Yudian (H.K.) Automation Technology Co. Ltd.
Website: http://www.yudian.us http://www.yudian.com.hk
Email: sales@yudian.com.hk
Tel: +852-2770 8785 Fax: +852-2770 8796

AI-519 ARTIFICIAL INTELLIGENCE INDUSTRIAL CONTROLLER

Operation Instruction

Ver. 8.2

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

CONTENTS

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1. SUMMARY

1.1 Main Features

- Universal thermocouples and selectable RTDs and linear current/voltage signals. Integrating non-linear graduation tables, digital calibration and auto zero technology to achieve accurate and stable measurement.
- Advanced artificial intelligence (AI) control algorithm with auto tuning function without overshooting.
- Auto/manual bumpless switch and soft-start function.
- New generation X3 and X5 current output modules with accuracy 0.2%F.S., improving the precision of control and retransmission.
- Advanced modular structure giving plenty of output options to satisfy all kinds of applications. Quick delivery and easy maintenance.
- User-friendly and customized operating interface for easy learning and simple manipulation. All parameters can be promoted to quick operator access in Field Parameter Table or kept in password protected Full Parameter Table.
- Worldwide power supply of 100-240VAC or 24VDC and various dimensions. Power frequency 50Hz or 60Hz and unit of ℃/ ℉ are selectable in parameter.
- High quality hardware design, using high performance tantalum capacitor or ceramic capacitor. Compared to competing models, it consumes less electricity, experiences less temperature shifting, provides higher stability and reliability, and can work in a wider range of temperature.
- ISO9001 and CE certified, achieving world class level of quality, anti-interference ability and safety.

POINTS TO NOTE

- Always adjust parameters according to input / output type and function. Only correctly wired instruments with appropriate parameters shall be put into use.

1.2 Ordering Code Definition

AI series instruments adopt advanced modularized hardware design. There are maximum five module slots: multi-function input/output (MIO), main output (OUTP), alarm (ALM), auxiliary output (AUX) and communication (COMM). The modules can be purchased in bundle with instrument or separately, and can be installed easily. The input type can be freely set to thermocouple, RTD, or linear current/voltage.

The ordering code of AI-519 series instrument is made up of 8 parts. For example:

AI-519	A	N	X3	L5	N	S4	—	24VDC
①	②	③	④	⑤	⑥	⑦		⑧

It implies that the model is AI-519, front panel dimension is 96×96mm, no module installed in MIO (Multi-function I/O) slot, X3 linear current output module installed in OUTP (main output), L5 (dual relay contact output module) in ALM (alarm), no module installed in AUX (auxiliary output), RS485 communication interface with photoelectric isolation is installed. The power supply of the instrument is 24VDC.

Order code in details:

① **Model of the instrument**

AI-519 economical type instrument with measurement accuracy 0.3%F.S. It adopts artificial intelligent control technology, with functions of auto/manual bumpless switch.

② **Front panel dimension**

A front panel 96×96mm(width×height), cut out $92^{+0.5}$×$92^{+0.5}$mm, depth behind mounting surface 100mm.

A2 On top of A, there is additional light bar with 25 segments and 4 levels of luminosity.

B front panel 160×80mm(width×height), cut out $152^{+0.5}\times76^{+0.5}$mm, depth behind mounting surface 100mm.

C front panel 80×160mm(width×height), cut out $76^{+0.5}\times152^{+0.5}$mm, depth behind mounting surface 100mm.

C3 On top of C, there is additional light bar with 50 segments and 2 levels of luminosity.

D front panel 72×72mm(width×height), cut out $68^{+0.5}\times68^{+0.5}$mm, depth behind mounting surface 95mm

D2 front panel 48×48mm(width×height), cut out $45^{+0.5}\times45^{+0.5}$mm, depth behind mounting surface 95mm, with 10 terminals

D5 width 22.5mm, DIN-Rail mount, external keypad E8 (or communication if address/BAUD rate is correct) required for display and parameter setting

D6 front panel 48×48mm(width×height), cut out $45^{+0.5}\times45^{+0.5}$mm, depth behind mounting surface 95mm, with 12 terminals

E front panel 48×96mm(width×height), cut out $45^{+0.5}\times92^{+0.5}$mm, depth behind mounting surface 100mm

E2 On top of E, there is additional light bar with 25 segments and 4 levels of luminosity.

E5 48×96mm(width×height), DIN-Rail mount, external keypad E8 (or communication if address/BAUD rate is correct)) required for display and parameter setting

F front panel 96×48mm(width×height), cut out $92^{+0.5}\times45^{+0.5}$mm, depth behind mounting surface 100mm

③ **Module type of multiple function I/O (MIO). N means none, no module installed.**

I2 Single channel on-off signal input module. When a n external switch is connected, SV=SP1 When the switch is open; SV=SP2 when the switch is closed.

I4 4~20mA/0~20mA analogue input module, with 24VDC power supply. Directly connecting to 2-wire transmitter.

V24/V12/V10 Isolated 24V/12V/10V DC voltage output module with maximum current of 50mA, supplying power for external transmitter.

④ **Module type of main output (OUTP). For control output or SV/PV retransmission.**

L1 Large capacity, large size, normal open relay output module (Capacity: 250VAC/2A)

L2 Small capacity, small size, normal open + normal close relay output module (Capacity: 250VAC/1A recommended for alarm)

L4 Large capacity, small size, normal open + normal close relay output module (Capacity: 250VAC/2A)

K1 “Burnt-proof” single-phase thyristor zero crossing trigger output module, triggering one loop of a TRIAC or a pair of inverse parallel SCR with current of 5~500A.

K3 “Burnt-proof” three-phase thyristor zero crossing trigger output module, triggering 3-phase circuit. Each loop can trigger TRIAC or a pair of inverse parallel SCR with current of 5~500A.

K5 “Burnt-proof” single-phase thyristor phase-shift trigger output module, suitable for 200～240VAC power grid.

K6 “Burnt-proof” single-phase thyristor phase-shift trigger output module, suitable for non-standard power environment below 380VAC.

X3 Photo-electric isolated linear current output module, 0~20mA or 4~20mA, occupying internal 12VDC power.

X5 Photo-electric isolated linear current output module, 0~20mA or 4-20mA. Equipped with isolated power supply without occupying internal 12VDC power.

W1 TRIAC no contact normal open discrete output module (Capacity: 100~240VAC/0.2A, burnt-proof)

W2 TRIAC no contact normal closed discrete output module (Capacity: 100~240VAC/0.2A, burnt -proof)

G Solid-state relay, SSR voltage output module (DC12VDC/30mA)

⑤ **Module type of alarm (ALM). For AL1 and AL2 alarm outputs.**

L0 Large capacity, large size, normal open relay output module (Capacity: 250VAC/2A, recommended for alarm)

L0/L2/L4 Single relay output alarm, support AL1 one channel alarm

L3 Dual normal open relay output module, support AL1 and AL2 alarm

⑥ **Module type of auxiliary output (AUX). For AU1 and AU2 alarms and control auxiliary output.**

L0/L1/L2/L4 Single relay output alarm

L3 Dual normal open relay output module, support AL1 and AL2 alarm

G Solid-state relay, SSR voltage output module (DC12VDC/30mA)

W1 TRIAC no contact normal open discrete output module (Capacity: 100~240VAC/0.2A, burnt-proof)

W2 TRIAC no contact normal closed discrete output module (Capacity: 100~240VAC/0.2A, burnt -proof)

R RS232 communication interface module, occupying internal 12VDC power.

⑦ **shows the module type of communication (COMM).**

S RS485 photo-electric isolated communication interface module, occupying internal 12VDC power.

S1 RS485 photo-electric isolated communication interface module, occupying internal 24VDC power.

S4 RS485 photo-electric isolated communication interface module, with isolated DC/DC power convertor, without drawing power from instrument internally.

SL RS485 photo-electric isolated communication interface module + single channel normal open relay output module, occupying internal 12VDC power.(Only available for D6 panel size)

⑧ **Power supply of the instrument.** If left blank, the power of the instrument is 100-240VAC. 24VDC means the power supply of 20~32VDC or AC power (24V AC power has to be specified upon order).

POINTS TO NOTE

1. K3 module occupies two slots, OUTP and MIO. MIO cannot be used if K3 is installed. If setpoint switching feature is required, put I2 module in COMM slot. Then set parameter bAud to 1. Two setpoints switching function can be used in COMM instead of MIO.

2. The voltage output modules like V24, \/10 or V12 are often used for supplying power for external transducer or feedback resistance of transmitter. These modules can be installed in any slot except that of D6 dimension instrument. To standardize the wiring, it is recommended to be installed in the first idle slot in the order of MIO, AUX, and COMM.

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.

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 (24V/12V/10V voltage output module), I2 (on-off signal input module) and I4 (linear current input module). The 12V power is commonly supplies output or communication module. Generally, the relay contact output and TRIAC no contact discrete output are self-insulated from the other circuit, no matter whether other modules are installed or not. SSR voltage output 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 X4, which has its own isolated power supply. For example, if an X module is installed in OUTP (main output) slot, and an S or X module is installed in COMM (communication interface) slot, then OUTP and COMM cannot be electric isolated, so S or X should be replaced with S4 or X4.

No contact switch module: W1 and W2 are new types of no contact switch modules which apply the advanced technology of “burn proof” and zero crossing conduction. It can replace the relay contact switch. Compared to the relay contact output module, W1 and W2 have longer life and lower interference. They

can largely decrease the interference spark of the equipment, and greatly improve the stability and reliability of the system. Since the driver element is TRIAC, it is suitable for controlling 100-240VAC (not for DC power) with current up to 80A. For the current larger than 80A, an intermediate relay is needed. 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.

Relay 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. There are four types of relay modules: L1, L2, L3 and L4. For control output, L1 or L4 large capacity module is recommended. L4 is equipped with high performance relay with small volume and large capacity but it costs higher. L2 module is small in size. Both of its normal open and normal close terminals have varistor spark absorption but the capacity is small. It is suitable for alarm output. L1 and L are large in size and large capacity. For those panel size with 48mm width (including D6, E, F and etc). large size modules cannot be installed in both PCB board. L3 provides dual output to support two loops of alarm, for example, AL1+AL2. If mechanical switch is not preferred or L3 is not allowed due to size limitation mentioned above, G5 (dual SSR DC voltage output) with external SSR can be chosen.

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

Warranty and maintenance: Free repair and maintenance will be given in specified period of time since the delivery. In order to get full and correct repair, please state clear the phenomena and causes of the malfunction of the instrument.

1.3 Technical Specification

- **Input type: (universal input)**

  Thermocouple: K, S, R, E, J, T, B, N, WRe3-WRe25, WRe5-WRe26 etc

  Resistance temperature detector: Cu50, Pt100

  Linear voltage: 0～5V, 1～5V, 0～1V, 0～100mV, 0～20mV, 0~500mV etc

  Linear current (I4 module in MIO): 0～20mA, 4～20mA, two-wire transmitter etc.

  Extended input: By keeping all native input specification, another extra specification can be ordered (gradient table may be required).

- **Measurement 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℃)

  Cu50(-50～+150℃), Pt100(-200～+800℃)

  Linear Input: -9990～+32000 units defined by user.

- **Measurement accuracy :** 0.3 (0.3%FS ± 0.1℃)
- **Resolution :** 0.1℃ for K, E, J, N, Cu50, Pt100; 1℃ for S, R
- **Temperature shift :** ≤0.015%FS /℃ (typical value is 70ppm/℃)
- **Sampling cycle :** A/D converter sampling 8 times per second
- **Response time :** ≤1s (when digital filter parameter FILt=1)
- **Alarm function:** Four different alarm type, high limit, low limit, deviation high limit and deviation low limit, optional with alarm blocking at the beginning of power on.
- **Control mode:**

  On-off control mode (Hysteresis adjustable)

  Standard PID with auto tuning

AI PID with auto tuning, adopting AI artificial intelligence algorithm.

- **Control Period :** 0.5～120.0 seconds selectable at interval of 0.5 seconds
- **Output mode (modularized)**

Relay contact output (NO+NC, L1 or L4 module): 250VAC/2A 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 SSR).

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

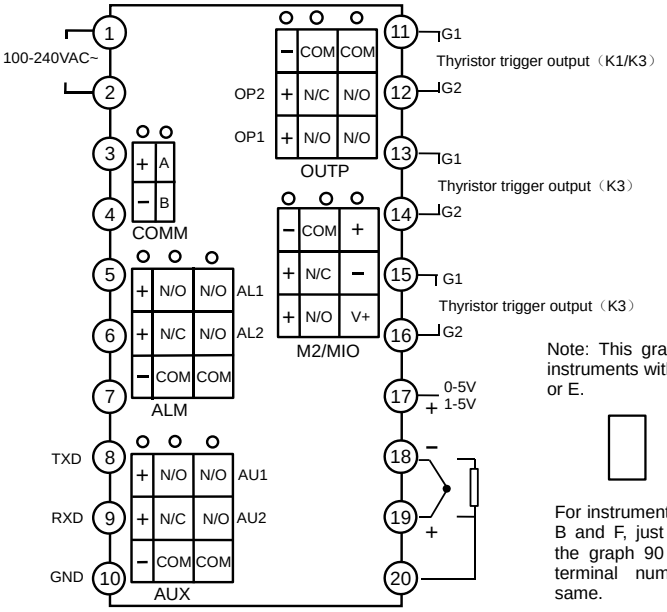
Linear current output: 0～20mA or 4～20mA (Output voltage ≥11V, maximum load resistance 500ohm, output precision 0.2%FS)

- **Electromagnetic compatibility (EMC) :** ±4KV/5KHz according to IEC61000-4-4; 4KV according to IEC61000-4-5.
- **Isolation withstanding voltage :** between power, relay contact or signal terminal ≥2300VDC; between isolated electroweak terminals ≥600VDC
- **Power Supply :** 100～240VAC, -15%, +10% / 50-60Hz; 120～240VDC; or 24VDC/AC, -15%, +10%.
- **Power consumption:** ≤6W
- **Operating Ambient :** temperature -10～60℃; humidity ≤90%RH
- **Front panel dimension:** 96×96mm, 160×80mm, 80×160mm, 48×96mm, 96×48mm, 48×48mm, 72×72mm
- **Panel cutout dimension:** 92×92mm, 152×76mm, 76×152mm, 45×92mm, 92×45mm, 45×45mm, 68×68mm
- **Depth behind mounting surface:** ≤100mm

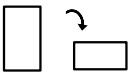
●

1.4 Rear Terminal Layout and Wiring

Wiring diagram at back side



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



For instruments with dimension B and F, just clockwise rotate the graph 90 degree and the terminal numbers keep the same.

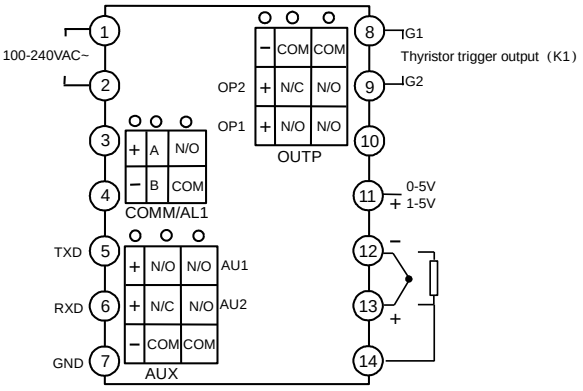
1: For linear voltage input, if the range is below 500mV, connect to terminals 19 and 18. 0～5V or 1～5V signal can be input from terminals 17 and 18.

2: 4～20mA signal can be converted to 1～5V signal by a 250 ohm resistor and input from terminals 17 and 18. If I4 module is installed in MIO slot, 4～20mA signal can be input from terminals 14+ and 15- and 2-wire transmitter can be input from terminals 16+ and 14-.

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

4: Main output from terminals 13+ 11- as current output, single channel SSR voltage output.

Wiring diagram of D size instruments (72×72mm)

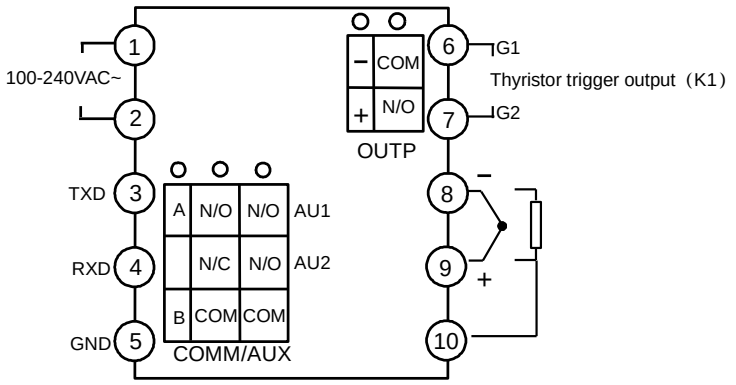


1: Linear voltage signal of range below 500mV input from terminals 13 and 12. 0～5V and 1～5V input from terminals 11 and 12.

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

3: S, S1 or S4 module can be installed in COMM slot for communication. If relay, TRIAC no contact switch, or SSR driver voltage output module is installed in COMM, it can be used as AL1 alarm output. If I2 module is installed in COMM and parameter “bAud” set to 1, then on-off signal in MIO is simulated. Setpoints SV1 and SV2 can be switched by connecting an external mechanical switch at terminals 3 and 4.

Wiring diagram of D2 size instruments (48×48mm)



1: D2 size instruments don not support native 0～5V or 1～5V linear voltage input. The workaround is done by voltage divider into 0～500mV or 100～500mV. External precise resistor 25ohm can be parallel shunt to convert 4～20mA to 100～500mV then input from terminals 9 and 8.

2: For COMM/AUX slot,

installing S or S4 communication module provides communication, installing L2 module provides AU1 alarm output,

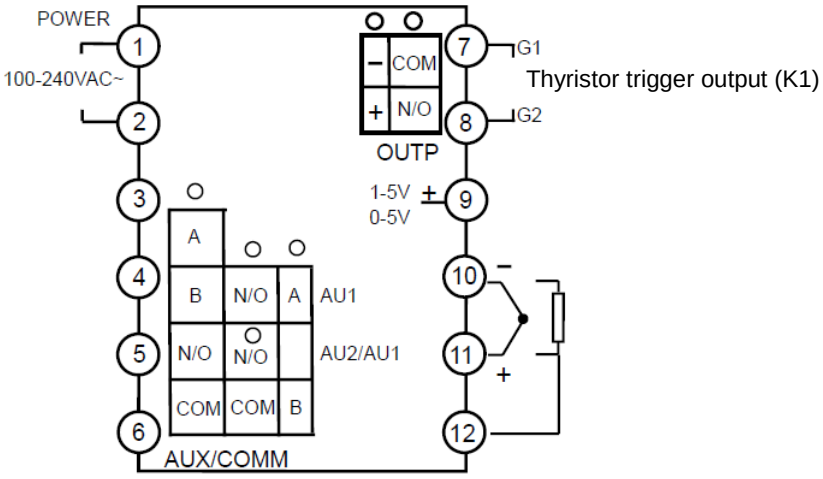
installing L2 module provides AU1 alarm output,

installing L3 dual relay module (with parameter bAud=0) provides AU1 and AU2 alarm output,

installing L3 (with parameter bAud=2) provides AU1 and AL1 alarm output,

installing I2 module (with parameter bAud=1) provides MIO on-off input simulation SP1/SP2. The external switch should be connected to terminal 3 and 5.

Wiring diagram of D6 size instruments (48×48mm)



1: Linear voltage of 500mV below input from terminal 10, 11. 0～5V or 1～5V linear voltage input from terminal 9 and 10.

2: External precise resistor 250ohm can be parallel shunt to convert 4～20mA to 1～5V then input from terminals 9 and 10.

3: For COMM/AUX slot, installing S or S4 communication module provides communication,

installing L2 module provides AU1 alarm output,

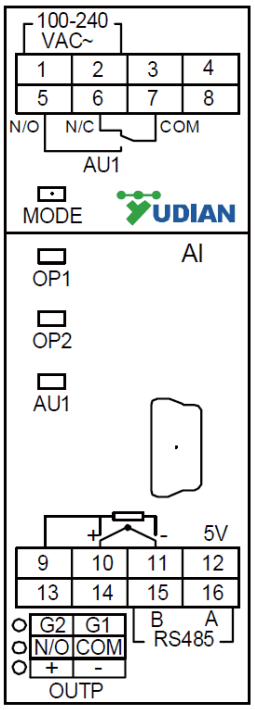
installing L3 dual relay module (with parameter bAud=0) provides AU1 and AU2 alarm output,

installing SL module provides RS485 communication and AU1 alarm output.

Wiring diagram of D5 size instruments

1: D5 size instrument are fixed with one channel alarm and communication.

2: Main output can be selected among G, X5, L2, K1, K5, K6 or W1.



Wiring diagram of D7 size instruments (22.5 x 100mm)

1: Input

0~5V/1~5V input from 12+, 11-

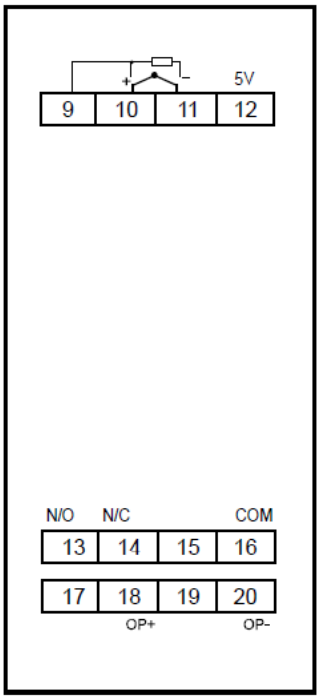
500mV below input from 10+, 11-

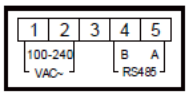
4~20mA with 250ohm shunt resistor converted to 1~5V, input from 12+, 11-

2: Fixed with one channel alarm and communication

3: Main output can be selected among G, X3, L2, K1, K5, K6 or W1. Alarm is mandatorily defined as AU1

4: Instrument power and communication wires are connected to the back side connectors along the rail.





Wiring diagram of E7 size instruments (22.5 x 100mm)

1: **Input**

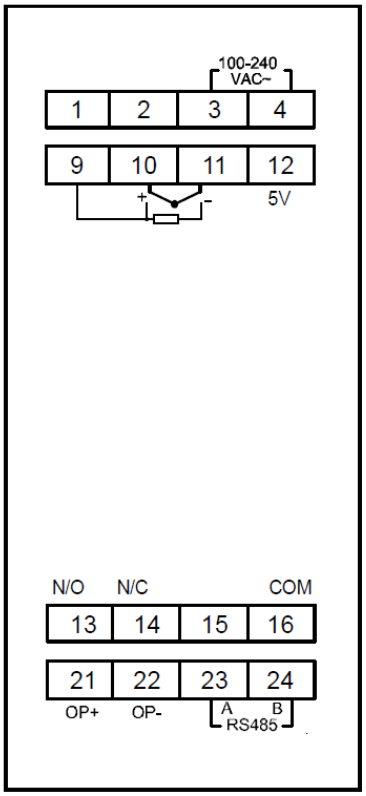
0~5V/1~5V input from 12+, 11-

500mV below input from 10+, 11-

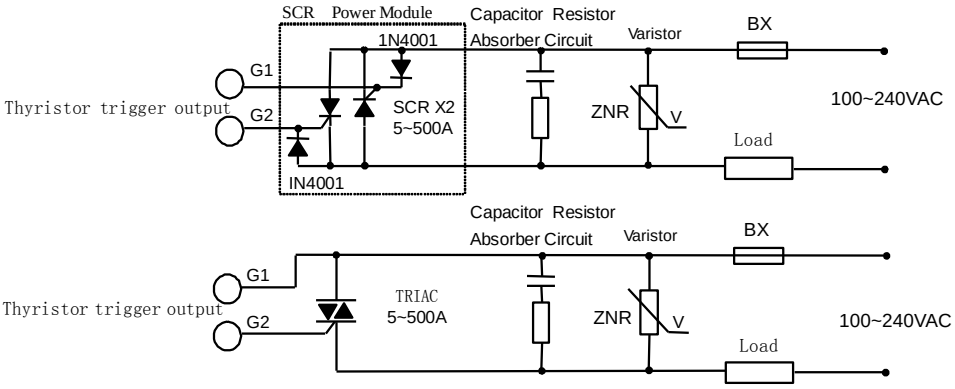
4~20mA with 250ohm shunt resistor converted to 1~5V, input from 12+, 11-

2: Fixed with one channel alarm and communication

3: Main output can be selected among G, X3, L2, K1, K5, K6 or W1. Alarm is mandatorily defined as AU1



Thyristor trigger output wiring diagram (applicable for K1, K3, K5 or K6 module)



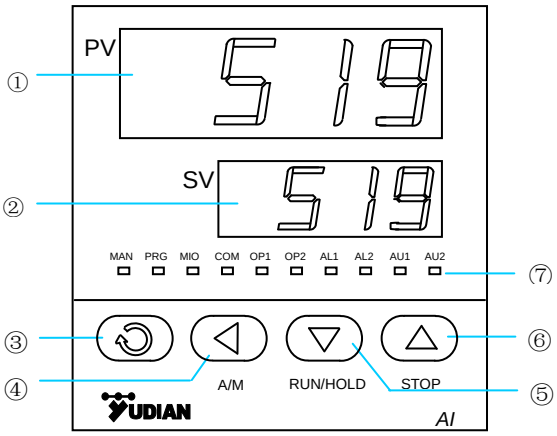
1: According to the voltage and current of load, choose suitable varistor to prevent the thyristor. Capacitor resistor absorber is needed for inductance load or phase-shift trigger output.

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

3: K5 phase-shift trigger module is only suitable for 200～240VAC / 50Hz power. K6 phase-shift trigger module is only for 380VAC below non-standard environment.

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 code.

③ Setup key, for accessing parameter table and conforming parameter modification.

④ Data shift key, and also for auto tuning, auto/manual switch.

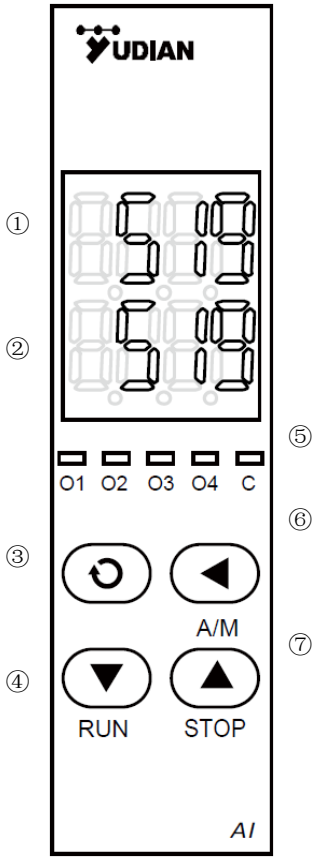
⑤ Data decrease key, and also run/pause switch

⑥ Data increase key, and also stop key

⑦ LED indicator. PRG indicator is non-applicable for AI-519. The lighting of MAN means in manual output status. MIO, OP1, OP2, AL1, AL2, AU1 and AU2 indicate I/O operation of the corresponding module. For example, That the COMM indicator is lighting means that 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 setpoint (SV). This status is called basic display status. When the input signal is out of the measurable range (for example, the thermocouple or RTD circuit is break, or input specification sets wrong), the upper display window will alternately display “orAL” and the high limit or the low limit of PV, and the instrument will automatically stop output. If the lower display window alternately display “HIAL”, “LoAL”, “HdAL” or “LdAL”, it means high limit alarm, low limit alarm, deviation high alarm, and deviation low alarm happening. The alarm display can also be turned off by setting parameter AdIS to oFF. If “EErr” is displayed, it means internal self-test error, and the instrument should be sent back for repair.

2.2 D7/E7 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.

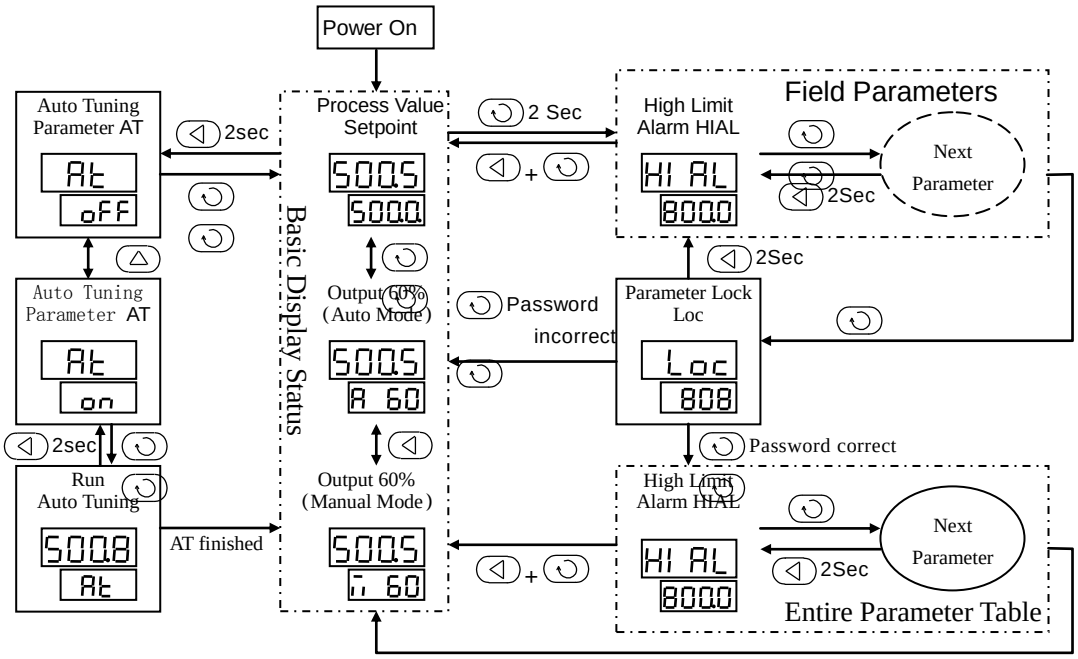
④ Data decrease key, and also run/pause switch

⑤ Five LED indicator. O1, O2, O3 and O4 represents OP1, OP2, AU1 and AU2 respectively. C indicator flashes during it is communicating with upper device.

⑥ Data shift key, and also setpoint control operation

Data increase key, and also stop key

2.3 Parameter Setting Flow Chart



2.4 Operation Description

Parameter Setting

In basic display status, press and hold for about 2 seconds can access Field Parameter Table. Pressing can go to the next parameter; pressing 、 or can modify a parameter. Press to decrease the data. Press to increase the data. The decimal place dot flashes where the data is changing, looking like a mouse cursor. Press the button and hold, the speed of data change will go faster, and going further faster along with the shift of cursor. Press to direct move the cursor. Press and hold can return to the preceding parameter. The parameter will be saved. Press (don't release) and then press key simultaneously can escape from the parameter table. The parameter will be saved. 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.

In Field Parameter Table, press till the last field parameter Loc appears. Setting Loc=password and then press can access System Parameter Table.

Setpoint / Output Magnitude Switch

In the basic display status, pressing can switch lower display window between displaying setpoint or output magnitude. If the instrument is in manual operating mode, even the lower display window is switched to setpoint display, it will automatically return to output magnitude display after a period of time.

Setpoint (SV) Setting

If the parameter lock “Loc” isn't locked, we can set setpoint (SV) by pressing , or . The range of setpoint is between the parameter SPL and SPH.

Auto / Manual Control Mode Switch (A/M)

When output magnitude is displayed in lower display window, pressing AT key ( ) can switch between auto-control and manual control without bumping. If the instrument is in manual control mode and the lower display window is

displaying output magnitude, the output magnitude can be modified by pressing ⟨▽⟩ or ⟨△⟩. By setting M-A parameter, the instrument can be locked at automatic or manual control mode to avoid entering manual operation by mistake.

Auto Tuning (AT)

When artificial intelligence PID control or standard PID control is chosen (CtrL=APId or nPId), the PID parameters can be obtained by running auto-tuning. In basic display status, press ⟨◁⟩ for 2 seconds, the “At” parameter will appear. Press ⟨△⟩ to change the value of “At” from “oFF” to “on”, then press ⟨↵⟩ to active the auto-tuning process. During auto tuning, “At” will flash at lower display window and the instrument executes on-off control. After 2 cycles of on-off action, the instrument will obtain the values of PID control parameters. If you want to escape from auto tuning status, press and hold ⟨◁⟩ for about 2 seconds until the "At" parameter appears again. Change “At” from “on” to “oFF”, press ⟨↵⟩ to confirm, then the auto tuning process will be cancelled. After satisfying PID parameters are obtained, At is recommended to be “FoFF” which prevents activating auto tuning in basic display status.

Note 1: The advanced artificial intelligence algorithm is able to avoid overshooting problem of standard PID algorithm and achieve precise control.

Note 2: If the setpoint is different, the parameters obtained from auto-tuning are possibly different. So you’d better set setpoint to an often-used value or middle value first, and then start auto-tuning. For the ovens with good heat preservation, the setpoint can be set to the highest applicable temperature. It is forbidden to change SV during auto tuning. Depending on the system, the auto-tuning time can be from several seconds to several hours.

Note 3: Parameter CHYS (on-off differential, control hysteresis) has influence on the accuracy of auto-tuning. Generally, the smaller the value of CHYS, the higher is the precision of auto tuning. But the value of CHYS parameter should be large enough to prevent the instrument from error action around setpoint due to the oscillation of input. CHYS is recommended to be 2.0.

Note 4: AI series instrument has the function of self-adaptation. It is able to learn the process while working. The control effect at the first run after auto tuning is probably not perfect, but excellent control result will be obtained after a period of time because of self-adaptation.

3. PARAMETERS AND SETTINGS

3.1 Parameter Lock (Loc) and Field Parameters

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

The parameters need to be displayed and modified in the work field are called Field Parameters. The set of field parameters is a subset of the whole parameter set, and can be freely chosen by user.

Loc can authorize different security right as below:

Loc=0～1, allowed to modify field parameters and setpoint, and execute auto tuning;

Loc=2, allowed to modify field parameters, but can’t modify setpoint.

Loc=3～255: can only modify “Loc”

Setting Loc=PASd (Password, a number between 256 and 9999. Default is 808) and then pressing ⟨↵⟩ to confirm will enter the complete parameter table and modify all parameters.

1 to 8 field parameters can be defined by parameters EP1 to EP8. If the number of the field parameters is less than 8, the first idle EP parameter should be set to “nonE”.

Parameters	EP1	EP2	EP3	EP4	EP5	EP6	EP7	EP8	Loc
Default Value	HIAL	LoAL	HdAL	LdAL	nonE	nonE	nonE	nonE	0

You can redefine field parameters and Loc to change operation style. For example, you can execute auto tuning from field parameter instead of by pressing ⟨◁⟩ in basic display status, and only take HIAL and HdAL as field parameter.

Parameters	EP1	EP2	EP3	EP4	EP5	EP6	EP7	EP8	Loc	At
Default Value	HIAL	HdAL	At	nonE	nonE	nonE	nonE	nonE	0	FoFF

3.2 Complete 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 (Process Value) >HIAL; alarm off when PV<HIAL-AHYS Alarm output action can be defined by parameter AOP.	-9990～+30000 units
LoAL	Low limit alarm	Alarm on when PV<LoAL; alarm off when PV>LoAL+AHYS	
HdAL	Deviation high alarm	Alarm on when PV-SV>HdAL; alarm off when PV-SV<HdAL-AHYS	
LdAL	Deviation low alarm	Alarm on when PV-SV<LdAL; alarm off when PV-SV>LdAL+AHYS 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 : don't display AdIS in the lower display window when alarming; on : alternately display AdIS in the lower display window when alarming.	oFF on
AOP	Alarm output allocation	From right side to left side, the first, second, third and fourth digit of AOP individually indicate the alarm output terminal of HIAL, LoAL, HdAL, and LdAL. 0 shows no output. 1,2,3 or 4 indicates alarm outputted to AL1, AL2, AU1 or AU2. For example, **AOP = 3 3 0 1** **LoAL HdAL LoAL HIAL** It shows that HIAL is sent to AL1, LoAL has no output, HdAL and LdAL are sent to AU1. Note 1: When AUX is used as auxiliary output in bidirectional (heating/refrigerating) control, allocating alarm to AU1 and AU2 does no effect. Note 2: Installing L3 dual relay output module in ALM or AUX can implement AL2 or AU2 alarm.	0～4444
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 (no integral when PV-SV > proportional band); POP: output PV. The instrument works as a temperature retransmitter. SOP: output SV. The instrument works as a set current output.	onoF APId nPId POP SOP
Act	Acting method	rE: Reverse acting. Increase in measured variable causes an 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	Auto/Manual Control Mode Selection	MAn: Manual control mode. Manually adjust output value of OUTP. Auto: Auto control mode. The instrument calculate and control the output value. FMAn: Fixed in manual control mode. Forbid switching to auto-mode by short-cut keys from panel. FAut: Fixed in auto control mode. Forbid switching to manual mode by short-cut keys from panel.	MAn Auto FMAn FAut
At	auto tuning	oFF: Auto tuning function is disable on: Active auto turning function to calculate the values of parameters P, I, d and CtI. After auto tuning is accomplished, "At" will be automatically changed to oFF. FoFF: Auto tuning is disabled, and activating auto tuning from basic display status is forbidden.	
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 be obtained by auto tuning. They can also be manually input if you already know the correct values.	10～9999 units
I	Time of Integral	No integral effect when I=0	0～9999 seconds
d	Time of Derivative	No derivative effect when d=0	0～999.9 seconds
CtI	Control period	Small value improves control accuracy. For SSR, thyristor or linear current output, 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.	0.5～120.0 seconds

<table>
<tr><td></td><td></td><td>CtI is recommended to be 1/4 – 1/10 of derivative time. (It should be integer times of 0.5 second.)
When output type is set to relay (OPt or Aut is set to 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.</td><td></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 (refrigerating) system, when PV<SV, output turns off; when PV>SV+CHYS, output turns on.</td><td>0～2000 units</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>
<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>WRe5-Wre26</td><td>31</td><td>0～500mV voltage input</td></tr>
<tr><td>10</td><td>extended input specification</td><td>32</td><td>100～500mV 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
(Module I4 in MIO)</td><td>34</td><td>0～5V voltage input</td></tr>
<tr><td>16</td><td>0～20mA
(Module I4 in MIO)</td><td>35</td><td>0～10V</td></tr>
<tr><td>17</td><td>K (0~300.00℃)</td><td>36</td><td>2～10V</td></tr>
<tr><td>18</td><td>J (0~300.00℃)</td><td>37</td><td>0～20V</td></tr>
</table>
Note 1: Setting InP=10 for extended input. If user specified gradient input other than provided upon ordering, for example, WRe520, JPt100 (BA2), G(Cu53), F2, Square root of 0～5V or 1～5V, INP=10 will be used up.
Note 2: Input specification and related parameter are already set in factory if the input is specified upon order.</td><td>0～37</td></tr>
<tr><td>dPt</td><td>Radix point position</td><td>Four formats (0, 0.0, 0.00, 0.000) are selectable
1: For thermocouples or RTD input, only 0 or 0.0 is selectable, and the internal resolution is 0.1. When S or R thermocouple is used, dPt is recommended to be 0.
2: When linear input is used and measurement value or corresponding parameter value may be larger than 9999, please avoid choosing 0 but 0.000 instead. The display value will become 00.00 when the value is larger than 9999.</td><td>0, 0.0, 0.00, 0.000</td></tr>
<tr><td>ScL</td><td>Signal scale low limit</td><td>Define scale low limit of input. It is also the low limit of transmitter output (CtrL=POP or SOP) and light bar display.</td><td rowspan="2">-9990～ +30000 units</td></tr>
<tr><td>ScH</td><td>Signal scale high limit</td><td>Define scale high limit of input. It is also the high limit of retransmission output (CtrL=POP or SOP) and light bar display.</td></tr>
<tr><td>Scb</td><td>Input Shift Adjustment</td><td>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</td><td>-1999～ +4000 units</td></tr>
<tr><td>FILt</td><td>PV input filter</td><td>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.</td><td>0～40</td></tr>
<tr><td>Fru</td><td>Selection of power frequency and temperature scale</td><td>50C: 50Hz, ℃. Input has maximum anti-interference ability to 50Hz frequency;
50F: 50Hz, ℉. Input has maximum anti-interference ability to 50Hz frequency;
60C: 60Hz, ℃. Input has maximum anti-interference ability to 60Hz frequency;
60F: 60Hz, ℉. Input has maximum anti-interference ability to 60Hz frequency;</td><td>50C, 50F, 60C, 60F</td></tr>
<tr><td>OPt</td><td>main output type</td><td>SSr: to output SSr driver 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,</td><td>SSr
rELy
0-20
4-20
PHA</td></tr>
</table>

		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. PHA: single-phase phase-shift output. K5 module should be installed in OUTP slot. PHA is only for 50Hz power supply, and don't support bidirectional control system.	
OPL	Output low limit	0～100%: OPL is the minimum output of OUTP in single directional control system. -1 ～ -120%: the instrument works as a bidirectional system having heating/refrigerating dual output. When Act=rE or rEbA, OUTP (main output) works as heating, and AUX (Auxiliary output) works as refrigerating. When Act=dr or drbA, OUTP works as refrigerating, and AUX works as heating. In a bidirectional system, the heating and refrigerating ability are generally different. OPL = -(power when AUX output is maximum /power when OUTP output is maximum) x 100%. For example, for a heating/refrigerating air condition, its maximum power of refrigerating is 4000W, and maximum power of heating is 5000W, and AUX works as refrigerating, then OPL=- (4000/5000)x100% = -80% The range of AUX output can't be freely defined by user. If the internal calculation requires maximum output of AUX (AUX output=OPL), then in 4～20mA output, the AUX output is 20mA. User can't limit the maximum AUX output to 10mA.	-120～ +100%
OPH	Output upper limit	OPL limits the maximum of OUTP (main output) when PV<OEF. OPH should be greater than OPL.	0～110%
OPrt	Soft start time	At the beginning of power on, if PV<OEF, it takes OPrt for the output value of OUTP to rise to OPH; if PV>OEF, then the time for output value of OUTP to rise to 100% is not more than 5 seconds. This function is only needed by special requirement. Soft start function doesn't affect the maximum output at auto tuning or manual control. If it is needed to lower the impulse current of induction load, CtI=0.5 second, and OPrt=5 second.	0~3600 second
OEF	Work range of OPH	When PV<OEF, the upper limit of OUTP is OPL; 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 (%)	-9990～ +30000 units
Addr	communication address	In the same communication line, different instrument should be set to different address.	0～80
bAud	baud rate	the range of baud rate is 1200～19200bit/s. For D2 dimension instrument, when COMM/AUX slot is used as AUX, bAud should be set to 0.	0～19200
AF	advanced function	AF is used to select advanced function. The value of AF is calculated as below: AF=Ax1 + Bx2 + Cx4 + Dx8 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. For instruments with light bar, when C=0, the light bar indicates the output value; when C=1, the light bar indicates the process value. D=0, Loc=808 can access the whole parameter table; D=1, Loc=PASd can access the parameter table. Note: AF=0 is recommended except for advanced user.	0～15
PASd	password	When PASd=0～255 or AF.D=0, setting Loc=808 can enter the whole parameter table. When PASd=256～9999 and AF.D=1, only setting Loc=PASd can access the whole 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.	-9990～ +30000 unit
SPH	Upper limit of SV	Maximum value that SV is allowed to be.	
SP1	Setpoint 1	Generally, SV=SP1	SPL～ SPH
SP2	Setpoint 2	when I2 is installed in MIO slot, SP1 and SP2 can be switched by an external switch. If the switch is off, SV=SP1; if the switch is on, SV=SP2.	
EP1～ EP8	Field parameter definition	Define 0～8 of the parameters as field parameters.	nonE and all parameter codes

Additional Notes

Decimal Places

When the measuring value and all parameter value shows 0.1℃ or 0.1℉ during measuring temperature (depends on parameter setting Fru), the range of parameter will become –999.0℃～+3000.0℃ or –999.0℉～+3000.0℉, even the default range is-9990～+30000. The decimal place after 999.9 will be truncated. For linear signal definition, the decimal place are only for display. The value showing does not affect internal resolution and scale.

Alarm blocking at the beginning of power on

Some unnecessary alarms often occur at the beginning of power on. In a heating system, at the beginning of powers on, its temperature is much lower than the setpoint. If low limit and deviation low limit are set and the alarm condition 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.

Temperature Transmitter

Besides AI PID, stand PID control and on-off control, if the output is defined as current output, the instrument can also retransmit PV (process value) into linear current. The precision of current output is 0.2%FS, as 0.5%FS transmitter counted whole system.

Parameter setting suggestion

CtrL=POP

InP=0

SCL=0.0

SCH=400.0

Opt=4-20

The input reads from a K thermocouple, ranging 0～400℃, output current as 4～20mA.