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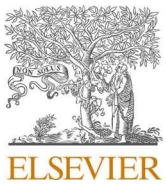

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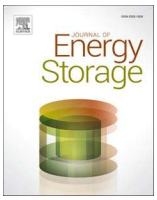

Research papers

Integrated dual battery charging system of electric vehicles using multiphase propulsion motor

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ABSTRACT

This paper conceptualizes the use of two batteries (dual battery) with their integrated charging unit of electric vehicles (EVs) using multiphase (asymmetrical six-phase) induction machine in propulsion system. A modified, but simple buck-boost (DC-DC) converter has been proposed for the development of integrated dual battery charger (IDBC). Proposed dual battery system increases the fault tolerant capability of IDBC, which is suitable for all the operating modes of EVs (i.e. plug-in, propulsion, and regeneration). Buck-boost operation of IDBC enables the operation in a wide range of battery voltage, controlled effectively with simplified scheme. Together with the low component count of IDBC, use of multiphase (asymmetrical six-phase) induction machine in propulsion system controlled with indirect field oriented control further improve the performance with enhanced fault tolerant capability. Complete developed system of EV was analytically implemented by using MATLAB/Simulink. Further, experimental validity and applicability of controller operated on rectifier side (RS) and machine drive side (MDS) converters was tested by using Cortex M4, 32 bits development board (STM32F407G) in the process of processor-in-loop (PIL) simulation. An additional FT32RL board was also employed to increase the data transfer rate externally between the host and target hardware.

1. Introduction

In view of the increased environmental concerned, together with the higher energy demand has resulted in the tremendous electrification and development of electric vehicles (EVs) and hybrid electric vehicles (HEVs) [1–3]. With the present trend in technological development in transportation sector, it is expected that the EVs will completely replace the conventionally employed vehicles in coming few years. Among various components of EVs, battery charging unit is still a prominent challenge in the electrification process of this sector. To address the issue, many new findings are available in last few years [4–7]. Among the various types of battery charger, on-board (OB) is preferably installed inside the vehicle. This is because of their capability to charge the employed battery in a wide range of voltage at any place together with their reduced size, lower weight and cost effectiveness [8–10]. OB charger is usually proposed to be a single stage conversion circuit [11–12] with reduced number of components. It is equipped with a bidirectional DC-DC converter connected between DC link and battery to be charged. In other type of OB integrated charger, components used in propulsion process is also re-used particularly, connected motor winding, traction converter, relays and switches, during charging process of battery [13]. This results in reduced size and cost of OB battery charger. Charging process may be slow for single-phase input supply [14], whereas in fast charging with three-phase input supply, the undesirable pulsation is also noted due to motor winding current in the process [15,16] resulting in noise, vibration, low efficiency of employed charger. To overcome such issues, an integrated converter tropology [17] was proposed with low component count. In this work, with better association of drive unit, an improved performance at high speed was highlighted. Motor winding reconfiguration in conjugation with few relays and clutches [18] resulted in isolated charger (three-phase) for the operation at unity power factor. Use of multiphase (more than three-phase) motor in the propulsion of EVs has further added many potential advantages, in comparison with the conventional machine. This makes the propulsion system with an improved reliability, higher power density, smaller size and capability to operate under fault condition (though with reduced efficiency) etc. [19–21]. A five-phase motor (hybrid excited flux-switching: HEFS) was used in the system, where an integrated battery charger (IBC) was proposed which was based on single-phase [22] and three-phase [23], where reduction in torque pulsation

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