

Distribution Network Power Quality Improvement by D-STATCOM & DVR Under Various Fault Conditions

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Abstract - The concept of Flexible Alternating Current Transmission Systems (FACTS) and Custom Power has been researched extensively by researchers throughout the world and the studies suggest out that power quality is widely studied by the researchers. On the whole FACTS uses Power electronic devices and methods to control the high voltage side of the network for improving the flow of power. Custom Power Devices are mainly for low-voltage distribution, and improving poor quality of power and reliability of supply affecting entities such as factories, offices and homes. The quality of Power and Reliability are becoming important issues for critical and sensitive loads. DSTATCOM is mainly used to mitigate different faults such as Single Line to Ground (SLG) fault and Double Phase to Ground (DPG) fault and three-phase fault. The fast Response of DSTATCOM makes it the efficient solution for enhancing the power quality of the distribution system. DSTATCOM can use with different types of controllers. In this work, Simulation of Distribution STATIC Compensator (DSTATCOM) and DVR has been carried out to improve the quality of power under different abnormal conditions and results have been presented through simulations. KEYWORDS: FACTS, DSTATCOM, DVR, PQ.

Key Words: Introduction¹, Related Work², Methodology³, Experimental Results⁴, Conclusion⁵, References⁶

1. INTRODUCTION

Power quality improvement has always been the main concern of the power engineers and in the recent year with the increased usage of the digital equipments the power quality has brought the power quality improvement to a centre stage. In the present times almost all the industries use electronic controllers which are extremely sensitive to

the quality of the power to be used. A minor variation would also lead to serious aberration and may cause the system to fail. Much of this modern load equipment itself uses electronic switching devices which then can contribute to poor network voltage quality. The beginning of competition into electrical energy supply has created greater commercial awareness of the issues of power quality while equipment is now readily available to measure the quality of the voltage waveform and so quantify the problem. Along with advancement in technology, the worldwide economy organization has evolved towards globalization and the profit margins of many activities tend to decrease. The increased sensitivity of the vast majority of processes like (industrial, services and even residential) to PQ problems turns the availability of electric power with quality a crucial factor for competitiveness in every sector of activity. The nonstop process industry and the information technology services are most significant area. In a event of even a minor disturbance the results would lead to a huge amount of financial loss and consequent loss of productivity and competitiveness.

2. RELATED WORK

Several studies have been shown that transformer with automatic tap-changing can be used to improve voltage stabilities for both steady state and transient state stabilities. Some of these studies have investigated and are proposing new models of tap-changing transformers. A static VAR compensator used to improve the voltage stability because of the opening line in presence of induction motor or due to start induction motor or because recovery of the short circuit IM terminals or due to the heavy load capacity. With the SVC we can also use capacitors in series. C. Palanichamy and N. sundar Babu [14] presented a work on a visual package of educating preparatory transmission line series compensation. They presented that the transmission of electrical power over great distance imposes very sever economical technical limitations. Here series compensation is very effective in

overcoming such economical technical limitations. Series compensation technique using capacitors has gained special interest because of its cost effectiveness. They have proved two series algorithms using user friendly softwares package based in visual basics for study of transmission line series compensation to achieve maximum power transfer. Matt matele [15] presented a work on enhancing of transmission capacity of power corridors by means of series compensation. K. Ramar & M.S Raviprakash[16] presented a work on design of compensation of long AC transmission line for maximum power transfer limited by voltage stability. They proposed a comprehensive approach to reactive power management in ac transmission line for maximum power transfer. The transmission line presented by its equivalent π model. The series shunt compensation scheme was separately analyzed for different load model. Voltage constraint where taken into consideration during the design of compensation schemes. A. Leonidaki, G.A. Manos and N.D.Haziargyrio [17] presented a work on "An effective method to locate series compensation voltage stabilities enhancement" they presented that the series compensation of transmission line is one of the effective means of increasing the loading margins of an interconnected power system. In this paper they gave a methodology for identifying the critical transmission line with respect to voltage stability issues via sensitivity analysis. This methodology applies to (N-1) configuration taking into account future expansion plans taking the examples of Hellenic interconnected transmission system.

3. METHODOLOGY

DSTATCOM is a voltage source converter (VSC) that is connected in shunt with the distribution system by means of a tie reactance connected to compensate the load current. In general, a coupling transformer is installed between the distribution system and the DSTATCOM for isolating the DSTATCOM from the distribution system. 3.1 Isolation transformer: It connects the DSTATCOM to the distribution network and its main purpose is to maintain isolation between the DSTATCOM circuit and the distribution network. 3.2 Voltage source converter: A voltage source converter consists of a storage device and devices of switching, generating a sinusoidal voltage at any required frequency, magnitude and phase angle. In the DSTATCOM application, this temporarily replaces the supply voltage or generates the part of the supply voltage which is absent and injects the compensating current into the distribution network depending upon the amount of unbalance or distortion. In this work, an IGBT is used as the switching device. DC charging unit: This unit charges the energy source after a compensation event and also maintains the dc link voltage at the nominal value. 3.3 Harmonic filters: The main function of harmonic filter is to filter out the unwanted harmonics generated by the VSC and hence, keep the harmonic level within the permissible

limit. Energy storage unit: Energy storage units like flywheels, batteries, superconducting magnetic energy Storage (SMES) and super capacitors store energy.

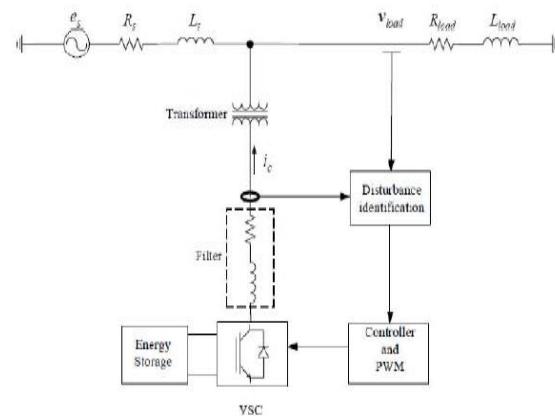


FIG 1. System scheme of DSTATCOM.

DYNAMIC VOLTAGE RESTORER (DVR) SYSTEM

Figure 2 depicts a Dynamic Voltage Restorer (DVR) system with a series insertion transformer connected between the distribution transformer and the sensitive load.

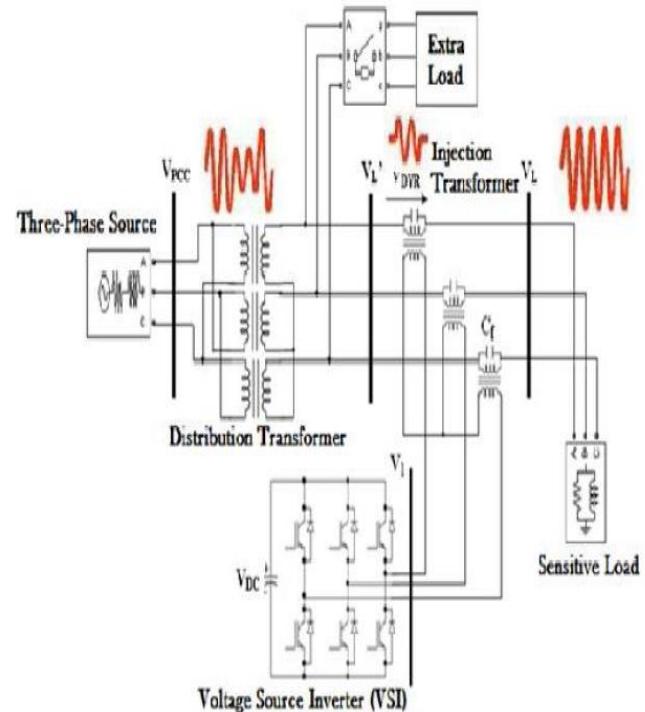


Fig.2.Schematic diagram of a dynamic voltage restorer system

The electrical system viewed from the Point of Common Coupling (PCC) has been modeled as a 3-phase voltage

source with a short circuit impedance. The DVR can compensate voltage sags by means of the injection of the inverter voltage through the series connected transformer. Essentially, the DVR consist of a series-connected injection transformer, a voltage source inverter (VSI), a filter capacitor and an energy-storage device connected to the inverter DC link. Figure 2 shows the single-phase equivalent circuit to study the transfer function between the DVR inverter voltage (VDVR) and the sensitive-load voltage (VL). Where LT' and RT' represent the leakage inductance of the transformer and its equivalent series resistance, respectively. Cf is added to make a second-order filter together with LT' in order to filter the inverter output voltage. The voltage supply has been represented by a voltage source V_s with a short-circuit impedance R_{sh} and L_{sh} in series with a distribution transformer represented by its leakage inductance (LT) and an equivalent resistance (RT). The sensitive load has been modeled by a parallel-connected R-L.

4. EXPERIMENTAL RESULTS



Fig 3 Line voltage

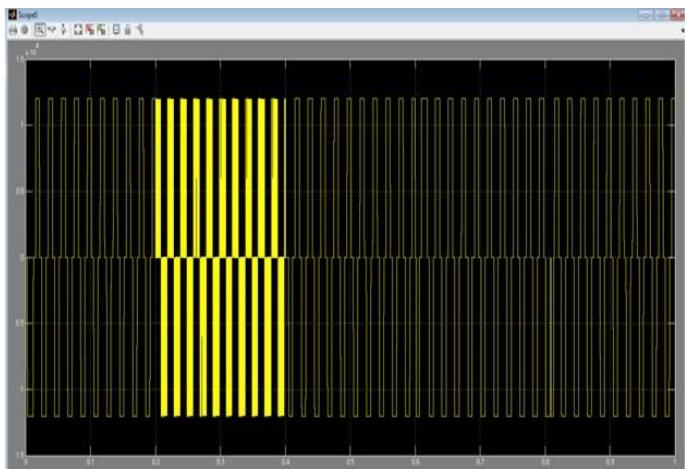


Fig 4 DVR Output

As seen in the figure 4 above we see that the occurrence of fault the DVR injects voltage into the system to maintain the power level

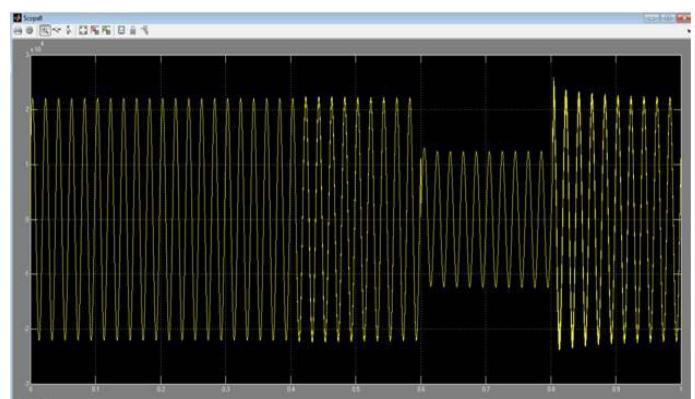


Fig 5 STATCOM Output

As seen in the figure 5 above we see that the occurrence of fault the STATCOM injects current into the system to maintain the power level

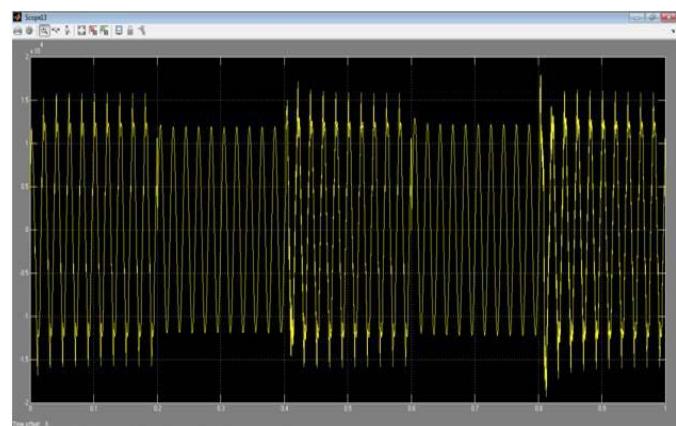


Fig 6 Output voltage

As seen in the output voltage waveform we see that the DVR comes into play at time duration t= 0.2 to t= 0.4 and STATCOM comes to play at time t= 0.6 to t=0.7 and thus the system is able to maintain the power quality

5. CONCLUSION

Distribution networks with static linear and non linear loads. Proportional-Integral (PI) controller is used with the device to improve its performance. Test system is analyzed and results are presented in the simulation section. The results shows the satisfactory performance of DSTATCOM in the distribution networks under fault conditions and it can be concluded that DSTATCOM effectively improves the power quality in distribution networks with static linear.

As opposed to fundamental frequency switching schemes already available in the MATLAB/ SIMULINK, this PWM control scheme only requires voltage measurements. This characteristic makes it ideally suitable for low-voltage custom power applications. The simulations carried out showed that the DVR provides relatively better voltage regulation capabilities. It was also observed that the capacity for power compensation and voltage regulation of DVR and D-STATCOM depends on the rating of the dc storage device

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