Reduction of Harmonics for Power Quality Improvement by using STATCOM

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Abstract

Non Linear Loads in the Power System are the Source of production of harmonics, due to the harmonics in system power quality get decreases and affect the load side as well as consumer side. Thus it is necessary to control the harmonics to improve the power quality of the system.

There are number of control techniques to improve the power quality with the FACTS devices. In this paper performance of Static Synchronous Compensator (STATCOM) for Power Quality improvement has been studied. The simulation is done in MATLAB/SIMULINK environment.

Keywords - *Harmonics, Power Quality, Linear load, Non-Linear Load, STATCOM*

I.INTRODUCTION

In Electrical Power System, Non Linear loads outcome in creation of harmonics as a result of load current waveform get indistinct. Owing to which production of current harmonics from load side & they have a tendency to flow towards the source through point of common coupling(PCC)[1].These current harmonics supplementary give grow to voltage harmonics due to which neighboring consumers get affected[1].Non Linear load causes many power quality problems as they are time varying in nature. Nowadays different type of Non-linear load is used in industry that is EAF[2] ,dynamic load ,rectifier also linear load is having some harmonics content. There are different techniques to moderate the harmonics of the power system in this paper we used STATCOM. The next generation of FACTS devices is STATCOM. The STATCOM is used in the power system for special purposes as reactive power damages, line hammering minimization, power oscillation damping etc. STATCOM is a grouping of VSC (voltage source converter) in equivalent with the capacitor which acts as a DC energy source link fixed to the transmission line. Almost Sinusoidal current of varying magnitude at the PCC (point of connection) is injected by the STATCOM [2].

Power system consist of enormous network having different type of loads connected in it. As load changes system performance get affected, As day by day Power Quality issues may get increased to reduce this issues we considered a multi machine system with different load condition ,with dissimilar load situation system harmonics has been studied. To reduce this harmonic FACTS device that is STATCOM is used.

II. STATIC SYNCHRONOUS COMPENSATOR

STATCOM configuration shown by Fig.1 which consists of voltage source converter & a coupling transformer , a dc capacitor. The VSC (voltage source converter) generate a balanced group of three sinusoidal voltages at the primary frequency with hastily convenient amplitude and phase angle [2].

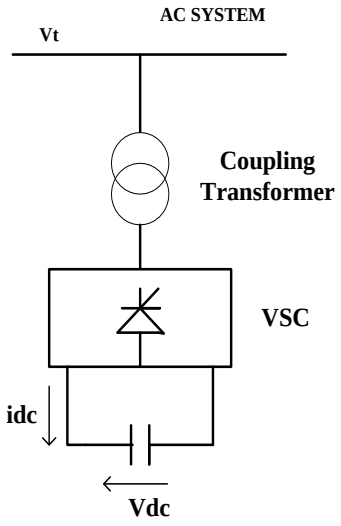

Fig.1.Static Synchronous Compensator (STATCOM)

III. MULTI MACHINE POWER SYSTEM

The model considered for analysis is four machine/ two area multi machine system which is shown in fig.2.The multi machine system shows the all power system equipment with the load connected to it. Firstly linear load is connected with the system and analysis of harmonics is done with MATLAB/SIMULINK environment.

The Multi machine system consisting two areas naming as area 1 and area 2 .Area 1 consist two generators along with two transformers connected at bus 1(B1). Similarly Area 2 having two generators with two transformers connected at bus 2(B2).Both the bus are connected via bidirectional transmission line naming as Line 1 and Line 2.

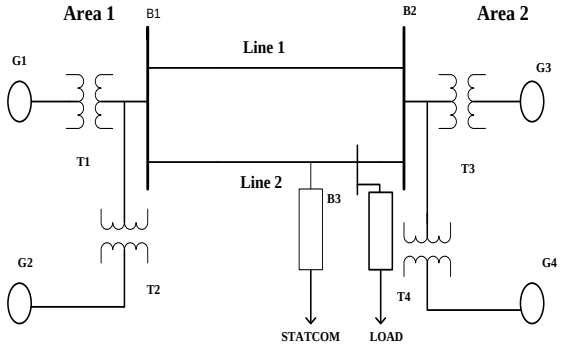

Fig.2. Single line diagram of Multi machine System

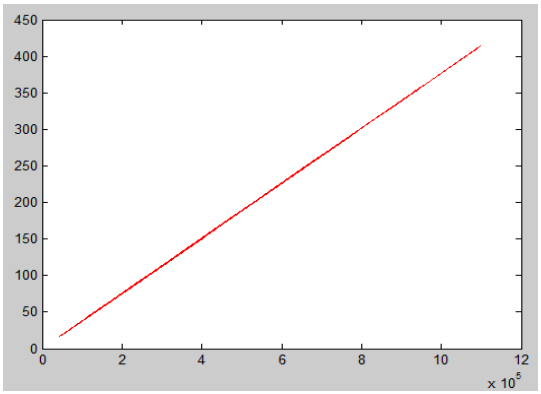

Fig.3.Linear Load Characteristics

In this Paper the we used Dynamic Load as a Non Linear load. A load is measured as non-Linear if the load impedance change with the practical voltage[2]. The varying impedance can be distinct as the current given by the Non-Linear load will not be sinusoidal even when it is connected to a sinusoidal voltage[2]. As because of harmonics non sinusoidal current production will occur that interacts by means of the impedance of the electrical distribution system and produce voltage deformation that can involve both the electrical distribution system equipment as well as the loads which are connected to it[2].

IV. TYPES OF LOAD APPLIED FOR ANALYSIS

A. Linear load

If Circuit is composed of ideal resistor inductor, capacitor then it is called as Linear circuit. In Linear circuit the production reaction is directly relative to the input Fig.3 illustrate the characteristics of Linear Load.

B. Non Linear Load

In heavy industries mostly Non Linear loads were found for example huge VFD, electric arc furnaces, grave rectifiers for electrolytic refining, etc [2].The dynamic load is also a Non linear load which is moving Load and having current harmonics.

The dynamic load type of characteristics can be obtained with the help of MATLAB simulink model which is shown in the fig.4. The above MATLAB simulink model gives the nature of characteristics shown in the figure which give the characteristics of the dynamic type of load. The x axis shows voltage, whereas y axis represents current. As shown in the figure non linearity of the load varies in both the polarities.

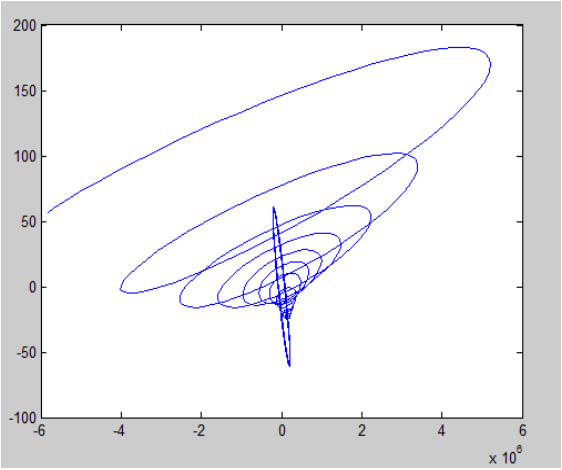

Fig.4.Non Linear Load Characteristics

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V. HARMONIC EFFECT IN SYSTEM

Harmonics have deleterious effects on electrical equipment as given below:

- Capacitor bank failure because of reactive power overload, resonance.
- Excessive losses, heating, and oscillations in induction and synchronous machines.3
- Generation of harmonic fluxes and increase in flux density in transformers, eddy current heating and consequent de rating.
- In excess of voltage and extreme currents in the power system, resulting from resonance.
- De rating of cables due to additional eddy current heating and skin effect losses possible dielectric breakdown.
- Telecommunication circuits with inductive interference.
- Indication interference & relay malfunctions, mainly in firm state & microprocessor controlled systems.
- Interference with large motor controllers and power plant excitation systems.

The AC show of electrical energy a system self-possessed of static equipment is used called FACTS. It is destined to improve controllability and raise power swing capability of the network. It is usually a power electronics-based system.

VI. SIMULATION RESULTS

CaseI- Under Steady State Condition Without STATCOM, Without Non-Linear Load.

As fig.5 shows the three phase voltages and three phase current under steady state operation of the system, There is no Non linear load connected in the system similarly voltage and current giving the stable results under steady state condition.

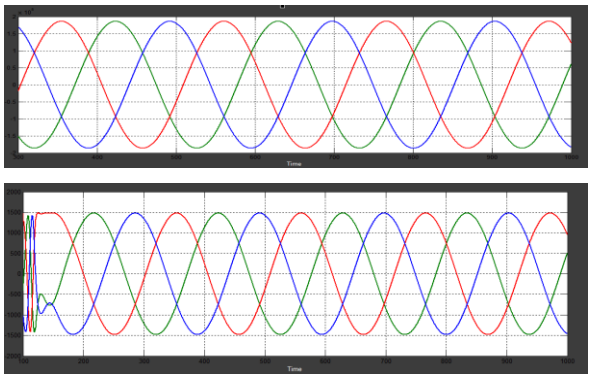


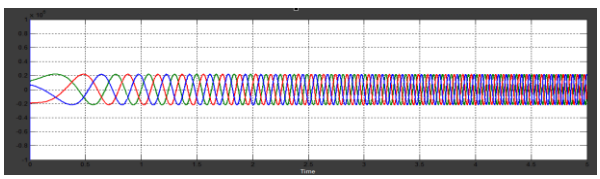
Fig 5. Simulation Result of V_B1 & I_B1 under normal operating condition without STATCOM & Without Non-Linear Load

Table I-With Linear Load THD representation of Voltage and current

With Linear Load	
Voltage(THD)	Current(THD)
Va=0.39%	Ia=0.42%
Vb=0.25%	Ib=0.25%
Vc=0.44%	Ic=0.41%

Case II-Without STATCOM, With Non-Linear Load At B1

The Fig .6 shows the simulation Results under the Non linear load condition without STATCOM .The voltage and current at bus 1 shows in following simulation results.



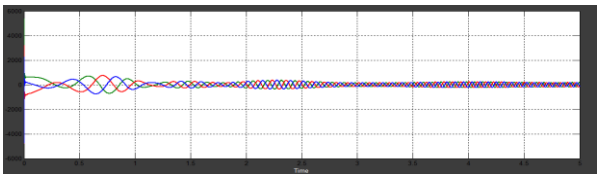


Fig 6. Simulation Result of V_B1 & I_B1 with Non Linear Load,Without STATCOM

Case III- With Non-Linear load ,Without STATCOM At B2

The Fig.7 shows the Voltage and current at bus 2 under the Non-linear load without STATCOM The simulation result obtained by using MATLAB /SIMULINK.

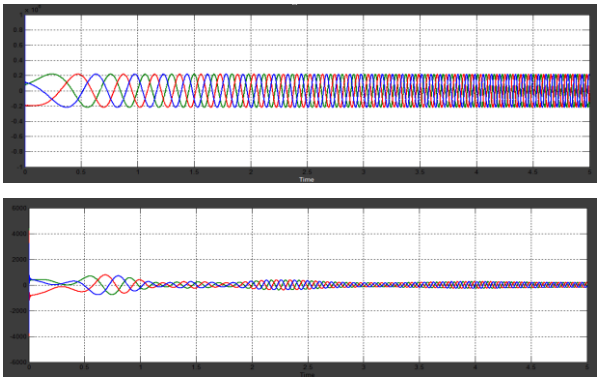


Fig 7. Simulation Result of V_B2 & I_B2 with Non Linear Load, Without STATCOM

Case IV- With Non linear load ,With STATCOM at B1 & B2

The system with Non Linear load with STATCOM gives better performance with Flexible AC transmission system which improves the bus voltage and current performance, with STATCOM the system voltage and current harmonics get improved. Fig .8 and 9 shows the simulation results of system voltage and current at B1 & B2.

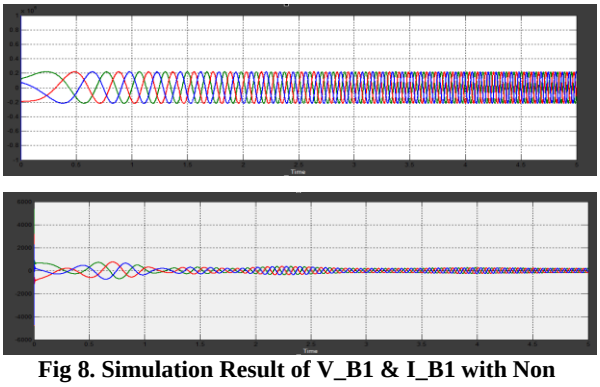


Fig 8. Simulation Result of V_B1 & I_B1 with Non Linear Load, With STATCOM

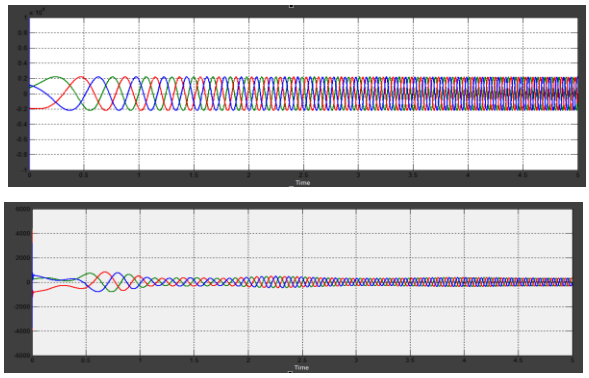
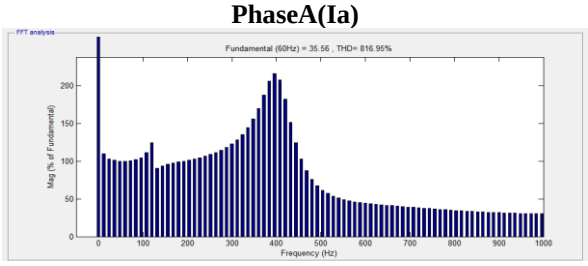


Fig 9. Simulation Result of V_B2 & I_B2 with Non Linear Load, With STATCOM

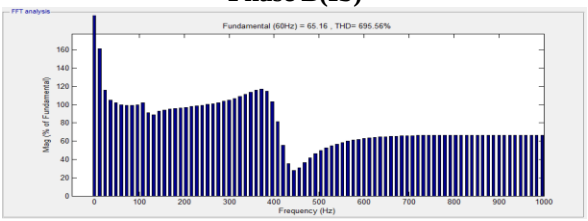
Case V- FFT Analysis for three phase current with Non linear load without STATCOM

The Fig .10 naming as Phase A (Ia), Phase B(Ib), Phase C(Ic) Shows total harmonic distortion (THD) for three phase current with Non linear load Without STATCOM Shows harmonic calculation for each phase.

PhaseA(Ia)



Phase B(Ib)



Phase C(Ic)

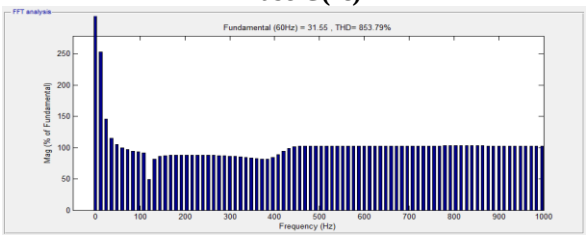
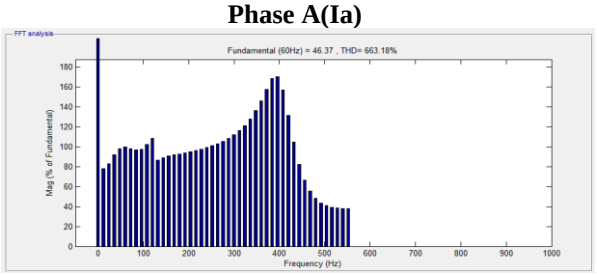


Fig 10.Total Harmonic Distortion(THD) of three phase current with Non-Linear load without STATCOM

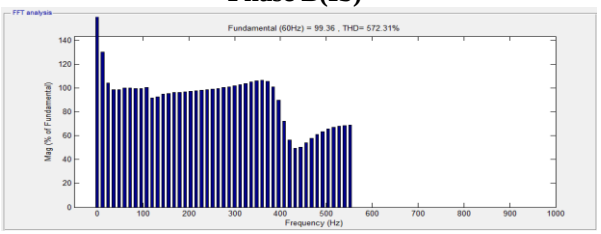
Case VI- FFT Analysis for three phase current with Non linear load with STATCOM.

The Fig.11 naming as Phase A(Ia), Phase B(Ib), Phase C(Ic), shows the total harmonic distortion for each phase when Non Linear load connected in system. While Fig .12 illustrate the graphical image of three phase THD with Non linear load with & without STATCOM.

Phase A(Ia)



Phase B(Ib)



Phase C(Ic)

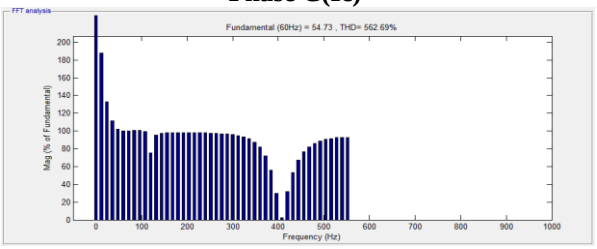


Fig 11.Total Harmonic Distortion(THD) of 3 phase current with Non-Linear load with STATCOM

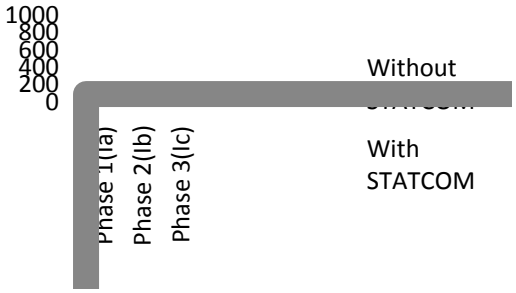
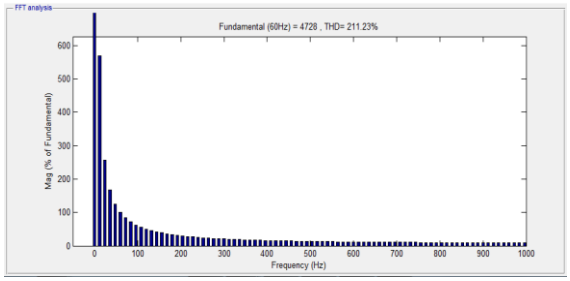


Fig 12.Graphical Representation of Three phase current Total Harmonic Distortion(THD)

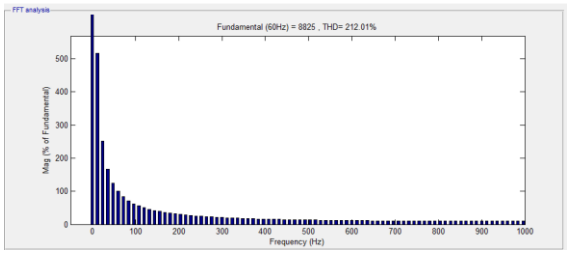
Case VII-FFT analysis for three phase voltage With Non linear load without STATCOM.

The Fig.13 naming as Phase A(Va), Phase B(Vb),PhaseC(Vc) shows the total harmonic distortion (THD) for voltage of each phase without STATCOM.

Phase A (Va)



Phase B (Vb)



Phase C (Vc)

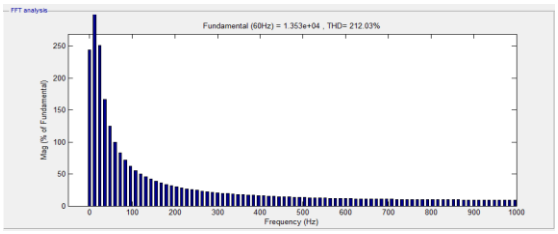
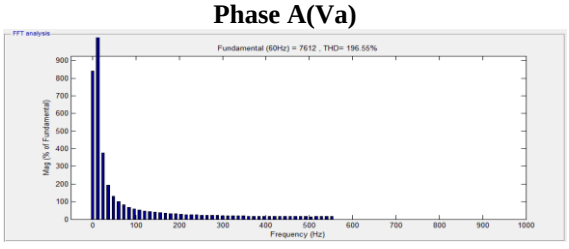


Fig 13.Total Harmonic Distortion(THD) of three phase voltage with Non-Linear load without STATCOM

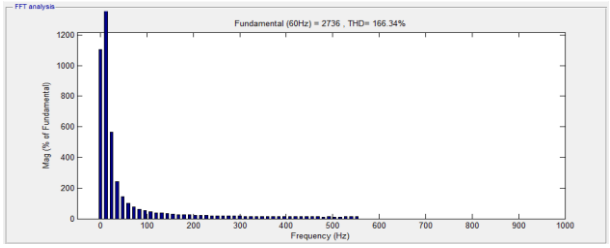
Case VIII-FFT analysis for total harmonic distortion (THD) with Non linear load With STATCOM

The Fig.14 naming as Phase A(Va),Phase B(Vb).Phase C(Vc) shows the total harmonic distortion for voltages of each phase with Non linear load with STATCOM as well as Fig.15 shows the graphical representation of total Voltage harmonics with and without STATCOM.

Phase A(Va)



Phase B(Vb)



Phase C (Vc)

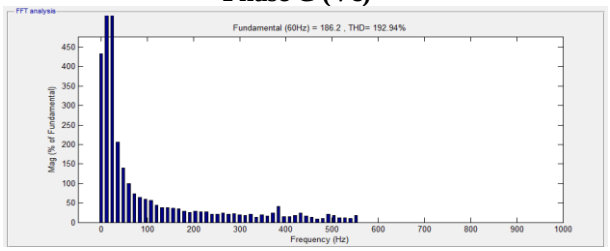


Fig 14.Total Harmonic Distortion (THD) of three phase voltage with Non-Linear load with STATCOM

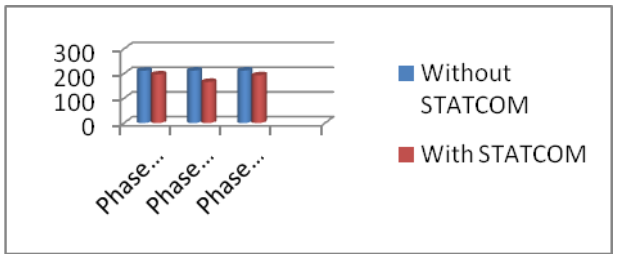


Fig15.Graphical Representation of Three phase Voltage Total Harmonic Distortion(THD)

VII. CONCLUSION

In this paper linear and Non-Linear load are studied. STATCOM is used to recover the power Quality by dropping harmonics. The System is studied under different condition with Linear load & Non-Linear Load harmonics of the system are studied.

Under Steady State operation condition System performance is balanced but with the Non-Linear load system harmonics increased. The harmonics get reduced by using STATCOM. Hence Power Quality issue (Harmonics) are reduces by using a device STATCOM.

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