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Challenges and Mitigation Strategies for Power Quality in the Indian Transmission Network

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ABSTRACT

PQ is an important for ideal transmission system. reliability and continuously of electricity supply is the most important for consumer satisfaction also the activities of industrial and service companies in this paper the main power quality (PQ) problems are presented with their associated causes and consequences. The economic impact associated with PQ are characterized. Also, this paper tries to give the solution for reducing the losses produced because of harmonics and increasing the quality of power at consumers' side. this paper reviewed the power quality problems, effect of power quality problems and methods to improve the power quality problems
Keyword: - Power quality problem. voltage sag, harmonic, interruption Standards Harmonics, Supercapacitors. Mitigation techniques, DSTATCOM

1. INTRODUCTION

In modern power system there is need of power is increasing due to increasing power demand of consumer Power systems, there is increase demand so we need to increase generation of power but there is problem of quality .consumer need reliable power with uninterrupted power supply at smooth sinusoidal voltage However, in practice, power systems, especially the distribution systems, have numerous nonlinear loads, affect the quality of power supplies and the stability of system is lost .The consumption of electrical energy is increasing day by day in different applications i.e. heating, cooling, illumination, various kinds of machines and semiconductor devices. The timing, duration, magnitude and switching phenomenon of the equipment's are governed by the consumer. Therefore, the power quality is not consistent all the time. A good power quality refers to constant voltage and frequency within the prescribed range during all operations [1-3] Apart from nonlinear loads, some system events, both usual capacitor switching, motor starting Faults could also inflict power quality (PQ) problems As the power quality problem majorly occur in distribution system e.g., Voltage sags and harmonics.swell,fluctuation transient, unbalance,intruptionetc Nowadays, reliability and quality of electric power is one of the most discuss topics in power industry. There are numerous types of Quality issues and problems and each of them might have varying and diverse causes. The types of Power Quality problems that a customer may encounter classified depending on how the voltage waveform is being distorted. There are transients, short duration variations (sags, swells and interruption), long duration variations (sustained interruptions, under voltages, over voltages), voltage imbalance, waveform distortion (dc offset, harmonics, inter harmonics, notching, and noise), voltage fluctuations and power frequency variations. Among them, three Power Quality problems have been identified to be of major concern to the customers are voltage sags, harmonics and transients. This paper is focusing on these major issues. Poor quality of electrical power causes additional power losses, reduced power system efficiency and economy. Therefore, estimation of these power quality parameters is very important to lower the adverse effects on power system. However, some techniques are desired to overcome these impacts which causes due to power quality issues. STATCOM (Static Compensator), DVR (Dynamic Voltage Restorer), DSTATCOM (Distribution Static Compensator), UPS (Uninterrupted Power Supply), UPQC (Unified Power Quality Conditioner), SVC (Static VAR Compensator), TVSS (Transient Voltage Surge Suppressor) and Filters are used to improve the power quality of power system [07-10].

2. POWER QUALITY

A power quality audit can uncover hidden problems like voltage sags, harmonics, and transients that might not be immediately apparent but can still cause damage to equipment or disrupt operations. By addressing power quality issues, businesses can improve the overall reliability and efficiency of their electrical systems, reducing downtime.

2.1 Reduces equipment failure and maintenance costs

Identifying and mitigating power quality problems can help prevent equipment damage, extend the lifespan of components, and minimize maintenance expenses.

2.2 Optimizes energy consumption and reduces costs

Power quality audits can help identify areas where energy consumption can be reduced, leading to cost savings and improved energy efficiency.

2.3 Power Quality Standards

Power quality is a worldwide issue, and keeping related standards current is a never-ending task Most of the ongoing work by the IEEE in harmonic standards development has shifted to modifying Standard 519-1992.The quality of electricity has become a strategic issue for electricity companies, the operating, maintenance and management personnel of service sector and industrial sites, as well as for equipment manufacturers, for the following main reasons: a. The economic necessity for businesses to increase their competitiveness b. The wide spread use of equipment which is sensitive to voltage disturbance and/or generates disturbance itself. IEEE 519 IEEE 519-1992, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, established limits on harmonic currents and voltages at the point of common coupling (PCC), or point of metering [13]. The limits of IEEE 519 are intended to: 1) Assure that the electric utility can deliver relatively clean power to all of its customers; 2) Assure that the electric utility can protect its electrical equipment from overheating, loss of life from excessive harmonic currents, and excessive voltage stress due to excessive harmonic voltage. Each point from IEEE 519 lists the limits for harmonic distortion at the point of common coupling (PCC) or metering point with the utility. The voltage distortion limits are 3% for individual harmonics and 5%THD. All of the harmonic limits in IEEE 519 are based on a customer load mix and location on the power system. The limits are not applied to particular equipmentB.IEC 61000-3-2 and IEC 61000-3-4 (formerly 1000-3-2 and 1000-3-4) specifies limits for harmonic current emissions applicable to electrical and electronic equipment having an input current up to and including 16 A per phase.

2.4 Power Quality Problems & Issues

Power Quality problems are related to grounding, Various power quality problems, causes and their effects There are several effect power quality problems due to which an electrical machinery fail or not operate safely and also effect on sensitive equipment. There are some problems discuss below Voltage Sag: Sag is defined as the variation of RMS voltage from its normal value for a time greater than 0.5 cycles of the power frequency. Short duration variation is caused by fault conditions; short duration under-voltages are called “Voltage Sags” or “Voltage Dips [IEC]”. Voltage sag is a reduction in the supply voltage magnitude followed by a voltage recovery after a short period of time. The major cause of voltage dips on a supply system is a fault on the system, i.e. sufficiently remote electrically that a voltage interruption does not occur. Other sources are the starting of large loads and, occasionally, the supply of large inductive loads [6]. The impact on consumers may range from the annoying to the serious tripping of sensitive loads and stalling of motors. It is a sudden reduction in the magnitude (rms value) of bus voltage below 0.9 piu. of nominal voltage for significant duration from a half Cycle of a power frequency to one minute, it is mainly due to sudden switching caused by temporary disconnection. Voltage surges/spikes are the opposite of dips – a rise that may be nearly instantaneous (spike) or takes place over a longer duration (surge). A voltage surge takes place when the voltage is 110% or more above normal. The most common cause is heavy electrical equipment being turned off. Under these conditions, computer systems and other high-tech equipment can experience flickering lights, equipment shut down, errors, Possible Solutions are surge suppressors, voltage regulators, uninterruptible power supplies

3. POWER QUALITY MITIGATION TECHNIQUES

Poor power quality creates numerous adverse effects on power system such as flicker, reduction in overall useful life of equipment due to overheating, damage to different sensitive electronic instruments, loss of production etc. Therefore, these power quality issues need to be reduced/eliminate by using some technique

3.1 Isolation Transformers

Isolation transformers are used to isolate sensitive loads from transients and noise deriving from the mains. In some cases, isolation transformers keep harmonic currents generated by loads from getting upstream the transformer. The particularity of isolation transformers is that any noise or transient that come from the source in transmitted through the capacitance between the primary and the shield and on to the ground and does not reach the load.

3.1 Constant Voltage Transformers (CVT)

CVT were one of the first PQ solutions used to mitigate the effects of voltage sags and transients. To maintain the voltage constant, they use two principles that are normally avoided: resonance and core saturation. If not properly used, a CVT will originate more PQ problems than the ones mitigated. It can produce transients, harmonics (voltage wave clipped on the top and sides) and it is inefficient (about 80% at full load)

4. CONCLUSIONS

The Power quality is important in all the area the solutions to problems, equipment, regulations. Due to rising non-linear load harmonic problems are increased. This paper IS GIVES INFORMATION TO understand the power quality. research to find an efficient answer to the power quality problems. So, this paper has a good future scope and will help research workers, users and suppliers of electrical power to gain a guideline about the power quality The corrective measures are also discussed which can be remedy for power quality problems generated in different equipment's. harmonic standards are also considered in this paper. As conclusion, these Power Quality issues are unwanted phenomenon which are unavoidable but can be reduced using all techniques, but not limited to the techniques that have been discussed. There is no one mitigation technique that will suitable with every application, and whilst the power supply utilities strive to supply improved Power Quality. It means, Power Quality problem cannot be eliminated but we can reduce and try to avoid this problem form occur. The best way to avoid Power Quality problem is by ensuring that all equipment to be installed in the industrial plants are compatible with Power Quality in the power system. This can be achieved by procuring equipment with proper technical specifications that incorporate Power Quality performance of its operating electrical environment.

5. REFERENCES

[1] M. Srivastava, S. K. Goyal, A. Saraswat and G. Gangil, "Simulation Models for Different Power System Faults," 2020 IEEE International Conference on Advances and Developments in Electrical and Electronics Engineering (ICADEE), 2020, pp. 1-6.
[2] Sheesh Ram Ola, Amit Saraswat, Sunil Kumar Goyal, S. K. Jhajharia, Baseem Khan, Om Prakash Mahela, Hassan Haes Alhelou, and Pierluigi Siano", A protection scheme for a power system with solar energy penetration, Applied Sciences, vol. 10, No. 4, pp. 1-22, 1516, 2020.
[3] M. H. Bollen, "Understanding power quality problems," IEEE Piscataway, vol. 3, pp. 1–35, 2013
[4] Arul A. An Analysis of Opportunities and Barriers of Integrating Renewable Energy with Smart Grid Technologies in India; 2015
[4] C. E. Lin, T. C. Chen, and C. L. Huang, "A real time calculation method for optimal reactive power compensator," IEEE Trans. Power Syst., vol. 4, pp. 643-652, May 1989
[5] J. H. Choi, G. W. Park, and S. B. Dewan, "Standby power supply with active power filter ability using digital controller," in APEC'95, 1995, pp. 783-789
[6] Sheesh Ram Ola, Amit Saraswat, Sunil Kumar Goyal, S. K. Jhajharia, Bhuvnesh Rathore and Om Prakash Mahela, "Wigner distribution function and alienation coefficient-based transmission line protection scheme", IET Generation Transmission and Distribution, vol. 14, No. 10, pp. 1842-1853, 2020.
[7] S. K. Goyal, J. Singh, A. Saraswat, N. Kanwar, M. Shrivastava and O. P. Mahela, "Economic Load Dispatch with Emission and Line Constraints using Biogeography Based Optimization Technique," 2020 International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2020, pp. 471-476.
[8] M. T. Tsai and C. H. Liu, "Design and implementation of a cost-effective quasi line-interactive UPS with novel topology," IEEE Transactions on Power Electronics, vol. 18, pp. 1002- 1011, 2003.
[9] M. O. Durham, K. D. Durham, and R. A. Durham, "TVSS designs," IEEE Industry Applications Magazine, vol. 8, pp. 31-36, 2002.
[10] S. Gupta, R. Garg, and A. Singh, "Grid integrated PMSG based wind energy system: modelling, control and simulation," in Power Electronics, Intelligent Control and Energy Systems

[11] J. S. Subjak Jr. and J. S. Mcquilkin, "Harmonics causes, effects, measurements, analysis: An update," IEEE Trans. Ind. Applicat., 1034-1042, Nov./Dec. 1990.
[12] J. C. Wu and H. L. Jou, "A new UPS scheme provides harmonic suppression, input power factor correction," IEEE Trans. Ind. Electron., vol. 42, pp. 629-635, Dec. 1995.
[13] Bhim Singh, Kamal Al-Haddad, Ambrish Chandra" A Review of Active Filters for Power Quality Improvement" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 46, NO. 5, OCTOBER 1999.
[14] J. C. Wu and H. L. Jou, "A new UPS scheme provides harmonic suppression, input power factor correction," IEEE Trans. Ind. Electron., vol. 42, pp. 629-635, Dec. 1995.