

## RHM5K-CH

Precision Unipolar Temperature Controller



### GENERAL DESCRIPTION:

Operating from a single DC supply, the RHM5K-CH can be used to achieve control at off-ambient temperatures. It uses a PID control loop to drive resistive heaters or thermoelectric coolers. The RHM offers a high level of stability and can drive up to 5 A with a small footprint.

On-board 12-turn trimpots control temperature setpoint, proportional gain, and output voltage limit. A single 10-pin terminal strip provides easy access to the DC supply, sensor, resistive heater, and measurement connections.

The RHM5K-CH is suited for applications where heating or cooling (not both) is required. This product is ideal for applications where temperature stability is critical and space is tight, such as heated optics (non-condensing circumstances), CCDs, preheated liquids and chamber stabilization.

### FEATURES:

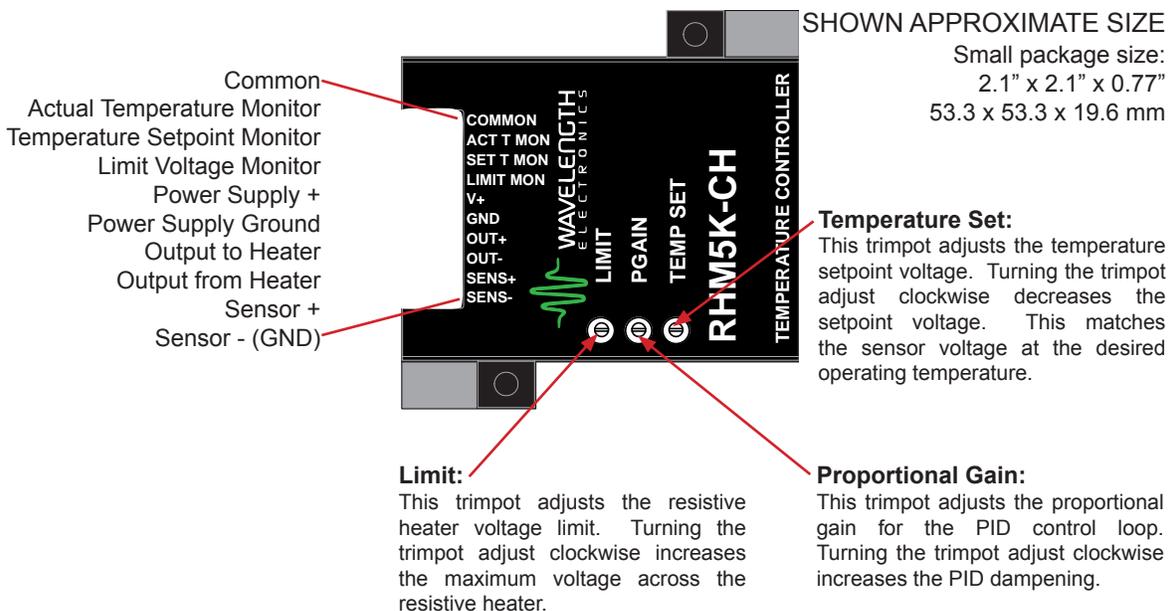
- 5 A Drive Current
- Single supply operation: +5 V to +30 V
- < 0.003°C stability (24 hours)
- Voltage limit
- > +27 V compliance with +30 V input
- Supports Thermistors, IC sensors or RTDs
- Temperature Setpoint, Proportional Gain, and Limit Voltage are user adjustable

### Ordering Information

RHM5K-CH	5 A Resistive Heater Controller
WCB-108	4-Pin Unterminated Cable
WCB-109	6-Pin Unterminated Cable
TCS10K5	10 kΩ Thermistor -- 5 pack
TCS605	5 kΩ Thermistor -- 10 pack
TCS610	10 kΩ Thermistor -- 10 pack
TCS620	20 kΩ Thermistor -- 10 pack
TCS650	50 kΩ Thermistor -- 10 pack
TCS651	100 kΩ Thermistor -- 10 pack

**Figure 1**

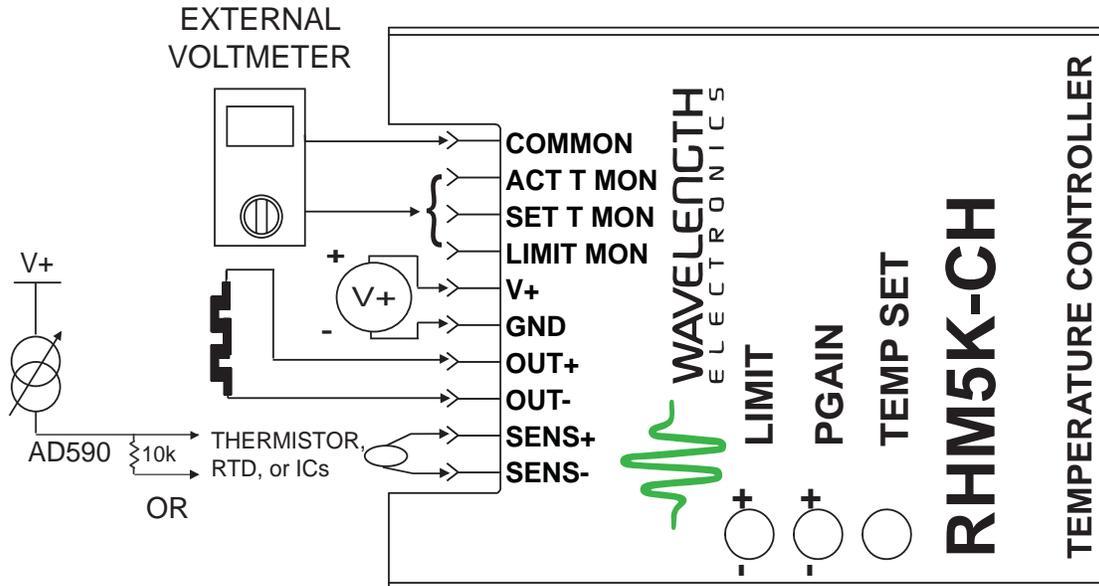
Top View and Pin Descriptions



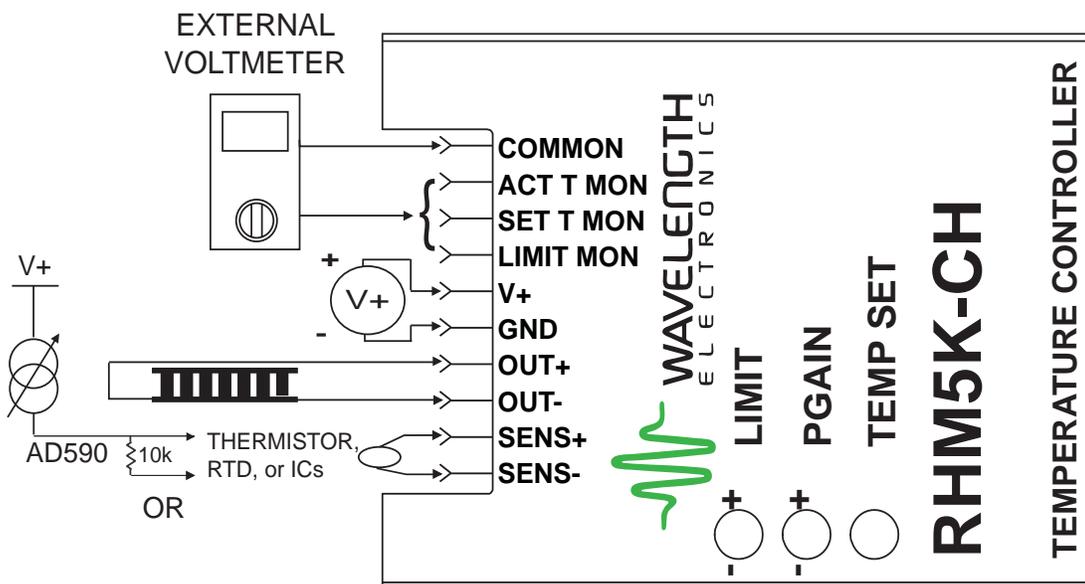
**Figure 2**  
External Connections

**QUICK CONNECT**

The following is a diagram of the components you will need to operate the RHM5K-CH, and their connections. Much more detail is included in the PIN DESCRIPTION section. Please review the entire datasheet before operating your **resistive heater** with the RHM5K-CH.



The following is a diagram of the components you will need to operate the RHM5K-CH, and their connections. Much more detail is included in the PIN DESCRIPTION section. Please review the entire datasheet before operating your **thermoelectric element** with the RHM5K-CH.



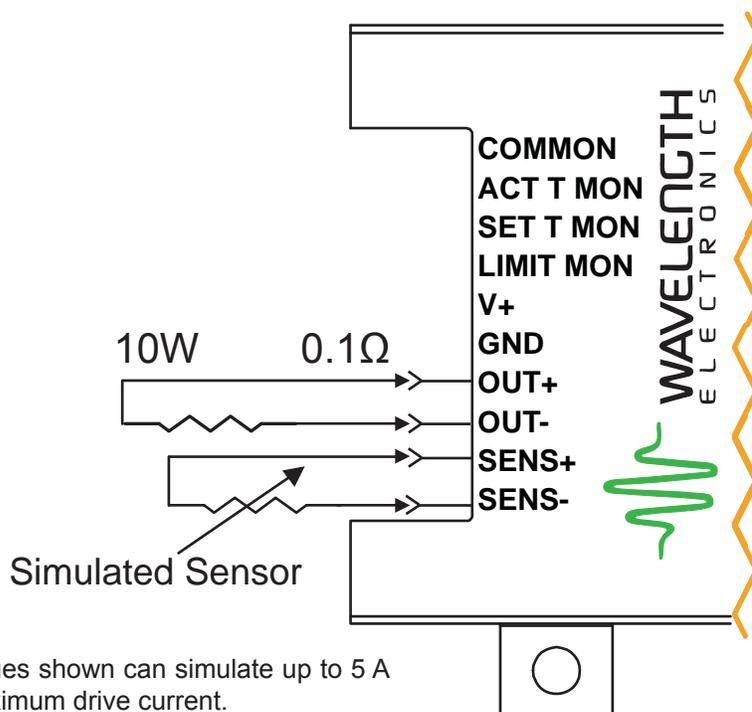
### Figure 3 Test Load Configuration

(for confirming hookup and settings)

A test load can be implemented for initial configuration of the RHM5K-CH. The following guidelines should be considered.

**Load Resistor** - Connect a power resistor between OUT+ and OUT-. Use the online Safe Operating Area (SOA) Calculator at: <http://www.teamwavelength.com/support/calculator/soa/soatc.php> to ensure that the value of the resistor allows for safe operation of the RHM. The maximum achievable current through the resistor is  $(V^+ - 2 V) / R_{LOAD}$ . The power rating on the resistor should be sufficient to handle the maximum current.

**Sensor Resistor** - Connect a resistor between Sensor+ and Sensor-. A potentiometer can be used if desired to simulate a changing sensor resistance. The voltage produced by the resistor will be equal to the resistance multiplied by the bias current selected by the internal jumpers. The resistor value should be chosen to produce a sensor voltage of 0.2 to 5.0 volts.



Values shown can simulate up to 5 A maximum drive current.

ELECTRICAL AND OPERATING  
SPECIFICATIONS

RHM5K-CH

ABSOLUTE MAXIMUM RATINGS		SYMBOL	VALUE	UNIT	
<b>RATING</b>					
Supply Voltage, standard (See SOA Calculator for all voltage levels)		V*	+5 to +30	Volts DC	
Operating Temperature, case		T <sub>OPR</sub>	0 to +70	°C	
Storage Temperature		T <sub>STG</sub>	-40 to +150	°C	
Size (WxDxH)			2.1 x 2.1 x 0.77 53.3 x 53.3 x 19.6	inches mm	
Weight			4	ounces	
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>RESISTIVE HEATER OUTPUT</b>					
Supply Voltage		+4.5		+30	V
Output Current Range <sup>(1)</sup>		0		5	A
Voltage Limit Range <sup>(2) (3)</sup>		(V* - 2.4)		(V* - 1.25)	V
Compliance Voltage <sup>(4)</sup>		(V* - 3)		(V* - 2.5)	V
Internal Power Dissipation <sup>(5)</sup>				20	W
Maximum Output Power	Load resistance of 5.4 Ω			135	W
<b>TEMPERATURE CONTROL</b>					
P (Proportional Gain)		9		100	A / V
I (Integrator Time Constant)			1		sec
D (Differentiator Time Constant)			6		msec
Short Term Stability (1 hour)	10 kΩ Thermistor @ 17°C	0.0005		0.002	°C
Long Term Stability (24 hour)	10 kΩ Thermistor @ 17°C	0.002		0.005	°C
Temperature Coefficient	10 kΩ Thermistor @ 25°C		20		ppm/°C
<b>MONITOR SIGNALS</b>					
Setpoint Monitor <sup>(6)</sup>		0		5.0	V
Quiescent Current			< 10		mA
Setpoint Monitor Output Impedance			41.5		kΩ
Actual Temp Monitor Output Imped.			400		kΩ
Setpoint vs. Actual Accuracy			16		mV
Sensor Voltage vs. ACT T			4		mV
<b>SENSOR</b>					
Bias Current	100 μA, 1 mA, or 10 mA				

**NOTES**

- (1) Maximum Output Current is dependent on the supply voltage and the resistance of the sensor. Care should be taken not to exceed the maximum internal power dissipation of 20 W. Please review the online Safe Operating Area (SOA) Calculator at: <http://www.teamwavelength.com/support/calculator/soa/soatc.php> to ensure safe operation.
- (2) The voltage limit potentiometer can be adjusted to produce voltages on Limit Mon of 0 V to (V\* - 1.25 V), but the effective range of output voltages is 2 V to (V\* - 3 V).
- (3) The limit current is equal to the limit voltage divided by the load resistance of the resistive heater or thermoelectric.
- (4) Maximum Output Voltage will vary depending on input voltage. A maximum compliance voltage of 27 V will be obtained with +30 V input. A maximum compliance voltage of 2.5 V will be obtained with a 5 V input.
- (5) Maximum internal power dissipation. Derating begins at 40°C ambient temperature. See the online Safe Operating Area (SOA) Calculator at: <http://www.teamwavelength.com/support/calculator/soa/soatc.php> for details.
- (6) Range is dependent on input supply voltage, and bias current and sensor choice. The maximum sensor range will be (V\* - 1.2 V) for supply voltages less than 6.3 V.

## PIN DESCRIPTIONS

PIN#	PIN	NAME	FUNCTION
1	<b>Common</b>	Common	This pin provides ground potential to be used with the monitor outputs, pins 2-4. This ground is starred with the circuit ground to provide the most accurate monitor measurement. This pin is at ground potential, but should not be used for anything other than the monitors.
2	<b>ACT T MON</b>	Actual Temperature Monitor	This output is used to monitor the voltage, and therefore temperature, of the sensor. When controlled, the ACT T MON voltage will closely match the voltage set at pin 3 (SET T MON).
3	<b>SET T MON</b>	Temperature Setpoint Adjust	This output is used in setting the temperature setpoint of the sensor. This voltage will range from 0-5 V and should match the voltage across the sensor when it is at the desired temperature. The maximum voltage will be $(V^+ - 1.2 V)$ for supply voltages less than 6.3 V.
4	<b>LIMIT MON</b>	Monitor Limit	This voltage is the maximum voltage between pins 7 and 8 (OUT+ and OUT-). The voltage limit potentiometer can be adjusted to produce voltages on Limit Mon of 0 V to $(V^+ - 1.25 V)$ , but the effective range of output voltages is 2 V to $(V^+ - 3 V)$ .
5	<b>V+</b>	Power Supply	This pin along with pin 6 (GND) provides power to the control electronics and the output stage.
6	<b>GND</b>	Ground	This pin, along with pin 5 ( $V^+$ ) provides power to the control electronics as well as the resistive heater. This is the only ground connection designed as a high current return.
7	<b>OUT+</b>	Output Out	This pin sources the current to the resistive heater.
8	<b>OUT-</b>	Output In	This pin sinks the current returned from the resistive heater.
9	<b>SENS+</b>	Sensor Out	This pin is used to source reference current through the temperature sensor. An internal jumper in the unit will select between a 100 $\mu A$ , 1 mA, or 10 mA reference current. The bias current should be configured based on the sensor chosen. Typical sensors include, but are not limited to, thermistors, RTDs, LM335, and AD590.
10	<b>SENS-</b>	Sensor In (GND)	This pin is used as the bias current source return pin. This pin is at ground potential but should not be used for anything other than the sensor current source return.

## OPERATING INSTRUCTIONS

### 1. HEATSINK THE RHM

When the RHM5K-CH must dissipate more than 5 W of power, a heatsink must be properly attached to the base plate to maintain internal power dissipation within a safe range. An online Safe Operating Area (SOA) Calculator is available at:

<http://www.teamwavelength.com/support/calculator/soa/soatc.php>

to determine internal power dissipation for your specific application. An SOA chart at the end of this datasheet can be used for manual calculations.

Thermally conductive grease should be used between the heatsink and the module for optimum performance.

### 2. CONFIGURE SENSOR BIAS CURRENT

The jumpers can be accessed with the cover removed. See Figure 4 for jumper locations.

The optimal sensor voltage range is 200 mV to ( $V^+ - 2.7$  V) with an absolute maximum of 7 V.

**NOTE:** Although the compliance voltage of the ACT T MON may be as high as 7 V, the maximum range of the setpoint voltage is 5 V.

With this in mind, the sensor bias current jumper should be configured as follows:

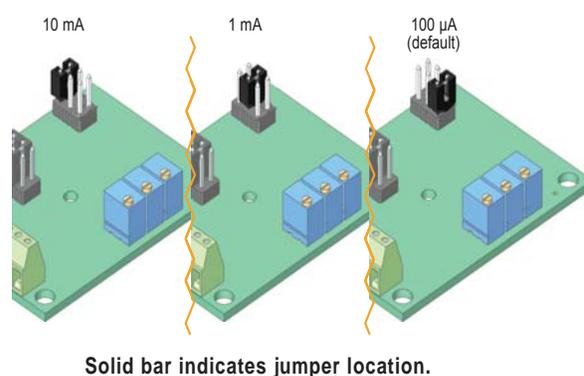
#### **Resistive Sensors (Thermistors & RTDs):**

The bias current jumper should be configured so that the bias current multiplied by the resistance of the sensor is within the acceptable range.

**LM335:** Configure the jumper for a bias current of 1 mA.

**AD590:** Remove the sensor bias jumper. Attach a 10 k $\Omega$  resistor between Sensor+ and Sensor-. Attach the AD590 between  $V^+$  and Sensor+. The sensor voltage generated will be 10 mV / K.

**Figure 4**  
Sensor Current Settings (Jumper Set 1)



## OPERATING INSTRUCTIONS

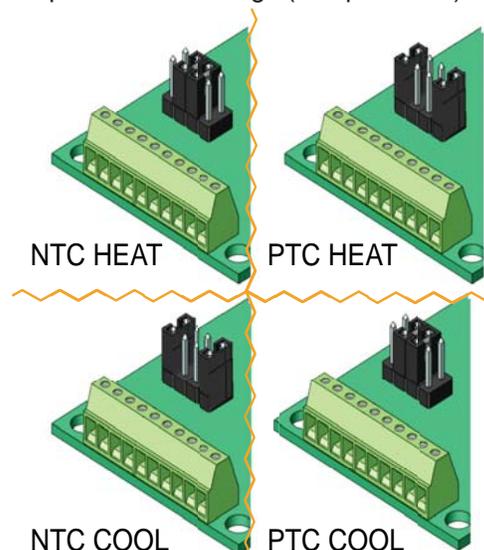
**3. CONFIGURE LOOP DIRECTION JUMPER**

The loop direction can be changed to accommodate heating or cooling operation with PTC or NTC sensors. Figure 5 shows the options for configuring the loop direction jumpers

The resistance or voltage for an NTC sensor increases as the temperature decreases. To configure the RHM to cool with NTC sensors place the jumpers in the outside positions. For heating operation with NTC sensors, place the jumpers in the inside positions.

The resistance or voltage for a PTC sensor increases as the temperature increases. To configure the RHM to cool with PTC sensors place the jumpers in the inside positions. For heating operation with PTC sensors, place the jumpers in the outside positions.

**Figure 5**  
Loop Direction Settings (Jumper Set 2)

**4. CONNECT POWER, SENSOR, AND THERMOELECTRIC or RESISTIVE HEATER**

**Power (Pins 5 and 6):** The RHM5K-CH operates from a single power supply. Connect a positive voltage to V<sup>+</sup> (pin 5) and GND (pin 6). Ensure the power supply has sufficient current capacity for the requirements of the load.

The power supply should be carefully selected so that the internal power dissipation for the RHM is not exceeded. A Safe Operating Area (SOA) Calculator is available online at:

<http://www.teamwavelength.com/support/calculator/soa/soatc.php>

to ensure that the maximum power specification is not exceeded with your application.

The supply should also be chosen so that the controller does not exceed the maximum current specification of 5 A. The maximum output current will be  $(V^+ - 2 \text{ V}) / R_{\text{LOAD}}$ .

**OPERATING INSTRUCTIONS**

**Sensor (Pins 9 and 10):** Epoxy or otherwise affix the temperature sensor to the device being heated in your application. Connect the sensor to pins 9 and 10. For sensors where polarity is important, pin 9 is SENS+, and pin 10 is SENS- .

**Output (Pins 7 and 8):**

**Thermoelectric:** The polarity of the thermoelectric connections to OUT+ and OUT- may need to be reversed depending on the sensor type and whether the device is configured for heating operation or cooling operation. The chart in Figure 6 details when the leads should be reversed. The standard connection is assumed to be the thermoelectric positive connection attached to OUT+ and negative connection to OUT-.

**Resistive Heater:** For resistive heater operation polarity is not important for the connections to OUT+ and OUT-. The loop direction jumpers do need to be configured as detailed in step 3 for proper operation.

**Figure 6**  
TEC Settings

	POLARITY	
	OUT+ Pin 7	OUT- Pin 8
NTC Cool	Standard	
NTC Heat	Reversed	
PTC Cool	Reversed	
PTC Heat	Standard	

**5. SETUP VOLTAGE LIMIT**

Monitor the voltage on Pin 4. Turning the LIMIT trimpot CW increases the maximum allowable voltage between OUT+ and OUT-. The voltage limit measurement on pin 4 can be adjusted from 0 V to (V+ - 1.25 V), but the effective range of output voltages is 2 V to (V+ - 3 V).

Note: When using a variable power supply, the voltage limit must be adjusted to compensate for increases or decreases in the supply voltage.

The maximum output current will be limited by the voltage limit divided by the resistance of the resistive heater:

$$I_{OUTMAX} = V_{LIMIT} / R_{RH}$$

Check the Safe Operating Area (SOA) chart in this datasheet to ensure that the maximum power dissipation specification is not exceeded.

An online SOA Calculator is available at: <http://www.teamwavelength.com/support/calculator/soa/soatc.php>.

**6. SET OPERATING TEMPERATURE**

**SET T MON (Pin 3):** This voltage will depend on the sensor selected. Use one of the following equations based on the sensor type you will be using.

## OPERATING INSTRUCTIONS

### Thermistors and RTDs:

$$V_{\text{SETPOINT}} = I_{\text{REF}} \times R \quad (I_{\text{REF}} \text{ in amps, } R \text{ in ohms})$$

“R” equals the resistance value of the sensor at the desired operating temperature. The reference current ( $I_{\text{REF}}$ ) will be 10 mA, 1 mA, or 100  $\mu$ A.

### LM335 & AD590:

$$V_{\text{SETPOINT}} = 2.730 \text{ V} + (0.010 \text{ V} / ^\circ\text{C} \times T_{\text{DESIRED}})$$

where  $T_{\text{DESIRED}}$  is the setpoint temperature in  $^\circ\text{C}$ .

Decrease the voltage by rotating the TEMP SET potentiometer clockwise. Watch the ACT T MON (pin 2) voltage approach the setpoint voltage with a time lag.

The setpoint can be increased by adjusting the TEMP SET potentiometer CCW. It has a range of 0 to 5 V. If the supply voltage is less than 6.3 V, the setpoint range is 0 to ( $V^+ - 1.2 \text{ V}$ ).

## 7. SET PROPORTIONAL GAIN

The factory setting for the proportional gain is 29. This gain can be adjusted from 1 to 100 to optimize the system for overshoot and settling time. Turning this potentiometer clockwise increases the gain.

The PGain adjustment is non-linear and adjusts more quickly as the potentiometer is turned further clockwise. The chart in Figure 7 shows approximate PGain values versus number of turns clockwise, starting with a fully counter-clockwise adjustment.

With the unit powered off, the resistance of the potentiometer can also be measured at the test points shown in Figure 8 to more accurately set the proportional gain. The proportional gain can be calculated as follows:

$$\text{PGain} = 200 \text{ k}\Omega / R_{\text{MEASURED}}$$

Further information on tuning the control parameters for temperature control systems is contained in the Tech Note at:

<http://www.teamwavelength.com/downloads/notes/tn-tc01.pdf#page=1>.

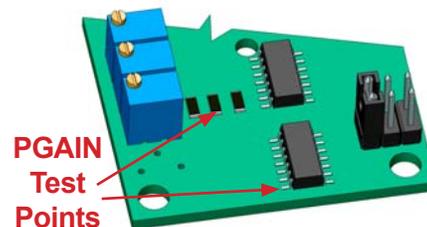
## 8. MONITOR ACTUAL TEMPERATURE

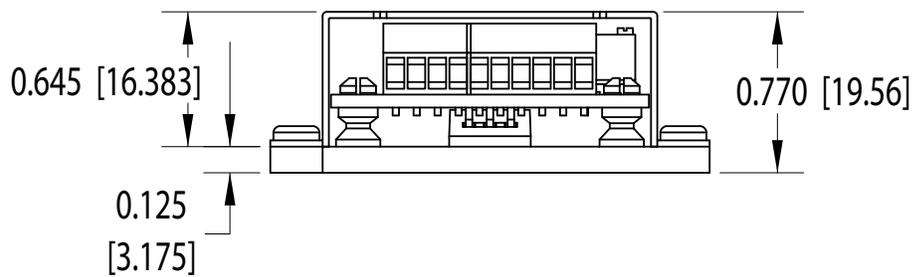
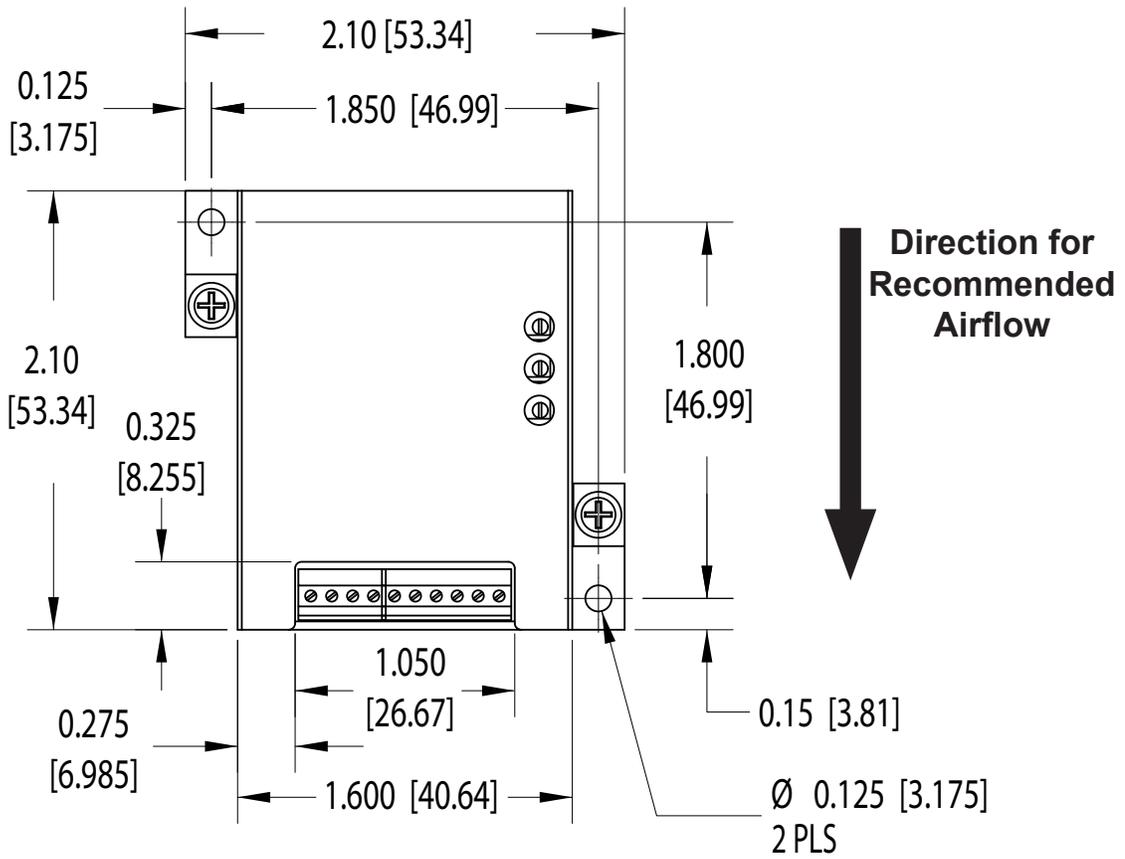
The actual temperature can be monitored on pin 2 of the output connector. Based on the sensor equations in step 6, the sensor voltage should begin at ambient temperature and move in the direction of the setpoint temperature.

**Figure 7**  
PGain Adjustments

Potentiometer Adjustment	Fully CCW	3 Turns	6 Turns	9 Turns	10 Turns	11 Turns	12 Turns	13 Turns
PGAIN	9	10	13	23	29	38	67	100

**Figure 8**  
PGain Test Points

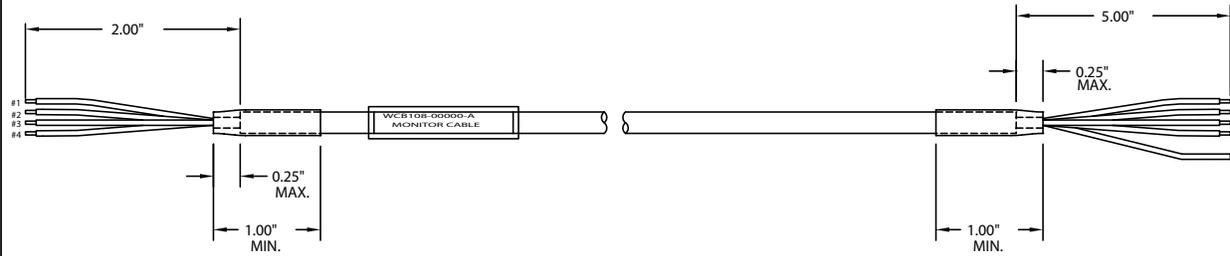




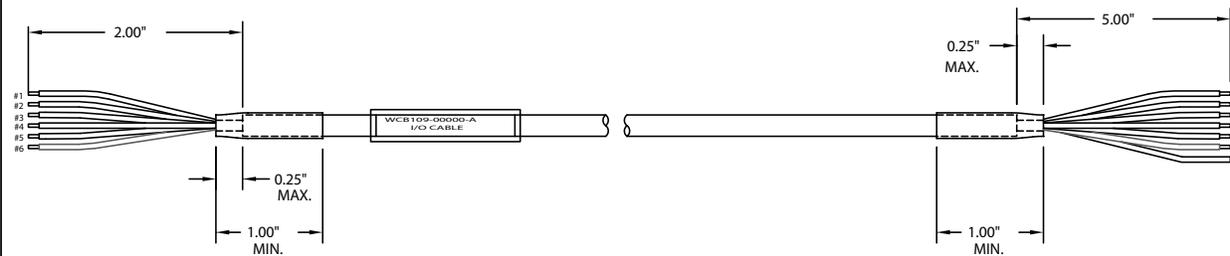
**\*All Tolerances are ± 5%**  
**Dimensions are in Inches [mm]**

The following cables are offered separately as accessories to facilitate RHM5K-CH connection and integration.

### WCB-108 4-Wire Monitor Cable



### WCB-109 6-Wire I/O Cable



**\*All Tolerances are ± 5%**  
**Dimensions are in Inches [mm]**

**Caution:**

Do not exceed the Safe Operating Area (SOA). Exceeding the SOA voids the warranty.

An online tool is available for calculating Safe Operating Area at:

<http://www.teamwavelength.com/support/calculator/soa/soatc.php>.

The SOA (Safe Operating Area) curve combines the effects of current, voltage, and power limitations for the RHM5K-CH. This curve illustrates the unsafe operating area where the RHM5K-CH can be damaged due to thermal stress on the output power stage. CAUTION: Never allow the chassis temperature to exceed 75°C.

To determine if the operating parameters fall within the SOA of the device, the maximum voltage drop across the controller and the maximum current must be plotted on the SOA curves. These values are used for the example SOA determination:

$$V^+ = 8 \text{ volts}$$

$$V_{\text{LOAD}} = 5 \text{ volts}$$

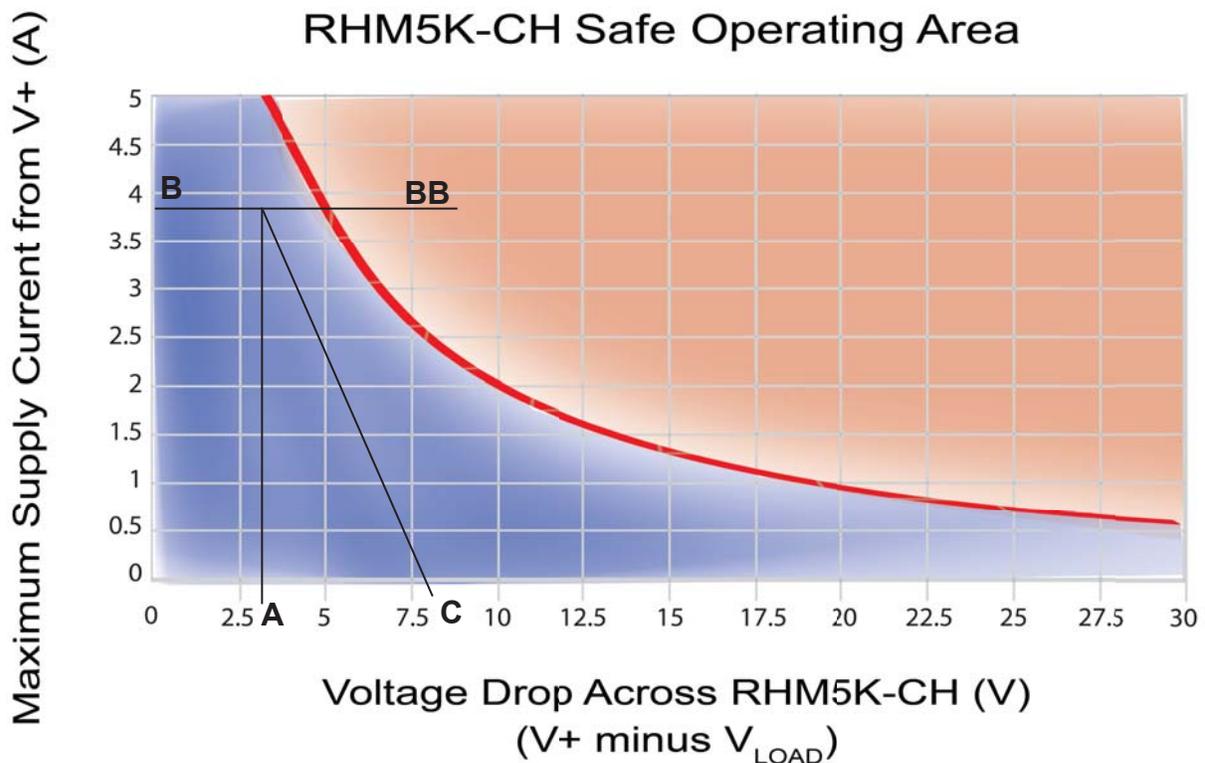
$$I_{\text{LOAD}} = 4 \text{ amps}$$

} These values are determined from the specifications of the heater.

Follow these steps:

1. Determine the maximum voltage drop across the driver,  $V^+$  minus  $V_{\text{LOAD}}$ , and mark on the X axis.  
Example: 8 volts - 5 volts = 3 volts (Point A)
2. Determine the maximum current,  $I_{\text{LOAD}}$ , through the driver and mark on the Y axis:  
(4 amps, Point B)
3. Draw a horizontal line through Point B across the chart. (Line BB)
4. Draw a vertical line from Point A to the maximum current line indicated by Line BB.
5. Mark  $V^+$  on the X axis. (8 V, Point C)
6. Draw the Load Line from where the vertical line from point A intersects Line BB down to Point C.

Refer to the chart shown below and note that the Load Line is in the Safe Operating Area.



**CERTIFICATION:**

Wavelength Electronics, Inc. (Wavelength) certifies that this product met it's published specifications at the time of shipment. Wavelength further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by that organization's calibration facilities, and to the calibration facilities of other International Standards Organization members.

**WARRANTY:**

This Wavelength product is warranted against defects in materials and workmanship for a period of 90 days from date of shipment. During the warranty period, Wavelength will, at its option, either repair or replace products which prove to be defective.

**WARRANTY SERVICE:**

For warranty service or repair, this product must be returned to the factory. An RMA is required for products returned to Wavelength for warranty service. The Buyer shall prepay shipping charges to Wavelength and Wavelength shall pay shipping charges to return the product to the Buyer upon determination of defective materials or workmanship. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Wavelength from another country.

**LIMITATIONS OF WARRANTY:**

The warranty shall not apply to defects resulting from improper use or misuse of the product or operation outside published specifications.

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**EXCLUSIVE REMEDIES:**

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REVISION HISTORY		
REVISION	DATE	NOTES
REV. A	5-Dec-10	Initial release