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Three port bi-directional DC to DC converter for electric vehicles

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Electric vehicles run by battery power face the problems of short range and battery degradation over time due to high charging and discharging current gradients. During the acceleration of the vehicle, sometimes the motor demands high power from the battery and during sudden braking, kinetic energy of the vehicle is converted to electrical energy and that power is returned to the battery. The major problem is that the battery performance gets severely degraded when exposed to such high charging and discharging current gradients. This paper proposes a new topology where it adds a super capacitor bank parallel to the battery to support catering high current gradients especially during peak power demands and to absorb as much energy as possible during braking without burdening the battery. Thereby it minimizes charging and discharging current gradients of the battery and hence, reduces its degradation.

The power electronic topology of the proposed system consists of bi-directional DC-DC converters between the battery and the DC link and between the super capacitor bank and the DC link. In addition, a three phase inverter sits in between the DC link and the motor of the electric vehicle. The two bi-directional DC-DC converters and the three phase inverter form the three port power electronic system. The battery provides the average power during the drive cycle while the above average power demand is supplied by the super capacitor during accelerations. When brakes are applied, the regenerative energy of the motor is captured by the super capacitor by utilizing its ability of fast dynamic response. At the point where the battery voltage is lower than a critical limit, the super capacitor is used as a source to charge the battery as well. The bi-directional DC-DC converter connected to the battery is in the current control mode and the bi-directional DC-DC converter connected to the super capacitor is in the voltage control mode. The designed topology is implemented in PSCAD and the simulations are carried out to study the feasibility of the approach.