Harmonic Compensation Using Shunt Active Power Filter With Neuro Fuzzy Logic Controller

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Abstract-Now a day due to the increasing presence on the network of nonlinear loads; they constitute a harmonic pollution source of to the network, which generate many disturbances, and disturb the optimal operation of electrical equipments. In this work, we propose a solution to eliminate the harmonics introduced by the nonlinear loads. In this work we presents the analysis of a three-phase active power filter (APF) compensating the harmonics and reactive power created by nonlinear balanced and unbalanced low power loads in steady state and in transients.

In this work the troubles formed by non linear load as well as the solutions having been applied so far are briefly reviewed. A new simple and effective reference current generation method of a shunt active filter is proposed In this paper we developed MATLAB model of a typical power supply system with a nonlinear load and shunt active power filter is carried out and the results are presented which imply a better dynamic performance of the proposed scheme compared to the fuzzy logic controller for controlling voltage source inverter.

Keywords :- Active Power Filters, Harmonics, fuzzy logic controller, Inverters, Matlab-Simulink Software, Pulse Width Modulation (PWM).

I. INTRODUCTION

Electrical power is the most efficient and popular form of energy and the recent society is heavily needy on the electric give. The existence cannot be predictable devoid of the delivery of electricity. The same time quality of the electric power supplied is also very vital for the efficient functioning of the end consumer apparatus. The expression power superiority becomes the largest part main in the power sector and both the electric power supply company and the end user are worried about it. The quality of power delivered to the patrons depends on the voltage and frequency ranges of the power. If there is any variation in the voltage and frequency of the electric power delivered from that of the standard values after than the quality of power delivered is artificial.

1.1 Power Quality Problems

Along with the power quality troubles, the bring in interruption is, undisputedly, the harshest, as it affect all tools linked to the electrical net. on the advance troubles, as the portray under and exemplify in outline 1.1(a) to 1.1(i), further than of leading to a number of equipment fall down, can also harm them:

(a) Harmonic distortion Harmonic distortion

When non-linear loads are connected to the electrical net, the current that flow throughout the lines takes in harmonics, Non-linear loads create harmonics by drawing current in abrupt short pulses, rather than in a smooth sinusoidal manner [2]. and the resulting voltage drops cause by the harmonics on the lines impedances causes buckle on the feed voltages.

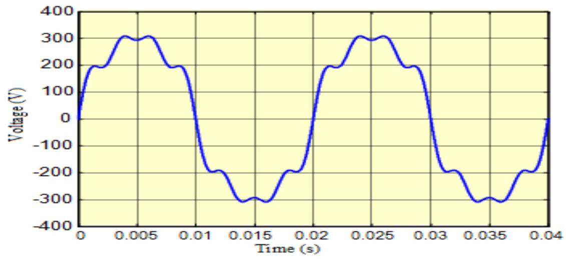

Figure1.1–a) Harmonic distortion

(b) Noise (electromagnetic interference):-

Keep up a correspondence to high frequency electromagnetic noise, which can, for illustration, be produced by the rapid switching of electronic power converter. [2]

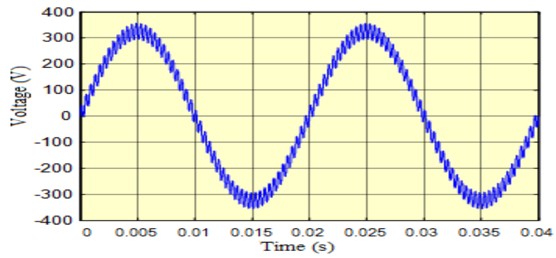

Figure1.1-b) Noise (electromagnetic interference)

(c) Inter-harmonics

Appear with the presence of current components that are not related to the primary frequency [1].This mechanism can be formed by arc heating system or by cyclo-converters (equipments that, being fedat50HZ.

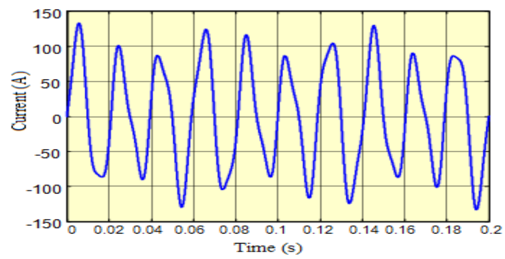

Figure1.1- c) Inter harmonics

(d) Momentary Interruption

Crop up, for incidence, when the electrical system has automatic rearrange circuit breakers, that opens when a fault occurs, closing automatically after some.

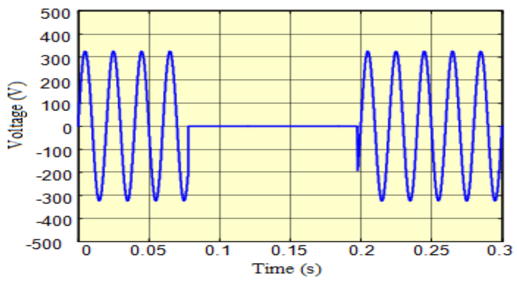

Figure1.1-d) Moment aryinterruption

(e) Voltage Sag

Can be caused, for instance, by a temporary short-circuit at another branch of the same electrical system, which his eliminating after some milli seconds by the opening of the branch circuit breaker.

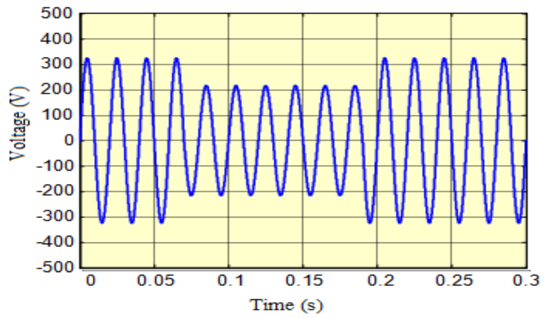

Figure1.1-e) Voltage sag

II. HARMONIC "POLLUTION" CAUSES

The vast majority of the troubles that occur on electrical systems have its or iginson the excessive distortion of the currents or voltages near the final user [4].The main cause for this manner ,which can be regarded has a sort of electromagnetic environment pollution, is duet o the growth of the custom f electronic equipment fed by the electrical network ,such like computers, printers, television set, electronic bal lasts for gas-discharge lamp, electronic controller for poles a part varieties of manufacturing loads, etc. almost every electronic equipment [1].

A commuted converter of the type DC-DC, DC-AC. One of the most usual rectifiers for low-power equipments is the single-phase full wave rectifier with capacitive filter ,which has a very much in distinct current utilization, as it can be seenondetails1.2(a)and1.2(b).The current's high harmonic content distorts the voltage on the loads duet o the voltage drop in the electrical system impedances. Phase firedcontrollers,generallyusedtocontrolpowerconsumptiono fheatingsystems and to adjust luminous passion flamps, as well consume currents with substantial harmonic content and with high-frequency electromagnetic intrusion. Even the ordinary fluorescentlamps contribute significantly for the presence of harmonics in the electrical lattice [1],due to then on-linear actions of the electrical discharges on the gaseous surroundings, and also to the ballast's magnetic circuit, that can operate on the diffusion district.

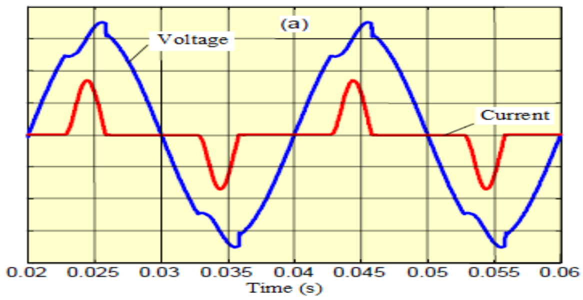

Figure 1.2 - a) Voltage and current in a single phase rectifier with a capacitive filter

III. SOLUTION FOR HARMONICS PROBLEMS

Next, there will be presents a number of conventional (passive filtering) and modern (active filtering)solutions for the harmonic problem in equipments and electrical systems.

1.3.1 Low Power (Single-phase systems):-

The simplest passive filter consists of an inductor series connected to the entrance of the"polluteutensils", which frequently is a rectifier with cap acitive filter output (Fig1.3a) [10].This is are liable and low cost promise .However, the induct orisbulky and deep(duet otheirononits magnetic conduit),which practically confines this declaration to low power equipments (less than .6kVA).Avery common amend through in the development t of single-phase electronic apparatus, in order to drasticallyless en thecreatedharmonics,istouseastep-upDC-DCconverterafterdeRectifier Bridge(Fig1.3b).That track, when suit ably controlled, allow that the current fanaticalbytheapparatusisvirtuallysinusoidal,anditcanbeuse duptothe power usually presented in single-phase outlets(on.3000VA).Load

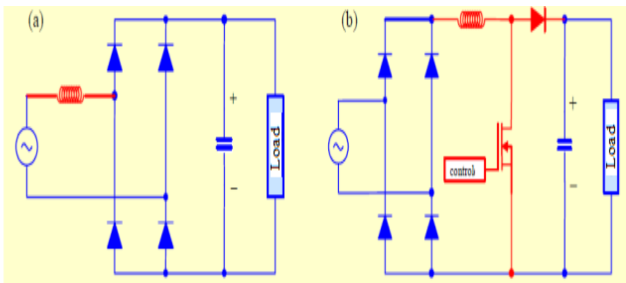

Figure 1.3 - Solutions to reduce the harmonics of the current in the input of the equipments: a)Series inductance; b)Step-up converter

Shunt Active Filter

The Shunt controls Active Filter has the function to recompense the load currents harmonics, allow also compensate the rushed power (power fact oral teration). It also allows balancing the currents on the three phases(eliminating impartial wire current even when3rdharmexists) [9].As it is given gone on Figure 1.3,asoutcomeofthe shunt active filter process ,the lines current grow to be sinusoidal ,and its amplitude drops ,dipping losses on the wires and avoid voltage twist on the loads. Figure1.4presentstheelectrical proposal of a three-phase shunt active filter [1].The filter is as a rule collected by aninverter, which create the compensate currents, and byits regulator.

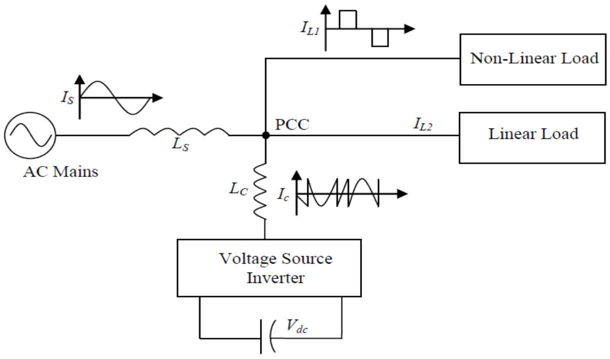

Figure1.4 Shunt Active Filters

IV. LITERATURE REVIEW

[1]A.Priyadharshini, N.Devarajan, AR.Uma saranya, R.Anitt, This paper presents a new adaptive hysteresis band controller for three phase shunt active power filters implemented using the Fuzzy logic. The simulations were carried using Matlab SimPowerSystems and Fuzzy logic toolboxes under two load configurations, balanced and unbalanced. The results are found quite satisfactory in order to keep the switching frequency constant, and to compensate the current harmonics, unbalance and reactive power in three phase electrical systems.

[2]George Adam, Alina Georgiana Stan (Baciu), Gheorghe Livinţ, Harmonic Distortions are the major cause for power quality problems. For this analyzing the harmonics present in non linear loads is significant. Here a survey is made to show details of harmonics present in various non linear loads.

[3]Hideaki Fujitaand Hirofumi Akagi,This paper discusses the control strategy of the UPQC, with a focus on the flow of instantaneous active and reactive powers inside the UPQC. Experimental results obtained from a laboratory model of 20 kVA, along with a theoretical analysis, are shown to verify the viability and effectiveness of the UPQC.

[4]Konstantin Borisov, Herbert L. Ginn III and Andrzej M. Trzynadlowski,Shunt active power filters are used to eliminate the current harmonics and to improve the power factor in systems with non-linear loads. At the present time, different methods exist to control active power filters. Some of them are based on instantaneous reactive power theory [1] and others are based on the synchronous reference frame using Park's transformation [2]. The purpose of this paper is to present a new control method of shunt active power filters in unbalanced systems,both in load currents, and in AC supply voltage, with a high contents of harmonics. The method is based on the time domain analysis carried out by P. Filipski. With this control method one can make that the set formed by the nonlinear load and the shunt power filter behaves every time like a resistance, UPF (with unity power factor), or that the current absorbed by the set is perfectly sinusoidal, by simply acting on a switch. The system has been simulated for different load and line conditions. Waveforms of the line currents are shown, with their harmonic distortion contents.

[5] WanchakLenwari and MilijanaOdavic,In recent years, the increase of non-linear loads in electrical power system has sparked the research in power,quality issue. The shunt active power filter (SAPF) is a power electronic device which has been developed to improve power quality. The current control of shunt power filters is critical since poor control can reinforce existing harmonic problems. Various control strategies have been proposed by many researchers. In this paper, a comparative evaluation of the performance of two current control techniques, resonant and predictive controller, is presented with identical system specification. The design procedure and principle of both current control methods are also presented in detail. Simulation results show the comparison of transient response, steady state control and performance in the presence of variation of supply impedance between two control techniques.

V. HARMONICS AND SHUNT ACTIVE FILTER

Harmonics are cause if one of the main issues in a power system. Harmonics supply distortion in current and voltage waveforms consequential into corrosion of the whole power system. The first step for harmonic assessment is the harmonics from non-linear loads. The result of such analysis is compound more than many years; much significance is given to the method of study and control of harmonics. Harmonics present in power system too has non-integer multiples of the essential frequency and have a intermittent waveform. The harmonics are generating in a power system from two types of loads. [1]

Table 3.1: The measured results for the modern set of non-linear loads [1]

S NO.	MODERN SET OF NON-LINEAR LOAD	POWER FACTOR	THD I (current) (%)	3^{rd}	5^{th}	7^{th}	9^{th}	11^{th}
1	Printer	0.49	83.6	46.7	41.3	36.2	28.6	21.5
2	Laptop	0.52	83.8	49.6	43.5	36.2	27.5	17.7
3	Television	0.66	72.5	55.1	36.8	20.3	11.4	10.8
4	Fluorescent lamp	0.57	11.1	10.72	2	1.8	0.9	0.6
5	Personal computer	0.53	60.1	52.8	43.5	31.6	19.3	8.4

5.1 Rectifiers

Rectifiers are the basic load employed in every system [1]. Rectifiers are used to convert AC to DC current, while converting due to the involvement of thyristors (non linear load) produces harmonics. It consume the current in the circuit and which at last will have dc output with ac components (i.e. harmonics).This distorted current also lead to distortion in line voltage. Total harmonic distortion in line current in single phase rectifier is 88.82 %. But, three phase diode rectifier has total harmonic distortion of 52.84% [16]. Comparison of the line-current waveforms shows that the line current in a single-phase rectifier contains significantly more distortions when compared to a three- phase rectifier.

Fuzzy Set Theory

In modern days, the integer and variety of applications of fuzzy logic have increased to a large extent. The applications range from user products such as cameras, camcorders, washing machines, also microwave ovens to industrial system control, medical instrumentation, decision-support setup, and portfolio selection.

Membership Functions

Fuzziness in a fuzzy set is characterized by its membership functions. It classifies the element in the set, whether it is discrete or regular. The membership functions can also be formed by graphical representations. The graphical image may include various shapes. There are certain restrictions respecting the shapes used. The rules composed to represent the fuzziness in a request are also fuzzy. The "shape" of the membership function is an main criterion that has to be considered. There are various methods to form membership functions. This chapter confers on the features and the different methods of inward membership functions.

Introduction

Inverters are use to make reversal by change a direct current into an alternating current. When the output of a circuit is AC in that condition depending on the input i.e. either DC or AC, the devices are identified as AC-AC cyclo-converters or DC-AC inverters. DC to AC inverters is a device that's AC output has magnitude and frequency which is whichever fixed or variable. For that of DC to AC inverters the output AC voltage can be also single phase or three phases. As well, the magnitude of the AC voltage is from the range of 110-380V AC while the frequencies are 400 Hz, 60Hz or 50Hz.

Add up to ofthe rudimentary application of inverters would be an UPS. As soon as the main power is not available UPS use batteries and inverter to supply AC power. A rectifier is use to refresh the batteries use when the central power is back. Additional application of an inverter integrated Variable frequency drives. The adjustable frequency drives controls the frequency and voltage of power provided to the motor, thusan inverter is used for scheming the speed of AC motor. An inverter is also use in an induction motor to alter the speed by changing the frequency of AC output.

Types of Inverters:- There are two types of inverters

Single Phase Inverters

Three Phase Inverters

Single Phase Inverters:- There are a lot of different topologies that can be used for inverter circuits. Inverter circuits are calculated in a different way depending on the way the inverter is offer to be.

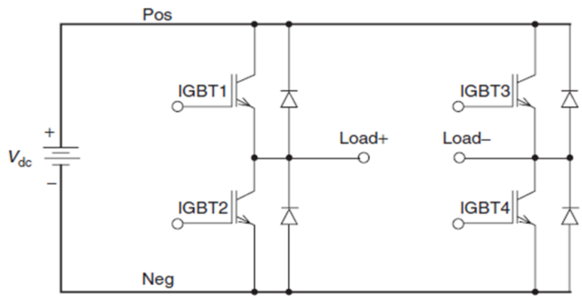

Figure 5.1 shows a single phase inverter.

Three Phase Inverters:- Like to the Single Phase Inverters, the Three Phase Inverters too have dissimilar topologies which can be used. Figure 5.2 shows a three phase inverter circuit. It is a combination of H bridge circuit as it consists of three single phase inverters equally connected to one of the three load terminals. Into single phase inverter, at hand is a phase difference of 180 degrees among odd legs, while three phases inverter there is a phase difference of 120 degrees. This phase vary of 120 degrees in three phase inverter help out in reduce the odd harmonics as of the three legs of the inverter. Also, if the result is pure AC waveform then the even harmonics can be dropping too. In classify to adjust the output of a three phase inverter; the amplitude of output voltage is decrease by a factor with respect to the input voltage. This factor is given by the following equation

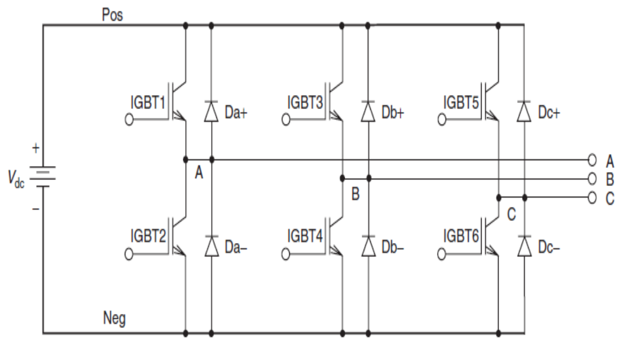

Figure 5.2: Three Phase Inverter.

Pulse Width Modulation Technique:-

Block diagram of a single phase inverter with a high frequency filter that is used in order to eliminate the harmonics from the output waveform. Hence, VO is the ac output while Vin is the input dc voltage.

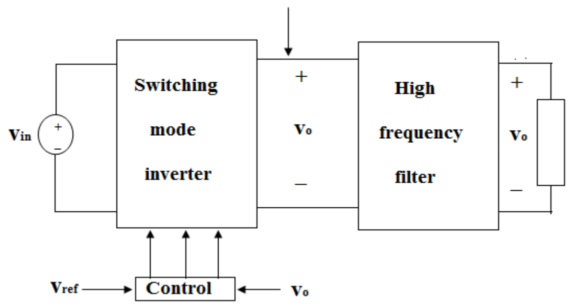

Figure 5.3: Single Phase Inverter with Filter

Three Phase circuit with linear load:-

It is Matlab Simulink model of three phase circuit with linear load, it gives the source side and load side voltage and current waveform which follow the Ohm's law and purely sinusoidal in nature.

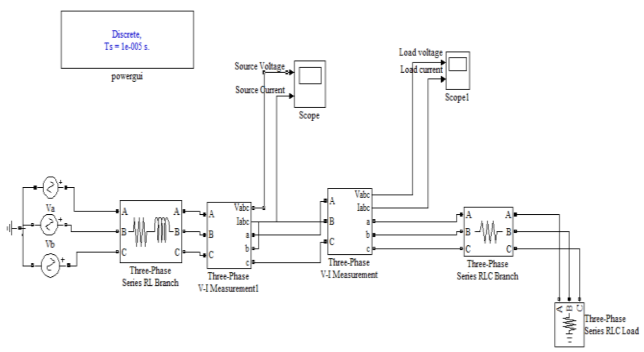

Figure 6.1 MATLAB simulink model of three phase circuit with linear load

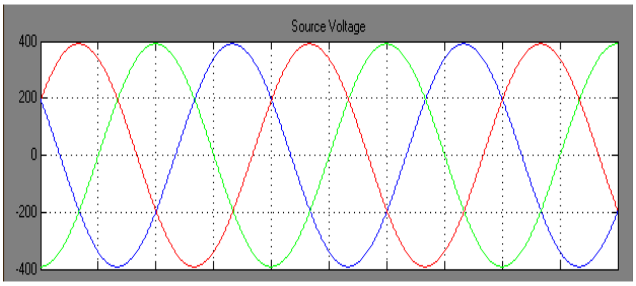

Figure 6.2 Source side voltage waveform of linear load circuit

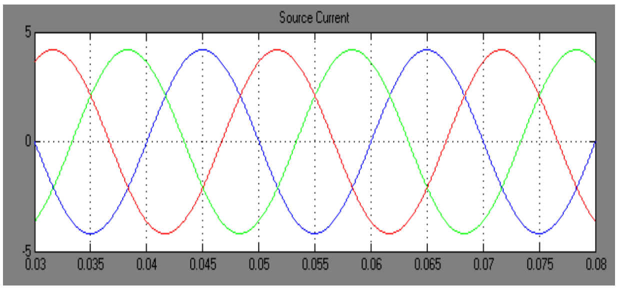

Figure 6.3 Source side current waveform of linear load circuit

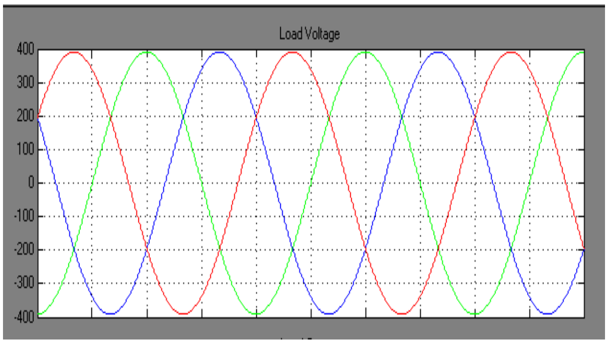

Figure 6.4 Load side voltage waveform of linear load circuit

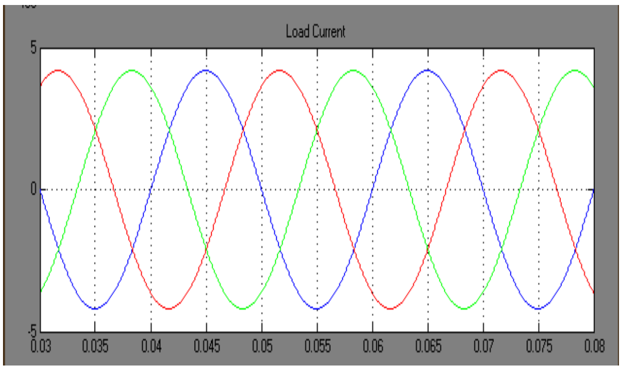

Figure 6.5 Load side current waveform of Linear load circuit

FFT analysis of current waveform of linear load circuit

It is the Fast Fourier Transform analysis of the current waveform of linear load which give the total harmonics distortion of current 0.00% it means there is no harmonics presents. When we use linear load. It is also shown in figure 6.3 that current is linear (Sinusoidal).

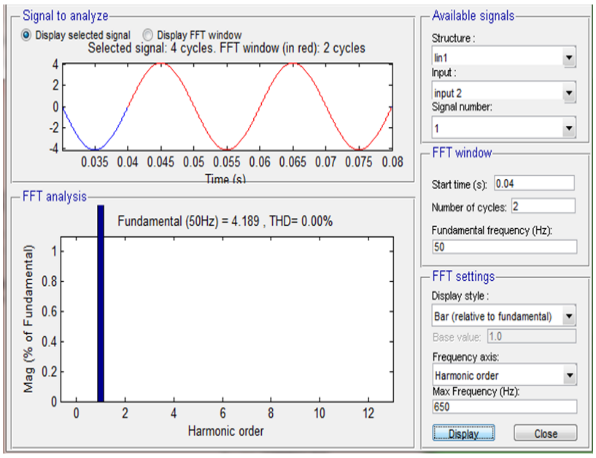

Figure 6.6 FFT analysis of current waveform of linear load circuit

6.2 Three Phase circuit with nonlinear load:-It is Matlab Simulink model of three phase circuit with Non linear load, it gives the source side and load side voltage and current waveform which do not follow the Ohm's law and waveform of current is distorted in nature.

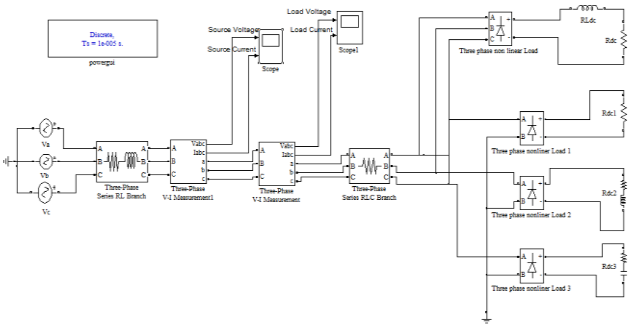

Figure 6.7 MATLAB simulink model of three phase circuit with nonlinear load

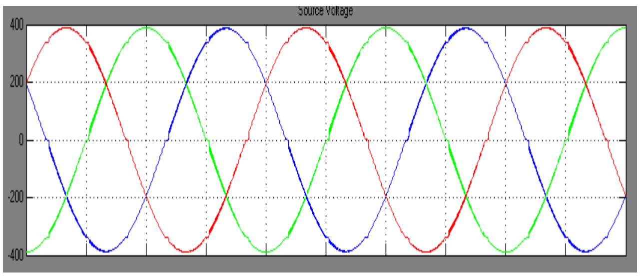

Figure 6.8 Source side voltage waveform of Non linear load circuit

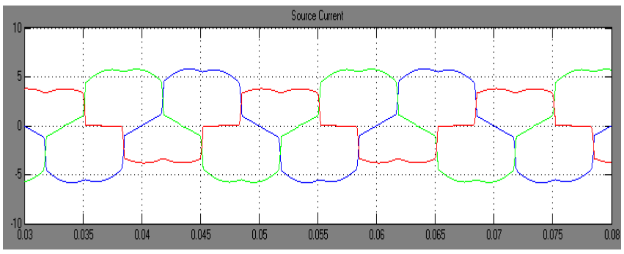

Figure 6.9 Source side current waveform of Non linear load circuit

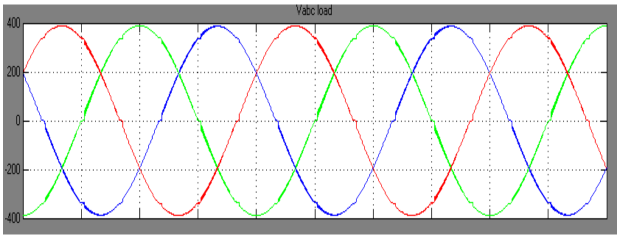

Figure 6.10 Load side voltage waveform of Non linear load circuit

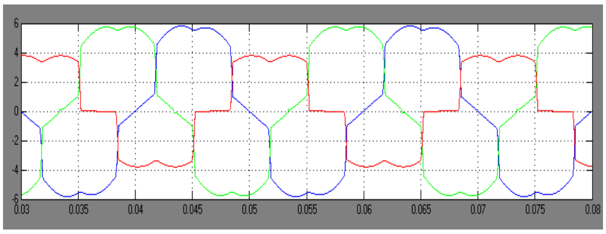

Figure 6.11 Load side current waveform of non-linear load circuit

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