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Role of DSTATCOM in Distribution Network under Various Fault Conditions

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ABSTRACT: In recent years, Power engineers are increasingly concerned over the quality of the electrical power. The electronic devices are very delicate to disturbances and become less tolerant to power quality problems such as voltage sags/dips, swells and harmonics. Power Quality enhancement in a distribution network is achieved by shunt compensation device known as distribution static compensator (DSTATCOM). A DSTATCOM connected at the point of common coupling (PCC), has been utilized to mitigate PQ problems. DSTATCOM is mainly used to mitigate all types of fault, intelligently (such as Single Line to Ground (SLG) fault and Double Phase to Ground (DPG) fault and three-phase fault). The fast retaliation of DSTATCOM makes it the efficient solution for enhancing the power quality of the distribution system. DSTATCOM can use with different types of controllers. In this paper, Design and Simulation of Distribution STATIC Compensator (DSTATCOM) with PI controller to improve the quality of power under different abnormal conditions like single line to ground fault(SLG), double line to ground(DPG) fault in distribution networks with linear loads, has been presented and results are proved by the simulation.

KEYWORDS: DSTATCOM, VSC, PCC, CPD, Sag.

I.LITERATURE SURVEY

There are many different methods to mitigate voltage sags, but a Custom Power (CPD) device is considered to be the most efficient method. There are many types of CPD. The concept of custom power was introduced by N.G. Hingorani. The term custom power means the utilisation of power electronic controllers for distribution systems. The concept of custom power was introduced by N.G. Hingorani. The term custom power means the utilisation of power electronic controllers for distribution systems. Bhim Singh explain DSTATCOM (Distribution Static Compensator) for load balancing, neutral current elimination, power factor correction and voltage regulation in three-phase, four-wire distribution system feeding commercial and domestic consumers. Sumate Naetiladdanon describe that DSTATCOM can compensate voltage sags by injecting the reactive power into the distribution system.

II.INTRODUCTION

In present time, distribution system is facing the poor power quality problems such as poor power factor, unbalanced loading of three phases, voltage drop and harmonic injection. The reasons for the poor power quality are reactive, unbalanced and nonlinear loads (such as motors, adjustable speed drives (ASDs), variable frequency drives (VFDs) and power electronic converter) used in domestic and industrial applications. The reactive loads affect the active power flow and cause the voltage drop at load end point. Moreover, the nonlinear loads (ASDs, VFDs and power electronic converter) inject the harmonics in the system which distorts the voltages at PCC and affect the performance of other loads connected to same terminals. Such power quality problems can be mitigated by connecting the DSTATCOM at PCC. [1]

DSTATCOM is a class of custom power devices for providing reliable distribution power quality. They employ a shunt of voltage boost technology using solid state switches for compensating voltage sags and swells. The DST A TCOM applications are mainly for sensitive loads that may be drastically affected by fluctuations in the system voltage. [2] By the help of these devices we are able to mitigate the problems related to power quality.

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Under this work, DSTATCOM has been used to improve the quality of power under different conditions. The general theory about the DSTATCOM operation and its main components is discussed in next part.

III.DSTATCOM STRUCTURE

DSTATCOM is considered as one of the most famous type of shunt compensation custom power devices that may be used in the field of power quality improvement. These devices are connected directly at load buses in parallel as shown in Fig. 1. It injects a current I_{sh} to correct the voltage sag at the load bus by adjusting the voltage drop across the Theveninn's equivalent impedance (Z_{th}) seen from the coupling point. The value of I_{sh} can be controlled by adjusting the output voltage of the voltage source converter (VSC). The circuit diagram of the system shown in Fig.1 [3]
The main components of DSTATCOM are – (i) a VSC (voltage source converter), (ii) controller, (iii) filter, (iv) Isolation transformer and (iv) energy storage device (DC capacitor). The system scheme of DSTATCOM is shown in Figure 2. These are briefly described as follows:

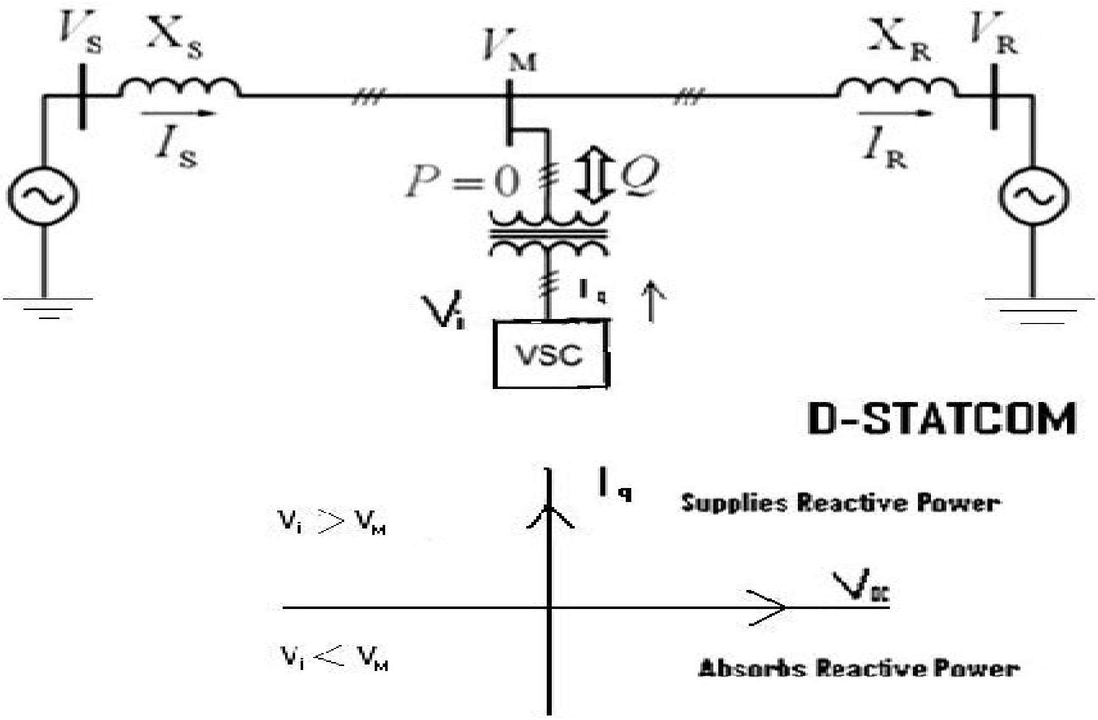

Fig. 1 DSTATCOM working Principle

1. Voltage Source Converter (VSC): A voltage source converter consists of a storage device and devices of switching, generating a sinusoidal voltage at any required frequency, magnitude and phase angle. In the DSTATCOM application, this temporarily replaces the supply voltage or generates the part of the supply voltage which is absent and injects the compensating current into the distribution network depending upon the amount of unbalance or distortion. In this work, an IGBT is used as the switching device
2. Isolation transformer: It connects the DSTATCOM to the distribution network and its main purpose is to maintain isolation between the DSTATCOM circuit and the distribution network.
3. DC charging unit: This unit charges the energy source after a compensation event and also maintains the dc link voltage at the nominal value.

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4. Harmonic filters: The main function of harmonic filter is to filter out the unwanted harmonics generated by the VSC and hence, keep the harmonic level within the permissible limit.
5. Energy storage unit: Energy storage units like flywheels, batteries, superconducting magnetic energy Storage (SMES) and super capacitors store energy. It serves as the real power requirements of the system when DSTATCOM is used for compensation. [4]

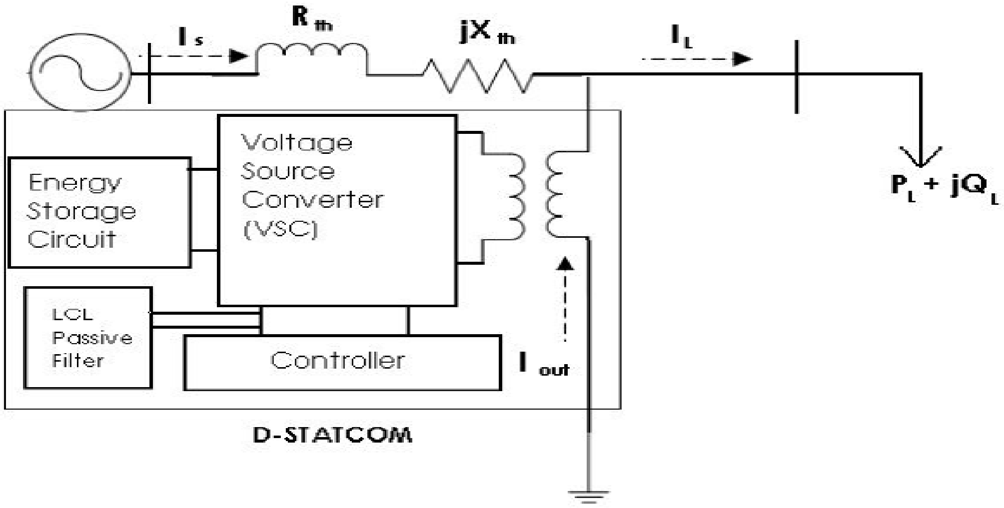

Fig.2 block representation of DSTATCOM

IV. PARAMETERS OF THE TEST SYSTEM

Simulation model of the test system is shown in Figure 3. System parameters of the test system are given in Table 1. In this test model two similar loads with different feeders have been considered, in which one of the feeder is connected to DSTATCOM and the other is kept as it is. This test system is analyzed with non linear load under different fault conditions. The technique of control implements a PI controller which starts from the difference between the injected current (DSTATCOM current) and reference current (identified current) that determines the reference voltage of the inverter (modulating reference signal).
System test parameters are mentioned below in table 1.

Table 1

S. no.	System Quantities	Standards
1.	Source	11kV, 3-ph, 50 Hz
2.	Transformer	200MVA,50Hz
3.	Pi controller	K_p =0.1, K_i=1
4.	Fault duration	0.3 - 0.5
5.	Load	10kW
6.	Simulation stop time	1

V. SIMULINK MODEL OF TEST SYSTEM

The SIMULINK model of test system shown in fig.3.The test system consist two feeders connected with a transformer and loaded with linear load. To obtain results one feeder connected with DSTATCOM whereas other feeder kept without DSTATCOM. This system is analyzed under three different fault conditions.

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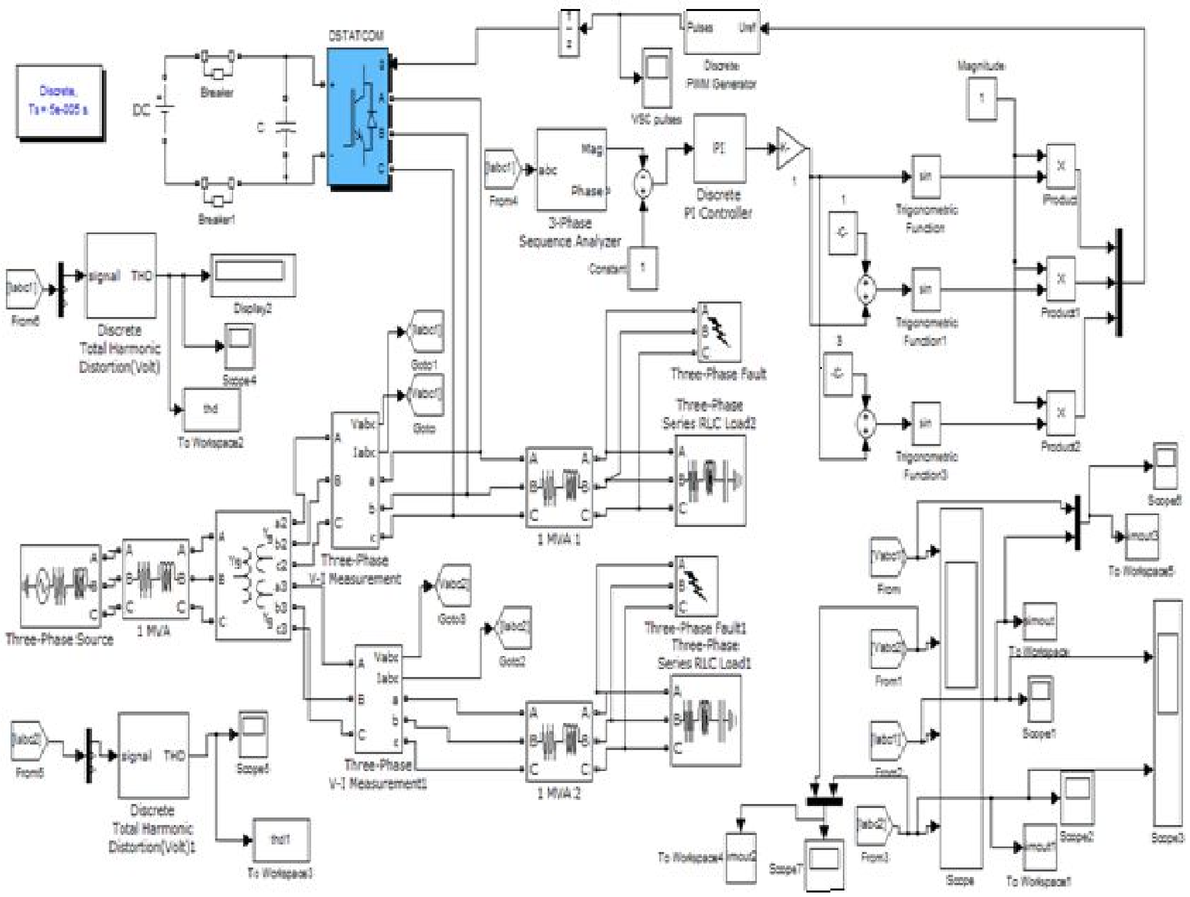

Fig.3 Simulink Model of test system

VI. SIMULATION RESULTS

Fig.6 shows the test system implemented in MATLAB/SIMULINK to carry out simulations for the DSTATCOM. The test system comprises a transmission system. The system has been analyzed under different fault conditions. The simulations of the D-STATCOM in fault condition are done using unbalanced and balanced faults. In SLG fault analysis, phase A is the faulted phase, while in DPG fault the faulted phases are phases A and B. In addition, in three-phase fault, the faulted phases are phases A, B, and phase C.

A. Simulation results for SLG fault: In this case a single line to ground fault is considered for both the feeders and the fault resistance is 0.001 ohm and the resistance to ground is 0.001 ohm. The fault is created for the period of 0.3s to 0.5s. Output waveforms of the load current with compensation and without compensation is shown in fig.4 (a) and fig.4(b) respectively.

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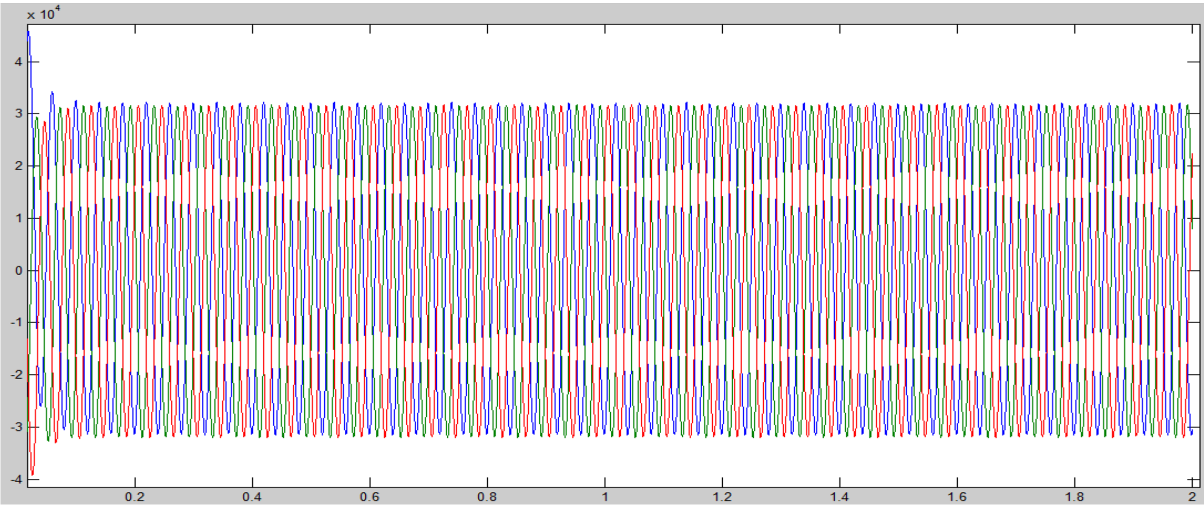

Fig. 4(a) load current with DSTATCOM

The load current waveform of phase with fault as shown in fig.4(b) which is without DSTATCOM. The falut phase has large magnitude of current due absence of DSTATCOM.

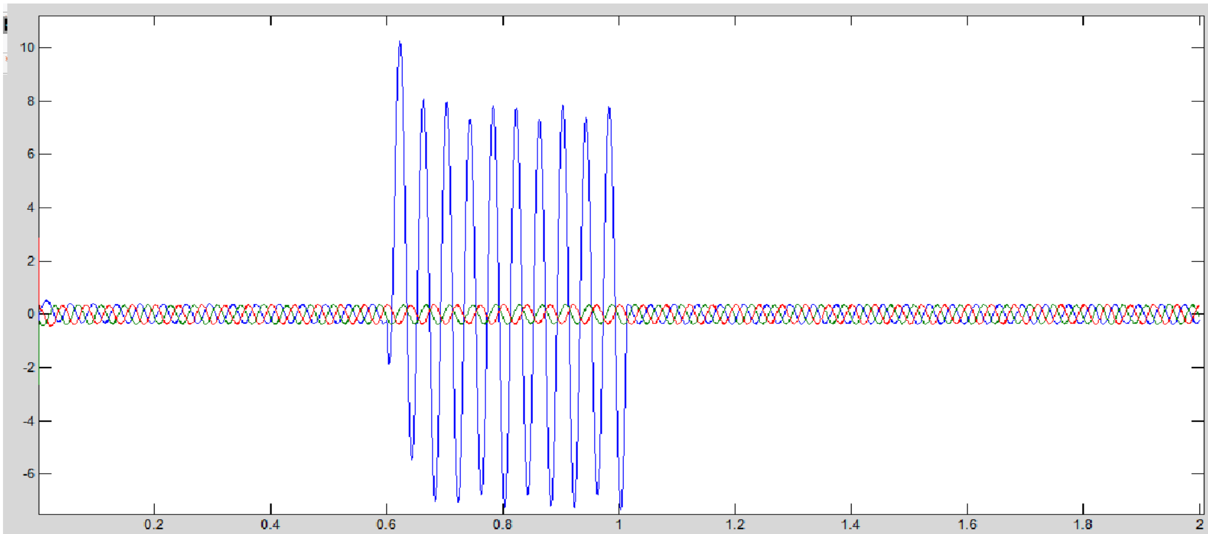

Fig. 4(b) load current without DSTATCOM

B. Simulation results for DPG fault: In this case a Double line to ground fault is considered for both the feeders and the fault resistance is 0.001 ohm and the resistance to ground is 0.001 ohm. The fault is created for the period of 0.3s to 0.5s. Output waveforms for the load current with compensation and without compensation is shown in fig.5(a) and fig.5(b) respectively.

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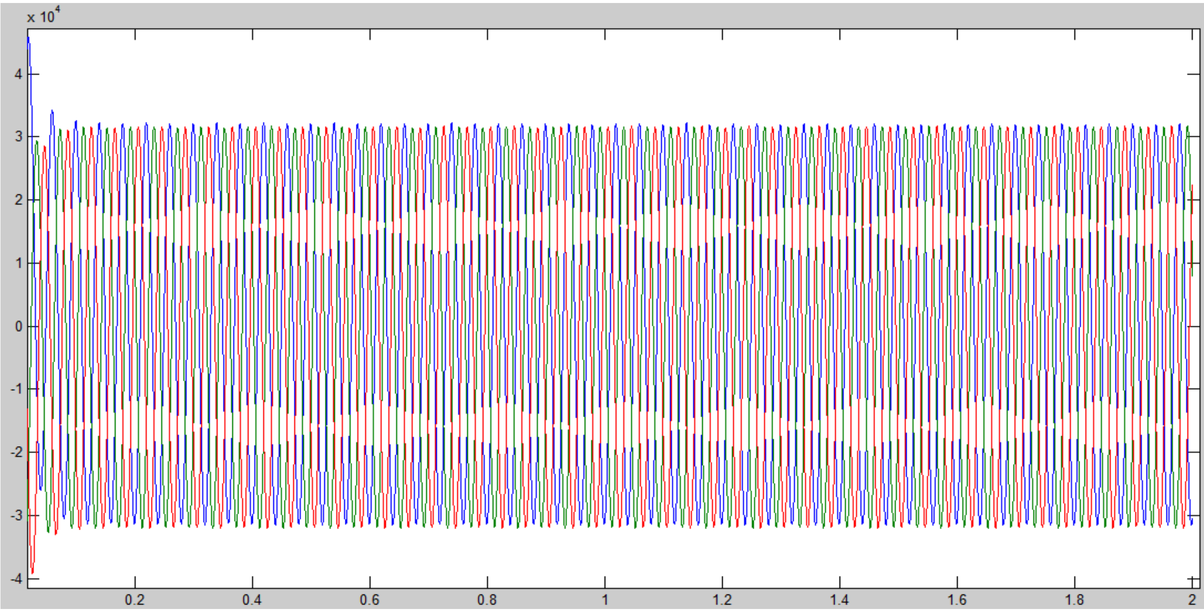

Fig. 5(a) load current with DSTATCOM

During double line to ground phase fault, the phases in which fault occur draw large amount of current as shown in fig. 5(b).

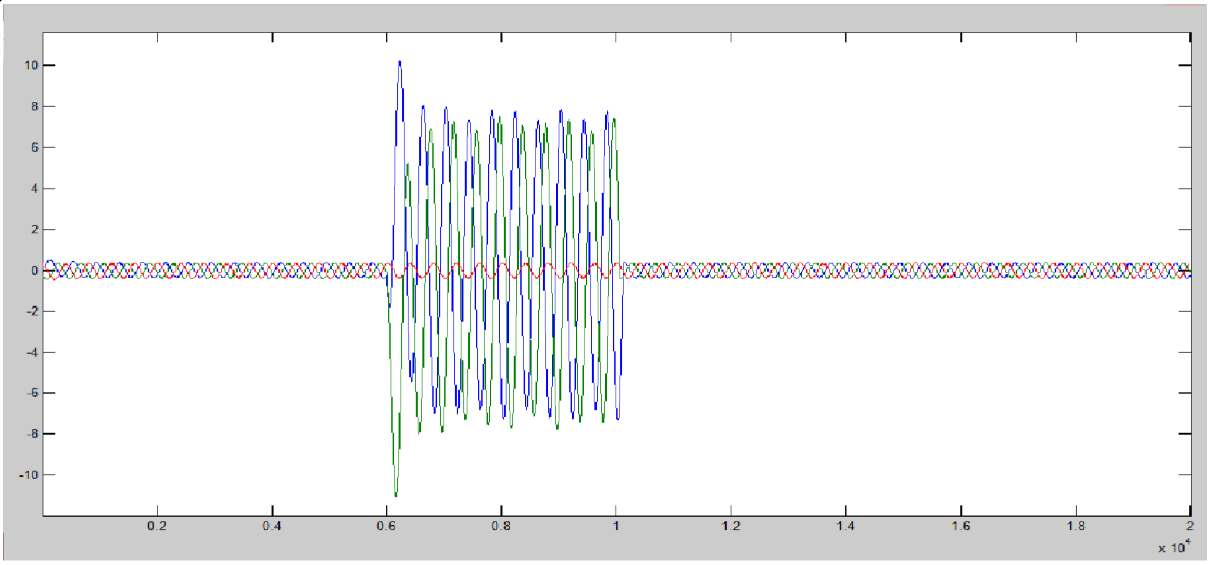

Fig.5 (b) load current without DSTATCOM

The fig.4 and fig.5 respectively, shows the wave shapes that the current in the phase where fault is created is increasing during the fault duration in the uncompensated feeder. And the system where DSTATCOM is connected unbalancing is reduced.

C. Simulation results for three-phase fault: In this case a three phase line to ground fault is considered for both the feeders and the fault resistance is 0.001 ohm and the resistance to ground is 0.001 ohm. The fault is created for the

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duration of 0.3s to 0.5s. Output wave for the load current with compensation and without compensation is shown in fig.6 (a) and fig.6 (b) respectively.

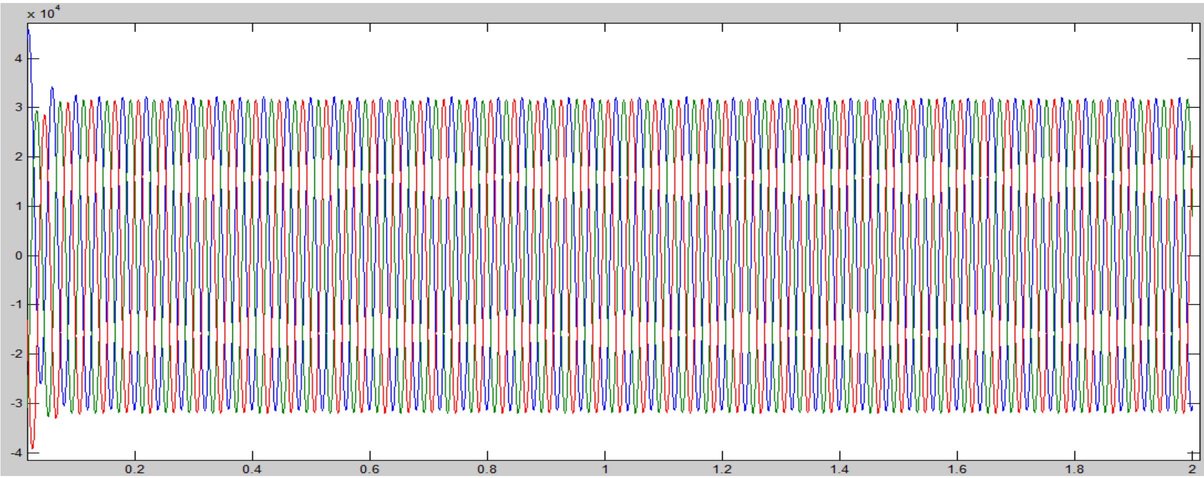

Fig.6 (a) load current without DSTATCOM

The load current wave shape during three- phase fault without DSTATCOM as shown in fig 6(b). It is dangerous type of fault in electric network. The DSTATCOM can play an important to eliminate fault current.

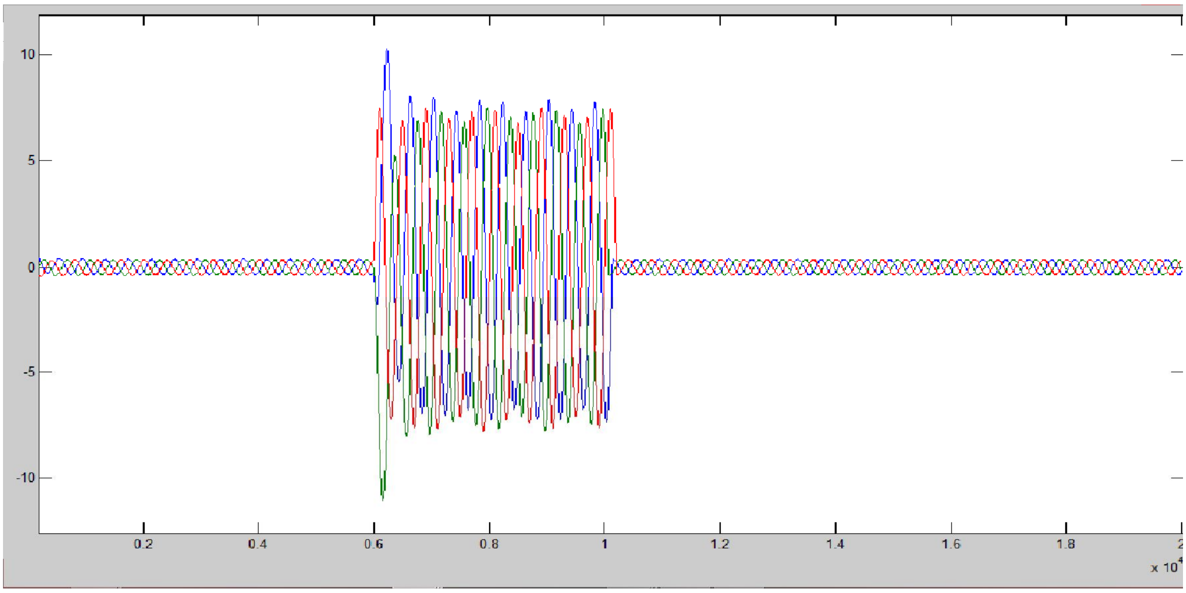

Fig.6 (b) load current without DSTATCOM

Here it is clear from the output wave shapes that the current in the phase where fault is created is increasing during the fault duration in the uncompensated feeder, that is why here the unbalancing in the system where DSTATCOM is connected is reduced clearly. However these results become clear from the total harmonic distortion graphs, taken one by one for compensated and non compensated feeders linear loads.

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VII. TOTAL HARMONIC DISTORTION RESULTS

The THD graphs with compensation and without compensation are given in fig.7 (a-b). The total harmonic distortion without compensation is 21.80%, which is reduced to 0.51% where DSTATCOM is connected.

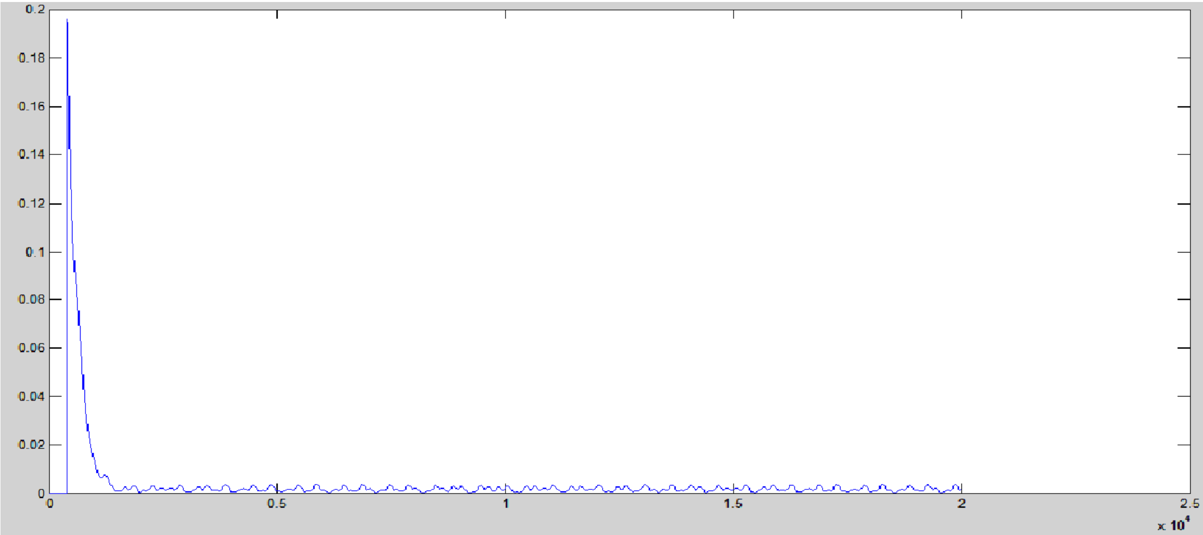

Fig.7 (a) THD wave of DSTATCOM feeder

The THD wave shape of feeder which connect with DSTATCOM show clearly elimination of total harmonic distortion , on other hand feeder without DSTASTCOM has a large amount of total harmonic distortion as shown in fig. 7(b).

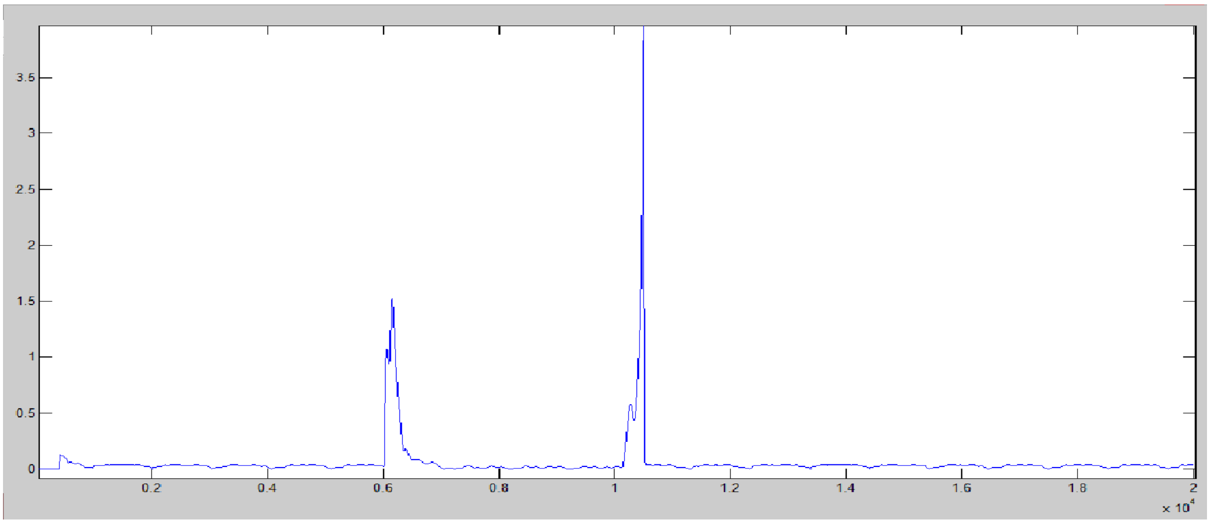

Fig. 7(a) THD wave of without DSTATCOM feeder

VIII. CONCLUSION

In this work, DSTATCOM has been modeled and simulated in MATLAB/SIMULINK environment. The performance of DSTATCOM has been analyzed for linear loads and static non-linear loads. DSTATCOM has been found to regulate

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PCC current under varying load conditions and load unbalancing. According to IEEE-519 standards the THD level must remain below 5% and DSTATCOM effectively reduces THD level of load current below 5% in all cases presented in this work. It is clear from comparison of THD analysis for different types of loads under normal and various faults conditions that DSTATCOM effectively compensate current harmonics. It is therefore, concluded that DSTATCOM has a huge scope in improving power quality levels in distribution systems.

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