National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Design of High Power Interleaved Boost Converter with Enhanced Efficiency and Equal Current Distribution using Novel Control Algorithms
Speaker	: Yedukondalu Guttula (Rollno : 518ee1012)
Supervisor	: Prof. Susovon Samanta
Venue	: EE-401
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Abstract	: In Electric Vehicle (EV) applications, the interleaved boost converter (IBC) can be used in place of a conventional boost converter (CBC) to improve efficiency and reduce the size of the drive train. This is due to the inherent property of ripple cancellation, and equal current distribution of IBC. However, to reduce the size, improve efficiency, and maintain equal current distribution in each phase of IBC proper analysis of IBC is required. The ripple current analysis plays a vital role in choosing the inductor and filter capacitors to minimize the size of an IBC. This research work presents, a simple and generalized formula for the input ripple current of N phase IBC. Also, presented the design of the inductor with two different core materials as Ferrite and Sendust. The thermal analysis of IGBT modules to select an appropriate heat sink has been presented. The minimum phase selection has been done by considering several constraints such as the area product of the core, discrete components size based on ripple analysis, cost of all components, and converter efficiency. By considering all these constraints a 7.5kW 3 &minus φ IBC converter is designed in the laboratory. The IBC has a low-efficiency problem compared with CBC when it is operated in the region of low to medium load conditions. This is due to the fact that at low to medium load conditions, the switching and core losses are more dominant than conduction losses in the IBC. Therefore, an efficiency improvement is necessary for IBC under low to medium load conditions, when the number of phases increases. In the present research work, to achieve this objective, an efficiency-based rotating phase-shedding control algorithm has been implemented for a 3 &minus φ IBC with an automatic phase selection. In the case of phase number selection, the required unknown parameter value i.e. &ldquoEquivalent Phase Resistance&rdquo has been estimated online in order to improve phase shedding performance. The other problem of the IBC is, the unequal current distribution of individual phases is caused by the variation in the resistive parasitics of passive and active components of each phase. This results in thermal imbalance, uneven aging, and efficiency degradation of IBC. This problem has been addressed in previous works, and numerous current sharing control techniques have been developed. However, in order to generate the required control effort from these control schemes for compensating the uneven current sharing, a variety of sophisticated methods were adopted. These methods increase the design complexity of the controller proportional to the increased number of phases. In this research work, a new current balance algorithm (CBA) is implemented by adaptively changing the duty ratio with a simple voltage mode control (VMC) to reduce control effort and design complexity in order to achieve equal current distribution in each phase of IBC. The present research also investigates the control and energy management of IBC-based active configured battery and ultracapacitor (UC)-based hybrid energy storage systems (HESS). In general, the battery/UC HESS power allocation is done by a frequency-sharing algorithm by allotting high-frequency components of load demand to UC and low-frequency components to the battery. The conventional frequency sharing EMA&rsquos with UC loop restricts the UC operation to a reference voltage to prevent it from overcharging/undercharging. This leads to a very narrow utilization of the UC voltage range. However, UC voltage can safely be varied from zero to maximum rated voltage. In the present research work, UC boundary-based frequency-sharing approach has been used for UC charging/discharging. The EMA has been modified in such a way that the UC voltage loop activated only when the UC voltage crosses its operating boundary limits. An experimental prototype of the system is designed and the proposed EMA has been tested in the different operating regions for validation.