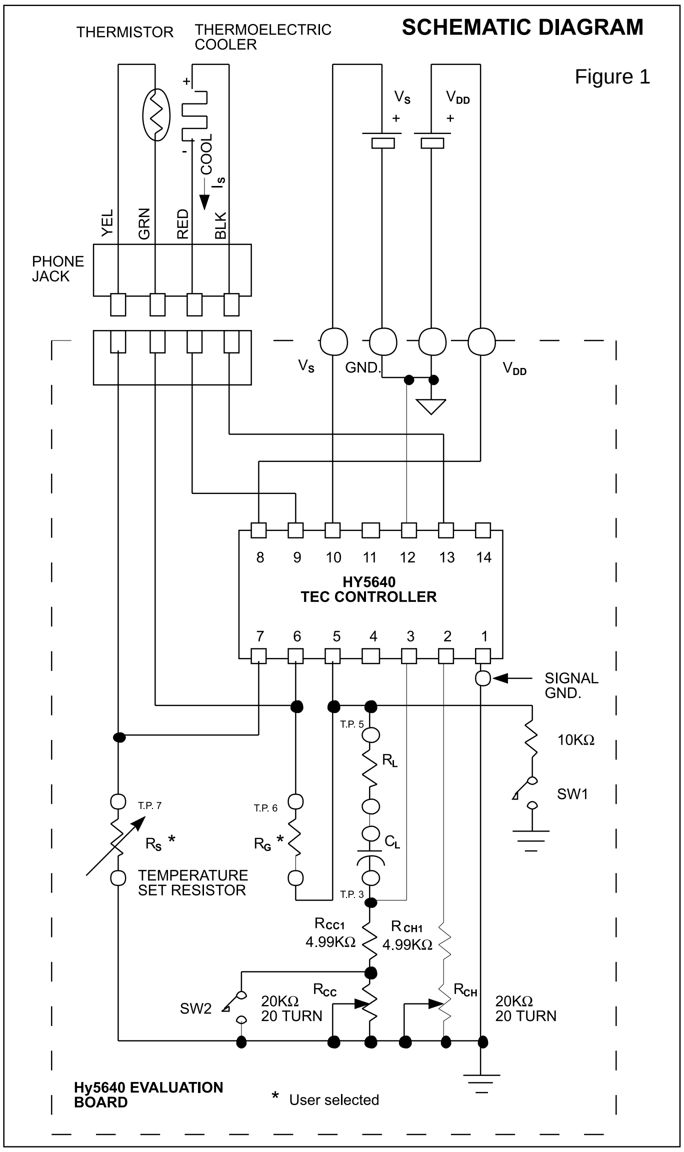
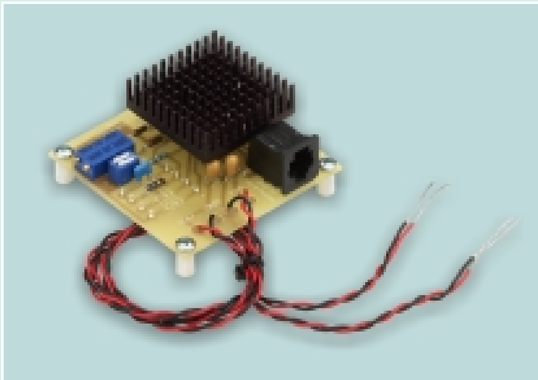
Thermoelectric Cooler Controller Evaluation Board

The HY5640 Evaluation Board is a printed circuit board containing the HY5640 TEC Controller plus most of the other components required to make an evaluation temperature controller for Thermoelectric Coolers. This evaluation board provides the means for a designer to quickly interface the HY5640 with a Thermoelectric Cooler and to evaluate performance before designing a printed circuit board. A schematic diagram for the test board is shown below. The evaluation board contains loop compensation components of 1µF and 6.8 MΩ (C_L and R_L). These components can easily be replaced if it is found that other values are more suitable. Terminals for the temperature set resistor (R_S) are provided on the Evaluation Board for the user to set the desired TEC temperature.





Procedure for Setting Up the HY5640 Evaluation Board

1. Connect a Thermoelectric Cooler and a Thermistor to the evaluation board as shown in the schematic diagram. A phone jack along with interconnect cables are provided for interfacing the Evaluation Board to the Thermoelectric Cooler and Thermistor.
2. Select a Temperature set resistor (R_S) that will program the HY5640 to regulate the TEC to the desired temperature. For example: A 56KΩ resistor will set the TEC to a temperature of –10°C if Dale 1M1002, 10KΩ thermistor is used. See the "Set Temperature vs. Program resistor (R_S)" curve in HY5640 Data Sheet to determine the correct value of R_S for your application. **Caution:** The HY5640 controller will supply maximum programmed cooling current to the TEC if R_S is not present. The thermoelectric cooler could be damaged if this condition exists for a prolonged period of time.
3. A 1 µF capacitor and a 6.8MΩ resistor have been selected for the loop stabilization components C_L and R_L. These values will more than likely be satisfactory for most applications. They can easily be changed if they are not. (Reference the HY5640 Data Sheet)
4. There is a position for R_G, the loop gain control resistor, on the evaluation board. However, this resistor has been omitted. This is because there is a 10MΩ resistor internal to the HY5640 that is in parallel with R_G that will, in most cases, provide sufficient loop gain.

Procedure for Setting Up the HY5640 Evaluation Board *(continued)*

5. Connect the V_S and V_{DD} power supplies to the test board. The desired values for these supplies should be set before the power supplies are connected to the evaluation board. Note that V_S should be able to supply more than 2 Amperes of current. Before turning on the power supplies, make certain the TEC, the Thermistor and the temperature set resistor (R_S) are connected to the Evaluation Board. In addition, SW1 and SW2 should be “off.”
6. Turn on the power supplies. The current flowing through the TEC will either be in a direction to cool the TEC or to heat it depending on the value of the temperature set resistor R_S and the temperature of the Thermistor. If R_S is greater in value than the resistance of the thermistor, the HY5640 will supply maximum cooling current. If R_S is smaller in value than the thermistor the HY5640 will supply maximum heating current. The HY5640 will continue to supply maximum heating or cooling current until the resistance of the Thermistor equals the value R_S. The current supplied by the HY5640 will then decrease to a value required to maintain the TEC at the set temperature.
7. Potentiometer R_{CC} controls the maximum TEC current in the cooling mode and Potentiometer R_{CH} controls the maximum current in the heating mode. The Evaluation Board has been adjusted at the factory so that a maximum of 0.8 Amperes flows through the Thermoelectric Cooler when cooling and 0.3 Amperes when heating. If a higher or lower value of cooling current is desired, push Switch #1 to the "on" position. This action forces the HY5640 to supply maximum cooling current to the TEC. This maximum cooling current can be adjusted to the desired value with the potentiometer labeled R_{CC}. Do not exceed the maximum current specification for the TEC. Return SW1 to the “off” position after the adjustment of R_{CC}. If a higher or lower value of heating current is required, push Switch #2 to the “on” position. This forces the HY5640 to deliver maximum heating current to the TEC. This maximum heating current can be adjusted to the desired value with the potentiometer labeled R_{CH}. Return SW2 to the “off” position after the adjustment of R_{CH}. Note that both SW1 and SW2 must be in the “off” position for normal operation.

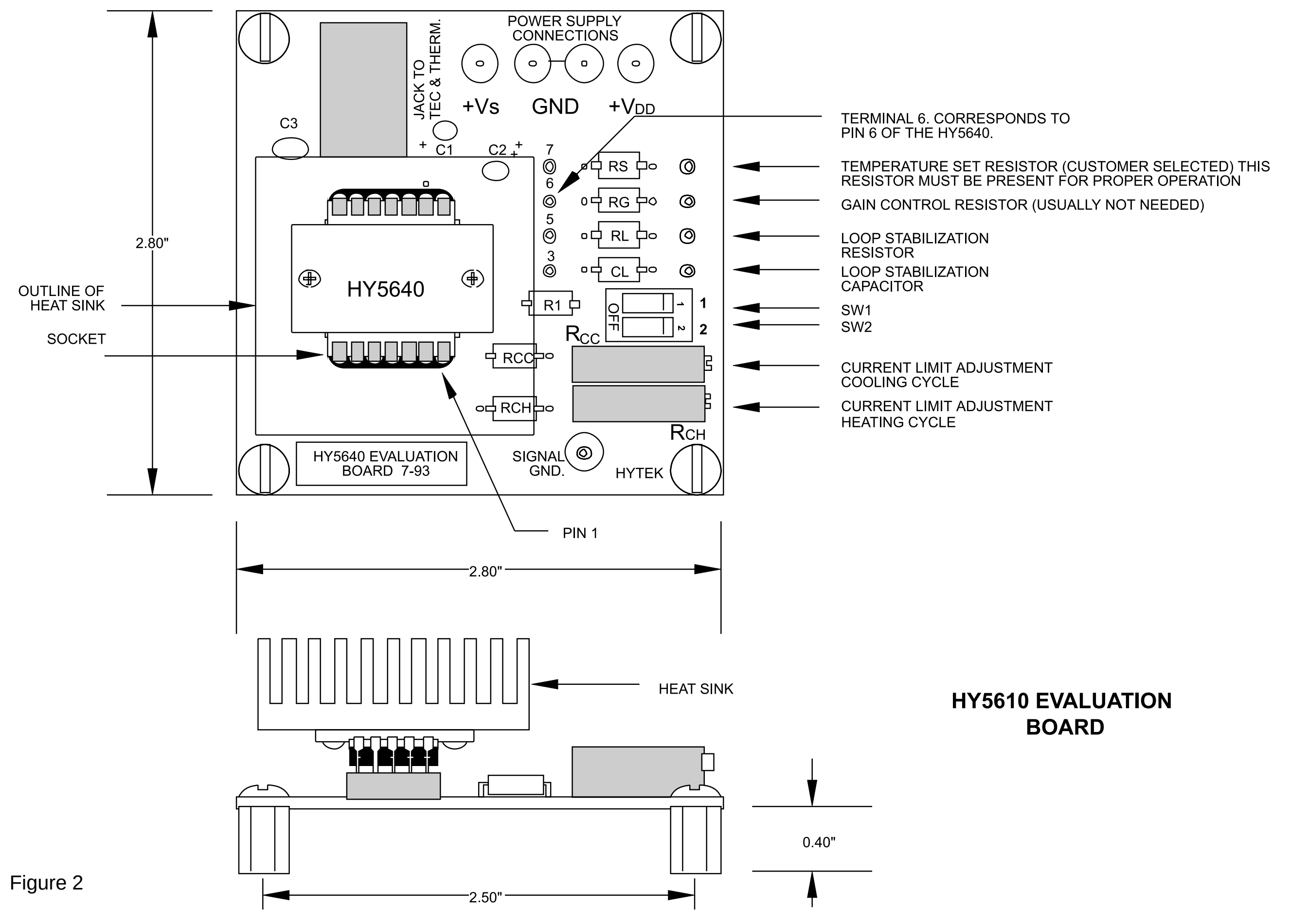


Figure 2

Measuring the Temperature Regulating Performance of the HY5640

The output of the temperature measuring circuit of the HY5640 is Pin 6. Test Point 6 on the evaluation board corresponds to this output. The temperature measurement circuit of the HY5640 is illustrated in Figure 3 where R_T is the thermistor that measures the temperature of the Thermoelectric Cooler and R_S is the temperature set resistor. The output voltage (E_O) at Test Point 6 is given by the equation below. This output feeds the integrator portion of the HY5640 which in turn applies power to the TEC. Cooling of the TEC results until R_T equals R_S. This produces a voltage (E_O) of 2.048 Volts between TP 6 and signal ground. The Voltage/Temperature coefficient at TP 6 is approximately 50 mVolts per °C when this occurs. Monitoring Test Point 6 will tell the user when the loop is stabilized and how accurately the temperature is controlled. When the loop has stabilized, the voltage at TP 6 will be stable to better than 1 mVolt. This equates to a temperature stability of better than .02 °C.

TEMPERATURE MEASUREMENT STAGE OF THE HY5640

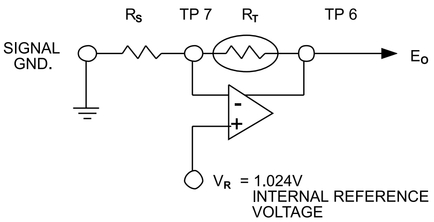


FIGURE 3

1. $E_O = (R_T/R_S + 1)V_R$, $E_O = 2.048V$ when $R_T = R_S$

2. $\Delta E_O/\Delta T = V_R(\Delta R_T/R_T)/\Delta T$ = 50mVolts Per °C.

Where:

$(\Delta R_T/R_T)/\Delta T \cong 0.04$ Per °C. and $V_R = 1.024$ Volts.

$\Delta E_O/\Delta T$ is the Voltage/Temperature coefficient of the circuit in Figure 3 when $R_T = R_S$.

$(\Delta R_T/R_T)/\Delta T$ is the approximate temperature coefficient of the Dale 1M1002 10KΩ thermistor.

The temperature controlling stability of the HY5640 vs. Thermoelectric Cooler (TEC) drive current is measured using the test setup illustrated in Figure 4. The thermoelectric cooler and temperature sensing thermistor are placed in a temperature chamber. An identical thermistor is mounted in intimate contact with the sensing thermistor. Both thermistors are embedded in an aluminum block that is attached to the top surface of the TEC. The bottom face of the TEC is attached to a heat sink. The temperature of the controlling thermistor is set to approximately 25°C by selecting an R_S value of 10KΩ. R_S is a precision temperature stable resistor. TEC drive current is monitored as the temperature of the chamber is increased above 25°C. Resistance of the second thermistor is recorded and converted to temperature for various TEC drive currents. A typical plot of Temperature stability vs. TEC Drive Current is shown in Figure 6.

TEMPERATURE VARIATION WITH LOAD CURRENT CHANGE

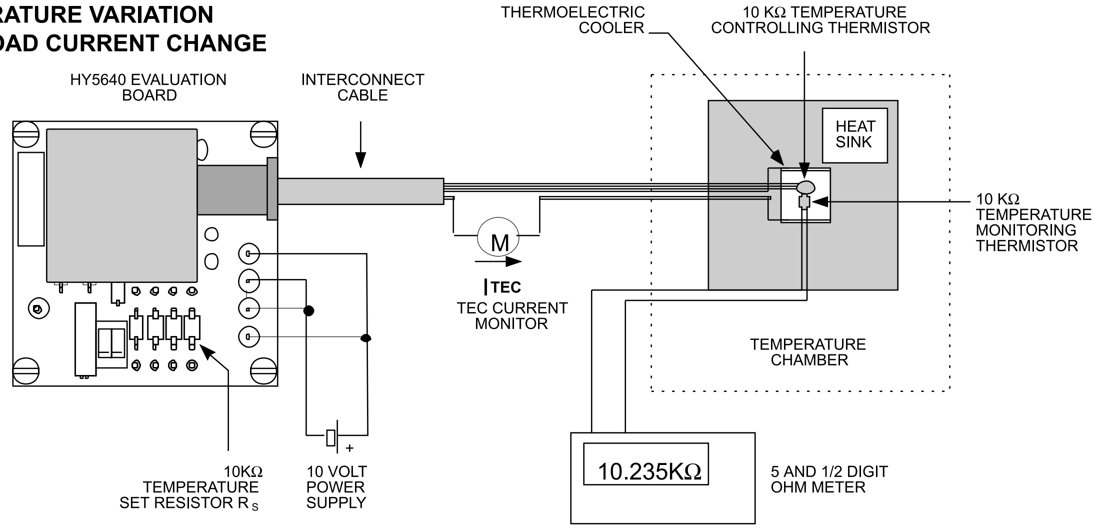


Figure 4

The temperature controlling stability of the HY5640 vs. Base Temperature* is measured using the test setup illustrated in Figure 5. The HY5640 is placed inside the temperature chamber. The thermoelectric cooler/thermistor assembly is placed outside the chamber. In addition, the 13KΩ temperature set resistor Rs is located outside the chamber to eliminate any temperature effects due to this resistor. This value of Rs sets the temperature of the controlling thermistor to approximately 18°C. The temperature of the test chamber is varied from –55°C to +110°C. Resistance of the temperature measuring thermistor is recorded and converted to temperature. A typical plot of Temperature stability vs. Base temperature of the HY5640 is shown in Figure 7.

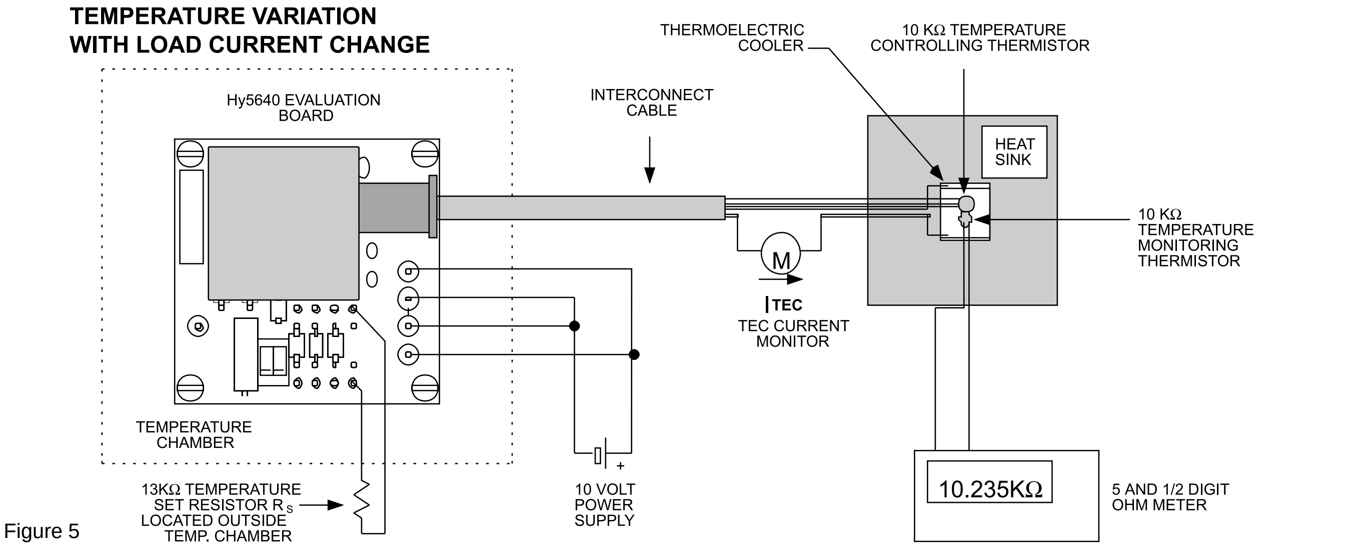


Figure 5

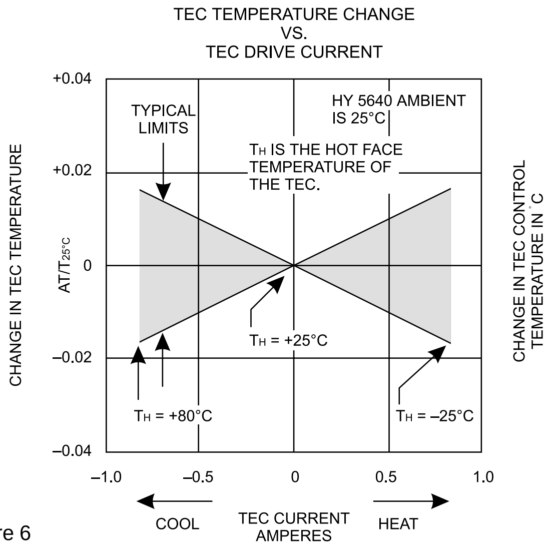


Figure 6

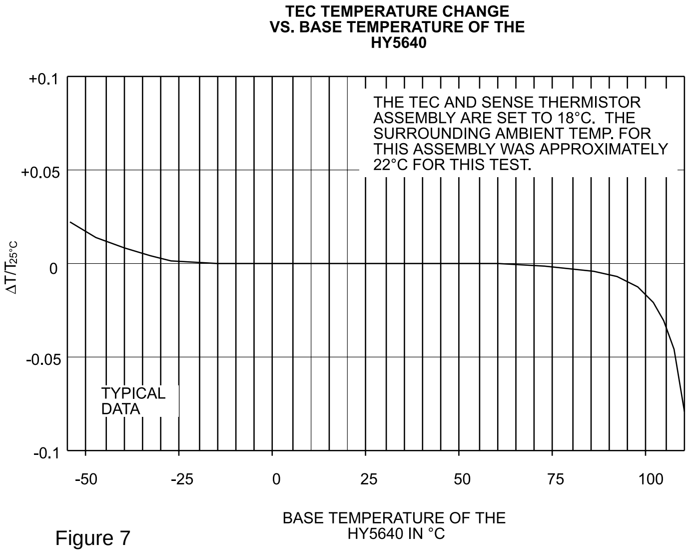


Figure 7

* Base Temperature is the temperature of the aluminum heat spreader (Base) of the HY5640. In the experiment illustrated in Figure 5, the programmed temperature of the TEC assembly and its ambient temperature are almost equal. The TEC current is therefore almost zero amperes thus eliminating any self heating effects in the HY5640. In this case, the temperature of the HY5640 is virtually equal to the temperature of the chamber. In practice, the temperature of the base of the HY5640 is a function of the TEC drive current, the HY5640 heat sink size, the air flow across the heat sink and the temperature of the surrounding air.