

Hybrid PV-Battery Priority Logic Control on Dual Input and Multiple Output Converter

Amizhthan V¹, Jai Kishore D², Honey Keerthana R³, Mr. Suresh N⁴

^{1,2,3,4}Department of Electrical and Electronics Engineering Sri Venkateswara College of Engineering

Abstract

This project presents the implementation of a Hybrid PV– Battery Priority Logic system using a Dual Input Multiple Output (DIMO) converter, inspired by the reference work on high-gain DIMO topologies. The main objective is to design and simulate an efficient solar photovoltaic (PV) energy system integrated with a boost converter, MPPT (Maximum Power Point Tracking) controller, and battery storage in MATLAB/Simulink. The system is developed to maximize solar energy utilization and maintain a stable power supply under fluctuating sunlight conditions. The MPPT algorithm continuously tracks the PV panel's optimal power point to achieve maximum energy extraction, while the PI (Proportional–Integral) controller regulates the DC-link voltage, ensuring smooth and stable operation. A battery with State of Charge (SoC) monitoring is introduced to store surplus energy and supply power during low irradiance or night-time operation. The priority control logic intelligently manages power distribution between the PV source, battery, and load, ensuring uninterrupted energy flow. Simulation results validate that the proposed hybrid system performs efficiently, maintaining voltage stability and reliable energy management even under dynamic environmental variations. The project demonstrates the potential for integration into standalone renewable systems, microgrids, and sustainable energy infrastructures, contributing to smarter and cleaner power solutions.

Keywords: DIMO Converter, Hybrid PV-Battery System, Mppt Control, PI Controller, Priority Logic.

I. INTRODUCTION

The demand for reliable and sustainable energy has grown rapidly over the past decade due to the increasing global energy crisis, environmental pollution, and depletion of fossil fuels. Among all renewable sources, solar energy has emerged as one of the most promising alternatives because it is abundant, clean, and freely available. However, the major challenge with solar power systems lies in their intermittent nature — solar energy generation depends heavily on sunlight intensity, weather conditions, and time of day. This makes it difficult to maintain a continuous power supply when the solar irradiance fluctuates.

To overcome this limitation, hybrid renewable energy systems that combine solar energy with battery energy storage have become increasingly popular. In such systems, the battery acts as a backup source when solar power is insufficient, ensuring uninterrupted energy supply to the load. This hybrid configuration enhances the reliability, stability, and efficiency of renewable energy systems, making them suitable for standalone or off-grid applications such as rural electrification, street lighting, and portable power systems.

In a conventional setup, managing multiple energy sources and maintaining stable output usually require

multiple DC–DC converters, which increases the system’s complexity, size, and cost. To address this, researchers have introduced a more efficient solution — the Dual Input Multiple Output (DIMO) converter. The DIMO converter can handle multiple energy inputs (in this case, PV and battery) and deliver controlled power to multiple outputs using a single integrated circuit. This significantly reduces component count, minimizes power losses, and improves system compactness.

In this project, a Hybrid PV–Battery System using a DIMO Converter is designed and implemented with an intelligent Priority Logic Control strategy. The priority logic ensures that the load is primarily powered by the solar PV source whenever sufficient sunlight is available, thereby utilizing renewable energy to the maximum extent. When solar power becomes inadequate — such as during cloudy weather or nighttime — the control logic automatically switches the supply to the battery. This smart power management reduces dependency on conventional sources and ensures efficient energy utilization. In summary, this project integrates renewable energy conversion, intelligent control, and power electronics into a compact and efficient hybrid system. By combining the DIMO converter architecture, MPPT algorithm, and priority-based logic, the system ensures continuous power delivery with optimal utilization of available solar energy. The results from simulation and hardware implementation confirm that the proposed model is not only technically sound but also cost-effective and scalable for small to medium renewable energy applications.

II LITERATURE REVIEW

This section summarizes previous works related to hybrid PV– battery systems, MPPT control, and multi-input converters. The proposed work adds novelty through the implementation of priority logic and a simplified control structure.

Hybrid renewable systems are widely studied for improving the reliability and efficiency of renewable energy utilization. Recent works highlight the advantages of **multi-input converters** in integrating multiple power sources like PV, wind, and batteries into a single system.

Rajendran et al. (2022) presented an in-depth study on the use of multi-input DC–DC converters for hybrid photovoltaic (PV)–battery applications. Their research focused on how such converters can simultaneously handle multiple energy inputs while maintaining a stable DC-link voltage. The authors concluded that multi-input converter architectures enhance the overall **energy efficiency** of hybrid systems by reducing power conversion stages and improving reliability. By minimizing the number of intermediate converters, these designs enable compact and cost-effective power management solutions, making them suitable for standalone and grid-connected renewable systems.

Kumar et al. (2023) explored the implementation of **Maximum Power Point Tracking (MPPT)** control using an **Arduino-based controller** for solar PV systems. Their work demonstrated that low-cost microcontroller platforms could effectively extract maximum power from PV modules under varying irradiance and temperature conditions. The study proved that hardware-based MPPT control could achieve high accuracy with minimal power losses, highlighting its practicality for small-scale renewable energy applications. This approach provides a foundation for affordable, efficient control strategies in hybrid PV–battery systems.

Singh et al. (2021) emphasized the importance of intelligent **energy management** in hybrid renewable systems that integrate solar, wind, and battery storage. They proposed a **priority-based control logic** to determine the operational sequence of multiple sources depending on resource availability and load demand. Their findings revealed that such intelligent control improves power balance, system stability,

and battery life by preventing overcharging and deep discharging. The use of logic-based source prioritization enhances the dynamic performance of hybrid systems operating under fluctuating environmental conditions.

Despite these advancements, most conventional hybrid renewable energy systems still rely on **multiple converter stages**, which lead to increased cost, control complexity, and conversion losses. To overcome these limitations, the current project employs a **Dual Input Multi-Output (DIMO) converter**. This single converter integrates both PV and battery inputs, controlled by intelligent MPPT, PI, and priority logic units. The proposed system simplifies hardware design, reduces switching losses, and improves overall efficiency, thereby providing a compact and reliable power management solution for hybrid renewable energy applications.

III SYSTEM DESIGN AND METHODOLOGY

The System integrates a **Photovoltaic (PV)** source and a **Battery** through a **Dual Input Multiple Output (DIMO)** converter, ensuring continuous power supply and efficient energy utilization. The PV panel acts as the primary source and generates DC power based on solar unit. Then a MPPT control strategy is used to ensure that the PV operates at its maximum power point under varying sunlight conditions. The battery operates as a backup source that charges or discharges depending on the load demand and solar conditions. Both sources are interfaced through a **DIMO converter**, which enables **simultaneous control** of charging, discharging, and load regulation.

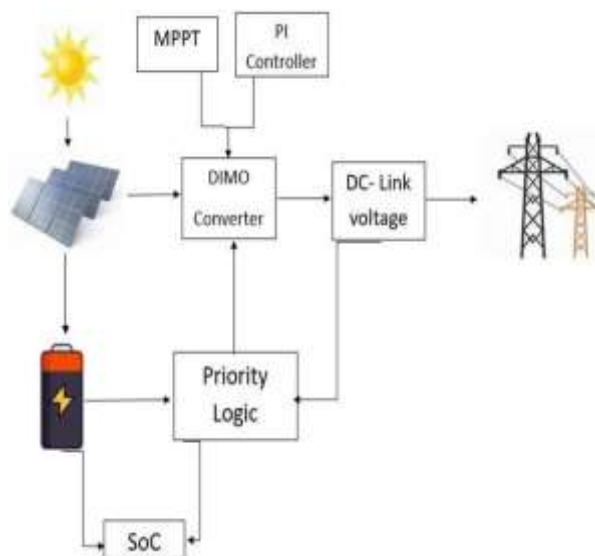


Fig. 1 Structural Block Diagram of Hybrid PV-Battery Priority Logic

The **DIMO converter** combines two input sources (PV and battery) and produces a regulated DC output. Each source has its own inductor and switching device (MOSFET).

- **MOSFET S1** controls the PV leg, and
- **MOSFET S2** controls the battery leg.

A DC-link Capacitor maintains voltage stability A **Proportional–Integral (PI)** controller regulates the DC-link voltage by adjusting the duty ratio. The Priority logic determines the active source based on voltage conditions:

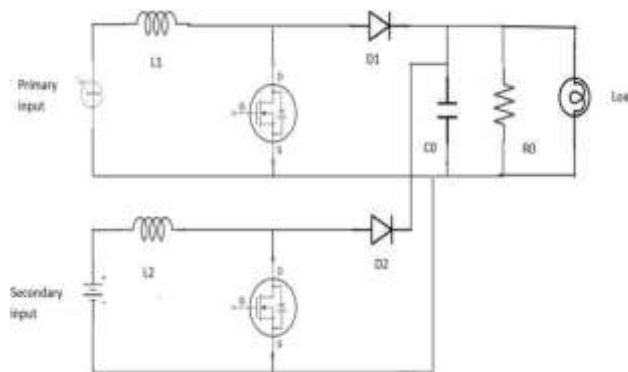


Fig 2 Circuit diagram of a DIMO converter

The working of the Hybrid PV–Battery System using a DIMO Converter is based on the intelligent management of power between the photovoltaic (PV) array, battery, and the load. The DIMO converter serves as the central power processing unit that controls energy flow according to the availability of solar energy and the state of charge (SoC) of the battery. The main objective is to maintain a stable DC-link voltage, ensure maximum power extraction from the PV, and provide uninterrupted power to the load. The entire system operation can be explained in the following stages:

PV Power Generation and MPPT Operation

The PV array converts solar irradiance into DC electrical power. However, the voltage and current from the PV panel vary depending on sunlight and temperature. To make sure the PV always operates at its Maximum Power Point (MPP), an MPPT (Maximum Power Point Tracking) controller is used. In this project, the Perturb and Observe (P&O) algorithm is implemented — it slightly perturbs the PV voltage and observes the resulting power change.

- If power increases, the operating voltage is shifted in the same direction.
- If power decreases, it reverses the change. This process continues until the maximum power point is reached. The MPPT controller generates a duty ratio (D_1), which controls the MOSFET switch connected to the PV side of the DIMO converter, ensuring maximum power extraction at all times.

DIMO Converter Power Processing

The Dual Input Multi-Output (DIMO) converter is the heart of the system. It has two input ports — one connected to the PV source and another to the battery — and a single DC output feeding the load. Each input is connected to its own inductor and MOSFET leg, allowing both sources to operate independently or together. When both PV and battery are available, the DIMO converter intelligently combines their power through controlled switching, maintaining the DC-link voltage.

The converter performs two main operations:

- Boost operation: Increases the PV or battery voltage to maintain a stable DC-link
- Buck operation: If the source voltage exceeds the desired DC-link, the converter steps it down accordingly.

This dual functionality allows the system to adapt to changing energy and load conditions seamlessly.

PI Controller for Voltage Regulation

The PI (Proportional–Integral) controller ensures that the DC-link voltage remains constant regardless of fluctuations in solar input or load demand. The measured output voltage (V_{dc}) is compared with a reference voltage

The difference (error) is processed by the PI controller, which adjusts the converter’s second duty ratio (D_2) to regulate the output voltage.

This keeps the voltage ripple low and maintains power quality. Mathematically,

$$V_{error} = V_{ref} - V_{dc} \text{-----} 1$$

$$D_2 = K_p(V_{error}) + K_i \int V_{error} dt \text{-----} 2$$

where K_p and K_i are proportional and integral gains. Battery Management and Priority Logic

The battery acts as both an energy backup and a storage unit. The priority logic controller decides the system's operating mode based on PV power and battery state of charge (SoC):

- Case 1 – PV Power > Load Power: The extra power charges the battery while the load is supplied directly by the PV.
- Case 2 – PV Power < Load Power: The battery discharges through the converter to supply the load.
- Case 3 – No PV Power (Night/Cloudy): The battery alone powers the load.
- Case 4 – Battery Fully Charged: The battery is disconnected from charging, and PV power feeds only the load.

This intelligent priority logic ensures that the system automatically switches between PV and battery without any interruption.

Load Power Supply and DC-Link Stability

The DIMO converter output is connected to a DC-link capacitor, which acts as an energy buffer. It filters voltage ripples and ensures a constant DC supply to the load.

Regardless of environmental variations, the load experiences a stable voltage due to the combined action of the MPPT, PI, and

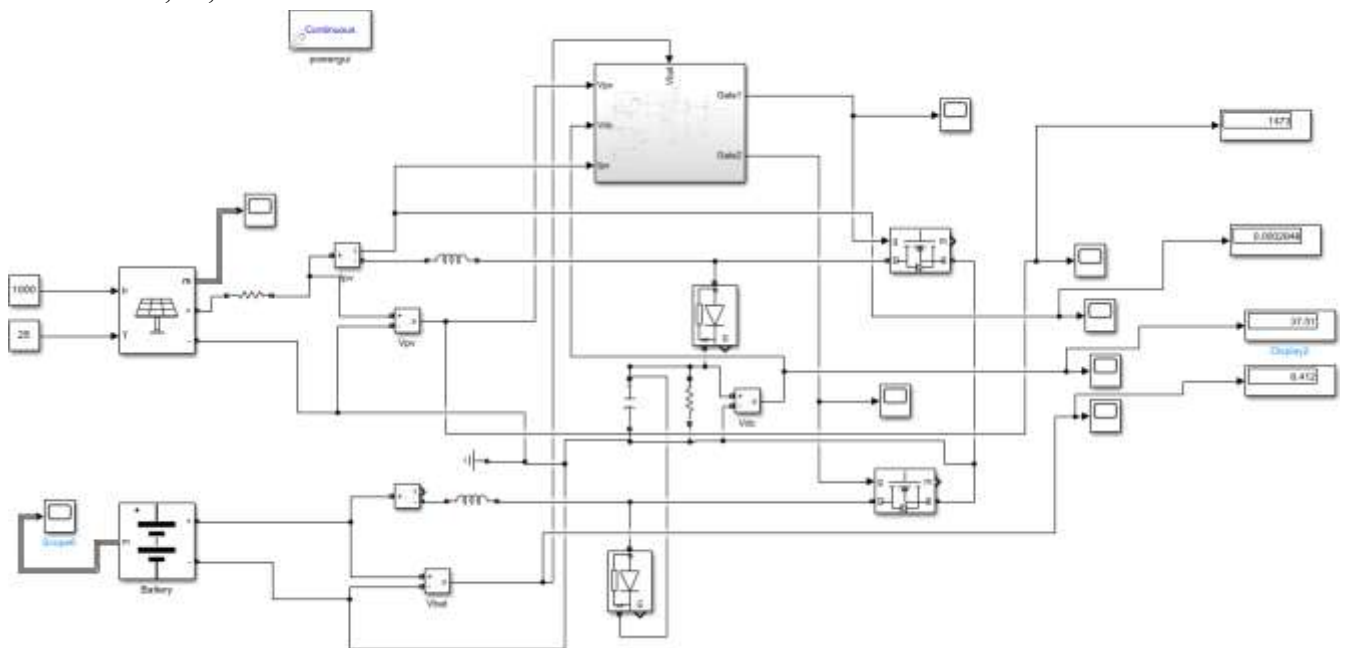


Fig.3: Hybrid PV-Battery priority logic on DIMO converter.

logic control. Thus, the system guarantees continuous and regulated power under all operating conditions.

Table – 1: Operating Modes:

| Condition | Operation Mode | Power Flow |
|-----------------|-------------------|---------------------------------|
| Sunny(High) | PV- Dominat | PV->Load + Battery(charging) |
| Cloudy/ Evening | Hybrid | PV+Battery->Load |
| Night / No Sun | Battery- dominant | Battery-> Load |
| Fully charged | PV- only | PV->Load |
| Low Battery Soc | PV- only | PV-> load(battery disconnected) |

OUTPUT AND RESULT

opportunities to extend and enhance this system in future work. The control strategy can be improved by implementing advanced algorithms such as Fuzzy Logic or Artificial Neural Network (ANN)-based MPPT, which can achieve faster and more accurate tracking under rapidly changing solar conditions. The PI controller used for voltage regulation can be replaced with adaptive or predictive controllers to improve the dynamic response and stability of the system.

Future developments can also include the integration of IoT- based monitoring and control, allowing remote data logging of PV performance, battery state of charge (SoC), and system efficiency. Additionally, the system can be scaled to support three or more inputs, incorporating other renewable sources such as wind or fuel cells to form a multi- source hybrid system. For hardware implementation, GaN or SiC MOSFETs can be used to improve switching efficiency and reduce thermal losses. The concept can also be extended to grid- tied configurations with bi-directional converters to enable energy export to the grid, supporting smart microgrid applications.

In summary, the project forms a strong foundation for developing next-generation renewable energy converters that are more efficient, intelligent, and suitable for future smart energy networks.

V CONCLUSION

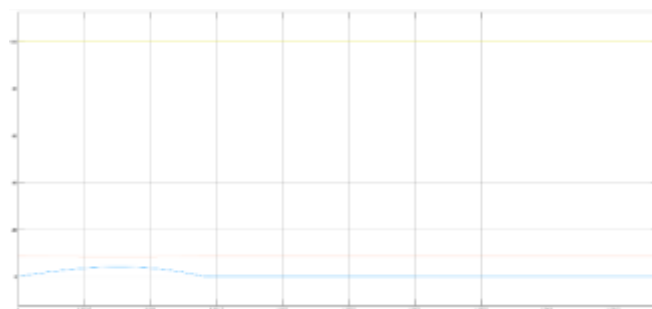


Fig 4: battery’s output curve

IV FUTURE SCOPE

The proposed Hybrid PV–Battery System using a DIMO Converter demonstrates a compact, efficient, and intelligent power management architecture. However, there are several The proposed Hybrid PV–Battery Priority Logic system on a DIMO converter effectively integrates renewable solar power with battery storage to ensure continuous and reliable energy delivery. The inclusion of MPPT control maximizes power extraction from the PV module, while the PI controller stabilizes the DC-link voltage

during varying irradiance and load conditions. The implementation of an intelligent priority logic allows the converter to dynamically switch between PV and battery sources based on solar availability and State of Charge (SoC), thereby achieving energy efficiency and system autonomy. Simulation results in MATLAB/Simulink verified the feasibility of the model, maintaining a stable DC-link voltage of 300–350 V under a 200 W load, proving its effectiveness for standalone applications

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