*hytek microsystems*

Subminiature Controller for Thermoelectric Coolers

The HY5610 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 HY5610 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 12 Volt power supply.
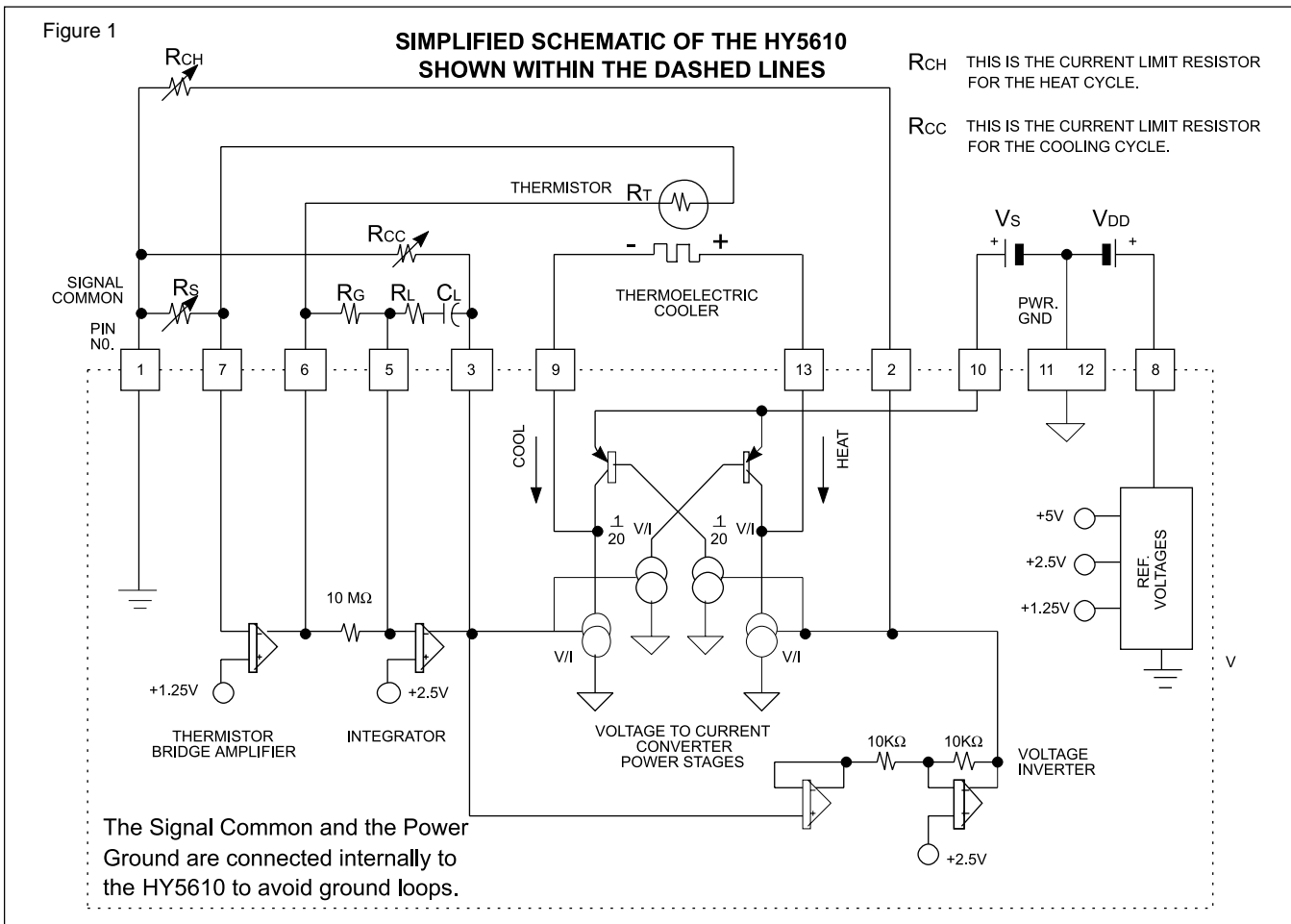
Maximum ratings:

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	℃
Storage Temperature	T_{STG}	–65 to +150	℃
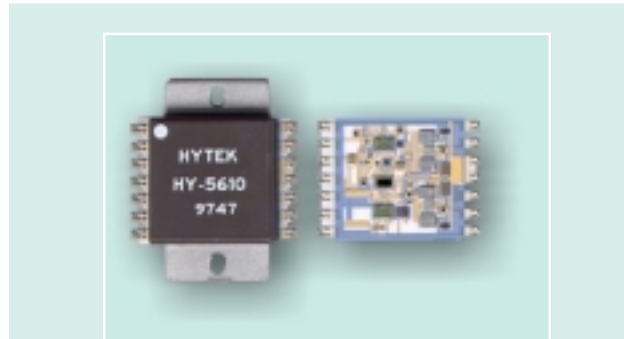
Features

✦ 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
✦ Thru-hole or surface-mount packaging

Figure 1

SIMPLIFIED SCHEMATIC OF THE HY5610 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 HY5610 to avoid ground loops.

Description of the HY5610 Pin Outs

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

The temperature set resistor for the HY5610 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 HY5610 has been designed for a negative temperature coefficient thermistor. A thermistor or RTD (5KΩ – 10KΩ) 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 HY5610 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 HY5610 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 18KΩ will limit the maximum cooling current to 2 Amperes and an R_{CH} value of 16KΩ will limit the maximum heating current to 1.4 Amperes.

• **V_{DD} (Pin 8 to Pins 11 & 12) +7 < V_{DD} < +20 Volts**

This input supplies the voltage to the internal circuitry of the HY5610. 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 HY5610 power drive circuitry. The maximum current drain at this terminal should not exceed 2 Amperes.

• **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 HY5610. 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 V_{MAX} of the selected TEC. Setting Vs higher than this can cause excessive heating of the controller.
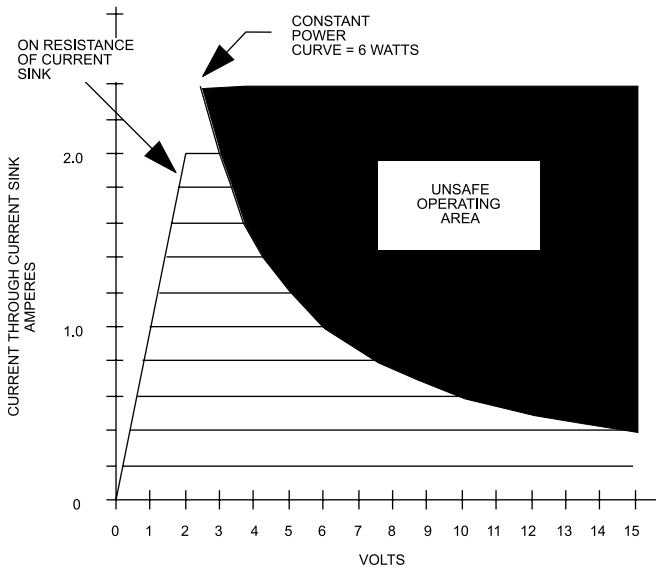
**HY5610 CURRENT SOURCE
CHARACTERISTICS**

ON RESISTANCE
OF CURRENT
SINK

CONSTANT
POWER
CURVE = 6 WATTS

CURRENT THROUGH CURRENT SINK
AMPERES

2.0

1.0

0

UNSAFE
OPERATING
AREA

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

VOLTS

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

**DETERMINATION OF THE
HY5610 OPERATING
POINTS USING LOAD LINES**

LOAD LINE FOR A
ITI Ferro Tec MODEL
6300/018/018A TEC (1.5Ω)

CURRENT THROUGH CURRENT SINK
AMPERES

2.0

1.0

0

UNSAFE
OPERATING
AREA

LOAD LINE FOR
A MELCOR MODEL
FC 0.45-66-05 TEC

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
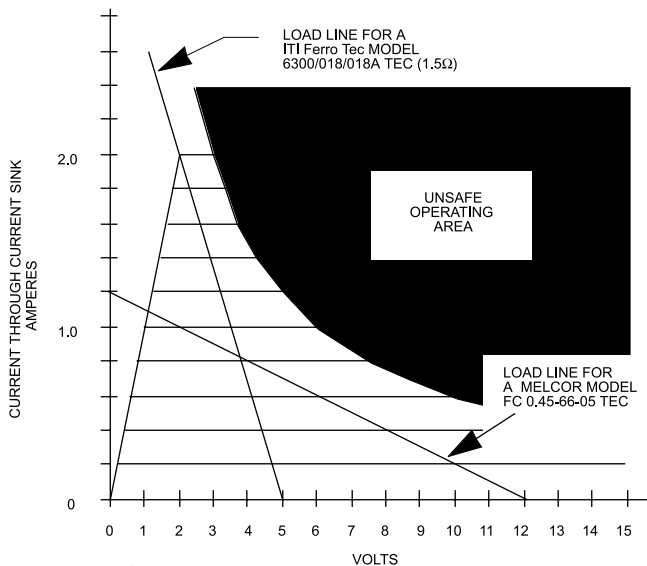
VOLTS

FIGURE 3

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

Figure 2 illustrates the characteristics of the HY5610 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 HY5610 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 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 HY5610 current source characteristic's define the locus of operation voltage and current for both the HY5610 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 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 R_{CC} and R_{CH}.

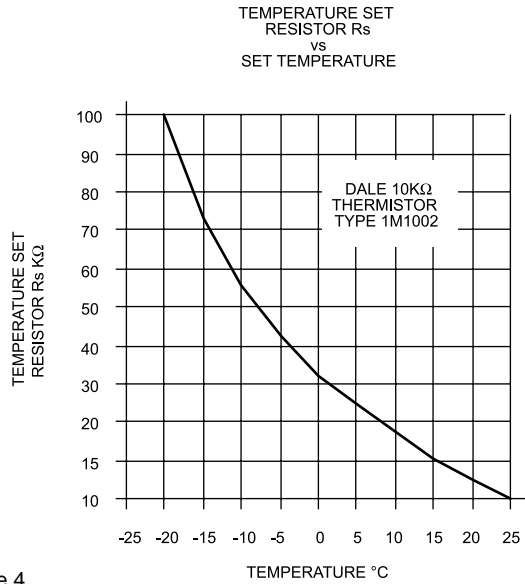Note that the power dissipated in the HY5610 never exceeds the 6 Watt maximum power dissipation in both of these examples.
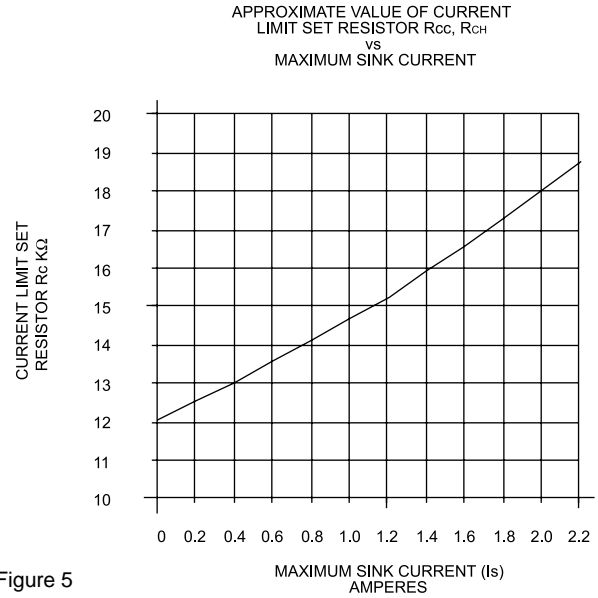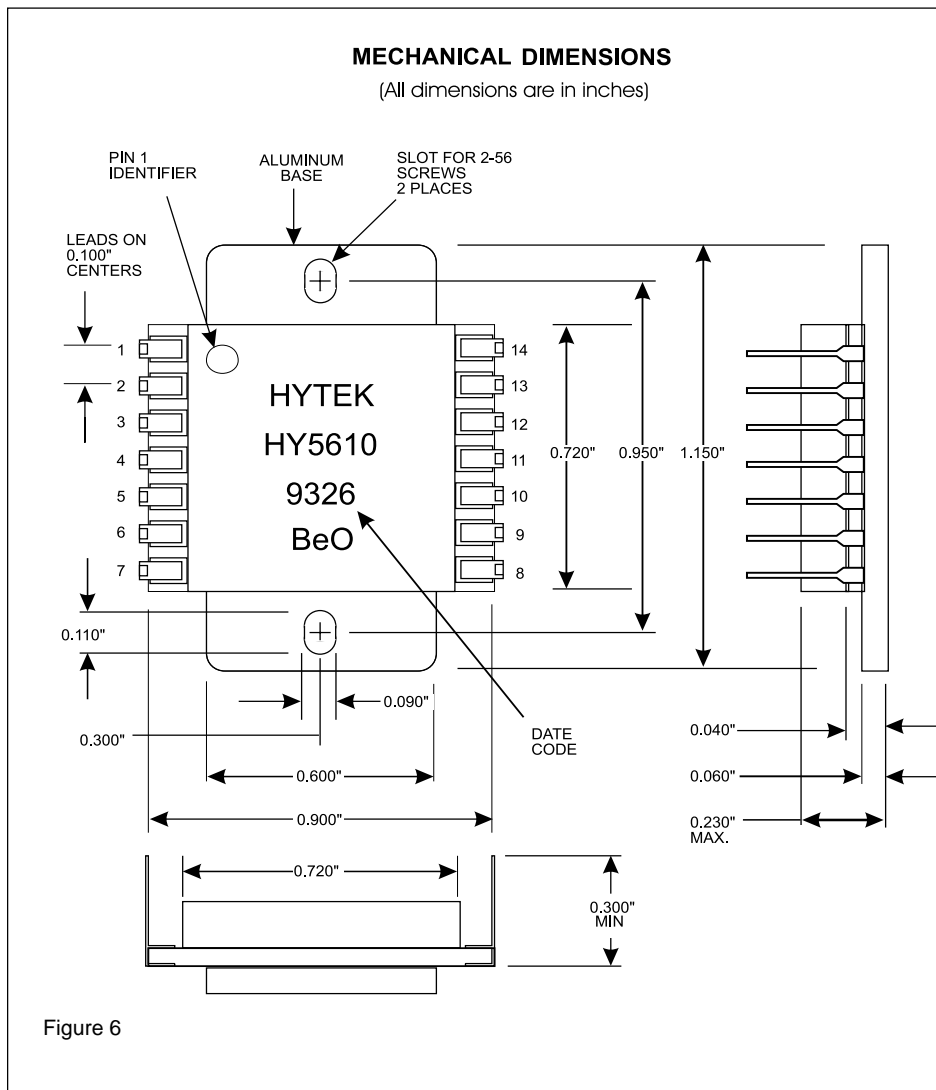
TEMPERATURE SET
RESISTOR Rs
vs
SET TEMPERATURE

DALE 10KΩ
THERMISTOR
TYPE 1M1002

TEMPERATURE SET RESISTOR Rs KΩ

TEMPERATURE °C

Figure 4

APPROXIMATE VALUE OF CURRENT
LIMIT SET RESISTOR Rcc, Rch
vs
MAXIMUM SINK CURRENT

CURRENT LIMIT SET RESISTOR Rc KΩ

MAXIMUM SINK CURRENT (Is)
AMPERES

Figure 5

MECHANICAL DIMENSIONS
(All dimensions are in inches)

PIN 1
IDENTIFIER

ALUMINUM
BASE

SLOT FOR 2-56
SCREWS
2 PLACES

LEADS ON
0.100"
CENTERS

HYTEK
HY5610
9326
BeO

0.720" 0.950" 1.150"

0.110"

0.090"

0.300"

0.600"

0.900"

0.720"

DATE
CODE

0.040"

0.060"

0.230"
MAX.

0.300"
MIN

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 HY5610 is mounted is flat and clean, otherwise the ceramic substrate may break.

2. Use a thermal compound such as Dow Corning 340 between the HY5610 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.