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Development of PCU for e:HEV for Mid-Size Vehicles

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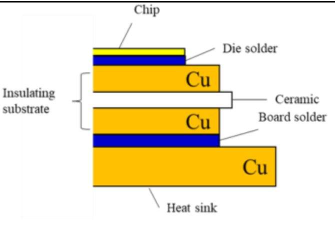
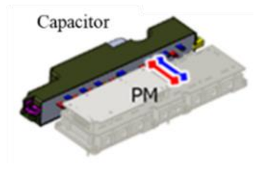
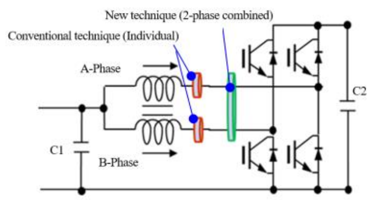
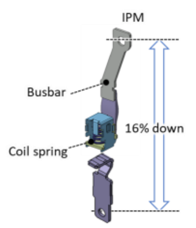
Climate change is a crucial issue for the world community. Fuel economy regulation is becoming stricter every year in every region, and there is demand for vehicles with low CO_2 emissions. In 2013, Honda developed the two-motor hybrid system of the SPORT HYBRID i-MMD, which can operate in different modes. In one mode, the vehicle runs using motors based on the series hybrid system for its main driving force. In another mode, the engine and tires are directly linked so that the vehicle runs using the engine for its driving force. Honda also developed the PCU to be mounted in the SPORT HYBRID i-MMD. Honda has been engaged in enhancing the performance of this system and expanding the range of applicable vehicle models. In 2016, the second-generation PCU with enhanced performance was developed, and in 2020, the third-generation PCU was developed for the hybrid system to be mounted in compact vehicles under the new name of e:HEV.

In order to further expand the range of applicable vehicle models, a PCU has now been developed for C and D segment cars. The group of cars on which this PCU is intended to be mounted implement the design philosophy called the Honda architecture, which deploys the same components on large numbers of vehicles. This design philosophy also served as a basis with regard to the PCU, and the development aim was to simultaneously satisfy the need for downsizing to enable mounting in the engine compartment of C-segment sedans and the need for power output to handle the power performance of D-segment SUVs.

The new model PCU achieves smaller size and enhanced power density with a structure made up mainly of an IPM(intelligent power module), VCU(voltage control unit), and connectors(Fig.1). In order to make the IPM compact, copper was chosen for the W/J(water jacket) material, the metal portions of the insulation substrate were made thicker to enhance the heat dissipation performance, and the chip area was reduced by a maximum 29.4%. The IPM and condensers were also mounted on the same layer, enabling their connection in the least amount of space. The effect of these measures yielded a 38.6% reduction of size for the IPM. The VCU was made more compact by aggregation of its components. In a VCU with a coupled inductor system, the conventional approach of placing current sensors for the A-phase and B-phase as a method of drift suppression is replaced by a system that that uses a single sensor to detect drift. Heat generation in the VCU is suppressed and a 20% reduction in reactor size was achieved. For the three-phase connection structure, the conventional pin connection was changed to a flat surface contact structure, realizing a reduction in overall height.

By means of these technical elements, the target volume of 10.20 [L] was surpassed with a volume of 10.16 [L]. In terms of power density, this achieved 43.8 [kVA/L].

<table>
<tr><td></td><td colspan="2">IPM</td><td colspan="2">VCU</td><td>PCU</td></tr>
<tr><td rowspan="2">Details</td><td>RC-IGBT downsized</td><td>Internal structure layout optimized</td><td>Reactor downsized</td><td>Current sensor components aggregated</td><td>3-phase connector overall height reduced</td></tr>
<tr><td>
</td><td>
</td><td colspan="2">
</td><td>
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<tr><td>Technique</td><td>To enhance heat dissipation performance, the copper on the insulation substrate was made thicker and the W/J material was changed</td><td>Capacitor and IPM were mounted on the same layer</td><td>Heat generation was reduced by drift suppression</td><td>Drift detection system changed</td><td>Flat surface contact</td></tr>
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Fig.1 Techniques adopted to enhance power density

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