Implementation of Shunt Active Power Filter for Harmonic Compensation by Various Logic Controllers

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Abstract-Electrical power is the most efficient and popular form of energy and there cent society is heavily needy on the electric give .The existence cannot be predict table 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.

I. INTRODUCTION

There are lots of filter topologies in the literature like active, passive and hybrid. In this development the use of hybrid power filters for the upgrading of electric power quality is studied and study.

1.2.1 Power Quality Problems:-

Along with the power quality troubles,the bring in interruption is, un disputedly, the harshest, as it affect all tools linked to the electrical net. On the advance troubles.

(a) Flicker:-

It happen due to intermittent variations of convinced loads, causing voltage fluctuations(which consequences ,for instance ,in oscillations on electric light intensity) [3]

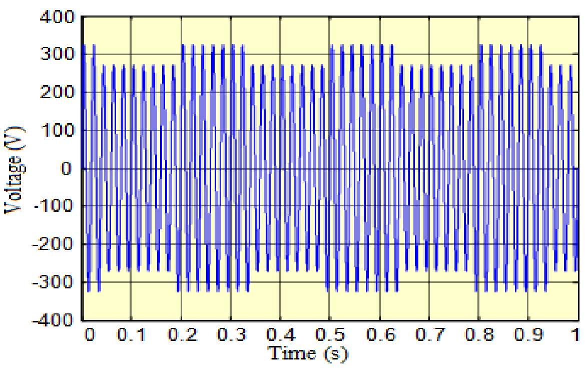

Figure1.1-g) Flicker

(i) Transients:-

Happen as a result of transit or y phenomenon, such as capacitor bank switching or atmospheric discharges.

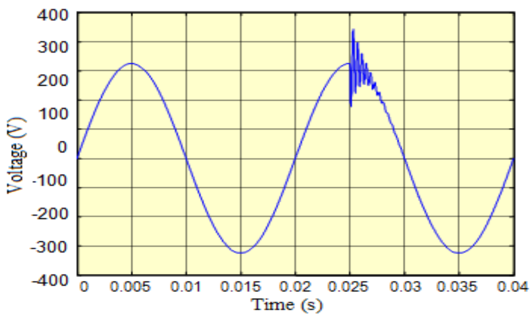

Figure1.1-i) Transients

1.2.2 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 capacitive filter output (Fig1.3a) [10].This is are liable and low cost promise. However, the inductor is bulky and deep.

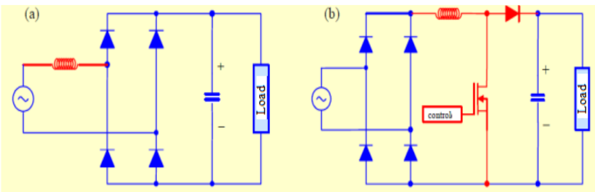

Figure 1.3 - Solutions to reduce the harmonics of the current in the input of the equipment: a)Series inductance ;b) Step-up converter

1.2.3 Medium and High Power:-

For an extended point, the electrical power sharing companies only have been impressive re active power confines tothetraditionallyclients.Theusuallyadoptresolutionbythemanufacturingconsistedontheuseofpowerfactorimprovementcapacitors bank. More in current epoch, the quandary associated to the current harmonics flowing throughout the electrical system, have compulsory many industrial patronsto apply harmonic decrease techniques base on in active filters.

1.2.4 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 oralteration). It also allows balancing the currents on the three phases(eliminating impartial wire currentevenwhen3rdharmexists)

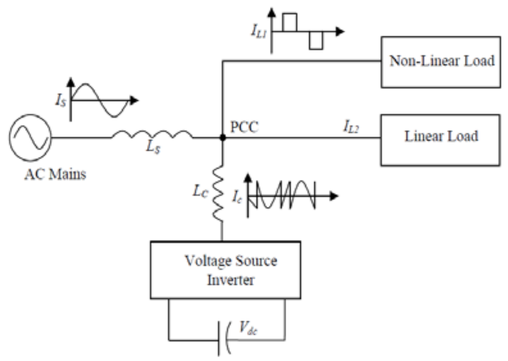

Figure 1.4 Shunt Active Filters

Current supplied by source from figure 3.1 the direct currents can be written as

$$i_s(t) = i_L(t) - i_c(t) \qquad (3.1)$$

The source voltage is given by

$$v_s(t) = V_m(t)\sin\omega t \qquad (3.2)$$

if a nonlinear load is applied, then the load current will have a fundamental component, and the harmonic components can be represented as

$$i_L(t) = \sum I_n \sin(n\omega t + \phi_n)$$

$$i_L(t) = I_1 \sin(n\omega t + \phi_1) + \sum I_1 \sin(n\omega t + \phi_n)$$

Direct load power can be given as

$$P_L(t) = V_s(t) * I_L(t)$$

$$P_L(t) = P_f(t) + P_r(t) + P_h(t)$$

From equation (3.5) real (Fundamental) power is drawn by the load

$$P_f(t) = V_m I_1 \sin^2 wt \times \cos\phi_1 = V_s(t) \times I_s(t)$$

II. LITERATURE SURVEY

[1]]García-González, A. García-Cerrada and O. Pinzón-Ardila, The analysis and the application of a current controller in an active power filter (APF) based on a PWM voltage-source electronic converter with three legs and four wires. The neutral wire is connected to the middle point of the DC-capacitor voltage.

[2] Parimala V1, Ganeshkumar D2, Benazir Hajira A3,This paper presents the improvement of power quality in three phase four wire system with balanced and unbalanced sourcecondition based on three phase shunt active power filter.

[17] D.K.Chaturvedi, Sr. Member, IEEE, Sinha Anand PremdayaIn this paper, a modified neural and neuron-fuzzy models have been developed for short-term load forecast using 33/11kV substation data. The substation load is recorded hourly and then neural networks / neuro-fuzzy models have been tunned with preprocessed data. In the test case for implementation.

[4] Arun Shankar V.K,Senthil Kumar N This paper explores the modeling of a Proportional Integral (PI) and fuzzy logic controller (FLC) based, shunt active power filter(SAPF) for a three wire network to compensate current harmonics fed to a nonlinear load. In the fuzzy logic controlled SAPF mathematical model of the system is not required since it is based on an inference system incorporating intelligence derived through human expertise.

[5] Roozbeh Naderi. A New Hybrid Active Neutral Point Clamped Flying Capacitor Multilevel Inverter"in this proposed A new hybrid 5-level inverter topology and modulation technique isproposed. Compared to 5-level ANPC as the most similar topology, this new topologyrequires two less switches at the cost of an additional capacitor and six diodes.

III. 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 measured results for the modern set of non-linear loads

S NO.	MODERN SET OF NON-LINEAR LOAD	POWER FACTOR	THD I {current} (%)	3rd	5th	7th	9th	11th
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

IV. FUZZY SET THEORY

If *U* is a collection of objects denoted generally by *x*, then a fuzzy set *A* in *U* is defined as a set of prearranged pairs. A algebraic expression for this mapping is given in

$$A = \{x, u\square_A(x) \,|\, \mathbf{x}\ €U\}$$

Where { u~$_A$(x)} is called a membership function for the fuzzy set *A*. The membership function maps every element of *U* to a membership grade between 0 and 1.

$$A_\alpha = \{x : u\sim_A(x) > \alpha \text{ and } | x \in U\}$$

4.1 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.

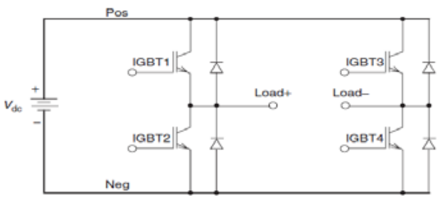

Figure 4.1: Single Phase Inverter

4.2 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.

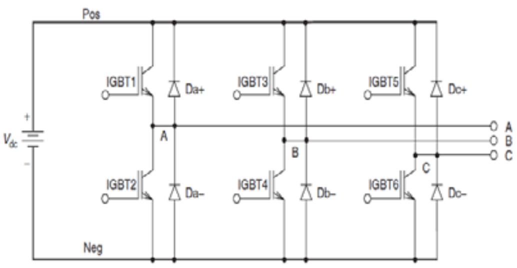

Figure 4.2: Three Phase Inverter.

4.3 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, V_O is the ac output while V_{in} is the input dc voltage.

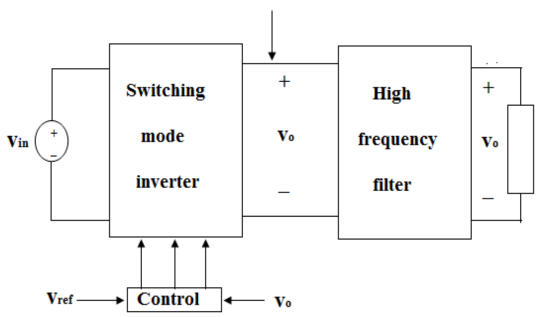

Figure 4.3: Single Phase Inverter with Filter

4.4Three 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.

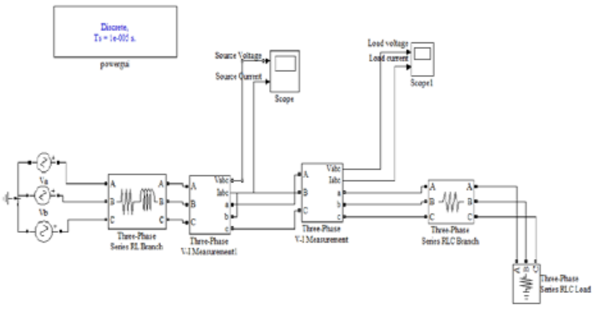

Figure 4.4 MATLAB simulink model of three phase circuit with linear load

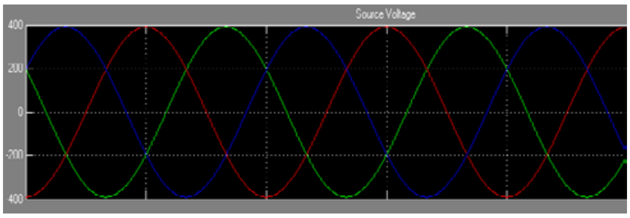

Figure 4.5 Source side voltage waveform of linear load circuit

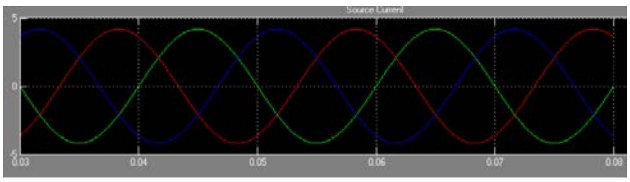

Figure 4.6 Source side current waveform of linear load circuit

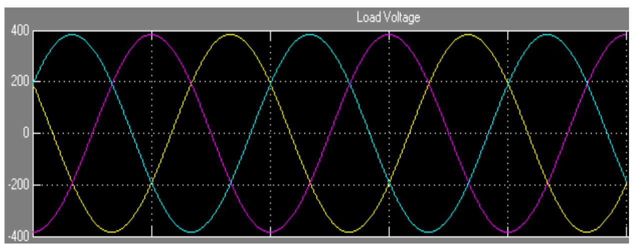

Figure 4.7 Load side-1 voltage waveform of linear load circuit

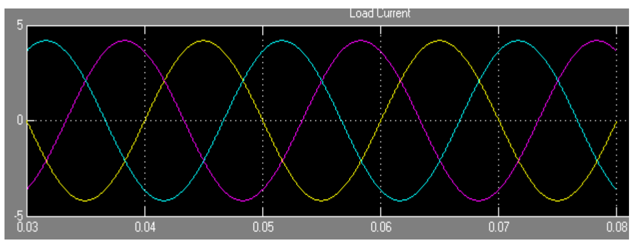

Figure 4.8 Load side-1 current waveform of Linear load circuit

4.5 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 4.9 that current is linear (Sinusoidal).

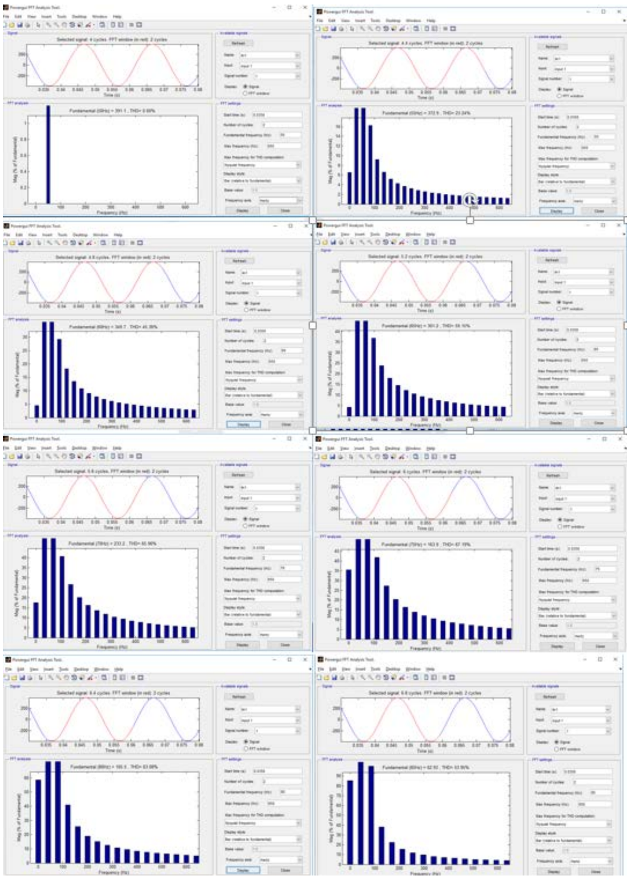

Figure 4.9 FFT analysis of current waveform of linear load circuit

Parameter	Linear	
	Frequency	THD(%)
Fundamental (50Hz)	391.1	0
Fundamental (55Hz)	372.9	0.2324
Fundamental (60Hz)	349.7	45.36
Fundamental (65Hz)	301.2	59.15
Fundamental (70Hz)	233.2	65.96
Fundamental (75Hz)	163.9	67.19
Fundamental (80Hz)	105.5	63.8
Fundamental (85Hz)	62.93	53.95

Table 6.1 Different values of Frequency and TSD for linear Load

Hysteresis 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 4.10 that current is linear (Sinusoidal).

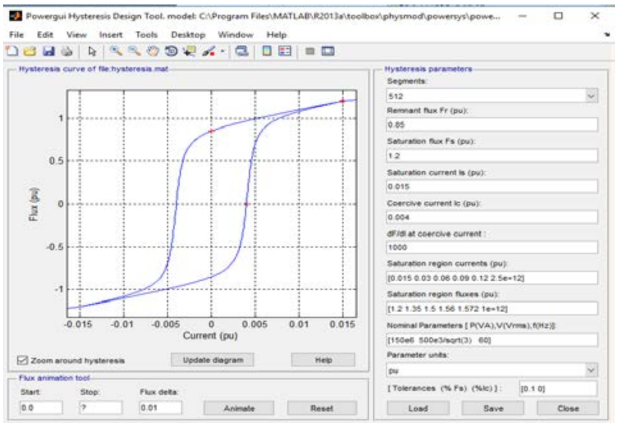

Figure 4.10 Hysteresis analysis of current waveform of linear load circuit

4.11 Three Phase circuit with linear 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.

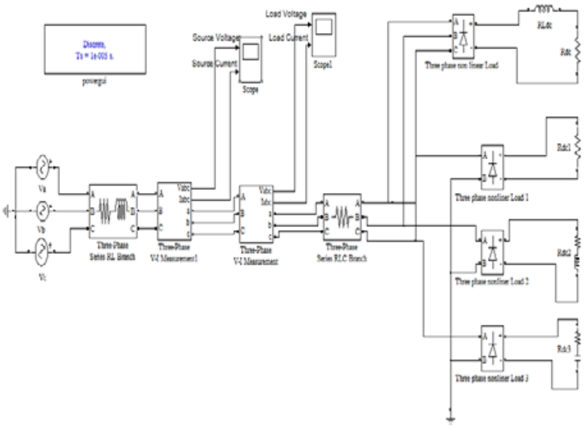

Figure 4.11 MATLAB simulink model of three phase circuit with nonlinear load

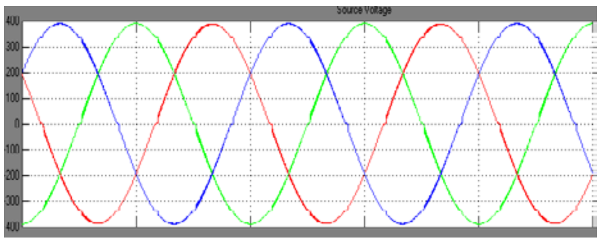

Figure 4.12 Source side voltage waveform of Non linear load circuit

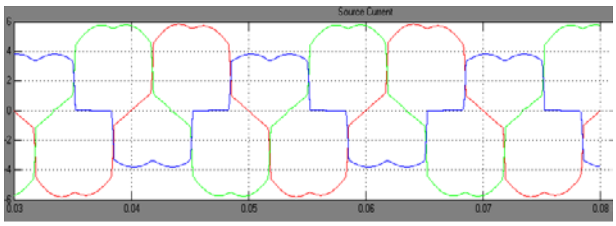

Figure 4.13 Source side current waveform of Non linear load circuit

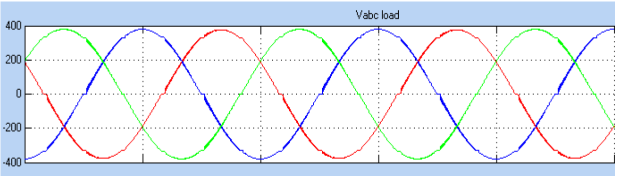

Figure 4.14 Non Linear Load side voltage waveform of non-linear load circuit

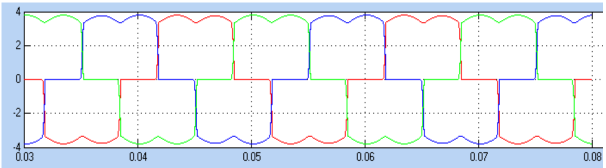

Figure 4.15 Non Linear Load side current waveform of non-linear load circuit

FFT analysis of current waveform of Non linear load circuit:-

It is the Fast Fourier Transform analysis of the current waveform of Non Linear load which give the total harmonics distortion of current 18.50 % it means there is harmonics presents.

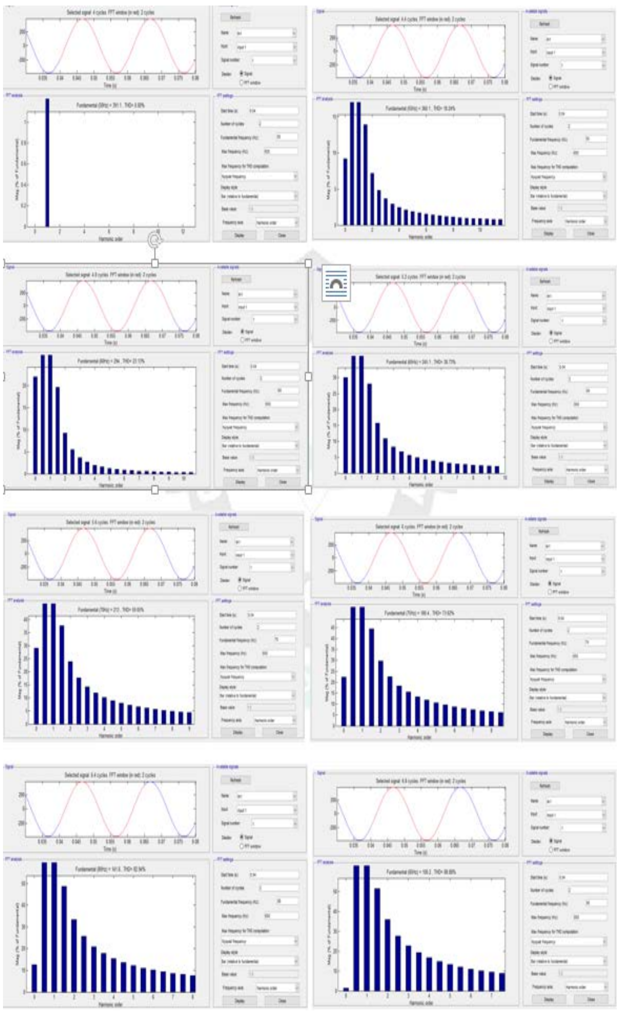

Figure 4.16 FFT analysis of current waveform of non liner load circuit

Parameter	Non-Linear	
	Frequency	THD(%)
Fundamental (50Hz)	391.1	0
Fundamental (55Hz)	360.1	18.24
Fundamental (60Hz)	294	23.13
Fundamental (65Hz)	245.1	38.73
Fundamental (70Hz)	213	59.05
Fundamental (75Hz)	180.4	73.62
Fundamental (80Hz)	141.6	82.94
Fundamental (85Hz)	100.2	88.88

Table 4.2 Different values of Frequency and TSD for Non linear Load

Hysteresis 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.

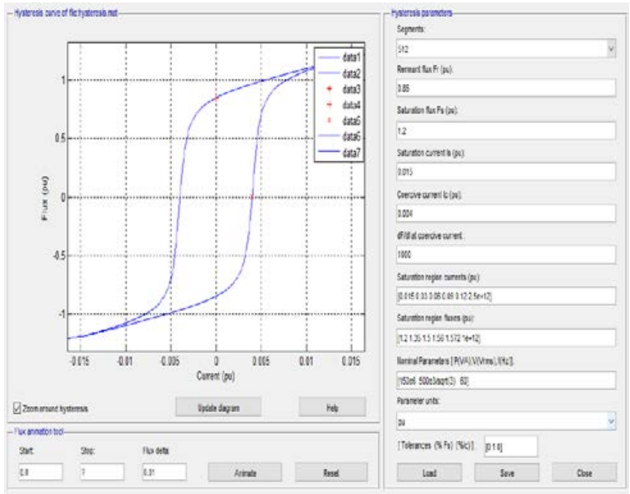

Figure 4.17 Hysteresis analysis of current waveform of non liner load circuit

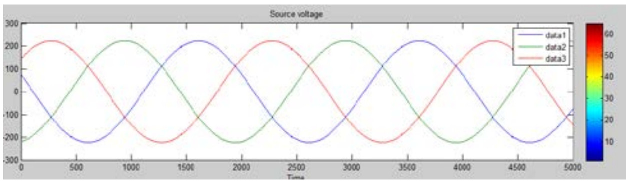

Figure 4.18 Source Voltage final waveform

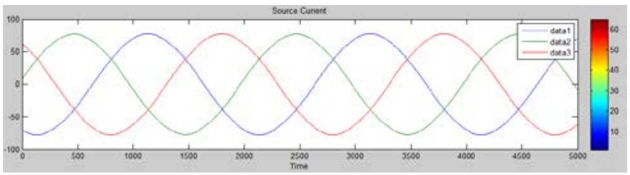

Figure 4.19 Source Current final waveform

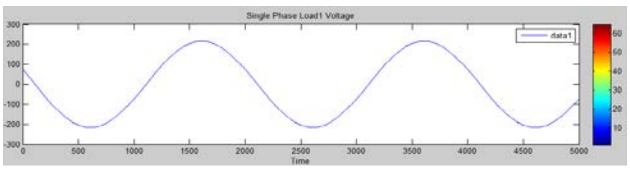

Figure 4.20 Single-Phase Load-1 Voltage final waveform

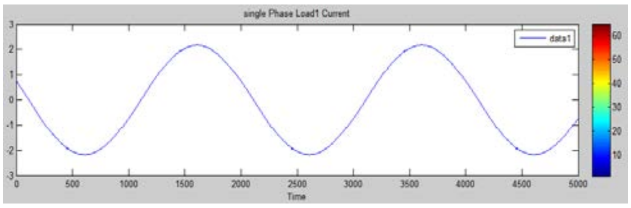

Figure 4.21 Single-Phase Load-1 Current final waveform

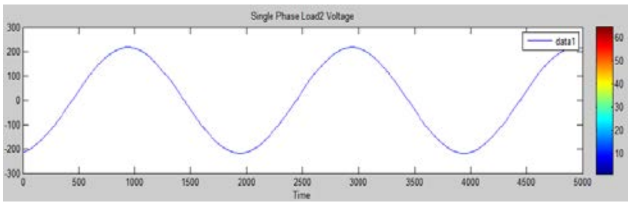

Figure 4.22 Single-Phase Load-2 Voltage final waveform

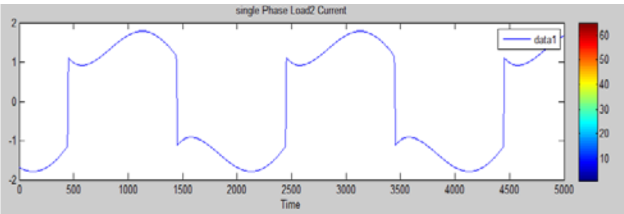

Figure 4.23 Single-Phase Load-2 Current final waveform

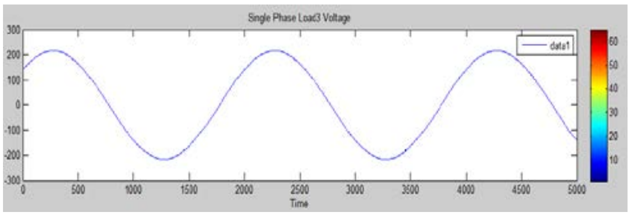

Figure 4.24 Single-Phase Load-3 Voltage final waveform

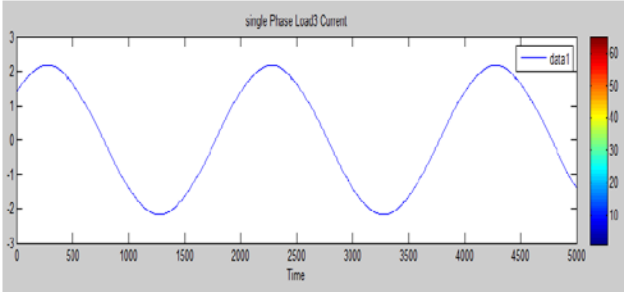

Figure 4.25 Single-Phase Load-3 Current final waveform

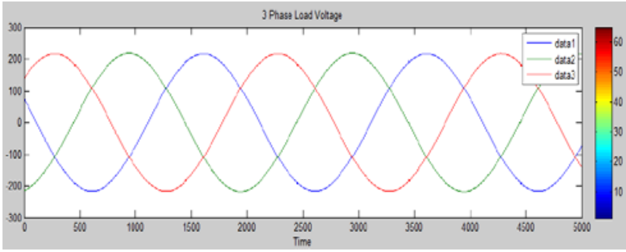

Figure 4.26 3-phase Load Voltage final waveform

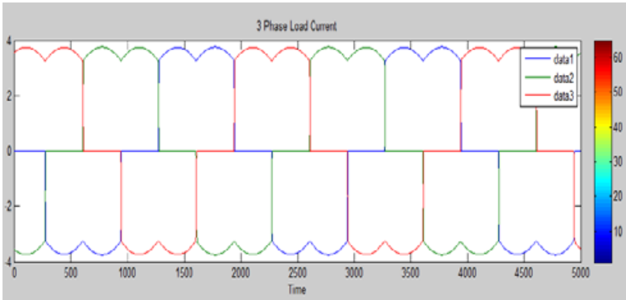

Figure 4.27 3-phase Load Current final waveform

V. RESULT COMPRESSION OF DIFFERENT MODEL

Parameter	Linear		Non-Linear		Extra- Non-Linear		Fuzzy Logic Controller	
	Frequency	THD (%)	Frequency	THD (%)	Frequency	THD (%)	Frequency	THD (%)
Fundamental (50Hz)	391.1	0	391.1	0	1.98	26.67	0.56	18.88
Fundamental (55Hz)	372.9	0.2324	360.1	18.24	1.824	36.29	0.005131	32.56
Fundamental (60Hz)	349.7	45.36	294	23.13	1.484	45.63	0.004035	27.71
Fundamental (65Hz)	301.2	59.15	245.1	38.73	1.123	53.37	0.003319	29.93
Fundamental (70Hz)	233.2	65.96	213	59.05	0.9127	59.92	0.003313	38.95
Fundamental (75Hz)	163.9	67.19	180.4	73.62	0.8048	72.48	0.002716	48.06
Fundamental (80Hz)	105.5	63.8	141.6	82.94	0.6719	87.6	0.002284	61.68
Fundamental (85Hz)	62.93	53.95	100.2	88.88	0.5066	115.71	0.001756	74.82

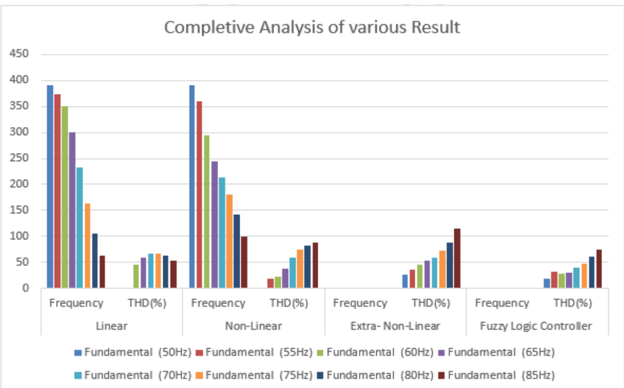

TABLE 6.6 Comparisons of All Model

Comparison	Case-1 (Linear Load)	Case-2 (Non- Linear Load)	Case-3 (Non Linear load with Shunt active Filter)
Ohm's Law	Applicable	Not Applicable	Not Applicable
Crest Factor	1.41	Could be 3 to 4	Could be 3 to 4
Source Side Current Waveform Shape	Pure Sinusoidal	Distorted	Sinusoidal
Total Harmonics Distortion	0%	18.50%	0.68%
Load Type	Capacitive and Inductive load	Power Electronics Devices(Diode and Thyristor etc)	Non-Liner load With Active power Filter with Fuzzy Logic controller

The performance of a Fuzzy Logic Controlled based Shunt Active Filter is verified. Order of harmonics of the current wave form (THD=18.50%) with connected non-liner load reduced to (THD=0.68%) with connected Shunt Active Filter with Fuzzy Logic Controller.

VI. CONCLUSION

This thesis presents the harmonics of power system. Inverter circuit and shunt active power filter.

In this thesis weexplained the application of the fuzzy logic controller to control the compensating voltage.

Fuzzy logic Controller for the three-phase circuit is pretend and the THD calculated verify the lessening of harmonics base shunt active filter.

We use the MATLAB/Simulink software to suggest the shunt active power filter base model.

The SAPF is capable to recompense unbalanced nonlinear load currents of a three-phase system.

We evaluate three case of MATLAB/Simulink model and results of THD of different cases.

Though various optimization techniques are present, research is being done for the best eliminated results of THD.

In this thesis proposes a technique to reduce the converter losses in the shunt active power filter.

FUTURESCOPE

Practical analysis can be done on shunt active power filter by designing a model in the laboratory to demonstrate the simulation outcome for balanced and unbalanced non-linear loads under in distinct source voltage situation with fuzzy-Nero controller. The future shunt active power filter can pay compensation on insist the harmonic current as well as the THD.

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