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SIMULATION AND ANALYSIS OF REACTIVE POWER COMPENSATION USING DSTATCOM

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Abstract — In this paper, one of the power quality issues is discussed (i.e. reactive power) at load side. Maximum of the loads in the distribution line, being inductive in nature, consume considerably of the reactive power. As a result, the power factor of the load weakens, leading to the limitation of the active power flow in the line. The device used for this issue is, D-STATCOM (Distributed- Static Synchronous Compensator) which having components like voltage source converter, capacitor. This new D-STATCOM provides the voltage regulation or power factor correction by reactive power compensation at wye connected load. The simulation of D-STATCOM is done in MATLAB/ Simulink. Reactive power compensation can be seen from the results as shown here.

Keywords- Power Quality, DSTATCOM, Reactive power, Voltage regulation, Power factor, Spwm.

I. INTRODUCTION

With the growing use of non-linear loads and complication in the network, the power system network faces challenges to supply quality power to the users. Electric power be there to deliver is affected by many factors at the distribution system which has to be compensated to improve the quality and quantity of power been delivered. This discussion is about the Reactive power compensation one of the power quality issue, its requirement, and concerns. Power Quality concerns about the utility ability to provide continuous power supply. The quality of electric power is characterized by factors such as "stability of supply, voltage level variation, transients". Synchronization of electrical quantities permits electrical systems to function correctly and without failure or malfunction of an electric device.[1-2]

1.1 Significance of Power Quality:

PQ states the degree of correspondence of practical power supply with ideal power supply. 1. If PQ is decent (good) then any load associated to the electric network runs powerfully without decreasing its performance. 2. If PQ is poor then any load connected to the network leads either to the failure of the apparatus or reduction in its lifetime and performance. In order to avoid the significances of poor PQ and to recover the utility performance the electric power are investigated to resolve the PQ issues in order to determine the efficient compensation procedure.[2]

1.2 Reactive power compensation:

Reactive power is an issue of great concern for the procedure of alternating current (AC) power systems. It has always been a task to obtain the balance between a minimum quantity of reactive power flow (to maximize capability for active power flow) and an appropriate quantity of reactive power flow to maintain a proper system voltage profile. Even if it does not do any useful work but its compensation is necessary for many reasons. The majority of the load in a usual AC power system is inductive; the current lags behind the voltage. Inductors (reactors) are said to store or absorb reactive power, because they store energy in the form of a magnetic field. Therefore, when a voltage is at first applied across a coil, a Magnetic field builds up, and the current reaches the full value after a certain period of time. This in turn origins the current to lag the voltage in phase. Since the voltage and current are out-of-phase, this leads to the appearance of an "imaginary" form of power known as reactive power. Reactive power does no measurable work but is transferred back and forth between the reactive power source and load every cycle. Capacitors are said to generate reactive power, because they store energy in the form of an electric field. Therefore when current permits through the capacitor, a charge is built up to produce the full voltage difference over a definite period of time. Thus in an AC network the voltage across the capacitor is charging at each time. Since, the capacitor tends to oppose this change; it origins the voltage to lag behind current in phase.[3]

II. Distributed static synchronous compensator

The distribution STATCOM is similar to a transmission STATCOM in that it contains a VSC of the required rating. However, the VSC used in a DSTATCOM is a converter with PWM control over the magnitude of the injected AC voltage while maintaining a constant DC voltage across the capacitor. Faster power semiconductor devices such as IGBT or IGCT are used as an alternative to GTO. The fast switching capability provided by IGBT (or IGCT) switches permit the use of more sophisticated control schemes to deliver functions of balancing (by injecting negative sequence current), active filtering (by injecting harmonic currents) and flicker mitigation.[4]

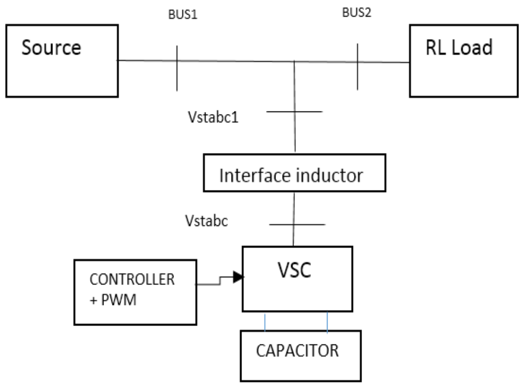

Fig.2.1 Simple Block diagram of DSTATCOM

The D-STATCOM is three phase shunt connected power electronics based device. It is connected near the load at the distribution system as shown in fig 2.1. It is also a one type of the voltage- source converter, which converts a DC input voltage into AC output voltage in order to compensate the active and reactive power needed by the system. A VSC is connected to bus through interface inductor. A voltage source converter (VSC) is a power electronics device, which can generate sinusoidal voltage with required magnitude frequency and phase angle. PCC is the point of common coupling at which the generation or absorption of reactive Power takes Place to and from the system and the device. At the distribution voltage level, the switching device is generally the IGBT due to its lower switching losses and reduced size.[6-7]

III. SINUSOIDAL PULSE WIDTH MODULATION

In this modulation technique, there are multiple numbers of output pulse per half cycle and pulses are of different width. The width of each pulse is changing in proportion to the amplitude of a sine wave estimated at the center of the same pulse. The gating signals are generated by comparing a sinusoidal reference with a high frequency triangular signal. The RMS ac output voltage.

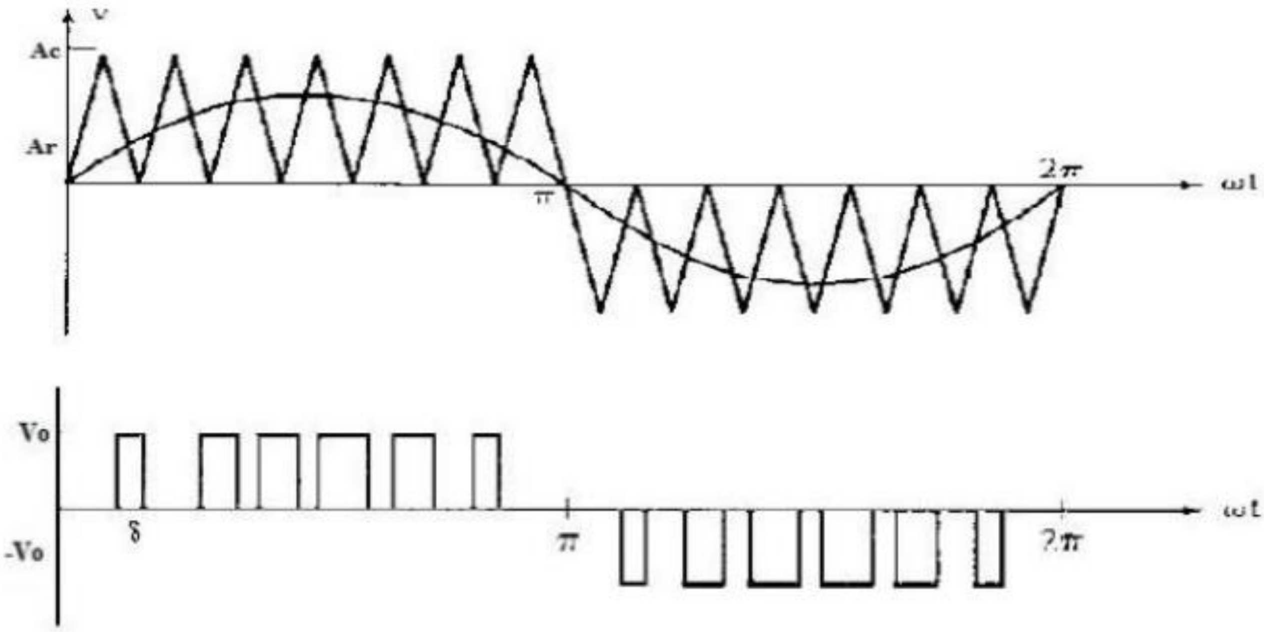

Fig.3.1 SPWM technique

The most common and widely held technique for generating True sine Wave is Pulse Width Modulation (PWM). Sinusoidal Pulse Width Modulation is the best technique for this. This PWM technique includes generation of a digital waveform, for which the duty cycle can be modified in such a way so that the average voltage waveform corresponds to a pure sine wave. The simplest way of generating the SPWM signal is through comparing a low power sine wave reference with a high frequency triangular wave. This SPWM signal can be used to control switches. Through an LC filter, the output of Full Wave Bridge Inverter with SPWM signal will generate a wave roughly equal to a sine wave. This technique produces a much more similar AC waveform than that of others. The primary harmonic is still present and there is somewhat high amount of higher level harmonics in the signal.[5]

IV. DSTATCOM Simulation and Result:

(A) System parameter and rating:-

The power system consists of a three phase source of **415V, 50Hz** which supplies real and reactive power to **a RL load** consuming **active power 50KW** and **reactive power 30KVAR**. In this condition, source (grid) is responsible for handling the total real power and reactive power demands of the load.

DSTATCOM having the three phase inverter with switching element as IGBT, and a dc capacitor of **700V constant**. **Operation time** of converter is kept at **t =0.2 sec**.

(B) DSTATCOM Simulation :-

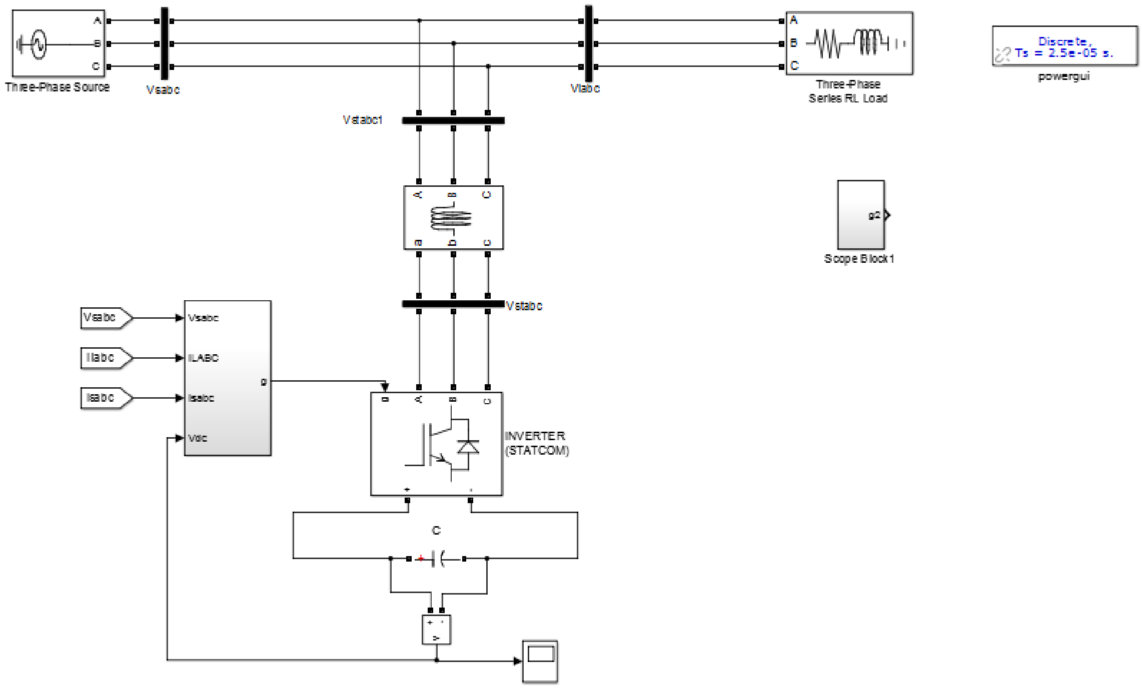

Fig. 5.1 DSTATCOM Simulation

(C) Instantaneous reactive power control and sine PWM :-

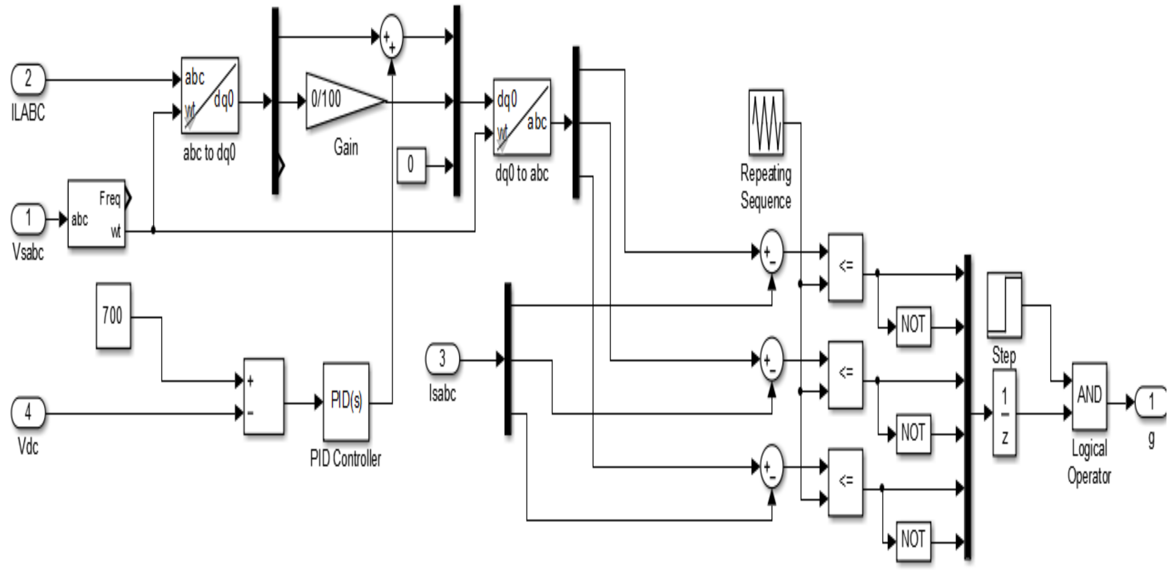

Fig. 5.2 Controller + PWM blocks

(D) Measurement blocks :-

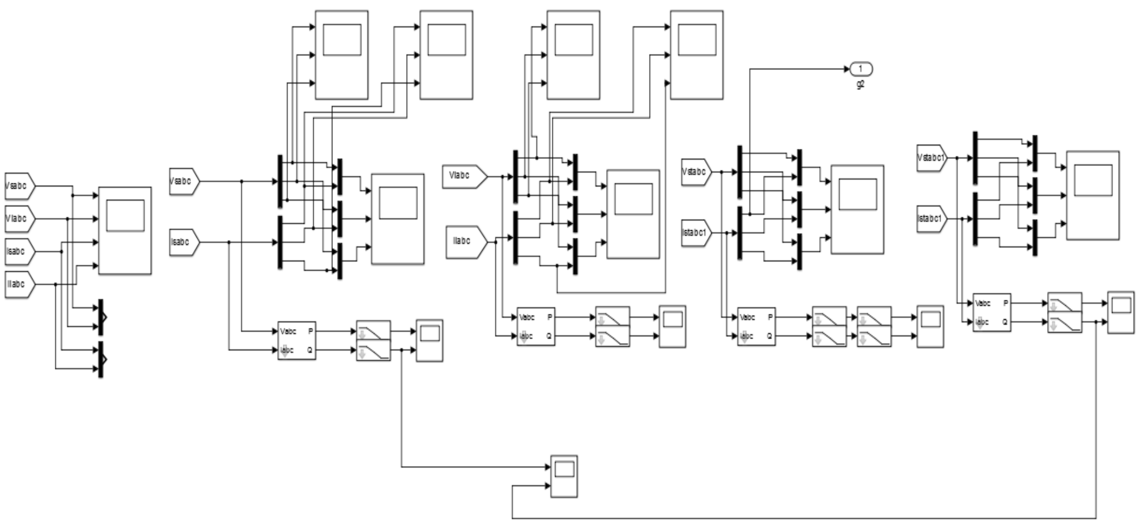

Fig. 5.3 Measurement blocks

(E). Simulation results :-

- **BUS1 Voltage and Current:**

Fig.5.4 is the voltage and current wave forms of the three phase system, taken at the source (grid) side. For t = 0 to 0.2 sec, current lag voltage i.e. reactive power is supplied by source to load. But after t = 0.2 sec, current and voltage gets in phase i.e. power factor improves by D-STATCOM.

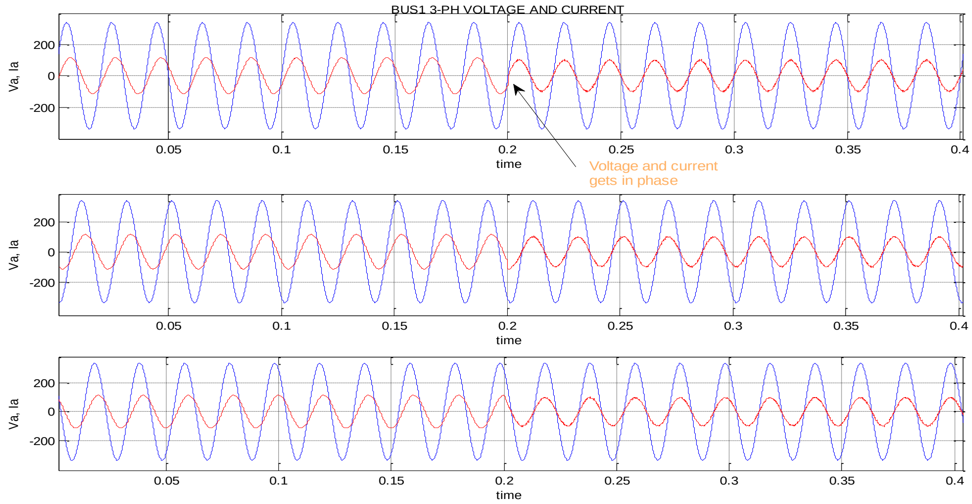

Fig. 5.4 BUS1 Voltage and Current

- **BUS1 Active and Reactive power:**

Fig. 5.5 shows source active power and reactive power supplying a load 50KW and 30KVAR.

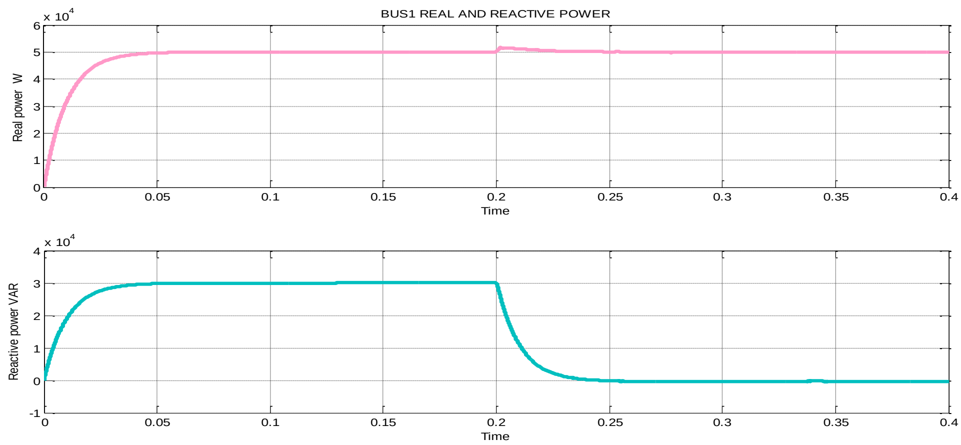

Fig. 5.5 BUS1 Active and Reactive power

- **BUS2 Voltage and current:**

Fig.5.6 shows voltage and current wave forms measured at load Side of the system. This current is lagging the voltage by some angle based on reactive power requirement of a load.

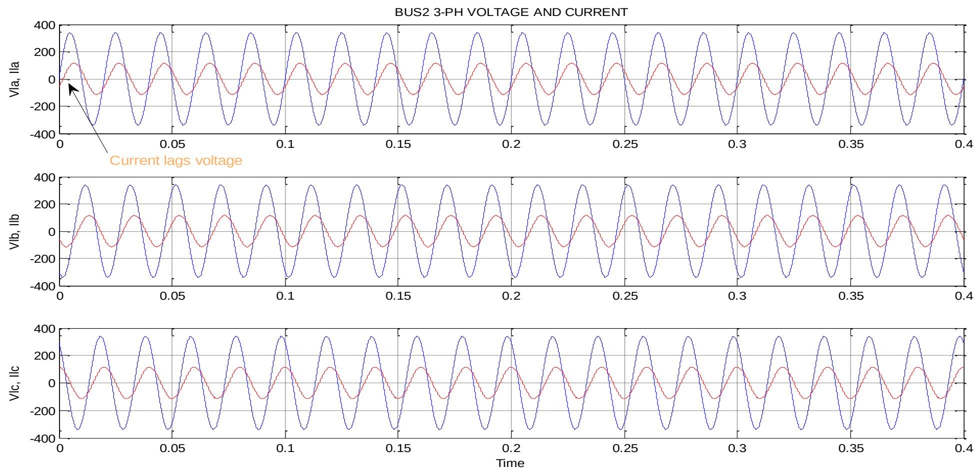

Fig. 5.6 BUS2 Voltage and Current

- **BUS 2 Active and Reactive Power:**

Fig.5.7 shows, load consuming power of 50KW and 30KVAR.

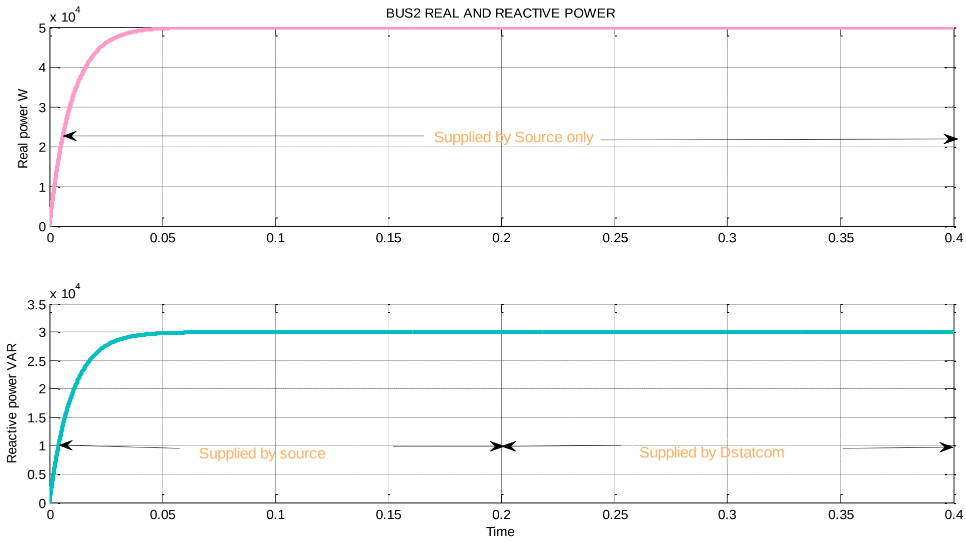

Fig. 5.7 BUS2 Active and Reactive power

- **VSC output:**

Fig.5.8 gives the VSC output in which, after 0.2 sec inverter operates and generates current as needed by load for reactive power compensation. This output is in PWM form, to bring it in a sine wave form, a smoothing reactor or interface inductor is to be connect to filter out the carrier wave of 25 KHz.

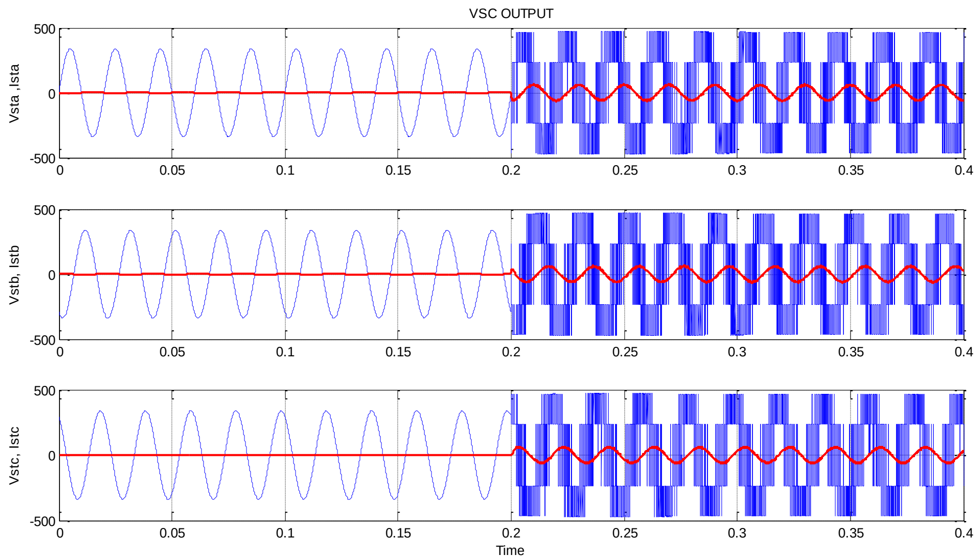

Fig. 5.8 Voltage source converter output

- **Final output of VSC at Point of common coupling:**

Fig.5.9 is the final waveform of VSC after smoothing reactor (at PCC) and apply for reactive power compensation.

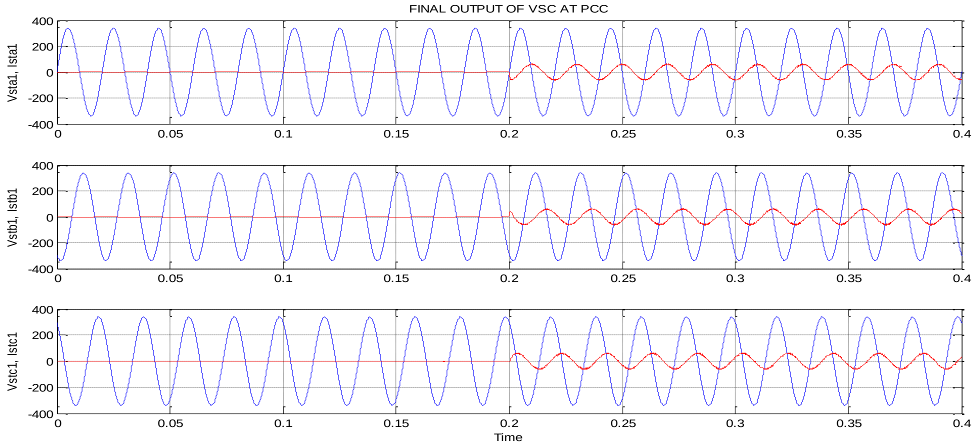

Fig. 5.9 Final Voltage source converter output at PCC

- **D-STATCOM Active and Reactive power flow:**

As D-STATCOM not having any sustainable dc energy source, active power is tends to zero and 100% reactive power compensation done after 0.2sec. (Fig.5.10)

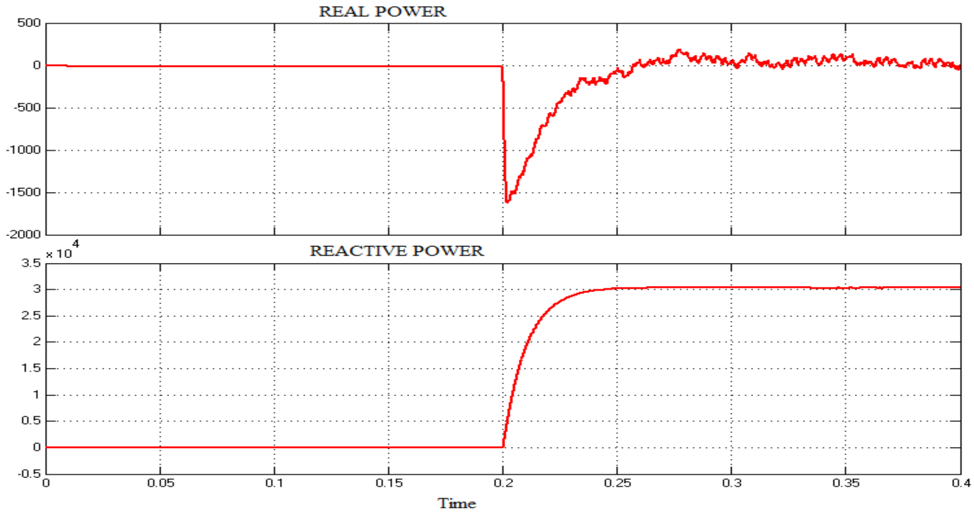

Fig. 5.10 D-STATCOM Active and Reactive power flow

- **Overall Reactive Power Flow supplied to load:**

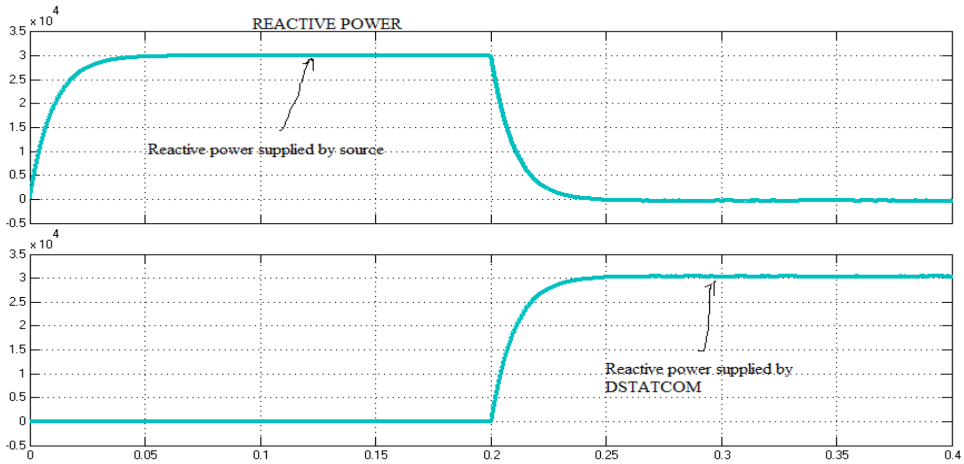

Fig. 5.11 Reactive power flow required by load

- **Measurement table:**

Time	Power Sharing		
	Power drawn by load	Power supplied by D-STATCOM	Power supplied by Source
T = 0 to 0.2 sec	P = 50KW Q = 30 KVAR	P = 0 Q = 0	P = 50KW Q = 30KVAR
T = 0.2 sec onwards	P = 50KW Q = 30KVAR	P = 0 Q = 30KVAR	P = 50KW Q = 0

V. CONCLUSION

This paper aimed to compensate reactive power at distribution side for better voltage regulation and improves power factor which leads to increase active power capacity and also maintains power quality. New thing here is to maintain reactive power as per load requirement. With the use of D-STATCOM it can be concluded that it gives efficient results of improved power factor as well as reduced amount of voltage spikes at operation, reduced losses. Simulation results are the reflection of the efficiency of DSTATCOM.

VI. REFERENCES

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