

AUTOMATED FAST CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLE TRANSPORT SYSTEM

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Abstract

This paper presents an automated fast charging infrastructure for the electric vehicle battery charging to meet the daily trip schedule with minimum number of vehicles. The charging infrastructure includes power conversion and automated charging. Power conversion stage is designed with uncontrolled bridge rectifier for the front end rectification and boost converter in the dc-dc conversion stage to meet nominal voltage for battery. The charging process is automated for identifying the car arrival events, number of cars present in parking lot and measuring the SOC and charging circuit control through FPGA. The simulation and experimental results are presented to validate the proposed charging system.

Keywords: —. Electric Vehicle, State-of-Charge(SOC), FPGA, Battery-to-battery circuit, Boost convertor, 3phase full bridge Rectifier, Charging circuit,Control Circuit.

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INTRODUCTION

Sales of electric-vehicles (EVs) are increasing very fast around the world because of the reliability and energy security of EVs. Electric vehicle charging structure play a important role. Based on the Society of Automatic Engineers (SAE), charging systems can be divided into three levels. In our paper we model the charging system in MATLAB / SIMULINK. The charging structure bridge rectifier boost circuit, converter to DC/AC, constant current / constant voltage control (CC / CV) is used for the converter. Car transportation is a mode of transport that provides access to a collection of vehicles in the form of coordinated short-term car rental, acting as a replacement for private car ownership with a variety of travel, environmental and social benefits. The combination of the mobility concept of car transportation with electric vehicles (EVs), known as e-car transportation, can contribute not only to a more efficient use of shared vehicles, but also to a more sustainable urban mobility in smart cities. In this regard a hardware model is implemented with the help of Spartan-6 fpga board for the automatic control of charging process by finding the car is available in parking lot or not and whether the SOC is sufficient for the completion of travel process.

CHARGING INFRASTRUCTURE

This charging circuit has two input stages, which consists of
(i)Rectifier to convert AC grid supply to DC, for our work we have chosen 3-phase full bridge rectifier.
(ii)Convertor in order to step up or step down the DC voltage.

The main work is to identify the functional parameters of the power electronics components examining the boost convertor, so that they can fulfill the power [1] requirements of each charging posts. To the other end, it is essential to focus on finding the required electronics components to provide the charging posts with the required electronic components to provide the charging posts with the required level of voltage, rather than evaluating the efficiency of this part of the system.

a)**Diode Rectifier:**Post recharges of a battery, while considering an optimal power storage strategy from the grid overnight, can minimize the electricity cost and the power supplies to EV batteries through the day time. In case of an three-phase grid voltage rectification scenario i.e., AC, can be combined with the DC car that can be used to charge the EV

batteries and this can be demonstrated or performed with the full bridge rectifier by using the standard six diodes in MATLAB/SIMULINK.

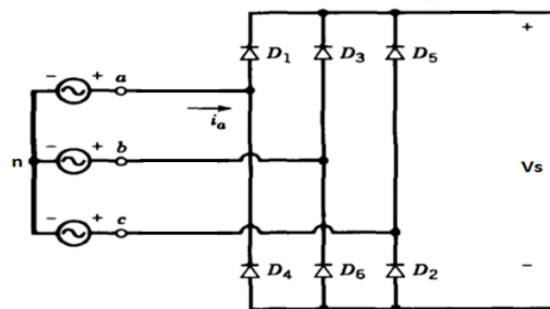


Fig .1: 3-Phase full bridge rectifier

b) **Boost Converter:** This converter appears in Fig.12 Using a simple diode and an IGBT diode with initial parameter values in MATLAB / Simulink, raises the voltage to a higher output value for charging the batteries on the charging sides. The charging side's required battery voltage is set at 420 V (i.e. 15 percent higher than the EV battery voltage, i.e. 365 V), where the boost voltage required to charge the charging side's battery is set at 483 V (i.e. 15 percent higher than its required battery voltage).Using a value of 230V as the grid voltage and the input voltage to the boost converter is set as 345 V based on , the output voltage V_a as 483 V, the frequency f_s at 100 kHz and the output current I_a at 30A. Then, the values of resistance, the duty cycle, the critical inductance and the minimum capacitance can be calculated from the below mentioned equations (3) and (4) accordingly, where V_a shows the required output voltage ripple, The values to these design circuit parameters are taken in order with requirements, i.e. to achieve a charge of a 80 A-h battery in eight hours.

$$\text{Resistance (R)} = V_a / I_a. \quad (1)$$

$$\text{Duty cycle (k)} = 1 - V_0 / V_a. \quad (2)$$

$$\text{Inductance (Lc)} = (1-k)2kR / (2 f_s). \quad (3)$$

$$C_{min} = I k / (f_s V_a) \quad (4)$$

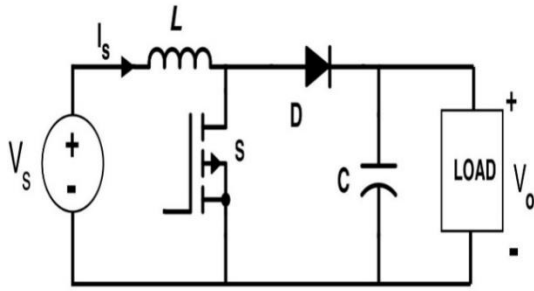


Fig 3. Boost Converter Circuit

Battery to Battery circuit is [2] used for charging the electric vehicle battery with the help of charging post battery. The charging post side battery will get charged during the night time when the load demand is very less, so that we can charge the battery with less cost.

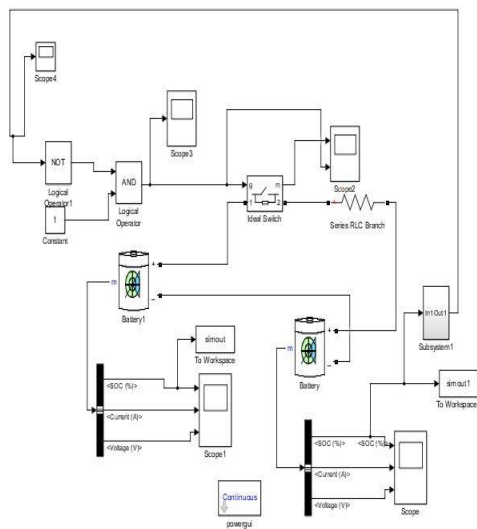


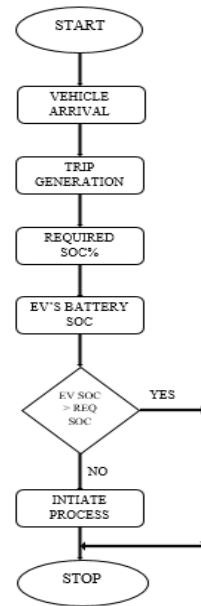
Fig 4. Battery to Battery Charging Circuit

AUTOMATIC CHARGING CONTROL ALGORITHM

The control circuit design and logic is totally carried out with help of the Spartan-6 FPGA board. We used 3 slide switch buttons for the selection of the destination and another 3 slide buttons for the arrival of the car events. We connected the 3 potentiometers which resembles the car batteries, by varying the potentiometer we can change the SOC of the potentiometer.

The logic follow the steps outlined below[3]:

1. In the second step the trip will be generated i.e. Total distance to be travelled and time taken.
2. In this step the SOC that is required to complete the entire trip is identified and it is given to the system.
3. The arrival event of the electric vehicle will be noted and it will be sent in to the line.
4. In this step the SOC of different arrival vehicles is compared and greater SOC vehicle is chosen for the trip.
5. In this step the SOC of the vehicle and SOC required is compared.
6. In this step if the SOC is sufficient then the process is terminated and vehicle is ready for the trip. If SOC is not sufficient then the vehicle charging process will takes place.



Flow chart for automatic charging control algorithm

RESULTS

BOOST CONVERTOR OUTPUT

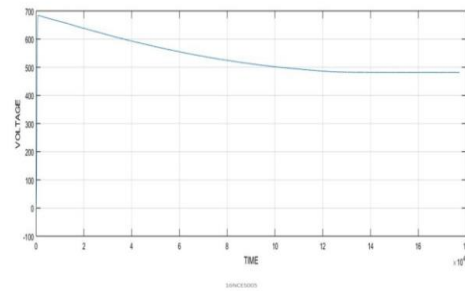


Fig.5 Output voltage obtained at Boost Converter

EV CHARGING PROCESS

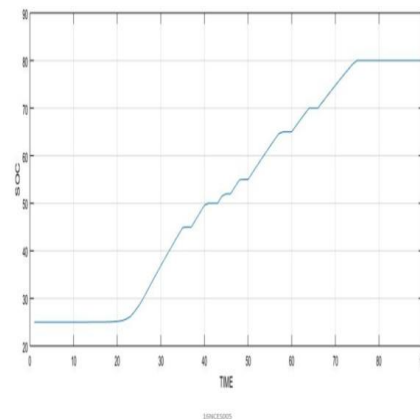


Fig.6 Charging Status of the battery from 25% to 80

In the above fig.6 we can see that the initially the SOC of the vehicle is 25% and charging process takes place till the SOC of the vehicle reaches to the 80% the is the required SOC for the trip completion. Once it reaches the required SOC the charging process has stopped and it is shown with the help of a flat line.

CONTROL CIRCUIT HARDWARE

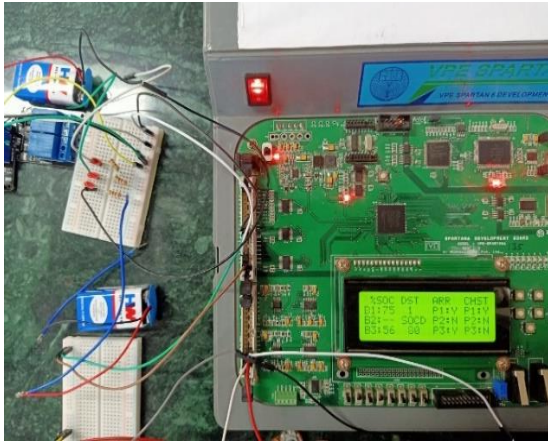


Fig.7 Charging process for EV 1

In the above fig.7 two cars are present in charging post among the two vehicles car 1 has more SOC when compared to another car. So the charging process is taking place in post1. It will continue until the required SOC is reached.



Fig.8 Complete of charging process for EV1

In the above fig.8 we can see that once the electric vehicle battery reaches the required soc the charging process has stopped at the charging post side and the relay will trips down.

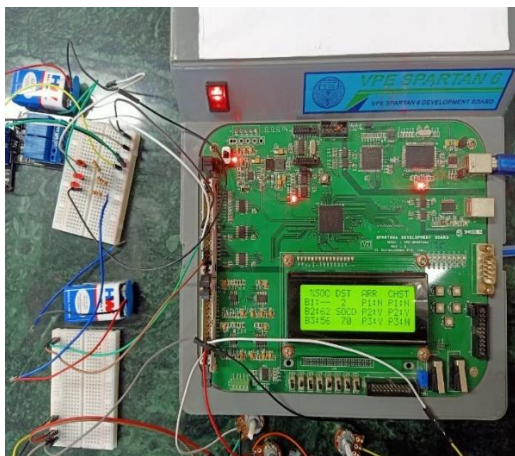


Fig.9 Charging process for EV2

In the above fig.9 two cars are present in charging post among the two vehicles car 2 has more SOC when compared to the another car. So the charging process is taking place in post 2. It will continue until the required SOC is reached.



Fig.10 Complete of charging process for EV2

In the above fig.10 we can see that once the electric vehicle battery reaches the required soc the charging process has stopped at the charging post side and the relay will trips down.

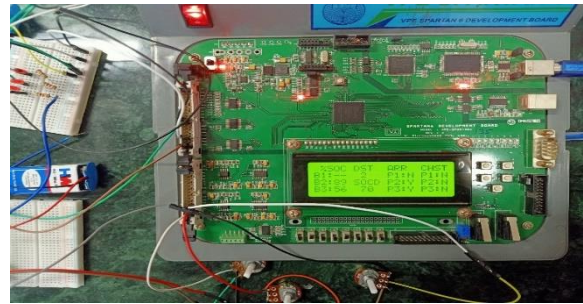


Fig.11 Charging process for the EV3

In the above fig.11 three cars are present in charging post among the three vehicles car 3 has more SOC when compared to another car. So the charging process is taking place in post3. It will continue until the required SOC is reached.

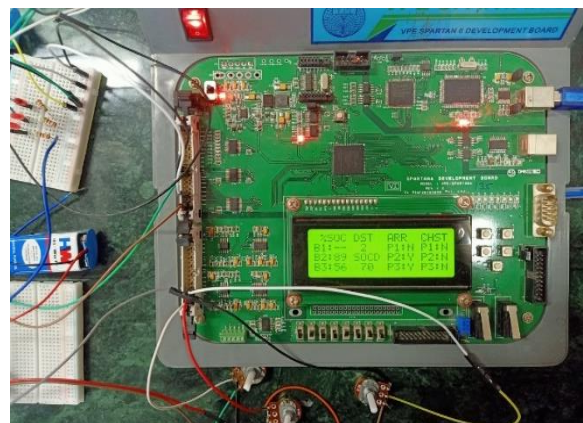


Fig.12 Completion of the charging process.

In the above fig.12 we can see that once the electric vehicle battery reaches the required soc the charging process has stopped at the charging post side and the relay will trips down.

CONCLUSION

Thus an automatic fast charging infrastructure for battery charging of electric car for a transportation system is developed. Sizing of power electronic components is done to suit requirement for six vehicles. The performance of front-end

rectifier and boost converter is analysed. An automatic charging algorithm is developed based on SOC of available vehicles for a particular time slot using SPARTON 6 FPGA controller. Experimental results are presented to validate power structures of charging infrastructure.

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