AI-516D65 Dedicated Artificial Intelligence Temperature Controller User Manual

(V9.3)

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Table of Contents

1 Overview

1.1 Main Features

●The input adopts a highly accurate and stable digital calibration system, supporting multiple thermocouple types with a maximum resolution of 0.01°C.

●Utilize an advanced AI-based PID control algorithm with no overshoot and auto-tuning (AT) capability.

●User-friendly operation design for easy learning and use.

●Support self-editing operation permissions and interface, allowing users to “tailor” the instrument to their needs.

●The anti-interference performance meets the requirements of electromagnetic compatibility (EMC) under harsh industrial conditions.

⚠Precautions
This manual introduces the AI-516 Artificial Intelligence PID Temperature Controller, Version 9.3. Some of the features mentioned in this manual may not be applicable to other versions of the instrument. The model and software version number of the instrument will be shown on the display during startup. Users should be aware of the differences between different models and versions when operating the device. Please read this manual carefully to ensure the proper use of the instrument and fully utilize its functionalities. Before use, the AI instrument must be configured correctly according to their input/output specifications and functional requirements. The instrument can only be put into operation after the parameters have been properly set.

1.2 Model Definition

The model is temporarily fixed as AI- 516 D65 K1 L0 S

① ② ③ ④ ⑤

① indicates the basic function of the instrument

AI-516 (An economical temperature controller with 0.25-class accuracy, featuring AI-based artificial intelligent control technology, multiple alarm modes, and communication functions)

② indicates the dimensions. The D65 model measures 81mm*53mm*48mm and features a built-in silicon-controlled rectifier (SCR), with the output directly connected to the load, supporting a maximum current of 2A.

③ indicates the output type, K1 represents a zero-crossing trigger output mode.

④ indicates with alarm function, corresponding to logic AU1, NOUT and LOUT will be output only when both OP1 and AU1 are active.

⑤ indicates with 485 communication function, supporting AIBUS or MODBUS protocol, switchable via the AFC parameter.

Note: This instrument uses automatic zeroing and digital calibration technology, making it a maintenance-free instrument. If the instrument exceeds the specified tolerance limits during metrological verification, the issue can typically be resolved by cleaning and drying the internal components. If drying and cleaning do not restore accuracy, the instrument should be considered faulty and returned to the manufacturer for repair.

1.4 Technical Specifications

●**Input specifications** (Compatible with a single instrument)**:**

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

Linear voltage: 0~100mV, 0~20mV, 0~60mV, etc.

Expanded specifications: The users are allowed to specify an additional input specification while retaining the above input specifications (a reference table may be required)

●**Measurement range:**

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

E(0~800℃), J(0~1000℃), B(200~1800℃), N(0~1300℃)

Linear input: -9,990~+32,000, defined by user

●**Measurement accuracy:** 0.25 class

●**Sampling period:** 8 samples per second; when the digital filter parameter FILt=0, the response time is ≤ 0.5 seconds

●**Control period:** Adjustable from 0.24-300.0 seconds

●**Control mode:**

ON/OFF control mode(adjustable hysteresis)

AI artificial intelligence adjustment, featuring advanced control algorithms with fuzzy logic PID control and auto-tuning function

●**Input specifications**:

NOUT and LOUT load capacity: 250VAC/2A

●**Alarm functions:** Four types - high limit, low limit, deviation high limit, deviation low limit, with a power-on alarm bypass option

●**Electromagnetic compatibility:** IEC61000-4-4 (electrical fast transient), ±4KV/5KHz; IEC61000-4-5 (surge), 4KV

● **Isolation withstand voltage:** ≥2300V between the power supply, relay contacts, and signal terminals; ≥600VDC between isolated low-voltage signal terminals

●**Power supply:** 100~240VAC, -15%, +10% / 50~60Hz; 120-240VDC;

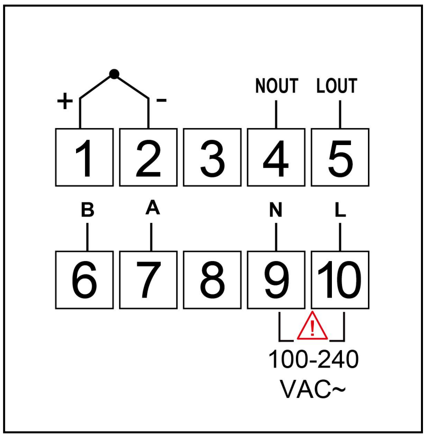
●**Power consumption:** 5W without load

●**Operating environment:** -10~60℃; Humidity ≤90%RH

1.5 Wiring Methods

Note: Due to technical upgrades or special orders, if the wiring diagram provided with the instrument differs from this manual, please refer to the included wiring diagram.

9 and 10 are for connecting the 220VAC power input. 1 and 2 are for thermocouple or mV input. 6 and 7 are 485 communication terminals. 4 and 5 are for output to the load. When outputting from terminals 4 and 5, the terminals are powered, and no additional high-voltage wiring is required. The load can support a maximum current of 2A.



2 Display and Operation

2.1 Panel Description

① Upper display window: Display measured values PV, parameter names, etc.

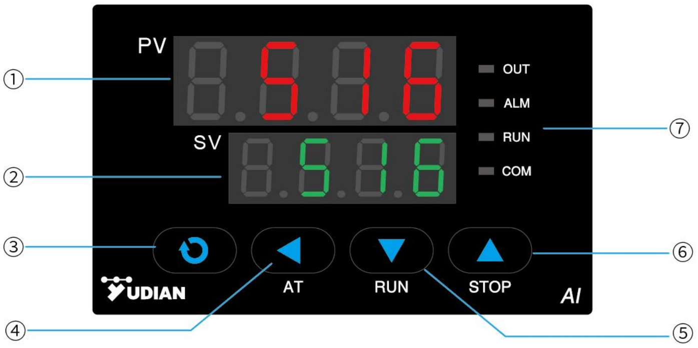
② Lower display window: Display the set value SV, alarm code, parameter values, etc.

③ Set key: Used to enter the parameter setting mode and confirm parameter modifications

④ Data shift (also serves as a fixed-point control operation)

⑤ Data decrease key (also serves as Run/Pause operation)

⑥ Data Increase key (also serves as Stop operation)

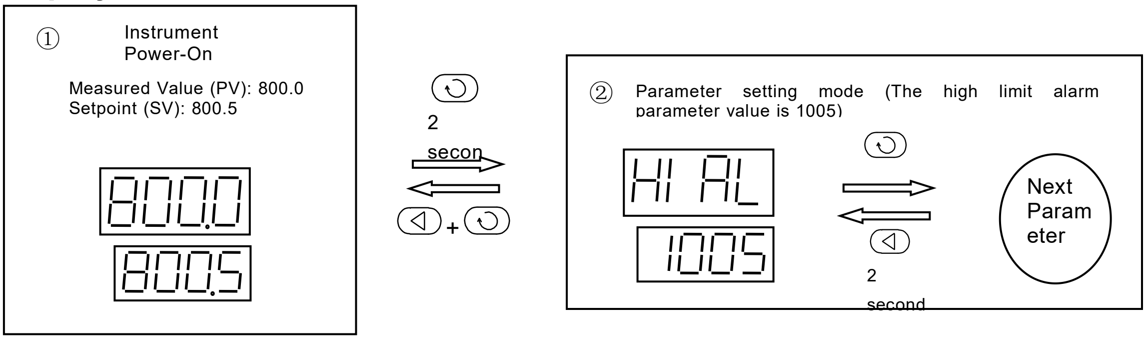


⑦ 4 LED indicators, OUT indicates OP1 logic output; ALM indicates AU2 logic output: The RUN light is on, indicating that the system is in operation; the COM light is on, indicating that the system is communicating with the host computer.

(Note that ALM corresponds to AU2 logic, while LOUT and NOUT require both AU1 and OP1 outputs to be active for conduction)

The instrument enters the basic display state after power-on. At this time, the upper and lower display windows show the measured value (PV) and setpoint (SV), respectively. The lower display window may also alternately display the following characters to indicate status: ① "orAL": Indicates that the input measurement signal is out of range. ② "HIAL", "LoAL", "HdAL", or "LdAL": Indicate high limit alarm, low limit alarm, deviation high limit alarm, or deviation low limit alarm, respectively. ③ "StoP": Indicates the system is in a stopped state. "HoLd": Indicates the system is in a paused or ready state.

2.2 Display State



2.3 Operation Methods

2.3.1 Setting Parameters

Press the ⟲ key in the basic display state and hold it for about 2 seconds to enter the customized field parameter setting state. Parameter values can be modified directly by pressing the keys such as ◁, ▽, and △. Press the ▽ key to decrease the value and the △ key to increase the value. The decimal point of the modified value will flash (acting as a cursor). Press and hold the key to quickly increase/decrease the value, with the speed increasing automatically as the decimal point shifts to the right. The users can also press the ◁ key to directly move the position (cursor) and modify the data, making the operation faster. Press the ⟲ key to save the modified parameter value and display the next parameter. Hold the ⟲ key to go down quickly. Press the ◁ key and hold it for more than 2 seconds to return to display the previous parameter. First press and hold ◁ key, then press the ⟲ key again to directly exit the parameter setting mode. If no key is pressed, the instrument will automatically return to the basic display mode after approximately 25 seconds.

2.3.2 Shortcut Operation Functions

All functions of the AI-516 can be completed by modifying parameters. However, for some commonly used functions, such as modifying the setpoint and controlling the program's run/stop operations, shortcut operations have been designed to simplify usage. These shortcut functions can also be disabled to prevent accidental operations.

Setting setpoint: Press the ◁ key to enter the current setpoint modification mode. Then press the ◁, ▽, △ or other keys to directly modify the setpoint value.

Run control: To start the run control, press and hold the ▽ key for approximately 2 seconds until the lower display shows the "run" symbol. The AI-516 will either start the program or release the running state in the stopped state.

Stop control: Press the "△" key and hold it for about 2 seconds until the lower display shows the "StoP" symbol, which will stop the output control of the instrument.

Auto-tuning AT: Press the ◁ key and hold it for 2 seconds, the At parameter will appear. Press the △key to change the "OFF" to "ON" in the lower display window, then press the ⟲ to confirm, the auto-tuning function will begin. (Note: If the instrument's SPr parameter is set to be active and the temperature is in the heating limit state, the auto-tuning will pause and will automatically start after the heating is completed.) The lower display will blink the "At" symbol, and after 2 oscillation cycles of ON-OFF control, the instrument will automatically calculate the PID parameters. To cancel the auto-tuning process in advance, press the ◁ key again and hold it for about 2 seconds to call out the At parameter, then set "ON" to "OFF" and press the ⟲ key to confirm. If the instrument is in program run mode, the auto-tuning will cause the program timer to pause to ensure that the setpoint remains unchanged.

Note 1: The AI-516 utilizes an advanced PID control algorithm integrated with AI technology, addressing the issue of overshooting typically associated with standard PID algorithms while offering high control accuracy. This improved PID algorithm is referred to as the APID algorithm. When the instrument is set to use either APID or PID control mode for the first time, the auto-tuning function can be activated to assist in determining the appropriate PID control parameters.

Note 2: The parameter values obtained during auto-tuning may vary with different setpoints. Before performing the auto-tuning function, set the setpoint SV to the most commonly used value or the middle value. If the system is a well-insulated electric furnace, set the setpoint to the maximum value used by the system. The SV value should not be modified during the auto-tuning process. Depending on the system, the time required for auto-tuning can range from several seconds to several hours.

Note 3: The control hysteresis parameter CHYS also affects the results of auto-tuning. Generally, the smaller the CHYS setting, the higher the accuracy of the auto-tuning parameters. However, if the CHYS value is too small, it may cause misoperation in the on/off control due to input fluctuations, which could lead to completely incorrect tuning parameters. CHYS=2.0 is recommended.

Note 4: The control effect immediately after auto-tuning may not be optimal. However, due to the learning function, the best performance will be achieved after running for a period of time.

3 Parameter Function

3.1 Custom Parameter Table

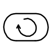
The AI-516's parameter table programmable definition function allows users to define custom parameters for the instrument. To protect important parameters from unauthorized modification, the parameters that need to be displayed or modified on-site are called on-site parameters. The on-site parameter table is a subset of the complete parameter table and can be defined by the user. These parameters can be directly accessed for modification, while the complete parameter table can only be accessed by entering a password. The parameter lock Loc provides various levels of operation permissions and password input for accessing the complete parameter table. Its functions are as follows:

Loc=0: Allow modification of on-site parameters and direct modification of the setpoint in the basic display state.

Loc=1: Prohibit modification of on-site parameters, but allow direct modification of the setpoint in the basic display state.

Loc=2~3: Allow modification of on-site parameters, but prohibit modification of the setpoint and program values operation via shortcuts. However, shortcut operations such as program run/pause/stop and setpoint control are allowed.

Loc=4~255: Prohibit modification of any parameters other than Loc itself, and also disable shortcut operations.

Set Loc=808 and press  to confirm, the users can enter the display and modify the complete parameter table. Once the complete parameter table is accessed, all parameters except for read-only ones can be modified.

Parameters EP1~EP8 allow users to define 1~8 on-site parameters. If fewer than 8 on-site parameters are needed, the first unused parameter should be defined as nonE. For example, if the required parameter table includes HIAL, HdAL, and At, the EP parameters can be set as follows: EP1=HIAL, EP2=HdAL, EP3=At, EP4=nonE.

Note: Starting from version V9.1, the Loc parameter can be set to restrict communication writing. Please refer to the communication protocol documentation for more details.

3.2 Complete Parameter Table

The complete parameter table is divided into 8 major sections: Alarm, Regulation and Control, Input, Output, System Functions, Setpoint/Program, and On-Site Parameter Definitions. These sections are arranged in the following order:

Parameter	Parameter Meaning	Description	Setting Range
HIAL	High Limit Alarm	When the measured value PV exceeds the HIAL value, the instrument will trigger a high limit alarm. When the measured value PV drops below HIAL-AHYS, the high limit alarm will be cleared. Note: Each alarm can be freely defined to trigger actions on output ports such as AL1, AL2, AU1, AU2, or no action at all. Please refer to the later section for the alarm output definition parameter AOP.	-9990~ +32000 Unit
LoAL	Low Limit Alarm	When the PV is below LoAL, a low limit alarm is triggered. When the PV exceeds LoAL+AHYS, the low limit alarm is cleared. Note: If necessary, HIAL and LoAL can also be set as deviation alarms (refer to the AF parameter description).	
HdAL	Deviation High Limit Alarm	When the deviation (measured value PV - setpoint SV) exceeds HdAL, a high deviation alarm is triggered. When the deviation is less than HdAL-AHYS, the alarm is cleared. This alarm function is disabled when HdAL is set to the maximum value.	
LdAL	Deviation Low Limit Alarm	When the deviation (measured value PV - setpoint SV) falls below LdAL, a low deviation alarm is triggered. When the deviation exceeds LdAL+AHYS, the alarm is cleared. This alarm function is disabled when LdAL is set to the minimum value. Note: If necessary, HdAL and LdAL can also be set as absolute value alarms (refer to the AF parameter description).	
AHYS	Alarm Hysteresis	Also known as alarm dead zone or hysteresis, this function helps prevent frequent triggering of the alarm relay at the threshold. Its role is explained above.	0~9999 Unit
AdIS	Alarm Indication	OFF: The alarm symbol will not be displayed on the lower display when an alarm occurs. on: The alarm symbol will alternate with the measurement values on the lower display when an alarm occurs, serving as a reminder. This mode is recommended. FOFF: Energy-saving/Confidential display mode. In this mode, the instrument will turn off the display of measurement and setpoint values, helping to save power or maintain confidentiality of process temperatures. The lower display will show the current station number, and the alarm symbol will appear when an alarm occurs.	

AOP	Alarm Output Definition	The four digits of the AOP—the ones digit, tens digit, hundreds digit, and thousands digit—are used to define the output positions for the four alarms: HIAL, LoAL, HdAL, and LdAL, respectively, as shown below: AOP = 3 3 0 1 ; LdAL HdAL LoAL HIAL The value ranges from 0 to 4. 0 means no alarm output from any port, and 1, 2, 3, 4 correspond to the alarm being output by AL1, AL2, AU1, and AU2, respectively. For example, setting AOP=3301 means that the high limit alarm (HIAL) is output from AL1, the low limit alarm (LoAL) has no output, and both HdAL and LdAL are output from AU1. Thus, either HdAL or LdAL triggering an alarm will cause AU1 to activate. Note 1: To use AL2 or AU2, an L3 dual relay module can be installed at the ALM or AUX position.	0~4444
nonc	Normally Open/Normally Closed Selection	A single alarm relay can simultaneously provide both normally open and normally closed outputs. However, the dual-channel alarm module L3 only has a normally open output. The normally open output can be defined as a normally closed output through the nonc parameter. When nonc=0, the L3 relays installed at positions AL1, AL2, AU1, and AU2 will all be normally open outputs. When nonc=15, the instrument will output normally closed alarms. When some channels require normally open outputs and others require normally closed outputs, the nonc value can be calculated using the following formula. nonc=A X 1+B X 2+C X 4+D X 8 In the formula, A, B, C, and D represent the normally open/closed selection for AL1, AL2, AU1, and AU2, respectively. A value of 1 indicates a normally closed output for the corresponding alarm, while a value of 0 indicates a normally open output.	0~15
CtrL	Control mode	OnoF: Adopt ON-OFF control, only suitable for applications with low control requirements. APID: Advanced AI-based PID control algorithm, recommended for use. nPID: Standard PID control algorithm with anti-saturation integral function. PoP: Directly output the PV value, allowing the instrument to function as a temperature transmitter. SoP: The SV value is directly used as the output value.	
Srun	Operating Status	run: Running control state, PRG indicator light is on. StoP: Stop state, with the lower display flashing "StoP" and the PRG light off. HoLd: Hold running control state. If the instrument is set for unlimited-time constant temperature control (when parameter Pno=0 for AI-516 or AI-516P), this state is equivalent to the normal running state but prevents running or stopping operations from being performed on the panel. If the instrument is set for program control (Pno>0), the instrument maintains control output but pauses the timer. In this case, the lower display flashes "HoLd," and the PRG light blinks. The running control or stop can be executed via the panel keys to exit the hold running state. Note: It is not possible to enter the hold running state using only the panel operation. This state can only be entered by directly modifying this parameter or through programming during program execution.	

Act	Direct/Reverse Action	rE: Reverse action control mode. When the input increases, the output decreases, such as in heating control. dr: Direct action control mode. When the input increases, the output increases, such as in cooling control. rEbA: Reverse action control with the added feature of eliminating the low limit alarm and deviation low limit alarm upon power-up. drbA: Direct action control with the added feature of eliminating the high limit alarm and deviation high limit alarm upon power-up.	
At	Auto-tuning	OFF: The auto-tuning At function is turned off. on: Start the auto-tuning function for PID and Ctl parameters; after the tuning is complete, it automatically returns to FOFF. FOFF: The auto-tuning function is turned off, and starting auto-tuning from the panel is prohibited. AAt: Fast auto-tuning function. After auto-tuning function is complete, it automatically returns to OFF. Note: When the AT parameter is set to the AAt option, the instrument can automatically activate the advanced fast auto-tuning function after power-on when the instrument is in full power heating output state. This allows the PID parameters to be pre-set without the need for traditional cycle oscillation auto-tuning, enabling accurate control in most cases with the first heating. If the AAT function fails to complete before the instrument exits the full power output state, the AAT process fails, the auto-tuning process will be terminated, and the PID parameters will not be modified.	
P	Proportional Band	Define the proportional band for APID and PID regulation, with the unit being the same as the PV value, rather than a percentage of the range. Note: The At function is typically used to determine the P, I, D, and Ctl parameter values, but for familiar systems, such as batch-produced heating equipment, the known correct P, I, D, and Ctl values can be directly input.	1~32000 Unit
I	Integral Time	Define the integral time for PID regulation in seconds, and the integral action is canceled when I=0.	1~9999 seconds
d	Derivative Time	Define the derivative time for PID control, with the unit in 0.1 seconds. When d=0, the derivative action is disabled.	0~3200 seconds

<table>
<tr>
<td>Ctl</td>
<td>Control Cycle</td>
<td>When SSR, SCR or current output is used, it is typically set between 0.5-3.0 seconds. When using relay switch outputs or in heating/cooling dual-output control systems, a short control cycle can shorten the lifespan of mechanical switches or cause frequent switching between heating and cooling outputs. If the cycle is too long, it may reduce control accuracy. Therefore, it is generally set between 15-40 seconds, with the recommended Ctl set to 1/5~1/10 of the differential time (which should roughly equal the system's lag time).
If the output uses relay switch (when OPt or Aut is set to rELY), the actual Ctl will be limited to over 3 seconds, and the auto-tuning At will automatically set Ctl to an appropriate value, balancing control accuracy and mechanical switch lifespan.
When the control mode parameter CtrL is set to ON-OFF mode, Ctl defines the delay time for output disconnection or ON action after power-up, preventing immediate reconnection after disconnection. This function is designed to protect the compressor's operation.</td>
<td>0.2~300.0 seconds</td>
</tr>
<tr>
<td>CHYS</td>
<td>Control Hysteresis (Dead Zone, Hysteresis)</td>
<td>This is used to prevent the relay from frequent switching in ON-OFF control mode.
For reverse action (heating) control, when PV is greater than SV, the relay turns off. The output reconnects when PV is less than SV-CHYS. For direct action (cooling) control, when PV is less than SV, the output turns off. The output reconnects when PV is greater than SV+CHYS.</td>
<td>0~9999 Unit</td>
</tr>
<tr>
<td>InP</td>
<td>Input Specifications Code</td>
<td>InP is used to select the input specification, and its value corresponds to the following input specification:
<table>
<tr><td>0 K</td><td>17 K (0~300.00℃)</td></tr>
<tr><td>1 S</td><td>18 J (0~300.00℃)</td></tr>
<tr><td>2 R</td><td>25 0~75mV voltage input</td></tr>
<tr><td>3 T</td><td>28 0~20mV voltage input</td></tr>
<tr><td>4 E</td><td>30 0~60mV voltage input</td></tr>
<tr><td>5 J</td><td>35 -20~+20mV voltage input</td></tr>
<tr><td>6 B</td><td>38 10~50mV voltage input</td></tr>
<tr><td>7 N</td><td>39 15~75mV voltage input</td></tr>
<tr><td>8 WRe3-WRe25</td><td></td></tr>
<tr><td>9 WRe5-WRe26</td><td></td></tr>
<tr><td>10 User-specified extended input specifications</td><td></td></tr>
<tr><td>12 F2 radiation high temperature thermometer</td><td></td></tr>
<tr><td>13 T (0~300.00℃)</td><td></td></tr>
</table>
Note 1: When setting InP=10, a custom input nonlinear table can be defined or it can be input by the manufacturer for an additional fee.</td>
<td>0~106</td>
</tr>
<tr>
<td>dPt</td>
<td>Decimal Point Position</td>
<td>Four display formats are available for selection: 0, 0.0, 0.00, and 0.000.
Note: When using a standard thermocouple input, only the 0 or 0.0 formats can be selected. Even when the 0 format is selected, an internal resolution of 0.1°C is maintained for control calculations. For type S thermocouples, it is recommended to select the 0 format. When InP=17, 18, or 22, the instrument has an internal resolution of 0.01°C, and the display formats 0.0 or 0.00 can be selected.</td>
<td></td>
</tr>
<tr>
<td>SCL</td>
<td>Input Scale Lower Limit</td>
<td>Used to define the lower scale value for the linear input signal. When the instrument is used for transmission output or bar graph display, it also defines the lower scale limit for the signal.</td>
<td>-9990~+32000 Unit</td>
</tr>
</table>

SCH	Input Scale Upper Limit	Used to define the upper scale value for the linear input signal. When the instrument is used for transmission output or bar graph display, it also defines the upper scale limit for the signal.	
Scb	Input Offset Correction	The Scb parameter is used to apply a translation correction to the input, compensating for errors in the sensor, input signal, or thermocouple cold-junction compensation. Note: Generally it should be set to 0. Incorrect settings can lead to measurement errors.	-9990~ +4000 Unit
FILt	Input Digital Filtering	The FILt determines the strength of the digital filtering. The higher the setting, the stronger the filtering, but the slower the response speed of the measurement data. When the measurement is subject to significant interference, gradually increase FILt to reduce the instantaneous fluctuations of the measurement value to less than 2~5 counts. When the instrument undergoes metrological verification, FILt should be set to 0 or 1 to improve the response speed. The unit of FILt is 0.5 seconds.	0~99
Fru	Power Supply Frequency and Temperature Unit Selection	50C indicates that the power supply frequency is 50Hz, providing maximum resistance to interference for inputs at this frequency. The temperature unit is °C. 50F indicates that the power supply frequency is 50Hz, providing maximum resistance to interference for inputs at this frequency. The temperature unit is °F. 60C indicates that the power supply frequency is 60Hz, providing maximum resistance to interference for inputs at this frequency. The temperature unit is °C. 60F indicates that the power supply frequency is 60Hz, providing maximum resistance to interference for inputs at this frequency. The temperature unit is °F.	
OPt	Output Type	SSr: The output provides SSR driving voltage or zero-crossing trigger time signal for SCR. Modules such as G, K1, or K3 should be installed to adjust the output power by modifying the on-off time ratio, with a typical cycle of 0.5-4.0 seconds. rELy: This setting should be used when the output is for a relay contact switch or when the system has mechanical contact switches (such as in contactors or compressors). To protect the mechanical contacts' lifespan, the system limits the output cycle to 3-120 seconds. It is generally recommended to set the cycle time to 1/5-1/10 of the system's lag time. 0-20: 0~20mA linear current output, the installation of the X3 or X5 linear current output module is required. 4-20: 4~20mA linear current output, the installation of the X3 or X5 linear current output module is required. PHA1: Single-phase phase-shift output. To achieve phase-shift output, the K50/K60 phase-shift trigger output module must be installed.	
OPL	Output Low Limit	When set to 0~100%, this represents the minimum output limit for the adjustment output OUTP in typical unidirectional control.	0~110%
OPH	Output High Limit	When the measured value PV is lower than the OEF, it limits the maximum output value of the main output OUTP. The OPH setting must be greater than the OPL.	0~110%

OEF	OPH Effective Range	When the measured value PV is less than the OEF, the output high limit of OUTP is OPH. When PV exceeds the OEF value, the regulator output is not limited and reaches 100%. Note: This function is used in situations where full power heating is not allowed at low temperatures. For example, when drying moisture in a furnace or preventing too rapid heating, a heater may be allowed only up to 30% of the maximum heating power when the temperature is below 150°C. In this case, the settings can be: OEF=150.0(°C), OPH=30(%).	-999.0~ +3200.0 ℃ or Linear Unit
Addr	Communication Address	The Addr parameter is used to define the instrument communication address, and the valid range is 0~99. Instruments on the same communication line should have different Addr values to distinguish them from each other.	0~99
bAud	COMM Module Function Selection	The bAud parameter defines the communication baud rate, with a configurable range of 0~28800 bit/s (28.8K). When the COM port is not used for communication, the bAud parameter can be set to configure the COM port to other functions: bAud=0: Configure the COMM port for 0~20mA measured value transmission output bAud=1: Serve as an external digital input, with functionality equivalent to the MIO position. If the MIO position is occupied, the I2 module can be installed in the COMM position. bAud=2: Configure the COMM/AUX port as AU1 + AL1 output, applicable for D2 or D6 size instruments requiring event output (requires L3 module installation). bAud=3: Configure the COMM/AUX port as AUX output, applicable for D2 or D6 size instruments. bAud=4: Configure the COMM port for 4~20mA measured value transmission output. bAud=8: Configure the COMM port for 0~20mA setpoint transmission output. bAud=12: Configure the COMM port for 4~20mA setpoint transmission output.	0~28.8K

AF	Advanced Function Code	The AF parameter is used to select the advanced function, and its calculation method is as follows: AF=A×1+B×2 +C×4 +D×8+E×16+F×32+G×64 +H×128 A=0: HdAL and LdAL function as deviation alarms. A= 1: HdAL and LdAL function as absolute value alarms, allowing the instrument to have 2 groups of absolute value high limit alarms and absolute value low limit alarms. B=0: The alarm and ON-OFF hysteresis work as unilateral hysteresis. B=1: As bilateral hysteresis. C=0: The third row of the instrument includes one decimal place. C=1: The third row of the instrument does not include a decimal point (only applicable for three-row display). D=0: The password to access the parameter table is the public 808. D=1: The password is the value of the parameter PASd. Long press the left button to find LOC after switching to the field parameter. E=0:HIAL and LOAL function as the absolute value high limit alarm and the absolute value low limit alarm, respectively. E=1: HIAL and LOAL change to deviation high limit alarm and deviation low limit alarm, respectively, allowing for 4 deviation alarms. F=0 indicates fine control mode, where the internal control resolution is 10 times the display resolution, but for linear input, the maximum display value is limited to 3,200 units. F=1 represents high-resolution display mode. This mode should be selected when the required display value exceeds 3,200. G=0: A high limit alarm is allowed when the measurement value increases due to sensor disconnection (the high limit alarm setting value should be below the signal's upper range limit). G=1: A high limit alarm is not allowed when the measurement value increases due to sensor disconnection. Please note that in this mode, even normal high limit alarms (HIAL) will be delayed by approximately 15 seconds before being triggered. H=0: HIAL and LOAL follow independent alarm logic. H=1: HIAL and LOAL are changed to interval alarms, where an alarm will only trigger when LOAL>PV>HIAL. The alarm code will be HIAL, and the output will also use HIAL. Note: For non-expert users, this parameter can be set to 0.	0~255

AFC	Communication Mode	The AFC parameter is used to select the communication mode, calculated as follows: AFC=A×1+D×8+G×64. A = 0: The communication protocol used by the instrument is standard MODBUS. A = 1: The communication protocol used by the instrument is AIBUS. A = 2: The communication protocol used by the instrument is MODBUS compatibility mode. A = 4: The communication protocol used by the instrument is compatible with S6 module communication functionality. D = 0: No parity check. D = 1: Even parity check. G = 0: AUX is used for normal operation. G = 1: AUX is used as an event input. Note: When the AFC is set to the MODBUS protocol, it supports two commands: 03H (read parameter and data) and 06H (write single parameter). When AFC = 0 or 4, the 03H command can read up to 20 words of data in a single request. When AFC= 2, the 03H command will read a fixed amount of 4 words of data. For detailed information, please refer to the communication protocol instruction.	0~255
PASd	Password	When PASd is set between 0-255 or AF.D=0, setting Loc=808 allows access to the complete parameter table. When PASd is set between 256-9999 and AF.D=1, Loc=PASd must be set to access the complete parameter table. Note: Only expert-level users are allowed to set PASd. It is recommended to use a unified password to avoid forgetting it.	0-9999
SPL	Setpoint Lower limit	The minimum value allowed to be set for the SP* parameter.	-9990~ +30000 Unit
SPH	Setpoint Upper Limit	The maximum value allowed to be set for the SP* parameter.	
PonP	Power-on Automatic Operation Mode	Cont: If the instrument was in a stop state before power-off, it will continue in the stop state; otherwise, it will resume execution from the last stopped point after power-on. StoP: After power-on, regardless of the situation, the instrument will enter the stop state. run1: If the instrument was in a stop state before power-off, it will continue in the stop state; otherwise, it automatically restarts the program from the beginning after power-on. dASt: After power-on, if there is no deviation alarm, the program will continue to execute; if there is a deviation alarm, the operation will stop. HoLd: If the instrument is powered off during operation, it will enter a paused state upon power-on, regardless of the situation. However, if the instrument was in a stop state before power-off, it will remain in the stop state after power-on.	
EP1-EP8	Field Use Parameter Definition	1~8 field parameters can be defined as commonly used parameters that require modification by the on-site operator after the Loc lock is applied. If there are fewer than 8 field parameters, their values can be set to nonE.	

3.3 Special Functions Supplementary Notes

3.3.1 Alarm Bypass on Power-On

When the instrument is just powered on, it often leads to unnecessary alarms. For example, in electric furnace temperature control (heating control), when powered on, the actual temperature is far below the set temperature. If the user has configured low limit alarms or deviation low limit alarms, the instrument will trigger an alarm immediately upon power-on, even though there may not be any actual issues with the control system. On the contrary, in cooling control (direct-acting control), powering on may lead to high limit alarms or deviation high limit alarms. Therefore, the AI instrument provides a power-on alarm bypass feature. When the Act parameter is set to rEbA or drbA, the instrument will not trigger an alarm immediately upon power-on, even if the corresponding alarm conditions are met. The alarm will only occur if the alarm condition is cleared, and the same condition is met again.

3.3.2 Communication Function

The AI series instruments can install an S or S4 type RS485 communication interface module at the COMM position to enable multi-device connection with a computer. Through the computer, various operations and functions of the instrument can be controlled. For computers without an RS485 interface, an RS232C/RS485 converter or USB/RS485 converter can be added. Each communication port can directly connect 1-60 instruments, and with the addition of an RS485 repeater, up to 80 instruments can be connected. A single computer can support multiple communication ports for connection. Note that each instrument should be set to a different address. When a large number of instruments are involved, two or more computers can be used, with these computers forming a local network. The manufacturer provides AIFCS application software, which can run on Chinese Windows operating systems. It allows for centralized monitoring and management of 1~120 AI series instruments of various models, and can automatically record measurement data and print reports. If users wish to develop their own configuration software and need to obtain the communication protocol, they can request it for free from the instrument sales personnel. There are various configuration software options available that support communication with AI instruments.

3.3.3 Temperature Transmitter

In addition to conventional APID/PID or ON-OFF control, the instrument can also directly output the measured value (PV) or setpoint value (SV) from the OUTP terminal. When defined as a current output, the AI-516 can function as a temperature transmitter, with a 4~20mA current output accuracy of 0.3% FS corresponding to the displayed value. The related parameter settings are as follows:

CtrL=PoP for the transmitting output PV value and CtrL=SoP for the transmitting output SV value.

OPt: select the output specification, usually select 4~20mA output or 0~20mA output.

Parameters such as InP, SCH, SCL, and Scb are used to select the thermocouple specification for input, as well as the lower and upper limits of the PV value for the transmitter output and any translation corrections.

For example: The instrument is required to have a K-type thermocouple transmitter function, with a temperature range of 0~400℃ and an output of 4~20mA. Then each parameter is set as follows: InP=0, ScL=0.0, ScH=400.0, OPt=4-20. The transmitter defined with these settings will operate as follows: When the temperature is less than or equal to 0°C, the output at the OUTP position (with an X3 or X5 linear current module) will be 4mA. When the temperature reaches 400°C, the output will be 20mA. Between 0~400℃, the output will vary continuously from 4mA to 20mA.

3.3.4 Fine Control

Fine control refers to the fact that the resolution of the PID calculation is 10 times higher than the display resolution. For example, while the instrument may display the temperature signal as 1°C, the internal PID calculation and control will still operate with a resolution of 0.1°C. This allows for significantly higher control accuracy compared to the displayed resolution. In previous versions of the AI series instruments, only the temperature signal used fine control mode. In the new version, fine control mode is applied by default for linear inputs whenever the display value range is below 3000 counts (as most industrial applications typically do not exceed 3000). This ensures higher control accuracy and more stable output. However, if a display value range greater than 3000 is required, the setting AF.F = 1 can be used.

3.3.5 Multi-Segment Linear Correction Function for Input Signals

When the input specification InP is set by adding 64, the instrument enables the multi-segment linear correction function for the input signal. The setting method is as follows: set the Loc parameter to 3698 to enter the table setting mode. (If the original Loc=808, first change Loc to 0, exit the parameter setting mode, then re-enter the parameter setting mode and set Loc to 3698). The separate settings are as follows:

A00: 0;
A01: Input signal and display setting:

A 01=A×1+E×16+G×64

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

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

G indicates signal type: G=0, thermocouple; G=1.

For example: If the signal is thermocouple input, temperature class, then set A01=2×1+1×16+0×64=18
A02: Starting temperature
A03: Measurement range = Maximum measurement value-A02
A04: Temperature interval per segment = A03/number of segments
d00~d59:: Temperature setting value per segment

For example: The type K thermocouple input range is from 0 to 300 degrees, with one decimal place, and corrections are applied every 100 degrees. Then set parameters A00=0, A01=18, A02=0.0, A03=300.0, A04=100.0, d00=0.0,d01=100.0, d02=200.0, d03=300.0. To make a correction, simply set the corresponding temperature point higher or lower. For example, if the instrument displays 200.0°C, but the calibration device measures 202.0°C, change d02=200.0 to d02=202.0.

Note: The correction value applies to each point, and the transition between points is automatically linear. Once this function is enabled, the instrument will only display values within the temperature range set in the table. If the actual temperature exceeds the table range, the instrument will display an orAL over-range alarm.

3.3.6 High-Temperature Furnace Nonlinear Power Control Function

For high-temperature furnaces with nonlinear loads, the resistance changes drastically with temperature. Taking a silicon-molybdenum rod furnace as an example, the room temperature resistance is only about 6% of the resistance at 1600°C. If the output power of the instrument is not limited or adjusted, two issues may arise. First, during low-temperature startup, the furnace current may exceed the maximum allowable load of the power grid, SCR, and transformer, potentially damaging the SCR, furnace, and transformer or causing the power grid to trip. Additionally, since the furnace power varies by more than 10 times between the low and high temperature regions at the same instrument output, this means that the proportional band P in the PID parameters must change by more than 10 times across different temperatures to achieve accurate temperature control in both the low and high-temperature regions. Using the OPH limiting parameter method can only limit the output power and cannot adjust the proportional band. To ensure precise temperature control in both low and high-temperature regions, multiple sets of PID parameters must be configured, which not only complicates the setup but also reduces the effectiveness. The custom output limit transformation function solves both the output limitation and the transformation of the proportional band P. This function limits and adjusts the instrument's output based on the measured temperature. It not only restricts the power in the low-temperature zone but also automatically corrects the proportional band parameters at different temperatures. Both the power limitation and the changes in the proportional band are applied in a continuous piecewise linear manner, which is more effective than using proportional grouping. The power limitation only proportionally reduces the instrument's actual output, while the display range of the instrument remains 0~100%. For example, when used with a silicon-molybdenum rod furnace, the settings can be as follows (customers may modify the data according to their requirements):

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

When the parameters A00=1 and A01=1050 are set, the instrument enables the custom output limit transformation function. A02 represents the starting temperature for output limitation, A03 represents the temperature range for output limitation, and A04 represents the segment length for the non-linear data temperature segments. In this case, 1500/750.0=2, which means there are 2 segments. The more segments there are, the more complex and detailed the curve can be. d00 indicates the maximum output power below A02, with the unit being 100% × (1/2000). d00=120.0 represents 6%, d01 represents 55%, and d02 represents 100%.

This curve means that when the temperature is below 100°C, the output power is limited to 6%. Between 100°C and 850°C, the power limit smoothly transitions from 6% to 55%. Between 850°C and 1600°C, the power limit transitions from 55% to 100%. Above 1600°C, there is no power limitation, and it remains at 100%.

Note: The range of d-value is 0~59, which corresponds to a maximum of 60 segments of power limitation. This function cannot be used simultaneously with the multi-segment linear correction function. If special input specifications are required at the same time, please contact the sales personnel to discuss embedding them into the instrument. However, this may incur a one-time additional fee.

4 Frequently Asked Questions

4.1 How to Auto-Tune?

When the measured value PV is at room temperature, set the setpoint SV to approximately 60% of the commonly used temperature (for signals like pressure or flow, the commonly used setpoint value can be directly set). then press and hold for two seconds to call out the At parameter, change the parameter value from OFF to ON and press to confirm to enable auto-tuning. Once the At symbol stops flashing, the instrument will be ready to operate normally.

4.2 How to enter the internal parameter list?

Press and hold for two seconds to enter the parameter list, then press briefly to find the next parameter. If the full parameter is locked, find the password lock parameter LOC and set it to 808, then press briefly to view all parameters.

4.3 The instrument panel is flashing “orAL”?

This indicates that the instrument has not detected an input signal. First, check whether the sensor model corresponds to the input specification parameter InP. Then, verify if the wiring to the instrument’s input terminal is correct. If no issues are found, measure whether the signal from the sensor is correct, as the sensor may be damaged.

4.4 How to set the alarm parameters?

First, set the alarm parameter to the desired value (e.g., to set a 200°C high limit alarm, change the HIAL parameter to 200). Then, go to the internal parameters and find the AOP parameter to define the alarm signal output port (e.g., to output the high limit alarm from AL1, set the units digit of the AOP to 1. For specific definition, please refer to the user manual for the AOP parameter description.)

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