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Current Controlled Charging Scheme for Off Board Electric Vehicle Batteries from Solar PV Array

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Abstract **- During the recent decade, the automobile industry is booming with the evolution of electric vehicle (EV). Battery charging system plays a major role in the development of EVs. Charging of EV battery from the grid increases its load demand. This leads to propose a photovoltaic (PV) array-based off-board EV battery charging system in this study. Irrespective of solar irradiations, the EV battery is to be charged constantly which is achieved by employing a backup battery bank in addition to the PV array. Using the septic converter and three-phase bidirectional DC–DC converter, the proposed system is capable of charging the EV battery during both sunshine hours and non-sunshine hours. During peak sunshine hours, the backup battery gets charged along with the EV battery and during non-sunshine hours, the backup battery supports the charging of EV battery. The proposed charging system is simulated using Simulink in the MATLAB software and an experimental prototype is fabricated and tested in the laboratory and the results are furnished in this study.**

Keywords: Electric Vehicle, Charging Current, Supported rating, PV array.

I. INTRODUCTION

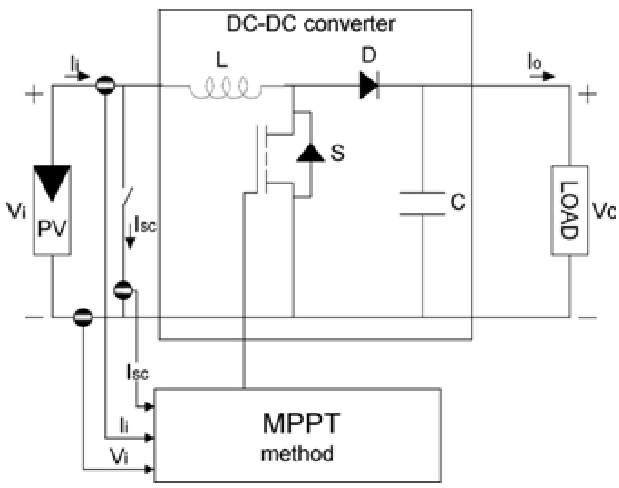
The transportation sector has seen a major shift towards electric vehicles as it not only stops our dependence on fossil fuels and stop pollution from these vehicles that vehicles release.

Hence, we are moving towards cleaner sources of energy. Also, photovoltaic resources are increasing in demand as they are the source of clean energy and don't emit carbon dioxide Two types of charging method are there ON Board charging and OFF Board charging. ON Board charging is when Battery is kept in the Electric vehicle and charging circuit is not on the vehicle itself but near the charging station. And the battery is charged directly through the DC supply. OFF Board charging is when the charging circuit is kept in the vehicle itself, and it can be charged using AC supply as there is rectifier circuit kept on the vehicle which converts the AC into DC which then charges the battery. But charging batteries using solar photovoltaic has problems of its own as if a high output solar PV array is operating on MPPT conditions output of the solar PV is kept at the maximum power possible and when one EV battery is kept for charging it can damage the battery with very high charging current

The MPPT is used to operate the solar PV array so that maximum power can be extracted while it is in operation for these different algorithms such as NHS, Monkey king etc. are used or using modified PSO algorithm for MPPT. Based on different sensors setup which monitors the potential difference and current across the solar PV i.e. multi-sensors MPPT operation.

II. METHODOLOGY

Current-controlled hill climbing MPPT Off board EV charging using two sensors scheme which is a current and potential difference of the solar PV array. This proposed setup is for batteries charging in parallel and series .Where the number of batteries connected to the charging unit is an input to the charging current. In the system charging system, the sepic converter provides the constant output voltage irrespective of the PV array voltage by adjusting its duty ratio using the PI controller. The sepic converter consists of one IGBT switch, one diode, two inductors and two capacitors as shown in Fig. The major advantages of the sepic converter are:



i. It can operate in both boost and buck modes depending on the duty ratio;

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ii. It provides the output voltage with the same polarity as input voltage unlike buck–boost and cuk converters. The voltage gain of the sepic converter is provided by the following equation:

$$\frac{V_{dc}}{V_{PV}} = \frac{D}{1-D} \quad (1)$$

Where Vdc is the dc link voltage, VPV is the PV array voltage and D is the duty ratio of the sepic converter. The values of inductors and capacitors of the sepic converter are chosen as per (2)–(4).

$$L_a = L_b = \frac{V_{PV_{min}} D_{max}}{2\Delta i_{PV} f_{sw}} \quad (2)$$

$$C_1 = \frac{I_{dc} D_{max}}{\Delta V_{C1} f_{sw}} \quad (3)$$

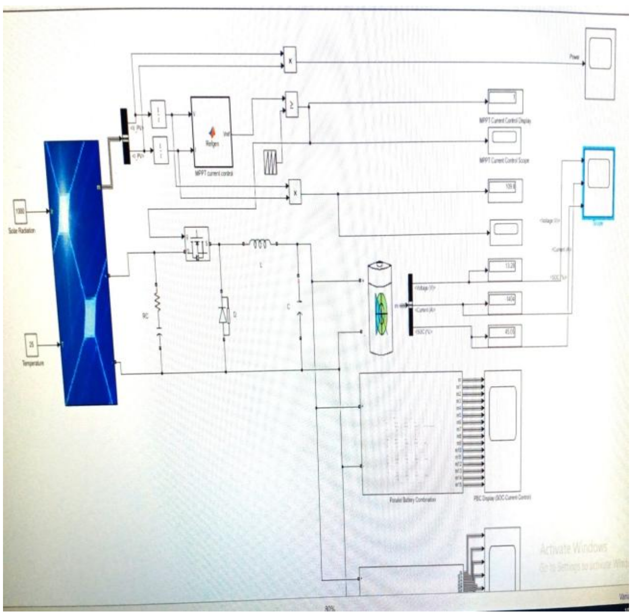
$$C_2 = \frac{I_{dc} D_{max}}{\Delta V_{dc} f_{sw}} \quad (4)$$

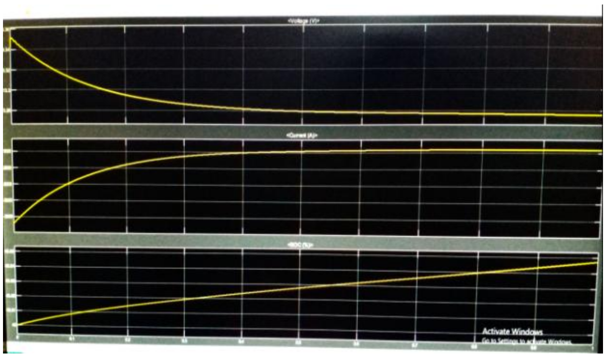
Where VPV_{min} is the minimum PV array voltage, ΔiPV is the input current ripple, fsw is the switching frequency, Idc is the dc link.

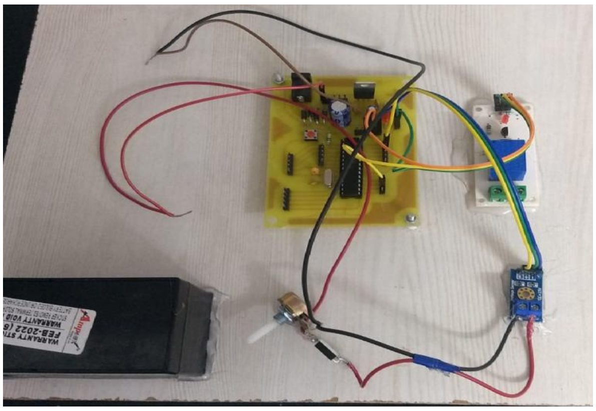
Current, ΔVC1 is the capacitor, C1 voltage ripple, ΔVdc is the output voltage ripple, and Dmax is the maximum duty ratio calculated as follows:

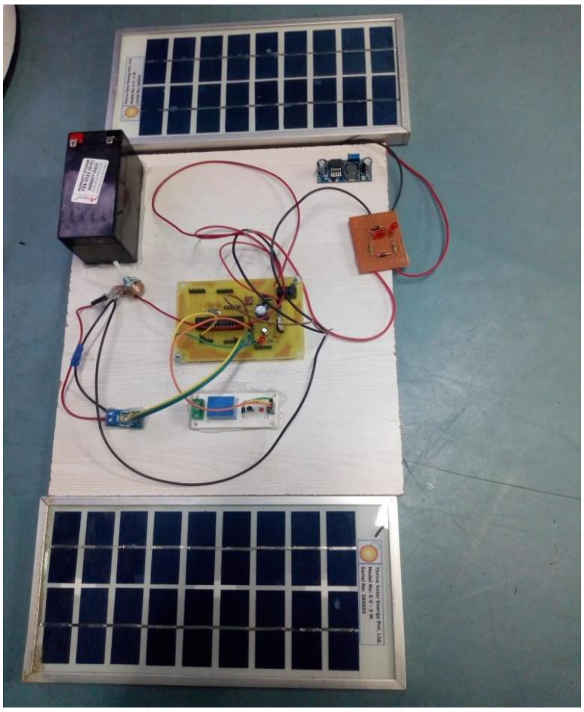
$$D_{max} = \frac{V_{dc} + V_D}{V_{PV_{min}} + V_{dc} + V_D} \quad (5)$$

Where V_D is the diode voltage drop.









III. RESULTS AND CONCLUSION

In this paper, an off-board EV battery charging system fed from PV array is proposed. This paper discusses the flexibility of the system to charge the EV battery constantly irrespective of the irradiation conditions. The system is designed and simulated in Simulink environment of the MATLAB software. The hardware prototype is fabricated and tested in laboratory for the three modes of operation of the proposed charging

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system separately and the results are furnished. In OPAL-RT Real time simulator OP4500, experimental investigation is carried out in RCP methodology and the dynamic response of the system is furnished both in simulation and experimental investigation. Correlation between the simulation and experimental results emphasize the effectiveness of the proposed charger.

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