

Power Quality improvement using passive shunt filter

Pranjali Bafila

Assistant Professor, Department of Electrical Engineering, Seemant Institute of Technology,
Pithoragarh- 262501, India

Abstract: Power system harmonics are a menace to electric power systems with disastrous consequences. The line current harmonics cause increase in losses, instability, and also voltage distortion. With the proliferation of the power electronics converters and increased use of magnetic, power lines have become highly polluted. Both passive and active filters have been used near harmonic producing loads or at the point of common coupling to block current harmonics. Shunt filters still dominate the harmonic compensation at medium/high voltage level, whereas active filters have been proclaimed for low/medium voltage ratings. With diverse applications involving reactive power together with harmonic compensation, passive filters are found suitable. Passive filtering has been preferred for harmonic compensation in distribution systems due to low cost simplicity, reliability, and control less operation. The uncontrolled ac-dc converter suffers from operating problems of poor power factor, injection of harmonics into the ac mains, variations in dc link voltage of input ac supply, equipment overheating due to harmonic current absorption, voltage distortion due to the voltage drop caused by harmonic currents flowing through system impedances, interference on telephone and communication line. Passive filter have been used traditionally for mitigating the distortion due to harmonic current in industrial power systems. But they have many drawbacks such as resonance problem, dependency of their performance on the system impedance, absorption of harmonic current of nonlinear load, which could lead to further harmonic propagation through the power system.

INTRODUCTION:

Nonlinear loads such as saturated coils and transformers are the main cause of producing harmonics in power system. Power electronic creates most of the due to its non liner characteristics pollution issues. Most of the pollution issues are created due to the nonlinear characteristics and fast switching of Power electronics. Classically, shunt passive filters, mainly consist of tuned LC filters and or high passive filters are used to reduce the harmonics and power capacitors are used to improve the power factor. But they have the limitations of fixed compensation, large size and can also exile resonance conditions. In this work both shunt passive filter is used for power quality improvement. Transformers, motors, cables, interrupters and capacitors are the some equipment which is affected by harmonics converters mainly produces notches and they basically affect the electronic control devices.

TECHNIQUES FOR POWER QUALITY IMPROVEMENT:

There are two routes to the reduction of power quality problems. The first way is known as load conditioning, which assures that the equipment is made less sensitive and effective to power disturbances. The second technique is, to install line-conditioning systems that counteract or suppress the power system disturbances .In distribution systems passive filters have been used to limit of harmonic currents.

OBJECTIVE:

In modern electrical distribution systems there has been a sudden increase of harmonics because of single phase and three-phase non-linear loads. These non-linear loads are cause of harmonics. Passive power filters have been used to overcome these problems. In this paper passive shunt filter is used for total harmonic distortion. Matlab simulation is used for presenting it. Basically the cause of harmonic is nonlinear load. For removing it passive shunt filter is used. Results are discussed in thesis work with the help of Matlab. Results of passive filter are also discussed. Total harmonic distortion is also calculated with the help of Matlab simulation.

REVIEW OF PAPER:

The literature is presented a brief introduction about passive shunt filter, uses of passive shunt filter for harmonic reduction in a power system. The research work has been also discussed some Matlab results regarding passive shunt filter. It also

shows literature survey of control techniques normally used in reduction of harmonics and reactive power. MATLAB simulation of passive filter is also discussed. During the last decade, substantial research has been carried out in innovating different new configurations for harmonic mitigation in ac-dc converter with R-L load. The following papers provide guidance for completion of thesis work.

K. V. Kumar, have been presented the performance comparison of Shunt Active Power Filter (SAPF) and Hybrid Active Power Filter (HAPF) with three different nonlinear loads synchronous reference frame theory are employed in this MATLAB simulation study.

B. Singh, K. Al-Haddad, presented a comprehensive review of active filter (AF) configurations, selection of components, control strategies.

J. W. Dixon, has been studying analytically and testing using computer simulations and experiments. In this paper, it has been cleared that the filter keeps the line current almost sinusoidal and in phase with the line voltage supply.

L. A. Morán, describes different problems in power quality in distribution systems and their solutions with power electronics based equipment. Series, shunt and hybrid active power filters are described showing their compensation characteristics and principles of operation. Different power circuits topologies are analyzed and discussed and control scheme for each type of active power filter are analyzed.

Mahesh Singh], identified the prominent concerns in the area and thereby to recommend measures that can enhance the quality of the power equipments, keeping in mind their economic viability and technical output. In this paper electromagnetic transient studies are presented for the following two custom power controllers: the distribution static compensator (D-STATCOM), and the dynamic voltage restorer (DVR). **Charles. S.** proposed a three of the three-phase shunt active filtering algorithms in time-domain. These algorithms have been compared for a non-linear load. The comparison of the simulation results show the effectiveness of both the algorithms although the time domain current detection modified algorithm is more complex in terms of its implementation aspects.

INTRODUCTION TO PASSIVE FILTER:

The power system is growing fast and electric utility is expected to supply fine quality of electric power with high efficiency and reliability. Efficiency and reliability can be improved with the help of additional power electronic controllers, but these devices introduce large distortions in current and voltage. These power quality issues became more serious in the past decade, with the proliferation of the solid state devices in rectifiers, variable speed drives, UPS, computers, printers, electronic equipments, etc. in the industrial, commercial and residential sectors. The voltage and current distortions generated by these equipments spread throughout the power system, causing malfunction of power system components, which are designed for operation under pure sinusoidal conditions.

CHARACTERISTICS OF PASSIVE FILTER WITH FIXED ELEMENTS:

Passive filters were preferred in the earlier days for harmonic compensation because they are simple in structure and easy to install. Different topologies of passive filters were emerged during stages of research. They are generally classified into series and shunt passive filters. Series passive filters use high series impedance to block harmonics, and shunt filters divert harmonics by means of a low impedance shunt path. The series filters must be designed to carry full load current, whereas shunt filters carry only a fraction of the current that a series filter carries. Also shunt filters, if properly designed, supply reactive power to the load at the fundamental frequency. Hence the most practical approach is to use shunt passive filters. The shunt passive filter is made up of passive elements resistance, inductance and capacitance. When the inductive and capacitive reactance of the passive filter become equal at a particular harmonic frequency, shunt passive filter acts as low impedance path for that harmonic component.

The selection of these element ratings depends on

1. Reactive power to be injected
2. Harmonics to be mitigated
3. Quality factor of the tuned filter circuit
4. Tolerance in supply frequency permitted
5. Tolerance in filter capacitance and inductance value due to ageing and temperature changes

Shunt passive filters are again categorized as single tuned, double tuned, high pass damped filters, etc. A single tuned filter is a series RLC circuit tuned for particular harmonic frequency, whereas double tuned filter is tuned for two harmonic frequencies. The double-tuned filter is preferred mainly in high-voltage applications, because of the reduction in the number of inductors to be subjected to full line voltages. Triple- and quadruple-tuned filters are rarely used because of the difficulty of adjustment of filter components. Automatically tuned filters use a control system, which measures the fundamental frequency reactive power to be compensated by the filter and uses the information to automatically switch the capacitance or to vary the inductance. But the measurement or computation of reactive power is complex and time consuming.

Damped Filters provide low impedance for a wide spectrum of harmonics with a single arm filter and are less sensitive to temperature variation, frequency deviation, component manufacturing tolerances etc., but they increase switching and maintenance problems. Also, to achieve a similar level of filtering performance as tuned filters, the damped filters need to be designed for higher fundamental VA ratings and hence losses in the resistor and reactor are high. Out of these available categories, the best one is to be selected that is suitable for the specific load conditions. In order to understand the effectiveness of shunt passive filter in compensating reactive power and harmonics of typical nonlinear load, phase controller for varying power consumed by a series R-L element, is considered.

CATERIZATION OF PASSIVE FILTER

The classification of Passive filter is done on the type of harmonic generation component source present in the system & passive component sys resistor, inductor & capacitor connected in the system & are given as

- 1: PASSIVE SERIES FILTER
- 2: PASSIVE SHUNT FILTER
- 3: PASSIVE HYBRID FILTER

A very classical type of passive filter is shown in the figure where filter is connected in the parallel with distribution system through power common coupling point having nonlinear load characteristics

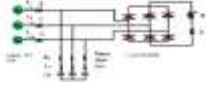
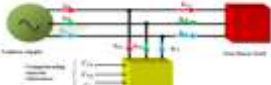
PASSIVE SERIES FILTER:

The system which come with the voltage source type harmonic which are the bi product of diode rectifier with R-L connected load it is prefer to use the series type passive filter as considered as potential remedy of harmonic mitigation. A The system which come with the voltage source type harmonic which are the bi product of diode rectifier with R-L connected load it is prefer to use the series type passive filter as considered as potential remedy of harmonic mitigation. Passive type series filter has property of purely inductive type or LC tuned characteristics. The main component of passive series filter is AC line reactor & DC link filter. The operating principle of

The system which come with the voltage source type harmonic which are the bi product of diode rectifier with R-L connected load it is prefer to use the series type passive filter as considered as potential remedy of harmonic mitigation. A passive type series filter has property of purely inductive type or LC tuned characteristics. Series passive filter is given by these two component connected in series that AC line reactor improve system magnitude of inductance in system that alters the path of current drawn in the rectifier circuit. These whole processes of offering magnitude in the system make system current waveform more continuous compare to without use of filter technology in the system.

PASSIVE SHUNT FILTER:

It is the most common method for the cancellation of harmonic current in the distribution system. Passive harmonic filter are basically designed on principle of either single tuned or band pass filter technology. As the name suggests shunt type filter are connected in system parallel with load. Passive filter offer a very low impedance in the network at the tuned frequency to divert all the related current & at given tuned frequency. Because of passive filter always have tendency of offering some reactive power in the circuit so the design of passive shunt filter take place for the two purpose one is the filtering purpose & another one is to provide reactive compensation purpose of correcting power factor in the circuit at desired level. The advantage with the passive shunt type filter is that it only carry fraction of current so the whole system AC power losses are reduced compare to series type filter. The given figure shows the schematic diagram of 6 pulse converter system connected with shunt passive type filter which are simply employed ever connection in distribution system have R-L load in system.

	
<p>Schematic diagram of a six pulse ac-dc converter with R-L load and passive shunt filter at input</p>	<p>The classic passive shunt filter</p>

PASSIVE HYBRID FILTER :

The use of passive shunt filter creates the problem of voltage regulation at light loads. It also increases the dc voltage ripple and ac peak current of the rectifier. On the other hand, passive series filter suffers from lagging power factor operation as well as the voltage drop across the filter components both at fundamental frequency as well as harmonic frequencies. To overcome these drawbacks, a combination of both these configurations is presented as passive hybrid filter. This configuration is able to supplement the shortfalls of both these passive filters and simultaneously it results in improvement in harmonic compensation characteristics for varying load condition even under stiff and distorted ac mains voltage.

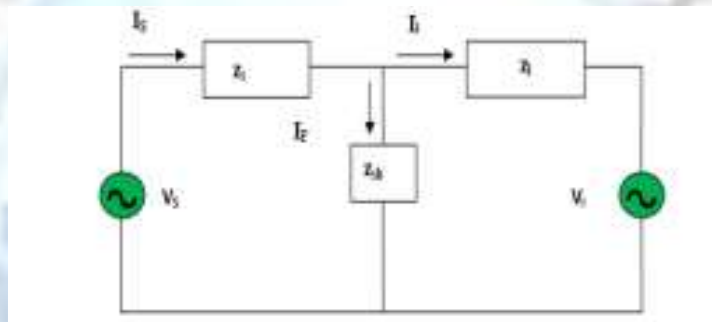


Fig.1 of Equivalent circuit diagram passive tuned shunt filter based configuration

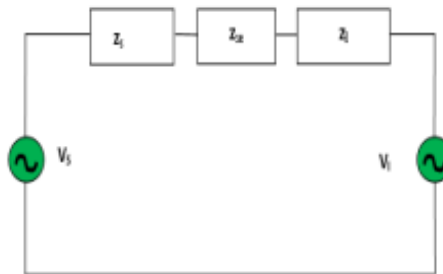


Fig.2 Equivalent circuit diagram of passive tuned series filter based configuration

RESULTS AND DISCUSSIONS:

SIMULATION RESULTS

The simulation results are obtained through MATLAB in SIMULINK by taking system parameter as given below. The system parameters which are used for the study of Passive shunt filter with TCR and TSC combination is given below.

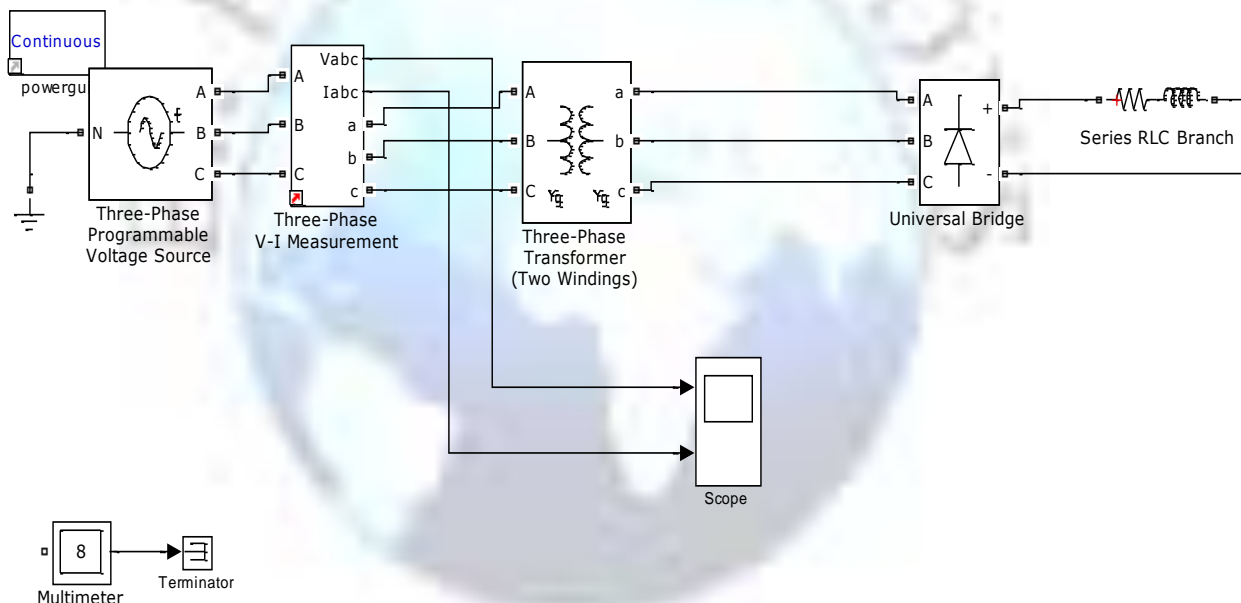
Components	Specification
AC Source	$V_s=415\text{V}$, $f=50\text{Hz}$
Nonlinear Load	Universal bridge $R_L=40, (\Omega)$ $L_L=50\text{e-}3(\text{H})$
Passive Filter	$\text{LPF}=16\text{e-}3$, $\text{RPF}=0.83$, $\text{CPF}=25\text{e-}6$

MATLAB BASED MODELING OF PASSIVE FILTER:

To demonstrate the performance of these passive filters feeding a three-phase converter with R-L load, these passive filters are modeled in MATLAB environment along with SIMULINK and power system block set toolboxes. Different components of these converters such as low pass filter with R-L load are simulated

PASSIVE SHUNT FILTER BASED CONVERTER WITH R-L LOAD:

Fig. below shows the MATLAB model of a passive series filter based six pulse ac-dc converters with R-L load. Depending on the harmonic spectrum of the supply current, the passive filters designed are low pass filter tuned for 5th order harmonic frequency. The subsystem named shunt filter consists of 5th harmonic frequency. Based on the design carried out the filter component values are $L=16\text{e-}3$, $C=25\text{e-}6$, $R=0.83$



MATLAB based model of a six pulse ac-dc converter R-L load without passive filter

THREE PHASE PROGRAMABLE VOLTAGE SOURCE:

This block implements a three-phase zero-impedance voltage source. The common node (neutral) of the three sources is accessible via input 1 (N) of the block. Time variation for the amplitude, phase and frequency of the fundamental can be pre-programmed. In addition, two harmonics can be superimposed on the fundamental.

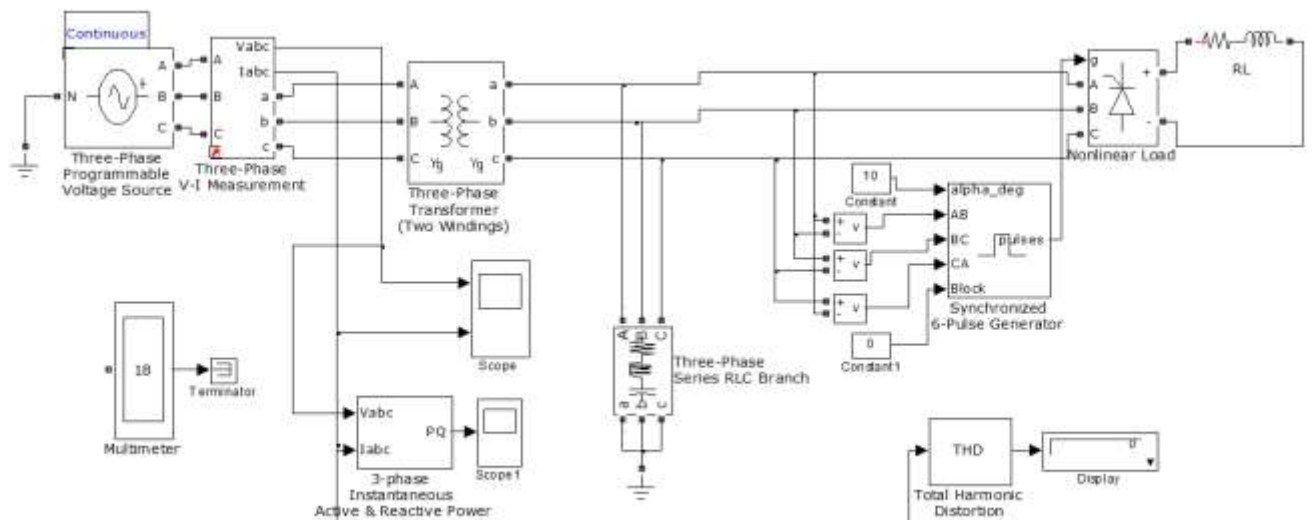
PERFORMANCE OF A SIX PULSE AC – DC CONVERTER R-L WITHOUT PASSIVE FILTER:

The performance of a six pulse ac-dc converter R-L without passive filter is shown in figure below. It shows waveforms of three phase transformer winding (two winding), waveforms of RLC branch current and RLC branch voltage.

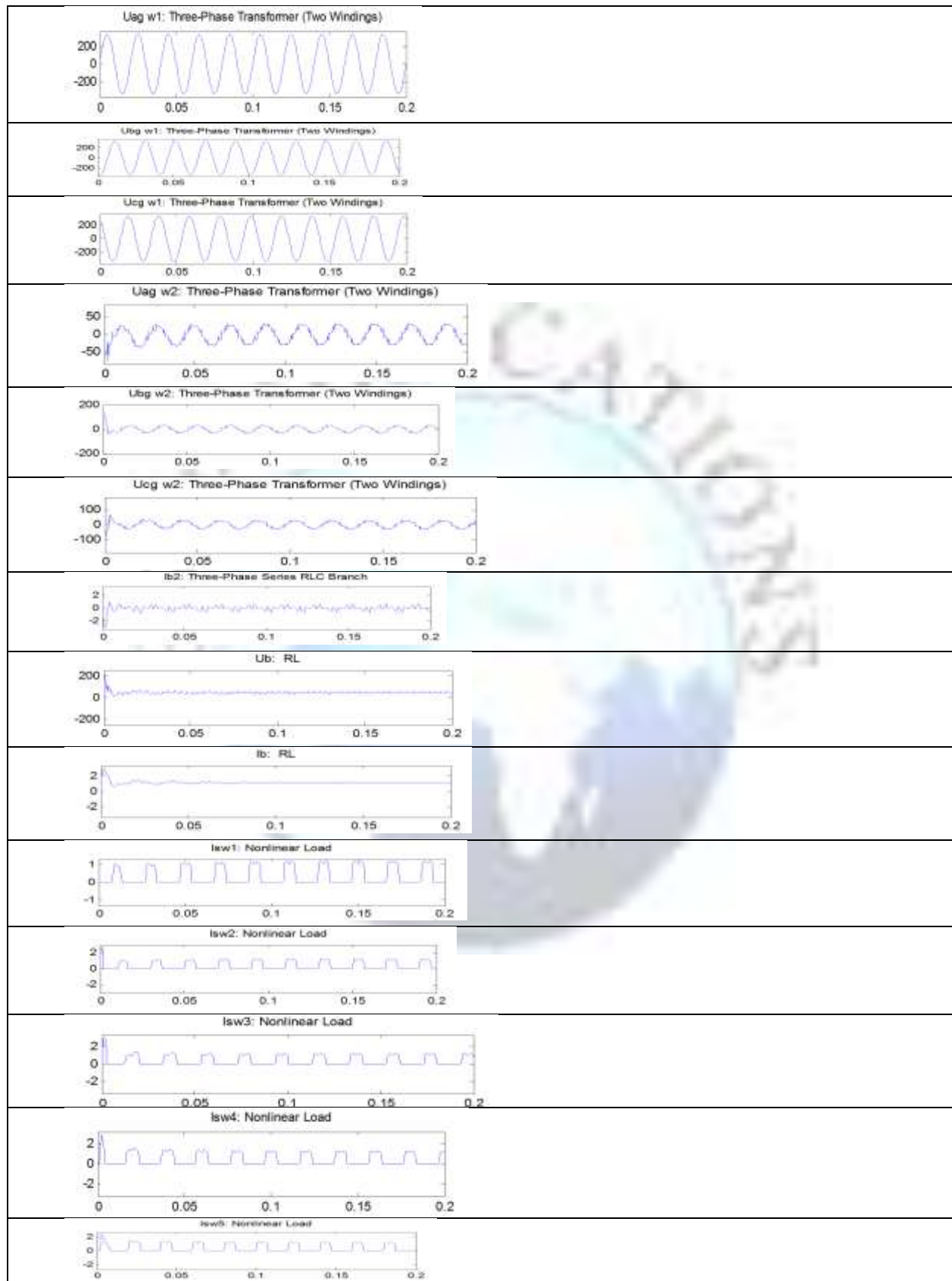


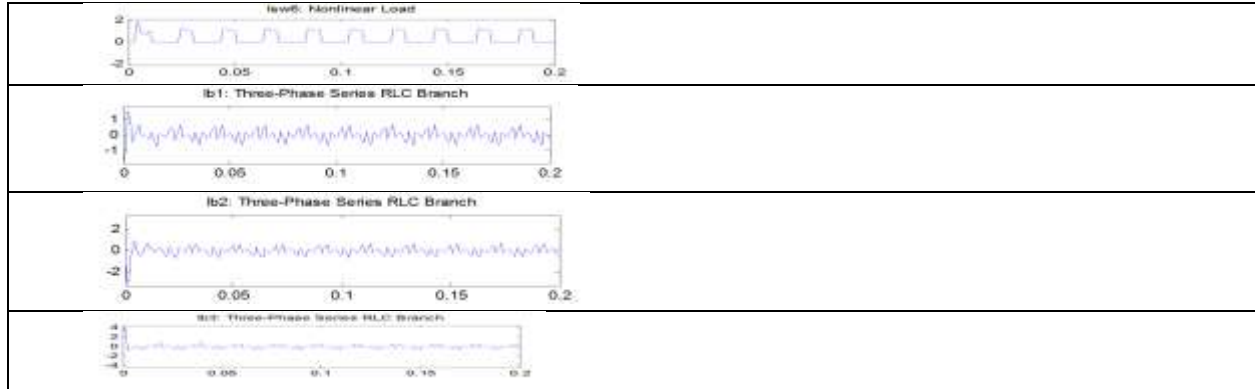
MATLAB BASED MODELING OF A PASSIVE SHUNT FILTER BASED CONVERTER WITH RL LOAD

Figure shows below the MATLAB model of passive shunt filter. The configuration of passive shunt filter has been simulated and developed for 6 pulse ac-dc converter with R-L load. The performance of a six pulse converter with passive shunt filter is presented here.



PERFORMANCE OF PASSIVE SHUT FILTER BASED CONVERTER WITH RL LOAD:





CONCLUSION:

The effect of multiple harmonic sources can be investigated by applying the superposition principle. The SVC harmonic generation modeled by positive-, negative-, and zero-sequence harmonic sources. The system represented by linear models at each harmonic frequency. The precise evaluation of harmonic distortion must have accurate load modeling.

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