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CASCADED H-BRIDGE MULTILEVEL INVERTER FOR INDUCTION MOTOR DRIVES

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ABSTRACT

For induction motor drives, this research suggests a cascaded H-Bridge Multilevel inverter. Compared to typical inverters, multi-level inverters (MLI) have a number of benefits, including lower total harmonic distortion (THD), decreased switching loss, improved power quality, and higher output voltage. The primary characteristic of multilevel inverters is their usage of numerous tiny dc sources to provide a range of output levels. This study uses the H-bridge cascaded MLI because it uses the fewest components for a given voltage level. Five layers of the H bridge cascaded MLI are planned. To produce pulses for the MLI, the straightforward multi carrier SPWM technique known as phase disposition (PD) is used.The H-bridge cascaded MLI with five levels using PD modulation technique is designed for induction motor drives. The performance of designed MLI fed induction motor drives is investigated extensively for various operating conditions through MATLAB simulation. The performance of MLI is also compared with conventional three phase inverter in terms of THD. The promising and interesting results obtained are comprehensively presented.

***Key words**: Cascaded H-bridge Inverter, Multilevel Inverters, Pulse Width Modulation (PWM), induction motor drives.*

I .INTRODUCTION

Induction motor drives have been widely employed for a long time in industrial applications requiring variable speed control. This is due to the induction motor's straightforward design and low maintenance needs. Multilevel inverters (MLI) are becoming more and more common in induction motor drive applications in recent years [1-3]. It is particularly utilised in drive applications requiring high current and medium to high voltage. Multilevel inverters have a lot of benefits over traditional inverters. The primary benefits include minimal switching losses, improved power quality, low total harmonic distortion (THD), and reduced electromagnetic interference (EMI). The primary benefit of multilayer inverters [4–8] is that they lessen the voltage stress on each component. Multilevel inverter topologies are divided into three categories. They are flying diodes and capacitors. One of the most widely utilised inverter topologies for medium-voltage (MV) drives that require high power is the cascaded H-bridge (CHB) multilevel inverter. It is made up of several single-phase H-bridge power cell units. In reality, a CHB inverter's working voltage and cost of manufacture are

the key factors that affect how many power cells it contains. Comparing all three types of inverters, the cascaded H-bridge multilevel inverter requires the fewest components for the same voltage level [9–11]. Different modulation strategies evolved as a result of the development of multilevel inverters. There are several Phase disposition (PD), alternating phase opposition disposition (APOD), and phase opposition disposition are examples of multi carrier PWM method types (POD). Of the three modulation strategies, the phase disposition method offers the best harmonic profile [12–15].

II. CASCADEDMULTILEVELINVERTERFEDINDUCTIONMOTORDRIVES

The MLI fed induction motor drives is shown as a block diagram in Fig.1. The cascaded H bridge MLI circuit consists of individual H-bridge cell which is fed by individual dc supply. Each H-bridge cell contains four switches. In this topology, IGBT is used as switch because of its low switching losses.Each H-bridge generates three different output voltages, +Vdc, 0 and –Vdc using various combinations of switching with the four switches. For five levels, each leg consists of two H-bridge cells as shown inFig.2

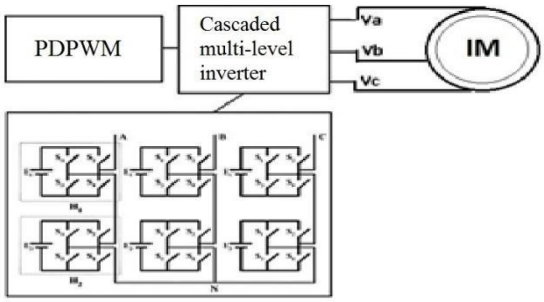

Fig.1. Block diagram of proposed system

The number of output phase voltage levels in a cascaded inverter is given in equation(1),

$$m=2H+1 \qquad (1)$$

Where H is the number of H-bridge and m is the inverter level. The constant switching frequency pulse-width modulation technique is most popular and very simple switching schemes. For m-level inverter (m – 1) carriers with the same frequency f_c and the same amplitude A_c are disposed such that the bands occupied are contiguous. The reference waveform has peak- to-peak amplitude A_m, the frequency f_m. The reference is continuously compared with each of the carrier signals. If the reference is greater than s carrier signal, then the active device corresponding to that carrier is switched off. The frequency modulation index and amplitude modulation index is given in equation (2) and (3).

$$M_a = \frac{A_m}{(m-1)A_c} \qquad (2)$$

$$M_f = \frac{f_c}{f_m} \qquad (3)$$

Phase disposition pulse width modulation (PDPWM) scheme provides the best harmonic profile among all the multi-carrier pulse width modulation technique and it is simple [12]. In PDPWM technique all the carrier waves are in phase. All the carrier waves have same frequency and amplitude. This scheme is shown in Fig3.

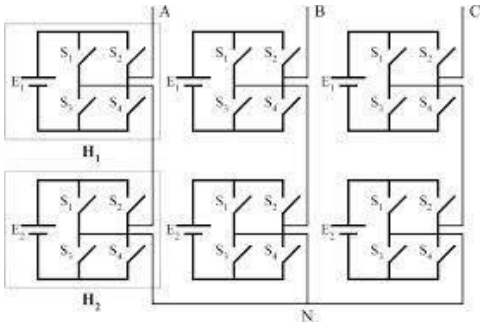

Fig- 2: Five level cascaded H-bridge multilevel inverter topology

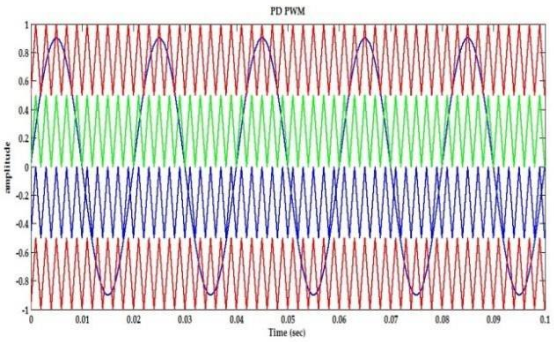

Fig-3 Phase disposition pulse width modulation (PDPWM) technique

1.III. PERFORMANCE OF FIVE LEVEL H BRIDGE CASCADED MULTILEVEL INVERTER FED INDUCTION MOTOR DRIVES:

The performance of five level-MLI fed induction motor drives is investigated for various operating conditions. The PDSPWM is used to generate switching pulses for the MLI. The switching frequency is chosen as 5 KHz. The dc voltage of each cell is 188 Volts. The performance of designed MLI fed induction motor drives is tested extensively for various operating conditions. The major operating conditions are,

1. Frequency of 50Hz with a step change in load torque from 0% to 100%.
2. Frequency of 50Hz with a step change in load torque from 100% to 50%.

.3.1 Operating Condition 1:

In this test step change of load torque is applied from 0 Nm to 7.5Nm. Modulation index is 0.9 and supply frequency is given as 50 Hz. Waveform of load torque is shown in Fig.4.

3.2 Operating Condition 2:

In this test step change of load torque is applied from 7.5 Nm to 7.5/2 Nm. modulation index is 0.9 and supply frequency is given as 50 Hz. Waveform of load torque is shown in Fig.5.

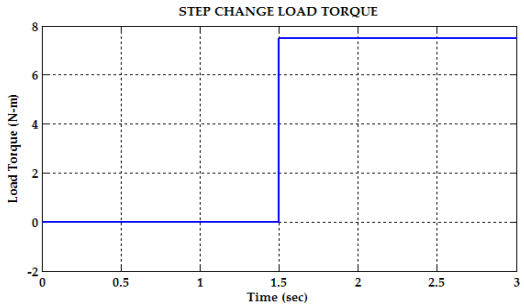

Fig-4 Load torque for operating condition 1

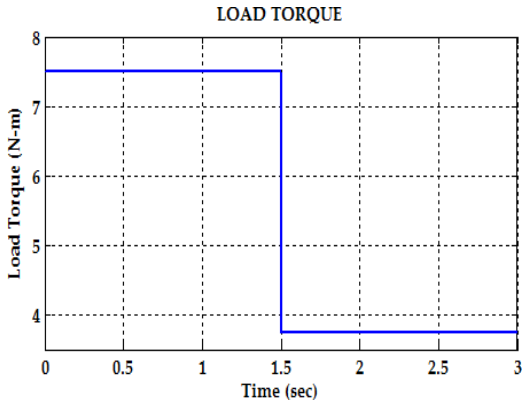

Fig-5. Load torque for operating condition 2

IV SIMULATION RESULTS:

The performance of the proposed five level-cascaded multilevel Inverter is compared with conventional popular three phase two level inverter in terms of total harmonic distortion of both voltage and current. For performance comparison, MLI fed IM drive and conventional inverter fed induction motor drive is operated with the frequency of 50Hz under 100% load torque. For the both inverter, the switching frequency is chosen as 5KHz. The results obtained is consolidated and presented in TableI. From the results obtained, it is obvious that the THD of voltage and current for MLI fed IM drives is much lesser as compared to conventional inverter fed IM drive.

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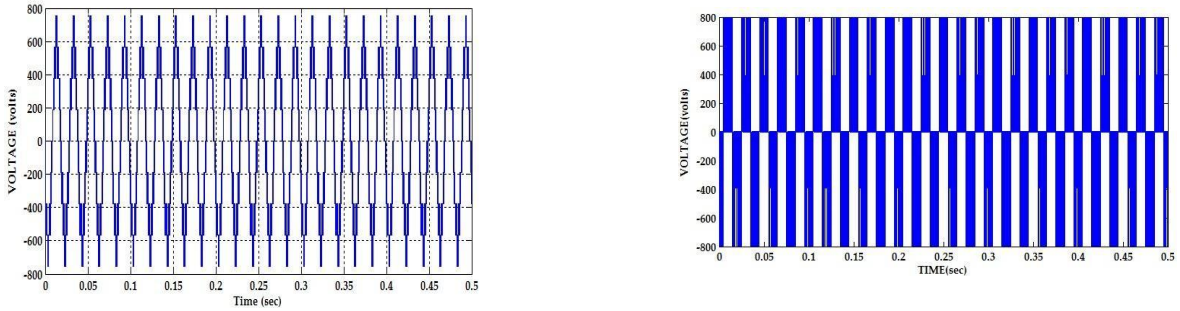
Switchingfrequency KHz	ConventionalInverter fedinductionmotor		FivelevelMLIfedinductionmotor	
5KHz	CurrentTHD %	VoltageTHD%	CurrentTHD %	VoltageTHD%
	2.73	85.37	0.52	17.39

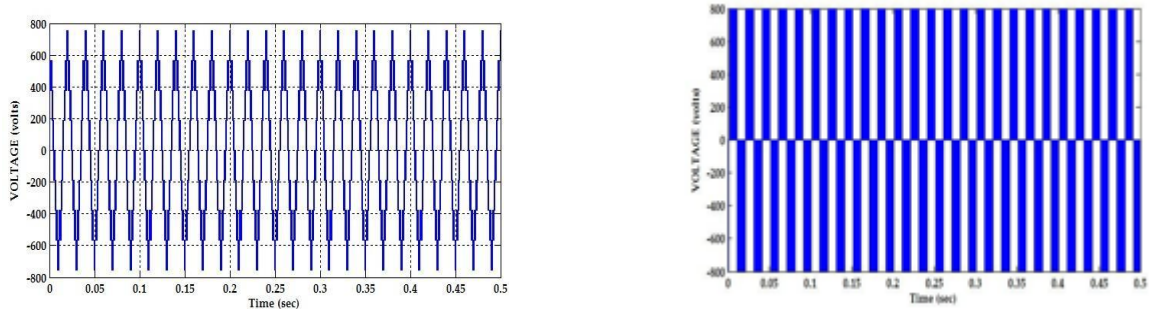
Table-I Comparison of conventional and MLI fed induction motor

The line voltage V_{ab} of the conventional three phase two level inverter and MLI are shown in Fig.6 (a) and (b) respectively. The line voltage V_{bc} of the conventional three phase two level inverter and MLI are shown in Fig.7(a) and (b) respectively. The line voltage V_{ac} of the conventional three phase two level inverter and MLI are shown in Fig.8 (a) and (b) respectively. The phase currents of the conventional three phase two level inverter and MLI are shown in Fig. 9(a) and (b) respectively.



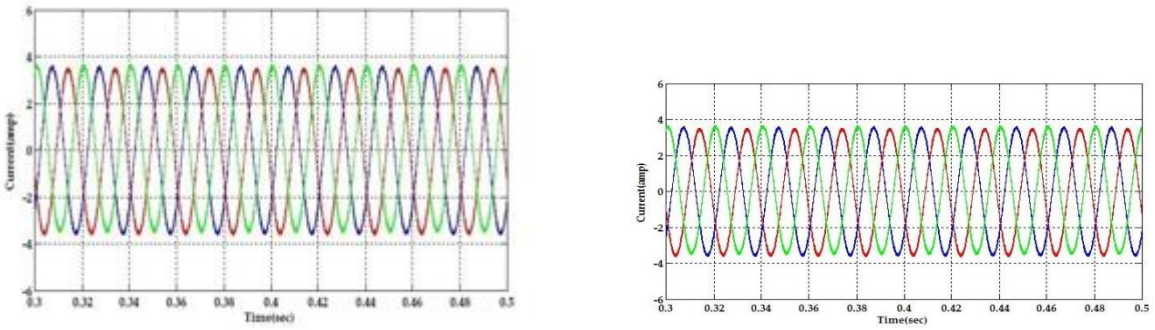
(a) (b)

Fig-6 Line voltage V_{bc} of induction motor load for (a) multi-level inverter (b) conventional inverter



(a) (b)

Fig-7. Line voltage V_{ac} of induction motor load for (a) multi-level inverter (b)conventional inverter.



(a) (b)

Fig-8. Three phase current of induction motor load for (a)multi-level inverter (b)conventional inverter.

IV.CONCLUSION:

A 5-level cascaded multi-level inverter is designed to drive an induction motor. In this work, a simple and common PD pulse width modulation technique with a switching frequency of 5 KHz is considered. Examine the performance of a designed MLI driven induction motor drive for different modulation indices/frequencies under 0%, 50% and 100% load torque. MLI powered induction motor drives have been shown to work well under a variety of operating conditions. The designed MLI's performance is also compared with a traditional two-level three-phase inverter in terms of THD. The results show that the 5-stage MLI has lower voltage and current THD. Therefore, the designed MLI has proven to be a promising alternative to induction motor drives.

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