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Voltage SAG Mitigation Analysis

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Abstract: Power quality is the generally imperative prospect in the power system environment. Generally as often as possible occurring disturbances, pretending the quality of power are voltage sags and swells. There are increase the use of high end electronics and high efficiency variable speed drive and other power electronic controlled load the power quality has now become a major concern to both the utilities and customers. Utilities as they want to deliver highest quality power and cannot accept bad quality power to the grid. Customers on the other hand don't want the performance of their device to come down because of somebody else polluting the grid they are using. Voltage sag is the most common type of power quality and performance degrading disturbance in the system and this paper analyzes the mitigation techniques that can be used to improve both the power quality and the performance of the load.

Keywords- *Voltage SAG, power quality, MATLAB software.*

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1. INTRODUCTION

Power quality in the modern grid system is most essential. There are no two questions about it [1]. The term power quality especially electric power quality is the measurement of degree of any deviation from the nominal values of the voltage magnitude and frequency. Power quality may also be defined as the degree to which both the utility and deliver of electric power affects the performance of electrical load or equipment [2]. From a customer point of view quality problem is considered when due to variation in voltage, current and frequency the customer end equipment results in disoperation or degradation in the performance for no fault of the customer [3]. There are many issues that constitutes a power quality problem which will in turn affect the performance of customers equipment. Frequency deviation happens in presence of harmonics and other deviation from the intended frequency of the AC supply. Voltage magnitude deviation or fluctuations are categorized into voltage swelling and sagging from the intended magnitude. There can be short spans of overvoltage, sagging, and transients over voltages. An unbalanced three phase system is also considered to be
deviation from the intended supply [2].For this paper the major concern is the issues arising due to the voltage sagging. Voltage sags is caused by a fault in the utility system, a fault within the customers facility or a large increase of the load current, like starting a motor or transformer energizing .Voltage sags are one of the most occurring power quality problems. For an industry voltage sags occur more often and cause severe problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems [5]. Harmonic currents in distribution system can cause harmonic distortion, low power factor and additional losses as well as heating in the electrical equipment. It also can cause vibration and noise in machines and malfunction of the sensitive equipment. The development of power electronics devices such as Flexible AC Transmission System(FACTS) and customs power devices have introduced and emerging branch of technology providing the power system with versatile new control capabilities [1].There are different ways to enhance power quality problems in transmission and distribution systems. Among these, the D-STATCOM is one of the most effective devices. A new PWM-based control scheme has been implemented to control the electronic valves in the DSTATCOM. 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. In this paper, the configuration and design of the DSTATCOM with LCL Passive Filter are analyzed. It is connected in shunt or parallel to the 11 kV test distribution system. It also is design to enhance the power quality such as voltage sags, harmonic distortion and low power factor in distribution system.

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Fig 1: Describes the demarcation of the various power quality issues.

2. Voltage Sags:

Two parameters need to be considered for a voltage sag, first is duration and second is magnitude. This depends on the various sources and how those sources generated these two parameters. Other parameters that describe the voltage sags are, the point on wave where the voltage sag occurs and how the phase angle changes during the voltage sag. A phase angle jump during a fault could be due to change in voltage and frequency ration. This becomes problem for devices using zero crossing switching.

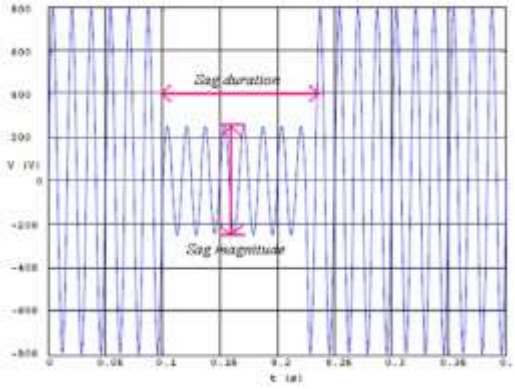

Figure 2: Voltage Sag Duration & its Magnitude

Voltage sag can occur at any instant of time ranging from 0.1 to 0.9 p.u and that lasts for half a cycle to one minute. Voltage sag can be either balanced or unbalanced which mainly depends on type of fault. The main sources of voltage sag are any type of fault in power system or by the starting of large motor loads. Mainly, voltage sags are considered as major threats to the power quality. Similarly voltage swells occurs at any instant of time ranging from 1.1 to 1.8 p.u and that lasts for half a cycle to one minute. But voltage swells are less frequent compared to that of voltage sags which are mainly produced because of sudden switching off of large loads or energization of capacitor banks [3]. Due to these faults, under full load conditions, it may cause severe or high voltage drops in the system. Due to these disturbances, system may undergo shutdown or fail including large voltage and current imbalances in the system. Various techniques can be adopted or used by the customer in order to mitigate these voltage sags / swells to have better quality of power supply to the equipment for its effective functioning.

3. Dynamic Voltage Restorer (DVR):

It is quite a challenging task to mitigate the voltage sag so that the desired load voltage magnitude remains unaffected and maintained during the whole disturbance cycle [5]. The voltage sag can be mitigated by the voltage and power injection into the distribution system using the power electronics based devices [6]. One approach is dynamic voltage restorer that can be used to correct the voltage sag at distribution level.

A DVR is a solid state power electronics switching device consisting of IGBT, a capacitor bank and injection transformers. It is connected as shown below. During normal operation, DVR injects small voltage to compensate for the drop happening due to the injection transformer and device loses. When voltage sag occurs in distribution system, the DVR control system calculates and synthesizes the voltage required to maintain output voltage to load by injecting a controlled voltage with a magnitude and phase angle into the supply system [6]. The reponse time of DVR is very short and is limited by the power electronics devices and the voltage sag detection time.

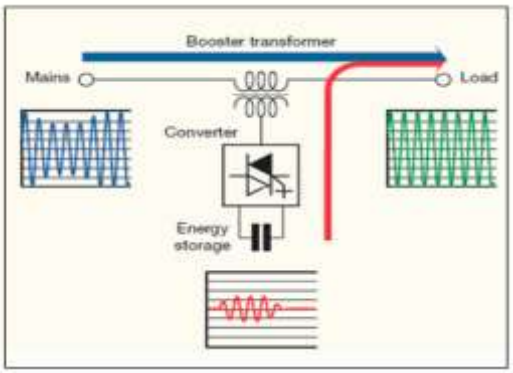

Figure 3 :- Single Line Diagram of DVR

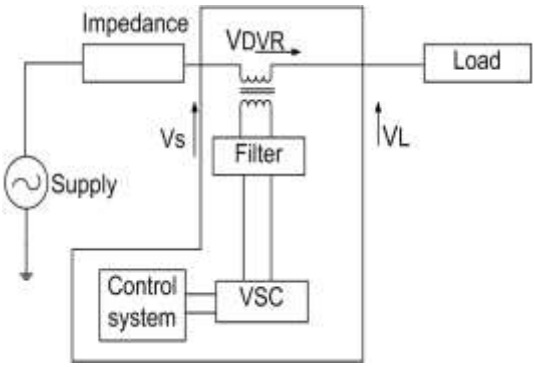

Figure 4. Basic structure of dynamic voltage restorer.

The general configuration of the DVR mainly consists of the following components such as,

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(a)An boosting Transformer
(b)A filter for reducing harmonic
(c)The battery energy Storage system
(d)A Voltage Source Converter
(e)DC charging circuit

There are simulation result of DVR is here shown below in Fig.5

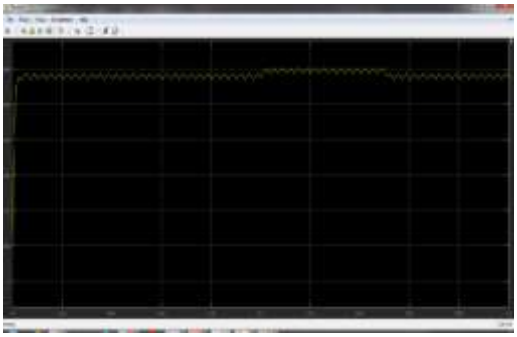

Figure 5:- Simulation Result of DVR

The DVR is used for mitigate the voltage sag at the distribution side. But in this Fig. shown that the DVR can make the voltage waveform smooth by injecting the required voltage in voltage waveform of power supply for mitigate the voltage sag.

4. Distribution Static Compensator (DSTATCOM):

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Figure-5.1, The D-STATCOM is a three phase and shunt connected power electronics based reactive power compensation equipment which can generates and absorbs the reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system. It 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. The D-STATCOM employs an inverter to converts the dc link voltage Vdc on the capacitor to a voltage source of adjustable magnitude and phase. The VSC converts the dc voltage across the storage device into a set of three-phase ac output voltages

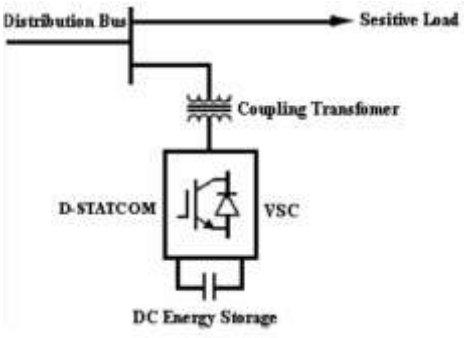

Figure 6: Configuration of a DSTATCOM.

These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power. The operation of DSTATCOM is as follows: the voltage is compared with the AC bus voltage system(Vs). When the AC bus voltage magnitude is above that of the VSI voltage magnitude (Vc),the AC system sees the D-STATCOM as inductance connected to its terminals. Otherwise if the VSI voltage magnitude is above that of the AC bus voltage magnitude, the AC system sees the D-STATCOM as capacitance to its terminals.

Sag Condition

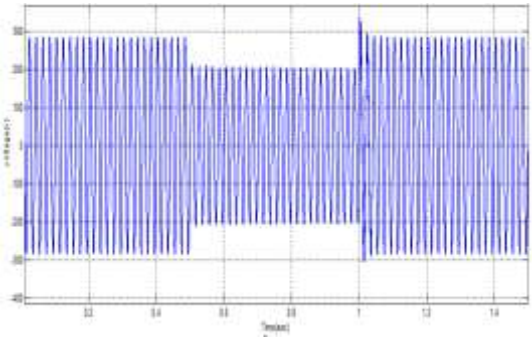

Fig 7 : - Voltage Waveform During Voltage Sag Sag Compensated Voltage

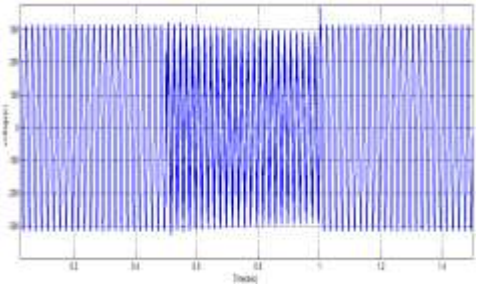

Fig:-8 Voltage Waveform During Voltage Sag Using DSTATCOM

The D STATCOM is having main advantage is that it does not having required separate power supply sources . and it is continuously connected to the grid. So that it can continuously mitigating the voltage sag at the grid substation when it is required. The DSTATCOM MATLAB Simulink waveform is shown in Fig.

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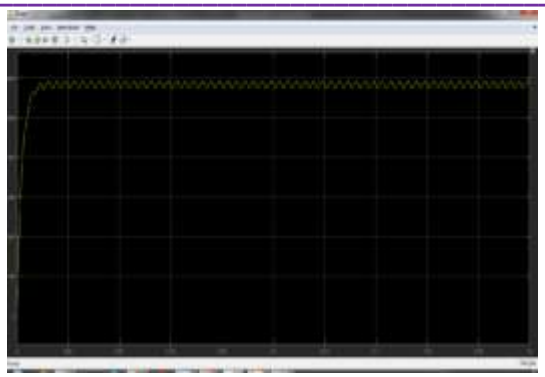

Fig 9 :- Simulink Result of DSTATCOM

5. RESULTS & CONCLUSION

This paper is Discussed the results analysis of voltage Sag Mitigation of two FACTS Devices DVR & DSTATCOM. This paper represents that DVR cannot mitigating the voltage waveform smooth during voltage sag, but the DSTATCOM can better mitigating the voltage waveform during voltage sag as compare than DVR.

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