Power Quality Improvement using SVPWM based Dynamic Voltage Restorer (DVR)

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Abstract - Power Quality in electric power systems network is one of the most concerned subjects of electric power system for researchers and academic scholars. Power quality degradation has serious economic impact for consumers, utilities and electrical equipment manufacturing industries. A portion of the fundamental power quality issues are sag, swell, transients, harmonic, and flickers and so forth. The higher index of reliability & power quality to satisfy the customer has reflected the need for the development & application of compensation systems. They have a tendency to retain the various disturbances by injecting desired voltage, current or both into the system; in this manner relieving the main source from meeting the reactive power demand of the load. This work presented a power quality enhancement strategy using space vector pulse with modulation (SVPM) based dynamic voltage restores.

Keywords- Power quality improvement, SVPWM, Dynamic voltage restorer. Power quality control.

I. INTRODUCTION

The electric power system is considered to be composed of three functional blocks - generation, transmission and distribution. For a reliable power system, the generation unit must produce adequate power to meet customer's demand, transmission systems must transport bulk power over long distances without overloading or jeopardizing system stability and distribution systems must deliver electric power to each customer's premises from bulk power systems. Distribution system locates the end of power system and is connected to the customer directly, so the power quality mainly depends on distribution system. The reason behind this is that the electrical distribution network failures account for about 90% of the average customer interruptions. In the earlier days, the major focus for power system reliability was on generation and transmission only as these more capital cost is involved in these. In addition their insufficiency can cause widespread catastrophic consequences for both society and its environment. But now a day's distribution systems have begun to receive more attention for reliability assessment.

Initially for the improvement of power quality or reliability of the system FACTS devices like static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), interline power flow controller (IPFC), and unified power flow controller (UPFC) etc are introduced. These FACTS devices are designed for the transmission system. But now a days more attention is on the distribution system for the improvement of power quality, these devices are modified and known as custom power devices. The main custom power devices which are used in distribution system for power quality improvement are distribution static synchronous compensator (DSTATCOM), dynamic voltage Restorer (DVR), active filter (AF), unified power quality conditioner (UPQC) etc.

Power quality is an issue that is becoming increasingly important to electricity consumers at all levels of usage. Sensitive equipment and non-linear loads are common place in both the industrial and domestic environment and disturbances can originate from these loads which includes non-linear loads like adjustable speed drives, traction drives, starting of large induction motor etc., typical power quality disturbance are voltage fluctuation, flickering, sag, swell, spikes in waveforms, harmonic distortion and unbalance.

Poor power quality can be defined as any event related to power system network that actually results in financial loss. The effects of poor power quality can be equipment failure, malfunctioning of equipment, overheating, damage to sensitive equipment, electronics communication interferences, penalties imposed by utilities and refusal of new sites to get connected to the grid.

With the recent advancements in power electronic devices, there are many possibilities to reduce these problems in the power system. One of them is the use of Flexible AC Transmission System (FACTS) devices. FACTS technology has a collection of controllers that can be used individually or coordinated with other controllers installed in the network. The FACTS controllers offer great opportunity to regulate the transmission of alternating current, increasing or diminishing the power flow and ability of connecting networks that are not adequately interconnected. The connection of these devices in the power system helps in improving the power quality and reliability. In this project compensation of reactive power using different kinds of FACTS devices are studied analyzed.

Under normal power supply conditions, the DVR should be in off condition such that it should not inject any voltage through the series transformer. At the same time the power has to flow from grid to load. So the low voltage side of the series transformer is shorted either by a solid state bypass switch or by switching one of the inverter legs. The series transformer will then act as a short circuited current transformer. Since no switching takes place, the power loss is only that of the series transformer. This loss should be kept a minimum as DVR will be in off condition in most of the time. The short circuit impedance of the injection transformer determines the voltage drop in the DVR under normal condition. So this impedance must be low. The short circuit impedance also affects the fault current through the VSI on secondary side caused by a short circuit at load side and In case of fault or over current exceeding the rating of DVR on the load side, solid-state bypass switches or electromechanical by-pass switches must be provided as a measure to protect DVR from getting damaged.

When a disturbance occurs the DVR will be in the compensating mode and the switches will be modulated to generate the required compensating voltage. When the DVR is compensating, the required energy for compensation has to be supplied by an energy source.

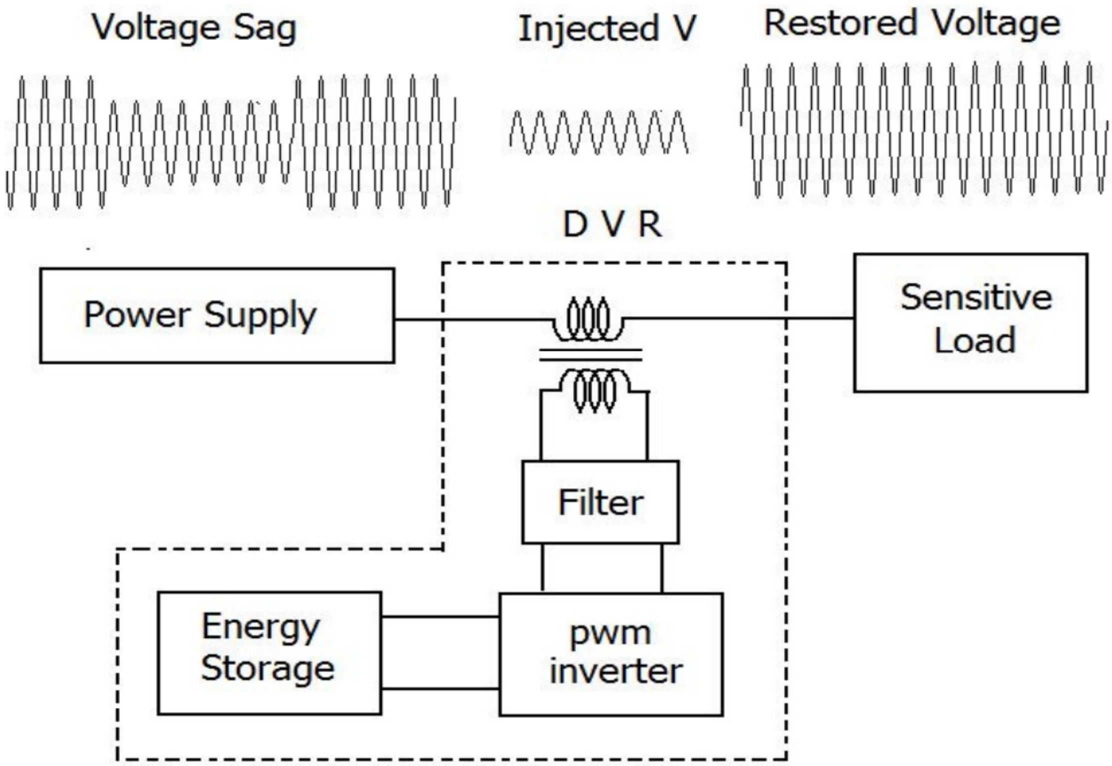

Figure 1.1 Topology of a conventional DVR.

II. PROPOSED SYSTEM

The Proposed system is based on a multilevel DVR system as demonstrated in figure 2.1. Configuration of a proposed multilevel DVR system. There is multiple level of voltage control with space vector pulse width modulation strategy has been used to design proposed system on Matlab. A space vector based DVR has been demonstrated in figure 2.3. There is a discrete SVPWM generator block is used in SVPWM based DVR. There is universal bridge connected with unit delay.

Figure 2.4 Demonstrated SVPWM techniques for power quality control. There are following fundamental blocks are used as demonstrated in figure 2.4.

- A phase modulator.
- A Discrete PI controller
- 3- Phase Sequence Analyzer
- A SVPWM modulator

A Discrete PI controller:- PI controllers are widely known for their flexibility combined with the relatively easy tuning capability. This application note describes the conversion from the continuous to the discrete time domain, which is essential for every implementation on a digital controller. To design proposed system implements the discrete time representation of the PI controller.

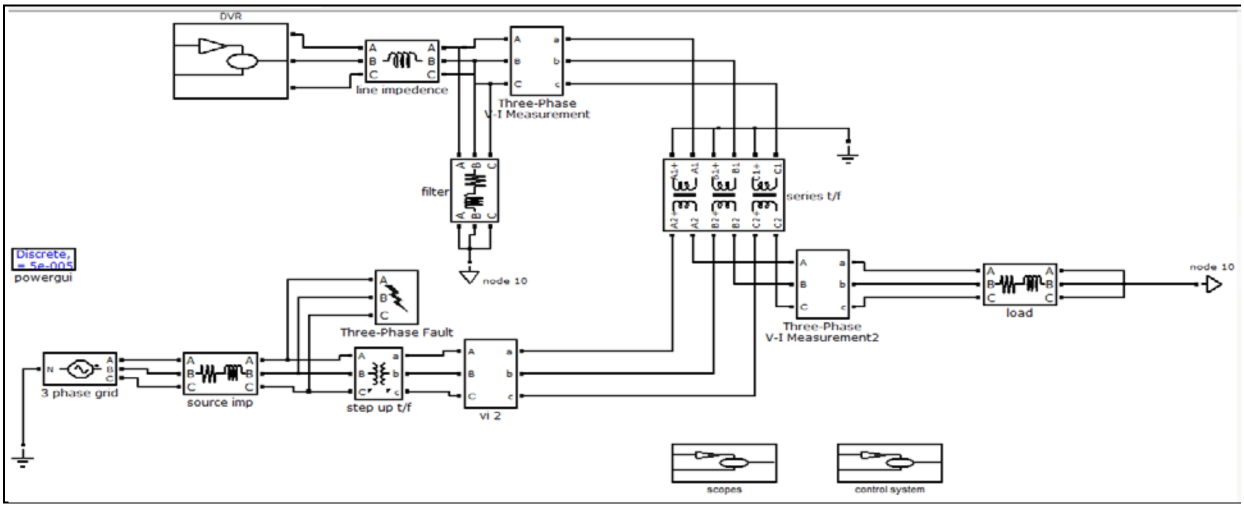

Figure 2.1 multi level DVR

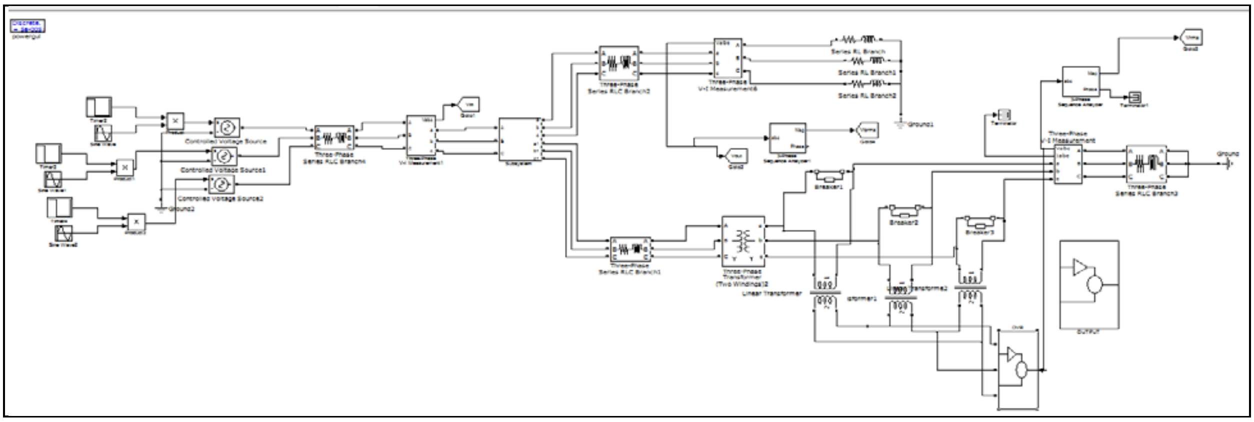

Figure 2.2 SVPWM (space vector pulse width modulation) based DVR.

3- Phase Sequence Analyzer:- The Three-Phase Sequence Analyzer block is used to yields the magnitude and phase of the positive- (denoted by the index 1), negative- (index 2), and zero-sequence (index 0) components of a set of three balanced or unbalanced signals. The signals can contain harmonics or not. The three sequence components of a three-phase signal (voltages V_1 V_2 V_0 or currents I_1 I_2 I_0) are computed as follows:

$$V_1 = (V_a + aV_b + a^2V_c)/3V_2$$
$$= (V_a + a^2V_b + aV_c)/3V_0$$
$$= (V_a + V_b + V_c)/3$$

Where V_a,V_b,V_c = Three voltage phasors at specific frequency

$$a = e^{j2\pi/3} = 1\angle 120^0$$

A SVPWM modulator: - The most widely used PWM schemes used in proposed work for three-phase voltage source inverters are carrier-based sinusoidal PWM and space vector PWM (SVPWM). There is an increasing trend of using space vector PWM (SVPWM) because of their easier digital realization and better dc bus utilization.

The SVPWM can be implemented by using wither sector selection algorithm or by using a carrier based space vector algorithm. The types of SVPWM implementations are:-

a) Sector selection based space vector modulation

b) Reduced switching Space vector modulation

c) Carrier based space vector modulation

d) Reduced switching carrier based space vector modulation.

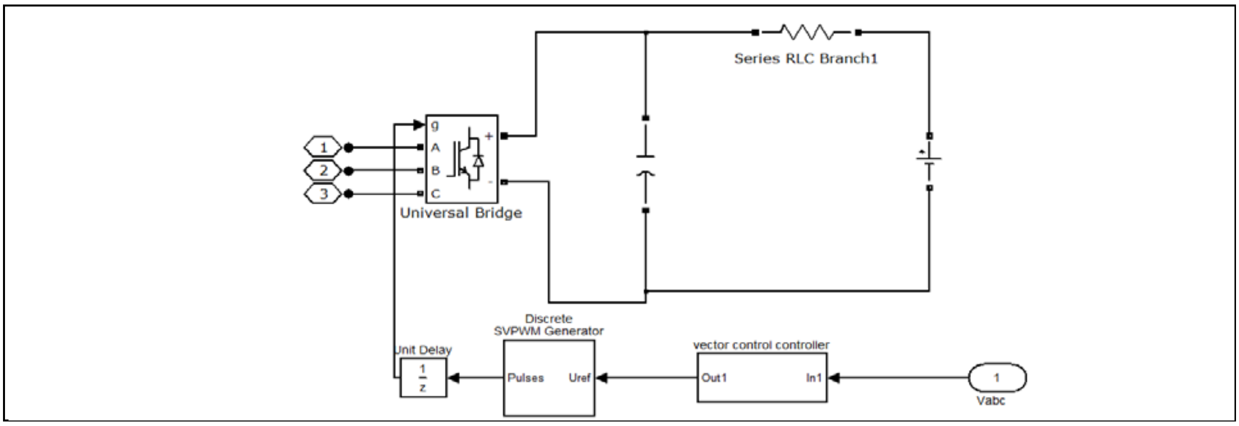

Figure 2.3 SVPWM based DVR.

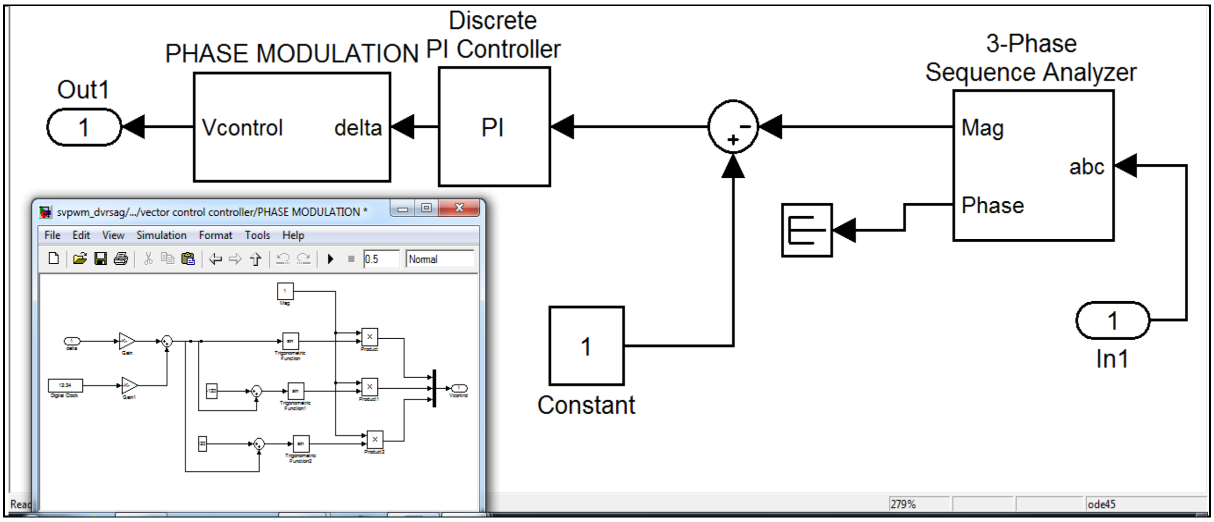

Figure 2.4 SVPWM techniques.

III. SIMULATION RESULTS

Matlab based simulation results are provided in figure 3.1 and figure 3.2 wave form of proposed system to verify performance of the proposed multilevel SVPWM DVR topology. The simulations are performed for two different case studies of voltage sag disturbances. Simulation results are given.

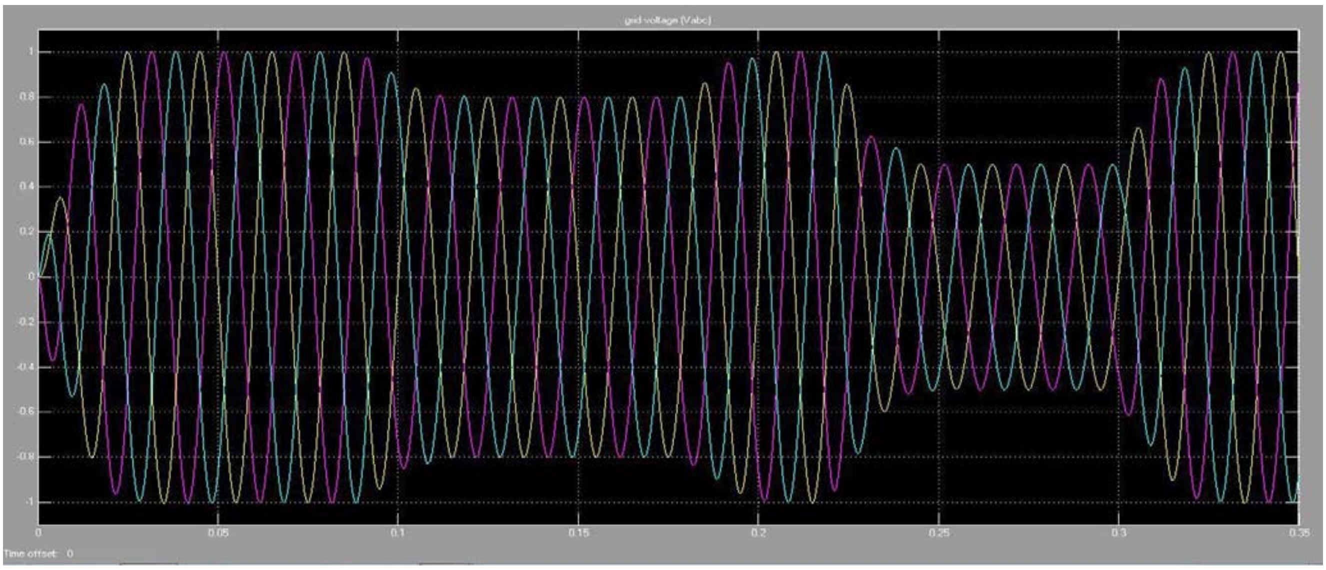

Figure 3.1 Distortion in power supply.

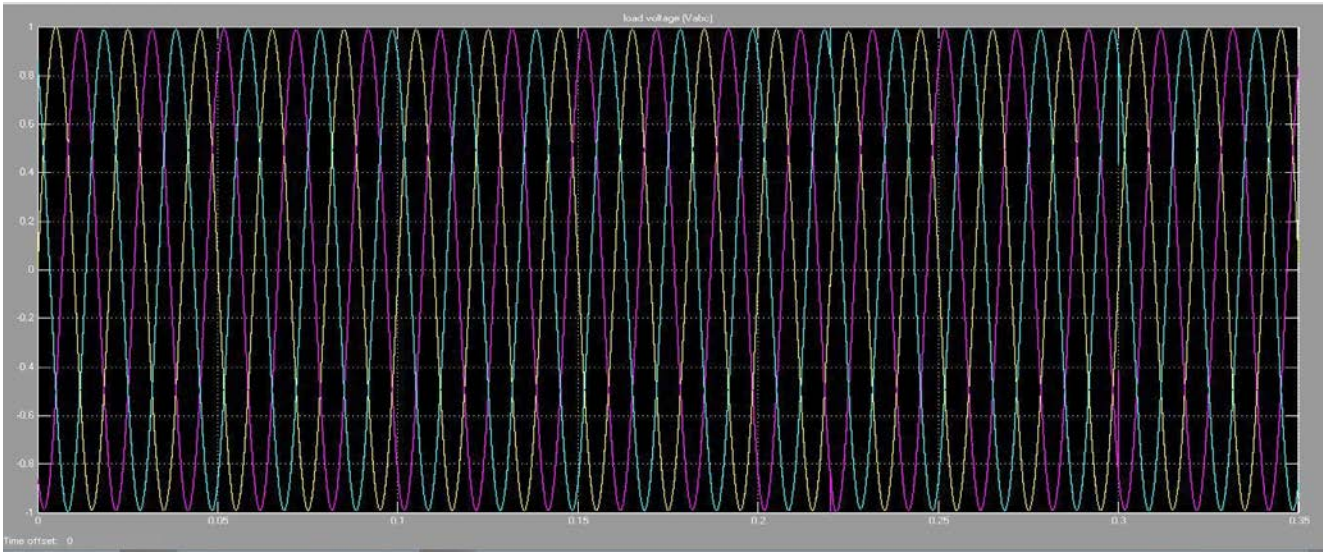

Figure 3.2 Proposed result of multilevel DVR.

IV. CONCLUSION

An effective and fast Dynamic Voltage Restorer (DVR) based on space vector pulse width modulation (SVPWM) is proposed for mitigating the problem of voltage sag or dip and other fault conditions in power system network distribution systems in this work. A discrete PI controller and 3-phase synthesizer is used which utilizes the error signal which is the difference between the reference voltage and actual measured load voltage to trigger the switches of an inverter using a space vector Pulse Width Modulation (SVPWM) scheme.

Proposed system is modeled and simulated in Matlab. Simulation results indicate that the non-linear control techniques provide better compensation to the system as compared to the linear PI technique based DVR connected to the feeder during static non-linear loads. In further work some other types of controllers as fuzzy controller and adaptive PI fuzzy controller can be used in the DVR compensation technique for power quality application. Investigation of the effectiveness of multi-level DVR can be investigated. The efficiency and performance of DVR can be established for active loads like PV source and Wind turbine.

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