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Cascaded Multilevel Inverter for Induction Motor Drive

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Abstract: In this paper presents a symmetrical five level cascaded inverter topology for Induction motor drive. It can continuously works at lower power stage. For this symmetrical circuit, when the number of level is increased, the voltage and power will also get increased. For reducing harmonics the Sinusoidal PWM method is used. The multilevel inverter gives the output to drive the three phase Induction motor .Its overall system performance is developed by employing multilevel inverter. It increases the act of the entire system in terms of harmonics and tension in the bearings of a motor. The torque ,phase voltage and speed characteristics are observed. The THD for different modulation index is estimated. The power factor is increased. The simulation of the circuit is attained by using MATLAB/simulink.

Index Terms—*Cascaded multilevel inverter, Induction motor drive, THD.*

I. INTRODUCTION

In recent times Cascaded Multilevel inverter has grown to be very popular in large power AC supplies and adjustable-speed drive appliances. it has the advantages of adjustability and modularity. Flying capacitor, diode clamped and cascaded multilevel inverters are the topologies of multilevel inverters. The cascaded multilevel inverter is composed by H-bridge inverter connected in series. Each H-bridge unit has separate dc supplies[1]. The number of output-phase voltage levels in inverter is expressed by $m= 2^{S-1}+1$,s denotes the number of DC sources available in the inverter circuit.

The multilevel voltage source inverters exclusive configuration allows them to attain high voltages. They does not require any additional components like voltage sharing circuit, transformer for increasing the power levels . They are individually suitable to high voltage automobile drives ,because of low output voltage total harmonic distortion. Basically, the number of power cells in a Cascaded inverter is requirement is depends on its operating voltage[2]. the need of components in the Cascaded H-bridge multilevel inverter is less at the same voltage level as compared to other types of inverter. The common utility of the multilevel inverter is to produce a preferred voltage level. Its produces the staircase output waveform. The optimized sinusoidal PWM technique is used for minimizing the number of semiconductor switching devices Sanjiv Kumar and Pramod Agarwal presented ,the nine level inverter topology for an open end winding induction motor drive. in this the nine level inverter output is obtained by connecting the three-level inverter at both ends which feeding power to each end of the open-end induction motor[5]. The five level cascaded MLI is designed for improving induction motor drive performances. The proposed system does not require clamping diodes and capacitor bank[3]. There is several modulation techniques used for reducing switching losses in the symmetrical cascaded inverter.

The POD sinusoidal PWM technique is used for producing pulses for MLI. At every level in the inverter, a predetermined DC voltage is added with the reference voltage wave. so its reduces the inverter's switching losses at lower speed level.

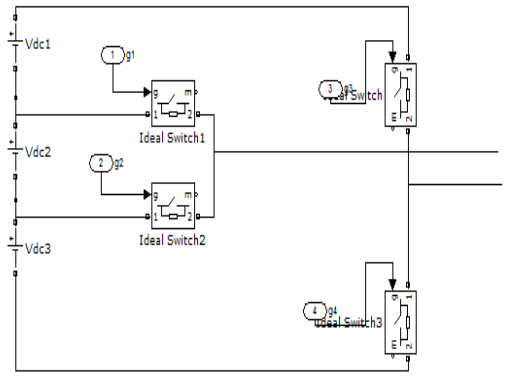

Fig.1.Five level Cascaded Multilevel Inverter

The major benefit in this control scheme is that, at lower speed levels out of two, though the inverter switching accumulates only in one inverter ,other one is preset at one level[4]. therefore switching losses are reduced and also efficiency of whole system gets developed.

This paper is organized as follows: Section 2 explores Induction motor drives using multi level inverter and its block diagram Section 3 deals Topology of five level cascaded inverter and POD PWM Technique. Section 4 gives about simulation diagram .Section 5 investigates the results by simulation, also it gives the conclusion about multilevel inverter used for drive application .

II. INDUCTION MOTOR DRIVES USING MULTI LEVEL INVERTER

Induction motors are simple in construction and maintenance free .it can operate in any environmental condition like polluted and explosive environment. The block diagram of multilevel inverter fed induction motor is as shown in fig 2.

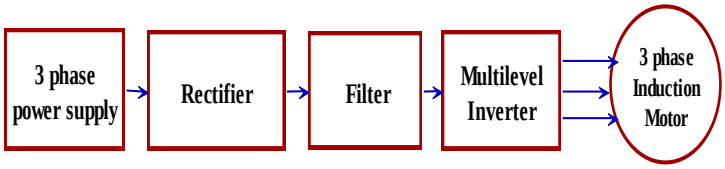

Fig.2.Block Diagram

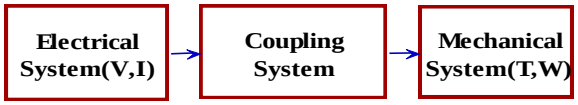

Fig.3.Energy Conversion of Motor

The brushes, slip rings, commutates are absent in the motor so it cost is less .it does not produce any sparks due to absences of brushes . The three phase Induction motor has self-starting torque. The number of voltage levels in the inverter is increases, the power rating of the switches will increase. Therefore, the harmonic content of the output voltage waveform is decreases. The power factor will be increased. The three phase

supply is given to the Diode Rectifier .The Rectifier dc output is given to the LC Filter. The LC filter used for reducing the Harmonics .The DC voltage is applied to the inverter. Their output is fed to the three phase induction motor.

III. PROPOSED FIVE LEVEL INVERTER

The figure 4 shows the five level inverter circuit which consist of three DC sources which are equal and 4 switches S_1,S_2,S_3,S_4.This type of inverter does not need any clamping diodes, transformer and flying capacitor. It can generate five different output voltages +2Vdc, +Vdc, 0Vdc ,–2Vdc and –vdc by connecting the different combinations of four switches with DC sources. The output voltage of a five level inverter is the sum of all the individual inverter output phases. The H-Bridge devices switches at both fundamental frequency and low switching frequency and each H-bridge system produces a quasi square waveform .The pulse is given to the inverter according to switching timings. Each switching device conducts for 180˚.This topology of inverter is suitable for high voltage and power applications.

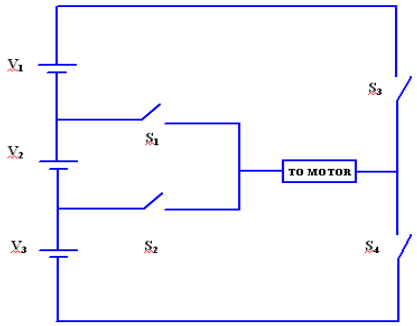

Fig.3.Proposed Five Level Inverter

A. PWM Technique

The carrier based Technique are Alternative phase Opposition Disposition (APOD),Phase Disposition(PD), phase Opposition Disposition(POD),Phase Shifted Carrier PWM(PSCPWM).In this paper Phase Opposition Disposition Technique is used. The carrier signals are above the sinusoidal reference zero point and the signals are out of phase with those below the zero point. This technique employs a number of carriers (N-1) which are all carrier signal in phase above and below the zero reference point. In 5level inverter all the four carrier waves are phase shifted by 180 degree among the above and below zero reference point. The reference signal is compared with all four carrier waves thus the gate pulses are generated .These are associated with each switching components. The PDPWM technique is illustrated in fig 4.

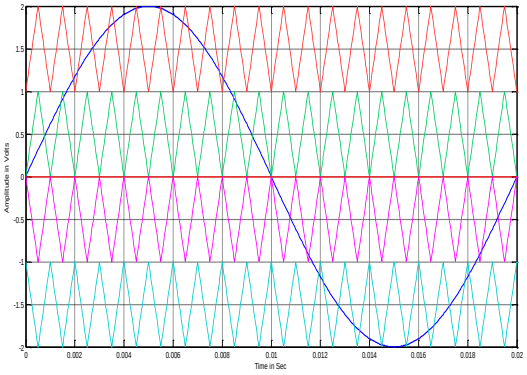

Fig.4.Multicarrier Arrangement

S1	S2	S3	S4	OUTPUT VOLTAGE
1	0	0	1	2Vdc
0	1	0	1	Vdc
0	0	0	0	0
1	0	1	0	-Vdc
0	1	1	0	-2Vdc

Table 1.Switching table

IV. MULTI LEVEL INVERTER FED INDUCTION MOTOR

Figure 5 illustrates the overall circuit of the proposed five level inverter along with three phase induction motor. The Cascaded Multilevel inverter has been used for wide range of applications. Because of their flexibility and modularity, they have been utilized in series and shunt connected FACTS controllers. In recent years Induction motor gives high performance for a drive control. The motor normally can operate under 230V or 460V. The input frequency to the motor is 50Hz or 60Hz.The Electrical winding failure occurs due to overload conditions. The induction motor can operates under both steady state and dynamic state at various modes of operation .

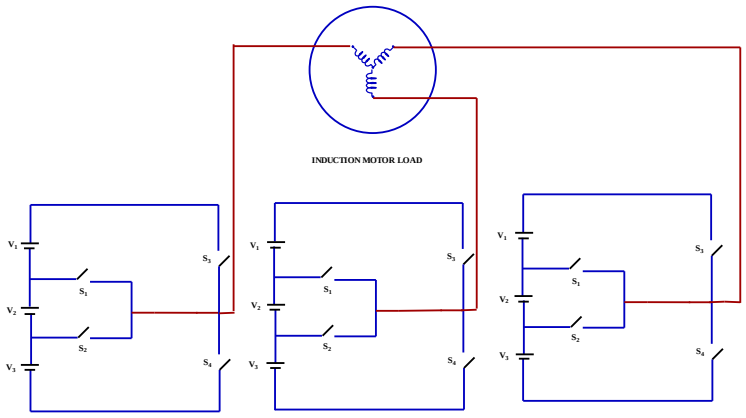

Fig.5.MLI fed Three Phase IM

Induction machine modelling has attractive features .Usually ,DC motors are preferred for the Adjustable speed drive due to their torque response and high speed .But they have intrinsic drawbacks of mechanical brushes, which experiences wear and tear.AC motors are chosen because its less cost, less maintenance, better efficiency, lower weight and more reliability. Three phase induction motors are frequently used in many industrial application. .They have three phase stator winding and rotor winding. The improvement in Power

semiconductor technology has caused the growth of high power and high speed semiconductor devices with the purpose of achieve a smooth, low THD, continuous process. Three phase ac voltage is supplied to stator winding which generate induced voltages. in the rotor winding. The three phase induction motor is used as a load. The equivalent circuit for one phase of the rotor in the motor is shown in fig 6.

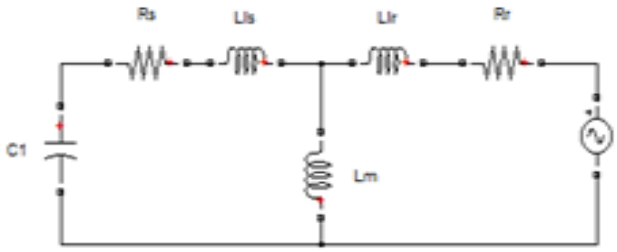

Fig.6.Equivalent Circuit

V. SIMULATION RESULTS AND DISCUSSION

The five level cascaded inverter fed induction motor drives performance is examined for Power factor, Torque, Speed characteristics . The Phase Opposition Disposition sinusoidal pulse width modulation technique is used for generating switching pulses. The switching frequency is preferred as 50Hz.The ac input is filtered by the Diode Rectifier .The cascaded inverter forms a three phase H bridge by connected in series. The inverter output is given to Induction motor. The motor runs at efficient condition. While the motor running, the torque ,motor speed can be noted.

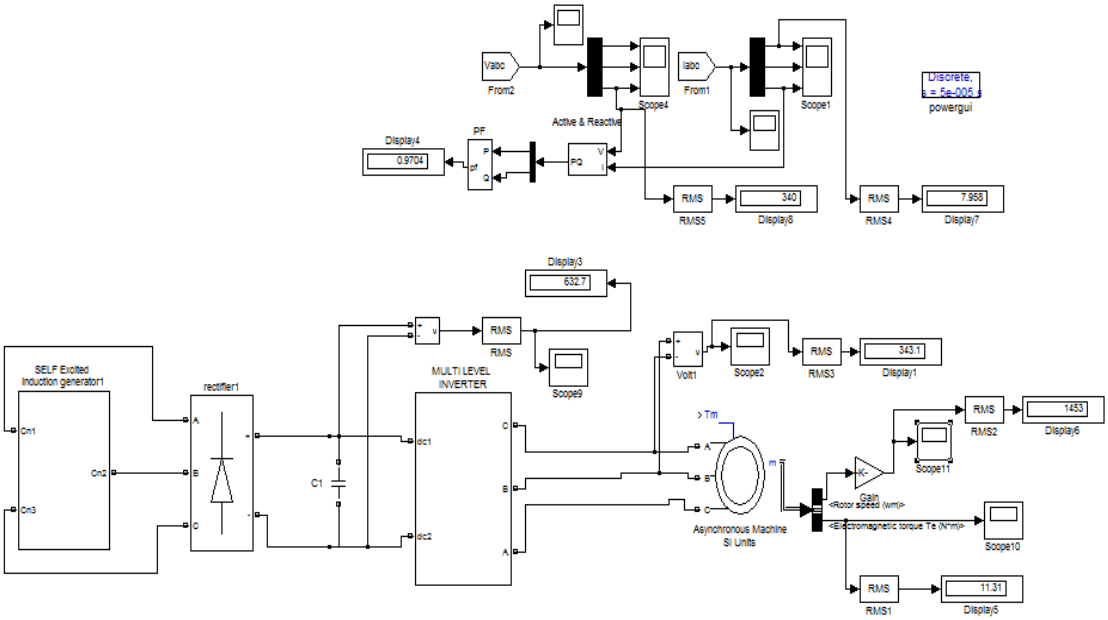

Fig.7.Simulation diagram

The inverter produces the output nearly sinusoidal voltage waveform by sticking together many isolated voltage levels. If H bridge inverters level is increases, the amount of Var can be increased .It does not need any redesigning the power levels. A series of three single phase full bridges formulated a phase for the inverter. A three phase inverter topology is basically compiled of three equal phase legs of the series connection of H bridge inverters, which can be generated as different output voltage waveforms.

In this topology, voltage ,power level and power conversion cells may be easily balanced. The dc link supply for each full bridge converter is provided individually, and this is usually attained by means of diode rectifiers fed from isolated secondary windings of a three-phase transformer. The Phase shifted transformers can supply the high power quality at the utility connection. The cascaded H bridge MLI circuit consists of individual H-bridge cell which is fed by individual dc supply.

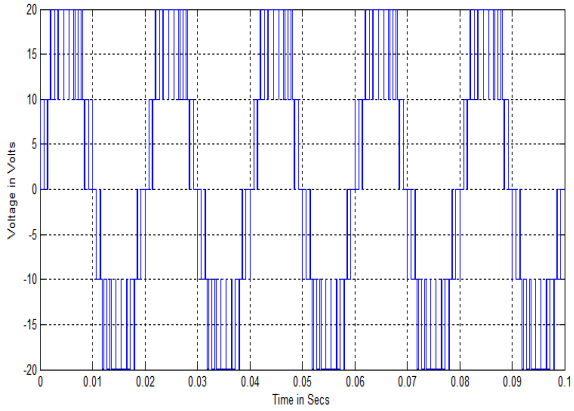

Fig.8.Output of Five level Inverter

The figure 8 shows the output of five level cascaded Multilevel inverter which contains five different output voltages. The dc sources are equal. Each H-bridge cell contains four switches. In this topology, ideal switch is used as switch because of its low switching losses.

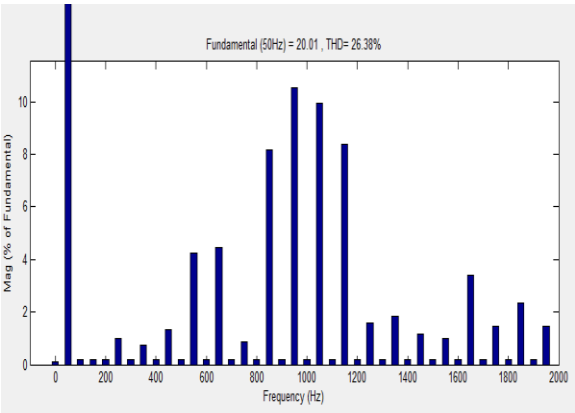

Fig.9.Output of FFT Analysis

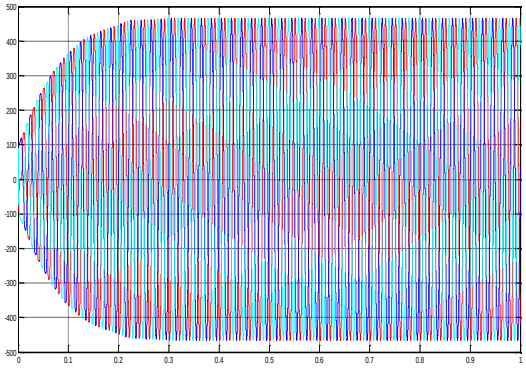

Fig.10. Input Three Phase Voltage

Tabulation. 2.Modulation Index vs THD

M	THD(%)
1	26.38
0.9	32.88
0.8	37.45
0.7	40.33
0.6	43.91
0.5	49.96

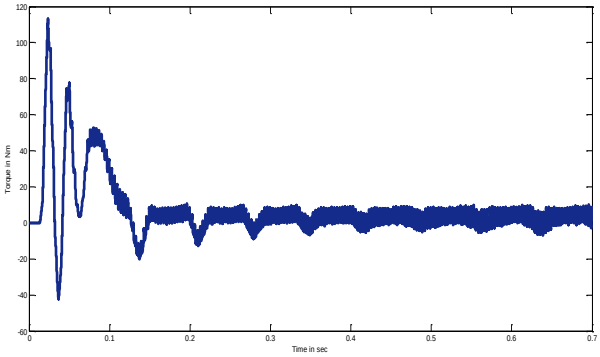

Fig.11.Torque Waveform

The THD is computed for different modulation index values. 26.38% is obtained in FFT analysis. The simulation results shows the output voltage waveform with good harmonic spectrum.

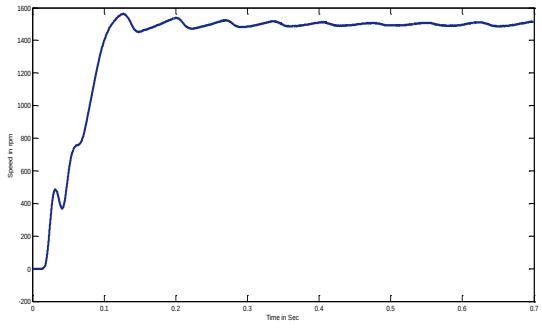

Fig.12.Speed Waveform

VI.CONCLUSION

In this paper, a new topology for symmetrical five level is introduced with less count switch technique. The cascaded inverter fed induction motor drives performance is executed. The PODPWM Technique is used for reducing harmonics. The THD value at different modulation technique has been tabulated. The proposed topology is observed in MATLAB/Simulink. The induction Motor speed and torque are monitored. It is observed that the performance of the induction motor drive's power factor is improved. The simulation results show that, the cascaded multilevel inverter fed Induction Motor drives has a satisfactory performance.

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