An Multi-Objective Approach For Power Quality Improvement: UPQC

DISSERTATION II

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By

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MAY (2015)

CERTIFICATE

This is to certify that the Thesis titled "**An Multi-Objective Approach For Power Quality Improvement: UPQC** " that is being submitted by "**Robinjit Singh**" is in partial fulfillment of the requirements for the award of MASTER OF TECHNOLOGY DEGREE (POWER SYSTEMS), is a record of bonafide work done under my /our guidance. The contents of this Thesis, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

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Examiner I **Examiner II**

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Firstly I thank to the Almighty God and Savior, for his grace that was sufficient to make this thesis a success. I am highly grateful to the faculty members of **LOVELY PROFESSIONAL UNIVERSITY**, for providing this opportunity to carry out thesis work. I would like to express my gratitude to the Head of the Department for all the encouragement and guidance provided. I also extend my sincere gratitude to my Thesis guide **Mr. Sanjeev Kumar Bhalla** for the valuable guidance. His encouragement and patience throughout my thesis stands beyond description in words.

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This is to certify that Robinjit Singh bearing Registration no. 11308973 has completed objective formulation of thesis titled, "**An Multi-Objective Approach For Power Quality Improvement: UPQC"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the thesis has ever been submitted for any other degree at any University. The thesis is fit for submission and the partial fulfillment of the conditions for the award of M.Tech Degree.

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DECLARATION

I, student of **MASTER OF TECHNOLOGY (POWER SYSTEMS)** under Department of **ELECTRICAL ENGINEERING** of Lovely Professional University, Punjab, hereby declare that all the information furnished in this dissertation report is based on my own intensive research and is genuine. This Thesis does, to the best of my knowledge, contain part of my work which has been submitted for the award of my degree either of this university or any other university without proper citation.

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ABSTRACT

Modern power system comprises of complex networks, where many generating stations and load centers are interconnected through long power transmission and distribution networks. Utility distribution networks, critical commercial operations and sensitive industrial loads all suffer from various types of outages and interruptions which can lead to significant financial loss, loss of production, idle work forces etc. Today due the changing trends and restructuring of power systems, the consumers are looking forward to the quality and reliability of power supply at the load centers. Power quality problem is an occurrence manifested as a non-standard voltage, current or frequency that results in a failure or a mis-operation of end use equipments. With shifting trend towards distributed and dispersed generation, the issue of power quality is taking new dimensions. The concept of custom power was introduced to distribution systems for improving the system performance. The aim therefore, in this work, is to identify the prominent concerns in the area and thereby to recommend measures that can enhance the quality of the power, keeping in mind their economic viability and technical consequences. The Unified power quality conditioner (UPQC) is an effective custom power device for the enhancement of power quality due to its quick response, high reliability and nominal cost. A Unified power quality conditioner is used to compensate distortion, unbalanced voltage and current conditions. It is efficiently capable of protecting sensitive loads against the voltage variations or disturbances. UPQC employs two converters that are connected to a common DC link with an energy storage capacitor. The main components of UPQC are shunt and series converters, DC capacitors low pass and high pass filters and series and shunt transformers. In this thesis, a systematic approach to Phase lock loop (PLL) is proposed.

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LIST OF ABBREVIATION

IEEE	Institute of Electrical and Electronic Engineers
DVR	Dynamic Voltage Restorer
STATCOM	Static Synchronous Compensator
DSTATCOM	Distribution Static Synchronous Compensators
AC	Alternate Current
FACTS	Flexible AC Transmission Systems
APF	Active Power Filters
DC	Direct Current
DFACT	Distribution FACTS
PI	Proportional Integral
SVPWM	Space Vector Pulse Width Modulation
PWM	Pulse Width Modulation
SPWM	Sinusoidal Pulse Width Modulation
FFT	Fast Fourier Transform
FT	Fourier Transform
IEC	International Electro technical Commission
IGBT	Insulated Gate Bipolar Transistors
IPQT	Instantaneous p-q Theory
ITIC	Information Technology Industry Council
MATLAB	Matrix Laboratory
PCC	Point of Common Coupling
PLL	Phase Lock Loop
PQ	Power Quality
SSSC	Static Synchronous Series Compensator
SVC	Static VAR Compensator
UPFC	Unified Power Flow Controller
UPQC	Unified Power Quality Conditioner
THD	Total Harmonic Distortion
PSCAD	Power System Computer Aided Design
VAR	Voltage Ampere Reactive
CP	Custom Power Devices

CHAPTER 1

INTRODUCTION

1.1 Definition of Power quality

1.1.1 Description

Power quality can be defined as to have good quality of power without breakdown at all levels like distribution, generation and so on. Now day's pollution is a crucial problem in the world, like other pollution electrical pollution is also a crucial at the level utilizing electricity. So it is necessary to study the problems of end users at the distribution level. For the pollution of ac supply system many causes like are flash-over, lightening, voltage distortions, voltage in-balances, disturbances etc. When customer's equipment draws non-sinusoidal current, it may also cause pollution of the supply system. Voltage, current or frequency deviations of the supply system can disturb the working of customer's equipment. Power quality problems are also related to the voltage up and downs, surges, spikes, unwanted interruptions etc. These problems most exist in the supply system of the power right from the generating side of the system, various non-linear loads like furnaces, uninterrupted power supplies, switched mode power supplies. By power quality problems capacitor banks might fail to work in substance. These problems may also increase losses in the distribution system, voltage in-balances, and out dated-operation of induction motors in the industries, interference in the communication networks, electronic controllers and so on. These power quality problems seems to be more critical in semi-conductor based inverters in the purpose of industries so as to have the reliable and sustainable stability of the system. In the branch of power electronic based strategies which are growing more sensitive to the voltage enhancement of the grid system, as they generate [1] PQ problem due to the unbalanced three phase rectifier bridge load. Due to these problems quality has become more important in the respective field of electrical engineering for the power distribution and utilization .It has become the utmost responsibility of the power generating companies to supply their users a good quality of power. At the same time the manufacturers of the electric equipments which work without any type of distractions in adequate power supply. So number of techniques has been used in the devices. Many organizations have developed various methods for giving flexible equipments to the end users. So it has become very helpful for giving new ideas to engineers working in the field of power electronics, information technology, electric drives etc. So the equipments based on power electronics use power converters at the emerging stage. The techniques are which are used to improve power quality exist in electric load and consumption supply variations. As these aroused to have better controllability and enhanced functioning of the entire grid system. Particularly in many situations PQ issues may exist in distribution system and solid-state static compensators are relatively in touch for enhancing the quality of system. Further these mitigation thoughts are designed in such a way that they particularly through image on power filter rectification inverters. As per above discussions the most suitable compensating device for the improvement in stability at the PCC is power conditioner in a unified manner [3]. The whole strategy involved is focused upon SRF method for generating reference voltage and current inputs respectively. For the particular switching operation regarding voltage and current power filter errors occur. These errors are passed on to the input side of hysteresis comparator (both in case of series and shunt inverter), on comparing the signal with respect to actual load voltages and current so as to carry out the switching of both inverters to eliminate the distortions [2]. MATLAB/SIMULINK results are revealed as such and a comparative analysis is draft out with and without compensating device based on desired topology set up in the entire system.

1.2 Reactive power

Reactive power emerge as a truly factor in the design and sinusoidal operation of alternating current electric power systems for certain durations. At every aspect, it has been noticed that, the impedances of the network components are though reactive in nature, where as the real power shows a angular phase shift between the voltages at the source and end users (which opt to be relevant within certain limits), hereby the power to be injected requires a phase difference in same voltages (which is feasible only within very narrow limits). The question here arises why there is need to inject reactive power anyway? The answer is simple to suggest that reactive power is consumed not only by most of the capacitive and inductive, but also by most of the varying non-linear loads, so it is desired to be supplied somewhere prior to the common point coupling. If somewhere it is not possible to inject due to some constraints, reactive power can be generated as such where it is needed. In accordance the same can be thought about real power, but the constraints are considered to be less severe and due to the greater generator size seems to be critical. As far these differences are only technical orientated. Decisions and commitments made at this stage have a tremendous effect on all other phases of system expansion and dictate the financial posture a utility must assume. It must be recognized that suitable reactive power injection must provide the electric utility with the capability of meeting customer needs for a reasonably priced, reliable, quality electric energy source. It is evident from the fact that injection is not entirely neglected unless the generation of reactive power is at the same voltage level. This completely explains the indigenous fact that in the same network, reactive compensation is in the form of capacitors in the distribution system [4]. There is a fundamental relation between active and reactive power. While doing so voltage resulted in the capacitor cause current to lag behind effectively in phase. There is a fundamental relation between active and reactive power. Based on the above discussion, instantaneous power in an inductor is given as;

$$P= \text{Vmax Imax} \cos \omega t \cos(\omega t - \theta) \quad \ldots\ldots 1$$

$$\text{Or,} \quad p= \frac{\text{Vmax I max}}{2} \cos\theta\,(1 + \cos 4\omega t) + \frac{\text{V max I max}}{2} \sin\theta \sin 4\omega t \ldots. 2$$

Further the instantaneous reactive power is stated as below;

$$Q= \frac{\text{V max I max}}{2} \sin\theta \sin 4\omega t \quad \ldots\ldots. 3$$

Hereby,

p = power generated at a instant (t)

V max = Maximum value of voltage

I max = Maximum value of current

ω = $2\pi f$

t = time period for the power injected

θ = Angle by which voltage and current lead or lag in phase

From the above mathematical analysis, it is clear that instantaneous reactive power generate pulses twice the system frequency and its average value is seems to be zero, Maximum Instantaneous reactive power is expressed as;

$$Q = \text{V max I max} \sin\theta \quad \ldots\ldots..4$$

1.3 Reactive Power Compensation

1.3.1 Description

In order to improve the working criteria of an ac system, reactive power compensation is concerned at the point of quality consideration. By this the quality of the system related issues concerned with the governing system and end-users are greatly benefitted on the particular recommendation of evaluating such type of problems keen to the security of the grid system. As this emerging effect is based on load and voltage so by increasing the load on a system, distortions cause effect to voltage and current waveforms i.e. rather making it non-sinusoidal. To reduce voltage up and downs, proper voltage utilization is needed at the outset terminals. In radial distribution systems VAR injection increases the stability and correction of power factor merely to a large varying factor sinusoid ally. In the linear circuit it is the power injected instantaneously on a grid distribution system. Reactive power compensation is usually overshooting from insight two phenomena; at first the compensation when the load particularly to balance the real power without any saturation of power on the actual demand, to overcome with the non-linear loads injecting distortions in the supply linkages. Second vision is to optimize the voltage support according to the way of injecting maximum power in to the ac supply system. Further in most prominent cases the real power seems to be overcoming the reactive power in order to cope for the needs of the end-users and the utility suppliers. In other words the way reactive power is injected at a frequency doubles the rated value, fore coming circulation of harmonics between supply and the load. The Reactive power injection is the quarterly cycle of variation to and fro from the power system relatively for the power balancing and handling of the unbalanced non-linear loads [5] .Although the reactive power injection has been circulated completely as the automated production lines are far considerable to be more darting to analyze the brief concept of the power quality improvement in relevance to the widely innovated strategies of the utility and the end-users to cope with the system providing analysis of the customized solid state controllers with the effective performance of the grid distribution system. Further many operating problems have been arise as a effect of varying load conditions with re-mature effect of the line parameters, considering the sure enhancement of quality of power keeping in mind the effective nature of the device so far has to be implemented with rigorous structure of the solid-state controllers to get a fast response.

1.3.2 Need for Reactive Power Compensation

1) Firstly to improve the performance of the power system.
2) In an ideal ac power system the need for reactive power to be injected falls on a point i.e. variation in voltage or frequency at a supply terminals must be considerably remove the distortion , variations ,harmonics stability etc
3) By performing compensation the chance for the interference between different loads due to variations in current is merely reduced.
4) It develops the faster and more powerful semi-conductor values more effectively in a relevant manner.

1.4 Power Enhancement Related Problems

1.4.1 Short Duration Voltage Variation

Some-times voltage variations in a depending in a system due to the fault in a system. Voltage may drops or increases, this is due to the reason of loose connections of wiring or large loads get energized to need more starting currents.

1) **Voltage Sag:** Voltage sag is a reduction in line voltage as shown below. This merely due to the starting of large induction and synchronous generators or motors particularly during the short circuit faults, in the grid reduction in voltage amplitude by which sag occurs.

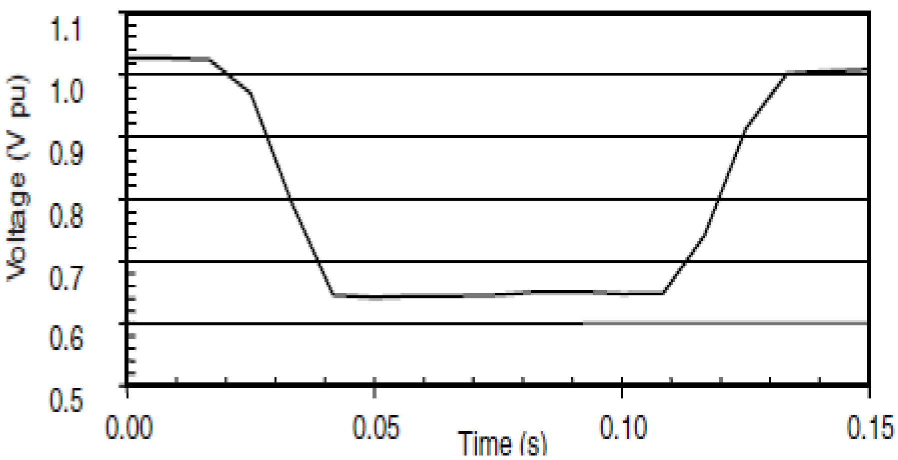

Fig1.1 RMS Voltage Waveform

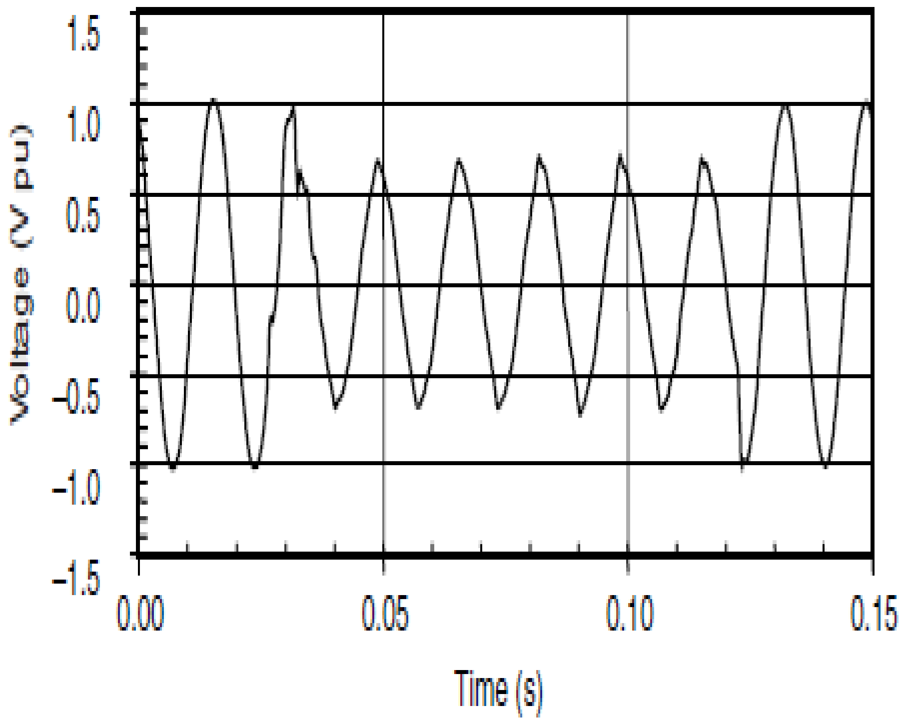

Fig1.2 Voltage Sag caused by SGF (Single-line to ground fault)

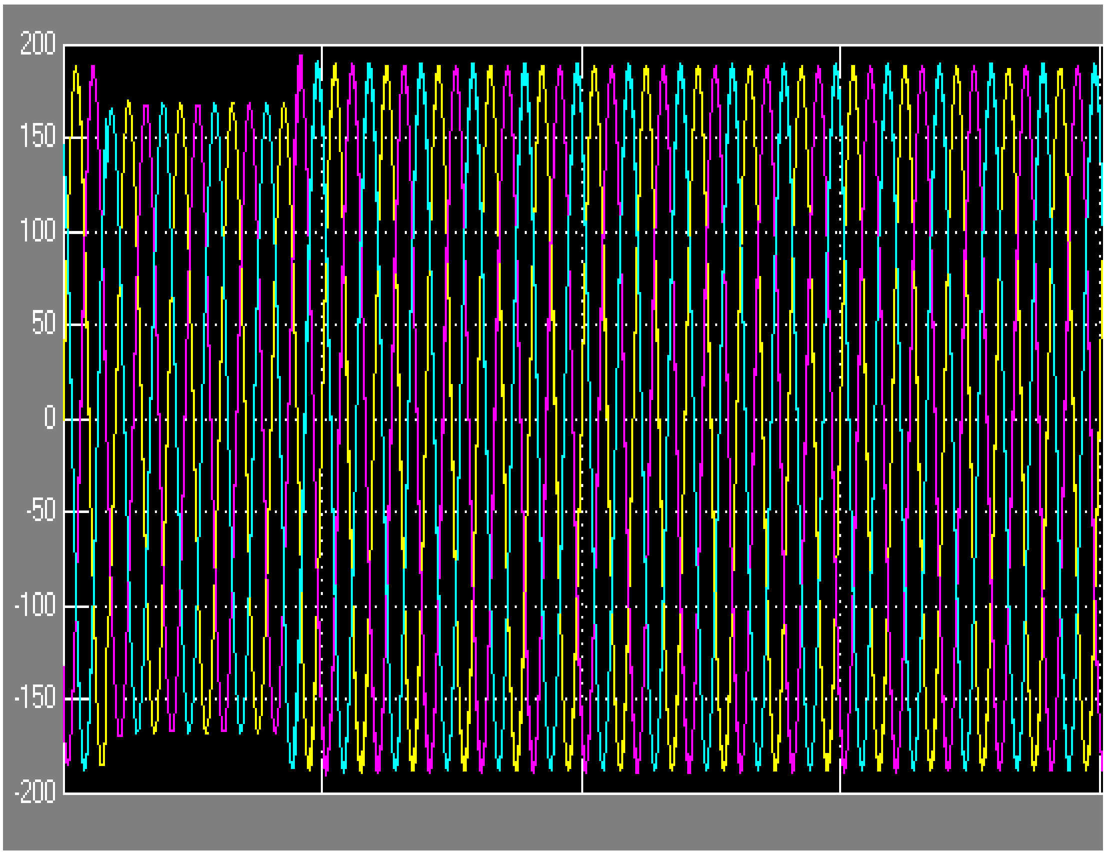

Fig1.3 MATLAB waveforms showing sag when a fault occur

2) Voltage Swell: Voltage swells is the sinusoidal increase in the corresponding grid voltage is shown below in the figure. This is particularly due to the fault in the system or occurrence of the in-correct tap settings in the industrial sub-stations. Sometimes it increases by sudden switching OFF and energizing of a capacitor bank.

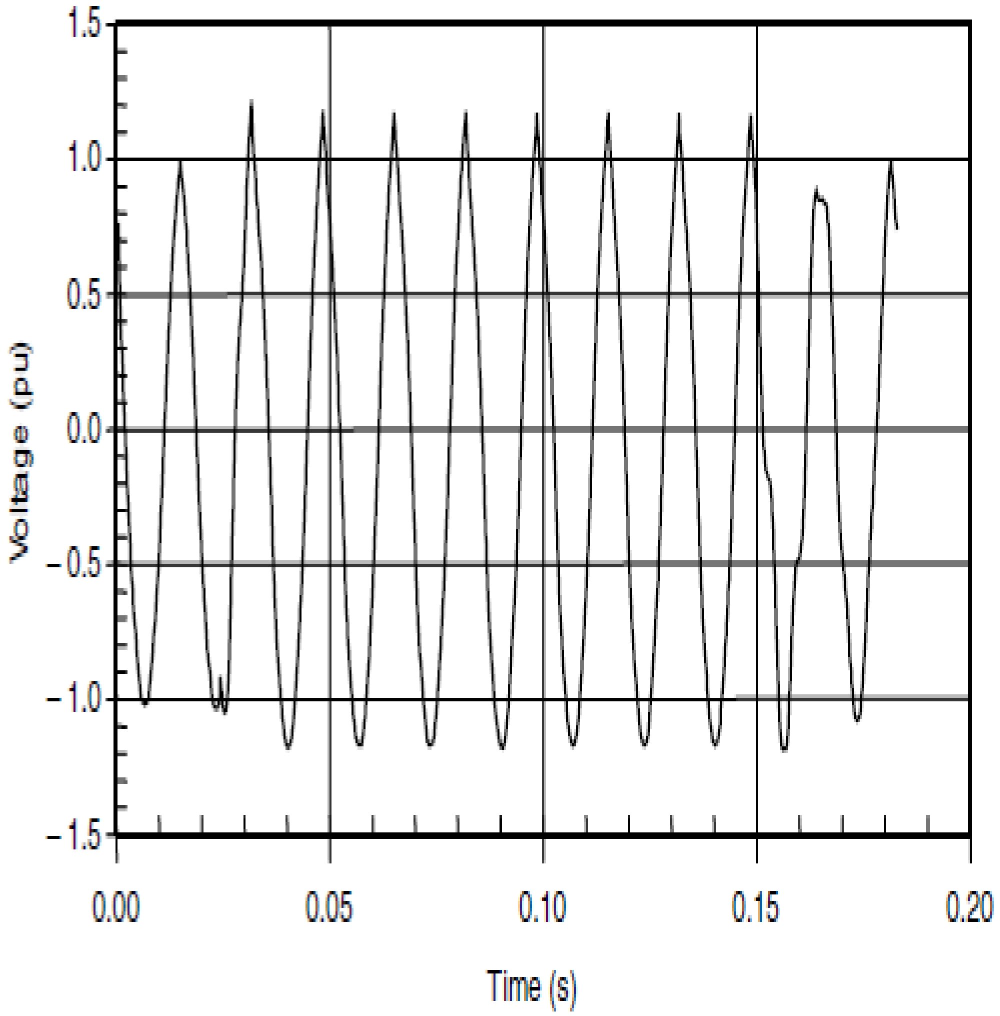

Fig1.4 Voltage Swell caused by SGF

2) **Interruption:** When line voltages or current is reduced to less than 10% of nominal value as shown in graph below. It is due to the faults arising in the system working in the random particularly to effect more consistently so as to show variable effect on the system changing considerably within the page limit so as to allow better allowance with the changing effect of the particular grid system. This variation in the system can adversely affect the conditioning parameters with the effect of the changing load conditions so as to overcome the system considerably in the relevant

manner to look after the effect of the spikes that causes disturbance in the system ranging from the drafting matter to the grid system controllability.

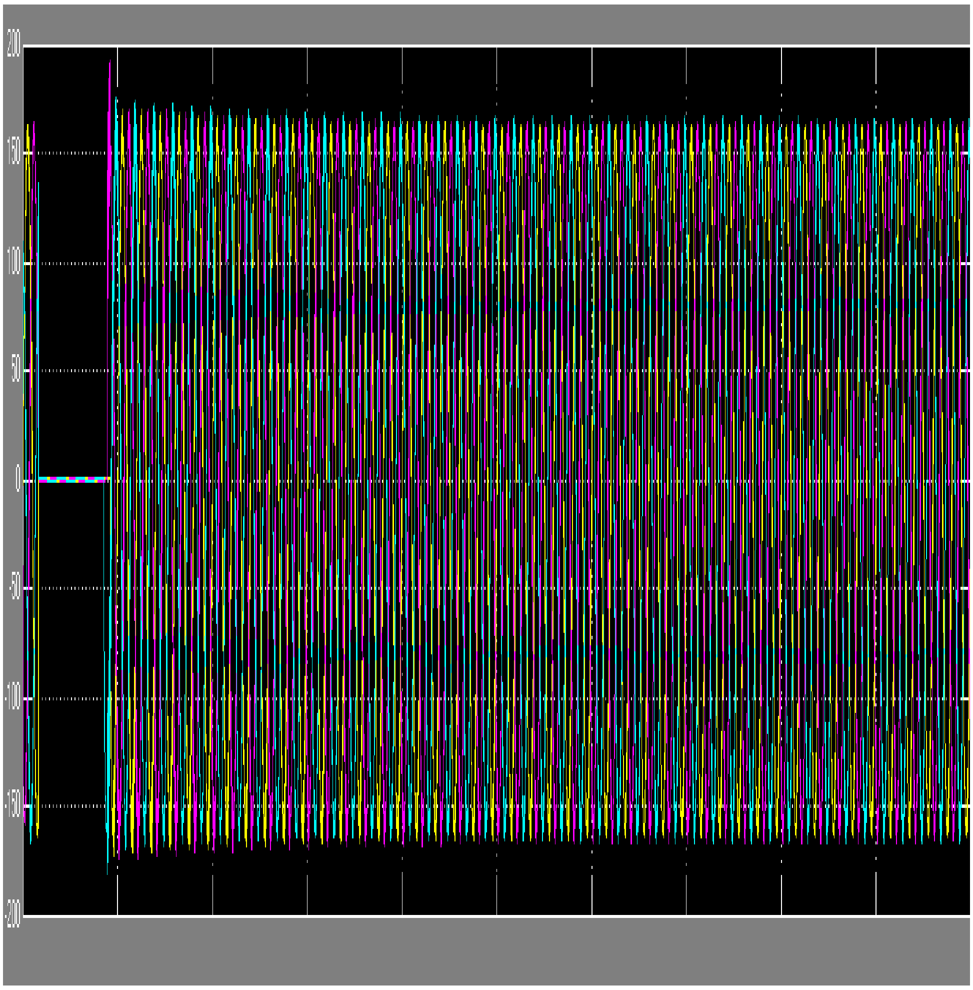

Fig1.5 Interruption due to power system fault

1.4.2 Prolonged Duration Voltage Variation

These duration variations are classified as over voltages, under voltages or sustained interruptions.

1) **Voltage crossing peak:** It is the increase in the voltage prior to the effect of load conditions. This is mainly due to the sudden load variations or the effects causing in the transformers causing joint to joint variations in the system of the quality improving so as to validate the entire procedure as an effect of the randomly changing load parameters especially when the load is of universal bridge with RL load.
2) **Voltage lagging:** Decrease in the line voltage, which is due to sudden load turning OFF and ON capacitor bank switching so as to improve the power factor of the

line varying consistently during the loading conditions that can rapidly affect the working phenomena of the entire grid system effectively.

3) **Sustained Interruptions:** It is that adverse condition when the source voltage reaches up to the absolute zero condition for a particular period of time.

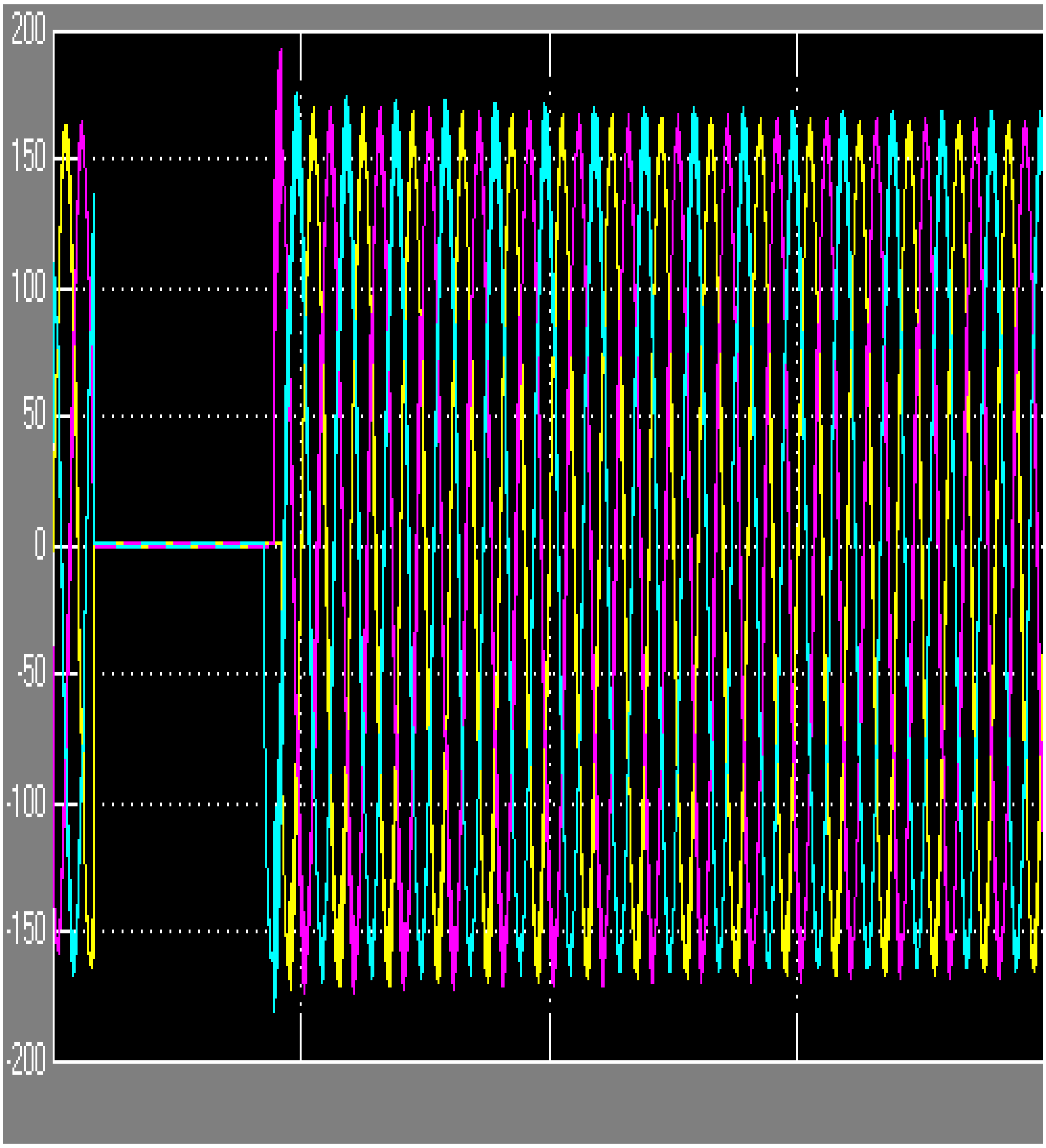

Fig1.6 Figure showing the interruptions

1.4.3 Voltage Imbalance

In a three phase distribution system, amplitude the voltage get vary to one other in the relative manner so as to change itself the working condition of the particular phase as if the voltage variations in the impedances causing certain attenuations so as to enhance the variability in the distorted voltage changing abruptly so as to overcome the issues of the quality arising in the distribution system.

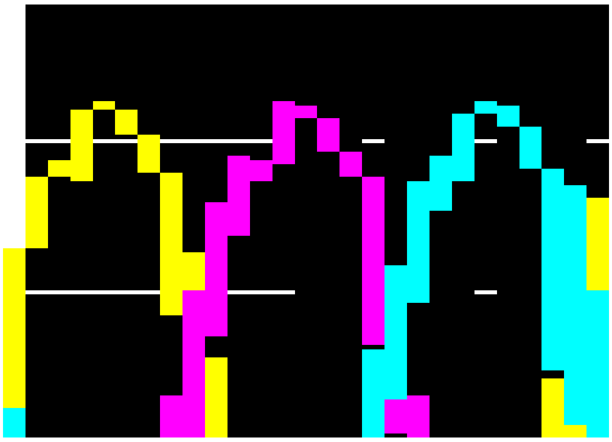

Fig1.7 Figure showing the voltage imbalance

1.4.4 Waveform Distortion

Waveform distortion is the effect that arises when a sinusoidal wave get deviated or distorted from a inclined source of the certain parameters changing device so as to enhance the grid controllability and to change the quality variations according to the loading conditions of the system relatively in an changing manner so as to clearly define the quality of the system in solid state controllers with effect of the reference frame theory by which the reference signal is generated and the waveform gets distorted according to the loading conditions of the holding capacity of the line parameters as relatively to effect the co-ordination of the grid connected.

1.4.5 DC Offset

Sometimes the case arises when dc voltage or current may originate in an ac power system, this is known as dc offset. This is due to the occurrence of the asymmetrical waveforms occurring in the distorted condition so as to overcome the effect of disturbing the conditions of the controller so as to maintain the desired effect causing the system vulnerable working criteria of the dc supply coming from the capacitor interlinked in between the two power filters relatively in an apparent manner.

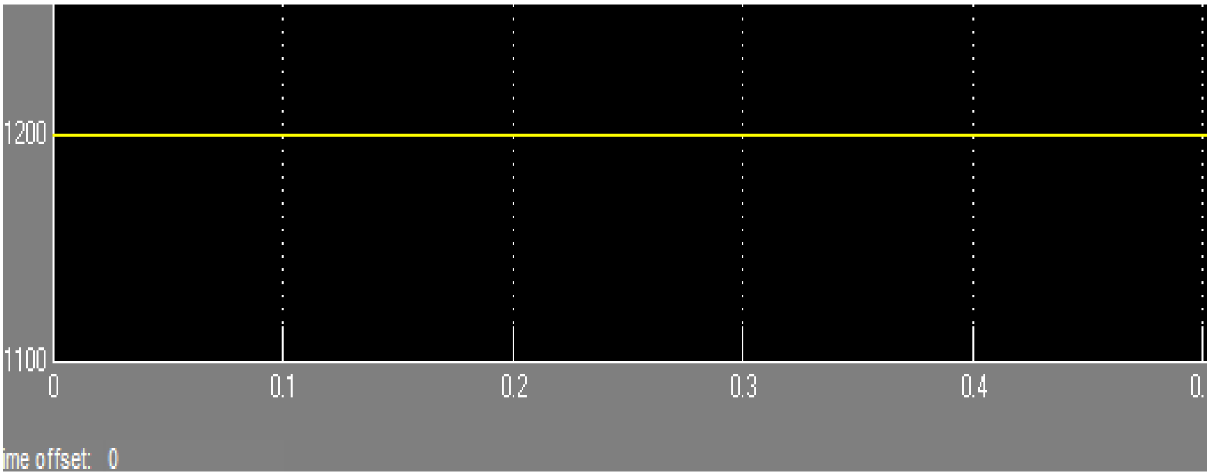

Fig1.8 Figure showing dc offset

1.4.6 Harmonics

In case of an unbalanced non-linear loads certain frequencies that are distorted prior to the integer multiples of supply frequencies and these are known as harmonics. These are sinusoidal parameter changing needs that vary with system circumstances as such they are not affected by the variation of the controlled losses due to which the local load variations are not seems to be vertical operating with the loading capacity of the desired system in particularly the band-width of the situation of the randomly changing load in an abruptly parameters that could change the system priority. The non-linear characteristics as to cater with daily changing load in the system, the quality of the system is relatively improved by eliminating the unwanted harmonics arising in the system.

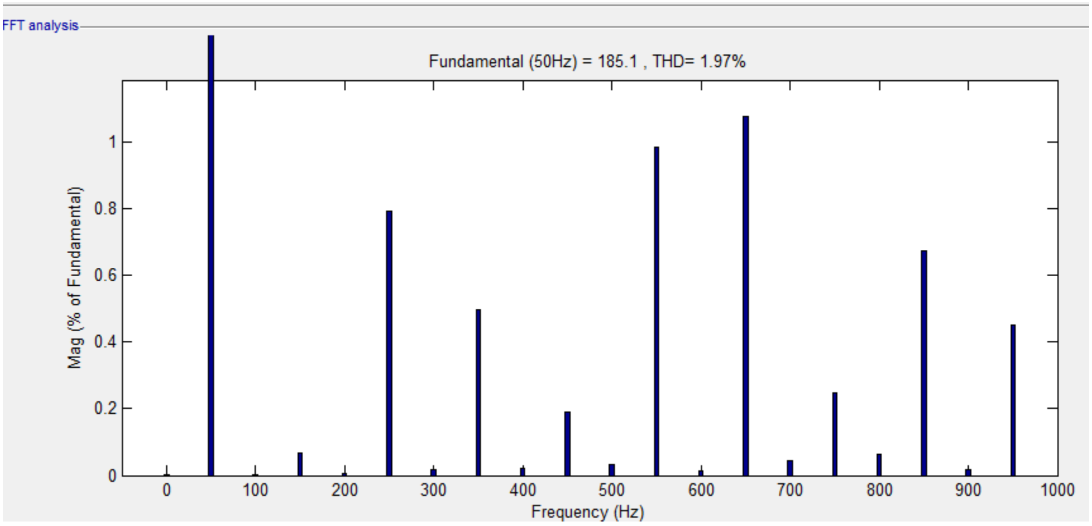

Fig1.9 THD Spectrum for voltage harmonics reduction

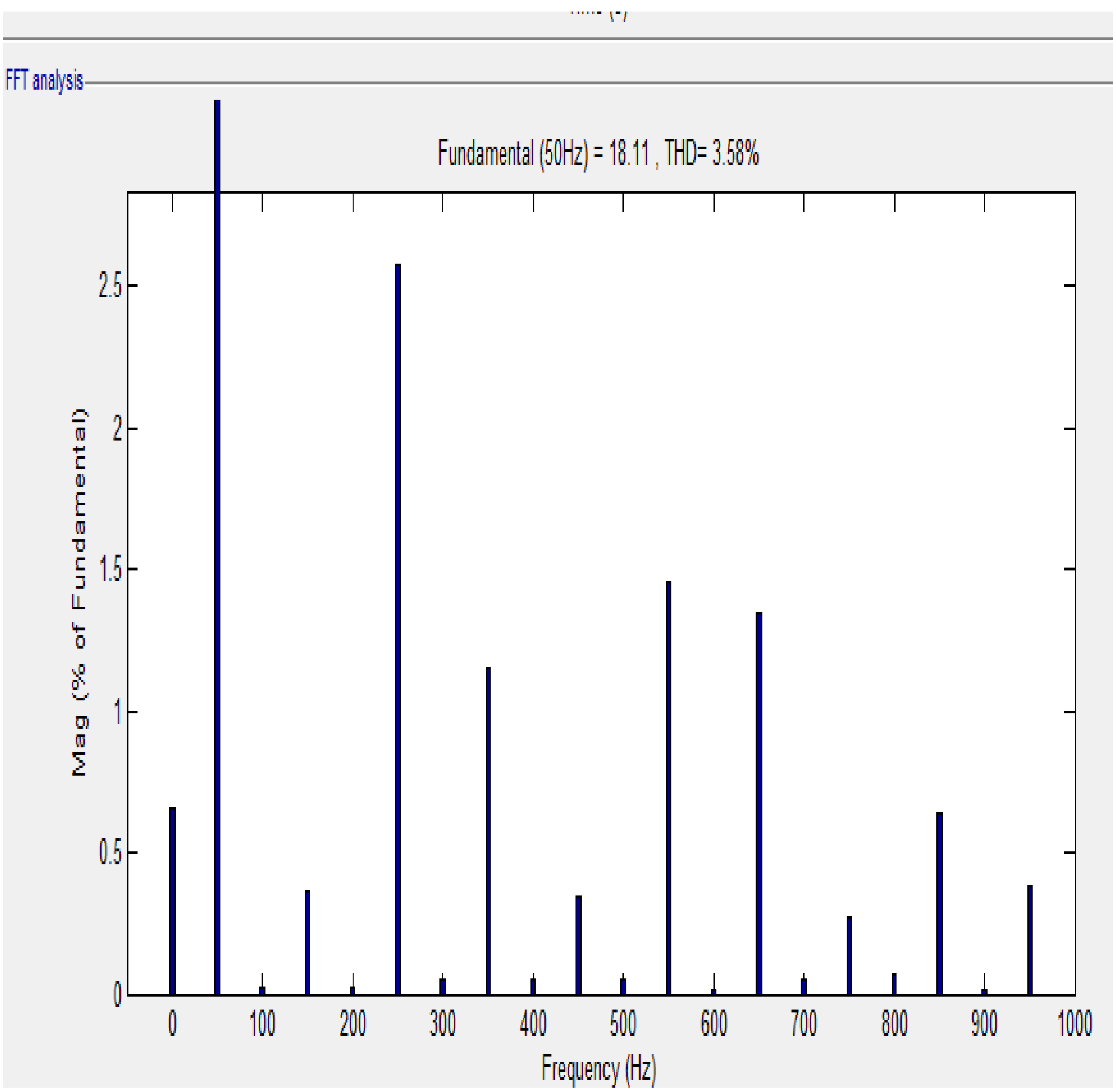

Fig1.10 THD Spectrum for current harmonics reduction

Harmonic considerable levels can be illustrated well as such plotting which measures the percentage magnitude of the voltage Vs the frequency attenuations varying effectively with the scope parameters in an appropriate manner randomly so as to cope with the grid voltage and enhanced the quality of the relative system in order to sustain the magnitude of certain varying loads. As such these are such kind of distractions that do not allow to system to operate effectively, alias the system get varying from the quality point of view in relative to the system parameters. The effective utilization of the system THD can be reduced indigenously to the system conditions in order to cope with the system getting disturbed from the outdated conditions in an manner to bear enough the voltage harmonics in the system distorted waveforms so obtained are regulated as such.

CHAPTER 2
LITERATURE SURVEY

RVD.Rama Rao (2011) *et al.* [7] This is concerned with power quality by using UPQC to eliminate switching operation so as to turn ON and OFF operation of switches. Hereby remarkable outsourcing configuration of control system with out -dated results. There are many sensitive loads based on certain parameters variations. Whenever there arise a condition of three phase fault, it is necessary to analyze the cause. In order to control three phase power filter for comparing the reference signals. The author hereby depicts the novel strategy method.

Yasir Muhammad (2011) *et al.* [8] this paper involves the idea about tap-changer. A case study for real feeder is simulated to calculate number of tap changer operations. An algorithm is designed for tap changer operations and for a given case system of load bus voltages and the number of tap changer operations are counted. Then SVC system is used with specified parameters for reactive power compensation. As reactive power is the main reason for voltage de-regulation. Hence compensated and voltage profile is improved. The important result that is obtained in this paper is the reduction in number of operations of OLTC. This is compensated when voltage is compensated for its reactive load variations.

P.Ajitha (2012) *et al.* [9]. This paper presents study about inverter in back to back configuration which simultaneously for both voltage sag and reactive power compensation. Here neural network is used as tool which is considered for solving power quality problem UPQC and controls quadrature voltage injection method. Effective VA optimization is used considering sag. But time duration of compensation takes for few cycles. In this paper the proposed concept of neural network has been used. Neural network controller with PI controller is used. The entire method is carried out in MATLAB/SIMULINK.

C. Hari Krishna (2012) *et al.* [10] Author describes unique and show cases methodology for identifying weakest bus in conjunction with voltage collapse in the distribution system. The simulation results are viewed in MATLAB/SIMULINK.

Barnas K. (2012) *et al.* [11] It describes the influence of reactive power on transmission power losses level in distribution network depending on control strategy , with fast development of new technologies (D-STATCOM) such analysis give an opportunity to find a new way to control reactive power flow. This paper gives an idea about different methods of compensation i.e. individual group central and mixed compensation; here quality of compensation is investigated on the basis of power loss. This paper includes the control strategies of reactive power compensation. Here in power factor control strategy, the controller keeps the power factor at a set level. Voltage control strategy is analyzed by FACT devices i.e. STATCOM. In this strategy, the controller keeps reactive power demand on the level of desired requirement for both the inductive and capacitive load.

N Narendra Reddy (2013) *et al.* [12] The author uses a unified power flow conditioner in the system. This paper completely deals with the most complete FACT's device is UPFC, from the experimental results this paper proves that it can mitigate the problems related quality.

S.Vamsi Krishna (2013) *et al.* [13] .In this paper topology is employed to calculate voltage stability index (VSI) for better optimal reactive power compensation. A voltage stability indicator is defined. This shows method involved in robust economical and simple for calculation to be implemented in MATLAB/SIMULINK.

M.Chandra Shekhar (2014) *et al.* [14] this paper discusses the problem that occurs in distribution networks. It also works on simulation. Whole simulation is done with brushless dc motor non-linear load by using MATLAB/SIMULINK.

P.Kana (2014) *et al.* [15] Here THD output is reduced by using UPQC. The entire system is evaluated using 14-bus system and a multi-bus system. Simulation of thirty bus system is yet to be done. Closed loop system may be simulated by using neural network or hysteresis control.

K Nirmala (2014) *et.al* [16]. Here the simulation model for test system can be done with conditioning device or without. Distortions and harmonics are reduced relatively in accordance with working of the power device.

CHAPTER 3
PROBLEM FORMULATION

3.1 ENHANCING QUALITY OF POWER SYSTEM

3.1.1 Definition

The quality of power is very important as the low power greatly affects the consumers-common people in many perspectives. Poor power can greatly affect the implements, machines, enhanced loss of power thereby interfering with power lines. The enhanced power usage has significantly affected the quality of power supply. Thus it has become most necessity to maintain the status of quality of power.

3.1.2 Statement of Problem

Power quality problems are also related to the voltage up and downs, surges, spikes, unwanted interruptions etc. These problems most exist in the supply system of the power right from the generating side of the system, various non-linear loads like furnaces, uninterrupted power supplies, switched mode power supplies. By power quality problems capacitor banks might fail to work in substance. These problems may also increase losses in the distribution system, voltage in-balances, and out dated-operation of induction motors in the industries, interference in the communication networks, electronic controllers and so on. These power quality problems seems to be more critical in semi-conductor based inverters in the purpose of industries so as to have the reliable and sustainable stability of the system. In the branch of power electronic based strategies which are growing more sensitive to the voltage enhancement of the grid system, as they generate PQ problem due to the unbalanced three phase rectifier bridge load. Due to these problems quality has become more important in the respective field of electrical engineering for the power distribution and utilization .It has become the utmost responsibility of the power generating companies to supply their users a good quality of power. At the same time the manufacturers of the electric equipments which work without any type of distractions in adequate power supply. So number of techniques has been used in the devices. Many organizations have developed various methods for giving flexible equipments to the end users. So it has become very helpful for giving new ideas to engineers working in the field of power electronics, information technology, electric drives etc.

So the equipments based on power electronics use power converters at the emerging stage. The techniques are which are used to improve power quality exist in electric load and consumption supply variations. As these aroused to have better controllability and enhanced functioning of the entire grid system. Particularly in many situations PQ issues [6] may exist in distribution system and solid-state static compensators are relatively in touch for enhancing the quality of system. Further these mitigation thoughts are designed in such a way that they particularly through image on power filter rectification inverters.

3.2 Working Tool to Enhance Quality

3.2.1 Description of Quality Conditioner

It is an optimized power device that is used in distribution system to rectify the distortions, interruptions, interferences in critical loads. It is a sort of hybrid APF that is the only widely employed device to rectify many power issues synchronizing removal of loopholes in voltage and current. It comprises of two voltage source converters i.e. one shunt and one series PF joined by common dc bus. The shunt PF is in parallel to the load thereby providing VAR support, whenever there is a dip in voltage supply, whereas series inverter supplies considerable amount of voltage thereby enhancing the functioning of power system.

3.2.2 Basic configuration of UPQC

The basic components of UPQC are as follows:

1) Series converter: It is a voltage-source converter that is joined in series with the AC line in order to overcome the variations in voltage. It generally removes flickering voltage or unbalanced terminal voltage load thereby forcing the shunt branch to absorb the variable loads of currents. Hysteresis band controller helps in controlling the output voltage. The gate pulses are generated by making comparisons of reference voltage with Hysteresis band controller output and reversible comparisons of reference current signal generated as in SRF with real voltage loads.

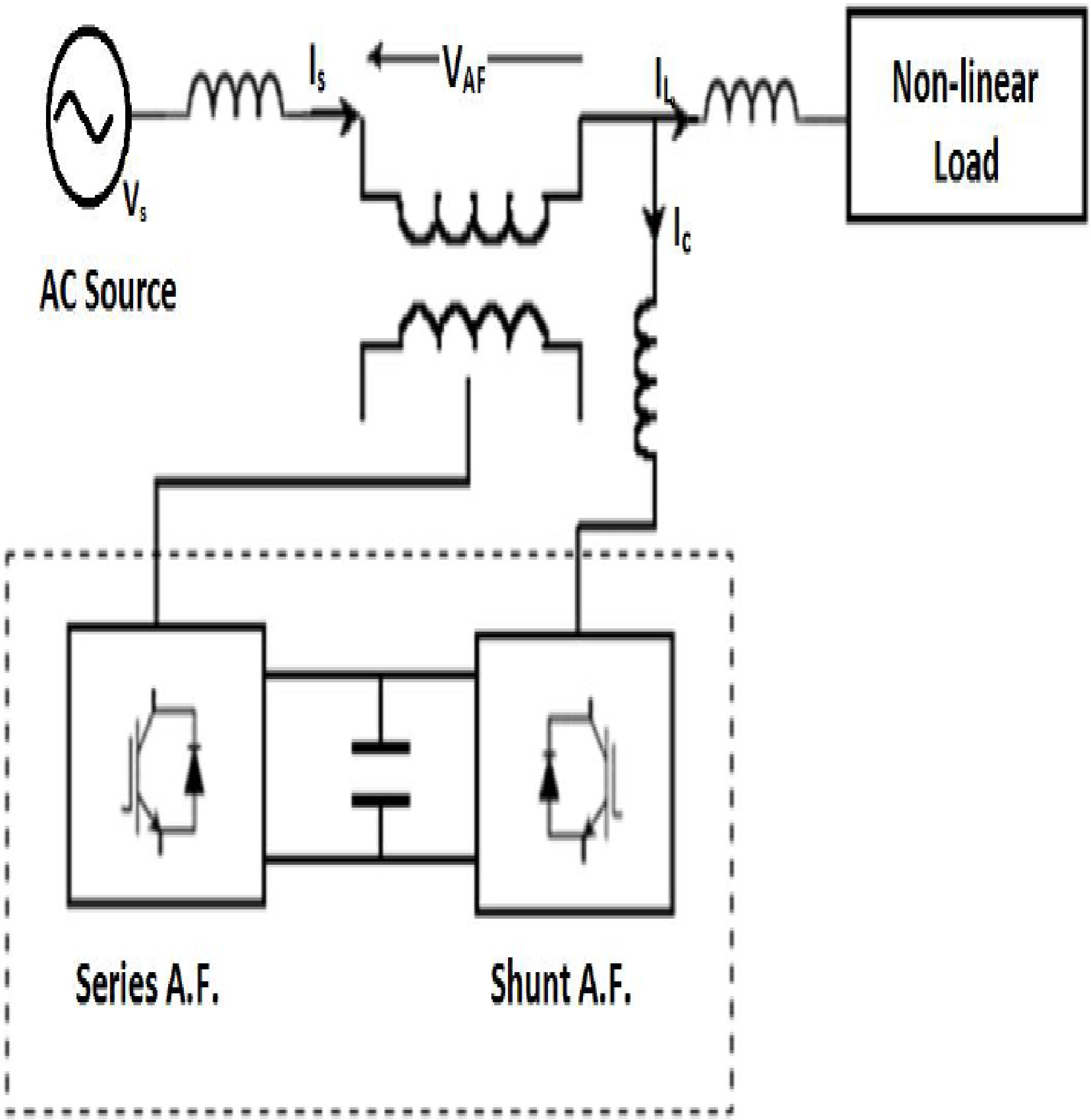

Fig3.1 Simplified Configuration of UPQC

2) Shunt converter: This is a source voltage converter joined parallel to the ac line thereby cancelling current variations and thus improving power. It also regulates dc link voltage thus significantly reducing dc capacitor rating. The dynamic Hysteresis band helps in adjusting the output current so that it follows easily the reference signal.

3) Capacitor bank: It comprises two components connected in series. The transformer neutrals are directly connected to the dc link that is in midway of series APF and shunt APF. The zero sequenced voltage appears in the primary winding of series transformer that compensates the zero sequenced voltage. Thus no zero sequenced current flows thus ensuring the system current to be balanced.

4) Low pass filter: They attenuate the high frequency components generated by the high frequency switching.

5) High pass filter: They absorb the switching current ripples.

6) Series Shunt transformers: They make adjustments in voltages and currents and thus solve the purpose of electrical isolation of UPQC. UPQC compensates reactive power at standardized and harmonic frequency rates.

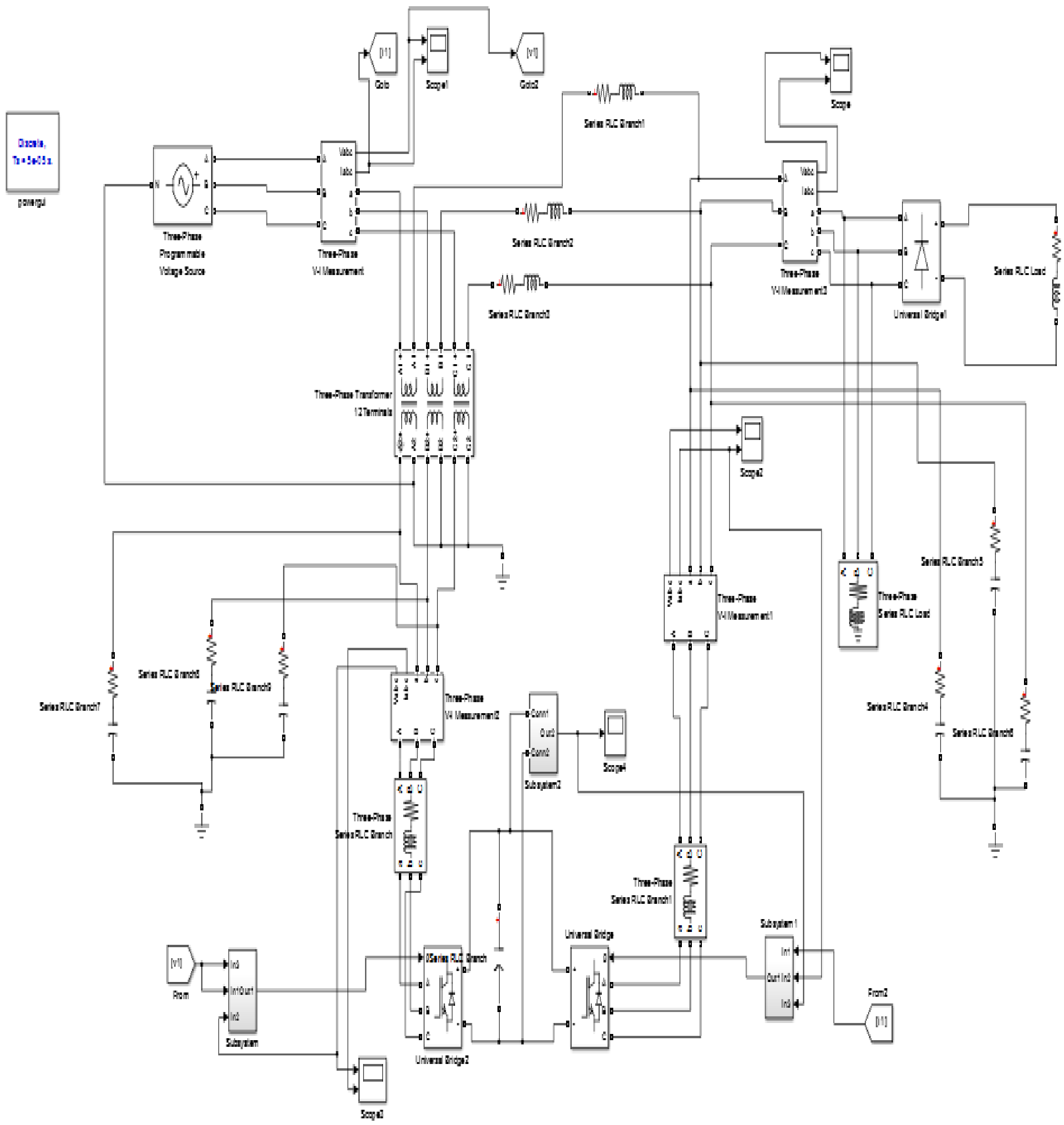

Fig3.2 MATLAB view of UPQC

3.2.3 Superiority of UPQC over other devices

Every device of power has pros and cons. UPQC is considered to be at edge over other appliances as it is flexible in usage than any other device. It also provides solution to heavy loads of current and variations in supply voltage. Moreover, it can correct the imbalance in source voltage and variable load current in single go, whereas most devices of power either correct current or variable voltage. Thus, the purpose of two devices is fulfilled by UPQC single handed only.

3.2.4 Objectives

Balanced voltage is most important to analyze security in the system of power. Most systems of power are seriously paralyzed by the low supply of power, reduced stable voltage and overloaded appliances. Here my objective is to make use of customized power device-UPQC using synchronous reference frame method. Hereby the control strategy is synchronous reference frame theory that compares voltage and current signal with reference signal by implementing Hysteresis voltage and current controller. Most power related difficulty areas are power burden, unbalanced load and high neutral currents. These difficulties can be overcome by implementing FACTS devices on various systems depending on the type of loading conditions. Here, active power filters along with hybrid passive filters are applied on the systems along with the suitable configurations, so as to overcome the difficulties in voltage sag, swells, interruption. In short these power electronics based converters appear to be an essential interface to improve reactive power of the interconnected system.

CHAPTER 4
METHODOLOGY

4.1 Synchronous Reference Frame Theory (SRF)

4.1.1 Description

Synchronized Reference frame theory is widely used for rectifying unbalanced non-linear loads. The non-linear here is the three phase diode bridge rectifier. The voltage and current loads can be compensated by generalised usage of UPQC. This theory is used for the functioning of both series and shunt compensator. Phase locked loop is best considerable for this theory. Here, the moment of inertia of reference is generally infinite. The d-q points are assumed as having value of dc. The dc offset is shed by utilizing low pass filters. This theory changes a-b-c coordinates to d-q-0 or vice-versa simultaneously with PLL to give Sin and Cos coordinates. In both, Hysteresis voltage controller manages series power filter and shunt power filter is controlled by Hysteresis current controller

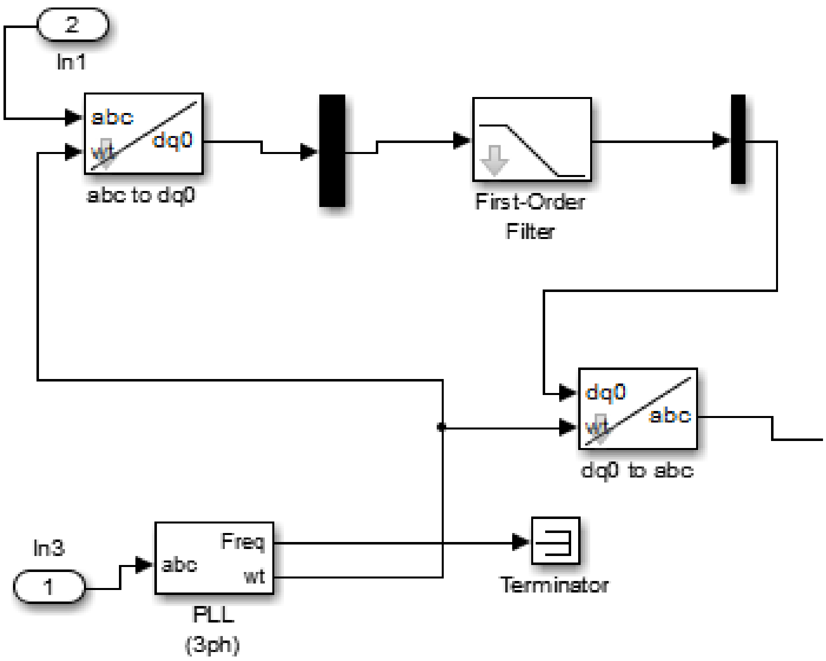

Fig4.1 Figure showing the SRF theory

4.1.2 Reference Voltage signal generation

At first the reference voltage and current are obtained by transforming a-b-c to d-q-0 components and then it is compared with real voltage load whereas reference current is compared with real current load. The signal so generated is applied to Hysteresis controller thereby producing pulses. These pulses are passed on series and shunt filters of power which perform switch ON and switch OFF for both filters.

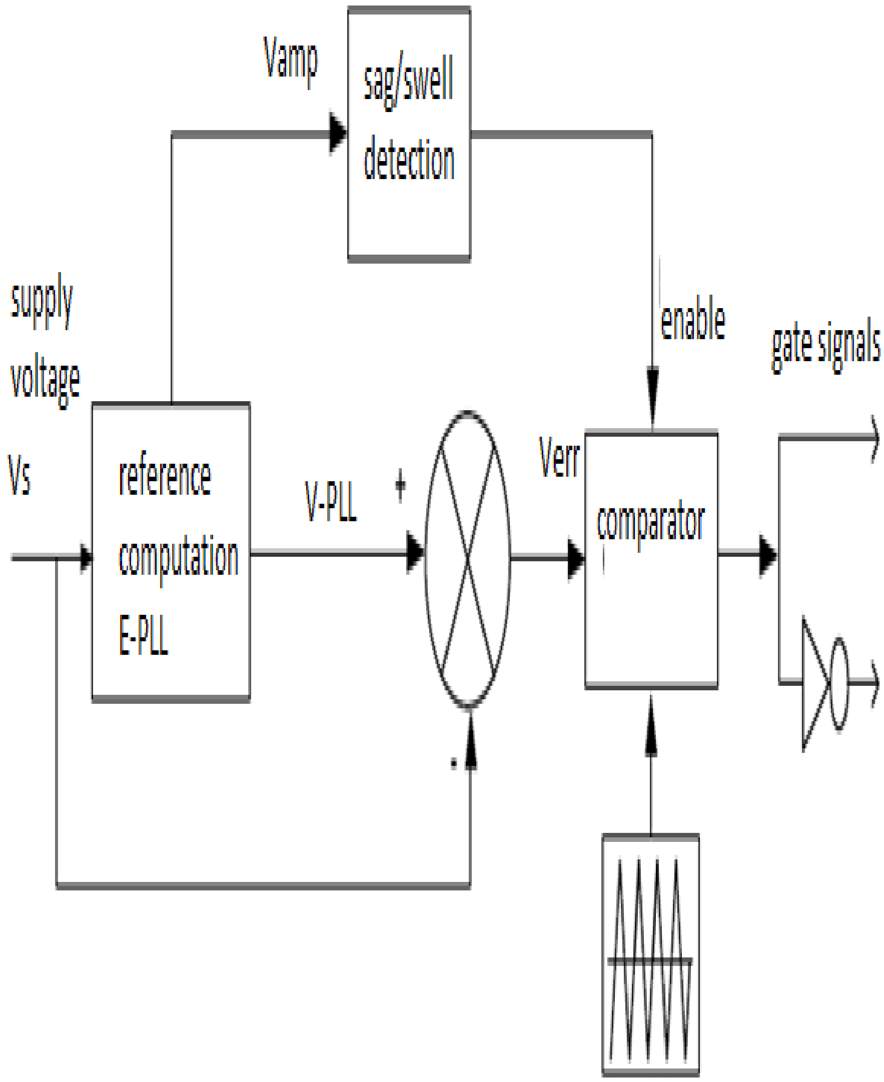

Fig 4.2 Control scheme of Series inverter

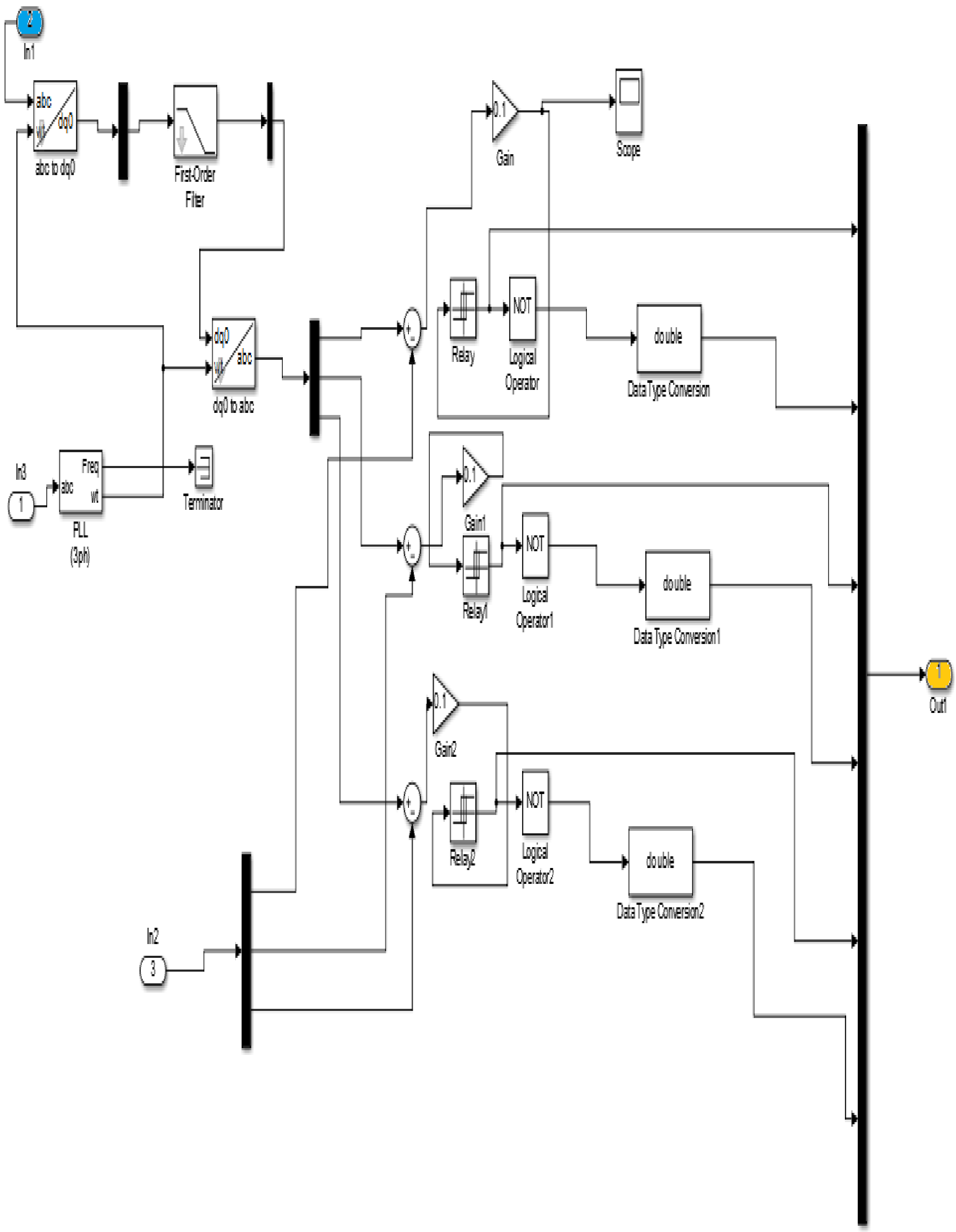

Fig4.3 Hysteresis voltage controller in MATLAB

4.1.3 Reference current signal generation

The block diagram for generating reference current signal is shown below. Here, rapidly incoming voltage and current signals are changed into d-q components. The real and virtual power components are obtained from source current and actual voltage. The reference currents are compared with three phased source current and then errors are processed by Hysteresis current controller thereby generating gate signals.

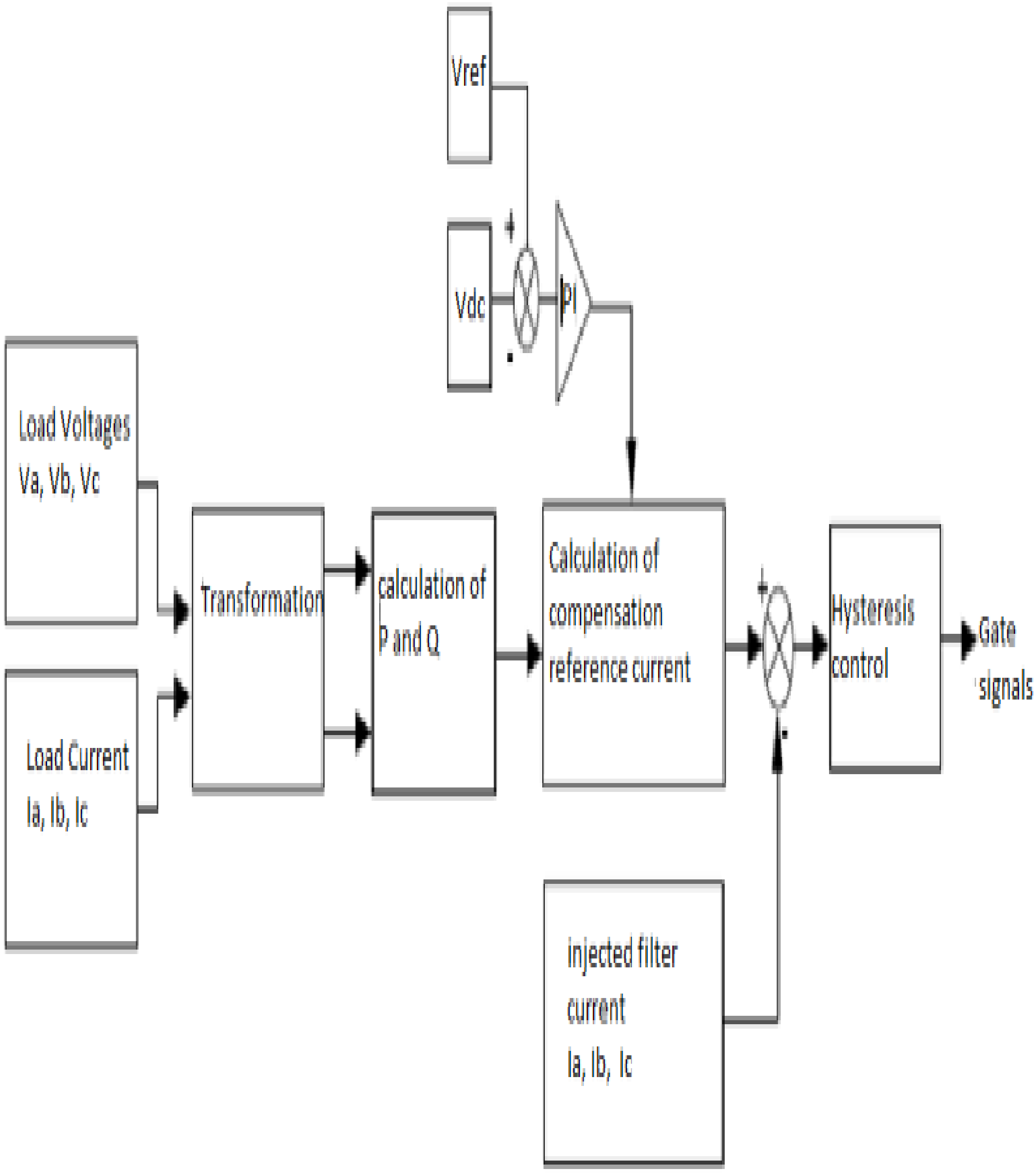

Fig4.4 Control scheme of shunt inverter

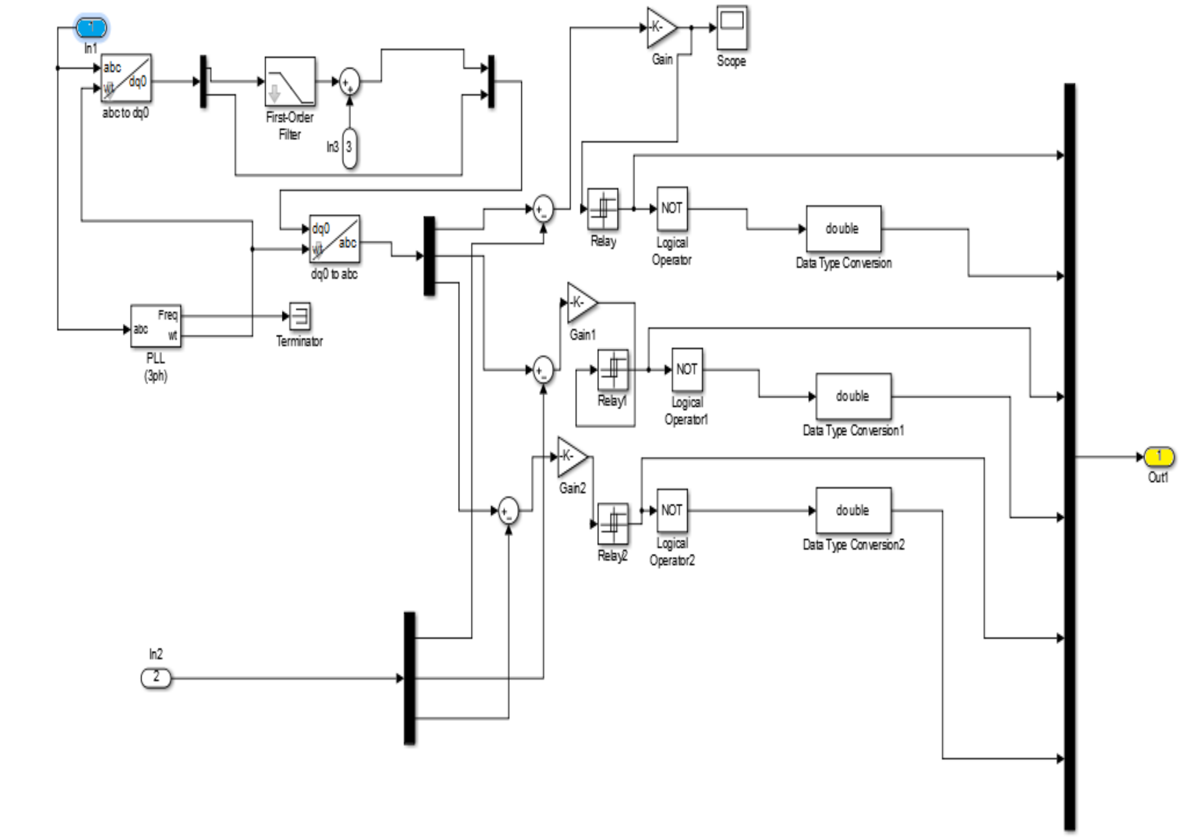

Fig4.5 Hysteresis Current Controller in MATLAB

4.1.4 PI Controller

Here PI controller is used to keep dc link voltage at reference value; dc capacitor requires certain real power that is proportional to the difference between real and reference voltages generated in SRF method.

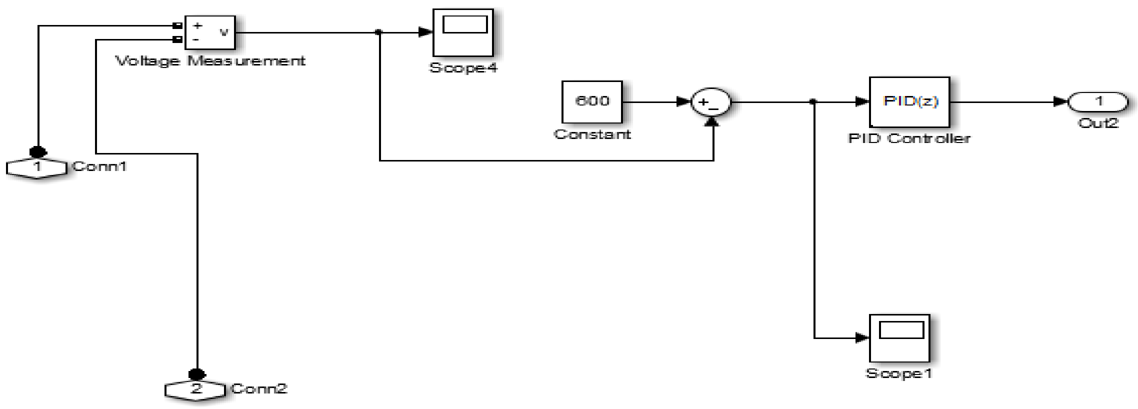

Fig4.6 Control scheme for the PI Controller

CHAPTER 5

SIMULATION AND RESULTS

In this thesis work, the role of the Power Conditioning device is carried out;

- Distribution network without UPQC.
- Distribution network with UPQC.

5.1 Comparative Analysis of SIMULINK Results

5.1.1Without Compensation

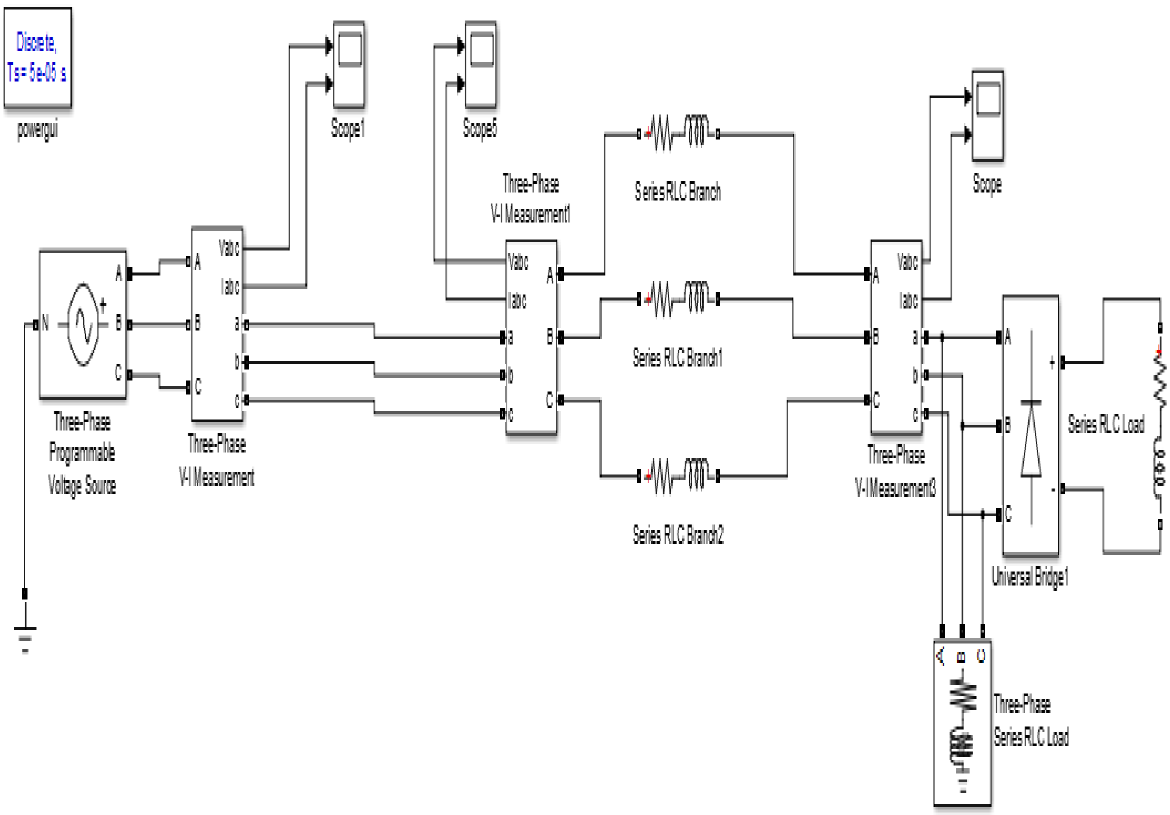

Fig5.1 MATLAB /SIMULINK model of Distribution network without compensation

- **System parameters**

System Voltage	230 V
System Frequency	50 Hz
Loads (Linear & Non-linear)	1 KW ; 450 W
Line parameters (Resistance & Inductance)	0.01ohm; 3mH

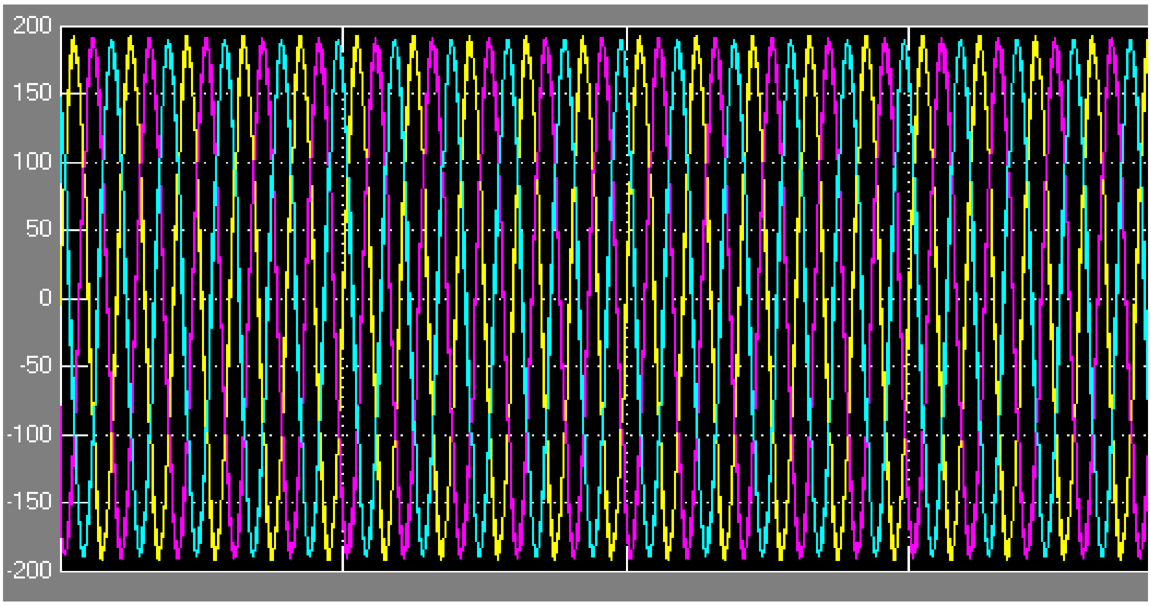

Fig5.2 (a). Source side voltage waveforms without compensation

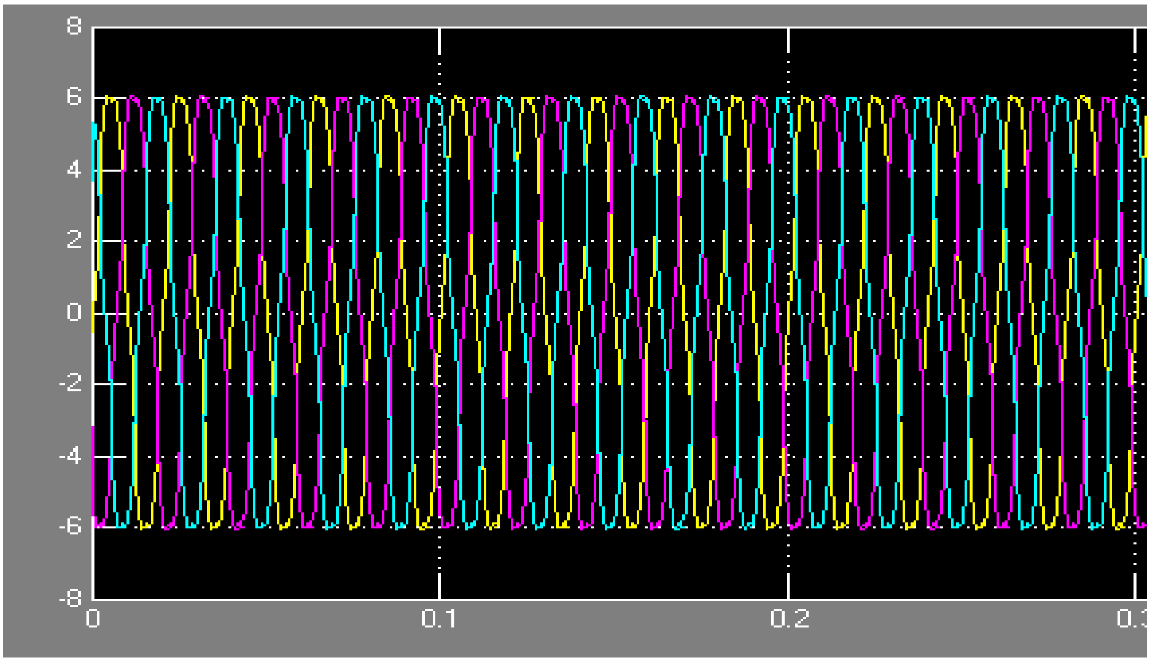

Fig5.2 (b). Source side current waveforms without compensation

In case without UPQC, the THD in line voltage and source current without compensation plotted out as 5.27% and 10.30%.

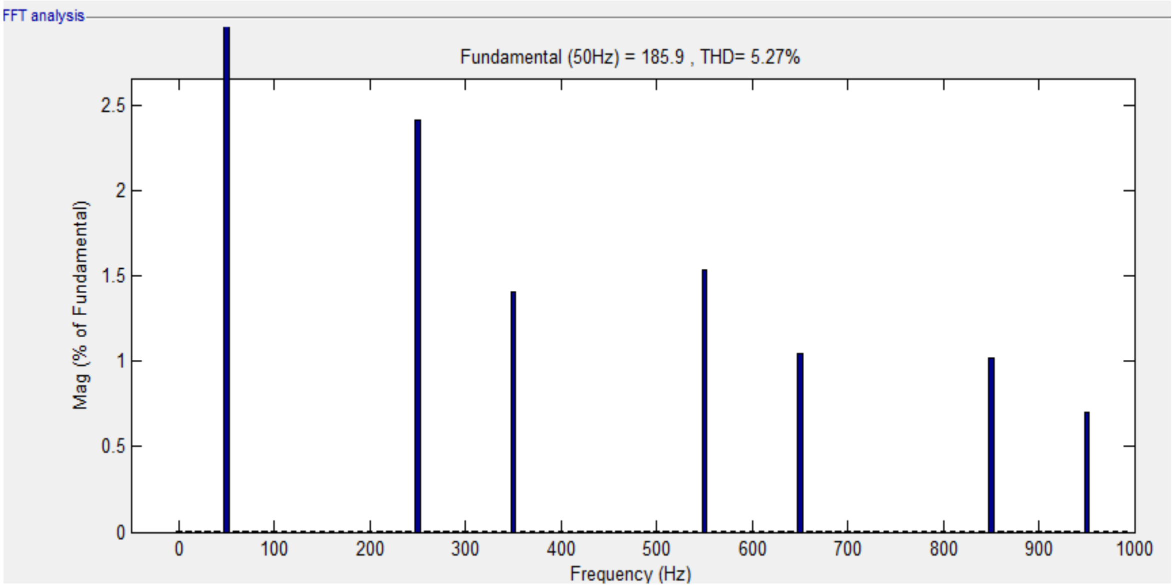

Fig5.3 (a). THD spectrum for source voltage without compensation

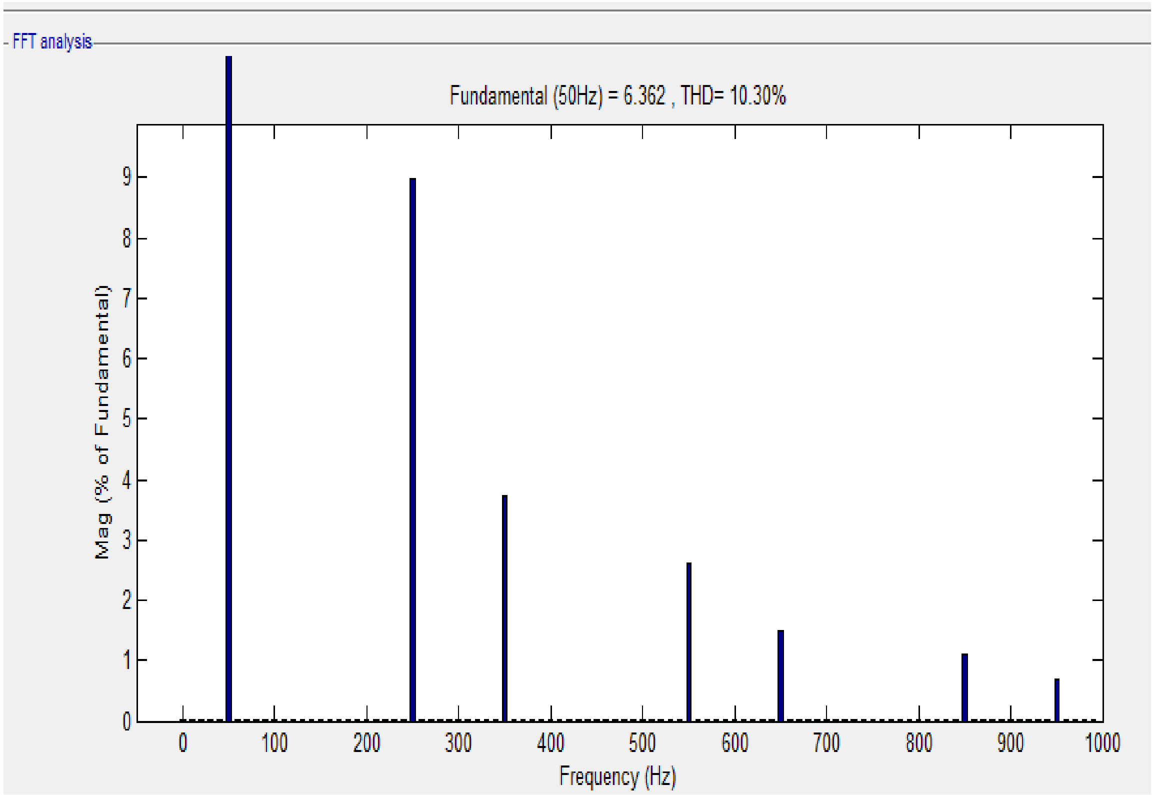

Fig5.3 (b). THD spectrum for source current without compensation

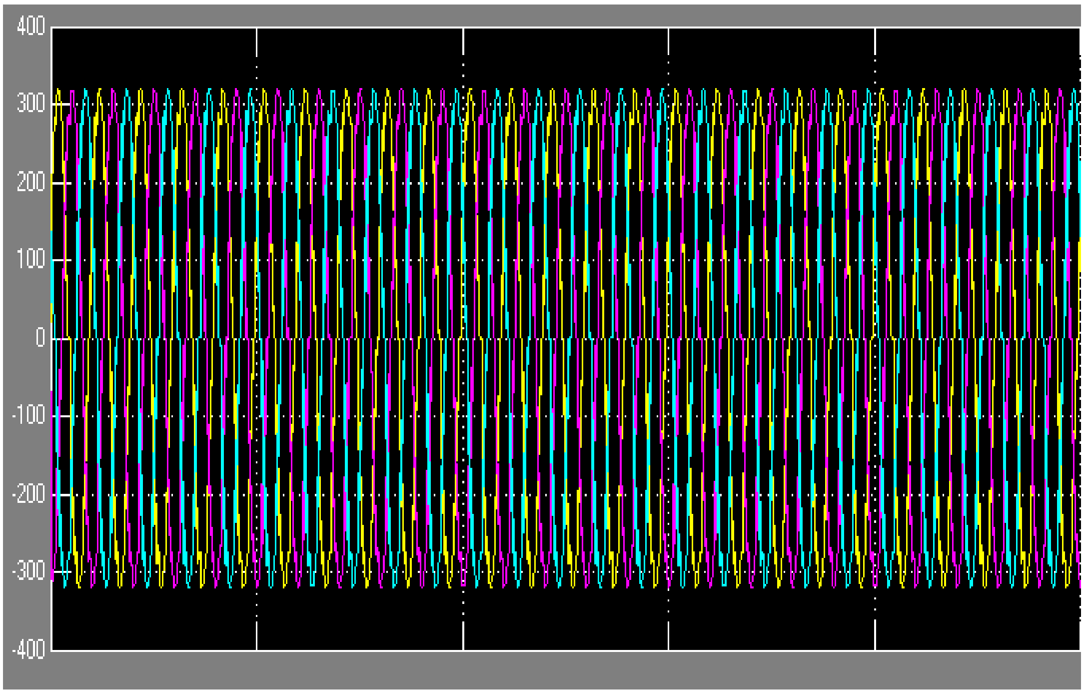

Fig5.4 (a). Load side voltage waveforms without compensation

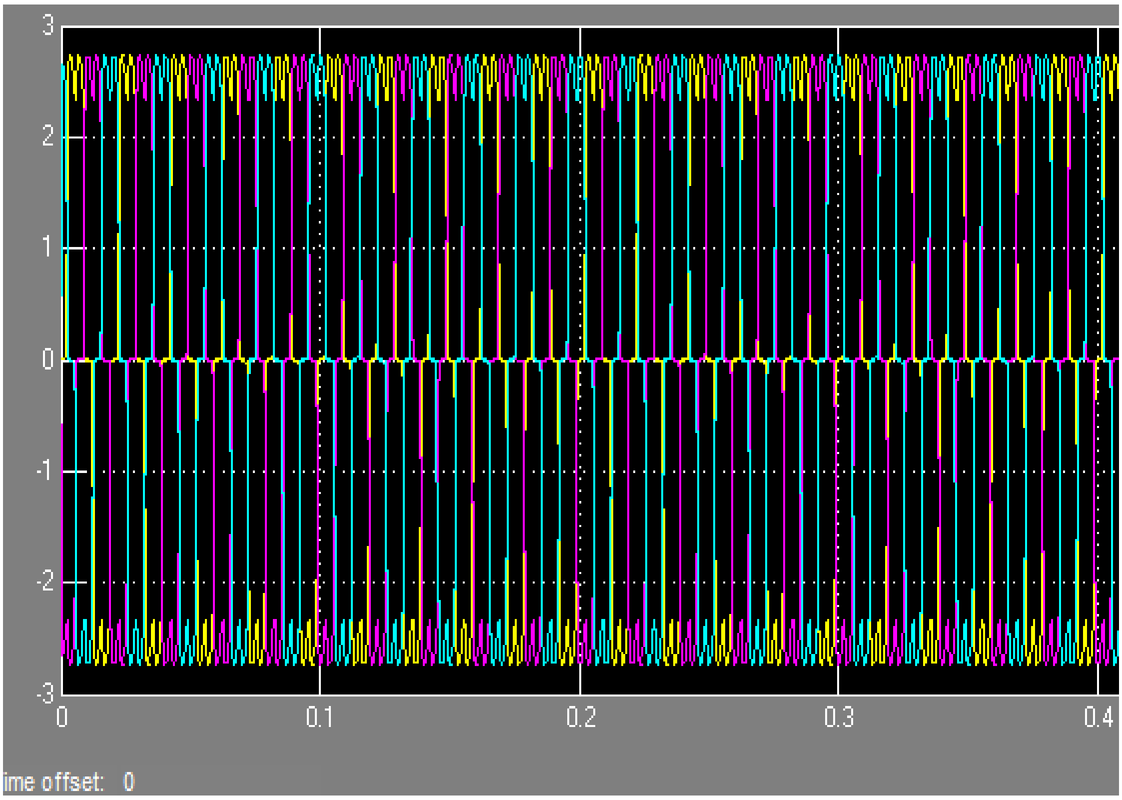

Fig5.4 (b). Load side current waveforms without compensation

In case without UPQC, the THD in load voltage and current are relatively 7.49% and 26.34%.

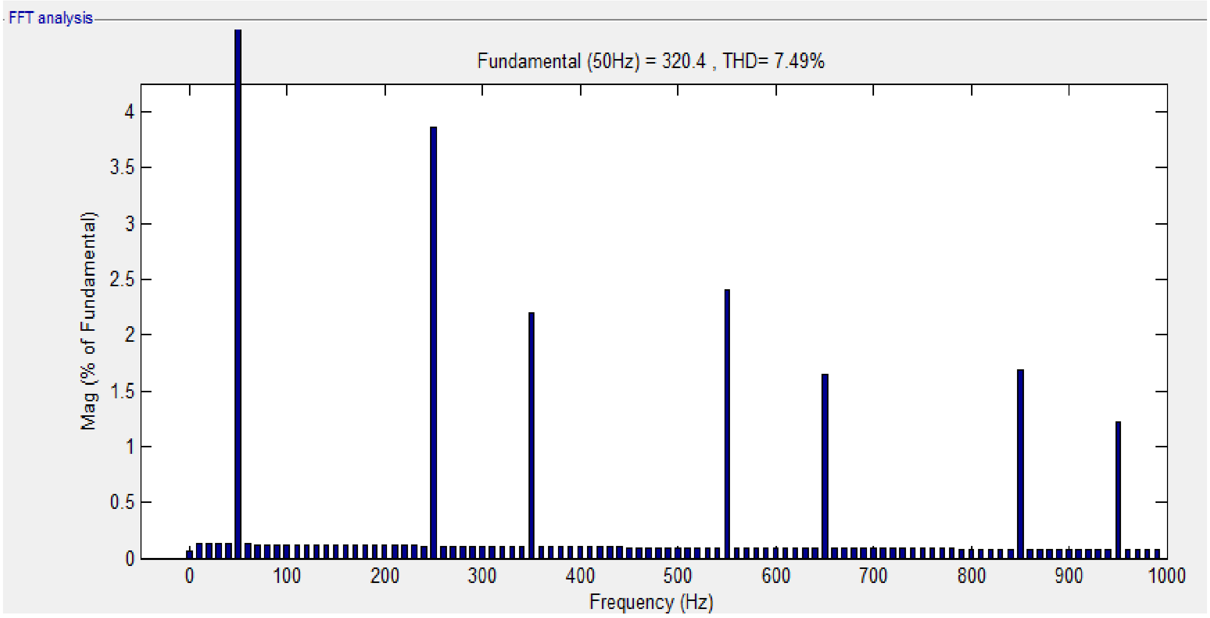

Fig5.5 (a). THD spectrum of load side voltage without compensation

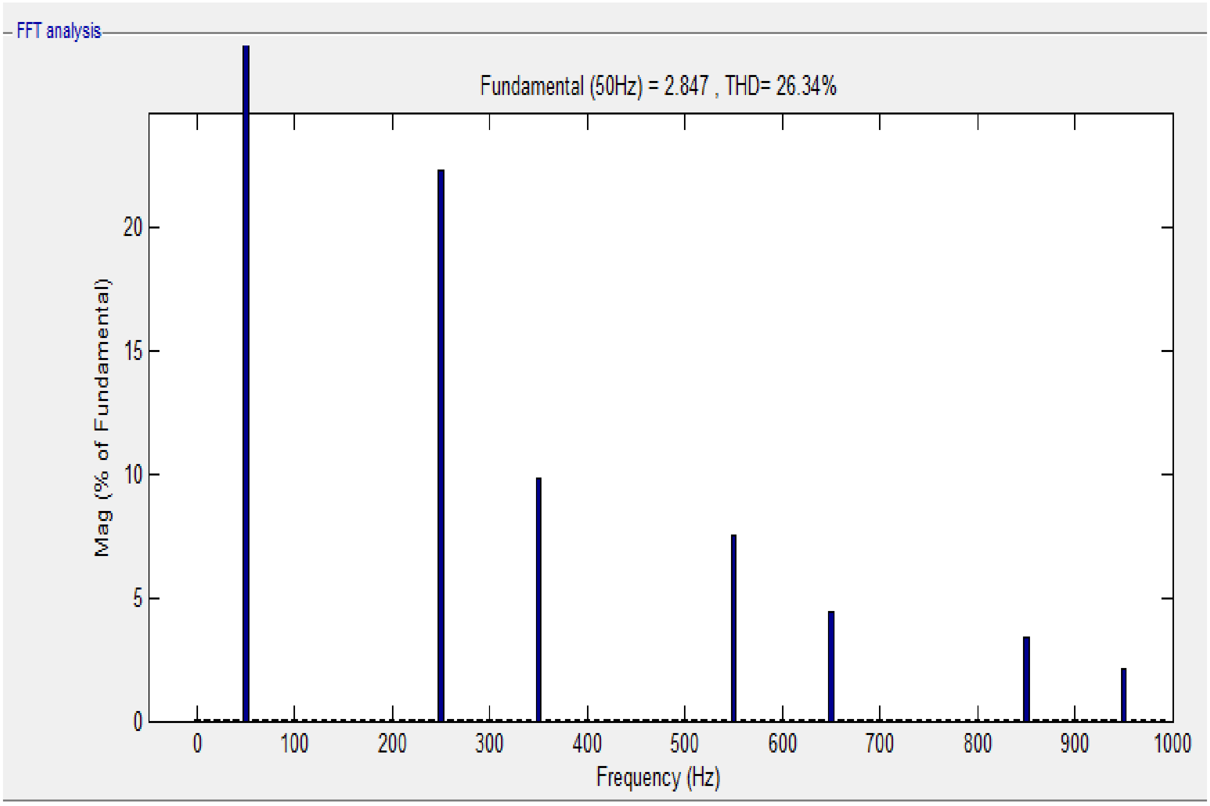

Fig5.5 (b). THD spectrum of load side current without compensation

5.1.2 with Compensation

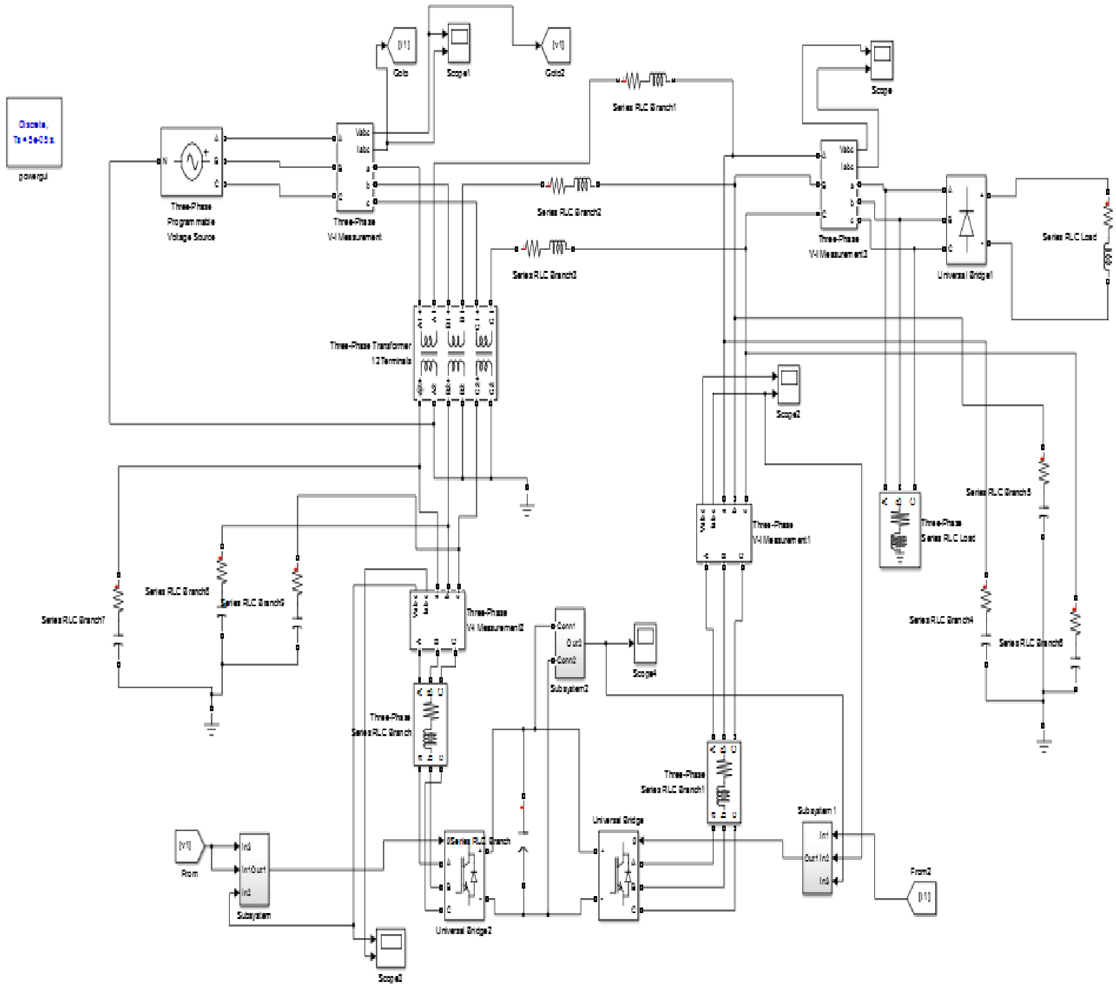

Fig5.6. MATLAB/SIMULINK model of Distribution network with compensation

- **System parameters**

System Voltage	230 V
System Frequency	50 Hz
Loads (Linear & Non-linear)	1KW; 450W
dc link Voltage	650 V
dc midway capacitor rating	2100µf
Line parameters (Resistance & Inductance)	0.01 ohm; 3mH
Series Transformer (n1:n2); MVA	2:5; 10MVA
Shunt filters (Resistance & Capacitance)	0.01 ohm; 15µf
Series filters (Resistance & Capacitance)	0.01 ohm; 15µf

In case with UPQC, the THD of source voltage and source current with compensation are reduced to 1.97% and 3.58% respectively.

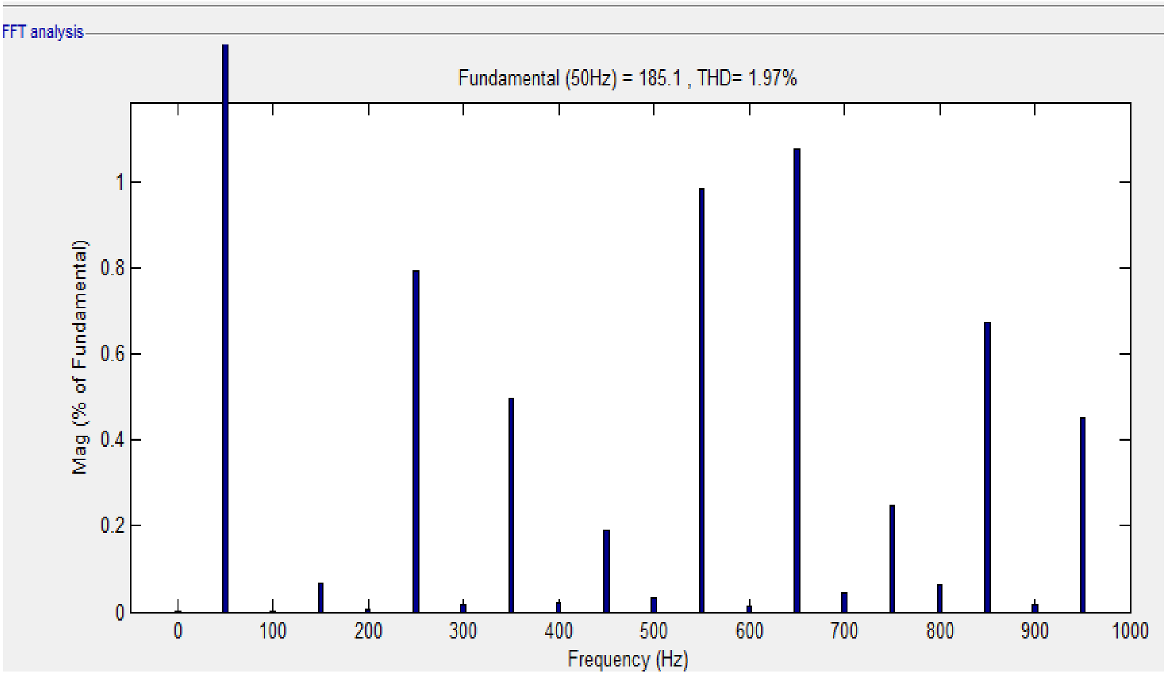

Fig5.7 (a). THD spectrum for source voltage spectrum with compensation

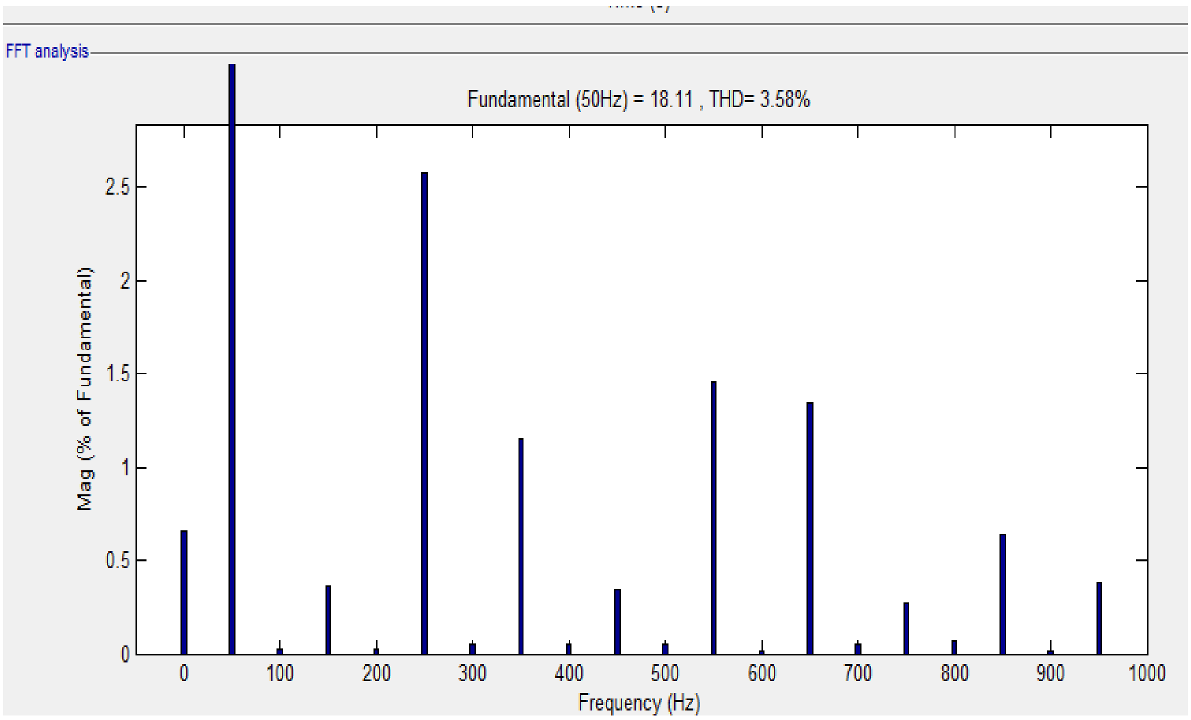

Fig5.7 (b). THD spectrum of source current with compensation

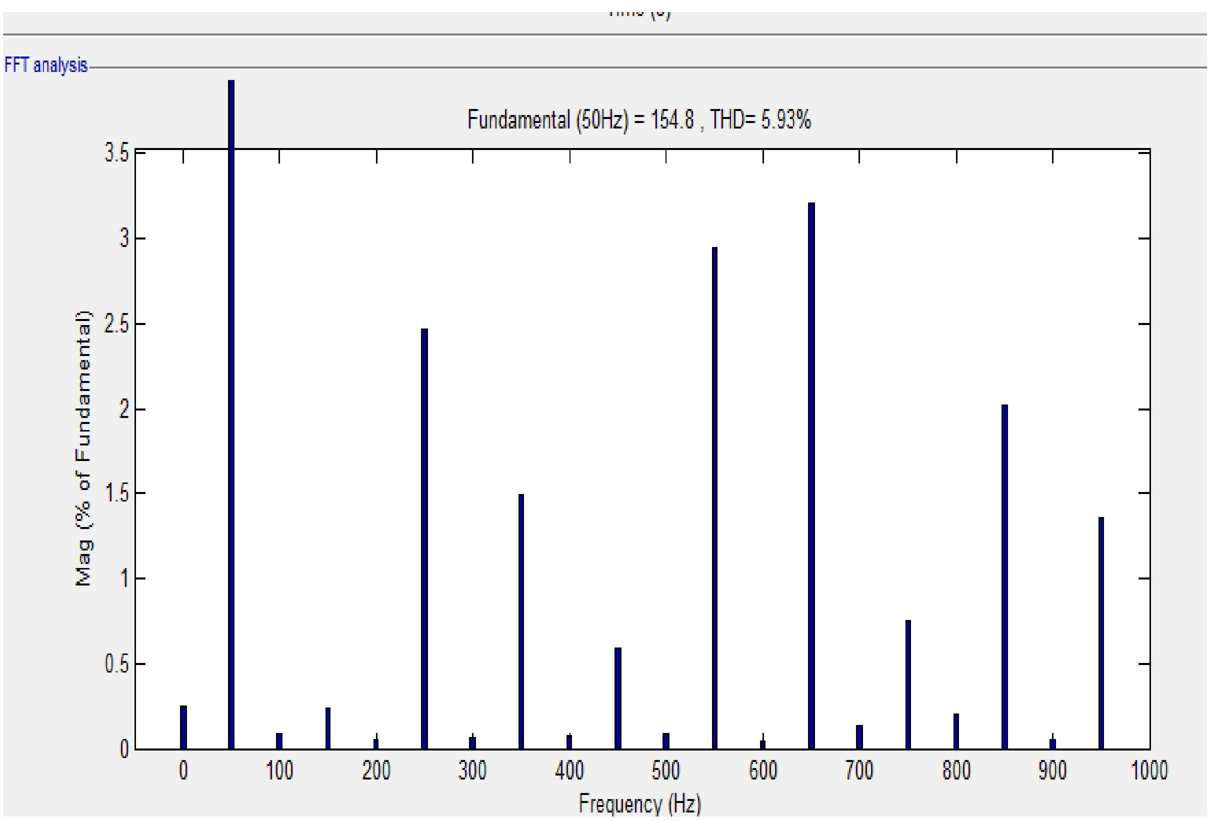

Fig5.8 (a). THD spectrum for load side voltage with compensation

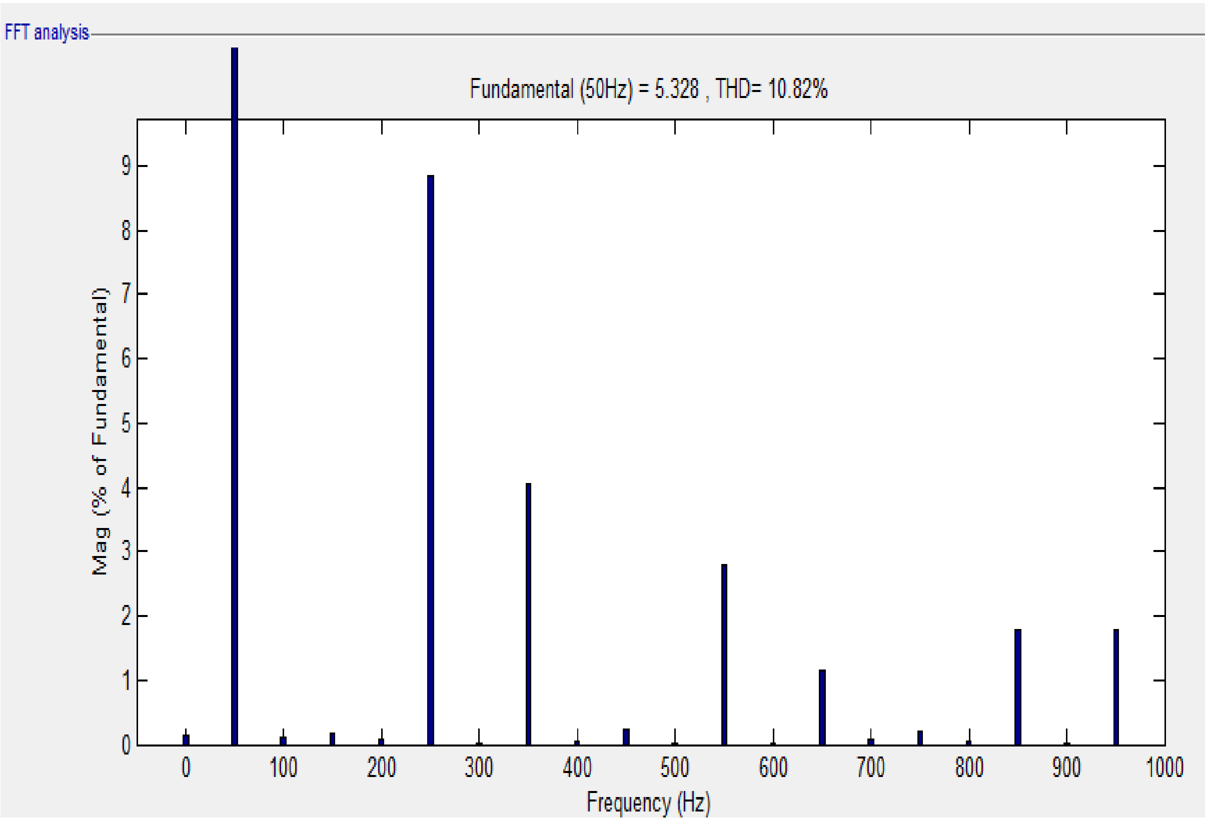

Fig5.8 (b). THD spectrum for load current with compensation

5.1.3 MATLAB description of Power Conditioner when a SLG fault occurs

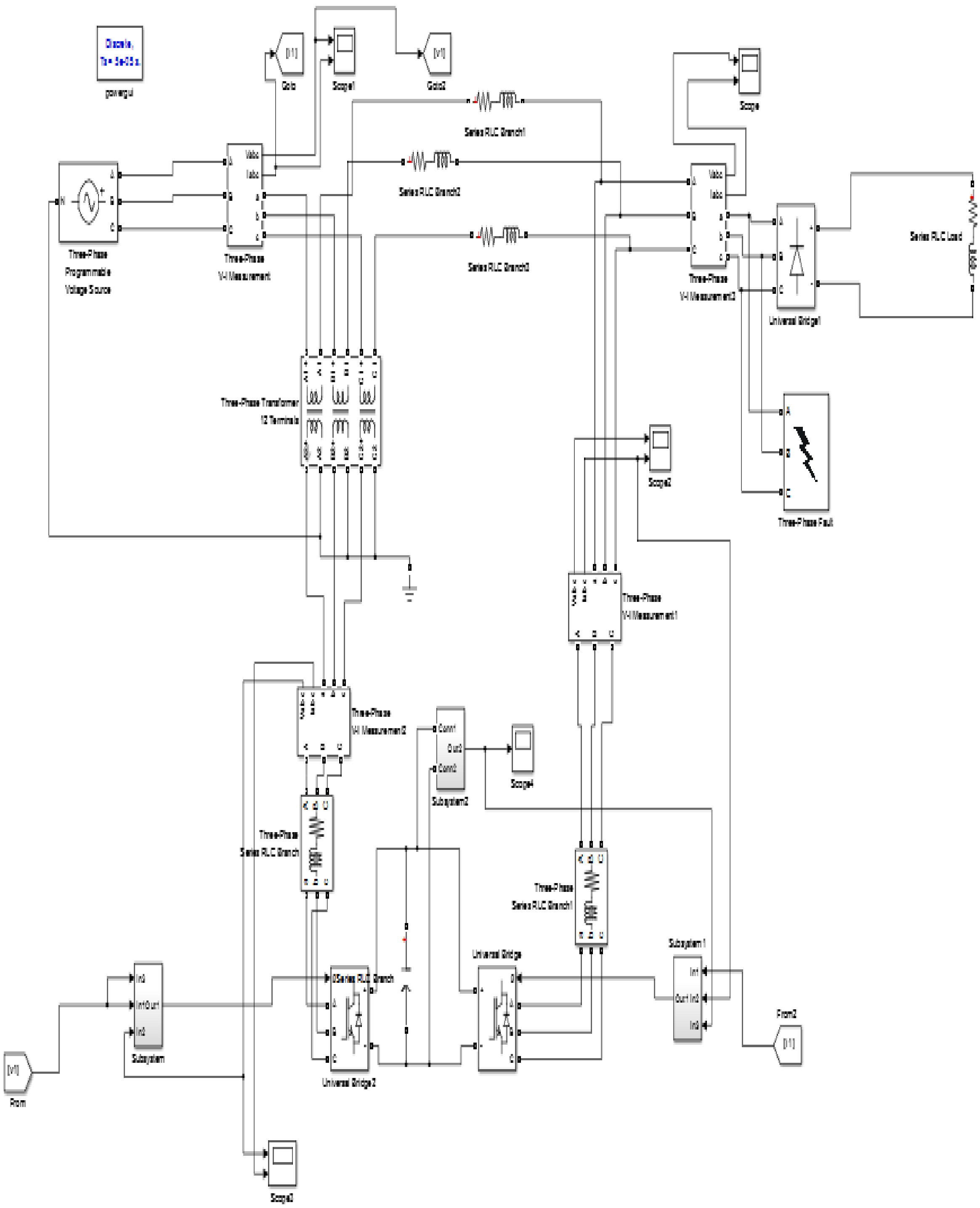

Fig5.9 Figure showing a fault on distribution system

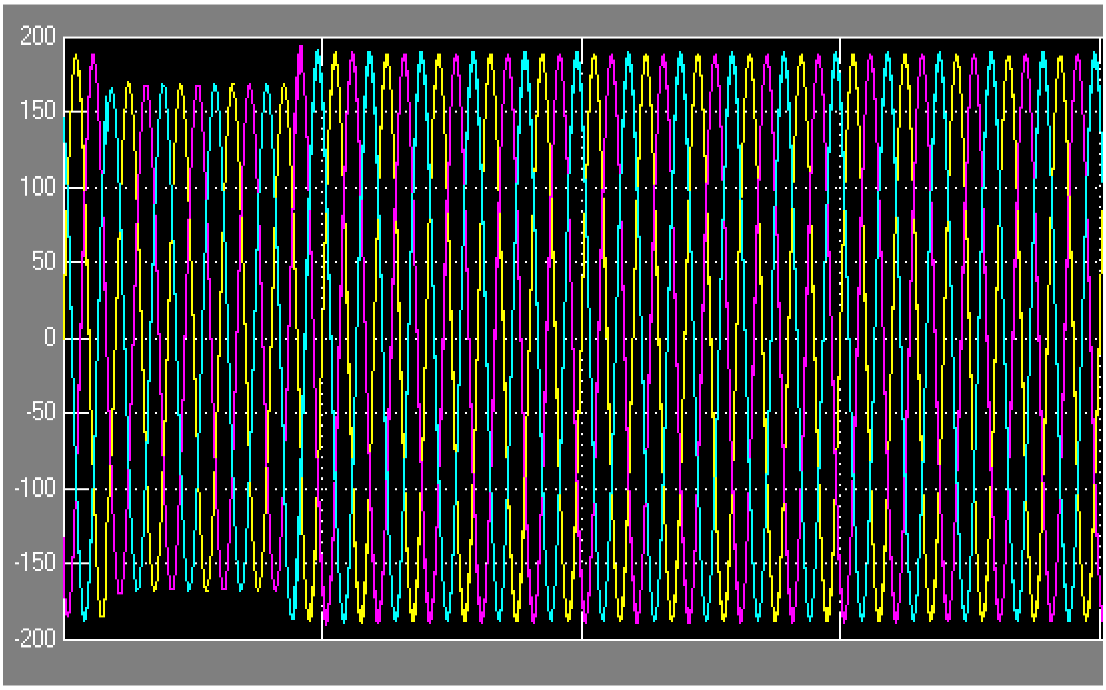

Fig5.10 Sag/dip results out on a line voltage when fault occurs on distribution system

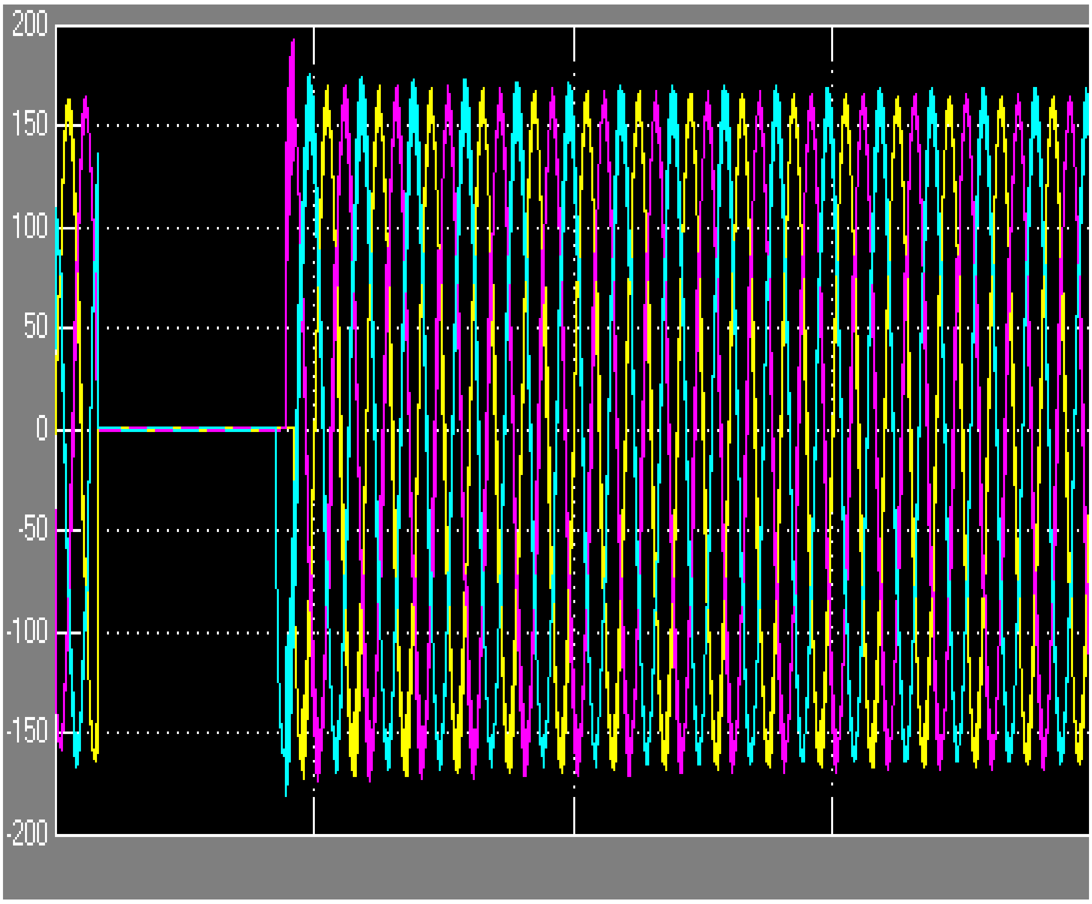

Fig5.11 load voltage compensated after sag is cleared

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

Hereby the Compensating strategies have improved the power capability of system to a wider extent most effective work is analyzed by the Unified power Quality conditioner. The proposed system work for voltage, current harmonics and power under the critical load conditions with visualized performance of the Synchronous Reference frame theory (d-q theory). Further the voltage and current harmonics in this thesis work has been relatively reduced to the THD level of 1.97% and 3.58% respectively. As a conclusion objectives have been achieved with a chosen unbalanced non-linear load with the effect of linear load on the grid connected distribution system.

6.2 Future Scope

With the successive implementation of reactive power compensation theory for the quality assurance in three phase system with appropriate results in terms of THD, Transient response, Switching of the inverters and the reference signal generation. Suitable work has been done on extending this theory for the reliable operation of the active power filters. As far the switching required in the active power filter is effectively high up to the range of 10 kHz with the lease of abundant instantaneous power. Further the system can be able to increase its flexibility and robustness by implementing further strategies to reduce on switching frequency and switching losses. For future work, this above work can be intended to extent the study to enhance the working of system with hybrid structure of both series PF and shunt PF with centralized mode of artificial neural networks.

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