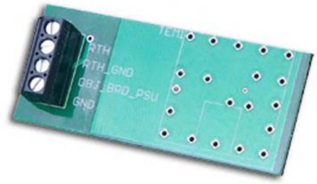
Thermal Considerations when using the MOTEVM-OBJ Object Board

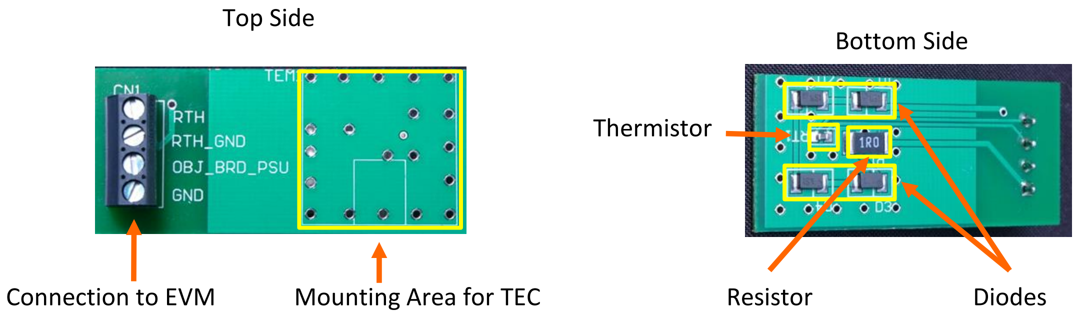


Introduction

The MOTEVM_OBJ board, provided with the MOT70x_EVM or available separately, is a convenient way to evaluate system behavior when used with the MOT700x TEC Driver Module.

Regardless of whether the Object Board is being used, or a “real world” application is being evaluated, consideration of the thermal properties of the system is necessary to achieve optimum results. For convenience we will look at the Object Board implementation but the same considerations apply to all applications.

Object Board Overview

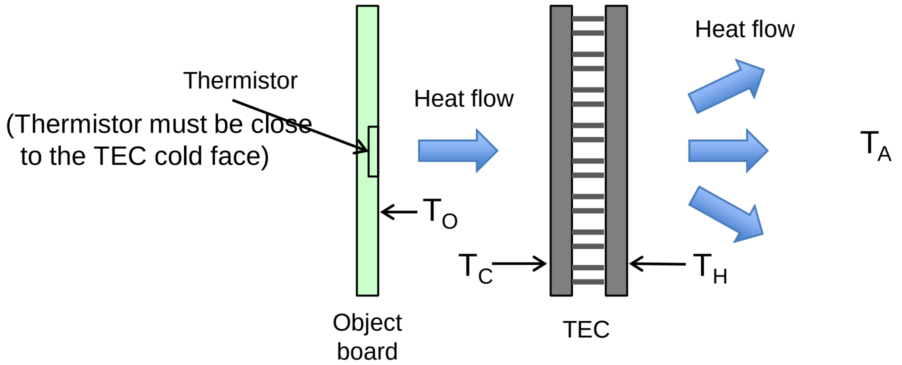


The bottom side of the board consists of 4 diodes and a resistor which dissipate power, simulating a real world load (the “Object”), e.g. a laser. Mounted in close proximity is a thermistor which allows measurement of the object temperature (T_O). The top side of the board is a flat surface to which the TEC can be attached.

Design Considerations

System Temperatures

Let’s consider the temperatures at various points in the system. First we have the Object itself which sits at T_O. This is the temperature we wish to keep constant. The TEC has a cool side, which we will call T_C, and a hot side which we will call T_H. By varying the current through the TEM we can create a differential temperature drop across it equal to T_H minus T_C. Finally we have the ambient temperature of the system, T_A.



To a first approximation T_O will be equal to T_C (they are in close thermal proximity on the board, which has large interconnected copper areas on both sides). Likewise T_H will be approximately the same as T_A. However, when we consider power dissipation of the object we must modify these equations.

Power Dissipation

The Object will dissipate power during operation and this heat must be dissipated via the TEC to maintain the desired object temperature. The Object temperature will remain close to T_C, but may deviate by as much as 5˚ for larger thermal loads. The hot side of the TEC must dissipate this power or it's temperature will rise compared to T_A, typically anywhere from 5˚ to 15˚ depending on the load. The thermal resistance between the TEC and ambient will be a function of it's surface area, and can be effectively increased by adding a heatsink.

Supplemental Cooling

Larger TECs offer a lower thermal resistance, by virtue of increased surface area. Alternatively some form of supplemental cooling can be used. Adding a heatsink, as mentioned previously, effectively increases the surface area of the TEC, thus lowering the thermal resistance.

We can also add a fan to the system to further decrease the thermal resistance by displacing locally heated air and replenishing with air at the ambient temperature.

The fan/heatsink combination device, MOTEVM_HSFN can be employed to investigate these effects. It is shown here mounted to an Object Board / TEC assembly:

Selecting a TEC

Three parameters are required to select the appropriate TEC for the system: T_H, $T_{C\ and}$ P_D.

T_H will be determined by the ambient temperature, T_A, of the system, as described above. Addition of a heatsink and/or fan will have the effect of reducing the delta temperature between the hot side of the TEC and the ambient temperature.

T_C will be determined by the desired object temperature, T_O, also described above.

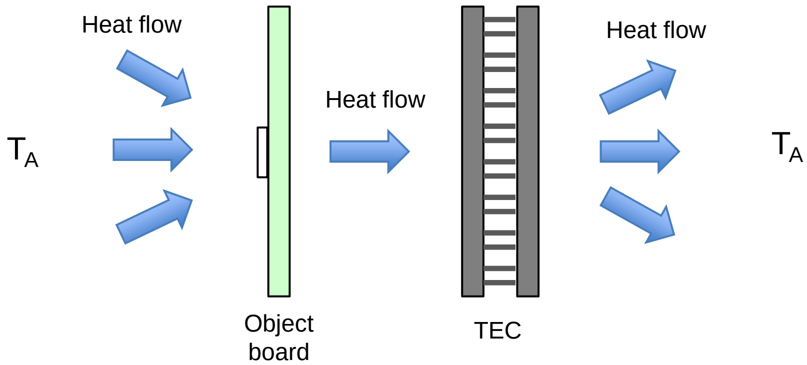
The power dissipation of the object, P_D, is calculated according to the load dissipation.

In the case of the MOTEVM_OBJ board the power dissipation can be varied by means of a pot on the MOT700-EVM board.

With the above parameters the TEC manufacturer's datasheets can be examined to find a matching device. Finally, the electrical requirements of the TEC should be compared to the capabilities of the MOT700x module to ensure a a match in terms of current and maximum voltage requirements.

Thermal Leakage

Another factor not yet considered is thermal leakage from the Object itself to ambient. Usually it is desired to maintain the Object below ambient temperature, but unless steps are taken heat will flow from ambient to the Object, raising its temperature, and requiring further heat to be removed via the TEC. In this case we need to increase the thermal resistance from the Object to ambient. This can be achieved by adding a thermal barrier, in the case of the object board this can be accomplished by simply attaching a piece of styrofoam to the bottom side of the object board.



In some real world applications the thermistor may be inside a hermetically sealed assembly, e.g. a laser diode assembly. In this case it is also necessary to consider the passive heat load of the entire assembly (since the whole assembly itself will typically be cooled to below ambient temperature). This additional passive load should be figured into the calculations described previously, by adding this load to the active power dissipated by the load, for selecting a suitable TEC. For example, in the case of a laser in a standard 9mm can, cooling the assembly to 10˚ below ambient results in about 0.5W of additional passive heat load.

Thermal Coupling

The object being controlled should be closely coupled thermally to both the cold side of the TEC and also the measurement thermistor. In the case of the object board the thermistor is mounted to be in good thermal contact with the side of the board where the TEC is attached. In addition the TEC itself should be in good contact with the object, compression mounting, thermal epoxy or thermal grease, or solder mounting are commonly used methods.

If difficulty is encountered in maintaining a constant object temperature, with the temperature “hunting” around the set point by several degrees, this is typically a sign that the thermistor is not well coupled thermally to the object.

Conclusion

To achieve optimum performance it is necessary to provide adequate heat dissipation to the “hot” side of the TEC, depending on the system power dissipation it may be necessary to add heatsinks and/or fans.

It is also necessary to insulate the Object itself from the ambient temperature.

Which actions are appropriate will depend on the application. For example, a laser assembly with embedded TEC will usually have the hot side of the TEC connected to the case which can then be attached to supplemental heatsinking. The Object (the laser itself) is insulated within the case.

Contact Information:

Modular One Technology
5902 Wessex Court
Parker TX 75002

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