NEURO-P3 (PHOTOVOLTAIC POWER PROCESSING)

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Keywords:

MPPT, ESP32, PV monitoring, Artificial Intelligence, Solar efficiency, IoT.

Introduction:

The demand for efficient solar energy systems is increasing with the shift toward clean energy. Neuro-P3 focuses on improving the efficiency of Maximum Power Point Tracking (MPPT) using an AI-based approach.
Traditional methods like Perturb & Observe and Incremental Conductance often fail to maintain high efficiency under rapidly changing conditions such as shading or fluctuating sunlight. This results in power loss and instability.
In this project, a neural network is used to predict the Maximum Power Point (MPP) based on inputs like irradiance, temperature, and panel data. Instead of reacting to changes, the system predicts them in advance.
The predicted MPP is used to control a DC-DC converter, ensuring the panel operates close to its optimal point at all times. This reduces unnecessary oscillations and improves response speed.
By continuously monitoring and calculating MPPT efficiency, the system prioritizes conditions that yield maximum output so as to be used in heavy industries.
Overall, Neuro-P3 provides a more stable and efficient MPPT solution, especially in dynamic environmental conditions.

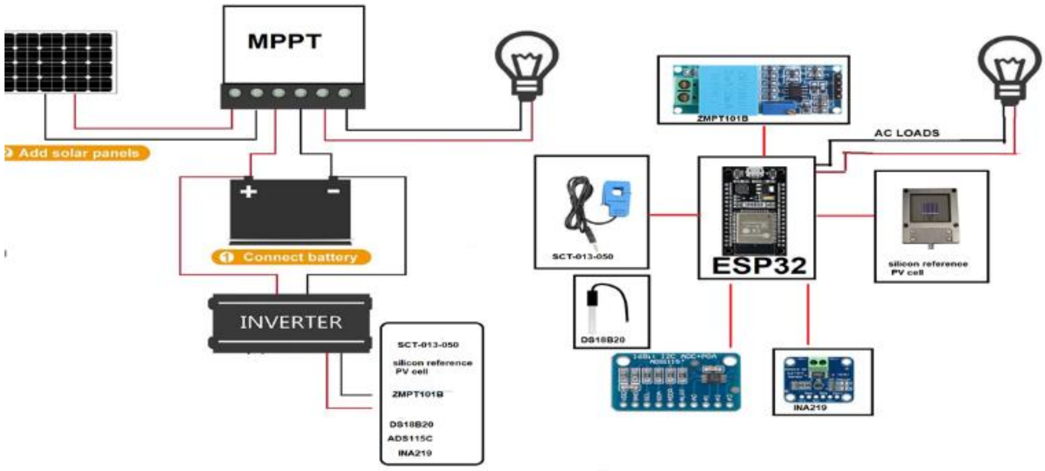

Figure 1: Physical design of the setup of Neuro-P3

Objectives:

1. To accurately track the Maximum Power Point (MPP) under varying environmental conditions to maximize solar power output.
2. To improve MPPT efficiency by reducing oscillations and slow response seen in conventional methods like Perturb & Observe and Incremental Conductance.
3. To monitor and evaluate system efficiency by analyzing input and output parameters such as voltage and power in real time.
4. To prioritize system operations based on MPPT efficiency, ensuring high-priority tasks are executed when maximum energy is available.

Methodology:

The proposed system collects real-time data such as solar irradiance, temperature, and panel voltage/current using current, voltage, and temperature sensors connected to a solar panel. An ESP32 microcontroller is used for data acquisition and IoT-based transmission of this data. The collected data is processed using MATLAB and Google Colab, where a neural network model is trained and tested. The system also performs comparative analysis of data across different time intervals and varying environmental conditions to improve prediction accuracy.

Based on this analysis, the neural network predicts the optimal Maximum Power Point (MPP). This predicted MPP is used to control a DC-DC converter, ensuring the solar panel operates near its maximum efficiency. The generated power is stored in a battery and supplied to the load through an inverter. An HTML-based interface is used for real-time monitoring of system parameters.

The efficiency of the MPPT is continuously evaluated by comparing input and output power. Tasks are prioritized based on efficiency levels to ensure maximum energy utilization. The system continuously monitors and updates its performance through IoT integration, providing stable and efficient operation under dynamic conditions.

Result and Conclusion:

The implemented solar energy monitoring system successfully acquired real-time data from voltage, current, temperature, and irradiance sensors. The ESP32-based controller performed MPPT (Maximum Power Point Tracking) and regulation while transmitting system data to a cloud dashboard. The results showed that the PV voltage consistently operated close to the optimal Maximum Power Point (MPP), indicating high MPPT efficiency.

Compared to conventional methods, the system exhibited reduced oscillations around the MPP and faster response to changes in irradiance, minimizing power losses. The calculated efficiency, based on input and output power measurements, remained high under stable conditions and showed improved performance even during minor environmental variations. Additionally, the alignment between temperature and irradiance readings confirmed reliable sensing, which further contributed to accurate MPP prediction and efficient energy extraction. Overall, the system demonstrated improved MPPT efficiency, stable operation, and effective utilization of available solar energy.

References:

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Future Scope:

The future scope of this project includes:

1. The system can be enhanced using deeper learning models or hybrid AI techniques to further improve MPPT efficiency under highly dynamic conditions like partial shading.
2. The model can be extended to large-scale solar farms, industries enabling centralized efficiency optimization and better energy management across multiple panels.
3. The system can be integrated with smart grid technology to enable efficient energy distribution, load balancing, and real-time optimization based on demand and availability.