Torque Recommendations for TO-220 Devices

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INTRODUCTION

When the TO-220 was first introduced, most applications required something less than the full power handling capabilities of this package. Hence, the TO-220 is almost taken for granted in terms of its excellent power handling capacity and ruggedness. Today, however, advances in semiconductor technologies are bringing application demands closer to the TO-220's capabilities, so an understanding of these is more relevant than ever.

A reliable power electronics design requires close attention to both thermal management and mechanical mounting of devices. To ensure a successful implementation, designers must be aware of and understand the thermal resistance of the interface between the device and the heat sink, issues in mechanical fastening, the thermal properties of the interface medium, and the flatness (or roughness) of the interface surfaces of the device and the heat sink.

Vishay Siliconix has conducted a laboratory experiment to help designers understand the torque spec for the TO-220 and its impact on thermal resistance. The experiment likewise addresses the difference between various interface mediums and the applicable torque for the assembly fastener, which is typically an M3 screw. Set-up for the experiments and their consolidated results are reported below.

THE EXPERIMENT SET-UP

Our experimental set-up was similar to that used for thermal characterization of power MOSFETs, and consisted of a MOSFET/heat sink assembly and a semiconductor thermal test system.

For the MOSFET/heat sink assembly, a specially designed heat sink assembly of a copper block (4 in. x 4 in. x 0.75 in.) was used to simulate an infinite heat sink attached to the case of the TO-220 device. The design of the heat sink also ensured the best possible flatness of the device-mounting surface could be achieved through appropriate machining techniques. The cooling system maintained the ambient at the desired temperature of 25 °C. The fastening method employed a standard M3 screw-washer-nut. A calibrated torque wrench was used to assemble the part with known torque values.

The device under test (DUT) was an engineering sample of the Vishay Silicionix SUP50N06-16L power MOSFET in the TO-220 package. The DUT was mounted to heat sinks with the following assembly variations in the heat transferring interface between part tab and the heat sink:

(a) Part mounted directly onto the heat sink (no use of thermally conductive grease or heat sink compound)

(b) Part mounted on the heat sink with grease

(c) Part Mounted on the heat sink with "Bergquist" SIL-PAD A1500

(d) Part mounted on the heat sink with "Bergquist" BOND PLY 100

(e) Part mounted on the heat sink with Mylar without grease

(f) Part mounted on the heat sink with Mylar with grease

FIGURE 1. “Analysis Tech” Semiconductor Thermal Test System

Figure 1 shows the semiconductor thermal test system used for the experiment. The power stimulus generation and junction temperature derivation was managed through built-in computerized equipment especially designed for this function.

The electrical schematic is shown in Figure 2. This arrangement facilitated temperature calibration for the DUT and then the actual testing.

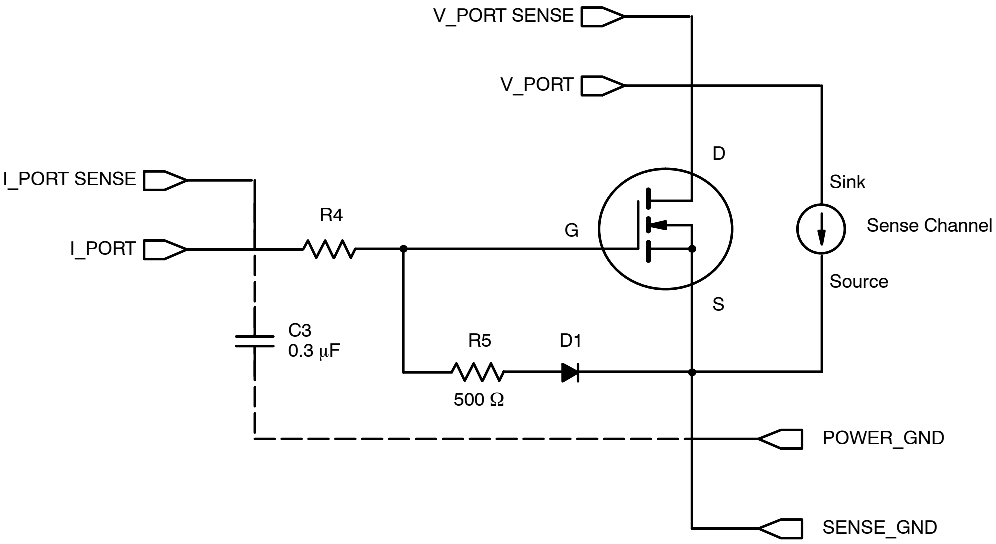
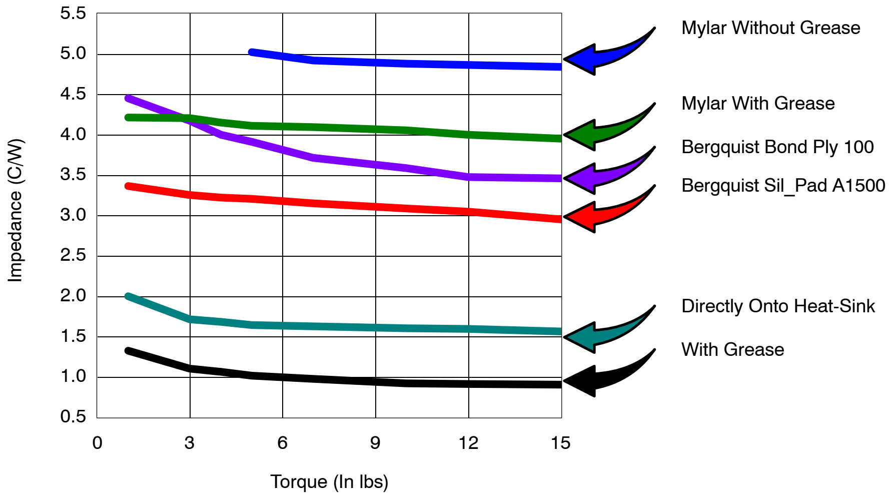


FIGURE 2. Electrical Schematic Diagram

TABLE 1: Rth(j-c) VS. TORQUE						
Torque (In lbs)	$R_{th(j-c)}$		Bergquist		$R_{th(j-c)}$	
	■ Directly Onto Heat-Sink	■ With Grease	■ Sil Pad A1500	■ Bond Ply 100	■ Mylar Without Grease	■ Mylar With Grease
1	2.00	1.32	3.36	4.45		4.21
3	1.71	1.10	3.25	4.17		4.20
4	1.68	1.06	3.22	4.00		4.15
5	1.64	1.01	3.20	3.91	5.02	4.11
7	1.62	0.97	3.15	3.71	4.92	4.09
10	1.60	0.92	3.08	3.58	4.88	4.05
12	1.59	0.91	3.04	3.47	4.86	4.00
15	1.56	0.90	2.95	3.46	4.84	3.95

FIGURE 3. R_{th} vs. Torque (TO-220)



For each of the assembly variations, a steady-state value of thermal resistance was obtained against known torque values from 1 in-lb to 15 in-lb.

The results are tabulated in Table 1. The corresponding chart in Figure 3 facilitates visual comparison.

OBSERVATIONS

The Torque Spec For TO-220 – 15 in-lb

The negative slopes of each curve indicate that an increase in the torque value does improve (decrease) the thermal resistance value. However, there is a point of diminishing return beyond 10 in-lb. The curve almost flattens around 15 in-lb.

The Impact Of Torque On Thermal Resistance

The increase in the mounting torque beyond 15 in-lb does not improve the thermal resistance value.

Comparing Interface Mediums

As Figure 3 shows, the part directly mounted on the heat sink with grease (heat sink compound) performs the best. The use of any medium to electrically isolate the part from the heat sink results in higher thermal resistance, however. Mylar without grease is the worst-case scenario with the thermal resistance value increasing to 4.8 °C/W.

Breaking Torque For The Assembly

This value was obtained last with a destructive test. The screw was tightened with gradually increasing torque. The M3 screw broke at around 26 in-lb to 27 in-lb.

CONCLUSION

Typically 15 in-lb torque is adequate for fastening a TO-220 device on the heat sink and obtains the best (lowest) possible thermal resistance value. Use of a heat sink compound improves the thermal resistance by almost 0.6 °C/W, but electrical isolation between part tab and heat sink increases the thermal resistance of the interface by a factor of 3 to 6.