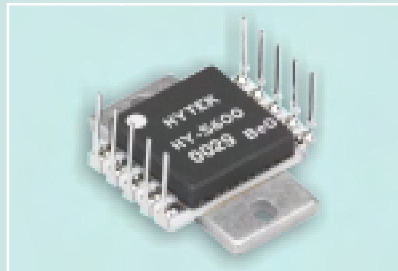
Subminiature Controller for Thermoelectric Coolers

The HY5600 is a subminiature proportional temperature controller for thermoelectric coolers (TEC). This device is intended for "cool only" fixed temperature applications where front panel controls and digital readouts are not required. The HY5600 operates in conjunction with a thermistor bridge to precisely measure and regulate the temperature of a device affixed to a TEC. With proper heat sinking, this device will sink up to 2 Amperes of current and will operate at a supply voltage up to 12 Volts.



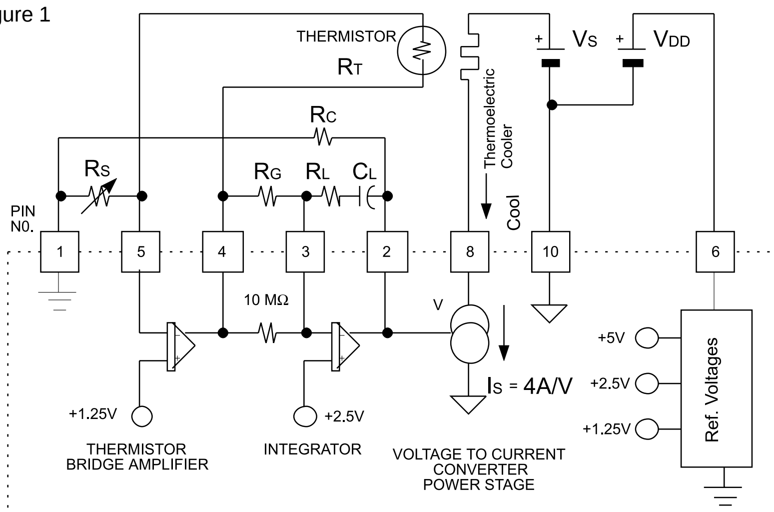
Maximum ratings:

Rating	Symbol	Value	Unit
Supply Voltage	V_{DD}	+20	Volts DC
Supply Voltage 2 ((Voltage on Pin 8)	V_S	+12	Volts DC
Current Sink	I_S	2.5	Amperes
Maximum Power Dissipation	P_{MAX}	6	Watts

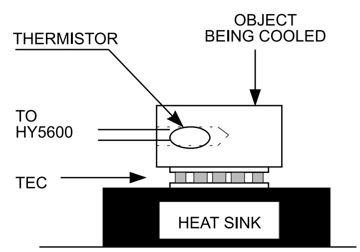
Features:

- Proportional/Integral (PI) control
- Small size
- Drive current to 2 amps
- Operation to 12 volts
- Control –55°C to ambient
- Temperature stability to 0.01°C
- Thru-hole or surface-mount packaging

Figure 1



MOUNTING THE TERMISTOR



The thermistor should be located as close to the TEC as possible in order to avoid thermal lag. In addition, the thermistor should be attached to the device being cooled with a good thermally conductive epoxy or thermal compound. This material should be electrically nonconductive.

Theory of operation

The HY5600 TEC controller consists of a thermistor bridge amplifier, an integrator/gain stage and a voltage-to-current converter power drive stage. This is illustrated in the simplified schematic diagram for the HY5600 in Figure 1. The thermistor bridge precisely measures the temperature of a device attached to a Thermoelectric Cooler (TEC). The bridge is balanced when the thermistor value is equal to the value of the temperature set resistor (Rs). When power is first applied to the TEC, the temperature of the device attached to the TEC is higher than the desired set temperature. The resistance of the thermistor is therefore less than the temperature set resistor. This causes the current sink to turn on to its maximum programmed value. This maximum current is set with resistor Rc. The HY5600 will continue to sink maximum current until the programmed temperature is reached. The current will then decrease to the value required for maintaining equality between the thermistor and the programming resistor (Rs).

Description of the HY5600 pin outs

• Temperature Set Resistor Rs (Pin 1 to Pin 5)

The temperature set resistor for the HY5600 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 Rs. For example, if a Dale 10KΩ thermistor is used as the temperature sensing device, a set resistor of approximately 56KΩ will set an operating temperature of –10°C. A graph of Rs vs. set temperature is shown in figure 4 when using a Dale 1M1002 thermistor.

• Thermistor, R_T (Pin 4 to Pin 5)

The thermistor should be located in close proximity to the device being cooled. It should be in good thermal contact with this device to avoid stability problems.

The HY5600 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 is changed.

• Gain Set Resistor, R_G (Pin 3 to Pin 4)

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. A 1OMΩ resistor, which is in parallel with R_G is internal to the HY5600. In many cases, an external resistor (R_G) is not required.

• Loop Stability Network, R_L and C_L (Pin 2 to Pin 3)

The RC 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 1µF capacitor and a 4.7MΩ 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 Resistor, Rc (Pin 1 to Pin 2)

This resistor limits the maximum current that the HY5600 can sink. This feature will prevent damage to the TEC during turn-on. If the supply voltage for the TEC does not exceed the maximum TEC voltage, then this resistor may not be needed. Figure 5 shows the approximate values for Rc required to program a desired turn on current.

• V_{DD} (Pin 6 to Pin 10) $+7 \leq V_{DD} \leq +20$ Volts

This input supplies the voltage to the internal circuitry of the HY5600. The maximum current drain at this terminal is 5mA.

• Thermoelectric Controller, TEC (Pin 8) $+3 \leq V_S \leq +12$ Volts

Pin 8 connects the TEC to the programmable current sink in the HY5600. The other lead of the TEC is connected to + Vs. At turn on, the current into Pin 8 is maximum if the temperature of the sensing thermistor is greater than the programmed set temperature. This maximum turn on current can be limited by Rc. Once the TEC reaches its set temperature, the current through the TEC will drop to exactly the value required to maintain the correct set temperature.

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.

HY6500 CURRENT SOURCE CHARACTERISTICS

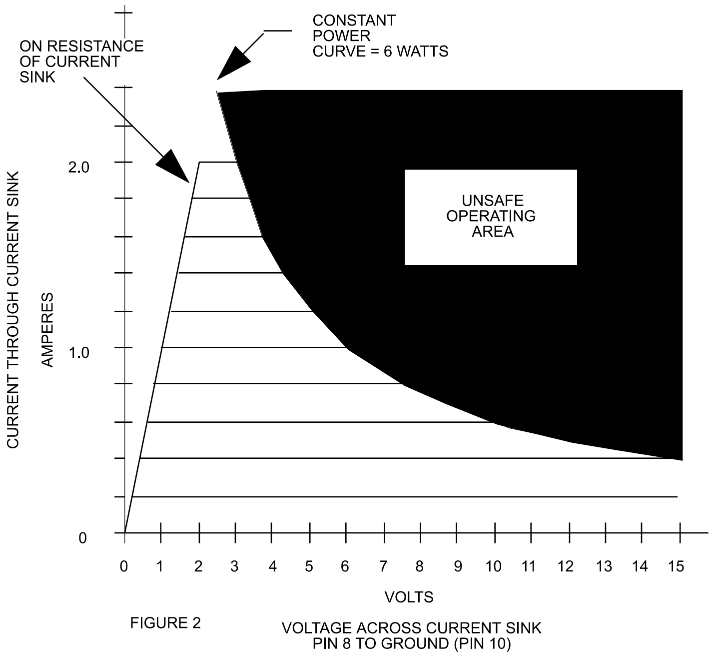


FIGURE 2

Figure 2 illustrates the characteristics of the HY5600 current sink. It also illustrates the unsafe operating area where the power dissipated in the device exceeds the maximum 6 Watt rating for this device.

Note that the resistance of the current switch is approximately one ohm when the current switch is saturated.

DETERMINATION OF THE
HY5600 OPERATING
POINTS USING LOAD LINES

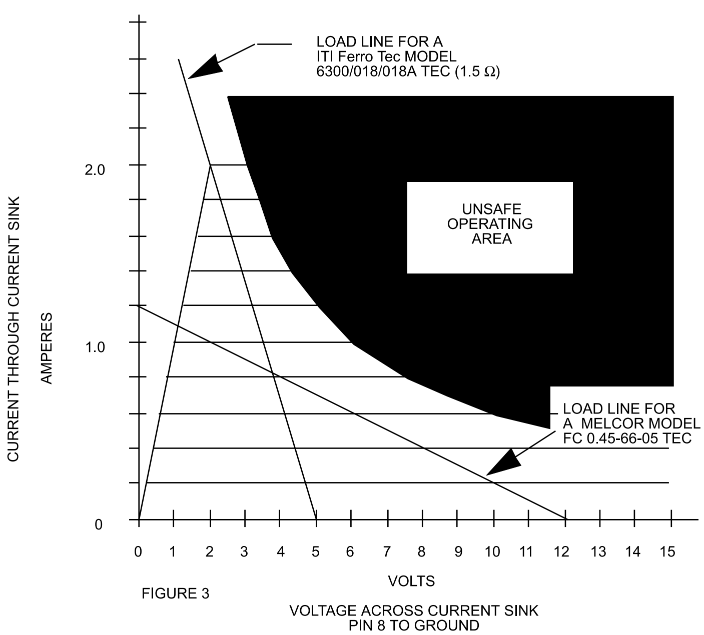


FIGURE 3

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 Tek 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 HY5600 current source characteristics defines the locus of operation voltage and current for both the HY5600 and the TEC. In this application the current was limited to 1.8 Amperes by proper selection of Rc.

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.

Note that the power dissipated in the HY5600 never exceeds the 6 Watt maximum power dissipation.

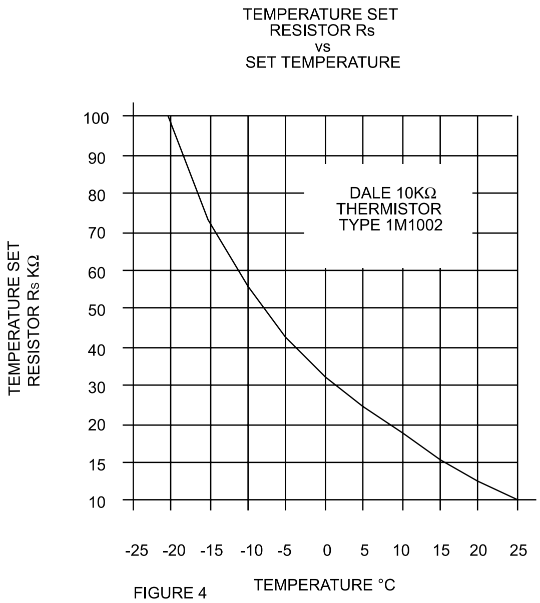


FIGURE 4

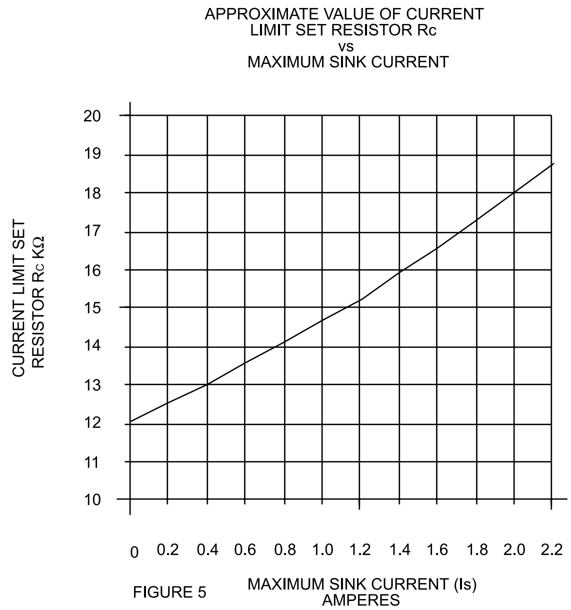


FIGURE 5

MECHANICAL DIMENSIONS

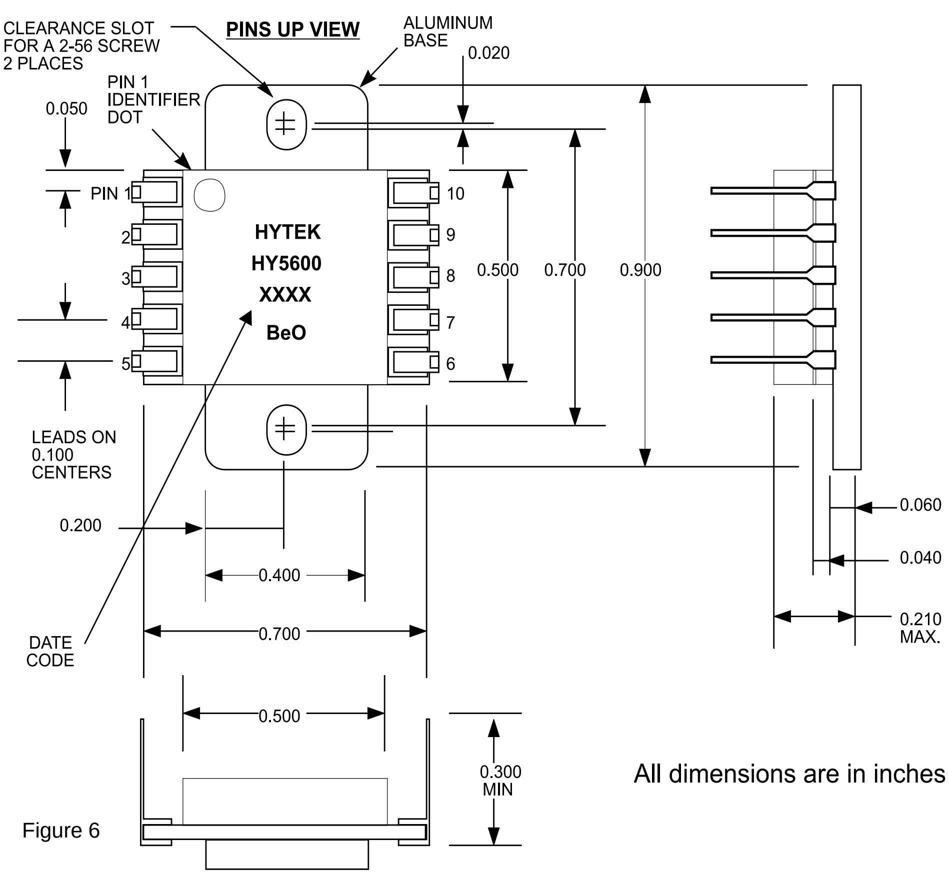


Figure 6

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 HY5600 is mounted is flat and clean, otherwise the ceramic substrate may break.
2. Use a thermal compound such as Dow Corning 340 between the HY5600 and the heat sink for good thermal conduction.

Specifications subject to change without notice.