



# SERIES 4000

DIGITAL TEMPERATURE  
CONTROLLER

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Instruction Manual

## Introduction

Congratulations on your purchase of an Athena® Series 4000. It is a U.L. listed, 1/4-DIN digital indicating temperature controller for use in a variety of applications. The Series 4000 is more accurate than an analog unit, and, most importantly, the digital indicator eliminates parallax errors and operator interpolation, problems common to full scale analog controllers.

If you have questions or require any assistance with your controller or with any temperature control problem, please contact your Athena representative or call technical support at 1-800-782-6776. Outside the U.S., please call 610-828-2490.

Other temperature control products and services available from Athena Controls:

- Analog and Microprocessor DIN panel and sub-panel controls
- SCR power controls and solid-state relays
- Thermocouples, RTDs, and transmitters
- Hot runner controllers and accessories
- Custom design and manufacturing

## Precautions

After unpacking, inspect the instrument for any physical damage that may have occurred in shipping. Save all packing materials and report any damage to the carrier immediately.

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## Output Configurations

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Type "B"	Relay with 7 A at 120 V and 5 A at 240 V contacts, on-off and time proportioning
Type "F"	Signal current, 4-20 mA <sub>dc</sub>
Type "T"	Solid state relay 1 A, 120/240 V resistive load; 1 A, 120/240 V, 10 A inrush, inductive load
Type "S"	Pulsed 20 V <sub>dc</sub> , for driving solid state relays

## Preliminary Instructions

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### Unpacking

Carefully unpack the instrument, inspect for shipping damage. Report any damage to the carrier immediately.

### Locating

Select a location for the controller where it will not be subjected to excessive shock, vibration, dirt, moisture or oil. The ambient temperature of the area should be between 30° and 130° F. (Dust, oil, water resistant cover is available to protect from harsh environments. Contact factory for details.)

# Mounting

## Mounting

Mount controller into 92 mm (3-5/8") square cutout (1/4-DIN). See Figure 1 for cutout and case dimensions. The plug-in controller does not have to be removed from its housing for mounting.

Remove the two screws in the back of the case that hold the mounting slides, and then remove the slides. Insert case from front of panel and reinstall the two slides and two screws. The length of the slides must be reduced if the controller is to be mounted in an extra thick panel. If the controller has been unplugged from its housing, the top of the housing can be determined by the serial number tag.

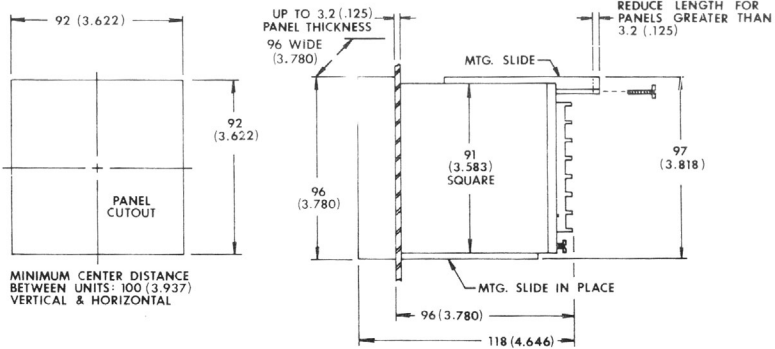


Figure 1: Cutout and case dimensions

# Power Wiring Circuits



Consult serial tag on the unit and select power wiring diagram for the model specified. All wires are connected to the terminals on the back of the case. Screw terminals are provided. Make appropriate connections using proper size wire for rated controller load power circuits. (On -B output model use AWG #14 wire; for -F, -S and -T outputs use #14, 16, or 18 wire.) The unit can be supplied with 120 V or 240 Vac, 50/60 Hz. Select proper terminal for the voltage used.

## Typical Wiring Diagrams

### -T & -B Outputs - 120 Vac

B-Type - 840 W maximum. 120 Vac heater. (Non-inductive loads only) For larger loads replace heater connections with contactor, as required. Maximum inductive load rating is 3 A at 120 V and 1.5 A at 240 V. The N.C. contacts can be used for cooling.

Note: For 240 Vac supply move connection shown on terminal 9 to terminal 10 and fuse both of the supply legs.

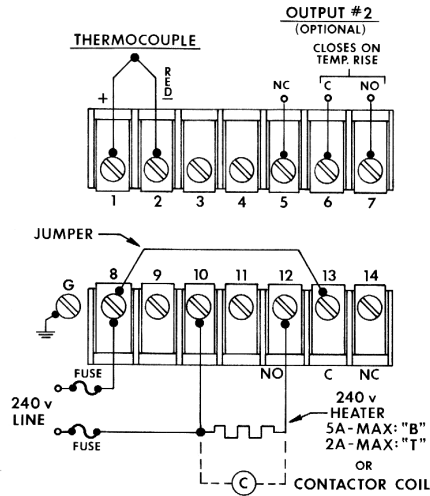


Figure 2: Typical 120 Vac for -B & -T Output

# Power Wiring Circuits

**CAUTION**

Possible fire hazard. Because these controls or associated equipment may not always fail safe, an approved temperature and/or pressure safety control should be used for safe operation.

T-Type - solid state relay with SPST contacts. The -T units can handle contactors or resistive loads up to 1 A with 10 A inrush maximum. For -T units use a 1 A, 250 V fast blow fuse.

**-F, -S Output - 120/240 Vac**

The -F output is 20 mA at the low temperature end of the proportional band and 4 mA at the upper end of the proportional band. Maximum load resistance is 1000 ohms. The -S output is a time-proportioned 20 Vdc signal. These controllers cannot be used with a device that does not have an isolated input. An ungrounded thermocouple must be used if there is ac leakage or a ground in the input of the device connected to the controller's output.

NOTE: For 240 Vac supply move connection shown on terminal 9 to terminal 10 and fuse both of the supply legs.

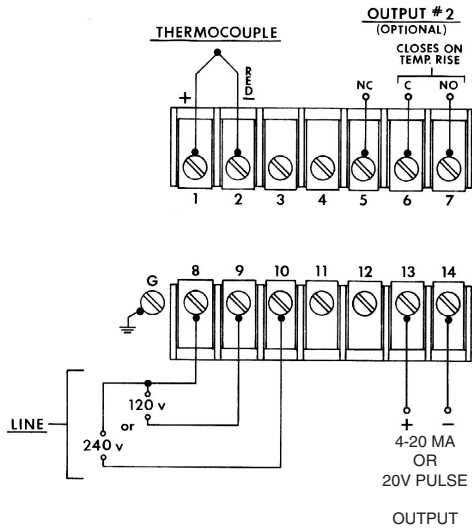


Figure 3: Typical 120/240 Vac for -F and -S Output

## Thermocouple Wiring Circuits

Use thermocouple and extension wire that conforms to the appropriate thermocouple type specified on the serial number tag. In thermocouple circuits, the negative lead is colored red. Extension wires must be of sufficient size so that on long runs the thermocouple circuit resistance does not exceed 100 ohms.

Do not run thermocouple leads in the same conduit as the power lines. If shielded thermocouple wire is used, terminate the shield only at the controller end using the corner screw provided for that purpose.

### Standard Thermocouples

I.S.A. Type	Materials	Color Code (U.S.A.)
J	Iron-Constantan (I/C)	White (+)/Red(-)
K	Chromel-Alumel (C/A)	Yellow (+)/Red (-)
T	Copper-Constantan	Blue (+)/Red (-)

## RTD Wiring Circuits

NOTE: RTDs tend to be shock sensitive and require extra care in handling and installation

The 4200 is designed for 100 ohm platinum RTDs. Two-wire RTDs are connected to terminals -1 and -2 with a jumper connecting 2 to 3. Keep leads short and use heavy gauge copper extension wires if necessary, to minimize lead resistance. For long runs 3-wire RTD should be used and wire gauge should be sufficient that resistance does not exceed 10 ohms.

### **DO NOT RUN RTD LEADS IN THE SAME CONDUIT AS POWER LINES.**

If shielded RTD wire is used, terminate the shield only at the controller end, using the corner screw provided for that purpose.

## Thermocouple Placement

Proper thermocouple placement can eliminate many problems in the system. The probe should be placed so that it can detect any temperature change with little thermal lag. In a process that requires fairly constant heat output, the probe should be placed close to the

heater. In processes where the heat demand is variable, the probe should be close to the work area. Some experimenting with probe location can often provide optimum results.

In a bath process, the addition of a stirrer will help to eliminate lags. Since the

thermocouple is basically a point measuring device, putting more than one thermocouple in parallel will provide an average temperature reading and produce better results in air-heated processes.



# Operation

The typical control system contains the sensor, controller (4000) and the process (load). The sensor produces a small signal proportional to the measured temperature of the process. This signal is amplified by the controller, where it is compared with setpoint temperature. If the temperature of the sensor is below setpoint, the output circuitry will be actuated to apply power to the process. This is indicated by means of an LED light. The digital meter displays the sensor's (process) temperature, and when switched to right or left, the primary or secondary control setpoints.

## **-B - Relay Output**

The "B" output is a relay rated at 7 A, 120 Vac and 5 A, 240 Vac. These contacts can be wired to provide power to a heater within the above rating. A contactor can be operated to handle a larger load. Solenoids can be operated to control oil or gas heaters.

The controller operates as a narrow band controller when the band adjustment is set at the narrow position. As the band is widened, the unit becomes a time-proportioning controller, which provides close temperature control. The percentage of the time when the relay is energized is varied by the controller to meet the load requirements. Maximim cycle time setting is 15 seconds.

## **-F - Current Output**

Current proportional output of the -F unit is a 4 to 20 mAdc signal into 1000 ohm maximum. This output can be used to drive power controllers, motor positioners or electropneumatic actuators.

## **-S - Pulsed Voltage Output**

This output is similar to the -F output with the exception of a pulsed time base rather than a fully proportional current output signal. This output is designed to drive solid state contactors.

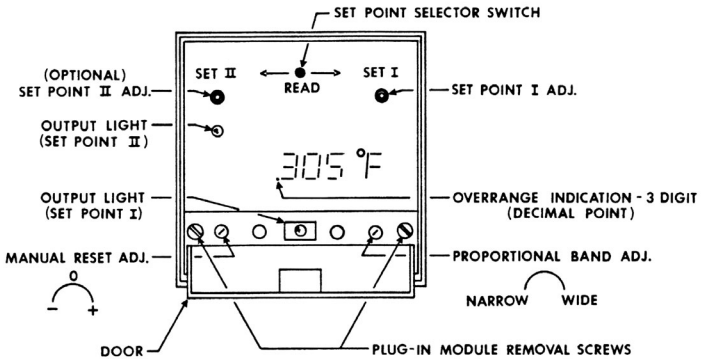
## **-T - Solid State Output**

The -T output unit has a solid state relay with SPST contacts rated at 1 A, 120/240 Vac (10 A inrush maximum). These contacts can be wired to provide power to a heater within the above ratings, and a contactor can be added to handle larger loads. Solenoids can be operated to control oil or gas heaters.

# Front Panel Layout

Layout of the front panel is shown below. To reach the adjustments, swing the top of the door forward and down. The proportional band adjustment is on the right side and sets the gain of the controller. The offset (manual reset) adjustment is on the left and corrects for offsets from the setpoint temperature. The output indication (LED) can be seen through a window in the door.

Units ordered with Option A (3-Mode PID) will not have a manual reset adjustment. Instead, these units have an automatic rate and reset selector switch on the internal 3-mode board.



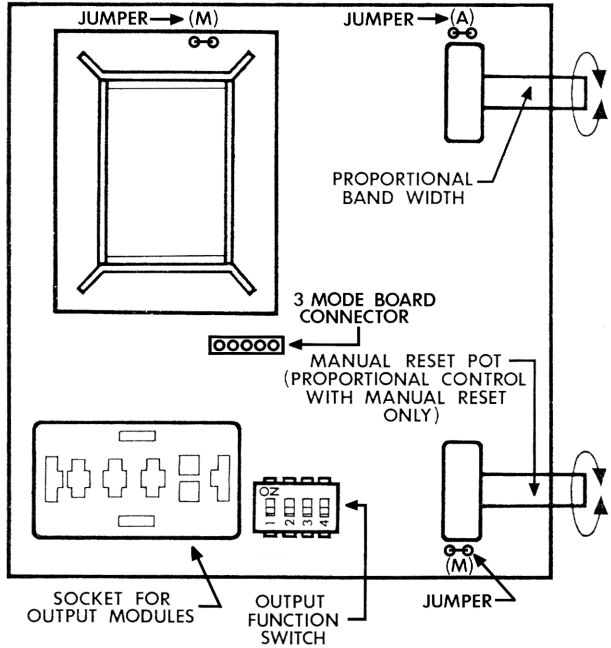
# Output Function Switches

## Output Function Switch Chart

(BOTTOM BOARD ILLUSTRATION)

CYCLE TIME (SECONDS)	SETTING
15	
10	
5	
1.5	
1	
.5	
mAdc "F"	

OUTPUT MODE	
PRO-PORTIONAL	
ON/OFF	



### NOTE:

—SWITCH NO. 4 IN "ON" POSITION IS FOR: "B" OR "T" OUTPUTS WHEN DRIVING MECHANICAL DEVICES, E.G., CONTACTORS.

—SWITCH NO. 4 IN "OFF" POSITION IS FOR "T", "F", OR "S" OUTPUTS WHEN DRIVING DEVICES THAT CAN WITHSTAND RAPID CYCLING, E.G., SOLID STATE DEVICES, SOLENOIDS, ETC.

Figure 5: Output Function Switch Chart

## Output Function Switches

NOTE: Reconfigured or field-modified units should always be checked to assure that output switch positions are correct.

### How to Configure Output Function Switches

There is a switch assembly on the bottom board (see bottom board illustration). This four-position switch regulates cycle time and output selection. It is factory-configured for the plug-in output ordered. Check the output function chart to make sure the configuration is correct for your application. Figure 5.

Switches 1&2: These switches act together to select either proportional current output or one of the time proportioning cycle times. (See the output function switch chart.) Use longest times to get best relay life expectancy. If meter shows temperature swings following each “on” cycle, select a faster time to reduce “ripple.”

Switch 3: Selects either on/off or proportional action. “On” provides proportional action. “Off” provides on/off action.

Switch 4: Selects output for either mechanical or solid state relays.

On: Provides slow proportional times for mechanical relays

Off: Provides 20 mAdc when used with the “F” module or fast time proportioning times when used with “S” or “T” modules.

NOTE: Switch 4 changes the cycle times in conjunction with switches 1 and 2. Check output function switch chart.

### **Proportional Band Adjustments for All Outputs**

The proportional band adjustment widens or narrows the band over which proportional action occurs. Too narrow a band can cause the temperature to swing about the setpoint. This can be seen on the display. Too wide a band can cause an error between the setpoint and the actual temperature (droop error) as measured at the sensor.

Proper setting of this adjustment is the point where the temperature swings just stop. When adjusting the proportional band control, do so in small increments, allowing time between each adjustment for the process to stabilize.

Turning the adjustment in a clockwise direction widens the proportional band and should reduce swings to straight line control with most processes.

### **Offset (Manual Reset)**

After the proportional band is set, the process display temperature may stabilize at a point other than the setpoint, high or low, as shown on the display. This can be corrected with the offset (manual reset) adjustment. If the display indicates a low temperature, turn the offset (manual reset) adjustment clockwise (+ direction) until the display is correct. Turn the offset (manual reset) adjustment counterclockwise (- direction) for high temperature as indicated by the display.

For applications requiring multiple setpoints over wide temperature spans, some automatic droop compensation can be achieved by cutting jumper "A" (See bottom board diagram for location, Figure 5).

NOTE: If close control cannot be obtained after carefully repeating the above procedures, check to see if the thermocouple probe is in good contact with the heated process, and if the heaters are correctly sized for the application. Applications involving large changes in setpoint operating temperature, or large load changes, will require readjustment of the proportional band and offset (manual reset) pots.

### **Dead Band**

An adjustable 0 to 5 degree deadband can be accessed by setting switch #3 to off and cutting the jumper next to the manual reset pot. (See Figure 5.) The band can be adjusted using the proportional band adjustment.

## How to Set the Auxiliary Output (Optional)

Deviation Type: B, C or D

The Deviation auxiliary output is triggered when the temperature deviates from the main setpoint by a preset amount. Units can be ordered with high, low or common high/low trip points.

Full Scale Type: E

The full scale auxiliary output is triggered when temperature goes above its setting. The setting can be placed anywhere within the span of the unit.

Setting

To set either type or auxiliary output press and hold the “read” switch to the left. The display will indicate the present setting. Adjust set II to the desired trip point in either actual or deviation degrees, whichever applies. The output on terminals 5, 6, and 7 will be energized when the auxiliary setting is exceeded.

## Optional 3-Mode (PID)

Installation

The Series 4000 is available with optional plug-in PID. To install this option in the field, simply plug the 3-mode card into the connector located next to the output module socket and then cut jumpers (2) labeled M (see bottom board drawing for location, Figure 5).

## Adjustments

NOTE: Each process will tolerate differing warm-up curves. Often, a fast warm-up is more important than the elimination of overshoot. If it is important to eliminate overshoot, a slower setting should be used, but it will also add to the time it takes the process to reach the setpoint.

In general, it is best to maintain the tightest parameters possible (narrow proportional band, faster 3-mode) that still deliver optimal process response. If temperature settles above or below setpoint, use manual reset for trim adjustment.

### How to Set 3-Mode (PID) Action

3-Mode (PID) action automatically corrects for errors in proportionally controlled processes.

1. For slow processes, move the switch located on the 3-mode board to slow (S), proportional band wide, and go to step 4; otherwise:
2. Set the switch to the fast position (F) for very fast and/or low mass processes. Use the middle position for most others as a first try.
3. Set the proportional band located on the front panel to full wide (270 degrees clockwise).
4. Plug controller in. Turn your process on.
5. Observe warm-up. If it takes the process too long to reach the setpoint, make the switch setting faster. If, on the other hand, it overshoots the setpoint by an amount that is not acceptable, a slower switch setting should be tried.
6. Turn proportional band pot 1/4 turn toward narrow (counter-clockwise). Process could begin to oscillate again. If it doesn't, proceed to step 7. If it oscillates, back up 1/8 turn clockwise.
7. Tighten proportional band by turning the pot counter-clockwise. Observe the process. If oscillation continues, widen back by 1/8 turn. Continue until the process stabilizes.

In general, it is best to maintain the tightest parameters possible (narrow proportional band, faster 3 mode) that still deliver optimal process response. If temperature settles above or below setpoint, use manual reset for trim adjustment.

## Maintenance

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Some simple preventive maintenance steps on the controllers are:

1. Keep the controller fairly clean, and protect it from dirt, oil, and corrosion. An optional dust cover is available for use in hostile environments.
2. Periodically recheck all electrical connections.

**CAUTION:** Since the front panel and the meter face are plastic, do not use solvents to clean them.



## Specifications

<b>Line Voltage:</b>	120/240 Vac, +10% -15%, 50/60 Hz
<b>Power Consumption:</b>	Less than 5 VA
<b>*Common Mode Rejection:</b>	Maximum error +/- 1 deg C with 240 Vac, 60 Hz applied as a common mode signal between sensor input and chassis ground
<b>*Series Mode Rejection:</b>	Maximum error +/- 1 deg C with series mode signal of 100 mV pk-to-pk at 60 Hz
<b>Sensor Break Protection:</b>	Up scale standard. Zero out- put for open sensor
<b>Thermocouple:</b>	Maximum lead resistance 1000 ohms for rated accura- cy; cold junction compensa- tion standard
<b>RTD:</b>	1000 ohms (0 deg C) Platinum. DIN coefficient standard

**\*NOTE: Applies to all units with exception of "F" output controllers when used with other than Athena SCRs or stagers.**

## Specifications

**Setpoints:** Momentary switch displays Set I or Set II (optional). 25-turn pot provides 1° or 0.1° settability, range dependent:

Set I - Adjustable over full span;

Set II - *Process alarm* (-E) adjustable over full span and *deviation alarm* (-B, -C, -D) adjustable +/- 0.5% to +/-5% of span.

**Setpoint Repeatability:** +/-0.1% to +/-0.2% of span

**Setpoint Resolution:** 1° or 0.1°

**Calibration Accuracy:**

- a. T/C input +/-0.4% of span over 10% to 90% of range
- b. RTD inputs +/-0.1% of span for 1° F or 1° C ranges; +/-0.2% of span for 0.1° F or 0.1° C ranges

**Ambient Stability:**

- a. T/C input 3  $\mu\text{V}/^\circ\text{F}$  ambient to input
- b. RTD input 0.1% for 80° to 130° F

**Process Indication:** Filtered LED, 3 or 3-1/2 digits. 2 readings per second update; readability is 1° F, 1° C, 0.1° F or 0.1° C, range dependent

Dimensions: See Figure 1

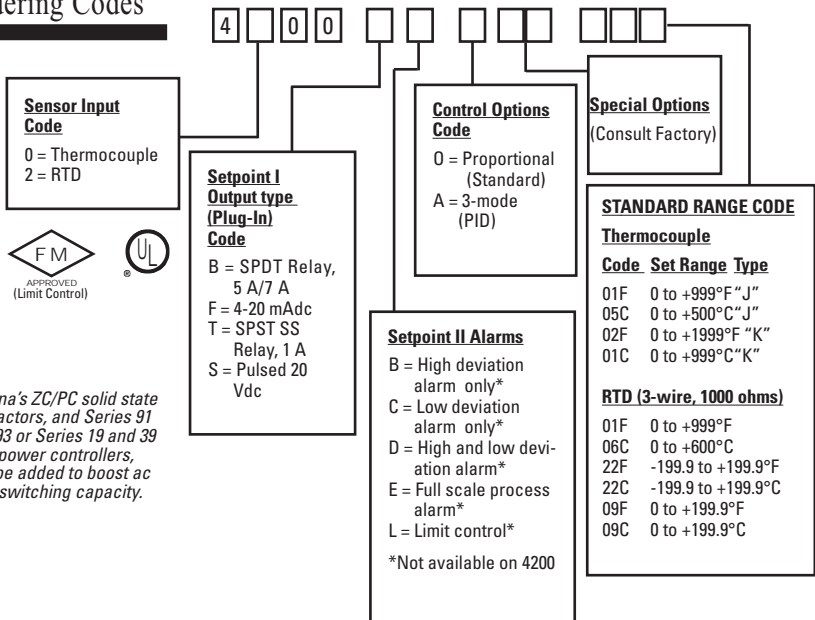
Weight: Less than 2 lb (0.9 kg)

All specifications subject to change.

# Specifications

Output Type	Setpoint I (Plug-In)				Setpoint II	
	B	T	S	F	B,C,D	E
Output	SPDT relay resistive load rating: 7 A @ 120 V; 5 A @ 240 V; 50 VA inductive	SPST SS relay, zero voltage switched 1 A @ 120/240 Vac; 10 A inrush; 2-4 mA leakage	Pulsed dc for driving Solid State contactors 0-20 V; open ckt; 0-20 mA short ckt; not isolated from TC	4-20 mAdc into 1000 ohm max; not isolated from TC	SPDT relay 3A @ 120 Vac resistive (4000 only)	SPDT relay 3A @ 120 Vac resistive
Proportional Band	Adjustable for .2 to 5% of span				on/off (see differential below)	on/off (see differential below)
Output Cycle Time (Switch Selectable)	on-off 5-10-15 seconds	0.5-1.0-1.5 5-10-15 seconds	0.5-1.0-1.5 seconds	Continuous proportioning	Not applicable	
Manual Reset (Offset)	Standard — adjustable for full proportional bandwidth (eliminated if PID is ordered)				Not applicable	
Optional 3-Mode (PID) Action	Fast = 3 sec rate, 0.8 min. reset; Medium = 21 sec rate, 1.5 min. reset; Slow = 68 sec rate, 5 min. reset				Not applicable	
Differential	0-5° adjustable				+/-1° F or +/-1° C	1% maximum of unit span
Indication	Red LED "ON" when output signal is present or relay is energized				Red LED "ON" when relay is energized	
Operating Ambient	30° to 131° F (0-55° C)					

# Ordering Codes



# Troubleshooting

Symptom	Probable Cause
1. Controller dead. No output light, no digital display	<ul style="list-style-type: none"> <li>- No line voltage input</li> <li>- Open PC board to backplate connector (defective connector)</li> <li>- Open power transformer</li> </ul>
2. No output, step 1 ok, display reads ambient	<ul style="list-style-type: none"> <li>- External backplate jumper missing (all models except "S" and "F")</li> <li>- Defective relay</li> <li>- Open heater or heater circuit wiring</li> </ul>
3. No output	<ul style="list-style-type: none"> <li>- Open thermocouple or T/C wiring</li> </ul>
4. a. Full output, no control. Power light stays on. 4. b. Full output, no control. Power light goes off.	<ul style="list-style-type: none"> <li>- Thermocouple connections reversed</li> <li>- T/C lead wires shorted between T/C and control</li> <li>- Relay contacts welded closed</li> </ul>

Check	Corrective Action
<p>Verify 120/240 Vac, 50/60 Hz input voltage. Check heater for shorts. Look for open breakers or open external fuse.</p> <p>Check continuity through power transformer primary. Remove input power. With ohmmeter, read between pins: 8 and 9 for 225 or 450 ohms +/-10% and 8 and 10 for 680 or 1000 ohms +/-10%</p> <p>If no readings in either step above, remove controller from housing and repeat resistance measurements as above, but directly on PC board lands corresponding to pins 8, 9, and 10. Correct readings indicate open PC board to backplate connector problem. Incorrect readings indicate power transformer problems.</p> <p>Refer to wiring diagram.</p> <p>Visually inspect relay contacts.</p> <p>Heater continuity and wiring.</p> <p>T/C continuity. Disconnect T/C connections from instrument. Measure T/C circuit resistance. Ohmmeter should read 100 ohms or less.</p> <p>Connection polarity. T/C wires are color-coded. Red is the negative (-) lead. (for U.S.A.) T/C lead wiring.</p> <p>Disconnect power and load. Measure resistance between pins 12 and 13. Should read infinity.</p>	<ul style="list-style-type: none"> <li>- Replace heater, if shorted</li> <li>- Restore power</li> <li>- Replace either power transformer or backplate connector</li> <li>- Install jumper</li> <li>- Replace relay if contacts are worn or dirty</li> <li>- Replace open heater, correct defective wiring</li> <li>- Replace T/C. Correct defective wiring</li> <li>- Connect correctly</li> <li>- Repair or replace</li> <li>- If resistance reading is near 0 ohms, replace relay</li> </ul>

# Troubleshooting

Symptom	Probable Cause
5. Process control temperature differs from setpoint when read with an external pyrometer. Controller's display agrees with setpoint.	<ul style="list-style-type: none"> <li>- T/C lead wires shorted close to process</li> <li>- Wrong type of T/C being used, etc.</li> <li>- Standard electrical wiring being used in place of T/C wire</li> <li>- Gradient error</li> </ul>
6. Temperature overshoots, or oscillates.	<ul style="list-style-type: none"> <li>- Process overpowered</li> <li>- Bandwidth too narrow</li> <li>- Process or sensor lag</li> </ul>
7. Process control temperature stabilizes above or below setpoint as read on display.	<ul style="list-style-type: none"> <li>- Offset (manual reset) incorrectly adjusted</li> <li>- Partial short to ground in heater when used on 240 V line</li> <li>- No output from suspect control</li> <li>- Controller reading other zones of multi-controlled process</li> <li>- Full output from suspect control</li> <li>- Apparent stabilization from other zones of multi-controlled process</li> <li>- Improperly sized heater</li> </ul>

Check	Corrective Action
Check T/C lead wires at back of probe	<ul style="list-style-type: none"> <li>- Replace defective wiring</li> </ul>
Wire color indicates type of T/C	<ul style="list-style-type: none"> <li>- Install correct T/C for temperature range of instrument. See instrument serial number tag for T/C type.</li> </ul>
Verify type of wire	<ul style="list-style-type: none"> <li>- Run only T/C wire between process and controller.</li> </ul>
Check out above three items first	<ul style="list-style-type: none"> <li>- Use electronic indicator in parallel with suspect instrument's T/C input.</li> </ul>
Compare "on time" to "off time." Short on to off time indicates too much heater capacity for the process	<ul style="list-style-type: none"> <li>- Reduce total heater power</li> </ul>
Check bandwidth	<ul style="list-style-type: none"> <li>- Widen band</li> </ul>
Loose heater or sensor fit. Poor relative location.	<ul style="list-style-type: none"> <li>- Improve fit, locate closer together</li> </ul>
Offset (manual reset)	<ul style="list-style-type: none"> <li>- Adjust (+) to increase controlled temp. (-) to decrease temp.</li> </ul>
Heater to ground resistance	<ul style="list-style-type: none"> <li>- Replace defective heater</li> </ul>
See symptom 2 (no output)	<p>NOTE: Fuse blowing is not caused by the controller. Blown fuses are caused by shorts in the heater circuit, and must be corrected to prevent damage to the controller.</p>
See symptom 4 (full output)	
Design parameters for process heat required	

## Warranty

### Two-Year Limited Warranty

THIS EQUIPMENT IS WARRANTED TO BE FREE FROM DEFECTS OF MATERIAL AND WORKMANSHIP. IT IS SOLD SUBJECT TO OUR MUTUAL AGREEMENT THAT THE LIABILITY OF ATHENA CONTROLS, INCORPORATED IS TO REPLACE OR REPAIR THIS EQUIPMENT AT ITS FACTORY, PROVIDED THAT IT IS RETURNED WITH TRANSPORTATION PREPAID WITHIN TWO (2) YEARS OF ITS PURCHASE.

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### ***Unit Repairs***

It is recommended that units requiring service be returned to an authorized service center. Before a controller is returned for service, please consult the service center nearest you. In many cases, the problem can be cleared up over the telephone. When the unit needs to be returned, the service center will ask for a detailed explanation of problems encountered and a Purchase Order to cover any charge. This information should also be put in the box with the unit. This should expedite return of the unit to you.

This document is based on information available at the time of its publication. While efforts have been made to render accuracy to its content, the information contained herein does not purport to cover all details or variations in hardware, nor to provide for every possible contingency in connection with the installation and maintenance. Features may be described herein which are not present in all hardware. Athena Controls assumes no obligation of notice to holders of this document with respect to changes subsequently made.

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