Powder Coating Oven Manual

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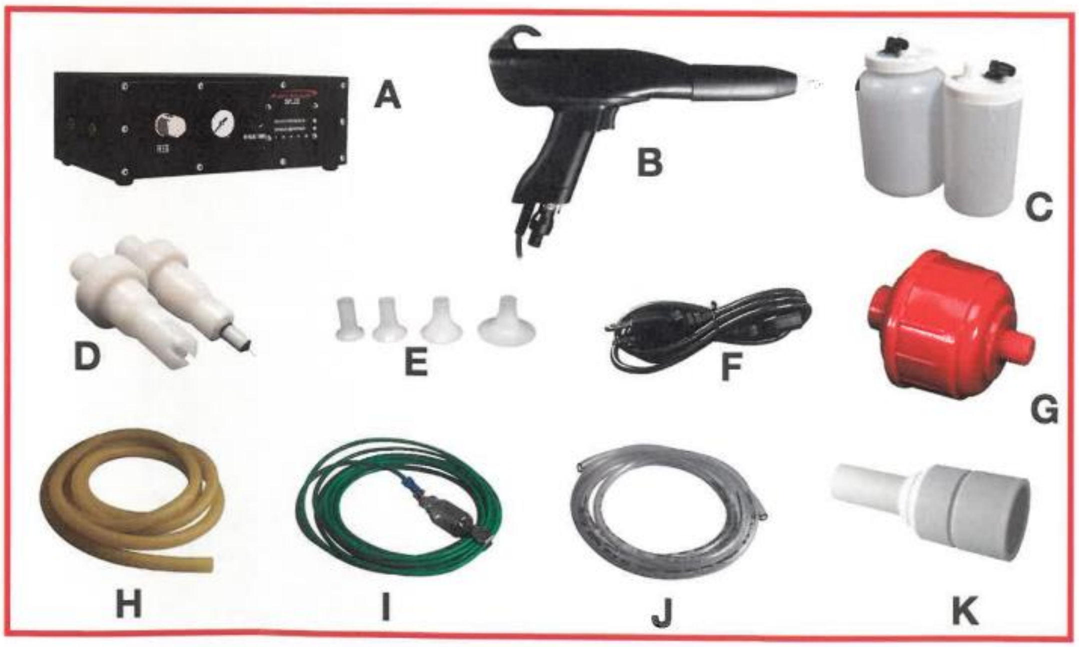
Project Overview

Powder Coating is a dry finishing process created by utilizing an electric change that causes a dry powder to fuse to a surface (e.g., metals such as Aluminum or steel, glass, and even plastics) and is then permanently cured to the surface by baking the part in a high temperature curing oven. This creates a hard finish that is typically tougher than conventional paint. For this project, a team of engineering students will design and fabricate a “mobile” gas-powered oven that is capable of housing small to larger parts such as an off-road bumper or even the SAE Baja frame. This system should be able to be easily moved by a single person and would thus be “mobile”. The product will be housed in the Renewable Energy lab compound area and will be used for numerous future NAU projects. This design will be optimized to be “mobile”, heat generated by a propane heater system, develop a racking system allowing small to large parts to be cured, and have various controls to regulate the curing oven. Professor Pete has new powder coating equipment (~$1k worth of equipment) that will be utilized with this oven. In addition to building this oven, the team will collaborate with the bumper build team to power-coat 3 different bumpers. Additionally, there are other parts required to be powdered coated in the renewable energy lab. Students will need to have skills in the area of fabrication, structural strength analysis, control systems, possible welding or other metal fabrication techniques, computer & heat transfer analysis, and the ability to learn about the powder coating process.

Material List

A. Control Box
B. Gun with Lead Wire
C. Standard Hopper (1 lb and 2 lb)
D. Standard and Flat Spray Nozzle
E. Conical Nozzle Tips
F. Power Cable
G. Filter
H. Latex Power Hose
I. Ground Cable with Clip
J. Hopper Pressure Hose
K. Wide Mouth Multi- Coat Nozzle



Getting Started with Powder Coating (Assembly)

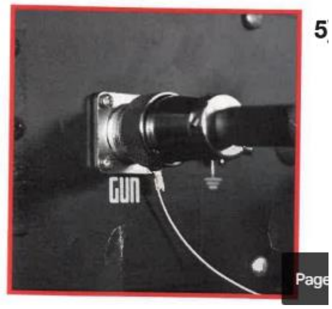
1. Insert the hopper pressure hose into the “Feed Air Out” quick disconnect fitting on the back of the control box.

2. Insert the other end of the hopper pressure hose into the top of the hopper lid

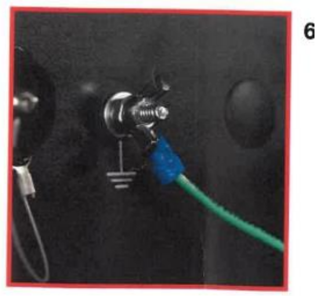
3. Connect one end of the latex powder hose to the 3/8” barb fitting on the hopper lid

4. Connect the other end of the latex powder hose to the gun barb at the base of the powder coating gun

5. Connect the gun lead wire to the control box



6. Remove the wing nut from the ground lug. **Do not remove the hex nut from the ground lug.** Place the eye – end of the ground cable on the ground lug, and re – tighten the wing nut.



7. Connect your shop air line (air compressor) to the “Air In” fitting on the control box. Install the filter to prevent debris and contaminants from entering the system and damaging the internal air solenoid. This filter is disposable and should be replaced regularly. (Maximum air pressure: 60 psi)

8. Ensure the power switch is in the “off” position, and connect the power cord to the Power Entry Module

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Powder Coating Steps

1. Sand parts to remove all impurities
2. Use Rust- Off to ensure all the rust is off of the parts.
3. Use Super Degreaser or similar product to clean your parts.
4. Use AllPrep Iron Phosphate to promote long-term adhesion between the powder and the substrate. AllPrep is highly recommended if you are not blasting the substrate.
5. Ensure that your parts are properly grounded to a true earth ground.
6. Fill your hopper with powder.
7. Turn the KV adjustment knob all the way down. (counterclockwise)
8. Turn on the Feed Air all the way down. (counterclockwise)
9. Point the gun away from yourself and any parts to be coated, and pull the trigger.
10. With the trigger held, slowly increase the Feed Air until the powder comes out of the gun with the consistency of someone exhaling cigarette smoke.
11. Turn the KV adjustment knob until you reach an output of 70-80 KV. (For the second coat use an output of 100 KV)
12. Identify any Faraday areas (tight corners, angles, holes, etc.) and coat them first.
13. Parts can be preheated to help with adhesion.
14. Inspect your coating using a bright flashlight to ensure the substrate is covered evenly.
15. Follow the cure schedule for the powder that you are using. This will be listed on both the powder label and the Technical Data Sheet. The TDS can be found on each product's page on the Columbia Coating Website.

Cleaning Up Process (Disassembly)

Never disassemble your gun beyond what is described here because it may damage parts!

1. Shut off the main power switch
2. Disconnect the Latex Powder Hose from the hopper and gun
3. Hold both ends of the latex hose in one hand, and insert the air compressor air nozzle into one end. Blow out the powder while shaking the latex hose.
4. Remove the Conical Nozzle Tip (if being used) and blow off any residual powder
5. Unscrew the Nose Cone from the gun and blow off any remaining powder
6. Remove the Standard or Flat Spray Nozzle and blow off any remaining powder
7. Blow air through the gun body from both ends, then reassemble.
8. Remove the Hopper Pressure Hose from the hopper lid. This step is important to ensure that no powder makes its way into this line while cleaning
9. Remove the hopper lid and gasket, then blow off. Then empty the hopper and blow it out as well.

Hyper Smooth 02 LED Trouble Shooting

Powder is not sticking:

- Ensure that you have a good ground connection.
- Make sure you are using the appropriate KV setting.
- Check your input air pressure. Decrease the input pressure if the powder is being blowm past the part.
- Preheat the part.

Powder looks textured after cure cycle:

- If the powder has a rough texture, then the powder was applied too thin.
- If the powder has a wavy/ orange peel texture, then the powder was applied too thick.

Veins/Wrinkles/Hammerstones not textured after cure cycle:

- The powder was applied to thin.
- If the part was too hot when the powder was applied this can happen as well.

Powder has "fish-eyes" in it:

- Before cure cycle: either the KV setting is set too high: the powder flow is too low, or the gun is being held too close to the part.
- After the curing cycle: the part is outgassing, or there is contamination in your lines.

Powder is cracking of flaking off:

- The powder is under cured.

Control System Instructions

1. Press the set button for three seconds until you reach the Sn function
2. Change the Sn function to K for thermocouple type input
3. Press the set button until you reach the CF function
4. Change the CF function input to F for degrees Fahrenheit
5. Press the up button for three seconds to reach the SP (set point) function
6. Change the set point value to the desired temperature then press the set button
7. Press the set button and hold for three seconds until the functions appear
8. Press the set button until you reach the ALP1 function
9. Change the ALP1 function value to 0
10. Press the down button until you reach the tE1 function
11. Change the tE1 value to the number of minutes needed to cure
12. Press the down button until you reach the uPt function
13. Change the uPt function value to 1 so that it will count down in minutes
14. Press the down button until you reach INT
15. Change the INT value to 1
16. Turn on the heater

Control System Information

1. Specifications

Table 1: Specifications

Input type	Thermocouple: K,E,J,T,S. RTD: Pt100, Cu50
Input range	Cu50(-56 to 302), Pt (-198 to 1111), K (-20 to 2370), E (-20 to 1292), J (-20 to 1651), t (-190 to 750), S (-20 to 2912)
Display	Two lines, four digits, temperature and time or temperature and set temperature
Display Resolution	Temperature : 1 °F /°C Time: 1 second/minute
Accuracy	Temperature: ±0.5 % of input range Time: 1 second/minute
Control Mode	Temperature: PID, manual control, on-off Time: Timed PID, timed on-off, independent timer
Timer Mode	Single delay, double delay, count up, count down
Timer Range	1 – 9999 seconds or minutes
Anti-Short Cycle Delay Timer Range	1 –200 minutes
Control Output	SSR control output: 12 VDC, 50mA
Alarm	Timer alarm, process high/low alarm, deviation high/low alarm
Power Supply	90 to 265 VAC , 50 to 60 Hz

2. Terminal Assignment

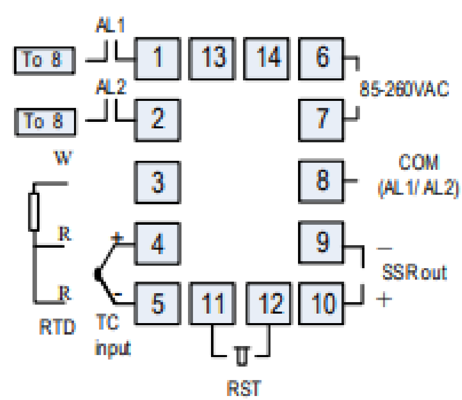

Figure 1: Wiring Diagram

2.1 Sensor Connection

Please refer to table 3 for the input sensor type (Sn) setting codes. The initial setting for input is for a type K thermocouple. Set Sn to the correct sensor code if another type of sensor is used.

2.1.1 Thermocouple

The thermocouple should be connected to terminals 4 and 5. 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.

When using an ungrounded thermocouple that is in touch with a large conductive subject, the electromagnetic field picked up by the sensor tip might be too large for the controller to handle, the temperature display will change erratically. In that case, connecting the shield of thermocouple to terminal 5 (circuit ground of the controller) might solve the problem. Another option is to connect the conductive subject to terminal 5.

2.2 Power to the Controller

The power cables should be connected to terminals 6 and 7. Polarity does not matter. It can be powered by 120V or 240VAC 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 neutral wire to terminal 6 and hot to 7.

2.2.1 Timer reset terminals

Terminals 11 and 12 are for connecting to a reset switch. If you need to start the timer after the controller is powered up, you should short these two terminals together with a jumper wire. To use the reset function, these terminals should be connected to a switch. Opening the contact of the switch will rest the timer. Close the contact of the switch will start the timer.

2.3 Control output connection

The SSR control output of the controller SWA-2451B provides a pulsed 12V DC signal for the SSR. Connect terminal 10 to the positive input and terminal 9 to the negative input of the SSR. See Figure 7 for details.

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

2.4.1 SSR output power does not come from the input of the SSR. The output of the SSR is a single pole switch between terminals 1 and 2 of the SSR. The input of the SSR is for controlling or triggering the SSR. (Please note we are talking about the SSR itself, not the SSR control output of the controller).

When switching a North American 240V AC power (2 hot wires), the heater will be live even when the SSR is off. Users should install a double pole mechanical switch to the power input, to cut both hot wires at same time when not in use.

2.4.2. For all controller models listed in this manual, the power is controlled by regulating the duration of on time for a fixed period of time. It is not controlled by regulating amplitude of the voltage or current. This is often referred as time proportional control. For example, if the cycle rate is set for 100 seconds, a 60% output means controller will switch on the power for 60 seconds and off for 40 seconds (60/100 = 60%). Almost all high power control systems use time proportional control because amplitude proportional control is too expensive and inefficient.

3. Front Panel and Operation

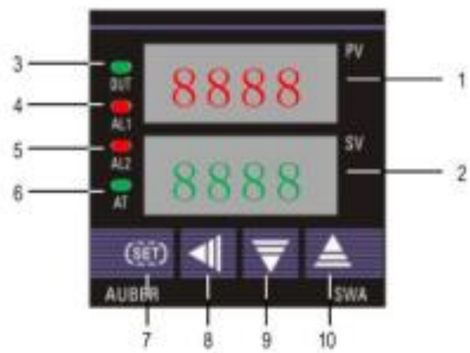

Figure 2: Front Panel

1. PV display: Indicates the sensor read out, or process value (PV).

2. SV display: Indicates the time when timer is used. If timer is deactivated, it indicates the set temperature (SV). In manual control mode, an “H” is displayed on the most left digit to indicate number is for percentage of output (%).

3. Output indicator: It is synchronized with SSR output on the controller (terminal 9 and 10). When it is on, SSR output is triggered, and your external SSR & heater (or cooler) are powered.
4. AL1 indicator: It is synchronized with alarm 1 relay (AL1). When timer is on, it works as the timer relay output indicator. When timer is deactivated, it lights when Alarm 1 condition meets.
5. AL2 indicator: It is synchronized with alarm 2 relay (AL2). It lights when Alarm 2 condition meets.

6. Auto-tune indicator: It lights up when auto-tune starts.

7. SET key: Press and hold this key for 3 seconds will enter the temperature control parameter setting mode. When the controller is in temperature, or timer parameter setting mode, press this key momentarily will lead the display to the next parameter.

8. Automatic/Manual function key/Data shift key ◄: press ◄ for 3 seconds to enter manual tuning mode. Press ◄ for 3 seconds again to exit.

9. Decrement key ▼: Decreases numeric value of the setting value. Press for 3 seconds to enter the timer setting mode.

10. Increment key ▲: Increases numeric value of the setting value. Press for 3 seconds to enter the temperature setting mode

3.1 Display Modes

Display mode 1: Normal operation display.

PV is the abbreviation for Process Value. SV is the abbreviation for Set Value. When the power is turned on, the upper display window shows the measured temperature value. If the timer is used, the lower window shows set timer value. When timer starts, it shows the time as it counts up or down. If the timer is disabled (INT = 0), the lower display shows the set temperature.

Display mode 2: Changing temperature set value (SV)

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

Display mode 3: Timer parameter set up.

Press the ▼ key for 3 seconds to change the display status into timer parameter setting mode. The upper display window shows the timer parameter symbol to be changed, the lower display shows its value. Press the ◄, ▼or ▲ to change the setting. Then, press SET to go to next parameter. If no key is pressed for 10 seconds, the display will return to mode 1 automatically. The change of value will take effect without the need for pressing the SET key.

Display mode 4: Manual mode.

Press the ◄ key for 3 seconds to enter the manual mode. In this mode, the lower display has an H on the most left. The number on the right is the percentage of power output. Press the ▼or ▲ to adjust the power. Press the ◄ key for 3 seconds again to exit this mode.

Display mode 5: Temperature control parameter setting.

Press the SET key for 3 seconds to enter the temperature control parameter setting mode. The upper display window shows the parameter symbol to be changed, the lower display shows its value. Press ◄, ▼or ▲ to change the setting. Then, press SET to go to next parameter. If no key is pressed for 10 seconds, the display will return to mode 1 automatically. The change of value will take effect without the need for pressing the SET key.

3.2 Parameter Name, Range and Initial Setting

3.2.1 Alarm parameter

This controller has two alarm outputs: Alarm 1 (AL1, NO relay) and Alarm 2 (AL2, NO relay). Two red alarm indicators are located on the front panel: AL1 and AL2. Alarm 1 and AL1 indicator are synchronized. Alarm 2 and AL2 indicator are synchronized. When the AL1 (AL2) indicator is ON, alarm 1 (alarm 2) relay pulls in. When the AL1 (AL2) indicator is OFF, alarm 1 (alarm 2) relay drops off.

Each alarm is set by three parameters: ALP, AL and Hy. ALP1, AL1 and Hy1 are for Alarm 1. ALP2, AL2 and Hy2 are for Alarm 2. Alarm 1 can be set as either temperature alarm (ALP1 = 1 ~ 4) or timer alarm/output (ALP1 = 0). Alarm 2 can only be used for temperature alarm (ALP2 = 1 ~ 4). See ALP definition below.

"ALP" defines the type of alarm.

ALP = 0, timer alarm/output (alarm 1 only)

ALP = 1, high limit temperature alarm.

ALP = 2; low limit temperature alarm.

ALP = 3; deviation high temperature alarm.

ALP = 4, deviation low temperature alarm.

Note: When ALP1 is set to 0 (for timer output), parameter AL1 and Hy1 are not in use. Only ALP1 can be set to 0. ALP2 = 0 is not functional for SWA-2451B.

"AL" is for the alarm temperature setting. When alarm is set for high/low limit alarm, its value is the temperature that alarm will turn on. When alarm is set for high/low deviation alarm, its value indicates that the alarm will turn on when temperature is deviated AL degree from the set temperature (SV). Note: when alarm is set to deviation alarm (ALP1 / ALP2 is set to either 3 or 4), AL1 / AL2 can only be set to 100 as maximum.

"Hy" is the hysteresis band of temperature alarm. This parameter also uses for ON/OFF control mode (see 4.2.2 below). In heating mode, for high limit or deviation high alarm mode, the alarm will turn off when the temperature is Hy degree below alarm on setting; for low limit and deviation low alarm mode, the alarm will turn off when temperature is Hy degree above the alarm on setting.

3.2.2 Hysteresis Band "Hy

The Hysteresis Band parameter Hy is also referred as Dead Band, or Differential. It permits protection of the on/off control from high switching frequency caused by process input fluctuation. Hysteresis Band parameter is used for on/off control, as well as auto-tune process. For example: When controller is set for on/off heating control mode, the output will turn off when temperature goes above SV+ Hy and on again when it drops to below SV-Hy.

3.2.3 At (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.

3.3 System Parameters:

Mode 2: Press ∧ key for 3 seconds then release

Code	Sign	Description	Setting Range	Initial Setting
SP	SP	Set Value	Decided by DIL, DIH	100

Mode 5: Press SET key for 3 seconds then release

Code	Sign	Description	Setting Range	Initial Setting
AL1	AL1	Alarm 1 setting	-1999 to 9999	999.9
AL2	AL2	Alarm 2 setting	-1999 to 9999	0
SC	SC	Input offset	-20 to 20	0
P	P	Proportional constant	0.1 to 200	15
I	I	Integral time	0 to 2000	240
d	D	Derivative time	0 to 200	30
At	At	Auto-time	On/Off	OFF
t	t	Cycle time	2 to 120	2 or 120
Hy	Hy	Hysteresis band	0.1 to 100	1
Hy 1	Hy 1	Alarm 1 Hysteresis band	0.1 to 100	1
Hy 2	Hy 2	Alarm 2 Hysteresis band	0.1 to 100	1
dP	dP	Decimal point position	0 or 1	1
ALP1	ALP1	Alarm 1 definition	0 to 4	0
ALP2	ALP2	Alarm 2 definition	0 to 4	1
CooL	COOL	Cooling control	On/Off	OFF
outH	outH	Output high limit	0 – 100%	100
LoCk	Lock	Configuration privilege	0 to 50	0
Sn	Sn	Input type	See Table 3	K
oPA	OPA	Output mode	0	0
dIL	DIL	Input low limit	-1999 to DIH	0
dIH	DIH	Input high limit	DIL to 9999	999.9
CF	CF	Display unit	C,F	C

Mode 3: Press ∨ key for 3 seconds and release

Code	Sign	Description	Setting Range	Initial Setting
tE1	TE1	Timer 1	0 to 9999	10
tE2	TE2	Timer 2	0 to 9999	0
uPt	UPT	Timer unit and timer mode	0 to 3	0
Int	INT	Timer control mode	0 to 8	1

3.4 Control action explanations

3.4.1 PID

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.

Proportional Constant (P): P is also called the proportional band. Its unit is the degree of temperature. For example, P = 50 means the proportional band is 50 degrees. 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 150 to 200 ° C. The smaller the P value is, the stronger action will be for the same temperature difference between SV and PV. **Please note: for on/off control mode, P is set to 0.**

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.

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. However, when the controller is in on/off mode (P = 0) and cooling control is turned on, d means Delay Timer of the Anti-Short Cycle Delay (Asd) function. The delay time ranges from 1-200 minutes.

3.4.2 On/off control mode

It is necessary for inductive loads such as motors, compressors, or solenoid valves that do not like to take pulsed power. It works like a mechanical thermostat. When the temperature passes the SV+Hy, the heater will turn off. When the temperature drops back to SV-Hy, the heater will turn on again. (In cooling mode, the cooler turns on when temperature passes SV+Hy, and turns off when temperature drops back to SV-Hy). **To use the on/off mode, set P = 0 and Hy to the desired band.** Then I and D parameters are not used when controller is in heating mode. It can be left at any value. In the cooling mode, the D value is used for Anti-Short Delay time. Its value is in minutes.

3.4.3 Cooling control

When controller is used for cooling control and load is a compressor, it should not turn on the compressor when its refrigerant is at high pressure (just after turned off). Otherwise, the compressor can be damaged in short time. Two methods are commonly used to prevent the rapid cycling of the compressor. One is to use on/off control mode (instead of the PID control mode) with wide enough hysteresis band, and long cycle rate. The other is to use the Anti-Short Cycle Delay (ASd) function. ASd establishes the minimum time that the N.O. contacts remain open (after reaching cutout) before closing again. The delay overrides any Load Demand and does not allow the N.O. contacts to close until the set time-delay value has elapsed. ASd gives time to release the refrigerant pressure through evaporator. This controller allows the user to use both methods to protect the compressor. You should set the P = 0 for on/off mode. Hy should not be less than 2 degrees unless you really need a tight control. The cycle rate should be set for 20 second or longer. The D is typically set to 4- 6 (minutes).

3.4.4 Manual mode

Manual mode allows the user to control the output as a percentage of the total heater power. It is like a dial on a stove. The output is independent of the temperature sensor reading. One application example is controlling the strength of boiling during beer brewing. You can use the manual mode to control the boiling so that it will not boil over to make a mess. The manual mode can be switched from PID mode but not from on/off mode. This controller offers a "bumpless" switch from the PID to manual mode. If the controller outputs 75% of power at PID mode, the controller will stay at 75% when it is switched to the manual mode, until it is adjusted manually. See Figure 3 for how to switch the display mode. To activate the manual control, pressing the ◄ key for 3 seconds or until the bottom display shows H at the most left digit. The H indicating the controller is in manual mode. The number at the right is the percentage of output. Press the ▼or ▲key to adjust the power. To switch back to PID mode, pressing the ◄ key for 3 seconds or until the H disappeared.

3.5 Cycle time "t"

It is the time period (in seconds) that the controller uses to calculate its output. e.g. When t = 2, if the controller decides output should be 10%, the heater will be on 0.2 second and off 1.8 seconds for every 2 seconds. Smaller t values result in more precision control. For SSR output, t is recommended for 2 (2 seconds).

Please note, cycle time t parameter is not used under ON/OFF mode (P = 0)

3.6 Input sensor type for "Sn"

Table 3: Code for Sn and its range

Sn Code	Input Device	Display Range ℃	Display Range ℉
Cu50	Cu50 (RTD)	-49 to 160	-56 to 302
Pt	Pt100(RTD)	-199 to 610	-198 to 1111
k	K (thermocouple)	-30 to 1300	-20 to 2370
E	E (thermocouple)	-29 to 719	-20 to 1292
J	J (thermocouple)	-29 to 905	-20 to 1651
t	T (thermocouple)	-198 to 400	-190 to 750
S	S (thermocouple)	-29 to 1619	-20 to 2912
0-5	0 – 5V (0 – 10 mA)	N/A	
1-5	1 –5 V (4 – 20 mA)		

3.7 Decimal point setting "dP"

In case of thermocouple or RTD input, dP is used to define temperature display resolution. When dP = 0, temperature display resolution is 1º (C or F). When dP = 1, temperature display resolution is 0.1º (C or F). The temperature will be displayed at the resolution of 0.1º for input below 1000º and 1º for input over 1000º (C or F).

3.8 Limiting the control range, "DIL" and "DIH"

1) For temperature sensor input, the "DIL" and "DIH" define the set value range. DIL is the low limit, and DIH is the high limit. Sometimes, you may want to limit the temperature setting range so that the operator cannot set a very high temperature by accident. For example, if you set the DIL = 100 and DIH = 130, operator will only be able to set the temperature between 100 and 130.

2) For linear input devices, "DIL" and "DIH" are used to define the display span. For example, if the input is 0 - 5V. DIL is the value to be displayed at 0V and DIH is the value at 5V.

3.9 Input offset "SC"

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

3.10 Output definition "OPA"

This parameter should be kept at zero for this model.

3.11 Heating, and Cooling Mode Selection "COOL"

When COOL = ON, the controller is set for cooling control. When COOL = OFF, the controller is set for heating control.

3.12 Temperature Unit Selection, Celsius or Fahrenheit, "C, F"

This parameter sets temperature units, C for Celsius, F for Fahrenheit. When it is for current or voltage input, this parameter is voided.

3.13 Output range high limit "OUTH"

OUTH allows you set the output range high limit. OUTH can be used when you have an overpowered heater to control a small subject. For example, if you set the OUTH = 50, the 5000W heater will be used as 2500W heater (50%) even when the PID wants to send 100% output.

3.14 Lock up the settings, parameter "LOCK"

To prevent the operator from changing the settings by accident, you can lock the parameter settings after initial setup. Table 4 shows the privileges associated with each lock code.

Table 4: LOCK parameter

LOCK value	SV Adjustment	Other Parameter
0	Yes	Yes
1	Yes	Locked
2 and up to 50	No	Locked

3.15 Set Time for Timer "TE1" and "TE2"

"TE1" is for setting value for the timer. Press ▼ for 3 seconds and change the value directly. "TE2" is for setting time of timer 2, it is only valid for dual timer working mode.

3.16 Time Unit and Timer Counting Mode "UPT"

UPT = 0, timer counting down in seconds.

UPT = 1, timer counting down in minutes.

UPT = 2, timer counting up in seconds.

UPT = 3, timer counting up in minutes.

3.17 Timer control mode "INT" *

INT = 0. The timer is disabled. The controller functions as a regular dual display controller. The lower display shows the set temperature instead of time.

INT = 1. The timer starts after the temperature reaches set point. When set time reaches, controller's output stops and timer relay pulls in (turns on). It can be connected to a buzzer to warn the operator.

INT = 2. The timer starts after the temperature reaches set point. When set time reached, relay pulls in. The controller's output will continue to be on.

INT = 3. The timer starts after the temperature reaches set point. When set time reaches, controller's output stops. Relay pulls in when timer starts and drops out when it reaches the set time.

INT = 4. Timer function is independent of temperature controller. After powered up (or reset), timer starts. The relay will pull in (close) when it reaches the set time.

INT = 5. Timer function is independent of temperature controller. After powered up (or reset), timer starts and the relay pulls in (close). It will drop out (open) when it reaches the set time.

INT = 6. Timer function is independent of temperature controller. After powered up (or reset), the relay drops out (open) for preset time TE1, then pulls in for preset time TE2. This process cycles (dual timer cycling mode).

INT = 7. Timer function is independent of temperature controller. After powered up (or reset), the relay drops out (open) for preset time TE1, then pulls in for preset time TE2. The relay will remain drop out (open) until reset. After reset, the relay will keep open for preset time TE1 then pulls in for preset time TE2 again (dual timer no cycling mode).

INT = 8. Timer function is independent of temperature controller. After powered up (or reset), the relay pulls in for preset time TE1 then drops out (open) for preset time TE2. This process cycles (dual timer cycling mode).

Control System (Trouble Shooting)

Timer won't start:

- Check the connection between terminals 11 and 12. These two terminals must be jumped together to enable the timer. A momentary NC switch on pin 11 and 12 can serve as a timer reset switch.

No heating

- The OUT LED is synchronized with output relay. If there is no heat when it is supposed to check the out first. If it is not lit, the controller parameter setting is wrong. If it is on check the external SSR (if the SSR's red LED is ON). If the SSR is ON, then the problem is either the SSR, it's 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.

Poor Accuray

- Please make sure calibration is done by immersing the probe in liquid. Comparing with reference in air temperature is not recommended because the respose time of the sensor depends on its mass. Some sensors have response time > 10 minutes in the air. When the air 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. Copper extension wire with the wrong polarity connected on the thermocouple will cause the reading to drift more than 5 °F .

Display "HH" or "LL"

- This is an input error message. The possible reasons are: the sensor is not connected or not connected correctly; the sensor input setting is wrong; or the sensor is defective. In this case, the instrument terminates its control function automatically. If this happens when using the thermocouple sensor, you can short terminal 4 and 5 with a copper wire or paper clip. If the display shows "HH", check the input setting, Sn, to make sure it is set to the right thermocouple type. If the Sn setting is correct, the controller is defective. For the RTD sensors, check the input thermocouples. Then check the wiring. The two red wires should be connected to terminal 4 and 5. The white wire should be connected to terminal 3.

Cannot change set temperature

- Please check parameter dIH and dIL. These two parameters limit the set temperature range. If you set dIH and dIL at the same values (like 100), the set temperature (SP) can only be set at 100, and user cannot adjust it.

Control system won't turn on

- Ensure that the power cord is not disconnected from the conductor compact connector.