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Advanced Maximum Power Point Tracking For Solar Panels Via Buck-Boost Converter Technology

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Abstract: The Maximum Power Transfer Theorem states that a solar module cannot transfer maximum power to the load independently due to impedance mismatch. To address this, a Maximum Power Point Tracking (MPPT) system is essential for extracting maximum power. This paper proposes an MPPT system using a buck-boost converter controlled by a PWM Generator. In this system, the output power of the photovoltaic (PV) module is measured and processed within the Simulink model. The MPPT control logic continuously compares the current output power with the previous value and adjusts the converter's duty cycle to track the maximum power point. This iterative process continues until the output power approaches the maximum power point. The proposed system employs an Incremental conductance algorithm to enhance tracking accuracy and efficiency while ensuring optimal power transfer from the PV module to the load and battery.

***Keywords* - PWM, Incremental conductance MPPT, Photovoltaic (PV), Buck-Boost Converter.**

I. Introduction

Solar energy can be converted into electrical energy through two primary methods: **solar thermal** and **solar photovoltaic**. The solar thermal approach operates similarly to conventional AC electricity generation using steam turbines. However, instead of relying on fossil fuels, it utilizes heat derived from concentrated solar rays to produce steam. On the other hand, solar photovoltaic systems employ silicon cells or other semiconductor materials to directly convert sunlight into electrical energy. To address the intermittent nature of solar energy and ensure power availability during nighttime, energy storage systems such as batteries are essential. In recent years, significant advancements have been made in the development of cost-effective flat-panel solar modules, concentrator systems, and other innovative technologies.

Solar power plants and photovoltaic modules are becoming increasingly accessible and cost-effective, paving the way for widespread adoption and large-scale energy production in the near future. This paper focuses on the operational principles of solar panels and the role of Maximum Power Point Tracking (MPPT) systems in enhancing their efficiency. By incorporating power electronic devices, the MPPT system significantly boosts the output power of solar panels.

The MPPT algorithm plays a crucial role in maximizing the efficiency of solar panels at a relatively low cost. In this design, a DC-DC converter is utilized to implement the MPPT algorithm. Among the various types of DC-DC converters, the buck-boost converter has been selected due to its suitability for this application.

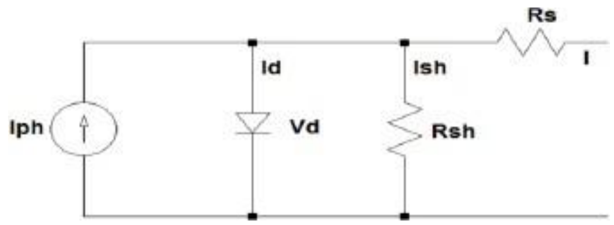


Fig 1: Equivalent Circuit of Solar Cell

Figure 1 illustrates the equivalent circuit of a solar cell, which is represented as a series resistance Rs Connected in parallel with the following components:

i. Current source
ii. An exponential diode
iii. A parallel resistor R_{sh}

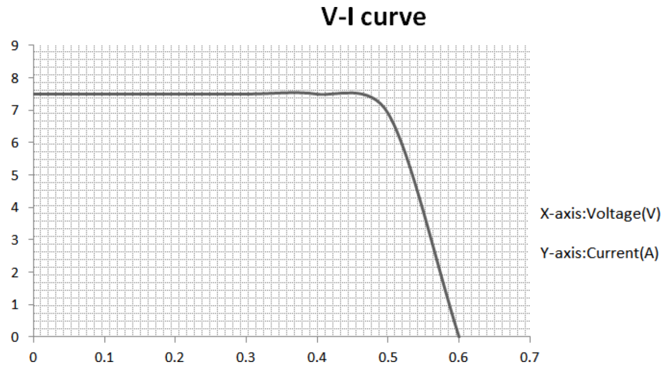
In general, photovoltaic (PV) generation systems, a microcontroller-based charge controller is typically employed to manage the connection between the solar module, battery, and load. The primary function of the charge controller is to regulate the charging process, ensuring that the batteries are neither overcharged nor undercharged. By maintaining optimal charging conditions, the charge controller significantly enhances the efficiency of PV battery systems. Furthermore, microcontroller-based designs offer intelligent control capabilities, further improving the overall system efficiency.

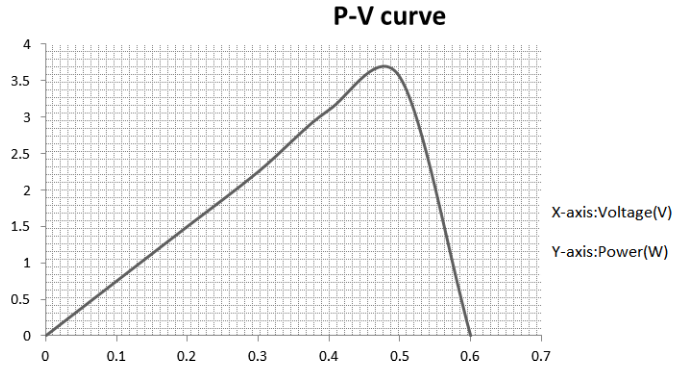
II. SOLAR CELL V-I CHARACTERISTICS

The voltage-current (V-I) characteristics of solar cells vary significantly depending on their design and operating conditions. As illustrated in Figure 1, the V-I curve of a typical photovoltaic cell exhibits a nonlinear relationship, which poses a challenge in extracting the maximum possible power from the solar panel. The V-I curve consists of two distinct plots: one representing the current response as voltage increases, and the other depicting the power-voltage (P-V) relationship, derived from the equation P=I×V.

The P-V curve reveals a single peak, known as the maximum power point (MPP), where the solar panel operates at its highest efficiency. This peak corresponds to a specific combination of voltage and current, enabling the panel to deliver its maximum power output. However, due to fluctuations in environmental factors such as temperature and irradiance, the panel cannot consistently maintain this peak power point. These variations cause deviations in the system's performance, making it necessary to continuously monitor and adjust the operating conditions.

The primary objective of the system is to track the P-V curve in real-time and ensure that the panel operates near its maximum power point. By doing so, the system maximizes energy extraction from the photovoltaic array, enhancing overall efficiency and performance.





III. PROPOSED INCREMENTAL CONDUCTANCE ALGORITHM

The incremental conductance algorithm depends on the slope of the P–V curve, which is affected by the solar ir radiation level and load resistance. As the algorithm uses the current and voltage of the PV module in the calcula tion, the effect of solar irradiation and load changes on the current and voltage of the PV module must be con sidered in the algorithm. Table 1 shows the summary of changes in the voltage and current of the PV module against the changes in solar irradiation level and load resistance. As shown in Fig. 3, when the PV system operates at load line 2 (point F) and solar irradiation suddenly increases, the operating point of the PV system moves to point G. Therefore, both voltage and current increase. Conversely, when the PV system operates at load line 1 (point E) and solar irradiation suddenly de creases, the operating point of the PV system moves to point H. Thus, both voltage and current decrease. In the conventional incremental conductance algo rithm, these two types of changes are not properly considered. Meanwhile, if the PV system operates at load line 1 and load resistance increases, the PV sys tem will operate at load line 2. Therefore, the PV module voltage increases and the PV module current decreases. Alternatively, the voltage decreases and the current increases when the load resistance decreases.

The proposed algorithm is shown in the flow chart in Fig. 6. When the irradiance changes, the current and voltage will be affected accordingly. This algorithm uses the instantaneous changes of current and voltage of PV modules. While the traditional incremental conductance algorithm makes a judgment on the position of the system operating point, the improved incremental conductance algorithm makes a judgment based on the directions of power, voltage and current. Considering the system at the left side of the MPP, for the system running in the positive direction (dv >0) the duty cycle will continue to move in the disturbance direction of the previous step, while for the system running in the negative direction (dv 0) the duty cycle will continue to move in the opposite direction of the disturbance of the previous step, whereas for the negative system operating direction.

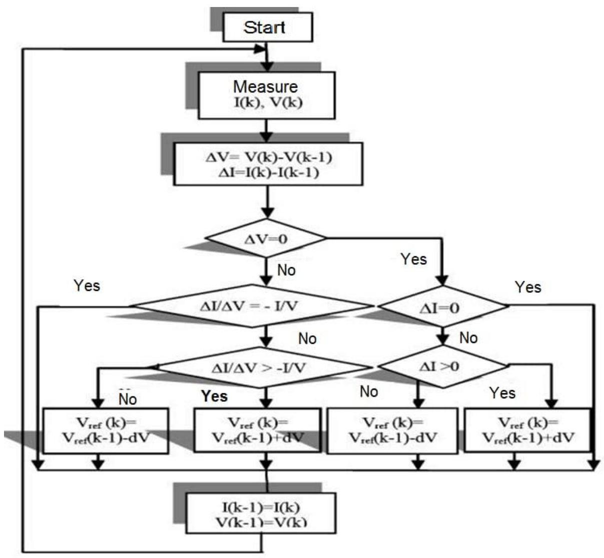


Fig 3(b): Flow chart of the proposed incremental conductance algorithm

IV. PROPOSED SYSTEM

In this approach, the PWM-based charge controller guarantees the transfer of maximum power to the load by dynamically adjusting the duty cycle. This adjustment ensures that the panel's resistance matches the load resistance, aligning with the principles of the Maximum Power Transfer Theorem. The system integrates a buck-boost converter, where the PWM signals are generated within the Simulink model. The MPPT control logic, implemented in Simulink, continuously monitors the PV panel's power output and adjusts the converter's duty cycle accordingly. This enables the system to efficiently extract maximum power from the solar panel, regardless of whether the load resistance is higher or lower than the optimal resistance for maximum power output.

V. RESULTS AND OBSERVATIONS

A. SIMULATION RESULTS

The simulation was conducted using MATLAB to determine the resistance value corresponding to the maximum power output. The solar cell model was selected from the SIM ELECTRONICS library in MATLAB. Multiple solar cells were interconnected in series and parallel configurations to construct a functional solar panel capable of delivering the specified voltage and current ratings.

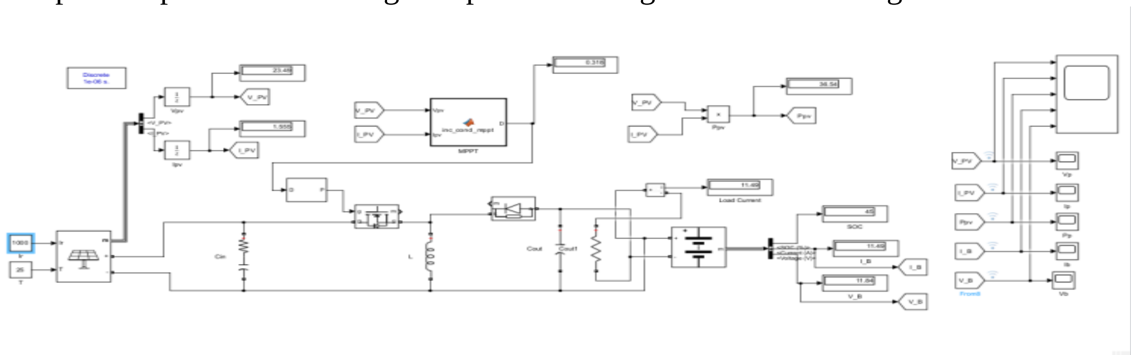


Fig 4(a): Model of Purposed System

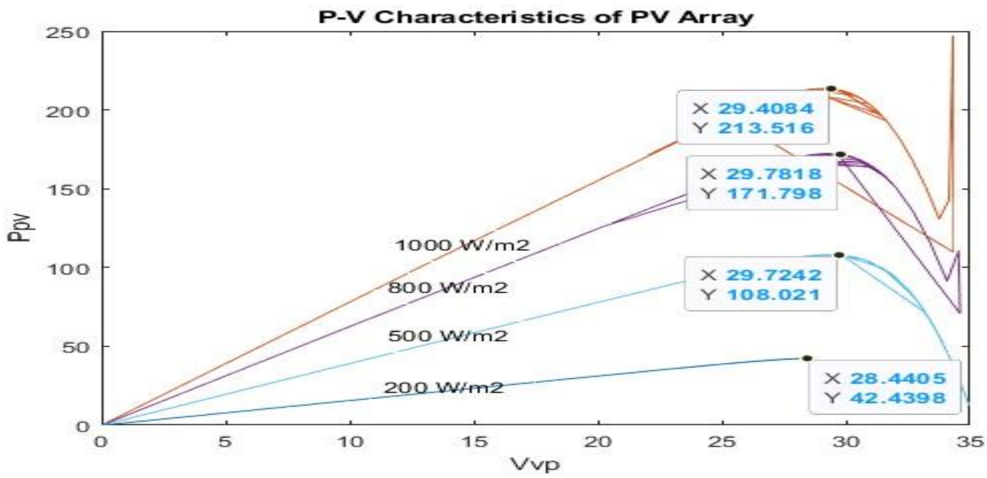


FIG 4(B): Power Generated by PV Panel at Different Irradiance

Output: The simulation outcomes demonstrate the panel's ideal performance characteristics, illustrating the relationship between voltage, current, power, charging and discharging Current as the solar Irradiation varies while Supplying constant Load current. These variations are graphically represented

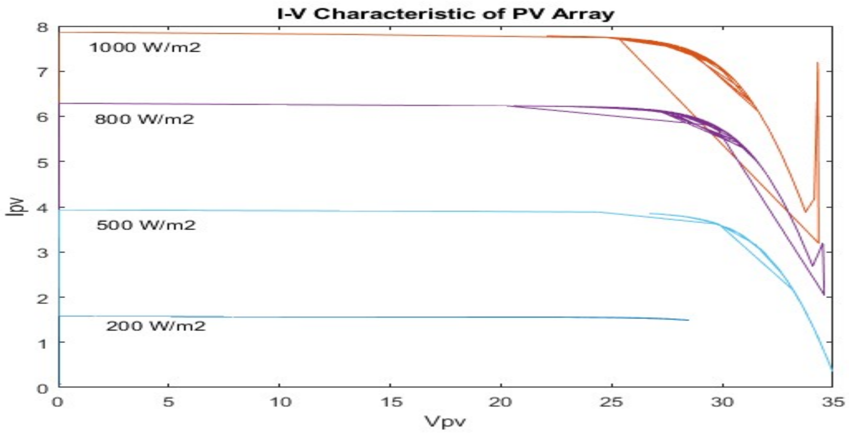


Fig 5: PV generated current at different Irradiance

The solar panel is constructed by arranging multiple solar cells in both series and parallel configurations. The panel consists generated maximum 213 watt at an illumination level of 1000 W/m². The solar cell model used in this setup is available in the MATLAB library.

Design of MPPT:

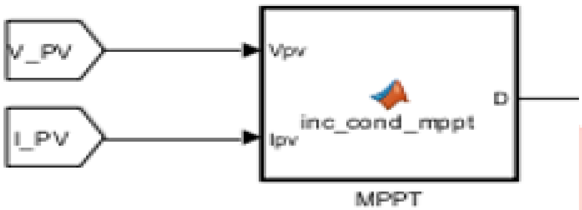


Fig 6: Design of MPPT

The MPPT is developed in MATLAB by utilizing the Embedded MATLAB Function block available in its standard library. The C code is integrated into the embedded function block, which produces an output value representing the duty cycle. This value is then fed into the PWM generator block to create the required PWM signal to the MOSFET Switch used in Buck Boost Converter.

B. DESIGN OF BUCK BOOST CONVERTER

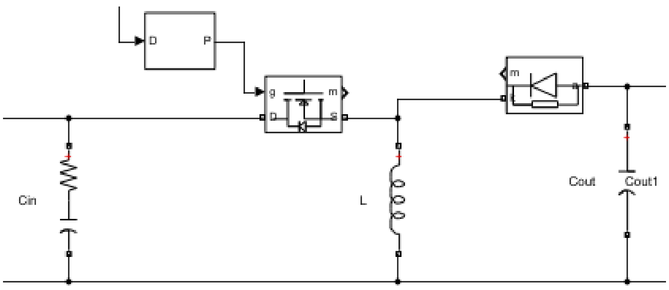


Fig 7: Design of Buck/Boost converter in MATLAB

The design of the buck-boost converter incorporates MOSFETs, diodes, and RLC elements, which are sourced from MATLAB's power system library.

C. DESIGN OF LC FILTER FOR BUCK BOOSTCONVERTER.

The input voltage (Vin) is 36 V, with an open-circuit voltage (Voc) of 12 V and a maximum power output (Pmax) of 213 W. At the maximum power point, the current is 7.35 A, and the voltage is 29 V. The operating frequency of the system is 40 kHz. The inductance (L) is calculated as 63×10−6 H, and the capacitance (C) is 1.57×10−6 F.

D. Scope Output at 1000 w/m2

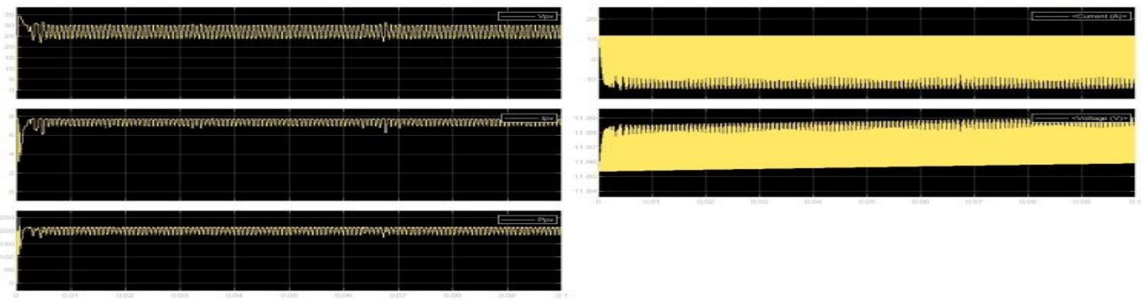


Fig 9: Scope Output

It is observed at Battery is drawing Load current for charging as PV Panel supplying sufficient current for load and additional current utilize for Charging of battery. Battery voltage increasing means battery is getting charged.

E. Scope Output at 200 w/m2

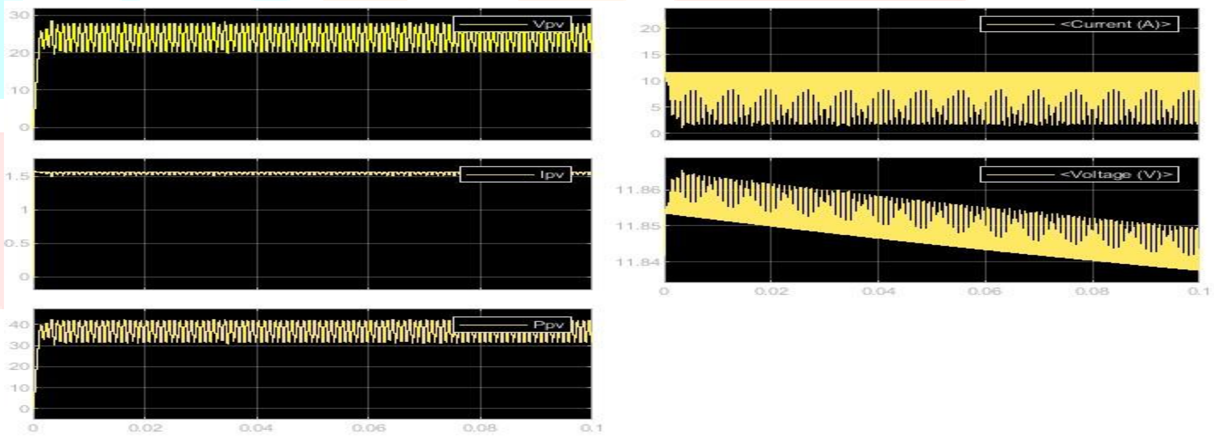


Fig:10 Scope Output

It is observed that at 200 w/m2 irradiance Battery is supplying Load current as PV Panel supplying insufficient current for load to maintain constant load current and battery getting discharged. Battery voltage decreases as shown in above fig.

The system switches to boost mode when the load resistance exceeds 18 ohms, which is higher than the resistance at which maximum power is achieved. In the output graph, the yellow line represents the solar panel's output, while the violet line indicates the output of the DC-DC converter. The difference between the two lines corresponds to losses in the converter, including switching losses and other inefficiencies. The MATLAB simulation was successfully executed, demonstrating the system's ability to accurately track the Maximum Power Point (MPP) of the solar panel.

V. CONCLUSION

This study presents a simple but efficient photo-voltaic system with maximum power point tracking. Description of each component like solar panel, DC-DC converter and charge controller is presented here. MATLAB simulations of I-V characteristics of solar panel are shown here. As, our aim was to design a system which can extract maximum output power, so we explained about maximum power point (MPP) and maximum power point tracking (MPPT). There are different algorithms for better result we used the Incremental Inductance method. As Irradiation decreases from 1000 w/m2 to 200 w/m2, battery current changes from Charging Current to Discharging Current while load current was constant.

VI. REFERENCES

[1] Jaber A. Abu-Qahouq, Batarseh I., and Yuncong Jiang, "Improved Solar P-V Cell MATLAB Simulation Model and Comparison," Circuits and Systems (ISCAS), pp. 2770–2773, 2010.

[2] M. E. Ropp and D. P. Hohm, "Comparative Study of Maximum Power Point Tracking Algorithms," IEEE Progress in Photovoltaics: Research and Applications, vol. 11, pp. 47–62, 2003.

[3] Juliano De Pellegrin, Hélio Leães Hey, Johninson Imhoff, and Pacheco Roger Gules, "A Maximum Power Point Tracking System with Parallel Connection for PV Stand-Alone Applications," IEEE Transactions on Industrial Electronics, vol. 55, no. 7, pp. 2674–2683, 2008.

[4] XiangQian Tong, XiangDong Sun, YanRu Zhong, and BiYing Ren, "Maximum Power Point Tracking Method Based on the Intermittent Step-Varied Search for PV Array," Power and Energy Engineering Conference, pp. 1–4, 2010.

[5] Tim C. Green, Carlos A. Hernandez-Aramburo, and Chee Wei Tan, "Analysis of Perturb & Observe Maximum Power Point Tracking Algorithm for Photovoltaic Applications," 2nd IEEE International Conference on Power and Energy (PECon 08), December 1–3, 2008.

[6] Alex Joseph and Kamal, "PV Array Characteristics Analysis under Partial Shading & Modeling of P&O MPPT Applied Boost Converter using MATLAB/Simulink," ICEETS, vol. 2, pp. 596–601, 2013.

[7] M. J. Youn and I. S. Kim, "Variable-Structure Observer for Solar Array Current Estimation in a Photovoltaic Power-Generation System," IEEE Proceedings-Electric Power Applications, vol. 152, no. 4, pp. 953–959, 2005.