



Article Title: **Renewable Integration in Electric Vehicle Charging With Modular Multilevel Converter**

Renewable Integration in Electric Vehicle Charging With Modular Multilevel Converter

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ABSTRACT

In this given approach the MMC reconfigurable feature, flexibility, and ease of use have achieved tremendous relevance and for a renewable energy system for charging system that reduces total harmonic distortion. In this study, a practical method for implementing MMC is proposed, controlling the converter's power flow with a solar PV system. With a bi-directional battery converter, this grid-tied MMC system efficiently charges the electric car battery system. The MMC receives the PV output, balances the voltage, and then sends it to the MMC's HFC. The MPPT algorithm is used to monitor the maximum power generated by the PV panel. The proposed work is implemented in MATLAB/Simulink in order to assess its performance. THD is reduced more effectively using the prescribed work.

Keywords: MMC – (Modular Multilevel Converter), EV – (Electric Vehicle), PWM – (Pulse Width Modulation), PI – (Proportional and Integral).

1 Introduction

Electric cars are anticipated to help reduce CO₂ emissions, which will help with the issue of pollution and global warming. However, compared to the distance covered by filling the combustion car's reservoir per minute, recharging does not cover as much ground. Because of this, several studies are being conducted to reduce battery charging time and increase EV autonomy [1]. Embedding a battery in the MMC decreases the size of the powertrain by dividing the battery pack into sub modules, despite the fact that the MMC is troublesome for a tiny electric car. This architecture calls for an additional independent on-board charger, which raises the price and volume [2]. A recently proposed EV converter that function as both a battery charger and a driving converter has been deemed economically effective because it does not require an additional on-board AC charger. A high voltage DC bus based on capacitors, which is troublesome in high voltage applications like quick charging, is a drawback of this technique [3]. The goal of this article is to integrate the powertrain and battery charger for electric vehicles by integrating the group powertrain-charger, which consists of the battery, electrical machine, DC charger, and AC charger through a single converter based on



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customizable modular multilevel converter [4]. The MMC one of the most promising multilevel topologies, has recently drawn a lot of interest from both academia and business. Some of this converter's important benefits are its modular design, low device ratings, simple scaling, and potential use of redundant cells for fault-tolerant applications [5].

The power losses in the cell balancing converter utilized by the conventional inverter are not taken into account in the comparison, penalizing the MMC. Additionally, compared to conventional inverters, which dramatically lose efficiency at low speed/voltage and light loads, the overall efficiency is nearly constant [6]. MCs improve the waveform of the output quality by reducing voltage distortion achieving high power levels using medium-voltage devices, reducing stress in the switching devices, decreasing adverse consequences, such as common-mode voltage that decreases stress on the bearings of the motors used in electric vehicles, and improving the overall harmonics examined which decreases the use of bulky filters, especially when used in conjunction with other devices [7]. The half bridge sub module topology's simplicity and sparse component count are its key benefits. The overall capacitance of the MMC is typically greater than that of topologies with a single capacitance because to the capacitors contained in the sub modules [8-9]. The dc-link voltage controller is designed for balancing the power flow in the system. As the model predictive controller handles non-linear constraints it also incorporate the MPPT stage [10]. The contribution of the paper is to implement Modular Multilevel converter for solar based grid connected system and achieve energy management system using Bi-Directional battery converter and MMC based grid tied system in EV and reduce the total number of DC sources and Total harmonics Distortion in the proposed system also to reduce the circuit complexity and switching stress.

2 Proposed System Explanation

In order to use the three phase inverter for grid to battery charging, effective voltage is thus delivered utilizing MMC converter. With the aid of a PWM rectifier, it is necessary to charge the battery from the three-phase grid system and to control the EV battery to a specific range of SOC.

A PV panel makes up the proposed system shown in Figure 1, from which the numbers I_{PV} and V_{PV} are computed. A voltage equalizer that is attached to an MMC receives these voltage and current measurements. It translates the high frequency and low frequency data and consists of sub modules. A P&O algorithm is used, which quickly converges to the maximum power point and recognizes power fluctuations. An LC filter absorbs the higher order switching harmonics of the converter's output voltage while a PWM generator lowers the switching frequency ratio and removes minimal-order harmonics.



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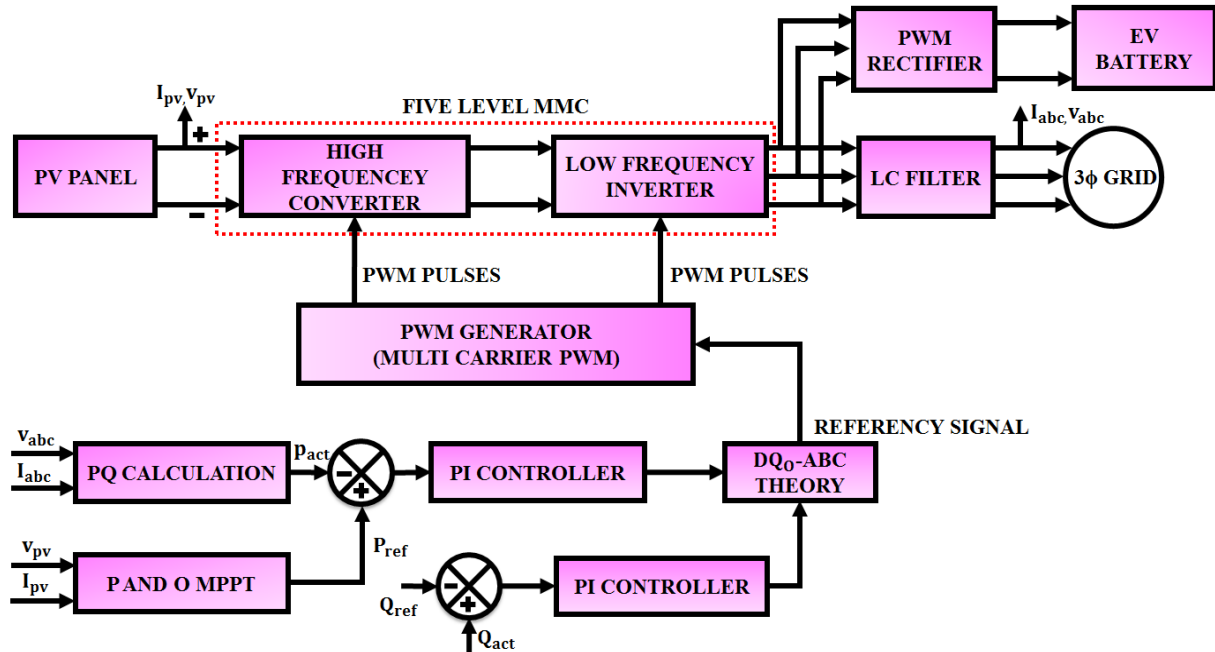


Figure 1: Proposed Diagram

3 Proposed System Modelling

3.1 PV Panel

A semiconductor transistor that has been exposed to light is a solar cell. Few of the variously energetic particles in this solar output are caught at the p-n contact. In contrast to band gap, this sector employs the greatest energy rays. A single diode is utilized to construct comparable devices that are frequently used to represent PV cells, which offers a better balance between accuracy and usability. In Figure 2, the equivalent schematic is shown.

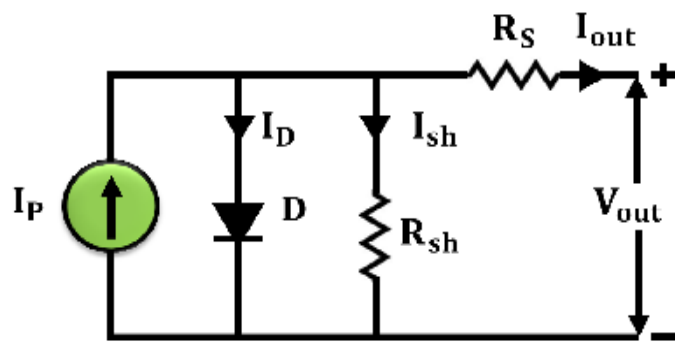


Figure 2: Corresponding circuit of PV cell

The V-I characteristic equation is given by,

$$I_{out} = I_{sh} - I_{sat} \left[\exp \left(\frac{V_{out} + I_{out} \cdot R_s}{V_{th}} \right) - 1 \right] - \left(\frac{V_{out} + I_{out} \cdot R_s}{R_{sh}} \right) \quad (1)$$



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Thus the showing of PV classification is achieved and from (1), the yield voltage and the input voltage are assessed.

3.2 Five Level MMC

One of the most alluring converter topologies in the High Voltage Direct Current transmission industry is the MMC. The most recent sorting technique that is currently in use features a simple algorithm.

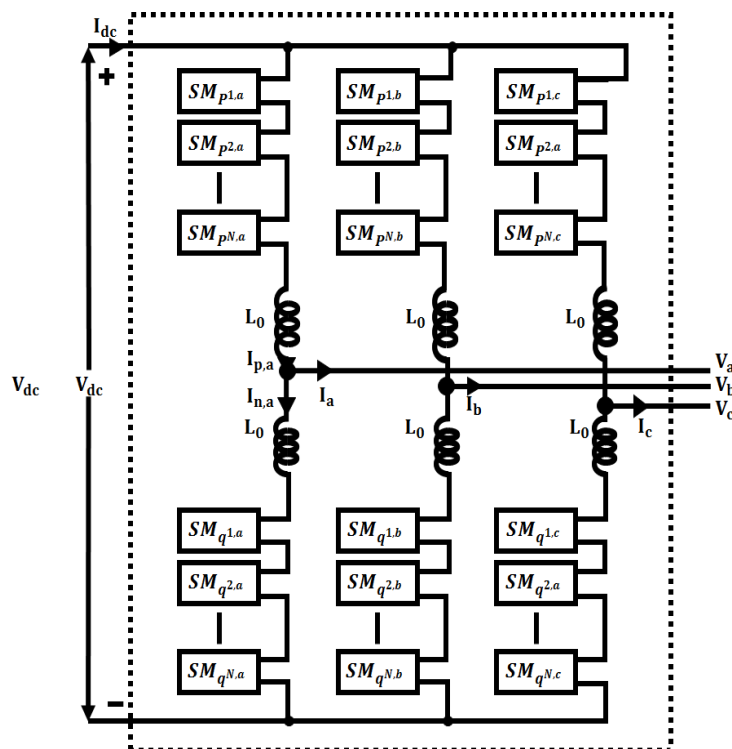


Figure 3: MMC Converter

Figure 3 indicates a 3 ϕ grid connected MMC in which every phase leg comprises of two arms and every arm consists of N number of identical SMs connected in series and inductor L_0 in series connection. The SMs in every arm are regulated for generating the desired AC voltage and the inductance of the arm suppresses the components of higher frequency in the current of arm. The MMC topology is applicable for the applications of medium voltage and its basic component is a sub-module.

3.3 P&O MPPT

To find the maximum power point, the entire P-V curve is perturbed somewhat, which lengthens the process's reaction time. On the other hand, increasing the amount of the perturbation results in steady state oscillation around the MPPT. Numerous researchers have



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proposed modifications to the P&O algorithm to address the steady state oscillations and reaction time issue.

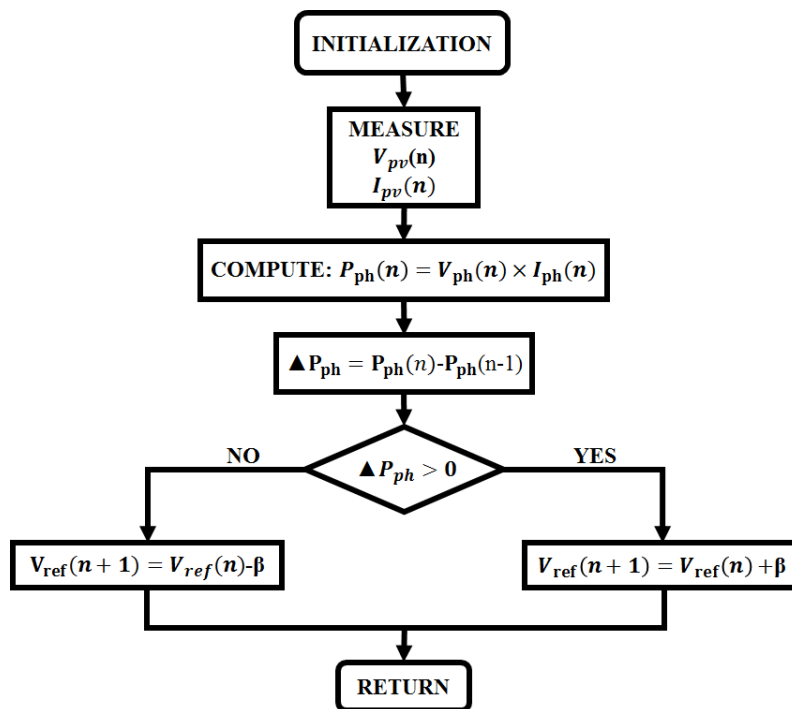


Figure 4: P&O Algorithm

It progresses continuously through observation and perturbation until the operative point combines at the MPP. The P&O technique estimates the time required to reach the maximum power point by equating the voltage and power of time with the model at a given time (K-1). Figure 4 indicates the flowchart of the P&O algorithm.

3.4 PI Controller

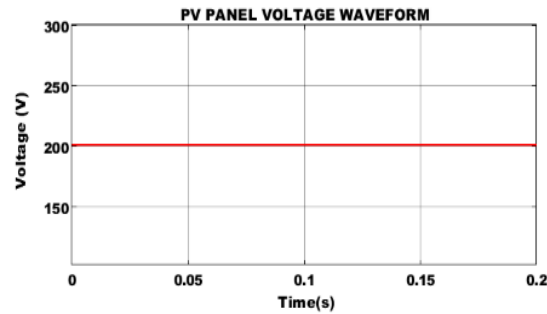
A closed loop approach based on PI controllers is used to maintain constant dc link voltage. Through the use of a PWM generator, the output from the PI is sent to the MMC, increasing the duty set's on time. The output of the MMC converter is then routed into a three-phase VSI, which transforms the dc supply into an AC supply by Dq theory that is delivered to the grid and it generates the reference signal transmits to the PWM generator, it generates the pulse and passes to the low frequency inverter.

4 Result and Discussions

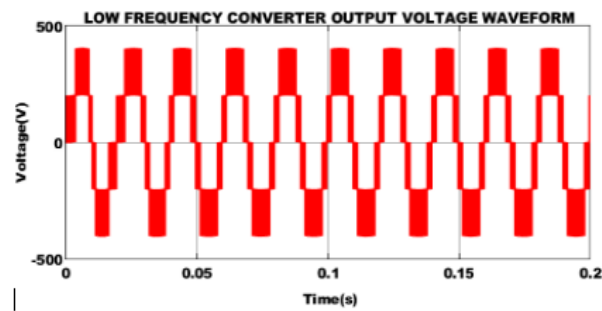
The MMC is used to charge the PV array at the power level where the PV array produces the maximum amount of electricity. Examined is the MMC-based maximum power point controller for the proposed system. The data that will be utilized for training are chosen using MATLAB/SIMULINK.



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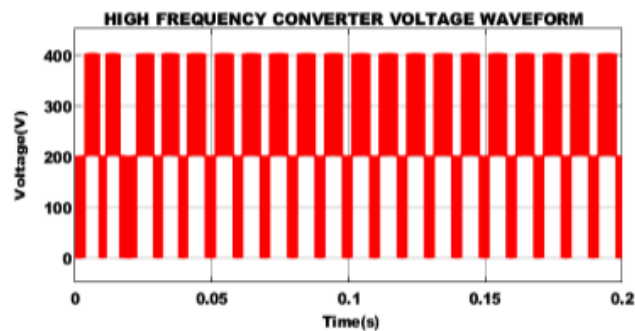
(a)



(b)

Figure 5: (a) Solar Panel Voltage Waveform (b) Low Frequency-Converter Voltage Waveform

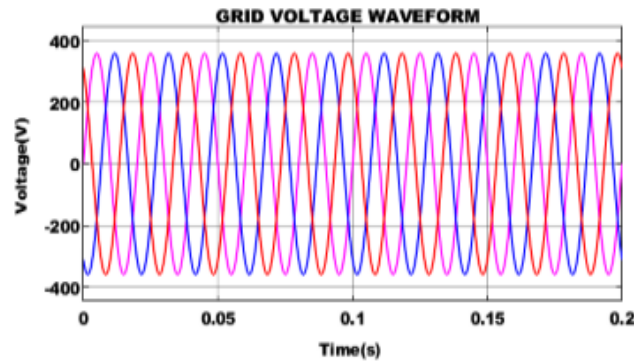
The Solar panel voltage waveform and converter output voltage waveform is shown in Figure 5. In this waveform the voltage in PV maintains the constant value at 200V and (b) shows the waves get slightly differ value as 500 V.



(a)



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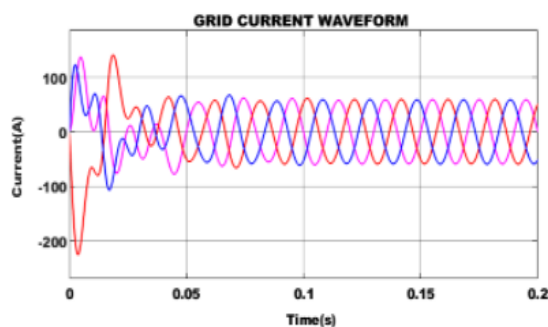


(b)

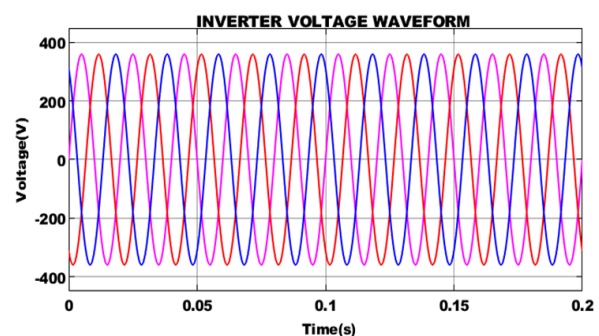
Figure 6: (a) High Frequency Voltage Waveform (b) Grid Voltage Waveform

The High frequency voltage waveform and grid voltage waveform is shown in Figure 6. In this waveform the voltage differs value at 400V and (b) shows the waves get slightly differ value as 400V.

The grid current waveform and inverter voltage waveform is shown in Figure 7. In this waveform the voltage varies at 100A and (b) shows the waves get slightly differ value at 400V. The Inverter Current waveform and Real Power waveform is shown in Figure 8. In this waveform the voltage fluctuates value at 200V and (b) shows the waves get increases and maintains the constant value at 4.5 W.



(a)



(b)

Figure 7: (a) Grid Current Waveform (b) Inverter Voltage Waveform



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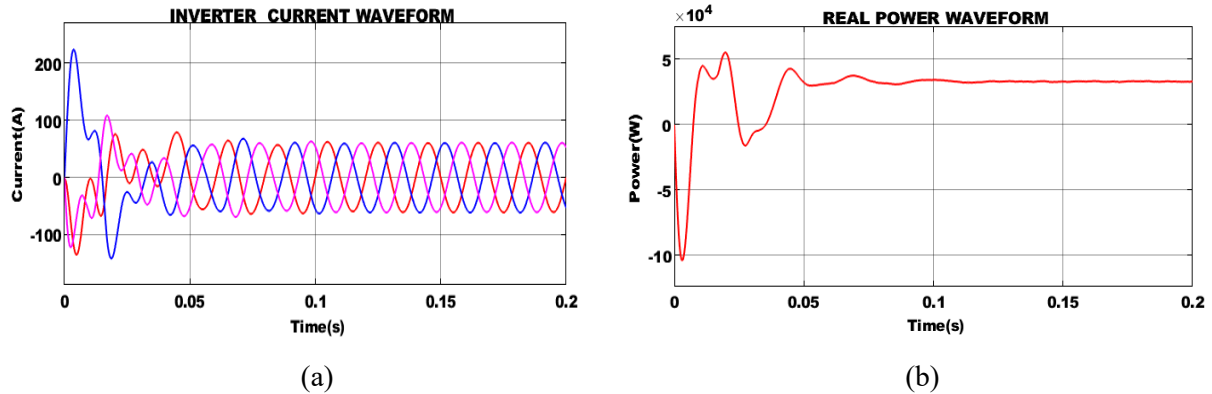


Figure 8: (a) Inverter Current Waveform (b) Real Power Waveform

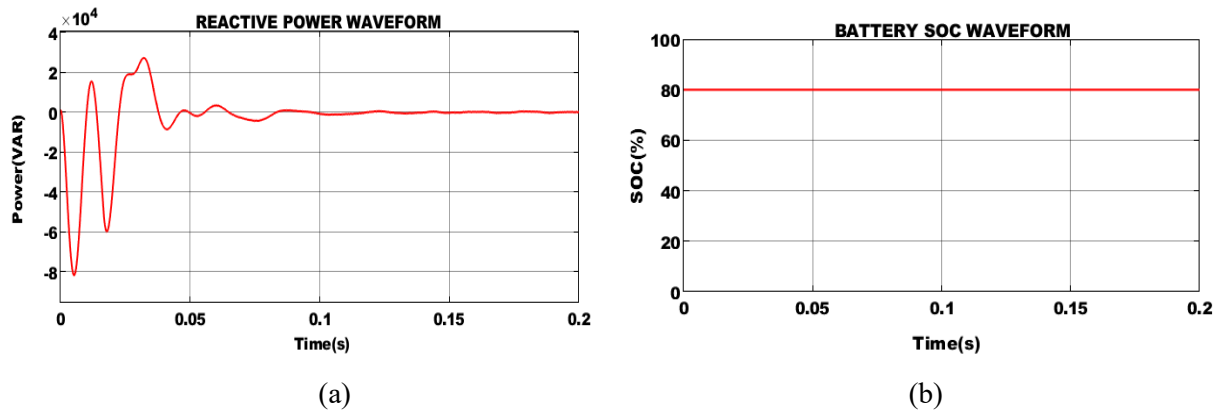


Figure 9: (a) Reactive Power Waveform (b) Battery SOC Waveform

The Reactive Power waveform and battery SOC waveform is shown in Figure 9. In this waveform the waves get increased and maintains the constant value at 0VAR and (b) shows the waves maintains the constant value at 80 %

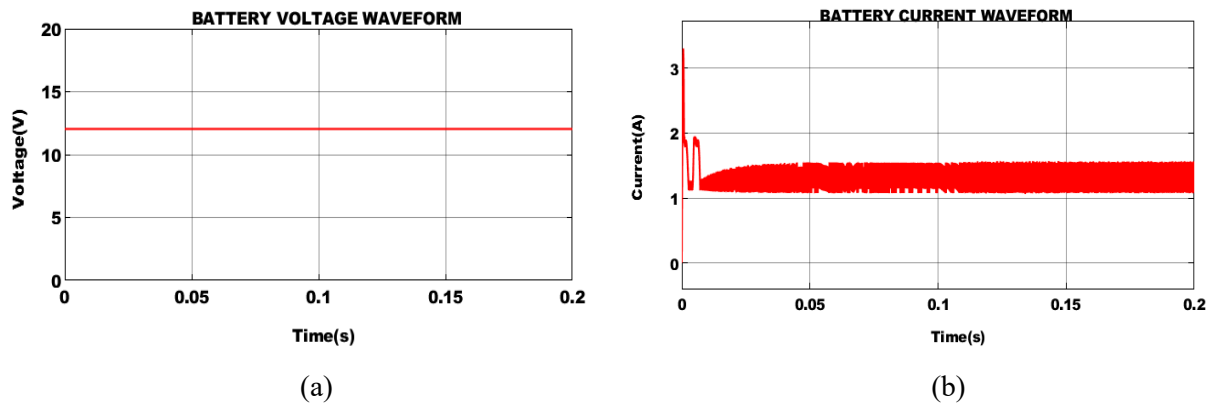


Figure 10: (a) Battery Voltage Waveform (b) Battery Current Waveform



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The battery voltage waveform and current waveform is shown in Figure 10. In this waveform the voltage maintains the constant value at 13V and (b) shows the waves get slightly increases after it maintains the constant value as 1A.

The assessment of the Efficiency Comparison of the controllers are listed in Figure 11, in which they are listed as 90.2% and 92.6% as INC and P&O respectively.

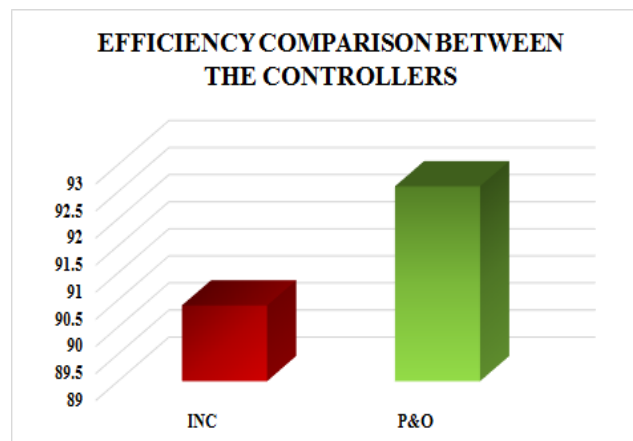


Figure 11: *Efficiency comparison*

5 Conclusion

The energy balancing method for an MMC topology-based PV system is presented, and its fundamental idea is to transmit power between the arms and converter legs in order to provide a balanced grid power transmission. The recommended approach enables balancing the MMC circuit for dealing with unequal PV power generation through the development of current references, tracking the maximum power using the P&O algorithm, and PI controller. The simulated results produced better waveforms, demonstrating the effectiveness of the proposed method. This is particularly crucial for enhancing grid dependability. The proposed concept is finally put into practice using the MATLAB 21/Simulink programme to monitor the battery system in electric vehicles and use a bi-directional battery converter.

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