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AI-719 / AI-719P

ARTIFICIAL INTELLIGENCE INDUSTRIAL CONTROLLER

Operation Instruction *Ver. 8.2*

(Applicable for accurate controls of
Temperature, Pressure, Flow, Level and Humidity etc.)

CONTENTS

1. SUMMARY

1.1 Main Features

- Input measurement accuracy is up to F.S. 0.1%, supporting thermocouples, RTD, voltage, current and self-defined non-linear calibration table.
- Advanced artificial intelligent control algorithm, preventing overshoot, auto tuning (AT) and new precise control mode.
- Modular structure, conveniently providing plentiful output options, able to satisfy the requirements of various applications, make quick delivery and convenience the maintenance of the instrument.
- Environmental friendly and energy saving design to implement low energy consumption and low temperature drift.
- User-friendly and customized operating interface.
- Customizable user privilege and interface. Self-define password to tailor-made the instrument parameters.
- Universal power supply 100-240VAC or 24V AC/DC and various installation dimensions availalbe.
- Anti-interference feature to fulfill the Electromagnetic compatibility (EMC) requirement of severe industrial condition.

POINTS FOR ATTENTION

- This manual is AI-719/AI-719P ARTIFICIAL INTELLIGENCE INDUSTRIAL CONTROLLER Version 8.2.

Certain functions in this manual are probably not applicable for the instrument of other versions. When the power is on, instrument model and software version will be displayed. User should pay attention to the difference between different versions when using the instrument. Please read this manual carefully in order to use the instrument correctly and make it to its full use.

- Please correctly set parameters according to input / output type and function. Only correctly wired instruments with parameters correctly set can be put into use.

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-719/AI-719P series instrument is made up of 9 parts. For example:

AI－719	**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-719, 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 L3 (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 24V AC/DC, an extended input type is F2 (F2 radiation type pyrometer) .

The following is the meanings of the 9 parts:

① Model number:

AI-719 Economical type instrument with measurement accuracy 0.1% F.S. It adopts artificial intelligent control technology, and has the functions of control, alarm, retransmission and communication.

AI-719P Base on AI-719 added 50 segments time-programmable functions.

② Front panel dimension:

A(A2) Front panel 96×96mm(width×height), cut out 92×92mm, depth behind mounting surface 100mm.
A2: added light bar with 25 segments and 4 levels of luminosity.

B Front panel 160×80mm(width×height), cut out 152×76mm, depth behind mounting surface 100mm.

C(C3) Front panel 80×160mm(width×height), cut out 76×152mm, depth behind mounting surface 100mm.
C3: added light bar with 50 segments and 2 levels of luminosity.

D Front panel 72×72mm(width×height), cut out 68×68mm, depth behind mounting surface 95mm

D6 Front panel 48×48mm(width×height), cut out 45×45mm, depth behind mounting surface 95mm`

E(E2) Front panel 48×96mm(width×height), cut out 45×92mm, depth behind mounting surface 100mm
E2: added light bar with 25 segments and 4 levels of luminosity.

E5 Rail mounted 48×96×110mm(width×height×depth), installed on DIN trail and programmed by external display E8.

F Front panel 96×48mm(width×height), cut out 92×45mm, depth behind mounting surface 100mm

③ Module specification of multiple functions I/O (MIO): I2, I4, K3, V12 or V24 etc. N indicates no module is installed.

④ Module specification of main output (OUTP): L1, L2, L4, L5, W1, W2, G, K1, K3, X3, or X5 etc.

⑤ Module specification of alarm (ALM): L0, L2, L3, L4, W1, W2, or G etc.

⑥ Module specification of auxiliary output (AUX): L0, L1, L2, L3, L4, W1, W2, G, K1, X3 or X5 etc.

⑦ Module specification of communication (COMM): S, S1, S4 or V12/V24 etc.

⑧ Power supply: Leaving blank referring to 100~240VAC universal. "24VDC" refers to 20~32V DC or AC power.

⑨ Specification of optional extended graduation (If it is not required, leave it blank). AI-719/719P itself supports input types including conventional thermocouples, RTDs, linear voltage, current and resistance inputs. If it is necessary, an additional specification not found in input type selection (InP) table 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: The maintenance (excluding damage due to misuse) within designated warranty period is free of charge. Please state clear the malfunction phenomenon and reason to make sure it will be being repaired in full coverage.

Delivery from user to factory should be responsible by user.

1.3 Modules

1.3.1 Slots of modules

AI-719/719P series instruments provides 5 module slot (D-sized instrument provides 3 slots: OUTP, AUX and COMM/AL1; D6-sized one provide 2 slots: OUTP and COMM/AUX). Different modules enable the controller to provide different functions and outputs.

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

  I4 (Current Input) reads input from 2-wire transmitter or 4-20mA signal. It provides 24VDC loop power to transmitter as well.

  I5 (On-off input/Event input) as an external switch, enables the instrument to switch between set points SP1 and SP2. On the other hand, I5 can acts as a switch to switch between RUN/STOP mode.

  K3/K9 module uses up MIO and OUTP slots to provide three-phase thyristor zero-crossing/phase-shift output.

- **Main output (OUTP):**

  Output mode can be set to ON-OFF, standard PID regulating, and artificially intelligent APID regulating. It can also be set as retransmission of process value (PV) or set point (SP). Installing L1 or L4 module provides relay contact output. Installing X3 or X5 module provides 0-20mA/4-20mA/0-10mA linear current output. Installing G module provides SSR 12V voltage output. Installing W1/W2 module provide TRIAC no-contact switch output. Installing K51 module provides single phase thyristor phase-shift triggering. Installing L5, W5 or G5 provides direct/reverse valve motor control.

- **Alarm (ALM):**
  Installing L0 or L2 provides 1 normally open + normally close alarm relay output (AL1). Installing L3 provides 2 normally open alarm relay outputs (AL1+AL2).
- **Auxiliary output (AUX):** In a heating/refrigerating dual output system, installing X3, X5, L1, L4, G, W1 or W2 provide a second regulating output. In a single output system, installing L0, L2 or L3 relay module acts as alarm. Installing R module (RS232C port) communicates with computer.
- **Communication Interface (COMM):** Installing S or S4 module (RS485 communication port) communicates with computer. Installing I2 (ON-OFF switch module) provide event input. Installing V5/V10/V12/V24 voltage output module provides power for external sensor (except for D6-sized one).

1.3.2 Common modules:

N (or blank) No module installed
L0 Large-size high-capacity relay contact switch output module (Relay capacity: 250VAC/2A, alarm use)
L1 Large-size high-capacity relay NO contact switch output module (Relay capacity: 250VAC/2A)
L2 Small-size low-capacity relay NO+NC contact switch output module (Relay capacity: 250VAC/1A, alarm use)
L3 Dual large-size relay NO contact switch output module (Relay capacity: 30VDC/2A, 250VAC/2A)
L4 Small-size high-capacity relay NO+NC contact switch output module (Relay capacity: 250VAC/1A

L5 Dual large-size relay NO contact switch output module (Relay capacity: 30VDC/2A, 250VAC/2A)
W1 Thyristor no contact normally open discrete output module (Capacity: 100~240VAC/0.2A, burn-proof)
W2 Thyristor no contact normally close discrete output module (Capacity: 100~240VAC/0.2A, burn-proof)
W5 Dual Thyristor no contact and 5V output module, specially for valve motor regulating (Capacity: 100~240VAC/0.2A, burn-proof)
G SSR voltage output module (12VDC/30mA)
G5 Dual SSR voltage output module (12VDC/30mA)
K1 Single loop thyristor zero crossing trigger output module (Each loop triggers a 5~500A two-way thyristor or two -way anti-parallel SCR, burn-proof)
K3 Three loop thyristor zero crossing trigger output module (Each loop triggers a 5~500A two-way thyristor or two -way anti-parallel SCR, burn-proof)
K51 Single-phase 220VAC thyristor phase-shift trigger output module
K61 Single-phase 380VAC thyristor phase-shift trigger output module
K9 Three-phase thyristor phase-shift trigger output module
X3 Photoelectric programmable linear current output module
X5 Photoelectric programmable linear current output module, with isolated power supply
S Photoelectric RS485 communication interface module.
S1 Photoelectric RS485 communication interface module, with instrument internal 24V isolated power.
S4 Photoelectric RS485 communication interface module, with isolated power supply.
R Photoelectric RS232 communication/printing interface module. (Printing feature optional)
V24/V12/V10 Isolated 24V/12V/10V DC voltage output with maximum current of 50mA to power external transmitter.

I2	Frequency signal input interface
I5	ON-OFF switch input interface as external switch
I4	4-20mA/0-20mA analogue input interface, giving loop power 24VDC/25mA for two-wire transmitter.
SL	[For D6 panel size] Photoelectric RS485 communication interface module, as well as a single relay NO contact switch output module (Relay capacity: 250VAC/2A), powered up by internal 12VDC.

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, users 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 of 12V power supply built in the instrument and isolated to the main circuit. The 24V power supplies voltage output modules, such as V24/V12/V10/V5, I2 and I4. The 12V power supplies output or communication modules. 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) are all powered by 12V power supply. If more than one of the above modules are installed, electric isolation fails because they share isolated power. Hence isolated powered module S4 or X5 should be used. For example, if an X3 module is installed in OUTP (main output) slot, for isolation, S4 or X5 should be installed in COMM slot.

1.3.5 Further Details of Module Applications

- **Voltage output module:** The voltage output modules like V24, V12, \/10 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 of current below 80A. For the current larger than 80A, an intermediate relay is needed. W5, two way no contact switch, is designed for position proportional output, directly driving 220VAC/200W below motor at 1A. W5 also provides one 5V voltage output for 1K valve feedback resistance.
- **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 L1, L4 or etc. L2 module is small in size and consists of normal open and normal close terminals with spark absorption. However the capacity of L2 is low as 1A, hence is suitable for alarm. L1/L3 is larger in size

and capacity 2A. For the instrument at 48mm width (e.g. D2, E, F, E5 and etc), only one of L1/L3 can be installed otherwise modules will be collided. L3 is a dual output relay to give two alarms such as AL1+AL2. If mechanical switch is not preferable or there is a height limit, user can choose G5 (dual SSR voltage driver) connecting external solid-state relay (SSR) instead.

1.4 TECHNICAL SPECIFICATION

- **Input type: (Either of below specifications can be used selectively in the one instrument)**
  Thermocouple: K, S, R, E, J, T, B, N, WRe3-WRe25, WRe5-WRe26.
  Resistance temperature detector: Cu50, Pt100
  Linear voltage: 0～5V, 1～5V, 0～1V, 0～100mV, 0～20mV, -5~+5V, -1V~+1V, -20mV~+20mV or etc.
  Linear current (external precise shunt resist needed): 0～10mA, 0～20mA, 4～20mA or etc.
  Extended input: Apart from the above-mentioned Input type, an additional type can be provided upon request. (Graduation index is needed)
- **Instrument Input 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～+300℃)
  Linear Input: -9990～+30000 defined by user
- **Measurement Accuracy:** 0.1%FS (Note: Thermocouples should be externally compensated with Cu50 copper

RTD. The internal compensation will add extra +/-1℃ compensation error.)

- **Temperature shift :** ≤35PPm /℃ (Note: Thermocouples should be externally compensated with Cu50 copper RTD. The internal compensation will add extra +/-1℃ shift error.)
- **Sampling Cycle :** Sampling 12.5 times every second. When the digital filter FILT=0, the display response time ≤0.3s.
- **Control Cycle :** 0.24-300.0 seconds adjustable
- **Control Method:**
  ON-OFF control mode (dead band adjustable)
  AI PID with auto tuning, adopting artificial intelligence algorithm and fuzzy logic PID regulating.
- **Output Specification (modularized)**
  Relay Output (NO+NC): 250VAC/1A or 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 solid-state relay, SSR).
  Thyristor Trigger Output: To trigger TRIAC of 5～500A, a pair of inverse paralleled SCRs or SCR power module.
  Linear Current Output: 0～10mA or 4～20mA scalable. (Output voltage with X3≥10.5V; with X5≥7V)
- **Electromagnetic Compatibility (EMC):** ±4KV/5KHz according to IEC61000-4-4 (Electrical Fast Transient); 4KV according to IEC61000-4-5 (Electrical surge) and no system hang and I/O malfunction at 10V/m high frequency EM interference. Measurement fluctuation is less than ±5% of the full scale.

- **Isolation withstanding voltage :** Between power, relay contact or signal terminals ≥2300VDC; between isolated electroweak terminals ≥600V
- **Power supply :** 100～240VAC, -15%, +10% / 50~60Hz; 120～240VDC; or 24VDC/AC, -15%, +10%.
- **Power consumption:** ≤0.5W (upon no output or alarm); maximum consumption ≤4W
- **Operating Ambient :** Temperature -10～60℃; humidity ≤90%RH
- **Front panel dimension:** 96×96mm, 160×80mm, 80×160mm, 48×96mm, 96×48mm, 72×72mm, 48×48mm
- **Panel cutout dimension:** 92×92mm, 152×76mm, 76×152mm, 45×92mm, 92×45mm, 68×68mm, 45×45mm
- **Depth behind mounting surface:** ≤100mm

1.5 Energy-saving and environment-friendly design

AI-719/719P 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-719/719P 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-518/518P/519/519P

series instrument from 0.3% to 0.25%, AI-708/708P series from 0.2% to 0.15%, AI-719/719P series (upgraded AI-808/808P) to 0.1%.

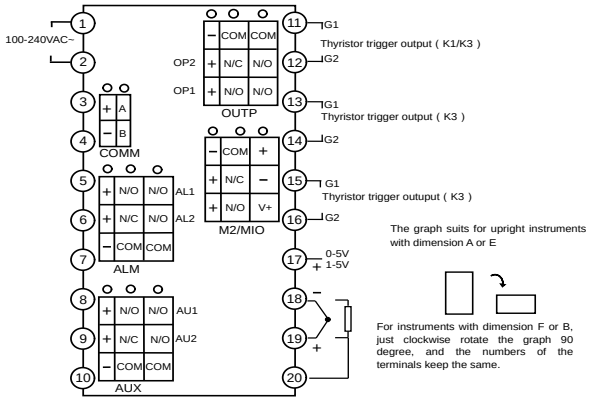
1.6 Rear Terminal Layout and Wiring

Wiring graph of instruments

Note 1: For linear voltage input, if the range is below 1V, connect to terminals 19+ and 18-. 0～5V or 1～5V signal can be inputted from terminals 17 and 18.

Note 2: 4～20mA linear current signal can be converted 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+ and 14-.

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



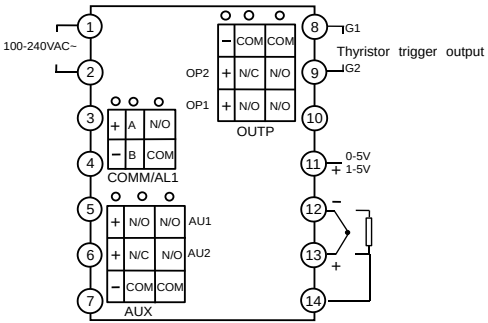
Note 4: When main output selected linear current or SSR voltage, output form terminal 13+, 11-,

Wiring graph of D dimension instruments (72×72mm)

Note 1: Linear voltage signal of range below 1V should be inputted from terminals 13+ and 12-, and signal of 0～5V and 1～5V should be inputted from terminals 11+ and 12-.

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

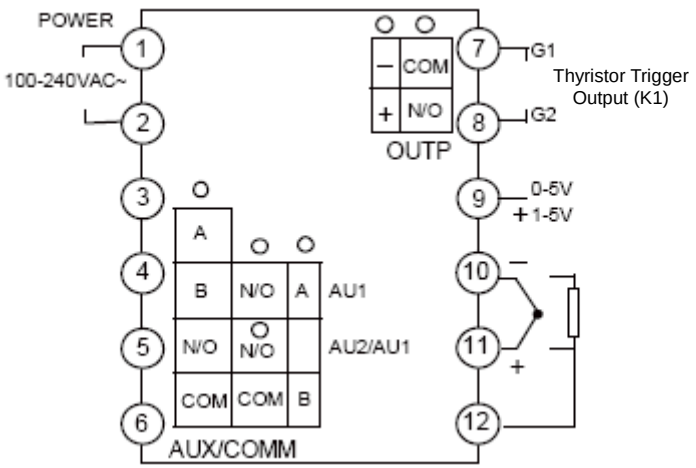
Note 3: S or S4 module can be installed in COMM slot for communication. If a relay/TRIAC no-contact-switch/SSR drive voltage output module is installed in COMM/AL1, it can be used as alarm. If I2 module is installed in COMM/AL1 and parameter “bAud” is set to 1, it simulates MIO module ON-OFF input, switching SP1/SP2 by externally connecting a switch between terminals 3 and 4.

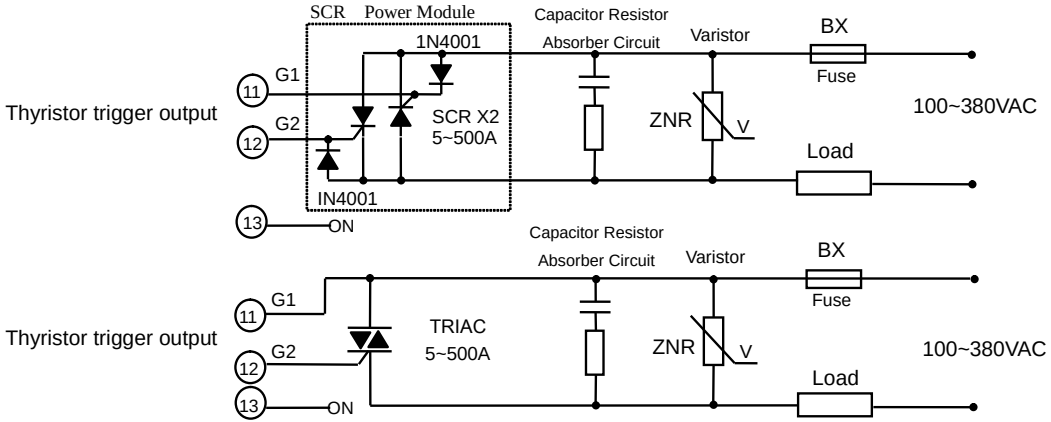


Wiring graph of instruments with D6 dimension as below:

Note 1: 0～5V/1～5V input from 9+, 10-; 500mV below input from 11+, 10. 4～20mA linear current can be converted to 1～5V by a 250Ω resistor, input from 9+ and 10-.

Note 2: At COMM/AUX slot, installing L6 module provides two alarms while installing SL module provides one alarm (as well as communication feature).





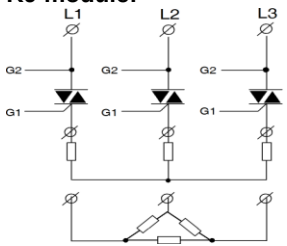
Note 1: According to the voltage and current of load, choose a suitable varistor to protect the thyristor. A resistor-capacitor circuit (RC circuit) is needed for inductance load or phase-shift trigger output.

Note 2: SCR power module is recommended. A power module includes two SCRs, is similar to the above dashed square.

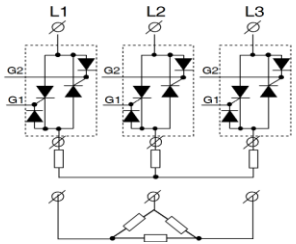
Note 3: K6 TRAIC trigger module must be used when the power is 380VAC. K5 must be used at 200~240VAC and the

frequency must be 50Hz. When K51 or K61 is used, terminal 13 must be connected zero.

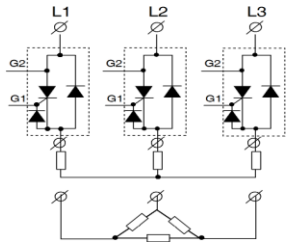
K9 module:



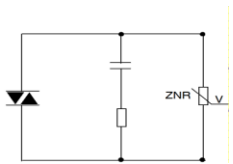
Three-phase and three-wire star and triangle wiring diagram (two-way thyristor)



Three-phase and three-wire fully-controlled power module star and triangle wiring diagram (single-phase thyristor antiparallel)



Three-phase and three-wire half-controlled power module star and triangle wiring diagram (single-phase thyristor + diode)



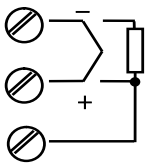
Note: The two ends of each thyristor or power module must be in parallel with the resistance and capacitance absorption components and the piezoresistor at the same time, otherwise it may lead to grid peak pulse interface, cause abnormal trigger, and even damage the thyristor

Note 1: Select the piezoresistor in accordance with the load voltage and current to protect the thyristor. If there is inductive load or phase-shift trigger, resistance and capacitance absorption must be added.

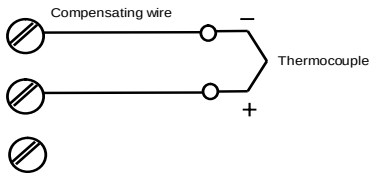
Note 2: It is recommended to use the thyristor power module. A power module includes 2 one-way thyristor, as shown in the dotted part of the figure.
Note 3: The AC range is 380VAC, and the power frequency must be 50Hz.
Note 4: The two trigger lines have polarity, so please do not get polarity reversed;

Choosing thermocouple cold junction compensation mode based on wire connection

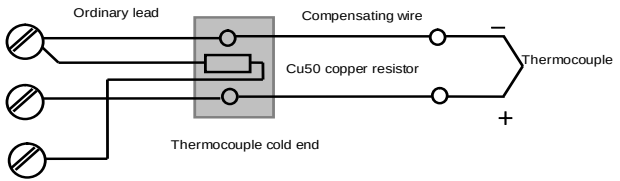
When using thermocouple as the input, cold junction should be applied for temperature compensation based on the thermocouple temperature measuring principles. AI instrument can automatically compensate cold junction referencing the temperature around the wiring terminals. Due to measuring components' 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



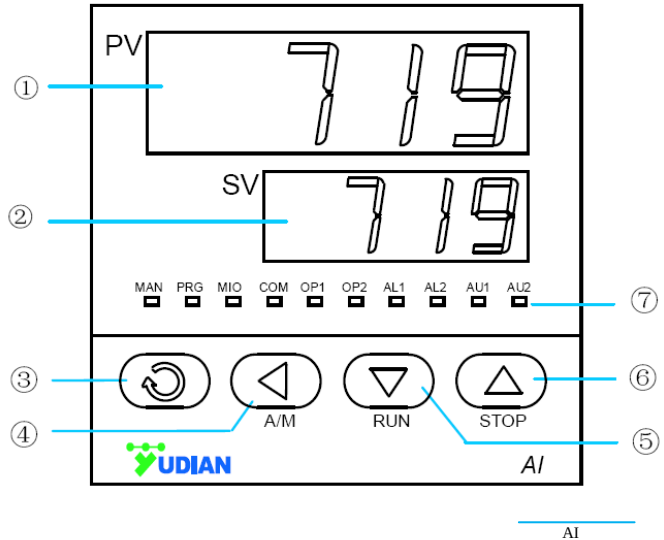
(1) Internal automatic compensation mode
(Compensating wire shall be directly connected to the connection terminals)



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

2. DISPLAYS AND OPERATIONS

2.1 Front Panel Description



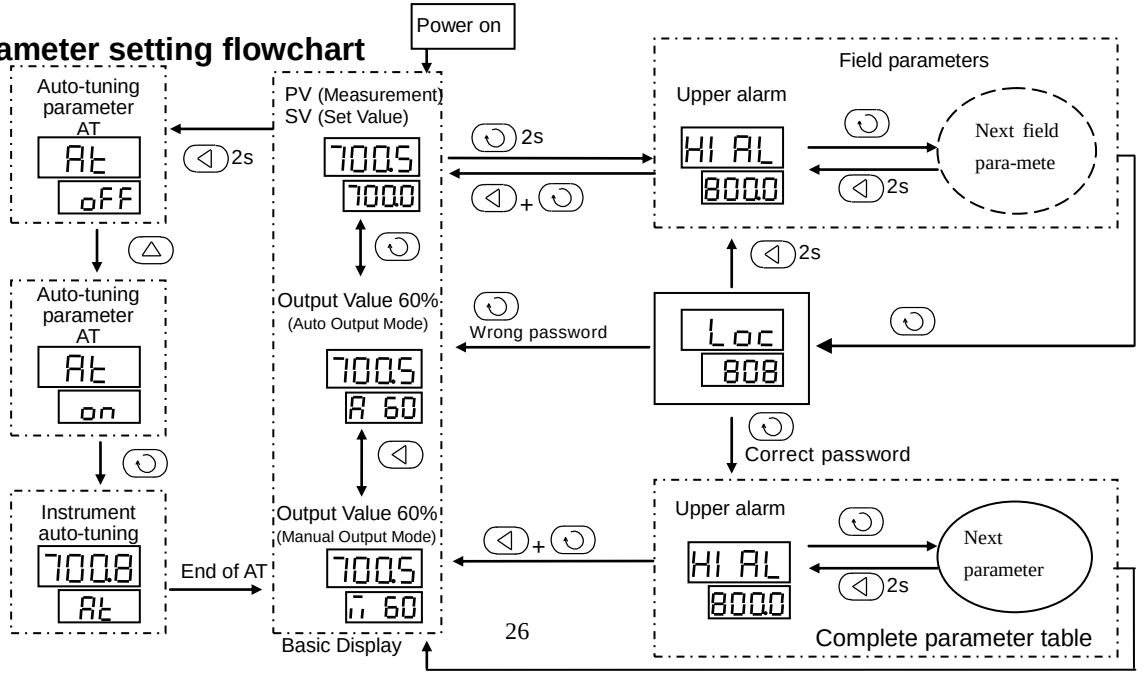
① Upper display window: Displays PV, parameter code, etc.
② Lower display window: Displays SV, parameter value, or alarm message
③ Setup key: For accessing parameter table and conforming parameter modification.
④ Cursor shifting (also control operation)
⑤ Value decrease key (also changing RUN/HOLD)
⑥ Value increase key (also STOP)
⑦ Total 10 LED indicating lights:
MAN – Lights on implies it is in manual output mode.
PRG – Program is running
MIO, OP1, OP2, AL1, AL2, AU1 and AU2 indicate I/O operation of the corresponding module.
COMM - The instrument is communicating with upper device.

Basic display status : When power on, the upper display window of the instrument shows the process value (PV), and the lower window shows the set point (SV). This status is called basic display status. Symbol description was shown as following table:

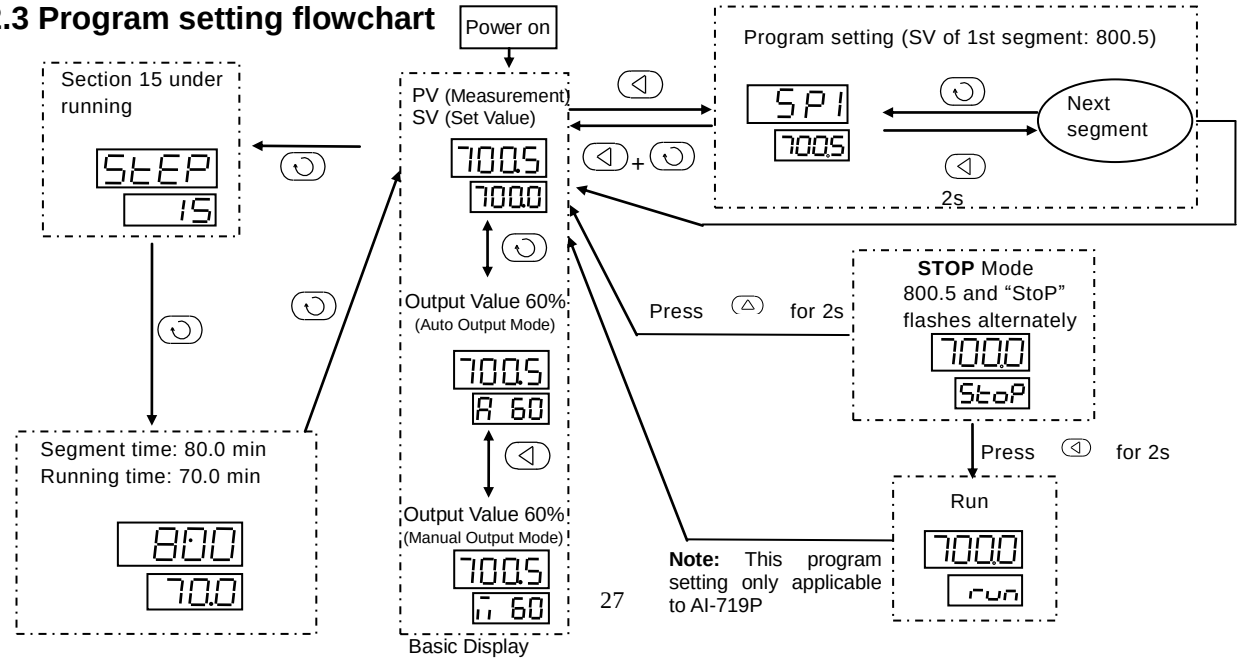
Symbol	Description
orAL	Input specification setting is incorrect Or Input wiring is disconnected/ thermocouple problem Or Short circuited
HIAL	High limit alarm
LoAL	Low limit alarm
HdAL	Deviation high alarm
LdAL	Deviation low alarm
EErr	Internal data lost
FErr	Valve feedback or external set point out-of-range
STOP	The instrument is in STOP status. No output is given out.
HoLd	The instrument is in HOLD status. (AI-719P only)
rdy	The instrument is in READY status. (AI-719P only)

Note 1: The alarm message can turn off by setting parameter AdIS to oFF.
Note 2: When occur orAL alarm, instrument will cut the output in short period.

2.2 Parameter setting flowchart



2.3 Program setting flowchart



2.4 Operation Description

2.4.1 Parameter Setting

In basic display status, press  and hold for about 2 seconds can access Field Parameter Table. Press  can go to the next parameter. Press  ,  or  modify values. Press  to decrease the value. Press  increase the value. There is a dot flashing while the value is changing just like a cursor. Hold the keys will speed up the value changing speed, as well as the flashing frequency of the cursor. Press  to move the cursor to the designated digit position. Press  to save the value and show the next parameter. Hold  to go down the parameter table quickly. Press and hold  can return to the previous parameter. Press  (don't release) and then  simultaneously can escape from the parameter table. The instrument will escape auomatically from the parameter table if no key is pressed within 25 seconds, and the change of the last parameter will not be saved.

2.4.2 Short-cut Operation Keys

All the functions of AI-719/719P can be performed by changing parameters. For some common functions such as set value changing and program status changing, there is short-cut operation keys. These short-cut keys can be prohibited to avoid careless operation.

Changing SV: In single set-point control mode (Pno = 0), SV is shown on lower display window. Press  to make it flash, then press  ,  and  to change the value.

Program Segment Setting: In program segment control mode (Pno≥1), SV is shown on the lower display. Press  to enter the program segment menu. Current SV comes first, then press  to show the time. The segment SV and time will arrange in "SV-time-SV" sequence. The segment can be modified during the program segment is running.

Program RUN Control: Press  for 2s to RUN. "run" will be shown the lower display. AI-719P will start the program if it is at the STOP state. If the parameter PAF.F=1 (AI-719P) and the program is running, this will enter "HoLD" status. The timer will pause. Press "run" again will resume the program.

STOP Control: When the lower display is showing SV, press "  " for 2s to "StoP", output will be stopped. AI-719P stops program and the segment parameter StEP will become 1
.

Auto-tuning (AT): Press  for about 2s, "At" parameters will appear. Press  to change "OFF" to "on", then press  to start auto-tuning. (If the SPr parameter is effective and in ramp slope limit, auto-tuning will be paused until heating is finished) The lower display will flash "At". After two oscillating cycles of "ON-OFF" control, it can automatically work out the PID parameters. To quit auto-turning, press  for 2s, changing "on" to "OFF" and press  to confirm. If the program steps is running, auto-tuning will pause the program timer, so as to ensure that the SV

will not change. For dual action (heating/cooling) system, two PID values is required to be tuned separately. The instrument will calculate P2, I2 and d2 cooling PID parameters if "At" is activated when cooling output AUX is working.

Manual Tuning: Usual auto-tuning is calculated based on ON-OFF binary regulating. The output sits between OPL and OPH. Under certain circumstances which large changes are not allowed, such as valve regulating, usually auto-tuning is not appropriate. AI-719/719P provides manual tuning to cope with this. The method is to regulate by manual output first. Auto-tuning should be activated after after the system is stable. It will calculated based on current output (between +10% and -10%) instead of that between OPL and OPH. Please note that the manual output is recommended to lie between 10%~90% and PV and output values are steady before activating the auto-tuning.

Note 1: Advanced artificial intelligent technology and PID regulating algorithm by AI-719/719P, which is named as "APID" is able to overcome the overshoot issue by standard PID algorithm.

Note 2: PID values vary from different system. Before activating the auto-tuning, set point value, SV, should be set at the commonly used value or mean value. Set the SV to a maximum one if the heat isolation of a furnace is good. SV value is not allowed to be changed during auto-tuning. The time required for this process may takes seconds to hours.

Note 3: Control Hysteresis, CHYS, affects the result of auto-tuning too. Generally the least the CHYS, the higher is the PID auto-tuning accuracy. However low CHYS value may cause incorrect ON-OFF output during fluctuating input. CHYS=2.0 is recommended.

Note 4: The PID values may not give the best performance immediately after the auto-tuning is finished. The performance will gradually improve over some time because there is a learning feature.

Note 5: Regardless of auto-tuning or manual tuning, the control period, Ctl, will be limited not longer than 3 seconds, no matter what value it is set previously, to increase the accuracy and to provide better response time (manual tuning).

2.4.3 DIN guide installation type instrument

AI-719-E5 and AI-719P-E5 are DIN rail mounted. E5 series provides no display or keypad but it supports RS485 communication with a computer or touch screen to set the parameters and operate. An optional hot-plugged accessory keypad (with two-row LED display), E8, is available. It can be handheld or installed on rail. The LED indicator lamp on the E5 instrument case will flash once during every signal sent between the instrument and computer. If the instrument has not received signals from the computer for 6s, the lamp will flash alternatively (on and off at equal time intervals). The meaning for lamp signal is explained as below.

Flashing slowly in cycle of 1.6s - No communication but the instrument works normally with no alarm.

Flashing quickly in cycle of 0.6s - No communication but there is warnings such as an alarm.

Flashing quickly in cycle of 0.3s - Out of range in input (such as broken thermocouple and thermal resistance RTD) and other severe warnings

No flash for a long time - The instrument is out of power supply or damaged;

Lamps on continuously (over 8s) - The instrument is connected with power but it has been damaged.

3. PARAMETERS AND SETTINGS

3.1 Parameter Lock (Loc) and Field Parameters

AI-719/719P 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.

3.2 The Parameter Table

The parameters can be divided to 8 groups including alarm, control, input, output, communication, system, setpoint and field parameter definition. They are listed as below in sequence:

Code	Name	Description	Setting Range
HIAL	High limit alarm	Alarm on when PV>HIAL Alarm off when PV<HIAL-AHYS, When the value set to maximum will disable this function Alarm output action can be defined by parameter AOP.	-9990～ +32000 units
LoAL	Low limit alarm	Alarm on when PV<LoAL; Alarm off when PV>LoAL+AHYS When the value set to minimum will disable this function	
HdAL	Deviation high alarm	Alarm on when PV-SV>HdAL; Alarm off when PV-SV<HdAL-AHYS When the value set to maximum 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 minimum will disable this function 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	Avoid frequent alarm on-off action because of the fluctuation of PV	0～2000 units
AdIS	Alarm display	**oFF**: Will not display alarm message in the lower display window when alarming; **on**: Alternately display alarm message in the lower display window when alarming.	oFF / on

<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:
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: When AUX is used as auxiliary output in bidirectional (heating/refrigerating) control, alarm to AU1 and Au2 won’t work.
Note 2: Installing L3 dual relay output module in ALM or AUX can implement AL2 or AU2 alarm.
</td>
<td>0～4444</td>
</tr>
<tr>
<td>CtrL</td>
<td>Control mode</td>
<td>onoF: on-off control. For situation not requiring high precision</td>
<td>onoF</td>
</tr>
</table>

		APId: advanced artificial intelligence PID control. (Recommended) **nPId**: standard PID algorithm with anti integral-saturation function (no integral when PV-SV > proportional band) **PoP**: Transmit PV. The instrument works as a temperature re-transmitter. **SoP**: Transmit SV. The instrument works program generator. **MAnS**: Downward compatible to AI-708J manual operation mode. Details please refer to manual of AI-708J.	APId nPId POP SOP MAnS
Srun	Running Status	**Run: operation control status, PRG lamp on.** **StoP: stop status, the lower display flashes "StoP", PRG lamp off.** **HoLd: keep controlling. If the instrument adopts fixed temperature control without time limit (AI-719 or AI-719P, Pno=0), this status is treated as normal status. But it is forbidden to carry out operation or stop operation from the panel. If the instrument is program step control (Pno>0), under such status the instrument will keep control output but pause timer, at the same time, the lower display will flash "HoLd", and RUN lamp flashes. Panel keys can be used to carry out operation control or stop operation to relieve "HoLd" status.** Note: "HoLd" status cannot be achieved only with panel operation, which can only be reached by directly modifying parameters or by means of programming, communication with computer or event input.	StoP / run / HoLd

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.	rE dr rEbA drbA
A-M	Automatic/ Manual Control Switch	**MAn**: Manual Control. User manually adjusts the output (OUTP). **Auto**: Automatic Control. Output (OUTP) magnitude depends on the calculations on mode set by CtrL. **FMAn**: Fixed Manual Control. This mode forbids front panel short-cut key switching back to automatic control. **FAut**: Fixed Automatic Control. This mode forbids front panel short-cut key switching back to manual control.	MAn Auto FMAn FAut
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 .	oFF / On / FoFF

P	Proportional band	Proportional band in PID and APID control. Instead of percentage of the measurement range, the unit is the same as PV. 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	I defines the integral time, in unit of second. I=0 disables the effect of integration.	0～9999 seconds
d	Time of Derivative	d defines the derivative time, in unit of 0.1 second. d=0 disables the effect of derivation.	0～3200 seconds

CtI	Control period	Small value can improve control accuracy. For SSR, thyristor or linear current output, it is generally 0.5~3 sec. For Relay output or in a heating/refrigerating dual output control system, generally 15~40 sec, 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 (equivalent of the system lag time). 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, for compressor protection.	0.2～300.0 Sec
P2	2nd Proportional band	The 2nd proportional band in PID and APID control. Instead of percentage of the measurement range, the unit is the same as PV. 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
I2	2nd Time of Integral	I defines the integral time, in unit of second. I=0 disables the effect of integration.	0～9999 seconds
d2	2nd Time of	d defines the derivative time, in unit of 0.1 second. d=0 disables the effect of	0～3200

<table>
<tr><td></td><td>Derivative</td><td>derivation.</td><td>seconds</td></tr>
<tr><td>Ctl2</td><td>2nd Control period</td><td>For SSR, thyristor or linear current output, it is generally 0.5~3 sec.
For Relay output (parameter OPt or Aut = rELy), Ctl will will be limited to more than 3 seconds, usually recommended between 20~40 seconds.</td><td>0.2～300.0 Sec</td></tr>
<tr><td>CHYS</td><td>Control Hysteresis</td><td>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.</td><td>0～2000</td></tr>
<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 (-80～+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>
</table>
</td><td>0～37</td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<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>MIO input 1: 4～20mA (I4 module installed)</td><td>34</td><td>0～5V voltage input</td></tr>
<tr><td>16</td><td>MIO input 2: 0～20mA (I4 module installed)</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>-5V～+5V</td></tr>
</table>
Note: Extended input specification (when InP=10) can be input by user or by factory, with extra service charge.
</td><td></td></tr>
<tr><td>dPt</td><td>Display Resolution</td><td>0, 0.0, 0.00 and 0.000 four display forms are available.
Note 1: For conventional thermocouple or thermal resistance inputs, 0 or 0.0 can be</td><td>0 / 0.0 / 0.00 /</td></tr>
</table>

		selected. Even if the form of 0 is selected, the internal should still maintain 0.1℃ resolution for control algorithm, when S, R or B type thermocouple is used, the form of 0 is recommended. When INP=17, 18, or 22, the internal of the instrument should maintain 0.01℃ resolution, for which 0.0 or 0.00 can be used. Note 2: When linear input is used, if the process values (PV) or other relevant parameters are larger than 9,999, the form of 0.000 is recommended rather than the form of 0, become the display form will turn into 00.00 if larger than 9,999.	0.000
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.	-1999～ +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	0～40

		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.	
Fru	Power frequency / temperature scale	**50C**: 50Hz,display ℃. , **50F**: 50Hz, display ℉ **60C**: 60Hz,display ℃. , **60F**: 60Hz, display ℉. Input has maximum anti-interference ability to 50Hz or 60Hz frequency when parameter is correctly set.	50C, 50F, 60C, 60F
SPSL	Scale low limit of external Set Point	Define the low limit of the external set point. Define the valve position feedback low limit, if the position-proportional output is used instead. This valve can be obtained automatically be valve auto-tuning.	-9999～ +30000 units
SPSH	Scale high limit of external Set Point	Define the high limit of the external set point. Define the valve position feedback high limit, if the position-proportional output is used instead. This valve can be obtained automatically be valve auto-tuning. **Warning**: *Valve position value shown is for reference only. Do not try to alter the SPSH and SPSL parameter values after the valve auto-tuning if it is not done by professionals.*	
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.	SSr rELy 0-20

		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. **0-20**: 0～20mA linear current output with X3 or X5 module in OUTP slot. **4-20**: 4～20mA linear current output with X3 or X5 module in OUTP slot. **PHA1**: Single-phase phase-shift output with K51 module in OUTP slot. **PHA1** is only for 50Hz power supply, and don't support bidirectional control system. **PHA3**: Three-phase phase-shift output with K51 module in OUTP slot. **PHA1** is only for 50Hz power supply, and don't support bidirectional control system. **nFEd**: Position-proportional output without valve feedback, controlling the direct/reverse way of valve motor. The valve running is defined by parameter Strt. **FEd**: Position-proportional output with valve feedback. The valve running should be less than 10 seconds. The valve feedback will be feed as 0~5/1~5V inputs. **No external set point is possible at this model.** **FEAt**: Valve position auto-tuning. The controller will close the valve and record the signal in parameter SPSL. It will fully open the valve and record in SPSH. It will jump back to **FEd** mode after it is done.	4-20 PHA

Aut	Auxiliary output type	Define AUX only when AUX is worked as the auxiliary output of a heating/refrigerating bidirectional systerm. **SSr**: to output SSr driver voltage or thyristor zero crossing trigger signal. G or K1 module should be installed. The output power can be adjusted by adjusting 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 AUX slot. **4-20**: 4～20mA linear current output. X3 or X5 module should be installed in AUX slot. (Not applicable for heating/refrigerating bidirectional control.) Note: In a heating/refrigerating bidirectional control system, if any of OPt or Aut is set to rELy, then CtI is limited to 3～120 seconds.	SSr rELy 0-20 4-20
OPL	Output low limit	0～100%: OPL is the minimum output of OUTP in single directional control system. -1～-110%: The instrument works for a bidirectional system, and has heating/refrigerating dual output. When ACt=rE or rEbA, OUTP (main output) works for heating, and AUX (Auxiliary output) works for refrigerating. When Act=dr or drbA, OUTP works for refrigerating, and AUX works for heating.	-110～ +110%

		In a bidirectional system, OPL for define the limitation of maximum cooling output. So, when the OPL= -100%, means no limitation on cooling output. If set OPL=-110%, it gives current output (e.g. 4~20mA) excess 10% on maximum output. When the output type is SSR output or relay output, maximum of cooling output should not set more than 100%	
OPH	Output upper limit	When PV is lower than OEF, it is required to limit the maximum output of OUTP; but when PV is larger than OEF, the modification output upper limit of the system is 100%. The instrument will automatically tune the position of valves when power on if OPH is lower than 100 when the non-feedback positions output in proportion (Opt = nFEd); if OPH=100, the instrument will automatically tune the position of valves when the output is 0% and 100%, which can reduce the starting time when power on. The setup of OPH must be larger than OPL.	0～110%
Strt	Valve running time	Strt defines valve running time when position-proportional output is used. If there is valve feedback signal, the controller will automatically determine the difference based on Strt value. The shorter the valve running time, the larger the difference will be as well as the lower the valve positioning accuracy will be. If there is no valve feedback signal or the feedback is out of range, the controller will determine the valve motor rotating time based on the contrast of Strt running time and output.	10~240 seconds

Ero	Output when out of range	When the control mode is PID or APID, Ero defines the output value when it is out of range (usually it is caused by sensor error or broken). Parameter AF2 defines the validity of Ero and set the mode. When Ero is set automatically been adjusted, the controller will save the integral output value and adjust Ero value, provided that the deviation is less than 4 measuring units. When Ero is set to be adjusted manually, it will only be adjusted by hand.	-110~110 %
OPrt	Input soft starting time when power on	If PV is lower than OEF when getting power on, the maximum allowable output of OUTP will rise to 100% after OPrt time. If PV is larger than OEF when getting power on, the rising time for input will be limited within 5s. This function is only applicable to customers with special requirements. During manual output or auto-tuning, the maximum output will not be limited by soft starting. If soft starting function is required to reduce the impact current of inductive load, Ctl shall be equal to 0.5s, while OPrt shall be equal to 5s.	0~3600s
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～ +3200
Addr	Communication address	In the same communication line, different instrument should be set to different address.	0～80

bAud	Baud rate	Range of baud rate can be 1200～19200bit/s (19.2K). COMM slot can be used for functions other than communication, by the following setting: bAud=0: COMM/AUX slot as AUX (For D2 panel only) bAud=1: As external ON-OFF input, as the same function as in MIO slot. If MIO slot is occupied, I2 module can be installed in COMM slot. bAud=2: As alarm ALM (For D panel only) bAud=3: As measurement PV re-transmission to 0~20mA bAud=4: As measurement PV re-transmission to 4~20mA	0～19.2K
Et	Event input type	When I2 ON-OFF input module was installed, event input can be carried out. **nonE**: Disable event input function **ruSt**: RUN/STOP switch. Connected in short time to start running the program. Keep connecting more than 2 sec, the program STOPs. **SP1.2**: In fixed-point control (AI-719P parameter Pno=0), set value SV=SP1 when MIO is open. SV=SP2 when MIO is closed. **PId2**: Switching 1st PID and 2nd PID. In single direction control, P, I, d and Ctl are active when MIO is open. P2, I2, d2 and Ctl2 is active instead when MIO is closed. **Eact**: External ON-OFF switch for heating/cooling. P, I, d and Ctl are active for heating regulating when MIO is open. P2, I2, d2 and Ctl2 are active for cooling regulating when MIO is closed. The cooling output is at OUTP slot. Parameter Act will be	nonE / rest / SP1.2 / PId2

		changed automatically based on the status of MIO.	
AF	Advanced Function	AF is used to select advanced function. The value of AF is calculated as below: AF=A x 1 + B x 2 + C x 4 + D x 8 + E x 16 + F x 32 + G x 64 + H x 128 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 only); D=0: The common password “808” can access full parameter table; D=1: The password to access parameter table will be “PASd” value; E=0: Normal application on HIAL and LoAL; E=1: HIAL and LoAL changed to deviation high alarm and deviation low alarm; F=0: Fine control mode. The internal control resolution is 10 times as much as that of display, but the maximum display value during linear input is 3,200 units; F=1: Wide range display mode which is selected when the required display value is larger than 3,200; G=0: When the thermocouple or RTD input is burnt out, PV value will increase and trigger the high limit alarm.	0～255

		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 H=1, MODBUS compatible communication. Note: AF=0 is recommended for non-expert users.	
AF2	Advanced Function 2	Second group of advanced functions available. The value of AF2 is calculated as below: AF2=A x 1 + B x 2 + C x 4 + D x 8 + E x 16 + F x 32 + G x 64 + H x 128 A=0: Set point by key-in or internal set; A=1: Set point by external signal, feeding in from 5V input terminals; B=0: External set point signal is 1~5V; B=1: External set point signal is 0~5V; C=0: Normal input mode; C=1: The input signal will be taken square root; D=0: SCH/SCL be the range of scale of retransmission; D=1: SPSL/SPSH be the range of scale of retransmission (DO NOT use this function when there is valve feedback signal); E=0: Outputs 0 if the input sensor wire is broken;	

		E=1: Outputs parameter Ero value if the input sensor wire is broken; F=0: Ero set automatically;(Automatically setting Ero is one of self-learning artificial intelligent control. The controller records the latest average output value at the moment when PV reaches SV. This value is used for reference by PID calculations to improve the performance. For safety, the largest Ero learning value is 70% of the output. If a larger Ero value is required, it should be set manually based on the most commonly used value.) F=1: Ero set manually; G=0: Reserved; H=0, Normal control mode; H=1, J1 module is installed in MIO slot, enabling the controller to use two thermocouples. The auxiliary thermocouple connects from 16+ 14- while the main one connects 18- 19+. When either one of those fails, the display shows “EErr” and switch to another one.	
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 can’t access the parameter table again.	0～9999
SPL	Low limit of SV	Minimum value that SV is allowed to be.	-999～

SPH	Upper limit of SV	Maximum value that SV is allowed to be.	+3000 unit
SP1	Setpoint 1	When Pno=0 or 1, SV = SP1	SPL～SPH
SP2	Setpoint 2	When I2 module installed in MIO slot and parameter Et=SP1.2, SP1 and SP2 can be switched by an external switch. If the switch is open, SV=SP1; if the switch is closed, SV=SP2.	
SPr	Ramp Slope limit (Only for AI-719P)	Once SPr was set, if PV<SV when program start, the first step of ramp slope will limited by SPr value until the temperature reach the first SV , under this limitation, the RUN lamp will keep flashing. 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-719P)	To define the number of program in use. **Pno= 0,** disable the program running mode, then AI-719P will same as AI-719 as constant temperature mode, meanwhile, can set the parameter “SPr” to limit the ramp time; **Pno=1**, AI-719P working as single program controller, with just one temperature point and one holding time’ **Pno**=**2~50**, AI-719P working as normal programmable controller.	0~30

PonP	Program run mode after power restart (Only for AI-719P)	**Cont :** Continue to run the program from the original break point. If STOP STATUS is activated before power cut, then it (the program) will keep stop status after power restart. **StoP** : Stop the program after power restart **run1** : Start to run the program from step 1 unless the instrument was in “stop” state before power cut. **dASt** : If these have deviation alarm after power resume, then stop the program, otherwise, continue run the program from the original break point. **HoLd** : Go into HOLD state after power on. If it is in StoP state before power cut, then keep in StoP State after power on.	Cont / StoP / run1 / dASt / HoLd

PAF	Program Running mode (Only for AI-719P)	PAF = Ax1 + Bx2 + Cx4 + Dx8 + Ex16 + Fx32 When A=0: Disable ready (rdy) function A=1: Enable ready (rdy) function B=0: Ramp mode. When there is temperature difference during programs, broken line transition shall be adopted. Different ramp slope modes can be set. This is also valid for cooling. B=1: Soak mode (fixed temperature mode). Each step is provided with set values SV and temperature holding time, the temperature rising rate between steps can be limited by SPr. The condition before reaching next steps can be limited by rdy parameter. Note: when B=0, if the last steps of the program is not an ending command, soak mode will override to end the program the time is up C=0: Time unit as minute C=1: Time unit as hour. D=0: Deactivate PV start function. D=1: Activate PV start function. E=0: When it is a programmable generator, the upper display shows the measurement PV E=1: When it is a programmable generator, the upper display shows the step number of the program running F=0: Standard operating mode F=1: Performing RUN operation will lead the controller into pause (HoLd) status when the program is running.	

EP1～EP8	Field parameter definition	1~8 field parameters can be defined as commonly used Loc parameters required for field operation after lock; Set nonE to hide the EP.	nonE and all parameter codes

3.3 Additional Remarks of Special Functions

3.3.1 Single-phase phase-shift trigger output

When OPt is set to PHA, installing a K51/K61 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. Currently the trigger module can be only used in 50Hz power supply.

3.3.2 Position-Proportional Output

AI-719/AI-719P is able to drive motor to control a valve, supporting two modes, with valve position feedback and without valve position feedback. For position-proportional output without valve position feedback (OPt=nFEd), if OPH is less than 100, the controller will perform valve-auto-tuning which is automatically close the valve during powering on.

The time will be valve running time. OPH limits the largest valve opening when PV is less than OEF condition. If OPH=100 is set, the controller will adjust valve position of output between 0%~100%. Then it will not adjust the valve during powering on to shorten the start up time.
For position-proportional output with valve position feedback (OPt=FEAt), the controller will automatically close the valve and then fully open the valve. The feedback signal will be used to auto-tuned and saved. Then parameter OPt will jump back to FEd and the control mode will be normal. If the feedback signal is out of range over 2%, the signal will be seek abnormal and the controller will change to the mode without feedback signal, showing “FErr” in the lower display. The feedback signal can be 1K resistance (must be used with W5 or U5 module) or 0~5V/1~5V signal (0~20mA/4~20mA current signal can be converted into linear voltage by resistor shunt). For use of position-proportional output, it is recommended to have A2, E2 and etc light bar indicator panel. The indicator will show the valve opening percentage instead of the output calculated.

3.3.3 Setpoints Switch/External program control button

If I5 module is installed in MIO slot (or bAud=1 and I2 installed in COMM slot). User can connect external on-off switch to realize some control function. Setting Et = ruSt, pressing RUN to run the program, pressing and hold for 2 seconds or longer to STOP the program. For AI-719 (or AI-719P with Pno=0) and Et = SP1.2, it can switch between two set values SP1/SP2.

3.3.4 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.

3.3.5 Communication function

S or S4 module can be installed at COMM slot to communicate with a computer. The instrument can be controlled by computer. AI instruments can be connected to the computer through RS232 or USB communication port. Every communication port of a computer can connect up to 60 AI instruments, or 80 AI instruments if a repeater is installed. A computer with 2 communication ports can connect up to 160 instruments. Please note that every instrument connecting to the same communication line should be set to a unique communication address. If the number of instrument are enough, 2 or more computers can be used and a local network can be set up.

If users want to develop their own distributed control system by themselves, the communication protocol of AI instruments can be freely offered. There are many distributed control system software support AI instruments.

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

Besides AI PID, stand PID control and on-off control, if the output is defined as current output, the instrument can also retransmit PV (measured value) or SV (setpoint) into linear current and output from OUTP. The precision of current output is 0.3%FS corresponding to displayed value. Base on that ability, AI-719 become temperature re-transmitter and AI-719P can become program generator

The corresponding parameters are set as below:

CtrL=POP: Retransmitting PV

CtrL=SOP: Retransmitting SV.

OPt, OPL, OPH and output specification choices are limited, generally 4～20mA or 0～20mA output.

InP, SCL, SCH and Scb are used for selecting input specification, setting low limit or high limit of PV and adjusting input.

For example, in order to retransmit temperature read from K thermocouple, range 0～400℃, to current 4～20mA, the parameters are set as below: InP=0, ScL=0.0, ScH=400.0, OPt=4~20, and X3 or X5 linear current module is installed in OUTP slot. When the temperature is less than or equal to 0℃, the output is 4mA. When the temperature equals to 400℃, the output is 20mA.

3.3.7 Fine control

Fine control means that the PID operating resolution is ten times as high as the display resolution. For example, the temperature signal of the instrument displays 1℃, but the internal PID still operate and control as per 0.1℃ resolution, thus can realize the control accuracy much higher than the display resolution. In former AI series

instruments, only temperature signal adopts fine control mode. The new edition approves default fine control mode when the displayed value range is below 3,000 characters (on most of industrial application occasions, the value should not exceed 3,000 characters) during linear input, so as to get higher control accuracy and more stable output. When the required display value range is larger than 3,000, AF.F=1.

3.3.8 User-defined input specifications

When INP=10, the input specification of the instrument is a kind of user-defined input type, and linear table can be edited, the setup method is as follows: set Loc parameter as 3698, and then enter the table setup status (if the original Loc=808, the Loc shall be zeroed, exit the parameter setting status, and then reenter the parameter setting status and set Loc as 3698). Of which the parameter A 00 defines the use of the table, 0 is used to input non-linear measuring, 1 is used to high temperature furnace non-linear control, with parameters of A01~A04 and d00~d60 respectively set as follows:

A 00=0

A 01 defines input type (when the table is used to build special input specifications), with values defined as follows:

A 01=A×1+E×16+G×64

A stands for instrument range: 0, 0~20mV (0-80Ω); 1, 0~60mV (0-240Ω); 2, 0~100mV (0-400Ω); 3, 0~1V; 4, 0~5V, 10, 0~20mA or 0~10V (MIO position installed with I4 or I31 module)

E=0, it means that that output value still should be determined as per ScH/ScL parameters during linear input of signals. When E=1, the table output value is the display value.

G represents resistance or voltage (current) type input signals or temperature or non-temperature type input signals, with definition as follows:

G=0, thermocouple; G=1, thermal resistance; G=2, linear voltage (current); G=3, linear resistance

For instance: if signals are 1-5V voltage inputs, they are non-temperature type, and the setup A01=4×1+0×8+0×16+2×64=132

A 02 is used to define lower input signals, lower signals x 2000/range, for instance, as for 1-5V signal inputs, the setup A02=1×2000/5=400.0

A 03 stands for the range of input signals, for instance, among 1-5V inputs, the range is 5-1V=4V, and the setup A03=4×20000/5=1600

A 04 represents the spacing of the input signal table, A04=A03/curve section No., if only one section, A04=A03=1600

d 00 stands for the starting value of the curve table, corresponding to the output value when the input signal is A02. For instance, it can be set as 0.

d 01 represents the value of the first section of the curve table, corresponding to the output value when the input signal is A02+A04. For instance, it can be set as 2,000 (full range).

d 02-d60 stands for the values of sections 2-60 of the curve table, if all applications can modify the very completed curve, such as extracting, logarithm and exponent curves.

3.3.9 User-defined transformation of output limits and control of silicon molybdenum furnace

As for non-linear high temperature furnace, the resistance will change with the temperature. Taking silicon molybdenum furnace for an example, its room temperature to resistance occupies only 6% or so of that at 1,600 degrees. If there is no limit or transformation of output power, it will lead to another problem. First of all, the current

of the electric furnace will be too large for starting at a low temperature, beyond the maximum allowable load of the grid, the silicon controlled and the transformer, which may damage the silicon controlled, the electric furnace and the transformer or cause trip. Besides, because the maximum power difference between the low temperature zone and the high temperature zone of the furnace at the same instrument output is as much as ten times, the proportional band P in the PID parameters will suffer more than ten times' variation at different temperatures to realize accurate temperature control in the high and low temperature zones. The approach to limit the parameters OPH can only limit the output power rather than the transformation of the proportional band, in order to reach accurate temperature control in the high and low temperature zones, several groups of PID must be set, which will be very complicated and low efficient.

User-defined output limit and transformation function solves the limit output and the transformation of the proportional band P at the same time, which carry out limit and transformation on the basis of measured temperatures, which not only limit the power of the low temperature zone but also automatically modify the parameters of the proportional band at different temperatures. And the limit of power and transformation of the proportional band are continuous fold line method. The following setup can be adopted in case of silicon molybdenum furnace (the customers can also change the data as required):

A00=1, A 01=1050, A 02=100.0; A03=1500; A04=750.0, d 00=120.0; d 01=1100, d02=2000

When A 00=1 and A 01=1050, the instrument starts user-defined output limit switching function, A 02 stands for the starting temperature of the output limit, A 03 stands for the highest temperature of the output limit, A 04 stands for

the sectional length of the non-linear data temperature section. In this example, 1500/750.0=2, the more sections, the more complicated and finer the curve is. d 00 stands for the maximum output power for less than A 02, with unit of 100%× (1/2000), d 00=120.0 represents 6%, d 01 represents 55%, and d 02 represents 100%.

This curve means that the output limit is 6% under 100℃, 6%-55% between 100 and 850℃, 55%~100% between 850 and 1600℃, and not 100% above 1600℃.

Note: This function cannot be used along with user-defined input functions at the same time. If special specification inputs are required at the same time, please contact the salespersons to insert them into the internal of the instrument, but a disposable additional payment may be demanded.

4. Further description for the operation of AI-719P series instrument

AI-719P program-typed temperature controller is used in the application where the setpoint should 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 Concepts and functions Program

StEP: The No. of the program Step can be defined from 1 to 50, and the current Step is the program Step being executing.
StEP time: Total run time of the program step. The unit is minute or hour. The valid value range is from 0.1~3200.
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 50 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 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:

There are 5 events handling method selectable for power resume after power cut off. Please refer to parameter PonP.

PV startup and PV preparation function (rdy function) :

At the beginning of starting a program, resuming a program after power cut or continuing to run a program after it is just modified, the PV (process value) are often quite different from the set point. PV startup function and PV preparation function can make PV and set point consistent, and avoid unexpected result. When PV startup function enabled, the instrument will adjust the running time automatically to make the expected set point is the same as the current PV.

For example, the program is set that the temperature will be raised from 25℃ to 625℃ in 600 minutes. But the current PV is 100℃, then the instrument will automatically to run this program start from 75 minutes, that mean changed the temperature raised from 100℃ to 625℃ in 525 minutes (600-75) min.

At the above situation(PV=100, SV=25, first step SV), when PV preparation function is enable, the alarm function will be blocked at that time, and PV will be adjusted to approach SV until the deviation alarm condition is released (PV is between SV-LdAL and SV+HdAL). After deviation alarm was off, the controller starts to run the program again. Preparation function (rdy Function) is helpful to keep the integrity of the program, but it will prolong the program time because the start of the program is postponed.

PV startup function is prior to PV preparation function. If both function are enabled, the system apply PV startup first, if PV startup function works, PV preparation function will not be activated.

Curve fitting:

Curve fitting is adopted as a kind of control technology for AI-719P 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+CtI) ; 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. stEP Programming and Operation

4.2.1 Ramp Mode(PAF : B=0)

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).

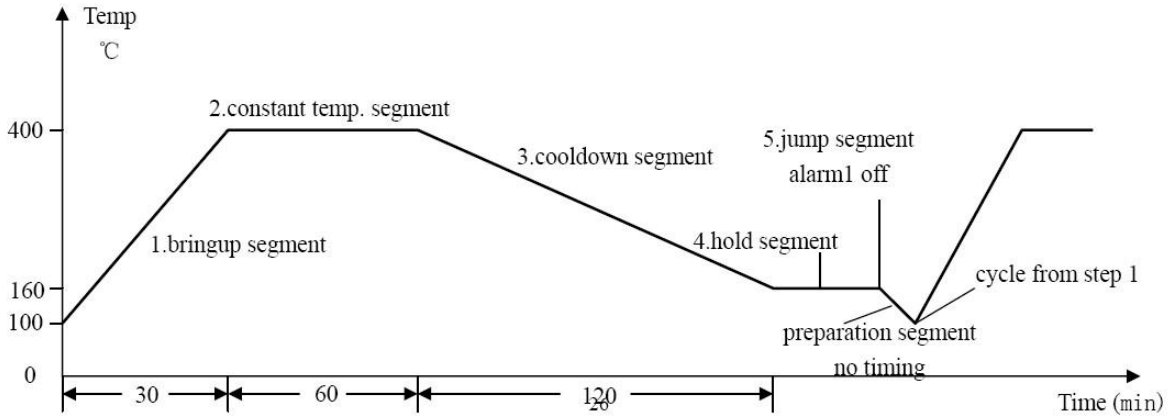
StEP2: **SP 2=400 , t 2=60.0** Temperature raised to 400℃, slope of raising curve is 10℃/minute, The program take 60 minutes to raise temperature to SP3 (400 degree). It means keep the same temperature in 60 minutes.

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.


Temp
℃
400
160
100
0
2.constant temp. segment
3.cooldown segment
5.jump segment
alarm1 off
1.bringup segment
4.hold segment
cycle from step 1
preparation segment
no timing
30
60
120
Time (min)

4.2.2 Soak mode(PAF : B=1)

Suitable for the process which does not need to establish the temperature slope, can simplify the programming and more effective. Each step also can set parameter “SPr” to define temperature raise slope, if “SPr=0” raising speed will set to maximum. Because cannot know the actual time which spend on temperature raising, user can enable “rdy” function to ensure the correct soak time.

4.2.3. Program Set Values and Time Setting

Set “t-xx” = 0.1～3200 (min)

Set the time of xx StEP. (Time units can be change to Hour by parameter “PAF”.)

Set “t-xx” = 0.0

The program hold on StEP xx, program will hold running and hold counting time.

Set “t-xx” = -121.0

The program stops, and switches to stop status.

Set “t-xx” = -0.1～-122.0

Negative value of this range represents a jump operation which will jump to step xx and event output. Range -1~-120 is for step jumping application. The step jumping cannot greater than “Pno”(No. of Program step).

Decimal point use for control the event output from AL1 and AL2. (Modular), Note, if parameter AOP was assigned alarm action will trigger from AL1 and AL2, the event output also will cause alarm from AL1 and AL2.

When set

-XXX.1, AL1 activate, AL2 release

-XXX.2, AL1 release, AL2 activate

-XXX.3, AL1 and AL2 activate
-XXX.4, AL1 and AL2 release
Example:
Example 1 : t -5 = -1.1 ; means when the program arrived step 5, AL1 activate, AL2 release and will jump to step 1 continues running
Example 2 : t-6 = -0.3 ; means when the program arrived step 6, AL1 and AL2 activate and continuous next step.
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-719P has the advanced function of flexible program arrangement. Normally, when the program stops, the StEP will be automatically set to1. Thus if StEP is not change to other value, a program will start from step1. If multiple curves are defined, the control can jump to different curve by setting step 1 as jump segment.

Example: There are three curves with the length of 3 steps represent three groups of process parameter, they are separately arranged on StEP2-StEP4, StEP5-StEP7, StEP8-StEP10. Settings are as follows:
t- 1=-2.0 Execute the program of curve 1 (StEP2-StEP4)
t- 1=-5.0 Execute the program of curve 2 (StEP5-StEP7)
t- 1=-8.0 Execute the program of curve 3 (StEP8-StEP10)

Note: Can choose the curves by setting the value of StEP “t-1“ set to -2.0, -5.0 or -8.0 before the program startup.