.

Any of the above events excludes the manufacturer's liability, including warranty liability.



Only devices with the same serial number on the name plate on the housing cover and electronic name plate (displayed on LCD) are allowed.



MacBAT 5 can be ordered to be complied of the requirements of the Measuring Instruments Directive 2014/32/EC of European Parliament and Council (MID) which apply to volume conversion devices intended for residential, commercial and light industrial use.



The MacBAT 5 compliant with MID, on the name plate, next to the "CE" sign has the supplementary metrology marking consists of: capital letter "M" followed by last two digits of the year of its affixing, surrounded by a rectangle.



According to MID directive it is permissible to use terminal boxes, surge suppressors and Zener barriers in systems of measurement circuits. It is required that these components were designed for sealing.



To connect MacBAT 5 with gas meter or transducer, it is necessary to use cables appropriate with used in gas meter or transducer explosion-proof cable glands. Before installing always refer to the technical documentation of gas meter/transducer, which should contain a detailed information about conditions and methods of installation, types of wires etc.



MacBAT 5 can be ordered with GSM or NFC functionality, such device becomes a radio equipment and fulfills the requirements of the Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonization of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC (RED).



Use of the device is only possible where working GSM module does not interfere with the operation of other equipment (e.g. medical).

Connection of measurement circuits LF, HF, Encoder and digital inputs:


The intrinsically safe circuits used in MacBAT 5 shall meet all conditions for intrinsically safe circuits specified in EN 60079-14, and in particular:



- For intrinsically safe measuring circuits connect cables with separated two wires or use multi-core type A or type B cables according to point 12.2.2.8 of directive EN 60079-14.
- Cables and wiring of intrinsically safe circuits must be kept separate from the cables and wires of non-intrinsically safe circuits.
- Cables and wiring of intrinsically safe circuits should be permanently mounted and protected from the possibility of mechanical damage.
- Cables of intrinsically safe circuits are recommended to be marked with blue color.
- Connect the cable shield to the housing gland. This way grounding of the cable shield of intrinsically safe circuits will occur at one point – next to MacBAT 5 device. During use of measuring transducers, cable shield should be insulated.

4.2 Ex marking

Device is approved for use in potentially explosive atmospheres.

Marking:  II 1G Ex ia IIB T4 Ga



Certificate: FTZU 17 ATEX 0047X

Operating environment:

Device is approved to use at the 0, 1 and 2 zones threatened with explosion of mixture of: vapors, gases and explosive vapors with air which are placed in IIB or IIA explosive group and temperature class T1, T2, T3, T4.

5 Metrological properties

5.1 Temperature measurement

The temperature sensor **CT6A** (Optional: Pt1000/2w or Pt1000/4w/cl.A) is part of each MacBAT 5 device. The sensor is available in 2 types of sheath length: fixed length "50" and adjustable length "140,160,180". Each piece of sensor is checked at the manufacturer's laboratory to meet the accuracy class requirements.

WARNING! Length of sensor sheath needs to be adjusted to diameter of gas pipeline.

Technical data:

- Measurement range: $-40\text{ °C} \div +80\text{ °C}$,
- Transducer - platinum resistor Pt1000 class A,
- Connection cable with 4- or 2- wires, 2 m (standard), max 10 m,
- Measuring resistor is galvanically isolated from the housing,
- For mounting of sensor in thermometer sleeve is used connector with thread M20×1,5.

Mounting of temperature sensor with the usage of supplied connector provides protection against penetration of moisture, liquids and dust into the thermometer sleeve. This protection meets the requirements of the degree of protection IP54 in accordance with EN 60529.



The CT6A temperature sensor must always be attached to the gas pipeline in closed thermowell sleeve. Do not insert the sensor directly into the gas pipeline.



Only temperature sensors whose serial number on the name plate is identical like the one presented on device display are allowed to operate. Name plate of the sensor is affixed to the cable and secured by additional foil jacket. Do not damage the plate during installation and operation of the device.

| Measuring range: | Maximum permissible errors for measurements of t^1 | |
|------------------------------------|--|--------------------|
| | Ambient temperature | |
| | 20 °C ($\pm 3\text{ °C}$) | (-25 \div 70) °C |
| Measurement of gas temperature t | | |
| (-30 \div 70) °C | $\pm 0,1\%$ | $\pm 0,2\%$ |

¹ – values of errors referred to correct values of temperature, expressed in [K].

5.2 Pressure measurement

| Measuring ranges: | Maximum permissible errors for measurements of p_1 and p_2 | |
|---|--|-------------------------------|
| | Ambient temperature | |
| | 20 °C ($\pm 3\text{ °C}$) | (-25 \div 70) °C |
| Measurement of gas pressure p_1 (for billing) or p_2 (auxiliary, optional) | | |
| (0,8 \div 6) bar abs (0,8 \div 10) bar abs (2 \div 10) bar abs ² (4 \div 20) bar abs ² | $\pm 0,2\%$ of measured value | $\pm 0,5\%$ of measured value |

| | | |
|---|---------------------------|------------------------|
| (7 ÷ 35) bar abs ² (4 ÷ 70) bar abs ² (10 ÷ 70) bar abs ² (10 ÷ 100) bar abs ² | | |
| Standard ranges for pressure p2 measurement (auxiliary, optional) | | |
| (0 ÷ 100) mbar G | ± 0,5 mbar | ±1 mbar |
| (0 ÷ 1) bar G | ± 1 mbar | ± 2 mbar |
| (0 ÷ 7) bar G | For values: up to 2,8 bar | |
| | ± 0,08 % of range | ± 0,12 % of range |
| | above 2,8 bar | |
| | ± 0,2 % measured value | ± 0,3 % measured value |
| 4 ÷ 16 bar G ³ | For values: up to 9 bar | |
| | ± 0,15 % of range | ± 0,3 % of range |
| | above 9 bar | |
| | ± 0,2 % measured value | ± 0,4 % measured value |
| Non-standard ranges for pressure p2 measurement (auxiliary, optional) | | |
| (0 ÷ 170) mbar G (0 ÷ 300) mbar G | ± 0,5 mbar | ± 1 mbar |
| 4 ÷ 34 bar G ^{*3} 5 ÷ 55 bar G ^{*3} 14 ÷ 62 bar G ^{*3} | ± 0,2 % of range | ± 0,4 % of range |

² – range of indications from 0,9 bar to p1 max

³ – range of indications to atmospheric pressure



Devices with sensors of low gauge pressure (ranges up to 1 bar) show a significant effect of mechanical stress on the indication of the pressure p2. In order to achieve the declared accuracy, after installation of the device on the target location, it is necessary to set the indication to zero by the zero setting mechanisms.

5.3 Compressibility calculation

In MacBAT 5 there is possibility to choose calculation method of compressibility factor:

| Value ConfAlgZ | Calculation method |
|-----------------------|--|
| 0 | <u>AGA8-92DC (full gas composition)</u> |
| 1 | SGERG-88 (Hs-d-XCO2-XH2 or full gas comp.) |
| 2 | AGA8-G1 (Hs-d-XCO2-XH2 or full gas comp.) |
| 3 | AGA8-G2 (d-XCO2-XH2-XN2 or full gas comp.) |
| 4 | AGA NX19-mod (d-XCO2-XN2 or full gas comp.) |
| 5 | K1=const. |
| 8 | SGERG-mod-H2 (Hs-d-XCO2-XH2 or full gas comp.) |



*When using methods SGERG-88, SGERG-mod-H2, AGA8-G1, AGA8-G2, AGA NX-19mod and K1=const., device requires programming of parameters values such as calorific value **Hs** and relative density **d** to be adequate for currently set base conditions (**Tb** and **pb**) for volume calculation and reference conditions for combustion (**T1** and **P1**, here always **P1=pb**). Set of*

base conditions in many European countries: $p_b=1,01325$ bar; $T_b=273,15$ K; $T_1=298,15$ K.
When programming full gas composition, no further recalculations are necessary.



Despite fact, that methods AGA8-G2 and AGA NX-19mod are not using calorific value **Hs** for calculation of compressibility factor, it must be programmed, because it is necessary for correct computing of energy counter.

According to selected computing method, device requires programming full gas composition or few specific gas parameters. Permissible ranges of these parameters are mentioned in following tables.

5.3.1 Ranges of using gas composition parameters

Gas composition (molar fraction) must be in following ranges:

| Parameter | Name | unit | value in range | |
|-----------------------|---|-------------------|---|---|
| | | | basic | extended* |
| Hs | calorific value | MJ/m ³ | 30 .. 45 | 20 .. 48 |
| d | relative density | | 0,55 .. 0,8 | 0,55 .. 0,9 |
| C1 | methane, CH ₄ | % | 70 .. 100 | 50 .. 100 |
| C2 | ethane, C ₂ H ₆ | % | 0 .. 10 | 0 .. 20 |
| C3 | propane, C ₃ H ₈ | % | 0 .. 3,5 | 0 .. 5 |
| nC4 | n-butane, n-C ₄ H ₁₀ | % | sum (nC4 + iC4) in range 0 .. 1,5 | sum (nC4 + iC4) in range 0 .. 1,5 |
| iC4 | i-butane, i-C ₄ H ₁₀ | % | | |
| nC5 | n-pentane, n-C ₅ H ₁₂ | % | sum (nC5 + iC5 + neoC5) in range 0 .. 0,5 | sum (nC5 + iC5 + neoC5) in range 0 .. 0,5 |
| iC5 | i-pentane, i-C ₅ H ₁₂ | % | | |
| neoC5 | neo-pentane, n-C ₅ H ₁₂ | % | | |
| C6H14 | n-hexane, n-C ₆ H ₁₄ | % | 0 .. 0,1 | 0 .. 0,1 |
| C7H16 | n-heptane, n-C ₇ H ₁₆ | % | 0 .. 0,05 | 0 .. 0,05 |
| C8H18 | n-octane, n-C ₈ H ₁₈ | % | sum (C8H18 + C9H20 + C10H22) in range 0 .. 0,05 | sum (C8H18 + C9H20 + C10H22) in range 0 .. 0,05 |
| C9H20 | n-nonane, n-C ₉ H ₂₀ | % | | |
| C10H22 | n-decane, n-C ₁₀ H ₂₂ | % | | |
| H₂ | hydrogen | % | 0 .. 10 | 0 .. 10 |
| N₂ | nitrogen | % | 0 .. 20 | 0 .. 50 |
| CO₂ | carbon dioxide | % | 0 .. 20 | 0 .. 30 |
| H₂O | water | % | 0 .. 0,015 | 0 .. 0,015 |
| H₂S | hydrogen sulphide | % | 0 .. 100** | 0 .. 100** |
| CO | carbon oxide | % | 0 .. 3 | 0 .. 3 |
| He | helium | % | 0 .. 0,5 | 0 .. 0,5 |
| Ar | argon | % | 0 .. 100** | 0 .. 100** |
| O₂ | oxygen | % | 0 .. 100** | 0 .. 100** |
| C6+ | hexane & higher hydrocarbons | % | 0 .. 0,2 | 0 .. 0,2 |

* using extended range, standard EN 12213 provides increased uncertainty during computation of compressibility factor

** when programming full gas composition, sum of components must be equal to 100%, additionally from gas composition are calculated: calorific value and relative density, that must be in defined ranges

During programming of gas composition using keyboard, sum of components must be equal to 100.000%. It is also possible to do remote modification of gas parameters using transmission protocols. In case of remote modification, default permissible deviation from 100% of components sum is 0.001%.

Gas parameter must be in following ranges:

| Parameter | | Calculation method | | | | | |
|--------------|----------------------|------------------------|-----------------------|-----------------------|----------------------------|------------------------|-----------------------------|
| | | SGERG-88 ConfAlgZ=1 | AGA8-G1 ConfAlgZ=2 | AGA8-G2 ConfAlgZ=3 | AGA NX-19mod ConfAlgZ=4 | K1=const ConfAlgZ=5 | SGERG-mod-H2* ConfAlgZ=8 |
| XCO2 | [%] | (0÷30) | (0÷30) | (0÷30) | (0÷15) | --- | (0÷30) |
| XH2** | [%] | (0÷10) | (0÷10) | (0÷10) | --- | --- | (0÷100)*** |
| d | - | (0,55÷0,9) | (0,554÷0,87) | (0,554÷0,87) | (0,554÷0,75) | (0,07÷2) | (0,06÷0,9) |
| Hs | [MJ/m ³] | (20÷48) | (18,7÷45,1) | --- | --- | (0÷66) | (6÷48) |
| XN2 | [%] | --- | --- | (0÷50) | (0÷15) | --- | --- |
| K1 | - | --- | --- | --- | --- | (0÷2) | --- |

* The method has been defined in "DVGW Technical report PK 1-5-3"

** Typically, pipeline quality gas does not contain any hydrogen.

*** Maximum amount of hydrogen can be set in range 10..100 %, by default is set to 30%.

5.3.2 Gas compositions with higher amount of hydrogen

The method AGA8-92DC in standard implementation lets to calculate compressibility factors of mixtures with component hydrogen which amount is up to 10% - all properties in ranges listed in point 5.3.1. The parameter **XH2ExtOn** lets to enable / disable using the method in extended range of hydrogen (up to 100 %). By default the extended range of hydrogen is enabled. In extended range few properties of gas are widen:

| Parameter | Name | unit | value in range |
|----------------------|------------------|-------------------|----------------|
| Hs | calorific value | MJ/m ³ | 6 .. 48 |
| d | relative density | | 0,06 .. 0,9 |
| H₂ | hydrogen | % | 0 .. 100* |

* the allowable maximum value is limited by parameter XH2ExtMax, by default 30%

The methods SGERG-mod-H2 and AGA8-92DC let to calculate effectively compressibility factors of mixtures of natural gas with artificially added hydrogen in amount up to 100 %. By default the maximal amount of hydrogen has been limited to 30 % but can be changed by using the parameter **XH2ExtMax**.

6 Inputs and outputs

6.1 Inputs

In fully equipped device 8 digital inputs, marked as DI1 to DI8 can be connected to the device:

- 6 configurable potential-free contact inputs (DI1 to DI5 and DI8):
 - o Measuring inputs LF1, LF2 (inputs DI3, DI4) – frequency up to 2Hz (optionally up to 60 Hz) with the possibility of cooperation with Wiegand transmitters, detection of flow direction (when using two LF inputs with phase shifted pulses)
 - o TS input – tamper switch, normally closed (input DI5),
 - o Up to 6 digital inputs (inputs DI1, DI2, DI3, DI4, DI5, DI8)¹
- 2 configurable NAMUR inputs (inputs DI6, DI7):
 - o 2 HF pulse inputs, frequency 0÷5000 Hz, detection of flow direction (when using two HF inputs with phase shifted pulses)
 - o HF2 (DI7) input can work with NAMUR encoder,
 - o Up to 2 NAMUR digital inputs¹

¹ – Number of inputs acting as digital (signaling) depending on the configuration of the counting inputs

6.1.1 Counting inputs: LF, HF, EN, SCR

Device can be equipped with following counting inputs:

- LF1 (3) – pulse input for connection with low frequency output of gas meter (connectors 19/20), active in all power modes, i.e. BATT, FULL;
- HF1 (6) – pulse input for connection with high frequency output of gas meter in NAMUR standard (connectors 25/26), active only in FULL power mode;
- EN (9) – digital input for connection with encoder output of gas meter, in NAMUR standard (connectors 27/28) active in all power modes, i.e. BATT, FULL. WARNING! Usage of NAMUR encoder in BATT mode significantly reduces battery life of the device, frequency of readings in BATT mode, that influences battery life, is configurable in parameter **ENBatPer**;
- SCR (8) – digital input for connection with gas meter's SCR encoder output (connectors 29/30) active in all power modes, i.e. BATT, FULL. WARNING! Usage of SCR encoder in BATT mode significantly reduces battery life of the device, frequency of readings in BATT mode, that influences battery life, is configurable in parameter **ENBatPer**.

| ETL | NAMUR encoder | SCR enc. (2400bps) | SCR enc. (300bps) |
|----------------|------------------------|------------------------|-------------------------|
| 3 years | <i>ENBatPer = 1min</i> | <i>ENBatPer = 1min</i> | <i>ENBatPer = 3min</i> |
| 4 years | <i>ENBatPer = 2min</i> | <i>ENBatPer = 2min</i> | <i>ENBatPer = 4min</i> |
| 5 years | <i>ENBatPer = 3min</i> | <i>ENBatPer = 3min</i> | <i>ENBatPer = 6min</i> |
| 6 years | <i>ENBatPer = 4min</i> | <i>ENBatPer = 4min</i> | <i>ENBatPer = 9min</i> |
| 7 years | <i>ENBatPer = 6min</i> | <i>ENBatPer = 7min</i> | <i>ENBatPer = 15min</i> |

ETL – estimated time life of the device

Available configurations:

- STOP (00) – counting halted – for e.g. doing preliminary configuration of measuring system;
- LF1 (30) – Vm and main counters are driven from LF1 input, without control input; default
- LF1/LF2 (34) – Vm and main counters are driven from LF1 input, control counter Vm2 driven from LF2 input;
- LF1/HF1 (36) – Vm and main counters are driven from LF1 input, control counter Vm2 driven from HF1 input;
- LF1/EN (39) – Vm and main counters are driven from LF1 input, control counter Vm2 driven from EN input;
- LF1/SCR (38) – Vm and main counters are driven from LF1 input, control counter Vm2 driven from SCR input;
- HF1 (60) – Vm and main counters are driven from HF1 input, without control input;
- HF1/LF1 (63) – Vm and main counters are driven from HF1 input, control counter Vm2 driven from LF1 input;
- HF1/HF2 (67) – Vm and main counters are driven from HF1 input, control counter Vm2 driven from HF2 input;
- HF1/EN (69) – Vm and main counters are driven from HF1 input, control counter Vm2 driven from EN input;
- HF1/SCR (68) – Vm and main counters are driven from HF1 input, control counter Vm2 driven from SCR input;
- EN (90) – Vm and main counters are driven from EN input, without control input;
- EN/LF1 (93) – Vm and main counters are driven from EN input, control counter Vm2 driven from LF1 input;
- EN/HF1 (96) – Vm and main counters are driven from EN input, control counter Vm2 driven from HF1 input;
- SCR (80) – Vm and main counters are driven from SCR input, without control input;
- SCR/LF1 (83) – Vm and main counters are driven from SCR input, control counter Vm2 driven from LF1 input;
- SCR/HF1 (86) – Vm and main counters are driven from SCR input, control counter Vm2 driven from HF1 input;
- D-LF1/LF2 (134) – Vm is driven depending on detected direction of flow – indirectly from LF1 input, control counter Vm2 driven from LF2 input (direction independent),
- D-HF1/HF2 (167) – Vm is driven depending on detected direction of flow – indirectly from HF1 input, control counter Vm2 driven from HF2 input (direction independent)

6.1.2 Configuration of counting input encoder (EN, SCR)



Properly configured gas meter equipped with encoder should have synchronized values of encoder's Vo counter and gas meter counter.



After setting configuration of counting inputs with encoder, further modifications of volume counter at measurement conditions are not possible.

Gas meter equipped with encoder output of NAMUR or SCR standard periodically sends information with absolute state of gas meter counter. Conversion device with configuration of counting inputs using encoder takes read of encoder's counter Vo and uses it as volume counter at measurement conditions **Vm (Vm2)**.

For installing or replacing gas meter for another one, equipped with encoder, it is required to perform the following procedure:

- stop counting of gas in conversion device by setting special configuration **ConfImp**=0. Counting of flow from any input will be stopped;
- install / replace gas meter;
- in conversion device – set volume counters at measurement conditions **Vm** and **Vm2** to value same as one in new gas meter;
- start counting of gas in conversion device by setting appropriate counting configuration.

For additional protection the device is equipped with function of gas meter installation. The function is activated by change the parameter **ConfImp**. The function of installation use the first telegram read from encoder for synchronization counters **Vm** (**Vm2**) and the second and next telegrams are used for driving the counters.

6.1.3 Reverse flow support

The purpose of this functionality is to ensure conformity of the gas meter counter with a dedicated device counter (**Vm** or **Vm2** and auxiliary **Vo**) in case of reverse flow situations.

- There are 2 configurations of pulse inputs dedicated to detecting reverse flow from the internal encoder module: D-LF1/LF2 and D-HF1/LF2; A phase shifted signal between two inputs is required.
- In configurations D-LF1/LF2 and D-HF1/LF2, the internal encoder module receives two LF1/LF2 input signals (HF1/HF2) and outputs the processed relative LFs (HFs) counter. This LFs (HFs) counter will increase or decrease depending on the detected flow direction. The auxiliary inputs (**LF2**, **HF2**) operate only in one direction (they can only grow independently of the direction of flow).
- Failure to detect the sequence (phase shift) results in the lack of volume counting to the **Vm** counter - it is possible in the case of e.g. damage to one of the pulse circuits.
- Detection of reverse flow results in immediate resetting of **Qm** flow.
- The reverse counter **VmR** and the reverse increment **dVmR** are driven only when the reverse count is detected on the main counting path, i.e. on the **Vm** counter (i.e. in 8 configurations: SCR, SCR/LF1, SCR/HF1, EN, EN/LF1, EN/HF1, D-LF1/LF2, D-HF1/LF2). In other configurations, any gas reversal will be visible only on the **Vm2** counter.
- The **Vm** counter (or **Vm2** and auxiliary **Vo**) can increase and decrease - to track the counter of the gas meter. Size of reverse flow is represented by the **dVmR** increment and the **VmR** counter.
- The **Vb** counter (similarly **E**, **M** and their emergency versions) is frozen during the reverse flow. Operation is resumed when the volume **Vm** measured in the reverse direction is balanced with the appropriate amount of volume in the forward direction.
- The **Vm2** counter is driven from the control input - it always increases (unless it comes from the encoder input enabling reverse flow). When the reverse flow occurs, this will cause permanent non-compliance of the **Vm** and **Vm2** counters. Unless the user manually resets the counters, there will be compliance: $Vm2 = Vm + VmR$.
- When the main counting input is an encoder (NAMUR or SCR) - the **Vm** will react to the forward and reverse drive according to the read out meter of the **Vo** encoder (e.g. SCR/LF). Then, the control counter **Vm2** will be driven from a conventional (impulse) source, so that each subsequent pulse will increase the value of this counter (e.g. when the gas is reversed, the

encoder will give a reverse signal by reducing the counter, but the LF pulse can be generated and drives the counter **Vm2** forward).

After the reverse flow is detected, a **Reverse flow** alarm will be generated. This alarm will be closed when **dVmR** reaches 0.

6.1.4 Digital inputs

Optionally MacBAT 5 can be equipped with up to 8 binary inputs, which may – according to chosen configuration of counting inputs – work as digital (signaling) inputs. These inputs are intrinsically safe. Inputs DI1..DI5 and DI8 are adapted to work with potential-free reed contacts. Inputs DI6 and DI7 are adapted to work with inductive NAMUR transmitters. When active state is detected on digital input, appropriate event will be stored in device's memory.

Device allows to change name of digital input, which will be used during record of event. Modification of name is possible by editing parameters **DI1Desc÷DI8Desc**.

Additionally, it is possible to configure polarization of each digital input. It's done at parameter **DIPol**. Value of this parameter reflects binary state of 8 bit number, in which bits are responsible for polarization of appropriate input (bit0 – DI1, bit1 – DI2, etc.). If bit has value of 1, active state of that input is input shorted.

6.2 Outputs

Optionally MacBAT 5 can be equipped with up to four controlling outputs of „open collector” type, which allow cooperation with external systems of automation and signaling. Outputs are made in intrinsically safe version, so it's required to use Ex barriers when connecting external non-intrinsically safe devices.

Available work modes of outputs:

- output switched off (open) (**DOxMode** = 0)
- counter output (volume or energy), active – closed (**DOxMode** = 1)
- status output (active – closed) (**DOxMode** = 2)
- output switched on (closed) (**DOxMode** = 4)
- counter output (volume or energy), active – open (**DOxMode** = 5)
- status output (active – open) (**DOxMode** = 6)
- frequency output (only DO2) (**DO2Mode** = 8)
- events output (active – closed) (**DOxMode** = 9)
- events output (active – open) (**DOxMode** = 10)

It is possible to configure properties of output pulses for each output, with parameters **DOxPulseLen** (pulse length – high state) and **DOxPulsePer** (period duration), „x” – means output number, values 1÷4.

Description of available modes is in following paragraphs.

6.2.1 Counter output

This mode allows to output pulses proportional to increments of selected counter. To use this mode (**DOxMode** = 1 or 5), index of selected counter has to be programmed into **DOxIdx** parameter.

Pulse factor (**DOxFactor** – value increase of selected counter per one output pulse) is by default set to 1 if selected counter is from volume group and set to 10 if selected counter is from energy group.

6.2.2 Status/events output

These modes are allowing to control outputs with selected events. There are two types of event-controlled modes:

- status output (modes 2 and 6): when configured (index of selected event is programmed into parameter **DOxEvt**), output is controlled as long as selected event is active,
- event output (modes 9 and 10): when configured (index of selected event is programmed into parameter **DOxEvt**), output is controlled as long as selected event is active or it's turned off when configured time **DOxEvtTm** passes, whichever occurs first.

6.2.3 Frequency output

DO2 can be set to frequency mode (**DO2Mode** = 8), where it can output signal with frequency controlled by selected parameter from the list: **Qb**, **Qm**, **QE**, **QM**, **p1**, **p2**, **t**, **p1g**, **AtmPress**, **tamb** – programmed into parameter **DO2Fldx**.

Range of frequency is 1÷5000 Hz. Configuration of minimum and maximum frequency is performed on parameters **FOMin** and **FOMax** accordingly. Scaling of selected controlling parameter (to match values of this parameter with min and max frequency) is performed on parameters **DO2FMin** and **DO2FMax**. Current output frequency is presented on parameter **FOut**.

7 Communication with the MacBAT 5

7.1 Serial ports

In basic configuration MacBAT 5 is equipped with wireless transmission port COM3 in standard IEC 62056-21 (OPTO). Additionally the device can be equipped with two channels of serial transmission: COM1 and COM2 in standard RS-485. These ports are optional.

All of transmission ports are working independently and allow to transmit with speed given below.

Possible settings of parameters for ports COM1, COM2 and COM3:

| Port | Transmission baud rate: [bit/s] | Transmission address |
|--------------|---------------------------------|----------------------|
| COM1: | 2400 - 256000 | 1-65534 |
| COM2: | 2400 - 256000 | 1-65534 |
| COM3: | 2400 - 38400 | 1-65534 |

7.2 NFC transmission

Optionally the device can be equipped with Near Field Communication (NFC) interface working at 13,56MHz frequency according to the ISO/IEC 14443 standard.

To configure the device, use mobile devices that support the NFC communication standard based on the Android system.

7.3 GSM network transmission

Optionally the device can be equipped with built-in modem 2G/3G/4G with external or internal antenna. The device supports up to nine independent data sending schedules. Each of the schedules is programmed according to the following rules: selection of the year of occurrence, month selection, selection of days of the month, selection of days of the week, time of occurrence, fixed number of minutes of sending data in relation to the programmed time, and connection type: report sent to the TCP data server, sending SMS, connection to the FTP server.

Schedules are configured using the *ConfiT!* Software. A tool for their definition is implemented in the device profile.

The data sent via the GSM network may contain data such as:

- current data
- data recorded with a programmable registration period
- hourly registration data
- daily registration data
- data from the monthly registration
- events and alarms
- structure of DP and ZD tables

After performing schedule operations, the device goes into the Call Window mode for a programmed time period. In this mode it is possible to query the device on demand by superior systems, e.g. SCADA.

After the data transfer has been completed, the device can connect to the FTP server to keep the current configuration and current data. Via the FTP server it is also possible to reconfigure the device and replace the software in OTA mode (Over The Air) without affecting the operation of the device.

The device is available online when using external power supply. This means that it can be read by external systems on demand, and in the event of an alarm, the service is immediately informed. In this mode, full diagnostics of the device are also available, direct reading of all available parameters, including statistical counters of the device, archived data recorded, a complete list of events. This mode also allows you to reconfigure parameters in real time.

7.4 Transmission protocols

Realization of transmission protocols is based on fact that device readout is done by host PC. Commands sent to device are to give in return specific type of information. Information received by and send from device is organized in functional blocks of programmed length. Optimal length of blocks adapted to quality of connection can have essential influence on efficiency of data sending. Device supports data transmission protocols:

- GazModem – version 3 – this is native protocol of the device
- ModBUS – RTU and TCP (modem only).

Device recognizes transmission protocol automatically.

Transmission protocols implemented in MacBAT 5 differ from each other by functionality of remote readout and parameters modification.

7.4.1 Restrictions of remote data access

Device's software allows to restrict remote access to measurement data when using all available transmission protocols. When lock of remote access is active, only readings of following data is possible from device:

- Nameplate;
- Structure of table with available parameters (DP);
- Structure of events table (ZD);

Readout of current and archival data is not possible.

Configuration of that function is done with parameter **LockRead**. When set to 0 – device allows remote readout of all data without limitations. When value is set to 1 – device will automatically lock ability for remote readout when interruption in readouts was longer than set time limit, configurable on parameter **LogoutTm**.

When lock is active, any readout attempt will cause sending by device:

- in GazModem protocol: response 7D hex with empty data field;
- in ModBUS protocol: response 83 hex with empty data field;

To make readouts possible again, user must send authorization command to device (by using ModBUS or GazModem protocol), which contains login credentials, i.e. account number and password.

7.4.2 Types of transmitted data – GazModem

GazModem protocol allows to: readout of current measurement data, readout of registered data, readout of events and alarms, time synchronization, modification of parameters values.

All data structures are described in document *“MacBAT 5 User data structure”*.

7.4.3 Types of transmitted data – ModBUS

ModBUS protocol allows to readout of current data and modifications of parameters. All of data structures are described in document *“MacBAT 5 Default ModBUS map”*.

Structure of current and archival data for readout may be customized to suit User's needs. On request of User, Producer may generate ModBUS map, which will determine new order of current data and records of archival data and will assign them to requested ModBUS registers.

To make device work with ModBUS map – prepared map has to be uploaded to device with use of software tool. Version of uploaded map may be checked by readout of parameter **VerDs6**.

To make modifications with use of ModBUS protocol, it's necessary to unlock modification possibility first. To do this, standard authorisation data, i.e. account number and password, has to be written to register of authorisation (0xFFFFE) by consecutive two character strings.

Unlocking of modifications possibility in ModBUS RTU will be automatic – when device successfully verifies authorisation data. From that point, modification will be unlocked until forced logout (by writing empty character string into register 0xFFFFE) or after passing time to automatic logout (configured in parameter **LogoutTm**).

8 Functions

8.1 Entering data into the device

Configuration data can be entered into the MacBAT 5 using device keyboard or by remote transmission.

Remote configuration through digital communication channels (serial ports COM1, COM2, optical, NFC and modem) can be performed with *ConfIT!* software available from manufacturer's website: <http://www.plummac.com>

Configuration can be performed after login of user with adequate authorization level.

8.2 Passwords and privileges

Authorization system distinguishes 5 levels of privileges that may be used for logging into device and 2 (levels <=1) informational levels:

- (9) PRODUCER
- (7) METROLOGIST
- (4) ADMINISTRATOR
- (3) CUSTOMER
- (2) READER
- (1) BASIC
- (0) LOGOUT

Main features:

- a) Higher level has all privileges of lower level and additional privileges;
- b) Accounts of levels 2, 3, 4 are within protection range of hardware configuration lock **CFG**;
- c) Account of level 7 is within protection range of hardware metrological lock **MET**;
- d) Account of level 9 allows full, fixed access to device configuration (when **MET** is off). Reserved only for manufacturer;
- e) Logging on levels 4 and 7 with use of hardware locks is possible only when switches **SecurLvlAdm**=1 or =3 and **SecurLvlMet**=3 (see below);
- f) Required privileges levels for each configurable parameter available in the device are listed in document *"MacBAT 5 User data structure"*.

In detail:

- Levels 2-4 and 7 may use up to five fixed accounts (for each level, i.e. 201-205, 301-305, 401-440, 701-705) built into device. By default, one account for each level is active: 201, 301, 401 and 701, with default password: 4096. Adding a user is performed by setting password (different than 0) for that user. Users 401 and 701 cannot be removed.
- Any modification of parameters requires login as selected user with correct password or disabling one of hardware locks. After first login with use of keyboard - next modifications do not require authorization. When entering sleep mode of the device, user is automatically logged out. Next change of parameter requires to login again. Information about active user logon is presented on status bar on main screen. Modification of parameters via transmission requires to enter user identifier and correct password every time.

The privileges system lets use two different protection means:

- software protection (accounts and passwords);
- hardware protection (sealed hardware switches);

Device has ability to configure both protection means to adjust the security system to regulations in local gas market. To configure it are used independently 2 parameters: **SecurLvlMet** and **SecurLvlAdm**.

Each configurable parameter of the device is protected on designed level. Details are described in documentation "User data structure". For parameters up to level 9 adjustment of the protections means is possible by using **SecurLvlMet** and for parameters up to level 4 - **SecurLvlAdm**.

Parameter: **SecurLvlMet** is possible to configure on values 3 and 4, **SecurLvlAdm** is possible to be configured on values 1, 2, 3, 4. Description of each value (level):

- **Level 4:** configuration of parameters is possible when:
 - appropriate hardware switch is disabled (MET or CFG);
 - AND**
 - the customer has used the proper account number with valid password.

- **Level 3:** configuration of parameters is possible when:
 - appropriate hardware switch is disabled (MET or CFG);

When hardware locks are disabled but e.g. used transmission protocol expect authorization data then giving account "0" and password "0" is allowable. It is still possible to use proper accounts and passwords in this case.

- **Level 2:** configuration of parameters is possible when:
 - the customer has used the proper account number with valid password;

Position (activity) of hardware switch CFG is ignored – it means that the hardware switch is treated as disabled.

- **Level 1:** configuration of parameters is possible when:
 - hardware switch CFG is disabled;
 - OR**
 - the customer has used the proper account number with valid password.

Level 1 expect using at least one mean to confirm access – either hardware switch or account + password. When hardware lock is disabled but e.g. used transmission protocol expect authorization data then giving account "0" and password "0" is allowable. It is still possible to use proper accounts and passwords in this case.

- In addition to described security levels, there is additional setting for enabling configuration of parameters when hardware locks are enabled – but only parameters with low access levels 2 and 3. This setting is performed on parameter **CustAccess**. Setting it to value 1 will allow such modifications, 0 – blocks it.

All of device's parameters designed for configuration are described in document "MacBAT 5 User data structure", where are also indications what kind of privileges are required to do modification.

Default settings give following privileges for specific group of users:

- METROLOGIST
 - privileges for data readout
 - privileges for configuration of all device's parameters (including calibration of legally relevant measuring inputs of pressure and temperature)
- ADMINISTRATOR
 - privileges for data readout
 - privileges for configuration of device parameters typically altered during installation process and basic configuration of the device
- CUSTOMER
 - privileges for data readout
 - privileges for configuration of non-metrological parameters, e.g. limits
- READER
 - privileges for data readout
 - privileges for configuration of private permanent password

8.3 Clock

Device is equipped with real time clock. Synchronization of clock is possible via:

- automatically (2G/3G/4G modem is required and must be configured to cyclically connect to GSM network)
- PUSH mode – time can be set using any interface (port) to access the device: keyboard, COM1 and COM2 (RS485), optical interface (IEC 62056-21), NFC and modem.

Information about clock modification is saved into device's events memory (time before and after modification). Access to time modification with use of keyboard is protected by password.

An option is available for automatic change to summer/winter time. Change of time can be realized automatically, according to built-in calendar or manually, by setting new time by user.

Change of time both automatic and manual has no influence on gas volume counting in main counters **Vb** and **E**. An event **Time changed** will appear in device memory in case of changing time in configuration of automatic change to summer/winter time.

8.3.1 Clock adjustment modes

There are three modes of clock adjustment:

- **RTCMode=1 (URGENT mode)** – all time settings are immediate. This mode is not recommended in normal using of the device because does not protect the registration step (such urgent setting can e.g. jump over the full hour – in effect the hourly record will be lost).
- **RTCMode=2 (OPTIMAL mode)** – mode with registration protection and with accelerated step response to clock setting requests. In this mode, the delay of response to time settings is typically relatively short and results only from the protection of periodic and hourly registration.
- **RTCMode=3 (FLUENT mode)** – all time adjustments are sent for smooth tuning of the clock. In this case - when the time difference does not exceed maximum permissible deviation - there is no sign of tuning the clock in archives.

If the time change made has damaged the hour duration by more than ± 30 seconds, the information will be saved in TimeLOG.

8.4 Archives

Device has ability to store measurement data in different periods of time, with possibility to choose set of registered parameters by user.

Device stores parameters containing:

- main and error (disturbance) counters;
- increments of counters (load records);
- peaks of increments of counters (maximum loads) + timestamps;
- measured value of pressure and temperature;
- measured additional and technological parameters;
- information about main properties of programmed gas composition;

8.4.1 Archival data with programmable period (registration type R - periodic)

Registration period can be programmed in range from 1 to 60 minutes (only whole divisors of 60), set by **Dtau** parameter.

Registration is synchronized by internal clock. Cycle of record registration always contains the beginning of hour. If registration period is programmed to 12 minutes, counting from 12:00, registration records will be as following: 12:00, 12:12, 12:24, 12:36, 12:48, 13:00, 13:12, 13:24 etc.

Memory area is organized in the form of a circular buffer, i.e. when the memory is full, entering the current sample automatically deletes the oldest data fragments.

Registration type R can store up to 36000 records (over 4 years @ 60 min period).

Description of archival data set registered with programmable period is available in document *"MacBAT 5 User data structure"*.

8.4.2 Archival data with fixed period (registration type D)

Device is also registering archival data with fixed, predetermined period. These include:

- Hourly data (registration period – clock hour);
Storage period of hourly data is up to about 11500 records (over 16 months);
- Daily data (registration period – gas day, registration at billing hour, by default set at 06:00);
Storage period of daily data is up to about 1400 records (about 4 years);
- Monthly data (registration period – gas month, registration at billing hour, by default set at 06:00 and in billing day, by default first day of the month);
Storage period of monthly data is up to about 450 records;
- Periodic data 2 (registration period configurable with the most often: 1 hour, the rarest: 1 year). By default 10th, 20th, last gas day of month.
Storage period of periodic data 2 is up to about 800 records;

Description of archival data sets registered with fixed period is available in document *"MacBAT 5 User data structure"*.

8.4.3 Change of registered data set

Device's software allows to change sets of both registered data types independently.

Change of registered data set also changes time horizon of stored data in archive memory. Increase in count of registered parameters shortens period of saved data in memory, decreasing count of

parameters increases this period. Change in horizon of storing data in memory is proportional to changed set, e.g. if previous set of registered data contained 10 parameters and new set contains 11 parameters, then horizon of stored data will shorten by about 10%.

Change of registered data set type R is done with use of parameters **AddRegR1** to **AddRegR10**, and change of registered data set type D is done with use of parameters **AddRegD1** to **AddRegD10**. To run registration of chosen parameter (excluding parameters in text/string format), one of said parameters has to be programmed with index of chosen parameter to register. To remove parameter from registration – the corresponding parameter has to be set to value -1.



Before making any changes in registered data sets it's recommended to read all needed archives, because changes in data set could make impossible to access archives before changes in data sets of types R or D.

8.4.4 Momentary registration

This special type of registration allows to register changes in defined parameters, when step change of given parameter is detected. When such change is detected, registration is done immediately and next checks of value change are performed with 1 second intervals for next 5 seconds. Parameters recorded in momentary registration are configured on ten parameters **AddRegC1** to **AddRegC10**, where any of them could trigger this type of registration. User can define trigger criteria on parameters **dRegC1÷dRegC10** (values of step change) and limits of tracked parameters (**RegCXMin**, **RegCXMax**, where X is a number of tracked parameter, values 1..3) – tracking will be active, when parameter value is outside defined limit.

8.4.5 Periodic registration 2

This type of registration allows to register parameters from D data set according to configured schedule. User can configure desired registration pattern on binary type parameters: **RegTWeek** (days of the week), **RegTMonth** (months), **RegTDay** (days in month) and **RegTHour** (hours). Nearest event of incoming periodic registration is presented on parameter **RegTNext**.

8.4.6 Single registration

This function allows to perform registration of all types on request – helpful when e.g. device has to be disconnected from current measuring installation to perform maintenance or repair and it's needed to save current state of registration. To use this function, parameter **SingleReg** has to be programmed with time when such registration should be performed (in UNIX format). If programmed time is older than current time, registration will be performed immediately.

8.4.7 Alarms and events

System alarms are related to failures, which have influence on measured values used in calculations of increments of main counters. During system alarms, according to alarm type, calculations are made with substitute values. Additionally, states of current and registered values are changed, if failure has influence on them. When system alarms are active, main counters (**Vb**, **E**, **M**) are stopped and emergency counters (**Vbe**, **Ee**, **Me**) are started instead.

Temporary and constant events are related to failures, which do not have influence on correct values of main counters. They do not stop main counters and don't change status of registered and measured data. Exception are events **Device Startup** and **Time changed**, which are changing state of measured and registered data to discontinuity.

In MacBAT 5 there are 5 types of memory of events and alarms:

- Alarms memory (i.e. AlarmLOG);

Memory that contains records for alarms and interventions, which are essential from the viewpoint of measurements and calculations accuracy. This memory has capacity of approximately 3000 records. Filling level is presented on parameter **AlarmLOG** and if it is at 100%, system alarm is generated (**AlarmLOG full**) and main counters are stopped. In addition, configuration of device is blocked. This type of memory requires periodic clearing – acknowledgment of closed alarms (confirmation by operating personnel, that they are acquainted with list of alarms stored in memory). In order to do clearing, parameter **AlarmLOG** should be set to zero.

- Events memory (i.e. ProcessLOG);

Memory that contains records for non-essential events from the viewpoint of measurements and calculations accuracy, but important for technological reasons (signaling, limits, etc.). This memory has capacity of approximately 3000 records. If memory is filled, older records are deleted automatically.

- Interventions memory (i.e. SetupLOG);

Memory that contains records for important interventions from the viewpoint of measurements and calculations accuracy. This memory has capacity of approximately 1000 records. Filling level is presented on parameter **SetupLOG**. Filling the memory to 100% does not generate any alarm, device is still working normally, but further important changes in configuration are not possible. Erasing of this memory is possible with at least Metrologist privileges level (7). In order to do erasing, parameter **Erasing** should be set to 4 (to use this function, it should be unlocked first by programming serial number of the device to parameter **ConfTrig**).

- Important time change memory (i.e. TimeLOG);

Memory that contains records typically for cases when the hour duration has been damaged by more than ± 30 seconds. The records of hourly registration important for “Load recorder” will be marked with information Time error if the hour duration has been damaged. Hourly increment of Vb (Vm) marked “Time error” is banned to become a peak hour (maximum load) for current period (day, month). This memory has capacity of approximately 4000 records. If memory is filled, older records are deleted automatically.

- Gas changes memory (i.e. GasLOG);

Memory that contains records of all gas changes made in the device. This memory has capacity of approximately 300 records. If memory is filled, older records are deleted automatically.

- Main counter Vb changes memory (i.e. VbLOG);

Memory that contains records of all main counter Vb changes made in the device. This memory has capacity of 1000 records. If memory is filled, farther changes are suspended. VbLOG is protected against being cleared.

8.4.8 Functionalities of Load recorder and Maximum loads

The device has got the functionalities of load recorder and maximum loads.

Load recorder: the basic functionality is to count typically 24 hourly increments of Vb (Vm) during the gas day (23 or 25 when there is the day of winter<>summer time change). The increments (loads) dVb (dVm) are registered in dedicated archive (menu position **Data > Recorder > LoadRecorder**) and the current loads are possible to be read in **Data > Recorder > Current** menu.

Maximum loads: the basic functionality is to select from all hourly increments of Vb (Vm) during the gas day or from all daily increments of Vb (Vm) during the gas month the maximum value and save it together with the time of its occurrence. The maximum loads dVb (dVm) are registered in dedicated archive (menu position **Data > Recorder > Maximum Loads**) and the current loads are possible to be read in **Data > Recorder > Current** menu.

The list of maximum loads:

- Hourly peak of volume at base conditions Vb during the gas day
- Hourly peak of volume at base conditions Vb during the gas month
- Daily peak of volume at base conditions Vb during the gas month

- Hourly peak of volume at measurement conditions Vm during the gas day
- Hourly peak of volume at measurement conditions Vm during the gas month
- Daily peak of volume at measurement conditions Vm during the gas month

8.5 Software update

MacBAT 5 is equipped with function for program updating.

Software update may be locked for user (based on national law). Function of this lock is placed on parameter **LockFW1**. Value of 1 turns on the lock.

User has possibility to block program update by setting parameter **LockFW2** (forced updates from any source, PUSH mode) or **LockFW3** (automatic updates from modem, PULL mode). Value of 1 turns the lock on.

Software update is only possible in situation, when alarms memory has sufficient space for safe recording of information about update (parameters **AlarmLOG** and **SetupLOG** have to be lower than 95%).

After program updating, event **Software update** is saved in device's memory on alarm list. There is information about user, who authorized program, previous and current program series and status of the process (UpCode=0 means update successful, the other values – a problem has occurred).

8.6 Main counter Vb changes

By default Vb changes are blocked in MID-compliant device. If your national regulations let to change Vb counter during using – please inform Manufacturer to activate this option during production process. If the option of Vb changes is active – to change of Vb the hardware switch MET needs to be opened. All changes are saved in the special memory – VbLOG protected against being cleared.

VbLOG is possible to be read by the display (see the menu structure below) or by using dedicated GazModem protocol command.

9 Device start up

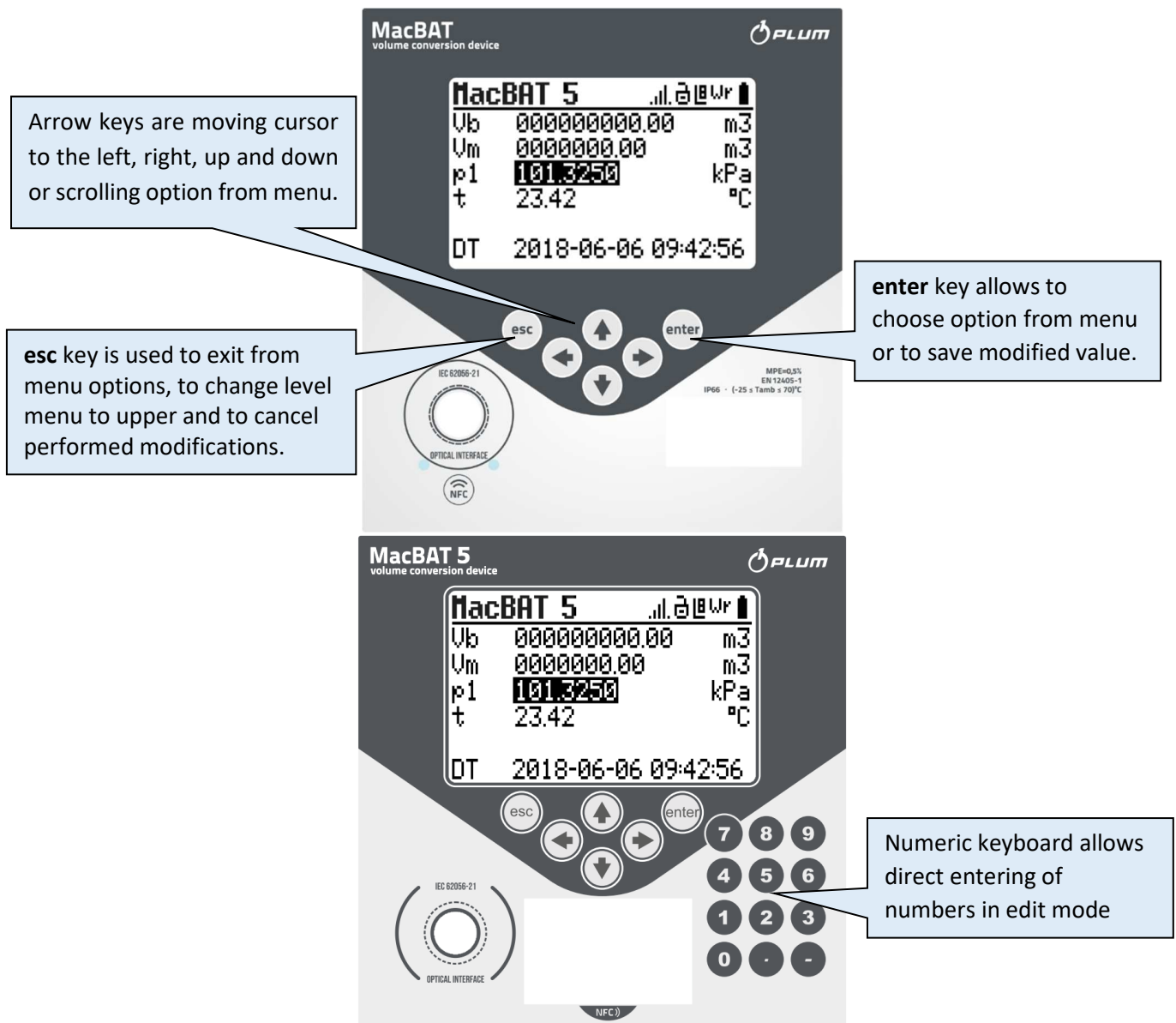
After connection of power supply (internal battery or external), device starts up automatically. In normal operation, the device display is turned off when device is not manually operated. Pressing any key (except **esc**) will cause display to turn on.

In case of longer storage it's recommended to disconnect internal batteries.

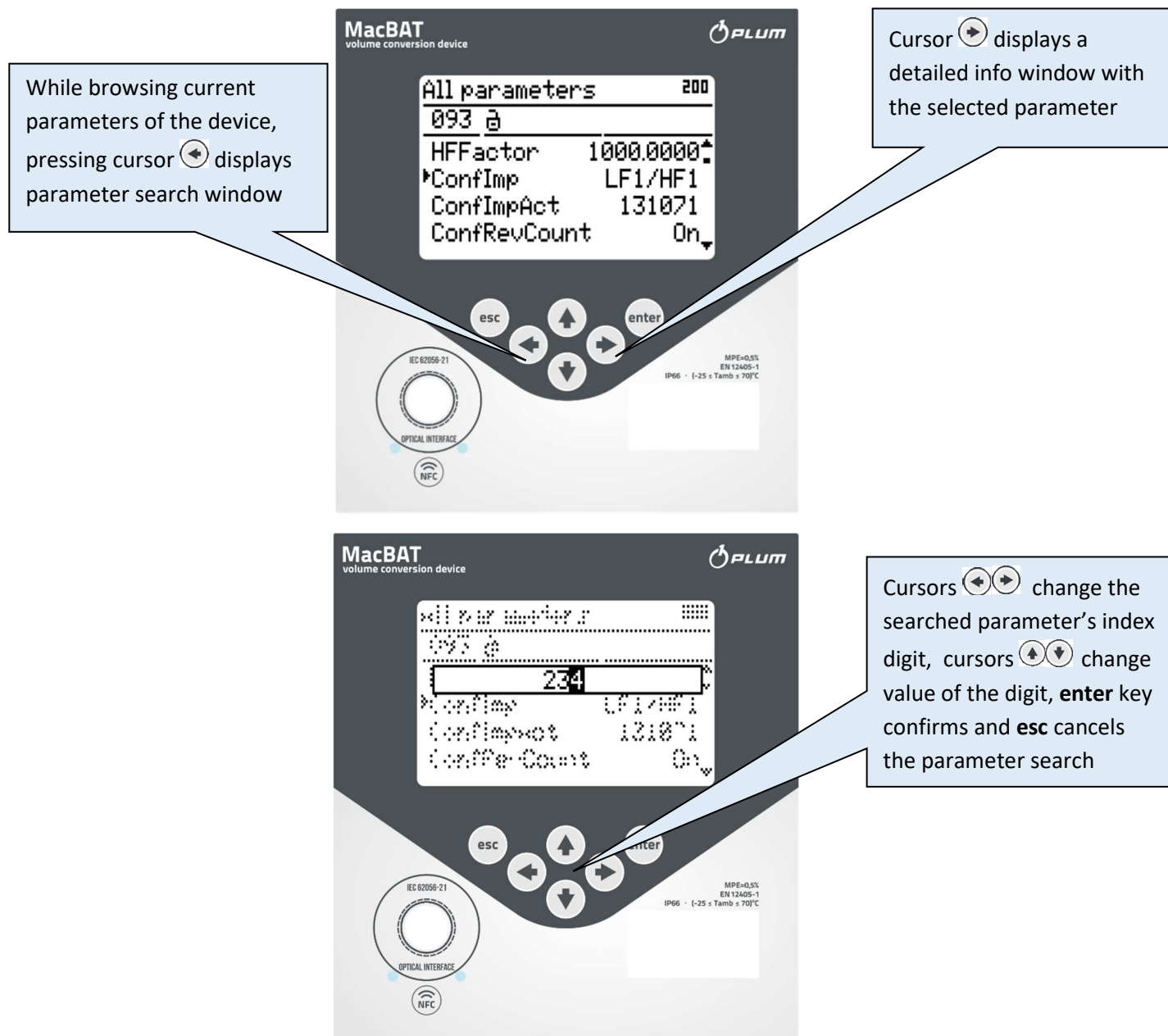
10 Operation

10.1 Keyboard

Local communication between user and device is realized by keyboard and graphic display. Keyboard is equipped with two function keys **enter**, **esc** and four arrow keys. Optionally, a numeric keypad is available.



When viewing values of parameters, it is possible to go quickly to searched parameter. To do so, it is necessary to know index of searched parameter.















An example of archive data window:

| | | | | |
|---------------------|-----------|-----|---------------------------------------|-------------|
| Hourly data | 204 | --- | Type of data | menu number |
| \$Vb | m3 | --- | \$Param.name | Param.unit |
| 2020-08-03 13:00:00 | | --- | Timestamp | |
| | 101681.65 | --- | | Param.value |
| St: OK | | --- | Status of sample (OK / Err / TimeErr) | |

If the name of the parameter id preceded by the symbol of \$ - it means that the parameter has status "VERIFIED".

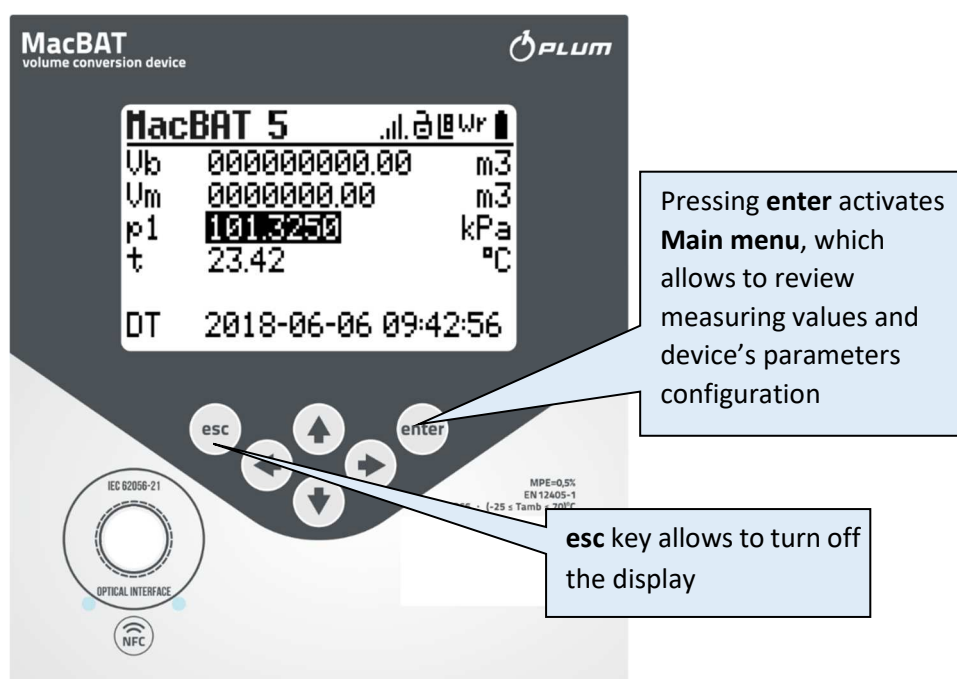
10.2 Signaling of operating state

Description of symbols displaying on status bar:

| | |
|---|--|
|  | Battery 10-100% (the icon changes its filling depending on the percentage of battery charge) |
|  | Battery discharged or close to discharge: <10% |
|  | External supply |
|  | Hardware configuration lock ON (both locks MET and CFG are ON) |
|  | Hardware configuration lock OFF (MET or CFG is OFF) |
|  | User logged locally (in this example – level 4 of privileges) |
|  | Active alarms or events, pulsation – new alarms /events |
|  | Active events, pulsation – new events |
|  | No active alarms, pulsation – there were unchecked alarms/events that have ended |
|  | Modem signal reception strength (in this example – 4 out of 5 bars) |
|  | Device has MID-compatible software and has active protection of MID parameters |
|  | Device has MID-compatible software but has inactive protection of MID parameters |

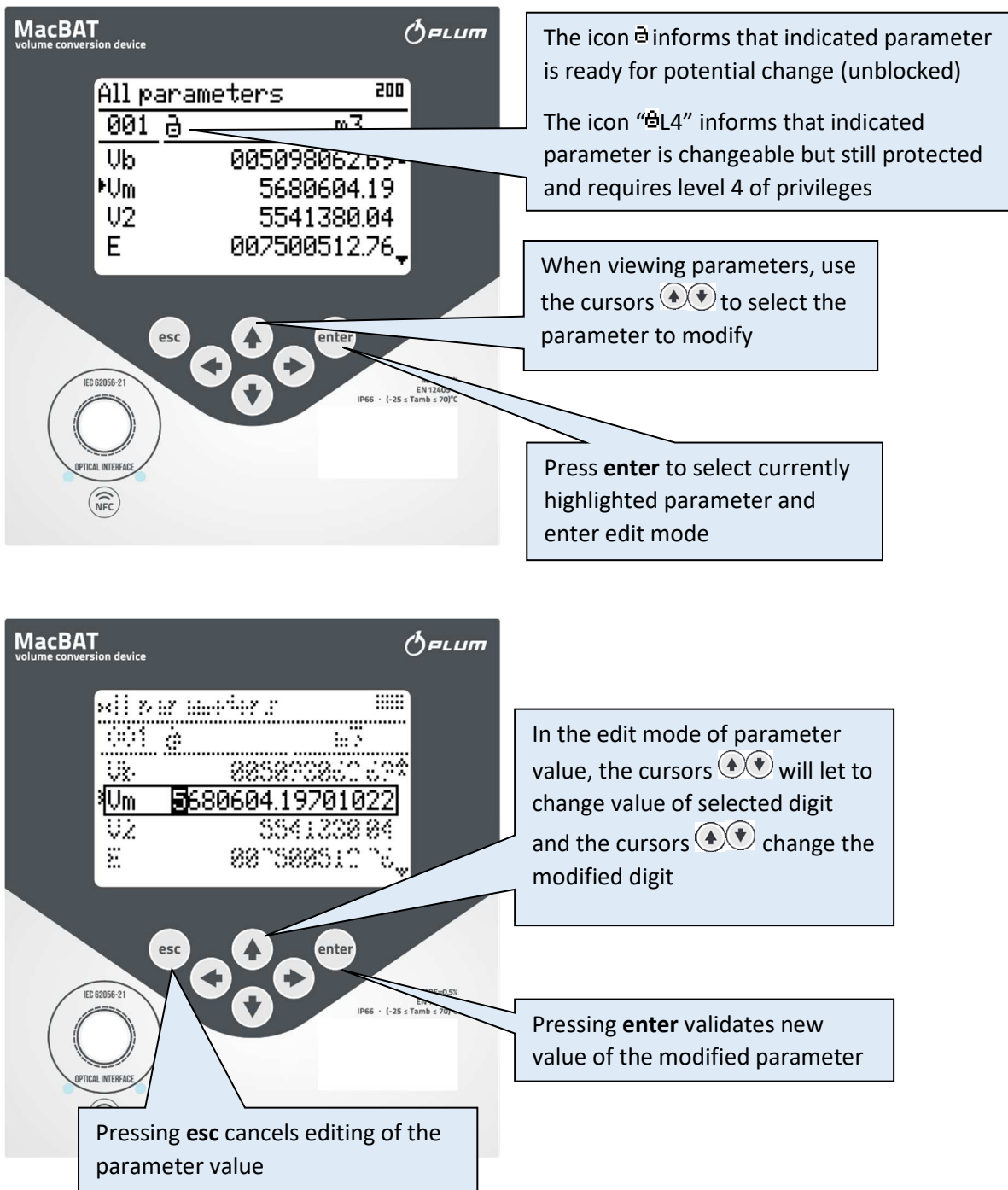
10.3 Main menu functions


As standard, display panel is turned off. Pressing any of keys from keyboard (besides **esc**) causes turning on of display with main measuring values displayed. Example:






System alarms, that are recorded by device, are cause of displaying - on top of the display at status bar – informational icon “Er” or “Wr”. Blinking of this icons means, that new events appeared. If no active alarms are present, then icon “OK” appears. Besides that, if measured value of pressure or temperature is out of range – current value of parameter is displayed with alternating background color.

Modification of parameters with use of keyboard could be performed as follows:







The icon  informs that indicated parameter is ready for potential change (unlocked)

The icon “L4” informs that indicated parameter is changeable but still protected and requires level 4 of privileges

When viewing parameters, use the cursors   to select the parameter to modify

Press **enter** to select currently highlighted parameter and enter edit mode

In the edit mode of parameter value, the cursors   will let to change value of selected digit and the cursors   change the modified digit

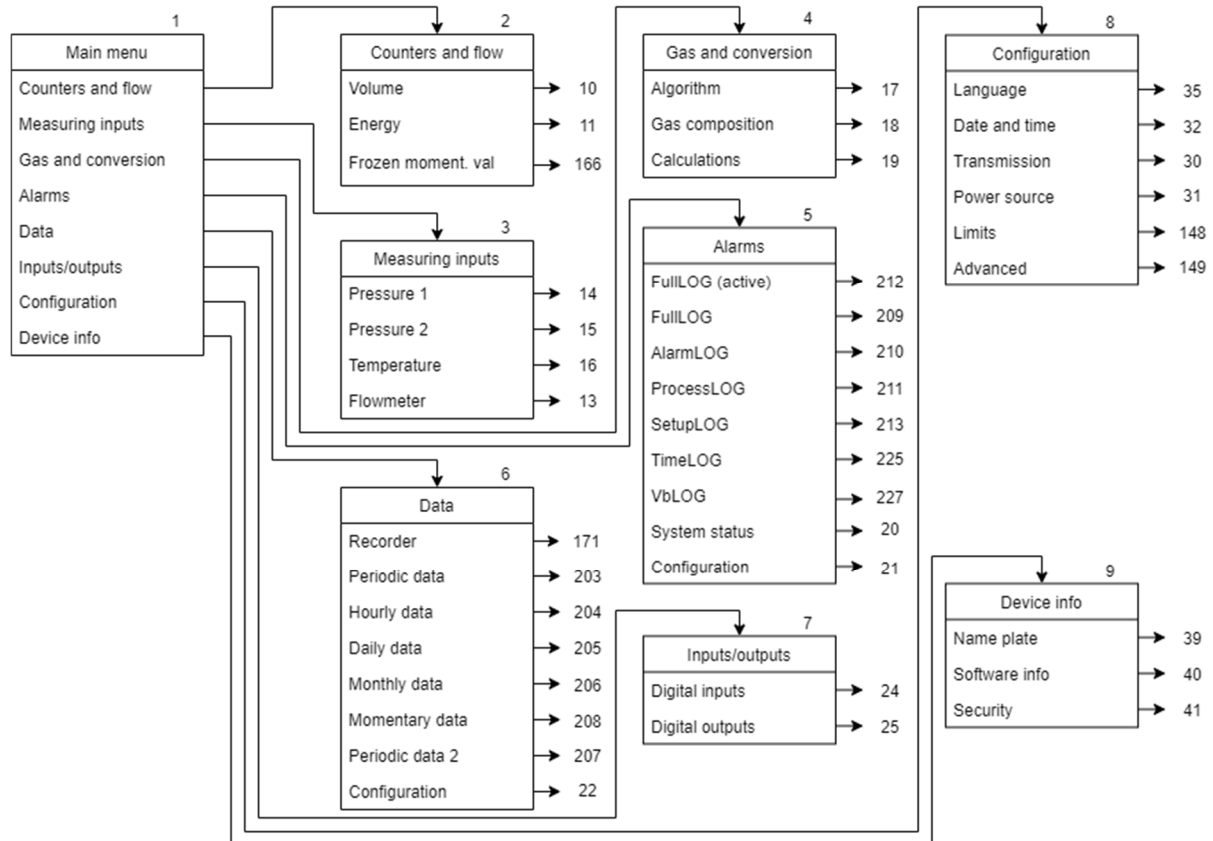
Pressing **enter** validates new value of the modified parameter

Pressing **esc** cancels editing of the parameter value

10.4 Menu structure

The device operation is based on items selected from the menu. Pressing **enter** on main screen will show Main menu, selection of options is done with cursors keys. Next – **enter** on selection will open sub-menu and **esc** will cause jump to previous menu.

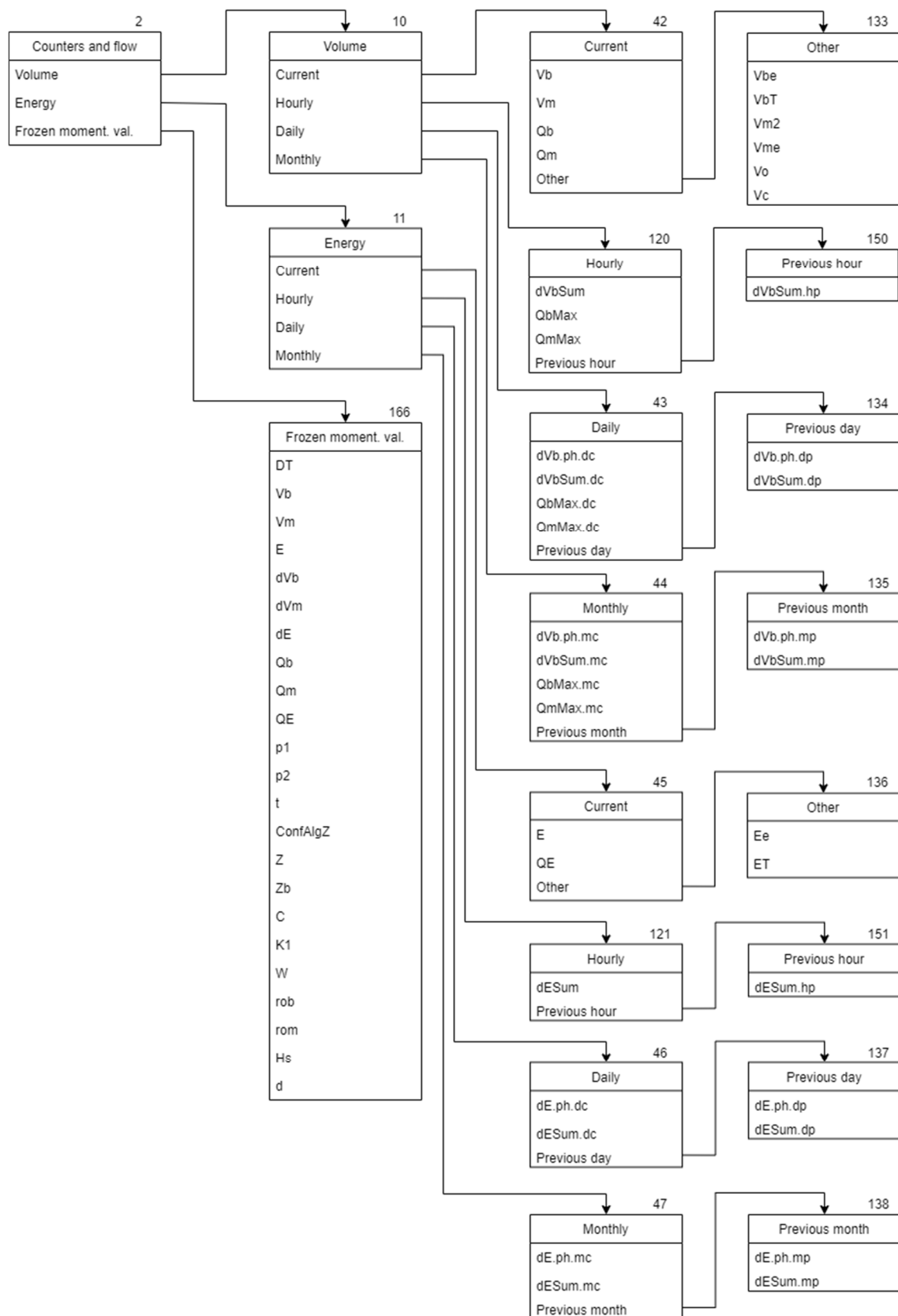
10.4.1 Main menu



This menu consists of following sub-menus:

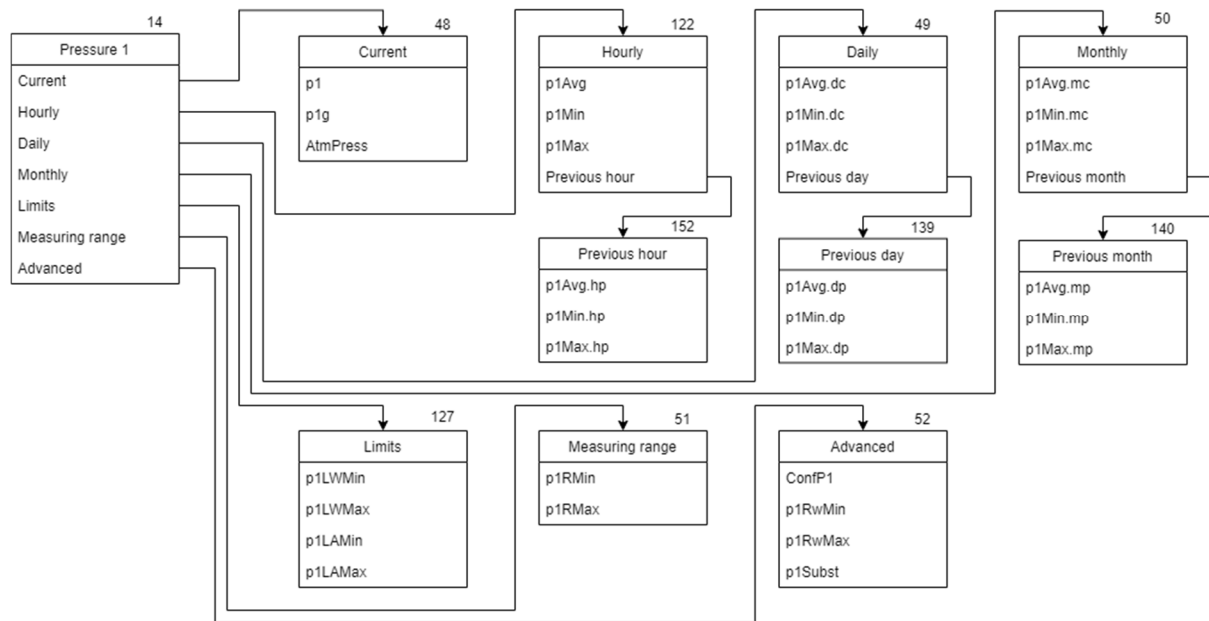
- **Counters and flow** – groups parameters for counting of volume and energy. It allows to view current values and also average, minimal and maximal values from hourly, daily and monthly time periods for increments of volume and energy, also for flow values.
- **Measuring inputs** – groups parameters for measuring sensors: pressure 1, pressure 2, temperature and gas meter (flowmeter). It allows to view current values and also average, minimal and maximal values from hourly, daily and monthly time periods. Configuration of these sensors is possible from this menu.
- **Gas and conversion** – groups parameters for gas composition, calculation methods of compressibility factor and shows calculated properties of gas.
- **Alarms** – allows access to full set of alarms and events registered in the device.
- **Data** – allows access to full set of registered data recorded in the device.
- **Inputs/outputs** – configuration and current state of available inputs and outputs.
- **Configuration** – allows to set configuration of all device's parts.
- **Device info** – information about device: name plate, software information and current state of security settings.

10.4.2 Counters and flow



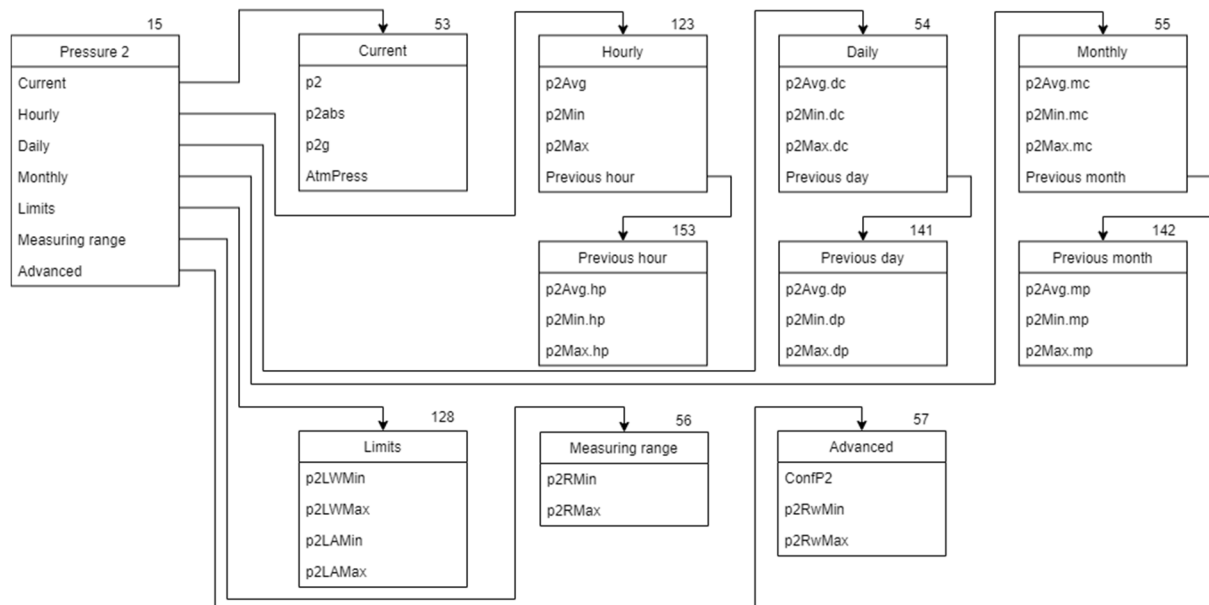
This menu groups parameters for counting of volume and energy. It allows to view current values and also average, minimal and maximal values from hourly, daily and monthly time periods for increments of volume and energy, also for flow values.

10.4.3 Measurements – Pressure 1



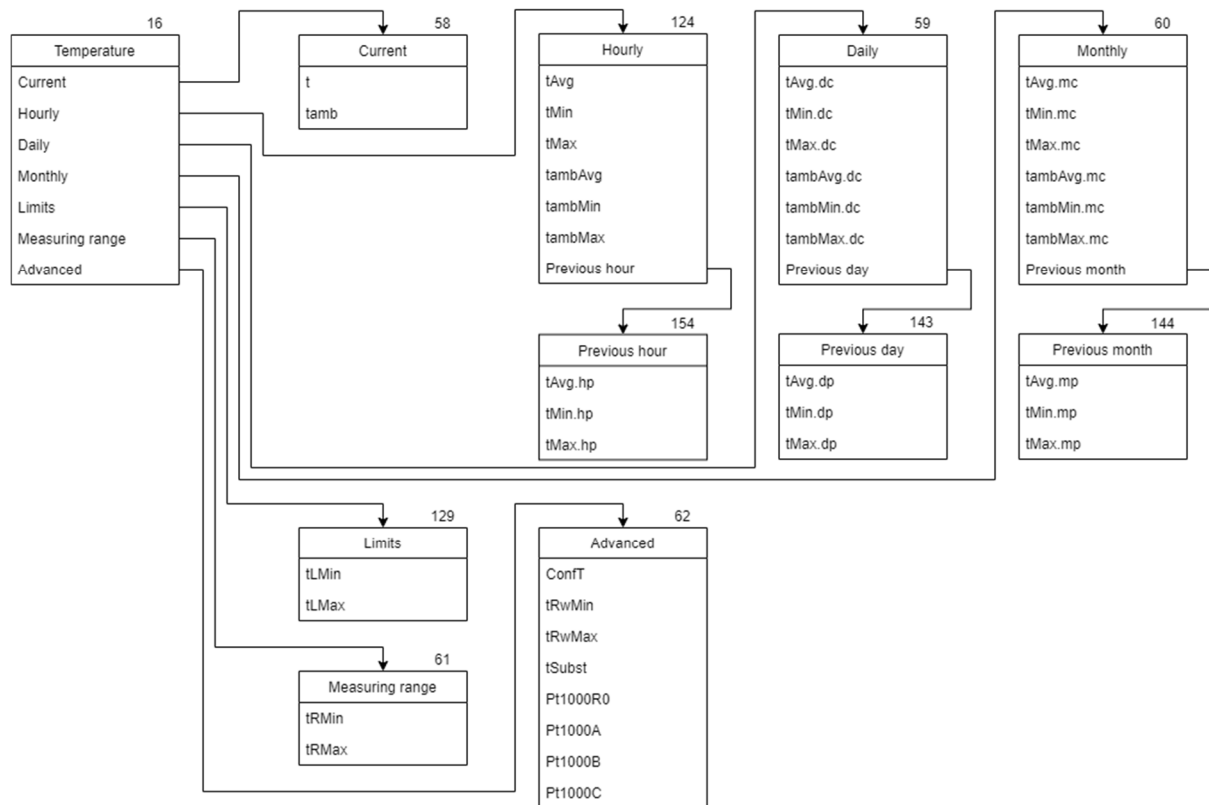
This menu groups parameters for pressure sensor 1. It allows to view current values and also average, minimal and maximal values from hourly, daily and monthly time periods. Configuration of this sensor is possible from this menu.

10.4.4 Measurements – Pressure 2



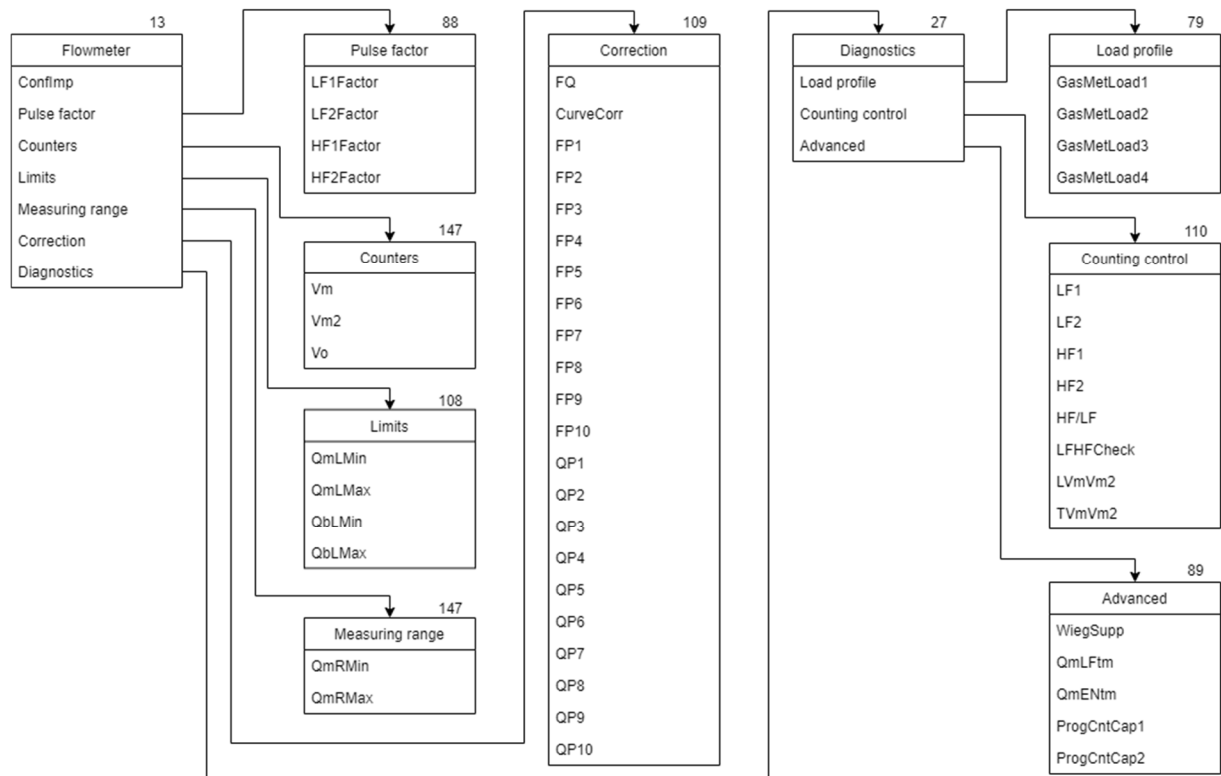
This menu groups parameters for pressure sensor 2. It allows to view current values and also average, minimal and maximal values from hourly, daily and monthly time periods. Configuration of this sensor is possible from this menu.

10.4.5 Measurements - Temperature



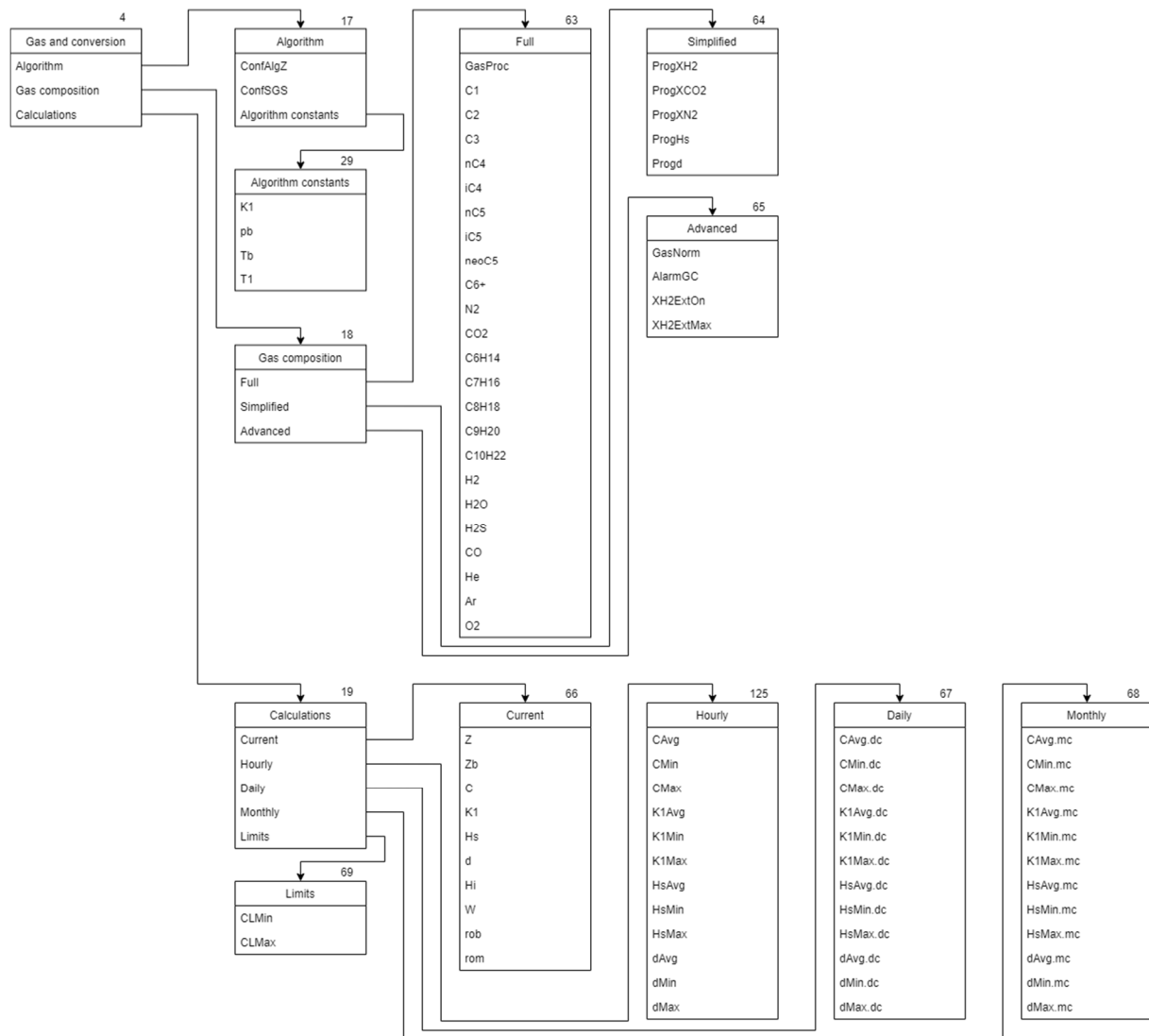
This menu groups parameters for temperature sensor. It allows to view current values and also average, minimal and maximal values from hourly, daily and monthly time periods. Configuration of this sensor is possible from this menu.

10.4.6 Measurements – Gas meter (flowmeter)



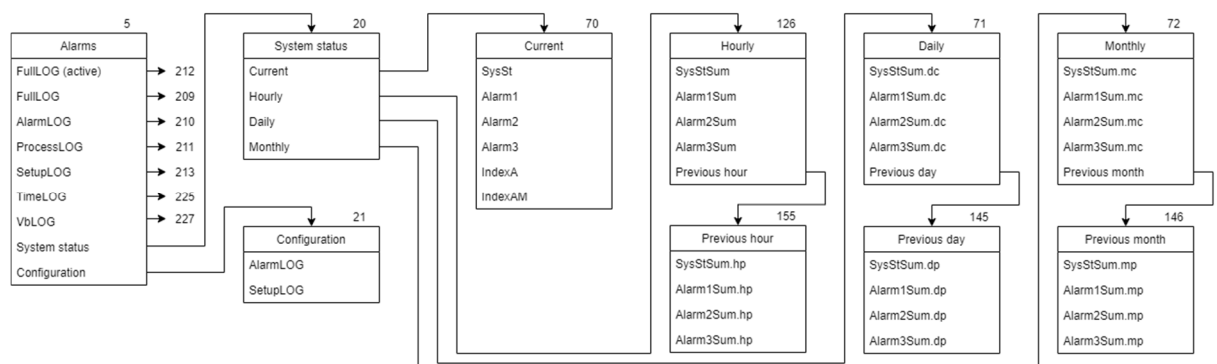
This menu contains settings for gas meter – basic pulse inputs configuration, flow ranges, correction, counting control and limits of flow. Diagnostics of gas meter are also available.

10.4.7 Gas and conversion



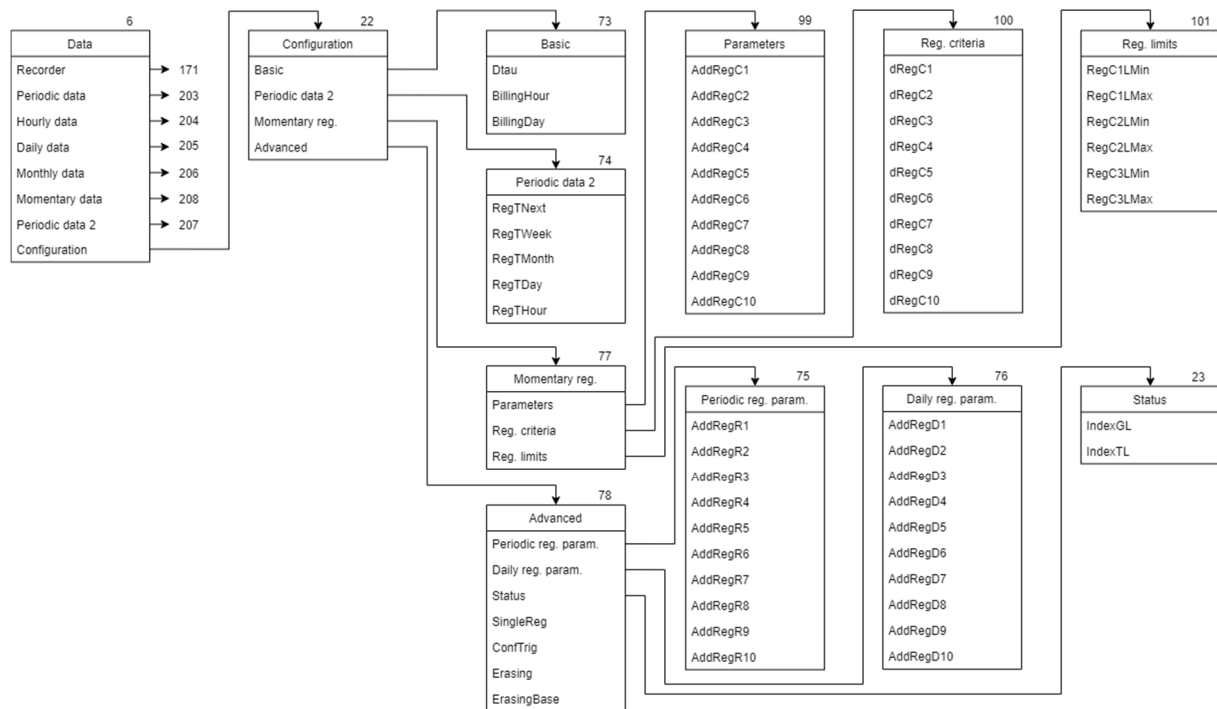
This menu groups parameters for gas composition, methods and shows calculated properties of gas.

10.4.8 Alarms



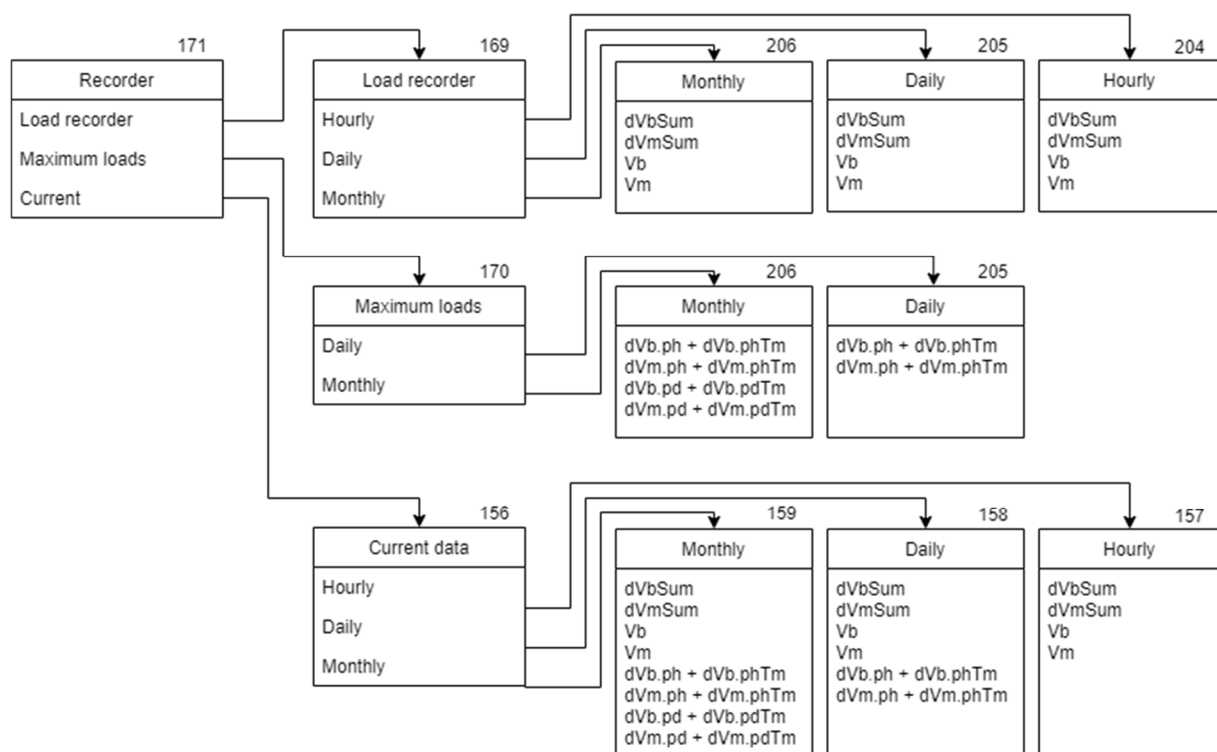
This menu allows access to full set of alarms and events registered in the device.

10.4.9 Data



This menu allows access to full set of registered data recorded in the device. Configuration of registered parameters is available here.

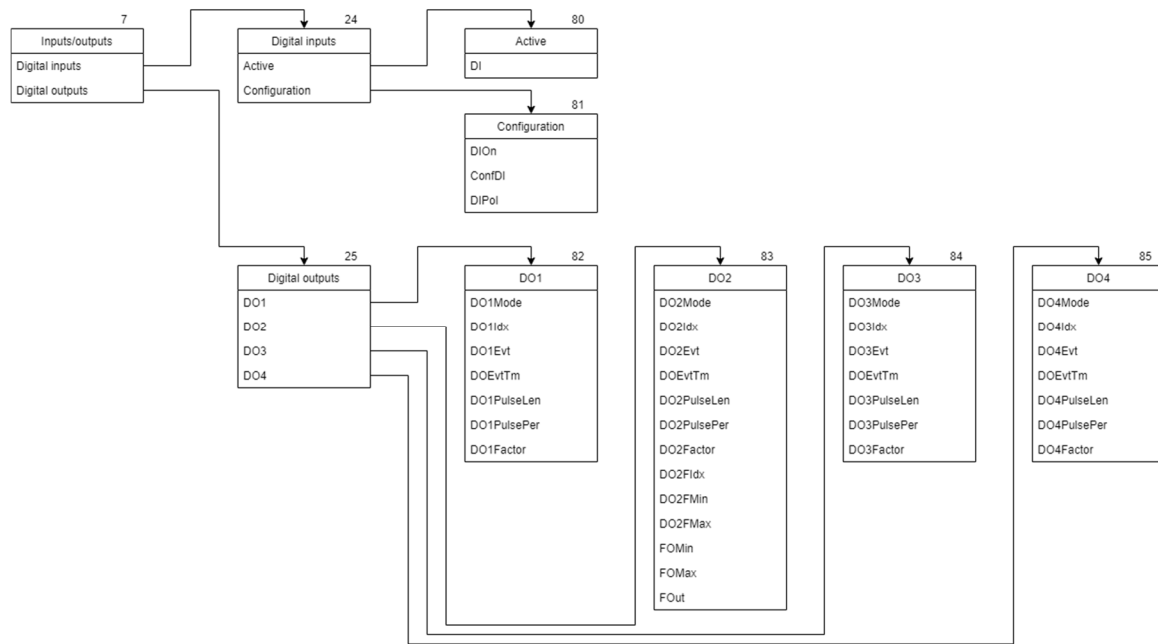
10.4.9.1 Recorder



This menu allows access to most parameters important for “Load recorder” and “Maximum loads” functionalities.

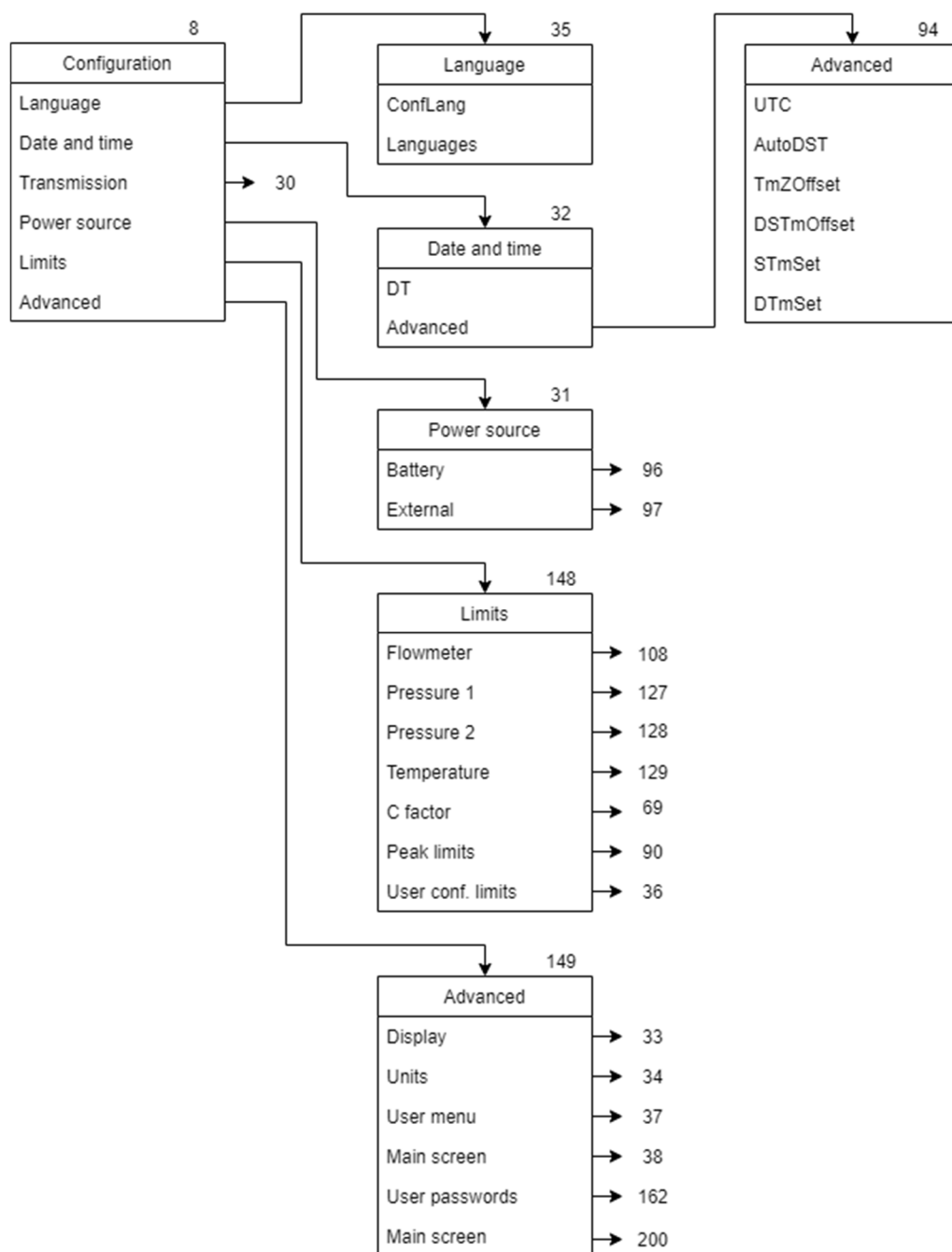
10.4.10

Inputs/outputs



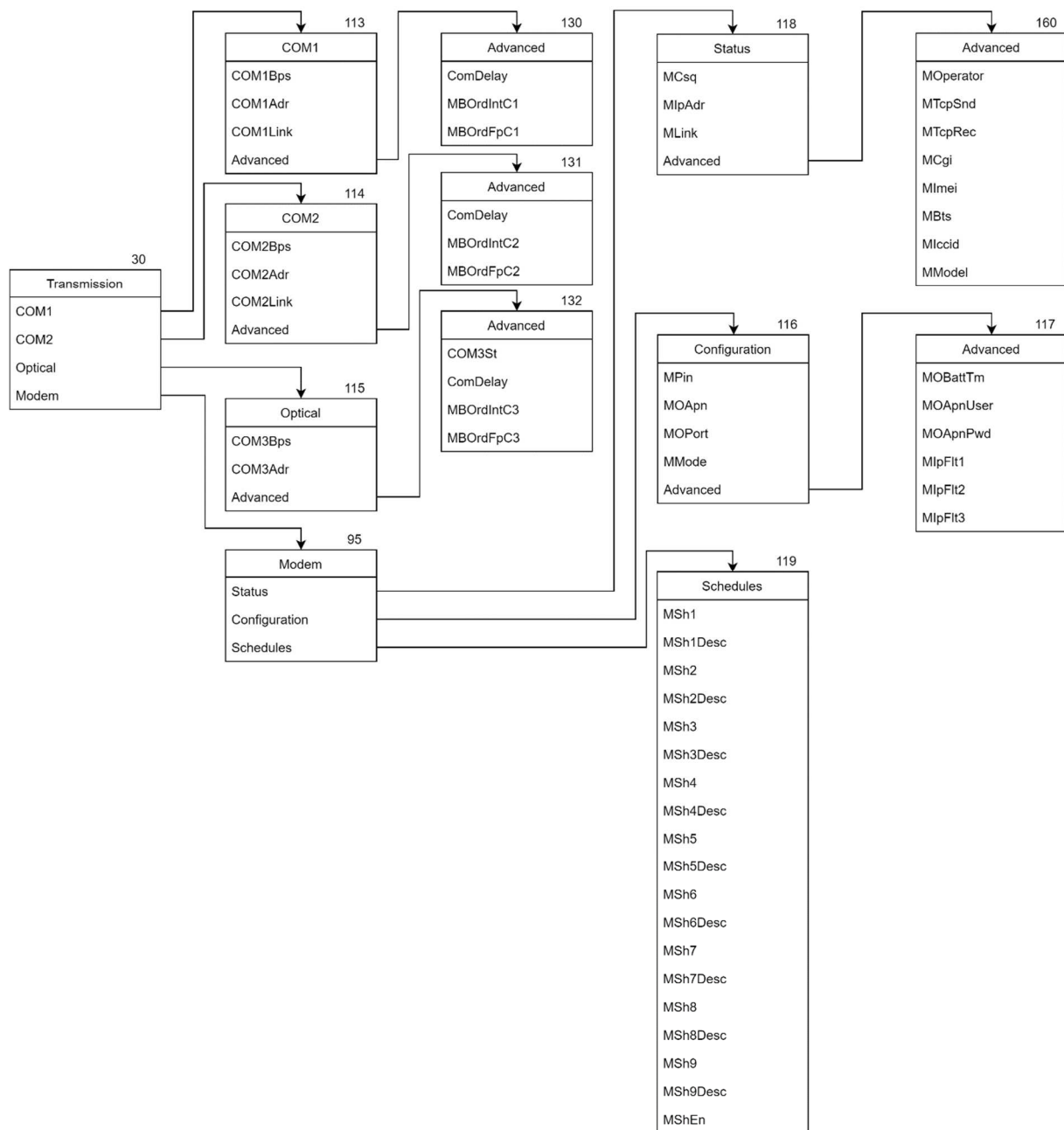
This menu contains configuration and current state of available digital inputs and outputs.

10.4.11 Configuration



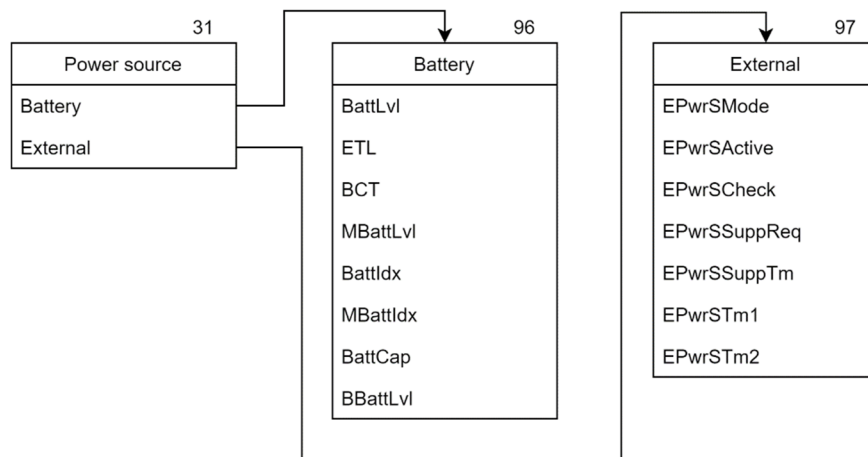
This menu allows to set configuration of all device's parts. Some of sub-menus are expanded below.

10.4.12 Configuration – Transmission



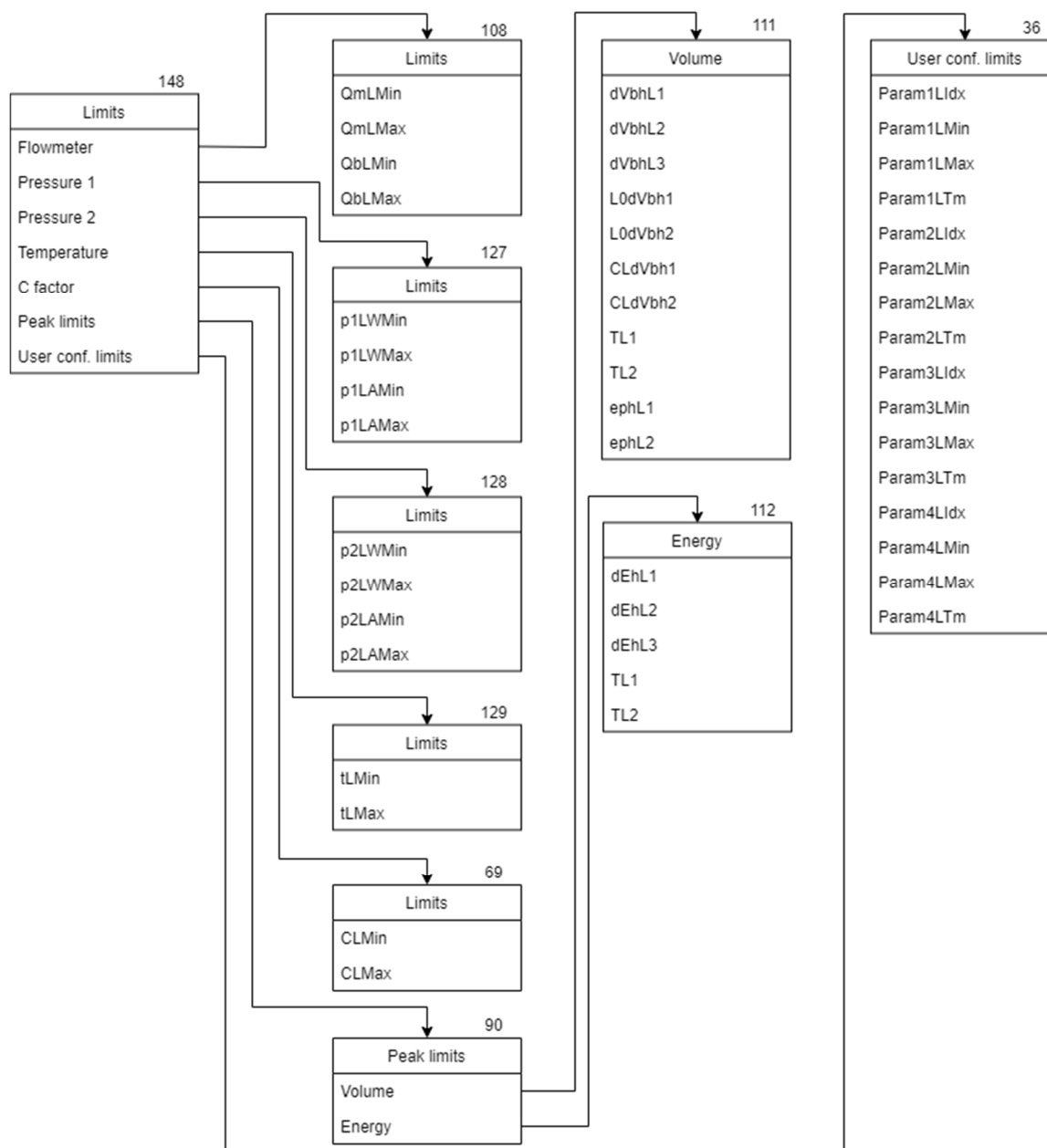
This menu contains settings and current state for transmission interfaces: serial, optical and modem.

10.4.13 Configuration – Power source



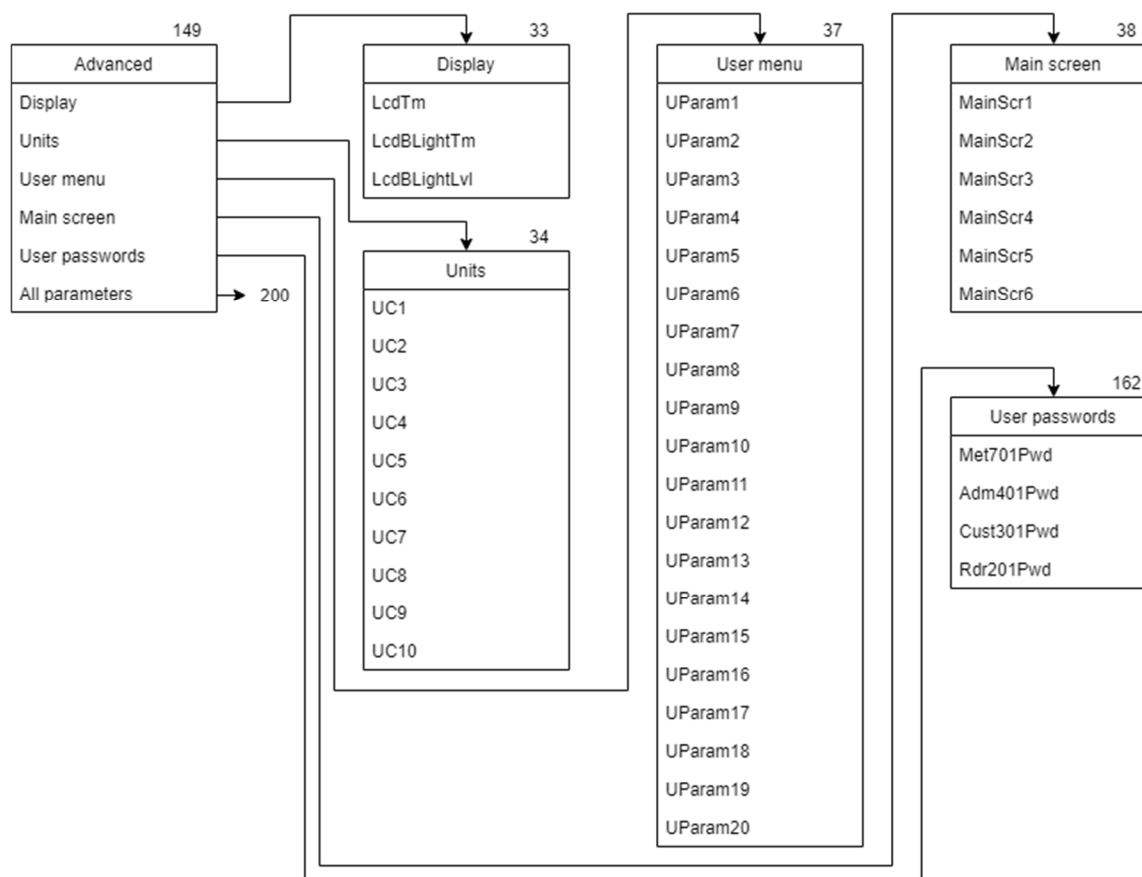
This menu allows to configure parameters for device's power source (battery or external).

10.4.14 Configuration – Limits



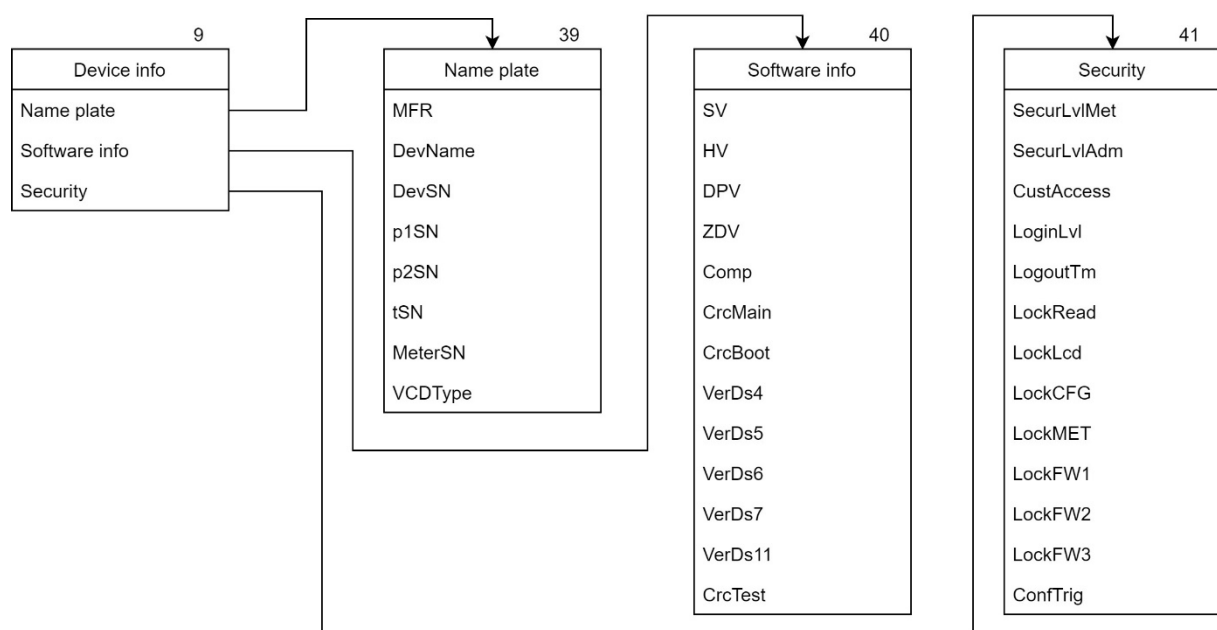
This menu allows to set various limits available in the device.

10.4.15 Configuration – Advanced



This menu allows to configure some advanced settings – display properties, units for values used in the device, set of parameters for user menu and for main screen.

10.4.16 Device info



This menu shows information about device: name plate, software information and current state of security settings.

11 Installation

11.1 Mechanical installation

MacBAT 5 can be mounted on a wall or gas pipeline. After installation, pulse tube should be connected with gas pressure sensor which has metric thread M12 x 1.5. Pulse tube should be equipped with three-way valve that allows cutting off the gas supply to the sensor or connection of an additional calibration device.

Special shelves for installation of MacBAT 5 with three-way valve are shipped by manufacturer with unit on special request. Gas temperature sensor shipped with unit, needs to be placed in thermometric sleeve in gas pipeline and after that connected to proper MacBAT 5 inputs.

Device is designed to cooperate only with CT6A type sensors.

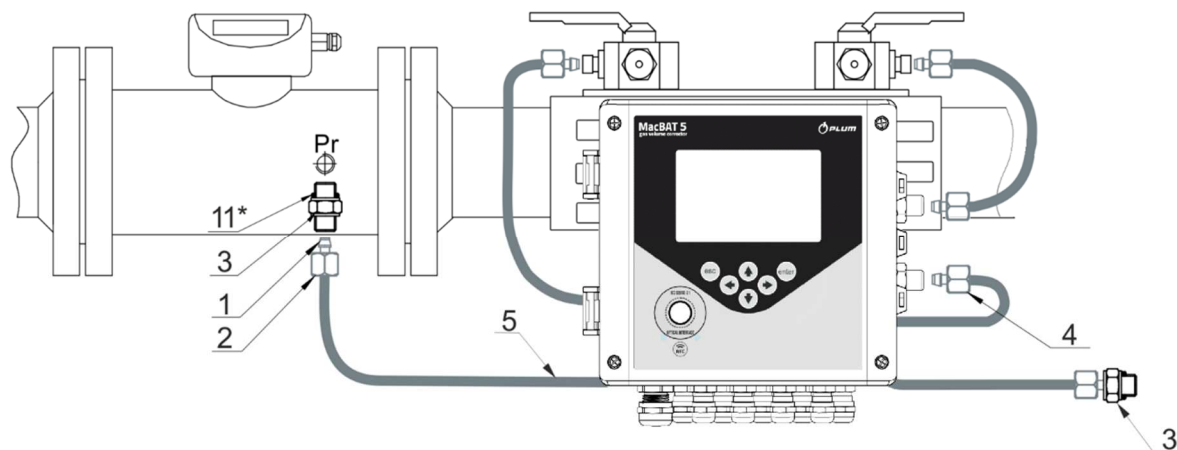
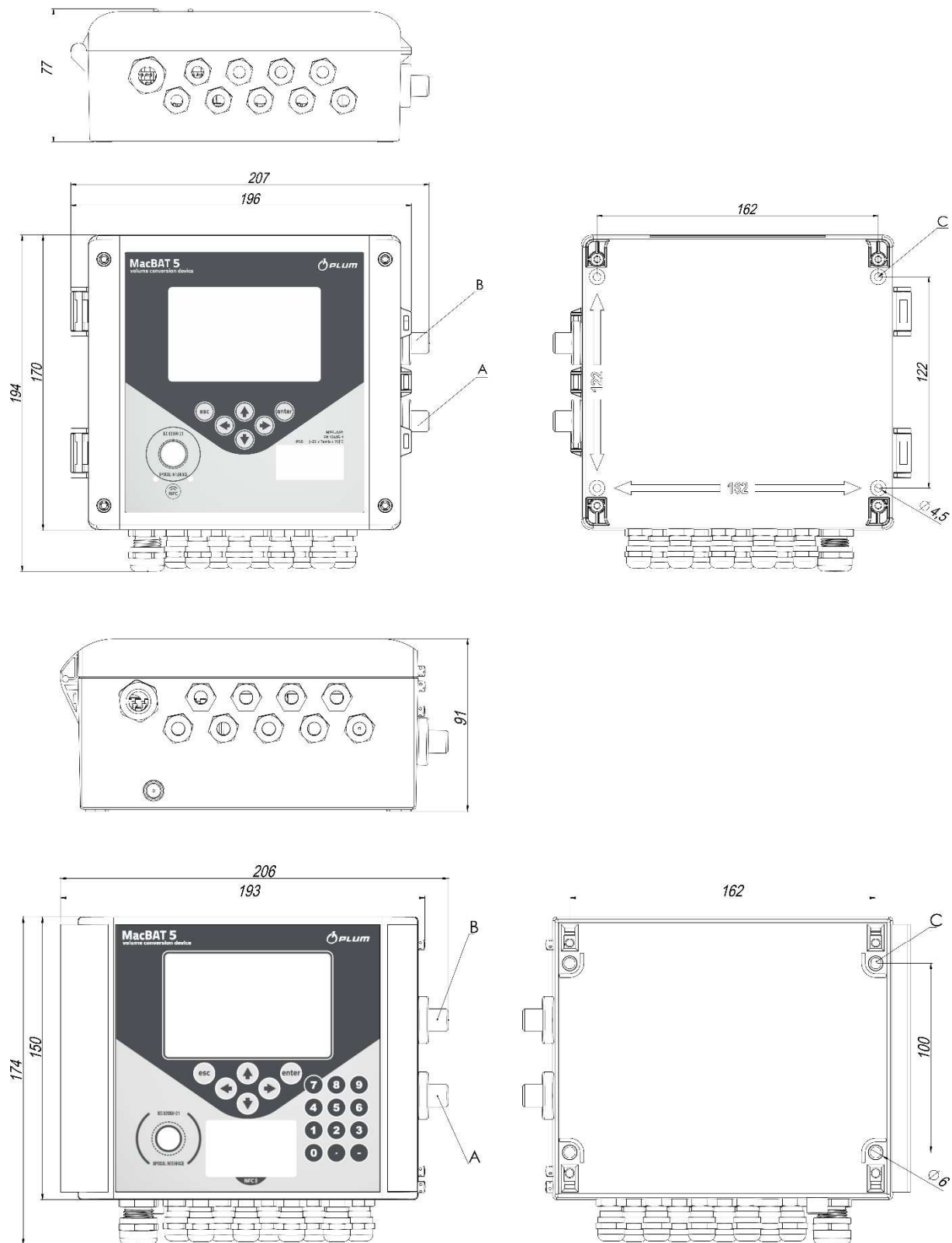


Figure 11. Mounting on gas pipeline



(upper – plastic housing, lower – metal housing)

Figure 12. Mounting dimensions: A, B – pressure sensors, C – mounting hole

11.2 Preparation of the wires

Wires must be prepared according to instruction presented below. Shielding of the power supply wire should be insulated at the device point and grounded at the power supply point.

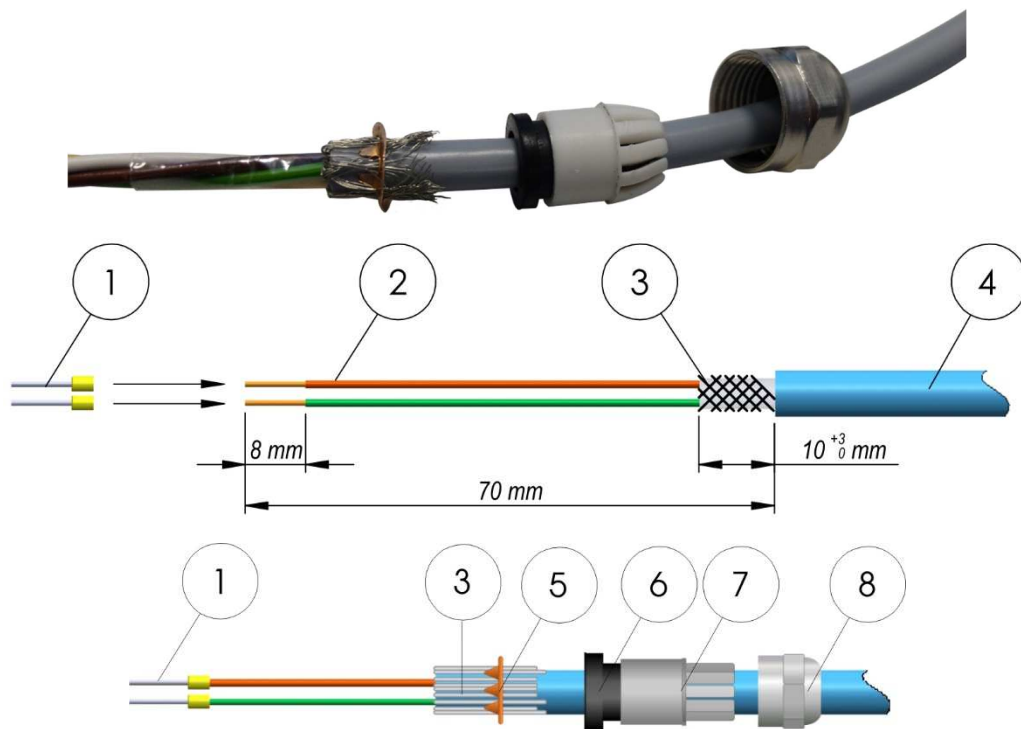
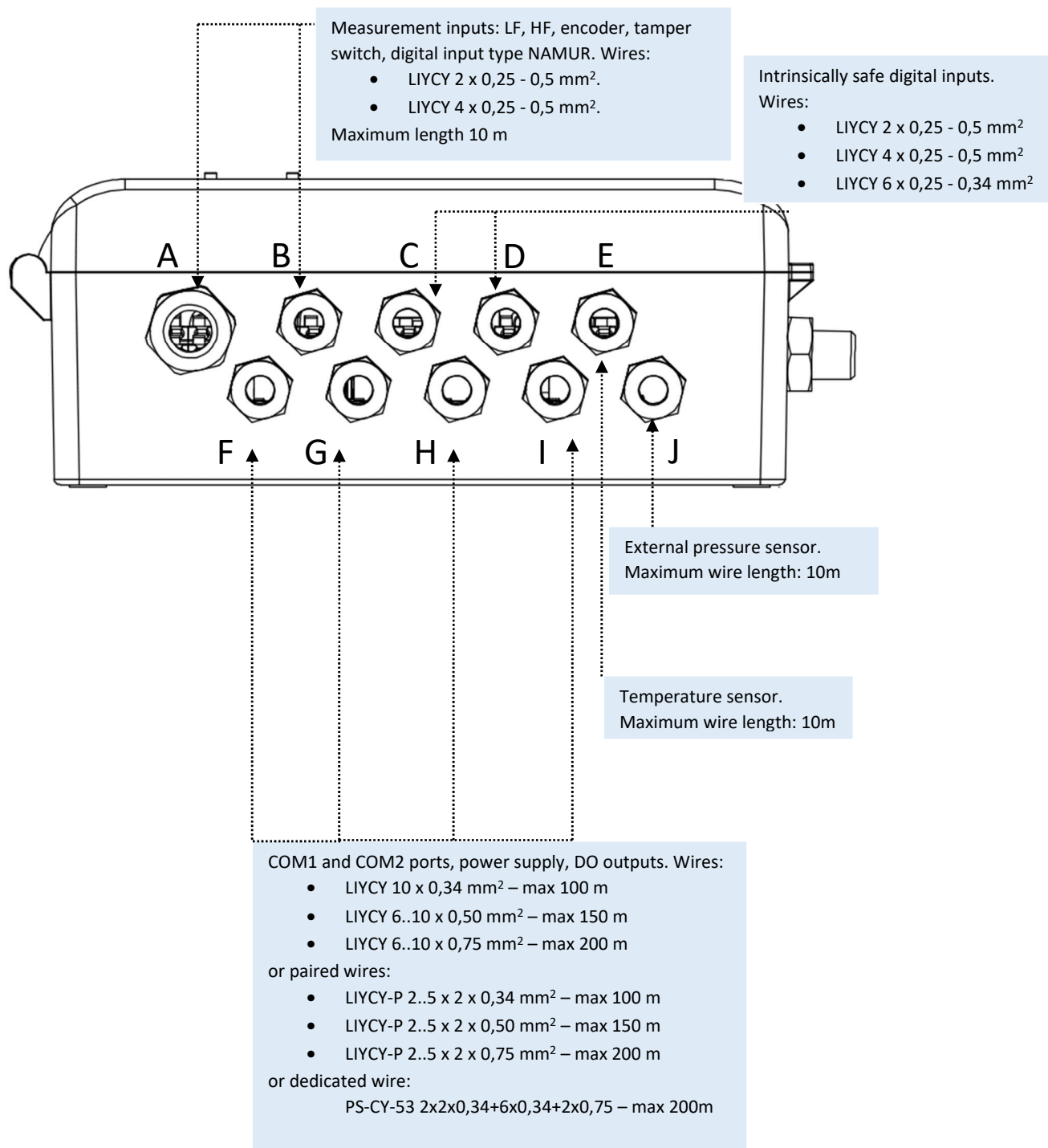


Figure 13. Assembly manual and preparation of the wires for cable glands: 1 – ending sleeves; 2 – wires, 3 – shielding, 4 – cable, 5 – contact, 6 – seal, 7 – claw, 8 – sealing nut

11.3 Recommended wires



Bushing A have cable diameter range from 4.0 to 8.0 mm (0.16 - 0.30 in, AWG 6 – AWG 1).

Bushings B..G have cable diameter range from 3.0 to 6.5 mm (0.12 - 0.25 in, AWG 9 – AWG 2).

11.4 Connection of the wires

In order to connect measurement wires, they need to be inserted to terminal strip chamber through adequate cable glands A-J. Cable glands are prepared for grounding of the wires shield.



For connection of external circuits is used self-tightening connector. After inserting not insulated part of the wire (8 mm length) into connector hole, it clamps itself. In order to confirm proper connection, pull back wire gently. Stranded wires ends should be clamped in ending sleeve or use other method of wire preparation which is consistent with standard EN 60079-14.

Due to the diameter of cable gland and connection clamp, use multi-conductor cables with cross-section from 0,25 to 0,75 mm².



The manufacturer's declaration of the IP66 housing tightness class will be valid, only if cables with appropriate diameters of the cable glands are used, the glands are properly tightened and ensuring proper placement of sealing and tightening the housing cover to the device casing.

In first step, connect MacBAT 5 counting inputs with gas meter LF and HF pulses outputs. LF transmitter needs to be reed connector type (potential-free connector). The device is equipped with input, which verifies operating state of gas meter reed control contact – a reed type connector, which is normally short. Any sort of manipulations with gas meter head (like influence with strong magnetic field or disconnection of plug from pulses transmitter) causes break in control circuit and generation of alarm in MacBAT 5. If gas meter is not equipped with tamper switch – it's input on unit terminal strip must be short-circuited.

Group of terminals 1..8 is used for connection external power supply and separated transmission circuits in standard RS-485.

Group of terminals 15..24 is used for connection intrinsically safe digital inputs circuits. Digital inputs supports up to 5 circuits with potential-free connectors (reed type connector).


Group of terminals 25..28 can be used as 2 digital inputs of NAMUR type.

11.5 Grounding of the housing

It is not necessary to connect ground to the device.

12 Specifications

12.1 General specifications

| | |
|----------------------------|---|
| Dimensions | 206 x 194 x 75 mm (polycarbonate) or 210 x 170 x 90 mm (aluminium) (L x W x H) |
| Weight | about 1,5 kg (polycarbonate) or 2,4kg (aluminium) |
| Housing material | Polycarbonate or aluminum casting (AlSi) |
| Ambience temperature range | -25 °C ÷ +70 °C, battery Saft LS33600, Tadiran SL2780 -25 °C ÷ +50 °C, battery EVE 34165 |
| Humidity | Max 95%. The device can operate in condensing or non-condensing humidity |
| Housing protection class | IP 66 |
| Keyboard | 6 or 18 buttons |
| Display | LCD - graphic 128x64 pix. with backlight |
| Operating environment | Approved to use at the 0, 1 and 2 zones threatened with explosion of mixture of: vapors, gases and explosive vapors with air which are placed in IIB or IIA explosive group and temperature class T1,T2,T3,T4. |
| Ex housing marking |  II 1G Ex ia IIB T4 Ga certificate FTZU 17 ATEX 0047X |
| Inputs | <ul style="list-style-type: none"> Up to 5 configurable potential-free contact inputs: <ul style="list-style-type: none"> Measuring inputs LF1, LF2 (inputs DI3, DI4) – frequency up to 2Hz (optionally up to 60 Hz) with the possibility of cooperation with Wiegand transmitters, TS input – tamper switch, normally short (input DI5), Up to 5 digital inputs (inputs DI1, DI2, DI3, DI4, DI5),¹ Up to 2 configurable NAMUR inputs (inputs DI6, DI7): <ul style="list-style-type: none"> 2 HF pulse inputs, frequency 0÷5000 Hz, HF2 (DI7) input can work with NAMUR encoder, Up to 2 NAMUR digital inputs,¹ SCR input for SCR encoder (optionally, interchangeable with DI8 potential-free digital input, depends on hardware configuration), Absolute pressure p1 sensor. In the standard version, a built-in sensor with measurement range of 6 bar is installed. Sensor is finished with metric thread M12 × 1.5,² Thermometer Pt1000 type CT6A, Absolute pressure or overpressure p2 sensor (optional),² <p>¹ – Number of inputs acting as digital depending on the configuration of the counting inputs</p> <p>² – Pressure sensors p1 or p2 can be built into the device or both be external or mixed (1 internal and 1 external)</p> |
| Control outputs | <ul style="list-style-type: none"> Up to 4 outputs of „open collector” type: <ul style="list-style-type: none"> DO1, DO3, DO4: binary DO2: configurable – binary or frequency (1÷5000 Hz), |

| | |
|--------------------------|---|
| Internal supply | <ul style="list-style-type: none"> • 1 ÷ 3 lithium batteries (3,6V) size D, type: LS33600 (Saft), SL2780 (Tadiran), ER34615 (EVE). • Additional lithium battery: 1/2AA type: LS14250 (Saft), ER14250H (Fanso). |
| External supply | <ul style="list-style-type: none"> • Source of power supply with 5.7 V nominal output voltage (max. 6.51 V, 3.5 W) |
| Transmission ports | <ul style="list-style-type: none"> • COM1 (optional) - standard RS-485, active with external power supply, • COM2 - standard RS-485, galvanic insulated, typically active with external power supply, active on battery power when the casing is opened, • COM3 – optical interface, standard IEC 62056-21, • GSM 2G/3G/4G modem (optional) with external or internal antenna, • NFC (optional) – radio interface ISO/IEC 14443 A (nominal frequency 13,56 MHz). |
| Transmission protocols | GAZMODEM, GAZMODEM2, GAZMODEM3, MODBUS RTU, MODBUS TCP |
| Modem, external antenna | Antenna with connector type FME. Formally, the length of the antenna cable is unlimited, but the usable length of the antenna cable is still determined by cable loss and signal strength at the installation site. From the MID and EMC side, the permissible length of the antenna cable is over 10m. |
| 2G modem, maximum power | <ul style="list-style-type: none"> • Class 4 (+33dBm ±2dB) dla EGSM900 • Class 1 (+30dBm ±2dB) dla GSM1800 |
| 3G modem, maximum power | <ul style="list-style-type: none"> • Class 4 (+33dBm ±2dB) for EGSM900 • Class 1 (+30dBm ±2dB) for GSM1800 • Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK • Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK • Class 3 (+24dBm +1/-3dB) for UMTS 2100, WCDMA FDD Bdl • Class 3 (+24dBm +1/-3dB) for UMTS 900, WCDMA FDD BdvIII |
| LTE Cat 1, maximum power | <ul style="list-style-type: none"> • Class 4 (+32.5dBm ±2dB) for EGSM900 • Class 1 (+30dBm ±2dB) for GSM1800 • Class E2 (+26.5dBm ± 3dB) for GSM 900 8-PSK • Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK • Class 3 (+23dBm ±2dB) for LTE 800, LTE FDD Bd20 • Class 3 (+23dBm ±2dB) for LTE 900, LTE FDD Bd8 • Class 3 (+23dBm ±2dB) for LTE 1800, LTE FDD Bd3 • Class 3 (+23dBm ±2dB) for LTE 2100, LTE FDD Bd1 |

| | |
|--|---|
| Earthing | Internal intrinsically safe circuits, including pressure and temperature sensors internal circuits, do not stand 500V test given in EN60079-11 to earthed or isolated metal parts of its enclosure. The type of protection does not depend on the separation. Metal bushings of product and metal parts of its pressure sensors are galvanically connected. It can be installed as fully floating or bonded. It must be taken into account during installation. |
| Mechanical environment conditions class | M2 - unit can be installed at places exposed to vibrations and shocks with considerable and high level of intensity generated by mechanical devices, close passing vehicles, heavy machinery, transmission belts, etc. |
| Electromagnetic environment conditions class | E2 - unit can be installed at places exposed to typical industrial disturbances |
| Environment class | O – unit can be installed outdoors |
| Base conditions | Base pressure (absolute) pb , default 1,01325 bar, Base temperature Tb , default 273,15K (0°C), Combustion temperature T1 , default 298,15K (25°C). |
| The maximum permissible error (MPE) according to standard „EN 12405-1” | 0,5 % at reference conditions |
| | 1 % at nominal operating conditions |
| Ranges of using SGERG-88 method | Gas pressure p1 ≤ 120 bar Gas temperature t in range: -10,15°C ÷ 64,85°C Gas pressure p1 ≤ 35 bar Gas temperature t in range: -15°C ÷ 65°C Gas pressure p1 ≤ 25 bar Gas temperature t in range: -20°C ÷ 65°C Gas pressure p1 ≤ 15 bar Gas temperature t in range: -25°C ÷ 65°C |
| Ranges of using AGA8-G1 and AGA8-G2 methods | Gas pressure p1 in range 0 ÷ 100 bar Gas temperature t in range: -25 ÷ 65 °C for $p_{max} \leq 20$ bar -10 ÷ 65 °C for $p_{max} > 20$ bar |
| Range of using AGA8-92DC method | Gas pressure p1 in range 0 ÷ 650 bar Gas temperature t in range -48 ÷ 77 °C |
| Range of using AGA NX-19mod method | Gas pressure p1 in range 0 ÷ 7,5 bar Gas temperature t in range -30 ÷ 70 °C |
| Types of computations | Computation as a function of pressure and temperature according to compression factor (PTZ), function of temperature according to compression factor (TZ) or constant compression factor (PT) (point 4.3 according to EN 12405-1:2018) |
| Expected time of keeping metrological features – 5 years. | |

12.2 Identification of the radio-equipment

| Radio-equipment identification (identification of built-in radio functions) | | |
|---|---|---------|
| <p>Each device equipped with radio equipment (built-in modem or NFC communication interface) is marked with a label containing special code representing the identification of built-in radio equipment.</p> <p>The general code format is „zGCxyLw”, where:</p> <ul style="list-style-type: none"> capital letters are constant sections small letters are positions for digits representing options in the section <p>Meaning of digits:</p> | | |
| Section | Description | Remarks |
| zG | „z” - symbolic marking of the main modem’s technology (this is not a part of the formal marking) | |
| | 3 – modem with highest (main) technology 3G 4 – modem with highest (main) technology LTE | |
| Cxy | „xy” – two digits where: | |
| | The first digit, „x”, describes the communication interface NFC: 0 – without NFC communication interface 1 – with built-in NFC communication interface | |
| | The first digit, „y”, describes the technology of modem’s data transmission (modem highest (lower options)): 0 – without built-in modem 1 – modem 3G (2G) EU, bands EU 2 – modem LTE-cat.1 (3G/2G) EU, bands EU 5 – modem LTE-cat.1 (3G) US, bands US 6 – modem 3G (2G) US, bands US 7 – modem 2G EU, bands EU | |
| Lw | Type of used antenna with options of connection The position of letter „L” – type of antenna A- antenna HSA-0918-TCQ5 FME HONGSENSE TECHNOLOGY CO., LTD B- internal antenna, type 1 „w” – type of antenna’s connection, where: 0 – integrated internal antenna, without external connector 2 – device equipped with the external connector type FME | |

The example of marking 1: „**code: mod. 4GC12A2**”, where:

- 4G** – symbolic marking of the main modem’s technology (this is not a part of the formal marking)
- C1y** – the device equipped with built-in NFC communication interface
- Cx2** – the device equipped with built-in modem LTE-cat.1 (with 3G/2G) EU (EU bands)
- A2** – antenna HSA-0918-TCQ5 FME HONGSENSE TECHNOLOGY CO., LTD connected to external FME connector

The example of marking 2: „**code: mod. C10**”

- C1y** – the device equipped with built-in NFC communication interface
- Cx0** – the device not equipped with modem

The example of marking 3: „**code: mod. C00**”, alternatively „**code: NO MODEM**” or without the label
– the device equipped neither with NFC nor modem

13 Intrinsically safe parameters

External power supply (POWER SUPPLY) - Terminals 2 (V_{IN}) to 1 (GND):

$$U_i = 6.51 \text{ V}; P_i = 3.5 \text{ W}; I_i = 1.1 \text{ A}; L_i = 0; C_i = 12 \text{ }\mu\text{F}$$

External power supply of communication ports (COM SUPPLY) – Terminals 4 (V_{IN}) to 3 (GND):

$$U_i = 6.51 \text{ V}; P_i = 0.8 \text{ W}; I_i = 0.4 \text{ A}; L_i = 0; C_i = 2.64 \mu\text{F}$$

Port COM1 – Terminals 5 (D-), 6 (D+) to GND

Port COM2 – Terminals 7 (D-, Rx), 8 (D+, Tx) to GND

$$U_o = 6.51 \text{ V}; I_o = 0.8 \text{ A}; P_o = 1.1 \text{ W}; P_i = 0.66 \text{ W}; L_i = 0; C_i = 0;$$

$$\text{Gas group IIA: } L_o = 800 \text{ }\mu\text{H}; C_o = 500 \text{ }\mu\text{F}$$

$$\text{Gas group IIB: } L_o = 200 \text{ }\mu\text{H}; C_o = 25 \text{ }\mu\text{F}$$

External DIGITAL SENSOR – Terminals 10 (VOUT) to 9 (GND)

$$U_o = 6.51 \text{ V}; I_o = 0.29 \text{ A}; P_o = 0.47 \text{ W}; L_i = 0; C_i = 0$$

$$\text{Gas group IIA: } L_o = 2 \text{ mH}; C_o = 500 \text{ }\mu\text{F}$$

$$\text{Gas group IIB: } L_o = 1 \text{ mH}; C_o = 25 \text{ }\mu\text{F}$$

Outputs DIGITAL OUTPUTS – Terminals 11 (DO1+), 12 (DO2+), 13 (DO3+), 14 (DO4+) to GND

$$U_i = 15 \text{ V}; I_i = 0.123 \text{ A}; P_i = 0.33 \text{ W}; L_i = 0; C_i = 0; U_o = 6.51 \text{ V}$$

$$\text{Gas group IIA: } L_o = 18 \text{ mH}; C_o = 7 \text{ }\mu\text{F}$$

$$\text{Gas group IIB: } L_o = 10 \text{ mH}; C_o = 1.7 \text{ }\mu\text{F}$$

Contact inputs – Terminals 16 (DI1+), 18 (DI2+), 20 (DI3+), 22 (DI4+), 24 (DI5+) to GND and 26 (DI6+), 28 (DI7+), 30 (DI8+), 29 (DI8-) to GND

$$U_i = 6.51 \text{ V}; L_i = 0; C_i = 120 \text{ nF}$$

$$\text{Gas group IIA: } L_o = 800 \text{ mH}; C_o = 500 \text{ }\mu\text{F}$$

$$\text{Gas group IIB: } L_o = 400 \text{ mH}; C_o = 25 \text{ }\mu\text{F}$$

Additionally only for contact input – Terminal 24 (DI5+) to GND

$$P_o = 27 \text{ mW}; U_o = 6.51 \text{ V}; I_o = 16.5 \text{ mA}$$

NAMUR inputs (HF1, HF2) – Terminals 26 (DI6+) to 25 (DI6-), 28 (DI7+) to 27 (DI7-)

$$U_o = 9.6 \text{ V}; I_o = 33 \text{ mA}; P_o = 78 \text{ mW}; L_i = 0; C_i = 0$$

$$\text{Gas group IIA: } L_o = 800 \text{ mH}; C_o = 100 \text{ }\mu\text{F}$$

$$\text{Gas group IIB: } L_o = 400 \text{ mH}; C_o = 13 \text{ }\mu\text{F}$$

Input SCR ENCODER input – Terminals 30 (DI8+), 29 (DI8-) to GND

$$U_o = 9.6 \text{ V}; I_o = 0.021 \text{ A}; P_o = 48 \text{ mW}; L_i = 0; C_i = 0$$

Gas group IIA: $L_o = 800 \text{ mH}$; $C_o = 100 \text{ }\mu\text{F}$

Gas group IIB: $L_o = 400 \text{ mH}$; $C_o = 13 \text{ }\mu\text{F}$

Sensor Pt1000 – Terminals 32 (I+), 31 (I-), 34 (U+), 33 (U-) to GND

$U_i = 6.51 \text{ V}$; $L_i = 0$; $C_i = 250 \text{ nF}$

External pressure sensors – Terminals 36 (PS1), 38 (PS2), 40 (PS3), 37 (PS4), 39 (PS5) to 35 (GND)

Terminals 42 (PS1), 43 (PS2), 44 (PS3), 45 (PS4), 46 (PS5) to 41 (GND)

$U_i = 6.51 \text{ V}$; $L_i = 0$; $C_i = 200 \text{ nF}$

14 Configuration

After device installation and connection according to manual, it is necessary to configure device measurement system parameters. In order to ensure correct operation it's recommended to program following parameters:

- Pulse LF and HF weight – Setting of pulse weight must be compatible with description on name plate of gas meter.
- Volume at measurement conditions – Value of volume counter at measurement conditions V_m in device should be the same as value of gas meter mechanical counter. Setting of the counter should be done with meter stopped.
- Registration period (archival data saving).
- Time setting – Current time should be set in the device.
- Transmission parameters
- Gas parameters programming – Gas parameters should be compatible with gas supplier analysis.
- Zeroing range of pressure input p2 – If device has measurement pressure input with range up to 1.0 bar, it is necessary to do zeroing.
- Activate accounts of users, which will have access to device configuration

15 Manufacturer data

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