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Improvement of Power Quality in Electric Vehicle Charging

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ABSTRACT—In the present scenario, because of the growing demand for fuel and the need for eco-friendly means of trans- portation led Electric Vehicles came to light. These vehicles will eliminate pollution and help in conserving natural resources. Therefore, Electric Vehicles will give us an era with new possibili- ties. Today when the advancement of technology growing rapidly, many researchers are trying to implement hybrid technology. This will increase efficiency and gives better output. But, in order to run the Electric Vehicle efficiently there should be a systematic setup from construction to charging stations. Charging stations have to be built at regular intervals since electric vehicles have to get charged periodically. These charging points have power quality-related problems like voltage lag, harmonics, losses, noises, etc. Harmonics and noises will reduce the life of the battery and increase coat and stress to the grid. In this paper, we will see the methods to improve the power quality and also increase the life of the battery by overcoming power quality issues.

Index Terms—Electric Vehicles, Harmonics, EV chargers, Re- newable Energy.

I. INTRODUCTION

Renewable energy is power produced from renewable natu- ral resources like wind, sunlight, etc. These energy resources are plentiful and always around us. Generating renewable energy will lower pollution. The increase in energy demand and the need for eco-friendly transportation made electric vehicles more popular. It uses electricity as fuel and has no greenhouse gas emissions. Electricity can be generated from renewable sources and can store in a battery. According to the world energy council, 17 percent of greenhouse gases are emitted from traditional vehicles, and suggested replacing this with electric vehicles as it uses less fuel for their functioning, thus reducing pollution. The three categories of electric vehi- cles include battery electric vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles (PHEV). In PHEVs, an internal combustion engine is powered by gasoline and an electric motor is powered by other fuels like batteries. It can be charged by an ICE, a wall outlet, charging hardware,or regenerative braking. Until the battery is almost empty, the vehicle normally runs on electric power. At that point,it will automatically transition to using ICE. Hybrid electric vehicles have an internal combustion engine and one or more electric motors that draw power from batteries to operate. The electric motor in battery electric cars, commonly referred to as all-electric vehicles, replaces the internal combustion engine. According to the International Energy Agency, there will be more than 145 million electric vehicles on the planet by 2030. Growing EV adoption will cause a variety of issues for the electrical systems' distribution grid, including worsening line corrosion, depleting distribution transformers, and, most importantly, declining power quality (PQ). The majority of the new problems in the power grid are directly tied to the kind ofEV charger and charging technique used with EVs. Chargers must have a good level of power quality, be dependable, and be economical to use in order to satisfy the demands of EV operators. Voltage drop in the network and feeder and transformer overload are among the most crucial problems. The addition of vehicle connections to the network may also have an effect on the network's power quality.

II. ASPECTS OF POWER QUALITY

The most crucial components of power quality are active and reactive power, current, voltage values, current content, and harmonic voltage. The values of the energy must fall within the boundaries established by the standards in order to draw the conclusion that it has a good power level.

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Voltage: Voltage quality, which encompasses both steady- state changes in power quality and brief disturbances that may have an impact on loads, is the quantitative concept of power quality. Some of the categories used to rate tension include transients., flicker, harmonics and inter harmonics, temporary interruptions, voltage magnitude, unbalanced voltage, swells, dips, and power level.

Power: The power system requires both actual and reactive power for proper operation. For real power to be transmitted through the network in an AC transmission system, reactive power flow is required. The ratio between the actual power flowing to the load and the apparent power in the circuit is known as the power factor in electrical engineering, and the dimensionless value in the closed interval is -1 to 1. Thecircuit's capacity to conduct work at a specific moment is known as active power. For the same amount of transmittable power, a load with a low power factor in an electrical power system generates more current than a load with a high power factor.

Harmonics: Harmonics are the sinusoidal component of periodic waves with frequencies that are multiples of the basic power frequency. The mixing of the results of the first, second, third, and additional harmonic in harmonic power- waveform distortion. The result is voltage and current pollution on the sinusoidal waveform. Harmonics are emitted in brief pulses as nonlinear devices use currently. Harmonics in load current frequently result in overheated neutrals, blown fuses, discharged circuit breakers, and overheated transformers. The harmonic levels may reach extremely high levels, which might put additional strain on grids, depending on the charging profile or mode of one or more EV users. Inappropriate voltage variations and additional specific and harmonic power losses can result during EV charging, in addition to harmonic distortions.

Electric charging stations, parking lots, client premises, or other locations are likely to be used for EV charging. Total harmonic signal distortion, or THD, is a measurement of current harmonic signal distortion and is outlined as the power ratio between the power of the fundamental frequency and the sum of all the harmonic components. THD establishes the linearity and power effectiveness of audio systems.

Harmonic Distortion: The usage of power inverters makes harmonic distortion—recognized as the primary PQ issue—possible without the appropriate filtering technique. The likelihood of parallel and serial resonances, condenser bank and transformer overheating, neutral overcurrent, and erroneous protective system activity may all be increased by harmonic distortion.

III. NEED FOR POWER QUALITY IMPROVEMENT

Future EV expansion will have an impact on power quality, which is a major issue for grid efficiency, security, and smart grid security. Power electronic converters, which are extremely non-linear systems, are used by electric vehicle interface systems because of their mode of operation and the nature of switching power semiconductor components. As a result, the converter's input current frequently contains significant harmonics. In particular, harmonics and power factors sufferas a result of this issue in the power system. To determine whether it has a sufficient power level, the energy levels should fall within the parameters specified in the requirements. powerlevel

EV charging presents unique electricity demand concerns that need to be properly controlled. Therefore, harmonics computation and evaluation are the main problems encoun- tered when charging an electric vehicle. The calculations show that the source side is significantly disrupted by these high- power electronic loads. Voltage and current are observed in order to establish the intended control output. The harmonic disturbance graph can be used to calculate the total harmonic distortion value. The efficiency of charging electric vehicles must be improved to address these issues. This essay examines various techniques for enhancing the power quality in electric vehicles.

IV. METHODS

The proposed model in [1], Total harmonic distortion (THD), voltage profile, and other power quality metrics were used to evaluate the impact of chargers and the impact of each indicator on these metrics was identified. An IEEE 33- bus distribution sample network was optimized with the aimof functions of voltage drop and THD to reduce the effects of the chargers.

In [2], the Least Mean Square (LMS) control technique is used for compensating harmonics and disturbances caused by the non-linear loads. A power quality improvement scheme based on passive filtering is proposed to suppress harmonics and absorb reactive power in [3]. The paper [4] proposes Kalman Decoupled Harmonic Power Flow (KDHPF) tech- nique to calculate the harmonic current in the grid system. The power

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loss, error rate, and Total Harmonic Distortion (THD) is optimized by the Multiobjective Firefly Algorithm (MOFA) optimization method. Solving the problem with Transformer, Rectifier, and Boost converter in [5] When the grid is con- nected to EV charging, it creates disturbances that cause a decrease in the power factor of the grid side. To make the grid stable, a system of Inverter, Transformer, Rectifier, Boost converter, and load is proposed. The output waveform of this system is smoothened with the help of an inductor.

In [6], the proposed setup consists of a DC power, an inverter, a transformer, a rectifier, a boost converter, and a load. The DC source is used so that the proposed setup can be made compatible with renewable energy resources. In order to improve power quality and reduce current source harmonics,

[7] suggests a hybrid active power filter architecture for DC- link control utilizing particle swarm optimization (PSO). In [8], the conventional boost and buck-boost Power Factor Correction (PFC) converters are incorporated between the full bridge diode rectifier and dc-link capacitor. In [9] Power Quality problem mitigation through STATCOM is used.A Static Synchronous Compensator (STATCOM) is a quick- acting device that has the ability to supply or absorb reactive current, controlling the voltage at the point of connection to a power grid. It is implemented to assist electrical networks that frequently have poor voltage regulation and poor power factor and is a member of the FACTS family. It is connected to the utility grid through a transformer. In [10] Power Quality Enhancement using HSeAF is done. Here, a powerful Transformer-less Hybrid Series Active Filter (THSeAF), which may correct current-related problems and offers a long-lasting and trustworthy voltage supply, is utilised. The power quality of future smart homes is improved by this low-cost configu- ration option of any series transformer. Utility smart metres will be safeguarded against voltage distortions thanks to this compensator, which cleans the current drawn from the utility. It will then help to improve the accuracy of smart metering by preventing incorrect power and energy balance calculations.

In order to maintain a steady supply for the customer during spikes or dips in grid voltage, this compensator might inject or absorb active power. A quick electric vehicle charging station is essential.

V. RESULT AND DISCUSSION

The findings in [1] demonstrate that THD and voltage drop increase with increasing distance between the charging station and the main feeder. THD is also higher during off-peak hoursand lower during peak hours. Compared to peak hours, off-peak hours have less voltage decrease. Therefore, choosing the right spot to build charging stations is crucial. In [2], the total harmonic distortion (THD) of grid current and grid voltage using LMS is 3.07 % and 0.09%. Even though the load current THD is 29.49%, the THD of grid current and grid voltage lies within the IEEE standard for harmonics. In [3],the charging station and charging pile simulation model are built using MATLAB’s Simulink platform, and the harmonic current characteristics are examined by simulation, confirming the viability of the power quality enhancement plan. This plan offers a fresh concept for improving the power quality of charging stations.

In [4], the current harmonics distortion range was attained within the limit of IEEE Std.519-1992 is less than 5% of THD, and 90% of accuracy was obtained. In [5], the output waveform of this system is smoothened with the help of an inductor. This system will reduce harmonics and stress on the grid side. Hence the power factor is increased. The Transformer when placed near the station will increase losses and stress which leads to an increase in power demand. In order to increase the power demand, EV charging should have a limit per day. A waveform is obtained in [6] that is free from harmonics as output. This will help in increasing the power factor. The results of simulations in [7] demonstrate that this system is capable of reducing harmonics.

In [8], the PF is unity and the supply current THD is mea- sured as 3.3%, which is within the recommended regulations. In [9], using STATCOM with active power compulsion, it absorbs and injects the active power eliminating the negative impact of rapid changes during operation. The fluctuation in voltage and current during the performance is decreased and using it results in the smooth control of reactive power and harmonics suppression. Hence stability and power quality are improved. The source voltage waveform in [10] is non- sinusoidal, giving a fundamental value of 169.7 V before the filter connection and a THD of 25.00% as a result. After connecting the filter, the load voltage has a THD of 5.98% and a fundamental value of 169.4 V. The fundamental value practically remains unchanged with the filter applied, proving that the grid injects the basic load voltage component while the filter merely injects the harmonic component.

VI. CONCLUSION

This paper provides methods to improve power quality in electric vehicle charging. The experiment shows that in order to improve the efficiency and working conditions of EVs, it is important to eliminate power quality issues. In the above methods, power quality improvement using STATCOM is more effective. By using it with active power compulsion, it eliminates the detrimental effects of abrupt changes dur- ing operation by absorbing and injecting the active power, resulting in the smooth management of reactive power and harmonics reduction. This method to improve power quality is not expensive and allows fast current control, good accuracy,and stability to the power system.

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