» New Products

High Voltage Junction Boxes for Isuzu ELF EV

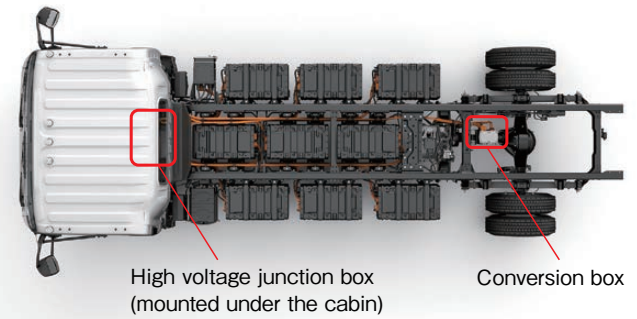
1. INTRODUCTION

The global warming caused by increasing emissions of greenhouse gases such as CO_2 has given rise to various abnormal weather to be a major environmental problem all over the world. The Japanese government declared to aim at the “Carbon Neutrality” by 2050 to solve these problems and has settled on “Green Growth Strategy Through Achieving Carbon Neutrality in 2050”. Targets such that 100% of new car sales should be Electric Vehicles (EV) by the middle of the 2030s were presented to the automotive industry and the spread of Electric Vehicles such as Battery Electric Vehicles (BEV) and Hydrogen Fuel-Cell Vehicles (HFCEV) has been accelerated.

Considering the BEV, a high voltage junction box is required to distribute the power from batteries to various high voltage units and equipment. The high voltage junction box requires such technologies as the heat radiation design against an increased electric power flow, the insulation design against a higher voltage and the metal housing design to protect from an electric shock at a collision, none of which are required for a low voltage junction box used in a gasoline fueled vehicle.

Further, as our developed high voltage junction box is a product mounted on a frame under a cabin of a commercial vehicle (Figure 1), higher corrosion resistance and superior vibration resistance are required in comparison to that on a passenger car.

We have developed and successfully launched our high voltage junction box mounted on the “ELF EV”, which was the first mass-produced battery truck of Isuzu Motors Limited, by merging and advancing our design technology and production technology which have been developed on our high voltage junction boxes already in production for passenger vehicles and our present low voltage junction boxes and wire harnesses.



(This photo was offered by Isuzu Motors Limited.)

Figure 1 The position where the boxes are mounted[1].

2. AN OUTLINE AND STRUCTURE OF THE PRODUCT

An EV version was newly introduced in the “Isuzu ELF” series, which have been just brought out to be fully new model series for the first time since the last 17 years. We developed the conversion box (Figure 2) for “ELF EV” which was sold for domestic use and have started to deliver the mass-produced product since July 2023. Further, we have developed the high voltage junction box (Figure 3) for the same vehicle (called in U.S. as N series EV) which will be sold in North America and planned to start the mass-production in the first half of 2024.

Figure 2 Conversion box.

Figure 3 High voltage junction box (9-pack specification).

Our high voltage junction box developed this time has such functions as to distribute power from battery packs to inverters, motors, heaters, A/C compressors and other equipment appropriately when running and on the other hand, to distribute power from the power charger to the

battery packs appropriately when charging. High current circuits are constructed with busbars punched out from a copper strip by presswork, which have a larger surface area and a larger cross-section in comparison with wires, and those circuits for low to medium current are constructed with either busbars or wires in combination to realize the optimum circuit arrangement. The busbar is secured in plastic parts to secure the required insulation distance and satisfy the required withstand voltage performance.

The high voltage junction box includes high voltage fuses to protect onboard equipment from an overcurrent, current sensors to detect battery state and the Master Battery Management System (MBMS). Further, an interlock circuit is equipped for protection from an electric shock from a high voltage. Signal circuits and interlock circuits connected to the MBMS are constructed with low voltage wire harnesses in which wire routes, positioning methods and circuit protection are appropriately designed using our present wire harness design technology.

According to the number of onboard battery packs (3, 5, 7 up to 9 packs according to the driving mileage of a vehicle), four models of the high voltage junction box were deployed in our lineup to respond with flexibility to various needs from our customer.

3. FEATURES OF THE HIGH VOLTAGE JUNCTION BOX

Our high voltage junction box has the three features shown below including its production method.

1) Established the space-saving design in consideration with the enlarged amount of heat generated by higher current

Our high voltage junction box, which could be connected with 3 packs of battery at maximum for domestic use and 9 packs at maximum for the North American use has been capable for the increased current since the “ELF EV” was launched, which was then sold for domestic use. Considering the increased heat generation caused by the increased current, a high heat-resistant performance is secured by controlling the temperature of mounted components to be no higher than their heat withstand temperature through optimizing the structure of busbars (cross-section and circuit route) and the layout of other inner components based on the visualized heat generation state in our heat simulation (Figure 4).

We have realized a high space factor in our high voltage junction box through placing plastic components between a low heat-resistant MBMS against busbars and relays from which heat was generated to control the heat transmission from the heat-generating source (Figure 5).

Furthermore, wires were also applied to the inner circuit in combination with the busbars for the optimum circuit arrangement based on our technology developed in our wire harness development. Adopting those technologies

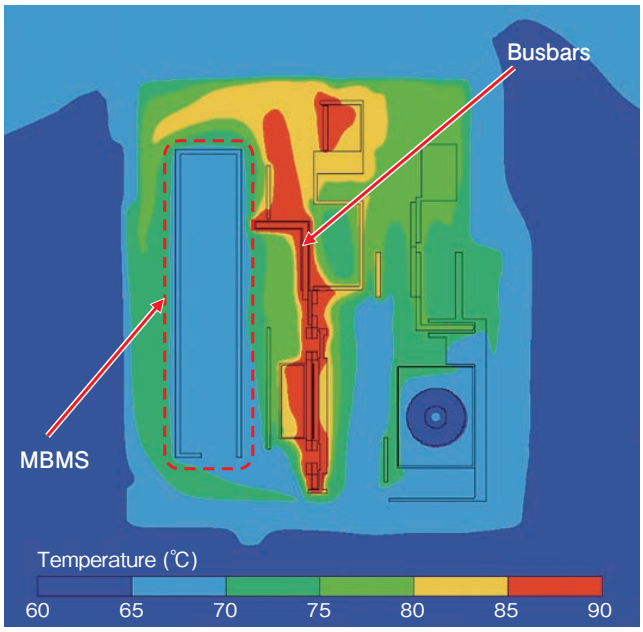


Figure 4 Results of thermal analysis.

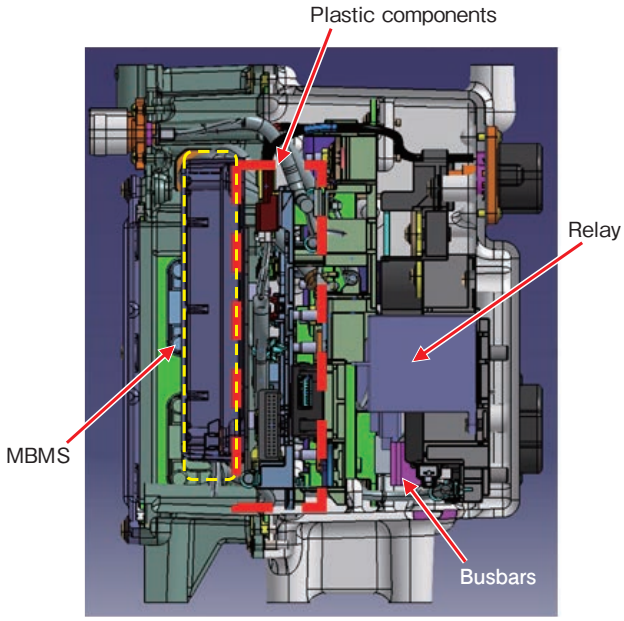


Figure 5 Layout of internal components.

mentioned above, we have realized a product that enables to connect to up to a maximum of 9 battery packs even though it was maintaining a product size same as that for the vehicle of domestic use (3 packs at maximum).

The space factor which is the ratio of the volume of components installed in the box against the volume of internal space of the metal housing has been improved by 5 times in comparison with that of our present product. (Figure 6)

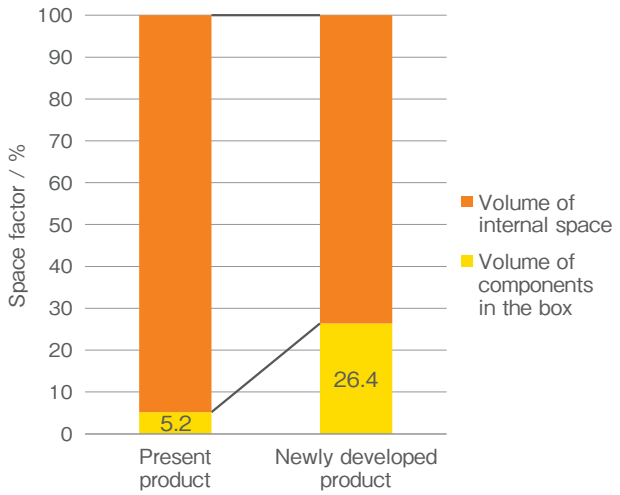


Figure 6 Comparison of the space factor with our present product.

2) The high voltage junction boxes with different number of battery packs were deployed in our product lineup

We have set up 4 models of the high voltage junction boxes in our lineup to satisfy various set-up of battery packs according to the cruising range required by a user. We have not only satisfied a flexibility to our customer's requirements mentioned above but also reduced cost by applying common components and the metal housings casted in a common die but partly machined for minor variations (Figure 7).

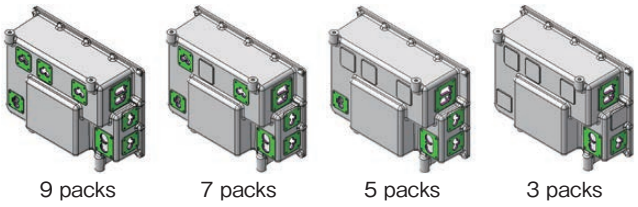


Figure 7 Variation of the metal housing.

3) Review our production process to reduce CO_2 significantly

We have adopted such a production method of aluminum die-cast to produce the metal housing of the product as we directly bring melting aluminum material in from a material manufacturer (a smelter) and cast the product instead of applying usual aluminum ingots (Figure 8). With this process which has no melting process of ingot, we are saving CO_2 by approximately 40% in comparison with the emission generated in the case of re-melting the ingot, and hence reduce the emission of CO_2 during the production process.

Figure 8 Transportation of molten metal[2].

4. CONCLUSION

We have realized such a high voltage junction box capable handling 9 pack circuit specifications even in the equivalent space of the one handling packs for vehicles for domestic use and the space factor of components installed in the housing has been improved by 5 times in comparison with that of our present product. It is forecasted that from now on, still higher voltage and larger current will be increasingly required to be handled in the junction box and that the volume of internal components will increase further. We will work on the development of a wide range of automotive products[3] using the technology built up in this development to contribute to accelerate the spread of BEV and accomplish the target of the Carbon Neutrality in 2050.

REFERENCES

1) Photo of the position where the boxes are mounted (ISUZU N series NRR EV truck)
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https://www.isuzucv.com/en/nseries/nseries_ev
2) Photo of transportation of molten metal
Daiki Aluminum Industry Co., Ltd. HP > CSR > Commitment to the environment > CO2 reduction (Referred on Jan. 24, 2024)
https://daikialuminium.com/csr/environment/co2/
3) Furukawa AS HP > Products (Referred on Feb. 14, 2024)
https://www.furukawaas.co.jp/english/products/

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