Instruction Manual

PU90 Ramp and Soak PID Temperature Controller

Version 8.26(Aug 2019)

Caution

- This controller is intended to control equipment under normal operating conditions. Failure or malfunction of the controller may lead to abnormal operating conditions, which 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.
- **This controller carries a 2 years warranty, this warranty is limited to the controller only**

1. Features

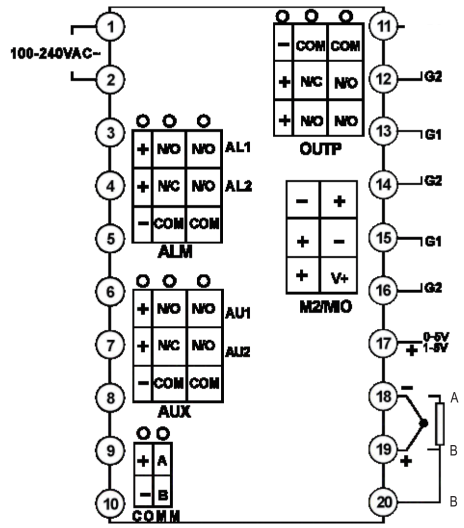
- 30 programmable steps for ramp/soak process control.
- High flexibility in program and operation. It has programmable/maneuverable commands such as jump (for loops), run, hold and stop. The program can even be modified while it is running.
- The program can also control the two relays that are used for alarms. This feature can be used to notify the operator of the stage of the operation, or to signal other equipment.
- The "wait" and "PV startup" may allow the program to run more efficiently. Five power-off/power-on event handling(see 5.3.15) modes are available, which can prevent the program control from being adversely affected by unexpected power interruptions

2. Specifications

Table 1. PU90 features

Input type	Thermocouple(TC):K,S,R,T,E,J,B,N, WRe3-WRe25, WRe5-WRe26 RTD:PT100,Cu50 DC current: 4-20mA, 0-20mA DC voltage: 0~75mV,0~20mV,0~100mV, 0~60mV, 0~500mV, 100~500mV 1~5V, 0~5V, 0~10V, 2~10V, 0-20V Resistance: 0~80 Ohm, 0~400 Ohm
Input range	Please see section 5.3.6 for detail.
Accuracy	± 0.2% Full scale: RTD, linear voltage, linear current and thermocouple input with ice point compensation or Cu50 copper compensation. 0.2% Full scale or ± 2 ºC: Thermocouple input with internal automatic compensation.
Response time	≤ 0.5s (when FILt = 0)
Display resolution	1°C/F or 0.1°C/F
Control mode	Fuzzy logic enhanced PID control On-off control
Output mode	Relay contact (NO): 250VAC/7A, 120V/10A, 24VDC/10A SSR Drive output 12VDC, 4-20mA
Alarm relay rating	Relay contact (NO): 250VAC/1A, 120VAC/3A, 24V/3A
Alarm function	Process high alarm, process low alarm, deviation high alarm, and deviation low alarm
Power supply	85~260Vac/50~60HZ, 24VDC/AC(available on request)
Power consumption	≤ 5 Watt
Ambient temperature	0~50ºC, 32~122ºF
Dimension	48mm*48mm,48mm*96mm,96mm*96mm
Mounting cutout	45mm*45mm,44mm*92mm,92mm*92mm

3. Terminal Wiring



3.1 Sensor connection

Please refer to table 3 for the input sensor type(InP)setting codes, the initial setting for input is for K type thermocouple. set "InP" to the right sensor code if another sensor type is used

3.1.1 Thermocouple

The thermocouple should be connected to terminal 18 and 19, Make sure that the polarity is correct. there are two commonly used color codes for the K type thermocouple. US color code uses yellow(positive) and red(negative). imported DIN color code uses red(positive) and green/blue(negative). the temperature reading will decrease as temperature increases if the connection is reversed.

3.1.2. RTD sensor

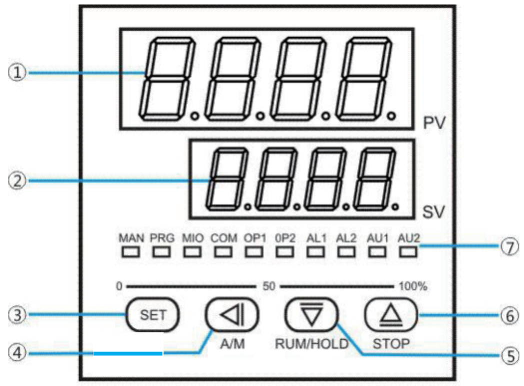
For a three-wire RTD with standard DIN color code, the two red wires should be connected to the terminals 18 and 19, and the white wire should be connected to terminal 20, for a two-wire RTD, the wires should be connected to terminals 18 and 19, jump a wire between terminals 19 and 20, Set controller input type InP to 21

3.1.3. Linear input (V, mV, mA or resistance)

Voltage(V) and milli-amperage(mA) current signal inputs should be connected between terminals 17 and 18, terminal 17 is positive and 18 is negative, 4-20mA can be converted to 1-5V and input from terminal 17 and 18 as well

4. Front Panel and Display Mode

4.1. Front Panel



① Upper display
② Lower display
③ Set key
④ Shift key(Auto/manual transfer key)
⑤ Decrease key
⑥ Increase key
⑦ 10 LED indicators, MAN indicator off means auto control mode MAN on means manual control mode, PRG means ramp and soak control mode, MIO, OP1,OP2,AL1,AL2,AU1,AU2, indicates respective function,COM indicates the communication status

Right after power on, the controller goes to PV/SV display mode if the lower display shows "orAL" and flashes, means over range or input code has not been configured correctly the output will be put to "0" if this happens

4.2. Controller display mode

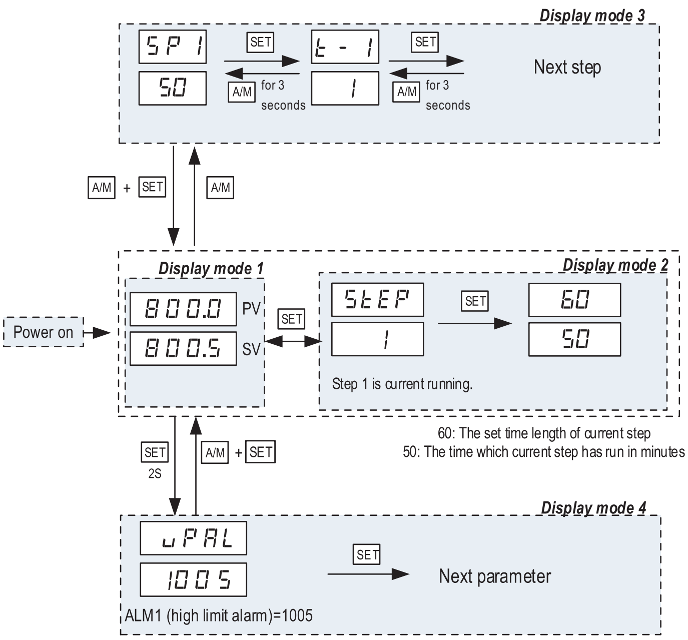


Figure 3. Display modes.

Display mode 1: normal operating mode. When the power is turned on, the upper display window shows the measured value (PV) and the lower window shows the four-digit set value (SV).

Display mode 2: checking the step. Press the SET key once to change the display from mode 1 to mode 2. The upper display window shows "STEP" and the lower windows shows the current step number. Press SET key again to show the timer information. PV window shows the set time for the current step. SV window shows remaining time in minutes or hours. Press SET key again to return to the display mode 1

Display mode 3: programming mode. Press A/M key once to change the display from mode 1 to mode 3. This mode is used for setting and changing the program.

Display mode 4: Parameter setting mode. Press and hold the SET key for 2 seconds to enter the display mode 4. The top window shows the name of a parameter and the bottom window shows its value. Use the UP and DOWN arrow key the change the value; use the SET key to save the change and go to the next parameter.

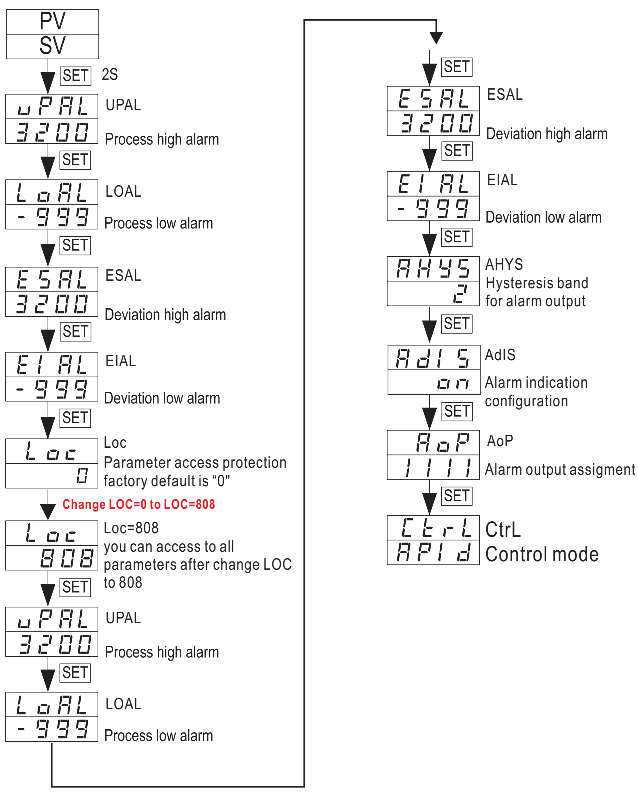
5. Parameter Settings

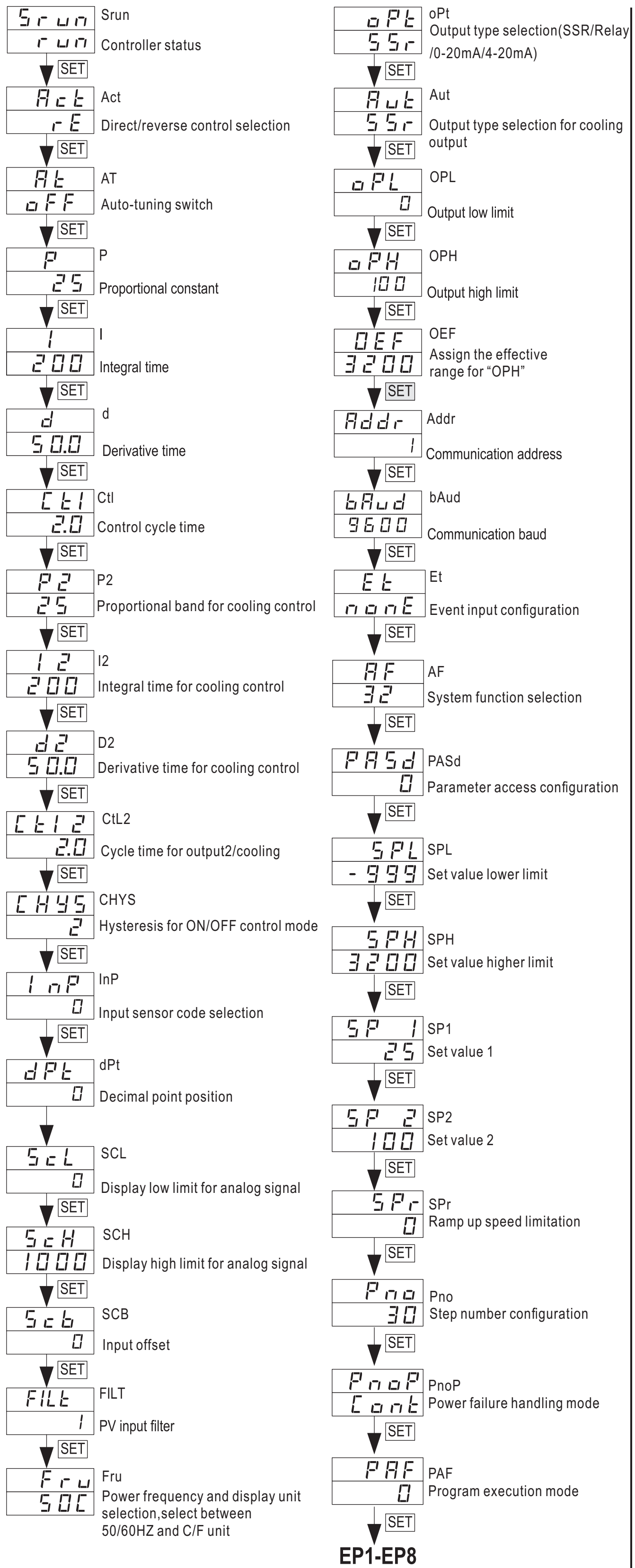
5.1. Parameter setup mode

When the display mode is 1 or 2, press SET and hold for roughly 2 seconds until the parameter setup menu is displayed (display mode 3). Please refer to 5.3 for how to set the parameters.

5.2. Setup flow chart

While in the parameter setup mode, use ▲ and ▼ to modify a digit and use A/M to select the digit that needs to be adjusted. Press the A/M and SET key at the same time to exit the parameter setup mode; otherwise, the instrument will automatically exit if no key is pressed for 10 seconds. Figure 4 is the setup flow chart. Please note that changed parameter will be automatically registered without pressing the SET key. If the controller is locked (see 7.16), only limited parameters (or no parameters) can be changed.





5.3. List of system parameters

Table 2. System parameters.

Code	Description	Setting Range	Initial Setting	Remarks
uPAL	process high alarm	-999~3200	3200	See. 5.3.1 for details
LoAL	process low alarm	-999~3200	-999	
ESAL	deviation high alarm	-999~3200	3200	
EIAL	deviation low alarm	-999~3200	-999	
AHYS	hysteresis band	0~200	2	
AdIS	alarm indication	ON/OFF	ON	
AoP	alarm output assigment	0~6666	1111	
CtrL	control mode	OnoF,APID,nPID,PoP,SoP	APID	See. 5.3.2 for details
Srun	controller status	run,Stop,Hold	run	See. 5.3.3 for details
Act	direct/reverse control selection	rE,dr,rEbA,drbA	rE	See. 5.3.4 for details
At	auto-tuning	OFF,on,FOFF	OFF	See. 5.3.5 for details
P	proportional band	0~3200 °C/°F	25	See. 5.3.6 for details
I	integral time	1~9999 Secs	200	
d	derivative time	0~3200 Secs	50.0	
CtI	control cycle time	0.2~300.0 Secs	2.0	See. 5.3.7
P2	proportional band for cooling	0~3200 °C/°F	25	See. 5.3.8
I2	Integral time for cooling control	1~9999 Secs	200	
d2	derivative time for cooling control	0~3200 Secs	50.0	
CtI2	control cycle time for cooling	0.2~300.0 Secs	2.0	See. 5.3.9
CHYS	hysteresis for ON/OFF control	0~2000	2	See. 5.3.10
InP	Input sensor code	0~37	0	See. 5.3.11
dPt	decimal point	0/0.0/0.00/0.000	0	See. 5.3.12
ScL	lower limit for analog input	-999~3200	0	See. 5.3.13
ScH	higher limit for analog input	-999~3200	1000	
Scb	input offset	-999~4000	0	See. 5.3.14
FILt	Filter strength	0~40	1	
Fru	power frequency and C/F selection	50C/50F/60C/60F	50C	See. 5.3.15
oPt	output type	SSr/rELy/0-20/4-20/PHA1	anyone of them	See. 5.3.16
Aut	cooling output type	SSr/rELy/0-20/4-20	anyone of them	See. 5.3.17
oPL	output lower limit	-110~+110%	0	See. 5.3.18
oPH	output higher limit	0~+110%	100	
OEF	OPH effective range	-999~3200	3200	
Addr	address	0~80	1	See. 5.3.19
bAud	baud rate	0~19200	9600	See. 5.3.20
Et	event input	nonE,ruSt,SP.1.2, PId2,Eact	nonE	See. 5.3.21
AF	system function	0~255	32	See. 5.3.22
PASd	access protection	0~9999	0	See. 5.3.23
SPL	SV lower limit	-999~3200	-999	See. 5.3.24

SPH	output higher limit	-999~3200	3200	See. 5.3.24
SP 1	Set value 1	-999~3200	0	See. 5.3.25
SP 2	Set value 2	-999~3200	0	
SPr	ramp up speed	0~3200°C/minute	0	See. 5.3.27
Pno	step number	0~30	30	See. 5.3.28
PnoP	power failure handling mode	Cont,StoP,run1 dASt,HoLd	Cont	See. 5.3.29
PAF	program execution mode	0~255	0	See. 5.3.30
EP1~EP8	Field parameters	EP1=UPAL EP3=ESAL EP2=LOAL EP4=EIAL	N/A	See. 5.3.26

5.3.1 Alarm parameters

This controller offers four types of alarm, "UPAL" "LOAL" "ESAL" "EIAL"

- **UPAL**: high limit absolute alarm. if the process value is greater than the value specified as "UPAL",then the alarm will turn on.it will turn off when the process value is less than "UPAL-AHYS"
- **LOAL**: low limit absolute alarm, if the process value is less than the value specified as "LOAL" then the alarm will turn on, and the alarm will turn off if the process value is greater than "LOAL+AHYS"
- **ESAL**:Deviation high alarm, if the temperature is above "SV+ESAL" the alarm will turn on, and the alarm will turn off if the process value is less than "SV+ESAL-AHYS"
- **EIAL**: Deviation low alarm, if the temperature is below "SV-EIAL", the alarm will turn on, and the alarm will turn off if the temperature is greater than" SV-EIAL+AHYS"
- **AHYS**, Hysteresis band for alarm, this parameter prevent the alarm relay from being ON/OFF frequently around the alarm point due to fluctuation
- **AdIS,** When alarm is triggered, the AL1 and AL2 indicator will light up. at the same time,The lower display could display the alarm code "UPAL,LOAL, ESAL, EIAL" and setting value alternately, this helps to notify the operator that the alarm is triggered if you put AdIS as "off" then the lower window won't display the alarm code when alarm is on, if you put AdIS as "on" then the lower window will display the alarm code when alarm is triggered
- **AOP**, Assign relays to different alarm, AL1 and AL2 refers to the two relays that are installed inside of the controller for alarm purpose, please do not confuse the relays with alarm parameter UPAL,LOALESAL,EIAL, The parameter AOP(alarm output definition) allows user to select which relay to be triggered when the alarm set condition is met, You can set multiple alarms to active one relay(either AL1 or AL2), but you can't activate both relays with just one alarm. below is the format of the AOP value, the AOP value consist of a 4 digits number, like 4321. the numbers on the unit position defines the which relay will be triggered when "UPAL" alarm is on, the numbers on the ten's position defines which relay will be triggered when "LoAL" alarm is on, the numbers on the hundred's position defines which relay will be triggered when "ESAL" alarm is on, the numbers on the thousand's position defines which alarm will be triggered when "ELAL" alarm is on.

$$AOP=\underset{EIAL}{\underline{4}}\quad\underset{ESAL}{\underline{3}}\quad\underset{LoAL}{\underline{2}}\quad\underset{UPAL}{\underline{1}}$$

The range of the AOP is 0-4, 0 means no relay will be triggered even if alarm condition is met, 1 means AL1 relay will be triggered, 2 means AL2 relay will be triggered, 3 means AU1 relay will be triggered, 4 means AU2 relay will be triggered take "4321" as an example, it means that the AL1 relay will be triggered when UPAL alarm is ON, AL2 relay will be triggered when LOAL alarm is on, AU1 relay will be triggered when ESAL alarm is on, AU2 relay will be triggered when EIAL alarm is on.

5.3.2 Control mode

This controller incorporates 5 different control modes, the parameter code are OnoF, APID, nPID, PoP, SoP.

OnoF: ON/OFF control mode, for simple application which don't need
APID: Artifical intelligence PID control mode
nPID: Standard PID control mode
PoP: The controller will retransmit the PV value as analog output to feed to recorder or other device, this works if the main output is analog output
SoP:The controller will retransmit the SV value as analog output to feed to recorder or other device. this works if the main output is analog output

5.3.3 Controller status

This parameters defines the controller status, available with 3 options, run, Stop ,Hold.

Run, controller at running mode
StoP, controller stop operating.
Hold, for ramp and soak controller, if you put the status at "Hold" the temperature controller will hold at the current SV for as long as you want. then the ramp and soak controller will work just like a regular PID controller.

5.3.4 Direct/reverse or heating/cooling mode selection

This parameter available with 4 options, rE,dr, rEbA, drbA. these parameters are used to define the control action, whether you need heating or cooling control mode.

rE: reverse control mode, for heating application
dr: direct control mode, for cooling application
rEbA: reverse control mode with alarm suppression, unnecessary absolute low limit and deviation low limit alarm will be suppressed.
drbA: direct control mode with alarm suppression, unnecessary absolute high limit and deviation high alarm will be suppressed.

5.3.5 Auto-tuning switch

This parameter is auto-tuning switch parameter, OFF, on, FOFF

OFF: auto-tuning off
on: auto-tuning on
FOFF: auto-tuning off, and you can not activate the auto-tuning from the front panel

5.3.6 P.I.D values and PID control mode

Please note that this controller has two PID control mode, APID and nPID, nPID is a normal conventional PID control mode, it's similar to PID control mode from other controllers on the markets, APID is a unique fuzzy logic enhanced PID control with advance algorithm

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.

(1)Proportinal constant "P"
Please note that the P constant is not defined as proportional band as in the traditional model under **APID** control mode, its unit is not in degrees. A larger constant results in larger and quicker action, which is the opposite of the traditional proportional band valve. it also functions in the entire control range rather than a limited band.
If you are controlling a very fast response system (>1°C/°F/second) that fuzzy logic is not quick enough to adjust, set the control mode as nPID will change the controller to the traditional PID system with a moderate gain for the P.

(2) Integral time "I"
Integral action is used to eliminate offset. Larger values lead to slower action. Increase the integral time when temperature fluctuates regularly (system oscillating). Decrease it if the controller is taking too long to eliminate the temperature offset. When I = 0, the system becomes a PD controller.

(3) Derivative time "D"
Derivative action can be used to minimize the temperature overshoot by responding to its rate of change. The larger the number, the faster the action.

5.3.7 Control cycle time for reverse/heating action

CtL: Control cycle time for reverse/heating action, for SSR, analog and phase angled output, the range will 1.0~3.0 seconds. for relay output, the value will be greater than 3 seconds, the most optimal value will be calculated via auto-tuning process(This is a big difference between our PID and other PID on the markets, most of PID on the markets , the cycle time are predetermined, but for our PID, the control cycle time will be calculated via auto-tuning process, this will increase the control accuracy dramatically)
Under ON/OFF control mode, the Ctl will be used to define the ON delay time. this is very useful for some of application with the compressor involved. they need this feature to protect the compressor.

5.3.8 P.I.D values for cooling control action

P2,**I2**,**d2** defines the P,I,D values for cooling control action, it is similar to the PID values which had been elaborated in 5.3.6.

5.3.9 Control cycle time for cooling control action

Ctl2, This parameter defines the control cycle time for cooling control action,similar to the parameter Ctl which had been elaborated in 5.3.7.

5.3.10 Hysteresis for ON/OFF control mode

CHYS, This parameters is used to remove the frequent ON/OFF action of the relay around the set point in an ON/OFF control situation. for reverse/heating control, the relay will release if PV>SV, and relay will pull-in when PV<SV-CHYS, for direct/cooling control application, the relay will release when PV<SV, and relay will pull-in when PV<SV+CHYS.

5.3.11 Input sensor code InP

InP, Please see table 3 for acceptable sensor type and its range

Table 3. code for InP input and its range.

InP code	Input sensor type	Display range (° C)	Display range (° F)
0	K (thermocouple)	-50~+1300	-58~2372
1	S (thermocouple)	-50~+1700	-58~3092
2	R(thermocouple)	0~1700	32~3092
3	T (thermocouple)	-200~350	-328~662
4	E (thermocouple)	0~800	32~1472
5	J (thermocouple)	0~1000	32~1832
6	B (thermocouple)	0~1800	32~3272
7	N (thermocouple)	0~1300	32~2372
8	WRe(3/25)(thermocouple)	0~2300	32~4172
9	WRe(5/26)(thermocouple)	0~2300	32~4172
10	Special input	N/A	N/A
12	Radiant high temperature sensor	N/A	N/A
17	K, with 2 decimal point	0~300.00	32~572.00
18	J, with 2 decimal point	0~300.00	32~572.00
20	Cu50	-50~+150	58~302
21	Pt100	-200~800	-328~1472
22	Pt100(-100~+300.00)	-100~+300.00	-148~+572.00
15	4-20mA(specify when order)	-9990~32000 **defined** by user with SCL and SCH	
16	0-20mA(specify when order)		
25	0~75mV		
26	0~80Ω		
27	0~400Ω		
28	0~20mV		
29	0~100 mV		
30	0~60 mV		
31	0~500mV		
32	100~500mV		
33	1~5V 4~20mA (w/ 250Ω Resistor)		
34	0~5V		
35	0~10V		
36	2~10V		
37	0~20V		

5.3.12. Decimal point setting "dPt"

The parameter dPT defines how many decimal point you will see for PV and SV value, the display format can be 0, 000.0 ,00.00 , 0.000. see table 4 for details

1) Thermocouple and RTD

For thermocouples and RTD sensors, dPt can be set to 0 or 0.0 or 0.00
when dPt=0, temperature display resolution is 1°C/F
when dPt=000.0, temperature display resolution is 0.1°C/F, the temperature will be displayed at the resolution for 0.1°C for input below 1000°C,display will be 1°C for input over 1000°C
For some of application where customer need 2 decimal points even when the input is K,J,PT100, in this case, the InP can be set as "17" "18" "22", and set "dPt" as 00.00, the display resolution will be 00.01°C/F

2) Linear input(Voltage, current, or resistance input, InP=25~37)

For other linear input signal, dPt can be set to all display format

Table 4. dPt parameter setting

dPt value	0000	000.0	00.00	0.000
Display format	0000	000.0	00.00	0.000

5.3.13 Limiting the control range, "SCL" and "SCH"

When you set InP=15,16, 25~37, the input will be analog inputs, parameter "SCL" and "SCH" are used for scaling display, "SCL" is the value to be displayed when the signal is at its low limit of the linear input, "SCH" is the value to be displayed when the signal is at its high limit of the linear input. for example, for 4-20mA signal,"SCL" corresponds to the value when signal is 4mA, and "SCH" corresponds to the value when signal is 20mA.

5.3.14 Input offset "Scb" and input filter strength "FILt"

Input offset Scb is used to add an offset value to compensate the sensor error or simply to shift the reading. for example, if the controller displays 2°C when probe is in ice/water mixture, setting Scb=-2, will shift the temperature reading to 0°C

If measurement input fluctuates due to noise, then a digital filter can be used to smooth the input. "FILt" may be configured in the range of 0 to 40. Stronger filtering increases the stability of the readout display, but causes more delay in the response to change in temperature. FILt = 0 disables the filter.

5.3.15 Frequency of power supply and display unit

These parameters have 4 options, "**50C**" "**50F**" "**60C**" "**60F**". 50 means the power supply is 50HZ AC source, C means the display will be in Celcius, 60 means the source is 60HZ AC source, F means the display will be in Fahrenheit ,to have a most optimal anti-inteference effect, make sure to choose the frequency according to your source, for instance, a typical north America source,the supply will be 110V 60HZ and display in Fahrenheit, in this case, user should chose 60F. for a domestic user in china, the setting will be 50C, 50HZ in Celcius unit.

5.3.16. Output definition "oPt"

These parameter defines the output type, options are "**SSr**", "**rELy**" "**0-20**", "**4-20**" "**PHA1**" this controller is a modularized controller, the output modular were plug into the PCB board, it's possible to change the output by user themself, First thing user have to do is unplug the current output modular, for example, relay output modular and replace it with a SSR drive modular, a software configuration needs to be one which is change the output code from "rELy" to "SSr". each code represent an output, "rELy" for relay output, "SSr" for ssr drive output, "0-20" for 0-20mA output, "4-20" for 4-20mA output. "PHA1" phase angled output.

5.3.17. Output definition for cooling action "Aut"

This controller available with dual output, the cooling output can be relay, SSR drive, 0-20mA, 4-20mA etc, this parameter "Aut" defines the cooling output type and in case you want to change the cooling output yourself, change the settings accordingly similar to "oPt" in 5.3.15

5.3.18 Output range limits "oPL" and "OEF" "oPH"

oPL and oPH allows 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. For example, if oPL=20, the controller will maintain a minimum of 20% power output even when input sensor failed.
OEF assign the effective range of the output high limit function. makes the OPH function relevant to the process value, if the PV< OEF, the output high limit function kicks in, when PV>OEF, the output high limit function will be disengaged. this is very useful for some of application where the maximum power has to be under certain degree when the temperature less than certain value. for example, if you put OEF=300°C, and OPH=20%, when PV<300°C, the maximum output will be 20% ,when PV increase and eventually greater than 300°C, the maximum output will be no longer 20%, the limits will be 100%. the actual output will be determined by the controller itself.

5.3.19 Device address "Addr"

This controller available with RS-485 option, one may integrate this controller to a communication system, this parameters defines the address of the controller. the

5.3.20 Communication speed baud rate "bAud"

This parameter defines the communication speed between controller and other device such as PLC. the options are 1200bps,2400bps,4800bps,9600bps,19200 bps.

5.3.21 Even input configuration "Et"

Controller with event input function as an option, this parameter makes sense if you order controller with event input function. it has several options "**nonE**" "**ruSt**" "**SP1.2**" "**Pld2**" "**EACt**"

nonE: event input function disabled, this is factory default value

ruSt: a remote normally open push button switch can be connected to the controller ,press the switch for a short period of time less than 2 seconds will initiate the program, push the switch and hold it for more than 2 seconds will put the controller in "Stop" pattern.

SP1.2:A ramp and soak controller can be converted to a standard PID controller if you set Pno=0, in this case, controller can have maximum 2 setting values, SV=SP1,SV=SP2, for example, SP1=100°C, SP2=250°C, a switch can be connected to the controller, if you pull-in the switch, SV=SP2, which is 250°C, when the switch release, the SV=SP1, 100°C. this features is useful for application where they have 2 setting points which needs to be switched back and forth according to the products they are making.

PId2:This controller can have up to two groups of PID values, P,I,D and Ctl as the First group of PID values, P2,I2,d2 and Ctl2 as second group of PID values, release the switch will assign the First group of PID values to the control process, which means P.I.D and Ctl kicks in, if the switch pull-in, second group of PID values, P2,I2, d2 will kick-in.

EACt: If this parameter is assigned to "Et", a remote switch be used to switch the control mode between heating/cooling mode, release the switch will put the controller on heating mode with P, I, D , CtL parameters kick-in, pull-in the switch will put the controller on cooling mode with the P2,I2,D2 Ctl2 kick-in. the "Act" will be altered automatically.

5.3.22 "AF" system function configuration

Parameter "AF" is used to some of advanced system functions of this controller, below is the details on how to calculate the AF value based on below formula.

AF= A x 1+ B x 2+ C x 4 +D x 8 + E x 16+ F x 32 + G x 64 + H x 128

A=0, ESAL and EIAL will be deviation alarm, **A**=1, ESAL and EIAL will be absolute alarm, if you put A=1, then the controller will have 2 group of absolute high limit alarm and 2 group of absolute low limit alarm.
B=0, Hysteresis for alarm and ON/OFF control will be unilateral hysteresis, if B=1. the hysteresis for will be bilateral hysteresis.
C=0, Bar graphics shows the output value, C=1, bar graphics shows the PV value
D=0, Password for engineering parameters is "808", D=1, password for engineering parameters is "PASd" you can assign any password to have a greater protection against unauthorized access.
E=0, UPAL and LOAL will be absolute high and absolute low alarm, if E=1, UPAL and LOAL will be switched to deviation high and deviation low alarm, together with ESAL and EIAL, the controller could have 2 groups deviation high alarm and 2 groups of deviation low alarm.
F=0, Ultra precision control mode, the actual control resolution is 10 times higher than the display, for analog input, the maximum display is 3200, F=1, conventional control accuracy, set F=1 if the display will exceed 3200.
G=0, The absolute high alarm will be triggered if temperature sensor break apart
G=1, The absolute high alarm won't be triggered if temperature sensor break apart.
If you put AF=160, the communication protocol will be RS-485 mode.

5.3.23 "PASd" engineer parameter access configuration

When PASd=0~255, or AF.D=0, you put LOC=808 will enable the user to access entire engineer parameters.
If PASd set to value between 256~9999 and AF.D=1, the engineering parameters can't access without input the password assigned under PASd, for example, if you set PASd=2687, to access to engineer parameters, user have to key-in password 2687 to access the engineer parameters.

5.3.24 "SPL" and "SPH" setting value low limit and high limit

SPL is setting value low limit, SPH is the setting value high limit, for example, if you put SPL=0 and SPH=400, the setting value will be from 0~400.

5.3.25 "SP1" and "SP2" dual setting value.

Controller can also be used as a standard PID controller, in this case, two setting values can be assigned to the same controller, when Et=SP1.2, a remote switch can be used to switch the setting value between SP1 and SP2, for example, if SP1= 100, SP2=400, at some point, user might want to use the controller with the setting value at SP1(100), in this case, you can switch the SV back and forth between SP1 and SP2.

5.3.26 "EP1~EP8" field parameters and access protection parameter "Loc"

By assigning system parameters as Field Parameters (EP1 ~ EP8), you can select which parameter can be displayed or changed when controller is locked. Up to 8 parameters can be assigned as Field Parameter. The Field Parameter can be any parameter listed in Table 2 except Field parameters themselves and the Loc parameter.
By setting Loc to different values, different access privilege can be granted to user, if Loc=0, user can access and configure parameters under field parameter EP1~EP8 ,all shortcut and setting value, step time duration are configurable.
Loc=1, user can access and configure parameters under field parameter EP1~EP8 ,all shortcut and setting value, step time duration are configurable, but user can not Run, Stop, Pause, execute auto-tuning on the controller.
Loc=2, user can not access to the field parameter list, but user can Run,Stop,Pause, and execute the auto-tuning on the controller.
Loc=3, user can access and configure parameter under field parameter list, all short cut operation is disabled.
Loc=4~255, All parameters are locked expect the Loc parameter itself.

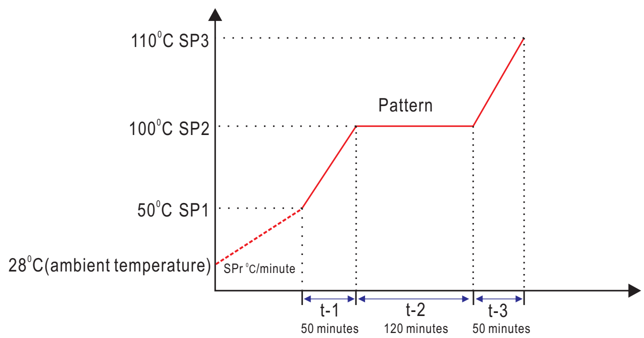
To prevent the parameters and the program being changed accidently, you can completely or partially lock the parameters and the program after the initial setup. the configuration privilege is determined by "Loc", please refer to the table 5 for the privilege levels.

Table 5. "Loc" value and the configuration privilege level

Loc value	Privilege	EP1 - 8 Adjustment	Program Adjustment	Step Selection
0	limited	Yes	Yes	Yes
1		Yes	No	Yes
2		Yes	No	No
3 and up		No	No	No
808 (Default)	unlimited	Yes	Yes	Yes
PAsd	unlimited	Yes	Yes	Yes

5.3.27 Ramp up speed limitation "SPr".

In field application, when power up the ramp and soak controller, the process value could be less than the SP1, which is the SV of the step 1 in the profile, when this happens, the controller will heat up from the PV to the SP1 based on the ramp up speed SPr, this only works for the first step of the profile under ramp and soak mode below figure to help you understand the concepts.



Above figure illustrate an application, the SP1 is 50°C, means the program starts from 50°C, but when user power on the heater, the temperature is only 28°C which is less than 50°C, when this happens, the controller will heat up from 28°C to 50°C based on the preset ramp up speed which is SPr °C/minute, when temperature reach to 50°C, the program will be activated automatically, the time elapsed won't be counted into the total time duration of the pattern. this only works

5.3.28 Number of steps/segments needed for ramp and soak controller "Pno"

This controller has maximum 30 steps/segments in total, which can be divided into different patterns with different steps, for some of applications, only limited steps will be needed ,for example, 8 steps, then you can set Pno=8, if you set Pn0=0,this ramp and soak controller will be converted to a conventionally PID controller, Spr will still applicable even if you are setting Pn0=0.

5.3.29 Power failure handling mode "PonP"

Power failure is part of the scenario one could expect during the process, once power failure happens, the controller has several options on how to handle it. manually unplug the power and put the back in is also considered as power failure. below are the options and detailed information about each handling mode:
Cont: The controller continue the program from where it left off, but if the controller was at "Stop" mode, it will be at "Stop" mode after power resume
Stop: The controller will be at "Stop" mode after power resume regardless of the status before the power failure
run1:The controller goes back to step 1 unless the controller was at "Stop" mode before power failure. the "Stop" mode will inherit before and after power failure
dASt: The controller will continue the program from the point where the power was cut off if there is no deviation alarm, if the condition for deviation alarm is met, then the controller will goes to "Stop" mode.
HoLd: The controller will be put at "HoLd" mode after power resume unless the controller was at "Stop" mode, the "Stop" mode will inherit.

5.3.30 Program execution mode "PAF"

This controller has quite a lot of advanced features, this parameter is used to define various program execution mode, the value of PAF is calculated by below formula
PAF=A x 1+ B x 2 + C x 4+ D x 8 +E x 16 + F x 32
letter A to F, each of the letter represents one of the functions which could be useful for certain application, below is the details

A=0, "**Wait**" function disabled, A=1 "**Wait**" function activated
B=0, ramp and soak mode, the ramp up/ramp down rate and soak time can be programmed separately, this is standard ramp and soak mode.
B=1, Temperature constant mode.
C=0, The program running based on minutes, C=1, the program running based on hours
D=0, without PV startup function, D=1, with PV startup function
E=0, upper window display the process value when temperature converted into a transmitter, E=1, PV window display the step number when controller converted into a transmitter.
F=0, Press Run key won't put the controller on Hold status during the process
F=1, if you press RUN key during the control process, controller will be put in Hold status.

6. Program Ramp/Soak on the controller

6.1 Terminology

Program step(SP 1): is a control step with its set value and set time are specified. the step number(n) can range from 1 to 30. the current step is the step that is being executed.
Step n: is the n-th step in the program, its set temperature is expressed as SP[n], for example, for the 1st step, the set temperature is SP-1(SP 1), the set time is t-1(t - 1)
Step set temperature SP[n]: is the set point at the beginning of step n.
Step set time t-[n], is the time from step n to the next step (n+1) the unit is in hours or minutes, and the valid range is from 1 to 9999
Running time: Running time is how long the current step has been running. when the running time reaches the step set time, the program will jump to the next step automatically.
Jump: Go to a specified program step, this step can be any steps in the program (step number 1 to 30). this feature can be used to perform a control loop or to skip certain steps. while checking the current step number, if the step number is modified. the program will also jump.
Run (run): The program is being executed, when the program is under the "run" status, the PRG indicator is solid on, the timer counts down, and the set point value changes according to the preset ramp curve
Hold(HoLd):If the controller is on hold status, the temperature is still being controlled, but the timer is paused so the current set point remains.
Stop (StoP): Execution of the program is stopped. When the program is stopped, the lower window will flash between "stop" and the current set value, the timer and the output control will stop, and the running time and event output switch will reset. If the "run" operation is activated while the controller 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. Five handling modes are available to the user, Please see "5.3.27", parameter "PonP", this parameter defines the way that the controller handle the power failure handling mode.
Event output: A programmed relay action, two alarm relays (AL1 and AL2) can be programmed to pull in or drop out to activate or deactivate external equipment.
Wait: If the difference between the PV and SV is larger than the deviation alarm settings at the beginning of a step(or at powering up), controller will put program to "hold", and the timer won't start running until PV falls within the wait band (see "Wait band" below). During this time, controller will try to bring the temperature to the SV of the current step as fast as possible.
This "**Wait**" feature is useful when the user is very strict about the temperature and the time of a critical step. it is also useful when the user does not want to control the ramp speed and want the system to reach the set temperature as soon as possible. please see section 8.2 for examples. During this period when program was put to "Hold", the relays assigned to deviation alarms(ESAL, EIAL) will not be activated; but relays can still be activated by process alarms(UPAL, LOAL)
Wait band(deviation range) : A temperature range defined by deviation alarms and hysteresis band. the lower boundary is (SV-EIAL+AHYS), and the upper boundary is(SV+ESAL-AHYS). The wait band/deviation range has effects on program execution and deviation alarms.
At the beginning of a step or at powering up the controller, the program will be put on "hold" if PV is out of the wait band; if then PV falls within the wait band, program will resume, once a step starts running, it won't be put to "hold" even if PV falls out of the deviation range again.When a program step is running, deviation alarms will be triggered if PV is greater than (SV+ESAL+HYS) or less than (SV-EIAL-HYS), and the corresponding relay(s) will pull in.When PV falls within the wait band, i.e. PV is less than(SV+ESAL-HYS) and greater than (SV-EIAL+HYS), the alarm will be deactivated and the corresponding relay will drop out.

6.2. Program

6.2.1. Program Setup

SET LCK=0 and Press the A/M key to bring the controller into the program setup mode. The controller will show the current step number in the top window "SP XX" and show the set temperature in the lower window. the default value is "-0.1", displayed as " - 0.1 ",use the A/M key to choose which digit to edit, at the same time you can hear the beeping sound as you press the A/M key and indicated by a flashing decimal point, and use the UP or DOWN arrow key to adjust the set temperature, press SET key will save the change and go to the step set time, the top window will show "t- XX" and the lower window will show the default time which is "-0.1", use the UP,DOWN and A/M key to change the value, then press SET key to confirm and go to the next Step. at each program step, the set temperature and the set time is displayed in turn, repeat this operation until all steps in your program have been entered.
Note 1: The above operation is inhibited if the program setup function is locked(refer to 5.3.25 for details of the LoC parameter)
Note 2:In parameter setting mode or programming mode, to go back to the previous parameter, hold the A/M key and do not release, the parameter will roll back to previous one , to exit the program editing mode, you can either hold the A/M key and SET key at the same time or leave the key pad untouched for 10 seconds

6.2.2 Step set time

The set time between step n and step (n+1) is specified by t-[n], the step time can be set to any value from -0.1~3200, the unit is in minutes or hours, the step time t-[n] can also be assigned with a negative value to perform a special command such as jumping to a specified step or activate an alarm relay(see6.2.10 for details)

6.2.3 Program ramp

Ramp means change the temperature from one point to another during a specified time. To program a ramp, you need to set the start temperature SP[n], the end temperature SP[n+1], and the time duration T-[n], the ramp speed is

Ramping speed=(SP[n+1]-SP[n])/t[n]

During this ramping step, the displayed set temperature will linearly change from SP[n] to SP[n+1] in proportion to the time that has been past in this step. For example, at step 3, you want the controller to ramp up from 200 to 300 degrees in 50 minutes, then you'll need to set SP3=200^{0}C, T-3= 50 min and SP4=300^{0}C
The ramp up speed is 2^{0}C/min. if this step has been run for 10min, the set temperature is 220^{0}C at this moment.
The ramping speed should be less than or equal to the maximum ramping speed that the current system can achieve at full power. In other words , the ramping time should be longer than the minimum time needed for the system to heatup from SP[n] to SP[n+1], otherwise, the process temperature will gradually fall behind the schedule. For example, the maximum heating speed of an electric water kettle is 20^{0}C/min, but the ramping step is set as SP1=90^{0}C, t-1=1min, and SP2=212^{0}C, The controller will not be able to achieve this goal. in the end of this step, the water temperature is probably at 110^{0}C.

At the beginning of the every step, the controller will check wether the process temperature is within the wait band, if temperature falls within the wait band, the program will continue, and the timer for this step will be started. if the temperature is out of the wait band, the program will pause, controller will keep on trying to reach the set temperature, and the timer won't be engaged until this condition is satisfied; in the meantime, the deviation alarm is triggered, this feature is called "Wait" this feature only applies to the beginning of the each step, if a step has already been running, even if the temperature goes beyond the wait band, the program will still continue, but the deviation alarm will be triggered. if the maximum speed of a system is unknown or varies with environmental conditions, users can use the "WAIT" feature to ensure that the temperature and the time during a ramp/ soak step are kept within a reasonable range required by the process, this is done by setting the deviation alarms close to the SV. in another word, keep the deviation range small.
For example, a user want to preheat a small oven from room temperature to 400^{0}C, and maintain it for 10min before preceding to the next step; the acceptable deviation is +/- 3^{0}C, so the program can be set as SP1=400, t-1=10, SP2=400, t-2=xx, And set ESAL=3, EIAL=3, and keep the Hys=0.3(default value).
So the lower boundary of the deviation range is 398.7^{0}C and the upper boundary of the deviation range is 402.7^{0}C, after the program is started, the controller will start bringing up the temperature. once the process temperature reaches 398.7^{0}C, the controller will start the step 1 and counting down for 10 minutes. please see section 8 for more examples.

6.2.4 Program soak

The soak step maintains the temperature for a specified time. it can be considered as a special case of ramping with a zero degree slope. to program a soak, you need to set the start and the end temperature to be the same, i.e; SP[n]=SP[n+1], and the soaking time is specified by t-[n], for example, at step 3, the user wants the parts to be soak in the oven at 200°C for 60 minutes, then the program for this step should be SP3=200, t-3=60 and SP4=200.

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 set temperature to the next step set temperature, these two concepts are very different.

6.2.5 Program Run

When the program is running, the PRG indicator will lit, to start running a program or resume a program that is on "hold", press the Down arrow (V) key for about 2 seconds until the lower window shows "r u n"

6.2.6 Program Hold

"Hold" means the program is being temporarily stopped. when the program is on hold, the lower display will show "HoLd" and SV alternately, under any of the following situations, the program will be put on "hold"

1)Step time t-[n]=**-0.0**, for example, if you put t-3=-0.0, then the program will be put on hold when program goes to step 3

2)A jump command is programmed to a step where the program jump to another jump step, in this case, the program will be put on "hold"

3)Program is manually put into "Hold" by pressing down arrow(V) key for 2 seconds

4)A step is programmed to jump to itself, i.e: t-[n]=-n.0

6.2.7 Program Stop

When a program is stopped, the step number is reset to 1, the event output is cleared, and the control output is turned off. the lower display window will show "StoP" and the PRG indicator off.

the program can beg stopped by the following methods

1)Step time t-[n]=**-121.0**, this is a command to stop the program

2)Manually stop the program by press the UP arrow (Λ)key for 2 seconds until the lower display window shows "stop". when the program is stopped. the lower window will flahs "StoP "and the current set temperature.

6.2.8 Program Jump

The program can go to a specified step. to jump the program from the current step n to step x, set t-[**n**]=-**x**.0, where x is the step number and it can be any value between 1 and 30, the minus value is a special indicator telling the controller this is a program command, not a step time.

Note: if a step is programmed to jump to itself, it would result in a "Hold" status that will never be released, for example, if t-6=-6.0, the program will be held at step 6 then.

6.2.9 Commands for special events and general formats on the commands

The step time range can be positive and negative value, when the time range is positive value, it means ramp up/ramp down or soak time at certain step. when the time range is a negative value, it means a command for the program. such as jump ,stop, hold and pulling in or release a relay at certain point. below table is the details:

t=-A.B		Respective functions
-A	B	This is the format of the command, -A is the integer B is the value behind the decimal point
0	0	for example, if t-5=0.0, means controller will be put on hold at step 5.
-1~-122	0	If -A falls in the range of -1~-122, and B=0, means the command is for jump purpose, the program will jump to -A step after it finish the previous step. for example, if t-5=-20.0, means the program goes to step 20 after it finish the step 4, because step 5 is a jump step
-0	1~4	if -A=-0, and B falls in the range of 1~4, means the program goes to next step and an event output will be generated at the same time t-5=-0.1,means the program goes to step 6 and AL1 will be pulled-in, AL2 will be release at the same time t-5=-0.2, means the program goes to step 6 and AL1 will be release and AL2 will be pulled-in t-5=-0.3, means the program goes to step 6 and AL1 and AL2 will be pulled-in at the same time t-5=-0.4, means the program goes to step 6 and AL1 and AL2 will be released at the same time
-1~-120	1~4	if -A falls in the range of -1~-120, and B falls in the range of 1~4, means the program jump to specified steps and at the same, AL1 and AL2 will be pulled-in or release at the same time, for example if t-5=-10.1, means when program goes to step 5, it will jump to step 10 directly, and at the same time, AL1 will be pulled-in and AL2 will drop off. if t-5=-12.2, means when program goes to step 5, it will jump to step 12 directly, and at the same time, AL1 will drop off and AL2 will be pulled-in if t-6=-15.3, means when program goes to step 6, it will jump to step 15 directly and at the same time, AL1 and AL2 will be pulled-in at the same time if t-10=-1.4, means when program goes to step 10, it will jump to step 1 and start overall again , at the same time AL1 and AL2 both relay will drop off.

6.2.10 The last step of a profile

The last step of a profile can be "Stop" "Hold" or "Jump", at the same time , event output can be programmed as well. if the last step is not a stop, hold, jump command, the program will continue to hold the temperature at the current SV and after that the controller will go to "Stop" status.

6.2.11 Check the Step Number and Jump the Program

To check at which step the program is running, press the SET key once. The upper window will show "StEP" and the lower window will show the step number. Press SET key again, the controller will show the set time for the current step in the upper window, and show the running time in the current step in the lower window. Press the SET key twice to return to the normal operating mode. If no key is pressed in 10 seconds, it will automatically return to the normal operating mode. While checking the step number or time, the step number or time will be updated as the program executes.

To manually jump to another step in the program, press the SET key once to show the step number in the lower window, then press the UP arrow (Λ) or DOWN arrow (V) key to change the step number, and press the SET key to confirm the change. The program will be jumped to the specified step immediately. The controller will show the step set time for the new step in the upper window. And the running time in the lower window will be cleared to 0. If the step number is not changed, press SET key won't affect the execution of the current step, but the display window will show step set time and running time.

This is a convenient feature when you want to skip the current step and manually jump to another step. For example, if you want to jump to step 5 while the program is running, press SET key to check the step number, then change the step number to 5, and then press SET key to confirm.

6.2.12. Multiple Program Segments

The maximum steps of this controller is 30 steps, which gives the flexibility to store multiple short programs and select which step of program to run. User can manually select a starting step to run the program, or program a jump step in step 1, right after user start the program, the program will jump to specific step and execute different patterns, Table 6, program example.

Step #	SP[n]	t-[n]	Note
1	80	**-5.0**	Jump to step 5.
2	200	**30.0**	Program 1 (step 2 to 3).
3	200	**-121.0**	Turn off all output and stand by at step 1.
4	0	**-0.1**	
5	800	**30.0**	Program 2 (step 5 to 6).
6	800	**-121.0**	Turn off all output and stand by at step 1.
7	80	**20.0**	Program 3 (step 7 to 13).
8	400	**60.0**	
9	1500	**20.0**	
10	1500	**90.0**	
11	800	**60.0**	
12	100	**60.0**	
13	100	**-121.0**	Turn off all output and stand by at step 1.
14	0	**-0.1**	
15	0	**-0.1**	
…	…	…	…
30	0	**-0.1**	

In the example above, there are three short patterns stored. pattern 1, step 2 to step 3, Pattern 2, step 5 to step 6, pattern 3, step 7 and step 13. the step time of step 1 can be programmed as following jump command so user can choose to run which pattern right after power on.

t-1=-2.0 jump to step2 and run pattern 1
t-1=-5.0 jump to step 5 and run pattern 2
t-1=-7.0 jump to step 7 and run pattern 3

You can also choose the program by manually setting the step number before the program starts, for example, if the pattern 2 is needed in the current process, press SET key to the Step indicating window, and change the step number to number 5, then the program will go to pattern 2. press SET and go back to PV/SV display status

7. Programming Examples

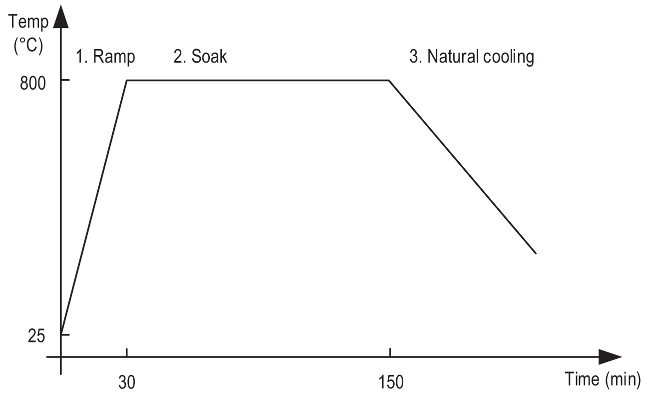
Program in the PU90 series controller have a uniform format of temperature-time-temperature. the temperature set point of the current step will linearly ramp to the set point of the next step over the time interval between the two steps, usually, it is not recommended to program a ramp that is faster than what is the system is capable of achieving because it will result in actual temperature fall behind the schedule unless you are using the "Wait" feature(see section 6.1 for its definition), the time units are in minutes or hours, negative values of the time interval represent program commands

7.1 Example 1: holding the oven temperature at 800°C for 2 hours

Assuming that the heater is able to heat the oven from 25°C to 800°C within 30 minutes, we can compose a program like this:

Step 1: SP 1=25, t-1=30.0, gradually heating up from 25°C to 800 °C, over a time period of 30 minutes (25.8°C/minute)
Step 2: SP 2=800, t-2=120.0, maintain the temperature at 800°C for 120 minutes
Step 3: SP 3=800, t-3=-121.0, stop the program and let the oven cool down naturally.

The temperature profile is shown below in Figure 12.



7.2 Example on Profile with event outputs

The following example includes 6 steps: ramp up, maintaining the temperature ,ramp down, jump cycling,hold and event output. in the following example, it is assumed that the deviation high/low alarm ESAL=EIAL=50°C

Step 1: SP 1=100, t-1=30.0, temperature heating up from 100°C. start linear temp -erature heating up from 100°C to 400°C in a time period of 30 minutes(ramp up speed is 10°C/minute).
Step 2: SP 2=400, t-2=60.0,Maintain 400°C for 60 minutes.
Step 3: SP 3=400, t-3=120.0,Reduce the temperature from 400°C to 160°C in 120 min. so the ramp down speed is -2°C/minute
Step 4: SP 4=160, t-4=-0.1, active the relay AL1 and go to next step 5.
Step 5: SP 5=160, t-5=0.0, hold(pause) the program at step 5. operator/user needs to press the DOWN arrow key to resume running the program.
Step 6: SP 6=100, t-6=-1.4 Switch off AL1 and jump back to step 1.

Note 1:When the program jumps back to step 1 (SP 1=100, t-1=30.0), the oven temperature is still at 160°C, the program will pause until the temperature drops within the deviation alarm range of the new set point. as the deviation high alarm is set to 5°C, the program will resume(from the beginning) as soon as the temperature drops below 105°C.
Note 2: the current step 5 can be omitted, i.e; we can change the step 5 to SP 5= 160 and t-5=-5.0. when two jumps steps are programmed next to each other, the program will pause

The temperature control block is shown below.

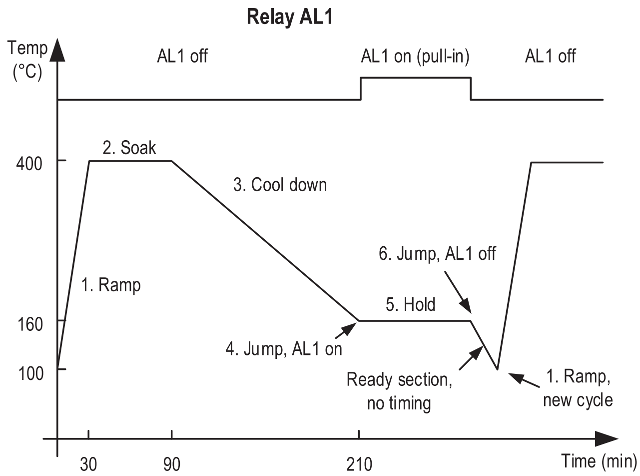


Figure 13. Temperature profile and relay AL1 action in the example program.