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Improved Performance of FOPI Based Wind Energy Conversion System Using Multilevel Inverter

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ABSTRACT: In this paper for improvement in the performance of system and reduction in total harmonic distortion (THD) three-level inverter is used in place of two-level inverter. The system comprises of permanent magnet synchronous generator (PMSG), Fractional Order PI Controller (FOPI), Neutral-Clamped three-level inverter. The FOPI controller is connected across the inverter which shows better results when comparing with two-level inverter. The use of three-level inverter provides improved load voltage, output active power, output reactive power and reduction in harmonic distortion whereas the use of FOPI controller gives smooth and stable output for above system at resistive load.

KEYWORDS: FOPI Controller, PMSG, Neutral -Clamped three- level inverter.

I.INTRODUCTION

The rapid exhaustion of non-renewable energy sources, air contamination, and ozone harming substance outflow has constrained us to consider some renewable energy sources, as sunlight based, wind, tidal/wave, biomass and little hydro energy. Among these assets, wind vitality is the most favored and broadly utilized sustainable power source asset because of its favorable circumstances [1]. The greater part of the new improvements for substantial multi megawatt turbines found in industry depend on synchronous generators using permanent magnet with various arrangements of three phase windings [2, 3, 4]. The utilization of multilevel inverter and the manufactured strategies add to enhanced execution of the control of wind vitality transformation framework [5, 6]. Multilevel inverter innovation is being consolidated in different sustainable power source based power generation advancements like wind and sunlight based for higher power and voltage application [7].

Another power change framework is investigated in this paper pointing wind turbines evaluated at the megawatt level. The proposed setup comprises of a medium-voltage, lasting magnet synchronous generator associated with a minimal effort three phase diode connect rectifier, a dc–dc four-level lift converter as the middle stage, and a four-level diode-braced inverter on the matrix side. The dc-interface capacitor voltages are adjusted by the lift converter, and in this way the control many-sided quality for the matrix tied inverter is incredibly rearranged. To control the lift converter and matrix tied inverter, a basic strategy in view of a two-stage display prescient methodology is exhibited [8].

For improving the performance of the wind energy conversion system many control methods have been developed, such as proportional integral controller, cascaded pi controller design, fuzzy logic controller, and synchronous d-q frame phase- locked loop control, robust control; DTC based sliding mode control [9]and so on. The controller activity can be performed in voltage source converter or in current source converter; among all the consecutive pulse width modulation (PWM) current source converter is thought to be the most encouraging converter for medium voltage PMSG wind energy conversion system [10]. As of late, partial request control strategy has been utilized as a part of different applications. Fractional calculus used to control wind turbine generator has been accounted for in [11]. The fractional order controllers can possibly enhance the control execution and increment the system robustness [12]. The d-q change is expelled in the wake of utilizing one cycle control technique for PMSG of wind energy conversion system it give control of generator's speed and the dc connect voltage should keep stable [13]. Speculation of PI controller is started from survey the relationship of FOPI in the time space [14].

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II. LITERATURE SURVEY

Performance Improvement of Grid Connected DFIG Fed by Three Level Diode Clamped MLI Using Vector Control [22], Giribabu Dynamina (2016) et al. presents a vector control method for doubly fed induction generator (OFIG) based Wind energy conversion systems (WECS) to independently control the active and reactive power. The performance of OFIG based WECS at the rotor side is poor. To improve the performance of the system two level inverter (TLI) is replaced with Diode c1amped multilevel inverter (OCMLI) which is commonly used MLI topology due to its merits compared to other. The **PI** controllers in the VC of DFIG systems are replaced with AN FIS controllers to improve steady state and transient performance. The proposed OCMLI fed WECS is simulated in MATLAB/SIMULINK environment where the MLI fed system using ANFIS controller results better performance compared to TLI.

Dual-Boost NPC Converter for a Dual Three-Phase PMSG Wind Energy Conversion System [23], G. Estay (2012) et al. proposes the development of wind energy conversion systems (WECS) is currently focused in reaching higher power ratings (_10MW). Medium voltage operation is at this power level, particularly at grid side, a desirable feature. Therefore, great attention has been given to high-power medium-voltage multilevel converters for WECS. Nevertheless, most modern multi-megawatt turbines use low-voltage multiphase permanent magnet synchronous generators (PMSG) operating at 690V, which requires the use of several converters connected in parallel to reach the multi-megawatt level. This paper presents a low- to medium-voltage converter interface for a dual three-phase PMSG based WECS. Two full bridge diode rectifiers followed by boost converters are used to control each set of three-phase windings of the dual PMSG. The boost converters elevate the voltage to feed each one of the capacitors of the dc-link of the medium voltage NPC grid-tied inverter. The generator side converter has high power density and is a cost effective solution compared to traditional back-to-back solutions. Simulation results are presented to provide a preliminary overview of the performance of the system.

III. PROPOSED SYSTEM

Wind energy obtained from wind turbine is transferred to the permanent magnet synchronous generator. The generated electrical output power is then transferred to the load via back to back, AC-DC-AC converter. In this paper inverter is controlled by fractional order PI controller.

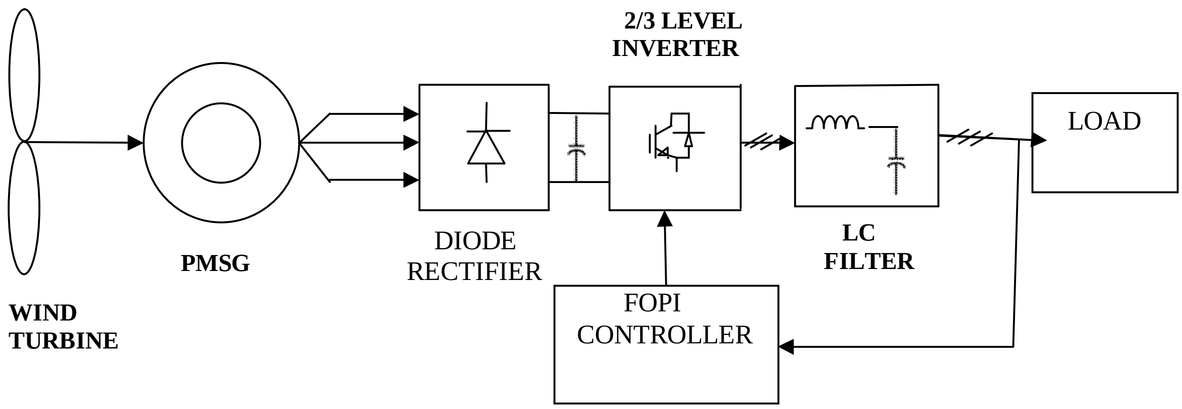

Figure 1 Wind energy conversion system using FOPI controller with two/three level inverter

IV. TWO LEVEL INVERTER

The regular converter utilized for the vector control is two-level inverter. This two level inverter output voltage waveform is delivered by utilizing PWM with two voltage levels. This causes the output voltage and current to be

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mutilated and the total harmonic distortion (THD) of the voltage and current is poor. Multilevel inverter output voltage and current is more sinusoidal and the total harmonic distortion (THD) is better.

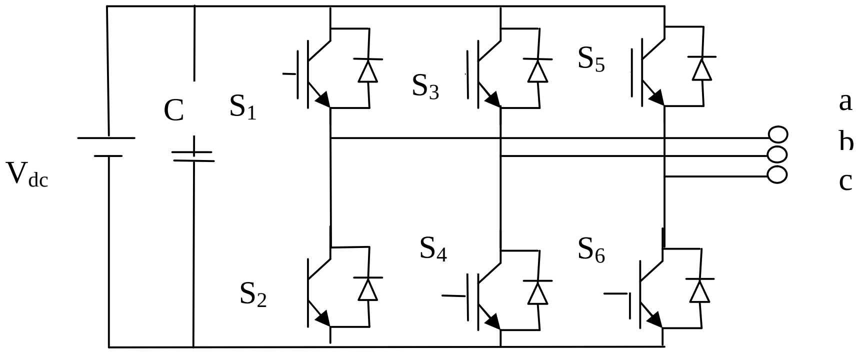

Figure 2 Three phase two-level inverter

The circuit comprises of three half- bridges, which are commonly phase shifted by 120 to produce the three stage voltage waves. The dc supply is normally gotten from a diode connect rectifier.

V. MULTILEVEL INVERTER

By utilizing multilevel inverter smooth AC waveform can be created which have low twisting in its output. Thus total harmonic distortion (THD) is diminished in output voltage and current waveforms. The multilevel inverters are mainly classified as follows:

1. Flying Capacitor
2. Diode Clamped
3. Cascaded H- Bridge.

THREE-LEVEL INVERTER

The most usually utilized multi level topology is the diode clamped inverter, in this the diode is utilized as the clamping gadget to clamp the dc transport voltage which accomplishes load voltage in step. Hence, the primary idea of utilizing diodes in this MLI is to restrain the voltage weight on exchanging devices. An m-level inverter requires (m-1) voltage sources, 2(m-1) switching devices and (m-1) (m-2) diodes. As the quantity of voltage levels expands the load voltage quality is enhanced in this way the voltage waveform turns out to be more sinusoidal. The three-level diode-clamped inverter with one stage leg is represented in Figure 2 . The capacitors CI and C2 are arrangement associated, these capacitors are utilized to part the DC-transport voltage into three-levels where the neutral point n, is signified as center purpose of capacitors. The three levels of output voltage Van are denoted as E, 0 and - E. To acquire the voltage level E, the switches SI and S2 are to be exchanged ON. So also, to acquire the voltage level - E and 0.
D_1 and D_2 these two diodes help in clipping the changing voltage to half of the DC transport voltage. The operation of inverter utilizing this clipping diodes is clarified as when the two switches SI and S2 are exchanged ON, the voltage crosswise over " a " and '0'is Vdc, i.e., Vao = Vdc.In this case, DI' adjusts the voltage sharing amongst SI' and S2',by SI' hindering the voltage crosswise over CI and S2' obstructing the voltage crosswise over C2.

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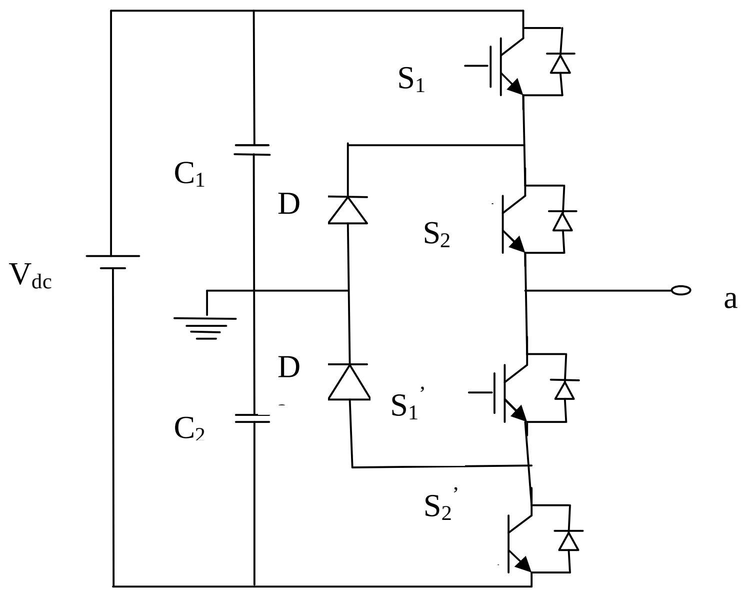

Figure 3 One leg of three-level neutral point clamped inverter

VI. CONTROLLER

The fractional order PI controller has been utilized as a part of different control fields. Fractional calculus is speculation of ordinary calculus. The fractional order PI controller's transfer function is given by:

$$G(S)_\alpha = K_P + \frac{K_i}{s^\alpha} \quad (1)$$

Where K_P is the proportional constant, K_i is the integral constant and α is the fractional PI order. In the case of conventional PI controller (α =1).

The fractional order PI controller block contains transfer function. In simulation the transfer function can be written in the form of

b = {0.4, 500}; nb={1,0}; a={1,0}; na={0.8,0}; G = fotf(a,na,b,nb)

Where b is coefficients present in numerator of transfer function, nb is order of s domain, a is the coefficients in numerator and na is the fractional order term. It gives transfer function as

$$G(s) = \frac{0.4s+500}{s^{0.8}} \quad (2)$$

VII. RESULTS

(A) For System Using Two-Level Inverter- The result for three-phase inverter using IGBT is represented in the figure 4. The figure 4(a) shows the value of load voltage, the magnitude of voltage is -100to100V. The result has been taken for single-phase the positive half square wave is achieved when switch S1 is in ON condition and negative half square wave is achieved when switch S2 is ON. This process is repeated after each cycle.

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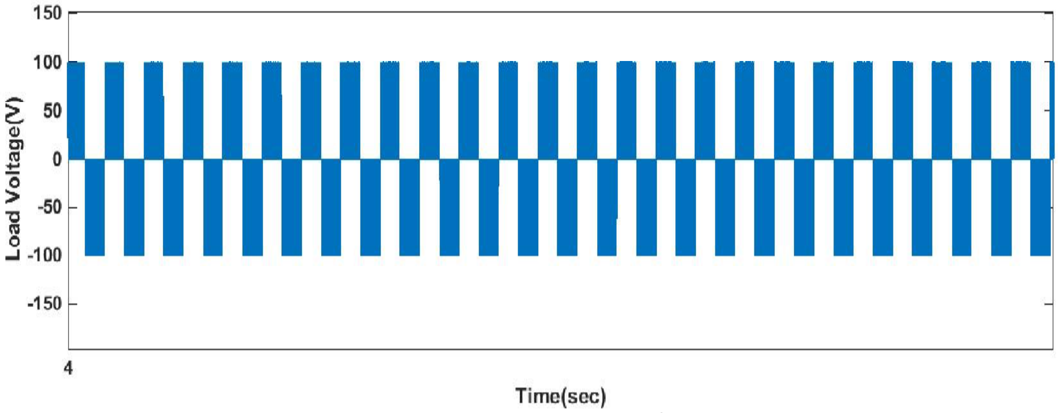

Figure 4(a) Load voltages in square wave mode for three phase two-level inverter

Figure4 (b) shows output active power whose magnitude is approx 350W after 3sec the magnitude of power became stable due to FOPI Controller which gives smooth and stable output.

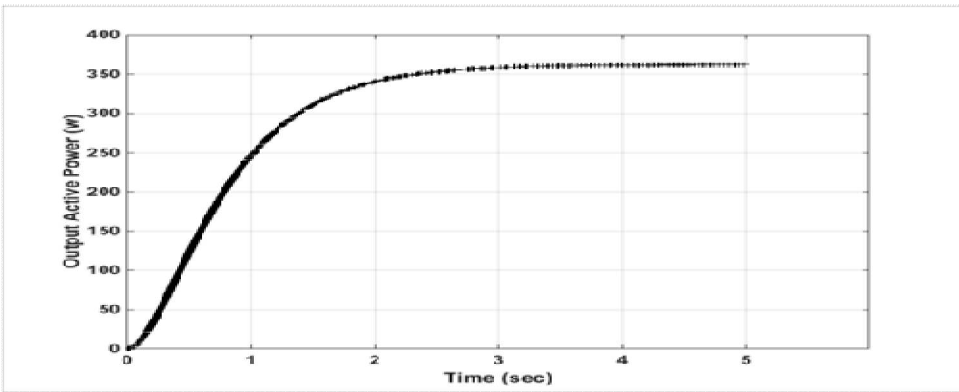

Figure 4 (b) Output Active Power for two-level inverter

Figure 4(c) shows reactive power whose value is very small which is essential because the load is resistive in nature. After analysing the two results from figure 4(b) and 4 (c) shows that the useful power is maximum and reactive powere is minimum.

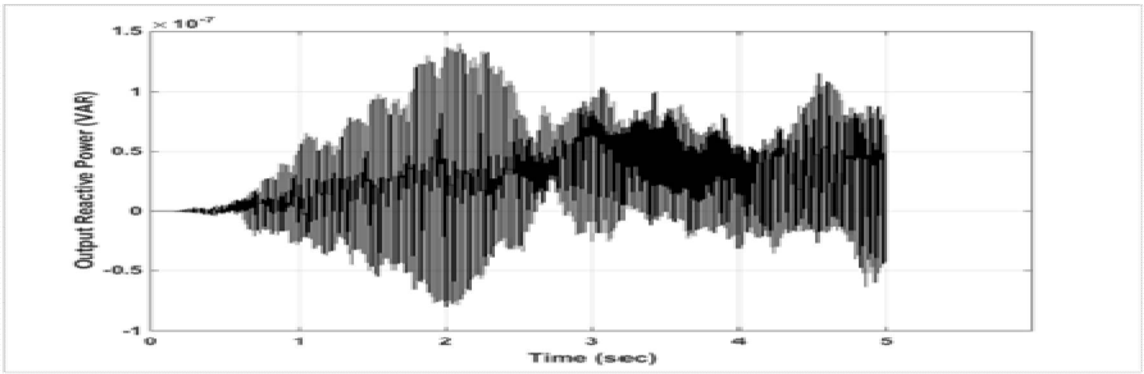

Figure 4 (c) Output reactive power for two-level inverter

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Figure 4(d) shows THD for two level inverter which has been measured from 4.8 sec for 2 cycle. From figure it is clear that the value of THD is 68.53%.

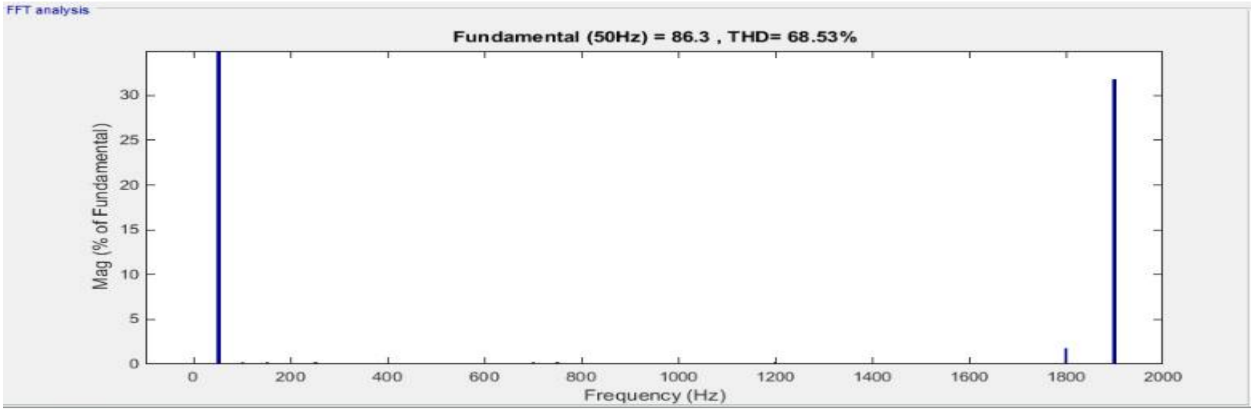

Figure 4 (d) Total Harmonic distortion (THD) for two-level inverter

(B)For System using Three-Level Inverter-The result for three-level inverter is represented in the figure 5(a)

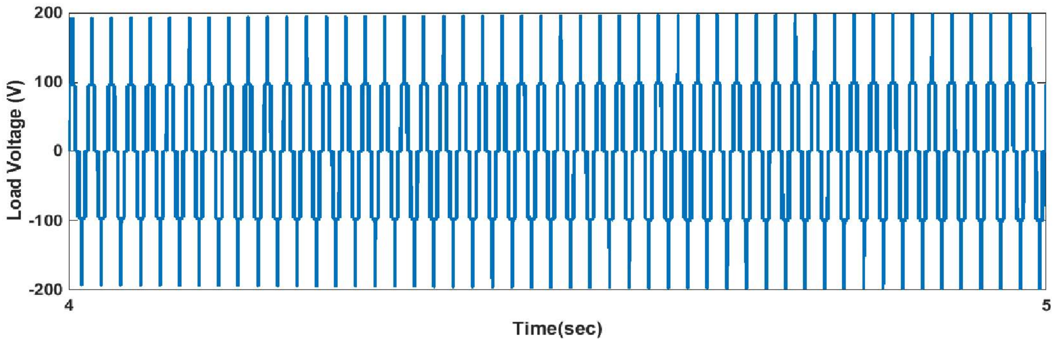

Figure 5(a) Load Voltage for three-level inverter

The result shows the value of load voltage, the magnitude of voltage is -200to200V, -100to100V and 0. Figure 5 (b) shows output active power whose magnitude is approx 350 W.

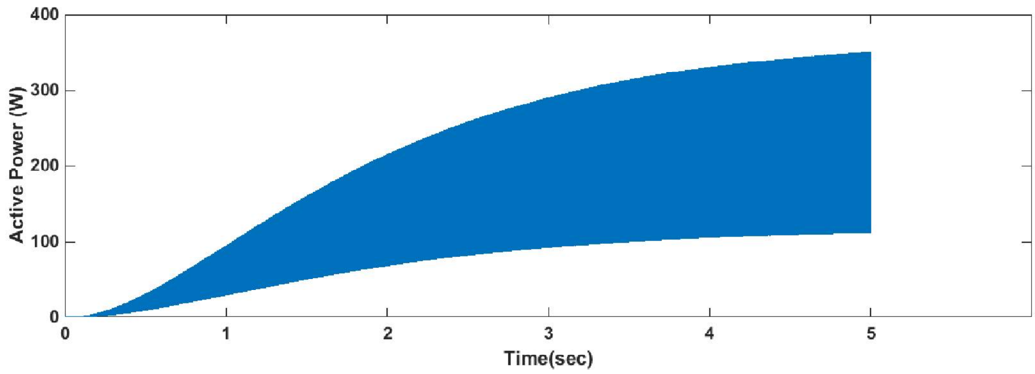

Figure 5(b) Output Active Power for Three-level inverter

Figure 5 (c) shows output reactive power which is smaller than the reactive power obtained from the system using two-level inverter, reduction in values of reactive power is advantage of three-level inverter.

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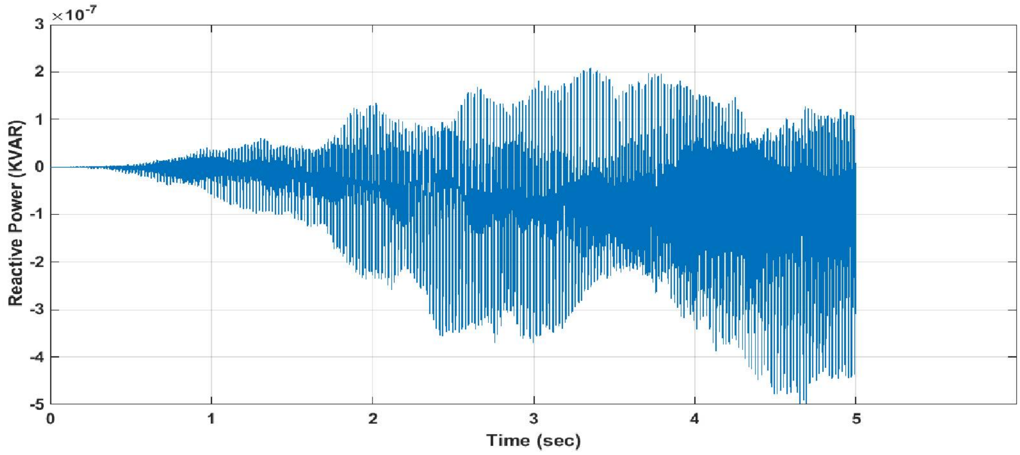

Figure 5(c) Output Reactive Power for Three-Level Inverter

Figure 5(d) shows THD whose value is 46% for 2cycle from 4.8sec.

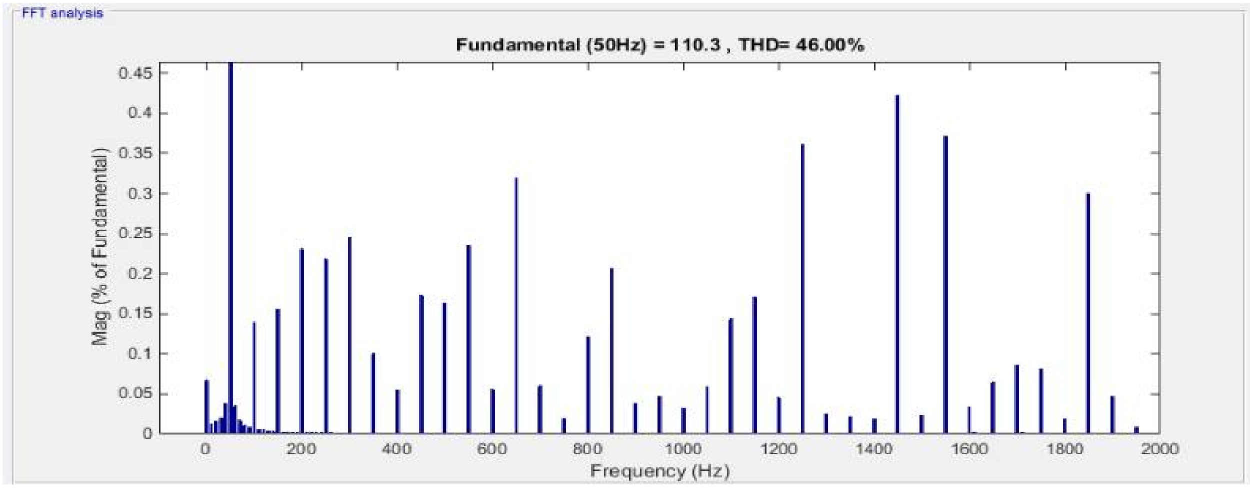

Figure 5(d) Total Harmonic Distortion for Three-Level inverter

After comparing the THD values for system using two level inverter and three-level inverter it is cleared that there is 22% reduction in harmonic distortion for the system using three-level inverter.

VII. CONCLUSION

This paper presented the improvement in the value of load voltage and total harmonic distortion, usage of three-level inverter provides following advantages:-
(a) The output voltage level is twice the DC sources.
(b) The harmonic distortion is less.
(c) The increasing fundamental value is achieved
(d) The FOPI Controller provides smooth and stable output.

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