Chapter 7
Power Quality Disturbances in Energy Systems and Optimization Techniques

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ABSTRACT

The evolution of electrical power systems from traditional to smart requires numerous elements to be studied and adapted to the new methods. This study provides an outline of smart grid (SG) and its challenges, and PQ refers to the consistency and reliability of electrical power supply. It is a measure of how well the energy supplied to equipment meets its requirements. In this chapter, the author discussed a brief history of power quality improvement (PQI) devices as well as an introduction to the new tools, optimization techniques, difficulties of SG, and the problems associated with PQ. Human-Machine Interface (HMI) is a critical component of the SG system, and it provides a graphical representation of the grid, enabling operators to visualize the status of the grid and identify potential problems before they occur. In this chapter, PQ disturbances such as voltage sag, swell, flicker, and harmonics

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are explained with simulation results.

INTRODUCTION

Two major variables are examined when estimating PQ in electrical systems are reliability and power supply (Alshehri & Khalid, 2019). The capability to provide continuous service to customers is defined as reliability, whereas PQ issues refer to voltage fluctuations, aberrant waveforms, and harmonic distortions (Lai et al., 2022). Multiple methods exist which present distribution system reliability indices to show the dependability levels of individual customers and feeders along with system-oriented substation-linked indices (Moghaddam et al., 2020). History-based assessment combines with predictive assessment as the main strategies to evaluate distribution system dependability. The inaccessibility of system topological information, current health information of distribution components such as distribution transformers and feeders, and historical data impedes the efficient operation and maintenance of distribution systems (X. Chen et al., 2022).

The phasor measurement unit acts as a device which simultaneously measures electrical waves in the system through a synchronized time reference. Real-time data for voltage as well as current measurements alongside frequency checks and phase angle data of electrical waves is provided through these PQ network monitoring sensors. Modern systems employ phasor measurement units (PMU) as sensors for network-wide PQ monitoring which also provides autonomous adaptation in some instances. The PMU device serves as a tool to monitor electrical waves across electricity grids while it operates from a central time source. PMUs track electrical network PQ while reporting instant voltage and current measurements together with frequency and phase angle data for electrical waves. PMUs assist in fault detection as well as network stability monitoring and achieve enhanced power system reliability levels (Hoffmann et al., 2021). They are also utilized to keep track on the performance of renewable energy sources (RES) like wind and solar power facilities (Gupta & Sharma, 2018). PMUs can be installed at various grid locations to measure the voltage, current, frequency, and phase angle of electrical waves. The PMUs can then provide real-time data to a central control, where it is examined to detect any anomalies or grid disturbances, for example, if the PMUs detect a sudden reduction in voltage or frequency, it could indicate a system problem (Rihan et al., 2011). This information will then be used by the operator to swiftly find and isolate the fault, preventing it from spreading and creating a blackout similarly, if the PMUs detect a phase angle discrepancy between two grid points, it could suggest a potential stability problem. The operator can then take corrective steps to stabilize the grid and avoid future problems. The accuracy of PMUs is determined by numerous aspects,