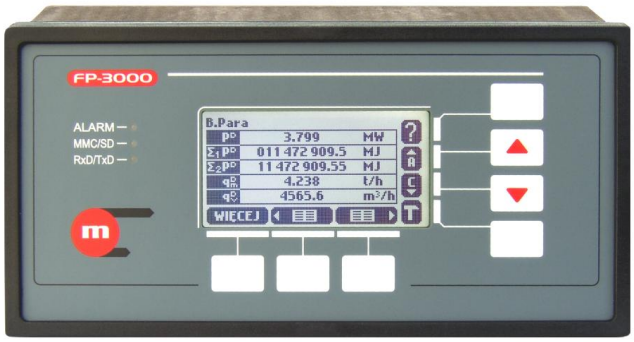
FP-3000
FP-3010
(version 2.33)



FP-3000

FP-3010

Flow and Energy Computer for Steam, Liquids and Gases

OPERATING MANUAL

Rev. 2010-06-18

This manual is available on CD

metronic
APARATURA KONTROLNO - POMIAROWA

Safety notes

! Safe operation of the flow computer can only be ensured if all hints and warnings in this operating manual are thoroughly read and followed.
■ The unit could be dangerous if installed or used incorrectly.
The unit is safely manufactured using state-of-the-art technology and complies with the respective EU regulations.
The flow computer can not be installed in a hazardous area.

Manufacturer note

The manufacturer reserves the right to improve and update the technical details.
For details of improvements or additions to these instructions, please contact your local sales representative.

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Sections marked are available only on CD.

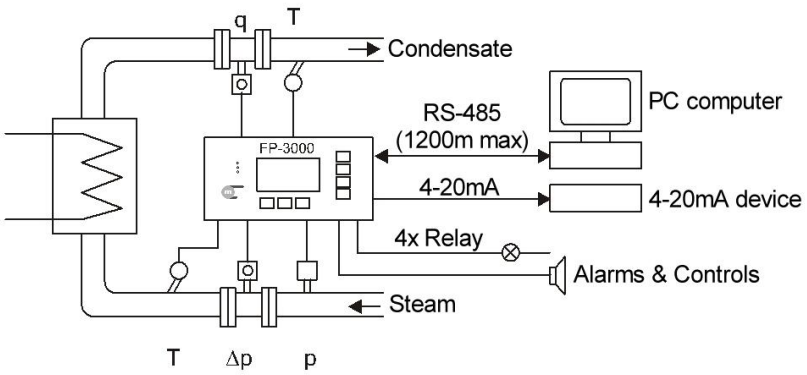
1. PURPOSE AND APPLICATION SCOPE OF FLOW COMPUTER

1.1. Purpose

FP-3000 and FP-3010 devices are modern, universal flow computers designed for measurement of:

- flow and heat of steam and water according to IAPWS-IF97,
- flow and heat of liquids other than water according to characteristics provided by user,
- flow of technical gases.

FP-3000 flow computer can be used for three different applications of an installation whereas FP-3010 for two of them. Math functions enable calculation of flow and energy balances. The flow computer is designated for industrial application in independent measurement applications and as component of computerized measurement and control systems. Extended functions of event and process values recording make it possible to perform analysis of technological processes and emergency conditions. Data logging of process values on removable MMC/SD memory cards enables to use this device in places beyond the reach of computer networks. Output alarms provide with signaling and simple controlling.



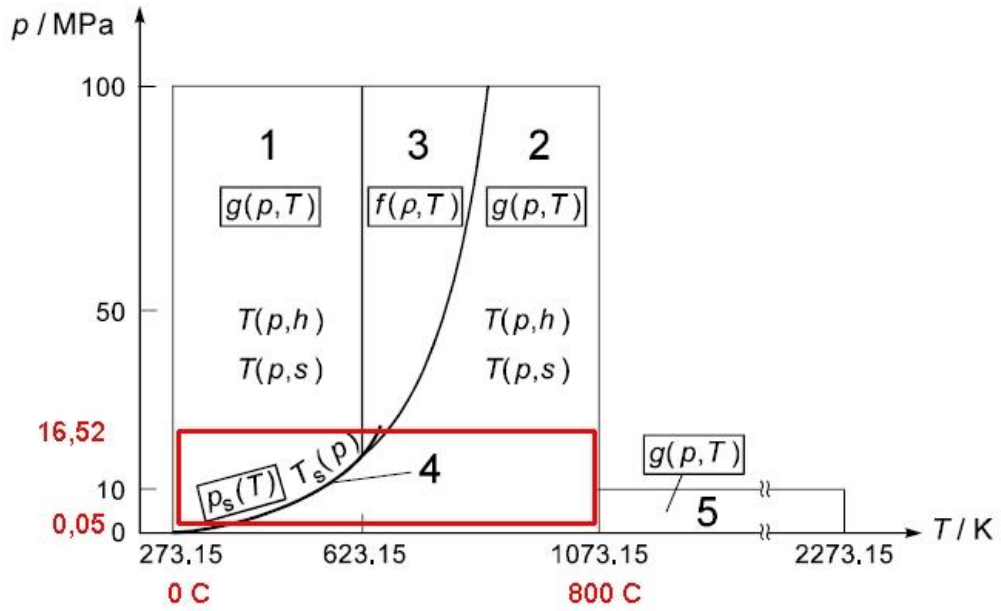
Application of FP-3000 or FP-3010 flow computer- example

The device has a panel mount construction designated for installation in control cabinets. Graphic LCD display enables convenient readout of measured and calculated values. Comprehensive programming menu allows simple device configuration.

The flow computer is a freely programmable in a broad range and enables configuration of results displaying depending on users needs. In order to ensure convenient and clear readout of process values all functions and the way they are displayed should be properly configured.

1.2. Application scope

The flow computer performs flow and heat measurement of superheated or saturated steam or water according to IAPWS-IF97 recommendations in the operating range of temperature 0…800 ºC and absolute pressure 0,05…16,52 MPa.



Limits of water and steam calculation

Flow and energy measurements of liquids other than water are performed in the range of tabular values entered by user – density and enthalpy as function of temperature.

Flow computer can cooperate with:

- mass flowmeters,
- volume flowmeters,
- differential pressure devices with approximation by square root curve,
- differential pressure devices (orifices and nozzles) according to iteration algorithm according to PN-EN ISO 5167 standard (only for water and steam).

Device has three types of inputs enabling connection of various types of sensors and transmitters:

- RTD - designated for direct connection of resistive temperature sensors Pt-100, Pt-200, Pt-500, Pt-1000 or Ni-100, Ni-1000,
- 0/4-20mA – enable connection of transmitters and sensors in current loop 4-20mA or 0-20mA,
- PULS - enable flow measurement from pulse transmitter in range 0,001 Hz …10 kHz or implementation of binary inputs functions (e.g. flow direction).

Number of inputs for both types of flow computers is shown in the table:

Type of input	FP-3000	FP-3010
RTD	2	2
0/4-20mA	6	2
PULS	2	1

Within available number of inputs up to three (FP-3000) or two (FP-3010) different measuring main applications can be built.

Except of measurements concerning main applications of an installation flow computer can fulfill up to eight user defined additional measurements or calculations like sums and differences of heat flow rates or flows from other applications, efficiency etc.

1.3. Available options

Both flow computers are offered in basic and extended option. Basic option can handle only one main application of an installation – A . Extended option includes:

- for FP-3000: three main applications – A, B, C and three auxiliary applications - X, Y and Z,
- for FP-3010: two main applications – A and B.

Device in basic option may be later upgraded to extended option by purchasing a relevant license (see section 17).

Device (both in basic and extended option) may be equipped with analog 4-20mA output. It may be installed only at manufacturer's service. Device options are described with a code:

FP-3000	- x	- x	
	- 0		basic option with one main application A
	- 1		extended option with A, B, C, X, Y, Z applications
		- 0	option without analog 4-20mA output
		- 1	option with analog 4-20mA output

FP-3010	- x	- x	
	- 0		basic option with one main application A
	- 1		extended option with A and B applications
		- 0	option without analog 4-20mA output
		- 1	option with analog 4-20mA output

2. GENERAL INFORMATION

2.1. Process values layout in A, B, C, X, Y and Z application

Devices FP-3000 and FP-3010 perform measurements and calculations according to their configuration. Each measurement or calculation value has its own symbol and belongs to one of the applications. There are six applications marked with letters A, B, C, X, Y and Z in FP-3000 whereas in FP-3010 there are only two applications A and B. Both devices are also available in option with only one A application (see section 1.3).

Applications A, B C are designated for grouping process values corresponding to separate main applications of installation. Each main application is determined with help of wizard and all necessary process values are loaded automatically.

Auxiliary values can also be loaded to the systems – both measured values (if any measurement inputs were left) and calculations (defined by formulas). Each such auxiliary value can be entered to any system A to Z. It is recommended to load into systems A, B, C values linked with the given main application (e.g. water level or calculated efficiency) whereas remaining values (e.g. sum of heat flowrates of all main applications) – into systems X, Y, Z.

2.1.1. Process values symbols

Auxiliary values may be given any symbols consisting of one or two letters. Values loaded automatically into applications A, B and C have symbols assigned by the device. These symbols have the following meaning:

P	heat flow rate or difference of heat flowrates between supply and return
q	volumetric flow of gas in normalized units (volume referred to reference conditions)
q_m	mass flow
q_v	volumetric flow
p	measured pressure
p_c	saturated steam or boiling water pressure determined theoretically based on measured temperature
T	measured temperature
T_c	saturated steam or boiling water temperature determined theoretically based on measured pressure
ρ	medium density
h	medium enthalpy
Δp	pressure difference at the orifice in differential pressure device
ΔT	temperature difference between supply and return
k	thermal coefficient of water.

To the above listed symbols a block letter in the upper index can be added which means:

- kind of medium to which this quantity refers (D - steam, W - water, G - gas, other letters may be used for other liquid media) or
- S - supply, R - return, if there is the same medium in both pipelines of main application.

If a process value does not refer strictly to one pipeline but to main application as a whole (e.g. difference of heat flowrates between supply and return, mass flow in closed system or common pressure in both pipelines), then this mark in the upper index is not added.

Examples of values symbols:

Steam – condensate closed system

- P^D steam heat flow rate (refers only to steam – D in upper index)
- P^W condensate heat flow rate (refers only to condensate – W in upper index)
- P difference of heat flow rates between steam and condensate (no mark in upper symbol because this quantity is relevant to the system as a whole and not to a given pipeline)
- q_m mass flow of both steam or condensate (no mark in upper symbol because this quantity is common to both pipelines of main application)

Water – water system

- T^S supply temperature (letter S in the upper index means that this quantity refers only to the supply pipeline; letter W would have no sense because water flows in both pipelines)
- T^R return temperature (letter R in the upper index means that this quantity refers only to the return pipeline)
- ΔT temperature difference between supply and return (no mark in upper symbol because this quantity is relevant to the system as a whole and not to a given pipeline)
- p common pressure in supply and return (no mark in upper symbol because this quantity is common to both pipelines of main application)

Groups of values for all types of measurement in different applications with their explanation are given in section 5.4.

Symbols may be displayed in abridged form (as above) or in full form i.e. with added information about application to which they belong , e.g.:

- $A.P^D$ full form, heat flow rate of steam in application A
- P^D abridged form.

Abridged form is used exclusively where it can be learned from context to which system the value belongs – e.g. on common screen (on the left at the figure below) where the application symbol is printed in title above the table. However on individual screen full form is used.

Both individual values and whole applications can be given text description – captions, i.e. a name in form of one text line. The caption is displayed together with a symbol wherever it is possible. In examples above system A was given the caption „Steam-condensate" and $A.q_m$ – „Mass flow rate".

2.1.2. Totalisers symbols

Except of process values described above (of the last second) the device can display also statuses of heat energy and flow totalisers. For each value which is heat or flow rate, up to four totalisers marked as Σ_1, Σ_2, Σ_H and Σ_L can be used. For more details see section 9. Totaliser cannot be assigned a caption. Totalisers symbols are as follows:

- $A.\Sigma_1P^D$ full form, main totaliser of steam heat energy in application A
- Σ_1P^D abridged form

B.$\Sigma_2 q_m$	full form, additional totaliser of steam mass flow in application B
$\Sigma_2 q_m$	abridged form

2.1.3. Process values assigned to the same transmitter

In some industrial installations two (or more) different process values may be assigned to the same measuring input i.e. physically to the same measuring transmitter. For more details see section 7.1.

Example:
Hot water flows through two heat exchangers in sequence and measurement of heat energy at each of exchangers was implemented in applications A (first exchanger) and B (second exchanger). Temperature at the outlet of the first exchanger is then equal (or rather assumed to be equal) to temperature at the second exchanger inlet. Therefore only one temperature transmitter can be used and two values can be assigned to it:

- A.T^R return temperature in system A (temperature at the first exchanger outlet)
- B.T^S supply temperature in system B (temperature at the second exchanger inlet).

Though both values given above are assigned to the same transmitter and always indicate the same value, they are treated by device as independent. Each may have its own caption, own alarm thresholds, can be separately archived etc.

2.2. Screens navigation

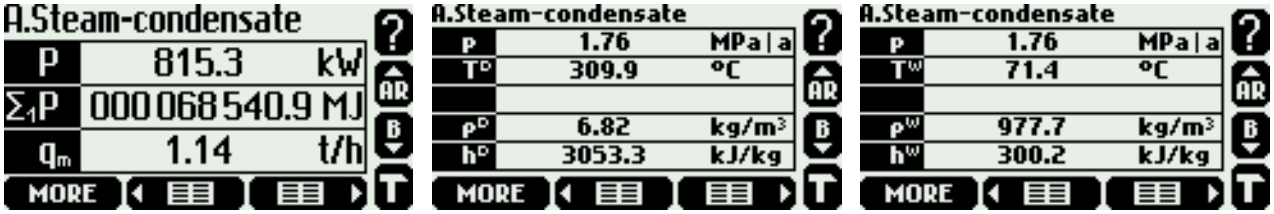
Information on all values and totalisers is organized in form of screens. Navigation between screens is performed using buttons or may be switched to automatic mode. While commissioning user should configure screens sets with all required process values. To simplified readout not used or not necessary data presentation should be deactivated. Display mode configuration was described in section 11.

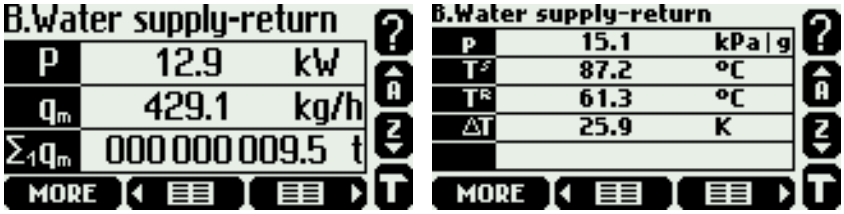
2.2.1. Main and additional screens

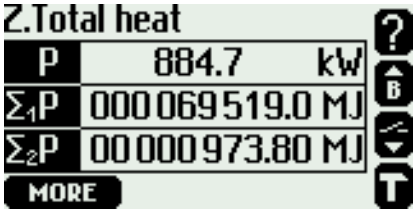
Basic information is displayed in form of main screens and additional screens. Navigation between them is performed using vertical cursors (two central buttons on the right side).

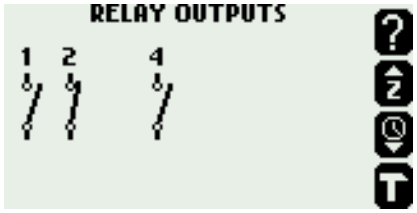
Main screens contain up to 4 tables for every application A, B, C, X, Y and Z. Up to 5 or 3 process values and totalisers can be set into every table depending on the letter size. Navigation between tables within application is performed using horizontal cursors (central and right bottom button).

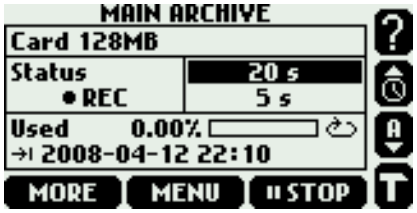
Example:
In application A main screen has three tables, application B screen – two, and application Z – one.











Additional screens are: relay outputs screen, date and time screen and main archive screen. Relay outputs screen informs about status of relays (closed or open, relays not used are not displayed). On date and time screen button **ADJUST** enables setting the clock and calendar. Main archive screen displays information about status of archiving. Bottom buttons enable control archiving (archive operation is described in section 12).

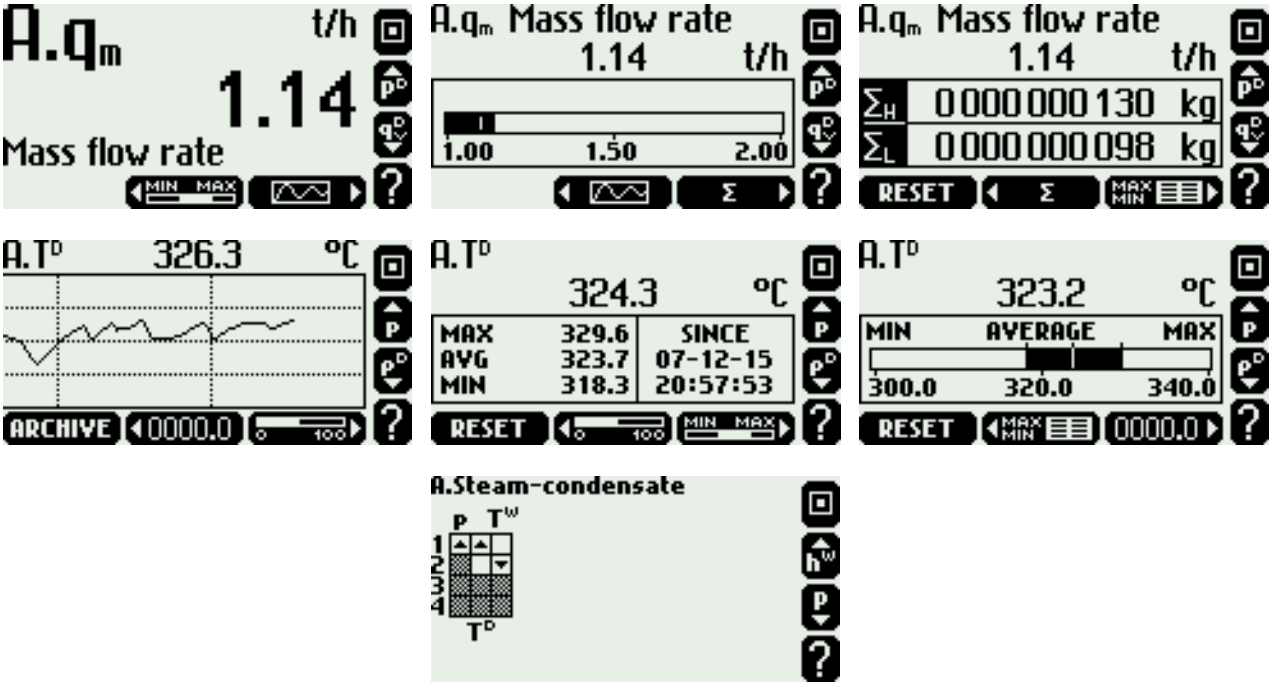
While displaying any main screen a horizontal cursor is kept longer than 1 sec. automatic scrolling of all tables is started within current application. When vertical cursor is kept pressed - automatic scrolling of all tables of all applications starts. Pressing any button interrupts automatic scrolling. It is also possible to configure the scrolling function to display only selected tables.

2.2.2. Detailed screens

Pressing button **MORE** while displaying main screen (table) one can switch over to the set of detailed information on process values within the application. Detailed screens show always only one process value with some additional information. With some exceptions detailed screens can preset data in various ways:

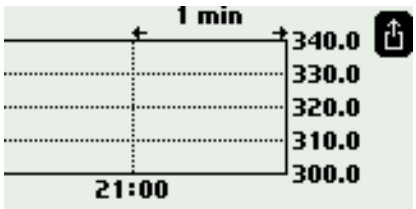
- **Large digits** – value printed with big letter
- **Trend graph** – last 140 values in form of graphic diagram
- **Bargraph** – value in form of analog bargraph
- **Totalisers 1, 2** – value of main (Σ_1) and additional (Σ_2) totalisers
- **Totalisers H, L** – values of overflow and underflow totalisers (Σ_H and Σ_L)
- **Min, max** – minimum, maximum and average values
- **Min, max (bar)** – minimum, maximum and average values in form of bargraph.

Density(ρ), enthalpy(h), pressure difference (Δp) and water thermal coefficient (k) may be displayed only in form of **Large digits.** Screens **Totalisers 1, 2** and **Totalisers H, L** are available for values with active totalisers. A screen with all activated alarm and control thresholds for application is displayed as a detailed screen.
Example:



Above three screens **Large digits**, **Bar graph** and **Totalisers H, L** were included to the $A.q_m$ value whereas screens **Trend graph**, **Min, max** and **Min, max (bar)** for $A.T^D$. A screen of alarm and control thresholds was also included – thresholds were defined for pressure (A.p), steam temperature ($A.T^D$) and condensate temperature($A.T^W$).

Range of bargraph and trend diagram can be set separately for every value. Range of horizontal and vertical axis of **Trend graph** are displayed after pressing button ?.

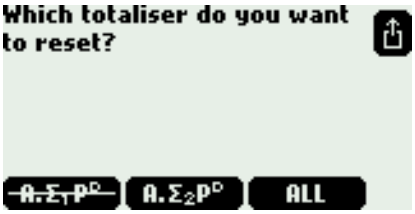


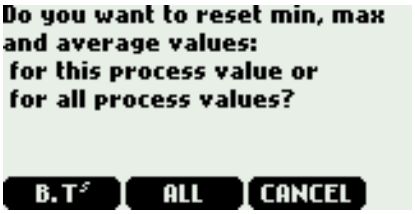
Navigation between various process values is executed with vertical cursors, while navigation between various data presentation of the same value – with horizontal cursors. Longer pressing the vertical cursor starts automatic scrolling. Pressing one can always return to the main screen.

The left bottom button on some detailed screens serves some special functions:

- on **Trend graph screen** starts an archive browser if the value is archived (see section 12.1.4),
- on screens **Totalisers 1, 2** and **Totalisers H, L** allows to reset resettable totalisers,
- on screens **Min, max** and **Min, max (bar)** allows to reset and begin monitoring minimum, maximum and average values.

Before resetting totalisers or minimum, maximum and average values the device requires choosing the option and confirmation, as on the figure below.

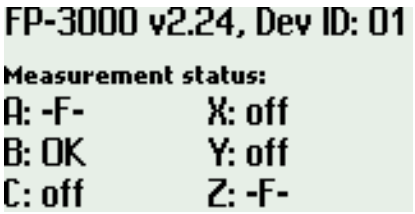




By pressing ALL button all active resettable totalisers are simultaneously reset in all applications. Similarly ALL button starts monitoring of minimum, maximum and average values from the beginning for all values in all applications. Totalisers other than resettable (see section 9) cannot be reset in this way (symbols of such totalisers are marked of).

2.2.3. General information on status of all applications

Button available on all screens with process values displays a screen with short informing about status of main and auxiliary applications, and about firmware version and network address of the device.



2.3. Units

Each value representing any physical value and each totaliser have its own unit. For some physical quantities available is only one unit (e.g. temperature is always displayed in Celsius degrees), for other one of few options can be chosen. List of available units shows the table below.

Heat flow rate	kW	MW	MJ/h	GJ/h		
Heat energy	kWh	MWh	MJ	GJ		
Mass flow	g/s	kg/s	kg/h	t/h		
Mass	kg	t				
Volumetric flow	m^3/s	dm^3/s	m^3/h	dm^3/h		
Volume	dm^3	m^3				

Pressure	kPa|a	MPa|a	bar|a	kPa|g	MPa|g	bar|g
Pressure difference	kPa	MPa	bar			
Temperature	°C					
Temperature difference	K	°C				
Enthalpy	kJ/kg					
Density	kg/m^3					
Specific volume	m^3/kg					
Coefficient k	MJ/m^3K					

Pressure may be displayed in absolute (ended with „|a") or in gauge units (ended with „|g") referred to an average atmospheric pressure. The value of average atmospheric pressure in area of the device application should be entered in settings – **Barom pres**. submenu.

For additional values also any other unit may be entered in form of text (up to 6 signs) but then the device will not understand its meaning and will not be able to recalculate it. An additional value without entered unit is treated as a quantity without unit.

2.4. Main menu

Except for process values overview and some actions described in section 2.2.2 all functions are accessed in main menu. Main menu can be entered from every main screen and additional screen with button . From detailed screens main menu cannot be entered, first one have to return to the main screen by pressing button .

Basic contents of main menu is as follows:

Log in
Archiving commands
Settings
Load or save settings
Media manager
Characteristic manager

Required menu item should be marked with vertical cursor, then selected with the enter button (left bottom). To quit main menu and return one should choose button (top right).

To get access to functions requiring authorization (protected by password) it is necessary to log in first. After logging additional functions are available in the main menu. Information on functions requiring authorization is given in sections 2.5 and 15.

Archive commands allows to establish a new main archive file and hourly archive file, start, stop, resume recording, use an archive browser. Menu of archive commands can be entered directly from archive screen with **MENU** button. Archiving was described in section 12.

Device operation is defined by hierarchic **Settings** menu. General rules of navigation in settings and the edition was described in section 2.6. Meaning of respective settings was

described together with corresponding functions in sections 2 to 14. A full set of settings can be saved in a file on MMC/SD card as well as settings previously saved can be downloaded. For this purpose choose option **Load or save settings**. More information was given in section 2.6.3.

The flow computer can operate with any liquid media and with measuring transmitters with any nonlinear characteristic. This requires to download a relevant file from MMC/SD card (density and enthalpy as temperature function or characteristics of a transmitter in defined text format). This information is stored in data base of other media and characteristics. The last two options in main menu allow to browse the data bases, add new or delete not used files to get free space. The method of loading liquid media characteristics was described in section 5.1.3 whereas nonlinear characteristics of measuring transmitters – in section 7.5.

2.5. Password-protected commands

It is possible to setup passwords to get access to some flow computer functions. Maximum 25 authorized user names can be entered to the device. Each of them may have individual entitlements and password. The most important user is administrator (named ADMIN). Administrator has always entitlements to all functions requiring authorization. He can also enter and delete names of other users, set or reset their entitlements and change their passwords. Some functions are available only to ADMIN and other users cannot get access to them.

Functions which can be established to be password-protected are as follows:

- resettable totalisers reset,
- minimum, maximum and average values monitoring reset,
- archive controls (setting new archive files, stopping and resuming of archiving, erasing MMC/SD card),
- settings change (or a group of settings change),
- date and time adjust.

Administrator decides which of these functions require authorization and which users are allowed to execute them. If none of users gets authorization for a given operation then the only authorized person is ADMIN. Execution of an password-protected function is recorded with date, time and user name in the authorization register (see section 13.3).

The following operations are available exclusively to administrator:

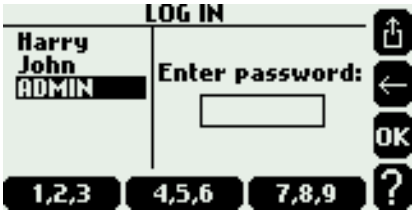
- loading of settings from a file (section 2.6.3),
- readout of authorization register and calibration register (section 13),
- inputs and outputs test (section 16),
- new firmware download (section 17),
- resetting the device memory to factory setup (section 18).

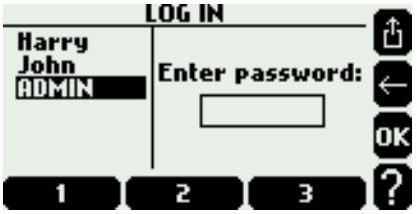
Method of password-protected functions selection and entering authorized users names is described in section 15. Below presented is a method of getting access to password-protected functions for users requiring authorization.

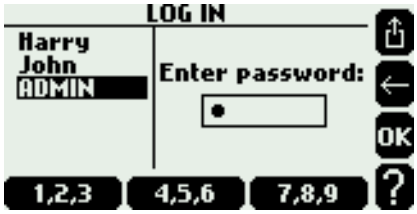
To execute password-protected functions authorized user can do it in two ways:

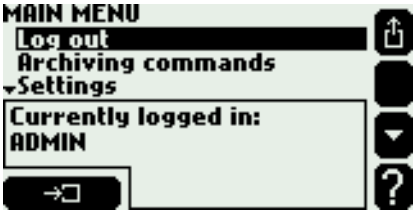
- log in first and then execute all functions he needs, and log out afterwards,
- execute the function and enter his password when he is asked.

To log in user has to select **Log in** option from the main menu, then choose his name from the list and enter the password.









The password consists of digits from 1 to 9 (without 0) entered with bottom buttons. Each digit requires to press a button twice: first to selects group of digits {1,2,3}, {4,5,6} or {7,8,9}, then the digit from the group. Password is confirmed by pressing **OK** button. User passwords may be 3 to 7 digits long whereas administrators password 5 to 7 digits long. In a factory new device administrator password is set to „1".

After logging in the main menu option **Log in** turns automatically into **Log out** and some additional items appear. The main menu is then as follows:

If user logged-in:

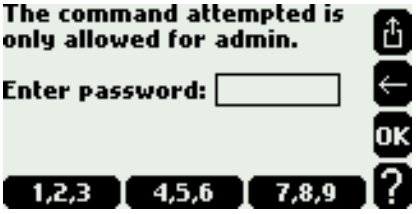
- **Log in**
- **Archiving commands**
- **Settings**
- **Load or save settings**
- **Audit trail**
- **Media manager**
- **Characteristic manager**
- **Change password**

If ADMIN logged-in:

- **Log out**
- **Archiving commands**
- **Settings**
- **Load or save settings**
- **Audit trail**
- **Media manager**
- **Characteristic manager**
- **Change password**
- **Administrative data**
- **Test inputs and outputs**
- **Software and licences**
- **Factory state**

Logged-in state is indicated by ALARM green LED lit on. Logged-in user can execute all functions with his entitlements. He can also change his password (**Change password** option in main menu). Afterwards user should log-out using **Log out** option in main menu. In case of forgetting the device will log-out automatically after time-out of inactivity.

If only one function has to be executed it is more convenient to bypass logging procedure. Choosing the password-protected function the device will display authorization requirement as shown below:



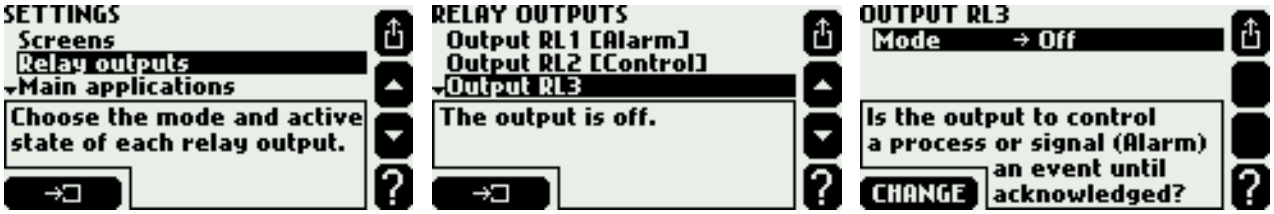
Similarly as during logging procedure user should select his name and enter the password. Only users authorized for a given operation are displayed on the list. If the only authorized person is administrator the list is bypassed and only administrator's password should be entered. Authorization is valid only for this one operation.

2.6. Settings

Flow computers FP-3000 and FP-3010 are devices with broad scope of application – they can cooperate with various types of installations and measurement transmitters as well as fulfill various tasks depending on their configuration. Method of flow computer operation – kind of performed measurements and calculations, form of process values displaying, method of archiving and other tasks – is defined with help of settings group.

2.6.1. Navigation principles

All settings are in hierarchic menu which is entered by selection of **Settings** submenu in the main menu. Navigation is executed by entering successive submenu to find the required setting.



The example above shows how to reach a setting of relay output RL3 operation mode. From settings menu select **Relay outputs** submenu (placing backlight bar with use of vertical cursors and then pressing button). New submenu appears where one should select **Output RL3**. submenu. To return to previous menu one always have to press button . In the frame below menu some extra explanation information is displayed.

Settings may be viewed and changed without interrupting device normal operation. Changes made do not influence immediately device operation. If some changes are made the device will display confirmation question as follows:

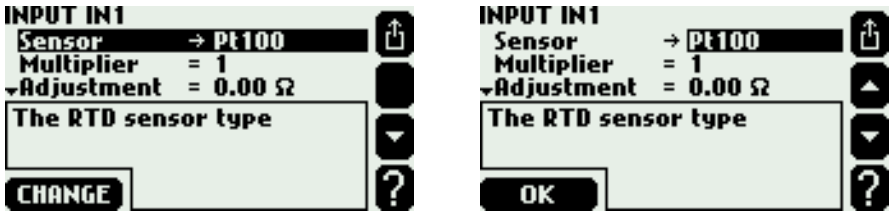
When **SAVE** button is pressed device operation will be interrupted for few seconds. Then the device will resume operation with new settings. Pressing **QUIT** button denies all changes that were made whereas pressing **RESUME** allows to continue edition of settings.

Meaning of respective settings was described with relevant functions in sections 3-14.

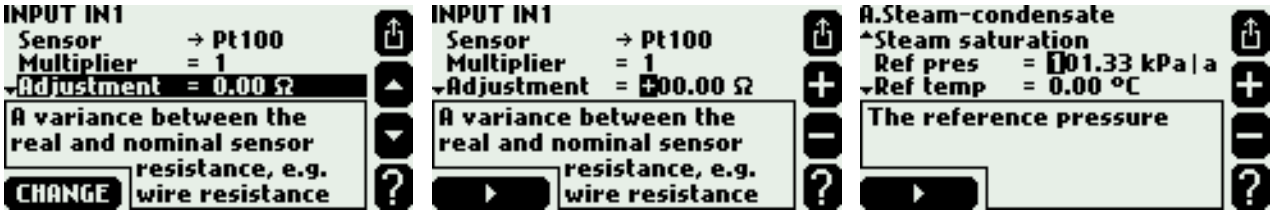
2.6.2. Settings editing

In this section method of editing numerical and text settings selected from a menu list is described. Entering few remaining settings which do not belong to any of these groups was described in sections explaining their meaning.

To change any setting place cursor on it a and press **CHANGE**. If it is a one-from-the-list setting, cursor moves to the selected option and begins to blink. Choose required option using vertical cursors and confirm new selection with button **OK**. Button interrupts edition returning to previous selection.



When **CHANGE** is pressed after selecting numerical setting blinking cursor moves to the first digit or sign of the number being changed.



Select the digit value or sign with buttons + or – and confirm with the left bottom button. Cursor moves then to the next digit. In this way change successively all digits. With button edition can be interrupted returning to the previous value. The entered number must be in within range, otherwise it will be rejected.

Some numerical settings have constant decimal point position and cannot be changed. Then cursor moves over decimal point stopping at digits only. In other cases decimal point can be also set. Then dot (decimal point) is available during selection between digit 9 and 0. If the edited number must always be positive the sign will not be displayed and cursor moves to the first digit at once.

More complicated settings require selection of values from a list, then entering a number or entering two different numbers in succession. In this case the above described operations should be executed in proper sequence.

For loading captions a separate screen is called:

Horizontal and vertical arrow buttons move cursor along the whole screen. Left bottom button, depending on cursor position, can insert or delete a mark from edited text or change set of characters on keyboard. Button is used to leave edition confirming a new text description. There is no possibility to interrupt edition and return to previous text.

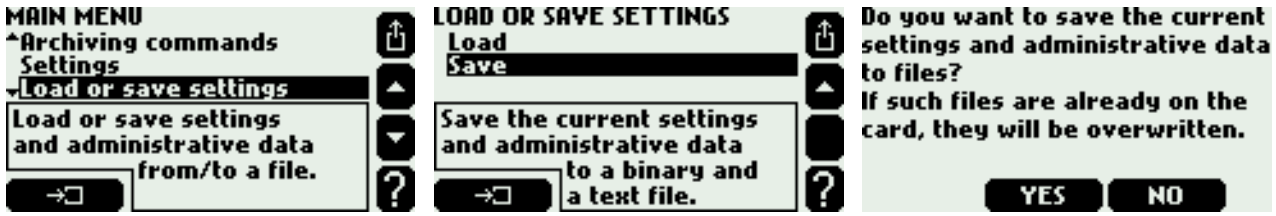
To insert a character from keyboard place cursor on it and press **ENTER**. Position in which the character will be inserted is indicated by vertical dash in a frame with edited text. This dash is in place where cursor was at the moment of leaving the frame. To shift the dash move cursor to the frame, put it (using horizontal arrow buttons) in proper place and then return to the keyboard using vertical arrow button. To delete a character from the edited text place cursor on it and press **DEL** button. To change set of characters on keyboard place cursor in **ABC** field (block letters), **abc** (small letters) or **12-?!.** (digits and symbols) and then press **SELECT** button.

Similarly to descriptions other text settings are loaded: symbols of auxiliary values, units (if they are not selected from list) and users names. In these cases only dimension of frame with text and set of available characters may be different.

Settings loading is much easier using PC computer and Terminal.exe program (see section 2.9).

2.6.3. Saving and loading settings from a file

Full set of settings can be saved to a file on MMC/SD memory card selecting **Load or save settings** function from main menu and submenu **Save**.



Two files text and binary will be created. Text file (extension .txt) allows to read settings on PC computer using typical text editor. Binary file (extension .set) enables to load settings to the same or other device in future. File name contains the name of device and its RS-485 network address, e.g.: „*FP3000 01 Settings.txt*" and „*FP3000 01 Settings.set*". If files with these names already exist on the MMC/SD card, they will be replaced by the new ones. Names of created files can be changed only in PC computer.

Together with settings data from administrator menu with users and passwords (see section 15) and data bases for other media and user characteristics (see section 5.1.3 and 7.5) are saved. Contents of data bases are saved only in a binary file.

To download settings from a file to the device one have to select **Load** function from menu **Load or save settings** and then indicate a relevant file.

Files with extension " .set" are displayed on the list. All information from binary file will be loaded including administrator menu, passwords and data bases. Previous data will be deleted irretrievably. Loading settings from a file is available only to administrator.

2.7. MMC/SD memory card

The flow computer at the rear panel has a card slot for SD or MMC memory card. Cards with capacity 32MB to 4GB formatted to FAT16 are only accepted.

2.7.1. Applications

The card can be used for archiving of process data as well as for loading files with various information to device. Archiving of data includes:

- saving selected process values with interval selected from 3 sec to 24 hours in main archive file (section 12.1),
- saving selected set of totalisers and average values of selected process values at every hour in hourly archive file (section 12.2),
- saving selected events as alarms, faults, superheated steam saturation power on and off, etc. in event register file (section 13.2),
- saving password-protected commands in authorization register file (section 2.5 and 13.3).

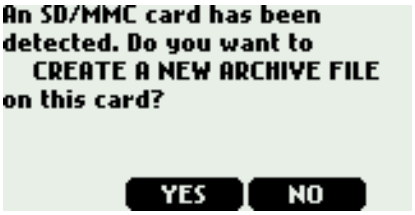
Other operations requiring use of SD/MMC card are:

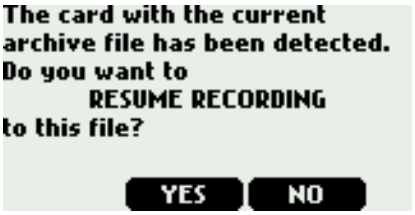
- loading liquid medium characteristic (section 5.1.3),
- loading nonlinear transmitter characteristic (section 7.5),
- saving or loading settings (section 2.6.3),
- updating flow computer firmware and loading extension licences (section 17).

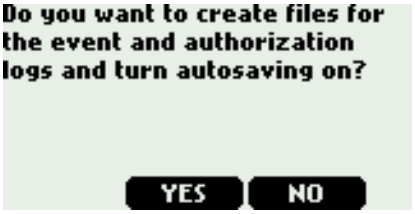
Use of all archiving functions (including overview of archive contents on screen) requires that the card has Lock switch in off position (write protection for SD card). From the locked card it is possible only to load characteristics, enter settings or install new firmware.

2.7.2. Card insertion

The device recognizes a card inserted into its slot after ca 5 seconds. The device may display one or more of the following questions:







A question about creating of a new archive file will be displayed if some archiving values have been changed in settings or there is no current archive file on the card. If the current file is on the card device will suggest to resume archiving. A question about creation of a new hourly archive file (totalisers and average values archive) will be displayed if some settings were changed or there is no relevant file on the card. A question about creation of log files will be displayed if there are no such files on the card. Archiving was described in section 12 and logs in section 13.

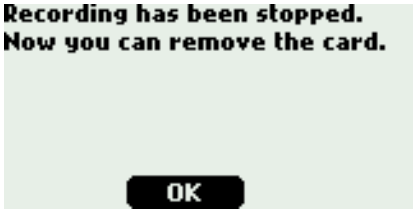
In typical situation if a card has been inserted to the device slot after it had been taken out for copying data, it is recommended to answer all questions for YES. The procedure is similar if a card was taken out for its readout and it was replaced by a new one. However if card was inserted to load data from a file to the device (e.g. liquid medium characteristics) the questions should be answered rather for NO.

2.7.3. Card removal

Card cannot be taken out from the device slot if data recording is on (a green LED diode marked SD/MMC on the front panel is on). In this case archiving should be stopped before removing the card. It can be done in two ways:

- select the archive screen and press **STOP** button,
- select **Archiving commands** function from the main menu and then command **Stop recording.**

Stopping archiving may take several seconds. Then a following message is displayed:



Only then the card may be removed from the slot.

2.8. Backlight and contrast of LCD

Backlight may be constantly switched on or off or it may turn off after set time (1 to 10 minutes) from last use of any button.

To select backlight operation mode and to adjust contrast select **LCD display** function from settings menu:

Contrast is adjusted with **+** or **–** buttons with immediate effects on screen. If changes are denied when leaving settings menu the previous contrast will be returned.

2.9. Terminal Program

It is possible to use *Terminal.exe* program on a PC computer connected to RS-485 port (section 14). Display and LEDs status are transmitted on-line to computer and displayed on PC screen. Program displays also active buttons as equivalent to buttons on device front panel. Therefore all operations which can be executed directly on device are also available remotely on computer with a mouse.

Terminal.exe program has some additional functions allowing easier settings entering. One can enter numerical and text values directly from computer keyboard (ranges, constants, descriptions, units, formulas, users names, passwords and others). Also scrolled selection lists for settings are available.

2.10. Summer and winter time automatic adjustment

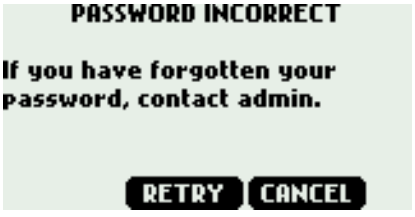
Device automatically adjusts clock from summer time (DST - daylight saving time) to standard (winter) time. It is executed on the last Sunday of October at 3:00 and on the last Sunday of March at 2:00. Automatic time adjustment allows to maintain continuity of archiving. In each record date and hour are marked with a letter S (summer time) or W (winter time).

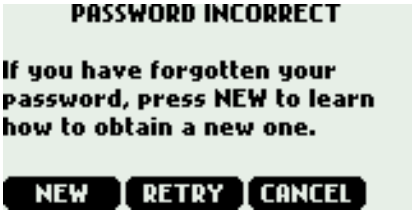
```
2006-10-29;02:00:00;S
2006-10-29;02:30:00;S
2006-10-29;02:00:00;W
2006-10-29;02:30:00;W
2006-10-29;03:00:00;W

2007-03-25;01:00:00;W
2007-03-25;01:30:00;W
2007-03-25;03:00:00;S
2007-03-25;03:30:00;S
```

In particular situations when automatic clock adjustment is not required it can be deactivated in settings - **DST** position.

2.11. Retrieving forgotten passwords and obtaining service password

If a wrong password is entered by user or administrator during logging or authorization one of the following messages is displayed:





If a wrong password was entered by mistake press **RETRY** button and enter it once again.

If user forgot his password he can get a new one from administrator (see section 15). However if administrator forgot his password he must contact factory service. On screen which is displayed after incorrect password was entered press **NEW** button - a code will be displayed based on which manufacturer can generate a new password for administrator.

In the same way (i.e. by giving code) user can get a service password from manufacturer. To log in as a serviceman select user's name **ADMIN** and enter service password. Operator then has all entitlements of administrator and among others has an access to calibration functions and can load service program to the device. Serviceman cannot however change administrator's password.

3. DEVICE CONFIGURATION

A factory new flow computer has all functions deactivated – it does not execute any measurements or calculations. It merely displays date and time. To perform its relevant tasks the device should be configured or proper settings should be loaded. All settings are gathered in hierarchic menu which is entered by selecting **Settings** option from main menu. General rules of navigation and method of settings changing were described in section 2.6.

At customer's request device can be initially configured by manufacturer as a separate service. For this purpose customer must deliver detailed information on installation, type of applied measurement transmitters etc. User can later modify delivered settings, in particular he can do some corrections e.g. activate and deactivate screens with results, adjust alarm thresholds or change archiving frequency. Manufacturer can initially configure device before its shipment to customer or he can deliver full set of settings later in file form e-mailed which user can copy to SD/MMC memory card and download to the device (see section 2.6.3).

3.1. Contents of settings menu

Below there are listed all settings menu options – most of them opens way to successive submenu containing various groups of settings. In brackets there are numbers of sections where respective group of settings was described in details.

Screens	(section 11)
Relay outputs	(section 4)
Main applications	(section 5 and 6)
Aux applications	(section 6, this option is only for FP-3000)
Inputs	(section 7)
Alarms and control	(section 8)
Totalisers	(section 9)
Nominal month beginning	(section 9)
4-20mA output	(section 10)
Main archive	(section 12.1)
Hourly archive	(section 12.2)
Serial communication	(section 14)
LCD display	(section 2.8)
Barom pres	(section 2.3)
DST	(section 2.10)

Screens. User can choose which from available screens are to be displayed and configure contents of tables on main (general) screens, resolution of displayed values (except totalisers) and ranges of bargraphs and diagrams. Here also automatic scrolling is configured.

Relay outputs. Operation mode of respective outputs is set i.e. control or alarm function, their operation active state (normally open, closed or pulsing). Respective functions of relay outputs are determined in successive settings groups where they are assigned to selected events. For example if an output relay is to signal a crossing of alarm threshold, then appropriate relay should be assigned to this threshold. To enable such assignment

a relay output should be set the proper mode first. The same relay output can be assigned to few different events (e.g. one relay can signal crossing threshold of few process values).

Main applications. Types of main applications are determined which are serviced by respective systems. First of all user should answer questions asked by wizard concerning structure of the main application. Then required parameters for the chosen application should be entered (like type and dimensions of used differential pressure device, etc.). After that the set of process values and calculated values is automatically generated. User can select their units and give them text descriptions (captions). Here also additional measurements and calculations may be defined and entered.

Aux applications (only for FP-3000, not available for FP-3010). Only simple process values and calculated values can be entered as an addition. It is not possible to set e.g. compensated steam flow measurement as an auxiliary application.

Inputs. All process values, both automatically generated by wizard and auxiliary ones should be assigned to particular measurement inputs. Here also all inputs operation mode is set (e.g. type of RTD sensor or current signal type), measurement parameters (e.g. values for 4 mA and for 20 mA) and action in case of transmitter failure (e.g. relay output alarm or event log). In some cases more than one process value can be assigned to the same input.

Alarm and control. To each value except of density (ρ), enthalpy (h), pressure difference (delta pressure) (Δp) and water thermal coefficient (k) up to 4 thresholds for alarms and control can be assigned. Threshold is defined with two parameters level and hysteresis. It can be activated over threshold level or below threshold level. Threshold over crossing can cause various actions e.g. alarm signaling with relay output.

Totalisers. Each value being heat flowrate or flowrate can have up to 4 totalisers (with some limitations). Totalisers may be not resettable, user resettable (from front panel keyboard) or can be periodically reset. For each totaliser unit and display resolution (number of decimal digits) have to be selected.

4-20mA output. Optionally device can be equipped with analog current output 4-20mA. Output can be assigned to any process value or calculated value. Method of conversion to current value is defined by setting values corresponding to 4mA and 20mA. Action in case of value error (e.g. transmitter failure) can also be defined.

Nominal month beginning. For needs of periodical automatic reset of totalisers and for monthly totaliser log the beginning of month can be set to full hour (0 to 23) in any day of month between 1 and 28 or on last day of the month.

Main archive and **Hourly archive**. User can select process values and calculated values to be archived in main archive file on SD/MMC memory card. Also selected totalisers and average process values can be recorded in hourly archive file.

Serial communication. User sets parameters of serial transmission: speed, parity control device address and selects operation mode Modbus RTU or ASCII.

Two last menu items allow to enter average atmospheric pressure in area of device operation (for gauge and absolute pressure recalculation) and parameter to activate automatic clock adjustment to summer (DST) and winter (standard) time.

3.2. Configuration sequence

Setting of some parameters may require previous setup of others. For example to assign alarm threshold to a relay output first the relay output has to be set to proper mode. Therefore it is recommended to enter settings in sequence they are listed in menu except for **Screens** which should be configured at the end.

4. RELAY OUTPUTS AND EVENT MESSAGES

Flow computer is equipped with four relay outputs named RL1…RL4. To be able to use these outputs they should be configured before entering other settings. Otherwise it will not be possible to assign them to events when further settings are entered. If output relays are not dedicated for operation they should be left deactivated.

4.1. Outputs activating events

Relay outputs can react to the following events:

- alarm/control threshold over crossing,
- saturation of superheated steam,
- 4-20mA transmitter or RTD sensor failure or disconnection,
- close or open of binary input (in **State** mode operating).

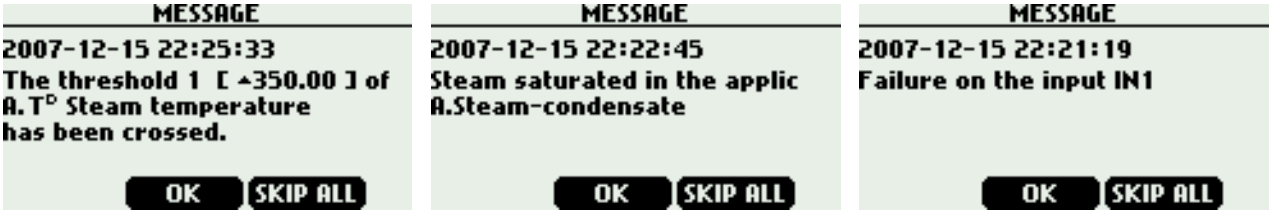
If output is to react to a selected event it should be assigned to this event in relevant settings. These are respectively: settings of alarm/control threshold, settings of measurement system (submenu **Steam saturation**) and settings of measurements inputs (submenus **Actions when failure**, **Actions when closed** and **Actions when open**). Each output can be assigned to any number of events. An output becomes active in case of occurrence of at least one of events it was assigned to. However to be able to assign an relay output to events it should be earlier activated by selection of one of two operation modes.

4.2. Control and alarm mode

Each output can operate in control or alarm mode or it can be deactivated – in last case it is deleted from relay outputs screen and it cannot be assigned to events.

Relay output set to control mode becomes active for time of event to which it was assigned. Relay output returns to his normal state when all events end.

Output set into alarm mode becomes active when one of assigned events occur. Simultaneously a message about an event is displayed and red ALARM diode starts pulsing.



After confirming the message (by pressing **OK** button) the output becomes deactivated. Red ALARM diode stops pulsing but it remains on until the event disappears. If another event occurs before confirmation of message then its message will be displayed after confirmation of the previous one even if the new event itself disappeared to that moment. The output becomes deactivated after confirmation of the last waiting message. Button **SKIP ALL** is used to confirm all waiting messages at one time.

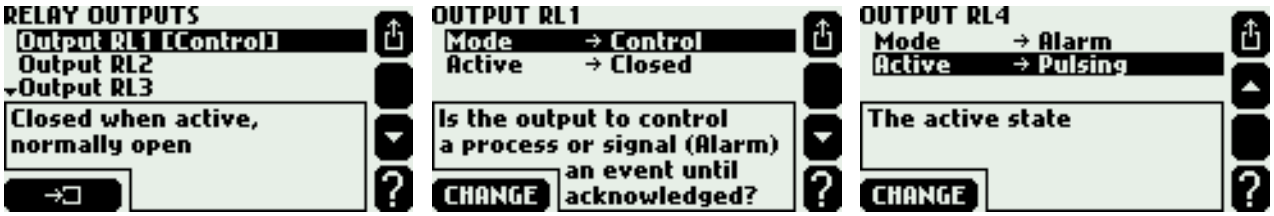
4.3. Relay outputs assignment and alarm message activation

To assign a relay output to a selected event user have to choose **Alarm** or **Control** from menu.

On selection lists there are available only outputs set into proper mode (alarm or control mode). In **Alarm** menu one can choose **Message only,** without relay output assignment. In this case an event will be signaled only by a message and ALARM diode on a front panel and no relay output will become active.

4.4. Relay outputs configuration

To configure a relay output (i.e. to set its operation mode and active state) one should select **Relay outputs** from settings menu and then select corresponding output in the subsequent submenu.



An active state may be closed or open and for alarm mode also pulsing.

5. MAIN AND AUXILIARY APPLICATIONS

FP-3000 flow computer can handle three and FP-3010 two independent installation applications. Process values and calculations relevant to a single installation application are grouped in one system named main application. In FP-3000 there are three such main application named with letters A, B and C whereas in FP-3010 only two: A and B.

To configure measurements user have to choose **Main applications** from settings menu. Configuration starts with help of a wizard leading through the possible structure of an application. This procedure consists of few questions one have to answer. The wizard finishes its work with a set of parameters still to be configured for the new installation. For example if wizard was declared that steam flow measurement is performed with differential pressure device then the parameter **Diff pres device for Δp^D** will appear where some settings have to be entered. Steam or water heat energy measurement also require entering a reference pressure constant and a temperature constant referring to which enthalpy should be calculated.

In next steps user have to choose units and enter captions (**Units and captions** submenu), enter auxiliary values if needed (**Auxiliary values,** see section 6), assign calculated values to device inputs (**Assign to inputs**, see section 7) and enter caption to the application itself (**Caption**).

5.1. Media types

The device can be configured to the measurement of following types of media: superheated steam, saturated steam, technical gases due to ideal gas equation, hot or cold water and other user defined liquid media.

5.1.1. Superheated and saturated steam

Steam density and enthalpy are calculated according to IAPWS-IF97 standard for pressures 0,05…16,52 MPa and temperatures up to 800 ºC. Enthalpy is referred to a user selected reference point (see section 5.8).

In all applications with superheated steam there must be of both pressure and temperature measured. Device can detect superheated steam approaching saturation state and alarm such event (see section 5.7). If due to inaccurate measurement measured steam temperature is slightly lower than condensation temperature at this pressure, density and enthalpy will be calculated for condensation temperature. However if measured temperature is lower than condensation temperature more than 20 ºC , an error (–E–) is displayed instead of density and enthalpy values and all other values calculated on their basis.

In systems with saturated steam user can choose if pressure or temperature is measured. The other quantity is always calculated theoretically based on saturation curve. Supervisory measurement of the second quantity can be entered as an auxiliary value within the application.

5.1.2. Water

Water density and enthalpy are calculated according to IAPWS-IF97 standard for pressures 0,05…16,52 MPa. Enthalpy is referred to a user selected reference point (see section 5.8).

Water temperature is always measured whereas pressure may be measured. Typically it is assumed to be constant and its value is entered in settings. If due to measurement inaccuracy water temperature is slightly higher than boiling temperature at given pressure density and enthalpy will be calculated for boiling temperature. However if measured temperature exceeds boiling temperature by more than 20 ºC an error (–E–) is displayed instead of density and enthalpy values as well as all other values calculated on their basis.

In steam with condensate loop systems condensate pressure can be treated as equal to steam pressure or its constant value may be entered in settings. There is no possibility of separate steam and condensate pressure measurement in an application. In case of such need two separate applications should be used: one for steam measurement and the second for condensate measurement. Energy balance for both systems can be then implemented with help of auxiliary value (math formula). Condensate temperature may be measured or it may be assumed that condensate remains at boiling temperature – then its temperature is calculated theoretically based on measured steam pressure.

5.1.3. Other liquid media

Flow computer can also measure and calculate process values in installations with any liquid medium other than water. For this purpose tables with medium density and enthalpy as function of temperature should be downloaded from the file from SD/MMC memory card to the device. The pressure can be measured as an auxiliary value only.

A file with information on liquid medium should be prepared on PC computer using a text editor or a spreadsheet program and saved on MMC/SD card. Accepted file formats are .txt or .csv. Method of loading a file to the device is described in the further part of this section. Below there is an example of such file's contents.

```
#medium Liquid L
0.0     820.0
100.0   810.0
200.0   803.0
#
0.0     0.0
200.0   620.0
```

The file must begin with word `#medium` followed by name of medium (up to 12 characters, here `Liquid`) and its symbol (big Latin letter other than B, D, E, G, R, S, W, here `L`). After that a density table consisting of pairs of numbers (temperature in ºC and density in kg/m^3) begins. The table ends with symbol `#` followed by an enthalpy table consisting of pairs of numbers (temperature in ºC and enthalpy in kJ/kg). Both tables must be ordered with temperature from lower to higher values. In the example at temperature 200ºC medium density is 803 kg/m^3 and enthalpy 620 kJ/kg. Intermediate values between points are subject to linear interpolation. Therefore for example at temperature 50ºC there will be assumed density 815 kg/m^3 and enthalpy 155 kJ/kg. Medium temperature cannot exceed range of any of the tables (in this example 0…200 ºC); otherwise an error (–E–) is output instead of density or enthalpy values as well as all other values calculated on their base.

Information on liquid media are stored in a data base with all settings. To view contents of the base and to add and remove media table choose **Media manager** submenu from main menu.

To add new medium table user have to insert MMC/SD card containing a relevant file in main directory and press button **NEW ONE**. A list will be displayed for choose. On the list there are only files with extensions .txt or .csv. New medium can also be added during system configuration with help of wizard without need of entering separately a media manager (see section 5.2). To remove medium one have to place cursor on its name and press button **REMOVE**. On media list next to the name there are displayed symbol and occupied memory space. At the screen bottom there is displayed remaining free memory space. There can be up to 16 various media tables in the data base at a time.

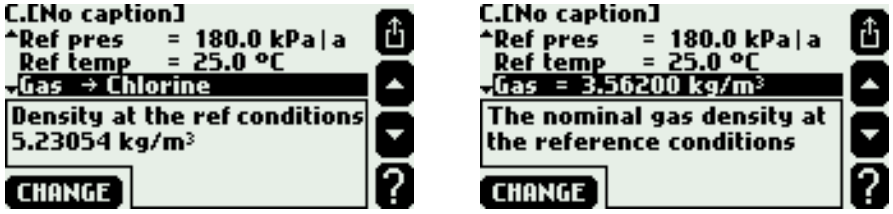
5.1.4. Technical gases

The flow computer can also measure and calculate process values in installations with technical gases. A gas pressure and temperature can be either measured or constant values for one or both has to be entered. Actual gas density is calculated according to ideal gas equation based on density in reference (standard) conditions.

The following flowrates are calculated: mass, actual volumetric and standard volumetric. Units of standard flowrate are preceded by letter C e.g. Cm^3/h. The reference conditions (pressure and temperature) are entered in the system settings.

The density of measured gas at reference conditions should also be entered in the settings. User have to enter proper value or choose one of the gases from the list. Densities form the list are referred to 0 ºC and 101,33 kPa. For other entered reference conditions density will be calculated automatically according to the ideal gas equation and displayed in a frame below settings.

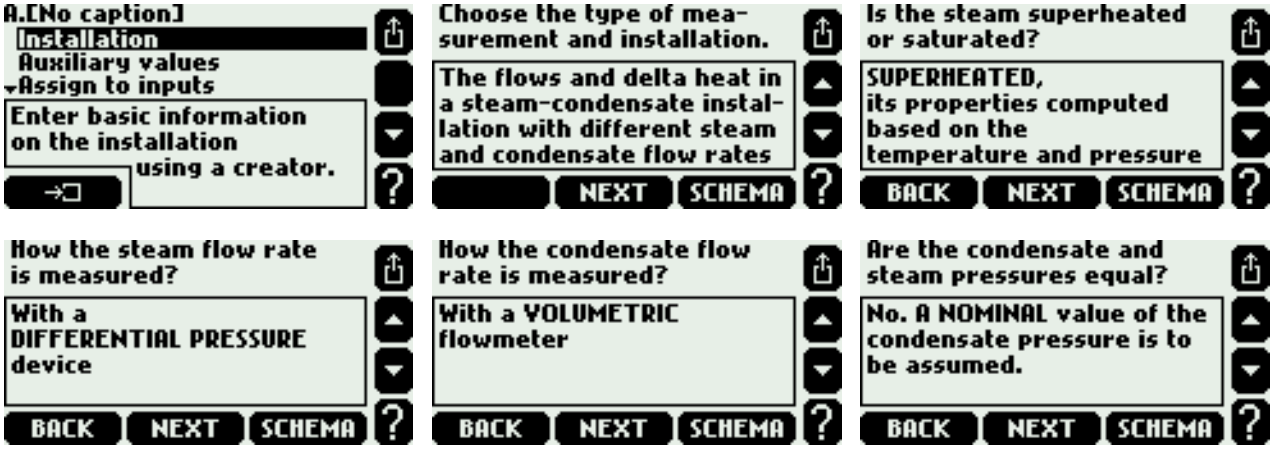
Air	1,29300 kg/m^3
Oxygen	1,42895 kg/m^3
Nitrogen	1,25050 kg/m^3
Carbon dioxide	1,97700 kg/m^3
Hydrogen	0,08987 kg/m^3
Helium	0,17850 kg/m^3
Chlorine	3,21400 kg/m^3
Methane	0,71680 kg/m^3
Acetylene	1,17090 kg/m^3



5.2. Main application configuration wizard

New application setup should begin with a wizard helping configure the installation type, medium type and applied flowmeters. For this one should choose **Installation** from the menu. Wizard is asking successive questions which should be answered. The first question is always the same: **Choose the type of measurement and installation.** User can choose one of eight available options or switch off the system. All eight types of possible installations were described in section 5.4. Next questions depend on answers given earlier.

A question is displayed at the top of screen and selected answer in a frame below. User selects the answer using up and down buttons and confirms the choice with **NEXT** button. A **BACK** button is to return to the previous question. Below there is an example sequence of questions and answers for configuring measurement system:



The wizard always asks question about method of flowrate measurement. The following answers are available:

- **With a MASS flowmeter**
- **With a VOLUMETRIC flowmeter**
- **With a DIFFERENTIAL PRESSURE device**
- **COMPUTED from the flowrates in other installations (by a formula)**

In some installations additionally user have to determine the place of flowmeter – on the supply or return pipeline. If a differential pressure device was selected, the wizard inserts automatically **Diff pres device for Δp submenu opening** submenu in which parameters of this flowmeter should be entered (see section 5.5). If in a given main application no flowmeter has been installed its flowrate can be calculated based on other flowrates, and the last of the listed answers should be selected. This is the case for example when two main applications are connected in series and flowrate is measured only in one of them. Then to system menu **Formula for q_m** submenu is inserted where method of flowrate calculation should be determined (see section 5.6). If mass or volume flowmeter was selected there is no need to enter any additional settings to system menu. Flowmeter parameters should be then entered in input settings.

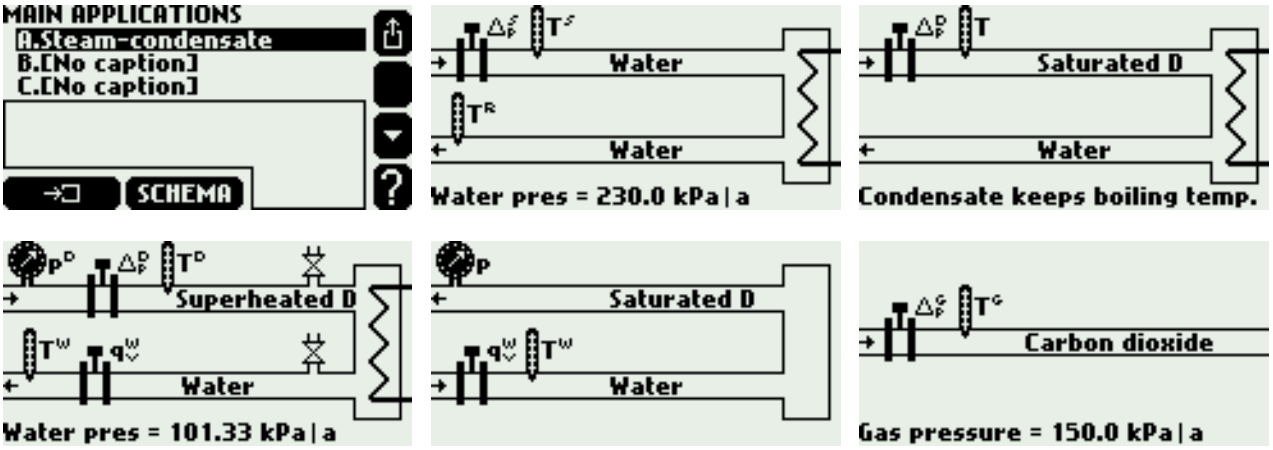
If the installation was selected to liquid measurement then the next question wizard will ask about medium type. For selection there are always water and all liquid media in the data base (see section 5.1.3). To use a medium which is still not in the data base user has to select answer **Add on a new medium from a file**. List of available files on inserted SD/MMC card will be displayed. Medium from selected file will be added to the data base and set as medium the application.

If the water or gas pressure or gas temperature is declared constant, **Nom pres** (nominal pressure) or **Nom temp** (nominal temperature) will be inserted to menu. The relevant constant nominal values should be entered here.

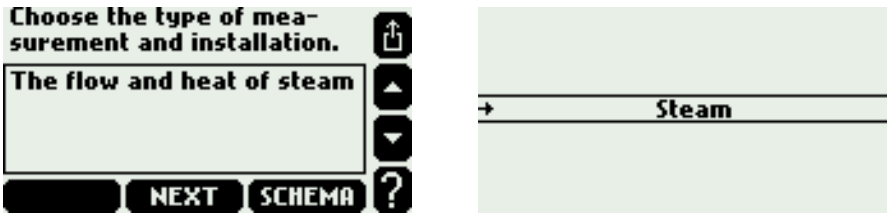
After finish of wizard's work all necessary values are entered to the main application. In submenu **Units and captions** it is possible to choose the units (see section 2.3) and enter the captions. If user chooses answer **None** when asked for installation type wizard will finish its work and all earlier entered values will be deleted. However wizard has no influence on auxiliary values which also can be entered to main application even if the installation type was set to **None**.

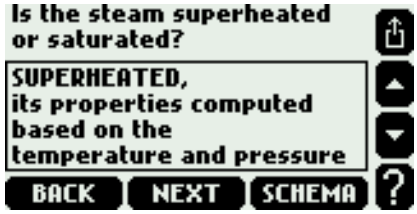
5.3. Graphic schema

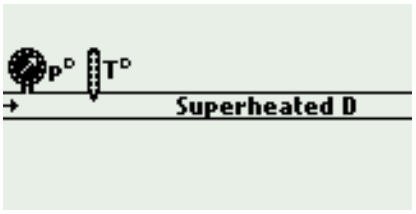
Configuration of installation type can be presented as a graphic schema. To display the schema one should place a cursor on one of the applications A, B or C in main application menu and press button **SCHEMA.**

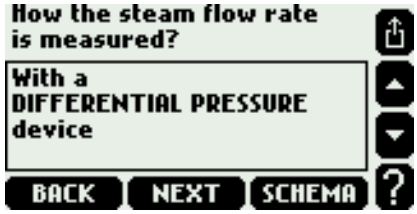


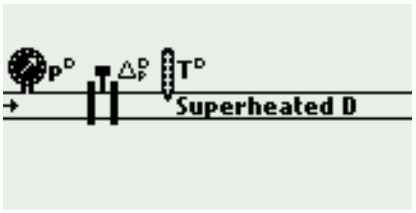
The schema can also be accessed with **SCHEMA** button while using wizard. The schema contains only partial information as far as the wizard questions are answered. With new answers next elements are added to the schema. Schema does not contain information entered beyond wizard such as e.g. constant pressure value.









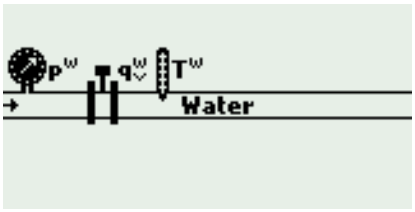


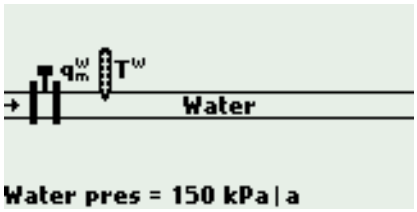
Pressing any button leave schema and return back to wizard or application menu.

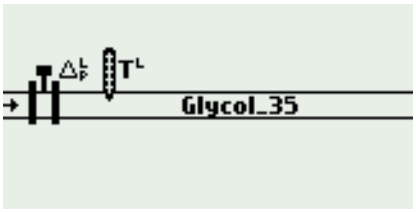
5.4. Installation types

5.4.1. The flow and heat of a liquid

Choosing in wizard kind of medium: water or other liquid medium. If water was chosen it should be determined if the pressure is measured or entered as a constant.







List of process values

P^W heat flow rate
q_m^W mass flow rate
q_v^W volumetric flow rate
p^W pressure (only for water if pressure measurement was declared)
T^W temperature
ρ^W density
h^W enthalpy
Δp^W pressure difference at orifice in differential pressure device (only if differential pressure device was chosen).

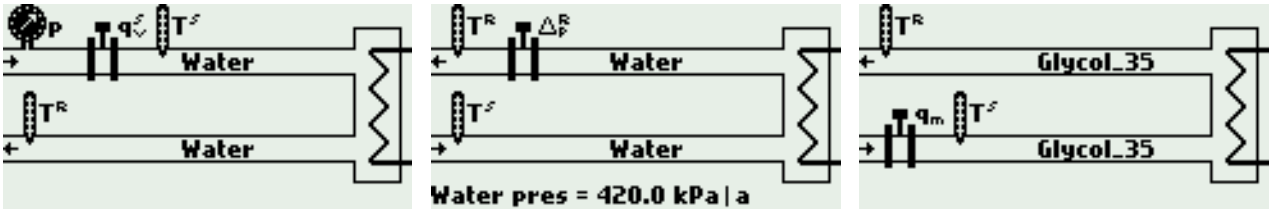
The upper index letter means a kind of medium. Letter W used in the example above means water whereas other liquid media have their own symbols (see section 5.1.3).

5.4.2. The flow and delta heat of a liquid in a closed supply-return installation

Choosing kind of medium in wizard: water or other liquid medium. If water was chosen it should be determined if the pressure is measured or entered as a constant. It is assumed that water pressure at supply and return pipeline are the same.

It should be also declared if system fulfills heating (i.e. supplies energy thus supply temperature is higher than return temperature) or cooling (i.e. takes energy away thus

supply temperature is lower than return temperature). Heat flow rate difference (P) and temperature difference (ΔT) will be calculated according to this selection. In the schema a principle was assumed that a pipeline with higher temperature is drawn on top.

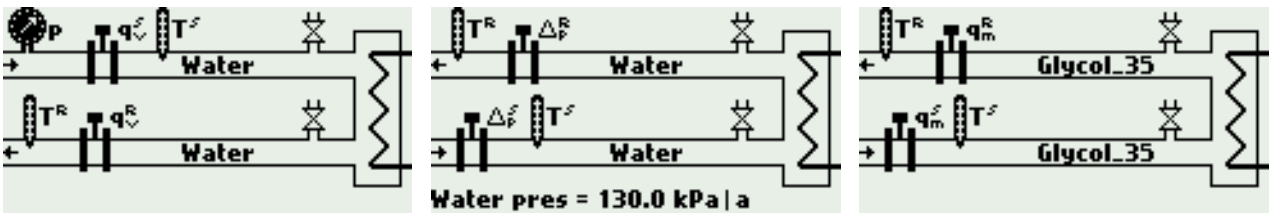


List of process values

P	heat flow rate difference between supply and return
q_m	mass flow
q_v^S	volume flow at supply
p	pressure (only for water if pressure measurement was declared)
T^S	supply temperature
ρ^S	density at supply
h^S	enthalpy at supply
Δp^S	pressure difference at orifice in differential pressure device (only if differential pressure device installed at supply was chosen).
q_v^R	volume flow at return
T^R	temperature at return
ρ^R	density at return
h^R	enthalpy at return
Δp^R	pressure difference at orifice in differential pressure device (only if differential pressure device installed at return was chosen).
ΔT	temperature difference between supply and return
k^S	water thermal coefficient (only if volume flowmeter was installed at supply)
k^R	water thermal coefficient (only if volume flowmeter was installed at return)

5.4.3. The flows and delta heat of a liquid in an installation with separate supply and return flowrates

Choosing kind of medium in wizard: water or other liquid medium. If water was chosen it should be also determined if the pressure is measured or entered as a constant. It is assumed that water pressure at supply and return are the same. It should be also declared if system fulfills heating (i.e. supplies energy thus supply temperature is higher than return temperature) or cooling (i.e. takes energy away thus supply temperature is lower than return temperature). Heat flow rate difference (P) and temperature difference (ΔT) will be calculated according to this selection. In the schema a principle was assumed that a pipeline with higher temperature is drawn on top.

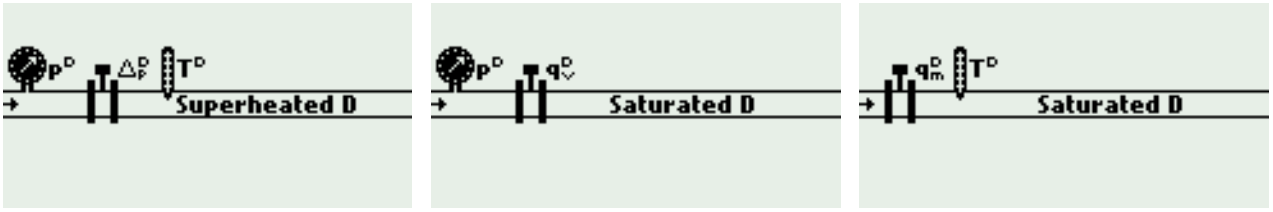


List of process values

P	heat flow rate difference between supply and return
q_m^S	mass flow rate at supply
q_v^S	volume flow rate at supply
p	pressure (only for water if pressure measurement was declared)
T^S	temperature at supply
ρ^S	density at supply
h^S	enthalpy at supply
Δp^S	pressure difference at orifice in differential pressure device (only if differential pressure device was chosen).
q_m^R	mass flow rate at return
q_v^R	volume flow rate at return
T^R	temperature at return
ρ^R	density at return
h^R	enthalpy at return
Δp^R	pressure difference at orifice in differential pressure device at return (only if differential pressure device was chosen)
ΔT	temperature difference between supply and return

5.4.4. The flow and heat of steam

Choosing kind of steam in wizard: superheated or saturated. If saturated steam was chosen it should be determined if pressure or temperature is measured.



List of process values

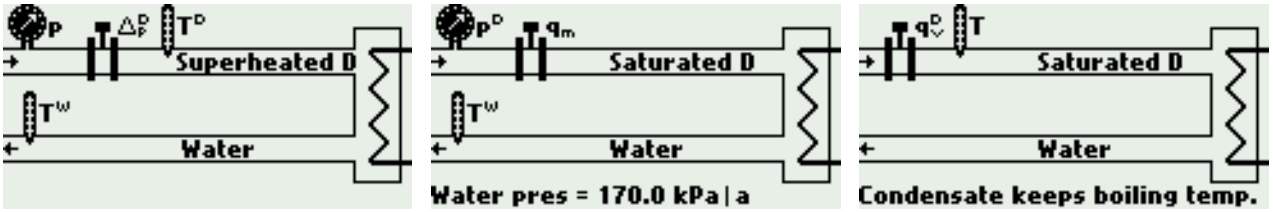
P^D	heat flow rate of steam
q_m^D	mass flow rate of steam
q_v^D	volume flow rate of steam
p^D	steam measured pressure (only for superheated or saturated steam with pressure measurement)
p_c^D	saturated steam pressure calculated based on saturation curve (only for saturated steam with temperature measurement)
T^D	steam measured temperature (only for superheated or saturated steam with temperature measurement)
T_c^D	saturated steam temperature based on saturation curve (only for saturated steam with pressure measurement)
ρ^D	steam density
h^D	steam enthalpy
Δp^D	pressure difference at orifice in differential pressure device (only if differential pressure device was chosen)

5.4.5. The flow and delta heat in a closed steam-condensate installation

In this installation is assumed that condensate is returned continuously (condensate mass flow rate is equal to steam flow rate). If condensate is accumulated and periodically pumped out, system described in section 5.4.6 should be selected.

Choosing kind of steam in wizard: superheated or saturated. If saturated steam was chosen it should be determined if the pressure or temperature is measured.

It should also be declared if condensate pressure is equal to steam pressure or entered as a constant value. In some installations if steam and condensate pressures are equal one can abandon condensate temperature measurement and assume calculations at boiling temperature.



List of process values for condensate with constant (entered) pressure:

- P — delta heat between steam and condensate
- P^D — steam heat flow rate
- q_m — mass flow rate
- q_v^D — steam volume flow rate
- p^D — steam measured pressure (only for superheated or saturated steam with pressure measurement)
- p_c^D — saturated steam pressure calculated based on saturation curve (only for saturated steam with temperature measurement)
- T^D — steam measured temperature (only for superheated or saturated steam with temperature measurement)
- T_c^D — saturated steam temperature calculated based on saturation curve (only for saturated steam with pressure measurement)
- ρ^D — steam density
- h^D — steam enthalpy
- Δp^D — pressure difference at orifice in differential pressure device (only if differential pressure device was chosen)
- P^W — condensate heat flow rate
- q_v^W — condensate volume flow rate
- T^W — condensate temperature
- ρ^W — condensate density
- h^W — condensate enthalpy

List of process values for condensate with pressure equal to steam pressure and measured temperature:

- P — delta heat between steam and condensate
- P^D — steam heat flow rate
- q_m — mass flow rate
- q_v^D — steam volume flow rate
- p^D — steam and condensate measured pressure (only for superheated or saturated steam with pressure measurement)
- p_c^D — saturated steam and condensate pressure calculated based on saturation curve (only for saturated steam with temperature measurement)

T^D steam measured temperature (only for superheated or saturated steam with temperature measurement)
T_c^D saturated steam temperature calculated based on saturation curve (only for saturated steam with pressure measurement)
ρ^D steam density
h^D steam enthalpy
Δp^D pressure difference at orifice in differential pressure device (only if differential pressure device was chosen)
P^W condensate heat flow rate
q_v^W condensate volume flow rate
T^W condensate temperature
ρ^W condensate density
h^W condensate enthalpy

List of process values for condensate remaining in boiling temperature:

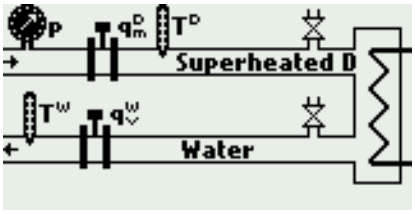
P delta heat between steam and condensate
P^D steam heat flow rate
q_m mass flow rate
q_v^D steam volume flow rate
p^D steam and condensate measured pressure (only for superheated or saturated steam with pressure measurement)
p_c^D saturated steam and condensate pressure calculated based on saturation curve (only for saturated steam with temperature measurement)
T^D superheated steam measured temperature (only for superheated steam)
T_c saturated steam temperature calculated based on saturation curve; it is also boiling condensate temperature (only for saturated steam with pressure measurement)
ρ^D steam density
h^D steam enthalpy
Δp^D pressure difference at orifice in differential pressure device (only if differential pressure device was chosen)
P^W condensate heat flow rate
q_v^W condensate volume flow rate
T_c^W condensate temperature (only for superheated steam)
ρ^W condensate density
h^W condensate enthalpy

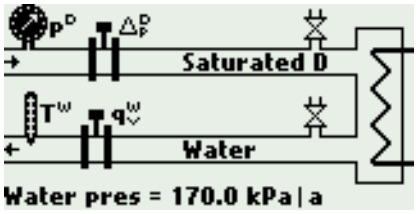
5.4.6. The flows and delta heat in a steam-condensate installation with separate steam and condensate flow rates

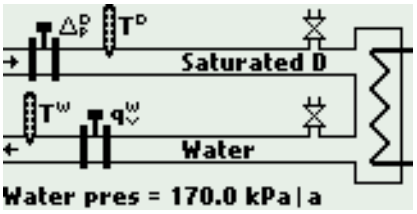
This installation should be chosen also when condensate is accumulated and periodically pumped out.

Choosing kind of steam in wizard: superheated or saturated. If saturated steam was chosen it should be determined if the pressure or temperature is measured.

It should also be declared if condensate pressure is equal to steam pressure or entered as a constant value.







List of process values for condensate with constant (entered) pressure:

- P — delta heat between steam and condensate
- P^D — steam heat flow rate
- q_m^D — steam mass flow rate
- q_v^D — steam volume flow rate
- p^D — steam measured pressure (only for superheated or saturated steam with pressure measurement)
- p_c^D — saturated steam pressure calculated based on saturation curve (only for saturated steam with temperature measurement)
- T^D — steam measured temperature (only for superheated or saturated steam with temperature measurement)
- T_c^D — saturated steam temperature calculated based on saturation curve (only for saturated steam with pressure measurement)
- ρ^D — steam density
- h^D — steam enthalpy
- Δp^D — pressure difference at orifice in differential pressure device (only if differential pressure device was chosen)
- P^W — condensate heat flow rate
- q_m^W — condensate mass flow rate
- q_v^W — condensate volume flow rate
- T^W — condensate temperature
- ρ^W — condensate density
- h^W — condensate enthalpy.

List of process values for condensate with pressure equal to steam pressure:

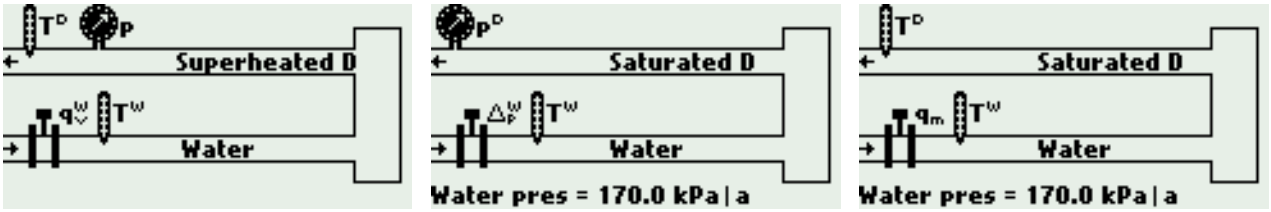
- P — delta heat between steam and condensate
- P^D — steam heat flow rate
- q_m^D — steam mass flow rate
- q_v^D — steam volume flow rate
- p — steam and condensate measured pressure (only for superheated or saturated steam with pressure measurement)
- p_c — saturated steam and condensate pressure calculated based on saturation curve (only for saturated steam with temperature measurement)
- T^D — steam measured temperature (only for superheated or saturated steam with temperature measurement)
- T_c^D — saturated steam temperature calculated based on saturation curve (only for saturated steam with pressure measurement)
- ρ^D — steam density
- h^D — steam enthalpy
- Δp^D — pressure difference at orifice in differential pressure device (only if differential pressure device was chosen)
- P^W — condensate heat flow rate
- q_m^W — condensate mass flow rate
- q_v^W — condensate volume flow rate

T^W condensate temperature
ρ^W condensate density
h^W condensate enthalpy.

5.4.7. The flow and delta heat in a steam-generating installation with the supplied water flowrate measured

Choosing kind of generated steam in wizard: superheated or saturated. If saturated steam was chosen it should be determined if the pressure or temperature is measured.

It should also be declared if supplied water pressure is equal to generated steam pressure or entered as constant value.



List of process values for water with constant (entered) pressure:

P delta heat between generated steam and supplied water
P^D steam heat flow rate
q_m mass flow rate
q_v^D steam volume flow rate
p^D steam measured pressure (only for superheated or saturated steam with pressure measurement)
p_c^D saturated steam pressure calculated based on saturation curve (only for saturated steam with temperature measurement)
T^D steam measured temperature (only for superheated or saturated steam with temperature measurement)
T_c^D saturated steam temperature calculated based on saturation curve (only for saturated steam with pressure measurement)
ρ^D steam density
h^D steam enthalpy
P^W water heat flow rate
q_v^W water volume flow rate
T^W water temperature
ρ^W water density
h^W water enthalpy
Δp^W pressure difference at orifice in differential pressure device (only if differential pressure device was chosen)

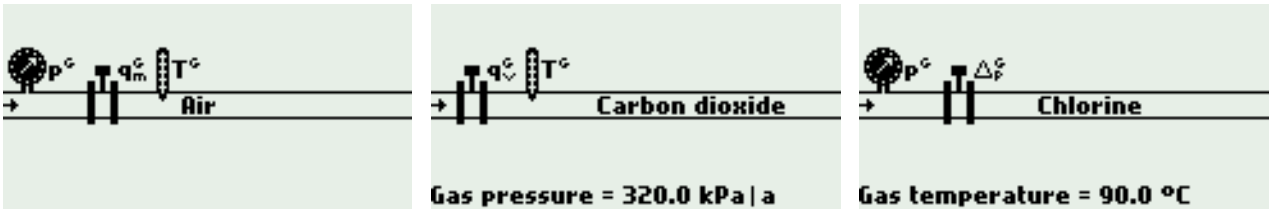
List of values for water with pressure equal to generated steam pressure:

P delta heat between generated steam and supplied water
P^D steam heat flow rate
q_m mass flow rate
q_v^D steam volume flow rate
p steam and water measured pressure (only for superheated or saturated steam with pressure measurement)
p_c saturated steam and water pressure calculated based on saturation curve (only for saturated steam with temperature measurement)

T^D steam measured temperature (only for superheated or saturated steam with temperature measurement)
T_c^D saturated steam temperature calculated based on saturation curve (only for saturated steam with pressure measurement)
ρ^D steam density
h^D steam enthalpy
P^W water heat flow rate
q_v^W water volume flow rate
T^W water temperature
ρ^W water density
h^W water enthalpy
Δp^W pressure difference at orifice in differential pressure device (only if differential pressure device was chosen).

5.4.8. The flow of a gas

It should be declared if the pressure and temperature is measured or entered as a constant value.



List of process values
q^G gas volume flow rate in standard units (volume calculated to reference conditions)
q_m^G gas mass flow rate
q_v^G gas actual volume flow rate
p^G gas pressure (only if pressure is measured)
T^G gas temperature (only if temperature is measured)
ρ^G gas density
Δp^G delta pressure at orifice in differential pressure device (only if differential pressure device was chosen).

5.5. Differential pressure device

If in wizard differential pressure device was declared, then in installation menu **Diff pres device for Δp** submenu is set automatically. Parameters for this device should be entered here. If two differential pressure devices were chosen, one on supply and the second on return pipeline, two such submenus are set.

Flow computer can calculate flowrate for differential pressure devices according to PN-EN ISO 5167 standard (only for steam and water) or approximate the flowmeter characteristic with square root curve. It can also cooperate with flowmeter with variable flow cross section ILVA type manufactured by Spirax Sarco.

According to PN-EN ISO 5167 standard one of differential pressure devices can be chosen:

Orifice, flange taps	Orifice – flange tappings
Orifice, D-D/2 taps	Orifice D-D/2 pressure tappings
Orifice, corner taps	Orifice – corner tappings
ISA1932 nozzle	ISA1932 nozzle
Long radius nozzle	Long radius nozzle
Venturi nozzle	Venturi nozzle
Venturi tube, cast	Venturi tube - cast
Venturi tube, mach	Venturi tube - machined
Venturi tube, rough	Venturi tube – rough welded sheet iron

Then the pipeline and orifice diameters as well as their temperature expansion have to be entered. Instead of entering expansion user can choose one of the following materials for pipeline and orifice:

Acid-resist steel	16,7 ppm/K
Carbon steel	11,2 ppm/K
Stainless steel	10,0 ppm/K
Cast iron	10,6 ppm/K
Brass	20,0 ppm/K
Aluminium	22,4 ppm/K

To use an approximate square root algorithm user should choose **Square root approx** in **Type** menu, then enter nominal pressure and temperature for orifice calculations and delta pressure to flow rate conversion rate.

The device can accept delta pressure transmitters with both linear and square root characteristic (see section 7.3 and 7.4.1). But it is recommended to apply transmitters with linear characteristic, in this case extraction of square root is calculated by the device processor.

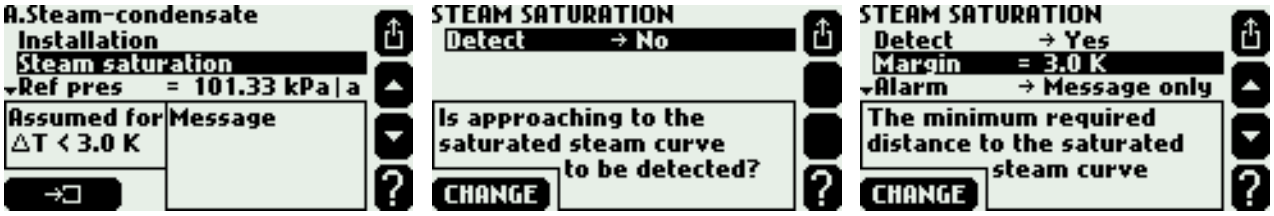
5.6. Flow rate calculation by formula

If in application no flowmeter was installed (as its flowrate can be calculated based on other application flowrate) it is to be declared in wizard as a **Formula for q_m** . Formulas and the way of entering it was described in section 6.3. In a formula for flow rate calculation all values (including auxiliary ones) from all applications can be used but the result produced by formula must be mass flow.

Example: Main application A and B handle two heat exchangers in series. In system B flow is the same thus in wizard question about flowrate measurement method is chosen **COMPUTED from the flowrates in other installations (by a formula).** In menu **Formula for q_m** the following formula has to be declared: $B.q_m = A.q_m$.

5.7. Superheated steam saturation detection

In installation with superheated steam there is possibility to detect saturation condition. To use this function user should choose **Yes** in **Detect** menu of **Steam saturation** submenu and enter minimal required margin over saturation temperature. Steam is recognized as saturated when temperature falls down below this margin. Hysteresis is always 0,5 K.



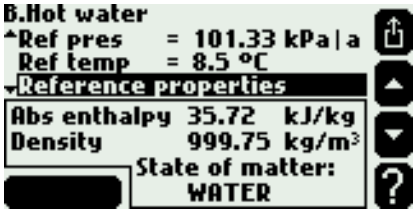
Example: Steam detection was activated and required margin was set to 3,0 K. Steam measured pressure is 1.7 Mpa – at this pressure steam gets saturated in temperature about 204,3 ºC. The device will detect steam saturation when its temperature falls down below 207,3 ºC (= 204,3 ºC + 3,0 K). When temperature grows 0,5 K above this value i.e. to 207,8 ºC (= 204,3 ºC + 3,0 K + 0,5 K) the device will assume that saturation is over.

Saturation detection cause to stop calculations and replace values: steam density, enthalpy, flowrate and other calculated values based on them with **–S–** symbol. Combined totalisers also stop. Saturation condition can be announced by message on display, can activate relay output alarm (see section 4) and be recorded to event log (see section 13.2).

Close to saturation alarm thresholds can be also set. It gets active when difference between measured steam temperature and saturation temperature falls down below set level (see section 8).

5.8. Reference point for enthalpy calculation

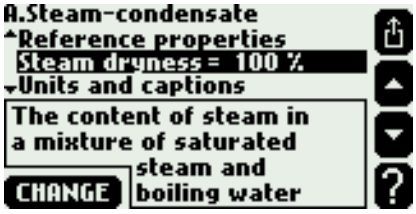
Water and steam enthalpy is calculated according to IAPWS-IF97 standard in reference to user chosen point. The reference point is entered relevant values in **Ref press** and **Ref temp** submenus. Highlighting on **Reference properties** the value of enthalpy and density for the reference point are displayed.



Example: As reference point 101,33 kPa and 8,5 ºC was chosen. According to the standard water enthalpy in these conditions is 35,72 kJ/kg. Measured water temperature is 78,3ºC and pressure is entered as a constant and equals 250 kPa. According to the standard water enthalpy in these conditions is 327,98 kJ/kg. Therefore calculated water enthalpy (h^W) will be 292,26 kJ/kg (= 327,98 – 35,72). For installations with liquid media other than water reference point is not entered. Enthalpy is calculated only according to the entered table (see section 5.1.3).

5.9. Saturated steam dryness fraction

For systems with saturated steam dryness fraction may be entered. It determines what percentage of medium mass is saturated steam. It is assumed that the rest consists of water at boiling temperature in form of suspension small drops. Dryness fraction influences density and enthalpy calculation, it is entered in 70 to 100% range. 100% value means that saturated steam is completely dry.

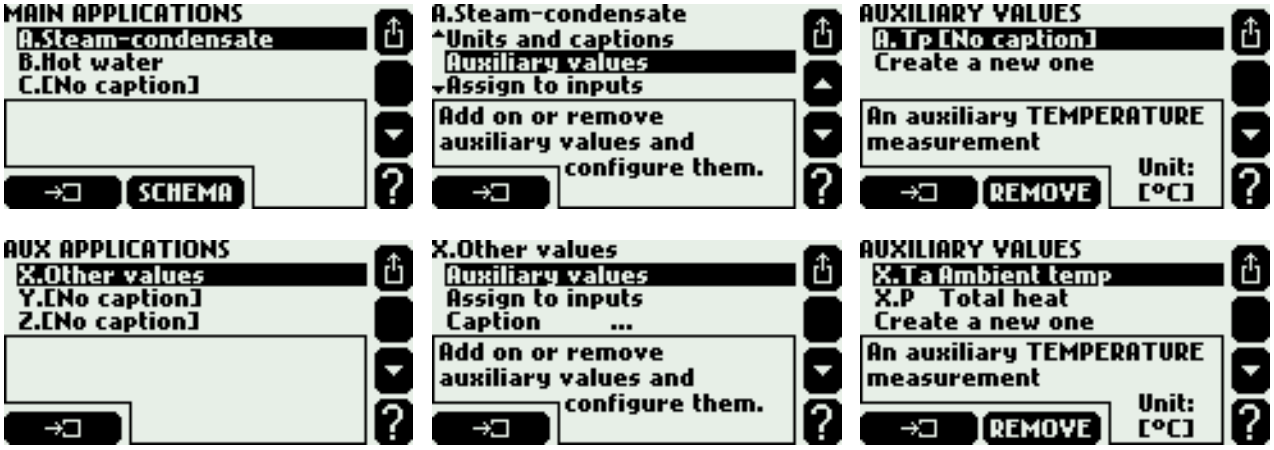


6. AUXILIARY PROCESS VALUES AND AUXILIARY APPLICATIONS

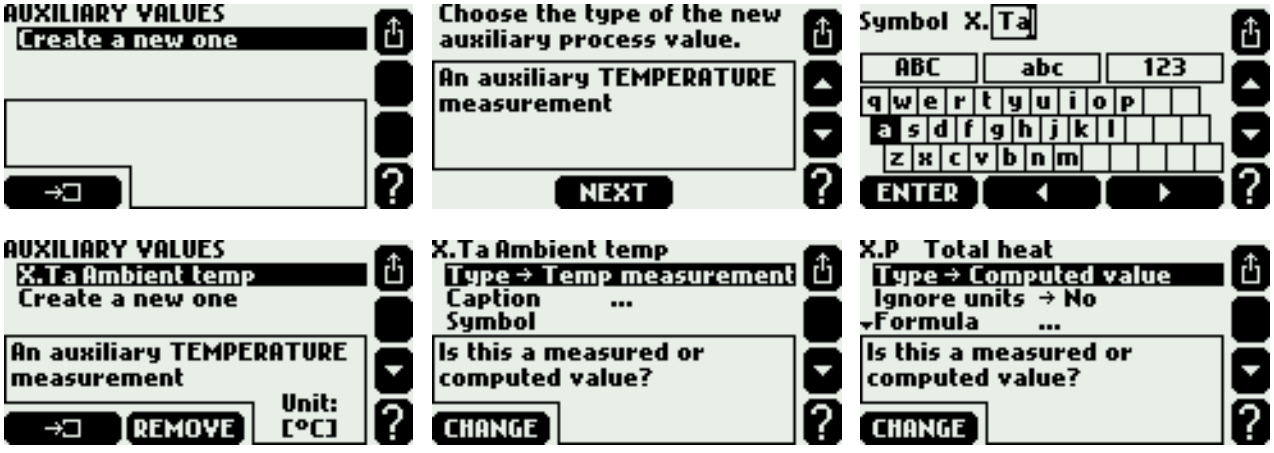
Except of process values defined automatically in main applications he flow computer allows to measure or calculate up to eight additional values. Those values can be displayed in main or auxiliary applications according to user needed and convenience.

6.1. Adding and removing auxiliary values

To add on, remove or edit auxiliary values user have to choose submenu **Auxiliary values** from main application or auxiliary application menu.



To add on a new auxiliary value **Create a new one** function should be chosen and defined type of value and its symbol. A new item opening submenu with settings of a new value will be added to menu.



The following auxiliary values types are possible:

- **An auxiliary TEMPERATURE measurement**
- **An auxiliary PRESSURE measurement**
- **An auxiliary measurement of ANOTHER quantity**
- **A value COMPUTED by a given formula**

Once set value type and symbol can still be changed and caption can be entered. Other settings depend on value type and were described in sections 6.2 and 6.3.

To remove an auxiliary value place cursor at a given position and press button **REMOVE**.

6.2. Auxiliary measured values

An auxiliary value set into temperature measurement mode has always unit ºC and does not require to enter any additional settings. Value set to pressure measurement type or any other quantity requires to enter unit. For pressure it is chosen from a list (see section 2.3) whereas for other quantities a text string as a unit should be entered (up to 6 characters).

Auxiliary measured value should be assigned to a device input (see section 7).

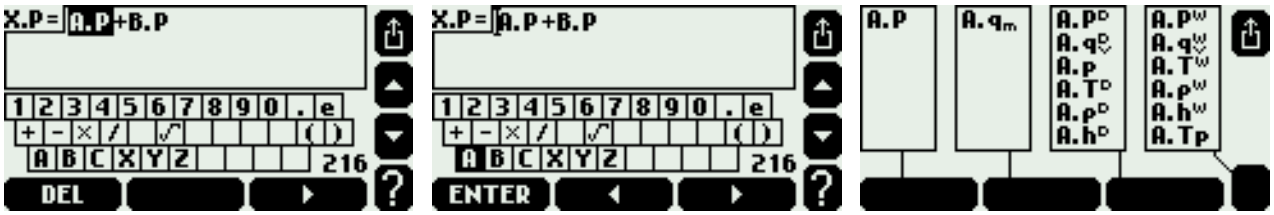
6.3. Auxiliary values computed with formulas

Each value set as computed type requires a formula to be entered. In formulas user can use symbols of other process or computed values, numerical constants, four math operations, square roots and brackets.

Calculations are performed taking units into account. Formula must have physical sense e.g. density cannot be added to power. Pressures and temperatures are brought to absolute values before calculations. Formula result must be one of physical quantities listed in section 2.3 or quantity without unit. If for resulting physical quantity accessible are more than one unit, a relevant unit should be taken from a **Unit** list.

In particular cases taking units into account can be deactivated by selection of **Yes** in **Ignore units** menu. Physical sense of formula is then not checked and calculations are performed exclusively for numerical values. Unit of calculated result should be written in text form (up to 6 characters). In formula for mass flowrate units cannot be deactivated in calculations (see section 5.6).

To enter or edit a formula a **CHANGE** button has to be pressed.



Formulas editor is similar to captions editor (see section 2.6.2). To enter a new process value to formula first an application symbol has to be chosen from the displayed keyboard, and then a process value symbol from the next screen. Total number of used symbols in all formulas is limited, the remaining number is displayed in the right bottom corner of screen. Formulas edition is much easier with use of Terminal program (see section 2.9).

7. MEASURING INPUTS

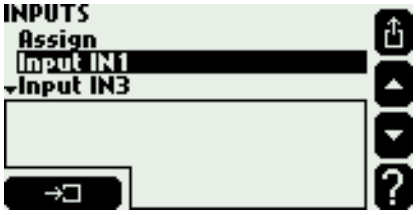
7.1. Process values assignment to measuring inputs

Process values must be assigned to measuring inputs. For this purpose an assignment table is used in settings menu. It can be accessed in submenu **Inputs,** in **Assign** submenu. The assignment table can be also accessed form main application or auxiliary application menu (**Assign to inputs**), but only process value for the one application appear in the table.

Rows in the table correspond to process values and columns to inputs (10 inputs for FP-3000 and 5 inputs for FP-3010). Symbol **+** in a square means that a respective result is assigned to the input. Shadowed square mean that an assignment is impossible. To change the assignment state user have to place cursor on the square using arrows buttons and press **ASSIGN** or **UNASSIGN** button.

More than one temperature value or pressure value can be assigned to the same input. But it must be values from different applications and must have the same unit. Only temperature can be assigned to RTD inputs (IN1 and IN2).

Assigned inputs have to be configured using submenu of **INPUTS** menu. Unassigned inputs are not accessible in this menu and cannot be configured.



Configuration of different input types was described in next sections.

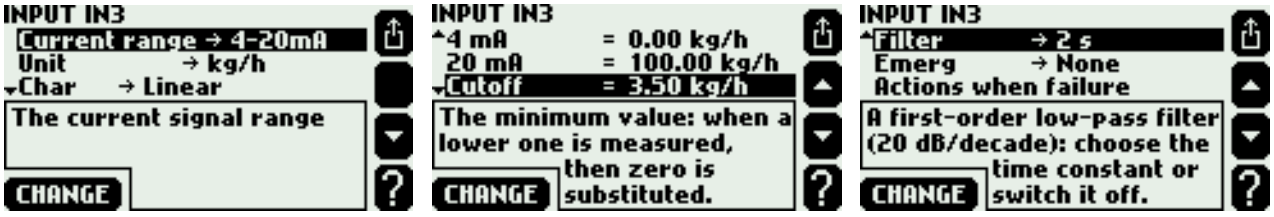
7.2. RTD inputs

To RTD inputs (IN1 and IN2) platinum (Pt) and nickel (Ni) sensors can be connected in 2- or 4- wire configuration. Sensor type is chosen in **Sensor** submenu whereas resistance for 0ºC is determined by selection in **Multiplier**, where value 1 designates Pt100 or Ni100, value 2 – Pt200 or Ni200 etc. In **Adjustment** submenu wires resistance can be entered to correct the temperature computation.

Measured temperature can be filtered with a digital damping low band pass filter with time constant chosen in **Filter** submenu.

Pt100 sensor can work in range -200…850 ºC corresponding to resistance range 18,52…390,48 Ω, whereas Ni100 sensor in range -60…250 ºC corresponding to 69,5….289,2 Ω. Out of the range is treated as a sensor failure and the value is displayed together with symbol –F– (failure) as the same to all other values calculated on its base. Failed measured value can be replaced by an emergency value (the last correctly measured value or a constant value set in **Emerg** submenu). Failure can be reported with a message on the display or with a relay output alarm (see section 4) and can be also recorded in the event log (see section 13.2) depending on settings in **Actions when failure** submenu.

7.3. Current inputs 4-20mA and 0-20mA



Measurement transmitters with analog current loop signal 4-20mA or 0-20mA can be connected to a current input (IN3…IN8 for FP-3000 and IN3…IN4 for FP-3010). Type of signal is selected in **Current range** submenu**.** Dependence between measured quantity and current signal is selected in **Char** submenu. It may be **Linear** , square root (**Transm** $\sqrt{\Delta p}$) or any other user defined characteristic (see section 7.5). Square root curve is available only for delta pressure transmitter and means that output current signal is proportional to square root of measured value. If linear or square root transmitter characteristic was chosen then the signal range have to be entered for 0/4 mA and 20 mA. Entered here resolution (number of decimal digits) does not influence on displayed resolution which is selected in display settings (see section 11.2).

Range is entered in process value units. However range of pressure transmitters can be entered in absolute or gauge units independently from displayed unit. Unit of this range depends on selection made in **Transmitter** submenu. It is recommended to set up gauge units for gauge pressure transmitter and absolute units for absolute pressure transmitter.

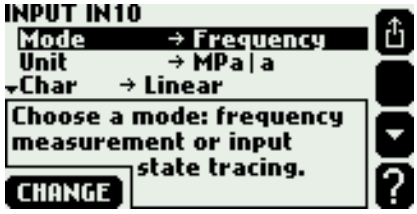
Measured value can be filtered with a digital damping low band pass filter with time constant chosen in **Filter** submenu. Additionally for values other than temperature and pressure **Cutoff** can be activated. In this case if measured value is lower than cutoff value it will be replaced by zero.

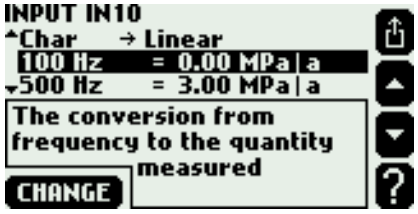
Current higher than 22 mA or lower than 3.6 mA (for 4-20mA signal) is interpreted as a measurement sensor failure and the value is displayed together with symbol **–**E– (over 22 mA) or –||– (less than 3.6 mA) as the same to all other values calculated on its base. Failed measured value can be replaced by an emergency value (the last correctly measured value or a constant value set in **Emerg** submenu). Failure can be reported with a message on the display or with a relay output alarm (see section 4) and can be also recorded in the event log (see section 13.2) depending on settings in **Actions when failure** submenu.

7.4. Binary inputs

Binary inputs (IN9…IN10 in FP-3000 and IN5 in FP-3010) can operate in one of three modes: frequency measurement, pulse counting or state monitoring.

7.4.1. Frequency measurement

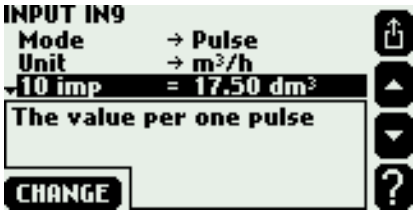




To binary inputs operating in frequency measurement mode measuring transmitters with output frequency in the range 0,001 Hz …10 kHz can be connected. Dependence between measured quantity and frequency signal is selected in **Char** submenu. It may be **Linear**, square root (**Transm** $\sqrt{\Delta p}$) or any other user defined characteristic (see section 7.5). Square root curve is available only for delta pressure transmitter and means that output frequency signal is proportional to square root of measured value. If linear or square root transmitter characteristic was chosen then the signal range have to be entered for lower and upper frequency. Entered here resolution (number of decimal digits) does not influence on displayed resolution which is selected in display settings (see section 11.2).

For quantities other than temperature and pressure user can activate **Cutoff**. In this case if measured value is lower than cutoff value it will be replaced by zero.

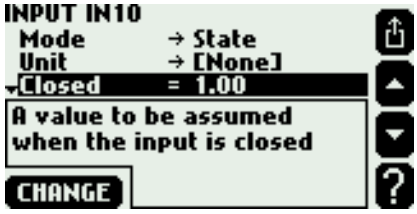
7.4.2. Pulse counting

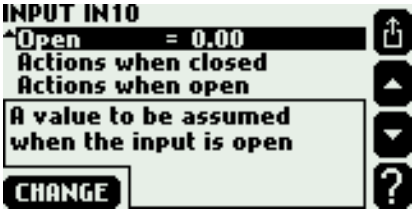


Pulse counting should be chosen if a flowmeter with a constant pulse value was connected to the binary input. Pulse value should be entered giving a flow value corresponding to the relevant number of pulses. Flowrate value will be computed based on measured frequency whereas main (Σ_1) and additional (Σ_2) totalisers will count input pulses multiplied by entered pulse value. In this way no one pulse will be lost even if a cutoff value is set for flowrate.

User can activate **Cutoff**. In this case if measured value is lower than cutoff value it will be replaced by zero.

7.4.3. State monitoring





A process value assigned to the binary input in state monitoring mode may have two values: one when the input is closed and the other when it is opened (e.g. input closed equals -6,25, and opened +12,5). Both values should be entered in settings. This mode is available only for the inputs assigned an auxiliary values and can be used for indication of flow direction, as a multiplying factor in sophisticated applications.

Both closed and open state can be signaled with a message on the display or as a relay output alarm (see section 4), also can be recorded in the event log (see section 13.2) and it can be used to switch over to second archive speed (see section 12.1). Relevant settings are entered in submenu **Actions when closed** and **Actions when open**.

7.5. Nonlinear characteristics for measurement transmitters

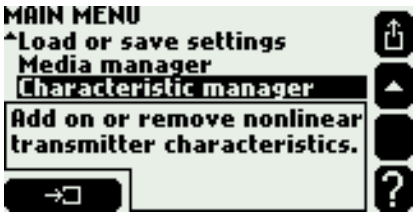
The flow computer can also accept the current loop or frequency signal other then linear nor square root. Transmitter characteristic is then entered to the device in table form from a file. Such file should be prepared on PC computer in text editor or in spreadsheet and copied to the MMC/SD card. Accepted extensions are .txt and .csv. The method of loading file to the device was described in the further part of this section.

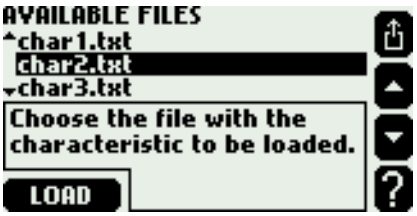
An example of file contents with the transmitter characteristic with frequency signal is given below.

```
#char Nonlinear
100.0  30.0
200.0  40.0
300.0  52.0
```

A file must begin with string `#char` which is followed by the name (up to 12 characters, here `Nonlinear`). In the next line the table begins of pairs of numbers: transmitter signal in mA or Hz and corresponding measured value. The table must be ordered in sequence of growing signal values. In the example value 30.0 corresponds to 100 Hz frequency. Values between the table points are linearly interpolated (here in the example 35.0 corresponds to frequency 150 Hz). Values outside the table are linearly extrapolated (here in the example 25.0 corresponds to 50 Hz, and 64.0 to 400 Hz).

Characteristic tables are stored in the data base in settings. To view the base contents and to add on or remove characteristic table user have to choose **Characteristic manager** submenu from main menu.



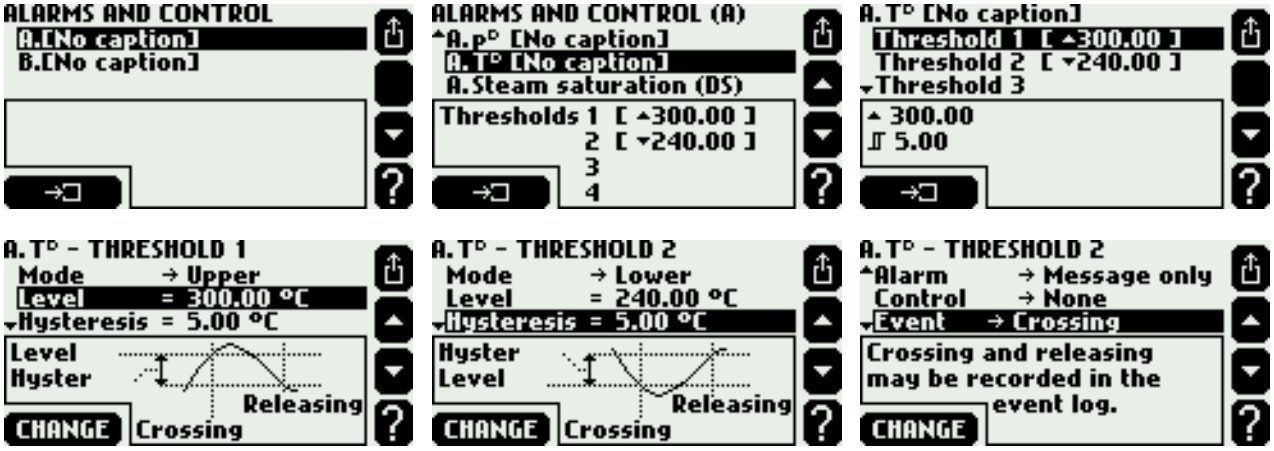


To add on a new characteristic the MMC/SD card containing a relevant file have to be inserted. In **Characteristic manager** menu user have to press **NEW ONE** button. A list of files with .txt or .csv. extensions will be displayed and the highlighted file can be chosen with the **LOAD** button. A new characteristic can also be added during input configuration without need of entering the characteristic manager. For this purpose in **Char** submenu user should choose **From file**.... This will display a list of available files and allow to add the characteristic table.

To remove characteristic table user have to highlight its name and press **REMOVE** button. On the list of characteristic tables occupied memory volume is displayed next to the name. At the bottom of the screen the remaining free memory space is displayed. In the data base may be up to 16 different characteristics attached.

8. THRESHOLDS

For each process value except of density (ρ), enthalpy (h), delta pressure (Δp) and water thermal coefficient (k) up to four alarm and control thresholds can be set. It is configured in settings menu in **Alarms and control** submenu.



To activate a threshold first mode (**Upper** or **Lower**) have to be selected and then the threshold value and the hysteresis value. Upper threshold gets active when the value exceeds the threshold level and releases when the value declines below that level by at least as much as hysteresis. Lower threshold gets active when the value declines below the level and releases when the value exceeds that level by at least as much as hysteresis.

In systems with superheated steam thresholds may be set to a process value called **Steam saturation (DS)**. This special thresholds get active when difference between measured steam temperature and saturation temperature at measured pressure is below set level. This is to alarm when superheated steam conditions are too close to its saturation.

Crossing a threshold (activation) can be signaled with a message on the display, as an relay output alarm (see section 4), can be reported in the event log (see section 13.2) and may cause switch over to the second archiving speed (see section 12.1).

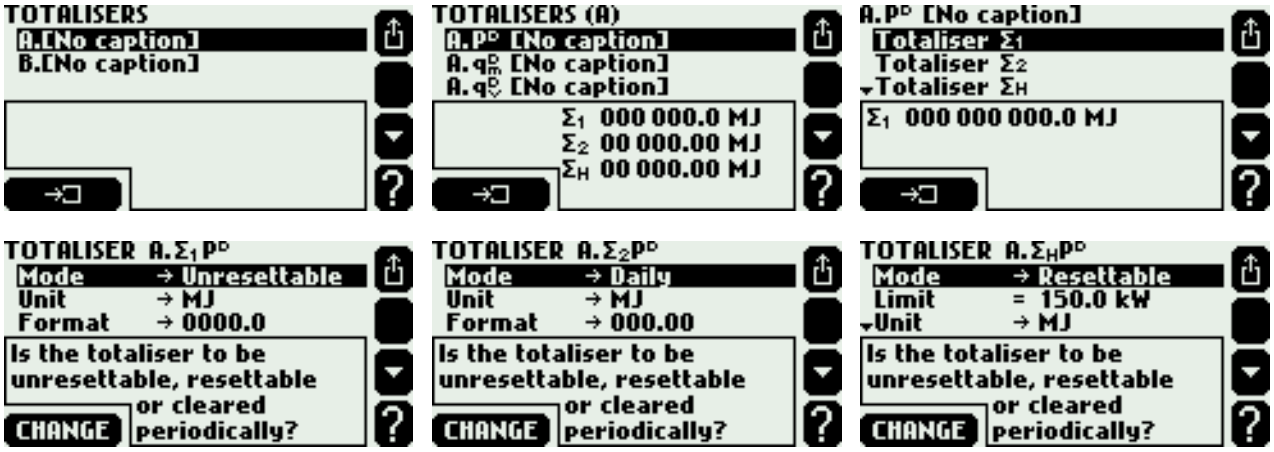
Information about crossing/releasing of thresholds is displayed on the screen called alarm and control thresholds (see section 2.2.2). A displayed symbol ▲ means crossing of an upper threshold whereas a symbol ▼ means crossing of a lower threshold. A shaded square means that a respective threshold is not defined.

9. TOTALISERS

For process values being heat flowrate or flowrate as well as additional values with entered unit ended with **/h**, **/min** or **/s** up to four totalisers can be set:

- main totaliser (Σ_1),
- auxiliary totaliser (Σ_2),
- overrange totaliser (Σ_H),
- underrange totaliser (Σ_L).

In settings menu in **Totalisers** submenu user can set up totalisers for all active main and auxiliary applications.



Main and auxiliary totalisers add flowrate or heat values in one second periods. An exception is when process value was assigned to binary input operating in pulse counting mode. Then totalisers count pulses multiplied by their values.

Example 1: Flowrate value is 1800 kg/h. Each second 0,5 kg (=1800 kg/h / 3600 s × 1 s) is added to main and auxiliary totaliser.

Example 2. Volumetric flowrate is measured with pulse flowmeter with output 1 pulse = 10 dm^3. The flowmeter was connected to binary input set into pulse counting mode. The flowmeter rotates with such speed that one pulse comes every 20 seconds i.e. frequency is 0,05 Hz. Therefore the flowrate is 0,5 dm^3/s. However the main and auxiliary totalisers do not totalise flow 0,5 dm^3 every second. They increase their value by 10 dm^3 every 20 seconds when a pulse comes.

An overrange totaliser totalises only amount over set limit. If the value is lower than the limit the totaliser stops.

Example. An overrange totaliser was activated for heat flowrate and a limit was set to 150 kW. Heat flowrate value is 162 kW. Each second a value of 12 kJ (= [162 kW – 150 kW] × 1 s) is totalised.

An underrange totaliser totalises only amount under set limit. If the value is higher than the limit the totaliser stops.

Example. An underrange totaliser was activated for heat flowrate and a limit was set to 20 kW. Heat flowrate value is 17 kW. Each second a value of 3 kJ (= [20 kW – 17 kW] × 1 s) is totalised.

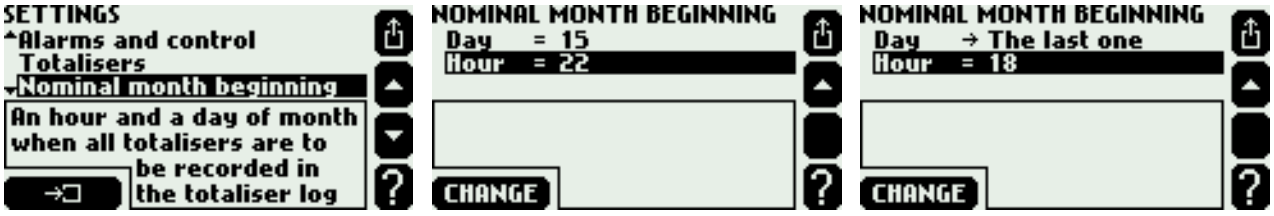
A totaliser may operate in one of the following modes:

- **Unresettable**
- **Resettable** (this mode cannot be used for main totaliser)
- **Hourly**

- **Daily**
- **Monthly**

An unresettable totaliser operates constantly from the moment of its activation in settings, it cannot be reset from keyboard neither it is reset automatically. A resettable totaliser can be reset from keyboard on totaliser screen (see section 2.2.2). Reset can be executed only for one totaliser or for all resettable totalisers at once. An hourly, daily and monthly totaliser is reset automatically periodically:

- hourly reset totaliser at full hours,
- daily reset totaliser at any full hour of a day selected in **Hour** submenu in settings **Nominal month beginning** menu,
- monthly reset totaliser at any day of a month between 1st and 28th or on the last day of the month (**Day** submenu in settings **Nominal month beginning** menu) at any full hour like daily reset totaliser.



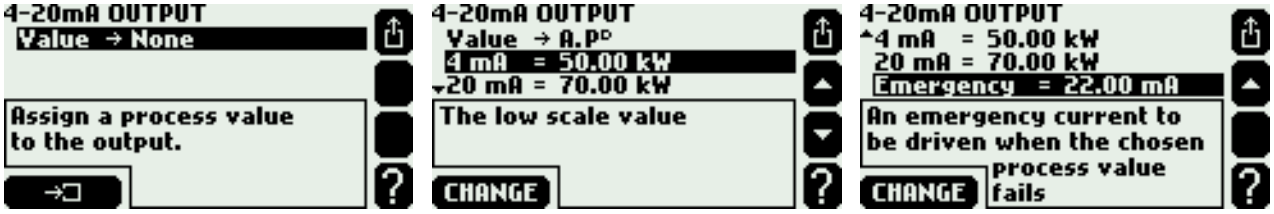
Each totaliser has its own unit. For energy, mass and volume unit can be selected from a list according to the table in section 2.3. A unit change causes a relevant rescaling of totalized value. The totaliser value can be displayed with resolution from 0 to 4 decimal digits. The resolution does not influence accuracy of the totaliser and can be any time changed.

Value of every active totaliser is recorded into totaliser register at the end of each month according to settings in submenu **Nominal month beginning** (see section 13.1). Additionally value of some user chosen totalisers may be recorded into hourly archive file on SD/MMC memory card at every full hour (see section 12.2).

An operator with service entitlements can set main totalisers to any initial values and reset all remaining totalisers including also those unresettable ones.

10. CURRENT LOOP OUTPUT 4-20mA

The flow computer may be optionally equipped with one current loop output 4-20mA, (see section 1.3). An output can generate a signal proportional to one selected process value. To configure the output user have to select **4-20mA output** submenu from settings menu.



Activation of the output requires assigning selected process value from the list in **Value** submenu. Also the range have to be entered for two points: 4 mA and 20 mA. Current signal is always in the range 3,6…22 mA. For values forcing smaller current the output stays at 3.6 mA. Similarly expected current above 22 mA stops at 22 mA.

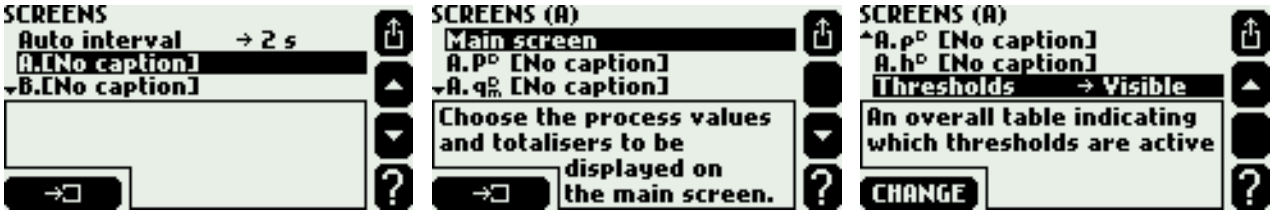
If process value has no value (e.g. during transmitter failure when no emergency value was activated or during saturation of superheated steam), an output can generate an error current value informing about such situation. This value should be entered in **Emergency** submenu. If emergency value is deactivated the output current value remains unchanged if fault is detected.

11. DISPLAY CONFIGURATION

In this section configuration of screens for process values was described while screen image and navigation principles were presented in section 2.2.

To configure display user have to choose **Screens** submenu from settings menu.

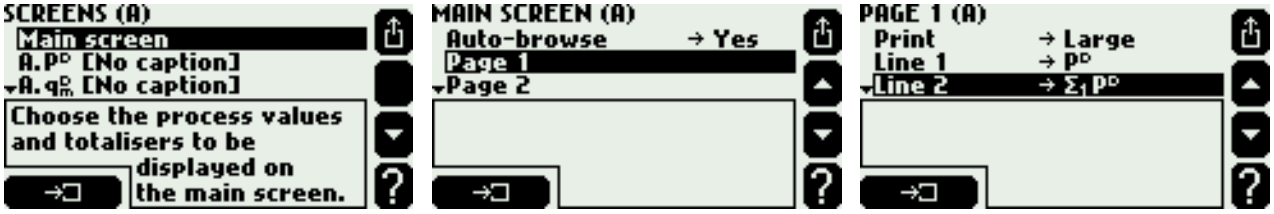
In **Auto interval** submenu time for single screen presentation during automatic scrolling is set. The last three items allow to activate or hide auxiliary screens: relay outputs screen, date and time screen and archive screen. The main screen and individual screens are set for every application separately.



Main screen submenu opens menu where tables for process values are configured, see section 11.1. Next menu items allow to set individual screens for process values with all detailed settings like displayed value resolution, range of diagrams and bargraphs. Individual screens user can also activate or hide there, see section 11.2. The last item **Thresholds** allows to present a thresholds screen.

11.1. Main screens

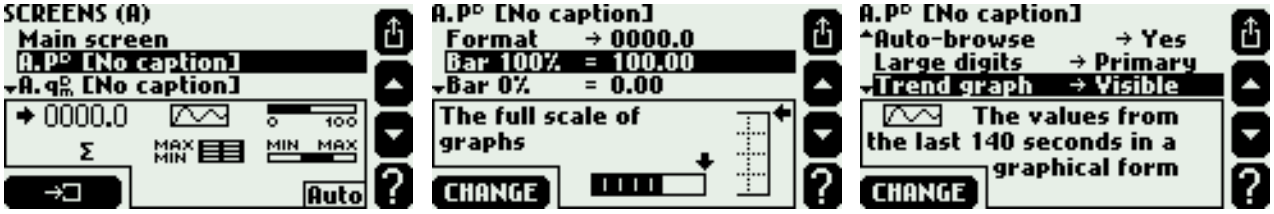
To configure main screen user have to select **Main screen** submenu. In **Auto-browse** submenu user can determine if the main screen of this system should be presented during automatic scrolling. Next menu items allow to configure process value table screens.



In **Print** submenu letter size may be chosen for the table. Next menu items allow to choose the process values or totalisers for the table lines. The selection is based on choosing from the list. If the process value has an active totalisers, then in the next step user should decide which value or o totaliser should be displayed. The same process value or totaliser can be displayed in different tables and even many times in the same table. A table is considered to be activated if at least one of its rows is not empty.

11.2. Individual screens, resolution and range of diagrams

To choose a set of individual screens and enter other settings for a single process value user have to choose the value from **SCREENS** menu.



In **Format** submenu resolution for display and archive can be selected. A value is displayed with maximum of 5 digits. If not all of them can be displayed they will be shorted with approximation. The selected resolution does not influence accuracy of computations. In the next two items range of bargraph and diagram on trend screen (and archive browser) is set.

In **Auto-browse** user can determine if a given process value is to be presented during automatic scrolling. Totalisers screens are available only if totalisers are active. User can choose which screens are to be visible and which hidden .One screen may be the default one - means that it will always be displayed as a first one when this value is reached. If no screen is default one, then a screen which was viewed as the last one will be displayed at first.

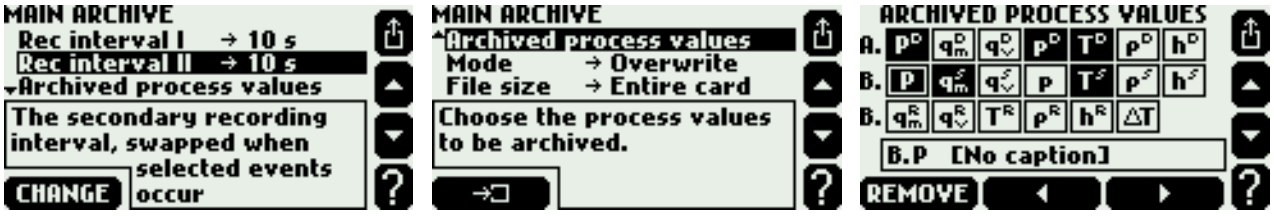
12. ARCHIVING

The flow computer can handle two types of archives files. In the first called main archive file selected process values are recorded. In the second one – hourly archive file – values of selected totalisers and hourly average, minimum and maximum of selected process values are recorded. Both archive files are stored on MMC/SD card in text format. These files can be copied to PC computer hard disk using memory card reader or via RS-485 port with help of FP-3000-Raport program. The main archive can also be browsed in form of diagram or table on the device display.

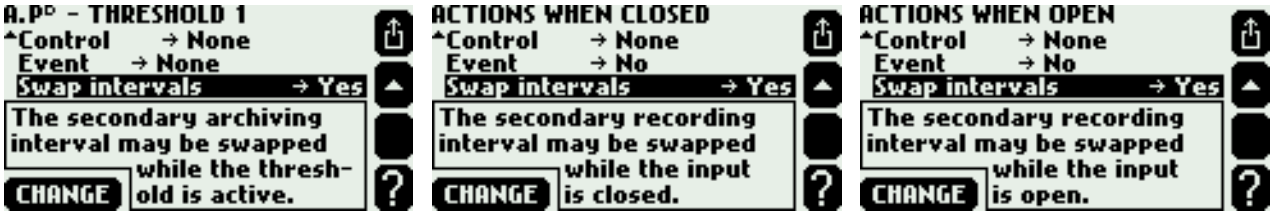
12.1. Main archive

12.1.1. Settings

Configuration is accessed in submenu **Main archive** from **Settings** menu.



The first two menu items are to select the two archiving speeds. In normal operation the **Rec interval I** is used. **Rec interval II** may be swapped for the time of alarm thresholds activation or controlled with closing or opening binary inputs. If the second record interval is to be used by a given threshold or binary input it should be declared in its settings – **Swap intervals** submenu.



If the second archive speed is not used it is recommended to set it equal to the first one. This is important when using an archive browser in the device because the time scale is selected automatically due to both intervals.

To determine the set of process values for archiving user have to choose **Archived process values** submenu. A table with values of all applications will be displayed. Shaded squares mean that given process value is archived. To add on or remove value user have to place cursor on the square press the left bottom button **ADD ON** or **REMOVE**.

Mode submenu allows to select archiving mode. **Overwrite** option means continuation of archiving by overwriting the new records on the oldest ones. **Stop when full** option means that archiving will be stopped when out of free space.

In **File size** submenu user can limit the size of main archive file on the SD/MMC card.

12.1.2. Archiving control

Commands to control recording are in **Archiving commands** submenu in **MAIN MENU** or are accessed with **MENU** button on the archive screen. Only the commands possible to execute are visible on the screen (e.g. archiving cannot be stopped if it was not started).

To begin archiving user have to create an archive file first. For this purpose **New file** command is used. If a card is not empty device will suggest to delete it. However it should be remembered that also possible log files and hourly archive file will be deleted. After the file was created the device will automatically suggest to start archiving.

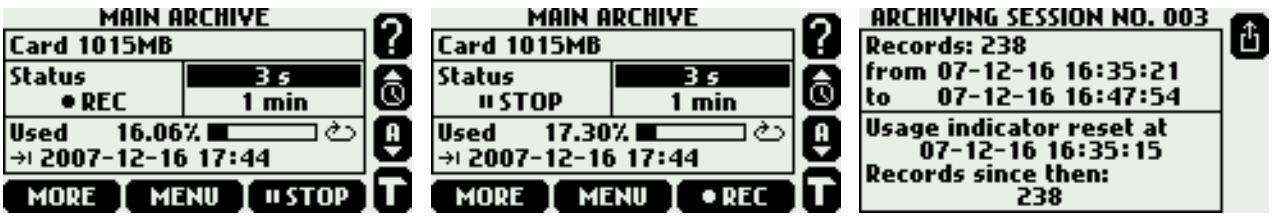
Archiving can be stopped and resumed on user demand. Commands **Resume recording** and **Stop recording** are used for this purpose. During archiving card cannot be removed from the device slot, first recording must be stopped. When archiving is stopped data records are still being saved however not to file but to a buffer in internal nonvolatile memory. While resuming recording the device will ask if records from the buffer are to be appended to the main archive file. Thanks to this function archiving can be stopped for some time in order to copy recorded data to PC computer without loosing new data. The buffer capacity is 32 000 characters. Archiving 20 process values every 30 seconds it is sufficient for over 90 minutes but archiving 50 values every 3 seconds it is sufficient for 4 minutes only.

Instead of resuming archiving to the current main archive file it is also possible to create a new file. However it will not be possible then to continue archiving to the previous file. Resumption will also be impossible if the archive file is modified in computer (this regards also the change of file name) and if archiving settings or archived values settings (e.g. their units) are changed.

When the memory card has been inserted to the device slot first it is checked if there is a current main archive file. If it is the recording action is suggested – resuming or new file creating (see section 2.7.2).

12.1.3. Archive screen

The information about archiving status is displayed on archive screen.



On top the information about card capacity is displayed. Below on left there is archiving status. It can be:

NO FILE there is no current archive file on the card,

STOP there is a current archive file on the card but recording is stopped,

REC data is being recorded,
FULL archiving has been stopped due to the lack of free space on the card.

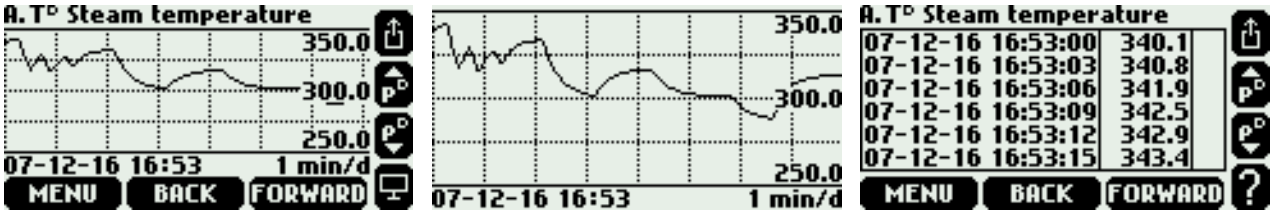
On the right there are displayed first (higher) and second (lower) recording speed. Actual speed is highlighted. Below there is memory space usage indicator and expected date and time when the card space will be filled up. Usage forecast is always computed for actual frequency under assumption that recording will be active all the time.

If the archive is set to overwrite mode the usage indicator may be reset. For this purpose **Reset usage indicator** command is used. It does not remove any records. After resetting indicator takes into account only these records which have been added on to the archive since its resetting.

MORE button allows to get additional information: number of records in the archive, date and time of the youngest and oldest record, date and time of usage indicator resetting as well as number of records saved since that time.

12.1.4. Archive browser

Archived process values can be browsed on display in form of a graphic diagram or a table form. For this purpose choose **MENU** button and **Browse** command on main archive screen or press **ARCHIVE** button on one of process values trend screen (the **ARCHIVE** button is accessed if the value is archived).



Date and time displayed under the graph refer to its left table edge. **BACK** and **FORWARD** buttons allow to scroll records whereas vertical arrow buttons serve to choose the other process value. The right bottom button enables to increase the picture.

After pressing **MENU** button bottom buttons change their function and allow to switch between graph and table (**TABLE** or **GRAPH**) or to jump to a record with chosen date and time (**JUMP TO**) and change the displaying option of a graph (**OPTIONS**).

12.2. Hourly archive

This archive file can record selected totalisers (up to 15) and a set of hourly averages, minimums and maximums for chosen process values (also up to 15) at full hours.

12.2.1. Settings

Configuration is accessed in submenu **Hourly archive** from **Settings** menu.

To choose a set of totalisers and process values to be archived the **Archived totalisers** and **Archived process values** submenu have to be used form **Hourly archive** menu in **Settings** menu - a table with totalisers or process values available for all applications is displayed. Shadowed value field mean that the totaliser or value is declared for archiving. To add on or remove value user have to place cursor on the square press the left bottom button **ADD ON** or **REMOVE**. Simultaneously there can be archived not more than 15 totalisers and not more than 15 process values.

12.2.2. Archiving control

To start data recording user have to create first an hourly archive file choosing **Create hourly archive** command in **Archiving commands** submenu in **MAIN MENU** or to press **MENU** button on main archive screen. If this command is not available it means that the file is already existing on the SD/MMC card.

Recording takes place at full hours if a file is on a card and at least one totaliser or process value was chosen in settings. The card may be removed from device at any moment (this archive does not require stopping) and then records are saved in internal nonvolatile memory buffer. At the next time card insertion records from the buffer are automatically saved to the file. Thus the card can be removed for a short time to copy the file to a computer without data lose. In buffer there is space for 3 records, therefore the card should not be removed from slot for longer than 2 hours.

In distinction from main archive file there is no possibility to create the new hourly archive file on the same card. On one card there can be only one hourly archive file which the device recognizes by name. A new file can be created only when the previous file was removed or its name is changed in computer. Few hourly archive files can be created on various cards instead and they can be inserted to device one by one. Also archiving settings change does not require creation of a new file – only a consecutive caption with a new set of archived totalisers and values will be recorded to the file.

Device automatically suggests to create a new file (see section 2.7.2) at the card insertion to a slot when there is no hourly archive on the card.

13. AUDIT TRAIL

The flow computer has four logs recording various types of measurement events and operations executed by user. These are as follows: totaliser log, event log, authorization log and calibration log. The logs are stored in internal nonvolatile device memory and may be browsed on display. Furthermore event log and authorization log can be copied to text file on MMC/SD card and read via RS-485 and then processed in FP-3000-Raport program.

13.1. Totaliser log

In totalisers log once a month values of all active totalisers and working time are recorded Data is Recorded on the day and the hour indicated in settings in **Nominal month beginning**. In the log there are stored 13 last records.

13.2. Event log

In event log there are recorded:

- power supply turning on and off,
- settings change,
- date or hour change,
- resetting of maximum, minimum and average values,
- resetting of totalisers,
- beginning and the end of declared thresholds crossing,
- beginning and the end of superheated steam saturation,
- beginning and the end of declared input signal failure,
- change of state of selected binary inputs.

In the log there are stored 500 last events.

In settings user should declare which thresholds crossing are to be recorded, in which systems steam saturation is to be recorded, for which analog inputs failures should be recorded and for which binary inputs closing and opening should be recorded. For this purpose an **Event** submenu is used in settings respectively of alarm and control threshold, measurement system (submenu **Steam saturation**) and measuring inputs (submenu **Actions when failure**, **Actions when closed** and **Actions when open**).

13.3. Authorization log

In authorization log there is recorded each execution of one of commands listed below but only when the respective command requires authorization (is password protected), (see section 2.5 and 15). These are:

- creation of a new main archive file,

- resumption or stopping of archive recording
- resetting of maximum, minimum and average values,
- resetting of totalisers,
- date and hour change,
- change of main settings (i.e. all except of listed below),
- change of thresholds settings (value and hysteresis value),
- change of display settings (screens configuration and backlight and contrast of display),
- change of archiving settings (recording interval, set of archived values and recording mode),
- loading of new settings from a file,
- installation new firmware.

In the log there are stored 500 last actions.

13.4. Calibration log

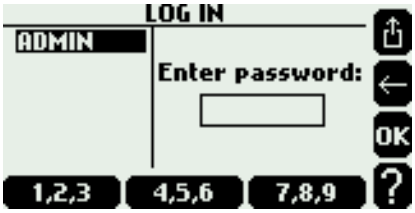
In calibration log each calibration procedure performed by service or manufacturer is recorded. Each record includes the following information:

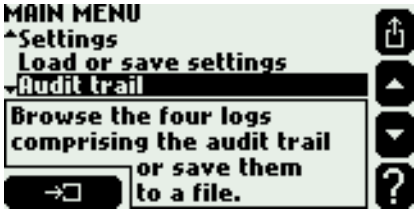
- date and hour of execution,
- service executor (serviceman or manufacturer),
- type of procedure (calibration procedure or calibration setup removal).

In the log there are stored 50 last calibration procedures.

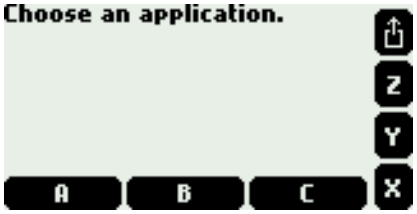
13.5. Logs browsing on device display

In order to browse logs user should log in first. Totaliser log and event log may be browsed by any user whereas authorization log and calibration log is available only for administrator. To browse logs user have to choose **Audit trail** submenu from main menu.





When totaliser log is selected the device displays list of accessible records by dates.



Other logs are displayed in form of a scrolled list. Each line corresponds to one record (event or action). Simultaneously on display there are visible three records. In a frame underneath additional information about highlighted record is displayed.

13.6. Saving logs to MMC/SD memory card

Contents of event and authorization logs can be saved to text file on memory card. This file can be then read by FP-3000-Raport program. The file contains supervisory fields enabling determination if their contents has not been modified outside the device.

Saving can be executed any moment at administrator's request or it may proceed periodically automatically. To save log contents to a file user have to choose **Save to file** submenu in audit trail menu and select a log. Similarly to log browsing this action requires logging first.

If there is no file for chosen log on the card yet this command will create a new file and will save to it all records from the log. After that user will be asked if he wants to activate autosave mode. However if there is already a file on the card only new records (i.e. those which have not been saved to file yet) may be saved and autosave mode may be activated or deactivated. In a frame underneath there is information if a log file already exists and how many unsaved records are there.

Due to autosave mode activation future records will automatically be saved to the file. Autosaving allows therefore to avoid problem of log overflow. In internal nonvolatile device memory there are still stored only 500 last records but all previous are saved on file which capacity is limited only by free space on a card. Saving new records to file takes place once per day at midnight or when the number of unsaved records exceeds 250. In spite of activated autosave mode the card can be for some time removed from the device (e.g. to copy a file to computer). New records will be added to file after the next card insertion. However it is recommended not to remove the card for too long time to avoid losing some records due to log overflow. File removal or its name change will lead to autosaving deactivation.

When card without any log files is inserted the device displays an inquiry whether to create such files and activate autosaving (see section 2.7.2).

Browsing logs on the display regards only to records from the internal memory (i.e. last 500). Browsing file content is enabled with FP-3000-Raport program.

14. SERIAL PORT RS-485

Flow computer may be connected to RS-485 network as a slave. Transmission settings are in **Serial communication** submenu in **Settings** menu.

There two protocols implemented (**Protocol** submenu): **ASCII** and **Modbus RTU**. ASCII protocol is dedicated for communication with programs delivered by manufacturer e.g. FP-3000-Raport or Terminal. Modbus RTU protocol serves for communication with universal visualization programs and enables readout of all process values and totalisers. Protocol details are described in appendix A.

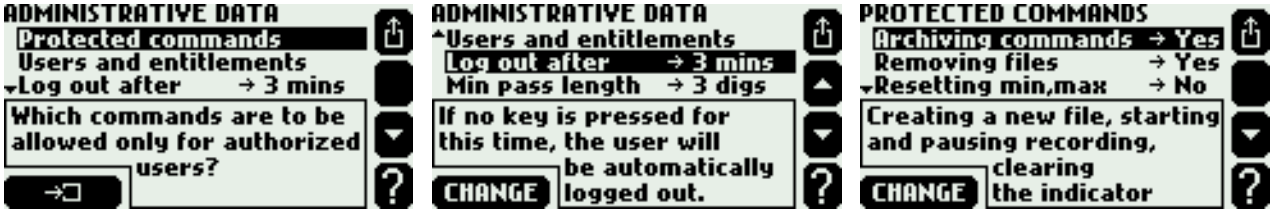
Device ID of instrument identifies it in network and must be unique (no other device in the same network can have the same address). **Baud rate** and **Parity** must be set the same as in computer or controller which is the network master.

In ASCII protocol transmitted packages may be protected with CRC code. Device always adjoins a code to transmitted packages while computer program can it also compute but it does not have to. When **No** option in **CRC7 check** submenu is selected the device will not check code integrity in received packages.

In **Min delay** submenu minimum time interval between enquiry reception and answer transmission is chosen. **Max delay** submenu regards only to ASCII protocol. If device does not manage to send an answer in the selected time then it sends a code “not ready”.

15. USERS AND PASSWORD PROTECTED COMMANDS

Selection of protected commands, adding on and deleting users names as well as giving them entitlements is available only for administrator. For this purpose after user have to logging with an ADMIN password and choose **Administrative data** submenu from main menu.



Protected commands submenu opens a list of command groups which may be declared as password protected. These commands were given in section 2.5. Authorization for settings change are divided into four groups:

- main settings (i.e. all except of listed below)
- threshold settings
- screen settings (configuration of screens and display backlight and contrast)
- archiving settings (recording interval, set of archived values and recording mode).

If password protection for any group was activated protection of main settings would automatically be activated as well. Protection deactivation for main settings will automatically deactivate protection for the remaining settings groups. .

In **Log out after** submenu a nonactivity time period can be chosen after which user or administrator will automatically be logged out. In **Min pass length** submenu minimum required number of digits in users passwords is selected. This selection does not influence passwords entered earlier.

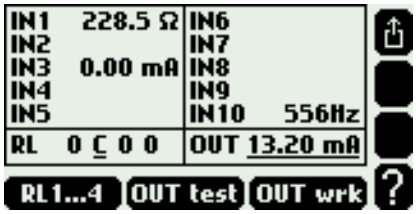
Users and entitlements submenu opens list of users and table of their entitlements.

Table lines correspond to users and columns to respective commands. Only those commands are displayed which require authorization. In a frame under the table there is command name corresponding to the column pointed with cursor. Symbol **+** in the square means that the user is allowed for execution of a given command. To allow or forbid entitlement user have to point with a cursor the proper square and press the **ALLOW** or **FORBID** button. If a user is authorized for main settings change then automatically he is also authorized for the remaining settings groups – these squares are then shadowed.

To add a new user administrator have to place cursor on the users list and press **NEW ONE**. Pressing **MENU** button bottom buttons change their function and enable to remove the user (**REMOVE**) or to change password (**PASSWRD**) and user name (**RENAME**).

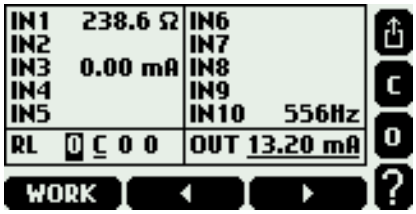
16. INPUTS AND OUTPUTS TEST

During field installation of the device it is useful to use inputs and outputs test function. It allows to monitor inputs signal, relay outputs state and current output. It is also possible to force the states at all outputs. Test is available only for administrator. To start test user have to choose **Test inputs and outputs** submenu from main menu after logging with ADMIN password. Before starting the test the device must be configured.



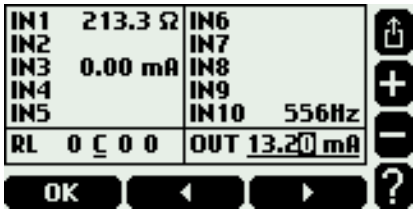
In the upper part of screen there are displayed signal values at active inputs. At the bottom at left side there are displayed relay outputs states (**O**=open, **C**=closed), at the right side expected output current for 4-20mA output. Underlining means that given state was forced for test and is not the device normal operation.

Button **RL1...4** are used to force required relay outputs state or to return back to normal operation.



With horizontal arrow buttons cursor user can choose the output and force closing (button **C**) and opening (button **O**) or return to normal operation (button **WORK**). Changes are executed immediately.

To force a required current at 4-20mA output user have to press **OUT test** button.



The current value is entered using arrow buttons and **+** or **-** buttons, then accepting test value with **OK** button. To return to normal operation press **OUT wrk** button.

17. SOFTWARE LOADING AND LICENCE INSTALLATION

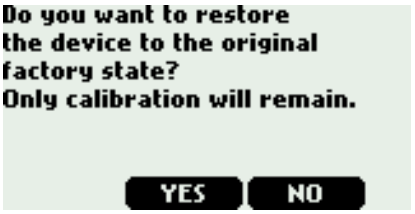
The flow computer functions are successively expanded and supplemented. It is possible to obtain a new firmware version in form of a file with .ver extension from manufacturer's service. New firmware can be loaded from MMC/SD card into device only by administrator. User have to log in using ADMIN password and choose **Load and install** submenu from **Software and licences** menu in **MAIN MANU**. From the list the new firmware file have to be selected. Software exchange may take about one minute. All information saved in the device (settings, logs contents etc.) remain intact.

Only main application A is available in the basic version of flow computer. Use of all applications **ABCXYZ** (for FP-3000) or **AB** (for FP-3010) requires extended licence. The licence may be loaded to device before its shipment to customer or purchased later and then it is supplied in form of a file with .lic extension. The licence file is valid only for device (or devices) with dedicated serial number and is loaded identically as a file with a new firmware.

The **Licence granted** and **Software version** menu items allow to read the list of installed licences, current firmware version and the device serial number.

18. RESTORING DEVICE TO THE FACTORY STATE

In particular situations it may be necessary to reset nonvolatile memory of the device and to restore it to the factory state. This command can be executed only by administrator. After logging **Factory state** submenu from the main menu have to be chosen.



The following data will be deleted:

- settings
- other media and user characteristics data base
- information about users, passwords and entitlements
- contents of all four logs
- totalisers values.

Neither will be possible to resume archiving to the current main archive file, it will be necessary to create a new file.

The information on possessed licences, serial number and calibration settings will be left.

This function is recommended to be executed before new settings programming or dawnloading to the device with unknown settings.

19. MOUNTING AND CONNECTION OF DEVICE

19.1. Mechanic installation

The flow computer FP-3000 is a device designed for panel surface mounting. It may be mounted on panels with wall thickness from 1 to 5 mm. The device should be mounted so as to avoid direct heating by other devices. It should be situated in place distant from elements with high electromagnetic disturbance emission (power relays, frequency converters). For convenient mounting of electric cables it is recommended to leave about 30 mm free space at the rear side of the device. If MMC/SD memory card removal is planned proper access to the slot at the rear panel should be provided so that the card could be freely inserted and removed. In particular this operation should not cause any electric shock risk from other elements of cabinet equipment.

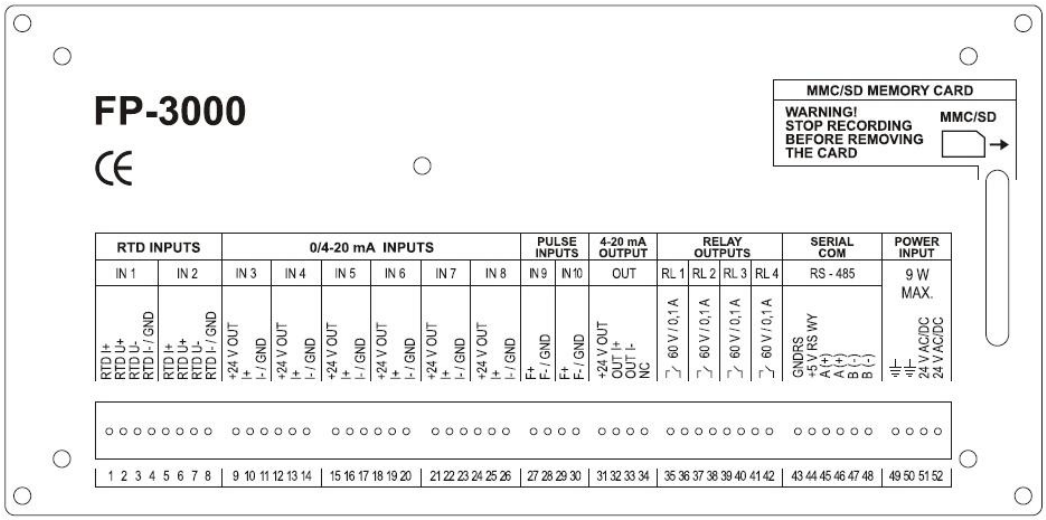
When mounting the device a seal between panel wall and the frame should be fixed. The device is mounted with latch brackets fasten on its side walls.

	FP-3000	FP-3010
Mounting cut-out in panel – width	186 $^{+1,1}$ mm	138 $^{+1}$ mm
Mounting cut-out in panel – height	92 $^{+0,6}$ mm	68 $^{+0,7}$ mm
Depth of mounting	ok. 72 mm	ok. 122 mm

19.2. Electrical connection of device

All electric circuits are connected to plugged-in terminals on the rear panel.

In FP-3000 device there are 9 terminals enabling connection of wires with up to 0.5 mm^2 cross section. In case of use of thicker field cabling it is necessary to apply an intermediate junction block in the cabinet.

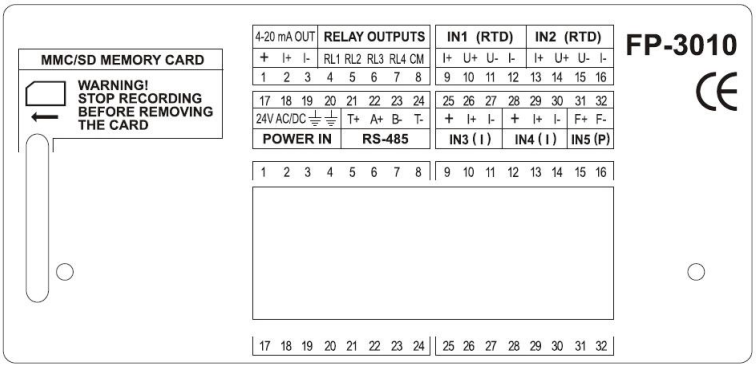


FP-3000. Rear panel drawing.

Terminal no.	FP-3000 – TERMINAL DESCRIPTION	
ANALOG INPUTS RTD (IN1,IN2)		
1	RTD I+	RTD INPUT (IN1)
2	RTD U+	
3	RTD U-	
4	RTD I- /GND	
5	RTD I+	RTD INPUT (IN2)
6	RTD U+	
7	RTD U-	
8	RTD I- /GND	
ANALOG INPUTS 0/4-20 mA (IN3..IN8)		
9	+24 V OUT	INPUT 0/4-20mA (IN3)
10	I+	
11	I- /GND	
...	X6	
24	+24 V OUT	INPUT 0/4-20mA (IN8)
25	I+	
26	I- /GND	
PULSE INPUTS (IN9..IN10)		
27	F+	BINARY / PULSE INPUT (IN9)
28	F- /GND	
29	F+	BINARY / PULSE INPUT (IN10)
30	F- /GND	
ANALOG OUTPUT 4-20 mA (option)		
31	+24 V OUT	ANALOG OUTPUT 4-20mA
32	OUT I+	
33	OUT I-	
34	NC	
RELAY OUTPUT (PK1..PK4)		
35	+/~	**RELAY OUTPUT** 60V/0,1A (RL1)
36	-/~	
...	X 4	
41	+/~	**RELAY OUTPUT** 60V/0,1A (RL4)
42	-/~	
SERIAL COM		
43	GND RS	**SERIAL PORT RS-485**
44	+5 V RS OUT	
45	A+	
46	A+	
47	B-	
48	B-	
SUPPLY		

49	PE	DEVICE SUPPLY (24 V DC/AC)
50	PE	
51	24 V AC/DC	
52	24 V AC/DC	

FP3010 device has 4 terminals allowing to connect wires with up to 1.5 mm^2 cross section.



FP-3010. Rear panel drawing.

Terminal no.	FP-3010 – TERMINALS DESCRIPTION	
OUTPUT 4-20mA (option) and RELAY OUTPUTS		
1	+ (supply output. +24V)	OUTPUT 4-20mA
2	I+	
3	I-	
4	RL1	RELAY OUTPUTS RL1 .. RL4
5	RL2	
6	RL3	
7	RL4	
8	CM (common for RL1..RL4)	
ANALOG INPUTS RTD (IN1, IN2)		
9	RTD I+	RTD INPUT (IN1)
10	RTD U+	
11	RTD U-	
12	RTD I- /GND	
13	RTD I+	RTD INPUT (IN2)
14	RTD U+	
15	RTD U-	
16	RTD I- /GND	
SUPPLY AND COM PORT		
17	+/~	SUPPLY 24 V DC/AC
18	+/~	
19	PE	
20	PE	
21	T+	SERIAL PORT RS-485
22	A+	
23	B-	

24	T-	
ANALOG INPUTS (IN3, IN4) AND PULSE INPUT (IN5)		
25	+ (supply output. +24V)	INPUT 0/4-20mA (IN3)
26	I+	
27	I- /GND	
28	+ (supply output. +24V)	INPUT 0/4-20mA (IN4)
29	I+	
30	I- /GND	
31	F+	BINARY / PULSE INPUT (IN5)
32	F- /GND	

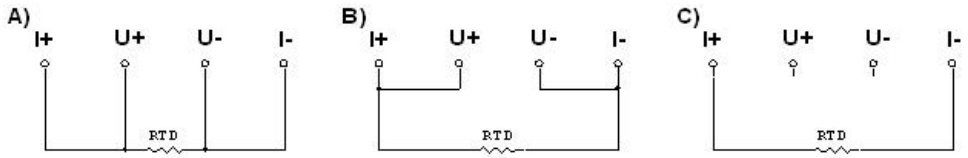
19.2.1. Power supply connection

Construction allows to supply device with AC voltage or DC stabilized or not stabilized voltage. It is recommended to supply the device from separating transformer 230 VAC / 24VAC. This type transformer for 10 VA or 30 VA is available as an accessory equipment. In case of DC voltage polarity is of no importance. The device has built in polymer fuses (requiring no service) which in the event of failure interrupt supply circuit. Few minutes after short circuit was cleared the fuses return to normal operation.

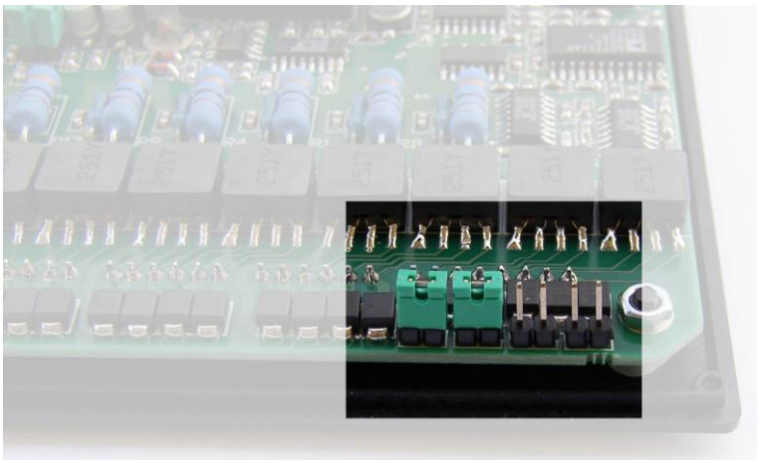
Device ground is connected to terminals marked with ⏚ symbol. Because of EMC distortion suppression it is recommended to connect this terminal to reference potential of cabinet (PE or „GND / 0 V"). In exceptional cases (old installations) when disturbance level at PE potential is high the device ground should not be connected or it should be connected via a special EMC filter. Connection of signal ground terminals (marked as GND) with ⏚ terminal will cause short circuit of the device galvanic isolation.

19.2.2. Temperature transmitters connecting (IN1 and IN2)

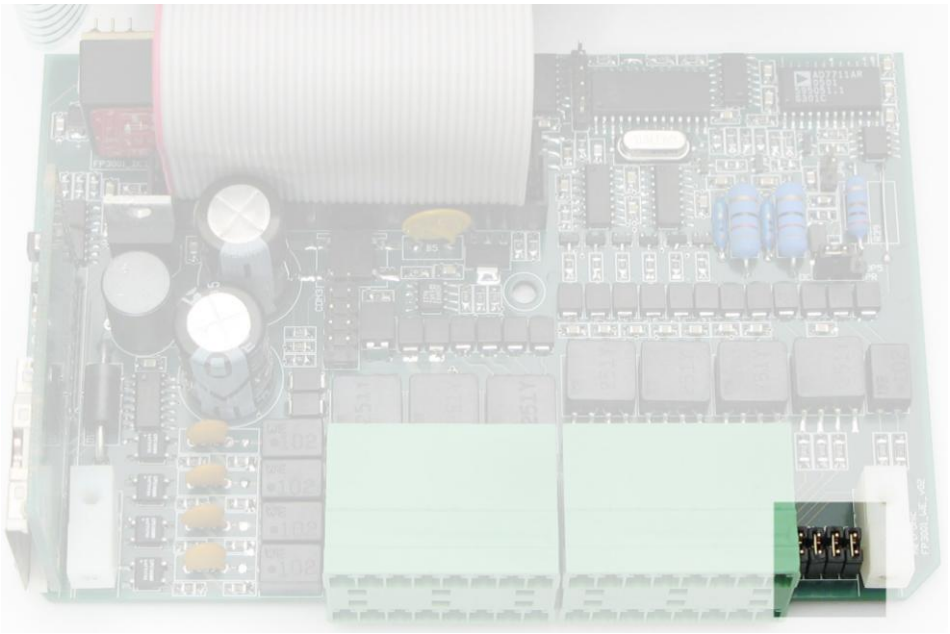
IN1 and IN2 inputs are designed for direct connection of RTD temperature sensor. To ensure high precision measurement sensors should be in 4-wire configuration. It is possible to connect sensors in 2-wire configuration but this requires to short circuit inputs RTD U+ , RTD I+ and RTD U- , RTD I- respectively. This connection may be done with jumpers inside the device. A software correction of connecting wires resistance is possible too.



FP-3000, FP-3010. RTD sensor connection
a) 4-wire connection; b) 2-wire connection ,terminals I+, U+ and I-, U- shorted outside the device; c) 2-wire connection, terminals I+, U+ and I-, U- shorted inside the device with relevant jumpers



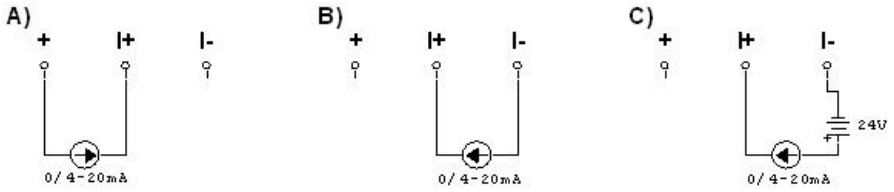
FP-3000. Jumpers for configuration of RTD 2-wire inputs (on the photo IN1 in 4-wire configuration, IN2 – 2-wire).



FP-3010. Jumpers for RTD 2-wire inputs configuration .J1 and J2 for IN1 input, J3 and J4 for IN2 input. On the photo both inputs in 2-wire configuration..

19.2.3. Analog transmitters 0/4-20mA connecting

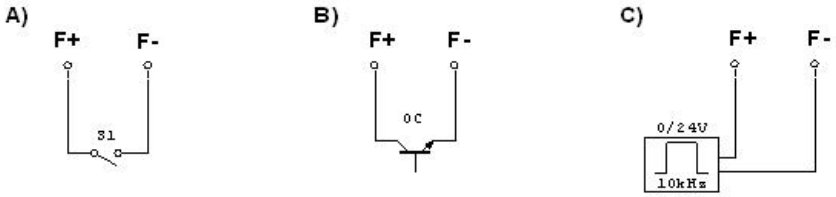
Inputs IN3 to IN8 in the FP-3000 device and respectively inputs IN3 and IN4 in the FP-3010 are designed for connection of measurement transmitters with output current loop signal 0-20mA or 4-20mA. Each of the inputs has got a +24 V output voltage terminal enabling supply of measurement transmitter loop. Voltage source supplying the transmitter loop cannot be loaded with current higher than 22 mA.



FP-3000, FP-3010. Connection of analog signals 0/4-20mA
a) transmitter supplied by the device; b) active transmitter; c) transmitter supplied by external voltage source

19.2.4. Connecting transmitters to PULS inputs

The FP-3000 device has two binary inputs: IN9 and IN10. In FP-3010 there is only one binary input IN5. Depending on the device configuration these inputs can operate as an input state detecting, pulses counting or frequency measuring.

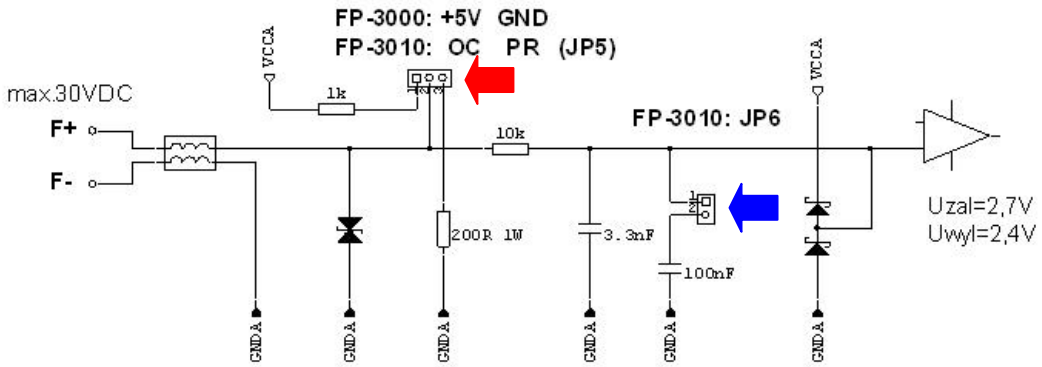


FP-3000, FP-3010. Signals connection to PULS type inputs
a) signal from the contact type transmitter - jumpers in OC (+5V) position, recommended an additional low band pass filter; b) signal from the transistor OC type transmitter – jumpers in position OC (+5V); c) signal from the active pulse transmitter – no jumpers or jumpers in PR (GND) position

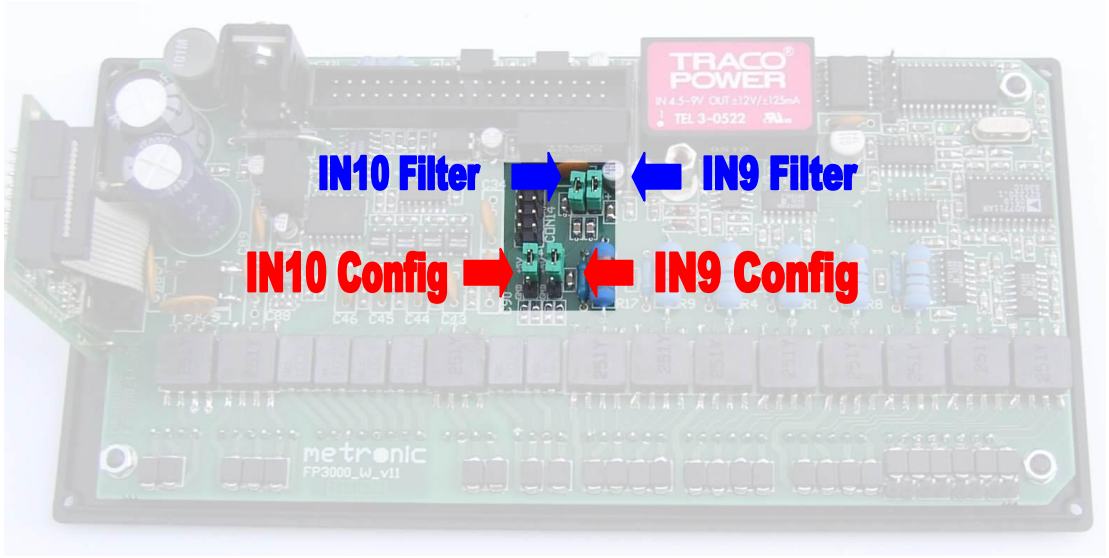
Depending on jumpers configuration inside the device signals of three types can be connected to the input:

- passive – contact or transistor OC type contact, jumper in +5V position in FP-3000 or OC in FP-3010 (factory setting),
- active current – operating with low impedance input 220Ω – jumper in GND position in FP-3000 or PR in FP-3010,
- active voltage – no jumper, high impedance input.

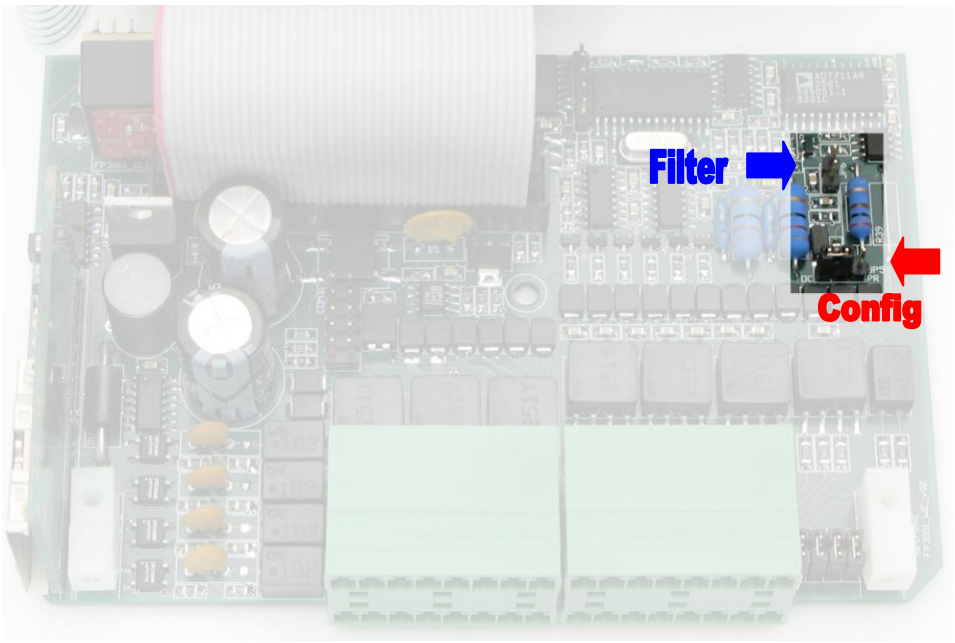
In case of contact type input voltage in open state is 5 VDC and current in short circuit condition – about 5 mA. In current input configuration activation level is above 12,3 mA and deactivation level below 11 mA. For high impedance voltage input activation level is above 2,7 V and deactivation level – below 2,4 V. Input voltage range should be from 5 to 24 VDC. For signals with frequency below 1 kHz, in particular for signals generated by a contact there should be connected an additional low pass filter. The filter is activated with a jumper inside the device (in factory configuration it is disconnected). Jumpers for inputs configuration are on inputs PCB and require disassembling the housing. It is recommended that configuration be performed by qualified technical service.



FP-3000, FP-3010. Signal forming for PULS type inputs; jumpers for configuration of signal type input and of an additional low band pass filter



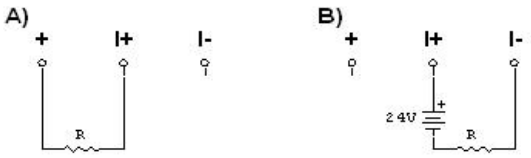
FP3000. Jumpers for binary inputs configuration (in option with analog 4-20mA output jumpers are located under the output board); jumpers situated closer to the top edge at the photo serve to switch on the filter, jumpers closer to the right edge are relevant to IN9 input.



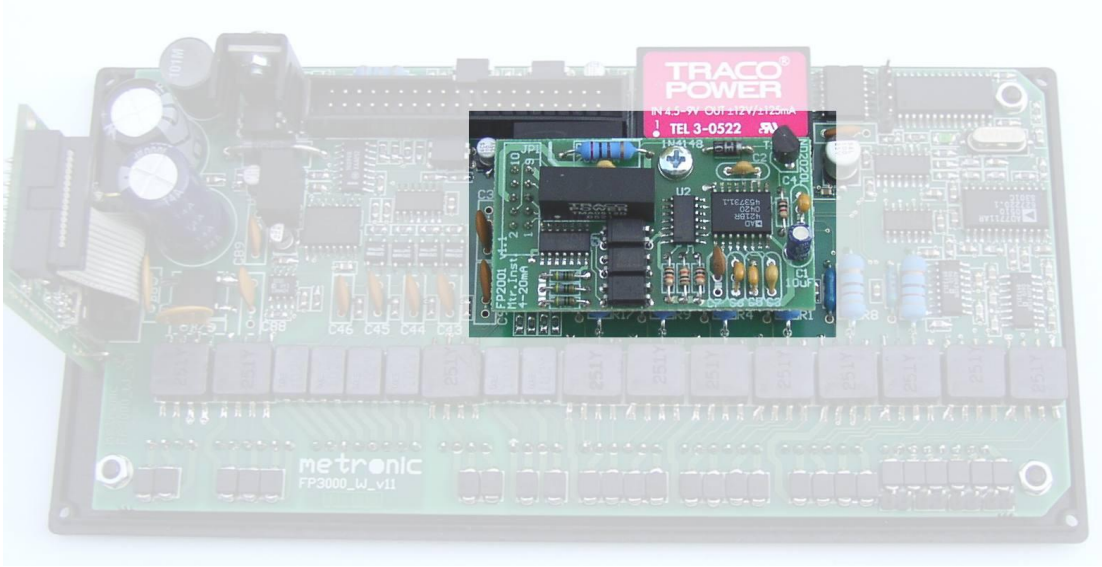
FP3010. Jumpers for binary inputs configuration. J5 - input configuration (lower at the photo), J6 – additional low pass filter (higher at the photo).

19.2.5. Connecting to analog output 4-20mA

Device may be equipped with an optional current loop 4-20mA analog output board. The current loop may be supplied from the device from the internal +24V voltage source, from external supply unit connected into circuit or supplied from the receiver (if its construction allows for that). Current output is isolated from other device circuits.



FP-3000, FP-3010. Connection of receiver to analog output 4-20mA a) current loop supplied from the device; b) current loop supplied from the external voltage source

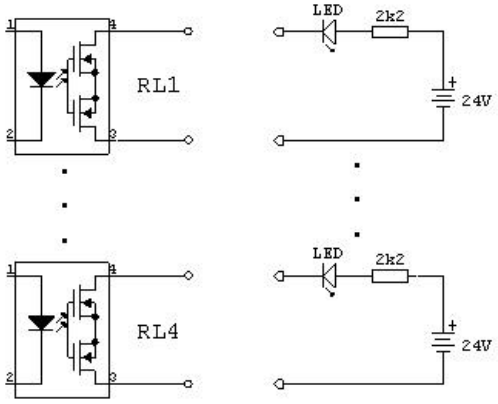


FP-3000. Analog output 4-20mA board; similarly the board is installed in FP-3010

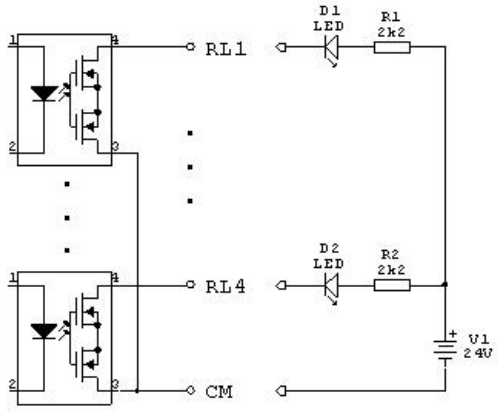
19.2.6. Connecting to relay outputs (RL1 to RL4)

Device is equipped with 4 isolated solid state relays with 100 mA / 60V DC or AC loading capability. For FP-3000 each relay is separated from each other and has two terminals. For FP-3010 the relays have one common pole marked as CM.

Solid state relays outputs are protected with series capacitor and resistor 4,7 nF and 30 Ω are designed for overvoltages suppression during inductive load switching (e.g. contactor coil). Nevertheless in case of inductive loads relevant protective elements against overvoltages should be applied (protective diode, varistor).

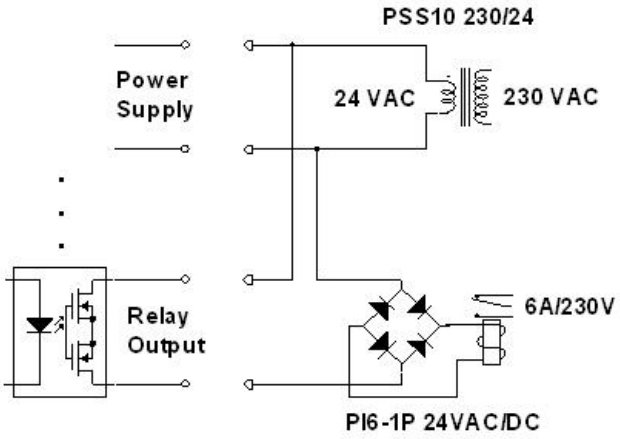


FP-3000. Output relays connection (example).



FP-3010. Output relays connection (example).

To control higher power devices an external relay should be applied (e.g. PI6-1P-24VAC/DC type manufactured by Relpol SA for loads up to 6A / 250VAC).

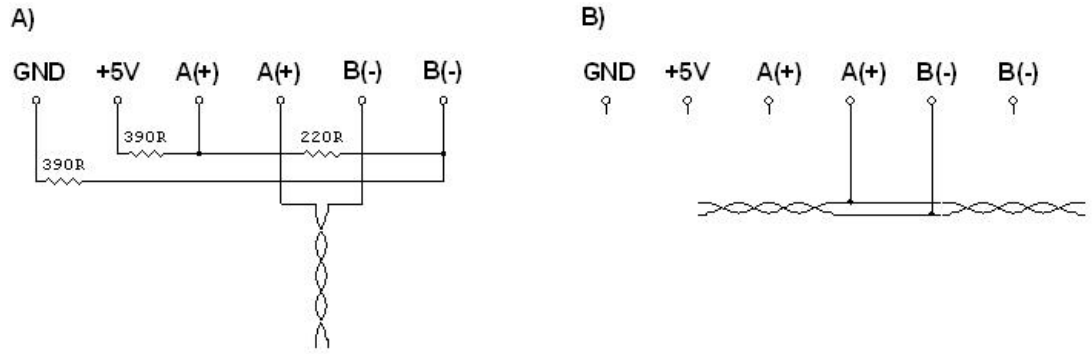


FP-3000, FP-3010. Additional external relay connection (example).

19.2.7. Connecting to communication port RS-485

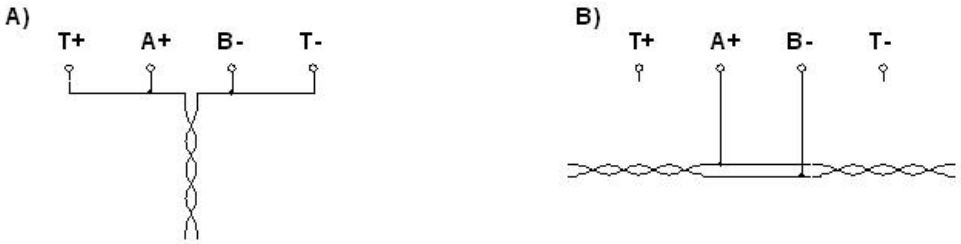
The device should be connected to RS-485 bus in parallel, the terminal marked A(+) to line A and terminal marked B(-) to line B according to rules for RS-485 systems.

In FP-3000 at the terminals there are additional lines marked „GND RS” (terminal no. 43) and „+5V” (terminal no. 44). Terminal „GND RS” may be used for connecting to reference potential or screen of data transmission cable. Double line terminals A(+) and B(-) enable easy connection of terminating resistor. However service removal of a plug from the device will cause disconnection of the resistor from the line. It may interrupt data transmission between other still operating devices. For the same reason double terminals should not be used for connection of a successive device in a chain.



FP-3000. Device connection to RS-485 bus
a) at the end of the bus with line RS-485 terminating resistors; b) between other devices connected to the bus

The FP-3010 has termination resistors build in. To activate bus termination terminals pairs of T+ and A+ (no. 21 and 22) and B- and T- (no. 23 and 24) have to be connected together. Removal of terminals plug will break termination system.



FP-3010. Device connection to RS-485 bus
a) at the end of the bus using internal termination resistors; b) between other equipment connected to the bus

RS-485 bus cannot in a star topology. Devices should be connected successively, only ends of RS-485 highway should be terminated with resistors matched to the line impedance. In field conditions it is obligatory to use a twisted pair cable, best with a screen. The screen should be grounded or connected with reference potential. RS-485 standard permits to connect up to 32 devices at maximum line length of 1200 m.

RS-485 interface system is isolated from other device circuits.

19.3. MMC/SD memory card installation

MMC/SD card slot is at the device rear panel. This localization prevents against unauthorized persons access. A card is inserted to the socket slot according to the drawing at the device housing. After installation the card should protrude about 9 mm. At the device front panel there is a LED diode marked MMC/SD. When it is lit green it means that archiving is on and the card must not be removed from the slot. Card removal while recording may cause a risk of data lost. To remove the card archiving should be stopped. However it is not necessary or recommended to turn off device supply for MMC/SD card insertion or removal.

Memory card is a delicate element. It should be handled and kept with care. Electric contacts should be clean.

FP-3010. MMC/SD card socket;
Socket in FP-3010 is situated similarly.

20. TECHNICAL DATA

User interface, front panel	
Display	Graphic LCD 160x80 points, backlight LED white, readout field 66 mm x 35 mm
LED signal diodes	3 two-colour, green-red
Keyboard	7 membrane buttons
Analog inputs RTD	
Number of inputs	FP-3000: 2 electronically multiplexed FP-3010: 2 electronically multiplexed
Sensor type	Pt-100 x K, Ni-100 x K (K = 1..11) K – multiplier, e.g..: for Pt-200 K = 2
Measuring range	-200 .. +850 °C for Pt100 x K -60 .. +150 °C for Ni100 x K
Sensor connection	2- or 4-wires
Leads resistance compensation	Constant within range -99.99 Ω - +99.99 Ω
Maximum resistance of connecting leads	50 Ω
A/C converter resolution	18 bits
Accuracy (for T_a = +20 °C)	± 0,5 °C (typical ± 0,3 °C)
Temperature drift	Max ± 0,02 °C / °C
Galvanic isolation between inputs	No, common potential GND for all inputs
Galvanic isolation to supply voltage	400 VAC
Analog inputs 0/4-20 mA	
Number of inputs	FP-3000: 6 electronically multiplexed FP-3010: 2 electronically multiplexed
Signal type	0-20mA (0 – 22 mA) or 4-20mA (3,6 – 22 mA)
Transmitter connection	Passive (supplied from measuring loop) or active converter (field supplied or from FP-3000 supply unit)
Input resistance	100 Ω ±10%
Transmitters supply	24 V DC / max 22 mA (FP-3000: total current max 0,125 A for all inputs IN3 .. IN8)
A/C converter resolution	18 bits
Accuracy (T_a = 20 °C)	±0,1% of the range (typical ±0,05% of the range)
Temperature drift	Max ±50 ppm / °C
Galvanic isolation between inputs	No, common potential GND for all inputs
Galvanic isolation to supply voltage	400 VAC

Binary / pulse inputs	
Number of inputs	FP-3000: 2 FP-3010: 1
Maximum input voltage	±28 VDC
Galvanic isolation between inputs	No, common potential GND for all inputs
Galvanic isolation to supply voltage	400 VAC
Frequency measurement	
Measurement range	0,001 Hz to 10 kHz (0,001 Hz to 1 kHz with connected filtering capacitor)
Minimum pulse width	20 μs (0,5 ms with connected filtering capacitor)
Accuracy (T_a = 20 °C)	0,02%
Configuration: OC/contact	**Jumper in OC position**
Open contact voltage	+5 V
Short circuit current	5 mA
Configuration: current input	**Jumper in PR position**
Input resistance	220 Ω
ON / OFF threshold	Approx. 12,3 mA / 11 mA
Configuration: voltage input	**No jumper**
Input resistance	>10 kΩ
ON / OFF threshold	2,7 V / 2,4 V
Compensated flow and heat energy measurement	
Accuracy of compensated steam, water, other liquid or technical gas flow	< 2% (typical < 0,5%)
Measurement and values computation interval	1 s
Analog outputs 4-20 mA (option)	
Number of outputs	FP-3000: 1 FP-3010: 1
Output signal	4-20mA (3,6 – 22 mA)
Maximum voltage between I+ and I-	28 VDC
Loop resistance (for U_{cc} = 24 V)	0 .. 500 Ω
Converter resolution C/A	16 bits
Accuracy	0,1% of the range
Current loop supply	External or from internal supply unit 24 V DC / 22 mA
Galvanic isolation to supply voltage	400 VAC

Relay outputs	
Number of outputs	FP-3000: 4, with galvanic isolation FP-3010: 4, one common terminal
Outputs type	Solid state relay
Maximum load current	100 mA DC/AC
Maximum voltage	60 V DC/AC
Galvanic isolation	400 VAC
Serial port RS-485	
Maximum load	32 receivers / transmitters
Maximum line length	1200 m
Maximum differential voltage A(+) – B(-)	±14 V
Maximum total voltage A(+) – „ground" or B(-) – „ground"	-7 .. +12 V
Transmitter minimum output signal	1,5 V (at R_0 = 27 Ω)
Receiver minimum sensitivity	200 mV / R_{WE} = 12 kΩ
Data transmission line minimum impedance	27 Ω
Termination resistors internal system	FP-3000: no FP-3010: yes, activated with jumpers
Short circuit/ thermal overload protection	yes
Transmission protocol	Modbus RTU (current readout and totalisers) ASCII
Transmission speed	1.2, 2.4, 4.8, 9.6 ,19.2, 38.4, 57.6, 115.2 kbps
Parity control	Even, Odd, None
Frame	1 start bit, 8 data bits, 1stop bit
Galvanic isolation	400 VAC
Archiving, MMC/SD card	
Type of memory card	MMC / RS-MMC / SD NOTE: only cards tested by manufacturer guarantee correct recording
Card capacity	32 MB .. 2 GB
Approximate recording time interval at 3s for 16 process values	Approx. 31 days for 128MB card Approx. 7 days for 32MB card
Recording format	Text file, FAT16
MMC card socket	According to MMC/SD standard, without ejector
Supply	
Supply voltage	24 VAC (15 .. 26,5 VAC) or

	24 VDC (15 .. 35 VDC)
Power consumption	Max 9 VA / 9 W
Dimensions – housing	
Housing type	For panel surface, nonflammable plastic material „Noryl”
Dimensions (height x width x depth)	FP-3000: 96 mm x 192 mm x 63,5 mm FP-3010: 72 mm x 144 mm x 130 mm
Housing depth with terminals (without extra space for cables)	FP-3000: approx. 72 mm FP-3010: approx. 122 mm
Panel cut-out dimensions	FP-3000: 186 $^{+1,1}$ mm X 92 $^{+0,6}$ mm FP-3010: 138 $^{+1}$ mm X 68 $^{+0,7}$ mm
Panel maximum thickness	5 mm
Mass	FP-3000: ca. 0,7 kg FP-3010: ca. 0,5 kg
Protection class from the front panel	IP-54
Protection class from the rear panel	IP-30
Climate conditions	
Ambient temperature	0 .. +50 °C
Relative humidity	0 .. 75% (without steam condensation)
Storage temperature	-20 .. +80 °C

21. COMPLETE DELIVERY AND ACCESSORIES

21.1. A complete delivery of flow computer consists of:

- Flow computer FP-3000 -x-y / FP-3010 -x-y 1 pcs.
- This operating manual 1 pcs.
- CD with operating manual and software 1 pcs.

21.2. Accessories

- Conv 485USB-I (USB to RS-485 Converter with galvanic isolation)
- Conv 485USB (service USB to RS-485 Converter, no galvanic isolation)
- Conv 485E (Ethernet to RS-485 Converter)
- FP-3000-RAPORT.EXE (software for archived data reporting)
- FP-3000-PMU.EXE
- 2 GB SD Memory Card (manufactured by SanDisk)
- SD Memory Card Reader (manufactured by SanDisk)
- PSS 10 VA, 230 V AC / 24 V AC (Power supply transformer, manufactured by Breve)
- PSS 30 VA, 230 V AC / 24 V AC (Power supply transformer, manufactured by Breve)
- PI6-1P-24VAC/DC (Extension output relay for 6A/230V AC, manufactured by Relpol SA)

CONV485USB-I, CONV485USB, CONV485E

PSS30 230V /24V and PSS10 230V/24V (manufactured by BREVE)
PI6-1P 24VAC/DC (manufactured by Relpol SA)

22. Entity launching the product on European Union market:

Manufacturer METRONIC Aparatura Kontrolno – Pomiarowa
31-261 Kraków, ul. Wybickiego 7
Tel / fax +48 12 6326977,+48 12 6237599
www.metronic.pl

Notes:

A. Modbus RTU protocol

Modbus RTU protocol allows for readout only of process values and totalisers. Readout uses 04 function – Read Input Register, registers with addresses starting with 3xxxx. To simplify notation in the further part only registers addresses in decimal notation are used and not their full name (3xxxx) corresponding to MODBUS protocol.

A.1. Serial transmission parameters and general information

- Operation mode: Modbus RTU
- Address: 001 (001, .. , 099)
- Speed: 9600 (1200, .. , 115,2k)
- Parity EVEN (NONE, ODD, EVEN)
- Response delay (min): 50ms (10, 20, 30, 50, 70, 100, 150, 200,300, 400ms).

Transmission parameters do not allow to set maximum time („Response delay (max):") because in Modbus RTU mode response to a command is sent immediately. The maximum delay is not more than few ms.
According to MODBUS standard in RTU mode a frame (transmitted information) is as follows:

Start	Address	Function	Data	CRC control	End
T1 ... T4	1 byte	1 byte	n bytes	2 bytes	T1 ... T4

Information transmitted from the master computer to the device is a query whereas the device sends a response.
The FP-3000 device accepts 04 command – process values readout function (current process values and totalisers).

Readout function (query) has a form:

Address (1B)	Function (1B)	Initial address (2B)	Number of registers (2B)	CRC (2B)

Address – an address of a device (1 to 99)
Function – 04 HEX – process values and totalisers readout (input registers)
Initial address - an address of a device from which data are to be sent
Number of registers – two-byte registers for readout
CRC – control value corresponding to Modbus standard

In response the device transmits a sequence of characters in form of:

Address (1B)	Function (1B)	Number of bytes (1B)	Data sequence (nB)	CRC (2B)

Address – acknowledge
Function – acknowledge, in case of error 80 HEX value is added on to the command code
Number of bytes – n bytes transmitted in response (but not number of registers)

Data sequence – n bytes of register contents
CRC – control value corresponding to Modbus standard

A.2. Process values (main and auxiliary values) – register addresses

Process values are available in floating point format.
The following table contains register addresses for main values.

Designation of system types:

W	the flow and heat of a liquid
W-W (closed)	the flow and delta heat of a liquid in a closed supply-return installation
W-W (different)	the flows and delta heat of a liquid in an installation with separate supply and return flowrates
S	the flow and heat of steam
SS-W (up to cond.)	the flow and delta heat in a closed superheated steam-condensate installation (steam condensation without further condensate cooling)
ST.S(p)-W (up to cond.)	the flows and delta heat in a closed saturated steam-condensate installation (steam condensation without further condensate cooling, pressure measurement)
ST.S(T)-W (up to cond.)	the flows and delta heat in a closed saturated steam-condensate installation (steam condensation without further condensate cooling, temperature measurement)
SS-W (closed)	the flow and delta heat in a closed superheated steam-condensate installation
ST.S(p)-W (closed)	the flows and delta heat in a closed saturated steam-condensate installation (pressure measurement)
ST.S(T)-W (closed)	the flows and delta heat in a closed saturated steam-condensate installation (temperature measurement)
SS-W (different)	the flows and delta heat in a superheated steam-condensate installation with separate steam and condensate flow rates
ST.S(p)-W (different)	the flows and delta heat in a saturated steam-condensate installation with separate steam and condensate flow rates (pressure measurement)
ST.S(T)-W (different)	the flows and delta heat in a saturated steam-condensate installation with separate steam and condensate flow rates (temperature measurement)
S production	the flow and delta heat in a steam-generating installation with the supplied water flowrate measured
G	the flow of a gas

Explanations:

1. In brackets there are given values which appear only in some configurations
2. If water and steam pressures are equal the common pressure is marked with symbol p (or p_c). If only steam pressure is measured and water pressure is constant, then steam pressure is marked with symbol p^D (or p_c^D).
3. Upper index; D- means steam, W- water, S- supply, R – return (upper and lower indices are displayed one below another)

Designation of main and auxiliary values:

P – heat flowrate
q_v / q_m – volumetric / mass flowrate
p / p_c / Δp – pressure / pressure in saturation conditions / delta pressure (in differential pressure measurement)
T/ T_c / ΔT – temperature / temperature in saturation conditions / temperature difference
ρ – specific density
h – enthalpy
k – thermal coefficient of water

Register addresses for main values

Type of installation															Register addresses (in decimal format)		
W	W-W (closed)	W-W (different)	S	SS-W (up to cond.)	ST.S(p)-W (up to cond.)	ST.S(T)-W (up to cond.)	SS-W (closed)	ST.S(p)-W (closed)	ST.S(T)-W (closed)	SS-W (different)	ST.S(p)-W (different)	ST.S(T)-W (different)	S production	G			
Main values															**Application A**	**Application B**	**Application C**
	P	P		P	P	P	P	P	P	P	P	P	P		0, 1	52, 53	104, 105
P^W			P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	q^G	2, 3	54, 55	106, 107
$q_m{}^W$	q_m	$q_m{}^S$	$q_m{}^D$	q_m	q_m	q_m	q_m	q_m	q_m	$q_m{}^D$	$q_m{}^D$	$q_m{}^D$	q_m	$q_m{}^G$	4, 5	56, 57	108, 109
$q_V{}^W$	$q_V{}^S$	$q_V{}^S$	$q_v{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_V{}^D$	$q_v{}^G$	6, 7	58, 59	110, 111
(p^W)	(p)	(p)	p^D	p	p	p_c	$p^{(D)}$	$p^{(D)}$	$p_c{}^{(D)}$	$p^{(D)}$	$p^{(D)}$	$p_c{}^{(D)}$	$p^{(D)}$	(p^G)	8, 9	60, 61	112, 113
T^W	T^S	T^S	T^D	T^D	T_c	T	T^D	$T_c{}^D$	T^D	T^D	$T_c{}^D$	T^D	T^D	(T^G)	10, 11	62, 63	114, 115
ρ^W	ρ^S	ρ^S	ρ^D	ρ^D	ρ^D	ρ^D	ρ^D	ρ^D	ρ^D	ρ^D	ρ^D	ρ^D	ρ^D	ρ^G	12, 13	64, 65	116, 117
h^W	h^S	h^S	h^D	h^D	h^D	h^D	h^D	h^D	h^D	h^D	h^D	h^D	h^D		14, 15	66, 67	118, 119
(Δp^W)	(Δp^S)	(Δp^S)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^D)	(Δp^G)	16, 17	68, 69	120, 121
				P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W		18, 19	70, 71	122, 123
		$q_m{}^R$								$q_m{}^W$	$q_m{}^W$	$q_m{}^W$			20, 21	72, 73	124, 125
	$q_V{}^R$	$q_V{}^R$		$q_V{}^W$	$q_V{}^W$	$q_V{}^W$	$q_V{}^W$	$q_V{}^W$	$q_V{}^W$	$q_V{}^W$	$q_V{}^W$	$q_V{}^W$	$q_V{}^W$		22, 23	74, 75	126, 127
	T^R	T^R		$T_c{}^P$			T^W	T^W	T^W	T^W	T^W	T^W	T^W		24, 25	76, 77	128, 129
	ρ^R	ρ^R		ρ^W	ρ^W	ρ^W	ρ^W	ρ^W	ρ^W	ρ^W	ρ^W	ρ^W	ρ^W		26, 27	78, 79	130, 131
	h^R	h^R		h^W	h^W	h^W	h^W	h^W	h^W	h^W	h^W	h^W	h^W		28, 29	80, 81	132, 133
	(Δp^R)	(Δp^R)		(Δp^W)	(Δp^W)	(Δp^W)	(Δp^W)	(Δp^W)	(Δp^W)	(Δp^W)	(Δp^W)	(Δp^W)			30, 31	82, 83	134, 135
	ΔT	ΔT													32, 33	84, 85	136, 137
	(k^S, k^R)														34, 35	86, 87	138, 139

The following table contains register addresses for auxiliary values. Auxiliary values are in sequence as they were entered during set up of the device.

Auxiliary values	Register addresses (in decimal format)					
	Application A	Application B	Application C	Application X	Application Y	Application Z
1	36, 37	88, 89	140, 141	156, 157	172, 173	188, 189
2	38, 39	90, 91	142, 143	158, 159	174, 175	190, 191
3	40, 41	92, 93	144, 145	160, 161	176, 177	192, 193
4	42, 43	94, 95	146, 147	162, 163	178, 179	194, 195
5	44, 45	96, 97	148, 149	164, 165	180, 181	196, 197
6	46, 47	98, 99	150, 151	166, 167	182, 183	198, 199
7	48, 49	100, 101	152, 153	168, 169	184, 185	200, 201
8	50, 51	102, 103	154, 155	170, 171	186, 187	202, 203

A.2.1. Process value format.

All process values (main values and auxiliary values) are in floating point format requiring two Modbus RTU registers (4 bytes) according to IEEE-754 standard for 32-bit numbers.

IEEE-754 standard for 32-bit floating point single number of single precision :

Address register	e.g.: 0001 (hex)				e.g.: 0000 (hex)	
Byte	4		3		2	1
Bit	31	30..24	23	22..16	15..08	07..00
IEEE-754	S	E (8b)		M (23b, only fraction part)		

where:

- M (mantissa): is a normalized value within the interval [1;2)- right side open interval. Only fraction part of mantissa is noted (e.g. for binary number 1,1011101 mantissa equals to 1011101, more precisely in notation on 23 bits: 10111010000000000000000).
- E (exponent): exponent value is shifted by 127 (bias)
- S (sign): 0 – positive number, 1 – negative number.

The number value can be calculated from the formula:

$$x = (-1)^S * M * 2^{(E-bias)} \quad ; \text{where bias: } 127$$

For example a sequence of response characters (HEX):

01 04 04 **9E E4 43 1C** A4 A2 (read from the device)

- acknowledgment of an address (01) and function (04), number of bytes (04),
- value 9E E4 43 1C, in sequence register 0000 and 0001,
- CRC (A4 A2).

Presenting the value in appropriate sequence (0001 and 0000): 43 1C 9E E4

and in binary form:

01000011 00011100 10011110 11100100

one can read

- mantissa: 1,0011100 10011110 11100100 (in decimal notation: approx. 1,22265625)
- exponent: 10000110 – 01111111 = 00000111 (in decimal notation: 7)
- sign: 0

what gives a decimal result: $(-1)^0 * 1{,}22265625 * 2^7 = 156{,}5$

A.3. Totalisers

For each flowrate or heat flowrate value up to 4 totalisers may be active:

- main totaliser (Σ_1),
- auxiliary totaliser (Σ_2),
- overrange totaliser (Σ_H),
- underrange totaliser (Σ_L).

Totalisers are available in two formats: floating point and integer number.

NOTE!
Totalisers values in Modbus RTU registers are updated every 5 sec.

A.3.1. Register addresses for totalisers in floating point format

Each totaliser value is 4 registers long (8 bytes).

The following table contains register addresses for totalisers of the main values.

NOTE!
Symbols established in following table corresponds with the table in section A.2.

Register addresses for totalisers of the main values (in 64-bit floating point double format).

Type of installation															Totaliser type	Register addresses (in decimal format)		
W	W-W (closed)	W-W (different)	S	SS-W (up to cond.)	ST.S(p)-W (up to cond.)	ST.S(T)-W (up to cond.)	SS-W (closed)	ST.S(p)-W (closed)	ST.S(T)-W (closed)	SS-W (different)	ST.S(p)-W (different)	ST.S(T)-W (different)	S production	G		Application A	Application B	Application C
Main values																		
	P	P		P	P	P	P	P	P	P	P	P	P		1	256...259	496...499	736...739
															2	260...263	500...503	740...743
															H	264...267	504...507	744...747
															L	268...271	508...511	748...751
P^W			P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	q^G	1	272...275	512...515	752...755
															2	276...279	516...519	756...759
															H	280...283	520...523	760...763
															L	284...287	524...527	764...767
q_m^W	q_m	q_m^S	q_m^D	q_m	q_m	q_m	q_m	q_m	q_m	q_m^D	q_m^D	q_m^D	q_m	q_m^G	1	288...291	528...531	768...771
															2	292...295	532...535	772...775
															H	296...299	536...539	776...779
															L	300...303	540...543	780...783
q_V^W	q_V^S	q_V^S	q_v^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_v^G	1	304...307	544...547	784...787
															2	308...311	548...551	788...791
															H	312...315	552...555	792...795
															L	316...319	556...559	796...799
				P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W		1	320...323	560...563	800...803
															2	324...327	564...567	804...807
															H	328...331	568...571	808...811
															L	332...335	572...575	812...815
		q_m^R								q_m^W	q_m^W	q_m^W			1	336...339	576...579	816...819
															2	340...343	580...583	820...823
															H	344...347	584...587	824...827
															L	348...351	588...591	828...831
	q_V^R	q_V^R		q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W		1	352...355	592...595	832...835
															2	356...359	596...599	836...839
															H	360...363	600...603	840...843
															L	364...367	604...607	844...847

The following table contains register addresses for totalisers of the auxiliary values. Auxiliary values, as well as their totalisers are in sequence as they were entered during set up of the device.

Register addresses for totalisers of auxiliary values (in 64-bit floating point double format).

Auxiliary values	Totaliser type	Register addresses (in decimal format)					
		Application A	Application B	Application C	Application X	Application Y	Application Z
1	1	368...371	608...611	848...851	976...979	1104…1107	1232…1235
	2	372...375	612...615	852...855	980...983	1108…1111	1236…1239
	H	376...379	616...619	856...859	984...987	1112…1115	1239…1242
	L	380...383	620...623	860...863	988...991	1116…1119	1242…1245
2	1	384...387	624...627	864...867	992...995	1120…1123	1245…1248
	2	388...391	628...631	868...871	996...999	1124…1127	1248…1251
	H	392...395	632...635	872...875	1000...1003	1128…1131	1251…1254
	L	396...399	636...639	876...879	1004...1007	1132…1135	1254…1257
3	1	400...403	640...643	880...883	1008...1011	1136…1139	1257…1260
	2	404...407	644...647	884...887	1012...1015	1140…1143	1260…1263
	H	408...411	648...651	888...891	1016...1019	1144…1147	1263…1266
	L	412...415	652...655	892...895	1020...1023	1148…1151	1266…1269
4	1	416...419	656...659	896...899	1024...1027	1152…1155	1269…1272
	2	420...423	660...663	900...903	1028...1031	1156…1159	1272…1275
	H	424...427	664...667	904...907	1032...1035	1160…1163	1275…1278
	L	428...431	668...671	908...911	1036...1039	1164…1167	1278…1281
5	1	432...435	672...675	912...915	1040...1043	1168…1171	1281…1284
	2	436...439	676...679	916...919	1044...1047	1172…1175	1284…1287
	H	440...443	680...683	920...923	1048...1051	1176…1179	1287…1290
	L	444...447	684...687	924...927	1052...1055	1180…1183	1290…1293
6	1	448...451	688...691	928...931	1056...1059	1184…1187	1293…1296
	2	452...455	692...695	932...935	1060...1063	1188…1191	1296…1299
	H	456...459	696...699	936...939	1064...1067	1192…1195	1299…1302
	L	460...463	700...703	940...943	1068...1071	1196…1199	1302…1305
7	1	464...467	704...707	944...947	1072...1075	1200…1203	1305…1308
	2	468...471	708...711	948...951	1076...1079	1204…1207	1308…1311
	H	472...475	712...715	952...955	1080...1083	1208…1211	1311…1314
	L	476...479	716...719	956...959	1084...1087	1212…1215	1314…1317
8	1	480...483	720...723	960...963	1088...1091	1216…1219	1317…1320
	2	484...487	724...727	964...967	1092...1095	1220…1223	1320…1323
	H	488...491	728...731	968...971	1096...1099	1224…1227	1323…1326
	L	492...495	732...735	972...975	1100...1103	1228…1231	1326…1329

A.3.2. Floating point format for totalisers

According to IEEE-754 standard for 64-bit floating point double (8 byte value or 4 register in Modbus RTU):

Register address	e.g.: 0213 (hex)				e.g.: 0212 (hex)		e.g.: 0211 (hex)		e.g.: 0210 (hex)	
Byte	8		7		6	5	4	3	2	1
Bit	63	62..56	55..52	51..48	47..40	39..32	31..24	23..16	15..8	7..0
IEEE	S	E (11b)		M (52b, fraction part only)						

Where:

- M (mantissa): is a normalized value within the interval [1;2)- right side open interval. Only fraction part of mantissa is noted

- E (exponent): exponent value is biased by 1023 (bias).
- S (character): 0 – positive number, 1 – negative number

The number value can be calculated from the formula:

$$x = (-1)^S * M * 2^{(E-bias)}$$

where bias: 1023

A.3.3. Register addresses for totalisers in integer format

The totaliser values are also available in double integer (4 byte) format. Only not rounded integer part of the totaliser value is available in this format in range from –999 999 999 to 999 999 999.

Each totaliser value is 2 registers long (4 bytes).

The following table contains register addresses for totalisers of the main values.

NOTE!
Symbols established in following table corresponds with the table in caption A.2.

Register addresses for totalisers of the main values (in integer format).

Type of installation															Totaliser type	Register addresses (in decimal format)		
W			S	SS-W (up to cond.)	ST.S(p)-W (up to cond.)	ST.S(T)-W (up to cond.)	SS-W (closed)	ST.S(p)-W (closed)	ST.S(T)-W (closed)	SS-W (different)	ST.S(p)-W (different)	ST.S(T)-W (different)	S production	G				
Main values																Application A	Application B	Application C
	P	P		P	P	P	P	P	P	P	P	P	P		1	1408, 1409	1528, 1529	1648, 1649
															2	1410, 1411	1530, 1531	1650, 1651
															H	1412, 1413	1532, 1533	1652, 1653
															L	1414, 1415	1534, 1535	1654, 1655
P^W			P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	P^D	q^G	1	1416, 1417	1536, 1537	1656, 1657
															2	1418, 1419	1538, 1539	1658, 1659
															H	1420, 1421	1540, 1541	1660, 1661
															L	1422, 1423	1542, 1543	1662, 1663
q_m^W	q_m	q_m^S	q_m^D	q_m	q_m	q_m	q_m	q_m	q_m	q_m^D	q_m^D	q_m^D	q_m	q_m^G	1	1424, 1425	1544, 1545	1664, 1665
															2	1426, 1427	1546, 1547	1666, 1667
															H	1428, 1429	1548, 1549	1668, 1669
															L	1430, 1431	1550, 1551	1670, 1671
q_V^W	q_V^S	q_V^S	q_v^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_V^D	q_v^G	1	1432, 1433	1552, 1553	1672, 1673
															2	1434, 1435	1554, 1555	1674, 1675
															H	1436, 1437	1556, 1557	1676, 1677
															L	1438, 1439	1558, 1559	1678, 1679
				P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W	P^W		1	1440, 1441	1560, 1561	1680, 1681
															2	1442, 1443	1562, 1563	1682, 1683
															H	1444, 1445	1564, 1565	1684, 1685
															L	1446, 1447	1566, 1567	1686, 1687
		q_m^R								q_m^W	q_m^W	q_m^W			1	1448, 1449	1568, 1569	1688, 1689
															2	1450, 1451	1570, 1571	1690, 1691
															H	1452, 1453	1572, 1573	1692, 1693
															L	1454, 1455	1574, 1575	1694, 1695
	q_V^R	q_V^R		q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W	q_V^W		1	1456, 1457	1576, 1577	1696, 1697
															2	1458, 1459	1578, 1579	1698, 1699
															H	1460, 1461	1580, 1581	1700, 1701
															L	1462, 1463	1582, 1583	1702, 1703

The following table contains register addresses for totalisers of the auxiliary values. Auxiliary values, as well as their totalisers are in sequence as they were entered during set up of the device.

Register addresses for totalisers of the auxiliary values (in integer format)

Auxiliary values	Totaliser type	Register addresses (in decimal format)					
		Application A	Application B	Application C	Application X	Application Y	Application Z
1	1	1464, 1465	1584, 1585	1704, 1705	1768, 1769	1832, 1833	1896, 1897
	2	1466, 1467	1586, 1587	1706, 1707	1770, 1771	1834, 1835	1898, 1899
	H	1468, 1469	1588, 1589	1708, 1709	1772, 1773	1836, 1837	1900, 1901
	L	1470, 1471	1590, 1591	1710, 1711	1774, 1775	1838, 1839	1902, 1903
2	1	1472, 1473	1592, 1593	1712, 1713	1776, 1777	1840, 1841	1904, 1905
	2	1474, 1475	1594, 1595	1714, 1715	1778, 1779	1842, 1843	1906, 1907
	H	1476, 1477	1596, 1597	1716, 1717	1780, 1781	1844, 1845	1908, 1909
	L	1478, 1479	1598, 1599	1718, 1719	1782, 1783	1846, 1847	1910, 1911
3	1	1480, 1481	1600, 1601	1720, 1721	1784, 1785	1848, 1849	1912, 1913
	2	1482, 1483	1602, 1603	1722, 1723	1786, 1787	1850, 1851	1914, 1915
	H	1484, 1485	1604, 1605	1724, 1725	1788, 1789	1852, 1853	1916, 1917
	L	1486, 1487	1606, 1607	1726, 1727	1790, 1791	1854, 1855	1918, 1919
4	1	1488, 1489	1608, 1609	1728, 1729	1792, 1793	1856, 1857	1920, 1921
	2	1490, 1491	1610, 1611	1730, 1731	1794, 1795	1858, 1859	1922, 1923
	H	1492, 1493	1612, 1613	1732, 1733	1796, 1797	1860, 1861	1924, 1925
	L	1494, 1495	1614, 1615	1734, 1735	1798, 1799	1862, 1863	1926, 1927
5	1	1496, 1497	1616, 1617	1736, 1737	1800, 1801	1864, 1865	1928, 1929
	2	1498, 1499	1618, 1619	1738, 1739	1802, 1803	1866, 1867	1930, 1931
	H	1500, 1501	1620, 1621	1740, 1741	1804, 1805	1868, 1869	1932, 1933
	L	1502, 1503	1622, 1623	1742, 1743	1806, 1807	1870, 1871	1934, 1935
6	1	1504, 1505	1624, 1625	1744, 1745	1808, 1809	1872, 1873	1936, 1937
	2	1506, 1507	1626, 1627	1746, 1747	1810, 1811	1874, 1875	1938, 1939
	H	1508, 1509	1628, 1629	1748, 1749	1812, 1813	1876, 1877	1940, 1941
	L	1510, 1511	1630, 1631	1750, 1751	1814, 1815	1878, 1879	1942, 1943
7	1	1512, 1513	1632, 1633	1752, 1753	1816, 1817	1880, 1881	1944, 1945
	2	1514, 1515	1634, 1635	1754, 1755	1818, 1819	1882, 1883	1946, 1947
	H	1516, 1517	1636, 1637	1756, 1757	1820, 1821	1884, 1885	1948, 1949
	L	1518, 1519	1638, 1639	1758, 1759	1822, 1823	1886, 1887	1950, 1951
8	1	1520, 1521	1640, 1641	1760, 1761	1824, 1825	1888, 1889	1952, 1953
	2	1522, 1523	1642, 1643	1762, 1763	1826, 1827	1890, 1891	1954, 1955
	H	1524, 1525	1644, 1645	1764, 1765	1828, 1829	1892, 1893	1956, 1957
	L	1526, 1527	1646, 1647	1766, 1767	1830, 1831	1894, 1895	1958, 1959

A.4. Error code

If error massage is sand as a response a value of 80 (hex) added on to the command code value.
Error codes possible for the device are:

- 01 HEX – incorrect function (in case of diagnostics also impermissible subfunction),
- 02 HEX – incorrect initial address,
- 03 HEX – incorrect number of points.

Queries are not confirmed by a response in case of:

- parity error,
- CRC errors,
- address error.