Mitigation Of Voltage Sag Using Dynamic Voltage Restorer

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***Abstract*—Voltage Sag and swells in the medium and low voltage distribution grid are considered to be the most frequent type of power quality problem based on recent power quality studies. Their impact on sensitive loads is served. The impact ranges from load disruptions to substantial economic losses up to millions of dollars. Different solutions have been developed to protect sensitive loads against such disturbance but the DVR considered to be the most efficient and effective solution. Its appeal includes lower cost, smaller size and its dynamic response to the disturbance. In this paper, an enhance voltage sag compensation strategy is proposed, which mitigates the phase jump in the load voltage while improving overall sag compensation time. An analytical study shows that the proposed method significantly increases the DVR sag support time (more than 50%) compared with the existing phase jump compensation methods.**

***Index Terms*—Dynamic Voltage Restorer (DVR), voltage sag, Voltage swells. Power quality.**

I. INTRODUCTION

Dynamic Voltage Restorer (DVR) are now becoming more established in industry to reduce the impact of voltage dips on sensitive loads. A voltage dip is commonly defined as any low voltage drop between 10% and 90% the nominal RMS voltage, lasting between 0.5 cycles and 1 min. In comparison with interruptions, voltage dips affect a large number of customers and for some cases may cause extremely serious problems. Voltage dips are one of the most occurring power quality problems. They occur more often and cause severe problems and economical losses.

There are different ways to mitigate voltage dips, swells and interruptions in transmission and distribution systems. At present, a wide range of very flexible controllers which capitalize on newly available power electronics components are emerging for custom power applications. Among these, the distribution static compensator and the dynamic voltage restorer are the most effective devices, both of them based on the voltage source converter principal Figure 1 shows a typical DVR series connected topology. The DVR essentially consists of a series inverter (VSI), inverter output filter and an energy storage device connected to the DC link.

The basic operation principle of the DVR is to inject an appropriate voltage in series with the supply through injection transformer whenever voltage sag or voltage swell is detected. In addition to voltage sags and swells compensation, DVR can also perform other tasks such as harmonic compensation and Power Factor correction. Compared to the other Custom Power devices, the DVR clearly provides the best economic

The only possible way to mitigate the phase jump is to restore the load voltage to the prefault value. Such an approach is addressed as presag compensation in. However, the phase jump compensation using the presag method requires a significant amount of active power from the dc link capacitor. Thus, this method will require a larger size capacitor or will result in shorter sag support time. In and, an interesting technique is proposed to increase the compensation time while mitigating the voltage phase jump. In this method, once the dc link voltage drops to the threshold limit, the magnitude of the injected voltage is reduced by synchronizing the phase-locked loop (PLL) to the grid voltage. This allows further utilization of the dc link capacitor energy and extends the compensation time by some extent. However, it continues to consume the energy in the dc link capacitor throughout the duration of compensation and imposes limitation on compensation time enhancement.

II. DYNAMIC VOLTAGE RESTORER

A Dynamic Voltage Restorer (DVR) is a recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. The DVR was first installed in 1996. It is normally installed in a distribution system between the supply and the critical load feeder. A DVR is a custom power device in conjunction with the Voltage Source Inverter (VSI) which injects the voltage in series with the power distribution system through a series Injection Transformer (SIT) during a voltage sag. There re various circuit topology and control schemes that can be used to implement DVR In addition to voltage sags and swells compensation, DVR can also added other features such as: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations. The general configuration of the DVR consists of an Injection / Booster transformer, a Harmonic filter, a Voltage Source Converter (VSC), DC charging circuit and a Control and Protection system as shown in Figure 2.1.

The basic component of DVR:

DVR can be applied for medium voltage and in low voltage application. It basically consists of following parts

Injection Transformers:

The injection transformers limits coupling of noise and transients' energy from primary to secondary side. Generally, HV side of the injection transformer is connected in series to the distribution system and the power circuit of DVR can be connected at low voltage side Its main function is

Inject the voltage into the circuit to mitigates the voltage sag.

Voltage Source Inverter and Filter Circuit:

Voltage source inverter should be control in such a way as to generate the voltage which are same as the reference voltage. PWM is used as the switching strategy for the inverter.

The output from the inverter is connected to LC filter with the filtering inverter side scheme. There two types of filters used:

Passive Filter In DVR, filters convert the inverted PWM waveform into sinusoidal waveform by eliminating the unwanted harmonic component generated by the VSI action.

DC Charging Circuit: The DC charging circuit has two main functions: the first is to charge the source after a sag compensation event and second is to maintain dc link voltage at the nominal dc link voltage. To charge the dc link various topologies are used such as an external power supply or by connecting the dc side of the DVR to the controlled or uncontrolled rectifier to maintain the dc voltage.

Control and Protection: The control process generally consists of hardware with programmable logic. In past it consists of digital signal processing boards which provide controls like detection and correction. Filters can also be used. There are different types of filters algorithm: Fourier Transform (FT), Phase Lock Loop (PLL), and Wavelet transform (WT) out of all this here used Phase Lock Loop (PLL).

The dq0 transformation or Park's transformation to control DVR. The dq0 method gives sag depth and phase shift information with start and end times. The quantities are expressed in instantaneous space vectors. Firstly, convert the voltage from abc reference frame to dq0 reference frame. For simplicity zero phase sequence components are ignored.

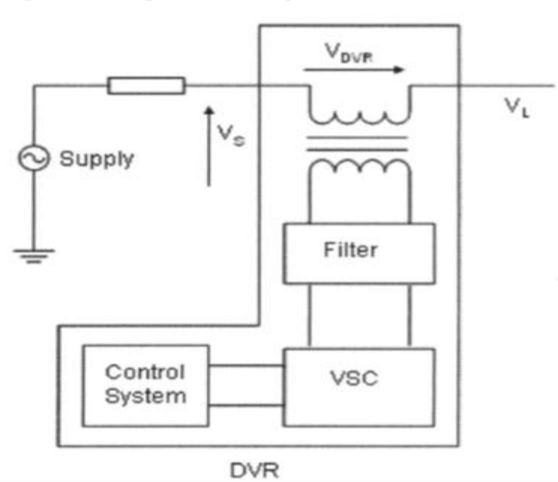

Fig 2.1 DVR series connected topology

III SIMULATION AND RESULTS

A detailed simulation of the DVR control system was performing using MATLAB/SIMULINK program in order to verify operation.

In order to understand the performance of the DVR with control, in voltage sags and swells mitigation, a simple distribution network is simulated using SIMULINK. A DVR is connected to the system through a series transformer with a capability to insert a maximum voltage of 50% of the phase to ground system voltage. Apart from this, a series filter is also used to remove any high frequency components of power. The control system only measures the rms voltage at load point. Voltage sag is created at load terminals by a three- phase fault. Load voltage is sensed. And the magnitude is compared with reference voltage. Pulse Width Modulated (PWM) control technique is applied for inverter switching so as to produce three phase 50 HZ sinusoidal voltages at the load terminals. The dq0 transformation controller input is an actuating signal which is the difference between the Vref and Vin. And gives signal to the inverter using a Pulse Width Modulation (PWM) scheme to drive the error to zero. The proposed DVR utilizes energy drawn from the supply line source during normal operation and stored in capacitors and which is converted to an adjustable three phase as voltage suitable for mitigation voltage sags.

Figure 3.1 showed the simulated diagram with DVR. The main components of simulation are: main supply voltage phase 240V, Line impedance, series transformer ratios, filter inductance, filter capacitors, line resistance, line frequency, isolation transformer etc. In this simulation model the delta-wye connection used for transformer to eliminate the harmonics of the primary side.

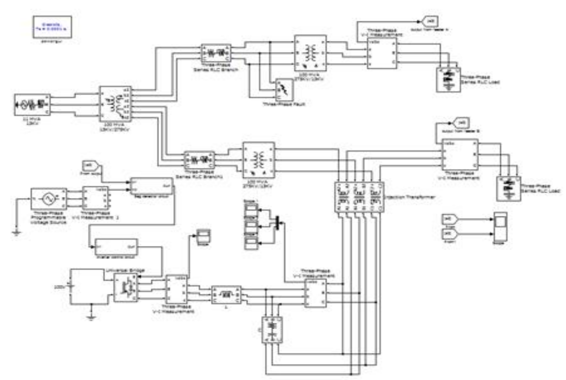

Fig.3.1 System with DVR

Based on Figure 3.1 three phase 12-terminals transformer was selected as injection transformer. The low voltage side of the transformer was set to delta connection and the high voltage side of transformer connected series with the grid or main circuit. After that, the line side filter scheme was added to the line in order to get the better and smooth of the output waveform.

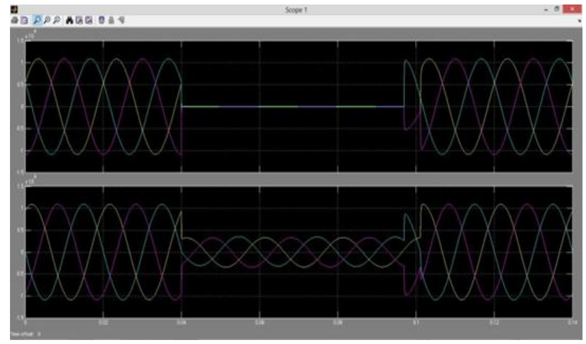

Fig.3.2: Voltage output for feeder A and feeder B respectively.

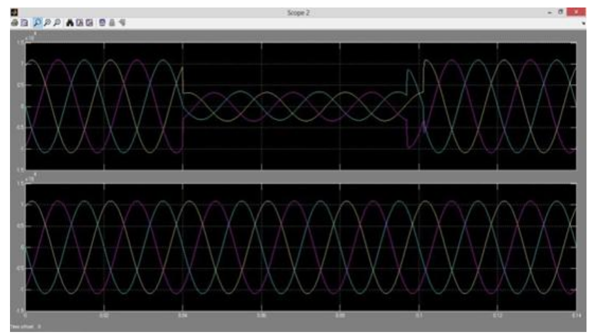

Fig. 3.3: Actual sag and reference voltage.

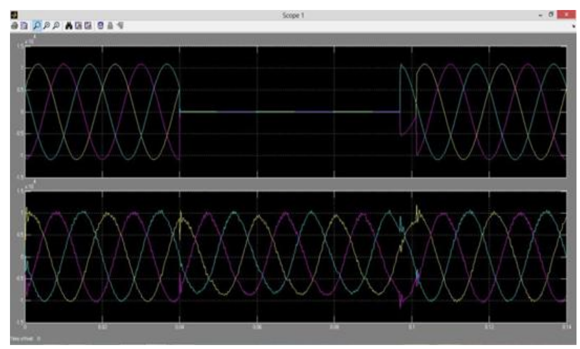

Fig.3.4: Output voltage after compensation

IV CONCLUSION

Based on this paper, the demand for quality power has become a challenging issue for industrial area and consumers. Among them voltage unbalance is considered as the major affecting problem leads to degradation in performance of electrical equipments. FACTS devices used for compensation are the best method to overcome such problem. Among them DVR considered the most efficient and cost effective.

Even though the system cannot compensate 100 percent of voltage during sag, it is an acceptable because the output voltage after compensation still in range of the nominal value. The simulation was implemented by using the distribution network where the effectiveness of the DVR system is better compared to the transmission network.

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