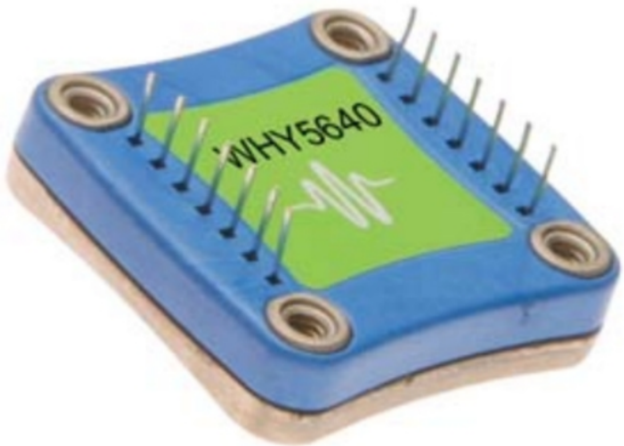
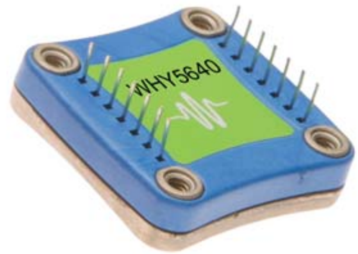

WHY5640

May, 2014

WAVELENGTH ELECTRONICS

WHY5640

Subminiature Temperature Controller



(BOTTOM VIEW)

RoHS Compliant

GENERAL DESCRIPTION:

The WHY5640 is a general purpose analog PI (Proportional, Integral) control loop for use in thermoelectric or resistive heater temperature control applications. The WHY5640 maintains precision temperature regulation using an active resistor bridge circuit that operates directly with thermistors or RTD temperature sensors. Supply up to 2.2 Amps of heat and cool current to your thermoelectric from a single +5 Volt power supply.

Connect two or more WHY5640 units together and drive higher output currents.

FEATURES:

- +5 to +26 V Control Electronics Supply
- +4.5 to +30 V Power Drive Supply
- Low Cost
- 0.008˚C Stability (typical)
- PI Temperature Control
- High ±2.2 Amps Output Current
- Control Above and Below Ambient
- Small Package Size

Online SOA Calculator at
http://www.teamwavelength.com/support/calculator/soa/soatc.php

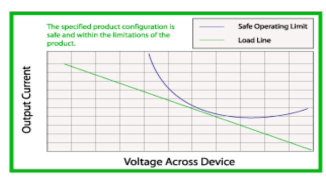
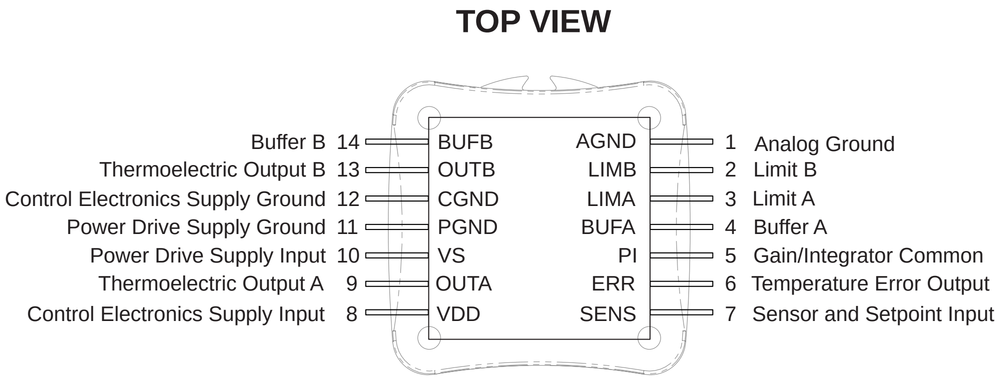


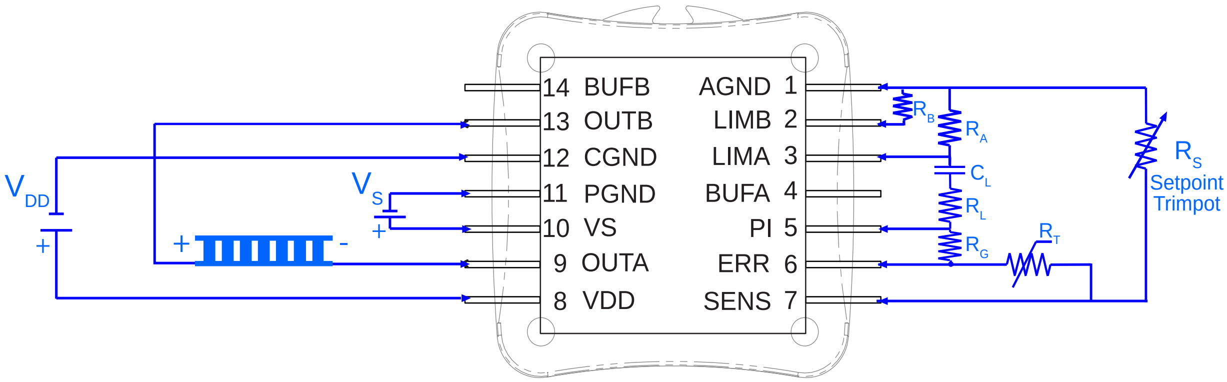
Figure 1

Top View Pin Layout
and Descriptions



IF YOU ARE UPGRADING FROM THE WHY5640 to the WTC3243: The position of Pin 1 on the WHY5640 is reversed (or mirrored) relative to the position of Pin 1 on the WTC3243.

Figure 2
QUICK CONNECT --
External Connections with
Thermistor Operation



Component Symbol	Purpose	Page Reference
C_L	Integrator Time Constant Adjust Capacitor (PI)	12
R_A	Current Limit Set Resistor (Limit A)	6
R_B	Current Limit Set Resistor (Limit B)	6
R_G	Integrator Time Constant Adjust Resistor (PI)	12
R_L	Proportional Gain Adjust Resistor (PI)	12
R_S	Setpoint Resistor	7
R_T	Thermistor	7

V_S and V_{DD} may be separate supplies or a single supply.

ELECTRICAL AND OPERATING SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS RATING	SYMBOL	VALUE	UNIT
Supply Voltage 1 (Voltage on Pin 8)	V_{DD}	+5 to +26	Volts DC
Supply Voltage 2 (Voltage on Pin 10)	V_S	+4.5 to +30	Volts DC
Output Current (See SOA Chart)	I_S	±2.2	Amperes
Power Dissipation, $T_{AMBIENT}$ = +25˚C	P_{MAX}	9	Watts
Operating Temperature, case	T_{OPR}	-40 to +85	˚C
Storage Temperature	T_{STG}	-65 to +150	˚C

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
TEMPERATURE CONTROL					
Short Term Stability, 1 hour	T_{SET} = 25˚C using 10 kΩ thermistor	0.001	0.005	0.01	˚C
Long Term Stability, 24 hour	T_{SET} = 25˚C using 10 kΩ thermistor	0.003	0.008	0.01	˚C
Setpoint vs. Actual Temp Accuracy	T_{SET} = 25˚C using 10 kΩ thermistor		<1%		
Control Loop		P	PI		
P (Proportional Gain)		1		100	A/V
I (Integrator Time Constant)		1		10	Sec.
OUTPUT					
Current, peak, see SOA chart			± 2.0	± 2.2	Amps
Compliance Voltage, Pin 9 to Pin 13	Full Temp. Range, I_S = 100 mA	$\|V_S - 0.7\|$	$\|V_S - 0.5\|$		Volts
Compliance Voltage, Pin 9 to Pin 13	Full Temp. Range, I_S = 1 Amp	$\|V_S - 1.2\|$	$\|V_S - 1.0\|$		Volts
Compliance Voltage, Pin 9 to Pin 13	Full Temp. Range, I_S = 2 Amps	$\|V_S - 1.6\|$	$\|V_S - 1.4\|$		Volts
POWER SUPPLY					
Voltage, V_S		4.5		30	Volts
Voltage, V_{DD}		5		26	Volts
Current, V_S supply, Quiescent			45	90	mA
Current, V_{DD} supply, Quiescent			10	15	mA
INPUT					
Offset Voltage, initial	Pin 5 and 7		1	2	mV
Bias Current	Pins 5 and 7, $T_{AMBIENT}$ = 25˚C		20	50	nA
Offset Current	Pins 5 and 7, $T_{AMBIENT}$ = 25˚C		2	10	nA
Common Mode Range	Pins 5 and 7, Full Temp. Range	0		V_{DD}-1.5	V
Common Mode Rejection	Full Temperature Range	60	85		dB
Power Supply Rejection	Full Temperature Range	60	80		dB
Input Impedence			500		kΩ
THERMAL					
Heatspreader Temperature Rise	$T_{AMBIENT}$ =25˚C	28	30	33	˚C/W
Heatspreader Temperature Rise	With WHS302 Heatsink, WTW002 Thermal Washer	18	21.5	25	˚C/W
Heatspreader Temperature Rise	With WHS302 Heatsink, WTW002 Thermal Washer, and 3.5 CFM Fan	3.1	3.4	3.9	˚C/W

PIN DESCRIPTIONS

PIN #	PIN	NAME	FUNCTION
1	AGND	Analog Ground	The analog ground connection is internally connected to Pins 11 and 12 (the power supply ground connections) and eliminates grounds loops for stable operation of the sensor amplifier bridge and limit current resistors.
2	LIMB	LIMIT B	A resistor connected between Pin 2 (LIMB) and Pin 1 (AGND) sets the maximum output current drawn from the Pin 10 (V_S) supply input and delivered to Pin 13 (OUTB). This is cooling current when used with NTC sensors.
3	LIMA	LIMIT A	A resistor connected between Pin 3 (LIMA) and Pin 1 (AGND) sets the maximum output current drawn from the Pin 10 (V_S) supply input and delivered to Pin 9 (OUTA). This is heating current when used with NTC sensors. Also connect integrator capacitor C_L to Pin 3 (LIMA) when operating the WHY5640 as a standard PI controller.
4	BUFA	BUFFER A	Connect Pin 4 (BUFA) to Pin 3 (LIMA) of another WHY5640 when operating the devices in a master/slave configuration.
5	PI	Proportional Gain/ Integrator Common	When using the WHY5640 as a standard PI controller, connect one end of the proportional gain resistors R_G and R_L to Pin 5 (PI).
6	ERR	Temperature Error Input	When using the WHY5640 as a standard PI controller, connect one end of the proportional gain resistor R_G to Pin 6 (ERR).
7	SENS	Sensor and Setpoint Input	Pin 7 (SENS) is the common sensor bridge amplifier connection for the sensor, R_T, and setpoint, R_S, resistors.
8	VDD	Control Electronics Supply Input	Power supply input for the WHY5640's internal control electronics. Supply range input for this pin is +5 to +26 Volts DC.
9	OUTA	Thermoelectric Output A	Connect Pin 9 (OUTA) to the negative terminal on your thermoelectric when controlling temperature with Negative Temperature Coefficient thermistors. Connect Pin 9 (OUTA) to the positive thermoelectric terminal when using Positive Temperature Coefficient RTDs.
10	VS	Power Drive Supply Input	Provides power to the WHY5640 H-Bridge Power Stage. Supply range input for this pin is +4.5 to +30 Volts DC. The maximum current drain on this terminal should not exceed 2.5 Amps.
11	PGND	Power Drive Supply Ground	Connect the V_S power supply ground connection to Pin 11 (PGND). Pin 11 (PGND) and Pin 12 (CGND) are internally connected.
12	CGND	Control Electronics Supply Ground	Connect the V_{DD} supply ground connection to Pin 12 (CGND). Pin 12 (CGND) and Pin 11 (PGND) are internally connected.
13	OUTB	Thermoelectric Output B	Connect Pin 13 (OUTB) to the positive terminal on your thermoelectric when controlling temperature with Negative Temperature Coefficient thermistors. Connect Pin 13 (OUTB) to the negative thermoelectric terminal when using Positive Temperature Coefficient RTDs.
14	BUFB	Buffer B	Connect Pin 14 (BUFB) to Pin 2 (LIMB) of another WHY5640 when operating the devices in a master/slave configuration.

IF YOU ARE UPGRADING FROM THE WHY5640 to the WTC3243: The position of Pin 1 on the WHY5640 is reversed (or mirrored) relative to the position of Pin 1 on the WTC3243.

SAFE OPERATING AREA & HEATSINK REQUIREMENTS

Caution:

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

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_S = 12 volts

V_{LOAD} = 5 volts }These values are determined from the specifications of the TEC or resistive heater

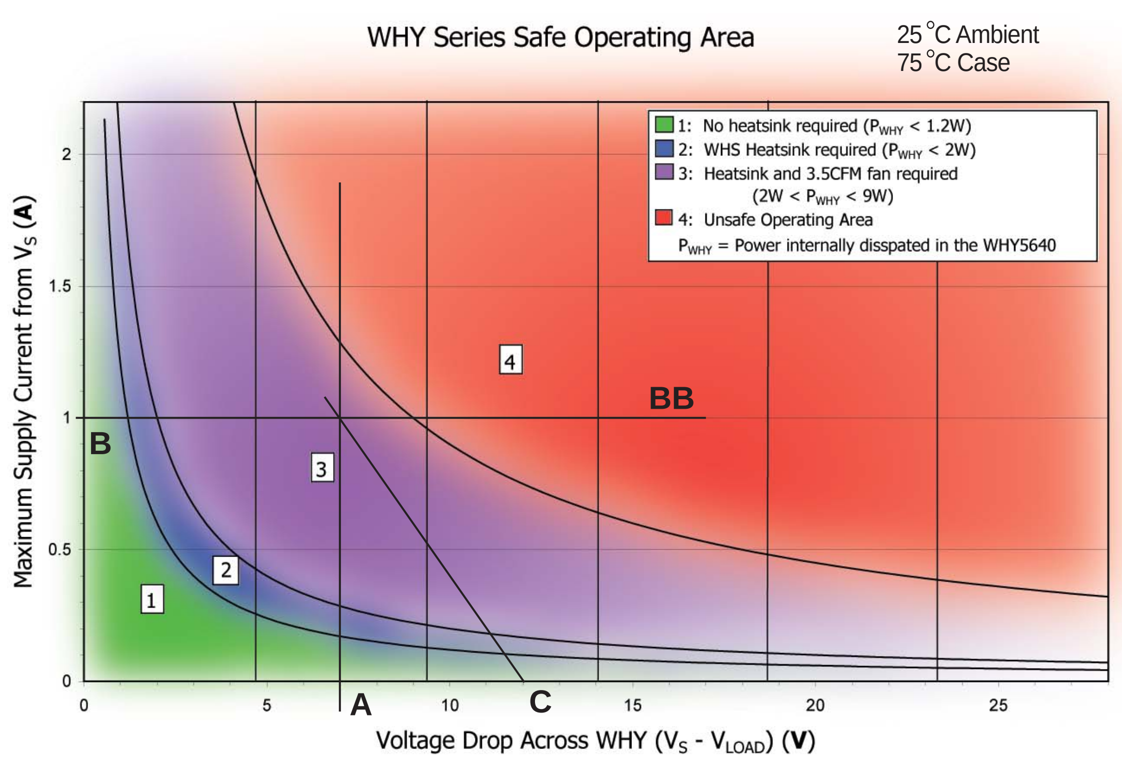
I_{LOAD} = 1 amp

Follow these steps:

1. Determine the maximum voltage drop across the controller, V_S - 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: (1 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_S 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.

Refer to the chart shown below and note that the Load Line is in the Unsafe Operating Areas for use with no heatsink (1) or the heatsink alone (2), but is outside of the Unsafe Operating Area for use with heatsink and Fan (3).

An online tool for calculating your load line is at http://www.teamWavelength.com/support/calculator/soa/soatc.php.



OPERATION

1. CONFIGURING HEATING AND COOLING CURRENT LIMITS

Refer to Table 1 to select appropriate resistor values for R_A and R_B.

Setting Current Limits Independently Using Trimpots

The 5 kΩ trimpots shown in Figure 3 adjust the maximum output currents from 0 to 2.3 Amps

Heat and Cool Current Limits

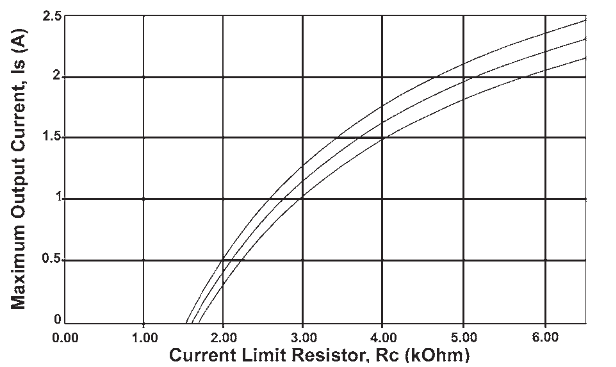


Table 1
Current Limit Set Resistor vs Maximum Output Current

Maximum Output Current (Amps)	Maximum Output Current (kΩ) R_A, R_B
0.0	1.60
0.1	1.69
0.2	1.78
0.3	1.87
0.4	1.97
0.5	2.08
0.6	2.19
0.7	2.31
0.8	2.44
0.9	2.58
1.0	2.72
1.1	2.88
1.2	3.05
1.3	3.23
1.4	3.43
1.5	3.65
1.6	3.88
1.7	4.13
1.8	4.42
1.9	4.72
2.0	5.07
2.1	5.45
2.2	5.88
2.3	6.36

Figure 3
Fixed Heat and Cool Current Limits

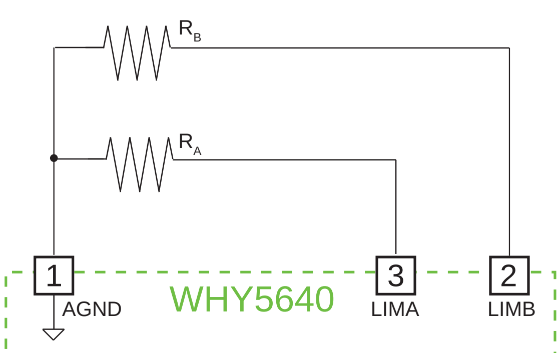
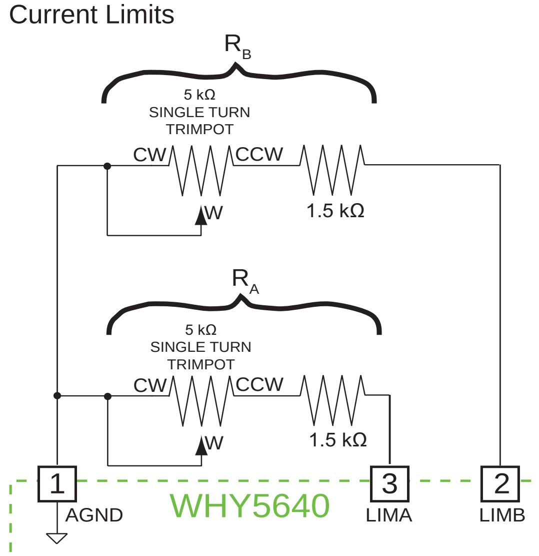


Figure 4
Independently Adjustable Heat and Cool Current Limits



2. RESISTIVE HEATER TEMPERATURE CONTROL

The WHY5640 can operate resistive heaters by disabling the cooling output current. When using Resistive Heaters with NTC thermistors, connect Pin 3 (LIMA) to Pin 1 (AGND) with a 1.5 kΩ resistor.

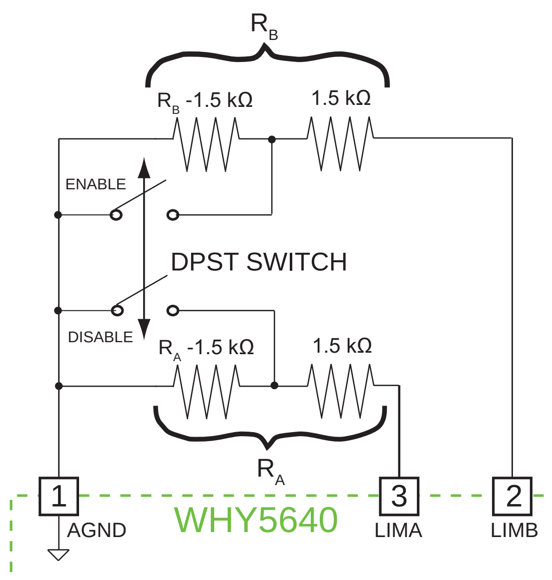
Connect Pin 2 (LIMB) to Pin 1 (AGND) with a 1.5 kΩ resistor when using RTDs, LM335 type and AD590 type temperature sensors with a resistive heater.

3. DISABLING THE OUTPUT CURRENT

The output current can be enabled and disabled, as shown in Figure 5, using a DPST (Double Pole–SingleThrow) switch.

Figure 5

Disabling Output Current



4. OPERATING WITH THERMISTOR SENSORS

Figure 6 illustrates how to connect the WHY5640 for operation with NTC (Negative Temperature Coefficient) thermistors.

Connect a setpoint resistor, R_S, (or trimpot) across Pins 1 (AGND) and 7 (SENS). Connect the thermistor, R_T across Pins 6 (ERR) and 7 (SENS).

Select setpoint resistor, R_S, equal to the thermistor resistance at the desired operating temperature.

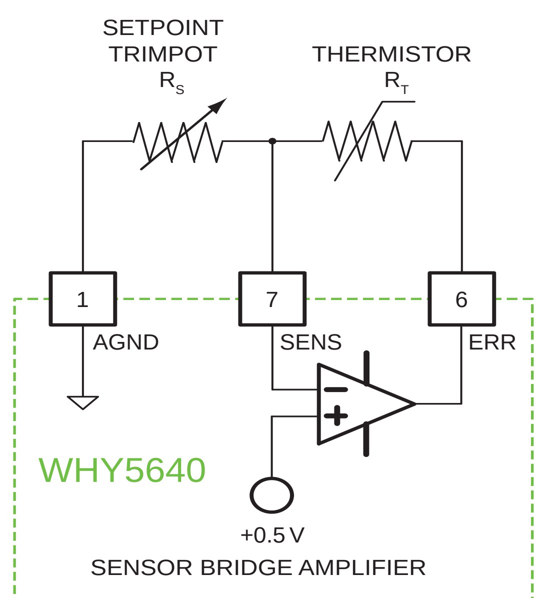
When the setpoint resistor, R_S, and thermistor, R_T, are equal resistance values the Sensor Bridge Amplifier is balanced and the voltage on Pin 6 (ERR) will equal 1 Volt with reference to Pin 1 (AGND).

If the setpoint resistor, R_S, is larger than the thermistor resistance, R_T, then the control loop will produce a cooling current since the temperature sensed by the thermistor is above (hotter than) the setpoint temperature.

If the setpoint resistor, R_S, is smaller than the thermistor resistance, R_T, then the control loop will produce a heating current since the temperature sensed by the thermistor is below (cooler than) the setpoint temperature.

Figure 6

Thermistor Operation



5. USING AN EXTERNAL SETPOINT VOLTAGE WITH THERMISTOR SENSORS

Figure 7 illustrates how to connect the WHY5640 for operation with NTC (Negative Temperature Coefficient) thermistors using an external setpoint voltage to control the desired operating temperature. This setup is useful when operating the WHY5640 in a DAC controlled system.

Equation 1 illustrates how to determine the setpoint voltage, V_{IN}, given a desired thermistor resistance (temperature).

Resistor, R_1, is a fixed resistance value that can be used to scale or adjust the setpoint voltage, V_{IN}, allowing control above and below the ambient temperature. In most applications select resistor R_1 equal to two times the desired operating thermistor resistance, R_T.

NOTE: Pin 9 (OUTA) and Pin 13 (OUTB) must be swapped to maintain the proper heating and cooling current polarity through the thermoelectric. Pin 9 (OUTA) becomes the heating current sink and Pin 13 (OUTB) becomes the cooling current sink.

Example 1 demonstrates how to use an external voltage setpoint to control a 10 kΩ thermistor from a range of 20 kΩ to 0 kΩ.

Figure 8 illustrates the setpoint voltage, V_{IN}, versus thermistor resistance, R_T, for Example 1.

Example 1
Using a 10kΩ Thermistor with External Voltage Control

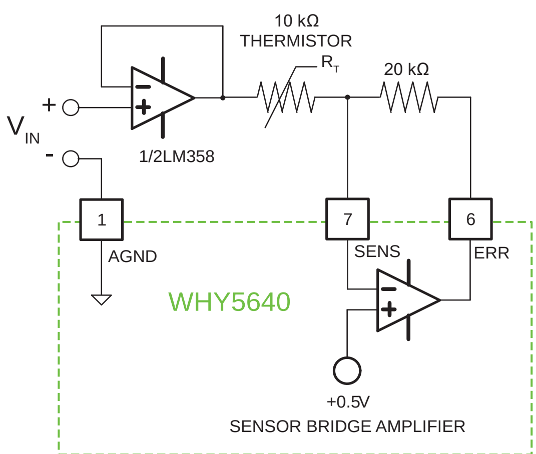
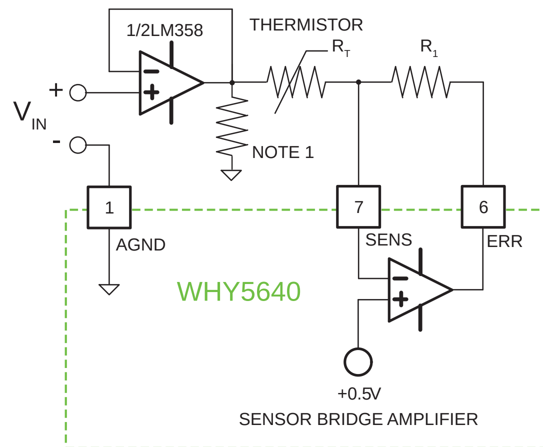


Figure 7
External Voltage Control Using Thermistor Sensors

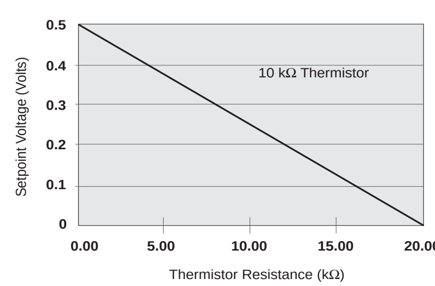


NOTE 1: If multiple units are controlled by the buffered op-amp, a 100 Ω resistor from the op-amp output to ground must be added.

Equation 1
Voltage Controlled Setpoint Using Thermistors

$$V_{IN} = 0.5 - \frac{R_T}{2R_1}$$

Figure 8
Example 1 Setpoint Voltage vs Thermistor Resistance



OPERATION, continued

6. OPERATING WITH RTD SENSORS

Figure 9 illustrates how to connect the WHY5640 for operation with PTC (Positive Temperature Coefficient) RTD sensors (Resistance Temperature Device). Resistors, R_2, should be chosen large enough to prevent self heating of the RTD due to the current flowing through it.

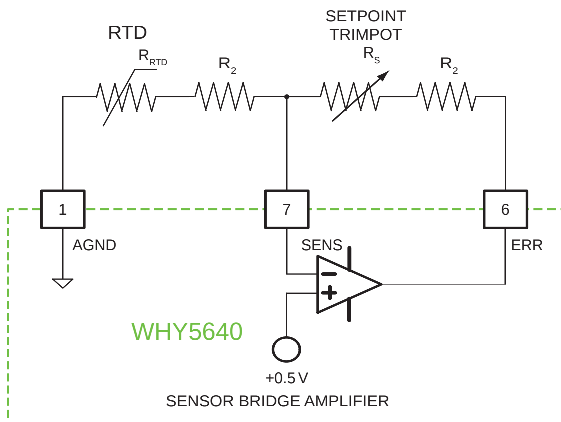
Select setpoint resistor, R_S, equal to the RTD resistance, R_{RTD}, at the desired operating temperature.

When the setpoint resistor, R_S, and RTD, R_{RTD}, are equal in value the Sensor Bridge Amplifier is balanced and the voltage on Pin 6 (ERR) will equal 1 Volt with reference to Pin 1 (AGND).

If the setpoint resistor, R_S, is larger than the RTD resistance, R_{RTD}, then the control loop will produce a heating current since the temperature sensed by the RTD is below (cooler than) the setpoint temperature.

If the setpoint resistor, R_S, is smaller than the RTD resistance, R_{RTD}, then the control loop will produce a cooling current since the temperature sensed by the RTD is above (hotter than) the setpoint temperature.

Figure 9
RTD Operation



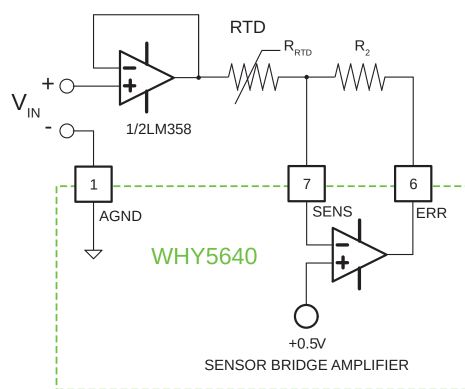
7. USING AN EXTERNAL SETPOINT VOLTAGE WITH RTD SENSORS

Figure 10 illustrates how to connect the WHY5640 for operation with PTC (Positive Temperature Coefficient) RTD sensors using an external setpoint voltage to control the desired operating temperature. This setup is useful when operating the WHY5640 in a DAC controlled system.

Equation 2 illustrates how to determine the set point voltage, V_{IN}, given a desired RTD resistance (temperature).

Resistor, R_2, is a fixed resistance value that can be used to scale or adjust the setpoint voltage, V_{IN}, allowing control above and below the ambient temperature. In most applications select resistor, R_2, equal to two times the desired operating RTD resistance, R_{RTD}.

Figure 10
External Voltage Control
Using RTD Sensors



Equation 2
Voltage Controlled Setpoint
Using RTD Sensors

$$V_{IN} = 0.5 - \frac{R_{RTD}}{2R_2}$$

Example 2 demonstrates how to use an external voltage setpoint to control a 100 Ω RTD from a range of 0 Ω to 200 Ω.

Figure 11 illustrates the setpoint voltage, V_{IN}, versus RTD resistance, R_{RTD}, for Example 2.

Example 2

Using a 100 Ω RTD with
External Voltage Control

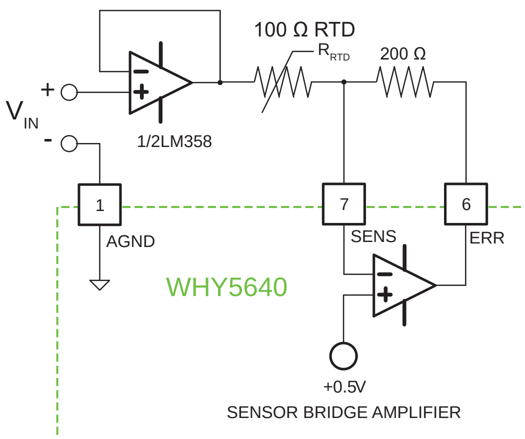
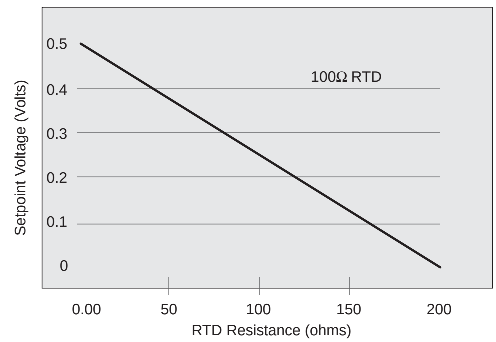


Figure 11

Example 2 Setpoint Voltage
vs. RTD Resistance



8. OPERATING WITH AD590 AND LM335 SENSORS

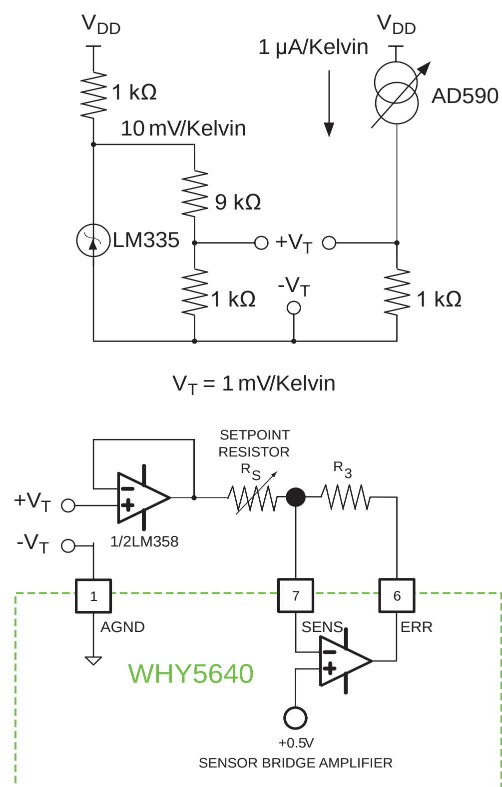
Figure 12 illustrates how to connect the WHY5640 for operation with PTC (Positive Temperature Coefficient) linear sensors AD590 and LM335.

Equation 3 illustrates how to determine the setpoint resistance, R_S, given a desired operating temperature measured in Celsius.

Resistor, R_3, is a fixed resistance value that can be used to scale or adjust the setpoint resistor, R_S. Select resistor R_3 equal to 10 kΩ for most applications.

Figure 12

AD590 and LM335
Operation



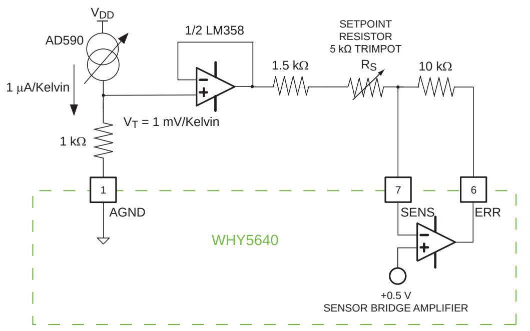
Equation 3

AD590 and LM335 Setpoint
Resistance Calculation

$$R_S = 2R_3[0.5 - (273.15 + T_{CELSIUS})(1mV / Kelvin)]$$

Example 3

Using an AD590 Example

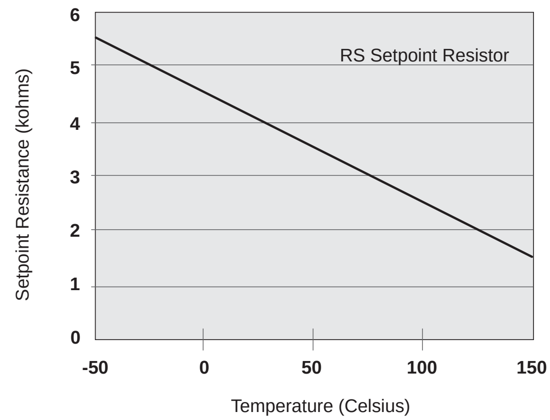


Example 3 demonstrates how to use an AD590 to control from –50˚C to +150˚C.

Figure 13 illustrates the setpoint resistance, V_{IN}, versus AD590 temperature, for Example 3.

Figure 13

Example 3 Setpoint Resistance vs AD590 Temperature



9. MONITORING SETPOINT AND ACTUAL SENSOR VOLTAGES

Figure 13 illustrates how to configure the WHY5640 so the setpoint and actual sensor voltages can be monitored externally.

The WHY5640 internal sensor bridge amplifier becomes balanced (or Pin 6 (ERR) equals 1 Volt) when the sensor voltage equals the setpoint voltage in Figure 14.

The circuit shown in Figure 14 uses a constant current source to produce a sensing current through the resistive temperature sensors resulting in a sensor voltage. A typical sensing current for 20 kΩ and lower thermistors is 100 µA. For thermistors higher than 20 kΩ use 10 µA. RTDs require a sensing current of 1 mA.

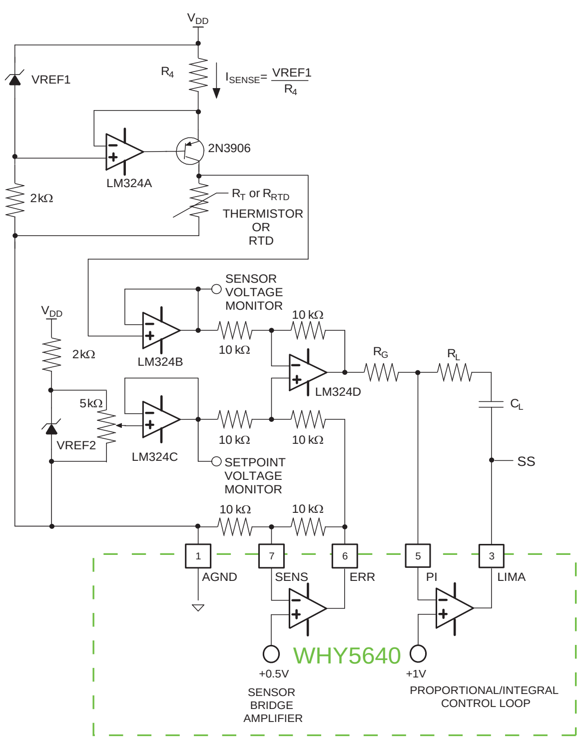
Note: PTC (Positive Temperature Coefficient) sensors such as RTD sensors, the AD590, and the LM335 require that the output Pins 9 (OUTA -) and 13 (OUTB +) be reversed from the connection diagram on page 2 (Figure 2) to produce the proper cooling and heating currents through the thermoelectric.

When using a 10K Thermistor, per Figure 14, connect the TEC as follows:

OUTPUT B+ ⟶ TEC -
OUTPUT A- ⟶ TEC +

Figure 14

Monitor Setpoint and Actual Sensor Voltages



10. ADJUSTING THE CONTROL LOOP PROPORTIONAL GAIN & INTEGRATOR TIME CONSTANT

The control loop parameters are set by the values of two resistors and a capacitor (R_G, R_L, and C_L; refer to page 2). All three components interact to set the proportional gain and the integrator time constant.

Recommended values for the three components are shown in Table 2 for common sensor and load combinations. A "fast" load can change temperature quickly; conversely a "slow" load is slower to respond to temperature change commands.

Equations for determining the proportional gain and integrator time constant are also provided in order to tune the controller to a variety of load conditions not covered in Table 2.

The relationship between the three components is summarized by the gain-integrator product, k_T, in Equation 6.

Equation 4
Calculating the Proportional Gain, k_P

$$k_P = 4\left(\frac{R_L}{R_G}\right) \textit{ amps / volt}$$

Equation 5
Calculating the Integrator Time Constant, t_C

$$t_C = \left(\frac{R_G C_L}{4}\right) \textit{ seconds}$$

Equation 6
Relationship between k_P, t_C and k_T

$$k_T = k_P t_C \quad \textit{amp•seconds / volt}$$

Table 2
Recommended Gain and Integrator Values

Sensor Type/ Thermal Load Speed	Gain [k_P]	Integrator Time Constant [t_C, seconds]	R_G	R_L	C_L
Thermistor / Fast	5	3	800 kΩ	1.0 MΩ	15 µF
Thermistor / Slow	20	4.5	400 kΩ	2.0 MΩ	47 µF
RTD / Fast	50	0.53	144 kΩ	1.8 MΩ	15 µF
RTD / Slow	100	1	88 kΩ	2.2 MΩ	47 µF
AD590 or LM335 / Fast	20	1	400 kΩ	2.0 MΩ	10 µF
AD590 or LM335 / Slow	50	4.5	320 kΩ	4.0 MΩ	15 µF

Equation 6 can be related to component values by algebraic substitution, as shown in Equation 7.

Equation 7

Relating k_T to component values

$$k_T = C_L R_L \quad \textit{amp•seconds / volt}$$

The value of R_G is then calculated by using either Equation 8 or Equation 9:

Equation 8

Relating k_T to component values

$$R_G = \left(\frac{4R_L}{k_P} \right) \quad \textit{ohms}$$

Equation 9

Relating k_T to component values

$$R_G = \left(\frac{4t_C}{C_L} \right) \quad \textit{ohms}$$

When calculating component values, keep in mind these points:

1. As k_T becomes larger, choosing component values becomes more difficult because larger C_L values are required.
2. Keep R_L as small as possible; higher values of R_L are more noisy, and values above 4 MΩ will impact temperature control stability.
3. As R_L becomes smaller, C_L must be larger. Use a non-polarized capacitor for C_L; we recommend a ceramic capacitor, particularly for surface mount applications. SMT ceramic capacitors greater than 47 μF are less commonly available.

11. FINE TUNING R_G, R_L, AND C_L

The R_G, R_L, and C_L component values can be fine-tuned experimentally. Start with component values from Table 2, and operate the temperature controller system to determine if the load temperature settling time is satisfactory. If it is not, then follow these steps to fine-tune the component values.

1. Short C_L to remove the integrator term.
2. Increase the proportional gain k_P by increasing R_L until the temperature begins to oscillate; this is the Critical Gain value of the system. Measure the period of the oscillations in seconds.
3. Decrease R_L by half.
4. Use Equation 5 to calculate R_G and C_L so that the value of t_C is slightly greater than the oscillation period measured above.

12. INCREASING OUTPUT CURRENT DRIVE

The WHY5640 is specifically designed to operate in a master/slave output current boosting configuration. Two or more WHY5640 controllers can be coupled to boost the output current.

Figure 15 shows how to connect two WHY5640 controllers together to increase the output current drive to 4.4 Amps.

Pin 4 (BUFA) and Pin 14 (BUFB) provide buffered outputs of Pin 3 (LIMA) and Pin 2 (LIMB), respectively. The slave controller is controlled by the master controller by connecting Pin 4 (BUFA) of the master unit to Pin 3 (LIMA) of the slave unit. Similarly, Pin 14 (BUFB) of the master unit then connects to Pin 2 (LIMB) of the slave unit.

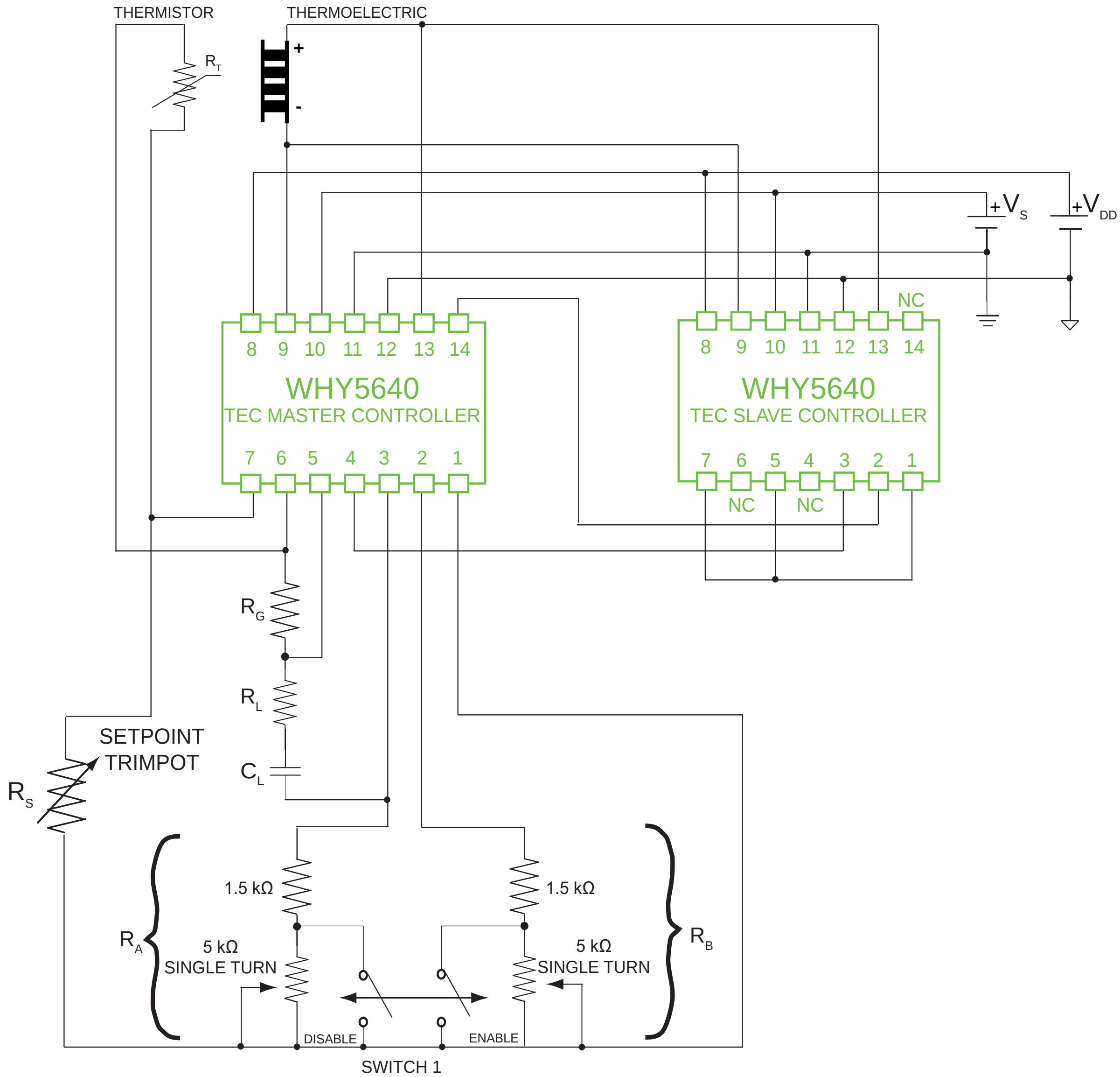
Each successive slave unit uses its buffered out-puts, Pins 4 and 14, to drive the next slave units output drive section via its Pins 3 and 2. The master controller sets the current limits for all successive slave controllers connected to the master controller, requiring only one set of heat and cool limit resistors.

Use Table 3 to determine the limit setting resistors, R_A and R_B , based on the number of WHY5640 controllers paralleled together.

Table 3
Current Limit Set Resistor vs
Maximum Output Current vs Number of
Paralleled WHY5640 Controllers.

Maximum Output Current (Amps)					
1 WHY5640 Controller	2 WHY5640 Controllers	3 WHY5640 Controllers	4 WHY5640 Controllers	5 WHY5640 Controllers	Current Limit Set Resistor (kΩ)
0	0	0	0	0	1.60
0.1	0.2	0.3	0.4	0.5	1.69
0.2	0.4	0.6	0.8	1	1.78
0.3	0.6	0.9	1.2	1.5	1.87
0.4	0.8	1.2	1.6	2	1.97
0.5	1	1.5	2	2.5	2.08
0.6	1.2	1.8	2.4	3	2.19
0.7	1.4	2.1	2.8	3.5	2.31
0.8	1.6	2.4	3.2	4	2.44
0.9	1.8	2.7	3.6	4.5	2.58
1	2	3	4	5	2.72
1.1	2.2	3.3	4.4	5.5	2.88
1.2	2.4	3.6	4.8	6	3.05
1.3	2.6	3.9	5.2	6.5	3.23
1.4	2.8	4.2	5.6	7	3.43
1.5	3	4.5	6	7.5	3.65
1.6	3.2	4.8	6.4	8	3.88
1.7	3.4	5.1	6.8	8.5	4.13
1.8	3.6	5.4	7.2	9	4.42
1.9	3.8	5.7	7.6	9.5	4.72
2	4	6	8	10	5.07
2.1	4.2	6.3	8.4	10.5	5.45
2.2	4.4	6.6	8.8	11	5.88
2.3	4.6	6.9	9.2	11.5	6.36

Figure 15
Boosting Output Current Drive



13. HELPFUL HINTS

Selecting a Temperature Sensor
Select a temperature sensor that is responsive around the desired operating temperature. The temperature sensor should produce a large sensor output for small changes in temperature. Sensor selection should maximize the voltage change per °C for best stability.

Table 4 compares temperature sensors versus their ability to maintain stable load temperatures with the WHY5640.

Mounting the Temperature Sensor
The temperature sensor should be in good thermal contact with the device being temperature controlled. This requires that the temperature sensor be mounted using thermal epoxy or some form of mechanical mounting and thermal grease.

Avoid placing the temperature sensor physically far from the thermoelectric. This is typically the cause for long thermal lag and creates a sluggish thermal response that produces considerable temperature overshoot.

Mounting the Thermoelectric
The thermoelectric should be in good thermal contact with its heatsink and load. Contact your thermoelectric manufacturer for their recommended mounting methods.

Table 4
Temperature Sensor Comparison of voltage change per degree C.

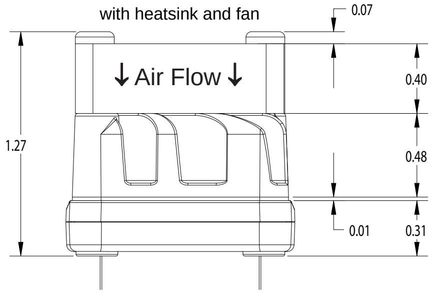
SENSOR	Thermistor	RTD	AD590	LM335
RATING	Best	Poor	Good	Good

Heatsink Notes
If your device stabilizes at temperature but then drifts away from the setpoint temperature towards ambient, you are experiencing a condition known as thermal runaway. This is caused by insufficient heat removal from the thermoelectric's hot plate and is most commonly caused by an undersized thermoelectric heatsink.

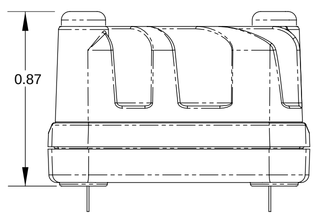
Ambient temperature disturbances can pass through the heatsink and thermoelectric and affect the device temperature stability. Choosing a heatsink with a larger mass will improve temperature stability.

MECHANICAL SPECIFICATIONS

with heatsink and fan



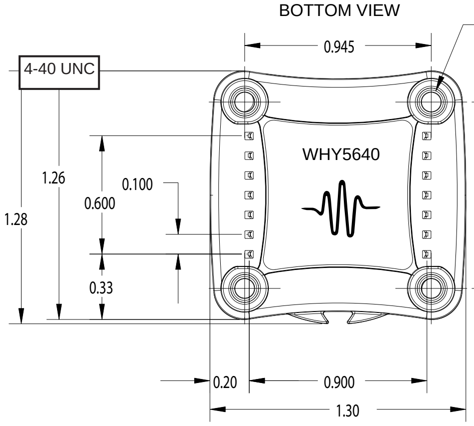
with heatsink

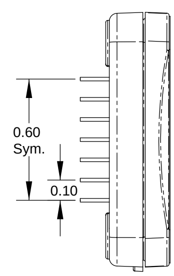


Weights

WHY5640	0.6 oz
WHS302 Heatsink	0.5 oz
WXC303/4 Fan	0.3 oz

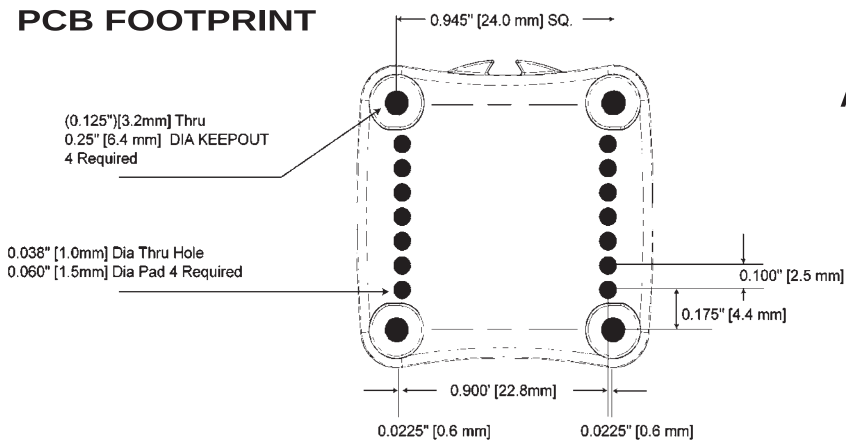
BOTTOM VIEW





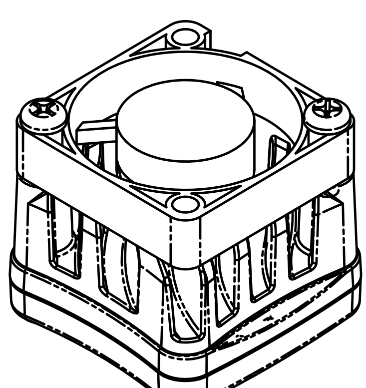
PIN DIAMETER: 0.020”
PIN LENGTH: 0.126”
PIN MATERIAL: Nickel Plated Steel
HEAT SPREADER: Nickel Plated Aluminum
PLASTIC COVER: LCP Plastic
ISOLATION: 1200 VDC any pin to case
THERMAL WASHER: WTW002
HEATSINK: WHS320
FANS: WXC303 (+5VDC)
or WXC304 (+12VDC)

PCB FOOTPRINT



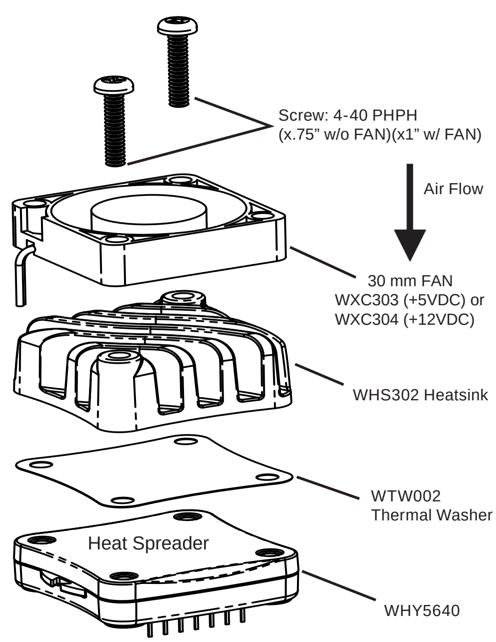
All tolerances are ±5%.

WHY5640 ASSEMBLED WITH HEATSINK & FAN



* Actual fan wire configuration may be different than shown.

Fan can be rotated on the WHY so the location of the wires matches your PCB layout.



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REVISION HISTORY

REVISION	DATE	NOTES
REV. H	Feb-08	Updated formatting
REV. I	31-Aug-09	Updated mechanical dimensions and links to support new website
REV. J	3-Jun-11	Added Quick Connect diagram
REV. K	16-Dec-11	Updated mechanical specifications
REV. L	2-Apr-12	Updated Proportional Gain and Integrator Time Constant calculations
REV. M	8-May-2014	Updated power supply specs