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Modeling and Analysis of Distributed Static Synchronous Compensator for Voltage Mitigation in Distributed System

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Abstract:
Distributed Static Synchronous Compensator (DSTATCOM) used in microgrid to balances the voltage (V_G) and current (I_G) at the load is presented in this psper . The proposed control method has to mitigate the voltage sag and harmonics than conventional method.The space vector modulation used to enhance the power factor at load side during normal operating condition. The mitigation of voltage problem is identified and rectified in the Distribution System (DS) thus the way of enhancing performance of the system. Renewable energy is used to balance the power across the load because the fault occurs in the source of the distribution system. The Photovoltaic(PV) based converter has generated the power and fed into the distribution line of the microgrid system. The voltage source inverter has converted the PV power for voltage mitigation. The analysis of DSTATCOM has been modelled and implemented in MATLAB/ Simulink.
Keywords: *PV, DSTATCOM, Microgrid, Voltage sag, Distribution System (DS)*

INTRODUCTION

In recent days increasing the utilisation of flexible ac transmission system used in Distribution System (DS) for compensating the reactive power (voltage and current), voltage drop and harmonics of load current [1-2]. The performance of static compensator (STATCOM)is high-speed control of reactive power, voltage balanced, flashcontrol, and balance the PQ problem [3]. During transient condition the total harmonic distortion, stability problem is increased when the load is non linear. In the microgrid, the PQ problem has a high penetration of voltage drop [4-5]. In a single phase application, the photovoltaic based converter has enhanced the source of the converter. In the microgrid, the voltage balance is a significant problem, and it solved by the FACTS devices are designed. The power electronics components have to generate reactive power and the grid voltage [6-9]. The design of the compensating device has chosen the capacitor, inductor value by modelling the distribution system. In conventional STATCOM has utilised the hysteresis controller for fast current control but harmonics is increased. In proposed utilise the space vector modulation has enhanced the voltage regulation and reduced harmonics [10-12]. In DSTATCOM the DC link voltage acts as a storage element which sustains power ratings, reducing theharmonics using resonant elements.

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The active voltage and current flow is controlled by following factors; DC link fed VSC voltages and angle between the AC systems [13].

The three-phase source voltage and current are changed from sinusoidal waveform because of disturbance occurs in the distribution system. The disturbance occurs in short duration, transient oscillation and faults the voltage of the source is reduced that time, and load voltage is dropped. The three-phase inverter injects the decreased voltage, and the space vector controller regulates the generated voltage.

PERFORMANCE OF DSTATCOM

The three-phase (3ϕ) voltage source inverter (VSI) based DSTATCOM generate the voltage which is fed to the transmission line to compensate for the voltage. The circuit of DSTATCOM has six insulated gate bipolar transistor with an anti-parallel diode, passive elements and transformer. The isolation transformer is connected between source and the load for injecting the compensated voltage from the DSTATCOM. Figure 1 shows the proposed block diagram.

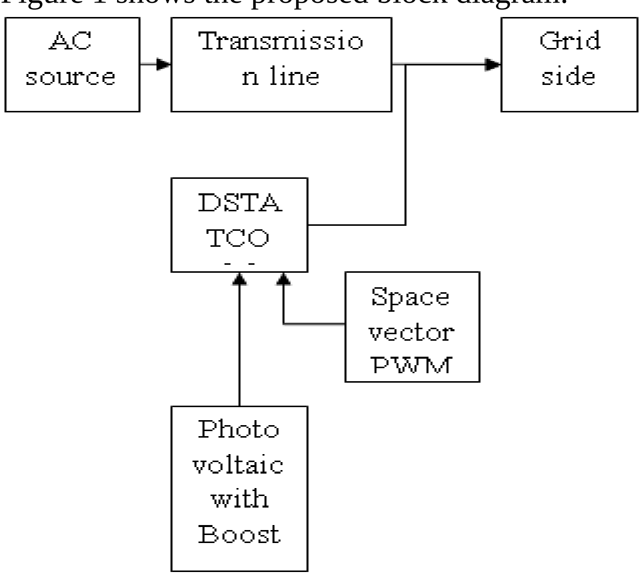

Figure 1: Block Diagram of Proposed Methodology

3ϕ AC source has supplied the power to load continuously when the fault occurs at the source side the voltage of the three-phase is, and it affects the load power. During transient condition the load parameter and dc bus voltage is oscillated. The static synchronous compensator overcomes the problem for load voltage compensation. The photovoltaic based boost converter has connected at the DSTATCOM for supply the power and inject into the transmission line when the fault occurs. Figure 2 shows the photovoltaic based boost converter. PV has generated the dc voltage by irradiation fall on the semiconductor material the electrons flow; thus the form of electricity generation. The single diode photovoltaic model is used, and the boost converter has to enhance the voltage. Figure 3 shows the circuit diagram of the proposed method.

$I_{pv} = I_{ph} - I_0 - I_{RP}$(1)

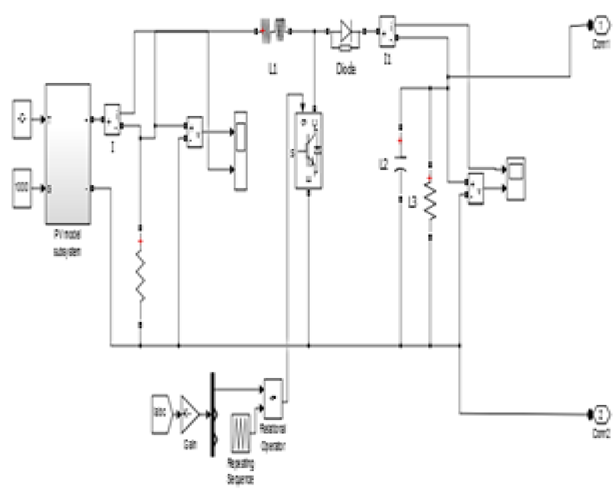

Figure 2: Photovoltaic Based Boost Converter

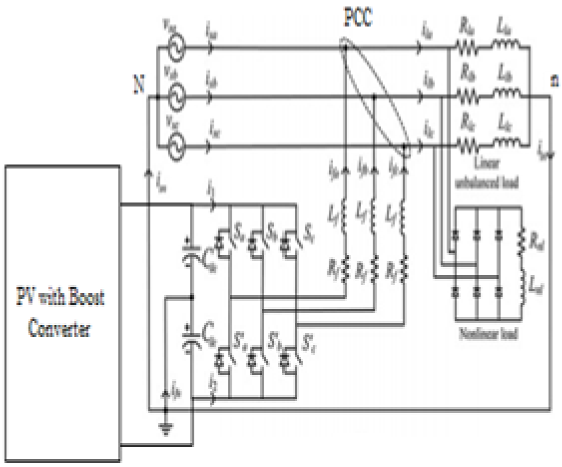

Figure 3: Circuit Diagram of Proposed Method

In the distribution system the shunt capacitance has reduced the high switching frequency, and modelling of the static compensator is obtained by the voltage control method. The STATCOM maintain the terminal voltage by the dc link voltage, dc capacitance, filter inductance and shunt capacitance. The capacitor voltage balance maintains the losses of the inverter. The DSTATCOM attained the reactive power and reduce the harmonics of load current.

CONTROL METHOD

The angle is calculated by the three-phase voltage source, and it is fed into the vector generation and produces the reference voltage. The space vector modulation (SVM) generates the pulse and fed to the 3ϕ inverter in DSTATCOM. Figure 4 shows that the controls diagram of DSTATCOM in DS. The equation of calculating the reference load terminal voltage is given in equation 3-5.

$$V_t^* = \sqrt{V^2 - \left(\left|\overline{I_{la1}^+}\right| X_s\right)^2} - \left|\overline{I_{la1}^+}\right| R_s \tag{2}$$

$$v_{ta}^*(t) = \sqrt{2} V_t^* Sin(\omega t - \delta) \tag{3}$$

$$v_{tb}^*(t) = \sqrt{2} V_t^* Sin\left(\omega t - \frac{2\Pi}{3} - \delta\right) \tag{4}$$

$$v_{tc}^*(t) = \sqrt{2} V_t^* Sin\left(\omega t - \frac{2\Pi}{3} + \delta\right) \tag{5}$$

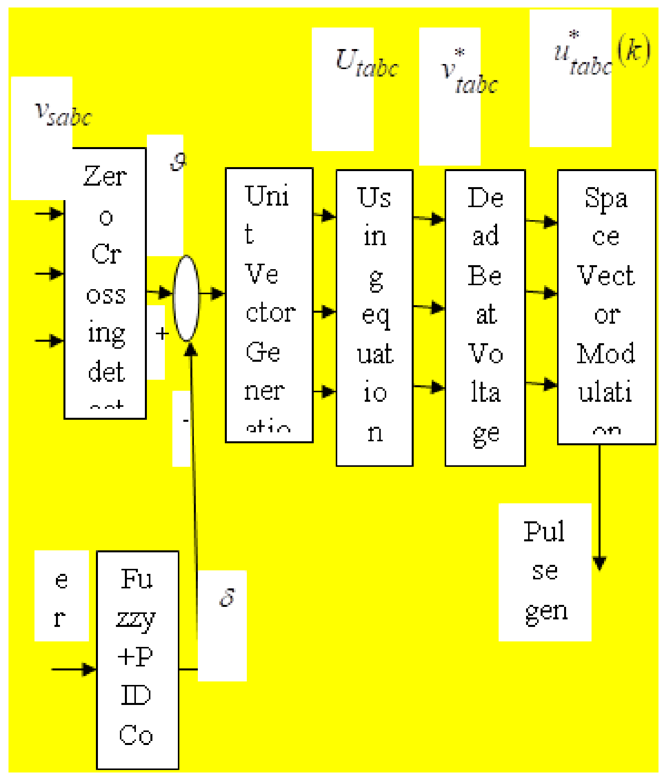

Figure 4: Control diagram of DSTATCOM in Distribution System

RESULT AND DISCUSSION:

The simulation based on DSTATCOM in 3ϕ non-linear loads is representing in figure 5. The space vector modulation is used to reduce the harmonics at the non-linear load. An effective compensation of voltage sag and current sag in the DS is obtained.

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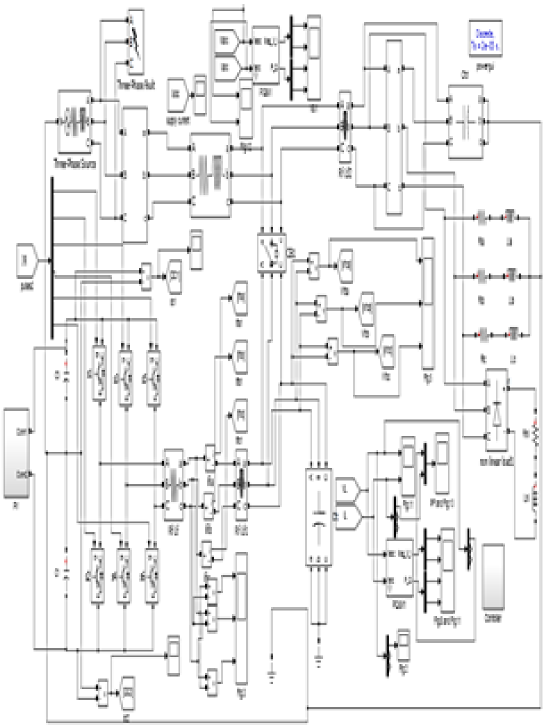

Figure 5: Simulation circuit of DSTATCOM based Space Vector Modulation

The 3ϕ inputsag voltage (220V) and swellcurrent (30amps) in the DS are representing in Figure 6 and 7. Fault occurs in the source side at 0.5-1 sec; the fault is compensated by the three-phase inverter which is supplied by the photovoltaic source.

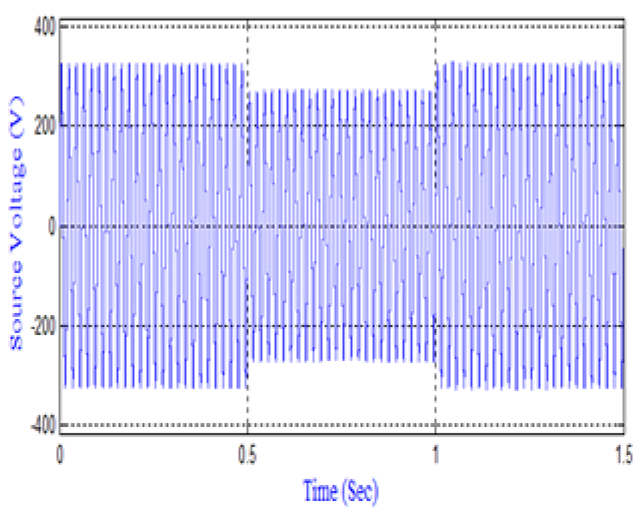

Figure 6: Input Voltage of DSTATCOM

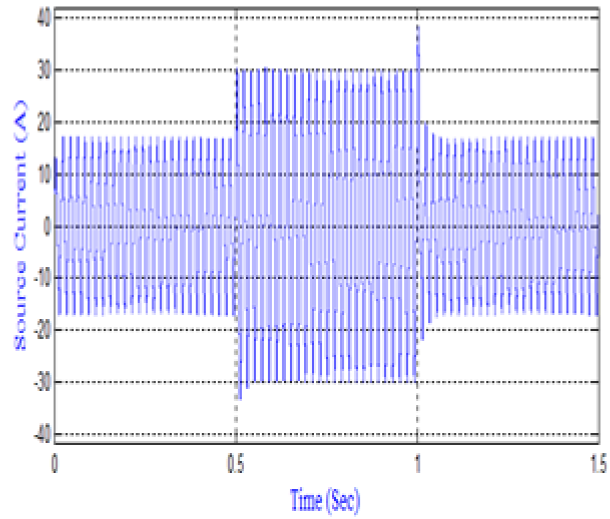

Figure 7: Input Current of DSTATCOM

Transformer gets the power from inverter DSTATCOM device. The input of the DSTATCOM is attained from PV source is around 24V. The compensated load voltage (V_{Load}) about 320V and load current (I_{Load}) about 15amps are injected from the transformerin DS system isrepresenting in Figure 8 and 9.

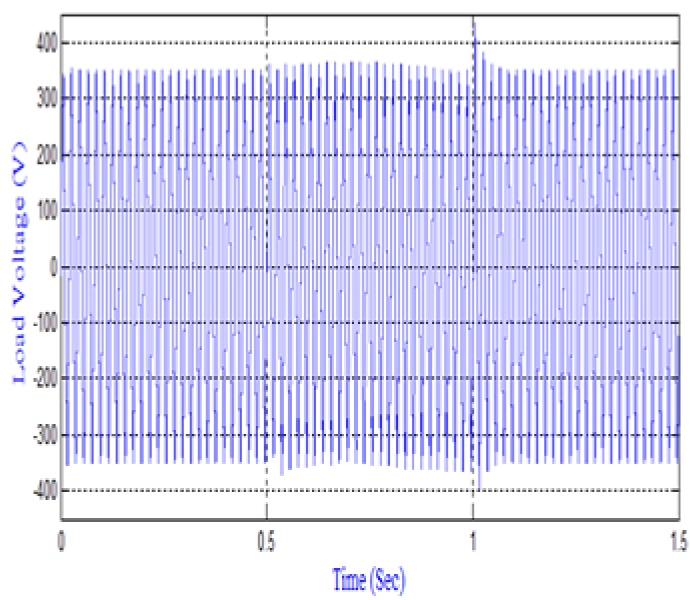

Figure 8: Compensated Voltage at load side of the DS

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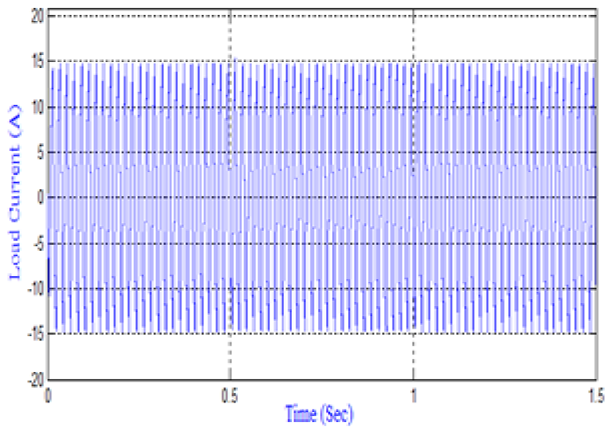

Figure 9: Compensated Current at load side of the DS

Harmonics present in the DS system has measured in load current (I_{Load}) of the three phase load using the FFT analysis method. The attained value of the proposed system THD is 9.74% and represent in below Figure 10. THD of this proposed system is less compared to conventionalmethod.

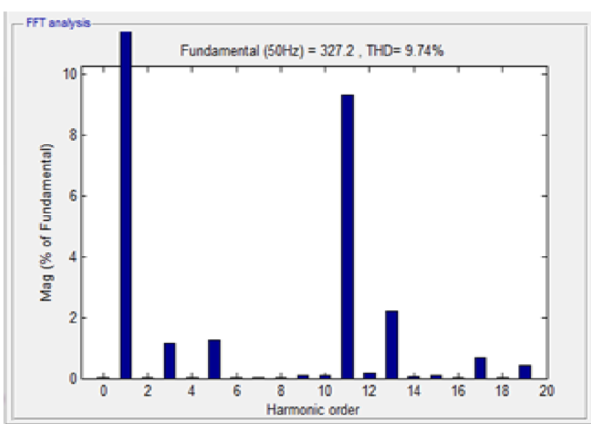

Figure 10: Total Harmonic Distortion (THD) value of load Current

CONCLUSION

The 3ϕ inverter balances linear and non-linear load voltage of the distribution system based on DSTATCOM. The split capacitor has used in the three-phase inverter for voltage regulation which is supplied by the photovoltaic fed boost converter. The modelling and analysis of DSTATCOM have implemented and verified in MATLAB Simulink. The performance of DSTATCOM based on photovoltaic has reduced the harmonic compensation, load voltage and current compensation through space vector modulation results. Moreover, it evades the unbalanced DC capacitor voltage issue related with accepted split capacitor three-leg VSI-based DSTATCOM methodology.

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