State of Art of Poly phase Inverter use for Vehicle Applications

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***Abstract*--The objective of this paper is to study the behavior of polyphase inverter system. Our analysis will begin with the development of single-phase equivalent circuits, the general form of which is suggested by the similarity of an induction machine to a transformer. A method is presented showing that a 5-level cascade multilevel inverter for whether it is a fixed-frequency source such as a power system or a variable-frequency, variable-voltage motor drive. A method is presented showing that a 5-level cascade multilevel inverter for salient pole induction motor drive can be implemented using only a single DC link to supply a standard 5-leg inverter along with three full H-bridges supplied by capacitors. Ultimately conditions are given in terms of the power factor (P.F) and modulation index that determine when the capacitor voltage can regulated.**

Keywords: SPWM Technique, Poly phase Inverter, Poly phase Induction Motor**.**

1. Introduction

The Five phase Induction Motor are basically AC machines characterized by a stator winding composed of generic number of phases. An electric drive & Generation technology Multiphase machine has several advantages over the traditional three phase machine such as reducing the amplitude and increasing the frequency of torque pulsation, eliminating the rotor harmonic current per phase & without increasing the voltage per phase, lowering the dc-link current harmonics and higher reliability, high fault tolerance. Earlier multiphase motor where not used widely because of the drawback that the supply for the polyphase motor was not available, In multiphase inverter we can generate n number of phase, as each leg of the inverter represent the phase, thus by increase the number of leg in the inverter we can increase the number of phases. For the five phase motor we require five leg inverter. The input to the inverter is a dc supply. The Sematic of five phase inverter is shown below…...

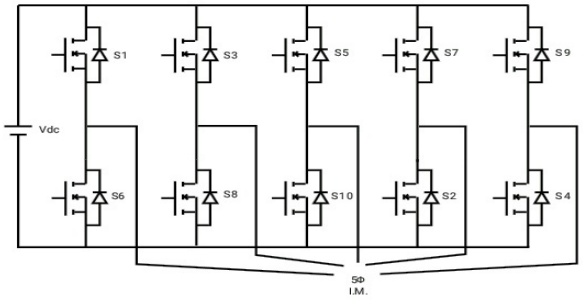


Fig (a). Basic Circuit of Polyphase Inverter Fed to Polyphase Induction Motor

2. Advantages of polyphase systems over single phase systems are:-

1. Polyphase transmission line requires less conductor material than a single-phase line for transmitting the same amount power at the same voltage.

2. Polyphase machine gives a higher output than a single phase machine For example, output of a 3-phase motor is 1.5 times the output of single-phase motor of same size whereas polyphase is 2.52 times better.

3. Polyphase motors gives a uniform torque where most of the single-phase motors have a pulsating torque.

4. Polyphase induction motors are self-starting and are more efficient than three phase system.

5. Polyphase machine is very much cheaper according to per unit of output

6. Power factor of a single-phase motor is lower than that of polyphase motor of the same

7. Rotating magnetic field can be set up by providing polyphase current through stationary coils.

8. Parallel operation of polyphase alternators is simple as compared to that of three-phase alternators because of pulsating reaction in three-phase alternator. It has been found that the above advantages are best realized in the case of polyphase systems. Consequently, the electric power is entered and transmitted in the form of three-phase system.

3. Mode of Operation:-

The basic power circuit diagram of five phase voltage Source Inverter (VSI) is shown below. Power MOSFET (IRF 3205) is used as the power switches. The anti-parallel diodes provides reverse current path such that when a Particular MOSFET is gated on, one output terminal and one Input terminal will be connected.

In poly phase inverter three switches from the upper switches and two from the lower switches are turned on at a time and vice versa. The two switches which form the leg of the inverter are complimentary to each other, for example when switch S1 is on Switch S6 is off so as to avoid short circuit. The switching sequence & the mode of operation of a five phase

Inverter are shown below:-

For the same output power as that of three phase inverter, if five Phases is preferred then the power gets distributed among the legs of five phase & the mode of operation of a poly phase inverter.

In this type of inverter no two switches of same leg is switched on at the same instant. Because it leads to damage of the inverter. At any instant of time three upper switches and two lower switches or three lower switches and two upper switches are switched on. The switching sequence for ten-step4 inverter is shown in Figure (b). It can be observed that, the width of each pulse is 180°.In five phases ten step inverter three switches from the upper switches and two from the lower switches are turned Each switch is conducting 36°. The two switches which form the leg of the inverter are complimentary to each other. The switches in the same leg should not conduct it will lead to short circuit. Harmonics of the order five and multiples of five are absent from both the line to line and line to neutral voltages and consequently absent from the current. The switching sequence as shown in Table 1.

Table 1. Switching sequence of five leg inverter

MODE	SWITCHES ON
1.	1,7,8,9,10
2.	8,9,10,1,2
3.	9,10,1,2,3
4.	10,1,2,3,4
5.	1,2,3,4,5
6.	2,3,4,5,6
7.	3,4,5,6,7
8.	4,5,6,7,8
9.	5,6,7,8,9
10.	6,7,8,9,10

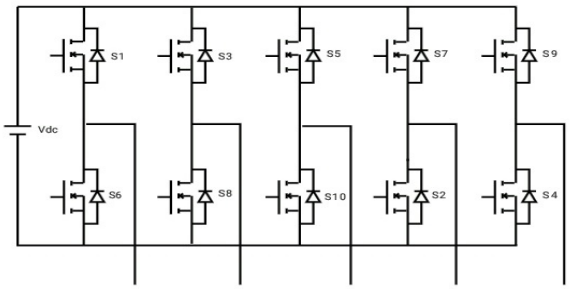
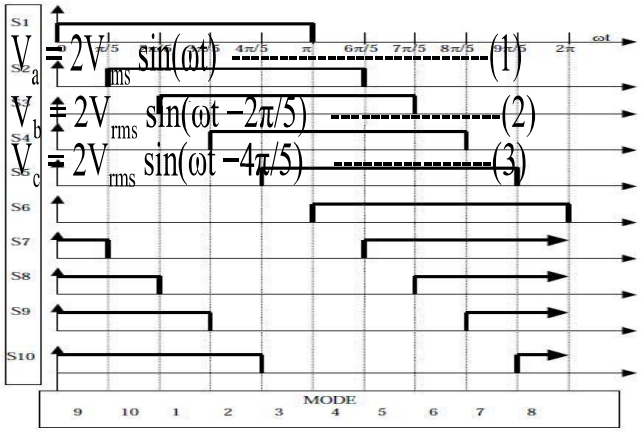


Figure (c): Switching Sequence of Poly Phase Inverter

As shown in Figure (b).MOFET (IRF 3205) are used as switching devices. Pulse generators are used to drive the gate terminals of MOSFET switches. The output poly phase waveforms.in Figure(c).In ten step inverter the output waveforms are Similar to square wave, thus total harmonic distortion will be high. It degrades the performance of the induction motor. Hence in order to get a near sinusoidal wave Sinusoidal Pulse Width Modulation is employed. In SPWM inverter instead of feeding the gate terminals with direct pulse a modulated pulse is fed. This modulated pulse is obtained by comparing a sinusoidal reference wave with triangular carrier wave.

4. Poly Phase Stator & Rotor Equations

Poly phase stator voltage of induction motor under balanced condition is expressed as follows:-



$$V_a = 2V_{rms}\sin(\omega t) \quad (1)$$

$$V_b = 2V_{rms}\sin(\omega t - 2\pi/5) \quad (2)$$

$$V_c = 2V_{rms}\sin(\omega t - 4\pi/5) \quad (3)$$

$$V_d = 2V_{rms}\sin(\omega t + 4\pi/5) \quad \text{----------(4)}$$
$$V_e = 2V_{rms}\sin(\omega t + 2\pi/5) \quad \text{----------(5)}$$

$$\begin{bmatrix} V_q \\ V_d \\ V_x \\ V_y \\ V_0 \end{bmatrix} = \frac{2}{5}\begin{bmatrix} 1 & \cos\alpha & \cos 2\alpha & \cos 3\alpha & \cos 4\alpha \\ 0 & -\sin\alpha & -\sin 2\alpha & -\sin 3\alpha & -\sin 4\alpha \\ 1 & \cos 3\alpha & \cos 6\alpha & \cos 9\alpha & \cos 12\alpha \\ 0 & -\sin 3\alpha & -\sin 6\alpha & -\sin 9\alpha & -\sin 12\alpha \\ 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \end{bmatrix}\begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \end{bmatrix}$$

$$\text{Where } \alpha = \frac{2\pi}{5}$$

The Machine model in original form is transforms original sets of n variables with new sets of n variables. The decoupling transformation matrix is given as:-
Once the stator voltage V_a,V_b,V_c,V_d and V_e are transformed to d-q frame then we implemented the flux linkage equations, current equations, torque equations and rotor speed equations so as to obtain current in terms of I_{qs},I_{ds},I_{qr},and I_{dr} then we use inverse transformation equation to obtain the stator currents in machine variable form. Inverse Transformation equations to transform current in arbitrary reference frame to current in machine variables to study the nature of current in stator is expressed as,

5. Sinusoidal pulse width modulation (SPWM) technique

Sinusoidal pulse width modulation (SPWM) technique is used to generate the pulses power electronic switch i.e. MOSFET or IGBT. In this technique a carrier wave is compared with the sine wave. Simulink model of SPWM technique & its output is shown below:-

$$\begin{bmatrix} i_{as} \\ i_{bs} \\ i_{cs} \\ i_{ds} \\ i_{es} \end{bmatrix} = \sqrt{\frac{2}{5}}\begin{bmatrix} 1 & 0 & 1 & 0 & 1 \\ \cos\alpha & \sin\alpha & \cos 2\alpha & \sin 2\alpha & 1 \\ \cos 2\alpha & \sin 2\alpha & \cos 4\alpha & \sin 4\alpha & 1 \\ \cos 3\alpha & \sin 3\alpha & \cos 6\alpha & \sin 6\alpha & 1 \\ \cos 4\alpha & \sin 4\alpha & \cos 8\alpha & \sin 8\alpha & 1 \end{bmatrix}\begin{bmatrix} i_{ds} \\ i_{qs} \\ i_{xs} \\ i_{ys} \\ i_{0s} \end{bmatrix}$$

Figure (i): Simulink Model of SPWM Technique

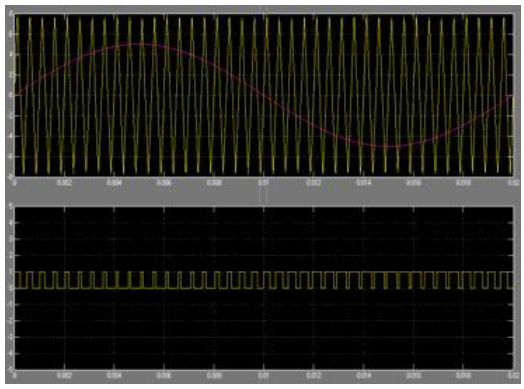


Figure (j): Output of SPWM Technique

6. MATLAB Model of Inverter Induction Motor

6.1 Five Leg Inverter Model

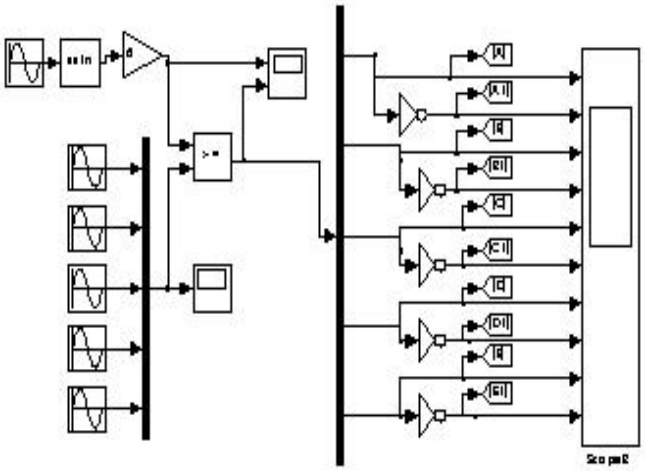


Figure (k): Simulation model of SPWM technique for five leg inverter

7. Simulation Result of five leg Inverter

The output voltages for all the four types of inverters are simulated by using "sim power system" block sets of the Matlab/Simulink software.

The inbuilt MOSFET/Diode blocks are used to simulate.

Inverters topologies are analyzed through their total harmonic distortions and the speed and torque curves of the motor are observed. The appropriate gate pulses are set by PWM technique and the simulation is run. It is clearly seen that the output is a balanced Polyphase supply for a balanced DC supply.

Output of Five Leg Inverter

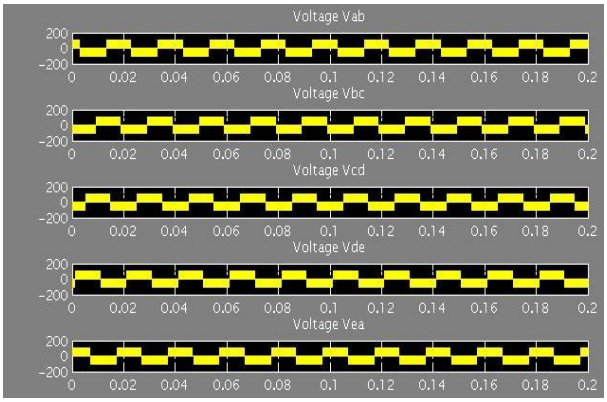


Fig (l). Output voltage

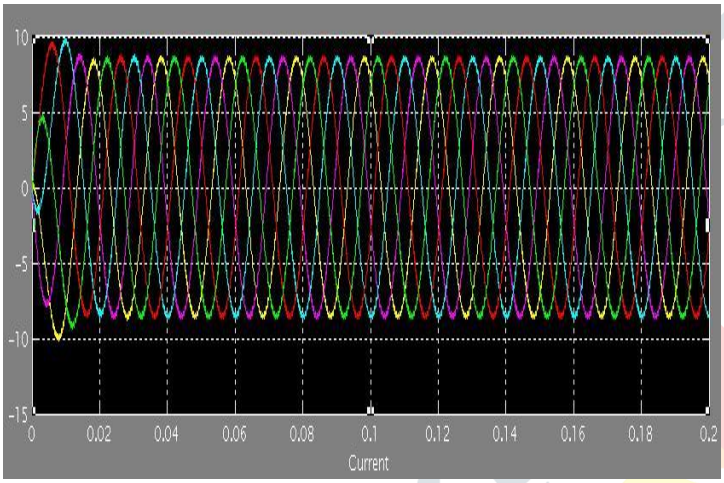


Figure (m): Output Current

8. Poly Phase Induction Motor model

In this model simulation starts with generation of poly phase supply which is obtained by using five leg inverter, the output of five leg inverter is used as the supply to the poly phase induction motor. SPWM technique is used to generate the pulses for the switches used inverter. The Poly phase supply of the induction motor is transformed into d-q axis Using transformation equation which is shown in figure

K & N. Once the supply voltage is converted into V_q &V_d.

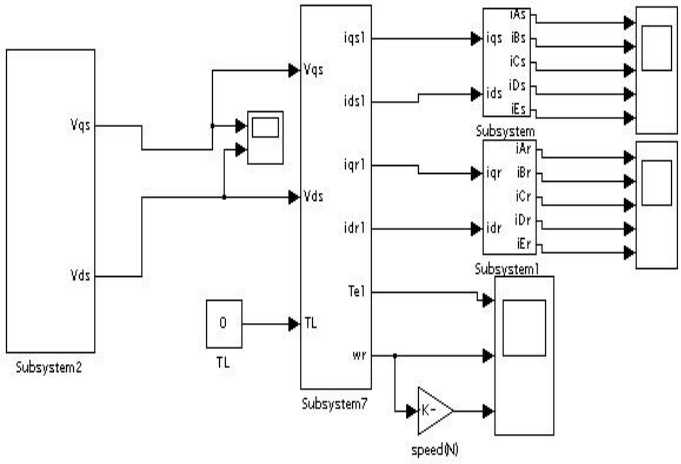


Figure 12: Five Phase Model of Induction Motor

9. Results of Five Phase induction Motor Fed from inverter

Induction Motor shown in the model has been tested for:

HP =3;
Pole =4;
Inverter Voltage =100Vdc;
Frequency =50Hz;
Stator Resistance =1.26;
Rotor Resistance =1.03;
Stator Impedance =1.495;
Rotor Impedance =0.5340;
Mutual Impedance =47.595;
Moment of Inertia =0.0040;
Results after simulation are;

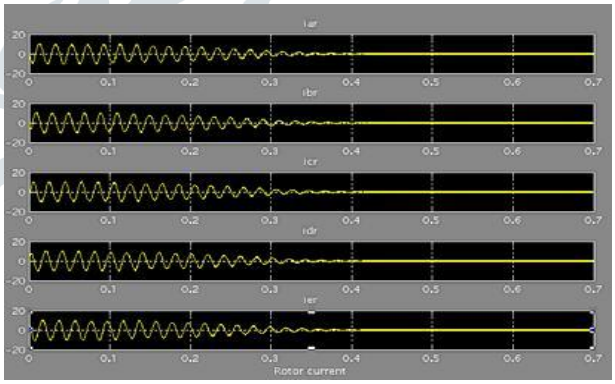


Figure (n): Stator Current

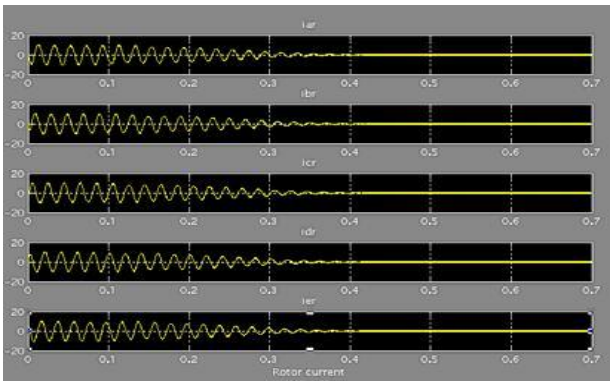


Figure (o): Rotor Current

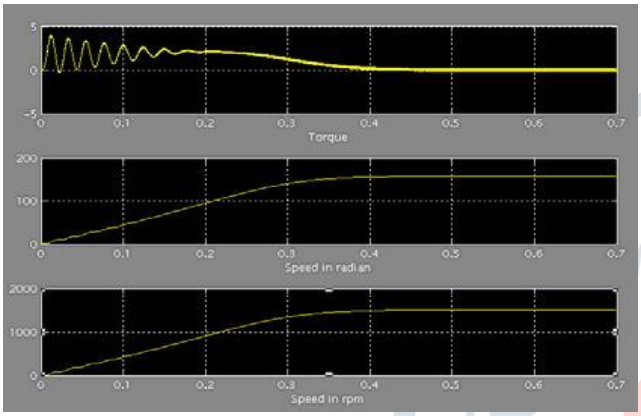


Figure (p): Torque and Rotor Speed

10. Conclusion

In this paper Implementation and Dynamic simulation of a poly phase induction motor fed from five level inverter using Matlab is studied. And the various application as well. The successful implementation of the proposed inverter Connection scheme is elaborated by using simulation results.

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