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DESIGN & DEVELOPMENT OF CASCADED H-BRIDGE MULTI LEVEL INVERTER FED INDUCTION MOTOR DRIVE

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ABSTRACT:
Nowadays, the industries demanding more power with low harmonics for the high power applications. Thus Multilevel Inverter concept is introduced. The concept of the Multilevel Inverters becoming trendier for the high power applications due to less harmonics and high power ratings. The importance of the multilevel converters has been increase since the last decade. The ability to synthesize waveforms for high voltage with better harmonic spectrum, these new types of multilevel converters is suitable for high power applications. Several topologies have been introduced, amongst these topologies, the Cascaded H-bridge Multilevel Inverter is proposed. Also the main concept is Harmonics. So to reduce the harmonics the modulation topologies (PWM techniques) for multilevel inverters are proposed. The proposed topologies are IPD (In-phase Disposition), POD (Phase Opposition Disposition) and APOD (Alternate Phase Opposition Disposition). The simulations for the same are carried out for single phase and three phase open loop and closed loop configurations in MATLAB/Simulink software. Also %THD will be measured for the same and compared also. %THD will give the how much harmonics are presented is the system. And the analysis of the same will be done for the single phase and three phase also. The proposed concept can be implemented level shift PWM technique with RES system using mat lab/Simulink software.

Keywords: Cascaded H-bridge multi level inverter, level-shiftPWM, Total Harmonic Distortion.

I INTRODUCTION

Now a days in the field of medium voltage and high power applications multi level voltage source inverter(VSI) playing vital role; as it has better waveform quality, low dv/dt stresses on switching devices and no electromagnetic interferences problem compared to conventional two level voltage source inverter [1].In many practical applications a sinusoidal voltage becomes necessity; owing to cost effectiveness of multi level inverter became popular choice as it generates staircase voltage closer to sinusoid, also as the number of levels increases waveform quality improves and the filter requirement reduces [2].Basically, there are three classes of multi level inverter as a) Neutral/diode clamped multi level inverter [3]; b) flying capacitor multi level inverter [4] &c) cascaded H-bridge multilevel inverter (CMLI) [5]. For same voltage level, cascaded H-bridge inverter requires less number of switching devices, reduced voltage unbalancing problem

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[6].There are various methods of modulation technique to minimize the Total Harmonic Distortion (THD) and to control the output voltage of multilevel inverter; carrier based PWM is one of them [8]. It is a so called sine triangle PWM; as a reference is sine wave and carrier is triangular wave. Level shifted method is a type of sine PWM technique and it has three types, namely: In phase disposition, phase opposition disposition, alternative phase opposition disposition

II CASCADED H-BRIDGE INVERTER

1 Principle of Operation:

The circuit arrangement of a single phase five level voltage source inverter is shown in fig.1 (a), it consists of two single phase full bridge inverter with separate DC source [6]. Each voltage source inverter is capable of producing voltage levels 0, +Vdc, or –Vdc. In symmetrical mode for 'x' number of separate DC sources; the output voltage level will be 2x+1. Hence two separate DC sources produce voltage levels of +2Vdc, +Vdc, 0, -Vdc & -2Vdc in symmetrical mode.

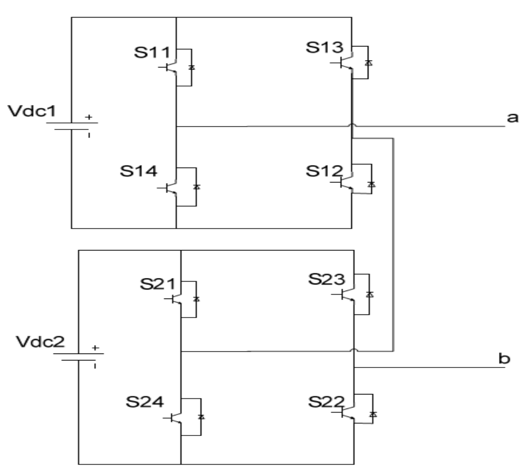

Fig.1 (a) single phase five levels Cascaded H-bridge inverter

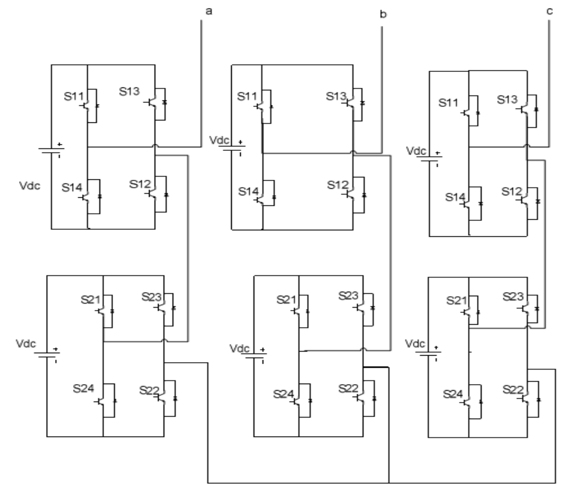

Fig.1 (b) three phase circuit arrangement for five level in star configuration.

The Cascaded H-bridge is basically of two types:

a) Symmetrical CMLI: if Vdc1=Vdc2, The output voltage of the inverter is the sum of the each inverter's phase voltage i.e. Vab = Vao+Vbo. All the possible combination of switching sequence for five levels is shown in Table I, where '1' shows conducting state of a switch and '0' shows non-conducting state of the switch. For 5-level inverter the phase output voltage for resistive load is shown in fig. 3.1 (c).

TABLE I

Vab	S11	S12	S21	S22
2Vdc	1	0	1	0
Vdc	1 1 1 0	0 0 1 0	1 0 1 1	1 0 0 0
0	0	0	0	0
-Vdc	0 0 1 0	1 1 1 0	1 0 0 0	1 0 1 1
-2Vdc	0	1	1	0

Fig.1 (c) output voltage of five level inverter.

b) Asymmetrical CMLI: if Vdc1≠Vdc2; then by using the fig.1 (a) seven levels of voltage can be produced if Vdc1=2Vdc2 in asymmetrical mode [19]. The switching transition for seven levels asymmetrical inverters is shown in Table II.

TABLE II

Sl. No	S11	S12	S21	S22	Vab
01.	1	0	0	0	3Vdc
02.	1	0	0	1	2Vdc
03.	0	0	1	0	Vdc
04.	0	0	0	0	0
05.	0	0	0	1	-Vdc
06.	0	1	1	0	-2Vdc
07.	0	1	0	0	-3Vdc

In achieving higher voltage levels the asymmetrical configuration has certain limitations such as tedious calculation of switching transition, loss of modularity and modulation index restrictions [20]. In this paper further symmetrical mode has considered.

2 Applications

• Industry up-to multi-MW range in Tractions and Naval systems [20].
• High Power Propulsion systems.
• STATCOM, FACTS, UPFC Active power filters, etc [21-22].
• A Green Energy source with Photo Voltaic cells [23].
• Storage battery charger where high power and efficient energy conversion are required with improved power quality [7].

III. PWM STRATEGY

Among the various methods of PWM, level-shift PWM technique is used to simulate the above mentioned levels [11].
Level-shift PWM is of three types:

a) Phase Opposition Disposition (POD): in this category of level shift PWM technique modulating signal above the reference (zero) line is 180 degrees out ofphase with modulating carrier signals below the reference line [24].

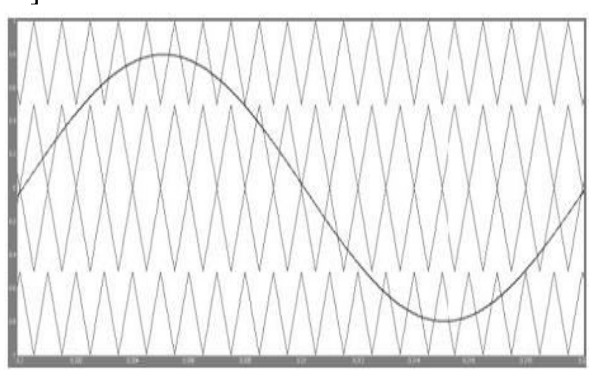

Fig.2 Phase opposition disposition level shift PWM

b) In Phase Disposition (PD):in this technique all the modulating signals are in phase, and a sinusoidal reference signal is continuously compared to producing the gating signals [25]

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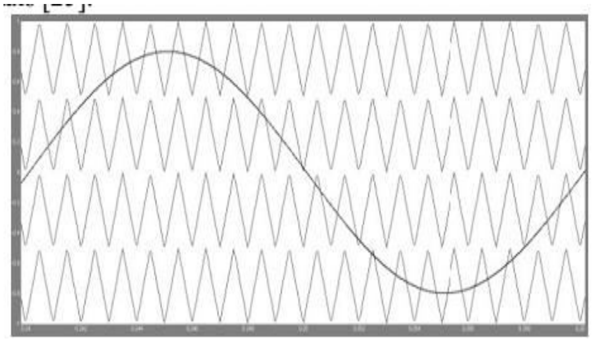

Fig.3 In Phase Disposition level shift PWM

c) Alternative Phase Opposition Disposition (APOD): in this PWM each modulating carrier is 180 degrees out of phase with its adjacent neighbor carriers

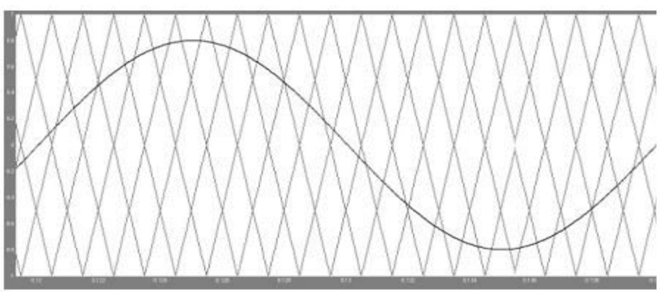

Fig.4 Alternative POD level shifts PWM

IV INTRODUCTION OF INDUCTION MOTOR

An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. Other commonly used name is squirrel cage motor due to the fact that the rotor bars with short circuit rings resemble a squirrel cage (hamster wheel).An electric motor convert's electrical power to mechanical power in its rotor. There are several ways to supply power to the rotor. In a DC motor this power is supplied to the armature directly from a DC source, while in an induction motor this power is induced in the rotating device. An induction motor is sometimes called a rotating transformer because the stator (stationary part) is essentially the primary side of the transformer and the rotor (rotating part) is the secondary side. Induction motors are widely used, especially poly phase induction motors, which are frequently used in industrial drives.

The Induction motor is a three phase AC motor and is the most widely used machine. Its characteristic features are-

- Simple and rugged construction
- Low cost and minimum maintenance
- High reliability and sufficiently high efficiency
- Needs no extra starting motor and need not be synchronized
- An Induction motor has basically two parts – Stator and Rotor

The Stator is made up of a number of stampings with slots to carry three phase windings. It is wound for a definite number of poles. The windings are geometrically spaced 120 degrees apart. Two types of rotors are used in Induction motors - Squirrel-cage rotor and Wound rotor AC Induction Motor. The AC induction motor is a rotating electric machine designed to operate from a 3-phase source of alternating voltage. For variable speed drives, the source is normally an inverter that uses power switches to produce approximately sinusoidal voltages and currents of controllable magnitude and frequency. A cross-section of a two-pole induction motor is shown in Slots in the inner periphery of the stator accommodate 3-phase winding amebic. The turns in each winding are distributed so that a current in a stator winding produces an approximately sinusoid ally-distributed flux density around the periphery of the air gap. When three currents that are sinusoid

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ally varying in time, but displaced in phase by 120° from each other, flow through the three symmetrically-placed windings, a radically-directed air gap flux density is produced that is also sinusoid ally distributed around the gap and rotates at an angular velocity equal to the angular frequency, of the stator currents. The most common type of induction motor has a squirrel cage rotor in which aluminum conductors or bars are cast into slots in the outer periphery of the rotor. These conductors or bars are shorted together at both ends of the rotor by cast aluminum end rings, which also can be shaped to act as fans. In larger induction motors,
Copper or copper-alloy bars are used to fabricate the rotor cage winding.

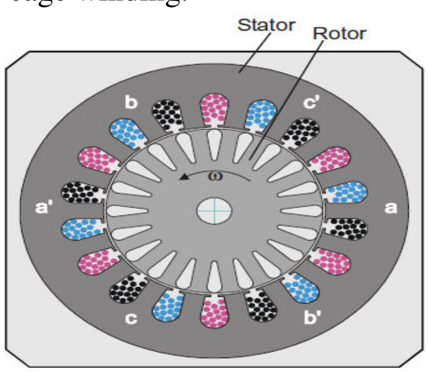

Fig 53-Phase AC Induction Motor

As the sinusoidally-distributed flux density wave produced by the stator magnetizing currents sweeps past the rotor conductors, it generates a voltage in them. The result is a sinusoidally-distributed set of currents in the short-circuited rotor bars. Because of the low resistance of these shorted bars, only a small relative angular velocity, r, between the angular velocity, s, of the flux wave and the mechanical angular velocity of the two-pole rotor is required to produce the necessary rotor current. The relative angular velocity, r, is called the slip velocity. The interaction of the sinusoidally-distributed air gap flux density and induced rotor currents produces a torque on the rotor. The typical induction motor speed-torque characteristic is shown in Figure 2.2.

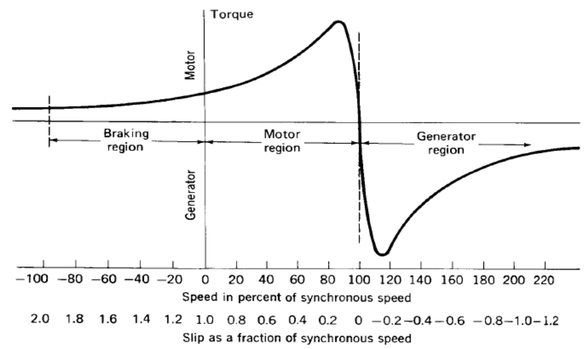

Fig 6 AC Induction Motor Speed-Torque Characteristic

Squirrel-cage AC induction motors are popular for their simple construction, low cost per horsepower, and low maintenance (they contain no brushes, as do DC motors). They are available in a wide range of power ratings. With field-oriented vector control methods, AC induction motors can fully replace standard DC motors, even in high-performance applications.

V MATLAB/SIMULINK RESULTS

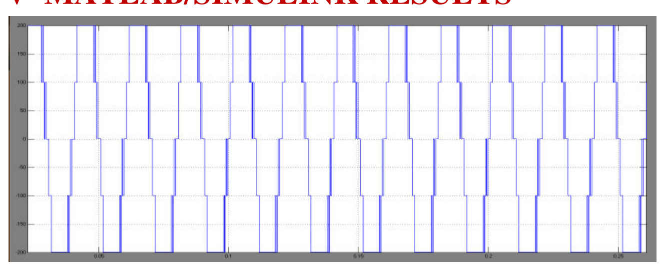

Fig 7 Single Phase 5-level output voltage

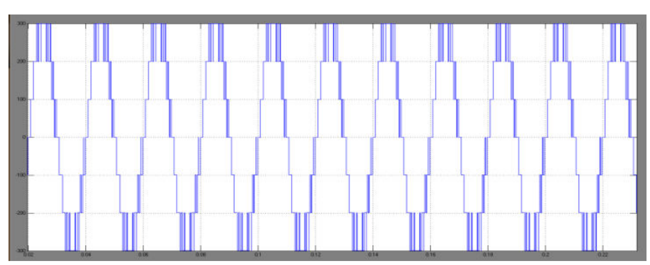

Fig 8 Single Phase 7-level output voltage

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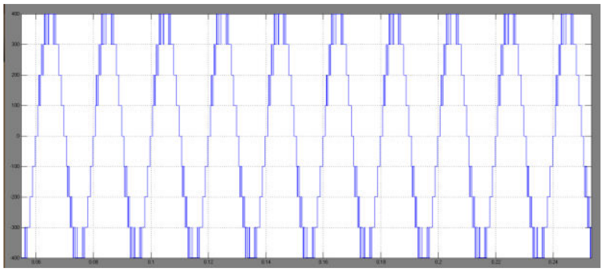
Fig 9 Single Phase 9-level output voltage

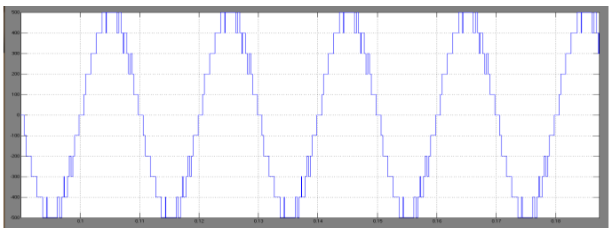
Fig 10 Single Phase 11-level output voltage

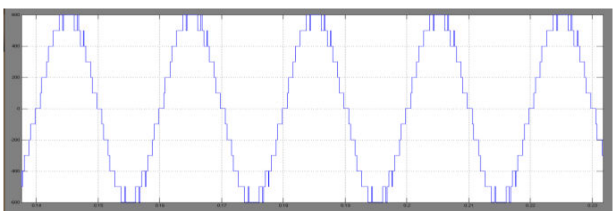
Fig 11 Single Phase 13-level output voltage

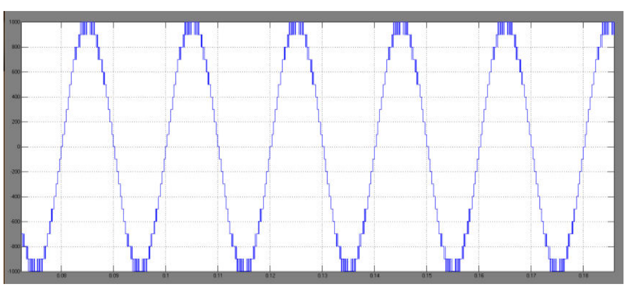
Fig 12Single Phase 21-level output voltage

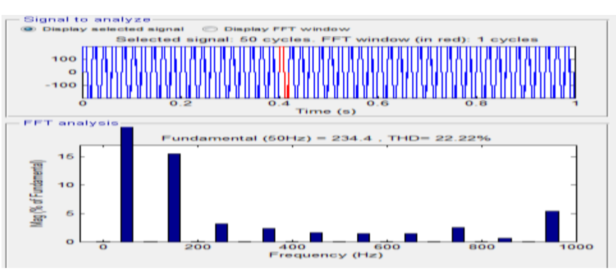

Fig 13 Single phase 5-level FFT analysis using PD

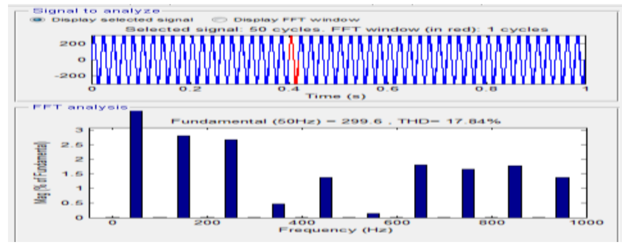

Fig 14 Single phase 7-level FFT analysis using PD

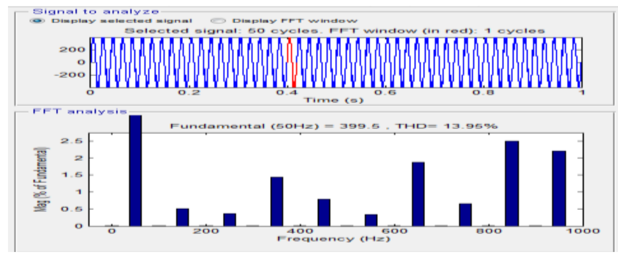

Fig 15 Single phase 9-level FFT analysis using PD

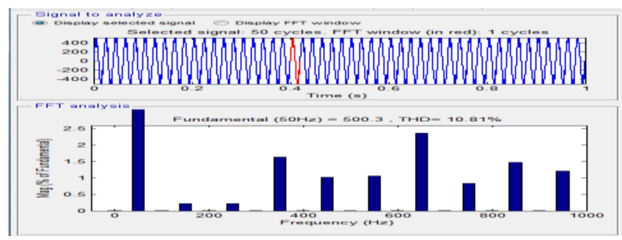

Fig 16 Single phase 11-level FFT analysis using PD

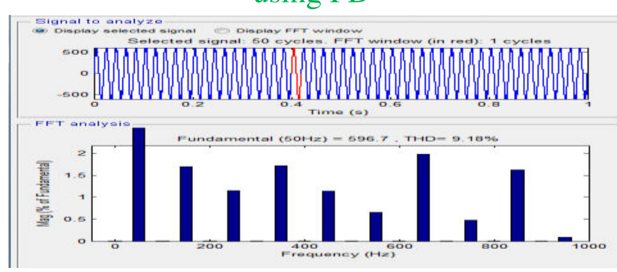

Fig 17 Single phase 13-level FFT analysis using PD

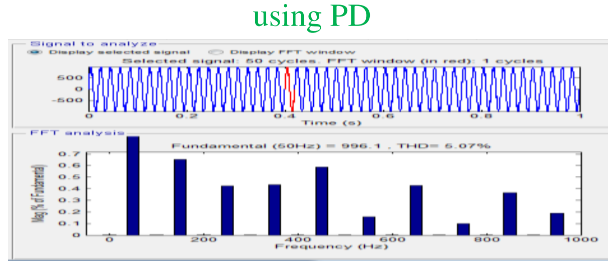

Fig 18 Single phase 21-level FFT analysis using PD

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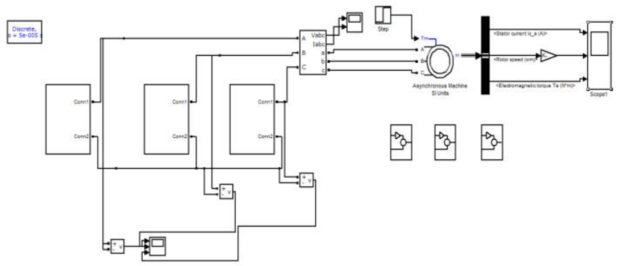

Fig 19 Three-phase inverter system with induction motor system

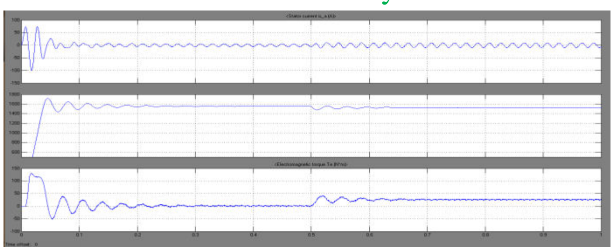

Fig.20 shows the induction motor performance under 1/4th load

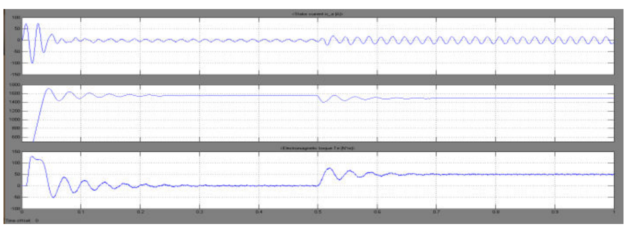

Fig.20 shows the induction motor performance under half load

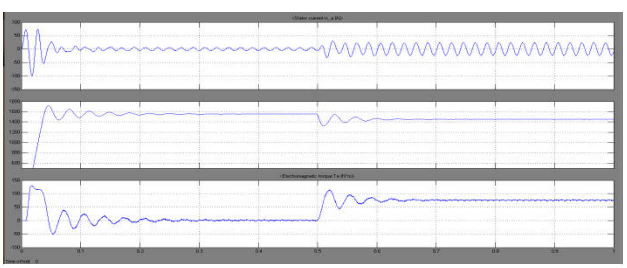

Fig.20 shows the induction motor performance under 3/4th load

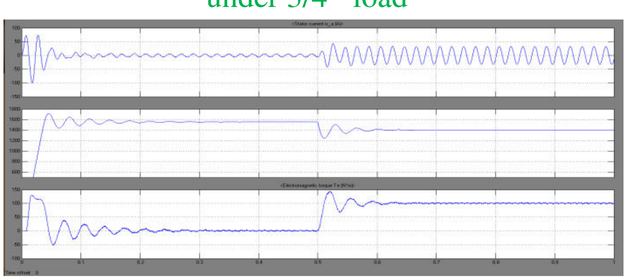

Fig.20 shows the induction motor performance under full load

VI CONCLUSION

The objective of work was to implement level-shift PWM method to symmetrical cascaded H-bridge inverter fed Induction motor drive. Their Fourier analysis studied at different load variations. For this Multi-level inverter fed Induction motor we simulated Speed, Electromagnetic Torque and Stator current. It has very low Total Harmonic distortion using PD, POD & APOD Techniques. FFT analysis has done for Induction Motor with different load variations. We have simulated No-load, 1/4 load, half load, ¾ load & full load for Speed, Torque & Current Characteristics. Different load conditions we can observe the speed, electromagnetic torque & Stator currents. The multilevel voltage source inverter with Induction Motor drive are widely adopted in many practical applications like Industrial purposes, torque control drive with PWM technique, Electrical Vehicles. We can easily feed this Drive by Renewable energy sources like solar and wind. Design & Operation is very simple and economical compare to all other Inverters.

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