

ANALYSIS AND EXPERIMENTAL VALIDATION OF SEVEN LEVEL INVERTER SYSTEM

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Abstract: This paper deals with thorough investigation on seven 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 seven level inverter fed induction motor drive system is simulated using matlabsimulink and the results are presented. The system is also fabricated and tested to compare the simulation results with experimental results. It is observed that there is a close agreement between simulation results and experimental results.

Keywords: THD, Induction motor, Multi level inverter, Cascaded inverter, Matlab Simulink.

1. GENERAL

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.

Nowadays, in high voltage and high power motor drive applications, multilevel inverters are the cost effective solution 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.

In multi level inverters, the number of output voltage and current waveforms are increased without increasing the size of the filter. The term multilevel starts with the three-level inverter introduced by Nabae et al. By increasing the number of levels of the inverter, the output voltage waveform contains more steps generating a staircase waveform, which is implemented on a multi level inverter with DC sources. By applying this concept, specific harmonics can be eliminated and the output voltage Total Harmonic Distortion (THD) can be improved, thus generating a low distorted sinusoidal waveform.

2. SEVEN LEVEL INVERTERSYSTEM

Seven level inverter fed induction motor drive system uses Asymmetric Cascaded Multilevel Inverter (ACMLI) consisting of two cascaded H-bridge inverters: a main bridge inverter and an auxiliary bridge inverter. The load is connected in such a way that the sum of the outputs of these inverter bridges will appear across the load. The ratio of power supplies between the auxiliary bridge and main bridge is 1:2.

3. SIMULATION RESULTS OF SEVEN LEVEL INVERTER

A seven level inverter fed induction motor drive is simulated using matlabsimulink and the results are presented. The single phase structure of cascaded seven level inverter with resistive load is shown in Figure 1. It has two cascaded 'H' bridge inverters: A main bridge inverter which has DC input voltage of 200 V and an auxiliary bridge inverter with input voltage of 100 V. The output voltage across the load of 7 level inverter is shown in Figure 2. It can be seen that the output has seven levels. The speed response of the drive system is shown in Figure 3. The speed increases and settles at 1410 rpm. The variation in torque is shown in figure 4. FFT analysis is done for the output current as well as output voltage and the results are presented. The simulation value of current THD is 6.06 percent and voltage THD is 7.94 percent.

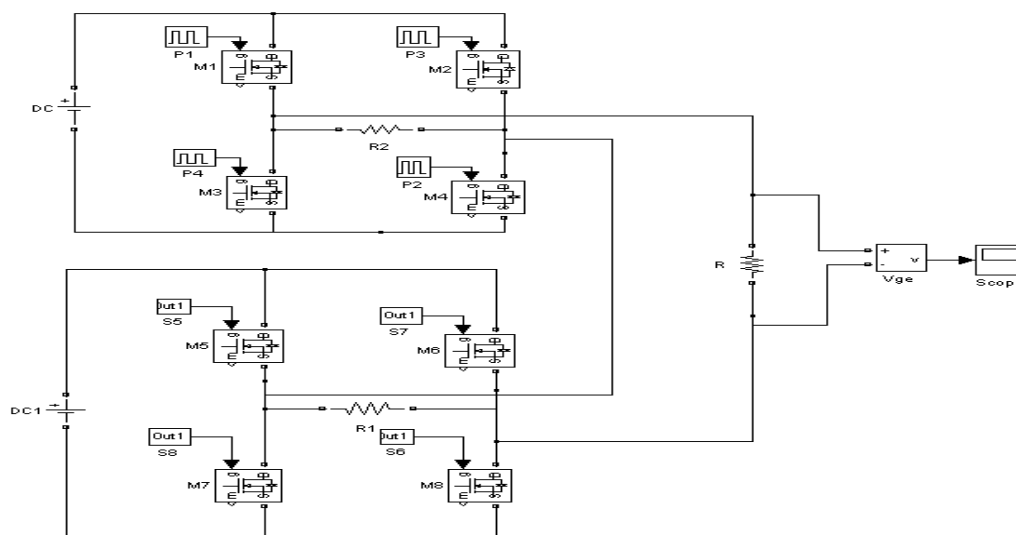


Figure 1. Single phase structure of seven level inverter

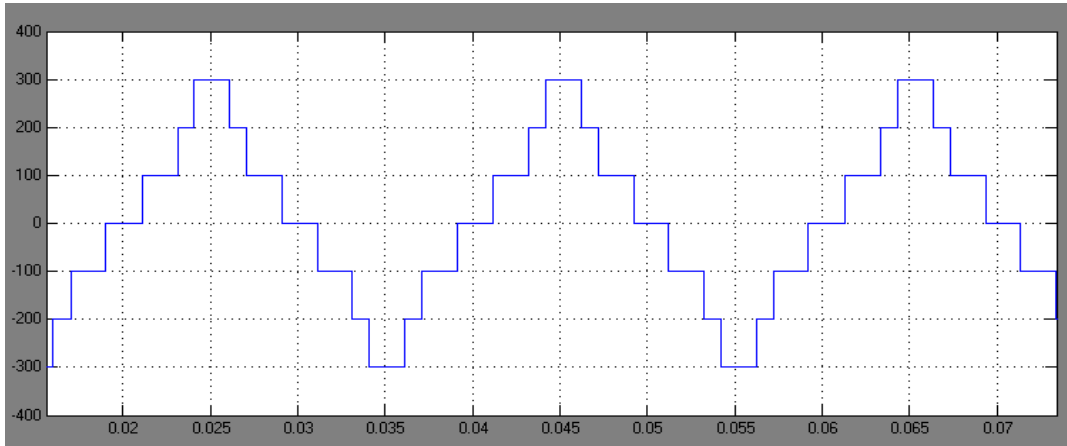


Figure 2. Output voltage of seven level inverter

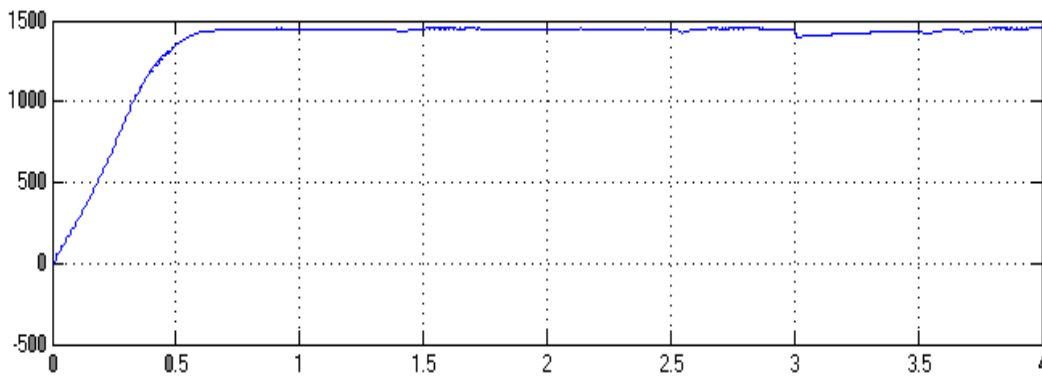


Figure 3. Rotor speed of seven level inverter fed Induction motor drive

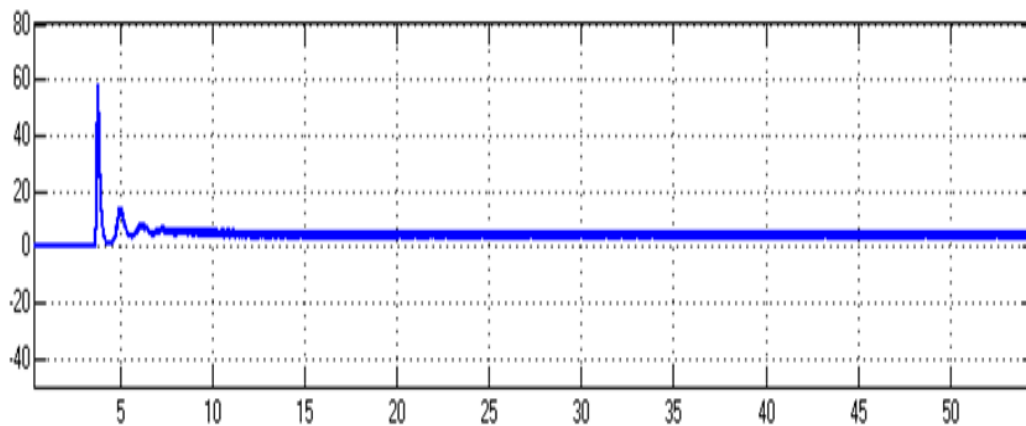


Figure 4. Torque curve of seven level inverter fed induction motor drive

4.EXPERIMENTAL VERIFICATION

The hardware is fabricated and tested in power electronics laboratory. The top view of the hardware is shown in Figure 5. The hardware consists of control circuit module, main bridge, auxiliary bridge and load. DC input voltage of main bridge is shown in Figure 6. DC input voltage of auxiliary bridge is shown in Figure 7. Driving pulses for switching devices are shown in Figure 8. Four driver ICs are used to amplify the pulses. Single phase output voltage of seven level inverter is shown in Figure 9. The experimental value of current THD of seven level inverter is 5.67 percent and voltage THD is 7.12 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 78.88 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 seven level inverter

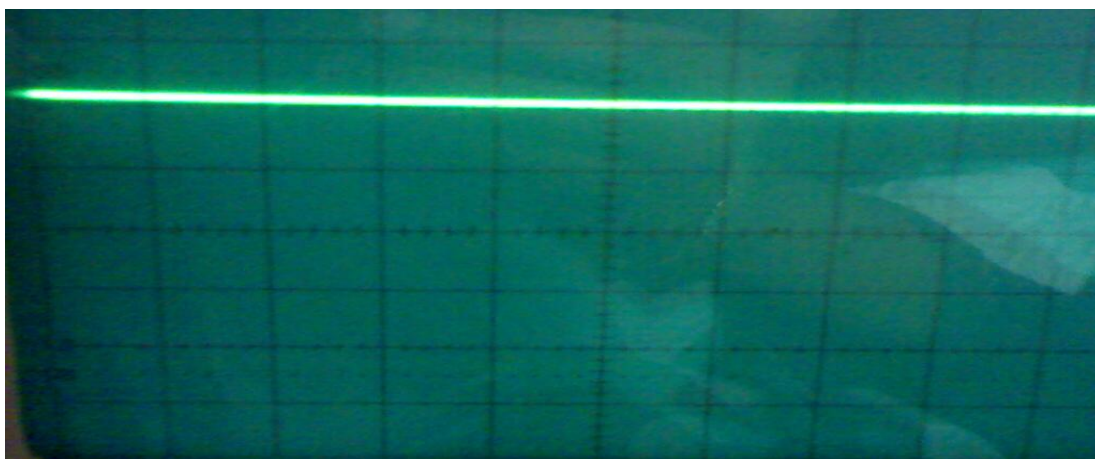


Figure 6. Main bridge DC input voltage of seven level inverter



Figure 7. Auxiliary bridge DC input voltage of seven level inverter

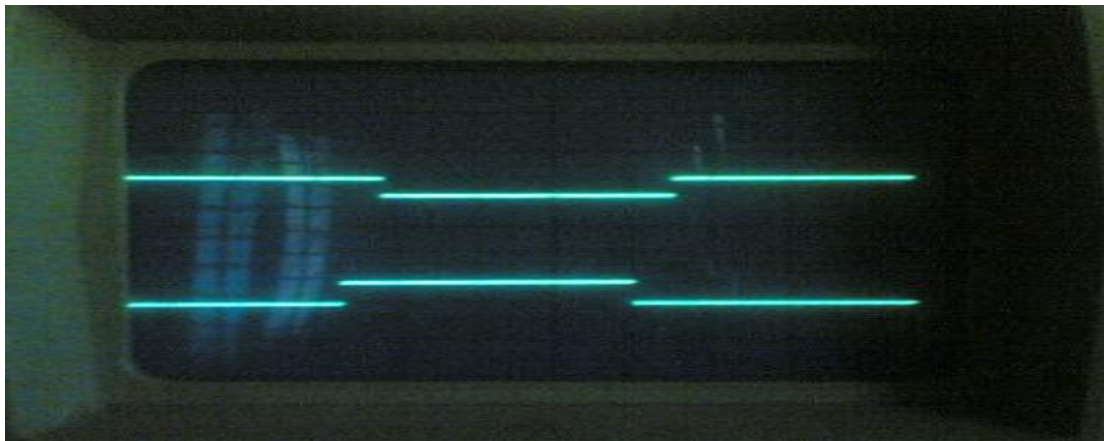


Figure 8. Driving pulses for switching devices of seven level inverter

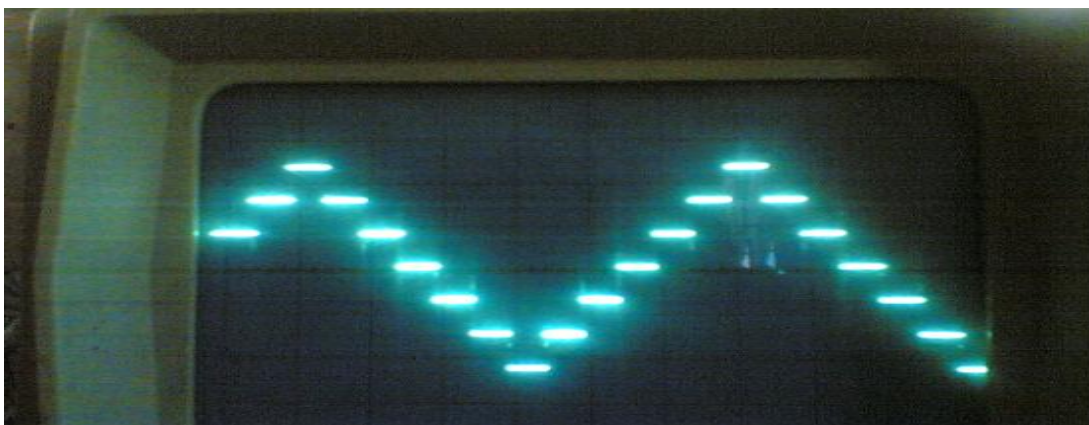


Figure 9. Output voltage of seven level inverter system.

Table 1. Simulation and experimental THD values of seven level inverter system

SI No	Parameter	Simulation THD	Experimental THD
1	Current	6.06 %	5.67 %
2	Voltage	7.94 %	7.12 %

Table 2. Losses and efficiency of seven 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 (%)
45.31	3.54	6.03	9.57	35.74	78.88

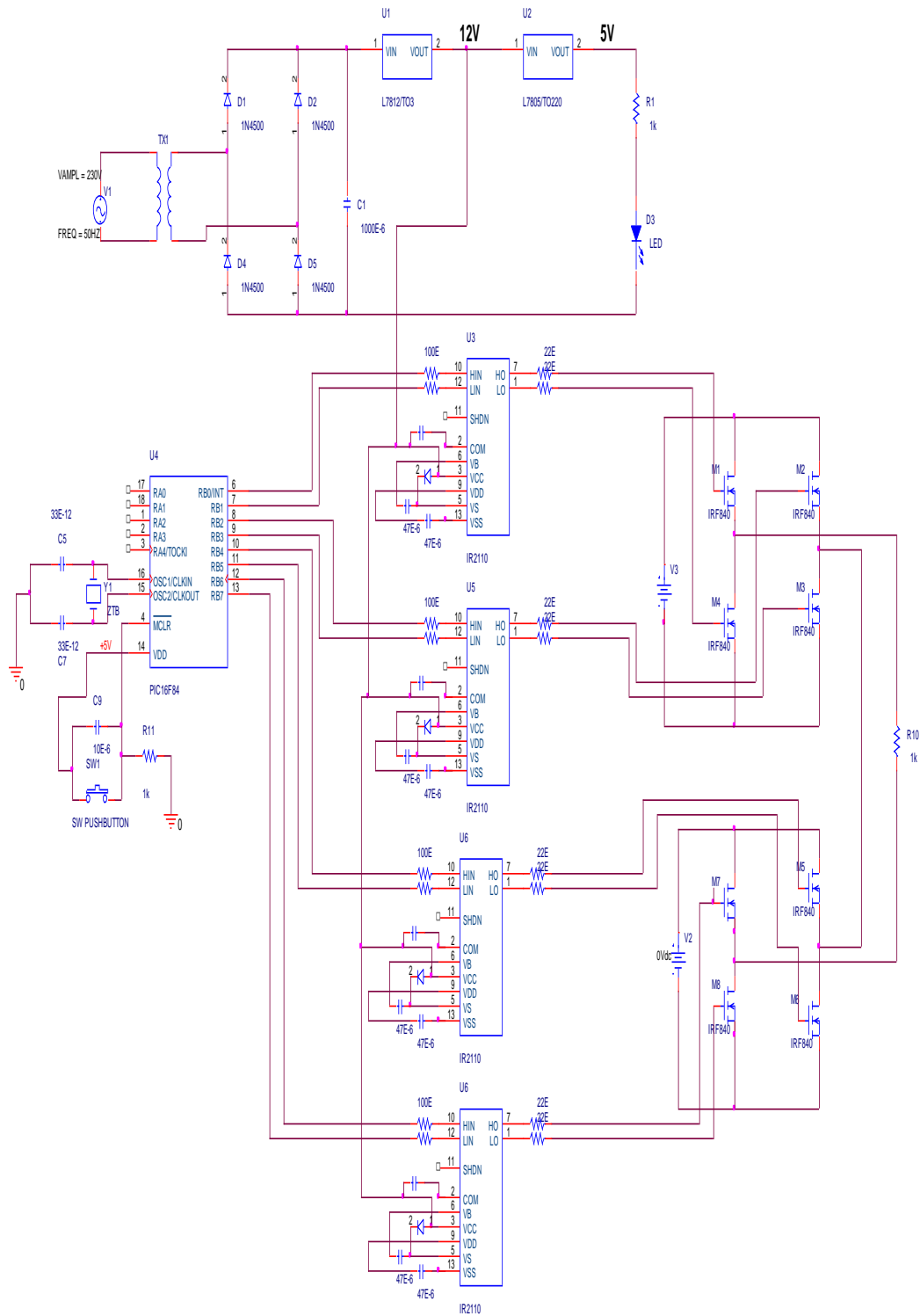


Figure 10. Complete hardware circuit of seven level inverter.

5.CONCLUSION

Seven level cascaded inverter fed induction motor drive system with unequal DC sources is modeled, simulated and implemented successfully. Simulation and experimental results for stator voltage, stator current, rotor speed and FFT spectrums of seven level inverter system are presented. The Experimental results of current THD and voltage THD are 5.67 percent and 7.12 percent respectively. Rotor speed is 1410 rpm and the efficiency is 78.88 percent. It is observed that there is close agreement between experimental results and simulation results.

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