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The Role of DSTATCOM as Active Filter to Mitigate Harmonics in Distribution System

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Abstract— This paper describes various power quality problems in distribution systems and their using application of Distribution Static Compensator (D-STATCOM). Here DSTATCOM uses as shunt active power filter system to mitigate harmonics which is created by nonlinear loads. Generally, a distribution static compensator (DSTATCOM) has been used for, reactive current compensation, harmonic current mitigation and load balancing are necessary in distribution system. This paper is aimed to improve power quality and harmonics distortion mitigation. This paper includes the detail discussion and configuration on the recently developed control scheme for DSTATCOM. The all schemes have been implemented using Matlab simulink toolbox and tested on various cases. The simulation results are presented, and discussed for various strategies.

Key words: power quality (PQ), Distribution Static Compensator (DSTATCOM), Synchronous Reference Frame theory (SRFT)

I. INTRODUCTION

The Electric power system can be broadly divided into in three main parts [3]. a) Generator: supply the power. b) The Transmission system: feeds the power from the generating centres to the load centres. c) The Distribution system: feeds the power to nearby consumers and industries.so, electric distribution system is such important part of an electric system. The distribution system is feeds the bulk power sources which are located far away from the load centre served to the consumer [4]. But, last few decades Modern industries increase the utilization of new technologies and new policies. This involves the use of non-linear and power converters based switched devices in distribution systems continuously increasing. This equipment has drawn various power quality problems like voltage sag/ swell, flicker, harmonics, low power factor etc. This problems left major impacts on the electric supply, the harmonics currents from AC mains and increase the supply demands [5]. A survey on power quality problems is discussed about suitable corrective and preventive actions to identify these problems [5].The various researchers are suggested variety of custom power devices to mitigate various power quality (PQ) problems in a distribution system. These custom power devices such as the distribution static compensator (DSTATCOM), the dynamic voltage restorer (DVR), Unified Power Quality Conditioner (UPQC), out of these The DSTATCOM is a shunt-connected device, which can mitigate the current related power quality problems [1],[8].

The effectiveness and performance of DSTATCOM depends upon the control methods used for extraction of reference current component to generate the switching signals for the voltage source converter [5], [8]. For the control algorithms of DSTATCOM, various control algorithms are mentioned in the various literatures such as the instantaneous reactive power theory (instantaneous p-q theory), modified power balance theory, Synchronous reference frame control technique (SRFT), Artificial Neural Network and fuzzy based controller, PWM hysteresis current, [5],[8] etc. But, this paper consists detail discussion about control algorithm Synchronous Reference Frame theory (SRFT) for harmonic mitigations.

II. CONFIGURATION OF DSTATCOM

The STATCOM is shunt connected device When used in low voltage distribution system, the static compensator (STATCOM) is identified as Distribution STATCOM (DSTATCOM). The D-STATCOM is a three-phase and shunt connected power electronics based device. It is connected near the load at the distribution systems. The major components of a D-STATCOM are shown in Figure 1. It consists of a dc capacitor, three-phase inverter (IGBT, thyristor) module, ac filter, coupling transformer and a control strategy. The basic electronic block of the D-STATCOM is the voltage sourced inverter that converts an input dc voltage into a three phase output voltage at fundamental frequency. Referring to figure 2, the controller of the D-STATCOM is used to operate the inverter in such a way that the phase angle between the inverter voltage and the line voltage is dynamically adjusted so that the D-STATCOM generates or absorbs the desired VAR at the point of connection

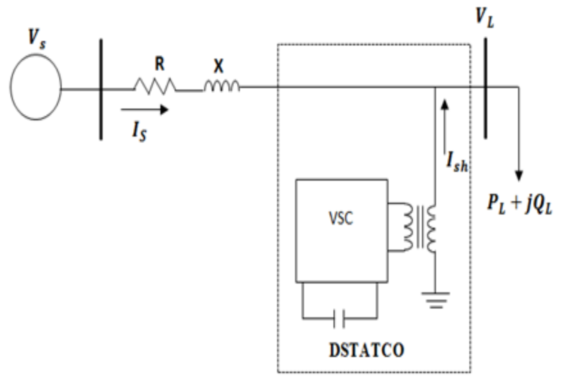

Fig. 2: Block Diagram of D-STATCOM

III. CONTROL ALGORITHM

For reactive power compensation, a DSTATCOM provides reactive power as needed by the load, and therefore, thus the source is being supplied only real. Hence, source current remains at unity power factor. The switching of the DSTATCOM decided based on reference source current. If the source reference current is balanced its helps to achieved load balancing in system [7]. These Reference source current for switching purpose of the DSTATCOM is being extracted by these technique.in these paper we are used p-q theory is based control scheme.

A. Synchronous Reference Frame Theory (SRFT) Method:

The SRFT done transformation of currents based on synchronously rotating d–q frame.Fig.3 shows the basic block diagram of SRFT theory.

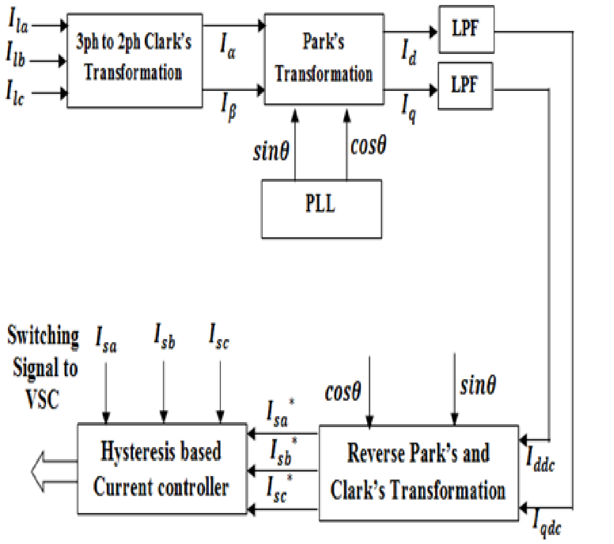

Fig. 3: Basic block diagram of SRFT method

Sensed inputs three-phase PCC voltages and load currents are fed to the controller. Sensed PCC Voltage signals fed trough phase-locked loop (PLL) to generate unit voltage templates such as sine and cosine signals. Current signals have been transformed a-b- c to α–β frame using clark's transformations which is given in eq(1). Then generated I_α and I_β signals converted into d-q frame using following equation, it is also known as park's transformations.

$$\begin{bmatrix} I_d \\ I_q \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} I_\alpha \\ I_\beta \end{bmatrix} \quad (1)$$

Generated signals I_d and I_q are fed to low-pass filters (LPFs) at this palace SRF isolator extracts the dc component I_{ddc} and I_{qdc}.

$$\begin{bmatrix} I_{\alpha dc} \\ I_{\beta dc} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} I_{ddc} \\ I_{qdc} \end{bmatrix} \quad (2)$$

Later this signals transformed back to three-phase reference source currents in a–b–c frame coordinates using reverse Park's transformation (shown in eq.3), which are fed to a hysteresis current controller to generate final switching signals for DSTATCOM inverters.

$$\begin{bmatrix} I_{sa}^* \\ I_{sb}^* \\ I_{sc}^* \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} I_0 \\ I_{ddc} \\ I_{qdc} \end{bmatrix} \quad (3)$$

Reactive power compensation could also be provided by holding I_q component zero for calculating the reference source currents. Therefore, this theory is Similar to the p–q theory.

IV. SIMULATION AND RESULT DISCUSSION

The Performance of DSTATCOM is checked with the use of nonlinear load. Here we take three phase bridge rectifier with R-L load and as nonlinear load. The Test system parameters with their values and units are shown in table I.

Sr. No.	System Quantities	Parameters Value
1.	Source	3-phase,415 V (L-L),50HZ
2.	Load	3-phase nonlinear load: R=10 ohm L=100 mh
3.	DSTATCOM	Capacitor :3000 uf DC bus voltage : 700 V
4.	Interfacing Inductor	3mh

Table I: Test system parameters

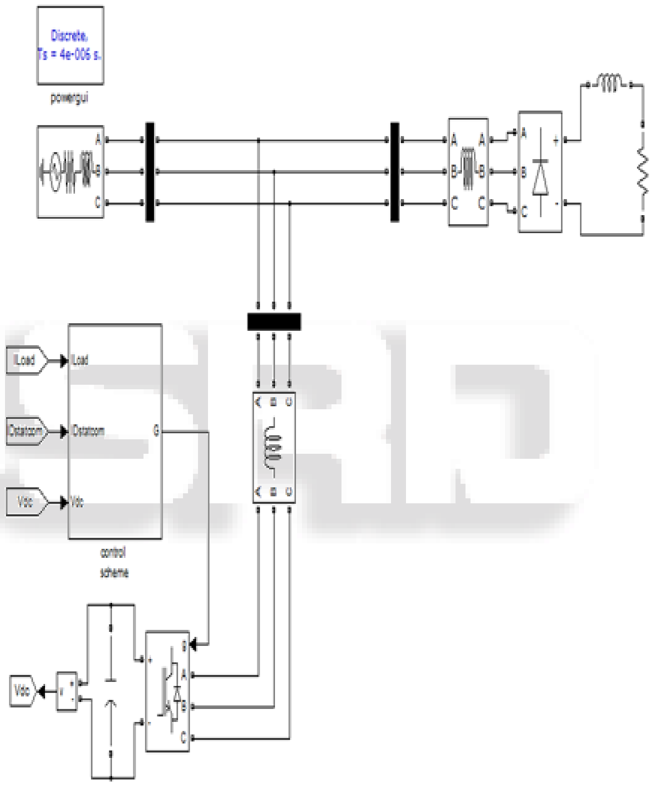

Fig. 4: Simulink model of test system-1

Figure 4 shows the performance of DSTATCOM is investigated with three bridge rectifier with R-L load. Figure 5 shows the Results for test systems-1.

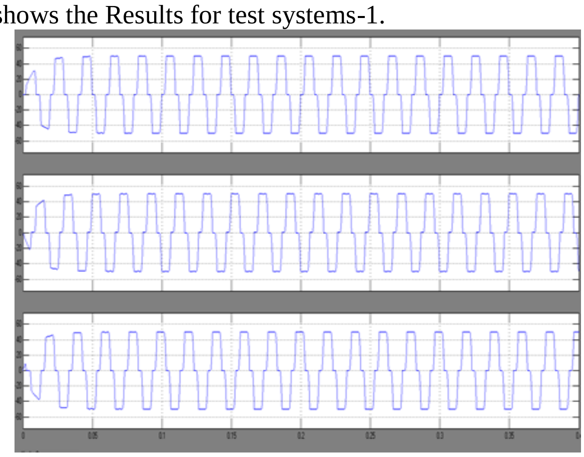

Fig. 5 (a):

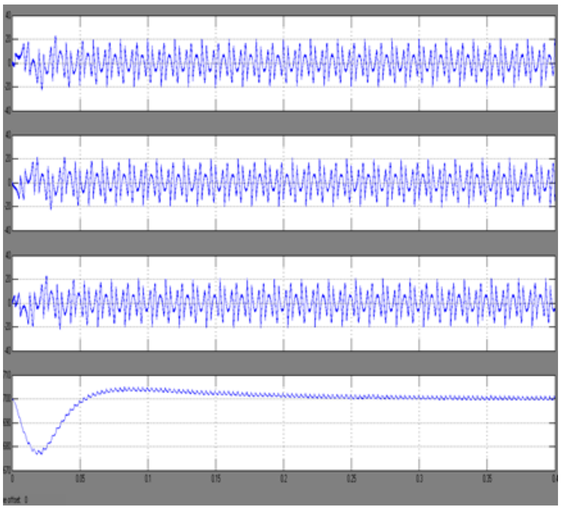

Fig. 5 (b):

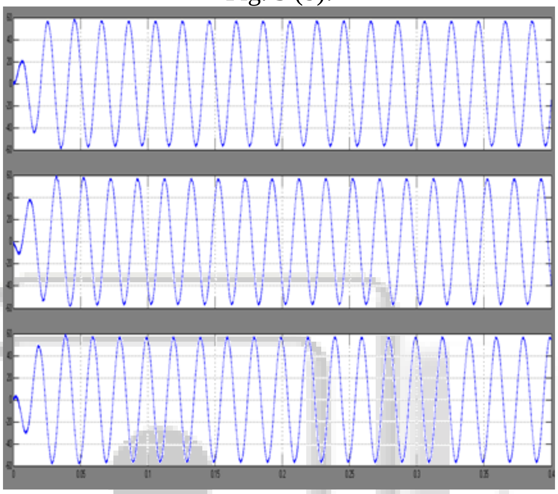

Fig. 5 (c):

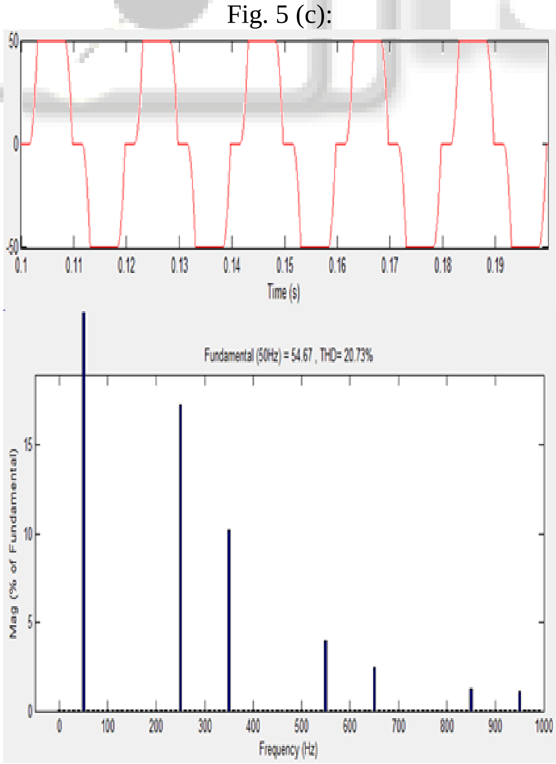

Fig. 5 (d):

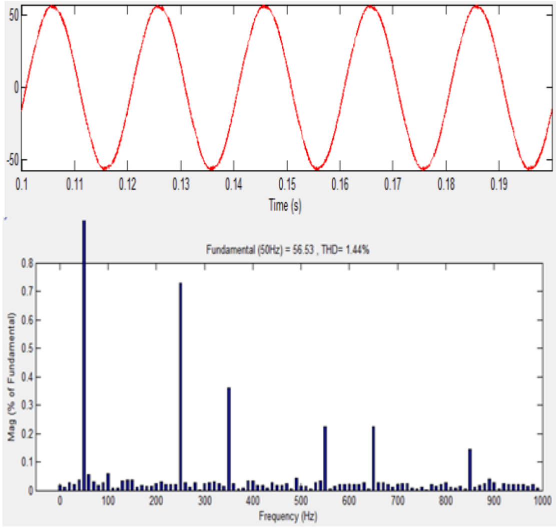

Fig. 5 (e):

Fig. 5: (a) Load current, (b) the compensating current and dc bus voltage, (c) Source current,
(d) THD analysis of current before compensation,
(e) THD analysis of current after compensation

Sr. no.	Before compensation	After compensation
Total Harmonic Distortion (THD) analysis	20.73%	1.43%

Table II: THD analysis for test system-1

Table no. II show the results for before and after compensation. The table shows that Total Harmonic Distortion (THD) before compensation of DSTATCOM is 20.73%, and after compensation of DSTATCOM it comes reduced up to 1.43 %.

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VI. CONCLUSION

In this paper the performance analysis of DSTATCOM using Synchronous Reference Frame theory (SRFT) have been carried out. Simulation results shows that effectiveness of DSTATCOM for harmonic reduction in distorted current and validity and flexibility of the proposed scheme. In the test systems Total Harmonic Distortion (THD) of current reduces from 20.73 % to 1.43 % which complies with IEEE harmonic control standard (IEEE--519).

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