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VOLTAGE SAG AND SWELL MITIGATION USING DVR WITH SVPWM TECHNIQUE

Pravinbhai C Parmar[1], Prof. Mansukh K Kathiria[2], Prof. Komal A Sonagra[3]
[1]PG Scholar, [2,3]Assistant Professor, Electrical Department, GEC, Bhuj, Gujarat, India

ABSTRACT: Nowadays, the fast developments in power electronics increases use of sensitive and nonlinear load in power system. The fast developments in power electronic technology have made it possible to mitigate voltage disturbances in power system. Power Quality problem in a system leads to various disturbances such as voltage fluctuations, transients and waveform distortions those results in a mis operation or a failure of end user equipment. Voltage disturbances challenging the industry are Voltage sag and Swell, among them voltage sags are considered the most significant problem to sensitive loads. To solve this type of short duration voltage variation problem, power electronics controller based custom power devices are used. In this paper usefulness of including DVR in distribution system for purpose of voltage sag and swell mitigation by using PI Controller with SRF theory is used. SVPWM pulse generation technique is utilized in this paper for generating required gate pulses. Appropriate results are presented to assess the performance of DVR as a potential custom power solution. To verify the performance of the proposed method simulation results carried out by MATLAB with its Simulink and Sim Power System toolboxes.

I. INTRODUCTION

TheGenerally we can define power quality as any power problem manifested in voltage, current, or frequency deviations that results in failure or disoperation of customer equipment [1]. Presently, most of the industries use power electronics conversion and switching for manufacturing and processing. One of the major concerns in electricity industry today is power quality problems to sensitive loads. This is due to the advent of a large numbers of sophisticated electrical and electronic equipment, such as computers, programmable logic controllers, variable speed drives, and so forth. Power distribution systems, ideally, should provide their customers with an uninterrupted flow of energy at smooth sinusoidal voltage at the ideal magnitude level and frequency. Good quality of electric power is necessary for right functioning of industrial processes as well as protection to the industrial machines and its long usage. Among various power quality problem voltage sag and swell are most significant short duration variation problem. Voltage sag and swell [1] can cause sensitive equipment to fail, shutdown and create a large current unbalance.A sag is a decrease to between 0.1 and 0.9 pu in rms voltage or current at the power frequency for durations from 0.5 cycle to 1 min [2]. Faults on electrical power system like short circuit due to insulation breakdown at heavy load conditions can cause voltage sag. Voltage swell, in contrast can be defined an increase to between 1.1 and 1.8 pu in RMS voltage or current at the power frequency for durations from 0.5 cycle to 1 min [2]. Switching off of large loads, Energization of capacitor banks etc. can be considered as the common causes of voltage swell.Among various custom power devices to mitigate voltage sag and swell series connected device called DVR is commonly used. In this paper, the performance of the DVR used for the load bus voltage control have been analysed and compared when Voltage sag & swell occur in the distribution system across the load bus. In this paper, Synchronous reference frame theory is used for generating reference voltages and Space Vector Pulse Width Modulation technique is used to generate the switching pulses for Voltage source Inverter. Simulation studies have been performed to check the results in a three-phase distribution system.

Dynamic Voltage Restorer

DVR is a series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and critical load feeder as shown in Figure-1. Usually the connection is made via a transformer, but configurations like DVR with no storage and supply-side-connected shunt converter also exist. The resulting voltage at the load bus bar equals to the sum of the grid voltage and the injected voltage from the DVR.

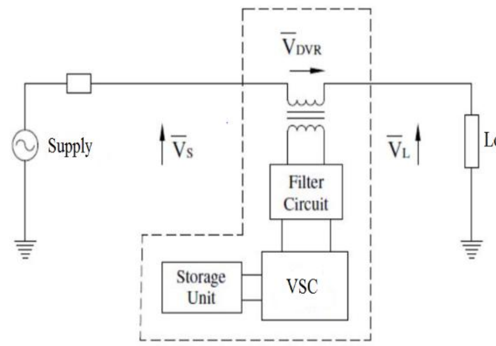

Figure 1.DVR Configuration

The converter generates the reactive power needed while the active power is taken from the energy storage. The compensation for voltage sags and Swells using a DVR can be performed by injecting/absorbing reactive power or real Power.

Fundamental Components of DVR

- Series Injection Transformer
- Voltage Source Converter (VSC)
- Filter

- Control System
- DC Energy Storage Device

Control Strategy

In Figure-2 shows the control block diagram of the DVR in which the synchronous reference frame (SRF) theory is used for the control of self-supported DVR [4]. The voltages at PCC (Vt) are converted to the rotating reference frame using the abc-dqo conversion. The harmonics and the oscillatory components of voltages are eliminated using low pass filters.

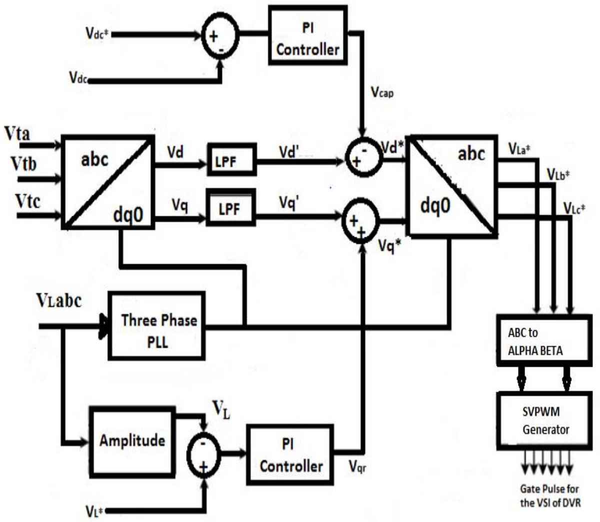

Figure-2Block Diagram of DVR control strategy with SRF theory

Three-phase reference supply voltages (VLa*,VLb*,VLc*) are derived using the sensed load voltages, terminal voltages and dc bus voltage of the DVR as feedback signals. The SRF theory based method is used to obtain the direct axis (Vd) and quadrature axis (Vq) components of the load voltage. The load voltages are converted into the d-q-0 frame using the Park's transformation [4]. The resultant voltages (Vd*, Vq*, Vo) are again converted into the reference supply Voltages using the reverse Park's transformation. Reference supply voltages (VLa*,VLb*,VLc*) are then converted into alpha beta component with the help of alpha beta conversion. Then the SVPWM generator generates required gating pulses for switches of VSI.

II. SPACE VECTOR PULSE WIDTH MODULATION

Space vector pulse width modulation technique is A Modern and computation–intensive PWM method for variable frequency drive applications.The space vector modulation is a highly efficient method to generate the six PWM pulses necessary at the power stage for two-level inverter [5], [6]. The circuit model of a typical three-phase voltage source PWM inverter is shown in Figure-3. S1 to S6 are the six power switches that shape the output, which are controlled by the switching variables a, a′, b,b′, c and c′. When an upper transistor is switched on, i.e. When a, b or c is 1, the corresponding lower transistor is switched off, i.e., the corresponding a′, b′ or c′ is 0. Therefore,the on and off states of the upper transistors S1, S3 and S5 can be used to determine the output voltage.

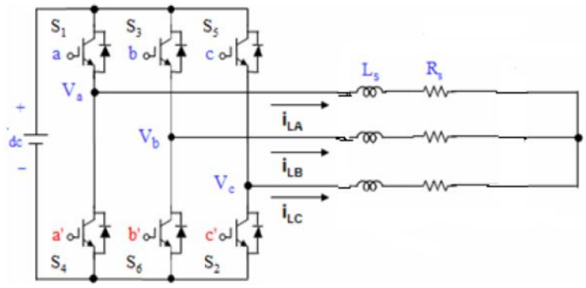

Figure-3Three Phase Voltage Source Inverter

The main aim of space vector PWM technique is to approximate the reference voltage vector Vref using the eight switching patterns. One basic method of approximation is to produce the average output of the inverter in a small period, T to be the same as that of Vref in the same period as shown in figure-4.

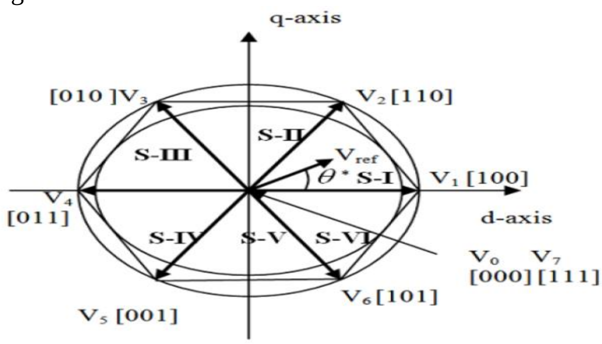

Figure-4 Vector Representation of Switching Gates

III. SIMULATION AND RESULTS

AC Line Voltage	415v,50Hz
Line Impedance	Ls = 3mH, Rs = 0.01Ω
Linear Load	10 kva, 0.80 pf, lag
DC Voltage of DVR	300 V
AC Inductor	2.0 mH
Series Transformer	10 kva, 200V/300V

Table-1. Parameter Value used in Simulation

The Simulink model for the system is shown in Figure-5.For testing the viability of the DVR with its controller in mitigating sag and swell which occurs at a 415V distribution Feeder, the following approach is adopted

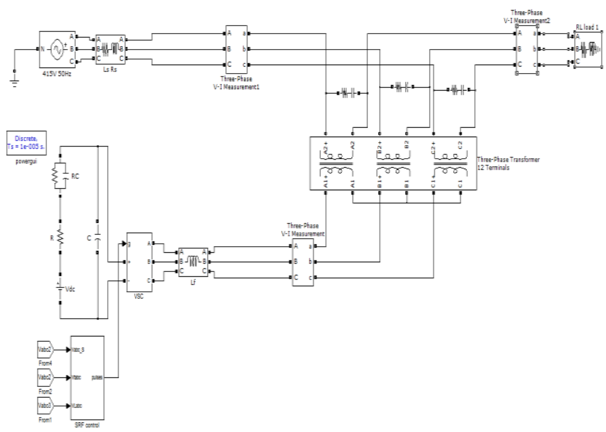

Figure-5 Simulink Block Diagram of DVR

Figure-6 shows the Source Voltage waveform of system under voltage sag and voltage swell conditions. At 0.2 s, a sag in supply voltage is created for five cycles, and at 0.4 s, a swell in the supply voltages is created for five cycles.

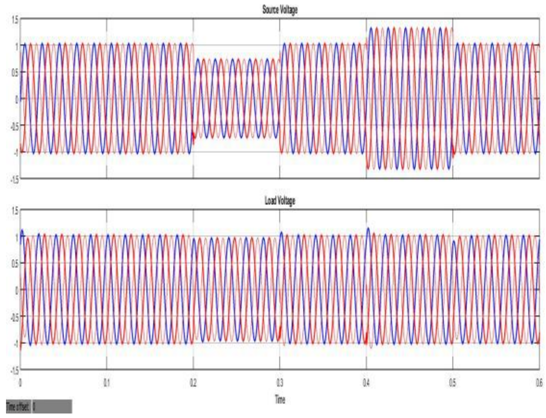

Figure-6. Supply voltage with sag and swell and Compensated Load Voltage

Voltage sag and swell are mitigated by DVR very effectively at 0.2 to 0.3 and 0.4 to 0.5 time interval respectively as shown in figure-6.

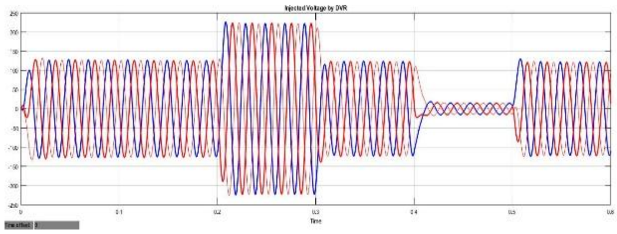

Figure-7Injected Voltage by DVR

Voltage injected by DVR to mitigate Voltage sag and swell is shown in figure-7.

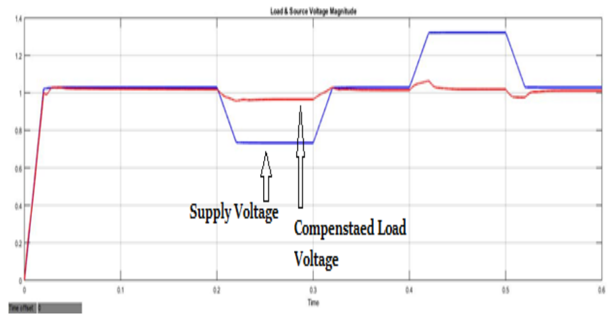

Figure-8Supply Voltage mag. And Load Voltage mag.

Figure-8 Shows the Supply Voltage magnitude and load Voltage magnitude to understand that DVR maintain Load Voltage nearly 1 pu during normal, Sag and swell condition by injecting appropriate amount of injecting voltagein the system.

IV. CONCLUSION

The modelling and simulation of DVR using MATLAB/Simulink has presented in this paper for short duration voltage variation power quality problem like sag and swell. The simulation result clearly shows that DVR with SRF control theory and SVPWM pulse generation technique mitigate voltage sag and swell very well.

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