The Myth of Heat Spreaders

EUVL
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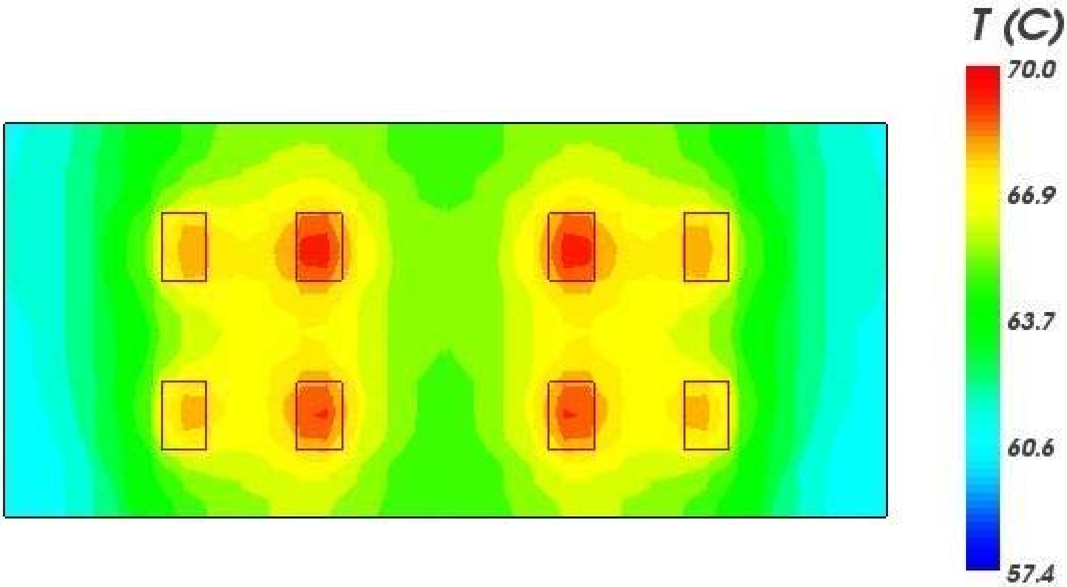
In the process of designing a new housing for higher power Class A amplifiers, I did a few simulations using the same heat sink profile but different heat source configurations. The results are educational to say the least.

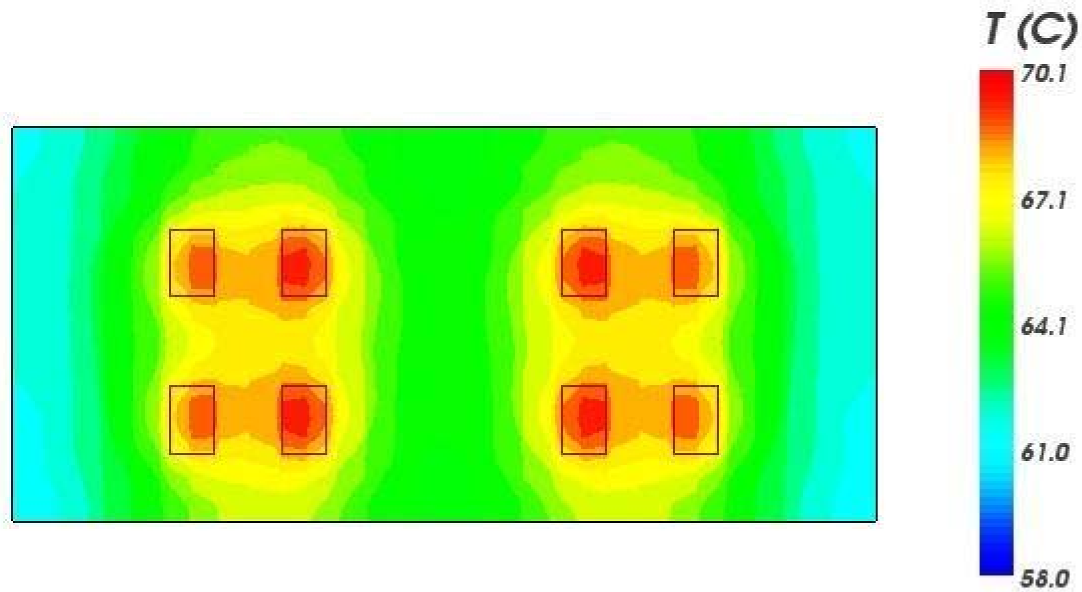
The simulation package used was proven. Results agreed well with experimental measurements with the standard Conrad 350x150x50mm heat sink used in the F5X case. In this particular simulation, however, I chose to use another extrusion profile with overall dimensions of 400x175x60mm. Fin spacing is 13mm. Backing plate thickness is 9mm. Fins are vertical and black anodised.

The heat source used are 8x MOSFETs with a 20x30mm footprint, each dissipating 25W. One of the first results is shown here without too much optimisation :

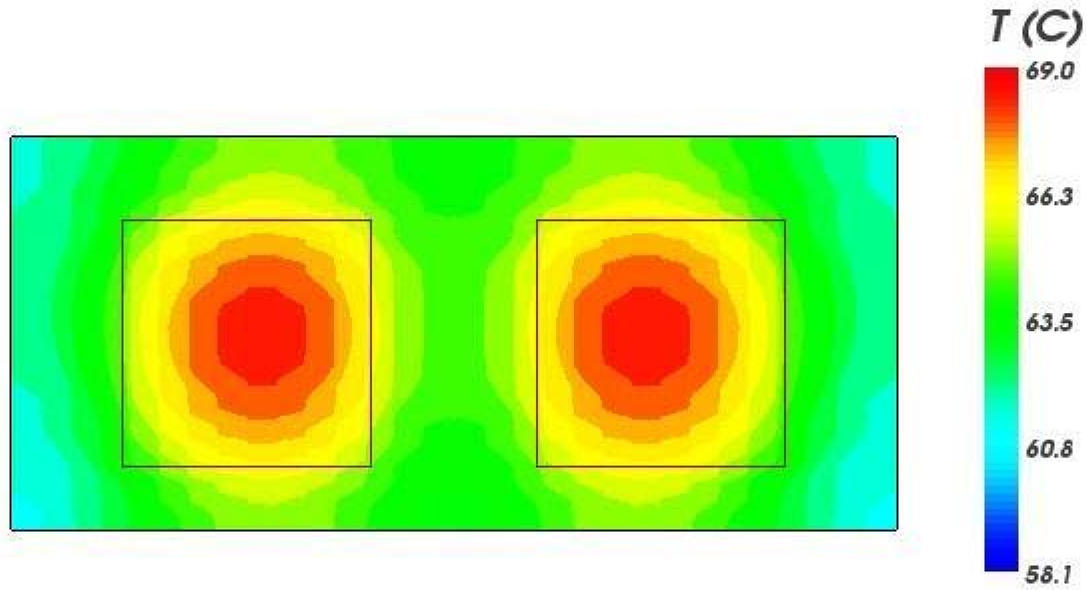


The local temperature at the inner devices are somewhat high, but the sink has surprisingly uniform temperature distribution. Over 80% of the sink has temperature between 63°C and 70°C. But the outer MOSFETs are at a lower temperature than the inner ones, so why not try to make them more equal (for better thermal tracking) ?

Moving the inner MOSFETs outwards by 10mm and shifting the lower ones upwards by 5mm, the 8x MOSFETs now have much more equal temperatures. Note that by reducing the spatial distribution of the heat sources, the maximum and average heat sink temperature hardly increases. This indicates we are sitting close to the optimum.

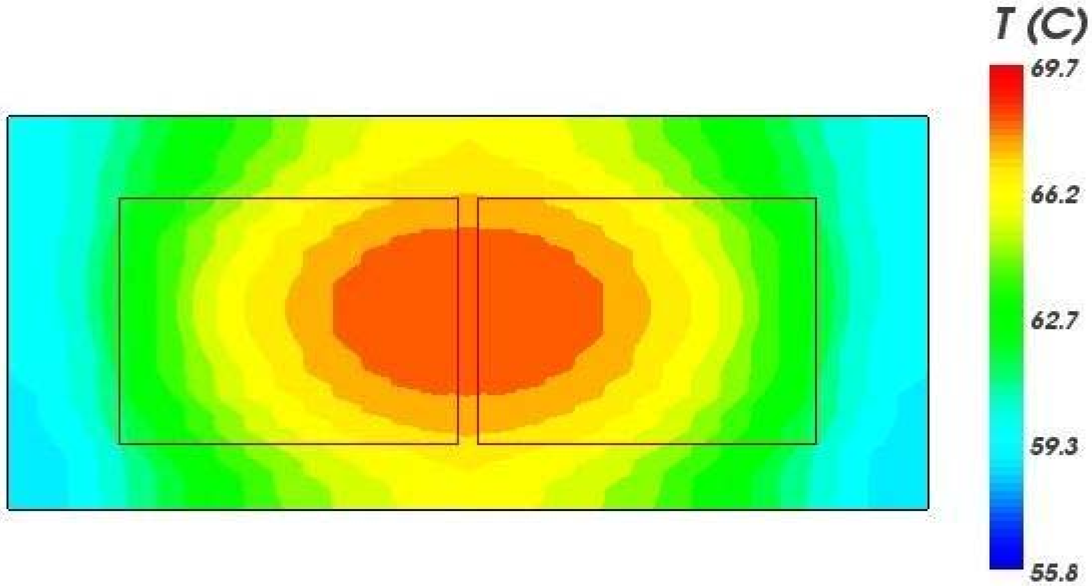


Some might think that increasing the source size by a heat spreader might bring about benefits. So let’s merge all 4x 25W heat sources on one side into one large source of 100W.



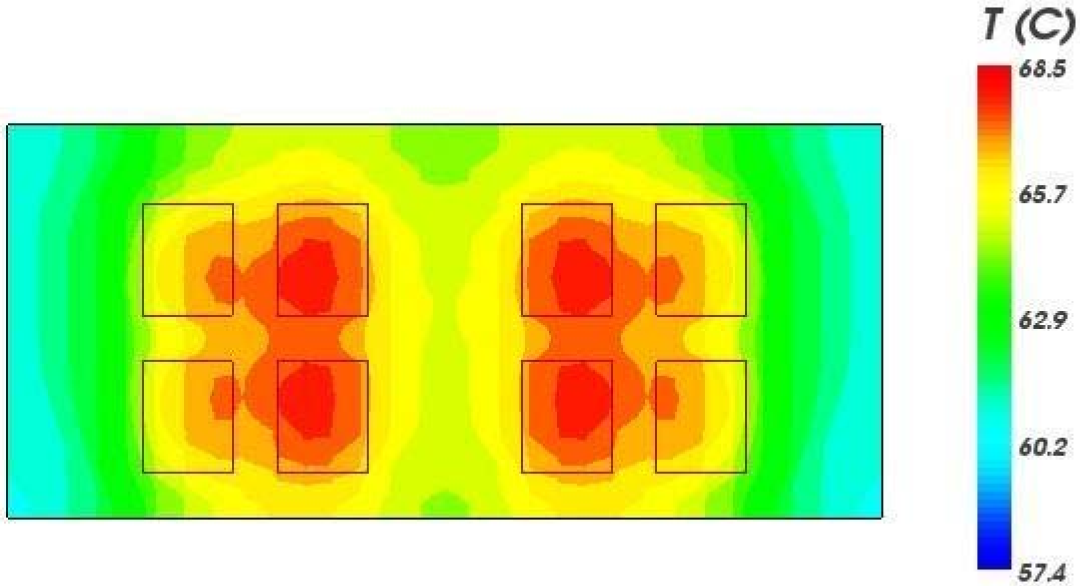
The maximum temperature of the sink drops by 1°C, but one has to take into account temperature between the heat spreader and the MOSFETs. Even using 10mm copper, the temperature difference is not going to be less than 1°C. So in the end, all extra cost and trouble but no performance gain when measured at the MOSFET case.

How about increasing the heat source footprint even further, such that they almost merge in the middle ?



If anything, not better than before. Taking into account of the accuracy of such simulations based on simplified assumptions, one can only say that they are equal. So the large spreaders do not bring the improvement to justify their costs.

Before we trash the spreader completely, how about using smaller spreaders, one per MOSFET ?



This is the best result so far, though by a small amount.

In Fig. 2, the dissipation of each MOSFET is concentrated at a small footprint. A high local temperature is unavoidable. By increasing the footprint of each MOSFET, the heat transfer from MOSFET to heat sink takes place over a larger area, evening out the localised peak temperature somewhat.

Even though a single spreader as in Fig. 3 has double the area as in Fig. 5, it is less effective in spreading the heat as the four smaller pads. This is because when the heat dissipation is uniformly distributed, the middle of the area always have the highest temperature. In using 4 smaller pads but wide enough apart, the one peak in the middle is being broken down into 4 smaller peaks which are some distance from each other. Thus, the spreading actually becomes more effective.

But how can we then increase the footprint of the device without adding (too much) extra thermal resistance ?

I can only think of one way – soldering a piece of 4mm thick copper directly onto the MOSFET, using low temperature solder. Not a job for everyone, but then also not humanly impossible.

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References :

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