"IMPROVING POWER QUALITY AND EFFICIENCY SOLAR POWERED ELECTRIC VEHICLE CHARGING SYSTEM USING FEEDBACK CONTROL" : A REVIEW

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ABSTRACT

Considering the EV demand characteristics as well as arrival and departure times, battery capacity, state of charge, and hybrid grid-RES systems (such as solar, mini-hydro, and wind), a first of its kind detailed model of fast charging EV stations linked to such a system has been suggested. Profit maximization and reduced grid energy consumption are both helped by this. Simulations are conducted utilizing a new metaheuristic method known as the hybrid genetic with pattern search (hGPS) algorithm for the first time. Their purpose is to optimize the charging station's NPV, or net present value. A sequential Monte Carlo simulation and a demand distribution based on EV behaviors and hourly intervals are used to conduct the investigations. The economic considerations acquired using the hybrid genetic with pattern search (hGPS) method reveal that it optimizes profit compared to the Genetic method (GA) and Pattern Search (PS) algorithms. By limiting the total amount of power that can be transferred between the system network and the grid, the suggested approach clearly reduces the grid's impact on the system network..

Keywords: EV, Genetic Algorithm (GA), hybrid grid-RES, hybrid genetic with pattern search (hGPS) algorithm, NPV, pattern search (PS), and RES

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I. Introduction

Electric vehicles (EVs) are a greener and more cost-effective alternative to traditional car driven by internal combustion engines (ICEs). There are a number of companies that produce electric vehicles, and manufacturing is expected to surge in the next years [1]. Electric vehicles (EVs) are more cost-effective to operate than internal combustion engine (ICE) cars because they can be powered by renewable energy sources (RESs) generated in the area [2]. The broad use of electric vehicles is, however, hindered by numerous issues. Electric vehicles are more expensive up front, but they end up saving money in the long term compared to internal combustion engine vehicles. Furthermore, public charging infrastructure development is an expensive and time-consuming endeavor, and there are now only a few number of stations available [2]. Furthermore, charging an electric vehicle consumes a significant amount of grid power. Thus, power outages and unwanted voltage swings can result from the disorganized charging of numerous EVs, which could disrupt grid operation [3]. The peak demand for electric vehicles may necessitate an increase in power generation. Yet, substantial expenditures on infrastructure will ensue from this. A different, more cost-effective solution is smart grids, which allow electric vehicles to coordinate their charging activities. This can improve electric power use, regulate frequency [4], and reduce intermittent renewable energy source power output. [5].

II. Literature review

A comprehensive literature review on maximum power point tracking (MPPT) methods and techniques, PV solar, and other renewable energy sources is provided in this chapter. Multiple studies have shown that solar panels can transform 21% to 40% of the sunlight that hits them into usable electricity. If you want your solar panels to work more efficiently, you need an algorithm like Maximum PowerPoint Tracking. Li Yong and Samad Sarminah [6] It was observed in 2020 that the use of combination systems to generate power has significantly increased in popularity. A system that combines photovoltaics (PV) with energy storage has garnered attention in this area. Here, a PV and battery combined energy system is designed with a grid-connected control system in mind.

The study's emphasis on the development of a control system for a hybrid energy system integrating PV panels and battery energy storage (BES) was emphasized by Xun Ge et al. [7] 2020. There have been efforts to lower production costs, however PV systems still have a high capital cost. Enhancing the efficiency of solar production systems to produce more power has also been the focus of numerous research initiatives.

N. Priyadarshi and colleagues [8] In order to get the most out of solar electricity in 2019, maximum power point trackers (MPPT) were said to be essential. This work proposes an intelligent fuzzy particle swarm optimization (FPSO) MPPT method to achieve this objective. Furthermore, an inverter control technique has been gated using a modified space vector pulse width modulation (SVPWM) method that is based on ripple factor correction. Variations in solar irradiation, partial shade, and loading conditions are used to test the proposed system's performance.

Dr. Kermadi Berkouk, E. M. [9] A particle swarm optimization (PSO)–based modified maximum power point tracking (MPPT) approach is suggested in the 2019 debate. Using a photovoltaic (PV) system and a Lithium-ion (Li-ion) battery, this approach aims to optimize power production even when partial shading is present. Using a variable sample time, the proposed method aims to decrease the amount of time lost during the exploring step. To achieve this, a comparator is set up to compare the output voltage of the PV array with the reference voltage of the PSO algorithm.

In their 2019 study, Emad M. Ahmed et al. investigated the problems caused by the three-phase, four-wire (3P4W) infrastructure of a distribution network that has been integrated with photovoltaic (PV) installations, including imbalanced loads, reactive power generation, and harmonics content. To integrate PV systems into the grid, this study suggests a distributed Maximum power point tracking (MPPT) controller that is both flexible and reliable.

The most important factors influencing the performance of photovoltaic (PV) modules, according to K. Ding, X. Bian, H. Liu, and T. Peng [11] 2019, are array configuration, irradiance, and module temperature. There must be a clear understanding of how these impacts relate to the power output of the PV array.

[12] Rozana Alik and Awang Jusoh Describes a procedure for testing and an improved Perturb and Observe (P&O) method for 2018 that deals with the effects of partial shading on PV systems. By comparing all PV curve peaks, this testing technique was able to calculate the global maximum power point (GMPP). The voltage at maximum power point tracking (VMPP), which is calculated using a variable step size P&O approach, is used to estimate the boost converter's duty cycle.
Priyadarshi Neeraj [13] The year 2018 was the A grid-connected photovoltaic (PV) system was built for experimental purposes using the dSPACE DS 1104 control board. Optimal tracking efficiency requires a maximum One approach that has been suggested is the use of an adaptive neuro-fuzzy inference system (ANFIS) based power point tracking (MPPT). The system's performance is enhanced by fuzzy

logic control (FLC), which is responsible for generating the switching signal to the power switches of the inverter.
Researchers Alivarani Mohapatra et. al. (14) In 2017, a variety of approaches to maximum power point tracking (MPPT) in PV generating systems that work in partial shadowing situations were systematically studied. A great deal of research has gone into various algorithms, PV modeling approaches, PVarray combinations, and controller topologies up to this point.

Dr. R. Benkercha Dear Sir/Madam, John Colak [15] In 2017, a more popular renewable energy technology called the Grid Connected Photovoltaic Solution (GCPV) was proposed. Improving efficiency and decreasing energy losses has been the focus of numerous research initiatives. One of the most important components used to increase efficiency is the DC/DC boost converter..

2. EV Charging Techniques
(a) Grid-based EV charging
Charging electric vehicles through the grid has many impacts on the existing grid infrastructure, despite how simple and convenient it may seem. Charging stations put extra strain on the grid infrastructure because their power demands can vary from 1 kW to 50 kW during peak and off-peak hours, depending on the type of station. A study by Zeming Jiang, Hao Tian, Mohammed J. Beshir, Surendra Vohra, and Ali Mazloomzadeh found that demand would rise throughout the day if electric vehicle users started charging at their specific workplace. On a typical workday, the peak energy demand of the network was recorded between 3 and 5 pm due to EV activity, according to the research done there [8].Salman Habib, Muhammad Kamran, and Umar Rashid conducted research into the effects of vehicle entry, exit, and charging methods on pollution, grid stability, and economic growth. Furthermore, the loading of these vehicles could compromise grid stability if the charging of EV batteries is not adequately organized or timed. Additional major impacts on grids [9] from EV use include:

• Higher generation expenses as a result of higher demand.
• An overloaded transmission line.
Overloaded distribution transformers
• Severe transmission line damage and losses
• Damage to grid infrastructure.
• Voltage fluctuations at EV charging stations.

Furthermore, there are zero positive environmental impacts from charging electric vehicles via the grid. It is important that people realize that emissions of carbon dioxide from EVs are not negligible. But these electric vehicles can't run without increasing carbon emissions because more carbonizing fuels (coal, gas, etc.) are needed to generate electricity. Reason being, charging stations become less effective in reducing emissions when grid CO_2 levels rise.

(b) Charging EV through Renewable Energy Sources

Renewable energy technology is gradually displacing traditional fossil fuels. The proximity of these power sources to the power plant, according to Mohammed Hadi Amini, Mohsen Parsa Moghaddam, and Orkun Karabasoglu, allows for significant improvements in system efficiency with little losses, voltage shifts, and infrastructure expenses. Intelligent coordination and the storage capabilities of PHEVs also allow for the varying A lessening of the impact of RES on electricity systems has been discussed [10].Electric vehicle (EV) operations will be the primary focus of the Solar Powered Charging Stations' (SPCS) placements:
• while working with electric automobiles, including while leaving the vehicle parked for over an hour.
• Commercial and residential use of electric vehicles.

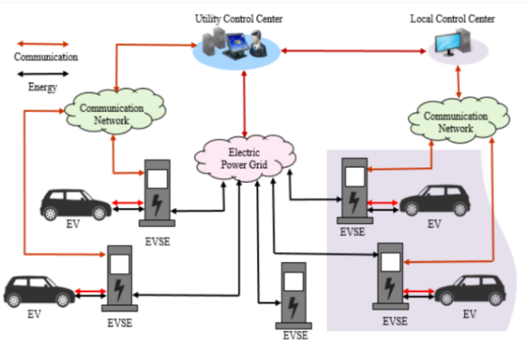


Fig. 1. Cyber-physical nature of EV system [27]

1. System Modelling

First, we'll utilize PVsystem to investigate, size, and analyze data on whole PV systems. Then, we'll use MATLAB to build a 50 kW PV-powered charging station for EVs. Figure 2 shows the main components used in the specified design, which include photovoltaic systems, EVCS, controllers, inverters, connectors, cables, and mounting solutions..

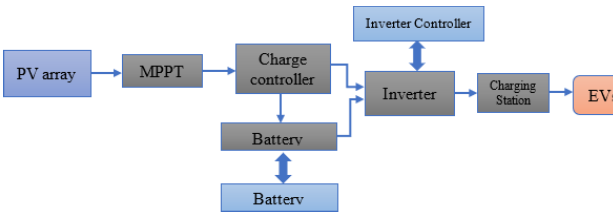


Figure 2: MATLAB implementation of the blocks.

a) Solar PV Array

For a 50kW system using PV Syst V6.88, the SunPower SPR-E20-435-COM is the best option due to its extensive PV array, which is composed of numerous individual PV modules or panels connected in 9 series and 13 parallel strings to provide the necessary current and voltage. Increasing the array's surface area would boost total solar energy generation.

b) Inverter

We will select an ABB inverter based on the design's power requirements. To illustrate, we have the option of using either one 50 kW inverter or two 25 kW inverters if our design is 50 kW. These inverters are designed to work with voltages ranging from 300 volts to 950 volts, with a power output of 50 KW and an efficiency level of up to 98.54%

C) A controller for Maximum Power Point Tracking (MPPT)

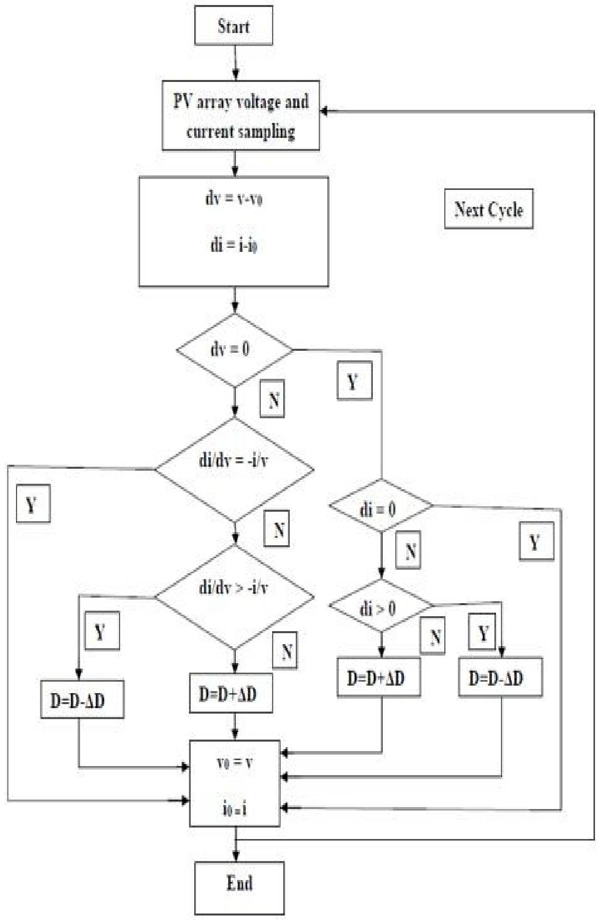


Fig 3: Incremental conductance MPPT algorithmflow chartlithium ion battery

The PV panel's instantaneous conductance value is shown on the left side, as opposed to the right side. There is a reach to MPPT when LHS = RHS. This strategy eliminates the impact of solar light variation on accuracy since it considers both factors. The primary argument in favor of using the INC technique is how cost-effective it is. Consequently, this method controls the duty cycle by pulse width modulation of a direct current boost converter until the criterion indicated earlier is satisfied.. The INC MPPT flow chart is provided below.

We have chosen an LG chem model EM048290P5B1 290Ah lithium-ion battery. A minimum of 255 modules must be connected in 51 parallel strings, each containing 5 batteries. Overall, it provides liberty for more than two days.

c) MATLAB/SIMULINK Implementation

Simulink is a graphical MATLAB plugin used for system modelling and simulation. Simulink displays systems as block diagrams on the screen. Transfer functions, summing junctions, and other virtual input and output devices such as oscilloscopes and function generators are examples of virtual input and output devices. are just a few of the many block diagram elements that are accessible. Data may be easily transferred between MATLAB and Simulink thanks to their connections. A Simulink model of an EV PV charging station is employed.

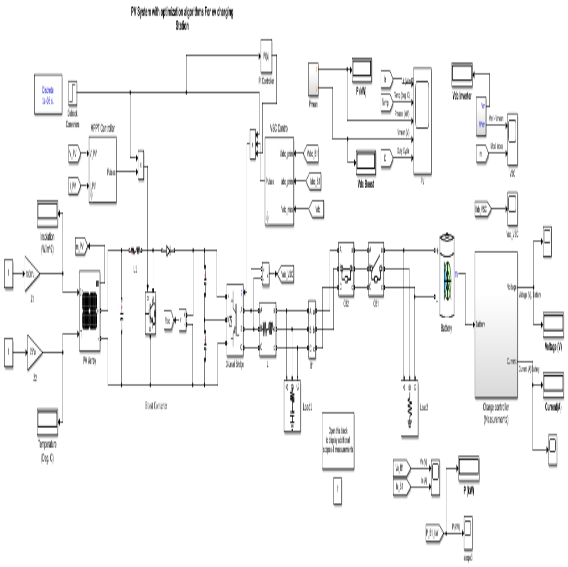


Figure 4: Matlab implementation of an electric vehicle (EV) charging station

1. Result and Discussion

Here we have a look at a solar PV Simulink model that was built specifically for the MATLAB application and used for research. Using a genetic algorithm and incremental conductance (INC) as two MPPT strategies/methods, the authors show how to improve efficiency (GA). We run the simulation with an irradiation range of 1000 to 225 W/m2 and a temperature range of 25 to 50°C. Presented here is the MATLAB/Simulink simulation model of an INC MPPT PV system, along with some discussion of its construction. To make a solar array work as if there were clouds blocking the sun, you can adjust the irradiation value. Following is a breakdown of the irradiation level variation: 10,000 225, 000 W/m2. As a result of variations in irradiation, the output of a PV array changes. The variation in irradiation makes it necessary to retrace MPPT to a new point. The simulation considers the system's steady-state and dynamic-state responses to a sudden change in solar irradiation. A network of sixty-six strings, with five modules per thread, linked in parallel, produces the necessary voltage.

As the converter initially draws the system to the MPP, a few transients are observed in the system during model simulation. Listing 1 contains a summary and comparison of the findings.

Table 1: output Parameters with INC MPPT Method

S.No	Parameters	INC Method
1.	Panel Voltage Vpv (V)	251.71
2.	Panel Current Ipv (A)	268.07
3.	Irradiation (W/m2)	2000
4.	Temperature (0C)	50
5.	PV Maximum Power/MPPT (KW)	90.41
6.	Boost Converter OutputVoltage (V)	501.50
7	Boost Converter Outputcurrent (A)	260.89

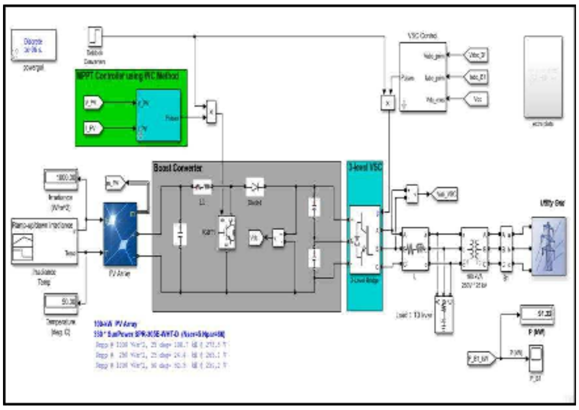


Figure 5: Voltage and current of a PV array using the INC Method

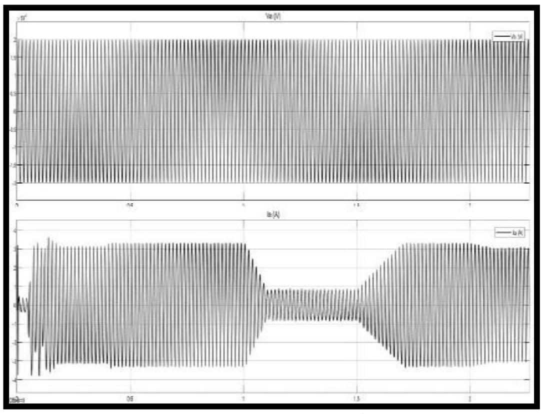


Figure 6: Voltage and current for the INC MPPT method on the utility grid

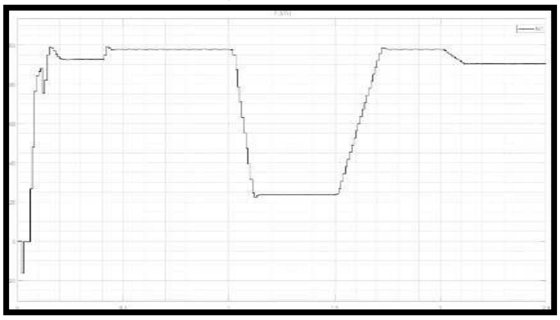
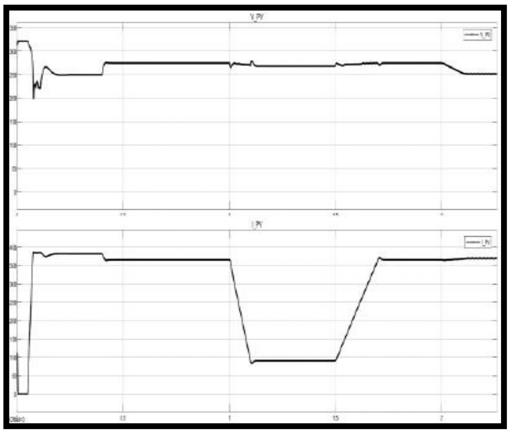


Figure 7: Maximum PV array power using the INC Method

MPPT Method Simulation Modeling and Result Analysis

PV system simulation model is presented in this section On MATLAB/Simulink, a design for GA MPPT is demonstrated and explored. The goal of changing the irradiation value is to simulate a cloud cover that prevents sunlight from shining straight on a photovoltaic array. It is necessary to trace MPPT to a new point as a result of the variation in irradiation. This simulation takes into account the system's response to a sudden shift



in solar irradiation in both steady state and dynamic state. GA MPPT techniques were used to simulate this model connection together with the MPPT control system, and the effects on a number of variables, including output power, voltage, and current.

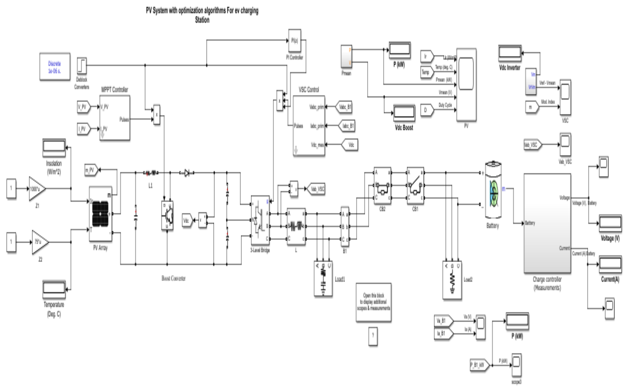


Figure 8: System simulation model using the GA MPPT technique

When the model is simulated, it is discovered that there are As the converter draws the system to the MPPT at the beginning of simulation, some transients are generated in the system. Table 2 provided a summary and comparison of the findings.

S. No.	Parameters	GA Method
1.	Panel Voltage Vpv (V)	251.81
2.	Panel Current Ipv (A)	268.91
3.	Irradiation (W/m2)	2000
4.	Temperature (0C)	50
5.	PV Maximum Power/MPPT (KW)	92.26
6.	Boost Converter Output Voltage (V)	502.13
7	Boost Converter Output current (A)	260.82

Table 2: Output Parameters with GA MPPT Method

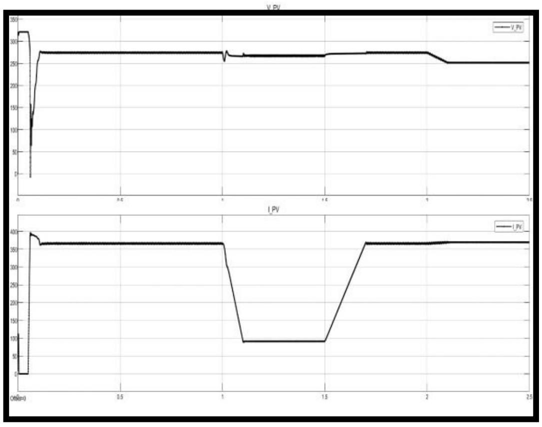


Figure 9: PV array voltage and current with GAmethod

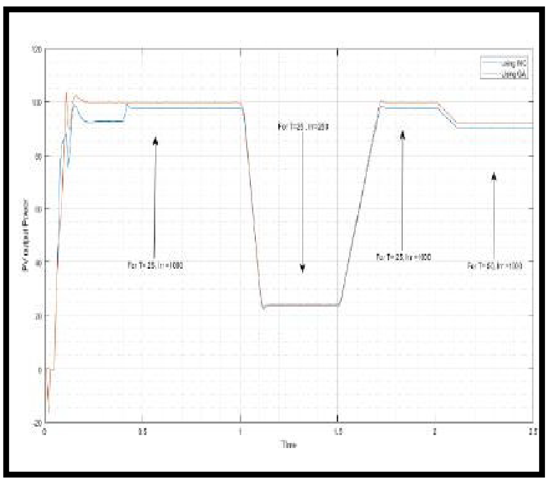


Figure 10: Voltage and current for the GA MPPT technique on the utility grid

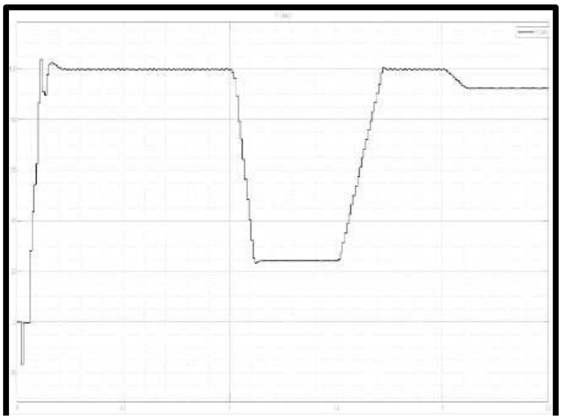


Figure 11: Maximum PV array power using GA

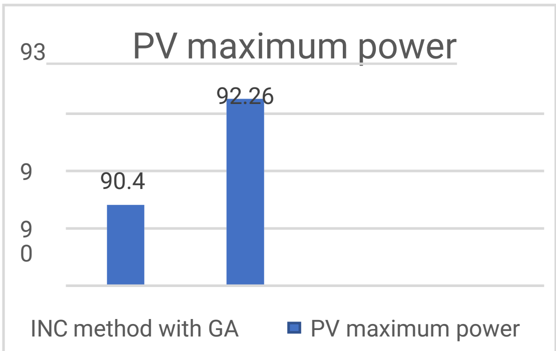


Figure 12: Comparison of PV array maximum power with GA Method

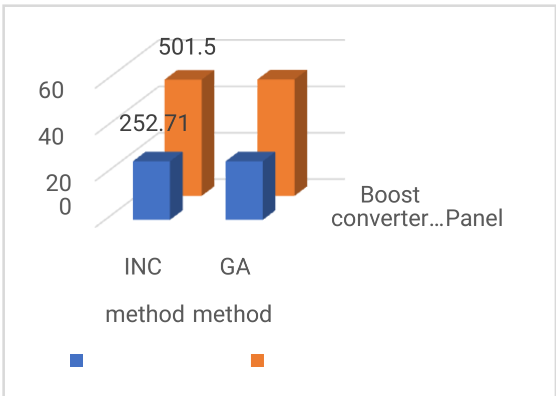


Figure 13: Comparison of PV voltage and converter output voltage with INC and GA Method

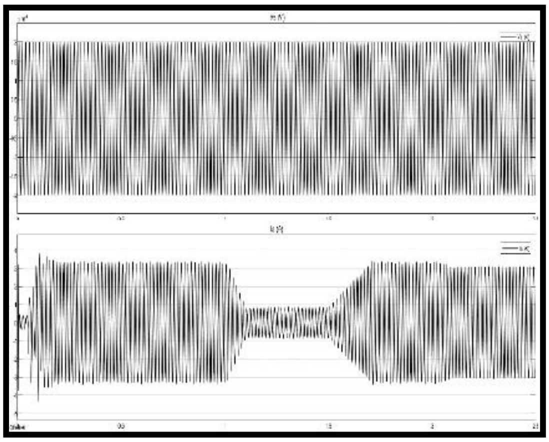


Figure 14: PV maximum power and converter output power comparison using the INC and GA methods

For both examples under examination, findings from the INC and GA approaches were reviewed in this part, and values and plots were shown using various figures and tables. Both the panel end and the Boost converter end were used to calculate values.

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