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Analysis of the Impact of Electric Vehicle Charging Station on Power Quality Issues

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Abstract:** The sector of transport is being electrified because to rising worries about pollution and energy consumption, as well as technological breakthroughs in batteries. As a new technology, electric cars are still trying to find their niche. Its many benefits include less pollutant that contributes to climate change, less fuel use, and simplicity of use. Since chargers function as electric-electronic converters, power quality issues may arise while charging electric vehicles (EVs). More and more people are driving electric vehicles, which brings up concerns about how these vehicles may affect the electricity system and its quality. Power balancing and the effect of charging an electric car on voltage, current, and total harmonic distortion are the primary topics covered in this article. This research presents and analyses power quality concerns in EV charging stations based on monitoring data. Various chargers' harmonic current emissions are studied. The purpose of this study is to examine how the loads placed on the distribution network by electric vehicle charging stations affect reliability indices, power losses, voltage stability, and economic losses. This article uses MATLAB simulations to examine the effects of EVs on the electricity distribution network.

***Keywords:** EV Station, Power Quality, NC Loads, Stability, THD.*

1. INTRODUCTION

The suitability of electrical power supplied by the utility to the power consumer is measured by power quality (PQ). Problems with utility service continuity, transient voltages and currents, and fluctuations in voltage magnitude can all result from low PQ, making it an important factor to consider. One of the main causes of poor power quality is harmonic distortion. We have three hypotheses that we are trying to test with this study. First, we postulated that distribution feeders might be affected by the power quality problems caused by electric vehicle charging, due to the fact that EV charge controllers are nonlinear loads and

EVs consume a lot of power. Two, we also postulated that different stages of an electric vehicle's charging cycle would cause the charge controller's total harmonic distortion (THD) to vary over time. Thirdly, we postulated that an upper limit on the number of electric vehicle charging stations that could be linked to a single feeder would be imposed by the cumulative effects of several charge controllers on the same feeder, which would lead to distortion higher than that of any one charge controller.

Electric vehicle (EV) charging loads have a negative effect on power system operating characteristics, which has been noted with the widespread revival of EVs. Electric vehicle charging station loads have a negative effect on the power distribution network. Problems with dependability, voltage instability, lower reserve margins, higher peak load demand, and reduced reserve capacity are all outcomes of the rapid charging stations' heavy charging demands. Additionally, the utility's penalty for the power system's declining performance is an important consideration.

The purpose of this study is to examine how the loads placed on the distribution network by electric vehicle charging stations affect reliability indices, power losses, voltage stability, and economic losses. This project uses MATLAB simulations to examine the effects of EVs on the electricity distribution network. When the distribution transformer is overloaded with electric vehicle chargers, this project shows the voltage profile, harmonics, and losses that occur.

Power Quality
How closely an actual supply system resembles an ideal one is conveyed by the Power Quality of that system. All linked loads should operate satisfactorily and efficiently if the system's Power Quality is excellent. Operating costs and the establishment's impact on carbon emissions will be negligible. The performance of the electrical institution will deteriorate, loads connected to it will fail or have a shortened lifetime, and power quality will be bad overall. Due to low power quality, the operating costs and carbon footprint of the establishment will be considerable, and/or it may not be possible to operate at all. Any problem with the energy network that leads to a financial loss is an example of poor power quality. The word "power quality" might imply something quite different to people. The principle of powering & grounding sensitive measurement equipment in an optimum way suited for the equipment is defined as power quality according to IEEE1100, the standard of the Institute of Electrical & Electronic Engineers. When there are more power quality concerns, all electrical equipment are more likely to malfunction or fail. Whether it's a computer, printer, generator, transformer, electric motor, home appliance, or piece of communication gear, the electrical machine is there. All of these equipment have an undesirable reaction to power quality difficulties, the severity of which depends on the nature of the problems. Power quality may be described as the set of electrical constraints that enable a piece of equipment to operate in its aggregated manner without significant loss of lifespan or performance. This description might be simpler and more to the point.The two qualities that we usually want from the lifetime and performance of an electrical equipment are provided by this definition. An issue with quality may arise if there is a power-related

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disadvantage that compromises either attribute. Given this definition of force excellence, this section serves as an introduction to the other fundamental terminology related to power quality. The definitions of the words are included in enclosures wherever they are needed to clarify anything. Here we break out the role of power quality factors in an electrical system.
The word "power quality" is simple, but it depicts a separate problem that might arise in every network that supplies electricity, and it is also subjective. What constitutes "good" or "bad" power is according to the user. If the device works as expected, the user will think the power is OK. People worry that the electricity will be terrible if the equipment breaks down too soon or doesn't work as it should. All depends on how the power user sees it. Power quality could exist in a variety of grades or levels between these two extremes. If you want to fix power quality concerns once and for all, you need start by learning what they are.

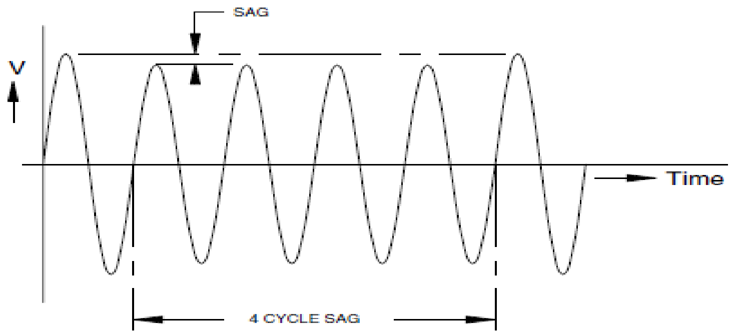

Fig: Voltage sag

Voltage spikes and dips are caused by low-frequency phenomena known as power frequency disturbances. They could be created by a power system's switching activities or by a power outage. As far as electrical equipment's vulnerability is concerned, the outcomes are same. Distortions like ringing, notching, and impulse are caused by transients, which are short-lived, rapid occurrences in power systems. Factors that affect power frequency disturbances are distinct from those that cause transient energy to be transmitted down power lines, subsequently dissipated, and passed to other electrical circuits. When a power system experiences harmonics, it distorts the waveform at low frequencies. It adds harmonic components to the frequency spectrum. Power system components and functioning are negatively impacted by current and voltage harmonics. Interactions between harmonics and power system characteristics (R, L, and C) can have disastrous results in some cases. Research on power quality is more complicated when it comes to the idea of bonding and grounding. There are three main justifications for grounding. The primary goal of grounding in the United States is to ensure safety, as stated in the National Electrical Code (NEC). Voltage spikes and dips are caused by low-frequency phenomena known as power frequency disturbances. They could be created by a power system's switching activities or by a power outage. As far as electrical equipment's vulnerability is concerned, the outcomes are same. Distortions like ringing, notching, and impulse are caused by transients, which are short-lived, rapid occurrences in power systems. Factors that affect power frequency disturbances are distinct from those that cause transient energy to be transmitted down power lines, subsequently dissipated, and passed to other electrical circuits. When a power system

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experiences harmonics, it distorts the waveform at low frequencies. It adds harmonic components to the frequency spectrum. Power system components and functioning are negatively impacted by current and voltage harmonics. Interactions between harmonics and power system characteristics (R, L, and C) can have disastrous results in some cases. Research on power quality is more complicated when it comes to the idea of bonding and grounding. There are three main justifications for grounding. The National Electrical Code (NEC) mandates safety grounding in the United States, which is the primary goal of grounding.

The below Fig shows the Power quality issue

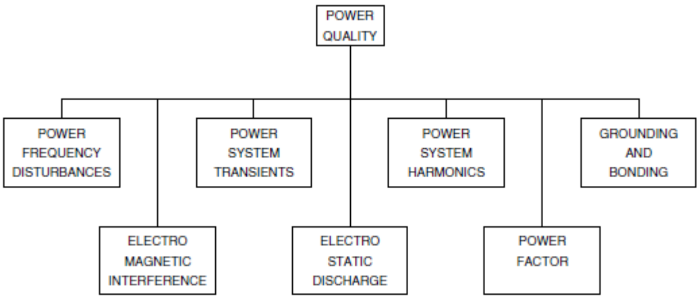

Fig: Power quality issue

Second, bonding and grounding provide a low-impedance channel for the fault current to flow, which the power source's protective device may use to isolate the faulty circuit in the event of a ground fault. The establishment of a ground connection plane is the third justification for grounding electrically sensitive equipment. Here we have what is called the Signal Reference Ground (SRG).According to the SRG Both the facility and the user may have different preferences when it comes to the setting. The SRG can't exist in a vacuum. A whole ground system is created when it is linked to the facility's safety ground. When electric and magnetic fields interact with sensitive electronic circuits and devices, this phenomenon is known as electromagnetic interference (EMI). EMI occurs at very high frequencies. When compared to power level electrical transients and disturbances, the procedure for attaching electromagnetic interference (EMI) to vulnerable equipment is distinct. As we will see later on, specialised methods are necessary to mitigate the impacts of electromagnetic interference (EMI). Interactions between transmitted or radiated radio frequency fields with communication devices or private information are known as radio frequency interference (RFI). Although the two phenomena are distinct, it is useful to include RFI in the category of EMI.

Electric Vehicle Charging Technologies
The elements influencing the development of charging technologies are depicted in the figure. One other thing to keep in mind: the technology that is accepted is also determined by the charging site.

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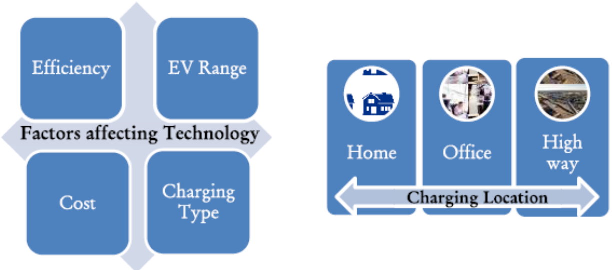


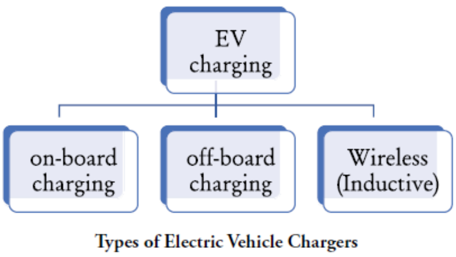
Fig: Factors that decides charging technologies

This section has been divided into four main categories that will be considered in the following sections:

1. Types of EV charging technologies
2. Types of EV charging systems and processes
3. Grid infrastructure required for EV charging stations
4. Software environment at charging station, DISCOM control centre and consumer

A. Types of EV Charging Technologies

In order for electric vehicles to advance in various ways (in terms of efficiency, EV range, prices, etc.), advancements in battery system technology are essential. Techniques and skills for charging and discharging also matter. To make EVs more usable and popular, they should be adapted to various settings (at home, at the office, on roads, etc.) and tailored to drivers' requirements. There are two main types of electric vehicle charging: on-board and off-board. This design enables both bidirectional power flow and unidirectional power flow, meaning that both approaches may be used to charge the EV battery in the grid and pump electricity back into the grid. The figure depicts the standard configuration of an electric vehicle's on-board & off-board charging infrastructure.



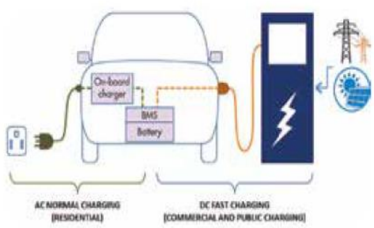


Fig: On-board and Off-board charging topology of EV

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There aren't enough electric vehicle charging outlets nowadays. Two distinct kinds of charging stations are now in use. charge stations in both public and private spaces. While a small number of public charging stations have been installed in various places, the vast majority of stations are privately owned. The rate of charging at these private stations is greater. The components of an EVCS, as shown in the figure, are a rectifier, a converter, and a transformer. The basic components of an electric vehicle charger are a rectifier and a converter.

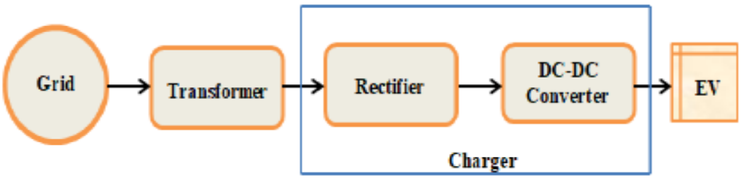


Fig: Block diagram of an Electric Vehicle Charging Station

Evaluating the effects of EVs is necessary since EV loads are growing at a rapid pace. The following figure illustrates the effect on the power system of widespread EV adoption. Smart grid infrastructure, a transportation system with fewer greenhouse gas emissions, and widespread use of electric vehicles all have their advantages. However, the consequences for the power network architecture are substantial and detrimental.

2. SIMULATION RESULTS

Underneath the graphic is a representation of the MATLAB SIMULINK model that was used to examine the effects of EVCS on the utility grid.

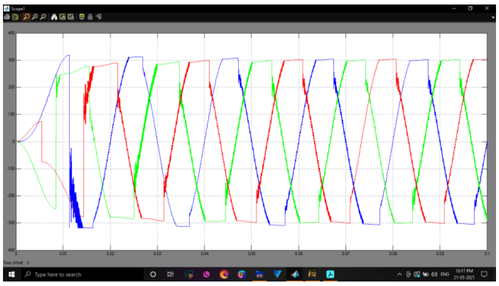
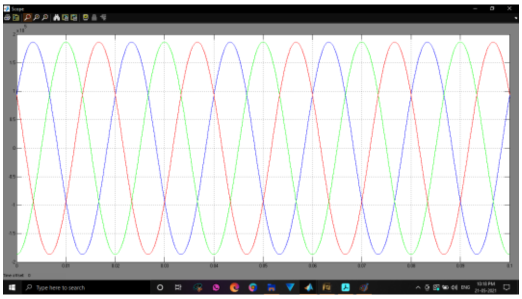


Fig: Input Voltage, after connecting Charger.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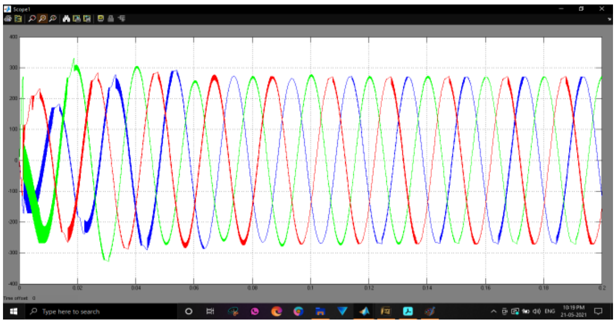
When many EV chargers are linked, the voltage at the supply end likewise decreases. This issue arises as a result of overloading caused by a high number of EVs. Figure shows the voltage pattern variation both before and after the EV charger connection. When comparing the voltage with and without the connection of EV chargers, as shown in Fig., it is clear that harmonic disruption has an impact on the voltage.



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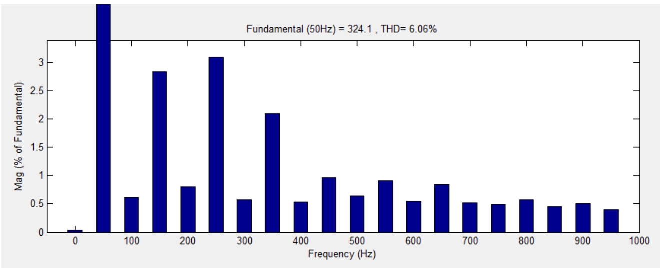

Fig (a): Harmonics, when 1 EV chargers are connected at a charging station

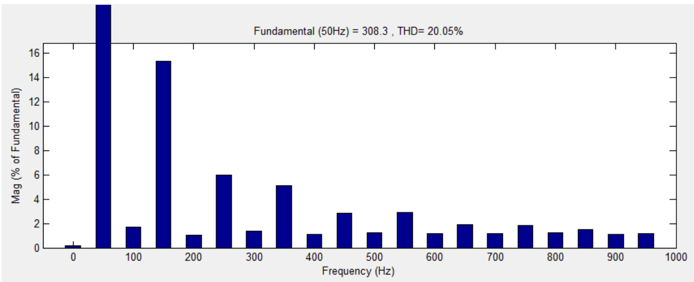

Fig (b): Harmonics, when 3 EV chargers are connected at a charging station

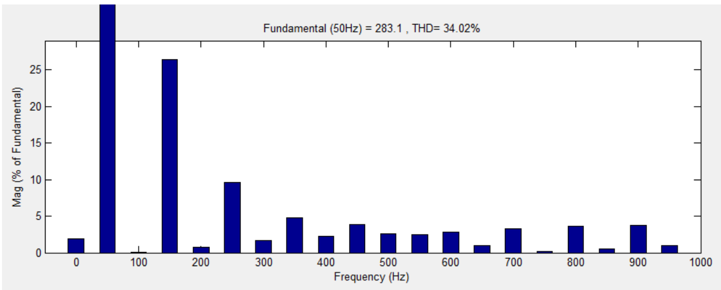

Fig (c): Harmonics, when 5 EV chargers are connected at a charging station

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Disruptions to a power system are known as harmonics. Connecting an electric vehicle charger to the electrical grid causes harmonics since the load is not linear. Because most electric vehicle chargers are hardwired into the power distribution network, the cumulative impact of harmonics poses a risk to the whole power grid. Figures (a), (b), and (c) below demonstrate the harmonics produced in the MATLAB/Simulink models at various EV charging ratios.

3. CONCLUSION

Electric vehicles are becoming more appealing to customers due to its prominent attributes of reducing environmental pollution and being the most affordable form of transportation. Because there aren't enough public charging stations, most electric vehicles are plugged into home outlets, meaning the power industry isn't making money from this market. Nevertheless, the penetration of EVs poses risks to the power infrastructure and impacts power quality for several reasons. Using MATLAB/Simulink, this project analyses power quality concerns such as harmonics, voltage fluctuation, and transformer power losses. This project also covers the mitigation strategy that makes use of renewable resources that are already accessible. For the electricity sector to progress sustainably, power quality regulations are necessary, even if EVs offer several advantages, such as reducing greenhouse gas emissions and stabilising the grid when it's under loaded.

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