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Mitigation of Harmonics in Multilevel Inverter Using IGBT as a Switch

Bhenuka Khare[1], Viswan Das[2]

Department of Electrical Engineering, CSVTU University, Bhilai, Chhattisgarh, India

Abstract: ***Multilevel inverter is one of the most recent and popular type of advances in power electronics. It synthesizes desired output voltage waveform from several dc sources used as input for the multilevel inverter. This present paper deals with study and analysis of three phase multilevel inverter and their different topologies and configurations. The main purpose of our study is to study the modulation techniques and compare them with each other analyzing their advantages and disadvantages. In our paper the cascaded H bridge multilevel inverter is structure. The term multilevel converter is utilized to refer to a power electronic circuit that could operate in an inverter or rectifier mode. ne first impression of multilevel power converter is that the large no of switches may lead to complex pulse-width modulation (PWM) switching algorithm. However early developments in this area demonstrated the relatively straight forward nature of multilevel PWM. Our project presents the fundamental voltage source and current-regulated method. In this paper third, fifth and seventh level harmonic is analysed. Simulation work is done using the MATLAB software which validates the proposed method and finally THD comparison is presented for analysis.***

Keywords: Pulse Width modulation, Multilevel Inverter, Cascaded H-Bridge Inverter, Total Harmonic Distortion, Matlab

1. Introduction

Multilevel converters are mainly utilized to synthesis a desired single- or three-phase voltage waveform. The desired multi-staircase output voltage is obtained by combining several dc voltage sources. Solar cells, fuel cells, batteries and ultra-capacitors are the most common independent sources used. One important application of multilevel converters is focused on medium and high-power conversion. Nowadays, there exist three commercial topologies of multilevel voltage-source inverters: neutral point clamped (NPC), cascaded H-bridge (CHB), and flying capacitors (FCs). Among these inverter topologies, cascaded multilevel inverter reaches the higher output voltage and power levels (13.8 kV, 30 MVA) and the higher reliability due to its modular topology. Cascaded H Bridge Multilevel Inverters are mostly used for static var applications i.e., in renewable resources' of energy and battery based applications. Cascaded H Bridge Multilevel Inverters can be applied as a delta or wye form. This can be understood by looking at the work done by Peng where he used an electrical system parallel with a Cascade H Bridge. Here inverter is being controlled by regulating the power factor. Best application is when we used as photovoltaic cell or fuel cell. This is the example of Parallel connectivity of the H Bridge Multilevel Inverter.

H Bridge can also be used in car batteries to run the electrical components of the car. Also this can be used in electrical braking system of the vehicles.

A multilevel inverter can be implemented in different topology with its own advantages and limitation, the simplest technique adopted is parallel or series connection of conventional inverters to form the multilevel inverter. More complex structures involve, inserting inverter within inverter to form a multilevel inverter. Whatever approach is chosen, the subsequent voltage or current rating of the multilevel inverter becomes a multiple of the individual switches and so that the power rating of the inverter can exceed the limit imposed by the individual switching devices. Pulse width modulation (PWM) of multilevel inverter is typically an extension of two level inverter. In our paper we analyse the 5 level of multilevel inverter. One of the biggest problems in power quality aspects is the harmonic contents in the electrical system. Generally harmonics may be dividing in to two types- Voltage Harmonic & Current Harmonic. Current harmonic is usually generated by harmonics contained in voltage supply and depends on the type of load such as resistive load, capacitive load, and inductive load. Both harmonics can be generated by either the source or the load side.

Harmonics generated by load are caused by nonlinear operation of devices. Including power converters, arc-furnaces, gas discharge lighting devices, etc., Load harmonics can cause the overheating of the magnetic cores of transformer and motors. On the other hand, source harmonics are mainly generated by power supply with non-sinusoidal voltage waveform. Voltage and current source harmonics imply power losses, electromagnetic interference (EMI) and pulsating torque in AC motor drives. Any periodic waveform can be shown to be the superposition of a fundamental and a set of harmonic components by applying Fourier transformation. These components can be extracted. The frequency of each harmonic component is an integral multiple of its fundamental. There are several methods to indicate of the quantity of harmonics contents.

2. Methods

The traditional two or three levels inverter does not completely eliminate the unwanted harmonics in the output waveform. Therefore, using the multilevel inverter as an alternative to traditional PWM inverters is investigated. PWM inverters generate high frequency and high amplitude common mode voltages.

Phase –shifted PWM is the most commonly used modulation technique for cascaded multilevel inverters because it offers

an evenly power distribution among cells and it is very easy to implement independently of number of inverters.

In the three level inverter zero level is added with two level inverter. The output voltage waveform is similar to the two level inverter. The power circuit of three level inverter is composed of four power switches. The same switches in same leg should not be turned on in order to avoid the short circuit with dc source. In three level inverter when (S_1,S_2) are on and (S_3,S_4) are off, load voltage is equal to $+V_{dc}$ whereas, in the case of (S_1,S_2) are off and (S_3,S_4) are on, $-V_{dc}$ is seen on load. To apply zero voltage on load, (S_1,S_4) should be on and (S_2,S_3) should be off or vice versa. The state 1 describes that when S_1 and S_3 are turned on the source voltage is fed to the load. In the state 0 there is no connection between source and load hence output voltage is zero. However in state 1, the source is connected to load in the reverse direction as that of in state 0. Hence the voltage is in reverse direction.

The harmonic spectrum analysis is carried out for the output voltage waveform of the three level inverter. THD value obtained for the three levels output voltage. When comparing the two levels and three level harmonic spectrum analyses. Three level inverter is having the better quality of output. By applying 220 volt dc supply on the 3 level inverter, 5 level inverter on the cascaded H- bridge inverter and analyse the result by the harmonic calculation with THD level of all the multilevel inverter. simulation dig shown in fig 12.All the level which are 3 level, 5 level and seven level work on the basis of this subsystem.

Fig.13 shows a five level cascaded H-bridge multilevel inverter. The converter consists of two series connected H-bridge cells which are fed by independent voltage sources. The outputs of the H-bridge cells are connected in series such that the synthesized voltage waveform is the sum of all of the individual cell outputs. The output voltage is given by

$$V=V_1+V_2$$

Where the output voltage of the first cell is labelled V_1 and the output voltage of the second cell is denoted by V_2. There are five level of output voltage i.e. 2V, V, 0, -V, -2V.The main advantages of cascaded H-bridge inverter is that it requires least number of components, modularized circuit and soft switching can be employed. But the main disadvantage is that when the voltage level increases, the number of switches increases and also the sources, this in effect increases the cost and weight. The cascaded H-bridge multilevel inverters have been applied where high power and power quality are essential, for example, static synchronous compensators, active filter and reactive power compensation applications, photo voltaic power conversion, uninterruptible power supplies, and magnetic resonance imaging. Furthermore, one of the growing applications for multilevel motor drive is electric and hybrid power.

The proposed seven levels 3 phase CHB inverter is simulated in MATLAB. Like other conventional multilevel inverter topologies the proposed topology can be extended to any required number of levels. The inverter output voltage, load current and gating signals are shown in figure. The inverter can operate in three different modes according to the polarity of the load voltage and current. As these modes will be repeated irrespective of the number of inverter levels and for the sake of simplicity the modes of operation will be illustrated for 7 level inverter.

3. Results

From the Table 1 different inverter THD values are compared. The proposed inverter THD value is obtained as shown in table.

Table 1: Analysis of THD % of Multilevel Inverter

Kind of the MLI	3 level MLI	5 level inverter	7 level inverter
THD	37.17%	28.83%	21.83%

4. Discussion (Or Results and Discussion)

In our project the cascaded H-bridge multilevel inverter circuit with three levels, five level and seven level inverter is used for analysing purpose and compared with the base paper that is new novel topology for multilevel inverter is introduced which reduces the number of switches compared to other for the same level of output voltage.
The comparison of proposed result with base paper is shown in table 2.

Table 2: Comparison of THD % of Multilevel Inverter

Inverter type	No of switches used	Level of inverter	THD %
Cascaded H bridge inverter	8	5 level	28.83%
Modified H bridge inverter	6	5level	26.42%

This paper present simulation results for a 5 level cascaded H- Bridge inverter using PWM techniques and simulation result are compared. The THD value are decrease when the level of inverter is increase. Compared to typical PWM switching schemes, multilevel fundamental switching will lead to lower switching losses. As a result, using the multilevel fundamental frequency switching scheme will lead to increased efficiency.

5. Conclusion

This paper discuss about performance characteristics of various cascaded H-Bridge utilizing PWM technique. Comparison of THD level component is also tabulated which shows by reducing no of switches. THD is almost same and it reduced the complication of circuit a great extent and if we increase the level it will reduce the harmonics.

6. Acknowledgements

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Diagrams

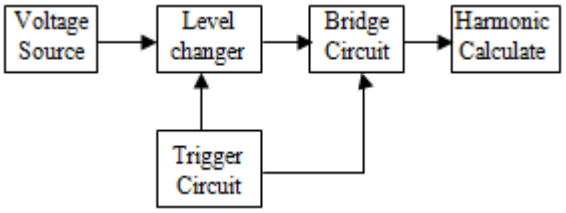

Figure 1: Block Diagram of Proposed Methodology

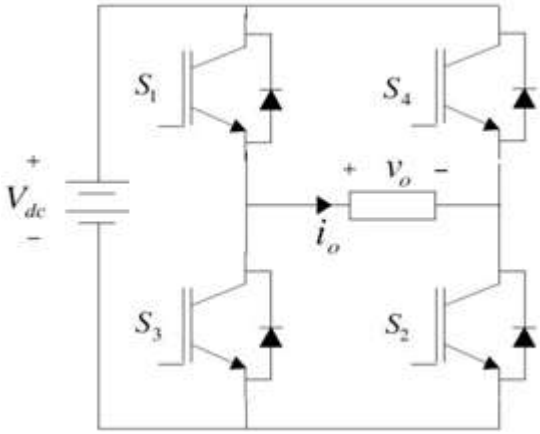

Figure 2: 3 Level Inverter Diagram

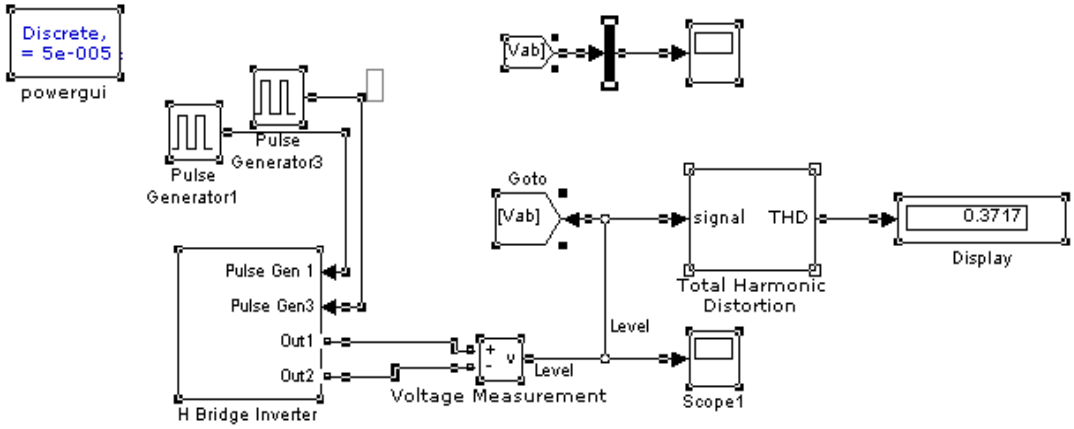

Figure 3: Simulation Model of 3 Level Inverter

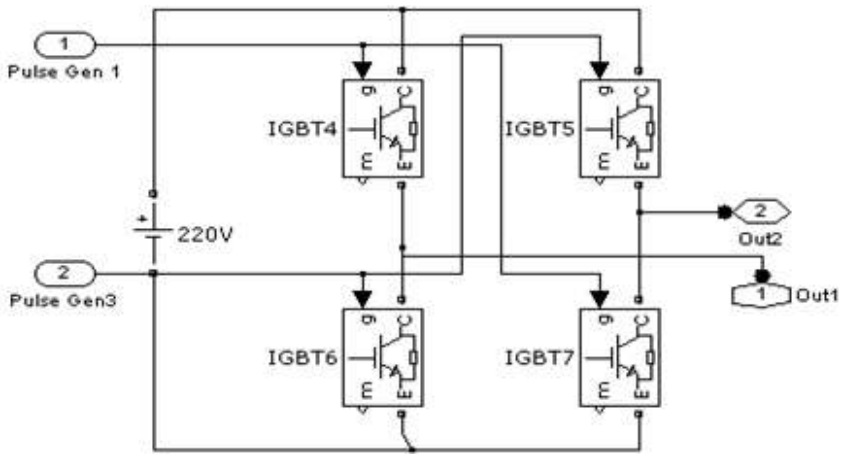

Figure 4: Subsystem Model of 3 Level, 5 Level & 7 Level Multilevel Inverter

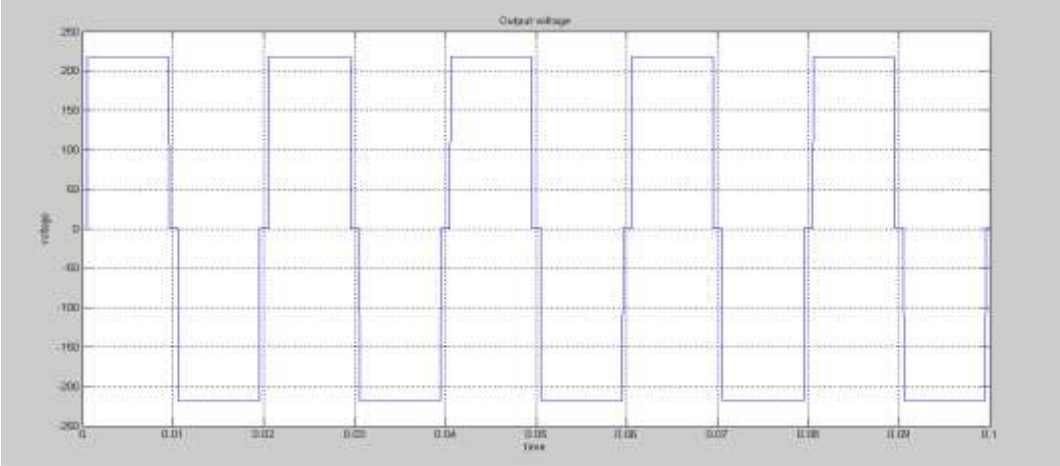

Figure 5: Output Waveform of 3 level Inverter

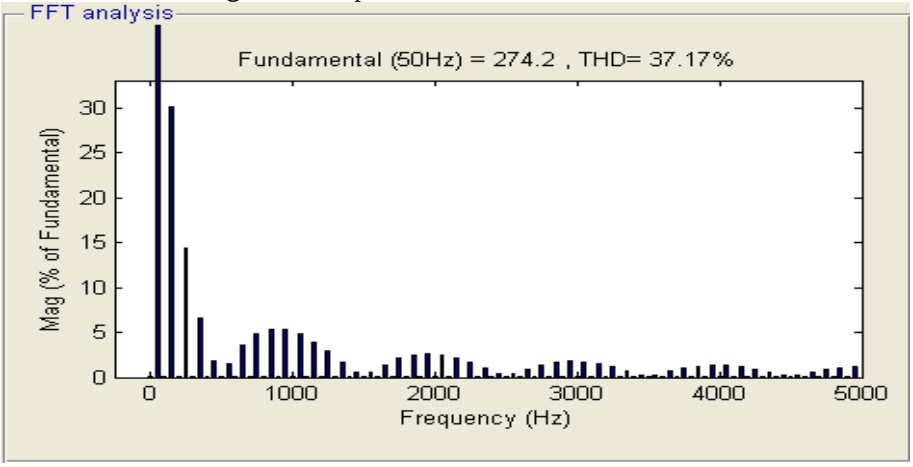

Figure 6: FFT Analysis of 3 Level Inverter

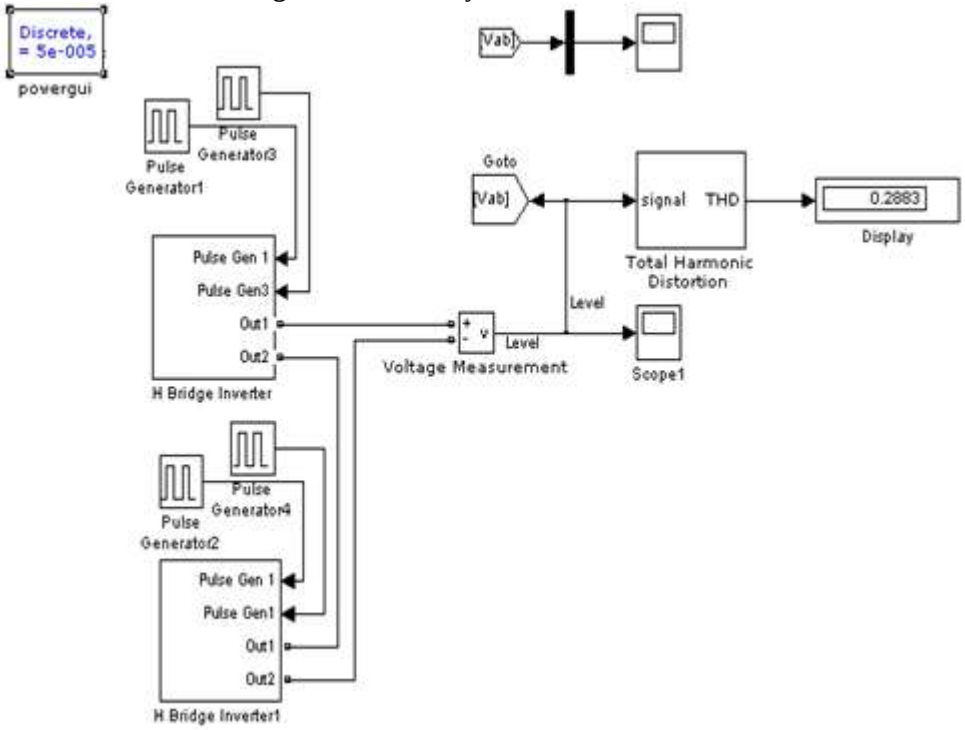

Figure 7: Simulation Model of 5 Level Inverter

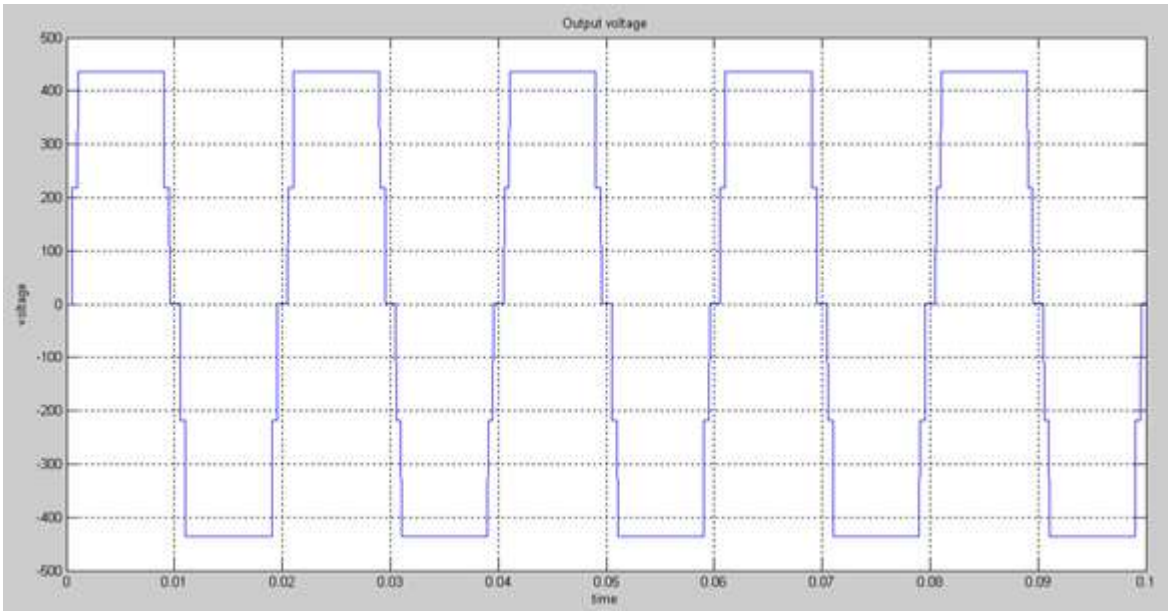

Figure 8: Output of 5 Level Inverter

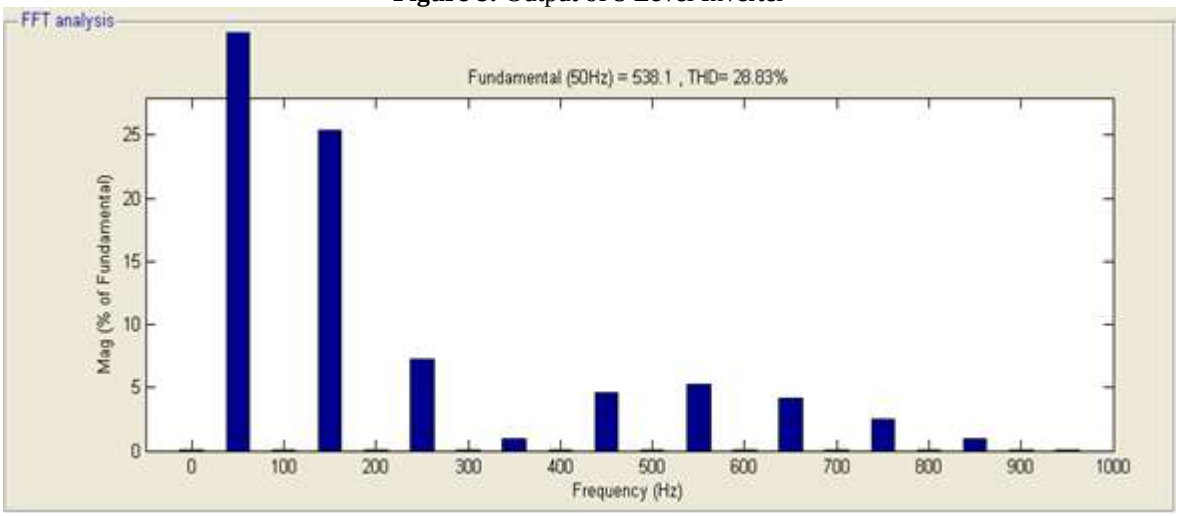

Figure 9: FFT Analysis of 5 Level Inverter

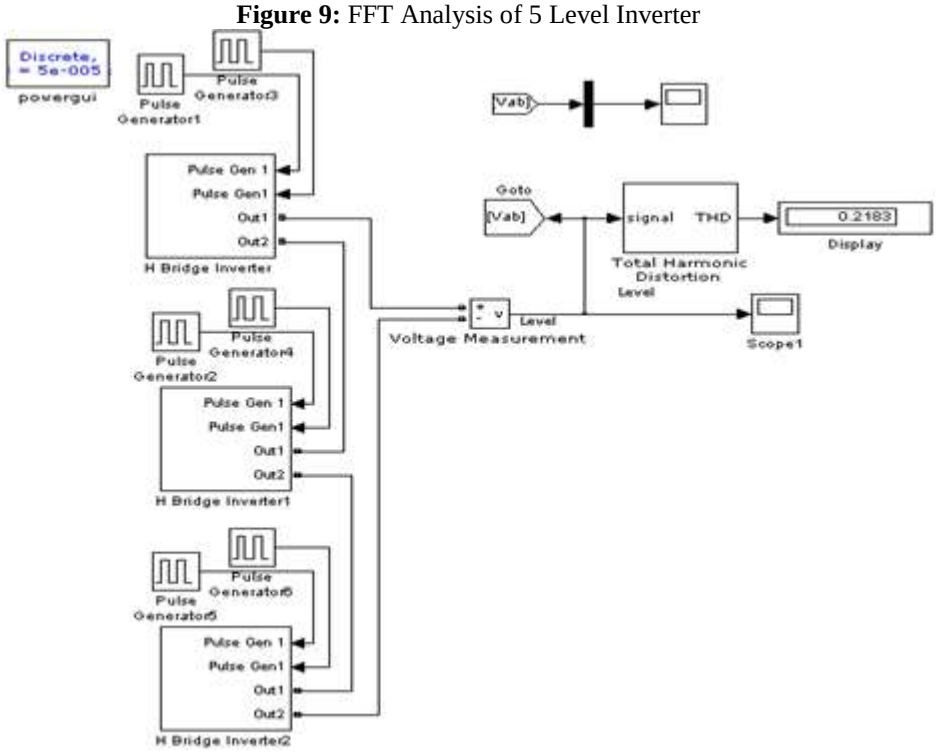

Figure 10: Model of 7 Level Inverter

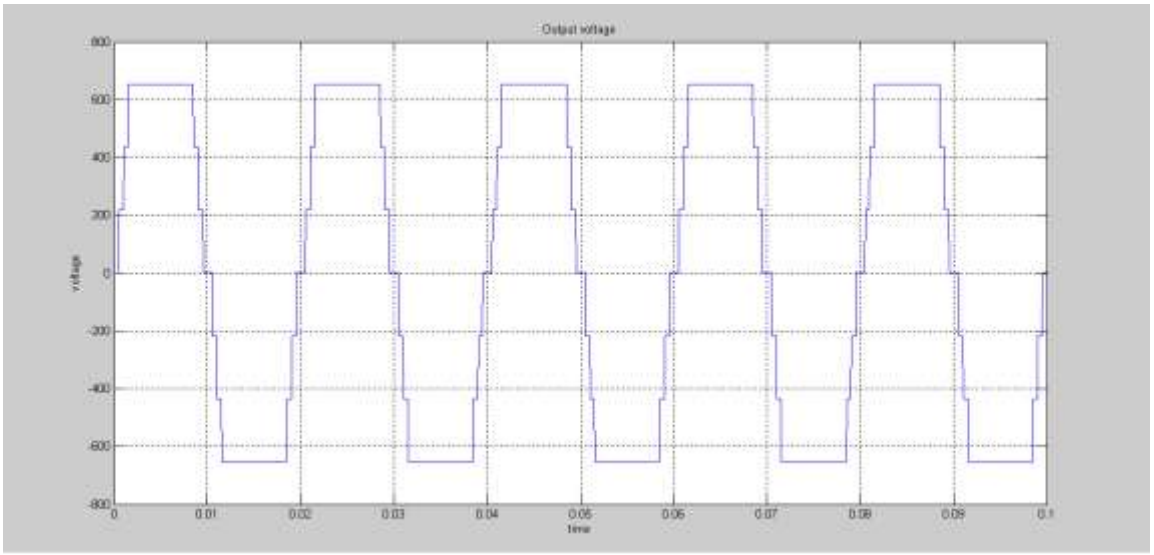

Figure 11: Output of 7 Level Inverter

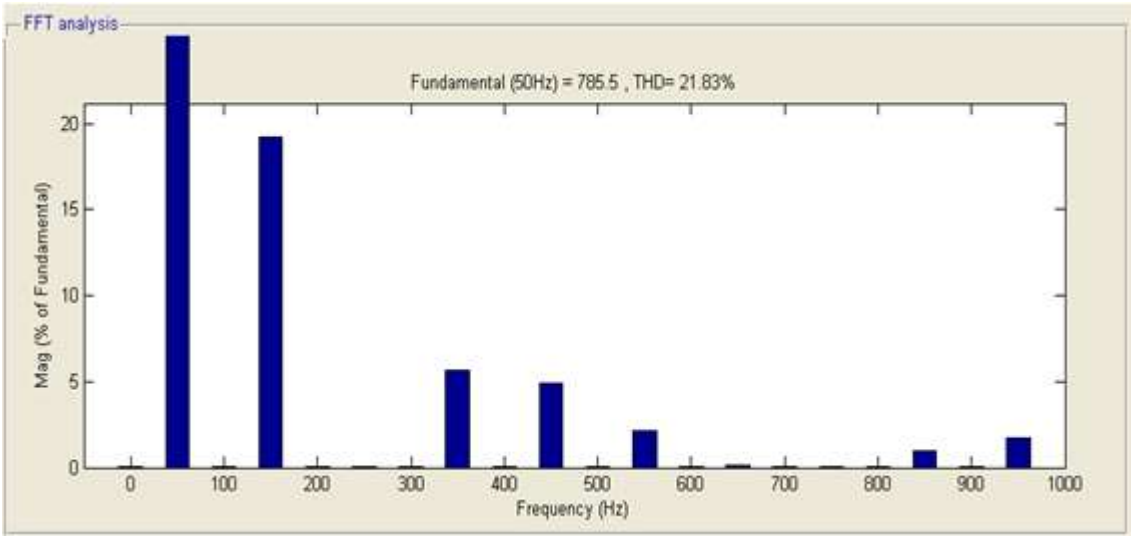

Figure 12: FFT Analysis of 7 Level Inverter

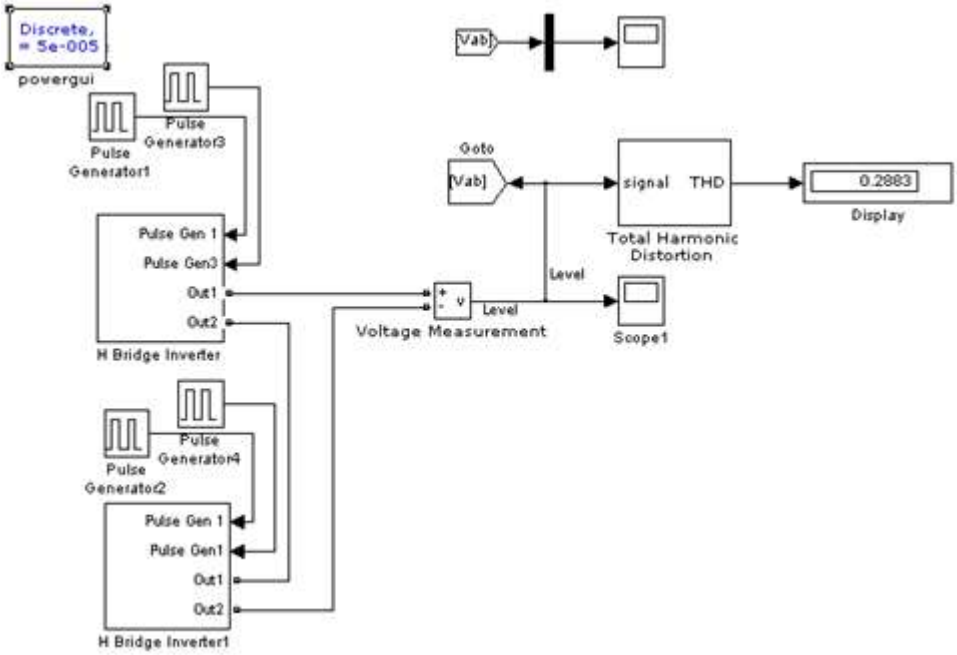

Figure 12: Simulation Model of 5 Level Inverter

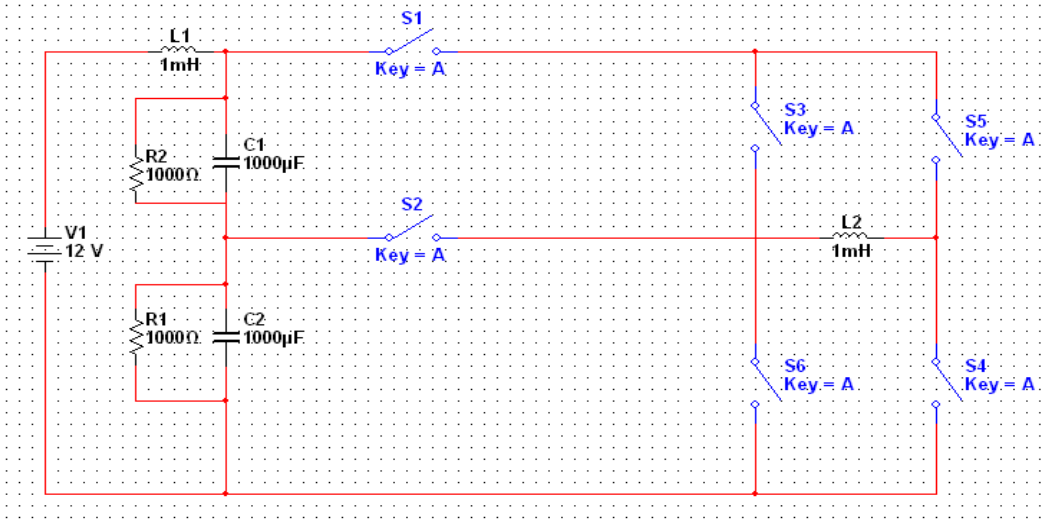

Figure 14: Circuit diagram of 5 Level Inverter

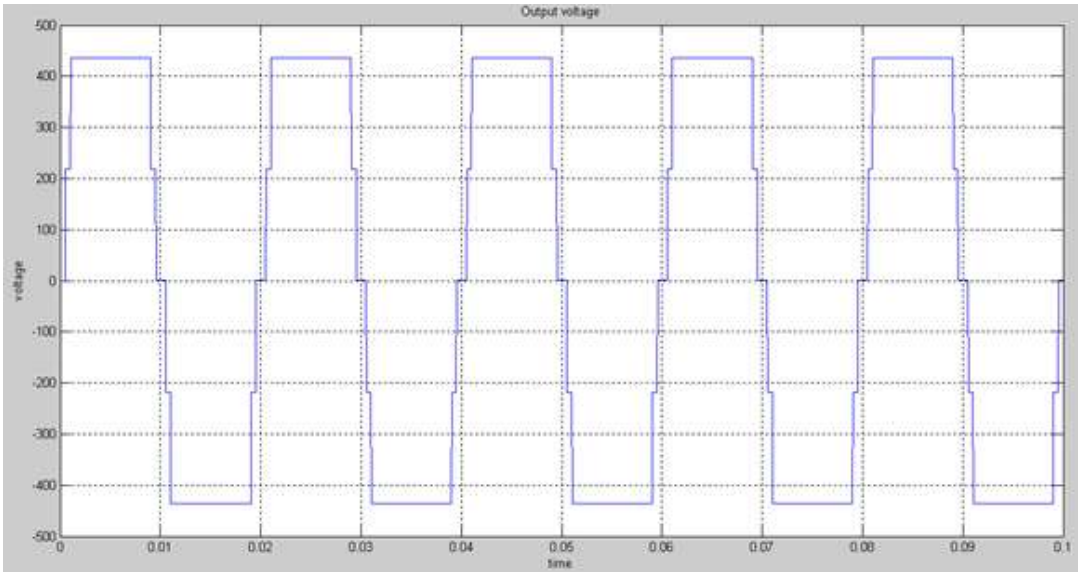

Figure 15: Output of 5 Level Inverter

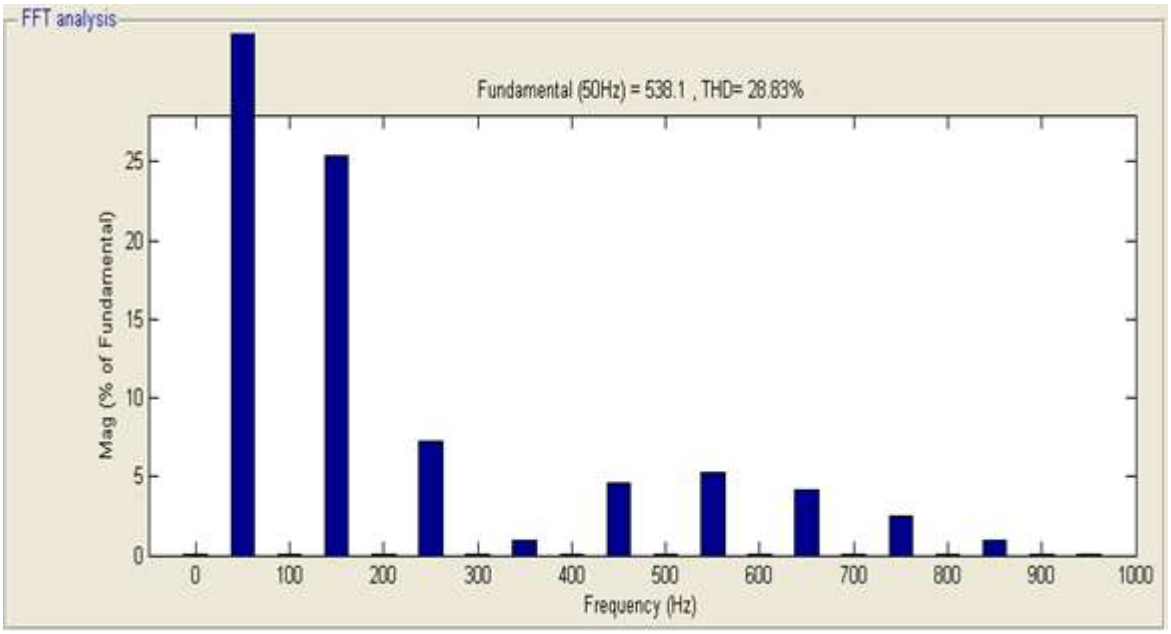

Figure 16: FFT Analysis of 5 Level Inverter