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DESIGN AND IMPLEMENTATION OF A FUZZY LOGIC CONTROLLER FOR MULTILEVEL INVERTER TOPOLOGY

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Abstract
It has been found that by using Fuzzy Logic Control scheme can greatly reduce harmonics distortions generated by the Multilevel Inverter. Harmonics reduction is the main consideration in the inverter circuit. The performance of the multilevel inverter increased by the reduction of THD. Multilevel inverters widely accepted for high-power high-voltage applications. In this research work, a new topology with a reversing-voltage component is proposed to improve the multilevel performance. This topology requires fewer components compared to existing inverters (particularly in higher levels) and requires fewer carrier signals and gate drives. The output voltage is regulated at a desired level in the face of source voltage disturbances or load disturbances using fuzzy logic control scheme. Both PI control scheme and fuzzy logic control scheme are analysed by using Matlab simulation. The inverter is proposed to deliver 40V / 300W. The source voltage variation can be anywhere between 24 volts and 50 volts DC. A prototype of the seven-level proposed topology is built and tested to show the performance of the inverter by experimental results. The percentage THD values of the multilevel inverter was analysed by using PI control scheme and Fuzzy Logic Control scheme. In this research work the current harmonics distortion was reduced by using Fuzzy Logic Control scheme, there was reduction of current THD 2.49 % , which increases the performance of the multilevel inverter.

Keywords: Multilevel Inverter, Fuzzy Logic, Mat lab, VTHD, CTHD

1. Introduction

Multilevel inverter is an effective solution for increasing power and reducing harmonics of ac waveform. Multilevel power conversion was first introduced more than two decades ago. The general concept involves utilizing a higher number of active semiconductor switches to perform the power conversion in small voltage steps. There are several advantages to this approach when compared with the conventional power conversion approach. The smaller voltage steps lead to the production of higher power quality waveforms and also reduce voltage (dv/dt) stress on the load and the electromagnetic compatibility concerns. Another important feature of multilevel converters is that the semiconductors are wired in a series-type connection, which allows operation at higher voltages and the series connection is typically made with clamping diodes, which eliminates overvoltage concerns. The multilevel output is generated with a multi winding transformer. However, the design and manufacturing of a multi-winding transformer are difficult and costly for high-power applications. A novel four-level inverter topology is also proposed, and it is valid for inverters with even number of voltage levels and not capable of outputting a zero-voltage state. As a result, the inverter output phase voltage for zero modulation indexes is a bipolar waveform taking two distinct values and exhibits high RMS value and considerable harmonic energy concentrated at the switching frequency. This is a disadvantage of the proposed

inverter, particularly when it should output low or zero voltage to a load. Another approach is selection based on a set target which can be either the minimum switches used or the minimum used dc voltage. It also requires different voltage source values which are defined according to the target selection. However, this approach also needs basic units which are connected in series, and the basic units still require more switches than the proposed topology. Another disadvantage of the topology is that the power switches and diodes also need to have a different rating which is a major drawback of the topology. In this research a new topology with a reversing-voltage component is proposed to improve the multilevel performance by compensating the disadvantages mentioned. This topology requires fewer components compared to existing inverters (particularly in higher levels) and requires fewer carrier signals and gate drives. Hence this new topology is named as Reversing Voltage (RV) topology.

2. Multilevel Inverter and THD

2.1 Multilevel Inverter

Multilevel inverters have been widely used for high-power and high-voltage applications. Their performance is highly superior to that of conventional two-level inverters due to lower switch ratings, lower electromagnetic interference, reduced Total Harmonic Distortion (THD), and higher dc link voltages. However, they have some disadvantages such as increased number of components, complex pulse width modulation control method, and voltage-balancing problem.

2.2 Types of Multilevel Inverter

a. Diode clamped Multilevel Inverter
b. Flying capacitor Multilevel Inverter
c. Cascaded Multilevel Inverter

2.3 Total harmonic distortion

The total harmonic distortion was a measurement of the harmonic distortion present and was defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. THD was used to characterize the linearity of audio systems and the power quality of electric power systems. In power systems, lower THD means reduction in peak currents, heating, emissions, and core loss in motors. Total harmonic distortion was measured as the percentage. Lower percentages were better.

2.3.1 Sources of harmonics

a. The following sources create the harmonics in electrical circuits.
b. Adjustable speed drives
c. Power supplies
d. Electronic ballast
e. UPS

f. Arc furnaces
g. Welding units and Computers

2.3.2 Common Symptoms of Harmonics

a. Due to harmonics the following symptoms are observed in electrical equipments.
b. Transformer heating
c. Motor and Generator heating and vibrations
d. Nuisance fuse operations
e. Insulation deterioration
f. Electronic control malfunctioning
g. Voltage regulator mal operation

3. Proposed Work

The inverter output voltage may not retain stable due to the disturbances that may occur in the source and load sides. To overcome this draw back Fuzzy logic control scheme are used in seven level inverter circuit.PIC microcontroller are used in Fuzzy logic control scheme. In this research work the performance of the multilevel inverter was improved by reverse voltage topology. This topology requires fewer components compared to existing inverters and requires fewer carrier signals and gate drives. The output voltage is regulated at a desired level by using fuzzy logic control scheme.

4. Development of seven level Inverter using RV topology with PI controller and Fuzzy logic controller

A Seven level inverter using RV topology with PI controller model was implemented in Matlab Simulink software with PD-SPWM technique. The following Figure1 shows the simulation circuit diagram of seven level inverter using RV topology with PI controller.

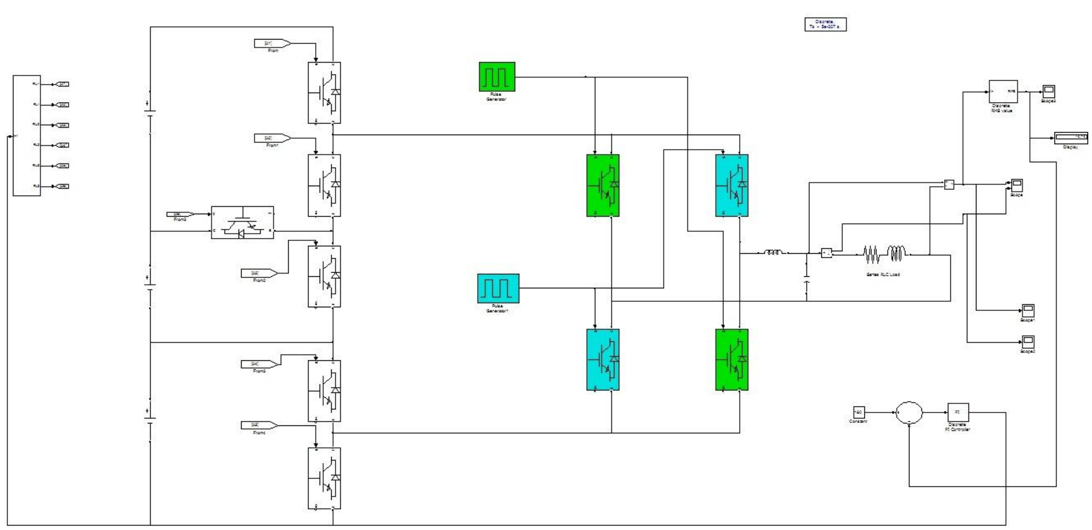

Figure 1 simulation circuit diagram of seven level inverter using RV topology with PI controller

A Seven level inverter using RV topology with fuzzy logic controller model was implemented in Matlab Simulink software with PD-SPWM technique. The following Figure 2 shows the simulation circuit diagram of seven level inverter using RV topology with Fuzzy logic controller.

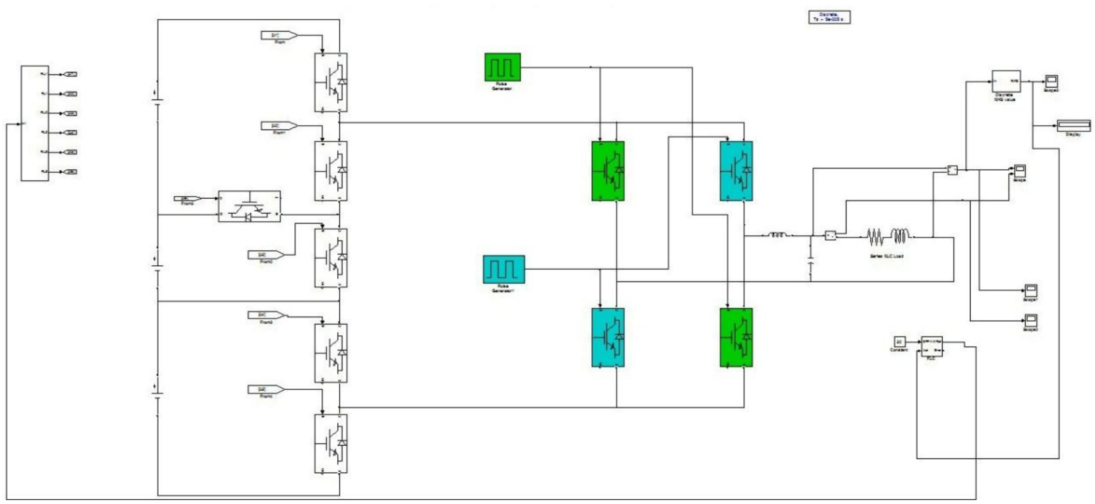

Figure 2 Simulation model of seven level inverter using RV topology with Fuzzy logic controller

The following Figure 3 shows the experimental setup of seven level RV topology inverter with Fuzzy logic controller. It consists of level generation and polarity generation and microcontroller units.

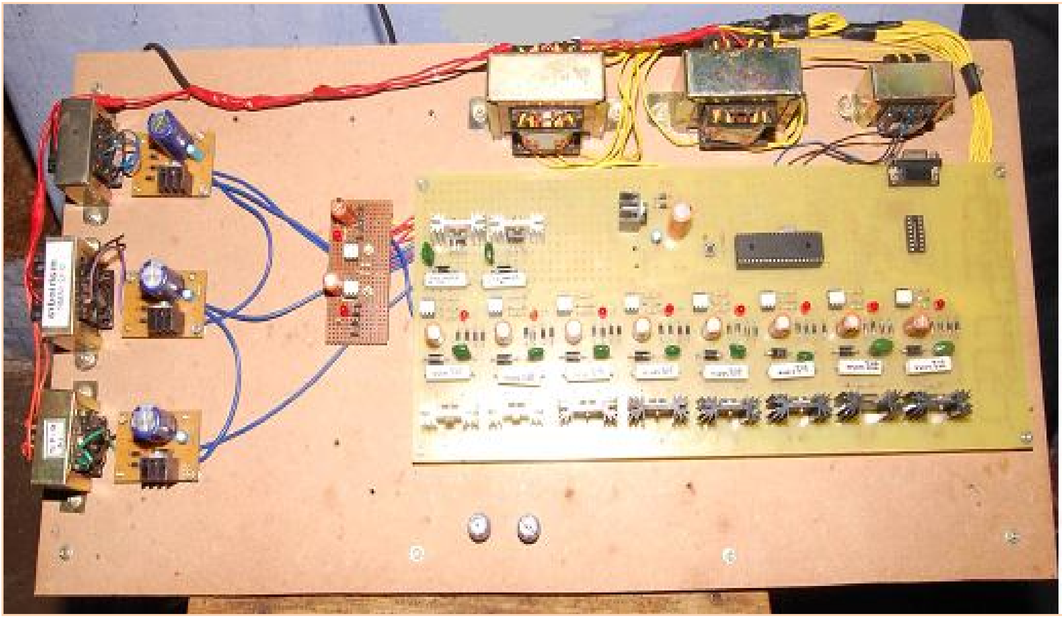

Figure 3 Experimental setup for Seven level inverter using RV Topology with Fuzzy logic controller

5. Experimental Result of seven levels Inverter using RV topology with PI controller and Fuzzy logic controller

5.1 Output Voltage waveform and THD analysis of the seven level inverter using RV Topology with PI controller

The following Figure 4 and 5 shows the output voltage and current waveform of the seven level inverter using RV Topology with PI Controller.

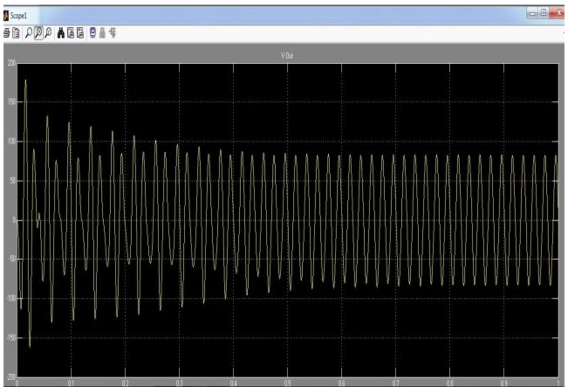

Figure 4 output voltage waveform of the seven level inverter using RV Topology with PI controller

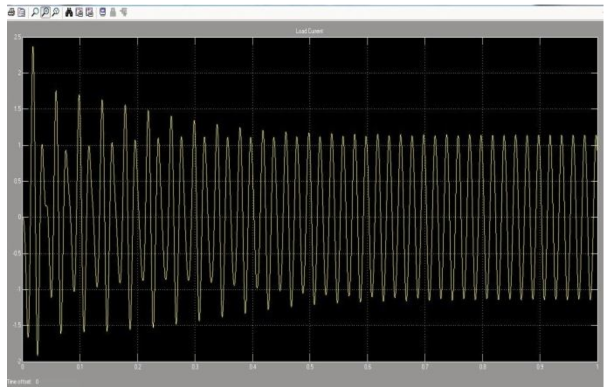

Figure 5 output Current waveform of seven level inverter using RV topology with PI controller

The following Figure 6 shows the voltage THD of the seven level RV topology inverter with PI Controller.

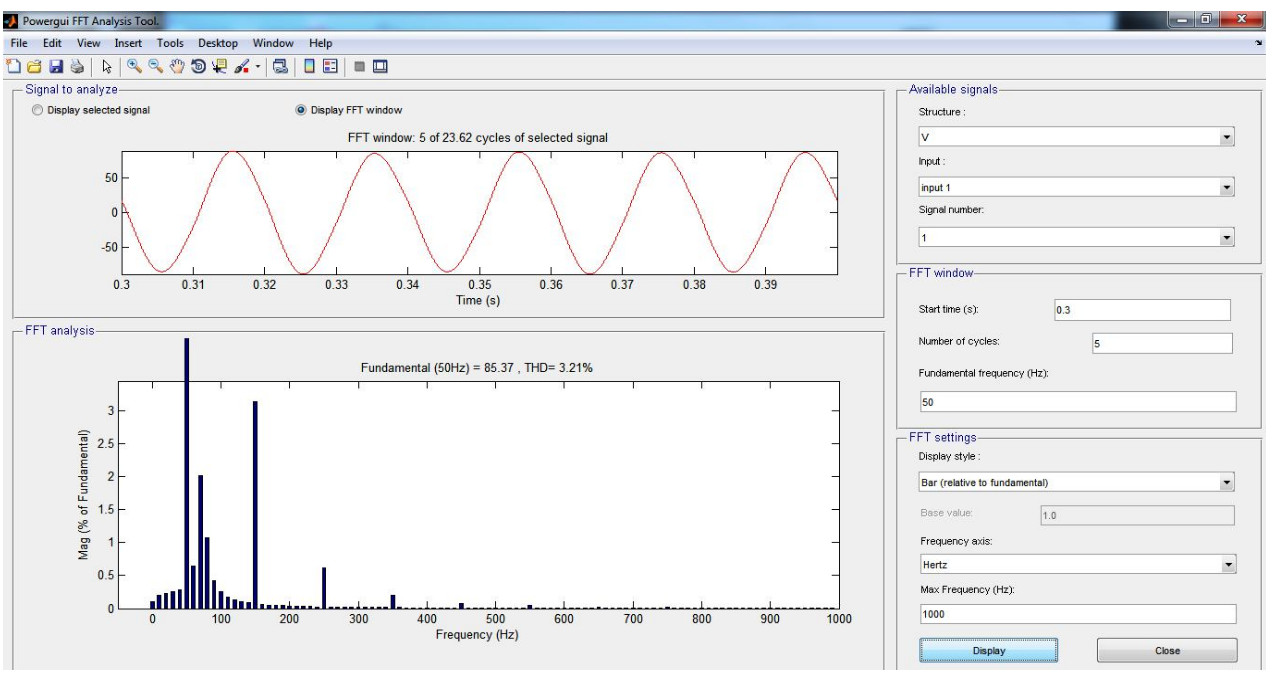

Figure 6 Voltage THD - FFT analysis of the seven level RV topology inverter with PI Controller

The following Figure 7 shows the voltage THD of the seven levels RV topology inverter with PI Controller.

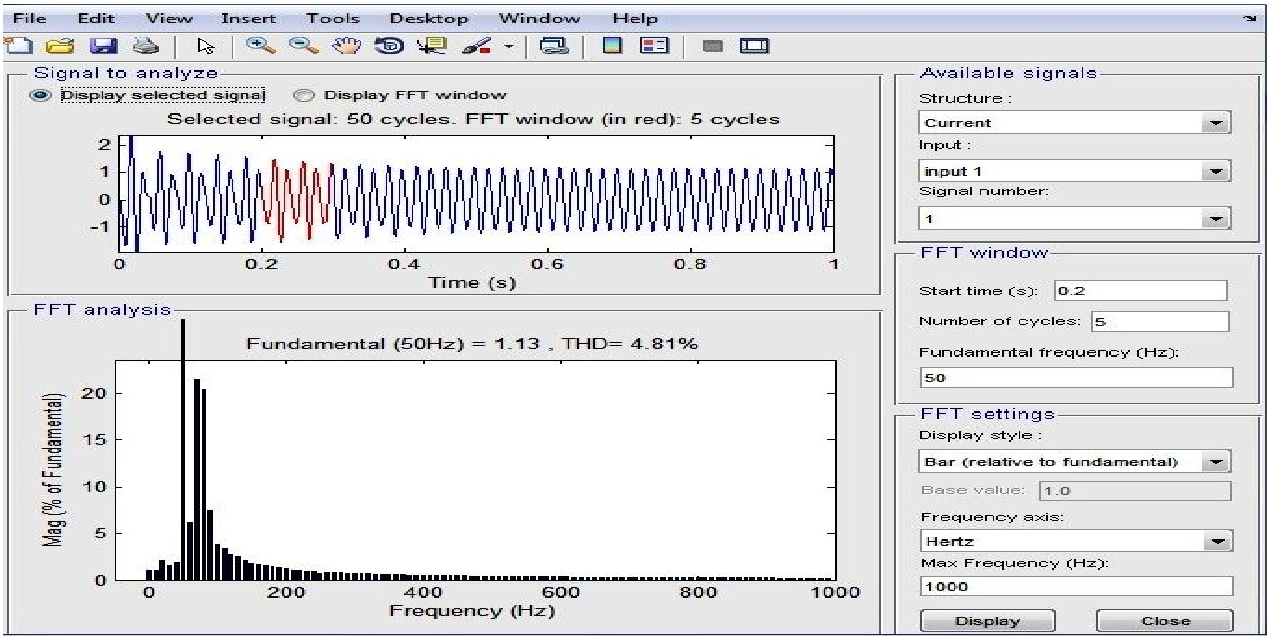

Figure 7 Current THD - FFT analysis of the seven level RV topology inverter with PI Controller

5.2 Output Voltage waveform and THD analysis of the seven level inverter using RV Topology with Fuzzy Logic controller

The following Figure 8 and 9 shows the output voltage and current waveform of the seven level inverter using RV Topology with Fuzzy logic controller.

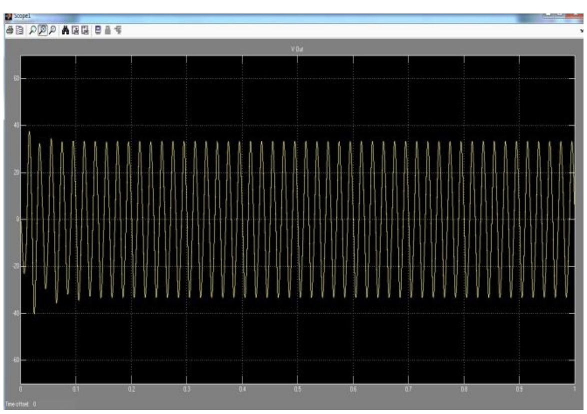

Figure 8 output voltage waveform of seven level inverter using RV Topology with Fuzzy logic controller

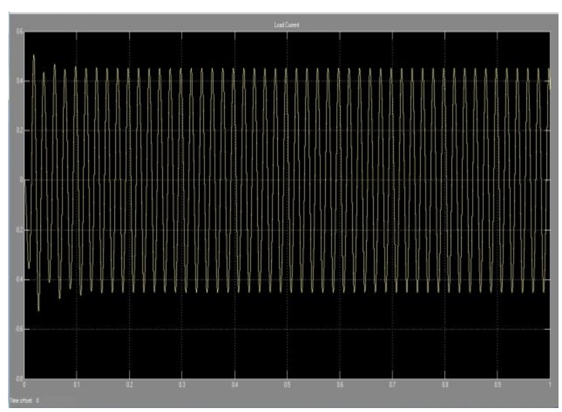

Figure 9 output Current waveform of seven level using RV topology with Fuzzy logic controller

The following Figure 10 shows the voltage THD of the seven level RV topology inverter with Fuzzy logic controller.

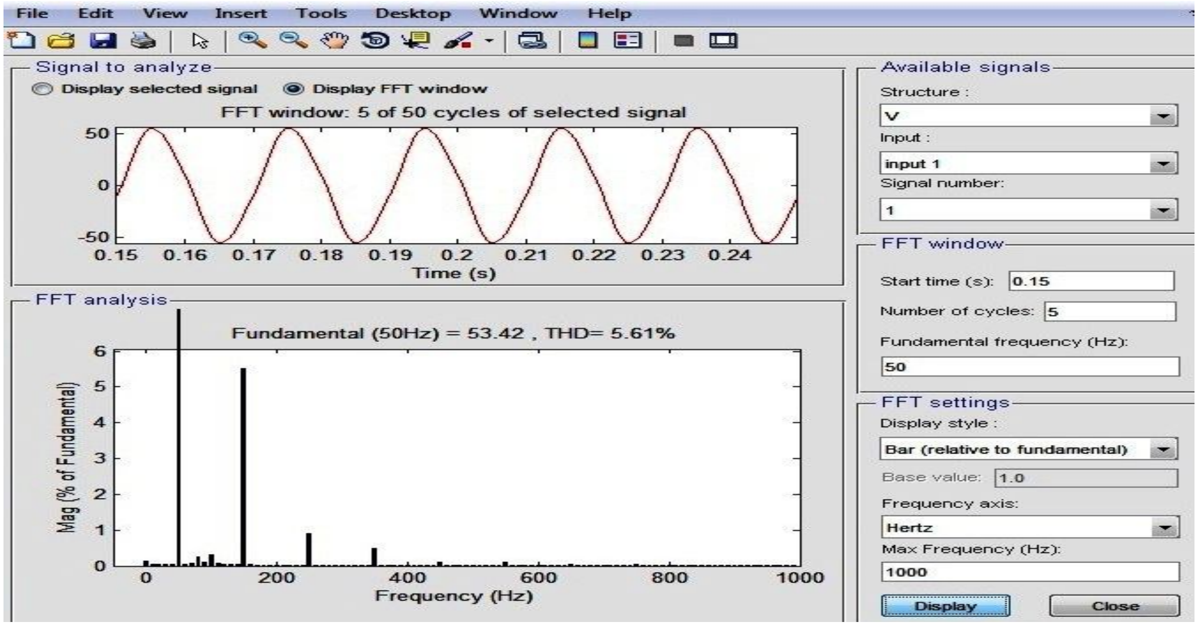

Figure 10 Voltage THD **-** FFT analysis of the seven level RV topology inverter with PI Controller

The following Figure 11 shows the voltage THD of the seven level RV topology inverter with Fuzzy logic controller.

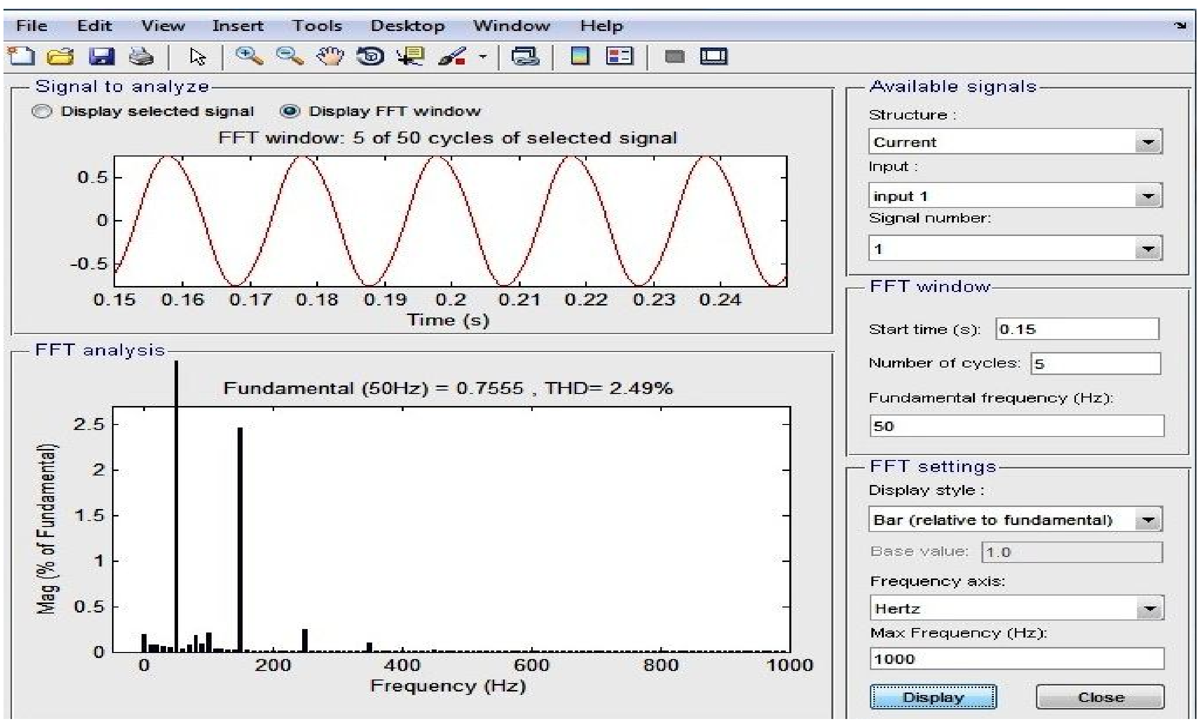

Figure 10 Voltage THD **-** FFT analysis of the seven level RV topology inverter with PI Controller

6. Acknowledgement

Thank God and His almighty power to finish His research work by using me and my Project Guide my friend for His ultimate work.

CONCLUSION

The percentage THD values of the multilevel inverter was analysed by using PI control scheme and Fuzzy Logic Control scheme. The result shows that the current harmonics distortion was reduced by using Fuzzy Logic Control scheme, there was reduction of current THD 2.49 %, which increases the performance of the multilevel inverter.

In this topology, the switching operation is separated into high- and low-frequency parts. This will add up to the efficiency of the converter as well as reducing the size and cost of the final prototype. The PD-SPWM control method is used to drive the inverter.

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