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-518/AI-518P

ARTIFICIAL INTELLIGENCE INDUSTRIAL CONTROLLER

Operation Instruction

Ver. 7.1

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

CONTENTS

1. SUMMARY

1.1 Main Features

- Adopt digital calibration technology for input measurement with input measurement accuracy 0.3% F.S., non-linear calibration tables for standard thermocouples and RTDs are available in the instrument.
- Adopt advanced artificial intelligence control algorithm, no overshoot and with the function of auto tuning (AT) and self-adaptation.
- Adopt advanced 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.
- Friendly and customized operating interface leads to easy learning and simple manipulation. parameter can be promoted to immediate operator access in Field Parameter Table or password protected in Full Parameter Table.
- With worldwide power supply of 100-240VAC or 24VDC and various installation dimensions for users to choose.
- ISO9001 and CE certified, achieving world class level of quality, anti-interference ability and safety.

POINTS FOR ATTENTION

- This manual introduces AI-518/AI-518P ARTIFICIAL INTELLIGENCE INDUSTRIAL CONTROLLER of Version 8.0. Certain functions introduced by this manual are probably not applicable for the instrument of other version. When power on, instrument’s 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 five module slots: multi-function input/output (MIO), main output (OUTP), alarm (ALM), auxiliary output (AUX) and communication (COMM). The modules can be purchased together with or separately from the instrument, and can be assembled freely. The input type can be freely set to thermocouple, RTD, or linear current/voltage.

The ordering code of AI-518 series instrument is made up of 9 parts. For example:

AI-518	A	(F2)	N	X3	L5	N	S4	—	24VDC
①	②	③	④	⑤	⑥	⑦	⑧		⑨

It shows that the model of this instrument is AI-518, front panel dimension is 96×96mm, an extended input type (F2 radiation type pyrometer) is available, no module is installed in MIO (Multi-function I/O) slot, X3 linear current output module is installed in OUTP (main output), ALM (alarm) is L5 (dual relay contact output module), no module is installed in AUX (auxiliary output), a RS485 communication interface with photoelectric isolation is installed, and the

power supply of the instrument is 24VDC.
The following is the meanings of the 9 parts:

① **Shows the model of the instrument**

AI-518 economical type instrument with measurement accuracy 0.3%F.S. It adopts artificial intelligent control technology, and has the functions of control, alarm, retransmission and communication.

② **shows the front panel dimension.**

A(A2) front panel 96×96mm(width×height), cut out 92×92mm, depth behind mounting surface 100mm. A2 has a 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 has an additional 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

D2 front panel 48×48mm(width×height), cut out 45×45mm, depth behind mounting surface 95mm`

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

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

③ **shows the optional extended graduation spec (If none, leave it blank). AI-518 series instruments support many input types including popular thermocouples, RTDs, linear voltage, current and resistance inputs. If needed, an additional specification not mentioned in input type selection (InP) table can be extended.**

④ shows the module type of multiple function I/O (MIO). Selectable modules are I2, I4, K3 and V. N means none, no module installed.
⑤ shows the module type of main output (OUTP). Selectable modules are L1, L4, W1, W2, G, K1, K3, K5, X3, X5 etc.
⑥ shows the module type of alarm (ALM). Selectable modules are L1, L2, L4, L5, W1, W2, G, etc.
⑦ shows the module type of auxiliary output (AUX). Selectable modules are L1, L2, L4, L5, W1, W2, G, K1, X3, X5, etc.
⑧ shows the module type of communication (COMM). Selectable modules are S, S4, V, etc.
⑨ shows the power supply of the instrument. If left blank, the power of the instrument is 100-240VAC. "24VDC" means the power supply of 24V direct current.

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: Free repair and maintenance will be given in 3 years since the delivery. In order to get full and correct repair, write the phenomena and causes of the malfunction of the instrument.

1.3 Modules

1.3.1 Slots of modules

AI-518 series instruments have five slots for modules to be installed (D dimension instruments have 3 slots: OUTP, AUX and COMM/AL1; D2 dimension instruments have 2 slots: OUTP and COMM/AUX). By installing different modules, the controller can meet the requirements of different functions and output types.

- **Multiple function Input/Output (MIO):** can input signal from 2-wire transmitter or 4-20mA signal by installing I4 (current input) module. If a I2 (on-off signal input) module is installed, the instrument can switch between setpoints SV1 and SV2 by an external switch. Cooperating with OUTP and installing a K3 module can realize three-phase thyristor zero cross triggering output.
- **Main output (OUTP):** is commonly used as control output such as on-off control, standard PID control, and AI PID control. It can be also used as retransmission output of process value (PV) or setpoint (SV). Installing L1 or L4 modular can realize relay contact output; installing X3 or X5 module can realize 0-20mA/4-20mA/0-10mA linear current output; installing G module can realize SSR voltage output; installing W1 or W2 module can implement TRIAC no contact switch output.

- **Alarm (ALM):** is commonly used to be alarm output. Support 1 normally open + normally close relay output (AL1) by installing L1 or L2 module or 2 normally open relay outputs (AL1+AL2) by installing L5 module.
- **Auxiliary output (AUX):** In a heating/refrigerating dual output system, module X3, X5, L1, L4, G, W1, W2 can be installed for the second control output. It can also output alarm by installing L1, L2 or L5 module, or be used for communicating with computer by installing R module (RS232C interface).
- **Communication Interface (COMM):** Module S or S4 can be installed in for communicating with computer (RS485 communication interface), and it can also be used as power supply for external sensor when equipped with a voltage output module.

1.3.2 Commonly used modules:

N (or null) no module installed

L2 normally open + normally close relay output module (small volume, capacity: 30VDC/1A, 250VAC/1A, suitable for alarm)

L1/L4 Large capacity normally open relay output module (large volume, Capacity: 30VDC/2A, 250VAC/2A)

L5 Dual normally open relay output module (Capacity: 30VDC/2A, 250VAC/2A)

W1/W2 TRIAC no contact normally open (W2 is normally close) discrete output module (Capacity: 100-240VAC/0.2A)

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

K1 Single-phase thyristor zero crossing trigger output module (can trigger one loop of a TRIAC or a pair of inverse parallel SCR with current of 5-500A)

K3 Three-phase thyristor zero crossing trigger output module (can trigger 3-phase circuit; each loop can trigger TRIAC or a pair of inverse parallel SCR with current of 5-500A)

K5 Single-phase thyristor phase-shift trigger output module (can trigger one loop of TRIAC or a pair of inverse parallel SCR with current of 5-500A)

X3/X5 Linear current output module (continuous 0-22mA output, selectable in the range of 0-10mA, 4-20mA etc.). X5 is equipped with photoelectric isolated power supply.

S/S4 RS485 communication interface module. S4 is equipped with photoelectric isolated power supply.

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

I2 Switch / frequency signal input interface for inputting external switch or frequency signal, has a 12VDC power supply for external transducer.

I4 4-20mA/0-20mA analogue input interface, has a 24VDC/24mA power supply for a transmitter.

1.3.3 Installation and replacement of modules

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

1.3.4 Electric isolation of the modules

There are a group of 24V and a group 12V power supply built in the instrument and isolated to the main circuit. The 24V power commonly supplies voltage output module, such as V24/V12/V10, I2 and I4. The 12V power is commonly supplies output or communication module. Generally, the relay contact output and TRIAC no contact discrete output are self insulated from the other circuit, no matter whether other modules are installed or not. SSR voltage output do not need to be insulated from input circuit, because SSR itself has isolation function. Therefore, only the electric isolation between the communication interface and the current output should be considered. Those modules, for example, S (RS485 communication interface), R (RS232 communication interface) and X3 (linear current output), all need the 12V power supply. If more than one of the above modules are installed, in order to be electric isolated, only one of them can be module without electric isolation, the other modules should be S4 or X4, 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 can not be electric isolated, so S or X should be replaced with S4 or X4.

1.3.5 Further descriptions about module applications

- **Voltage output module:** The voltage output modules like V24, V10 or V12 are often used for supplying power for external transducer or feedback resistance of transmitter. These modules can be installed in any 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 largely lower the interference spark of the equipment, and greatly improve the stability and reliability of the system. Since the driver element is TRIAC, it is suitable for controlling 100-240VAC (not for DC power) with current up to 80A. For the current larger than 80A, an intermediate relay is needed.

- **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 220VAC supply, such as contactor and electromagnetic valve, W1 module is recommended. To control DC or AC below 100V, users can only use relay module. L2 module is small, and both its normal open and normal close terminals have the function of varistor spark absorption, but the capacity is small. It is suitable for alarm output. L1 and L5 have big volume and big capacity. In the 48mm dimension instrument (for example, D2, E, F and E5), only one of L1 or L5 can be installed. L5 has dual output, can be used to support two loops of alarm, for example, AL1+AL2. If you don’t like mechanical switch, you can choose G5 (dual SSR voltage driver) and connect with external SSR instead.

1.4 TECHNICAL SPECIFICATION

- **Input type: (Either of below specifications can be used selectively in the same instrument)**
  Thermocouple: K, S, E, J, T, N
  Resistance temperature detector: Cu50, Pt100
  Linear voltage: 0～5V, 1～5V, 0～1V, 0～100mV, 0～20mV, etc.
  Linear current (external precise shunt resist needed): 0～10mA,0～20mA, 4～20mA, etc.
  Extended input (install I4 module in MIO) : 0～20mA, 4～20mA or two line transmitter.
  Optional: 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℃), T(-100~+350℃), E(0～800℃), J(0～1000℃), N(0～1300℃)
  Cu50(-50～+150℃), Pt100(-200～+600℃)
  Linear Input: -1999～+9999 defined by user
- **Measurement accuracy :** 0.3%FS
- **Resolution :** 0.1℃ for K, E, T, N, J, Cu50, Pt100; 1℃ for S

- **Response time :** ≤0.5s (when digital filter parameter dL=0)
- **Control mode:**
  On-off control mode (deadband adjustable)
  Standard PID with auto tuning
  AI PID with auto tuning, adopting artificial intelligence algorithm.
- **Output mode (modularized)**
  Relay output (NO+NC): 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: can trigger TRIAC of 5～500A, a pair of inverse paralleled SCRs or SCR power module.
  Linear current output: 0～20mA, 4～20mA (Output voltage ≥11V, maximum load resistor 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 terminals ≥2300VDC; between isolated electroweak terminals ≥600VDC
- **Power supply :** 100～240VAC, -15%, +10% / 50-60Hz; 120～240VDC; or 24VDC/AC, -15%, +10%.

- **Power consumption:** ≤5W
- **Operating Ambient :** temperature 0～50℃; 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

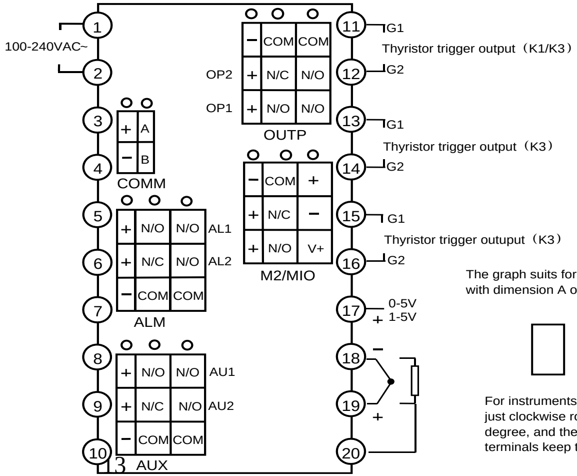
1.5 Rear Terminal Layout and Wiring

Wiring graph for instruments except D and D2 dimension.

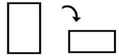
Note 1: For linear voltage input, if the range is below 500mV, connect to terminals 19 and 18. 0～5V or 1～5V signal can be inputted from terminals 17 and 18.

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

Note 3: The compensation wires for different kinds of thermocouple are different, and



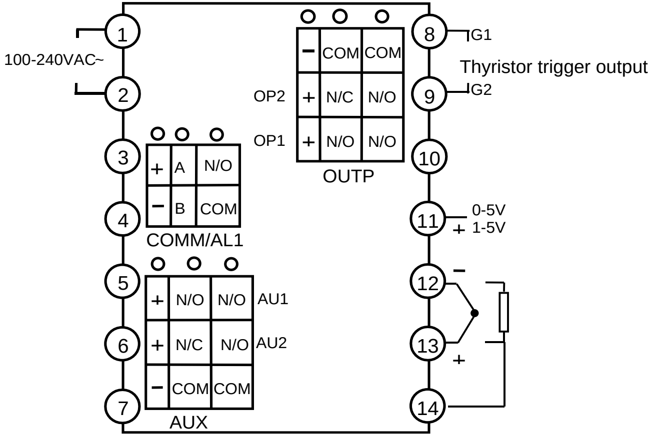
The graph suits for upright instruments with dimension A or E



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

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.

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

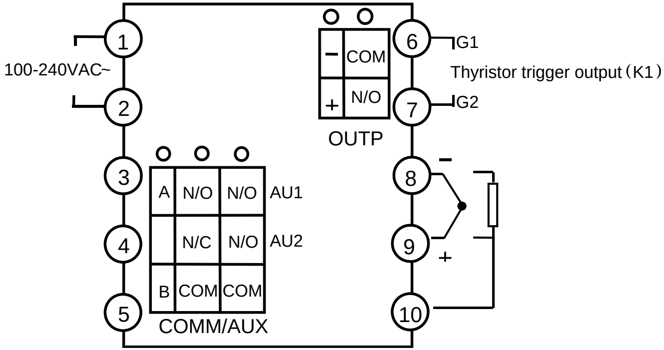


Note 1: Linear voltage signal of range below 500mV should be inputted from terminals 13 and 12, and signal of 0～5V and 1～5V should be inputted from terminals 11 and 12.

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

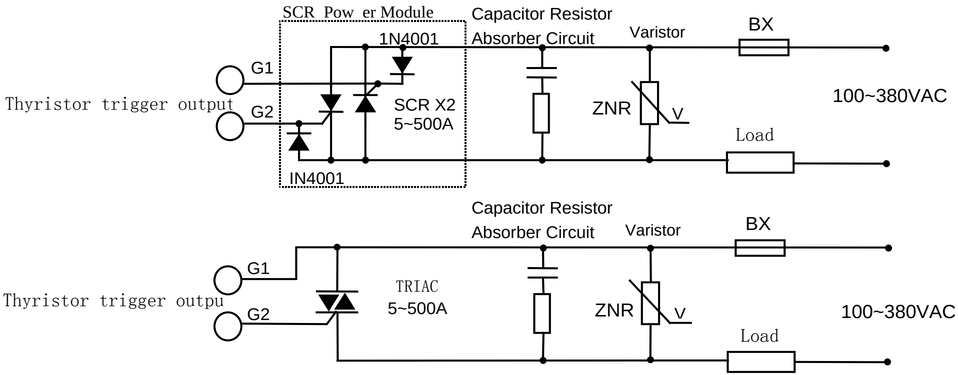
Note 3: S or S4 module can be installed in COMM slot for communication. If relay, TRIAC no contact switch, or SSR driver voltage output module is installed in COMM, it can be used as alarm output. If I2 module is installed in COMM and parameter “bAud” is set to 1, then on-off signal can be inputted,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

Wiring graph of instruments with D2 dimension as below:



Note 1: D2 dimension instruments don't support 0～5V or 1～5V linear voltage input. However, 0～5V or 1～5V signal can be converted to 0～500mV or 100～500mV by connecting external precise resistors, 4～20mA can be converted to 100～500mV by connecting a 25ohm resistor, then be inputted from terminals 9 and 8.

Note 2: For COMM/AUX slot, if S or S4 communication module is installed in, it can be used for communication; if L2 or L5 module is installed in, and parameter bAud is set to 0, it can be used for AU1 or AU1+AU2 alarm output; if L1, L2, L4, G, K1, W1 or W2 is installed, it can be the auxiliary output in bidirectional (heating/refrigerating) control (Auxiliary output doesn't support analog current output); if I2 is installed and bAud is set to 1, then it can input on-off signal to switch SV1 and SV2 by connecting a switch between terminals number 3 and 5.



Note 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.

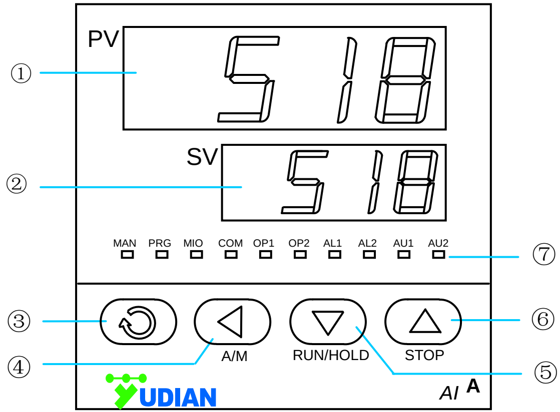
Note 2: SCR power module is recommended. A power module includes two SCRs, is similar to the above dashed square.

Note 3: K5 (Phase-shift trigger module) only support 220～380VAC and 50Hz power.

2. DISPLAYS AND OPERATIONS

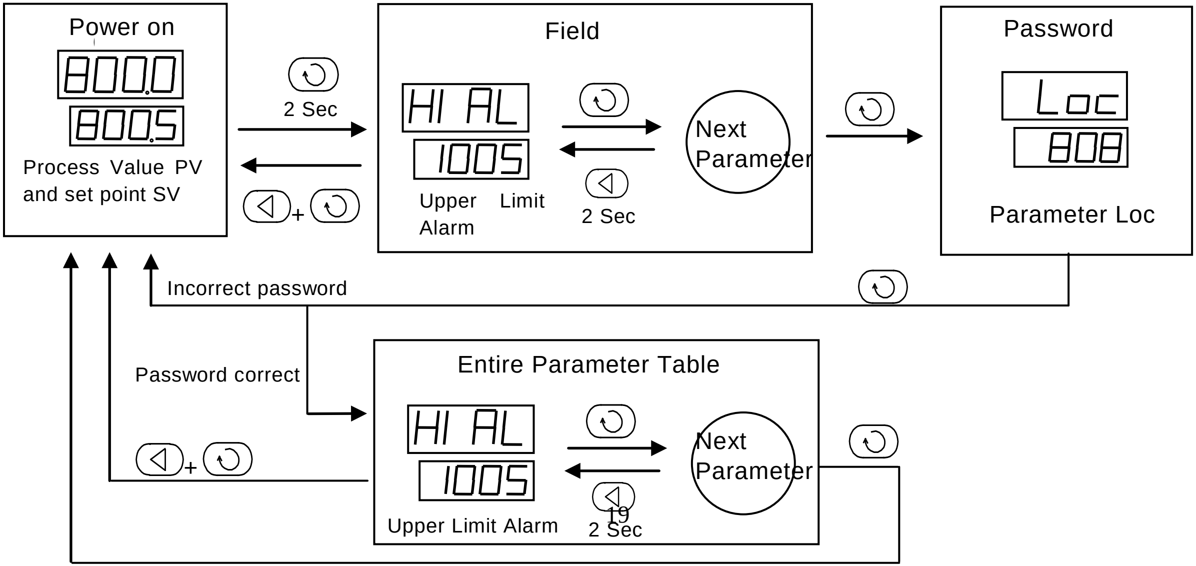
2.1 Front Panel Description

① Upper display window, displays PV, parameter code, etc.
② Lower display window, displays SV, parameter value, or alarm
③ Setup key, for accessing parameter table and conforming parameter modification.
④ Data shift key, and auto tuning.
⑤ Data decrease key, and also run/pause switch
⑥ Data increase key, and also stop key
⑦ LED indicator. MAN and PRG indicators is non-applicable for AI-518. PRO is on indicating the program of AI-518P is running. MIO, OP1, OP2, AL1, AL2, AU1 and AU2 indicate I/O operation of the corresponding module. For example, COMM indicator is flashing meaning that the instrument is communicating with computer.



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”, “dHAL” or “dLAL”, it means high limit alarm, low limit alarm, deviation high alarm, and deviation low alarm happening.

2.2 Parameter Setting Flow Chart



2.3 Operation Description

2.3.1 Set Value Setting

In basic display status, if the parameter lock “Loc” isn't locked, we can set setpoint (SV) by pressing (<)、(∨) or (∧). Press (∨) key to decrease the value, (∧) key to increase the value, and (<) key to move to the digit expected to modify. Keep pressing (∨) or (∧), the speed of decreasing or inscreasing value gets quick. The range of setpoint is between the parameter SPL and SPH. The default range is 0～400.

2.3.2 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 and hold (<) can return to the preceding parameter. Press (<) (don't release) and then press (⟲) key 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.

In Field Parameter Table, (⟲) till the last field parameter Loc appears. Setting Loc=808 and then press (⟲) can access System Parameter Table.

2.3.3 Auto Tuning

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.

Note 1: AI-518 instruments apply the advanced artificial intelligence algorithm, which has avoided the overshoot 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 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: In a heating/refrigerating dual output system, auto tuning should be executed at the main output (OUTP).

Note 5: 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 entire parameter set, and can be freely chosen by the user.
Loc can authorize different security right as below:
Loc=0, allowed to modify field parameters and setpoint, and execute auto tuning;
Loc=1, allowed to modify field parameters and setpoint, but can’t execute auto tuning;
Loc=2, allowed to modify field parameters, but can’t modify setpoint or execute auto tuning.
Loc=3～255: can only modify “Loc”
Setting Loc=PASd (Password, a number between 256 and 9999. The initial value is 808) and then pressing to confirm, can enter the whole parameter table and modify all parameters.
1 to 8 field parameters can be defined by parameters EP1to EP8. If the number of the field parameters is less than 8, the first idle EP parameter should be set to “nonE”. The initial values of EPs and Loc are EP1=HIAL, EP2=LoAL, EP3=HdAL, EP4=LdAL, EP5=nonE, EP6=nonE, EP7=nonE, EP8=nonE and Loc=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. The EP paramters and Loc should be set as below:
EP1=HIAL, EP2=HdAL, EP3=At, EP4=nonE, Loc=1

3.2 The Entire 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.	-1999～ +9999 units
LoAL	Low limit alarm	Alarm on when PV<LoAL; alarm off when PV>LoAL+AHYS	
dHAL	Deviation high alarm	Alarm on when PV-SV>HdAL; alarm off when PV-SV<HdAL-AHYS	
dLAL	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)	

dF	Deadband	Avoid frequent alarm on-off action because of the fluctuation of PV	0～200 units
CtrL	Control mode	0: on-off control. For situation not requiring high precision; 1: AI MPt control. Allowed to quick activate auto-tuning (pressing (<) in basic display status.) 2: AI MPt control. Activate auto-tuning. 3: After auto-tuning finished, the instrument automatically set CtrL=3, and quick auto-tuning function is disabled. 4: Comparing with the control mode of CtrL=3, Parameter P is defined as 10 times as its original value. Ex., if set P=5 incase of Ctrl=3 and set P=50 incase of Ctrl=5, then these 2 setting have then same control effect. In the application of rapidly changed temperature (changes by more than 100℃/second), pressure or flow control, or in the application where inverter is used to control water pressure, P is often very small, even smaller than 1. If CtrL is set to 4, then parameter P can be enlarged 10 times, and so finer control is obtained.	0～4

M5	Hold parameter	Parameter M5, P, t, CtI etc. are only for AI MPt control, and have no effect to on-off control. M5 is defined as measurement variation after output is changed by 5% (0.5mA if OP1=1) and when controlled process is basically stabilized. "5" indicates that output variation is 5 (5% or 0.5mA). Generally M5 parameter of the same system will changes with measurement value, and so M5 parameter should be configured with process value around operating point. Take temperature control of electric furnace as an example, the operating point is 700□ . To find out optimum M5 parameter, assuming that when out remains 50%, the temperature of electric furnace will finally be stabilized at 700□ , and when output changes to 55%, the temperature will final be at 750. Then M5 (optimum parameter)=750-700=50□ . M5 parameter mainly determines the degree of integral function, similar as integral time of PID control. The smaller M5 parameter is, the greater integral function is; where the larger M5 parameter is, the smaller integral function is (integral time is increased). But if M=0, then integral function an artificial intelligence control function will be removed and the instrument is turned to be an PD adjustment that used as a secondary controller during cascade control.	0～9999 units or 0～999.9□

P	rate parameter	P is in reverse proportion to measurement variations caused by output changes by 100% in one second. It is defined as the following: if CtrL=1 or 3, then P=1000/measurement variation per second, the unit is 0.1□ or 1 defined unit . Ex., instrument use 100% power to heat and there is no heat loss, if temperature in crease 1□ each second, then P=1000/10=100. If CtrL=4, then P parameter will be configured by increasing 10 times. Ex., P should be set to 1000 in the above example. P is used to control proportional and derivative function in direct proportion. Decreasing P parameter will decrease proportional and derivative function. P parameter does not affect integral function.	0～9999 seconds

t	Lag time parameter	Parameter t is applied as one of the important parameters of AI artificial intelligence control algorithm. "t" is defined as follows: time needed for a electric furnace from the beginning of elevating temperature to get to 63.5% against the final speed of temperature elevating, provided there is no heat loss. The unit of parameter “t” is second. For industrial control, hysteresis effect of the controlled process is an important factor impairing control effect. The longer is system lag time, the more difficult to get ideal control effect. Lag time parameter “t” is a new introduced important parameter for AI artificial intelligence algorithm. AI series instrument can use parameter “t” to do fuzzy calculation, and therefore overshoot and hunting do not easily occurs and the control have the best responsibility at the time. The optimal t equals to derivative time in PID control. Parameter “t” gives effect on proportional, integral and derivative function. If t≤CtI, derivative function of system will be eliminated.	0～2000 seconds

<table>
<tr><td>CtI</td><td>Control period</td><td>Small value can improve control accuracy.
For SSR, thyristor or linear current output, it is generally 0.5 to 3 seconds.
For Relay output or in a heating/refrigerating dual output control system, generally 15 to 40 seconds, because small value will cause the frequent on-off action of mechanical switch or frequent heating/refrigerating switch, and shorten its service life. CtI is recommended to be 1/4 – 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>0.5～120.0 seconds</td></tr>
<tr><td>Sn</td><td>Input specification Code</td><td>
<table>
<tr><th>Sn</th><th>Input spec.</th><th>Sn</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>Spare</td><td>22</td><td>Spare</td></tr>
<tr><td>3</td><td>T *</td><td>26</td><td>0～80ohm resistor input</td></tr>
<tr><td>4</td><td>E</td><td>27</td><td>0～400ohm resistor input</td></tr>
<tr><td>5</td><td>J</td><td>28</td><td>0～20mV voltage input</td></tr>
</table>
</td><td>0～37</td></tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td>
<table>
<tr><td>6</td><td>Spare</td><td>29</td><td>0～100mV voltage input</td></tr>
<tr><td>7</td><td>N</td><td>30</td><td>0～60mV voltage input</td></tr>
<tr><td>8</td><td>Spare</td><td>31</td><td>0～500mV voltage input</td></tr>
<tr><td>9</td><td>Spare</td><td>32</td><td>100～500mV voltage input</td></tr>
<tr><td>10</td><td>extended input specification</td><td>33</td><td>1～5V voltage input</td></tr>
<tr><td>15</td><td>4～20mA (installed I4 in MIO)</td><td>34</td><td>0～5V voltage input</td></tr>
<tr><td>16</td><td>0～20mA (installed I4 in MIO)</td><td>35</td><td>0～10V</td></tr>
<tr><td>17</td><td>Spare</td><td>36</td><td>2～10V</td></tr>
<tr><td>18</td><td>J (0～300.00℃) *Spare</td><td>37</td><td>0～20V</td></tr>
</table>
Please set Sn=10 if there is a customized input specification.
</td>
<td></td>
</tr>
<tr>
<td>dIP</td>
<td>Radix point position</td>
<td>Four formats (0, 0.0, 0.00, 0.000) are selectable
dIP=0, display format is 0000, no radix point
dIP=1, display format is 000.0
dIP=2, display format is 00.00
dIP=3, display format is 0.000</td>
<td>0~3</td>
</tr>
</table>

		Note 1: For thermocouples or RTD input, only 0 or 0.0 is selectable, and the internal resolution is 0.1. dIP only affect the display, and has no affect to the accuracy of measurement or control.	
dIL	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.	-1999～ +9999 units
dIH	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.	
Sc	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 mistake.	-1999～ +4000 units
oP1	main output type	oP1 select the control output type: oP=oP1.A x 1 + oP1.B x 10 oP1.A shows the output type of OUTP. It should be compatible with the module installed in OUTP sockets. **oP1.A=0,** if output modules such as SSR voltage output, relay contact discrete output, thyristor cross zero trigger output, and TRIAC no-contact discrete output are	0~48

installed in OUTP.

oP1.A=1, 0～10mA linear current output. Linear current output module should be installed to main output.

oP1.A=2, 0～20mA linear current output. Linear current output module should be installed to main output.

oP1.A=3, spare

oP1.A=4, 4~20mA linear current output. Linear current output module should be installed to main output.

oP1.A=5～7, No applicable in AI-518.

oP1.A=8, single channel phase-shift output. K5 module should be installed. In this mode, AUX can not work as refrigerating output.

oP1.B shows the AUX output type. It works only when parameter oPL<0.

oP1.B=0, time proportional output. Output modules such as SSR voltage output, relay contact discrete output, thyristor cross zero trigger output, and TRIAC no-contact discrete output can be installed in OUTP.

oP1.B=1, 0～10mA linear current output. Linear current output module should be installed to main output.

oP1.B=2, 0～20mA linear current output. Linear current output module should be installed to main output.

		oP1.B=3, spare **oP1.B=4,** 4～20mA linear current output. Linear current output module should be installed to main output. AUX does not support position proportional output or phase-shift trigger output. For example, OUT and AUX all output 4～20mA linear current, then OPt=44.	
oPL	Output low limit	0～110%: OPL is the minimum output of OUTP in single directional control system. -110 ～ -1%: the instrument works for a bidirectional system, and has heating/refrigerating dual output. When CF.A=0, OUTP (main output) works for heating, and AUX (Auxiliary output) works for refrigerating. When CF.A=1, OUTP works for refrigerating, and AUX works for 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 for 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	-110~+110%

		AUX output is 20mA, and user can't limit the maximum AUX output to 10mA.	
oPH	Output upper limit	OPL limits the maximum of OUTP (main output). OPH should be greater than OPL.	0～110%
ALP	Alarm output allocation	From right side to left side, the first, second, third and fourth digit of ALP individually indicate the alarm output terminal of HIAL, LoAL, dHAL, and dHAL. 0 shows no output. 1 and 2 are spare for future use. 3,4,5 and 6 respectively indicate alarms outputted to AL1, AL2, AU1 or AU2. For example, ALP = 5 (LoAL) 5 (HdAL) 0 (LoAL) 3 (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, alarm to AU1 and Au2 won't work. Note 2: Installing L5 dual relay output module in ALM or AUX can implement AL2 or AU2 alarm.	0～9999
CF	System function selection	CF is used to select some system function. The value of CF is calculated as below: **CF=A×1+B×2+C×4+D×8+E×16+F×32+G×64+H×128** **A=0**, reverse action control mode. When this mode is selected, an increase in PV	0～255

		results in a decrease in the control output. Ex, heating control. **A=1,** direct action control mode. When this mode is selected, an increase in PV results in an increase in the control output. Ex, cooling control. **B=0,** without the function of alarm suppressing at power on or setpoint changing. **B=1,** having the function of alarm suppressing at power on or setpoint changing. Refers to the description in the latter text. **For AI-518P,** **C=0,** When the instrument work as a program generator, the upper window displays the program step; **C=1**, it displays PV (measurement value). **D=0,** The unit of program time is minute; **D=1**, the unit is second. **For AI-518,** **C=0,** The setpoint is restricted between LoAL and HIAL; **C=1**, no restriction on the setpoint. **D=0,** Sends PV during retrasmission; **D=1**, Sends SV during retransmission. **E=0,** disable the function of sectional power restriction **E=1,** enable the function of sectional power restriction **F only works on A2/C3 dimension instrument which has a light bar.** **F=0,** light bar indicates output value **F=1,** light bar indicates measurement value **G=0,** When alarm is triggered, the alarm symbol is alternatively displayed on the lower	

		window. It is helpful for user to know the cause of the alarm. **G=1,** disable alarm symbol display. **H=0,** unilateral hysteresis is applied; **H=1,** bilateral hysteresis is applied (in order to compatible with old version V6.X). **For example:** if it is expected that the instrument service as reverse action control; has the function of alarm suppressing at power on; no restriction on the range of setpoint; no sectional power restriction; no light bar; alternatively display alarm symbol when alarming, then we get A=0, B=1, C=1, D=0, E=0, F=0, G=0. And so parameter "CF" should be set as follows: **CF=0×1 + 1×2 + 1×4 + 0×8 + 0×16 + 0×32 + 0×64 = 6**	
Addr	Communication address	In the same communication line, different instrument should be set to different address.	0～100
bAud	baud rate	the range of baud rate is 1200～19200bit/s.	0～19200

dL	PV input filter	The value of dL will determine the ability of filtering noise. There is one intermediate-value filter system and one second order integral digital filter system in AI series instrument. Intermediate value filter takes intermediate value among three continuous values, while integral filter has the same effect as resistance-capacity integral filter. If measurement input fluctuates due to noise, then digital filter can be used to smooth the input. Parameter “dL” may be configured in the range of 0 to 20, among which, 0 means no filter, 1 means intermediate-value filter and 2～20 means that intermediate-value filter and integral filter can be selected simultaneously. 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 “dF” gradually to make momentary fluctuation of measured value less than 2 to 5. When the instrument is being metrological verified, “dF” s can be set to 0 or 1 to shorten the response time.	**dL**

run	System running mode	**For AI-518P, parameter RUN is used to define the event-handling mode when program is running.** Abrupt actions affecting control execution of program are called event, as the outcomes of events are always probably unpredicted, the aim of event handling is to turn those unpredicted things into predicted results. **Run=A×1+D×8** Among which: A is used to select 5 kinds of power-cut event handling modes; D is used to select 4 kinds of run /modify event-handling modes. **There are five handling functions for AI-518P series instrument when power resume after power cut.** **A=0,** start to run the program from step 1 unless the instrument was in “stop” state before power cut. **A=1,** if these is deviation alarm after power resume, then stop the program, otherwise, continue to run the program from the original break point. **A=2,** continue to run the program from the original break point.. **A=3,** stop the program. **A=4,** go into HOLD state after power on. If it is in StoP state before power cut, then keep in StoP State after power on. **Run/modify event handling** **D=0,** neither PV startup nor PV preparation function. Program is executed as	**run**

		planed. This mode guarantees constant running time of the program, but it can't guarantee the integrity of the whole curve. **D=1,** With the function of PV startup and without the function of preparation. **D=2** With the function of preparation and without the function of measurement value startup. **D=3** With the function of measurement value startup and preparation. For details about PV startup function and PV preparation function, see program instruction later chapter. **For example:** if it is needed that the instrument continue program running from the original break point after power on, have the function of measurement value start up and preparation, then you can set as below: A=2,D=1, and so we get parameter: **Run=2×1+3×8=26**	

Loc	Parameter lock	If parameter Loc is set to other values than 808, then only field parameters in the range of 0 to 8 and parameter Loc itself can be set. When parameter Loc is set to 808, user can set all parameters. Parameter Loc provides several operation privileges. When user has completed setting some important parameters such as input and output, parameter Loc can be set to other values than 808 in order to avoid field operators' accidental modification of some important operation parameters. See the following: **1. for AI-518 series instrument** **Loc=0,** allowed to modify field parameters and setpoint. **Loc=1,** allowed to view field parameters, and to set setpoint. But the modification of field parameters (except parameter Loc itself) is not allowed. **Loc=2,** allowed to display and view field parameters, but the modification of field parameters and setpoint (except parameter Loc itself) is not allowed. **Loc=808,** configuration of all parameters and setpoint is allowed. **2. For AI-518P series instrument** **Loc=0,** allowed to modify field parameters, program value (time and temperature value) and program segment number StEP. **Loc=1,** allowed to modify field parameters and StEP value, but the modification of program is not allowed. **Loc=2,** allowed to modify field parameters, but not allowed to modify StEP value and program. **Loc=3,** only allowed to modify parameter Loc itself, all other parameters, program and StEP value can not be modified. **Loc=808,** allowed to set all parameters, program and StEP value. **Note:** that 808 is the password of all AI series instrument. In application the instrument should be set to other values to protect from modifications of parameters. Meanwhile the management of production should be enforced to avoid arbitrary	0～9999

EP1～EP8	Field parameter definition	1 to 8 field parameters can be defined by parameters EP1to EP8. If the number of the field parameters is less than 8, the first idle EP parameter should be set to “nonE”. The initial values of EPs and Loc are EP1=HIAL, EP2=LoAL, EP3=HdAL, EP4=LdAL, EP5=nonE, EP6=nonE, EP7=nonE, EP8=nonE and Loc=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. The EP paramters and Loc should be set as below: EP1=HIAL, EP2=dHAL, EP3=At, EP4=nonE, Loc=1	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 K5 module in OUTP slot can single-phase phase-shift trigger a TRIAC or 2 inverse parallel SCRs. It can continuously adjust heating power by control the conduction angle of thyristor. With non-linear power adjustment according to the characters of sine wave, it can get ideal control. The trigger adopts self-synchronizing technology, so it can also work even when the power supplies of the instrument and the heater are different. Phase-shift trigger has high interference to the electric power, so user should pay attention to the anti-interference ability of other machines in the system. Now the K5 module can be only used in 50Hz power supply.

3.3.2 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 power on, its temperature is much lower than the setpoint. If low limit and deviation low limit are set and the alarm conditions are satisfied, the instrument should alarm, but there is no problem in the system. Contrarily, in an refrigerating system, the unnecessary high limit or deviation high limit alarm may occur at the beginning of power on.

Therefore, AI instruments offer the function of alarm blocking at the beginning of power on. When Act is set to rEbA or drbA, the corresponding low or high alarms are blocked until the alarm condition first clears. If the alarm condition is satisfied again, the alarm will work.

3.3.3 Setpoints switch

If an I2 module is installed in MIO slot, a switch can be connected to terminal number 14 and 16 to switch between two different setpoints SP1 and SP2.

3.3.4 Communication function

S or S4 module can be installed at COMM slot to communicate with a computer. The instrument can be controlled by computer. A RS232C/RS485 or USB/RS485 converter can enable a computer connect to AI instruments 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 to up to 160 instruments. Please note that every instrument connecting to the same communication line should be set to a unique communication address. When number of the instruments is big enough, 2 or more computers can be used and built into a local network.

AIDCS application software, a distributed control system software developed by Yudian, can control and manage 1～160 AI instruments, record the data, generate and print reports. If users want to develop their own distributed control system by themselves, the communication protocol of AI instruments can be free offered. There are already many famous distributed control system software support AI instruments.

3.3.5 Temperature re-transmitter / set 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 (process value) or SV (setpoint) into linear current and output from OUTP. The precision of current output is 0.2%FS. The corresponding parameters are set as below:

When CtrL=POP, PV is retransmitted to linear current, the instrument works as temperature re-transmitter. When CtrL=SOP, SV is transmitted and outputted, and the instrument works as an set current output.

OPt is used to choose output type, generally 4～20mA or 0～20mA output.

Parameter 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. The upper limit of transmitter output can be high up to 110% of the range, which means when PV is 0～440℃, output current is 4～21.6mA.