

# **AI-708H/808H Intelligent Flow Totalizer**

**Operation Instruction V7.0**

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## 1. General

### 1.1 Main features

AI-708H/808H series flow totalizers can accumulate the mass, volume or length of an object, and can provide batch control over the accumulation. Features:

- Modularized structure and hardware compatible with other AI series instruments and modules, which make it easy to maintain and quick delivered.
- Modularized and configurable inputs. The flow input can be 1-5V, 0-5V, 4-20mA or frequency signal, and special user defined input specification is also available. The temperature input can be configured to Pt100 RTD, K, E, J type thermocouple, voltage, or current signal. The pressure input can be various voltage or current signal.
- Abundant functions such as retransmission, high/low alarm of momentary flow, temperature and pressure, abnormal signal detecting, and communication with computer are available.
- Square root/no square root selectable, 8-digits accumulation value and 4-digits momentary process value, small signal cut-out can be set at any range.
- It has perfect temperature and pressure compensation used for general gas, saturated steam, overheat steam and liquid. The compensation calculation with the method of table look-up has a high accuracy in the steam measurement application. Special function can be carried out by enhancing the compensation formula upon customers' demand.
- Advanced computation algorithm assure enough accuracy in the application of flow measurement even if the frequency input signal is very small.
- As used as batch controller, it has 4-bit accumulator for control and 12-bit accumulator for total sum individually.
- With high precision current module installed, the totalizer can provide retransmission with 14 bit output resolution and 0.2%FS output precision.
- No panel DIN rail mounted type is also available, can be operated by computer via RS485 communication interface.

### 1.2 Ordering Code

Advanced modular hardware design is utilized for AI series instrument. The input, communication and the retransmission function are determined by modules equipped, which can be purchased separately from instrument, and can be assembled freely. The instrument may be equipped with maximum modules of 6. The input type of pressure or temperature can be set freely. The type number of AI series instrument is made up of 8 parts, for example:

|                |          |           |           |           |           |           |           |
|----------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|
| <u>AI-808H</u> | <u>A</u> | <u>I0</u> | <u>I2</u> | <u>L4</u> | <u>L5</u> | <u>X3</u> | <u>S4</u> |
| ①              | ②        | ③         | ④         | ⑤         | ⑥         | ⑦         | ⑧         |

It shows that the base model is AI-808H; front panel dimension is 96x96mm; temperature and pressure inputs are from I0 module (which means that temperature input is thermocouple or RTD, and pressure input is 0-5V or 1-5V); flow input is I2 module(used for frequency signal input); an L4 relay module is installed in OUP socket for batch

control; L5 dual relay module is installed in ALM for providing two alarm output; X3 module is installed in AUX socket for retransmission, and S4 RS485 communication interface is installed in COMM socket for communicating with computer.

① **Show the basic function of instrument**

**AI-708H** type flow totalizer (without temperature or pressure compensation)

**AI-808H** type flow totalizer (with temperature or pressure compensation)

② **Show the instrument dimension, the depth of the instrument is 12-13.5mm(foreside) and 100mm (rearward)**

| Model        | Front Panel<br>(width x height)       | Cut-out<br>(width x height) | Depth Behind Mounting Surface | Remarks  |
|--------------|---------------------------------------|-----------------------------|-------------------------------|--|
| <b>A(A2)</b> | 96x96mm                               | 92x92mm                     | 100mm                         | A2 has a light bar with 25 segments and 4 levels of luminosity.  |
| <b>B</b>     | 160X80mm                              | 152x76mm                    | 100mm                         |  |
| <b>C(C3)</b> | 80x160mm                              | 76x152mm                    | 100mm                         | C3 has a light bar with 50 segments and 2 levels of luminosity   |
| <b>D</b>     | 72x72mm                               | 68x68mm                     | 95mm                          |  |
| <b>E</b>     | 48x96mm                               | 45x92mm                     | 100mm                         |  |
| <b>E5</b>    | 48x96x112<br>(width x height x depth) |                             |                               | E5 is no panel DIN rail mounted. It can be installed on DIN rail and programmed by connecting to external display. |
| <b>F</b>     | 96x48mm                               | 92x45mm                     | 100mm                         |  |

③ ~ ⑧ shows the module types installed on the following sockets: **M1 (temperature and pressure inputs), M2 (flow input), OUTP (main output), ALM (alarm), AUX (auxiliary output, can be used for alarm output, ON/OFF signal input and flow retransmission output), COMM (communication).**

("√" means the module allowed to be installed on the according socket)

| Module    | Module Descriptions   | M1 | M2 | OUTP | ALM | AUX | COMM |
|-----------|---|----|----|------|-----|-----|------|
| <b>N</b>  | no module installed   | √  | √  | √    | √   | √   | √    |
| <b>I0</b> | Temperature input is thermocouple, RTD or mV signal input; pressure or flow input is 0-5V or 1-5V voltage signal. | √  |    |      |     |     |      |
| <b>J4</b> | Dual 0-20mA or 4-20mA current signal inputs   | √  |    |      |     |     |      |
| <b>J5</b> | Dual two-wire retransmitter inputs  | √  |    |      |     |     |      |
| <b>I2</b> | Single frequency signal input, providing 12V/50mA DC power supply for external transducer.                        |    | √  |      |     |     |      |
| <b>I3</b> | Single 0-5V/1-5V voltage signal input, with 24V/50mA power supply for external transducer.                        |    | √  |      |     |     |      |
| <b>I4</b> | 4-20mA/0-20mA analogue input interface, providing a 24VDC/24mA power supply for a two-wire transmitter.           |    | √  |      |     |     |      |

|                                 |   |   |   |   |   |   |   |
|---------------------------------|---|---|---|---|---|---|---|
| <b>V5/V10/<br/>V12/V2<br/>4</b> | Isolated 5V, 10V, 12V or 24V DC output with maximum current 50mA.<br>(use instrument's internal 24V isolated power) | √ | √ | √ | √ | √ | √ |
| <b>L2</b>                       | 1 relay contact (NO+NC) output.<br>(small volume, 30VDC/1A, 250VAC/1A)  |   |   | √ | √ | √ |   |
| <b>L4</b>                       | 1 relay contact (NO+ NC) output.<br>(30VDC/2A, 250VAC/2A)   |   |   | √ | √ | √ |   |
| <b>L5</b>                       | 2 relay contact (NO) outputs. (30VDC/1A, 264VAC/1A)   |   |   |   | √ | √ |   |
| <b>W1</b>                       | TRIAC no contact normal open output.<br>(100~240VAC/0.2A)   |   |   | √ |   |   |   |
| <b>W2</b>                       | TRIAC no contact normal closed output.<br>(100~240VAC/0.2A)   |   |   | √ |   |   |   |
| <b>G</b>                        | SSR voltage outputs (12VDC/30mA)  |   |   | √ |   |   |   |
| <b>X3</b>                       | 0 ~ 20/4 ~ 20mA linear current output module.<br>(Use internal 12VDV power of the instrument)                       |   |   |   |   | √ |   |
| <b>X5</b>                       | 0 ~ 20/4 ~ 20mA linear current output module.<br>(With its own isolated power)                                      |   |   |   |   | √ |   |
| <b>S</b>                        | Photoelectric isolated RS485 communication module<br>(use instrument's internal 12V isolated power)                 |   |   |   |   |   | √ |
| <b>S4</b>                       | Photoelectric isolated RS485 communication module<br>with its own photoelectric isolated power                      |   |   |   |   |   | √ |
| <b>R</b>                        | RS232 communication interface<br>(use instrument's internal 12V isolated power)                                     |   |   |   |   | √ |   |

#### Further description about module functions

- Module sockets:** OUP socket works for batch control or alarm output; ALM works for alarm output; AUX works for alarm output, flow retransmission or external ON/OFF input; COMM works for communication.
- Voltage output module:** The voltage output modules like V24, V10 or V12 are often used for supplying power for external transducer or feedback resistance of transmitter. These modules can be installed in any socket. To standardize the wiring, it is recommended to be installed in the first idle socket in the order of MIO, AUX, and COMM. I2, I3, I4, and J5 modules also provide 24V voltage output. You must make sure the total output current of all these modules should be less than 60mA.
- Electric isolation of the modules:** There are a group of 24V and a group 12V power supply built in the instrument and isolated to the main circuit. The 24V power commonly supplies voltage output module, such as V24/V12/V10, I2 and I4. The 12V power is commonly supplies output or communication module. Generally, the relay contact output and TRIAC no contact discrete output are self insulated from the

other circuit, no matter whether other modules are installed or not. SSR voltage output do not need to be insulated from input circuit, because SSR itself has isolation function. Therefore, only the electric isolation between the communication interface and the current output should be considered. Those modules, for example, S (RS485 communication interface), R (RS232 communication interface) and X3 (linear current output), all need the 12V power supply. If more than one of the above modules are installed, in order to be electric isolated, only one of them can be module without electric isolation, the other modules should be S4 or X4, a which has its own isolated power supply. For example, if an X module is installed in OUP (main output) socket, and an S or X module is installed in COMM (communication interface) socket, then OUP and COMM can not be electric isolated, so S or X should be replaced with S4 or X4.

4. **No contact triac switch module** : W1 and W2 are new types of no contact switch module which apply the advanced technology of “burn proof” and zero crossing conduction. It can replace the relay contact switch. Compared to the relay contact output module, W1 and W2 have longer life and lower interference. They can largely lower the interference spark of the equipment, and greatly improve the stability and reliability of the system. Since the driver element is TRIAC, it is suitable for controlling 100-240VAC (not for DC power) with current up to 80A. For the current larger than 80A, an intermediate relay is needed.

**Calibration & Maintenance:** The instrument applies the technology of automatic zero and digital calibration, and is free of maintenance. If the error exceeds certain range, generally, cleaning and drying the inside of the instrument can fix it. If not, send the instrument back to the factory to examine and repair.

**Warranty:** Free repair and maintenance will be given in 36 months since the delivery. In order to get full and correct repair, write the phenomena and causes of the malfunction of the instrument.

**Special Requirement:** AI-808H can provide special calculating function according to customer's requirement. With special order, user can defined his own input non-linear adjustment table, and can add special formula for arithmetic and logical calculation.

### 1.3 DIN Rail Mounted Instruments

DIN rail mounted instrument (dimension E5) has no display window. It is often operated by communicating with host computer through a RS485 communication interface.

The address and baud rate parameters can be set by the instrument's internal switch. There is a switch of 10 bits behind the front cover of the instrument. The bit 1~7 is a binary number from 0 to 100 indicating the communication address. The eighth bit indicates baud rate, “0” means baud rate is set to 9600, and “1” for 19200. The other two bits is spare for future use. The updated parameters won't be active until the instrument power on again.

E5 dimension instrument has one LED indication light. When the instrument is communicating with the host computer, the light flashes with light on time different to light off time. When the instrument hasn't received signal from the host computer for 6 seconds, the indication light should flash with the same light on time and light off time. The flash frequency can tell the work status of the instrument:

That the on-off period is as long as 1.6 second means no communication and no

alarm (it can be treated as normal);

The light flashing with period 0.6 second means no communication and general error occurs.

The light quickly flashing with period 0.3 second means no communication and severe error such as input over range occurs.

The light keeping off means the instrument power off or damaged; the light keep on (longer than 8 seconds) means the instrument is on but is damaged.

The parameters of E5 dimension instrument can also be set by connecting ADP1 display to the 1394 socket.

Note: The 1394 socket of the instrument only supports Yudian ADP1 display.

linear current output) are designed for this purpose.

## 1.4 Technical Specification

- Frequency units: Hz
- Temperature units: °C (display resolution 0.1°C), decimal point position can be defined for special compensation method.
- Pressure units: MPa (display type like X.XXX or XX.XX), decimal point position can be defined for special compensation method. KPa is option for special request (display type like XXX.X or XXXX)
- Accumulation time: Fixed at 1 hour for flow accumulation, and the unit can be freely set for batch control.
- Momentary flow unit: Different units can be set, like M<sup>3</sup>/hour, kg/hour, ton/hour. The decimal point can be freely set.
- Accumulation flow unit: the unit and resolution is the same as momentary flow, for example: if the momentary flow keep the value of 100.0t/h, and the accumulation time is 1 hour, then after one hour the accumulation flow increases by 100.0t.
- Flow input type:
  - Frequency (I2 module installed in M2): 0-3200Hz, the low level signal is 0-1V, the high level signal is 3-24V
  - Voltage (I3 module installed in M2): 1-5V, 0-5V, providing 24VDC/24mA power output
  - Current (I4 module installed in M4): 4-20mA, 0-20mA, 0-10mA, providing 24VDC/24mA power output
  - Others (special module installed): for special input specification
- Temperature input type:
  - Thermocouple (I0 module in M1 socket): K (0-999°C), E (0-800°C), J (0-999°C)

Resistance temperature Detector (I0 in M1): Pt100 (-200 -- +600°C)

Voltage (I0 in M1) : 0-20mV, 20-100mV, 0-100mV, 0-1V, 0.2-1V

Current (J4 in M1) : 4-20mA, 0-20mA

Two-wire retransmitter (J5 in M1) : directly connect to two wire retransmitter.

➤ Pressure input type:

DC Voltage : 1-5V, 0-5V

Current (J4 in M1) : 4-20mA, 0-20mA

Two-wire retransmitter (J5 in M1) : directly connect to two wire retransmitter.

➤ Measurement accuracy:  $\pm 0.2\%$  FS, for temperature、pressure、frequency、momentary flow without temperature- pressure compensation.

➤ Temperature drift:  $\leq 0.01\%$ FS /°C (typical value is 50ppm/°C)

➤ Temperature/pressure compensation method (only for AI-808H)

General gas: temperature- pressure compensation (calculate by equation for ideal gases)

Saturated steam: temperature compensation (table look-at, temperature range: 100°C-276°C)

Saturated steam: pressure compensation (table look-at, absolute pressure range: 0.1-3.2Mpa)

Saturated steam: temperature- pressure compensation (table look-at, temperature range: 150°C-590°C pressure range: 0.1-22Mpa)

General liquid: only use temperature compensation, PA is compensation factor.

Extended calculation formula: special calculation formula can be made to order.

➤ Calculation accuracy for temperature- pressure compensation: the calculation error is less than 0.3% FS, and after compensation, the overall error is less than 0.5% FS.

➤ Accumulation accuracy: the error is less than 0.01%FS (just the frequency error produced by crystal oscillator).

➤ **Electromagnetic compatibility (EMC)** :  $\pm 4$ KV/5KHz according to IEC61000-4-4; 4KV according to IEC61000-4-5.

➤ **Isolation withstanding voltage** : between power, relay contact or signal terminal  $\geq 2300$ VDC; between isolated electroweak terminals  $\geq 600$ VDC

● **Power supply** : 100 ~ 240VAC, -15%, +10% / 50-60Hz; 120 ~ 240VDC; or 24VDC/AC, -15%, +10%.

● **Power consumption**:  $\leq 5$ W

● **Operating Ambient** : temperature -10~60°C; humidity  $\leq 90\%$ RH

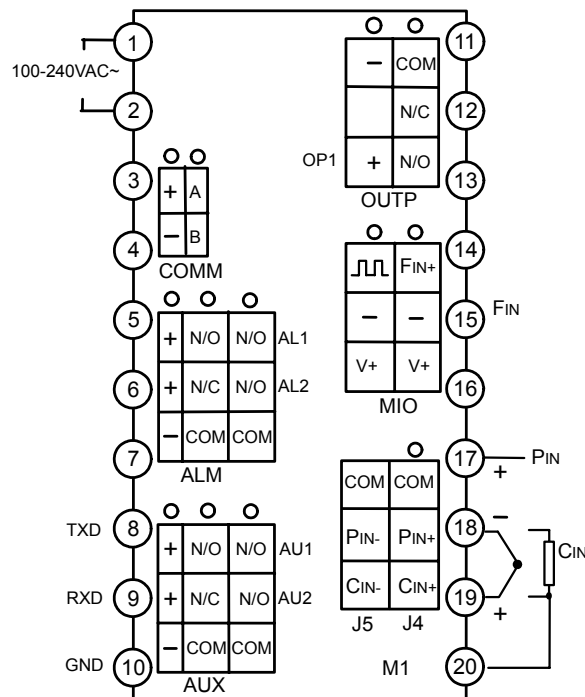
● **Front panel dimension**: 96×96mm, 160×80mm, 80×160mm, 48×96mm, 96×48mm, 48×48mm, 72×72mm

● **Panel cutout dimension**: 92×92mm, 152×76mm, 76×152mm, 45×92mm, 92×45mm, 45×45mm, 68×68mm

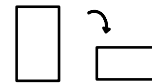
● **Depth behind mounting surface**: 100mm



## 1.5 Wiring and rear terminals layout



Note: This graph suits for upright instruments with dimension A, C, E.



For B, F dimension instruments, clockwise rotate this graph for 90 degree, and the numbers of the terminals keep the same.

### Note:

1. Fin, Cin and Pin indicate the input interface of flow, temperature and pressure.
2. When I0 module is installed in M1 socket, 0-5V or 1-5V signal for pressure is inputted from terminals 17+ and 18-.
3. The compensation wires for different kinds of thermocouple are different, and should be directly connect to the terminals. When the internal auto compensation mode is used, connecting the common wire between the compensation wire and the terminals will cause measurement error.
4. When I4 module is installed in MIO socket, V+ indicate the positive polar of internal 24V power output. Wire a two-wire retransmitter according to 16+ and 14-.

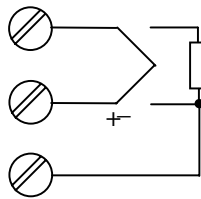
### Select thermocouple reference junction compensation mode by using different wiring mode

Reference junction compensation is needed junction for thermocouple input. All instrument supply good reference junction compensation for thermocouple input through 4 different compensation modes selective using software configuration and different external wiring.

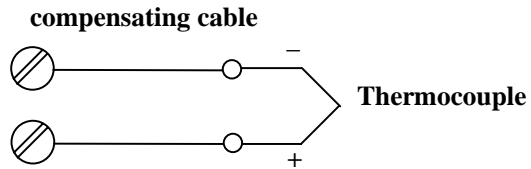
- **Internal automatic compensation:** this is the default mode, and can satisfy a lot of industrial application. But because temperature sensor is installed inside the instrument or at wiring terminals, and may be easily affected by the heat generated in the instrument and by compensating lead wire connection and surroundings, measurement error may be produced up to 2—4 °C sometimes.
- **Compensation with Cu50 copper resistor sensor externally connected:** the compensation precision is high. In the application in which high measurement precision is needed, you can buy a Cu50 copper resistor and had better prepare an

external wiring box, and then put the copper resistor together with thermocouple reference junction far away from exothermic object. Compensation error is less than  $0.5^{\circ}\text{C}$  for this mode.

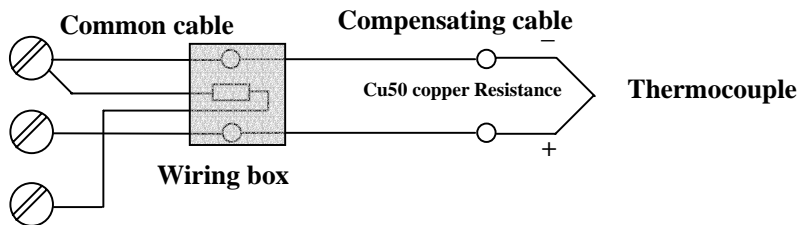
**Wiring diagrams for the above compensation modes:**



**Corresponding wiring diagram of the instrument**



**(1) Internal automatic compensation connected**  
(compensating cable directly connected to instrument's terminals)

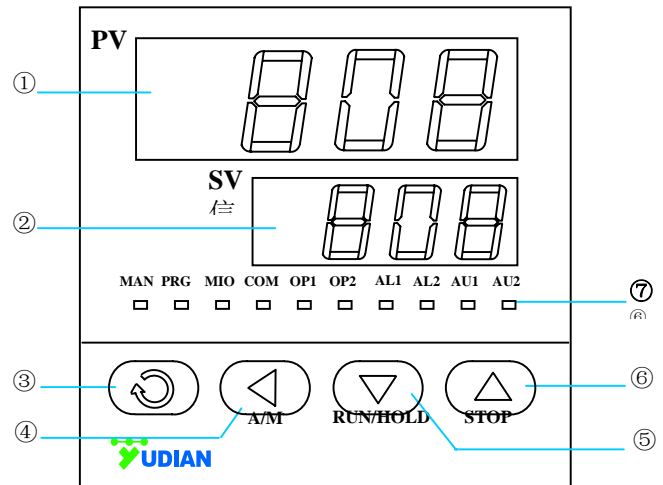


**(2) Automatic compensation mode by externally connected copper resistance**  
*Note: wiring box should be well way from the heat generating object.*

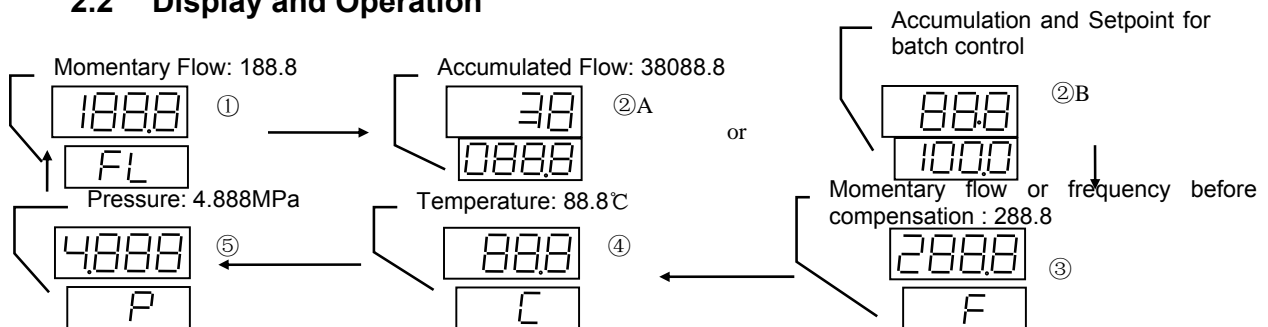
## 2. DISPLAYS AND OPERATIONS

### 2.1 Front Panel Description

- ① Upper display window, displays PV, parameter code, etc.
- ② Lower display window, displays SV, parameter value, or alarm
- ③ Setup key, for accessing parameter table and conforming parameter modification.
- ④ Data shift key, and auto/manual control switch.
- ⑤ Data decrease key
- ⑥ Data increase key
- ⑦ 10 LED indicators: MAN light on indicates manual control status; MIO, OP1, OP2, AL1, AL2, AU1, AU2 individually indicates the input/output action of the according modules; COMM light on indicates communicating with the host computer.



### 2.2 Display and Operation



#### 2.2.1 Display status switch

Press (④) key to switch between different display mode.

Mode ① (FL) : displays monetary flow.

Mode ②A : When the instrument works for flow accumulation (parameter Act=0), display 8 digital accumulated flow.

Mode ②B : When the instrument works for batch control (parameter Act=1~255), the upper window display 4 digital accumulated flow, and the lower display window displays 4 digit control setpoint.

Mode ③ (F) : When the flow input is voltage or current signal, it displays the momentary flow before the compensation; when frequency signal, it displays the frequency.

Mode ④ (C) : displays temperature.

Mode ⑤ (P) : displays pressure.

If autotmatic display switching function is set (refer to parameter CF), the display mode ③,④, or ⑤ will automatically switch to display mode ②A or ②B after 30 seconds.

If the temperature-pressure compensation function is disabled (parameter bC=0) and the flow input signal is not frequency, then the upper display window will not display the flow before compensation.

If the instrument has no temperature or pressure signal input, then the temperature or pressure will not be displayed.

### 2.2.2 Parameter Setting

Press  $\text{Ⓚ}$  and hold for about 2 seconds until the parameter code is displayed. Pressing  $\text{Ⓚ}$  can go to the next parameter; pressing  $\text{⏪}$ ,  $\text{⏩}$  or  $\text{⏴}$  can modify a parameter. Press and hold  $\text{⏪}$  can return to the preceding parameter. Press  $\text{⏪}$  (don't release) and then press  $\text{Ⓚ}$  key simultaneously can escape from the parameter table.

### 2.2.3 Manually reset the accumulated value

When the instrument is used for flow accumulation (Act=0) and the parameter Loc=0 or 808, pressing  $\text{⏴}$  and holding for about 2 seconds can reset the 8 digit accumulated value to zero.

After each zero reset operation, the accumulation time will be reset to zero also, and the zero reset counter Cn will increase by 1. The zero reset counter Cn records total zero reset times in the instrument.

When the flow accumulation value exceeds 99999999, the accumulated flow will be automatically reset to zero, and Cn increases by 1.

If the accumulated value has not been manually reset, then Cn and the 8 digit accumulated value can work together as a 12 digit accumulator.

Cn and accumulated value can't be manually modified. Cn will be automatically reset to zero after it is greater than 9999.

When the instrument works for batch control (Act=1 ~ 255), manually reset operation is disabled.

### 2.2.4 Power failure memory for accumulated value

The accumulated value is saved in memory, and will not be lost even when power failure.

## 2.3 Batch control

The AI-708H/808H series instruments can work for flow accumulation and batch control. (set parameter Act=1~255).

When the instrument is used as batch control, there is a 4 digit accumulator for batch control. When the accumulated value reaches the control setpoint (SV+FSb), a relay in OUP socket will be triggered (OP1 light on). The accumulated value will be reset to zero automatically after the relay is released. The latching time of the relay can be set to any length. If it is set to infinite long, an external operation is needed to release the relay. In batch control mode, the parameters CLn, FLJH and FLJL can work together as a 12 digit accumulator for calculating the total accumulated value.

When the parameter Act, the latching time for batch control relay, is set to 255, it means the time is infinite long, and after the relay is triggered, it will not be automatically released. At this situation, pressing  $\text{Ⓚ}$  key or using an external switch (Installing I2 in COMM socket, connecting a switch at terminal 3 and 4, and setting parameter Baud to 0) can release the relay, and make it available for next control action.


In mode ②B, pressing  $\text{⏪}$ ,  $\text{⏩}$  or  $\text{⏴}$  can modify batch control setpoint SV.

### 3. PARAMETERS AND SETTINGS

#### 3.1 Parameter Lock (Loc) and Field Parameters

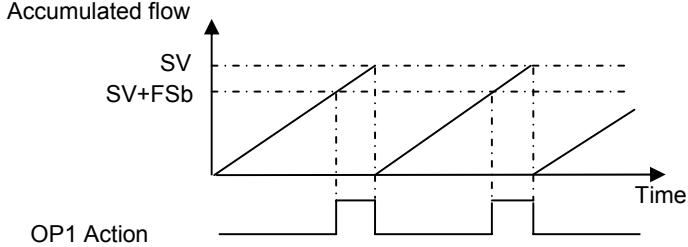

In order to protect important parameters from being modified by mistake, but also offer enough flexibility for field control, parameter lock (Loc) and field parameters are introduced.

The parameters need to be displayed and modified in the work field are called Field Parameters. The set of field parameters is a subset of the full parameter set, and can be freely chosen by the user. User can select up to 8 field parameters through parameter EP1~EP8.

Loc can authorize different security privilege. For details, please read the description of parameter "Loc" in the full parameter table. Setting Loc=808, and then pressing  to confirm, can enter the full parameter table and modify all parameters.

#### 3.2 The Full Parameter Table

| Code        | Name                                | Description   | Setting Range    |
|-------------|-------------------------------------|---|------------------|
| <b>FHIA</b> | High limit alarm for momentary flow | Alarm is triggered when momentary flow >FHIA;<br>alarm is released when momentary flow <FHIAF-FdF;<br>Alarm action output can be defined by parameter ALP.  | 0 ~ 30000 units  |
| <b>FLoA</b> | Low limit alarm for momentary flow  | Alarm triggered when momentary flow <FLoA;<br>alarm released when momentary flow >FLoA+FdF  |                  |
| <b>FdF</b>  | Alarm hysteresis for momentary flow | Avoid frequent alarm on-off action because of the fluctuation of PV   | 0 ~ 9999 units   |
| <b>CHIA</b> | High limit alarm for temperature    | Alarm is triggered when temperature >CHIA;<br>alarm is released when temperature <CHIAF-1.0°C;  | -199.9 ~ 999.9°C |
| <b>CLoA</b> | Low limit alarm for temperature     | Alarm triggered when temperature <CLoA;<br>alarm released when temperature >CLoA+1.0°C  |                  |
| <b>PHIA</b> | High limit alarm for pressure       | Alarm is triggered when pressure >PHIA;<br>alarm is released when pressure <PHIAF-0.010MPa;   | 1.999 ~ 30.00MPa |
| <b>PLoA</b> | Low limit alarm for pressure        | Alarm triggered when pressure <PLoA;<br>alarm released when pressure > PLoA+0.010MPa  |                  |
| <b>ALP</b>  | Alarm output allocation             | ALP defines the alarm output allocation. Its value is calculated as below:<br>ALP=Ax1+Bx2+Cx4+Dx8+Ex16+Fx32<br>A=0, FHIA alarm triggers AL1 relay; A=1, FHIA triggers AL2.<br>B=0, FLoA alarm triggers AL1 relay; B=1, FLoA triggers AL2.<br>C=0, CHIA alarm triggers AL1 relay; C=1, CHIA triggers AL2.<br>D=0, CLoA alarm triggers AL1 relay; D=1, CLoA triggers AL2.<br>E=0, PHIA alarm triggers AL1 relay; E=1, PHIA triggers AL2.<br>F=0, PLoA alarm triggers AL1 relay; F=1, PLoA triggers AL2. | 0~63             |
| <b>Act</b>  | Relay action time for batch control | Act=0, batch control function is disabled, and the instrument is only used for flow accumulation.   | 0~255 (x 0.24s)  |

|            |                                     |  |                  |
|------------|-------------------------------------|--|------------------|
|            |                                     | <p>Act=1-254, when the flow accumulation for batch control gets to SV+FSb (setpoint+offset), OP1 relay (the relay installed in OUTP socket) will be triggered. Parameter Act determines the latching time of the relay, the unit of which is 0.24s. After the latching time passed, OP1 relay will be released, the accumulator for batch control will be reset to zero, and the accumulation start again.</p> <p>You can set parameter FSb to make it equal to the flow accumulation value during the relay latching time, this will make the actual flow accumulation equal to setpoint value SV.</p>  <p>When Act=255, the relay latching time is infinitely long, then after the action of batch control relay OP1 is triggered, it will not terminate or reset automatically. At this time, you can terminate or reset the batch control action, i.e., release the OP1 relay and start the next batch control, by pressing  key or triggering an external discrete input signal.</p> |                  |
| <b>FSb</b> | Batch offset control                | <p>When the instrument is used for batch control, the relay's actual action point is "SV+FSb". "FSb" is usually set to be a negative value. For example, if there is a 5 units of flow during the relay switching time, you can set FSb=-5 to make the actual control value equal to SV value. That is to say, if SV=1000, then when the 4 digits flow accumulation value reach 995, AL2 relay is triggered immediately, and make the actual control value just equal to 1000.</p>   | -1999 ~ +9999    |
| <b>SPE</b> | Accumulation rate for batch control | <p>When the instrument is used for flow accumulator, the time unit in accumulation rate is fixed, i.e., the time unit is 1 hour. When the instrument is used for batch control, you can modify parameter "SPE" to change the accumulation rate time. The formula is as the following:<br/> accumulation rate time= SPE*0.48 (seconds)<br/> Normal setting is like the following:<br/> SPE=7500, represents that the time unit of the accumulation rate is 1 hour.<br/> SPE=750, represents that the time unit is 0.1 hour.<br/> SPE=125, represents that the time unit is 1 minute.<br/> In order to get good control accuracy, you can properly set parameter</p>   | 25~7500 (x0.48s) |

|             |   |   |          |
|-------------|---|---|----------|
|             |   | <p>SPE according to the action period of batch control.</p> <p>For example, provided that the momentary flow keep 100.0 unchanged, the flow accumulation value will increase by 100.0 after 1 hour if you set the accumulation rate time to be 1 hour (SPE=7500), and the flow accumulation value will increase by 100.0 after 1 minute if you set the accumulation rate time to be 1 minute (SPE=125). The smaller the parameter SPE, the faster the flow is accumulated.</p>  |          |
| <b>Sn</b>   | Input Specification (temperature / pressure / flow) | <p>The hundred's place, ten's place and unit's place of parameter Sn represents the signal input specification for temperature, pressure and flow respectively. For convenient description, we use Sn-1 to represent the unit's place of parameter Sn, use Sn-2 to represent the ten's place of parameter Sn, and use Sn-3 to represent the hundred's place of parameter Sn.</p> <p>Sn-1=0, flow input signal is pulse frequency (with I2 module installed).<br/> Sn-1=1, flow input signal is 0-5V/0-20mA (with I3/I4 module installed).<br/> Sn-1=2, flow input signal is 1-5V/4-20mA (with I3/I4 module installed).<br/> Sn-1=3, flow input signal is 0-5V, at terminals 17+, 18- (with I0 module in M1).<br/> Sn-1=4, flow input signal is 1-5V, at terminals 17+, 18- (with I0 module in M1).</p> <p>Sn-2=0, no pressure signal input.<br/> Sn-2=1, pressure signal is 0-5V, at terminals 17+, 18- (with I0 in M1).<br/> Sn-2=2, pressure signal is 1-5V, at terminals 17+, 18- (with I0 in M1).</p> <p>Sn-3=0, no temperature signal input.<br/> Sn-3=1~4, temperature signal input is K, E, J, N type thermocouple respectively (with I0 in M1).<br/> Sn-3=5~6, temperature signal input is Cu50, Pt100 type RTD respectively (with I0 in M1).<br/> Sn-3=7~8, temperature signal input is 0~1V and 0.2~1V, at terminals 19+, 18- (with I0 in M1).<br/> Sn-3=9, temperature signal input is 0~20mV, at terminals 19+, 18- (with I0 in M1).<br/> Sn-3=9, temperature signal input is 4~20mA or two-wire transmitter (with J4 or J5 in M1).</p> | 0~999    |
| <b>CdIP</b> | Temperature point position                          | <p>It only works for customized compensation method.</p> <p>CdIP=0, the temperature display format is XXXX;<br/> CdIP=1, the temperature display format is XXX.X;<br/> CdIP=2, the temperature display format is XX.XX;<br/> CdIP=3, the temperature display format is X.XXX.</p>   | 0~3      |
| <b>Co</b>   | reference working                                   | Parameter Co is used to set the reference working temperature of the  | -199.9 ~ |

|             |   |   |                     |
|-------------|---|---|---------------------|
|             | temperature of the flow sensor  | flow sensor. If Sn-3=0 is set, and parameter bC is set to have temperature compensation, at this time, the system will assume that the temperature is fixed at Co for compensation calculation.   | +999.9℃             |
| <b>CdIH</b> | Temperature range   | When the temperature input is a linear voltage or current signal such as 0.2-1V、0-1V、4-20mA and 0-10mA, this parameter is used to define the measurement range of temperature transmitter (the maximum temperature minus the minimum temperature). The low scale of temperature transmitter is defined by parameter "CSc".  | 0~999.9℃            |
| <b>CSc</b>  | Temperature input offset / Temperature lower limit                            | When temperature input is RTD or thermocouple, parameter CSc is used to make input shift to compensate the error produced by sensor itself. For example, provided input signal keep unchanged, if when parameter "CSc" is set to 0.0℃, the temperature measurement of the instrument is 101.0℃, then when parameter "Sc" is set to -1.0℃, the temperature measurement display will be 100.0℃.<br>When the temperature input is a linear voltage or current signal, parameter CSc is used to define the low scale of temperature transmitter. For example, if the measurement range of a temperature transmitter is 0-400℃, then you can set like the following: CSc=0.0, CdIH=400.0; if the measurement range of a temperature transmitter is 100-400℃, then you can set CSc=100.0 and CdIH=400.0   | -199.9 ~ 999.9℃     |
| <b>PdIP</b> | Pressure point position   | It only works for customized compensation method.<br>PdIP=0, the pressure display format is XXXX;<br>PdIP=1, the pressure display format is XXX.X;<br>PdIP=2, the pressure display format is XX.XX;<br>PdIP=3, the pressure display format is X.XXX.  | 0~3                 |
| <b>Po</b>   | Reference working pressure  | This is gauge pressure. For absolute pressure, you should add 0.1013Mpa. When the set value is larger than 9.999Mpa, the display resolution will change from 0.001Mpa to 0.01Mpa automatically.   | 0 ~ 30.000MPa       |
| <b>PA</b>   | Atmospheric pressure at the instrument site / temperature compensation factor | If pressure compensation is needed, PA represents the atmospheric pressure at the instrument site. The unit is Mpa. The atmospheric pressure above sea level is set to be 0.101Mpa. If the temperature transmitter has a zero shift error, you can also use this parameter to make a input correction.<br>When bC=5, the instrument has temperature compensation only. This case suits for general liquid measurement which need temperature compensation. At this time, PA represents temperature compensation factor. The setting range is from -1.999 to +9.999, and the unit is %/℃.<br>The instrument compensation density formula is as the following:<br><b><math>\rho_B / \rho_o = 1 + PA \times (C - C_o) / 100</math></b><br><b><math>\rho_B</math></b> is the density after compensation, <b><math>\rho_o</math></b> is the density at reference temperature of <b><math>C_o</math></b> , <b><math>C</math></b> is the actual temperature of liquid, <b><math>C_o</math></b> is the reference temperature. | 0 ~ 1.000MPa or %/℃ |
| <b>PdIH</b> | Range of pressure input   | When the flow input is frequency signal, the pressure input can be 0-5V、1-5V、0-10mA or 4-20mA. When the set value is larger than 9.999Mpa,  | 0 ~ 30.000MPa       |



|             |   |  |                                  |
|-------------|---|--|----------------------------------|
|             |   | the display resolution will change from 0.001Mpa to 0.01Mpa automatically.   |                                  |
| <b>PSc</b>  | Scale low limit of pressure input       | Generally, it is set to 0.   | -1999 ~ 9999MPa                  |
| <b>Cut</b>  | The cut off ratio for small flow signal | For linear input: Cut=0.0~50.0%, if flow input is less than range multiply cut off ratio (FdIH* Cut), then the flow input is ignored or set to be zero.<br>For frequency input: Cut=0.0~50.0Hz, if flow input is less than Cut, then the flow input is ignored or set to be zero.  | 0~50.0%<br>Or<br>0~50Hz          |
| <b>Frd</b>  | Scale high limit of frequency input     | It represents the scale high limit of frequency input (range), and is used to calculate the flow range for frequency input. You can set it to be a value which is a little larger than the maximum frequency in actual use.  | 5~3200Hz                         |
| <b>FdIP</b> | Decimal point place for flow display    | FdIP=0, the flow display is like XXXX<br>FdIP=1, the flow display is like XXX.X<br>FdIP=2, the flow display is like XX.XX<br>FdIP=3, the flow display is like X.XXX<br>When the instrument is used for temperature-pressure compensation, the flow display value will exceed 9999, at this time, the decimal point place will move to right by 1 digit automatically.<br>When the flow display is like XXXX (FdIP=0), and if the flow display value exceeds 9999, then the display mode will change to XX.XX because it is impossible for the decimal point place to move to right by 1 digit. Therefore in the application where the flow display value will exceed 9999, you had better set FdIP=3 to make the flow display be like X.XXX, and the unit can be changed from Kg to Ton or from Ton to Kton. | 0~3                              |
| <b>FdIH</b> | Flow input range                        | FdIH represents the momentary flow value when the input voltage or current is at the maximum value, or the input frequency equals to the range high limit Frd. It is the range of flow transmitter. It is provided that the pressure and temperature equals to reference working pressure Po and reference working temperature Co respectively.<br>For detail calculation of FdIH, please refer to latter description.   | 10 ~ 9999 flow units             |
| <b>FSc</b>  | Input shift for momentary flow          | It is used to make input shift to compensate the error produced by sensor itself. The Input shift value equals to FSc*0.005%. This parameter is only used to make input shift for analog flow input, it takes no action for frequency input.   | -1000 ~ 2000 (x 0.005% of range) |
| <b>FdL</b>  | Digital filter strength for flow signal | It is used to set the digital filter strength for flow signal. When a large value is set, the flow input is stabilized but the responsibility at the time is deteriorated. In the application where there is a small frequency input and the retransmission output is needed, you can properly set this parameter to make the fluctuated frequency value change into stable current retransmission output.<br>When FdL=0, the filter function is disabled.   | 0~20                             |
| <b>CF</b>   | Function selection                      | CF=A×1+C×4+D×8+E×16+F×32+G×64+H×128<br>For frequency input, the instrument takes no square root extraction.  | 0~255                            |

|           |  |  |        |
|-----------|--|--|--------|
|           |  | <p>For linear voltage or current input, parameter CF.A is used to define square root extraction like the following:</p> <p>A=0, there is no square root extraction for linear input signal and temperature-pressure compensation density ratio.</p> <p>A=1, the instrument takes square root extraction for linear input signal and temperature-pressure compensation density ratio. You should set like this for differential transmitter. But for frequency input, this setting takes no effect.</p> <p>A=2, there is no square root extraction for input signal, but the instrument takes square root extraction for temperature-pressure compensation density ratio. No matter what types of input, linear voltage/current or frequency, this setting takes effect.</p> <p>C=0, the accumulation continues when the flow input is over range.</p> <p>C=1, the accumulation stops when the flow input is over range.</p> <p>D=0, the display mode 3、4 and 5 will switch back to mode 2A and 2B automatically after 30 seconds.</p> <p>D=1, there is no automatic switching back, so the instrument can keep displaying temperature or pressure.</p> <p>E=0, For batch control, OP1 relay contact is normal open. When the flow accumulation value is greater than the setpoint, the relay contact will be closed.</p> <p>E=1, For batch control, OP1 relay contact is normal close. When the flow accumulation value is greater than the setpoint, the relay contact will be open.</p> <p>F=0, communication protocol is version V5.X.</p> <p>F=1, communication protocol is version V6.0.</p> <p>G=0, the flow input is linear input signal.</p> <p>G=1, With flowmeters the relationship between the flowrate and the output signal may deviate from an ideal curve –linear or squared. The instrument is able to compensate for this deviation with an additional non-linear table (see latter text for details).</p> <p>H=0, display the frequency or flow before temperature-pressure compensation.</p> <p>H=1, display the frequency or flow after temperature-pressure compensation.</p> |        |
| <b>bC</b> | Temperature-pressure compensation mode | <p>bC=0, no compensation.</p> <p>bC=1, temperature-pressure compensation for common air (calculation with equation for ideal gases).</p> <p>bC=2, temperature compensation for saturated steam (look up table, temperature range: 100°C~276°C).</p> <p>bC=3, pressure compensation for saturated steam (look up table, absolute pressure range: 0.1~3.2Mpa).</p>   | 0~9999 |

|             |   |  |                       |
|-------------|---|--|-----------------------|
|             |   | <p>bC=4, temperature-pressure compensation for superheated steam (look up table, 150°C~590°C, 0.1~22Mpa).</p> <p>bC=5, temperature compensation for common liquid, PA is compensation factor.</p> <p>bC=6, use temperature difference to calculate heat, it equals to the temperature difference times the flow value.</p> <p>bC=8, for common air with saturated vapor. Temperature- pressure compensation, deduct vapor by looking up the table according to temperature.</p> <p>Other settings beyond 6 are used for special compensation calculation.</p>  |                       |
| <b>FoH</b>  | flow range for retransmission output              | It is momentary flow range for retransmission output. For example, if you set like: FoH=5000, loL=40, loH=200, then when the momentary flow value is great than or equals to 5000, the retransmission output current is 20mA, and when the momentary flow value equals to 0, the retransmission output current is 4mA.   | 10~25000<br>flow unit |
| <b>loL</b>  | Low scale for retransmission output current       | It is used to define the low scale for retransmission output current. If a retransmission output of 0-10mA is needed, you can set loL=0. If a retransmission output of 4-20mA is needed, you can set loL=40.   | 0~60<br>(x 0.1mA)     |
| <b>loH</b>  | High scale for retransmission output current      | It is used to define the high scale for retransmission output current. If a retransmission output of 0-10mA is needed, you can set loH=100. If a retransmission output of 4-20mA is needed, you can set loH=200.   | 0~220<br>(x 0.1mA)    |
| <b>Addr</b> | communication address                             | In the same communication line, different instrument should be set to different address.   | 0~100                 |
| <b>bAud</b> | Communication baud rate                           | The instrument can communicate with host computer. It is recommended to be 9600.   | 0~19200               |
| <b>CLn</b>  | Zero reset counter                                | <p>When the instrument is used as flow accumulator, each time you make zero reset operation from key pad or when the 8 digits accumulator exceeds 99999999, the accumulation value will be reset to zero, and parameter CLn will increase by 1. Parameter CLn is for display only, modification by operator is impossible.</p> <p>When the instrument is used for batch control, not matter that the 4 digits batch accumulator is zero reset manually or automatically, parameter CLn will not change. Only when the 8 digits total accumulator combined by FLJH and FLJL exceeds 99999999, parameter CLn will increase by 1. Therefore CLn, FLJH and FLJL can be combined together to be a 12 digits accumulator.</p> <p>When CLn exceeds 9999, it will reset to zero automatically.</p> | 0~9999                |
| <b>FLJH</b> | The most significant 4 digits of flow accumulator | It is the most significant 4 digits of the 8 digits flow accumulator. Parameter FLJH is for display only, can not be modified by operator.   | 0~9999                |
| <b>FLJL</b> | The least significant 4 digits of flow            | It is the least significant 4 digits of the 8 digits flow accumulator. Parameter FLJL is for display only, modification by operator is impossible.   | 0~9999                |

|                     |                            |   |                              |
|---------------------|----------------------------|---|------------------------------|
|                     | accumulator                | When the instrument is used for batch control, you can get total flow accumulation value by reading parameter CLn , FLJH and FLJL. Since this parameter is updated every 3 minutes, so the reading accumulation value maybe less than the real accumulation value.  |                              |
| <b>Loc</b>          | Parameter lock             | Loc=0, modification of field parameters is allowed, and zero reset operation for flow accumulation from key pad is also allowed.<br>Loc=1, modification of field parameters is allowed, but zero reset operation for flow accumulation from key pad is not allowed.<br>Loc=2, modification of field parameters is not allowed, but zero reset operation for flow accumulation from key pad is allowed.<br>Loc=3, modification of field parameters is not allowed, and zero reset operation for flow accumulation from key pad is not allowed either.<br>Loc=808, modification of all parameters is allowed, and zero reset operation for flow accumulation from key pad is also allowed.<br>If parameter set is locked, setting Loc=808 can unlock temperately. After the temperate parameter changing, Loc will reset to zero again. Now you can set Loc to 808 again to unlock permanently. | 0~9999                       |
| <b>EP1~<br/>EP8</b> | Field parameter definition | 1 to 8 field parameters can be defined by parameters EP1 to EP8. If the number of the field parameters is less than 8, the first idle EP parameter should be set to "nonE".<br>You can define field parameters and Loc to change operation style. For example, user often modify the parameters FHIA and CHIA, Then the EP paramters and Loc should be set as below:<br>Loc=0, EP1=FHIA, EP2=CHIA, EP3=none   | nonE and all parameter codes |

### Compensated with an additional linearization table

With flowmeters the relationship between the flowrate and the output signal may deviate from an ideal curve –linear or squared. The instrument is able to compensate for this deviation with an additional linearization.

The linearization table enables up to 60 pairs of values to be entered.

Set parameter Loc=3698, you will enter into the configuration of the linearization table (If former setting of parameter Loc is 808, at first you need to escape from the parameter setting status by setting Loc=0, and then enter into the parameter setting status again by setting Loc=3698.)

A00 function code. It is not used temporarily, and should be set to be 0.

A01 input type. For AI-708H/808H type instrument, the input type is set by parameter Sn, so this parameter should be set to be 0.

A02 the low scale of input signal. The range is from –20000 to +20000.

A02= the low scale of input signal\*20000/the range of amplifier.

For example, if the flow input is 0-5V (the range of amplifier is 5V), and you expect to make compensation to get 1-5V input, you can set like: A02=1\*20000/5=4000.

A03 input signal span. For example, for 1-5V input, the span is 5-1V=4V, and you can set like: A03=4\*20000/5=16000.

A04 the span between adjacent sample points. The number of sample

points= $A03/A04$ . If only one sample point needed, then  $A04=A03$ .

d00 the starting point of linearization table. It is the output of linearization table when the input signal is A02. You can set it to be 0.

d01 the first output point of linearization table. It is the output of linearization table when the input signal is  $A02+A04$ .

d02~d60: 2~60 output values of linearization table.

Sn-1 should be set according to the description in the parameter table. The instrument will process the input signal with offset, extraction and small signal cut function. If linearization compensation is needed, set H of parameter CF to 1, and set the above linearization compensation table.

## 4. Configuration Examples

To decide the reference pressure  $P_o$  or the reference temperature  $C_o$ , you should select the most commonly used pressure or temperature (or the highest pressure or temperature) to avoid too big compensation factor (density ratio). If the flow value after compensation is too small, the resolution will be low and the error will be increased. If the flow value after compensation is greater than 25000, overflow will take place.

When the instrument is specially used for flow accumulation, the time unit for momentary flow must be "hour" to assure that the accumulated flow and the momentary flow have the same engineering unit. When the instrument is used for batch control, you can set parameter "SPE" to change the time unit.

The numerical value of parameter "FdIH" (ignoring the decimal point) should be between 500 and 9999. You had better set it to be a four-digit number to guarantee good resolution and precision. At the same time, you should make sure that the momentary flow after compensation be less than 25000, otherwise overflow will take place and the excess will be ignored.

When decide on the decimal point place (parameter "FdIP"), you should keep in mind that is described at below.

When the instrument is used for temperature-pressure compensation, the flow display value will exceed 9999, at this time, the decimal point place will move to right by 1 digit automatically.

When the flow display is like XXXX (FdIP=0), and if the flow display value exceeds 9999, then the display mode will change to XX.XX because it is impossible for the decimal point place to move to right by 1 digit. Therefore in the application where the flow display value will exceed 9999, you had better set FdIP=3 to make the flow display be like X.XXX, and the unit can be changed from Kg to Ton or from Ton to Kton.

### Example 1:

use a vortex flow transmitter to measure the flow of saturated steam, temperature compensation is needed and the temperature sensor type is Pt100, the flow factor (K) of the transmitter is 3200, and the reference temperature is 200°C (if the flow transmitter supplier doesn't provide a reference temperature, you can use the most commonly used temperature as a reference temperature). By looking up table, you can get that the liquid density  $\rho_o = 7.864 \text{Kg/M}^3$  at the reference temperature of 200°C. The required range of accumulated flow at the reference temperature is 2T/h. The time unit for the momentary flow is "hour", and you can set like below ( $t=3600$ ):

$S_n=600$  (temperature input type is Pt100, no pressure, flow input signal is frequency)

$C_o=200.0^\circ\text{C}$

$F_{rd} = \text{flow range} \times K / (\rho_o \times t) = 2000 \times 3200 / (3600 \times 7.864) = 226.07 \text{ (Hz)}$

Since  $F_{rd}$  should be an integer, and also some extra space should be saved to the

flow range, Frd can be set to 190.

$$FdIH = t \times Frd \times \rho_0 / K = 3600 \times 190 \times 7.864 / 3200 = 1680.93 \text{ (Kg/h)} = 1.681 \text{ (T/h)}$$

$$FdIP = 3$$

bC=2 (saturated steam, temperature compensation)

### Example 2:

A vortex flow transmitter is used to measure the mass flow or standard volumetric flow of compressed air. The temperature-pressure compensation is needed and the temperature sensor type is Pt100, the pressure input signal is 1~5V, the high scale of frequency input (Frd) from the transmitter is 300Hz, the flow factor (K) of the transmitter is 2000, the reference temperature is 50 °C, and the reference pressure is 1Mpa (if the flow transmitter supplier doesn't provide a reference pressure, you can use the most commonly used pressure or the high limit scale as a reference temperature). By calculation, you can get that the liquid density  $\rho_0$  at the reference temperature and pressure is 11.882Kg/ m<sup>3</sup>. The absolute pressure of air equals to the reference pressure plus 0.1013Mpa, i.e., 1.1013Mpa. At standard condition (0°C and 1 standard atmosphere ) the air density  $\rho_s$  is 1.293Kg/ m<sup>3</sup>. You can set like below:

$$Sn = 620$$

$$Co = 50.0 \text{ (}^\circ\text{C)}$$

$$Po = 1.000 \text{ (MPa)}$$

$$PA = 0.101 \text{ (MPa)}$$

$$Frd = 300 \text{ (Hz)}$$

bC=1 (temperature-pressure compensation for common air, calculation with equation for ideal gases)

If it is needed to display and accumulate mass flow, you can set FdIH and dIP like below:

$$FdIH = (3600 \times Frd \times \rho_0) / K = 3600 \times 300 \times 11.882 / 2000 = 6416 \text{ Kg/h} = 6.416 \text{ (T/h)}$$

$$FdIP = 3$$

If it is needed to display and accumulate standard volumetric flow, you can set FdIH and dIP like below:

$$FdIH = 6416 / \rho_s = 6416 / 1.293 = 4962 \text{ (m}^3\text{/h)},$$

$$FdIP = 0$$

If the momentary flow after compensation may exceed 9999, it is recommended to set like below:

$$FdIH = 4.962 \text{ (K m}^3\text{/h)}, \quad FdIP = 3$$

### Example 3:

Use orifice plate to measure flow of superheated steam, with differential pressure input, temperature-pressure compensation is needed. When the pressure is 5Mpa and the temperature is 400°C, the maximum momentary flow is 100T/h (input voltage is 5V). You can set like below:

Co=500 (°C)

Po=5.000 (MPa)

PA=0.101 (MPa)

FdIH=100.0 (T/h)

FdIP=1 (the decimal point is at ten's place)

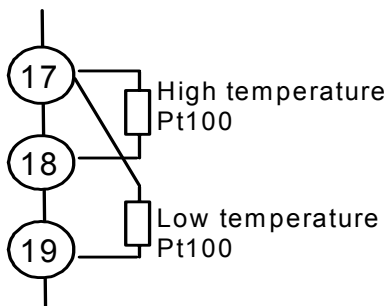
bC=4 (superheated steam).

### Example 4:

Measure the heat consumption of water. The heat consumption equals to the water flow times the temperature difference between entrance and exit. The temperature difference is measured by 2 Pt100 sensor, these 2 Pt100 sensor are connected to a dual RTD input module J21 installed in M1 socket. You can set like Sn-3=9 and CdIH=213.0 (calculation according to temperature resistance curve of Pt100, the servo current output 0.25mA of J21 module and the input range of 20mV when Sn-3=9. For Pt100, the resistance changes differently at different temperature section, if the temperature difference measured is not correct, you can modify parameter CdIH). Set Co as reference temperature difference, set FdIH as the range of momentary heat at reference temperature difference, and then set bC=6, You can get the heat calculation formula like below:

FL (heat) =F×C

F: flow, C: temperature difference, FL: momentary heat.



The above is the wiring graph of bridge connection. J21 module should be installed in M1 socket. Each Pt100 is connected to the instrument by 2 wires, and the resistance of the four wires should be equal.



## 5. Calculation principle of the instrument

### 5.1 Calculation procedure of flow compensation

**Step 1:** get the flow F before compensation at first

$$F = V \times F_{dIH} + F_{Sc} \quad \text{for voltage/current input}$$

Or

$$F = f \times F_{dIH} / f_{rd} + F_{Sc} \quad \text{for frequency or pulse input}$$

Among which:

V is voltage or current signal input, the numerical value is 0-100%. Before used for calculation, V is processed by the functions of small signal cut off and square root/no square root according to the settings of parameter Cut and CF.

f is frequency signal input. The unit is Hz. Before used for calculation, signal preprocessing like small signal cut off is done on f according to the setting of parameter Cut.

F get from above formula is the flow at reference pressure  $P_o$  and reference temperature  $C_o$ .

**Step 2:** get temperature-pressure compensation density ratio  $\rho_B / \rho_o$  according to the setting of parameter bC. If the compensation need to look up table (for example, saturated steam and superheated steam), you can get the actual density  $\rho_B$  by looking up table using actual temperature C and actual pressure P, and you can also get the reference density  $\rho_o$  by looking up table using reference temperature  $C_o$  and reference pressure  $P_o$ . Then you can get temperature-pressure compensation density ratio  $\rho_B / \rho_o$ .

**Step 3:** get compensated flow  $F_B$

$F_B = F \times \rho_B / \rho_o$  if no square root is need for temperature-pressure compensation density ratio.

$F_B = F \times \sqrt{\rho_B / \rho_o}$  if square root is need for temperature-pressure compensation density ratio.

### 5.2 Relevant compensation formula and table:

#### 5.2.1 Temperature-pressure compensation for common air

When bC=1, the instrument make compensation for common air using the equation for ideal gases. The formula is below:

$$\rho_B / \rho_o = (P + P_A) \times (C_o + 273.2) / ( (P_o + 0.1013) \times (C + 273.2) )$$

Among which:

$\rho_B$  is the actual density after temperature-pressure compensation.

$\rho_o$  is reference density at reference temperature  $C_o$  and reference pressure  $P_o$ .

P is actual pressure (gauge pressure).

C is actual temperature (°C).

PA is atmosphere pressure at factory site, 0.1013 MPa is one standard air pressure..

### **5.2.2 Temperature compensation for common liquid**

No compensation is needed for liquid. To get high precision, temperature compensation can be taken (bC=5). PA is temperature compensation factor, the range is from -1.999 to +9.999, the unit is %/°C. The formula is below:

$$\rho_B / \rho_o = 1 + PA \times (C - Co) / 100$$

Among which:

$\rho_B$  is the actual density.

$\rho_o$  is reference density at reference temperature Co.

C is actual temperature (°C).

Co is reference temperature.

### **5.2.3 Compensation for saturated steam and superheated steam**

For steam, the compensation calculation by looking up table has a higher precision. You can look up relevant material for the relationship between steam density and temperature & pressure.