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ISSN 2249-3352 (P) 2278-0505 (E)
Cosmos Impact Factor-5.86

Solar Tracking System fed EV charging Controller with filter to Reduce charging time and to Enhance its Performance

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ABSTRACT:
For environmentally conscious transportation, there has been a lot of buzz about electric vehicle (EV) charging systems that use renewable energy sources like solar power. A PV 180-degree tracking system fed EV battery charge controller was designed and implemented to optimise the charging process, as presented in this research. By altering the charging parameters in real-time based on solar input, the suggested method uses a Twin T notch filter to minimise charging time. The PV 180-degree tracing system makes sure that the panels are always facing the sun so that they may collect as much energy as possible, and the Twin T notch filter makes sure that there isn't any noise and that the power is delivered smoothly. The technology shows, in both modelling and experiment, that it can significantly reduce charging time compared to traditional approaches while keeping charging performance safe and reliable. This strategy could encourage the broad use of renewable energy-powered electric vehicles by making EV charging facilities more efficient.

KEY WORDS: PV System, Electric Vehicles, Tracking and Twin T Filter.

I. INTRODUCTION:

Concerns over pollution and resource depletion have increased the popularity of electric vehicles (EVs) [1]. The increasing demand for electric vehicles necessitates the installation of charging stations. Electric vehicle batteries are normally charged by utility power. [2-4] present grid-based charger topologies for charging EV batteries. These topologies require large amounts of grid power to charge the EV batteries. On the other hand, the charger's unidirectional current flow architecture prevents the actual current from flowing backwards from the car to the grid. EV

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batteries can be used as a kind of energy storage to harness power when demand is high [5]. Over whelming majority.

Most of the time, electric cars are parked with a large amount of energy stored. It's an electric car when not in use, the grid receives power from the battery to cover peak demand. To do this, the electric vehicle charger must allow bidirectional active power flow [6]. The way electric vehicles send power to the grid is known as "Vehicle to Grid" (V2G). In this mode, EV charging is capable of providing reactive power support to the grid [7-10]. Supports reactive power near the end of the load[9].PV disruption is eliminated by using EV batteries as buffer storage and connecting charging stations to the grid[10, 11].Demonstrated the effectiveness of on-board charging in charging EV batteries. Batteries with low power consumption, on the other hand, are charged on board. As such, off-board chargers are a more practical choice than on-board chargers. [12–13] Examine the off-board charger topology.

Current research envisions a single-stage, solar-powered, off-board charging station for gridconnected electric vehicles. This outlet allows power to flow in both directions. A bi-directional converter connects the electric vehicle to his DC intermediate circuit at the charging station. Bidirectional converters protect EV batteries from second harmonic currents and DC link ripple, extending battery life. Furthermore, the battery performance of electric vehicles is no longer determined by the intermediate circuit voltage. The bidirectional converter's duty cycle controls battery charging and discharging. PV arrays are used to charge electric vehicle (EV)batteries, sending additional power to the utility company, alleviating the need for generators. The VSC provides the required reactive power regulation for the grid. Connecting solar-powered EV charging stations to the grid improves the quality of the grid power supply. It operates independently in grid failure mode to generate power for the PV array and charge the EV batteries. The system is also evaluated under various dynamic conditions, such as: B. Fluctuations in photovoltaic solar radiation, grid voltage imbalance, and changes in reactive power in the grid. The charging station will sync with the network when restored. Active and reactive power reference instructions are used in the charging station control architecture.

Electric vehicle owners use the reference active power command to determine whether to charge or discharge the electric vehicle battery.

The reference reactive power is selected according to the inductive/capacitive reactive power parameters required for continuous operation of the charging station. Charging stations are configured so that electric vehicle owners can choose their own charging and discharging times.

System operation when mains power is needed to charge an EV battery, it is called G2V (Grid to Vehicle). The system is called V2G (Vehicle to Grid), in which the battery of an electric vehicle discharges to power the grid. Depending on the situation, the charging station can also adjust reactive power (delay/lead).

II. PROPOSEDE SYSTEM DISIGN

a)PV Source

$$I = I_L - I_O \left(e^{\frac{q(v - IR_S)}{AKT}} - 1\right) - \frac{V - IR_S}{R_{SH}}$$

A solar cell's output voltage is denoted by V, while its output current is denoted by I. The dark saturation current (I0), electron charge (q), diode quality factor (A), Boltzmann constant (k), absolute temperature (T), and series and shunt resistances (RS and RSH, respectively) of solar cell are all variables in this equation. The connections and primary semiconductor material of a solar cell provide an electric current flow that is opposed to RS. Determining where the shunt resistance RSH came from is no easy feat. The p-n junction is not perfect, and when contaminants are present around the cell's edges, it forms a short-circuit route. Ideally, RSH would have an infinite value and RS would have zero. This perfect setting does not exist, however, therefore producers work to reduce the negative effects of both resistances in their goods.

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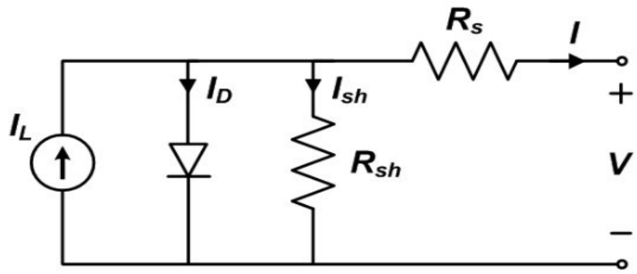

Figure 1 Equivalent circuit of a solar cell

Sometimes, while trying to simplify the model, the effect of the shunt resistance is ignored, leading to the assumption that RSH is infinite. Consequently. In a photovoltaic (PV) panel, several solar cells are linked in parallel & series arrays. This setup guarantees that PV panel's output voltage and current are up to snuff with what's required by the grid / equipment. Equation (2.2) provides the output current-voltage characteristic of a PV panel, taking into account the previously indicated simplification. The equation uses the variables np & ns to denote the number of solar cells in series and parallel, respectively.

$$I = n_p I_L - n_p I_O \left(e^{\frac{q(v - IR_S)}{AKTn_s}} - 1 \right)$$

b)Solar Trackers

This project will focus on active solar trackers, one of the recently released solar tracking systems, due to the considerable usage of electrical and electronic knowledges in these systems. Also, the majority of PV systems use this method to collect sunlight. Improving the efficiency of active solar trackers and developing more advanced PV material manufacturing techniques are the best ways to harness the Sun's vast energy resources.

There are two primary kinds of active solar trackers, namely single-axis and dual-axis, depending on how the solar modules are rotated. Rotating solar PV panels along a single axis, often perpendicular to the North meridian, is what single-axis trackers (SAT) do. Different orientations of the axis relative to the ground allow for different SAT configurations, such as tilted (TSAT), horizontal (HSAT), and vertical (VSAT) models.

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The solar modules can rotate from east to west in response to the sun's locations thanks to SATs. When it comes to simplicity, performance, and adaptability, SATs strike a decent balance.

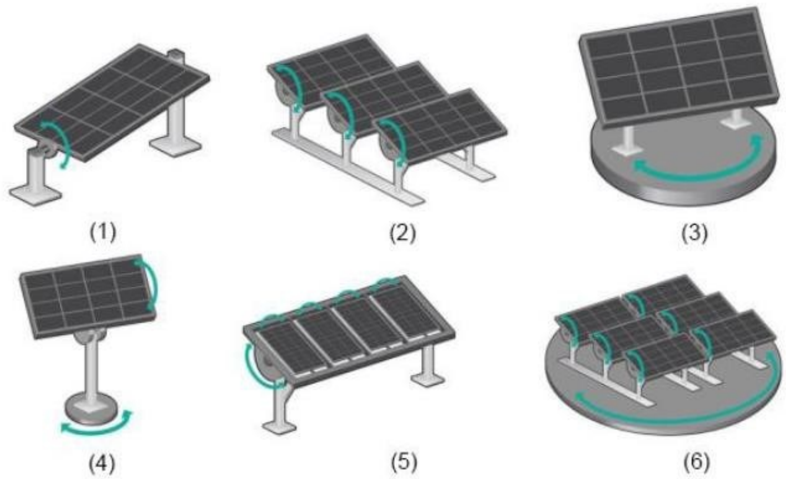

Figure 2 PV tracking systems (1) TSAT (2) HSAT (3) VSAT (4) TTDAT (5) HDAT (6) AADAT.

An improvement on SAT, the dual-axis tracker (DAT) allows for movement in two directions at once. In the bottom photographs of Figure 2.

When it comes to solar module mounting options, DATs provide the most flexibility. Consequently, the PV generator can run more efficiently for an extended period of time while sunshine is visible.

When discussing ways to improve tracking systems, it is important to define efficiency precisely. When applied to PV modules, this term denotes the optimal way in which a tracker can use a specific type of PV module. Although DATs cannot improve the solar PV materials' "radiation-topower" efficiency, these mounting solutions do assist in optimising the use of existing material technologies. The research on the structure and functioning of small-scale TTDATs will be the basis of this project's work. Electronic parts and laboratory apparatus will constitute the bulk of the project's tools.

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c)DC/DC Converter with MPPT

It is the job of a buck-boost converter to adjust load side voltage so that it is higher than or lower than source side voltage. The buck-boost converter's circuit layout is shown in Figure 3.3.

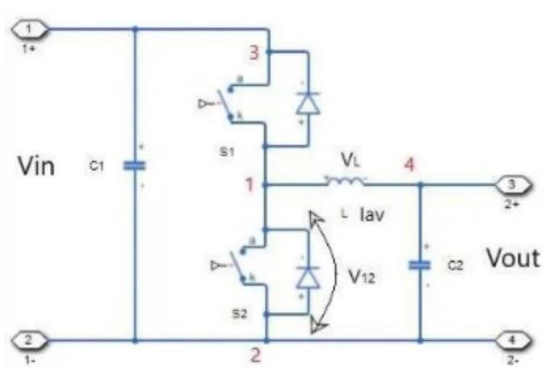


Figure 3 circuit diagram of buck-boost converter

The inductor's current begins to rise & store energy when switches enter the conduction state. It is claimed that circuit is in charging condition. The diodes disperse inductor's stored energy into load when switches are turned off. Changing the on-time of the switch allows for a variable output voltage.

d)Algorithm of Perturb Observe Method

The P&O approach, as seen in the flow diagram, may find the reference current value to maximise output power by comparing present and historical power and voltage readings [4].

An electric motor can be driven by an MPPT even in the absence of a storage battery. Particularly when starting a vehicle with a load, they offer considerable benefits. A beginning current significantly higher than the PV panel's short-circuit rating may be necessary for this. The motor can be started with the low voltage and high current produced by an MPPT, which can transform the comparatively high voltage and low current from the panel.

As soon as the motor starts operating and its current demand decreases, the MPPT will return the voltage to its usual operating level automatically. Here, the MPPT acts like a car's gearbox—low gears provide more torque to the wheels until the vehicle reaches speed, just like a real-life gearbox.

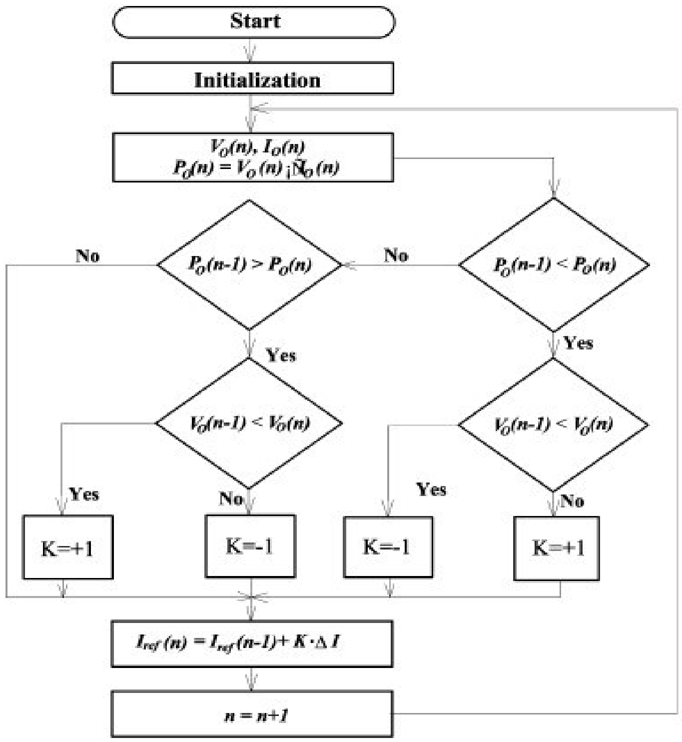
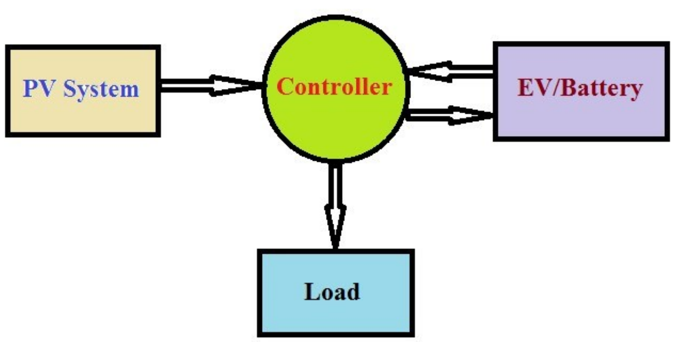


Figure 4 Flow chart of the MPPT algorithm with P&O method

e)**Test system design**



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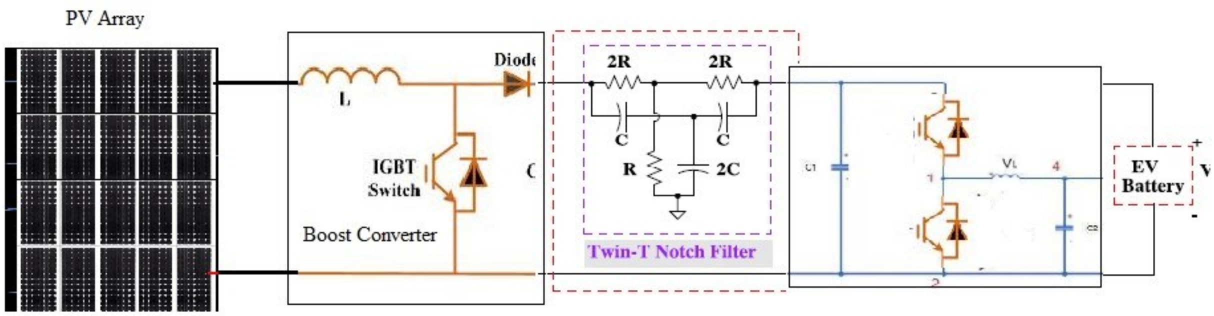
(a)



(b)

Figure 5 Proposed PV system (a) single line representation (b) Proposed network

A sun-tracking photovoltaic (PV) fed electric vehicle (EV) charger is an advanced system designed to enhance solar energy capture for charging electric vehicles by aligning PV panels with the sun's position throughout the day. Unlike fixed solar PV systems, a sun-tracking PV setup uses a tracking mechanism—typically either single-axis or dual-axis tracking—that continuously adjusts the angle of the solar panels to optimize sunlight exposure. This maximizes the energy generation capacity, especially during morning and evening hours when the sun's angle is low.

The sun-tracking PV-fed EV charger is beneficial because it increases the overall energy output, allowing EV charging to occur more efficiently and potentially reducing the charging time. This is particularly advantageous in off-grid or remote locations where maximizing renewable energy capture is essential. The tracking system may be integrated with a Maximum Power Point Tracking (MPPT) algorithm to ensure optimal power extraction under varying sunlight conditions, further enhancing system efficiency.

Challenges of sun-tracking PV systems include the higher initial cost due to the added mechanical components, increased maintenance needs, and the requirement for precise control systems to adjust the panels' position accurately. However, the increased energy yield often outweighs these costs, making sun-tracking PV systems a promising option for sustainable EV

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charging solutions, contributing to the reduction of greenhouse gas emissions by promoting the use of renewable energy for transportation.

f)EV Battery charging network with Filter

Fast charging systems use a variety of filters to shorten charging times, lower noise and harmonics, and increase power quality. By reducing ripple in the battery's input voltage and current, these filters improve charging performance. The following is a list of the many filters utilised in rapid charging systems, followed by an analysis of the situations in which the Twin-T Notch Filter displays exceptional performance. Fast charging systems use the following types of filters:

Twin T notch filter

Rather than rejecting an entire spectrum of frequencies, notch filters are able to isolate a narrower range of frequencies by virtue of their high Q and extreme selectivity. For instance, it could be required to eliminate harmonics, reject or reduce a certain frequency-generating electrical noise (like mains hum) that has been introduced into a circuit by inductive loads like EVs.

The notch filter network with two T-transistors is the most typical design. The twin-T arrangement, also known as a parallel-tee, is essentially two tee sections with two RC branches. Each section uses three capacitors and two resistors, with the tee sections arranged in opposite directions to generate a deeper notch.

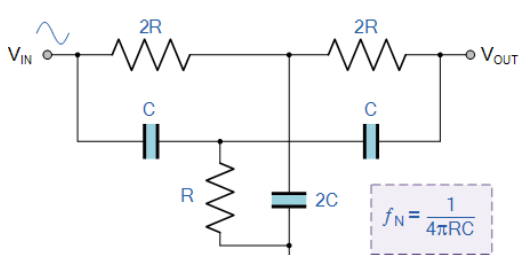

Figure 6 Twin-T Notch Filter Design

half of the design is a low-pass filter made up of 2R and 2C capacitors arranged in a top T-pad format, and half of it is a high-pass filter made up of C and R resistors arranged in a bottom T-pad configuration. The frequency that is most attenuated by the twin-T notch filter design is called the "notch frequency" or fN and is represented as

$$f_N = \frac{1}{4\pi RC}$$

The passive RC network design of this twin-T notch filter has one drawback: the maximum output voltage (Vout) below the notch frequency is usually lower than the maximum output voltage above the notch frequency. Losses are higher in the high-pass segment due to the reactants of the two series capacitors (C) being larger than the two conjunction resistances (2R) in the low-pass filter section.

III.SIMULATION RESULTS ANALYSIS

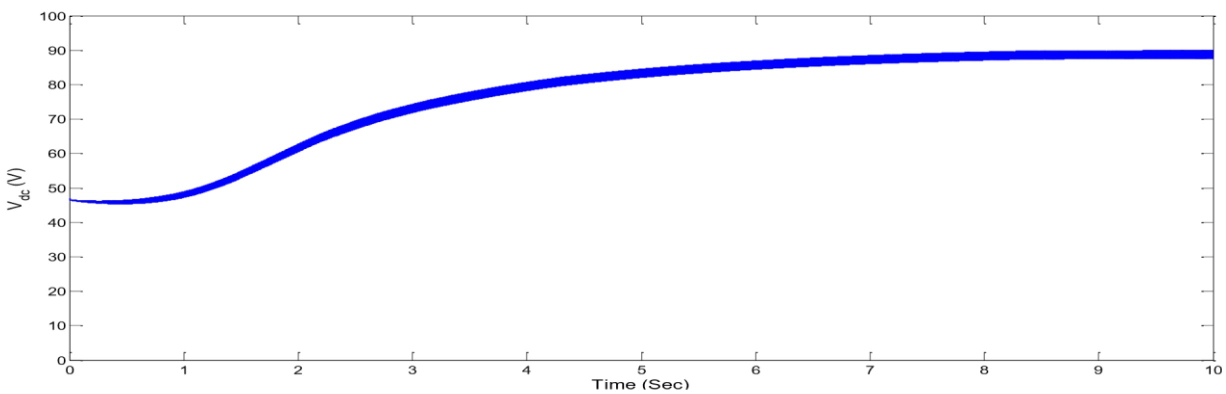

Figure 7 DC link voltage without filter

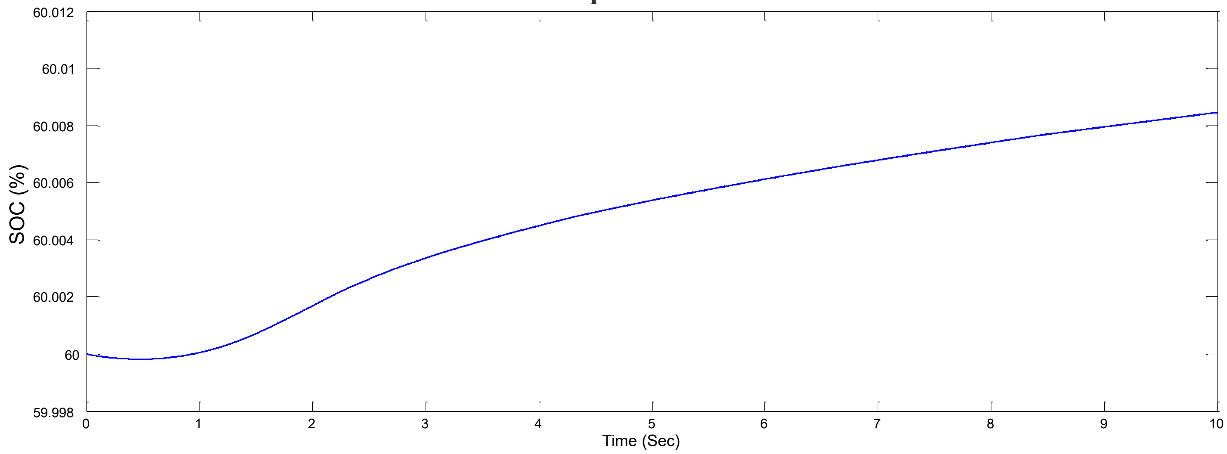

Figure 8 Battery SOC without filter

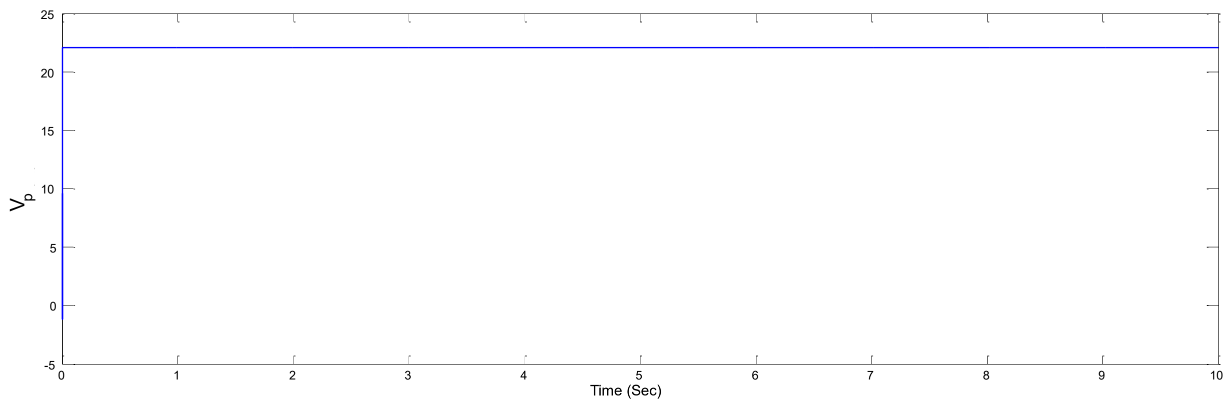

Figure 9 PV output voltage

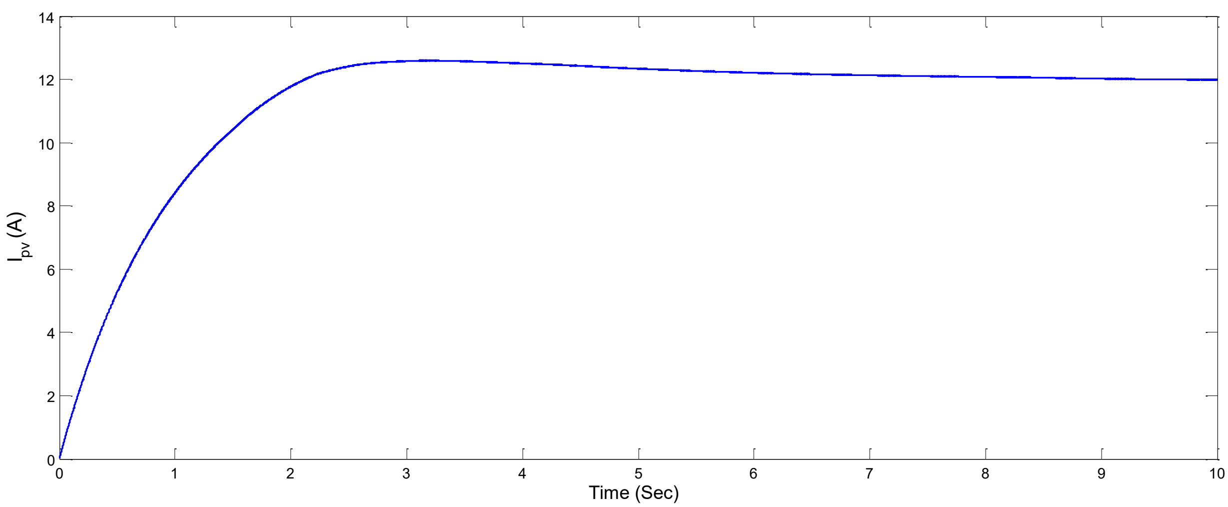

Figure 10 PV output current

When comparing battery voltages with and without a filter, it is evident that a filter-based controller provides superior performance due to its ability to reduce harmonic distortion. Without a filter, battery voltages are often subject to fluctuations caused by harmonics, which can lead to increased stress on the battery, reduced efficiency, and potentially shorter battery lifespan.

In contrast, a filter-based controller smooths out these voltage fluctuations by mitigating harmonic content, resulting in a more stable and consistent voltage. This lower Total Harmonic Distortion (THD) enhances battery efficiency and reliability, as the filtered power supply ensures that the battery charges and discharges in a more controlled manner. Consequently, filter-based controllers are preferred in power systems requiring high stability and reliability, as they provide a cleaner power profile, reduce thermal stress on components, and contribute to improved overall system performance. Fig 7 and 11 represents the DC voltages, due to this charging time will reduces.

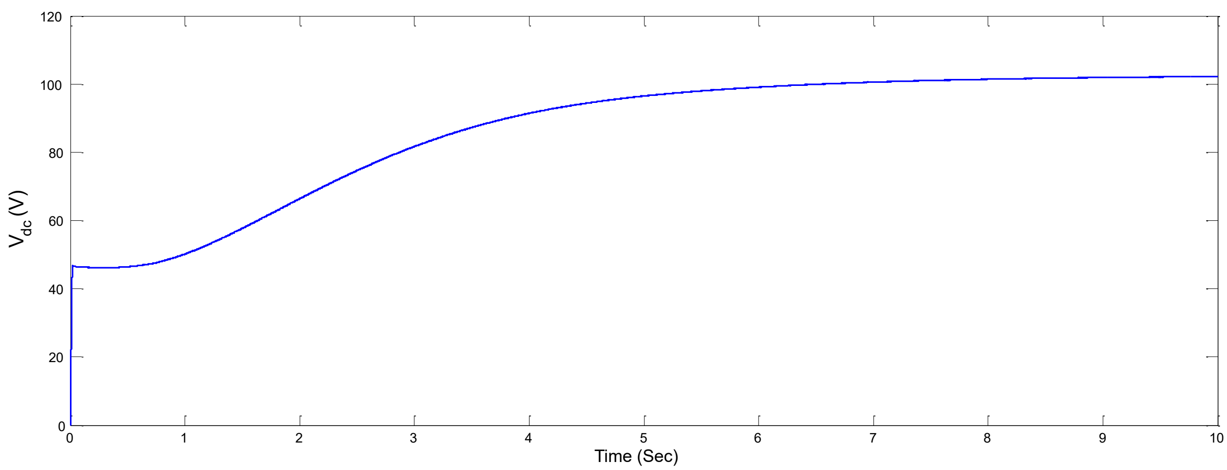

Figure 11 DC link voltage with proposed system

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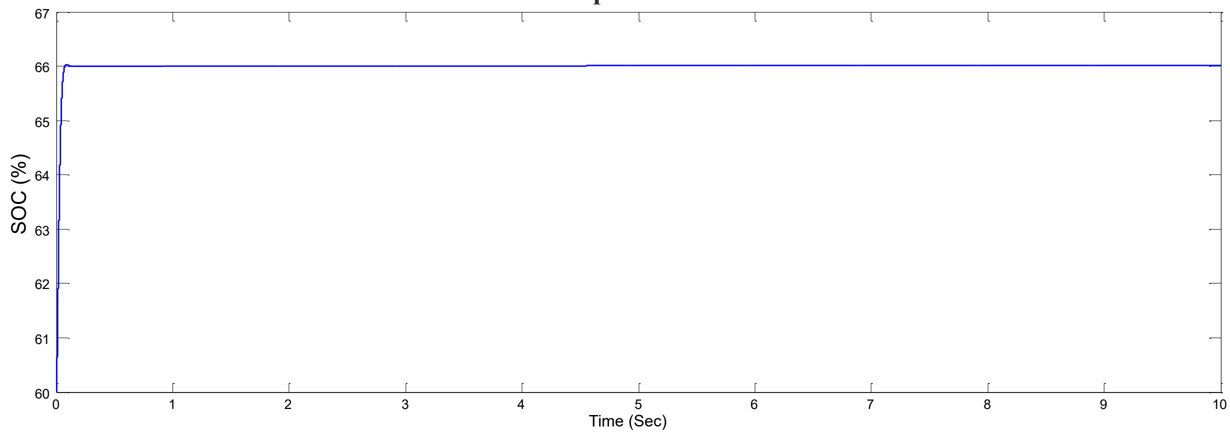

Figure 12 Battery state of charge with proposed system

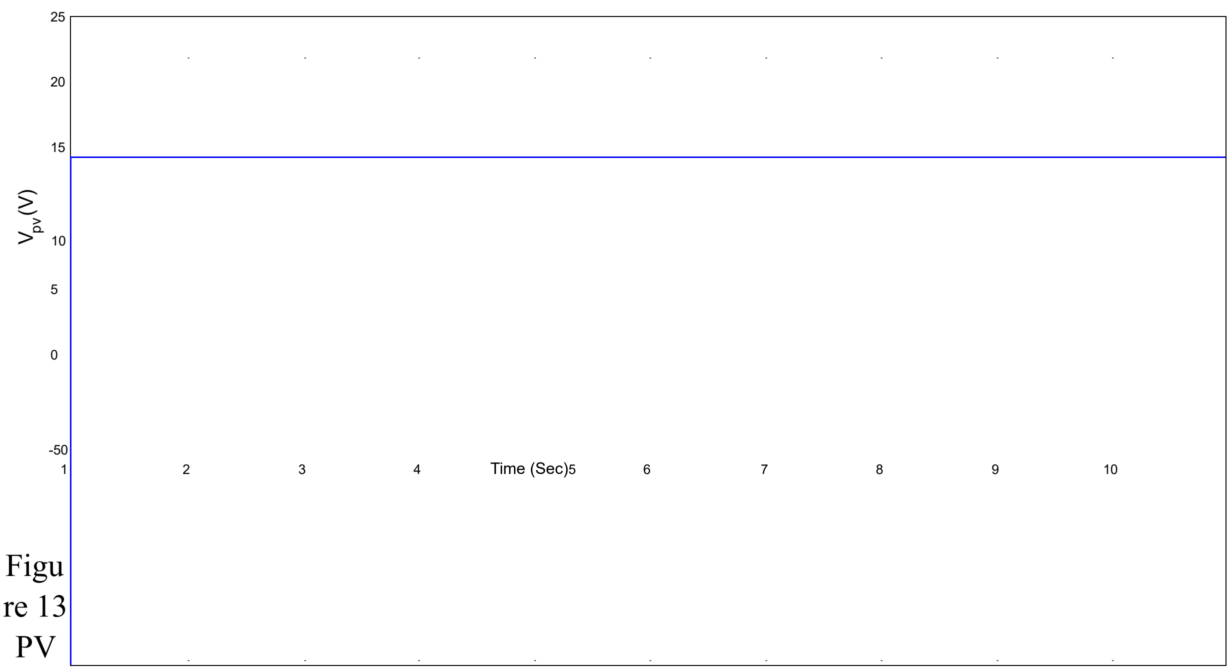

Figure 13 PV output voltage

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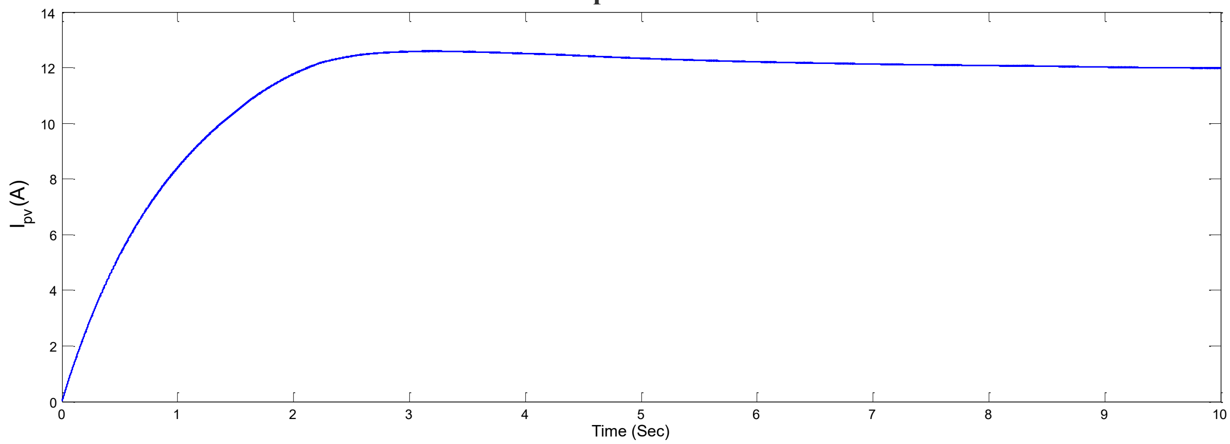

Figure 14 PV output current

IV Conclusion

This research effectively illustrates the design and execution of a PV 180-degree tracking system integrated with an EV battery charge controller, which markedly enhances the charging process. The technology maximises energy gathering and enhances the efficiency of solar-powered EV charging by continually aligning solar panels with the sun's position. The integration of the Twin T notch filter is essential for mitigating noise interference and facilitating seamless power transmission, hence decreasing charging duration while ensuring the safety and dependability of the charging process. The experimental and simulation outcomes confirm the superiority of the proposed approach compared to traditional EV charging techniques.

This research indicates that renewable energy-based EV charging infrastructure can enhance sustainable transportation. This method mitigates significant obstacles to electric car adoption by decreasing charging durations and enhancing overall efficiency. The suggested system advocates for environmentally sustainable activities and facilitates the extensive adoption of electric vehicles powered by renewable energy sources, hence fostering further progress in eco-friendly transportation options.

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