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Power Quality Improvement Using DVR

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Abstract: *The most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality of the electric power supplied is also very important for the efficient functioning of the end user equipment. The term power quality became most prominent in the power sector and both the electric power supply company and the end users are concerned about it. The quality of power delivered to the consumers depends on the voltage and frequency ranges of the electric power delivered from that of the standard values then the quality of power delivered is affected. Power quality is one of the major concerns in the present era. It has become important, with the introduction of sophisticated devices, whose performance is very sensitive to the quality of power supply that results in a failure of end user equipments. One of the major problems dealt here is the voltage sag. To solve this problem, custom power devices are used. One of those devices is the dynamic voltage restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks.*

Index Terms: *Dynamic Voltage Restorer (DVR), Voltage Sags, Voltage Swells.*

I. Introduction

Power quality problems encompass a wide range of disturbances such as voltage sags/swells, flicker, harmonics distortion, impulse transient and interruptions. Voltage sags can occur at any instant of time, with amplitudes ranging from 10-90% and a duration lasting for half cycles to one minute. Voltage swell, on the other hand, is defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 minute.Voltage swells are not as important as voltage sags because they are less common in distribution systems. Voltage sag and swell can cause sensitive equipments (such as found in semiconductors or chemical plants) to fail, or shutdown, as well as create a large current unbalance that could blow fuses or trip breakers. These effects can be very expensive for the customers, ranging from minor quality variations to production downtime and equipment damage.There are many different methods to mitigate voltage sags and swells, but the use of a custom power device is considered to be the most efficient method. Switching off a large inductive load or energizing a large capacitor bank is a typical system event that causes swells.

II. Conventional System Cofiguration Of Dvr.

Dynamic voltage restorer is a series connected devices designed to maintain a constant RMS voltage value across the sensitive load. The dynamic voltage restorer consists of the following main parts:

a. An injection /series transformer
b. A harmonics filter
c. A voltage source converter (VSC)
d. An energy storage
e. A control system

a. Injection / Series Transformer

The Injection / Series transformer is a specially designed transformer that attempts to limits the coupling of noise and transient energy from the primary side to the secondary side. Its main tasks are:

(1) It connects the DVR to the distribution network through the HV windings and transformer and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage.
(2) In addition, the injection/ series 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 contentgenerate by the VSC to permissible level. Low pass filters are used to eliminate the harmonics generated in the VSC. These filters are made by the combination of resistors, capacitors and inductors.

c. Voltage Source Inverter

A VSC is a power electronic system consists of a storage device ad 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 voltages or to generate the part of the supply voltage which is missing. There are four main types of switching devices. They are metal oxide semiconductor field effect transistor (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.

d. Energy Storage

The purpose of storage devices is to supply the necessary energy to the VSC through a dc link for the generation of injected voltages. The different kinds of energy storage devices are superconductive magnetic energy storage (SMES), batteries and capacitance.

e. Control System

The main requirement in the utilization of DVR is its control system to achieve faster response to the variations of load voltages. The main purpose of control system is to generate pulses for the operation of VSC during system disturbances such that required voltage is injected by the DVR to maintain constant voltage magnitude across the load terminals. Many researchers have done o performances analysis and control of the DVR.

III. Working Of Dvr

The main function of a DVR is the protection of sensitive loads from voltage sags/ swells coming from the network. The DVR is located on approach of sensitive loads. If a fault occurs onother lines, DVR inserts series voltage and compensates load voltages to pre fault value. The momentary amplitudes of the three injected phase voltages are controlled such as to eliminate any detrimental effects of a bus faults to the load voltage. 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 works independently of the type of fault or ay event that happens in the system, provided that the whole system remains connected to the supply grid.The DVR has two modes of operation. They are standby mode and boost mode. In standby mode, the injection transformer's low voltage winding is shorted through the converter. No switching of semiconductor occurs in this mode of operation, because the individual converter legs are triggered such as to establish a short circuit path for the transformer connection. Therefore, only the comparatively low conduction losses of the semiconductors in this current loop contribute to the losses. The DVR will be most of the time in this mode. In boost mode, the DVR is injecting a compensation voltage through the injection transformer due to a detection of a supply voltage disturbance.

IV. Control Algorithm

The basic functions of a controller in a DVR are the detection of voltage sag/ swellevents in the system. Computation of the correcting voltage, generation of trigger pulses to the sinusoidal PWM based DC to AC inverter, correction of any anomalies in the series voltage injection and termination of the trigger pulses when the event has passed. The controller may also be used to shift the DC to AC inverter into rectifier mode to charge the capacitors in the dc energy link in the absence of voltage sags/ swells.The dqo transformation or Park's transformation is used to control DVR. The dqo method gives the sag depth and phase shift information with start and end times. The quantities are expressed as the instantaneous space vectors. Firstly convert the voltage from abc reference frame to dqo reference. The control scheme for the proposed system is based on the comparison of a voltage reference and the measured terminal voltage ($V_{a,}V_b,V_c$). The voltage sag is detected when the supply drops below 90% of the reference value whereas voltage swell is detected when supply voltage increases up to 25% of the reference value. The error signal is used as a modulation signal that allows generating a commutation pattern for the power switches constituting the voltage source converter. The commutation pattern is generated by means of the sinusoidal pulse width modulation technique. Voltages are controlled through the modulation.

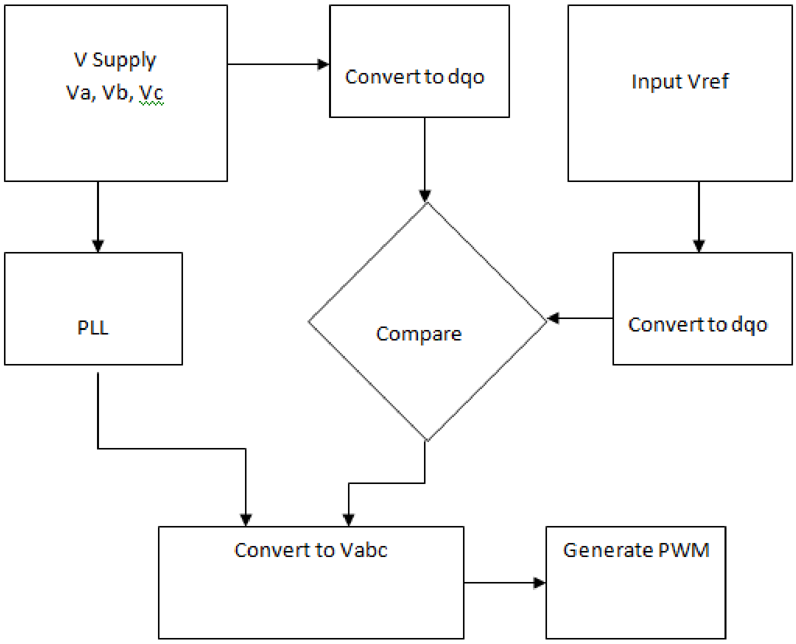

Fig 1 Control Algorithm

V. Results And Discussion

a. Voltage Sag

Fig 3 shows the three phase input supply voltage. This voltage represents the grid transmission voltage.

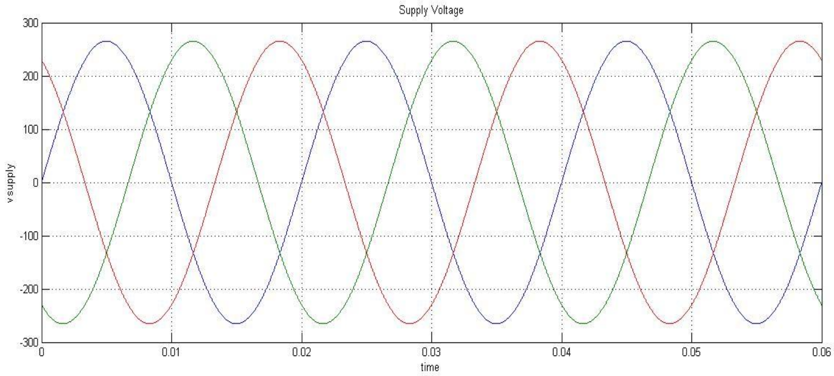

Fig 3 Supply Voltage

Fig 4 represents the simulation of voltage sag. During transission, this reduction in voltage may occur due to any fault that may occur in the grid.

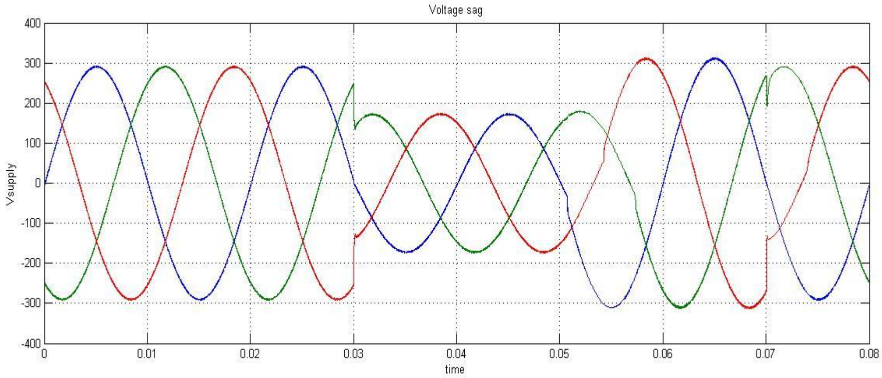

Fig 4 Voltage Sag

Fig 5 represents the voltage injected by DVR into the transmission line in order to mitigate voltage sag. The reduction in voltage caused due to any fault is injected by DVR as a result a constant voltage is provided at the receiving terminal.

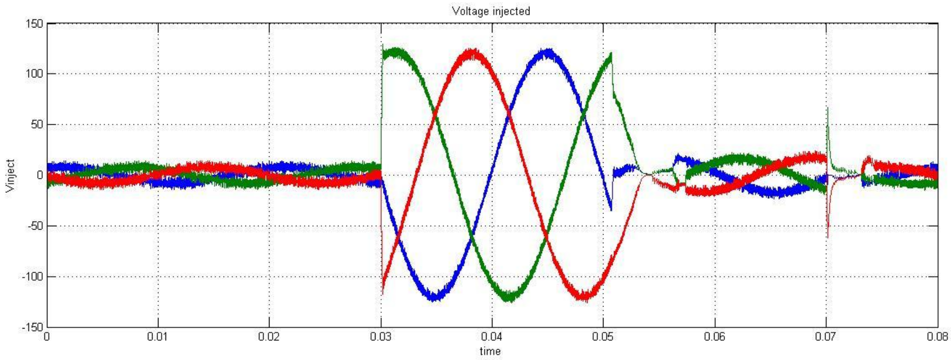

Fig 5 Injected Voltage by DVR

Fig 6 shows the output voltage at the end of the transmission line. This voltage is produced with the help of DVR after resolving voltage sag.

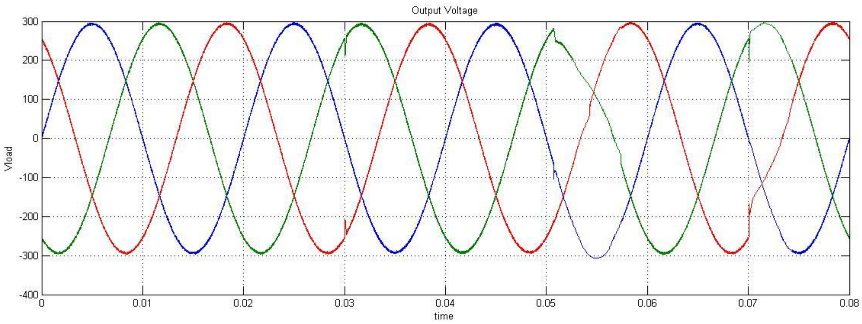

Fig 6 Output Voltage

a. Voltage Swell

Fig 7 represents the simulation of voltage swell. During transission, this rise in voltage may occur due to any fault that may occur in the grid.

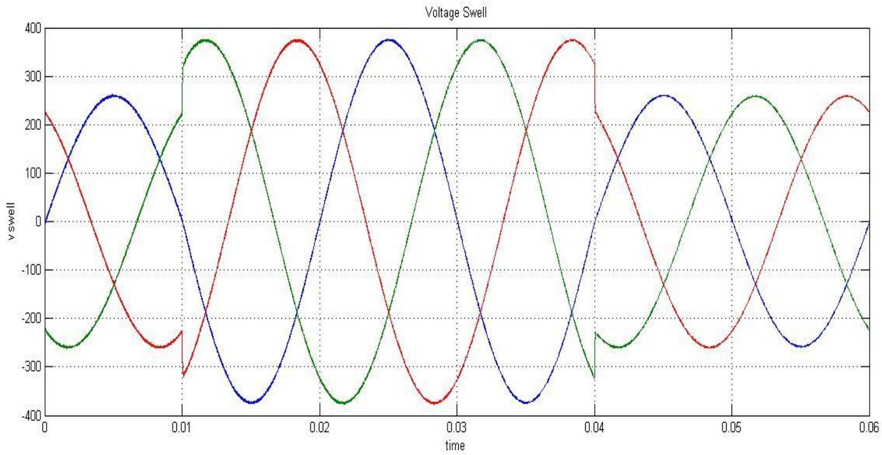

Fig 7 Voltage Swell

Fig 8 represents the voltage injected by DVR into the transmission line in order to mitigate voltage swell. The rise in voltagecaused due to any fault is removed by DVR as a result a constant voltage is provided at the receiving terminal.

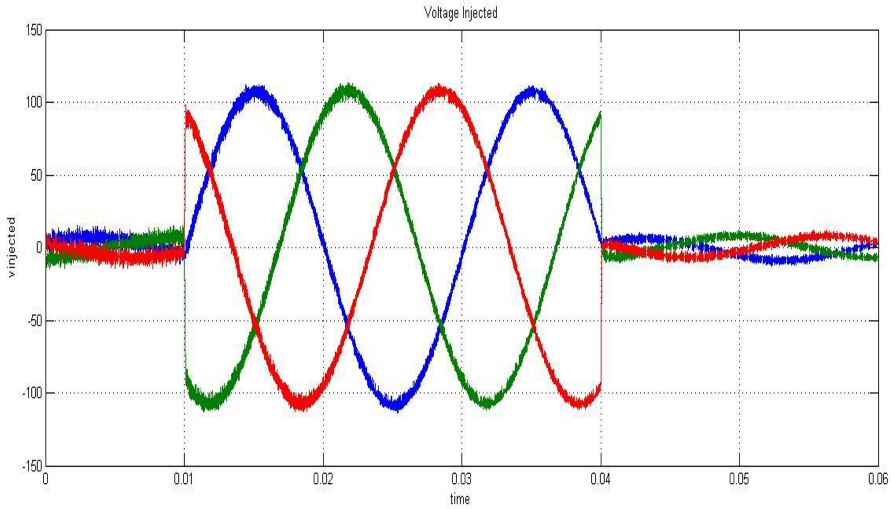

Fig 8 Injected Voltages by DVR

Fig 9 shows the output voltage at the end of the transmission line. The voltage is produced with the help of DVR after resolving voltage swell.

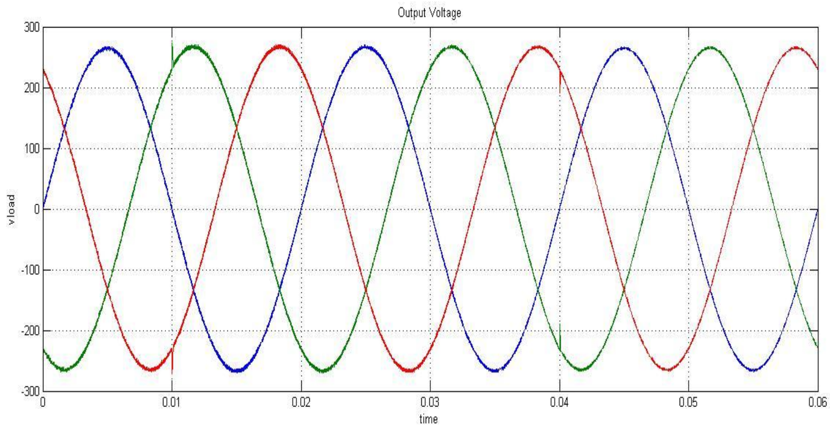

Fig 9 Output Voltage

VI. Conclusion

The modelling and simulation of a DVR using MATLAB/SIMULINK has been presented. A control system based on dqo technique which is a scaled error between source side and its reference for sag/ swell correction has been presented. The simulation results show that the DVR compensates the sag/swell quickly and provide excellent voltage regulation. DVR handles both balanced and unbalanced situation without any difficulties and inject the appropriate voltage component to correct rapidly any anomaly in the supply voltage to keep the load voltage balanced and constant at the nominal value

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