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A Comprehensive Study of 5-level and 7-level Inverters Connected to the PI and FOPID closed loop DC boost converter

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ABSTRACT

Even in smart power systems, harmonic distortion is an essential problem. There are plenty of techniques for reducing THD with advanced control strategies. In that queue, FOPID controller is tested with both 5Level and 7Level multilevel inverters. Both multilevel inverters are tested their performance with FOPID and observe required results. The results of the simulation are obtained from the test system and the results of FOPID are compared with 5level and 7level inverters. In reducing THD, the performance of the 7-level FOPID inverter was superior and the importance of the device was highlighted. The steady state error of FOPID with 7level shows lesser than FOPID based 5level inverter.

Key words: FOPID-Fractional order PID, MLIs- Multilevel inverters, Matlab, %THD.

1. INTRODUCTION

The conversion of DC-AC 's power has become a leading technique in the fields of electric power production , transmission, distribution and also use. To fulfill this aim of modern installation, In several key areas, DC-AC converters ("inverters") play a significant role such as HVDC power transmission, static VAR compensators, electric drives, Flexible AC Transmission Systems (FACTS), renewable energy integration (such as solar PV, DFIG and variable speed wind turbine system, fuel cells) and electric vehicle/hybrid electric vehicles. Based on the nature of output waveform, inverters are classified as: two level or square wave inverters, quasi square wave inverters, two-level PWM inverters and multilevel inverters (MLIs) [1].
Traditional single-cell dual buck inverters provides high reliability, however they cannot be directly used in high voltage applications, due to the limited marketing switching device voltage rating [2]. Several controllers were investigated in this paper: PI and FOPID Integrated with Boost converter multi-inverter output at 7 levels. With its total output power and THD each system is calculated [3]. An extensive examination of some of the new multi-level inverter topologies proposed recently is presented, including the above mentioned goals Multi-level inverters have shown a broad interest in the science community and industry over the past three decades [4].

1.1 Boost Converter with 5level Inverter Open Loop

This area has been discussed with DC boost converter on a 5-level open loop. The converter input voltage is 72V. It was shown in fig.4a. The switching pulse of boost converter and inverter amplitude are fixed 1Volt and looks like square waveform shown in fig 4b and fig 4d respectively.
The system supported the utpo 230V voltage increase after properly choosing the L and C boost converter.It has some disturbance with more THD are 8.64%. Effective controllers are required to reduce the THD to the prescribed limit.The voltage across inverter has 5level steps since inverter is 5level and magnitude aroud 240V. The current over R-load of approximately 2.3A and the observed power output is almost 260W. Propely from fig4 to fig.4j are set to all parameters observed.

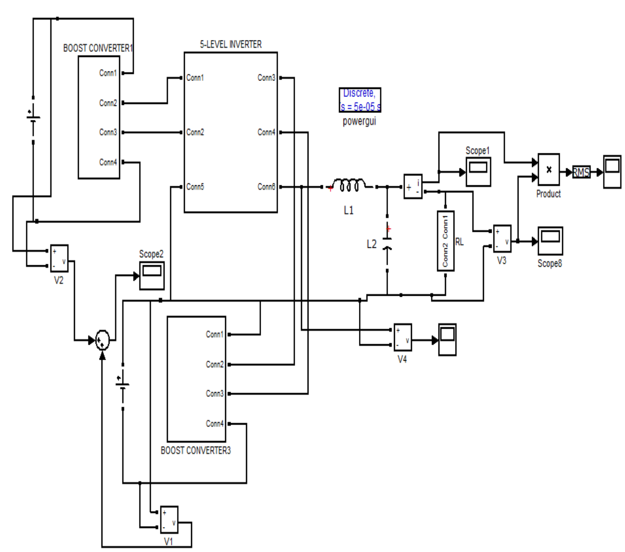


Figure 4: Boost converter with 5level inverter without controller

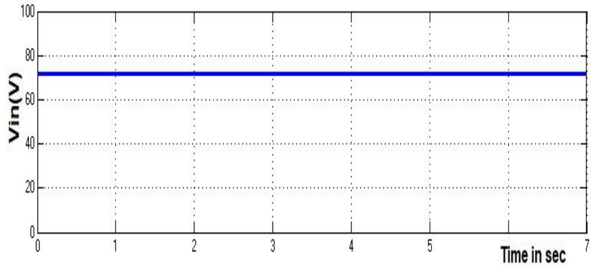


Figure 4a: Input voltage of boost converter

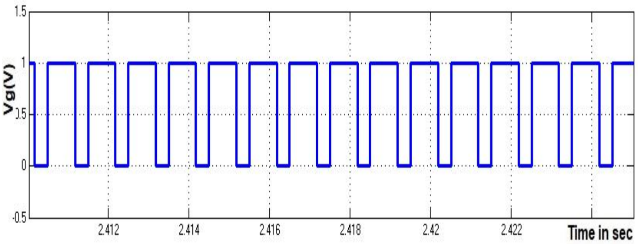


Figure.4b: Switching pulse of boost converter

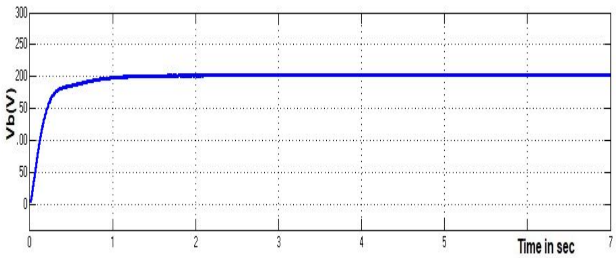


Figure 4c: Voltage across boost converter

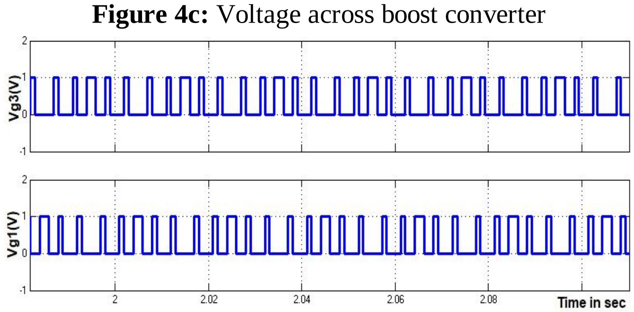


Figure 4d: Switching pulse of inverter M1,M3

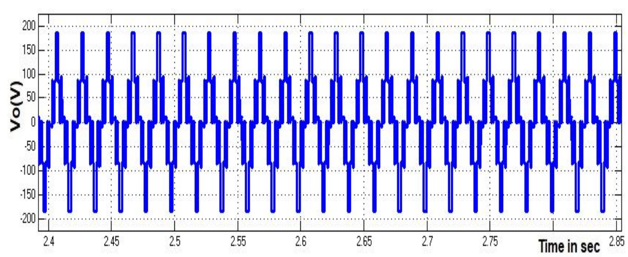


Figure 4e: Voltage across five level inverter

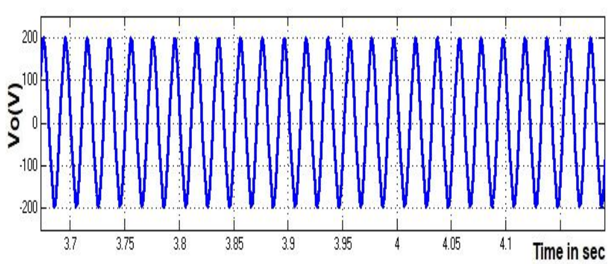


Figure 4f: Voltage across R-load

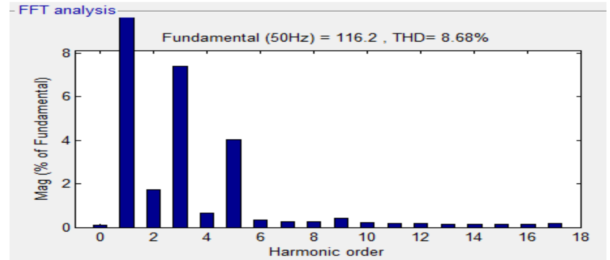


Figure 4g: Voltage THD

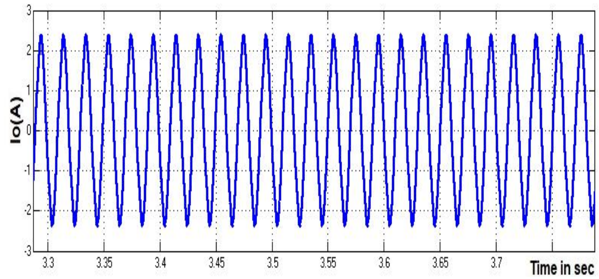


Figure 4h: Current through R-load

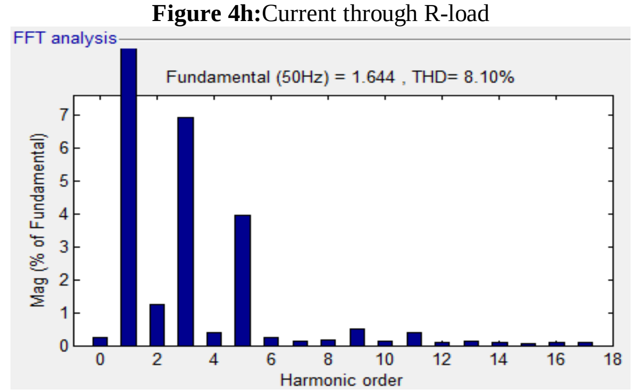


Figure 4i: Current THD

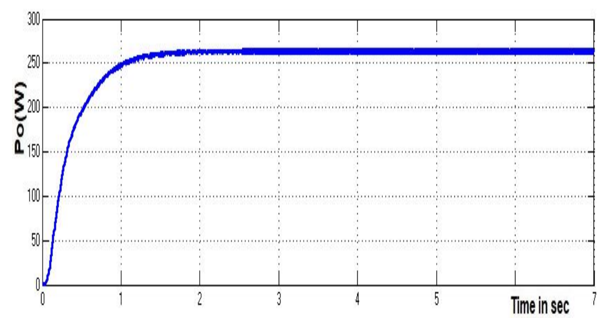


Figure 4j: Output power

1.2 7level Inverter with open loop boost converter

The figure 5a shows a simulink designed with a 7-level inverter with an open loop boost converter. The THD of the system will decrease proportionally as the steps are increased. It was asserted in fig.5and From Fig.5a to Fig.5k, different system results were represented. In fig5h, the most important point to be noted is THD almost 4.63% and THD currently 4.70%.

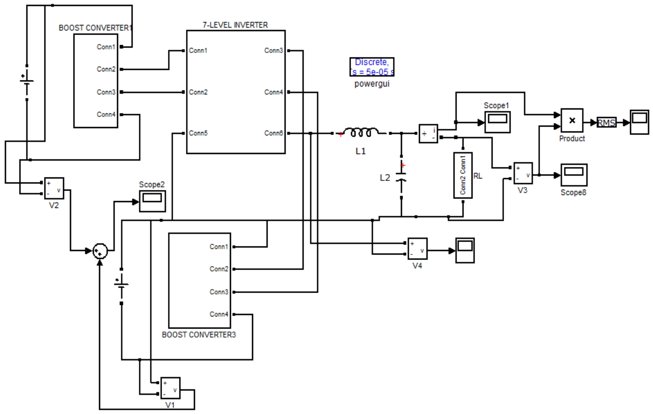


Figure 5a: Circuit diagram of boost converter with seven level inverter

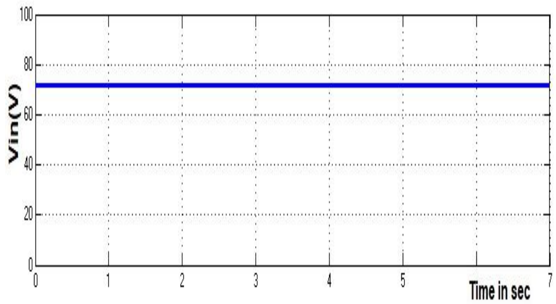


Figure 5b: Input voltage

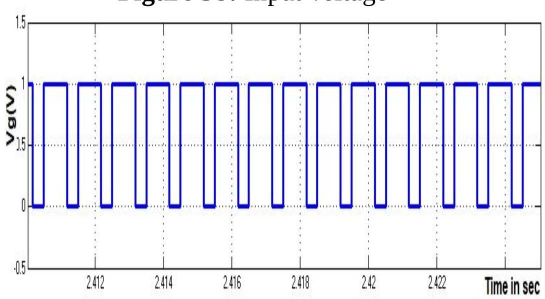


Figure 5c: Switching pulse of boost converter

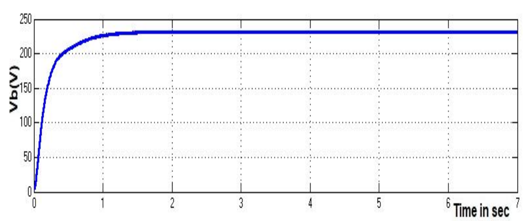


Figure 5d: Voltage across boost converter

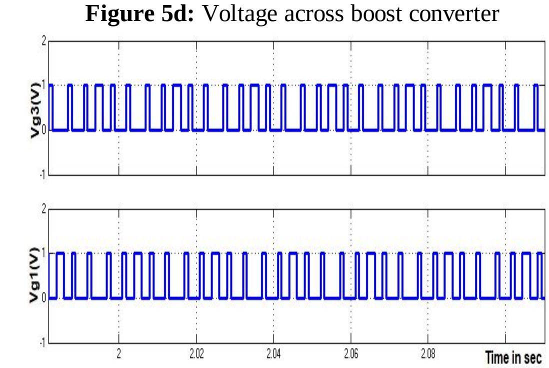


Figure 5e: Switching pulse of inverter M1,M3

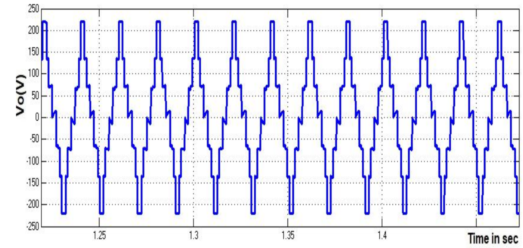


Figure 5f: Voltage across five level inverter

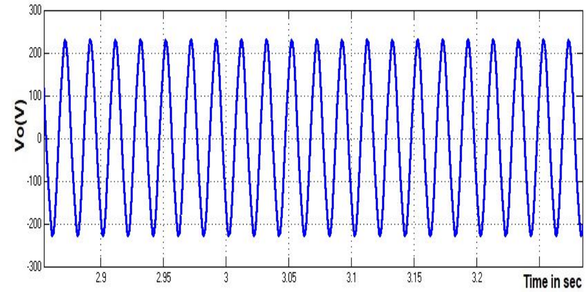


Figure 5g: Voltage across R-load

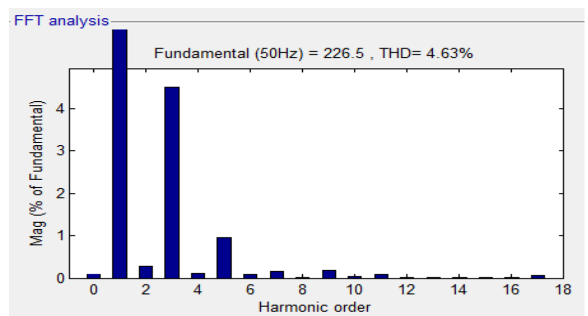


Figure 5h: Voltage THD

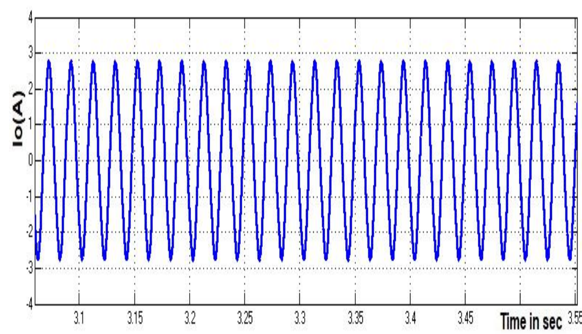


Figure 5i: Current through R-load

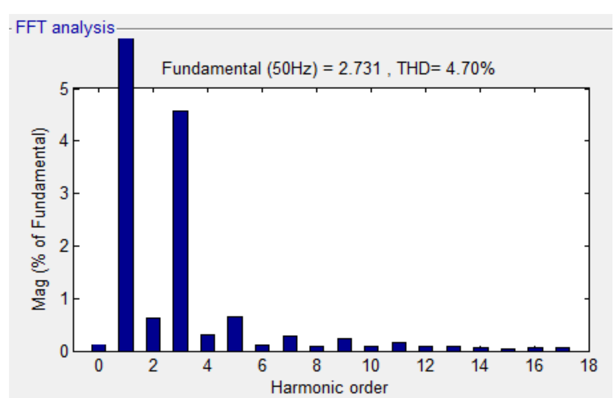


Figure 5j: Current THD

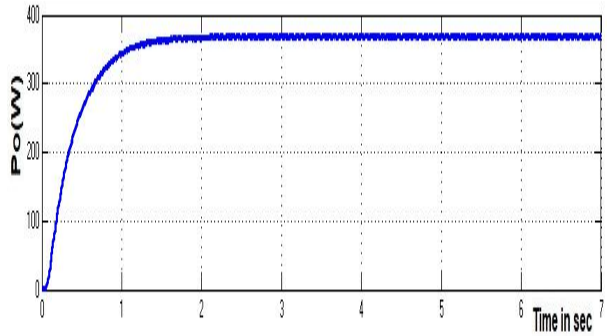


Figure 5k: Output power

2. BOOST CONVERTER WITH FIVE LEVEL INVERTER CLOSED LOOP PI CONTROLLER

The PI controller has been designed using Matlab 12a version. The Ziegler-Nicholes were selected for Kp and Kd.The value of control parameters were selected to refine the output of 5level inverter with reduced voltage and current THD nearly 4.57% and 4.55% respectively.

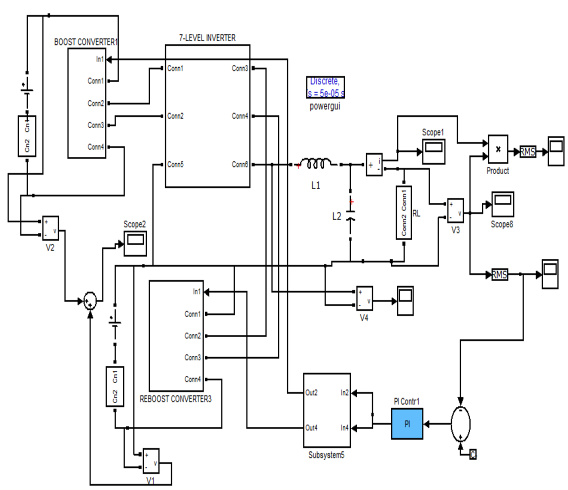


Figure 6:.Boost converter with five level inverter closed loop PI controller

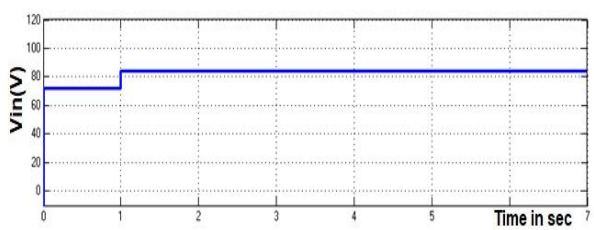


Figure.6a: Input voltage

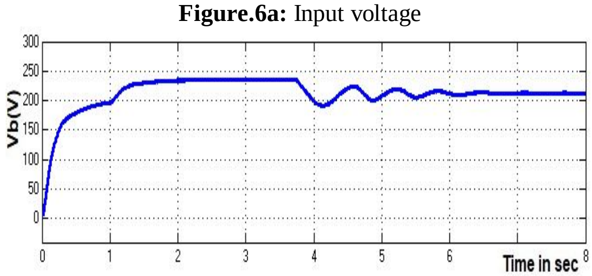


Figure 6b: Voltage across boost converter

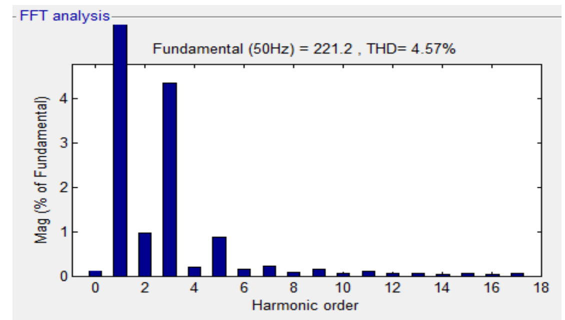


Figure 6c: Voltage THD

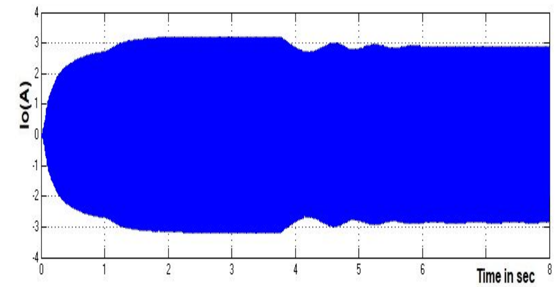


Figure 6d : Current through R-load

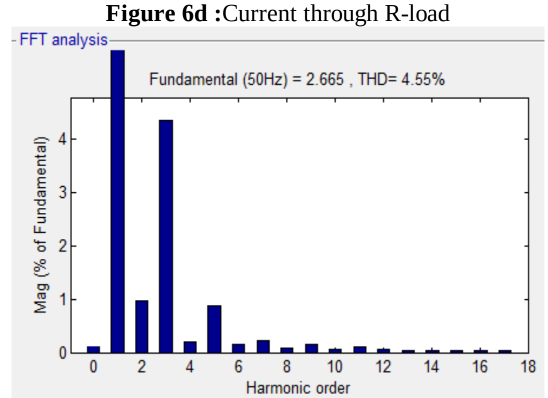
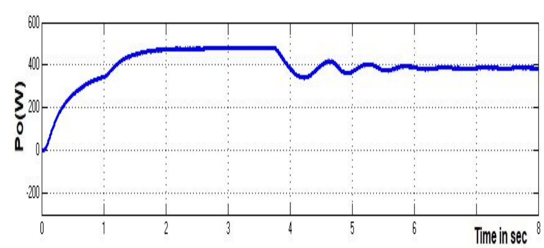


Figure 6e: Current THD



2.1 Seven level inverter with closed loop FOPID controller with DC boost converter

The system proposed was designed to minimize THD and increase the inverters in 7-level output efficiency. The new FOPID controller with a dynamic control ability over PI has been supplanted here. In 1997, Podlubny proposed the concept of FOPID controllers. It also demonstrated that this type of controller is better suited to control fractional controls than the classic PID controller. Podlubny proposed a FOPID controller with a PI functions $PI^{\lambda}D^{\mu}$. The result of a conventional PID with λ and µ fractional is an outgrowth. Figure .D_1 showed the fractional order structure of the PID controller block. The integrated differential equation for the control action of a fractional order PID controller is provided by:

$$[u(t) = K_p e(t) + K_i D^{-\lambda} e(t) + K_d D^{\mu} e(t)] \quad (1)$$

The functionality of FOPID transfer in domain S is set by

$$u(s) = (k_p + k_i / s^{\lambda} + kE \cdot s^{\mu}) e(s) \quad (2)$$

The Specified λ and μ are Real arbitrariness numbers. If λ=1 and μ=1, a classical PID controller is obtained. Te control possibilities using PID and FOPID are shown in Fig.D_2 [6].

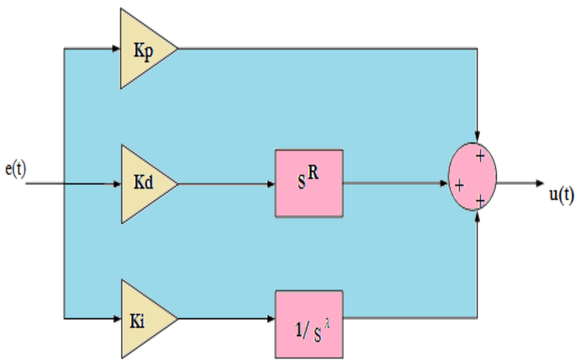


Figure D_1: FOPID controller

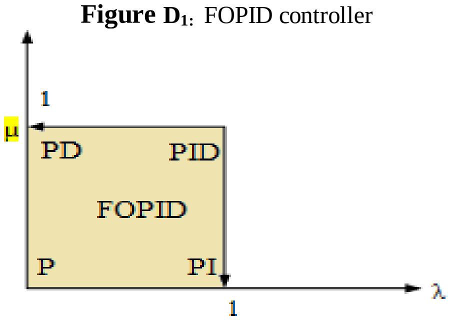


Figure D_2: Domains of PID and FOPID

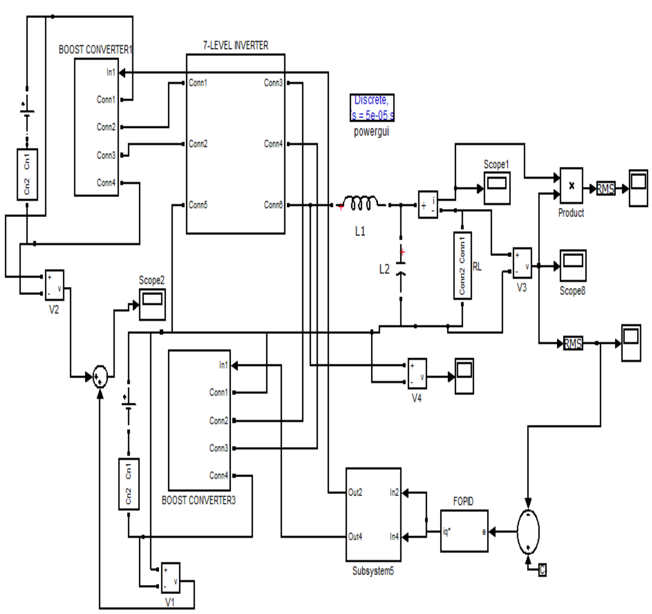


Figure 7: Circuit diagram of boost converter with 7-level inverter closed loop FOPID controller

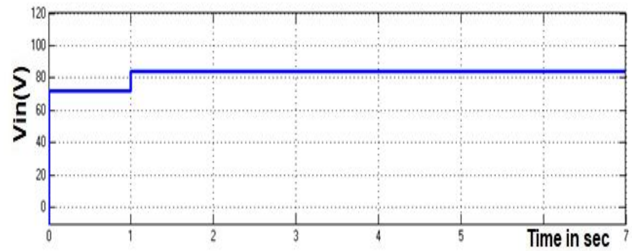


Figure 7a: Input voltage

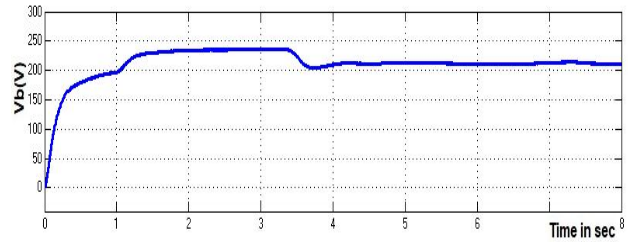


Figure 7b: Voltage across boost converter

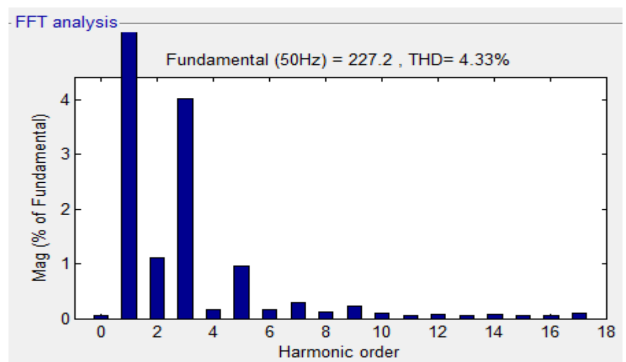


Figure 7c: Voltage THD

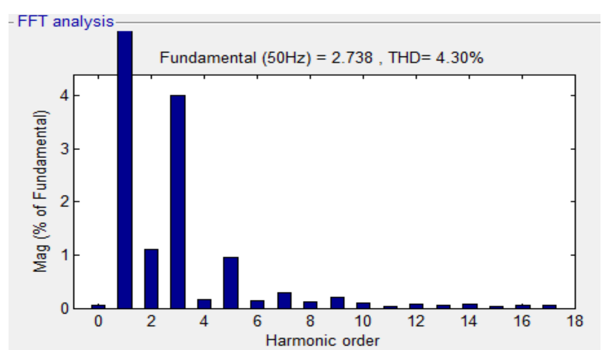


Figure 7d: Current THD

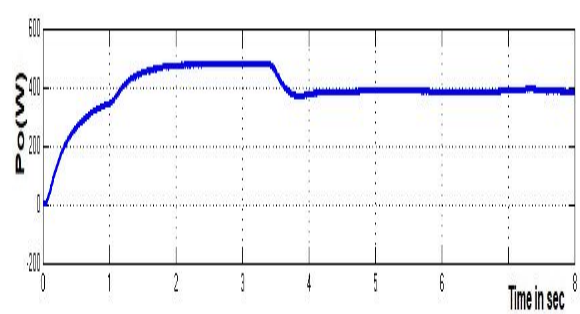


Figure 7e: Output power

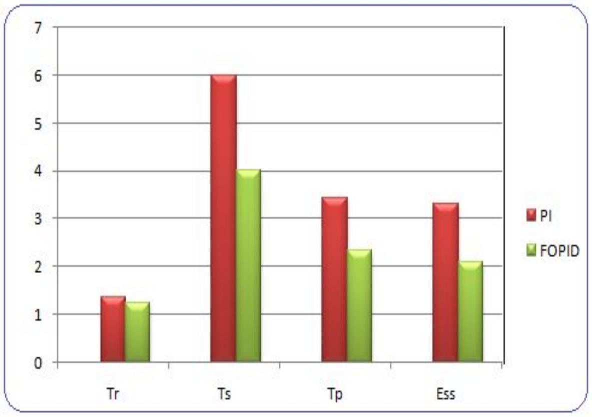


Figure 7f: Comparison of Time Domain Parameters

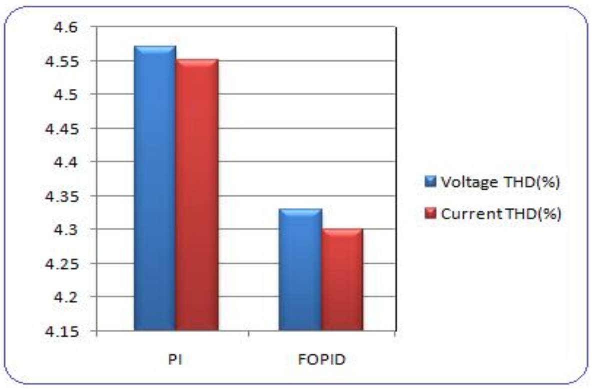


Figure 7g: Comparison of THDs of PI and FOPID controllers

3. RESULTS AND DISCUSSION

The 5-level and 7-level inverters were discussed throughout this article. The results were observed for both inverters. In 7-level and 5-level inverters, newly designed FOPID controls have been developed to reduce the system THD. Table.1 shows the Output voltage, THD and Output power Comparison. FOPID 7 level inverter gets better results than the 7 level PI and 5 level inverter controllers. The 5-level THD voltage is 8.68 as well as 7level is 4.63 respectively. Output powers of inverters are 260W and 370W respectively. As a result, 7levevl multi-level inverters efficiency is superior to 5level inverters.

Table 1: Comparsion of Output Voltage,THD and Output Power

Boost With MLI	Vin(V)	Vo(V)	Voltage THD (%)	Current THD (%)	Po(W)
5-Level	**72**	**190**	**8.68**	**8.10**	**260**
7-Level	**72**	**230**	**4.63**	**4.70**	**370**

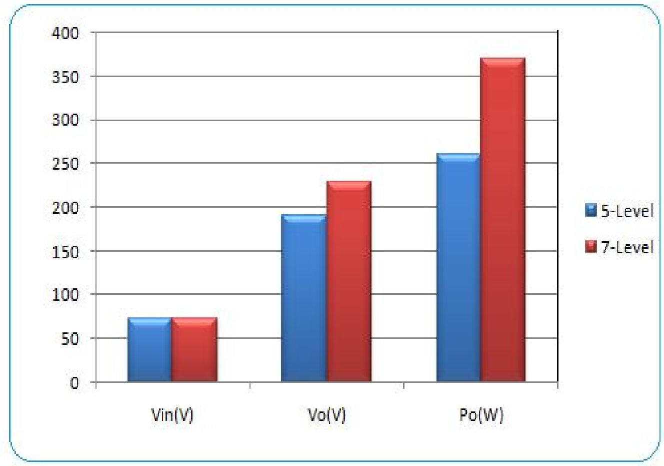


Figure 5k: Comparison electrical parameters of MLI

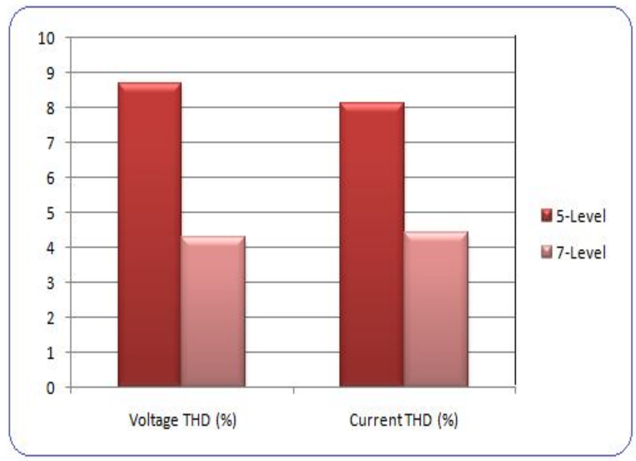


Figure 5L: Comparison electrical parameters of MLI

4. CONCLUSION

In electrical systems, multi-level inverters were accepted with the FOPID controller system since they offered many advantages**.** More multi-level inverter levels will enhance the performance. More multi-level inverter levels will increase system performance. In this research paper, from simulations and results, 7-level multi-level inverters delivered a higher efficiency than 5-level multi-level inverters in terms of significant factor such as output power, voltage THD and Current THD. It is also probably suited to better integrate industrial applications and an electrical system.

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