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A NEW CONTROL TECHNIQUE OF DVR FOR MITIGATING POWER QUALITY PROBLEMS

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Abstract – ***Now a days the Power Quality problems is one of the major concerns it associates a wide range of disturbances such that the voltage sags/swells, flicker, harmonics distortion, impulse transient, and interruptions. As compared to the other power quality problems Voltage sags/swells can occurs more frequently than other. In the power distribution system these sags/swells are the most important power quality problems. To regulate these problems one of the most important custom power devices that has been emerged to improve the performance of power quality by using Dynamic Voltage Restorer (DVR). DVR is a series connected compensator; in this the voltage can be injected in series. At the point of common coupling the DVR maintains the load voltage at a nominal magnitude and phase by compensating the voltage sag/swell, voltage unbalance and voltage harmonics presented. These systems are able to compensate voltage sags by increasing the appropriate voltages in series with the supply voltage, and therefore prevent loss of power. In this project, DVR can be analyzed by using a different voltage injection schemes. By using battery energy storage system (BESS) the rating of DVR will be reduced. For controlling the capacitor-supported DVR a new control technique is proposed. With a reduced rating voltage source converter (VSC) the control of DVR is demonstrated. By using the unit vectors reference load voltage is determined. Synchronous reference frame theory (SRF) is used for the conversion of voltages from rotating frame to the stationary frame. By using MATLAB results are verified. This entire module is developed in SIMULINK.***

Key Words*: Dynamic Voltage Restorer, BESS, Voltage Source Converter, SRF, unit vectors*

1. INTRODUCTION

In a distribution system power quality problems will increase day by day due to the sensitive equipment pieces. Power quality defines as the ability of a system or an equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. Power quality [1] mainly deals with continuity of the supply and quality of the voltage. Power quality problems are sag, swell, harmonic distortion, transients, etc... When any power quality problems will occur it will affect on the performance of the equipment pieces. Voltage sags and swells will give severe impact on non linear loads or sensitive loads. Therefore some of the mitigation techniques [2] will be used to compensate the power quality problems. The dynamic voltage restorer has become a popular as a cost effective solution for the protection of sensitive loads from a voltage sag and swell.

There are several developments will occur in the DVR. To enhance the capability of the DVR artificial neural network will be used and in this project for reducing the rating of DVR battery energy storage system is used. ANN reduces the harmonic distortion as compared to that of the PI controller. Total Harmonic Distortion of PI controller and ANN will be shown. Therefore harmonics will be controlled.

2. OPERATING PRINCIPLE

In the proposed DVR connected system three phase supply voltages is connected to three phase loads through three phase series injection transformer. The equivalent voltages are connected to the point of common coupling through short circuit impedance. when any power quality problem will occur voltage will be injected in phase by using $T_r, L_r, and\, C_r$ represents the filter components therefore load voltage will be undistorted DVR consists three phase VSC with IGBTs and at a DC bus, BESS is connected. The schematic diagram of a DVR connected system is as shown in Fig -1

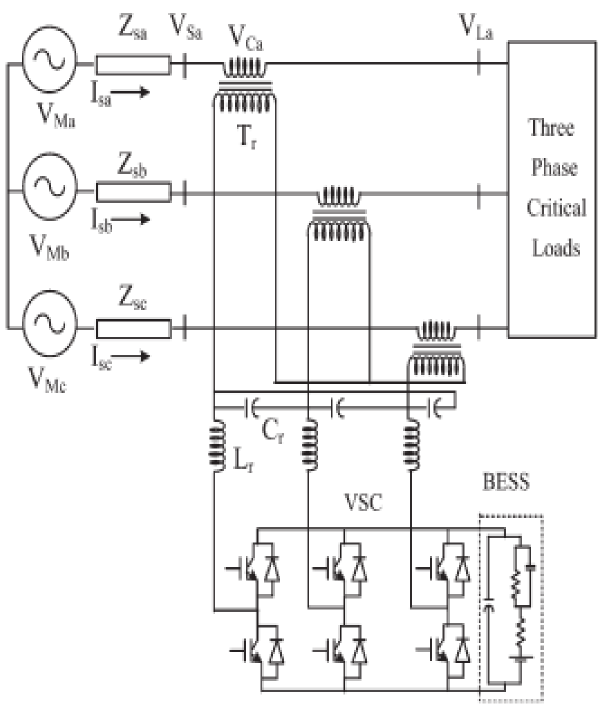

Fig -1 DVR connected system

3. VOLTAGE INJECTION SCHEMES

In this project a new control technique is proposed to control the DVR. The voltage Vinj is inserted such that the load voltage Vload is constant in magnitude and is undistorted, although the supply voltage Vs is not constant in magnitude or is distorted. The voltage can be injected in four ways. In first scheme the injected voltage is in phase with that of the supply voltage .In scheme 2 the injected voltage of DVR is at small angle of 30^0 and in scheme 3 the DVR voltage injection is at an angle of45^0. The voltage injection is in quadrature with the current in scheme 4. The DVR compensation rating in scheme 1 is less as compared to that of the scheme 4.

Therefore injected voltage is higher as compared to that of the in phase injected voltage. Phasor diagram of the DVR voltage injection schemes is as shown in Fig -2 and comparison of DVR ratings is as shown in Table -1

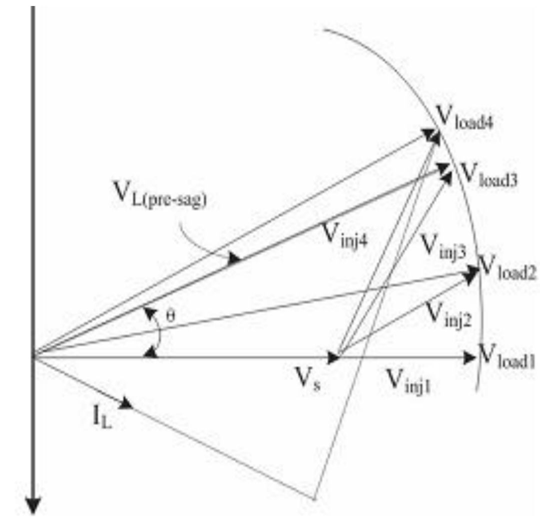

Fig -2 Voltage injection schemes

	Scheme-1	Scheme-2	Scheme-3	Scheme-4
Phase Voltage (V)	90	100	121	135
Phase Current (A)	13	13	13	13
VA per phase	1170	1300	1573	1755
KVA (% of Load)	37.5%	41.67%	50.42%	56.25%

Table -1 Comparison of DVR ratings for sag mitigation

4. CONTROL BLOCK DIAGRAM

The DVR with BESS consists of VSC with IGBTs, injection transformers passive filters, pi controller and energy storage. Fig -3 shows the control block diagram of DVR with Battery energy storage system. The voltage sag compensation using a DVR can be performed by absorbing or injecting the real power or the reactive power. At the fundamental frequency if the voltage injection is in quadrature with load current, then the compensation is made with injecting reactive power and in this scheme DVR is a self-supported dc bus. However, if the voltage injection is in phase with load current, a DVR injects the real power. Hence at the dc bus of the VSC a battery is required. The control technique has some limitations such as the optimization of the size of energy storage and voltage injection capability (converter and transformer rating)

If injected voltage is in quadrature with the load current the voltage injection is Vinj4 and this case is suitable for a self-supported DVR as in this injection involves no active power. However, rating will be reduced by Vinj1 in this scheme the DVR is operated with a battery energy storage system (BESS).

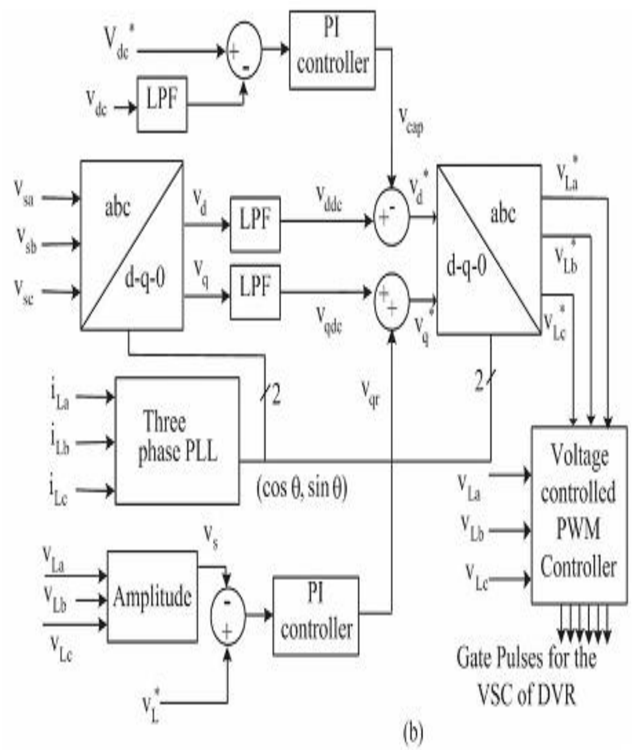

Fig -3 Control Block of the self supported DVR

In a control block diagram phase locked loop is (PLL) used.PLL is an electronic circuits with voltage or current driven oscillator that is constantly adjusted to match inphase the frequency of an input signal. PI controller increases the speed of response. Low pass filters (LPF) is also used for eliminating the harmonics.

5. SIMULINK WAVEFORMS

The proposed DVR with BESS is simulated in MATLAB/SIMULINK [3]. An equivalent load 10-kVA 0.8-pf lag linear load is considered. At different supply voltage disturbances, such as the voltage swell and sag the performance of the DVR is analyzed. Fig -4 shows the dynamic performance of a system under voltage swell and sag at critical load. 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. It is observed that the load voltage is regulated to constant amplitude under both sag and swell conditions. Load voltages vL, PCC voltages vS , amplitude of load voltage VL, DVR voltages vC, Source currents iS, PCC voltage Vs, and dc bus voltage Vdc, reference load voltages vLref, are also depicted in Fig -4. The dynamic performance of DVR during harmonics in the supply voltages applied to critical load is demonstrated in Fig -5. At 0.2 s, the supply voltage is distorted and continued for five cycles. The load voltage is maintained sinusoidal by injecting proper compensation voltage by the DVR. The voltages at the PCC and its harmonic spectrum of phase A are shown in Fig -6.

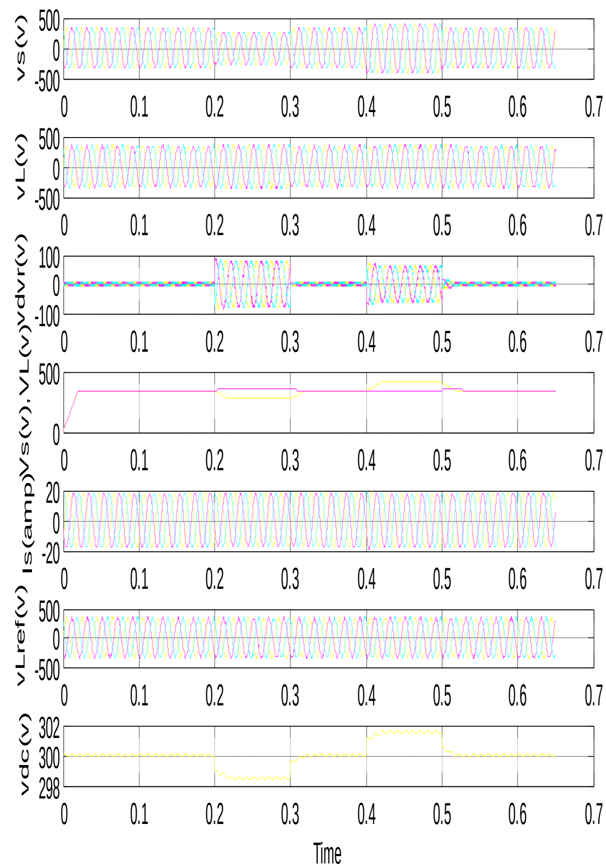

Fig -4 Dynamic performance of a DVR with in-phase injection when voltage swell and sag applied to critical load.

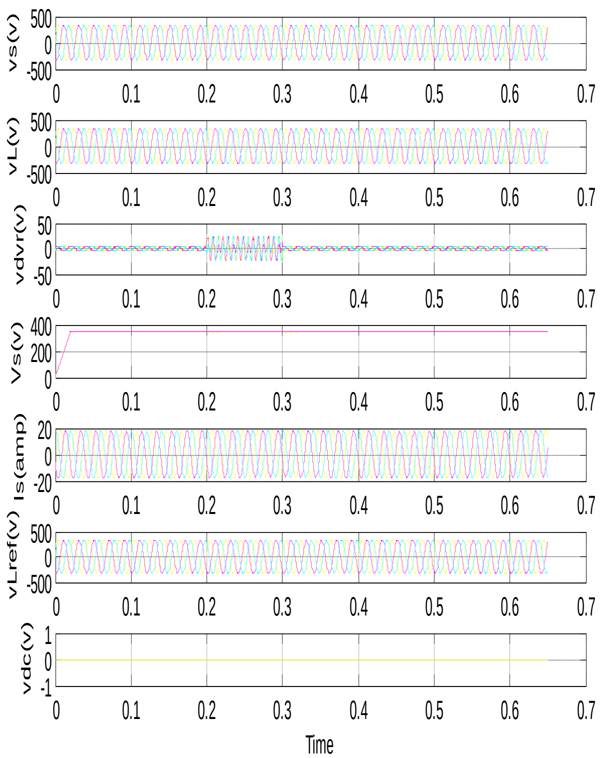

Fig -5 Dynamic performance of a DVR during the harmonics in voltage at supply

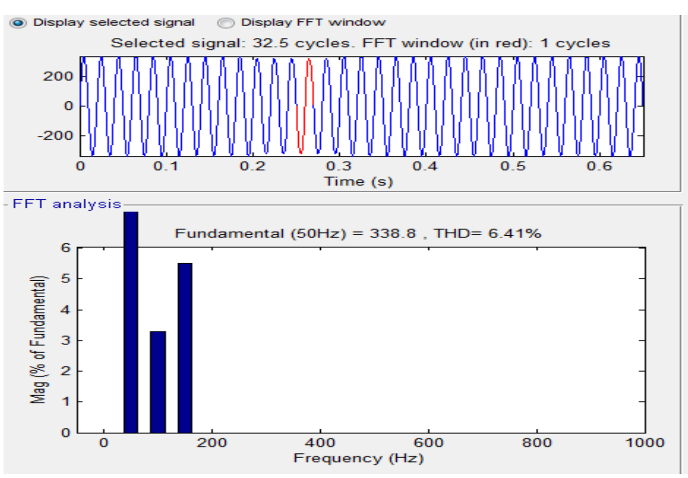

Fig -6 PCC voltage and harmonic spectrum during the disturbance

When PI is used the total harmonic distortion is 6.41%. BY using artificial neural network THD is reduced to 5.89% is as shown in Fig -7.

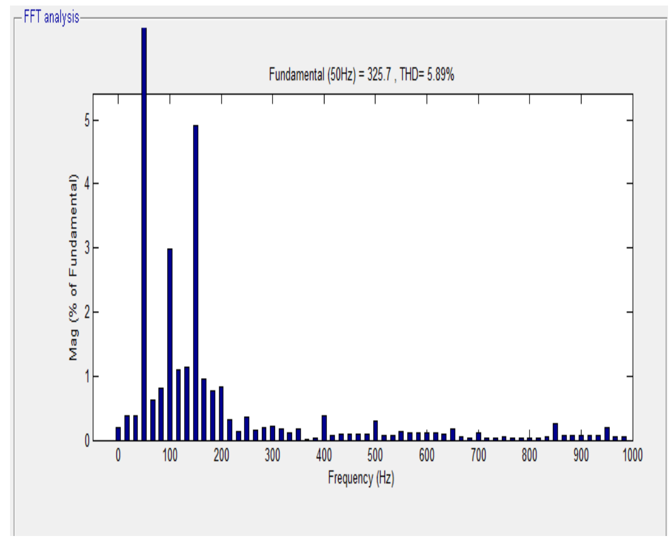

Fig -7 Harmonic spectrum during the disturbance

6. CONCLUSION

The simulation shows that the DVR performance is satisfactory in mitigating voltage sags/swells and harmonics. From simulation results also shows that the THD value will be reduced by using ANN as compared to that of the PI controller. The rating will be reduced by using BESS. The supply voltages keep the balanced load voltage and constant at the nominal value.

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