📘 Project Report

Simulation and Analysis of Solar PV System with MPPT using MATLAB/Simulink

Project Title:

Simulation and Analysis of Solar PV System with MPPT using MATLAB/Simulink

Submitted by:

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Abstract

Renewable energy plays a vital role in meeting the global energy demand while minimizing environmental impact. Among renewable sources, solar photovoltaic (PV) technology has gained widespread attention due to its abundance and sustainability. However, the efficiency of PV systems is strongly influenced by temperature, irradiance, and load variations. To maximize power extraction, **Maximum Power Point Tracking (MPPT)** techniques are employed.

This project focuses on simulating a solar PV system integrated with an MPPT controller using MATLAB/Simulink. Two popular MPPT algorithms—**Perturb and Observe (P&O)** and **Incremental Conductance (INC)**—are analyzed and compared. The simulation results validate the ability of MPPT to improve PV output efficiency, thereby enhancing system performance.

1. Introduction

The increasing demand for clean and reliable energy has accelerated the adoption of solar PV systems worldwide. Despite their advantages, PV systems suffer from non-linear I–V and P–V characteristics, which reduce power output under variable operating conditions. To address this limitation, MPPT algorithms are widely implemented in PV systems.

The objective of this project is to design and simulate a solar PV system with MPPT in MATLAB/Simulink and compare algorithm performance under varying conditions.

2. Literature Review

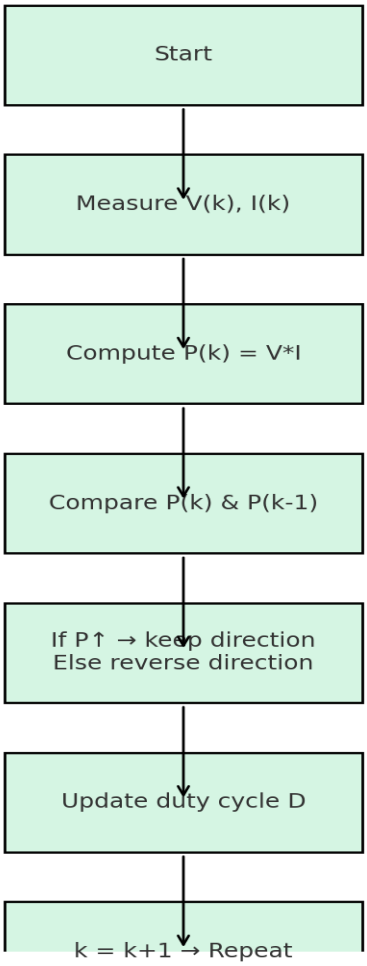
- **S. Jain and V. Agarwal (2004):** Presented a reliable MPPT scheme for PV applications using boost converters.
- **T. Esram and P. Chapman (2007):** Compared different MPPT algorithms, highlighting their trade-offs.
- **Femia et al. (2005):** Analyzed Perturb & Observe and Incremental Conductance methods, showing effectiveness in dynamic conditions.

From the literature, it is evident that although P&O is simple and widely used, Incremental Conductance offers improved accuracy under rapidly changing conditions.

3. MPPT Algorithms

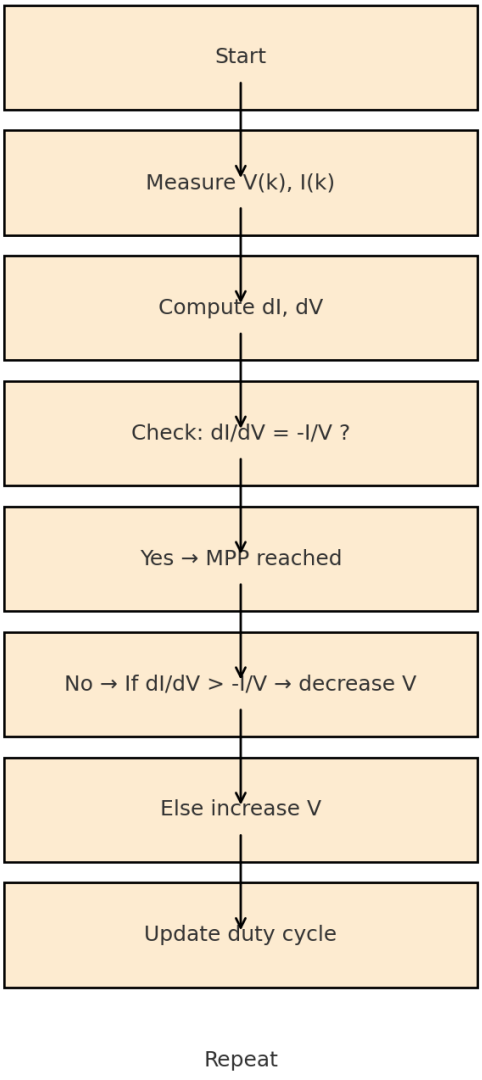
3.1 Perturb and Observe (P&O) Method

- Simple and easy to implement.
- Periodically perturbs voltage and observes change in power.
- Oscillates around MPP but may be less effective in rapidly changing weather.



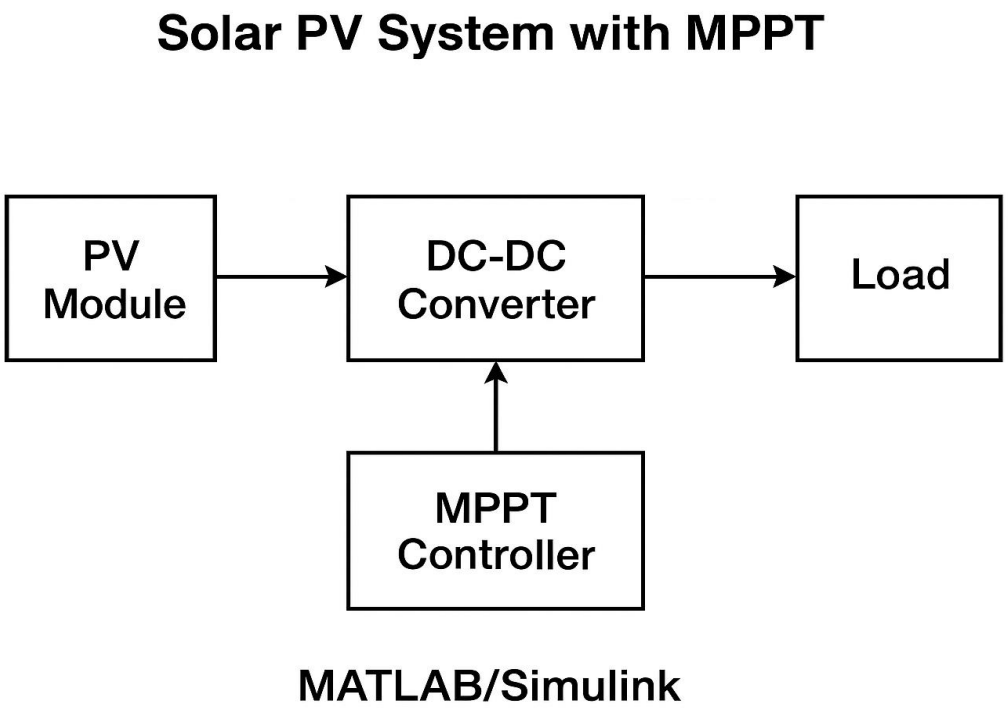
3.2 Incremental Conductance (INC) Method

- Based on the derivative of the power-voltage curve.
- Condition: **dP/dV = 0** at MPP → (dI/dV = –I/V).
- More accurate under fast irradiance changes compared to P&O.



4. MATLAB/Simulink Simulation

The simulation is developed in MATLAB/Simulink with the following components:

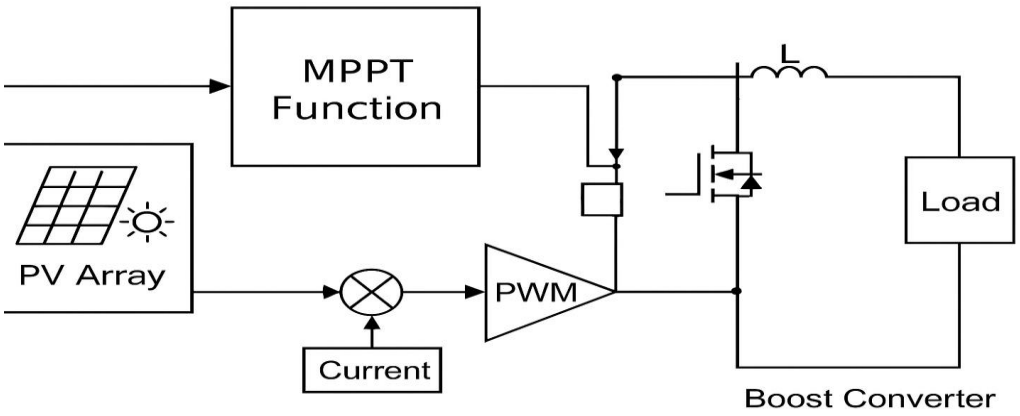


System Description

The system consists of the following major components:

1. **Solar PV Array** – Generates DC power proportional to sunlight and temperature.
2. **DC-DC Converter (Boost Converter)** – Steps up the PV voltage to required levels.
3. **MPPT Controller** – Ensures maximum power extraction by dynamically adjusting duty cycle.
4. **Load** – Represents the demand connected to the PV system.

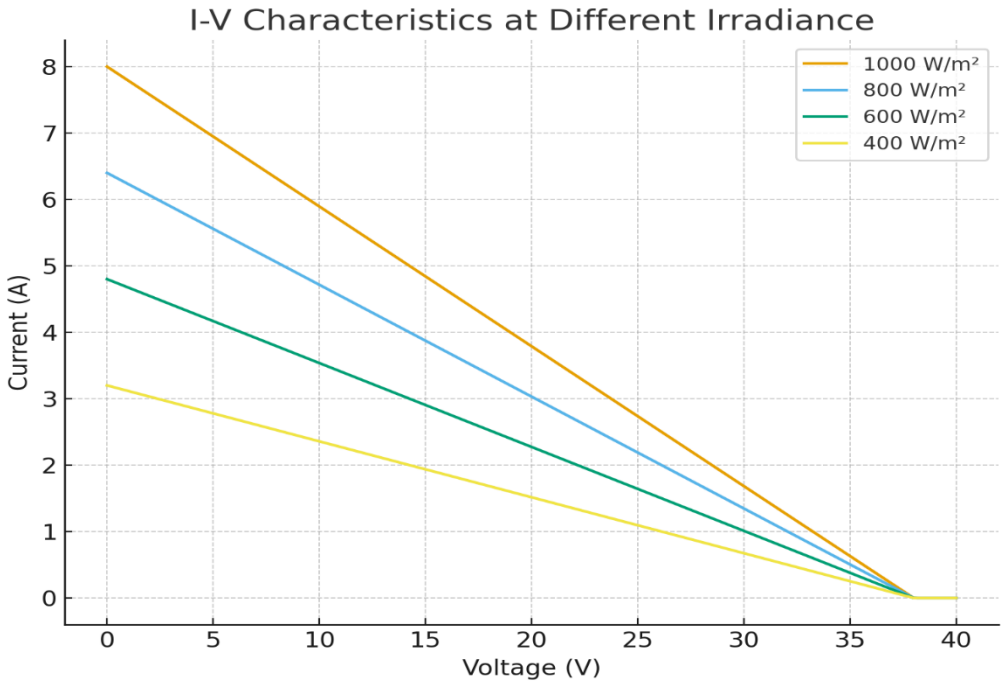
Simlink Diagram

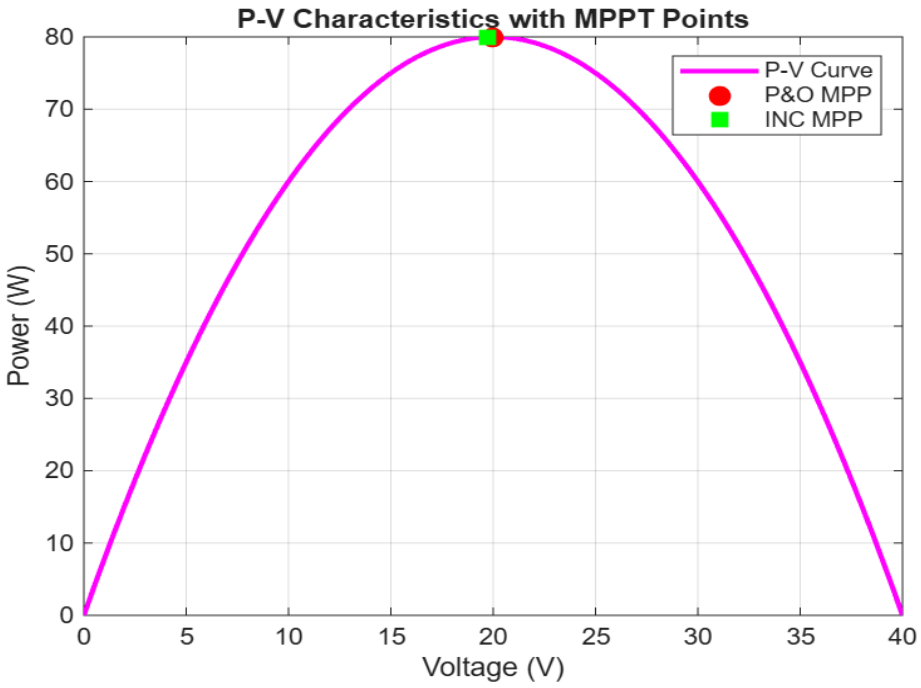


5. Results and Discussion

Graphs

- I–V and P–V curves of PV module.
- Output power comparison (with and without MPPT).





6. Conclusion and Future Scope

This project demonstrated the effectiveness of MPPT techniques in improving solar PV efficiency. Among the studied algorithms, **Incremental Conductance** provided better accuracy and faster tracking under varying conditions compared to P&O.

Future Scope:

- Implementation of hardware prototype.
- Integration with grid-connected systems.
- Exploration of hybrid MPPT algorithms and AI-based controllers.

References

1. T. Esram 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, 2007.
2. N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, “Optimization of perturb and observe maximum power point tracking method,” *IEEE Transactions on Power Electronics*, vol. 20, no. 4, pp. 963–973, 2005.
3. S. Jain and V. Agarwal, “A new algorithm for rapid tracking of approximate maximum power point in photovoltaic systems,” *IEEE Power Electronics Letters*, vol. 2, no. 1, pp. 16–19, 2004.