

Battery Wiring Module for Electric and Hybrid Electric Vehicles

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We have been producing wiring modules for high-voltage battery packs used in electrified vehicles. With the recent rapid expansion of the market, we have been promoting product development for electric vehicle (EV) applications. The number of battery cells used in an EV battery pack increases to extend the mileage, which in turn requires a reduction in the volume of battery wiring parts. For the widespread use of EVs, the safety of battery packs is another important factor. This report introduces our development on battery wiring modules for EVs.

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

1. Introduction

The recent worldwide tightening of fuel consumption/exhaust gas, zero emission vehicle (ZEV),*¹ and other controls/regulations has rapidly popularized battery-driven vehicles such as hybrid electric vehicles (HEVs), plug-in hybrid vehicles (PHVs), and electric vehicles (EVs). The annual unit sales of these electrified vehicles in 2030 are predicted to reach more than five times current sales.⁽¹⁾ In particular, the Chinese government is planning to require automobile manufacturers to sell environment-friendly vehicles at a certain ratio to their total unit sales, in addition to complying with carbon dioxide (CO₂) emission control regulations. In such a situation, all automobile manufacturers are promoting the development of EVs and putting them onto the market.

Sumitomo Electric Industries, Ltd. develops and mass-produces various kinds of high-voltage devices, including wiring harnesses and connectors mainly for HEV and PHV applications. In order to respond to the rapidly expanding EV market, we should also promote the development of EV-related technologies.⁽²⁾ Compared to the devices used in conventional HEVs and PHVs, those for EV applications are required to withstand higher current/output power. This implies that the major problems we will face in the development of new EV devices are how to reduce their size and how to enhance their cooling performance.

This paper provides an outline of our new battery wiring module, a high-voltage component installed in the battery body of an EV battery pack, together with our approach toward spreading the use of EVs.

2. Outline of Battery Wiring Module

Figure 1 shows an example of the typical locations of high-voltage system components in an EV. A high-voltage battery pack storing the energy necessary to run the EV is located on the bottom of the vehicle. DC power from the battery is transmitted to the inverter through the high-voltage wiring harness. The inverter converts the DC power to AC power and transmits it to the motor. The

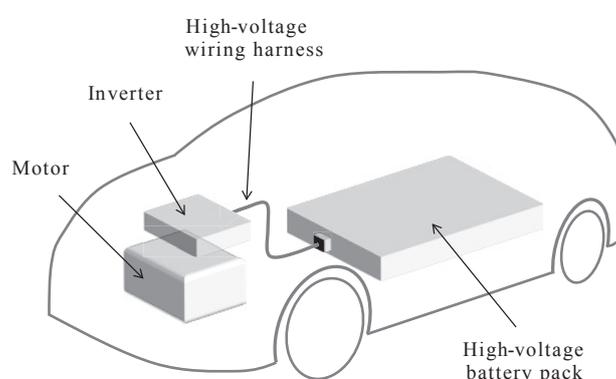


Fig. 1. Location of high-voltage system components in EV (example)

motor converts the power to wheel driving force.

An example of Sumitomo Electric's battery wiring module for EV applications is shown in Photo 1. This wiring module is a wiring component used to electrically connect the cell electrodes of the high-voltage battery in series or in parallel. Each wiring module consists of bus bars and wiring harnesses with terminals, both of which are encased in a plastic molding. To electrically connect each electrode to a bus bar, the bolt protruding from the battery cell is passed through an opening in the bus bar and then

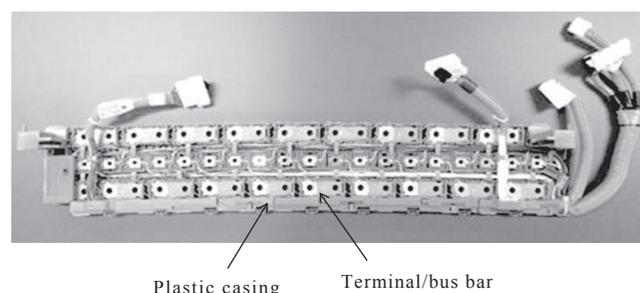


Photo 1. An Example of a battery wiring module

the bolt is tightened with a nut on the upper surface of the bus bar.

Locating the bus bars alternately after displacement from the cell electrode array has made it possible to connect neighboring battery electrodes in series and in parallel and thereby supply high voltage battery power to the vehicle.

The terminals placed over the bus bars are called voltage detection terminals. Each terminal is connected to a battery monitoring unit through a wiring harness to continually send battery cell voltage information to the monitoring unit.

Since the total battery voltage reaches several hundreds of volts, sufficient insulation is required between neighboring bus bars and between each bus bar and the peripheral components. The plastic molding encasing the bus bars meets the above requirement for insulation and also protects the components used in the battery wiring module.

Since a high-voltage battery consisting of many cells causes misalignment between the cell electrodes, the wiring module is required to cope with such misalignment. As shown in Photo 2, our wiring module is constructed so that the plastic casings are connected through the bus bars. This construction allows the battery wiring module to elongate or contract in response to a misalignment between the electrodes.

Compared to a construction that uses a plastic hinge spring or other component to allow the casing to elongate and contract, the construction of our wiring module is effective in enhancing the rigidity of the module. This construction is also flexible in increasing or reducing the number of plastic casings of a uniform shape in response to a change in the number of battery cells.

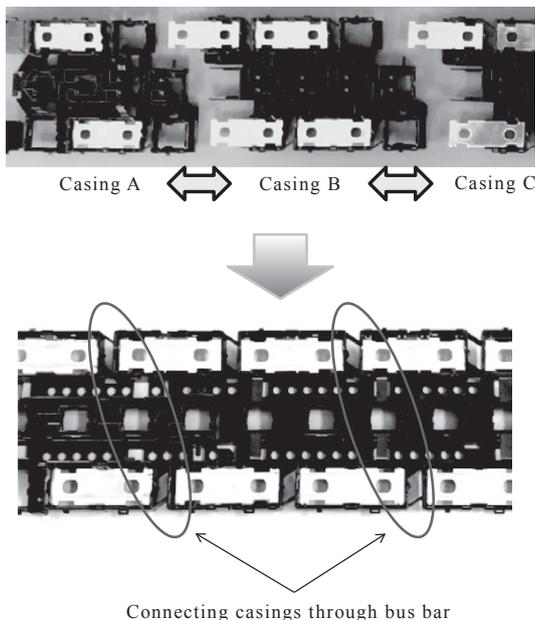


Photo 2. Connection of casings in battery wiring module

3. Efforts toward the Development of EV-related Technologies

Compared to conventional battery packs for HEV and PHV applications, those for EV applications are required to be high in capacity and output power. To meet this requirement, the numbers of battery cells and battery modules in each battery pack, as well as the sizes of wiring parts and connectors, are increasing.

On the other hand, the battery packs to be used in EVs are required to be as compact as possible to provide the same wide in-vehicle space as that in conventional vehicles. EV battery packs are also required to ensure a high level of safety as their capacity increases.

To address these challenges, we have been developing a battery wiring module with particular focus on the following points:

3-1 Use of FPC for voltage detection circuit

A battery pack is equipped with voltage detection wires to transmit the cell voltages to the monitoring unit. To increase the number of cells that can be housed in a single battery pack, it is necessary to reduce the space for locating the voltage detection wires. Since a flexible printed circuit (FPC) has an advantage over electric wires in terms of increased wiring density, reduced thickness, and being able to be located in a narrow space and bent along a curve, we have been promoting the development of a battery wiring module comprising an FPC. An example of a battery wiring module comprising an FPC is shown in Photo 3.

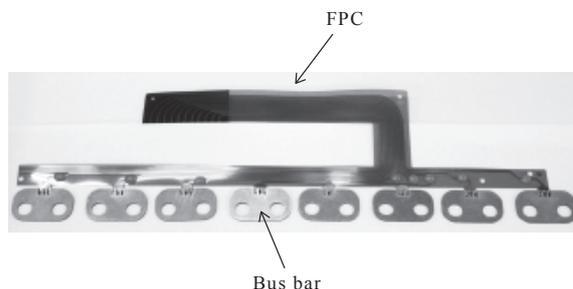


Photo 3. Battery wiring module comprising an FPC

Compared to a battery wiring module comprising electric wires, the module shown in Photo 3 is expected to reduce the volume and weight of the wiring material by about 50%. The high-voltage circuits, which are packed densely in a battery pack, are liable to cause short-circuiting in two or more circuits, tracking, and other failures.

In designing the FPCs, we pay particular attention to high-voltage safety in consideration of the specifications of the battery pack. As a result, our battery wiring modules ensure a high level of reliability in durability and other performance benchmarks.

3-2 Mounting fuse on voltage detection circuit

With increases in the capacity of battery packs and the number of cells used in each pack, the number of voltage detection circuits equipped with a fuse is increasing as a measure to protect the circuits from accidental short-circu-

iting. We have also been developing an FPC-based battery wiring module that incorporates a cell fuse in the wiring to ensure the safety of the battery pack even if an accidental short-circuit occurs.

An example of mounting the cell fuse function is shown in Photo 4.

The cell fuse to be used in the circuit should be designed or selected after taking into account the current matching between the FPC-based battery wiring module and peripheral circuits. We are designing the fuses and FPCs to be optimal for the specifications of the battery and peripheral components.

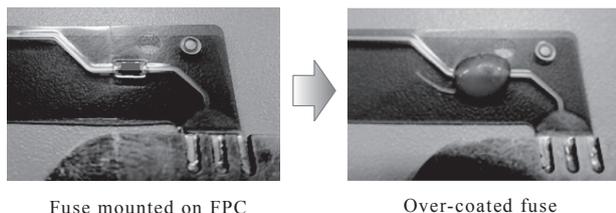


Photo 4. An Example of mounting cell fuse function

The fuse mounting portion should be designed so that a short-circuit will not reoccur after the fuse blows. For this purpose, we are providing an adequate insulation distance between the fuse circuit and peripheral circuits or protect the mounted parts from exposure to water, depending on the specifications of the battery pack.

3-3 Mounting thermistor on FPC

It is necessary for a battery pack to measure the cell temperature to control/cut the output power of the battery depending on the cell temperature. A thermistor is used to measure the cell temperature. Since our FPC-based battery wiring module allows installation of a thermistor element on the FPC circuit, it is possible to integrate the thermistor circuit into the FPC.

An example of mounting a thermistor on an FPC is shown in Fig. 2.

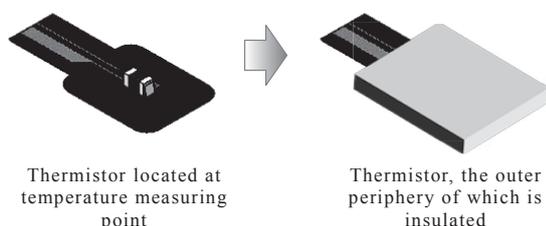


Fig. 2. An Example of mounting thermistor on FPC

Since the cell temperature must be measured with a high degree of accuracy, the thermistor is located in contact with or close to the outer periphery of the cell. This

requires insulation of the thermistor from the cell. For the thermistor shown in Fig. 2, its peripheries are covered with an insulating material.

3-4 Connection between bus bar and FPC

Depending on the specifications of the battery pack, various methods can be used to connect the FPC to the bus bar that electrically connects the cell electrodes. A solder connection, which is an example of the bus bar/FPC connection method, is shown in Photo 5.



Photo 5. Solder connection between bus bar and FPC

A solder connection makes it possible to collectively connect between the bus bars and FPCs in the FPC surface mounting process, thereby shortening the FPC-based wiring module fabrication process. Concerning the connection reliability of soldered bus bar/FPC joints, we subjected the samples to vibration resistance, thermal shock, and other long-term durability tests and confirmed that the joints have high connection reliability in battery pack environments.

4. Conclusion

This paper has reported the technical development of a battery wiring module for EV applications with a focus on the following four points:

- ① Use of FPC for voltage detection unit
- ② Mounting of fuse on voltage detection circuit
- ③ Mounting thermistor on FPC
- ④ Connection between bus bar and FPC

We have been developing and mass-producing various kinds of high-voltage products, including high-voltage wiring harnesses and high-voltage connectors that are used in battery packs. Using the technical expertise we have acquired, we will promote the development of high-quality, safe wiring modules for EV applications.

Technical Term

- *1 ZEV: Zero emission vehicles (ZEVs) include electric vehicles or fuel cell vehicles.

References

- (1) Nagoya Marketing Division, Fuji Keizai Management Co., Ltd., "Thorough analysis investigation into HEV and EV-related market 2017," Fuji Keizai Management Co., Ltd., p. 3-7 (2017)
- (2) Y. Hirano et al., "High Voltage Battery Wiring Module Corresponding to Changes in Number of Battery Cells," SEI Technical Review, No.80, April 2015, P46 (2015)

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