MODULAR ONE TECHNOLOGY

MOT7000/7001 Series & MOT3000-25

Precision Temperature Controller for Peltier Modules

FEATURES:

- **±2A, ±2.5A, or ±3A Maximum TEC Current**
- **Temperature Stability Better than ±0.002°C**
- **Adjustable TEC Voltage Limit**
- **Independent Cooling and Heating Current Limit**
- **Voltage Programmable TEC Current Set**
- **Slow Start Circuit for TEC Protection**
- **Very Low Noise and Low Ripple Design**
- **TEC Current Monitor**
- **TEC Temperature Monitor**
- **Over-temperature and Under-temperature Alarm**
- **Precision Reference Voltage Output**
- **Low Power Consumption**
- **Small Footprint**
- **Full RoHS compliant**

APPLICATIONS

- **Fiber Optic Laser Modules**
- **WDM, DWDM Laser-Diode Temperature Control**
- **Fiber Optic Network Equipment**
- **EDFA Optical Amplifiers**
- **ATE, Instrumentation**
- **Fiber Laser**
- **Direct-drive Laser Diode**

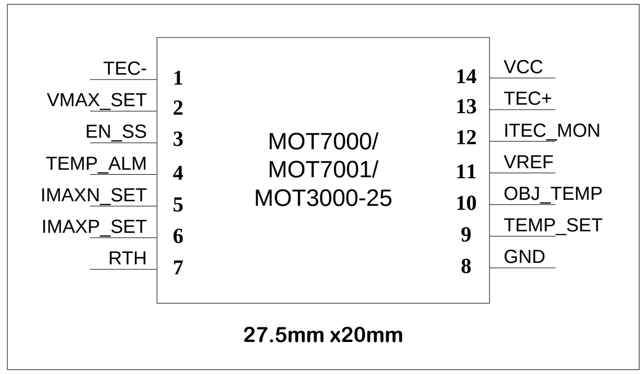
OVERVIEW

The MOT7000/7001 & MOT3000-25 are precision temperature controllers used for driving Peltier modules (TECs) where high accuracy temperature control is a prime requirement. These electronic modules incorporate all the necessary components to minimize end equipment design, including an internal control loop compensation network.

Extensive filtering and unique ripple-cancellation techniques optimize component size and efficiency while reducing noise.

Differential design has been used throughout in order to maintain better than ±0.002°C temperature stability.

PIN CONFIGURATION



MODULE SELECTION TABLE

Part #	Description
MOT7000-20	±2A Output Current
MOT7000-30	±3A Output Current
MOT7001-20	±2A Output Current
MOT7001-30	±3A Output Current
MOT3000-25	±2.5A Output Current

Output current, rather than voltage is directly controlled to eliminate current surges.

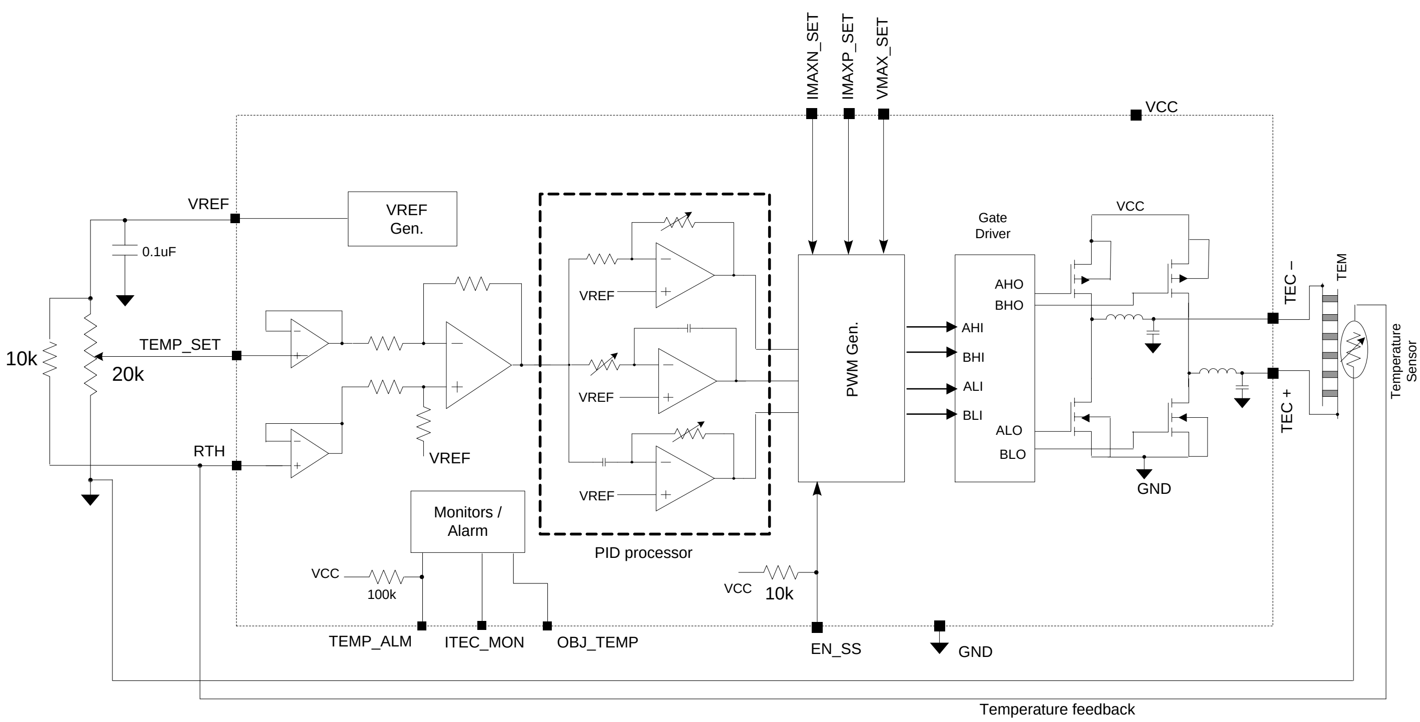
All variants in the MOT7000/7001 series and MOT3000-25 operate from a single supply and provide bipolar output currents. True bipolar operation controls temperature without “dead zones” or other nonlinearities at low load currents. An analog control signal precisely sets the TEC current.

A proportional-integral-derivative (PID) controller is used to stabilize the temperature control loop. Internal loop compensation is optimized for driving laser assemblies or other low-frequency TECs applications. An internal instrumentation amplifier can interface to an external NTC or PTC thermistor, thermocouple, or semiconductor temperature sensor for temperature monitoring. Analog outputs are provided to monitor TEC temperature and current. In addition, over-temperature and under-temperature outputs indicate when the TEC temperature is out of range.

An on-chip voltage reference provides bias for a thermistor bridge, control potentiometer or external DAC.

These modules have a small footprint (20mm x 27.5mm) and operate over the -40°C to 85°C temperature range.

MOT7000/7001 SERIES & MOT3000-25 BLOCK DIAGRAM



Note: IMAXP_SET and IMAXN_SET are availble with MOT7001-xx and MOT3000-25.

For MOT7000-xx leave these two pins as no connect

PIN DESCRIPTION

Pin #	PIN Name	Description
1	TEC-	Negative TEC module connection. Connect to negative side of the TEC module.*
2	VMAX_SET	Maximum TEC voltage. A resistor from this pin to GND sets the maximum voltage across the TEC. The value of this voltage x4 is the maximum voltage at the TEC terminals. This pin may be left open for maximum output voltage.
3	EN_SS	Enable & Slow Start. Default is enabled. Internally pulled high. A low signal disables the module.
4	TEMP_ALM	Temperature Alarm. If the object temperature moves outside a ±1.5°C window around the set temperature this pin will be pulled low. Once the temperature returns to within the window TEMP_ALM will return to a high level (internal pull-up).
5	IMAXN_SET	Negative current Adjust. A resistor from this pin to GND sets the maximum negative current of the module. See tables in page 5.
6	IMAXP_SET	Positive current Adjust. A resistor from this pin to GND sets the maximum positive current of the module. See tables in page 5.
7	RTH	Thermistor input.
8	GND	Ground (0V)
9	TEMP_SET	TEC temperature set. A voltage from 0V to 1.5V sets the required TEC current, which in turn sets the temperature. (If left open, internal bias sets the temperature to approximately 25°C)
10	OBJ_TEMP	Temperature output. An analog voltage indicates the temperature of the Peltier Module. 1.5V is equivalent to 25°C.
11	V_{REF}	1.5V Reference voltage output.
12	ITEC_MON	TEC current monitor output. The voltage at this pin has a linear relationship to the TEC current.
13	TEC+	Positive TEC module connection. Connect to positive side of the TEC module.*
14	V_{CC}	Positive supply voltage +3V to +5.5V.

* The correct connection of this pins depends not only on possible colour coding of the TEC wires, but also which side of the TEC itself is thermally connected to the object. After powering on the system, if the control loop does not appear to be working the connections may need to be reversed.

FUNCTIONAL DESCRIPTION

The MOT7000/7001& MOT3000-25 are precision TEC module controller/driver designed for applications where very precise temperature control is required. It is a bidirectional current driver allowing both cooling and heating control of the object. Both object temperature and output current are monitored and are available as analog voltages, which can be read by a host controller. The object temperature can be set precisely using either a simple potentiometer or an external DAC under host control. Temperature stability of better than 0.002°C can be achieved.

Internal loop compensation is optimized for use with laser modules or other low frequency TEC applications, no additional external compensation is required. *For specific applications where additional loop compensation may be required please contact the factory.*

TEC Drivers

The differential output pins (TEC+ and TEC-) drive the Peltier module directly. The driver transistors and compensation networks are included within the MOT7000/7001 & MOT3000-25. No additional external components are required for use with laser assemblies and other low-frequency TEC applications.

Setting TEC Temperature

The TEMP_SET pin is used to set the required TEC temperature. Once set, the controller maintains this temperature with a high degree of accuracy. A voltage from 0V to 1.1V at the pin results in the TEC being driven with a varying duty cycle until the set temperature is reached, as measured by the temperature feedback loop. (Depending on the original ambient temperature and the desired object temperature the TEC will heat or cool as required). Once reached the set temperature will be accurately maintained. The nominal relationship between the input voltage and the resulting TEC temperature is shown in Chart 1 and, numerically, in Table 1.

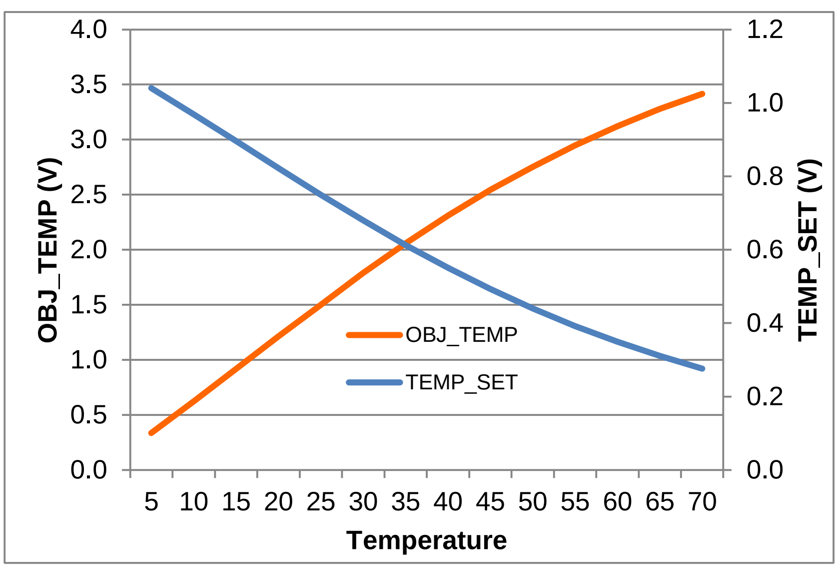


Chart 1 – MOT7000/7001 Temperature characteristics for TEMP_SET and OBJ_TEMP

Temp (˚C)	TEMP_SET (V)	Temp (˚C)	TEMP_SET (V)	Temp (˚C)	TEMP_SET (V)
5	1.04	30	0.68	55	0.39
10	0.97	35	0.61	60	0.35
15	0.90	40	0.55	65	0.31
20	0.82	45	0.49	70	0.28
25	0.75	50	0.44		

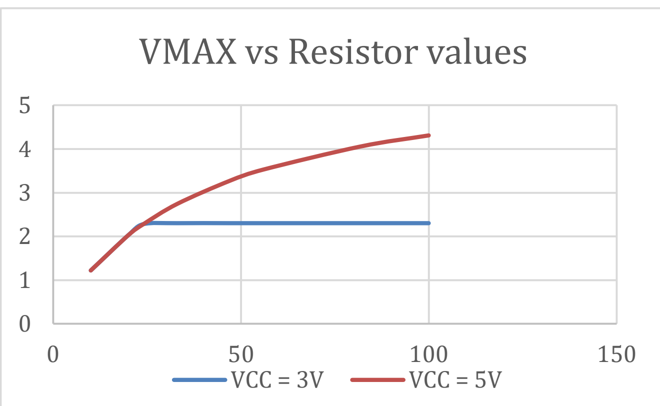
Table 1 – TEMP_SET Control Voltage versus Temperature

Note: The data shown assumes a 10k thermistor, with characteristics as shown in Appendix 1. Use of other thermistors will result in correspondingly different values.

Maximum Output Voltage (VMAX)

The maximum output voltage at the TEC pins can be limited by a resistor from the VMAX_SET pin to ground. If this pin is left open the maximum output voltage will be available. The maximum output voltage will be 4x the voltage appearing at the VMAX_SET pin, up to the maximum specified output voltage. This pin is internally connected to VREF (1.5V) through a 39K resistor, with the external resistor to ground completing a voltage divider.

The formula for calculating R and VMAX is therefore: VMAX = 6 R / (39K + R)



Resistor (kOhms)	VCC = 3V	VCC = 5V
100	2.3	4.3
82	2.3	4.1
56	2.3	3.5
47	2.3	3.3
33	2.3	2.7
24	2.3	2.3
20	2.0	2.0
10	1.2	1.2

Maximum Positive and Maximum Negative output current (MOT7001-xx) and MOT3000-25

The maximum positive and negative currents outputs for MOT7001_xx and MOT3000-25 are adjustable independently. A resistor connected from Pin 6 to ground sets the positive current and a resistor connected from pin 5 to ground sets the negative current. The following two tables give the required resistor values and the maximum currents associated with each value for MOT7001-xx and MOT3000-25 modules.

MOT7001-30		MOT3000-25		MOT7001-20	
Max. Positive & Negative Currents	Resistor (kΩ)	Max. Positive & Negative Currents	Resistor (kΩ)	Max. Positive & Negative Currents	Resistor (kΩ)
+/-3.0	Open	-	-	-	-
+/-2.5	200	+/-2.5	Open	-	-
+/-2.0	78	+/-2.0	157	+/-2.0	Open
+/-1.5	39	+/-1.5	59	+/-1.5	120

Current Monitor Output

ITEC_MON provides a voltage output proportional to the TEC current. The relationship between the output voltage and the TEC current is:

$V_{ITEC\_MON} = 1.5 + 0.4*ITEC$ - MOT7000/7001-30
$V_{ITEC\_MON} = 1.5 + 0.6*ITEC$ - MOT7000/7001-20
$V_{ITEC\_MON} = 1.5 + 0.48*ITEC$ - MOT3000-25

Temperature Sensor

The Peltier module temperature is monitored as part of the control loop. The temperature sensor is connected to the RTH input pin. The monitored temperature is available as an analog output voltage at the OBJ_TEMP pin. The relationship between object temperature and the voltage appearing at the OBJ_TEMP pins is shown in Chart 1 and numerically in Table 2:

Temp (˚C)	OBJ_TEMP (V)	Temp (˚C)	OBJ_TEMP (V)	Temp (˚C)	OBJ_TEMP (V)
5	0.34	30	1.79	55	2.95
10	0.62	35	2.06	60	3.12
15	0.92	40	2.31	65	3.28
20	1.21	45	2.54	70	3.42
25	1.50	50	2.75		

Table 2 – OBJ_TEMP Output Voltage versus Temperature

Notes:
1. The data shown is based on simulation and will vary from device to device.
2. When operating at 3.3V the OBJ_TEMP output will saturate at higher temperatures (>60˚C), consequently 5V operation is recommended for higher object temperatures.

Over & Under Temperature Alarm

The controllers monitor temperature deviations from the set temperature value and flags an alarm at the TEMP_ALM pin (active low) if the object temperature is outside a ±1.5°C window.

Enable & Slow Start

All the modules feature a slow start and enable circuit in order to protect the TEC module. The TEC current will be disabled if EN_SS is pulled low to ground (EN_SS=0).
To enable the module this pin should be taken high, a pull-up resistor internal to the module allows this pin to be left open to provide automatic turn on at power up.

Voltage Reference

The internal reference of the MOT700x and MOT3000-25 is brought out and is available at the V_{REF} pin. This is a 1.5V precision reference voltage and can be used for a control potentiometer and/or external DACs / ADCs and thermistor bridges.

Absolute maximum ratings over operating free-air temperature range:
(unless otherwise noted) †

Supply voltage, V_{CC}	-0.3 to 6 V
Peak Output Current	3 A
Storage temperature:	-55°Cto 125°C
Free-air operating temperature range:	-40°C to 85°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the module. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Electrical Specifications:

(V_{CC} = 5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values at T_A = +25°C.)

Parameter	Symbol	Conditions	Min	Typ.	Max	UNITS
Positive Power supply voltage (V_{CC})	V_{CC}		+3.0		+5.25	V
Maximum Supply Current	I_{CCMAX}	MOT7000/7001-20, I_{OUT} = I_{MAX}			2.2	A
		MOT7000/7001-30, I_{OUT} = I_{MAX}			3.2	A
No load Supply Current	I_{CCO}	V_{CC} = 5V		30	50	mA
		V_{CC} = 3.3V		15	30	mA
Shut down supply current	I_{CCQ}	V_{CC} = 5V, EN_SS = GND		2	3	mA
TEC Outputs						
Maximum TEC output current	I_{MAX}	MOT7000/7001-20 MOT7000/7001-30	-2 -3		2 3	A
Differential Output Voltage (TEC+ - TEC-)	V_{OUT}	V_{CC} = 3V, I_{OUT} = I_{MAX}, VMAX_SET = 1.5V	-2.3		2.3	V
		V_{CC} = 5V, I_{OUT} = I_{MAX}, VMAX_SET = 1.5V	-4.3		4.3	
Output Switching Frequency	f_{OUT}	TEC+, TEC-	450		650	kHz
Temperature control range*	T_{OBJ}			5 - 65		°C
Temperature accuracy	T_{ACC}				±0.002	%
Over Temperature Shutdown	T_{SH}			165		°C
Control Inputs						
Temperature Set Voltage	V_{TS}	TEMP_SET pin	0		1.5	V
Input Current	I_{TS}	TEMP_SET pin	-1		1	uA
Temperature Sensor Input Voltage	V_{IRTH}	RTH pin	0		1.5	V
Temperature Sensor Input Bias Current	I_{IRTH}	RTH pin	-1		1	uA
VMAX Set Voltage	V_{MS}	VMAX_SET pin	0		1.5	

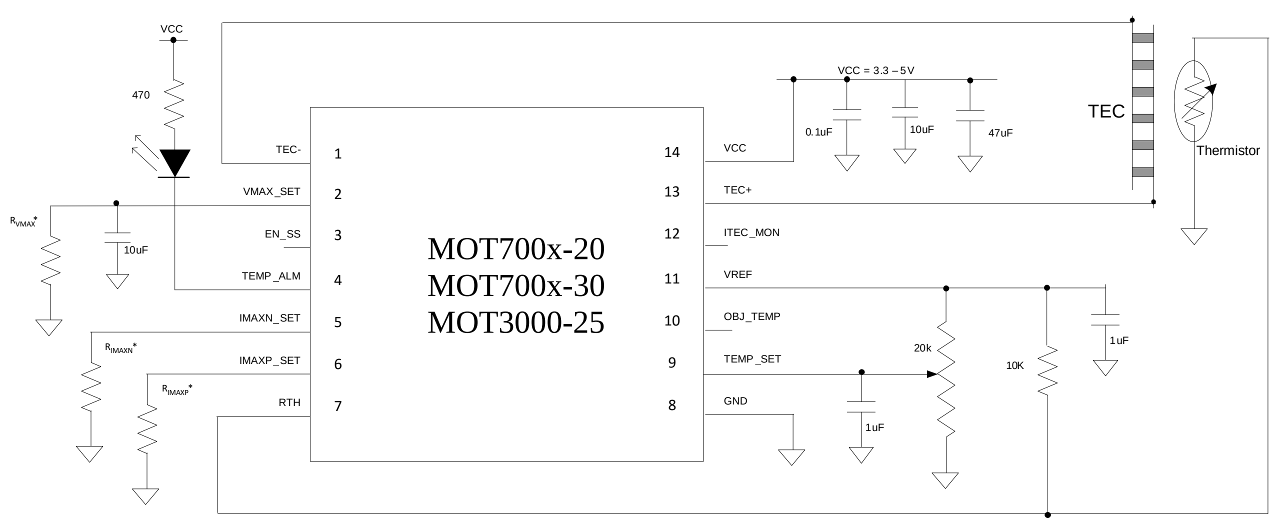
Electrical Specifications continued:

Parameter	Symbol	Conditions	Min	Typ.	Max	UNITS
Input Current	I_{TS}	VMAX_SET pin	-1		1	uA
Enable Input Current	I_{IENSS}	EN_SS = 0V			1	mA
Low Level Input Voltage	V_{ILENSS}	EN_SS Input	0		0.5	
Control Outputs						
Current Monitor Output Accuracy		ITEC_MON pin		±10		%
Object Temperature Output Voltage	V_{OT}	OBJ_TEMP pin	0		V_{CC}	V
Temperature Alarm Output Voltage	V_{OTA}	TMP_ALM active, I_{OTA} = -4mA			0.2	V
		TMP_ALM off, I_{OTA} = 1uA	V_{CC} – 0.2			V
Temperature Alarm Window	T_{TA}	With respect to set temperature		±1.5		°C
Voltage Reference						
Reference Voltage	V_{REF}	V_{CC} = 3V to 5.5V, I_{REF} = 150µA	1.475	1.50	1.515	V
Reference Load Regulation	ΔV_{REF}	V_{CC} = 3V to 5.5V, I_{REF} = +10µA to -1mA		1.2	5	mV

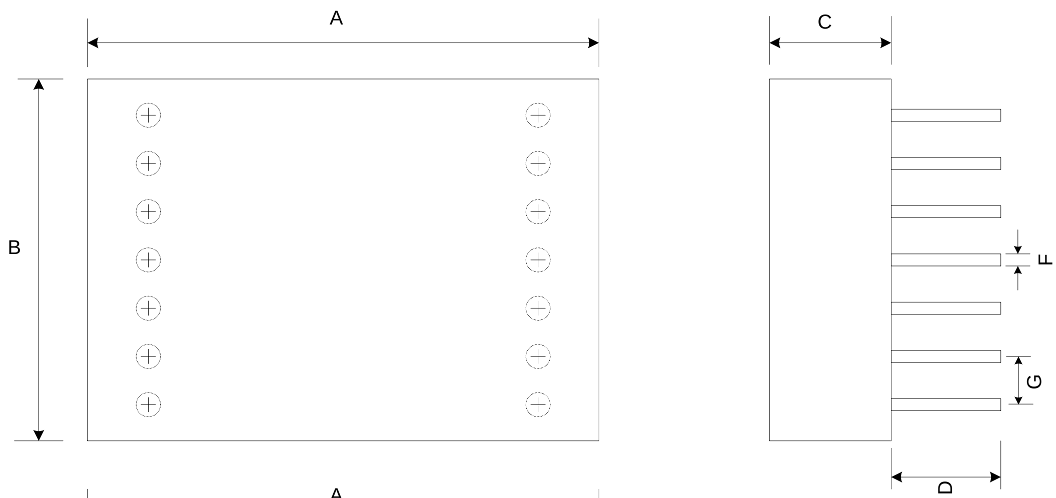
[1] All voltage values are with respect to network ground terminal.

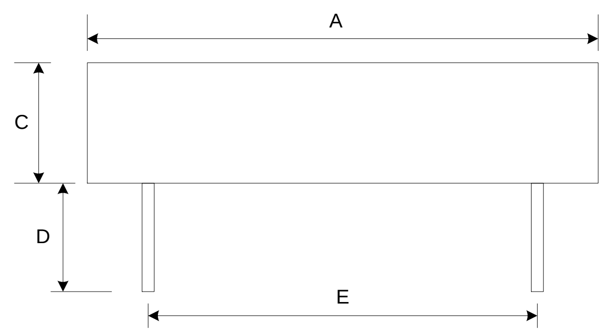
* The achievable control range is dependent on multiple factors including ambient temperature, the particular TEC in use and the heat dissipation characteristics of the TEC assembly itself.

TYPICAL APPLICATION DIAGRAM



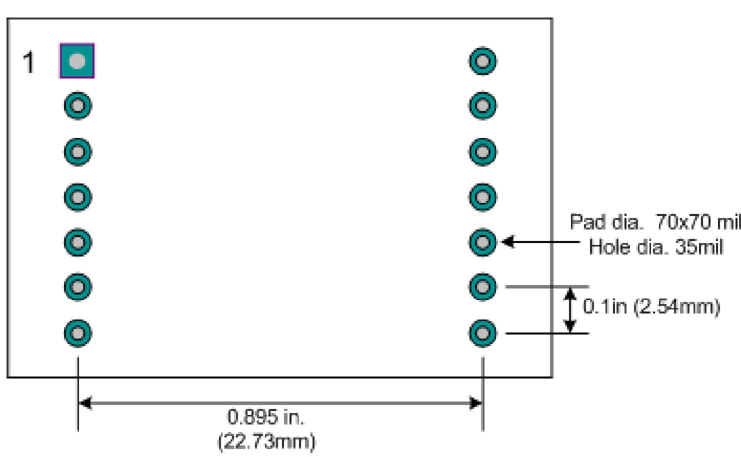
MECHANICAL OUTLINE





Dimension	Value	
	in	mm
A	1.08	27.5
B	0.79	20.0
C	0.315	8.0
D	0.165	4.2
E	0.89	22.73
F	0.025	0.64
G	0.1	2.54

PCB FOOTPRINT



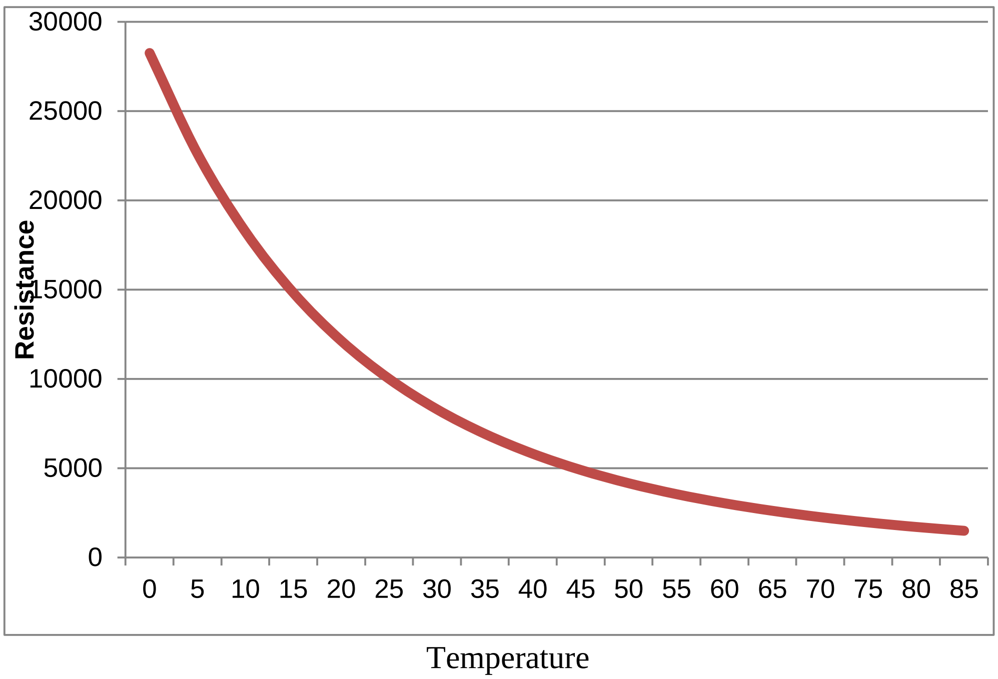
APPENDIX 1 – THERMISTOR CHARACTERISTICS

Temperature data shown in this document was characterized using a 10K NTC thermistor, NCP18XH103F03RB by muRata. This device has a B constant of 3380 over the range 25 – 50˚C (the most likely operating range for most applications), and a power dissipation constant, C, of 1mW/˚C.

The relationship between Temperature and Resistance is given by:

$B = \ln(R/R_0) / (1/T - 1/T_0)$ Note: T is in ˚K

Using T_0 = 25˚C (= 278˚K), and R_0 = 10K, the variation of resistance with temperature is as shown:



With the recommended resistor value of 10K from the RTH pin to VREF we can calculate the resulting feedback voltage appearing at RTH:

Temperature	0	5	10	15	20	25	30	40	50	60	70	˚C
Resistance	28255	22614	18243	14826	12136	10000	8293	5807	4157	3036	2258	Ohms
VRTH	1.108	1.040	0.969	0.896	0.822	0.750	0.680	0.551	0.440	0.349	0.276	V

Other thermistors (or other temperature sensing devices) may be used as long as the voltage appearing at RTH decreases with temperature, and falls within the range 0 to 1.5V over the desired object temperature control range.

Note: To use a PTC thermistor it should be connected between RTH and VREF, with a suitable value resistor from RTH to ground, to complete the voltage divider.

IMPORTANT NOTICE

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