Grid integrated ALO MPPT PV system for EV charging station applications

KONDA SANDHYA [1] | DR B.SHIVAJI[2]

[1]Pg Scholar, Dept of EPS, Kodada Institute of Technology & Science for Women-Kodad, Telangana.

[2] Associate Professor, Dept of EEE, Kodada Institute of Technology & Science for Women-Kodad,Telangana.

ABSTRACT: This paper presents the modelling of Ant lion optimization (ALO) maximum power point tracking (MPPT) for PV system. Recently, the deployment of PV source has been increased rapidly due to its inherent characteristics such as clean energy and reduces the greenhouse effects. However, due to abnormalities of environmental conditions, the power produced from the PV source is in highly intermittent nature. To stabilize the power produced by the PV source and enhance performance electric vehicle an ALO control approach is model in this work. The ALO MPPT approach is a metaheuristic search inspired by how antlions trap ants to find the best PV operating point. ALO approach provides superior performance over the existing perturbation/conductance MPPT approaches. To ensure high reliability and continuous operation of the EV charging station, the utility grid is integrated to the PV system. To check the efficacy of the proposed method simulations performed for steady state and dynamic irradiance variations of PV array.

KEYWORDS: MPPT, ALO, EV CHARGING STATION, PV SYSTEM.

I.INTRODUCTION: Academics, researchers, and stakeholders around the world are managing the challenges posed with the aid of the strength disaster and global warming. The use of opportunity strength assets, together with sun, tidal, and wind power, has end up extra famous these days as a result of those issues. Most of our electrical needs are met by means of non-renewable assets, which can be swiftly depleting [1], [2]. As a result, employing non-traditional strength has been connected to a discount in each environmental pollution and fossil gasoline-primarily based energy technology. Given the increasing population, suitable options ought to be investigated. By converting sunlight into power, photovoltaic (PV) systems enable the manufacturing of power this is both environmentally useful and strengthefficient [3]. Since PV electricity is still visible to be luxurious, finding approaches to lower the fee of PV systems has been a prominent place of studies. Power electronics can be applied to maximise PV output electricity in an effort to clear up the aforementioned issues [4]. For PV structures to make certain that the maximum quantity of strength is extracted in any ambient circumstance, most electricity point monitoring is crucial [5]. Because in their low strength output, these solar gadgets must be run equally in single- or two-diode configuration in order to reach maximum energy factor (MPP) era. One example of a PV era is perovskite sun cells (PSCs), whose photovoltaic modules are constrained to utilization in certain environmental situations (e.G., moving fog, shade, bird faces, and many others.).

The proposed have a look at [8] offers a comprehensive, crucial, and in-intensity investigation of the widely used and currently advanced global most electricity factor tracking (GMPPT) algorithms for photovoltaic (PV) structures. Optimization algorithms, hybrid techniques of distinctive optimization algorithms, hybrid strategies of optimization algorithms with conventional algorithms, and additional GMPPT algorithms are the four number one sorts of algorithms. This allows algorithmic comparisons. The previous century's primary gasoline supply become fossil fuels, however its dangerous effects at the surroundings made the introduction of different modes of transportation vital. One of the viable replacements that has brought about their development is the electric car (EV).

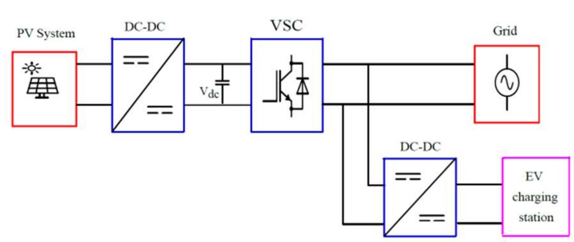
As the number of electrical motors on the road rises, the use of grid energy to price them becomes greater difficult [8]. When quite a few electrically driven motors used the grid, its manage and operation could unavoidably become worse. As a result, charging electric automobiles powered with the aid of renewable energy sources requires a reliable network [9]. Since the solar-powered EV charging station offered right here is powered through a PV device that is managed by using an MPPT controller, a radical investigation of the diverse MPPT techniques is achieved. The authors of [10] need to present a new number one scheme-based totally evaluation of the MPPT techniques, which have been divided into three categories (traditional, novel, and hybrid) according to the deployment of their input variables (sun irradiance, PV array temperature, and PV array terminal voltage and current). Six different schemes include the MPPT strategies. Previous MPPT studies are extracted from the literature and analyzed for every scheme. The primary advantages and disadvantages of the six MPPT plans are then compared and discussed. Numerous MPPT processes have been mentioned within the literature [11]. The DC/DC chopper, that's generally used in PV structures, could have its parameters changed to generate the maximum energy factor (MPP).

Because in their accuracy and system independence, metaheuristic MPPT techniques have these days turn out to be greater famous. Particle-swarm optimization (PSO)-centered MPPT algorithms, including Cuckoo Search Grey Wolf Optimization (GWO), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC), Slap Swarm optimization (SSO), Grass Hopper Optimization, Teaching-Learning based totally optimization, and Flying Squirrel Search optimization (FSSO), had been proposed by way of several students. Intelligence-based techniques are very good at manipulate and optimization. Currently, researchers have determined that bio-inspired optimization strategies for tracking GMPP have low settling instances, excessive precision, and true efficiency. To control the inverter output contemporary and optimize PV electricity in a boost-converter device, a sliding mode controller is hired. An SLMC controller is utilized in a lift converter for an MPPT since the electricity is squandered in a resistor and no inverter manage is needed. An open-supply Arduino card has been proposed for an experimental sliding mode manipulate (SLMC) software for MPPT of solar systems. There are primary steps inside the suggested strategy.

To verify the MPPT effects, the initial characteristic curves of PV panels primarily based on tracer variable load had been traced. Second, an MPPT manage software program has been set up onto the open-supply card to simplify or lower the hard birthday party and offer greater manipulate technique flexibility. A backstepping SLMC (BSLMC) approach that ensures machine balance by way of making use of Lyapunov criteria is delivered. This article makes use of a fuzzy inference system in preference to the saturation function and a changed SLMC for MPPT to assure easy conduct. The parameters of the proposed fuzzy BLSLMC (FBSLMC) are optimized the use of the particle swarm optimization (PSO) approach. A range of case studies are used to test the proposed controller due to the fact MPP is dependent on each temperature and solar radiation. Furthermore, the controller's overall performance is classed beneath partial colour conditions. In a sliding-mode controller is proposed for grid synchronization with PV.

Innovative, reliable, and powerful first-order sliding mode control algorithms for sun strength conversion are the goal of this research. Sliding mode manipulate for nonlinear hundreds is used to triumph over THD and primary-order greenback-boost converter issues. The proposed method makes use of a neural community and an adaptive terminal sliding mode controller (NN-ATSLMC) to make certain that the PV system operates optimally even within the face of uncertainty. The NN-ATSLMC controller and a DC/DC boost converter paintings together to force the device to its maximum power factor (MPP). This method ensures that the mistake will converge in a finite quantity of time with the aid of lowering the chattering effect without compromising robustness towards a diffusion of shocks and load situations. The authors' technique is that SLMC establishes the running point by creating a sliding floor. To reach this surface in a positive period of time, a control rule desires to be implemented to the DC/DC converter gate. PV peak strength may be acquired easily in a spread of situations via various the responsibility cycle of the converter. The PV changed into connected to the grid via a multilayer inverter. However, the recommended approach's primary flaw is that it seems complicated.

II.PROPOSED SYSTEM: This essay should address and explore the significant issues and points of controversy brought up by the literature review. Theoretical studies that look into optimization applications for renewable energy sources appear to have several advantages and stability. When working with the interface of many modules, there are a few factors to consider in contrast to well-known conventional procedures. One of the best ways to solve nonlinear issues is through soft computing-based MPPT techniques that have already been presented in the literature. Unfortunately, these MPPT algorithms are more costly and complex to develop than conventional methods.



In summary, a solar-powered EV charging station that can track GMPP in the shortest settling time with minimal oscillation, low overshoot, and minimal ripple needs an effective MPPT controller. Additionally, grid connectivity and stand-by batteries (SBBs) are essential since vehicles require a continuous power supply. The objectives of this study align with the highlighted research gap (i.e., appropriate modeling for each EV fleet). Thus, the main recommendation of this study is a novel sliding mode-based reconfigurable Pb&O MPPT controller for PV systems that is optimized through the use of a genetic algorithm (GAO). The first-order sliding mode controller (SLMC) generates the proposed MPPT algorithm. A control equation that keeps the system variables on a selected surface—also referred to as a sliding surface—is developed and implemented using the Genetic Algorithm (GAO). under the second section, this article suggests a grid-connected EV charging method that demonstrates its effectiveness under partial shade or at night when photovoltaic panel power is unpredictable or nearly nonexistent, respectively.

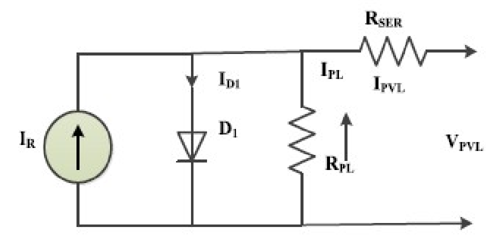


FIGURE 2. PV cell’s analogous circuit diagram.

The creation of a plan that facilitates the building of a dependable EV charging station and the comprehension of rendition, considering two aims, are among the study's first objectives.

• To create an MPPT method that can effectively track GMPP with the least amount of overshoot and settling time. An innovative MPPT controller is created in this paper. In terms of shortest settling time, improved accuracy, etc., the suggested GAO adjusted sliding mode based reconfigurable step size Pb&O controller is far more advantageous. To maximize system output, the proposed algorithm is integrated into the MPPT scheme.

• To design and construct a grid-connected PV-based electrically powered conveyance charging system that is dependable and provides continuous charging capabilities even in undesirable circumstances (e.g., partial shadowing conditions when PV panel generations are declining, grid failure environment, etc.).

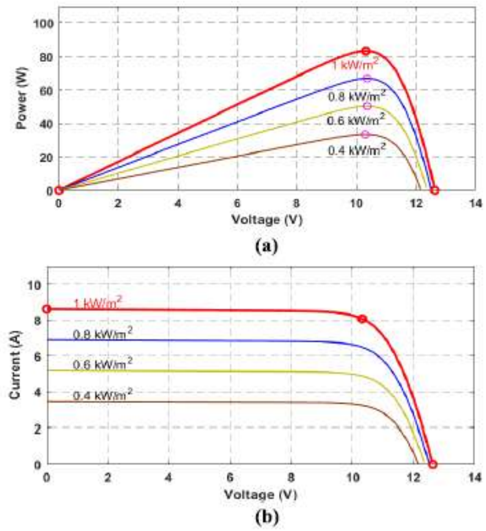


FIGURE 3. Solar cell's feature for (a) power vs. voltage and (b) current vs. voltage.

TABLE 1. Parameters of proposed boost converter.

Sl No.	Parameter	Value
1	Inductance (L)	0.1164 H
2	Input Capacitance (C_{IN})	4.8250 µF
3	Output Capacitance (C_{OUT})	4.0704 µF
4	Switching Frequency	10KHz

2.1 PV SYSTEM STRUCTURE REPRESENTATION Photovoltaic processes are used by PV cells to convert solar energy into electrical energy. It should be mentioned that there are many different configurations of PV systems. A solar photovoltaic cell's schematic arrangement is shown in Fig. 1. The output current of the PV cell could be used for:

$$I_{PVL} = I_R - I_{D1} - I_{PL} \quad (1)$$

where IPVL and VPVL are the discrete output current and voltage from the photovoltaic cell. IPL, ID1, and IR stand for parallel resistance (RPL), photovoltaic current, and diode, respectively. RSER stands for series resistance.

$$I_{D1} = I_{RSC} + e^{q\frac{V_{PVL}+I_{PVL}*R_{SER}}{nKT}} - 1 \quad (2)$$

Reverse saturation current is known as IRSC. The symbols q, T, n, and K stand for electron charge, ambient temperature, diode factor, and Boltzmann constant, respectively. The PV cell's produced current is expressed as:

$$I_R = \frac{W}{W_0}(I_{SCN} + \lambda(T - T_0)) \quad (3)$$

ISCN indicates short circuit current, whereas T0 and W0 stand for temperature and reference irradiance, respectively. The atmospheric temperature and irradiance coefficients were recorded as λ and W.

$$I_{PVL} = I_R - I_{RSC}[e^{q\frac{V_{PVL}+I_{PVL}*R_{SER}}{nKT}} - 1] - \frac{V_{PVL} + I_{PVL} * R_{SER}}{R_{PL}} \quad (4)$$

The P-V and I-V characteristics of PV cells are shown in Figure 2. Equation (5) formulates the corresponding equation.

$$\frac{dP}{dV_{PVL}} = \left\{ \begin{array}{c} 0 \text{ at } MPP \\ > 0, \text{ at left hand portion of } MPP \\ < 0, \text{ at right hand portion of } MPP \end{array} \right\} \quad (5)$$

The aforesaid equation is the fundamental concept for MPPT adaptive controller.

2.3 DC-DC CONVERTER

A. DC-DC BOOST CONVERTER The solar array can follow the MPP under certain irradiance and environmental conditions thanks to a DC-DC converter that connects it to the load. To keep the solar array operating continually at the MPP, the duty ratio of the converter switch is continuously adjusted using MPPT techniques. Table 1 lists the specifications of the DC-DC converters used in this instance. This shows the modifications made to the DC-DC converter under investigation.

B. THE BIDIRECTIONAL CONVERTER This article recommends controlling the storage and transfer of electricity between a PV system and a battery bank using a bidirectional DC-DC boost converter because of the advantages listed below. It provides the most cost-effective solution with the fewest external components. (ii) It uses the fewest parts required to accomplish voltage step-up and step-down. (iii) It has a reduced duty cycle when in operation. (iv) It works well across a broad range of input and output voltages. (v) It is less expensive than the majority of converters. After sunset, excess solar energy is collected, stored, and used to fuel a standby battery that powers electric automobiles. The charging and discharging of the stand-by battery (SBB) is controlled by a bidirectional boost DC-DC converter. The charging station is composed of a 240V, 40Ah SBB. For stand-by batteries (SBBs), a minimum 20% SOC discharge rate is estimated.

C. GRID IMPLEMENTATION WITH INVERTER MODULE The 230V, 50Hz AC grid is analyzed for the charging station's additional power requirements. An inverter connects a 500V DC bus to a 230V AC grid in MATLAB/Simulink. The PV array energy output is used to generate pulses for inverter switches utilizing a current control scheme depending on the EV's battery power. Here, 2000 W of electricity from the EV's battery is taken into account and compared to the power produced by the PV module. This leads to the generation of a reference current in an unbalanced d-q frame. For inverter control, a current PI controller in an unbalanced d-q frame is also used. 2.3 REPRESENTATION OF THE BATTERY STRUCTURE A 240V, 48Ah battery is intended to be used with the charging station. An electrically powered vehicle's battery is charged via a 500V DC bus using a PI controller and a DC-DC boost converter. The arriving EV's battery is expected to have a minimum SOC of 9% for modeling purposes. The necessary energy (Eev) to charge an EV battery can be determined using the battery's lowest voltage (Vlo), enduring percentage state of charge (SOCre), and amp-hour rating (Ahr).

$$E_{ev} = \frac{V_{no} * SOC_{re} * Ah_r}{100} \quad (6)$$

The model makes the assumption that the battery's internal resistance can be kept constant over cycles of charging and discharging.

2.4 FRAMEWORK OF METHODOLOGY

A. MPPT CONTROLLER IN GAO-SLIDING MODE A new method for creating SLMC with GAO is covered in this section. To operate the variable step size of a traditional Pb&O MPPT algorithm, the SLMC gains driving the control law and the sliding surface are modified. The proposed approach solves the design problem that necessitates comprehending the bounds of uncertainties, which might be difficult, by utilizing fresh knowledge for creating this kind of controller. This bound is often overstated, resulting in excessive gain and the well-known phenomena of chattering. The proposed methodology does not require knowledge of the uncertainty constraint, as is the case with all techniques used to reduce the chattering phenomena.

B. SLIDING MODE CONTROLLER DESCRIPTION One type of nonlinear control that works very well for controlling systems with changeable structures is sliding mode control. The basic principles of the sliding mode control approach are based on output feedback and an endless high-frequency switching control action. This high-speed control law essentially directs the system trajectories to a part of the state space that is often associated with a manifold or sliding surface. The main advantages of a system with sliding mode control features are as follows:

• intolerance for external disturbances and unmodeled dynamics.

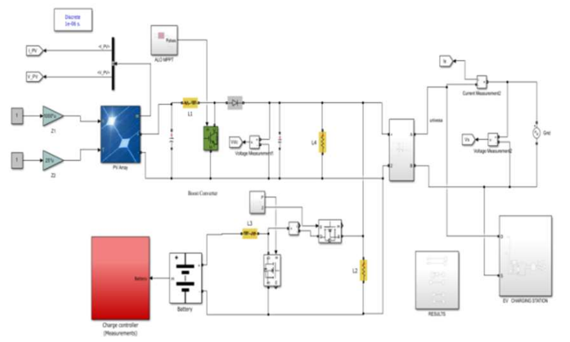
• A straightforward and adaptable controller structure.

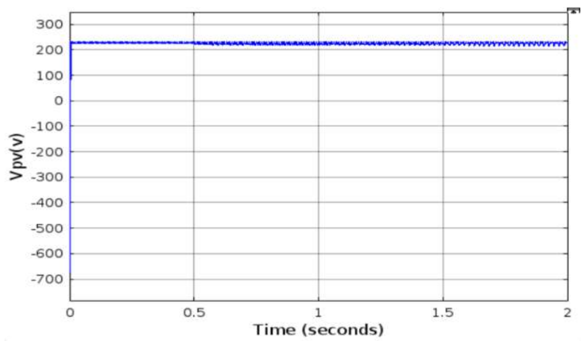
• The capacity to eliminate steady-state defects from the sliding Mode Controller design process and insert an action error into the sliding surfaces.

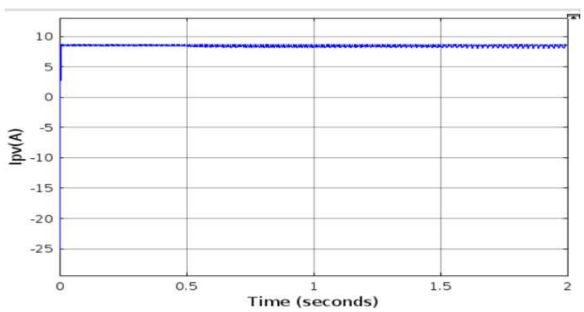
• Decoupling design methodologies, order reduction, disturbance rejection, sensitivity to parameter changes, and simplicity of use with standard power converters. These qualities make sliding mode control ideal for use in nonlinear systems, which accounts for its extensive industrial use in applications such as automotive and electrical drivers.

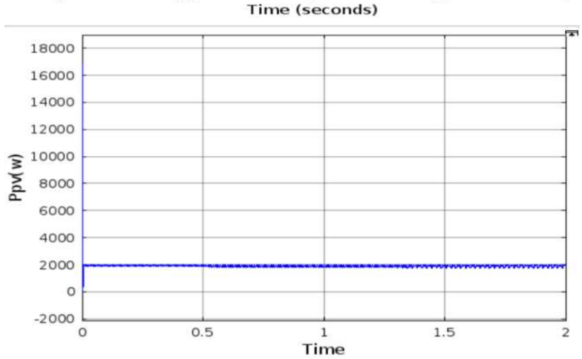
FIGURE 4. Successive steps of GAO algorithm.

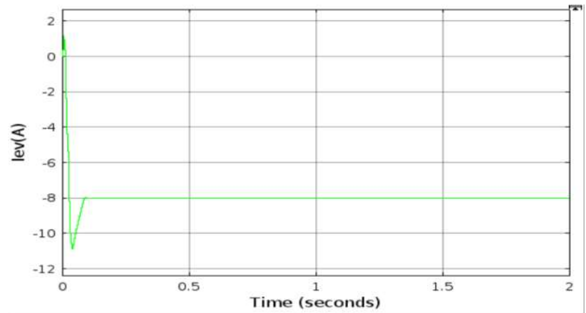
III.SIMULATION RESULTS:

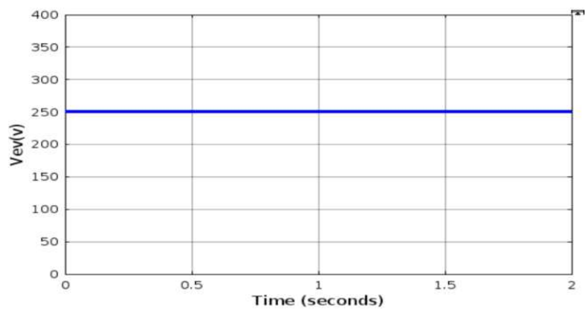


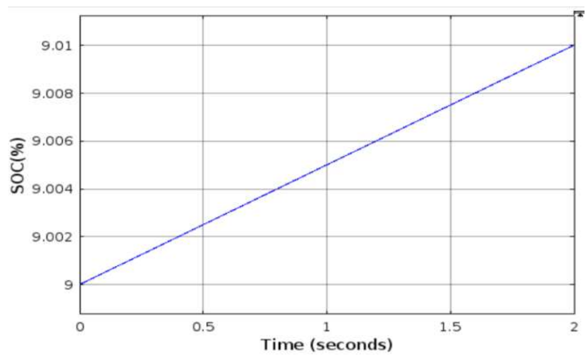




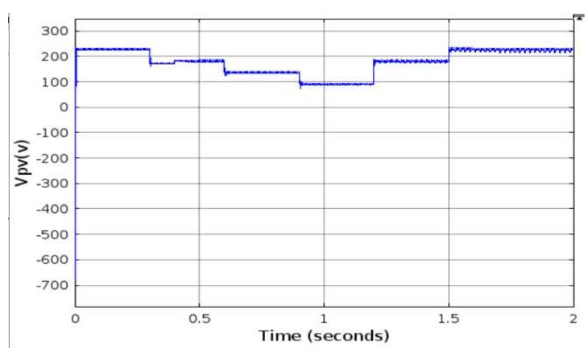


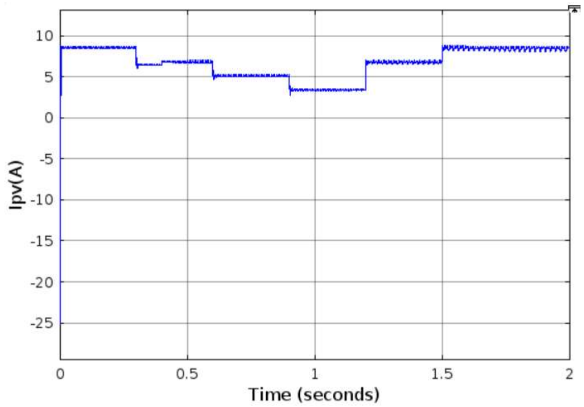


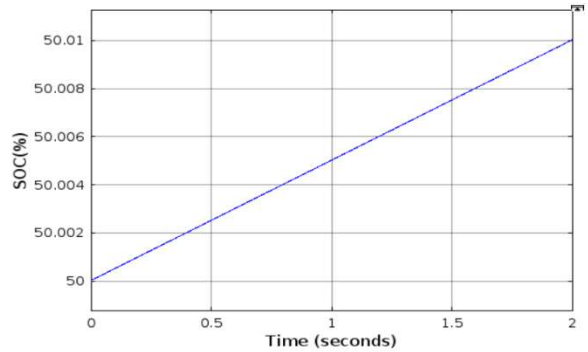


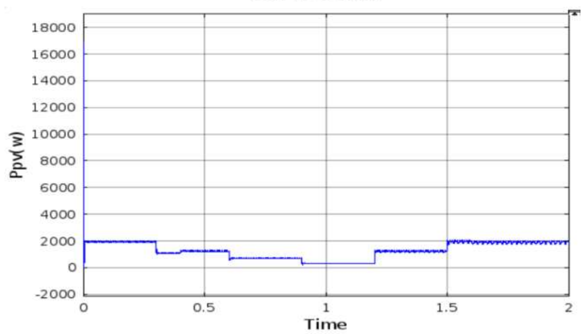


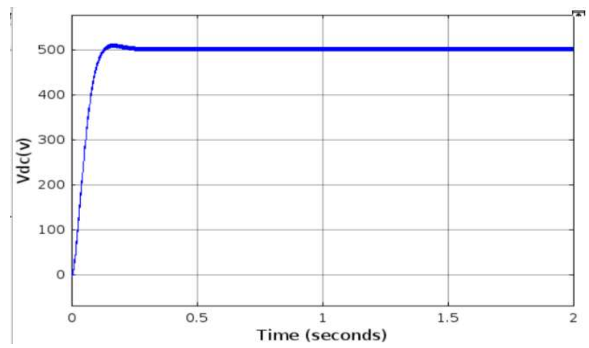
Case2

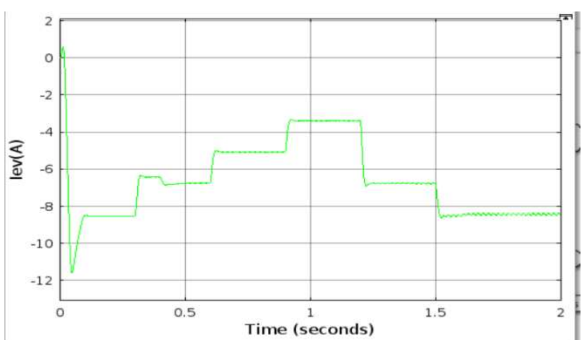


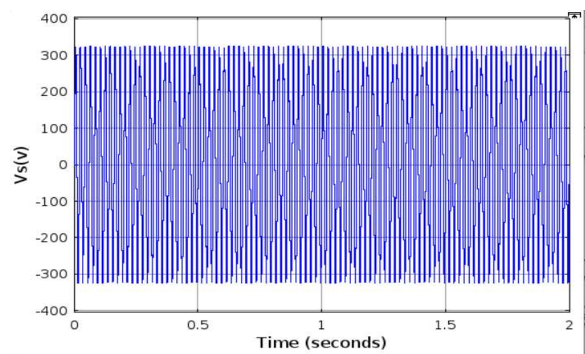

Ipv(A)
Time (seconds)

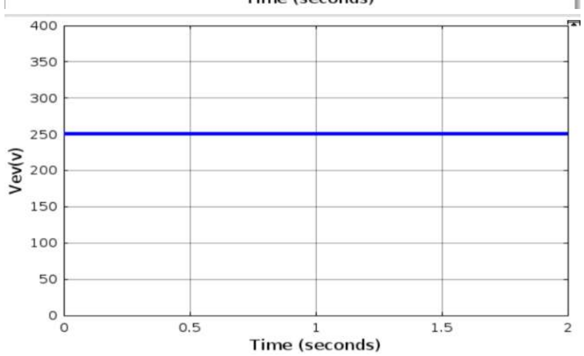

SOC(%)
Time (seconds)

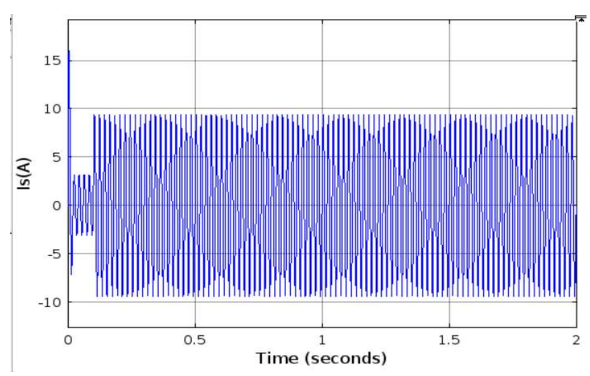

Ppv(w)
Time

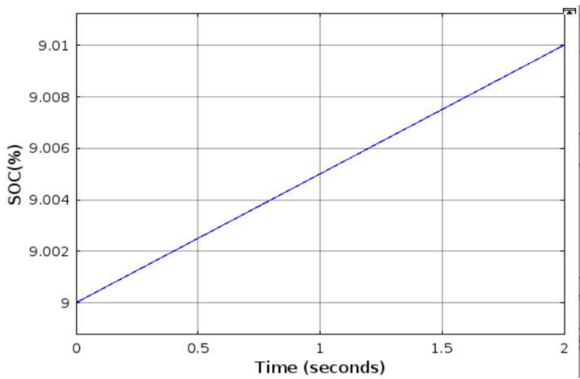

Vdc(v)
Time (seconds)

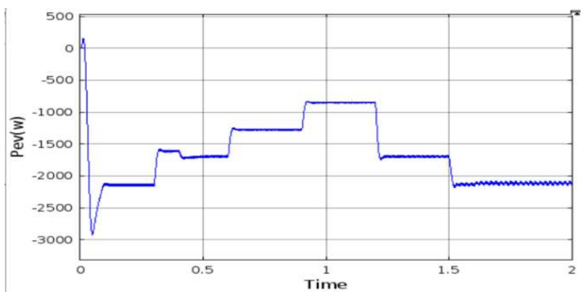

Iev(A)
Time (seconds)


Vs(v)
Time (seconds)

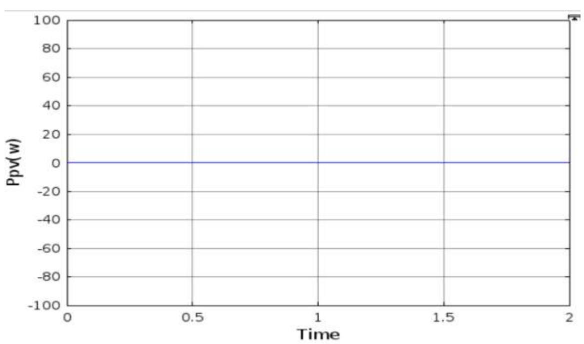

Vev(v)
Time (seconds)

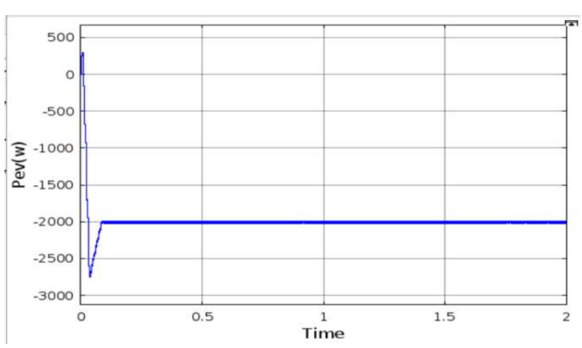

Is(A)
Time (seconds)





Case3





IV.CONCLUSION: This paper presents an ALO-based MPPT for a photovoltaic (PV) system. The ALO control approach is a metaheuristic optimization method that outperforms heuristic techniques such as P&O and INC and other popular evolutionary algorithms. ALO improves in dynamic conditions by avoiding local maxima better than P&O/INC, with faster settling than evolutionary methods. Simulation results indicate that the ALO-optimized MPPT reduces settling time, overshoot, and steady-state error, resulting in higher voltage and power peaks. This method demonstrates superior efficiency in off-grid PV systems under varying irradiance conditions. The simulations also show that the proposed method maintains a constant voltage for both the electric vehicle (EV) battery and the DC link capacitor, even under both steady-state and dynamic irradiance It achieves superior efficiency off-grid PV setups under irradiance variation conditions of the PV array.

REFERENCES: [1] J. Hashimoto, T. S. Ustun, M. Suzuki, S. Sugahara, M. Hasegawa, and K. Otani, ‘‘Advanced grid integration test platform for increased distributed renewable energy penetration in smart grids,’’ IEEE Access, vol. 9, pp. 34040–34053, 2021.

[2] H. M. K. Al-Masri, A. A. Al-Sharqi, S. K. Magableh, A. Q. Al-Shetwi, M. G. M. Abdolrasol, and T. S. Ustun, ‘‘Optimal allocation of a hybrid photovoltaic biogas

energy system using multi-objective feasibility enhanced particle swarm algorithm,'' Sustainability, vol. 14, no. 2, p. 685, Jan. 2022.

[3] R. Shirmohammadi, B. Ghorbani, M. Hamedi, M.-H. Hamedi, and L. M. Romeo, ''Optimization of mixed refrigerant systems in low temperature applications by means of group method of data handling (GMDH),'' J. Natural Gas Sci. Eng., vol. 26, pp. 303–312, Sep. 2015.

[4] F. Zaouche, D. Rekioua, J.-P. Gaubert, and Z. Mokrani, ''Supervision and control strategy for photovoltaic generators with battery storage,'' Int. J. Hydrogen Energy, vol. 42, no. 30, pp. 19536–19555, Jul. 2017.

[5] A. O. Baba, G. Liu, and X. Chen, ''Classification and evaluation review of maximum power point tracking methods,'' Sustain. Futures, vol. 2, May 2020, Art. no. 100020.

[6] A. Nadeem and A. Hussain, ''A comprehensive review of global maximum power point tracking algorithms for photovoltaic systems,'' Energy Syst., vol. 14, no. 2, pp. 293–334, May 2023, doi: 10.1007/s12667-021-00476-2.

[7] S. M. S. Hussain, M. A. Aftab, I. Ali, and T. S. Ustun, ''IEC 61850 based energy management system using plug-in electric vehicles and distributed generators during emergencies,'' Int. J. Electr. Power Energy Syst., vol. 119, Jul. 2020, Art. no. 105873.

[8] M. A. H. Rafi and J. Bauman, ''A comprehensive review of DC fastcharging stations with energy storage: Architectures, power converters, and analysis,'' IEEE Trans. Transport. Electrific., vol. 7, no. 2, pp. 345–368, Jun. 2021.

[9] T. S. Ustun and S. M. S. Hussain, ''Implementation of IEC 61850 based integrated EV charging management in smart grids,'' in Proc. IEEE Vehicle Power Propuls. Conf. (VPPC), Hanoi, Vietnam, Oct. 2019, pp. 1–5.

[10] S. H. Hanzaei, S. A. Gorji, and M. Ektesabi, ''A scheme-based review of MPPT techniques with respect to input variables including solar irradiance and PV arrays' temperature,'' IEEE Access, vol. 8, pp. 182229–182239, 2020, doi: 10.1109/ACCESS.2020.3028580.

[11] A. H. Chander, K. D. Rao, B. P. Teja, L. K. Sahu, S. Dawn, F. Alsaif, S. Alsulamy, and T. S. Ustun, ''A transformerless photovoltaic inverter with dedicated MPPT for grid application,'' IEEE Access, vol. 11, pp. 61358–61367, 2023.

[12] K. A. Mahafzah, M. A. Obeidat, A. Q. Al-Shetwi, and T. S. Ustun, ''Anovel synchronized multiple output DC–DC

converter based on hybrid flyback- Cuk topologies,'' Batteries, vol. 8, no. 8, p. 93, Aug. 2022.

[13] X. Zhang, B. Yang, T. Yu, and L. Jiang, ''Dynamic surrogate model based optimization for MPPT of centralized thermoelectric generation systems under heterogeneous temperature difference,'' IEEE Trans. Energy Convers., vol. 35, no. 2, pp. 966–976, Jun. 2020.

[14] N. Khanam, B. H. Khan, and T. Imtiaz, ''Maximum power extraction of solar PV system using meta-heuristic MPPT techniques: A comparative study,'' in Proc. Int. Conf. Electr., Electron. Comput. Eng. (UPCON), Aligarh, India, Nov. 2019, pp. 1–6.

[15] L. T. Omine, M. A. G. de Brito, J. O. P. Pinto, and R. C. García, ''Hybrid MPPT algorithms for photovoltaic systems,'' in Proc. IEEE 4th Southern Power Electron. Conf. (SPEC), Singapore, Dec. 2018, pp. 1–8.