AI-716/716P High Precision Intelligent Industrial Controller

Operation Instruction

（ver.9.1）

CONTENTS

1.SUMMARY

1.1 Main Features

- Input as thermocouple, thermal resistance, voltage and current can be freely selected, while expanded input and user-defined nonlinear calibration form are permitted.
- High precision and low temperature drift. In addition to automatic compensation, the cold end of the thermocouple can support high-precision compensation modes such as Cu50 copper resistance or freezing point
- Advanced AI intelligent PID algorithm eliminates over-adjustment and provides auto tuning (AT) function and brand new fine control mode.
- Advanced modular construction and directly three-phase and three-wire phase-shift trigger are adopted, which can widely meet the demands of various electrical heating applications, with quick delivery and convenient maintenance.
- Integrating the design of energy saving and environmental protection, high quality components are used to lower power consumption and lower temperature offset and to effectively save energy for customers.
- With sampling frequency of 12.5 times per second and the minimum control cycle of 0.24s, control accuracy on fast changing subject can be maintained
- Personalized operation method which is easy to learn and use
- User-defined operation authorization and interface

- Universal 100-240VAC input range for switching power supply or 24VDC power supply. Different panels and dimensions are available
- Emissions of and immunity to electromagnetic interference meets the electromagnetic compatibility (EMC) under severe industrial conditions.

POINTS FOR ATTENTION

- This Operating Instruction introduces AI-716/716P intelligent PID temperature controller of V9.1, in which part of functions may not suit other instruments. The model and software version of the instrument will be shown on the display when powered on. Users shall pay attention to the difference among various models and instrument versions. Please read the Operating Instruction carefully, correctly use and fully play the function of the instrument.
- Before the use of AI instrument, please specify appropriate input and output. The instrument should only be put into use with proper parameters.

1.2 Ordering Code Definition

Advanced modularized hardware design is utilized for AI series instruments. There are maximum 5 module slots: multi-function input/output (MIO), main output (OUTP), alarm (ALM), auxiliary output (AUX) and communication (COMM). The modules can be purchased together or individual, and can be assembled freely. The input type can be set to thermocouple, RTD, or linear current/voltage. The ordering code of AI-716/AI-716P series instrument is made up of 9 parts. For example:

AI－716	A	N	X3	L3	N	S4	－	24VDC	－	(F2)
①	②	③	④	⑤	⑥	⑦		⑧		⑨

It shows that the model of this instrument is AI-716, front panel dimension is A size(96×96mm), no module is installed in MIO slot, X3 linear current output module is installed in OUTP (main output), ALM (alarm) is L5 (dual relay contact output module), no module is installed in AUX (auxiliary output), S4 (RS485 communication interface module) is installed at COMM , and the power supply of the instrument is 24VDC, an extended input type (F2 radiation type pyrometer) is available.

The following is the meanings of the 9 parts:

① **Shows the model of the instrument**

AI-716（high precision AI intelligent regulator with measurement accuracy 0.1%F.S, without heating and cooling dual output as well as valve position control function）

AI-716P（Base on AI-716, added 30 segments programmable functions.）

② Shows the front panel dimension

	Panel Code	Dimension Width x Height (mm)	Depth behind mount (mm)	Opening Dimension Width x Height (mm)	Light Bar
Standar Depth	A	96×96	100	$92^{+0.5}$×$92^{+0.5}$	---
	A2				25 segments in 4 levels of luminosity at 1% resolution
	B	160×80	100	$152^{+0.5}$×$76^{+0.5}$	---
	B2				25 segments in 4 levels of luminosity at 1% resolution
	C	80×160	100	$76^{+0.5}$×$152^{+0.5}$	---
	C3				50 segments in 2 levels of luminosity at 1% resolution
	E	48×96	100	$45^{+0.5}$×$92^{+0.5}$	---
	E2				25 segments in 4 levels of luminosity at 1% resolution
	F	96×48	100	$92^{+0.5}$×$45^{+0.5}$	---
	D	72×72	95	$68^{+0.5}$×$68^{+0.5}$	---
	D2	48×48	95	$45^{+0.5}$×$45^{+0.5}$	---
	D6	48×48	95	$46^{+0.5}$×$46^{+0.5}$	---
Short Depth	A1	96×96	70	$92^{+0.5}$×$92^{+0.5}$	---
	A21				25 segments in 4 levels of luminosity at 1% resolution
	B1	160×80	70	$152^{+0.5}$×$76^{+0.5}$	---
	B21				25 segments in 4 levels of luminosity at 1% resolution

	C1	80×160	70	$76^{+0.5}$×$152^{+0.5}$	---
	C31				50 segments in 2 levels of luminosity at 1% resolution
	E1	48×96	70	$45^{+0.5}$×$92^{+0.5}$	---
	E21				25 segments in 4 levels of luminosity at 1% resolution
	F1	96×48	70	$92^{+0.5}$×$45^{+0.5}$	---
Dail Mount	D7	22.5×100	112	DIN rail mount. Specially designed compact dual LED display with operation buttons. Power and communication wiring method are grouped in hot-plugged terminals.	
	E5	48×96	100	DIN rail mount. Optional external E8 keypad is required to be plugged for parameter setting and operation.	
	E51	48×96	70	DIN rail mount. Optional external E8 keypad is required to be plugged for parameter setting and operation.	

③ **Module available in multiple functions I/O (MIO):** I4, K3, V and etc. N denotes that there is no module installed. Same as below.

④ **Module available in main output (OUTP):**L1、L2、L4、W1、W2、G、K1、K3、X3、X5 and etc.

⑤ **Module available in alarm (ALM):** L0、L2、L3、L4、W1、W2、G and etc.

⑥ **Module available for auxiliary output (AUX):**L1、L2、L3、L4、W1、W2、G and etc.

⑦ **Module available for communication (COMM):** S、S4、V24 and etc.

⑧ **Power supply of the instrument:** If it is left blank, the power of the instrument is 100~240VAC. "24VDC" means the power supply of 20~32V DC power (required to be specified upon ordering).

⑨ **Extended graduation specification:** (If there is none, leave it blank). AI-716/716P series instruments input is already universal supporting common thermocouples, RTDs, linear voltage, current and resistance inputs

(Please refer to the latter part of technical specification). If it is required, an additional specification can be extended.

Note 1: The instrument applies the technology of automatic zero and digital calibration, and is free of maintenance. If the error exceeds certain range, generally, cleaning and drying the inside of the instrument can fix it. If not, send the instrument back to the factory to examine and repair.

Note 2: Customer will be provided 5 years warranty with free maintenance to the instrument. If the instrument must be returned to the factory for maintenance, the failure phenomena and reasons must be clarified, so as to ensure correct and complete recovery.

1.3 Modules

1.3.1 Slots of modules

There are 5 module slots in AI-716/716P series instruments. Different modules installed will provide different functions and output types.

- **Multiple function Input / Output (MIO):**

By installing I4 module with 24VDC loop power, the instrument reads input signal from 2-wire transmitter or 4-20mA signal. Installing K3 module will provide three-phase thyristor zero-crossing triggering output.

- **Main output (OUTP):**

As control output such as on-off control, standard PID control, and AI PID control. It can also be used as retransmission output of process value (PV) or set point (SV). Installing L1 or L4 modular will provide relay contact output. Installing X3 or X5 module will provide 0-20mA/4-20mA/0-10mA linear current output. Installing G module will provide SSR voltage output. Installing W1 or W2 module will provide TRIAC no contact switch output. Installing K50 module will realize SCR phase shift trigger output.

- **Alarm (ALM):**

Installing L0 or L2 will provide 1 normally open + normally close relay output (AL1). Installing L3 module will provide 2 normally open relay outputs (AL1+AL2).

- **Auxiliary output (AUX):**

Installing L0, L2 or L3 relay module can work as alarm. Installing R module (RS232C interface) will provide communication feature with computer.

● **Communication Interface (COMM):**

Installing module S or S4 (RS485 communication interface) provides communication feature with computer. Installing voltage output module will provide power supply for external sensor or transmitter.

1.3.2 Commonly used modules

N (Or left blank) No module installed

L0 Large capacity and large size relay. Normally open(NO) + normally close(NC) relay output module. (Capacity:250VAC/2A)

L1 Large capacity and large size relay. NO relay output module. (Capacity: 250VAC/2A)。

L2 Small capacity and small size relay. NO+NC relay output module. (Capacity: 250VAC/1A, suitable for alarm)

L3 Dual channel, large capacity and large size relay. NO relay output module. (capacity: 250VAC/2A, suitable for alarm)

L4 Large capacity but small size relay. NO+NC relay output module. (capacity: 250VAC/2A)

W1/W2 TRIAC no contact NO (W2 is NC) discrete output module (Capacity: 100~240VAC/0.2A, burn-proof)

G Solid-state relay (SSR) voltage output module (12VDC/30mA)

G5 Dual SSR voltage output module

K1/K3 Single channel/3-channel thyristor zero-crossing trigger output module (Each channel triggers one loop of a TRIAC or a pair of inverse parallel SCR with current of 5~500A)

K50/K60 Single channel 220VAC/380VAC thyristor phase-shift trigger output module

X3 Photoelectric programmable linear current output module

X5 Photoelectric programmable linear current output module with own photoelectric isolated power supply

S Photoelectric RS485 communication interface module

S1 Photoelectric RS485 communication interface module. (Uses internal 24V isolated power)

S4 Photoelectric RS485 communication interface module with own photoelectric isolated power supply

R Photoelectric RS232C communication/ printing interface module (please specify if printing function is

required)

V24/V12/V10/V5 Isolated 24V/12V/10V/ 5V DC voltage output with maximum current of 50mA for power supply of external transmitter or circuit

U5 5V DC voltage output (using the internal 5V power supply of the instrument)

I2 Switch / frequency signal input interface for external switch or frequency signal, with 12VDC power supply for external sensor

I3 One channel 0-5v/1-5v voltage output interface (including 24V power output, and 24V internal power supply of the instrument is used to isolate the power supply)

I4 4-20mA/0-20mA analogue input interface with 24VDC/25mA power supply for 2-wire transmitter

I7 One channel 0-5A AC input module, installed at the Mio position, which can directly measure 5A AC current, with an additional error of 0.3%

I8 One channel 0-500VAC voltage input module, installed at the Mio position, which can directly measure 0-500vac AC voltage with an additional error of 0.3%

I1000/I500/I200/I100/I50/I20 0~1000VDC/0~500VDC/0~200VDC/0~100VDC/0~50VDC/0~20VDC input modules

1.3.3 Installation and replacement of modules

Before the instrument delivery, module installation is done on request, with corresponding parameter set correctly. Users can replace or install modules by themselves when needed. When replacing a module, you should pull the controller out of the housing at first, insert a small flat-tip screwdriver into the opening between the original module and the slot on motherboard to remove the old module, and then install a new module. Changing module type needs to modify the corresponding parameters.

1.3.4 Electric isolation of the modules

There are a group of 24V and a group 12V power supply built in the instrument and isolated to the main circuit. The 24V power commonly supplies voltage output module, such as V24/V12/V10/V5, I2 and I4. The 12V power is commonly supplies output or communication module. Generally, the relay contact output and TRIAC no contact discrete output are self insulated from the other circuit, no matter whether other modules are installed or not. SSR output voltage does not need to be insulated from input circuit, because SSR itself has isolation function. Therefore, only the electric isolation between the communication interface and the current output should be considered. Those modules, for example, S (RS485 communication interface), R (RS232 communication interface) and X3 (linear current output), all need the 12V power supply. If more than one of the above modules are installed, in order to be electric isolated, only one of them can be module without electric isolation, the other modules should be S4 or X5, which has its own isolated power supply. For example, if an X3 module is installed in OUTP (main output) slot, for isolate purpose, COMM slot should be install S4 or X5.

1.3.5 Further descriptions about module applications

● **Voltage output module:** The voltage output modules like V24, V12, V10 or V5 are often used for supplying power for external transducer or feedback resistance of transmitter. These modules can be installed in any slot. To standardize the wiring, it is recommended to be installed in the first idle slot in the order of MIO, AUX, and COMM.

● **No contact switch module:** W1 and W2 are new types of no contact switch module which apply the advanced technology of “burn proof” and zero crossing conduction. It can replace the relay contact switch. Compared to the relay contact output module, W1 and W2 have longer life and lower interference. They can be largely lower the interference spark of the equipment, and greatly improve the stability and reliability of the system. Protection elements are series wound to the output terminals, so it can control continuous current up to 0.2A with maximum allowed instantaneous current 2A. Since the driver element is TRIAC, it is suitable for controlling 100-240VAC (not for DC power) with contactor which current below 80A. For the current larger than 80A, an intermediate relay is needed.

● **Relay switch module:** The relay modules are widely used in industrial control. However, they are the only modules with life time limit and volume limit and have much electromagnetic interference. It is important to choose a suitable relay module. To control equipments with 100~220VAC supply, such as contactor and electromagnetic valve, W1 module is recommended. To control DC or AC above 50VAC, users can only use relay module, such as module L0、L1、L4 and etc. L2 module is small, and both its normal open and normal close terminals have the function of spark absorption, but the capacity is small. It is suitable for alarm output. L1 and L5 have bigger volume and capacity. In the 48mm dimension instrument (for example, D4, E, F and E5), only one of L1or L5 can be installed. L5 has dual output, can be used to support two loops of alarm, for example, AL1+AL2. If you don’t like mechanical switch, you can choose G5 (dual SSR voltage driver) and connect with external SSR instead.

1.4 Technical specifications

- **Input specifications (universal input):**
  Thermocouple: K, S, R, E, J, T, B, N, WRe3-WRe25, WRe5- WRe26, etc.
  Thermal resistance: Cu50, Pt100
  Linear voltage: 0~5V, 1~5V, 0~1V, 0~100mV, 0~20mV, -5~+5V, -100mV~+100mV, -20mV~+20mV, etc.
  Linear current (it is required to be connected to shunt resistors): 0~10mA, 0~20mA, 4~20mA, etc.
  Expanded specifications: Users can add an extra input specification on the basis of the above specifications.
- **Measuring range:**
  K (-50~+1300℃), S (-50~+1700℃), R (-50~+1700℃), T (-200~+350℃), E (0~800℃), J (0~1000℃)
  B (200~1800℃), N (0~1300℃), WRe3-WRe25 (0~2300℃), WRe5-WRe26 (0~2300℃)
  Cu50 (-50~+150℃), Pt100 (-200~+800℃), Pt100 (-100.00~+300.00℃)
  Linear input: -9990~+30000 user-defined
- **Measuring accuracy:** 0.2 (note: thermocouple should be connected to Cu50 copper resistor for compensation, while ±1℃compensation error will be extra added during internal compensation.)
- **Measuring temperature drift:** ≤ 35PPm/℃ (note: thermocouple should be connected to Cu50 copper resistor for compensation, while temperature drift error will be extra added during internal compensation.)
- **Sampling period:** 12.5 times per second; when setting digital filtering parameter FILt=0, the response time displayed is ≤ 0.5s.

- **Control cycle:** 0.24-300.0s adjustable

  Control modes:

  Position control mode (control hysteresis adjustable)

  AI intelligent control, including APID and nPID regulating as well as parameter self-tuning functions' advanced control algorithm
- **Output specification (modularization):**

  Relay output (NO+NC): 250VAC/1A and 30VDC/1A

  TRIAC no contact discrete output (NO or NC): 100~240VAC/0.2A (continuous), 2A (20mS instantaneous, repeat period≥5s)

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

  Thyristor zero crossing trigger output: Can trigger TRIAC of 5~500A, a pair of inverse paralleled SCRs or SCR power module.

  Linear current output: 0~20mA, 4~20mA can scaling by user. (Output voltage : X3≥10.5V; X5≥7V)
- **Electromagnetic compatibility:** IEC61000-4-4 (electrical fast transient) ±4KV/5KHz, IEC61000-4-5 (surge) 4KV and under10V/m high-frequency electromagnetic interference, no system error or I/O malfunction will occur. The fluctuation of the measured values will not exceed ±5% of the range.
- **Isolation withstand voltage:** among the power terminals, the relay contact and the signal terminals: ≥2300V; among isolated weak electrical signal terminals: ≥600V
- **Power supply:** 100~240VAC, -15%, +10% / 50~60Hz; 120-240VDC; or 24VDC/AC, -15%, +10%
- **Power consumption:** ≤0.5W (without any output or alarm actions); the maximum power consumption ≤4W

- **Operating environment:** Temperature: -10~60℃; Humidity: ≤90%RH
- **Panel size:** 96×96mm, 160×80mm, 80×160mm, 48×96mm, 96×48mm,72×72mm
- **Insertion depth:** ≤100mm

1.5 Energy-saving and environment-friendly design

AI-716/716P adopts energy-saving and environment-friendly design, which is reflected in extremely low temperature drift and its own extremely low power consumption. High-quality key components, which pass pair test, with low temperature drift is used. The typical temperature drift on the instrument is less than 25PPm/℃. Extra costs on those components are worthwhile to meet the energy-saving target. We try hard to lower the instrument power consumption, by choosing bright-lit LED displays at the same driving current of usual LED. Despite the cost is almost doubled, reduced power consumption, reliability and performance are lastly improved.

Compared with conventional temperature controller, the instrument with low temperature drift has less change in the measured temperature under the influence of ambient temperature, which can provide more stable product quality and less energy consumption. Thanks to low temperature drift, high precision instruments are more energy-saving compared with low precision ones. For instance, provided the sintering temperature range of a ceramic material is 1,000-1,010℃, because the temperature drift of an conventional instrument in the market is about ±5℃ (caused by ambient temperature difference in winter, summer, morning and evening), normal production can only be maintained under different ambient temperatures when the instrument is set at 1,005℃ (range of temperature: 1,000-1,010℃), but the temperature drift of AI-716/716P instrument can be reduced to be within ±1℃, for which stable production can be realized when the temperature is set at 1,001℃ (range of temperature: 1,000-1,002℃), as a result, the average temperature of the furnace can be reduced by 4℃. The lower the average temperature of the industrial furnace has, the less the power

consumption will be. 0.4%~0.6% of energy will be saved only relying on reduced temperature shift instrument. And the product quality will become more stable, color aberration will become lower, energy consumption will be further reduced and great contribution will be made to environmental protection. The same result can be obtained from a 0.05- level precision instruments. To realize energy saving and improve product quality, Yudian will adopt components with higher precision and lower temperature drift with prices unchanged, so as to improve the measuring accuracy of AI-716/716P to level 0.1, while the measurement accuracy of basic products can also reach level 0.2.

1.6 Wiring Diagram

Note: due to technical upgrading or special ordering, please follow the attached wiring diagram. If the attached wiring diagram of the instrument is inconsistent with this manual.

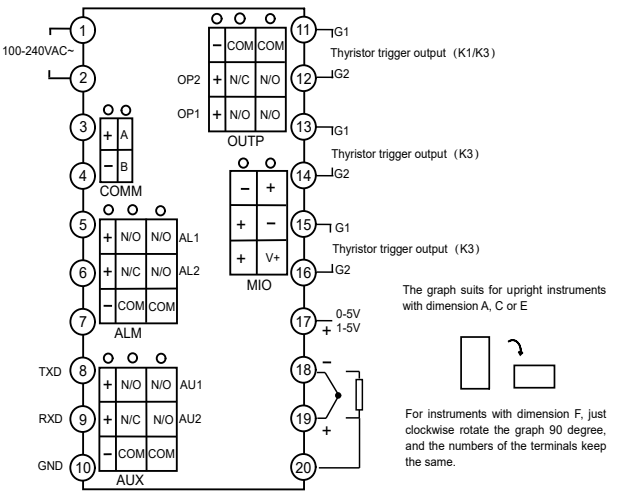
Wiring diagram of rear terminals of standard depth
Note:

①For linear voltage input, if the range is below 100mV, connect to terminals 19+ and 18-. 0~1V signal and above can be inputted from terminals 17+ and 18-.

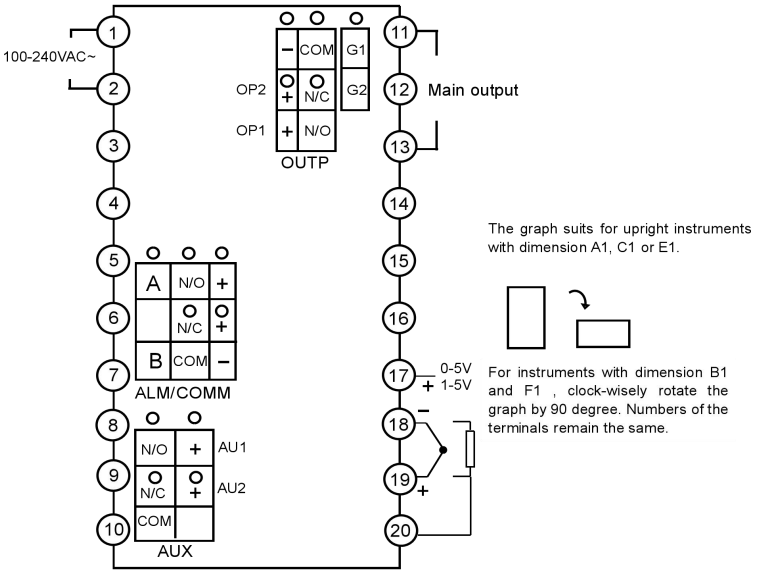
②4~20mA linear current signal can change to 1~5V voltage signal by connecting a 250 ohm resistor, and then be inputted from terminals 17+ and 18-. If I4 module is installed in MIO slot, 4~20mA signal can be inputted from terminals 14+ and 15-, and 2-wire transmitter can be inputted from terminals 16+ and14-.

③The compensation wires for different kinds of thermocouple are different, and should be directly connect to the terminals. When the internal auto compensation mode is used, connecting the common wire between the compensation wire and the terminals will cause measurement error.

④ When main output is selected linear current or SSR voltage, the output will be given from terminal 13+, 11-.



Wiring diagram of rear terminals of short depth:

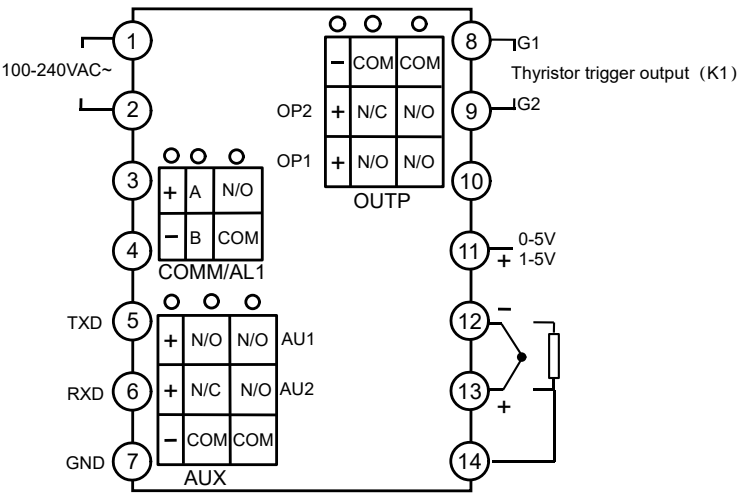


Wiring diagram of dimension D (72×72mm):

Note 1: Linear voltage signal of range below 100mV should be inputted from terminals 13+ and 12-, and signal of 0~1V should be inputted from terminals 11+ and 12-.

Note 2: 4~20mA linear current signal can be converted to 1~5V voltage signal by connecting a 250 ohm resistor and inputted from terminals 11 and 12.

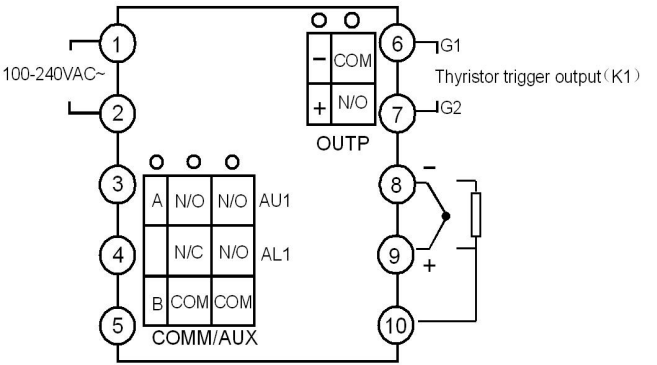
Note 3: S or S4 module can be installed in COMM slot for communication. If relay, TRIAC no contact switch, or SSR drive voltage output module is installed in COMM, it can be used as alarm output.



Wiring diagram of dimension D2 (48x48mm)：

Note 1: Dimension D2 instruments do not support 0~5V nor 1~5V linear voltage input. Instead, 0~5V or 1~5V signal can be converted to 0~100mV or 20~100mV respectively by voltage divider while 4~20mA can be converted to 20~100mV by connecting a 5ohm resistor in parallel, then be inputted from terminals 9+ and 8-.

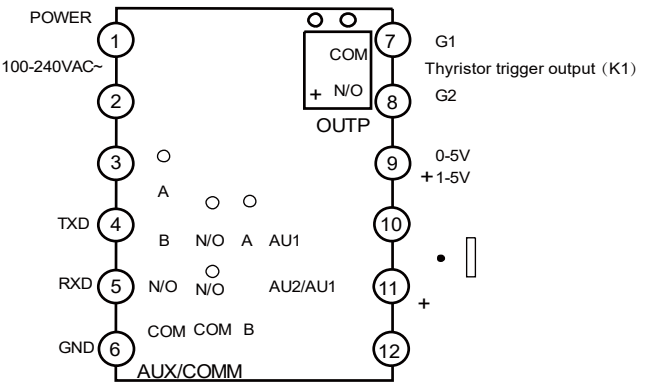
Note 2: In COMM/AUX slot of Dimension D2, S or S4 communication module provides RS485 communication. If L2 module is installed in, it acts as alarm at AU1. If L3 dual relay module is installed with parameter bAud = 0, it acts as AU1 and AU2 alarm output. If parameter bAud = 2, it acts as alarms at AU1 and AL1.



Wiring diagram of dimension D6 (48×48mm)：

Note 1: 0~1V linear voltage should be inputted from terminals 9+ and 10- . However below 100mV should be inputted from terminals 11+ and 10- .4~20mA can be converted to 1~5V by connecting a 250 ohm resistor, then be inputted from terminals 9+ and 10-

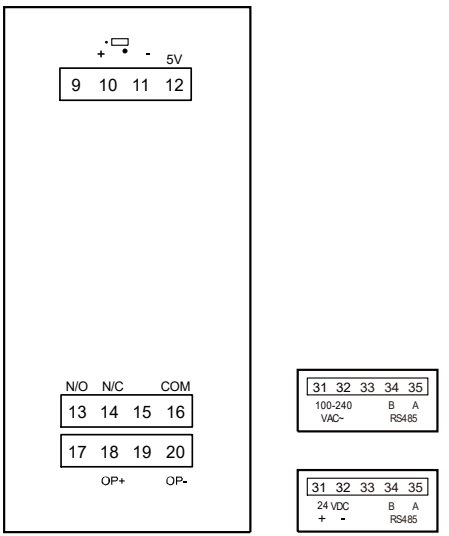
Note 2: For COMM/AUX slot, if L3 module is installed, it has two alarms; if SL module is installed,it has one alarm.

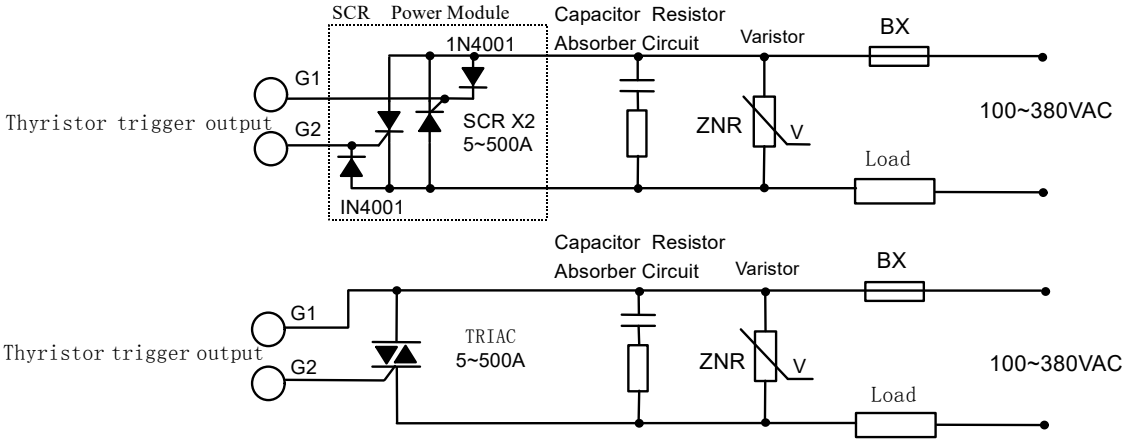


Wiring diagram of dimension D7(22.5 x 100mm)：

Note 1: 0~1V or above linear voltage should be inputted from terminals 12+ and 11-. However below 100mV should be inputted from terminals 11- and 10+ .4~20mA can be converted to 1~5V by connecting a 250 ohm resistor, then be inputted from terminals 12+ and 11-

Note 2: if fixed one alarm with the communication function,the main output can be selected among G, X3, L2, K1, K50, K60 or W1. Alarm could be defined as AU1.





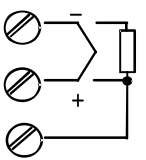
Note 1: According to the voltage and current of load, choose a suitable varistor to protect the thyristor. A resistor-capacitor circuit (RC circuit) is needed for inductance load or phase-shift trigger output.
Note 2: SCR power module is recommended. A power module includes two SCRs, is similar to the above dashed square.
Note 3: K60 TRAIC trigger module the power is 380VAC; K50 TRAIC trigger module only support 200~240VAC and 50Hz power.
Note 4: when the three-phase three wire electric furnace is used and the use time ratio is zero crossing trigger

control, only two-way bidirectional thyristors are required for reliable control, which can not only reduce the cost, but also save about 0.2% of the power (about 0.6% of the power controlled by the three-phase three-way thyristor electric furnace is consumed on the thyristor). When the three-way thyristor is used for full control without connecting to the zero line, the instantaneous trigger cannot cross the zero completely, which brings impact to the power grid and the trigger module. If the electric furnace wire cannot be charged when the thyristor stops triggering, it is recommended to add a leakage switch. If three-way thyristor full control must be used, it is recommended to add a zero line to the electric furnace.

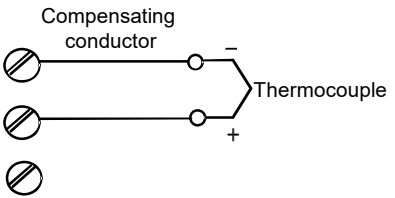
Choosing thermocouple cold junction compensation mode based on wire connection: when using thermocouple as the input, cold junction should be applied for temperature compensation based on the thermocouple temperature measuring principles. AI instrument can automatically compensate cold junction referencing the temperature around the wiring terminals. Due to measuring components' errors, instrument's inherent heating and other heat sources nearby, the deviation of automatic compensation modes is comparatively large, for which the worst may exceed 2℃. So if higher accuracy is required, an external junction box can be used. Put Cu50 copper resistor (to be purchased separately) and thermocouple cold junction together, and keep away from the heat sources, thus the measuring inconformity caused by compensation may be less than 0.3℃. Because the inherent errors of Cu50 copper resistor may cause certain errors at room temperature, it can be modified with "Scb" parameter. Change the externally connected copper resistor into precision fixed resistance, which may achieve constant temperature bath compensation. For instance, connect it to constant 60Ω resistor, check the reference table of Cu50 and find the compensation temperature of 46.6℃. At this moment, put the thermocouple cold junction into the constant temperature bath for accurate compensation at the temperature of 46.6℃., its compensation accuracy will be better than that of copper resistor. If the externally connected resistance is changed into short circuit, ice-point compensation may be archieved. At this moment, it is required to place the thermocouple cold junction (the joints of the

thermocouple or compensation wires and conventional wires)
into the ice-water mixture (0℃), its compensation accuracy may reach above 0.1℃.

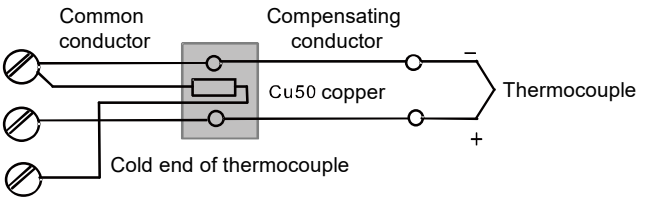
There are two compensation modes ' wiring diagrams as follows:



Instrument's corresponding wiring diagram



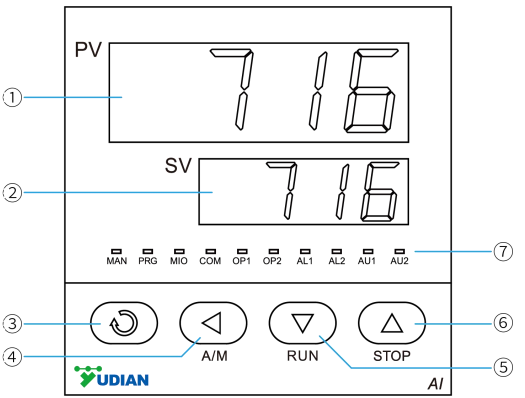
(1) Internal automatic compensation mode (Compensating wire shall be directly connected to the connection terminals)



(2) Externally connected to copper resistor automatic compensation mode (Thermocouple cold end terminal box had better keep away from heat sources)

2. Display and operation

2.1 Instruction of panel

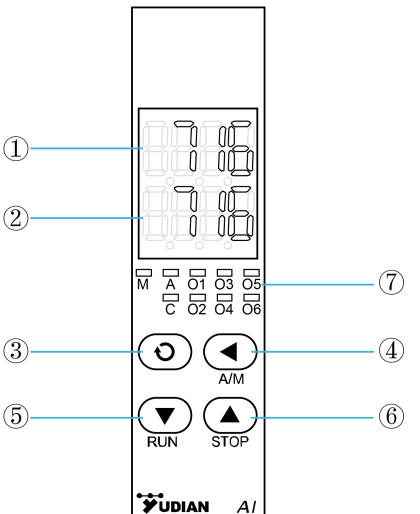


① Upper display window: Displays PV, parameter code, etc.
② Lower display window: Displays SV, parameter value, or alarm message
③ Setup key: For accessing parameter table and conforming parameter modification.
④ Data shift key, start auto tuning and auto/manual control switch.
⑤ Data decrease key, and also run switch
⑥ Data increase key, and also stop key
⑦ 10 LED indicators: the MAN light won't be used in this series, the PRG light is Running Status; the MIO, OP1, OP2, AL1, AL2, AU1 and AU2 respectively correspond to the module input/output actions; and the COM light indicates communication with the host computer in the ON state.

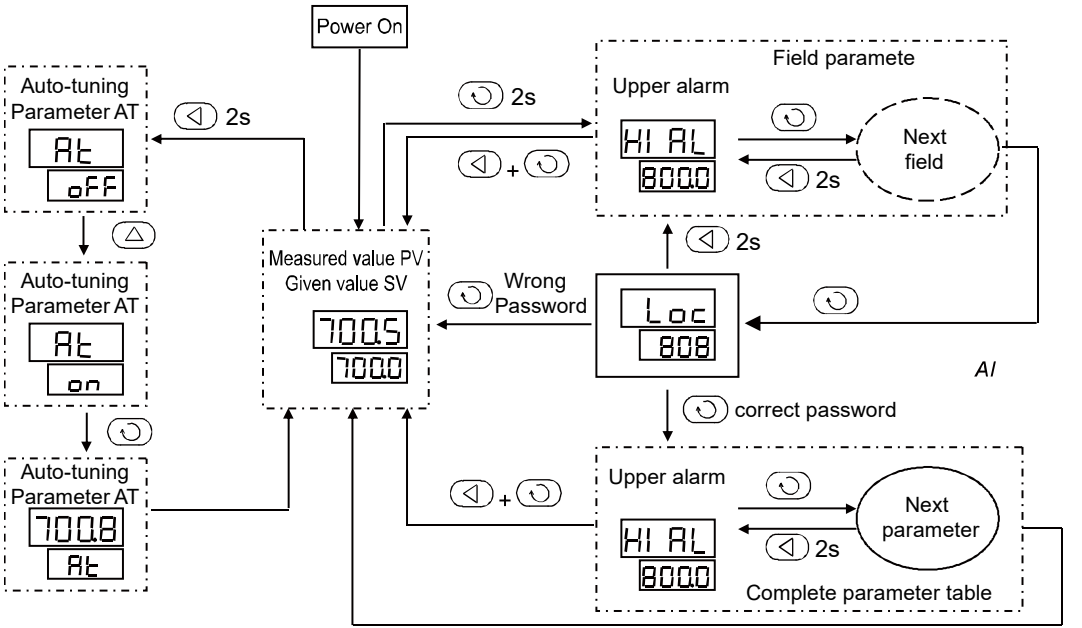
The instrument enters initial status once power on. Upper and lower display respectively show the measured value (PV) and the set value (SV). The display may also alternately show status or warnings "orAL" means that the input measured signals out of the range; "HIAL", "LoAL", "HdAL" or "LdAL" respectively represents the High Limit Alarm, Low Limit Alarm, High deviation alarm , or Low deviation alarm; "StoP" represents the instrument is in being STOP; "HoLD" and "rdy" respectively represents the instrument is in being HOLD and in READY status" (only for AI-716P)

2.2 D7 Rail Mount Panel Description

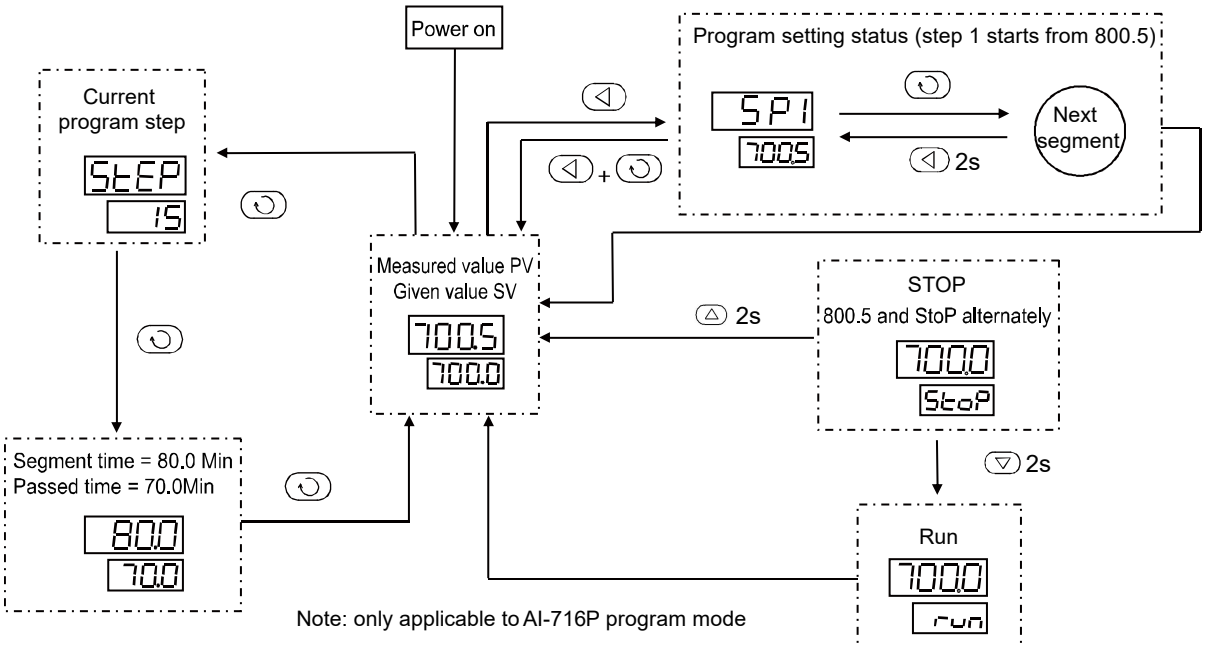
① Upper display window, displays PV, parameter code, etc.
② Lower display window, displays SV, parameter value, or alarm code.
③ Setup key, for accessing parameter table and conforming parameter modification.
④ Data decrease key (RUN/HOLD button)
⑤ Data increase key (STOP button)
⑥ Data shift key (set point cursor)
⑦ 9 LED indicators; OP1, OP2, AU1, AU2, AL1, AL2 and C corresponding to O1 to O6 are on, indicating that the instrument is communicating with the upper computer, M is on, indicating that the channel is manually switched, and M is not on, indicating that it is in the automatic cycle display status.



2.3 Parameter setting flowchart



2.4 Program setting flowchart



2.5 Operation Description

2.5.1 Parameter Setting

Press the key in the basic display state and hold it for about 2 seconds to enter the customized field parameter setting state. Directly press the 、 or and other keys to modify the parameter values. Press the key to decrease the data, press the key to increase the data, and the decimal point of the modified value will flash (like the cursor). Press the key and hold it, you can quickly increase / decrease the value, and the speed will automatically increase with the right shift of the decimal point. You can also press the key to directly move the position of the modified data (cursor), which is faster. Press the key to save the modified parameter value and display the next parameter. Press the key continuously to move down quickly; Press the key and hold it for more than 2 seconds to return to the previous parameter display; Press the key first and then press the key again to exit the parameter setting state directly; If there is no key operation, it will automatically return to the basic display state after about 25 seconds.

2.5.2 Short-cut operation

All function in AI-716/716P can be accessed through changing parameters. For common operation such as set point editing, changing the status of program RUN/STOP/HOLD, short-cut key is provided. These short-cut can be prohibited to avoid any incorrect operation.

● **Set value setting:** if the instrument uses the fixed-point control mode (when the parameter Pno=0), when the basic display state of the set value is displayed in the lower display window (the following display window displays the output value, and you can press the key ⟲ to switch to the set value display state, the same below), press the key ◁ to modify the current set value state, and then press the ◁、▽ or △ and other keys to modify the set value directly.

● **Program Setting:** the instrument uses the program control mode (when the parameter PNO ≥ 1), When the lower display window displays the set value, press the key ◁ once to enter the program setting state. First, the set value of the current running section is displayed, and then press the key ⟲ to display the next data. Each program is arranged in the order of "set value - time - set value". You can modify a program even while it is running.

● **Run the program:** Press and hold ▽ key for about 2 seconds until the lower display window displays the "run" message. AI-716P will start the program from STOP status. If parameter “PAF.F =1” and program status is RUN, this operation will HOLD the program. The timer will be paused. Perform RUN operation again will resume

the program.

● **Stop control:** when the lower display window displays the set value, press the key △ for about 2 seconds so that the lower display will display the STOP symbol, and the instrument stops control output. AI-716P stops the program, and the program segment number parameter step is modified to 1.

● **Auto Tuning:** Press ◁ for 2 seconds, “At” parameter will appear. Press △ to change the value of “At” from “oFF” to “on”, then press ↺ to activate the auto-tuning process. (If SPr parameter is set to be effective and the instrument is at the limit of increasing rate, auto-tuning will be paused temporary.) During auto tuning, the lower display blinks with “At”. After two fluctuating cycles by on-off control, the instrument will obtain the optimal PID control parameter value. If you want to quit from auto tuning, press and hold the ◁ key for about 2 seconds until the "At" parameter appear again. Change “At” from “on” to “oFF”, press ↺ to confirm, then the auto tuning process will be cancelled. If the instrument is running the program, the program timer will be paused to avoid changing SV.

Note 1: AI-716/716p adopts the advanced PID adjustment algorithm that integrates AI artificial intelligence technology, which solves the problem that the standard PID algorithm is easy to overshoot and has high control accuracy. We call this improved PID algorithm APID algorithm. When the instrument adopts APID or PID adjustment mode and is used for the first time, the self-tuning function can be started to assist in determining PID and other control parameters.

Note 2: the parameter values obtained by the system under different set values are not exactly the same. Before

performing the self-tuning function, the set value SV should be set at the most common value or the intermediate value. If the system is an electric furnace with good insulation performance, the set value should be set at the maximum value used by the system. It is forbidden to modify the SV value during the self-tuning process. Depending on different systems, the time required for self-tuning can range from seconds to hours.

Note 3: the control return error parameter CHS also has an impact on the self-tuning results. Generally, the smaller the setting value of CHS, the higher the accuracy of the self-tuning parameters. However, if the CHYS value is too small, it may cause the bit adjustment malfunction due to input fluctuation, which may set completely wrong parameters. It is recommended that CHYS=2.0.

Note 4: the control effect may not be the best at the end of self-tuning. Due to the learning function, the best effect can be obtained after a period of use.

Note 5: in the self-tuning or manual state, the control cycle (parameter CtI) of the instrument is temporarily limited to no more than 3 seconds regardless of the original setting, so as to improve the setting accuracy and the response speed of the instrument during manual operation.

3. Parameter

3.1 User-defined Parameter Table

AI-716/716P parameter table can program defined functions, which can be defined by users and protect important parameters from changed accidentally. We call those parameters required to be displayed or modified on site as “field parameters”. Field parameter table is a subset of the complete parameter table and can be defined and modified by users, while the complete table must be entered by passwords. Parameter lock (Loc) offers several authorization levels to several parameters:

Loc=0，Able to modify field parameters and allow all shortcut operations, such as change of set value (SV) and steps value(time and temperature value in program steps);

Loc=1，Able to modify field parameters and use shortcut to change set values and step values, but not allowed to use shortcuts to perform program RUN/HOLD/STOP, set value control and auto-tuning.

Loc=2，Able to modify field parameters, but not allowed to use shortcuts such as changing set value, program steps and auto-tuning, Able to perform shortcuts of program RUN/HOLD/STOP and set value control

Loc=3，Able to modify field parameters, but not allowed for all shortcuts.

Loc=4~255，Not allowed to modify any parameters except for Loc itself. All shortcuts are disabled.

Set Loc= password (the password can be any number between 256 and 9999, and the default password is 808), and press  to confirm to enter the display and modify the complete parameter table. Once entering the

complete parameter table, except for the read-only parameters, all other parameters can be modified.

Parameters EP1~EP8 allow users to define 1~8 field parameters. If the number of field parameters required is less than eight, the first parameter not used shall be defined as nonE. For instance, the parameter table we need has three parameters HIAL, HdAL and At, the EP parameter can be set as follows: EP1=HIAL, EP2=HdAL, EP3=At and EP4=nonE.

Note: Since V9.1, the Loc parameter can restrict the communication input. Please refer to the communication protocol for details.

3.2 Complete Parameter Table

The complete parameter table can be divided into 8 parts including alarm, regulating control, input, output, and communication, system function, set value/program step, and field parameter:

Code	Name	Description	Setting Range
HIAL	High limit alarm	Alarm on when PV>HIAL Alarm off when PV<HIAL-AHYS, Note: each alarm can be freely defined as controlling the action of AL1, AL2, AU1, AU2 and other output ports, or without any action. Please refer to the description of the alarm output definition parameter AOP later.	-9990~ +32000 units

LoAL	Low limit alarm	Alarm on when PV<LoAL; Alarm off when PV>LoAL+AHYS Note: HIAL and LoAL can also be set as deviation alarm if necessary (refer to the description of parameter AF)	
HdAL	Deviation high alarm	Alarm on when PV-SV>HdAL; Alarm off when PV-SV<HdAL-AHYS When the value set to Max, it will disable this function	
LdAL	Deviation low alarm	Alarm on when PV-SV<LdAL; Alarm off when PV-SV>LdAL+AHYS When the value set to Min. will disable this function Note: HdAL and LdAL can also be used as high limit and low limit alarms when needed. (Refer to the description of parameter AF)	
AHYS	Alarm hysteresis	Also known as dead band or lag. To avoid frequent alarm on-off action caused by the fluctuation of PV. Usage of AHYS is shown above.	0~2000 units
AdIS	Alarm display	oFF, No alarm message shown in the lower display even there is an alarm On, Alternately showing alarm message and value in the lower display when there is an alarm FOFF, When an alarm occurs and the input measurement signal exceeds the range, the alarm symbol and orAL symbol will not flash. Aon, the orAL symbol does not flash when the input measurement signal exceeds the range	

<table>
<tr>
<td>AOP</td>
<td>Alarm output allocation</td>
<td>
<table>
<tr><th>Alarm
Output to</th><th>LdAL
(x 1000)</th><th>HdAL
(x100)</th><th>LoAL
(x10)</th><th>HIAL
(x1)</th></tr>
<tr><td>None</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>AL1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>AL2</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>AU1</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td>AU2</td><td>4</td><td>4</td><td>4</td><td>4</td></tr>
</table>
Example as the following：
AOP = 3 3 0 1
LdAL HdAL LoAL HIAL
It shows that HdAL and LdAL are sent to AU1, LoAL has no output, HIAL is sent to AL1.
Note 1: Installing L3 dual relay output module in ALM or AUX, AL2 or AU2 can be used.
</td>
<td>0~4444</td>
</tr>
</table>

nonc	N.O. / N.C. selection	Single channel alarm relay can have normally open + normally closed output at the same time, but dual channel alarm module L3 only has normally open output. Normally open output can be defined as normally closed output through the nonc parameter. When nonc=0 is set, L3 relays installed at AL1, AL2, AU1 and AU2 are normally open. When nonc=15 is set, instrument alarms are normally closed. When some channels are normally open and some channels are normally closed, the nonc value can be calculated according to the following formula. nonc=A X 1+B X 2+C X 4+D X 8 In the formula, A, B, C and D respectively represent the normally open and normally closed selection of AL1, AL2, AU1 and AU2. When the value is 1, the corresponding alarm is normally closed output, and when the value is 0, the corresponding alarm is normally open output.	0~15
CtrL	Control mode	OnoF: on-off control, for situation not requiring high precision APID: advanced artificial intelligence PID control. (Recommended) nPID: standard PID algorithm with anti integral-saturation function PoP: direct PV retransmission, working as a temperature re-transmitter. SoP: direct SV retransmission, working as a program generator (AI-716P).	

Srun	Running Status	run: Control or program is in effect. “PRG” indicator lights up. StoP: Control or program is stopped. Lower display keeps flashing “StoP”. “PRG” indicator goes off. HoLd: Control or program is paused. If the controller is a constant temperature controller without time limit, (AI-716 or AI-716P with parameter Pno=0), this HoLd status is equal to normal status but panel shortcut to RUN or STOP operation is prohibited. in this status, for the controller works as program control (Pno>0), the output keeps going but the program timer is paused. At the same time, lower display flashes “HoLd” and PRG blinks. Panel shortcut to RUN or STOP is allowed to change this status. Remark: Using panel shortcut key is unable to activate HoLd status but only through changing Srun parameter or programmed in the program steps.	
Act	Acting method	rE: Reverse acting. Increase in measured variable causes a decrease in the output, such as heating control. dr: Direct acting. Increase in measured variable causes an increase in the output, such as refrigerating control. rEbA: Reverse acting with low limit alarm and deviation low alarm blocking at the beginning of power on. drbA: Direct acting with high limit alarm and deviation high alarm blocking at the beginning of power on.	

At	Auto tuning	oFF: Auto tuning function was off. on: Active auto turning function to calculate the values FoFF: Auto tuning function was off, cannot activate again by pressing key from panel. AAt: fast auto-tuning function, automatically returns to off after self-tuning. Note: the AT parameters are selected from that of AAT. When the instrument is in the state of full power heating output after power on, it can automatically start the advanced fast parameter auto-tuning function of AAT. PID parameters can be preset without traditional periodic oscillation auto-tuning. In most cases, accurate control can be achieved after the first heating. If the instrument exits the full power output state before the AAT automatically completes, the AAT fails, the auto-tuning is terminated, and the PID parameters will not be modified.	
P	Proportional band	Proportional band in PID and APID control. Instead of percentage of the measurement range, the unit is the same as PV. Remark: generally, optimal P, I, D and CtI can obtained by auto tuning. They can also be manually inputted if you already know the correct values.	1~32000 units
I	Time of Integral	No integral effect when I=0	1~9999s
d	Time of Derivative	No derivative effect when d=0	0~3200s

CtI	Control period	For SSR, thyristor or linear current output, it is generally 0.5 to 3 seconds. For Relay output or in a heating/refrigerating dual output control system, generally 15 to 40 seconds, because small value will cause the frequent on-off action of mechanical switch or frequent heating/refrigerating switch, and shorten its service life. CtI is recommended to be 1/5 – 1/10 of derivative time. (It should be integer times of 0.5 second.) When the parameter OPt or Aut = rELy, CtI will be limited to more than 3 seconds. Auto tuning will automatically set CtI to suitable value considering both control precision and mechanical switch longevity. When the parameter CtrL = onoF, CtI will used as timer to make delay time to avoid the power restart in short period. It suits for compressor protection.	0.2~300.0 s
CHYS	Control Hysteresis	CHYS is used for on-off control to avoid frequent on-off action of relay. For a reverse acting (heating) system, when PV > SV, output turns off; when PV<SV-CHYS, output turns on. For a direct acting (cooling) system, when PV<SV, output turns off; when PV>SV+CHYS, output turns on.	0~2000 units

<table>
<tr>
<td>InP</td>
<td>Input specification Code</td>
<td>
<table>
<tr><th>InP</th><th>Input spec.</th><th>InP</th><th>Input spec.</th></tr>
<tr><td>0</td><td>K</td><td>20</td><td>Cu50</td></tr>
<tr><td>1</td><td>S</td><td>21</td><td>Pt100</td></tr>
<tr><td>2</td><td>R</td><td>22</td><td>Pt100 (-8~+300.00℃)</td></tr>
<tr><td>3</td><td>T</td><td>25</td><td>0~75mV voltage input</td></tr>
<tr><td>4</td><td>E</td><td>26</td><td>0~80ohm resistor input</td></tr>
<tr><td>5</td><td>J</td><td>27</td><td>0~400ohm resistor input</td></tr>
<tr><td>6</td><td>B *</td><td>28</td><td>0~20mV voltage input</td></tr>
<tr><td>7</td><td>N</td><td>29</td><td>0~100mV voltage input</td></tr>
<tr><td>8</td><td>WRe3-WRe25</td><td>30</td><td>0~60mV voltage input</td></tr>
<tr><td>9</td><td>WRe3-Wre26</td><td>31</td><td>0~1V voltage input</td></tr>
<tr><td>10</td><td>Extended input specification</td><td>32</td><td>0.2~1V voltage input</td></tr>
<tr><td>12</td><td>F2 radiation type pyromter</td><td>33</td><td>1~5V voltage input</td></tr>
<tr><td>15</td><td>4~20mA(installed I4 module in MIO)</td><td>34</td><td>0~5V voltage input</td></tr>
<tr><td>16</td><td>0~20mA(installed I4 module in MIO)</td><td>35</td><td>-20~+20mV</td></tr>
<tr><td>17</td><td>K (0~300.00℃) *</td><td>36</td><td>-100~+100mV</td></tr>
<tr><td>18</td><td>J (0~300.00℃) *</td><td>37</td><td>-5~+5V</td></tr>
<tr><td>19</td><td>19 Ni120</td><td>38</td><td>20~100mV</td></tr>
</table>
● While InP=10, the non-linear table can be self-defined or input by factory under a paid service.
</td>
<td>0~39</td>
</tr>
</table>

dPt	Display Resolution	Four formats (0, 0.0, 0.00, 0.000) are selectable Note 1: For thermocouples or RTD input, only 0 or 0.0 is selectable, and the internal resolution is 0.1. When S type thermocouple is used, dPt is recommended to be 0. If Inp= 17,18 or 22, resolution will support display 0.0 or 0.00	
SCL	Signal scale low limit	Define scale low limit of input. It is also the low limit of transmitter output (CtrL=POP or SOP) and light bar display.	-9990~ +32000 units
SCH	Signal scale high limit	Define scale high limit of input. It is also the high limit of retransmission output (CtrL=POP or SOP) and light bar display.	
Scb	Input Shift Adjustment	Scb is used to shift input to compensate the error caused by transducer, input signal, or auto cold junction compensation of thermocouple. PV after compensation=PV before compensation + Scb It is generally set to 0. The incorrect setting will cause measurement inaccurate.	-9990~ +4000 units
FILt	PV input filter	The value of FILt will determine the ability of filtering noise. When a large value is set, the measurement input is stabilized but the response speed is slow. Generally, it can be set to 1 to 3. If great interference exists, then you can increase parameter “FILt” gradually to make momentary fluctuation of measured value less than 2 to 5. When the instrument is being metrological verified, “FILt” s can be set to 0 or 1 to shorten the response time.	0~40

Fru	Selection of power frequency and temperature scale	50C: Power at 50Hz and maximum anti-interference is achieved; Display in ℃ 50F: Power at 50Hz and maximum anti-interference is achieved; Display in ℉ 60C: Power at 60Hz and maximum anti-interference is achieved; Display in ℃ 60F: Power at 60Hz and maximum anti-interference is achieved, Display in ℉.	
OPt	Main output type	SSr: Output SSr drive voltage or thyristor zero crossing trigger signal. G, K1 or K3 module should be installed. The output power can be adjusted by the on-off time proportion. The period (CtI) is generally 0.5~4 seconds. rELy: for relay contact output or for execution system with mechanical contact switch. To protect the mechanical switch, the output period (CtI) is limited to 3~120 seconds, and generally is 1/5 to 1/10 of derivative time. 0-20: 0~20mA linear current output. X3 or X5 module should be installed in OUTP slot. 4-20: 4~20mA linear current output. X3 or X5 module should be installed in OUTP slot. (Not applicable for heating/refrigerating bidirectional control.) PHA: Single-phase phase-shift output. K50 module should be installed in OUTP slot.	
OPL	Output low limit	0~100%: OPL is the minimum output of OUTP in single directional control system.	0~110%

OPH	Output upper limit	OPL limits the maximum of OUTP (main output) when PV<OEF. OPH should be greater than OPL.	0~110%
OEF	Work range of OPH	When PV<OEF, the upper limit of OUTP is OPH; when PV>OEF, the upper limit of OUTP is 100%. For example, to avoid that the temperature raises too quickly, under 150℃, a heater can work only under 30% of power, then we can set OEF=150.0 (℃), OPH=30 (%)	-999.0~ +3200.0℃ Or linear units
Addr	Communication address	The Addr parameter is used to define the communication address of the instrument. The valid range is 0~100. Instruments on the same communication line shall be set with different Addr values to distinguish each other.	0~100

bAud	Comm module function selection	The bAud parameter defines the communication bAud rate. The definable range is 1200~19200bit/s (19.2k); When the COM position is not in communication, the COM port can be used as other functions by the baud parameter setting:： BAud=1, as an external switch input, located at the MIO slot. When the MIO slot is occupied, I2 module can be installed at the COMM slot. BAud=3, COMM slot retransmits 0~20mA process value; BAud=4, COMM slot retransmits 4~20mA process value; BAud=8, COMM slot retransmits 0~20mA set value; BAud=12, COMM slot retransmits 4~20mA set value	1200~ 19.2K

Et	Event input type(only for AI-716P)	When I5 module was installed, the meter have following functions, nonE : Disable event input function ruSt : Run / Stop switching function. Connected in short time, start to running program, keep connect more than 2 sec, program switch to stop. SP1.2 : Switching between setpoint 1 and setpoint 2 when use AI-716 or Pno=0 at AI-716P. MIO in open status, SV=SP1, when MIO in close status, SV=SP2 EAct: the external switch switches the heating / cooling control function, and this parameter will automatically modify the value of Act according to the on / off of Mio. Erun: external switching value switching operation / stop. The instrument stops when the switch is off, and operates when the switch is on.	
AF	Advanced function	AF is used to select advanced function. The value of AF is calculated as below: AF=Ax1 + Bx2 + Cx4 + Dx8 + Ex16 + Fx32 + Gx64 + Hx128 A=0, HdAL and LdAL work as deviation high and low limit alarms; A=1, HdAL and LdAL work as high and low limit alarms, and the instrument can have two groups of high and low limit alarms. B=0, Alarm and control hysteresis work as unilateral hysteresis; B=1, As bilateral hysteresis. C=0, The light bar indicates the output value; C=1, The light bar indicates the process value (for instruments with light bar	0~255

		only). D=0, Loc=808 can access the whole parameter table; D=1, Loc=PASd can access the parameter table. E=0, Normal application on HIAL and LoAL; E=1, HIAL AND LoAL will become to deviation high alarm and Deviation low alarm F=0, Fine control mode, internal control resolution was demonstration's 10 times. When on linear input mode, biggest display value is 3200 units F=1, Wide range display mode, when the value is bigger than 3200 ,chooses this option G=0, When the thermocouple or RTD input is burnt out, PV value will increase and trigger the high limit alarm. G=1, When the thermocouple or RTD input is burnt out, PV value will increase and NOT trigger the high limit alarm. After it was sets, High Limit alarm will have 30 sec. delay for trigger in normal usage. H=0, AIBUS communication protocol ,H=1, MODBUS communication protocol Note: AF=0 is recommended.	

AFC	Communcation mode	AFC is used to select communication mode, its calculation method is as follow: AFC=Ax1+Dx8 A=0, standard MODBUS; A=1, AIBUS; A=2, MODBUS compatible mode; A=4, compatible with S6 module. D=0, no calibration; D=1, even calibration. Note: AFC supports 03H (read parameters and data) and 06H (write a single parameter) under MODBUS. When AFC=0 or 4, the 03H can read up to 20 words at a time; When AFC=2, 03H reads 4 words. For more details, Please refer to the communication protocol description.	0~2
PASd	Password	When PASd=0~255 or AF.D=0, set Loc=808 can enter the full parameter table. When PASd=256~9999 and AF.D=1, only Loc=PASd can access the full parameter table. Please setting PASd cautiously, if the password is lost you cannot access the parameter table again.	0-9999
SPL	Low limit of SV	Minimum value that SP is allowed to be.	-9990~ +30000 units
SPH	Upper limit of SV	Maximum value that SP is allowed to be.	

SPr	Ramp Slope limit (only for AI-716P)	Provided that SPr is set, the program start with the first step of ramp slope limited by SPr value until the temperature reach the first SV, if PV<SV. PRG indicator blinks. For Ramp mode. SPr had effect on first step only. For Soak mode, SPr had effect on each step.	0~3200 ℃/Min
Pno	No. of Program step(only for AI-716P)	It is used to define the effective number of program segments. The value is 0~30, which can reduce the number of unnecessary program segments and make the operation and program setting convenient for the end customer. When Pno=0 is set, AI-716p is in constant temperature mode and can be fully compatible with the operation of AI-716; SPr parameters can also be set to limit the heating rate; When Pno=1~30 is set, AI-716p operates in the normal program control instrument operation mode.	0~30
PonP	Program run mode after power restart	Cont : Continue to run the program from the original break point. If STOP status is activated before power cut, then the program will keep at STOP status after power restarts. StoP : Stop the program after power restart run1 : Start to run the program from step 1 unless the instrument was in “STOP” status before power cut. dASt (AI-716P only) : Continue to run the program from the original break point. If there are any deviation alarm, it will stop the program HoLd (AI-716P only): No matter any circumstances, the instrument enters HoLd status after power resumes. If it is in StoP status before power cut, it will keep in StoP status after power resumes.	

PAF	Program Running mode(only for AI-716P)	PAF = Ax1 + Bx2 + Cx4 + Dx8 + Ex16 + Fx32+ Hx128 When A=0: Enable PV Preparation/Ready (rdy) function A=1: Disable PV Preparation/Ready (rdy) function B=0: Ramp mode. During the program is running and there is temperature difference in SV, the temperature points migrates as a line graph. Various heating mode can be defines, as well as cooling mode. B=1: Soak mode (Constant temperature mode). Each program step defines the set point and soaking time. The rate of increase in temperature can be reach next step is limited by rdy. On the other hand, even B=0, if the last step in the program is not a command for ending. C=0: Time unit in minute. C=1: Time unit in hour. D=0: Disable PV Startup function. D=1: Enable PV Startup function. E=0: When the instrument works as a program generator, upper display shows measured value PV. E=1: When the instrument works as a program generator, upper display shows the current step number within the program. F=0: Standard RUN mode F=1: Activate RUN shortcut will enter Hold status when the program is running H=0: Default H=1: Under ramp mode, Ready (rdy) function is avaiable for each step.	
EP1-EP8	Field parameter definition	Define 1~8 field parameters for those common used parameters when the Loc lock is applied. If there is none or less than 8 field parameters, please set as nonE.	

3.3 Additional Remarks of Special Functions

3.3.1 Single-phase phase-shift trigger output

When OPt is set to PHA1, installing a K50 or K60 module in OUTP slot can single-phase phase-shift trigger a TRIAC or 2 inverse parallel SCRs. It can continuously adjust heating power by control the conduction angle of thyristor. With non-linear power adjustment according to the characters of sine wave, it can get ideal control. The trigger adopts self-synchronizing technology, so it can also work even when the power supplies of the instrument and the heater are different. Phase-shift trigger has high interference to the electric power, so user should pay attention to the anti-interference ability of other machines in the system. Now the K50 or K60 module can be only used in 50Hz power grid.

3.3.2 Alarm blocking at the beginning of power on

Sometimes the fault alarm may occur at the beginning of power on. In a heating system, at the beginning of power on, its temperature is much lower than the set point. If low limit and deviation low limit are set and the alarm conditions are satisfied, the instrument should alarm, but there is no problem in the system. Contrarily, in an refrigerating system, the unnecessary high limit or deviation high limit alarm may occur at the beginning of power on. Therefore, AI instruments offer the function of alarm blocking at the beginning of power on. When Act is set to rEbA or drbA, the corresponding low or high alarms are blocked until the alarm condition first clears. If the alarm condition is satisfied again, the alarm will work.

3.3.3 Communication function

The AI-716/716p instrument can be installed with S or S4 type RS485 communication interface module at the comm position to realize multi computer connection with the computer. Various operations and functions of the instrument can be realized through the computer. For computers without RS485 interface, one RS232C/RS485 converter or USB/RS485 converter can be added. Each communication port can be directly connected to 1-60 instruments. After adding RS485 repeater, up to 80 instruments can be connected. One computer can support multiple communication port connections. Note that each instrument should have a different address. When there are a large number of instruments, two or more computers can be used to form a local network between computers. The manufacturer can provide the AIFCS application software, which can run under the Chinese Windows operating system, can realize the centralized monitoring and management of up to 120 AI series instruments of various models, and can automatically record and print the measurement data. If users want to develop configuration software by themselves, they can ask the instrument salesperson for free if they want to obtain the communication protocol. A variety of configuration software can support AI instrument communication.

3.3.4 Temperature re-transmitter / Program generator / Manual current output

In addition to the conventional APID/PID or ON-OFF position adjustment, the instrument can also directly output the measured value (PV) or the set value (SV) from the output end. When the output is defined as current output, AI-716 can be used as a temperature transmitter, AI-716P is used as a program given generator, and the

4~20mA current output accuracy is 0.3%FS of the corresponding display value. Relevant parameter settings are as follows:

CtrL=PoP is the PV value of transmission output, CtrL=SoP is the SV value of transmission output.

OPt、OPH, select the output specification amplitude limit, usually 4~20mA output or 0~20mA output.

InP 、SCH 、SCL 、Scb and other parameters, select the specification of input thermocouple or thermal resistance, lower limit, upper limit and translation correction of PV value of transmission output.

For example, the instrument is required to have the K-division thermocouple transmission function, the temperature range is 0~400 ℃, and the output is 4~20mA. Then the parameter settings are as follows: InP =0、ScL=0.0、ScH=400.0、OPt=4-20、OPH=100. For the transmitter thus defined, when the temperature is less than or equal to 0 ℃, the output of X3 or X5 linear current module installed at the OUTP position is 4mA; when the temperature is greater than or equal to 400 ℃, the output is 20mA; when the temperature is between 0~400 ℃, the output changes continuously between 4~20mA.

3.3.5 Fine control

Fine control means operation resolution is 10 times higher than display resolution ,e.g. The instrument display 1 ℃， but control resolution is 0.1℃,in this way ,the control accuracy is much higher than display resolution. Instruments of old version use fine control only when the input signal is a temperature while new version use fine control only when the value is less than 3000 under the condition of linear input signal. (most applications are less than 3000 at industrial applications),in this way the instrument can obtain higher precision

and more stable output ,and if need fine control when value more than 3000,can set AF.F=1.

3.3.6 User defined non-linear table

When the parameter InP=10 is set, the instrument input specification is a user-defined input type, and non-linear tables can be edited. The setting method is: set the Loc parameter to 3698 to enter the table setting state. The parameter A 00 defines the table usage: 0 is used for input non-linear measurement or multi segment linear correction of input signal, and 1 is used for non-linear power control of high temperature furnace; The parameters are A01~A04 and d00~d59 (where A02~A04 and d00~d59 have decimal places. If dPt is set to 0.0, the a02~d59 values should be divided by 10). The settings are as follows:

A 00=0; used for input non-linear measurement or multi segment linear correction of input signal
A 00=1; used for non-linear power control of high temperature furnace
A01 indicates input type: A01 = Ax1 + Ex16 + Gx64
A01.A indicates input range:

A01.A=0, 20mV(0~80ohm); A01.A=1, 60mV(0~240ohm); A01.A=2, 100mV(0~400ohm); A01.A=4, 0-5V; A01.A=10, 0~20mA or 0~10V(I4 or i31 module installed at Mio position)

A01.E Indicates input signal display:

A01.E=0, the value generated from the table should be scaled by parameter Sch and Scl again, and then displayed
A01.E=1, the displayed PV is the value generated from the table.
A01.G indicates the input signal type(to judge whether the input signal is temperature type or non temperature type).
A01.G=0, thermocouple

A01.G=1, RTD
A01.G=2, linear voltage/current
A01.G=3, linear resistance
For example**:**for a non-temperature, 1~5V voltage signal, A01=4x1 + 0x8 + 2x64 = 132

A 02 defines the input signal lower limit, which is equal to the signal lower limit × K/ range, such as 1-5V signal input, then set A02=1 × 25000/5=5000. （**K** is the signal coefficient, when A01.A is 0, the coefficient is 20000, when A01.A is 2, 4 and 10, the coefficient is 25000, when A01.A is 1, the coefficient is 30000.）

A 03 defines the input signal range, which is equal to the signal range × K/ range, for example, in 1-5V input, if the range is 5-1v=4v, then set A03=4 × 25000/5=20000。

A 04 defines the input signal table spacing, A04=A03/ number of curve segments. If there is only one segment, A04 is equal to A03; If it is divided into two sections, A04=A03/2.

d 00 represents the starting point value of the curve table, which corresponds to the output value when the input signal is A02. For example, it can be set to 0.

d 01 represents the value of the first segment of the curve table, which corresponds to the output value when the input signal is A02+A04. For example, the 1-5V input can be set to 20000 (full scale).

d 02-d59 refers to the values in paragraph 2-59 of the curve table. If all applications are applied, very complex curves can be corrected, such as square root, logarithmic and exponential curves.

3.3.7 Multi segment linear correction function of input signal

When the input specification InP plus 64 is set, the instrument has the function of input multi segment linear correction. The setting method is: set the Loc parameter to 3698 to enter the table setting state (if the original Loc=808, you need to set the Loc to 0, exit the parameter setting state, and then re-enter the parameter state to

set the Loc to 3698). The settings are as follows:

A00: 0;

A01: Input signal and display setting: A 01=A×1+E×16+G×64

A indicates signal range: A01.A=0, 0~20mv (0-80 Ω); A01.A=1, 0~60mv (0-240 Ω); A01.A=2, 0~100mv (0-400 Ω).

E indicates signal display: A01.E=0, no effect; A01.E=1, the table d00~d59 setting value is the display value.

G indicates signal type: A01.G=0, thermocouple; A01.G=1, thermal resistance. For example, if the signal is Thermocouple Input and temperature type, set A01=2 × 1+1 × 16+0 × 64=18

A02 starting temperature

A03 measurement range = maximum measurement value -A02

A04 temperature interval of each section =A03/ number of sections

d00~d59 temperature setting value of each section

For example, the range of K thermocouple input is 0 to 300 degrees, one decimal place, and corrected every 100 degrees. Then set the parameters A00=0, A01=18, A02=0.0, A03=300.0, A04=100.0, d00=0.0,d01=100.0, d02=200.0, d03=300.0. To correct the number, you only need to set the corresponding temperature point high or low. Take the following for example, if the instrument displays 200.0 degrees and the calibration equipment measures 202.0, you can change d02=200.0 to d02=202.0.

Note: the correction value is the value of each point, and there is an automatic linear transition between points. After this function is enabled, the instrument can only display within the temperature range set in the table.

When the actual temperature exceeds the table range, the instrument will display orALI over range alarm.

3.3.8 nonlinear power control function of high temperature furnace

For the high-temperature furnace with nonlinear load, its resistance will change dramatically with the change of temperature. Take the silicon molybdenum rod furnace for example, its room temperature is only about 6% of the resistance at 1600 ℃. If the output power of the instrument is not limited and changed, two problems will be caused. First, the electric furnace current is too large during low-temperature startup, which exceeds the maximum allowable load of the power grid, thyristor and transformer, causing damage to the thyristor, electric furnace and transformer or causing power grid tripping. In addition, when the instruments have the same output, the power of the electric furnace in the low-temperature zone and the high-temperature zone will differ by more than 10 times at most, which means that the proportional band P in the PID parameters needs to change more than 10 times at different temperatures in order to achieve accurate temperature control in both the low-temperature zone and the high-temperature zone. However, the method of limiting the parameter OPH can only limit the output power and cannot achieve proportional band conversion. If the high-temperature and low-temperature zones can meet accurate temperature control, multiple groups of PID need to be set, It is not only complicated to use, but also ineffective. The user-defined output limiting transformation function solves the functions of limiting the output and transforming the proportional band P at the same time. This function limits and transforms the instrument output according to the measured temperature, which not only limits the power in the low temperature area, but also automatically corrects the proportional band parameters at different temperatures. Moreover, the power limit and the change of the proportional band are in the continuous broken line mode, which is better than the grouping mode, This power limit only reduces the actual output of the

instrument in proportion, while the display range of the instrument output is still 0~100%. For example, when it is used for silicon molybdenum rod furnace, the following settings can be set (customers can also modify the data according to their own needs)

A00=1，A 01=1050，A02=100.0；A03=1500；A04=750.0，d00=120.0；d01=1100，d02=2000

When the parameter A00=1 and A01=1050 are set, the instrument enables the user-defined output limit transformation function. A02 represents the initial temperature of the output limit, A03 represents the temperature range of the output limit, A04 represents the segment length of the non-linear data temperature segment. In this example, 1500/750.0=2 indicates that there are two segments. The more segments, the more complex and refined the curve can be. d00 represents the maximum output power below A02, and its unit is 100% × (1/2000), d00=120.0 means 6%, d01 means 55%, d02 means 100%.

This curve means that the output is limited to 6% when the temperature is below 100 ℃; When the temperature is between 100~850 ℃, the power limit will smoothly transition from 6% to 55%; The power limit transits from 55% to 100% when the temperature is between 850~1600 ℃; The temperature above 1600 ℃ is not limited to 100%.

Note: the range of d value is 0~59, which is equivalent to a maximum of 60 power limits. This function cannot be used together with the input multi segment linear correction function. If special specification input is required at the same time, the sales personnel can be contacted to negotiate and solidify it inside the instrument, but it may require a one-time additional payment.

4.Program Control (AI-716P Only)

AI-716P program temperature controller is used in the application where the set point to be changed automatically with the time. It provides 30 segments program control which can be set in any slope and the function of jump, run, hold and stop can also be set in the program. Measurement startup function, preparation function and power-cut/power-resume event handling modes also provided.

4.1 Functions And Concepts

● **Program Step:** The number of the program StEP can be defined from 1 to 30. The current Step is the program Step being executing.

● **Program time:** Total run time of the program step. The unit is minute or hour. The value range is from 0.1 to 3200.

● **Running time:** The Time of 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.

● **run/Hold:** When program is in the running status, timer works, and set point value changes according to the preset curve. When program is in the holding status, timer stops, and set point remains to make temperature hold also. The holding operation（HoLd） can be programmed into the program step.

● **StoP:** When the stop operation is activated, the program will stop, running time will be clear, event output

switch will reset and the output control will stop output. If run operation is activated when instrument is in the stop status, the program will start-up and run again from the set StEP no. The stop function can be programmed into the program StEP. 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). If the program ran the last step of “Pno”, program will stop automatically.

● **Power cut / resume event handling**: refers to the unexpected power failure when the instrument is powered on or in operation. A variety of different processing schemes can be selected by setting PonP parameters.

● **PV preparation function (rdy function):** When the program is running and it is required to resume after accidental power restart, and if the PV (process value) is different with SV (set value) (If PV Startup feature is enabled, the system will use PV Startup in priority. If PV Startup effect is significant, PV Preparation/Ready function is not required. In circumstances which does not fit the criteria of PV Startup we will use PV Preparation/Ready function), as well as the difference is larger than deviation alarm (HdAL and LdAL), instrument will not immediately activate deviation alarm. Instead it will try to adjust the PV in order the deviation will be minimized to lower then the value of deviation alarm. The program timer will be paused. The deviation alarm(s) will be suppressed. Until the positive and negative deviation meet the requirement, the instrument will start the to run the program. This PV Preparation/Ready function is effective for those step(s) with unpredictable time required for increasing/decreasing temperature. Activation and deactivation of this function can be changed in PAF parameter. PV Preparation/Ready function ensures the integrity of the program curve. On the other hand, the extra preparation time may prolong the whole program time. Both PV Preparation/Ready function and PV Startup feature deal with the uncertainty of indifference between PV and SV during program running. Hence an

efficient and complete program profile can be achieved.

● **PV Startup:** When the program is running and it is required to resume after accidental power restart, the PV (process value) is often different from SV (set value). This scenario is unavoidable but also undesirable. For example, the program is set to raise the temperature from 25℃ to 625℃ in 600 minutes, at a rate of 1℃ per 1 minute. Assume when the program starts, PV is 25℃, the program profile runs smoothly. But if the PV is higher than 25℃, the program cannot be run as expected. PV Startup feature can ask the instrument to adjust the running time to fit in. If the current PV is 100℃, the instrument will automatically to run this program at the moment of 75 minutes, that mean changed the temperature raised from 100℃to 625℃in 525 minutes (600-75) min.

● **Curve fitting:** it is adopted as a kind of control technology for AI-716P 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 t (t=d+Ctl) ; the longer of the lag time, the curve will more smooth. 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 and the speed of heating-up (cooling-down). This phenomenon is normal.

4.2 Program Arrangement

4.2.1 Ramp Mode

Programming of instrument has uniform format of temperature-time-temperature, which means temperature “A”(SP 1), passed Time “A”(t01), then reached Temperature “B”(SP 2). The unit of temperature set is ℃ and the unit of time set is minute. The following example includes 5 steps, which is linear temperature heating up, constant temperature, linear temperature cooling down, jump cycling, ready, Hold.

StEP1: **SP 1=100 , t 1=30.0** Start linear temperature heating up from 100℃, and the time needed 30 minutes to reach SP 2(400 degree).

StEP2: **SP 2=400 , t 2=60.0** Temperature raised to 400℃, slope of raising curve is 10℃/minute, The program take 60 minutes to raise temperature to SP3 (400 degree). It means keep the same temperature in 60 minutes.

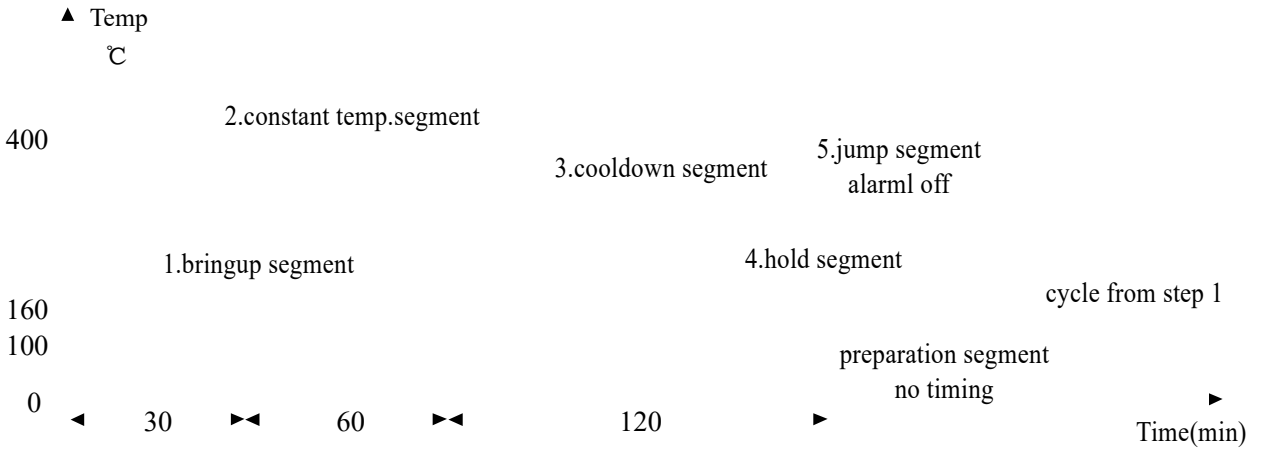
StEP3: **SP 3=400 , t 3=120.0** This is the step for temperature cooling down, slope of cooling curve is 2℃/minute, and the time needed is 120 minutes to reach SP4 (160degree).

StEP4: **SP 4=160 , t 4=0.0** When temperature reached 160 degree, the program get in Hold state. If need go to next step, it needed operator to executed the “run” for next step.

StEP5: **SP 5=160 , t05=-1.0** Jump to StEP1 to start from beginning.

In this example, it is assumed that the deviation high alarm is set to 5℃. Because the temperature of StEP 5 is 160℃, and the temperature of StEP1 is 100℃, when program jumps from StEP 5 to StEP 1, the program will change to preparation state at first(if preparation mode “rdy” was enabled), i.e., Control the temperature until the deviation between setpoint and PV is less than deviation high alarm value. After temperature is controlled to

105℃, the program will be started from StEP 1, and run the above steps again. The temperature control drawing was shown below.



The advantage of applying “temperature-time-temperature” arrangement is to provide a wide window of setting rate of increasing and decreasing temperature. The format of increasing and decreasing temperature steps keep the same format, for ease to learn. There is a high flexibly to set the curve, enabling possibility to input continuous increasing curves (e.g. using different rate of increasing curve to achieve functional heating) or continuous temperature holding steps.

4.2.2 Soak Mode

When the parameter PAF.B=1, soak mode is selected. This is suitable for the process which does not need to establish the temperature slope, simplifying the programming and using the quantity of steps more effectively. Each step contain the meaning of “temperature ~ holding time at that temperature”. Parameter “SPr” defines the rate of temperature change among steps. If “SPr=0”, the rate will set to maximum. Since the time of temperature increasing and it occupies the holding time, PV preparation/Ready feature “rdy” is advised to be used to ensure to obtain the correct soak time (holding time).

4.2.3 Time Setting

Each section of the program includes set value and time. The value range that can be set by set value is limited by SPL and SPH, which is -999~+3200 ℃, indicating the temperature value to be controlled (℃) or the linear definition unit. In addition to the running time, time also has special control functions. The meanings are as follows:

Set “t-xx” = 0.1~3200 (min)

Set the time of Step xx. (Time unit can be change to hour by parameter “PAF”.)

Set "t-xx" = 0.0

The program pauses (HoLd) on Step xx. The program will be paused and timer pauses counting.

Set "t-xx" = -121.0

The program stops(StoP), and go into stop status.

Set "t-xx" = -0.1~-122.0

Negative value in time value represents a command (a jump operation + event output). The integral part "-1~-120" refers to the step number to jumped to. Step number greater than Pno (Number of program step) with non-zero decimal space does nothing but proceed to next step. Decimal place refers to programming of event output at AL1 and AL2. –XXX.0 indicates the event is none but step jumping only. Please note that if parameter AOP assigns alarm action at AL1 or AL2, no matter event outputs or ordinary alarms will cause alarms from AL1 and AL2. The definition of -XXX.1 ~ -XXX.4 are as below:

-XXX.1, AL1 activated, AL2 released

-XXX.2, AL1 released, AL2 activated

-XXX.3, AL1 activated, AL2 activated

-XXX.4, AL1 released, AL2 release

Example 1: t- 5 = -1.1; When the program pointer arrives step 5, AL1 is activated. AL2 is released. The program jumps to step 1 to keep running.

Example 2: t- 6 = -0.3; When the program arrives step 6, AL1 and AL2 are activated. The program proceeds to the next step (Step 7).

Note: The program will be held if it jump from a control segment to another control segment (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 -6= -6), otherwise, the Hold status cannot be released.

4.2.4 Program arrangement of multi-curve operation

AI-716p has a flexible and advanced programming method. Since the AI instrument will automatically set the StEP to 1 after stopping (StOP), if the StEP value is not modified before starting the operation, the reoperation will generally start from the first section. For users who have compiled multiple temperature control curves, the method of setting the first section as a jump section can be used to execute different curves. If the user has 3 curves with length of 3 segments, the program can be arranged in 2~4, 5~7 and 8~10. To execute different curves after startup, the first segment can be set as follows:.

t- 1=-2.0 Execute the program of curve 1 (Step 2 ~ Step 4)

t- 1=-5.0 Execute the program of curve 2 (Step 5 ~ Step 7)

t- 1=-8.0 Execute the program of curve 3 (Step 8 ~ Step 10)

When the manufacturing methodology is required to be changed, the curves can be loaded by setting the “t-1“ as -2.0, -5.0 or -8.0. This jump selection step can also be omitted. The corresponding StEP number can be chosen before the program starts (run).

5. FAQs section

5.1 How to set auto-tuning?

When the PV is room temperature, set the SV to about 60% of the common temperature (for signals such as pressure or flow, it can be directly set to the common setting value), then press and hold ◁ for two seconds to call up the AT parameter, change the parameter value from off to on, and click ↺ to confirm to start the auto-tuning. It can work normally after the auto setting at symbol does not flash automatically.

5.2 How to access the internal parameter list?

Press and hold for two seconds to enter the parameter list, and then briefly press ↺ to find the next parameter. If the complete parameters are locked, find the password lock parameter LOC and set 808, and then press briefly ↺ to see all the parameters.

5.3 How to determine whether the instrument has output?

First, check whether the OP1 indicator on the instrument panel is on. If not, it is necessary to determine whether the instrument is running, and then check whether the instrument parameters are set correctly; If it is on, it indicates that the output status of the instrument is normal. You can use a multimeter to detect whether the output terminal signal of the instrument is normal. If the output signal is normal but the rear actuator does not work, you need to check other equipment or line faults along the output line. If there is no output signal, it can be judged that the instrument output module is abnormal.

5.4 Instrument panel flashes oral?

This indicates that the instrument does not detect the input signal. First, check whether the sensor model corresponds to the input specification parameter InP, and then check whether the input terminal wiring of the instrument is correct. If there is no problem, measure whether the incoming signal of the sensor is correct, and the sensor may be damaged.

5.5 How to enter the program segment setting?

Click  once on the initial display interface after the instrument is powered on to enter the program segment menu, and then click  to display the next data. Each program segment is arranged in the order of "set value - time - set value". The program segment settings are described in detail in the program control section of the manual.

5.6 How to set alarm parameters?

First, set the alarm parameter to the required value (for example, if you need to set a 200 degree upper limit alarm, change the HIAL parameter to 200), and then enter the internal parameters to find the alarm signal output port defined by the AOP parameter (for example, if you need to output the upper limit alarm from AL1, set the AOP number to 1. For specific definitions, see the AOP parameter introduction in the manual).