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Mitigation of Harmonics in Distribution System using STATCOM

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ABSTRACT

Voltage distortions, flicker and unbalances are the major synchronization problems in grid connected photovoltaic system leads to power quality issues. Also, sudden changes of load, application of non-linear loads and switching conditions causes power quality issues. To overcome these problems the proposed distributed system is implemented with custom power device (Distributed STATCOM). Load and source current parameters are used to generate the reference signal required for PWM generator. The reference signal required for DSTATCOM is controlled with PI Controller. This proposed system is to be implement and tested in MATLAB/Simulink and results to be verified with different controllers under different load conditions.

KEY WORDS: DSTATCOM, Phase Angle Controller, Current Controller and Harmonics.

1. INTRODUCTION:

Generally, with increase in the power demand due to increase in population, utilization, the Generation of power was really a challenge now a day. Due to high utilization of non-conventional energy sources [1] as a one of the distribution energy sources, may causes the stability problems such as voltage regulation and other power quality problems. Therefore, the power electronic based forced commutated converters are preferred in distribution system for maintaining the system stability, reliable performance and efficient work and also improving the quality of power at coupling junction point.

The current distortions in non-linear load may result same distortions in the system voltages and in some cases also shows the serious effect on power system. Generally, the problems in power system are more complicated and also have difficult to identify the problem when integrating the wind energy system with grid connection [2]. If these problems continuous, it's mainly causing the damage of system and also reduces the system efficiency. By controlling the system parameters such as magnitude of voltage, transmission impedance and load angle to maintain the power flow. The power flow controlling device is a device which is used for varying and controlling the system parameters [3].

A shunt device is a compensating device i.e., which is connected between the grid connected point called as PCC and the ground [4]. Shunt device either can absorb or generate the reactive power for controlling the magnitude of voltage at point of common coupling.

Along with, power quality is also one of the key parameters in present scenario. The main causes for power quality issues are due to sudden changes in load, switching conditions, utilization of non-linear loads and due to environmental conditions. This paper proposes the concept of power quality problems like harmonics in current and voltage sag and swell conditions. Many techniques available in literature to compensate power quality problems like series and shunt reactors, capacitor banks and many more facts techniques. Out of all techniques custom power device plays a key role due to its unique control action and flexibility in operation. This paper proposes an operation and modelling of custom power device i.e distributed statcom controller to mitigate problems.

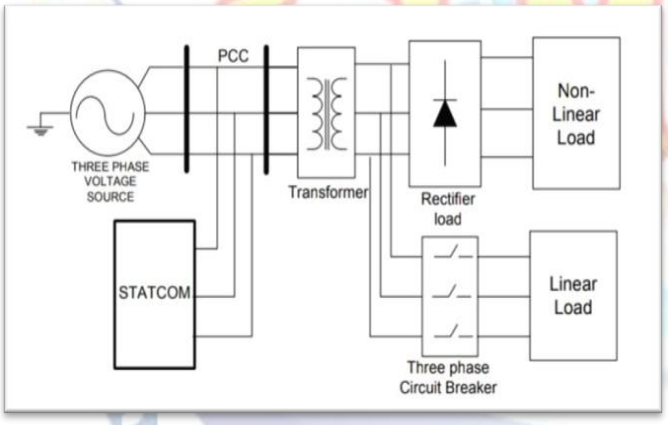

Figure 1: Block diagram of system connected to linear, nonlinear loads and STATCOM

LITERATURE SURVEY:

B. W. França [3], carried out an improved-on control procedure for double three-stage bound together force quality conditioner. This iUPQC control structures is an ABC reference outline-based control, where the SAF and PAF are controlled in a free manner. The SAF has a current circle to guarantee a sinusoidal framework current synchronized with the matrix voltage. The PAF has a voltage circle to guarantee a decent controlled burden voltage with low consonant contortion. These control circles are autonomous from one another since they act freely in every dynamic channel. The dc connect voltage control is made in the SAF**. Brahim Berbaoui [4]** provides an optimal control technique, which helps to maintain proper power sharing between series and shunt converters under fault conditions. In this paper the proposed power system is a hybrid connection of PEM fuel cell and super capacitor and the UPQC is used in this system to maintain proper synchronization between the systems and also to main the harmonic distortion factor. **Panda et al [5],** presented a control strategy based on synchronous reference frame and PAC method to control load current parameters for effective controlling of UPQC converters. The SRF based PAC controller with unit vector approach, compensate the harmonics in source current and also provide better voltage profile improvement in harmonic factor. This compensation process also controls the reactive power along with controlling of voltage sag and swell conditions.

STATCOM and its Control Technique:

A STATCOM is built with Thyristors with turn-off capability like GTO or today IGCT or with more and more IGBTs. A STATCOM based control technology has been proposed for improving the power quality which can technically manages the power level associates with the commercial distributed system. The proposed STATCOM control scheme for grid connected photo voltaic energy generation for power quality improvement has following objectives.

- Unity power factor at the source side.
- Reactive power support only from STATCOM to DG and Load.

A STATCOM is a controlled reactive-power source. The STATCOM is connected to the power system at a PCC (point of common coupling), through a step-up coupling transformer, where the voltage-quality problem is a concern [10]. It provides voltage support by generating or absorbing reactive power at the point of common coupling without the need of large external reactors or capacitor banks. Using the controller, the VSC and the coupling transformer, the STATCOM operation is illustrated in Figure 2.

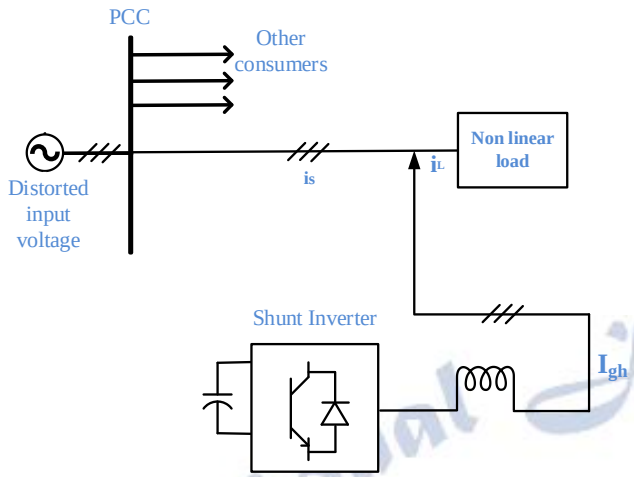

Figure 2: Basic Block Diagram for Static Compensator

The utilization of different types of electrical loads in three phase system, produces an unbalance in current, which causes the unreliable power. Thereby for maintaining the electrical reliability the statcom controller plays a key role. In this statcom control technique, the reference voltage and dc link capacitor voltages are compared and the result obtained from this is converted to two phase coordinators called as orthogonal vectors.

The STATCOM acts either as a source or a sink of reactive power. It provides voltage support by injecting or by absorbing reactive power at the point of common coupling without any large external reactors or capacitor banks. A PID controller is used with STATCOM for damping enhancement. The PID controller is designed using the Model Control Theory. In series converter controller the reference signal required for PWM controller is obtained by comparing rated and grid voltages. The controlling of dc voltage helps to exchange the active power between grid and distributed system. Hence the regulation of dc-link voltage helps to generate the unit vectors required for series controller. The expressions for three phase unit vectors are shown below,

$$U_a = U_n \sin(\theta)$$
$$U_b = U_n \sin(\theta - 120)$$
$$U_c = U_n \sin(\theta + 120)$$

The synchronizing angle (θ) is obtained by using phase locked loop from grid voltages. The expression for error voltage of dc-link voltage is shown below

$$\Delta V_{dc} = V_{dc(ref)} - V_{dc(actual)}$$

The output of conventional PI controller used for controlling dc-voltage is chosen as Im. The expressions for generating three phase currents from unit vectors and Im are expressed below

$$I_{sa}^{*} = I_m * U_{sa}$$
$$I_{sb}^{*} = I_m * U_{sb}$$
$$I_{sc}^{*} = I_m * U_{sc}$$

The reference currents mentioned in above are compared with system grid currents to obtain error currents which is required for hysteresis controller of series converter

$$\Delta I_a = I_a^{*} - I_{ga}$$
$$\Delta I_b = I_b^{*} - I_{ga}$$
$$\Delta I_c = I_c^{*} - I_{gc}$$

In this Instantaneous Power theory is used to generate required reference current as shown in figure 3. Direct axis current is obtained by comparing active powers and by comparison of reactive powers the quadrature axis current is obtained. By parks transformation technique three phase grid currents are transformed to two phase components namely direct and quadrature axis currents. These currents are compared with rated currents to identify the harmonic distortions. A conventional PI controller is used to regulate the steady state error and for generating proportional signals [12]. With the help of inverse parks transformation technique, the dq voltages are converted to three phase voltages and applies to pulse width modulator to generate suitable gate pulses required for shunt controller. The expression for calculation of instantaneous active and reactive powers are shown in below expression

$$P = v_{s\alpha} i_{s\alpha} + v_{s\beta} i_{s\beta} = \tilde{p} + \bar{p}$$
$$q = v_{s\beta} i_{s\alpha} - v_{s\alpha} i_{s\beta} = \tilde{q} + \bar{q} \quad (1)$$

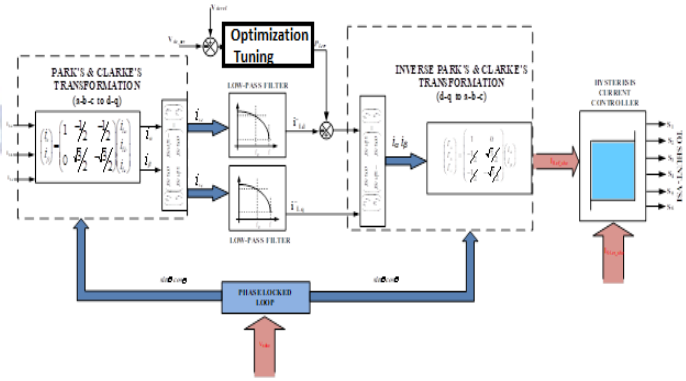

Figure 3: Shunt Converter Controller

The parameters of conventional PI controller are tuned with optimization techniques to achieve good power quality by reducing harmonics and voltage fluctuations [14].

4. SIMULATION STUDY:

The proposed control scheme is simulated using SIMULINK in power system block set. The main block diagram of the system operational scheme is shown in Figure. 1. The simulation diagram of the proposed grid interfaced system using Statcom is as shown in figure 4 & 5.

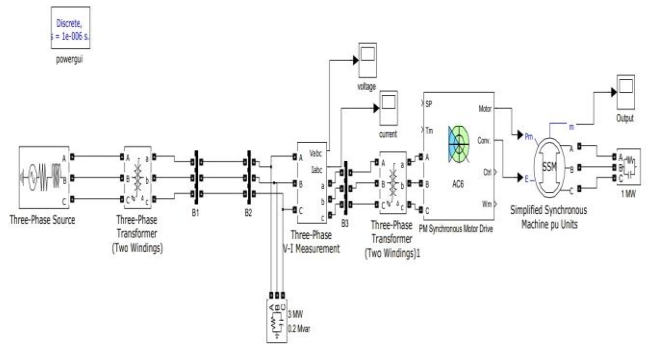

Figure 4: Simulation Diagram of Proposed system with non-linear load

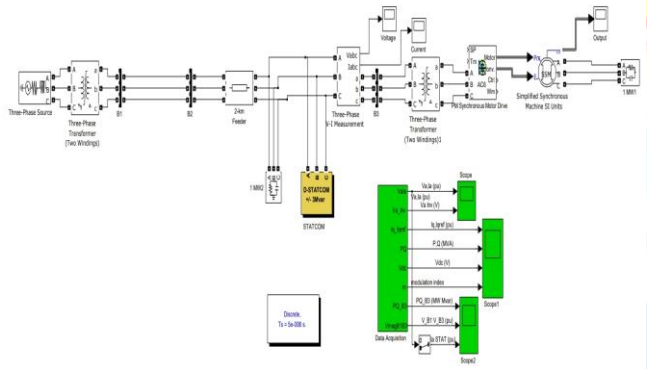

Figure 5: Simulation Diagram of Proposed system with non-linear load and STATCOM

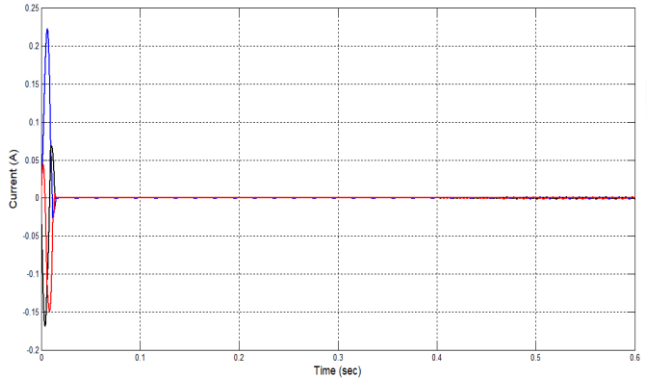

Figure 6: Simulation result for current under non-linear load

Figure 6 and 7, shows the result for source current, load current with and without statcom.

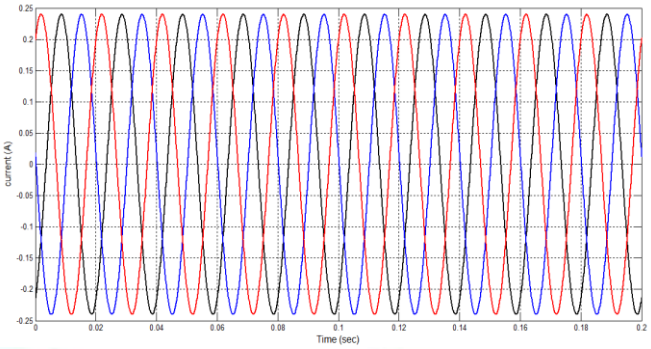

Figure 7: Simulation result for current under non-linear load with STATCOM controller

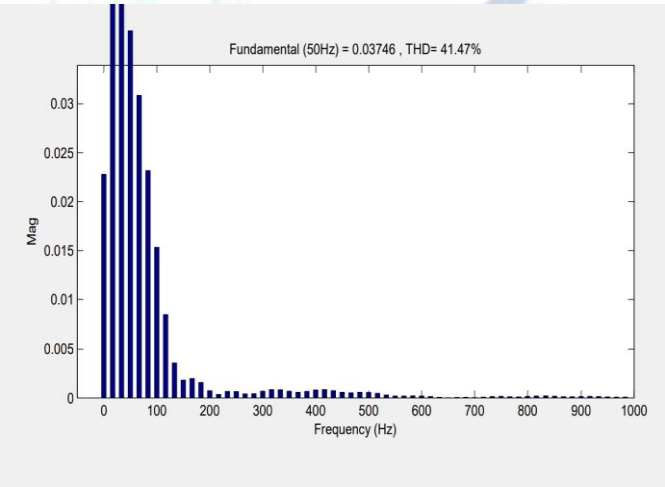

Figure 8: FFT analysis for Source current without STATCOM

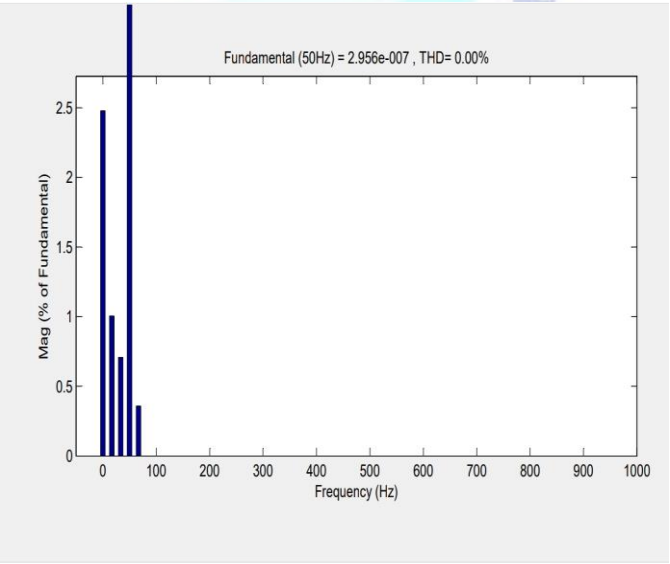

Figure 9: FFT analysis for Source current with STATCOM

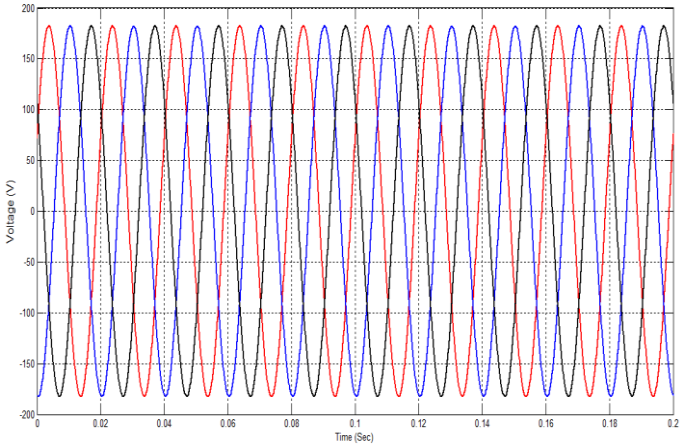

Figure 10: Simulation waveform for System Voltage

4. CONCLUSION

Now a days, reliability and quality of electric power is one of the most discussed topics in power system. Numerous types of power quality issues and power problems and each of the might have varying and diverse causes. Harmonic pollution is one of the attention seeking problems. It leads to several losses and destroys the quality of the power. To overcome these entire problems, STATCOM is one of the best solutions. STATCOM has so many advantages over conventional filters, devices and equipment on today scenario. STATCOM used mostly to eliminate harmonics from the power system. During this part of paper harmonics, sources of harmonics, effects, different devices and equipment with reduce harmonics are studied and analyzed different type of FACTS devices. We designed the model for distribution line connected with linear load, Nonlinear with and without compensation of harmonic using static synchronous compensator technique.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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