Engineering and Scientific International Journal (ESIJ)
Volume 12, Issue 4, October – December 2025
ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

Effects of Battery Vehicle Charging on Power Quality Connected to Distribution System

Dr.G.Muralikrishnan[1*], Jitenthra N[2], Ramesh B[3], Jackson K[4]
[1]*Assistant Professor, Department of EEE, S.A. Engineering College, Chennai, India*
[2,3,4]*Scholar, Department of EEE, S.A. Engineering College, Chennai, India.*

Abstract — The increasing magnitude of the Electric vehicles (EV) as part of these global energy transition highlights the necessity to understand their effects of the power quality dispersion networks. This project investigates the distortions caused by power electronic converters in EV battery chargers, which can significantly degrade power quality. The emergence of single-phase intensive loads, such as private EV charging stations, complicates the operation of Low Voltage Distribution Networks . Given the growing adoption of EV, addressing these power quality issues is crucial. This study focuses on evaluating the impact of charging station on key power factors Limits, of particularization Total Harmonic Distortion and electric field. Using MATLAB and Power Simulation simulations, to be the project analyses the power quality impacts associated with EV charging. The results provide insight into the extent to which EV chargers influence power quality and highlight the potential challenges and solutions in integrating EV infrastructure into existing power dispersion systems.

Keywords — *LVDN; EV; Battery Charging; THD; FFT.*

1. Introduction

The integration of the electric vehicles (EV) into Electricity and their associated fast charging station present significant challenges to the stability and quality of these Loads.. The widespread adoption of EV hinges on the charge quality and efficiency of both the power grid and the vehicle powering infrastructure. To meted the demands of EV controller, it is essential that chargers maintain high power quality while being both stable and cost-effective. Fabricators of the EV and related equipment need detailed information about the electrical network parameters to which chargers are connected and the potential impacts these adapter can have on connection performance and service standard.

Key issues that arise with the combination of the EV include voltage drops within the network and overloads in feeders and transformers. The connection of EV to the network can be affect-to the power factors, especially during to charging of large- capacity batteries, which typically draw high currents from the network. Such loads are considered medium to large and can significantly degrade power quality.

Numerous studies, documented in articles and standards, have inspected the impacts of EV on power quality. These research address of the impact of harmonic distortions to the substation apparatus, including transformers, wires, capacitors, instruments, relays, and control panels. Harmonic distortions can be also impacts distributed loads, particularly converters and motors. Furthermore, EV can contribute to power system operation by providing frequency control services.

Mitigation of the negative impacts of EV can be achieved through various methods, such as reducing the Non-linear Distortion of the current flow using AC/DC converter controlled via a virtual resistor. Optimization techniques, including Genetic Algorithms and swarm intelligence algorithms like the Gravitational Search Algorithm and Particle to Swarm Optimization , have been employed to address to the challenges of implementing EV charging infrastructure, considering energy costs and battery capacity limitations.

1.1 The Impacts of the EV Power Bank on the Energy Factors of the System

In this segment, the impact of the Electric Vehicle (EV) power bank on the energy factors of the node is analysis derived on the factors such as the battery state of charge, the spread level of EV, and the Battery percentage. Additionally, the influence of different types of EV and maximum- energy to power bank on the system is to evaluated.

1.2 The Impacts of the SOC on THD

To suppose the connection time of EV to the network and the State of Charge (SOC), which leads to the better network operation and improved power factors, several factors must be considered. The total of harmonic distortion into the network by EV chargers generally based on the Fast charging, the EV battery’s strength, and the total of the cars connected to the

Topology simultaneously, among to these other factors- For example, as shown in Fig. 1, a completely discharged battery results in a THD of approximately 20%,

DOI: **10.30726/esij/v12.i4.2025.124009**

whereas a battery with an SOC of 88% results in a THD of around 67%. This demonstrates the significant impacts of SOC on these number of waveform created to the topology. The adapter analyse in this to study has a maximum Energy output of approximately 7.5 kW, classifying it as be scale of 2 charger.

1.3 The Impacts of the EV spread Level on THD

An examination of EV presence to the grid during minimum-load and maximum-load periods indicates that more power can be carried to the EV without degrading power factors during low-load times. This study shows that the spread level of EV significantly affects THD. The analysis of different penetration levels, such as 30%, 50%, and 80%, reveals that as the penetration level of EV increases, the THD produced for the all three phases also improved. Based on the related rule, it is essential to limit EV penetration levels to ensure that THD does not exceed allowable values. The study employs Level 1 chargers with the waveform standard displayed in the SAE J1773 to standard.

1.4 The Impacts of the Overload Quick Chargers on THD

Into analyze to the impact of maximum-energy quick charging on the electrical network, a 10 d i s p e r s i o n network was analyzed. In this network, two power factors levels for charging stations (1000 k VA and 2000 k VA) were the evaluated with the results presented.

2. Methodology of the Study

Electric vehicle (EV) chargers, as non-linear loads, produce harmonics, to minimum voltage profiles, and power loss in dispersion transformers. In, Level 2 AC chargers are used, with a high current rating of 16 A and a capacity of 3.4 kW. Most EV operate within 0.5 kW to 1 kW using a single-phase supply 240 V, 50 Hz distribution system. This study develops mathematical models to analyze harmonic levels from EV chargers, predicting voltage drops, and evaluating transformer loading due to EV chargers. These models help predict power system behavior under various EV charging scenarios to improve power quality and network reliability.

2.1 Power Demand

Electric Vehicle (EV) batteries draw power from the distribution system, which can impact the system's stability due to non- linear power demands. The power demand of an EV depends on several factors, including the battery capacity, the duration of charging, and the State of Charge, which determines if the EV requires maximum or minimum power. The total power factor demand from all the EV is the sum of these single power demands of each EV, that can be significantly affect the overall power dispersion system.

2.2 Harmonics

Harmonics refer to the increase in the maximum-frequency components of electric field and amperage compared to the essential frequency. These harmonics distort the voltage and current wave forms, thereby affected by power factors. The extent of this distortion can be calculated by the Total Harmonic Distortion of both amperage and electric field.

For trickle charging, the harmonic level of current and voltage will be minimum compared to quick charging. Therefore, Electric Vehicles (EV)with a low State of Charge (SOC) are high likely to produce frequency.

Frequency Domain of Analysis - The Frequency domain is a crucial tool in power quality analysis, especially for examining the frequency components of electrical signals. In power systems, FFT helps identify and quantify harmonic distortions caused by non-linear system, such as be Electric Vehicle (EV) chargers. By converting time- domain signals into their frequency-domain characterized by, FFT active engineers to analyze Total Harmonic Distortion (THD) and other power quality parameters. This transformation helps understand the extent of harmonics and their impact on the power system's efficiency and stability. Additionally, FFT is essential for monitoring voltage and current distortions, evaluating the performance of electrical equipment under various loading conditions, and designing filters to mitigate these distortions. Essentially, FFT provides the analytical foundation necessary for improving power factors and ensuring the reliable operation of electrical networks, particularly with the growing adoption of EV chargers.

2.3 Simulation Analysis and Outcomes

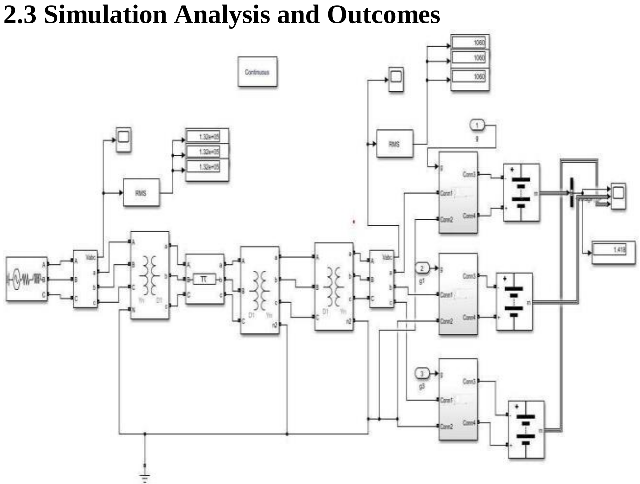

Fig.1: Battery Output

DOI: **10.30726/esij/v12.i4.2025.124009**

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

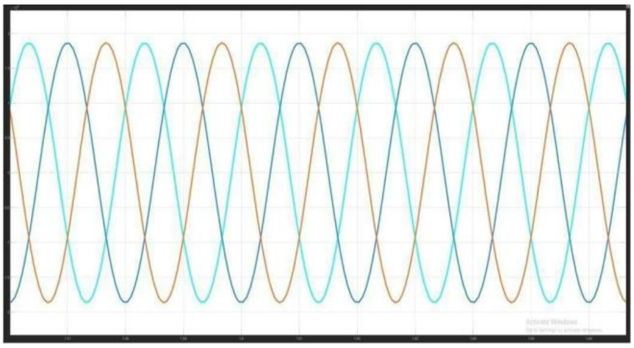

Fig.2: Charger pulse waveform

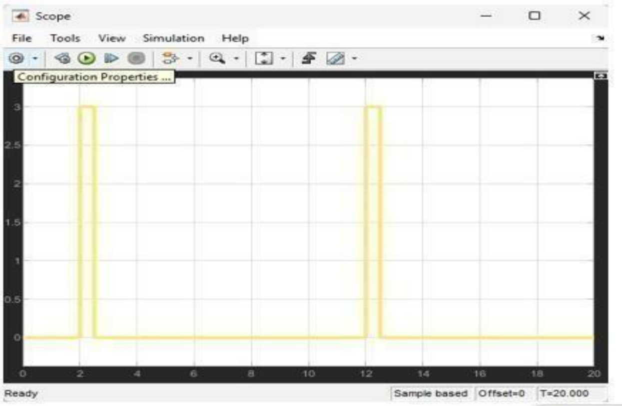

Fig. 3: Subsystem 1

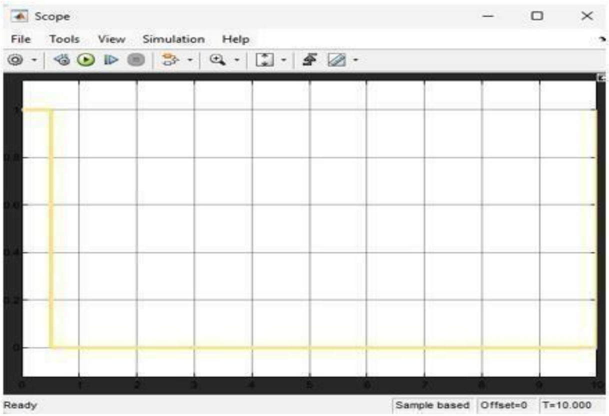

Fig. 4: Transformer Waveform

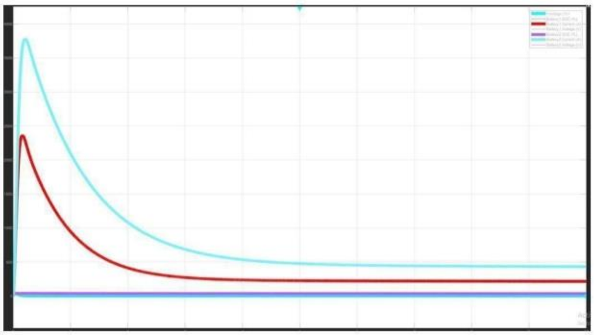

Fig. 5: Transformer Waveform

3. Voltage Profile and EV Charging

The minimum voltage profile is the significant dispute caused by the EV charger. Voltage balance by refers to the power lines power to remain stable after sudden increases or decreases in load. EV draw large amounts of power in a short time, which degrades the voltage profile and destabilizes the grid.

4. Transformer

The mass implementation of Electric Vehicles (EV) creates additional pressure on the dispersion transformers, impacting to their development. To mitigate this, the EV charger rate should be restricted access per day, and power terminal should be the located alone formed transformers to reduce to be power factors losses. Harmonics distortion currents are dependable for the load losses in the transformer, while harmonic distortion voltages do not cause load loss. These harmonic losses increase heating compared to a sincere sinusoidal wave. The harmonic withstand capacity of a transformer be calculated by the power factor called the k- power factor.

The Appearance of non-linear distortion causes overheating in transformers. Therefore, transformers should be selected based on their withstand by the capacity at maximum harmonic currents for complex loading Electric field. Hence to ideal outplacement stations is crucial.

Additionally, the examination of EV charging time revealed that power factors is minimum during the peak hours and high during off- high hours. Voltage drop is also less significant during off-maximum time compared to maximumtime. Harmonic analysis, filtered through FFT (Fast Fourier Transform) analysis, demonstrated the importance of managing harmonic levels to maintain power factor.

5. Conclusion

This paper analyzed to the impacts of different EV charger scenarios on the power factor of these power dispersion node, focusing on (Total Harmonic Distortion) indices and electric field drop. The study found that the maximum the number of power plant and the higher their energy levels, the greater the THD and electric field drop, sometimes exceeding acceptable ranges. To mitigate these negative effects, it fundamental to the use relevant instruments such as be battery and absorbed. The analysis of the configuration locations of the charging stations to the dispersion network— whether at the initiation, midpoint, or last phase of the main feeder—showed that

DOI: **10.30726/esij/v12.i4.2025.124009**

the farther the power terminals are from main energy source, to the maximum THD and

References

[1] Power factor of the Electric Vehicle Charging Stations and Optimal Placement in the Dispersion Network M. Shadnam Zarbil, A. Vahedi * Department of Electrical Engineering, Iran University of Science and Technology, Tehran, Iran.

[2] Effects of the Battery Vehicle power St a t i o n on the Quality of the Low Voltage Network Supply Effect Assessment to Electric Vehicle Charging is an AC and DC smart grids: A Comparative Study.

[3] Effects of bidirectional EV power stations on dispersion network: a Power Hardware-In- the-Loop implementation Battery Vehicles Under reduced Temperatures: A Review on Battery Performance, Charging Needs,and Power Grid Impacts

[4] Impact of Hot Arid Climate on ideal Placement of Electric Vehicle power Stations "The impact of the electric vehicle charging on a residential low voltage distribution network in Malaysia", IEEE Innovate. Smart meter Tech., "Effects of EV battery chargers on the powerfactorsof dispersion systems

[5] "Research on the harmonic characteristics of electric vehicle fast charging station "Current harmonics, voltage distortion, and powers associated with electric vehicle battery chargers distributed on the residential power system".

[6] "Load management in smart grids considering harmonic distortion and transformer berating", Innov. Smart Grid "Input current THD reduction via virtual resistant in EV charger", Optimal location of electric vehicle charging station and its impact on distribution network .

[7] "Impact of electric vehicle chargers on a low voltage distribution system", Current harmonics, voltage distortion, and powers associated with electric vehicle battery chargers distributed on the residential power system".

DOI: **10.30726/esij/v12.i4.2025.124009**