Power Quality Enhancement by Advance Method of Series Compensation

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Abstract - In power system, power quality is one of the important aspects as power quality problems are occurred due to occurrence of voltage swell, voltage Sag, transient, harmonics distortion, etc. in the transmission line. Out of these, voltage swell has less predominantly occurred and creates severe impact on transmission line and sensitive devices connected to it. By IEEE 1159 Voltage swell is an increase in RMS voltage level from 110% to 180% of nominal voltage at power frequency for the duration of 1/2 cycle to 1 minute [1][2]. The voltage swell is occurred due to de energizing of large heavy loads, switching off load, lightening strokes, etc. The occurrence of voltage swell is very low but when it is occurred it creates severe impact on transmission line and connected devices. Hence it is necessary to mitigate or compensate the voltage swell to improve power quality of transmission line. The compensation of voltage swell is done by using FACTS devices like DVR In this paper, the analysis of 400v transmission line with including DVR is simulated in MATLAB/SIMULINK software, which shows the voltage swell is compensated and voltage profile has been improved.

Key Words: Dynamic voltage restorer (DVR), maximum voltage injection, Phase advanced compensation (PAC).

1. INTRODUCTION

Reliable customer power device is dynamic voltage restorer (DVR) used to tackle the voltage sag, swell problem. It is a series connected norm power device, which is considered to be a cost effective unusual when compared with other available custom power devices to mitigate voltage sag and swells. The main purpose of the DVR is to supervise the load voltage waveform constantly and if any sag occurs, or excess voltage is absorbed from the load voltage. To reach the above functionality a reference voltage waveform and source voltage waveforms are similar in magnitude and phase angle. Thereby during any malformation of the voltage waveform it can be analyzed by comparing the reference and the actual voltage waveforms. The main principle of DVR operation is finding of voltage dips and inserting vanished voltage to the network. The series interconnection allows the DVR inserted voltage to be inserted to the utility source voltage. The amplitude and phase angles of the inserted three-phase voltages can be varied, thereby permitting control of real and reactive power exchanged between the DVR and the distribution system.

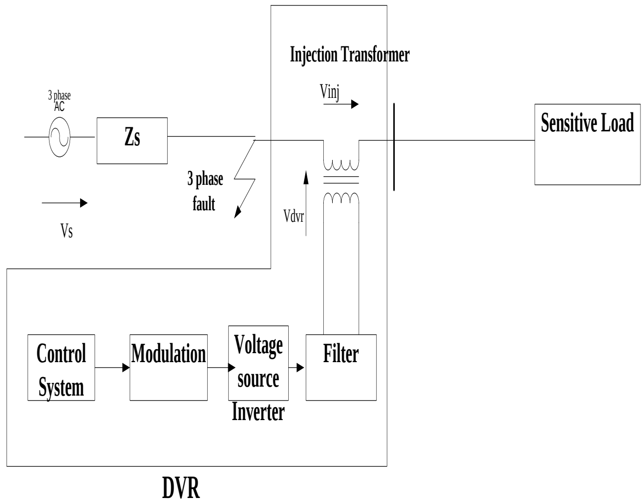

Fig. 1 Schematic Diagram of DVR

Fig. 1 shows the schematic diagram of DVR for distribution system. In the figure Vs is source voltage, VDVR is the series injected voltage of DVR. The restorer consists of an injection transformer, the secondary winding of transformer connected in series with the distribution line, to the primary winding of the injection transformer a VSC is connected through the filter and an energy storage device connected at with it. The inverter bridge output is filtered in order to compensate the switching frequency harmonics generated in the inverter. To correct larger faults DVR may need to increase active power. In this paper phase advanced compensation is used to correct the voltage dips and swells. This method includes the new closed loop load voltage and inner loop current mode control. In this method the error voltage is given out by comparing the source and reference voltage which gives to the gain in the system. In phase advanced multi-loop technique all three phase voltage are advanced by particular angle to minimize the quantity of supplied power by the DVR. This paper is therefore planned as follows: the propose method PAC is described in section 2; the simulation of a control scheme for DVR operation is accessible in section 3; the system parameters with their values shown in section 4; the results based on simulation are shown in section 5 and the effectiveness of the pro-posed DVR control systems are evaluated.

2. PRAPOSED METHOD

There are Many injection methods for DVR as In-phase compensation technique, pre-sag compensation technique, energy optimizing technique , phase advanced compensation technique uses for mitigate the voltage sags and swell. The pre-sag method tracks the supply voltage continuously and if it detects any distraction in supply voltage it will inject the difference voltage between the sag or voltage at PCC and pre-fault condition, hence the load voltage can be restored back to the pre-fault condition. In this method control of the injected active power cannot be possible and it is determined by external conditions such as the type of faults and load conditions.

Vdvr = Vprefault –Vsag

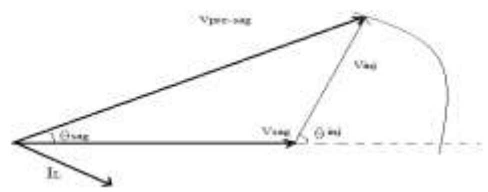

Fig. 2 Phasor Diagram of PAC

From this method it must be noticed that inserted reactive and active powers might be obtained. Moreover, injected voltage phase and magnitude could be obtained using the subsequent equations:

$$Si = ILVi = \sqrt{VL^2 + Vs^2 - 2VLVs\cos\theta L} \quad (1)$$

$$Pi = IL(VL\cos\theta L - Vs) \quad (2)$$

$$\theta s = \cos\left(\frac{VL\cos\theta Ls}{Vs}\right) \quad (3)$$

$$Vi = \sqrt{VL^2 + Vs^2 - 2VL\,Vs\cos(\theta L - \theta s)} \quad (4)$$

$$\theta i = \tan\left(\frac{VL\sin\theta L - Vs\sin\theta s}{VL\cos\theta L - Vs\cos\theta s}\right) \quad (5)$$

The above equations express that if $VL\cos\theta > Vs$ DVR have to make VS and IL in phase via injecting voltage; though, if $VL\cos\theta < Vs$ Pi is negative and active power may be set to zero without adjusting to θs zero. In other words, voltage sag is mitigated by reactive power. In this situation inserted voltage is perpendicular to load current. Its value for zero power flow is calculating using Pi3 equation. As compared to other injection techniques with PAC magnitude of inserted voltage is greater than that based on injection methods.

3. CONTROL SYSTEM DESIGN

Another name for dq0 transformation is Park's transformation. dq0 stand for direct- quadrature -zero transformation. In electrical engineering, to simplify the study related to three-phase circuit this mathematical transformation has been used. This method can be applied to decrease the three AC quantities to two DC quantities. It makes the calculation and simulation simpler. Basically this technique operates in such way that, it compares the reference voltage with the measured supply voltage. From the definition of voltage sag, the voltage sag is noticed when the source voltage falls less than 90% of the reference value. Hence it creates the error signal which is used as a modulation signal that permits to generate a commutation for the power electronic devices including the voltage source converter. Then, commutation pattern is used by Pulse Width Modulation (PWM). Thus, voltage can be controlled via modulation. The control system services abc to dq0 transformation to dq0 voltages. In normal conditions, the voltage will be constant and d-axis voltage is 1 pu and q-axis voltage is 0 in pu, but when fault occurs these voltages varies. By comparing d-axis voltage and q-axis voltage to preferred voltage, errors are generated for d and q respectively. These d-error and q-error components using dq0 to abc transformation.

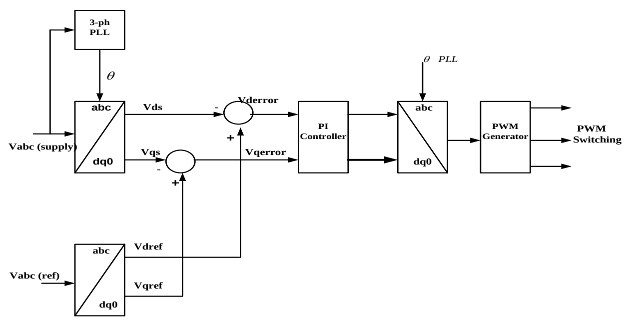

Fig. 3 Block Diagram of Control strategy

4. SYSTEM PARAMETRE

Parameters	Constant Values
3 phase Source	400V, 50Hz
Line Impedance	R=0.01Ω, L= 0.75mH
Sq. Cage Induction Motor	400V, 50Hz, 1440rpm
Injected Transformer Ratio	1:1

5. RESULT

The basic transmission line model having rating of 3-phase, 400V, 50 Hz.. The DVR is connected in series to transmission line to compensate the voltage swell is shown in fig.3.4.1, the voltage swell of 1.2 p.u. is created by using programmable voltage source for the duration of 0.2 to 0.4 second

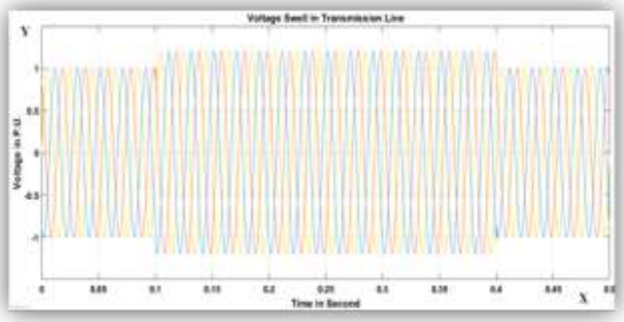

Fig 4.1 The fig.4.1 show the waveform of voltage swell of 1.2 p.u.

To compensate the voltage swell the DVR is connected in system and it mitigates the voltage swell effectively. The waveform for compensation of voltage swell by using DVR is show below in fig.4.2.

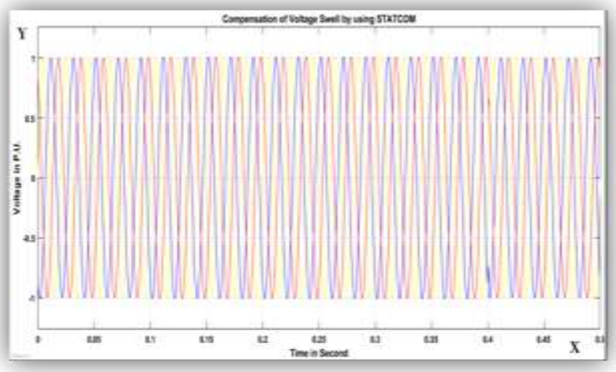

Fig 4.2 Waveform of compensation of voltage swell by using DVR

6. CONCLUSION

This project present, compensation of voltage swell by using DVR which has been develop with 3-phase, 400V, 50 Hz transmission line with all necessary components and control system. The scheme has been demonstrated on MATLAB / SIMULINK software. The voltage swell of 120% i.e. 1.2 p.u. is created by using programmable voltage source and this voltage swell is compensated by using DVR Hence, we conclude that the DVR is an effective device to improve the power quality by compensating the voltage swell

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