IMPROVING THE OUTPUT OF CASCADED FIVE LEVEL MULTILEVEL INVERTER USING LOW PASS BROADNBAND FILTER

Oni E. A , Oladapo.O.O and Ajayi Oluwatoyin. V.

Department of Science Laboratory Technology, LAUTECH, P.M.B 4000.

ABSTRACT

One of the major problems in the developing country is poor power quality. Poor power quality is caused by a system inability to maintain sinusoidal waves which are often caused by introduction of harmonics in power system. The main objective of this work is to develop and analyze the recompense features of cascaded multilevel inverter based low pass broadband power filter. This work explores modification of voltage harmonics using configuration of5 Level H-Bridge cascaded multilevel inverter based low pass broadband filter (LPF) and without low pass filter to improve power quality of the system. To moderate harmonic distortion, cascaded multilevel inverter based low pass broadband power filter is proposed and after compensation the source voltage harmonic distortion is changed. The harmonic distortion which produce multiple frequency of the expected frequency a system should functions inform of ripples was reduced and the Total harmonic distortion produced is around 11.17% and 12.13% with and without LPF respectively after the simulation analysis using Simpower systems block set of MATLAB/SIMULINK.

KEYWORDS

Cascaded multilevel inverter, lowpass power filter, harmonic distortion

1. INTRODUCTION

It is essential to recognize power quality issues in power systems. Power quality refers to a system's ability to maintain a sinusoidal power distribution voltage and current at a rated magnitude and frequency. Therefore, any disturbance in a distribution system is referred to as a power quality issue. Adequate supply of energy always has been one of the important factors of economic growth and development (Ekren, 2011). The impact of power quality in low voltages and high voltages is much more noticeable, due to its effect on equipment's life cycle such as laptops batteries, chargers and on electronic devices and in case of high voltages transmission line sag, swell and voltage dip which leads to increase in the economic aspects of both consumer end and industrial side. These power quality effects are caused due to the distorted sinusoidal wave also called harmonics (Ginga *et al*, 2016).

The presence of unbalanced load or nonlinear loads load like adjustable speed drives; electronically ballasted lighting and the power supplies of the electrical with equipment applied in present offices (Peng, 1998) makes a system imbalance by injecting harmonic and the significant amounts of harmonic injections and poor power factor are due to the increasing use of power electronics loads by both local consumers and industries. The introduction of power filters has tremendously improved power quality by eliminating the current.

In areas of medium voltage and higher applications, the use of multilevel inverter is essential (Vishnu *et al,* 2007).Any power conversion approach which diminishes the total harmonic distortion (THD) by getting the output voltage in steps and taking the output nearer to a sine wave are known as multilevel inversion. The general objectives of these multilevel inverter are generating an expected sinusoidal voltage from various stages of dc voltages, usually got from capacitor voltage sources (IEEE, 1992) and these multilevel inverter are significant in few power electronics applications like Flexible ac transmission systems, renewable energy sources, uninterruptible power supplies and active power filters (Ozdemir *et al*, 2007). Multi-level inverters (MLI) have appeared as a successful and practical solution for harmonic distortion in AC waveform and power increase. Any raise in the harmonic alteration component of the transformer can results in shorter insulation lifetime, increased temperature and insulation stress, extra heating losses, decreased output, efficiency, ability and deficiency of plant system performance happen thus of a raise (Akagi, 1983).

The circuit diagram of a low-pass filter is shown in Figure 1. The filter consists of an inductor and capacitor with resistances. The value set for the inductor and capacitor are $L = 20\mu H$ and $C = 50F$ respectively. The resistance $R_i = 1k\Omega$ and $R_c = 1\Omega$. By varying the values of L and C, the filtering quality of the filter is affected.

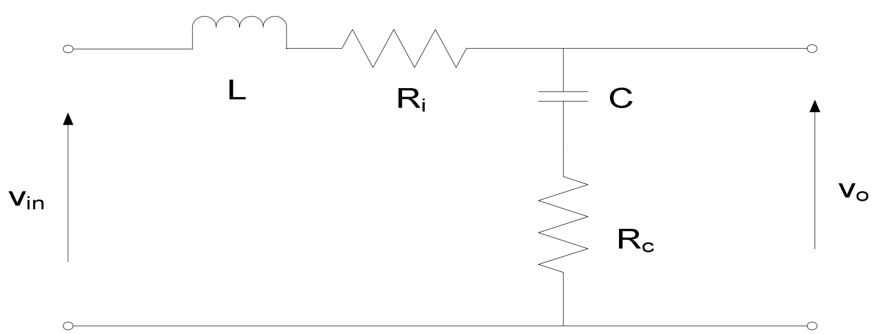

Figure 1 low-pass filter

2. CASCADED H-BRIDGE MULTILEVEL INVERTERS

Cascading two or more levels inverter does not totally eliminate the unwanted harmonics distortion in their output waveform (Vasudev, 2005). These types of inverter involve several H-bridge inverters which are connected in series for accurate sinusoidal output voltage. The output voltage generated by this multilevel inverter is the sum of all the voltages generated by each cell because each cell contains one H-bridge. This type of inverter has advantage compared to other types of multilevel inverter because components used are minimal which reduce the overall weight and price of components also less (Mohammadreza, 2010).

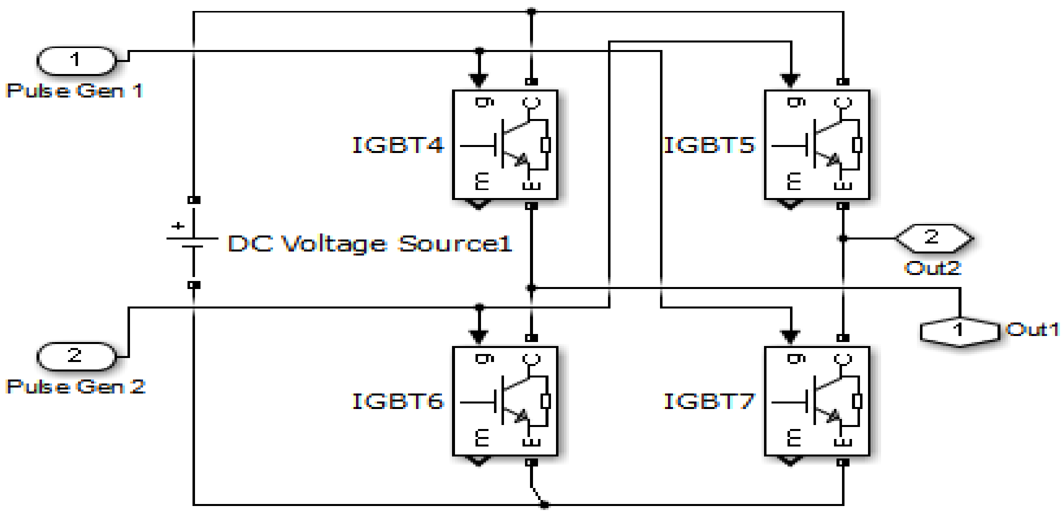

Figure 2 Simulink diagram for the H-bridge IGBT inverter

3. SIMULINK MODEL OF THE MULTILEVEL H-BRIDGE INVERTER WITHOUT LOWPASS FILTER

Figure 3 shows the developed Simulink model for a 5-Level cascaded H-bridge inverter without low-pass filter. The design consists of 5 H-bridge inverters of Figure 3.1 cascaded in order to boost the output voltage level which would be about 60-V as set in this work. The voltage output waveform from the H-bridge inverter is measured by the block set called 'Voltage Measurement.' The 'Scope' is used to display the waveform graphically.

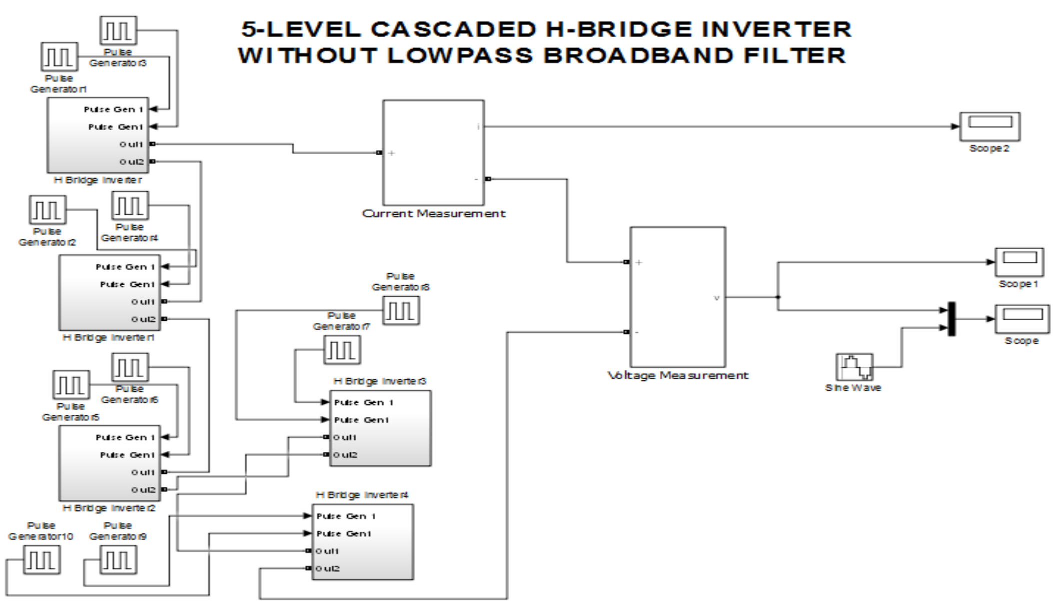

Figure 3 Simulink model for the mutilevel H-bridge inverter without lowpass filter

4. SIMULINK MODEL OF THE MULTILEVEL H-BRIDGE INVERTER WITH LOWPASS FILTER

The Simulink model for the 5-Level cascaded H-bridge inverter with low-pass filter is shown in Figure 4. The diagram consists of the LC lowpass filter connected across the output of the inverter. The extra resistor (1 Ohm) connected in series with the capacitor is because Simulink requires the use resistor to connect to the 'Voltage Measurement.' The lowpass filter helps to remove high frequency components in the output signal of the IGBTs.

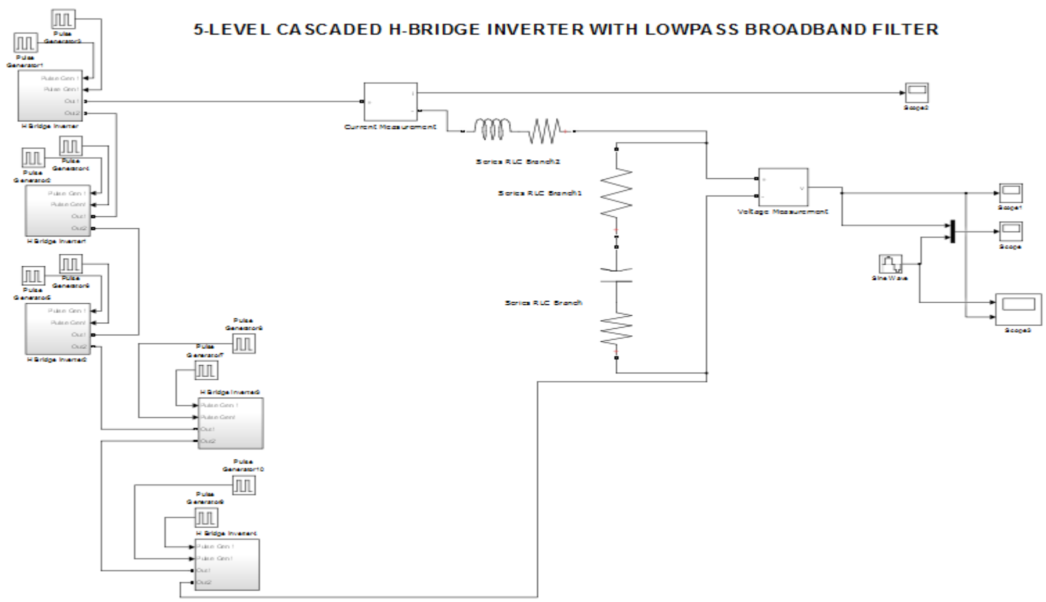

Figure 4 Simulink model for the mutilevel H-bridge inverter with lowpass filter

5. MATLAB/SIMULINK RESULTS

In this paper, the result shown below are based on the 5 level cascaded multilevel with or without low pass broadband filter, in fig 5, The figure consists of two graphs. The upper graph is the ideal sinusoidal voltage waveform needed for proper operation of the load (e.g. electric motor drive) being supplied. The lower graph is the output voltage waveform of the inverter. It is observed from the result that the output of the inverter is distorted as it is observed that the waveform contains steps. This signal distortion is as a result of frequency unbalance, and the ripples would make the load to be unstable. For instance, if the waveform is fed into a radio set, the audio output will contain undesirable noise. Total Harmonic Distortion(THD) of the inverter without the lowpass filtering is showed in fig 6 The THD is calculated to be 11.17% which is negligible. Although this is a low THD but the steps or ripples in the voltage waveform is a problem that needs to be solved to produce good power quality which brings about the introduction of low pass power filter.

Figure 7 presents the result of the inverter when the LC lowpass filtering is applied to the incoming voltage waveform from the IGBTs. The final voltage output is a filtered voltage waveform to supply a load. The figure also consists of two graphs. The upper graph is the ideal sinusoidal voltage waveform needed for proper operation of the load being supplied while the lower graph is the output voltage waveform of the inverter after filtering. It is observed that the steps or ripples present in the output without filtering have been drastically reduced. This reduction in the waveform ripples ensures that a considerably smooth signal is supplied to the load. The smoother the supplied voltage waveform, the better will be the operation of the load. For instance, a relatively smooth input voltage to a radio set would produce smooth audio signal to the listener. Total Harmonic Distortion(THD) of the inverter with the lowpass filter is showed in fig 8. The THD is calculated to be 12.13%. This is about 0.96 higher than the inverter without the LC lowpass filter; however, the 12.13% THD is also relatively low and can be negligible. This reveals that for a relatively low THD which is still negligible, the H-bridge inverter having a LC lowpass filter gives better output voltage waveform than that without lowpass filter.

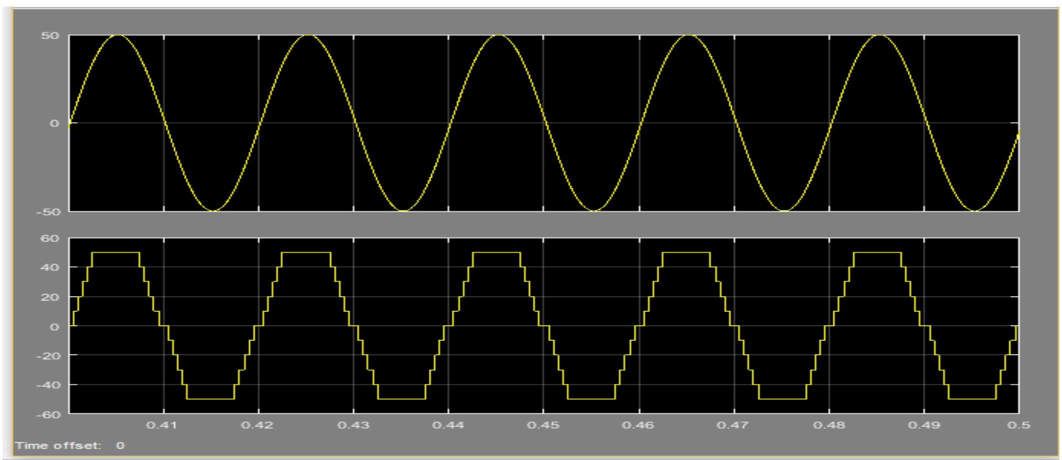

Figure 5 Output of the inverter without the lowpass filtering

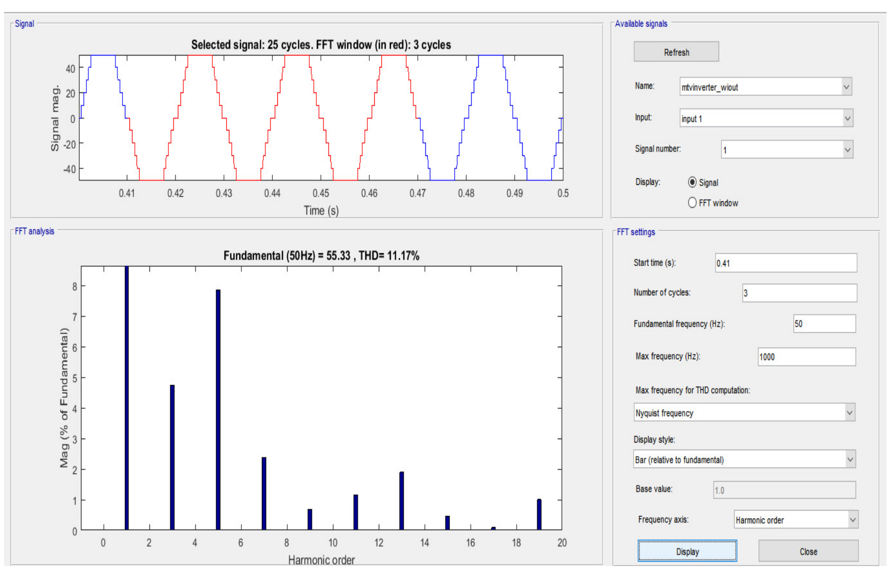

Figure 6 Total Harmonic Distortion of the inverter without the lowpass filtering

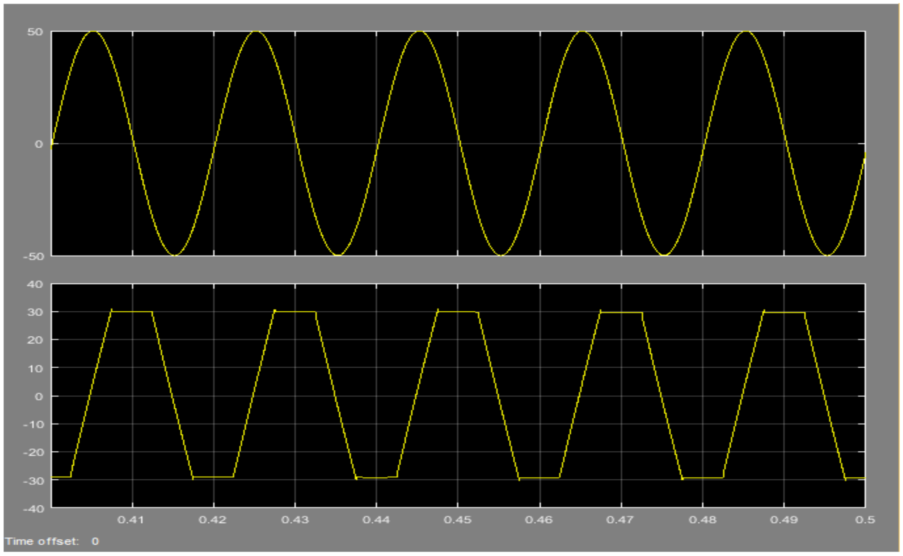

Figure 7 Output of the inverter with the lowpass filtering

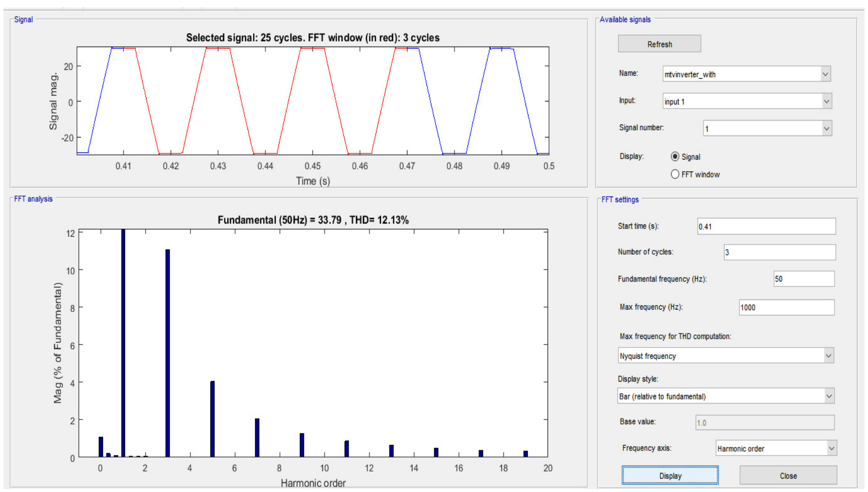

Figure 8 Total Harmonic Distortion of the inverter with the lowpass filtering

6. CONCLUSION

It can be concluded that harmonic distortion inform of ripples on the output of the Multilevel inverter has been mitigate. Efficient power quality can now be produced from a cascaded multilevel inverter when a low pass broadband filter compared to the normally used active power filter is added to its output. This new system provides room for extra perfections. The result show the total harmonic distortion informs of ripple was reduced when the filter was connected to the output of the multilevel inverter. The reduction in the harmonic oscillation that affects the load has been reduced and as such the use of LPF is strongly advised in cascading H-Bridge multilevel inverter.

REFERENCES

[1] Akagi H (2005) Active harmonic filters, Proc. of the IEEE Vol. 93, Issue 12, Dec. 2005 pp. 2128–2141.Akagi H,(1996) "New trends in active filters for power conditioning," Industry Applications, IEEE Transactions on, Vol. 32, pp. 1312-1322, 1996.

[2] Alakanti Karthik., S. Vasudev (2015) A New Multilevel Inverter Based Shunt Active Power Filter to Improve Power Quality International journal of advanced technology ISSN 2348–2370 Vol.07,Issue.08, July-2015, Pages:1333-1338

[3] Dzhankhotov V., Hybrid LC filter for power electronic drives: Theory and Implementation, 2009

[4] F. Z. Peng., J.-S. Lai., J. Mckeever., J. VanCoevering.(1995). A multilevel voltage-source inverter with separate DC source for static var generation," in Conf. Rec. IEEE-IAS Annu. Meeting, 1995, pp. 2541–2548.

[5] Ginga Madhu and Pardeep Mittal (2016)Analytical Review on MLI based Active Power Filter to Reduce Harmonics for Improvement in Power Quality, Indian Journal of Science and Technology, Vol 9(29), DOI: 10.17485/ijst/2016/v9i29/90497, August 2016,ISSN (Print) : 0974-6846 ISSN (Online) : 0974-5645Introduction to Multilevel inverter. (2014) retrieved from https://www.theengineeringprojects.com/2014/12/introduction-multilevel-inverters.html.

[6] J. S. Lai., F. Z. Peng.(1996) Multilevel converters – A new breed of power converters," IEEE Trans. Ind. Applicat., vol. 32, pp. 1098–1107.

[7] K.Vishnu Priya., A.Aswini (2007). Simulation of Five Level Cascaded H-Bridge Multilevel Inverter with and without OTT Filter.International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

[8] Mohammadreza D (2010), Analysis of different topologies of multilevel inverters, Chalmers University of Technology.

[9] N.S. Choi., J. G. Cho.,& G. H. Cho (1991) "A general circuit topology of multilevel inverter," in Proc. IEEE PESC'91, pp. 96–103.

[10] Singh B., Al-Haddad K., Chandra A (1999) A review of active filters for power quality improvement. IEEE Transactions on Industry Electronics, Vol. 46, No. 5, pp. 960–971.

[11] T. A. Meynard., H. Foch (1992) "Multilevel conversion: High voltage choppers and voltage source inverters," in Proc. IEEE PESC'92 , pp. 397–403.

[12] Yashobanta Panda (2005), Analysis of Cascaded Multilevel Inverter Induction Motor Drives, National Institute of Technology, Rourkela Odisha, India