A Review on Power Quality Issues and Reactive Power Compensation System

Kumar Ravi[1], Prof. Nand Lal Shah[2]
[1]EX Department, Rabindra Nath Tagore University, Bhopal (M.P), India
[2]Assistant Professor, EX Department, Rabindra Nath Tagore University, Bhopal (M.P), India
[1]ravijeet.rit@gmail.com [2]nandlalshah0177@gmail.com

* Corresponding Author: Kumar Ravi

Abstract:- *Power quality (PQ) events associated with utility network is a topic of equal importance to both utilities and customers because it has detrimental effects on the performance of equipments on load side and power network. The disturbances like transients, sag in voltage, swell in voltage, power system impulses, power system notches, glitches, momentary interruptions (MI), wave faults, over voltages, harmonic distortion and under voltages are responsible for poor quality. This paper shows the power quality issues in power system as well as comprehensive review on power quality issues and improvement of power quality using reactive power compensation.*

Keywords:.Renewable energy system, power quality, reactive power compensation

I. Introduction

Fossil fuel-fired power stations, nuclear power plants, hydroelectricity, wind farms, etc. are examples of the traditional large-scale generating electricity at centralized facilities. The scarcity of fossil fuel, the excessive amount of emissions, and the electricity power loss caused by long transmission lines are currently causing these problems. When considering frequency and voltage, "Power Quality" relates to the electricity device's capacity to produce a perfect power supply with a pure sinusoidal wave shape devoid of noise and that is always steady. However, a sizable number of loads consistently impose disruptions on the devices that deviate from this optimum power supply.

The system would lose efficiency if the power quality were to be interrupted. Controlling the power quality typically refers to changing merely the voltage. This is due to the fact that voltage is typically easier to manage than current. More specifically, a number of factors, including systems and services, amplitude of voltage fluctuations, transitory voltages and currents, harmonics contents (for AC), etc., can be used to describe the quality of power.

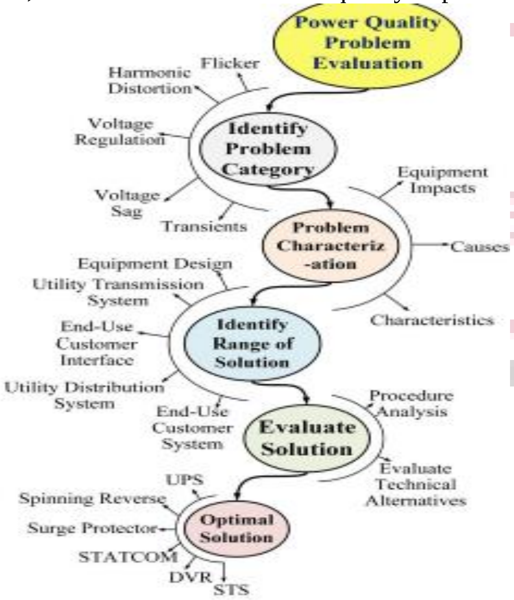

Figure 1 Flow Diagram For Evaluation of Power Quality Problems

Voltage fluctuation, which denotes variations in reference voltage, is one of the main problems with power quality. The fall in voltage level magnitude is known as "Voltage Sag." The phenomenon known as "Voltage Swell" describes a brief rise in voltage above the usual tolerances thresholds. It normally lasts little longer than a few seconds and has a duration of more than one cycle. A channel transfer burst is one that lasts just briefly. Surges and other rapid changes in condition are frequently the culprits. Voltage, current, or both may suddenly shift in the stable position.

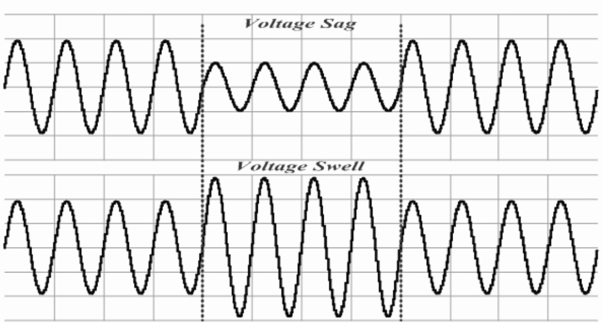

Figure 2 Voltage Sag and Voltage Swell

One of the additional services that system operators must purchase is reactive power in order to keep the voltage of the localized electricity system within the acceptable ranges to ensure the proper operating of the electrical energy equipment2. The low mobility of reactive powertrains, or VARs, can be used to explain why there is little competing in this sector. Due to the large losses in transmission network, the sources of reactive power should be located closer to the area where it is required (i.e. it should be pro- vided locally)

Var compensation is the control of reactive power with the purpose of enhancing the efficiency of ac power systems. Since most voltage stability concerns can be mitigated or resolved with an effective control of reactive power, the idea of Var compensating encompasses a broad and diversified range of both system and customer issues. Reactive power compensation is often approached from two angles: load compensation and voltage control. The goals of structural adjustment are to balance the real power drawn from the ac supply, correct for voltage control, eliminate harmonic current components caused by large and fluctuating nonlinear industry loads, and raise the power system coefficient value. In order to reduce voltage fluctuation at a specific power transmission termination, voltage support is typically needed. By raising the maximal active power that can be transferred, reactive power correction in transmission systems also increases the stability of the ac system. The performance of the high-voltage dc (HVDC) converting terminal is improved, transmitting efficiency is raised, steady-state and temporary overvoltage are controlled, and dangerous blackouts are prevented. It also contributes to maintaining a substantially flat voltage stability at all levels of power transmitting.

Shunt and series Var compensating is being used to change the ac power systems' inherent electrical properties. Shunt compensating alters the correct answer of the load, whereas series compensation affects the transmission and distribution control parameters. In both situations, it is possible to properly manage the reactive power flowing through the system, which enhances the efficiency of the entire ac power system.

II. RELATED WORK

(Das et al., 2018) [1] An overview of the best ESS placement, sizing, and use is given in this study. It takes into account a variety of network situations, intended performance goals, applicable tactics, ESS types, and the benefits and drawbacks of the suggested strategies and processes. The extensive comparison analysis of ESS technical attributes indicates that flywheel energy storage (FES) also merits considering in some distribution system situations, despite the fact that battery are frequently utilized as ESSs in a wide range of applications. This study offers suggestions for pertinent needs or practices, suitable ESS choice, intelligent ESS charging and discharging, ESS sizing, positioning and operations, and power quality problems. This paper also recommends areas for further research in regard to concerns with developing and implementing the best ESS installation plans, optimization approaches, societal impacts, & energy security.

(Gandoman et al., 2018) [2] The emergence of distributed and renewable energy sources in the previous two decades has presented new problems for utilities in terms of power quality, voltage stabilisation, and effective energy use. Power electronics are widely used to connect new energy systems, including smart buildings and power sources with less or no power storage, to transmission and distribution systems. In order to improve energy quality, flexible ac transmission systems (FACTSs) and voltage-source converters with intelligent dynamic controllers are becoming more and more common. Additionally, distributed FACTSs are crucial for optimizing power quality, maximizing energy efficiency, and assuring effective energy management in smart metering using renewable sources of energy. This essay provides a review of the literature on FACTS technologies devices and techniques for power quality and effective use of renewable energy sources.

(Hossain, Tur, et al., 2018)[3] This paper conducts a thorough investigation of the quality of the electricity in energy systems, including DC and renewable energy systems. Technologies for monitoring voltage stability and potential fixes for problems with power quality for energy systems are thoroughly investigated. Then we examine how to use specialized power electronic devices for micro grid systems, such as D-STATCOM, UPQC, UPS, TVSS, DVR, etc., to mitigate these issues. Due to its many benefits, STATCOM may be an option for renewable energy systems, whilst spinning reserve may improve the quality of the electricity in conventional systems. Finally, we research the DC devices' power quality. The two main benefits of DC systems are their easier setup and improved reliability, but they also have additional power quality problems, like instability and subpar fault detection.

(Sinsel et al., 2020) [4] This report gives a thorough review of the issues facing the electricity system and the technology being used to address them. The challenge-solution interaction matrix created in this study offers the following crucial insights: First, the ability of various solution technology to address certain problems varies greatly. Therefore, in addition to concentrating on cost-effective options, the solutions potential of various technologies might aid in prioritizing solutions technology. Second, it is possible to pinpoint groupings of technology-based solutions that can lessen particular issue groups. The classification devised in this research improves transparency of the intricate process of renewable energy integration and aids in better defining the necessity for particular solution technology.

(Nadeem et al., 2019)[5] There are various storage systems kinds, each with a range of prices, features, and potential uses. For the design of power technologies in the future, whether it is for long-term generation plans or short-term transitory operations, it is essential to comprehend these. Modern storage systems and their properties, as well as cutting-edge research prototypes, are comprehensively covered in this work. Potential application domains are selected based on their designs, capacity, and operational features. Finally, research areas concerning energy storage devices are examined together with their implications for the development of power systems.

(Águila Téllez et al., 2018) [6]This study shows that reactive current compensation in distribution network with distributed resources is an issue that needs to be analyzed from multicriteria that take into account multiple objective functions to be optimized; this leads to a comprehensive solution that considers an optimal placement and dimensioning of reactive current getting compensated aspects that contribute to the joint improved performance of the voltage stability, minimization of power losses, harmonic mitigation, and other factors. A theoretical heuristic that is based on the multiple criteria optimization method is also suggested as a solution to the described issue.

(Gayatri et al., 2018)[7] In light of this, the purpose of this work is to provide an overview of a microgrid and its modeling using real data from the environment. The difficulties and power quality issues that the microgrid faces are then noted, followed by a study of approaches for making up for these flaws utilizing different control techniques, algorithms, and devices.

K.L. Anaya and M.G. Pollitt et al. [8] This essay examines the practice of competitively procuring reactive power and other electrical ancillary services on a global scale. According to our research, there is very little competition in the reactive power market compared to other additional services (such frequency regulation and capacity reserves) and the energy market. Voltage stability difficulties are given rise to by the system operator's use of more market-oriented processes and resources (such distributed energy resources) for procuring reactive and active power services. Power Potential offers the chance to test the technical and business solution, as well as the new roles and interaction needed to launch a competing reactive power marketplace.

(Anaya & Pollitt, 2020)[9] This two-part review article evaluates the effects of high PV penetration on the entire power grid as well as potential mitigation measures. The second of the two papers focuses on the different mitigation strategies that have been suggested in the literature, including precise forecasting, frequency and voltage regulatory oversight techniques, harmonic compensation techniques, reactive power managerial staff, generator planning and dispatch strategies, and adaptive protection devices, which are required to address and mitigate the grid impacts brought on by high PV penetration. This article also highlights the barriers to executing these remedy measures and their cost bearer.

(Sampath Kumar et al., 2020)[10] The key to achieving increased DG utilization is the providing of grid support roles and ancillary services, such as reactive current regulation, fault ride-through, and harmonics compensating. These features are included in the latest generation of smart inverters, which may help to lower energy costs and the demand for additional operating system. The goal of this document is to provide a summary of the electrical power systems support services of improving low-voltage network performance

(Review et al., 2018)[11] This paper aims to provide current knowledge on optimal reactive power dispatch (ORPD), ORPD including FACTS, mathematical models of ORPD issues with appropriate constraint, mathematical models of FACTS in ORPD, and applications of ORPD. To enable researchers in the energy/power sector and conduct additional study, a development of computational tool based on differential derivatives has also been provided for performance improvement of conventional swarms approaches.

(Muhammad et al., 2020)[12] The stabilization methods may be broadly categorized into three groups, according to the findings of this study: a) compensating performed at the feeder side; b) compensation performed by adding intermediate circuitry; and c) compensation performed at the load side. Finally, various infographics are shown to emphasize the main conclusions of this study after examining the benefits and downsides of each generic technique.

(Hossain, Perez, et al., 2018)[13] The proposed three-level APF is practical to use, relatively less expensive, and shrinks the filter size. The designed system exhibits good performance in regulating voltages and significantly lowering harmonics, from 26.3 percent to 4.0 percent, according to both the modeling and experimental results.

(Kashif et al., 2018)[14] This article seeks to distinguish between various electrical machines typically used in WECS while highlighting their advantages and disadvantages. An extensive analysis of wind turbine typologies, WECS kinds according to operating speed, electrical generation, and turbine blade size is offered. Depending on the size of the equipment, a controlling oversight Plans for DFIG are also shown. stabilization difficulties and network problems issues, their causes, repercussions, and suggested solutions the dynamics of machines are highlighted.

(Bhutto et al., 2019)[15] In this investigation, a constantly loaded power system underwent the best active and reactive power correction. battery energy storage system is used (BESS). To accomplish this, a voltage stability assessment model that depicts the real and reactive power flow along the transmission system was embraced. In order to provide individual control of both the active and reactive injections to the network, the BESS is viewed as a mix of storage units and voltages sources converters (VSC).

(Adewuyi et al., 2019)[16] For electric energy storage systems (EESS), such as superconducting magnetic energy storage (SMES) and supercapacitor power storage, this work provides a generalised interconnectivity and dampening assignments passivity-based control (IDA-PBC) (SCES). In order to connect SCES and SMES devices to the power system network, current source converters (PWM-CSC) are employed systems, correspondingly.

(Montoya et al., 2018)[17] Decentralized sources of energy have replaced centralised ones in the power system reform process of recent decades. This phenomenon led to the development of Distributed Generating, an unique idea in electrical power systems, particularly in distribution networks (DG). Using DG is, on the one hand, important for securing energy production and cutting down on power losses. In this regard, this study offers a thorough analysis of several sorts of DG and looks into the brand-new problems brought on by its existence in electrical grids.

(Razavi et al., 2019)[18]A brief overview of voltage source converter (VSC) topologies and their working principles for energy applications, such as high voltage, is presented in this study.There are several possibilities for various energy sources because each converters topologies and controller mechanism choice is intimately tied to each individual application. Depending on their own unique technical requirements, applications criteria like dynamic performance, stability of the system, and total amount spent.

(Khazaei et al., 2018)[19] In recent years, connecting High Voltage Direct Current (HVDC) power transmission to a frail AC grid has proven to be difficult. This paper's primary goal is to present a thorough analysis of "converter control" strategies for two different types of HVDC systems: (1) those based on Line Commutated Converters (LCC) and (2) those based on Forced Commutated Converters in Weak AC Grids. For each HVDC technologies (forced commutated and line commutated), the control architecture is provided. The stability restrictions connected to HVDC systems—including LCC-HVDC, HVDC based on voltage source converters (VSC) and HVDC based on the current source converters (CSC)—are elaborated.

(Alenius et al., 2020)[20] The approach for real-time compensating of undesired reactive power is proposed in the current study, which separates the reactive power from the active power of a pv inverters. Using real-time grid impedance monitoring, the unintentional reactive. In the inverters, power is estimated and automatically compensated. The technique eliminates the varying reaction while allowing unfettered controller of the reactive current components. Unlike customary. The suggested approach does not necessitate any prior understanding of grid impedance values or fine adjustment. The even when the traditional system is calibrated to perfection, the method outperforms traditional electricity provides several tools a grid having a known inductance. Three-phase pho- simulations and tests are used to validate the approach a photovoltaic inverter linked to a shoddy network.

IV. Conclusion

As power system have a negative impact on the functionality of equipment on the load side and the power network, power quality (PQ) events connected to utility networks are an issue of similar significance to utilities and customers. Poor quality is caused by disturbances such as transients, voltage sags, swells, power system impulses, notches, glitches, momentary interruptions (MI), wave faults, overvoltages, harmonic distortion, and undervoltages. This paper demonstrates power system power quality problems, provides an in-depth analysis of power system power quality problems, and discusses how to use reactive power compensation to enhance power system power quality.

References

[1] Das, C. K., Bass, O., Kothapalli, G., Mahmoud, T. S., &Habibi, D. (2018). Overview of energy storage systems in distribution networks: Placement, sizing, operation, and power quality. Renewable and Sustainable Energy Reviews, 91(November 2016), 1205–1230. https://doi.org/10.1016/j.rser.2018.03.068

[2] Gandoman, F. H., Ahmadi, A., Sharaf, A. M., Siano, P., Pou, J., Hredzak, B., &Agelidis, V. G. (2018). Review of FACTS technologies and applications for power quality in smart grids with renewable energy systems. Renewable and Sustainable Energy Reviews, 82(August 2016), 502–514. https://doi.org/10.1016/j.rser.2017.09.062

[3] Hossain, E., Tur, M. R., Padmanaban, S., Ay, S., & Khan, I. (2018). Analysis and Mitigation of Power Quality Issues in Distributed Generation Systems Using Custom Power Devices. IEEE Access, 6(c), 16816–16833. https://doi.org/10.1109/ACCESS.2018.2814981

[4] Sinsel, S. R., Riemke, R. L., & Hoffmann, V. H. (2020). Challenges and solution technologies for the integration of variable renewable energy sources—a review. Renewable Energy, 145, 2271–2285. https://doi.org/10.1016/j.renene.2019.06.147

[5] Nadeem, F., Hussain, S. M. S., Tiwari, P. K., Goswami, A. K., &Ustun, T. S. (2019). Comparative review of energy storage systems, their roles, and impacts on future power systems. IEEE Access, 7(c), 4555–4585. https://doi.org/10.1109/ACCESS.2018.2888497

[6] ÁguilaTéllez, A., López, G., Isaac, I., & González, J. W. (2018). Optimal reactive power compensation in electrical distribution systems with distributed resources. Review. Heliyon, 4(8). https://doi.org/10.1016/j.heliyon.2018.e00746

[7] Gayatri, M. T. L., Parimi, A. M., & Kumar, A. V. P. (2018). A review of reactive power compensation techniques in microgrids. Renewable and Sustainable Energy Reviews, 81(June 2017), 1030–1036. https://doi.org/10.1016/j.rser.2017.08.006

[8] Anaya, K. L., & Pollitt, M. G. (2020). Reactive power procurement: A review of current trends. Applied Energy, 270(July 2019), 114939. https://doi.org/10.1016/j.apenergy.2020.114939

[9] Sampath Kumar, D., Gandhi, O., Rodríguez-Gallegos, C. D., & Srinivasan, D. (2020). Review of power system impacts at high PV penetration Part II: Potential solutions and the way forward. Solar Energy, 210(February), 202–221. https://doi.org/10.1016/j.solener.2020.08.047

[10] Review, S. I. A., Zhao, X., Chang, L., Shao, R., & Spence, K. (2018). Power System Support Functions Provided by. 3(1), 25–35.

[11] Muhammad, Y., Khan, R., Raja, M. A. Z., Ullah, F., Chaudhary, N. I., & He, Y. (2020). Solution of optimal reactive power dispatch with FACTS devices: A survey. Energy Reports, 6, 2211–2229. https://doi.org/10.1016/j.egyr.2020.07.030

[12] Hossain, E., Perez, R., Nasiri, A., &Padmanaban, S. (2018). A Comprehensive Review on Constant Power Loads Compensation Techniques. IEEE Access, 6(c), 33285–33305. https://doi.org/10.1109/ACCESS.2018.2849065

[13] Kashif, M., Hossain, M. J., Zhuo, F., &Gautam, S. (2018). Design and implementation of a three-level active power filter for harmonic and reactive power compensation. Electric Power Systems Research, 165(July), 144–156. https://doi.org/10.1016/j.epsr.2018.09.011

[14] Bhutto, D. K., Ahmed Ansari, J., Hussain Bukhari, S. S., & Akhtar Chachar, F. (2019). Wind energy conversion systems (WECS) Generators: A review. 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies, ICoMET 2019, 1–6. https://doi.org/10.1109/ICOMET.2019.8673429

[15] Adewuyi, O. B., Shigenobu, R., Ooya, K., Senjyu, T., &Howlader, A. M. (2019). Static voltage stability improvement with battery energy storage considering optimal control of active and reactive power injection. Electric Power Systems Research, 172(February), 303–312. https://doi.org/10.1016/j.epsr.2019.04.004

[16] Montoya, O. D., Garcés, A., & Espinosa-Pérez, G. (2018). A generalized passivity-based control approach for power compensation in distribution systems using electrical energy storage systems. Journal of Energy Storage, 16, 259–268. https://doi.org/10.1016/j.est.2018.01.018

[17] Razavi, S. E., Rahimi, E., Javadi, M. S., Nezhad, A. E., Lotfi, M., Shafie-khah, M., &Catalão, J. P. S. (2019). Impact of distributed generation on protection and voltage regulation of distribution systems: A review. Renewable and Sustainable Energy Reviews, 105(January), 157–167. https://doi.org/10.1016/j.rser.2019.01.050

[18] Jing, T., &Maklakov, A. S. (2018). A Review of Voltage Source Converters for Energy Applications. 2018 International Ural Conference on Green Energy (UralCon), 275–281.

[19] Khazaei, J., Idowu, P., Asrari, A., Shafaye, A. B., &Piyasinghe, L. (2018). Review of HVDC control in weak AC grids. Electric Power Systems Research, 162(February), 194–206. https://doi.org/10.1016/j.epsr.2018.05.022

[20] Alenius, H., Luhtala, R., Messo, T., &Roinila, T. (2020). Autonomous reactive power support for smart photovoltaic inverter based on real-time grid-impedance measurements of a weak grid. Electric Power Systems Research, 182(January), 106207. https://doi.org/10.1016/j.epsr.2020.106207