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An Approach for Use of DVR to Mitigate Voltage Sag

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Abstract: *The power quality problems are showing its impact on various customer including industries, commercial, as well as residential. Major quality problems are sag, swell, harmonics, transients and flickers etc. Today, the DVR is one of the most effective device in solving voltage sag problems. However, the cost and the installation restrictions have limited the implementation of DVR to where be the obvious requirement for a stable voltage supply. Major application of DVR is for voltage sag mitigation. DVR have been implemented in various fields including power quality improvement which is an important issue of recent day. According to previous studies, a DVR can handle both balanced and unbalanced situations without any kind of difficulties and can inject appropriate voltage component for correcting any voltage sag in the supply voltage in order to keep the voltage balanced and constant. There are a lot of new issues that have triggered the interest and motivation in improving power quality. Power quality has been an interest so that maximum profit can be achieved from the share markets. Dynamic voltage restorer is a power electronic based device. It protects sensitive loads from the various types of disturbances of the power supply.*

Keywords: *Power Quality, Dynamic Voltage Restorer, Mitigation, Voltage Sag*

I. Introduction

In this work, the study of Dynamic voltage restorer for the mitigation of voltage sag has been done. Dynamic Voltage Restorer (DVR) is of great importance in present power system because of consistent problems related to the power distribution including the voltage sag and voltage swell. Due to modernization in today's world, a large number of sophisticated electrical as well as electronic equipment such as computers and laptops, programmable logic controllers, microprocessors, electrical drives etc. are being used these days. Also for the advancement of DVR, it is important to study the advantages and disadvantages so that the disadvantages can be overcome and its features can be further enhanced. This work provides a detailed study of DVR, its application at two voltage levels, the low voltage level and medium voltage level. A simulation has been done with line fault in a power system and DVR has been implemented for compensating the voltage sag due to the fault. The output graph for the voltage with DVR and voltage without DVR has been studied. The DVR implemented in this work is Space vector pulse width modulated Voltage source inverter based.

II. Literature Review

The power quality problems are showing its impact on various customer including industries, commercial, as well as residential. Major quality problems are sag, swell, harmonics, transients and flickers etc.Variousreports and Research papers have been done on the subject of improving the power quality of the distribution system using the custom power devices. A review of the works done is presented as following.

P. T. Nguyen, Tapan K. Saha [6] presents the modelling aspects of various types of the voltage restorer working with various voltage sags using the simulation on PSCAD/EMTDC. The paper also provides the analysis the quality and capability of its compensation. Results of the simulation showed that the various types of modelled device works very well against balanced and unbalanced voltages due to faults in the distribution system.

D. MahindaVilathgamuwa, H. M. Wijekoon, S. S. Choi, [7] proposes a new concept of interline voltage restoration where two or more than two DVR belonging to different feeders are connected to a DC link in common. One is used to compensate the voltage sag while the other DVR which is connected to common DC Link replenish DC-Link energy storage. The IDVR is incorporated with a current mode control strategy in both the working modes of voltage sag compensation as well as power flow control.

Bingsen Wang, GiriVenkataramanan, [9], presented a new series of power controlling system by using a matrix converter with the help of energy storage which was proposed to cope with voltage sag problem. In order to compensate deep voltage sags of long durations in case of some weak systems, adequate energy storage device is very important. The paper develops a dynamic model of the complete system which includes matrix converter in dual synchronous reference frame coupled to flywheel machine and grid respectively. **Rosli Omar, N. A. Rahim,** [11], presented a paper discussing the design and the development of voltage compensation

techniques by using d-q-o transformation technique. The d-q-o coordinates controllers give a better performance than the conventional controllers. The variable in d-q-o coordinates are controlled which are then transformed inversely to original voltages and produces reference voltage to the DVR. **H. Lakshmi, T. Swapna,** [15], presents the modelling of several types of Dynamic Voltage Restorer which can work against various voltage sag with the help of simulation in PSCAD/EMTDC. The extracted load terminal reference voltage gives the reference signal for the series connected DVR. The performance of the DVR was observed satisfactory for the various power quality problems like swell, sag, unbalance as well as harmonics of the supply voltage.

III. Design Methodology

Conventional DVR uses Sinusoidal Pulse Width Modulated Voltage Source Inverter. But in this thesis, Space Vector Pulse Width Modulation technique is used. The main function of VSC is that it converts the DC voltage which is supplied by the Energy Storage Unit into an AC form of voltage. The DVR power circuit uses step up voltage injection transformer, therefore a VSI with even a low voltage rating would result to be sufficient.

This paper approaches the study of DVR and its application for the voltage sag mitigation. A new approached for the DVR control system has been studied and implemented to get better results as compared to previous techniques used for controlling the DVR. A controller with Space Vector Pulse Width Modulation technique is proposed to obtain higher amplitude index of modulation when compared to the conventional Sinusoidal Pulse Width Modulation technique. It is also easier to implement SV-PWM using the digital processors. A total of about 15 percent higher output is obtained if SV-PWM is used instead of the PWM technique. The main aim of the control system is to maintain a constant voltage at those points where sensitive load is connected. The aim of control system is to measure the r.m.s voltage at the point of load and there is no requirement of reactive power measurement. The switching strategy of the Voltage Source Converter is based on space vector PWM technique offering better response and simplicity. Using SPWM creates some problems like generation of large noise peaks in multiple carrier frequencies. So a different control method based on Space Vector Pulse Width Modulation technique is applied to the DVR's converter.

IV. DVR Controller

There are two main functions of DVR controller; one is to detect the occurrence of sag and derive parameters for the control signal which is to be injected by the DVR. The firing pulses of inverter should be proper. To control the DVR and to let it operate properly during the fault conditions only, controller is required. The load voltage is passes and sensed through a sequence analyser. The actual voltage magnitude is then compared with the reference voltage. The pulse width modulation technique is used for the control system for the inverter switching which then generates a three phase 50Hz sinusoidal voltage at load terminals. The chopping frequency is ranged for approximately 1000Hz. The PI controller is used to control an IGBT inverter which maintains the voltage at load terminals. The PI controller input denotes an actuating signal. This actuating signal is the difference between V_{ref} and V_{in}. The desired firing sequence depends upon the comparison of controller output and SVPWM signal generator.The error signal is processed by the PI controller which then generates required angle δ which finally drives the error to zero. Fig 4.4 shows the controller system for the DVR.

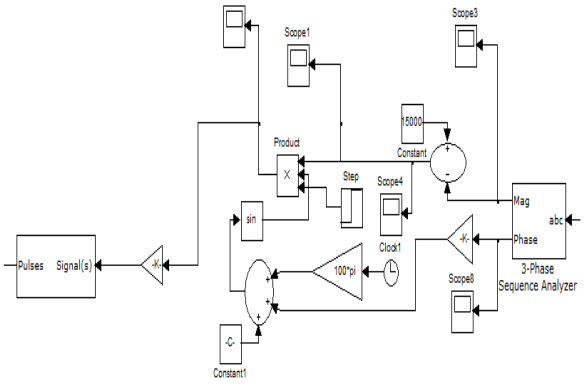


Fig 4.1 Model of DVR controller

The operation of the DVR controller scheme is described with the help of the flow chart.

The load voltage is fed as the input to the 3- phase sequence analyzer block. The magnitude and phase of the incoming voltage signal is analyzed and the magnitude component is next given to the difference block in

which the other input is the desired voltage level of 15k . This voltage level is represented using a constant block of the SimulinkLibrary .The difference of the two voltage level is derived as the output of the difference block and then it is multiplied with the sine function . The output of the sine function block is fed to the pulse generator which generates the square wave pulse of the corresponding magnitude level to serve as the gate signal or the gate pulse of the bridge rectifier. The output of the rectifier is now fed to the feeder line using the help of transformers which serve as isolation and injection transformers.

The following figure shows the comparative study of the voltage with sag and with DVR during the fault as well as the compensated voltage by the DVR during the faulty conditions. The work basically focuses on the analysis of Three phase fault and implementation of DVR for mitigating voltage sag. However , the impact of other faults have been simulated for better understanding.

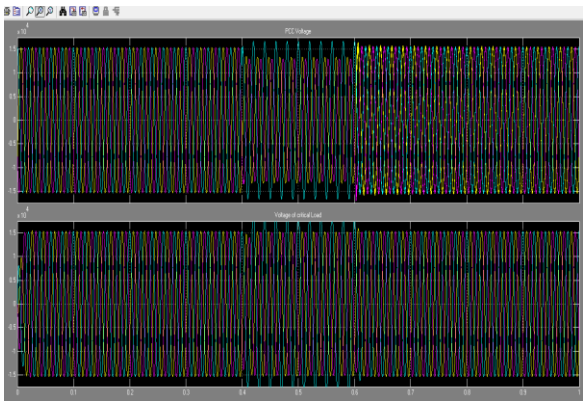


Fig 4.2 Voltage waveform during the Line to Line fault in the proposed system at PCC and Load end

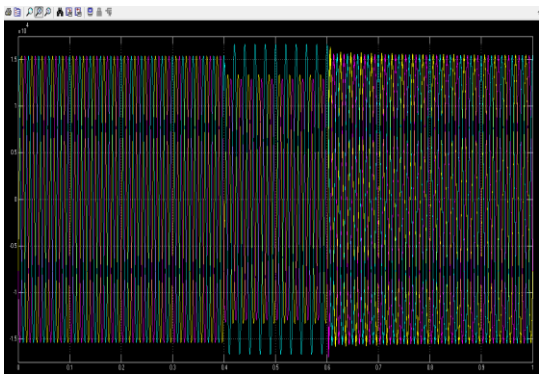
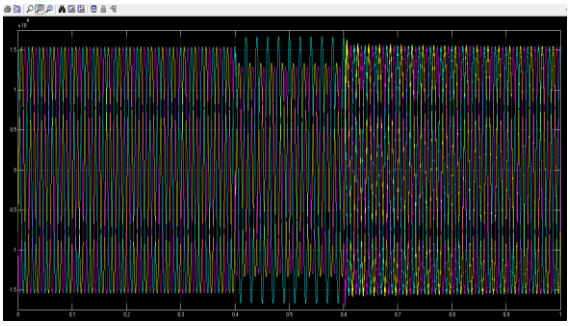


Fig 4.3 Three phase Voltage waveform during theDouble line to Ground fault in the proposed system .



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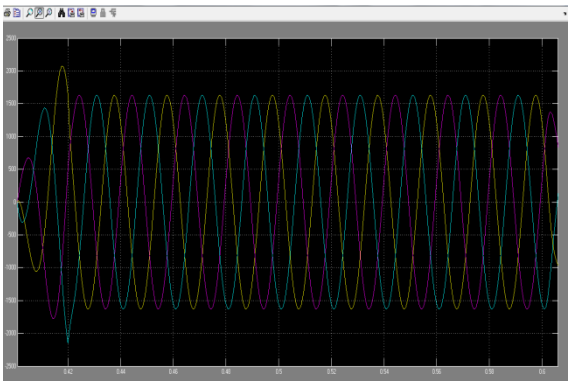

Fig 4.4 Injected voltage waveform at t=0.4 to t=0.6

V. Conclusion

Since there is an increased demand of power quality improvement in distribution system as distribution system is the one that is directly connected to consumer end, there is a need for development of the custom power devices in order to meet this requirement. The failure rate of electrical distribution system is 90% of the average customer interruptions. The main objective of the research work on such devices is improvement of the power quality and reliability of the distribution system with the use of these custom power devices. DVR is being developed and designed so that it can meet various different load demands for power quality improvement. The study of this device is of importance because to overcome the newer problems, the device should be updated with such problems and techniques. Also for the advancement of DVR, it is important to study the advantages and disadvantages so that the disadvantages can be overcome and its features can be further enhanced.

There is a lot of things that can be implemented in future DVR. The Energy source can be substituted by Non-conventional energy source. The controllers can be modified for a better and fast response. Fuzzy logic can be implemented for controlling of DVR more efficiently. Matrix converter can prove to be a better in future DVR to fulfill the converter need. The Injection transformer can be improved. The injection transformer can be proposed to a new level with proposed design that includes an auxiliary coil. This coil can be considered as reactor which provides a solution for inrush current limiter.

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