High Voltage Battery Wiring Module Corresponding to Changes in Number of Battery Cells

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We have developed "battery wiring module" for high voltage batteries of hybrid vehicle and started mass production of the modules as our first product group. The product is adopted by Honda Motor Co., Ltd. and mounted to the new model ACCORD/FIT HYBRID. The battery wiring module is a component having a function of connecting high voltage battery cells that are power source for a hybrid vehicle in series, and incorporates terminals and harness to detect the voltage between these cells. Parts equipped with the similar function are required in other eco-friendly vehicles, including electric vehicles and plug-in hybrid electric vehicles. The product further improves workability and versatility for customers in addition to the basic required performance, safety electric connection and insulation between ambient conductive materials. Followings are explanation of its advantages.

Keywords: battery wiring module, hybrid electric vehicle, electric vehicle, high-voltage battery, and cell combination

1. Introduction

In recent years, demand has been increasing for eco-friendly vehicles, such as Hybrid electric vehicles (HEVs) and Electric vehicle (EVs), against the backdrop of growing environmental awareness and soaring fuel prices.

Among eco-friendly vehicles, HEVs account for the largest percentage due to their balance between vehicle price and fuel economy. Hybrid electric vehicles are expected to account for 55% of all vehicles worldwide by 2030 (70% or more in Japan)(1).

Under these circumstances, Sumitomo Electric Industries, Ltd. has developed and mass-produced a number of HEV-related items, including high-voltage wiring harnesses and connectors. Recently, we developed a new product family of battery wiring modules, which have been adopted in the Accord/Fit Hybrid (models launched in 2013) manufactured by Honda Motor Co., Ltd. This paper reports on the features of the battery wiring module.

2. Battery Wiring Module Overview

Figure 1 shows an example placement of hybrid system-related components in a vehicle. Electricity is transmitted from the high-voltage battery (in the vehicle's rear in the figure) via a high-voltage wiring harness to the inverter. Electricity is then converted from DC to AC and sent to the motor. The motor converts this electricity to motive power to drive the wheels.

The battery wiring module is directly connected to the high-voltage battery, as shown in **Fig. 1**. In other words, it is placed roughly at the same location as the high-voltage battery.

Hybrid electric vehicles have a gasoline-fueled engine system for driving, although not shown in the figure(2), (3).

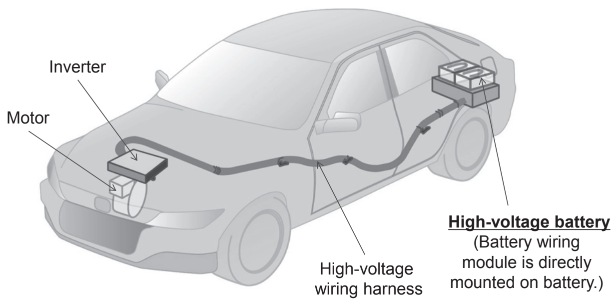

Fig. 1. Example placement of hybrid system-related components

Photo 1 shows the exterior of the battery wiring module. **Photo 2** shows an example battery wiring module mounted on a high-voltage battery.

The battery wiring module consists of plastic-molded parts that contain busbars*1 and wiring harnesses with terminals.

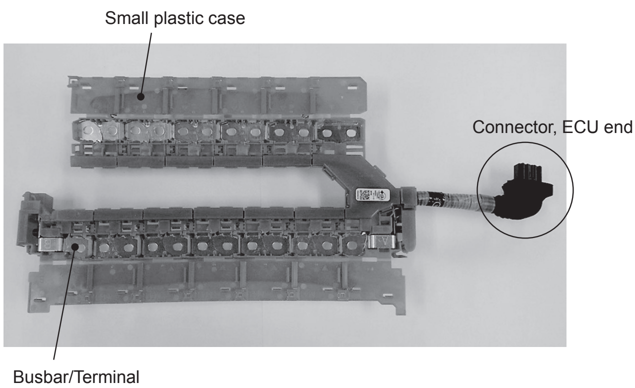

Photo 1. Battery wiring module (newly developed)

Photo 2. Example wiring module mounted on high-voltage battery (Battery is a mockup shown for reference purposes.)

Bolts projecting from battery electrodes are respectively inserted in the holes in the busbar. The busbar is placed in such a way that it links the positive and negative poles of neighboring battery cells. When nuts are fitted and tightened, each battery cell is electrically connected to supply electricity to the vehicle.

Terminals laid over the busbar are called the voltage detecting terminals, each of which sends a signal to the battery monitoring ECU as voltage information via the connected wiring harness.

Since the overall voltage of the battery reaches 100 to 300 V, it is necessary to provide good insulation between busbars and between the busbar and surrounding conductive parts. The plastic-molded part that surrounds the busbar is designed to provide the necessary insulation and to protect components in the battery wiring module.

3. Features of Newly Developed Module

Figure 2 shows a schematic diagram of a conventional battery wiring module for comparison purposes. A typical conventional battery wiring module consists of an integrally molded plastic case which encloses busbars having round bolt holes, voltage detection terminals, and a wiring harness. It is often the case that after being mounted on a battery, the battery wiring module is provided with a plastic molded cover from above to provide insulation and protection. Conventionally, the cover is separate from the battery wiring module.

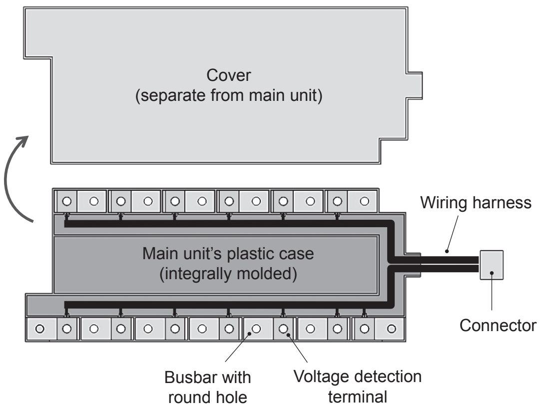

Fig. 2. Conventional battery wiring module

Figure 3 shows a schematic diagram of the newly developed module. There are three notable differences from the conventional module, as shown in the figure. Sections 3.1 to 3.3 below explain these differences in detail.

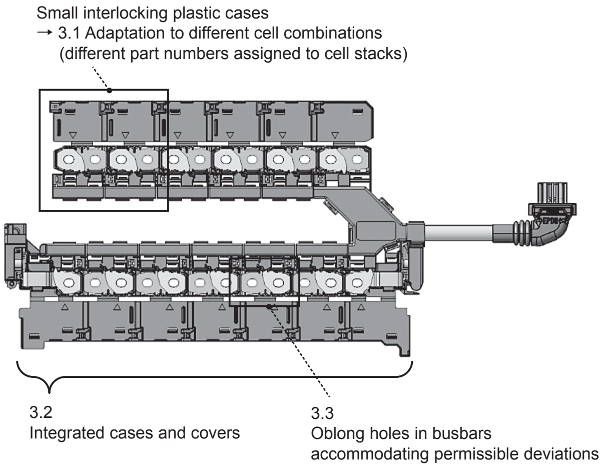

Fig. 3. Our newly developed module

3-1 Adaptation to different combinations of cells (cell stacks)

The most notable feature of the battery wiring module is its flexible adaptation to different combinations of cells (cell stacks, which are also known as "battery modules"*[2]). **Figure 4** shows how individual small plastic cases look (before being assembled into a battery wiring module). Every case has an interlocking mechanism. By connecting together a required number of cases, the battery wiring module becomes a finished product.

This structure is excellent in that battery wiring modules consiting of identical small plastic cases can be used even when a customer designs and manufactures several cell stacks differing in the number of cells (**Fig. 5**).

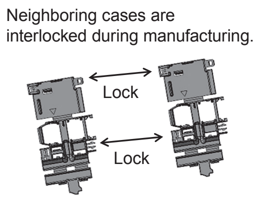

Fig. 4. Small plastic case interlocking structure

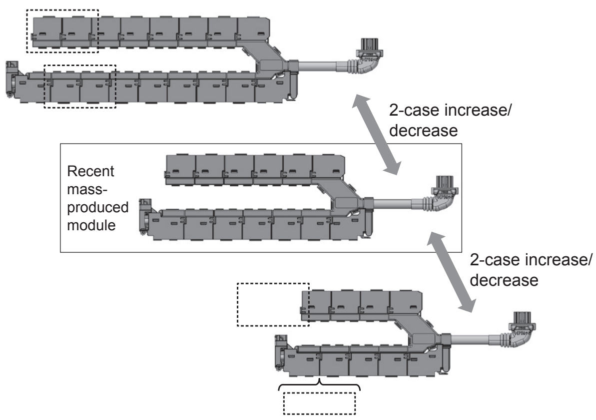

Fig. 5. Varying number of interlocked plastic cases (example of two units)

The number of cells installed on a vehicle depends on the battery output voltage requirement, since the voltage of each individual cell is invariable. Not every vehicle model manufactured by a single customer uses the same output voltage. The output voltage may be raised or reduced by varying the number of identically shaped cells in a stack.

In such cases, the integrally molded battery wiring module shown in **Fig. 2** would require the fabrication of another case suitable for the intended number of cells. In this regard, the newly developed module will require no other cases but the original small plastic cases, and only the number of interconnected cases will be adjusted. This eliminates the need for increased plastic case types and cuts the lead time and man-hours required for the fabrication of another mold. This is a substantial advantage for both the customer and the whole development staff.

3-2 Integrated cases and covers

The second feature of the battery wiring module is the integration between the cover and the plastic case of the main unit.

Conventionally, the cover has been separate from the case in most cases, as described above. However, the recently developed small plastic case incorporates the following two design elements devised to achieve integration with the main unit.

(1) Hinges provided on each case to connect the main unit and the cover

(2) Interlock mechanism provided on the busbar cover to connect the covers of neighboring cases

This design enables the covers to close at once, although the main unit is composed of non-integrally molded small plastic cases (**Fig. 6**). The integration between the covers and the main unit will ensure the fitting of the covers during the process following bolt tightening, and reduce man-hours required to prepare and set another cover.

Moreover, the wire housing cover (Cover 2 in **Fig. 6**), without the mechanism (2) above, is integrated with the main unit, yet is separate from the busbar section (Cover 1 in **Fig. 6**). This design allows the wire housing cover to close immediately after manufacturing the battery wiring module (the busbar section cannot be closed until bolts are tightened). Thus, the wire protection provided in an early stage remarkably improves the degree of assurance for the wires against externally caused damage during subsequent assembly and transportation processes.

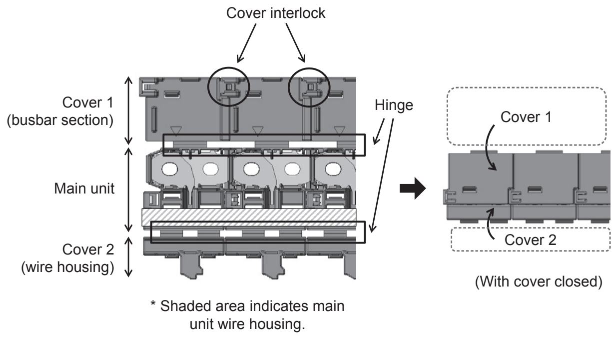

Fig. 6. Integrated cover structure

3-3 Oblong holes in busbars accommodating permissible deviations

The third feature is the oblong holes in the busbar (**Fig. 7**) bored to accommodate permissible manufacturing deviations of cell stacks.

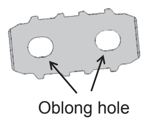

Fig. 7. Enlarged view of busbar

Individual battery cells have permissible manufacturing deviations (dimensional errors) in thickness. Moreover, a stack of cells involves the sum of manufacturing deviations, entailing a resultant deviation in the stacking direction from the ideal state (zero-error state, which is practically impossible) of the overall length and electrode bolt locations.

If the holes in the busbars of the battery wiring module are bored in the shape of a perfectly circular hole whose diameter is 0.2 to 0.3 mm larger than the bolt diameter to provide an ordinary clearance, the battery wiring module might fail to fit onto the cell stack. A solution to this problem can be enlarging the holes. However, this enlargement involves reducing metal portions in the direction of the short side of the busbar and entails degraded electrical connection and busbar strength (**Fig. 8**). Due to these reasons, the optimal shape of the holes is an oblong hole, while widening the hole only in the direction in which cells are stacked, and accommodating permissible deviations is necessary. The hole size is designed to meet the requirements for both accommodating deviations and making an electrical connection.

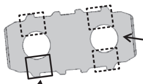

Fig. 8. Large perfectly circular holes in busbar

4. Conclusion

We have developed a battery wiring module that has the following three key features. Sumitomo Electric has recently begun to mass-produce the module.

(1) Adaptation to different cell combinations (different part numbers assigned to cell stacks)
(2) Integrated cases and covers
(3) Oblong holes in busbars accommodating permissible deviations

The Company has built a manufacturing framework exclusively for this module in consideration of the product's characteristics and use by customers, as well as the above-mentioned design features. Its exceptional level of quality is maintained by our meticulous attention to every detail of the manufacturing process, training, and logistics. The mass production of the battery wiring module is continuing presently.

Technical Terms

∗1 Busbar: A metal (conductive) rod or often a metal strip used to make an electrical connection. In the battery wiring module, each small plastic-molded part has one busbar.

∗2 Battery module: Battery cells are stacked and integrated into one unit. A battery module consists of battery cells, a battery wiring module, and other peripheral components. The number of cells is variable. When installing a high-voltage battery in an HEV or the like, it is often the case that this module is handled as a unit and multiple battery modules are mounted. To avoid confusion between the battery module and the battery wiring module, this paper uses the term "cell stack" for the battery module.

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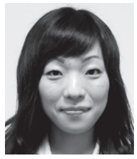

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