Advanced Temperature Controller
Ramp and Soak Temperature Controller
User Manual

This controller is intended to control equipment under normal operating conditions. If failure or malfunction of the controller may lead to abnormal operating conditions that may result in personal injury or damage to the equipment or other property, devices (limit or safety controls) or systems (alarm or supervisory) intended to warn of or protect against failure or malfunction of the controller must be incorporated into and maintained as part of the control system.

1 Front panel and operation

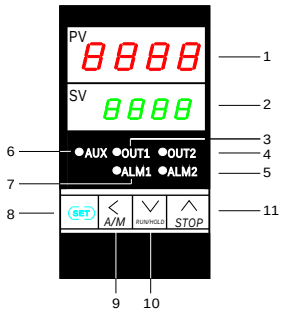


Figure 1. Front Panel

1:PV display: Indicates the sensor readout, or process value(PV)
2:SV display: Indicates the set value(SV) or output value(%)
3:OUT1: Output indicator, It is synchronized with control output and the power to the load. When it is on, the heater (or cooler) is powered.
4:OUT2: Output 2 is not applicable for this instrument.
5:ALM2: It lights up when AL2 relay is on
6:AUX: Auxiliary output indicator, when auxiliary function incorporated and activated, the indicator lights up.
7:AL1: It lights up when AL1 relay is on
8:SET key: When it is pressed momentarily, the controller will switch the lower (SV) display between set value and percentage of output. Whenpressed and held for two seconds will put the controller into parameter setting mode.
9:A/M: Auto/manual control function key/ data shift key
10:Decrement key/Run or STOP the program
11:Increment key/Stop the program key

1.1 Display Status

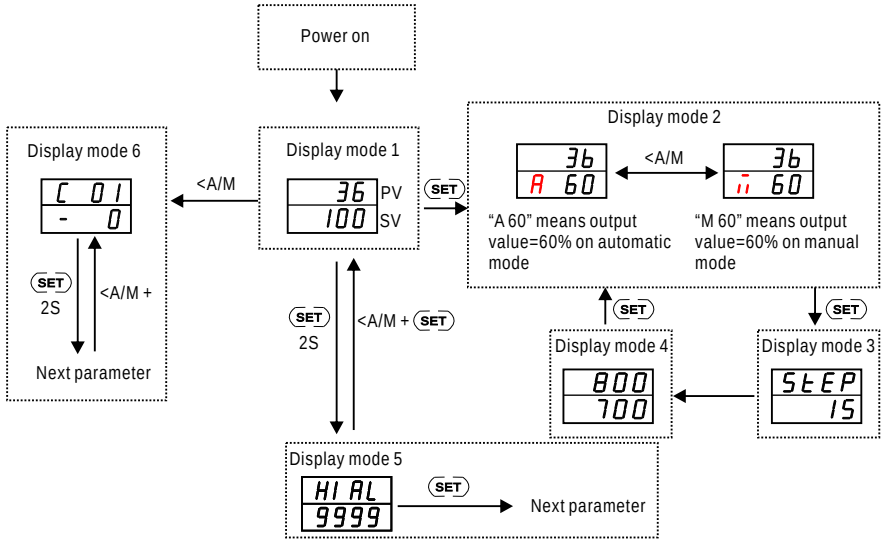


Figure 2. Display modes

Display mode 1: When the power is turned on, the upper display window shows the measured value(PV) and the lower window shows the set value(SV)
Display mode 2: Press the set key to change the display status into mode 2, the upper display window shows the process value(PV) and the lower display window shows the output value, this picture shows the output percentage is 60% when in automatic(PID) control mode.Pressing the <A/M key will switch the controller between PID and manual control mode with the output unchanged. This bumpless transfer allows the controller to be switched between manual and automatic mode without the output suddenly 'bumping' to a different value.
Display mode 3: Press the set key under display mode 2 to change the display into mode 3, which the upper display shows StEP and lower display shows the StEP being executed.
Display mode 4: Press the set key under display mode 3 to change the display into mode 4, the upper display shows the StEP time being executed. the lower display shows the time that the current StEP has been running.
Display mode 5: Press the set key under display mode 1 for 2 seconds to enter the display mode 5, where user can configure various system parameters
Display mode 6: Press the <A/M key under display mode 1 to enter the display mode 6, where users can configure a desired ramp/soak program.

1.2 Basic Operation

1.2.1 Changing Set Value

Press the ▼or ▲key once,and then release it . The decimal point on the lower right corner will start to flash . Press the ▼or ▲key to change SV until the desired value is displayed . If the change of SV is large , press the A /M key to move the flashing decimal point to the desired digit that needs to be changed . Then press the ▼or ▲key to start changing SV from that digit .The decimal point will stop flashing after no key is pressed for 3seconds . The changed SV will be automatically registered without pressing the SET key.

1.2.2 Display change

Press the SET key to change the display mode. The display can be changed between display modes 1 and 2

1 2. 3Manual /Automatic mode switch

Bumpless switching between PID mode and Manual mode can be performed by pressing the A /M key. In Manual mode , the output amplitude can be increased or decreased by pressing ▲and ▼ (display mode 2) .

1.2.4 Parameter Setup Mode

When the display mode is 1, press SET and hold for roughly 2 seconds until the parameter setup menu is displayed (display mode 5). Please refer to figure 3 setupflowchart

1.3 Setup flow chart

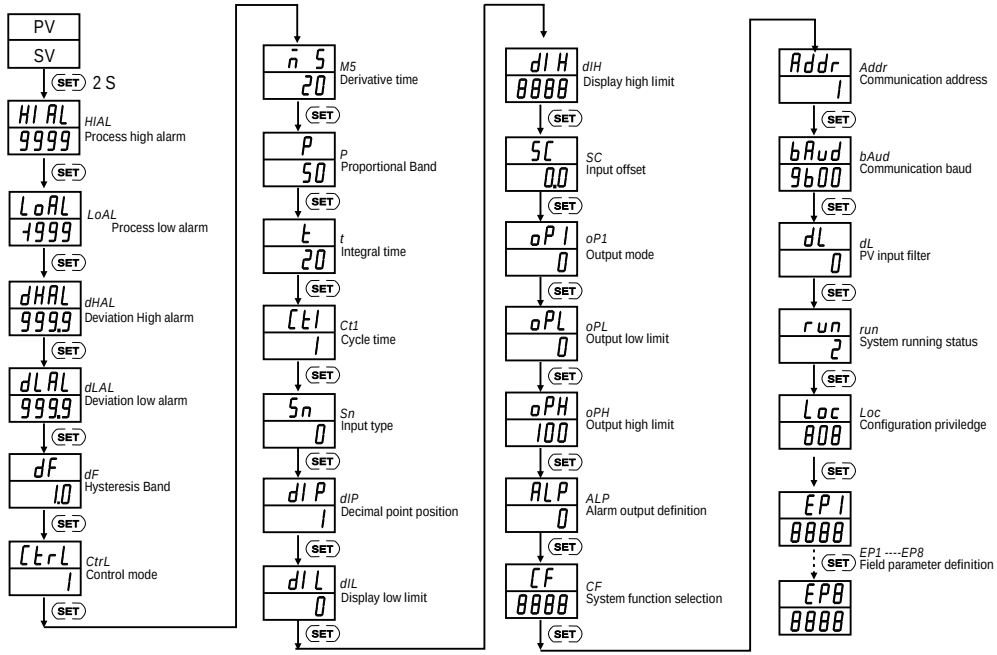


Figure 3. system parameter setup flow chart

1.4 Parameter Setting

Table 1 System Parameters

Code	Description	Setting Range	Initial setting	Remarks
HIAL	Process high alarm	1999~+9999 °C	9999	
LoAL	Process low alarm	1999~+9999 °C	-1999	
dHAL	Deviation high alarm	0～9999°C	999.9	
dLAL	Deviation low alarm	0～9999°C	999.9	
dF	Hysteresis Band	0~200.0 °C or 0~2000 for linear input	0.3	
CtrL	Control mode	0~4	3	
M5	Derivative time	0～999.9 °C	128.2	
P	Proportional band	0～9999 °C	120	
t	Intergral time	0~2000	88	
Ct1	cycle time	0~125	5 for SSR 20 for relay	
Sn	Input type	0~37	0	
dIP	Decimal point position	0~3	0	
dIL	Display low limit	1999~+9999 °C	0	
dIH	Display high limit	1999~+9999 °C	100	
SC	Input offset	-1.99～ +400.0 °C	0.0	
oP1	Output mode	0~4	0	
oPL	Output low limit	0~110 %	0	
oPH	Output high limit	0~110 %	100	
ALP	Alarm output definition	0~31	0	
CF	System funtion selection	0~19	0	
Addr	Communication address	0～5555	1	
bAud	Communication baud	0~20	9600	
dL	PV input filter	0~19200	5	
run	System runing status	0~2	2	
		0~127	2	
Loc	Configuration priviledge	0~9999	808	
EP1~EP8	Field parameters definition	nonE ~ A-M	nonE	

1.4.1 Alarm parameters

This controller offers four types of alarm, “HIAL” “LoAL” “dHAL” “dLAL”

HIAL: High limit absolute alarm. If the process value is greater than the value specified as “HIAL+dF” (dF is the Hysteresis Band),then the alarm will turn on. It will turn off when the process value is less than “HIAL-dF” .

LoAL: Low limit absolute alarm. If the process value is less than the value specified as “LoAL-dF” then the alarm will turn on,and the alarm will turn off if the process value is greater than “LoAL+dF”.

dHAL: Deviation high alarm. If the temperature is above “SV+dHAL-dF” the alarm will turn on, and the alarm will turn off if the process value is less than “SV+dHAL-dF” (we will discuss the role of dF in the later section)

dLAL: Deviation low alarm. If the temperature is below “SV-dLAL-dF”,the alarm will turn on, and the alarm will turn off if the temperature is greater than “SV-dLAL+dF”

The things you should know about alarm

1) Absolute alarm and deviation alarm

High (or low) limit absolute alarm is set by the specific temperatures that the alarm will be on. Deviation high (or low) alarm is set by how many degrees above (or below) the control target temperature (SV) that the alarm will be on.e.g. Assuming HIAL=1000 ℃, dHAL=5 ℃, SV=700 ℃. When the probe temperature (PV) is above 705, the deviation alarm will be on. When the temperature is above 1000 ℃, the process high alarm will be on. Later, when SV changes to 600 ℃, the deviation alarm will be changed to 605 but process high alarm will remain the same. Here the Hysteresis Band (dF) setting is ignored. Please see 1.5.2 for details.

2)Alarm Suppression feature Sometimes, user may not want the low alarm to be turned on when starting the controller at a temperature below the low alarm setting. The Alarm Suppression feature will suppress the alarm from turning on when the controller is powered up (or SV changes). The alarms can only be activated after the PV has reached SV.

3) Activate the AL1 and AL2 by time instead of temperature

For the controllers with the ramp and soak function, AL1 and AL2 can be activated when the process reaches a specific time. This is discussed in the section 3.7 of “Supplementary Instruction Manual” for ramp/soak version”.

1.4.2 Hysteresis Band “dF”

The Hysteresis Band parameter dF is also referred as Dead Band, or Differential. It permits protection of the on/off control from high switching frequency caused by process input fluctuation. Hysteresis Band parameter is used for on/off control, 4-alarm control as well as the on/off control at auto tuning. For example: 1) When controller is set for on/off heating control mode,the output will turn off when temperature goes above SV+dF and on again when it drops to below SV-dF. 2) If the high alarm is set at 800 ° C and hysteresis is set for 2 ° C, the high alarm will be on at 802 ° C (ALM1+dF) and off at 798 ° F (ALM1-dF). Please note that the cycle time can also affect the action. If the temperature passes the dF set point right after the start of a cycle, the controller will not respond to the dF set point until the next cycle. If cycle time is set to 20 seconds, the action can be delay as long as 20 seconds. Users can reduce the cycle time to avoid the delay.

1.4.3 Control mode “ Ctrl ”

Ctrl=0 On/off control. It works like a mechanical thermostat. It is suitable for devices that do not like to be switched at high frequency, such as motor and valves

Ctrl=1 Gets the controller ready to start the Auto tuning process by pressing the A/M key.

Ctrl=2 Start auto tuning. The function is the same as starting auto tuning from front panel.

Ctrl=3 This configuration is automatically set after auto tuning is done. Auto tuning from the front panel is inhibited to prevent accidental re-starting of the auto tuning process. To start auto tuning again, set Ctrl=1 or Ctrl=2.

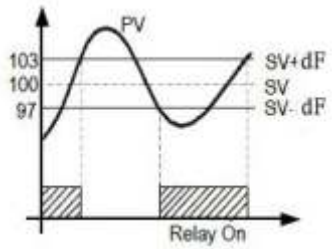
1.5 Control action explanations

1.5.1 PID

Please note that because this controller uses fuzzy logic enhanced PID control software, the definition of the control constants (P, I and d) are different than that of the traditional proportional, integral, and derivative parameters. In most cases the fuzzy logic enhanced PID control is very adaptive and may work well without changing the initial PID parameters. If not, users may need to use auto-tune function to let the controller determine the parameters automatically. If the auto tuning results are not satisfactory, you can manually fine-tune the PID constants for improved performance. Or you can try to modify the initial PID values and perform auto tune again. Sometimes the controller will get the better parameters. The auto-tune can be started in two ways. 1) Set Ctrl=2. It will start automatically after 10 seconds. 2) Set Ctrl=1. Then you can start the auto-tune any time during the normal operation by pressing the A/M key. During auto tuning, the instrument executes on-off control. After 2-3 times on-off action, the microprocessor in the instrument will analyze the period, amplitude, waveform of the oscillation generated by the on-off control, and calculate the optimal control parameter value. The instrument begins to perform accurate artificial intelligence control after auto tuning is finished. If you want to exit from auto tuning mode, press and hold the (A/M) key for about 2 seconds until the blinking of "At" symbol is stopped in the lower display window. Generally, you will only need perform auto tuning once. After the auto tuning is finished. The instrument will set parameter “Ctrl”to 3, which will prevent the(A/M)key from triggering auto-tune.This will prevent an accidental repeat of the auto-tuning process.

1.5.2 On/off control mode

It is necessary for inductive loads such as motors, compressors, or solenoid valves that do not like to take pulsed power. It works like a mechanical thermostat. When the temperature passes the set point, the heater (or cooler) will be turned off. When the temperature drops back to below the hysteresis band (dF) the heater will turn on again.To use the On/off mode, set Ctrl=0. Then, set the Hy to the desired range based on control precision requirements. Smaller dF values result in tighter temperature control, but also cause the on/off action to occur more frequently.



1.5.3. Manual mode

Manual mode allows the user to control the output as a percentage of the total heater power. It is like a dial on a stove. The output is independent of the temperature sensor reading. One application example is controlling the strength of boiling during beer brewing. You can use the manual mode to control the boiling so that it will not boil over to make a mess. The manual mode can be switched from PID mode but not from On/off mode. This controller offers a “bumpless” switch from the PID to manual mode. If the controller outputs 75% of power at PID mode, the controller will stay at 75% when it is switched to the manual mode, until it is adjusted manually. See Figure 2 for how to switch the display mode.

1.6 Cycle time “t”

It is the time period (in seconds) that the controller uses to calculate its output. e.g. When t=2, if the controller decides output should be 10%, the heater will be on 0.2 second and off 1.8 seconds for every 2 seconds. Smaller t values result in more precision control. For SSR output, it is set at 5 seconds or you can change to 2S. For relay or contractor output, it should be set longer to prevent contacts from wearing out too soon.Normally it is set to 20~ 40 seconds.

Table 2. Code for Sn and its range.

SN CODE	Input Device	Display Range(Celcius)
0	K(Thermocouple)	-50~+1300
1	S(Thermoucouple)	-50~+1700
3	T(Thermocouple)	-200~+350
4	E(Thermocouple)	0~+800
5	J(Thermocouple)	0~+1000
6	B(Thermocouple)	0~+1800
7	N(Thermocouple)	0~+1300
20	Cu50	-50~+150
21	Pt100	-200~+600
26	0~80Ω	-1999~+9999 Defined by user with dIL and dIH
27	0~400Ω	
28	0~20mV	
29	0~100 mV	
30	0~60 mV	
31	0~1V	
32	0.2~1V 4-20mA (w / 50Ω Resistor)	
33	1~5V 4~20mA (w / 250Ω Resistor)	
34	0-5V	
35	-20mA~+20mA	
36	-100mA~+100mA	
37	-5V~+5V	

1.7 Decimal point setting “dIP”

1) In case of thermocouple or RTD input, dP is used to define temperature display resolution.

dP=0, temperature display resolution is 1 ℃

dP=1, temperature display resolution is 0.1 ℃. The temperature will be displayed at the resolution of 0.1 ℃ for input below 1000 ℃ and 1 ℃ for input over 1000 ℃.

2) For linear input devices (voltage, current or resistance input, Sn=26-37)

Table 3. dP parameter setting

dIP Value	0	1	2	3
Display format	0000	000.0	00.00	0.000

1.9 Limiting the control range, “dIL” and “dIH”

1) For temperature sensor input, the “dIL”and “dIH” values define the set value range. dIL is the low limit, and dIH is the high limit.

e.g. Sometimes, you may want to limit the temperature setting range so that the operator can’t set a very high temperature by accident. If you set the dIL=100 and dIH =130, operator will only be able to set the temperature between 100 and 130.

2) For linear input devices, “dIL”and “dIH” are used to define the display span. e.g. If the input is 0-5V. dIL is the value to be displayed at 0V and dIH is the value at 5V.

1.10 Input offset “SC”

SC is used to set an input offset to compensate the error produced by the sensor or input signal itself. For example, if the controller displays 5^0C when probe is in ice/water mixture, setting SC=-5, will make the controller display 0^0C.

1.11 Output definition “oP1”

This parameter is not used for this model. It should not be changed.

1.12 Output range limits “oPL” and “oPH”

oPL and oPH allow you set the output range low and high limit. oPL is a useful feature for a system that needs to have a minimum amount of power as long as the controller is powered. e.g. If oPL=20, the controller will maintain a minimum of 20% power output even when input sensor failed. oPH can be used when you have an overpowered heater to control a small subject. e.g. If you set the oPH=50

e.g. If you set the oPH=50, the 5000 watt heater will be used as 2500W heater (50%) even when the PID wants to send 100% output.

1.13 Alarm output definition "ALP"

Parameter "ALP" may be configured in the range of 0 to 31. It is used to define which alarms ("HIAL" "LoAL" "dHAL" and "dLAL" is output to AL1 or AL2. Its function is determined by the following formula

ALP=AX1+BX2+CX4+DX8+EX16

If A=0, then AL2 is activated when Process high alarm occurs; If A=1, then AL1 is activated when Process high alarm occurs ;
If B=0, then AL2 is activated when Process low alarm occurs; If B=1, then AL1 is activated when Process low alarm occurs ;
If C=0, then AL2 is activated when Deviation high alarm occurs; If C=1, then AL1 is activated when Deviation high alarm occurs ;
If D=0, then AL2 is activated when Deviation low alarm occurs ; If D=1, then AL1 is activated when Deviation low alarm occurs ;
If E=0, then alarm types, such as "HIAL" and "LoAL" will be displayed alternatively in the lower display window when the alarms are on. This makes it easier to determine which alarms are on. If E=1, the alarm will not be displayed in the lower display window (except for "orAL") . Generally this setting is used when the alarm output is used for control purposes. For example , in order to activate AL1 when a Process high alarm occurs, trigger AL2 by a Process low alarm, Deviation high alarm, or Deviation low alarm, and not show the alarm type in the lower display window, set A=1, B=0, C=0, D=0, and E=1. Parameter "ALP" should be configured to: ALP=1X1+0X2+0X4+0X8+1X16=17 (this is the factory default setting)Note: Unlike controllers that can be set to only one alarm type (either absolute or deviation but not both at same time), this controller allows both alarm types to function simultaneously. If you only want one alarm type to function, set the other alarm type parameters to maximum or minimum(HIAL, dHAL and dLAL to 9999, LoAL to -1999) to stop its function.

1.14 System function selection "CF"

Parameter "CF" is used to set the heating or cooling, alarm suppression and power restriction function. Its value is determined by the following formula: CF=AX1+BX2+CX16

A=0, reverse action control mode for heating control.
A=1, direct action control mode for cooling control.
B=0, without alarm suppressing when turned on or when set point changes.
B=1, alarm suppressing at power up or set point changes.
C=0, without power restricted function
C=1, with power restricted function
The factory setting is A=0, B=0, C=0 (heating, without alarm suppression, without power restricted function, Therefore CF=0X1+0X2+0x16=0

1.15 Input digital filter "dL"

If measurement input fluctuates due to noise, then a digital filter can be used to smooth the input. "dL" may be configured in the range of 0 to 20. Stronger filtering increases the stability of the readout display, but causes more delay in the response to change in temperature. dL=0 disables the filter.

1.16 Manual and Automatic Mode Selection "run"

Parameter run is for selecting automatic or manual control mode.
run=0, manual control mode
run=1, automatic control mode (either PID or On/off control)
run=2, automatic control mode, in this state manual operation is prohibited
This parameter functions differently for controllers with the ramp/soak function (see supplemental manual for details).

1.17 Lock up the settings, field parameter "EP" and parameter "LocK"

To prevent the operator from changing the settings by accident, you can lock the parameter settings after initial setup. You can select which parameter can be viewed or changed by assigning one of the field parameters to it. Up to 8 parameters can be assigned into field parameter EP1-EP8. The field parameter can be set to any parameter listed in Table 2, except parameter EP itself. When LocK is set to 0, 1, 2, and so on, only parameters or setting values of program defined in an EP can be displayed. This function can speed up parameter modification and prevent critical parameters (like input, output parameters) from being modified. If the number of field parameters is less than 8, then define the first unused parameter as none. For example, if only ALM1 and ALM2 need to be modified by field operators, the parameter EP can be set as following: LocK=0, EP1=HIAL, EP2=LoAL, EP3=nonE. In this case, the controller will ignore the field parameters from EP4 to EP8. If field parameters are not needed after the instrument is initially adjusted, simply set EP1 to nonE. Lock code 0, 1 and 2 will give the operator limited privileges to change some of the parameters that can be viewed. Table 5 shows the privileges associated with each lock code.

Lock Value	SV adjustment	EP1-EP8 adjustment	Other parameters
0	yes	yes	Locked
1	yes	No	Locked
2	No	yes	Locked
3 and UP	No	No	Locked
808			Unlocked

Quick Guide for Advanced Temperature Controller

1. Wiring
   1) Power to the controller. Connect the 90-260VAC power to terminals 1 and 2.
   2) Control output connection. Connect terminals 3 and 5 for SSR Drive output, 3 for negative and 5 for positive.
   3) Sensor connection. For thermocouples, connect the positive wire to terminal 10, the negative to terminal 11.
      For a three-wire RTD with standard DIN color code, connect the two red wires to terminals 10 and 11, and connect the white wire to terminal 9.
      For a two-wire RTD, connect the wires to terminals 10 and 11, Then, jump a wire between terminals 9 and 10.
2. Set sensor type
   Set Sn to 0 for a K type thermocouple (default), 5 for a J type thermocouple, and 21 for a Pt100 RTD.
3. Switching between automatic and manual mode
   Set run=0 to active manual mode. Press the A/M key to switch between automatic and manual mode.
4. Setting the controller for cooling control.
   For cooling control, set CF=1, the initial setting is CF=0 for heating control
5. Setting target temperature (SV)
   Press the ▼ or ▲ key once, and then release it . The decimal point on the lower right corner will start to flash . Press the ▼or ▲key to change SV until the desired value is displayed . The decimal point will stop flashing after no key is pressed for 3seconds . You can press the A/M key to move the flashing decimal point to the desired digit that needs to change . Then press the ▼or▲ key to change SV starting from that digit .
6. Auto-tune
   You can use the auto-tune function to determine the PID constants automatically. There are two ways to start auto-tuning:
   1) Set Ctrl=2. It will start automatically after 10 seconds.
   2) Set Ctrl=1. Then during the normal operation, press the A/M key to start the auto-tune. The instrument will perform accurate artificial intelligence control after auto tuning is finished.
7. On/off mode
   Set Ctrl=0 to active the on/off control mode. Set the Hysteresis Band parameter dF to be a desired value.
8. Error Message and trouble shooting

   8.1 Display orAL
   This is an input error message. The possible reasons are: the sensor is not connected correctly; the input setting is wrong type;or the sensor is defective . In this case, the instrument terminates its control function automatically, and the output value is fixed according to the parameter oPL. If this happens when using thermocouple sensor, you can short terminal 10 and 11 with a copper wire. If the display shows ambient temperature, the thermocouple is defective.
   If it still displays orAL, check the input setting, Sn, to make sure it is set to the right thermocouple type. If the Sn setting is correct, the controller is defective.
   For RTD sensors, check the input setting first because most controllers are shipped with the input set for thermocouples. Then check the wiring. The two red wires should be connected to terminals 10 and 11. The clear wire should be connected to terminal 9.

   8.2 No heating
   When the controller output is set for relay output, the "O U T" LED is synchronized with output relay. If heat is not output when it is supposed to, check the OUT LED first. If it is not lit, the controller parameter settings are wrong. If it is on, check the external switching device (if the relay is pulled-in, or the SSR's red LED is on). If the external switching device is on, then the problem is either the external switching device output, its wiring, or the heater. If the external switching device is not on, then the problem is either the controller output, or the external switch device.

   8.3 Poor Accuracy
   Please make sure calibration i s done by immersing the probe in liquid.Comparing the reference in air is not recommended because response time of the sensor depends on its mass. Some of our sensors have response time> 10minutes in the air. When the error is larger than 5C, the most common problem is an improper connection between the thermocouple and the controller. The thermocouple needs to be connected directly to the controller unless a thermocouple connector and extension wire is used. Copper wire or a thermocouple extension wire with the wrong polarity connected on the thermocouple will cause the reading to drift more than 5 C.

   8.4 On on/off mode
   Although hysteresis is set to 0.3, the unit is running 5 degrees above and below. If the dF is very small and temperature changes very quickly, users will need to consider the delay of the cycle time (the parameter t). For example, if cycle time is 20 seconds, when the temperature passes the SV+dF after the beginning of a 20 seconds cycle, the relay will not act until the start of the next cycle 20 seconds later. Users may change the cycle time to a smaller value, such as 2 seconds, to get better precision control.

Supplementary Instruction Manual

For the Ramp/Soak option of Programmable Controller

Version 6.58

This is a supplementary manual for the Ramp/Soak controller. It is only for operating the programmable steps (ramp and soak steps) functions. The main manual for the Ramp/Soak is the same as the advanced temperature controller. It covers all the regular set up and operation instructions. The Ramp and Soak series programmable controllers with the ramp/soak option are designed for applications where it is desirable to have the set point automatically adjust itself over time.

1. Features
   50 steps of program control for ramping and soaking process.High flexibility in program and operation. It has programmable/maneuverable commands such as jump (for loops), run, hold and stop.The program can even be modified while it is running.The program can also control the two relays that are used for alarms. This feature can be used to notify the operator of the stage of the operation, or to signal other equipment. The safety start and ready function may allows the program to run more efficiently. 6 power-off/power-on event handling (see 3.10) modes can be selected. This can prevent the program control from being adversely affected by unexpected power interruptions.

2. Terms and Functions
   Program StEP: The value of the program StEP can range from 1 to 50. The current StEP is the program StEP being executed.
   StEP temperature, CXX: The StEP temperature is the set temperature at the beginning of the step XX (where XX can be any value from 01 to 50).
   StEP time, tXX: The StEP time is the ramping time from the current step temperature to the next step temperature. The unit is in minutes and the available value range is from 1 to 9999.
   Running time: The running time is the time that the current StEP has been running. When the running time reaches the StEP time,the program will jump to the next StEP automatically.
   Jump: The program can jump to any other steps in the range of 1 to 30 automatically as you programmed in the program StEP. It can also be used to perform cycle control. If StEP number is modified, the program will also jump. Furthermore if the program StEP reaches and finishes the 50th StEP, the program will jump back to the first StEP and run automatically.
   Run: When the program is in the "running"status, the timer counts down, and the set point value changes according to the preset ramp curve.
   Hold: When the program is in the "hold"status, the temperature is still controlled, but the timer is paused so the current set point remains.
   Stop: When the stop operation is activated, the program, timer, and output control will stop, and the running time and event output switch will reset. If the "run" operation is activated while the instrument is in the "stop"status, the program will start-up and run from the StEP 1.
   Power interrupt: It means the power has turned off or an unexpected power failure has occurred during running status. 6 handling modes are available to the user.
   Event output: Event output can be programmed in to the controller. It can trigger two alarm relays to make external equipment operate with interlock.
   Safety start: If the difference between the PV and SV is larger than the deviation alarm setting at the beginning of a step (or when powered up), the controller will adjust the PV until the alarm is turned off before the timer starts. See 3.10 for example.

3. Programming

3.1 Program Setup

Press the A/M key to bring the instrument into the program setup mode; the instrument will display the temperature set point of the current StEP (indicated by "C" in the upper display followed by the StEP number). Use the A/M key to choose which digit to edit (indicated by the flashing decimal point). After adjusting the temperature set point (–1999 to +9999), press the SET key once again, and the current StEP's ramping time will be displayed ("t" in the upper display). In each program StEP, the temperature and the time is displayed in turn. Hold down the A/M key and press V to go back to the previous parameter. Hold A/M and press SET to exit program setup mode. Modifying program steps while a program is running is permitted. See section 4 for a programming example. Note: the above operation is inhibited if the program setup function is locked(refer to 3.11for the introduction of the LocK parameter).

3.2 Program Ramp

To program a ramp, you need to set the start temperature CXX, the end temperature CXX+1, and the time duration tXX. For example, at step 3, if you want the controller to take 60 minutes to ramp up from 200 to 300 degrees, set C03=200, C04=300, t03=60. Note: Unless the deviation alarms are set to a narrow range, the ramping time decides when the program is going to the next step. Once the ramping time is finished the current step, the controller will execute the next step regardless if the temperature reaches the target temperature. Therefore, the ramp speed should be always lower than the maximum speed that the oven can offer at the full power. In other words, the ramping time should be longer than the minimum time needed for oven to jump from C03 to C04 at full power. If the ramping time is shorter than that, the time programmed for the next step will not be fulfilled. When program a temperature ramps down, you need to consider the speed of natural cooling (or forced air cooling) for the same reason.
If the maximum speed of the system is unknown or varies with environmental conditions, users should use the "safety start" function to ensure that the temperature and time during ramping and soaking are kept within a reasonable range required by the process. This is done by setting the deviation alarm close to the SV. At the beginning of a step, the timer will not start until PV is larger than SV-dLAL+dF and smaller than SV+dHAL-dF.
e. g. Set dHAL=30, dLAL=20, dF=5 and SV=100. At the beginning of the step, if the temperature is below 85 (SV-dLAL+dF=85) degrees, or above 125 (SV+dHAL-dF =125)degrees,the controller will stop the timer to wait until the temperature is above than 85 degrees or below than 125 degrees before continuing. *Please note that the dF value should be smaller than both dHAL and dLAL, Otherwise the controller will not start the next steps.*

3.3 Program Soak

The soak can be considered as a special case of ramping. It is a ramp with a zero degree slope. To program a soak, you need to set the start and the end temperature to be the same (CXX=CXX+1), e.g. At step 3, if you want the controller to soak the parts at 200 degrees for 60 minutes, set C03=C04=300, t03=60. Note: The StEP time is not how long the controller will stay at the set temperature for the current step. It is how long the controller will take from the current step temperature set point to the next step temperature set point. These two concepts are very different.

3.4 Program Hold

When the program reaches a StEP where the StEP time is set to zero, or when a jumping StEP transitions to another jumping StEP, the program will be set to "hold" status .You can also manually activate hold status by pressing the V key for about 2 seconds until "HoLd" appears in the lower display window.

3.5 Program Stop

When the program reaches a StEP where the StEP time is set to -121 , the controller will stop running . The StEP number is reset to 1 , the event output is cleared,and the control output is turned off.You can also manually execute the stop operation by pressing and holding the ∧key for roughly 2 seconds until the lower display window displays "StoP".

3.6 Run Program

In order to continue the program when the controller is in "hold" mode (or restart it from "stop"mode) lower window displays "run".When a program is running,

3.7 StEP Time/Command Parameter

When tXX is between 1 and 9999 (min), it is used to set the ramp and soak time. When it is set to zero or a negative number, it is used for executing other commands.
tXX=0 The instrument is put in hold mode on StEP number XX until manually released by the operator.
tXX=-1 to -240 represents an operation command such as run, hold, stop,jump and event output. The number is calculated according to the equation
tXX = -(A*30+B). "B"is the number (ranging from 1 to 30) of the next step for the program to jump to and "A" is the event that is triggered:
A=0 no effect (for jump function only)
A=1 switch on AL2
A=2 switch on AL1
A=3 switch on AL1 and AL2
A=4 Stop the instrument(B must be set to 1 when A=4)
A=5 switch off AL2
A=6 switch off AL2
A=7 switch off AL1 and AL2
Examples :
● Jump from StEP4 to StEP5 and switch on AL2 .
Time setup is : t04=-(1x30+5)=-35
● Jump from StEP6 to StEP1 and switch off AL2.
Time setup is : t06=-(5x30+1)=-151
● Stop program at StEP8
Time setup is : t08=-(4x30+1)=-121
The controller does not let a jump command jump to itself(for example : t06=-6) because the Hold status would never be released .

3.8 Displaying and modifying the running StEP number (StEP) of the program

Sometimes it is convenient to jump directly to a particular StEP and execute from there . If the program is still in the middle of the 4th StEP , and you wish to finish it in advance and execute the 5th StEP -the StEP modification feature will meet your need . The Ramp and Ramp series controller can start the program from any one of its 30 steps .Press the SET key(briefly)to display the StEP number . Press the ∧ ,V keys to change it . The StEP number increases or decreases automatically as the program executes . If the StEP number is manually changed , the running time will be cleared to 0and the program will begin with the new StEP . If the StEP number is not changed , pressing the SET key will not affect the operation of the program .

3.9 Multiple Curves

The flexible programming format of the Ramp & Soak controller can be used to store and recall multiple programmed curves. If a temperature curve doesn't require all 50 steps, the unused steps can be used to store another program. Several different curves can be stored and executed individually, as long as there are not more than 50 steps total (including necessary controls steps). For example, when a process curve only needs nine program steps, it is possibleto store three such process curves in the instrument. Simply change the StEP number to initiate a different curve. Suppose 8 steps represent three groups of process parameters. They are separately arranged on StEP2-StEP9, StEP10-StEP17, StEP18-StEP25. The step time of step 1 can be set as follows to choose the desired program:

T01=-2 Execute the program of curve 1 (StEP2-StEP9)
T01=-10 Execute the program of curve 2 (StEP10-StEP17)
T01=-18 Execute the program of curve 3 (StEP18-StEP25)
You can also choose the curves by manually setting the value of StEP before the program starts. For example, if curve 2 is needed in the current process, then set the value of StEP to 10.

3.10 Control Mode Parameter run

The function of the run parameter is defined differently in the ramp and Soak controller than it is for the controller without the ramp/soak option. Its operation is determined according to the equation
run = AX1+BX8
Where "A" is used to select one of 4 power outage/startup event handing modes, and "B" is used to select Safety Start and PV preparation function
Power Outage/Startup Modes:
A=0: When the instrument is turned on, the program will simultaneously jump to 29th program segment and clear event output status. This mode is suitable for applications in which power failure is not allowed at any time. The user may do error handling in segment 29, such as switching on the event output to trigger an alarm.
A=1: If there is no deviation alarm at power up, the program will continue running from the original break point and the event output state remains. Otherwise, the program will jump to the 29th segment and clear event output status.
A=2: After power is turned on, it will continue the program from the original break point, and the event output state will remain. This mode is suitable for the applications in which power failure does not affect production (default setting).
A=3: After power is turned on, controller goes to Stop status
A=4: After power is turned on, controller goes to Hold status, the controllers will goes to Stop status if the controller at Stop mode before power failure.
Safety Start and PV Preparation functions:
B=0, without Safety Start and PV preparation function, Program is executed as planned. This mode guarantees constant running time of the program, but it can't guarantee the integrity of the whole curve.
B=1, with the function of Safety Start and without the function PV preparation
B=2, with the function of PV preparation and without the function of Safety Start
B=3, with the function of Safety Start and PV preparation
About Safety Start and PV Preparation
Safety Start Function
At the first step of program, when the ambient temperature is differ from the C01(Set point of first step), the controller will automatically adjust the running time to make the expected set point the same as the current PV.
For example, in a system where the program configured from 25C to 625C within 600 minutes at the first step, but after the power on in the system, the process value is already at 100C which is higher than the original setpoint 25C for first step, in this case, the controller will automatically adjust the running time to 75 minutes and run the program. Please noted that Safety Start function only applicable for 1st step of a program
PV Preparation Function
In a system where the ambient temperature is differ from the Set point of executed steps, the controller will adjust the PV to SV and maintain the integrity of the program.
For example, in a heating step from 100C to 600C, the system suffers power off when temperature at 125C. and when power comes back , the PV of the system is actually at 105C, the controller will automatically adjust the process value to 125C where the power failed point and without increase the running time of the system. after process value reaches 125C, the program goes on as planned before.

3.11 Privilege for parameter set LocK

For ramp & soak controllers with ramp/soak option, the LocK has slightly different functions. The table 1 shows the privilege of each lock code.
Table 1. LocK parameter

LocK value	EP1-8 Adjustment	Program Adjustment	Step selection when running
0	Yes	Yes	Yes
1	Yes	No	Yes
2	Yes	No	No
3 and UP	No	No	No
808(default setting)	Yes	Yes	Yes

4. Programming Example

Programs in the Ramp & Soak controller have a uniform format of temperature-time-temperature. The temperature set point of the current step will linearly change to the set point of the next step over the time interval of the two steps. The first temperature set point should always be the ambient temperature at which the process starts to ramp up. DO NOT set the first temperature set point to the target temperature (see example 1 below) if you are not using the safety-start function. The time units are in minutes. Negative values of the time interval represent program commands.

4.1 Example 1

The following example holds the oven at 800 ° C for 2 hours. In this example, it is assumed that the heater is able to heat the oven from 25 ° C to 800 ° C within 30 minutes. If the heater does not have this ability, the soak section can begin when the oven is below 800 ° C after the 30 minutes ramping time is up. Please note that the value of C is the beginning temperature of the step. e.g. C01 is always the temperature at the beginning of the step 1. Usually C01 should be the ambient temperature, and t01 is the time from step1 to step2.
StEP1: C01=25, t01=30 Start linear temperature heating up from 25 ° C to 800 ° C, over a time period of 30 minutes (25.8 ° C /minute).
StEP2: C02=800, t02=120 Maintain 800 ° C for 120 minutes.
StEP3: C03=800, t03=-121 Stop the program and let the oven cool down.The equation used to get the command number is -(30 * Command# + Next Step) =-(30*4+1)=-121.
The temperature control block is shown below.

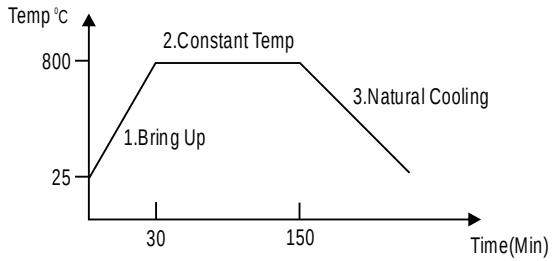


Figure 1. Holding oven at 800°c for 2 hours

4.2 Example 2

The following example includes 6 steps: linear temperature heating, maintaining a constant temperature, linear temperature cooling, jump cycling, ready, hold and event output. In the following example, it is assumed that the deviation high alarm dHAL=dLAL= 5 °C and dF=0.

StEP1: C01=100, t01=30 Start linear temperature heating up from 100 °C to 400 °C, over a time period of 30 minutes (10°C /minute).

StEP2: C02=400, t02=60 Maintain 400°C for 60 minutes.

StEP3: C03=400, t03=120 Reduce the temperature at a rate of |C04-C03|/ t03 = 2°C /minute for 120 minutes. This will bring it down to 160°C.

StEP4: C04=160, t04=-65 Alarm 1 is triggered, and the program jumps to

StEP5: The command number for turning alarm 1 on is "2" The equation used to get the command number is-(30*Command#+Next Step)=-(30*2+5)=-65

StEP5: C05=160, t05=0 A time value of zero puts the program in a Hold state. A run operation executed by the user is needed for the program to continue to StEP6.

StEP6: C06=100, t06=-181 Alarm 1 is switched off (unless it is also being triggered by an alarm condition outside the program), and the program jumps to StEP1 to start from the beginning. The command for switching Alarm 1 off is "6",so t06=-(30*6+1)=-181

StEP1: C01=100, t01=30 Since the temperature is still at 160°C, the program will pause until the controller can bring the temperature within the alarm range of the new set point. Since the deviation high alarm is set to 5°C, the program will resume (from the beginning) as soon as the temperature drops below SV+dHAL-dF=105°C.

The temperature control block is shown below.

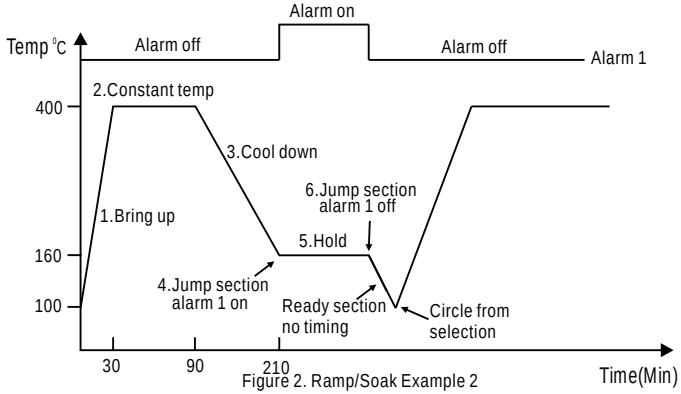


Figure 2. Ramp/Soak Example 2

5.Quick list of the New Key Functions for the Ramp/Soak Model

The following list contains a brief description of each key function for when the controller is in basic operation mode.

1)Mode Key(SET)

When pressed momentarily ,PV display shows the current step that the program is processing . When pressed again , the PV display shows the set time length of the current step . The SV display shows how long the current step has run in minutes . Press again to have the display return to the basic display mode .The PV shows the process temperature and SV can either show the set temperature or the status of the controller(Stopped,Running,or on Hold).Pressing and holding the mode key for two seconds will put the controller into parameter setting mode , just like the controllers without the ramp/soak option.

2)Auto/Manual function key(A/M)

Press this key to have the controller enter step setting mode in order to set the time , temperature and action of each step.

3)Decrement key V . Press and hold this key for two seconds to start the processing . Press and hold again to hold the processing.

4)Increment key Λ : Press and hold this key for two seconds to stop the processing of the program .

Table 2. Summary of New Key Functions

To start the processing	Press V for 2 seconds
To stop the processing	Press Λ for two seconds
To hold the processing	Press V for 2 seconds
Check current step	Press SET briefly
Check run time of current step	Press SET briefly twice
Go to Step X	Press SET briefly, Then use V or Λ to go to step
To program the steps	Press A/M key to enter programming mode. Then, SET key to go to next step

7.Frequently asked questions

7.1What is the difference between "Hold" and "Stop".

Hold does not stop heating,It holds the temperature at the current setting,(or at oPL,see 3.10 for details), "Stop" will stop heating. If you Hold the program (V key) and start Run (V key) again, it will start from the step that was put into hold.However,if you Stop the program(Λ key)and start Run(V key)again,it will start from step1.

7.2 How do I run this controller as a regular controller without the ramp/soak function?

Here are two methods.

1)Program a very long step. If you didn't use up all the steps for programming,you can use one of the unused steps for that. For example,assuming step 10 and 11 are unused, set C10=100,C11=10 and t10=9999,This sets Step 10 to control the temperature at 100 degrees for 9999 minutes.To begin the program, start Run(V key),press SET once to display StEP,use Λ to go to StEP 10. Press SET twice.The controller will run just like regular controller with PV displayed on top and SV in the bottom.You don't have to do this every time the controller powers up(assuming the A-M parameter has not changed from default).It will remain running StEP 10 until 9999 minutes (7 days) runs out,or until you reset it for another application .

2) Put the program on hold mode. This can be done either by manually pressing the Hold button at the desired temperature, or by programming a hold step (by setting tXX=0).

7.3 I just want to run the oven at 800 degrees for 120 minutes.

When I set C01=800, t01=120, the controller SV first displays 800, then it starts dropping with time. Did I do something wrong?

This is the most common mistake first time users make. Since this is a ramp controller, not a step controller, the time t01 (or tXX) is not the time that controller will stay at C01 (or CXX), it is the ramping time that controller will take from temperature C01 to C02. To hold the temperature constant for 120 minutes, you need to set two steps at the same temperature, or a 0 degree ramp (C02=C03=800 in this case). Then, set the ramping time for 120 minutes. Please see example 1.