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AN4839
Clamping of Power Semiconductors
Application Note

Replaces AN4839-5 AN4839-6 October 2022 (LN42153)

The Forward Voltage Drop and Thermal Resistance of a hockey puck semiconductor are affected by the clamping force applied to the device. This is because, unlike stud type devices, the internal interfaces between, for instance, the copper electrodes and the molybdenum discs and washers, used in the construction, are dry. These interfaces contribute a contact electrical and thermal resistance which add to the bulk resistances of the materials that constitute the device. Figure 1 shows the theoretical thermal resistance versus clamping pressure for the dry interfaces in a Dynex i² fully floating thyristor.

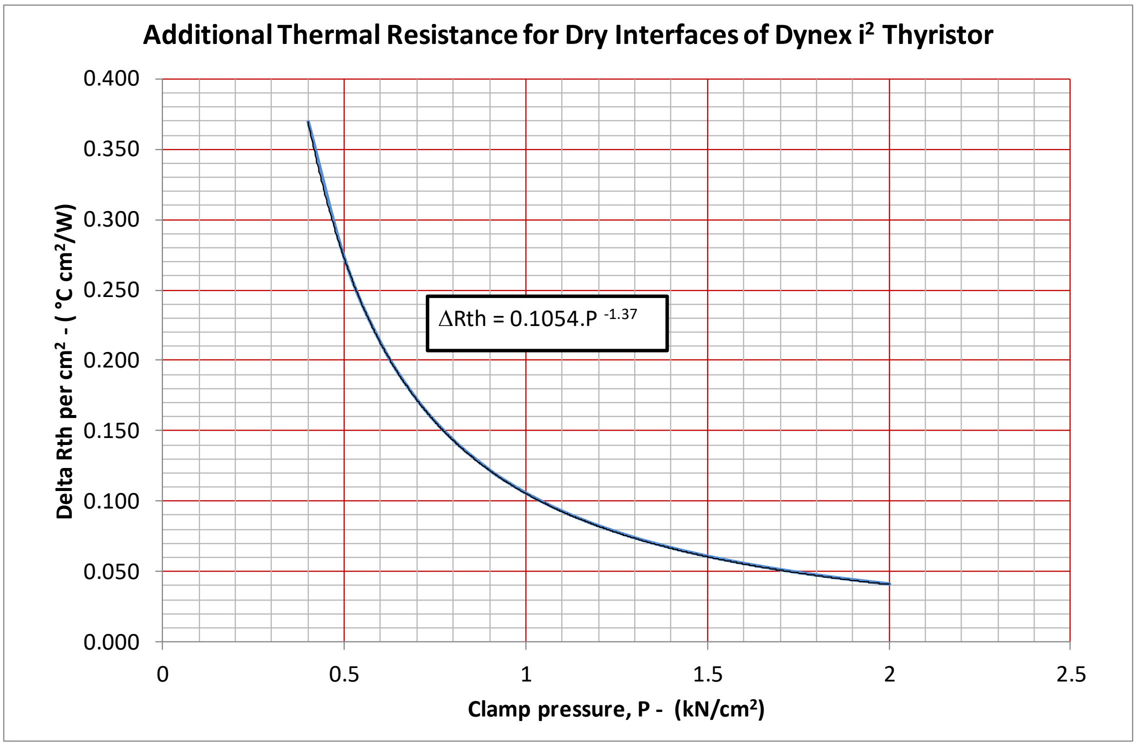

Figure 1: Thermal resistance of dry interfaces of a fully floating thyristor.

The clamping force recommended by Dynex Semiconductor in its data sheets has been established as being that force necessary to give good thermal and electrical contact between the internal and external interfaces of the device and heat-sinks. To determine this, Dynex Semiconductor measures the Forward Voltage Drop and Thermal Resistance of the device at different clamping forces, see figures 2 & 3.

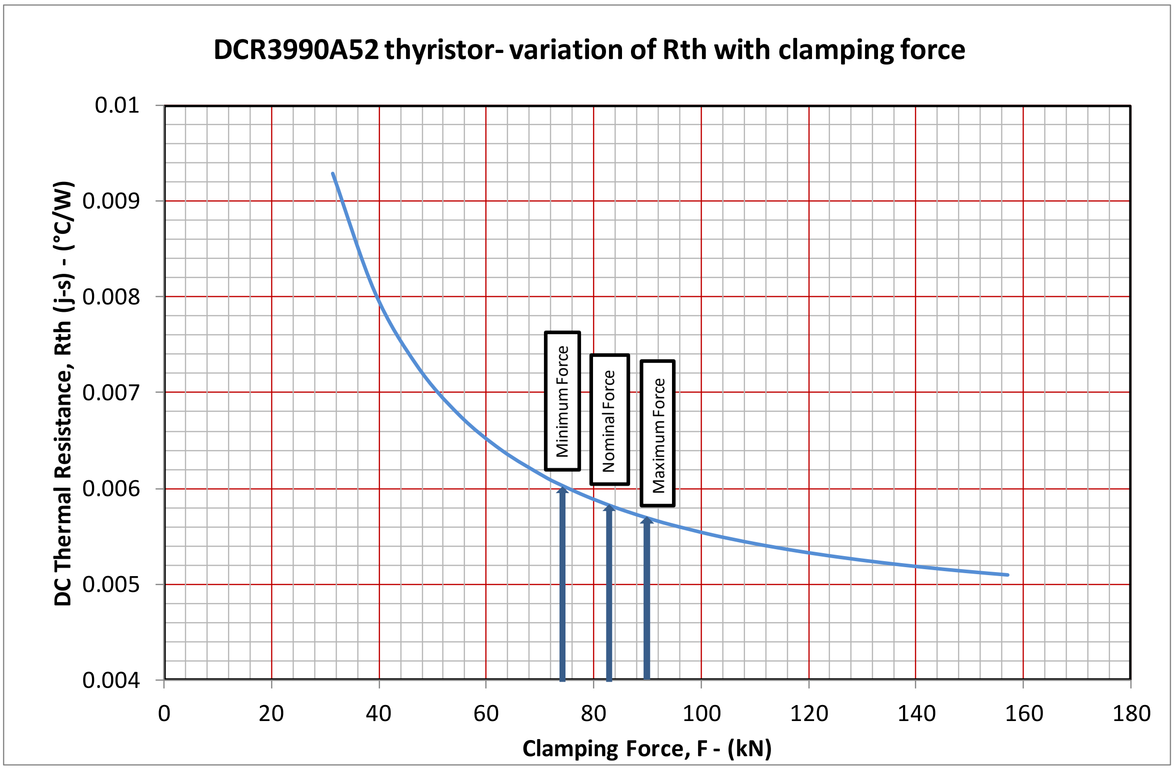

Figure 2: DCR3990A52 thyristor – variation of thermal resistance with clamping force.

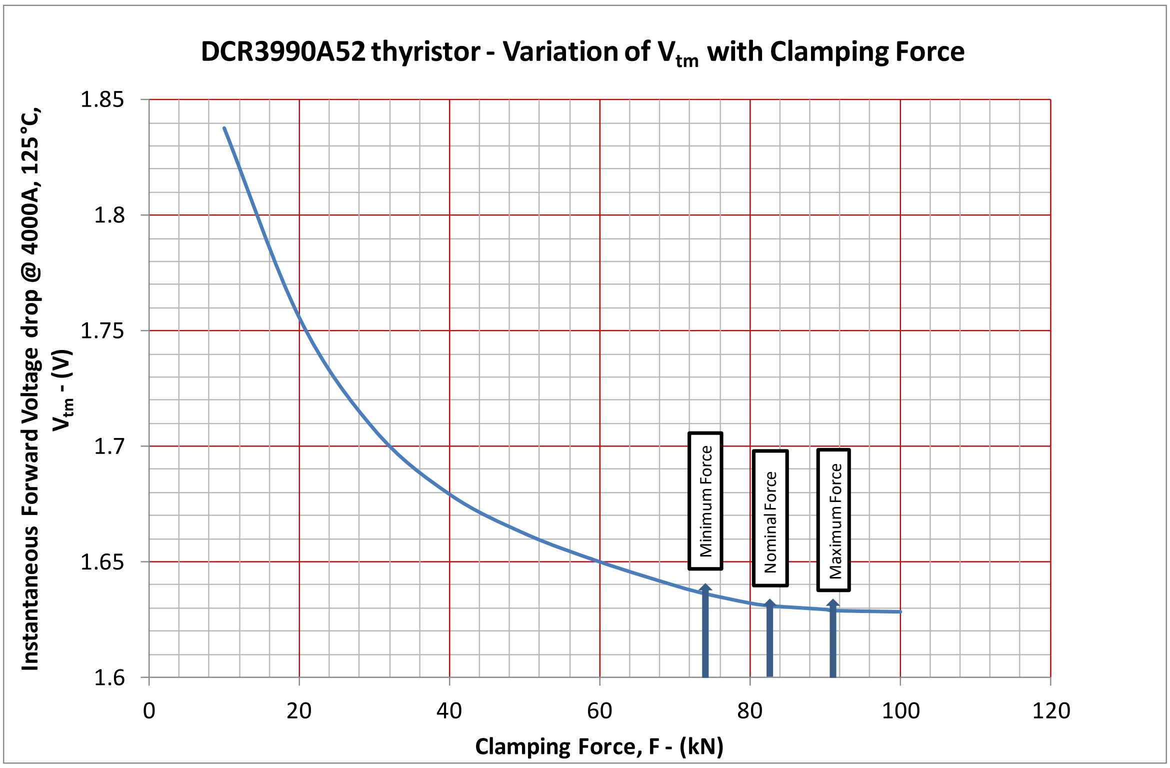

Figure 3: DCR3990A52 thyristor – variation of Forward Voltage Drop with clamping.

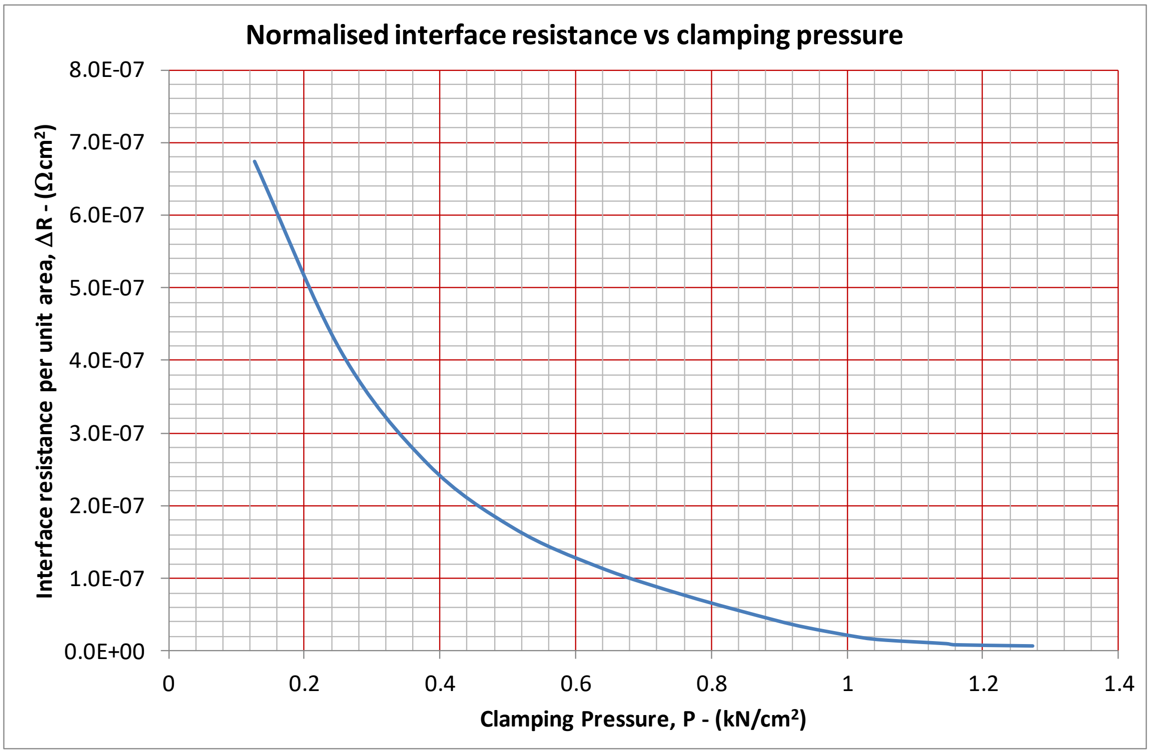

Figure 4: Normalised interface resistance variation with clamping pressure.

The minimum clamping force is determined as the force above which the Thermal Resistance and Forward Voltage Drop do not improve significantly. The maximum recommended clamping force is then taken to be 1.22 x the minimum value. The device is then subjected to temperature cycling tests at this higher force to verify that thermal expansion and contraction does not lead to degradation. The published figure is the mean value ±10%.

It is important, therefore, that the user takes due regard that clamping forces remain between these limits under all conditions that arise from variations in tolerances of the clamps and any thermal expansion and contraction that may affect their settings. In this way the user will be assured that the thermal and electrical characteristics are within those specified on the datasheet and that long-term tolerance to thermal cycling has been verified.

Of course, this clamping force must be evenly distributed over the entire surface of the semiconductor to ensure that the above conditions are obtained. Uneven clamping can result in high thermal resistance, forward voltage drop and mechanical damage to the thyristor. Care must therefore be taken, to ensure that the clamp applies force to the centre of the pole piece and that it is subsequently spread evenly over the whole contact area by means of suitably thick and stiff buffers.

A note of warning about the clamping of fully floating devices at room temperature and then applying heat from an external source during testing. This heat could come from a hotplate or oven used to raise the device temperature or perhaps indirectly from an adjacent device being tested on a power run.

Silicon is very strong in compression but relatively weak in tension. Because the temperature coefficients of expansion of the metal components in the thyristor housing are greater than that of silicon, if heat is applied from the outside of the puck, the metal components will put the silicon into tension and cracking can occur. If the heat is internally generated in the silicon, as in service, the silicon remains in compression and un-cracked.

NOTES ON MOUNTING HOCKEY PUCK SEMICONDUCTORS ONTO HEATSINKS USING DYNEX SEMICONDUCTOR CLAMPS.

NOTE: ***Too little jointing compound will lead to high thermal resistance. However, a more common error is to apply too much compound which can give high electrical contact resistance.***

DOUBLE SIDE COOLED.

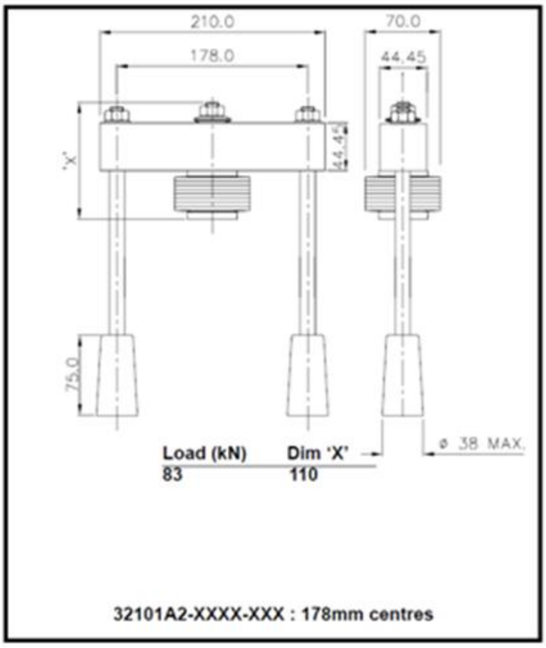

Figure 5: Typical Clamp for Double Side Cooling.

1. Check that the clamping force (in kN) printed on the bar is suitable for the device to be clamped (see data-sheet).
2. Slip the polyester film locator over the disc device.
3. Prepare the heat-sink surface by abrading the aluminium surface using medium grade emery cloth such as ELC120 or a 3M Scotchbrite™ pad, degrease with a solvent and carry out the mounting operation the same day. Similarly, prepare the semiconductor device and then apply a small amount of jointing or interface compound (see “Mounting Compounds” below).
4. After loosely assembling all the components with the disc device between the heat-sinks, finger tighten the two nuts on the tie bolts until they just touch their washers. Check that the bar is reasonably parallel to the heat-sink and make sure that it is centrally located, i.e. not at an angle to the channel in the heat-sink.
5. Using a socket spanner (wrench) at the bar end (and, if necessary, a nut runner to hold the threaded rod by means of its “Loctited” nut in the ceramic insulator) carefully tighten each nut alternately, a flat at a time. Apply a steady finger pull on the gauge under the central nut and when it comes free, cease to tighten the nuts. Slide the gauge to the full extent of its slot until the top leaf springs up to prevent the gauge slipping back under the nut. This procedure provides a gap of 0.3mm under the nut and will allow for any relaxation of the clamp, fins or device while in service. The heights at each end of the bar above the heat-sink should be within 1.0mm of each other.

6. If it is necessary to re-adjust the clamp or remove the device, then before loosening the tie rods, slip the two leaves of the gauge back underneath the central nut. This procedure will re-set the bar-clamp for further use.
7. A useful check of good mounting is to measure the electrical contact resistance of the device to heat-sink joint. 100A d.c. may pass across the joint and we recommend the maximum value should not exceed 2μΩ (0.2mV drop) for large devices or critical applications and 10μΩ (1.0mV) for smaller devices or less critical applications. High contact resistance may lead to the device overheating and/or pitting of the contact surfaces.

Warning: The central pressure bolt assembly is pre-set in the factory and sealed. Any subsequent adjustment of this bolt will alter the clamping force when tightened on the device and damage may result to the device by either lack of or excess clamping force.

SINGLE SIDE COOLED

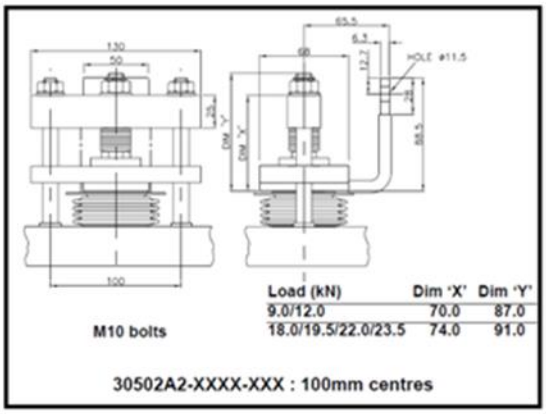

Figure 6: Typical Clamp for Single Side Cooling.

1. Check that the clamping force (in kN) printed on the bar is suitable for the device to be clamped (see data-sheet).
2. Slip the polyester film locator over the disc device.
3. Prepare the heat-sink surface by abrading the aluminium surface using medium grade emery cloth such as ELC120 or a 3M Scotchbrite™ pad, degrease with a solvent and carry out the mounting operation the same day. Similarly, prepare the semiconductor device and then apply a small amount of jointing or interface compound (see "Mounting Compounds" below).
4. Place the semiconductor device, the appropriate way up, on the heatsink followed by the busbar/insulator assembly. A small amount of heatsink compound should be applied between the disc and the busbar to prevent corrosion.
5. Place the pressure bar on top of the busbar/insulator assembly with the hexagon head of the central bolt bearing down on the insulator. The two insulated bolts should then be inserted through the holes on the pressure assembly, the busbar insulator assembly and the device locator, thereby aligning all three. Adjust the position of the gate connector on the semiconductor device to suit the insulation.
6. Screw the bolts into the heat-sink making sure that the pressure bar is kept parallel to the heat-sink. When the bolts start pulling down the pressure bar, tighten each bolt alternately a flat at a time. Apply a steady finger pull on the gauge under the central nut and when it comes free, cease to tighten the nuts. Slide the gauge to the full extent

of its slot until the top leaf springs up to prevent the gauge slipping back under the nut. This procedure provides a gap of 0.3mm under the nut and will allow for any relaxation of the clamp, fins or device while in service. The heights at each end of the bar above the heat-sink should be within 1.0mm of each other.

7. A useful check of good mounting is to measure the electrical contact resistance of the device to heat-sink joint. 100A d.c. may pass across the joint and we recommend the maximum value should not exceed 2μΩ (0.2mV drop) for large devices or critical applications and 10μΩ (1.0mV) for smaller devices or less critical applications. High contact resistance may lead to the device overheating and/or pitting of the contact surfaces.
8. If it is necessary to re-adjust the clamp or remove the device, then before loosening the tie rods, slip the two leaves of the gauge back underneath the central nut. This procedure will re-set the bar-clamp for further use.

MOUNTING COMPOUNDS

It is important to use a suitable interface compound between a semiconductor and its heat-sink. Two basic types are available:

- As designed for interfaces which are both thermally conducting and current carrying. This type, originally developed for electrical busbar joints, is referred to as a filled grease and contains metal or metal oxide particles.
- Developed only for good thermal performance. These are usually oils. Synthetic oils are preferable to mineral oils as they do not affect other materials.

	Rhodorsil 47V5	Dow Corning DC200	Aavid Thermalloy Sil Free	American Oil PQ Compound	Prysmian BICON BX13	Aremco Heataway™	Unial Universal Jointing Compound	Xiameter PMX-200
Max Temp	120°C	315°C	200°C	200°C	260°C	285°C	120°C	315°C
Min Temp	-65°C	-50°C	-40°C	-	-	-	-30°C	-50°C
Thermal Conductivity	0.12W/mK	0.155W/mK	0.793W/mK	0.699W/mK	-	9.665W/mK	-	0.155W/mK
Dielectric Strength	15V/m	-	0.225V/m	15V/m	0	0	0	-

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