solar based distributed statcom to improve power quality

1Hetanshu Panwala, 2Viveck Amravat
1Student, 2Student
Darshan University

Abstract - the power quality problem is not new at distribution side, but customer awareness of this problem has increased. For reactive power compensation, a wide range of research work has taken place to develop systems that can compensate reactive current dynamically under varying load condition in power systems. Custom power is a solution that having flexible solution to various power quality problems. DSTATCOM is one of the custom power device, and acts as an appropriate solution to reactive power compensation issue at minimum cost in power distribution networks. A voltage source converter based DSTATCOM can be made to inject or absorb reactive power into the ac system to improve the power factor/voltage regulation. The integration of solar PV generation can also be done with the D-STATCOM as the distributed generation is an enlarging area for the recent power system.

keywords - d-statcom, reactive power compensation, solar power generation, photovolatic array

I. INTRODUCTION

Devices immune to harmonic generating loads. Many researchers have focused on improving power quality based on renewable energy sources in distribution systems. Custom power devices (CPDs) were introduced to improve power quality and reliability. Of particular interest among these new devices are The power quality problems are not new on the distribution side, electricity utilities and end consumers of electricity are increasingly interested in meeting their growing energy demands. Power quality issues are getting more and more attention due to the increase in sensitive loads. Electrical equipment such as electric motors, transformers, generators, computers, printers, communication equipment, and household appliances. All of these devices and others react negatively to power quality issues, depending on the severity of the problem. Power quality issues are primarily related to the source and load type. Harmonic distortion and its effects are one of the most serious power quality issues. Therefore, the widespread use of power electronics-based devices and nonlinear loads leads to growing concerns about harmonic distortion in AC power systems. According to IEEE standards, power system harmonics should be limited in two different ways. One is the limit on the harmonic current that the user can inject into the utility system at the point of common coupling (PCC) and the other is the limit on the harmonic voltage that the utility can supply to anyone. Customers of PCC. Current harmonics are therefore often treated as a local problem of at least one feeder in the distribution network. The impedance of the distribution network attenuates the propagation of harmonics. Therefore, for best results, harmonic filtering should be performed close to the current harmonic source. This makes other those based on voltage source converter technology. A typical example of such a device is the distribution static compensator (DSTATCOM), which is widely used to compensate for power factor correction, source current harmonic reduction, and load compensation at the distribution level.

II. D-STATCOM

A distribution static compensator (D-STATCOM) is custom power device compensates for the reactive power and unbalance caused by the various loads in distribution system. It compromises of voltage source converter (VSC), a D.C capacitor, coupling inductor or coupling transformer and controller. Faster power semiconductor devices such as IGBT is used. The rapid switching capability provided by IGBT switches enable the use of more sophisticated control schemes to provide functions of balancing (by injecting negative sequence current),active filtering by injecting harmonic currents.
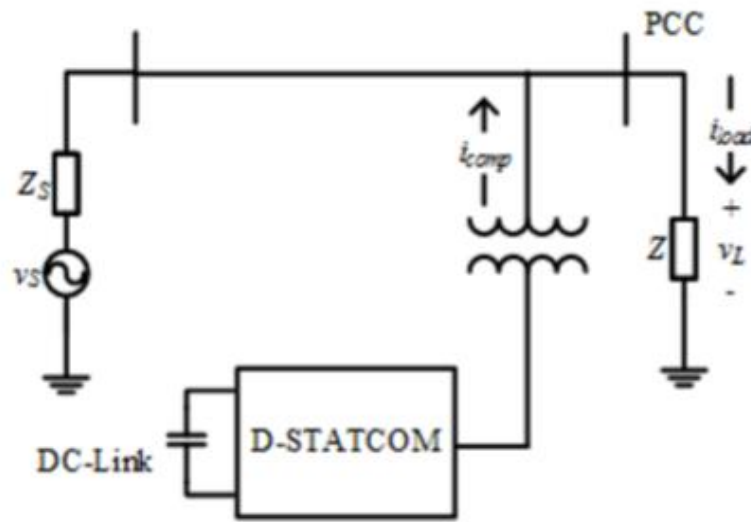
Fig 1. Single line diagram of DSTATCOM

D-STATCOM OVERVIEW

Mode of operation

- Capacitive Mode: When the output voltage of the VSC is greater than the ac system voltage, the VSC injects reactive power into the ac system. Thus, it acts in the capacitive mode as the ac system, in this case, draws capacitive current which leads the system voltage.

- Inductive Mode: When the ac system voltage is greater than the output voltage of the VSC, reactive power is absorbed by the VSC from the ac system. Thus, here it acts in the inductive mode.

- Floating Mode: When the output voltage of VSC equals the ac system voltage, the VSC neither generates nor absorbs any reactive power, thereby, acting in floating mode
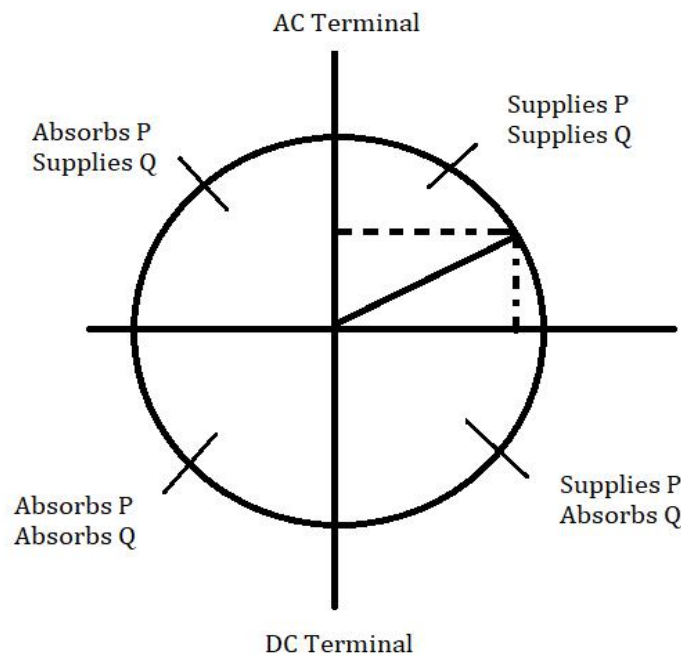

Fig 2. Operating regions

III. SOLAR POWER GENERATION FROM MPPT P&O TECHNIQUE

The perturb and observe (P&O) algorithm is generally the most commonly applied in the control of MPPT algorithm for the PV generator. It has simple structure, low cost, easy to implement, reduced number of parameters, the possibility to introduce improvements and may result in top-level efficiency. When the PV module operating point is on the left side of the curve ($\Delta P/\Delta V$ is positive), which means the PV module output power increases, the perturbation of the PV module voltage should be increased toward the MPP. If the operating point of the module was on the right side of the curve ($\Delta P/\Delta V$ is negative), then the perturbation of the PV module voltage should be decreased toward the MPP.
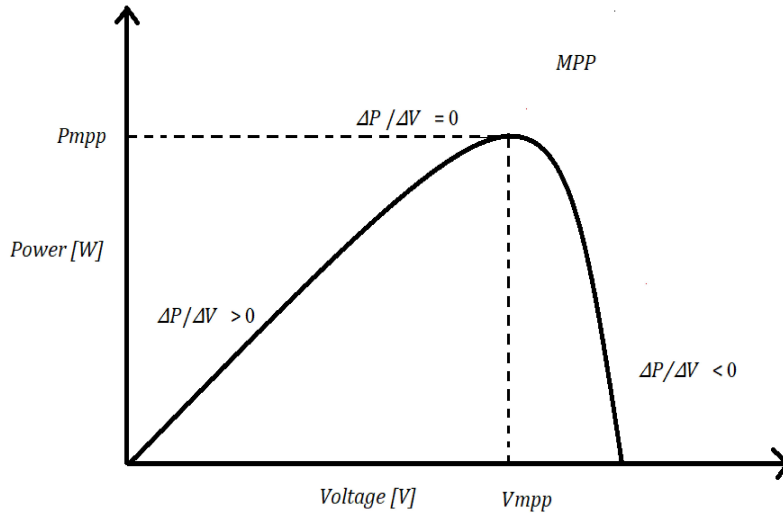

Fig 3. Behaviour of solar panel indicating MPP and operating principle

IV. SIMULATION AND RESULT

Simulation of MPPT P&O Algorithm

The Simulation of solar PV generation is performed in MATLAB Simulink as depicted. The maximum power point is obtained through P & O Algorithm. Irradiance is considered as 1000 W/m2. The workspace is added to measure Ipv, Vpv, Ppv in this model. It takes irradiation, operating temperature in Celsius and module voltage as input and gives the output current Ipv and output voltage Vpv.

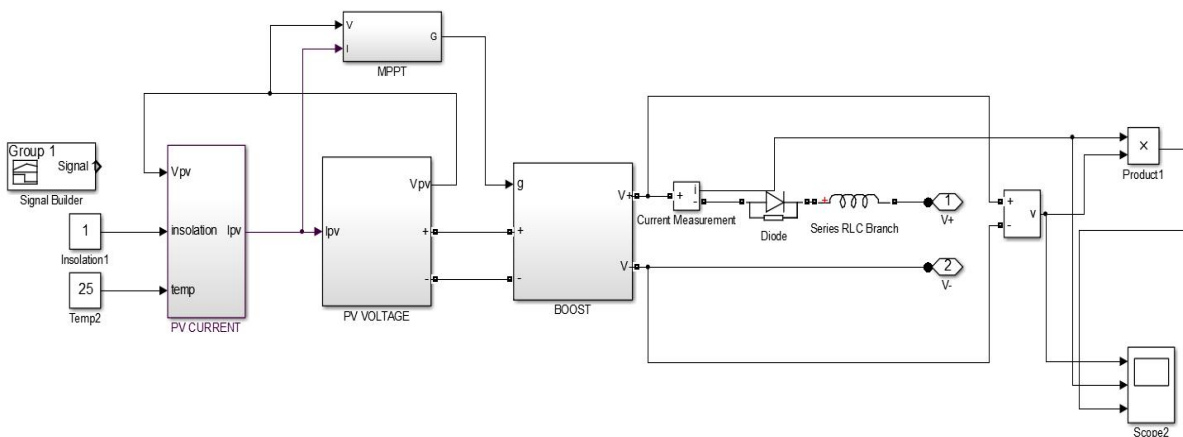Fig 4. Solar power balance system

Parameters used in simulation

- V_{pv} is the output voltage of a PV module (V)
- I_{pv} is output current of a PV module (A)

- T_r is the reference temperature = 295 K
- T is the module operating temperature in Kelvin
- I_{ph} is the light generated current in a PV module (A)
- I_o is the PV module saturation current (A)
- A is an ideality factor = 1.5
- k is constant = 1.3802×10^{-23} J/K
- q is Electron charge = 1.6×10^{-19} C
- R_s is the series resistance of a PV module
- I_{SCr} is the PV module short-circuit current at 26^0C and 1000W/m^2 = 2.55A
- K_i is the short-circuit current temperature co-efficient at I_{SCr} = 0.0014A $/^0$C
- λ is the PV module illumination (W/m2) = 1000W/m^2
- E_{go} is the band gap for silicon = 1.2 eV
- N_s is the number of cells connected in series
- N_p is the number of cells connected in parallel

The current output of PV module is

$$I_{pv} = N_p \times I_{ph} - N_p \times I_o \,[\, \exp \{q \times (V_{pv} + I_{pv}\, R_s\,) / N_s\, AkT\} - 1]$$

Fig 5. Waveform of solar power output i.e. voltage current and power.

DSTATCOM Control strategy

The first block shows the inverter. The left hand side of the block of simulation is the control algorithm that controls the inverter

Bottom block of controller is solar plant block which is used to supply power to the D-STATCOM it is fed through a capacitor

it is charged, by a capacitor and became source or power supply for the inverter. After that inductance is held, which is called

line commutating inductance when the inverter is connected to the system distorted output is obtained from it which is square

in shape to inductance is used to obtain pure signal which is in sinusoidal in form. The voltage at bus St_{abc} is pulsating and

voltage at bus St_{abc1} is pure sine wave after purifying. The D-STATCOM is connected at point of common coupling (pcc). The phase RL load is been used here which is rated. The aim is to compensate power at essential percentage required, Supply power from D-STATCOM to load to reduce burden from source and make it cost effective.
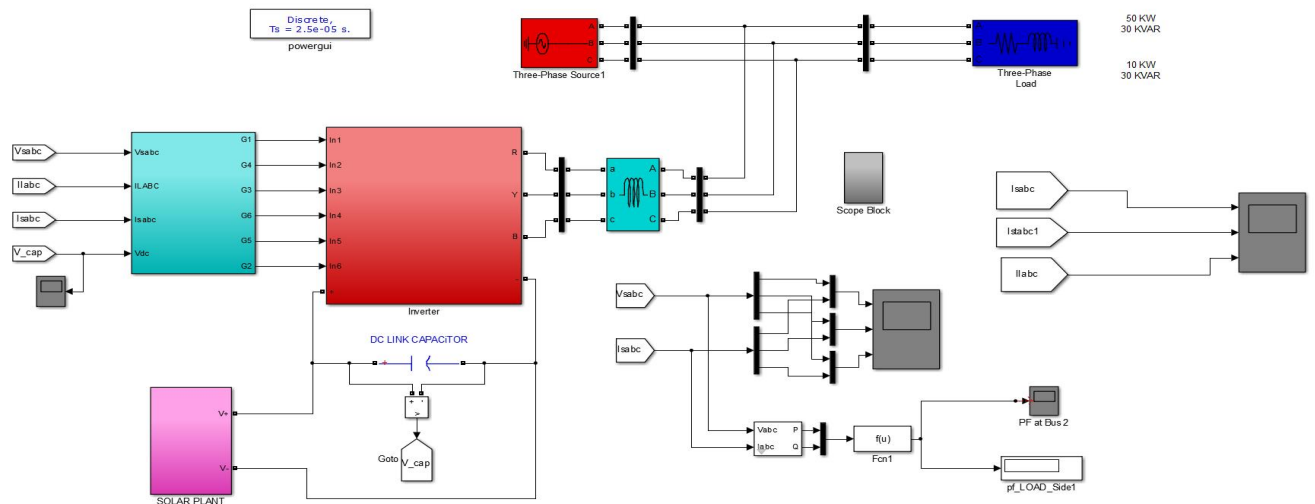
Fig 6. Matlab simulaton and control strategy of D-Statcom

Subsystem block of control strategy of D-STATCOM

This works from ABC to DQ 0. Clark Park's Transformation Theory The theory states that the criterion chosen is the load current, which follows the template of the source current. Here, three signals are fed into the PLL phase-locked loop. The function of the PLL is to take a voltage reference and fix it to a specific frequency. The other signal is the angular frequency, which is fed to the ABC TO DQ0 block when converting the signal to the DQ0 reference signal, whose frequency must be preserved. The generated Q signal is compensated by the percentage you want and the percentage you want to compensate. All signals are then fed back to the ABC block on DQ0 to obtain a 3-phase output. The output of this controlled signal is compared with the actual ABC signal from the D-STATCOM and is essentially the current flow from the current source. Comparing the results after connecting the D-STATCOM to the solar panel and before the solar panel, the D-STATCOM starts working after 0.5 seconds, passing the output to the 6-switch inverter, the AND logic operator is used.
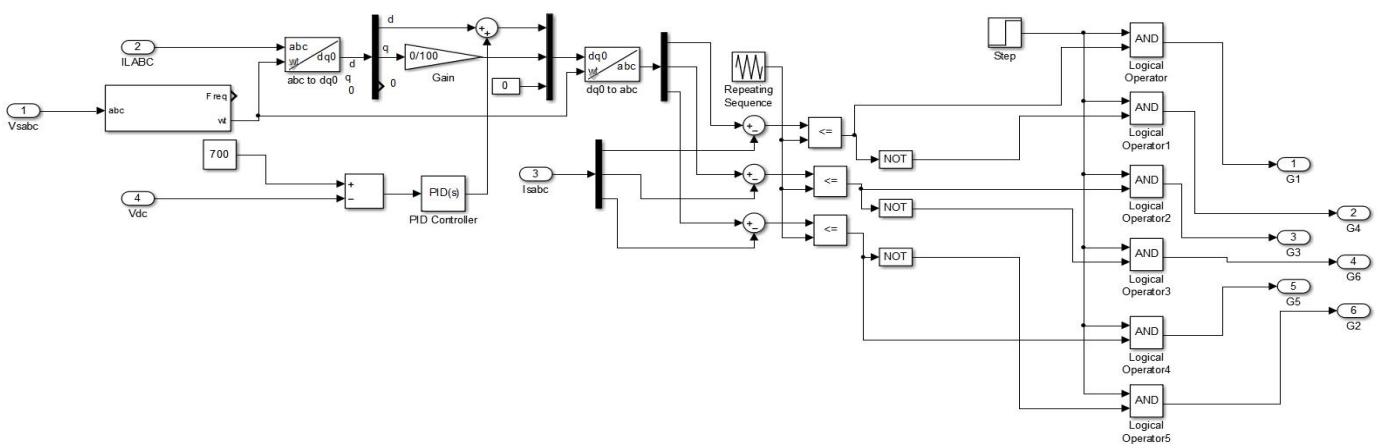

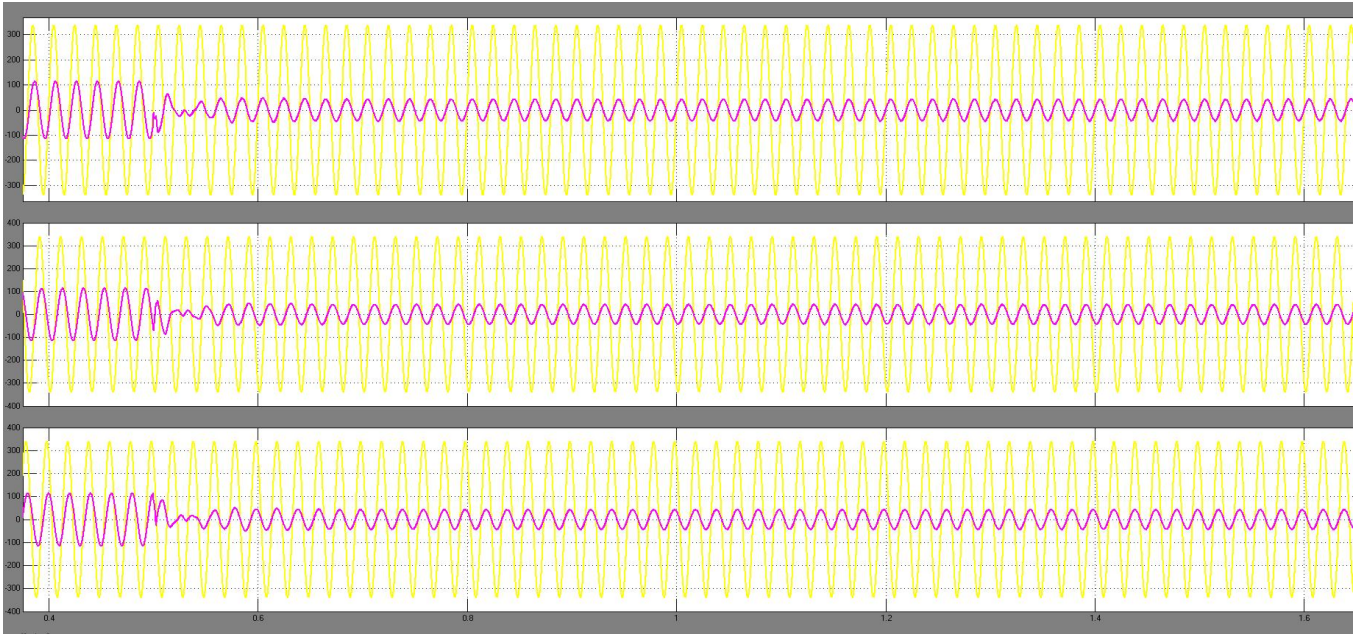
Fig 7. Control algorithm of the system

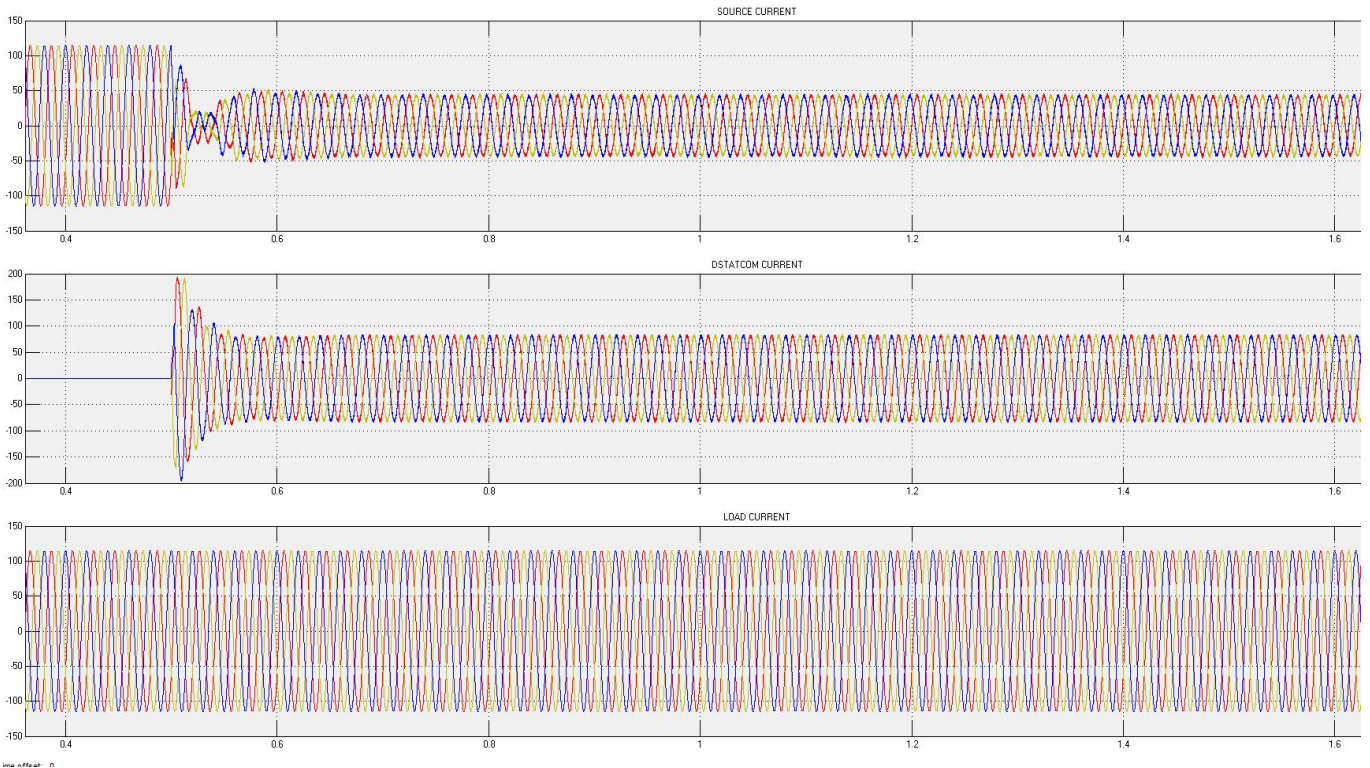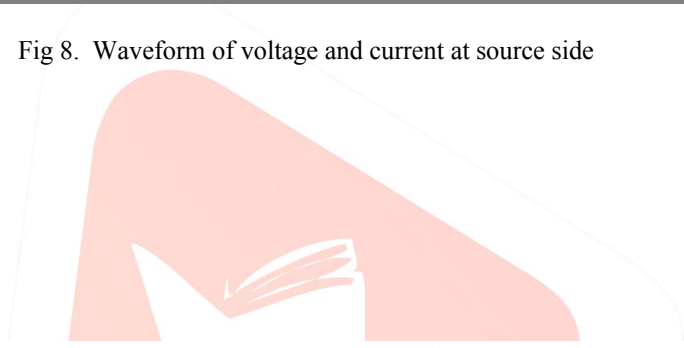Fig 8. Waveform of voltage and current at source side
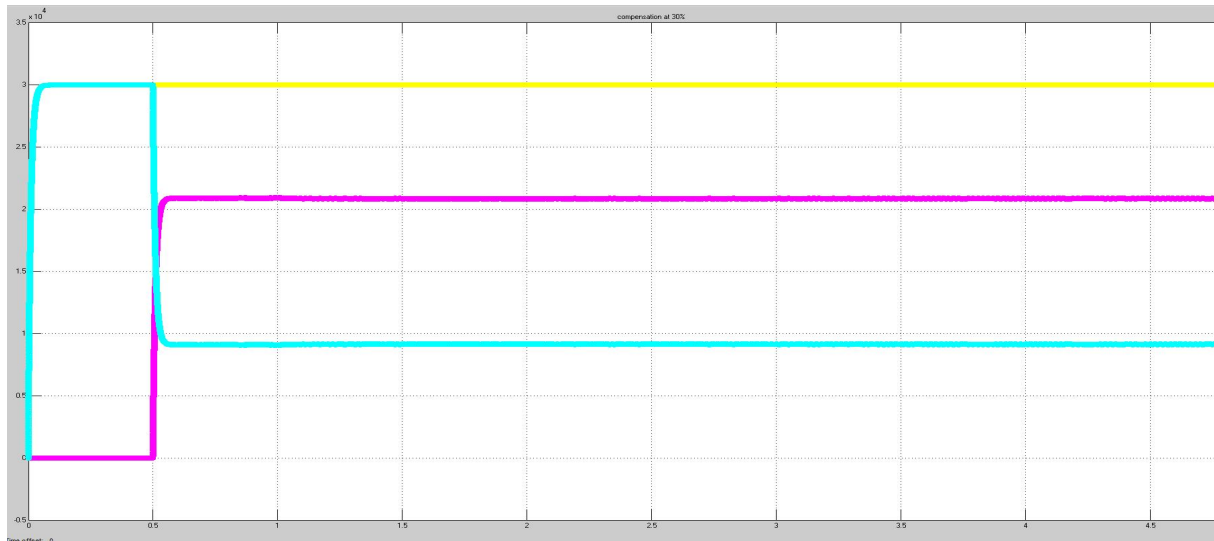

Fig 9. current waveform

Fig 10. Reactive power compensation at 30 %

- The yellow line indicates reactive power of the load
- Blue line indicates reactive power of the 3 phase source side.
- Pink line indicates reactive power flow from the D-STATCOM ,when system starts operating and after D-STATCOM is
  connected and power is compensated at 30% we can observe that source is supplying less compared to D-STATCOM to the system.
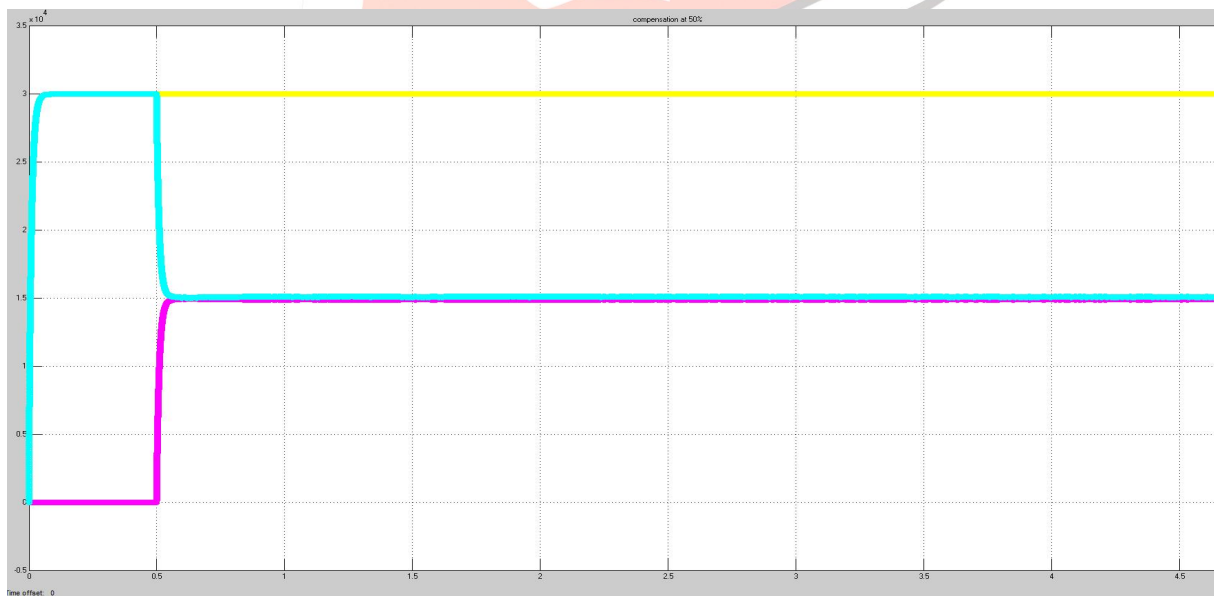

Fig 11. Reactive power compensation at 50 %

Here we are observing that when power is compensated at 50% both source and D-STATCOM are supplying equal amount of
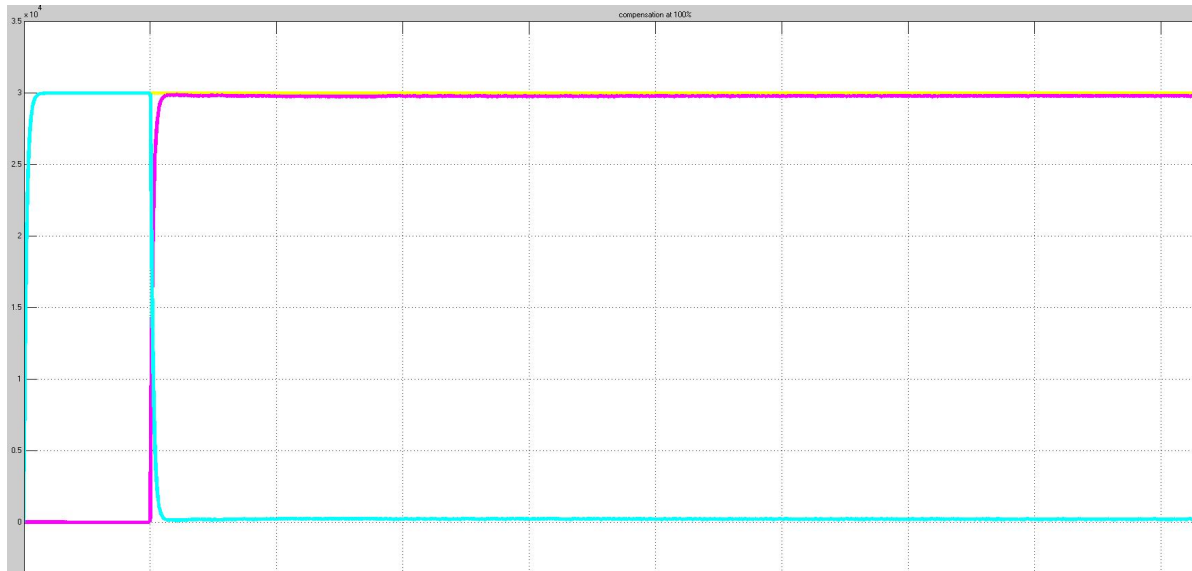Power to the system

Fig 12. Reactive power compensation at 100 %

Now here, when the d-statcom is connected in the system after 0.5 seconds of the simulation and when the power is compensated to 100% we can observe that reactive power of the D-STATCOM (Pink line) supplying The full load similar coming from the source (Blue line) and the source connected to the system stop supplying any power through it and it comes to zero.
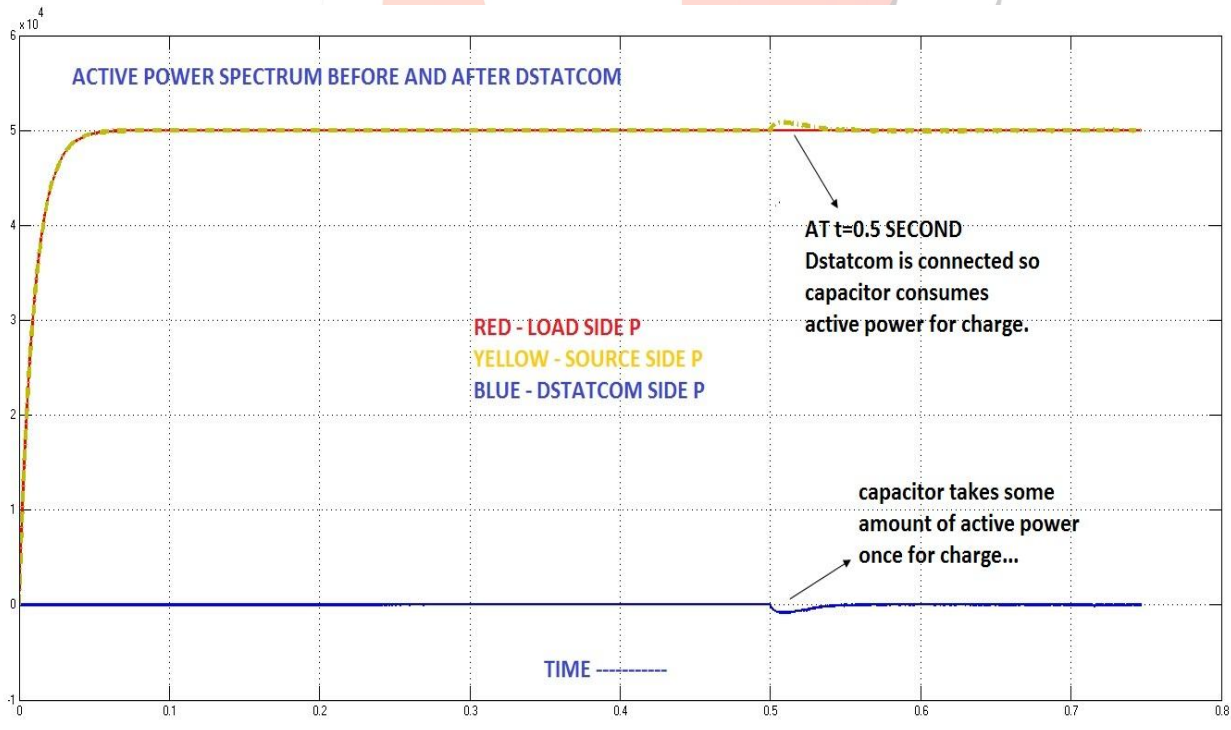

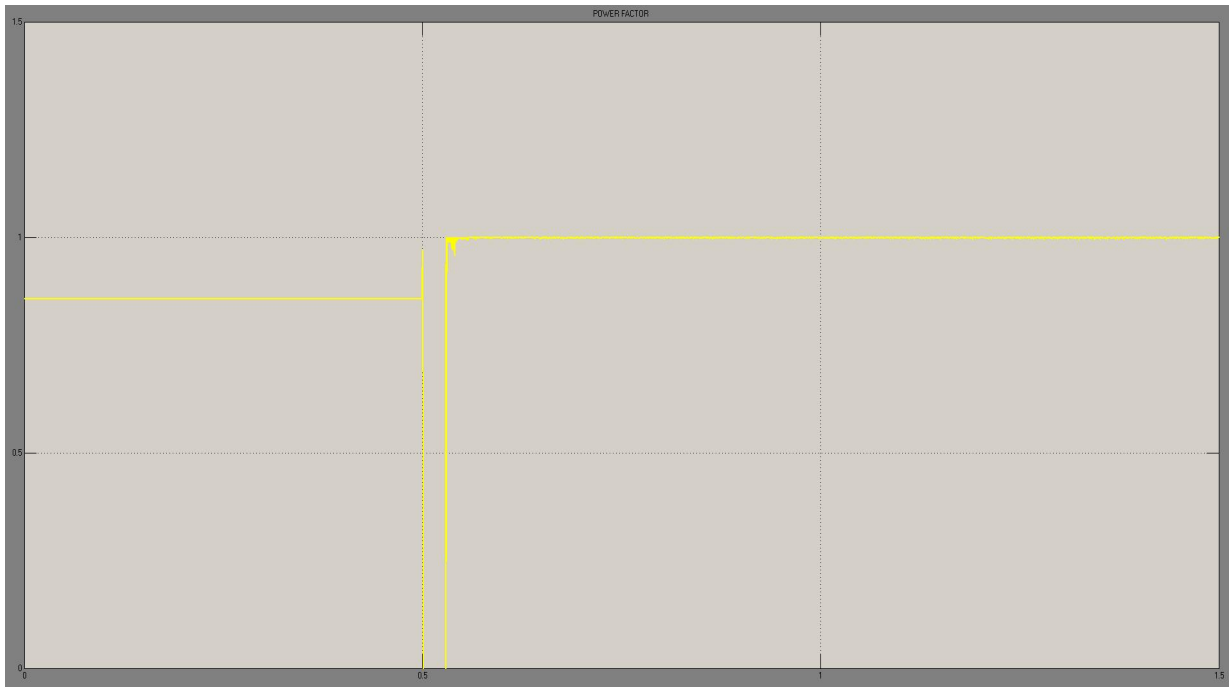Fig 13. Active Power Spectrum Before and After D-STATCOM

Fig 14. Power factor after connecting D-Statcom

Result Data

Load	compensation	Active power P	Reactive power Q
D-STATCOM compensation	30%	Source – 50 KW	Source – 8.1 KVAR
		DSTATCOM – 0 KW	DSTATCOM – 20.7 KVAR
	50%	Source – 50 KW	Source – 1.7 KVAR
		DSTATCOM – 0 KW	DSTATCOM – 1.7 KVAR
	100%	Source – 50 KW	Source – 0.3 KVAR
		DSTATCOM – 0 KW	DSTATCOM – 29.5 KVAR

V.   CONCLUSION

This paper aimed to compensate reactive power at distribution side for better voltage regulation and improve power factor we lead to increase active power capacity and also maintain power quality better. With the use of D-STATCOM it can be

concluded that compared to capacitor it gives effective results of improve power factor as well as reduce amount of voltage spike at operation which reduce losses.

VI. ACKNOWLEDGMENT

VII. REFERENCE

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