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MODELING AND SIMULATION OF DYNAMIC VOLTAGE RESTORER FOR VOLTAGE SAG MITIGATION IN DISTRIBUTION SYSTEM

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***Abstract*- Power quality deals with utilization of electric energy from the distribution system successfully without interference or interruption. Various factors like interruption in power supply, under voltage, over voltage, unbalanced voltage or current, harmonic distortion, flickering voltage, voltage fluctuation voltage sag etc. result in poor power quality. These power quality related problems can be solved with the help of various custom power devices. Voltage sags are considered to be the most common type of disturbances in the field based on current power disturbances studies. Their impact on sensitive loads is rigorous. The impact ranges from load disruptions to financial losses. In spite of the technical advances in electronics, there are some pieces of equipment that are so sensitive that they are unable to withstand voltage sags. There are many varies methods to mitigate voltage sags, but a Custom Power Supply device is considered to be the most efficient method. This dissertation is the study of Dynamic Voltage Restorer (DVR) which is the most efficient and effective device to protect sensitive equipment against voltage sags. It has low cost, smaller size and it has dynamic response to the disturbance.**

***Keywords*- Voltage sag, DVR, power system, mitigation**

I. INTRODUCTION

Power system should ensure good quality of electric power supply, which means voltage and current waveforms should be balanced and sinusoidal. Additionally, the voltage levels on the system should be within practical limits, generally within ±5% of their rated value. If the voltage is more or less than this pre-specified value, performance of equipments is sacrificed. Power quality is defined as the condition of voltages and system design so that the customer of electric power can utilize electric energy from the distribution system effectively without interference or disturbance [1]. Power quality may also be defined as the improvement of bus voltage, usually a load bus voltage, to maintain that voltage to be a sinusoid at rated voltage and frequency. Various factors like interruption in power supply, under voltage, over voltage, unbalanced voltage or current, harmonic distortion, flickering voltage, voltage fluctuation voltage sag etc. result in poor power quality. Voltage sags are the most common power disturbance whose effect is quite severe especially in industrial and large commercial customers such as the damage of the sensitivity equipments and loss of daily productions and finances. Voltage sag occurs due to reduction in voltage magnitude for certain time period. Voltage sag is also known as voltage dips. Voltage sag is defined as a decrease in root mean square voltage, (RMS) to values between 0.1 p.u to 0.9 p.u for durations of 0.5 to 1 minute [2]. The prime interest about voltage sags is their effect on sensitive electrical devices, such as personal computers, adjustable speed drives, programmable logic controllers, and other power electronic equipment. The least sensitive loads failed when the voltage dropped to 30 % of the specified voltage. On the other hand, the most sensitive components failed when the voltage dropped to 80-86 % of rated value. Utilities responsible for voltage sag include operation of circuit breakers, equipment failure, transmission/distribution system faults, bad weather, and industrial plant operation. FACTS devices like static synchronous compensator (STATCOM), static synchronous series compensator (SSSC) [3-4], interline power flow controller (IPFC), and unified power flow controller (UPFC) etc are used to improve the power quality. These FACTS devices are planned for the transmission system, but now days more concentration is on the distribution system for the improvement of power quality; these devices are customized and known as custom power devices. The superior custom power is dynamic voltage Restorer (DVR).

II. CONSTRUCTION AND WORKING OF DVR

The power circuit of DVR shows in fig.1 consist of five main essential components [6]; Storage Devices, Voltage Source Inverter (VSI), Passive Filters, By-Pass Switch, Voltage Injection Transformers

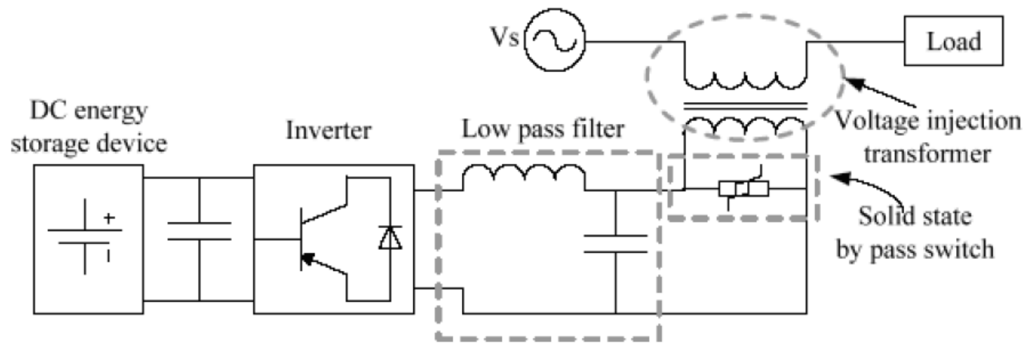

Fig.1. Power Circuit of DVR

The basic idea of DVR is that by means of an injecting transformer a control voltage is generated by a forced commuted convertor which is in series to the bus voltage. A regulated DC voltage source is provided by a battery which acts an energy storage device [5]. Under normal operating conditions when there is no voltage sags, DVR provides very less magnitude of voltage to compensate for the voltage drop of transformer and device losses. But when there is a voltage sag in distribution system, DVR will generate a required controlled voltage of high magnitude and desired phase angle which ensures that load voltage is uninterrupted and is maintained. The DVR is capable of generating or absorbing reactive power but the reactive power injection of the device must be provided by an external energy source or energy storage system. The response time of DVR is very short and is limited by the power electronics devices and the voltage sag detection time. The expected response time is about 25 milliseconds, and which is much less than some of the traditional methods of voltage correction such as tap-changing transformers.

III. MODELING OF DVR IN MATLAB

To validate the implementation of DVR, a MATLAB simulation is carried out. Fig. 2 shows a block diagram which represents three phase, 11kv, 50 Hz source voltage having Phase-to-phase RMS voltage of 11000 V, source resistance of 0.8 Ω, source inductance of 16.5e-3 H, with distribution line R,L parameters as R=0.8929 ohm and L=16.58e-4 H. Three phase to ground fault has been created on distribution line. Fault timing can directly be defined from the dialog box or by applying an external logical signal. Firstly the simulation was done without DVR and a three phase fault is applied to the system at point with fault resistance of 4 ohm and for time duration of 0.2 sec to 0.7 sec. Fig.3 shows both volatge and current waveforms on occurrence of L-L-L-G fault in the system. The second simulation model has been developed for the same system as discussed above but now a DVR is introduced at the load side to compensate the voltage sag occurred due to the three phase to ground fault. Fig. 4 below shows that the voltage profile has been compensated during the fault time by using the proposed DVR model

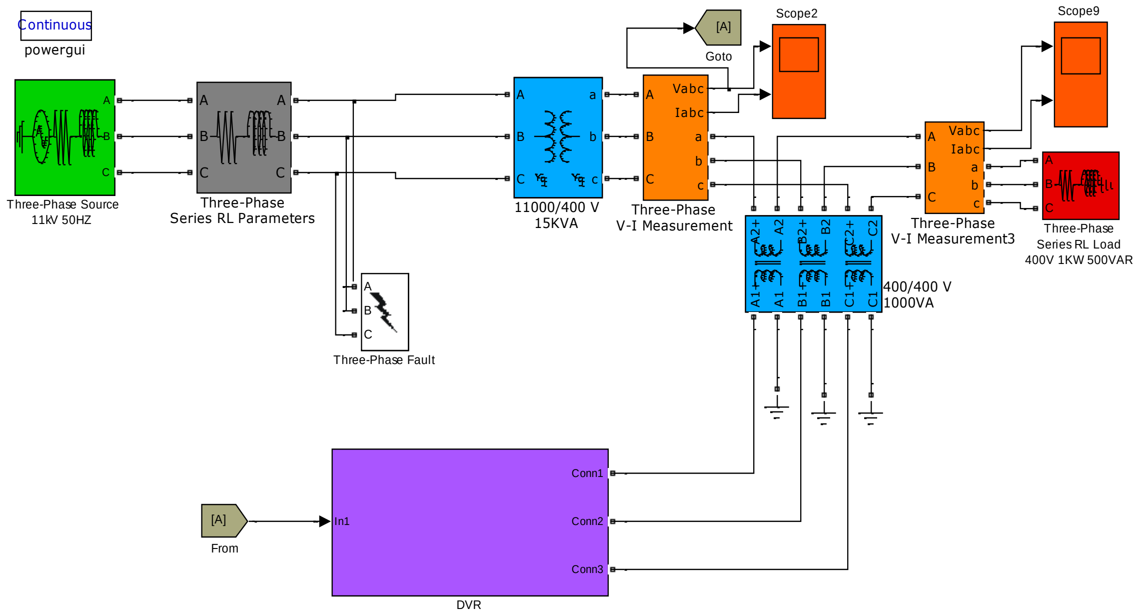

Fig. 2. Generation of voltage sag due a three phase fault in the distribution line without DVR.

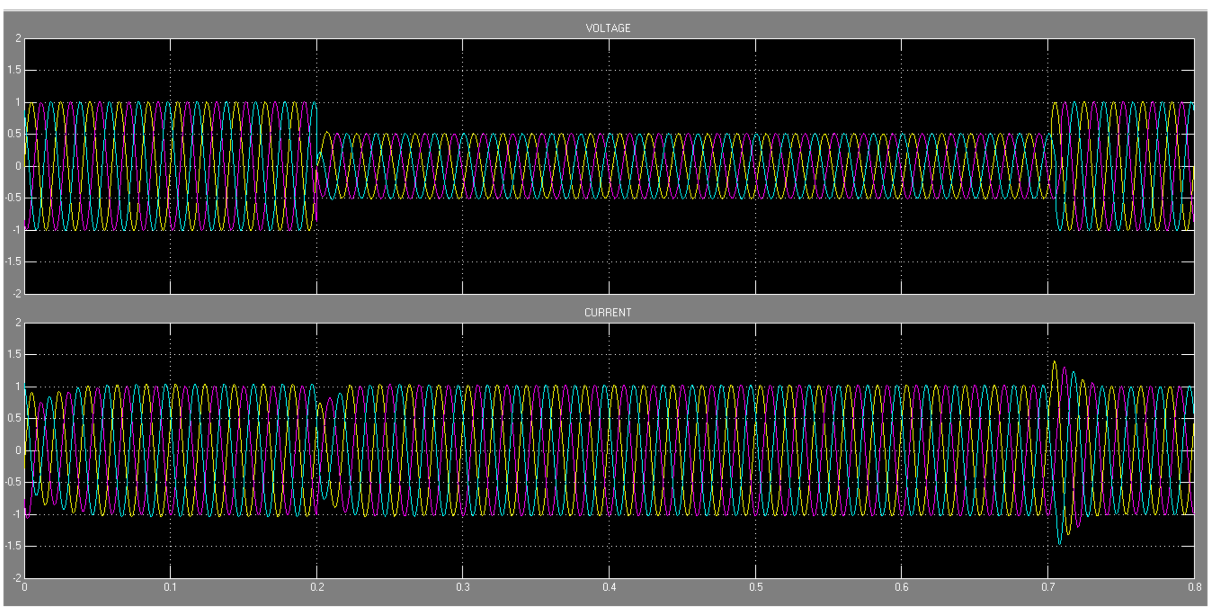

Fig. 3. Three phase per unit line voltage and current waveform without DVR for instantaneous sag

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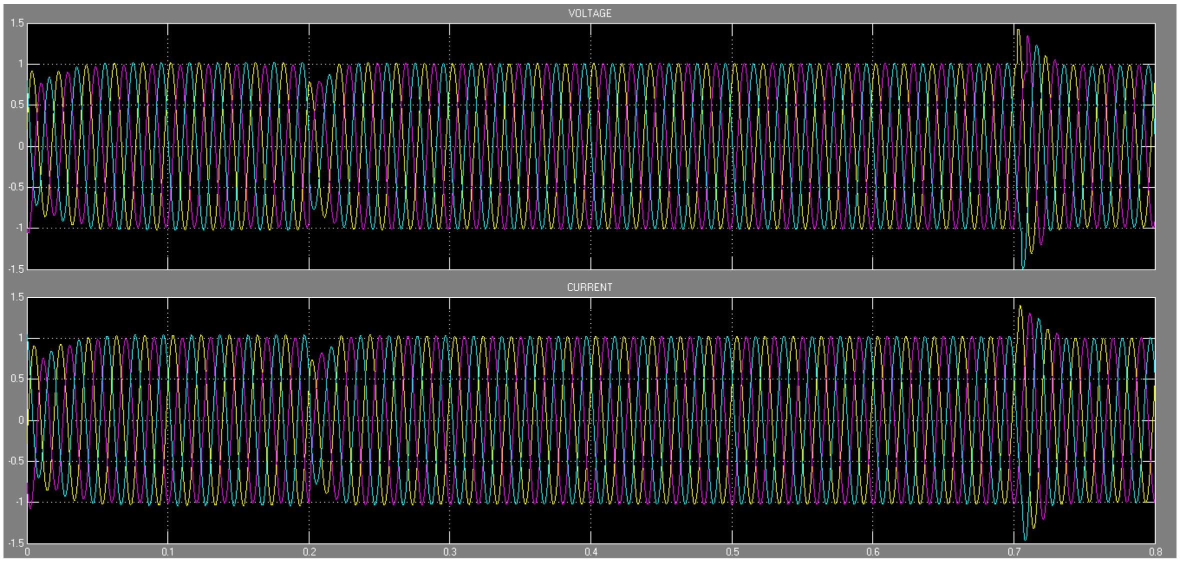

Fig. 4 Three phase per unit load voltage and current waveform with DVR for instantaneous sag.

IV. CONCLUSION

In the proposed work, the mitigation of voltage sag due to a fault in a distribution line has been done by DVR (Dynamic voltage restorer) using simulink in MATLAB. During a fault between 0.25 to 0.75 second, voltage has been dropped from 1 p.u to 0.5 p.u. On implementation of suitable DVR in the test system it has been observed that the voltage profile has been improved during fault condition which has been occurred between 0.25 to 0.75 second. Based on the simulation done, it can be proved that DVR is the dynamic fast response devices that able to overcome the voltage sag. DVR is the custom power device and hence there are so various combinations of main component that can be combined in order to get better results. Implementation of DVR is an efficient solution due to its relatively low cost, small size and its fast dynamic response.

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