

# Instruction Manual

## SYL-1512A2 PID TEMPERATURE CONTROLLER INSTRUCTION MANUAL

Version 2.5

### ⚠ 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. 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	One line, 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
Output mode	Relay contact: 3A at 240VAC, SSR: 8VDC, 40 mA
Alarm	Process high/low alarm
Power consumption	<2 Watt
Power supply	85-260VAC/50-60Hz or 85-260VDC
Dimension	24x48x75mm (1/32 DIN), (mounting cutout 45x22 mm)

### 2. Front Panel and Operation

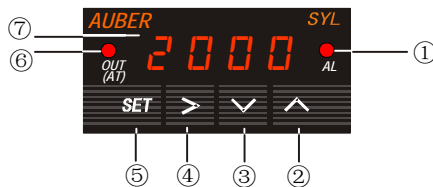


Figure 1. Front panel

- ① AL - Alarm/Relay J1 output indicator
- ② Value increment/Select next parameter
- ③ Value decrement /Select previous parameter
- ④ Auto tuning /Digit shift/Alarm mute
- ⑤ Set/Confirm/Control start (For limit control mode, press it for 5 seconds)
- ⑥ OUT - SSR output indicator / (AT) - blinking during auto-tuning process
- ⑦ The temperature of the probe (Process Value, or PV) is displayed during operation. The target temperature (Set Value or SV) is displayed when flashing (by press the ⊕ or ⊙ key once). The parameters value is displayed during controller set up.

### 3. Terminal Wiring (back view)

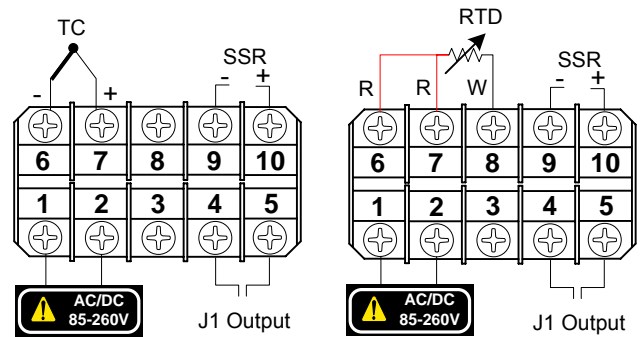


Figure 2. Wiring diagram with thermocouple input on the left and RTD input on the right

#### 3.1 Sensor connection

##### 3.1.1 Thermocouple

The thermocouple should be connected to terminals 6 and 7. 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 6 and 7. The white wire should be connected to terminal 8. For a two-wire RTD, the wires should be connected to terminals 7 and 8. Jump a wire between terminals 6 and 7. Set controller input type, Inty, to P100 (1° resolution) or P10.0 (0.1° resolution).

#### 3.2 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.

#### 3.3 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 J1 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. If the SSR control output option is selected, J1 can be used as alarm output.

##### 3.3.1. Connecting the load through SSR

Connect terminal 9 to the negative input and terminal 10 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 12 for details.

##### 3.3.2 Connecting the load through a contactor

Assuming the controller is powered by a 120V AC source and the contactor has a 120V AC coil, jump a wire between terminal 2 and 4. Connect terminal 5 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. See Figure 11 and 13 for details.

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

3.4.1 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.

3.4.2 The J1 relay is a "dry single pole switch". It does 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 J1 requires a different voltage than that for the controller, an additional power source will be needed (see Figure 13).

3.4.3 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. (Note, we are talking about the SSR itself, not the SSR control output of the controller). Figure 12 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.

4. 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.

4.1 System Configuration Parameters (accessed by code 0089)

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

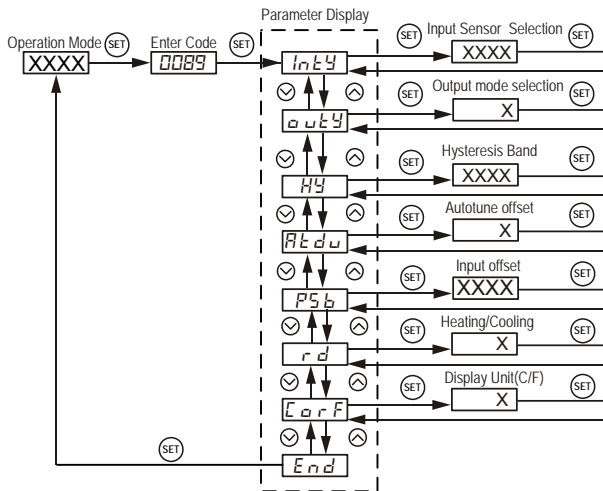


Figure 3. System setup flow chart

- (1) Press **SET** to enter setting mode;
- (2) Press **>**, **<** and **<** to enter parameters;
- (3) Press **SET** to confirm;
- (4) Press **<** or **>** to select the new parameter.

Table 1. System configuration parameters

Code	Description	Setting Range	Initial	Note
<i>Inty</i>	Inty	Input Sensor Type	See table 2	K 1
<i>Outy</i>	Outy	Control Output Mode	0, 1, 2, 3, 4, 5, 6	2 2
<i>Hy</i>	Hy	Hysteresis Band	0-9999	3 3
<i>Atdu</i>	Atdu	Autotune Offset	0-200(deg)	10 4
<i>PSb</i>	PSb	Input Offset	-100-100(deg)	0
<i>rd</i>	rd	Control Function	0: heating 1: Cooling	0
<i>CorF</i>	CorF	Display Unit	0: °C 1: °F	1
<i>End</i>	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
<i>t</i>	TC, Type T	-200-400°C; -320-752°F
<i>r</i>	TC, Type R	-50-1600°C; -58-2900°F
<i>J</i>	TC, Type J	-200-1200°C; -320-2200°F
<i>WRE</i>	TC, WRe3/25	0-2300°C; 32-4200°F
<i>b</i>	TC, Type B	350-1800°C; 660-3300°F
<i>S</i>	TC, Type S	-50-1600°C; -58-2900°F
<i>K</i>	TC, Type K	-200-1300°C; -320-2400°F
<i>E</i>	TC, Type E	-200-900°C; -320-1650°F
<i>P10.0</i>	RTD, Pt100	-99.9-600.0°C; -99.9-999.9°F
<i>P100</i>	RTD, Pt100	-200-600°C; -320-1100°F
<i>Cu50</i>	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 as alarm output; SSR output disabled.
  - 1 - Relay J1 as PID controlled relay contact output; SSR output disabled.
  - 2 - Relay J1 as alarm output; SSR PID control output.
  - 3 - Relay J1 as alarm output; SSR On/off control output.
  - 4 - J1 as On/off control relay contactor output. SSR output disabled.
  - 5 - J1 as Limit control output.
  - 6 - Relay J1 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 can not 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 auto tune process. That will prevent the system from damage due to overheating during the autotune.

4.2 PID Parameters (accessed by code 0036)

The PID parameters are listed in table 3. To change the parameters, press **SET**, enter code "0036", press **SET** again. The parameter flow chart is similar to Figure 3.

Table 3. PID and relevant parameters

Symbol	Description	Setting Range	Initial	Note
<i>P</i>	P	Proportional Constant	0.1-99.9(%)	5.0 5
<i>I</i>	I	Integral Time	0-1999(Sec)	100 6
<i>d</i>	d	Derivative Time	0-399(Sec)	20 7
<i>SouF</i>	SouF	Damp Constant	0.1-1.0	0.2 8
<i>ot</i>	ot	Cycle Rate	2-199(Sec)	2 9
<i>FILT</i>	FILT	Digital Filter Strength	0-3	0 10
<i>End</i>	End	Exit		

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.

**Note 5.** 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 6.** 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 response speed is slower, but the system is more stable. When I=0, the integration is turned off. It becomes to a PD controller that is useful for very slow system.

**Note 7.** 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, causing oscillation or even non-convergence. Normally, d is set to ¼ of the I value.

**Note 8.** Damp constant: This constant can help the PID controller further to improve the control quality. It uses artificial intelligence to dampen the temperature overshoot. When its value is too low, the system may overshoot. When its value is too high, the system will be over damped.

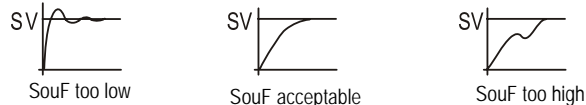


Figure 4. Damp constant

**Note 9.** Cycle rate (ot): It is the time period (in seconds) that the controller uses to calculate its output. e. g. If ot=2, and the 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 value results 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 20~30 seconds.

**Note 10.** 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 change in temperature.

**4.3 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**, enter code "0001", press **SET** again. Figure 5 is the parameter flow chart.

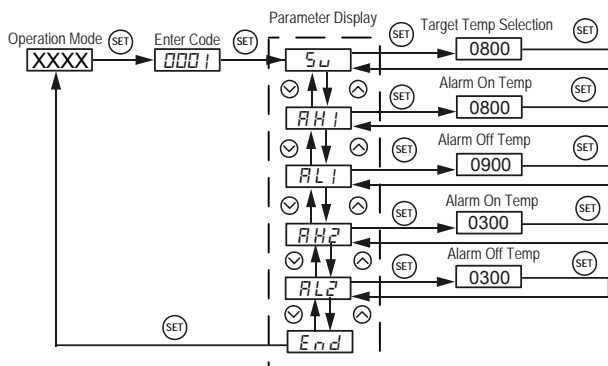


Figure 5. Flow chart for how to set target temperature and alarm

Table 4. Temperature and alarm parameters

Symbol		Description	Initial Setting	Note
SV	SV	Target temperature (Set Value)	800	11
AH1	AH1	Alarm 1 on temperature	800	12
AL1	AL1	Alarm 1 off temperature	900	
AH2	AH2	Alarm 2 on temperature	300	
AL2	AL2	Alarm 2 off temperature	300	
End	End	Exit		

**Note 11.** There are two ways to set the target temperature.

a. During the normal operation mode, press **⊖** or **⊕** once to switch the display from PV to SV. The display will start to blink. Press **⊖** or **⊕** again to increase or decrease the SV. When finished, wait 8 seconds and the setting will take effect automatically (the display will stop blinking).

b. Follow the flow chart shown in Figure 5. This method is easier for large temperature change. If no key is pressed after confirmation of SV, the controller will return to normal operation mode automatically in 1 minute.

**Note 12.** Alarm setting. When the SSR is used as the control output, the J1 relay can be used as an alarm (when outy is set to 0, 2, 3, or 6). The controller offers two alarm settings for the J1 relay. One is controlled by parameters AH1 and AL1, and the other is controlled by AH2 and AL2. AH1 and AH2 are the temperatures to turn the J1 relay on; AL1 and AL2 are the temperatures to turn the J1 relay off. When AH1(2) >AL1(2), the alarm is set for absolute high alarm as shown in Figure 6 below. When AH1 (2)<AL1(2), the alarm is set for absolute low alarm as shown in Figure 7 below. Users can press **⊖** key to tempoarily turn off the alarm. The alarm will be on again if the alarm set temperature is reached again. To permanently deactivate the alarm, set AH1=AL1 or AH2=AL2.

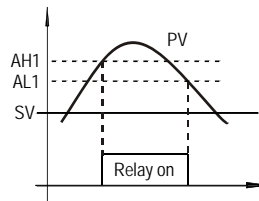


Figure 6. Absolute high alarm

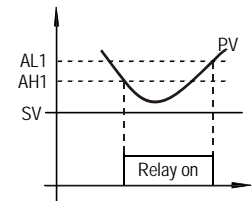


Figure 7. Absolute low alarm

**5. 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.

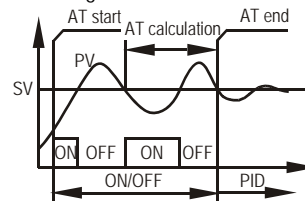


Figure 8. Auto tuning

5.1 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 and used for the system. Please note that auto-tuning is only for PID control mode (when "outy" is set at 1 or 2).

5.2 To stop the auto-tuning, press and hold **⊕** key until "AT" indicator stops blinking. Then, the previous PID parameters values are resumed.

**6. 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, and 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 turn 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 value results in tighter temperature control but also causes the on/off action to occur more frequently. In the PID parameters menu (code 0036), only ot and FILt is used. P, I, D and SouF are not meaningful for the on/off control mode.

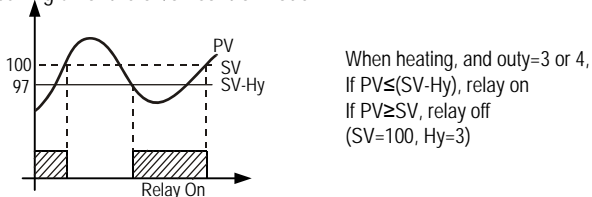


Figure 9. On/off control mode

**7. 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). The controller can't be reset when the temperature is within the hysteresis band (Hy).

To use the Limit control mode, set outy to 5 or 6, and set Hy to the range that you want reset to be blocked. Power up the controller, then start the heating by pressing **SET** key for 5 second or until the output indicator is on.

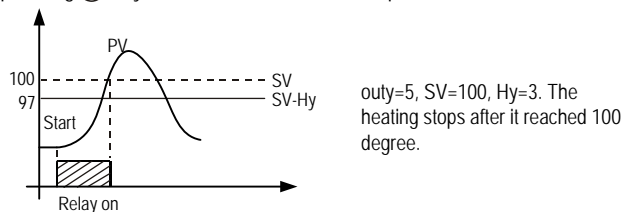


Figure 10. Limit control mode

**8. Application Example**

8.1 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

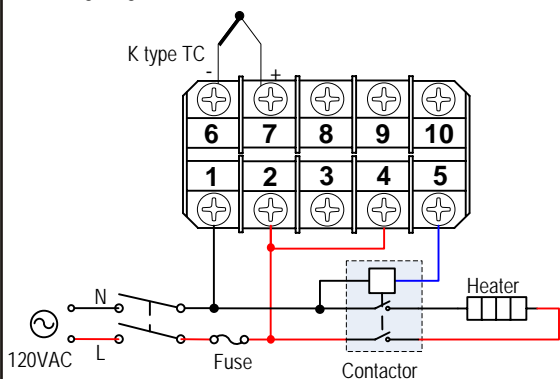


Figure 11. Typical wiring for high power and high temperature applications such as oven or kiln temperature control

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

8.2 A water tank needs to be controlled at 200.0°F. If temperature is over 205.5 °F, the alarm will turn on to warn the operator and turn off when the temperature drops below 205.3 °F. The system consists of a 1200W 120V AC heater, a Pt100 RTD sensor, a 25A AC SSR, and a 120 V AC buzzer.

a. Wiring diagram, see Figure 12.

Wiring the controller or heater with 240V AC is the same as with 120V AC

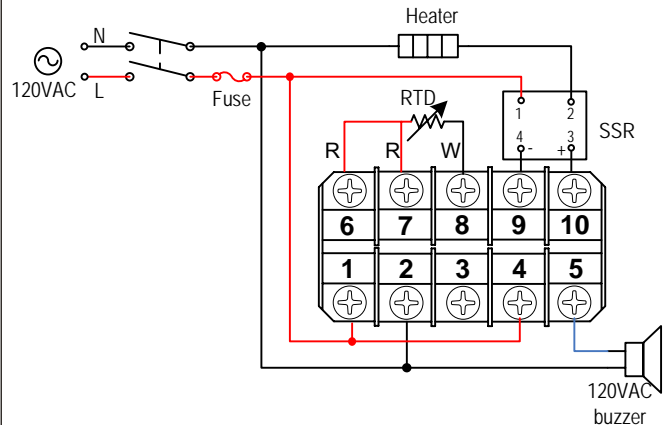


Figure 12. Typical wiring for high precision control set up. It shows how the RTD sensor and SSR should be wired.

b. Parameter setting. These are the parameters that need to be changed from the initial value: Inty=P10.0 for Pt100 RTD sensor with 0.1° resolution input, SV=200.0 °F for the target temperature. AH1=205.5 °F and AL1=205.3 °F for the alarm.

8.3 A furnace needs to be controlled to hold a temperature. Power source is 240V AC. Heating element is 1800W/240V. It is switched by a contactor. The coil voltage of the contactor is 24V AC. A K type thermocouple is used as the temperature sensor.

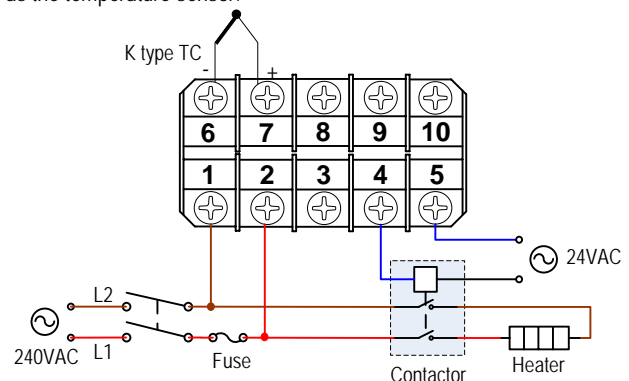


Figure 13. Wiring example for a load that requires different voltages than that for the controller power supply. This diagram also applies to a 24V solenoid valve if the contactor and heater are replaced by the valve.

8.4 Drive a load directly

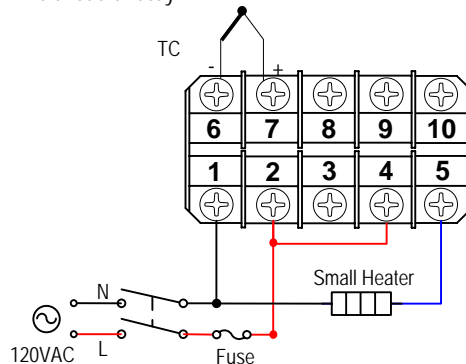


Figure 14. This is for loads that draw less than 3 Amp of current only. For parameter settings, please refer to "example (1)".

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