

# Improved Efficiency of an Advanced Incremental Conductance Method for an Off-Grid Photovoltaic System under Partial Shading Conditions

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## INTRODUCTION

Off-grid photovoltaic (PV) systems [1] are widely deployed in remote and isolated areas due to their independence from the utility grid and their ability to provide reliable and sustainable energy. Despite these advantages, their performance is highly sensitive to environmental conditions, particularly partial shading [2], which is one of the most critical challenges affecting PV systems. Partial shading introduces multiple local maxima on the power–voltage characteristic, leading to power losses, increased fluctuations, and reduced overall efficiency, as well as unstable system operation.

In the literature, several Maximum Power Point Tracking (MPPT) techniques have been developed to address this issue, among which the classical Incremental Conductance (IC) method is widely used due to its simplicity and ease of implementation [3]. However, under rapidly changing or complex shading conditions, the conventional IC algorithm often suffers from slow convergence, steady-state oscillations, and the inability to accurately track the global maximum power point.

Therefore, the development of advanced MPPT strategies becomes essential to enhance tracking performance, reduce oscillations, and ensure fast and accurate convergence under challenging operating conditions. In this context, improved control techniques based on adaptive mechanisms offer a promising solution for optimizing the performance and reliability of off-grid PV systems.

## METHOD

The proposed approach is based on an Advanced Incremental Conductance (AIC) MPPT technique designed for off-grid photovoltaic systems. The method enhances the conventional Incremental Conductance algorithm by introducing an adaptive step size mechanism that dynamically adjusts the control action according to operating conditions, enabling faster convergence and reduced oscillations. The system configuration consists of a PV array connected to a DC-DC step-up converter supplying a resistive load. The model is implemented and simulated using MATLAB/Simulink (version 2020b). To validate the effectiveness of the proposed method, the system is tested under complex partial shading scenarios, allowing the evaluation of tracking performance, dynamic response, and robustness compared to the classical IC algorithm.

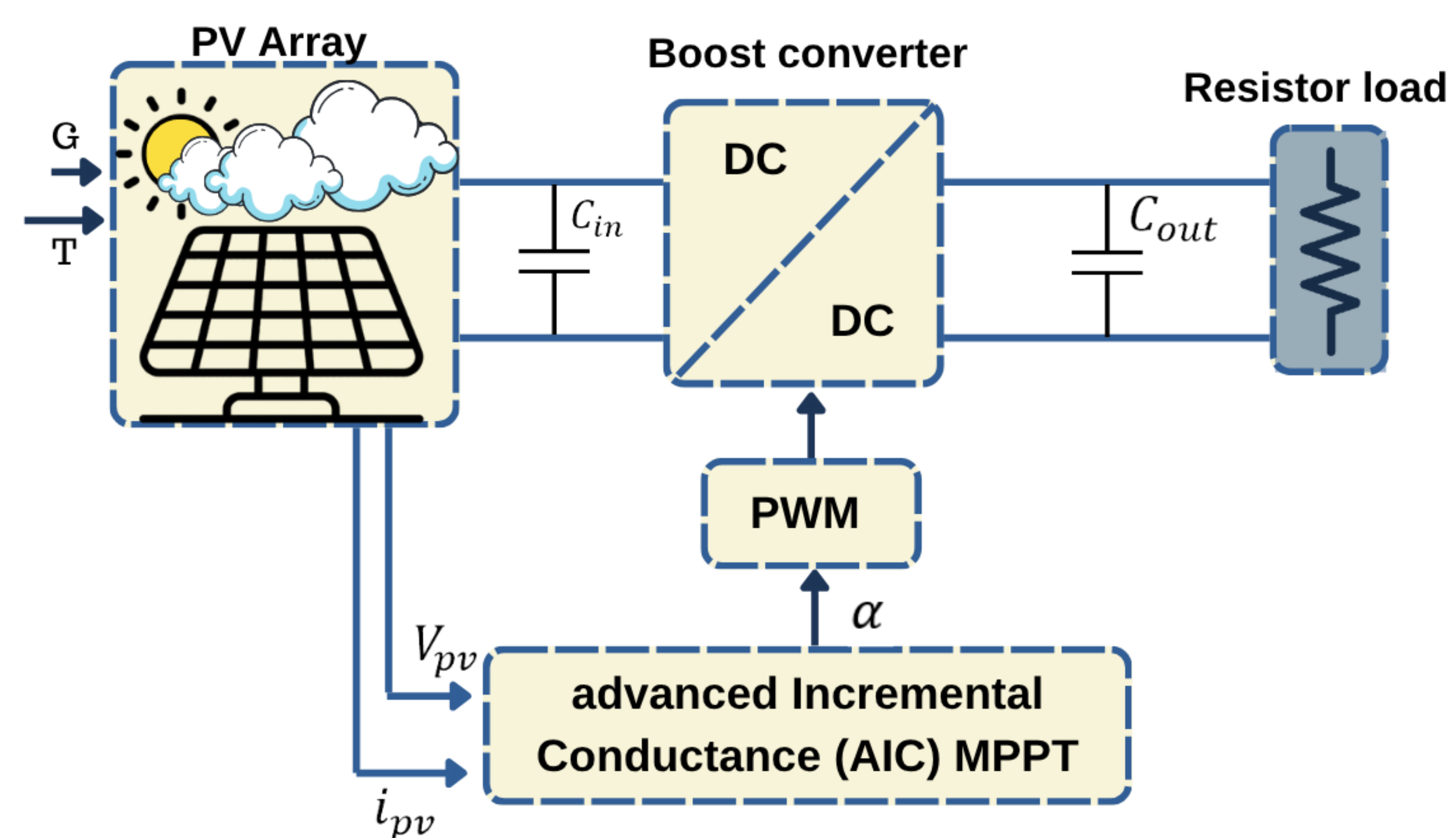


Figure 1. The suggested AIC technique for controlling the grid-off PV system

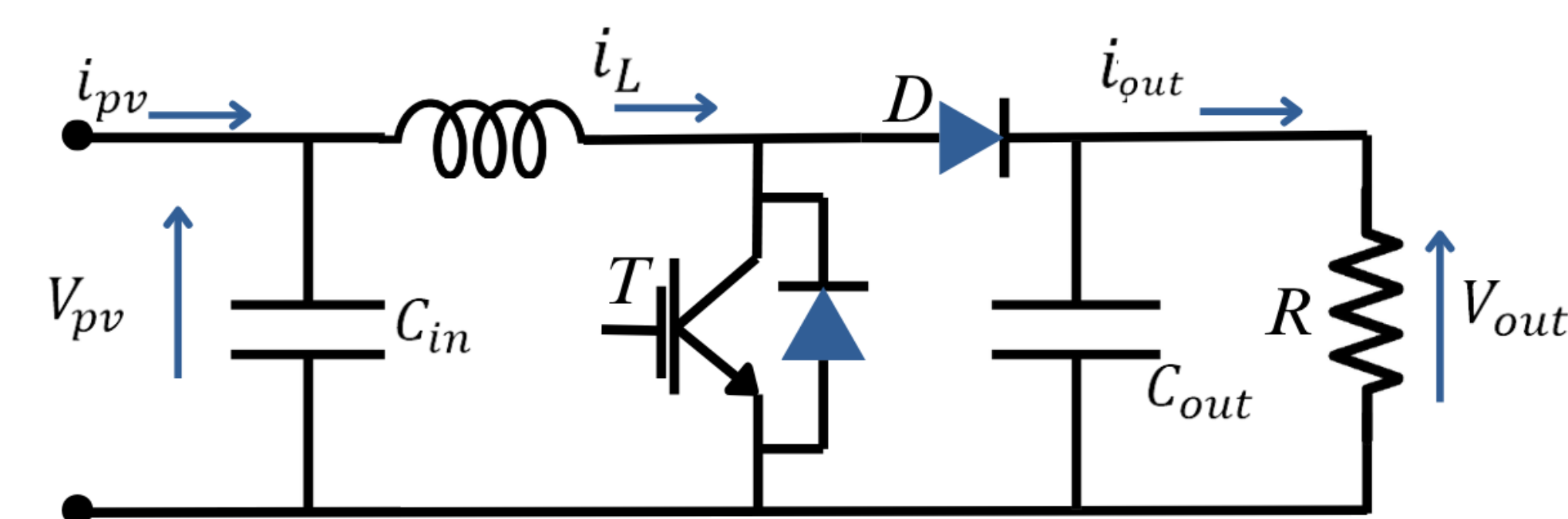


Figure 2. The DC-DC step-up converter circuit

## RESULTS & DISCUSSION

The performance of the proposed Advanced Incremental Conductance (AIC) MPPT technique is evaluated under complex partial shading conditions to assess its tracking capability and robustness. The obtained results demonstrate a significant improvement compared to the conventional Incremental Conductance (IC) method, particularly in terms of convergence speed, stability, and tracking accuracy. Under abrupt irradiance variations, the proposed AIC method rapidly converges to the maximum power point (MPP) in less than 0.2 seconds, ensuring fast adaptation to changing environmental conditions. In contrast, the classical IC algorithm exhibits slower dynamic response and noticeable oscillations around the MPP, which leads to power losses and reduced efficiency. Furthermore, the adaptive step size mechanism integrated into the AIC technique effectively minimizes steady-state fluctuations, resulting in smoother system behavior and improved power stability. The PV power output shows reduced oscillations and higher energy extraction compared to the benchmark method. The results also confirm that the proposed approach is capable of maintaining stable operation under multiple local maxima caused by partial shading, demonstrating strong robustness and reliability. Overall, the AIC method enhances tracking efficiency and ensures optimal performance of the off-grid PV system under challenging operating conditions.

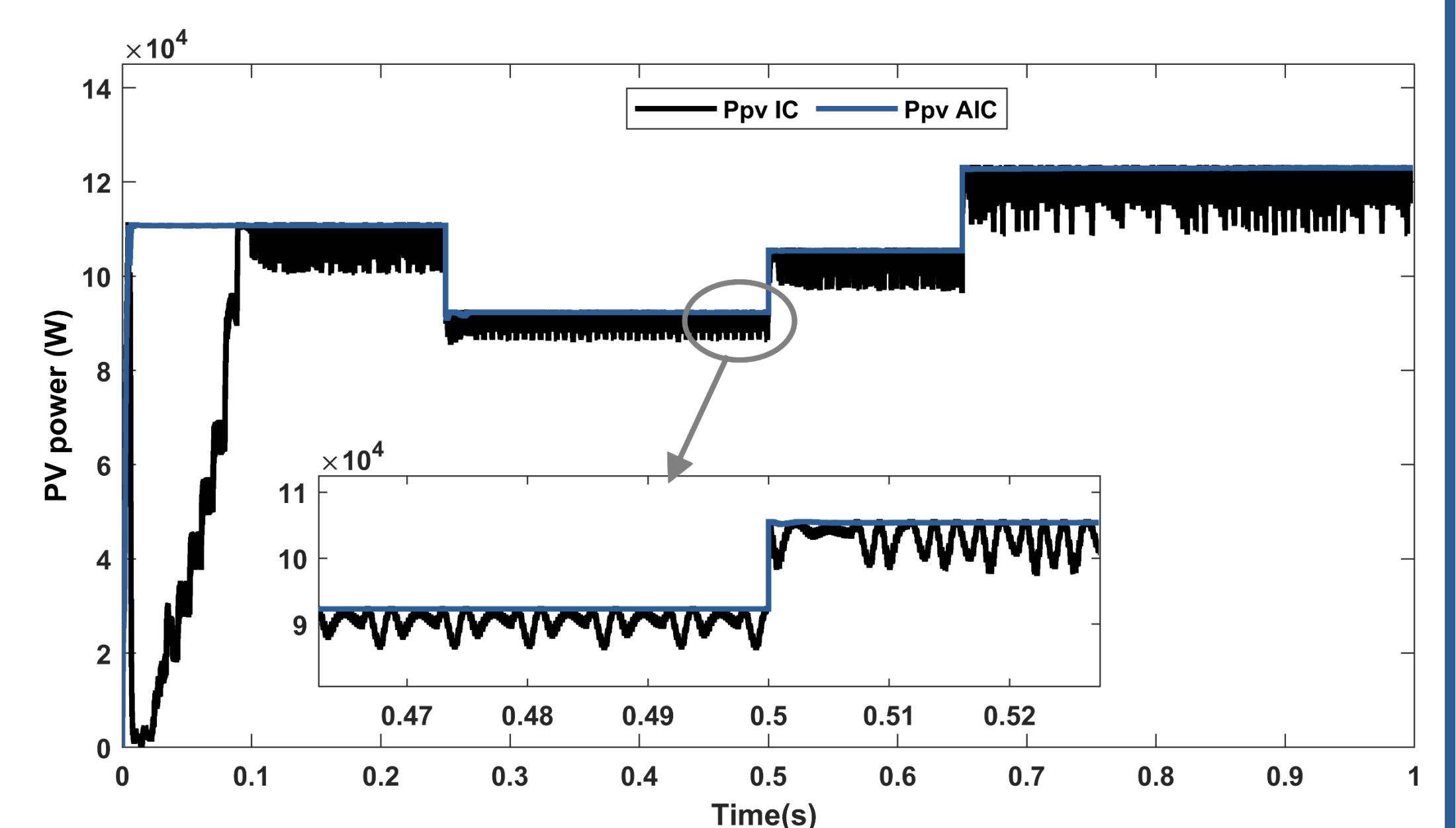


Figure 3. The pv power results under complex partial shading

## CONCLUSION

The proposed AIC method significantly enhances MPPT performance in off-grid PV systems under partial shading conditions. It ensures fast convergence, reduced oscillations, and improved tracking efficiency compared to the classical IC method, making it a reliable solution for efficient energy extraction.

## REFERENCES

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