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SERIES 4000

TEMPERATURE/PROCESS CONTROLLER

OPERATION MANUAL

ATHENA®

a higher level of control



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.

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.

Locating

Select a location for the controller where it will not be subject- ed 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.)

Approvals

E66598 Temperature Indicating and Regulating Equipment.

E66598 Temperature Indicating and Regulating Equipment.

Safety Warning



In addition to presenting a potential fire hazard, high voltage and high temperature can damage equipment and cause severe injury or death. When installing or using this instrument, follow all instructions carefully and use approved safety controls. Electrical connections and wiring should be performed only by suitably trained personnel.

Do not locate this instrument where it is subject to excessive shock, vibration, dirt, moisture, oil, or other liquids. The safe operating temperature range for this unit is 32°F to 140°F (0°C to 60°C).



This unit has been tested and found to be compliant with “NEMA Type 4X Enclosure - For Indoor Use Only.” When properly installed, this controller will maintain the integrity of a NEMA enclosure and remain “Watertight.” This rating is only applicable when the controller is properly installed into a suitably rated NEMA Type 4X housing.

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TITLE	Model 4000 Operation Manual	
DWG	900M508U01	
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Mounting

Measurements between centerlines of panel cutouts are the minimum recommended.

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.

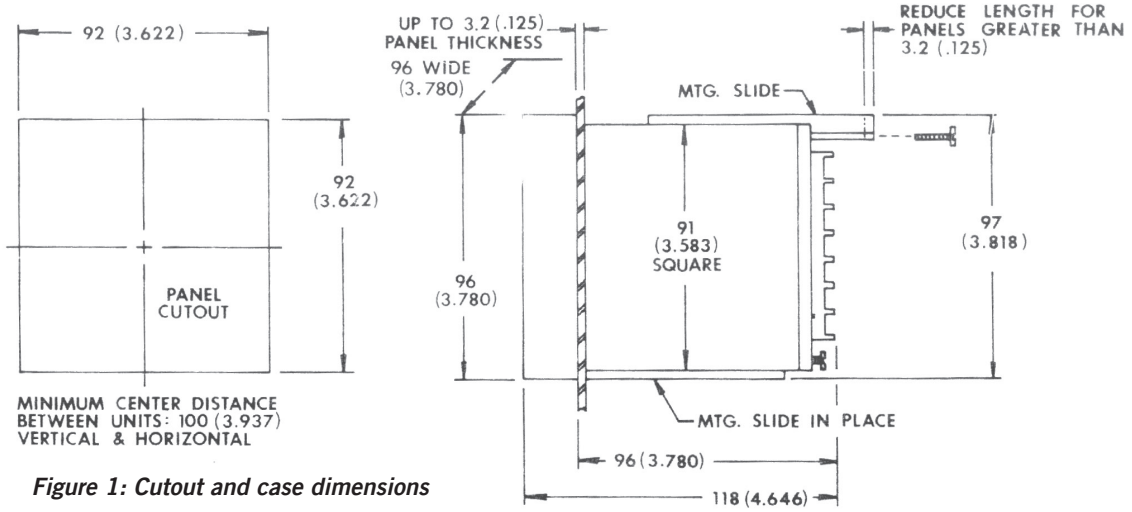


Figure 1: Cutout and case dimensions

Output Configurations

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 mAdc
Type “T”	Solid state relay 1 A, 120/240 V resistive load; 1 A, 120/240 V, 10 A inrush, inductive load (not U.L. rated)
Type “S”	Pulsed 20 Vdc, for driving solid state relays

Power Wiring Circuits

When properly installed through a NEMA enclosure, the integrity of the enclosure will be maintained and will remain “Watertight.”



IMPORTANT: All electrical wiring connections should be made only by trained personnel, and in strict accordance with the National Electrical Code and local regulations.

The Series 4000 controller has built-in circuitry to reduce the effects of electrical noise (RFI) from various sources. However, power and signal wires should always be kept separate. We recommend separating connecting wires into bundles: power; signal; alarms; and outputs. These bundles should then be routed through individual conduits. Shielded sensor cables should always be terminated at one end only.



If additional RFI attenuation is required, noise suppression devices such as an R.C. snubber at the external noise source may be used. If you wish, you may order this suppressor directly from Athena, part number 235Z005U01.

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 for -T & -B Outputs

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.

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 the connection shown on terminal 9 to terminal 10 and fuse both of the supply legs.

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.

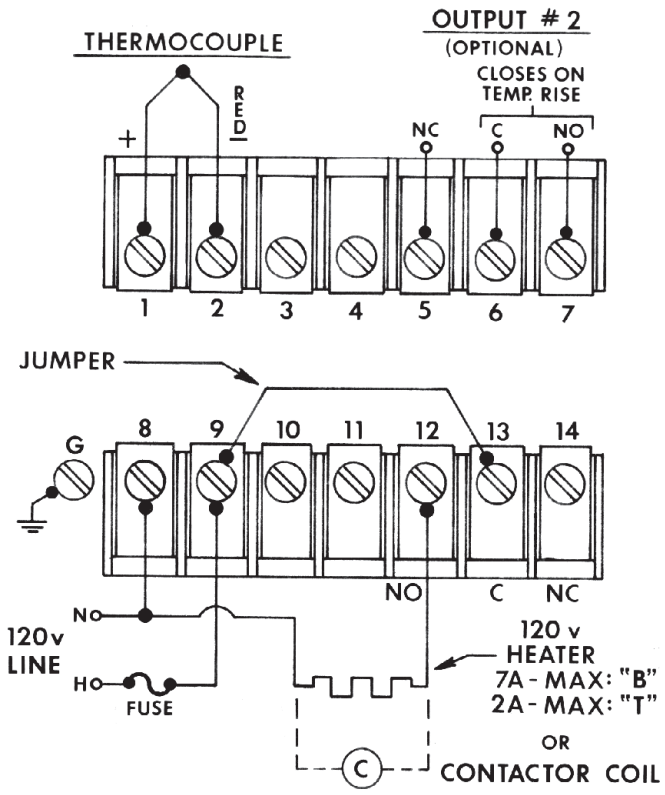


Figure 2. Typical 120 Vac for -B & -T Output

-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.

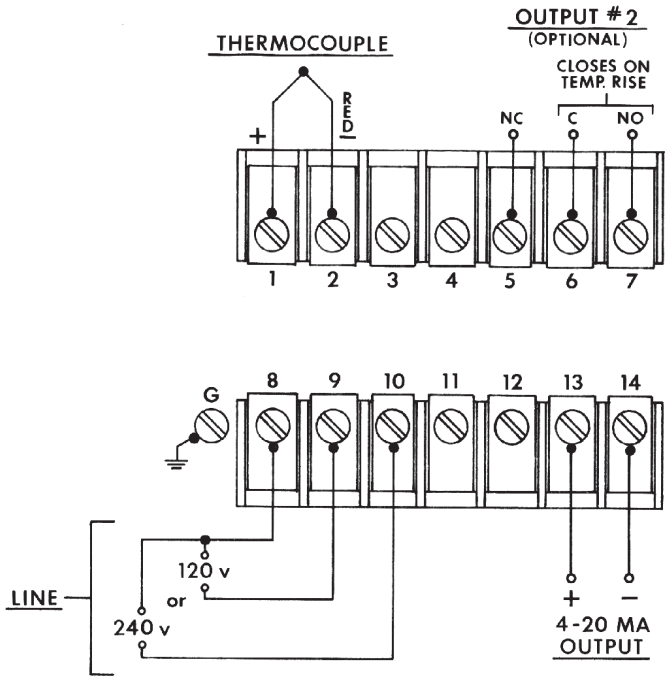


Figure 3: Typical 120/240 Vac for -F & -S Output

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 units are 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 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 in the lower center of the front panel. The deviation meter will swing to the extreme left. It will remain there until the temperature of the probe rises to within 50 °F of setpoint, and then will continue to rise to the null point (zero degree deviation). The deviation meter accurately displays the difference between the probe's (process) temperature and the desired setpoint temperature.

-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.

NOTE: To reach the plug-in module, push reset button while opening the door, and then remove two (2) screws.

Maximum 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 adjustment and reset selector switch on the internal 3-mode board.

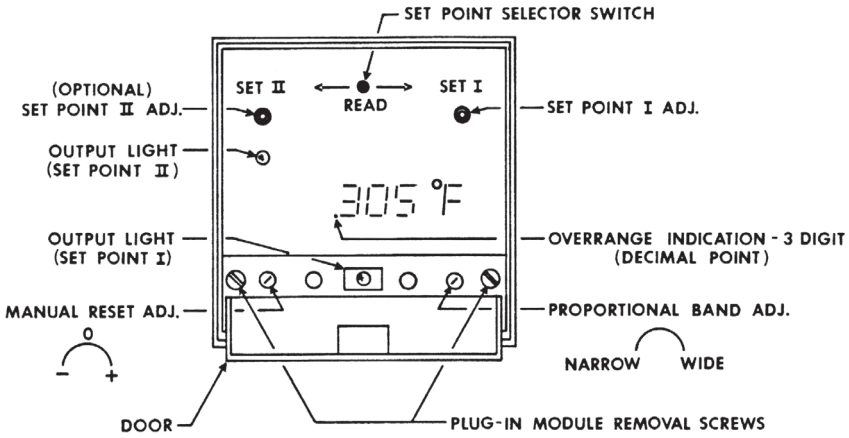
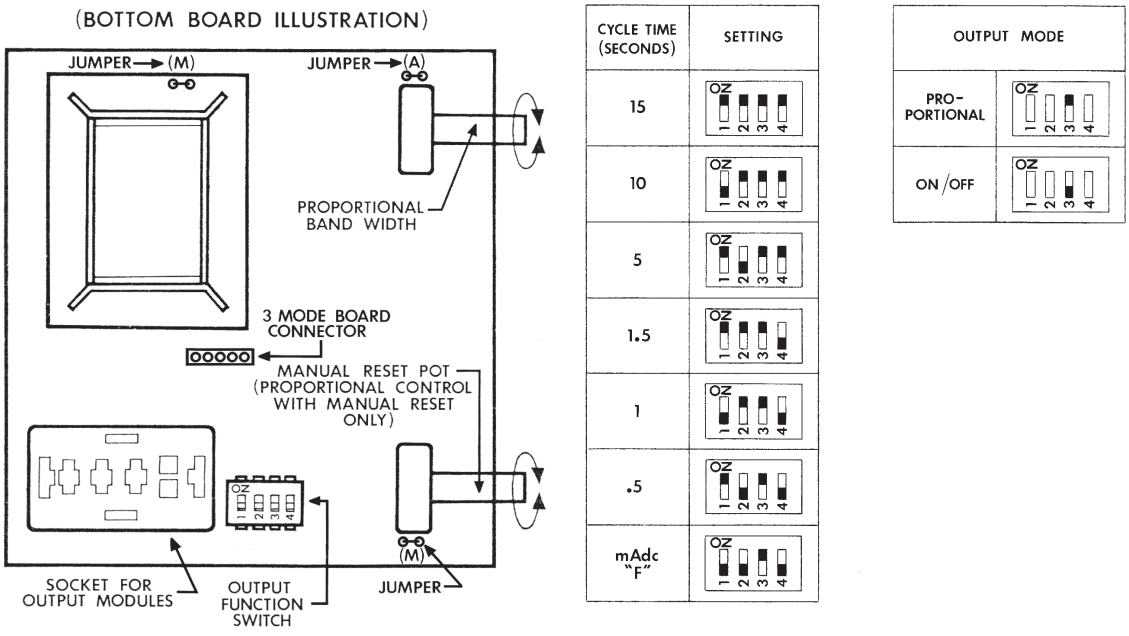


Figure 4. Wiring for Relay Normally Open Alarm Output

Output Function Switches

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



—***Switch No. 4*** in "**ON**" position is for "B" or "T" outputs when driving mechanical devices such as contactors.

—***Switch No. 4*** in "**OFF**" position is for "T", "F", or "S" outputs when driving devices that can withstand rapid cycling, such as solid state devices , solenoids, etc.

Figure 5. Output Function Switch Chart

Configuring 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.

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

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

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 deviation meter. 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) Adjustment

After the proportional band is set, the process 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 deviation meter indicates a low temperature, turn the offset (manual reset) adjustment clockwise (+ direction) until the display is correct.

Turn the offset (manual reset) adjustment counter-clockwise (- 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*

Deadband Adjustments

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 Auxilliary 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 degress, whichever applies. The output on terminals 5, 6, and 7 will be energized when the auxiliary setting is exceeded.

Optional 3 Mode (PID)

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 reset, faster rate) that still deliver optimal process response. If temperature settles above or below setpoint, use manual reset for trim adjustment.

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).

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.

Maintenance

Some 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



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

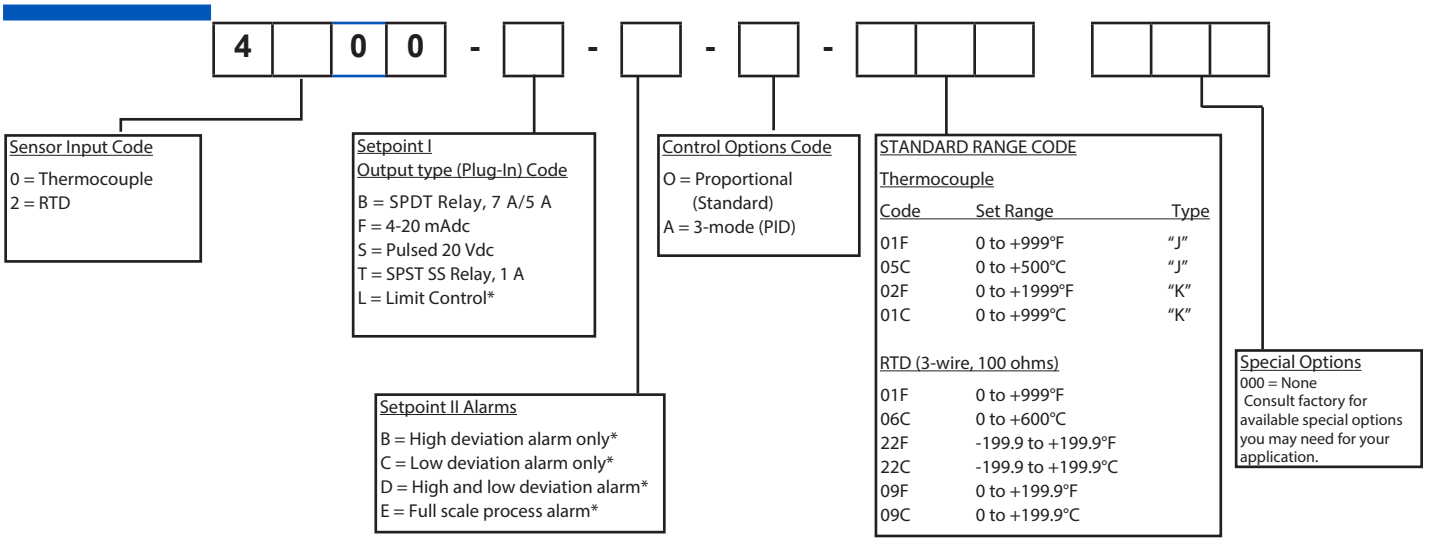
SPECIFICATIONS

Line Voltage	120/240 V ±10%, 50/60 Hz ±15%
Power Consumption	Less than 5 VA
Common Mode Rejection*	Maximum error ±1°C with 240 V, 60 Hz applied as a common mode signal between sensor input and chassis ground
Series Mode Rejection*	Maximum error ±1°C with series mode signal of 100 mV pk-to-pk at 60 Hz
Sensor Break Protection	Up scale standard, zero output for open sensor
Thermocouple	Maximum lead resistance 100Ω for rated accuracy, cold junction compensation standard
RTD	100 ohms (0°C) Platinum, DIN coefficient standard
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. Deviation alarm (-B,-C,-D), consult factory
Setpoint Repeatability	±0.1% to ±0.2% of span
Setpoint Resolution	1 or 0.1 (Range dependent)
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 V/°F ambient to input b. RTD input 0.1% for 80°F to 130°F (27° to 55°C)
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	Front Panel - 3.780 sq. in. (96 mm²) Case - 4.646″ (118 mm) Depth Behind Panel - 3.780″ (92 mm) Panel Cut-out - 3.622 sq. in. (92 mm²)

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

Output Type	Setpoint 1 (Plug-in)					Setpoint 2	
	B	F	S	T	L	B,C,D	E
	SPDT relay resistive load rating 7 A/120 V 5 A/240 V 50 VA inductive	4-20 mAdc into 1000 ohms maxmum; not isolated from thermocouple	Pulsed dc for driving SS contactors 0-20 V, open ckt 0-20 mA, short ckt not isolated from thermocouple	SPST SS relay, zero voltage switched 1 A 120/240 Vac, 10 A inrush, 2-4 mA leakage	Limit Controller	SPDT relay 3 A @ 120 Vac resistive (4000 only)	SPDT relay 3 A @ 120 Vac resistive
Proportional Band		Adjustable for .2-5% of span			Not applicable	On/Off (see differential)	On/Off (see differential)
Output cycle time (Switch selectable)	On-off 5-10-15 sec	Continuous Proportioning	0.5-1.0-1.5 sec	0.5-1.0-1.5 5-10-15 sec	Not applicable	Not applicable	Not applicable
Manual reset (Offset)	Standard-adjustable for full proportional bandwidth (eliminated if PID is ordered)				Not applicable	Not applicable	Not applicable
Optional 3-mode (PID) action	Past = 0.1 sec rate, 48 sec reset; medum = 18 sec rate, 90 sec reset; Slow = 65 sec rate, 300 sec reset				Not applicable	Not applicable	Not applicable
Differential	0-5° adjustable				Not applicable	±°F or ±°C	1% maximum of unit span
Indication	Red LED "ON" when output signal is present or relay is energized						
Operating Ambient	30°F to 131°F (0°C to 55°C)						

Ordering Codes



Example
Model 4000-B-E-05C = a controller with a thermocouple sensor input; and SPDT relay output (non plug-in) for setpoint I; a full scale process alarm for setpoint II; and a thermocouple J input range of 0 to 500°C.

*Not available on 4200

Athena's ZC/PC solid state contactors, Series 19 and 39 SCR power controllers, can be added to boost ac load switching capacity.

Troubleshooting

Before you call, please look at this section to see if your question is covered here. If you do call for technical assistance, be ready to supply the following information:

- complete model number of controller
- symptoms of the problem
- unusual events, if any, that preceded the problem
- remedies you have already tried

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.*

Symptom. Controller dead. No output light, no digital display.	***Check -*** Verify 120/240 Vac, 50/60 Hz input voltage. Check heater for shorts. Look for open breakers or open external fuse. Remove input power. Check continuity through power transformer primary. With ohmmeter, read between pins: 8 and 9 for 225 or 450 ohms +/-10% and 8 and 10 for 680 or 1000 ohms +/-10%
Probable Cause. - No line voltage input - Open PC board to back- plate connector (defective connector) - Open power transformer	**Corrective Action** - Replace heater, if shorted - Restore power - Replace either power transformer or backplate connector
Symptom. No output, step 1 ok, display reads ambient	***Check -*** 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. Visually inspect relay contacts. Heater continuity and wiring
Probable Cause. - External backplate jumper missing (all models except "S" and "F") - Defective relay - Open heater or heater circuit wiring	**Corrective Action** - Install jumper - Replace relay if contacts are worn or dirty - Replace open heater, correct defective wiring

Symptom. No output.	***Check -*** T/C continuity. Disconnect T/C connections from instrument. Measure T/C circuit resistance. Ohmmeter should read 100 ohms or less.
Probable Cause. - Open thermocouple or T/C wiring	**Corrective Action** - Replace T/C. Correct defective wiring
Symptom Full output, no control. Power light stays on	***Check -*** Connection polarity. T/C wires are color-coded. Red is the negative (-) lead. (for U.S.A.) T/C lead wiring.
Probable Cause. - Thermocouple connections reversed - T/C lead wires shorted between T/C and control	**Corrective Action** - Connect correctly - Repair or replace
Symptom. Full output, no control. Power light goes off.	***Check -*** Disconnect power and load. Measure resistance between pins 12 and 13. Should read infinity.
Probable Cause. - Relay contacts welded closed	**Corrective Action -** If resistance reading is near 0 ohms, replace relay.
Symptom Process control temperature differs from setpoint when read with an external pyrometer. Display agrees with setpoint.	***Check -*** Check T/C lead wires at back of probe Wire color indicates type of T/C - Verify type of wire
Probable Cause. - T/C lead wires shorted close to process - Wrong type of T/C being used, etc. - Standard electrical wiring being used in place of T/C wire - Gradient error.	**Corrective Action** - Replace defective wiring - Install correct T/C for temperature range of instrument. See instrument serial number tag for T/C type. - Run only T/C wire between process and controller. - Use electronic indicator in parallel with suspect instrument's T/C input
Symptom. Temperature overshoots, or oscillates	***Check -*** Compare "on time" to "off time"...short on to off time indicates too much heater capacity for the process. Check bandwidth Loose heater or sensor fit. Poor relative location.
Probable Cause. - Process overpowered - Bandwidth too narrow - Process or sensor lag	**Corrective Action** - Reduce total heater power - Widen band - Improve fit, locate closer together
Symptom. Process control temperature stabilizes above or below set- point as read on display.	***Check -*** Offset (manual reset) Heater to ground resistance. Design parameters for process heat required
Probable Cause. - Offset (manual reset) incorrectly adjusted - Partial short to ground in heater when used on 240 V line - No output from suspect control - Controller reading other zones of multi-controlled process - Full output from suspect control - Apparent stabilization from other zones of multi-controlled process - Improperly sized heater	**Corrective Action** - Adjust (+) to increase controlled temp. (-) to decrease temp. - Replace defective heater

TWO-YEAR LIMITED WARRANTY

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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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Athena Controls, Inc.

Plymouth Meeting, PA

+1 (610) 828 2490

AthenaControls.com

sales@athenacontrols.com

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