Analysis of Power Quality Problems and Its Mitigation by Using DVR and Statcom

PRACHI SHRINGI[1], POOJA SAINI[2], NEERAJ TIWARI[3]
[1,2,3] *Department of Electrical Engineering, Poornima College of Engineering, Jaipur, India*

Abstract -- Electric power system is a complex system. This system includes three stages i.e., generation, transmission and distribution. So, there is a possibility of mislaying of power quality. Hence power quality issues occur such as voltage sag, voltage swell, voltage imbalance, harmonic distortion, blackout, transients. This power quality issue has the great impact on consumers as well as utilities. So, to overcome these issue custom power devices (FACTS) came into existence. The main aim of this paper is to mitigate power quality issue like voltage sag and voltage swell by using custom power devices DVR and STATCOM. DVR resolves the problem of voltage sag/swell. STATCOM enhance the transmission capacity and voltage stability.

Index Terms-Custom Power Devices, DVR, STATCOM, Power Quality, Power System, Transients, FACTS

I. INTRODUCTION

Power Quality is one of the major issue in present time. With ever increasing demand of electric power, the existing transmission networks even in developed countries are found to be weak which results in poor quality of unreliable supply. Also, it is seen that in order to expand or enhance the power transfer capability of the existing transmission network a huge sum of finances are required and sometimes even difficulties are encountered in finding right-of-way for the new lines. Lot of research has gone into developing over the past few years to gain increased efficiency from the existing power system. This program is known as Flexible A.C. Transmission System (FACTS) or Custom Power Devices. FACTS is a new technology which employ high speed thyristors for switching in or out transmission line components such as capacitors, reactors or phase shifting transformer for some desirable performance of the system. the existing slow acting mechanical controls the system. The main objective of FACTS devices is to replace the existing slow acting mechanical controls required to react to changing system conditions by rather fast acting electronic controls. The mechanical controls require power system operators and designers to provide generous margins to assure a stable and reliable operation of the system. As a result, the existing systems cannot be made use of their full capacity. However, with the use of fast acting controls, the power system margin could be reduced and power system capability could be more fully utilized while maintaining the present levels of quality and reliability.

In this paper we will discussed about the DVR and STATCOM which are most efficient and effective modern custom power devices used in distribution systems [1]. FACTS devices like DVR (Dynamic Voltage Restorer) is series controller and STATCOM (Static Synchronous Compensator) is shunt controller. These devices are recent innovation of interfacing devices between distribution network and costumer appliances to overcome disturbances regarding voltage and current. Hence, improve power quality either by supply or absorbed the reactive power by load.

Generally, distribution systems have nonlinear loads which affect the power supply quality. Due to presence of nonlinear loads, the sinusoidal waveform is not observed. Poor power quality is the deviation of the voltage and the current from its ideal waveform. Other than nonlinear loads, switching utility faults, component failure, load changes, startup loads distort the magnitude of voltage. These distorted magnitudes of voltage affect the power quality and cause power quality issue such as overvoltage, under voltage, interruptions, oscillatory transient, impulsive transient, voltage imbalance and voltage fluctuation. Most of the power quality problems occur due to faulty connections or wiring, source of supply and load types [2].

II. CLASSIFICATION OF POWER QUALITY ISSUES

Power Quality can be classified as:

A. Voltage Swell

A voltage swell is momentary increase in the ac voltage for duration of a few seconds. It is caused by changing of load, utility failure. The effect of voltage swell is equipment gets damaged; tripping of circuit breaker takes place [2], [3].

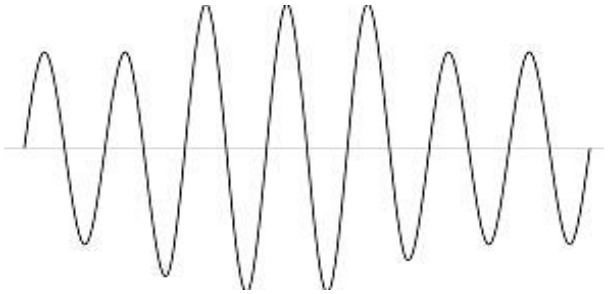

Fig 1- Voltage Swell

B. Voltage Sag

A voltage sag is reduction in the rms voltage for few seconds. It is caused by faults, nonlinear loads, short circuit and different load starting. The effect of voltage sag is data may be lost, system shutdown [2], [3].

Fig 2- Voltage Sag

C. Harmonics distortion

As nonlinear load does not follow ohms law, means voltage and current do not follow each other linearly. Due to this, harmonic distortion takes place and cause problem of voltage sag. Harmonics are caused by any device or equipment which has nonlinear voltage-current characteristics. For example, they are produced in electrical systems by solid state power converters such as rectifiers that conduct the current in only a portion of each cycle. Silicon Controlled Rectifiers (SCRs) or thyristors are examples of this type of power conversion device.

Fig 3- Harmonics Distortion

D. Brownouts

Brownout is a type of voltage fluctuation. Usually 3-5% voltage reduction. It is caused by poor wiring or connections [4].

E. Power Interruptions

It is a total loss of input voltage. Often referred to as a "blackout" or "failure" for events of a few cycles or more "dropout" or "glitch" for failure of short duration. It is caused by malfunction of costumer equipment, fault at main fuse box tripping supply [4].

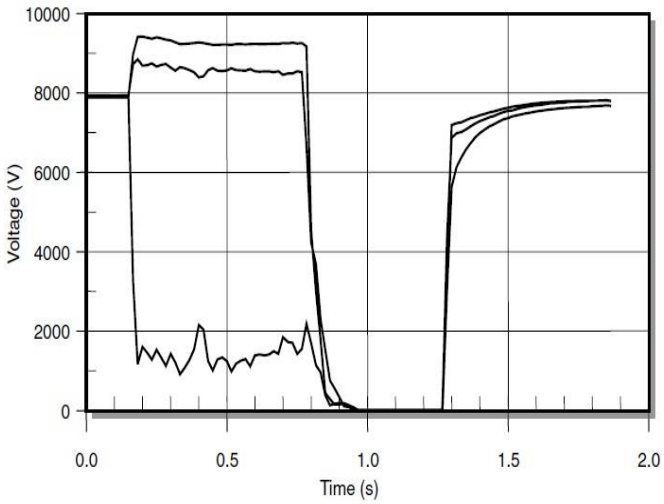

Fig 4:- Power Interruption

III. MITIGATION TECHNIQUES

There are various FACTS devices like DVR (Dynamic Voltage Restorer), STATCOM (Static Synchronous Compensator), UPFC (Unified Power Flow Controller), SSSC s(Static Synchronous Series Compensator), TCSC(Thyristor Controlled Series Capacitor) for improving power quality issues. But in this paper we will discuss about DVR and STATCOM.

(a) Dynamic Voltage Restorer (DVR):-

Voltage sag is most severe disturbances among all the power quality problems. This problem of voltage sag is overcome by using DVR. DVR is a recently proposed series controller. DVR is a solid state device that injects voltage in series with transmission line. It is connected between supply and load at point of common coupling.

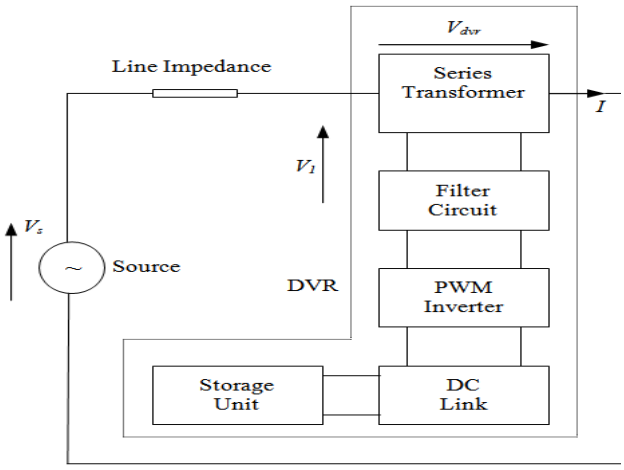

Fig 5- Block Diagram of DVR

DVR consists of following parts:-

1) Boosting Transformer:-

It connects the DVR to the distribution network via the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage. In addition, the Injection / Booster transformer serves the purpose of isolating the load from the system (VSC and control mechanism).

2) Filter Circuit:-

To filter the harmonics, passive filters are placed at high voltage side of DVR. The main task of filter is to keep the harmonic voltage content generated by the VSC to the permissible level.

3) Voltage Source Converter (PWM):-

It is made up of any switching devices like, Metal Oxide Semiconductor Field Effect Transistors (MOSFET), Gate Turn-Off thyristors (GTO), Insulated Gate Bipolar Transistors (IGBT), and Integrated Gate Commutated Thyristors (IGCT), six diodes connected in antiparallel, voltage source and large dc link capacitor. VSC provides constant voltage.

The IGCT is a recent compact device with enhanced performance and reliability that 18 allow building VSC with very large power ratings. Because of the highly sophisticated converter design with IGCTs, the DVR can compensate dips which are beyond the capability of the past DVRs using conventional devices.

4) Storage Unit:

Storage Unit is used to provide energy to the VSC via a dc link for the generation of injected voltages. The different kinds of energy storage devices are Superconductive magnetic energy storage (SMES), batteries and capacitance.

(b) Static Synchronous Compensator (STATCOM): -

STATCOM is a shunt controller. It is advanced form of SVC. It is used to regulate the voltage of the system. If the system voltage is low, STATCOM provide reactive power, it behaves like capacitive and if the system voltage is high, STATCOM absorb reactive power, it behaves like inductive [5]. The installation cost of STATCOM is $ 50/kVar. It is connected to weakest bus of the system.

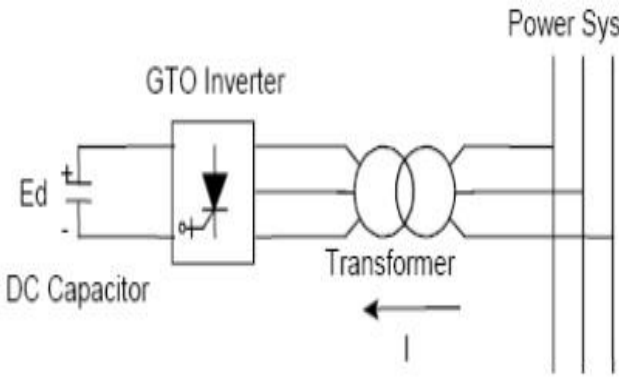

Fig 6- STATCOM

The above figure consist of GTO inverter driven by voltage across the capacitor and three phase output voltages are in phase with ac system voltage. By controlling the voltage reactive power and its polarity can be changed. The capacitor present act as storage unit and continue to deliver some energy for short time.

IV. CONCLUSION

In today's scenario power quality is the major problem for both utilities and consumer. Power quality problems mostly found in distribution network. To resolve this problems various FACTS devices was introduced. But the major issue like voltage sag/swell is resolved by DVR and voltage stability, power transmission efficiency can be enhance by STATCOM.

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