International Journal of Recent Research and Review, Vol. XVIII, Issue 1, March 2025
ISSN 2277 – 8322

GRID AND RENEWABLE POWERED ELECTRIC VEHICLE CHARGING STATIONS USING HYBRID METAHEURISTIC TECHNIQUE

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Abstract: The rapid adoption of electric vehicles (EVs) necessitates the development of efficient and sustainable charging infrastructure, particularly in regions like India, where energy demand and environmental concerns are rising. This study presents a techno-economic assessment of grid and renewable-powered electric vehicle charging stations, optimized using a hybrid metaheuristic technique that combines the Honey Badger Algorithm (HBA) and the Cat and Mouse-Based Optimizer (CMBO). By leveraging the strengths of both algorithms, this hybrid approach ensures efficient resource allocation and maximizes the use of renewable energy sources such as solar and wind power. The proposed model evaluates multiple objectives, including optimizing the charging station's placement, and reducing carbon emissions by integrating renewable energy into the charging infrastructure. A comprehensive analysis of capital and operational expenditures is conducted, with a focus on the Indian market, considering grid constraints, dynamic electricity tariffs, and government incentives. The study also assesses the impact of energy storage systems and grid stability, ensuring a robust and scalable solution for urban and rural areas. Simulation results demonstrate that the hybrid HBA-CMBO algorithm significantly improves the overall performance of charging stations by enhancing energy efficiency and reducing reliance on grid electricity during peak demand hours. This novel approach provides a promising framework for policymakers and stakeholders aiming to environmentally

sustainable EV charging networks in developing countries.

Keywords: Renewable Energy, Solar Wind Hybrid System, Honey Badger Algorithm, Electric Vehicle.

I. INTRODUCTION

Aggressive marketing and major aid from the government have been instrumental in accelerating recent technological advancements in the areas of electric power trains and batteries. There has been a significant decrease in the costs associated with the production of batteries over the course of the last three years. Experts predict that EVs will become more important to the car industry in the years to come. As a result of the electric vehicle (EV) conversion scenario and the roll-out timeframe that was specified in 2015, the number of electric vehicles (EVs) surpassed one million in October of 2018, as shown by the evidence. Through the implementation of several legislation, the government of the United States of America has created an incentive for the public sector to provide infrastructure for charging electric vehicles [1]. According to the Canadian Ministry of Transportation, the province of Ontario spent twenty thousand dollars in 2017 to install five hundred charging stations for electric vehicles in around two hundred and fifty different sites. It is anticipated by the German National Platform for Electric Mobility that there will be one million electric vehicles (EVs) by the year 2020. Additionally, it is anticipated that the demand for charging stations, particularly road charging stations, would exceed seventy thousand (CPs). [2] China developed a system that designates a certain quantity of solar-powered charging stations to address the constraints of renewable energy use and meet the increasing need for energy from electric cars. An international conference called the EV Initiative was scheduled to take place in May 2017 to promote the global development of electric automobiles. PHEVs and BEVs are two types of electric automobiles (EVs) that cost less than internal combustion engine vehicles (ICEVs). Recently, car manufacturers in several nations have been trying to meet client demand by launching new electric vehicle models. [Hansen, K., 2019] Utility and power companies have collaborated with many stakeholders to expand and improve the market for electric car charging infrastructure. Several countries lack the required infrastructure for charging electric vehicles, even if the legislation and regulations mentioned above are crucial. Electric cars, being a stochastic load, will impact the total load profile of the distribution network. This will complicate load forecasting and impact the substation architecture and distribution network grid. The effects of electric cars must be recognized and carefully considered demand throughout the planning and design phases to ensure distribution grid can meet the evolving needs of electric vehicles. There are few thorough review articles available that cover the risks and obstacles related to the sustainability of combined PV-EV charging, as highlighted by [3] this is despite the fact that some study has been carried out by researchers. When it comes to charging systems and electric vehicle charging schedule, there are presently no clear guidelines that address these challenges. Consequently, the purpose of this chapter is to provide an overview of the various control topologies and layouts that may be used for electric vehicle charging stations in order to provide efficient operation. There are a number of positive aspects and qualities that this chapter has. First things first: we must examine the existing charging infrastructure and electronic power converters. In order to determine whether or not it is possible to utilize standard AC and DC bus electric vehicle charging systems, as well as various charge patterns for large-scale electric vehicles, the second step is to investigate how the equipment functions in different modes of operation.

II. HYBID ELECTRIC VEHICLE

A combination of an electric power train and an ICE is what propels a hybrid electric car. As we'll see in a little, these two components may take several forms. When electricity demand is minimal, a hybrid vehicle's electric propulsion system kicks in. In low-speed settings, like urban areas, it's great since it cuts fuel usage by turning the engine off entirely when it's not in use, as when there's traffic. Reduced emissions of greenhouse gases are another benefit of this feature. If the hybrid electric car needs extra speed, it switches to the internal combustion engine. The two power trains may work together to boost efficiency. A common method for reducing or eliminating turbo lag in turbocharged cars like the Acura NSX is to install a hybrid power system. By providing speed boosts when required and bridging the gaps between gear changes, it increases performance. Regenerative braking is an additional energy recovery mechanism that certain hybrid electric vehicles (HEVs) use, while internal combustion engines (ICEs) are able to recharge the batteries.

Hybrid electric vehicles (HEVs) are ICE cars that supplement their ICE's performance and fuel economy with an electric power train. In order to get these traits. The use of HEV configurations is widespread among automakers.

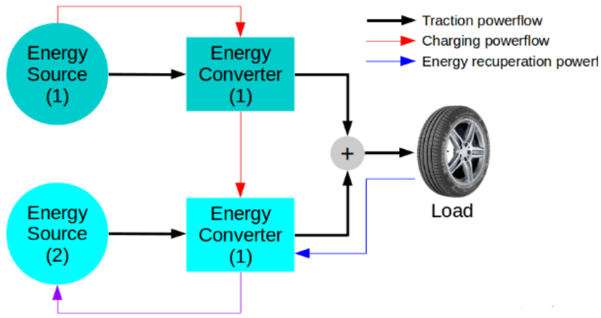

Fig. 1. HEV basic operating principle [6]

III. PROPOSED METHODOLOGY

Various components of the proposed work is given in this section.

AC Grid: The AC grid refers to the alternating current electrical grid, which supplies power to homes, businesses, and infrastructure. In the context of electric vehicles, it is the source of electricity for charging EV batteries.

DC Link: The DC link is a component in power electronic systems that connect different stages of power conversion. It typically consists of capacitors and inductors and serves to smooth out voltage and current fluctuations.

Battery: The battery is the energy storage device used in electric vehicles to store electrical energy for propulsion. It is typically a lithium-ion battery, although other types may also be used.

Boost Converter: It is commonly used in electric vehicle charging systems to step up the voltage from the battery to the level required for charging.

Bidirectional Converter: A bidirectional converter is capable of converting power in both directions, either from AC to DC or DC to AC. In electric vehicle charging systems, bidirectional converters are used for vehicle-to-grid (V2G) applications, allowing power to flow both to and from the vehicle's battery.

Vienna Converter: The Vienna converter is a type of three-level converter used in power electronics. It is commonly employed in grid-tied applications to convert AC power from the grid to DC power for use in applications such as electric vehicle charging.

Partial Power Processing: Partial power processing (PPP) is a technique used to reduce the power processed by a converter, thereby reducing losses and increasing efficiency. It involves processing only a fraction of the total power flowing from the source to the load.

Single Phase Inverter: A single-phase inverter is a device that converts DC power to single-phase AC power. It is commonly used in residential and small-scale applications, including electric vehicle charging stations that require single-phase AC power.

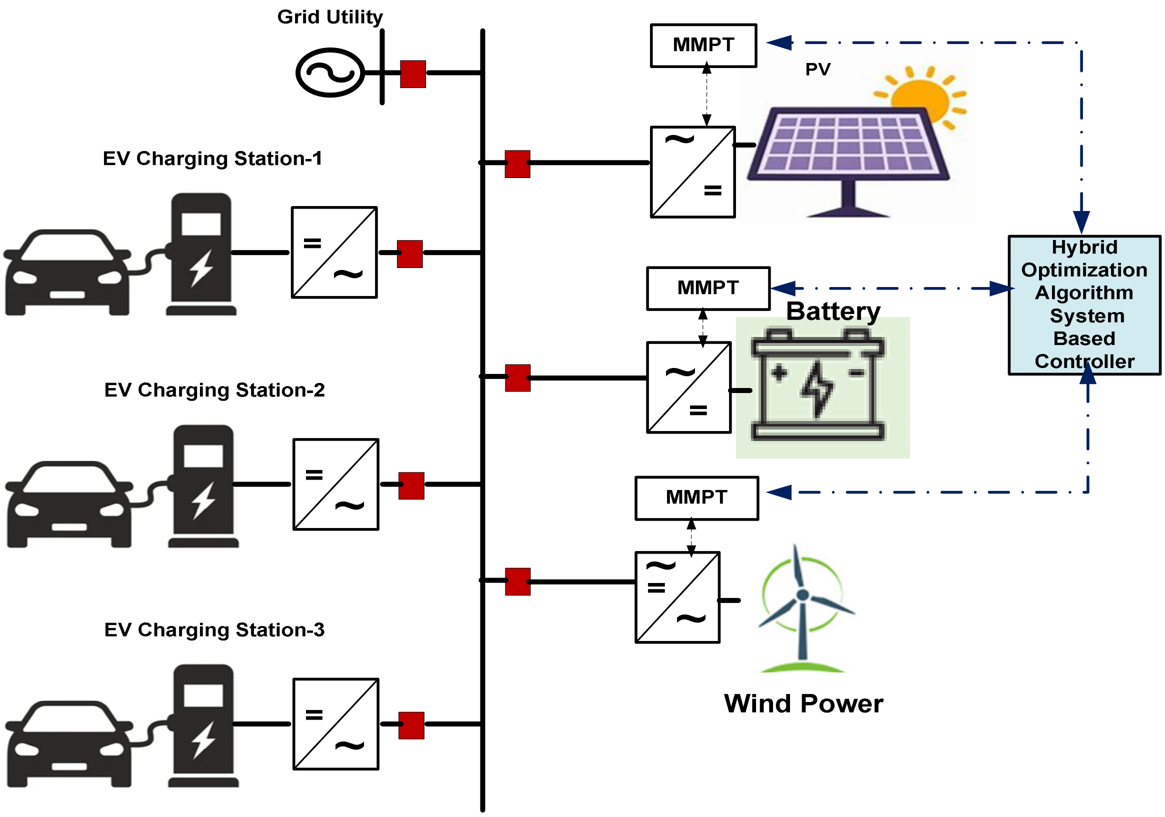

Fig. 2. Proposed flow diagram

More changes have been proposed to remove the boundaries of the traditional P&O method:

Adaptive phase size - adjusting the size of dynamic disorders can balance movement and accuracy dynamically.

Integration of the revised P&O - unclear logic with unclear logic helps to improve the hiking efficiency by reducing fluctuations.

Hybrid MPPT methods - a combination of P&O with other algorithms, such as increase, increase, strengthening and accuracy.

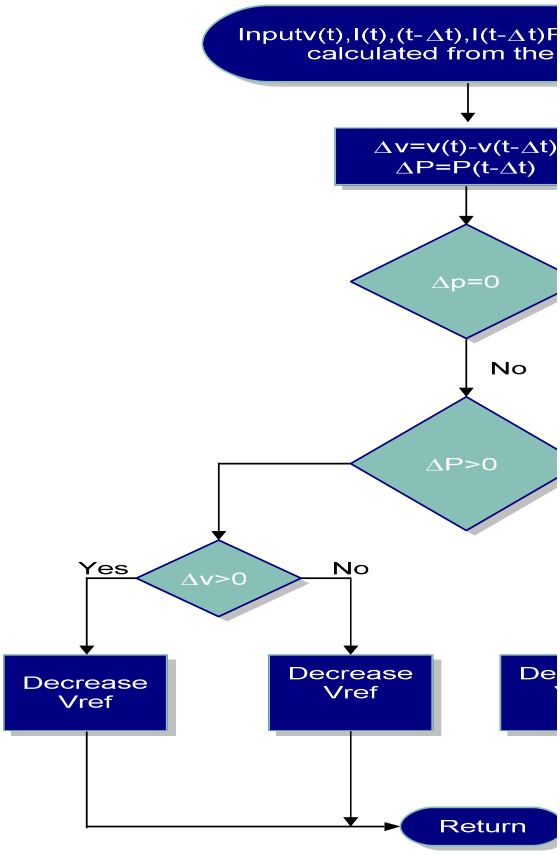

Fig. 3. The Flowchart of the P&O Algorithm

P & O MPPT algorithm is a widely used method to adapt solar harvesting. The simple implementation and cost-effectiveness makes it a popular choice for the Solar PV system. However, improvements such as adaptive phase size and hybrid technology can further increase efficiency and performance. With continuous progress, P&O is still a basic approach to maximizing the effectiveness of solar energy production.

IV. RESULTS AND DISCUSSION

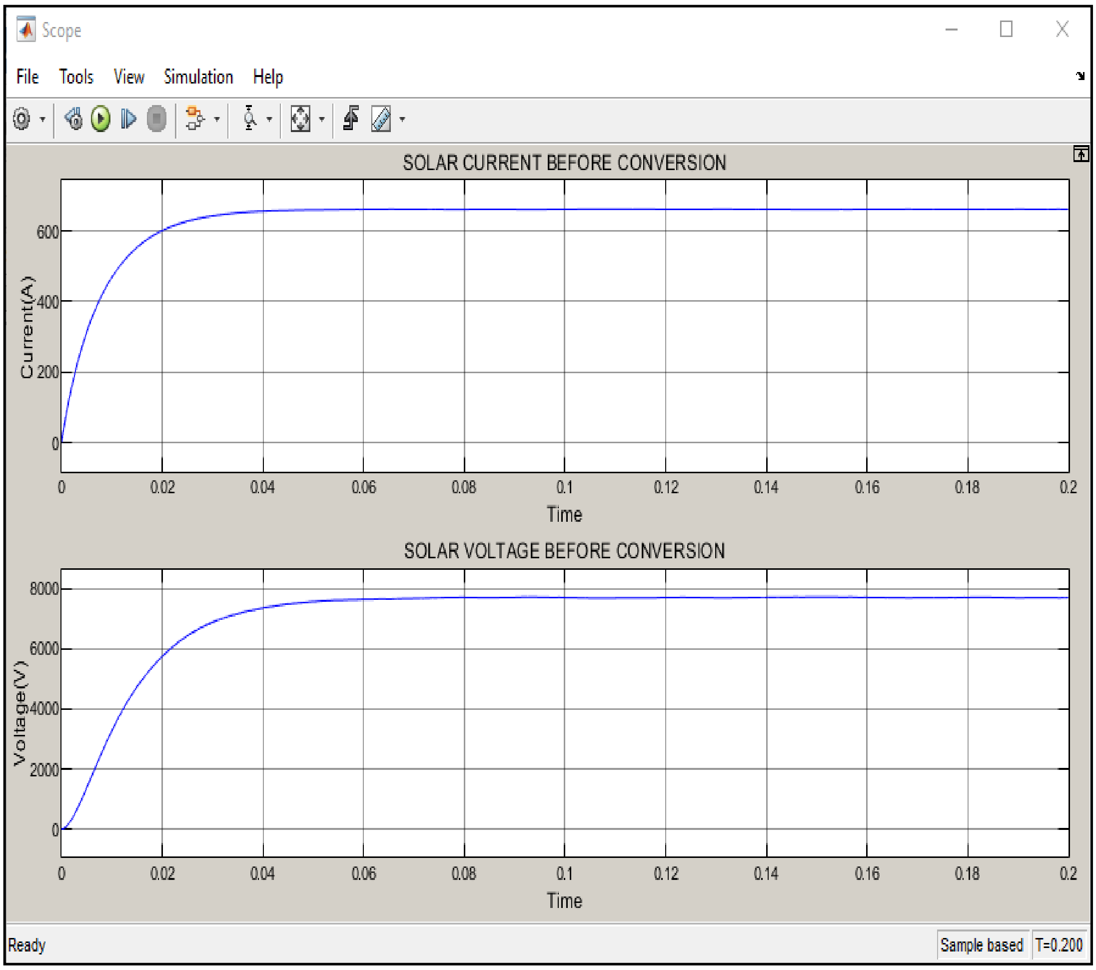

Fig. 4.Solar Voltage and Current Waveform before the Converter

Fig 4 solar voltage and current waveform before the converter, the current generated 660 A, Where Voltage generated 7800V from the solar.

Fig 5 showing the solar voltage and current waveform after the converter, the current generated 1470 A, Where Voltage generated 650V from the solar

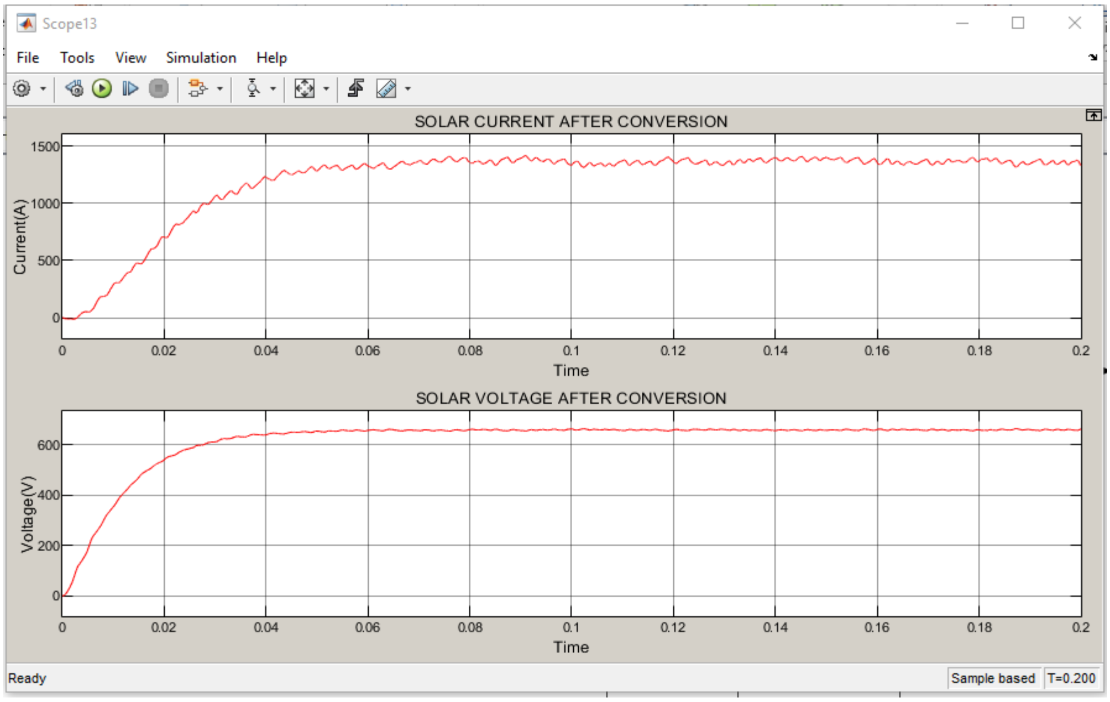

Fig. 5.Solar Voltage and Current Waveform

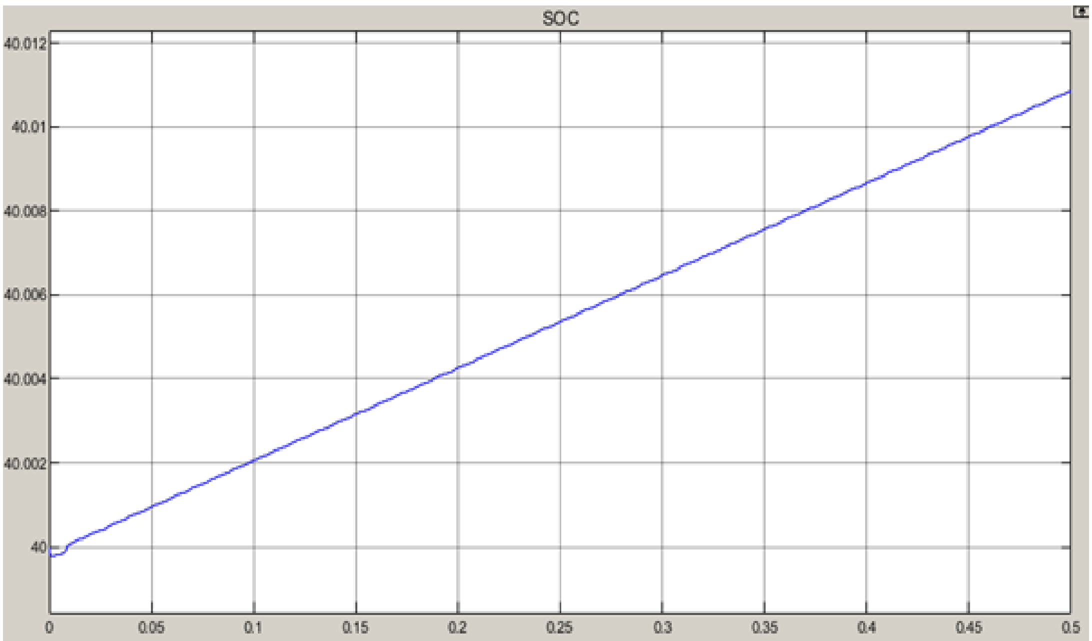

Fig. 6. SOC Charging at 40%

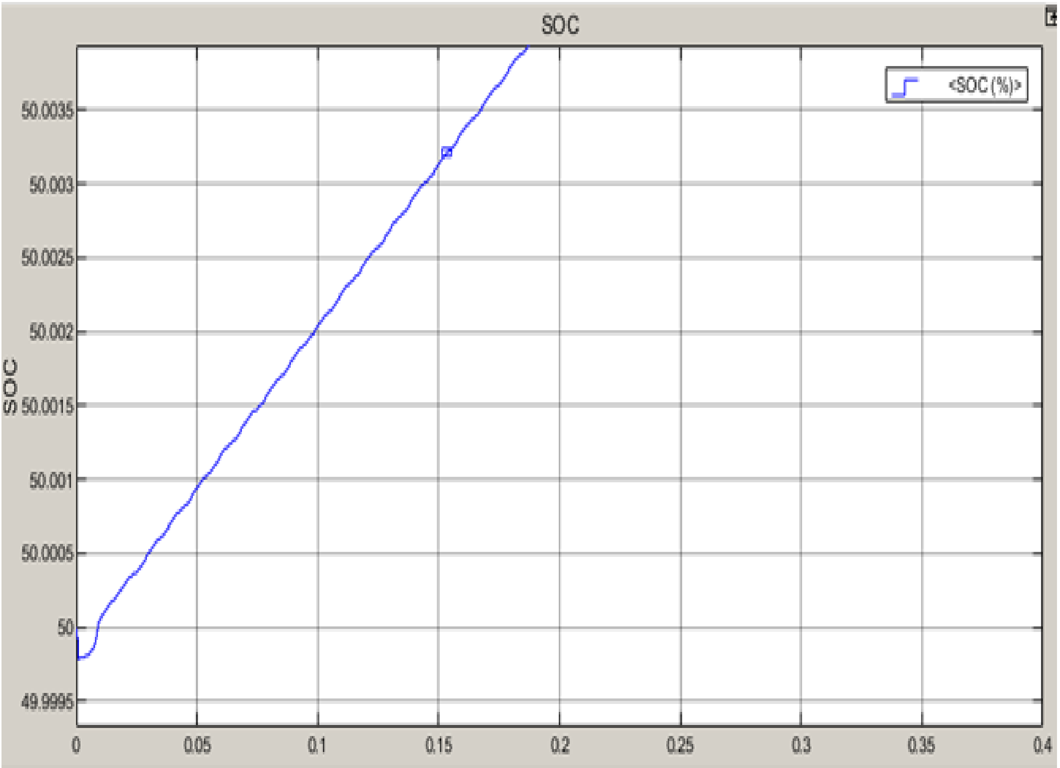

Fig.7. SOC charging at 50%

In the third case If soc between 50% to 90%, it will charge showing in fig. 8.

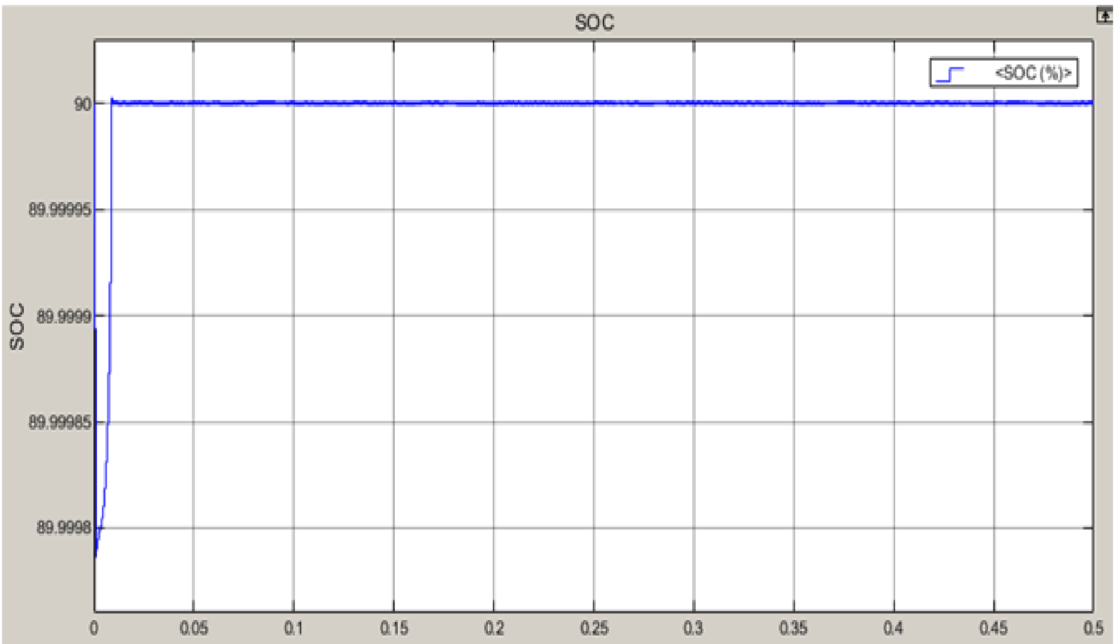

Fig. 8. SOC Charging at 90%

In the third case If soc between 50% to 90%, it will charge showing in fig 9.

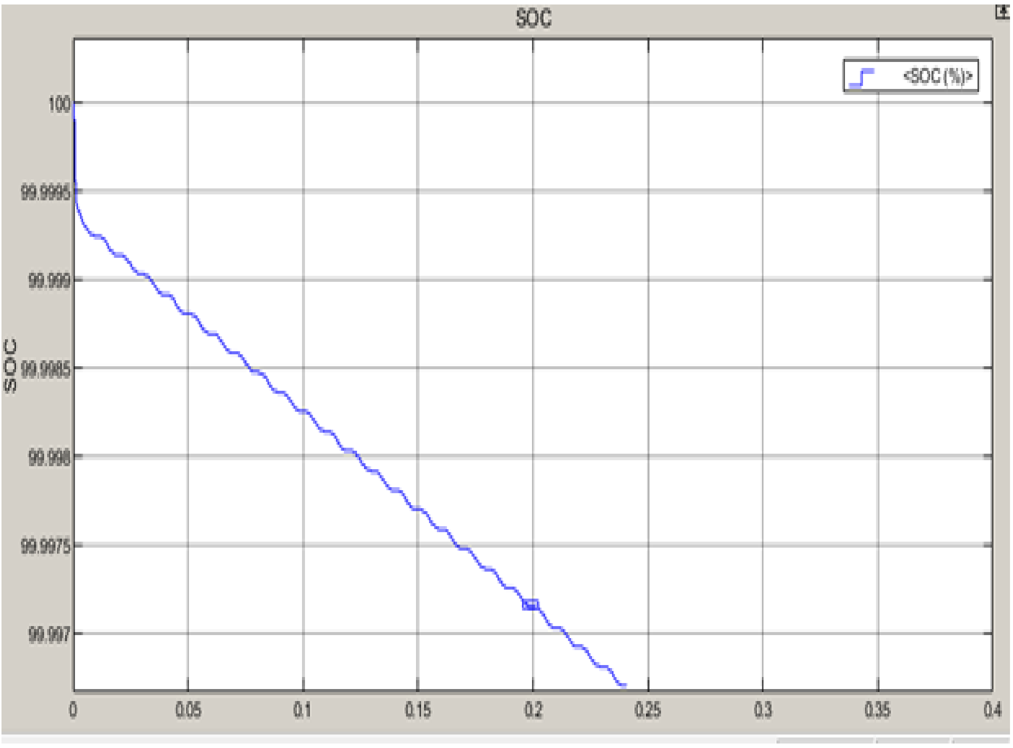

Fig. 9. SOC Discharging at 100%

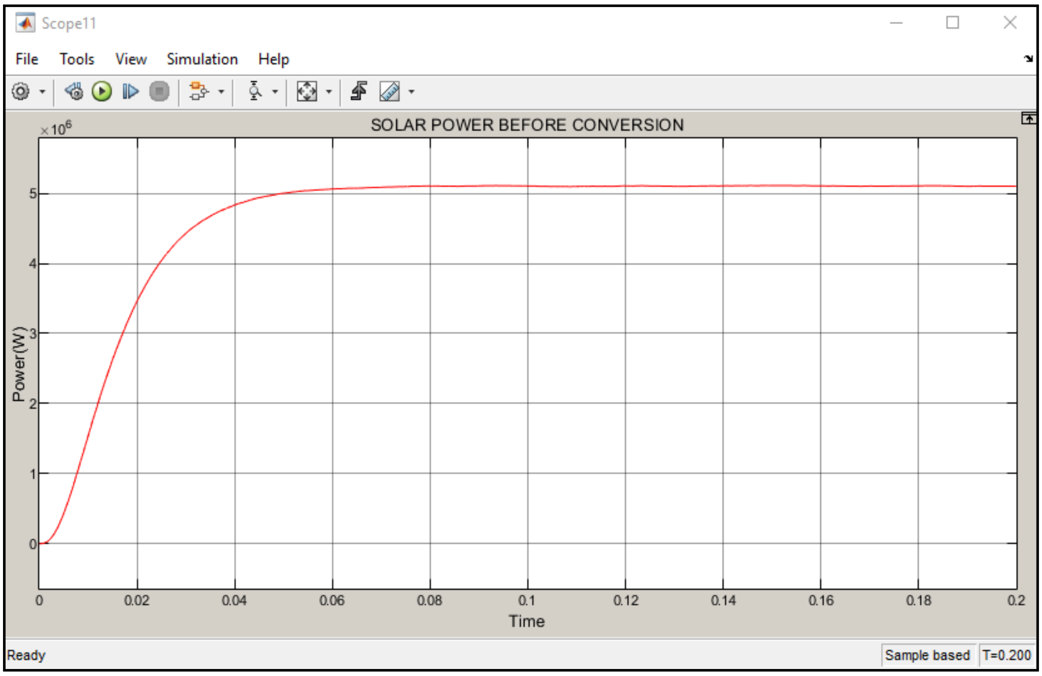

Fig. 10.Showing the Solar Power Waveform before the Converter

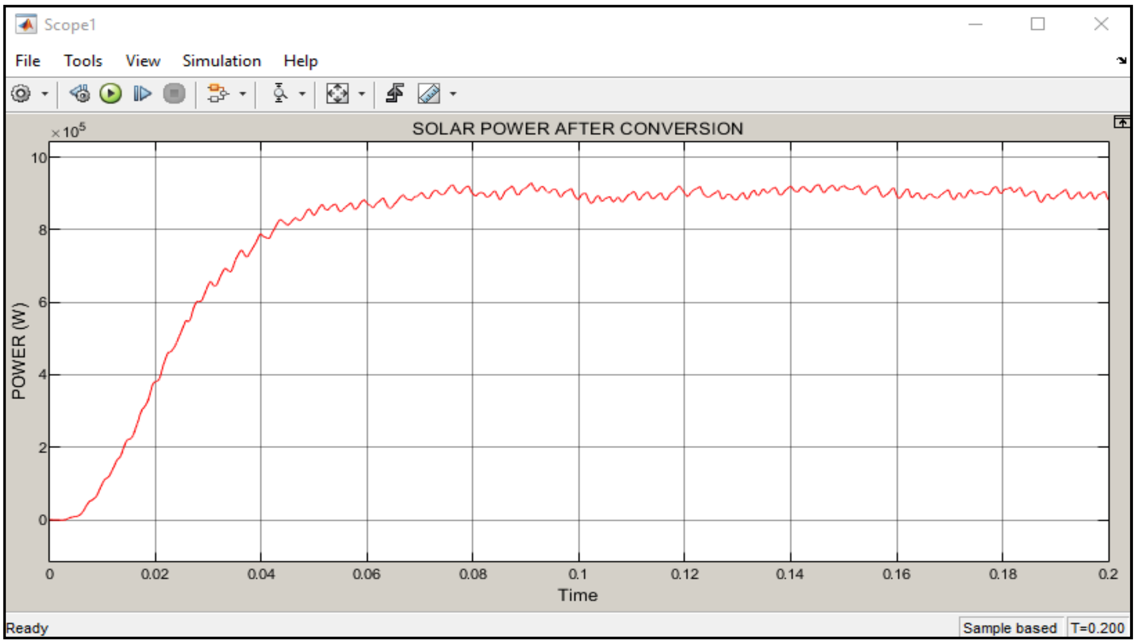

Fig. 11.Showing the Solar Power Waveform after the Converter, Approx 5megawatt Power Generated from the Solar

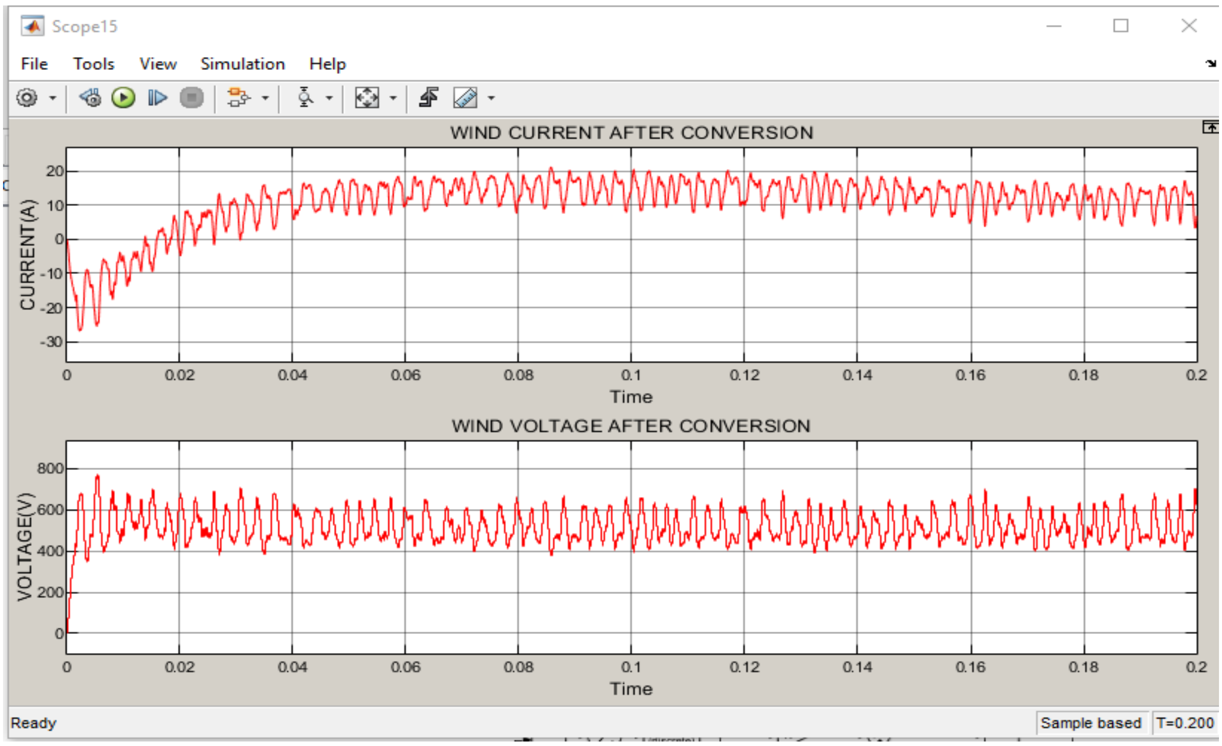

Fig. 12. Showing the Wind Voltage and Current Waveform after the Converter, the Current Generated 19 A

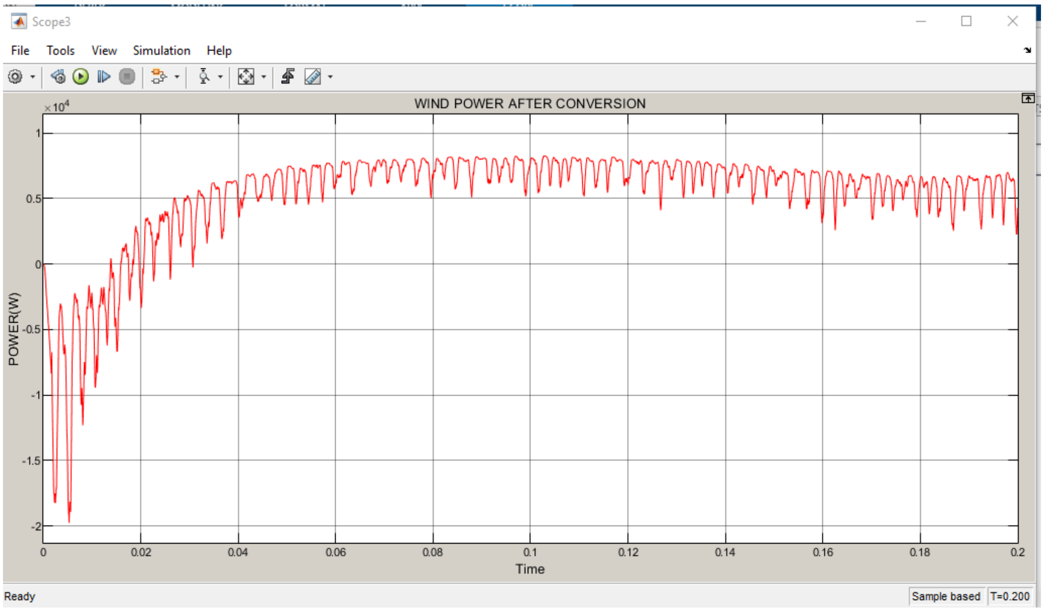

Fig. 13. Showing the Wind Power Waveform after the Converter

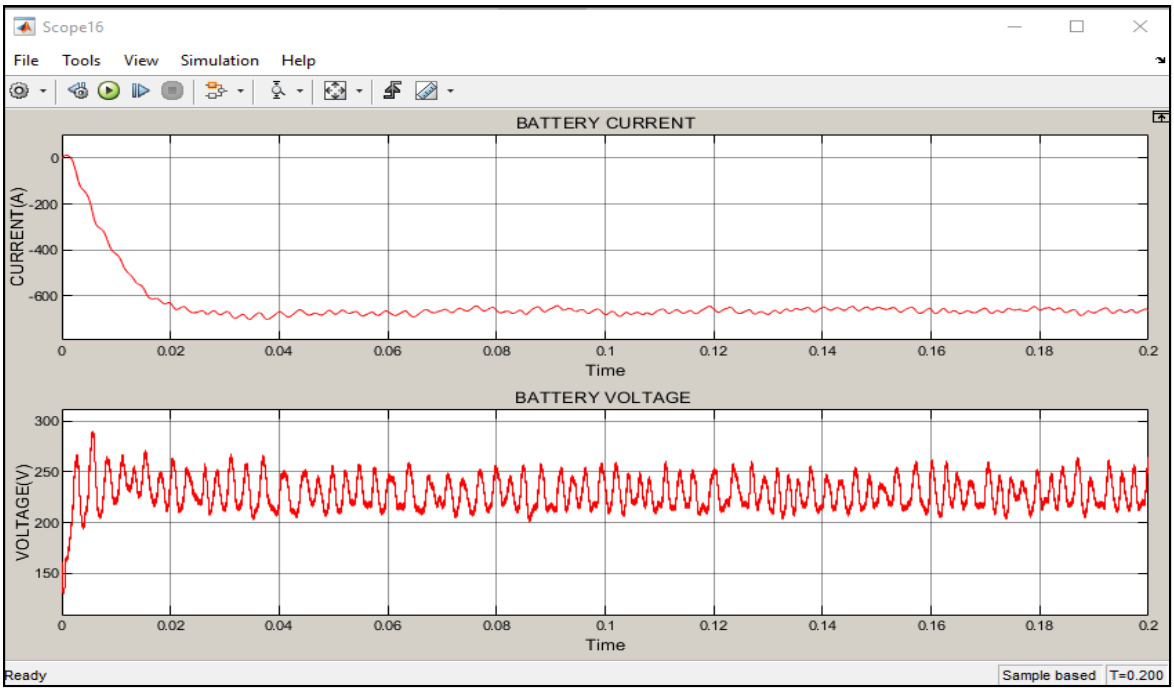

Fig. 14. Battery Voltage and Current of the System

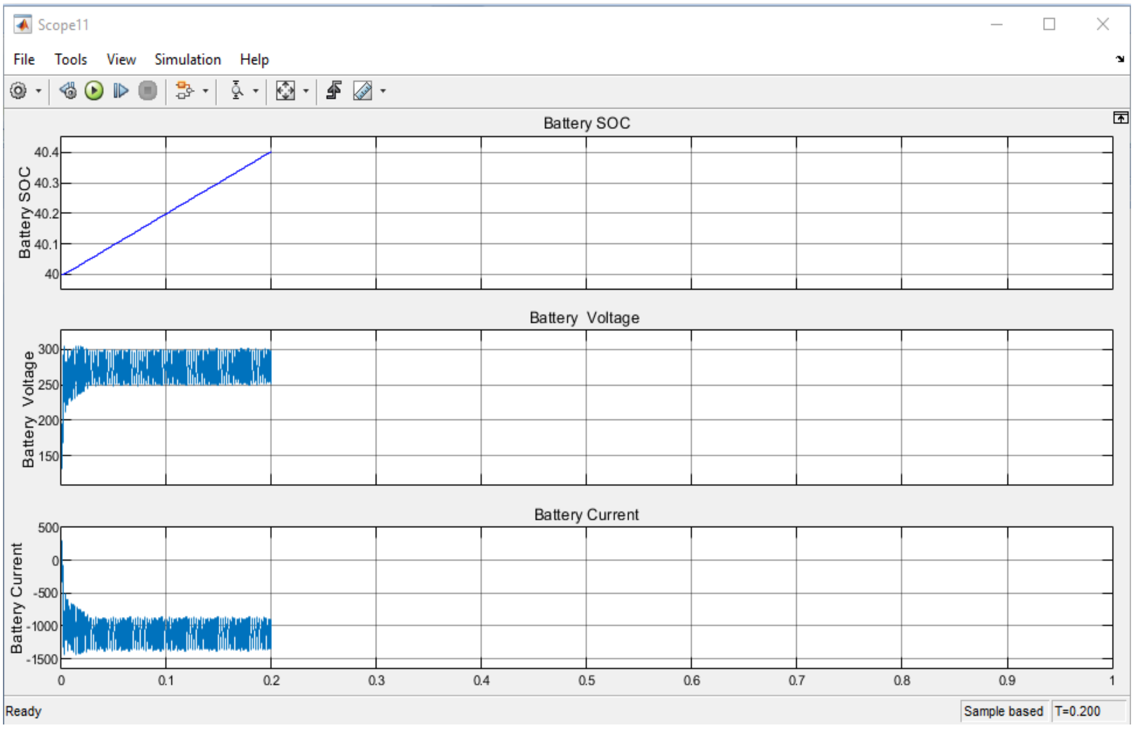

Fig. 15. Battery SOC, Battery voltage and battery current for EV1 Station

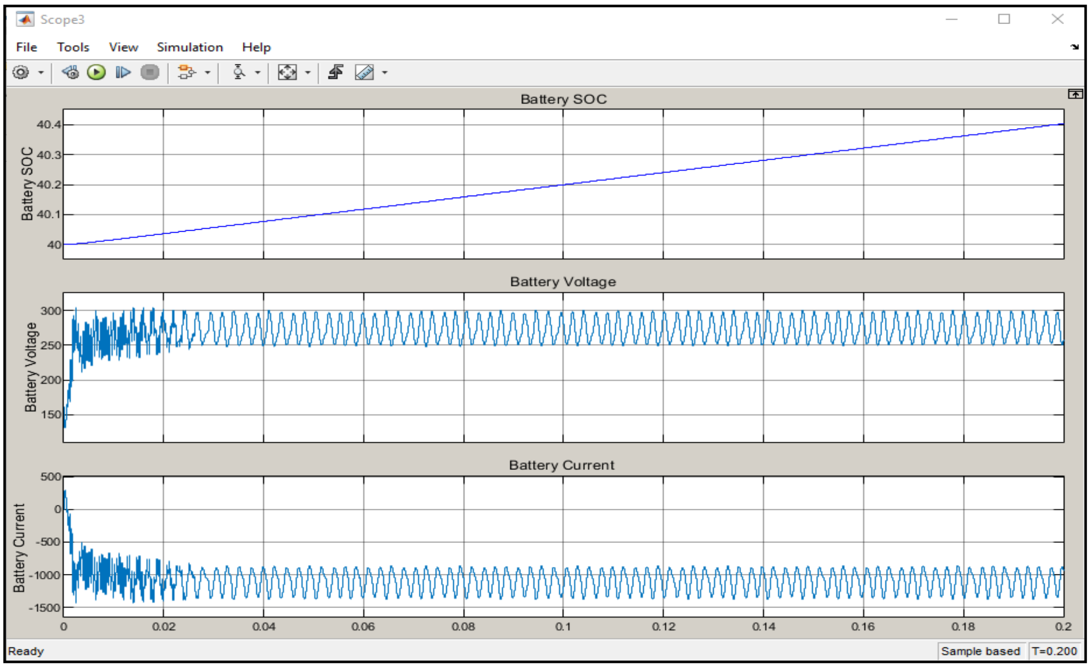

Fig. 16. Battery SOC, Battery voltage and Battery Current for EV4 Station

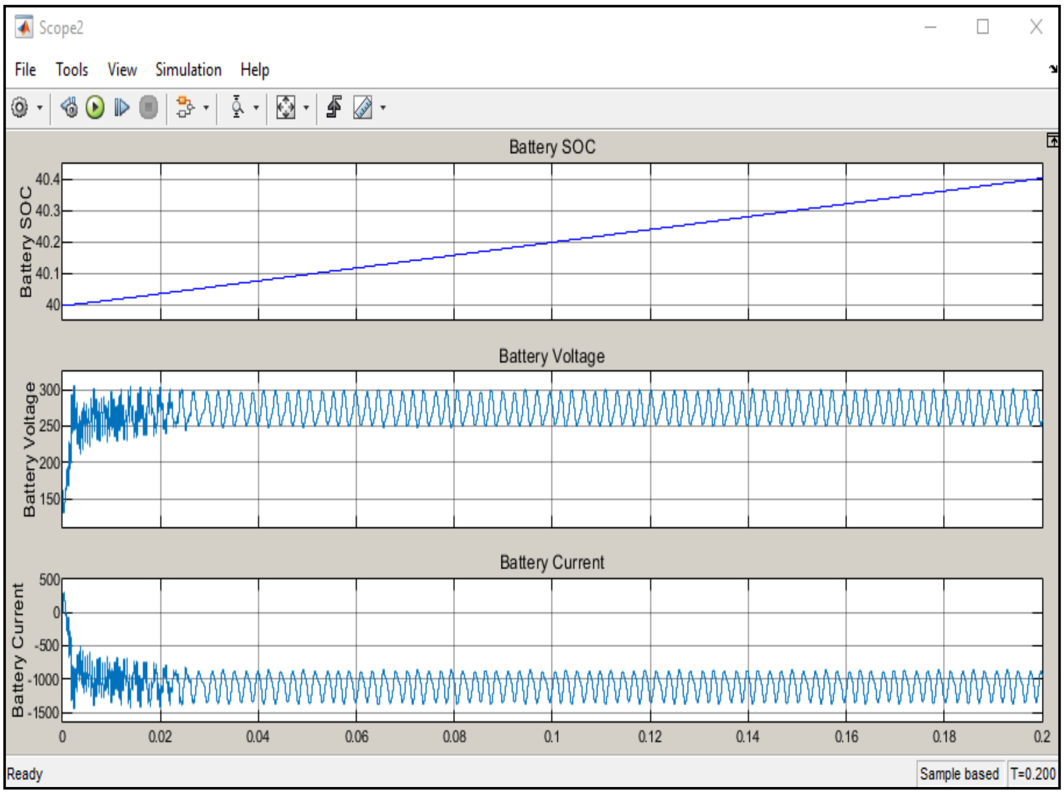

Fig. 17. Battery SOC, Battery voltage and battery current for EV3 Station

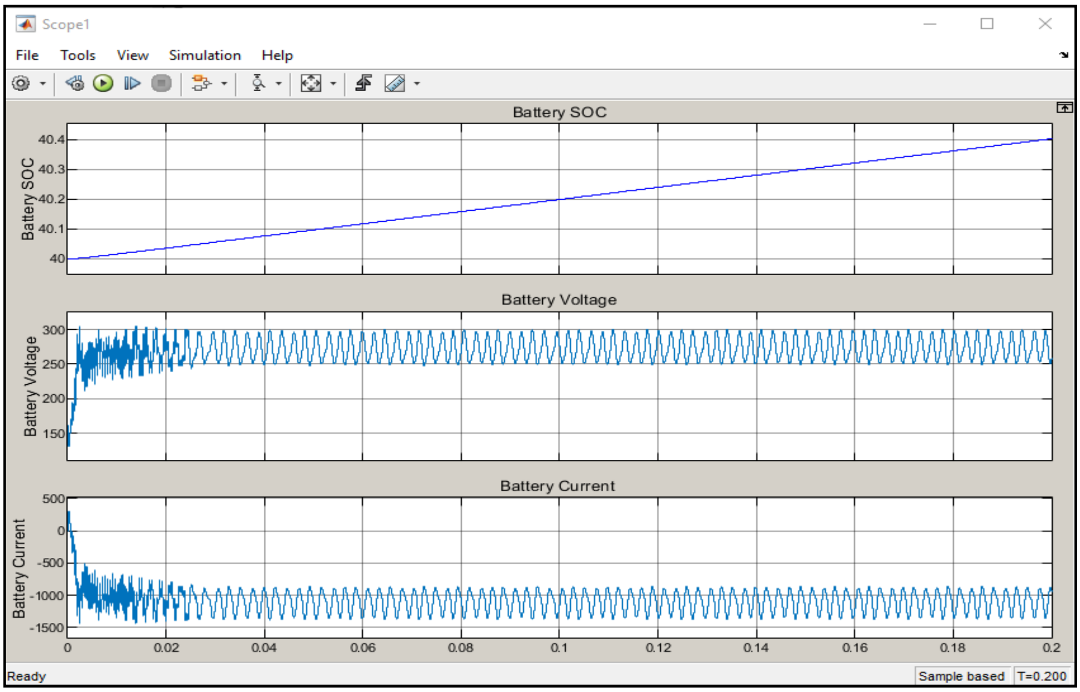

Fig. 18. Battery SOC, Battery Voltage and Battery Current for EV2 Station

V. CONCLUSION

This article focuses on addressing the challenges and optimizing the fast charging technique of electric vehicles (EVs) by leveraging the Vienna T-type converter and Partial Power Processing (PPP) technique. The Vienna T-type converter offers high power quality on both the AC and DC sides, but its complexity and cost pose challenges. The PPP unit is designed to reduce power processed by the converter, minimizing losses and size. Integrating these techniques aims to optimize EV fast charging, achieving faster charging times while minimizing grid impact and maximizing overall system efficiency. The research explores design, implementation, and performance evaluation, focusing on voltage and current fluctuations, harmonics, and efficiency. Ultimately, this work contributes to advancing EV charging infrastructure, promoting widespread EV adoption, and reducing greenhouse gas emissions in the transportation sector.

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