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# EV Charging Station with PV and Battery Based on a Multiport Converter

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## ABSTRACT

***The environmental effect of the transportation industry is growing, and electric vehicles (EVs) are seen as a possible solution due to their limited on-board battery capacity. As a consequence, there is a pressing need for charging stations to be situated in convenient locations. However, peak-time overload, unexpected power gaps, and voltage dips are all ways in which fast charging stations, and especially super-fast charging stations, may put a burden on the power grid. In this research, we investigate the viability of modelling a multiport converter-based EV charging station with PV power generation and a battery energy storage system in ANSYS TwinBuilder. In this research, we demonstrate that the reliability of a power grid may be enhanced by integrating solar photovoltaic (PV) power generation with an EV charging station and a battery energy storage (BES) system. When daily charging demand is in sync with adequate daytime PV supply, the effect on the power system is reduced. Results from a simulation study verify the benefits of the proposed multiport EV charging circuits using the PV-BES architecture in a number of charging modes. The EV charging station also makes use of SiC devices to improve efficiency. In this simulation study, power losses and efficiency across several modes and functions are analysed and compared to those of conventional charging circuits based on Si devices.***

## 1. INTRODUCTION

Electric vehicles (EVs) have emerged as a viable alternative to conventional gas-engine autos as people grow increasingly concerned about decreasing their consumption of fossil fuels and pollution [1]. Given the limited capacity of EV batteries, extensive deployment of charging stations is vital to the development and expanded usage of EVs [2]. However, the increasing number of fast and superfast charging stations that are directly linked to the electrical grid poses a threat to system reliability and stability [3]. Although research on the integration of photovoltaic (PV) systems with EV charging infrastructure exists [4], PV systems are currently considered to provide just a tiny share of the energy needed by EV charging stations. Due to the rising need for fast charging at all times of the day, rapid improvements in PV output have been optimising power utilisation during peak hours. The intermittent nature of solar energy may be mitigated by using batteries to smooth PV power [5], regulate DC bus or load voltage, and fill in power gaps.

This study employs a multiport DC/DC converter for the EV charging station instead of three separate converters because of the advantages of high power density and high efficiency afforded by multiport power converters [6]. The aforementioned research may be broken down into two groups, one focusing on AC bus systems and the other on DC bus systems, both of which are used in the designs of charging stations [7]. For this application, a DC bus charging station was chosen to make the most efficient use of solar power and to reduce the related expenses, waste, and pollution from converters [8]. Direct current (DC) sources include PV output and BES. It has been shown that nonisolated multiport converters, which are often derived from buck or boost converters, may provide benefits over isolated multiport converters [9], [10]. So as to improve efficiency and lessen power losses, this study employs a DC bus nonisolated construction with SiC switches. Following is a brief overview of the paper's results and its contributions.

Solar photovoltaic (PV) and battery energy storage system (BES) integration is preferred over the regular power grid for recharging electric automobiles. Then, we build a comprehensive operating mode, control scheme, and investigate the interaction between PV, BES, the power grid, and EV charging in a scenario with high penetration of PV integration and broad EV charging infrastructures. Losses and efficiency in terms of power are also compared and contrasted.

## 2. ELECTRIC VEHICLES

The traction power for the wheels of an electric vehicle (EV) comes from the battery pack, which is connected to the electric motor through a gearbox. Most of the time, the batteries are charged by a battery charger that draws their energy from the electrical grid. At the same time as it reduces the vehicle's speed by acting as a generator and putting energy back into the batteries, the motor may also be used for regenerative braking. The fundamental benefit of an EV is its simple design and minimal number of components. The biggest drawback is that the driving range is capped by the size of the battery, and recharging the battery may take anywhere from 15 minutes to 8 hours, depending on the distance travelled recently, the kind of battery, and the charging method.

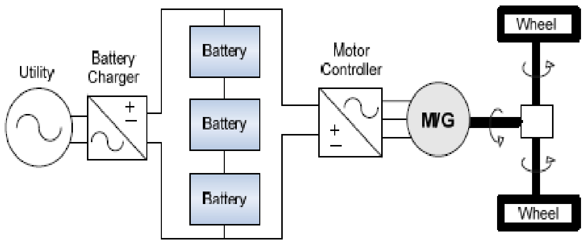

Figure 1: Typical EV configuration

### Plug-In Vehicles:

A small number of manufacturers have recommended installing a DC/DC battery charger at the DC connection of the PV structure's connection to the grid. The control estimate guarantees that the PEV battery is charged from the most efficient source by calculating the power produced by the PV and the power requirement of the PEV. Different scenarios are shown in light of the discrepancy between the PV command and the retail outlet's need. The flow of electricity in a PV halting area is managed in the case of by a system of computer-controlled swaps [10]. PC-controlled exchanges connect PV panels of varying ratings to PEV chargers and the power grid. The exchanges route all the power generated by the PV systems to the PEVs, the grid, or both, depending on the available light. DC/DC converters are used to connect several PV sheets to the DC network.

In light of certain predetermined points of suppression of the dc transport voltage, the DC/DC converter does an excellent job of controlling the power stream to the PEVs. Despite what most people would assume is impossible, the energy conversion unit powers three-way energy flow between the power system, PV modules, and PEVs. Several developers have suggested designing energy to dc stacks on a micro grid such that DC transport hailing is possible. They have likely expanded this strategy to charge PEVs in a micro grid region on several occasions.

The impressive charging station features both independent operation and networked functionality. The fluctuation in DC interface voltage levels stimulated by the shift in sun-positioned protection fuels the switching between modes.

The controller shifts the charging of PEVs to a non-peak time during the months with less solar-based protection and a higher zenith stack on the course transformer.

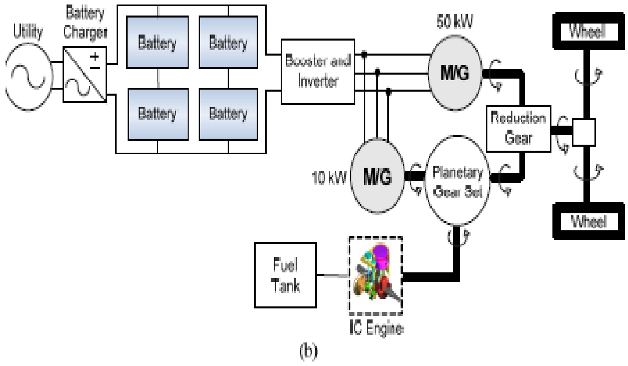

Figure 2: Configurations converted PHEV

## 3. PLUG-IN ELECTRIC VEHICLE CHARGER TOPOLOGY

Conventional DC bus charging stations with PV integration link the three power sources (PV, EV charger, and AC grid) through three independent converters (Fig. 3). A second bidirectional power source BES is included into the proposed DC bus charging station. The BES keeps the DC link voltage steady and compensates for power excess or shortage from the PV system. The following is a comprehensive discussion of the configuration's functionality and operational modes.

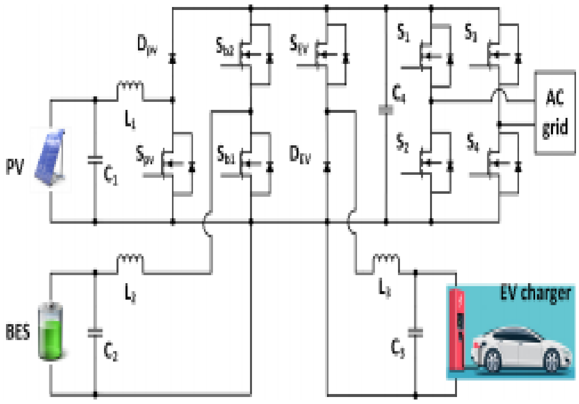

Figure 3: PEV charger topology

### a. *Photovoltaic Array Modeling:*

The cell is an integral component of the PV electrical phenomena network. PV exhibits employ solar cells and their surrounding regions that have been connected in a non-current or parallel method to increase the required current, power, and potential difference. In real life, each cell functions similarly to a diode, with the intersection defined by the semiconductor material. At the moment of junction, the low weight is absorbed by the electrical wonder sway, which instantly distributes the streams. Figure 4 depicts the (current-voltage) and (Power-Voltage) characteristics at completely random star intensities of the PV display, and diagram 5 depicts the ubiquitous presence of most electrical outlets on each yield.

$$I = I_{ph} - I_D - I_{sh} \qquad (1)$$

$$I = I_{ph} - I_o\,[\exp\,(q\,V_D / nKT)] - (v_D / R_S) \quad (2)$$

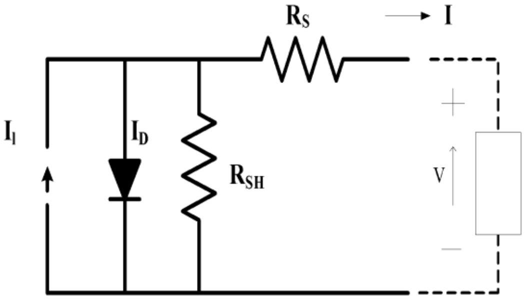

Figure 4: PV Electrical Equivalent circuit

**Operation of Multi Stage Converter:**

1. ***Mode 1: PV to EV:***

Switches Spv, Sb1, and Sb2 are disabled when SEV is enabled in this setting. Therefore, as seen in Figure, PV supplies electricity directly to the load. This stage's differential equations may be written as:

$$i_{PV} = C_1 \frac{dv_{C1}}{dt} + i_{EV}$$

$$C_2 \frac{dv_{C2}}{dt} = \frac{v_{Bat} - v_{C2}}{r_b} - i_{L2}$$

$$i_{EV} = C_3 \frac{dv_{C3}}{dt} + \frac{v_{EV}}{R_{EV}}$$

$$v_{C1} - v_{C3} = L_3 \frac{i_{L3}}{dt}$$

$$L_2 \frac{i_{L2}}{dt} = -v_{C2}$$

2. ***Mode 2: BES to EV***

According to Figure, BES discharges to the EV load when Spv and SEV are on while Sb1 and Sb2 are deactivated. In this setting, differential equations may be written as:

$$i_{PV} = C_1 \frac{dv_{C1}}{dt}$$

$$L_2 \frac{i_{L2}}{dt} = v_{DC} - v_{C2}$$

$$v_{DC} - v_{C3} = L_3 \frac{i_{L_3}}{dt}$$

$$C_2 \frac{dv_{C2}}{dt} = \frac{v_{Bat} - v_{C2}}{r_b} - i_{L2}$$

$$i_{EV} = C_3 \frac{dv_{C3}}{dt} + \frac{v_{EV}}{R_{EV}}$$

## SVM TECHNIQUE FOR TWO-PHASE INVERTER

Within the framework of the SVM method for the three-phase inverter. By calculating the duty ratio of two neighbouring space vectors to V* and changing the switching time of two zero space vectors, a reference voltage vector V* may be produced. In this research, we present a realisation approach for the two-phase inverter's SVPWM technique that does not include zero-space vectors. Reference vector V* switching durations are determined by modifying four voltage space vectors, as shown in Figure 5 of the model.

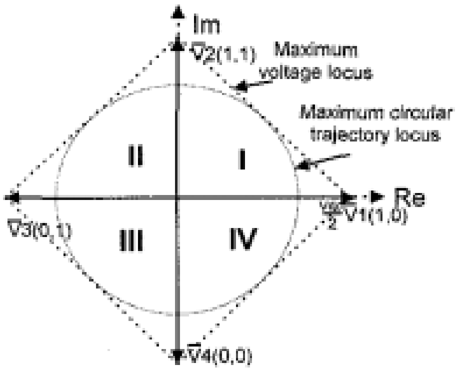

Figure 5: SVM Four possible space vectors

## 4. SIMULINK RESULTS

Experiments were conducted on a smaller scale, and the findings gained are applicable to those experiments (with power levels 5 times lower than the full scale). DCBUS voltage was maintained at 108 V and PMax was at 460 W, with these values serving as "Advisable Energy Levels" for sizing, simulation, and eventual full-scale implementation. As shown in Figure 5, a PWM controller and data logger are employed in tandem with various scientific instruments and electrical components.

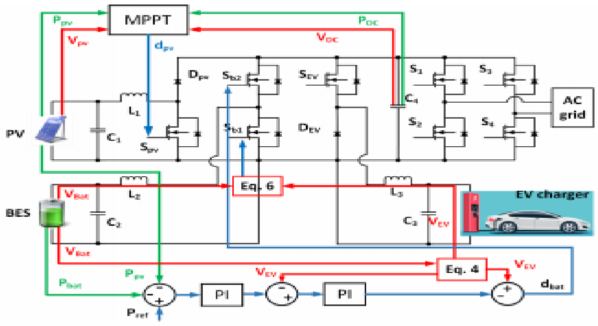

Figure 6: Schematic for the PV-based V2G System

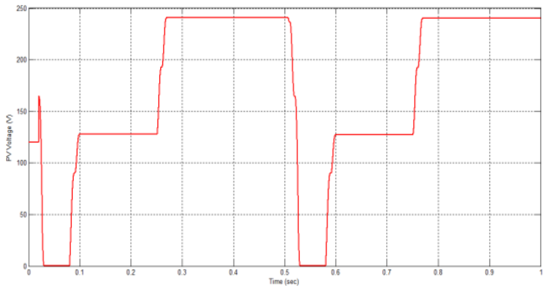

Figure 7: Simulation Waveform for PV Voltage

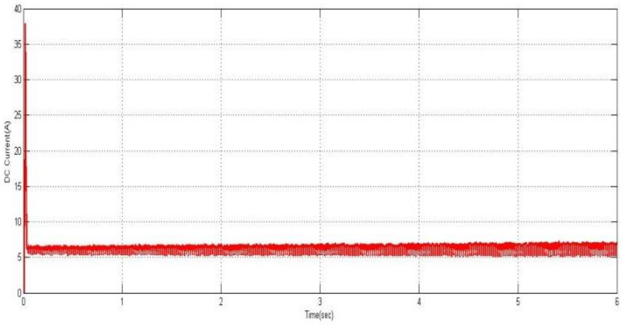

Figure 8: Simulation of PV Waveform Current

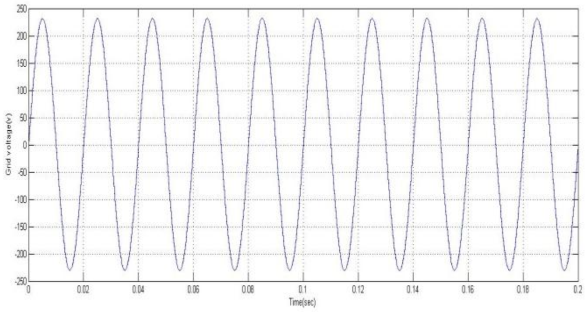

Figure 9: Waveform Simulation for Grid Voltage

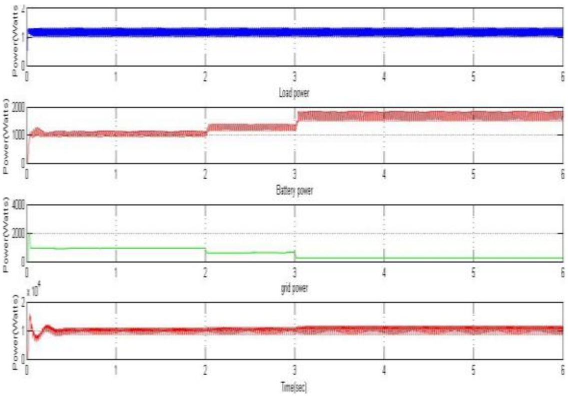

Figure 10: Simulation Waveform of System Powers under Various Load Conditions

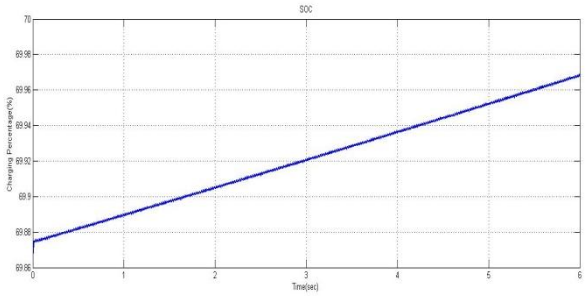

Figure 11: Waveform Simulation for Battery SOC

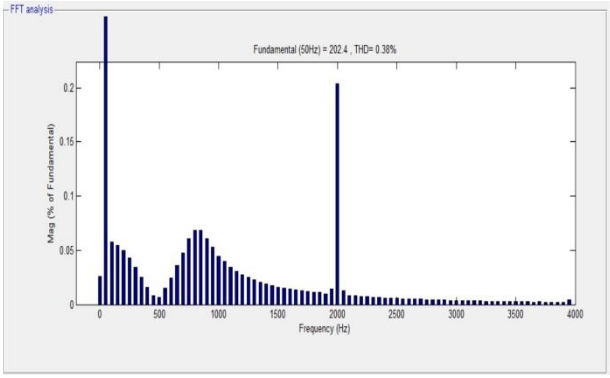

Figure 12: Voltage THD Simulation Waveform Inverter

## 5. CONCLUSION

Specifically, it is recommended that a PV and BES based EV charging station employ a space vector modulated multiport converter for its power needs. When photovoltaic (PV) output is insufficient for local EV charging, the proposed control architecture makes use of a battery energy storage (BES) controller, which then commences charging when PV output is in excess or power grid demand is low, as at night. By integrating PV generation and BES with EV charging, grid reliability and stability are enhanced. Matlab/Simulation thermal and simulation models of multiport converter-based EV charging stations and the proposed SiC equivalent were developed after researching the different operating modes and their benefits. The results of the simulation show that, under typical operating conditions, the efficiency of the three modes (PV-to-EV, PV-to-BES, and BES-to-EV) may be improved in comparison to Si based EV charging stations.

### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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