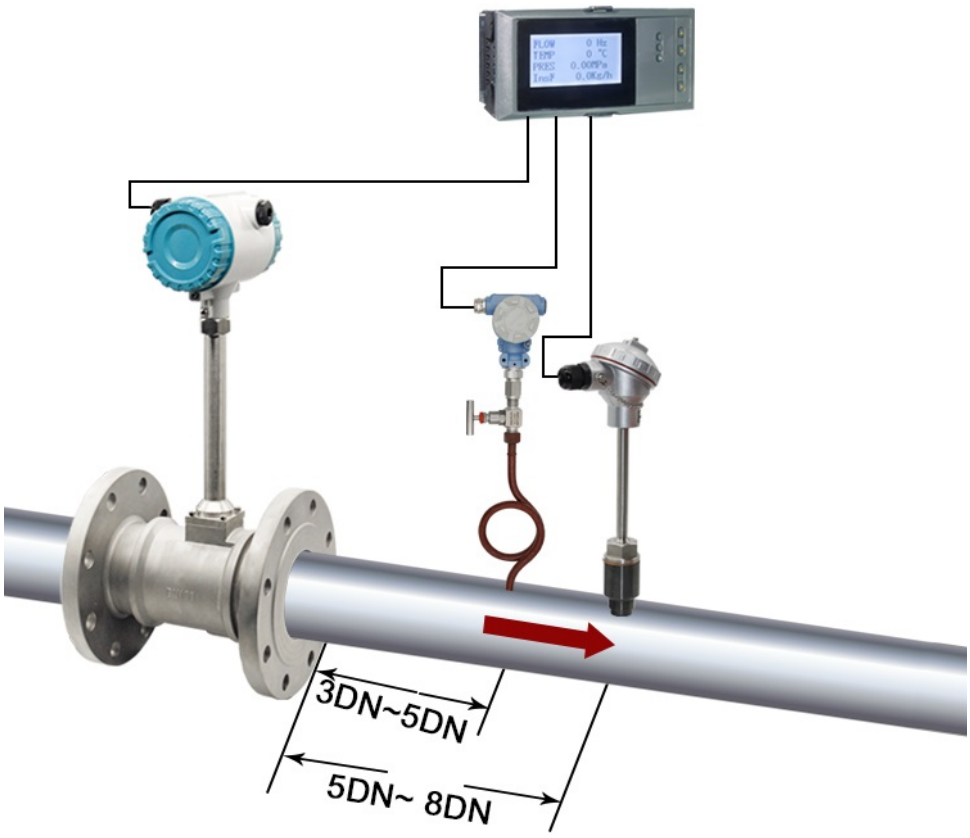
S-VTX

FLOW TOTALIZER TYPE 6600

Operating manual



LCD flow integrating control instrument (supporting type)

Operation Instruction

I. Introduction

LCD flow totalizer is mainly designed for trading discipline between supplier and customer in regional central heating, and calculating steam, and high precision flow measurement. It's a full-functional secondary instrument based on 32-bit ARM micro-processor, high-speed AD and large-capacity storage. The instrument has fully adopted surface-mount technology. It has good EMC ability and high reliability because of heavy protection and isolation in design. It is embedded RTOS, USB Host, and high-density FLASH memory, which can record 720-day length sampling data. It can automatically identify saturated steam and superheated steam. It can also be used for process monitoring and volume control of steam heat. History data recorded in instrument can be copied to USB disk at any time and analyzed by DTM software on PC. The instrument may be used together with vary flow sensors such as Orifice Plate, V-cone, vortex, and so on. Besides, it also features good performance in anti-theft and power failure protection.

II. Technical Parameters

Measurement input	
Input signal	Current: 0-20mA, 0-10mA, 4-20mA, √0-10mA, √4-20mA Input impedance: ≤100Ω Maximum limit of input current: ≤ 30mA
	Voltage: 0-5V, 1-5V, 0-10V (customized), √0-5V, √1-5V, 0-20mV, 0-100mV Input impedance: ≥ 500KΩ
	Thermal resistance: Pt100, Cu50, Cu53, Cu100, BA1, BA2
	Linear resistance: 0-400Ω
	Thermocouple: B, S, K, E, T, J, R, N, F2, Wre3-25, Wre5-26
	Frequency signal: range: 0-10KHz; wave shape: rectangular, sine wave, square wave
Output	
Output signal	Analog output: 4-20mA (load resistance ≤ 480Ω), 0-20mA (load resistance ≤ 480Ω) 0-10mA (load resistance ≤ 960Ω), 1-5V (load resistance ≥ 250KΩ) 0-5V (load resistance ≥ 250KΩ), 0-10V (load resistance ≥ 4KΩ) (customized)
	Alarm output: relay control output: AC220V/2A, DC24V/2A (resistive load)
	Feed output: DC24V±1, load current ≤ 50mA
	Communication output: RS485/RS232, 1200-9600bps, Protocol: MODBUS RTU. Communication distance: 1Km for RS-485 and 15m for RS-232.
Comprehensive parameters	
Measurement precision	0.2%FS±1d
Setting mode	Light touch control panel for setting parameter, which will be stored permanently even in case of power failure, and can be locked & protected with password.
Display mode	3.5" matrix 128*64 LCD screen with backlight (black characters on white screen). Display pages include Digits, Curves, Bar graphs, and so on. Pages switch conveniently on the panel. History data can be searched, and time scale of curves is changed by operating proper keys on the panel.
Record interval	9 options for your choice: 1s, 2s, 4s, 6s, 15s, 30s, 60s, 120s, and 240s
Storage time	3 days (record interval of 1s) – 720 days (record interval of 240s)

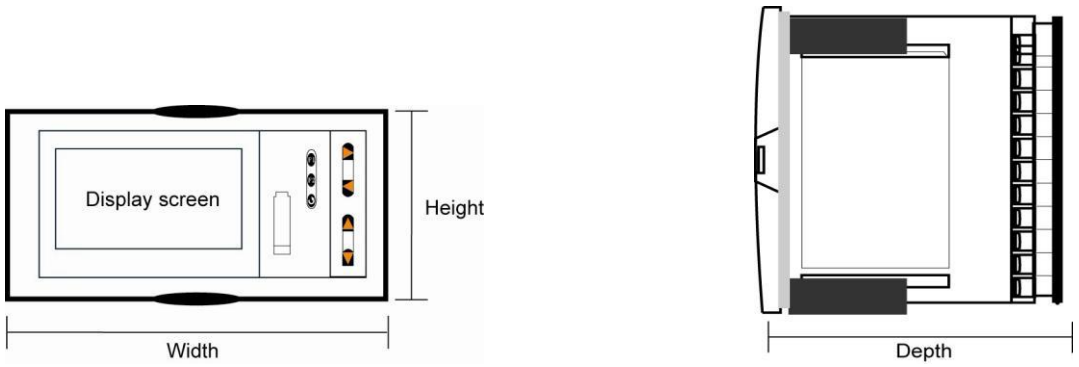
Print	Printer interface: RS-232C; Serial-interface printer: SP-A40SH
Operating environment	Ambient temperature: 0-50℃; relative humidity: ≤ 85RH; isolated from strongly corrosive gas
Power supply	AC 100-240V (switch power), 50/60HZ; DC 20-29V (switch power)
Power consumption	≤ 5W
Structure	- Standard panel mounted instrument structure

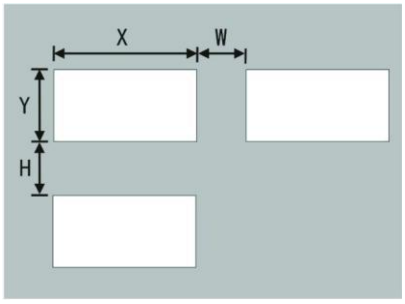
III. Installation

1. Installation position and environment

The instrument shall be installed away from motors and transformers to avoid impact, shock, and electromagnetic interference. Keep it horizontal during installation. The ambient temperature of the installation site shall be between 0℃ and 50℃, and the relative humidity shall not exceed 85%RH, where there're no condensate, corrosive gas, and combustible gas.

2. Dimension (mm)





	Dimension			Hole Size		Minimum Distance Between Instruments	
Type	Width	Height	Depth	X	Y	W	H
A	160	80	110	152+0.5	76+0.5	38	34
B	80	160	110	76+0.5	152+0.5	34	38
C	96	96	110	92+0.5	92+0.5	38	38

3. Installation

(1) Installing the instrument on mounting panel

Drill installation holes of proper size according to the instrument requirements and put the seal ring on the back of instrument. Then insert the instrument right to the installation hole and install the attaching clamps to back of the board to fix top and bottom surface of the instrument and push two clamps forward so that the instrument could be fixed on the board. Take the protective film off the screen. (If multiple instruments would be installed on one board, minimum distance between instruments as specified in table above shall be considered to ensure adequate heat dissipation and space for installation.)

(2) How to take the core out of enclosure

Core of the instrument may be taken out of the enclosure. Push aside two buckles on each side of

the front panel, and pull front panel outward to separate the core and enclosure. When reassembly, insert core into the enclosure tightly and fasten them with buckles for reliability.

(3) Installation instructions

★ Cable selection, instrument installation, and electrical wiring must comply with VD0100 “Relevant Rules on Circuit Installation under 1,000V” or relevant local rules;

★ Electrical wiring must be completed by professionals;

★ Fuse shall be used in load circuit to protect the circuit and ensure that the relay contact will be open in the case of short circuit or load exceeding the maximum capacity of relay;

★ Separate wiring shall be made for input, output, and power supply respectively and parallelism shall be avoided;

★ No other load shall be connected to the power terminal of the instrument;

★ Shielded twisted wires shall be used for sensor and communication.

(4) Standard wiring instructions

★ DC signal input (process input)

1. In order to reduce electrical interference, wires carrying low-voltage DC signals and sensors input shall be far away from high-voltage-bearing wires. If not, shielded wires shall be used and grounded at the same point;

2. Any device connected between sensors and terminals may influence measurement accuracy due to resistance or current leakage.

★ Thermocouple or pyrometer input

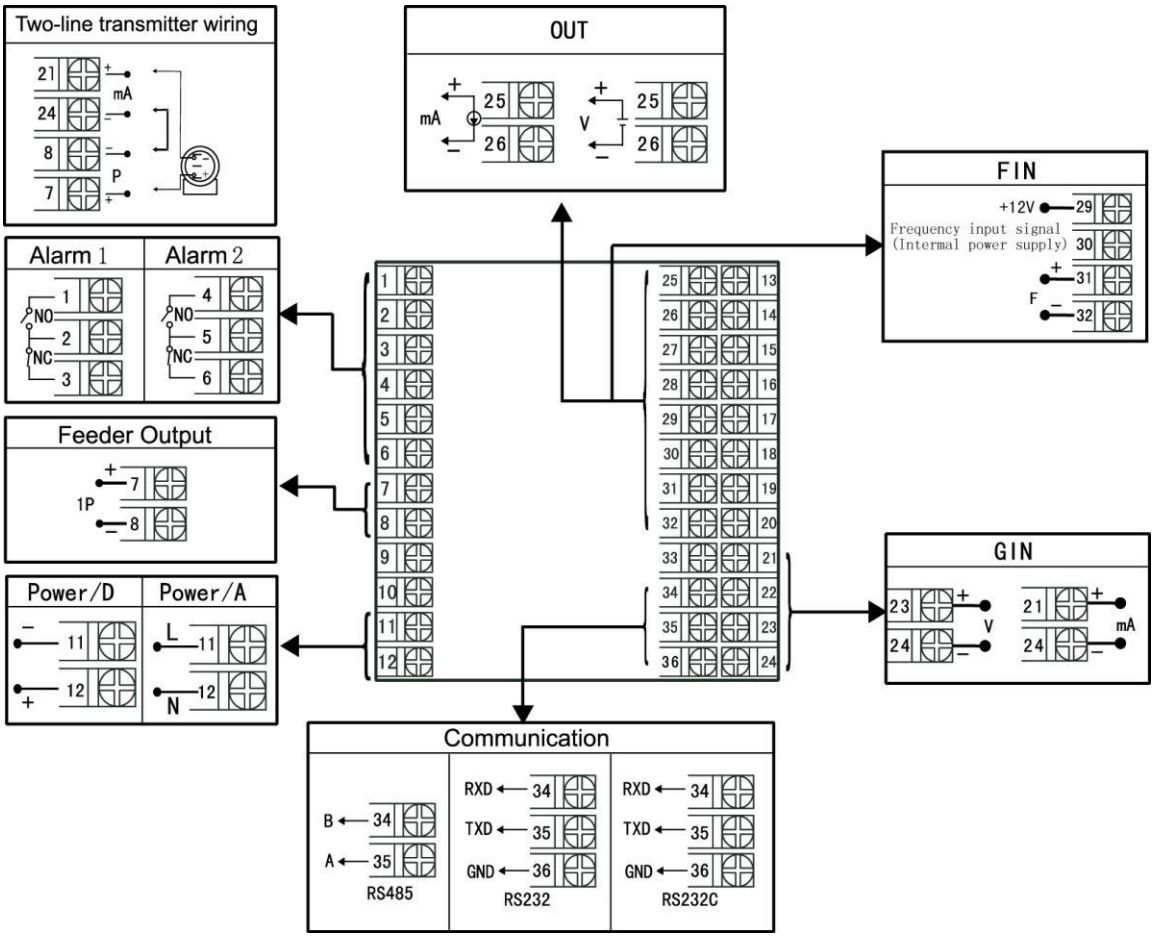
Compensating lead wires appropriate to the thermocouple shall be used as extension wires, which must be shielded.

★ RTD (thermal resistance) input

The resistance of three wires must be the same and shall not exceed 15Ω each.

(5) Wiring diagram

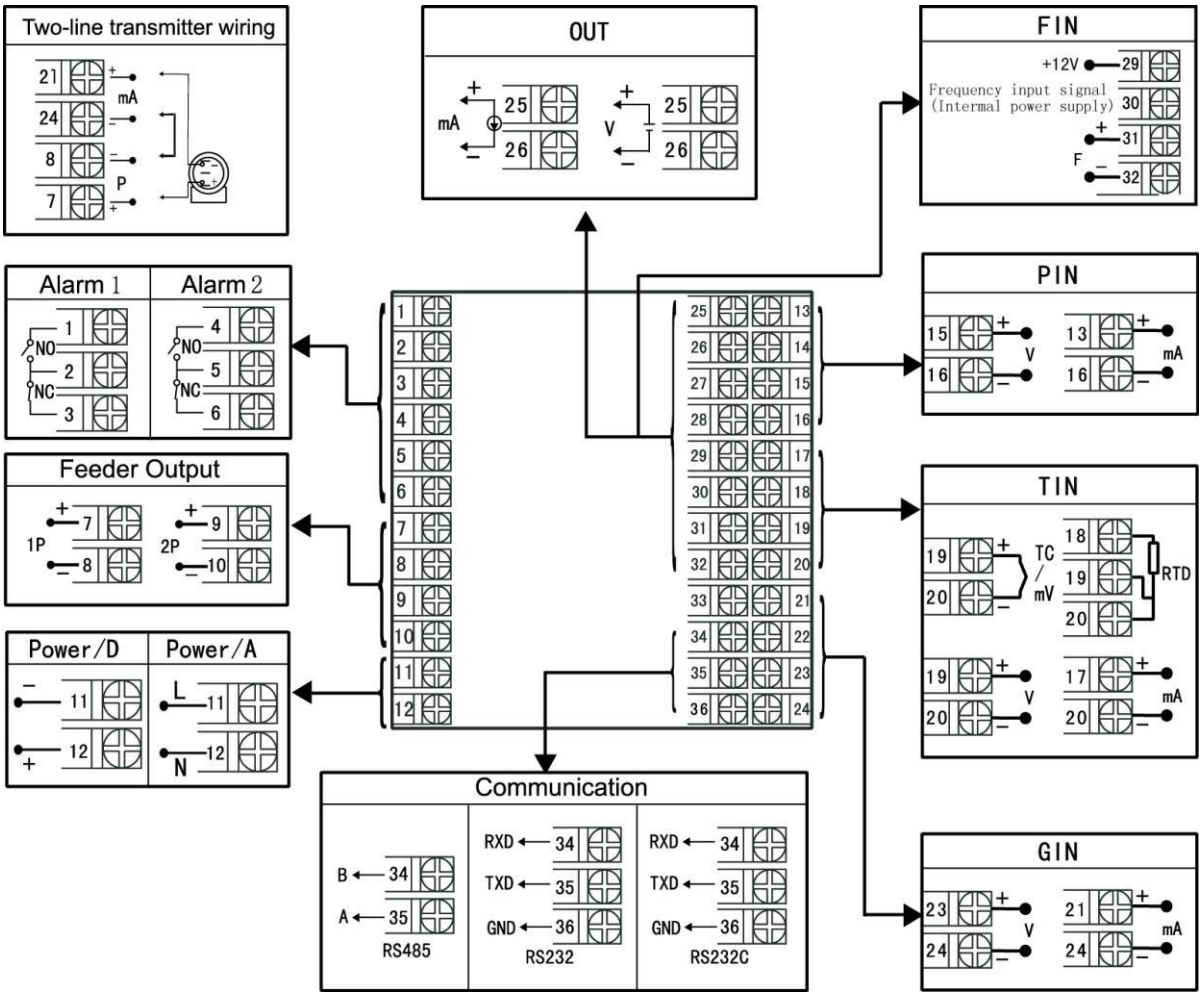
Wiring Diagram of no compensation flow



Note: in the above diagram, if one group of terminals has different functions, only one of them may be available.

For example, RS485 and RS232 are on the same group of terminals, so only one of them may be selected.

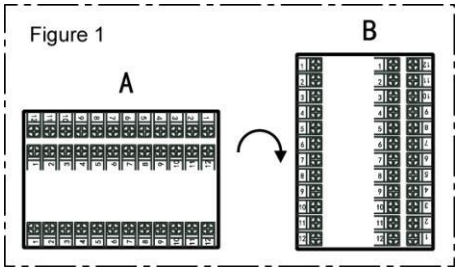
Wiring Diagram of with compensation flow



Note: in the above diagram, if one group of terminals has different functions, only one of them may be available.

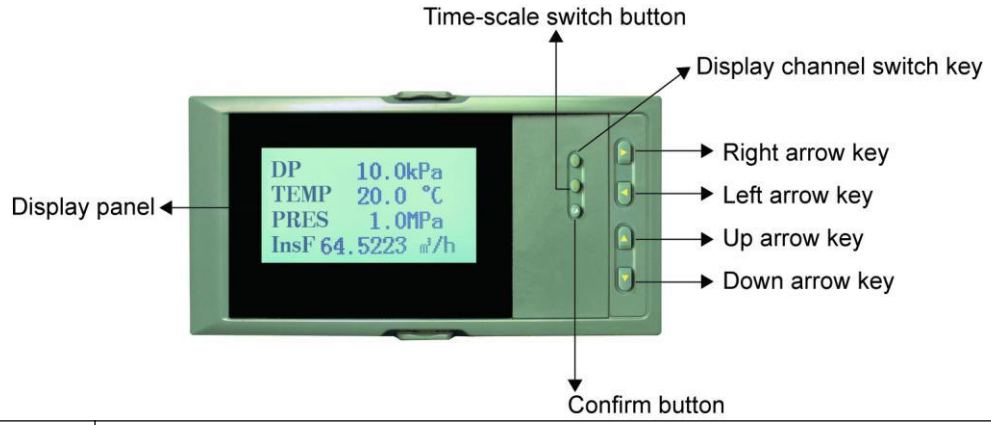
For example, RS485 and RS232 are on the same group of terminals, so only one of them may be selected.

The wiring terminal directions at rear cover of horizontal and vertical instruments are different; see Figure 1.



IV. Parameters Setting

1. Panel configuration



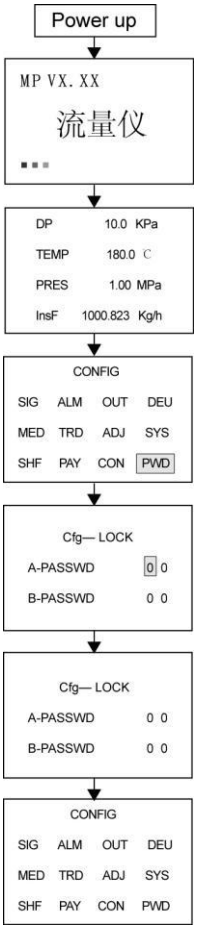
Name		Description
Operation keys	Enter	Menu page: to confirm item selection on the menu Parameter change: to confirm new set parameter Curve display: to enter configuration page combined with "▲" key Historical data display: to confirm the retrospective time to be modified in the next step; to clear cumulant and cumulative power-failure duration combined with "◀" key Parameter setting: to move position of decimal point combined with "◀" key
	▼ Down	Menu page: to move the cursor down Parameter change: to decrease the number before the cursor Measured value display: to turn display pages of the same channel Retrospective time change: to decrease time value before the cursor
	▲ Up	Menu page: to move the cursor up Parameter change: to increase the number before the cursor Retrospective time change: to increase time value before the cursor
	◀ Left	Menu page: to move the cursor left Parameter change: to move the cursor left Retrospective time change: to move the cursor left Historical data display: to search historical data backward from current time, or to stop the forward search of historical data
	▶ Right	Menu page: to move the cursor right Parameter change: to move the cursor right Retrospective time change: to move the cursor right Historical data display: to search historical data forward from current time, or to stop the backward search of historical data
	F1	Measured value display: to switch display between different channels End of setting: to enter measured value display
	F2	Real-time curve or historical curve display: to change time scale of curve display

2. Operation

1) Power-on

Turn on the instrument while ensuring it's properly wired. The system would take several seconds or minutes for initialization. Please wait a moment.

2) Unlocking



Power-on self test

Main measurement display

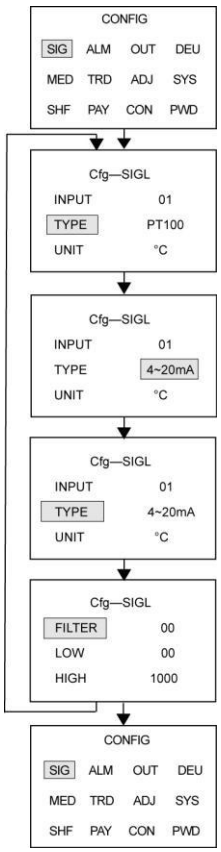
Press ↵ and ▲to enter configuration page.
Move the cursor to “Unlocking”.

Press “↵” to enter “Unlocking” setting.
Enter password with “▲”, “▼”, “▶”, and “◀” for unlocking (preset as 0)
Note: Only if both supplier password and customer password are input correctly, the instrument will be unlocked, when it will display the mark “√”.

Press “↵” to enter the password, and press “Ft” to return to the menu.

Start configuration parameters setting upon unlocking.
Note: If it returns to the display screen during setting, the passwords shall be entered again for unlocking.

3) Parameters setting (unlocked)



Move the cursor to the target item (take “channel” for example)
Press “↵” to enter channel parameters setting

Move the cursor to the parameter to be changed
For example, “Input type PT100”
Press “↵” to confirm the parameter to be changed

Press “▲” and “▼” to change the target parameter
For example, “Input type 4-20mA”

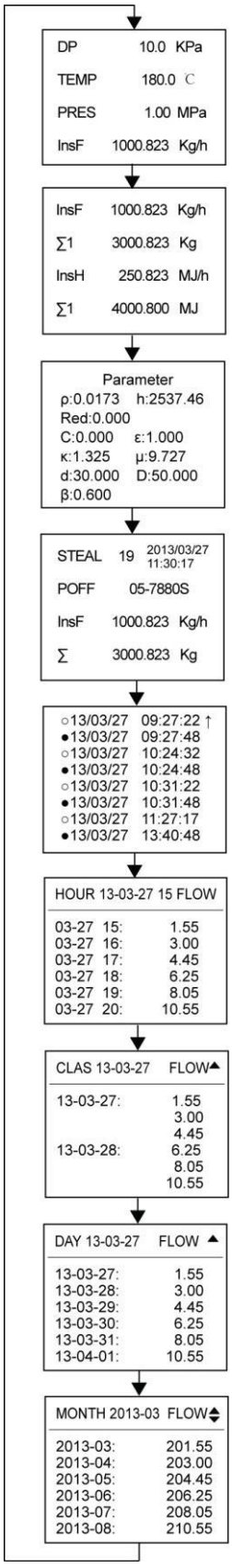
Press “↵” to save the new parameter

Press “▼” to enter filter coefficient setting and go through the above process. Setting of other parameters is the same as above.

Upon completion, press “Ft” to return to configuration page.
Press “▲”, “▼”, “▶”, and “◀” to set parameters of next item.

4) Display operation

a. Flow chart



Main measurement display

Press “F1” to switch to instantaneous cumulation display

Press “F1” to switch to intermediate parameters display

Press “F1” to switch to power-failure memory display

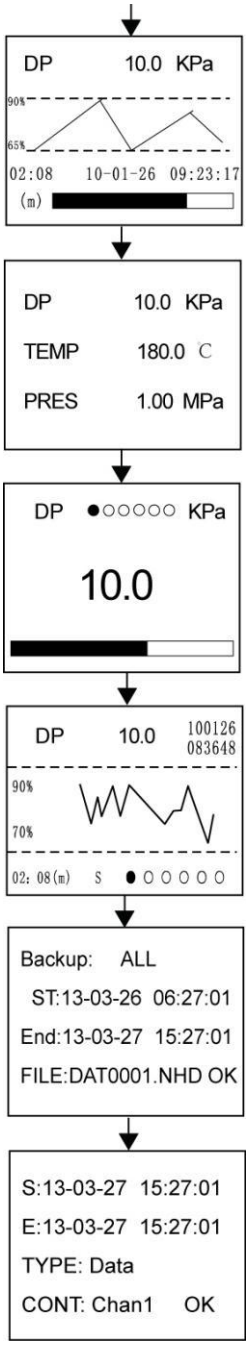
Press “F1” to switch to power-failure time display

Press “F1” to switch to hourly report display

Press “F1” to switch to shift report display

Press “F1” to switch to daily report display

Press “F1” to switch to monthly report display



Press "▼" to switch to real-time curve display
Press "F1" to switch to real-time curve of each channel

Press "▼" to switch to measurement display

Press "F1" to switch to bar graph display of each channel

Press "▼" to switch to retrospective display
Press "F1" to switch to retrospective display of each channel

Press "▼" to switch to data backup page
(provided that the recording function is activated).

Press "▼" to switch to data printing page
(provided that the printing function is activated)

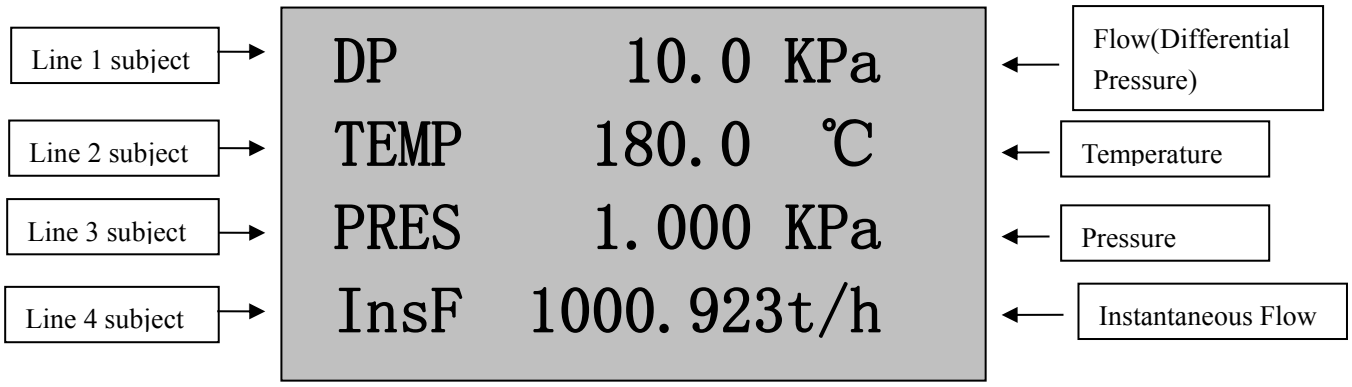
b. Instructions for each display:

① Parameters display:

There are 2 pages for flow and relevant parameters, including temperature compensation value, pressure compensation value, differential pressure or flow channel measured value, instantaneous flow, instantaneous heat, cumulative flow of each channel, totalized heat, balance, and residue.

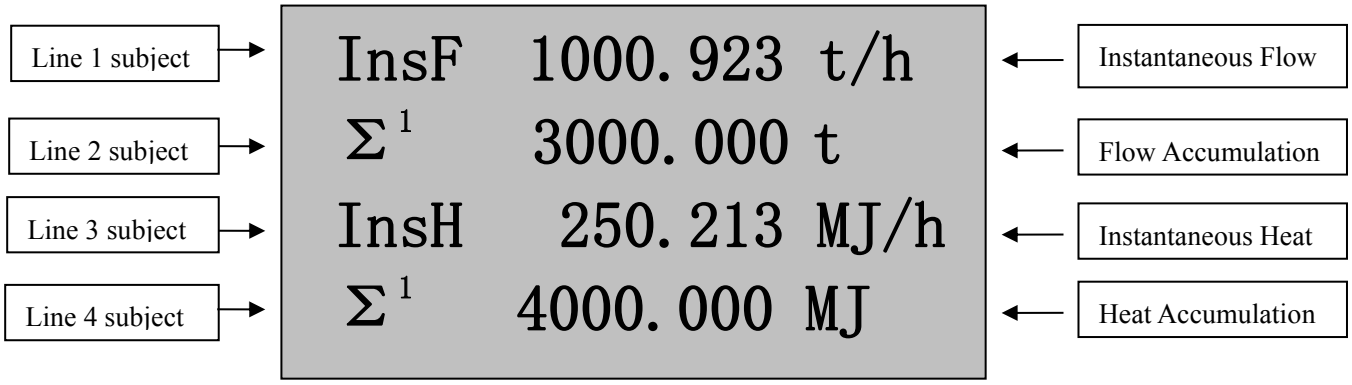
User may use "System" configuration to set items displayed in "Page 1" and "Page 2" and define their orders.

Page 1



Press “F1” to switch to instantaneous cumulation display

Page 2



② Press “F1” again to switch to intermediate parameters display:

ρ: 1.2045 – density in operating condition (Kg/m^3)

C: 0.605 – discharge coefficient

Red: 88346.393 - Reynolds number

ε: 1.000 – expansion coefficient of measured medium

h: 238.93 – enthalpy of measured medium (note: appearing if heat totalizing function is activated)

μ: 19.550 – dynamic viscosity of measured medium (10^{-6} Pa.s)

κ: 1.402 – isentropic exponent of measured medium

β: 0.600 – diameter ratio of throttling device

d: 30.000 – interior diameter of open hole of throttling device (mm)

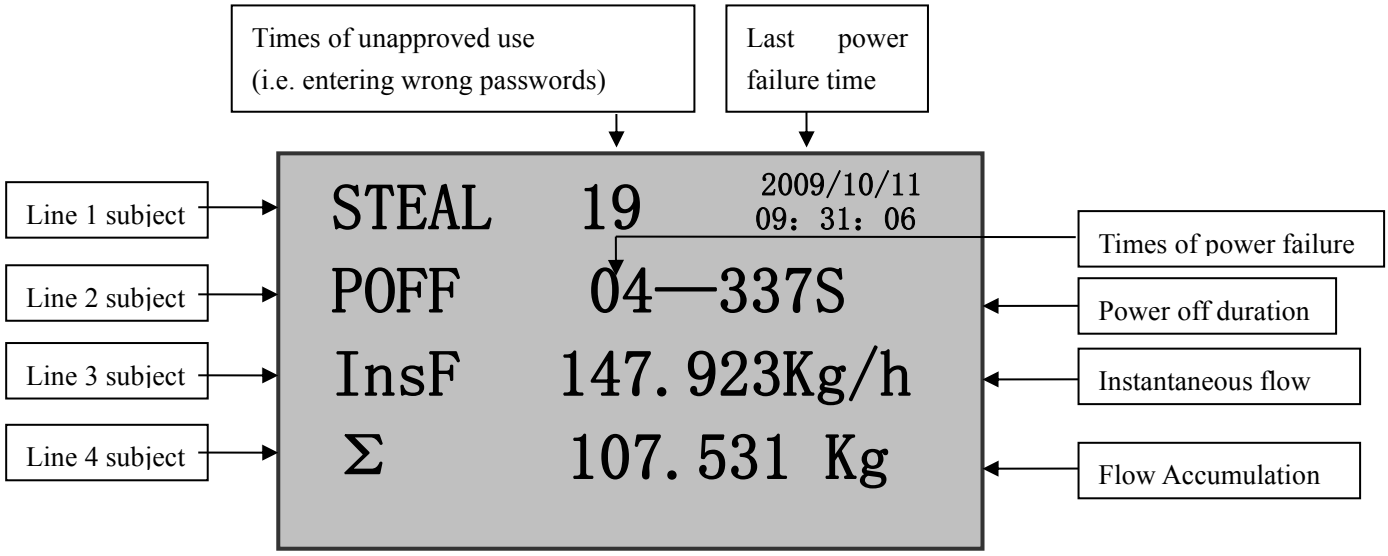
D: 50.000 – diameter of tube of throttling device (mm)

Z: 0.999 - compressibility factor of inorganic or organic gas

K: 1.000 – instrument factor

③ Press “F1” again to switch to power-failure memory display:

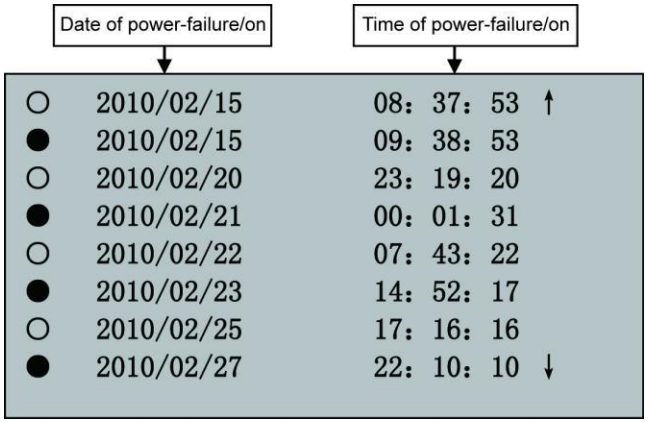
It will display time (year, month, date, hour, minute, and second) of last power failure, times of power failure and total failure duration (in seconds), and instantaneous flow and cumulative flow at the time of last power failure.



④ Press “F1” again to switch to power failure time display:

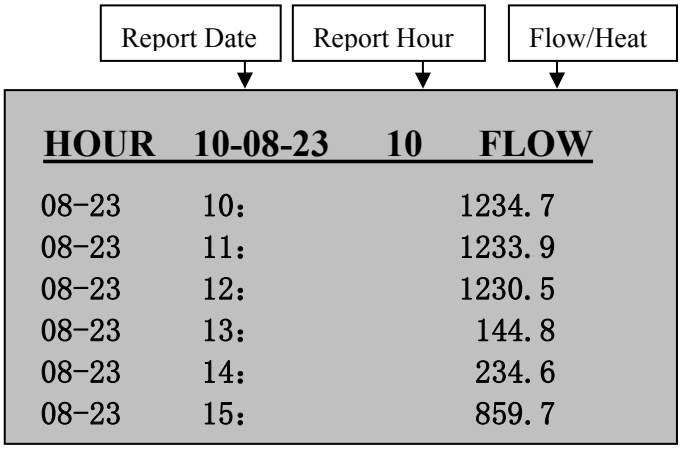
The following will be displayed only when “Power-failure Time” in “System” configuration is set as “ON”. It will display the actual time of power failure and power-on during operation, and can display 8 moments of recent power-failure/on in one page.

As seen below, line started with “○” means power failure record, while line started with “●” means power-on record. Other records may be checked by using left and right key for page turning.



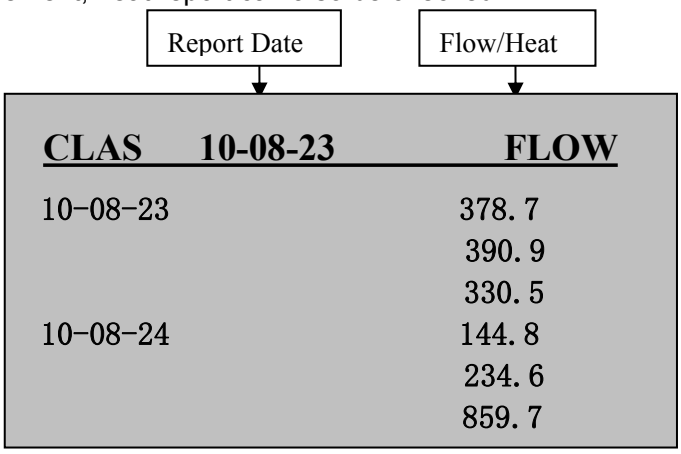
⑤ Press “F1” again to switch to hourly report display:

Hourly report is used to compile statistics of cumulative flow in every hour within one day, and reports may be checked by setting certain date and time. In case of steam or water measurement, heat report can also be checked.



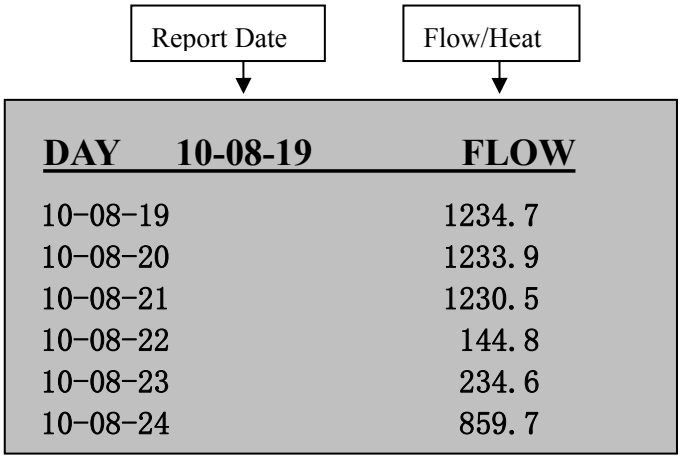
⑥ Press “F1” again to switch to shift report display:

Shift report is used to compile statistics of cumulative flow of some shift within one day, and 3 shift reports at maximum may be made in one day. Reports may be checked by setting certain date. In case of steam or water measurement, heat report can also be checked.



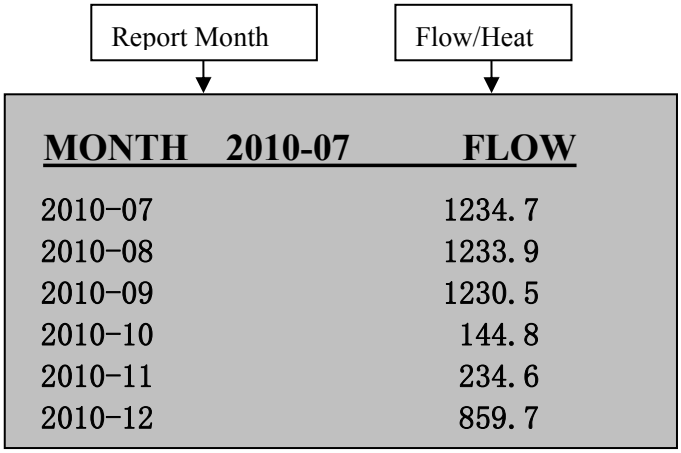
⑦ Press “F1” again to switch to daily report display:

Daily report is used to compile statistics of cumulative flow of current day, and reports may be checked by setting certain date. In case of steam or water measurement, heat report can also be checked.



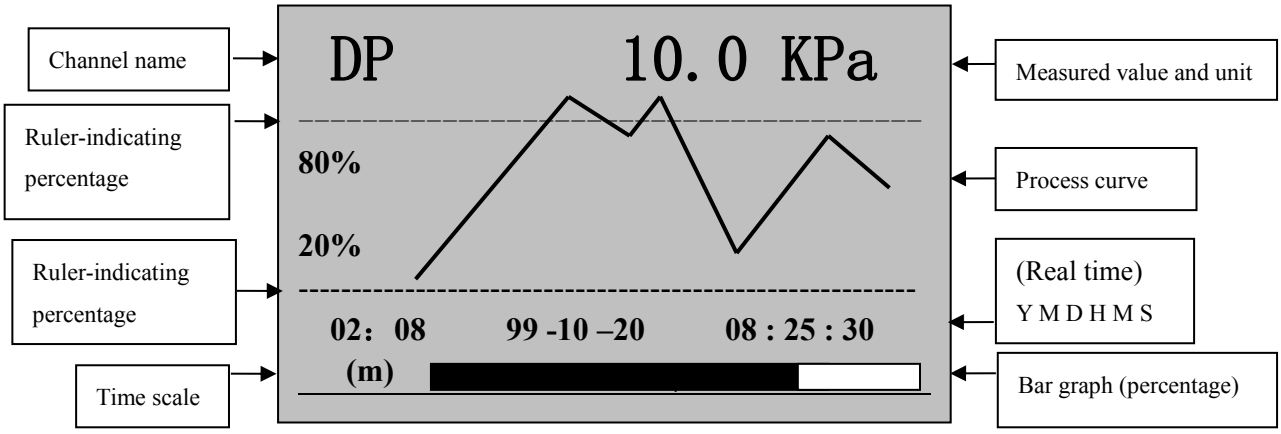
⑧ Press “F1” again to switch to monthly report display:

Monthly report is used to compile statistics of cumulative flow of current month, and reports may be checked by setting certain date. In case of steam or water measurement, heat report can also be checked.



c. Instructions for display of dynamic measurement process:

1) Real-time curve display



1: Time scale 02:08 (m) indicates that the screen shows the curve for a length of 2 minutes and 8 seconds.

If it shows 02:08 (h), then it indicates that the screen shows the curve for a length of 2 hours and 8 minutes.

If the recording interval is higher than 15 seconds, the unit of time scale will automatically switch from (m) to (h).

2: Press " F2 " to alternate time scale units to expand or shorten the length of historical data curve.

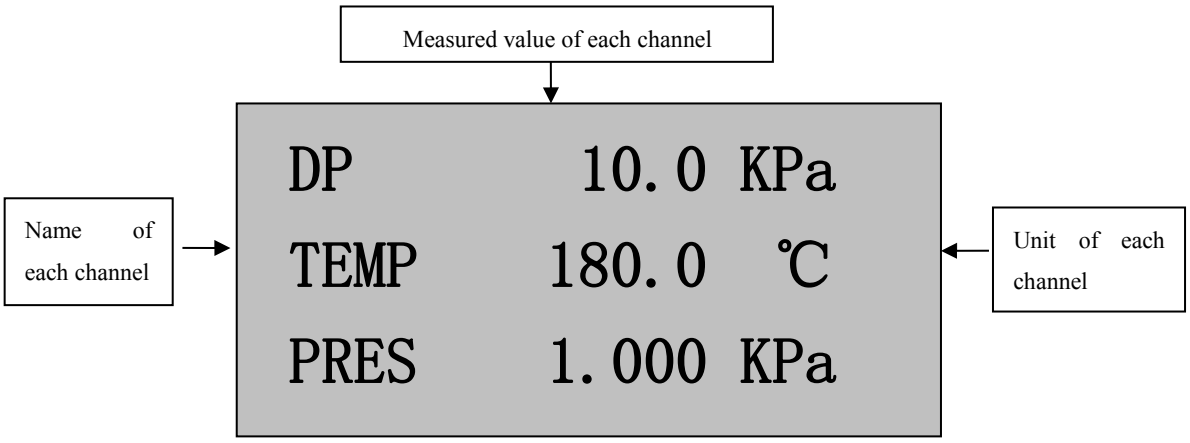
3: Rule-indicating percentage will change with fluctuation of process curve to give the best display performance under limited resolution.

4: Measurement subject and channel name is defined with value of "Channel 1 name", "Channel 2 name", "Channel 3 name", and "Channel 4" name in "System" configuration.

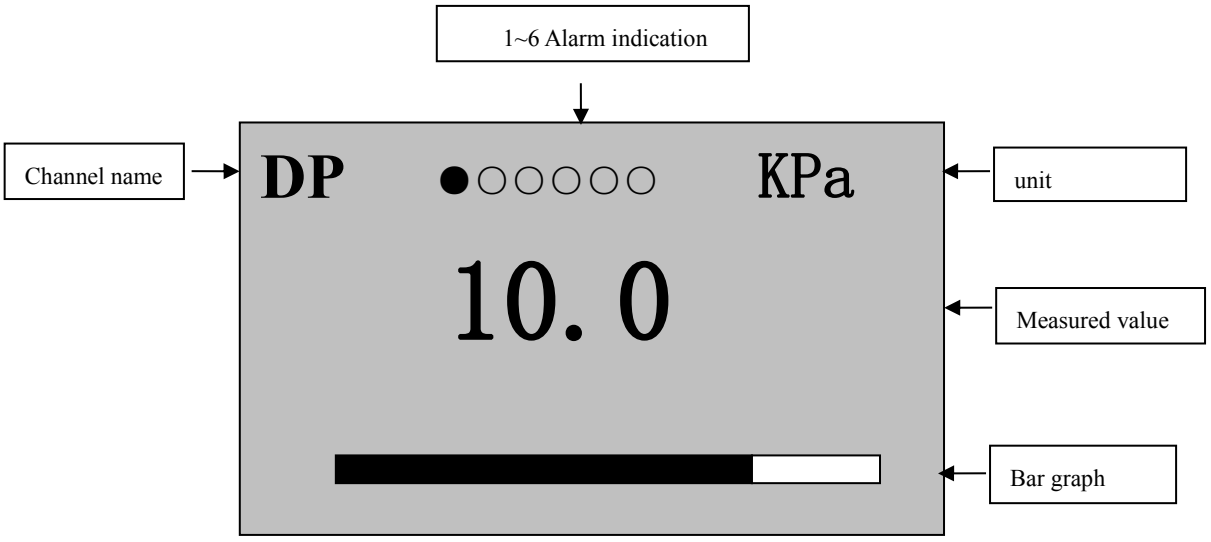
5: Press " F1 " in real-time curve display to switch to real-time curve display of flow (differential pressure), temperature, and pressure.

2) Real-time data measurement display

Press "▼" to switch from real-time curve display to measurement display



Press F1 again to show the alarm bar graph below:



1: Alarm 1, 2, 3, 4, 5, or 6 above may be defined to correspond to any input channel (channel 1, 2, 3, or 4) based on user's needs, and alarm at upper limit or lower limit may be set.

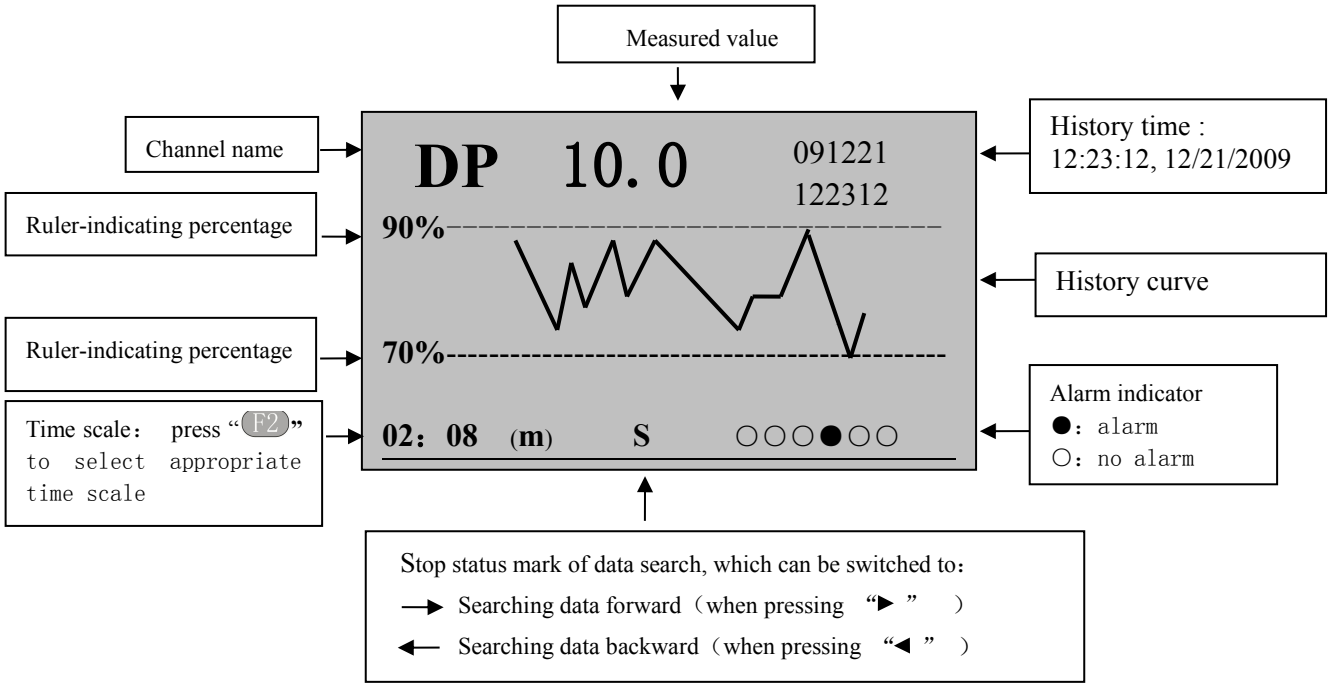
2: ● means the relay operates (alarm)

○ means the relay does not operate (no alarm)

3: Press " F1 " in the alarm bar graph to switch to alarm bar graph of flow (differential pressure), temperature, and pressure.

3) Retrospective display

Press "▼" to switch from real-time data measurement to historical data retrospective display



Note: instructions on historical data retrospective operation: (when the image above is displayed)

(1) Press "▶" to search historical data forward from current display and press "◀" to stop the search. Press "◀" to search historical data backward from current display and press "▶" to stop the search.

(2) Press “ F2 ” to change time scale to expand or shorten the length of historical data curve.

(3) Press “ ↺ ” to return the cursor to time display area on the right above corner, and press “ ◀ ” and “ ▶ ” to move the cursor and press “ ▲ ” and “ ▼ ” to increase/decrease value of year, month, date, hour, minute, and second. Press “ ↺ ” again for confirmation, and historical data curve of selected time will be shown on the screen.

(4) Relation between historical curve and historical data: the historical data will be at the intersection of historical curve and right frame of screen.

(5) Press “ F1 ” in the historical data retrospective display image to alternate between flow (differential pressure), temperature, and pressure.

Note: flow clearing

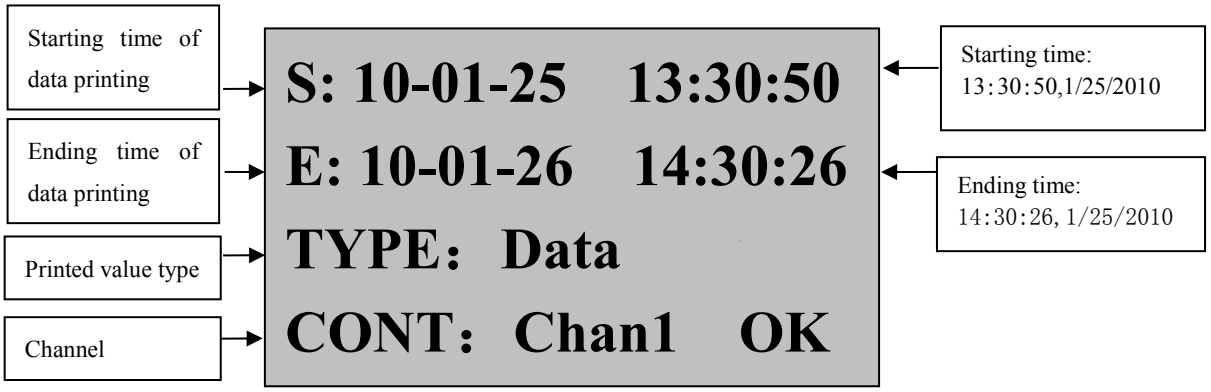
a. Press “ ↺ ” and “ ▲ ” to enter unlocking password setting in configuration page.

b. Passwords may be set as follows:

User sets system passwords	******	Preset as 00
Supplier and customer password = ****** + 1	Cumulative flow, cumulative heat, and times and time of power failure clearing allowed	Upon setting of passwords (for example, when the initial password is 100132, values will be cleared when entering password 100133), press “ F1 ” to return to measurement display, and press “ ↺ ” and “ ◀ ” for clearing.
Supplier and customer password = ****** + 2	Power failure times and time clearing allowed	
Supplier and customer password = ****** + 3	Cumulative flow and cumulative heat in channel 1 clearing allowed	
Supplier and customer password = ****** + 4	Cumulative flow in channel 2 clearing allowed	
Supplier and customer password = ****** + 5	Cumulative flow in channel 3 clearing allowed	
Supplier and customer password = ****** + 6	Cumulative flow in channel 4 clearing allowed	

4) Data printing display (available when printer function is activated)

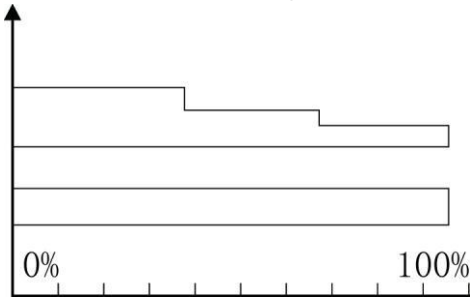
Press “▼” to switch from data backup display to data printing



1. Manual printing

1) When the printer in system configuration is set as “AS”, it will print the data or curve of current channel within the set time length; use “ ◀ ” and “ ▶ ”, “ ▲ ” and “ ▼ ” to change value of time, type, and channel; after that, move the cursor to “Print” and press “ ↺ ” for confirmation, and the screen will display "printing”, indicating that it starts to print data or curves.

Format of curve printing:



Differential pressure: Kpa
Start: 10-07-25 10-00-00
End: 10-07-25 09-58-00

Format of data printing:

100724142610: 625 ---------- measured value at the time of ending
100724142609: 625
100724142608: 625
100724142607: 656
100724142606: 687
100724142605: 750
100724142604: 750
100724142603: 812
100724142602: 812
100724142601: 875 ---------- measured value at the time of starting

2) When the printer in system configuration is set as “TS”, it will print data of all channels at current time; use “◀” and “▶”, “▲” and “▼” to change value of time, type, and channel, and set the type as “Data”; after that, move the cursor to “Print” and press “ ” for confirmation, and the screen will display "printing”, indicating that it starts to print data. Format of printing:

Alarm: ● ○ ○ ○ ○ ○ ----------Alarm status: ○: no alarm ●: alarm
∑= 0.053MJ ----------Cumulative heat
Instantaneous heat: 0.0000MJ/h----------Instantaneous heat
∑= 0.021Kg ----------Cumulative flow
Instantaneous: 15.0056Kg/h ----------Instantaneous flow
Pressure: 1.000Mpa ----------Measured pressure
Temperature: 50.0℃ ----------Measured temperature
Differential pressure: 10.0Kpa ----------Measured differential pressure
Time: 10-07-12 15-00-02 ----------Date and time
---

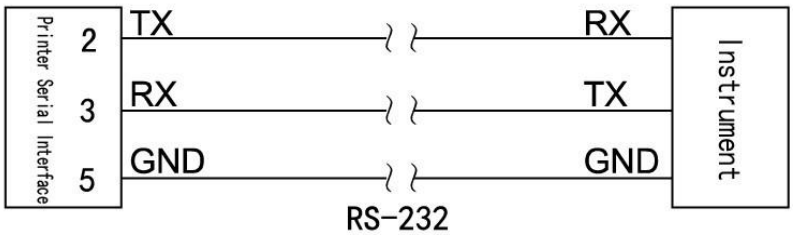
2. Timed printing

Set interval of timed printing in system configuration; when the interval of measurement equals to interval of time printing, it will automatically control the printer for timed printing (see format of printing above).

3. Alarm printing

When the alarm function is actuated in system configuration, in case of any alarm, it will automatically control the printer for alarm printing (see format of printing above).

Connection between instrument and serial-interface printer:



Note: baud rate of the instrument and printer must be the same (baud rate setting of the instrument could be referred to in Level 2 Parameters Setting and that of the printer could be referred to in printer instructions).

VI. Voltage Range Regulation in Frequency Input

1): With open collector, the input end has a voltage of 10V; with open emitter, there's no voltage;

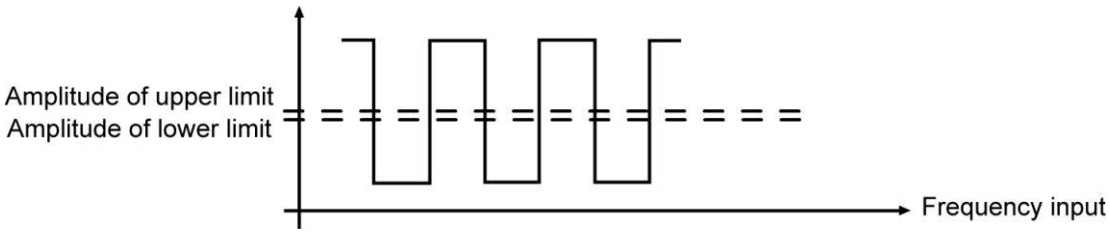
	Frequency input: OC	Frequency input: OE
JP2 status		

Voltage regulation:

1. Regulate upper limit of input voltage: regulate potentiometer W1 (clockwise rotation for decrease and counterclockwise rotation for increase) so that voltage at negative end of frequency input of pin pair 7 of LM339 is not more than upper limit of input voltage.

2. Regulate lower limit of input voltage: regulate potentiometer W2 (clockwise rotation for decrease and counterclockwise rotation for increase) so that voltage at negative end of frequency input of pin pair 8 of LM339 is not less than lower limit of input voltage.

★ Regulate W1 and W2 to keep the amplitude of upper limit / lower limit of voltage is within the range of wave shape. The voltage is preset as about 2.5V and 4.5V for lower limit and upper limit amplitude.



2): Frequency amplification (see figure below):

	Amplified voltage input (CP)	Normal voltage input (PP)
JP1 status		

★ For example, the frequency amplitude of magnetoelectric transducer is relatively low, which cannot be directly collected by the instrument, so amplification circuit is required in the instrument.

V. Parameters Description

1) “SIG” parameters – when flow with temperature/pressure compensation is calculated, input channel 01 means flow (differential pressure) signal, 02 means temperature signal, and 03 means pressure signal.

Name	Range	Description	Default Value
INPUT	01	The first input channel (unchangeable)	01
TYPE	See table of input types	Input signal type (see table of input signal types)	4-20mA
UNIT	See table of units	Engineering unit of input channel (see Note 1)	KPa
FILTER	0-19	Set the input signal filter coefficient	0
LOW	-9999 ~ 99999	Lower limit of measuring range (see Note 2 for decimal digit setting)	0
HIGH	-9999 ~ 99999	Higher limit of measuring range (see Note 2 for decimal digit setting)	1000
BAR-LOW	-9999 ~ 99999	Lower limit of bar graph	0
BAR-HIGH	-9999 ~ 99999	Higher limit of bar graph	1000
CUT-OFF	-25.0 ~ 100.0	Percentage of small signal cutoff (see Note 3)	-25.0
CUMULATE	ON	Flow value is cumulated	ON
INPUT	02	The second input channel (unchangeable)	02
TYPE	See table of input types	Input signal type (see table of input signal types)	PT100
UNIT	See table of units	Engineering unit of input channel (see Note 1)	℃
FILTER	0-19	Set the input signal filter coefficient	0
LOW	-9999 ~ 99999	Lower limit of measuring range (see Note 2 for decimal digit setting)	0
HIGH	-9999 ~ 99999	Higher limit of measuring range (see Note 2 for decimal digit setting)	1000
BAR-LOW	-9999 ~ 99999	Lower limit of bar graph	0
BAR-HIGH	-9999 ~ 99999	Higher limit of bar graph	1000
CUT-OFF	-25.0 ~ 100.0	Percentage of small signal cutoff (see Note 3)	-25.0
CUMULATE	ON: cumulation OFF: no cumulation	If the channel is used for flow signal, CUMULATE can be set ON, and flow value will be cumulated. If set OFF, will not be cumulated.	OFF
INPUT	03	The third input channel (unchangeable)	03
TYPE	See table of input types	Input signal type (see table of input signal types)	4-20mA
UNIT	See table of units	Engineering unit of input channel (see Note 1)	KPa
FILTER	0-19	Set the input signal filter coefficient	0
LOW	-9999 ~ 99999	Lower limit of measuring range (see Note 2 for decimal digit setting)	0.000
HIGH	-9999 ~ 99999	Higher limit of measuring range (see Note 2 for decimal digit setting)	1.000
BAR-LOW	-9999 ~ 99999	Lower limit of bar graph	0.000
BAR-HIGH	-9999 ~ 99999	Higher limit of bar graph	1.000
CUT-OFF	-25.0 ~ 100.0	Percentage of small signal cutoff (see Note 3)	-25.0
CUMULATE	ON: cumulation	If the channel is used for flow signal, CUMULATE	OFF

	OFF: no cumulation	can be set ON, and flow value will be cumulated. If set OFF, will not be cumulated.	

Note 1: Table of Unit (if special unit is required, it should be specified in the order.)

No.	0	1	2	3	4	5	6	7	8	9	10	11	12
Unit	℃	Kgf	Pa	KPa	MPa	mmHg	mmH2O	bar	Kg/h	Kg/m	Kg/s	t/h	t/m
No.	13	14	15	16	17	18	19	20	21	22	23	24	25
Unit	t/s	l/h	l/m	l/s	m^3/h	m^3/m	m^3/s	Nm^3/h	Nm^3/m	Nm^3/s	KJ/h	KJ/m	KJ/s
No.	26	27	28	29	30	31	32	33	34	35	36	37	38
Unit	MJ/h	MJ/m	MJ/s	GJ/h	GJ/m	GJ/s	kg	t	L	m^3	Nm^3	KJ	MJ
No.	39	40	41	42	43	44	45	46	47	48	49	50	
Unit	GJ	m	m/s	V	KV	A	KA	KW	HZ	%	PH	mm	

Note 2: decimal digit setting: if it's required to display value with decimal places in the setting of measuring range, press "↺" and "◀" to move the decimal place from right to left.

When the point moves to the first decimal place in the right, it will display value with one decimal place, and when the point moves to the second, it will display value with two decimal places.

For example, if upper limit of measuring range is set as "1.0", the instrument will display "1.0", and if it's set as "1.00", the instrument will display "1.00". Number of decimal places of upper limit of measuring range shall be set first, and that of lower limit will follow the same rule as upper limit.

Negative range setting: move the cursor to the first place in the left, and press "▼" so that the instrument will display "0", and then press "▼" again – the negative mark "-"will be displayed.

Note 3: Small signal cutoff: if the measured value < (upper limit of measuring range – lower limit of measuring range)* small signal cutoff percentage + lower limit of measuring range, the measured value will be displayed as lower limit of measuring range. (This function only serves voltage and current signals; for frequency signal, its engineering value will be cut off.)

2) "ALM" parameters

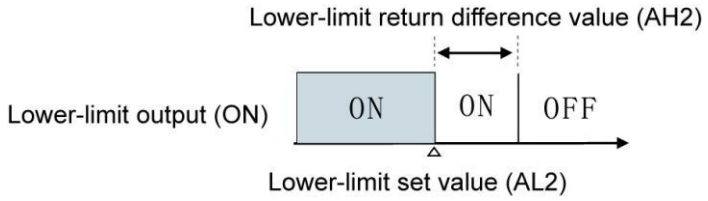
Name	Range	Description	Default Value
ALM-CHAN	01	The first alarm channel(unchangeable)	01
INPUT	1 – the 1st input channel 2 – the 2nd input channel 3 – the 3rd input channel 4 – the 4th input channel 5 –flow 6 –heat	Input channel (1 – 6) corresponding to the alarm channel	05
ALM-TYPE	NO: no alarm AL: Low alarm AH: High alarm SAL: reserved SAH: reserved LAL: Low cumulation alarm LAH: High cumulation alarm LALC: Low cumulation alarm and clear cumulation LAHC: High cumulation alarm and	Alarm type Note: when the alarm type is set as LAL, LAH, LALC or LAHC, the input channel must be set flow or heat	AH

	clear cumulation		
THRESHLD	-9999 ~ 99999	Set the alarm threshold value (see Note 4)	50
HYSTERES	0 ~ 99999	Set the alarm threshold hysteresis, which can prevent signal oscillation near the alarm threshold.	00
ALM-CHAN	02	The 2nd alarm channel(unchangeable)	02
INPUT	Same as above	Input channel (1 – 6) corresponding to the alarm channel	05
ALM-TYPE	Same as above	Alarm type Note: when the alarm type is set as LAL, LAH, LALC or LAHC, the input channel must be set flow or heat	AH
THRESHLD	-9999 ~ 99999	Set the alarm threshold value (see Note 4)	50
HYSTERES	0 ~ 99999	Set the alarm threshold hysteresis, which can prevent signal oscillation near the alarm threshold.	00

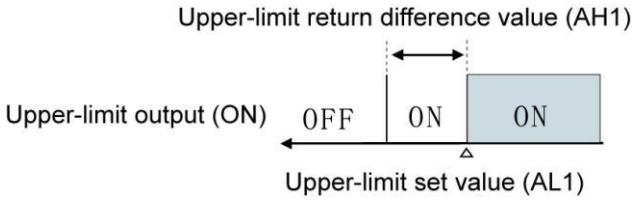
Note 4: Alarm mode: (Alarm threshold hysteresis can prevent signal oscillation near the alarm threshold, frequent alarms and cancellation of report)

Output status:

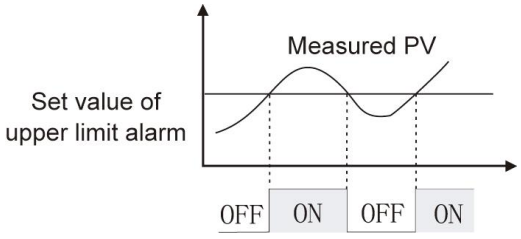
★ Signal value increases from a low value:



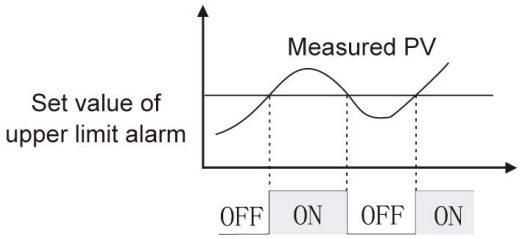
★ Signal value decreases from a high value:



★ High alarm output:



★ Low alarm output:



3) “OUTt” parameters

Name	Range	Description	Default Value
OUT-CHAN	01	The 1st output channel(unchangeable)	01
INPUT	1 – the 1st input channel 2 – the 2nd input channel 3 – the 3rd input channel 4 – the 4th input channel 5 –flow 6 –heat	Input channel (1 – 6) corresponding to the analog output channel	05
OUT-TYPE	No: no output Current: 0~20mA, 0~10mA, 4~20mA Voltage: 0~5V, 1~5V, 0~10V	Signal output type of transmission (any special requirement shall be specified)	4~20mA
OUT-LOW	-9999 ~ 99999	The lowest signal value of transmission	0
OUT-HIGH	-9999 ~ 99999	The highest signal value of transmission	1000
OUT-CHAN	02	The 2nd output channel(unchangeable)	02
INPUT	Same as above	Input channel (1 – 6) corresponding to the analog output channel	05
OUT-TYPE	Same as above	Signal output type of transmission (any special requirement shall be specified)	4~20mA
OUT-LOW	-9999 ~ 99999	The lowest signal value of transmission	0
OUT-HIGH	-9999 ~ 99999	The highest signal value of transmission	1000

4) “DEV” parameters

When some of following parameters marked with “*”, it means no setting is required.

Name	Range	Description	Default Value
DEVICE	Flange pressure plate, linear flow meter, etc.	Primary measuring devices such as orifice plate and vortex street are used (Note 1)	actual condition
C	0~ 999999	Discharge coefficient	actual condition
ε	0~ 999999	Expansion factor	actual condition
TUBE	A3 steel, Cr6SiMo, etc.	The material used to manufacture pipes, and different materials have different expansion coeffieient λ_D (Note 2)	actual condition
THROTTLE	A3 steel, Cr6SiMo, etc.	The material used to manufacture throttling parts(orifice plate, etc.), and different materials have different expansion coeffieient λ_d (Note 2)	actual condition
D20	0 – 999999	The pipe diameter D20 at 20℃ (in mm)	actual condition
d20	0 – 999999	Throttling piece diameter d20 at 20℃ (in mm)	actual condition
λ D	0 – 999999	Linear expansion coefficient of tube material – λ_D (in 10^{-6}mm/(mm.℃))	actual condition

λ_d	0 – 999999	Linear expansion coefficient of throttling piece material – λ_d (in 10^{-6}mm/(mm.℃))	actual condition
SQRT	YES/NO	YES: When differential pressure transmitter has no square root computation, and the instrument needs to do this for differential pressure signal. NO: When differential pressure transmitter has square root computation	YES
SEGMENTS	1 – 8	For measuring devices of other flow meters of differential pressure type or frequency-type vortex street flow meter, K coefficient may be divided into several segments (at maximum of 8 segments)	8
RANGE1	0 – 999999	K=K1, when : 0 ≤ differential pressure or frequency ≤ RANGE1	100
K1	0 – 999999	K1 coefficient	1
RANGE2	0 – 999999	K=K2, when : RANGE1 ≤ differential pressure or frequency ≤ RANGE2	100
K2	0 – 999999	K2 coefficient	1
RANGE3	0 – 999999	K=K3, when : RANGE2 ≤ differential pressure or frequency ≤ RANGE3	100
K3	0 – 999999	K3 coefficient	1
RANGE4	0 – 999999	K=K4, when : RANGE3 ≤ differential pressure or frequency ≤ RANGE4	100
K4	0 – 999999	K4 coefficient	1
RANGE5	0 – 999999	K=K5, when : RANGE4 ≤ differential pressure or frequency ≤ RANGE5	100
K5	0 – 999999	K5 coefficient	1
RANGE6	0 – 999999	K=K6, when : RANGE5 ≤ differential pressure or frequency ≤ RANGE6	100
K6	0 – 999999	K6 coefficient	1
RANGE7	0 – 999999	K=K7, when : RANGE6 ≤ differential pressure or frequency ≤ RANGE7	100
K7	0 – 999999	K7 coefficient	1
RANGE8	0 – 999999	K=K8, when : RANGE7 ≤ differential pressure or frequency ≤ RANGE8	100
K8	0 – 999999	K8 coefficient	1

Note 1: Primary instrument devices

Flange pressure plate	Machined classical Venturi tube
Angle pressure plate	Thick iron wielding section of Venturi tube
D and D/2 pressure plate	V-cone flow meter
ISA932 nozzle	Other differential pressure flow meter
Long diameter nozzle	Frequency-type vortex flow meter
Venturi nozzle	Linear flow meter
Casting-type Venturi tube	

Note 2: Tube or Throttle materials

15 steel, A3 steel	Cr6SiMo
A3F, B3 steel	X20CrMoWV121
10 steel	1Cr18Ni9Ti
20 steel	Ordinary carbon steel
45 steel	Industrial copper
1Cr13, 2Cr13	Copper
1Cr17	brass
12CrlMoV	Grey cast iron
10CrMo910	User-defined

5) “MED” parameters

When some of following parameters marked with “*”, it means no setting is required.

Name	Range	Description	Preset Value
MEDIUM	Steam, water, etc.	Flow medium to be measured, such as steam, water, and gas (Note 1)	actual condition
PRESSURE	-9999.9 ~ 999999	Local atmospheric pressure PA (in MPa). If the pressure compensation channel is absolute pressure, the atmospheric pressure should be set 0.	0.10133
T0	0℃ or 20℃	Standard conditions temperature, T0 = 0℃ or 20℃; Standard conditions Pressure, P0 = 0.10133Mpa.	20℃
ρ 0	0 ~ 999999	Density of medium in standard condition (in Kg/m3). It needs to be set if the medium is other gas or liquid.	actual condition
HUMID	0 – 100	Relative humidity of humid gas (in %)	0
HUMID0	0 – 100	Under standard condition of humid gas (in %)	0
DRYNESS	0 – 100	Dryness of saturated steam (in %)	100
Z	0 ~ 999999	Compressibility factor of gas in operating condition (dimensionless); This parameter needs to be set if the measured medium is other gas.	actual condition
κ	0 ~ 999999	Isentropic exponent of medium κ (dimensionless); this parameter needs to be set if the measuring device is throttling device of varied flow meters of differential pressure type (except V-cone flow meter) and the medium is other gas or liquid.	actual condition
μ	0 ~ 999999	Dynamic viscosity of medium μ (in Pa.s); this parameter needs to be set if the measuring device is throttling device of varied flow meters of differential pressure type (except V-cone flow meter) and the medium is other gas or liquid.	actual condition
A1	-9999.9 ~ 999999	Monomial coefficient of quadratic polynomial of liquid temperature compensation; see liquid density formula.	1
A2	-9999.9 ~ 999999	Quadratic coefficient of quadratic polynomial of liquid temperature compensation; see liquid density formula.	1
The following parameters will be applicable only when the medium is manufactured gas.			

Air	0 ~ 100.00	Air percent by volume (%)	actual condition
N_2	0 ~ 100.00	Nitrogen percent by volume (%)	actual condition
O_2	0 ~ 100.00	Oxygen percent by volume (%)	actual condition
He	0 ~ 100.00	Helium percent by volume (%)	actual condition
H_2	0 ~ 100.00	Hydrogen percent by volume (%)	actual condition
Ar	0 ~ 100.00	Argon percent by volume (%)	actual condition
CO	0 ~ 100.00	Carbon monoxide percent by volume (%)	actual condition
CO_2	0 ~ 100.00	Carbon dioxide percent by volume (%)	actual condition
H_2S	0 ~ 100.00	Sulfureted hydrogen percent by volume (%)	actual condition
NH_3	0 ~ 100.00	Ammonia percent by volume (%)	actual condition
CH_4	0 ~ 100.00	Methane percent by volume (%)	actual condition
C_2H_6	0 ~ 100.00	Ethane percent by volume (%)	actual condition
C_3H_8	0 ~ 100.00	Propane percent by volume (%)	actual condition
C_4H_{10}	0 ~ 100.00	Butane percent by volume (%)	actual condition
C_2H_4	0 ~ 100.00	Ethylene percent by volume (%)	actual condition
C_3H_6	0 ~ 100.00	Propylene percent by volume (%)	actual condition
C_4H_8	0 ~ 100.00	Butylene percent by volume (%)	actual condition
C_2H_2	0 ~ 100.00	Ethyne percent by volume (%)	actual condition
SUM	0 ~ 100.00	Sum of percent by volume of above 18 components, which would be calculated automatically by the instrument and unchangeable. The sum of percent by volume shall be: 100±0.01%	actual condition

Note 1: Flow medium:

Saturated steam temperature compensation	H2	C4H10
Saturated steam pressure compensation	Ar	C2H4
Steam	CO	C3H6
0.6Mpa water	CO2	C4H8
1.6Mpa water	H2S	C2H2
Air	NH3	Other gas
N2	CH4	Liquid
O2	C2H6	Manufactured gas
He	C3H8	

6) “TRD” parameters

Name	Range	Description	Preset Value
F-UNIT	Kg/h, Kg/m, etc.	Select flow unit (Note 1)	Kg/h
H-UNIT	KJ/h, KJ/m, etc.	Select heat unit (Note 2)	MJ/h
LOW-THR	0 ~ 999999	Low Threshold Value, See Note 3	0
LOW-VAL	0 ~ 999999	Small Flow Value, See Note 3	0
OVER-THR	0 ~ 999999	Over Threshold Value, See Note 3	100
OVER-MUL	0 ~ 999999	Over coefficient(dimensionless), See Note 3	0
ACCU-MUL	0 ~ 999999	Accumulation multiple rate(dimensionless), See Note 3	1

F-COMP	0 ~ 999999	Flow compensation during power down(see Note 5)	0
H-COMP	0 ~ 999999	Heat compensation during power down(see Note 5)	0
CONST-P	0 ~ 999999	Constant Pressure when pressure signal cut off	1
CONST-T	0 ~ 999999	Constant Temperature when temperature signal cut off	20
F-DIGIT	0 ~ 5	Maximum decimal digit of instantaneous flow (0 – 5 decimal digit)	3
H-DIGIT	0 ~ 5	Maximum decimal digit of instantaneous heat (0 – 5 decimal digit)	3
K	0 ~ 999999	Adjustment of instantaneous flow Kx+b, where K means proportional factor	1.00000
B	0 ~ 999999	Adjustment of instantaneous flow Kx+b, where B means constant factor	0.0
F-RANGE	0 ~ 999999	Measuring range of instantaneous flow, which is only used for display on computer and transmission.	2000.0
H-RANGE	0 ~ 999999	Measuring range of instantaneous heat, which is only used for display on computer and transmission.	2000.0

Note 1: the following units of instantaneous flow are available:

Kg/h, kg/m, kg/s, t/h, t/m, t/s, l/h, l/m, l/s, m^3/h, m^3/m, m^3/s, Nm^3/h, Nm^3/m, Nm^3/s

Note 2: the following units of instantaneous heat are available:

KJ/h, KJ/m, KJ/s, MJ/h, MJ/m, MJ/s, GJ/h, GJ/m, GJ/s

Note 3: calculation of cumulative flow:

If instantaneous flow < Low Threshold Value, Cumulative flow = Previous cumulative flow + Small Flow Value;

If Low Threshold Value ≤ instantaneous flow ≤ Over Threshold Value, Cumulative flow = Previous cumulative flow + instantaneous flow;

If instantaneous flow > Over Threshold Value, Cumulative flow = Previous cumulative flow + Over coefficient * (instantaneous flow – Over Threshold Value) + Over Threshold Value.

Note 4: Cumulative flow = Previous cumulative flow + Accumulation multiple rate * instantaneous flow.

Cumulative heat = Previous cumulative heat + Accumulation multiple rate * instantaneous heat.

Note 5: Complementary Cumulative Flow = Flow compensation during power down * duration of power down; Complementary Cumulative Heat = Heat compensation during power down * duration of power down;

7) “ADJ” parameters

Name	Range	Description	Default Value
INPUT	01	The 1st input channel (unchangeable)	01
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1
INPUT	02	The 2nd input channel (unchangeable)	02
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1

INPUT	03	The 3rd input channel (unchangeable)	03
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1
INPUT	04	The 4th input channel (unchangeable)	04
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1
OUT-CHAN	01	The 1st output channel (unchangeable)	01
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1
OUT-CHAN	02	The 2nd output channel (unchangeable)	02
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1
OUT-CHAN	03	The 3rd output channel (unchangeable)	03
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1
OUT-CHAN	04	The 4th output channel (unchangeable)	04
B	-9999 ~ 99999	Adjustment of signal value Kx+B, where B is constant factor	0
K	-9999 ~ 9999	Adjustment of signal value Kx+B, where K is proportional factor	1

8) “SYS" parameters

Name	Range	Description	Default Value
DATE	Y-M-D	Current date, year-month-day	Current date
TIME	H-M-S	Current time, hour-minute-second	Current time
CJC-B	-99999 ~ 999999	Cold junction compensation KX+B, where B is constant factor	0
CJC-K	-99999 ~ 999999	Cold junction compensation KX+B, where K is proportional factor	1
ADDRESS	1 ~ 255	Instrument address of communication	1
BAUD	1200/2400/4800/9600 bps	Baud rate of the serial communication	9600
PRINTER	NO, AS, TS	Printing mode: NO: no printing function AS: when manual printing data, it will print measured value of selected channel within the set time; TS: when manual printing data, it will print measured value of all channels at current time	AS

PRT-INTR	1- 2000 minutes	The interval time of equal-interval print	1 (minute)
PRT-STRT	H-M	Start time of equal-interval print	00:00
ALM-PRT	ON/OFF	ON: print when new alarm occur OFF: no print when new alarm occur	OFF
REC-INTR	1/2/4/6/15/30/60/120/240s	Record interval time	1 second
CH1-NAME	00: CH01, Channel 1 01: TEMP, Temperature 02: PRES, Pressure 03: FLOW 04: DP, Differential Pressure 05: TIN, Inlet Temperature 06: TOUT, Outlet Temperature 07: blank	Channel name of the 1st input channel	4
CH2-NAME	Same as above	Channel name of the 2nd input channel	1
CH3-NAME	Same as above	Channel name of the 3rd input channel	2
CH4-NAME	Same as above	Channel name of the 4th input channel	4
AUT-PAGE	ON: automatic page switch (interval of about 10s) OFF: manual page switch (press F1)	Page switch option: automatic/manual page switch	OFF
PAGE1	Page 1 has 4 lines, its content is defined by the following 4 bits: 1 0 X1 X2 X3 X4: X1: 1st line content X2: 2nd line content X3: 3rd line content X4: 4th line content	Line content: Xi Content 0 – blank 1 – measured value of signal channel 1 2 – measured value of signal channel 2 3 – measured value of signal channel 3 4 – measured value of signal channel 4 5 – instantaneous flow 6 – instantaneous heat 7 – instantaneous cold 8 – cumulative flow 9 – cumulative heat A – cumulative flow of channel 2 B – cumulative flow of channel 3 C – cumulative flow of channel 4 D – user balance E – residual flow subscribed	User-defined
PAGE2	Page 1 has 4 lines, its content is defined by the following 4 bits: 2 0 X1 X2 X3 X4: X1: 1st line content X2: 2nd line content X3: 3rd line content X4: 4th line content	Same as above	User-defined

PWR-PAGE	ON: Display of Power On/Down page is ON; OFF: Display of Power On/Down page is OFF	The last 8 power on/off time will be recorded in flow meter.	OFF
REPORT	ON: Display of hourly report, shift report, daily report, and monthly report pages are ON; OFF: the above pages are OFF	The instrument is capable of compiling hourly report, shift report, daily report, and monthly report. All reports can be inquired by turning on the "REPORT"	OFF
PASSWORD	To set supplier password and customer password		
CLEAR	Yes: to clear all reports; No: not to clear all reports;	Press " ", and a window for choosing to or not to clear reports will pop up. Use "◀" and "▶" to move the cursor on proper option, and press " " for confirmation.	

9) "SHF" parameters

Name	Range	Description	Default Value
SHIFTS	1 ~ 3	Number of shifts counted in one day, reports of 3 shifts may be made at maximum for one day.	3
SHF1-ST	00:00 ~ 23:30	Start time of shift 1 (H:M), which may be H:00 or H:30	00:00
SHF1-END	00:00 ~ 23:30	End time of shift 1 (H:M), which may be H:00 or H:30	08:00
SHF2-ST	00:00 ~ 23:30	Start time of shift 2 (H:M), which may be H:00 or H:30	08:00
SHF2-END	00:00 ~ 23:30	End time of shift 2 (H:M), which may be H:00 or H:30	16:00
SHF3-ST	00:00 ~ 23:30	Start time of shift 3 (H:M), which may be H:00 or H:30	16:00
SHF3-END	00:00 ~ 23:30	End time of shift 3 (H:M), which may be H:00 or H:30	00:00

10) "PAY" parameters

Name	Range	Description	Default Value
CHRG-DIV	ON/OFF	Time-division charge, which can be divided to peak period, valley period, and normal period.	ON
PEAK-ST	00:00 ~ 23:30	Start time of peak period	00:00
PEAK-END	00:00 ~ 23:30	End time of peak period	00:00
VALL-ST	00:00 ~ 23:30	Start time of valley period	00:00
VALL-END	00:00 ~ 23:30	End time of valley period	00:00
PEAK-FEE	0 – 999999	Flow unit price in peak period (RMB)	0
VALL-FEE	0 – 999999	Flow unit price in valley period (RMB)	0
NORM-FEE	0 – 999999	Flow unit price in normal period (RMB)	0
REM-CTRL	ON/OFF	Remain quantitative control, if activated, the 4th alarm contact will be used. The 4th contact will be ON when there is no remain quantitative, or it is OFF.	OFF
CHARGE	-99999 ~ 999999	The flow purchased by user (RMB Yuan) If it's a positive value, the "BALANCE" will increase; if it's a negative value, the "BALANCE" will decrease.	0

BALANCE	0 ~ 9999999	The balance of flow charge (RMB Yuan)	0

11) “CON” parameters

Name	Range	Description	Default Value
CONTROL	ON/OFF	The 4th alarm contact will be used when CONTROL is ON.	OFF
TRIGGER	MAN/AUTO	“MAN”：Before triggered, the 4th alarm contact remain its status. When triggered, alarm contact’s status depends on GOT-OUT. “AUTO”： The 4th Alarm contact’s status depends on GOT-OUT.	MAN
GOT-OUT	OFF/ON	“OFF”：When this accumulation got CTRL-VAL, the 4th alarm contact will be OFF, otherwise it is ON. “ON”：When this accumulation got CTRL-VAL, the 4th alarm contact will be ON, otherwise it is OFF.	ON
AUTO-CLR	ON/OFF	ON ： When this accumulation got CTRL-VAL, this accumulation will be cleared automatically. AUTO-CLR works only if TRIGGER is AUTO.	OFF
CTRL-VAL	0—— 999999	Control Value	100
ADVANCE	0—— 999999	Actually control will work if (this accumulation >= CTRL-VAL – ADVANCE).	0

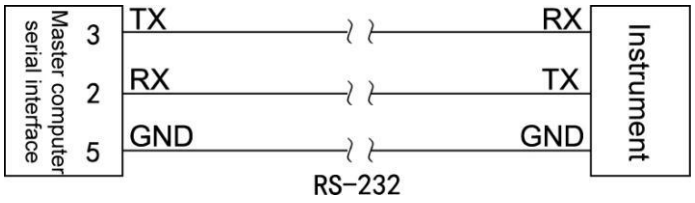
VII. Communication Setting

The instrument is capable of communication with master computer which may complete parameters setting, data collection, and monitoring of slave computer. Combined with industrial computer software, dynamic display, instrument data setting, graph generation, data storage, and printing can be realized in Chinese Windows system. Real-time data and curves collection as well as historical data and curves recording can also be achieved with our master computer management software, where historical data and curves can be exported to be Excel files for processing.

Communication: RS-485/RS-232 serial interface communication, baud rate between 1200 and 9600bps for choice;

Data format: 1 start bit, 8 data bits, 1 stop bit (see details in CD)

Wiring method:



VIII. Calculation

1. Mass flow expression

1.1 Mass flow expression for standard throttling device

$$q_m = \frac{C}{\sqrt{1-\beta^4}} \varepsilon \frac{\pi}{4} d^2 \sqrt{2\Delta P \times \rho} \times 3600 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(1)$$

Where: q_m: mass flow (Kg/h)

C: Discharge coefficient (dimensionless)

B: diameter ratio (dimensionless)

ε: expansion coefficient (dimensionless)

d: Throttling piece diameter (m)

△P: differential pressure (Pa)

ρ : medium density in operating condition (Kg/m^3)

In formula (1) above, β will be calculated below:

$$\beta = \frac{d}{D} \quad \cdots\cdots(2)$$

D: The pipe diameter (m)

In formula (2) above, d and D will be calculated below:

$$d = d_{20}\left[1 + \lambda_d (t - 20)\right] \quad \cdots\cdots(3)$$

$$D = D_{20}\left[1 + \lambda_D (t - 20)\right] \quad \cdots\cdots(4)$$

Where: d_{20} : throttling piece diameter at 20℃ (m)

d_{20} : the pipe diameter at 20℃ (m)

λ_d: linear expansion coefficient of orifice plate material (10^{-6}/℃)

λ_D: linear expansion coefficient of tube material (10^{-6}/℃)

t: operating temperature (℃)

In formula (1) above, ε and C will be calculated according to GB/T2624-2006 “Measurement of Fluid Flow by means of pressure differential devices inserted in circular cross-section conduits running full”. Formula (1) applies to mass flow of the following measuring devices: Flange pressure plate, Machined classical Venturi tube, Angle pressure plate, Thick iron wielding section of Venturi tube, D and D/2 pressure plate, V-cone flow meter, ISA932 nozzle, Long diameter nozzle, Venturi nozzle, Casting-type Venturi tube.

1.2 Mass flow expression for V-cone flow meter

In formula (1) above, β will be calculated below:

$$\beta = \frac{\sqrt{D^2 - d^2}}{D} \quad \cdots\cdots(7)$$

1.3 Simplified mass flow expression for throttling device

$$q_m = K\sqrt{\Delta P \times \rho} \quad \cdots\cdots(8)$$

Where: q_m: mass flow (Kg/h)

△P: differential pressure (Pa)

ρ: medium density in operating condition (Kg/m^3)

K: instrument coefficient

Formula (8) is a simplified expression derived from formula (1) where all coefficients are taken as constants, which applies to ther flow meter of differential pressure type. As instrument coefficient K is possibly not an invariable constant, K may be divided into 8 segments for segmented calculation to higher precision.

1.4 Mass flow expression for frequency-type flow meter such as vortex

$$q_m = \frac{3.6}{K} \times \rho \times f \quad \cdots\cdots (9)$$

Where: q_m: mass flow (Kg/h)

K: flow coefficient of vortex flow meter (pulse/L)

ρ: medium density in operating condition (Kg/m^3);

f: frequency of signal sent by vortex flow meter (Hz)

As flow coefficient K is possibly not an invariable constant, K may be divided into 8 segments for segmented calculation to higher precision.

Formula (9) applies to frequency-type flow meter such as vortex.

1.5 Mass flow expression for linear volumetric flow meter

$$q_m = \rho \times q \quad \cdots\cdots (10)$$

Where: q_m : mass flow (Kg/h);

q : volumetric flow measured by linear flow meter (m^3/h);

ρ: medium density in operating condition (Kg/m^3);

Formula (10) applies to measuring device of linear flow meter.

2. Volumetric flow expression

Volumetric flow in operating conditions:

$$q_v = \frac{q_m}{\rho} \quad \cdots\cdots (11)$$

Volumetric flow in standard condition:

$$q_{vN} = \frac{q_m}{\rho_N} \quad \cdots\cdots (12)$$

Where: q_v : volumetric flow in operating condition (m^3/h)

q_{vN} : volumetric flow in standard condition (Nm^3/h);

q_m : mass flow (Kg/h);

ρ : medium density in operating condition (Kg/m^3);

ρ_N : medium density in standard condition (Kg/m^3);

Standard condition means temperature of 20℃ or 0℃ （subject to user's choice） and atmospheric pressure of 0.10133MPa.

3. Density compensation formula

3.1 Gas density compensation formula

Dry gas density compensation formula:

$$\rho = \rho_N \times \frac{P \times T_N \times Z_N}{P_N \times T \times Z} \quad \cdots\cdots(13)$$

Density compensation formula for dry part of humid gas:

$$\rho = \rho_N \times \frac{(P - \phi \times P_{s\max}) \times T_N \times Z_N}{P_N \times T \times Z} \quad \cdots\cdots(14)$$

Where: ρ : medium density in operating condition

ρ_N : medium density in standard condition (Kg/m^3);

P : absolute pressure in operating condition (MPa);

T : absolute temperature in operating condition (T);

P_N : absolute pressure in standard condition (0.10133MPa);

T_N : absolute temperature in standard condition (273.15K or 293.15K);

Z : compressibility factor in operating condition (dimensionless);

Z_N : compressibility factor in standard condition (dimensionless);

φ : relative humidity in operating condition (%);

$P_{s\,max}$: saturated steam pressure in operating condition (MPa)

Compressibility factor Z could be solved by Redlich-Kwong equation:

$$Z^3 - Z^2 - (B^2 + B - A)Z - AB = 0 \quad \cdots\cdots(15)$$

$$A = \frac{0.4274802 P_r}{T_r^{2.5}} \qquad B = \frac{0.0866404 P_r}{T_r}$$

$$P_r = \frac{P}{P_c} \qquad T_r = \frac{T}{T_c}$$

Where: P_c means critical pressure of gas (MPa);

T_c means critical temperature of gas (K)

3.2 Water and steam density formula

Steam density may be solved by IAPWS-IF97 formula based on measured pressure and temperature.

Saturated steam dryness compensation formula:

$$v = x v_g + (1 - x) v_f \quad \cdots\cdots(16)$$

Where: v : specific volume of humid saturated steam (m^3/Kg);

v_g : specific volume of saturated steam (m^3/Kg);

v_f : specific volume of water (m^3/Kg);

x : dryness (%);

Water density may be solved in real time IAPWS-IF97 formula based on measured temperature and input atmospheric pressure.

3.3 Liquid density formula

Liquid (e.g. petroleum and diesel oil) density will be solved by formula below:

$$\rho = \rho_N \times \left(1 + A_1 \times (t - t_N) \times 10^{-2} + A_2 \times (t - t_N)^2 \times 10^{-6}\right) \quad \cdots\cdots (17)$$

Where: ρ : liquid density in operating condition (Kg/m^3);

ρ_N : liquid density in standard condition (Kg/m^3);

t_N : temperature in standard condition (℃);

t : temperature in operating condition (℃);

A_1 : monomial coefficient of quadratic polynomial (dimensionless);

A_2 : quadratic coefficient of quadratic polynomial (dimensionless);

3.4 Heat expression

Steam heat expression:

$$Q = q_m \times h \quad \cdots\cdots (19)$$

Where: Q : instantaneous heat (KJ/h);

q_m : mass flow (Kg/h);

h : enthalpy (KJ/Kg);

Steam enthalpy h will be calculated in real time by IAPWS-IF97 formula.

3.5 Heat expression for hot water

Heat expression for hot water:

$$Q = q_m \times \left(h_{\text{inlet temperature}} - h_{\text{outlet temperature}}\right) \quad \cdots\cdots (20)$$

Where: Q means instantaneous heat (KJ/h);

q_m means mass flow (Kg/h);

$h_{\text{inlet temperature}}$: enthalpy of hot water at the inlet (KJ/Kg);

$h_{\text{outlet temperature}}$: enthalpy of hot water at the outlet (KJ/Kg);

Hot water enthalpy h may be calculated in real time by IAPWS-IF97 formula.

IX. Example

Example 1: measuring mass flow of superheated steam with orifice plate with corner taps

- It's known that:

Tube material: #45 steel

Throttling element material: 1Cr18Ni9Ti

Tube caliber: 441.20mm

Throttling element caliber: 313.71mm

Atmospheric pressure: 0.10133Mpa

Differential pressure sensor: 4~20mA differential pressure transducer (two-wire system), measuring range: 0.00 ~ 60.00Kpa (no extraction);

Pressure sensor: 4~20mA pressure transducer (two-wire system), measuring

range: 0.00 ~ 3.00Mpa;

Temperature sensor: PT100

- Validation parameters

Differential pressure sensor: 14mA

Pressure sensor: 12mA

Temperature sensor: 200Ω

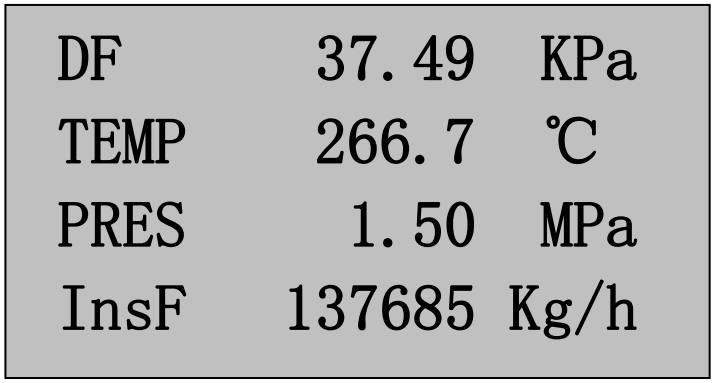
- Parameters setting:

Item		Content
Measuring device in “Device” configuration		V02: orifice plate with corner taps
Tube material in “Device” configuration		C05: #45 steel
Throttling element material in “Device” configuration		C12: 1Cr18Ni9Ti
Tube caliber in “Device” configuration		441.20mm
Throttling element caliber in “Device” configuration		313.71mm
Measured medium in “Medium” configuration		F03: steam
Atmospheric pressure in “Medium” configuration		0.10133Mpa
Differential pressure signal	Input channel	01
	Input type	4 ~ 20mA
	Input unit	Kpa
	Upper/lower limit of measuring range	0.00 ~ 60.00
Temperature signal	Input channel	02
	Input type	PT100
	Input unit	℃
	Upper/lower limit of measuring range	0.0 ~ 650.0
Pressure signal	Input channel	03
	Input type	4 ~ 20mA
	Input unit	Mpa
	Upper/lower limit of measuring range	0.00 ~ 3.00

- Formula:

$$q_m = \frac{C}{\sqrt{1-\beta^4}} \varepsilon \frac{\pi}{4} d^2 \sqrt{2\Delta P \times \rho} \times 3600$$

- Displayed result:



Example 2: measuring mass flow of superheated steam by vortex street (frequency) flow meter with pressure and temperature

- It's known that:

Atmospheric pressure: 0.10133Mpa

Vortex street sensor: 12V distributed power; frequency 0 ~ 2000Hz; coefficient K =500times/L

Pressure sensor: 4~20mA pressure transducer (two-wire system) for power distribution; measuring range: 0.00 ~ 1.00Mpa.

Temperature sensor: PT100

- Validation parameters

Vortex street sensor: 2000Hz

Pressure sensor: 16mA

Temperature sensor: 175.84Ω

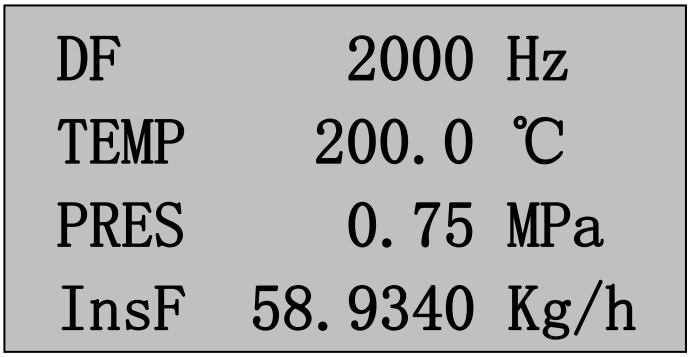
- Parameters setting:

Item		Content
Measuring device in "Device" configuration		V12: frequency-type vortex street flow meter
Coefficient segment in "Device" configuration		1
Segment 1 end point in "Device" configuration		1000
Coefficient K1 in "Device" configuration		500
Measured medium in "Medium" configuration		F03: steam
Atmospheric pressure in "Medium" configuration		0.10133Mpa
Differential pressure signal	Input channel	01
	Input type	4 ~ 20mA
	Input unit	Kpa
	Upper/lower limit of measuring range	0 ~ 2000
Temperature signal	Input channel	02
	Input type	PT100
	Input unit	℃
	Upper/lower limit of measuring range	0.0 ~ 6500.0
Pressure signal	Input channel	03
	Input type	4 ~ 20mA
	Input unit	Mpa
	Upper/lower limit of measuring range	0.00 ~ 1.00

- Formula:

$$q_m = \frac{3.6}{K} \times \rho \times f$$

- Displayed result:



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