# HANDHELD ULTRASONIC FLOW METER
# AFLOWT UFd PORT

## SHORT OPERATION MANUAL

**WARNING! Before use, review the entire set of operational documentation on the Flow meter that may be taken from the CD included in the delivery package or from our web site www.aflowt.com.**


## GENERAL

The Flow meter is designed to measure flow rate and volume of liquids ranging in composition and viscosity (water, acids, alkalis, solutions, slurries, petrochemicals, liquid food products etc.) in "real time" mode.

## FEATURES

- Superior resistance to wear (no moving parts);
- No welding or drilling works during installation;
- Electroacoustic transducers (XDCRs) are mounted on the straight pipeline section that may be installed horizontally, vertically or obliquely;
- Battery powered operation;
- Explosion-proof design;
- Measurement logs are maintained independently for multiple sites (200 sites as a minimum);
- Colour LCD with backlight (displaying of measured and calculated values);
- Self-test function;
- Convenient on-site adjustment with "prdigital" software;
- Heat meter functionality (calculation of liquid weight, as well as heat power and energy on the basis of data taken from external temperature sensors or contractual data).

**CAUTION!** You must not damage or remove the seals affixed on the Flow meter after verification! Otherwise, the warranty and verification statements lose their validity.

## TABLE OF CONTENTS

## 1 SPECIFICATIONS

| Parameter | Value |
|---|---|
| Nominal diameter of the pipeline, DN | From 20 to 5000 |
| Flow velocity, m/s; | Up to 20 |
| Measurement error | ± 3.0 % at 0.1 to 1.0 m/s flow velocity<br>± 1.5 % at 1.0 to 20 m/s flow velocity. |
| Temperature of medium, °C | From -30 to +150 |
| Length of straight pipe runs upstream and downstream the Flow meter | From 3·DN to 30·DN depending on the type of hydraulic resistance and sounding scheme |
| Interface | USB or RS-485, ModBus protocol |
| Power supply voltage, V | DC 3.6V from the battery or<br>DC 10...30V from an external power supply |
| Time of battery-powered operation (without mains supply), h | Up to 24 |
| Time between verifications, years | 4 |
| Mean time to failure, h | 75 000 |
| Mean life time, years | 12 |

## 2. MARKING

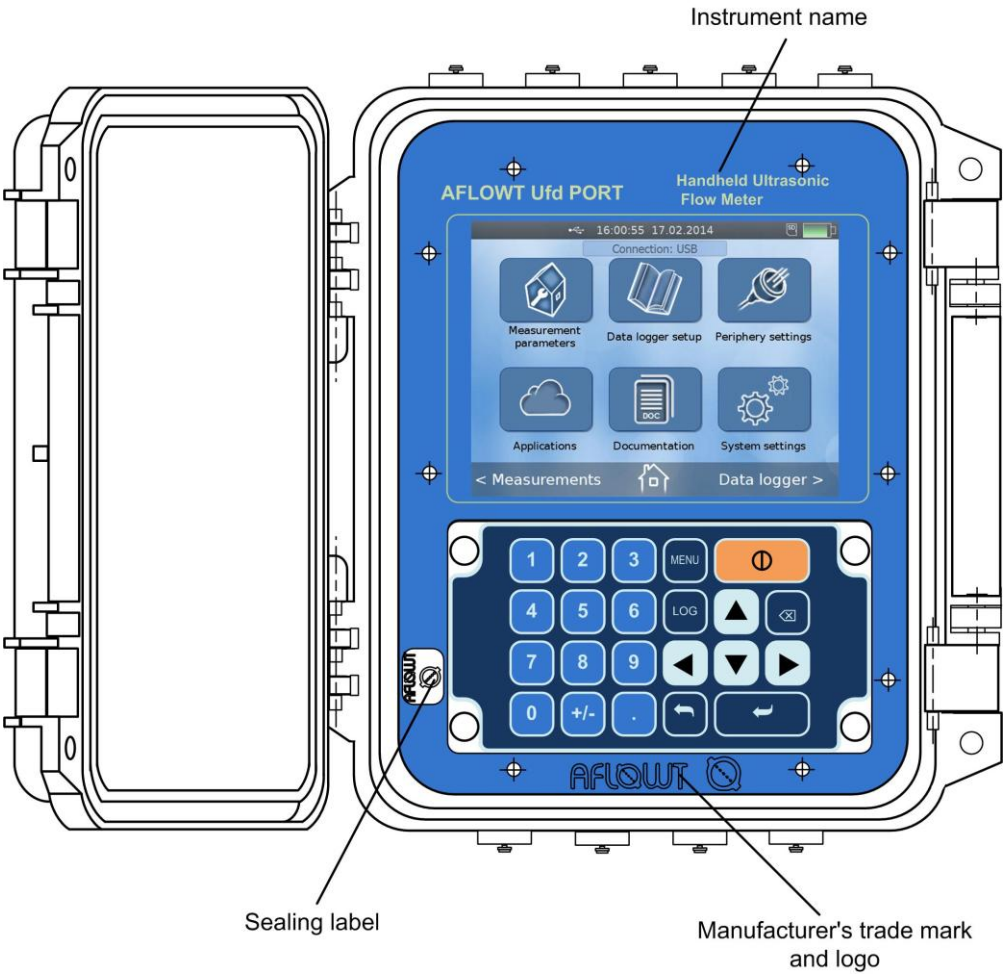



**Fig.1. Secondary Measuring Converter (CS)**

## 3. MOUNTING THE FLOW METER

### 3.1. General Requirements

- XDCRs shall be mounted at the place where air accumulation is eliminated
- XDCRs shall not be placed at the upper point of the pipeline; the best place to mount the XDCRs (if applicable) is the lower or uprising pipe run (see Fig.2)
- Liquid pressure in the pipeline shall be chosen so that to prevent gas development
- XDCRs shall be mounted in the pipe run where liquid pulsation and turbulence are minimal
- Straight pipe runs of length selected in accordance with the value of local hydraulic resistance shall be provided upstream and downstream of XDCRs
- For pipelines with DN of up to 300 mm, XDCRs can best be positioned in V-configuration, for pipelines with DN of more than 300 mm – in Z-configuration.

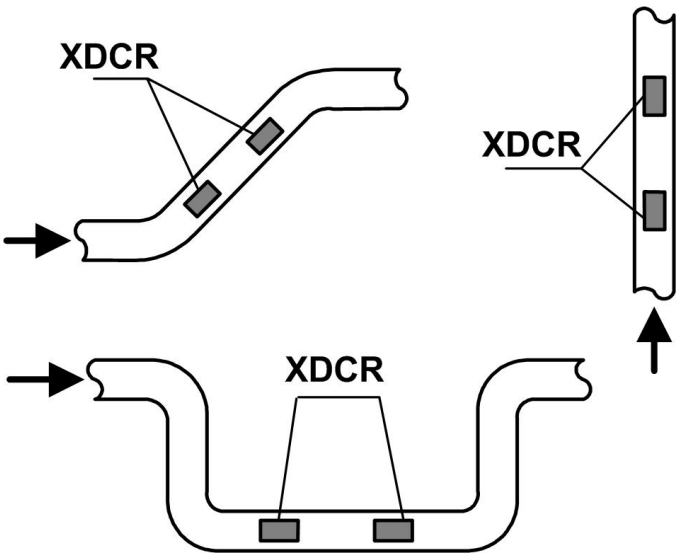



**Fig.2. Best places for mounting**

- Z-configuration – XDCRs are located on opposite sides of the pipeline in a plane going through its centerline. In this case, an ultrasonic beam goes from one XDCR to another without reflection from the inside surface
- V-configuration – XDCRs are positioned along one side of the pipeline in a plane going through its centerline. In this case, a signal from one XDCR reaches the other one via reflection from the inside surface (an ultrasonic signal path is twice longer than in case of Z-configuration)
- XDCRs can best be positioned so that a plane going through the both XDCRs and centerline of the pipe would make an angle of 45° with the vertical (see Fig.3).

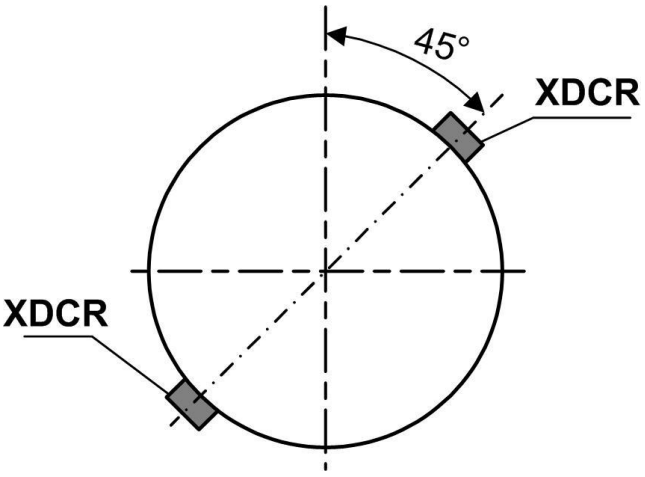
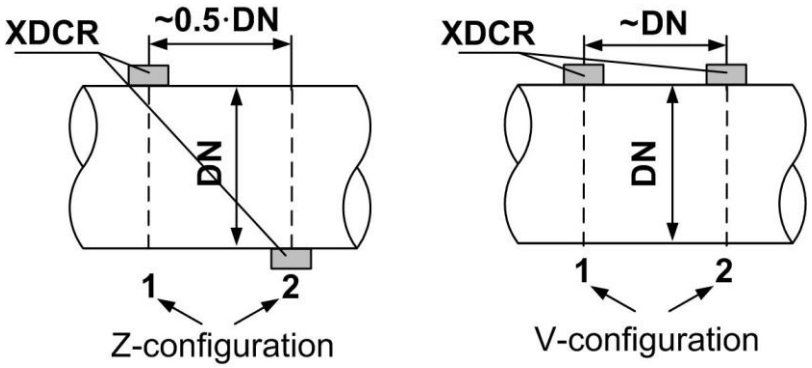



**Fig.3. Recommended positions of XDCRs with respect to the vertical plane**

## 3.2. Measuring and calculating configuration parameters

When determining configuration parameters for the pipeline, it is necessary to measure either its circumference or outer diameter.

3.2.1. Determining circumference of the pipeline

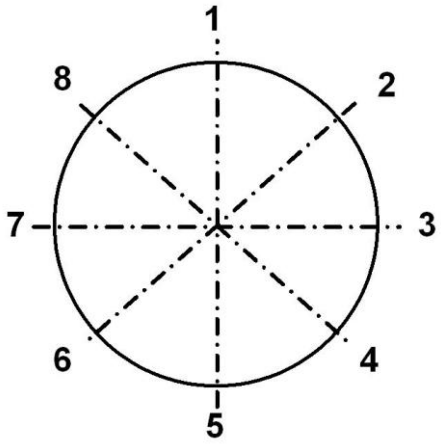



Measure the circumference of cross sections 1 and 2 (see Fig.4) with a measuring reel.

Calculate the average value of circumference $\mathbf{L_{circ\ avg}}$ as a half-sum of cross section circumferences 1 and 2. Enter the value in **Pipe circumference** field of **Pipe parameters** menu.

**Fig.4. Location of cross sections**

3.2.2. Determining outer diameter of the pipeline with a snap gauge




Eight points are marked on each of the selected cross-sections of the pipe run. The points are equispaced along each cross-section (Fig.5). The fixed feeler is placed directly on the point marked on the pipe run, and the moving element is shifted to the facing point until the movable element is in its maximum position towards the surface of the pipe run.

Calculate the average value of outer diameter $\mathbf{D_{out\ avg}}$ as a half-sum of cross section diameters 1 and 2. Enter the value in **Pipe outside diameter** field of **Pipe parameters** menu.

**Fig.5. Location of points on the cross-sections**

3.2.3. Determining outer diameter of the pipeline at XDCR installation points

Mark the points intended for mounting XDCRs on each of the selected cross-sections 1 and 2. Carry out measurements as outlined in section 3.2.2. Calculate the average value of outer diameter at the XDCR installation points $\mathbf{D_{pip\ avg}}$ as a half-sum of cross section diameters 1 and 2. Enter the value in **XDCR plane diameter** field of **Pipe parameters** menu.

Determine acoustic base distortion factor $\mathbf{K_b}$:

$$\mathbf{K_b = D_{pip\ avg} / D_{out\ avg}}$$

If inequality $0.985 \leq \mathbf{K_b} \leq 1.015$ is satisfied, the selected pipe run is considered suitable for mounting XDCRs.

3.2.4. Determining thickness of the pipeline wall

Carry out three measurements of pipeline wall thickness in points 2, 4, 6, 8 (Fig.5) of each cross-section (1 and 2) with use of a thickness gauge.

Calculate the average value of wall thickness for each cross section as a mean sum of measured values, determine a half sum of average thicknesses 1 and 2 and enter the calculated value in **Pipe wall thickness** field of **Pipe parameters** menu.

3.2.5. Defining equivalent roughness of the pipeline

Equivalent roughness of the inner surface of the pipeline is determined from the table:

| **Material** | **State of inner surface** | **Equivalent roughness, mm** |
|---|---|---|
| Brass, copper, aluminum, plastics, glass, lead | New, without sediments | < 0.03 |
| Steel | New, joint-free: | |
| | - Cold-drawn | < 0.03 |
| | - Hot-drawn | < 0.1 |
| | - Rolled | <0.1 |
| | New, welded | < 0.1 |
| | With a slight film of rust | < 0.2 |
| | Rusty | < 0.3 |
| | Oil-coated: | |
| | - New | < 0.05 |
| | - Used | < 0.2 |
| | Galvanized: | |
| | - New | < 0.15 |
| | - Used | < 0.18 |
| Cast iron | New | 0.25 |
| | Rusty | <1.2 |
| | With sediments | < 1.5 |
| | Oil-coated, new | < 0.05 |
| Asbestos cement | With/without lining, new | < 0.03 |
| | Without lining, in normal condition | 0.05 |

Enter the value of equivalent roughness in **Pipe roughness** field of **Pipe parameters** menu.

3.2.6. Defining kinematic viscosity ratio

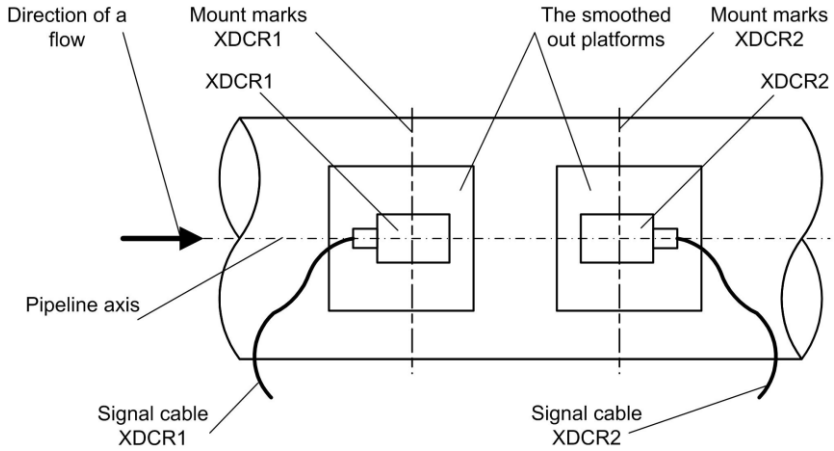
Kinematic viscosity ratio of water or other liquids is determined considering liquid temperature. The liquid is sampled, the value is measured using a viscometer and entered in **Fluid viscosity** field of **Fluid parameters** menu.

## 3.3. Mounting XDCRs on the pipeline

Measurement pipeline section (PS) on which pipeline configuration parameters have been determined is stripped to metal at cross-sections 1 and 2 (Fig.4). The stripped areas shall be of values enough to move XDCRs along the stripped surface at a distance equal to the XDCR unit length in any direction.

When mounting XDCRs, consider that the stripped areas shall be positioned at a distance equal to **Suggested XDCR spacing** parameter value (calculated by the Flow meter, see section 8.2).

The emitting surface of both XDCR pairs is lubricated with couplant. One unit from the XDCR pair is mounted by seating it in the middle of the stripped area as shown in Fig.6 and fixed with the mount clip supplied with the Flow meter. Position of the mount marks on the side walls of this XDCR is marked on the PS. Another XDCR from the pair is installed by seating it in the middle of the second stripped area and fixed on the PS in the same way. Then datum axis of the Flow meter shall be measured. Datum axis is the distance between acoustic centers of the XDCRs in the pair (mount marks on the side walls) along the PS axis.



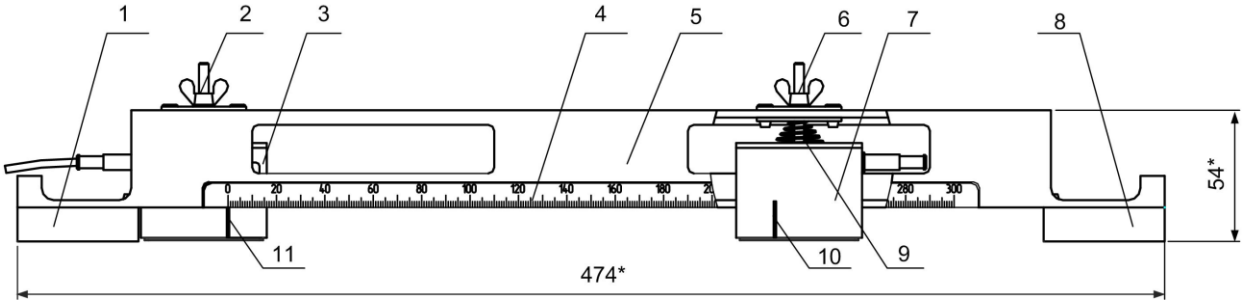

In case of V-configuration, the distance is measured directly. When mounting XDCRs according to Z-scheme, the PS is sequentially cinctured with a measuring reel through the XDCR1 and XDCR2 mount marks.

**Fig.6. Positioning XDCRs on the pipeline (V-configuration)**

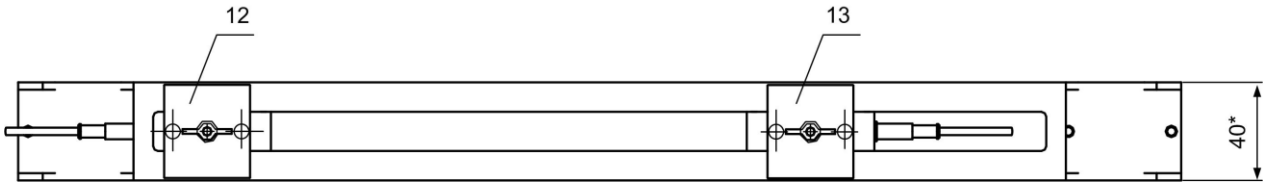
At this time, it is necessary to draw the lines on the pipe surface along the measuring reel up to intersection with the generator line going through the opposite XDCR (generator is a conventional line on the surface of the pipeline parallel to its axis). The distance between the half-arcs along the generator lines are measured with the measuring reel and the average value is calculated. The calculated value and the value of **Suggested XDCR spacing** parameter shall be checked for correspondence.

## 3.4. Magnetic rule

A magnetic rule (optional) is used to fix XDCRs on a stainless steel pipeline with permanent magnets (according to V-configuration scheme).




a) Side view




b) Top view

**Fig.7. Magnetic rule (300 mm) with two XDCRs**

The magnetic rule of 150 mm length is used to install XDCRs on pipelines with 20...50 mm DN and 300 mm magnetic rule – for pipelines with 50...300 mm DN.

The magnetic rule consists of:

- Two permanent magnets (left 1 and right 8)
- Bracket (5)
- Bars (12, 13) with fixing butterfly screws (2, 6) and springs (9) used to fix XDCRs on the rule
- Sighting rule (4) with 150 mm or 300 mm scale.

Two permanent magnets (1, 8) are fixed on opposite ends of a U-shaped bracket (5). Bars (12, 13) are moved along the groove in the upper plane of

the bracket to fix XDCRs in a desired position. A sighting rule is fixed on the side of the bracket.

XDCRs (3, 7) used with the magnetic rule are fitted with a special threaded stud on the top. To fix XDCRs, the stud (with a spring (9) on it is passed through a hole in the bar installed on the rule's bracket. The XDCRs are fixed with screws (2, 6).

When fixing either the left XDCR or the right one, make sure that the XDCR end more distant from the acoustic center faces towards the magnets.

Before mounting the magnetic rule on the pipeline, do the following:

- Fix the studs on both XDCRs in the holes of the bar with the springs and fixing screws
- Move the bar with the left XDCR fixed on it along the groove on the bracket towards the left magnet and locate it so that the mark (11) of the XDCR acoustic center be in line with "0" mark on the sighting rule. Then fix the left XDCR on the bracket with the fixing screw (2)
- Align the mark (10) on the right XDCR with the mark on the sighting rule that corresponds to the value of **Suggested XDCR spacing** parameter calculated by the flow meter. Fix the right XDCR with the fixing screw (6)
- Lubricate contact surfaces of both XDCRs
- Mount the magnetic rule assembly on the appropriately prepared pipeline in accordance with the instructions given in this manual. It is essential to position the magnets so that the XDCRs fixed on the bars be placed in the middle of the pipeline sections prepared for XDCR mounting, and the rule be in parallel with the pipeline axis
- Tightly fix the XDCRs to the pipeline surface with the fixing screws.

## 4. BATTERY MODULE

The Battery Module (AB - Accumulator Battery) located in the Secondary Converter powers the Flow meter without mains supply. The Battery Module includes three Li-pol batteries connected in parallel, circuit for measuring battery capacity and thermal protection circuit. If properly used, the Battery Module provides for at least 500 charge/discharge cycles.

Battery condition symbol  is displayed in the upper right corner of the display. While the Battery Module is being discharged, the green colour indicating charge level is gradually shifted towards the left side of the symbol. When charge level becomes close to critical (less than 7%), the filling and outline of the battery symbol change their colour from green to red.

On achieving minimum permissible limit of charge level (≈ 2…5 %), the Flow meter is automatically turned off. To prevent this, you should connect the Flow meter to an external power supply. At this time, the image of mains plug  appears on the battery symbol, and the symbol begins to fill with green colour from left to right. You can disconnect the external power supply as soon as the Battery Module gets fully charged (the battery symbol fully filled with green).

You can also check the Battery charge level in **System settings** menu (**Device status** option). The option contains **Power – battery** or **battery charging** fields indicating battery status and **Charge level** field (charge level in %). In addition, the flow meter displays the estimated time of battery powered operation with the display turned on/off. When the Battery is fully charged, **Power** field displays "**battery full**" status.

Before use, check the Battery and charge level. Charge the Battery if necessary. The Battery may be charged at any charge level. You can also charge the Battery with the Flow meter turned off. A full charge takes about 10 hours as a maximum.

Connect the Flow meter to the external power supply (mains adapter AC 220V, 50Hz or vehicle power network) via the connector on the lower side (with respect to the front panel) of the case. In the vehicle, power the Flow meter from the lighter socket.

**CAUTION! You must not connect the Flow meter to the vehicle power network at engine start up.**

Before storing the flow meter for a long time, fully charge and disconnect the Battery (or take it out of the flow meter). The Battery shall be stored indoor, in a dry storeroom, separately from the Flow meter, and fully charged.

**CAUTION! Never store the Battery in a discharged condition.**

While storing the Flow meter, charge the Battery at least twice a year.

**CAUTION! Use of the Battery in a manner not specified by the manufacturer may result in its failure or in the failure of the Flow meter.**

## 5. CONTROLLING THE FLOW METER

### 5.1. Menu system

Operation in various modes can be controlled from the keyboard via the system of nested menus and windows, from the display (using "intouch" function), or from a PC using USB or RS-485 ports.

Menu system includes the main menu (Fig.8), windows, commands and lists of parameters.


**Fig.8. Main menu**

### 5.2. Keyboard

The keyboard has 22 keys (see Fig.9) and makes it possible to:

- Navigate through menus and windows
- Control indicated parameters
- Input configuration data
- View logged data.


**Fig.9. Keyboard**

## 5.3. Functions of the keys

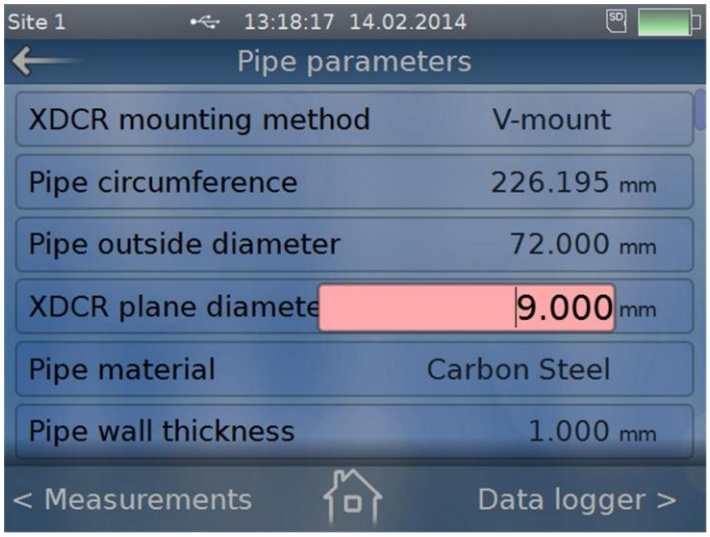
ENTER or ▶ key will take you to a lower level window.

◀ or ◀ key will take you back. Pressing MENU key will return you to the main menu from any menu item.

▲ and ▼ keys are used to select a desired option in the menu or window by placing a dark-blue highlight box over it. Pressing ENTER or ▶ key allows you to change values of the parameters (to enter the numeric value or select the value from the list).


In the mode of entering new numeric values, the old value is highlighted in a blue box on a light-grey or orange background, its digits change colour to white (see Fig.10) while the display backlight is dimmed. Use 0 … 9 keys to enter a new value, . key as a fraction sign and +/- key to specify a polarity sign.

**Fig.10. Entering a new value in "Pipe outside diameter" field of "Pipe parameters" window**




The orange background means that the value in the field is incorrect (see Fig.11).

**Fig.11. Incorrect numeric value in "XDCR plane diameter" field**

## 5.4. Entering numeric values

To change a digit in any position of the numeric value, highlight the value by a blue box and press ◀ key. At this time, the blinking cursor will appear on the left of the highest digit position.

Press ▶ to position the cursor to the right of the digit to be changed, press ⌫ to erase the digit and set a new one with 0 … 9 keys. If the value is correct, it will be displayed on a light-grey background.

## 5.5. Entering values from the list

When the value is changed by selecting a new one from the list, pressing  or  key shows a table with the list of options (see Fig.12). The currently active value is highlighted in blue. The display backlight is dimmed. Use  keys to navigate through the options. The currently selected option is highlighted in dark-blue. As soon as a new value has been selected or adjusted, press  key to confirm. At this time, the new value is highlighted in dark-blue. Press  key to abort the present activity.


**Fig.12. Selecting a new value from the list for "Pipe material" option in Pipe parameters menu**

## 6. "IN-TOUCH" FUNCTION

Use "In-touch" function to save time when selecting parameters from the list or adjusting their values digit by digit. You can open a lower level menu from the main menu by touching the corresponding icon on the screen (see Fig. 8).

Numeric values are changed according to the procedure described above (excluding "in-touch" selection of menu items).

The procedure of selecting optional values from the list also remains the same (excluding "in-touch" selection of the value from the table). There is no need to confirm the selection, as the selected value is saved automatically.

To go back to an upper level menu, touch  icon in the upper left corner of the display. Touching  icon takes you back to the main menu. **Measurements** or **Data logger** windows can be called up from any other window by touching the corresponding field in the bottom left (right) corner of the display.

If **Measurements** or **Data logger** windows were opened from a lower level menu (not from the main menu), touching  icon takes you back to that lower level menu.

Besides touching the corresponding icons, you can drag along the screen in horizontal direction to call up **Measurements** or **Data logger** windows from the main menu. Drag from left to right to open **Measurements** window and from right to left to go to **Data logger** window.

Drag menu items in vertical direction to select one of them.

## 7. CONTROLLING THE FLOW METER FROM A PC

The flow meter is controlled from a PC via "prdigital" software (see Fig.13) supplied on a CD. Also the program can be downloaded from our Web-site www.aflowt.com. The program is distributed free of charge.

The program "prdigital" works under the following operating systems: Windows Vista, Vista x64, XP, XP x64, 2000, Server 2003, Server 2003 x64, Windows 7, Windows 7 x64. By means of "prdigital" program, the user can adjust the Flow meter, specify numeric values or select options from the list in the same way as from the Flow meter's keyboard. However menus are opened and parameters are modified or selected by left-clicking on the required field on the PC display, numeric values are modified from the PC keyboard and selection is confirmed with "Enter" key.

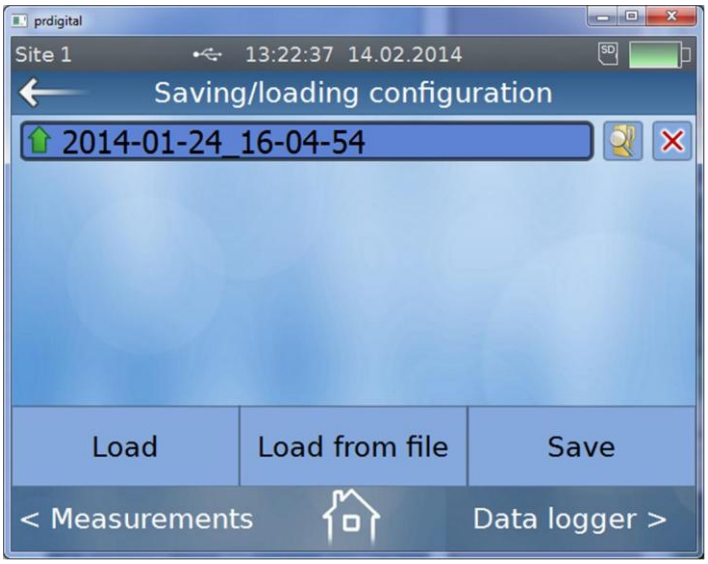

**Fig.13. "prdigital" main window**

In "prdigital" program, some options of **System settings** menu related to display control and adjustment and touch-screen keyboard (**Measurement** / **Site** menu) are unavailable.

The program provides the means for uploading logged data into a PC (**Archives** menu). To do this, click on **Export** button to invoke the corresponding window, enter a site name, date and time of the record and click on **Start** (see Fig.14). The program opens an associated directory where the data are recorded in **csv** format.


**Fig.14. "Export archival records" window**

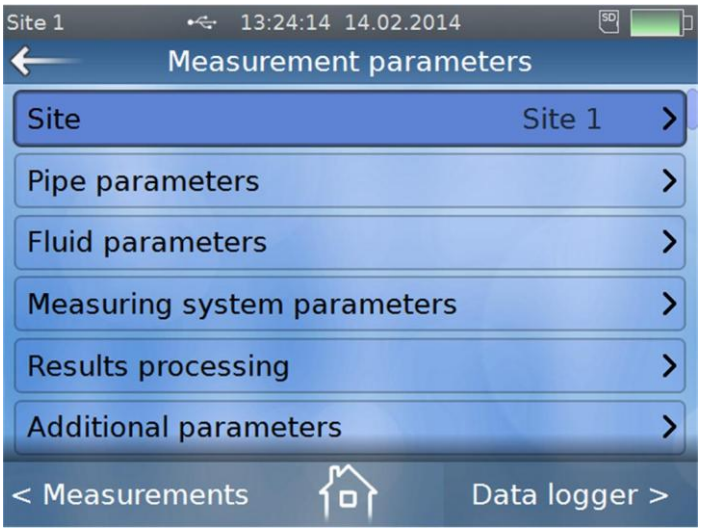
**Applications** menu includes **Saving / loading configuration** submenu (Fig.15) that makes it possible to save a database with configuration settings made for various sites on a PC and to record the previously created database into Flow meter's internal memory (with no need to repeat configuration measurements on these sites).




After the flow meter has been configured for other site, you can restore it to the previously saved settings with button to save adjustment time. Use button to search for loaded files through the corresponding PC directories. Use button to delete current configuration settings from a PC.

**Fig.15. "Saving / loading configuration" window**

## 8. PREPARING FOR MEASUREMENTS




Attach the XDCR pair to the connectors of the Secondary Measuring Converter (CS) so that the XDCR placed first relative to the flow direction is connected to XDCR1 terminal and another one (placed second regarding the flow direction) is connected to XDCR 2 terminal.

Open **Measurement parameters** menu (see Fig.16).

Open **Site** menu to start configuration.

**Fig.16. "Measurement parameters" window**

### 8.1. "Site" window


On enabling **Site** option, the program opens **Site selection** tab with the list of sites under review. **Site editing** window is opened on pressing button. The window makes it possible to modify actual site settings, delete an active site with button or enable **Site creating** option with button (see Fig.17). Button is used to copy configuration settings made for a previously configured site to a new one.

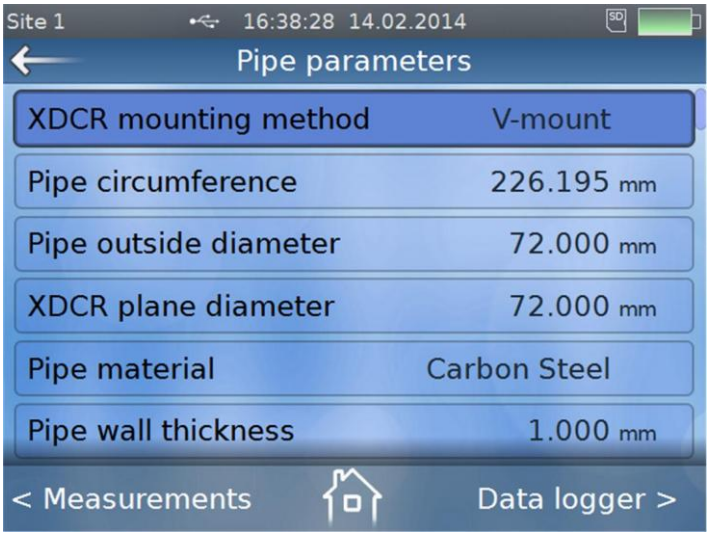
**Fig.17. "Site creating" window**

**Site creating** tab brings up the on-screen keyboard used to type in names of groups, sub-groups and sites. In "prdigital" program, alpha-numeric characters are typed in using a computer keyboard.

## 8.2. "Pipe parameters" window

Parameters measured and calculated while mounting the Flow meter on the pipeline (Fig.18) are as follows:

- **XDCR mounting method** – XDCR mounting scheme (**Z-mount** or **V-mount**)
- **Pipe circumference** – average circumference of outside diameter of the pipe
- or **Pipe outside diameter** – average value of outside diameter of the pipe
- **XDCR plane diameter** – average value of outside pipeline diameter in the longitudinal plane of XDCR installation
- **Pipe material** – pipeline material
- **Pipe wall thickness** – average value of wall thickness of the pipe
- **Pipe liner material** – material used for lining of the pipeline inner surface




- **Pipe roughness** – equivalent roughness of the inner surface of the pipeline
- **XDCR spacing** – distance between acoustic centers of XDCRs along the pipeline axis.

**Pipe sound speed** field displays the value of ultrasound velocity in the pipe wall depending on the type of material specified in **Pipeline material** field.

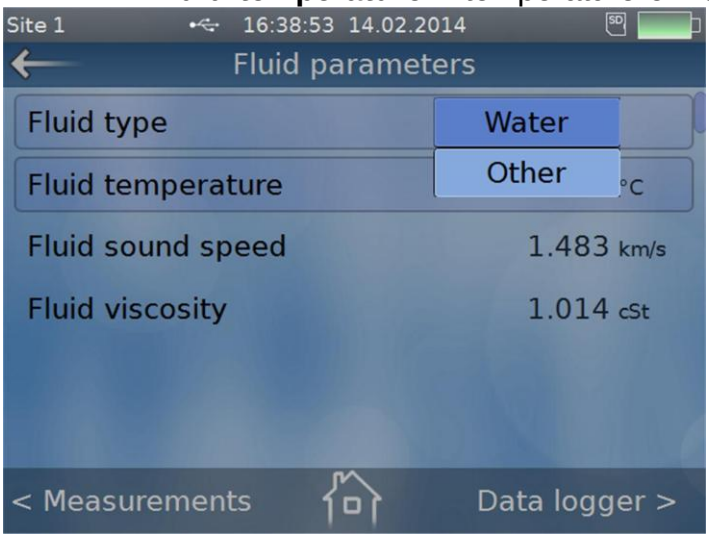
**Suggested XDCR spacing** field displays the value of datum axis calculated by the Flow meter.

**Fig.18. "Pipe parameters" window**

## 8.3. "Fluid parameters" window

The following settings are specified (see Fig.19):

- **Fluid type** – **Water** or **Other**
- **Fluid temperature** – temperature of fluid under control (specified by default or measured by a thermometer)




- **Fluid sound speed** – speed of ultrasound signal in fluid under control
- **Fluid viscosity** – kinematic viscosity of fluid under control measured using a viscometer.

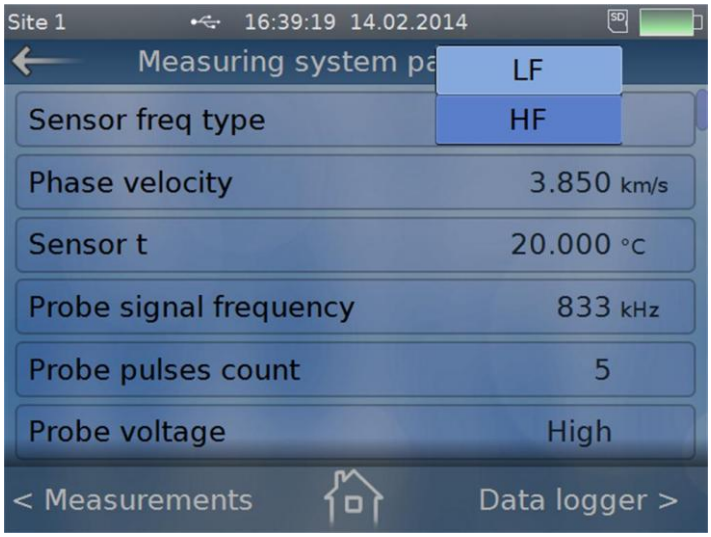
**NOTE**. **Fluid sound speed** and **Fluid viscosity** fields contain the values determined for water considering the user-specified temperature. The values in the fields become editable if **Other** value is selected in **Fluid type** field.

**Fig.19. "Fluid parameters" window**

## 8.4. "Measuring system parameters" window

The following settings are specified (see Fig.20):

- **Sensor freq type** – XDCR type: high frequency - **HF** or low frequency – **LF**
- **Phase velocity** – correction factor: the value is taken from the XDCR Product certificate (Passport)
- **Sensor t** – average temperature of XDCR contact surface (specified by default or measured by a thermometer)




- **Probe signal frequency** – frequency of sounding signal (within 200 to 2000 kHz range) – depending on XDCR type: **HF** or **LF.**

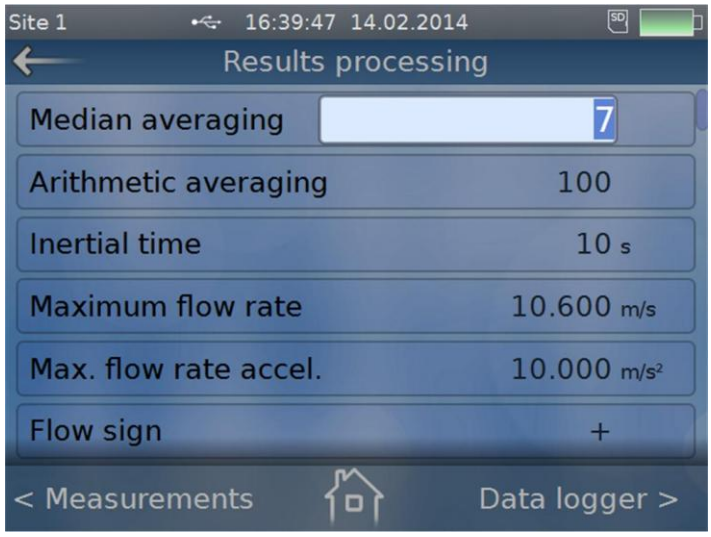
**NOTE**. If **HF** value is selected in **Sensor freq type** field, **Probe signal frequency** value is automatically set to **833 kHz**, which is optimal for high frequency XDCRs of 222 and 228 types. If you use XDCRs of type 207, manually enter **2000 kHz** in this field. **LF** value means that **300 kHz** frequency is set in the field by default (for low frequency XDCRs of type 212).

**Fig.20. "Measuring system parameters" window**

- **Probe pulses count** – number of pulses in a burst, from 1 to 5
- **Probe voltage** – level of sounding voltage: **Low** or **High**
- **Automatic gain control** – automatic gain control of sounding signal on/off
- **Manual gain** – constant level of sounding signal gain (AGC system off) in conventional units, 0 to 57
- **Signal detection threshold** – constant level of sounding signal detection threshold in conventional units, 1 to 30000
- **LB of signal search zone** – lower threshold of signal search gate, 0 to 10000 μs
- **UB of signal search zone** – upper threshold of signal search gate, 0 to 10000 μs.

## 8.5. "Results processing" window

The following settings are specified (see Fig.21):




- **Median averaging** – size of median averaging buffer in conventional units, 1 to 15
- **Arithmetic averaging** – size of arithmetic averaging buffer in conventional units, 1 to 400
- **Inertial time** – minimal duration of absence of USS signal, 5 to 300 s
- **Maximum flow rate** – maximal rate of flow in the pipeline, m/s
- **Max. flow rate accel.** – maximal speed of flow rate variation in the pipeline

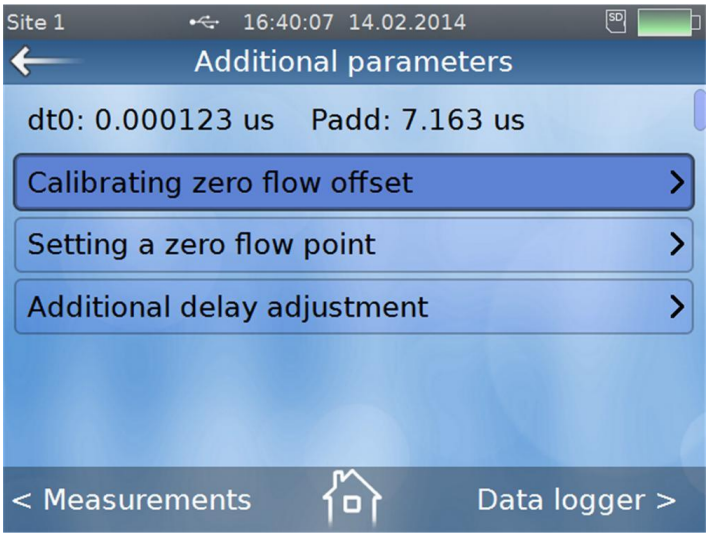
**Fig.21. "Results processing" window**

- **Flow sign** – forward (**+**) or reverse (**-**) direction of flow
- **Low flow cut-off** – minimal flow rate cut-off
- **Lower set point** – lower set point for flow rate
- **Upper set point** – upper set point for flow rate.

## 8.6. "Additional parameters" window

In this window (see Fig.22), the following extra settings can be specified:

- **Calibrating zero flow offset**




- **Setting a zero flow point**
- **Additional delay adjustment**.

Select **Calibrating zero flow offset** field. The value of zero flow offset is defined when the flow in the pipeline is fully stopped. Press **Start** button to enable calibration procedure.

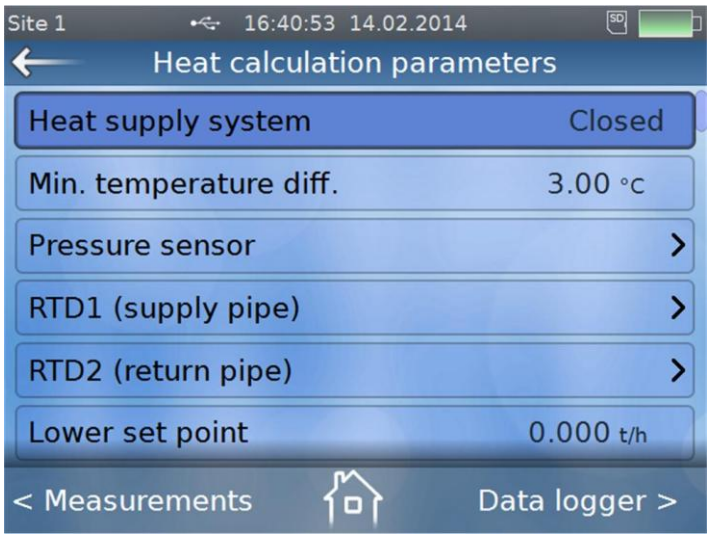
After the procedure is completed, press **Set** button. At this time **Zero flow offset dt0** parameter will automatically set to the value calculated by the Flow meter. **Zero flow offset dt0** parameter can be specified manually.

**Fig.22. "Additional parameters" window**

In case it is impossible to completely stop the flow of liquid in the pipeline, to determine zero offset, enable **Setting a zero flow point** option and follow on-screen instructions.

**Additional delay adjustment** field is used to check the value in **Additional delay** field and the value specified in the Flow meter's Equipment certificate (Passport) for correspondence.

## 8.7. "Heat calculation parameters" window




This window (see Fig.23) is used to specify settings for the heat system with temperature/pressure sensors or enter corresponding contractual data.

**CAUTION!** All of the measured values obtained from the heat system, temperature and pressure measurement channels can be used only for reference considering that their metrological specifications are not normalized.

**Heat supply system** value is selected depending on heat system type – **Opened** or **Closed**.

**Fig.23. "Heat calculation parameters" window**

Minimal difference in supply and return pipeline temperature and upper/lower mass flow rate set points are specified in corresponding fields.

**Pressure sensor** field is used to determine pressure sensor characteristics: range of current, pressure measurement range and rated system pressure declared by the distributor.

**RTD1 (supply pipe)** and **RTD2 (return pipe)** fields are used to specify standard sensor curves for sensors in use and contractual values of temperature.

Each temperature or pressure sensor can be connected or disconnected from the system. If disconnected, heat calculation is based on the contractual data.

**CAUTION!** If **Heat supply system** parameter is set to **Off**, heat calculation is not carried out!

## 8.8. System settings

**System settings** menu makes it possible to change general settings of the instrument. **Date & time** option (see Fig.24) is used to correct date and time, if necessary. New values are confirmed with Ok.

In **Menu language** field you can select the usable language: **English**.

**Units** option is used to select flow rate measurement units: **$m^3/h$**, **l/min** or **$m^3/s$**.


**Device status** field contains information about the actual power supply mode, (**Power** option), charge level of the Battery (AB), estimated time remaining for battery-powered operation with the display on/off, current firmware version, checksum of executable code, and serial number of the instrument.

**Power saving options** field sets the time for turning the display off after finishing work with the instrument (for power supply from mains or from the Battery).

**Fig.24. "System settings" menu**

**Calibrate the touch screen** and **Test the touch screen** options are used to set and check "in-touch" functions for a particular user.

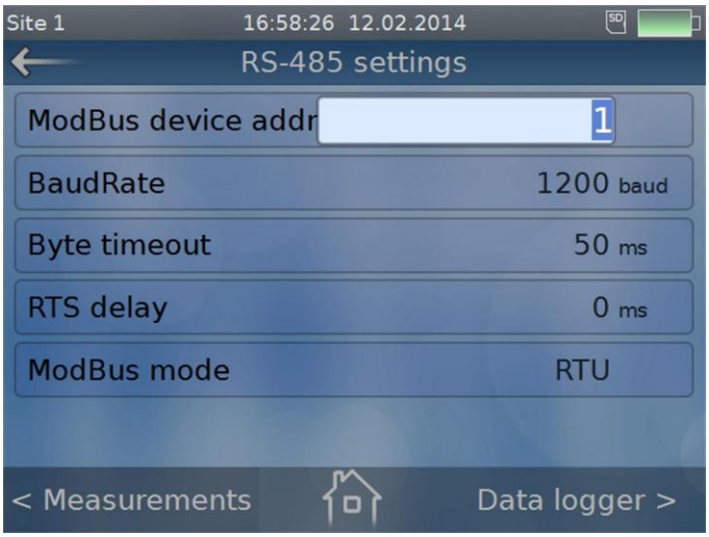
**Factory reset** field contains a table with the list of available options. Press **Yes** to confirm the selection or **No** to reject.

**Turn display off** and **Shut down the device** functions are enabled after pressing ↵ or ▶ button on the keyboard of the instrument.

**NOTE**. If the instrument is configured via the interface, **Turn display off**, **Power saving options**, **Calibrate the touch screen, Test the touch screen** and **Shut down the device** options are not available on a PC display.

## 8.9. Periphery settings

The menu is used to configure the universal output and RS-485 interface (see section **Communication interfaces**).




RS-485 connection is established in **RS-485 settings** window of **Periphery settings** menu (see Fig.25). The settings include Flow meter's address, data exchange rate selectable within 1200 to 115200 bit/s and other parameters.

**Fig.25. "RS-485 settings" window**

The pulse (discrete) output is configured in **Discrete output settings** window of **Periphery settings** menu (see Fig.26):

Select the type of output parameter (flow rate, volume etc.) and specify the active signal level (**Low** or **High**). The output conversion factor **KP** or **Ki** may be calculated, if required.

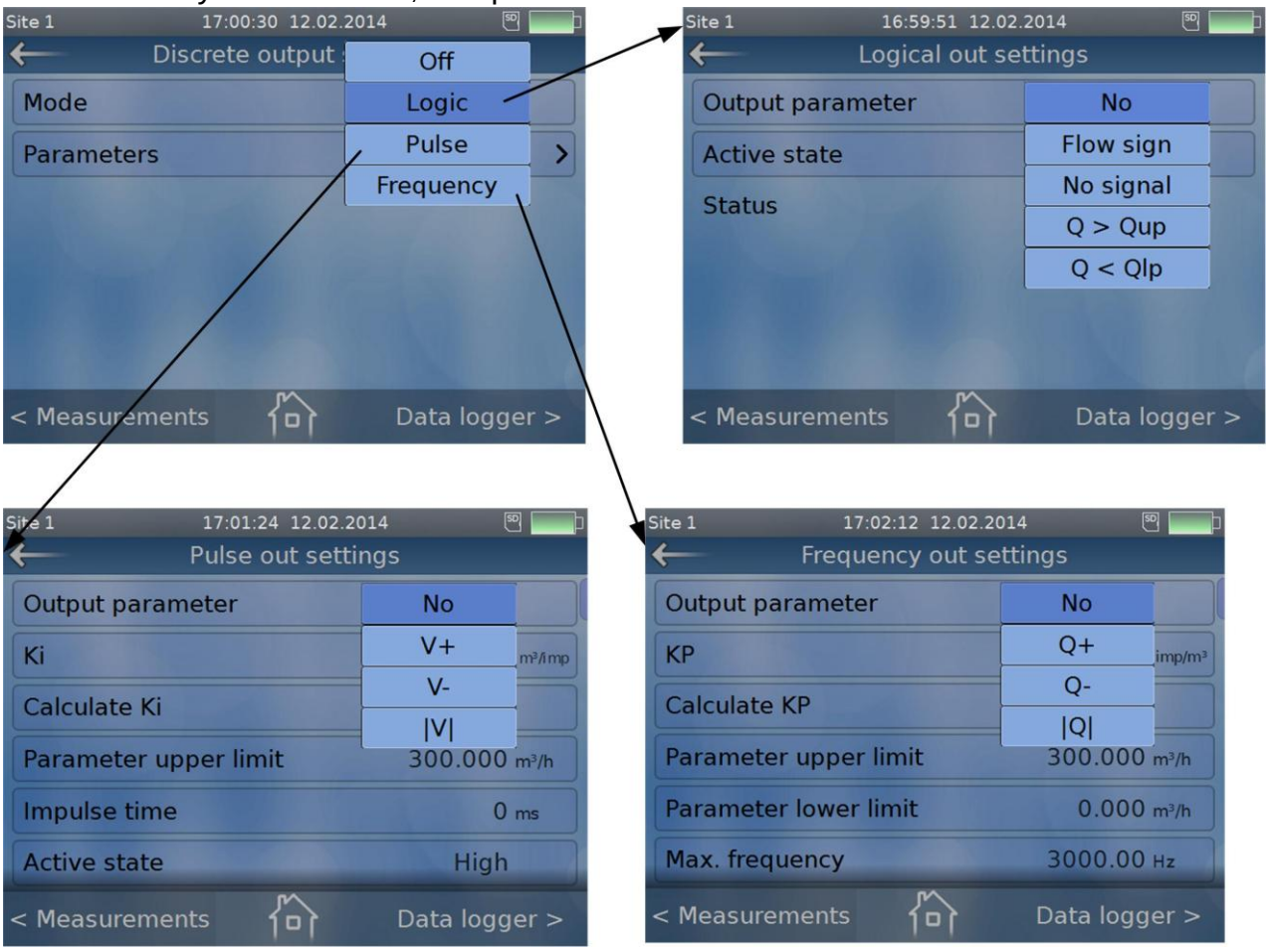
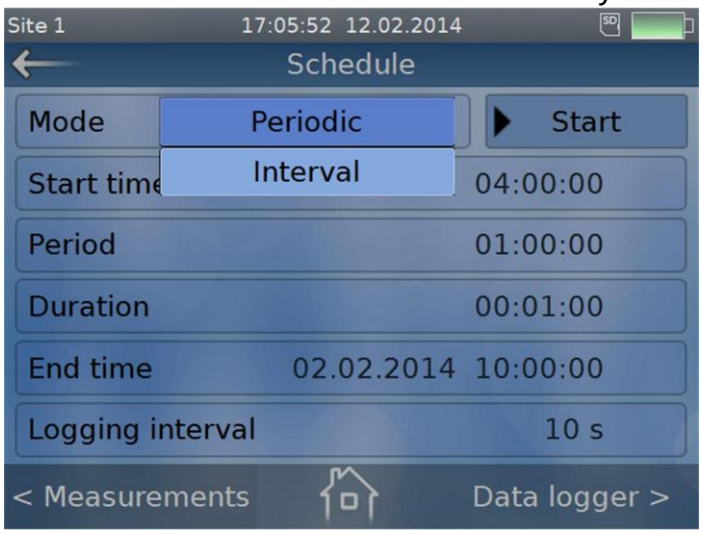



**Fig.26. "Discrete output settings" windows**

## 8.10. Schedule

**Applications** / **Schedule** window (see Fig.27) is used to specify flow meter's automatic start and stop in the "periodic" or "interval" modes (period and duration of measurements may be selected). Measurement results are recorded into the log in logging intervals specified by the user.




When the instrument starts working in the "Schedule" mode, this is indicated by "Clock" icon  and  "Sine" icon on the top line of the display (to the left of the time indicator). On achieving the stop time, "Clock" icon will be crossed out  .

**Fig.27. "Schedule" window**

## 8.11. Documentation

**Documentation** menu (see Fig.28) contains this Short operation manual so the user can access it at any time with no need to have its printed version or a PC at hand. In "prdigital" program, the Short operation manual is accessible in **pdf** format. The corresponding operational documentation can be viewed on a PC provided that **Adobe Reader** has been installed on your computer.

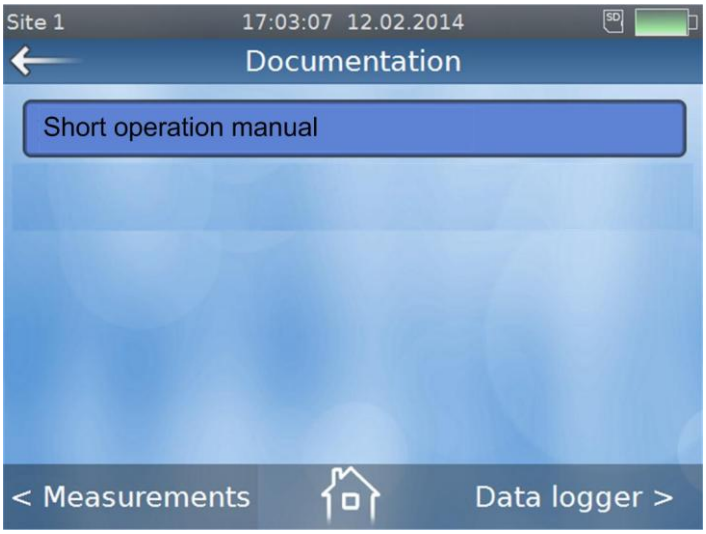



**Fig.28. "Documentation" menu**

## 8.12. Data logger setup

To set up a logging session before enabling measurements, select the logging interval value from the list in **Logger interval** field of **Data logger setup** menu (see Fig.29). Please note that logging configuration settings for a particular site can be changed only if the log does not contain records related to the site with that number. Otherwise, the previously recorded data will be displayed incorrectly. You can delete the logs if necessary in **Erase memory card** field.

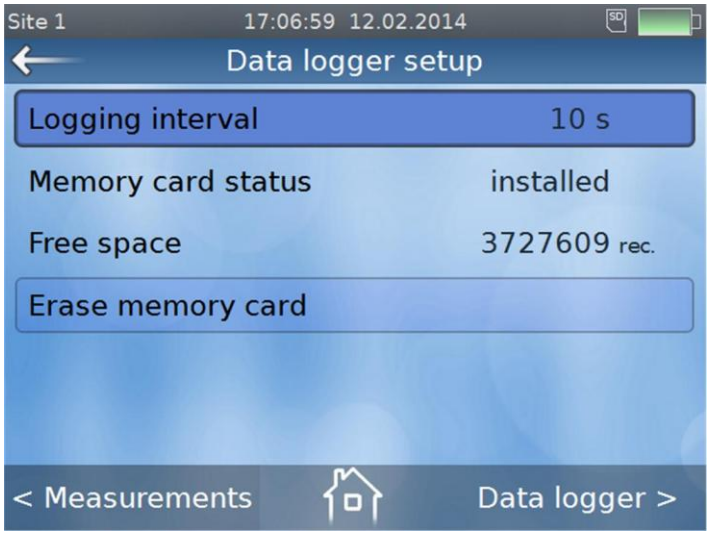



**Fig.29. "Data logger setup" menu**

On enabling the measurement mode, the logging session will start automatically.

## 9. OPERATION

### 9.1. Measurements

To turn on the instrument, press ⏻ button and hold it for a few seconds. The Flow meter performs a self-test procedure and shows "AFLOWT" screen (see Fig.30). On completing the self-test, the instrument displays the main menu (Fig.8).

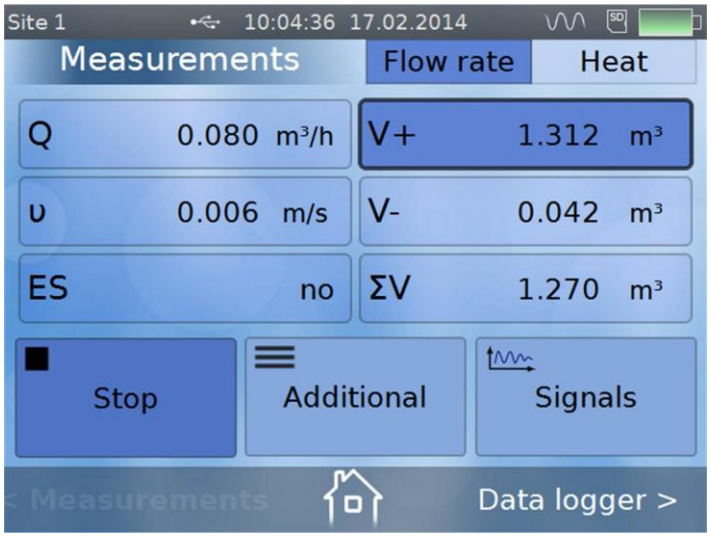

**Fig.30. "AFLOWT" screen**

Please check Battery charge level according to the Battery condition symbol on the display. If the level is low, connect the Flow meter to an external power supply. The instrument can be in operation while being charged.

Open **Measurements / Flow rate** window and press **Start** button. Select **"Yes"** in reply to **"Start measure? Yes**, **No"** message. When the instrument starts generating sounding signal, "Sine" symbol  appears in the upper line of the display indicating that the "Measurement" mode is on (see Fig.31).

Measured values of volumetric flow rate, flow velocity, volumes of forward flow, reverse flow and totalized volume (for both flow directions) as well as alarm messages (if any) are shown on the display.

Pressing **Additional** button makes it possible to view additional measurement parameters.

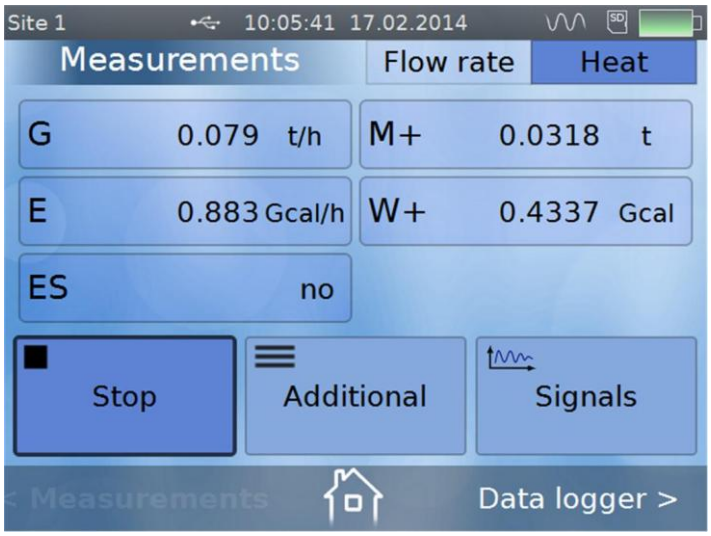



**Signals** button lets the user see a graph depicting the forward and reverse half-waves of sounding signal obtained during automatic signal detection.

**Fig.31. "Measurements / Flow rate" window**

Measurements of heat, mass flow rate and heat power with use of temperature and pressure sensors (or using contractual data instead) are performed in the same way.

Measured values are displayed on pressing **Heat** button in **Measurements** menu. The display shows the values of mass flow rate and heat power as well as total amount of heat and mass of liquid under review (Fig.32).




Just as for flow rate measurements, measurement results can be displayed in larger font size; and **Additional** button can be used to display the status of temperature and pressure measurement channels and to view the corresponding measured values.

**CAUTION!** All of the measured values obtained from heat system, temperature and pressure measurement channels can be used only for reference considering that their metrological specifications are not normalized.

**Fig.32. "Measurements / Heat" window**

## 9.2. Large font size view and graphs

On enabling the parameter indication window, the corresponding measurement results are displayed in larger font size (see Fig.33). The window also contains the corresponding chart displayed in real time mode. When **Stop** button is pressed, **"Stop measure? Yes**, **No"** message appears on the screen. On pressing **"Yes",** the measurements are stopped and the values measured for the last period are recorded into the log along with the measurement stop time.

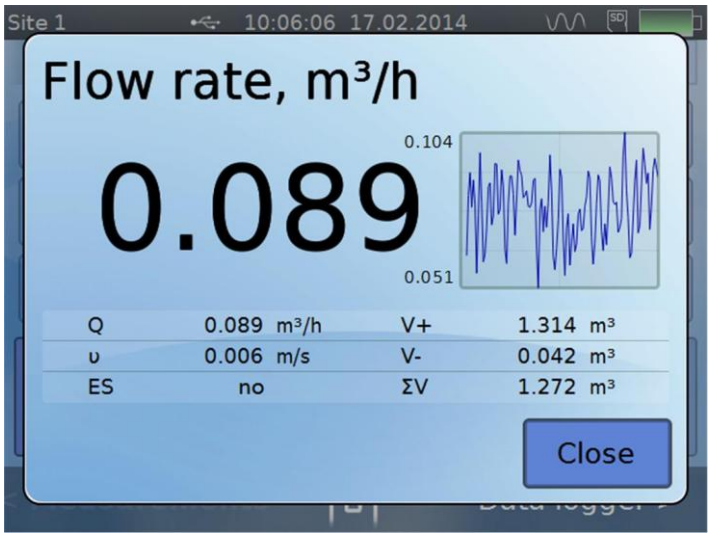



**Fig.33. Flow rate values indicated in large font size**

## 9.3. Logging of measurement results

Measurement and calculation results obtained for every site registered in the internal memory are recorded into a SD memory card. The flow meter supports the cards of up to 4Gb including SDHC cards. The memory card is inserted into the slot in the bottom part of the keyboard module.


Logged data (see Fig.34) can be viewed on pressing LOG button while in any window or menu item or by touching Data logger field on the display (use ▲, ▼ and ↵ buttons to scroll through the items). Using "In-touch" function, you can access logged data either by selecting date and time of logging after pressing icon or by scrolling through the records with ^ or ˇ buttons. ⩓ and ⩔ buttons will take you to the first or last record respectively.

**Fig.34. "Data logger" menu**

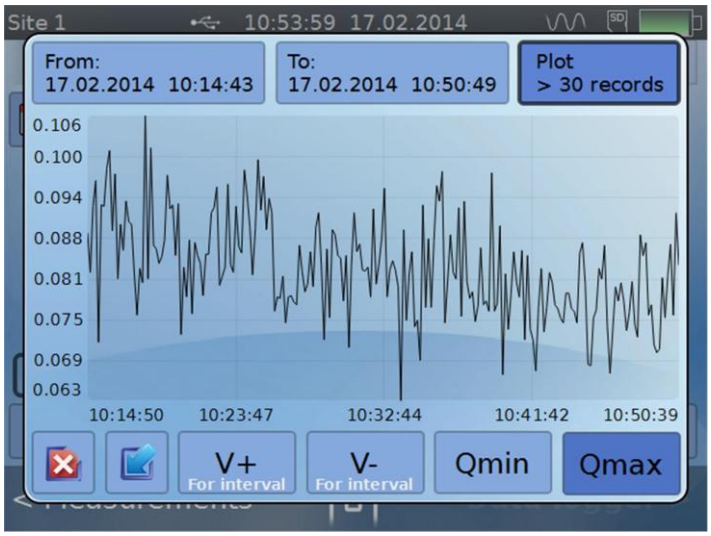



**Fig.35. Log data in graphical form**

Logged data may be displayed in graphical form (see Fig.35). Charts are plotted in real time mode on entering the start and stop time.

Pressing **Charts** button shows the measured values of flow rate and volume as a real time graph for a period previously selected by the user.

**Charts** submenu is exited with or button.

If you press button to exit the mode, symbol will appear under icon in the bottom line of the display indicating that **Charts** menu was used. The same takes place in "prdigital" program when exiting **Export** submenu. Symbol appears under icon indicating the fact of using this submenu (see Fig.36).


**Fig.36. "Charts" and "Export" windows in use**

Touch (click on) the symbols to close them. At this time, the screen becomes dimmed and the corresponding prompts marked with white crosses (indicating that log records and log graphs have been used) appear on the screen. Click on the white cross to erase the prompt.

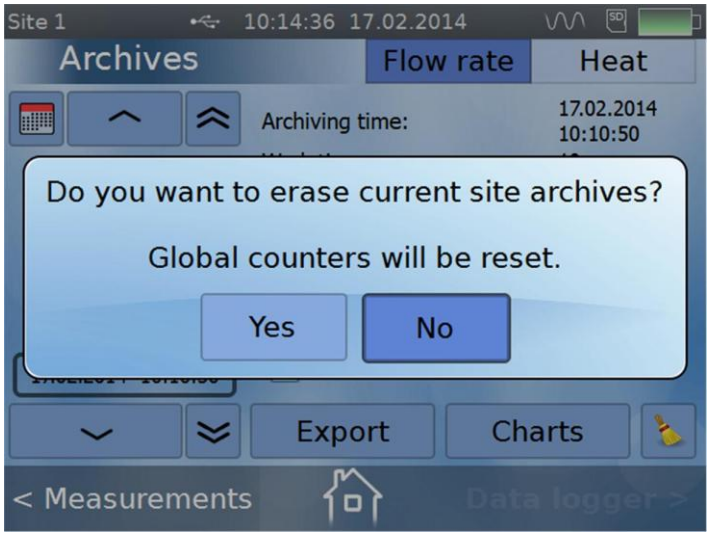



**Fig.37. Log deletion window**

Icon is used to delete logs related to an active site. The user is requested to confirm that he wants the logs to be deleted (Fig.37). Press **"Yes"** to clear the log memory or **"No"** to reject.

## 10. SELF-TEST FUNCTION

### 10.1. Displaying errors

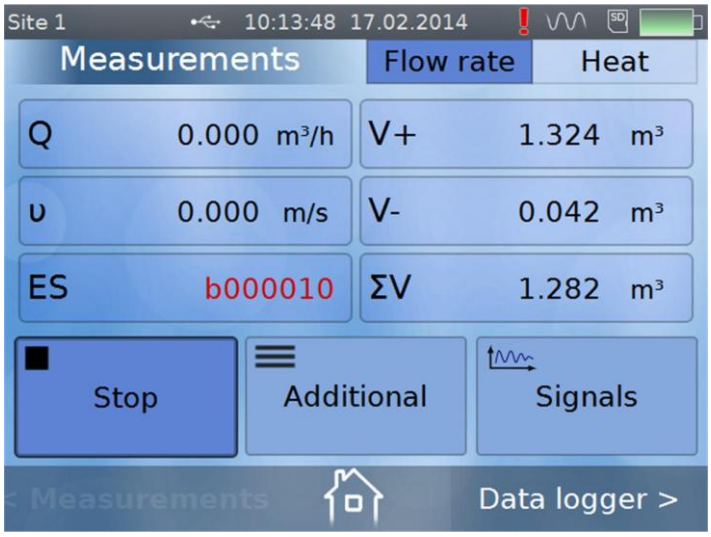
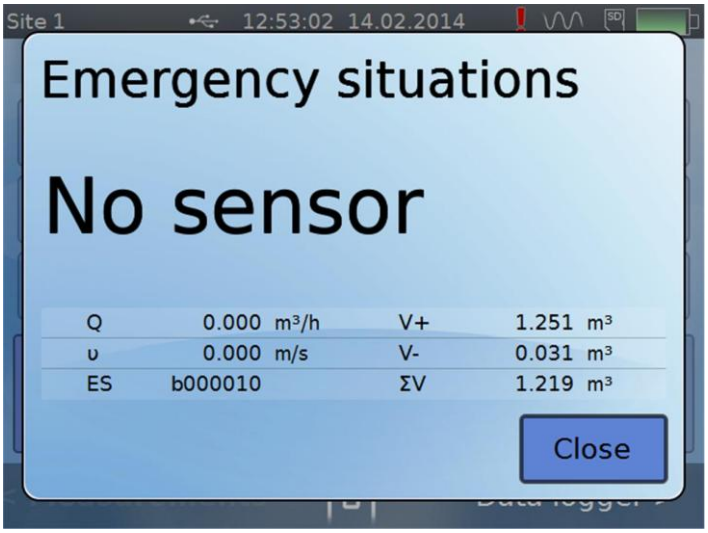



**Fig.38. ES code displayed in "Measurements / Flow rate" window**

The Flow meter tests its measuring functionality automatically and at regular intervals.

Should an error be detected, it is assigned the corresponding error code (see Fig.38). An error situation is indicated in **Measurements window** in the top right part of the display (to the left of the "Sine" icon) with a red exclamation mark. The error situation code (ES) is recorded into the log.




Pressing on the ES icon brings up an explanation box (Fig.39):

**Fig.39. ES explanation box**

Presence of several 1's in the ES code means that several errors have been detected at the same time (Fig.40):

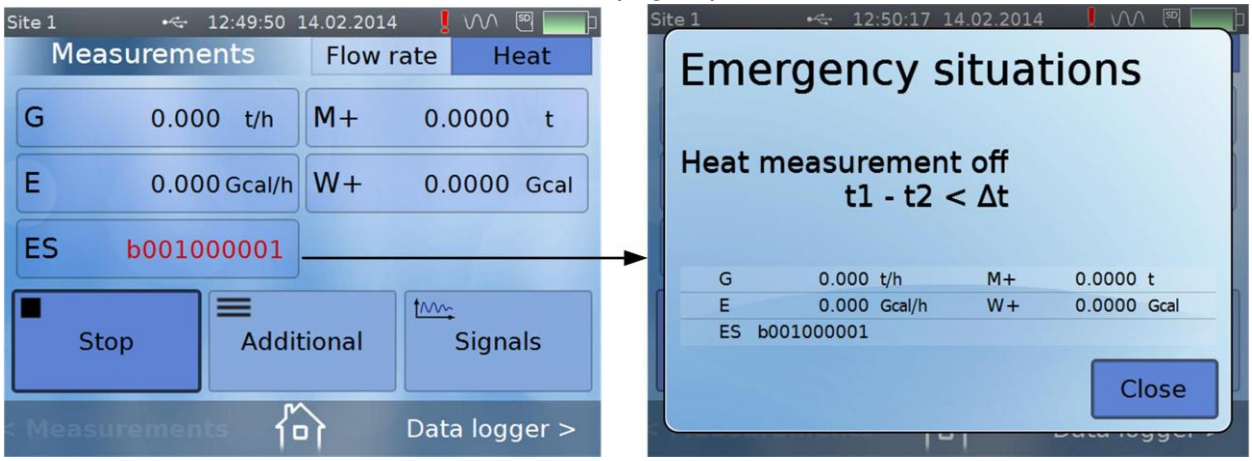



**Fig.40. Indication of multiple errors**

In case of error detection, check that:

- Power Supply is fully operational and Flow meter's input voltage meets the specifications
- XDCR, RTD and pressure sensor circuits are reliably connected
- Liquid is present and running through the pipeline
- There are no considerable gas (air) bubbles in the place of XDCR installation.

## 10.2. Explanation of ES codes displayed in "Flow rate" window

| Code | Description | Probable cause | Troubleshooting method |
|---|---|---|---|
| **b000001** | Short-term loss of signal | - | - |
| **b000010** | USS not detected | 1. Incorrect adjustment of the Flow meter<br>2. No liquid in the pipe, or too much gas in the liquid<br>3. Faulty electric connections between XDCR and CS<br>4. XDCRs are incorrectly installed on the pipeline<br>5. Sediments on the inner surface of the piping<br>6. Faulty XDCR<br>7. CS failure | 1. Check settings for correctness.<br>2. Make sure that the pipe is filled with liquid and there are no large air bubbles present.<br>3. Check integrity and reliability of electric connections between XDCR and CS.<br>4. Check that XDCRs are correctly mounted and fixed on the pipeline; check that XDCR emitting surfaces are properly lubricated.<br>5. Install XDCRs on a new pipe section if the signal level is insufficient.<br>6. Check functionality of the channel with other XDCRs.<br>7. Contact the Service Center. |
| **b000100** | Operator's error | Wrong configuration settings | Check the settings for correctness. |
| **b001000** | Qmax is exceeded | Measured flow rate value has exceeded the threshold | Make sure that the parameters are set correctly. |
| **b010000** | Q > Qhs | Flow rate value exceeds the upper set point | Make sure that the parameters are set correctly. |
| **b100000** | Q < Qls | Flow rate value is below the lower set point | Make sure that the parameters are set correctly. |

## 10.3. Explanation of ES codes displayed in "Heat" window

| Code | Description | Probable cause |
|---|---|---|
| **b000000001** | Totalizing of heat is stopped | Failure of any (flow rate, pressure, or temperature) sensor, or the preset temperature gradient is exceeded. |
| **b000000010** | Failure of flow rate sensor | Breakdown of XDCR cable. |
| **b000000100** | Q<0 | No flow situation. |
| **b000001000** | Failure of temperature sensor N1 | Breakdown of RTD1 cable. |
| **b000010000** | Failure of temperature sensor N2 | Breakdown of RTD2 cable |
| **b000100000** | Failure of pressure sensor | Breakdown of pressure sensor cable. |
| **b001000000** | t1-t2<Δt | Temperature difference in supply and return pipelines is below threshold value. |
| **b010000000** | G > Ghs | Mass flow rate value exceeds the high set point. |
| **b100000000** | G < Gls | Mass flow rate value is below the lower set point. |

If connection with a PC is lost (cable breakdown or contact loss), the program status line on the PC display will contain the running message: **"No connection with the device"** (Fig.41).

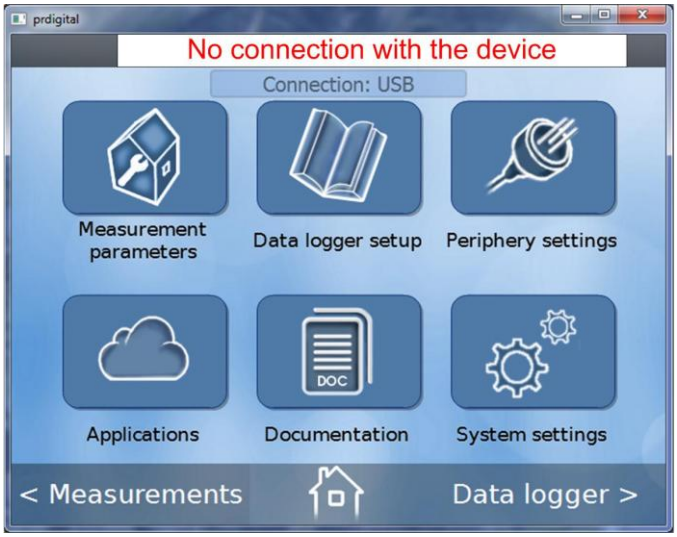



**Fig.41. "No connection" message**

## 12. INTERFACES

### 12.1. Pulse (discrete) output

The pulse (galvanically isolated) output is shown in Fig.42. The output is versatile both with regard to operating mode (frequency, pulse or logical) and function.

Settings of the output, its operating mode and function are configured at the factory.

To match the output stages to inputs of different types, the output is designed to work with either the internal power source (active mode) or an external power source (passive mode). The pulse output is set to the passive mode by default.

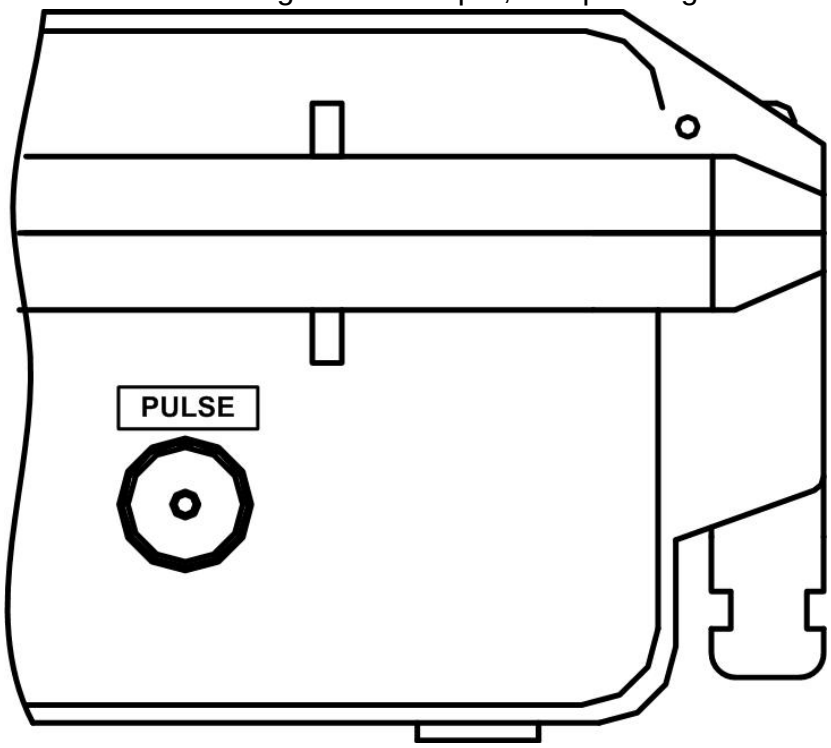



**Fig.42. Pulse (discrete) output**

### 12.2. Interfaces USB and RS-485

The flow meter is equipped with USB and RS-485 ports (see Fig.43) for communication with a PC. PC connection makes it possible to control the instrument from your computer, read measurement results, log data and diagnostic data as well as read and modify configuration settings.

When connecting the instrument to a PC, use manufacturer-supplied cables only.

USB input and output settings correspond to USB 2.0 specification. The RS-485 interface supports ModBus RTU protocol. Data exchange rate via RS-485 (1200 to 115200 bit/s) and other communication settings can be made from a PC or from the Flow meter's keyboard.

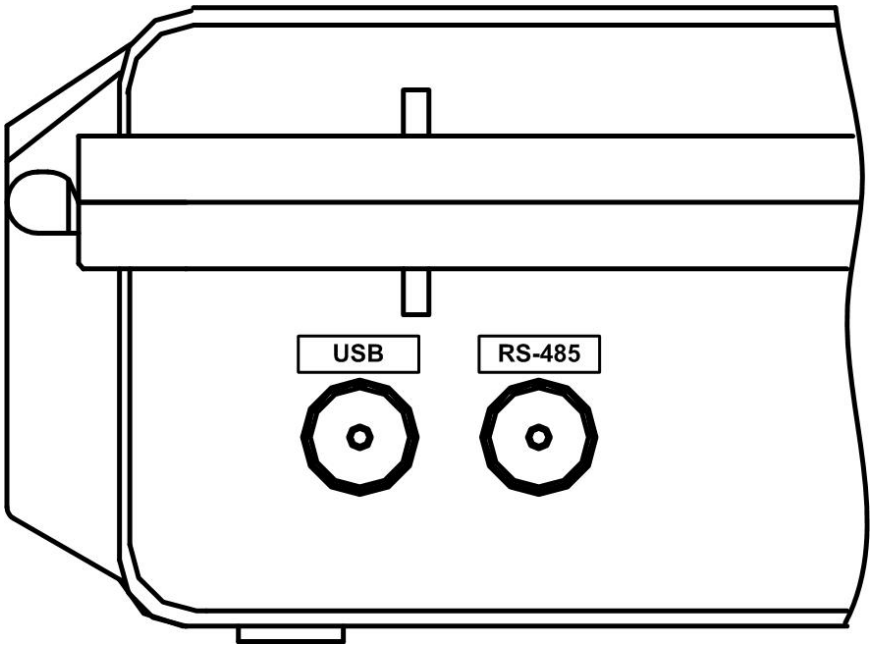



**Fig.43. Communication ports**

## 13. MAINTENANCE

It is recommended to check at regular basis that:

- Operating conditions are met
- Power supply voltage is present
- No external defects are detected
- Electrical and mechanical parts are reliably connected.

The presence of display indication means that power is applied to the Flow meter, the indicated information gives an idea of its performance.

When external defects are detected on the Flow meter, power cables or signal cables, contact the Service Center or regional dealer for the information about its operability.

With respect to design and operating conditions, the Flow meter relates to the instruments that must be repaired by authorized dealers or by the manufacturer.

The failure or fault is localized to an accuracy of a block: CS, XDCR and Power Adapter or signal cables. Faulty components are replaced by operable ones. If one XDCR is faulty, both XDCRs from a pair are replaced.

**NOTE!** When replacing XDCRs, it is necessary to determine the value of **Zero flow offset dt0** parameter and record it into the memory (see section 8.6).

Deep discharge of the Battery may result in its failure or in the failure of the Flow meter. To avoid this, follow the instructions for keeping the Battery in good condition (section 4 of this Manual).

When the Flow meter is sent for service, the Equipment Certificate must be enclosed.

* * *

**Manufacturer quality management system is certified to ISO 9001:2015**

* * *

**URL: http://www.aflowt.com**