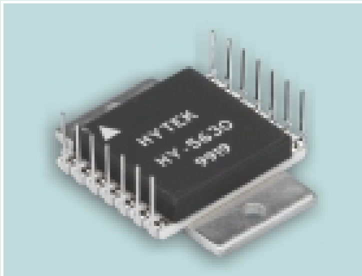
Subminiature Controller for Thermoelectric Coolers

The HY5630 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 HY5630 operates in conjunction with a thermistor bridge to precisely measure and regulate the temperature of a device affixed to a TEC while displaying stabilization condition via an external LED. 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 5 to 12 volt power supply.



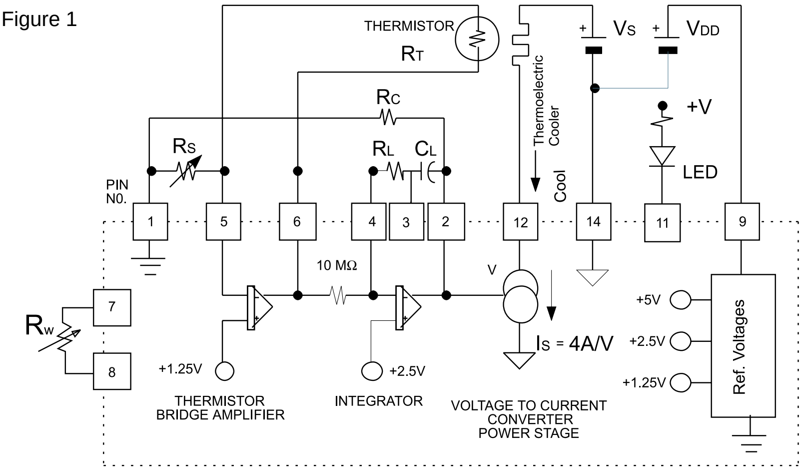
Maximum Ratings:

Rating	Symbol	Value	Unit
Supply Voltage	V_{DD}	+20	Volts DC
Supply Voltage 2 (Voltage on Pin 12)	V_S	+12	Volts DC
Current Sink	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:

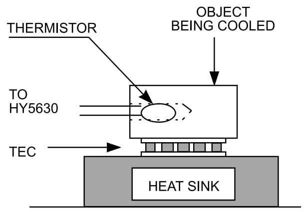
- ✦ Proportional/Integral (PI) control
- ✦ Small size
- ✦ Drive current to 2 amps
- ✦ Operation to 12 volts
- ✦ Control –55°C to ambient
- ✦ Integrated Window Comparator
- ✦ Temperature Stability to 0.01°C
- ✦ Thru-hole or surface-mount packaging

Figure 1



SIMPLIFIED SCHEMATIC OF THE HY 5630 SHOWN WITHIN THE DASHED LINES

MOUNTING THE THERMISTOR



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.

The HY5630 TEC controller consists of a thermistor bridge amplifier, a window comparator, an integrator/gain stage and a voltage-to-current converter power drive stage. This is illustrated in the simplified schematic diagram for the HY5630 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 HY5630 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). A window comparator measures the output of the thermistor bridge and can illuminate an external LED when the thermistor is within ±2.4°C of setpoint. This window can be narrowed with an external resistor (Rw).

Description of the HY5630 Pin Outs

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

The temperature set resistor for the HY5630 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 10KW 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 5 to Pin 6)

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 HY5630 has been designed for a negative temperature coefficient thermistor (5k to 20k nominal). 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.

• Stabilization Window Set Resistor, R_W (Pin 7 to Pin 8)

A circuit internal to the HY5630 measures the output of the Thermistor Bridge. A switch closure to power ground occurs when the output of this bridge is between 2.4 and 2.6V. This indicates that the temperature of the detector has stabilized to within 2°C of the programmed set temperature. This switching occurs between Pin 11 and power ground Pin 14 and can sink up to 200 mA of external LED current. A 2000 ohm potentiometer can be connected between pins 7 and 8 to increase the sensitivity of the Temperature Stabilization Indicator. This will narrow the temperature range at which switching occurs with coincident LED illumination.

• Loop Stability network, R_L and C_L (Pin 4 to pin 2)

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 Resistor, R_C (Pin 1 to Pin 2)

This resistor limits the maximum current that the HY5630 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 9 to Pin 14) $+7 \leq V_{DD} \leq +20$ Volts

This input supplies the voltage to the internal circuitry of the HY5630. The maximum current drain at this terminal is 5mA.

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

Pin 12 connects the TEC to the programmable current sink in the HY5630. The other lead of the TEC is connected to + Vs. At turn-on, the current into Pin 12 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 R_C. 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.

HY5630 CURRENT SOURCE CHARACTERISTICS

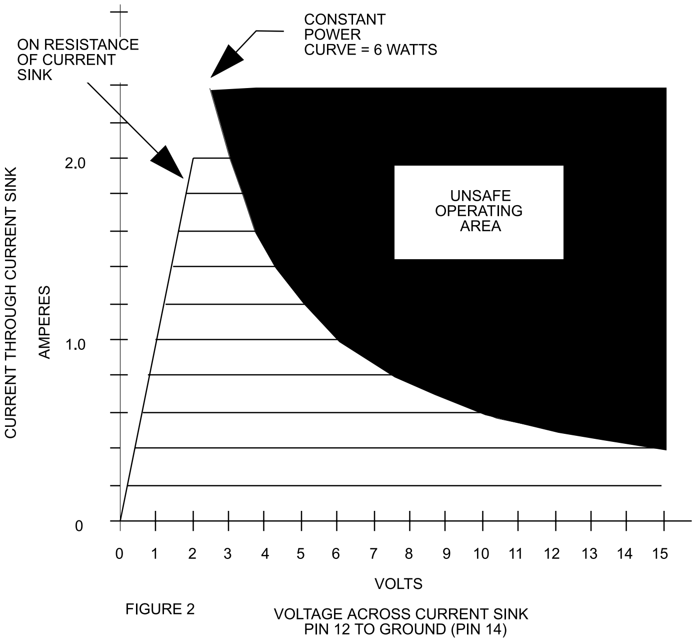


FIGURE 2

Figure 2 illustrates the characteristics of the HY5630 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 HY5630 OPERATING POINTS USING LOAD LINES

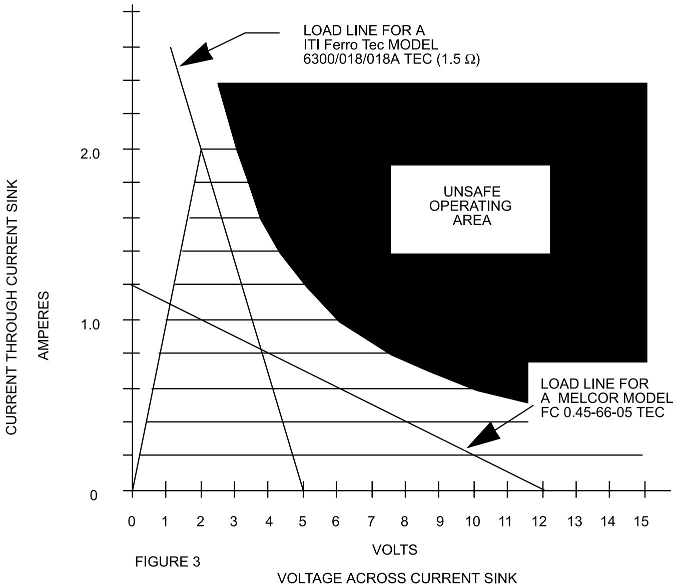


FIGURE 3

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 HY5630 current source characteristics define the locus of operation voltage and current for both the HY5630 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 HY5630 never exceeds the 6 Watt maximum power dissipation.

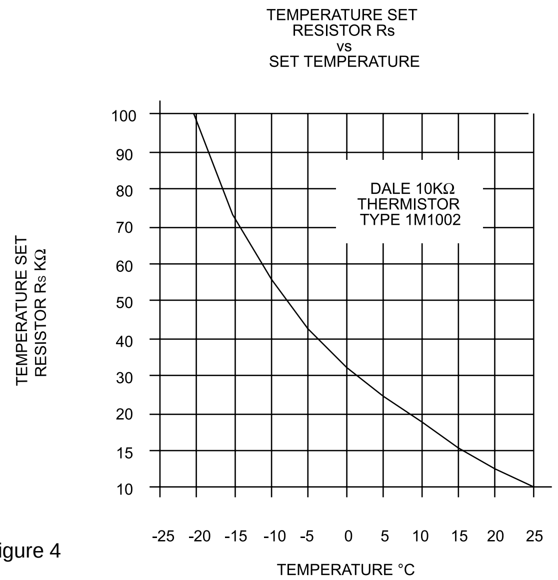


Figure 4

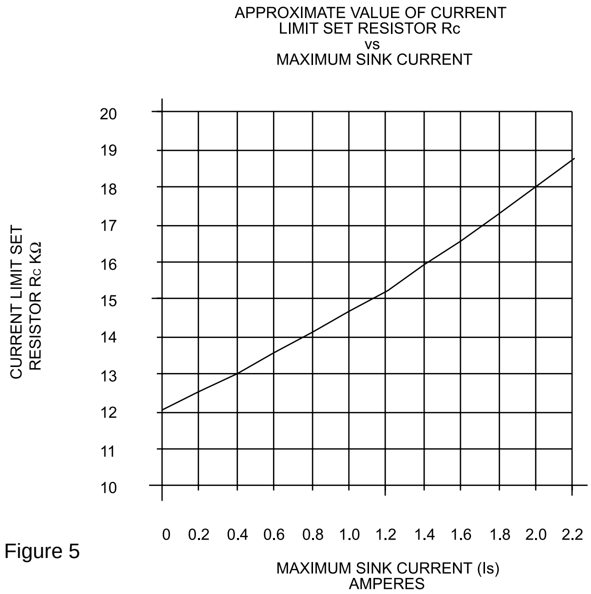
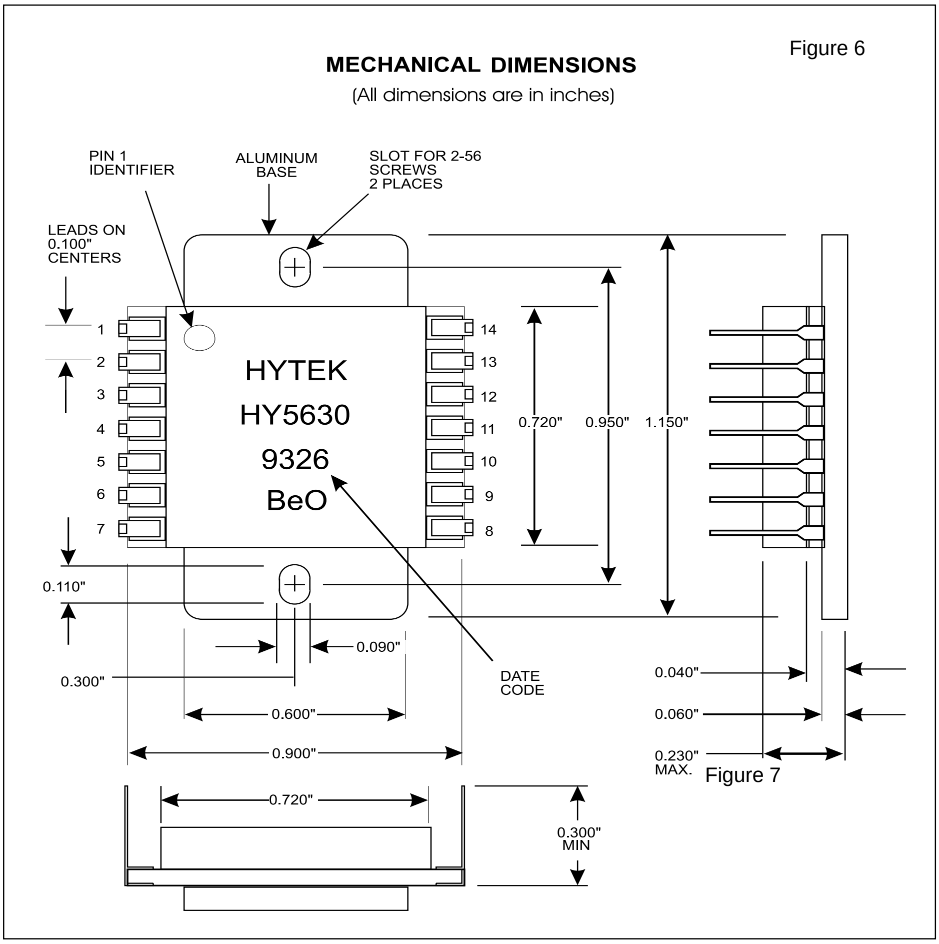


Figure 5



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 HY5630 is mounted is flat and clean, otherwise the ceramic substrate may break.
2. Use a thermal compound such as Dow Corning 340 between the HY5630 and the heat sink for good thermal conduction.

Specifications subject to change without notice.