# PERFORMANCE ANALYSIS OF THREE LEVEL INVERTER SYSTEM USING MATLAB SIMULINK

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**Abstract:** This paper deals with thorough investigation on three level inverter fed induction motor drive. The investigation parameters are Total Harmonic Distortion (THD), torque, speed and efficiency of voltage source inverter fed induction motor drive system. A three level inverter fed induction motor drive system is simulated using matlab simulink and the results are presented. The prototype of the system is also presented to compare the simulation results with experimental results. There is close agreement between simulation results and experimental results.

**Keywords:** Induction motor, Multi-level inverter, Total harmonic distortion, Matlab Simulink.

## I. INTRODUCTION

In a conventional two-level inverter fed induction motor drive system the presence of significant quantity of harmonics makes the induction motor to suffer from severe torque and speed fluctuations, especially at low speeds, which could result in cogging of the shaft. The presence of harmonic also causes electromagnetic interference and undesirable motor heating [1]. Large sized filters are required to reduce the magnitude of harmonics. This results in larger size and higher cost of the drive system.

Nowadays, in high voltage and high power motor drive applications, multilevel inverters provides the cost effective solutions and most promising alternative to achieve good quality of output power. Using the Multilevel inverter structure the power handling capability of the system can be raised in a systematic and powerful way. The term multilevel starts with the three-level inverter introduced by Nabae et al. Increase in number of levels of the inverter, results in the output voltage waveform containing more steps generating a staircase waveform, which has a reduced harmonic distortion. The performance of multilevel inverter enhances with the increase in number of levels of the inverter.

The inverters are either Current Source Inverter (CSIs) or Voltage Source Inverters (VSIs). Current source inverters are widely used for the implementation of fully generative induction machine variable speed drives. An important and attractive feature of CSI is its good fault protection capability and the inherent regeneration capability. However, a CSI-fed induction motor suffers from severe torque pulsations, especially at low speeds, which manifest themselves in cogging of the shaft. The usual technique of overcoming such problems in voltage source inverters is to pulse width modulate the input voltage waveforms. Pulse width modulated voltage source inverters are invariably used for AC/DC/AC conversion to provide a variable ac voltages to the induction motor. However, inverter fed induction motor suffers from the presence of significant amount of harmonics, which causes undesired motor heating, torque pulsation and electro-magnetic interference. In order to reduce the harmonics, large sized filters are needed, which results in larger size and increased cost of the system. However, the advanced achievements in the field of industrial electronics and power electronics made possible to reduce the magnitude of harmonics using multilevel inverter structures, in which the number of output voltage and current waveforms are increased without increasing the size of the filter. The performance of multilevel inverters will be better than a classical inverter. The THD (Total Harmonic Distortion) for multilevel inverters will be lower than that of a classical inverter.

The time harmonics in the output of inverter produces more heating in the stator of induction motor. The fifth harmonic produces opposing torque in the rotor. To reduce the harmonics and to improve the performance of induction motor, multilevel inverter is used. The proposed work deals with the study of a conventional VSI fed induction motor and a three level inverter fed induction motor drive. Matlab based simulation is carried out and the results are experimentally verified.

## II. SIMULATION RESULTS OF THREE LEVEL INVERTER SYSTEM

A three level inverter fed induction motor drive is simulated using matlab simulink and the results are presented. Variation in speed is shown in Figure 1. The speed increases and settles at 1120 rpm. Variation in torque is shown in Figure 2. FFT analysis is done for the voltage as well as current and the corresponding spectrums are shown in Figure 3 and figure 4 respectively. The simulation value of current THD is 7.03 percent and voltage THD is 11.38 percent.

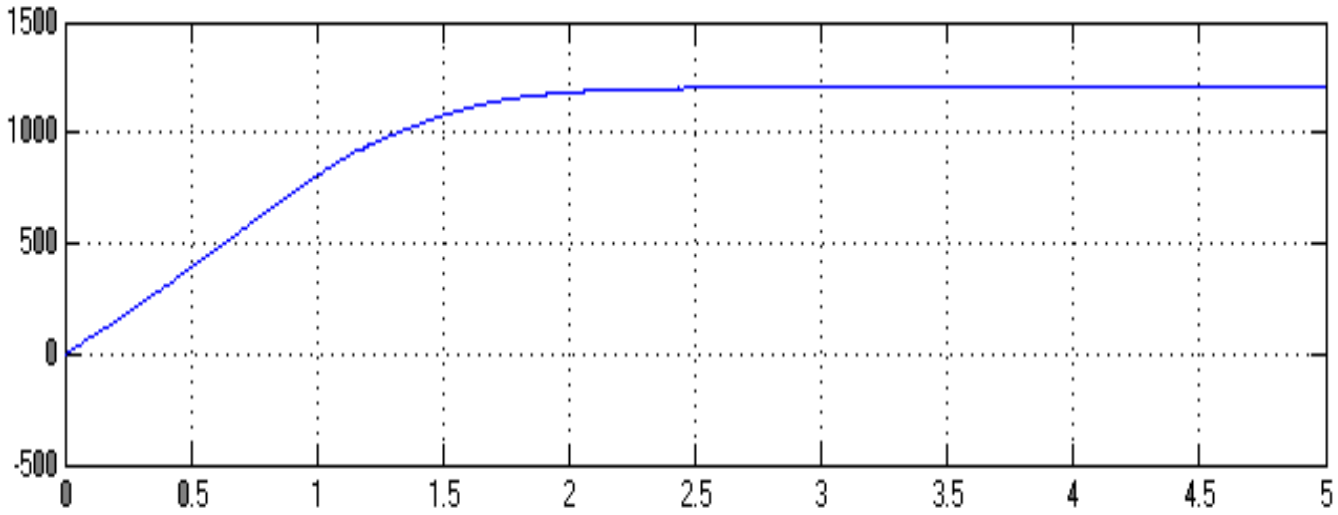


**Figure 1. Rotor speed of three level inverter fed induction motor drive**

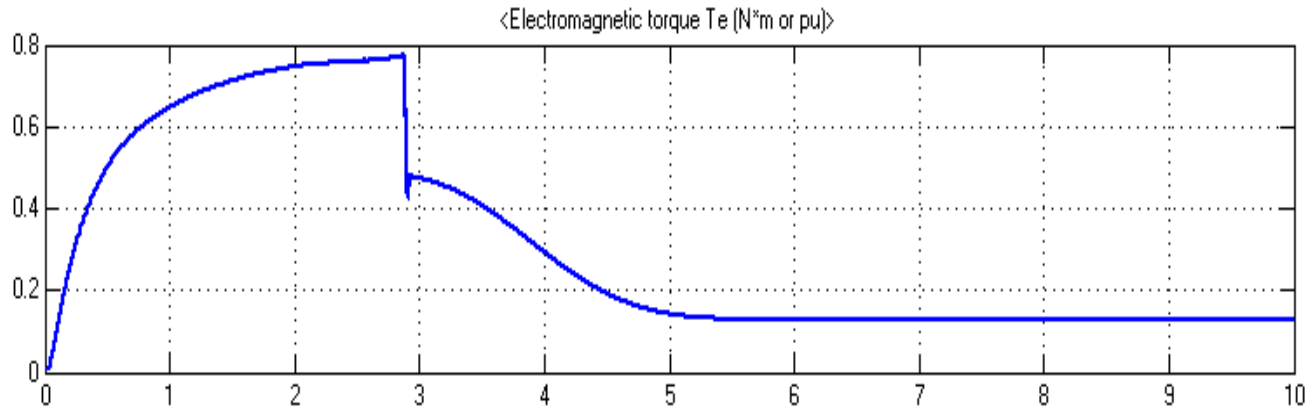


**Figure 2. Torque curve of three level inverter fed induction motor drive**

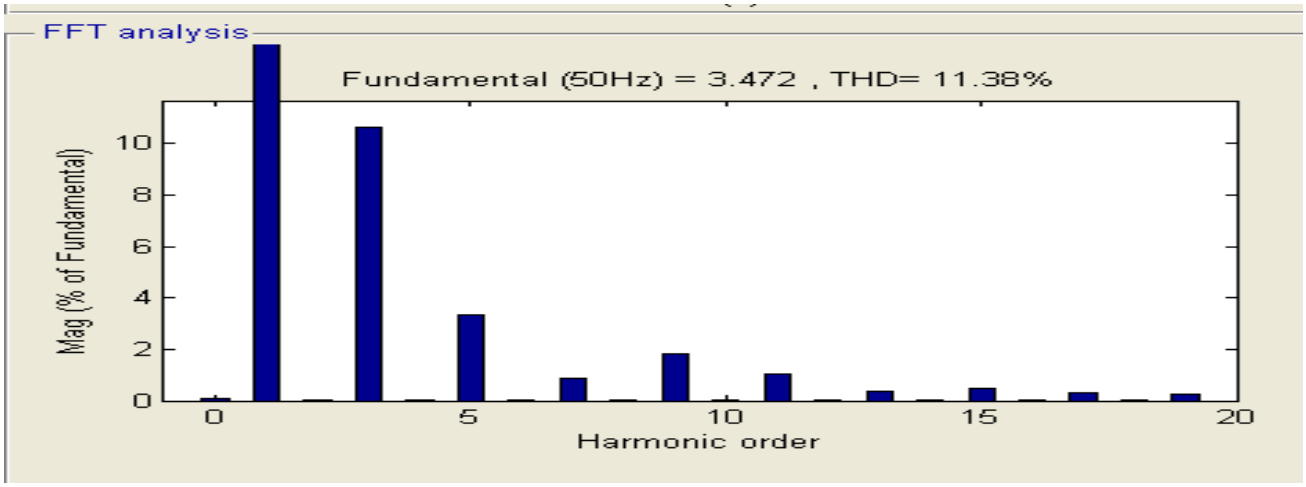


**Figure 3. FFT Spectrum for stator voltage of 3-level inverter**

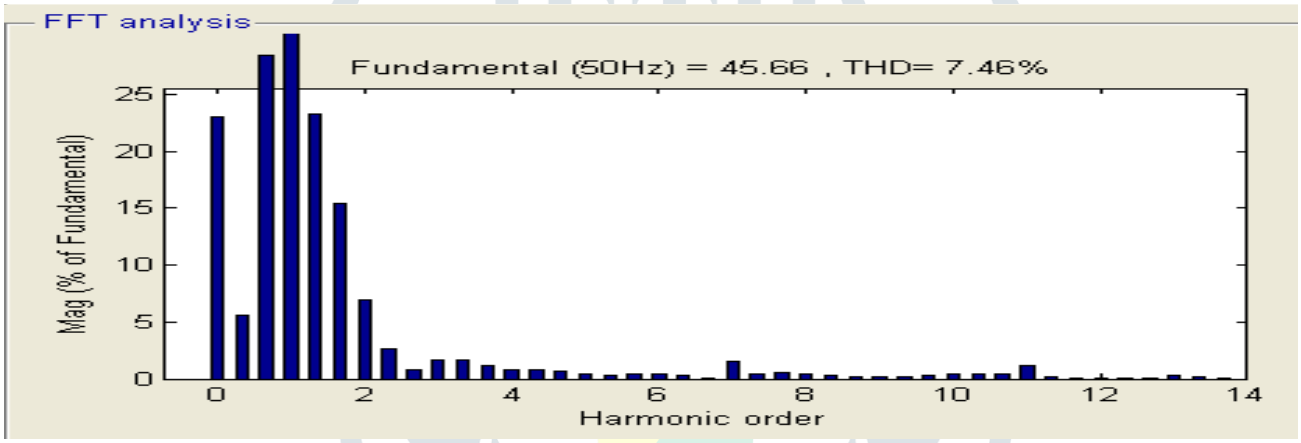


**Figure 4. FFT spectrum for stator current of three level inverter fed IM drive**

## III. EXPERIMENTAL RESULTS OF THREE LEVEL INVERTER SYSTEM

Three level inverter fed induction motor drive system is fabricated and tested in the Power Electronics laboratory. The snapshot of the hardware is shown in Figure 5. Stator input voltage of three level inverter is shown in figure 6. Driving pulses to the MOSFETs are shown in Figure 7. Output voltage of the inverter is shown in figure 8. Flow chart of the switching devices is shown in figure 9. The experimental value of current THD is 7.03 percent and voltage THD is 10.77 percent. Simulation and Experimental values of current THD and Voltage THD are shown in table 1. The efficiency of the system is found to be 70.78 percent. Losses and efficiency are shown in table 2. Complete hardware circuit of three level inverter system is shown in Figure 10.

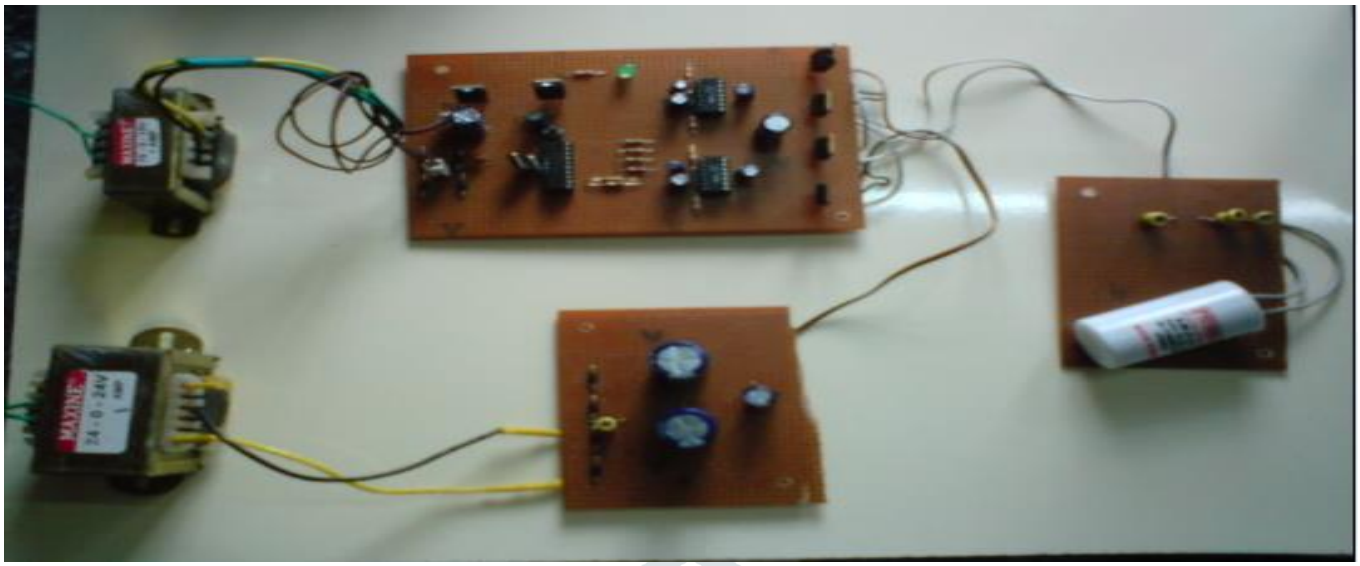

**Figure 5. Hardware snap shot of three level inverter**

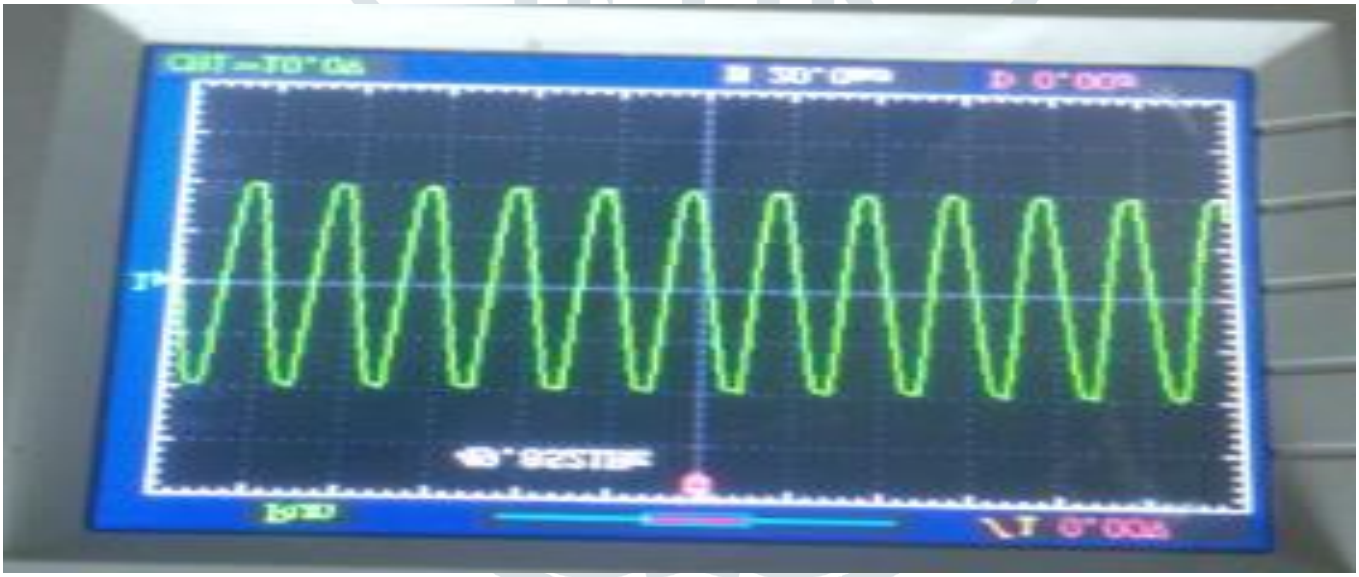

**Figure 6. Stator input voltage of three level inverter system.**


**Figure 7. Driving pulses for switching devices**


**Figure 8. Output voltage of three level inverter system**

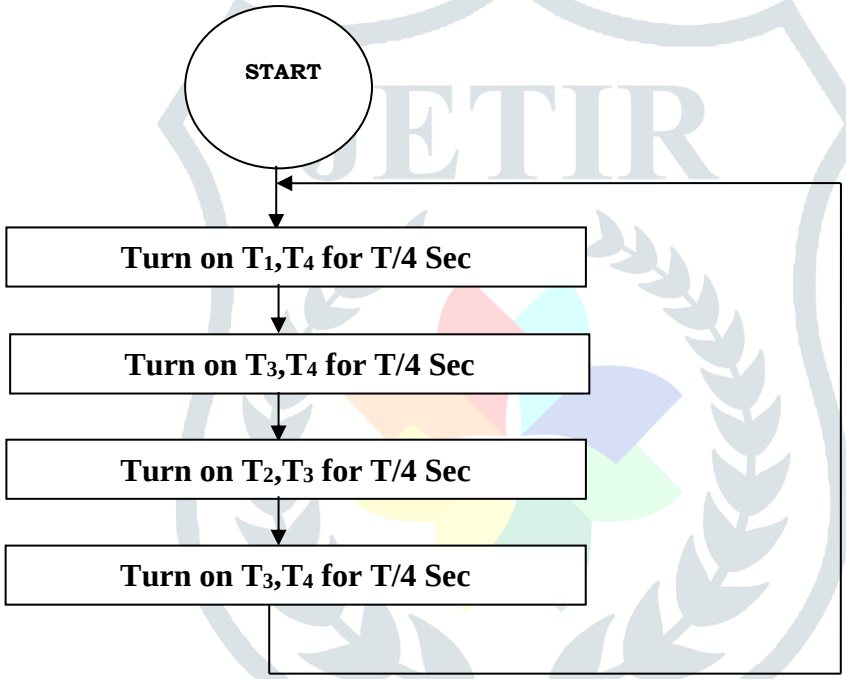


**Figure 9. Flow chart of switching devices**

Time period, T = $\frac{1}{f}$ = $\frac{1}{50}$ = 20 ms

Delay = $\frac{T}{4}$ = $\frac{20}{4}$ = 5 ms

**Table 1. Simulation and Experimental THD values of three level inverter system**

| Sl No | Parameter | Simulation THD | Experimental THD |
|---|---|---|---|
| 1 | Current | 7.46 % | 7.03 % |
| 2 | Voltage | 11.38% | 10.77% |

**Table 2. Losses and efficiency of three level inverter fed induction motor drive**

| Stator input power (W) | Stator loss (W) | Rotor plus mech loss (W) | Total loss (W) | Rotor output power (W) | Efficiency (%) |
|---|---|---|---|---|---|
| 38.05 | 4.37 | 6.75 | 11.12 | 26.93 | 70.78 |

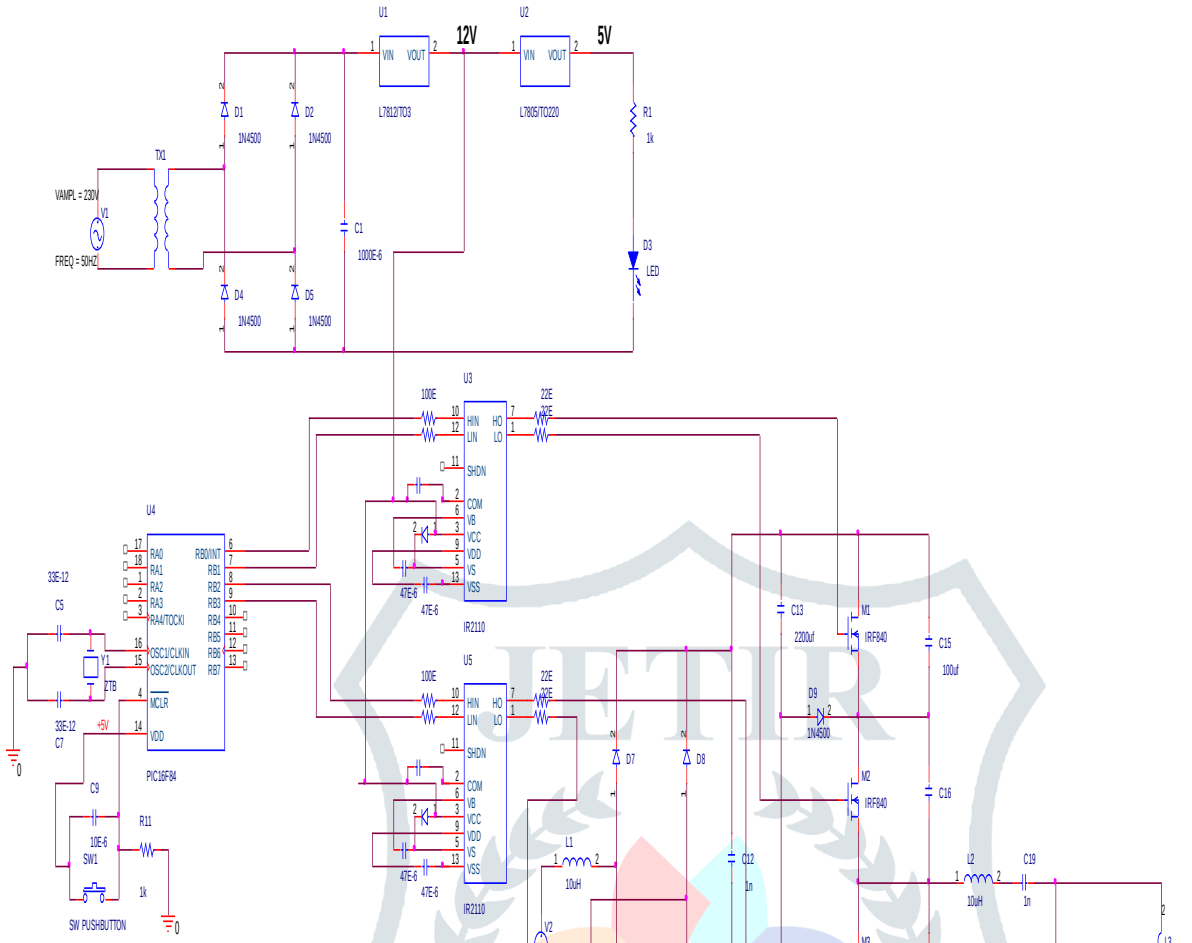


**Figure 10. Complete hardware circuit of 3 level inverter.**

## IV. CONCLUSION

Three level inverter fed induction motor system is modelled and simulated. The simulation results of torque, speed and FFT spectrums are presented. Three level inverter fed drive system is implemented successfully in the Power Electronics laboratory to validate the simulation results. By the laboratory tests, the efficiency of 3 level inverter fed induction motor is found to be 70.78 percent and rotor speed is found to be 1230 rpm. The experimental value of current THD is 7.03 percent and voltage THD is 10.77 percent. There is close agreement between the simulation and experimental results.

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