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Power Quality Issues and Mitigation Techniques

Anjali J Nair, Srihari S, Preethi P Nair
DeptofElectricalandElectronicsEngineeeringNSSCollegeofEngineering,Palakkad,India

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ABSTRACT—Power quality refers to the level of voltage, fre- quency, and stability of an electrical power supply. Issues in power quality can cause problems for electrical equipment and negatively impact the reliability and performance of the power system. These issues can arise from a variety of sources including power outages, voltage sags, voltage spikes, and harmonic distortion. In order to mitigate the impacts of power quality issues, it is important to understand the sources and causes of these problems and to implement appropriate measures to improve the quality of the electrical supply. This may involve the use of power conditioning equipment, such as voltage regulators and filters, or changes to the power system design and operation.

Index Terms—Power Quality.

I. INTRODUCTION

Power quality refers to the suitability of an electrical power supply to meet the demands of its intended use. In recent years, the increasing reliance on electrical equipment and the use of non-linear loads has led to an increase in power quality problems. These problems can result in a variety of impacts, including equipment failure, reduced system perfor- mance, and increased energy costs. In order to ensure that electrical equipment operates effectively and efficiently, it is important to address power quality issues. This may involve the implementation of power quality improvement measures, such as the use of power conditioning equipment and changes to the power system design and operation. This paper's goal is to give an overview of power quality issues and their effects.

II. SUMMARY

In [1] Current concerns center mostly on Power Quality (PQ) issues. Electric loads have changed significantly as a result of the widespread use of electronic equipment, including energy-efficient lighting, power electronics like programmable logic controllers (PLC), adjustable speed drives (ASD), and information technology equipment. As well as being the main contributors to power quality problems, these loads also suffer the most from them. These loads' nonlinearity causes all of them to modify the voltage waveform. The various sorts of power quality issues include voltage swell, extremely brief interruptions, noise, voltage spike, voltage sag, voltage unbal- ance, voltage fluctuations, harmonic distortions, and extendedinterruptions. Voltage sag is brought on by faults in the con- sumer installation, parallel feeder faults, failures in the trans- mission or distribution network, the connection of heavy loads, and the start-up of powerful motors. Very short interruptions are mostly because protection mechanisms were automatically opened and closed to decommission a malfunctioning portion of the network, lightning, insulator flashover, and insulation failure. Long interruptions are brought on by faulty equipment in the electrical system network, storms, things (trees, cars, etc.) impacting lines or poles, fire, errors made by people, poor coordination, or faulty safety equipment. Voltage spikes occur when heavy loads are disconnected, during lightning or when line or power factor correction capacitors are switched. Voltage swell occurs due to improperly regulated transformers, poorly dimensioned power supplies and during start or stop of heavy loads. The causes of harmonic distortion are all non-linear loads, such as data processing devices, switched mode power supplies, ASDs in power electronics, and high efficiency light- ing. Also, welding equipment, DC brush motors, arc furnaces, rectifiers and electrical devices operating above magnetic saturation causes distortion. Voltage fluctuations are caused due to oscillating loads, arc furnaces, and frequent start/stop of electric motors (for example, elevators). Electromagnetic interferences caused by Hertzian waves, such as microwaves, television diffusion, radiation from welding machines, arc furnaces, electronic equipment, and improper grounding could possibly cause noise. Voltage unbalance is due to large single- phase demands (such as those from induction furnaces and traction loads) and also, the three phases of the system's three single-phase loads were not distributed properly. Transmission, distribution, and end-use equipment are three separate levels where PQ issues can be managed.

2. As nonlinear loads are used more frequently, harmonics enter the power system and cause nonsinusoidal voltages and currents. It is vital to understand these nonlinear loads' characteristics and how they impact the power system. Harmonic analysis of the steel-making power system is investigated, with the major nonlinear demand being the ac Electric Arc Furnace (EAF). The utility power network provides a 161kV direct supply to the steel mill. The steel-making and steel-rolling loads are two of the main nonlinear loads in the system under study. Three delta-wye (161kV/11.4kV) primary transformers supply 11.4kV to the plant's local power distribution system. The primary nonlinear load in the EAF branch is a 50-ton capacity ac arc furnace. In the melting stage, the THDI% (Total Harmonic Current Distortion) reaches 32.4%. As the making process enters the refining stage, the arc voltage and current stabilize, and the THDI% is reduced to 14.8%. During the striking and melting phases, the arc's random nature fluctuates a lot, and its properties are unstable. As a result, the majority of methodologies focus on the steady-state harmonic analysis of EAF (i.e., the refining step). Even for the steady- state analysis, it is obvious that the arc V-I characteristic is extremely nonlinear, and it is quite difficult to create a closed- form solution to describe such behavior.
3. Despite the rarity of severe cascading blackouts in the power transmission system, it is extremely important to recognize the risk of such events. In addition to the apparent effects of blackouts, the growing interdependencies between different infrastructure components (such as communications, financial markets, and transportation) can result in a blackout having an impact on other crucial infrastructures. Some of the mitigation measures are (i) requiring a predetermined number of transmission lines to become overloaded before any distur- bances to the lines can happen. This could signify operator activities that are effective for handling overloads in a small number of lines but less effective for handling overloads in a large number of lines. (ii) lowering the likelihood that a line may go down due to overload. This makes the transmission lines stronger. This may roughly correspond, for instance, to the effect of higher emergency ratings, which would improve the likelihood that an overloaded line will continue to operate while the operators deal with the overload. (iii) Increasing the margin of generation. This entails having more power backup throughout the network to react to changes in the demand for electricity more successfully. It stands to reason that increased generator power should lessen the likelihood of blackouts. When we implement mitigation measures that minimize the likelihood of small blackouts, we usually witness an increase in the frequency and/or size of massive blackouts. In contrast, there is an increase in the frequency of small blackouts as we attempt to remove the large ones. The quantity or distribution of blackouts is barely affected when we combine the two forms of mitigation.

III. UCAP-DVRSYSTEM

A flexible solution for PQ problems, the Dynamic Voltage Restorer (DVR) linked in series has outstanding dynamic capa-bilities. One kind of capacitor is an ultracapacitor (UCAP). To reduce voltage sag and swell, ideal properties like high power and low energy density are necessary. provides a better DVR topology in [4] that can mitigate power quality issues deeply and extensively. Because UCAP delivers a significant quantity of power in a brief length of time, it is used as energy storage in the proposed DVR. A bidirectional DC-DC converter that connects the DVR to the ultracapacitor helps present a robust dc-link voltage and compensate for transient voltage sag and swell. DVRs employ the PI Controller to enhance power quality. Figure 3 depicts the block diagram of the combined UCAP-DVR system. It consists of a bidirectional DC-DC converter, a three-phase series inverter, and a UCAP energy storage device. The sensitive load of 15 is connected to the three-phase supply voltage of 415 V, 50 Hz, through line impedance.

The grid is connected in series to the three-phase voltage source inverter, which serves as a power stage and is in charge of compensating for voltage sag and swell. To maintain rigid dc-link voltage, the energy storage device UCAP can be linked through an abi-directional DC-DC converter rather than directly to the inverter.

A.Ultra-capacitor(UCAP)

An ultracapacitor is made up of the following components: the electrode, isolation membrane, connection pole, exhaust valve, electrolyte, sealing materials, and collector. The perfor- mance of an ultracapacitor is determined by the electrode ma- terials, electrolyte composition, separation membrane quality, and manufacturing technology. UCAPs are classified into three types based on their energy storage mechanisms: double-layer capacitors, metal-oxide electrode super-capacitors, and organic polymer electrodes. Fig. 4 displays the often employed carbon electrode double-layer capacitance. A novel strategy was put out to enhance the distribution power system's voltage profile. The suggested model includes a UCAP quick energy storage system and a DVR-compatible FACTS device. Due to the fact that the UCAP cannot be directly connected to the DVR's dc-link, the design, and modeling of a bidirectional DC-DC converter were addressed.

IV. CONCLUSION

For the smooth operation of modern society, high-quality electric power must be readily available. Others are more de- manding, while certain industries are content with the caliber of power utilities provide. The most demanding customers must take steps to stop the problems in order to avoid the sig- nificant losses associated with PQ issues. Among the numerous measures, choosing less sensitive equipment can be crucial. There are a range of strategies available for improving power quality, including the use of power conditioning equipment, changes to the power system design and operation, and the implementation of best practices for power management. By addressing power quality issues, it is possible to improve the reliability and performance of electrical power systems, ensuring that electrical equipment operates effectively and efficiently. Overall, power quality is a critical consideration for the design, operation, and maintenance of electrical power systems. By prioritizing power quality and taking action to address related problems, it is possible to ensure the long- term viability and performance of these systems. The double- layer capacitor gets its name from the formation of a double layer capacitor on the surface of two layers as a result of the positive plate's attraction to electrolyte anion and the negative plate's attraction to electrolyte cation during charging. It can immediately discharge all the energy it has been holding in reserve. Short-term, high-power applications are where UCAP shines.

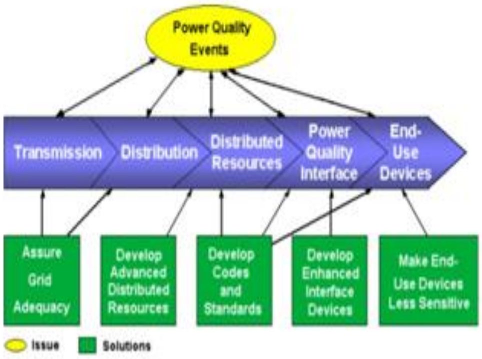

Fig.1.Solutionsfordigitalpower

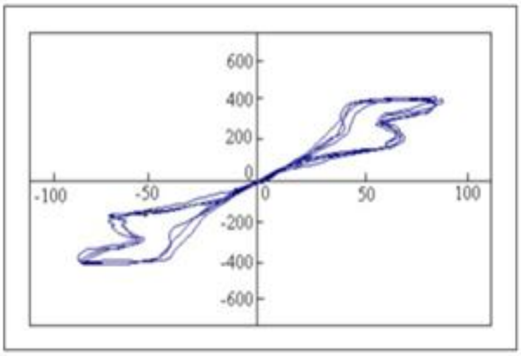

Fig.2.MeasuredV-Icharacteristicofthearc duringrefiningstage.

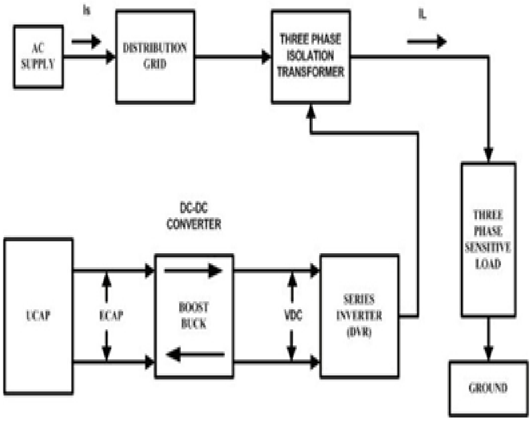

Fig.3.BlockdiagramofintegratedUCAP-DVR

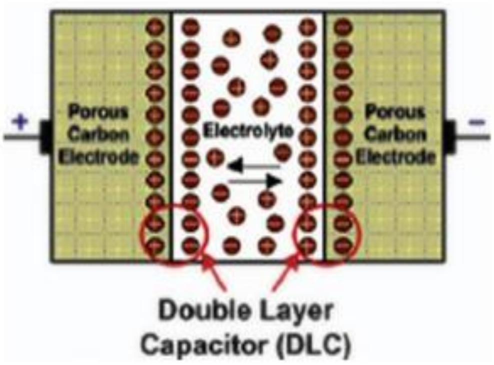

Fig.4.Ultra-capacitormodel

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