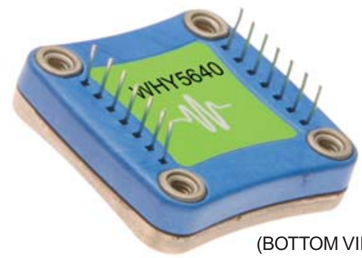
January 8, 2002

WAVELENGTH ELECTRONICS
ISO 9001 REGISTERED

WHY5640

Subminiature Temperature Controller



(BOTTOM VIEW)

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 Amps of heat and cool current to your thermoelectric from a single +5 Volt power supply.

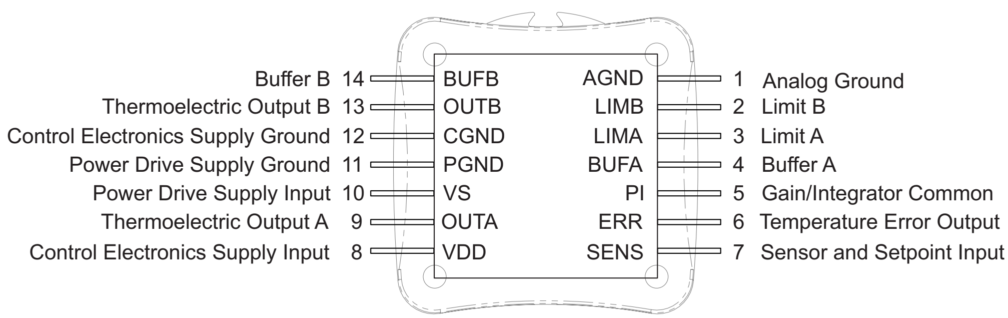
Connect two or more WHY5640 units together and drive higher output currents.

FEATURES:

- + 5 to + 28V Operation
- Low Cost
- 0.008 ˚C Stability (typical)
- PI Temperature Control
- High ± 2 Amps Output Current
- Control Above and Below Ambient
- Small Package Size

Figure 1
Top View Pin Layout
and Descriptions

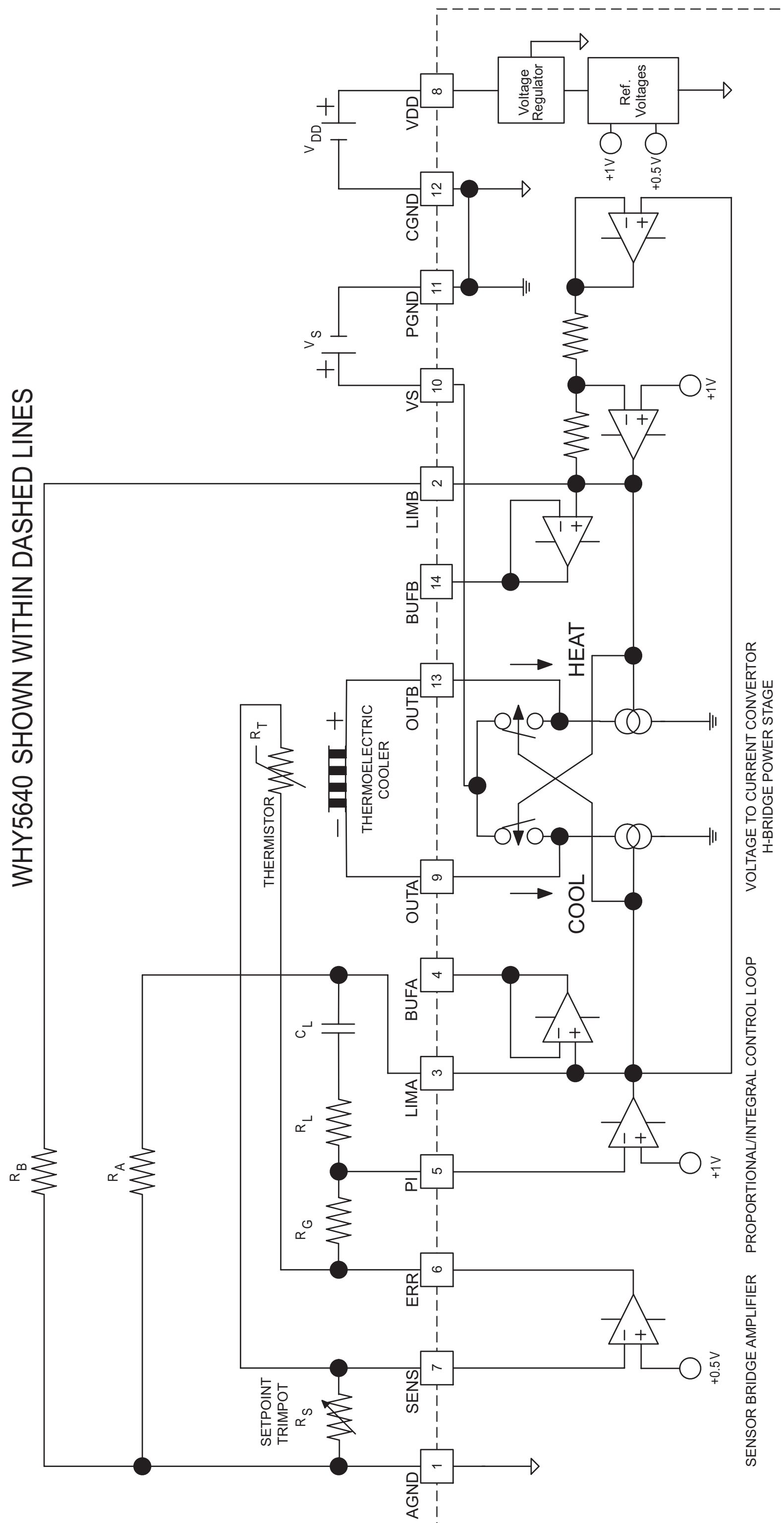
TOP VIEW



IF YOU ARE UPGRADE 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.

BLOCK DIAGRAM

External Connections
with Thermistor Operation



ELECTRICAL AND OPERATING SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS RATING	SYMBOL	VALUE	UNIT
Supply Voltage 1 (Voltage on Pin 8)	V_{DD}	+5 to +30	Volts DC
Supply Voltage 2 (Voltage on Pin 10)	V_S	+3 to +30	Volts DC
Output Current (See SOA Chart)	I_S	±2.5	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	± 2.5	Amps
Compliance Voltage, Pin 9 to Pin 13	Full Temp. Range, I_S = 100 mA	$\lvert V_S - 1.7 \rvert$	$\lvert V_S - 1.4 \rvert$		Volts
Compliance Voltage, Pin 9 to Pin 13	Full Temp. Range, I_S = 1 Amp	$\lvert V_S - 2.2 \rvert$	$\lvert V_S - 2.0 \rvert$		Volts
Compliance Voltage, Pin 9 to Pin 13	Full Temp. Range, I_S = 2 Amps	$\lvert V_S - 3.3 \rvert$	$\lvert V_S - 2.6 \rvert$		Volts
POWER SUPPLY					
Voltage, V_S		5		28	Volts
Voltage, V_{DD}		5		28	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 NO.	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) limits the output current drawn off the Pin 10 (VS) supply input and into Pin 13 (OUTB).
3	LIMA	LIMIT A	A resistor connected between Pin 3 (LIMA) and Pin 1 (AGND) limits the output current drawn off the Pin 10 (VS) supply input and into Pin 9 (OUTA). 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 +28 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 +5 to +28 Volts DC. The maximum current drain on this terminal should not exceed 2.5 Amperes.
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 UPGRADE 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.

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.

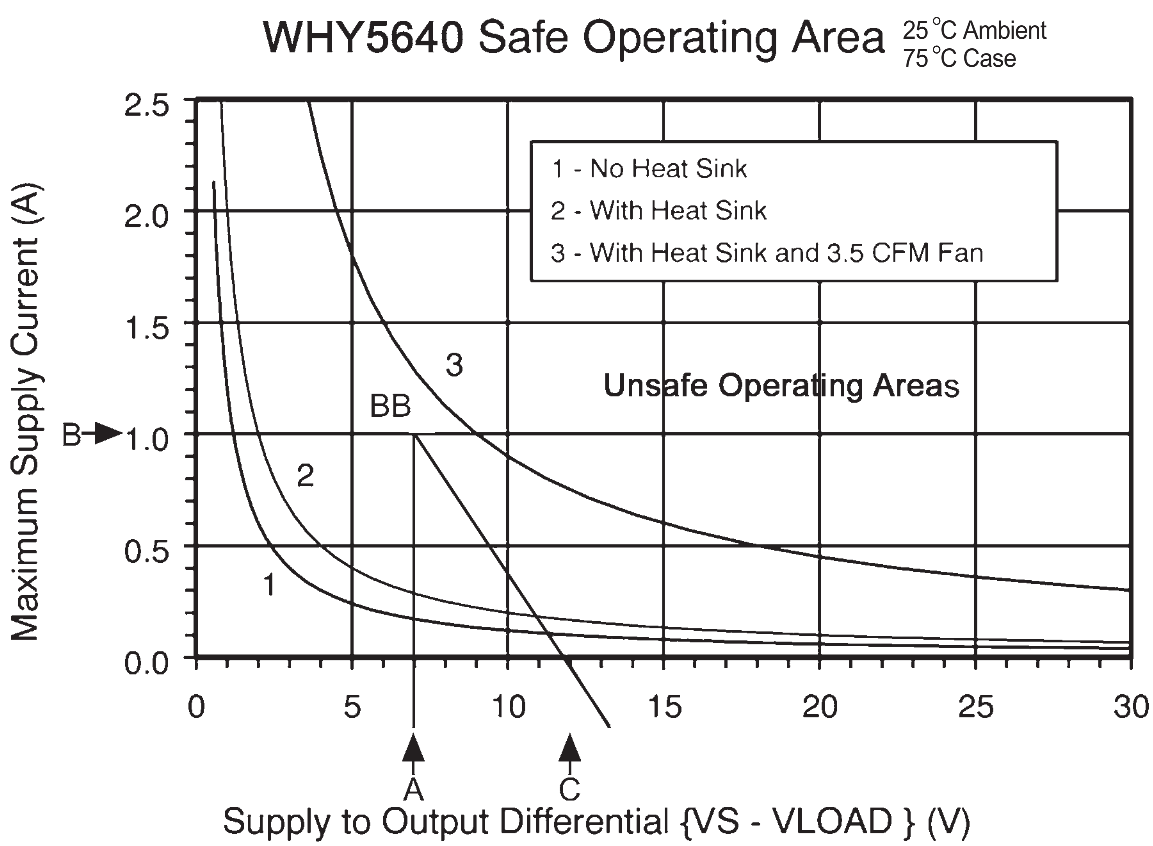
These values are used for the example SOA determination:

Vs= 12 volts
Vload = 5 volts
ILoad = 1 amp
} These values are determined from the specifications of the TEC or resistive heater

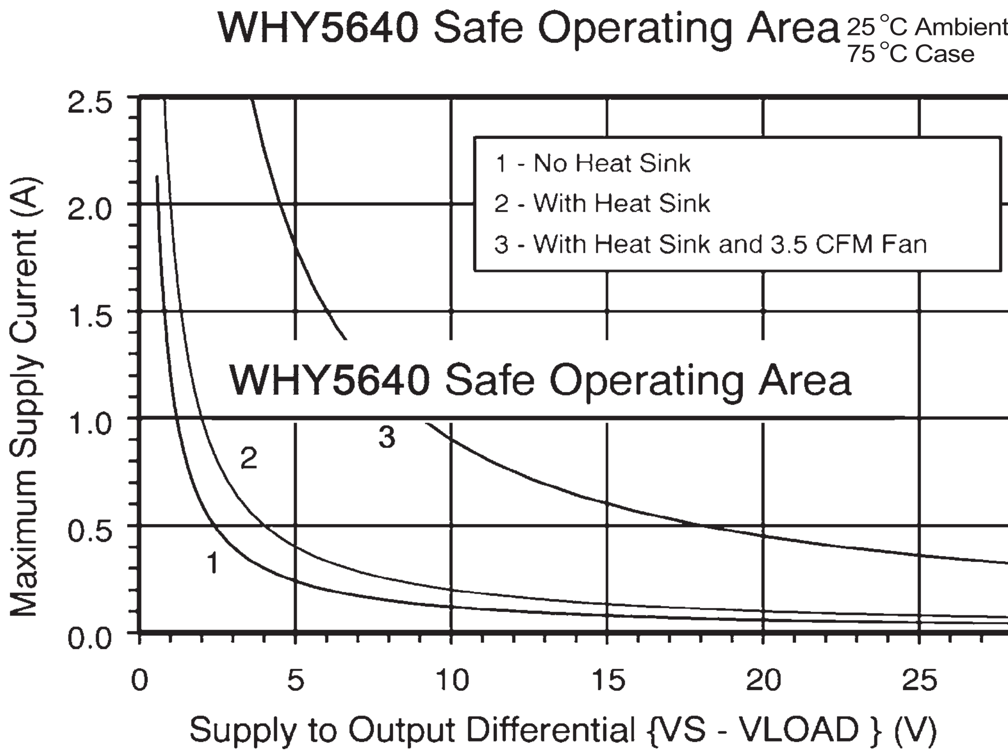
Follow these steps:

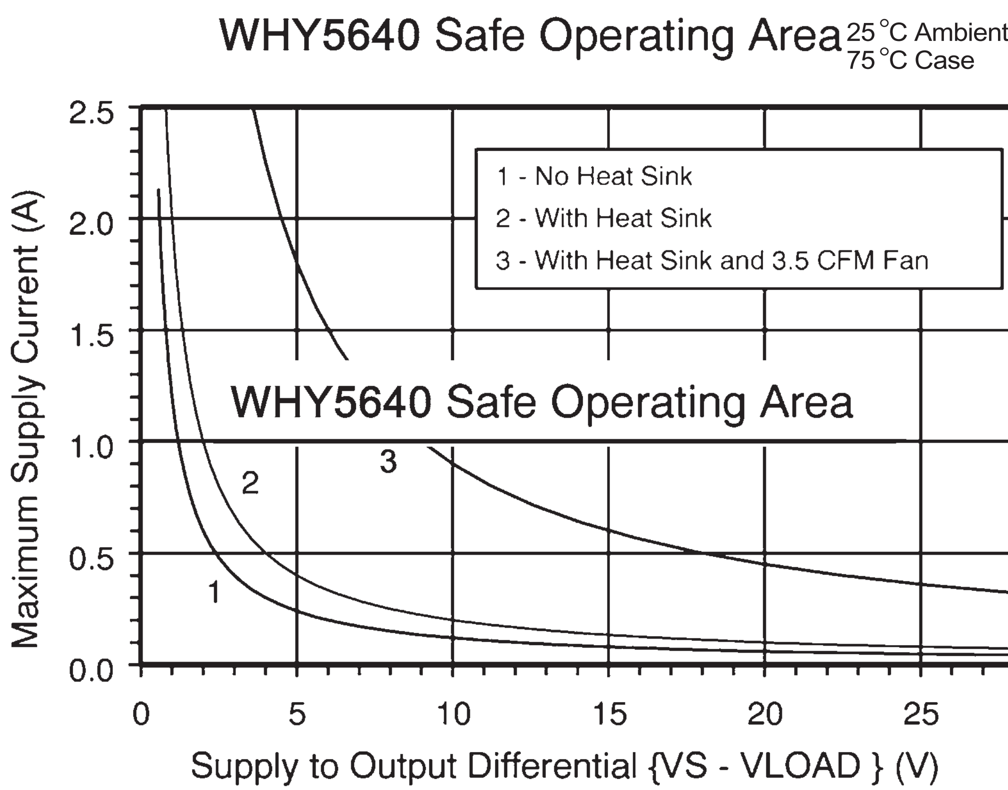
1. Determine the maximum voltage drop across the controller ,Vs-Vload, and mark on the X axis. (12volts - 5 volts = 7 volts, Point A)
2. Determine the maximum current, ILoad, through the controller and mark on the Y axis: (1 amp, Point B)
3. Draw a horizontal line through Point B across the chart. (Line BB)
4. Draw a vertical line from Point A to the maximum current line indicated by Line BB.
5. Mark Vs 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).



SOA Charts for Customer Use:





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

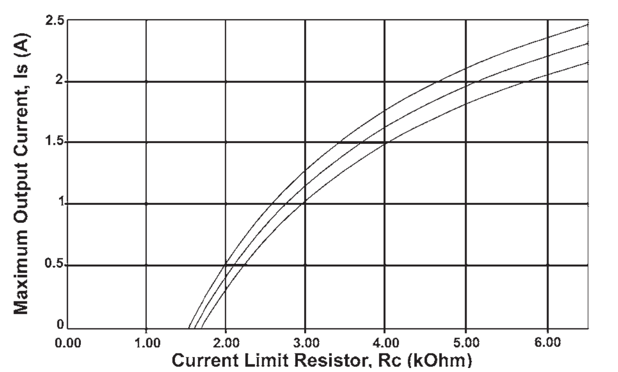


Table 1
Current Limit Set Resistor vs Maximum Output Current

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

Figure 2
Fixed Heat and Cool Current Limits

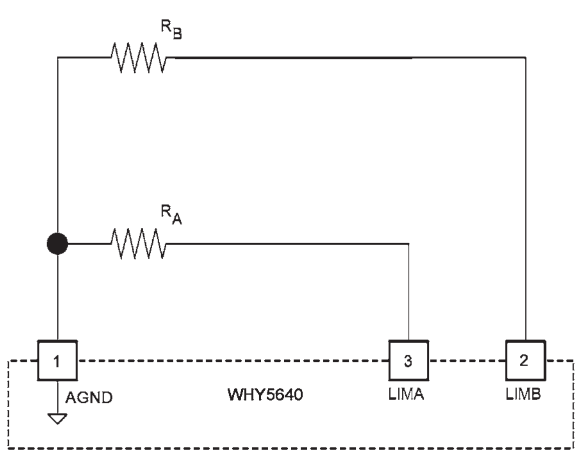
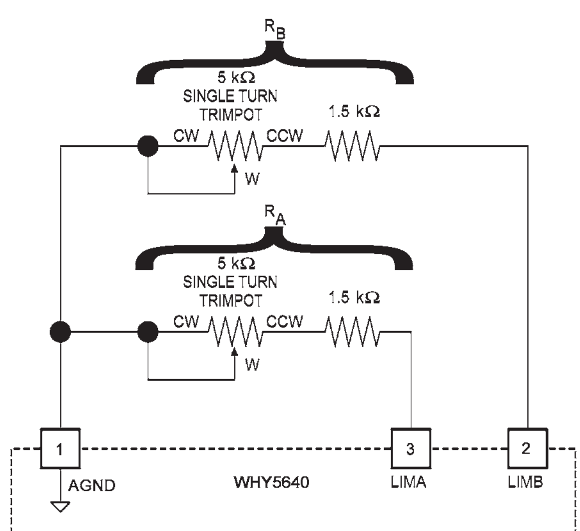


Figure 3
Independently Adjustable Heat and Cool Current Limits



OPERATION

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 RTD's, 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 DPDT (Double Pole–Double Throw) switch.

4. OPERATING WITH THERMISTOR SENSORS

Figure 5 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 4
Disabling Output Current

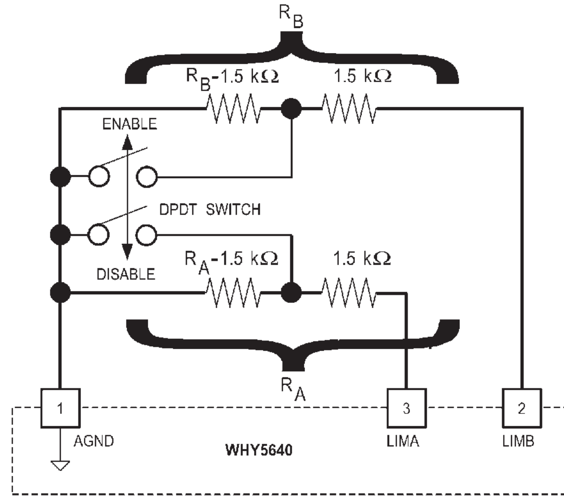
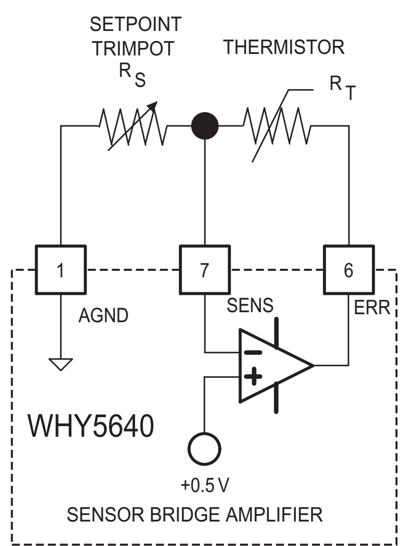


Figure 5
Thermistor Operation



OPERATION

5. USING AN EXTERNAL SETPOINT VOLTAGE WITH THERMISTOR SENSORS

Figure 6 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 7 illustrates the setpoint voltage, V_{IN}, versus thermistor resistance, R_T, for Example 1.

Example 1
Using a 10kΩ Thermistor with External Voltage Control

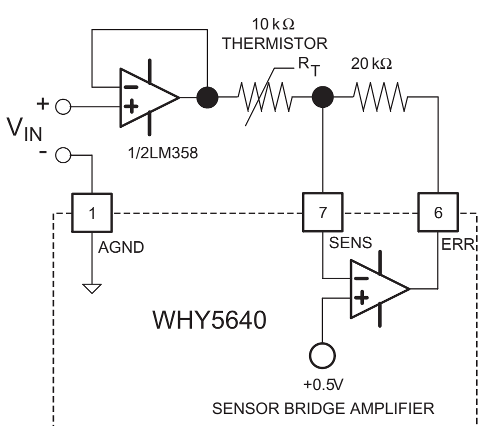
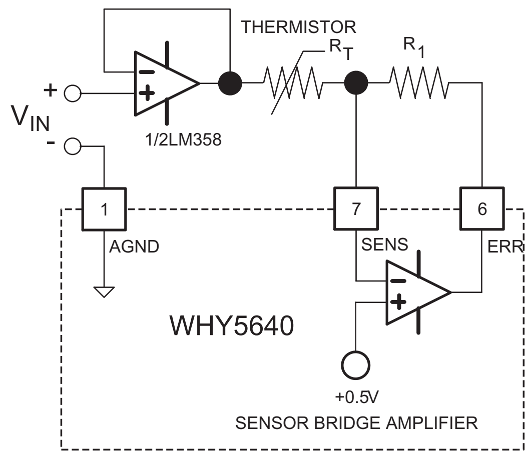


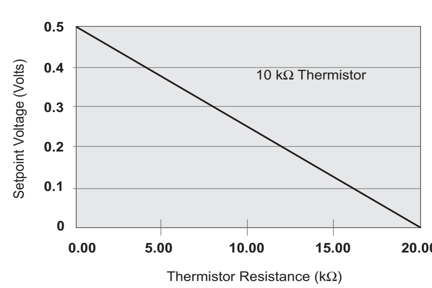
Figure 6
External Voltage Control Using Thermistor Sensors



Equation 1
Voltage Controlled Setpoint Using Thermistors

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

Figure 7
Example 1 Setpoint Voltage vs Thermistor Resistance



OPERATION

6. OPERATING WITH RTD SENSORS

Figure 8 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.

7. USING AN EXTERNAL SETPOINT VOLTAGE WITH RTD SENSORS

Figure 9 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 selecting resistor, R_2, equal to two times the desired operating RTD resistance, R_{RTD}.

Figure 8
RTD Operation

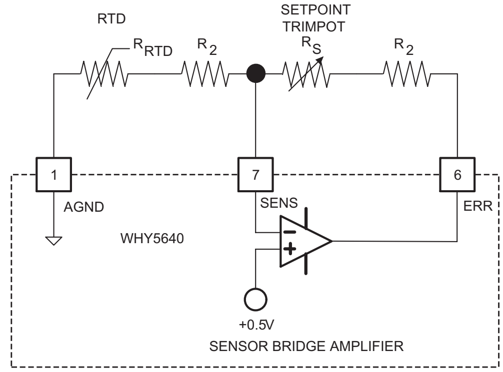
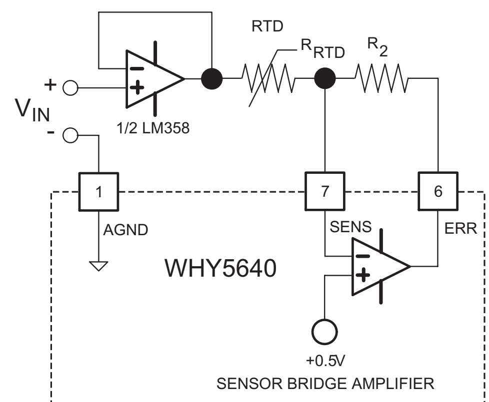


Figure 9
External Voltage Control
Using RTD Sensors



Equation 2
Voltage Controlled Setpoint
Using RTD Sensors

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

OPERATION

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

8. OPERATING WITH AD590 AND LM335 SENSORS

Figure 11 illustrates how to connect the WHY5640 for operation with PTC (Postive 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.

Example 2

Using a 100Ω RTD with External Voltage Control

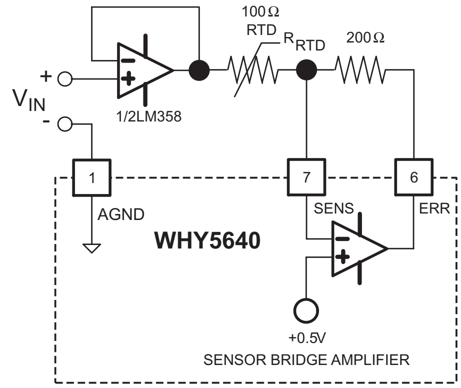


Figure 10

Example 2 Setpoint Voltage vs. RTD Resistance

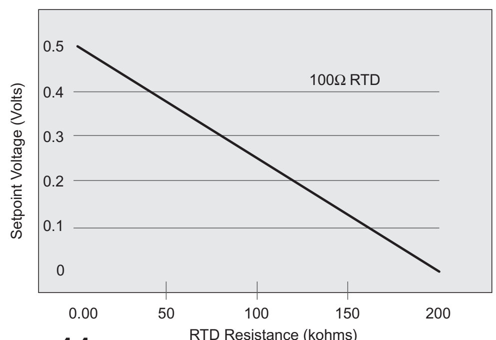
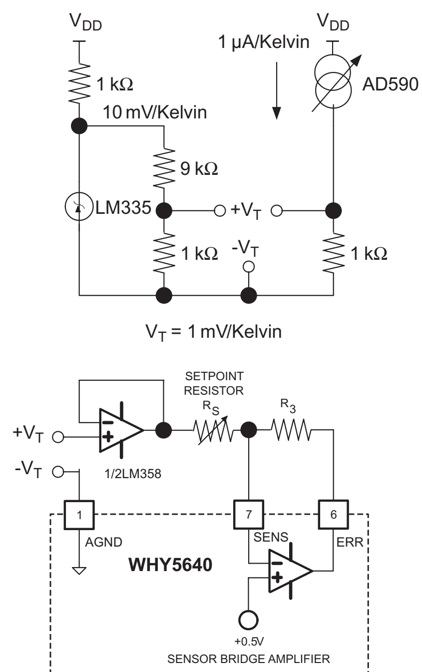


Figure 11

AD590 and LM335 Operation



Equation 3

AD590 and LM335 Setpoint Resistance Calculation

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

OPERATION

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

Figure 12 illustrates the setpoint resistance, V_{IN}, versus AD590 temperature, for Example 3.

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 13.

The circuit shown in Figure 13 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. RTD's require a sensing current of 1mA.

PTC (Positive Temperature Coefficient) sensors such as RTD sensors, the AD590, and the LM335 require that the output Pins 9 (OUTA) and 14 (OUTB) be swapped to produce the proper cooling and heating currents through the thermoelectric.

Example 3

Using an AD590 Example

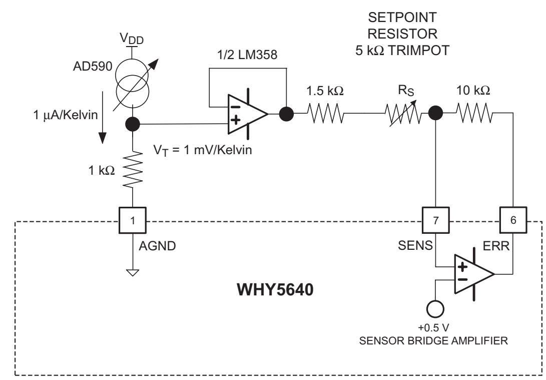


Figure 12

Example 3 Setpoint Resistance vs AD590 Temperature

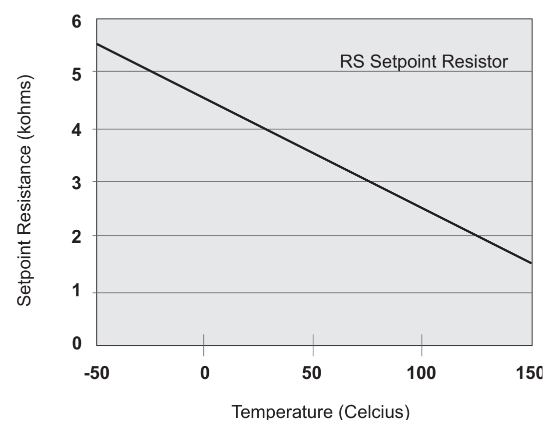
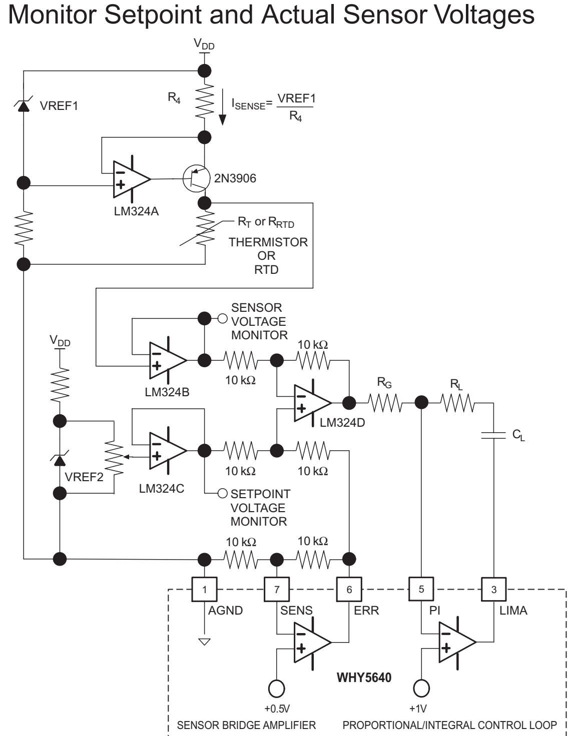


Figure 13

Monitor Setpoint and Actual Sensor Voltages



10. ADJUSTING THE CONTROL LOOP PROPORTIONAL GAIN

The control loop proportional gain can be adjusted by inserting a resistor, R_R, between Pin 5 (P) and Pin 3 (LIMA) and a resistor, R_G, between Pin 5 (PI) and Pin 6 (CRR).

Equation 4 demonstrates how to calculate the Proportional gain, P, given a value for R_P and R_G.

Table 2 lists the suggested resistor values for R_L and R_G versus sensor type and the thermal loads ability to change temperature rapidly.

11. ADJUSTING THE CONTROL LOOP INTEGRATOR TIME CONSTANT

The control loop integrator time constant can be adjusted by inserting a series of capacitors C_L and a resistor, R_L, between Pin 5 (PI) and Pin 3 (LIMA).

Equation 5 demonstrates how to calculate the integrator time constant, I_{TC}, given values for R_L and C_L.

Table 3 lists the suggested resistor and capacitor values for R_L and C_L versus sensor type and the thermal loads ability to change temperature rapidly.

Equation 4

Calculating P From R_L and R_G

$$P = 4\left(\frac{R_L}{R_G}\right) \text{ [Amps / Volts]}$$

Table 2

Proportional Gain Resistor R_L and R_G vs Sensor Type and Thermal Load Speed

R_L	R_G	Proportional Gain, [Amps/Volt]	Sensor Type/ Thermal Load Speed
4 MΩ	3.2 MΩ	5	Thermistor/Fast
4 MΩ	800 kΩ	20	Thermistor/Slow
4 MΩ	320 kΩ	50	RTD/Fast
4 MΩ	160 kΩ	100	RTD/Slow
4 MΩ	800 kΩ	20	AD590 or LM335/ Fast
4 MΩ	320 kΩ	50	AD590 or LM335/ Slow

Equation 5

Calculating I From R_R and C_L

$$I = \left(\frac{R_L C_L}{4}\right) \text{ [Seconds]}$$

Table 3

Integrator Time Constant vs Sensor Type and Thermal Load Speed

R_L	C_L	Integrator Time Constant	Sensor Type/ Thermal Load Speed
4 MΩ	7 µF	7	Thermistor/Fast
4 MΩ	10 µF	10	Thermistor/Slow
4 MΩ	1 µF	1	RTD/Fast
4 MΩ	3 µF	3	RTD/Slow
4 MΩ	3 µF	3	AD590 or LM335/ Fast
4 MΩ	10 µF	10	AD590 or LM335/ Slow

12. CHOOSING R_G, R_L, AND C_L

The WHY5640 maintains a constant load temperature using a PI (Proportional Gain, Integrator) control loop. The operation of the PI control loop is dependent on the selection of R_G, R_L, and C_L. Optimum values of R_G, R_L, and C_L can be determined by applying a constant current to the thermoelectric and measuring its thermal load response versus time.

Figure 14 illustrates a typical thermal load response to a constant current (power) being applied to the thermoelectric. Notice that the sensor voltage (temperature) does not immediately change when a current is applied to the thermoelectric. This delay is referred to as thermal lag, L, and dependent on the mass of the load and the amount of power being delivered to the thermoelectric. Eventually the changing sensor voltage begins to approach the final stable sensor voltage exponentially. The time it takes for the sensor voltage to reach 63% of the final temperature difference is referred to as the thermal time constant, τ. Small thermal loads powered by large thermoelectrics exhibit small thermal time constants. Large thermal loads powered by small thermoelectrics exhibit large thermal time constants. The final sensor voltage difference, V_D, is the result of the end sensor voltage, V_{TEND}, minus the beginning sensor, V_{TBEGIN}.

Figure 14
Thermal Load Time Response

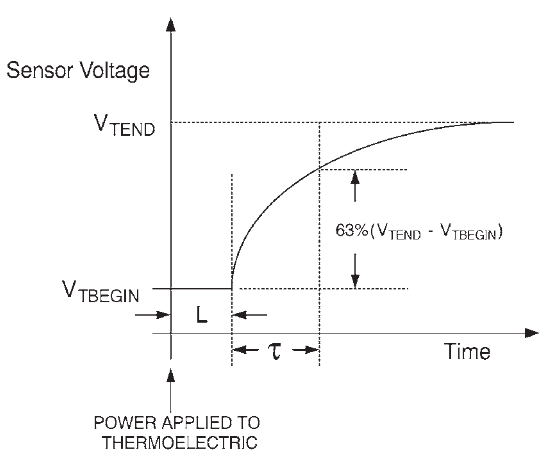


Figure 15 shows how to configure the WHY5640 to measure the thermal load response parameters, L, τ, and V_D.

Steps to configuring the WHY5640 to find L, τ, and V_D

a) Adjust the setpoint resistor, R_S, to the desired thermistor resistance that the load will eventually be stabilized at.

b) Select values for R_A or R_B so that the maximum output current is limited to approximately 1/4th the thermoelectric's maximum rating. The maximum output current will be referred to as the thermoelectric step current, I_{TESTEP}. Adjusting these values may require some experimentation.

Be sure to not overheat or under cool the device you are trying to temperature control. Excessive heating (cooling) or fast changes in temperature can damage some devices.

c) Disable the output current using the Enable/Disable Switch 1 before applying power to the WHY5640.

d) If you are controlling temperature above the ambient temperature then select heating current using the Heat/Cool Switch 2. Select cooling current with Switch 2 when controlling temperature below ambient.

e) Connect a digital oscilloscope or a multimeter connected to a data acquisition system between Pins 6 (ERR) and 1 (AGND).

f) Apply power to the WHY5640. Enable the output current using the Enable/Disable Switch 1 and immediately begin measuring the error voltage versus time. Once the error voltage flattens or changes little over time then stop taking measurements and analyze the thermal response, measuring L, τ, and V_D.

Equation 6 calculates V_D which is the difference between the beginning error voltage on Pin 6 (ERR) and the ending error voltage on Pin 6 (ERR).

Equation 6
Calculating V_D

$$V_D = (V_{TEND} - V_{TBEGIN})$$

Equation 7 calculates R_L given τ and C_L. Begin by assuming a value of 1 µF for C_L. If R_L begins to exceed 10 MΩ then increase C_L and recalculate R_L.

Equation 7
Calculating R_L

$$R_L = \frac{1.2\tau}{C_L}$$

OPERATION

Equation 8 calculates R_G given L, C_L, V_D, and I_{TESTEP}.

Equation 8

Calculating R_G

$$R_G = 13.7 \left(\frac{L}{C_L}\right)\left(\frac{V_D}{I_{TESTEP}}\right)$$

Easy Method for Measuring L and τ

Measuring L and τ can sometimes be very difficult without the right equipment. The following steps can be used to quickly determine L and τ.

a) Perform the same steps described above to find L, τ, and V_D.

b) Simply measure the time t_{90}% it takes V_D to reach approximately 90% of its final value. This is an approximation. This occurs when the error voltage begins to flatten significantly. The thermal time constant can be approximated as:

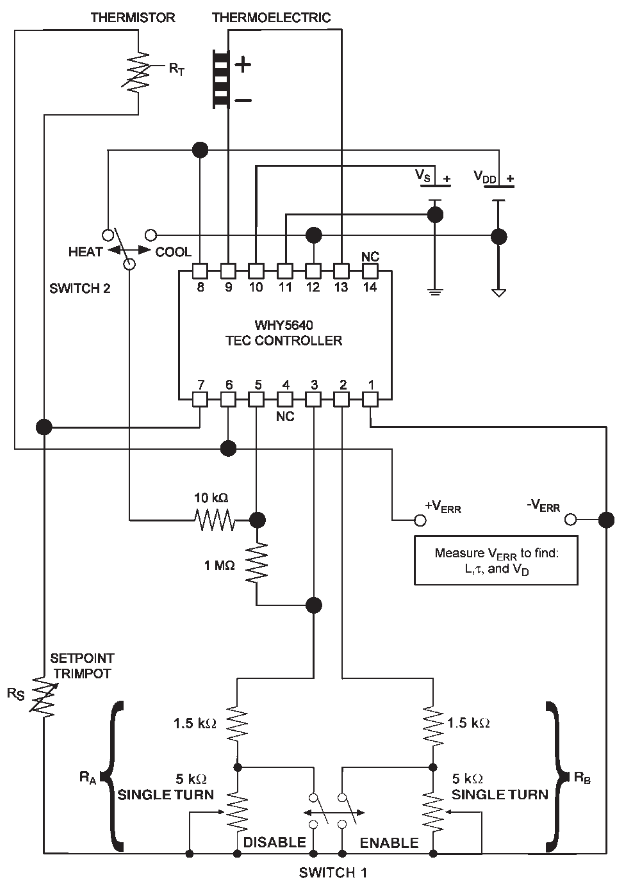
$$\tau = \frac{(t_{90\%})}{4}$$

The thermal lag can then be approximated from the thermal time constant, t, as:

$$L = \frac{t_{90\%}}{20}$$

Figure 15

Configuring the WHY5640 to measure L, τ, V_D



OPERATION

Example 4

Solving for R_G, R_L, and C_L when controlling a laser diode thermal load.

Figure 16 shows the WHY5640 configured to measure L, τ, and V_D for a hermetically sealed laser diode load using a 1.6 Amp thermoelectric and a 10 kΩ thermistor to sense temperature.

For this example, the desired thermistor resistance the laser diode will be operated at is 12 kΩ . Therefore, the setpoint resistor will be set to:

R_S = 12 kΩ

Since the setpoint resistance is greater than 12 kΩ , the laser diode will be cooled. Using the approximation in step (b), the maximum output current will be limited to (1.6 Amps/4) or 400 mA. Table 1 indicates that resistor R_A should be 1.83 kΩ to limit the output cooling current at 400 mA. Resistor R_A is already in series with a 1.5 kΩ resistor so R_A should be selected as:

R_A = 1.83 kΩ - 1.5 kΩ = 330Ω

Assume the thermistor resistance begins at 10 kΩ and ends at 14 kΩ some time after the 400 mA thermoelectric current is applied. Voltage difference, V_D will then be:

V_D = (1.083 V – 0.917 V) = 0.167 V

For this laser diode thermal load we find:

L = 1 second and τ = 5 seconds

Assume:

C_L = 1 µF

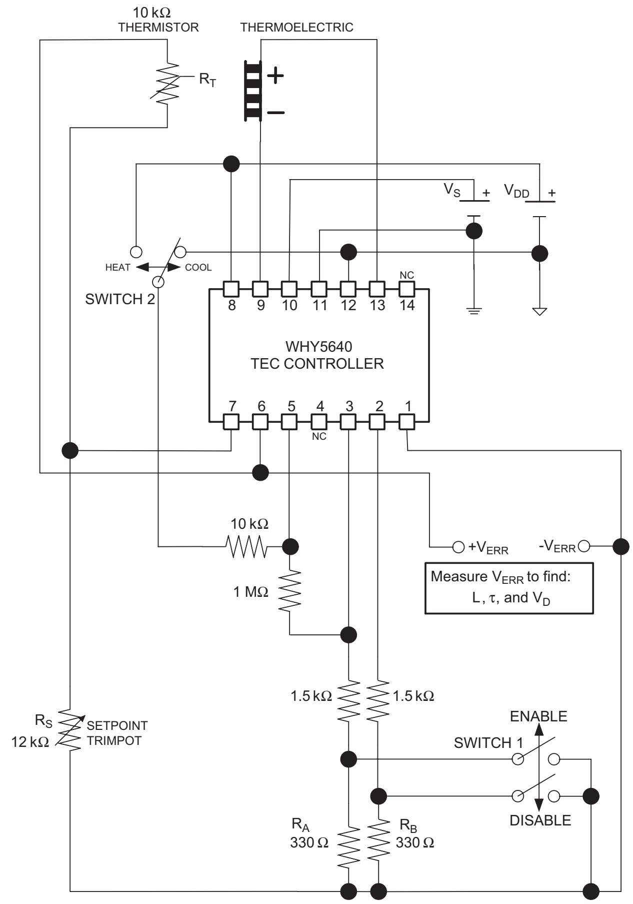
Then:

$$R_L = \frac{1.2\tau}{C_L} = \frac{(1.2)(5\text{ sec})}{1\mu F} = 6M\Omega$$

$$R_G = 13.7\left(\frac{L}{C_L}\right)\left(\frac{V_D}{I_{TESTEP}}\right) = 13.7\left(\frac{1}{1\mu F}\right)\left(\frac{0.167V}{400mA}\right) = 5.7M\Omega \text{ or } \sim 6M\Omega$$

Figure 16

Configuring the WHY5640 to measure L, τ and V_D for a Laser Diode Thermal Load Using a 1.6 AMP Thermoelectric and a 10 KΩ Thermistor.



13. 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 17 shows how to connect two WHY5640 controllers together to increase the output current drive to 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 outputs, Pins 4 and 14, to drive then 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.

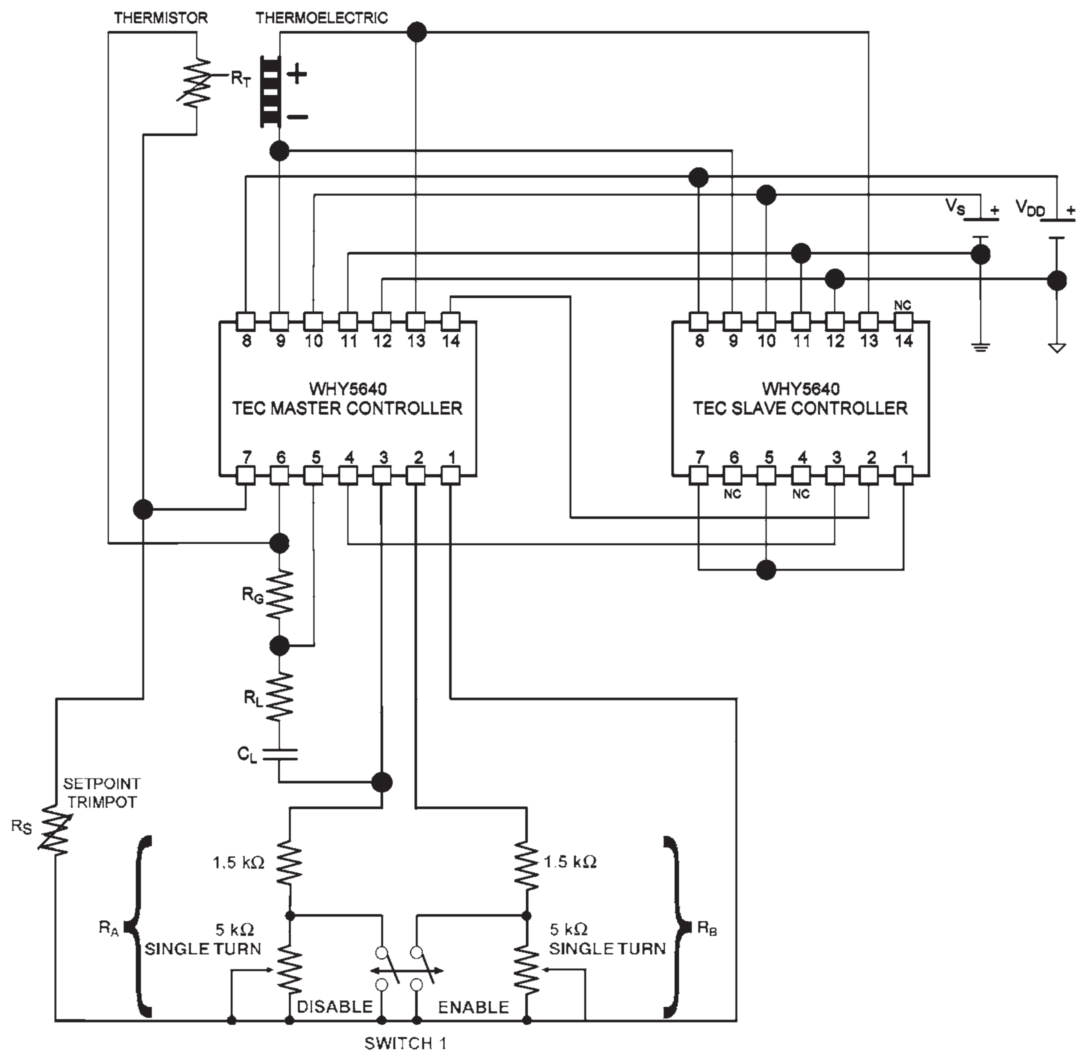
Use Table 5 to determine the limit setting resistors, R_A and R_B , based on the number of WHY5640 controllers paralleled together.

Table 4
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	3.95
1.9	3.8	5.7	7.6	9.5	4.42
2	4	6	8	10	4.72
2.1	4.2	6.3	8.4	10.5	5.07
2.2	4.4	6.6	8.8	11	5.45
2.3	4.6	6.9	9.2	11.5	5.88

OPERATION

Figure 17
Boosting Output Current Drive



15. 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 6 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.

Hint: Resistive temperature sensors and LM335 type temperature sensors should connect their negative termination directly to Pin 13 (GND) to avoid parasitic resistances and voltages effecting temperature stability and accuracy.

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 once at the desired operating temperature.

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.

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.

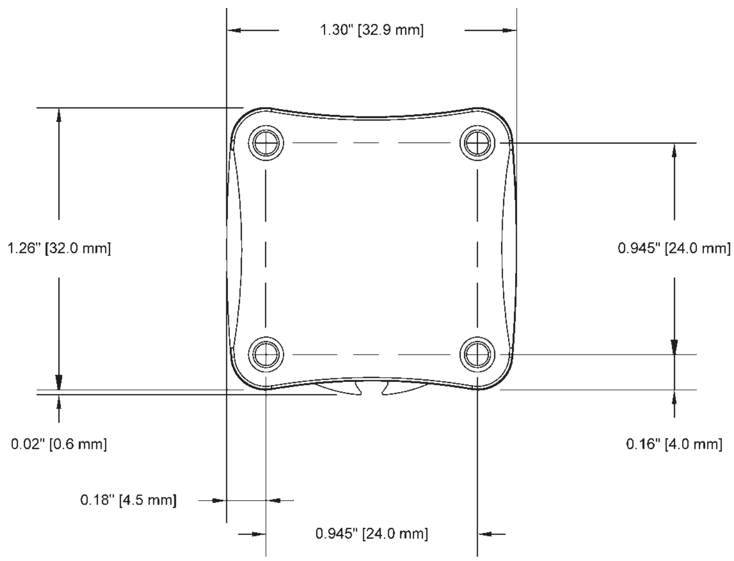
Ambient temperature disturbances can pass through the heatsink and thermoelectric and affect the device temperature stability. Choosing a heatsink with a larger mass will improve temperature stability.

Table 5
Temperature Sensor Comparison

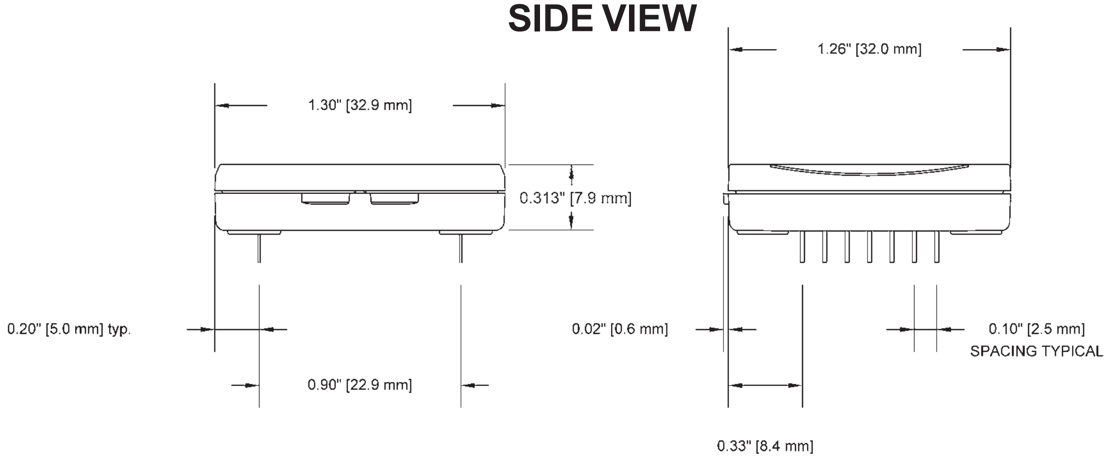
SENSOR	Thermistor	RTD	AD590	LM335
RATING	Best	Poor	Good	Good

MECHANICAL SPECIFICATIONS

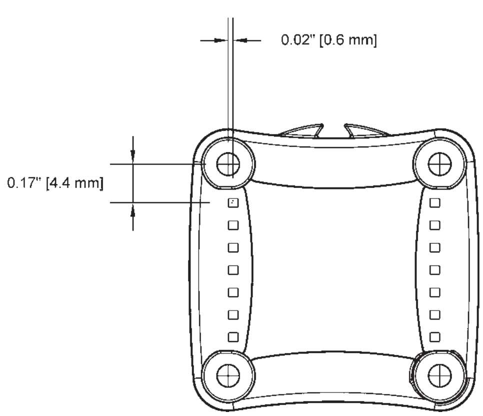
TOP VIEW



SIDE VIEW



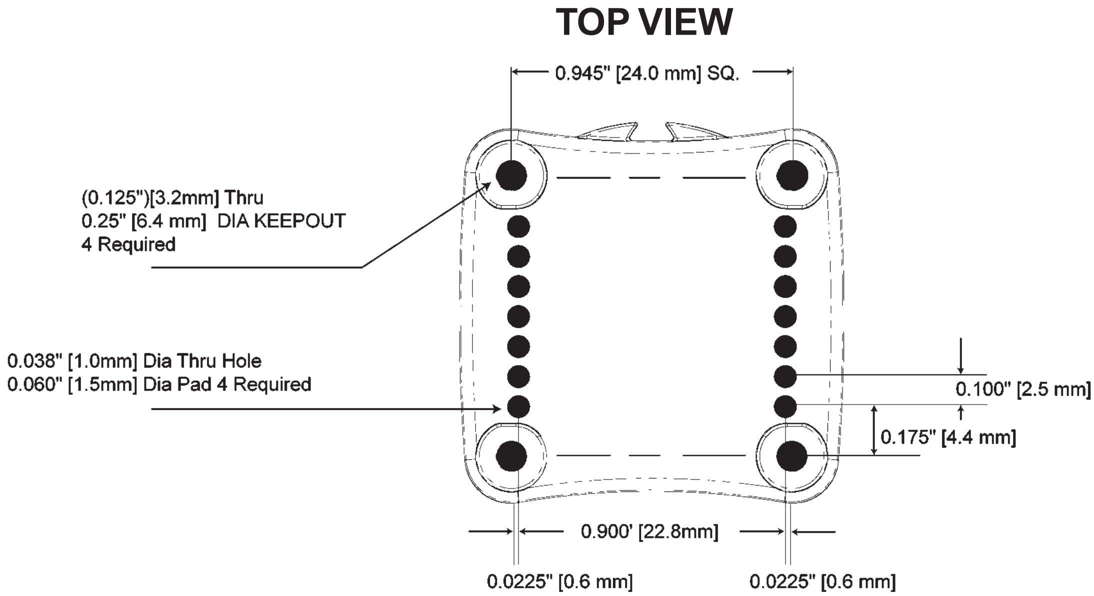
BOTTOM VIEW



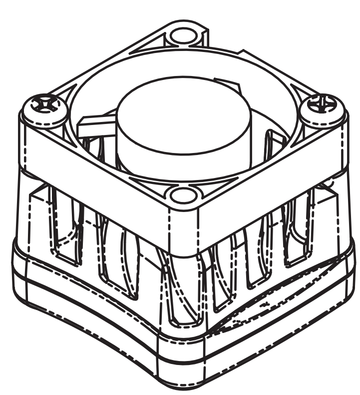
PIN DIAMETER:	0.028”
PIN LENGTH:	0.126”
PIN MATERIAL:	Nickel Plated Steel
HEAT SPREADER:	Nickel Plated Aluminum
PLASTIC COVER:	LCP Plastic
ISOLATION:	1200 VDC any pin to case
THERMAL WASHER:	WTW002
HEATSINK:	WHS302
FANS:	WXC303 (+5VDC) or WXC304 (+12VDC)

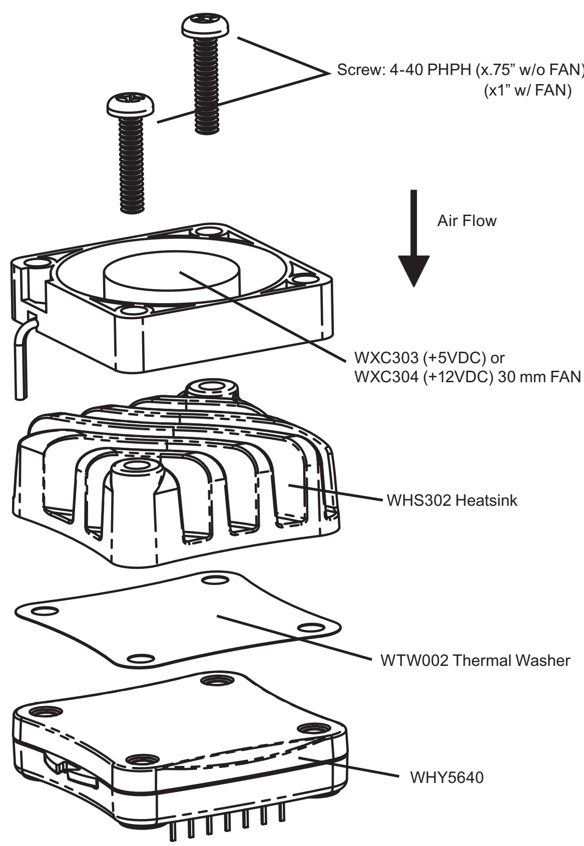
MECHANICAL SPECIFICATIONS

PCB FOOTPRINT

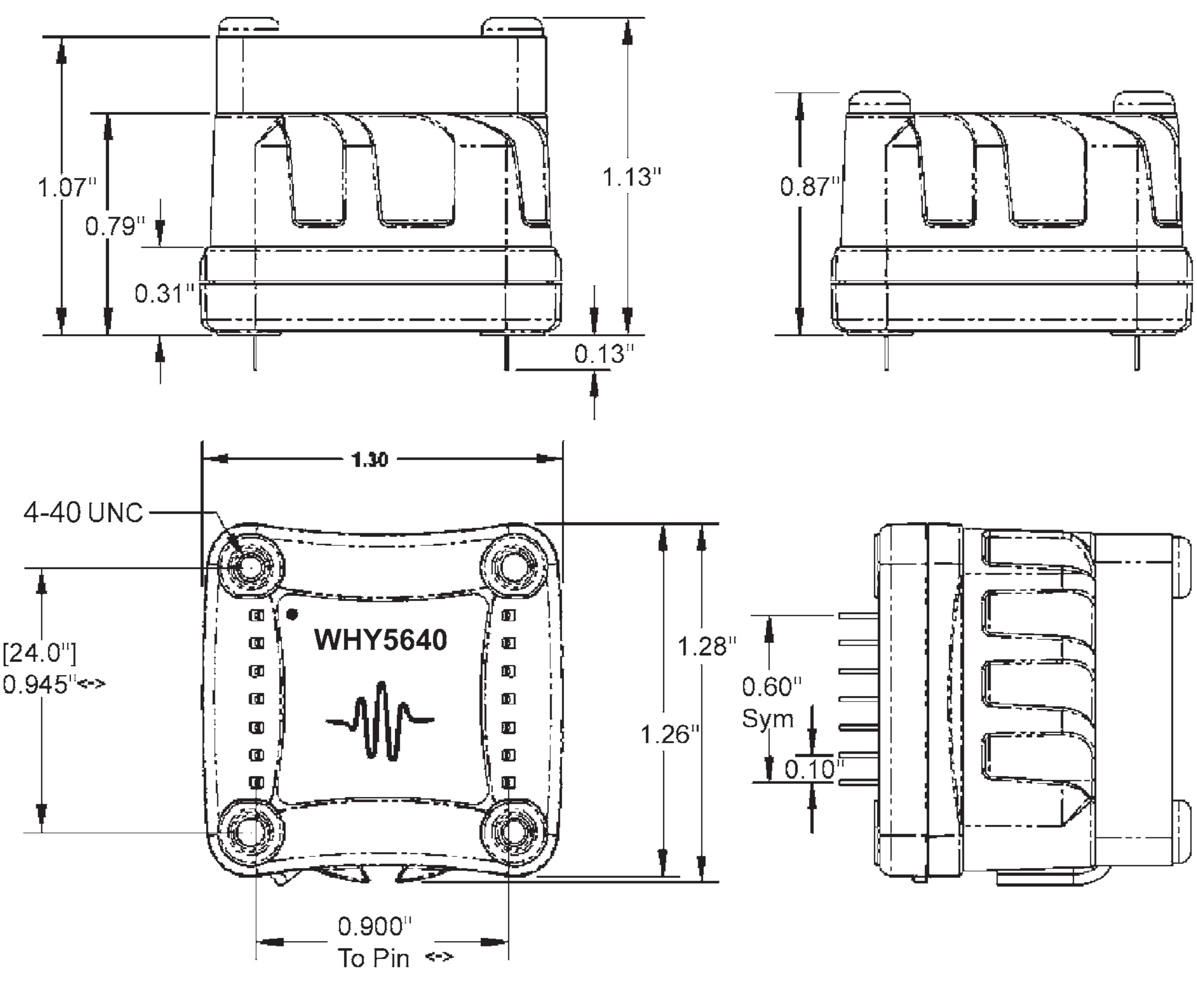


WHY5640 ASSEMBLED WITH HEATSINK AND FAN ACCESSORIES





MECHANICAL SPECIFICATIONS



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WARRANTY:
Wavelength, will, at it's option, either repair or replace products which prove to be defective.

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