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SIMULATION OF NON LINEAR SLIDING MODE CONTROLLED UPQC DEVICE FOR POWER QUALITY IMPROVEMENT

Sonali Patel[1], Prof. Jigar Thakar[2]
[1]PG Scholar, [2]Assistant Professor, Electrical Department, HGCE, Vahelal, Ahmedabad, Gujarat, India

ABSTRACT: In recent days, the quality of power has become more important to the most of the customer load. The unified power quality conditioner (UPQC) is the ultimate solution to provide the quality of power irrespective of the type of power quality problems. The proposed non-linear sliding surface reflects the controlling action of the DC-link capacitor voltage with a variation of the system's damping ratio and permits the DC-link voltage to obtain a low overshoot and small settling time. This NLSMC technique combines with a novel synchronous-reference frame (SRF) control technique for generation of a rapid and stable reference signal for both shunt and series converters. A new switching dynamics control strategy has been designed for the voltage source converters of UPQC and this design helps in the reduction of band violation of the hysteresis band as well as improvement in the tracking behaviour of UPQC during grid perturbations. The proposed control strategy of UPQC is validated through MATLAB/SIMULINK.

I. INTRODUCTION

The modern power distribution system is facing the different power quality problems. The extensive use of non-linear loads is further contributing to increased current and voltage harmonics issues. Furthermore, the penetration level of small/large-scale renewable energy systems based on wind energy, solar energy, fuel cell, etc., installed at distribution as well as transmission levels is increasing significantly. Unified power quality control was widely studied by many researchers as an eventual method to improve power quality of electrical distribution system. The function of unified power quality conditioner is to compensate supply voltage flicker/imbalance, reactive power, negative sequence current, and harmonics [1].

The word "Power Quality" is the most important facts of any power delivery system. Low quality power affects electricity consumers in many ways. The lack of quality power can cause loss of damage of equipment, production or appliances, increased in power losses, interference with communication lines. The widespread use of power electronics equipment has produced a significant impact on quality of electric power supply by generating harmonics in voltages and currents. Therefore, it is a very important to maintain a high standard of power quality [1]. The word active power filter (APF) is a widely used terminology in area of a power quality improvement. Conventional power quality mitigation equipments use passive elements and do not always respond correctly as a nature of power system condition change. One modern solution that deals with both load current and supply voltage imperfections is the UPQC. The UPQC is a one of the APF family members. Unified power quality conditioner (UPQC) has been proposed for simultaneously eliminating both types of PQ problems. The UPQC achieves its objectives by integrating series and shunt active power filters (APFs), where both share a common dc link. The shunt APF mitigates current related PQ problems by compensating harmonic and reactive component of load current whereas series APF generates a voltage in series with line to mitigate voltage related PQ problems. Varieties of power conditioning techniques are in use starting from passive filtering to active power conditioning. Among different new technical options available to improve power quality, Unified Power Quality Conditioner (UPQC) has found to be more promising.

This paper presents a comparative analysis of voltage source and current source UPQC. With the availability of new IGBT with reverse blocking capability, the use of current source active filters is increasing due to its inbuilt short circuit protection capability, higher efficiency at low power loads, simple open loop current control and effective filtering of harmonics A simple PI controller and robust hysteresis band PWM technique is used for derivation of reference and switching signals respectively. The resultant compensation system eliminates voltage as well as current harmonics with good dynamic response.

II. UPQC STRUCTURE

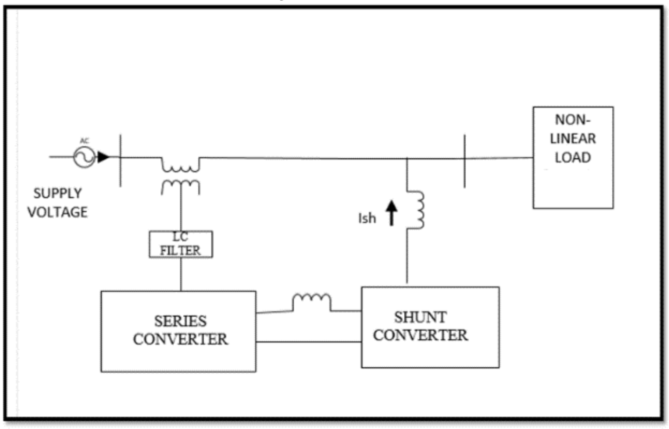

Figure 1. CSC based UPQC

A Current source converter based UPQC is built with two bridges of IGBT switches connected back to back through an inductor of sufficiently large value as shown in figure 1. The series filter is connected to AC mains supply through a series transformer of suitable rating. Series filter are mitigate the voltage related issue and shunt filter are mitigate the current related issue. In current source based UPQC a large inductor is used as a DC link. This dc link will function as DC sources and hence does not demand any external power source. However in order to maintain constant DC current/ voltage in the energy storage element a small fundamental current is drawn to compensate active filter losses.

SERIES CONTROLLER
The series filter is controlled by PWM control. A series active filter acts as controlled voltage source by imposing high impedance for the harmonic currents, blocking their flow from both loads to source and source to load directions. The source voltage may contain zero, negative sequence as well as harmonic component, which need to be eliminated by series compensator. In order for the load voltage to perfectly sinusoidal and balanced, the series filter should produce a voltage that makes the load voltage sinusoidal. The reference load voltages are obtained by multiplying a PLL based unit vector templates with a constant equal to peak amplitude of fundamental input voltage. Now reference voltage are compared with the measured value and output is given to the PWM for series controller pulse generation.

SHUNT CONTROLLER

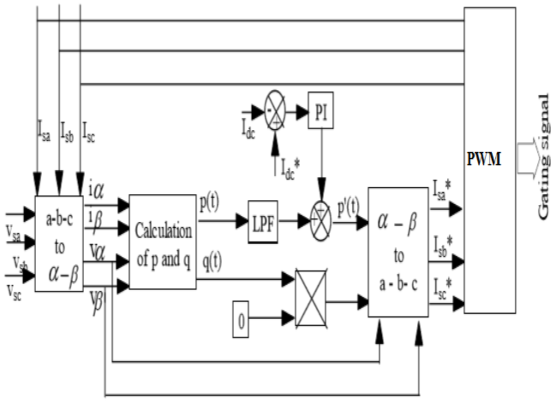

Figure.2 shunt controller

In case of CSC based UPQC, the dc link current is sensed and compared with reference dc link current. A PI controller then processes the error. The output signal from PI controller is regarded as switching power losses of shunt active filter, and is added to real power loss component to derive reference source current.These reference currents are then compared with actual source current and error given to PWM controller to derive the switching signals of shunt inverter. The schematic block diagram of shunt filter controller is shown in figure.2

Control Concept of UPQC
The classical connection of UPQC with transmission line shown on the figure.3, The UPQC uses a two back-to back VSCs, operated from a common dc link. The converter 2 injects the controllable voltage both magnitude and phase angle to the connected line via series transformer. The converter 1 called STATCOM supplies or absorbed the real power demand by the converter 2 via dc link which then support the real power exchange between them. Conceptually the UPQC can automatically control all the system parameter that affect the power flow in a line, namely, voltage, impedance, and phase angle, hence, the name suggested "unified". The UPQC provides complete control over power flow in the line. A circuit equivalent diagram of the UPQC is show in the fig.3.

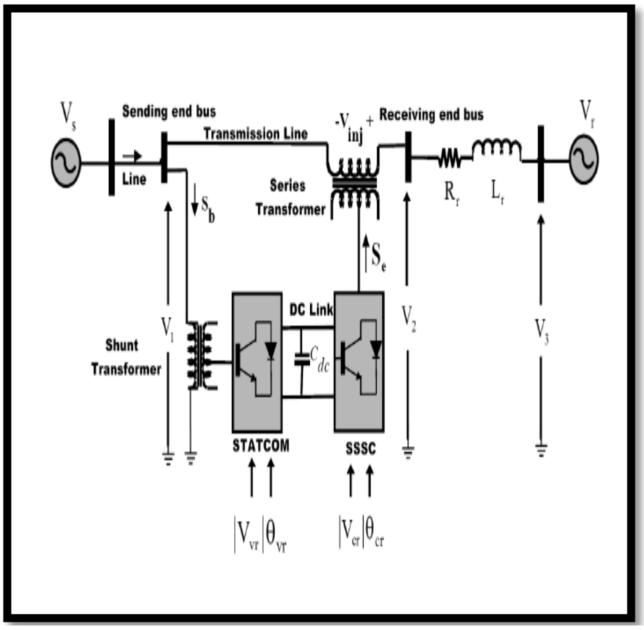

Fig.3 Connection diagram of UPQC with transmission line

UPQC Based Control System
There are modes of operation in which UPQC operates and they are:-
1. VAR Control Mode
2. Automatic Voltage Control Mode
3. Direct Voltage Injection Mode
4. Automatic Power Flow Control Mode

1. VAR Control Mode: The reference input is an inductive or capacitive VAR request. The shunt inverter control translates the V_{ar} reference into a corresponding shunt current request and adjusts gating of the inverter to establish the desired current. For this mode of control a feedback signal representing the dc bus voltage, V_{dc}, is also required [6].
2. Direct Voltage Injection Mode: The reference inputs are directly the magnitude and phase angle of the series voltage [6].
3. Automatic Power Flow Control Mode: The reference inputs are values of P and Q to maintain on the transmission line despite system changes [6].
4. Automatic Voltage Control Mode: The shunt inverter reactive current is automatically regulated to maintain the transmission line voltage at the point of connection to a reference value. For this mode of control, voltage feedback signals are obtained from the sending end bus feeding the shunt coupling transformer. The series inverter controls the magnitude and angle of the voltage injected in series with the line to influence the power flow on the line. The actual value of the injected voltage can be obtained in several ways [6].

III. SIMULATION AND RESULTS

Matlab Simulation of UPQC with Sliding Mode control

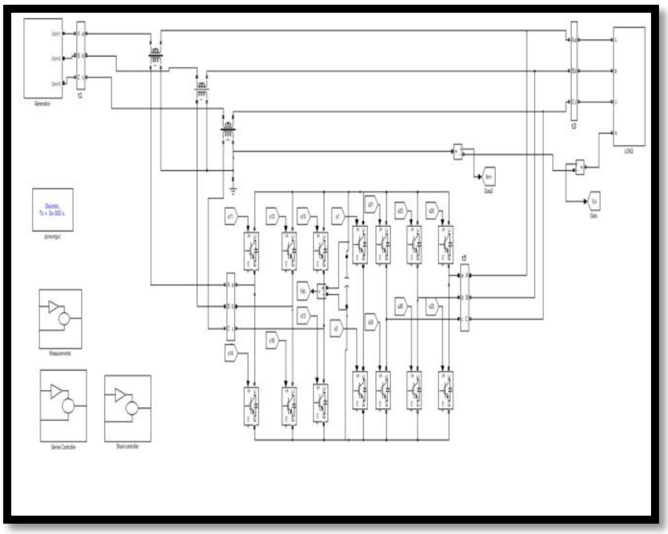

Fig.4 Matlab Simulation of UPQC with Proposed Controlling

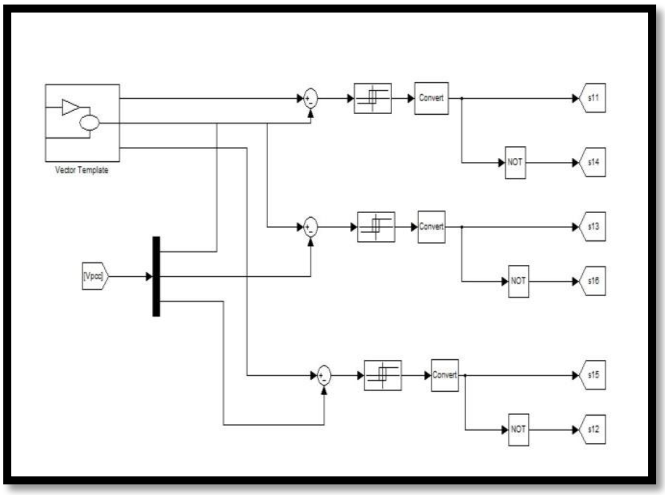

Fig.5 Series VSC control

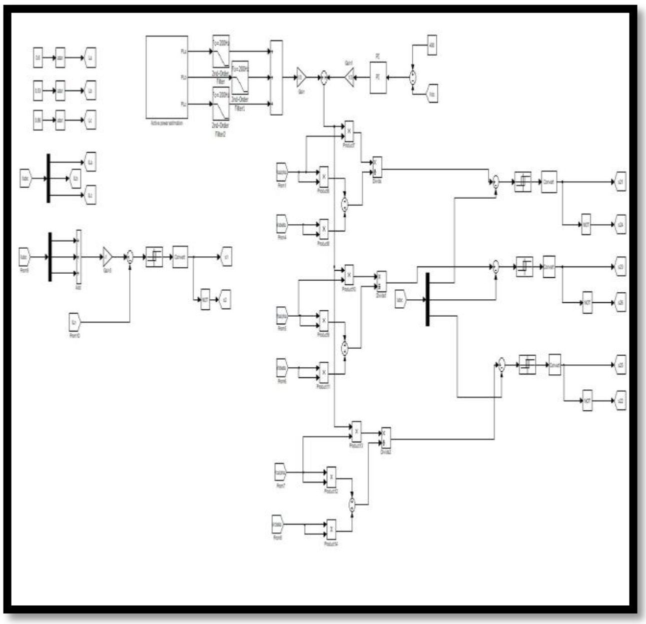

Fig 6 Shunt VSC Controlling

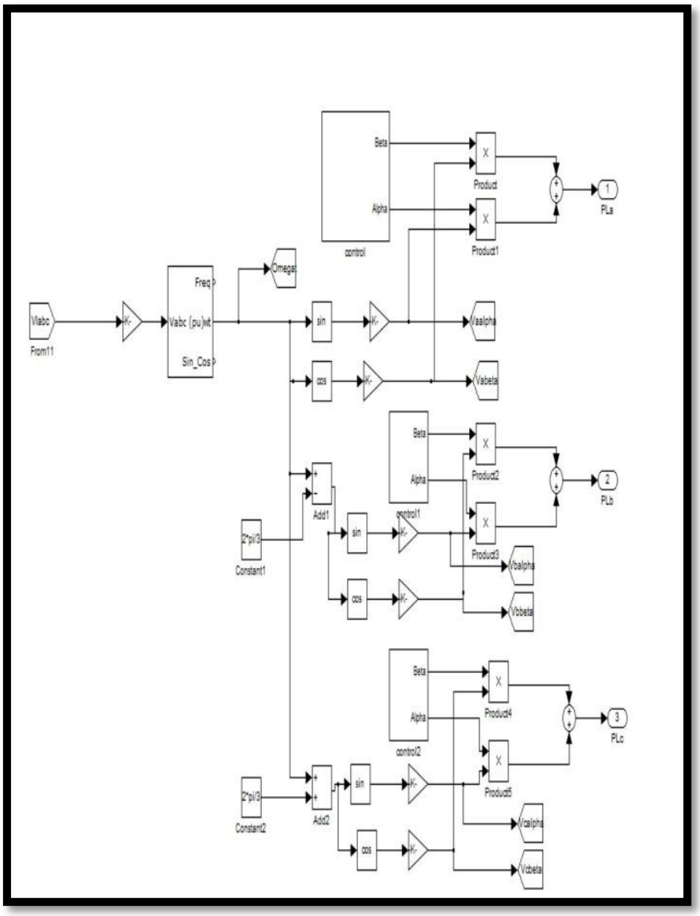

Fig 7- Sliding mode Control subsystem

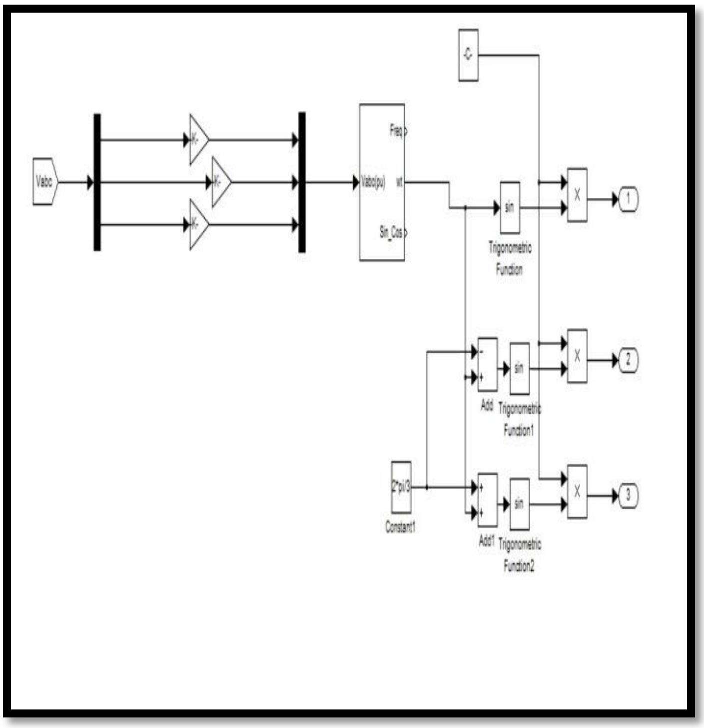

Fig 8- Vector Control logic

Simulation Results

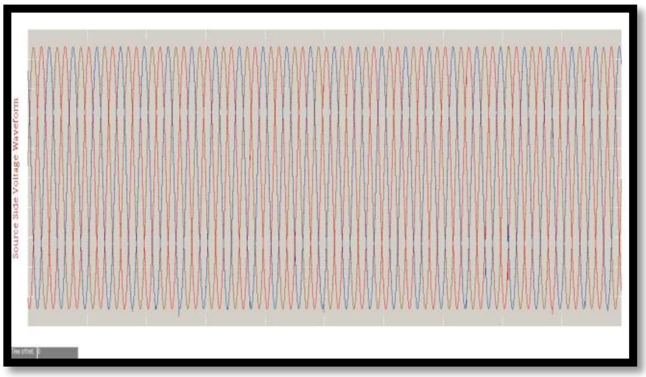

Fig 9- Source Side Voltage Waveform

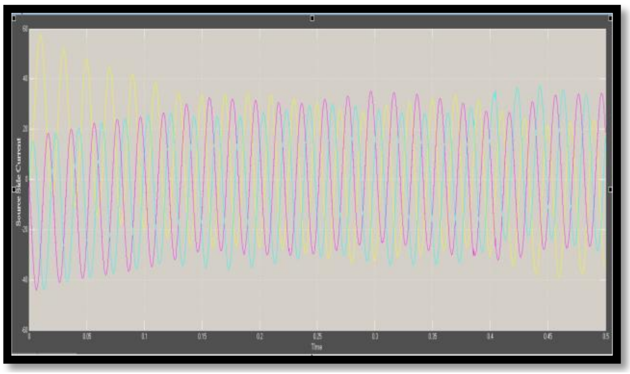

Fig 10- Source Side Current Waveform

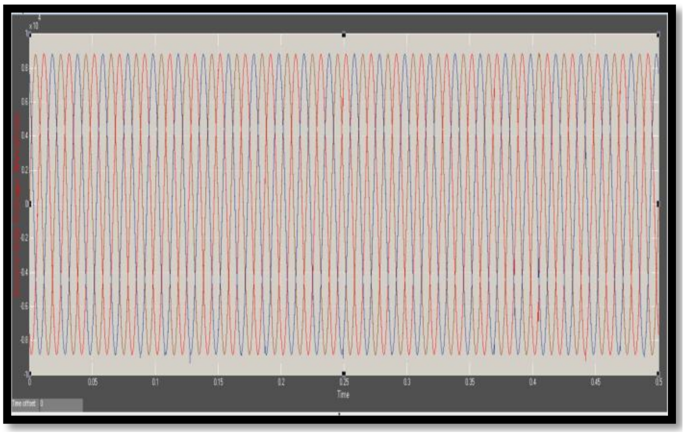

Fig 11- load Side Voltage Waveform

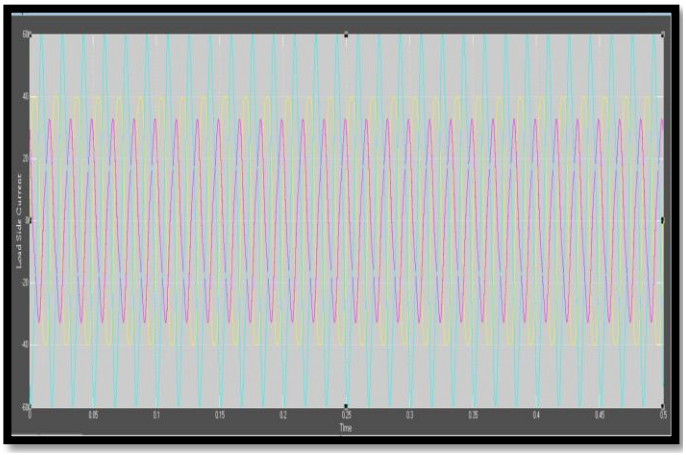

Fig 12- Load Side Current Waveform

THD Analysis with Sliding Mode Control

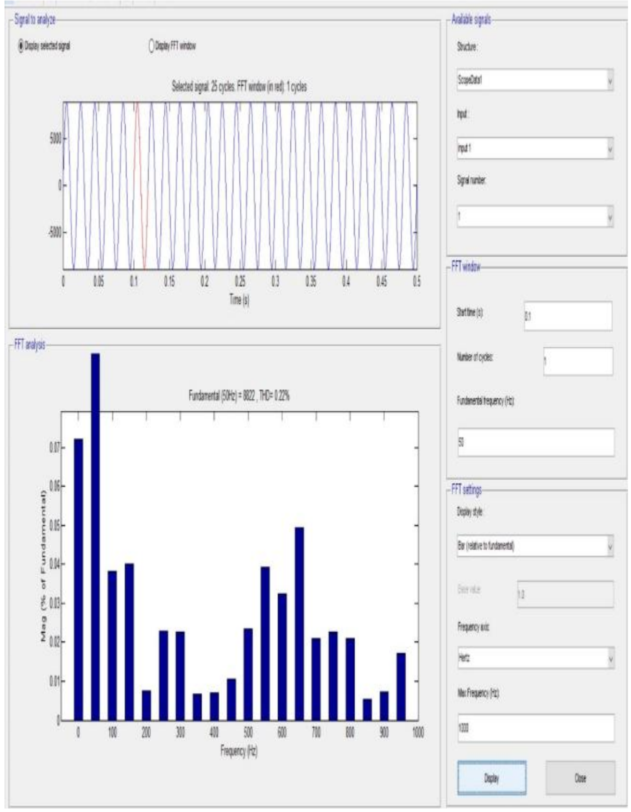

Fig 13- Source Voltage THD

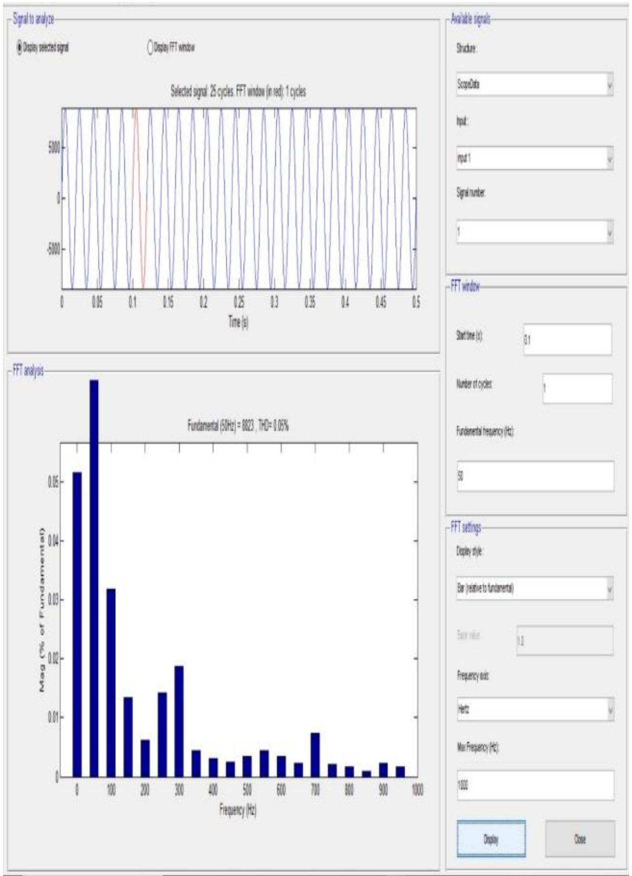

Fig 14- Load Voltage THD

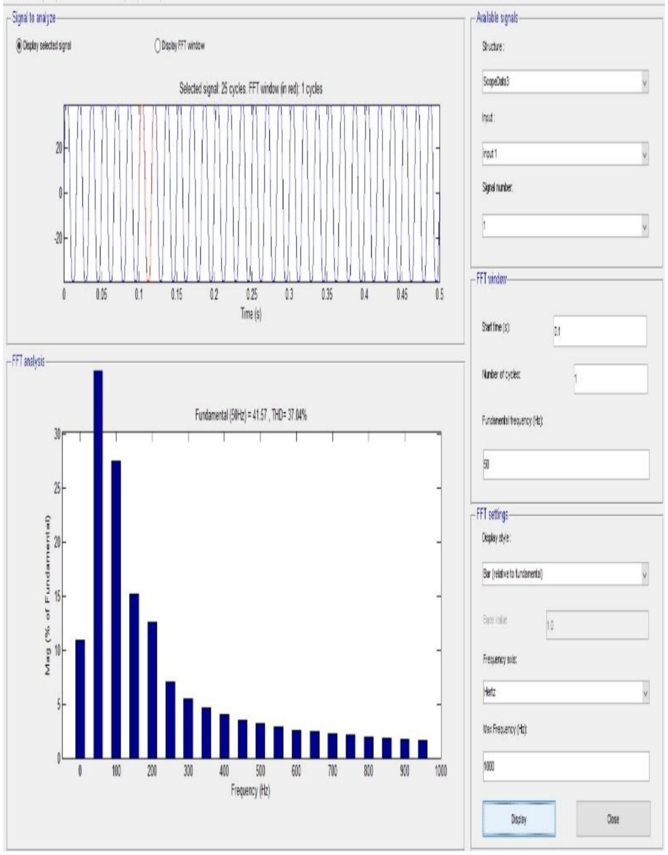

Fig 15 Source Current THD

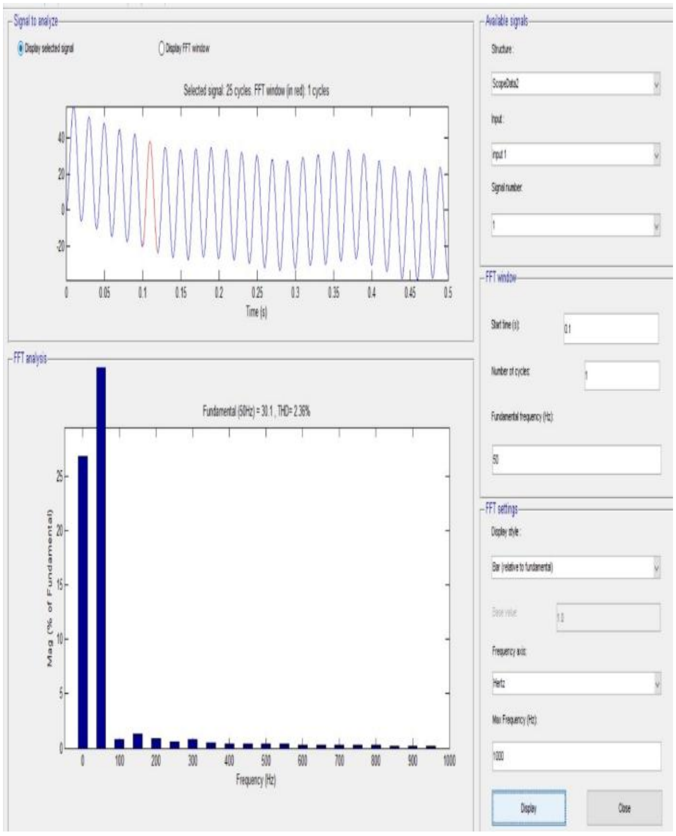

Fig 16- Load Current THD

Comparative Analysis of THD

Parameters	THD % with PI control	THD % with SMC control
Load Side Voltage	0.44 %	0.05%
Load Side Current	5.55 %	2.36%
Controlling	Simple	Difficult
Voltage Regulation	Good	Very effective
Effectiveness	Less effective	More effective

Table- Comparative Analysis of Control techniques

IV. CONCLUSION

In recent days, the quality of power has become more important to the most of the customer load. The CSC based UPQC is the solution for the power quality related problem.in this paper simulation is done under the nonlinear load condition. This project showcasing the application of UPQC for Power Quality Enhancement and mitigating the Power Quality Issues. From the simulation results we can say that after the application of UPQC in Three phase system the distortion in voltage, current waveform has been reduced. The power quality is improved using the control strategy of UPQC in Three phase compensated system.The Matlab Simulation of UPQC has been done for voltage and current waveform improvement. The THD analysis had been done and compared for the system with and without UPQC.

REFERRENCES

[1] Ketzer, M.B., Brandão, J.C.: 'Multivariable load current sensorless controllerfor universal active power filter', IET Power Electron., 2014, **7**, (7), pp. 1777–1786

[2] Patjoshi, R.K., Mahapatra, and K.K.: 'Performance analysis of shunt active power filter using PLL based control algorithms under distorted supply condition'. IEEE 2013 Students Conf. Engineering and Systems, 2013, pp. 1–6

[3] Shamsi-nejad, M.A., Khooban, M.H., Khalghani, M.R.: 'Dynamic voltage restorer control using bi-objective optimisation to improve power quality's indices', IET Sci. Meas. Technol., 2014, 8, (4), pp. 203–213

[4] Khadkikar, V.: 'Fixed and variable power angle control methods for unified power quality conditioner: operation, control and impact assessment on shunt and series inverter kVA loadings', IET Power Electron., 2013, 6, (7), pp.1299–1307

[5] Heydari, H., Moghadasi, A.H.: 'Optimization scheme in combinatorial UPQC and SFCL using normalized simulated annealing', IEEE Trans. Power Deliv., 2011, 26, (3), pp. 1489–1498

[6] Teke, A., Saribulut, L., Tümay, M.: 'A novel reference signal generation method for power-quality improvement of unified power-quality

conditioner', IEEE Trans. Power Deliv., 2011, 26, (4), pp. 2205–2214

[7] Mondal, S., Mahanta, C.: 'Nonlinear sliding surface based second order sliding mode controller for uncertain linear systems', Commun. Nonlinear Sci. Numer. Simul. 2011, 16, (9), pp. 3760–3769

[8] Khalick, A.El., Uchiyama, M.N., Sano, S.: 'Sliding mode contouring control design using nonlinear sliding surface for three-dimensional machining', Int. J. Mach. Tools Manuf., 2013, 65, pp. 8–14

[9] Huang, Y., Kuo, T.: 'Adaptive sliding-mode control for nonlinear systems with uncertain parameters', IEEE Trans. Syst. Man Cyber., 2008, 38, (2), pp. 534–539

[10] Cheng, G., Peng, K.: 'Robust composite nonlinear feedback control with application to a servo positioning system', IEEE Trans. Ind. Electron., 2007, 54, (2), pp. 1132–1140

[11] Lin, C., Liu, T., Wei, M., et al.: 'Design and implementation of a chattering free non-linear sliding-mode controller for interior permanent magnet synchronous drive systems', IET Power Appl., 2012, 6, (6), pp. 332–344

[12] Bandyopadhyay, B., Fulwani, D.: 'High-performance tracking controller for discrete plant using nonlinear sliding surface', IEEE Trans. Ind. Electron., 2009, 56, (9), pp. 3628–3637

[13] Khadem, S.K., Basu, M., Conlon, M.F.: 'Harmonic power compensation capacity of shunt active power filter and its relationship with design parameters', IET Power Electron., 2014, **7**, (2), pp. 418–430

[14] Sasitharan, S., Mishra, M.K.: 'Constant switching frequency band controller for dynamic voltage restorer', IET Power Electron., 2010, **3**, (5), pp. 657–667

[15] Rahmani, S., Al-Haddad, K., Kanaan, Y.: 'Two PWM techniques for singlephaseshunt active power filters employing a direct current control strategy',IET Power Electron., 2007, 1, (3), pp. 376–385

