MODELING AND SIMULATION OF A DISTRIBUTION STATCOM (D-STATCOM) FOR POWER QUALITY PROBLEMS

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Abstract: Active power filtering is boon in the field where power quality is a major concern. There are many control algorithm for active power filters .This paper is based on reactive power compensation by using shunt FACTS device STATCOM. The control algorithm used is Instantaneous Reactive Power Theory. In IRPT algorithm the three phase abc reference frame is transformed in two phase αβ reference frame by using PQ theory.

Keywords: DSTATCOM, IGBT , FACTS

1. Introduction

The efficiency of any system whether it is generation,distribution or transmission is measured on the basis of power quality .Nowadays it has been seen that there are several types of power quality issues. There are no of reasons for this issues such as presences of voltage harmonics, spikes, surges, notches sag/dip, swell etc. Because of use of solid state devices, the nature of loads becomes nonlinear, which shows its impacts on the source side. The use of solid state devices cannot be dispensed due to its advantages of the cost and size reduction energy conservation etc.

Power quality is defined as how much a system can delivered and stable power supply. Due to excessive use of nonlinear loads the efficiency of system has reduced but due to its advantages over conventional devices it cannot be replaced. If power quality is not maintained devices had to face many problems such as malfunction of equipments damages these devices.[1]

Many solid state devices such as thyristors, IGBT are used in solid state devices is widely used to feed controlled electric power to various loads.[2]

Power electronics devices used in conjunction with other devices to compensate the disturbance caused by nonlinear load.It can use as shunt, series or series shunt configuration.[3]

STATCOM

There are many FACTS devices which are used to mitigate different problems which are caused by voltage and current.There are many advantages of FACTS devices but the disadvantages of cost cannot be neglected.[4]

D-STATCOM

D-STATCOM is a compensating FACTS device which is used to balanced the flow of reactive power in any system.The reactive power power in any system is because of inductive load present in it. The disturbance in power flow causes low power factor, harmonics current , unbalance neutral current and voltage instability. These problems are resolve by using STATCOM in shunt with the system.[5]

D-STACOM is connected in shunt with the system. Since it is based on voltage source converter topology. It consist of IGBT along with capacitor in parallel. These is 3 leg VSC converter which is connected to the system with reactor. The pulse of IGBT is given as requirement of reactive power.[6]

Voltage source converters trigger the IGBT according to the control algorithm use. The VSI turns on the IGBT according to the pulses provides to the gate generates the required reactive power[7]

Since time domain approaches are mainly used for three phase system hence are some control algorithm based on time domain analysis

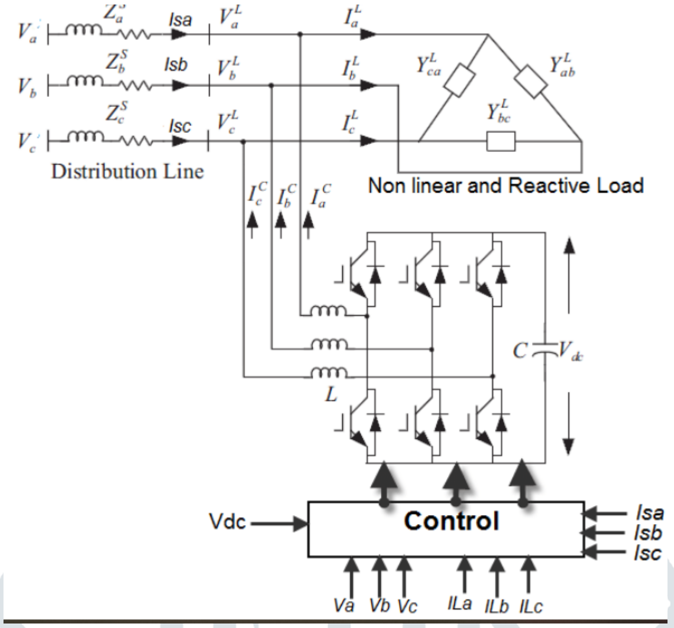
- P-Q theory
- Cross vector theory
- Global theory
- Synchronous detection theory
- Vectorial theory
- Synchronous frame based theory
- Instantaneous reactive power theory
- Back propagation Theory
- Learning vector theory
- Adaptive based theory**[8,9]**

METHODOLOGY

Instantaneous reactive power theory

The converter with dc bus capacitor is used as an active filter. The control algorithm of IRPT uses 2 PI controller.**[8]**

In 1983 IRPT is proposed by Akagi. These theory is based on Clarke's transformation where three phase quantity is transform into two phase quantity.**[10]**



Basic block diagram of IRPT is shown above where Vsa,Vsb Vsc and Isa, Isb, Isc which are fed to hysteresis control to generate the final to hysteresis loop control control to generate the final pulse of IGBT.**[10]**

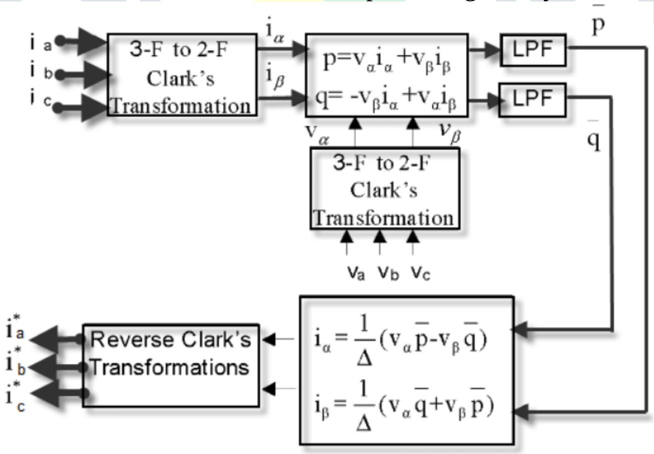
The instantaneous source voltage and source current signal in abc reference frame are transform in αβ orthogonal coordinates.

$$\begin{bmatrix} Vs\alpha \\ Vs\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} Vsa \\ Vsb \\ Vsc \end{bmatrix} \quad [1]$$

$$\begin{bmatrix} Il\alpha \\ Il\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} Ila \\ Ilb \\ Ilc \end{bmatrix} \quad [2]$$

In above equation from simplicity point of view the zero phase sequence of voltage and current signals are eliminated.**[10]**

For the above set of equations to the instantaneous active and reactive power is given by



$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} Vs\alpha & Vs\beta \\ Vs\beta & -Vs\alpha \end{bmatrix} \begin{bmatrix} Il\alpha \\ Il\beta \end{bmatrix} \quad [3]$$

And reference load current in αβ frame is

$$\begin{bmatrix} Il\alpha \\ Il\beta \end{bmatrix} = \frac{1}{Vs\alpha^2 + Vs\beta^2} \begin{bmatrix} Vs\alpha & Vs\beta \\ Vs\beta & -Vs\alpha \end{bmatrix} \begin{bmatrix} p \\ q \end{bmatrix} \quad [4]$$

$$\begin{bmatrix} Ica^* \\ Icb^* \\ Icc^* \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ \frac{-1}{2} & \frac{\sqrt{3}}{2} \\ \frac{-1}{2} & \frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} Ic\alpha * \\ Ic\beta * \end{bmatrix} \quad [5]$$

Now inverse Clarke transformation is applied i.e the transformation αβ frame to the abc reference frame which gives Isa* Isb* Isc* which is fed to the current controller with source current Isa, Isb ,Isc which results in generation of required gating pulse to IGBT.[11,12,13,14,15]

MODELING AND SIMULATION

Modeling and simulation of proposed method is done MATLAB Simulink

A three-phase generator with 415 V of voltage in phase to phase composed of an unbalanced load in three phases is intended and modeled in order to get the origin and load voltage and current waveforms.

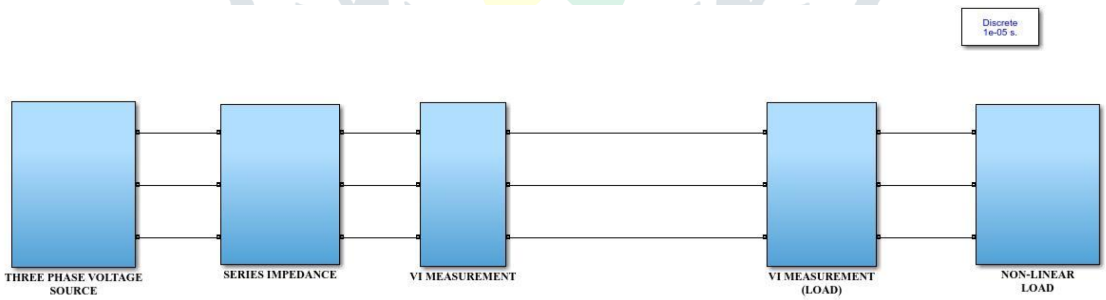
A shunt linked device with a three-phase, three-leg inverter with IGBTs as switching instruments is the compensator modeled.

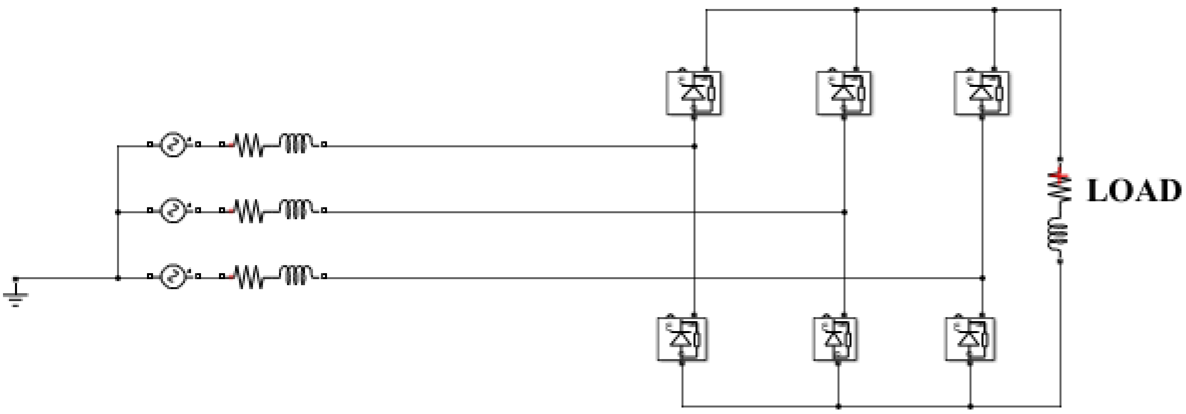
A non-linear load composed of a R-L converter with an R-L load of 20 and .0477H is used for an unbalanced system.

Simulation parameters	
Three phase supply voltage(L-L)	415V
Non Linear Load	Three phase uncontrolled rectifier with R-L connected load of 1.5 ohm & 40mH
D-C capacitor	20 mF
Interfacing reactance	R=.01ohm L= 4 mH
Reference dc link voltage	700 v

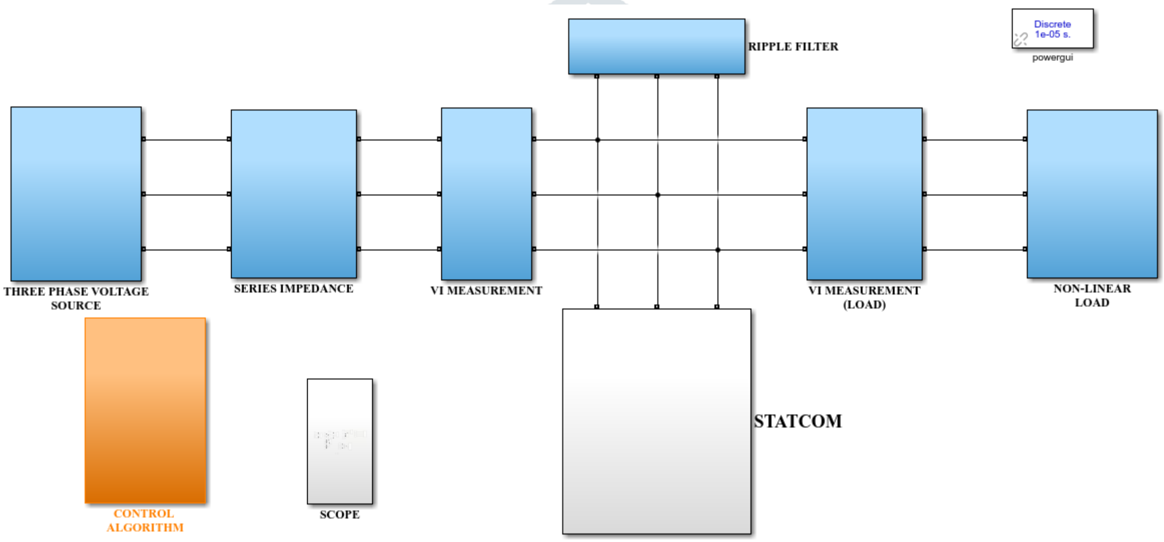
SIMULATION RESULTS

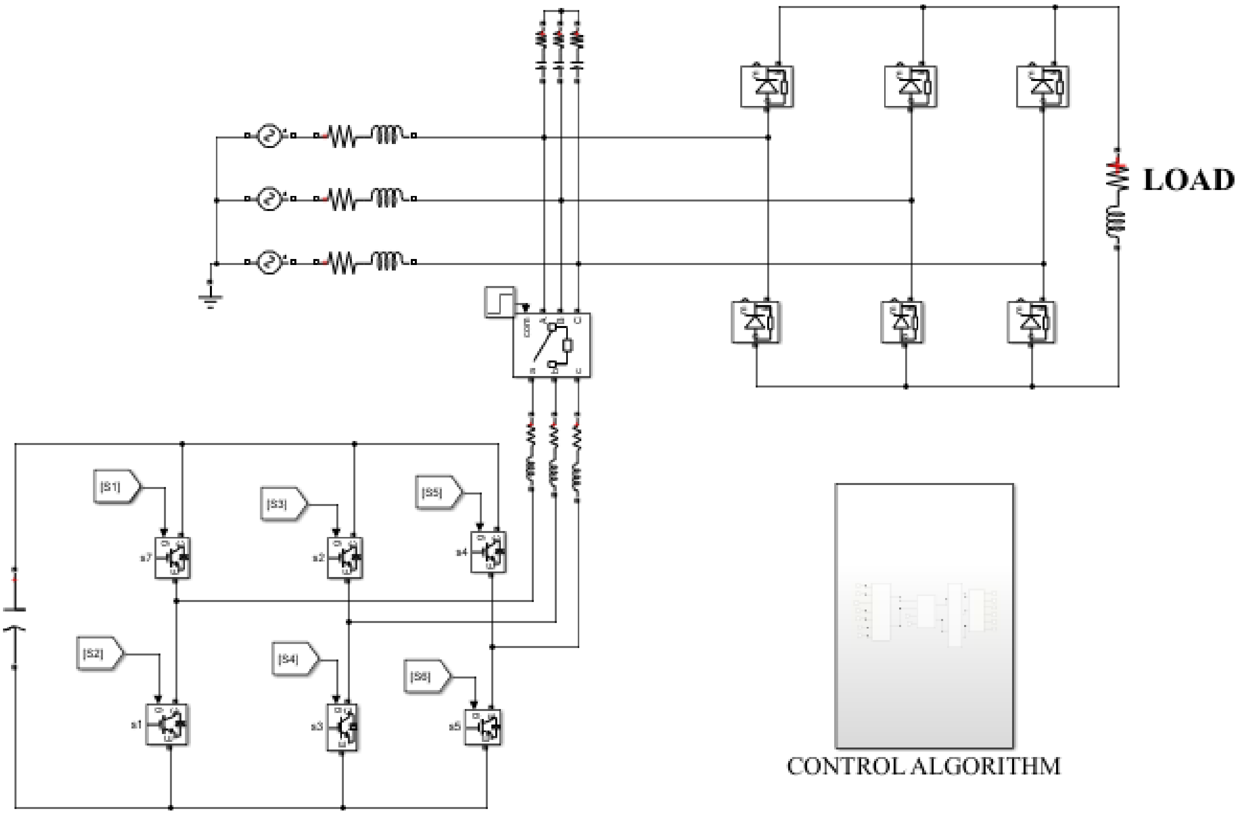
[A] BLOCK DIAGRAM & CIRCUIT DIAGRAM OF UNCOMPENSATED LINE





[B] BLOCK DIAGRAM & CIRCUIT DIAGRAM OF COMPENSATED LINE





Considering that 50 KVAR DSTATCOM is connected in shunt with the line. Initially till t=1sec D-STATCOM is not in operation but after t=1sec when the switch is on D-STATCOM starts injecting reactive power to the PCC.
Following are the simulation results

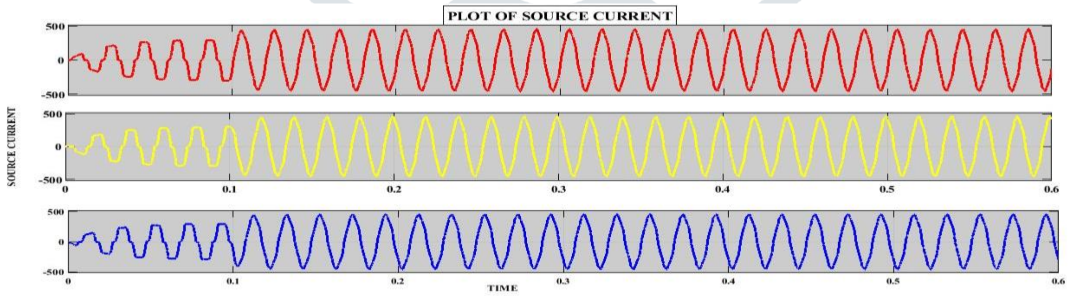


Figure 5 - Plot of source current

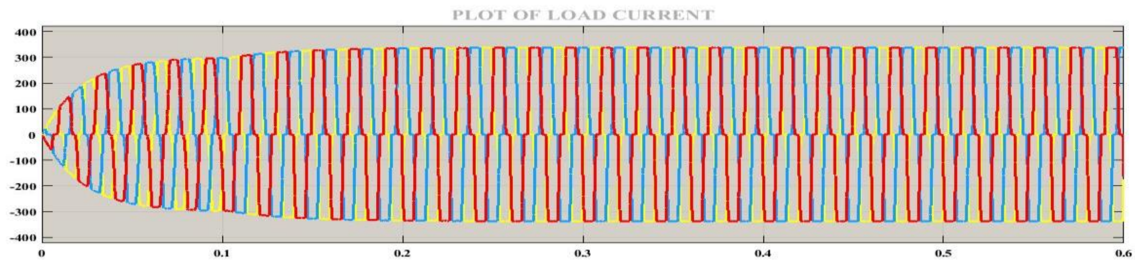


Figure 6 – Plot of load current

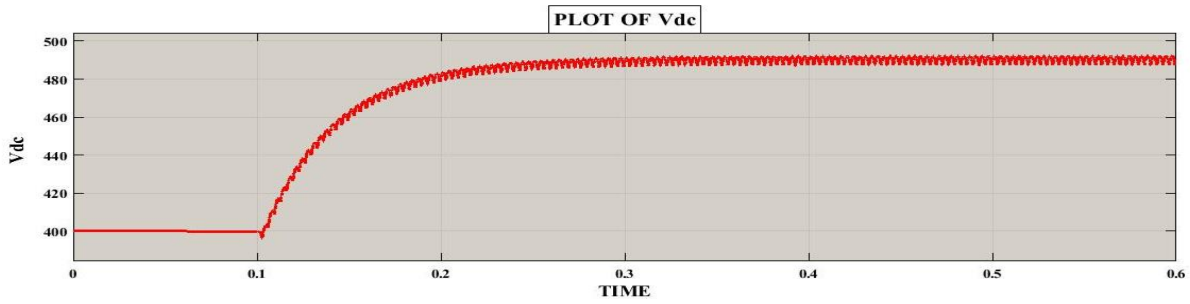
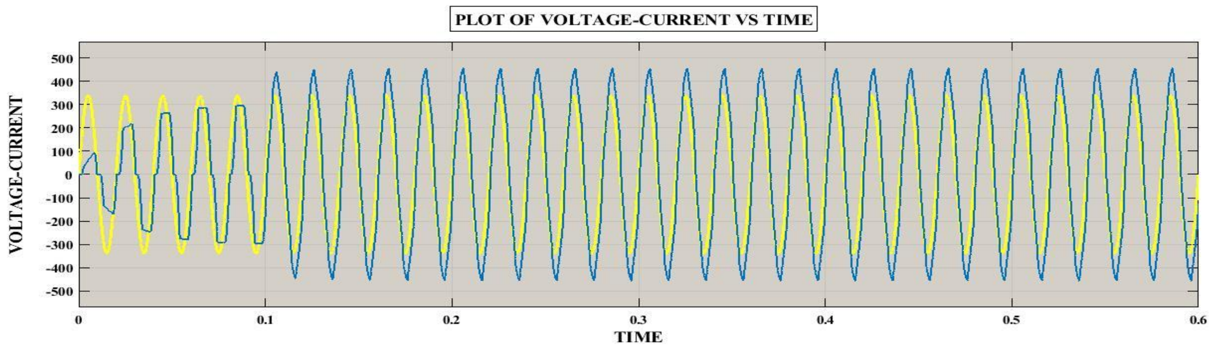


Figure-7 Plot of DC output voltage



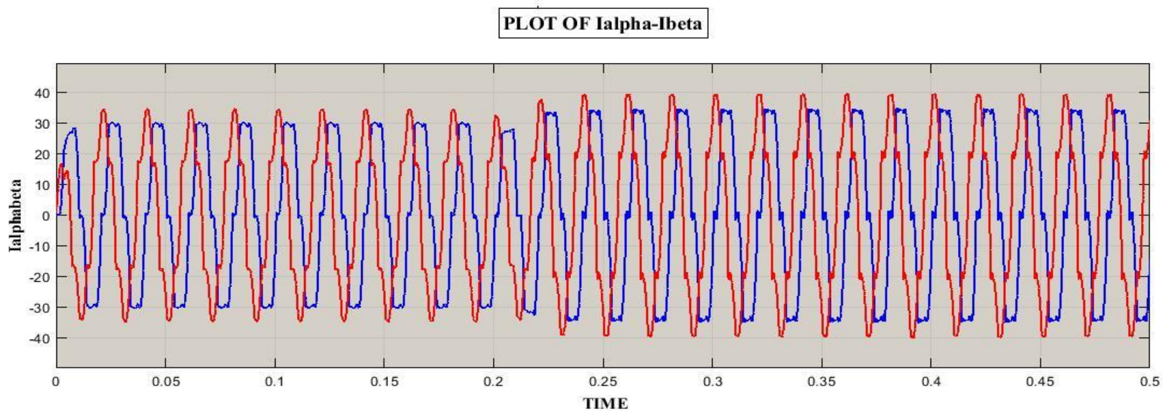


Figure-8 Plot of Ialpha-beta

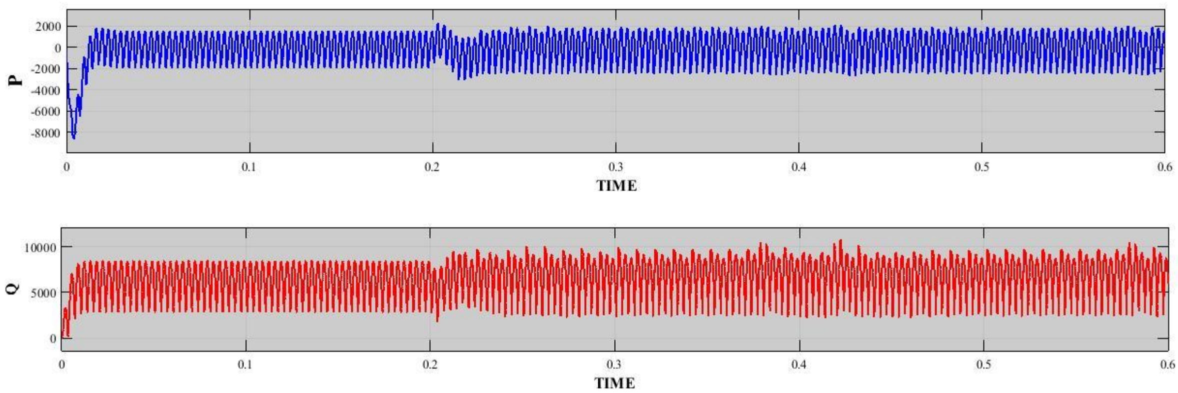
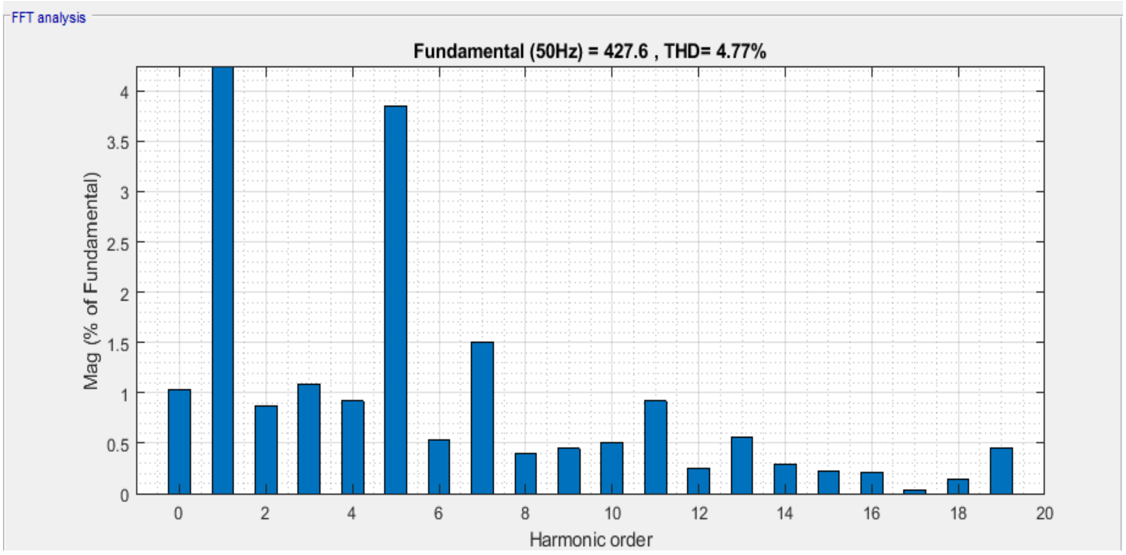


Figure 9 – Plot of P & Q



CONCLUSION

We researched and discussed the customized power device, i.e. in this article. D-STATCOM which works at small voltage and how passive energy is compensated by injection of reactive energy into the grid. In fact, the system is VSC, which is introduced on the system's demand in order to enhance the system's voltage profile and decrease energy loss. D-STATCOM therefore enhances the system's voltage stabilization. The total harmonics distortion was 14.38% before compensation and after compensation it is 4.77%.

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