JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 7, ISSUE 12, 2020

AN OVERVIEW OF POWER QUALITY ISSUES, MITIGATION TECHNIQUES, STANDARDS, CHALLENGES AND SOFTWARE TOOLS IN ELECTRICAL POWER SYSTEM

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Received: 14 March 2020 Revised and Accepted: 8 July 2020

ABSTRACT- The power quality issues are major causes of economic of our nation. The electrical energy utilized by the end users to become comfort, reduction in losses and affordable cost. This paper investigate with various power quality problems and solving this problem using different mitigation techniques in electrical power system .The main intention of power system to provide the good quality of power supply to the consumers. The power quality issues brought down the reliability and losses in the power networks. This paper significantly reviewed to solve the power quality problems and get better the power system and utilities.

KEYWORDS: Power Quality, Mitigation Techniques, IEEE-Standards, Measuring Devices, Electrical Software Tools

I. INTRODUCTION

In today's scenario the usage of power is more precious to the consumer's satisfaction. Due to power quality issues to create more complexity and losses in the electrical equipments. It is leads to lagging in power factor in industry loads. The problems related to each and every utility of distorted output. Many researchers to find the solution to overcome by power quality issues in electrical network. Recent powers electronics devices are used to regulates and reduce the switching losses, malfunction of operator, voltage imbalance, sudden increase load and harmonics. The classification of power quality issues and improvement techniques isfocused this paper. The IEEE standard term of power quality defines the energy entering to the sensitive equipment meet out different type's loads.Any power quality problem which is distortion of voltage, current or frequency.[1,2] The issue of faults is categorized instability of power supply, natural effects and losses in the power lines. However the stability of the system may concern to reduce the voltage regulation and efficiency. The Central and state government to take necessary steps tominimize the power quality issues to implement the non-conventional energy sources, distributed generation in compensating devices which helps to development of economy growth across the world.

The power quality engineers to educate the end users to usage of power in efficient manner.[9] The improvement of measuring devices is able to regulate the parameters of the system. The evaluation of these equipments is highly standard and tested by reputed centers.[3] Due to high penetration of the system induces more harmonics are generated. It is challenge to regulate this problem using effective techniques are involve to reduce distortion of the system. Normally, the interruption produces by primary sources of the power system. Some of affected sources are listed below.[4]

a) Staring of large rating of motors.
b) Sudden switching of (On/Off)loads
c) Types of non-linear loads
d) Furnace of arc, welding and Lathe works
e) Electromagnetic interference with cables
f) Energy dissipated in huge of capacitor banks.
g) Equipments of Information technology centers.
h) Mostly used power electronic devices

ISSN- 2394-5125 VOL 7, ISSUE 12, 2020

i) Environmental impacts

In world across mostly seventy percentage of globalenergy produced based on demand by fossil fuels. It is delivering more air pollution, emissions and global warming of consequences. So, all the countries take necessary action to reduce the above factors to promote the renewable energy integration in generation and distribution networks. The DG system strictly the regulations to operate the system with efficient and reliable in the networks. It is enhance the power quality problem with include some advanced power electronics based equipments.[6,7]

II. CLASSIFICATION OF POWER QUALITY INDICES

Power quality is very sensitive in power producers and users. The major impact of diversetype of loads such as linear and non-linear operation. The majorityof frequent power quality problems classified in terms of definition, various effects and control actions described in table.1 [8]

Table1. Power quality indices and parameters

S.no	Power quality indices	Narrative	Impact	Control Action
1.	Voltage dip (or) sag	Decreasing of nominal voltage rangebetween 10 to 90% with the time duration of 0.5cycle to 1 minute.	Feeder faults, operate large rating of motors and connecting of heavy loads	Information about malfunction operation,PLC based control system and tripping of relays.
2.	Voltage swell	Increasing of nominal voltage range between 110 to 180% with the time duration of 0.5 cycle to few seconds.	Due to sudden start/stop of heavy loads and regulated transformers.	Flickering in lights and damage of sensitive equipments.
3.	Voltage spike	Quickdeviation of nominal values of voltage in the order several μs to ms	Detachment of heavy loads,lightening and switching	Failures of insulation , electromagnetic interference
4.	Voltage flicker	Distortion of voltage variations in the range of 90 to 110%.	Switching of pulsating load and arc furnaces	Lack of luminous, human visual problem.
5.	Voltage unbalance	In three phase system all phases of the magnitudes and phase angles are unequal.	Traction loads, Induction furnace and not equal of single phase load distribution.	Negative phase sequence faults.
6.	Under-voltage	Decreasing nominal voltage value in order to recovery of this value to take long period of time.	Wrong operation of tapping transformers	Malfunction of voltage transformers
7.	Over-voltage	Increasing nominal voltage value in more than 110% within a 1 minute.	Switching off larger loads.	Inadequate of controlling voltage.
8.	Interruptions	Destruction of electrical supplies which classified in short term interruption duration of few milli seconds to 1 second. Long term interruption duration of > 2 seconds	Insulation flashover, lightning and striking of poles	Tripping of protection devices, malfunction
9.	Frequency variation	The frequency variations within the permissible limits of ± 0.5HZ.	Generator fails, High demand and , decrease in turbine speed	Governor control, and secondary control
10.	Harmonic distortion	Non- sinusoidal waves of voltage or currents distortion due to high value of	Failure of governor operation, lathe works and arc furnaces.	Tripping of thermal protection, on-linear loads and electromagnetic

		frequencies.		interference

III. CLASSIFICATION OF POWER QUALITY MITIGATION TECHNIQUES

The power quality indices lead to losses of industries and utilities. In order to enhance the power quality improvement vital role for correct these issues. So, every power sector to identify the problem and apply the suitable technique to degrade of issues. The issues are not fully eliminated, but control withinthe prescribed limits. Some of most common and currenttrends of mitigation techniques followed by control actionslisted inTable.2[5,9]

Table.2 PQ related Mitigation Techniques

S.no	Mitigation Techniques	Control action
1.	CPS: Constant power supply The supplying of power constantly generated, transmitted and distributed to requirement of loads.	More reliable of the network. Minimize the losses in power network..
2.	Modern Power electronic devices: Implement these devices prevents the supply to sensitive equipments. Improve the power factor of the load.	Maintain the constant voltage in terms of sag, swell and over voltages.
3.	UPS: Uninterruptible e power supply UPS is major roles to continuous power supply to the load even the outages. The Supplies power from batteries ,capacitors and super conducting coils	Mainly used for long interruption, sag, swell and flickering of supply.
4.	DVR:Dynamic voltage restorer Ability to control both real and reactive power in AC.Protect all type sources from the equipments.	Protect against Frequency variation, voltage sag and swell.
5.	Filters: It is mainly used for detect the undesirable voltage values and frequencies. Two types of filter namely active and passive filters.	Combination of both capacitor and inductor to eliminate high harmonic frequency ,noise and distortion of ac signals.
6.	Transformers: Transfer the electrical power from source to load. The types are star to star ,delat to delta and zig-zag	Isolate the transformer under fault conditions. Reduce the harmonics from the load.
7.	SVC: Static var compensator The combination of capacitors and reactors which minimize the reactive power injection in the transmission lines. Two parts of SVC namely TSR-Thyristor switched reactor TSC-Thyristor switched capacitor.	Regulates the voltage flickering through heavy loads, Improve voltage regulation and efficiency of the transmission lines.
8.	UPFC-Unified Power Flow Controller Used for real time control in AC transmission system. The new power electronic FACTS device helps to progress the power flow in the transmission lines.	Regulate the 3-phase transmission line parameters of voltage, impedance and phase angle.
9.	Energy storage devices: New power electronic technology is known as energy storage .Which is stored the energy in short period of time .The power delivered in disturbance of the system get restoration. The most popular devices are flywheels, super capacitors, battery storage systems (BES),capacitive energy storage system(CES) and super conducting magnetic storage system(SMES).	Regulated power in short period of time, Voltage sags and maintain the grid frequency.
10.	Soft computing techniques: In recent days used to optimize the power quality problems are solved by this AI concepts. Automatically adjust the parameters to enhancement of improve the power quality to the equipments, manufacture's and customers.	Regulated the power, voltage profile, frequency and harmonic distortion in generation, transmission and distribution networks.
11.	Renewable energy system: Spinning reserves capability in the power generating stations to mitigate the power quality issues. Also to	Control the active and reactive power in thenetwork.

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	improve the reliability in transmission lines.	Typically used in distributed generation and smart grids.

IV. POWER QUALITY PARAMETERS AND MEASUREMENT DEVICES

The term of measurement is to improved performance of power quality in commercial, industrial customers. The Analysis Mitigation of power quality parameters and measurement devices described in table3 .The power quality measurement is best practice to identify suitable application of the specific and standard instrumentation .The power engineer have adequate skills to operate these devices. [11,12]

Table.3 Power quality parameters and Measurement devices

S.no	Parameters	Measurement of parameter	Measurement devices
1.	Sag and Swell	Voltage magnitudes	Dynamic Voltage Restorer (DVR), Uninterruptable power supply (UPS),Static compensator(STATCOM) and Fly wheels etc.,
2.	Under Voltage and Over Voltage	RMS value	STACTCOM and Tap setting of Transformer and Static var compensator(SVC) [13]
3.	Voltage Interruption	Duration	UPS, Energy storage systems.
4.	Voltage Flicker	Interruptions	DVR and STACTCOM [14]
5.	Frequency	Power frequency	Power quality analyzer, Transient disturbance analyzer
5.	Harmonics	Interharmonics,Total harmonics distortion(THD)	Shunt Filter, Series Filter, Hybrid Filter and resonance filter and Harmonic analyzer[15]

V. INTERNATIONAL STANDARDS AND REGULATIONS

Owing to Effective implementation of parameters are crucial role of power producers and users. The development of quality of power depends upon some important standards recommended by every country. The following international standards and recommendations are presented in table.5[16]

Table.4International standards and regulations

S.no	Regulation Authorities	Recommendation and practices
1.	CERC- Central Electricity Regulatory Authority(2010)	Standardize the types of power quality parameter of operating voltages
2.	IEEE- Institute of Electricals and Electronics Engineers(519-2014)	Guidance given by design of system with non-linear loads under transients conditions.
3.	IEC- International Electro technical Commission	Reviews on permissible limits of voltage sag and harmonics
4.	CEER- Council of European Energy Regulators	Analysis of quality of power supply across 27 member countries in European Union
5.	CEA- Central Electricity Authority(2013)	Limit the harmonics in distributed generation.

VI. MAJOR CHALLENGES OF MITIGATION OF POWER QUALITY PROBLEMS

a) Motivate and create the awareness of consumers by public and private power agencies to use more number of energy efficient devices sequentially to control and develop the custom of energies.[17]
b) New technology design of SMES which incorporates to diminish the values of sag and swell also to increase the power quality in distribution networks..
c) One of the cost effective device namely, DVR is used to protect all types voltage imbalanced problems.
d) Integration of smart grid technologies is recent and future of mitigation of power quality issues.
e) The quality of parameters is regulated by the independent of agencies and implements PQ standards.
f) Reliability indices of SAIDI, SAIFI, MAIFI etc .,evaluate in standard levels.[18]
g) Regulatory commission should care take of all the power quality monitoring, controlling and management aspects.
h) Artificial intelligence techniques need to optimal the location of device and reduce the error with respective time duration.

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i) Consider cost effective methods to achieve the superior performance of power quality issue .The power factor correction method are play in a vital role for economic aspects.
j) Design a model with based on typical data and verifies in digital control terminologies.
k) Responsibility of power sectors are maintain good quality of power supplied to customers with specific standards and recommendations followed to the power quality parameters.

VII. SOLUTIONS TO POWER QUALITY PROBLEMS

In this section described in solutions to solve the issues of power quality in most concern. Before operation of power system to ensure all parameters in the system are nominal. The performance of the power system maintained by the following factors are given below [19,20]

a) More adequacy of the grid control
b) Reliability of the power network.
c) Properly designing of load requirement and supply system'
d) Constant voltage transformers, Voltage compensators, UPS, Surge arresters and using thyristor based switches.
e) Incorporation of non-conventional energy using DG's[21]
f) Energy restoring technologies, Batteries, Super capacitors, Flywheels and SMES etc.,
g) FACTS devices
h) Hybrid active and passive filters.
i) Ensure the power system stability and reliability in nature.
j) Identify the primary sources of the power quality issues.
k) Necessary action to take preventive control of the particular problem.
l) Evaluate the receiving supply of the equipment and effect of disturbances.
m) Determine the need for mitigation of equipments.
n) Install the power quality monitoring device where ever required

VIII. ELECTRICAL SOFTWARE TOOLS

Owing to power system is more complex and equating more number of dynamics. The evaluation of electrical parameters doing in manual is impossible. Electrical software's helps more important tasks to dealing of larger network. This software tools are widely used for designing the model, evaluation of fault analysis, testing methods and numerical data simulation the power system model. [22]The development of software packages give in more real time applications of stability and reliability in power system.Basically, this software tools are classified in two types are listed below in the table.[23]

Table.5 Software Package tools

S.no	Commercial software package tools	Research or educational software package tools
1.	MATLAB/ SIMULINK	MATPOWER (Open source tool)
2.	Power world (Canada)	SPS (Sim power systems)
3.	CYME (USA) –Power engineering solutions	PSAP (Power system analysis program)
4.	ETAP (Electrical power system analysis tool)	PSAT-Power flow analysis and short circuit tools[25]
5.	PSS/E (Transmission planning tool)	VST(Voltage stability toolbox)
6.	PSCAD (Power system computer aided design)	PAT(Power system analysis toolbox)
7.	SPARD (Power graphic energy computer systems)	CDT(Control design toolbox)
8.	NEPLAN (Power system optimize solution tools)	EST(Educational simulation tool)
9.	ERACS (Power system analysis) [24]	TSAT(Transient security assessment tool)

IX.CONCLUSION

The need of power day by day increasing and supplying quality of power sis foremost factor in energy industries.In most of the researchers to come across the solution of power quality problems alone. Here, thiscontext of paperpresented effectively in various power quality issues and mitigation techniques, important power quality parameters and measurement of devices, international standards , solutions and the challenges and opportunities of the power quality problems for end user applications. The new technology concept is compensate the power and protect the devices qualitatively and quantitatively of the electrical power system using different software package tools was given .This paper more helpful for beginners of researcher's easy way to understand the concepts of power quality.

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