AI ARTIFICIAL INTELLIGENCE INDUSTRIAL CONTROLLER

Operation Instruction

Ver. 6.0

(Suitable for accurate controls of temperature, pressure, flow, level, humidity etc.)

CONTE

1. SUMMARY

1.1 Main feature

- Advanced operation method leads to easy learning and simple manipulation; and the compatibility of operation is available among the instruments differ in the model and function.
- Provide nearly all of the functions contained by most similar industry automatic controller in the world, and the mature technique made it generally used in various kinds of industrial fields.
- Provide various models that can meet different needs either in the functions or price.
- With power supply of 85-264VAC or 24VDC and various installation dimensions for users to choose.
- Adopt digital calibration system for measurement input with measurement input accuracy less then 0.2% F.S., non-linear calibration for common sensors is available in the instrument.
- Adopt advanced AI artificial intelligence control algorithm, no overshoot and with the function of auto tuning and self-adaptation.
- Adopt advanced modular structure, equipped with plentiful output specifications, and can satisfy the needs of various applications. This makes it possible to shorten the date of delivery and convenience the maintenance of the instrument.
- Having passed the ISO9002 quality verification. Comply with EMC standard, and has the predominant performance of anti-interference.

POINTS FOR ATTENTION

- This manual introduces AI ARTIFICIAL INTELLIGENCE INDUSTRIAL CONTROLLER of Version 6.0. Certain functions introduced by this manual are probably not applicable for the instrument of other version. After power on, the instrument type and software version will be displayed; user must notice the difference between them when using the instrument. Please read the manual carefully to use the instrument correctly and make it to its full use.
- Correctly setting parameters about input output type and function before using AI instrument.
- Users of Version5.0 or other further version should pay more attention to the parameter CtrL and oP1 whose signification have been changed compare with the early version.

1.2 Model definition

Advanced modular hardware design is utilized for AI series instrument. The instrument with enhanced lateral plate can be equipped with maximum modules of 5.There are more than ten kinds of modules, some of which are double-duty module. Modules of special function can be customized on request.

The basal AI instrument has provided many functions enough to meet different requirements asked

by users. In order to expand its application bound, an optional software function is provided. The options make the instrument to be able to meet some users' special requirement. There is another manual about these options for those users with special requirement.

AI series instrument is classified by function as AI-708T (economical type); AI-708 (standard type); AI-808 (enhancement type) and AI808P (programmable type). Further more, AI series industrial controller also includes two types of flow totalizer named AI-708H, AI-708Y and multiloop meter named AI-708M (above see another manual for introduction). The input type can be set freely, the output and the auxiliary function are determined by modules equipped, which can be purchased separately from instrument, and can be assembled freely. Each instrument with standard lateral plate can be equipped with maximum modules of 4, and the instrument with enhanced lateral plate can be equipped with 5 modules. The type number of AI series instrument is made up of 10 parts, for example:

AI-808	**A**	**X**	**L2**	**N**	**S**	**L2**	**—**	**F2**	**—**	**3**	**—**	**24VDC**
1	**2**	**3**	**4**	**5**	**6**	**7**		**8**		**9**		**10**

It shows that the basal function of this instrument is AI-808 type, front panel dimension is 96×96mm, main output is linear current output without isolation, alarm 1 is relay contact output module, alarm 2 is not installed in, a RS485 communication interface with photoelectric isolation is installed. It is equipped with enhanced lateral plate, auxiliary output is relay contact output module. Optional input type (F2 radiation type pyrometer) and No.3 software function are also available. The following is the meanings of the ten parts.

1. Shows the basal function of instrument

- AI-708T economical type instrument, having most of functions AI-708 has except that its measurement accuracy is 0.5%F.S. and it has no retransmission function.
- AI-708 standard type instrument, having the function of on-off control and advanced AI artificial intelligence control, and is provided with many other functions such as various types of alarm mode, retransmission, communication, etc.
- AI-808 enhanced type instrument, be compatible with all the functions of AI-708, have the function of bumpless auto/man transfer and manual auto tuning.
- AI-808P artificial intelligence control instrument with programmable control function of 30 segments and most functions that AI-808 has.

2. Shows the front panel dimension, the depth of the instrument is about 13.5mm(foreside)+130mm(rearward)

A (A2) front panel 96 x 96mm (width x height), cut out 92 x 92mm

B front panel 160 x 80mm (width x height), horizontal, cut out 152 x 76mm

C (C2 C3) front panel 80 x 160mm (width x height), vertical, cut out 76 x 152mm

D front panel 72 x 72mm (width x height), cut out 68 x 68mm, build in depth 110mm

D2 front panel 48 x 48mm (width x height), cut out 45 x 45mm, build in depth 110mm

E front panel 48 x 96mm (width x height), vertical, cut out 45 x 92mm

F front panel 96 x 48mm (width x height), horizontal, cut out 92 x 45mm

3. **Shows the module type of main output (selectable modules are L2, L4, W1, W2, G, K1, K2, X etc.)**
4. **Shows the module type of alarm1 (selectable modules are L2, L4, W1, W2, G, K1, V, U etc.)**
5. **Shows the module type of alarm2 (selectable modules are L2, L4, W1, W2, V, U, I2 etc.)**
6. **Shows the module type of auxiliary function (selectable modules are X, R, S, V, U etc.)**
7. **Shows the module type of auxiliary output (selectable modules are L2, L4, W1, W2, G, K1, K2, X, V, U, I2 etc.), these modules must be collocated with enhanced lateral plate.**
8. **Shows the optional graduation spec. (If none, leave it blank). All the instruments of AI series have been stored with many input modules such as seven thermocouple types, two RTD types, and various types of linear voltage (current) and resistance input. If it is needed to use input specification beyond the specification mentioned above, an additional specification can be selected, such as F2 (radiation type pyrometer), EA2, BA1, BA2, square root input and so on.**
9. **Shows the function of optional software modules (If none, leave it blank), see the following text for details.**
10. **Shows the power supply of the instrument. If left blank, the power of the instrument is 85-265VAC, "24VDC" means the power of 20-32VDC.**

The functions of module in common use are as follows:

N (or none) without module installed

L2 relay contact (pressure sensing resistance absorption) output module

(Capacity: 30VDC/1A, 264VAC/1A)

L4 Large capacity and longevity relay contact (rescap absorption) output module

(Capacity: 30VDC/2A, 264VAC/2A)

W1 (W2) BCR no contact normal open (close) discrete output module

(Capacity: 85-264VAC/0.2A)

G SSR voltage output module (DC12V/30mA time proportional output)

K1 BCR zero cross trigger output module (can trigger TRIAC or 2 BCR inverse parallel connected with current rating of 5-500A)

K2 TRIAC zero cross trigger output modules (can trigger 3-phase circuit)

X linear current output module with photoelectric isolation (continuous 0-22mA output, selectable in the range of 0-10mA, 4-20mA etc.)

S RS485 communication interface module with photoelectric isolation.

R RS232 communication interface module with photoelectric isolation

V24 24V/25mA DC voltage output functionally insulated, can supply power for transmitter. Other voltage specification is also available.

U5 5V/25mA DC voltage output without isolation can supply power for valve feedback potentiometer.

V20 Power isolator, +8, -12V/25mA DC voltage output, can supply power for the modules of S, X, I2.

I1/I2 External digital / frequency / control input interface.

1.3 Description about the function of different instrument type

AI-708

AI-708 is standard type instrument, its measurement input accuracy is 0.2% F.S. Programmable input specification can be selected to be thermocouple, RTD, linear voltage (current) and resistance by parameter configuration. It has the functions such as on-off control, AI artificial intelligence control, communication, alarm and retransmission. Various output specifications is available including time proportional output (relay contact, SSR voltage, BCR on-off, BCR triggering signal and so on) and linear current (including 0-10mA, 4-20mA, etc.) It can be used in the industrial fields such as chemical industry, petrochemical industry, thermal power industry, pharmacy, and metallurgical industry in the character of high accuracy measurement, display, retransmission and 2 point, 3 point, 4 point control/alarm. It can be also used in the fields of light industry, mechanical industry, heat treatment and experimental set-up for temperature control. Perfect control effect is available by the function of artificial intelligence control.

AI-708T

AI-708T is economical type instrument. Its measurement input accuracy is 0.5% F.S. None retransmission. Some of its input specifications are different from other type of instrument, (see introduction of parameter Sn). It is an ideal substitute of lowprofile instrument when old devices were upgraded. There is no special description for AI-708T, please manipulate it according to the operating instruction of AI-708.

AI-808

AI-808 is enhanced type instrument. Besides having all the functions and characteristics AI-708 have, additional functions are as follows: Auto/man transfer operations, manual auto tuning and output value display. Adjust the position proportional output of valve directly. TRIAC phaseshift trigger output. It can be used in the industrial fields such as chemical industry, petrochemical industry, thermal power industry, pharmacy, and metallurgical industry.

AI-808P

AI-808P is programmable type instrument, having programmable control functions of 30 segments; its program capacity was increased greatly, and various special functions are available when it used.

1.4 Further description about module functions

In order to meet customers' requests more effectively, AI series instrument utilize modular structure with the features showed as below:

1.4.1 Before the instrument delivery, Module installation is done on request, with corresponding parameter set correctly. But user can exchange modules by themselves if modules are damaged or the function needs to be changed. When exchanging modules, you should pull the controller out of the housing at first, insert a small flat-tip screwdriver in the opening between the original module and the socket on motherboard to remove the module, and then install a new module. Module type changing needs to modify the parameters (see introduction about parameter oP1 and CF).

1.4.2 AI series instrument has four or five sockets for modules to be installed, named main output, alarm1, alarm2, auxiliary function and auxiliary output. The module types for each socket is different, you can refer to "model definition" for more details.

- **Main output (OUT):** Commonly used to be instrument output, and it can be also used as retransmission output when the instrument is configured to be transducer (on-off mode adjustment and current output).
- **Alarm1 (AL1):** Commonly used to be No.1 alarm output. It can be contemporary used as event output 1 if the instrument type is AI-808P. This output can be also used in the BCR zero cross trigger when oP1=3. And it will dominate the valve reversal in the position proportional output mode.
- **Alarm2 (AL2):** Commonly used to be No.2 alarm output. It can be contemporary used as event output 2 If the instrument type is AI-808P. Alarm2 can be used as external-switching value input to achieve the functions of Auto/man transfer or program run/stoP control.
- **Auxiliary function (COMM):** Module S can be installed for communication, module X can be installed for retransmission, and it can also be used as power supply of external sensors when equipped with voltage output module.
- **Auxiliary output (OUT2):** Only if the enhanced lateral plate is equipped onto the motherboard can the Auxiliary output be brought into use. On the occasion that heating output and refrigeration output are necessary, module L2, L4, G, K1, K2 can be installed for refrigeration output, switching output or alarm output.

1.4.3 Notice

If you want to install relay module on main output, you should set parameter oP1 to be 0, 3, 5 or 6, If the parameter is set to be 1, 2, or 4 (then you should install current output module), it will cause the relay oscillating and screaming.

- Refer to the L4, the relay contact (rescap absorption) output module, there is a capacity of

0.01uf paralleled across the contacts, 7so on the occasion of 220VAC/50Hz, current of 0.7mA will be caused in spite of the disconnection of the contacts.

- Some modules, such as V24 (V24 auxiliary voltage output), S (RS485 communication interface), R (RS232 communication interface) and X (isolated linear current output), I2 (External digital/frequency/control input interface), can be electrically insulated from instrument main input. But if two of those modules are installed in the same instrument, the two modules can't be insulated between each other, because they share the same isolated power supply. For example: if X module is installed on main output socket and S module on auxiliary function socket, then X and S can't be insulated between each other. In order to insulate the two modules from each other, users should use one of them together with module V20. V20 will convert the power from motherboard to isolated power of ±12V by means of high frequency oscillation, and supply power to module such as X, I2, S. Because its heavy power consumption, module V24 is not allow to used together with module V20.Relay contact output and BCR no contact discrete output are 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.
- On the occasion that using AC electromagnetic contactor, module W1 is recommended. Because of the application of new technology, it gains advantages such as longevity and no spark compare with other relay contact output module, so it can enhance the reliability of instrument greatly.

1.5 Maintenance of instrument

The instrument should be tested once a year for the basically error. With regard to the instrument used in abominable environment for some time, if the error exceeding certain range, then internal instrument should be cleared and dried, and generally doing so will solve the problem. It is not recommended to make error compensation by adjusting parameter "Sc".

Free repairs and maintenance will be given in 18 months from the delivery. If the damage is caused by misapplication or out of the time limit, appropriate charge is needed. We can promise five years of free maintenance for AI808 and AI808P if extra charge has been paid.

2. TECHNICAL SPECIFICATION

- **Input type: (Either of below specifications can be used selectively in the same instrument)**

  Thermocouple: K, S, E, R, J, T, B, N

  Resistance temperature Detector: Pt100, Cu50

  DC Voltage: 0—5V, 1—5V, 0—1V, 0—100mV, 0—20mV, etc.

  DC current (external shunt resist needed): 0—10mA, 1—20mA, 4—20mA, etc.

  Optional: apart from the above-mentioned Input type, additional type can be provided upon request. (Graduation index is needed)

- **Instrument Input range**

  K(-50--+1300℃), S(-50--+1700℃), R(-50--+1650℃), T(-200--+350℃),

  E(0—800℃), J(0--1000℃), B(0--1800℃), N(0—1300℃)

  Pt100(-200--+600℃), Cu50(-50--+150℃)

  Linear Input: -1999--+9999 defined by user.

- **Measurement accuracy**

  0.2%FS: RTD, linear voltage, linear current and input with ice point compensation or Cu50 copper compensation.

  0.2%FS±0.2℃: thermocouple input with internal automatic compensation.

  0.5%FS: AI-708T only

- **response time** ≤0.5s (when dL=0)

Note: for thermocouple B, the measurement accuracy of ±0.2% FS can be guaranteed when input range is between 600--1800℃,and not guaranteed when input range is between 0--600℃.

- **Control mode:**

  On-off control mode (deadband adjustable)

  AI artificial intelligence control, including fuzzy logic PID control and advanced control algorithm with the function of parameter auto tuning (MPT).

- **Output mode (modular)**

  Relay contact discrete output (NO+NC): 264VAC/1A or 30VDC/1A

  BCR NO contact discrete output (NO+NC): 85—264VAC/0.2A (continuous), 2A (20mS instantaneous, repeat period≥5s)

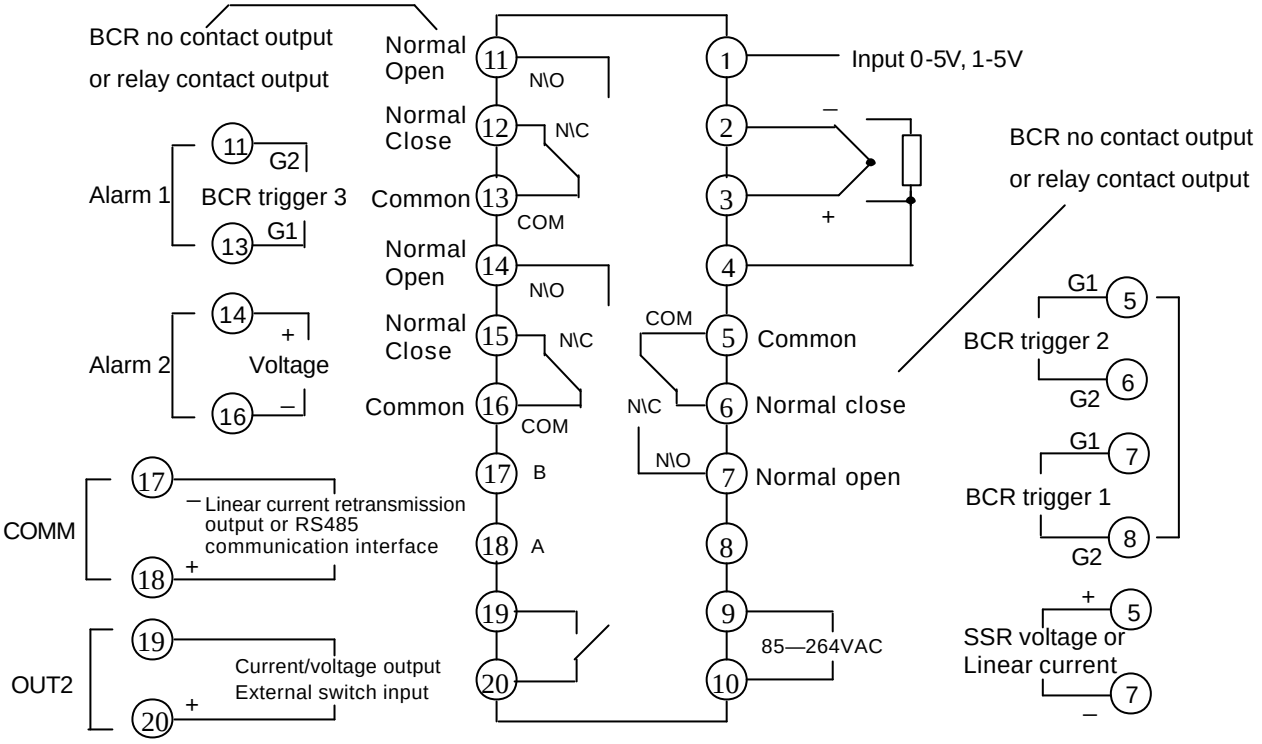
  SSR Voltage output: 12VDC/30mA (used to drive SSR).

  Linear current output: 0—10mA, 4—20mA (Output voltage greater than 11V)

  BCR cross zero trigger output: can trigger TRIAC of 5—500A, two parallel-connected BCR or BCR power module.

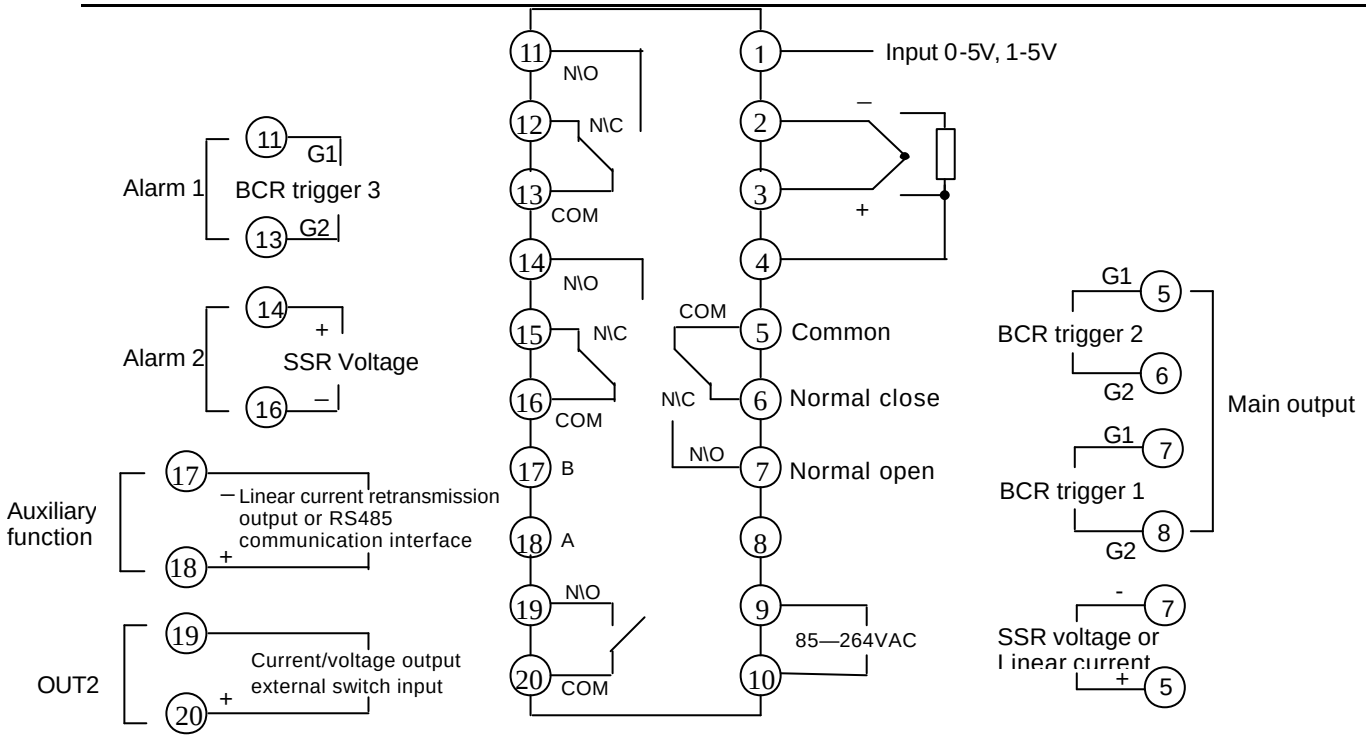
- **Alarm function:** upper limit, low limit, positive deviation and negative deviation, selectable using parameters.
- **Alarm output:** 2 modular output.
- **Manual function:** AUTO/MAN bumpless transfer(AI-808 series only)
- **Power supply voltage rating**: 85-264VAC/50-60Hz.
- **Power consumption:** ≤5W
- **Ambient temperature:** 0—50℃
- **Front panel dimension:** 96X96mm, 160X80mm, 80X160mm, 48X96mm, 96X48mm
- **Panel cutout dimension:** 92X92mm, 152X76mm, 76X152mm, 45X92mm, 92X45mm

3. INSTRUMENT INSTALLATION AND WIRING



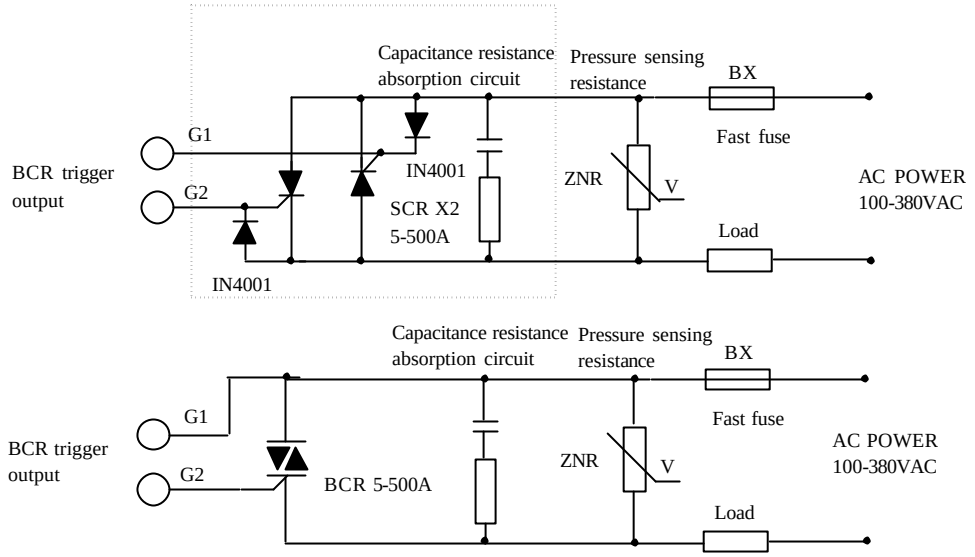
96x96mm, 80x160mm, 48x96mm, Front panel specification and wiring diagram

The input linear voltage use 3,2 terminal when measurement below 1V. Use 1,2 terminal when the signal below 0-5V or 1-5V. The input of linear current 4-20mA can use 250Ω resistance to convert it to voltage signal of 1-5V, or use 50Ω resistance to convert it to voltage signal of 0.2-1V, and then input from terminal 1, 2 or terminal 3, 2.



160x80mm, 96x48mm, Front panel specification and wiring diagram

The input linear voltage use 3,2 terminal when measurement below 1V. Use 1,2 terminal when the signal below 0-5V or 1-5V. The input of linear current 4-20mA can use 250Ω resistance to convert it to voltage signal of 1-5V, or use 50Ω resistance to convert it to voltage signal of 0.2-1V, and then input from terminal 1, 2 or terminal 3, 2.



Writing *diagram* for BCR trigger output

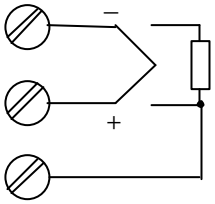
Note:

1、***Select pressure-sensing resistance to protect BCR on the basis of the voltage and current of load. Capacitance resistance absorption circuit is needed under inductive load or phaseshift trigger.***

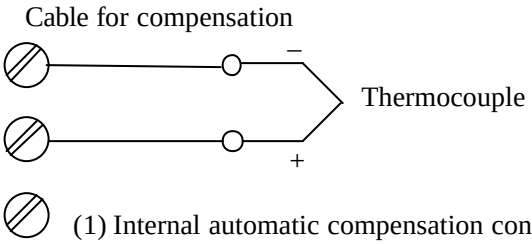
2、***BRC power module is recommended, there are two BCR in one module as showed in the broken line.***

3、***When module K5 (modulation trigger output) is used, the rating of power must be reduced to 220VAC-380VAC.***

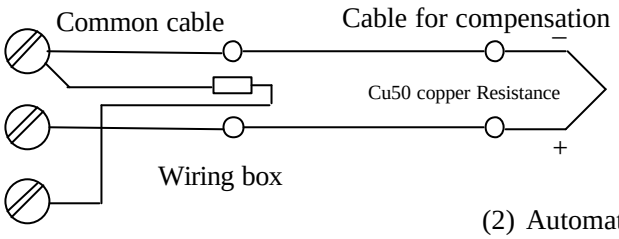
Wiring diagram for three compensation mode:



Corresponding wiring diagram
Of the instrument

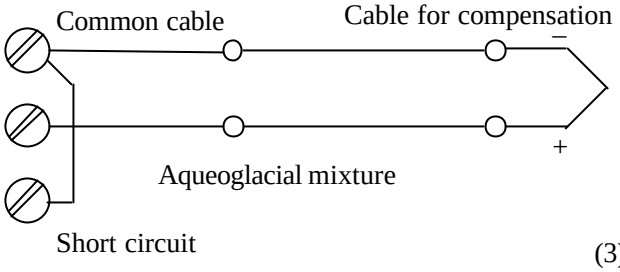


(1) Internal automatic compensation connected (cable for compensations directly connected to wiring terminals)

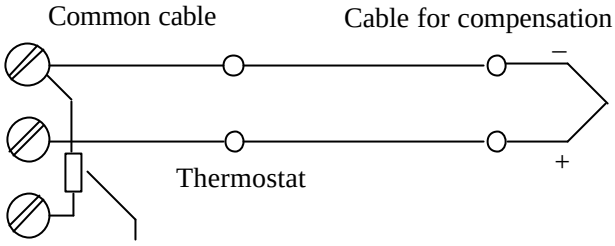


(2) Automatic compensation mode by externally connent copper resistance

Note: wiring box should be well way from the heat generating project, And copper resistance should be put between 2 wiring terminals at best.



(3)ice point compensation mode



(4) fixed temperature compensation mode

Note : the temperture of thermostat should be controlled at 50℃

Select reference junction compensation mode using different wiring mode

Temperature compensation is needed at reference junction for thermocouple input. AI instrument can supply automatic compensation through measurement of surrounding temperature. But because error exist in measurement and instrument itself generate heat (The temperature of wiring terminals of the instrument elevate synchronously), fairly great errors is produced in case of automatic compensation mode. We supply selective compensation modes with high precision for user in the application in which high temperature measurement precision is needed. Measurement accuracy of AI series instrument can be up to 0.2%F.S., but this value don't include reference junction compensation error.

Note: Incorrect compensation will increase the measurement error.

AI 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 leadwire connection and surroundings (if there is BCR radiator), measurement error may be produced up to 2—4℃ sometimes.
- Compensation with Cu50 copper resistance sensor externally connected: the compensation precision is high. In the application in which high measurement precision is needed, you can buy a Cu50 copper resistance and had better prepare an external wiring box, and then put the copper resistance together with thermocouple reference junction far away from exothermic object. Compensation error is less then 0.5℃ for this mode. If the measurement accuracy of ±0.2% F.S. is needed, then this compensation mode should be selected.
- Thermostat compensation: If we replace Cu50 by an accurate resistance, thermostat compensation is available. For example, an resistance of 60Ω is installed, we can get the compensate temperature of 46.6℃ by looking up into the Cu50 graduation index, and then put the thermocouple reference junction into thermostat of 46.6℃. The compensation precision is very high. The reference junction compensation error is determined by the control accuracy of thermostat, and may be less than 0.1℃.
- Ice point compensation: It is necessary to put thermocouple reference junction (where thermocouple leadwire connect with common leadwire). Inside aqueoglacial mixture the compensation precision is very high, with reference junction compensation error less than 0.1℃ if ice point and compensation leadwire is guaranteed.

4. FRONT PANEL AND OPERATION

① Output indicator lamp

② Alarm 1 indicator lamp

③ Alarm 2 indicator lamp

④ Manual adjust indicator lamp

⑤ Display transfer (and Setup key)

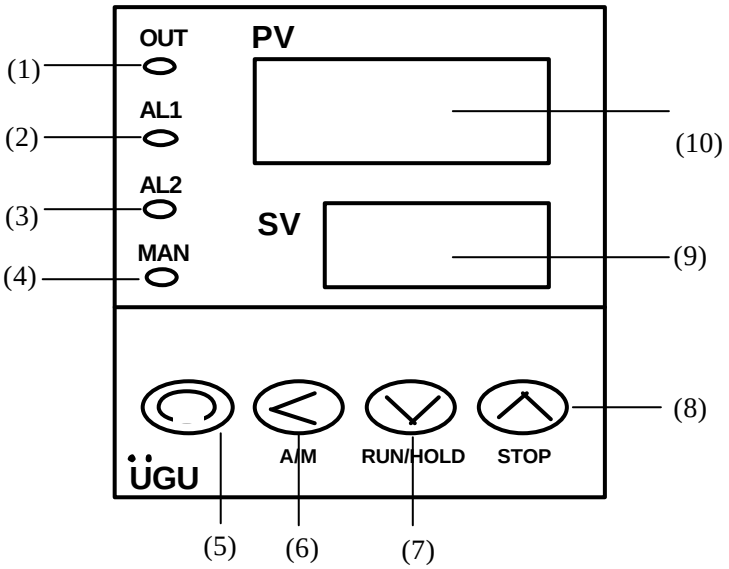
⑥ Data shift key

⑦ Data decrease key

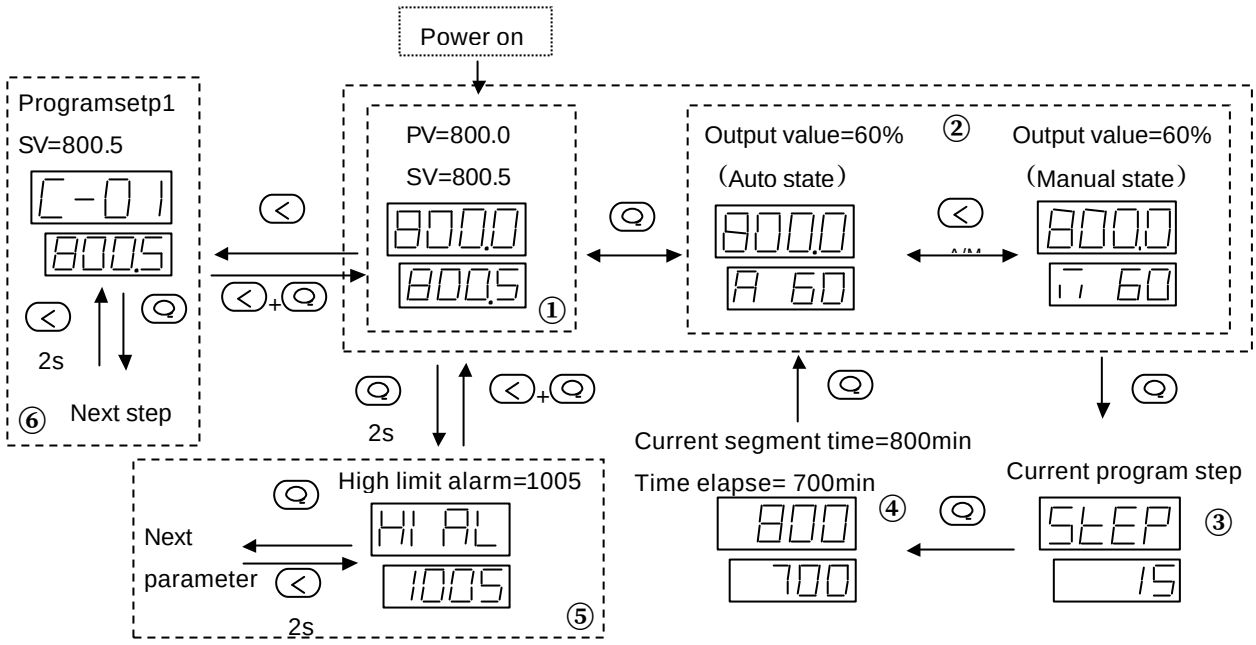
⑧ Date increase key

⑨ SV display

⑩ PV display



4.1 Display Status



Note: Not all types of instruments have the display status shown above. AI-708 has the status of ① and ⑤; AI-808 has the status of ①, ② and ⑤; while AI-808P has all of the display status list above.

After power on, display status ① will be shown, the upper display window displays four digit measured value (PV). The lower display window displays four-digit setpoint value.

Press key and change the display status into mode ② if the instrument type is AI-808 or AI808P, then output value will be displayed in the lower display window. ① and ② are the basal status of the instrument. During the basal status, "SV" display window can indicate certain state of the system by means of the alternate symbol. They are as follows:

- If the input measurement signal beyond the measurement range (caused by wrong setting of sensor spec. or open (short) circuit), "orAL" will be displayed with blinking. Then the instrument terminate its control function automatically, and the output value is fixed according to the parameter oPL.
- When alarm occurred, it will display "HIAL", "LoAL", "dHAL", or "dLAL", they indicate the high limit alarm, lower limit alarm, positive deviation alarm, and negative deviation alarm. In order avoid redundant blinking, the alarm blinking function can be closed by changing the parameter ALP (see the description of parameter ALP) If alarm is used for control.
- Refer to AI-808P, the blinking function also indicates the state of program as follows: Run Status (without blinking), stoP Status ("stoP" symbol blinking), Hold Status ("Hold" symbol blinking), Preparing ("rdy" symbol blinking).

There are 4 LED indicator lamp on the front panel, the significations are as follows:

- OUT output indicator lamp: the value of linear current is denoted by the luminance of the lamp and the value of SSR voltage output (time proportion mode) is according to the frequency of lamp blinking.
- Alarm1 indicator lamp: The lamp will be light when AL1 alarm/event is triggered.
- Alarm2 indicator lamp: The lamp will be light when AL2 alarm/event is triggered.
- MAN indicator lamp (for AI808/808P only): The lamp will be on when the instrument is on auto output state and off when the instrument is on manual output state.

4.2 Basal operation description

4.2.1 Display transfer

Press key can change the display status. AI-808 can be transferred between display status ① and display status ②. AI-808P can be transferred among the display status of ① ② ③ and ④. AI-708 has display status of ① only.

4.2.2 Data setup

If the parameter lock isn't locked, we can setup most of the data displayed in the lower display window. For example, setpoint input of AI708/708T/808 is as follows:

Press key to change the status to setpoint input. Now the decimal point of the last one digit

(unit's place) of the displayed SV value begins blinking (like curse). Press key to decrease the value, press key to increase the value, and key to move to the digit expected to modify. To complete the set point changing, press again.

4.2.3 Man/Auto mode switch (for AI-808/808P only)

Bumpless switching between AUTO and MAN can be performed by pressing key once. If the instrument works on Manual mode, its output value can be increased or decreased by pressing key and key under display status ②.

4.2.4 Setting parameters

If the instrument is on its basal display status (display status ① or ②), press and hold for about 2 seconds until parameter is displayed (display status ⑤). Then the key can be used to modify parameters. Press and hold the key can return to the preceding parameter. Press key (don't release) and then press key simultaneously can escape from the parameter setup. The instrument will escape auomatically from the parameter setup operation if no key is pressed within 30 seconds.

Note: refer to the instrument whose parameters are locked by setting parameter "Loc", most of its parameters are inhabited except those defined by field parameter "EP".

4.3 AI artificial intelligence control and auto tuning

AI artificial intelligence control, which is a new algorithm using fuzzy logical PID control, is adopted in AI series instrument. The ordinary PID algorithm can give accurate control to processes, with disadvantages of having large overshoot, having a long upset response time, and having difficulty for PID parameters to be determined, and is not suitable for process which are not stable or have a long lag time. Contrarily, fuzzy control algorithm can be suitable for processes that have a long lag time and have small overshoot, and it is easy for parameters to be determined, but it has bad control accuracy, and its control curve may have tiny saw-teeth. AI artificial intelligence algorithm has fuzzy control algorithm and concurrent PID algorithm improved with new derivative integral function added. Which of these two control algorithms is activated is determined by the deviation between measurement value and setpoint. When the magnitude of the deviation is large, the fuzzy control algorithm is activated to remove PID reset windup, and when the magnitude of the deviation is small, the improved PID algorithm is activated. Therefore, AI artificial intelligence control has the characteristic of having no overshoot, high control precision and easy parameter tuning and having good control effect for complicate process. Further more, AI series instrument has the function of selflearning, it is able to learn the process character while working. Users are probably unsatisfied with the control effect at the instrument first use after auto tuning, but predominant control result will be obtained after its first use because of the selflearning function.

In order to obtain perfect control, the instrument need to get optimum configuration parameter (MPT) through auto tuning when instrument is used at the first time. Note: If the setpoint value is different, the

parameter obtained from auto tuning will not always the same. So if you want to execute auto tuning, you must adjust setpoint to an often-used value first, and then press and hold the key for about 2 seconds until the "At" symbol is displayed in the lower display window if you want to start up auto tuning function (Auto tuning is not allowed to start up again unless you set parameter Ctrl to 2 manually if the function has been executed once). During auto tuning, the instrument executes on-off control. After 2-3 times on-off action, the microprocessor in the instrument will analyze the period, amplitude, waveform of the oscillation generated by the on-off control, and calculate the optimal control parameter value. The instrument begins to perform accurate AI artificial intelligence control after parameter auto tuning is finished. If you want to escape from auto tuning status, press and hold the key for about 2 seconds until the blinking of "At" symbol is stopped in the lower display window. Generally it will meet you need to perform auto tuning one time only. After the auto tuning is finished, the instrument will set parameter CtrL to 3 (factory set is 1), and now it is not allowed to start up auto tuning by pressing key on front panel. This will avoid repeat auto tuning by mistake.

If the setpoint value is different, the parameter obtained from auto tuning will not always the same. So if you want to execute auto tuning, you must adjust setpoint to an often-used value first, and then start up auto tuning function. Parameter CtI and dF have influence on the accuracy of auto-tuning. Auto tuning accuracy (deadband), generally, the smaller for these two parameters setting value, the higher for the precision of auto tuning. But dF parameter value should be large enough to prevent the instrument from error action around setpoint due to the oscillation of input. There are also some restrictions in application rot parameter "CtI" (refer to function description for these 2 parameters in the later text). Normally, parameters are recommended to be CtI=0-2, dF=0.3 (dF=0.8 for AI-708T).

On the basis of disturbance caused by on-off control, oscillation period, amplitude and waveform are analyzed to calculate optimum control parameters. The auto tuning for AI series instrument will gratify for 95% users. Because of the complexity of the automatic process, parameters calculated by auto tuning are probably not the optimal values on some special occasion (mentioned as follows), so manual parameter adjustment is needed.

- An electric furnace heated up by stages, and the stages may interact each other, then the value of parameter M5 may on the high side of its optimal value.
- Long lagged process.
- Quick responded physical quantity (flow and certain pressure) controlled by the slow valve, then the value of parameter P, t may on the high side of their optimal value.
- When some mechanical contact such as contactor or solenoid valve are used for control.
- Other special system such as nonlinear system and timevarying system.

During manual parameter adjustment, response curve of the system should be observed carefully.

- If it is short period oscillation (oscillation period is similar to the oscillation of auto tuning), you can increase P (first), or decrease the value of parameter M5 and t.
- If it is long period oscillation (oscillation period is several times of the oscillation of auto tuning), you can increase the value of parameter M5 (first), P and t.
- None oscillation but too severe steady-state error, you can decrease M5 (first) and increase P.

- If it must cost a long period of time to obtain stable control, you should decrease t (first), M5 and increase P.

Another method can be used in the parameter adjustment. Increase or decrease one of the MPT parameters (M5, P or t) by the range of 30%-50%, if the control effect is improved then go on, or else, do the opposite operation. In generalized case, parameter M5 should be modified first, and then modify the parameter P, t and CtI in turn.

Manual auto tuning (AI-808 only)

On-off control is adopted when auto tuning is executing, and the output will be positioned at the position defined by parameter "oPL" and "oPH". On some application in which some executive bodies such as control valve is used and therefore outputs are not allowed to be greatly changed, traditional auto tuning is not suitable. AI-808 series instruments have manual auto tuning mode, to do this, switching the instrument to manual mode at first, then start up auto tuning at manual mode after manual control is basically stable. After doing so, the output will be restricted in the range defined by the current manual output +10% and -10%, not by "oPL" and "oPH".

4.4. Program operation (for AI-808P only)

4.4.1 Setup program

Press the key once and release in the display status ①, the instrument will be in the setup program status. At first the instrument will display the temperature setpoint of the current StEP, and the last "unit's place) decimal point of the data will flash. Press the key to decrease the data, press the key to increases the data, and press the key to shift the decimal point position (cursor). After finish changing the temperature setpoint, press key once again, the program value (current StEP time) will be display. In each program StEP the temperature and the time is displayed in turn. Modifying the program during running is allowed. When setup the program, press and hold the key ,and press the key at the same time, the instrument will exit the program setup status. Press the key may return to set the preceding value.

Note: the above operation is inhibited if the program setup function is locked (refer to the later text for the introduction of parameter Loc).

4.4.2 Run/Hold

At stoP status, press and hold the key for about 2 seconds in the display status ①, until the lower display window displays the "Run" symbol, the instrument then will start the program. At running status, press and hold the key for about 2 seconds until the lower display window displays the "Hold" symbol, the instrument will be in hold status. At the status of Hold, READY and AUTO TUNING, the running indicator lamp flashes. At running status, the RUN indicator lap is on. At Hold status, the program is still executing, and the process value is control led around the setpoint, but the timer stop working, and the running time and setpoint remains. At Hold status, press and hold the key for about 2 seconds, until the lower display window displays the "Run" symbol, the instrument then restart.

4.4.3 StoP

Press and hold the key for about 2 seconds in the display status ① until the lower display

window displays the "stoP" symbol, the stoP operation is executed now. This operation forces the instrument to stop running, and the StEP number is reset to 1, the event output is cleared, the control output is also stopped, If user want to restart the program, the running operation can be executed and the program will restart form the 1st StEP.

4.4.4 Display and modify the running StEP NO. (StEP) of the program

Some times it is expected that the program begin with a certain StEP, or jump directly to one StEP and execute from there. For example, when the current program reaches the 4th StEP but the user hopes to finish the StEP in advance and execute the 5th StEP, the function of modifying the program StEP number will meet you need. Via setting StEP, AI-808P series instrument can start the program running from any StEP of 30 steps. If steps of the temperature curve the user needed are less than 30 steps. If steps of the temperature curve the user needed are less than 30 steps, the instrument also allows several different curves to be set and executed individually, if only the total steps (include necessary controls steps) don't beyond 30 steps.

For example, when a process curve only needs nine program steps, it is possible to set three such process curves in the instrument. Changing the StEP number with the production ill call up deferment curve.

To modify the StEP number, press the key once and release, the StEP number will be displayed. Press the , keys to change the StEP number. The StEP number increases or decreases automatically with the program executing. If the StEP number is manually changed, the running time will be cleared to 0 and program will begin with the new StEP. If the StEP number is not change, pressing the k will not affect the program running.

5. PARAMETER AND SETTING

Code	Description	Setting Range	Engineer Unit	Remarks
HIAL	High limit alarm	-1999—+9999	℃ or 1 defined unit	Linear unit defined by para. dIL and dIH when linear voltage/resistance input is selected
LoAL	Low limit alarm	-1999—+9999	℃ or 1 defined unit	
dHAL	Positive deviation alarm	0—9999	0.1℃ or 1 defined unit	
dLAL	Negative deviation alarm	0—9999	0.1℃ or 1 defined unit	
dF	Deadband	0 — 20℃ or 0 — 2000		ON/OFF control and alarm only
CtrL	Control mode	0—5 see the following text for details		
M5	Hold parameter	0—9999	0.1℃ or 1 defined unit	0 disable integral function
P	Rating parameter	1—9999		
t	Lag time	0—2000	SEC	
CtI	Control period/output smooth	0—125	SEC	Configure varied inputs
Sn	Input specification	0—37 see the following text for details		Configure varied resolution
dIP	Decimal point position	0— 3 see the following text for details		
dIL	Input Low Limit	-1999—+9999	℃ or 1 defined unit	
dIH	Input High Limit	-1999—+9999	℃ or 1 defined unit	
SC	Input Shift	-1999—+4000	0.1℃ or 1 defined unit	
OP1	Output mode	1-11 see the following text for details		
oPL	mV Low Limit	0—110	1%	
oPH	mV High Limit	0—110	1%	
ALP	Alarm output definition	0—63		
CF	System function selection	0—127		
Addr	Communication address	0—100		retransmission low limit Current
Baud	Communication baud rate	0—19200		retransmission low limit Current
dL	PV input filter	0—20		Define digital filter intensity
RUN	Running status	0. Manual 1. Automatic 2. Manual suppressing		AI-808 only
Loc	Configuration privilege	0—9999		
EP1-EP8	Field parameter definition	nonE—run		

5.1 Alarm parameter HIAL, LoAL, dHAL, dLAL

These 4 parameters set instrument's alarm function. Alarm signal will be triggered to make instrument's relay contact close (NC contact open), if alarm condition is satisfied. Alarm messages is displayed in turn in SV display window. When the cause of alarm is removed, then the alarm is cleared automatically.

Alarm condition is as following:

HIAL High Limit absolute alarm. If the process value is greater than the value specified as "HIAL+dF", then the alarm is set, and the alarm will be cancelled if the process value is less than the value of "HIAL-dF".

LoAL Low Limit absolute alarm. If the process value is greater than the value specified as "LoAL-dF", then the alarm is set, and the alarm will be cancelled if the process value is less than the value of "LoAL-dF".

dHAL Positive alarm. If PV minus SV is greater than the value specified as "dHAL+dF", the alarm is set, and the alarm will be cancelled if the process value is less than the value of "dHAL-dF". It also used as the second high limit alarm in case of on-off control.

dLAL Negative deviation alarm. If PV minus SV is greater than the value specified as "dLAL+dF", the alarm is set, and the alarm will be cancelled if the process value is less than the value of "dLAL-dF". It also used as low limit absolutely alarm in case of on-off control.

orAL Input over range or under range

Process variable exceeds the configured range (High Limit or Low Limit), caused by error configuration of sensor type, sensor disconnection or short-circuits. In the event of input over range, instrument will stop control automatically and the value specified in advance as the parameter "oPL" is output as the manipulated value.

Among which "orAL" don't need to be configured. Generally users don't need the whole 4 alarm. Limit value can be set to those parameters not used to avoid alarm function. Ex, the following configuration: HIAL=9999, LoAL=-1999. When the configuration dHAL+9999 (999.9℃ for temperature) or dLAL=9999 (999.9℃ for temperature) is set, even if the difference value is greater than 9999, dHAL or dLAL alarm will not be triggered.

The above mentioned 4 alarm can be set as alarm 1(AL1) or alarm2 (AL2) action (refer to the description of parameter "ALP"). User can install appropriate output module for alarm 1 or alarm 2, the most common use is relay contact output module, SSR voltage output module or BCR NO contact discrete output module can also be used.

5.2 Deadband parameter dF

Deadband parameter dF is set to permits protection of position control output from high switching frequencies caused by process input fluctuation. Deadband parameter is used for position control,

4-alarm control as well as the position control at auto tuning.

For example: dF parameter can affect upper absolute alarm as the following, provided upper alarm parameter "HIAL" is set as 800℃, dF parameter is set as 2.0℃.

- Instrument is in normal status at the beginning, when process value is greater than 802℃ (HIAL+dF), the upper absolute alarm can be triggered.
- Instrument is in upper alarm status at the beginning, when process value is less than 798℃ (HIAL-dF), then alarm can be cleared.

Another example: Provided the instrument is used for position control or at auto tuning. SV is set as 700℃, dF parameter is set as 0.5℃, control is reverse action (heat control).

- Output is on at the beginning, when process value is greater than 700.5℃ (SV+dF), then output is shut down.
- Output is off at then beginning, when process value is less than 699.5℃ (SV-dF), then output is on again to start heating.

As for position control, the larger for dF parameter value, the longer for output proportion period time and worse for control accuracy. Conversely, the smaller for dF parameter, the shorter for output proportion period time, and error action will occur easily due to input fluctuation and make mechanical contactors of relay or contactors shorten their service life.

dF don't affect AI artificial intelligence algorithm, but affect the position control at auto tuning, Theoretically the smaller for dF parameter, the batter for auto tuning accuracy, but error action, which caused by process value fluctuation due to noise, should be avoided. Watch process value for some time, if fluctuation is too large, increase input fitter parameter value dL at first to make the fluctuation smaller than 2-5 unit, then set dF parameter equal to process fluctuation value.

5.3 Control mode parameter CtrL

ON-OFF control mode an AI artificial intelligence control mode is available and can be selected through parameter CtrL for AI-708/708T series instrument.

CtrL=0 ON OFF control, suitable for the application which don't need high precision.

CtrL=1 AI artificial intelligence control, it is improved on the basis of PID control and fuzzy control, having more extensive adaptability to the process, and it is possible to get a good control for processes rapidly changed or having significant reaction lag time. This is the default setting value, and auto tuning can be started up from front panel on this setting.

CtrL=2 Starting up auto tuning, points for attention have been described in preceding text. The function is the same as starting auto tuning from front panel. After auto tuning is done, once setting parameter CtrL to 2 can start up more auto tuning.

CtrL=3 AI artificial intelligence control, this configuration is automatically set after auto tuning is

done. At this setting, starting auto tuning from front panel is inh9ibited to prevent error operation from starting auto tuning repeatedly.

CtrL=4 Comparing with the control mode of CtrL=3, Parameter P is defined as 10 times as its original value. Ex., if set P=5 incase of Ctrl=3 and set P=50 incase of Ctrl=5, then these 2 setting have then same control effect. In the application of rapidly changed temperature (changes by more than 200 ℃/second), pressure or flow control, or in the application where inverter is used to control water pressure, if CtrL=3 or CtrL=1 is set, then parameter P has to be set to a very small value, and sometimes only if parameter P is set to less than 1 can you get satisfied control effect, but if Ctrl=4 is set at this time, then parameter P can be enlarged 10 times, and so finer control is obtained.

Ctrl=5 (For AI-808 only), on this setting, the instrument can be used as servoamplifier or manual manipulator and the output value is defined by the measurement value.

5.4 AI artificial intelligence parameter M5, P, T, Ctl

These parameters are for AI artificial intelligence control algorithm, but not for ON-OFF control mode (if Ctrl=0 is set). AI artificial intelligence control, which is a new algorithm using fuzzy logical PID control, is adopted in AI series instrument. The ordinary PID algorithm can give accurate control to processes, with disadvantages of having large overshoot, having a long upset response time, and having difficulty for PID parameters to be determined, and is not suitable for process which are not stable or have a long lag time. Contrarily, fuzzy control algorithm can be suitable for processes that have a long lag time and have small overshoot, and it is easy for parameters to be determined, but it has bad control accuracy, and its control curve may have tiny saw-teeth. AI artificial intelligence algorithm has fuzzy control algorithm and concurrent PID algorithm improved with new derivative integral function added. Which of these two control algorithms is activated is determined by the deviation between measurement value and setpoint. When the magnitude of the deviation is large, the fuzzy control algorithm is activated to remove PID reset windup, and when the magnitude of the deviation is small, the improved PID algorithm is activated. Therefore, AI artificial intelligence control has the characteristic of having no overshoot, high control precision and easy parameter tuning and having good control effect for complicate process.

The following text is a description for the definition of MPt parameters and temperature control is taken as an example because it has a great difficulty and a wide-range application. AI artificial intelligence algorithm is suitable for various controlled processes such as pressure, flow-rate, level, temperature and so on.

5.4.1 M5 hold parameter

M5 is defined as measurement variation after output is changed by 5% (0.5mA if OP1=1) and when controlled process is basically stabilized. "5" indicates that output variation is 5 (5% or 0.5mA). "M5" parameter is called "M" for short in the latter text. Generally M5 parameter of the same system will changes with measurement value, and so M5 parameter should be configured with process value around operating point.

Take temperature control of electric furnace as an example, the operating point is 700℃. To find out optimum M5 parameter, assuming that when out remains 50%, the temperature of electric furnace will

finally be stabilized at 700℃ or so, and when output changes to 55%, the temperature will final be at 750 or so.

Then M5 (optimum parameter)=750-700=50℃. M5 parameter mainly determines the degree of integral function, similar as integral time of PID control. The smaller M5 parameter is, the greater integral function is, and the larger M5 parameter is, the smaller integral function is (integral time is increased). But if M=0, then integral function an artificial intelligence control function will be removed and the instrument is turned to be an PD adjustment that used as a secondary controller during cascade control.

5.4.2 P rate parameter

P is in reverse proportion to measurement variations caused by output changes by 100% in one second. It is defined as the following: if CtrL=1 or 3, then P=1000/measurement variations each second, the unit is 0.1℃ or 1 defined unit (for linear input).

Ex., instrument use 100% power to heat and there is no heat loss, if temperature in crease 1℃ each second, then P=1000/10=100. If CtrL=5, then P parameter will be configured by increasing 10 times. Ex., P should be set to 1000 in the a.m. example.

P is used to control proportional and derivative function in direct proportion, decreasing P parameter will decrease proportional and derivative function. P parameter does not affect integral function.

5.4.3 t lag time parameter

Parameter t is applied as one of the important parameters of AI artificial intelligence control algorithm. "t" is defined as follows: time needed for a electric furnace from the beginning of elevating temperature to get to 63.5% against the final speed of temperature elevating, provided there is no heat loss. The unit of parameter “t” is second.

For industrial control, hysteresis effect of the controlled process is an important factor impairing control effect. The longer is system lag time, the more difficult to get ideal control effect. Lag time parameter “t” is a new introduced important parameter for AI artificial intelligence algorithm. AI series instrument can use parameter “t” to do fuzzy calculation, and therefore overshoot and hunting do not easily occurs and the control have the best responsibility at the time.

Parameter “t” gives effect on proportional, integral and derivative function. Decreasing parameter “t” will strengthen proportional and integral function and weaken derivative function, with the extent of strengthening greater than that of weakening. And therefore as a whole decreasing “t” will strengthen feedback function. If t≤CtI, derivative function of system will be eliminated.

5.4.4 CtI output period

Parameter CtI can be set between 0.5 to 125 seconds. It represent the calculate speed of the instrument. When CtI increased, proportion function will be increased and derivative function will be decreased. If CtI≥5s, derivative function is absolutely eliminated, then the system is a proportional or proportional-integral system. The change of this parameter will nearly have no influence to the system if CtI is less than 1/5 of its original value.

The following principle is for adjusting parameter " Ctl" .

- In case of time proportional output mode, if SSR (Solid state relay) or SCR is used as executive bodies, then control period can be set smaller (generally 0.5 through 2 seconds) to improve control precision. If relay contact output is used, then parameter "Ctl" should be set to be larger than or equal 4 seconds generally, because a small value set will decrease service life of mechanical contacts. A large value set will increase service life of relay, but will decrease control precision, so select a value to satisfy both sides.
- In ease of linear current output, decreasing parameter CtI will speed up output responsibility and improve control precision, but will lead to frequently changed output current and arising therefrom frequent movement of executive bodies (ex. Control value). Now increasing parameter CtI appropriately will make value move smoothly.

5.4.5 M5, P, t, CtI setup

You can also modify, by your experience and referring the above-mentioned parameters such as M, P, T and CtI on the basis of parameter values after auto tuning. You can accumulate experience more easily to use these parameters than to use deterministic PID parameters because of these parameters describe system characteristic. AI artificial intelligence algorithm includes many control modes such as proportional (P). Proportional-Integral (P&I), proportional-derivative and AI artificial intelligence control to satisfy varied regiment.

Parameter setting process is as follows:

1. Executing parameter auto tuning at first (if system output are not allowed to be greatly changed, manual auto tuning can be executed from AI-808 instrument). And pay attention to some notes of this operation (there have been some descriptions in preceding text, such as: setting deadband parameter dF correctly to prevent on-off control from error action due to input fluctuation, adjusting digital filter parameter DL if necessary to prevent measurement from great fluctuation due to input noise and setting the setpoint for auto tuning correctly at the most commonly used value or at the highest temperature value for use). The ongoing auto tuning process normally needs a time from several minutes to several hours. (You had better write down the time taken). After auto tuning, observe for about one half of the time taken by auto tuning to see if the control precision is satisfied. If only according to notes for attention demanded by auto tuning, In 90% cases, the operation will get satisfied control effect.
2. If not satisfied with the control effect, you can make a further adjustment by stepwise trial on the basis of original parameter. Each time modify parameters M, P, and T separately by making it change to twofold or one half, ex., you can change parameter M5 from the original value "1000" to new value "500" or "2000". In most cases, you can get satisfying result after 1 to 5 trials. Normally, parameter "P" and "T" except "M5" can be correctly set by auto tuning in V6.0 instrument.
3. Therefore, after auto tuning, if the control has a fluctuation (measurement fluctuate around setpoint), then you can increase M5. If the control has a dead difference (the difference can not be removed even after slating for a long time), then you can decrease M5. Sometimes, adjusting parameter "M5" only can not solve the problem, you can adjust parameter "P" again (increase twice as much or decrease one half).

4. Too large parameter “P” and too small parameter “M5” will result in system fluctuation or overshoot (the former has a short period, the latter has a long period), conversely, too small parameter “P” and too large parameter “M5” will result in dead difference.

5. If parameter P is too small and parameter M5 is normal, then a long period overshoot will be resulted. If the control can not be satisfying yet after adjusting parameter M5 and P for many times, then you can adjust parameter T (increase to twice as much or decrease to one half). As regard to parameter CtI, if only taking service life of executive bodies (ex, value and AC contactor) into consideration, the smaller the setting, the higher precision the control has.

5.4.6 Technical summaries:

- Take temperature control as an example, parameter M5 represent the system performance of heat preservation, P represents system heating capability, T represents the lag time of system, and CtI is used to balance control effect (fast response and high precision) and to stabilize output (increase service life of execution bodies).
- Decreasing parameter M5 will strengthen integral function in direct proportion, increasing parameter P will strengthen proportional and derivative function simultaneously in direct proportion. Decreasing parameter “t” will strengthen proportional function while weaken derivative function, but proportional strengthening function is greater than derivative weakening function, and therefore decreasing parameter “t” will strengthen proportional-derivative function as a whole, and also strengthen integral function in the same proportion as strengthening proportional-derivative function do. Parameter CtI is used to balance proportional function and derivative function. The sampler CtI is set, the stronger derivative function is and the weaker proportional function is, but proportional-derivative function as a whole keep unchanged.
- Tuning parameter M5 to zero can remove integral function. Under one of these two condition of CtI ≥5 (seconds) or CtI=t (if parameter CtI is tuned to greater than T , then the instrument will automatically take CtI as T), derivative function will be removed, and increasing of CtI will prolong output period while weaken derivative function,. Generally, tuning CtI to 2 to 4 seconds will get very stable output.
- AI artificial intelligence algorithm has several great improvements, comparing to PID algorithm, which include

① Fuzzy regulation is used for control at the status of great deviation

② Except proportional, integral and derivative function, it has integral control for derivative function, and this is greatly helpful for the prevention of integral wind-up.

③ The deviation caused by setpoint change and measurement is processed by different ways, in order to prevent overshoot.

④ Its’ proportional, derivative and integral function is twice stronger than traditional PID control. Its’ control precision and system response speed is increased. It also has the function to prevent overshoot.

⑤ It has characteristic of self-adaptive control, i.e., An expert system is added with PID control to simulate process control, when the real control is not the same as the ideal result, adaptive system begins subcontrol, the result of which is added with PID output. This makes good control be remained even if parameters MPT is with a fairly big error.

5.5 Input specification parameter Sn

AI series instrument is available with varied input function. Different input type such as thermocouple, RTD and linear voltage can be selected in the same instrument through parameter setting. Automatic non-linear calibration of nigh precision for thermocouple and RTD is available in the instrument, with measurement input accuracy less than 0.2%. F.S. Special instrument, which uses special input specification such as EA2, BA1, BA2 and G index and evolution, can be customized according to the index table supplied by user. The following stable shows input specification corresponding to the set value of parameter Sn.

Sn	Input spec.	Sn	Input spec.	Sn	Input spec.
0	K	**1**	S	**2**	R
3	T	**4**	E	**5**	J
6	B	**7**	N	**8-19**	Spare
20	Cu50	**21**	Pt100	**22-25**	Spare for special RTD
26	0-80Ω resistance input	**27**	0-400Oresistance input	**28**	0-20mV Voltage input
29	0-100mV Voltage input	**30**	0-60mV Voltage input	**31**	0-1V Voltage input 0-500mV Voltage input
32	0.2-1V Voltage input 100-500mV input	**33**	1-5V Voltage input	**34**	0-5V Voltage input
35	-20-+20mV input 0-10V Voltage input	**36**	-100-+100V input 2-10V Voltage input	**37**	-5-+5V Voltage input 0-50V Voltage input

When Sn=10, a special instrument with special specification of arbitrary index such as Wre325, Wre526, Wre520, BA1, BA2, G, F2, extract root of 0-5V, 1-5V. Special order is needed.

5.6 Decimal point setting parameter dIP

5.6.1 In case of linear input, parameter DIP is used to define decimal point place according to users' habit.

dIP=0, display pattern is 0000, decimal point not displayed.

dIP=1, display pattern is 000.0, decimal point is at ten's place

dIP=2, display pattern is 00.00, decimal point is at hundred's place

dIP=3, display pattern is 0.000, decimal point is at thousand's place

Adjustment of this parameter affects display only, and gives no effect on measurement input accuracy and control precision.

5.6.2 In case of thermocouple of RTD input, dIP is used to define temperature display resolution.

dIP=0, temperature display resolution is 1℃

dIP=1, temperature display resolution is 0.1℃

adjustment of this parameter only affects the display, and gives no effect on control or retransmission output because the internal temperature measurement resolution is fixed at 0.1℃, then temperature will be displayed at the resolution of 0.1℃ for input below 1000℃ and 1℃ for input over 1000℃.

5.7 dIH and dIL: scale definition parameter for linear input/retransmission output

Linear input includes signals of various specifications such as mV, 5V, 1-5V, 0-10mA and 4-20mA, display range of which is from -1999-+9999 (decimal point can be defined by "dip").

When selecting instrument, it is recommended to select voltage-input type to substitute current input type. Ex, select the instrument of 0-1V or 0.2-1V voltage-input type for current input signals, by converting current signal to corresponding voltage signal through 100O or 50O resistance. Or select the instrument of 0-5V, 1-5V voltage input type for current input signals, by converting current signals to corresponding voltage signal though 500O or 250O resistance.

Parameter "dIH" and "dIL" are used to define the display span for linear input, and to set the engineering unit for measurement.

For example, a pressure transmitter is used to convert pressure signal (temperature, flow and humidity signals also possible) to stand 1-5V input (4-20mA can be obtained through an external wired 250O resistance). Among which, 1V corresponding to pressure 0 and 5V corresponding to pressure 1Mpa, and the display resolution of 0.001Mpa is expected. Each parameter can be set as the following:

Sn=33 (Select 1-5V DC Voltage input)

dIP=3 (Set decimal point, and the display pattern is "0.000")

dIL=0.000 (define the pressure display value corresponding to low input limit 1V)

dIH=1.000 (define the pressure display value corresponding to high input limit 5V)

5.8 Input shift parameter Sc

Parameter Sc is used to make input shift to compensate the error produced by sensor or input signal itself.

For thermocouple input, parameter Sc is used to correct reference junction compensation error.

The instrument itself will not produce error after a long time used, because the technology of digital calibration is used in the instrument to substitute potentiometer of bad stability, and the function of automatic zero modulation will guarantee no zero drift produced in the instrument.

Parameter "Sc" is used to make input shift to compensate the error produced by measurement. For example, provided input signal keep unchanged, if when parameter "Sc" is set to 0.0℃, the temperature measurement of the instrument is 500.0℃, then when parameter "Sc" is set to 10.0℃, the temperature measurement display will be 510.0℃.

Instruments are all calibrated before delivering, and so the default value of parameter "Sc" is zero. Only adjust this parameter when recalibration of measurement is necessary.

5.9 Output definition parameter “OP1”, “OPL” and “OPH”

Parameter OP1 is used to define the mode of main output signal, and parameter “oPL” and “oPH” is used to define output lower limit and upper limit. Note: setting of parameter “oP1” must conform to the module type installed as main output.

oP1=0, the mode of main output is time-proportional output (for AI artificial intelligence control) of on-off mode (for on-off control). If output modules such as SSR voltage output, relay contact discrete output, BCR cross zero trigger output, and BCR no-contact discrete output are installed as main output, then “oP1=0” should be set.

oP1=1, 0—10mA or any specification DC current output, continuous output mode. Linear current output module should be installed to main output.

oP1=2, 0—20mA or any specification DC current output, continuous output mode. Linear current output module should be installed to main output.

oP1=3, time proportional output mode, and alarm1 is also used as a control output. Three phase BCR triggering output can be performed in this mode. If K2 module is installed as main output module and K1 module is installed as alarm1 output module, then three BCR triggering signal can be supplied. Because in this mode alarm 1 of the instrument is used for output control, only alarm2 can be used as alarm output when alarm function is needed.

oP1=4, 4—20mA or any specification DC current output, continuous output mode. Linear current output module should be installed to main output.

oP1=5-7, (for AI-808/808P only), position proportional output, used for valve rotation control.

oP1=8-11, (for instrument with optional software, 50Hz power needed), 8 and 9 respectively represents output of single-phase/threephase phase-shift trigger, module K3/K4 should be installed. oP1=10, 11 represents period proportional single-phase/threephase output, module K1/K2 should be installed.

oPL, Restrain minimum value of adjust output. When the function of sectional power restriction is executed, it is the output upper limit if output value is lower than the value of lower limit alarm. If bidirectional adjustment software is installed, then instrument is turned to be a duo directional output system, when oPL<0, it represents the maximum output of refrigeration output.

oPH, Restrain maximum value of adjust output

5.10 Alarm output definition parameter “ALP”

Parameter “ALP” may be configured in the range of 0 to 63, and used to define which alarm type of “HIAL”, “LoAL”, “dHAL” and “dLAL” is output to AL1 or AL2. Its function is determined by the following formula:

ALP=A×1+B×2+C×4+D×8+E×16+F×32

If A=0, then AL1 is activated when upper alarm occurs;

If A=1, then AL2 is activated when upper alarm occurs;

If B=0, then AL1 is activated when lower alarm occurs;

If B=1, then AL2 is activated when lower alarm occurs;

If C=0, then AL1 is activated when positive deviation alarm occurs;

If C=1, then AL2 or OUT2 is activated when positive deviation alarm occurs;

If D=0, then AL1 is activated when negative deviation alarm occurs;

If D=1, then AL2 or OUT2 is activated when negative deviation alarm occurs;

If E=0, then alarm types, such as “HIAL” and “LoAL” will be displayed alternatively in the lower display window when alarm occurs. This makes it easier to find out alarm occurs.

If E=1, then alarm types will not be displayed in the lower display window (except for “orAL”). Generally this setting is given when alarm output is used for control purpose.

If F=0, when C=1, D=1, positive negative deviation alarm occurs on AL2.

If F=1, when C=1, D=1, positive negative deviation alarm occurs on OUT2.

For example: If it is needed that AL1 is activated when upper alarm or positive deviation alarm occurs, AL2 is activated when lower alarm or negative deviation alarm occurs, and alarm type is displayed in the lower display window when alarm occurs, then we reach a conclusion: A=0, B=1, C=0, D=1, E=0, F=0 Parameter “ALP” should be configured to:

ALP=0×1+1×2+0×4+1×8+0×16+0×32=10.

5.11 Function parameter “CF”

Parameter “CF” is used to select some system functions,

CF=A×1+B×2+C×4+D×8+E×16+F×32+G×64

A=0, reverse action control mode. When this mode is selected, an increase in PV results in a decrease in the control output. Ex, heating control.

A=1, direct action control mode. When this mode is selected, an increase in PV results in an increase in the control output. Ex, cooling control.

B=0, without the function of alarm suppressing at power on or setpoint changing.

B=1, having the function of alarm suppressing at power on or setpoint changing. Refers to the description in the latter text.

C=0, auxiliary function module of the instrument works as communication interface.

C=1, auxiliary function module of the instrument works as linear current transmit output.

D=0, inhibits remote setpoint input. (For AI-808/808P only)

D=1, allows remote setpoint input. (For AI-808/808P only)

E=0, without the function of sectional power restriction

E=1, with the function of sectional power restriction

F=0, with luminosity indicator for output value

F=1, with luminosity indicator for measurement value

G=0, the instrument works as AI-808P mode (for AI-808P only)

G=1, the instrument works as AI-808P (an old version instrument) mode (for AI-808P only)

For example: if it is expected that the instrument service as reverse action control, have the function of alarm suppressing at power on, have a communication interface which auxiliary module 4 works as, and is not allowed to receive remote setpoint input. Then we get A= 0, B= 1, C= 0, D= 0, E= 0, F= 0, G= 0. And so parameter “CF” should be set as follows:

CF=0×1+1×2+0×4+0×8+0×16+1×32+0×64=2

5.12 Communication interface related parameters Addr and Baud (concurrently scale definition of retransmission linear current).

When RS232C or RS485 communication interface is installed as auxiliary function, parameter “Addr” and “Baud” is used to define the communication address and baud rate respectively for communication modules in the instrument. Communication baud rate can be configured in the ranged of 300 to 19200bit/s, and the address of the instrument can be configured in the range of 0—100. Instruments should have different address configured when they are installed in the same communication line.

The data character format for communication interface is 8 data bits, 1 stop bits, and no parity bit. CRC calibration is used for data check, its correcting capability is thousands times beyond even-odd check. This makes communication data correct and reliable. AI series instruments can make up distributed control system together with computer. Demonstration software, which has detail description about distributed control system, is available for ordering. When trouble occurs on computer, communication interface, and line, the instrument itself can still work as usual to maintain the control of process.

If linear current output module is installed in the instrument as auxiliary function module, then parameter “Addr” and “Baud” is used to define the scale of linear current for the corresponding

retransmission output. And parameter “Addr” is used to define output low limit and parameter “Baud” is used to define output high limit. The unit is 0.1mA. For example, if a 4—20mA retransmission output need to be defined, then you can set like below: Addr=40,Baud=200.

5.13 Input digital filter parameter “dL”

There is one intermediate-value filter system and one second order integral digital filter system in AI series instrument, among which intermediate value filter takes intermediate value among three continuous values, and second order digital filter has the same effect as resistance-capacity integral filter. If measurement input fluctuates due to noise, then digital filter can be used to smooth the input. Parameter “dL” may be configured in the range of 0 to 20, among which, 0 means no filter, 1 means intermediate-value filter and 2—20 means that intermediate-value filter and second order integral filter can be selected simultaneously.

The multiples of second integral filter is the square parameter “dL”, and can be up to hundreds times. When a large value is set, the measurement input is stabilized but the responsibility at the time is deteriorated. Generally if great interference exist, then you can increase parameter “dL” gradually to make momentary fluctuation of measurement input less than 2 to 5 values. I f the instrument is being tested at laboratory, then parameter “dL” should be sit to 0 or 1 to short the time responsibility.

5.14 System running parameter run (for AI-808, AI-808P only)

System running parameter RUN

This parameter is only suitable for AI-808 and AI-808P series instrument, furthermore the functions defined are different in these two types of instruments.

1. **For AI-808 type, parameter RUN is used to define Automatic/manual working status as below.**

   Run=0, manual control state

   Run=1, automatic control state

   Run=2, automatic control state, in this state manual operation is prohibited. When the manual function is not required, it can avoid entering manual state due to operator’s false operating.

As auto/man transfer can be carried out directly from the keypad, it is not needed to adjust parameter RUN to perform auto/man transfer. However, when a computer is used to control the instrument via RS232C or RS485 communication interface, adjusting parameter RUN from computer can carry out the transfer of auto/man status.

2. **For AI-808P type, parameter RUN is used to define the event-handling mode when program is running.**

Abrupt actions affecting control execution of program are called event, as the outcomes of events are always probably unpredicted, the aim of event handling is to turn those unpredicted things into predicted results.

Run=A×1+D×8+F×32

Among which: A is used to select 5 kinds of outage/start event handling modes; D is used to select 4 kinds of run /modify event-handling modes; F is used to select two control state of Auto/Manual.

There are five outage-handling functions for AI-808P series instrument. The setting functions of A in parameter RUN is below:

A=0 Anyway, the program will jump to the 29th segment to begin the program running and clear event output status at the same time. This mode is suitable for the application of an extremely high process demand, in which power failure is not allowed at any time. User may do trouble handling in NO.29 segment, for example, switch on the event output to trigger alarm.

A=1 If these is no deviation alarm after power on, it will continue the program running from the original break point, and the event output state remains. Otherwise, the program will jump to the 29th segment to begin the program running and clear event output status at the same time. This mode is suitable for the application of a fairly high process demand.

A=2 After power on, it will continue the program running from the original break point, and the event output state remains. This mode is suitable for the application in which power failure does not affect the production.

A=3 Anyway, after power on, the instrument is stopped. This mode is suitable for the application in which outage handling is not needed.

A=4 If power is shut down when the instrument is running, anyway, the instrument will go into HOLD state after power on. If power is shut down when the instrument is in StoP State, it will keep in StoP State after power on.

Run/modify event handling

AI-808P series instrument supply the following modes for user to select to deal with the problems of Run/modify event by setting parameter B:

D=0 Common mode, program execute as planed. This mode guarantees constant running time of the program, but it can't guarantee the integrity of the whole curve.

D=1 With the function of measurement value start up and without the function of preparation.

D=2 With the function of preparation and without the function of measurement value start up.

D=3 With the function of measurement value start up and preparation.

F is used to select the control mode of Auto and Manual (for AI-808P only)

F=0 Auto control mode

F=1 Manual control mode

F=2 Works on Auto mode and is not able to be switch to Manual mode from front panel.

For example: if it is needed that the instrument continue program running from the original break point after power on, have the function of measurement value start up and preparation, and the instrument works on Auto mode, then you can set as below: A=2,B=1, and so we get parameter:

Run=2× 1+3× 8+0× 32=26

5.15 Privilege for parameter set Loc

If parameter Loc is set to other values than 808, then only field parameters in the range of 0 to 8 and parameter Loc itself can be set. When parameter Loc is set to 808, user can set al parameters. Parameter Loc provides several operation privileges. When user has completed setting some important parameters such as input and output, parameter Loc can be set to other values than 808 in order to avoid field operators' accidental modification of some important operation parameters. See the following:

1. for AI-708T/708/808 series instrument

Loc=0, modification o field parameters and setpoint is allowed.

Loc=1, allowed to display and view field parameters, and to set setpoint. But the modification of field parameters (except parameter Loc itself) is not allowed.

Loc=2, allowed to display and view field parameters, but the modification of field parameters and setpoint (except parameter Loc itself) is not allowed.

Loc=808, configuration of all parameters and setpoint is allowed.

2. For AI-808P series instrument

Loc=0, allowed to modify field parameters, program value (time and temperature value) and program segment number StEP.

Loc=1, allowed to modify field parameters and StEP value, but the modification of program is not allowed.

Loc=2, allowed to modify field parameters, but not allowed to modify StEP value and program.

Loc=3, only allowed to modify parameter Loc itself, all other parameters, program and StEP value can not be modified.

Loc=808, allowed to set all parameters, program and StEP value.

Note: that 808 is the password of all AI series instrument. In application the instrument should be set to other values to protect from modifications of parameters. Meanwhile the management of production should be enforced to avoid arbitrary operation.

If Loc is set to other values than the above mentioned, the result may be one of those above mentioned, and most of them are the same as when loc=1 is set.

If you Set Loc to be 808 during field parameter (EP1-EP8) setting, parameter Loc will automatically turned to be 0 when you finished setting field parameter, but if you set Loc to be 808 after the parameters are unlocked, parameter Loc will be saved as 808 permanently.

5.16 Field parameter definition: EP1—EP8

When configuration of the instrument is completed, most parameters will not need to be set by field operators. Furthermore, field operators may not understand many parameters, and may probably set parameters incorrectly by mistake and make the instrument unable to work.

Intelligent instruments are generally equipped with parameter lock function, but ordinary lock function always lock all parameters. Sometimes it is needed for field operators to modify or adjust some parameters such as M50, P, t, and upper alarm HIAL, and to modify some program such as the temperature and time value of a certain segment for AI-808Pseries instrument.

EP1—EP8 define 1—8 field parameters for operators' use in parameter table. Their parameter values are parameters such as HIAL, LoAL etc (except parameter EP itself). for AI-808P series instrument it should include setting values of program like C01, t01, etc. when Loc is set to 0, 1, 2, and so on, only parameters or setting values of program defined can be displayed, other parameters can not be displayed and modified. This function can speed up the parameter modification and prevent important parameters (like input, output parameters) form modifying falsely.

Parameters from EP1 to EP8 can define 8 field parameters at most, if the number of field parameters is less than 8(sometimes even none), it is necessary t define useful parameters from EP1 to EP8 in order, the first parameter which are not used is defined as none. For example, two parameters of HIAL (upper alarm) and LoAL (lower alarm) are need to be modified by field operators, the parameter EP can be set as following:

Loc=0,EP1=HIAL, EP2=LoAL, EP3=nonE.

Sometimes field parameters are not needed after we finish adjusting the instrument, we can set EP1parameter an nonE.

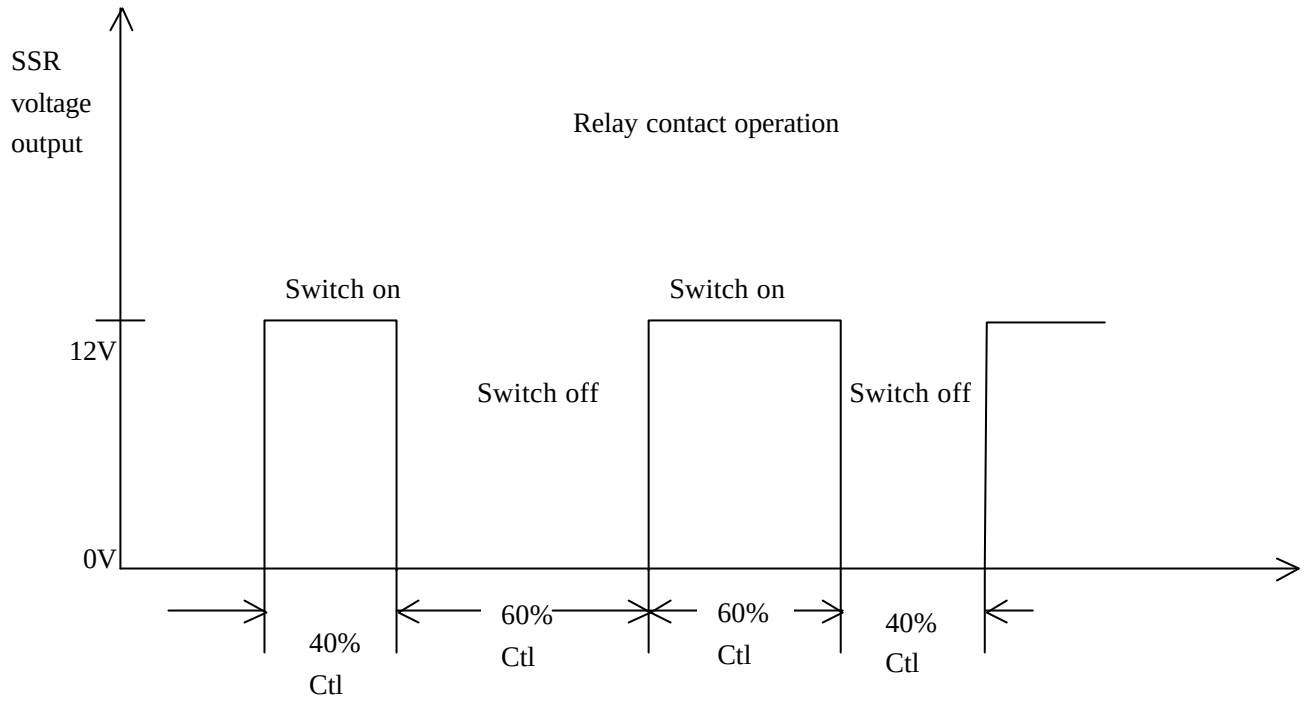
6. Additional remarks of instrument function

6.1 Time proportional output (when oP1=0, 3)

In case of time proportional output mode, the output value can change by adjusting, during a fixed base period, the ratio of relay on-off time (or the ratio of the time during which SSR High voltage output or low voltage output is activated).

Time proportional output can be regarded as a square wave, the base period of which equals to control period Ctl, and the output value of which direct proportional to the on-off ratio of the square wave. The on-off ratio may be configured to be in the range of 0% to 100%. For special applications, the range of time proportional output can be clamped by tuning parameters “OPL” and “OPH”. Fox example, if the output need to be clamped to between 20% and 60%, then “OPL=20,OPH=60” may just be set. Normally in case of time proportional output, if “OPL=0, OPH=100” is set, then there will be no output limit.

Below is a schematic diagram for time proportional output (waveform respectively for output being 40% and 60%)



6.2 Position proportional output

AI-808/808P series instrument can directly control the running of valve motor without using servo amplifier. For this control mode, it is needed to install 2 discrete module (relay contact discrete module of BCR no control discrete module can be used) in main output and alarm 1 socket to control respectively forward running/reverse running of the motor. Because AL1 is used for the reverse running of the motor, alarm output will not occur on AL1 in the during the position proportional output control.

oP1=5 Position proportional output without valve position feedback signal. It is needed to install 2 discrete module (relay contact discrete module of BCR no control discrete module can be used) in main output and alarm 1 socket to control respectively forward running/reverse running of the motor. It only sustains the valve whose haul period is less than 60 seconds.

oP1=6 Position proportional output with valve position feedback signal. The feedback signal is input from terminal 1 and 2. It can be used for the valve whose haul period is more than 20 seconds. Valve position feedback signal is input at 0-5V terminal of instrument. To guarantee the normal running of the instrument, it is needed for the valve position feedback voltage signal to be less than 1.5V when the valve is at fully closed position, and to be more than 2.5V when the valve is at fully open position.

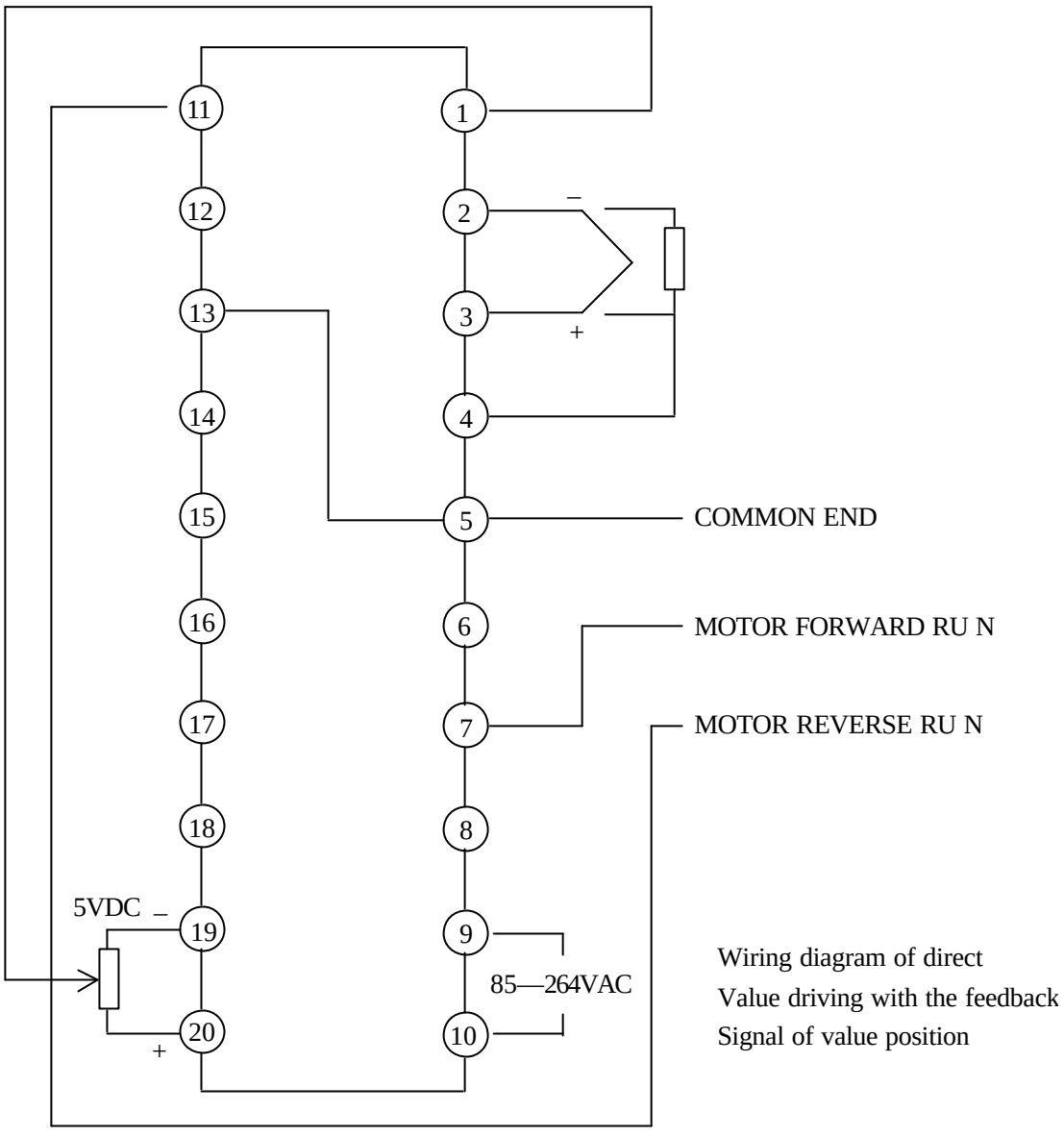
oP1=7 Valve automatic allocation in position proportional output with valve feedback signal. The instrument will fully close the valve and detect its position, then open the valve fully and detect the position. It is needed for the valve position feed back voltage signal to be in the range of 0-1.5V when the valve if full closed and the signal should be at lest 1V higher then the full close value. oP1 will be automatically set to 6 after allocation, and upper limit and lower limit of valve position can be clamped by setting parameter oPL and oPH.

Setting parameter dF can adjust the deadband of valve position, and the recommended setting rang is 1%-3%. A large value set can avoid frequent valve rotation, but too large value will result in the control accuracy dropping. Note: Parameter dF still has alarm function on this occasion.

If oP1=6 or 7, The measurement input of the instrument should not be 1—5V or 0—5V. If the measurement input is 1—5V or 0—5V(0—10mA or 4—20mA), then you can set the specification of main input of the instrument to be 0-1V or 0.2V-1V(or 0—100mV), and then externally connect suitable resistance for voltage or current dividing.

When a potentiometer is used for the valve position feedback signal, a non-isolated 5V-voltage output module can be installed as auxiliary function to convert resistance signal into voltage signal (terminal 9 has been connected to terminal 2 internally). Valve feedback signal of 0-5V or 1-5V can be input from terminal 1+ and 2-.

The connection diagram is as follows:



Wiring diagram of direct
Value driving with the feedback
Signal of value position

6.3 Remote setpoint input (for AI808/808P only)

If remote setpoint input is allowed, then the setpiont can be given by a 1—5V voltage signal inputted from 1—5V wiring terminal of the instrument. The scale of the remote setpoint is determined by parameter “dIL” and “dIH”.

If the voltage signal inputted from remote is less than 1V, then remote setpoint input is automatically inhibited, and local setpoint input is allowed. In the application of remote setpoint input, the measurement input of the instrument should not be 1—5V or 0—5V. If the measurement input is 1—5V or 0—5V(0—10mA or 4—20mA), then you can set the specification of main input of the instrument to be 0-1V or 0.2V-1V(or 0—100mV), and then externally connect suitable resistance for voltage or current dividing. With the function of remoter setpoint input, AI series instrument can make up cascade control system to fulfil complicated tasks, and can also use external voltage input to switch target setpoint, if a second setpoint is defined by setting “DIL=DIH=The second setpoint”, through a 1—5V voltage input.

If it is expected to use contact input to switch target setpoint, then U5 module (option module of 5V-voltage output) can be installed to get 5V voltage. AI –808P series instrument can not execute the function of remote setpoint input.

For AI-808P, its setpoint is summarized by remote setpoint input and internal Program Generator if remote setpoint input is allowed.

6.4 Alarm suppressing at power on

The function of alarm suppressing at power on: instrument alarm often occurs immediately after power on or setpoint changing. Take electrical furnace temperature control (heating control) as an example. The actual temperature is far below target setpoint at power on. If lower alarm or negative deviation alarm is configured, then the alarm condition may be satisfied at power on. But in fact the control system may not have problem. Contrarily in case of cooling control (direct action control), upper alarm may occur at power on. AI series instrument provides the function of alarm suppressing after power on or setpoint changing. Even if alarm condition is satisfied after power on or setpoint changing, alarm will not occurs.

If an alarm condition is satisfied again after it is cleared, then the alarm function is started up. The effect of alarm suppressing after power on depends on the selection of direct/reverse action. In case of reverse action control (heating control), lower alarm and negative deviation alarm are suppressed after power on. In case of direct action control (cooling control), upper alarm and positive deviation alarm are suppressed after power on. The corresponding deviation alarm is suppressed after setpoint changing.

6.5 Sectional power restriction

With regards to some high temperature electric resistance furnace whose heating materials is silicon-molybdenum bar or tungsten filament, the resistance of there heater in cold condition is much lower than that in hot condition, so the furnace current will exceed its rated current greatly in cold

condition. If the instrument works in automatic control mode, full power output in cold condition will lead to power switch trip and shorten the heating materials service life to a large extent.

The function of sectional power restriction will be executed if E=1 is set while setting parameter CF. Then the instrument output lower limit will be fixed on 0, while oPL is the output upper limit when output is lower than the value of lower limit alarm, if output is higher than the lower limit alarm value oPH is the upper limit. In this way, the instrument can work with 2 optional power according to the measurement in order to restrict the oversized current in cold condition. Lower limit alarm function will be canceled in sectional power restriction.

For example: If it is needed that output power should be restrict to 20% when the furnace temperature is lower than 600℃ and the 100% upper limit is allowed when the temperature is more than 600℃. Parameters is as follows:

LoAL=600, oPL=20, oPH=100, E=1 (see parameter CF for details).

6.6 Panel with luminosity indicator

AI series instrument contains intelligence panel display interface makes it possible that all types of instrument panel can be changed freely. The enhanced display panels are as follows:

A2 Luminosity indicator with 20 LBD (5 grades luminance each LBD, 1% resolution, 2x4 nixie tube available)

C3 Luminosity indicator with 50 LBD (2 grades luminance each LBD, 1% resolution, 2x4 nixie tube available)

D3 Enhance panel with LCD screen 144x144mm (Width x Height)

6.7 Communicate with computer

The operation and the function of the instrument can be executed by using computer sustained with AIBUS communication protocol when RS485 communication module (with photoelectric isolation) is installed. Besides various application software developed by users, we also provide AIDCS for communication, it will run under the operating system of Windows95/98/NT. By using this software, AI series instrument with the number of 1-200 can be centralized monitored and controlled, while automatic record and print is available.

An RS232/RS485 converter is needed when using RS485 communication interface for communication. Then you can connect 64 (maximum number) instruments with the computer and computer control is now available. If more than 100 instruments are needed for a system, each computer interface can be connected with 100 instruments with the help of RS485 Repeaters and computer LAN consists of 2 or more computers will be bring into use if it is necessary. Different address should be given to each instrument. Communicator protocol is free for users who want to develop the configuration software of their own. Here are the instrument communication parameters: 8 data bit, 1 or 2 stop bit, no parity bit, 16 bits summation check.

7. Further description about general work mode of AI Series instruments

7.1 ON-OFF control instrument (simple temperature controller)

ON-OFF control instrument is widely used in the application of simple temperature control, such as plastic machine, industrial boiler, dehydrator, food manufacturing machine, packing machine and so on, which don't need high precision of temperature control. It is also widely used for alarm task.

You can select the simple type instrument of AI-708 to perform ON-OFF control by installing one relay contact output module in the main output (midule1) socket. When ON-OFF control instrument is used for temperature control, generally, it uses its internal relay to control external intermediate relay, and this external intermediate relay controls an A.C contactor which controls the power on and power off of heater to control temperature. Input temperature sensors are mainly thermocouples, such as K, E and so on. Tt100 is also in used sometimes.

Deadband of ON-OFF control can be set by parameter dF. When AI series instruments are used for ON-OFF control, is should be set as below: Ctrl=0, oP1=0.

Besides setting input specification parameters properly, you also need to set alarm parameters such as HIAL, LoAL, dHAL and dLAL to limit value (the default factory set) to avoid unnecessary alarms. Parameters for AI artificial intelligence control, such as M50, P, t, and CtI, have no function in this occasion. After input related parameters are properly set, it is suggested to set parameter LOC and EP1 as below:

Loc=1: inhibit the modification of field parameters, inhibit the display and modification of other parameters

EP1=nonE: field parameters are not defined.

Because of the simple function of ON-OFF control instrument, generally, there is no need to set parameters. So all parameters are locked to avoid troubles made by unintentional modification.

Because of low accuracy of ON-OFF control mode, it is suggested to use AI artificial intelligence control mode for better effect, if the condition is allowed.

7.2 3-point (upper, lower alarm) control instrument

Typical 3-point control (upper-lower alarm type, also named as control plus upper alarm type) is also widely used. AI-708 series instrument performs 3-point control by installing a relay contact output module in main output socket and alarm 1 socket respectively. Comparing to 2-point control instrument, a relay output is added as upper alarm function for 3-point control instrument. To make the instrument have upper, lower alarm function, the parameters should be set as below: Ctrl=0,op1=0,CF.A=0, ALP=30, LOC=0, EP1=HIAL, EP2=nonE.

Refer to descriptions for the above mentioned parameters in the preceding text. The set of ctrl=0, op1=0 and cf=0 configure main output to be ON-OFF control, relay output and reverse action control. This means that main output relay is activated when measurement value is less than setpoint (SV), And main output execute lower alarm control, with setpoint set to be lower alarm value. (Note: if CF is set to 1, then main output executes upper alarm control functions). The set of ALP=30 means that alarm 1 output is activated when upper alarm occurs, and that alarm 2 output, with no module installed is activated when the other alarms occur. It also means that no alarm code is shown in the lower display window when alarm occurs.

Setting setpoint (SV) can set lower alarm value, and setting parameter HIAL can set upper alarm value. Because the set of parameter HIAL is needed at field, LOC=0,and EP1=HIAL should be set, i.e., HIAL can be modified as field parameter, and other parameters are locked with display and modification inhibited.

AI series instrument has plentiful control and alarm modes; this 3-point control instrument can also be set to have the function of high, high-high alarm or low, low-low alarm according to the need.

AL2 and OUT2 can be also used for alarm output, so the instrument can have 4 alarm output at the utmost.

7.3 Temperature Transmitter/Program Generator

AI-708T/708/808 series instrument can retransmit its analog input signal into linear current output of any range, and can be used as an instrument with the display and temperature retransmission function. You can set various thermocouple/RTE input, and any temperature retransmission range and current output specification, with the retransmission accuracy less than 0.1mA in the range of 0-20mA (i.e., less that 0.5% F.S.). Related parameters are as below:

If c=1 is set for parameter CF, and a linear current output module (isolated of non-isolated modules can be selected) is installed in the auxiliary function socket, then linear current retransmission output function is available in the instrument (but communication function cannot be added any more). The parameters concerned are shown below:

Sn: select thermocouple/RTD input specification

dIL: set low limit of retransmission output, the unit is ℃.

dIH: set high limit of retransmission output, the unit is ℃.

Addr: set the current output value of the instrument when analog input signal is less than or equal to the parameter value set as dIL, the unit is 0.1mA.

Baud: set the current output value of the instrument when analog input signal is more than or equal to the parameter value set as dIH, the unit is 0.1mA.

For example, if the instrument is expected to have retransmission function for thermocouple of K type , with the temperature range of 0--400℃, output range of 4—20mA, then each parameter can be set as below: sn=0, dIl=0, dIH=400, Addr=40, Baud=200.

Transmitter defined as above will output 4mA when temperature is below or equal to 0℃, 20mA when temperature is over or equal to 400℃, and a continuously changes between 0--400℃.

If ctrl=0(ON/OFF control mode) and oP1=1, 2 or 4(linear current output) is set, then the main output

of the instrument can also be used as retransmission output, with the current output defined by parameter oPL and oPH. In this occasion, the instrument will not have control function but have alarm function and the function of communication with computer.

As regards to AI-808P, if main OUT is defined as retransmission output its output represents the setpoint and the instrument is now used as Program Generator.

7.4 Temperature (pressure, flow of level) controller with high precision

2-point and 3-point control instrument, mentioned in the preceding text, can only perform the temperature control without high precision. The first advantage of AI series instrument is using advance AI artificial intelligence algorithm to perform unprecedented control with high precision. Its advance auto tuning (AT) function makes manual parameter setting unnecessary for user. The accurate control function can be performed with AI-708/808/808P series instrument. Among which, AI-808/808P has auto/man bumpless switching function and auto tuning function with limited output amplitude, has a more improved function than AI-708series instrument, and should be selected for the application of linear voltage output, especially for the application where control valve is used. AI-808Phas program control function, suitable for the application where setpoint need to be changed automatically with time.

To perform control with high precision, the following modes are often used as main output modes of AI-708/808/808P series instrument.

SSR voltage output: (time proportion output) equipped main output (OUT) with module G, to drive external solid state relay.

Single-phase/three-phase BRC zero cross signal output: (time proportion of period proportion output) equipped main output (OUT) with module K1/K2, equipped AL1 with module K1 (for three-phase only), can drive external BRC directly.

Linear current output: equipped main output (OUT) with module X. 0-10mA, 4-20mA, 0-20mA, etc. output signal. Need to externally connect executive bodies, such as BCR voltage regulator and control valve.

BCR no contact discrete output (time proportion, control AC signals only): equipped main output (OUT) with module L2/L4. Used to control AC contractor through an intermediate relay (or control small AC contractor directly).

Relay contact discrete output: used to control AC contractor through an intermediate relay.

Position proportion output: OUT and AL1 are equipped with modules of L1, L4 or W1, used to control the rotation of valve motor.

BRC phase-shift trigger output: OUT should be equipped with module K3 if it is single-phase trigger. If it is three-phase trigger, module K4 should be equipped onto AL1 and OUT2 to trigger other two BRC.

To use the instrument, besides correctly setting input related parameters, user need to understand the use of output related parameters, user need to understand the use of output related parameters (oP1, oPL, oPH), be familiar with control modes and the operation of auto tuning (parameter CtrL), and understand the use of control parameters (M50, P, t, CtI)

7.5 Manual manipulator/ servoamplifier

AI-808/808P has the function of transmitter, adjuster, manual manipulator and servoamplifier. These four functions can be executed simultaneously or they can be used separately. When CtrL=5, the instrument can be used as servoamplifier or manual manipulator and the output value is defined by the measurement value.

Specification of the instrument input signal is also defined by the parameter Sn. The input signal will be input from 2(-) and 3(+) , and the valve position feedback signal will be input from 1(+) and 2(-) (0-10mA, 4-20mA current signal should be converted to voltage signal via resistance of 500Ω and 250 Ω, 1K potentiometer signal can be converted to voltage signal by using an 5V power)

The instrument equivalent to a manual manipulator if oP1=1, 2, 4. Then the instrument main output will export current signal to a servoamplifier; AL1 is the input signal unusual alarm; OUT2 can be configured as alarm output or external auto/manual input (installed with module I2); COMM is used for communication or current retransmission output (see parameter CF, power isolator V20 is recommended), it can provide similar current signal which is insolated to OUT. This current signal will be provided to computer or adjuster for signal tracking.

Setup oP1=5, 6, 7, the instrument execute the function of position proportional output and can be used as servoamplifier. OUT and AL1 will dominate the running of valve motor (OUT for forward running, AL1 for reverse running). AL2 acts as alarm or auto/manual output. OUT2 can be configured as alarm output or external auto/manual input (installed with module I2). COMM is used for communication or current retransmission output.

You can define input signal unusual alarm by setting HIAL (upper limit alarm) and LoAL (lower limit alarm). dHAL (positive deviation alarm) and dLAL (negative deviation alarm) can act as the alarm output caused by the inequality between SV (valve position feedback signal) and PV (adjustor output). In order to avoid the false alarm (caused by the fast time difference between SV and PV) during valve running, parameter CtI should be defined as valve haul period.

If AL2 represent the stator signal of auto/manual output, it is a normally closed contact on manual status and normally open contact on auto status.

When OUT2 is configured as external auto/manual input (installed with module I2), the instrument works on manual mode when external switch is converted to close status, and on auto mode when external switch is converted to open status. Nevertheless, the instrument work module can be freely converted by panel operation whatever the switch status is. Setting of parameter run will not effect the input control from panel and external switch.

dIL=0 and dIH=100.0 is needed setting the output display unit to percent style.

This manual manipulation has the function of manual/auto bumpless switching. With this function, the output value will be changed from manual value to auto value gradually when the instrument work module is converted to auto mode. The switching timeconstant is governed by the setting of parameter t. The larger t indicate the more slowly change of output value and gradual change will be cancelled if t=0.

8. Further description for the operation of AI-808P series instrument

AI-808P program type temperature controller/regulator is used in the application where the setpoint should be changed automatically with the time. It is designed with advanced technique, powerful function in program and operation, powerful capability of anti-interference and high reliability structure. Therefore it can be widely suitable for various applications, and further improve the automatically of control equipment.

8.1 Main function

- 30 steps program control, any amplitude of the slope can be set for temperature (or pressure, flow, humidity and so on) heating up or cooling down.
- High flexibility in program and operation. It has programmable/maneuverable commands such as jump (loop). Run, Hold and stoP. It is allowed to modify the program at anytime no matter if the program is running or not.
- 2 event output function. Be able to control the interlock of other equipment via alarm output, and further improve the automation.
- External contact input module selectable. Program operations such as run, Hold and stoP can be executed via external contact input to perform tasks such as interlock, synchronizing start-up and so on.
- AI Artificial Intelligence controls mode. It has good performance without overshoot and undershoot, and has curve fitting function to obtain smooth curve control effect.
- Measurement start-up function and ready function can make program run more efficiently.
- 4 power-off/power-on event handling modes selectable. This can prevent the program control from being affected by unexpected power-off.

8.2 Concepts on operation terms

Program StEP: The NO. Of the program StEP can be defined from 1 to 30, and the current StEP is the program StEP being executing.

StEP time: the total running time of the whole program StEP. The unit is minute and the available value range from 1 to 9999.

Running time: time that the current StEP has run. As the running time reaches the StEP time, the program will jump to the next StEP automatically.

Jump: the program can jump to any other steps in the range of 1 to 30 automatically as you programmed in the program StEP, and realize cycle control. If the StEP No. Is modified, the program also will jump. Furthermore if the program StEP reaches and finished the 30th StEP, the program will jump back to the first StEP and run automatically.

Run/Hold: when program is in the running status, timer works, and setpoint value changes according to the preset curve. When Program is in the holding status, timer stops, and setpoint remains.

The holding operation can be programmed into the program StEP. When the program meets with the StEP, the StEP time of that is set to zero, or when a jumping StEP jumps to another jumping StEP, the program will get in Hold status. Hold/Run operation can also be performed manually at any time.

Stop: when the stoP operation is activated, the program will stop, the running time will be reset and timer will stop, event output switch is reset and the output control is stopped. If run operation is activated when instrument is in the stoP status, the program will start-up and run from the StEP NO. set. The stoP function can be programmed into the program StEP. The running StEP NO. Can be set at the same time. The stoP operation can also be performed manually at any time. (After stoP operation is done, the StEP NO. Will be set to 1, but user can modify it again).

Power on /power off: means power on of the instrument or unexpected power failure at running status. Altogether 4 handling modes are selectable for user.

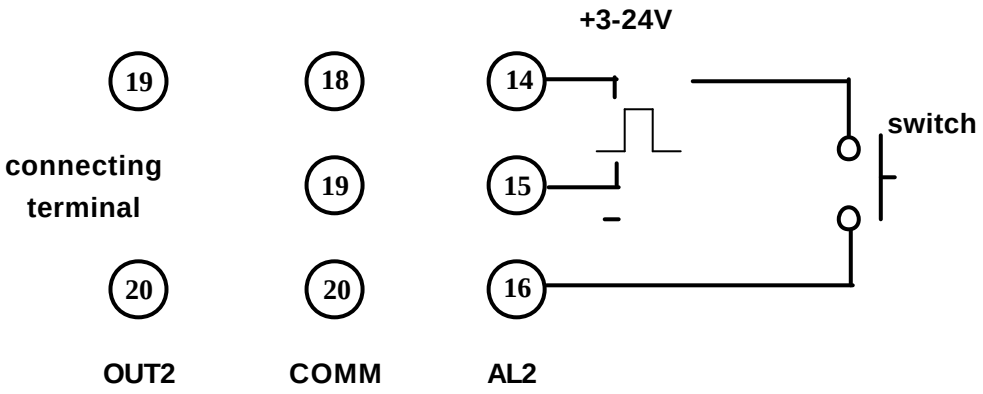
Event output: Event output can be programmed in the instrument, it can trigger two alarm contacts to make external equipment operate with interlock.

Measurement value start-up: Run/modify event, which is described in the later text, often cause the difference between the measurement value and the setpoint, the instrument will adjust the running time automatically to make them the same, if the function of measurement value start-up is allowed.

Ready: When run/modify event occurs, and if the deference between the measurement value and the setpoint is greater than the positive deviation alarm value (or less than the negative deviation), the instrument will not trigger the positive (negative) deviation alarm before the deviation is controlled to be less than the deviation alarm value. The program does not start-up either until the positive (negative) deviation is in the allowed range. (If the function of measurement value start-up is allowed, it is started up at first. If not, the ready function will be taken into action). The ready function is very useful for the StEP that the heating-up/cooling-down time cannot be predicted. Parameter dHAL and dLAL can be set large enough to close the ready function.

Curve fitting: curve fitting is adopted as a kind of control technology for AI-808P series instrument. As controlled process often has lag time in system response, by the way of curve fitting the instrument will smooth the turning point of the linear heating-up, cooling-down and constant temperature curves automatically. The degree of the smooth is relevant with the system's lag time, the longer of the lag time, the deeper of the smooth degree. On the opposite the smooth function will be weaker. Generally the shorter of the process lag time (such as temperature inertia), the better of the program control on effect. By the way of the curve fitting to deal with the program curves, will avoid overshoot. Note: The characteristic of the curve fitting will force the program control to generate fixed negative deviation during the linear heating-up and fixed positive deviation during the linear cooling-down, the deviation is direct proportional to the lag time (t) and the speed of heating-up (cooling-down). This phenomenon is normal.

External input event: The external input event will be activated by the on/off of the external mechanical switch connected to instrument. It can force the instrument to run, Hold and StoP. It can also make the program run automatically or many instruments start up at the same time under the program control. The instrument interface OUT2, COMM and AL2 can act as external event input interface, wiring diagram is as follows. If you set F=0 while setting parameter ALP, module I2 which is installed on OUT2 will act as an external event input interface. Module I which is installed on AL2 or COMM can also act as external event input interface (when C=1 in the parameter CF). A none selfhold switch is used to operate the external control interface. As regards to the interface installed on COMM or AL2, 3-24VDC impulse voltage (internal photocupler should absorb 3-5mA current) can also used for control. Press the switch and then release (about 0.3-1 second), the instrument will execute the operation of (run/Hold), press the switch and hold for at lest 4 seconds, the instrument will execute the operation of stoP.



8.3 Programming and operation

Programming of AI series instrument has uniform format of temperature-time-temperature, which means that temperature set for current StEP will change to temperature set for next StEP after the time set for the current StEP. The unit of temperature set is ℃ and the unit of time set is minute. The following example includes 6 steps, which is linear temperature heating up, constant temperature, linear temperature cooling down, jump cycling, ready, Hold and event output.

StEP1: **C01=100 , t01=30** Start linear temperature heating up from 100℃, and the time needed is 30 minutes.

StEP2: **C02=400 , t02=60** Raise temperature to 400℃, slope of raising curve is 10℃/minute, and the time for temperature to remain constant is 60 minutes.

StEP3: **C03=400 , t03=120** The StEP for temperature cooling down, slope of cooling curve is 2℃ /minute, and the time needed is 120 minutes.

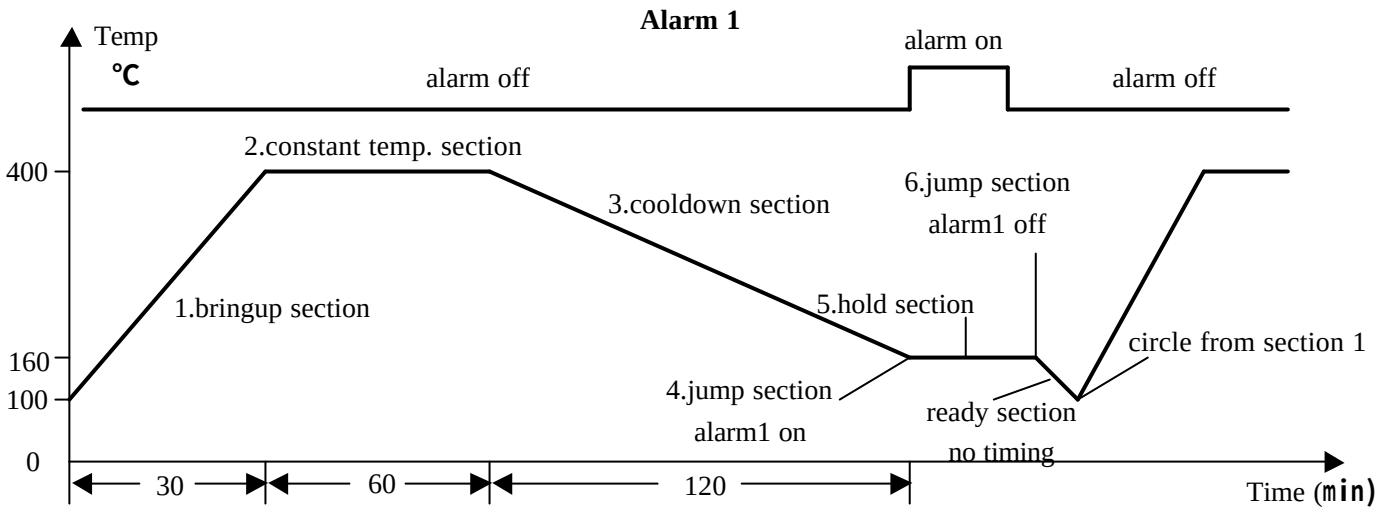
StEP4: **C04=160 , t04=-35**Temperature cool down to 160℃, then alarm 1 is triggered, and the program jump to StEP5.

StEP5: **C05=160 , t05=0** The program get in Hold state, and run operation executed by operator is needed for the program to continue running to StEP 6.

StEP6: **C06=100 , t06=-151** Alarm 1 is switch off, and jump to StEP1 to start from beginning.

In this example, it is assumed that the positive deviation alarm is set to 5℃. Because the temperature of StEP 6 is 160℃, and the temperature of StEP1 is 100℃, when program jumps from StEP 6 to StEP 1, the program will get in ready state at first, i.e., Control the temperature until the deviation between setpoint and PV is less than positive deviation alarm value. After temperature is controlled to 105℃, the program is started up from StEP 1 for temperature heating up. The temperature control block is shown below.

Note: if an alarm condition is satisfied and defined as alarm 1, then alarm 1 cannot be switched off at StEP 6 because alarm 1 is triggered by the alarm occurred.



8.3.1 Time setup

txx = 1—9999 (min)setting time of No. xx StEP

txx = 0 the instrument hold on No. xx StEP, program is held then

txx = -1—-240 minus value represent an operation command such as: run, Hold, stoP, jump and even output, the signification is as follows:

txx = - (Ax30+B)

B It is Value (range from 1 to 30) of the StEP that the program jump onto

A Dominant two even output, control the work of AL1, AL2 and automatic stop, as follows:

A=0 no effect (for jump function only)

A=1 switch on AL1

A=2 switch on AL2

A=3 switch on AL1 and AL2

A=4 Stop the instrument (B must be set to B=1)

A=5 switch off AL1

A=6 switch off AL2

A=7 switch off AL1 and AL2

txx = -241 A pulse of 0.5 second occurs on AL1, and then, the instrument goes on its program. The pulse will be cancelled if AL1 has been switch on (whatever by the event output or by the alarm signal)

Example:

- StEP4 is defined as: jump to StEP5 and then switch on AL1.

  Time setup is: **t 04 = -(1x30+5) = -35**

- StEP6 is defined as: jump to StEP1 and then switch off AL1.

  Time setup is: **t 06 = -(5x30+1) = -151**

- Program stop at StEP8

  Time setup is: **t 08 = -(4x30+1) = -121**

Note: The program will be held if it jump from a control section to another control section (an Hold action will be inserted between two control sections), external run/Hold operation is needed to release the Hold status. It is not allowed that the jump section jump to itself (for example: t 06= -6), otherwise, the Hold status can not be released.

8.3.2 Setpoint setup

Setting range of setpoint is from -1999 to +9999, indicating the required temperature (℃) or linear defined unit.

8.3.3 Program arrangement of multicurve operation

AI-808P has the advanced function of flexible program arrangement. According to the instrument character that the program will start out from StEP1 on stoP status, users can choose different running curve by setting t01,

For example: There are three curves with the length of 8 steps represent three groups of process parameter, they are separately arranged on StEP2-StEP9, StEP10-StEP17, StEP18-StEP25. Settings are as follows:

t01=-2 Execute the program of curve 1 (StEP2-StEP9)

t01=-10 Execute the program of curve 2 (StEP10-StEP17)

t01=-18 Execute the program of curve 3 (StEP18-StEP25)

Note: If t01 setup is omitted, you can also choose the curves by setting the value of StEP before the program startup. For example, if curve 2 is needed in the current process, StEP must be set to 10 at the very start of program running.

9. Optional software

(Dual output of heating/refrigeration)

The function of heating/refrigeration dual output is based on enhanced PID algorithm but not AI artificial intelligence control algorithm. The instrument will execute this function when oPL<0 (commonly equals -100). The specification of main output (OUT) is defined by parameter oP1 and it can be defined as linear current output and time proportional output, while auxiliary output (OUT2) can only defined as time proportional output. OUT2 output upper limit is governed by parameter oPL, for example: oPL=-50, it means auxiliary output upper limit is 50%.

In case of reverse action control mode, OUT control heating while OUT2 control refrigeration, and in case of direct action control mode, OUT2 control heating while OUT control refrigeration. AI artificial intelligence Parameter M5, P, t do not work under this control mode, they are replaced by the parameters shown as follows:

Code	Significant	Description	Setting range
P	Proportional band	Proportional band parameter for PID adjuster. If the unit of original proportional band is %, it can be multiplied by its measuring range and convert to the value needed.	0-9999℃ or 1 defined unit
I	Integrating time	Integral parameter for PID adjuster No integral action if I=0	0-9999 sec
d	Derivative time	Derivative parameter for PID adjuster No derivative action if I=0	0.0-999.9 sec
Cr	Relative scale ratio	In the control mode of heating/refrigeration dual output, Cr is used to define the proportional band of OUT2 (=PxCr). Cr=1.0, indicates that the proportional band of heating and that of refrigeration are the same.	0.1-10.0
CCtI	Auxiliary output period	In the control mode of heating/refrigeration dual output, this parameter indicates the output period of OUT2. If CctI=0, the output period of OUT2 is 0.5 second.	0-125 sec