

ANALYSIS OF DIFFERENT POWER QUALITY IMPROVEMENT TECHNIQUES IN MICROGRID

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ABSTRACT-The infinite energy supply and climate-friendliness of renewable non-traditional energy sources are further benefits. This is where distributed microgenerating units, or MicroGrids (MG), come into play. Power electronic converters connect the MGs, which are small-scale resources that produce electricity, to the main utility. The primary disadvantages of MGs are their connection to switching devices and converters, which causes power system disruptions. Due to the widespread usage of microgenerating units (MGs) in contemporary power systems, the intermittent nature of renewable energy sources, the greater penetration of nonlinear loads, and the dispersed nature of MGs, significant power quality (PQ) difficulties that are dangerous to both generation and terminate the supply. Reactive power compensation or the production of harmonics that interfere with electrical energy system regular operation might be PQ problems. These concerns need to be addressed as soon as possible in order to preserve good electrical power transmission and distribution. Utilities have implemented several lucrative programs and techniques to enhance electricity quality and result in consumer pleasure. About 350 recent review articles have been thoroughly examined in this regard, and this review article highlights a thorough discussion of the power quality issues using filters, controllers, Flexible AC Transmission Systems (FACTS), optimization techniques (OTs), and machine learning tools with modern and advanced control techniques. There is a thorough understanding of power quality and how to improve it in MG.

I. INTRODUCTION

The two ways of operation are often known as grid-connected mode (connected to the main grid) and islanded mode (supplying own loads exclusively and separated from the utility). The usage of power converters, which promote control flexibility and improve overall power system performance, is a result of the random remote position and an abundance of micro resources. However, a number of PQ obstacles are created by this power electronic interface, including the injection of harmonics and disturbances in the system. These disturbances are dangerous and can cause mal-operation of load and

source-side equipment and overheating, which must be taken care of. These disturbances are commonly termed PQ problems.

An MG system can have a number PQ problems, including harmonic distortion, voltage imbalance, voltage sag, voltage swell, voltage interruption, transient phenomena, frequency deviation, etc. For the MG system to function well and for the load side use power efficiently, these PQ difficulties need to be resolved. The PQ problem and their mitigation strategies related to current and upcoming developments are thoroughly discussed in this paper. Additionally, authors have described how a MG operates, discussing how to improve its planning and operation to extend its lifespan while taking climate concerns into account. Together with the dynamics, the MG construction and control are also discussed. The kinds, modes of operation, control, and coordination of a typical MG are summarized. The ability of the utility grid to provide customers with reliable, optimal, and continuous electricity is known as the PQ. Because it deals with DG coordination and allows power sharing based on load demand amongst DGs, MG control is crucial. The classification of MG control strategies into primary, secondary, and tertiary levels has been studied by the authors. While the tertiary level is concerned with the coordinated functioning of the MG, the primary and secondary levels deal with the MG's actual operation. Researchers with storage recommend using Distributed Energy Resources (DERs) for numerous purposes.

II. METHODOLOGY

Power quality and overview of issues –

The quality of the electrical power generated is crucial as the use of nonlinear power electronics loads has put manufacturers, consumers, and commercial and industrial utilities at risk. These days, maintaining electrical power quality under appropriate indices is a major problem. As a result, the power should guarantee that consumers have reliable, secure and continuous supply of electricity. The capacity to sustain a nearly sinusoidal voltage or current waveform with a specific rated magnitude and frequency is often how power quality is expressed. The electrical power grid system is affected by any departure from the wave-forms, which is known as a PQ problem. PQ issues may pose several problems to the power grid network, such as more losses, interference with neighbouring communication lines, maloperation of equipment, etc. Therefore, optimizing several factors such as voltage, frequency, real and reactive power imbalance, and harmonics is the primary need for ensuring the reliable operation of the MG.

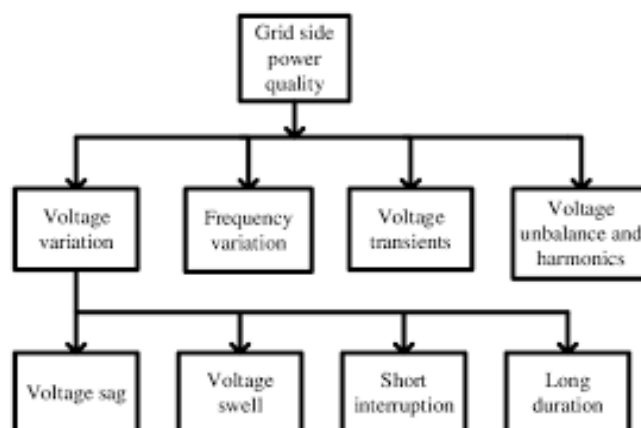


Fig. 1- Power quality and overview of issues

Integration of DERs in the form of MG plays a vital role in enhancing the overall system reliability, efficiency, and security, and meeting the requirements of the end-users. MG can supply the critical loads by either operating in islanded or grid-connected mode during the power failure from the main grids. The seamless operation of static transfer switch employed with robust controllers helps to perform the transition of one mode to another mode of operation. PQ disturbances such as

III. FILTERS

Filters play a vital role in regulating harmonics, compensating real power and neutral current, reducing voltage flickers and unbalance, balancing loads, and mitigating voltage distortions, sags, and swells. The filters can be generally categorized into three types, namely passive, active and hybrid power filters.

3.1 Passive power filters (PPFs)

The most basic type of filter is a passive filter, which is made up of passive components like capacitors and inductors that are tuned for a specific frequency or range of frequencies.

A schematic illustration of PPF. The literature reports on a variety of PPF topologies, including series, shunt, low pass, and high pass, bandpass, band rejection, LCL, and LLC. The passive filters are utilized to overpower harmonic currents and minimize bias in voltage which occurs in delicate components of the power system network. Several literatures suggest using passive filters to mitigate PQ issues in renewable energy systems such as photovoltaics (PV) and wind, electric

traction, and industrial power systems.

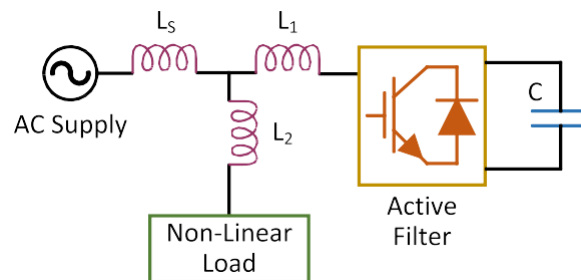


Fig. 2. Schematic structure of PPF

3.2 Active power filters (APFs)

As seen in Fig. 4, APFs are made up of passive storage components like capacitors and inductors as well as power electronics interfaces.

Due to a number of advantages, including 1) the quickest dynamic reaction, 2) smaller volume and weight, and 3) the capacity to adjust harmonics and the reactive power need of nonlinear loads, APFs are a viable substitute for traditional PPFs.

Because they inject actual power at the source frequency and the opposite phase, APFs vary from passive filters. to mitigate the harmonic components. The mitigation of harmonics with the help of an active power filter for a PV and fuel-cell-based MG system has been reported. Furthermore, the authors have discussed implementing an active power filter for current harmonics mitigation in an industrial power system. The APFs mostly find their application

in medium power applications, thus facilitating active response to voltage notch, voltage distortion, and power factor enhancement

Topologically, the active power filters are mainly of three types

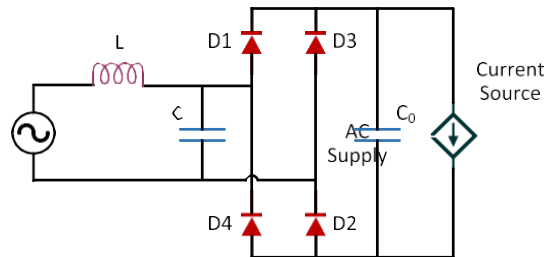


Fig.3. Schematic structure of APF.

3.3 Hybrid power filters (HPFs)

The combination of PPFs and APFs results in the HPFs, as illustrated in. They are assumed to be the best among other filters as they combine the advantages of PPFs being cost-effective and the merits of APFs for providing efficient harmonic mitigation and regulation of voltage. HPFs are reported to be available in different forms such as single-phase, three-phase three-wire, and three-phase four-wire. Further, each type mentioned earlier can be classified into active, or passive types. Many researchers have reported the implementation of HPFs along with their control methods in various fields such as PV, wind energy, electric traction, reducing inverter power rating, and frequency regulation. Further, a volume of work has been reported in the literature regarding harmonic regulation. The authors have also discussed the analysis and control of new reduced switch count HPFs for ensuring high output voltage at minimum distortions.

IV. MACHINE LEARNING TOOLS (MLTS)

Appropriate monitoring of power system dynamics is essential for introducing MLTs into the power system network in order to ensure consistent PQ. The frequency spectrum analysis approach, which is based on the capture of time-domain signals using the LabVIEW-based monitoring and analyzing tool, has been used by authors to study the fluctuations in the power system. The literature has documented a variety of harmonic analysis methods for PQ augmentation, including Artificial Neural Network (ANN), Fast Fourier Transform (FFT), and Fuzzy Logic Controller (FLC). The Phasor Measurement Unit (PMU) can identify and track PQ problems at a particular power line point.

device, which determines the phasor quantity. The phasor helps in finding the appropriate magnitude and phase angle of the supply voltage and current. Further, this information can also determine the frequency and analyze system conditions. Researchers have also discussed and implemented some applications of PMU for PQ improvement. Authors have adopted an Adaptive Linear Combiner (ADALINE) to detect PQ issues such as voltage sag, swell, transients, interruptions, etc. The main merits of this method are: 1) does not require setting up a threshold value for detecting PQ issues and 2) provides true and higher tracking ability. Kalman Filtering (KF) method is also adopted for detecting various PQ disturbances. It has proved to be a more efficient technique as the PQ issues can be identified in the wavelet domain. The application of the KF technique for PQ improvement has been thoroughly investigated in the literature. Another algorithm suggested by researchers for signal processing in both the time frequency domains is the Hilbert Transform (HT) method. This method effectively monitors primarily the voltage flicker type of PQ concerns by operating in a certain frequency range and using an analog allpass filter. The different MLTs for PQ occurrences are displayed. The main PQ problems and some potential PQ mitigation strategies are listed. An overview and evaluation of the literature on the use of machine learning and deep learning in power system control. Numerous writers have critically examined issues. Massive volumes of data pertinent to the evaluation of complex power system dynamic security concerns are analyzed, processed, predicted, and classified using machine learning approaches to uncover patterns and organize data in order to maintain dependability.

An outline of the various uses of AI-based methods in microgrids, including energy management, cyber security, protection, load and generation forecasts, and power electronics control, has been presented by the researchers. Authors have reported the application of machine learning and intelligent controllers for prediction, control, energy management, and vehicle-to-everything (V2X) in hydrogen fuel cell vehicles.

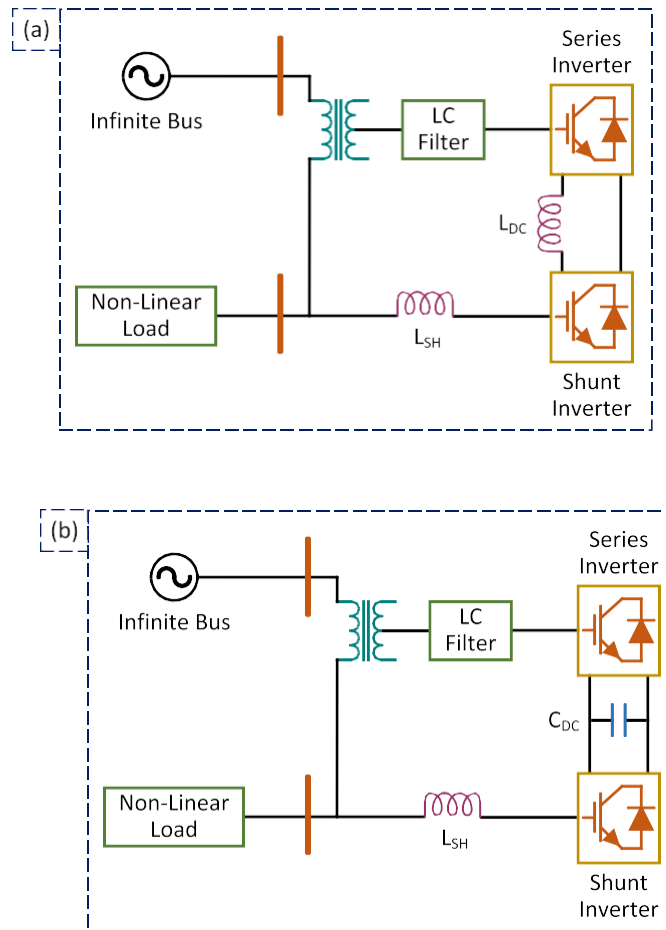


Fig. 4. (a) CSI based UPQC (b) VSI based UPQC.

VII. CONCLUSION

By combining renewable-based DERs, energy storage devices, and loads, the MG system opens the way to preserve the dependability, stability, and flexibility of the current electrical grid network. However, the caliber of power produced is negatively impacted by intermittent renewable energy generation, a high demand for nonlinear loads, and harmonic injection brought on by power electronic interfaces. Therefore, it is crucial to keep PQ regulation under control and provide compensation at all levels of authority. To improve the quality of electrical power supplied to the distribution systems, a thorough analysis of various PQ mitigation strategies, including filters, controllers, FACTS, OTs, compensators, conditioners, and machine learning tools, has been conducted. Highlighted in detail in this article. Further, deep insight into PQ and enhancement in MG have been enumerated.



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