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SequentialFive Leg Inverter for five phase supply

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Abstract

Multi phase supply will reduce the amplitude and increases the frequency of torque pulsations. This ensures the satisfactory performance of mechanical system inverter-fed motor even at lower speeds. Torque pulsation frequency with appropriate sinusoidal current in PWM operation is quite high and by mechanical inertia the ripples will be filtered easily, which increases the performance of the system. Reliability of the system can be improved as the driver continues running even after the failure of one of the phase, Where reliability is an important criteria five phase supply can be used. The performance of the drive is improved with respect to ripple torque. This paper proposes a sequential Five Leg Inverter to convert three phase to a five phase. Sinusoidal Pulse Width Modulation technique is used to control the output this bring a variable as well as a constant voltage and frequencies. The strength of fluctuations may be reduced with multiphase supply.

Keywords **–Five phase supply, 180^0 mode, Five leg VSI, Switching sequence, PWM technique**

I. INTRODUCTION

Multiphase(more than three phase) systems possess inherent advantages compared to their three phase systems. The applicability of multiphase systems is explored in electric power generation [2]-[5], transmission [6],[7]& utilization [8]-[17]. The research on multiphase drive systems has been diminished till the start of this century, the availability of cheap ratable semiconductor devices and digital signal processors [10]-[14]these multiphase has become a focus of research. It is to be emphasized here that the multiphase motors are invariably supplied by ac/dc/ac converters. Thus, the focus of the research on the multiphase electric drive is limited to the modeling and controlling of the supply systems [15]-[17]. Little effort is made to develop any static transformation system to change the phase number from three to n- phase [17]. Here the phase sequence is n>3 and odd [16] because Selection of an even number of phases should be avoided as it degrades the performance of the motor as the poles coincide with each other. Care must be taken so that the number of phases is not multiples of three, as it act as standard double circuit three phase line [12]. Therefore, a Five Phase Supply may be preferred. The research on multiphase generators has started recently and only a few references are available. This paper, proposes a DC supply to an output five-phase supply [9].

II.SEQUENTIAL FIVE LEG INVERTER

Multi phase machines capable for high power applications. The inherent advantages of multi phase over conventional three phases are an improvement in noise characteristics. Efficiency can be increased as multi phase leads to a decrease in stator copper losses. The amplitude, phase, and frequency of the voltages of five leg inverter should always be controllable & Most of the applications require sinusoidal voltage waveforms. The five-phase 180^0 mode VSI topology is shown in Fig. 1. It should be ensured that the switches of any leg of the inverter ($S_1$and S_6, $S_3$and S_8, $S_5$and S_{10}, $S_7$and S_2 or S_9 and S_4) cannot be switched on simultaneously as this would result in a short circuit across the dc link voltage supply. Similarly, in order to avoid undefined states in the VSI, and thus undefined ac output line voltages, the switches of any leg of the inverter cannot be switched off simultaneously as this will result in voltages that will depend upon the respective line current polarity. The thyristor conduct for 180^0 in a cycle. Thyristor pair in each arm is turned on with a time interval of 180^0. The thyristors in five leg inverter operated in a sequential way.

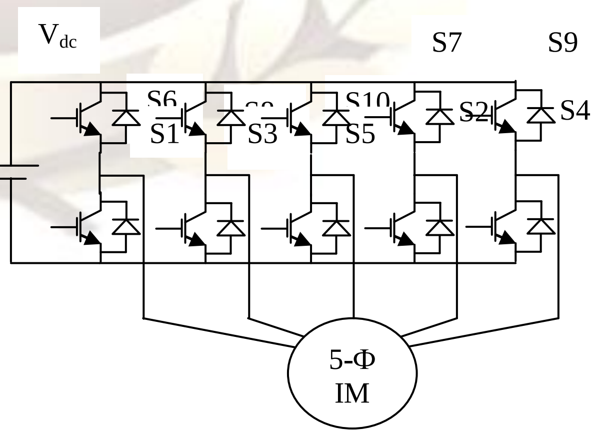


Figure1. Five Phase/Leg Inverter Topology.

The circuit totally explained with ten steps. During step-1, 0 ≤ ωt <π/5, switches conducting are1, 2, 3, 4, 5. It is shown Fig. 2.

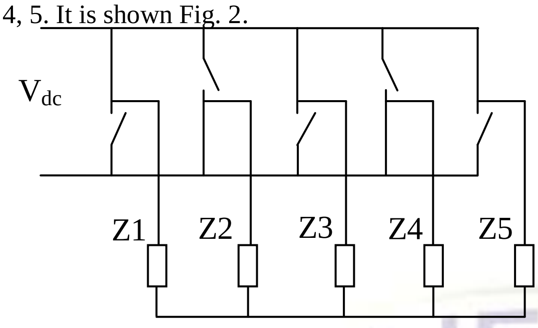


Figure 2. Equivalent Circuit for switching.

All impedances are same and Z1, Z2, Z5 are parallel having +ve sign and Z3, Z4 are parallel having –ve sign.

Current, $i_1 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{ao} = v_{bo} = v_{co} = i_1 * \frac{z}{3} = \frac{2}{5} V_s$$

$$v_{od} = -v_{do} = v_{oe} = -v_{eo} = i_1 * \frac{z}{2} = -\frac{3}{5} v_s$$

Similarly, step-2; π/5 ≤ ωt < 2π/5, the switches conducting are 2, 3, 4, 5, 6.

Current, $i_2 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{ao} = v_{do} = v_{eo} = -\frac{2}{5} V_s$$

$$v_{bo} = v_{co} = \frac{3}{5} v_s$$

Step-3; 2π/5 ≤ ωt < 3π/5, the switches conducting are 3, 4, 5, 6, 7.

Current, $i_3 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{bo} = v_{co} = v_{do} = \frac{2}{5} V_s$$

$$v_{ao} = v_{eo} = -\frac{3}{5} v_s$$

Step-4; 3π/5≤ ωt < 4π/5, the switches conducting are 4, 5, 6, 7, 8.

Current, $i_4 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{ao} = v_{bo} = v_{eo} = -\frac{2}{5} V_s$$

$$v_{co} = v_{do} = \frac{3}{5} v_s$$

Step-5; 4π/5 ≤ ωt < π, the switches conducting are 5, 6, 7, 8, 9.

Current, $i_5 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{co} = v_{do} = v_{eo} = \frac{2}{5} V_s$$

$$v_{ao} = v_{bo} = -\frac{3}{5} v_s$$

Step-6; π ≤ ωt < 6π/5, the switches conducting are 6, 7, 8, 9, 10.

Current, $i_6 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{ao} = v_{bo} = v_{co} = -\frac{2}{5} V_s$$

$$v_{do} = v_{eo} = \frac{3}{5} v_s$$

Step-7; 6π/5 ≤ ωt < 7π/5, the switches conducting are 7, 8, 9, 10, 1.

Current, $i_6 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{do} = v_{eo} = v_{ao} = \frac{2}{5} V_s$$

$$v_{bo} = v_{co} = -\frac{3}{5} v_s$$

Step-8; 7π/5 ≤ ωt < 8π/5, the switches conducting are 8, 9, 10, 1, 2.

Current, $i_6 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{bo} = v_{co} = v_{do} = -\frac{2}{5} V_s$$

$$v_{eo} = v_{ao} = \frac{3}{5} v_s$$

Step-9; 8π/5 ≤ ωt < 9π/5, the switches conducting are 9, 10, 1, 2, 3.

Current, $i_6 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{eo} = v_{ao} = v_{bo} = \frac{2}{5} V_s$$

$$v_{bo} = v_{co} = -\frac{3}{5} v_s$$

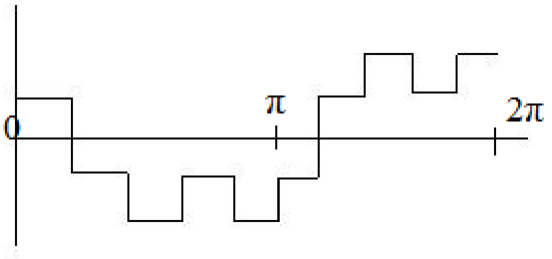
Step-10; 9π/5 ≤ ωt < 2π, the switches conducting are 10, 1, 2, 3, 4.

Current, $i_6 = \frac{V_s}{5Z/6} = \frac{6}{5} * \frac{V_s}{Z}$

Phase voltages,

$$v_{co} = v_{do} = v_{eo} = \frac{2}{5} V_s$$

$$v_{ao} = v_{bo} = -\frac{3}{5} v_s$$



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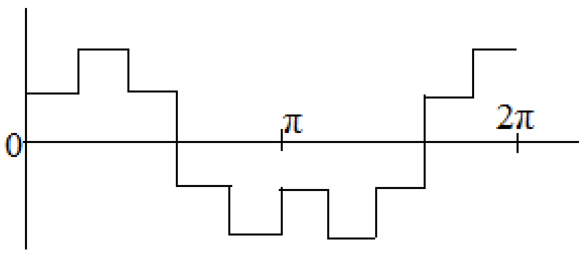

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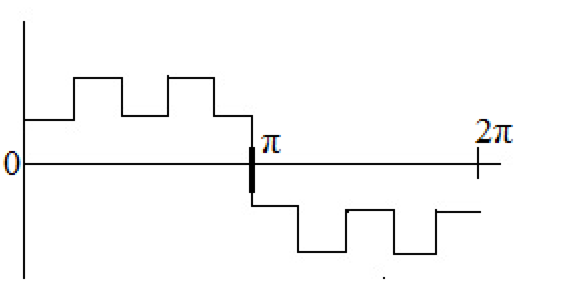

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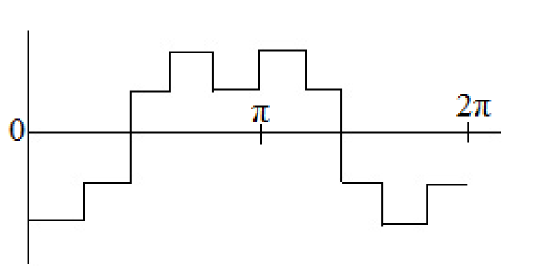

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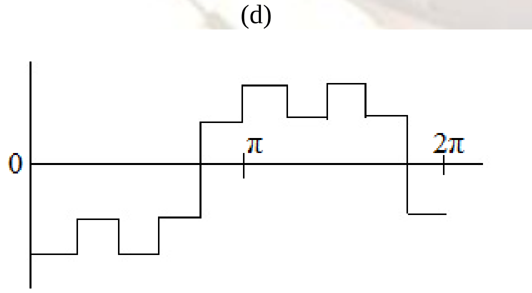
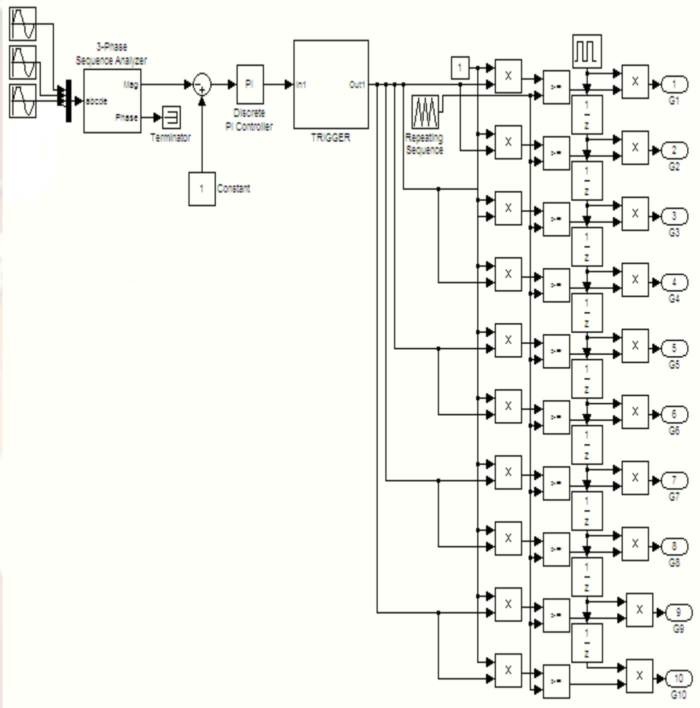


(e)

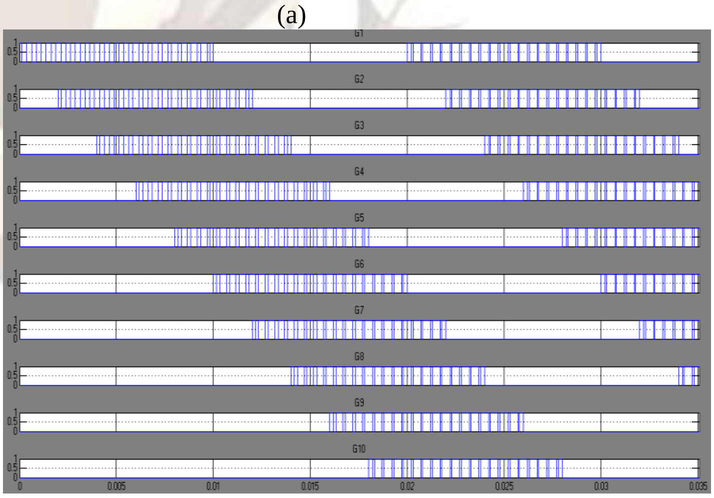
Fig 3.Voltage wave forms for 180 degree mode(i) phase a, (b) phase b, (c) phase c, (d) phase d, (e) phase e

III.SIMULATION RESULTS

The five leg inverter is at first simulated by using "simpowersystem"block sets of the Mat lab/Simulink software. The inbuilt IGBT/Diode blocks are used to simulate. The appropriate gate pulses are set by PWM technique and the harmonics are avoided by using an appropriate LC filter and a simulation is run. Output voltage for the five leg inverter is shown below. The simulation model is depicted in Fig. 4(c) and PWM technique for generation of pulses in fig 4(a) and the resulting input and output voltage waveforms are illustrated in Fig. 4(d). It is clearly seen that the output is a balanced five-phase supply for a DC supply. There was no earth current flowing when neutral earthed at load side. The output currents with voltage waveforms & Gate pulses are also shown in Fig. 4(d)& 4(b). The Total harmonic distortion (THD) of the inverter found is shown in fig 4(e).



(a)



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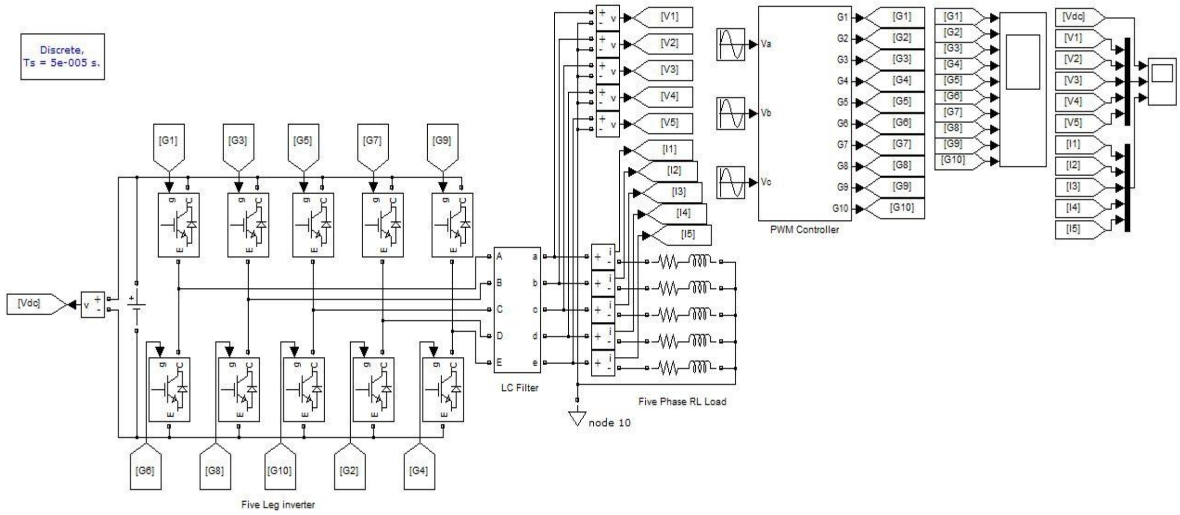

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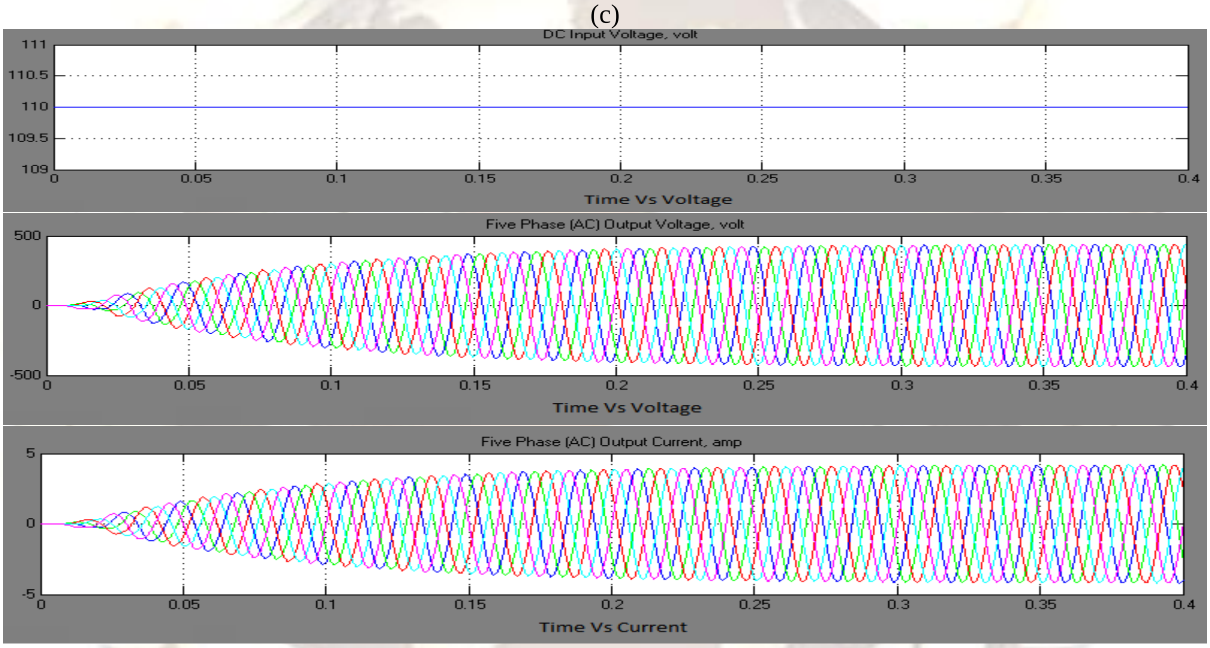

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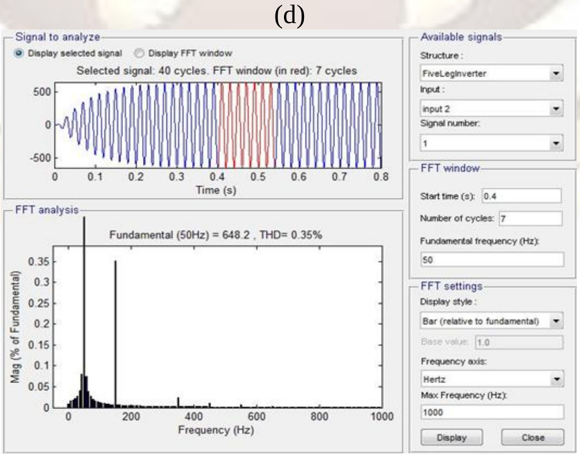

(e)

Figure 4.(a) Pulse Width Modulation technique simulation model (b) Triggering Pulses to Inverter delay of 36^0 each switch(c) Simulation model for Five Leg Inverter, , (d) Input & Output of Five Leg Inverter, (e)Total Harmonic Distortion for Five Leg Inverter.

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IV.CONCLUSION

This paper proposes a new five leg inverter connection scheme to invert the three-phase grid power (it will convert by rectifier as DC)DC to a five-phase output supply. The connection scheme and relation between input and output along with the switching sequence are illustrated. The successful implementation of the proposed connection scheme is elaborated by using simulation. It is expected that the proposed connection scheme can be used in drives applications and may also be further explored to be utilized in multiphase power transmission systems. From the application point of view it is suitable for driving the Five Phase IM as ripple free torque and Variable speeds are also available by varying the switching frequency. Also, we can get better results by using other control techniques. This inverter scheme costs less, because the IGBT cost and PWM setup kit is very economical and cheaper. The five leg inverter Total Harmonic Distortion (THD) is 0.35% which means the harmonic content is less and this amount of THD is acceptable. Switching frequency is 2000 Hz. The five phase power is o.5179 times more than the three phase power and 2.25 times more than the single phase power.

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