Power Quality Improvement Using Switched Capacitor Compensation With Reduce Harmonics System

[1] Vikash Kumar, [2] Sitaram Pal,

[1] Research Scholar M. Tech Power System, [2] Assistant Professor,

Department of Electrical and Electronics Engineering

[1,2] Rabindranath Tagore University, Bhopal-Chiklod Road, Raisen-464993(M.P)

Abstract: The electric utility industry and consumers of electrical energy are facing new challenges for cutting the electric energy cost, improving energy utilization, enhancing electric energy efficiency, improving supply waveform power quality, reducing any safety hazards to personnel and protecting electronic sensitive computer and automatic data processing networks. The growing use of nonlinear type electric loads causes a real challenge to any power quality and harmonic mitigation for electric utilities around the world, especially in the existing era of unregulated electricity market where competition, supply quality, security and reliability are now key issues for any economic survival. Network pollution is characterized by the nonlinear electric load ability to distortion modify and change the voltage and current waveform RMS due to its inherent nonlinearity.

INTRODUCTION

The global need for electrical energy sources, energy conservation measures, and rising world energy demand drive existing power systems and transmission lines toward their crucial stability and thermal limits and grid security, reliability, and voltage stability. This can result in sustained faults, Brownouts, Blackouts, and severe power quality problems. To reduce system's active and reactive power losses and resultant poor power factor problems due to poor power quality, fixed, switched, and modulated capacitor banks have been widely used. Fixed power filters which have low cost and simple robust structure are usually installed particularly in industrial utilization networks to improve power quality and reduce the level of harmonic distortion. Active power filters can be used to fulfill power quality requirements but they are expensive and consume large current rating. Other option is using the switched/modulated family of passive filters and capacitive compensators developed. Advent of Flexible A. C. Transmission System (FACTS) based Switched Capacitor Compensation (SCC) utilized with dynamic control systems for compensation of reactive power and harmonics to system

A.M. Sharaf & Pierre Kreidi [1] has studied Power Quality is distorted by harmonics or due to nonlinear loads, the low cost switched capacitor filter compensation used. The Unified Switched Filter Capacitive Compensation (U.S.C.S.) used in this paper and it is in family of static compensators, electrical energy saving device and switched passive filters. This scheme can be used for single phase or three phase four wire load of nonlinear nature. Feedback control logic is applied to this U.S.C.S. scheme, it contain dual loop controller of current and power, error is generated by this loops which is given to PID controller,

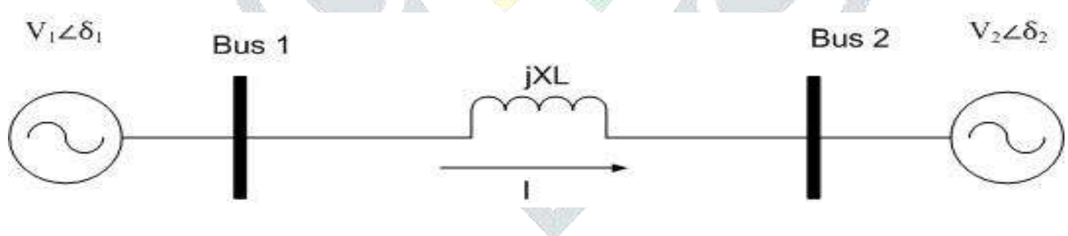
C.K. Duffey and R. P. Stratford [2] have focused aware with harmonic IEEE-519 standards. In 1973 two events occurred that changed the way that utilization equipment is applied on industrial power systems. The first was oil embargo that increased the cost of energy and second was the adjustable speed drives using static power converters. The result was IEEE 5 19- 198 1, “IEEE Guide for Harmonic Control and Reactive Compensation of Static Power Converters.

1 Motivation for Thesis

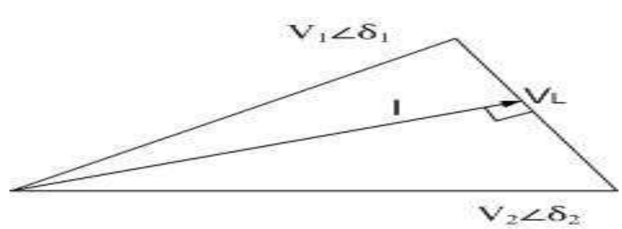
From above literature survey we can say that, Now-a-days all industries and domestic loads are using semiconductor equipments for easy workout of day to day work. Now humans are going to depend on electronics world. In electronics equipment we use the DC Supply, for this we use rectifier and inverter also variable speed drives are used. This equipment have nonlinear characteristics generate harmonics in system. Also we need always reactive power for system due to many characteristics of reactive power like it cannot travel far from source etc.,.

2.1Basic principal of power compensation in transmission system

Figure 2.1(a) shows the simplified model of a power transmission system. Two power grids are connected by a transmission line which is assumed lossless and represented by the reactance X_L, $V_1\angle\delta_1$ and $V_2\angle\delta_2$ represent the voltage phase of the two power grid buses with angle $\delta = \delta_1 - \delta_2$ between the two. The corresponding phase diagram is shown in Figure 2.1(b).



(a)



(b)

Figure 2.1 Power Transmission System: (a) Simplified Model (b) Phase Diagram

The magnitude of the current in the transmission line is given by,

$$I = \frac{V_L}{X_L} = \frac{|V_1\angle\delta_1 - V_2\angle\delta_2|}{X_L}$$

Necessity of reactive power compensation

“Reactive power (vars) is required to maintain the voltage to deliver active power (watts) through transmission lines. Motor loads and other loads require reactive power to convert the flow of electrons into useful work. When there is not enough reactive power, the voltage sags down and it is not possible to push the power demanded by loads through the lines.

2.2 Series compensation

Series compensation aims to directly control the overall series line impedance of the transmission line. Tracking back to Equations (2-1) through (2-5), the AC power transmission is primarily limited by the series reactive impedance of the transmission line. A series-connected can add a voltage in opposition to the transmission line voltage drop, therefore reducing the series line impedance.

2.3 Shunt compensation

Shunt compensation, especially shunt reactive compensation has been widely used in transmission system to regulate the voltage magnitude, improve the voltage quality, and enhance the system stability [27]. Shunt-connected reactors are used to reduce the line over-voltages by consuming the reactive power, while shunt-connected capacitors are used to maintain the voltage levels by compensating the reactive power to transmission line. capacitor C is shunt-connected. The voltage magnitude at the connection point is maintained as V.

2.4 Harmonic compensation by shunt passive filter

Harmonic regulations or guidelines such as IEEE 519-1992, IEC61000, etc. are currently applied to keep current and voltage harmonic levels in limits. Passive filter consisting of capacitor, inductor and resistor can be classified into tuned filters and high-pass filters. They are connected in parallel with nonlinear loads such as diode/thyristor rectifiers, ac electric arc furnaces, and so in. Figure 2.4 and 2.5 shows circuit configuration of passive filter. Among them, the combination of four single-tuned filters to the 5^{th}, 7^{th} , 11^{th} and 13^{th} harmonic frequencies and a second-order high-pass filter tuned around the 17^{th} harmonic frequency has been used in a high-power three-phase thyristor rectifier.

2.7 Passive filter

Passive filters connected between the non-linear load and source. The passive filter plays important role to compensation of the load current harmonics.

1. Series components must be rated for the full current, including the power frequency component. Such a requirement leads to larger component sizes and therefore costs.

2. Shunt filter components generally must be rated for only part of the system voltage (usually with respect to ground). Such requirements lead to smaller component sizes and therefore costs. Shunt filters are designed (or can be purchased) in three basic categories as follows:

1. Single-tuned filters.
2. Multiple- (usually limited to double) tuned filters.
3. Damped filters (of first-, second-, or third- order, or newer "c-type").

3.2 Switched capacitor compensation for harmonic mitigation

As shown in Figure 3.2 switch capacitor compensation has a meaning of reactive power compensation and harmonic compensation [28]. Switched capacitor compensation to provide or absorb the required reactive power and harmonic mitigation from power supply system. The capacitors store energy in an electric field, Inductors store energy in a magnetic field.

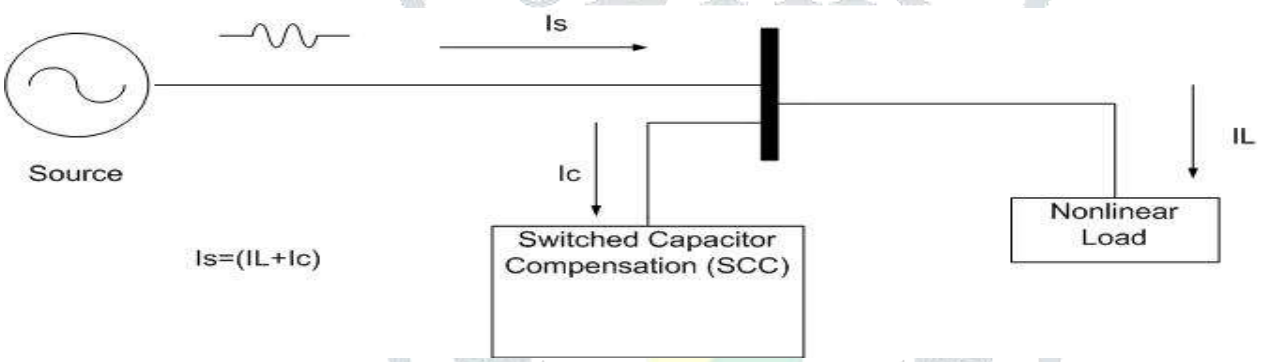


Figure 3.2 Circuit diagram for single-phase supply system to nonlinear load

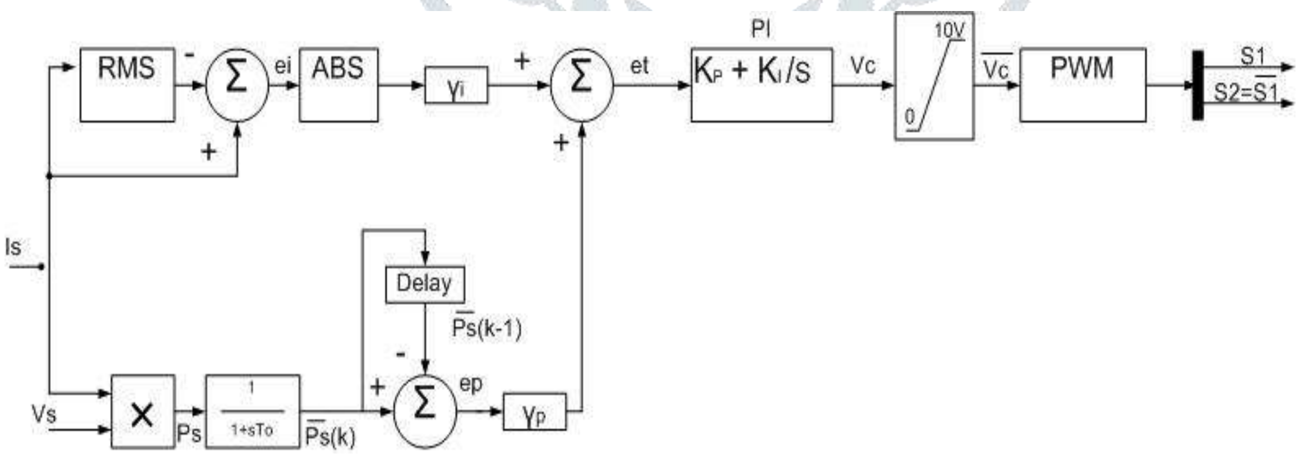


Figure 3.4 Control scheme for switched capacitor compensation (SCC)

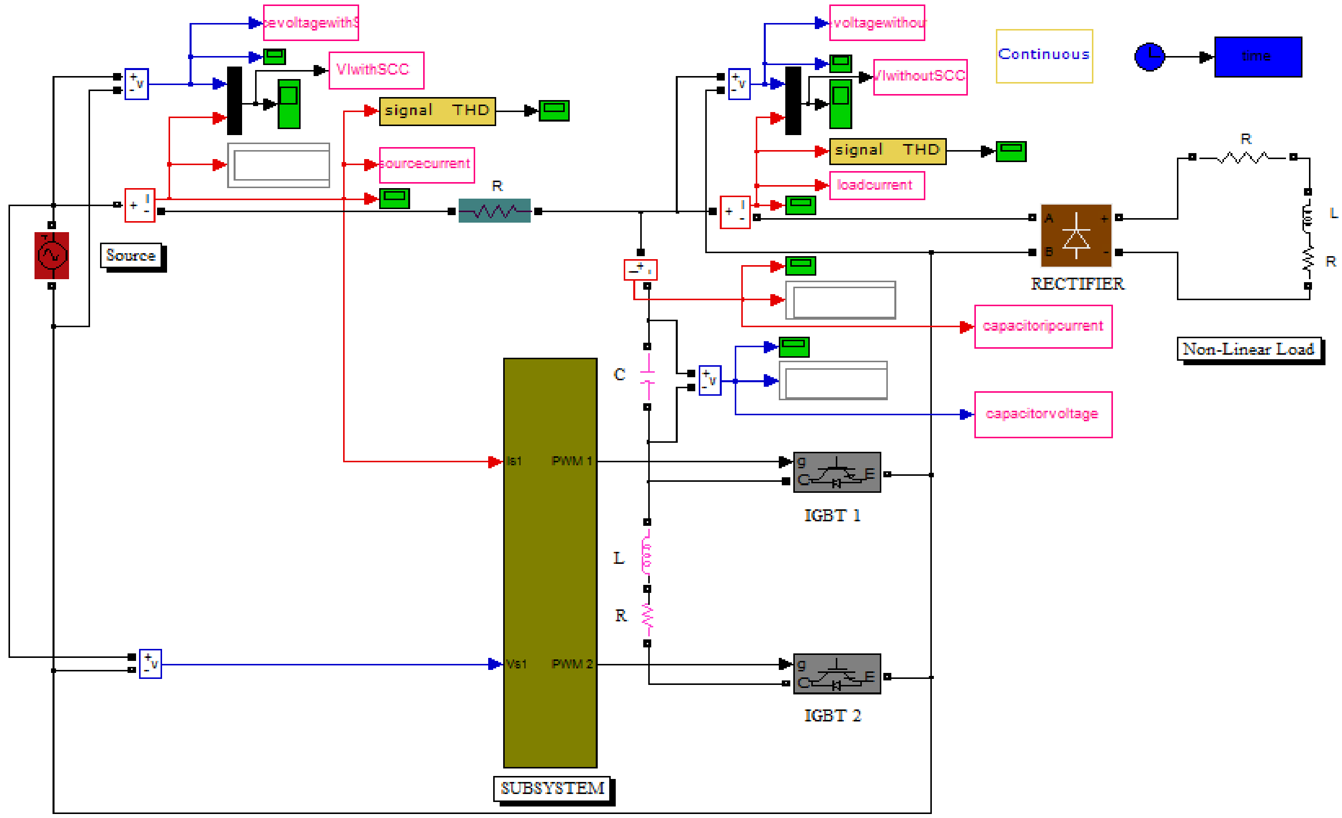
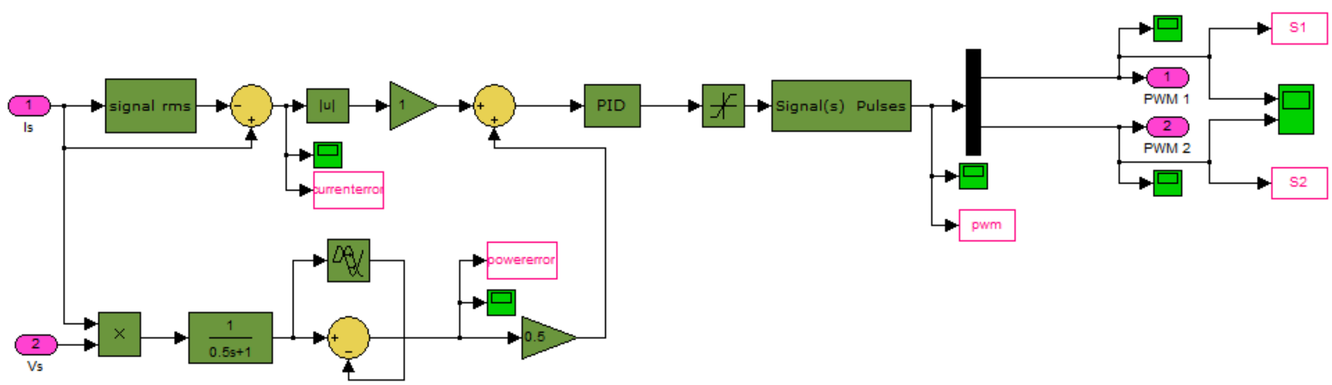
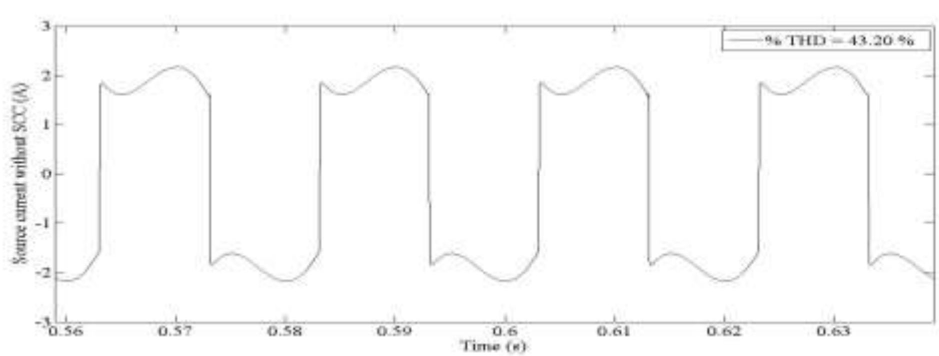


Figure 5.1 Circuit diagram of FACTS based switched capacitor compensation



Figu5.2 Block diagram of dual loop PI controller



5.3 Source current without SCC

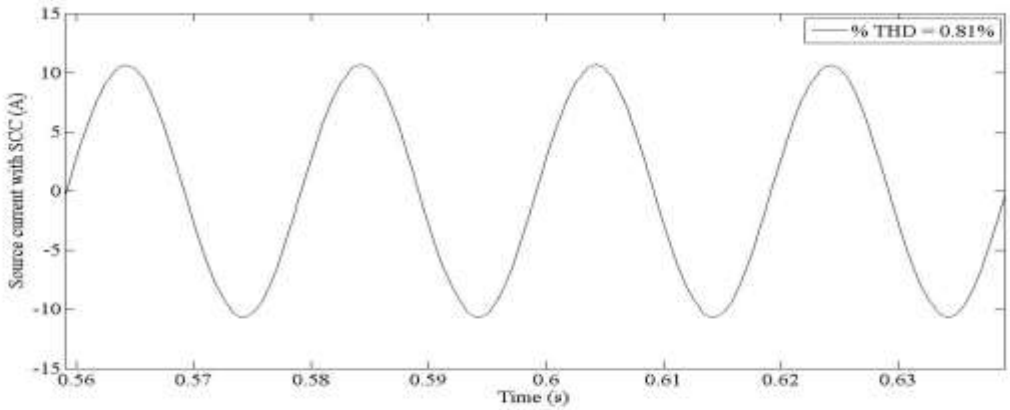


Figure 5.4 Source current with SCC As shown in figure 5.4 of source current with SCC, the source current has got smooth shape to distorted waveform. The % THD is reduced to 0.81 %.

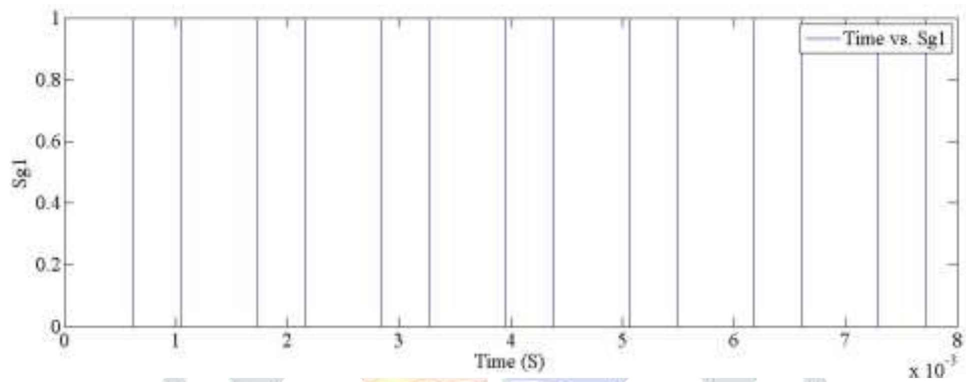


Figure 5.5 PWM gate pulse Sg1

As shown in Figure 5.5 switching pulses generated by PWM of switch 1 is shown. for analysis of switch.

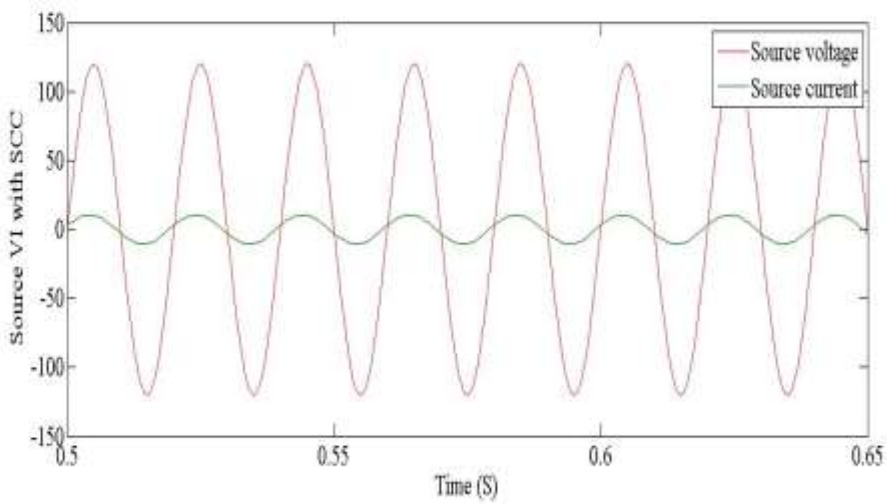


Figure 5.9 Source voltage and current with SCC

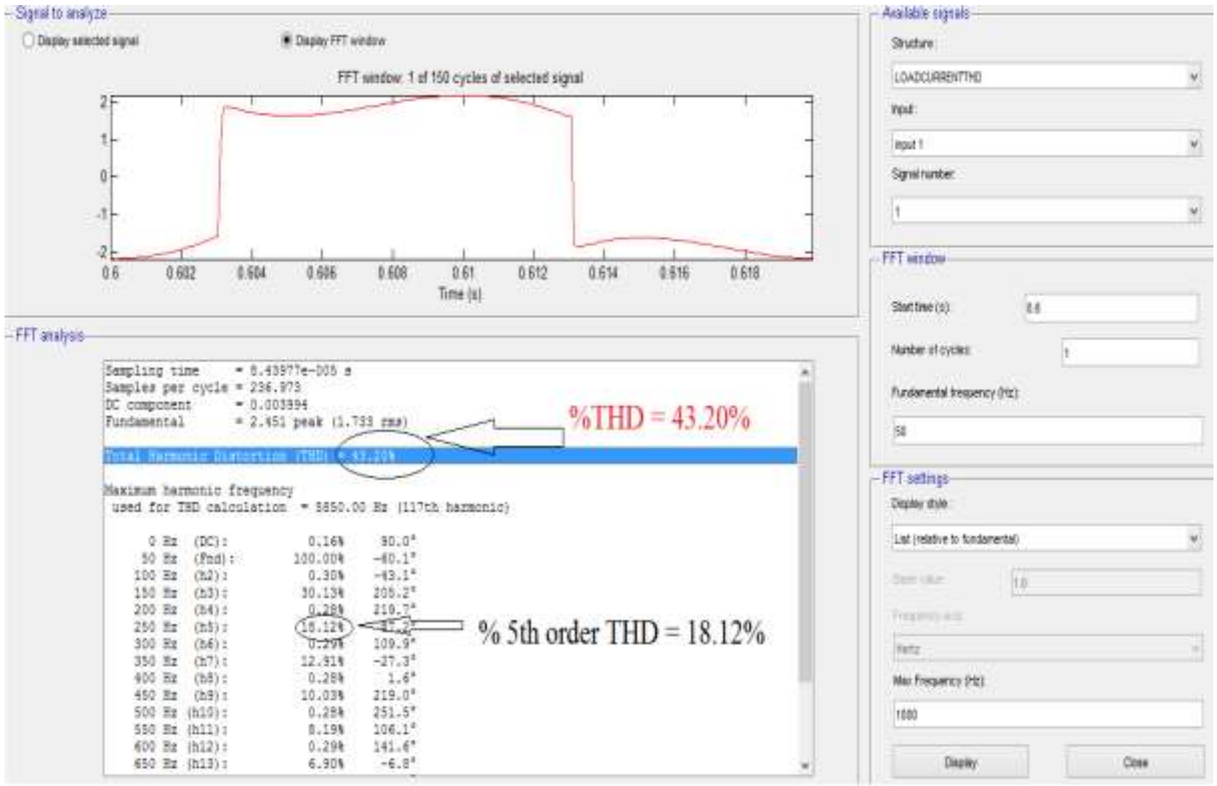


Figure 5.11 FFT analysis without SCC

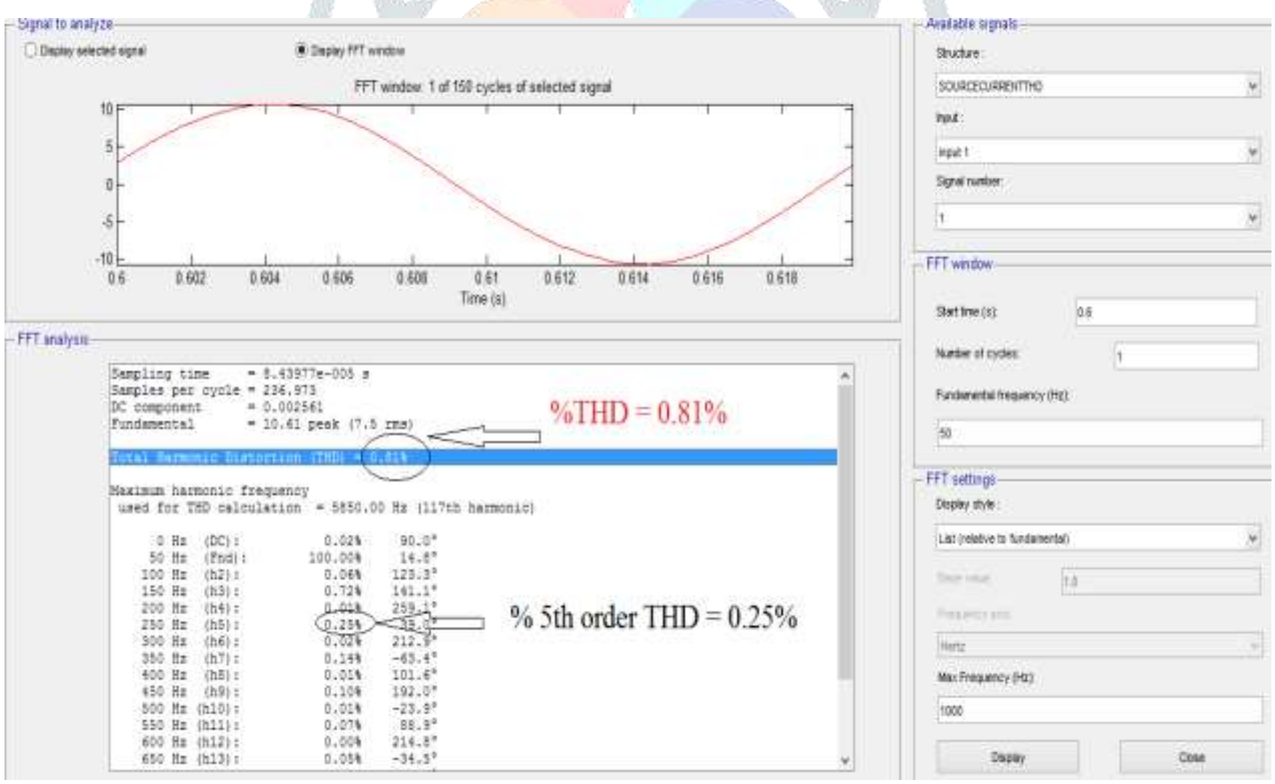


Figure 5.12 FFT analysis with SCC

As shown in Figure 5.12 the FFT analysis of 1 cycle is considered and at time of 0.6 Sec. it is started. The % THD is reduced from 43.20 % to 0.81 %. The waveform is sinusoidal and 5th order % THD is also reduced.

Results:

The simulation of SCC with and without connection to single-phase supply system is implemented. I have got % THD in current (**THDi**) reduction from **43.20 % to 0.81 %**. The **5th order % THDi** is also reduced from **18.12 % to 0.25 %**. The waveform is distorted for without SCC and it becomes sinusoidal after SCC connection. The Simulation has run for time of 3 second in MATLAB2010a/Simulink software.

Conclusion

During the course of this study it can be concluded that the increased use of static power converter and static power capacitors can set up system condition to cause power quality problems like harmonics in power system. In the simulation i have present dynamic dual loop current and power error tracking scheme for harmonic mitigation. The proposed dynamic control scheme is now simulated for a single-phase nonlinear load connected power system; it can also be tested for three-phase four-wire system. The main objective is to mitigation harmonics from source current. The 5th order harmonic reduction is also validated with simulation results. The 5th order harmonics creates negative sequence components.

Reference

[1] Power electronics hand book, 2nd edition by Muhammad H. Rashid.

[2] Pierre Kreidi, A.M. Sharaf, "**Power Quality Enhancement Using Unified Switched Capacitor Compensation**", *IEEE Trans. Proceeding 0-7803-7781-8/03*, May 2003.

[3] David D. Shipp, "Harmonic Analysis and Suppression for Electrical Systems Supplying Static Power Converters and Other Nonlinear Loads", *IEEE Trans. Paper IPSD 78-62*, February1979.

[4] Ray P. Stratford, "Harmonic Pollution on Power Systems-A Change in Philosophy". *IEEE Trans. on Industry Application, VOL. IA-16, NO. 5,* Oct. 1980.

[5] A.M.Sharaf and Kh.M.Abo-Al-Ez, "Harmonic Pollution on Power Systems-A Change in Philosophy",*IEEE Trans. ISIE*, July 2006.

[6] A.M. Sharaf & A.R.N.M. Reaz U1 Haque, "A Low Cost Stand Alone Photovoltaic Scheme for Motorized Hybrid Loads", *IEEE Trans. 0-803-8281-1/04*, Feb. 2004.

[7] A.M Sharaf and Roshan Chhetri, "A Novel Dynamic Capacitor Compensation/Green Plug Scheme for 3-Phase - 4 Wire Utilization Loads", *IEEE CCECE/CCGEI 1-4244-0038-4 2006 IEEE,*

[8] Adel M. Sharaf & Hassan A. Mahasneh, "A Low-Cost Modulated Filter Compensator for Energy-Efficient Enhancement in AC Utilization Systems". *IEEE Trans. 1-4244-1445-8/07/007,* July 2007. Thomas S. Key, "The Electricity – Industrial User Partnership in Solving Power quality Problems", *IEEE Trans. on Power Systems, VOL. 5, NO. 3,* Aug. 1990.