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WAVELENGTH ELECTRONICS

HTC 4000

Low Profile, Efficient Temperature Controller

RoHS Compliant

GENERAL DESCRIPTION

The advanced and reliable circuitry of the HTC Series achieves 0.0009°C temperature stability. Its small, low profile package is ideal for designs with space constraints. The linear, PI control loop offers maximum stability while the bipolar current source has been designed for higher efficiency.

The HTC Temperature Controllers are easily configured for any design. Virtually any type of temperature sensor can be used with the HTC and a built in sensor bias current source simplifies use with resistive temperature sensors. The independently adjustable Proportional Gain (P) and Integrator Time Constant (I) can be modified to optimize temperature overshoot and stability.

Other features offer added flexibility. A single resistor sets the maximum output current to your load. An onboard reference voltage simplifies potentiometer control of the temperature setpoint. You can also choose to operate remotely with an external setpoint voltage. Two monitor pins provide access to the temperature setpoint voltage and the actual sensor voltage.

FEATURES

- Compact Size
- ±4.0 A Output
- Interfaces with Thermistors, IC Sensors, & RTDs
- Single supply operation +5 V to +12 V
- +10.8 V compliance with +12 V input
- Stabilities as low as 0.0009°C
- Temperature Setpoint, Output Current Limit, Sensor Bias, Proportional Gain, and Integrator Time Constant are User Adjustable
- Monitor outputs for Temperature Setpoint and Actual Temperature
- Linear Bipolar Output operates thermoelectrics

ORDERING INFORMATION

Model	Description
HTC4000-62	±4 A Temp Controller (for 0.062” board)
PWRPAK-5V	+5 V @ 8 A Power Supply
HTCEVAL PCB	Evaluation Board, 0.062” thick (Includes HTC Heatsink, and thermal grease)
THERM-PST	Thermal grease

Figure 1

HTC Series Pin-Out, Top View

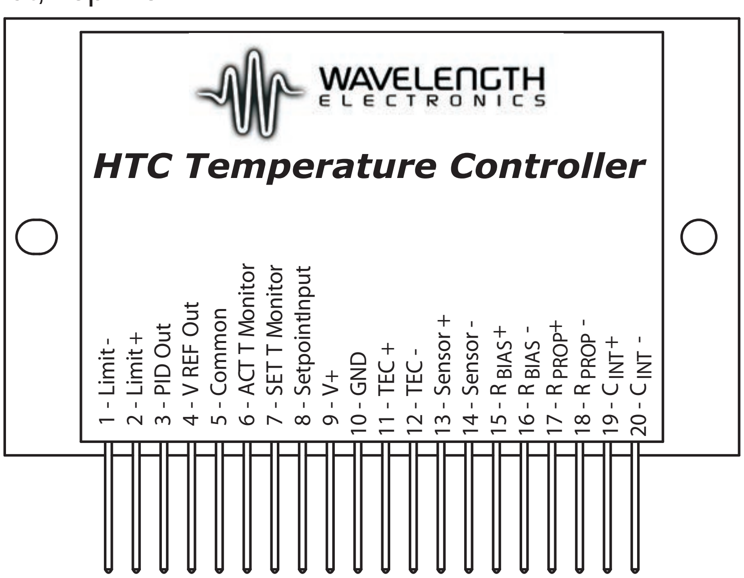


Figure 2
Quick Connect

This diagram shows HTC connections for basic operation.
Details for each component are on pages 7 & 8.

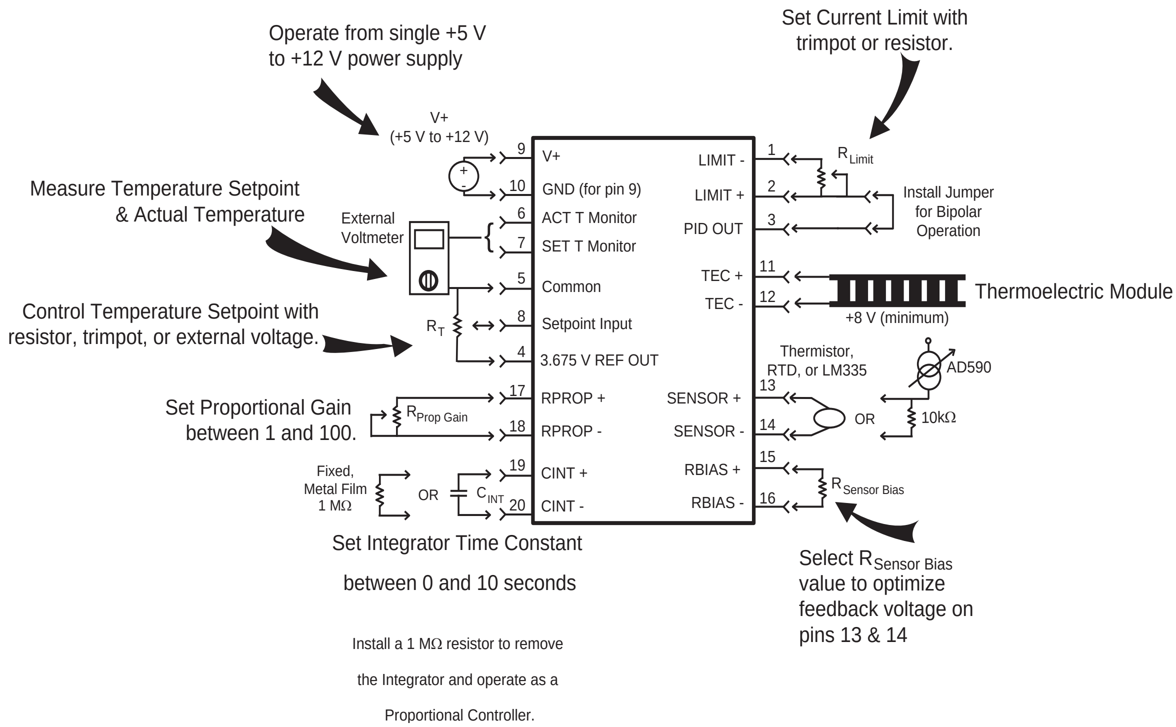
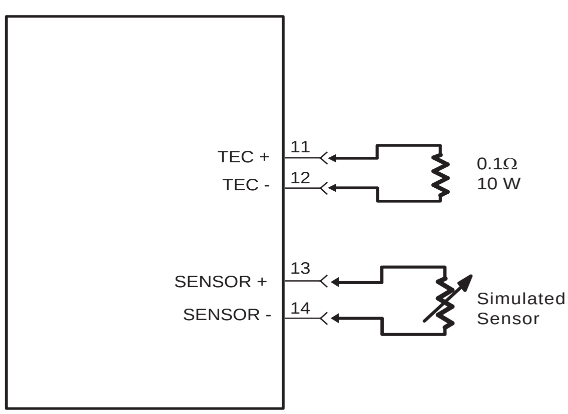


Figure 3
Test Load Configuration
(for confirming connections and settings)



Values shown can simulate any load up to the HTC Series maximum of 4 A.

ABSOLUTE MAXIMUM RATINGS	SYMBOL	VALUE	UNIT
Supply Voltage (Voltage on Pin 9 - contact factory for higher V operation) ❶	V+	+5 to +12	Volts DC
Output Current (See SOA Chart)	I_{OUT}	±4.0	Amps
Power Dissipation, $T_{AMBIENT}$ = +25˚C (See SOA Chart)	P_{MAX}	17	Watts
Operating Temperature, case	T_{OPR}	0 to +50	˚C
Storage Temperature	T_{STG}	-40 to +125	˚C

OPERATING PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNITS
TEMPERATURE CONTROL						
Short Term Stability (1-hr) ❷	OFF ambient temperature			0.0009		˚C
Short Term Stability (1-hr) ❷	ON ambient temperature			0.002		˚C
Long Term Stability (24-hr) ❷	OFF ambient temperature			0.0015		˚C
CONTROL LOOP			P	PI		
P (Proportional Gain) ❸			1		100	A / V
I (Integrator Time Constant) ❹			0		10	Sec.
Setpoint vs. Actual T Accuracy			0.2	2	5	mV
OUTPUT, THERMOELECTRIC						
Current, peak, see SOA Chart			±3.9	±4.0	±4.1	Amps
Compliance Voltage, ❺	V+ = 5 V	I_{OUT} = 500 mA		V+ – 1.2		Volts
Pin 11 to Pin 12		I_{OUT} = 2.0 A		V+ – 0.8		Volts
		I_{OUT} = 4.0 A		V+ – 1.2		Volts
Temperature Range ❻						
Current Limit Range ❸ (±2% FS Accuracy)				0 - 4000		mA
Output Power ❼ contact factory for higher power operation					17	Watts
POWER SUPPLY						
Voltage, V+				5	12	V
Current, V+ supply, quiescent				200		mA
SENSORS						
Sensor Bias Current Range ❸			1µ		10m	A
Resistive Sensor Type	Thermistors, RTDs					
IC Sensor Types ❽	AD590, LM335					

❶ If thermistor, TE module, or laser diode are case-common, the laser diode driver and TE controller power supplies must be isolated from each other.

❷ Stability quoted for a typical 10 kΩ thermistor at 100 µA sensing current. For details, refer to *TN-TC02 : How is Temperature Stability Measured?*. (http://www.teamwavelength.com/downloads/notes/tn-tc02.pdf#page=1)

❸ User configurable with external resistor.

❹ User configurable with external capacitor.

❺ Compliance voltage will vary depending on power supply voltage and output current.

❻ Temperature Range depends on the physical load, sensor type, input voltage, and TE module used.

❼ Output power is limited by internal power dissipation and maximum case temperature. See SOA chart to calculate internal power dissipation. Damage to the HTC will occur if case temperature exceeds 50°C.

❽ AD590 requires an external bias voltage and 10 kΩ resistor.

Size (H x W x D)	Weight	Connectors	Required Heatsink Capacity	Warm-up
0.34" x 2.65" x 1.6" [8.6 x 67 x 41 mm]	< 1.5 oz.	20 pin header, 0.1” spacing	5.6 °C / W / 3 in	1 hour to rated accuracy

PIN DESCRIPTIONS

PIN NO.	PIN	FUNCTION
1 2	LIMIT- LIMIT+	Resistor value of 0 Ω to 1 MΩ between pins 1 & 2 limits maximum output current.
3	PID OUT	Short pins 2 & 3 for bipolar operation. Bipolar operation allows current to flow in both directions, and is required when using the controller with TECs.
4	V REF OUT	3.675 Volt Reference < 50 ppm stability (15 ppm typical)
5	COMMON	Measurement ground. Low current return used only with pins 6, 7, & 8. Internally shorted to pin 10.
6	ACT T MONITOR	Temperature voltage monitor. Buffered measurement of voltage across Sensor + & Sensor–. [1 kΩ output impedance]
7	SET T MONITOR	Setpoint voltage monitor. Buffered measurement of the setpoint input (pin 8).
8	SETPOINT INPUT	Remote Setpoint voltage input. Input impedance = 1 MΩ. Range: 0 to V+ - 1.3 V. Damage threshold: Setpoint < -0.5 V or Setpoint > V+.
9	V+	Supply voltage input. +5 V to +12 V.
10	GND	Power Supply Ground. Used with pin 9 for high current return.
11 12	TEC+ TEC-	TEC+ & TEC- supply current to the TE module. With NTC sensors, connect TEC+ to positive lead of TE module. With PTC sensors, connect TEC- to positive lead of TE module.
13 14	SENSOR+ SENSOR-	A sensor bias current will source from Sensor+ to Sensor- if a resistor is tied across R_{BIAS}+ and R_{BIAS}-. Connect a 10 kΩ resistor across Sensor+ & Sensor- when using an AD590 temperature sensor. See page 7, step 4.
15 16	R_{BIAS}+ R_{BIAS}-	Resistance between pins 15 & 16 selects sensor current from 1 µA to 10 mA. Range is 0 Ω to 1 MΩ.
17 18	R_{PROP}+ R_{PROP}-	Resistance between pins 17 & 18 selects Proportional Gain between 1 & 100. Range is 0 Ω to 495 kΩ.
19 20	C_{INT}+ C_{INT}-	Capacitance between pins 19 & 20 sets the Integral Time Constant between 0 and 10 seconds. 0 seconds (OFF) = 1 MΩ resistor 0.1 to 10 seconds = 0.1 µF to 10 µF.

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

An online tool for calculating Safe Operating Area is available at:
http://www.teamwavelength.com/support/calculator/soa/soatc.php .

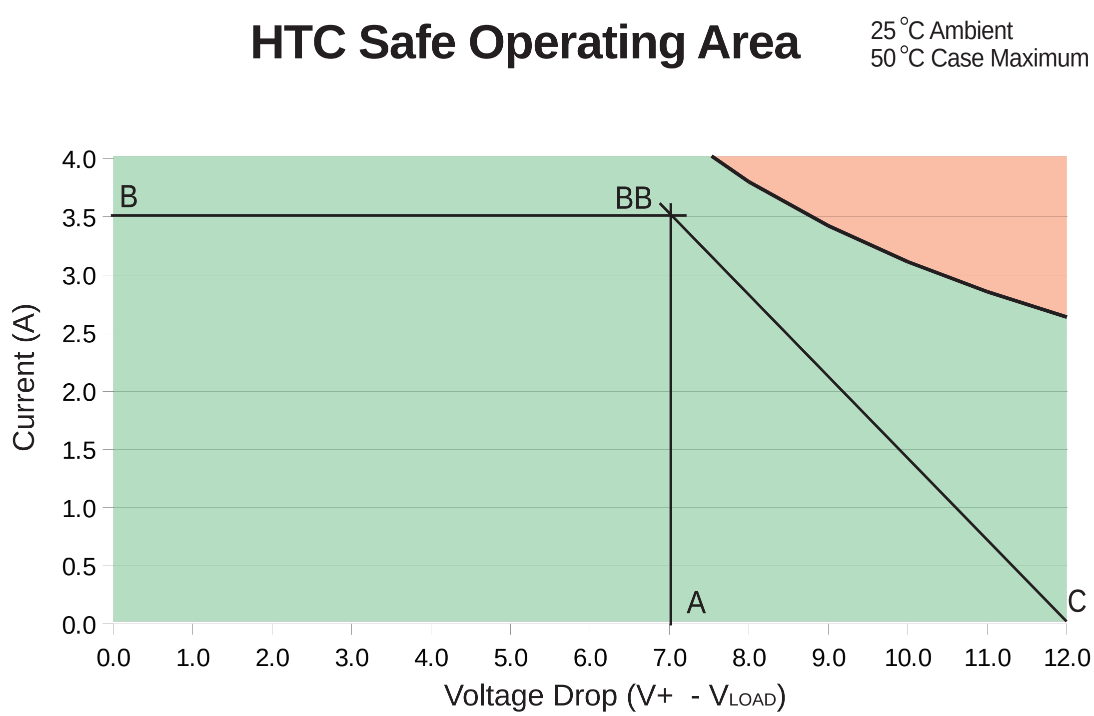
To determine if the operating parameters fall within the SOA of the device, the maximum voltage drop across the controller and the maximum current must be plotted on the SOA curves.
These values are used for the example SOA determination:

V+ = 12 volts
V_{LOAD} = 5 volts
I_{LOAD} = 3.5 amp } These values are determined from the specifications of the TEC

Follow these steps:

1. Determine the maximum voltage drop across the controller, V+ - V_{LOAD}, and mark on the X axis. (12 volts - 5 volts = 7 volts, Point A)
2. Determine the maximum current, I_{LOAD}, through the controller and mark on the Y axis: (3.5 amp, 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. (Point C)
6. Draw the Load Line from where the vertical line from point A intersects Line BB down to Point C.

This chart assumes you have appropriate heatsinking on the HTC.



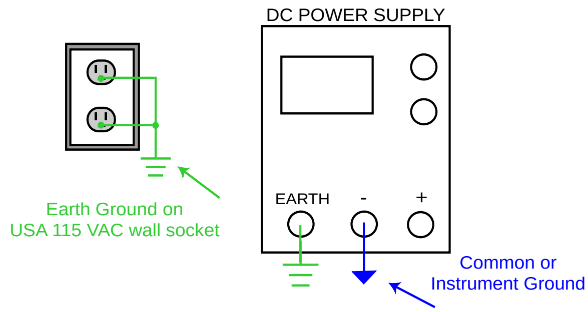
POWER SUPPLY AND NOISE

The HTC Series Temperature Controller is a linear controller designed for stable, low noise operation. We recommend using a regulated, linear supply for optimum performance. Depending on your requirements, you may be able to use a switching power supply. [A switching power supply will affect noise and stability.]

The recommended operating voltage is between +5 V and +12 V. The voltage available to the thermoelectric is the “Compliance Voltage.” Compliance voltage varies with the input voltage.

A heatsink is required to properly dissipate heat from the HTC mounting surface. Maximum internal power dissipation is 17 Watts.

GROUNDING

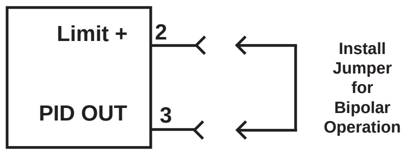


Unless Earth and Instrument Ground are connected via the power supply, Instrument Ground is floating with respect to Earth Ground

Special attention to grounding will ensure safe operation. Some manufacturers package devices with one lead of the sensor or thermoelectric connected to the metal enclosure or in the case of laser diodes, the laser anode or cathode.

WARNING: Precautions should be taken not to earth ground pins 11, 12, or 13. If any of these pins are earth grounded, then pins 5, 10, and 14 must be floating with respect to earth ground.

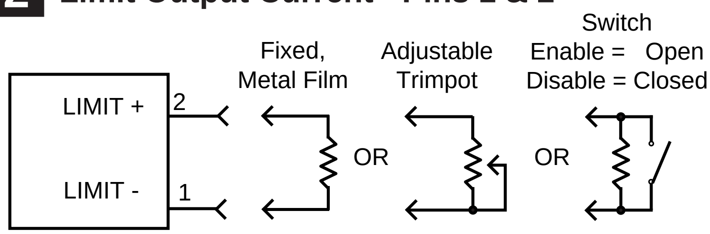
1 Output Current Bias - Pins 2 & 3



Thermistors are Negative Temperature Coefficient (NTC) sensors. Thermistor resistance decreases as temperature increases.

RTDs and IC Sensors are Positive Temperature Coefficient (PTC) sensors. A PTC sensor's resistance increases with increasing temperature.

2 Limit Output Current - Pins 1 & 2



Use a trimpot no more than twice the calculated value of R_{LIMIT} for best resolution.

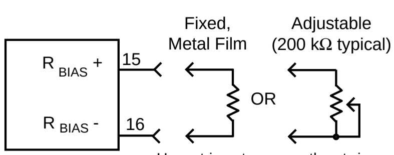
HTC4000 with TE

$$R_{LIMIT} = \frac{2752 * I_{LIMIT}}{1.8864 - 0.4128 * I_{LIMIT}}$$

I_{LIMIT}	R_{LIMIT}
1.0 A	1867 Ω
2.0 A	5188 Ω
3.0 A	12.7 kΩ
4.0 A	46.8 kΩ

Indicated resistor values will set I_{LIMIT} within ±5% of indicated value. If greater accuracy is required for I_{LIMIT}, refer to Technical Note TN-TC07: *Understanding and Improving the Accuracy of the Current Limit Setpoint on HTC Series Temperature Controllers*.

3 Sensor Bias Current - Pins 15 & 16



Use a trimpot no more than twice the calculated value of R_{BIAS} for best resolution.

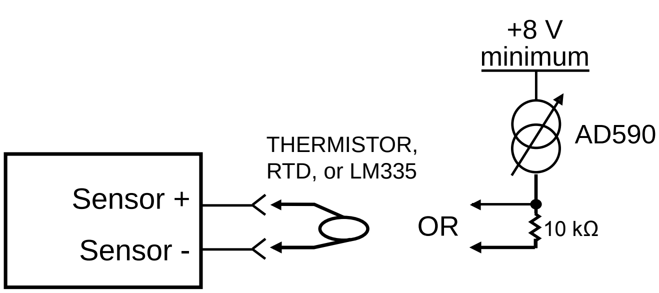
R_{BIAS} determines the bias current sourced to the sensor attached at pins 13 & 14. The chart indicates recommended currents for typical sensors. When using a voltage feedback sensor (such as an AD590), leave pins 15 & 16 open.

$$R_{BIAS} = \frac{1.225}{I_{BIAS}} - 122$$

I_{BIAS}	R_{BIAS}
10 mA	0 Ω
1 mA	1.1 kΩ
100 µA	12.1 kΩ
10 µA	122 kΩ

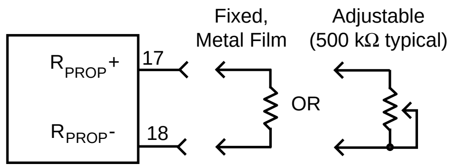
	10 µA	100 µA	1 mA	10 mA
10 kΩ Thermistor		X		
100 kΩ Thermistor	X			
RTD			X	X
LM335			X	

4 Sensor - Pins 13 & 14



Virtually any type of temperature sensor can be used with the HTC. It must produce a feedback voltage between 0.25 V and (V+ minus 1.3 V). See Step #3 (R_{BIAS}) to set the bias current to the sensor.

5 Proportional Gain - Pins 17 & 18



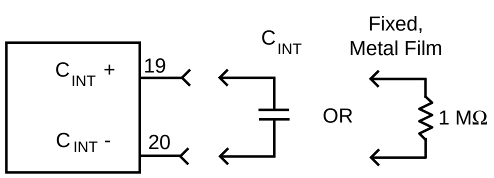
Use a trimpot no more than twice the calculated value of R_{PROP} for best resolution.

$$R_{PROP} = \frac{500\ k\Omega}{GAIN} - 5\ k\Omega$$

GAIN	R_{PROP}
1	495 kΩ
50	5 kΩ
100	0 Ω

R_{PROP} sets the gain of the system from 1 to 100. A higher proportional gain can help minimize the time to settling but may destabilize loads with long intrinsic lag times. Too low a gain may result in oscillations about setpoint. For most applications, a gain of 33 works (R_{PROP} = 10 kΩ). Change the proportional gain while the output is OFF.

6 Integrator Time Constant - Pins 19 & 20

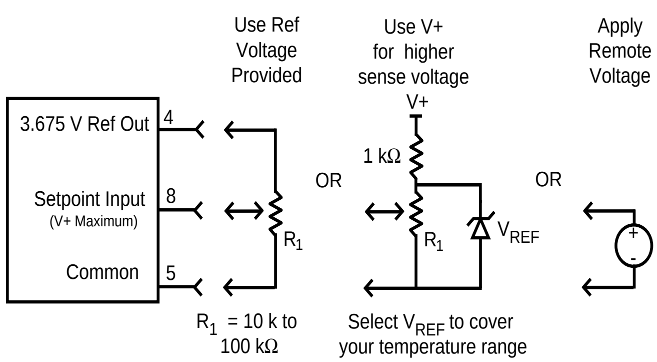


$$C_{INT} = \frac{T_{INT}}{1\ M\Omega}$$

T_{INT}	C_{INT}
0 (OFF)	1 MΩ
1 second	1 µF
5 seconds	5 µF
10 seconds	10 µF

C_{int} sets the integral time constant of the system from 0 to 10 seconds. Use a capacitor with Dissipation Factor less than 1% for best performance. These typically include metallized film polyester, polypropylene & some ceramic capacitors. Capacitors with Dissipation Factors >1% (typically electrolytic, tantalum, and ceramic) will cause drift in the Integrator circuit. To disable the integrator, use a 1 MΩ resistor across pins 19 & 20.

7 Temperature Setpoint - Pins 8 & 5 (Pin 4 optional)

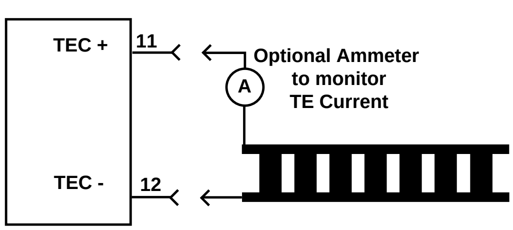


Example:
Desired Temperature: **25°C**
Sensor: **10 kΩ thermistor**
Resistance at 25°C: **10 kΩ**
Bias Current: **100 µA**
V_{SET} **= 10 kΩ * 100 µA = 1 V**

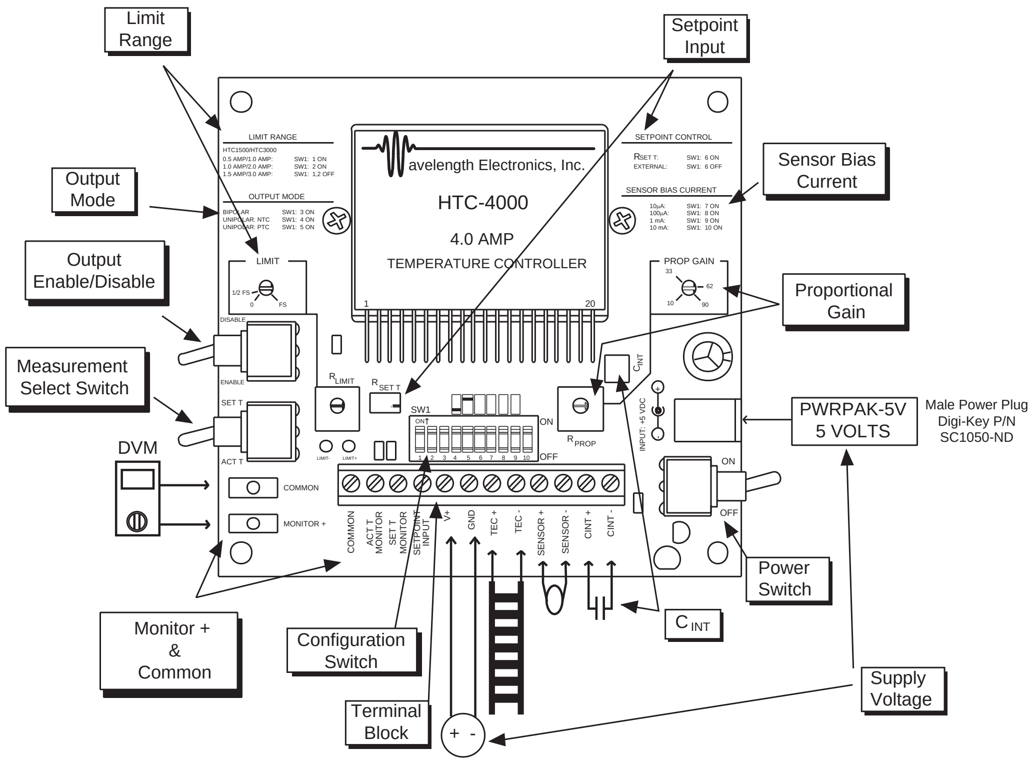
Monitor setpoint with a DVM at pins 7 & 5, or actual sensor voltage across pins 6 & 5.

The controller adjusts the temperature of the load until the voltage across the temperature sensor equals the Setpoint Input voltage (pins 8 & 15). To adjust the temperature setpoint, first determine the voltage across the sensor at the target temperature; apply that same voltage across pins 8 and 15 of the controller. The diagrams to the left show three possible configurations for setpoint voltage input.

8 TE Module & Output Current Measurement - Pins 11 & 12



Connect the TE module and an ammeter if you want to monitor TE current. Current flows from positive to negative when the HTC is cooling with an NTC temperature sensor. When using an LM335, AD590, RTD, or other PTC sensor, reverse the polarity of the leads (i.e. connect the positive lead of the TE module to TEC- and the negative lead of the TE module to TEC+).



To Install the HTC on the HTCEVALPCB Evaluation Board with HTC Heatsink

1. Feed the HTC pins through the large opening in the HTCEVALPCB board so that the HTC pins are on the top side of the evaluation board and the mounting tabs are against the back side of the board.
2. Line up the heatsink holes behind the HTC and insert the screws through the evaluation board and HTC unit into the tapped heatsink holes.
3. Line up the HTC pins on the solder pads on the evaluation board and tighten the screws.
4. Solder the HTC pins to the solder pads. NOTE: Do not exceed 700°F soldering temperature for more than 5 seconds on any pin.
5. If you are using a PCB that is not 0.062” thick, the HTC pins need to be bent. Clamp the pins between the HTC housing and the bend to avoid damage to the HTC.

Terminal Block

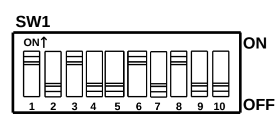
Wire your thermoelectric module and sensor via the 12-contact screw terminal connector. Connect the external setpoint voltage input here, also. Other signals are available on the PCB as well as on the terminal block: Actual and Setpoint monitors, Integrator Time Constant Capacitor, and Supply Voltage.

We recommend using a minimum of 22 AWG wire to the thermoelectric.

Configuration Switch - SW1

The Configuration Switch selects the OUTPUT MODE, LIMIT RANGE, SETPOINT INPUT, and SENSOR BIAS CURRENT. Before applying voltage to the HTCEVALPCB, check the switch settings for proper configuration.

The FACTORY DEFAULT settings are:



Limit Range: Lowest
(SW1:1 ON, SW1:2 OFF)

Bipolar Operation:
(SW1:3 ON, SW1:4 & 5 OFF)

Onboard Trimpot Control: (SW1:6 ON)

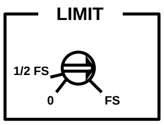
100µA Sensor Bias Current:
(SW1:7, 9 , & 10 OFF, SW1:8 ON)

The following page details the switch settings.

HTCEVALPCB SETTINGS

LIMIT RANGE

For best results, set R_{LIM} trimpot fully clockwise (full-scale) and use current limit switches.



Switch positions 1 & 2 set the "full scale" value to one of three current ranges. Select a range that includes your maximum operating current:

RANGE	SW1: 1	SW1:2
0 - 1.5 A	ON	OFF
0 - 3.0 A	OFF	ON
0 - 4.0 A	OFF	OFF

If you want to accurately measure the output current to the TE module, connect an ammeter in series with the TE module as described on page 8, step 8 of the datasheet.

OUTPUT MODE

The HTCEVALPCB can be set to operate the HTC controllers in bipolar (TEC) or unipolar (heater) operation. **The HTC4000 is not recommended for unipolar operation, or for use with resistive heaters.** Configure the switches for Bipolar NTC/PTC operation.

OUTPUT BIAS	SW1: 3	SW1: 4	SW1:5
Bipolar NTC/PTC	**ON**	**OFF**	**OFF**
Heating, Unipolar: NTC	OFF	ON	OFF
Heating, Unipolar: PTC	OFF	OFF	ON

SETPOINT INPUT

The temperature setpoint can be controlled by the onboard $R_{SET\ T}$ trimpot or with an external input voltage on the terminal block (SETPOINT INPUT). Switch position 6 determines how the setpoint is controlled.

Temperature Setpoint	SW1:6
Onboard $R_{SET\ T}$ Trimpot	ON
Remote SETPOINT INPUT	OFF

SENSOR BIAS CURRENT

Choosing the correct bias current for your sensor is important. Based on the resistance vs. temperature characteristics of your sensor, select a bias current that gives you a voltage feedback between 0.25 V and (V+ minus 1.3 V).

BIAS CURRENT	SW1:7	SW1:8	SW1: 9	SW1:10	Recommended for:
10 µA	ON	OFF	OFF	OFF	100 kΩ Thermistors
100 µA	OFF	ON	OFF	OFF	10 kΩ Thermistors
1 mA	OFF	OFF	ON	OFF	RTDs & LM335 IC Sensor
10 mA	OFF	OFF	OFF	ON	RTDs
0 mA	OFF	OFF	OFF	OFF	AD590

PROPORTIONAL GAIN

Begin with a proportional gain of 33 (factory default). The temperature vs. time response of your system can be optimized for overshoot and settling time by adjusting the R_{PROP} trimpot between 10 and 90. Increasing the gain will dampen the output (longer settling time, less overshoot).
For more information on PID controllers, see Technical Note *TN-TC01- Optimizing Thermoelectric Temperature Control Systems* (http://www.teamwavelength.com/downloads/notes/tn-tc01.pdf#page=1).

SUPPLY VOLTAGE

A DC voltage can be applied via the PWRPAK-5V input connector or the terminal block connections labeled V+ and GND. **USE ONLY ONE INPUT to supply power to the HTCEVALPCB.**

C_{INT}

A 1µF capacitor is mounted on the PCB, as shown on page 9, and will give you a one second integrator time constant. By adding capacitance across the C_{INT}+ and C_{INT}- inputs on the terminal block, you can increase the integrator time constant. See page 8, step 6 for more information. Use only capacitors with a dissipation factor less than 1%.
For more information on PID controllers, see Technical Note *TN-TC01 - Optimizing Thermoelectric Temperature Control Systems* (http://www.teamwavelength.com/downloads/notes/tn-tc01.pdf#page=1).

POWER SWITCH

This switch enables or disables the DC voltage from either the PWRPAK-5V input connector or the terminal block connections labeled V+ and GND. The green LED will light when power is applied to the HTCEVALPCB and the switch is "ON".

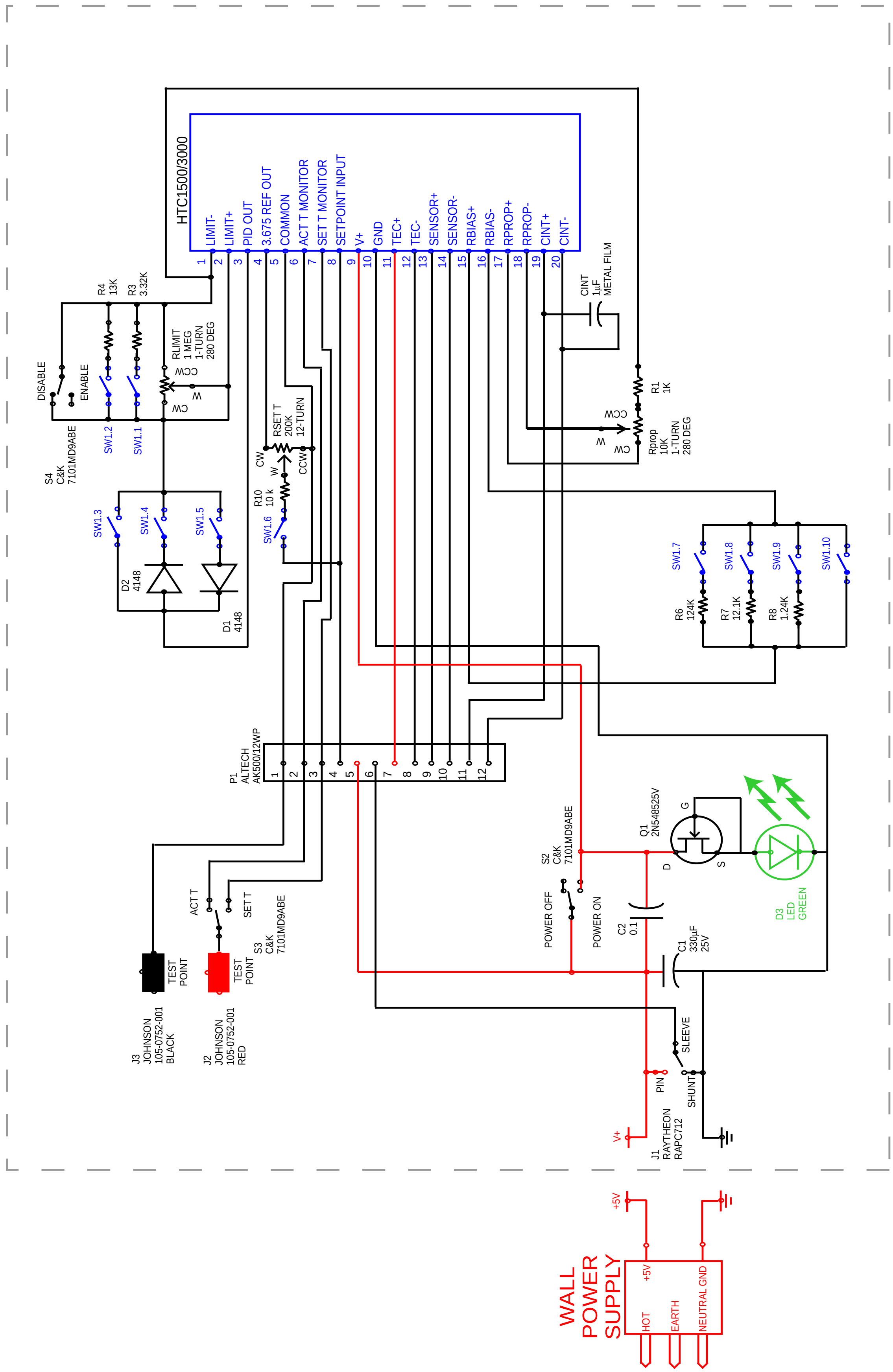
MONITOR + and COMMON

With a DVM connected to MONITOR + and COMMON, toggle the Measurement Select Switch to measure SET T (setpoint temperature) or ACT T (actual temperature). Alternatively, SET T and ACT T can be measured via the ACT T and SET T MONITORs (referenced to COMMON) on the terminal block.

OUTPUT ENABLE / DISABLE

The output current is enabled or disabled by toggling this switch.

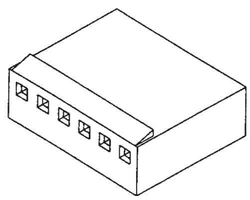
HTC EVALUATION BOARD



USING A CONNECTOR WITH THE HTC

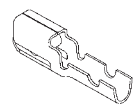
The HTC leads are meant to be soldered onto a circuit board. If you want to use a connector, we recommend the following:

Qty	Description	Molex Part Number
1	Molex Crimp Terminal Housing 20 pin (High Pressure)	10-11-2203
20	Molex Crimp Terminal 7879 (High Pressure)	08-55-0129



Molex Crimp Terminal Housing 20 pin (High Pressure)
(only 6 pins shown)

20 pin Molex Part Number: **10-11-2203**
L x W = 2.02” x .51” (51.3 mm x 12.9 mm)

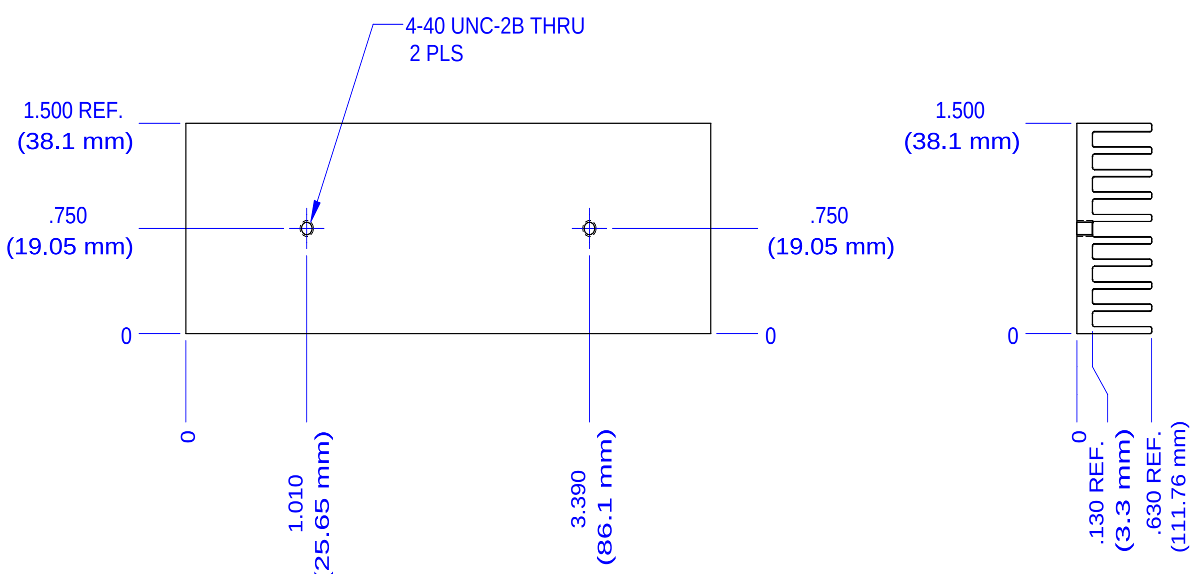


Molex Crimp Terminal 7879 (High Pressure)
for wire size 22 - 30 AWG, Select Gold Plating

Molex Part Number: **08-55-0129**
L x W = 0.44” x 0.76” (11.2 mm x 1.93 mm)

MECHANICAL SPECIFICATIONS -- HEATSINK

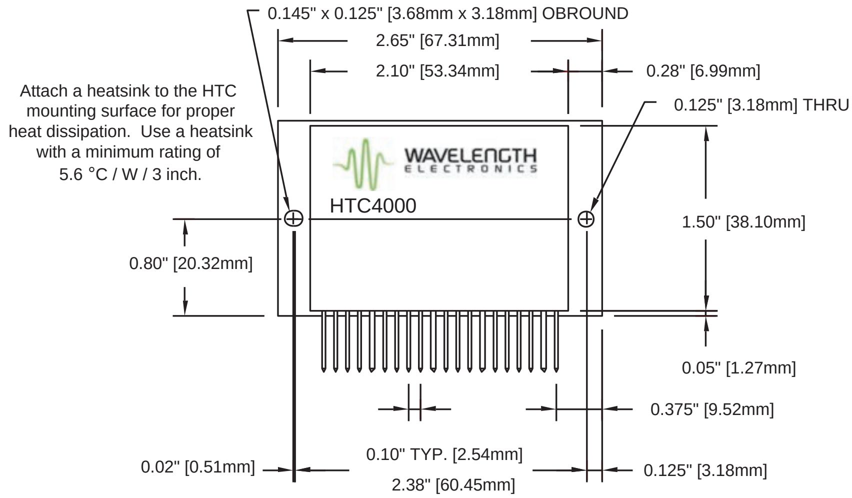
Wavelength Electronics P/N HTCHTSK shown.

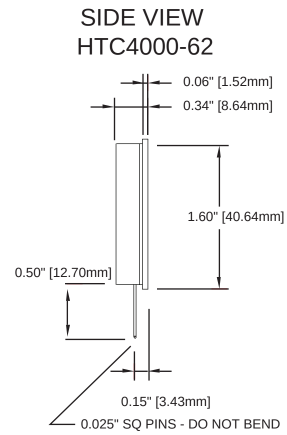


All Tolerances are ±5%

MECHANICAL SPECIFICATIONS -- HTC

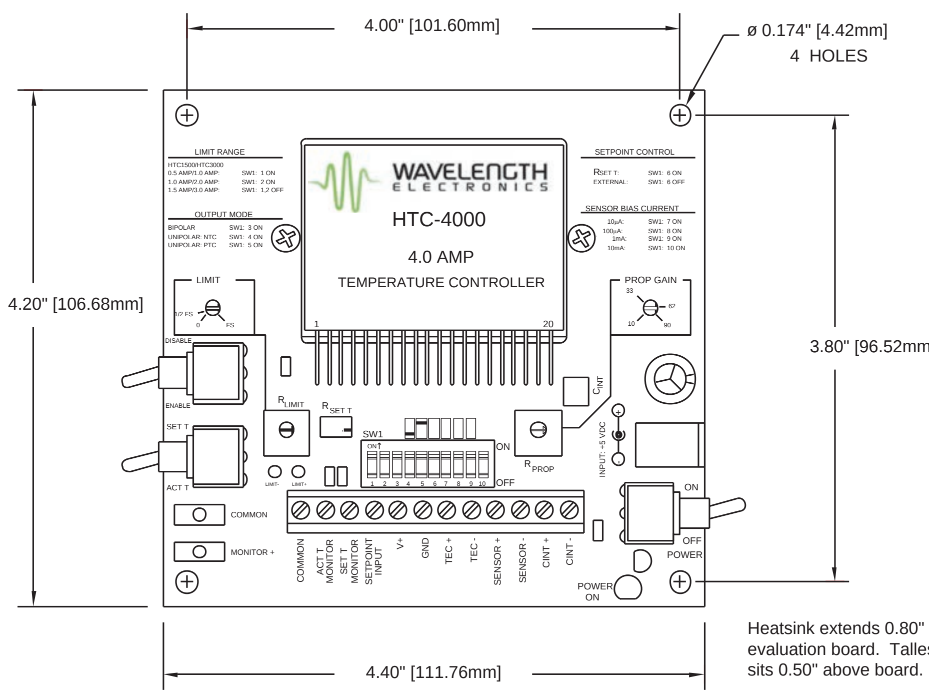
TOP VIEW (All models)





The HTCEVALPCB board is 0.062” thick.

Use HTC4000-62 with 0.062” thick boards.



Heatsink extends 0.80" behind evaluation board. Tallest component sits 0.50" above board.

PCB is 0.062” thick.

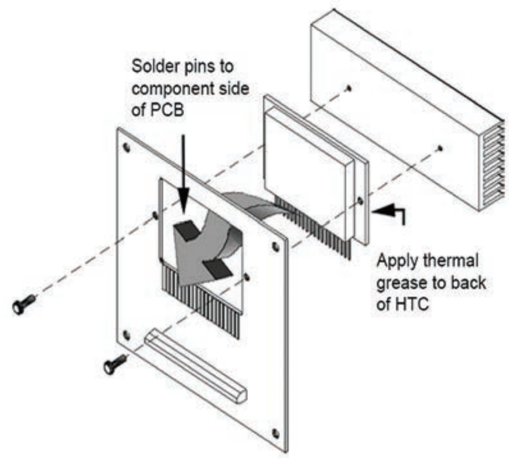
All Tolerances are ±5%

To mount the HTC4000 to the heatsink and optional evaluation PCB, refer to the drawings and instructions below:

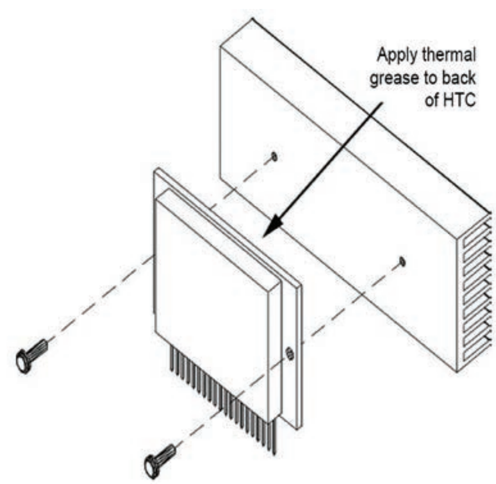
MOUNTING INSTRUCTIONS

Begin by applying thermal grease to the back of the HTC to ensure good thermal contact. We recommend Wavelength Electronics part number THERM-PST.

1. Feed the HTC pins through the large opening in the HTCEVALPCB board so that the HTC pins are on the top side of the evaluation board and the mounting tabs are against the back side of the board.
2. Line up the heatsink holes behind the HTC and insert the screws through the evaluation board and HTC unit into the tapped heatsink holes.
3. Line up the HTC pins on the solder pads on the evaluation board and tighten the screws.
4. Solder the HTC pins to the solder pads. NOTE: Do not exceed 700°F soldering temperature for more than 5 seconds on any pin.



If the HTC is to be used without the HTCEVALPCB board, apply the thermal grease as directed, line up the screw holes in the HTC and heatsink and attach with the supplied screws. Connect the HTC pins to your system by soldering them to the appropriate leads.



CERTIFICATION AND WARRANTY

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.

No other warranty is expressed or implied. Wavelength specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

EXCLUSIVE REMEDIES:
The remedies provided herein are the Buyer's sole and exclusive remedies. Wavelength shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

REVERSE ENGINEERING PROHIBITED:
Buyer, End-User, or Third-Party Reseller are expressly prohibited from reverse engineering, decompiling, or disassembling this product.

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SAFETY:
There are no user serviceable parts inside this product. Return the product to Wavelength for service and repair to ensure that safety features are maintained.

LIFE SUPPORT POLICY:
As a general policy, Wavelength Electronics, Inc. does not recommend the use of any of its products in life support applications where the failure or malfunction of the Wavelength product can be reasonably expected to cause failure of the life support device or to significantly affect its safety or effectiveness. Wavelength will not knowingly sell its products for use in such applications unless it receives written assurances satisfactory to Wavelength that the risks of injury or damage have been minimized, the customer assumes all such risks, and there is no product liability for Wavelength. Examples of devices considered to be life support devices are neonatal oxygen analyzers, nerve stimulators (for any use), auto transfusion devices, blood pumps, defibrillators, arrhythmia detectors and alarms, pacemakers, hemodialysis systems, peritoneal dialysis systems, ventilators of all types, and infusion pumps as well as other devices designated as "critical" by the FDA. The above are representative examples only and are not intended to be conclusive or exclusive of any other life support device.

REVISION HISTORY

REVISION	DATE	NOTES
REV. B	November 2012	Updated specifications, installation and operating instructions from Beta release

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