DOI: 10.22413/ijastems/2025/v11/i2/1

# Smc Controller Based Matlab Simulation for a Pv-Powered Electric Vehicle Charging Station

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***Abstract—This paper presents a MATLAB-based simulation of a Sliding Mode Control (SMC) strategy for an electric vehicle charging station powered by photovoltaic (energy. As the demand for sustainable transportation solutions increases, integrating renewable energy sources into electric vehicle charging infrastructures becomes essential. The proposed SMC controller effectively manages the power flow from the PV system to ensure optimal charging performance while maintaining stability and robustness against system uncertainties. The SMC controller is designed to adapt to variations in solar energy availability and load demands, enabling efficient energy management and enhancing the reliability of the charging station. Performance metrics such as charging efficiency, response time, and system stability are analysed under different operational scenarios by using MATLAB Simulink software 2018a***

## I. INTRODUCTION

Today, all countries and companies in the world are heading towards transitioning to electrical vehicles, governments are offering huge economic incentives, and companies are establishing timelines for a full shift from traditional to electrical vehicles. This is one method of decreasing greenhouse gas emissions, which are a significant issue for our world. Electrical vehicles are eco-friendly as they emit no pollutants and hardly any noise. [1]

Because renewable sources of energy can be placed anywhere, we have to utilize them to counteract the problem of increasing electricity use due to the transition from gasoline to electric vehicles. The use of renewable sources of energy, like wind and sun, lessens the demand for fossil fuels, which in turn decreases the emission of greenhouse gases [2]. Because of the sunshine throughout the year in Saudi Arabia and since PV panels can be fitted in limited spaces such as residential areas, we opted to utilize photovoltaics in our proposed system.

In order to reduce CO2 emissions and we are using a pv system in which Converse natural energy but charging stations. In that having and converter for charging converter for managing the battery storage a bus converter for supplying power to the PV power charging station which this are provides stability to reduce emissions and increase the stability of the environment for eco-friendly.

To guarantee user safety and effective operation, charging stations integrate safety features such as earth fault detection and secure connectors [5]. PV-based charging options will become more economical and efficient as solar technology develops, supporting the sustainable energy transition [10].

## II. LITERATURE SURVEY

[1] Jin, C., Tang, J., & Ghosh, P. (2013**).** A potential remedy for fuel shortages and environmental issues is the electric vehicle (EV). However, efficient scheduling and control by load aggregators are necessary for EV charging optimization. As a cyber-physical system, an EV charging network integrates power grids with several EVs and aggregators to effectively manage charging, as noted by Jin et al. (2013). For static charging scenarios, where demand is known ahead of time, they suggest optimization based on linear programming; for dynamic scenarios, where EV arrivals are unpredictable, they suggest heuristic techniques. Putting such tactics into practice guarantees a balanced grid load and raises consumer satisfaction.

[2] Hall, Dale, and Nic Lutsey. One promising way to lower greenhouse gas emissions and advance sustainability is through electric vehicles, or EVs. However, current power networks are under a lot of strain due to the growing demand for EV charging, which could result in disruptions and expensive modifications. With its Podis® power bus system, Wieland Electric tackles this issue and makes it possible for parking garages and subterranean facilities to have effective, secure, and adaptable EV charging infrastructure (Wieland Electric, n.d.).

[3] Vidyanandan, K.V. (2018). Since EVs cut pollutants and lessen dependency on pricey fossil fuels, they are revolutionizing the automotive sector. Thanks to government incentives, cost reductions, increased charging infrastructure, and battery technology breakthroughs, the number of EVs worldwide topped two million by the end of 2016. The two most popular EV technologies at the moment are plug-in hybrid electric cars (PHEVs) and battery electric vehicles (BEVs), each of which has advantages and disadvantages when it comes to replacing traditional automobiles [3].

[4] Wu, Yu, et al. Propose**.** EV charging stations are expected to see rapid growth in the coming years. However, the increasing demand for charging power and the unpredictable nature of charging behaviours pose challenges such as electricity shortages and power fluctuations. To maintain grid stability and balance supply and demand, technical measures like ancillary power reserves and demand-side energy management are crucial. Additionally, integrating renewable energy sources into the power system can help mitigate peak loads caused by EV charging, provided that effective system operation strategies are in place [4].

### A. SOLAR PV GENERATION

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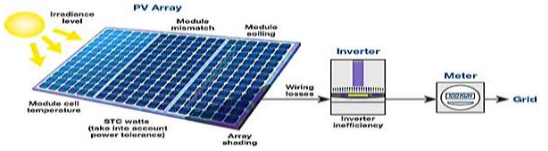



Fig.1 solar PV generation

Solar photovoltaic (PV) power captures sunlight to produce electricity using PV cells, which are combined in modules and arrays for greater power output. Solar panels, inverters, and mounting frames are these systems, which deliver clean energy to homes, businesses, and off-grid applications. Maximum PowerPoint Tracking techniques, like Perturb and Observe, achieve maximum energy harvesting by changing the operating point. While P&O MPPT is low-cost and simple, it is also constrained by oscillations and poor response to high rates of environmental changes. However, PV technology has evolved further, with efficiency improving and solar power becoming a reliable source of renewable energy [10]

B. BOOST CONVERTER.

A boost converter is a DC-DC step-up converter that uses a PWM-controlled switching transistor, an inductor, a diode, and a capacitor to ramp up the input voltage to a higher output voltage. It has several uses in LED lighting systems, renewable energy systems, battery-operated devices, and automobiles. Although boost converters have a very straightforward design, regulated output, and high efficiency, they are constrained by factors including EMI noise, output voltage ripple, and complex control. Despite these limitations, they are essential to modern power electronics, enabling effective voltage conversion for a variety of applications [13].

C. BUCK CONVERTER.

A Buck Converter is a DC-DC step-down converter that uses a switching transistor, inductor, diode, and capacitor to lower an input voltage to a steady output voltage. It is widely used in power supplies, industrial, automotive, electronic, and renewable energy-related applications. The Buck Converter is renowned for its tiny size, great efficiency, and voltage regulation capabilities. Additionally, it guarantees steady power delivery, lowers heat output, and prolongs battery life. It is a crucial part of modern power electronics in spite of problems like output voltage ripple and EMI noise [14].

D. **BATTERY.**

Batteries are storage devices for energy that supply electricity by converting chemical energy to electricity. Batteries contain electrochemical cells with an anode, a cathode, and an electrolyte to allow free ion movement and generate current. Batteries include lead-acid, nickel-cadmium, nickel-metal hydride, lithium-ion, and alkaline batteries, each of which is produced for a specific purpose. Lithium-ion batteries, being rechargeable and with high energy density, find large-scale application in portable devices, electric vehicles, and renewable energy storage. In green energy technology and new solutions, proper discharging and charging are critical because they help to maintain battery life and efficiency [17].

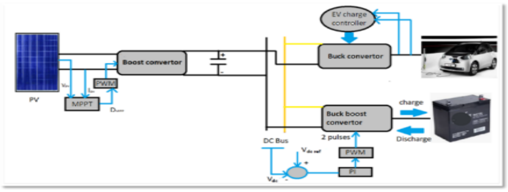
E. ELECTRIC VEHICLES.

With zero emissions, reduced operating costs, and enhanced energy efficiency, electric vehicles (EVs) are a more environmentally responsible option than conventional gasoline-powered automobiles. Commercial fleets, renewable energy networks, and private and public transportation all make extensive use of EVs. As a key player in the upcoming shift to a better, less environmentally damaging type of transportation, these benefit from lower fossil fuel usage, noise pollution, and improved performance [16].

III. SYSTEM DESCRIPTION

PROPOSED SYSTEM STRUCTURE.

The proposed electric vehicle (EV) charging station system is an off-grid setup powered primarily by solar energy. Solar radiation is captured by a photovoltaic (PV) array, which then transforms it into electrical energy for EV charging. An energy storage system that uses batteries is incorporated to store extra energy during peak production for later use because solar energy production is sporadic. A boost converter ensures maximum power point tracking while increasing the PV output voltage to the necessary DC bus level. The lithium-ion battery of the EV is then charged via a buck converter, which lowers the voltage. Furthermore, a bidirectional converter can be used as a boost converter to stabilize the DC bus in response to variations in solar output and EV load, as well as a buck converter to lower voltage for lead-acid ESS charging [12].




CONTROL SYSTEM

The control techniques of the proposed system are crucial due to the intermittent power generation variability of PV, which can result in significant output swings throughout the day while maintaining a nearly constant DC bus voltage.

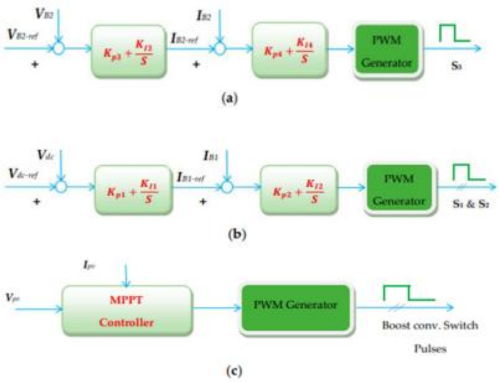



Fig 2: a. MPPT controller, b. EV charge controller, and c. storage battery converter controller are the suggested system controllers.

3.1 MPPT control

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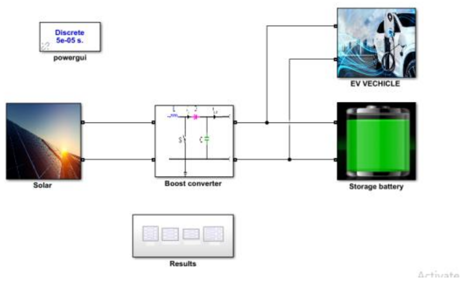
To make sure that the photovoltaic (PV) module shines at its best under changing solar radiation conditions, a friendly Maximum PowerPoint Tracking controller is just what you need! One of the most loved Maximum PowerPoint Tracking techniques is the Perturb and Observe method. This lovely technique involves giving the PV array's voltage a little nudge and then checking how much power it produces. If the power goes up, we keep nudging the voltage in that direction; if it doesn't, we switch it up and nudge it the other way. We find the Maximum PowerPoint by happily continuing this friendly process until the power stops increasing. Thanks to its straightforwardness and ease of use, the P&O approach is widely cherished and, when nicely tuned to the system, offers fantastic efficiency [8].

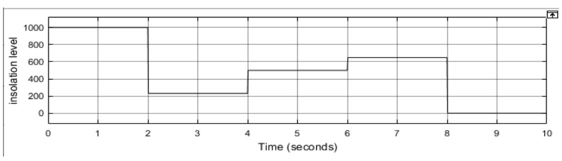
SLIDING MODE CONTROLLER

SMC is such a friendly and adaptable control algorithm that joyfully manages uncertainty and disturbance rejection while ensuring stability and performance remain strong, making it a wonderful fit for nonlinear systems. It effortlessly tracks and responds with remarkable speed by guiding the system towards a delightful sliding surface. Thanks to its sturdy ability to handle nonlinear dynamics, it can be used in a wide range of sectors, except for robotics, biomedical, aerospace, automobile, and power systems, all while being super user-friendly too! However, it's good to be aware of some minor challenges like chattering and higher power consumption. Even with these little hiccups, SMC continues to be an amazing tool for navigating complex and unpredictable systems in most engineering fields!.

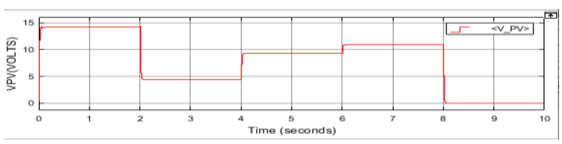
## IV. SIMULATION RESULTS



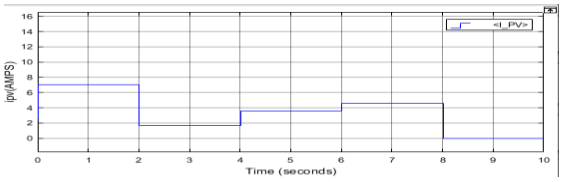

EV Charging Station Using a Separate Photovoltaic Power Source




degree of PV insolation




The PV voltage




Current in PV

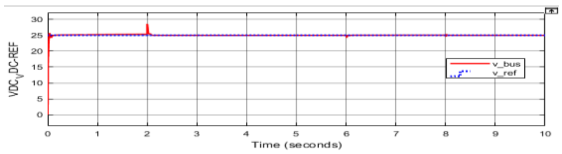
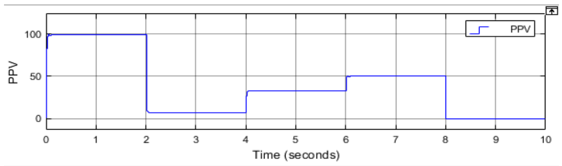
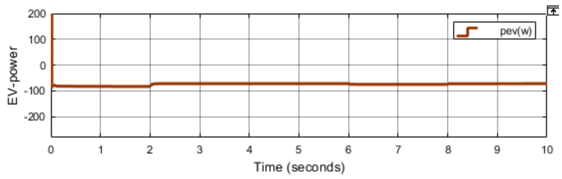



Figure 10: DC bus voltage,

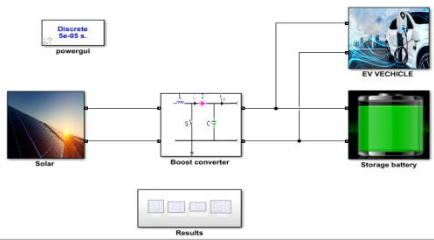


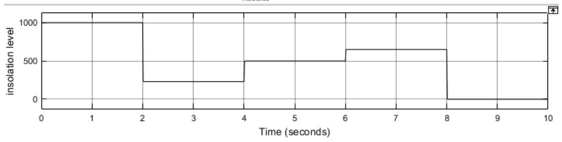

PV power



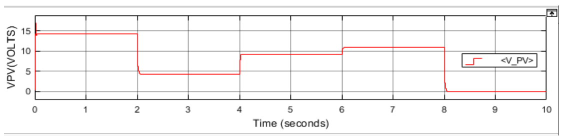

Ev _power

## EXTENSION RESULTS

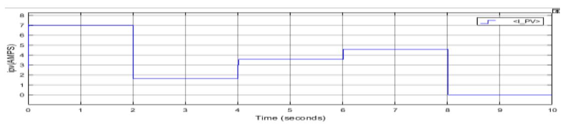



Irridation




Pv Voltage



Pv Current

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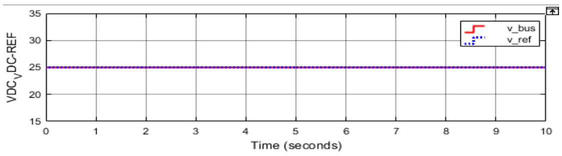
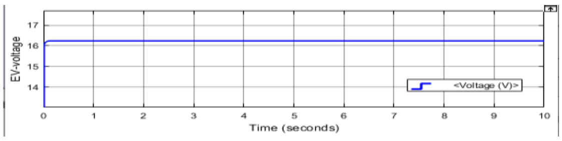
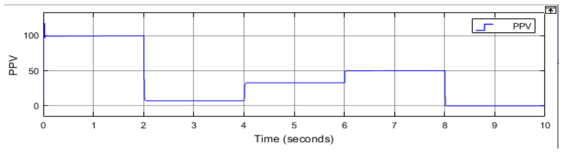



Vdc_vdcref




Ev voltage




Pv power

## IV. CONCLUSION

According to the project's conclusion, a solar-powered electric vehicle charging station's Sliding Mode Control (SMC) successfully demonstrates the viability of fusing cutting-edge control methods with renewable energy. The SMC approach effectively handles the dynamic problems of fluctuating charging loads and solar power unpredictability, ensuring the charging station operates dependably and effectively. The SMC controller increases the system's resilience to uncertainties while achieving the best charging performance. The results showed fast response times and good charge efficiency, confirming the controller's capacity to react in different conditions.

Future objectives

The future scope of the project involves a number of important areas for further research.

The performance of the SMC controller in real-world hardware implementation will initially be verified by transitioning from simulation to real-world hardware implementation. Consequently, the system will be optimized for use and possible challenges will be determined. Load balancing and energy management can be enhanced by combining the charging station with smart grid technologies, enabling a better utilization of resources. Integration would enable demand response features, optimizing charging times according to grid conditions.

## ACKNOWLEDGEMENT

We would like to thank our Guide, HOD Department of EEE Mr.N.Vara Prasad, Chaitanya Bharathi Institute Of Technology, Proddatur for supporting us to make this Publication.

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*DOI: 10.22413/ijastems/2025/v11/i2/1*

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