Guest Editorial
Editorial Special Issue on Power Electronics for Electric Vehicles

With increasing effort to reduce the pollution and to replace the fossil fuel, eco-friendly vehicles are getting much interested and regarded as the ultimate solution for the future society. Eco-friendly vehicles, which are called in this special issue as electric vehicles, cover hybrid electric vehicles, plug-in hybrid electric vehicles, fuel cell electric vehicles, and pure electric vehicles.

Power electronics in electric vehicles play an important role with respect of power conversion units, traction motors, battery charge and maintenance, and etc.

1) Power Conversion Units: Basically pwm dc-ac inverter to drive electric traction motors is the major unit for power conversion. Usually the traditional six switch inverter topology is adopted and the several modified topologies are considered. In electric vehicles, compared with the other car applications, such as ECU (engine control unit) and TCU (transmission control unit), the inverter is called as MCU (motor control unit). The input energy source of MCU for electric vehicles is generally battery, so that compared with other industry applications, the rectifier is not needed and dc source is directly input to the inverter. The MCU is implemented in the vehicles, so that it has several restrictions, such as environmental operational conditions, like temperature, vibration and life time, size, and reliability. In design of MCU, input capacitor, micro-controller, heat sink, current sensor, and speed feedback are the main considerable issues. The bidirectional dc-dc converter is used to boost the battery voltage to a certain dc-link voltage to feed the inverter and to feedback the regenerative energy from the motor to the battery. Recent researches report about the unified topology, which combines dc-ac inverter and bi-directional dc-dc converter. In this attempt, bi-directional dc-dc converter is eliminated and the battery is connected between neutral point of the motors and negative bus line of the inverter. The pwm dc-ac inverter is operated by the mixed pwm signals to drive the motor and to boost the battery voltage. Many technical issues, such as switch utilization ratio and overall motor efficiency, still remain to be studied. The low voltage dc-dc converter (LDC) is also the main units to charge 12V and 24V battery from high voltage battery and it provides the operation voltage with the entire electrical units in the vehicles, such as entertainment systems and head lamp. Therefore, the malfunction of LDC causes the severe accident, so that the robust protection system should be provided. In power conversion, high efficiency, high power density, and high reliability techniques are strongly required. Along with these techniques, in these days, new materials based on the power semiconductor switches initiate a new paradigm of power conversion units for electric vehicles.

2) Traction Motors: Traction motors play important role in electric vehicles to generate the driving power, which is part of or entire of engine. Therefore, the technology for traction motors is to convert the electrical energy into the mechanical energy with high efficiency. Toyota extends the operational range of traction motors for compact and high power density, results in 20% increase of motor power. The traction motor should be implemented in engine room and between engine and transmission, so that permanent magnet synchronous motors are mainly used. Induction motors and switched reluctance motors are also major candidates according to the required torque, driving pattern, driving performance, and manufacturing cost. In case of induction motors, even though they have low efficiency in low speed range, compared with the permanent magnet surface motors, with the superior characteristics, such as high reliability, low cost, and robustness, they are widely used in Europe and North America. Moreover, induction motors do not use permanent magnet, so that it has freedom of

back-emf problem and it is suitable for a vehicle with high speed and large constant speed range. In case of switched reluctance motors, according to the lack of magnet material and demagnetization characteristics of magnet, they are continually studied and the inherent problems, such as large torque ripple, noise, and power per volume, are tried to be solved. In special, in these days, interior permanent magnet motors (IPM) are widely applied for electric vehicles and various shapes of interior magnet are designed to enhance the overall performance. The design methodology to increase the power density of the motor with a required power, speed, and torque is the key technology. Beside of the traditional approach, in-wheel typed electric motors become a new issue. With this technology, the compactness of entire electric vehicles can be achieved.

3) Battery Charger: In plug-in hybrid electric vehicles and pure electric vehicles, a battery charger is the major unit. The battery charger is categorized into on-board charger and off-board charger. The power capacity of on-board charger is mainly 3.3kW and 6.6kW and the counterpart of off-board charger is 30kW-100kW. For on-board charger, the power density is the major issue, along with efficiency, such as below 5.8L, 5.8kg, and 93% efficiency. Because the battery charger is connected to the utility grid to get the proper power, the safety and power quality should be considered. In order to meet these requirements, several topologies are continually studied. Series resonant converter and LLC converter topologies are the mainly used for the battery charger and in order to eliminate the power factor correction circuit, an attempt to use small size of dc-link capacitor is utilized. However, in this technique, inherently large current ripple cannot be solved and the effect on the battery performance should be examined. In these days, instead of using additional hardware, the on-board charger is replaced by pwm dc-ac inverter and electric motor. In this technique, neutral points of electric motors are connected into the utility grid and the power is transferred through the electric motor and pwm dc-ac inverter. Zero-vector control and interleaving control can be applied and the interleaving control shows the superior performance over zero-vector control. The unbalanced inductances between three-phase winding in electric motor, which can be much more serious in IPM, and vibration of electric motor during the charging should be considered and solved. Along with topological approach, proper charging algorithms for Lithium battery continually studied. Constant current control (CC), constant voltage control (CV), constant current and voltage control (CC-CV), and pulse control can be regarded as the major candidates. In general CC-CV is the mainly applied and also pulse control is treated to enhance the battery performance and life time. Unfortunately, till now, informative experimental results according to these control algorithms, along with Lithium battery, are not reported due to the difficulty of use of the battery.

4) Charging Infra: Compared with the ac outlet and plug, dc outlet and plug suffer from the arc at inlet and outlet, so that the specific interface units and standards should be developed. Also, meter, payment system, battery energy estimation system, and etc. should be developed. Main issues can be listed as follows: connector, standard, communication interface, protocol, control system, vehicle detection system, smart socket, energy meter, parking meter, security system, stable power generation system, and etc.

In Special Issue on Power Electronics for Electric Vehicles, 13 selected papers handle the state-of-the-art of the above-mentioned technical issues. The Editorial Board would like to express our special appreciation on their contribution and hopes all readers get useful information from the papers.

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