

Design and Simulation of Solar PV System with MPPT using Perturb & Observe Method in MATLAB/Simulink

Priti Thakare
ELECTRICAL
RSR RCET BHILAI

ABSTRACT

The proposed work presents the implementation and validation of a Maximum Power Point Tracking (MPPT) algorithm based on the Perturb and Observe (P&O) technique for photovoltaic (PV) systems. The primary objective of the algorithm is to maximize the power extracted from the PV array under continuously changing environmental conditions such as solar irradiance and temperature.

Initially, the output voltage and current of the PV array are measured, and the corresponding output power is calculated. The computed power is then compared with the previously measured value to determine the direction of the operating point. If the present power exceeds the previous value, the operating point is updated toward the new maximum power point. This iterative process continues continuously, enabling the controller to track the maximum available power from the PV system.

Although the conventional P&O algorithm is simple and widely used, it produces small oscillations around the Maximum Power Point (MPP), which reduce the overall system efficiency. To overcome this limitation, a modified step-size adjustment strategy is incorporated into the proposed algorithm. The adaptive step-size approach minimizes steady-state oscillations while improving the tracking speed and stability of the system during sudden variations in irradiance and temperature.

Furthermore, the duty cycle of the DC–DC converter is continuously regulated to maintain proper impedance matching between the photovoltaic source and the load. This ensures efficient power transfer and enables the PV system to operate at or near its optimum operating point. The complete MPPT system is developed and simulated using MATLAB/Simulink, and the simulation results demonstrate improved tracking accuracy, enhanced system stability, reduced oscillations, and higher power extraction efficiency compared with the conventional P&O method.

. Keywords: Solar Photovoltaic (PV) System, Maximum Power Point Tracking (MPPT), Perturb and Observe (P&O) Algorithm, MATLAB/Simulink, Boost Converter, Solar Irradiance, Renewable Energy, Photovoltaic Array.

1 Introduction:

An element of energy is the measure of the actual energy that is perceived by the visible energy load flowing in the region. Basically a measure of how a current upload is converted into an active product. The smaller the power factor of the system, the less effective it is economically. [1]

1.1.Solar PV System

A photovoltaic (PV) system consists of several essential components that work together to convert solar energy into usable electrical power. The primary component is the solar cell, which directly converts sunlight into direct current (DC) electricity using the photovoltaic effect. Multiple solar cells are connected to form a PV module, and several modules are further combined to create a PV array for higher power generation. The output from the PV array is then regulated using a DC-DC converter, which adjusts the voltage level according to system requirements. To ensure maximum power extraction under varying environmental conditions, an MPPT (Maximum Power Point Tracking) controller is employed, which continuously adjusts the operating point of the system. In many applications, an inverter is also used to convert DC power into alternating current (AC) for compatibility with household or grid-connected systems. Additionally, batteries may be included for energy storage in standalone or hybrid systems. Together, these components ensure efficient, reliable, and continuous operation of the PV system.[1][2]

1.1.2 Solar Cell (Photovoltaic System)

A solar cell, commonly referred to as a photovoltaic (PV) cell, is a semiconductor device that converts solar energy directly into electrical energy through the photovoltaic effect. It is primarily fabricated from semiconductor materials such as silicon, which possess the ability to generate electricity when exposed to sunlight. When solar radiation strikes the surface of the PV cell, photons transfer their energy to the semiconductor material, releasing electrons and creating an electric current.

The term *photovoltaic* is derived from the Greek word *photo*, meaning light, and the unit *volt*, which represents electrical potential. Since a single solar cell generates only a small amount of voltage and current, multiple cells are electrically connected to form a photovoltaic module or solar panel. Several PV modules are further interconnected to create a PV array capable of producing sufficient electrical power for practical applications. Large-scale PV arrays, consisting of hundreds or thousands of interconnected solar cells, are widely employed for electricity generation in residential, commercial, and industrial sectors.

Photovoltaic systems have become one of the most promising renewable energy technologies due to their clean, reliable, and environmentally friendly nature. Small PV installations, commonly known as solar panels, are extensively used on rooftops and open spaces to supplement or replace conventional grid electricity. Larger grid-connected PV plants are increasingly being adopted to meet the growing demand for sustainable electrical energy.

The performance of a photovoltaic cell is strongly influenced by environmental conditions, particularly solar irradiance and temperature. Under Standard Test Conditions (STC), PV cells exhibit their maximum efficiency, which is typically around 20–25% for commercially available silicon-based modules. However, an increase in cell temperature reduces the output voltage and overall conversion efficiency. Consequently, effective thermal management and proper system design are essential for maintaining optimum PV performance and maximizing energy generation under varying climatic conditions.

[7]

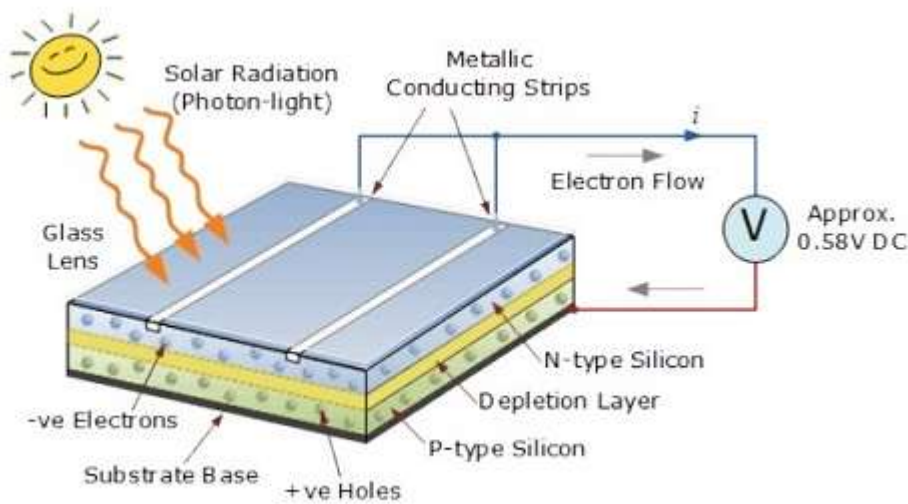
1.1.3 Working of Solar Cell

A solar cell operates on the principle of the **photovoltaic effect**, in which solar energy is directly converted into electrical energy. The fundamental structure of a solar cell consists of a **p–n junction** formed by joining p-type and n-type semiconductor materials, typically silicon. When sunlight with photon energy greater than the semiconductor bandgap falls on the surface of the solar cell, the incident photons are absorbed, resulting in the generation of electron-hole pairs within the semiconductor material.

A conventional silicon solar cell is fabricated by diffusing a thin layer of **n-type silicon (n-Si)** onto one surface of a **p-type silicon (p-Si)** wafer, thereby forming a p–n junction. This junction establishes an internal electric field that plays a crucial role in separating the generated charge carriers. A metallic contact is provided on the rear surface of the p-type layer, known as the **back contact**, while the front surface of the n-type layer is covered with fine metallic grid lines or finger electrodes, referred to as the **front contact**, which collect the generated current with minimal shading losses.

To maximize light absorption and improve electrical output, the active surface area of the solar cell is designed to be as large as possible. When solar radiation strikes the cell, three fundamental processes take place simultaneously: the generation of electron-hole pairs, the separation of these charge carriers by the internal electric field of the p–n junction, and the collection of electrons and holes at the respective metal contacts. These processes generate an electromotive force (EMF), allowing current to flow through an external load and thereby converting solar energy into useful electrical power.

The overall operation of a photovoltaic cell is therefore based on the continuous generation, separation, and collection of charge carriers. The efficiency of this energy conversion process depends on several factors, including the semiconductor material, solar irradiance, operating temperature, and the quality of the p–n junction. Owing to its simple operating principle and clean energy conversion capability, the photovoltaic cell has become the fundamental building block of modern solar power generation systems.[10]



Fig;1.1 working of solar

1.5 Solar Irradiance (G) and Photovoltaic Cell Temperature (T)

1.5.1 Solar Irradiance

Solar irradiance is defined as the amount of solar power incident on a unit surface area and is expressed in watts per square meter (W/m^2). It represents the instantaneous intensity of sunlight falling on a photovoltaic (PV) module. Mathematically, irradiance is the ratio of solar power to the surface area receiving the radiation. It should not be confused with solar irradiation, which refers to the total solar energy received over a specific period of time.

Solar irradiance is one of the most influential environmental parameters affecting the performance of photovoltaic systems. As the level of irradiance increases, a greater number of photons strike the surface of the PV cell, resulting in the generation of more electron-hole pairs. Consequently, the photocurrent or short-circuit current of the PV module increases almost linearly with irradiance. This leads to an upward shift in the current-voltage (I-V) characteristic and a corresponding increase in the output power of the PV system. Therefore, higher solar irradiance significantly enhances the energy conversion capability of photovoltaic modules. [9][10]

1.5.2 Standard Test Conditions (STC)

The electrical performance of photovoltaic modules is generally specified under Standard Test Conditions (STC) to ensure uniformity and facilitate comparison among different PV modules. According to STC, the operating conditions are defined as:

- **Solar Irradiance = 1000 W/m^2**
- **Cell Temperature = 25°C (298 K)**
- **Air Mass = AM 1.5**

These standardized conditions provide a common reference for evaluating the rated performance and efficiency of photovoltaic modules.

1.5.3 Effect of Solar Irradiance Variation

The variation in solar irradiance has a significant influence on the electrical characteristics of a photovoltaic system. When the cell temperature is maintained constant and the irradiance varies from 200 W/m^2 to 1000 W/m^2 , noticeable changes occur in both the current-voltage (I-V) and power-voltage (P-V) characteristics.

As the irradiance increases, the number of incident photons also increases, producing more electron-hole pairs within the semiconductor material. Consequently, the output current of the PV module increases almost linearly, while the open-circuit voltage exhibits only a slight increase. This increase in current causes the I–V characteristic curve to shift upward. Similarly, the maximum output power of the PV module also increases, resulting in an upward shift of the P–V characteristic.

Hence, solar irradiance plays a vital role in determining the power generation capability of photovoltaic systems. Higher irradiance levels lead to greater electrical output and improved overall system performance, whereas lower irradiance conditions reduce the generated current and output power.

2 . Literature Review

Literature Review Table

s.no	Title	Candidate details	Drawback/ soltuion
1	Perturb and Observe MPPT Algorithm for Solar PV Systems- Modeling and Simulation	Jacob James Nedumgatt, Jayakrishnan K. B., Umashankar S., Vijayakumar D., School of Electrical Engineering VIT University Vellore, India. jacob_jned@yahoo.com, jayakrishnankb007@gmail.com shankarums@gmail.com, vijayakumar.d@vit.ac.in.	Fixed Step Size Limitation The use of a fixed perturbation step size leads to a compromise between tracking speed and accuracy, resulting in either slow response or increased oscillations.[1]
2	Design and Simulation of a Photovoltaic System with MPPT Control using P&O Algorithm	Mr. Amit Malviyal , Mr. Burla Sridhar2 1Student, Electrical & Electronics, Oriental Institute Of Science And Technology 2Assistant Professor, Electrical & Electronics, Oriental Institute Of Science And Technology	Oscillation around Maximum Power Point The conventional Perturb and Observe (P&O) algorithm produces continuous oscillations around the maximum power point, which reduces the overall efficiency of the system.[1][5]

2.5 Problem Identification

Solar photovoltaic (PV) systems generate electrical power from solar energy; however, their output power varies continuously with changes in solar irradiance. Under varying irradiance conditions, the operating point of the PV array shifts away from the Maximum Power Point (MPP), resulting in reduced power generation and lower system efficiency. If the PV system operates without an effective Maximum Power Point Tracking (MPPT) controller, a significant portion of the available solar energy cannot be utilized efficiently. Therefore, a reliable MPPT technique is required to continuously track the MPP and maximize power extraction under changing irradiance conditions.[26][27]

3 .Methodology

3.1 System Description

The proposed photovoltaic (PV) system is designed to maximize the extraction of solar energy by employing a Maximum Power Point Tracking (MPPT) controller based on the Perturb and Observe (P&O) algorithm. The overall system consists of three major components: a photovoltaic (PV) array, a DC–DC boost converter, and an MPPT controller.

The PV array converts incident solar irradiance into electrical energy. Since the output characteristics of the PV array continuously vary with changes in solar irradiance and temperature, a DC–DC boost converter is incorporated to

regulate the output voltage and provide control over the operating point. The MPPT controller continuously measures the PV voltage and current, calculates the output power, and adjusts the converter duty cycle to ensure that the PV system operates at or near the Maximum Power Point (MPP). This configuration has been widely adopted in photovoltaic applications due to its simplicity, reliability, and high tracking efficiency.

3.2 Mathematical Modeling of PV System

The photovoltaic system is modeled using the widely accepted **single-diode equivalent circuit model**, which offers an effective balance between modeling accuracy and computational simplicity. The equivalent circuit consists of a photo-generated current source, a diode, a series resistance, and a shunt resistance.

The output characteristics of the PV module depend primarily on solar irradiance, cell temperature, and terminal voltage. Owing to the nonlinear relationship between current and voltage, the PV module exhibits nonlinear current-voltage (I–V) and power-voltage (P–V) characteristics. These curves vary significantly with changing environmental conditions and are fundamental for determining the Maximum Power Point (MPP). Therefore, the single-diode model serves as an effective tool for analyzing and simulating the performance of photovoltaic systems under different operating conditions.

3.4 Implementation of P&O MPPT Algorithm

The Perturb and Observe (P&O) algorithm is implemented to continuously track the Maximum Power Point of the photovoltaic system. The algorithm operates by introducing a small perturbation in the operating voltage of the PV array and observing the resulting variation in output power.

During each sampling interval, the PV voltage and current are measured to calculate the instantaneous output power. The calculated power is then compared with its previous value to determine whether the operating point is moving toward or away from the Maximum Power Point. If the output power increases, the perturbation continues in the same direction; otherwise, the direction of perturbation is reversed. This iterative process enables continuous tracking of the MPP despite variations in solar irradiance and temperature.

To improve the performance of the conventional P&O method, an adaptive step-size mechanism is incorporated to reduce steady-state oscillations around the MPP while maintaining fast tracking speed under rapidly changing environmental conditions.

3.5 MATLAB/Simulink Model Development

The performance of the proposed PV system is evaluated under varying environmental conditions by changing solar irradiance and cell temperature throughout the simulation. The MPPT controller continuously adjusts the duty cycle of the DC–DC boost converter to maintain operation at or near the Maximum Power Point.

The effectiveness of the proposed system is assessed by analyzing important performance parameters, including output voltage, output current, output power, tracking efficiency, and converter response. In addition, the current-voltage (I–V) and power-voltage (P–V) characteristics are examined under different irradiance and temperature conditions to verify the tracking capability of the MPPT algorithm. The simulation results demonstrate the ability of the proposed controller to extract maximum available power while maintaining stable system operation under continuously changing environmental conditions.

3.7 P&O MPPT Algorithm Implementation

The Perturb and Observe algorithm is implemented to track the maximum power point. The steps involved are:

1. Measure PV voltage (V) and current (I)

2. Calculate power ($P = V \times I$)
3. Compare current power with previous power
4. Adjust duty cycle accordingly:
 - If power increases $\rightarrow$ continue in same direction
 - If power decreases $\rightarrow$ reverse direction

This process is repeated continuously to maintain operation near the MPP.

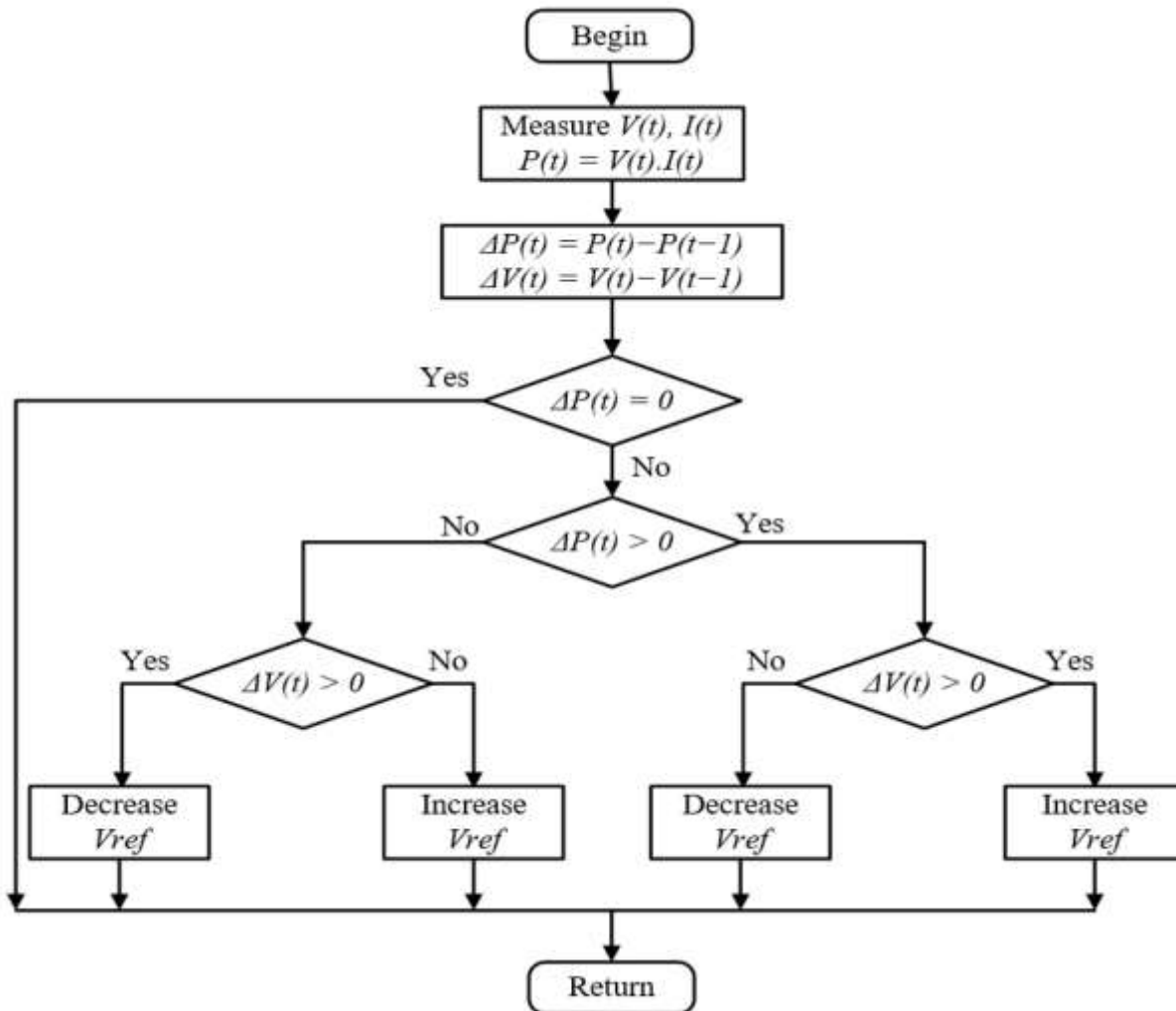


Fig:3.1 flow chart of P&O method working

The flowchart illustrates the operating principle of the **Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT)** algorithm used in photovoltaic (PV) systems. The algorithm begins by continuously measuring the instantaneous output voltage ($V(t)$) and current ($I(t)$) of the PV array. Using these measured values, the output power is calculated as $P(t) = V(t) \times I(t)$. The calculated power and voltage are then compared with their previously recorded values to determine the change in power (ΔP) and the change in voltage (ΔV).

Initially, the algorithm checks whether the change in power is zero. If ($\Delta P = 0$), the operating point is considered to be at or very close to the Maximum Power Point (MPP), and therefore no further adjustment of the operating voltage is required. However, if a change in power is detected, the algorithm determines whether the operating point is moving toward or away from the MPP.

When ($\Delta P > 0$), the output power has increased, indicating that the previous perturbation moved the operating point closer to the Maximum Power Point. Consequently, the reference voltage is adjusted in the same direction as the

previous perturbation. If ($\Delta V > 0$), the reference voltage is increased further, whereas if ($\Delta V < 0$), the reference voltage is decreased further.

Conversely, when ($\Delta P < 0$), the output power decreases, indicating that the operating point has moved away from the Maximum Power Point. In this situation, the direction of perturbation is reversed. Thus, if ($\Delta V > 0$), the reference voltage is decreased, whereas if ($\Delta V < 0$), the reference voltage is increased. This decision-making process is repeated continuously throughout system operation, allowing the controller to dynamically track the Maximum Power Point under varying solar irradiance and temperature conditions.

Although the conventional P&O algorithm is simple, reliable, and widely adopted in photovoltaic applications, it exhibits small steady-state oscillations around the Maximum Power Point. Nevertheless, due to its ease of implementation, low computational complexity, and satisfactory tracking performance, the P&O algorithm remains one of the most commonly used MPPT techniques in photovoltaic energy conversion systems.[12][11]

3.9 Proposed Solution

To overcome this problem, a MATLAB/Simulink-based Solar PV system integrated with a **Boost DC–DC converter** and the **Perturb and Observe (P&O) MPPT algorithm** is developed. The P&O algorithm continuously measures the PV voltage and current, calculates the output power, and adjusts the converter duty cycle to keep the PV array operating near the Maximum Power Point. The proposed model is evaluated under different solar irradiance conditions to analyse its tracking capability, output voltage, current, and generated power.

Research Gap

Most existing studies focus on the theoretical analysis of MPPT techniques or evaluate photovoltaic systems under fixed operating conditions. Comparatively fewer studies present a MATLAB/Simulink implementation that analyses the performance of a Solar PV system using the conventional Perturb and Observe (P&O) algorithm under different irradiance levels. Therefore, this work develops and evaluates a MATLAB/Simulink-based PV system with a Boost converter and P&O MPPT controller to investigate its performance under varying solar irradiance conditions.

4 Simulation and Analysis

Figure 4.1 illustrates the complete MATLAB/Simulink model of the proposed photovoltaic (PV) system, including all major components such as the PV array, DC–DC boost converter, PWM generator, measurement blocks, and the MPPT controller. The overall system configuration and interconnection of all components are presented in this figure.

The **Perturb and Observe (P&O) MPPT algorithm**, which is the core control strategy of the proposed system, is illustrated separately in **Figure 4.2**. This figure provides a detailed representation of the algorithm used to continuously track the Maximum Power Point (MPP) by regulating the duty cycle of the DC–DC converter.

Work 2: MATLAB/Simulink Model of the Solar PV System with MPPT

The MATLAB/Simulink model of the proposed solar photovoltaic (PV) system with Maximum Power Point Tracking (MPPT) is illustrated in Figure 4.2. The model includes the PV array, DC–DC boost converter, PWM generator, measurement blocks, and the MPPT controller.

The figure below illustrates the configuration and parameter settings of the MPPT controller used in the proposed system. Among the various available MPPT techniques, the Perturb and Observe (P&O) method has been selected because of its simple implementation, low computational complexity, and reliable tracking performance. The controller continuously measures the PV voltage and current, calculates the output power, and adjusts the converter duty cycle to ensure that the photovoltaic system operates at or near the Maximum Power Point (MPP) under varying irradiance and temperature conditions.

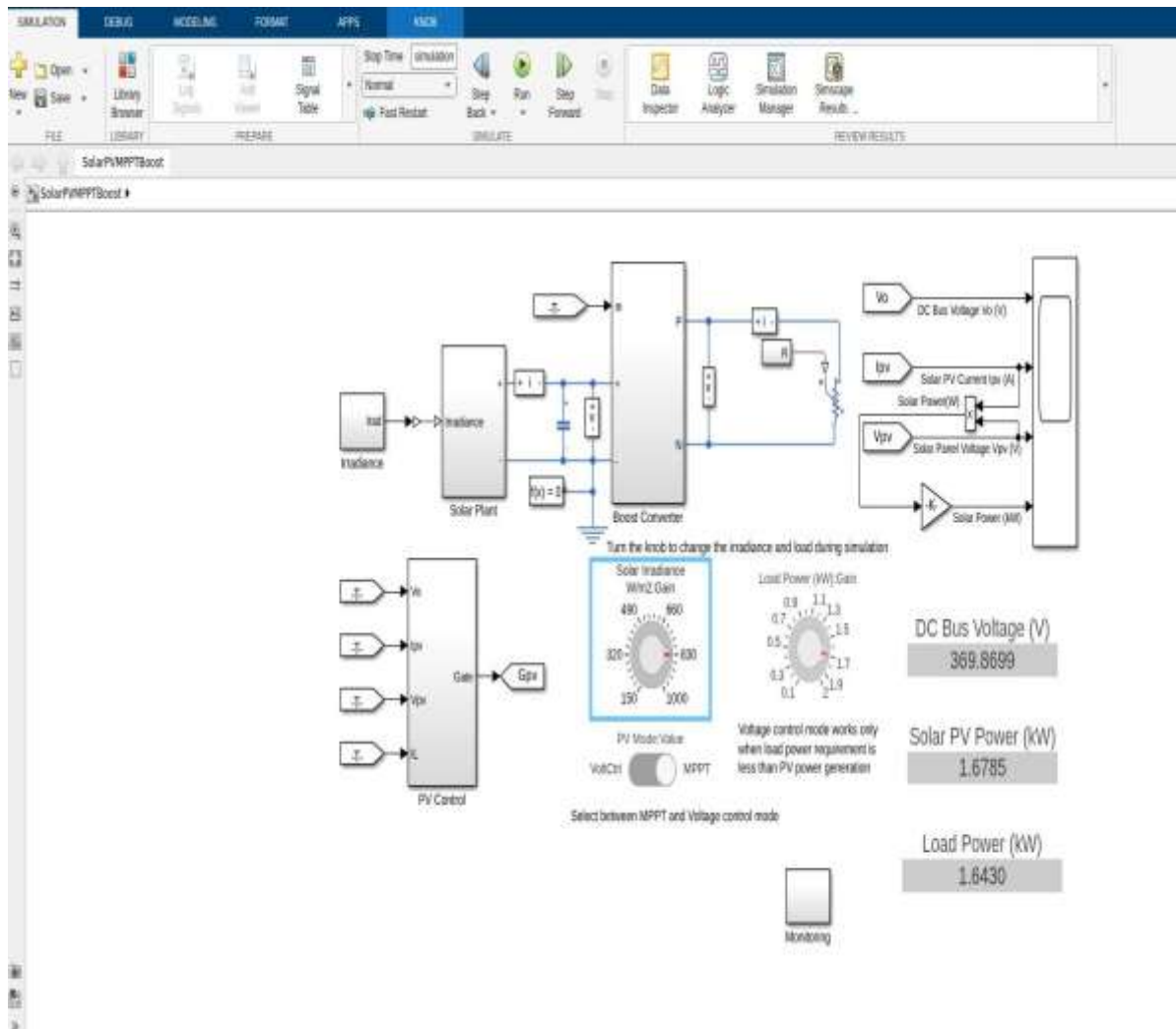
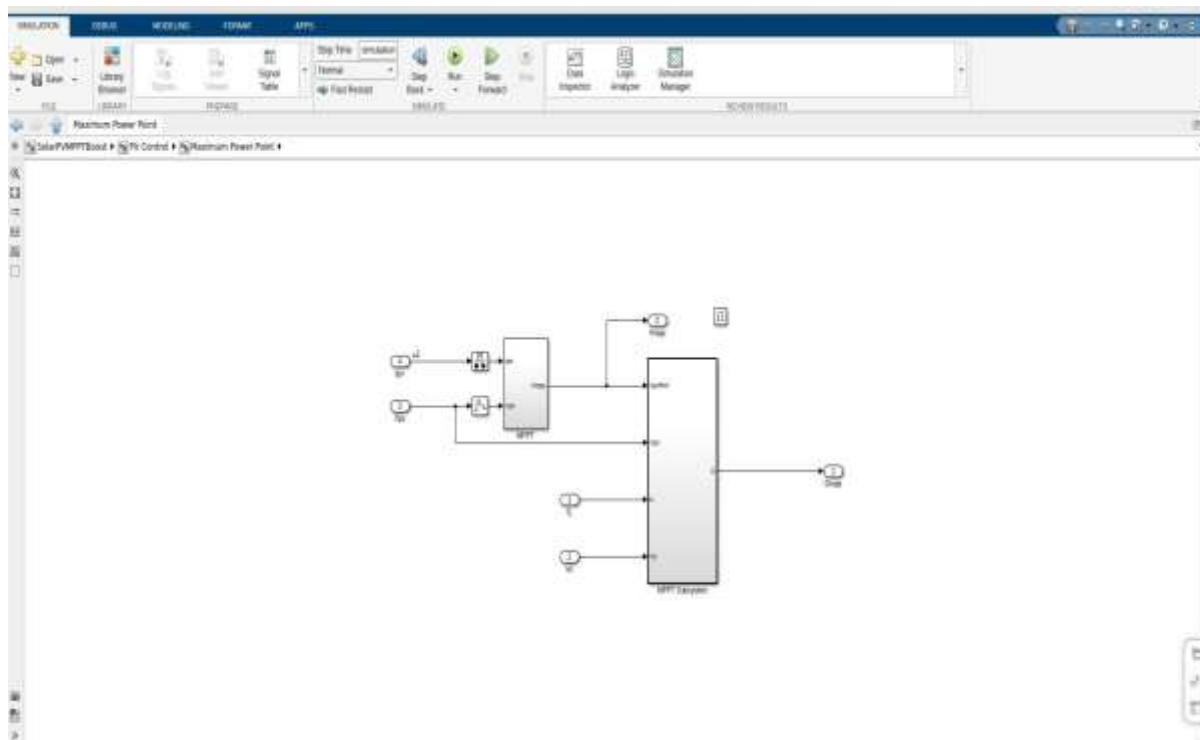


Fig. 4.1 MATLAB/Simulink Model of the Proposed Photovoltaic (PV) System

The parameter values of the P&O algorithm, including the sampling time and step size, are configured within the MATLAB/Simulink environment. These settings enable the controller to achieve fast and stable maximum power tracking while minimizing oscillations around the Maximum Power Point.



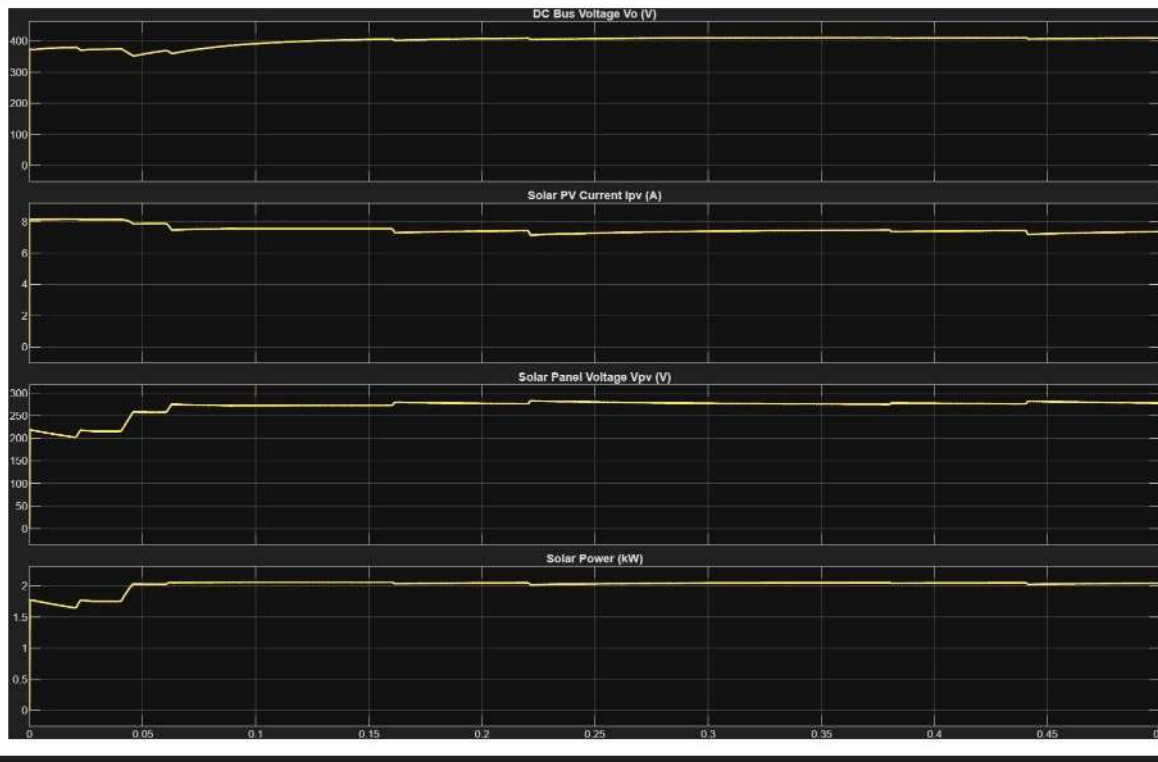
Fig;4.2 MATLAB Simulink model of solar PV system with MPPT

5. Results and Discussion

5.1 Effect of Perturbation Step Size on MPPT Performance

In the present study, the performance of the **Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT)** algorithm is evaluated by varying the perturbation step size in the MATLAB/Simulink environment. The simulation results indicate that the selection of the perturbation step size has a significant impact on the dynamic

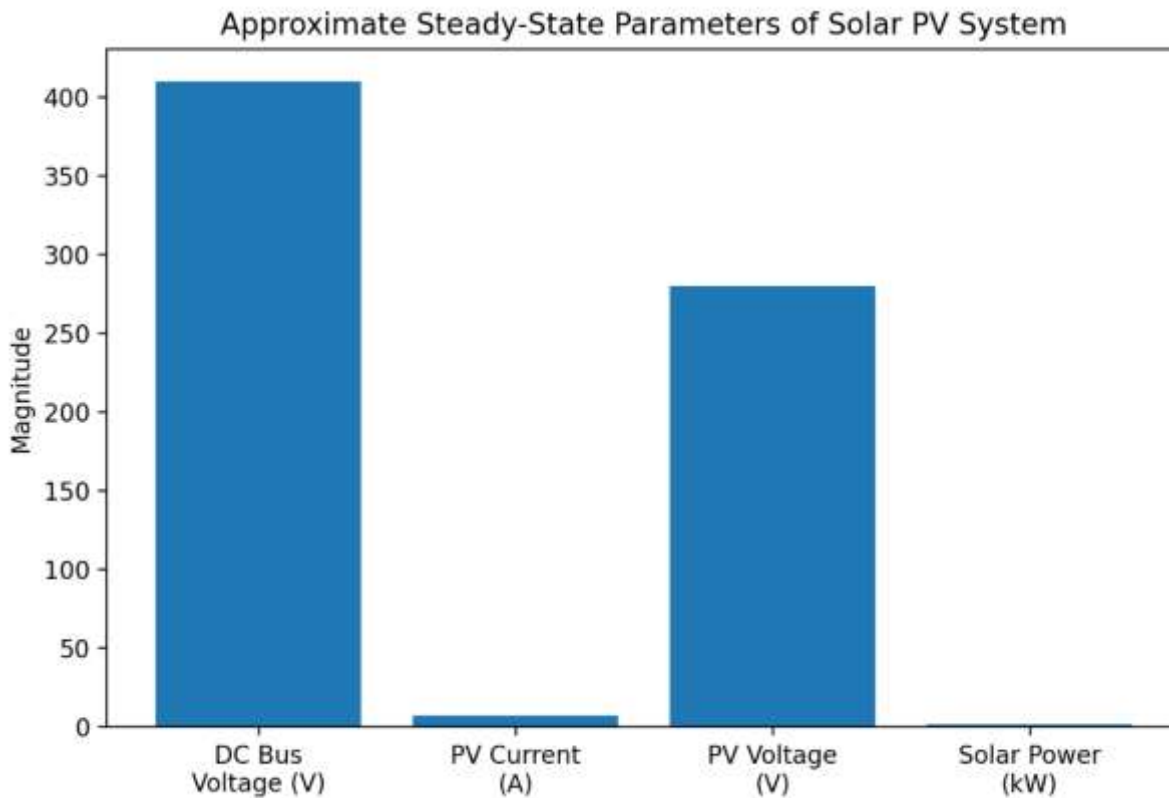
performance, tracking accuracy, and stability of the photovoltaic (PV) system.



When a **larger perturbation step size** is employed, the MPPT controller reaches the vicinity of the Maximum Power Point (MPP) more rapidly, resulting in faster tracking of the optimum operating point. However, the increased tracking speed introduces larger oscillations around the MPP, causing fluctuations in the output power and consequently reducing the overall energy conversion efficiency.

Conversely, when a **smaller perturbation step size** is selected, the oscillations around the Maximum Power Point are considerably reduced, leading to a smoother and more stable power output. Nevertheless, the tracking speed decreases, and the controller requires a longer time to reach the MPP, particularly under rapidly changing environmental conditions such as variations in solar irradiance and cell temperature.

The simulation results demonstrate that a trade-off exists between tracking speed and steady-state stability. Therefore, selecting an appropriate perturbation step size is essential for achieving optimum MPPT performance. An optimal step size enables the controller to maintain fast convergence toward the Maximum Power Point while minimizing steady-state oscillations, thereby improving the overall efficiency and reliability of the photovoltaic system.



6 Conclusions and Future Scope

6.1 Conclusions

The present work, “**Design and Simulation of Solar PV System with MPPT using Perturb and Observe Method in MATLAB/Simulink,**” successfully demonstrates the modeling, simulation, and performance analysis of a photovoltaic (PV) system integrated with a Maximum Power Point Tracking (MPPT) controller based on the Perturb and Observe (P&O) algorithm.

A comprehensive MATLAB/Simulink model was developed to evaluate the performance of the PV system under varying environmental conditions, including changes in solar irradiance and cell temperature. The simulation results reveal that solar irradiance has a significant influence on the output current and power of the PV system, whereas cell temperature primarily affects the output voltage. These environmental variations continuously shift the operating point of the PV array, thereby highlighting the importance of implementing an MPPT algorithm to ensure maximum power extraction.

The implemented P&O algorithm successfully tracks the Maximum Power Point (MPP) by continuously adjusting the operating point of the PV system. Simulation results confirm that the proposed MPPT controller improves power extraction, enhances system efficiency, and provides stable operation under different operating conditions. Although the conventional P&O algorithm is simple, reliable, and easy to implement, it exhibits small steady-state oscillations around the MPP, which slightly reduce the overall system efficiency.

In future work, the proposed system can be enhanced by implementing an **adaptive step-size Perturb and Observe (P&O) algorithm**, which offers a better compromise between tracking speed and steady-state accuracy. Such an approach can significantly reduce oscillations around the Maximum Power Point while maintaining fast convergence under rapidly changing weather conditions.

Furthermore, the integration of a **Battery Energy Storage System (BESS)** can be considered to improve system reliability and ensure continuous power supply during periods of low solar irradiance or nighttime operation. In

addition, advanced MPPT techniques based on **Artificial Intelligence (AI)**, **Fuzzy Logic**, **Artificial Neural Networks (ANN)**, or **Machine Learning (ML)** may be incorporated to further enhance tracking accuracy and overall system performance. These improvements would make the proposed PV system more suitable for standalone, grid-connected, and hybrid renewable energy applications.

6.2 Future Scope

The project entitled “Design and Simulation of Solar PV System with MPPT using Perturb and Observe Method in MATLAB/Simulink” establishes a comprehensive foundation for the modeling, simulation, and performance evaluation of photovoltaic (PV) systems employing Maximum Power Point Tracking (MPPT) techniques. The present work successfully demonstrates the implementation of the conventional Perturb and Observe (P&O) algorithm in the MATLAB/Simulink environment for efficient maximum power extraction under varying environmental conditions.

Although the conventional P&O algorithm provides a simple, reliable, and cost-effective solution for MPPT implementation, its performance can be further enhanced in future research. One potential improvement is the implementation of advanced MPPT techniques such as Incremental Conductance (INC), Fuzzy Logic Control (FLC), Artificial Neural Networks (ANN), Particle Swarm Optimization (PSO), or other hybrid optimization algorithms. These intelligent control techniques can significantly improve tracking accuracy, reduce steady-state oscillations around the Maximum Power Point (MPP), and provide faster convergence under rapidly changing solar irradiance and temperature conditions.

Furthermore, the proposed system can be extended by integrating a Battery Energy Storage System (BESS) to ensure continuous power supply during low irradiance periods and nighttime operation. The developed PV system may also be implemented as a grid-connected photovoltaic system, enabling power exchange with the utility grid and improving overall energy utilization. In addition, incorporating Internet of Things (IoT) technology for real-time monitoring and data acquisition can enhance system reliability, remote supervision, and predictive maintenance.

Future research may also focus on comparative performance analysis of different MPPT algorithms under partial shading conditions, varying weather environments, and dynamic load conditions. Such investigations would contribute to improving the efficiency, stability, and reliability of modern photovoltaic energy systems, making them more suitable for large-scale renewable energy and smart grid applications.

References

[1] Perturb and Observe MPPT Algorithm for Solar PV Systems-Modeling and Simulation.

Jacob James Nedumgatt, Jayakrishnan K. B., Umashankar S., Vijayakumar D., School of Electrical Engineering VIT University Vellore, India. jacob_jned@yahoo.com, jayakrishnankb007@gmail.com shankarums@gmail.com, vijayakumar.d@vit.ac.in.

[2] Modelling and Simulation of Perturb and Observe MPPT Algorithm Based on The PI Controller for Photovoltaic System. Ahlam Mohamad Shakoor Hersh Hasan Taha Petroleum and Energy Kirkuk Refinery Department Technical College of Engineering North Refineries Company Sulaimani Polytechnic University Ministry of Oil Sulaimani, Iraq Salah Al-Din, Iraq Ahlam.shakoor@spu.edu.iq harieshshassan@gmail.com Volume 7 - Issue 2- December 2022 DOI: 10.24017/Science.2022.2.6 Article history: Received: 19/06/2022 Accepted: 20/11/2022

[3] Design and Simulation of a Photovoltaic System with MPPT Control using P&O Algorithm Mr. Amit Malviya¹, Mr. Burla Sridhar² ¹Student, Electrical & Electronics, Oriental Institute Of Science And Technology ²Assistant Professor, Electrical & Electronics, Oriental Institute Of Science And Technology Volume 7, Issue 4, July-August 2025

[4] Maximum Power Point Tracking in Solar PV Systems , CEP Course on “Converter Topologies for Grid Connected PV System, Prof . Suryanarayana Doolla Dept. of Energy Science and Engineering Indian Institute of Technology Bombay

[5] ORIGAMI BASED FOLDING TECHNIQUES FOR SOLAR PANEL APPLICATIONS S. Yogesh, M. Yogalakshmi, M. Abishek, R. Ari Prasath Student, Department of Electrical and Electronics Engineering SRM Valliammai Engineering College, Kattankulatur, Tamil Nadu. India Dr. G. Madhusudanan Assistant Professor, Department of Electrical and Electronics Engineering SRM Valliammai Engineering College, Kattankulatur, Tamil Nadu. India

[6] **Title:** Modeling and Simulation of Photovoltaic System using MATLAB/Simulink

Authors: Huan-Liang Tsai, Ci-Siang Tu, Yi-Jie Su

Journal: International Journal of Computer and Electrical Engineering Link:

<https://www.ijert.org/modeling-and-simulation-of-photovoltaic-system-using-matlab-simulink>

[7] **ADVANCEMENTS IN SOLAR CELL TECHNOLOGIES AND THEIR MULTIFACETED APPLICATIONS IN A SUSTAINABLE FUTURE**

May 2025

International Journal of Progressive Research in Engineering Management and Science5(5):683-691

DOI: [10.58257/IJPREMS41252](https://doi.org/10.58257/IJPREMS41252)

[8] https://www.niser.ac.in/sps/assets/files/msc-phd/I-V_characteristics_of_solar_cell.

[9] Investigation the effect of the temperature and irradiance on the output parameters of solar cell Ali Natheer Tuaimah 2 Shaker A. A. AL-Saidi 1Department of Physics- Collage of Science-University of Thi-Qar, Iraq. 2Department of Physics- College of Education of Pure Sciences- University of Thi-Qar, Iraq. Website: jsci.utq.edu.iq Email: jsci@utq.edu.iq Volume 7, Number 1, June 2019

[10] SOLAR RADIATION ENERGY (FUNDAMENTALS) SOLAR ENERGY CONVERSION AND PHOTOENERGY SYSTEMS – Vol. I - Solar Radiation Energy (Fundamentals) - L. Wald

[11] The irradiance and temperature dependent mathematical model for estimation of photovoltaic panel performances M. Barukc'ić , V. C'orkluka, K. Miklošević Faculty of Electrical Engineering of Osijek, J.J. Strossmayer University of Osijek, Kneza Trpimira 2B, 31 000 Osijek, Croatia

[12] Optimization of Perturb and Observe Maximum Power Point Tracking Method Nicola Femia, Member, IEEE, Giovanni Petrone, Giovanni Spagnuolo, Member, IEEE, and Massimo Vitelli IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 20, NO. 4, JULY 2005

[13] DESIGN AND SIMULATION OF A DC – DC BOOST CONVERTER T. A. Aika *; F. O. Agbontaen 1Department of Electrical/Electronic Engineering, University of Benin, Benin City * ayemhenre.aika@uniben.edu

[14] Modelling and Simulation of DC-DC Boost Converter and Inverter for PV System Mohamed Aqeel Shafeek*1 , Hariprasad Yogaraju1 , Jasspeed Singh1 and Lingeswarran Thanaventhiran1 1 Manipal International University, MIU Boulevard, Putra Nilai, 71800, Negeri Sembilan, Malaysia

Malaysian Journal of Science and Advanced Technology journal homepage: <https://mjsat.com.my/>

[15] <https://in.mathworks.com/help/sps/ug/solar-pv-system-maximum-power-point-tracking-using-boost-converter.html>

[16] **A. K. Abdelsalam, A. M. Massoud, S. Ahmed, and P. N. Enjeti,**
"*High Performance Adaptive Perturb and Observe MPPT Technique for Photovoltaic-Based Microgrids,*"
IEEE, 2011.

[17] Design and Analysis of DC-DC Boost Converter JN Rai*, Nikhil Gupta** and Prashant Bansal***

Article Info Received: 20 Jan 2016 | Revised Submission: 10 Jun 2016 | Accepted: 28 Sept 2016 | Available Online: 01 Sept 2016

[18] 1N.Dinesh kumar, 2S.Dhivya, 3B.Ganga& 4R.Palani 1-4Department of Physics, Annamalai University, Chidambaram,Tamil Nadu,India- 608002.

© 2024 IJCRT | Volume 12, Issue 4 April 2024 | ISSN: 2320-2882

SIMULATION AND ANALYSIS OF DC-DC BOOST CONVERTER USING PSPICE SOFTWARE PROGRAM

[19] Design and Analysis of Pulse width Modulator (PWM) using Low Input Impedance Current Comparator Rockey Choudhary¹, Prof. B.P. Singh² 1 (M.Tech(VLSI design) at Mody Institute of Technology &Science,Laxmangarh (Sikar), India) 2 (Mody Institute of Technology &Science, Department of ECE,Laxmangarh (Sikar), India)

IOSR Journal of Engineering Apr. 2012, Vol. 2(4) pp: 931-936

[20] Discuss and provide examples for the PWM process Xinyi Fan Heriot-Watt University Riccarton Edinburgh EH14 4AS 2310450687@qq.com

2020 5th International Workshop on Materials Engineering and Computer Sciences (IWMECS 2020)

[21] <https://library.automationdirect.com/eemsushe/2024/12/DCBusOvervoltage-white-paper.pdf>

[22] **DC-Bus Voltage Regulation for DC Distribution System with Controllable DC Load**

April 2017 [Iman Mazhari](#) Babak Parkhideh

[23] <https://in.mathworks.com/help/simulink/ug/sample-time-with-scope-blocks-example.html>

[24] Smart Grid Sensors: Principles and Applications Hamed Mohsenian-Rad Cambridge University Press, 2022 ISBN: 9781108839433

[25] **A Strategy for Measuring Voltage, Current and Temperature of a Battery Using Linear Optocouplers**
by **Gopal Reddy Lakkireddy and Sudha Ellison Mathe**

*School of Electronics Engineering, VIT-AP, University Amaravati 522237, India Author to whom correspondence should be addressed.

[†]These authors contributed equally to this work. *World Electr. Veh. J.* **2022**, 13(12), 225; <https://doi.org/10.3390/wevj13120225>

[26] T. Esum and P. L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," *IEEE Transactions on Energy Conversion*, vol. 22, no. 2, pp. 439–449, June 2007.

[27] M. G. Villalva, J. R. Gazoli, and E. R. Filho, "Comprehensive Approach to Modeling and Simulation of Photovoltaic Arrays," *IEEE Transactions on Power Electronics*, vol. 24, no. 5, pp. 1198–1208, May 2009.