# How To...

## Optimize IGBT Design using T3Ster® & FloTHERM® - A salient example

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Several decades ago "Something smells like burning silicon" was the standard exclamation for determining the existence of a thermal design problem. The industry has come a long way since then, using simulation tools, thermal characterization and other techniques to make systems more robust. Sometimes this comes at a cost – making the design more expensive. In response to this, the logical evolution would be to combine all available tools to optimize a system for multiple parameters instead of pointing, looking and checking if something just spontaneously combusted!

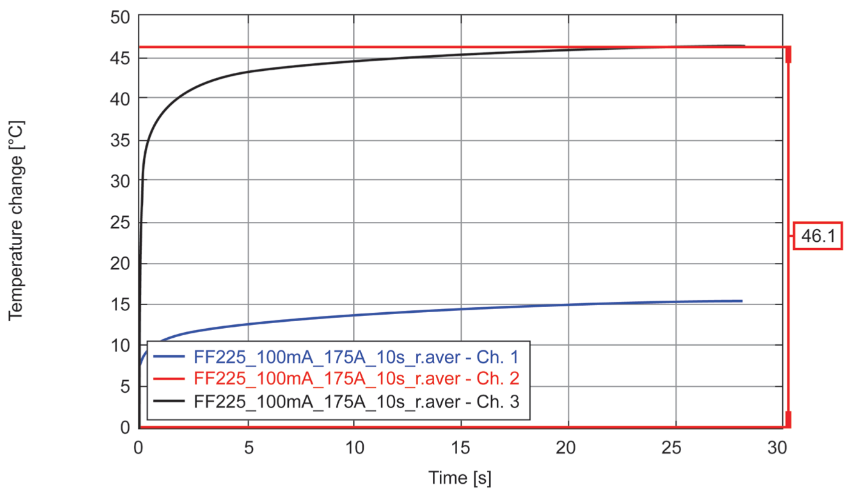


**Figure 1.** Junction Temperature of IGBT (Add 25°C for ambient conditions)

Insulated Gate Bipolar Transistors (IGBTs) have been the buzz in industry for a couple of years. Thousands of Watts dissipating through centimeter small surface areas, switching large electrical devices, such as MRI machines or E-Cars sounds like every design engineer's nightmare. But as the devices evolve, so do the engineers, tools and methods.

One of these evolved methods comes from combining T3ster and FloTHERM. Or, in other words, measure, simulate and optimize. Sounds simple, right? It is... to some extent. Using T3Ster® it is possible to obtain the temperature directly from the junction of a semiconductor, giving the advantage of not having to extrapolate data from external thermocouples. When the system is allowed to thermally stabilize, the thermal impact on the entire system can be observed from junction to heatsink in a transient fashion (Figure 1).

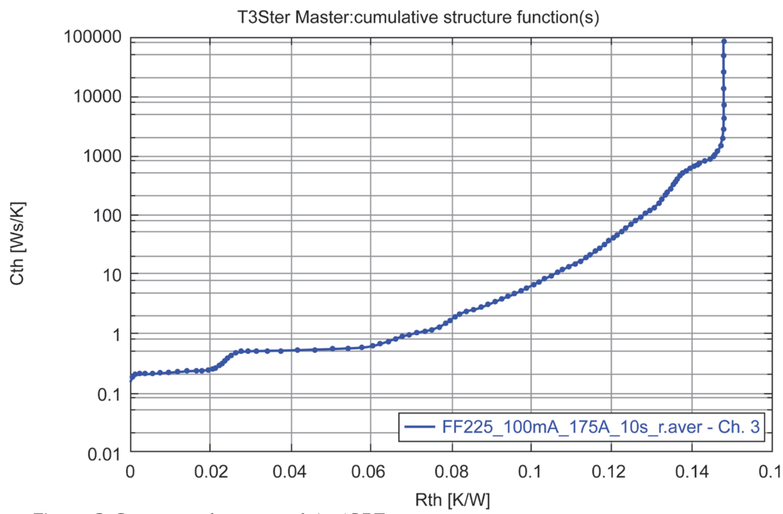


**Figure 2.** Structure function of the IGBT

Once this has been done, the T3ster Master software can evaluate a so-called 'structure function'. The structure function converts all the obtained thermal information and provides a resistance-capacitance network based on the heat-flow path. Do not worry, this is simpler than it sounds. In essence, every layer through which the heat has to spread from junction-to-heatsink has the capability of absorbing and transferring heat. Smaller layers do this much faster than larger layers, which is why the measurement is transient. When a temperature measurement is combined with time, we obtain our structure functions (Figure 2) – smaller layers (to the left of the graph) have smaller RC-nodes than larger layers (to the right of the graph).

What to do with the information that has been obtained? You could scratch your head, beat the computer in a rage and go home. Instead, it is easier to analyze the structure function for coherence, and then export it to FloTHERM (Figure 3). This can now be done quite simply – click, click, type, click and done.

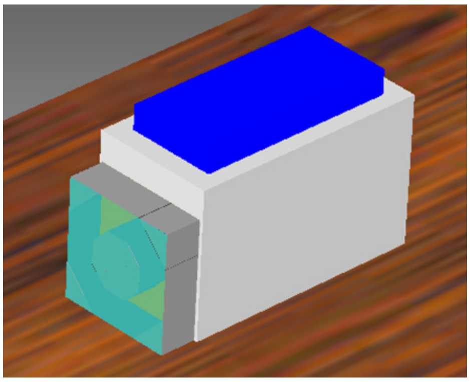

Figure 4. FloTHERM Model of the IGBT

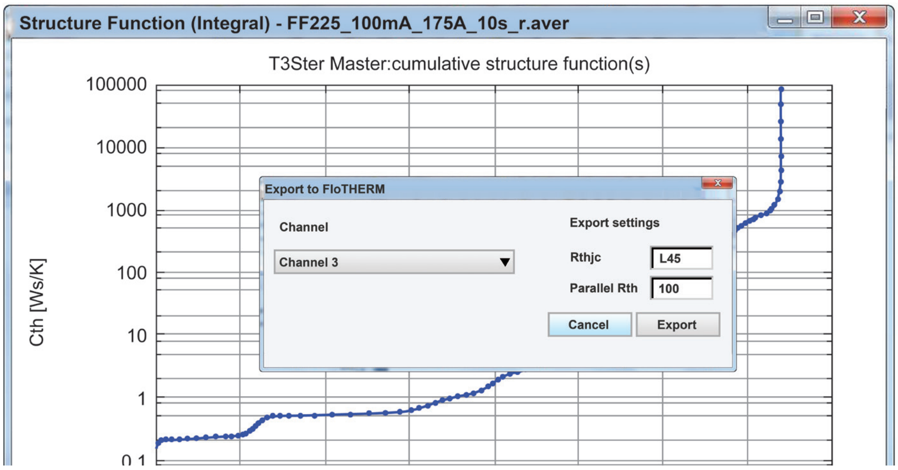


Figure 3. Export Window from T3ster Master to FloTHERM

The RC-Network is now packed into a block-like feature in FloTHERM and contains all the thermal information that was just measured from the small to larger layers. As a sanity check the model is reconstructed similar to the physical example (Figure 4). Now the simulation can be run as a transient, and should yield similar results to the measurement.

Once this has been accomplished the fun part can start. FloTHERM comes with a Command-Center feature. Sound impressive? It is. With this tool, parameters can be selected to create an optimized system. In practice, the example looks as follows: The key parameters are chosen based on what the designer sees as important. Perhaps only the thermal performance needs to be optimized, or the cost and performance need to be combined, depending on budget. In this example, thermal optimization was of the highest concern.

Running the Command-Center optimization, and iterating the number of fins and fin-size, it was possible to lower the junction temperature by 20°C, by increasing the number of fins, and making them smaller (Figure 5).

| | Initial Heatsink | After Optimization |
|---|---|---|
| Fin Width (mm) | 2.2 | 1.6 |
| Number of Fins | 9 | 17 |
| Junction Temp. (°C) | 137.6 | 118 |

Naturally, when several parameters need to be optimized, the system chooses the optimal combination by using the response surface (Figure 6).

This unique combination of software and hardware opens up a new world for electronic thermal design. Once the system has been characterized and verified, it can be continuously optimized, changed and tested within the software before building a new prototype of the final model. Not only does this save development time, but with advanced features like the Command-Center, manufacturing costs can also be cut. This creates a ripple effect throughout the supply chain ending with the consumer essentially allowing for robust systems, that are designed fit for purpose.

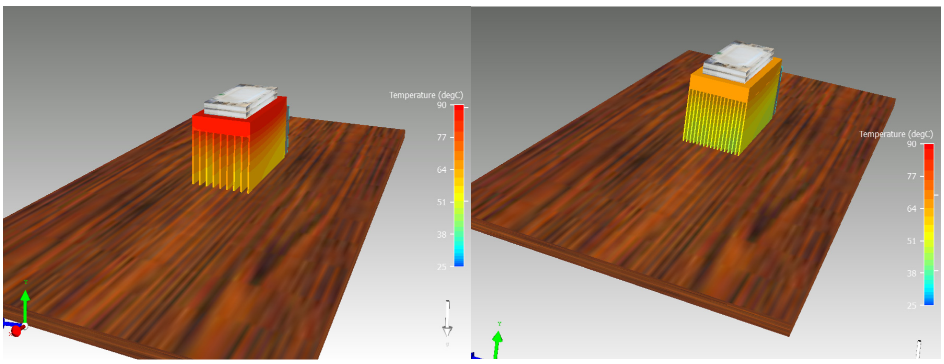

Figure 5. Comparison between the original model and the optimized result

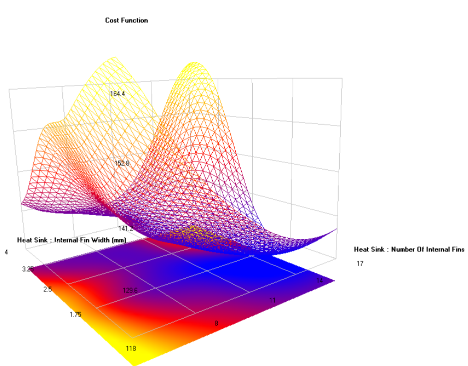

Figure 6. Surface Response Plot for the optimized parameters