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A Novel 7-Level Inverter Topology for Dynamic Performance of Induction Motor Drive

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Abstract : The Multilevel inverters are used to obtain high output power from medium voltage sources. in this paper a new topology of multilevel inverter is proposed. The importance of the converters will enhance if it connects to a drive. So, this inverter is connected to an induction motor to observe the dynamic performance. the induction motor is modeled in MATLAB SIMULINK. Before going to connect a drive the inverter circuit is analyzed with a simple resistive load, it was continued with the induction motor to work in open loop as well as closed loop operation to know the operation of the motor. Output voltages of inverter, currents, speed, torque and flux waveforms in open loop and closed loop operations of the system are presented in this paper.
Keywords : Multilevel inverter, elementary circuit, load torque, speed, flux, phase and line voltages.

1. INTRODUCTION

Now-a-days researchers are mostly interested in multilevel inverters due to the advantages of capability to operate at high switching frequency, less distortion output, lower switching losses and high efficiency compared to conventional inverters. In present scenario many industries requires high powers. Multilevel inverters are the inverters which are introduced as an alternative to both high and medium voltage conditions.

In industries the squirrel cage induction motor is mostly used. These motors are used as primary movers for loads which require high starting torques. The speed control in these motors can be achieved because of the resistors present in it. In these motors there are no slip rings; as a result the losses are less and has high efficiency compared to the slip ring induction motors.

2. PROPOSED TOPOLOGY

This proposed topology consists of a number of elementary circuits in its construction. The elementary circuit consists of two switches and a single DC source. The elementary circuit is shown below.

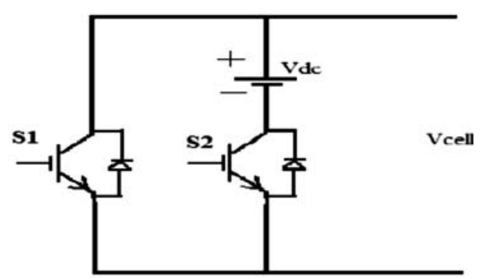

Fig. 1. Elementary Circuit.

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In the above circuit when the switch S1 is closed and switch S2 is open then the output obtained is ‘0’. When switch S1 is open and S2 is closed then the output obtained is Vdc.

This is the proposed design for output of 7 levels of phase voltage and 5 level line voltages

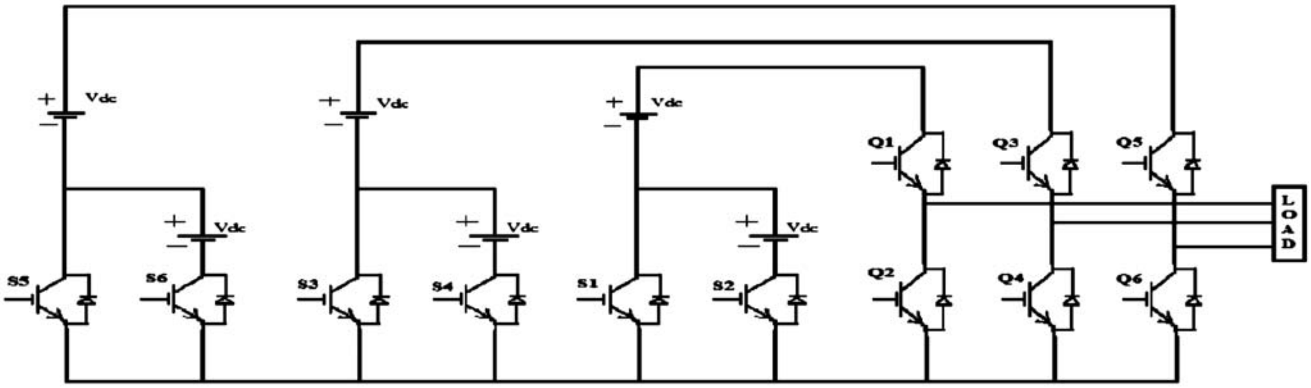

Fig. 2. Proposed Tropology.

Switching states of proposed topology :

Table 1.

			V_{an}				V_{bn}				V_{cn}			
V_{an}	V_{bn}	V_{cn}	S_1	S_2	Q_1	Q_2	S_3	S_4	Q_3	Q_4	S_5	S_6	Q_5	Q_6
0	$-V_{dc}$	V_{dc}	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
$\frac{2}{3}V_{dc}$	$\frac{-4}{3}V_{dc}$	$\frac{2}{3}V_{dc}$	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
V_{dc}	$-V_{dc}$	0	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
$\frac{4}{3}V_{dc}$	$\frac{-2}{3}V_{dc}$	$\frac{-2}{3}V_{dc}$	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
V_{dc}	0	$-V_{dc}$	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
$\frac{2}{3}V_{dc}$	$\frac{2}{3}V_{dc}$	$\frac{-4}{3}V_{dc}$	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
0	V_{dc}	$-V_{dc}$	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
$\frac{-2}{3}V_{dc}$	$\frac{4}{3}V_{dc}$	$\frac{-2}{3}V_{dc}$	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
$-V_{dc}$	V_{dc}	0	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF
$\frac{-4}{3}V_{dc}$	$\frac{2}{3}V_{dc}$	$\frac{2}{3}V_{dc}$	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF
$-V_{dc}$	0	V_{dc}	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF
$\frac{-2}{3}V_{dc}$	$\frac{-2}{3}V_{dc}$	$\frac{4}{3}V_{dc}$	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF

3. DESIGNING OF INDUCTION MOTOR BY MATHEMATICAL EQUATIONS

The motor equations with respect to d and q axis of the stator and rotor are

$$V_{ds} = R_s I_{ds} + P\psi_{ds} - \omega\psi_{qs} \qquad \psi_{ds} = L_s I_{ds} + L_m I_{dr}$$

$$V_{qs} = R_s I_{qs} + P\psi_{qs} + \omega\psi_{qs} \qquad \psi_{qs} = L_s I_{qs} + L_m I_{qr}$$

$$V_{dr} = R_r I_{dr} + P\psi_{dr} - (\omega - \omega_r)\psi_{qs} \qquad \psi_{dr} = L_r I_{dr} + L_m I_{ds}$$

$$V_{qr} = R_r I_{qr} + P\psi_{qr} + (\omega - \omega_r)\psi_{qr} \qquad \psi_{qr} = L_r I_{qr} + L_m I_{ds}$$

From the above equations the current equations are derived and used in the simulation.Torque and rotor speed Equations of induction motor

$$T_e = \frac{3}{2} \times \frac{p}{2} \times L_m [I_{dr} I_{qs} - I_{ds} I_{qr}]$$

$$T_e - T_L = JP\omega_r + B\omega_r$$

The transformation block is used because in *dq* transformation mutual inductance will not be present and the equations will be simplified. The induction motor is modeled and simulated in MATLAB SIMULINK.

4. OPEN LOOP OPERATION

The inverter output is given to the induction motor. The torque and speed waveforms are obtained. The rated load torque is applied in the induction motor madelling. The waveforms are obtained using matlab/simulink software.

The block diagram is as shown below

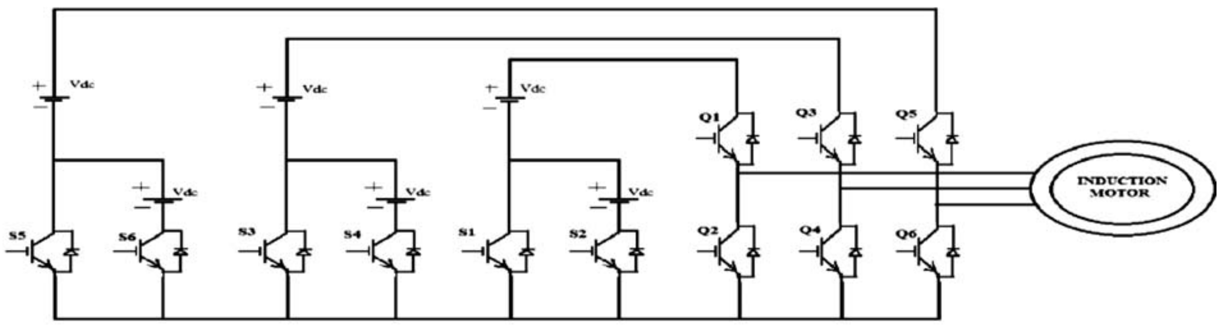

Fig. 3.

5. CLOSED LOOP OPERATION

The difference between the reference speed and the speed of the motor is given to controller. The output T_e^* is given to the limiter as shown in the figure. The slip speed is added with the rotor speed in order to obtain the synchronous speed. A gain is multiplied to convert it to FS which is given to the switches of the inverter .the output of the inverter is given to the motor. The closed loop operation is as shown below.

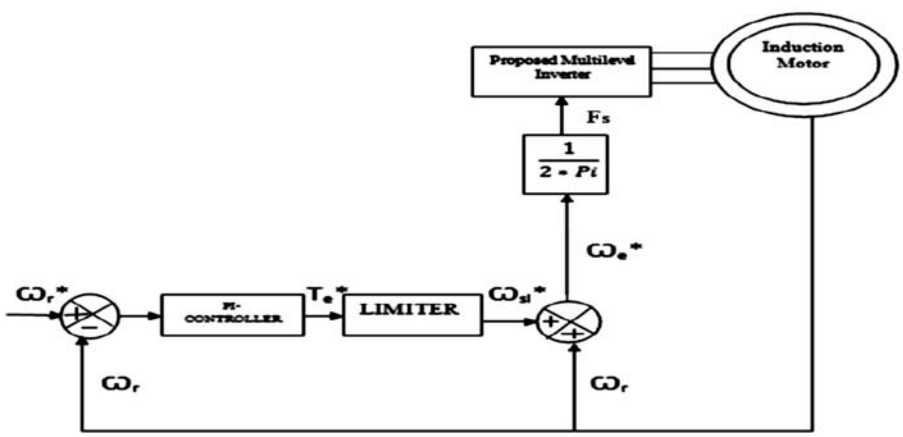

Fig. 4.

6. RESULTS AND DISCUSSION

The outputs of the proposed inverter are below

Phase voltages of the inverter

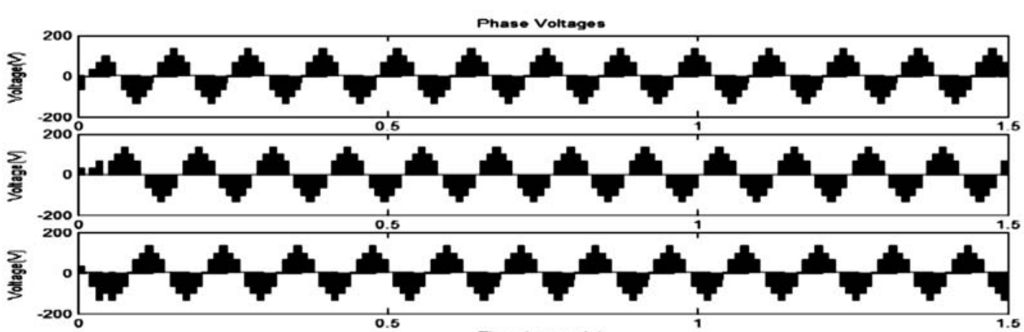

Fig. 5.

Line voltages of the inverter

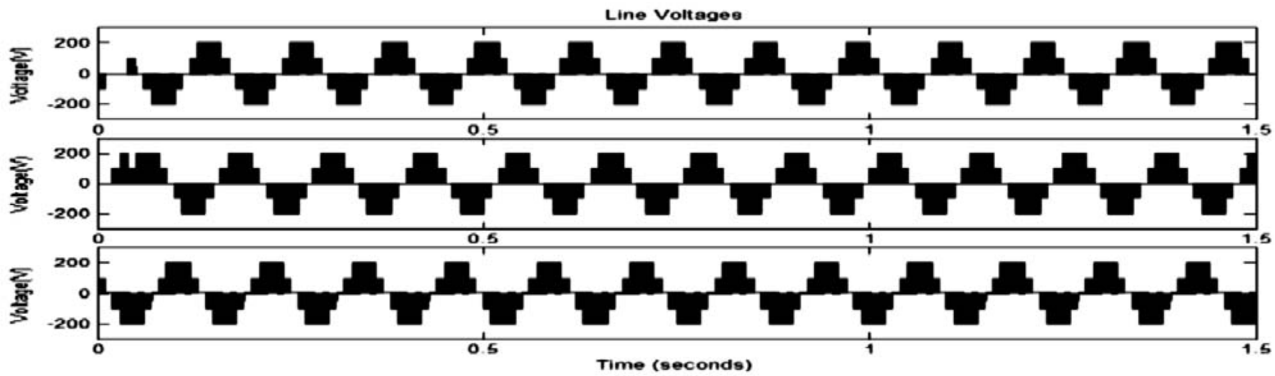

Fig. 6.

The modeled induction motor is as shown

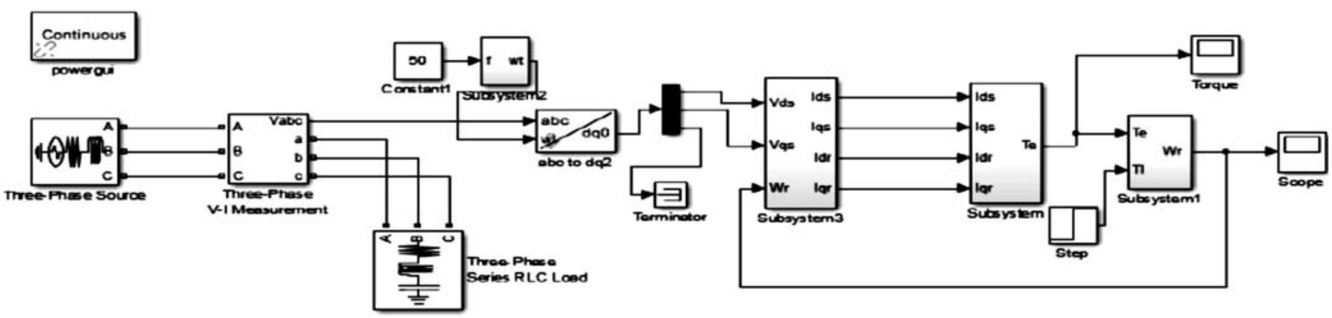

Fig. 7.

The outputs of the induction motor when T_L is applied 0.

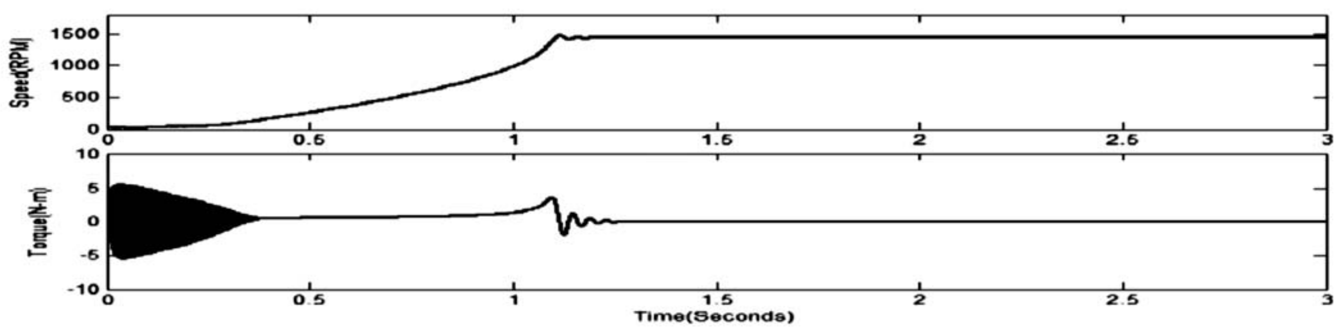

Fig. 8.

The T_L is applied when $t = 2$sec.

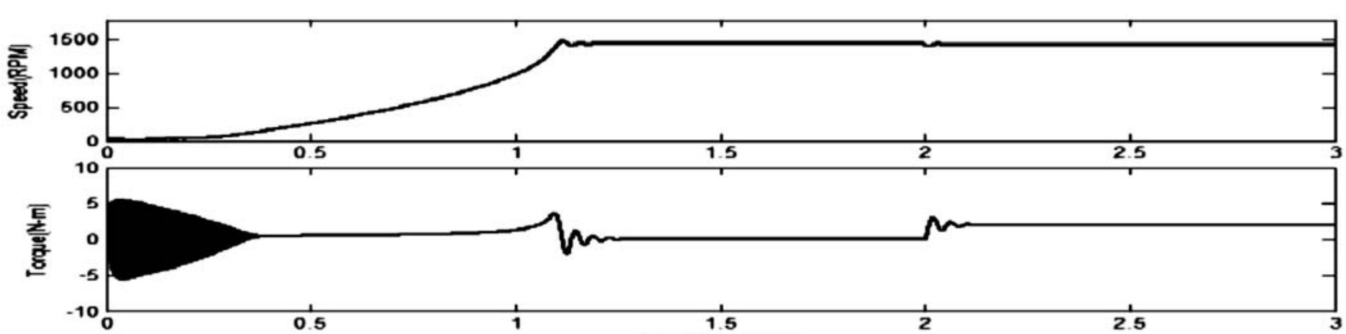

Fig. 9.

The outputs of the open loop operation are as below. The speed and torque waveforms obtained when T_L is not applied are:

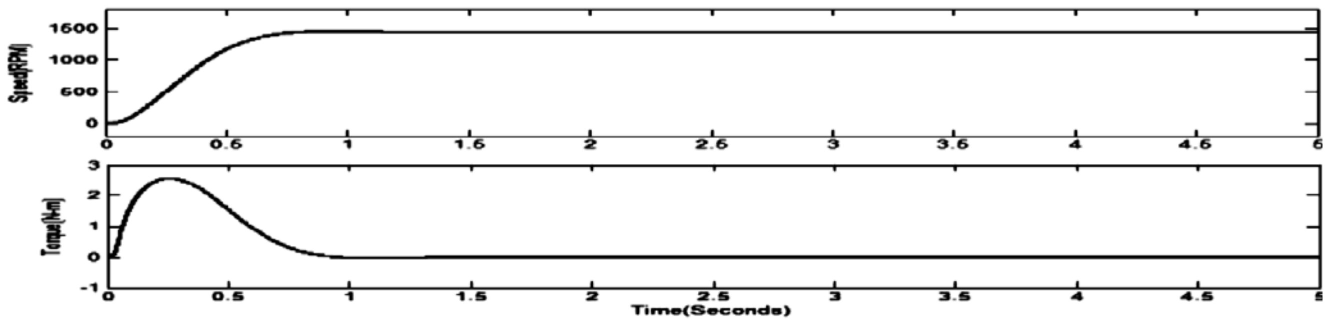

Fig. 10.

When T_L is applied the waveforms obtained are :

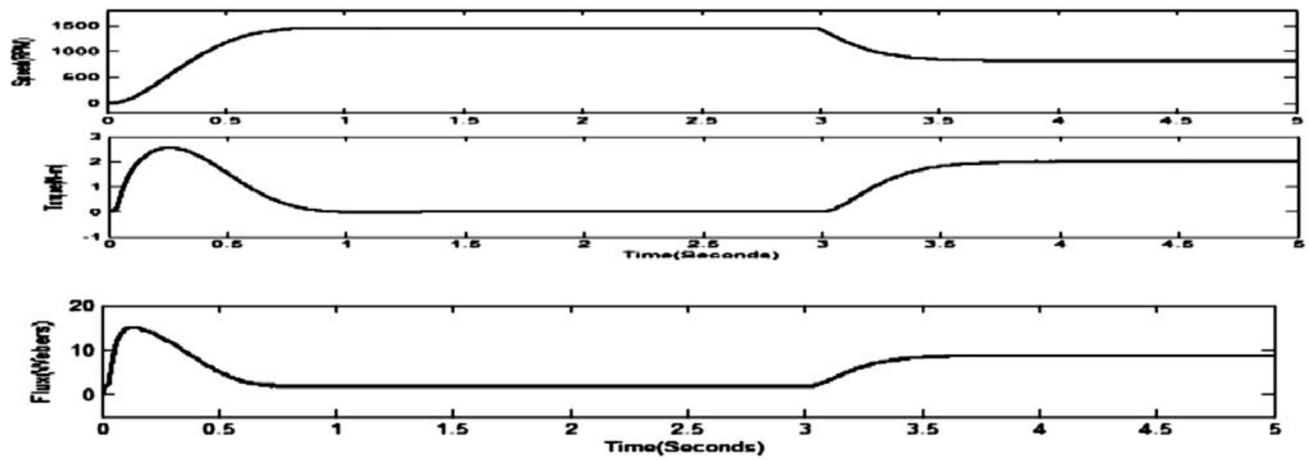

Fig. 11.

The closed loop operation waveforms are:

The speed and torque waveforms when T_L is not applied are:

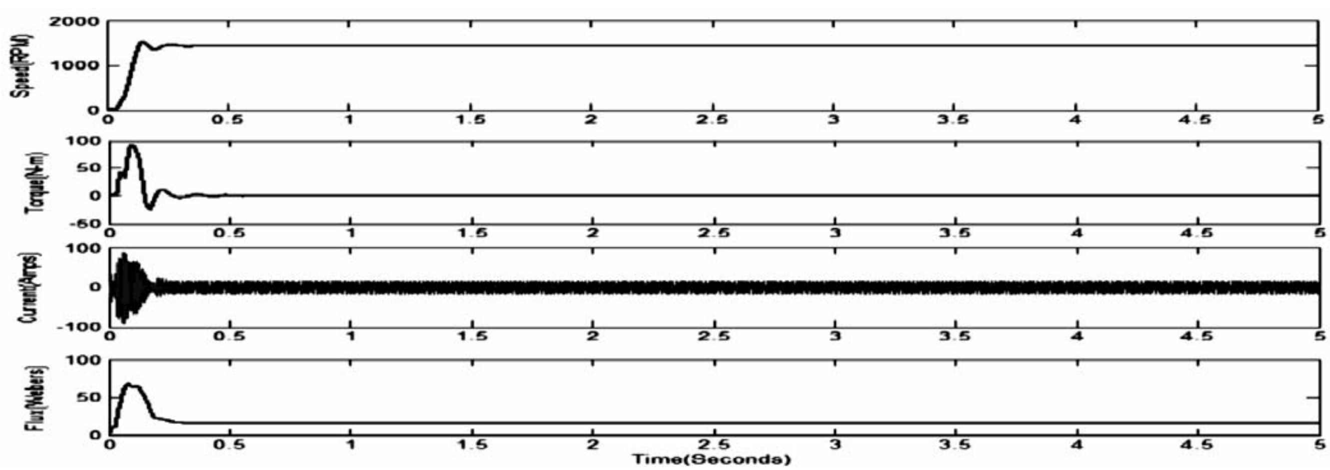

Fig. 12.

The speed and torque waveforms when T_L is applied at t = 2sec are:

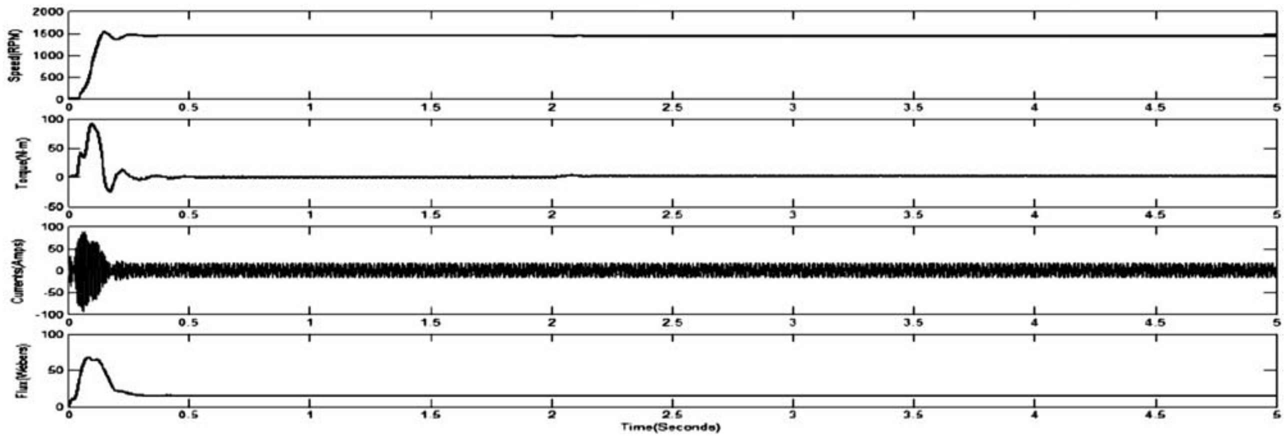

Fig. 13.

7. CONCLUSION

This paper presented a new topology for designing of multilevel inverter. This new topology has the advantages like the number of switches used in this topology is reduced to half when compared to the cascaded multilevel inverter. As a result the controlling of the system becomes easier, cost reduces and overall weight of the system also reduces. The multilevel inverter is simulated by using PWM. The inverter output has seven level phase voltages and five level line voltages. This output of this inverter is given to the induction motor. The motor outputs are obtained in both open loop and closed loop speed control operation. The simulation is done in MATLAB SIMULINK and the results are presented in this paper.

Nomenclature:

ω_r	Rotor Speed
T_L	Load Torque
L_s	Stator self-inductance
L_m	stator mutual-inductance
L_r	rotor self-inductance
V_{ds}	*d*-axis Stator Voltage with stationary frame
V_{qs}	*q*-axis Stator Voltage with stationary frame
ψ_{ds}	*d*-axis Stator flux with stationary frame
ψ_{qs}	*q*-axis Stator flux with stationary frame
ψ_{dr}	*d*-axis Rotor flux with stationary frame
ψ_{qr}	*q*-axis Rotor flux with stationary frame

8. REFERENCES

1. Electric Motor Drives Modeling, Analysis, and Control-R.KRISHNAN.
2. Electrical Machinery-P.S.Bimbra.
3. “V/F control of Three Phase Induction Motor Drive with Different PWM Techniques” Gaber El-Saady1* El-Nobi A. Ibrahim1,2 Mohamed Elbesealy1,3 ISSN Innovative Systems Design and Engineering 2222-1727 (Paper) ISSN 2222-2871 (Online) Vol.4, No.14, 2013

4. AHMED SALEM in his paper “Novel Three-Phase Multilevel Voltage Source Inverter with Reduced No. of Switches”
5. “Dynamic Modeling Of Induction Motor Using Rotating Reference Frame” Sonakshi Guptha and Dr. Sulochana Wadhwani IJAREEIE ISSN (Print):2320-3765 volume 3, issue 6, June 2014.
6. “High-Performance Torque and Flux Control for Multilevel Inverter Fed Induction Motors” Samir Kouro, Student Member, IEEE, Rafael Bernal, Hernán Miranda, Student Member, IEEE, César A. Silva, Member, IEEE, and José Rodríguez, Senior Member, IEEE.
7. “An Effective Control Technique for Medium-Voltage High-Power Induction Motor Fed by Cascaded Neutral-Point-Clamped Inverter” Baoming Ge, Fang Zheng Peng, Fellow, IEEE, Aníbal T. de Almeida, Senior Member, IEEE, and Haitham Abu-Rub, Senior Member, IEEE.
8. Rodriguez, J., Jih-Sheng, L., Fang Zheng, P.: ‘Multilevel inverters: a survey of topologies, controls, and applications’, IEEE Trans. Ind. Electron., 2002, 49, pp. 724–738.