# Power Quality Disturbances Diagnosis in Microgrid Integrated Electric Vehicle Charging Stations

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## Metadata

**Abstract:**
Electric Vehicle (EV) charging stations are becoming increasingly popular, and as a result, there is a growing concern about the impact they have on the power quality of the electric grid. This paper proposes a novel approach for detecting and classifying power quality disturbances caused by EV charging stations. The proposed approach is based on analyzing the voltage and current waveforms at the charging station, and then applying a voting classifier machine learning algorithm to classify the disturbance. The approach is evaluated on a dataset of power quality disturbances collected from simulations of EV charging stations. The results show that the proposed approach can accurately detect and classify a range of power quality disturbances, including voltage sags, swells, fluctuations and harmonics. The classification accuracy achieved by the proposed approach is higher than that of existing approaches, demonstrating its effectiveness in identifying power quality disturbances caused by EV charging stations. Overall, the proposed approach provides a promising solution for addressing the power quality issues arising from EV charging stations, and could be a valuable tool for utility companies and EV charging station operators in monitoring and improving the power quality of the electric grid.

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## Contents

### I. Introduction

A Microgrid is a small-scale power system that can operate independently or in conjunction with the main power grid. Microgrid are becoming increasingly popular as a reliable source of electricity for remote or isolated communities, or as a backup power source for critical facilities such as hospitals and data centres [1]. Microgrid typically rely on renewable energy sources, such as solar or wind power, and may also incorporate energy storage systems to provide a stable supply of electricity. However, Microgrid are also susceptible to power quality issues that can affect their performance and reliability. In this article, we will discuss the power quality issues in Microgrid, their causes, and possible mitigation strategies. Power quality refers to the degree to which electrical power delivered by a power system meets the requirements of the equipment that it is intended to operate. Power quality is affected by a number of factors, including voltage level, frequency, waveform shape, and the presence of harmonic distortion [2]. Poor power quality can lead to equipment failure, reduced equipment lifespan, and even safety hazards. There are several factors that can contribute to power quality issues in Microgrid. One of the primary causes is the presence of renewable energy sources, such as solar or wind power. These sources of power are inherently variable, meaning that they can fluctuate in output depending on the weather conditions or time of day [3]. This can cause voltage and frequency fluctuations that can lead to power quality issues. Another factor that can contribute to power quality issues in Microgrid is the presence of non-linear loads, such as electronic devices and LED lighting. These loads can create harmonic distortion, which can lead to voltage fluctuations and other power quality issues [4]. In addition, the size and complexity of a Microgrid can also contribute to power quality issues. Microgrid can be composed of a variety of different energy sources, such as solar panels, wind turbines, and batteries, each of which may have different characteristics and requirements. Coordinating these different sources of energy can be challenging, and may require sophisticated control systems to ensure that power quality is maintained. Voltage fluctuations occur when the voltage level of the power supply varies over time. These fluctuations could be brought on by a wide range of different circumstances, including changes in load demand or changes in the output of renewable energy sources. Voltage fluctuations can cause problems for equipment that is sensitive to changes in voltage, and can even damage equipment in extreme cases. Frequency fluctuations occur when the frequency of the power supply varies over time. These fluctuations can be caused by changes in the output of renewable energy sources or changes in load demand [5]. Frequency fluctuations can also cause problems for equipment that is sensitive to changes in frequency, and can lead to equipment failure in extreme cases. Harmonic distortion occurs when the waveform of the power supply is distorted due to the presence of non-linear loads. This can cause problems for equipment that is sensitive to harmonic distortion, and can even lead to equipment failure in extreme cases [6]. Electric vehicle (EV) charging stations can potentially contribute to power quality issues in Microgrid. The primary way in which EV charging stations can affect power quality is through their high power demand, which can create voltage and frequency fluctuations in the local grid [7]. When an electric vehicle is charged, it requires a large amount of power to be delivered to the battery in a relatively short period of time. This can cause a sudden increase in demand on the local grid, which can lead to voltage and frequency fluctuations. These fluctuations can affect the power quality in the local area, potentially causing issues for other equipment that is sensitive to changes in voltage or frequency. Another factor that can contribute to power quality issues related to EV charging stations is the location of the charging station within the Microgrid [8]. If the charging station is located far from the power source, it may require a long distribution line to deliver power to the charging station. This long distribution line can increase the impedance of the power system, leading to voltage drops and reduced power quality. Additionally, the use of fast chargers, which deliver a large amount of power to the vehicle in a very short period of time, can exacerbate the power quality issues related to EV charging stations [9]. Fast chargers require a very high power demand and can cause significant voltage and frequency fluctuations in the local grid, potentially leading to PQ issues. To mitigate the potential PQ issues related to EV charging stations, several strategies can be implemented. One strategy is to use smart charging systems, which can manage the charging of electric vehicles to reduce the peak power demand on the local grid [10]. Smart charging systems can also adjust the charging rate based on the available power supply, ensuring that the charging of electric vehicles does not exceed the capacity of the local grid. Another strategy is to use energy storage systems, such as batteries, to provide a buffer between the charging station and the local grid [11]. Energy storage systems can absorb excess power from the charging station during periods of high demand and release the power back into the grid during periods of low demand, helping to stabilize the power supply and improve power quality. The high power demand of EV charging stations can cause voltage and frequency fluctuations in the local grid, which can lead to power quality issues [12]. For example, a study by Mekhilef et al. (2013) found that the use of fast chargers for EVscan cause voltage dips and harmonic distortion in the power supply, which can affect the performance of other equipment in the Microgrid [13]. Similarly, a study by Soares et al. (2019) found that the use of EV charging stations in residential areas can cause voltage variations and unbalance in the power supply, which can lead to issues for other household appliances. [14] The location of EV charging stations within the Microgrid can also affect power quality. If the charging station is located far from the power source, it may require a long distribution line to deliver power to the charging station. This long distribution line can increase the impedance of the power system, leading to voltage drops and reduced power quality. A study by Kim et al. (2017) found that the location of EV charging stations in a distribution system can affect the power quality of the entire system, and that careful planning of the location of charging stations is necessary to avoid power quality issues [15]. Several strategies can be implemented to mitigate power quality issues related to EV charging stations. One strategy is to use smart charging systems, which can manage the charging of electric vehicles to reduce the peak power demand on the local grid. Smart charging systems can also adjust the charging rate based on the available power supply, ensuring that the charging of electric vehicles does not exceed the capacity of the local grid. A study by Wang et al. (2021) found that the use of a smart charging system for EVs in a Microgrid can reduce the peak power demand and improve power quality. Another strategy is to use energy storage systems, such as batteries, to provide a buffer between the charging station and the local grid. Energy storage systems can absorb excess power from the charging station during periods of high demand and release the power back into the grid during periods of low demand, helping to stabilize the power supply and improve power quality [16]. A study by Mou et al. (2015) found that the use of energy storage systems in conjunction with EV charging stations can improve power quality and reduce the impact of EV charging on the local grid. The deployment of EV charging stations is increasing, and this can create power quality issues in Microgrid. However, with the implementation of smart charging systems and energy storage systems, these issues can be mitigated, allowing for the efficient integration of electric vehicles into Microgrid systems [17]. In this paper, power quality disturbances due to integration of EV charging stations are mathematically modelled. A Discrete Wavelet Transform in combination with Voting Classifier is used to detect and classify PQD's occur in microgrid.

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