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Fast Charging of Batteries Utilized in Electric Vehicle by using Cuk Converter

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Abstract— *This research paper proposes bidirectional Cuk converter topology with a battery management system (BMS) consisting of a Li-ion battery as the main battery and a lead-acid battery as an auxiliary, to overcome the limited driving cycle and protected charging process concerns of EV battery storage. The proposed topology utilizes Cuk converter for power sharing in different scenarios and is simulated in MATLAB/SIMULINK and tested in hardware prototype.*

In addition, this study presents the design and development of an Cuk converter-based EV battery charger that offers a low-cost, high-power-densitybased charging solution with high efficiency and power factor. The proposed charger has fewer components functioning during a single switching cycle, resulting in decreased conduction losses and improved efficiency. A flyback converter synchronizes the orders for constant current and constant voltage charging, and the overall harmonic distortion in the supply current

The proposed EV battery storage and charging solutions have significant potential in addressing the challenges faced by EVs in terms of limited driving cycle and protected charging process. The results of this study demonstrate the improved efficiency, power density, and charging performance of the proposed solutions under different operational conditions, which can contribute to the development of more efficient and cost-effective EVs.

Keywords: *Electrical Vehicle (EV), Battery Management System(BMS),*

INTRODUCTION

What is need of electrical vehicles (EVs) . Why we required electrical vehicles in our day today life. We now that we use internal combustion engine (ICE) vehicles, but is has various drawback is rapidly increasing air pollution, fossil fuels consumption in the world, concerns relevant to security and price of energy and increasing global warming are combined to indicate that an acceptable solution is required to replace the internal combustion engine (ICE) vehicles.

The electrical vehicles has less moving parts than ICE vehicles. An electrical vehicles have zero exhaust emission hence, pollination is zero. EVs are quieter than ICE . EVs also have lower risk for major fire.

However this type of cars as an immature technologies suffer from some problems such as short driving range and high cost. To solve these problems, energy storage system (ESS) acts an important role. Performance of EVs is depend on the Energy Storage System.

According to today's technologies, batteries that can supply and EV to run and acceptable driving range comparing with ICE are very expensive. The different types of batteries such as lead acid, nickel cadmium (Ni-Cd), nickel metal hybrid (Ni-MH), and lithium ion (Li-ion) are employed in EVs applications. The well improved structure of this kind of battery which can be considered as maintenance free is known as value regulated lead acid(VRLA) battery lead acid battery has relatively good response time and their efficiency is in the range of 95% to99%.

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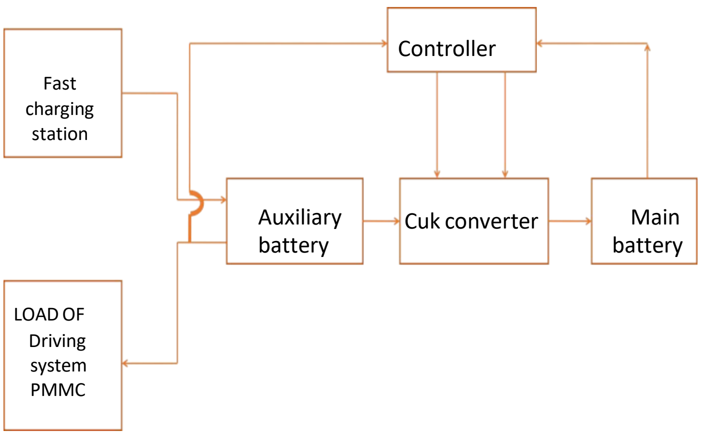
BLOCK DIAGRAM:



EVs suffers from various drawbacks such as limiting driving cycle, cost of battery and life time of the battery. Hence the performances of the EVs is depends on ESS that is BMS. To tackle this problems we proposed one BMS. In that two batteries are used, main as a Li-ion and auxiliary as a lead acid battery, PMMC DC motor, controller, cuk converter etc., Initially main and auxiliary batteries are charged at the fast charging station. Energy density of main battery is larger than auxiliary battery hence the time required to charge auxiliary battery is less. Auxiliary battery is discharged through driving system and it also helps to charge the main battery. This process is continued till the auxiliary battery is discharged up to its depth of discharged limit. Main battery discharged during driving system. Cuk converter is used to power sharing between two batteries and the controller is used to give the switching pluses to cuk converter. PMMC DC motor is used to drive the system.

MATLAB SIMULATION

The basic operation of proposed topology and the relevant control strategies are explained in details. The proposed topology is simulated in MATLAB/ Simulink software and some results are presented to show the performances of the system in different conditions. The system parameters required for the simulation study are shown in table

The fast charger block shown in Fig. is the full wave diode rectifier simulated to serve as a charger for the batteries (Charging station). The cuk converter shown in figure is used to share the power between batteries and system. There are various converters which can be implemented. But here, the converter which has the characteristics like low voltage ripples and continuous input output current is required. Cuk converter has this ability. PMMC DC motor is used as a driving system

Parameters	Value	Unit
Fs	50	Hz
L1	740	µH
L2	1480	µH
C1	5	µF
C2	5	µF
C3	900	nF
C4	900	nF

The fast charger block shown in Fig is the full wave diode rectifier simulated to serve as a charger for the batteries (Charging station). The cuk converter shown in figure is used to share the power between batteries and system. There are various converters which can be implemented. But here, the converter which has the characteristics like low voltage ripples and continuous input output current is required. Cuk converter has this ability. PMMC DC motor is used as a driving system.

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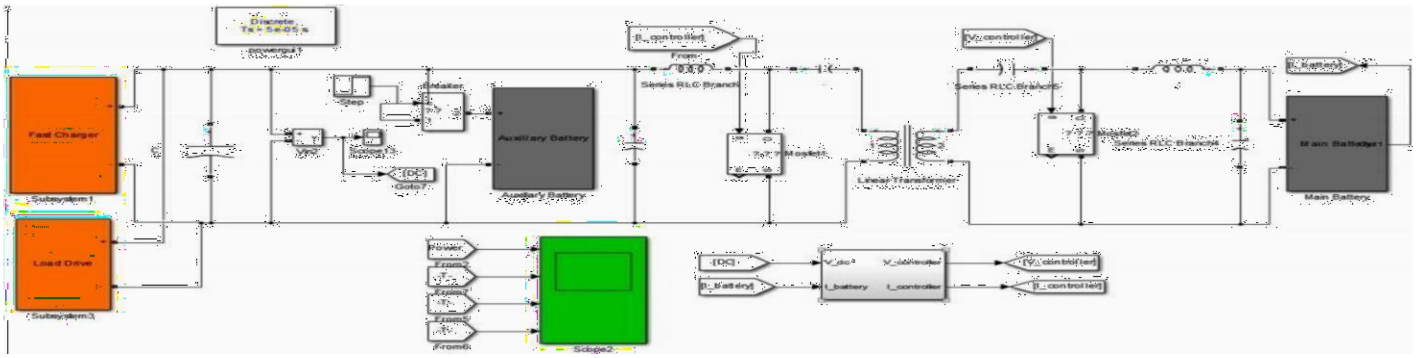
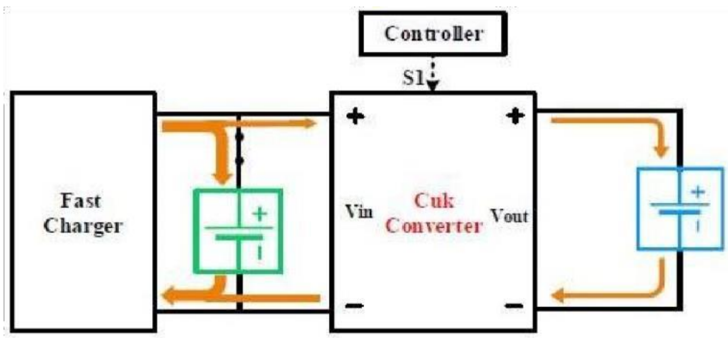
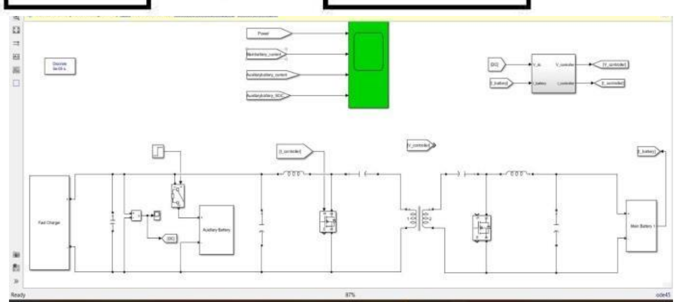
Simulation Model:-



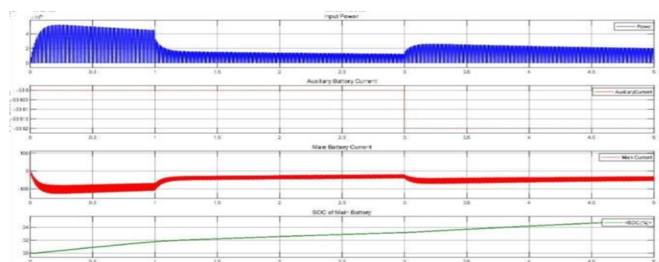
Worling Stages:-

A. Scenario #1: Fast charging





In this scenario auxilary batteries relay is closed and are charging in fast charging station fig.3 A shows current flow direction and relay status scenario #1. I n this scenario switch S1 is being control while switch S2 is off and power is flowing through parallel doide . A current contriller will provide costant current charging for main battery prevents harsh current changes in case of any varriation in the fast charge output current this will help expensive battery charging to be more efficient it will enhance battery life time. the bolck diagram of



current controller .In this working stage both the batteries are charged at fast charging station .Output of charger may change due to arrival and departure of ev.

1st graph in fig. output power changes of the fast charger over time. 2nd graph in fig. shows charging current of auxillary batery overtime .3rd graph in fig. showsmain battery overcurrent time. 4th graph shows SOC of main battery.

In this working stage auxilary batteries relay is closed and batteries are charged fast. Working Stage 1 showscurrent flow direction ralay status scenario

#1. In this scenario switch S1 controlled. This will help the expensive battery charging to be more efficient which will enhance battery liftime.

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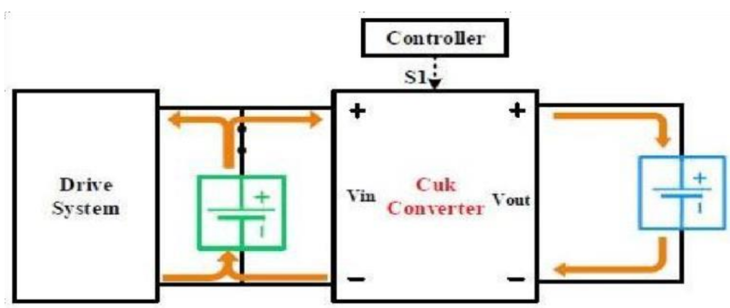
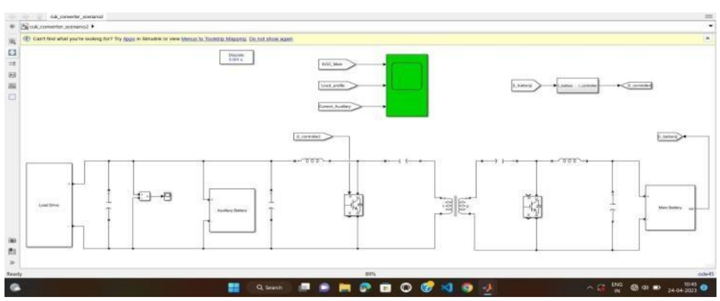
In this working stage both batteries are absorbing power from fast charging station. Output power of the charger may change due to arrival and departure of EVs. First graph shows output power changes of the fast charger over time. Negative value shows that batteries are charging. According to third graph charging current of main battery maintained constant regardless of any changes in the charger output power which verifies correct operation of the current controller. As illustrated in fourth graph slope of main battery SOC varies due to changes in charging current of the lead-acid battery.

Scenario #2: Load drive System Using Auxiliary Battery





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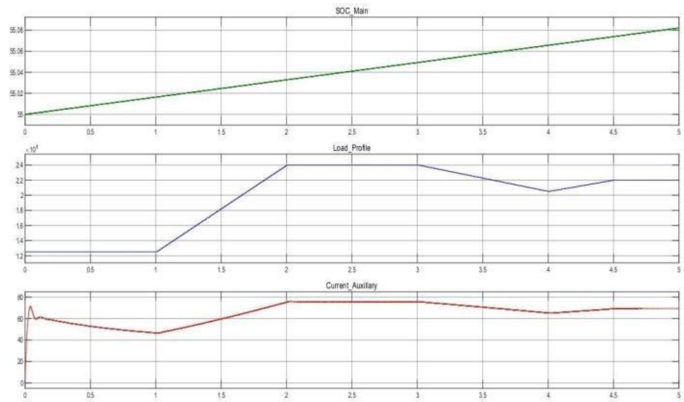
In this scenario the EV has started working and the fast charger is no longer connected. Auxiliary battery is the main energy source of the EV. The priority of the auxiliary battery is providing required energy of the drive system while excess power can charge Li-ion battery. The controller will ensure constant current charging mode of Li-ion battery (similar to scenario#1).

This scenariocontinues until lead-acid battery reaches its Depth of Discharge (DOD) limit. Fig. 3 (b) shows the current flow direction and relay status in scenario #2.



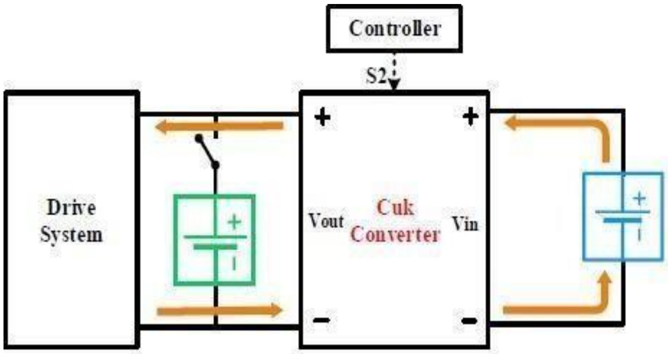
In this working stage EVs is start to drive and the auxiliary battery is providing energy to drive system as well as charging the main battery. This will continue until auxiliary reachesits depth of discharge.

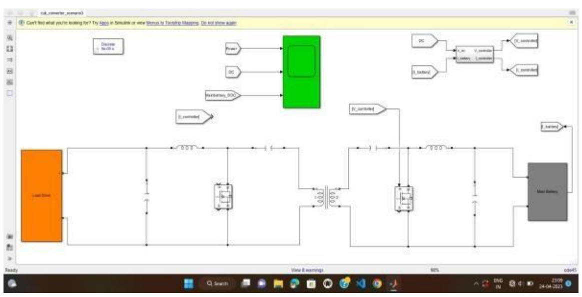
First graph in Fig 4.2 shows state of charge of main battery. Second graph in Fig 4.2 shows the load profile of drive system. Third graph in Fig 4.2 shows the auxiliary battery current.

In this scenario the EV has started working and the fast charger is no longer connected. Auxiliary battery is the main energy source of the EV. The priority of the auxiliary battery is providing required energy of the drive system while excess power can charge Li-ion battery. The controller will ensure constant current charging mode of Li-ion battery (similar to scenario#1). This scenario continues until lead-acid battery reaches its Depth of Discharge (DOD) limit.

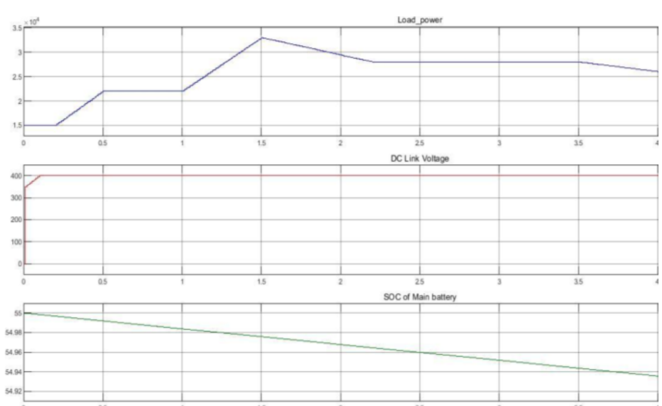
In this working stage, EV is in working state and the auxiliary battery is providing energy to the drive system while it is charging main battery. This stage will continue until auxiliary battery reaches its DOD limit. Similar to working stage 1, the main battery is charged with constant current. Second graph illustrates drive system load profile over time. This profile changes due to acceleration and braking conditions. Third shows current of the auxiliary battery.

Scenario #3: load Drive System Using MAIN BATTERY





In this scenario the lead-acid battery is not available or it has reached its DOD limit so the auxiliary battery's relay is opened. The Li-ion battery is the main ESS and it supplies the drive system. Role of the controller in this scenario is different from the last scenarios. The controller which is shown in Fig. , tries to stabilize DC link voltage at a constant value regardless of Li-ion battery voltage changes. Constant DC bus voltage helps inverter of the drive system to work smoothly and efficiently. Fig. shows the current flow in scenario #3.



In this working stage the auxiliary battery is not available any more and the main battery is the only energy sores of EVs.

First graph in Fig shows the load profile of the drive system. Second graph in Fig shows the DC link voltage with respect to load variation.Third graph in Fig shows the state of charge (SOC) of main battery.In this scenario the lead-acid battery is not available or it has reached its DOD limit so the auxiliary battery's relay is opened. The Li-ion battery is the main ESS and it supplies the drive system. Role of the controller in this scenario is different from the last scenarios. The controller which is shown in working stage 2, tries to stabilize DC link voltage at a constant value regardless of Li-ion battery voltage changes. Constant DC bus voltage helps inverter of the drive system to work smoothly and efficiently.

The auxiliary battery is not available anymore and the main battery is the only energy source of the EV. Load profile of the drive system is illustrated in first graph.

Voltage controller set-point is adjusted to 400V. As shown in second graph, the voltage controller maintained DC bus voltage at the set-point value regardless of load variations.

Conclusion:

A BMS including two different battery type and bidirectional cuk converter for ev proposed li-battery is dominenant type of battery in ev due to its advantages while other types like lead acid can be imploide in this application . the isolated cuk converter was utilised to manage contribution of batteries . RThree possible scenarios were consider to evaluate performance of the purposed topology and control algorithm . the result confirm that the purposed converter is able to handle different function in various condition is desirable .Following conclusion are made from this Project.

1. Reduce voltage traces on main battery by employing auxiliary battery .
2. 1enhanced battery lifeline .

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