CONTROL OF BATTERY OPERATED SYSTEM WITH A DC-DC BOOSTCONVERTER FED DSTATCOM USING SYNCHRONOUS REFERENCE FRAME THEORY &ACTIVE COMPONENT OF CURRENTALGORITHM

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ABSTRACT

This paper presents a comprehensive survey of DSTATCOM control strategies put forward recently. It is aimed at providing a broad perspective on the status of DSTATCOM control methods to researchers and application engineers dealing with harmonic suppression issues. Many control techniques have been designed, developed, and realized for active filters in recent years. The proposed DSTATCOM consists of a three-leg Voltage Source Converter (VSC) with a dc bus capacitor. The PV array or battery operated boost converter is proposed to maintain the dc link voltage of the dc bus capacitor for continuous compensation for the load. This paper presents to evaluate the performance comparison of two control strategies for extracting the reference currents to control the proposed DSTATCOM. The two control methods are Synchronous Reference Frame (SRF) theory and IcosΦ algorithm. The performance of the DSTATCOM is validated using MATLAB software with its simulink and Power System Block set (PSB) toolboxes. The simulation results for the two control methods are compared to validate the superior performance of the IcosΦ algorithm.

KEY WORDS: Distribution Static Compensator, Voltage Source Converter, Synchronous Reference Frame Theory, IcosΦ Controlling Algorithm.

INTRODUCTION

A Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure or a miss-operation of end user equipment's. Utility distribution networks, sensitive industrial loads and critical commercial operations suffer from various types of outages and service interruptions which can cost significant financial losses. With the restructuring of power systems and with shifting trend towards distributed and dispersed generation, the issue of power quality is going to take newer dimensions. In developing countries like India, where the variation of power frequency and many such other determinants of power quality are themselves a serious question, it is very vital to take positive steps in this direction. The present work is to identify the prominent concerns in this area and hence the measures that can enhance the quality of the power are recommended. This work describes the techniques of correcting the supply voltage sag, swell and interruption in a distributed system. At present, a wide range of very flexible controllers, which capitalize on newly available power electronics components, are emerging for custom power applications. Among these, the distribution static compensator and the dynamic voltage restorer are most effective devices, both of them based on the VSC principle. D-STATCOM[1] injects a current into the system to correct the voltage sag, swell and interruption. Comprehensive results are presented to assess the performance of each device as a potential custom power solution.

The FACTS (Flexible AC Transmission Systems)[2] technology is a new research area in power engineering. It introduces the modem power electronic technology into traditional ac power systems and significantly enhances power system controllability and transfer limit. DSTATCOM is based on a voltage-source inverter. The inverter under proper control can manage the capacitor i.e., the dc voltage source, to be charged (or discharged) to the required voltage level. In this way, or by PWM controller, the amplitude of the output voltage of the inverter can be controlled for the purpose of reactive power generation or absorption. The control strategy is very important to the operation of DSTATCOM in order to yield desired steady state performance and improve the integrated system dynamic behavior [3]. In this paper, the IcosΦ controlling algorithm is compared with Synchronous Reference Frame (SRF) theory to validate the effectiveness of the IcosΦ method. After tracking the reference currents with the help of these controllers and by comparing it with source currents, the switching of VSC will occur and hence cancel out the disturbances caused by the nonlinear loads. The Photo Voltaic (PV)module or battery operated boost converter is proposed to maintain the dc bus capacitor voltage of the VSC for providing continuous reactive power compensation, source current harmonic reduction and load compensation throughout the day. The proposed system is simulated under MATLAB environment using SIMULINK and sim power system tool boxes.

SYSTEM CONFIGURATION

Figure 1 shows the circuit diagram of the three-phase three-wire system which is used to feed the nonlinear load continuously. The nature of the nonlinear load is to cause distortion in the current. After connecting the nonlinear load, suddenly there will be a distortion in the distribution system. In order to eliminate these distortions, the control of DSTATCOM is achieved by using SRF theory and IcosΦ algorithm. The DSTATCOM consists of six Insulated Gate Bipolar Transistor (IGBT) with antiparallel diode based three-leg VSC connected in shunt with the dc bus capacitor. The PV module or battery with the DC-DC boost converter is connected with the dc bus capacitor, which is used to give a desired voltage across the capacitor for continuous compensation [4]. According to the gate pulse given, the switching of VSC will occur which injects a currents at the PCC through the interface inductor Lr.

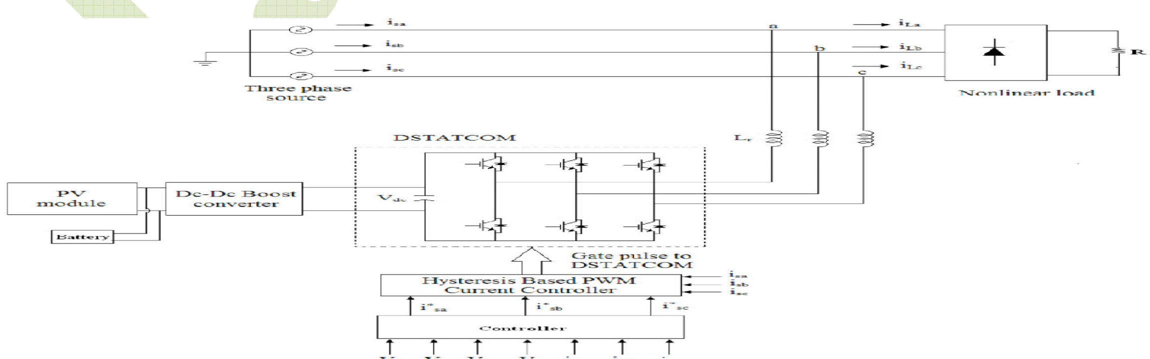

Figure 1.Circuit diagram of proposed DSTATCOM

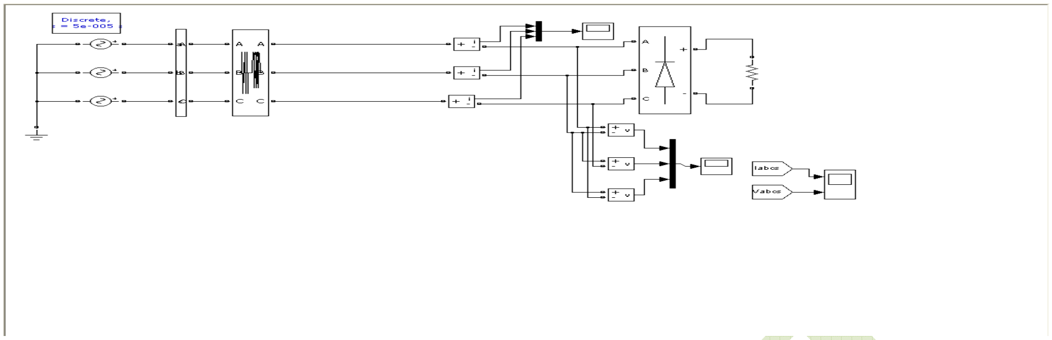

Figure 2.Matlab Circuit before compensation

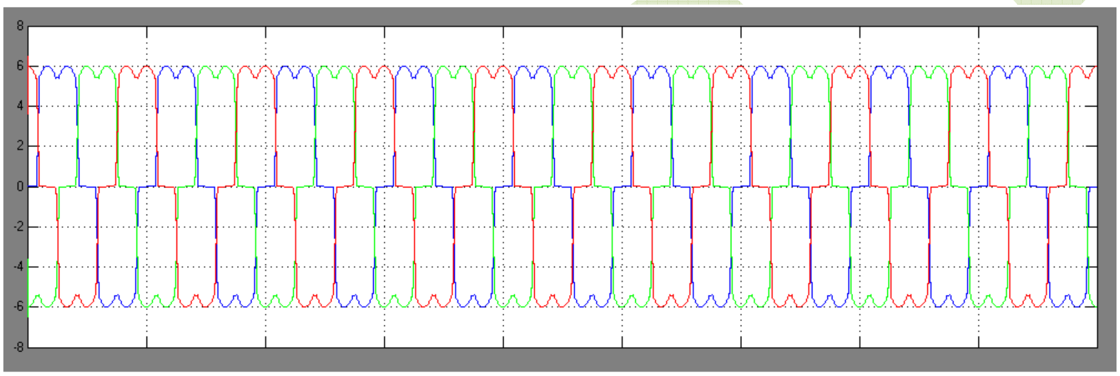

Figure 3.Source current before compensation

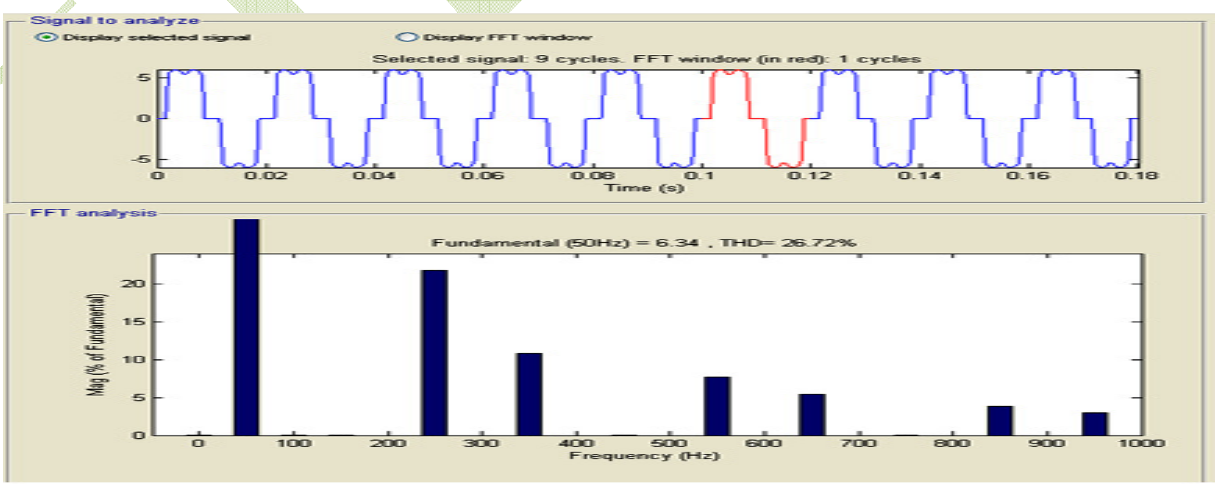

Figure 4.THD of Source current before compensation

SYNCHRONOUS REFERENCE FRAME THEORY

From this algorithm, the reference source current is generated to control the proposed DSTATCOM [1]. The load currents, PCC voltages and dc bus voltage are sensed as a feedback signal.The load currents from the a-b-c frame are first converted to α-β-0 frame and then to d-q-0 frame. The equation used for conversion is given below

$$\begin{bmatrix} i_d \\ i_q \\ i_0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos\theta & -sin\theta & \frac{1}{2} \\ cos\left(\theta - \frac{2\pi}{3}\right) & -sin\left(\theta - \frac{2\pi}{3}\right) & \frac{1}{2} \\ cos\left(\theta + \frac{2\pi}{3}\right) & sisn\left(\theta - \frac{2\pi}{3}\right) & \frac{1}{2} \end{bmatrix} \begin{bmatrix} i_{la} \\ i_{lb} \\ i_{lc} \end{bmatrix}$$

The input to the first PI controller is the error between the reference dc bus voltageV_{dc} *and the sensed dc bus voltage (V_{dc}) of DSTATCOM.

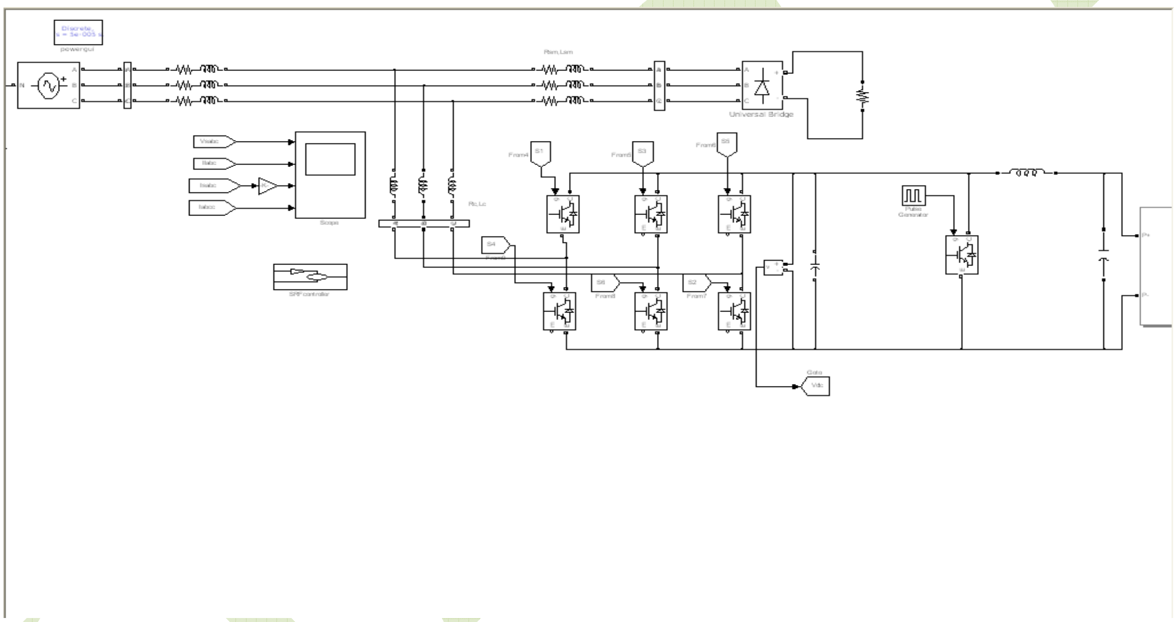

Figure 5.Matlab Circuit with SRF

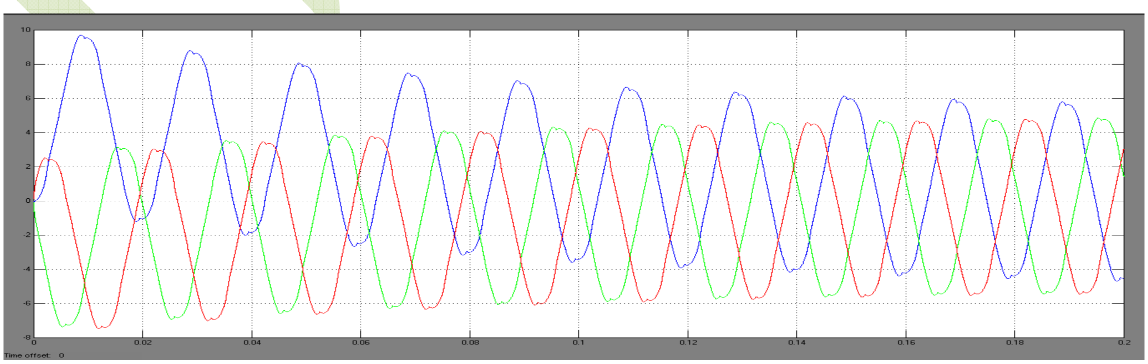

Figure 6. Source current with SRF

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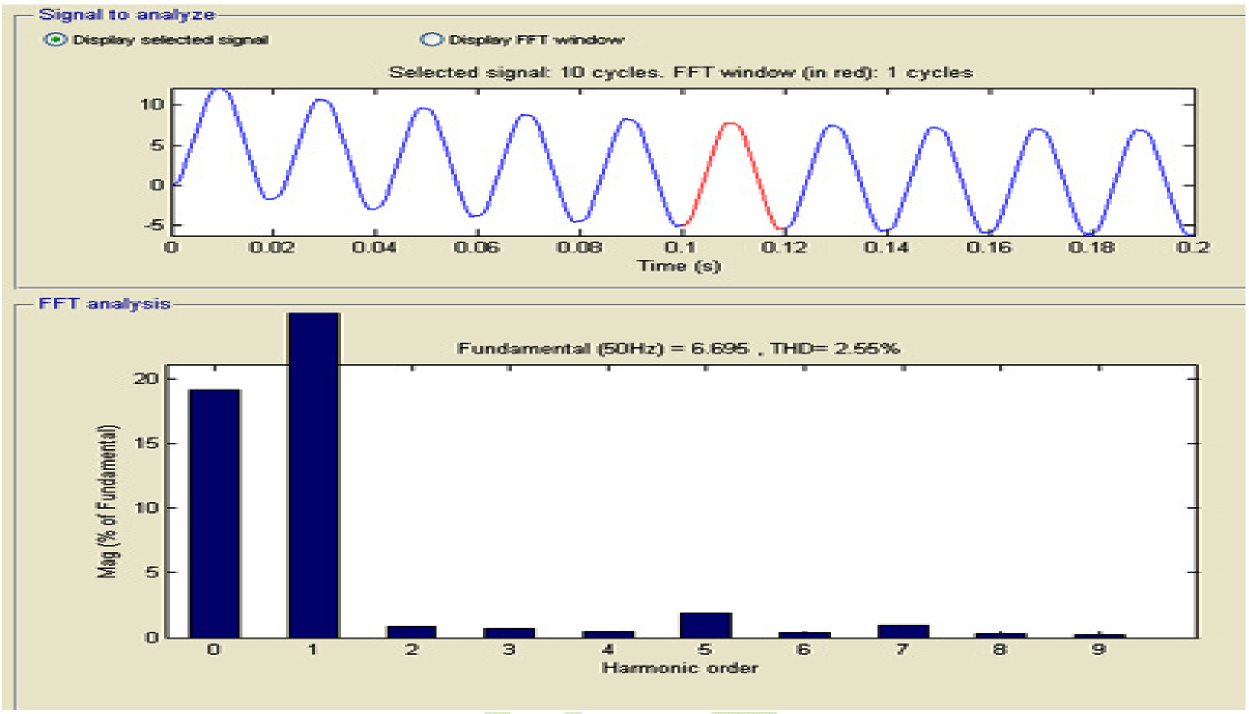

Figure 7.THD of source current with SRF

PROPOSED ICOSΦ ALGORITHM

IcosΦ algorithm is used to extract the reference currents. The source currents (i_{sa},i_{sb}, andi_{sc}), the loadcurrents (i_{La},i_{Lb}andi_{Lc}), the ac terminal voltages (v_a,v_b,v_c) and the dc bus voltage (V_{dc}) are sensed. The Icos Φ controlling algorithm is used to generate only the activecomponent of the load currents i.e. IcosΦ (where I = amplitude of fundamental load current andΦs = displacement angle of load current). Hence by combining the inphaseand quadrature component, the reference current can be generated.

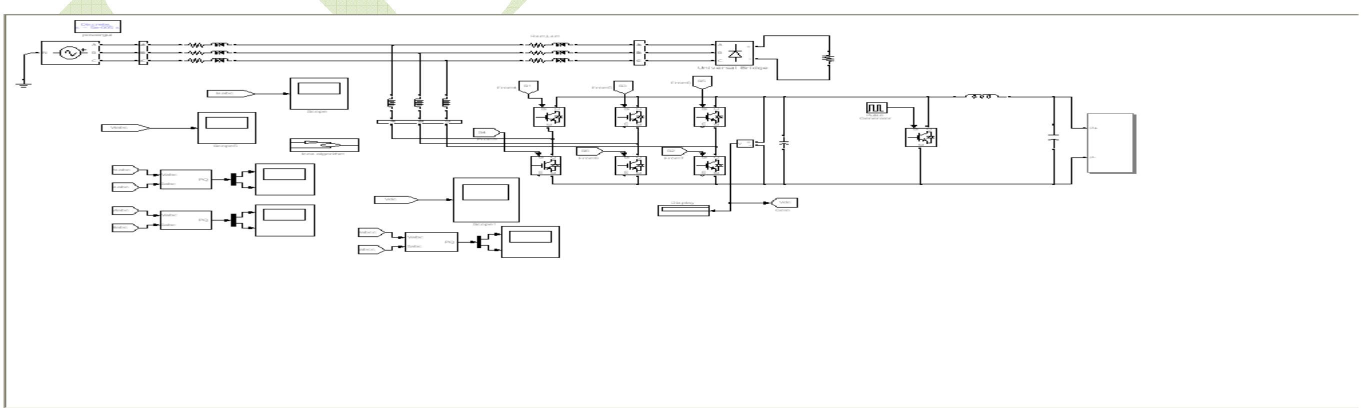

Figure 5.Matlab Circuit with IcosΦ algorithm

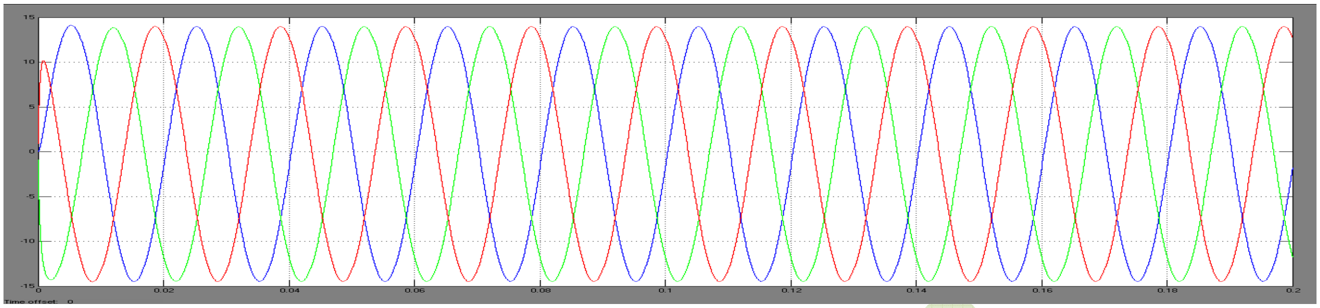

Figure 6. Source current with IcosΦ Algorithm

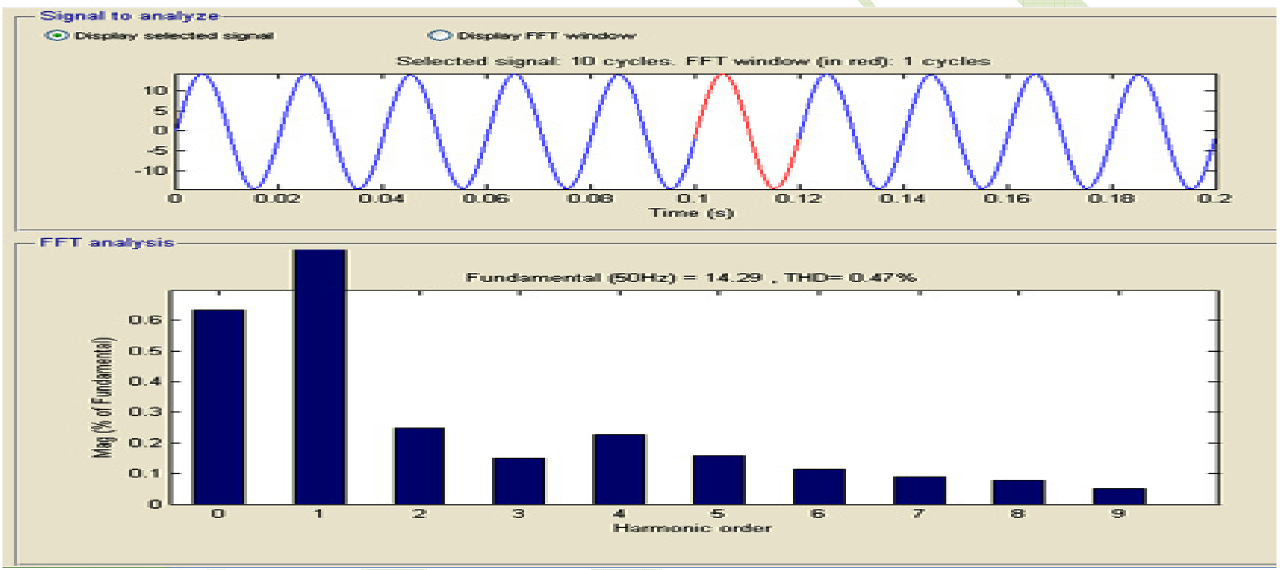

Figure 7.THD of source current with IcosΦ algorithm

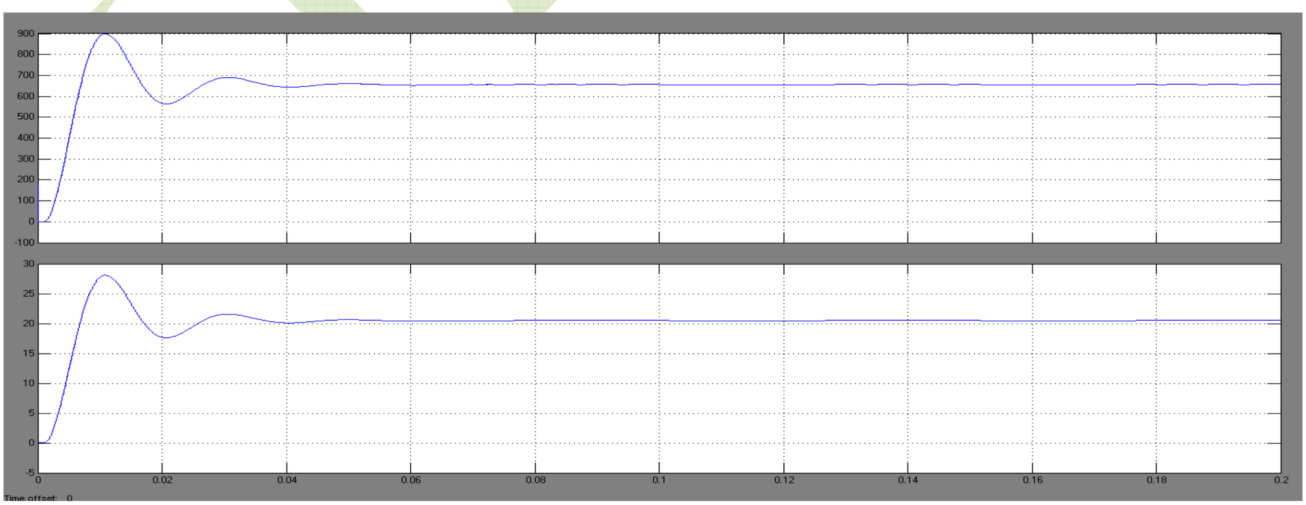

Figure 8.V_{dc}&I_{dc}

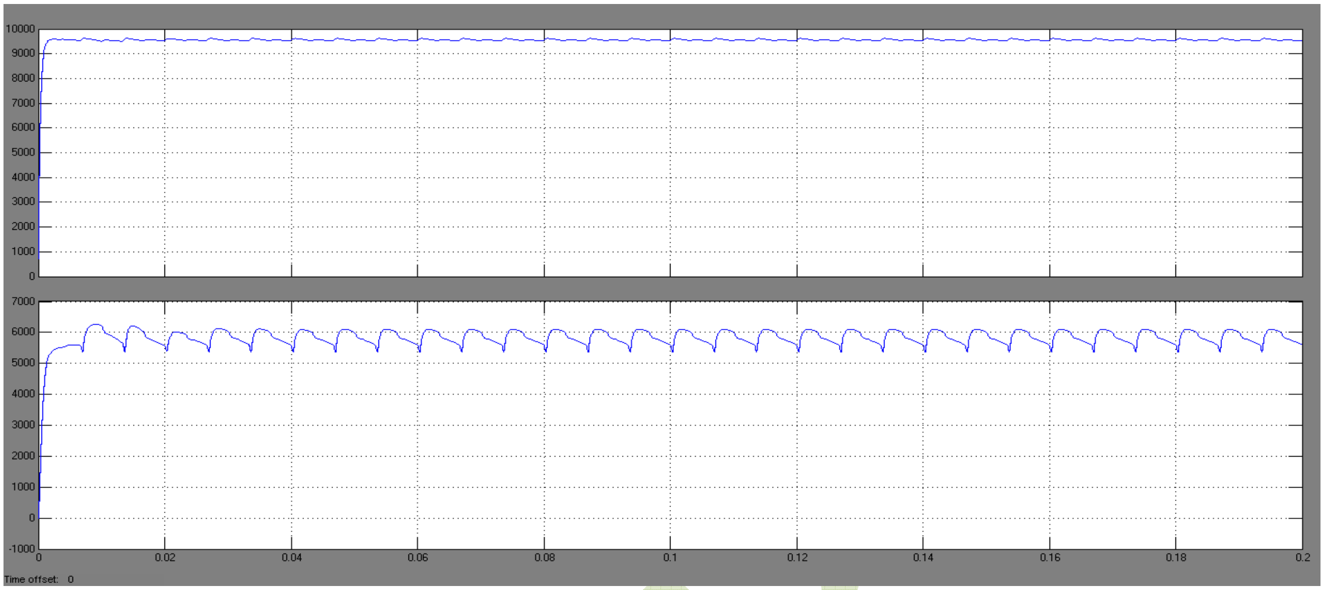

Figure 9.Active & reactive powers of source

CONCLUSION

The simulation of the battery operated DC-DC boost converter fed three-leg VSC is done with the help of SRF theory & IcosΦ method, When comparing SRF theory with IcosΦ method, the IcosΦ method is found effective because the sourcecurrent THD is reduced below the (IEEE-519-1992) permissiblelimit . The MATLAB software with its simulink and Power System Block set (PSB) toolboxes has been used to validate the proposed system.

Table 1.Comparison of THD values of DSTATCOM

THD in one phase	Before compensation	After compensation	
		SRF theory	IcosΦ algorithm
	25	**5.38**	**1.22**

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