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Effects of Integration of Electric Vehicle Charging Stations into the Grid

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***Abstract*— One of the best ways to address urgent sustainability issues like global warming, depletion of fossil fuel reserves, and emissions of greenhouse gases is to use electric vehicles (EVs). By reducing environmental damage and lowering emissions that contribute to climate change, incorporating electric vehicles into the distribution system will benefit public health. A microgrid is a tiny power network that collaborates with groups of loads as well as distribution generators, powerful software solutions, and other elements utilizing devices connected to the grid that function as a single controlled entity. Last but not least, the study states various ways to mitigate the effects of electric vehicles on distribution system power quality and get rid of harmonics.**

***Index Terms*— Integration of electric vehicles, micro grid, power distribution systems, ecological damage, harmonics.**

I. INTRODUCTION

For ensuring a sustainable future, issues like global warming, the depletion of fossil fuel reserves, and emissions of greenhouse gases (GHGs) require immediate attention. The primary reason for the rising consumption of fossil fuels and emissions of greenhouse gases is the rapid rise in global energy consumption. As a consequence of these issues, the renewable energy sector has carried out substantial research for identifying ways and where to replace traditional fossil fuels and lessen environmental problems. The electrification of the transportation sector is seen as a promising solution to this issue because it is one of the largest contributors to rising emissions of pollutants.MG is regarded as the smartest option for optimal operation because of the power grid's rapid expansion and the intricate structure of DES over long distances. However, electric vehicles have been put on hold and restricted to golf carts and delivery trucks due to the readily available availability of fossil fuels, advancements in combustion technology, and the ease with which internal combustion engines can be utilized. However, EV penetration remains low due to concerns about cruising range, deteriorating batteries, a lack of charging infrastructure, and high initial costs. Even though electric vehicles have a significant impact on the reduction of air pollution, they may harm the quality of the grid's power supply. Rechargeable batteries are used to power electric motors and store energy in electric vehicles. EV battery chargers employ electronic power devices to transform DC voltage to AC voltage since non-linearity has an impact on electricity quality. Nonlinear loads have a detrimental effect on power quality. Microgrid has transformed into a key investigation part in wise the structure and movement systems. Microgrid principally incorporates different environmentally friendly power sources using different innovative advances, for example, Power electronic-based technology. EVs can have a negative impact on energy systems, particularly power quality, but they can also significantly reduce CO2

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emissions and reliance on hydrocarbon-based generators. By reducing emissions that contribute to climate change and environmental damage, research into incorporating electric vehicles into the distribution system will improve public health. They may result in problems including power factor deterioration, voltage imbalance, or voltage variations, as well as harmonic or interharmonics in distribution systems. The harmonic frequency content is distorted by nonlinear loads like electric vehicle battery chargers. Harmonic distortion and poor power quality are the results of charging a lot of electric vehicles at once. Power transformer performance is harmed by harmonics as power losses rise and output power decreases. Power cables, capacitors, relays, and switch-based power electronic devices can all be affected by harmonic distortion. During the charging process, EV battery charging stations produce a lot of harmonic distortion. In order to resolve issues with the power distribution system, voltage and current harmonics must therefore be thoroughly investigated.

A. EV Chargers' Harmonics

Summing up the harmonics produced by a single charger is not the same as simultaneously charging multiple cars with the generated harmonics. The system where energy is stored of an EV charging station is made up of three main parts. They are battery, software, and power conversion system. There are no similarities between EV chargers systems and converters due to generating of harmonic voltages rather harmonic currents. Because they do not have a negative meaning as harmonic currents do, harmonic voltages are not included in the analysis [1]. The charging current and this charging voltage are virtually unrelated. There are three stages to the charger. These chargers are connected to end nodes, front nodes, and nodes that change at random. Taking into account that these charger levels represent 10 percent, 20 percent, and 30 percent of the total load on the feeder, the charger is connected to the feeder's end node for the front node, while it is connected to the source power supply for the end node. With his 6, 12, and 18 chargers each connected to a variable value, the supplier's test system was run.

B. EV Charging Station Harmonics

The controlling features of the EV battery chargers are included, and their operation is contingent on the ingredients. The performance of the power system is subject to appropriate opportunities and risks as a result of the adoption of electric vehicles, which have the potential to significantly increase loading. These chargers and current voltage have an impact rate design and flexibility of energy.

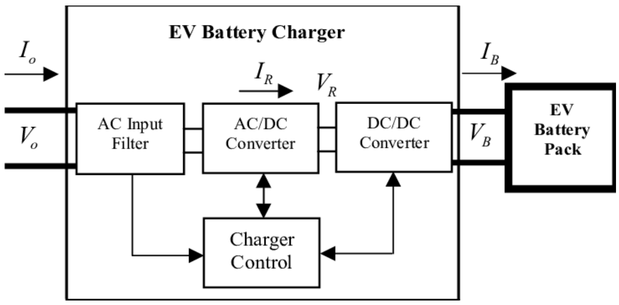

Figure 1: EV battery charger

C. EVs and Harmonics

The three types of EVs are BEV, HEV, and FCEV. Battery Electric Vehicle is abbreviated as BEV. Hybrid electric vehicle is the acronym for HEV. Fuel Cell Electric Vehicle is the acronym for FCEV [2]. Power quality is significantly affected by non-linear loads like electric vehicle charging stations, which cause voltage and current harmonics. In power systems, harmonics regarding voltage and current cause a variety of issues, including, damage to the equipment, a transformer that overheats, a low power factor, and a narrow range of voltage profiles.

D. AC Microgrids

There are three types of microgrid systems.AC, DC, and hybrid AC/DC are the three. With or without converters, this system permanently connects all DGs—consumers and storage—to the AC busbar network. Without the need for an inverter, AC generators like diesel, wind, and micro turbines can typically be connected directly to AC busbar. DC power sources like batteries, ESS, and PV systems also require DC/AC inverters. It is consequently associated in an orderly fashion with the air conditioner busbar. There are a lot of problems with AC MG, and these networks have complicated control and timing issues. This network, on the other hand, is still widespread today. In AC MG, the three-phase AC bus serves as the power connection point between MGs and these primary power grids. Installing the common connection area between the Microgrids and the main power grid is simple. A quick switch serves as the disconnect point. The DG powers the load when normal events take place, and any extra power generated is sent to the power grid. The AC microgrid will receive the necessary power from the main grid if the DG's output power falls below the load demand. A significant detail to make reference to is that air conditioner Microgrids' power quality guidelines are managed in view of ordinary power conveyance frameworks and methods of activity.

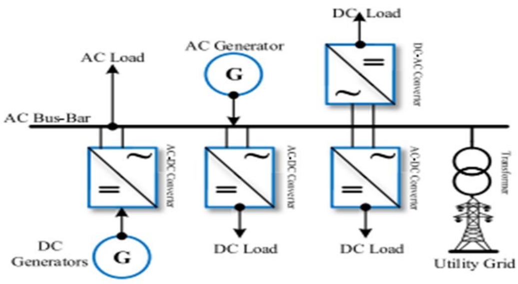

Figure 2: AC microgrid

E. DC Microgrids

The majority of microgrid generators produce DC that must be converted to AC in order to keep up with the AC grids of today. Because some devices require SC power to function, DC conversion is required at the system's end. Be that as it may, AC MG successfully lessens the DC-AC-DC energy transformation, prompting energy misfortune. Using high DC voltage operation as a benchmark, DC MG aims to solve the AC MG issue. By reducing the number of converters in a single MG system process, the DC-MG structure, in contrast to AC-MG, can provide significant energy savings.. The necessity of the class converters to communicate the DESs, stockpiling gadgets, and loadings. It is evident that DC MGs are less likely to cause power quality issues than AC-distributed grids and are better suited for residential distribution systems. DC MG eliminates the need for DG synchronization and ensures that control is highly dependent on the DC bus voltage, removing several control challenges in microgrid. Additionally, primary control is made much simpler by the absence of reactive power flow management [3]. Additionally, the power supply is unaffected because many modern devices use direct current and do not contain power electronics. The switching phase transients must be properly controlled in MG to prevent device destruction. Thus, the issue of his PQ for this situation warrants extra examination.

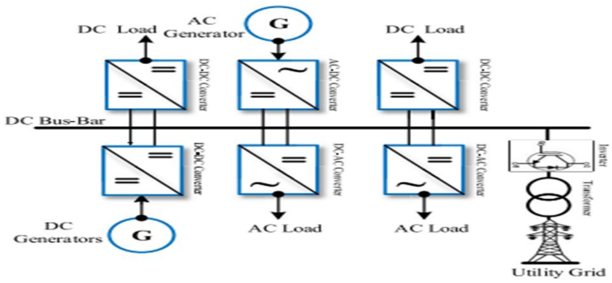

Figure 3: DC microgrid

III. EVS' INTEGRATION INTO THE GRID

A. Overview of Ev Technology

EV technology is utilized in PHEVs, also known as hybrid electric vehicles (HEVs). The hybrid electric vehicle, also known as a battery electric vehicle, was the first EV technology to enter the modern automotive market. The electric drive system of EV offers the necessary power to the EV motors at the time the vehicle is in motion. On the other hand, while the vehicle is parked and connected the EV charging system supplies the battery with energy from the grid. The controller, power converter, battery pack, and electric machine are the essential components of an electric vehicle's electric propulsion system [4]. By utilizing EVs to transmit owners, stored energy for the grid of electric vehicles can also actively participate in the electricity market. Electric vehicles can be controlled as auxiliary service providers to the grid through mechanisms known as V2G and G2V, which control their discharge to and charge from the grid. When it comes to balancing power on the grid in unidirectional V2G, EV batteries are regarded as switchable loads. A single battery in an electric car is insufficient to affect the grid. A large number of electric vehicles known as EV Aggregators act as a link between individual electric vehicles and market participants. Electric vehicles can connect to third-party aggregators on their own or as part of a fleet across cities or regions. Microgrids can receive fewer communication signals from EV aggregators. As a result, market operators can benefit from EV aggregators' ability to lower complexity and mitigate cybersecurity risks.

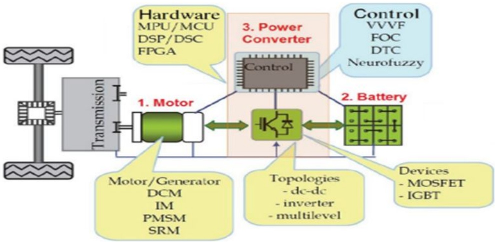

Figure 4: EV electric propulsion

B. Effects of Ev Integration into the Grid

Electric vehicle grid integration may have an effect on the power system's power quality. The vast majority of the examinations directed so far have inspected what EV mix means for power quality boundaries, for example, voltage profile, voltage awkwardness, power misfortune, and music. In light of their growing popularity, numerous efforts have been made to investigate the impact of electric vehicle grid integration. The effects of voltage profiles, harmonics, power losses, and electric vehicle grid integration on grid stability issues are thoroughly examined in this study. Electric vehicle penetration in the power grid has a significant impact on electricity prices as well [5]. The stability of the grid's voltage may suffer as a result of the integration of electric vehicles. The location, prevalence, and charging time of electric vehicles all play a role in this. Uncertainty regarding EV connection points, their prevalence, and the duration of connections and disconnections raise load requirements.

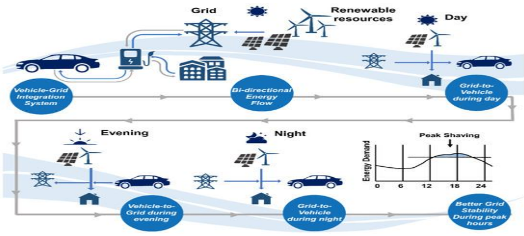

Figure 5: EV Utilization

C. EV integration's effects on the stability of the grid

The capacity of a power system to return to a steady-state operating state following a fault is known as power system stability. The significance of stability studies is demonstrated by the numerous reports of outages caused by system instability. While charging from the framework, EVs show up as non-straight loads with unexpected attributes in comparison to typical loads and can pressure the power framework. Additionally, it is challenging to predict this new load's behaviour due to uncertainties regarding EV connection points, charging time, and duration [6]. As a result, the power system's stability may become uncertain if electric vehicles are refuelled a lot.

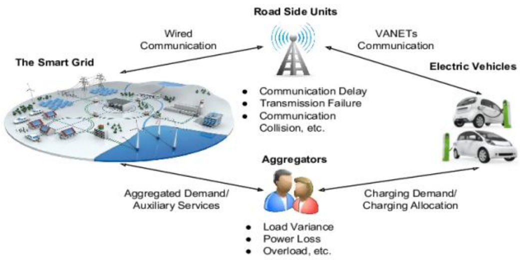

Figure 6: EV and grid interaction

- Voltage stability impacts:The term voltage soundness alludes to the power lattice's capacity to keep up with the voltage on all transports at voltage levels after an issue. Grid voltage stability can be significantly impacted by variations in demand for the load and features. After system contingencies, the power system may become more unstable if the load model's alpha is negative. For investigating a comprehensive examination of the effect of EV penetration on the stability of the grid's voltage of a test distribution network of 43 buses with interconnected EV charging stations was carried out [7]. The 43-bus test distribution network's weakest bus has a significantly shorter charging range when using an integrated EV charging station. The weakest buses' charging margins continue to decline as EV integration grows. However, the power grid's voltage stability is impacted by the location of EV charging stations, $(P/P_0) = a (V/V_0)^a + b$

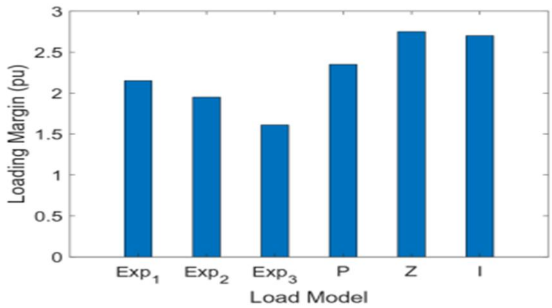

Figure 7: Graph between Load Model and Loading Margin

- Frequency stability impacts**:** The frequency may deviate from the permissible range if there is an imbalance in the power grid's load demand and generation demand. Frequency stability refers to a power system's capacity to maintain acceptable frequencies following a power system failure [8]. The charging grid's load demand will rise dramatically as more electric vehicles are sold, necessitating more power generation to maintain a frequency that is within acceptable limits.

D. Power quality impacts of EV integration

Investments in power generation, demand, prices, and emissions will undoubtedly rise with increasing EV penetration. The economic effects of incorporating electric vehicles into electricity markets have been the subject of numerous studies. The following are examples of how EV integration affects load profiles, energy prices, operating costs, and ancillary services.

IV. HARMONIC AND SUPERHARMONICS CHARACTERISTICS

A. Characteristics of Harmonics

Sources of harmonic pollution in microgrid have high penetration and decentralization to form a complete network [9]. Traditional local harmonic mitigation has the disadvantage of being difficult to implement and expensive to maintain.

B. Characteristics of Superharmonics

SH emissions have increased as a result of efforts to reduce the number of low-frequency harmonics in inverter output current and improve power factor. In this instance, SH is sent to the grid whenever the inverter is running because it comes from the circuit of the inverter. An SH measurement and mitigation method and the device can be the inverter if it is not producing power or working properly.

V. TECHNIQUES FOR MITIGATION

A. Harmonic mitigation

The effects of EV chargers and harmonic distortion as a whole can be enhanced by reducing odd harmonics to a minimum. The following techniques can be used to lessen harmonic distortion caused by EV chargers' odd harmonic current distortion:

- Low-pass harmonic filters:By connecting a capacitor to another resistor in parallel with the inductor, you can create a low-pass filter. Additionally, low-pass filters are regarded as the best and most efficient method for reducing harmonics in power systems [10]. Due to its simplicity, economy, resistance to maintenance, and high reliability, it is primarily utilized in power transmission and distribution networks.

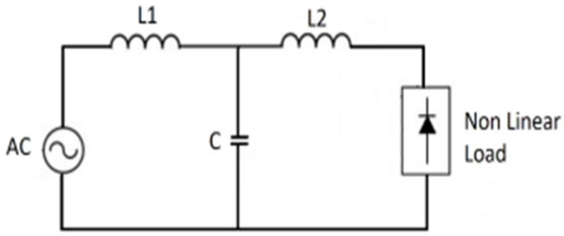

Figure 8: Low pass filter

- Active filter: A nonlinear load's harmonic current spectrum is out of phase with that of active filters. The active filter's harmonic current effectively eliminates all network harmonics when fed directly into the system in real-time. By continuously providing reactive power, both capacitive and inductive, active filters can improve power factors in addition to suppressing harmonic currents.

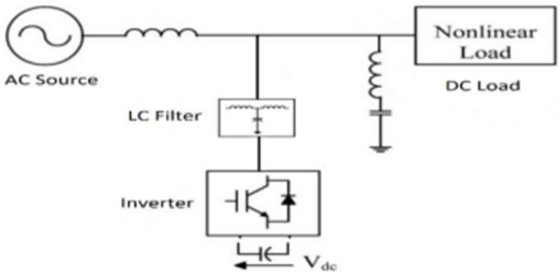

Figure 9: Active filter

- Hybrid control techniques:Grid-connected solar energy systems typically employ hybrid control technology. Passive-based control strategies have progressed to recover reactive power and avoid harmonic distortion by utilizing the current control loop of an attached inverter. This approach is planned to eliminate symphonies twisting by utilizing an ongoing control circle to create and follow the consonant substance [11]. Utilizing physics to model the energy of damped injections and locating system settings that will produce the appropriate response is the objective of control engineering.

B. Superharmonics Mitigation

- For improving the power quality of the PV as well as batteries in MG, DVRs are used to deal with voltage drops and spikes. With his fuzzy logic-based DVR, he overcame the MG-connected mesh's waviness and slack [12]. MPC was used to make the DVR work better and deal with Sage and MG swelling made of PV, a super capacitor, and a battery.
- Other tools for addressing issues with power quality include STATCOM and SVC. Due to the high prevalence of DREs as MGs, voltage fluctuations were mitigated by STATCOMs [13]. In power system MGs, STATCOMs were also utilized for reducing fluctuation in voltage and compensating for reactive power.

VI. CONCLUSION & FUTURE SCOPE

With significant progress in the mobility sector, high-efficiency electric vehicles of a new generation are gaining popularity. Electric vehicles should be used instead of gasoline vehicles due to the advantages of battery charging. The primary advantages of charging EV batteries include reduced oil pollution, high efficiency, and dependability. However, one of the problems energy providers face is poor power quality when charging EV batteries. In nonlinear loads, EV battery charging is taken into account because of power electronic components like rectifiers. In contrast, MG Grid is a novel power grid that can be utilized to fulfil energy demands in the future in the direction of green power and smart grids. In MG Grid, some power sources primarily use renewable energy. However, RES output is unstable and weather-dependent, despite the fact that numerous power electronics devices are required. Therefore, a crucial factor in the expansion of MG is the availability of PQ criteria, measurement, and mitigation strategies.

REFERENCES

[1] Pinilla, J.T.M., 2022. Hosting Capacity: A Tool to Modernize the Grid and to Contribute to the Integration of Distributed Energy Resources in Colombia. *Global Journals of Research in Engineering*, *22*(B1), pp.33-40.

[2] Kharrazi, A., Sreeram, V. and Mishra, Y., 2020. Assessment techniques of the impact of grid-tied rooftop photovoltaic generation on the power quality of low voltage distribution network-A review. *Renewable and Sustainable Energy Reviews*, *120*, p.109643.

[3] Xingang, Y., Aiqiang, P., Guangzheng, Y., Chenyang, L. and Yangxiu, Y., 2019, May. Supraharmonics measurement algorithm based on CS-SAMP. In *2019 IEEE Innovative Smart Grid Technologies-Asia (ISGT Asia)* (pp. 160-164). IEEE.

[4] Li, H., Lv, C. and Zhang, Y., 2019, July. Research on new characteristics of power quality in distribution networks. In *2019 IEEE International Conference on Power, Intelligent Computing and Systems (ICPICS)* (pp. 6-10). IEEE.

[5] Shabbir, N., Kütt, L., Jarkovoi, M., Iqbal, M.N., Rassõlkin, A. and Daniel, K., 2021. An overview of measurement standards for power quality.

[6] Tavakoli, A., Saha, S., Arif, M.T., Haque, M.E., Mendis, N. and Oo, A.M., 2020. Impacts of grid integration of solar PV and electric vehicle on grid stability, power quality and energy economics: A review. *IET Energy Systems Integration*, *2*(3), pp.243-260.

[7] Hamadi, A., Alam, M.S. and Arefifar, S.A., 2021. Analyzing the Impact of Electric Vehicle Charging Stations on Power Quality in Power Distribution System. *2021 SAE Technical Paper*, (2021-01-0199).

[8] Bouzelata, Y., Kurt, E., Uzun, Y. and Chenni, R., 2018. Mitigation of high harmonicity and design of a battery charger for a new piezoelectric wind energy harvester. *Sensors and Actuators A: Physical*, *273*, pp.72-83.

[9] Suman, S., Chatterjee, D. and Mohanty, R., 2022. Development of improved harmonic compensation technique for PV-wind hybrid distributed generator connected to microgrid. *Electric Power Systems Research*, *210*, p.108071.

[10] Town, G., Taghizadeh, S. and Deilami, S., 2022. Review of Fast Charging for Electrified Transport: Demand, Technology, Systems, and Planning. *Energies*, *15*(4), p.1276.

[11] Kurt, E., Cottone, F., Uzun, Y., Orfei, F., Mattarelli, M. and Özhan, D., 2017. Design and implementation of a new contactless triple piezoelectrics wind energy harvester. *international journal of hydrogen energy*, *42*(28), pp.17813-17822.

[12] Alkahtani, A.A., Alfalahi, S.T., Athamneh, A.A., Al-Shetwi, A.Q., Mansor, M.B., Hannan, M.A. and Agelidis, V.G., 2020. Power quality in microgrids including supraharmonics: Issues, standards, and mitigations. *IEEE Access*, *8*, pp.127104-127122.

[13] Naqvi, S.A.H., 2020. *Active Power Measurement in Energy Metering* (Master's thesis).

[14] Iqbal, M.N., Measurement Based Approach for Residential Customer Stochastic Current Harmonic Modelling.

[15] Yamahata, C., Stranczl, M., Sarajlic, E., Krijnen, G.J. and Gijs, M.A., 2012. Temporally aliased video microscopy: an undersampling method for in-plane modal analysis of microelectromechanical systems. *Journal of Microelectromechanical systems*, *21*(4), pp.934-944.

[16] Lim, J., Wang, P., Shaw, S., Gong, H., Armacost, M., Liu, C., Do, A., Heydari, P. and Nenadic, Z., 2022. Artifact propagation in subdural cortical electrostimulation: Characterization and modeling. *Frontiers in neuroscience*, *16*.

[17] Wang, X.K., Hao, Z. and Tan, S.K., 2013. Vortex-induced vibrations of a neutrally buoyant circular cylinder near a plane wall. *Journal of Fluids and Structures*, *39*, pp.188-204.

[18] Mirsafian, S., 1996. *Forced vibration of two beams joined with a nonlinear rotational joint*. University of Kansas.

[19] Niu, Y., Yang, T., Yang, F., Feng, X., Zhang, P. and Li, W., 2022. Harmonic analysis in distributed power system based on IoT and dynamic compressed sensing. *Energy Reports*, *8*, pp.2363-2375.

[20] Pond, T.L. and Martin, C.R., 2020. Electrical characteristics of the oxyfuel flame while cutting steel. *Experimental Thermal and Fluid Science*, *112*, p.109985.

[21] Chen, H. and Konofagou, E.E., 2014. The size of blood–brain barrier opening induced by focused ultrasound is dictated by the acoustic pressure. *Journal of Cerebral Blood Flow & Metabolism*, *34*(7), pp.1197-1204.

[22] Wang, K.W. and Harne, R.L., 2017. *Harnessing bistable structural dynamics: for vibration control, energy harvesting and sensing*. John Wiley & Sons.

[23] Halterman, K., Valls, O.T. and Wu, C.T., 2015. Charge and spin currents in ferromagnetic Josephson junctions. *Physical Review B*, *92*(17), p.174516.