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Meticulous Analysis of Speed Control of three phase Induction Motor Drive fed from Cascade H-Bridge Five Level Inverter

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Abstract : Cascaded H-Bridge Multilevel Inverter (MLI) for induction motor drives has wide use in industry because of its ruggedness, reliability and economical application. Induction motor drives require suitable converter topology to get the required speed and torque with less number of ripple harmonic.

Methods/Statistical Analysis : Multilevel inverter topology with more number of levels has emerged recently as a very important alternative area of medium voltage and high power control; also it is applicable to improve total harmonic distortion (THD) by reducing the harmonics.

Findings : In MLI input sources are low voltage DC source, therefore less rating of component require to achieve higher voltage and power.

Applications/Improvements : This paper gives control of three phase induction motor using five levels H-bridge MLI with help of MatLab simulation model. Control arrangement, mechanical speed and output torque signal is plotted and discussed with the conventional technique. Paper presents the features of induction motor drive instead of conventional type inverter, this analysis estimated that in induction motor drives have lower THD, less switching losses, improved power quality with high output voltage.

Keywords : Induction Motor Drives, Cascade- Bridge Inverter, Five Level Inverter, Multi level Inverter, THD.

1. INTRODUCTION

Research going in the direction of implementation on induction motor drives has been traditionally used for speed control applications in industries. Modern technology working with induction motor drives, because DC drives are applicable in the condition where application are dependents on high starting torque prerequisite. In comparison with Induction motor drives it is simple in construction and required less operating maintenance. Era of multilevel inverters (MLI) is gaining popularity and broadly used for induction motor drive applications. Medium voltage and high voltage induction motor drives are used with the multi level inverter fed DC source to attain high power and high voltage applications[1]. Multilevel inverters are popularly used contrast with usual inverter because of few advantages like low total harmonics distortion (THD), low switching losses, high power quality with reduced electromagnetic interference and low stress of voltage on each component[2]. The MLI are classified in the three diverse topologies are diode clamped MLI, flying capacitor MLI and H-bridge cascaded multilevel inverters[3].

Cascaded H-bridge multilevel inverter is used for high-power medium-voltage (MV) drives. It is the arrangement of a multiple units of single-phase cascaded cells. Practice application of the cascaded H-bridge is mainly determined by number of power cells in an inverter is its operating voltage and manufacturing cost. If we compare with other multilevel inverter, cascaded H-bridge multilevel inverter

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has less number of components for the same voltage level as compared to all three types of inverter[3]. The growth of multilevel inverter caused development of various modulation schemes. Modulation scheme is applicable based on the controlling requirement in different application similar to multi carrier PWM techniques namely phase disposition, phase opposition, phase opposition disposition. Phase disposition method provides the best harmonic profile of all modulation schemes [1]. In this technique carrier signal are in same phase and have same amplitude and frequency.

This paper present design of H Bridge cascaded MLI with five levels for application in induction motor drives. A control is going on phase displacement technique to generate switching pulses for the MLI fed drives.

The performance analysis of MLI over induction motor drive is simulated for different operating condition. The THD of MLI is compared with conventional inverter with same operating condition.

This paper is preceding as follows, section I gives the introduction of multilevel inverter for induction motor drives. Section II will present different topology of multilevel inverter particularly five level inverter with circuit diagram and control table of scheme. Section III will discuss MLI with induction motor drives. In section IV simulation and analysis result of MLI with H-Bridge cascaded inverter and induction motor drives are depicted. Concludes of paper is represents in the section V.

2. PROBLEM FORMULATION

Different topology of inverters is shown in Figure 1. We are not going to discuss all topology, but out of all this MLI inverter is widely used in the application as described in the above section. Cascaded H-bridge multilevel inverter is widely used for speed control application of induction motor drives.

Number of level indicates types of MLI and requirement of component. Five level H-bridge cascaded inverter for single phase with resistive load is shown in Figure 2. Here inverter consist of two series connected cascaded cells which are fed by two independent voltage sources. The outputs of the H-bridge cells are connected in series such that the synthesized voltage waveform is the sum of all of the individual cell outputs.

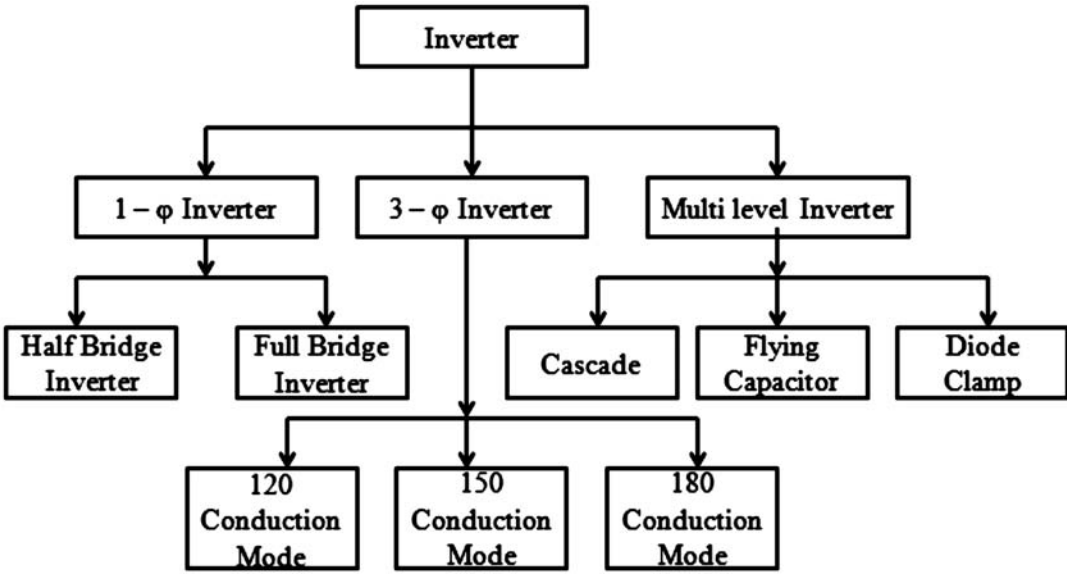

Figure 1: Classification of Inverter

If output voltage across bridge 1 is V_1 and output voltage across bridge 2 is V_2 then total voltage is derived using addition of V_1 and V_2. Five level of output voltage 2V, V, 0, -V, -2V is derived with different control techniques based on the requirement of application. Number of level increase with the increase of number of bridge and circuit component, power factor improvement has been achieved using higher level of MLI for induction motor drives. The major advantages of cascaded H-bridge inverter are that

it requires least number of components, modularized circuit and soft switching can be occupied. There is only main disadvantages in this MLI is that numbers of sources are required higher and it should be isolated to each other [4-6]. The cascaded H-bridge multilevel inverters have application like static synchronous compensators, reactive power compensation and active filter applications, photo voltaic power conversion, and uninterruptible power supplies, where high power and power quality is a major issue [7-10]. Table 1 shows control switching table of single phase cascaded five level H-bridges MLI using phase displacement techniques. As per five level MLI total eight power switches are operated as per fashion given in Table 1. Switch T_1 and T_3 from same leg of converter are operated alternately on and off to prevent short circuit current from source.

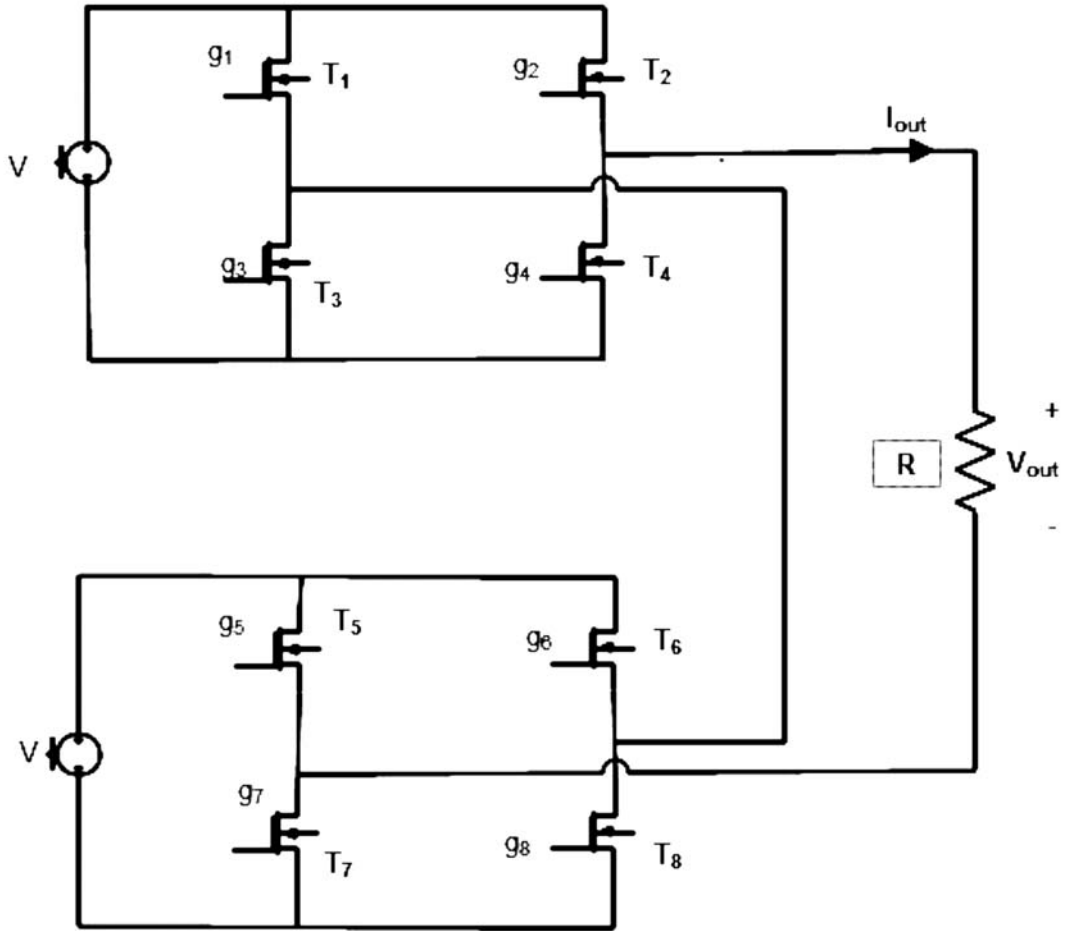

Figure 2: Five level MLI for Single phase with resistive load.

Table 1

Switching table of five level H-Bridge MLI

Voltage Level	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
2V	0	1	1	0	0	1	1	0
V	0	1	1	0	0	0	1	1
0	0	0	1	1	0	0	1	1
–V	1	0	0	1	0	0	1	1
–2V	1	0	0	1	1	0	0	1

3. INDUCTION MOTOR DRIVES USING MULTI LEVEL INVERTER

Multilevel inverter is applicable to convert direct current to alternating current with less harmonic content depending on level of type and topology. As per discussed in the above section output voltage of MLI is single phase supply. To operate MLI in three phase induction motor drives, three independent cascaded MLI is require, and they must be operate in 120 degree phase shifted to each other[3]. Figure 3 shows block diagram of five level H-bridge MLI with three phase induction motor. Circuit diagram of three phase MLI with three independent five level H-bridge is shown in Figure 4.

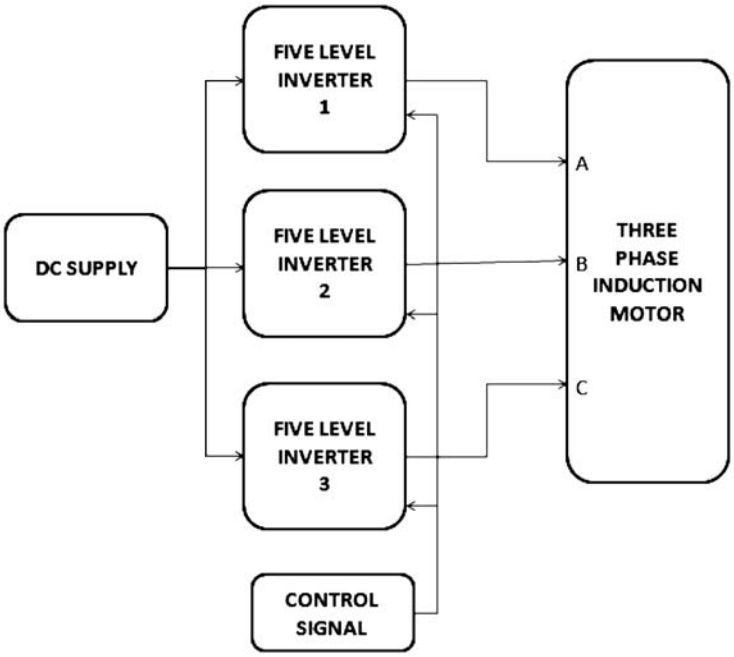

Figure 3: Block diagram of MLI with three phase induction motor

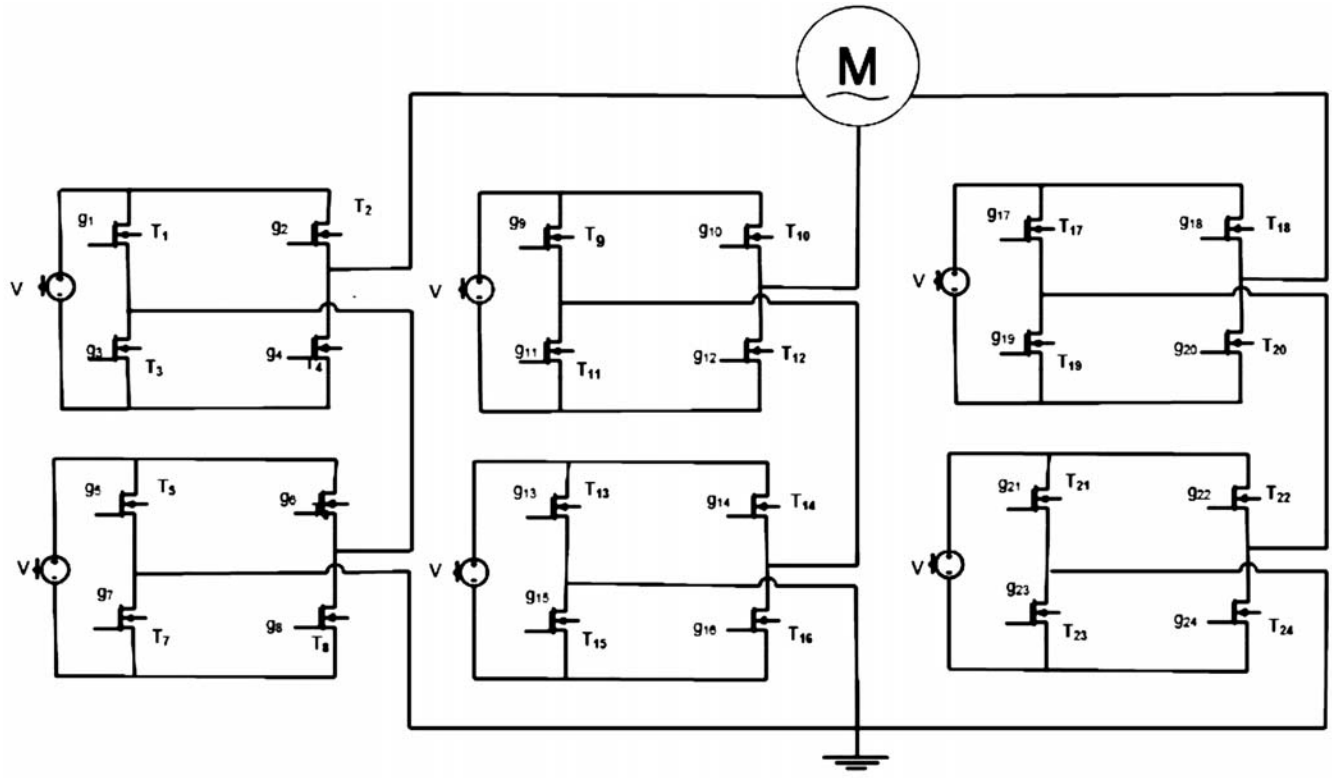

Figure 4: Circuit representation of Multilevel Inverter fed three phase AC voltage drives

4. MODELING AND SIMULATION

4.1. Multi level Inverter for single phase with resistive load

Five levels MLI with single phase coupled resistive load using MatLab simulation is shown in Figure 5. As per Table 1 switching signal is given using pulse generation block will operate on phase displacement techniques to operate series connection of two H-bridge in the five level MLI [11,12]. Linear relation of resistive load gives output voltage and output current of converter have similar. Simulated result of output voltage wave form for five level MLI with resistive load is and shown in Figure 6. It is showing five level of output as discussed in Table 1.

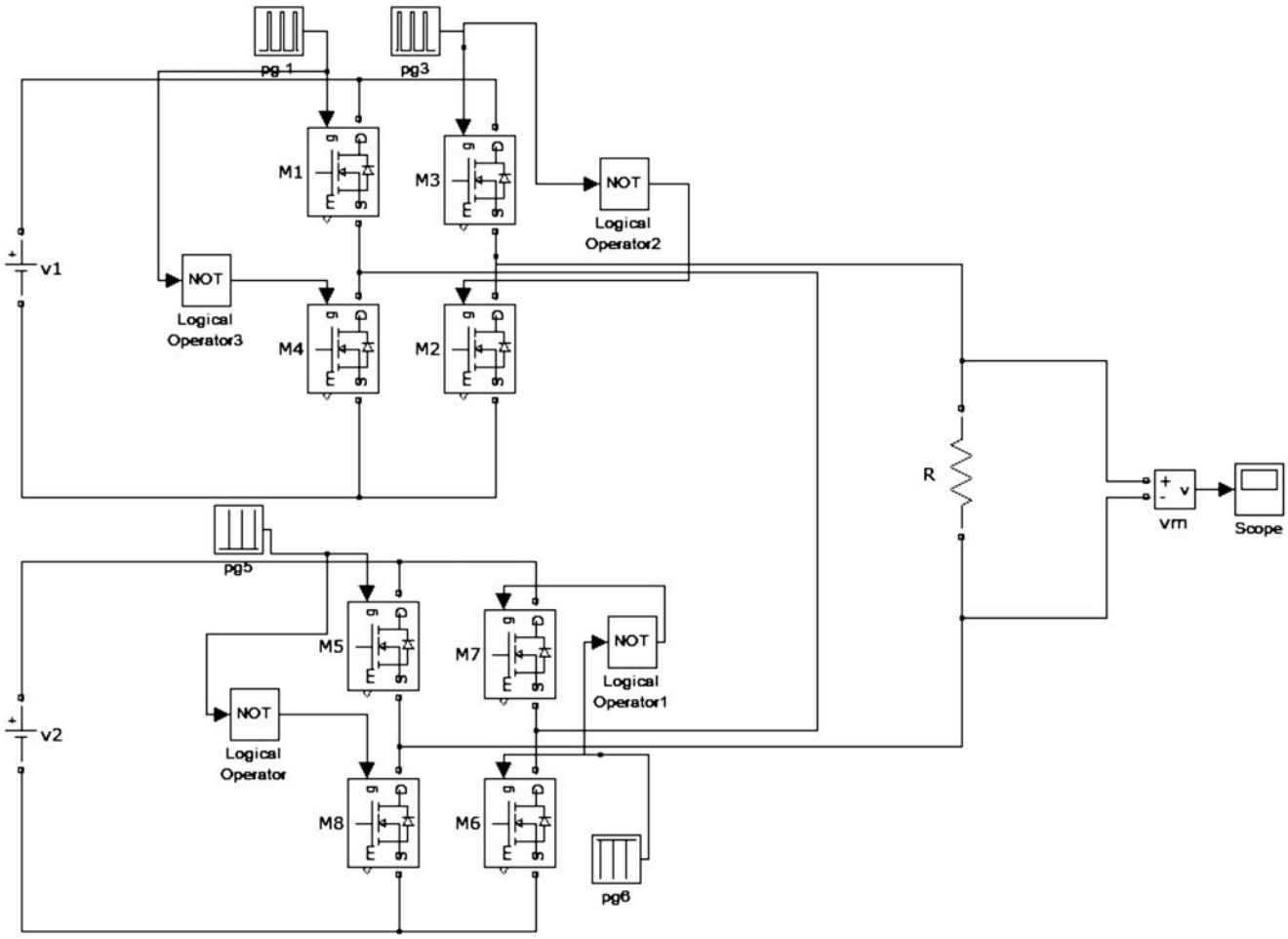

Figure 5: Five level MLI for Single phase with resistive load

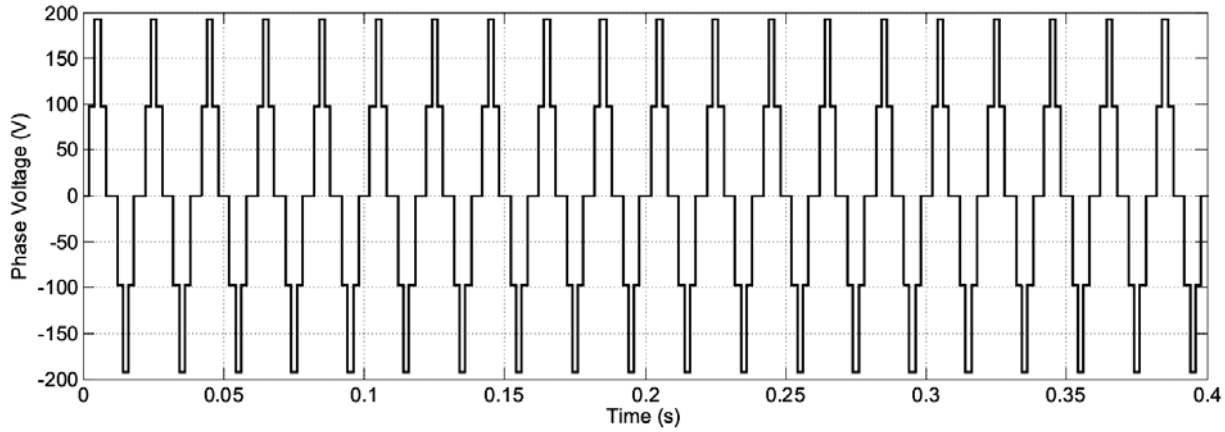

Figure 6: Output voltage waveform of five level MLI for Single phase with resistive load. [*x*- axis: 0.05 sec /div ; *y*- axis 50 Volt/div].

4.2. Modeling of three phase Induction drives using five level H-bridge MLI

Figure 7 is simulated model of three phase IM using five level H- bridge MLI. In this simulation three individual single phase MLI is connected with the induction motor. Asynchronous induction machine is simulated using MatLab simulator tools. Input supply voltage for three phase asynchronous IM is shown in Figure 8. Figure 9 and Figure 10 is the output wave form of the mechanical speed and electromagnetic torque for induction motor. In this case electromagnetic speed in induction motor is 1500 rpm.

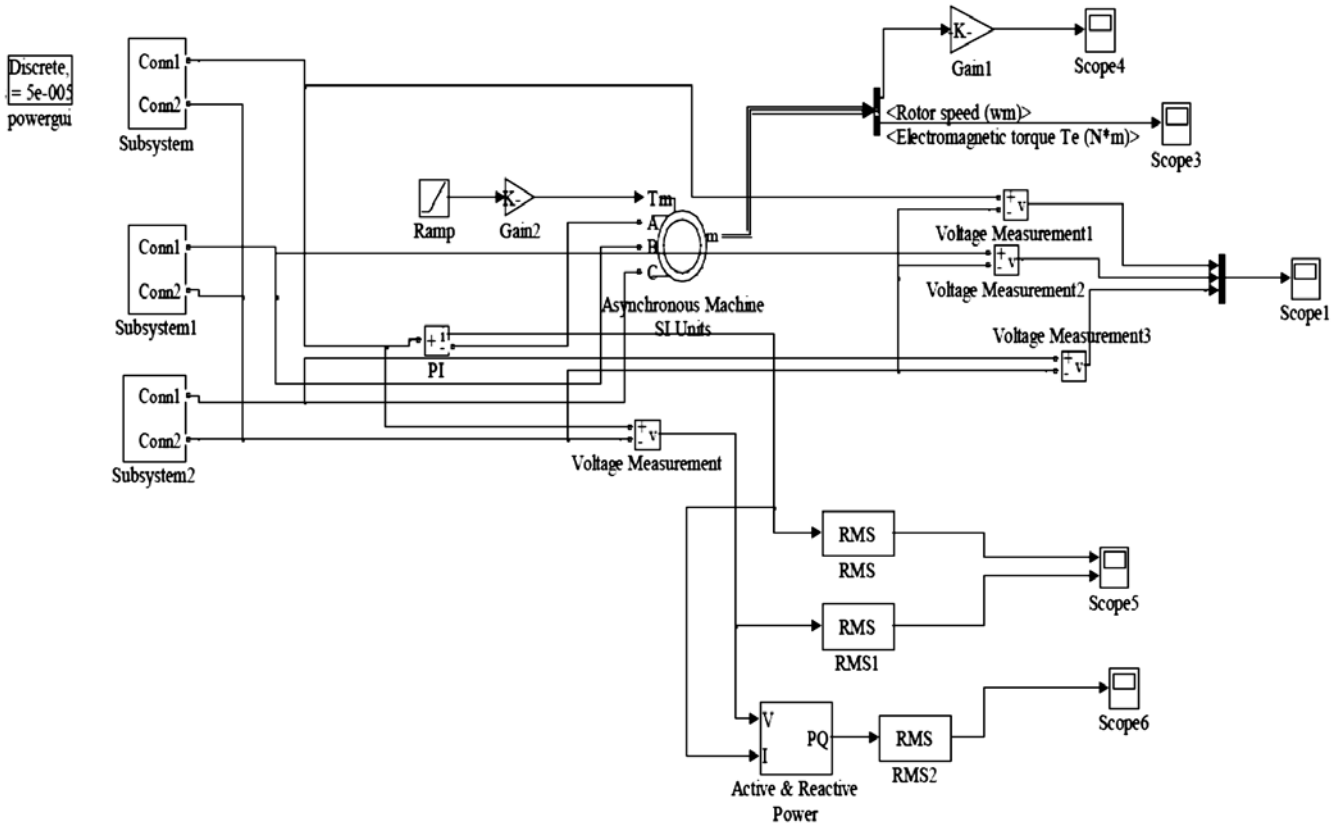

Fig. 7: Simulation of 3 phase IM using five level H-Bridge MLI fed input supply voltage for three phase asynchronous IM

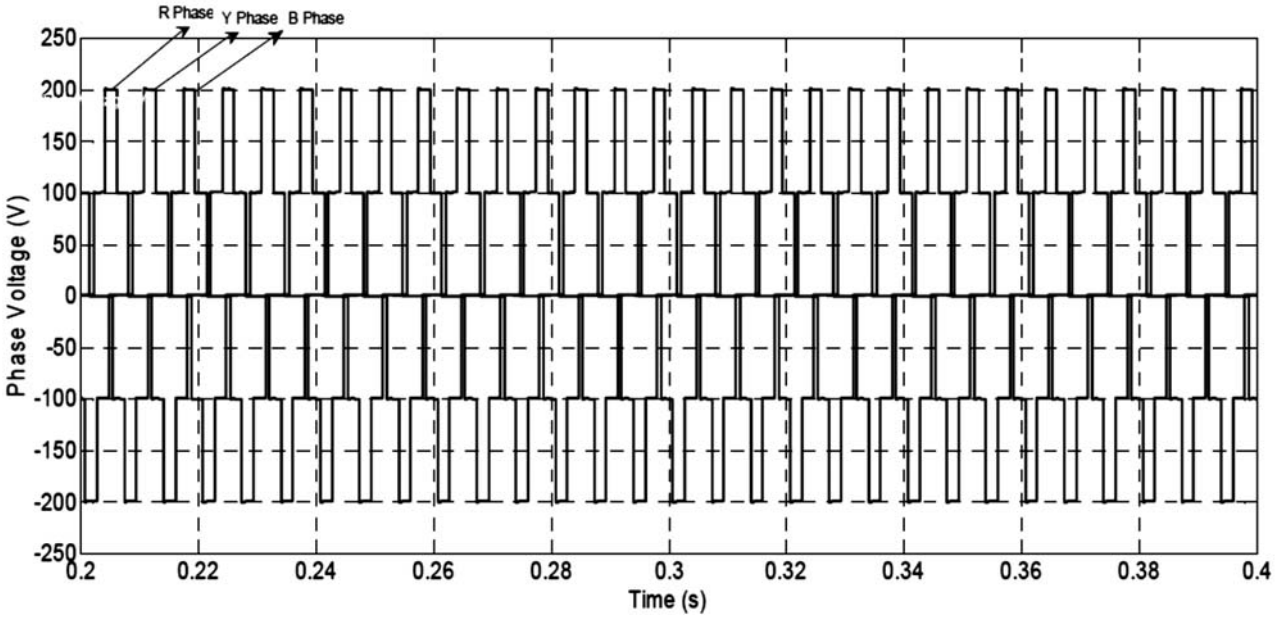

Figure 8: Output voltage waveform of 3 phase IM using five level H-Bridge MLI. [*x*- axis: 0.02 sec /div ; *y*- axis 50 Volt/div]

- Performance of IM, mechanical speed using propose scheme

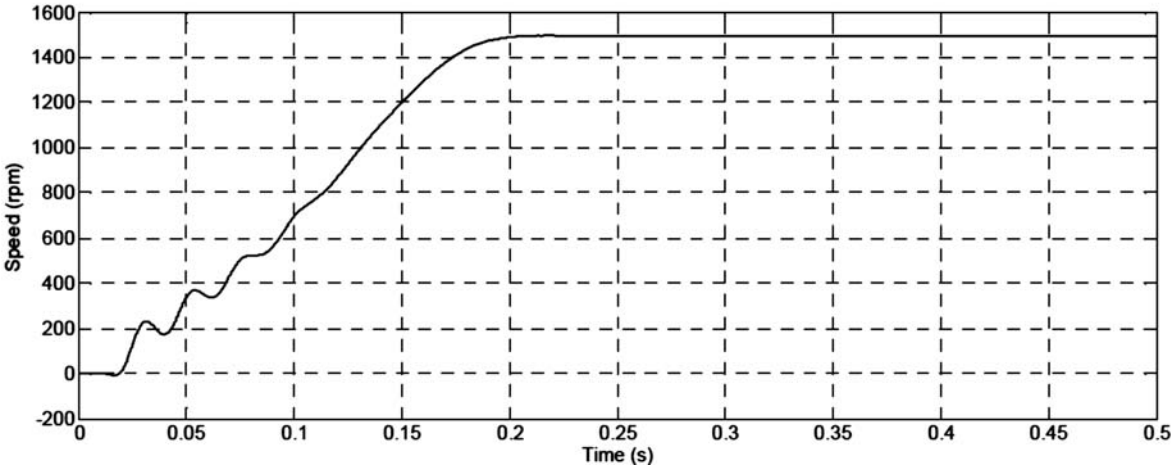

Figure 9: Speed of 3 phase IM using five level H-Bridge MLI. [*x*- axis: 0.05 sec /div ; *y*- axis 200 rpm/div]

- Performance of IM, electromagnetic torque using propose scheme

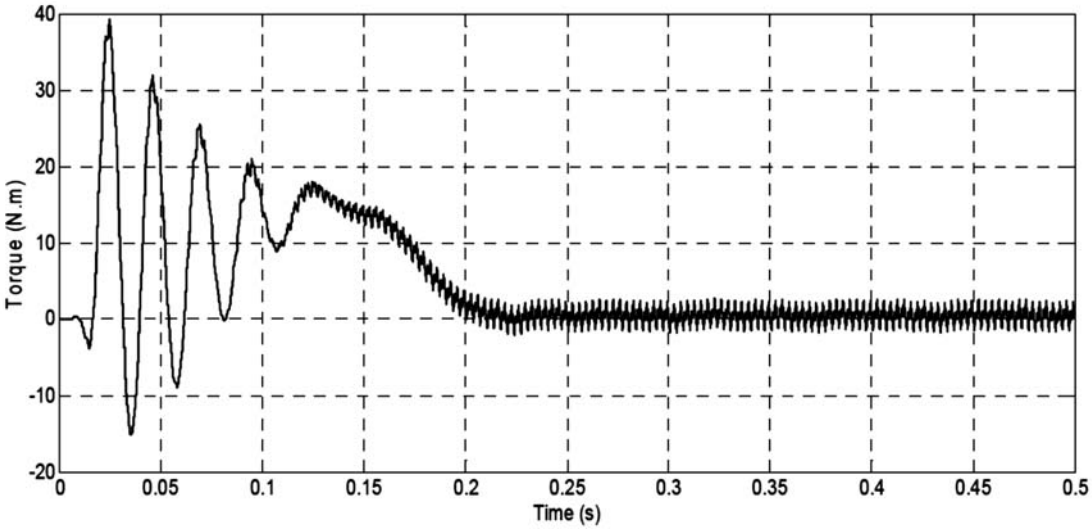

Figure 10: Electromagnetic torque of 3 phases IM using five level H-Bridge MLI. [*x*- axis: 0.05 sec/div ; *y*-axis 10 N.m /div].

5. CONCLUSION

The modeling of H-Bridge cascaded multilevel inverter fed induction motor drive was done and simulated using MATLAB simulink. The multilevel inverter fed induction motor system has been successfully simulated and the results of output voltage, motor speed, and electromagnetic torque for the system were obtained. The performance of MLI fed induction motor drive is simulated for various operating conditions. From comparison of multilevel inverter with conventional H bridge inverter the output ripple of the supply voltage are improve. Total harmonic distortion (THD) will improve consequently and motor was operate with less distorted voltage source. From the results obtained, it is observed that the MLI with five levels has lesser THD in voltage and current. Thus the designed MLI is found to be a promising alternative for induction motor drives.

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