

Intelligent Power Unit for the 2018 Model Year Accord Hybrid

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ABSTRACT

A compact intelligent power unit capable of being installed under rear seating was developed for the 2018 model year Accord Hybrid that is to be equipped with the SPORT HYBRID Intelligent Multi Mode Drive (i-MMD) system. The lithium-ion battery module was made more compact than in previous models, the structural parts were integrated, and the cooling structure was optimized. A 12 V DC-DC converter was also integrated with the power control unit in the engine compartment, making the intelligent power unit compact enough to install under the rear seat. As a result, the vehicle gained trunk room equal to gasoline-powered automobiles and realized a structure allowing continuous open space from the trunk through to the rear passenger compartment. The increased compactness also achieved a 10% reduction in weight.

1. Introduction

Global warming and air pollution are presently being treated as serious issues on a global scale, and these are major issues that should also be addressed by the automobile industry as a whole. The automobile manufacturers take the reduction of exhaust gas emissions as an urgent task, and in their search for effective solutions, they are pursuing the development of electric vehicles of all kinds, prominent examples being hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell vehicles (FCVs).

The two-motor hybrid system (SPORT HYBRID i-MMD) that Honda launched on the market in 2013 was initially installed in the Accord, which had both HEV and PHEV model lineups⁽¹⁾. In addition to an engine, this electric powertrain consists of an electric coupled continuously variable transmission (electric coupled CVT) with two built-in motors, a power control unit (PCU), and an intelligent power unit (IPU).

The IPU is made up of a high-voltage battery, the battery electronic control unit (ECU) that controls it, a high-voltage power distribution unit, and an air cooling

device. It functions to supply motor drive current, to discharge assist energy and store regeneration energy, to buffer surplus power when the generator is producing electricity, and so on. The IPU also manages the instantaneous input and output of energy and other such tasks in its comprehensive role of power management that supports hybrid systems.

The SPORT HYBRID i-MMD system that was announced in 2016 embodied a further evolution by means of technologies that increased the efficiency and reduced the size of the components^{(2),(3)}. In the Accord Hybrid, however, vehicle package constraints meant that the IPU had to be installed in the trunk, and as a result, the trunk room and usability were limited by comparison with gasoline-powered automobiles.

This paper introduces the development of the IPU for the new model SPORT HYBRID i-MMD system (Fig. 1) that is used in the 2018 model year Accord Hybrid. The development objective was a compact IPU capable of being installed under the rear seat of a hybrid sedan in order to provide trunk room equal to gasoline-powered automobiles, and realize a structure allowing continuous open space from the trunk through to the rear passenger compartment.

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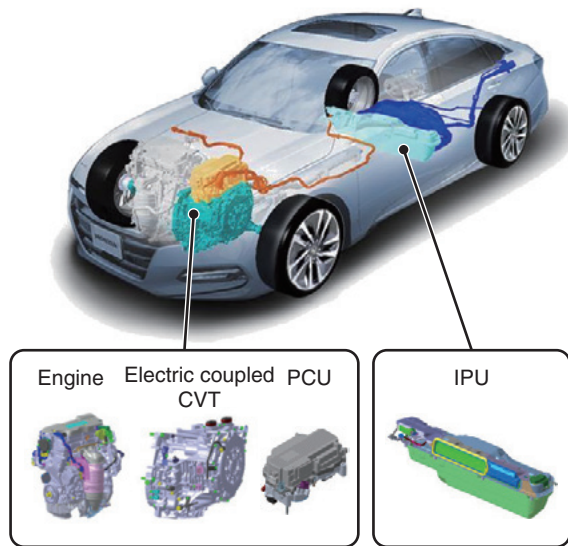


Fig. 1 Electric powertrain components in new SPORT HYBRID i-MMD system

2. Conceptual Approach

Figure 2 shows the configuration of the new model IPU. The IPU uses its case and cover to shape its space. The unit interior is occupied by a high-voltage Li-ion battery module, a high-voltage power distribution unit with an electric power shut-off function, battery cooling parts, and a battery ECU to monitor and control battery voltage and capacity.

In order to install the IPU under the rear seat, it has to be made a size that is compact enough to fit within the space constraints shown in Fig. 3. Table 1 shows the constraint

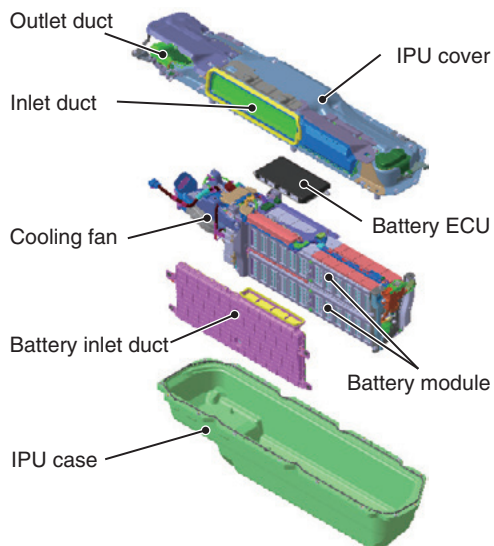


Fig. 2 Configuration of IPU

Table 1 Boundary constraints under rear seat

Direction	Constraint condition
Longitudinal	Passenger's leg space and fuel tank
Lateral	Space between side frames
Vertical	Rear seat height and cushion thickness Minimum ground clearance

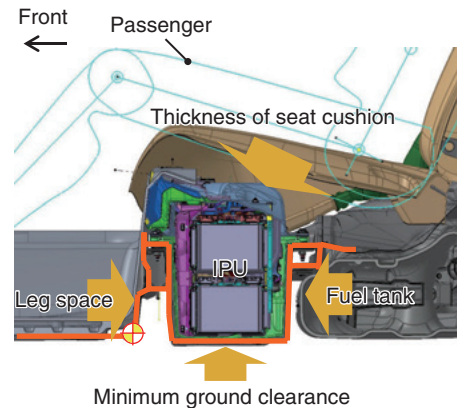
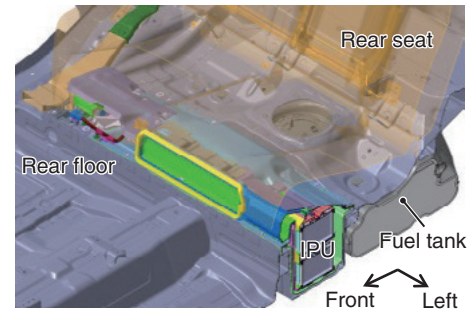


Fig. 3 Constraints on layout under rear seat

conditions in the directions that define that space.

Installation of the IPU under the rear seat was examined in the context of these layout constraint conditions.

3. Size Reduction Technology

3.1. Li-ion Battery Pack Size Reduction

As shown in Fig. 4, the Accord Hybrid IPU has 72 Li-ion battery cells installed. The previous model combined four modules, each containing 18 cells linked in a series. In the new model, this arrangement has been changed to have two modules, each containing 36 cells in a series, and the length in the cell stacking direction has been shortened. A center plate has also been added and the frame has been made stiffer so that the strength and stiffness of the modules are optimized to match the increase in the number of cells placed in a series.

The result was a 15.5% reduction in the ancillary

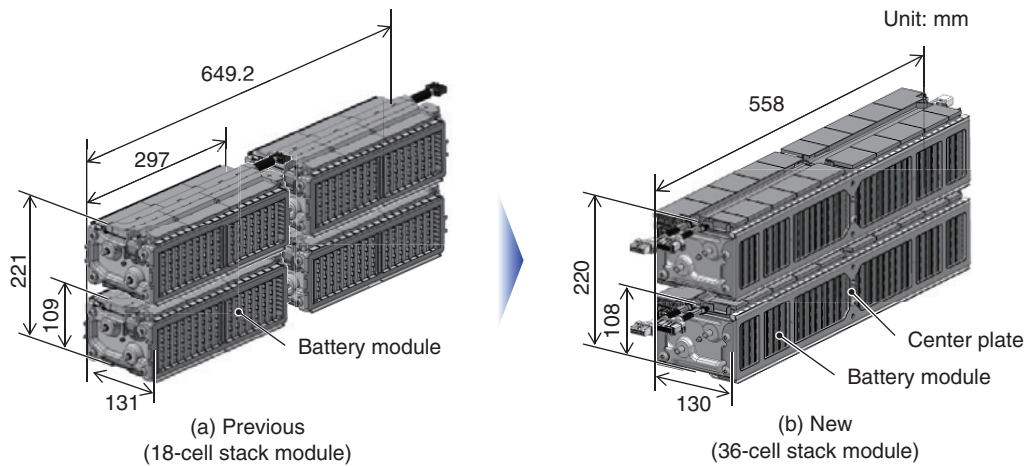


Fig. 4 18-cell stack battery module and modified 36-cell stack battery module

volume needed for module clamps and mountings, for high-voltage harness routing, and for harness connectors.

3.2. IPU Cover with Integrated Seat Stiffener Function

Most of the total height of the IPU is made up of the battery modules. In addition to that, however, there is the clearance between the cover, the case bottom, and the parts.

When the IPU is installed under the rear seat, there is a partial overlap of function between the IPU cover and the seat stiffener. By integrating the overlapping parts and functions, therefore, unnecessary clearance was eliminated.

The IPU cover also needs to be able to withstand the greatest load applied to it during a collision. The cover layout, materials, and thickness were therefore configured so that high-voltage parts, including the battery, would not come in contact with metal parts.

Figure 5 shows the CAE analysis results. These confirmed that the clearance between the cover and the high-voltage parts of the battery is maintained even if the cover on the upper surface of the IPU is displaced when the greatest load is applied.

3.3. Air Cooling Structure Integrated with IPU Case

The previous IPU had large ducts placed on both the inlet side and outlet side of the Li-ion battery modules to provide a route for cooling air to flow through. In the new model IPU, the case and cover connection surfaces were made into sealing structures so that the IPU interior would form an airtight structure. The use of a cooling fan to induce a cooling current then eliminated the need for an outlet duct.

Figure 6 shows the results for computational fluid dynamics (CFD) analysis of the cooling air flow. A flow channel is formed from the battery outlet to the air intake of the cooling fan. Figure 7 shows the distribution of the cooling air flow rate on the battery outlet side. This confirms that a cooling air flow is supplied to all the cells.

As a result, the new model IPU maintains cooling

performance equal to the previous model while reducing its dimension in the longitudinal direction of the vehicle by 26.3 mm (Fig. 8).

In a further step, where the previous IPU had the 12 V DC-DC converter unit built in, the new model SPORT

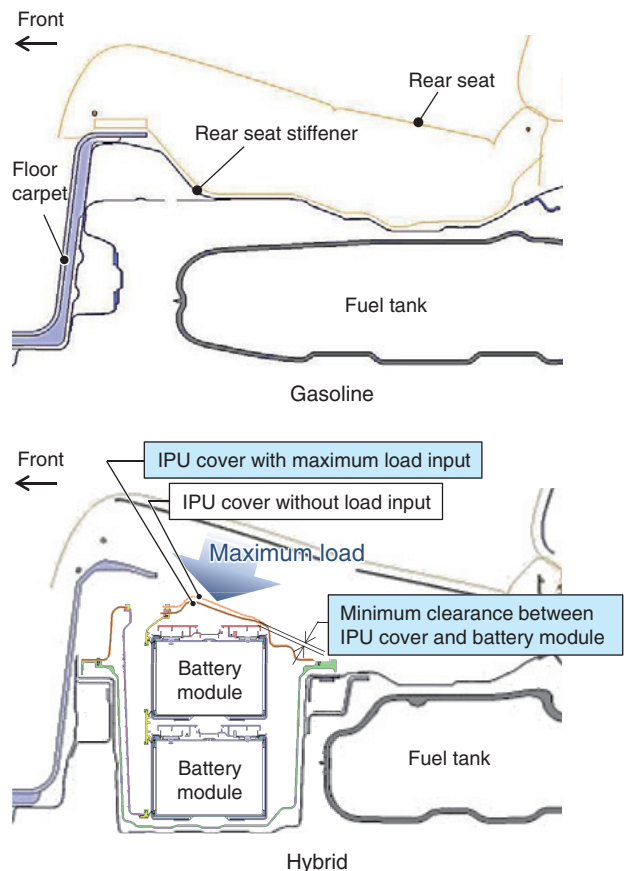


Fig. 5 Analysis results for IPU cover displacement under maximum load input

HYBRID i-MMD system functionally integrated this converter on the PCU side, in a single consolidated unit⁽⁴⁾.

By means of these techniques, the IPU volume was reduced by 32.1%, from the 70.8 L of the previous model to 48.1 L here. This enabled installation of the IPU under the rear seat.

As shown in Fig. 9, the 2018 model year Accord Hybrid successfully achieved the same VDA volume of 549 L as the gasoline-powered automobile. This additionally realized a continuous open space from the trunk through a large opening into the rear passenger compartment. This approach therefore achieved an affordable, highly efficient hybrid vehicle with trunk room equal to that of

gasoline-powered automobiles, together with a structure allowing continuous open space from the trunk into the rear passenger compartment⁽⁵⁾.

The size reductions were also accompanied by a reduction in IPU weight of 4.0 kg, making it 10% lighter than the previous model.

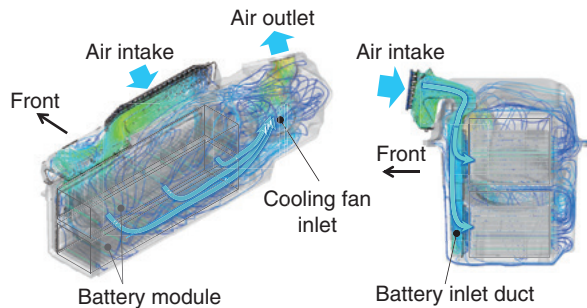


Fig. 6 Cooling air flow line inside IPU

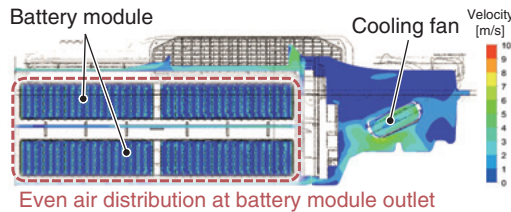


Fig. 7 Distribution of cooling air flow rate on battery outlet

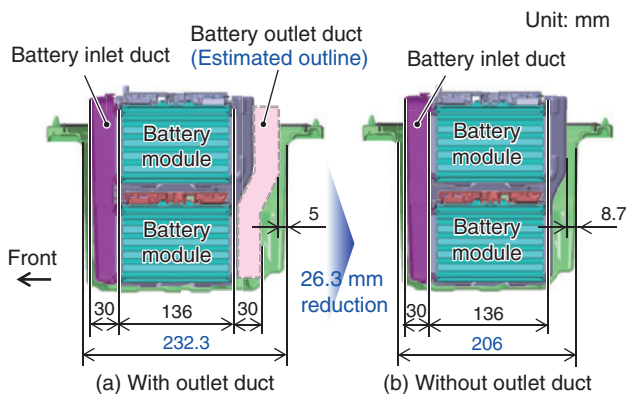


Fig. 8 Volume reduction of IPU due to elimination of battery outlet duct

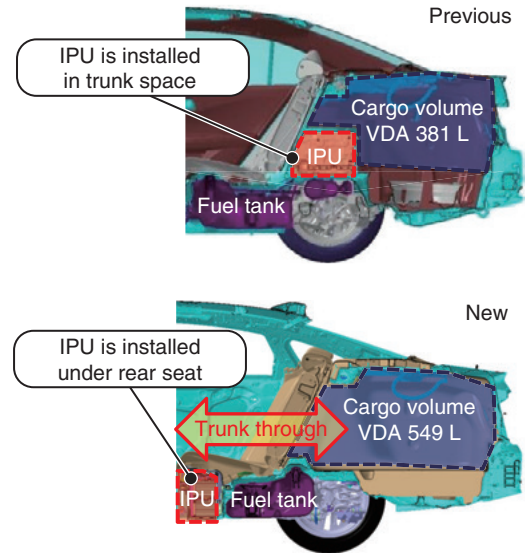


Fig. 9 Comparison of cargo volume of previous Accord Hybrid with that of new Accord Hybrid

4. Conclusion

An IPU capable of being installed under the rear seat was developed in order to achieve trunk room equal to gasoline-powered automobiles and realize a structure allowing continuous open space from the trunk through to the rear passenger compartment in the 2018 model year Accord Hybrid.

- (1) The Li-ion battery module was reduced in size, the IPU cover and car body seat stiffener were functionally integrated, and the air cooling structure was integrated with the case. These measures reduced the IPU volume by 32.1% from the 70.8 L of the previous model to 48.1 L, and enabled installation under the rear seat.
- (2) The reduction of the IPU size achieved a weight reduction of 4.0 kg over the previous model, making it 10% lighter.

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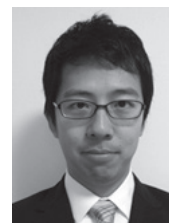
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