# *Subminiature Controller for Thermoelectric Coolers*

The HY5650 is a subminiature proportional 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 HY5650 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 and will operate from a 3 to 5 Volt power supply.
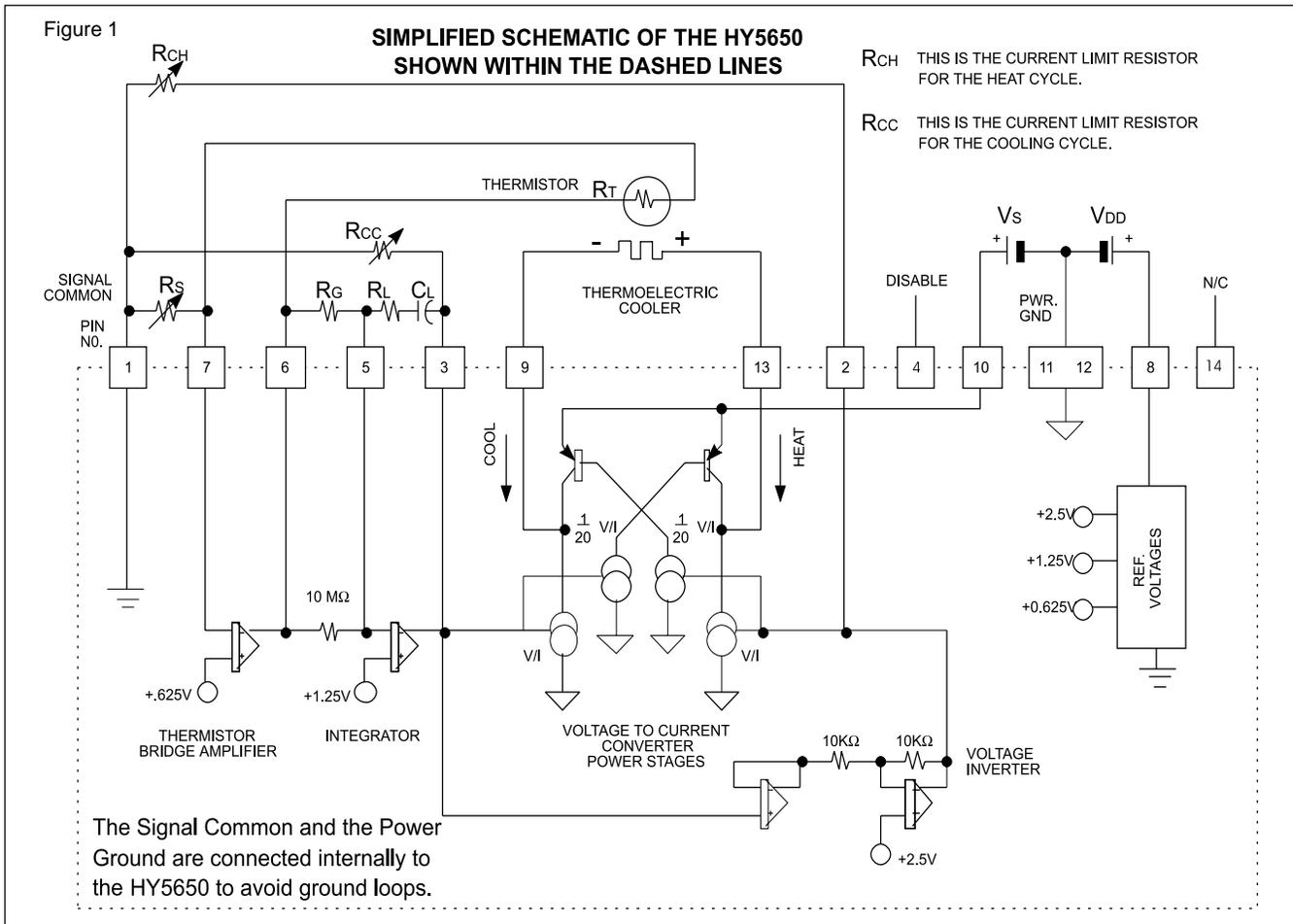
Maximum ratings:

Rating	Symbol	Value	Unit
Supply Voltage 1 (Voltage on Pin 8)	V_{DD}	+8	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	℃
Storage Temperature	T_{STG}	–65 to +150	℃
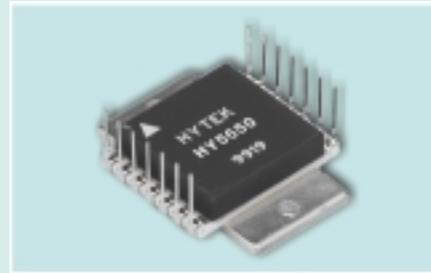
Features

- ◆ Proportional/Integral (PI) control
- ◆ Small size
- ◆ Drive current to +/–2 amps
- ◆ Single Supply Operation (3V to 5V)
- ◆ Control above/below ambient
- ◆ Temperature stability of 0.01°C
- ◆ Thru-hole or surface-mount packaging
- ◆ Digital Enable/Disable control

TEC Controllers

Laser Diode Drivers

Micro-heaters

Figure 1

SIMPLIFIED SCHEMATIC OF THE HY5650 SHOWN WITHIN THE DASHED LINES

R_{CH} THIS IS THE CURRENT LIMIT RESISTOR FOR THE HEAT CYCLE.

R_{CC} THIS IS THE CURRENT LIMIT RESISTOR FOR THE COOLING CYCLE.

The Signal Common and the Power Ground are connected internally to the HY5650 to avoid ground loops.

Description of the HY5650 Pin Outs

• Temperature Set Resistor Rs (Pin 1 to Pin 7)

The temperature set resistor for the HY5650 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 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 HY5650 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 Rcc 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 10MΩ resistor is internal to the HY5650 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 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 Resistors, Rcc & R_{CH} (Pin 1 to Pin 3, and Pin 1 to Pin 2)

These resistors limit the maximum current that the HY5650 can supply to the TEC when in the cooling cycle and in the heating cycle. Rcc 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 Rcc and R_{CH} required to program a desired turn on current. For example, an Rcc value of 14KΩ will limit the maximum cooling current to 2 Amperes and an R_{CH} value of 13.4KΩ will limit the maximum heating current to 1.4 Amperes.

• V_{DD} (Pin 8 to Pins 11 & 12) +3.0 < V_{DD} < +8 Volts

This input supplies the voltage to the internal circuitry of the HY5650. The maximum current drain at this terminal is 5mA.

• Vs (Pin 10 to Pins 11 & 12) +3 < Vs < +12 Volts

This input supplies the voltage to the HY5650 power drive circuitry. The maximum current drain at this terminal should not exceed 2 Amperes. Ideally, Vs is no more than 0.5V higher than Vmax of the selected TEC. Setting Vs 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 HY5650. 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 Rcc 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.

Ideally VS is no more than 1.5V higher than the VMAX of the selected TEC. Setting VS higher than this can cause excessive heating of the controller.

• Disable (Pin 4)

The TEC current can be disabled by applying a TTL high (+5V) to Pin 4 of the HY5620. The HY5620 is enabled when Pin 4 is connected to ground or left open (no connection).
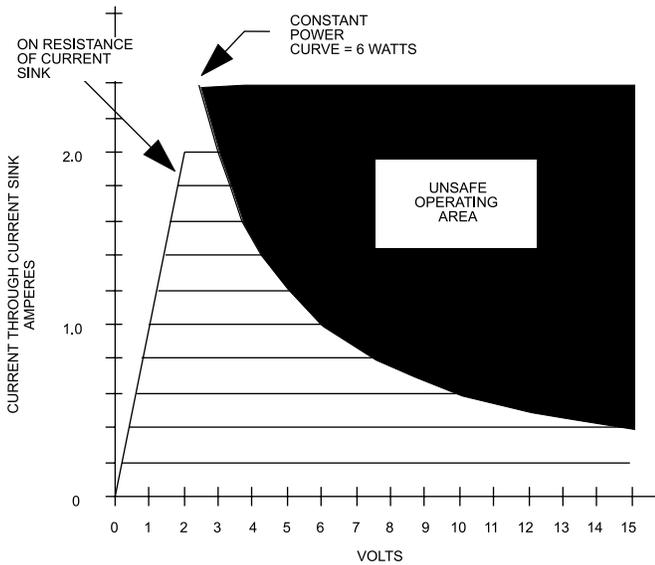
Hy5650 CURRENT SOURCE CHARACTERISTICS

FIGURE 2

SUPPLY VOLTAGE (Vs)
PIN 10 TO GROUND (PIN 11 & 12)

Figure 2 illustrates the characteristics of the HY5650 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 HY5650 is fully turned on.

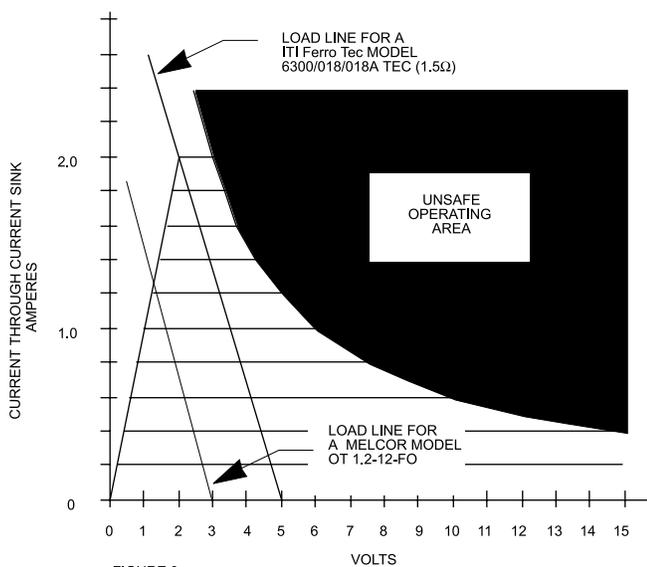## DETERMINATION OF THE HY5650 OPERATING POINTS USING LOAD LINES

FIGURE 3

SUPPLY VOLTAGE (Vs)
PIN 10 TO GROUND (PIN 11 & 12)

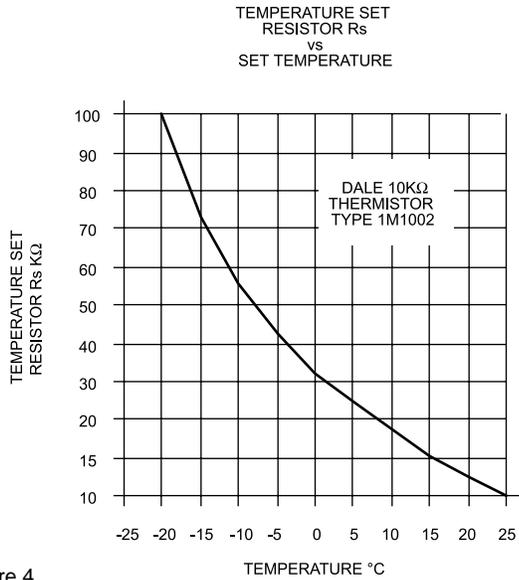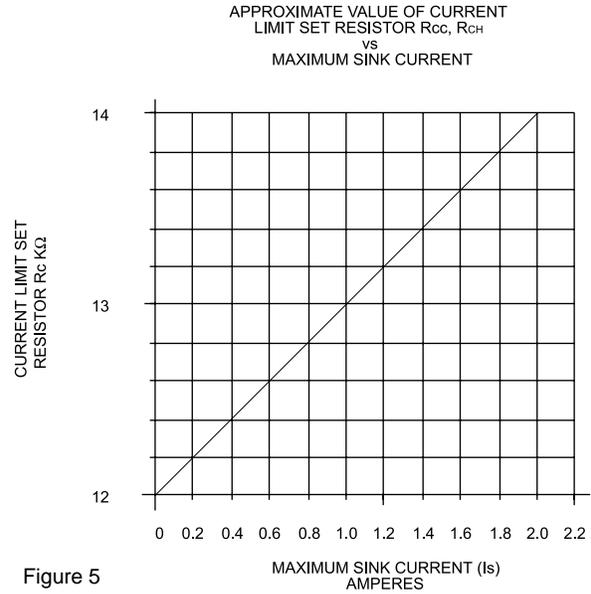**Figure 3** illustrates the locus of operating current and voltage for two different TECs.

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 HY5650 current source characteristics defines the locus of operation voltage and current for both the HY5650 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 R_{CC} and R_{CH}.

Example 2:
A supply voltage of 3 Volts was chosen for the Melcor OT 1.2-12-FO TEC. This device has a maximum rated voltage of 7.98 Volts at a current of 1.2 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 R_{CC} and R_{CH}.

Note that the power dissipated in the HY5650 never exceeds the 6 Watt maximum power dissipation in both of these examples.

TEMPERATURE SET
RESISTOR Rs
vs
SET TEMPERATURE

Figure 4

APPROXIMATE VALUE OF CURRENT
LIMIT SET RESISTOR R_{CC}, R_{CH}
vs
MAXIMUM SINK CURRENT
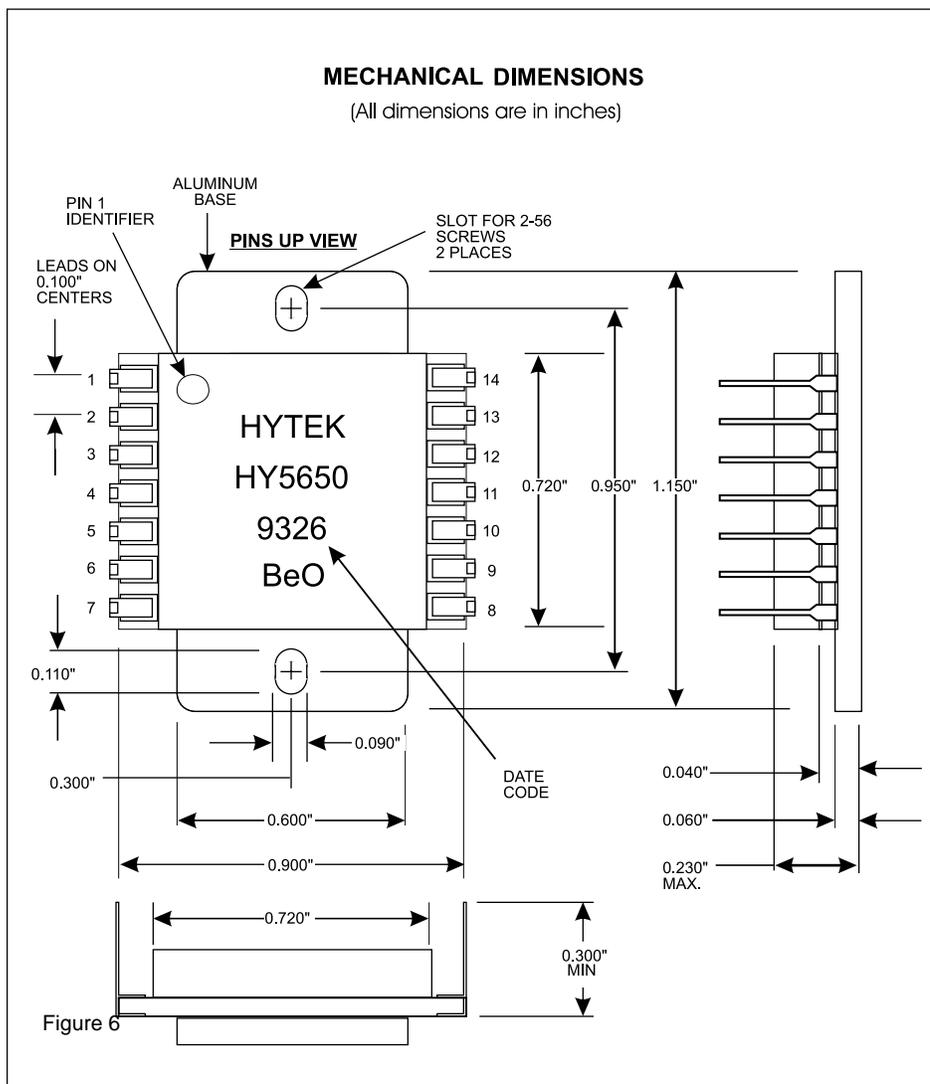

Figure 5

MECHANICAL DIMENSIONS
(All dimensions are in inches)

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
2	20 MΩ	0.1 µF	to
3	3 MΩ	1.0 µF	10MΩ
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 HY5650 is mounted is flat and clean, otherwise the ceramic substrate may break.

2. Use a thermal compound such as Dow Corning 340 between the HY5650 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.