MITIGATION OF VOLTAGE SAG/SWELL THROUGH DYNAMIC VOLTAGE RESTORER

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ABSTRACT

This paper describes the problem of voltage sags and swells and its severe impact on non-linear loads or sensitive loads. The dynamic voltage restorer (DVR) has become popular as a cost effective solution for the protection of sensitive loads from voltage sags and swells. The control of the compensation voltages in DVR based on dqo algorithm is discussed. It first analyzes the power circuit of a DVR system in order to come up with appropriate control limitations and control targets for the compensation voltage control. The proposed control scheme is simple to design. Simulation results carried out by Matlab/Simulink verify the performance of the proposed method.

I INTRODUCTION

Our technological world has become deeply dependent upon the continuous availability of electrical power. In most countries commercial power is made available via nationwide grids, interconnecting numerous generating stations to the loads. The grid must supply basic national needs of residential, lighting, heating, refrigeration, air conditioning and transportation as well as critical supply to governmental, industrial, financial, commercial, and medical and communications communities. Commercial power literally enables today's modern world to function at its busy pace. Many power problems originate in the commercial power grid, which with its thousands of miles of transmission lines is subject to weather conditions such as hurricanes, lightning storms, snow, ice and flooding along with equipment failure, traffic accidents and major switching operations. Modern industrial equipment's are more sensitive to power quality problems such as voltage sag, voltage swells, interruption, harmonic, flickers and impulse transient. Failures due to such disturbances create high impact on production cost [1]. So nowadays high quality power is became basic needs of highly automated industries. Voltage sags can occur at any instant of time, with amplitudes ranging from 10 – 90% and a duration lasting for half a cycle to one minute [3]. Voltage swell, on the other hand, is defined as a swell is defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 min. typical magnitudes are between 1.1 and 1.8 up. Swell magnitude is also is also described by its remaining voltage, in this case, always greater than 1.0.

Voltage swells are not as important as voltage sags because they are less common in distribution systems. Voltage sag and swell can cause sensitive equipment (such as found in semiconductor or chemical plants) to fail, or shutdown, as well as create a large current unbalance that could blow fuses or trip breakers. Switching off a large inductive load or Energizing a large capacitor bank is a typical system event that causes swells [1].

This paper introduces Dynamic Voltage Restorer and its operating principle. Then, a simple control based on dqo method is used to compensate voltage sags/swell. At the end, MATLAB/SIMULINK model based simulated results were presented to validate the effectiveness of the proposed control method of DVR.

II CONVENTIONAL SYSTEM CONFIGURATION OF DVR

Dynamic Voltage Restorer is a series connected device designed to maintain a constant RMS voltage value across a sensitive load. The DVR considered consists of:

a. an injection / series transformer

b. a harmonic filter,

c. a Voltage Source Converter (VSC),

d. an energy storage and

e. a control system , as shown in Figure.

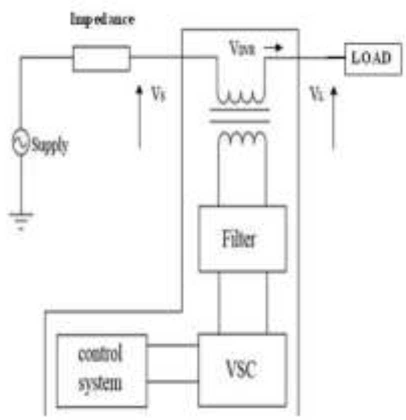

Fig 1: Schematic Diagram of DVR

The basic function of the DVR is to inject a dynamically controlled voltage VDVR generated by a forced commutated converter in series to the bus voltage by means of a booster transformer. The momentary amplitudes of the three injected phase voltages are controlled such as to eliminate any detrimental effects of a bus fault to the load voltage VL. This means that any differential voltages caused by transient disturbances in the ac feeder will be compensated by an Equivalent voltage generated by the converter and injected on the medium voltage level through the booster transformer.

The DVR has three modes of operation which are: protection mode, standby mode, injection/boost mode.

1. **Protection mode:** If the over current on the load side exceeds a permissible limit due to short circuit on the load or large inrush current, the DVR will be isolated from the systems by using the bypass switches (S2 and S3 will open) and supplying another path for current (S1 will be closed).

2. **Standby Mode: (VDVR= 0):** In the standby mode the booster transformer's low voltage winding is shorted through the converter. No switching of semiconductors occurs in this mode of operation and the full load current will pass through the primary.
3. **Injection/Boost Mode: (VDVR>0):** In the Injection/Boost mode the DVR is injecting a compensating voltage through the booster transformer due to the detection of a disturbance in the supply voltage.

In the Fig. 2, Vg is the source voltage, V1 is the incoming supply voltage before compensation,
V2 is the load voltage after compensation, is the series injected voltage of the DVR and I is the line current. The restorer typically consists of an injection transformer, the secondary winding of which is connected in series with the distribution line, a pulse-width modulated (PWM) voltage source inverter (VSI) bridge connected to the primary of the injection transformer and an energy storage device connected at the dc-link of the inverter bridge. The series injected voltage of the DVR, Vdvr, is synthesized by modulating pulse widths of the inverter-bridge switches. The injection of an appropriate Vdvr in the face of an up-stream voltage disturbance requires a certain amount of real and reactive power supply from the DVR. The reactive power requirement is generated by the inverter.

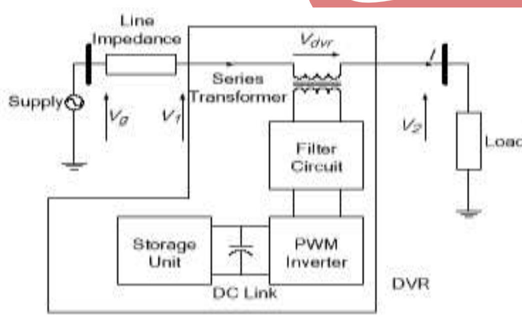

Fig.2 Block Diagram of General DVR Circuit

III Z-SOURCE INVERTER

Z-source inverter has X-shaped impedance network on its DC side, which interfaces the source and inverter H-bridge. It facilitates both voltage-buck and boost capabilities. The impedance network composed of split inductors and two capacitors. The supply can be DC voltage source or DC current source or AC source. Z-source inverter can be of current source type or voltage source type. Fig. 3 shows the general block diagram of Z-Source inverter.

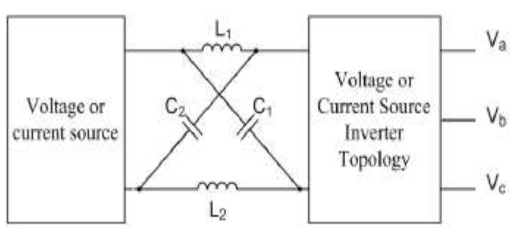

Fig3 General Block Diagram of Z-Source Inverter

IV SIMULATION DIAGRAM AND RESULT

Figure 4 shows the configuration of the proposed DVR design using MATLAB/SIMULINK, where the outputs of a three-phase half-bridge inverter are connected to the utility supply via wye-open connected series transformer. Once a voltage disturbance occurs, with the aid of dqo transformation based control scheme, the inverter output can be steered in phase with the incoming ac source while the load is maintained constant. As for the filtering scheme of the proposed method, output of inverter is installed with capacitors and inductors.

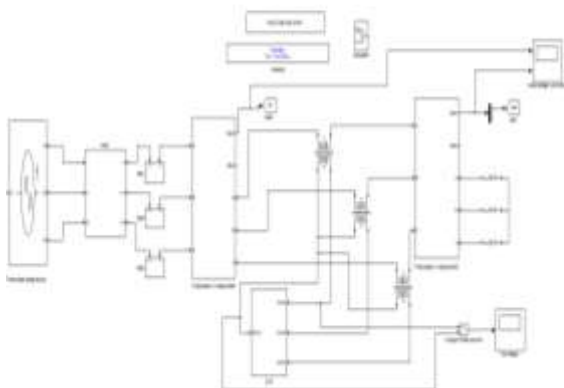

Fig 4: Simulation circuit for Voltage Sag/Swell with Dvr for the Proposed Model

DVR shown in figure: 5 is simulated for voltage sag/swell. The result for simulation of voltage sag is given in shown in figure: 6. Simulation started with 40% voltage sag from 0.10s to 0.20s. Figure shows the supply voltage, injected voltage, load voltage and load current. It is observed that DVR is able to inject the positive voltage component in all three phases during the supply voltage sag. It is noted that even variation in supply voltage, load voltage remains constant. It is also observed at the time instant of 0.10s and 0.20s load voltage has some minor transients but magnitude of load voltage and load current unaltered during this span of time.

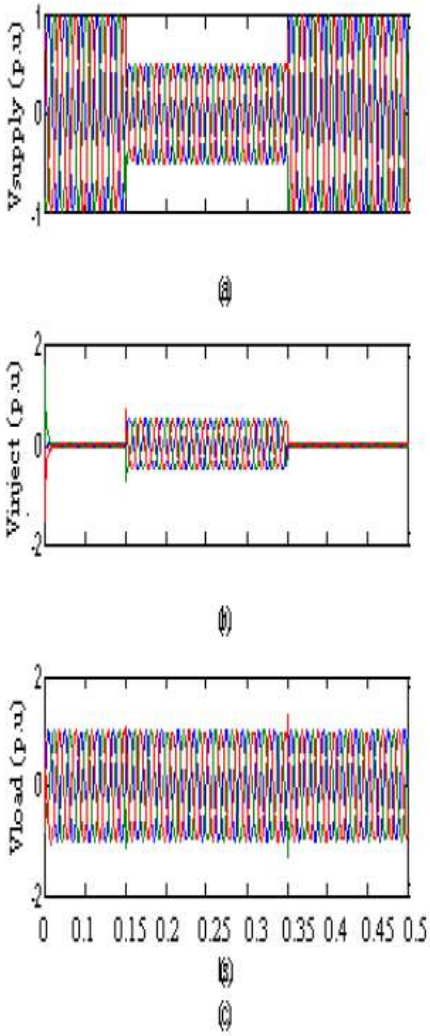

Fig 5: Simulation results for voltage sag and dvr voltage

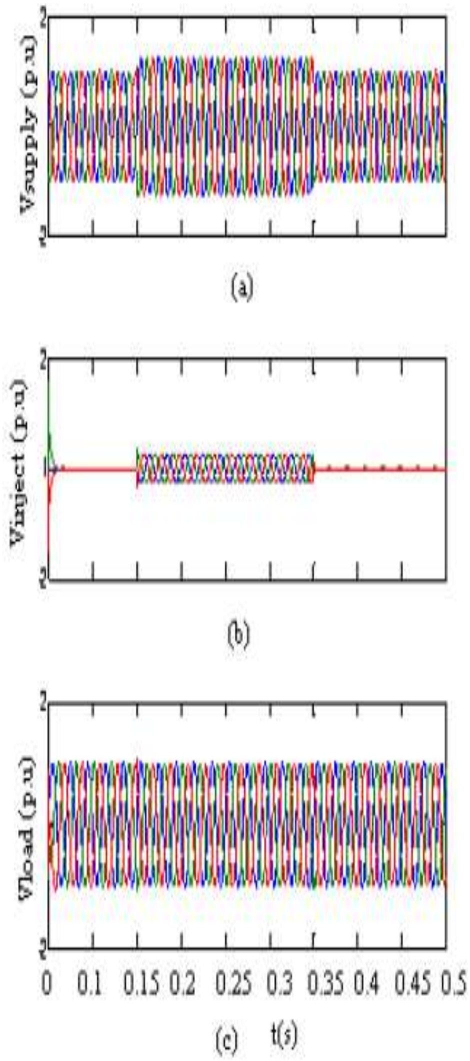

Fig 6: Three-phase voltages swell: (a)-Source voltage, (b)-Injected voltage, (c)-Load voltage

V CONCLUSION

In this paper voltage sag/swell compensation and elimination of fault using Single phase and Three phase Z-Source inverter based Dynamic Voltage Restorer is considered. The control technique is designed using in-phase compensation and used a closed loop control system to detect the magnitude error between voltages during pre-sag and sag periods. The modeling and simulation of closed loop control of voltage sag/swell mitigation were carried out using MATLAB software. The simulation results show that the developed control technique with proposed single phase & three phase DVR is simple and efficient. From the simulation results it was observed that dynamic voltage restorer compensates 25% of voltage sag and 30% of voltage swell.

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