

Development of Power Control Unit for a newly developed Hybrid Electric System

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Concerns about global warming and the depletion of petroleum resources are increasing further, and the movement to reduce CO2 emissions and ensure energy security is being activated worldwide. Exhaust gas regulations are being tightened year by year, and it is expected that the early spread of clean automobiles with low CO2 emissions will spread. As one of the solutions, the authors have developed hybrid electric vehicles(HEV) with remarkably excellent fuel efficiency and have been striving to popularize them. This time, we have developed a PCU to be installed in a new hybrid electric system that will be the next generation, achieving a smaller size, lighter weight, and lower loss than before.

One of the objectives of vehicle development is to adopt a newly developed electric 4WD system and implement a significant increase in output/torque to achieve improved stability and drivability. Therefore, the functions of the rear motor drive inverter (RrINV), which was separate in the previous model, were integrated into the PCU. As a result, it is possible to increase the current by water cooling and to drive the motor with the voltage after boosting, achieving improved of output/torque. In addition, the abolition of the RrINV also enabled the expansion of luggage space.

Table 1 shows the specifications of the newly developed PCU (5th generation PCU). In order to install a PCU with integrated RrINV function in a compact segment, the size of the internal parts was reduced by increasing the boost carrier frequency and reducing the loss of the power module. As a result, the volume is reduced by 13% and the mass is reduced by 29% compared to the previous model. In addition to being smaller and lighter, the system also reduced PCU losses by 6.1% compared to the previous model and achieved a peak power density (kVA/mm²) of IGBTs of 2.78 times, achieving low losses and high output.

This was achieved by:

Adoption of RC-IGBT that integrates IGBT and FWD / Miniaturization of power module by reducing element loss, improving cooler cooling performance, and improving inverter control / Miniaturization of reactors and filter capacitors due to higher frequency boost converter carrier frequency / Integration of DC-DC converter control circuit and power circuit.

As a result, the concept of installing a FrPCU with the RrINV function integrated into the compact segment has been achieved by reducing the PCU by 13% compared to the conventional one.

Table1 PCU specification for HEV System

		Previous model (4 th generation)	New model (5 th generation)
Max boost voltage		650V	600V
Boost carrier frequency		10kHz	20kHz
Motor max current	Fr	265Arms	230Arms
	Rr	—	125Arms
Weight		15.8kg (※1)	11.1kg
Volume		13.7Liters (※1)	11.9Liters

(※1)The sum of PCU and RrINV



Fig.1 The 5th generation PCU