

Development of IPU for SPORT HYBRID i-DCD

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ABSTRACT

An Intelligent Power Unit for the 2014 model year FIT SPORT HYBRID i-DCD was developed.

The total height of the Intelligent Power Unit was reduced by the flat installation of its component battery and Power Control Unit, while achieving miniaturization and reduced weight by modifying the frame and cooling duct structure.

By adopting a high-power, large-capacity, lithium-ion battery developed for the SPORT HYBRID, an energy performance 1.5 times greater than that of the conventional model was achieved. In addition, by reducing the volume of the Intelligent Power Unit 23% compared to that of the conventional model, energy density was increased by a factor of two.

Reducing the total height of the Intelligent Power Unit allowed it to be installed in both 2WD and 4WD, which have limited spare tire well volume, minimizing cargo room height and ensuring a sufficient cargo volume for practical use.

1. Introduction

Amid rising crude oil prices and an increasing awareness of global warming and other environmental issues, the sales ratio of fuel-efficient vehicles has increased, and automobile corporations are competing fiercely to develop hybrid technologies.

Previously Honda developed a lightweight, compact, single-motor parallel hybrid system, the Integrated Motor Assist (IMA), which has primarily been installed in compact vehicles. In order to further improve the efficiency of hybrid vehicles, the SPORT HYBRID intelligent Dual-Clutch Drive (SPORT HYBRID i-DCD) was developed and installed in the 2014 model year FIT (new FIT). Because the engine and the motor are separated by the clutch, this system experiences less friction during EV operation than the conventional IMA system. In order to enable EV operation over a broad range, the power and capacity of the battery were increased. This report introduces a high-power, compact Intelligent Power Unit (IPU) suitable for the SPORT HYBRID i-DCD.

2. Development Goals

The conventional IMA system uses the engine as the primary source of power and has superior mountability because it is compact and the motor is directly connected to the engine crank axis⁽¹⁾. In the SPORT HYBRID i-DCD, a single motor is used to ensure compactness, and the engine and motor were separated by integrating the clutch within the transmission. In this way, it became possible to provide the following three operation modes: EV operation in which

the engine is separated and the motor is the only power supply; hybrid operation, which uses the motor to assist the engine; and engine operation, which uses only the engine as a power supply. In order to enable EV operation over a wide range, it was necessary to further improve battery output and capacity. Also, in order to install the IPU in a compact vehicle, it was necessary to decrease its size and weight.

Meanwhile, for the SPORT HYBRID i-DCD, it was also necessary to decrease the total height of the IPU to make the i-DCD suitable for the vehicle body combining hybrid system and 4WD, which is Honda's first, and to ensure cargo room capacity. By developing an IPU capable of being used in both 2WD and 4WD, the number of parts for 4WD was decreased and costs were reduced.

3. IPU Structure

3.1. Appearance

Figure 1 shows the appearance and dimensions of the IPU as well as changes in dimensions compared to the 2011 model year FIT (previous FIT). The height of the IPU was reduced by 20% compared to the previous FIT. Figure 2 shows the changes in the volume and weight of the IPU compared to the previous FIT. The IPU for the new FIT has been reduced in both size and weight.

3.2. Configuration

Figure 3 shows the configuration of the IPU. The IPU comprises a battery module, Power Control Unit (PCU), Junction Board (J/B), Electronic Control Unit (ECU) and cooling fan. There are four battery modules installed in parallel, and the PCU is installed on the side of the battery

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module. Also, by using a flat-installation package in which the J/B is installed on the front of the battery module and a cooling fan is installed on the rear of the PCU, it was possible to minimize the height of the IPU to achieve a

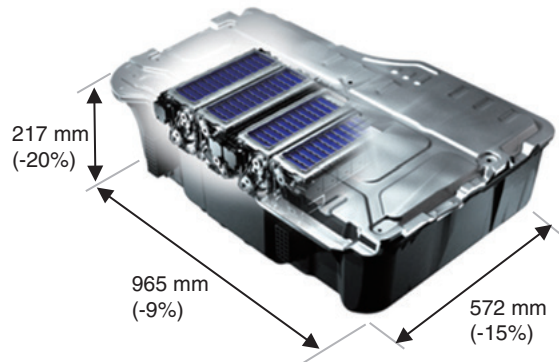


Fig. 1 Dimensions of IPU

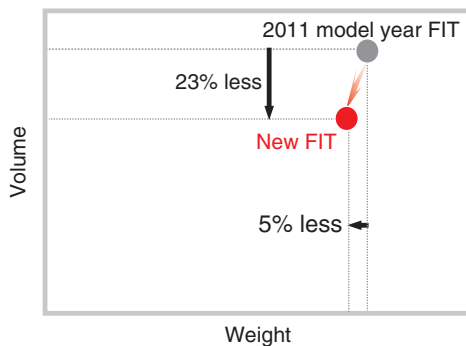


Fig. 2 Volume and weight of IPU

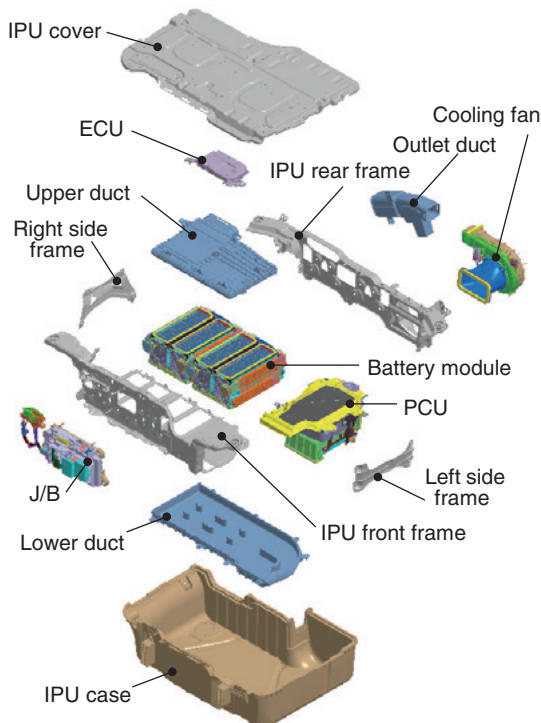


Fig. 3 Configuration of IPU

package with a low total height. Each component is held by two IPU frames that pass horizontally over the front and rear of the module.

3.3. Battery Module

Figure 4 shows the configuration of the battery module. A single module comprises 12 cells stacked in series. This module was also used in the 2014 model year Accord SPORT HYBRID i-MMD⁽²⁾.

3.4. PCU

Figure 5 shows the configuration of the PCU. The PCU comprises an inverter, DC/DC converter, and electric current sensor. Installing the inverter and DC/DC converter vertically allowed the PCU to be installed in the space beside the battery module.

3.5. Frame Structure

Figure 6 shows the frame structure of the previous FIT. The battery module and PCU are attached using the battery frame and PCU frame, and a structure that uses two IPU frames to suspend the battery module and PCU was utilized.

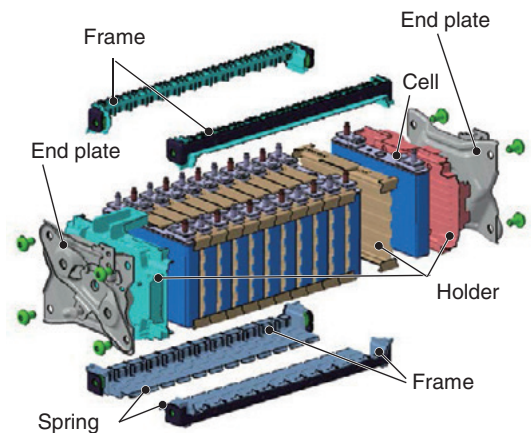


Fig. 4 Configuration of battery module

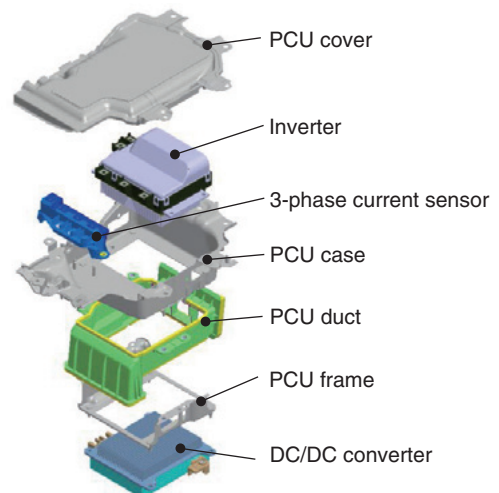


Fig. 5 Configuration of PCU

In contrast to this, the frame structure of the new FIT SPORT HYBRID i-DCD holds the component units with only two frames as shown in Fig. 3: the IPU front frame installed in the front of the module and the IPU rear frame installed in the rear of the module. It was therefore possible to not only reduce the number of parts and the cost but also to simplify assembly. Figure 7 shows the shape of the IPU front frame. The main frame is a press-formed product without joints. Also, a lower patch and an upper patch were welded to both ends of the main frame, the part that attaches to the vehicle, forming a closed section and increasing stiffness. The IPU rear frame has the same structure as that of the front frame.

In addition, a side frame that joins and attaches the front and rear frames was installed on each side of the IPU frame. This side frame minimized vibration by increasing the stiffness of the IPU in the longitudinal direction, thereby improving vehicle steering stability.

3.6. Cooling Structure

The battery module, inverter, and DC/DC converter must be efficiently cooled and controlled to within the optimal operating temperature range.

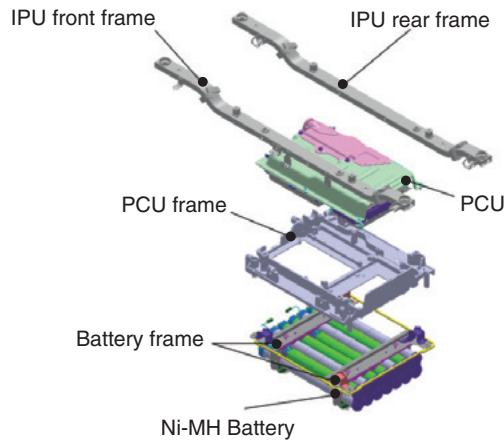


Fig. 6 Frame structure of 2011 model year FIT

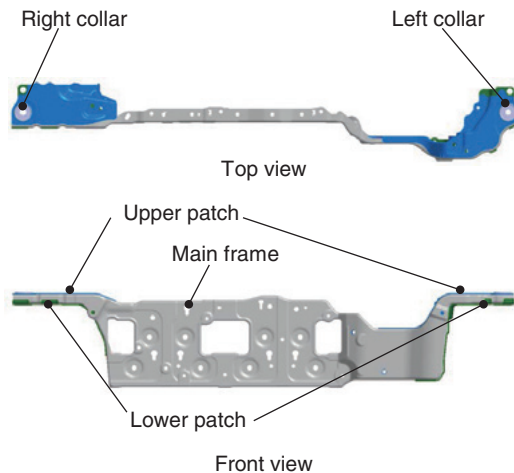


Fig. 7 IPU front frame of new FIT

Figure 8 shows the flow of cooling air. The cooling air taken up from the air-intake grill installed on the right side of the rear seat passes through the air-intake duct placed on the trunk side and flows into the IPU from the rear of the vehicle. Cooling air is evenly distributed to the four battery modules from the upper duct installed on top of the battery. After passing through the battery, the cooling air flows into the lower duct, cooling the inverter and DC/DC converter. Then, it passes through the cooling fan and is expelled into the spare tire well via the outlet duct.

3.7. 4WD Installation

Figure 9 shows the appearance of the IPU for 4WD. In 4WD, the rear differential is installed below the spare tire well, so the tire well is shallower than that for the 2WD. Therefore, by attaching the IPU stay during 4WD installation, the IPU is elevated 65 mm above the installation position of the 2WD. As far as the points in the IPU that were changed in the 4WD compared to the 2WD,

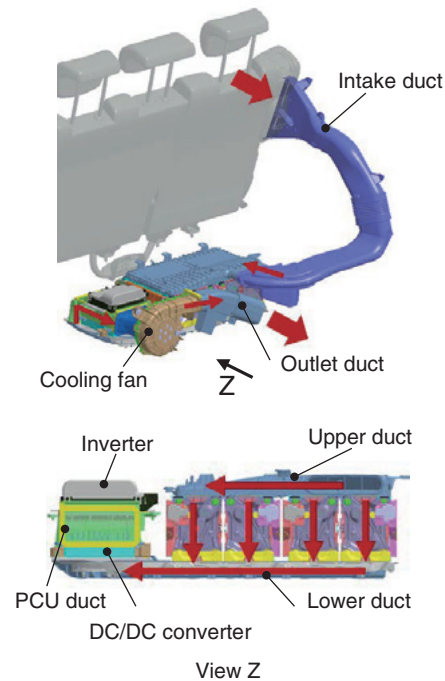


Fig. 8 Cooling air flow

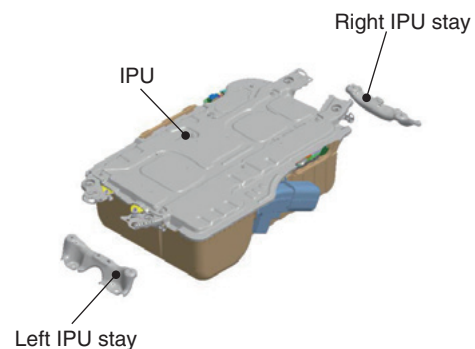


Fig. 9 Configuration of IPU for 4WD

only the position of the collar on both ends of the IPU frame was changed in order to attach the IPU stay, while the other parts are the same as in the 2WD.

3.8. IPU Vehicle Installation

Figure 10 shows the IPU mounted in the vehicle. Adopting an IPU package with a low total height prevents increasing the height of the cargo room in the 4WD. As a result, the height of the trunk is below the lower edge of the trunk rear gate opening, ensuring convenient use of the cargo room.

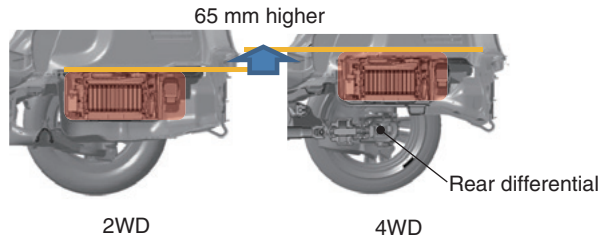


Fig. 10 Mounting of IPU

4. IPU Performance

4.1. Battery Performance

Table 1 shows a comparison of the battery specifications of the previous FIT and the new FIT, and Fig. 11 shows the results of an energy comparison. In the new FIT, the separation of the engine and the motor by the clutch allows EV travelling over a broad range as well as increased regeneration energy during deceleration. As a result, the new FIT requires more battery output and energy than the conventional FIT. While a Ni-MH battery was used in the previous FIT, a Li-ion battery is used in the new FIT, increasing rated voltage and system output to increase energy performance by approximately 1.5 times.

4.2. Cooling Performance

Figure 12 shows the results of a comparison of the previous and new FIT models in terms of battery cooling capacity in relation to battery-generated heat in the LA4 and US06 representative operation modes. Note that the maximum quantity of cooling air is established by considering NV during cooling FAN operation.

In the new FIT, the cell cooling capacity improvement due to the adoption of a square cell and the pressure loss reduction due to optimization of intake and outlet duct shape and cooling air flow path inside the IPU improved the cooling capacity performance by approximately 1.5 times over that of the previous FIT. As a result, it became possible to decrease the output limitation frequency by increasing the temperature of the battery in US06 mode, which is the high-heat-generating battery mode. Also, it is predicted that the cooling capacity will be capable of adequately supporting derivative models in which this IPU is planned to be installed.

Table 1 Specifications of battery

	2011 model year FIT	New FIT
Battery type	Ni-MH	Li-ion
Voltage	100 V	173 V
Output	10 kW	22 kW

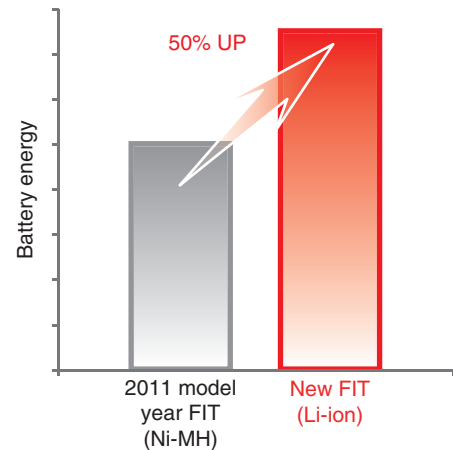


Fig. 11 Comparison of battery energy

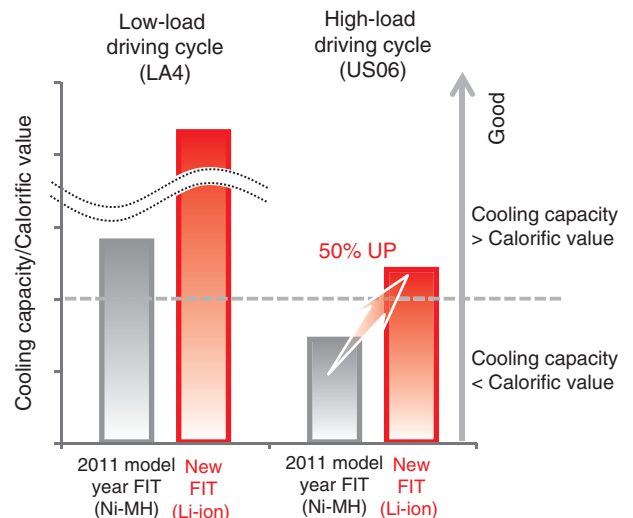


Fig. 12 Cooling capacity

5. Conclusion

An IPU for the 2014 model year FIT SPORT HYBRID i-DCD was developed. By utilizing an IPU package with a low total height, the IPU was made capable of being used in both 2WD and 4WD, while ensuring sufficient cargo room space even in 4WD.

In addition, using a lithium-ion battery improved energy performance by 1.5 times, and reducing the volume of the IPU by 23% allowed a two-fold increase in energy density.

The newly developed IPU will be installed not only in the new FIT, but also in the 2014 model year VEZEL.

Reference

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- (2) Ohnuma, Y., Takahashi, K., Matsuda, T.: Development of Li-ion Battery for SPORT HYBRID, Honda R&D Technical Review, Vol. 25, No. 2, p. 49-53

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