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Voltage Profile Improvement Using Dynamic Voltage Restorer (DVR) In Distribution System

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Abstract: **One of the major problems observed in distribution system in recent days is Power Quality. Today most of the people are using the sophisticated electrical equipment based on semiconductor device, these equipment pollute the power quality. Hence there is a need to improve voltage profile. The Dynamic Voltage Restorer (DVR) is recognized as the best solution for mitigation of voltage sag associated problems in the highly taped distribution system. This work presents the simulation modeling and analysis of advanced DVR system for solving these problems. The three phase fault is creating in the system and for analyzing the result. The role of DVR is to compensate the load current and voltage is investigated during the fault condition. Over all the DVR is improving the voltage quality as well as the reactive power demand during the uncharacteristic condition**

Keywords: **voltage regulator, DVR, Voltage source inverter, LC- filter, PWM generator.**

I. INTRODUCTION

It had been observed that in modern industrial devices most of devices are based on electronic devices such as programmable logic controllers and electronic drives. The power electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics in the entire problems associated with voltage dips is considered as one of the most severe disturbances to the industrial equipment. The problem of poor power quality like voltage sag for sensitive loads can be better dealt or solved by power electronics based Dynamic Voltage Restorer. With the application of DVR, the power system can be operated without voltage sag and the power supply by flexibly changing the distribution configuration after the occurrence of a fault. Basic functions of customer power applications are fast switching and current or voltage injection for correcting anomalies in supply voltage or load current.

The DVR is a series conditioner based on a pulse width modulated (PWM) voltage source inverter (VSI), which could generate or absorb real or reactive power independently. The condition of Voltage sags caused by unsymmetrical line to line, single line to ground (SLG), double line to ground fault and symmetrical three phase faults is, influenced in case of sensitive loads. The DVR injects the individual voltages to restore and maintained sensitive loads to its nominal value. The combination of the custom power devices DVR with PI controller for the power quality improvement in the distribution system. Here linear load are considered, only when different fault conditions are measured with these loads to analyze the operation of DVR to improve the power quality in distribution system.

A new control strategy has been developed for achieving maximum benefits by eliminating or mitigating voltage and power quality problem when abnormal condition occur in the distribution system,

for this purpose the dynamic voltage restorer is proposed to improve the power quality and to reduce the sag problem in the system. We have implemented the features of DVR for maximum utilization of distribution voltage, which are not fully utilized due to intermittent nature of distribution voltage because our system was highly tapped.

II. POWER QUALITY PROBLEMS AND SOLUTIONS

Power quality means the fitness of electrical power and its stabilized disposition to power consumer device. PQ problem is defined as any problem manifested in voltage, current or a frequency deviation that leads to the failure or disoperation

of consumer equipment. Power quality is not a single unit measurement it is a collection of several type which includes Capacitor switching, lightning surge (Transient), Interruptions, Sags/Swells (Disturbance), Harmonics, Flicker, Voltage regulation, Reliability, Power factor (Steady-state).

There are several types of power quality problems that a customer may encounter and may classified according or depending on how the voltage waveform is being distorted. There are transients, short duration of variations (sags, swells, and interruption), long duration variations (sustained interruptions, under voltages, over voltages), voltage imbalance, waveform distortion (dc offset, harmonics, inter harmonics, notching, and noise), voltage fluctuations and power frequency variations

Solutions of Power Quality Problems:

In general, there are two come within reach of followed to alleviate the tribulations associated with power quality. First approach is called load training, which guarantees that the equipment is less perceptive to power turbulence permitting the operation still below significant voltage deformation and the second approach is to mount line conditioning schemes that suppress or neutralizes the power schemes turbulences. The procession conditioning system or convenience side solutions will participate a major role in improving the inherent supply quality; some of the effective and economic measures can be identified which are as follows: Lightening and Surge Arresters, Thyristor Based Static Switches, Energy Storage Systems, Harmonic Filters etc

III. DYNAMIC VOLTAGE RESTORER

Among the several type of power quality problems (sags, swells, harmonics) voltage sags are the most severe type of disturbances. In order to overcome problems associated with power quality, the concept of custom power devices is introduced in recent times. One of those devices most recognizable and good in performance is the Dynamic Voltage Restorer, which is the most efficient and effective modern custom power device used in power distribution networks.

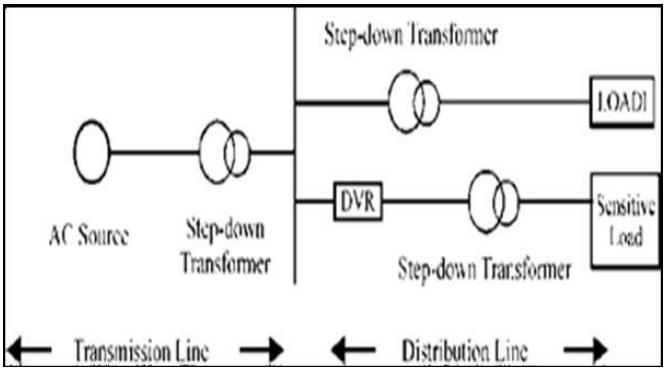


Fig. 3 location of DVR

Basic Principle of DVR Operation:

A DVR is a solid state power electronics switching device consisting of whichever GTO or IGBT, a capacitor depository as an power storage device and inoculation transformer. It is linked in series between a distribution and a load that shown in figure 4

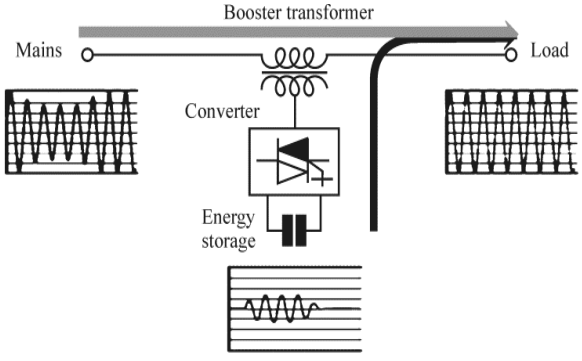


Fig. 4 Principle of DVR with a response time of less than one millisecond

The DVR is capable to generate or absorb reactive power but the active 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.

Basic Configuration of DVR:

The general arrangement of the DVR is composition of Injection/ Booster transformer, Harmonic filter, Storage Devices, Voltage Source Converter (VSC), DC charging circuit, Control and Protection system.

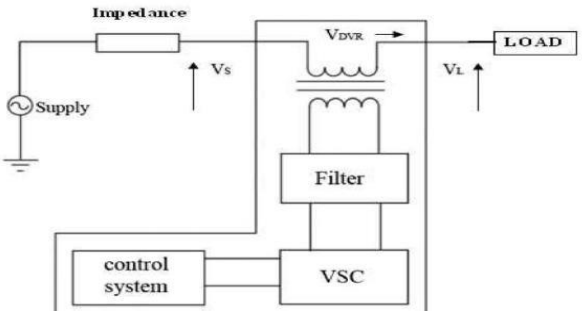


Fig. 5 Schematic diagram of DVR

There are four dissimilar methods of DVR voltage injection.

1. Pre-Sag/dip Compensation Method (PDC):

In this technique or procedure the injected vigorous power cannot be managed and it is determined by external condition such as the type of faults.
Where VL* is the pre sag voltage.
VDVR = Vpre fault – Vsag

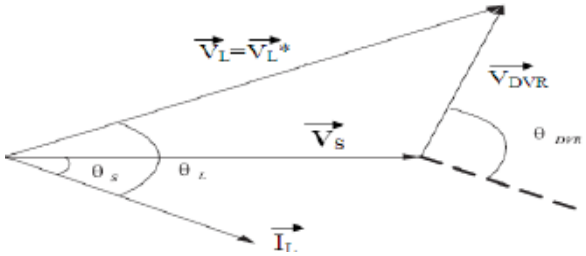


Fig. 6 Single-phase vector diagram of the PDC method

2. In - Phase Compensation Method (IPC):

This method is that the minimum amplitude of DVR injected voltage for certain voltage sag in comparison with other strategies. The practical submission of this scheme is in non-sensitive loads to phase angle jump. Where VL* is the pre sag voltage and IL* Pre-sag load current, θ1 = θS.

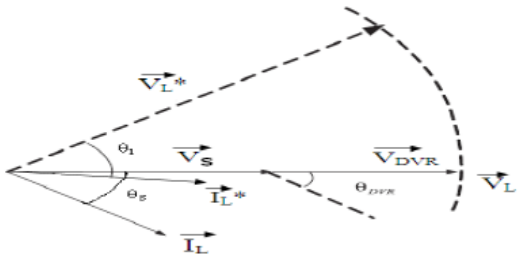


Fig. 7 Single-phase vector diagram of the IPC method

3. In-Phase Advanced Compensation Method (IPAC):

In this method the real power spent by the DVR is decreased by minimizing the power angle between the sag voltage and load current. In this method the vigorous power is generally injected into the system during disturbances.

4. Voltage Tolerance Method with Minimum Energy Injection:

This compensation method will maintain the load voltage within the tolerance area with small change of voltage magnitude as shown in Fig -8

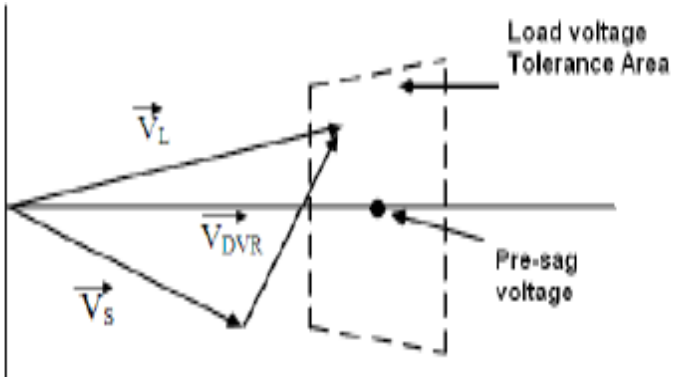


Fig. 8 Voltage tolerance method with minimum energy injection

IV. MATHEMATICAL MODELING OF DYNAMIC VOLTAGE RESTORER SYSTEM

Series Voltage Injection by DVR System:

The compensation of voltage sag/swell can be limited by a number of factors, which includes limited DVR power rating, loading situations, power class tribulations and types of sag/swell. The electrical circuit model to indicate voltage injection by a DVR system is shown in Fig.9

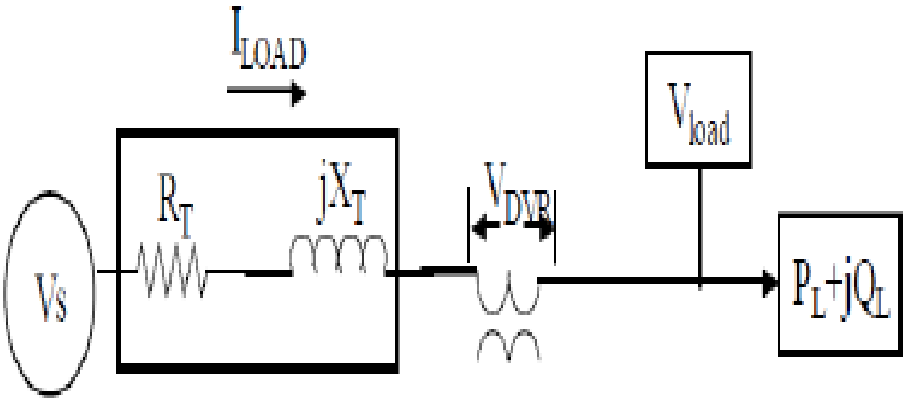


Fig. 9 Electrical Circuit Model for DVR Voltage Injection

V. IMPLEMENTATION OF DYNAMIC VOLTAGE RESTORER SYSTEM USING IN MATLAB/ SIMULATION

Proposed With and with –out DVR System Model:

In this SIMULINK model there is a system in which two parallel feeders are presented and in both the feeders, further loads are also connected in parallel. PI controller is used for the control purpose. Here DVR system is connected to the distribution system using a booster transformer. In order to study the effects of the entire DVR System the proposed system is modeled using MATLAB/SIMULINK environment by using different toolboxes.

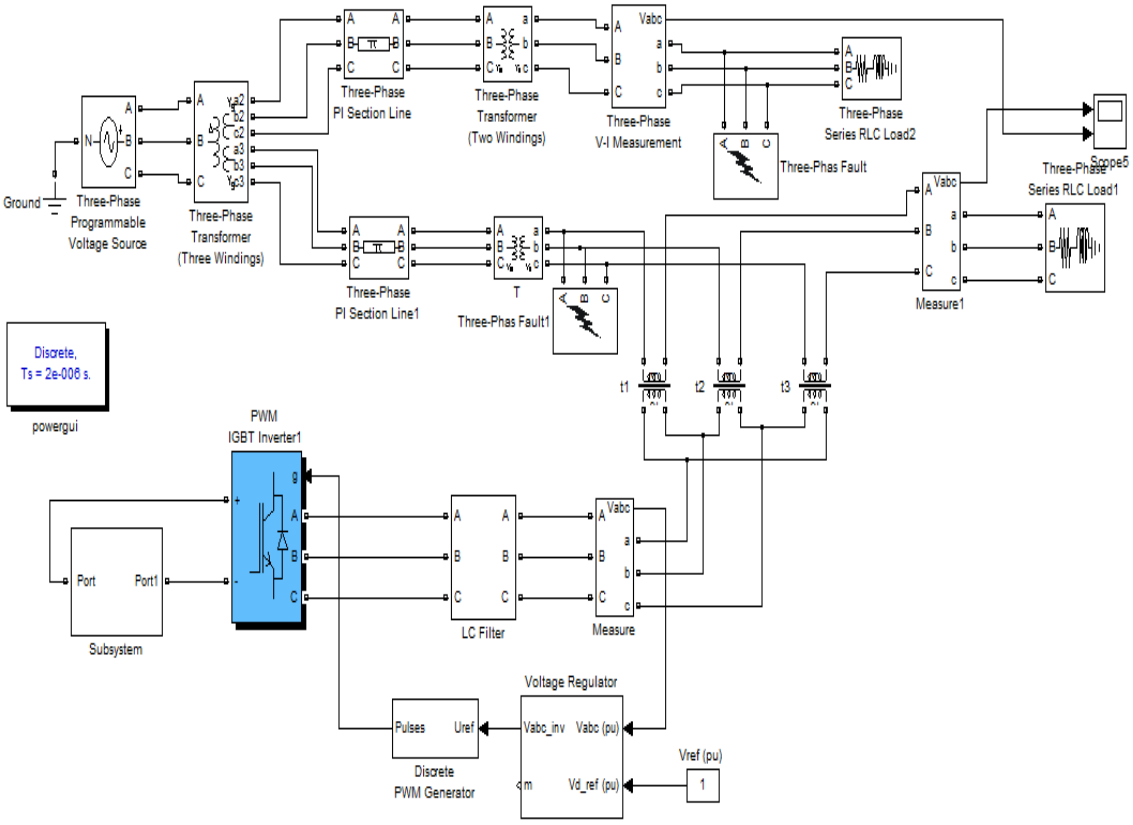
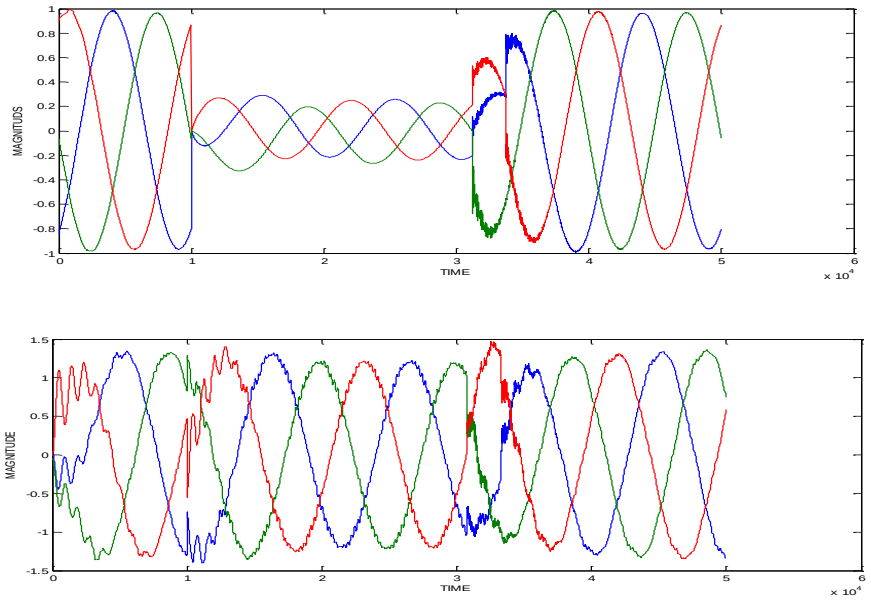


Fig. 10 Proposed with and without DVR System Model in MATLAB/SIMULINK

VI. SIMULATION RESULTS AND DISCUSSION

In this paper, simulation results for the developed Dynamic Voltage Restorer system connected to the distribution system is presented for both the with and without DVR system conditions. Several different conditions' i.e. voltage dip, single line to ground, double line to ground, triple line to ground etc. simulation result are presented to validate the developed models and control for the proposed DVR system.

Response for Voltage dips of 50% with and without DVR



Future Scope

The following issues are under recommendation for future work in DVR:

• Change the controller of DVR like fuzzy based controller, ANN based controller and PSO based controller scheme.

• The multi-level DVR can be investigated for future work.

• Use of DVR for interconnecting the renewable source to grid.

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