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POWER QUALITY IMPROVEMENT IN WIND SMART GRID ENERGY SYSTEM WITH CUSTOM DEVICE

Mrs.Lubna Ismatulla Shaikh[1], Dr. Chandrashekhar Thorat[2]
[1]*Department of Electrical Engineering, Govt. Polytechinc, Jalna (MS) India*
[2]*Govt. Polytechnic, Nagpur (MS), India*
[1]*lubnashaikh97@rediffmail.com)*
[2]*csthorat@yahoo.com*

Abstract: *Renewable energy sources, which are expected to be a promising alternative energy source, can bring new challenges when connected to the power grid. However, the generated power from renewable energy source is always fluctuating due to environmental conditions. In the same way, wind power injection into an electric grid affects the power quality due to the fluctuation nature of the wind. On the basis of measurements and norms followed according to the guidelines specified in IEC-61400 (International Electro technical Commission) standard, the performance of the wind turbine and thereby power quality is determined. The problem arising out of the wind turbine when connected to a grid system concerning the power quality measurements are active power, reactive power, voltage sag, voltage swell, flicker, harmonics, and electrical behaviour of switching operation. These are measured according to national / international guidelines. This paper presents the existence of power quality problem and their impacts , due to installation of wind turbines with wind smart grid energy system and improvisation of power quality with custom device*.

Keywords: *Custom Power Devices, Power Quality, Wind Smart Grid, Renewable Energy Source*

1. INTRODUCTION

One of the main responsibilities of a utility system is to supply electric power in the form of sinusoidal and currents with appropriate magnitudes and frequency for the customers at the points of common coupling (PCC). Although the generated voltage of synchronous machines in power plants are almost sinusoidal, some unsighted conditions such as lightning and short circuit faults and non linear loads cause steady state error or transient voltages and current disturbances. For instance, electric arc furnaces cause voltage fluctuations, power electronic converters generate current harmonics and distort voltage waveforms, and short circuits faults result in voltage sags and swells [1-4]. On the other hand most customer loads such as computers, microcontrollers and hospital equipment are sensitive and unprotected to power quality disturbances and their proper operation depends on the quality of the voltage that is supplied to them.

As a result of this Custom power devices are introduced to electrical system to improve the power quality of the electrical power. With the help of these devices we are capable to reduce the problems related to power quality. There are many types of Custom Power devices. Some of these devices include Active Power Filters (APF), Surge Arresters (SA). Battery Energy Storage Systems (BESS), Super conducting Magnetic Energy Systems (SMES), Static Electronic Tap Changers (SETC), Solid State Fault Current Limiter (SSFCL), Solid-State Transfer Switches (SSTS), Static VAR Compensator (SVC), Distribution Series Capacitors (DSC), Dynamic Voltage Restorer (DVR), Distribution Static synchronous Compensators (DSTATCOM) and Uninterruptible Power Supplies (UPS) , Unified power quality conditioner (UPQC). But in this paper the main focus is kept only on DSTATCOM, DVR and UPQC.

2. CLASSIFICATION OF POWER QUALITY PROBLEMS AND THEIR IMPACTS

The power quality is badly disturbed due to the extensively use of nonlinear and dynamic loads and various faults in power system. Moreover, the controlling equipment and electronic devices based on computer technology demand higher levels of power quality. This type of devices are sensitive to small changes of power quality, a short time change on PQ can cause great economical losses. Because of the two reasons mentioned above, no matter for the power business, equipment manufacturers or for electric power customers, power quality problems had become an issue of increasing interest. This paper takes into account the most common power quality problems like Voltage sag, Voltage swells and Current harmonic distortion.

3. VOLTAGE SAG

Voltage sags are generally related with system faults but can also be caused by energization of heavy loads or starting of large motors and overloaded wiring. The term sag describes as voltage decrease. Voltage sag problems in industrial equipment include relays opening due to the dip affecting the relay's coil voltage, under voltage sensors on the AC mains operating unnecessarily, circuit breakers or fuses operating, either due to the increase in current on non-dipped phases or due to a large increase in current immediately after the dip or a small section of highly-sensitive electronics that responds incorrectly to the sag.

4. VOLTAGE SWELLS

The voltage swells are usually associated with system fault conditions, but they are not as common as voltage sags. One way that a swell can occur is from the temporary voltage rise on the un faulted phases during a single line to ground fault .Swells can also be caused by switching off a large load or energizing a large capacitor bank, insulation breakdown, sudden load reduction and open neutral connection. Voltage swells can negatively affect the performance of sensitive electronic equipment, cause data errors, produce equipment shutdowns, may cause equipment damage and reduce equipment life. It causes nuisance tripping and degradation of electrical contacts.

5. CURRENT HARMONIC DISTORTION:

The harmonic voltage and current distortion are strongly linked with each other because harmonic voltage distortion is mainly due to non-sinusoidal load currents. Current harmonic distortion requires over-rating of series components like transformers and cables. As the series resistance increases with frequency, a distorted current will cause more losses than a sinusoidal current of the same rms value. Types of equipment that generate current harmonics are single-phase loads, switched mode power supplies, electronic fluorescent lighting ballasts, small Uninterruptible Power Supply (UPS) units and variable speed drives . The problems caused by current harmonics are overloading of neutrals, overheating of transformers, nuisance tripping of circuit breakers, over-stressing of power factor correction capacitors and skin effect. Harmonic distortion levels can be described by the calculating total harmonic distortion (THD) which measures the complete harmonic spectrum with magnitudes and phase angles of each individual harmonic component.

6. CUSTOM POWER DEVICES

6.1 D-STATCOM

The purpose of the DSTATCOM is to cancel load harmonics fed to the supply. It work as current source, connected in parallel with the nonlinear load, generating the harmonic currents the load requires also balance them in addition to providing reactive power[5]. In order to compensate undesirable components of the load current D-STATCOM injects currents into the point of common coupling. With an appropriated control strategy, it is also possible to correct power factor and unbalanced loads.

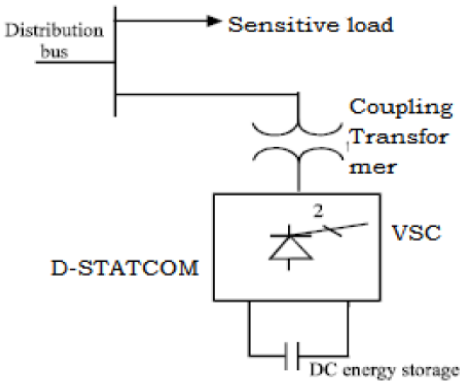

Fig. 1 D-STATCOM Block Diagram

6.2 DVR

DVR injects a voltage component in series with the supply voltage , thus compensating voltage sags and swells on the load side. Control response is of the order of 3msec, ensuring a secure voltage supply under transient network conditions. Voltage injection of arbitrary phase with respect to the load current implies active power transfer capability. This active power is transferred via the dc link, and is supplied either by a diode bridge connected to the ac network, a shunt connected PWM converter or by an energy storage device. It works as a harmonic isolator to prevent the harmonics in the source voltage reaching the load in addition to balancing the voltages and providing voltage regulation.

6.3 UPQC

The best protection for sensitive loads from sources with inadequate quality, is shunt series connection i.e. unified power quality conditioner (UPQC) .Recent research efforts have been made towards utilizing unified power quality conditioner (UPQC) to solve almost all power quality problems for example voltage sag, voltage swell, voltage outage and over correction of power factor and unacceptable levels of harmonics in the current and voltage The basic configuration of UPQC is shown in Figure . The main purpose of a UPQC is to compensate for supply voltage flicker/imbalance, reactive power, negative-sequence current, and harmonics . In other words, the UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. The UPQC, therefore, is expected as one of the most powerful solutions to large capacity sensitive loads to voltage flicker/imbalance.

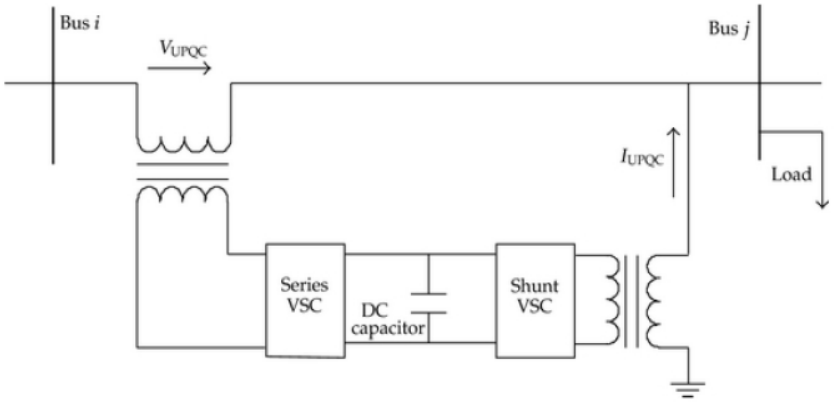

Fig. 2 Block Diagram of UPQC showing Bus i and Bus j

7. CONCLUSION

The paper analyses the factors responsible for power quality problems in the wind energy conversion system connected to grid and proper control schemes for power quality improvement. The paper has presented a technological review on the custom devices namely DVR, D-Statcom and UPQC used for power quality improvement , especially during the integration of non-conventional sources of energy such as wind into the grid network.. The paper concludes with outlining the basic roles of Custom devices in power system operation for power quality improvement.

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