Study of Integrated System on Power Electronics Unit for Electric Vehicle

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Abstract. Electric Vehicle (EV) is evolving to be practical enough, the effective integration of power electronics unit that applied in electric vehicle will greatly improve the performance of electric vehicle, and accelerate the development of electric vehicle. In this paper, studied the integration of power electronics unit system for electric vehicle. Based on the study of power electronics unit, different schemes of electric vehicle power electronics unit integration system is analyzed, proposed a scheme of integrated power electronics unit used in electric truck, and the trend of power electronics unit integration for the electric vehicles is analyzed.

1. Introduction

With the energy and environmental crisis intensifies, electric vehicle is considered to be the main product of future transportation and energy-saving development due to the transfer of pollution, centralized treatment and the high efficiency of energy use [1].At present, each country is gradually committed to the study of electric vehicle. It has already invested and will continue to invest a lot of energy and financial resources, electric vehicle will replace traditional vehicle in the future [2]. Now, multiple power electronic units are fully integrated into one system, which greatly improves the performance of automobiles and greatly promotes the development of electric vehicle.

This paper studied the power electronics unit integration system that applied on electric vehicle at home and abroad on the basis of Motor Controller Unit (MCU), DC/DC Converter, On-board Charger (OBC), Brake Pump Motor Controller, Steering oil Pump Motor Controller, high Voltage DC Converter, Power Distribution unit (PDU) and other power electronics unit. Then, a new integrated system on power electronics unit for electric truck is proposed. After the practical application, the integrated system is safe and reliable with superior performance.

2. Integrated Power Electronics

In recent years, Electric Vehicle (EV) is evolving to be practical enough.On the basis, improving the advantages of power electrics unit performance will accelerate the development of electric vehicle.Integrate power electronics unit such as Motor Controller Unit (MCU), DC/DC converter, On-board Charger (OBC), air pump motor controller, oil pump motor controller, high voltage DC converter, power distribution unit (PDU) , called the integrated system on power electronics Unit [3].it is as shown in Figure 1.

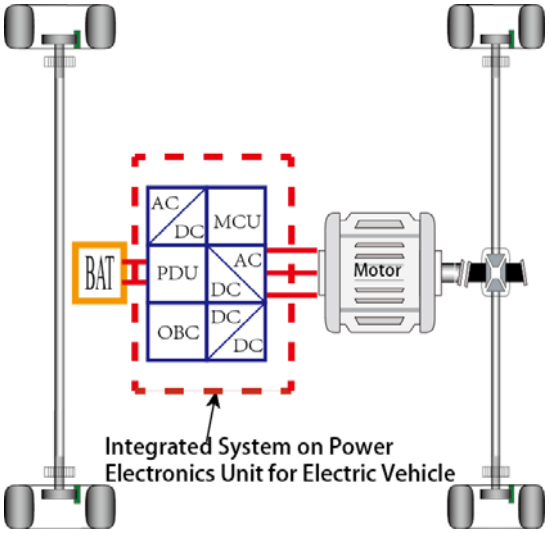

Fig.1 Integrated System on Power Electronics Unit

3. Study of individual Power Electronics Unit

3.1. Motor Controller Unit (MCU)

The biggest difference between electric vehicle and traditional vehicle is reflected in the composition of the power driving system. Electric vehicle power can be completely provided by the battery system, and the driving motor drives the vehicle to run. The Motor Controller Unit (MCU) is the core power electronic unit of the electric vehicle [4, 5]. The motor is driven to drive the vehicle by receiving the vehicle control command of the MCU. At the same time, the Motor Controller Unit (MCU) has motor system fault diagnosis protection and storage functions.

The major circuit of MCU includes the core controlling circuit and the driving circuit. The core controlling circuit includes the signal acquisition circuit, resolve analysis circuit, logic protection circuit, CAN communication circuit and so on. The driving circuit achieve the PWM to drive the motor by the IGBT.

3.2. DC/DC Converter

DC/DC converter is a power electronic device that convert the DC input voltage (or current) to a certain amplitude DC output voltage (or current) .DC power is supplied to the all vehicle by the power battery system. Because of the voltage levels of different power electronic devices on the electric vehicle are different, and the corresponding converter is required to obtain appropriate Tdc power. Therefore, the use of DC / DC converters for the corresponding demand transformation is a key technology.

3.3. Accessory Motor Controller

The accessory motor controller usually consists of a brake air pump motor controller and a steering oil pump motor controller.

Air pump motors are mainly used in braking systems, and the quality of air pump motors and their controllers is very important for vehicle safety and development. In electric vehicle, the oil pump motor is also a key motor, and the oil pump motor controller is subordinate to the power steering system. In the electric vehicle, the power steering system is powered by a power battery, and the motor is driven by a certain algorithm to realize power steering.

3.4. On-board Charger (OBC)

The On-board Charger (OBC) is installed in the electric vehicle.It is connected to the external AC charging station, and then converted to DC by the power electronic device to charge the battery [9-11]. At present, although the on-board charger has been used, it needs to be more perfect. With the continuous research of the smart grid, the development of two-way charger will be a trend in the future. Therefore, the two-way power converter plays an extremely important role in the on-board charger and even new energy. The development of two-way charging will become its major development trend.

3.5. Power distribution unit and high voltage principle

The power distribution unit is a high-voltage power supply that distributes the battery power to the high-voltage components of the vehicle through the central control box, such as motor controller unit, accessory motor controller, ahigh-voltage DC/DC so on. The power distribution unit is an extremely important part of the electric vehicle power electronics integrated system. The high voltage schematic diagram of a power electronics unit is as shown in Figure 2.

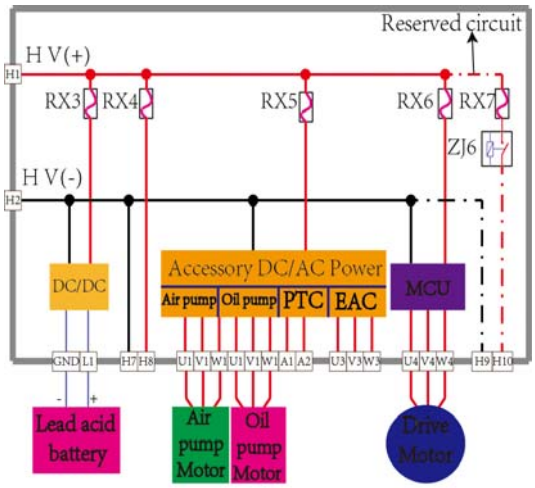

Fig.2 The diagram of the Power electronic high and voltage principle

We can see from Figure 2, In addition to integrating various types of power electronics unit, different high voltage fuses are also placed on their respective high voltage busbars to protect each high voltage bus. That's because in the power electronics unit, the cross-sectional area of each high-voltage bus is not the same according to the peak current demand.

4. Integrated System Solution for Power Electronics Unit

4.1. Integration Scheme for Pure Electric Unit

A widely used scheme can be called a integrated system for pure electric unit, which integrates the power electronics unit on the vehicle into a control box.

At present, many electric vehicles use this pure electric integration scheme. In the control box of this integration scheme for pure electric unit, which reduces the types of components and greatly simplifies the vehicle layout. In addition, this integration method reduces the number of high-voltage connecting harnesses, which provides a lot of convenience for the vehicle layout, and the integration also facilitates electrical control.

The Power electronic integrated system for pure electric unit applied in Toyota is as shown in Figure 3.

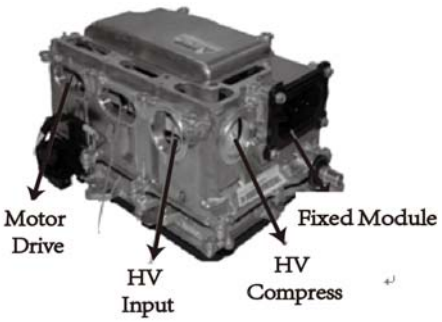

Fig.3 Power electronic integrated system for Pure electric unit

A major problem with pure electric integration is the electromagnetic compatibility (EMC) problem [3]. The integrated system for Pure electric unit integrates the power electronic unit on the vehicle into a control box, there are many power terminals, various signal lines and ccontrol lines in this limited space, so the control box is an electromagnetic distributed concentration and density.

4.2. Integration scheme for electromechanical hybrid.

The electromechanical hybrid integrated system integrates power electronics units and mechanical components. The advantage of this integrated system are mainly to reduce the number of high-voltage lines inside the system, connectors, water-cooled circulation pump and other components, the power assembly system is reduced in volume and weight, and the installation is convenient. The difficulty of this kind of integration is mainly that the motor will generate electromagnetic excitation force and will resonate with the components connected to it. This is a huge hidden danger for electric vehicle, especially in the complex area of power electronics integration. If it is damaged, it will have extremely serious consequences. In addition, the design of the electromagnetic circuit of the motor using this integrated system is difficult, reducing vibration and noise, and designing a simple and effective electromagnetic circuit is the biggest technical problem of integration. According to the current research situation, this kind of integration method is less applied. Tesla and many enterprises adopt the method of pure electric unit integration. The electromechanical hybrid integrated power electronics unit integrated system developed by Nissan is as shown in Figure 4.

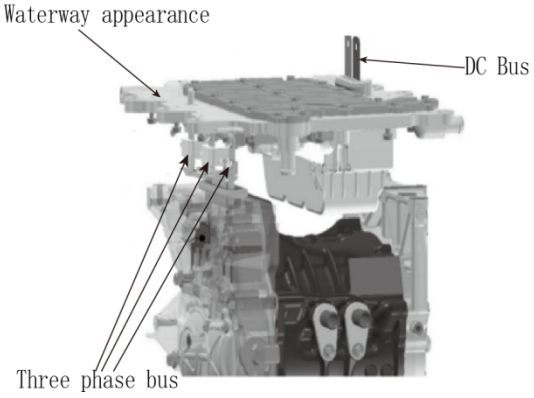

Fig.4 Integration solution for electromechanical hybrid

5. Integrated system for Water-cooled integrated power electronic unit

At present, the integration system for power electronic unit is generally divided into two categories as described above for EV. Depending on the required functions, the integrated power single subsystems

will have large differences, and some basis Different components use the same type of components to fully integrate different units.

This papaer proposed a water-cooled integrated power electronic unit integrated system for electric truck vehicle. The integrated system integrates a motor controller unit (MCU), a DC/DC converter, an on-board charger (OBC), a steering motor controller, a power distribution unit (PDU), a gas pump motor controller, and so on.

The main feature of this integrated system is the shared cooling water channel, which makes the structure of the whole system simpler. In addition, the system realizes the integration of multiple power electronic units, which greatly improves the system integration.

The external 3D and internal 3D views of a water-cooled integrated power electronic integrated system applied to an electric truck vehicle are as shown in Figure 5and Figure 6, respectively.

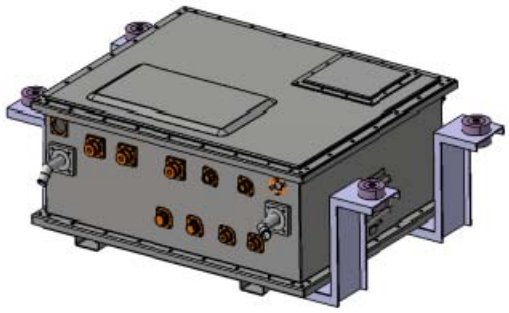

Fig.5 Integrated system for Water-cooled integrated power electronic unit external 3D

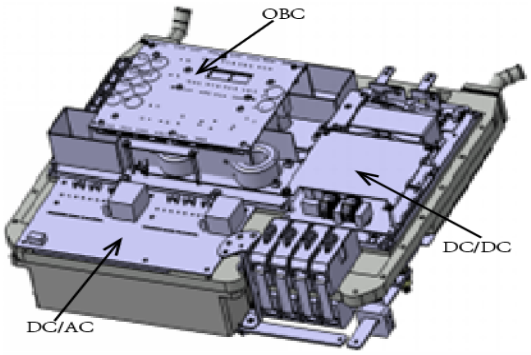

Fig.6 Integrated system for Water-cooled integrated power electronic unit internal 3D

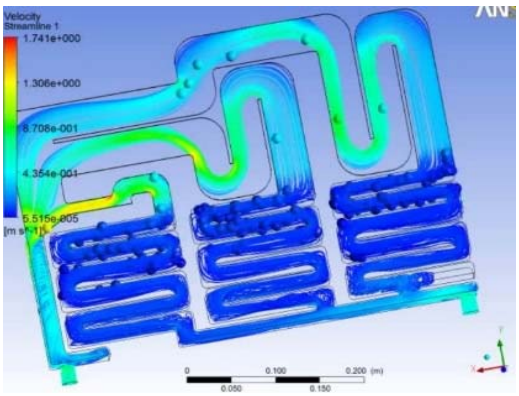

Fig.7 heat dissipation analysis of the water-cooled

Figure 7 shows the heat dissipation analysis of the water-cooled integrated system. From the heat dissipation analysis in the figure, the temperature at the inlet of the water channel is low and the temperature at the outlet is high. After analysis, the heat dissipation capacity of the water channel meets the needs of the integrated system of the entire power electronic unit.

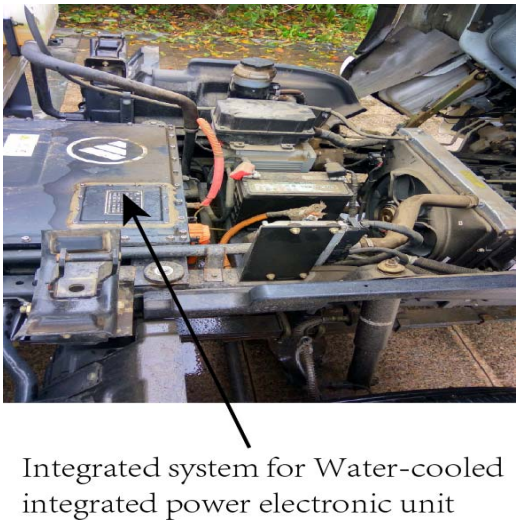

Fig 8. Integrated system for Water-cooled integrated power electronic unit

Figure 8 shows the water-cooled integrated power electronic unit integrated system for electric truck. The practical results show that the integrated system is superior in performance and completely reliable.

6. Development Direction of Power Electronics Unit

The latest integrated system for power electronics in electric vehicle is system-level integration, which is an integrated approach commonly used in engineering, meaning the integration of existing entities into a new system. System integration is the integration of function, and the technical difficulty is relatively low, which is relatively easy to implement [13-14]. However, the integration degree of the system integration is low, so the volume and weight cannot be significantly reduced compared with the independent components, and its composition is still dominated by discrete components, which cannot obviously reflect the advantages of integration. At present, system integration is mostly used in systems with large power, complex structure and functions.

Until now, the integration of power electronics units is a system-level integration for the electric vehicle. It should be integrated to achieve maximum advantages and gradually form a complete intelligent advantage platform according to its own characteristics.

7. Conclusion

In this paper, the power electronic unit integrated system for electric vehicle is analyzed, and the scheme of power electronic unit integrated system is analyzed. The trend of integrated system development is analyzed. In the future, the development of system integration technology is an important direction of power electronic unit integration for EV. Under this trend, pure electric unit integration will have a better prospect.

Acknowledgments

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