WHITEPAPER

Thermodynamics and ECM's PCB Stator Design: How do you get the heat out?

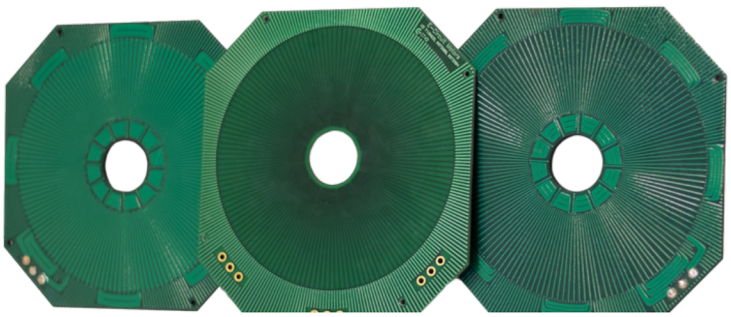
When people take a close look at our technology, one of the big questions we always get is – how do you get the heat out?

ECM loves to hear this question, because it means that you're really taking a close look at our technology. It also allows us to cover one of most important patents and advancements in PCB stators!

Thermal management has been a major focus of our design efforts.

ECM has developed a thermal design which has a continuous copper path from the parts of the stator where losses originate to the interface to the case. This is possible because our software, PrintStator, can identify unused spaces and shape the copper that do not carry current function into "heat pipes."

These non-hollow, 'heat pipes', are using the copper to conduct the heat from the center of the stator to the outside edge where the stator is clamped into the case and the heat can be rejected to ambient..



Creating Heat Pipes with ECM's Printstator software

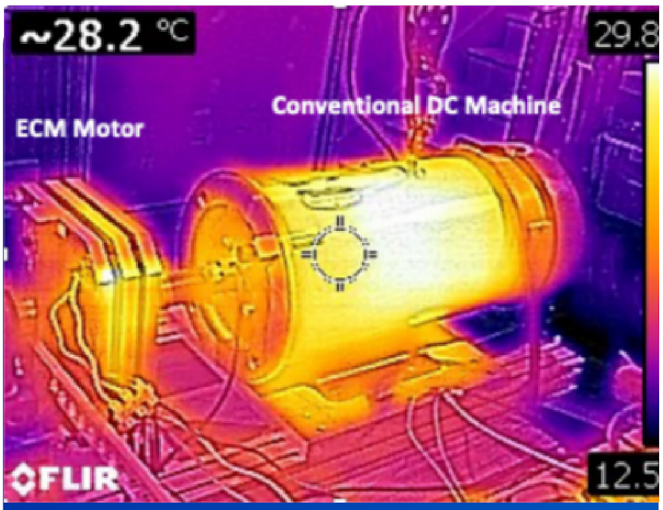
In this picture, you can see a typical stator with inner and outer end turns. The active area (which produces torque and is covered by magnets) is the area between the inner and outer via rings. The copper traces that you see outside the outer via ring are inactive (except for the end turns). Although they are not hollow, we call these traces "heat pipes." They are using the copper to conduct the heat from the center of the stator to the outside edge, where the stator is clamped into the case and the heat can be rejected to ambient. They are also functioning in the Z direction to bring the heat to the top and bottom layer of the board.

Thermodynamics:
How do you get the heat out?

ECM's Thermal Resistance

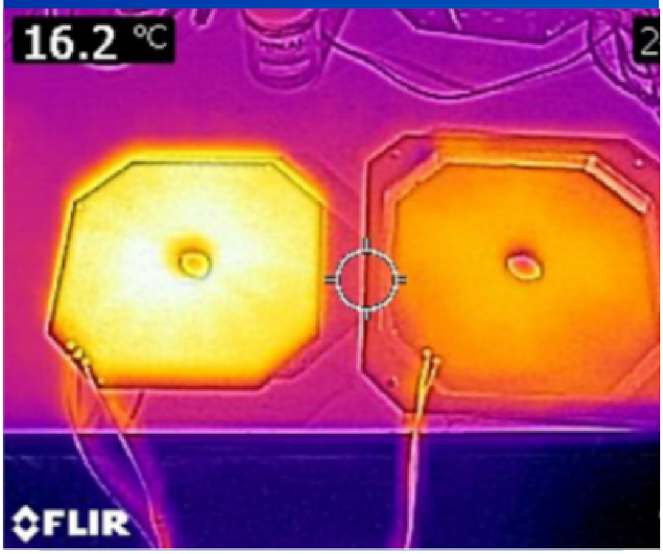
Because copper has a thermal conductivity of 400 W/mK, this leads to much better thermal performance despite the relatively low (0.3-1 W/mK) thermal conductivity of FR-4. Of course, copper in any other motor also has high thermal conductivity, but in traditional motor designs it is difficult to use copper wire both for windings and to effectively convey heat to the case. ECM's thermal resistance of the stator to case is modeled and incorporated in ECM's optimization to achieve varying level of "thermal safety factor" as needed for the application.

You can see in the images below just how effectively ECM's stator design brings the heat to the case, where it can be rejected to ambient.



In this picture, both machines are processing 500W. You can see that in the conventional machine (right) the heat is mostly internal. In the ECM machine (left) most of the heat is at the outer radius of the machine.

The picture below shows two ECM stators, both processing 40W. The stator on the left is sitting on an insulated pad (no heat sink). The stator on the right is in one half of a motor case. You can see how effectively ECM's stator design brings the heat to the to the case, where it can be rejected to ambient.



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