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HARDWARE-INTEGRATION OF THE POWER UNIT EXTERNAL EXCITATION FOR SYNCHRONOUS MACHINES ON THE MAIN BOARD AND COOLER OF THE DRIVE INVERTER

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HARDWARE-INTEGRATION OF THE POWER UNIT "EXTERNAL EXCITATION FOR SYNCHRONOUS MACHINES" ON THE MAIN BOARD AND COOLER OF THE DRIVE INVERTER

Technical task:
The invention relates to power electronics for electric drives. The power electronics are usually used to control a 3-phase electric machine for traction drives (EV, HEV of the PHEVs). A special version of the electric machine is the so-called externally excited synchronous machine.
In contrast to the permanently excited synchronous machine, this type of machine does not require magnetic materials on the rotor and generates the rotor magnetic field by means of an energized winding in the rotor. This provides additional degrees of freedom in the control and design of the electrical machine. This allows efficiency and performance increases. Current is supplied to the rotor winding via slip-ring contacts in accordance with the current state of the art.
The rotor winding must be controlled via an additional power electronic DCDC converter, which is usually integrated in the main converter as shown in Figure 1.
This DCDC converter (exciter circuit) generates an adjustable voltage Uf from the high-voltage voltage (HV voltage). Figure 2 shows a possible topology which can be realized with power semiconductors (MOSFETs and diodes).

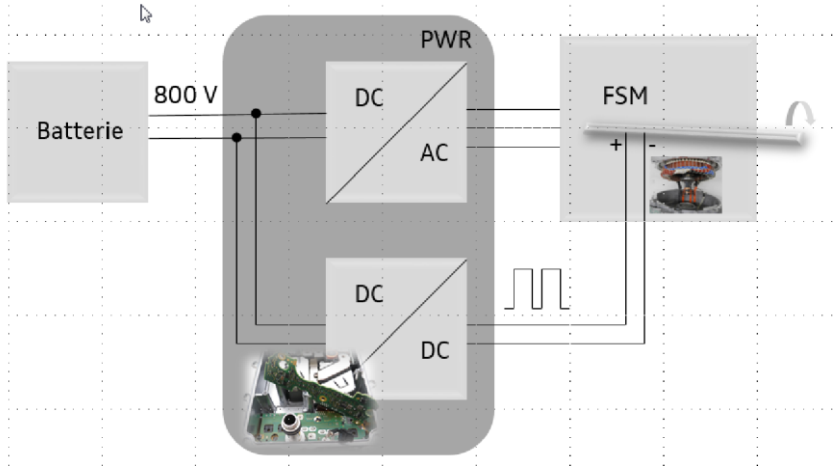

Figure 1:

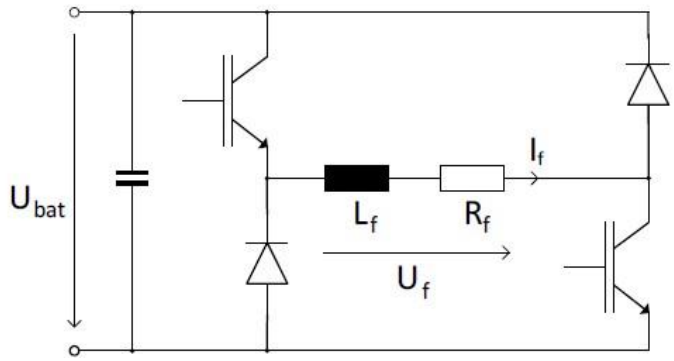

Figure 2:

Initial situation:
The exciter circuit is implemented according to the state of the art with discrete components on conventional PCBs. The components are cooled by free convection in air with the ambient temperature inside the power electronics. There are also implementations of the exciter circuit with power modules, which are also cooled only via free convection. However, these power modules mean an increased packaging expenditure, a very high development expenditure and are also very cost-intensive, since they must be developed customer-specifically.

Solution:
The power module of the main inverter is usually water-cooled according to the state of the art. A corresponding design is shown in Figure 3. Here, so-called PinFin structures within a closed metal cooler are surrounded by a cooling medium and the energy is dissipated from the semiconductors by forced convection. The invention is based on the task of improving the cooling of the exciter circuit. Due to the integration of the exciter circuit within the main inverter, this exciter circuit can also be connected to the heat sink of the inverter.

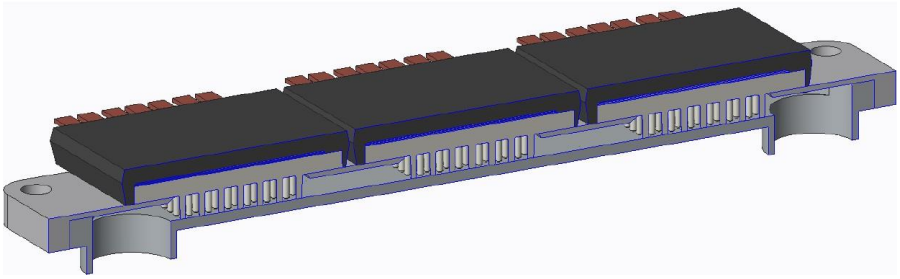

Figure 3:

In addition, the thermal connection to the main cooler is made by connecting the underside of the circuit board to the cooler. As shown in Figure 2, this enables the excitation circuitry to be connected to an SMD assembly on the top side of the existing circuit board. This allows a cost-effective integration of the circuit. For this only the existing board has to be slightly enlarged, see figure 6.
The actual heat dissipation or cooling connection of the top-side assembled power semiconductors takes place via so-called thermo vias in the circuit board. For this purpose, the cooler is pulled up so that the board rests directly on the cooler, separated only by a TIM (Thermal Interface Material) (Figure 8).
In the area of the conventional power modules, the cooler remains unchanged; these are still heated directly in the coolant via the PinFin structure.

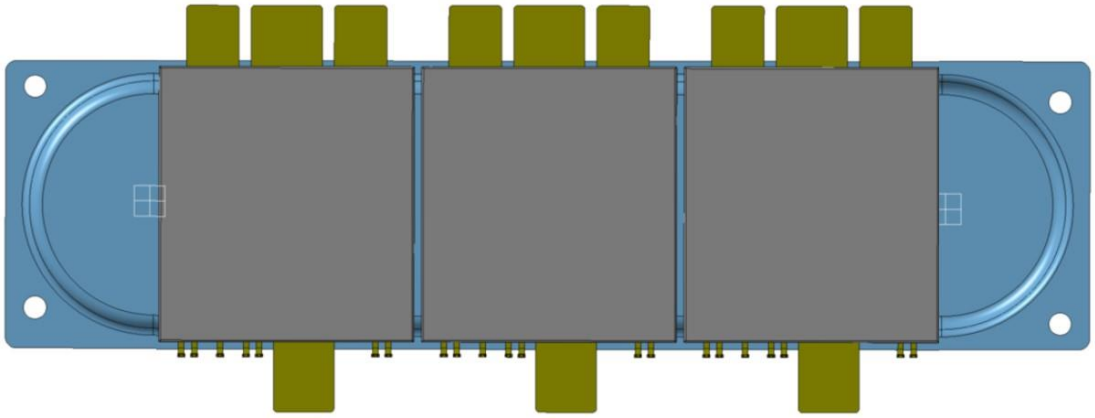

Figure 4: Power module on cooler State of the art

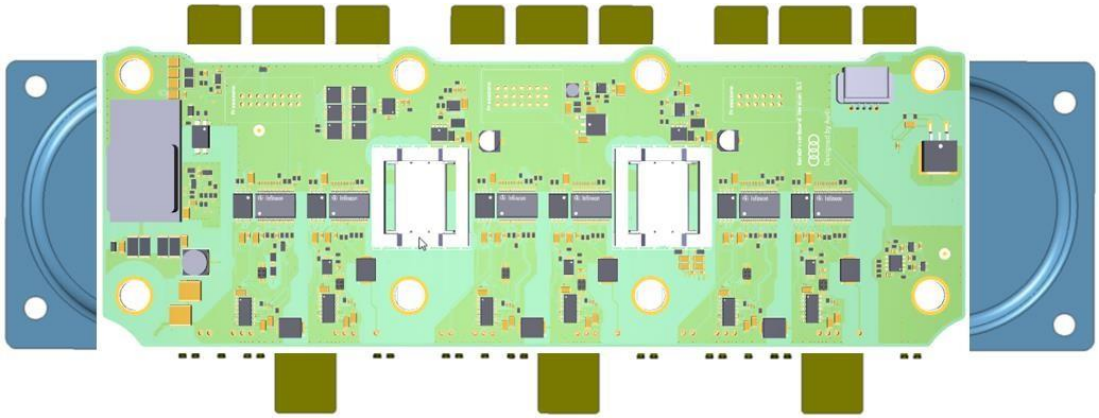

Figure 5: Power module on cooler incl. gate driver board State of the art

Invention/ Differentiation:

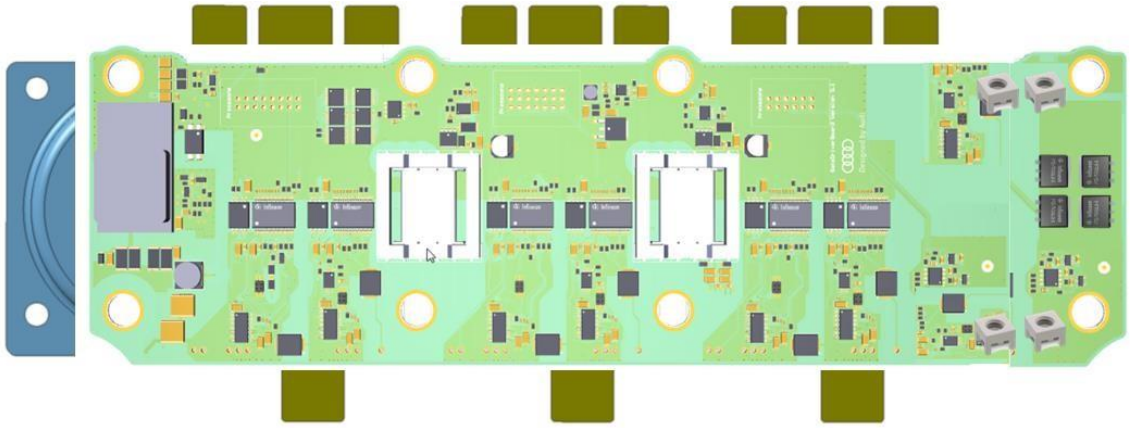

Figure 6: Extension board + integration exciter circuit

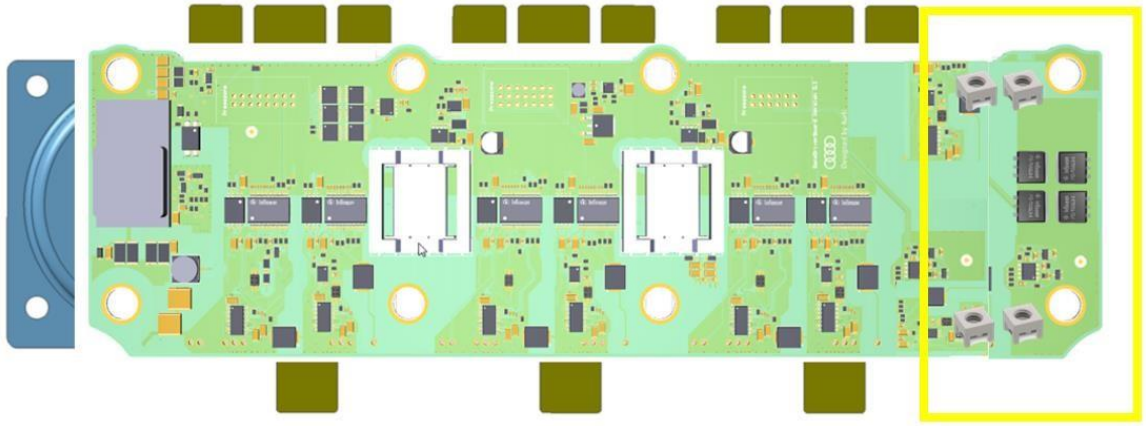

Figure 7: Integration exciter circuit

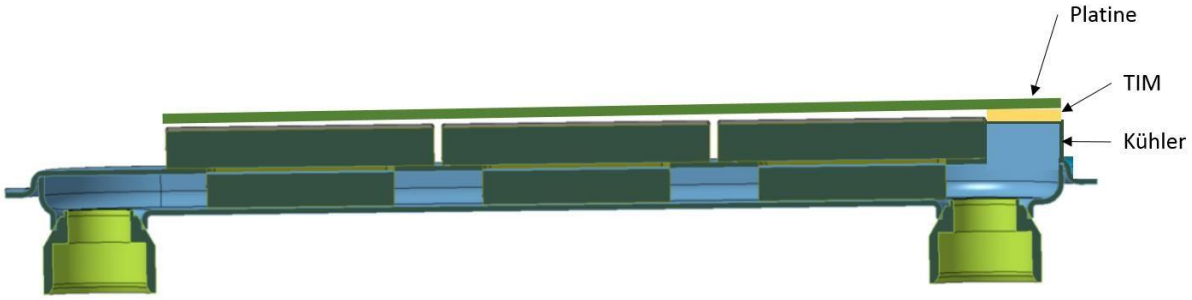

Figure 8: Cross section cooler incl. integration board

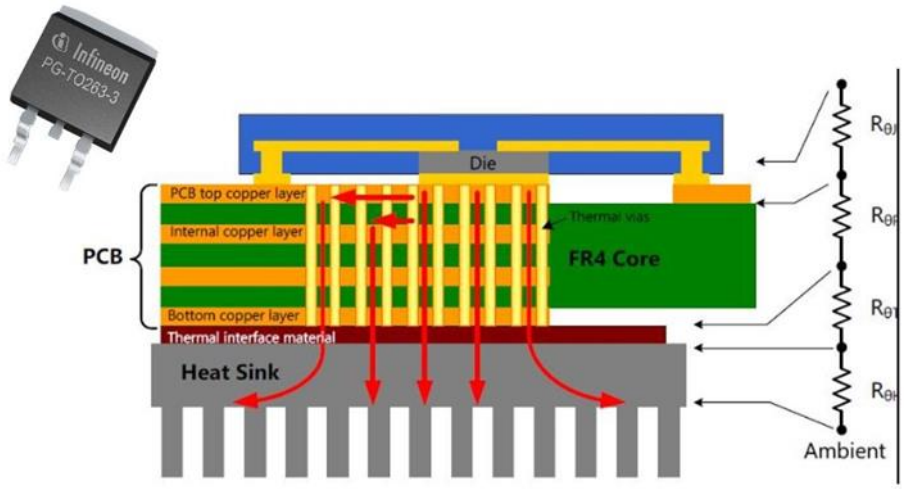

Figure 9: Principle of heat dissipation via thermo vias

Advantages:
With the invention, an overall cooler for the main inverter can be used to cool the exciter circuit. This means that the chip area for the exciter circuit can be significantly reduced compared to the state of the art, as can the costs. In addition, the circuit can be implemented using conventional power semiconductors, which is a considerable cost advantage.

- No additional circuit board for the exciter circuit including exciter module, as the circuit is integrated on an existing circuit board.
- Cost reduction - no additional power module for the excitation circuit necessary, since the target achievement is possible by conventional, favorable discrete components
- Cost reduction - production, power semiconductors can be assembled in the conventional SMD process.
- Space advantage - SMD components have a low overall height as comparatively high power modules for this application.
- Increased performance and service life of the exciter circuit
- Reduction of the chip area of the power semiconductors of the exciter circuit