A Study of Power Quality Problems and its Mitigation

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Abstract: ***The electrical energy is one of the easily used forms of energy. It can be easily converted to other forms of energy. With the advancement of technology, the dependency on the electrical energy has been increased greatly. Computer and telecommunication networks, railway network banking, post office, life support system are few application that just cannot function without electricity. At the same time these applications demand qualitative energy. However, the quality of power supplied is affected by various internal and external factors of the power system. The presence of harmonics, voltage and frequency variations deteriorate the performance of the system. In this paper the frequently occurring power quality problem- voltage variation is discussed. The voltage sag/dip is the most frequently occurring problem. There are many methods to overcome this problem. Among them the use of FACT devices is an efficient one.***

Keywords: Power quality, FACTS devices, Sag ,Swell

1. Introduction

Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality and continuity of the electric power supplied is also very important for the efficient functioning of the end user equipment. Most of the commercial and industrial loads demand high quality uninterrupted power. Thus maintaining the qualitative power is of utmost important. Studies of power quality phenomena have emerged as a main subject in recent years due to renewed interest in improving the excellence of the generation of power. As sensitive electronic equipment continues to proliferate, the studies of power quality have been further emphasized [1].

There are two main ways for improving power quality:

- The cost-free improving power quality.
- Not cost-free improving power quality.

The cost-free means for improving power quality Include actions like:

- Using of tap changing transformers.
- Operation of conventional compensating devices for example capacitor bank.
- Control by FACTS devices.

To overcome the problem related to the power quality custom power device is introduced. A number of power quality problem solutions are provide by custom devices. At present, a wide range of flexible AC controller which is capitalized on newly available power electronic components is emerging for custom power application. The well known FACTS devices are namely SVC, STATCOM, TCSC, SSSC and UPFC.

Figure.1 Overview of Major FACTS Devices

The D-STATCOM is one of the most effective devices. The D-STATCOM has additional capability to sustain reactive current at low voltage, and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage. To enhance the power quality such as voltage sags/swell, harmonic distortion and low power factor in distribution system. In this paper DSTATCOM are briefly

described and analyze various facts devices for overcome power quality problems.

2. Power Quality

The quality of electric power delivered is characterized by two factors namely-"continuity" of supply and the "quality" of voltage. As indicated by IEEE standard 1100,Power Quality is characterized as-

"The idea of controlling and establishing the touchy supplies in a manner that is suitable for the operation of the gear."

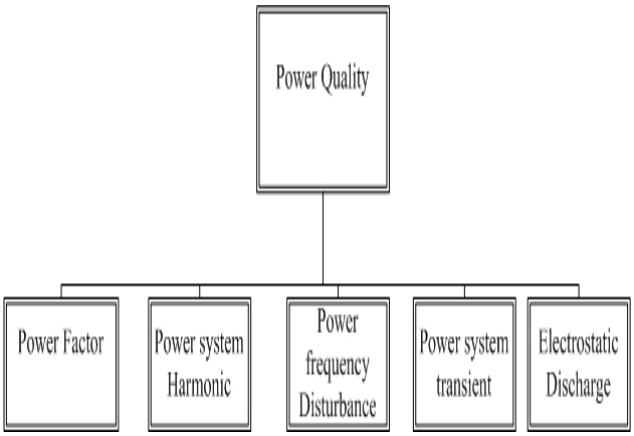

Figure 2: Power quality concern

3. Power Quality Problems

There are many reasons by which the power quality is affected. The occurrence of such problems in the power system network is almost indispensable. Therefore, to maintain the quality of power care must be taken that suitable devices are kept in operation to prevent the consequences of these problems. Here an overview of different power quality problems.

3.1 Very short interruption: Total interruption of electrical supply for duration from few milliseconds to one or two seconds.

3.2 Long interruption: Total interruption of electrical supply for duration greater than 1 to 2 seconds.

3.3 Voltage spike: Very fast variation of the voltage value for durations from a several microseconds to few milliseconds.

3.4. **Harmonic distortion:** Voltage or current waveforms assume non-sinusoidal shape. The waveform corresponds to the sum of different sine-waves with different magnitude and phase, having frequencies that are multiples of power-system frequency.

3.5 Voltage fluctuation: Oscillation of voltage value, amplitude modulated by a signal with frequency of 0 to 30 Hz.

3.6 Noise: Superimposing of high frequency signals on the waveform of the power-system frequency.

3.7 Voltage swell: Momentary increase of the voltage, at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds.

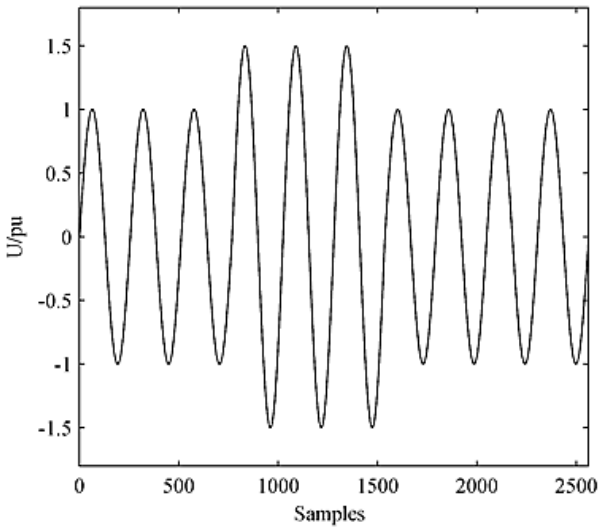

Figure 3: Voltage swell

3.8Voltage sag (or dip): A decrease of the normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for durations of 0,5 cycle to 1 minute.

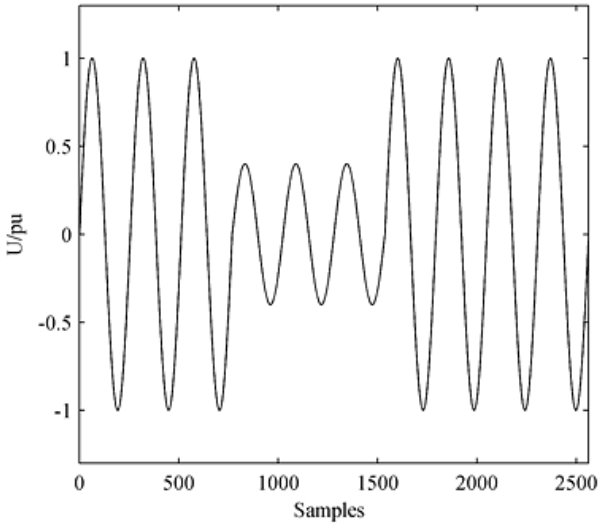

Figure 4: Voltage sag

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4. Solutions for PQ Problems

The mitigation of PQ problems may take place at different levels: transmission, distribution and the end use equipment. As seen in Fig. 5

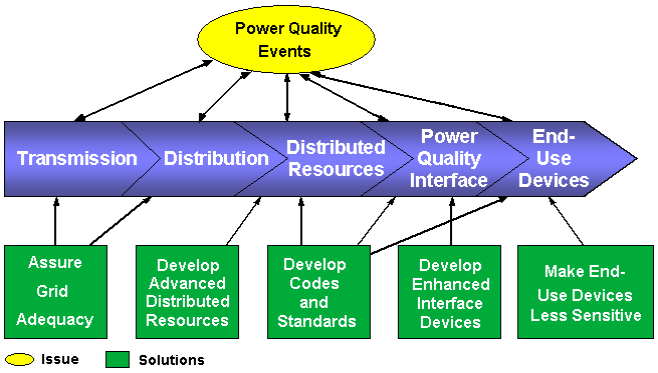

Fig.5 Power Quality Events

Flexible AC Transmission System (FACTS) controllers, based on the rapid development of power electronics technology, have been proposed in recent years for better utilization of existing transmission facilities. With the development of FACTS technique, it becomes possible to increase the power flow controllability and enhance power system's stability. In this paper describe various FACTS devices.

A. **Static VAr Compensator (SVC)**: A shunt-connected static var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage). This is a general term for a Thyristor Controlled Reactor (TCR) or Thyristor Switched Reactor (TSR) and/or Thyristor Switched Capacitor (TSC) (Fig. 6).

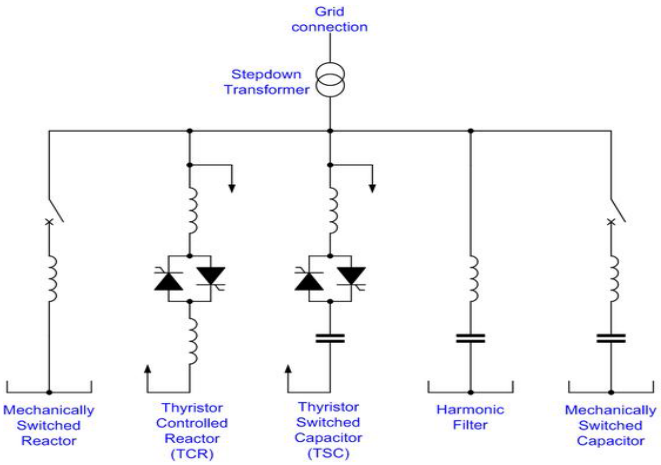

Figure 6 :SVC Devices

B. **Static Synchronous Compensator(STATCOM)**:

A Static synchronous generator operates as a shunt-connected static var compensator whose capacitive or inductive output current can be controlled independent of the ac system voltage. The STATCOM is the static counterpart of the rotating synchronous condenser but it generates/absorbs reactive power at a faster rate because no moving parts are involved.

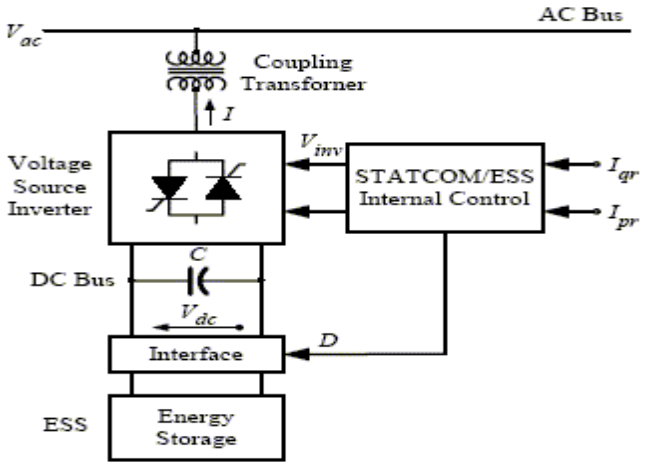

Figure 7 : Static Synchronous Compensator

C. **Thyristor Controlled Series Capacitor (TCSC)**
TCSC is series type compensator, used to increase power transfer as well as to enhance system stability. TCSC controllers use TCR in parallel with segments of series capacitor bank. The combination of TCR and capacitor allow the capacitive reactance to be smoothly controlled over a wide range and switched upon command to a condition where the bi-directional thyristor pairs conduct continuously and insert appropriate reactance into the line. The basic structure of the device is shown in Fig. 8

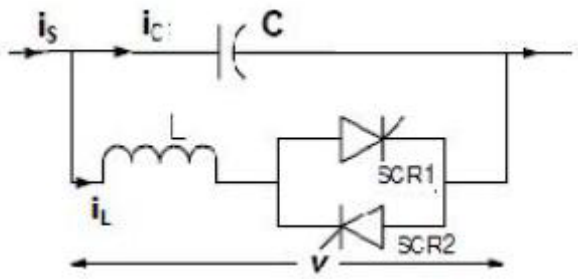

Figure 8 :TCSC

D. **UPFC:** The unified power flow controller is a typical facts device that is the most sophisticated and complex power electronic equipment. The UPFC consists of two voltage source converter, which are connected to each other with a common dc link. Series converter or static synchronous series compensator (SSSC) is used to add controlled voltage magnitude and phase angle in series with the line, while shunt converter or static synchronous compensator is used to provide reactive power to the ac system beside that, it will provide the power required for both inverter.

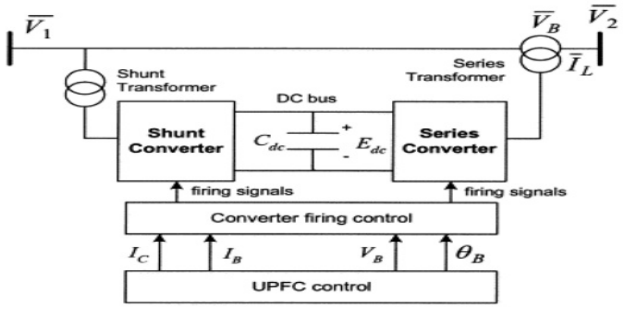

Figure 9 :UPFC

E. Static Synchronous Series Compensator (SSSC): SSSC is connected in series with a power system. It has a voltage source converter serially connected to a transmission line through a transformer. It can be considered as asynchronous voltage source as it can inject an almost sinusoidal voltage of variable and controllable amplitude and phase angle, in series with a transmission line. The injected voltage is almost in quadrature with the line current. A small part of the injectedvoltage that is in phase with the line current provides the losses in the inverter. Most of the injected voltage, which is in quadrature with the line current, provides the effect of inserting an inductive or capacitive reactance in series with the transmission line. The variable reactance influences the electric power flow in the transmission line. The basic configuration of a SSSC is shown in Fig.10

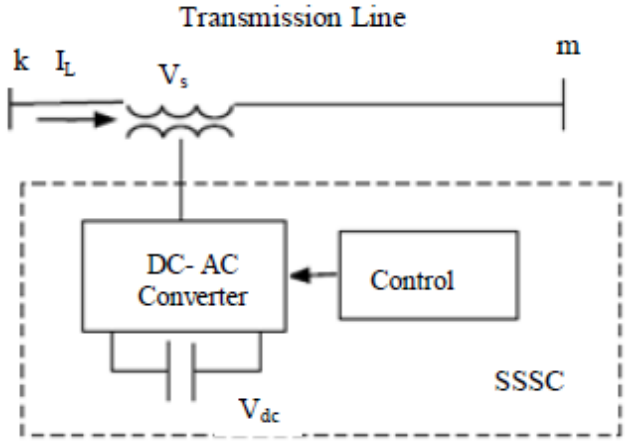

Figure 10 :SSSC

F. DVR: Dynamic voltage restorer is a static var device that has applications in a variety of transmission and distribution systems. It is a series compensation device, which protects sensitive electric load from power quality problems such as voltage sags, swells, unbalance and distortion through power electronic controllers that use voltage source converters (VSC)

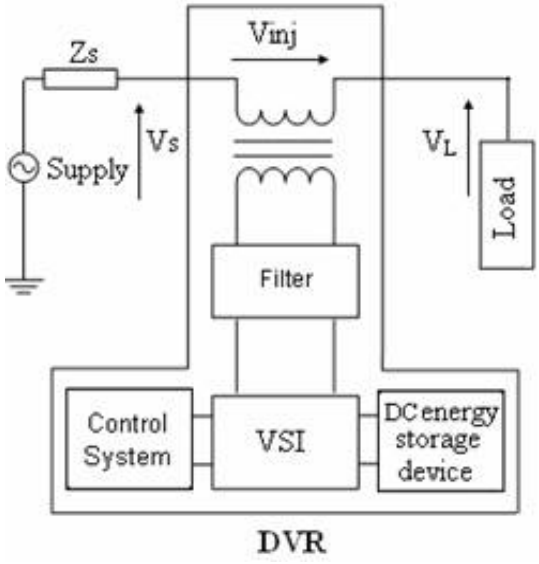

Figure 11:DVR

G.Distribution Statcom

A D-STATCOM, which is schematically depicted in Fig.11, consists of a two level voltage source converter (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. Such configuration allows the device to absorb or generate controllable active and reactive power. The Distribution STATCOM (D-STATCOM) has been utilized mainly for regulation of voltage, correction of power factor and elimination of current harmonics. Such a device is employed to provide continuous voltage regulation using an indirectly controlled converter.

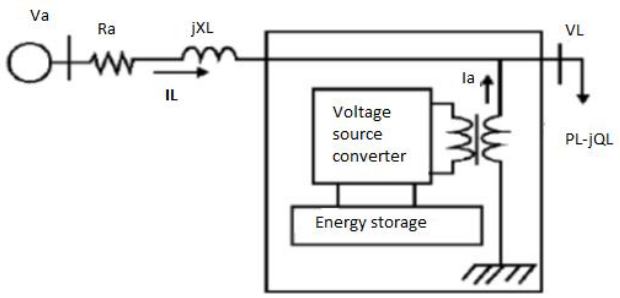

Figure 12 : Dstatcom

5. Conclusion

In this study various technique of power quality improvement are viewed and finally came into conclusion with two method i. e. Dstatcom and fuzzy controller.

References

[1] Sannino,Global power systems for sustainable development, ▪ in IEEE General Meeting, Denver, CO, Jun. 2004

[2.] Aamir Hanif and Mohammad Ahmad Choudhry[2008] Department of Electrical Engineering University of Engineering and Technology Taxila47050 Pakistan Investigating Voltage Restoration And Power Export In A Distribution System With Series Compensator Using Distributed Generation.

[3.] S.M Halpin, L.L.Grigsby the Electric Power Engineering Handbook, CRC

[4.] Eduardo F. Camacho, Tariq Samad, Mario Garcia-Sanz, and Ian Hiskens -Control for Renewable Energy and Smart Grid

[5.] S.M Halpin, L.L.Grigsby the Electric Power Engineering Handbook, CRCLLC (2001), PP15.22-23

[6.] Technical Note 10 October 2011 Endeavour Energy Power Quality & Reliability Centre Small Scale Domestic Rooftop Solar Photovoltaic Systems.

[7.] Jianwu Cao[2011] Florida State University Analysis and Implementation of Grid Connected Solar PV with Harmonic Compensation

[8.] Geibel, D., T.Degner,"Improvement of Power quality and Reliability with multifunctional PV-Inverters in distributed energy system", in EPQU2009.

[9.] Mde Alegria, J Andreu,J L Martin Ibanez, "Connection requirements for Wind farms: A survey on technical requirement sand regulations" Renewable and Sustainable Energy Reviews,2007, vol.11,1858-1872

[10.] S M Dehghan,M Mohammdian and A Y Varjani,"A New variable speed Wind energy Conversion System using Permanent Magnet Synchronous Genenerator and Z source Inverter",IEEE Trans Energy conv,2009,vol 24,714-724.

[11.] A Baggini, Handbook of Power Quality, John wiley&sons Ltd, UK (2008), pp 3-15

[12.] A Ghosh and G Ledwich, Power quality enhancement using custom power devices,Kluwer Academic, 2002

[13.] S.M.Muyeen,R Takahashi,T Murata,J Tamura"Application of STATCOM/BESS for Wind power smoothing and hydrogen generation"Electric power systems Reserch,2009,vol 79,pp365- 373.

[14.] A Ghosh, "Compensation of Distribution System voltage using DVR", IEEE Trans on power delivery, 2002, vol 17, pp1030-1036

[15.] H Fujita, H Akagi," The Unified Power Quality Conditioner', IEEE Trans on power electronics, 1998, vol.13, pp.315-322

[16.] M Hosseinpour, Y Mohamadrezapour,S Torabzade,"Combined operation of unified power quality conditioner and Photovoltaic