Instruction Manual

SYL-2362A2 PID TEMPERATURE CONTROLLER INSTRUCTION MANUAL

Version 2.6 (Oct, 2021)

⚠ **Caution**

- This controller is intended to control equipment under normal operating conditions. If failure or malfunction of it could lead to an abnormal operating condition that could cause personal injury or damage to the equipment or other property, other 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.
- Installing the rubber gasket supplied will protect the controller front panel from dust and water splash (IP54 rating). Additional protection is needed for higher IP rating.
- This controller carries a 90-day warranty. This warranty is limited to the controller only.

1. Features

- The PID control with artificial intelligent enhancement for precision temperature control.
- Auto-tuning function can find the best PID parameter automatically.
- On/off control mode for refrigerator, motor and solenoid valve control application.
- Bumpless transfer between Auto and Manual control.
- Limit control for safety protection and special applications.
- The output can be set for SSR output control or relay contactor control by the user.
- Two contact relays can be configured as one PID and one alarm output, dual alarm outputs, or dual On/off control.
- Support 10 different types of commonly used temperature sensor inputs.

2. Specification

Input type	Thermocouple (TC): K, E, S, R, J, T, B, WRe3/25 RTD (Resistance temperature detector): Pt100, Cu50
Input range	See table 2
Display	Dual lines, four digits, °F or °C
Display resolution	1°C, 1°F; or 0.1°C, 0.1°F with Pt100
Accuracy	±0.2% or ±1 unit of full input range
Control mode	PID, On-off. Limit, Manual
Output mode	Relay contact: 3A at 240VAC, SSR: 8VDC, 12 mA.
Alarm	Process high/low alarm
Power consumption	<2 Watt
Power supply	85~260VAC/50~60Hz or 85-360VDC
Sample rate	4 samples/sec
Operating condition	0 ~ 50 °C, ≤85%RH
Mounting cutout	45 x 45 mm
Dimension	48x48x75mm (1/16 DIN)

3. Front Panel and Operation

Figure 1. Front panel

① AL-1 Relay J1 output indicator
AL-2 Relay J2 output indicator
AT/M- On for manual mode. Blinking during auto-tuning process
OUT- SSR output indicator
② Value increment/Select next parameter
③ Value decrement/Select previous parameter
④ Auto tuning/Digit shift
⑤ Set/Confirm/Manual Auto switching/Reset (for Limit control mode)
⑥ Measured temperature, or, Process Value (PV)
⑦ Set temperature, or, Set Value (SV)

4. Terminal Wiring (back view)

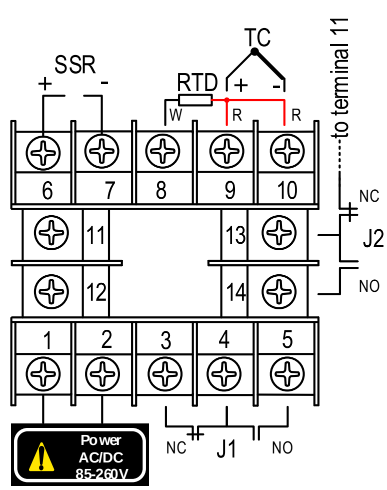


Figure 2. Wiring diagram

4.1 Sensor connection

4.1.1 Thermocouple

The thermocouple should be connected to terminals 9 and 10. Make sure that 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.

4.1.2 RTD sensor

For a three-wire RTD with standard DIN color code, the two red wires should be connected to the terminals 9 and 10. The white wire should be connected to terminal 8.
For a two-wire RTD, the wires should be connected to terminals 8 and 9. Jump a wire between terminals 9 and 10.
Set controller input type, Inty, to P100 (1° resolution) or P10.0 (0.1° resolution).

4.2 Power to the controller

The power cables should be connected to terminals 1 and 2. Polarity does not matter. It can be powered by 85 -260V AC or DC power source. Neither a transformer nor jumper is needed to wire it up. For the sake of consistency with the wiring example described later, we suggest you connect the hot wire to terminal 2 and neutral to 1. Since the controller is in a plastic shell, ground wire is unnecessary.

4.3 Output connection

Two control output options are offered by this controller. (1) The SSR control output provides an 8V DC signal that can control up to 4 SSRs in parallel. (2) The J2 relay output can be used to turn on a contactor or a solenoid valve. It can also drive a small heater directly if the heater draws <3 Ampere. For application that needs two control outputs, such as one for heating and other for cooling, J1 relay can be used for the second output with on/off control mode. Please note J1 can't be used for main control output. Both J1 and J2 can be used as alarm output if they are not used as control output.

4.3.1 Connecting the load through SSR

Connect terminal 7 to the negative input and terminal 6 to the positive input of the SSR. Set the system output configuration, outy, to 2, 3 or 6 - depending on the control mode used. See Figure 10 for details.

4.3.2 Connecting the load through a contactor

J1 relay is for alarm output only. Assuming the controller is powered by a 120V AC source and the contactor has a 120VAC coil, jump a wire between terminal 2 and 14. Connect terminal 13 to one lead of the coil and terminal 1 to the other lead of the coil. Set the system output configuration, outy, to 1, 4, or 5 -depending on the control mode used. Please see Figure 11 ~ 14 for examples.

Note: For first time users without prior experience with PID controllers, the following notes may prevent you from making common mistakes:

4.4.1 Power to the heater does not flow through terminal 1 and 2 of the controller. The controller consumes less than 2 watts of power. It only provides a control signal to the relay. Therefore, 20 gauge wires are sufficient for providing power to terminal 1 and 2. Thicker wires may be more difficult to install.

4.4.2 The J1, J2 relays are "dry single pole switches". They do not provide power by itself. Figure 11 shows how it is wired when providing a 120V output (or when output has the same voltage as the power for controller). If the load of relay requires a different voltage than that for the controller, an additional power source will be needed (Please see the alarm wiring of Figure 10 and controller output J2 of Figure 12 for examples).

4.4.3 SSR output power does not come from the input of the SSR. The output of the SSR is a single pole switch between terminal 1 and 2 of the SSR. The input of the SSR is for control, or triggering the SSR. (Please note we are talking about the SSR itself, not the SSR control output of the controller). Figure 10 shows how the SSR output should be wired. When switching a North American 240VAC power, the heater will be live even when the SSR is off. Users should install a double pole mechanical switch to the power input.

5. Parameter Setting

For safety reasons, the controller parameters are divided into three groups with different pass codes. You should only give the code to those who have the responsibility and knowledge of how to properly change it. Code 0089 contains the parameters for system configuration that may need to change during the initial set up. Code 0036 contains the parameters for tuning performance. Code 0001 is for controlling temperature and alarm settings.

5.1 System Configuration Parameters (accessed by code 0089)

The system configuration parameters are listed in table 1. To change the parameters, press SET key, enter code "0089" and press SET key again. Then, follow the flow chart in Figure 3.

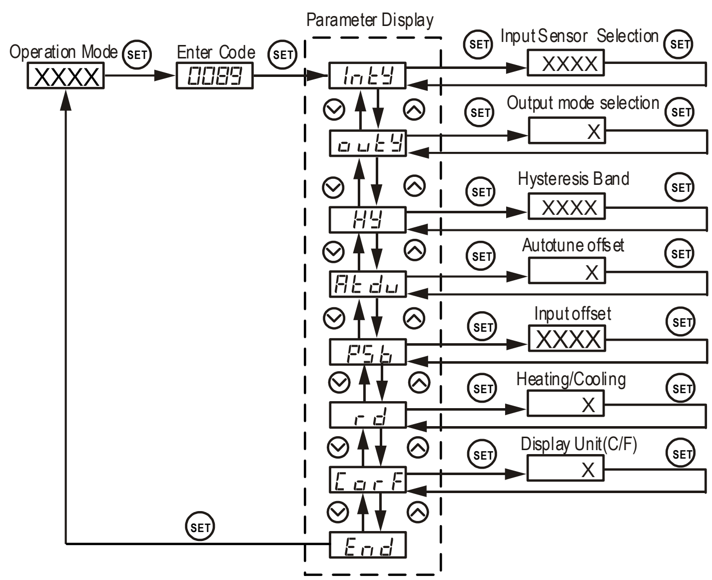


Figure 3. System setup flow chart

(1) Press SET key to enter setting mode;
(2) Press >, V and ^ keys to enter parameters;
(3) Press SET key to confirm;
(4) Press V or ^ keys to select the new parameter.

Table 1. System configuration parameters

Code		Description	Setting Range	Initial	Note
InEY	Inty	Input Sensor Type	See table2	K	1
ouEY	outy	Control Output Mode	0, 1, 2, 3, 4, 5, 6	2	2
HY	Hy	Hysteresis Band	0~9999	3	3
AEdu	Atdu	Autotune Offset	0~200(Deg)	10	4
PSb	PSb	Input Offset	-100~100(Deg)	0	5
rd	rd	Control Function	0: heating 1: Cooling	0	
CorF	CorF	Display Unit	0: °C, 1: °F	1	
End	End	Exit			

Note 1. The controller is preset for K type thermocouple input. If any other type of sensor is used, the **Inty** value needs to be changed to the corresponding symbol as shown in Table 2.

Table 2. Temperature sensor code

Symbol		Description	Working Temperature Range
t	t	TC, Type T	-200~400°C; -320~752°F
r	r	TC, Type R	-50~1600°C; -58~2900°F
J	J	TC, Type J	-200~1200°C; -320~2200°F
WrE	WRE	TC, WRe3/25	0~2300°C; 32~4200°F
b	b	TC, Type B	350~1800°C; 660~3300°F
S	s	TC, Type S	-50~1600°C; -58~2900°F
K	k	TC, Type K	-200~1300°C; -320~2400°F
E	e	TC, Type E	-200~900°C; -320~1650°F
P10.0	P10.0	RTD, Pt100	-99.9~600.0°C; -99.9~999.9°F
P100	P100	RTD, Pt100	-200~600°C; -320~1100°F
Cu50	Cu50	RTD, Cu50	-50.0~150.0°C; -60~300°F

Note 2. The value of **outy** determines the control mode. When it is set to:

0 - Relay J1, J2 as alarm output; SSR output disabled;
1 - Relay J1 as alarm output; J2 as PID controlled relay contact output; SSR output disabled;
2 - Relay J1, J2 as alarm output; SSR PID control output;
3 - Relay J1, J2 as alarm output; SSR On/off control output;
4 - Relay J1 as alarm output; J2 as On/off control relay contactor output; SSR output disabled;
5 - Relay J1 as alarm output; J2 as Limit control relay contactor output; SSR output disabled;
6 - Relay J1, J2 as alarm output; SSR for Limit control output.

Note 3. Hysteresis Band (also called dead band, or differential), Hy, is used for On/off control and Limit control. Its unit is in degrees (°C or °F). For On/off control mode, the output will be off when PV > SV and on again when PV < SV-Hy for heating. For cooling, the output will be off when PV < SV and on again when PV > SV + Hy. For Limit control mode, the controller cannot be reset (to turn on the output) when PV > SV - Hy for heating, and when PV < SV + Hy for cooling.

Note 4. The Autotune offset will shift the SV value down by the Atdu value during the Autotune process. That will prevent the system from damage due to overheating during the Autotune.

Note 5. Calibration offset, PSb is used to set an input offset to compensate the error produced by the sensor. For example, if the meter displays 5 ºC when probe is in ice/water mixture, setting PSb = -5, will make the controller display 0 ºC. To set negative value, shift to the very left digit, press down key until it shows “-”.

5.2 PID Parameters (accessed by code 0036)

The PID and relevant parameters are listed in table 3. To change the parameters, press SET key, enter code “0036”, and press SET key again. The parameter flow chart is similar to Figure 3.

The values of the P, I, and D parameters are critical for good response time, accuracy and stability of the system. Using the Auto-tune function to automatically determine these parameters is recommended for the first time user. If the auto-tuning result is not satisfactory, you can manually fine-tune the PID constants for improved performance.

Table 3. PID and relevant parameters

Symbol		Description	Setting Range	Initial	Note
P	P	Proportional Constant	0.1~99.9(%)	5.0	6
I	I	Integral Time	2~1999(Sec)	100	7
d	d	Derivative Time	0~399(Sec)	20	8
SouF	SouF	Damp Constant	0.1~1.0	0.2	9
ot	ot	Cycle Rate	2~199(Sec)	2	10
FILt	FILt	Digital Filter Strength	0~3	0	11
End	End	Exit			

Note 6. Proportional Constant (P): P is also called the proportional band. Its unit is the percentage of the temperature range. e.g. For a K type thermocouple, the control range is 1500°C. P=5 means the proportional band is 75°C (1500x5%). Assuming the set temperature (SV) = 200. When integral, I, and derivative, d, actions are removed - the controller output power will change from 100% to 0% when temperature increases from 125 to 200°C. The smaller the P value is, the stronger action will be for the same temperature difference between SV and PV.

Note 7. Integral time (I): Brings the system up to the set value by adding to the output that is proportional to how far the process value (PV) is from the set value (SV) and how long it has been there. When I decreases, the response speed is faster but the system is less stable. When I increases, the respond speed is slower, but the system is more stable.

Note 8. Derivative time (d): Responds to the rate of PV change, so that the controller can compensate in advance before |SV-PV| gets too big. A larger number increases its action. Setting d-value too small or too large would decrease system stability, cause oscillation or even non-convergence.

Note 9. Damp constant: This constant can help the PID controller further improve the control quality. It uses the artificial intelligence to dampen the temperature overshot. When its value is too low, the system may overshoot. When its value is too high, the system will be over damped.

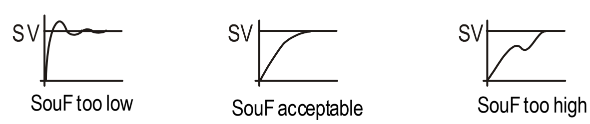


Figure 4. Damp constant

Note 10. Cycle rate (ot): It is the time period (in seconds) that controller uses to calculate its output. e.g. If ot=2, and controller output is set to 10%, the heater will be on 0.2 second and off 1.8 seconds for every 2 seconds. Smaller ot result in more precision control. For SSR output, ot is normally set at 2. For relay or contactor output, it should be set longer to prevent contacts from wearing out too soon. It normally set to 20~40 seconds.

Note 11. Digital Filter (Filt): Filt=0, filter disabled; Filt=1, weak filtering effect; Filt=3, strongest filtering effect. Stronger filtering increases the stability of the readout display, but causes more delay in the response to changes in temperature.

5.3 Temperature setting and Alarm setting (accessed by code 0001)

The temperature and alarm parameters are listed in table 4. To change the parameters, press SET key, enter code “0001” and press SET key again. The parameter flow chart is similar to Figure 3.

Table 4. Temperature and alarm parameters

Symbol		Description	Initial Setting	Note
5u	SV	Target temperature (Set Value)	800	12
AH1	AH1	J1 on temperature	800	13
AL1	AL1	J1 off temperature	900	
AH2	AH2	J2 on temperature	800	
AL2	AL2	J2 off temperature	900	
End	END	Exit		

Note 12. There are two ways to set the target temperature:

a. During the normal operation mode, press ^ or V keys once to switch the display from PV to set value. The display will start to blink. Press ^ or V keys again to increase or decrease the SV. When finished, wait 8 seconds and the settings will take effect automatically (the display will stop blinking).

b. Press SET key once. Use >, ^ and V keys to enter code 0001. Press SET key to confirm, then the display would be SV (5u). Press SET key again to display the SV setting. Use >, ^ and V keys to enter the new SV value and press SET key to confirm. Press V key to change the display to END. Then, press SET key to exit. You can also ignore the steps after confirmation of SV. The controller will returns to normal operation mode automatically if no key is pressed for 1 minute. This method is easier for large temperature change.

Note 13. Alarm setting. The J1 relay is controlled by parameters AH1 and AL1. And the J2 relay is controlled by parameter AH2 and AL2. AH1 (or AL2) is the temperature to turn the J1 (or J2) relay on; AL1 (or AL2) is the temperature to turn the J1 (or J2) relay off. When AH1>AL1 (or AH2>AL2), the J1 (or J2) alarm is set for absolute high alarm as shown in Figure 5 below. When AH1 <AL1 (or AH2<AL2), the J1 (or J2) alarm is set for absolute low alarm as shown in Figure 6 below. When AH1=AL1 (or AH2=AL2), the J1 (or J2) alarm is deactivated.

Please note that J2 can't be used as alarm when "outy" is set to 1, 4 or 5.

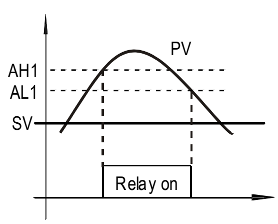


Figure 5. Absolute high alarm

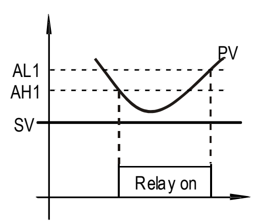


Figure 6. Absolute low alarm

6. Auto-Tuning

The Auto-tuning function (also called self-tuning) can automatically optimize the PID parameters for the system. The auto-tuning function will use the On/off mode to heat up the system until it passes the set point. Then let it cool down. It will repeat this about three times. Based on the response time of the system, the built-in artificial intelligence program will calculate and set the PID parameters for the controller. If your system has a very slow response, the auto-tuning could take a long time.

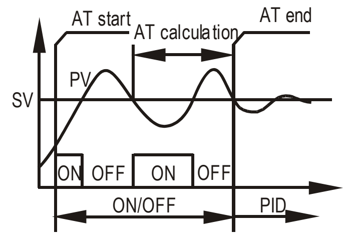


Figure 7. Auto-tuning

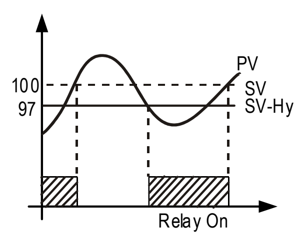
6.1 To activate Auto-tuning, press and hold > key until the "AT" indicator starts to blink, which indicates auto-tuning is in progress. When "AT" stops blinking, the auto-tuning is finished. Now, newly calculated PID parameters are set to be used for the system. Please note that Auto-tuning is only for PID control mode (when "outy" is set at 1 or 2).

6.2 To stop the Auto-tuning, press and hold > key until "AT" indicator stops blinking. Then, the previous PID parameters values are resumed.

7. On/off control mode

On/off control mode is not as precise as PID control mode. However, 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 (dead band) the heater will be turned on again.

To use the on/off mode, set Outy to 3 or 4 depending on the output device to be used. Then, set the Hy to the desired range based on control precision requirements. Smaller Hy values result in tighter temperature control, but also cause the on/off action to occur more frequently. In the PID parameters menu (code 0036), only ot and FILt are used. P, I, D and SouF are not meaningful.



When heating, and outy = 3 or 4,
If PV ≤ (SV - Hy), relay on
If PV ≥ SV, relay off
(SV = 100, Hy = 3)

Figure 8. On/off control mode

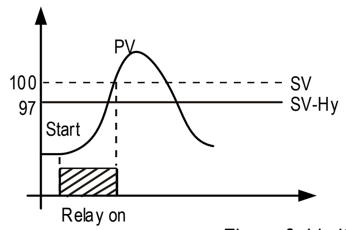
8. Manual mode

Manual mode allows the user to control the output as a percentage of the total heater power. It is like a stove dial. 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. To switch from the PID to the manual mode, press and hold the SET key until the "AT/M" indicator turned on (about 5 seconds). In the manual mode, the top display is for the process temperature. The bottom right is the percentage of power output. The bottom left display show an "M" for user to easily identify the controller is in manual mode. To switch from manual to PID mode, press and hold SET key until the "AT/M" indicator turned off. This controller offers "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.

9. Limit control mode.

The Limit control mode will shut the heater off when SV is reached. The heater will not be turned on again until the controller is reset manually (press the SET key for 5 seconds). When powered on, it will not start the heating until reset button is pressed. The controller can't be reset when the temperature is within Hysteresis Band (Hy).

To use the Limit control mode, set outy to 5 or 6. Then, set the Hy to the range that you want reset to be blocked. To start the heating or cooling, press SET key for 5 second or until the output indicator is on.



outy=5, SV=100, Hy=3. The heating stops after it reached 100 degree.

Figure 9. Limit control mode

10. Application Example

10.1 A water tank needs to be controlled at 150.0 °F. Alarm 1 will go off if T > 155.0 °F, Alarm 2 will go off, if T> 170.0 °F. The power source is 240V AC. The heating element is switched by a SSR. A Pt100 RTD sensor with 0.1° resolution input is used as the temperature sensor.

a. Wiring diagram

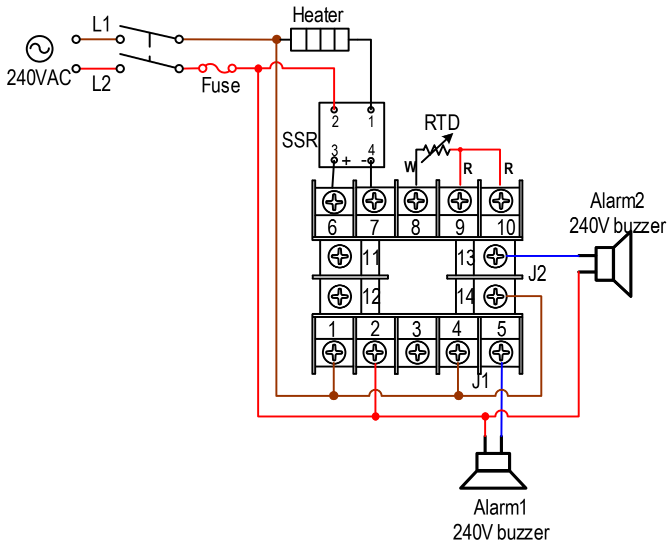


Figure 10. Typical wiring set up for beer brewing and bird incubator. For smoker control, the RTD sensor should be replaced by K type thermocouple

b. Parameter setting. These are the parameters that need to be changed from the initial value: Inty=P10.0, SV=150.0 °F, AH1=155.0 °F, AL1=154.0 °F, AH2=170.0 °F, AL2=169.0 °F.

Auto-tune is used to set the PID parameters. Power up the controller. Press and hold the > key until "AT" starts to blink. The controller starts the Auto-tuning. When the "AT" stops blinking, the new PID parameters are generated for the system. The controller is in normal operation mode. The tank will be maintained at 150.0 °F. **Please note that you don't not have to wire or set the alarm to control the temperature.**

10.2 A furnace needs to be controlled at 1200 °F. The power source is 120V AC. The heating element is 1800W/120V. It is switched on/off by a contactor. The coil voltage of the contactor is 120V AC. A K type thermocouple is used as the temperature sensor.

a. Wiring diagram

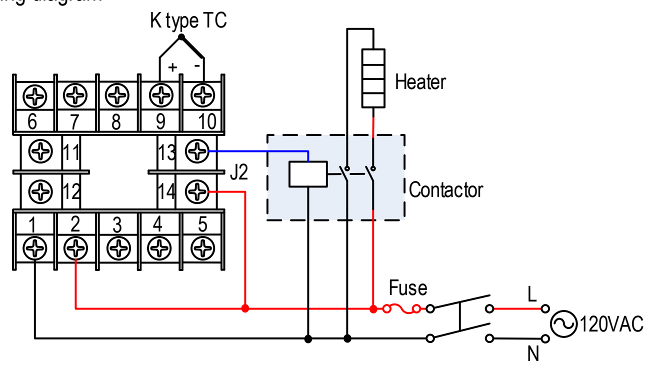


Figure 11. Typical wiring set up for powder coating oven and kiln. This diagram also applies to 240V AC power system, if both the heater and the coil voltage of the contactor are 240V AC.

b. Parameter setting. These are the parameters that need to be changed from the initial value: outy=1 for PID mode with J2 relay output; ot=20 to increase the relay life time; SV=1200 °F for the target temperature.

10.3 Drive a 24VAC solenoid valve directly in heating mode

A 24VAC solenoid valve is switched by J2 relay in on/off mode. The valve will be on until temperature reaches 200 °F. Then, it will shut off. When the temperature drops to below 195 °F, it will be on again. Power source is 120V AC. A K type thermocouple is used as the temperature sensor.

a. Wiring diagram

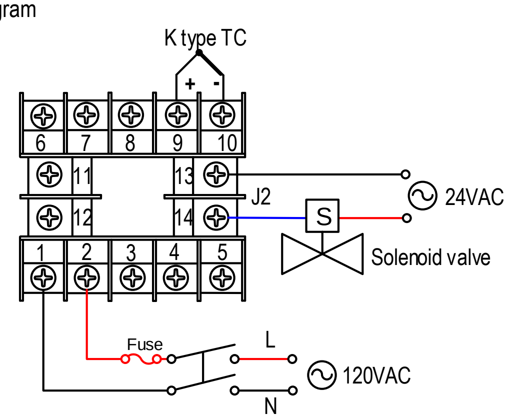


Figure 12. Typical wiring set up for a 24V gas, hot water valve, or a contractor with 24V coil voltage

b. Parameter setting. These are the parameters that need to be changed from the initial value: outy = 4 for on/off mode with J2 relay output; Hy = 5 degree, SV=200°F for the target temperature. Note, if this is to control a contactor with 24V coil, PID mode should be used. The setting should be same as example 2 except the SV value.

10.4 Control a small load without using any external SSR or relay.

a. Wiring diagram

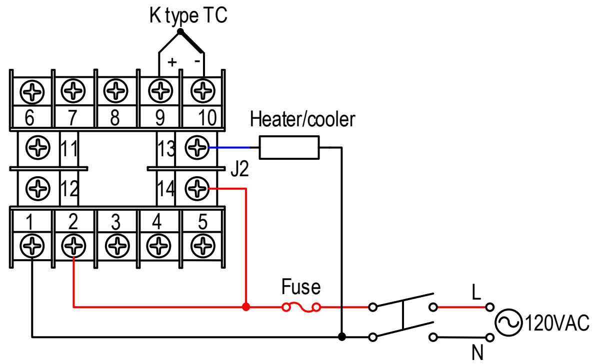


Figure 13. Typical wiring set up for driving a 120V AC heater or cooler directly. Only low power device can be wired in this way. The current limit for resistive load is 3 Amp. The current limit for inductive load is lower, depending on the inductance.

b. Parameter setting. These are the parameters that need to be changed from the initial value: outy= 1, 4 or 5 for J2 relay output depending the control mode. ot=20 to increase the relay life time. Rd=1 if the load is a cooling device.

10.5 Drive a 120V solenoid valve directly in cooling mode

a. Wiring diagram

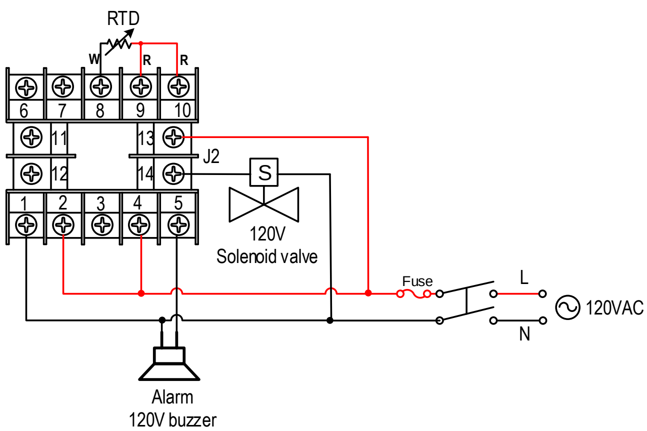


Figure 14. A simple auto draw-off system setup for maple syrup. Only low power solenoid valve (cooler) can be wired in this way. The current limit for resistive load is 3 Amp. RTD sensor is used for better accuracy (e.g. PL6350). One 120V buzzer is wired to the J1 relay, to work as a high temperature alarm.

b. Parameter setting. Set SV = 219°F. To use solenoid valve as a cooling device, please set outy = 4 (on/off mode), and rd = 1 (cooling mode). Set ot = 20 to increase the relay life time. Adjust Hy (hysteresis band) accordingly.

11. Error Message and trouble shooting

11.1 Display EEEE

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. If this happens when using thermocouple sensor, you can short terminal 9 and 10. If the display shows ambient temperature, the thermocouple is defective. If this happens when using the RTD sensor, check the input setting first because most controllers are shipped with input set for thermocouple. Then check the wiring. The two red wires should be on terminal 9 and 10. The clear wire should be on terminal 8.

11.2 No heating

When controller output is set for relay output, the "AL2" LED is synchronized with output relay. When controller output is set for SSR output, the "OUT" LED is synchronized with SSR control output. If there is no heat when it is supposed to, check the AL2 or OUT first. If it is not lit, the controller parameter setting is wrong. If it is on, check external switching device (if the relay is pulled-in, or the red LED of the SSR). 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.

11.3 Poor Accuracy

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

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