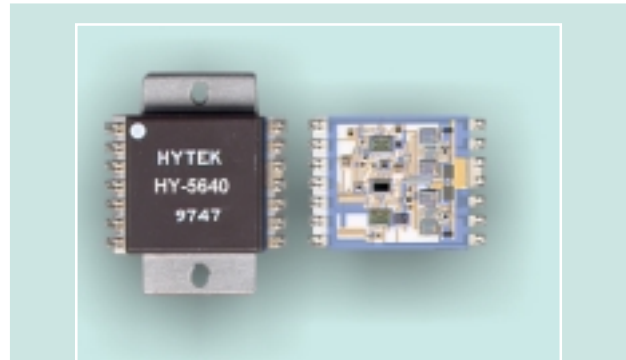


Subminiature Controller for Thermoelectric Coolers

The **HY5640** is a subminiature temperature controller for thermoelectric coolers (TEC). This device is intended for "heat or cool" fixed temperature applications where front panel controls and digital readouts are not required. The HY5640 uses a thermistor bridge to precisely measure and regulate the temperature of a device affixed to a TEC. With proper heat sinking, the power stage of this device will deliver up to +/- 2 Amperes of current to a TEC. This controller was designed for single power supply operation down to +5V. In addition, the device can be operated with dual supplies where V_s can be as low as +3V and V_{DD} as low as +5V.

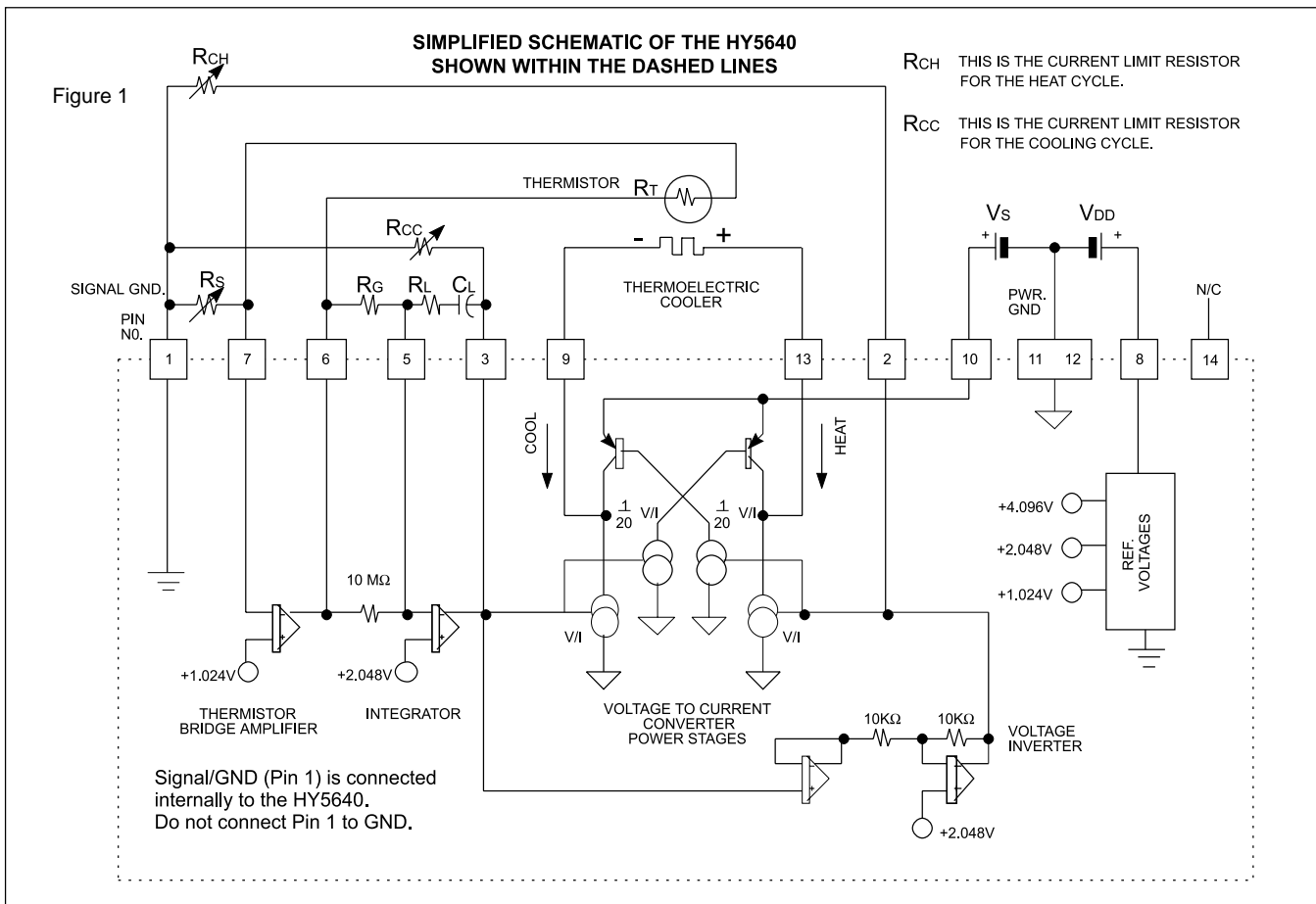
Maximum ratings:

Rating	Symbol	Value	Unit
Supply Voltage 1 (Voltage on Pin 8)	V_{DD}	+20	Volts DC
Supply Voltage 2 (Voltage on Pin 10)	V_s	+12	Volts DC
Current Sink (Heat and Cool Cycle)	I_s	2.5	Amperes
Maximum Power Dissipation	P_{MAX}	6	Watts
Operating Temperature (Case)	$T_{MAX/MIN}$	100/-20	°C
Storage Temperature	T_{STG}	-65 to +150	°C



Features:

- ◆ Proportional/Integral (PI) control
- ◆ Small size
- ◆ Drive current to +/-2 amps
- ◆ Operation to 12 volts
- ◆ Control above/below ambient
- ◆ Temperature stability of 0.01°C
- ◆ Single supply operation
- ◆ Thru-hole or surface-mount packaging option



Description of the HY5640 Pin Outs

- **Temperature Set Resistor R_s (Pin 1 to Pin 7)**

The temperature set resistor for the HY5640 controls the temperature at which the TEC will operate. When the circuit has stabilized, the resistance of the thermistor will be equal to that of the set resistor R_s . For example, if a Dale 10k Ω thermistor is used as the temperature sensing device, a set resistor of approximately 56K Ω will set an operating temperature of -10°C . A graph of R_s vs. set temperature is shown in figure 4 when using a Dale 1M1002 thermistor.

- **Thermistor, R_T (Pin 6 to Pin 7)**

The thermistor should be located in close proximity to the device being temperature controlled by the TEC. It should be in good thermal contact to avoid stability problems.

The HY5640 has been designed for a negative temperature coefficient thermistor. A thermistor with a positive temperature coefficient can also be used if the position of the temperature set resistor and temperature sensing resistor are changed. The same result can also be achieved by reversing the leads of the TEC in which case R_{cc} and R_{ch} must be interchanged.

- **Gain Set Resistor, R_G (Pin 5 to Pin 6)**

The ratio of the gain set resistor R_G to R_L controls the response time of the servo loop. A ratio that is too large can cause slow response and a ratio that is too small can cause loop instability. In most applications R_G may not be needed since a 10M Ω resistor is internal to the HY5640 and generally provides enough gain for good operation.

- **Loop Stability Network, R_L and C_L (Pin 3 to Pin 5)**

The R_c time constant of these two components is a first approximation of the thermal time constant of the servo loop. The thermal time constant of the combination of the device being cooled, the thermistor, and the TEC can be approximated by applying constant power to the TEC and measuring the length of time it takes to reach 66% of its final temperature.

For example, if the thermal time constant was observed to be 5 seconds, then a 1 μF capacitor and a 4.7M Ω could be chosen as the loop stabilizing components. Typical values for loop compensation components are shown in Table 1.

Note: The values of R_G , R_L , and C_L are generally selected by experiment. C_L should be a low leakage nonpolarized capacitor.

- **Current Limit Resistors, R_{cc} & R_{ch} (Pin 1 to Pin 3, and Pin 1 to Pin 2)**

These resistors limit the maximum current that the HY5640 can supply to the TEC when in the cooling cycle and in the heating cycle. R_{cc} limits the maximum current for the cooling cycle and R_{ch} limits the maximum current in the heating cycle. This feature prevents damage to the TEC during turn on. It is often desirable to limit the maximum value of heating current as much as 30% less than the maximum cooling current. This is because TECs are much more efficient heating than cooling. Figure 5 shows the approximate values for R_{cc} and R_{ch} required to program a desired turn on current. For example, an R_{cc} value of 17K Ω will limit the maximum cooling current to 1.5 Amperes and an R_{ch} value of 13.5K Ω will limit the maximum heating current to 0.5 Amperes.

- **V_{DD} (Pin 8 to Pins 11 & 12) $+5 < V_{DD} < +20$ Volts**

This input supplies the voltage to the internal circuitry of the HY5640. The maximum current drain at this terminal is 5mA.

- **V_s (Pin 10 to Pins 11 & 12) $+3 < V_s < +12$ Volts**

This input supplies the voltage to the HY5640 power drive circuitry. The maximum current drain at this terminal should not exceed 2 Amperes. Note that V_{DD} and V_s can be driven with the same power supply in the range of $+5V < V_{DD} = V_s < +12V$.

Ideally V_s is no more than 1.5V higher than the V_{MAX} of the selected TEC. Setting V_s higher than this can cause excessive heating of the controller.

- **Thermoelectric Cooler, TEC (Pin 9 to Pin 13)**

The cooling lead of the TEC should be connected to Pin 9 and the heating lead should be connected to Pin 13 of the HY5640. If the temperature of the thermistor is greater than the set temperature at turn on, maximum cooling current will flow into Pin 9 and out of Pin 13. Conversely, maximum heating current will flow into Pin 13 and out of Pin 9 if the temperature of the thermistor is less than the set temperature at turn on. The maximum turn on current is limited by R_{cc} and R_{ch} . Once the TEC reaches its set temperature, the current through the TEC will decrease to exactly the value required to maintain the correct set temperature.

HY5640 CURRENT SOURCE CHARACTERISTICS

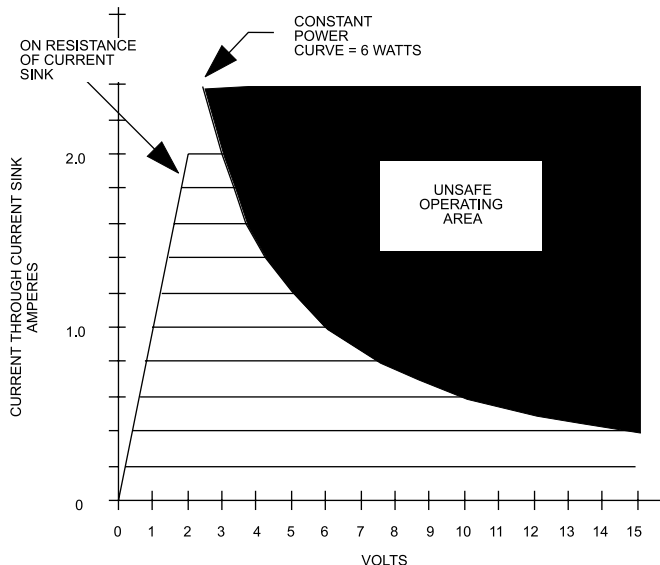


FIGURE 2 SUPPLY VOLTAGE (V_s)
PIN 10 TO GROUND (PIN 11 & 12)

DETERMINATION OF THE HY5640 OPERATING POINTS USING LOAD LINES

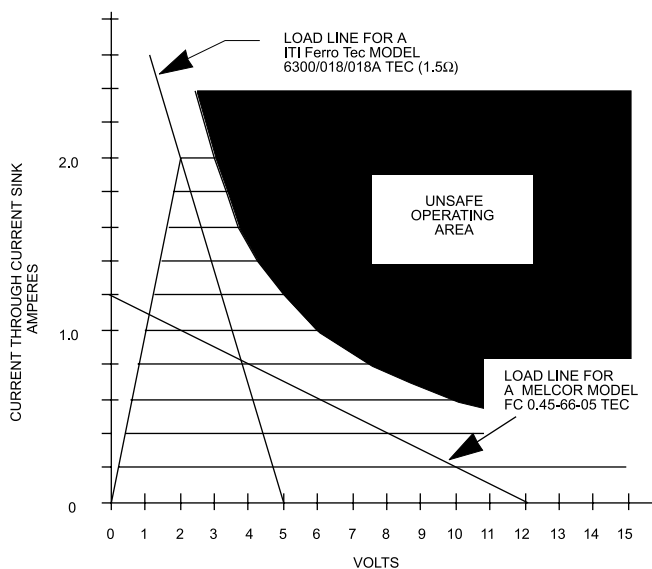


FIGURE 3 SUPPLY VOLTAGE (V_s)
PIN 10 TO GROUND (PIN 11 & 12)

Figure 2 illustrates the characteristics of the HY5640 power drive section. It also illustrates the unsafe operating area where the power dissipated in the device exceeds the maximum 6 Watt rating. This curve applies for both heating and cooling operation.

Note that the resistance of the power drive section is approximately one ohm when the HY5640 is fully turned on.

Figure 3 illustrates the locus of operating current and voltage for two different TECs.

Example 1:

A supply voltage of 5 Volts was chosen for use with the ITI Ferro Tec Model 6300/018/018A TEC. This device is rated for a maximum current of 1.8 Amperes at a maximum allowable voltage of 2.7 Volts. This is a load resistance of approximately 1.5 ohms. The intersection of the 1.5 ohm load line and the HY5640 current source characteristics defines the locus of operation voltage and current for both the HY5640 and the TEC. In this application the current was limited to 1.8 Amperes when cooling and to 0.6 Amperes when heating by proper selection of RCC and RCH.

Example 2:

A supply voltage of 12 Volts was chosen for the Melcor FC 0.45-66-05 TEC. This device has a maximum rated voltage of 7.98 Volts at a current of 0.8 Amperes. A load line for this device is also shown on the plot. Once again maximum turn on current is set by proper selection of RCC and RCH.

Note that the power dissipated in the HY5640 never exceeds the 6 Watt maximum power dissipation in both of these examples.

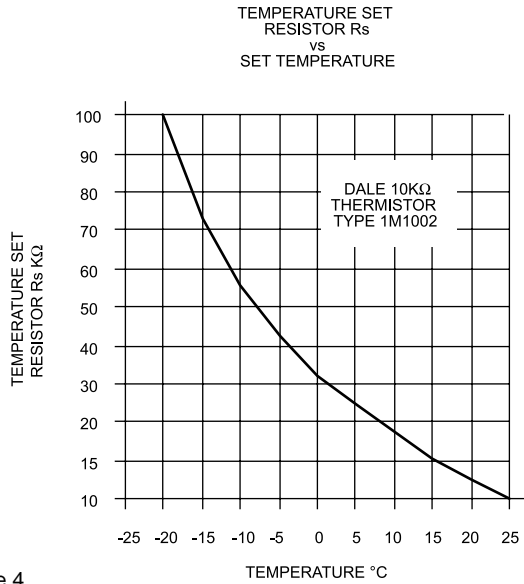


Figure 4

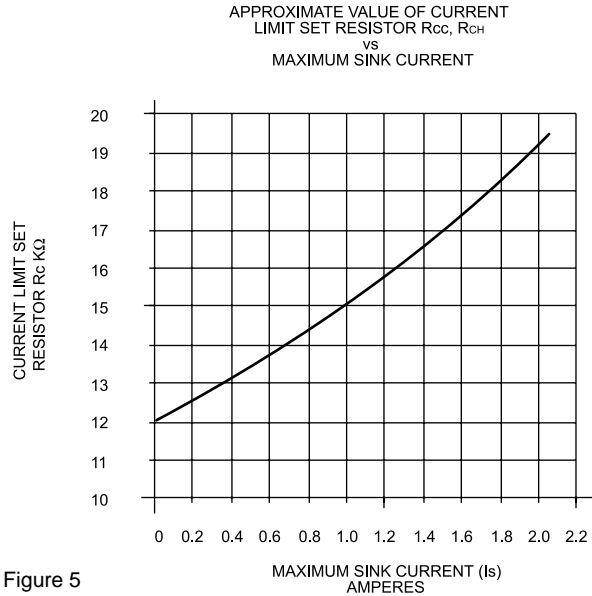


Figure 5

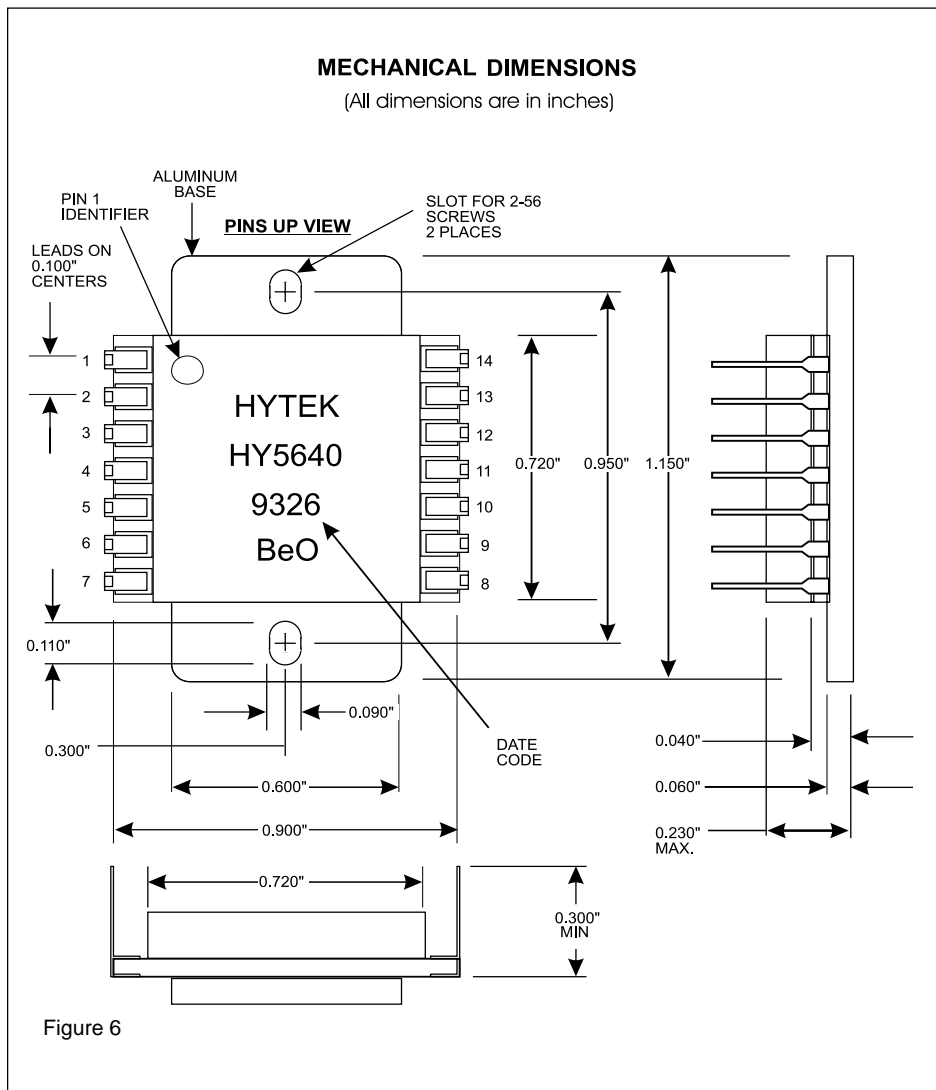


Figure 6

TYPICAL RESISTOR AND CAPACITOR VALUES FOR VARIOUS THERMAL TIME CONSTANTS

THERMAL TIME CONSTANT T (SECONDS)			
	R_L	C_L	R_g
1	10 MΩ	0.1 μF	100KΩ to 10MΩ
2	20 MΩ	0.1 μF	
3	3 MΩ	1.0 μF	
5	4.7 MΩ	1.0 μF	
10	10 MΩ	1.0 μF	
15	15 MΩ	1.0 μF	
20	20 MΩ	1.0 μF	

TABLE 1

NOTES:

1. Make certain the heat sink to which the HY5640 is mounted is flat and clean, otherwise the ceramic substrate may break.
2. Use a thermal compound such as Dow Corning 340 between the HY5640 and the heat sink for good thermal conduction.
3. Note that the Pin 1 identifier is shown in a bottom view. From a top view, Pin numbers ascend in clockwise fashion.

Specifications subject to change without notice.