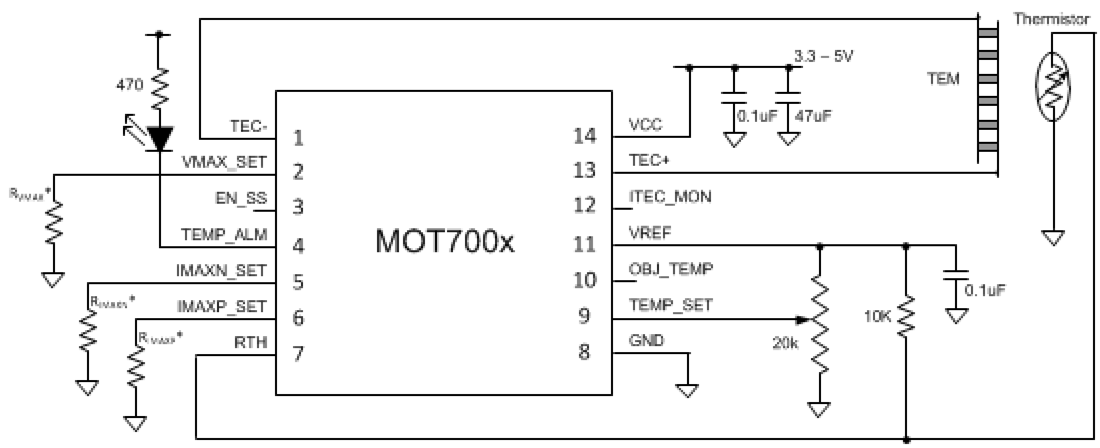
# Implementing a TEC Controller Using the MOT7000-xx/7001-xx And MOT3000-25


## Introduction

The MOT700x and MOT3000 are highly integrated TEC Controller Module. A complete system based on these modules can be realized using very few additional components:

- Thermoelectric cooler (TEC)
- Thermistor
- Control Potentiometer
- Decoupling capacitors
- Indicator LEDs

## Application Schematic

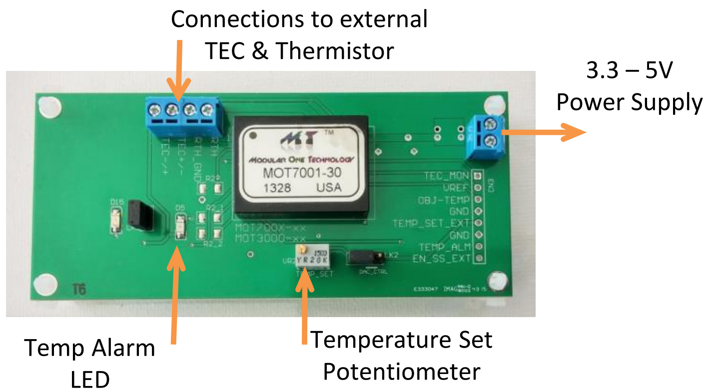



* If required maximum voltage, maximum positive current and maximum negative current applied to TEC can be reduced to match the TEC being used (see Selecting a TEC)

Notes: Values shown are for a 10K NTC Thermistor.

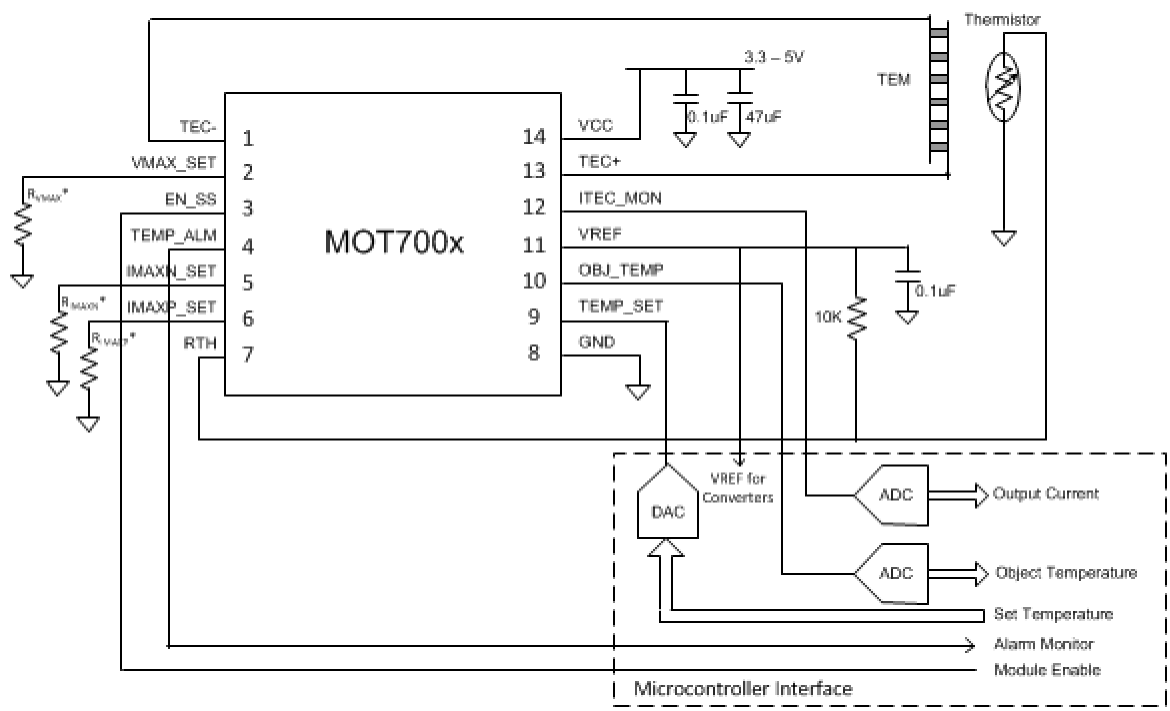
The Object Temperature and the output current to the TEC can be monitored by measuring the voltages at pins 10 and 12 respectively.

MOT701_xxTEC OEM Board:




The above picture illustrates the minimal external connections needed with the application schematic built on the MOT701_OEM board. This could be inserted into a suitable enclosure with power supply producing a complete Thermoelectric Cooler system!

### Microprocessor Interface




A more sophisticated system can be built by replacing the manual potentiometer with a microprocessor. A Digital-to-Analog Converter (DAC) provides the necessary control voltage. In addition the TEMP_ALM pin (which is active when the Object temperature falls outside the desired value, e.g. when the TEC is ramping the temperature to a new target value) can be monitored by a GPIO pin, and the object temperature and output current can be monitored by analog-to-digital converters (ADCs). The module enable pin (EN_SS) can also be driven by the microcontroller allowing the module to be shutdown and restarted remotely.

## Selecting a TEC

A number of factors determine the selection of the optimum TEC for a given application. The power being dissipated by the object and the delta temperature between the desired object temperature and ambient temperature are two of the main factors. The TEC manufacturer's website usually provides tools to help determine a suitable match for your application.

Once the TEC is selected it will be characterized by 4 key parameters:

- Maximum Voltage ($V_{MAX}$)
- Maximum Current ($I_{MAX}$)
- Maximum Power ($Q_{MAX}$)
- Maximum Delta Temperature ($DT_{MAX}$)

With these parameters you can match the TEC to an appropriate member of the MOT700x family: for $I_{MAX}$ up to 2A use the MOT700x-20, for currents up to 3A use the MOT700x-30 and for 2.5A use MOT3000-25.

Compare $V_{MAX}$ with the maximum output voltage of the MOT700x at your chosen operating voltage (3.3V or 5V). If the maximum output voltage of the MOT700x exceeds $V_{MAX}$ then an appropriate value should be chosen for $R_{VMAX}$ (see MOT700x data sheet for calculations).

*Note: If the TEC is being operated at less than $V_{MAX}$ and $I_{MAX}$ the power and temperature deltas achievable will need to be de-rated. Refer to the manufacturers' data sheets.*

## Case Study

As an example we have chosen to implement a design capable of dissipating 2 Watts.

*Note: If you're using the MOT705_xxTEC OEM and Object Board combo the max dissipation is 700mW so this case study would work comfortably for that configuration.*

Next step is to visit a manufacturers website. TE Technologies makes a variety of TECs suitable for this type of application so we visited www.tetech.com. On their site you will find full details and design graphs for their products and a nice selection tool: "**Peltier - Thermoelectric Cooler Module Calculator**".

Into this tool we enter the following:

1. $DT_{MAX}$ 70˚C (As they suggest)
2. Heat load Q 2.0W (Our goal)
3. Hot-side temp 50˚C (This is a good 1st estimate unless details of heat sink etc. are known).
4. Cold-side temp 0˚C (This is a practical lower limit for most applications)
5. Potted No.

The results show 2 groups of suggested modules: "**Suggested modules for lowest power consumption**" and **"Suggested modules for smallest size"**.

In the first group the TE-31-1.0-1.3 appears to be a good candidate for consideration, it's $I_{MAX}$ of 3.6A and $V_{MAX}$ of 3.8V are comparable to the MOT700x-30 specifications. Next we will examine the specifications more closely.

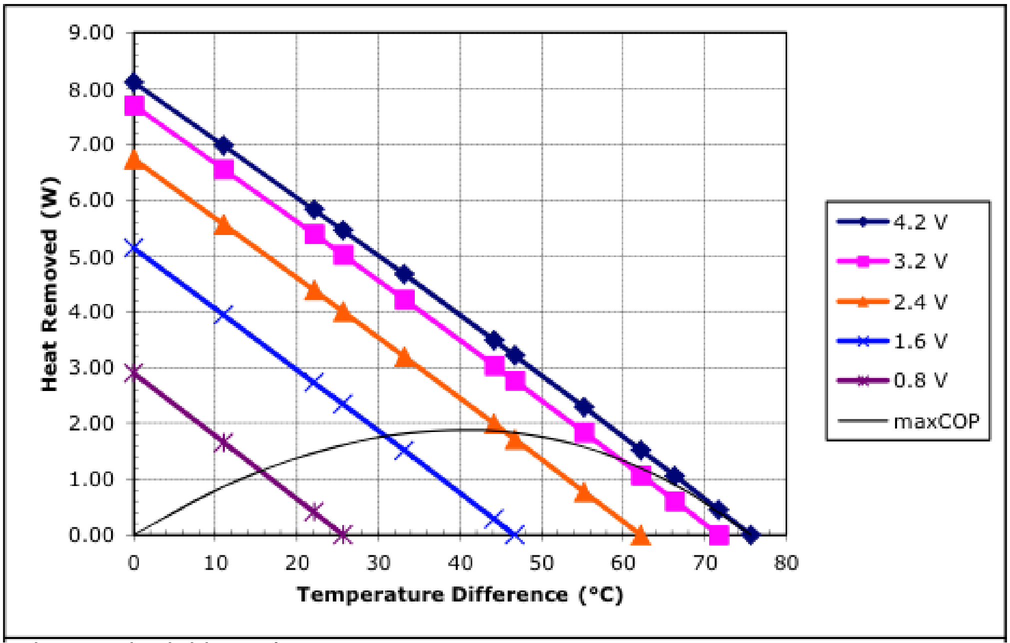
If we click on the module part number (TE-31-1.0-1.3) at the left of the table, then on the resulting page select the pdf graph icon to the right of the part number we can review the specifications and performance graphs.

(http://www.tetech.com/temodules/graphs/TE-31-1.0-1.3.pdf)

There are also instructions available on how to interpret the graph, we will use extracts from that to illustrate our case study (http://www.tetech.com/temodules/graphs/instructions.pdf).

Key parameters of the TE-31-1.0-1.3:

| | 27˚C hot side | 50˚C hot side |
|---|---|---|
| $V_{MAX}$ (V) | 3.8 | 4.2 |
| $I_{MAX}$ (A) | 3.6 | 3.6 |
| $Q_{MAX}$ (W) | 8.4 | 9.2 |
| $DT_{MAX}$ (deg C) | 69 | 78 |



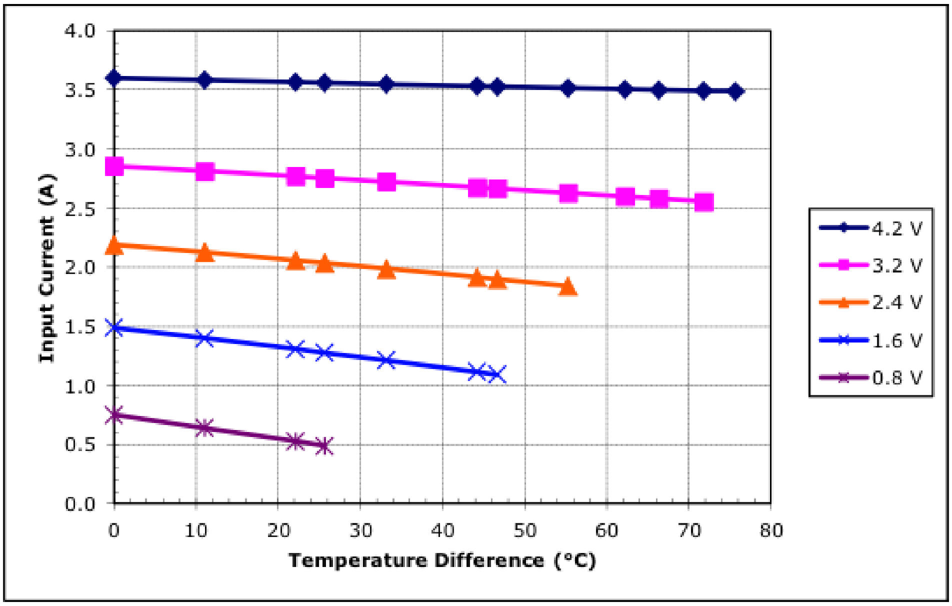

Step 1: Determine required drive voltage.

The chart indicates how much drive voltage we need to meet our heat dissipation and temperature goals. We follow across at 2W until we meet the 50˚C Delta-T (50˚ hot side – 0˚ minimum cold side temperature) and see we are approximately one third of the way between the 2.4V and 3.2V lines, let's say around 2.7V. The MOT700x has a maximum output voltage of 2.3 V with a 3.3V supply and 4.3V with a 5V supply, so we will assume a 5V system.

(Alternatively, we could go with a 3.3V system in which case the maximum Delta-T would be around 42 degrees at 2W – meaning we would need a larger heat sink or some other way of additional cooling to keep the hot side at that temperature)

Step 2: Determine the drive current requirements.

The next chart shows us how drive current varies with Delta-T and drive voltage. For simplicity we can see that for a drive voltage of 3.2V the input current will always be less than 3A, so we can use the MOT700x-30 as the controller if we limit the output voltage to 3.2V.




The additional charts deal with waste heat generated, and efficiency of the system. Further information on the website indicates how this data may be used to help with determining heat sink requirements etc., but is beyond the scope of this application note.

The MOT700x datasheet specifies a maximum output voltage of 4.3V with a 5V supply so we will need to add the $R_{MAX}$ resistor to limit the output to 3.2V. Looking at the table and chart in the datasheet a value of 120K Ohms will satisfy this requirement.

(If we had chosen the alternative to operate at 3.3V the maximum output voltage is 2.3V so no resistor would be required)

## Assemble TEC module with heat sink and fan

For this case study we will use the MOTEVM_OBJ board for convenience. Adequate heat sinking MUST be provided as you assemble your object board and TEC module. The TEC module by itself pumps heat as part of a temperature control loop, once that heat has been removed it has to flow onwards and be dissipated by the heat sink & fan assembly.

*Failure to heat sink the hot side of the TEC module properly may result in an uncontrollable rise in temperature for which the TEC controller is unable to correct. If left unchecked the temperature may rise beyond the specified limits for the TEC risking damage to it.*

A suitable heat sink and fan assembly, MOTEVM_HSFN, is available from ModularOne Technology –shown here attached to the object board.

## Thermistors

The schematics shown assume a 10K NTC Thermistor. PTC devices can be accommodated by swapping the positions of the thermistor and the 10K resistor. Similarly, thermistor nominal values other than 10K should have a corresponding change made in the resistor value from VREF to RTH.

A recommended 10K thermistor and its response characteristics can be found in the appendix of the MOT700x data sheet.

## Further Information

The MOT701_xxTEC & MOT705_xxTEC OEM Boards are a convenient way to explore the capabilities of the MOT700x and MOT3000 series and evaluate various TECs. More information can be found in the Application Brief “Thermal Considerations when using the MOTEVM_OBJ Object Board.”

Contact Information:

Modular One Technology
5902 Wessex Court
Parker TX 75002

Phone: 214-566-3708
Email: info@modularonetechnology.com
Web: www.modularonetechnology.com