

# Instruction Manual

## SYL-1612B-24V PID TEMPERATURE CONTROLLER INSTRUCTION MANUAL

Version 2.8

### ! 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 make the controller front panel protected from dust and water splash (IP54 rating). Additional protection is needed for higher IP rating.
- This controller carries 90-day warranty. The 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	9-15VDC/AC for 12V model; 20-28V DC/AC for 24V model
Dimension	24x48x75mm (1/32 DIN), (mounting cutout 45x22 mm)

### 2. Front Panel and Operation



Figure 1. Front panel

- AL- Alarm/Relay J1 output indicator
- Value increment/Select next parameter
- Value decrement /Select previous parameter
- Auto tuning /Digit shift
- Set/Confirm/Control start (For limit control mode, press it for 5 seconds)
- OUT- SSR output indicator /(AT) - synchronize with SSR output/ blink during auto-tuning process
- During operation, it displays the temperature of the probe (Process Value, or PV). When flashing (by press the  $\odot$  or  $\ominus$  key once), it displays the target temperature (Set Value or SV). When setup the controller, it displays the parameters value.

### 3. Terminal Wiring (back view)

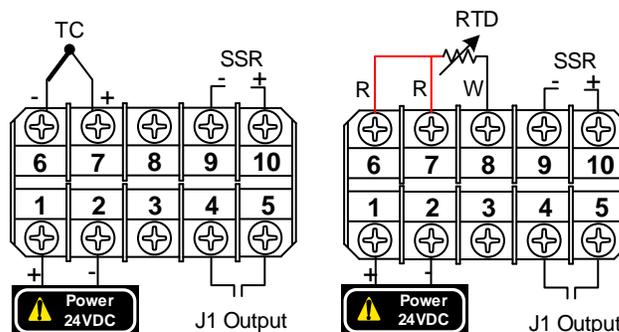


Figure 2. Wiring diagram with thermocouple input on the left and RTD input on the right

#### 3.1 Sensor connection

##### 3.1.1 Thermocouple

The thermocouple should be connected to terminal 6 and 7. Please make sure the polarity is correct. There are two commonly used color codes for the K type thermocouple on the market. US color code uses yellow and red, yellow is positive. Imported DIN color code uses red and green (blue), red is positive. If the connection is reversed, the temperature reading will decrease when temperature increases.

##### 3.1.2 RTD sensor

For three-wire RTD with standard DIN color code, the two red wires should be connected to the terminal 6 and 7. White wire goes to terminal 8. For two-wire RTD, the wires should be connected to terminal 7 and 8. Then, jump a wire between 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 DC power should be connected to terminal 1 and 2. Terminal 1 is positive and 2 is negative. When connecting to a AC power source, there is no polarity requirement. The 12V model can be powered by 9-15 VAC/DC; the 24V model can be powered by 20-28VAC/DC.

#### 3.3 Output connection

Two control output options are offered by this controller. (1) The SSR control output provides an 8VDC 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 less than 3 Ampere of current. If SSR control output option is selected, J1 can be used as alarm output.

##### 3.3.1 Connecting the load through SSR

Connect the terminal 9 to the negative input and terminal 10 to the positive input of the SSR. Set the system output configuration, outy, to 2, or 3 depending on the control mode used. See Figure 12, 13 for details.

##### 3.3.2 Connecting the load through built-in relay directly

Assuming the controller and the load are powered by 24VDC, jump a wire between terminal 1 and 4. Connect terminal 5 to one lead of the load and terminal 2 to the other lead of the load. Set the system output configuration, outy, to 1, 4, or 5 depending on the control mode used. See Figure 11 for details.

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### 3.4 For first time users that have no experience with PID controllers, following note might prevent you from making the most common mistakes.

3.4.1 The power to the load 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, a 20 gauge is sufficient for providing the power to terminal 1 and 2. Thicker wire could be hard to install.

3.4.2 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 24V 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, another power source will be needed.

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, 13 shows how the SSR output should be wired.

## 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 the person who has the responsibility and knowledge to change it. Code 0089 contains the parameters for system configuration that might need change during the initial set up. Code 0036 contains the parameters for tuning the 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.

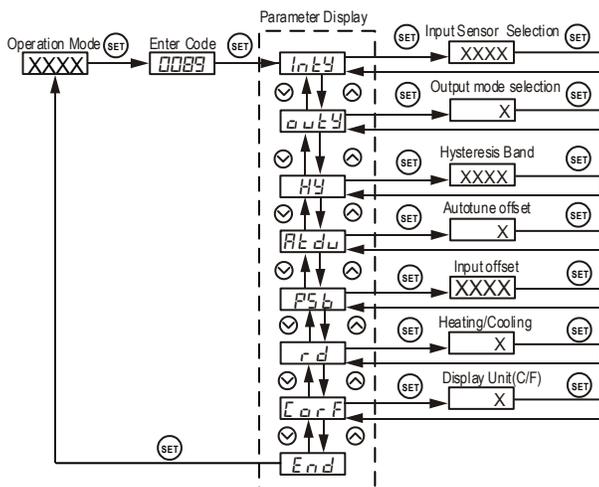


Figure 3. System setup flow chart

- (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	
Inty	Inty	Input Sensor Type	See table 2	K	1
Outy	Outy	Control Output Mode	0, 1, 2, 3, 4, 5	2	2
Hy	Hy	Hysteresis Band	0~9999	3	3
Atdu	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 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	TC, Type T	-200~400°C; -320~752°F
r	TC, Type R	-50~1600°C; -58~2900°F
J	TC, Type J	-200~1200°C; -320~2200°F
WRE	TC, WRe3/25	0~2300°C; 32~4200°F
b	TC, Type B	350~1800°C; 660~3300°F
S	TC, Type S	-50~1600°C; -58~2900°F
K	TC, Type K	-200~1300°C; -320~2400°F
E	TC, Type E	-200~900°C; -320~1650°F
P10.0	RTD, Pt100	-99.9~600.0°C; -99.9~999.9°F
P100	RTD, Pt100	-200~600°C; -320~1100°F
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 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

**Note 3.** Hysteresis Band (also called dead band, or differential), Hy, is used for on/off control and limit control. Its unit is degree (°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 damaging due to over temperature 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 °C when probe is in ice/water mixture, setting PSb=-5, will make the controller display 0 °C. To set negative value, shift to the very left digit, press down key until it shows “.”.

### 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	
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			

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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 6.** Proportional Constant (P): P is also called the proportional band. Its unit is the percentage of the temperature range. e. g. For 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 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 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, response speed is faster but the system is less stable. When I increases, respond speed is slower, but 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. Normally, d is set to 1/4 of the I value.

**Note 9.** Damp constant: This constant can help the PID control further to improve the control quality. It uses the artificial intelligent program to damp the temperature overshoot. When its value is too low, the system might overshoot. When it is too high, the system will be over damped.

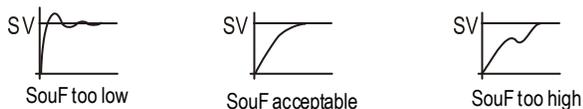


Figure 4. Damp constant

**Note 10.** Cycle rate (ot): It is the time period (in seconds) that controller used to calculate its output. e. g. If ot=2, and controller output is 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 to wear out too soon. It normally set to 20~30 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 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.

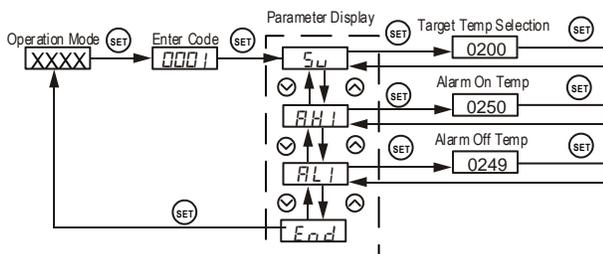


Figure 5. Flow chart for how to set target temperature and alarm

Table 4. Temperature and alarm parameters

Symbol	Description	Initial Setting	Note
SV	Target temperature (Set Value)	221	12
AH1	Alarm 1 on temperature	283	13
AL1	Alarm 1 off temperature	284	
AH2	Alarm 2 on temperature	300	
AL2	Alarm 2 off temperature	300	
End	Exit		

**Note 12.** 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 finish, wait 8 seconds and the setting will take effect automatically (the display will stop blinking).

b. Press **SET** key once. Use **⊖**, **⊕** and **⊙** keys to enter code 0001. Press **SET** key to confirm, then the display would be SV (SV). Press **SET** key again to display the SV setting. Use **⊖**, **⊕** and **⊙** keys to enter the new SV value and press **SET** to confirm. Press **⊙** key to change the display to END. Then, press **SET** to exit. You can also ignore the steps after confirmation of SV. The controller will return to normal operation mode automatically if no key is pressed for 1 minute. The flow chart below shows how to set the SV and alarm in details.

**Note 13.** 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 or 3). The alarm is controlled by parameters AH1/AL1 or AH2/AL2. AH1/AH2 is the temperature to turn the relay on; AL1/AL2 is the temperature to turn the 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. When AH1(2)=AL1(2), the alarm is deactivated.

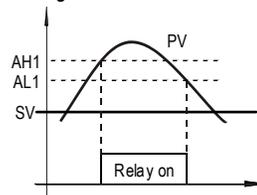


Figure 6. Absolute high alarm

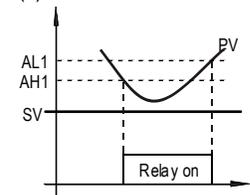


Figure 7. Absolute low alarm

### 5. Auto-Tuning

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 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.

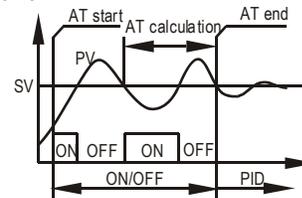


Figure 8. Auto tuning

**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 **SET** key until "AT" indicator stops blinking. Then, the previous PID parameters value are resumed.

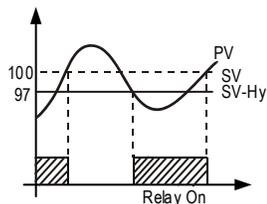
### 6. On/off control mode

On/off control mode is not as precise as PID control mode. But it is necessary for inductive load such as motor, compressor, and solenoid valve that does not like to take pulsed power. It works like a mechanical thermostat. When

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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 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 desired range based on control precision requirement. Smaller Hy results in tighter temperature control but also causes the on/off action more frequent. 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.



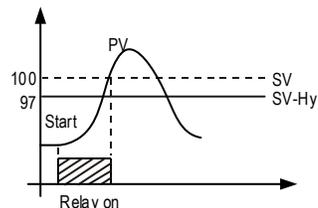
When heating, and outy=3 or 4,  
If  $PV \leq (SV - Hy)$ , relay on  
If  $PV \geq SV$ , relay off  
(SV=100, Hy=3)

Figure 9. On/off control mode

## 7. Limit control mode

The limit control mode will shut off the heater 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, 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 AL LED is on.



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

Figure 10. Limit control mode

## 8. Application Example

**8.1** A BBQ smoker needs to be controlled at 200°F. Power source is 24VDC. K type thermocouple is used as the temperature sensor. The system consists of a 24VDC fan, a K type thermocouple.

a. Wiring diagram

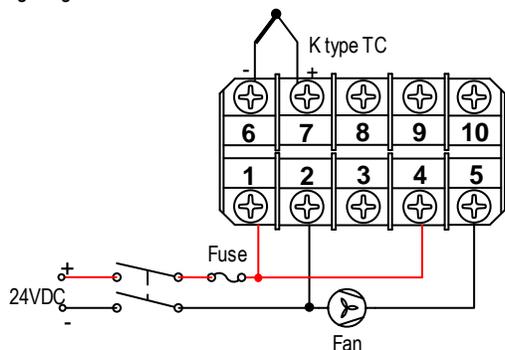


Figure 11. Typical wiring for BBQ smoker temperature control

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=10, the reason we set the cycle time at 10 is that the fan needs time to start; SV=250 °F for the target temperature. Following are the tuning parameters that we found work best for this type of application. P=1.2, I=300, d=70, SouF=0.7

**8.2** A thermoelectric cooler (TEC) needs to be controlled at 45 °F. If temperature is over 46 °F, the alarm will be on to warn the operator and off when dropped to below 45.5 °F. The system consists of a 90W 24VDC TEC, a Pt100 RTD sensor, a 10A DC SSR, and a 24VDC buzzer.

a. Wiring diagram, See Figure 12.

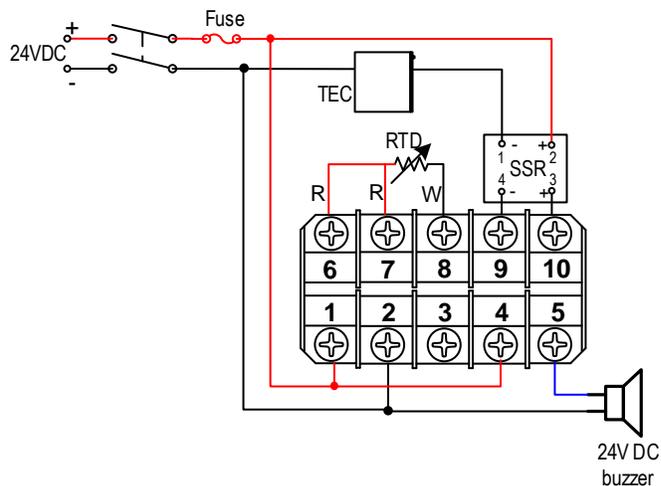


Figure 12. Typical wiring for high precision control set up. It shows how the RTD sensor, and SSR should be wired.

b. Parameter setting. These are the parameters that Need to be changed from the initial value: Rd=1 for cooling mode; Inty=P10.0 for Pt100 RTD sensor with 0.1° resolution input, SV=45 °F for the target temperature. AH1=46 °F and AL 1= 45.5 °F for the alarm.

**8.3** A BBQ smoker needs to be controlled at 200°F. Power source is 24VDC. K type thermocouple is used as the temperature sensor. The system consists of a 24VDC fan, a K type thermocouple and a 5A DC SSR.

SSR has infinite life time if it is used properly. It will make the controller last longer.

a. Wiring diagram

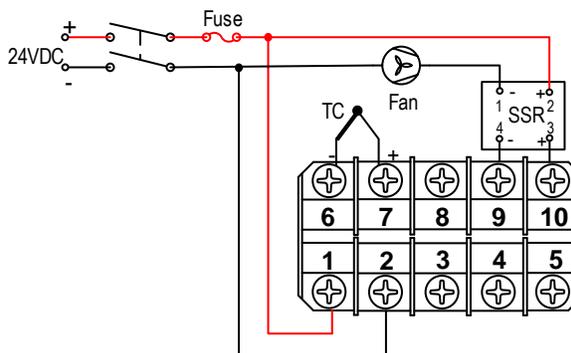


Figure 13. Typical wiring with SSR for BBQ smoker temperature control

b. Parameter setting. These are the parameters that need to be changed from the initial value: ot=10; SV=250 °F for the target temperature. Following are the tuning parameters that we found work best for this type of application. P=1.2, I=300, d=70, SouF=0.7

## 9. Error Message and trouble shooting

### 9.1 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 terminals 6 and 7. If the display shows the ambient temperature, the thermocouple is defective. If it still displays EEEE, check the input setting, Inty, to make sure it is set to the right thermocouple type. If Inty setting is correct, the controller is defective. For 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 terminals 6 and 7. The clear wire should be on terminal 8.

### 9.2 No heating

When controller output is set for relay output, the "AL" 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 AL 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.

### 9.3 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 a thermocouple connector or an 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.

## Auber Instruments

5755 North Point Parkway, Suite 99

Alpharetta, GA 30022

[www.auberins.com](http://www.auberins.com)

e-mail: [info@auberins.com](mailto:info@auberins.com) Tel: 770-569-8420

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