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Analysis and simulation of voltage sag/ swell of a distribution system without and with dynamic voltage restorer (dvr)

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***Abstract* - In this technological era, the question of the quality of voltage is rapidly increasing. New technologies are introduced and we are facing many new power quality requirements [18]. Modern industrial devices are mostly based on electronic devices such as programmable logic controllers and electronic control based drives. The electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics. One of these devices is the Dynamic Voltage Restorer (DVR), a modern custom power device used in the most efficient power distribution networks. In this paper, the usefulness of including DVR in distribution system for the purpose of voltage sag and swell mitigation is described. This paper presents modeling, analysis and simulation of a Dynamic Voltage Restorer (DVR) using MATLAB.**

***Index Terms* - Voltage sag, Voltage swell, Dynamic Voltage Restorer**

I INTRODUCTION

Power quality problems are of wide preferable area for the discussion due to the increased use of critical equipments like communication network, process industries etc. [5].

Power Quality problems encompass a wide range of disturbances such as voltage sags/swells, flicker, harmonics distortion, impulse transient and interruptions. Distribution system locates the end of power system and is connected to the customer. So the power quality mainly depends on distribution system. The reason behind this is that the electrical distribution system failure accounts for about 90% of the average customer interruption.

Presently these devices are modified for the use in distribution system so that power quality can be further improved. These modified devices are called Custom Power Devices. The basic Custom power devices which are used for power quality improvement in distribution system are DSTATCOM (Distribution Static Synchronous Compensator), DVR (Dynamic Voltage Restorer), UPQC (Unified Power Quality conditioner) etc. Among these device, Dynamic Voltage Restorer (DVR) belongs to series connected FACTS controllers. The primary function of a DVR is to compensate voltage sags and swells. But it can also perform tasks such as harmonics elimination, reduction of voltage transients and fault current limitation [18].

II. OPERATING PRINCIPLE

The fundamental principle behind DVR operation is that it injects a voltage waveform through an injection transformer that is the difference between pre-sag and sagged voltage. This is demonstrated in Fig. 1 [17].

This is made possible by the supply of required real/active power from an energy storage device along with reactive power. The injection transformer ratio and ratings of the energy storage device can put limitations on the maximum injection capability of DVR.

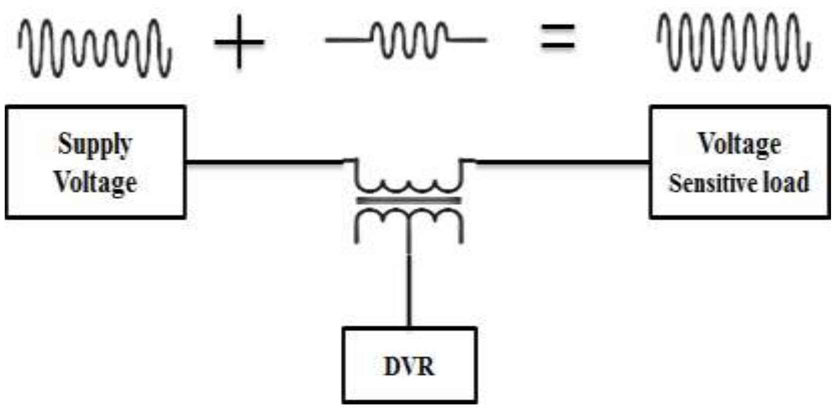

Fig 1:operation of dvr

Separate control over the magnitude of injected voltage is usually done for a three single phase DVRs.

III BASIC CONFIGURATION OF DVR`

The general configuration of the DVR as shown in the schematic diagram of DVR as shown in Fig. (2) [17]. Consists of:

A Injection/ Booster transformer
B Harmonic filter
C Voltage Source Converter (VSC)
D DC charging circuit
E Control and Protection system

A Injection/ Booster transformer

The Injection / Booster transformer is a specially designed transformer that attempts to limit the coupling of noise and transient energy from the primary side to the secondary side. It connects the DVR to the distribution network via the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage. In addition, the Injection / Booster transformer serves the purpose of isolating the load from the system (VSC and control mechanism).

B Harmonic filter

The main task of harmonic filter is to keep the harmonic voltage content generated by the VSC to the permissible level.

C Voltage Source Converter (VSC)

A VSC is a power electronic system consists of a storage device and switching devices, which can generate a sinusoidal voltage at any required frequency, magnitude, and phase angle. In the DVR application, the VSC is used to temporarily replace the supply voltage or to generate the part of the supply voltage which is missing.

There are four main types of switching devices: Metal Oxide Semiconductor Field Effect Transistors (MOSFET), Gate Turn-Off thyristors (GTO), Insulated Gate Bipolar Transistors (IGBT), and Integrated Gate Commutated Thyristors (IGCT). Each type has its own benefits and drawbacks.

The IGCT is a recent compact device with enhanced performance and reliability that allows building VSC with very large power ratings. Because of the highly sophisticated converter design with IGCTs, the DVR can compensate dips which are beyond the capability of the past DVRs using conventional devices.

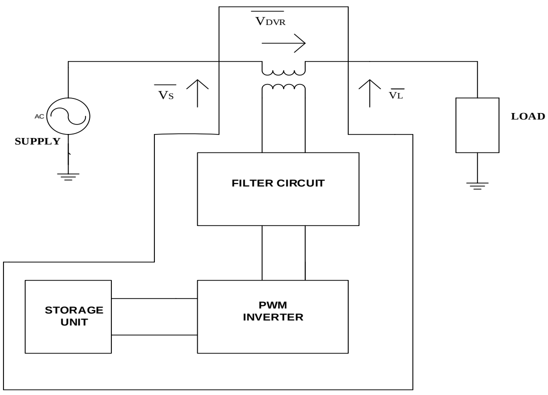

Figure :2 schematic diagram of dvr

D DC charging circuit

The dc charging circuit has two main tasks. The first task is to charge the energy source after a sag compensation event. The second task is to maintain dc link voltage at the nominal dc link voltage.

E Control and Protection system

The control mechanism of the general configuration typically consists of hardware with programmable logic. All protective functions of the DVR should be implemented in the software. Differential current protection of the transformer, or short circuit current on the customer load side are only two examples of many protection functions possibility

IV TEST SYSTEM

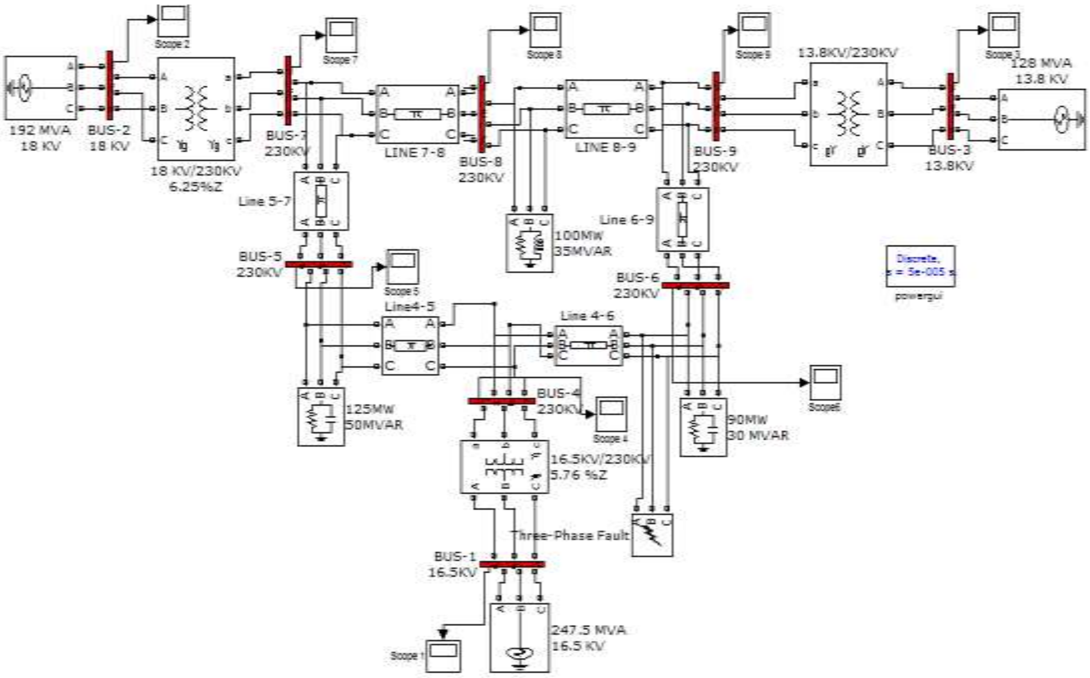

Fig 4.1 ieee 9 bus system

V RESULT

IEEE 9 BUS SYSTEM (without dynamic voltage restorer)
FAULT CONDITION (BUS NO 6)

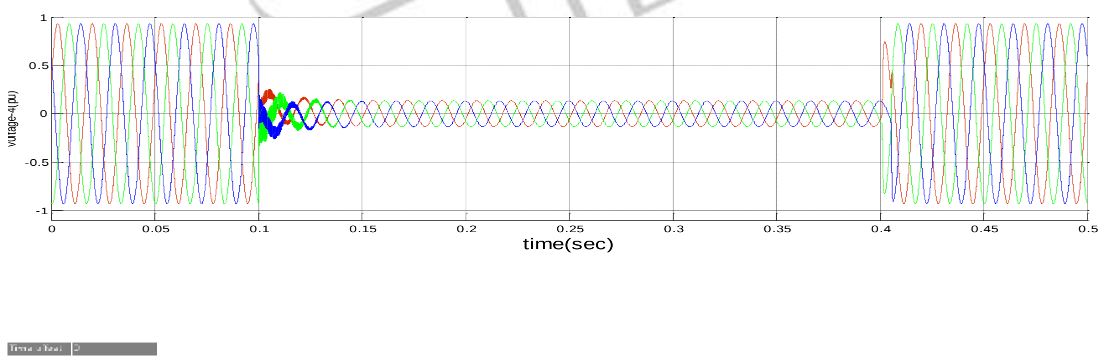

Fig No 4.2 bus no 4 voltage sags (without dynamic voltage restorer)

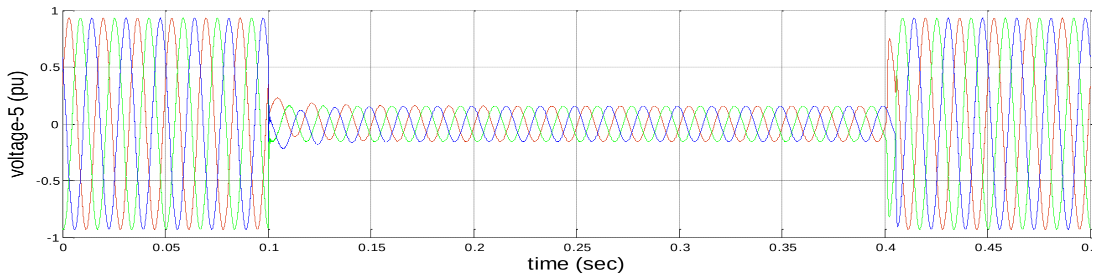

Fig No 4.3 bus no 5 voltage sags (without dynamic voltage restorer)

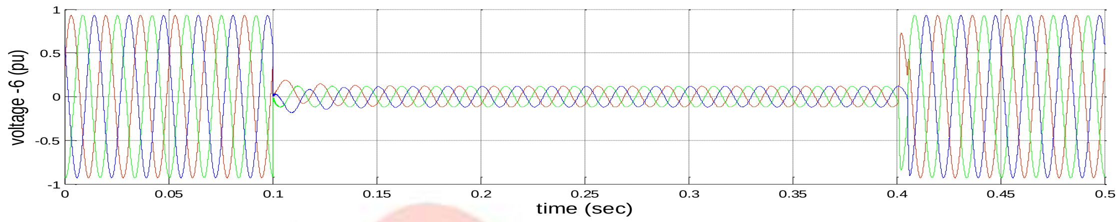

Fig No 4.4 bus no 6 voltage sags (without dynamic voltage restorer)

IEEE 9 BUS SYSTEM (with using dynamic voltage restorer)

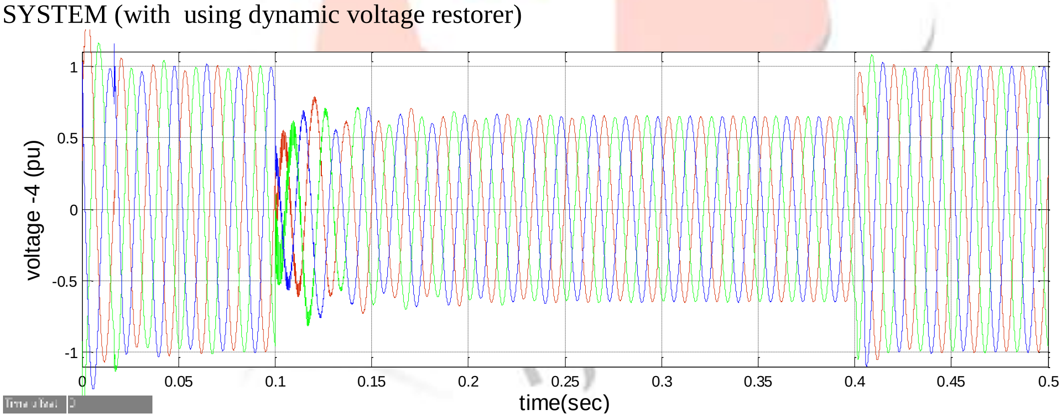

Fig No 4.5 bus no 4 voltage sags (with using dynamic voltage restorer)

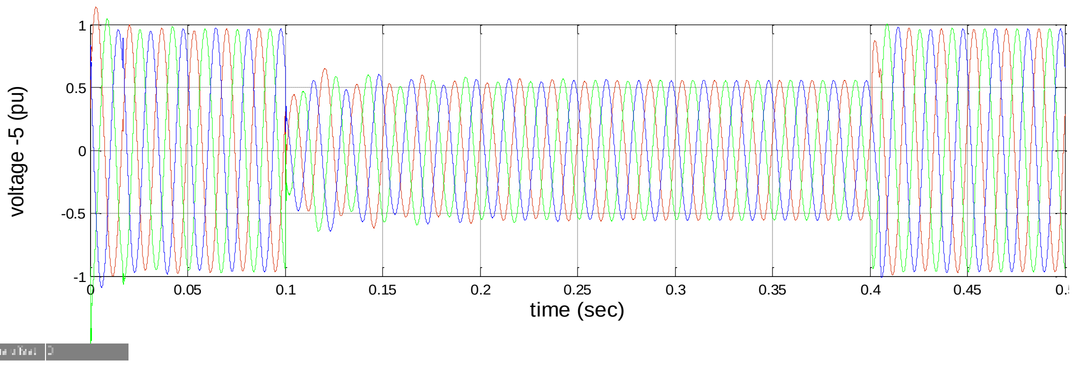

Fig No 4.6 bus no 5 voltage sags (with using dynamic voltage restorer)

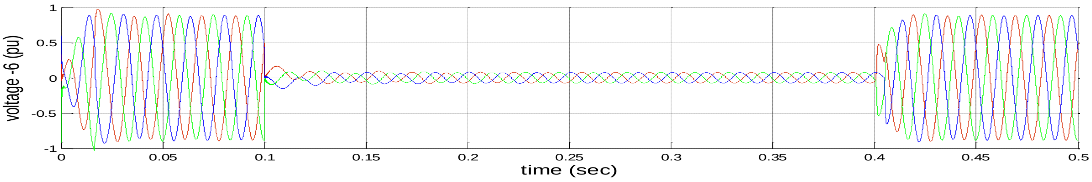

Fig No 4.7 bus no 6 voltage sags (with using dynamic voltage restorer)

Voltage swells:

IEEE 9 BUS SYSTEM (without dynamic voltage restorer)

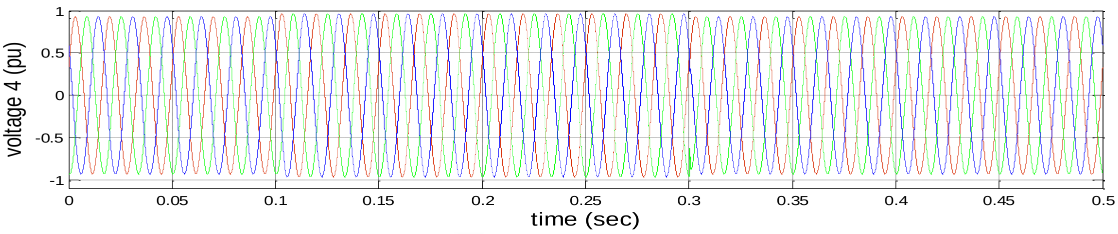

Fig No 4.8 bus no 4 voltage swells (without dynamic voltage restorer)

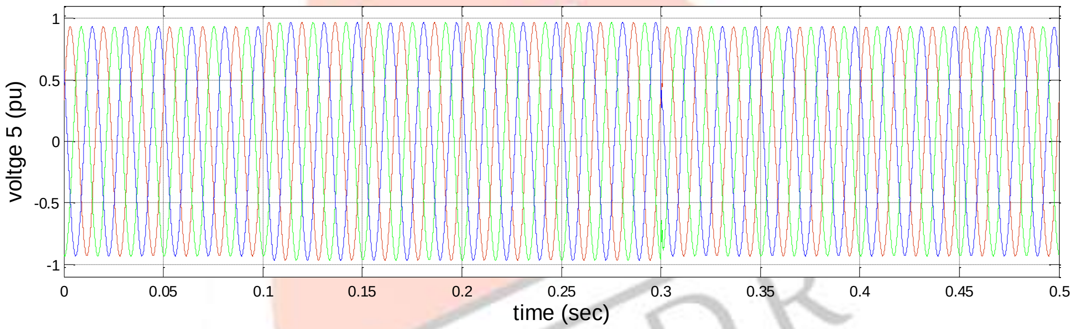

Fig No 4.9 bus no 5 voltage swells (without dynamic voltage restorer)

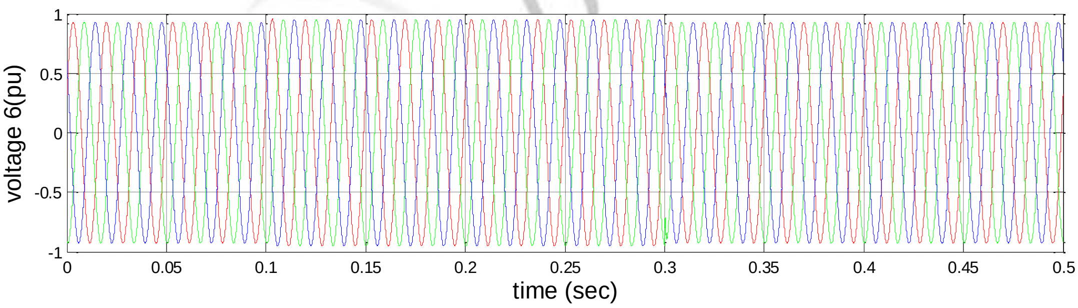

Fig No 4.10 bus no 6 voltage swells (without dynamic voltage restorer)

IEEE 9 BUS SYSTEM (with using dynamic voltage restorer)

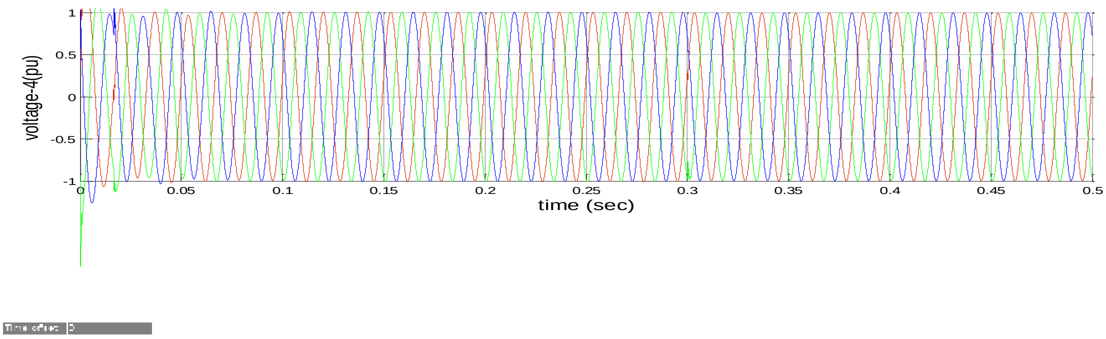

Fig No 4.11 bus no 4 voltage swells (with using dynamic voltage restorer)

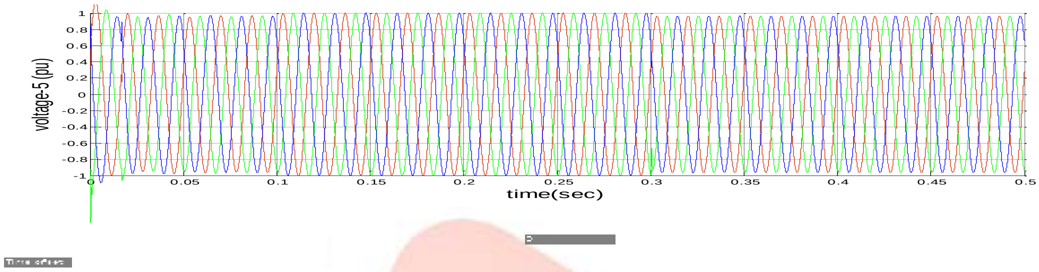

Fig No 4.12 bus no 5 voltage swells (with using dynamic voltage restorer)

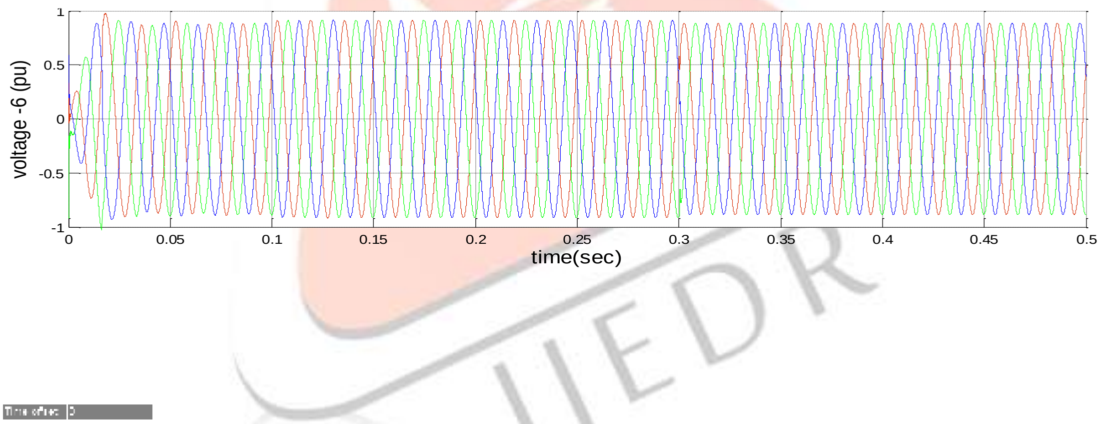

Fig No 4.13 bus no 6 voltage swells (with using dynamic voltage restorer)

VI CONCLUSION

The basic concept of voltage sag and swell is given. In MATLAB SIMULINK, IEEE 9 bus system is modeled and its result is obtained for normal and abnormal condition. From the waveform of abnormal condition, it can be seen that voltage sag takes place in the system due to three phase fault which make the system unhealthy and one need to take care of this. Care of voltage sag and swell can be taken out by using DVR. The simulation results clearly shows the voltage sag and swell due to three phase fault condition in distribution system.

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