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The Study of Harmonics in Three Phase Ups System Considering Linear and Non Linear Load

Harmonic current generation in three phase UPS system

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Abstract — *UPS (Uninterrupted power system) is an electrical apparatus that provides emergency power to a load when the input power source fails to operate. UPS is used to protect hardware such as computer data centres and other electrical equipments where uninterrupted power disruption could cause data loss. This paper proposes a simple optimal voltage control method for three-phase uninterruptible-power-supply systems. The proposed voltage controller is composed of a feedback control term and a compensating control term. The former term is designed to make the system errors converge to zero, whereas the latter term is applied to compensate for the system uncertainties and also to reduce the harmonics in the system. Moreover, the optimal load current observer is used to optimize system cost and reliability. The effectiveness of the proposed controller is validated through simulations on MATLAB/Simulink. The comparative results of resistive load and non linear load are presented to achieve an excellent performance such as fast transient response, small steady-state error, and low total harmonic distortion.*

Keywords- *UPS (Uninterrupted Power Supply), optimal load current observer, DSP, PWM, THD (Total Harmonic Distortion)*

I. INTRODUCTION

Uninterrupted Power Supply (UPS) supply emergency power in case of utility power failures. Recently, the importance of the UPS systems has been intensified more and more due to the increase of sensitive and critical applications such as communication systems, medical equipment, semiconductor manufacturing systems, and data processing systems [1] These applications require clean power and high reliability regardless of the electric power failures and distorted utility supply voltage. Thus, the performance of the UPS systems is usually evaluated in terms of the total harmonic distortion (THD) of the output voltage and the transient/steady state responses regardless of the load. In this paper two loads are considered, i.e normal resistive load and non linear load. The simulation results of normal load and non linear loads can be seen. A proposed system is designed to reduce the effect on the system due to non linear loads. Finally, the results clearly show that the proposed scheme has a good voltage regulation capability such as fast transient behavior, small steady-state error, and low THD under various loads.[3]

Many authors and researchers have discussed about the harmonics generation and its reduction techniques like; S. B.Bekiarov, A. Emadi have explained about the UPS sytem like their classification, operation, control etc[1]. S.Parthasarathy, P.Loganthurai, S.Selvakumaran, V.Rajasekaran have explained about the harmonic distortion and the methods to mitigate the harmonics using Phase Locked Loop (PLL) based passive power filters[2]

This paper presents the comparative study of linear and non linear load and its impact on three phase UPS system. The structure of paper is organized as: Section II describes the linear system consisting of resistive load and its THD measurements. Section III describes non linear loads with three phase diode rectifier and its THD measurement. Section IV describes the proposed model to reduce harmonics for UPS system. Section V is about the conclusion of the paper.

II. NORMAL LOAD SYSTEM WITH SIMULATION RESULTS

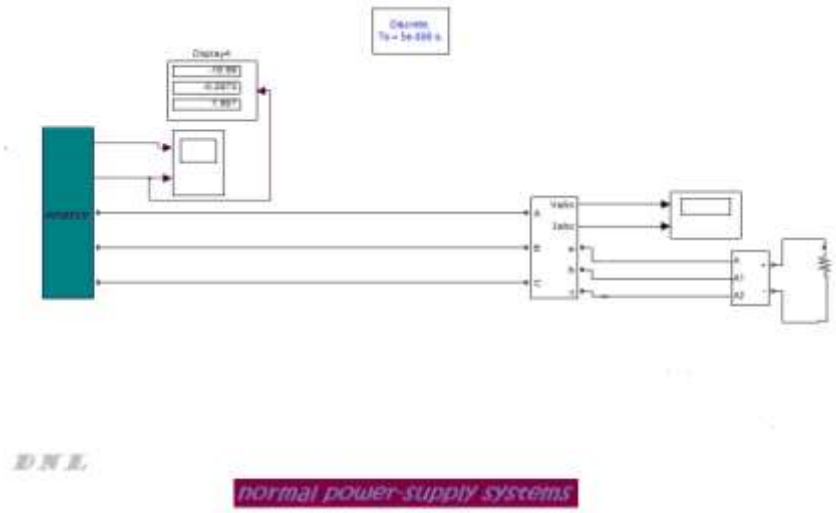

Fig 1. Normal power system with resistive load

Figure 1 shows the matlab model of normal power system with resistive load. As the load connected to the system is purely resistive, it do not affect the system. That means we get the voltage and current waveforms for this system as purely sinusoidal. The waveforms of voltage and current for normal system can be observed in figure 2.

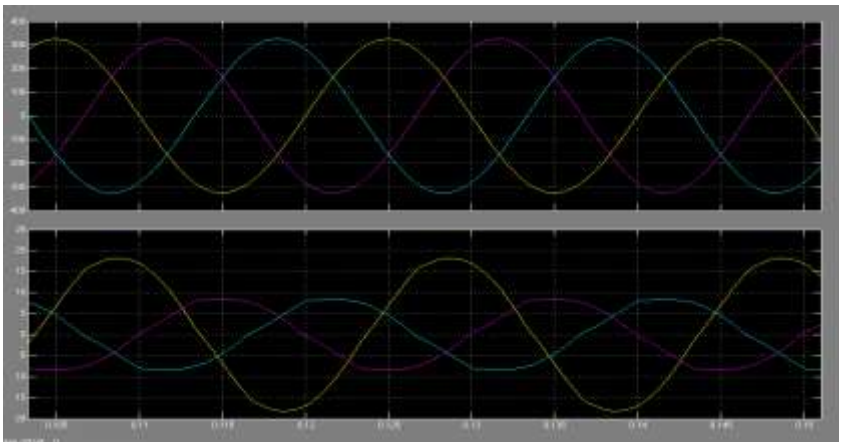

Fig 2. Voltage and current waveform for normal system

As the waveforms for voltage and current are purely sinusoidal, the harmonics in the system are very much less. This can be observed in FFT analysis in fig 3 and fig 4. The THD in source side as well as in the load side is 1.72%.

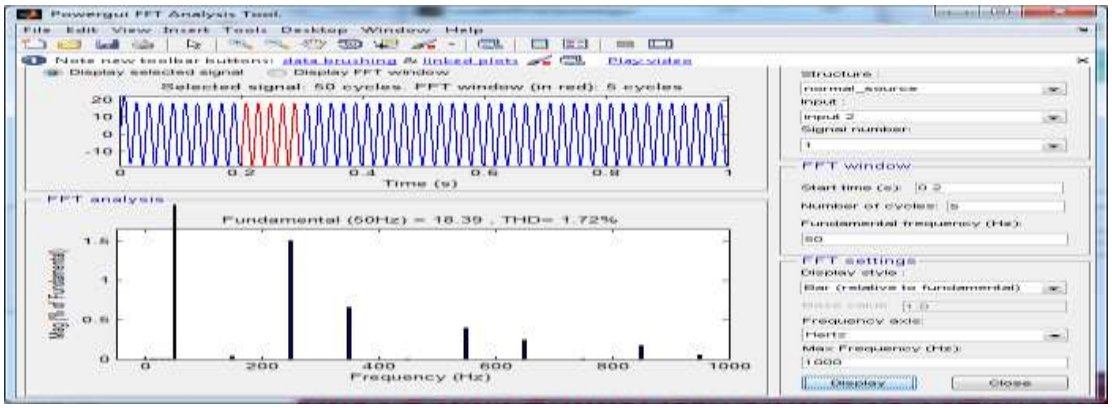

Fig 3. Source side FFT

In fig 3 we can see the source side FFT analysis of normal system. Here input 2 means current side THD. It can be observed that THD of source side current is 1.72%

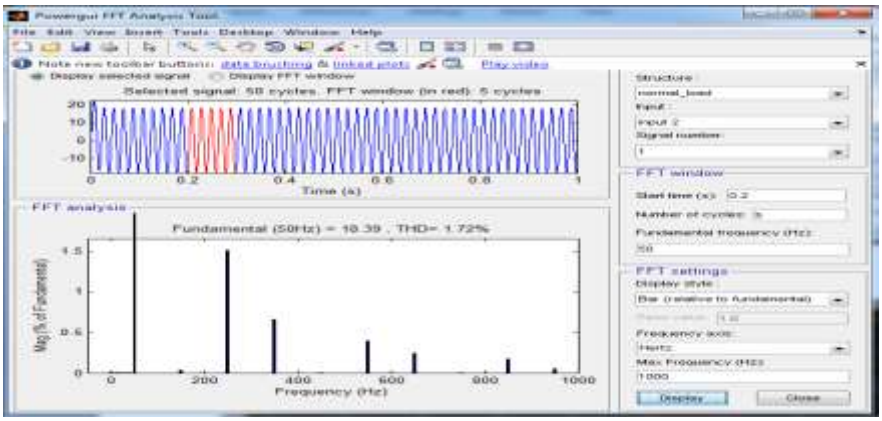

Fig 4 Load side FFT

Fig 4 shows the load side FFT of normal system. In this also THD of input 2 is shown which means current. The THD of load side current is 1.72%

III. NON-LINEAR LOAD SYSTEM WITH SIMULATION RESULTS

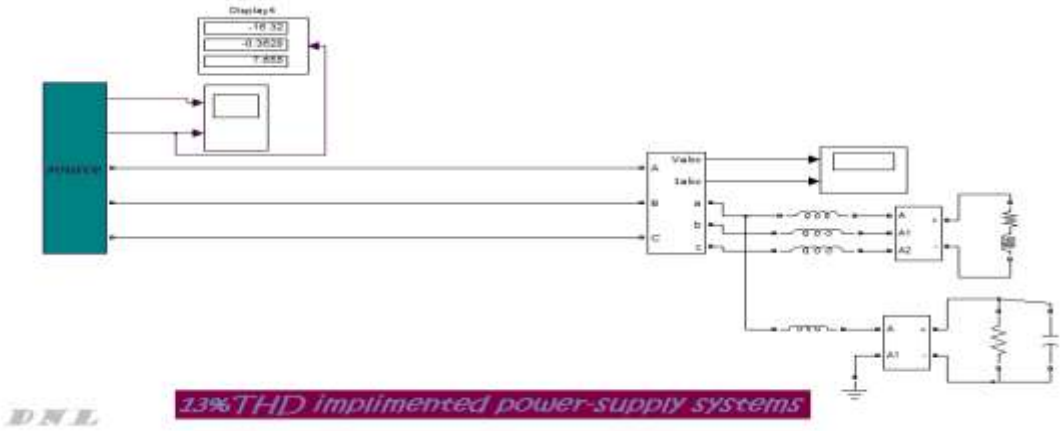

Fig 5. 13% THD implemented system with non linear loads

Figure 5 shows the power system with non linear loads. Due to these non linear loads, 13% harmonics is implemented in the system. In normal power system there was only resistive load due to which harmonics % was less and we got purely sinusoidal waveform. But in fig 5, non linear loads such as inductive loads are present due to which we do not get sinusoidal waveform. These loads affect voltage side so voltage waveform is non sinusoidal. This can be shown in fig 6.

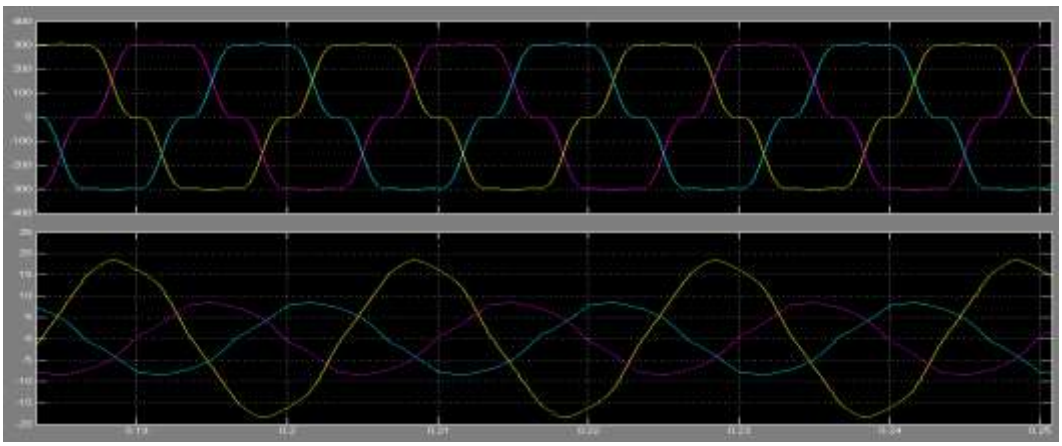

Fig 6. Voltage and current waveforms for non linear loads

Above fig shows the waveforms of source side voltage and current for non linear loads. It can be seen that due to non linear loads the voltage waveform here is non sinusoidal.

In fig 7 and fig 8, the FFT analysis for non linear loads is shown. Here also source 2 which means current is shown as we are considering current in this paper.

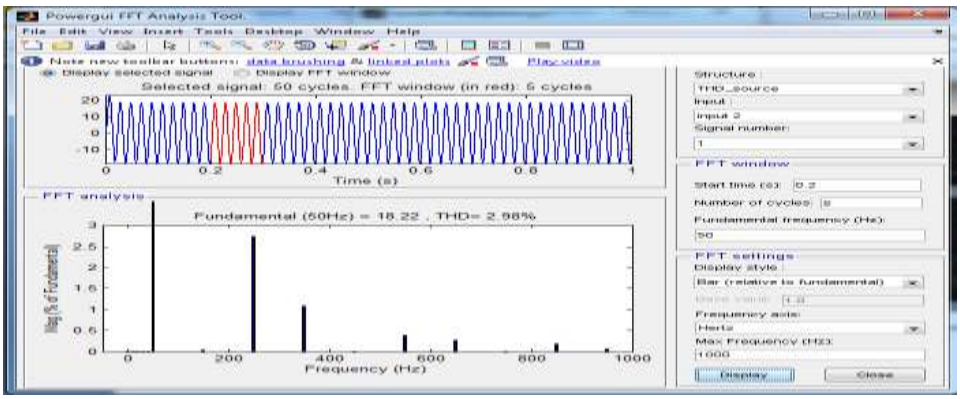

Fig 7. Source side FFT

Fig 8 shows the load side FFT analysis for non linear loads for source 2. The THD value for current is 2.98% which can be seen in above figure.

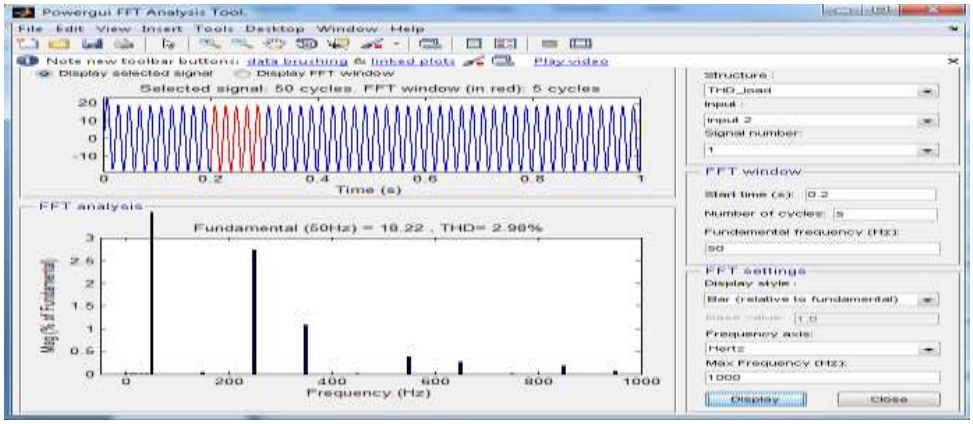

Fig 8. Load side FFT

In order to reduce the harmonics present in the system due to non linear loads, a proposed system is designed by using DSP which is explained in the below section.

IV PROPOSED SYSTEM WITH SIMULATION RESULTS

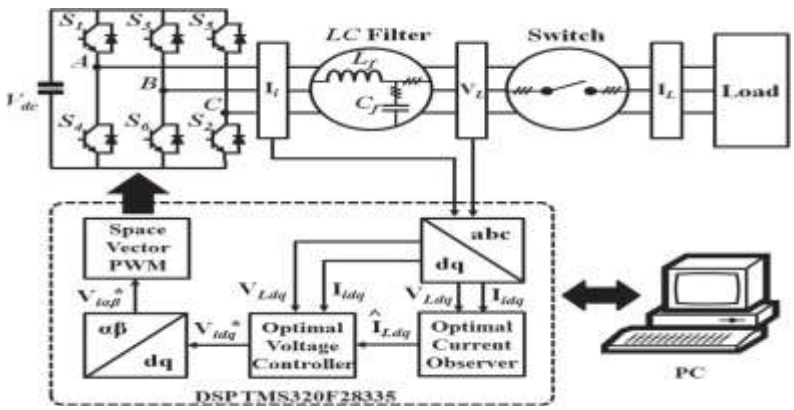

Fig 9. Proposed model

Figure 9 shows the proposed model diagram designed to reduce harmonics in the system. It consist of three leg stack cell, LC filter, DSP, switch. DSP consists of abc to dq transformer, optimal voltage controller, pulse width modulator. Firstly line current and voltage is taken as a reference and given to DSP. As the supply is three phase ac, abc to dq will convert into DC supply. After converting it into dc supply, it is given to optimal voltage controller and then converted into αβ axis by using dq to αβ transformation. Afterwards it is given to pulse width modulator which generates pulses and gives

to to IGBTs. Then by using LC filter the harmonics in the system are reduced. Vdc is a battery used to store dc supply in it. DSP is designed by using two theories viz; IRP (Instantaneous reactive power theory) and SRF (Synchronous Rotating Frame) theory. abc to dq transformation means park's transformation whereas dq to αβ transformation means clerk's transformation. The matlab model for proposed system is shown in fig 10.

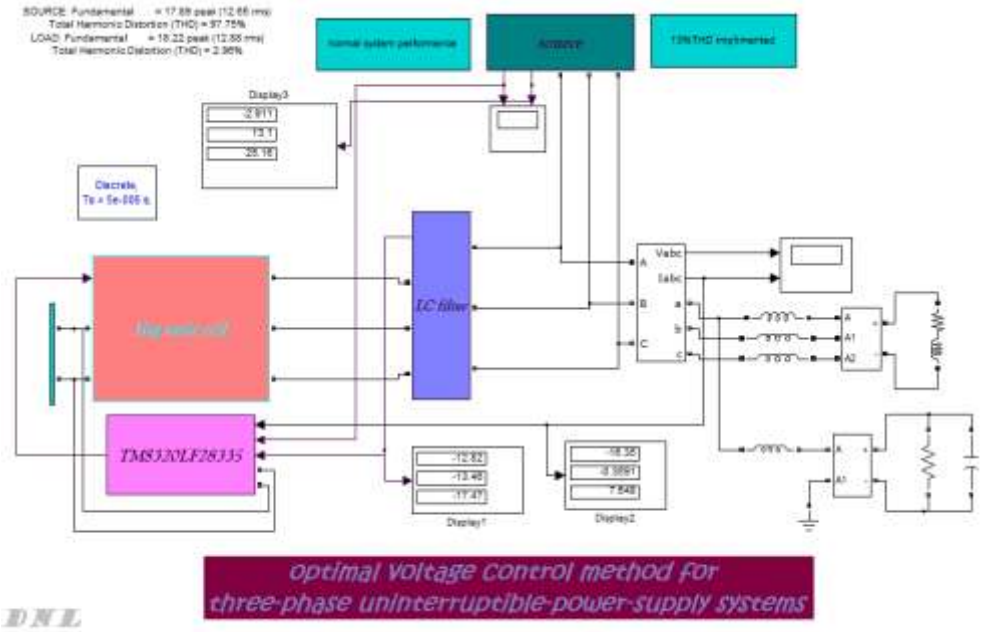

Fig 10. Matlab model for proposed system

The simulation results for the matlab model shown in fig 10 are shown below in fig 11 and fig 12. Both the voltage and current waveforms are non sinusoidal in fig 11 which are source side results. As due to external sources present in the system, a large amount of harmonics is present in the system.

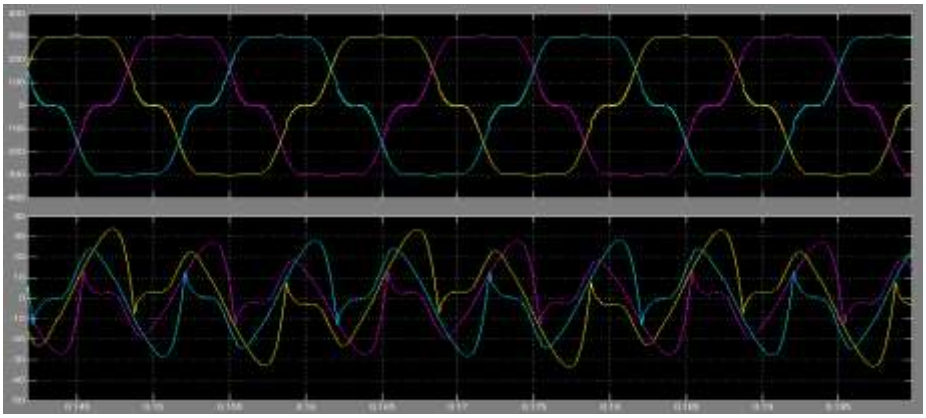

Fig 11 source side voltage and current waveforms

Fig 12 shows the load side voltage and current waveforms for proposed system. The harmonics in the current are reduced by using the proposed system and in the load side we can get purely sinusoidal system.

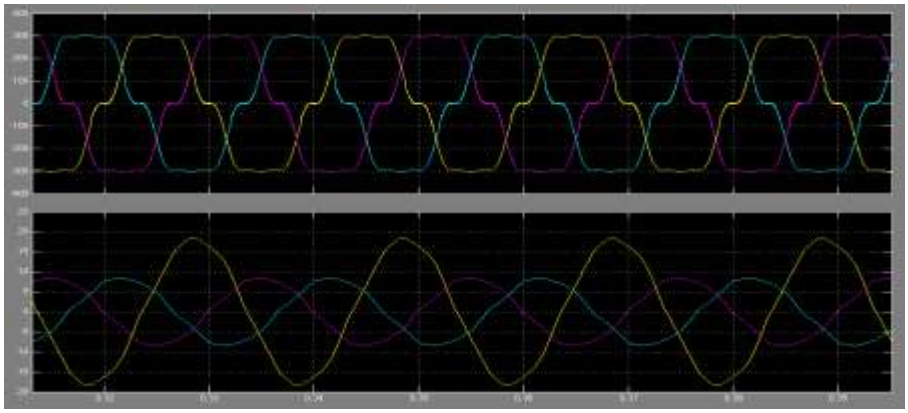

Fig 12. Load side voltage and current waveforms

Fig 13 shows and fig 14 shows the source side and load side FFT analysis for proposed system. It can be seen that source side THD for current is 97.75% whereas the load side THD for current is reduced upto 2.98%

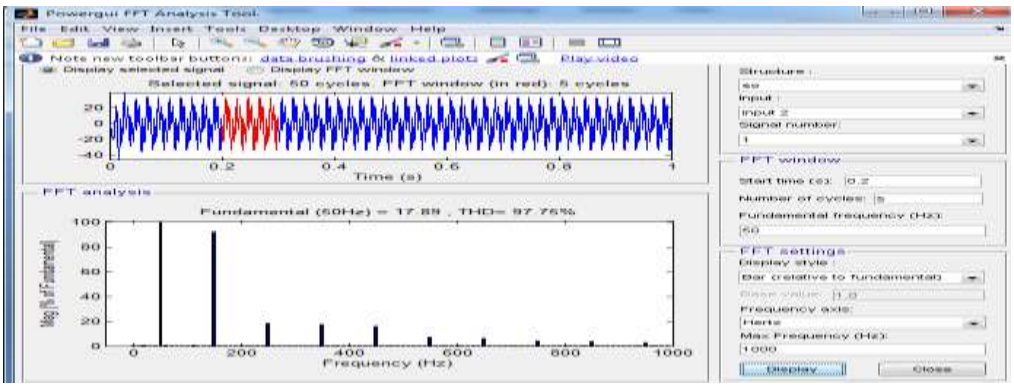

Fig 13. Source side FFT

In fig 13 as well as in fig 14 also the FFT analysis for source 2 is shown. The THD value we get at the load side is a very low value from which we can conclude that the harmonics present in the system are reduced.

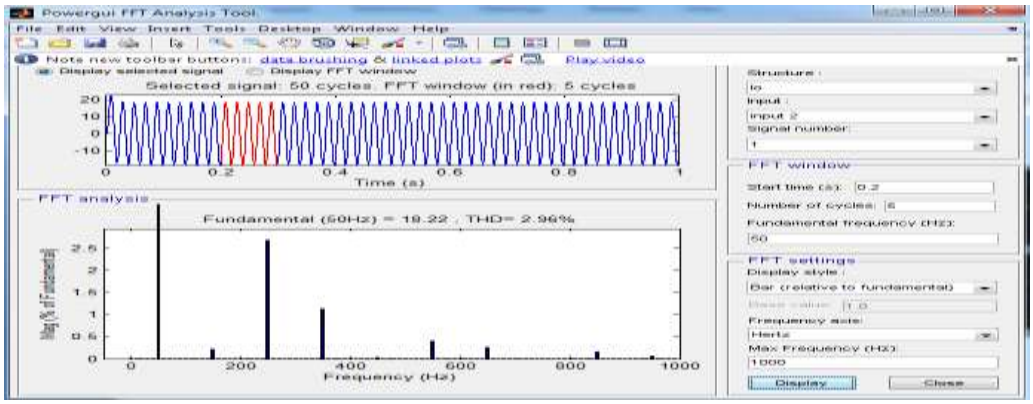

Fig 14. Load side FFT

V CONCLUSION

- The power system with resistive load does not contain any of the harmonics due to which we get purely sinusoidal waveform and its THD is 1.72% at source as well as load side
- The power system with non linear loads contains harmonics which affects the voltage and we get non sinusoidal waveform and THD for this system is 2.96%
- The proposed system designed to reduce harmonics contains external loads due to which the THD of load at source side is 97.75% and load current is non sinusoidal where as at the load side we get purely sinusoidal waveform and the THD value is decreased upto 2.96%

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