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Voltage Sag Mitigation Using Distribution Static Compensator System

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ABSTRACT

This paper presents the custom power devices to improve the power quality by using a Distribution Static Compensator (DSTATCOM). Custom power is a technology driven product and service solution which embraces a family devices such as DSTATCOM. It describes the techniques of correcting the supply voltage sag in a distribution system by DSTATCOM. The steady state performance of system with or without DSTATCOM is studied for voltage sag.

Keywords: *Custom Power Devices; DSTATCOM; Power Quality; THD.*

1. INTRODUCTION

Now a day's Power quality problems have received a great attention because of their economical impacts on both utilities and customers. Power Quality has caused a great concern to electric utilities with the growing use of sensitive and susceptive electronic and computing equipment (e.g. personal computers, computer aided design workstations, uninterruptible power supplies, fax machines, printers, etc) and other nonlinear loads (e.g. fluorescent lighting, adjustable speed drives, heating and lighting control, industrial rectifiers, arc welders, etc). All nonlinear and time varying temporal type electric loads fall generally in two wide categories, namely the analog arc (inrush/saturation) type and digital converter (power electronic) switching type.

Power Quality improvement using custom power devices considers the structure, control and the performance of series compensating DVR, the shunt compensating DSTATCOM and the shunt with series UPQC for power quality improvement in electricity distribution. Also addressed are other power electronic devices eg., solid state transfer switches and fault current limiters for improving power quality.

2. LITERATURE REVIEW

Several experts proposed many methods to improve the power quality such as Bhim Singh and Venkata Srinivas Kadagala (2012) - a new configuration of STATCOM (Static Compensator) with constant DC link voltage for the voltage regulation.

Mohamed Elsaid Elgamal et al (2012) used a fuzzy logic controlled multi level inverter based unified power flow controller system in a transmission line to maintain voltage profile and protect against voltage sags and swells. The controller is designed as a standalone module and tested in PSCAD-EMTDC environment.

Bhim Singh et al (2011) proposed a novel control approach for the control of four wire DSTATCOM under non ideal supply voltage conditions.

Mekri Fatiha et al (2011) deals with an Unified Power Quality Conditioner for current and voltage perturbations compensation in a power distribution network based on two 3-phase voltage source inverters acting respectively as a parallel active power filter and a series active power filter which share two DC link capacitors. The power flow, in the Unified Power Quality Conditioner system is analyzed.

Noroozian, R et al (2010) presented a DC distribution system supplied by an external AC system as well as local distributed resources (DRs) including distributed generations (DGs) and battery storage bank.

Hannan, M, A et al (2009) described the modeling of synchronous static compensator (STATCOM) of a power system based on the dynamic phasor model to investigate the performance of STATCOM for power quality analysis by using Electromagnetic Transient Program (EMTP) like simulation.

Yuanjie Rong et al (2009) given an adaptive harmonic detection to precisely detect the voltage with multiple zero crossings and adaptively obtain the reference signals,

which makes use of linear neurons to approximate the fundamental component in each phase followed by a symmetric component.

Amit Kumar, J et al (2008) discussed the voltage control of a critical load bus using a dynamic voltage restorer (DVR) in a distribution system.

Sen Ouyang and Jianhua Wang (2007) proposed a new approach to detection of transient disturbances in a noisy environment with an appropriate morphologic structure element.

El-Moursi, M, S and Sharaf, A, M (2006) investigated the dynamic operation of both static synchronous compensator (STATCOM) and static synchronous series compensator (SSSC) based on a new model comprising full 48-pulse GTO voltage source converter for combined reactive power compensation and voltage stabilization of the electric grid network. Amit

Kumar Jindal et al (2005) discussed the operation and control algorithms of shunt and series active filters. Jurado, F and Valverde, M (2005) presented a new flux modulation approach for the closed loop control of the output voltage of inverters for fuel cell power plants.

Clark W. Gellings and Richard J. Lordan (2004) proposed the constraints required to renewed investment and innovation in power delivery.

Bhim Singh et al (2003) presented the performance analysis of interior permanent magnet synchronous motor (IPMSM) fed from improved power quality converter inverter system as a variable speed drive for air conditioning.

Jeyasurya, B (1994) presented the application of artificial neural networks for on line voltage stability evaluation in modern energy control centers.

El Shatshat, R et al (2002) proposed an efficient and reliable active filter system for the power quality enhancement.

Baburam, A et al (1985) analyzed that the mathematical models incorporating the dynamics of a synchronous machine, transmission network and static shunt compensator.

In summary,

Power Quality issues are divided into five sub-categories those are:

(a) Harmonics (integral, sub, super and inter harmonics)
(b) Voltage swells, sags, fluctuations, flicker and Transients
(c) Voltage magnitude and frequency, voltage imbalance
(d) Hot grounding loops and ground potential rise (GPR)
(e) Monitoring and measurement of quasi-dynamic, quasi-static and transient type phenomena.

3. PROBLEM STATEMENT

This paper presents the main issues of the Power Quality problems and suggests the mitigation technique for voltage sag. This problem discussed in detail- the origin, consequences and possible mitigation techniques. The paper describes the techniques of correcting the supply voltage sag in a distribution system by custom power devices such as Distribution STATCOM (DSTATCOM). The steady state performance of the DSTATCOM is studied for various levels of voltage sag.

4. MODELING OF CUSTOM POWER DEVICES

The custom power devices mainly consists of power electronic components (the static transfer switch, active filters and converter based devices) to achieve the reliable high quality power supply with low sag to the industrial and commercial consumers.

The modeling approach take up in this paper is graphical in nature. The graphic facilities available in an industry standard power system package, namely, MATLAB (Simulink) are used to conduct model implementation to carry out extensive simulation studies.

In the converter based power electronics shunt connected device known as the D-STATCOM, plays most important role to improve the power quality. It has been used to counter/compensator the power system disturbances such as voltage dips, sags, flicker unbalance and harmonics.

For lower voltage sags, the load voltage magnitude can be corrected by injecting only reactive power into the system. For higher voltage sags, injection of active power, in addition to reactive power, is essential to correct the voltage magnitude. The response time of the DSTATCOM is very fast and only limited by the power electronics devices. The expected response time is about 25 ms and which is much less than some of the traditional methods of voltage correction such as tap changing transformers. DSTATCOM used in the paper is described in detail as below.

5. DSTATCOM

DSTATCOM is a fast compensating reactive power source that's applied on the distribution system to reduce voltage variations such as sags, surges, and flicker. Test system for DSTATCOM is shown in figure 1. DSTATCOM generates a variable voltage, V_d, that is very nearly in phase with the source voltage V_s. In this simplified circuit, L, consists of the inductance of the coupling transformer and filter. The voltage across the inductance, V_L, equals V_s-V_d and is small in per unit terms on the order of 5-20%. If $V_s > V_d$, V_L is in phase with V_s and current I_L lags Vs by 90°; DSTATCOM acting as a generator, produces leading reactive current. If $V_s < V_d$, V_L is anti-phase with V_s and current I_L leads Vs by 90°; DSTATCOM produces lagging reactive current.

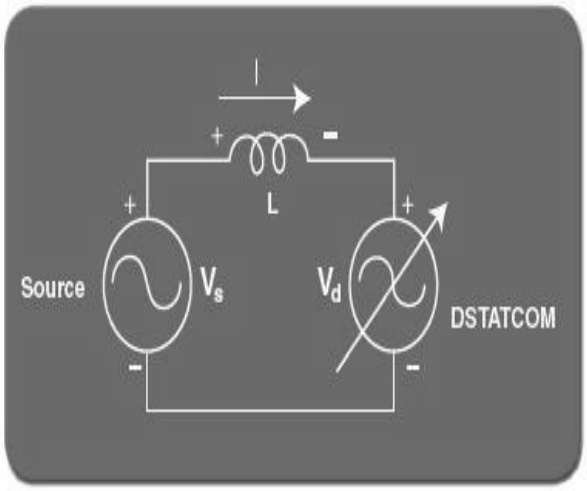

Fig.1. Test system for D-STATCOM

The test system is simulated under the environment of MATLAB Simulink and power system block set (PSB). The model used for this purpose is shown in the fig 2.

The simulation is carried out with the following three assumptions.- The voltage drops w.r.t. the reference value, - The load voltage is very close to the reference value, i.e., 1 pu, - The total simulation period is 1.4 s. Under these assumptions, the response of the voltage without DSTATCOM and with DSTATCOM was observed and shown in fig 3 and fig 4 respectively. The figures reveal that the effective voltage regulation provided by the DSTATCOM can be clearly appreciated. The regulated rms voltage corresponding to a rapid regulation response is obtained and transient overshoots are almost nonexistent.

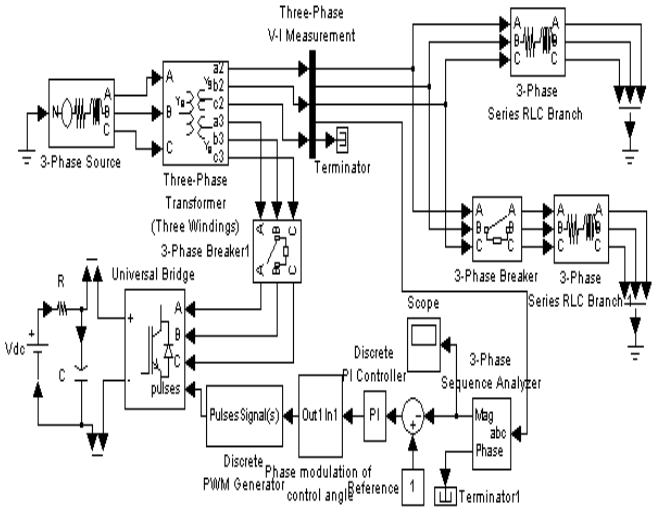

Fig 2: Simulink model for DSTATCOM

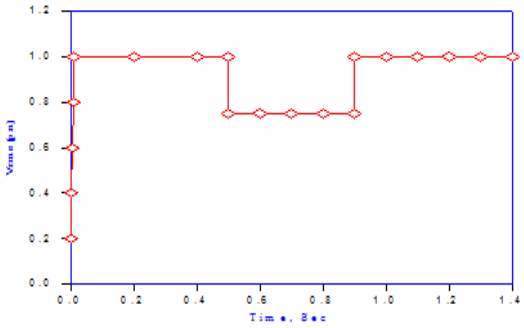

Fig 3: Voltage response without DSTATCOM

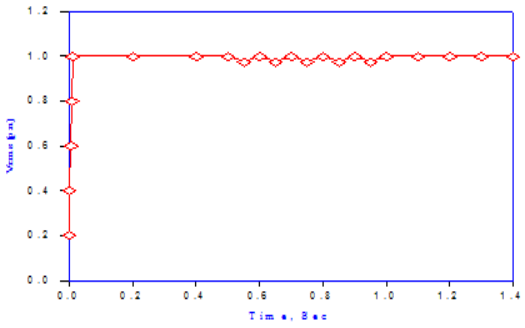

Fig 4: Voltage response with DSTATCOM

6. CONCLUSION

This paper presents the model of the custom power device namely, DSTATCOM and its application to mitigate voltage sag, which is very prominent as per utilities are concerned. Power quality measures can be applied both at the user end and also at the utility level. The proposed

DSTATCOM model is developed using MATLAB/Simulink and steady state performance is studied for the voltage sag. Simulation results are presented to demonstrate the voltage sag level of the DSTATCOM.

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