International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 02 | Feb 2020 www.irjet.net p-ISSN: 2395-0072

Open Loop V/F Control of Induction Motor Fed by Three Phase Diode Clamped Multilevel Inverter

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Abstract – *Induction motor have its own importance in automotive industries. Induction motor have high speed range, high reliability, low cost, rigidity in hostile environment. This motor can be controlled by various methods, open loop V/F control technique is one of them. The main objective of this paper is to control induction motor which is fed by three phase diode clamped multilevel inverter. The main purpose of diode clamped multilevel inverter is to improve quality of waveforms. In conventional inverter there will be high switching losses, which results in High THD values of voltage and current waveforms. Use of Multilevel inverter improves the drive performance. The simulation results of proposed control system are verified with the help of MATLAB.It is compared with conventional inverter and observed that, as output voltage level of inverter increases the Total Harmonic Distortion gets decreases.*

Key Words: Induction Motor, Diode Clamped Multilevel inverter, Multicarrier PWM, Total Harmonic Distortion, V/F control.

1. INTRODUCTION.

Induction motor is having high importance in automobile sector as production of electrical vehicle is going on. Induction motor have number of advantages such as High speed range, High reliability, Low cost, Rigidity etc. Induction motor drive we can use with Multilevel Inverter, to increase drives performance. Multilevel inverter have its own advantages on conventional inverter as it decreases total harmonic distortion which results in improved performance of fed drive. In this paper we have discussed open loop V/f control which is used to control speed of Induction motor [3].

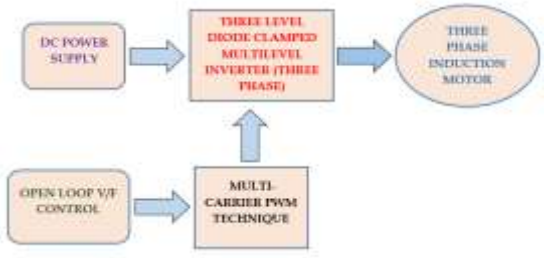


Fig -1: Block diagram of proposed system.

Block diagram of proposed system is shown in figure 1. Three phase three level diode clamped multilevel inverter is fed by DC power supply. Three phase induction motor is fed by this multilevel inverter. Multilevel inverter is controlled by Multicarrier PWM technique, V/F control technique is used for controlling the speed of three phase induction motor.

1.1 Induction Motor.

An induction motor is one of the most often used electric machines in high performance drive applications. Squirrel cage induction motor is popularly known as the workhorse of the modern industry. It is due to its simplicity in design, robust construction, reliability, tremendous self-starting capability and high-efficiency. Induction motor model is built in Matlab Simulink with the help of its mathematical equations [3].

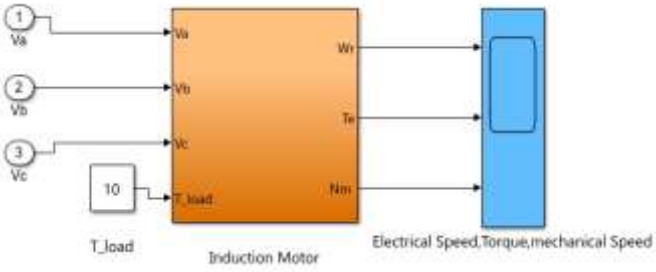


Fig -2: Matlab Block for Three phase Induction Motor.

1.2 V by F Control.

In v by f control technique speed of induction motor is controlled by adjusting magnitude of stator voltage and frequency. For any change in frequency V/F ratio must be maintained constant so as to maintain flux constant. In this case torque becomes independent on the supply frequency. As speed increases stator voltage must be increased proportionally so as to maintain constant V/F ratio. Open loop speed control can be used when accuracy in speed response is not concern. We provide reference speed that speed is converted in to corresponding frequency. This frequency is again converted in to angle theta. From this we generate unit vectors Va, Vb, Vc [3]

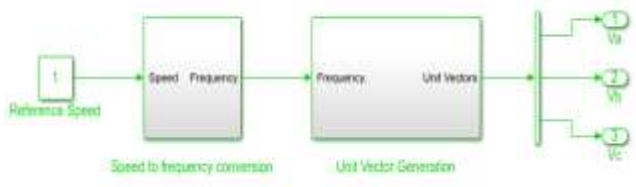


Fig -3: Matlab block for V/F control.

1.3 Diode Clamped Multilevel inverter.

Multilevel inverter have number of advantages over conventional two level inverter that uses high switching frequency pulse width modulation.Multilvel inverter can generate output voltage with very low distortion rate and at lower dv/dt.Input current drawn by these converters are also low. The main characteristic of this inverter is that, it can operate at lowest switching frequency. Diode clamped multilevel inverter is also called as neutral point clamped inverter [1].

Three level DCML:-

For three level diode clamped inverter we require two pairs of switches on single leg as shown in figure4.a)

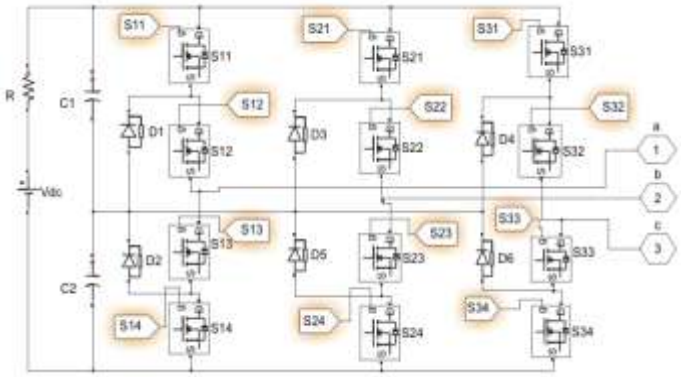


Fig -4.a): Simulink diagram for three level diode clamped inverter.

In General configuration of diode clamped multilevel inverter. The voltage on each switch and capacitor is Vdc.For N level inverter we require,

Number of voltage sources = N-1,
Number of Switching devices = 2(N-1)
Number of clamping diodes = (N-1) (N-2)
Number of DC bus capacitors = (N-1)

For three level diode clamped inverter, inverter have Number of switching devices=4 on each leg, Number of clamping diodes = 2 for each leg, Number of DC bus capacitors = 2.

Output voltage levels and switching states for three level DCML are as follow,

O/P voltage level	Switching Sates			
	S11	S13	S12	S14
Vdc	1	1	0	0
Vdc/2	0	1	1	0
0	0	0	1	1

Five level DCML:-

For five level diode clamped inverter we require four pairs of switches on single leg as shown in figure 4.b) For five level diode clamped inverter, inverter have Number of switching devices =8 on each leg, Number of clamping diodes = 12 for each leg, Number of DC bus capacitors = 4.

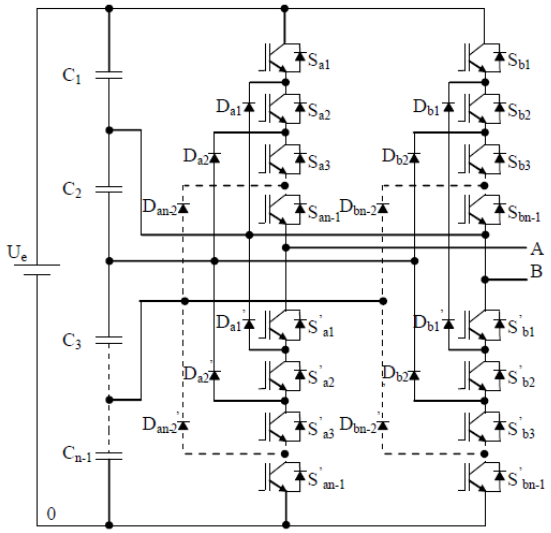


Fig -4.b): Simulink diagram for five level diode clamped inverter.

Output voltage levels and switching states for five level DCML are as follow,

O/P voltage level	Switching Sates							
	S11	S13	S12	S14	S15	S16	S17	S18
Vdc/2	1	1	1	1	0	0	0	0
Vdc/4	0	1	1	1	1	0	0	0
0	0	0	1	1	1	1	0	0
-Vdc/4	0	0	0	1	1	1	1	0
-Vdc/2	0	0	0	0	1	1	1	1

1.4 Multicarrier PWM technique.

In conventional SPWM technique we use only one carrier signal for generating gate pulses. For multilevel inverter we use multicarrier PWM technique. In multicarrier PWM technique we use number of carrier signals based on number of voltage levels in inverter. Figure 5 a) shows the multicarrier PWM used for three level diode clamped inverter. In this PWM two triangular carriers are compared with sine wave to generate PWM pulses which are shown in figure 5.b)

Figure 6.b) shows the multicarrier PWM technique for five level multilevel inverter. In this PWM technique four carrier signals are compared with sine wave to generate gate pulses which are as shown in figure 6.a)[7]

For three level DCML:-

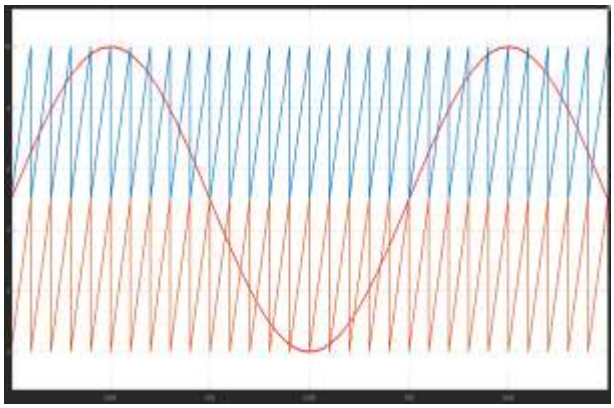


Fig -5.a): Multicarrier PWM technique for three level Inverter.

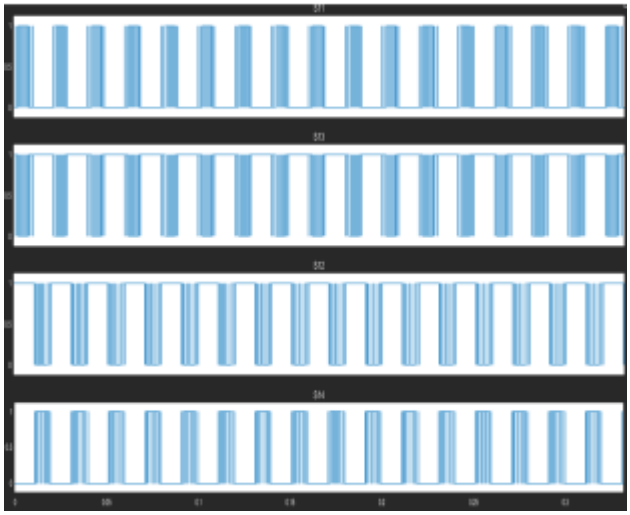
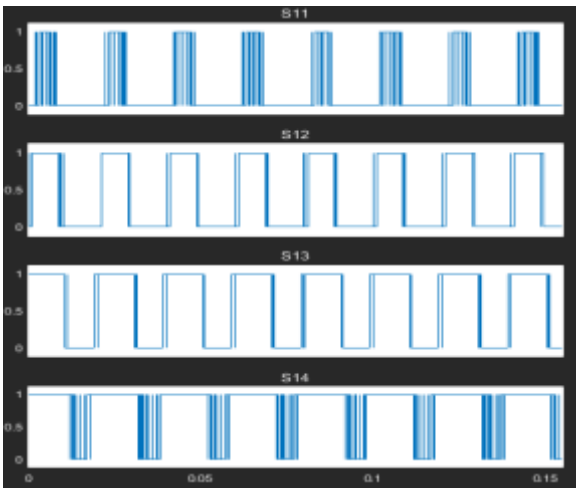


Fig -5 b): Gate Pulses for Switches S11, S12, S13, and S14.

For five level DCML:-



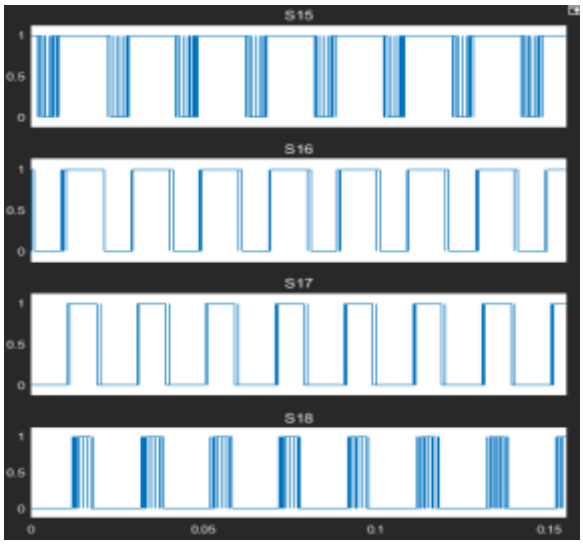


Fig -6 a): Gate Pulses for Switches S11, S12, S13, S14, S15, S16, S17 &S18.

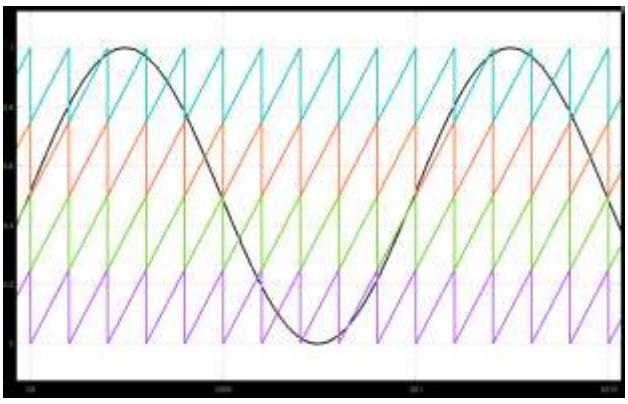


Fig -6.b): Multicarrier PWM technique for five level Inverter.

2. SIMULATION CIRCUIT AND WAVEFORMS.

Figure7 shows the Simulink diagram for proposed system. We provide reference speed at which we have to operate motor. That reference speed is converted to the corresponding frequency signal and with V by f gain we convert that in to unit vectors. These unit vectors are compared with multi carrier signals to generate gate pulses. Three phase diode clamped inverter is then operated with the help of these gate pulses. Output voltage of inverter is provided to the three phase induction motor for driving the same.

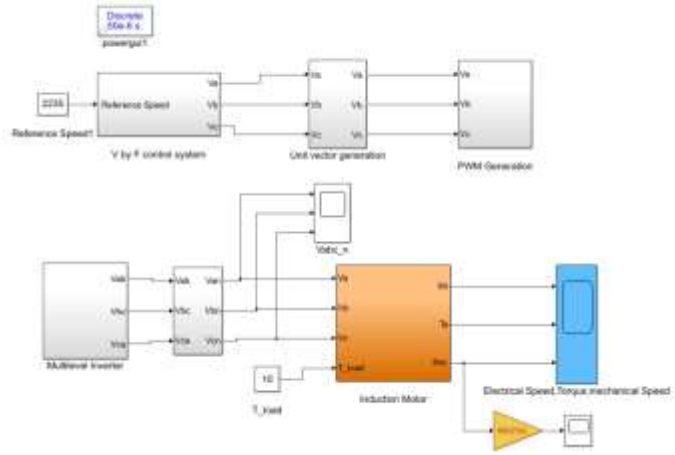


Fig -7: Simulink diagram of proposed system.

2.1 Output voltage and Current waveforms comparison.

Figure 8, 9 & 10 shows the voltage output waveforms for conventional, three level DCML and Five level DCML.

Conventional two level inverter voltage output.

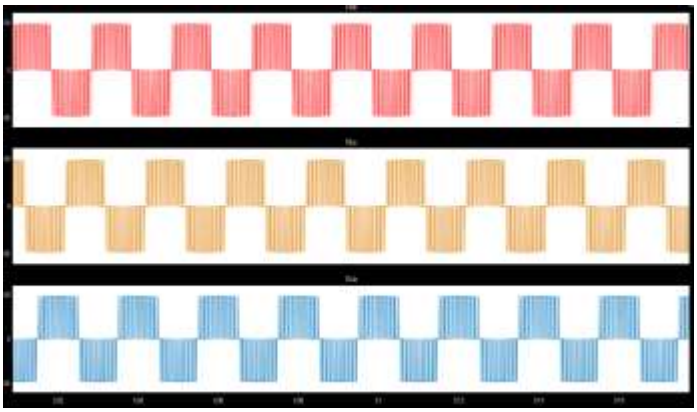


Fig -8: Output voltage from conventional two phase inverter.

Three level diode clamped inverter voltage output.

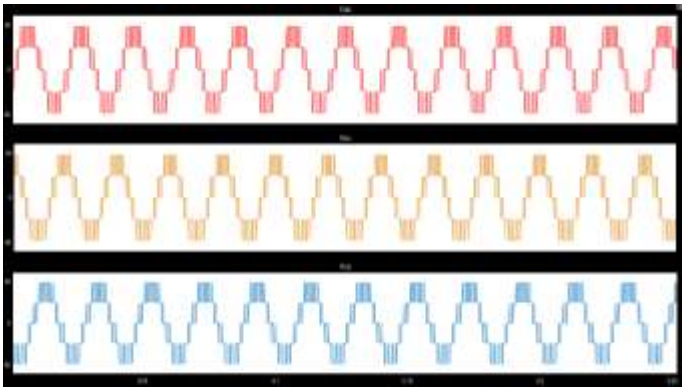


Fig -9: Output voltage from three level diode clamped inverter.

Five level diode clamped inverter voltage output.

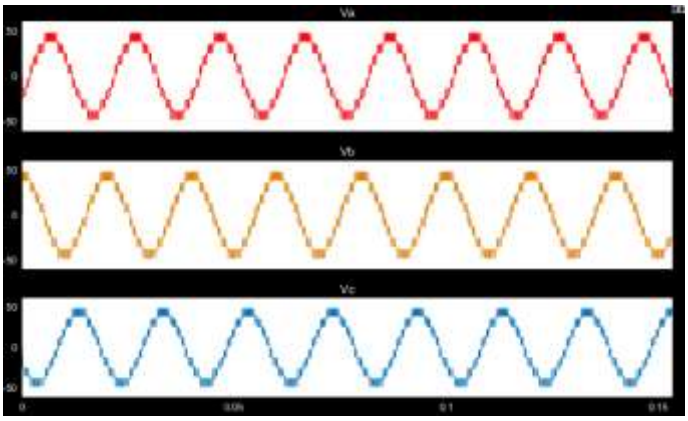


Fig -10: Output voltage from five level diode clamped inverter.

THD comparison:-

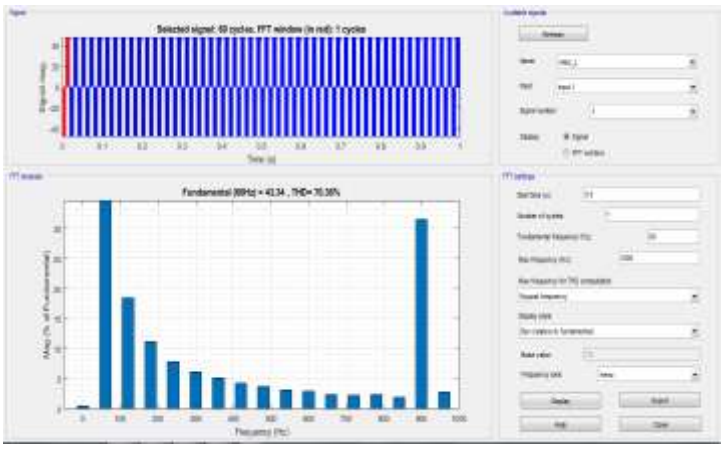


Fig -11: THD for conventional inverter voltage output.

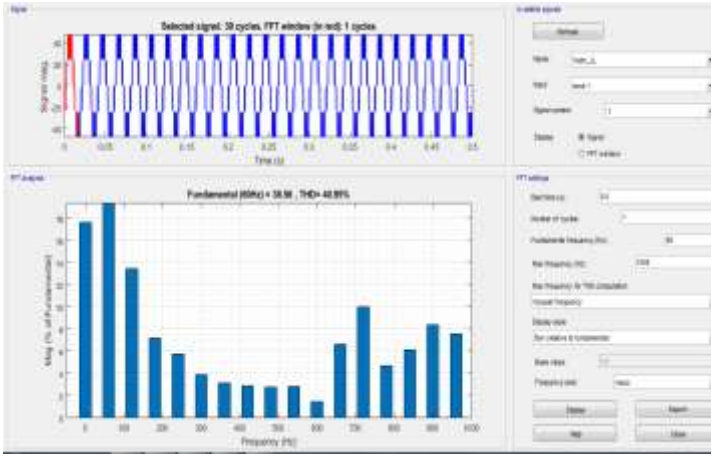


Fig -12: THD for Three level diode clamped multilevel inverter voltage output.

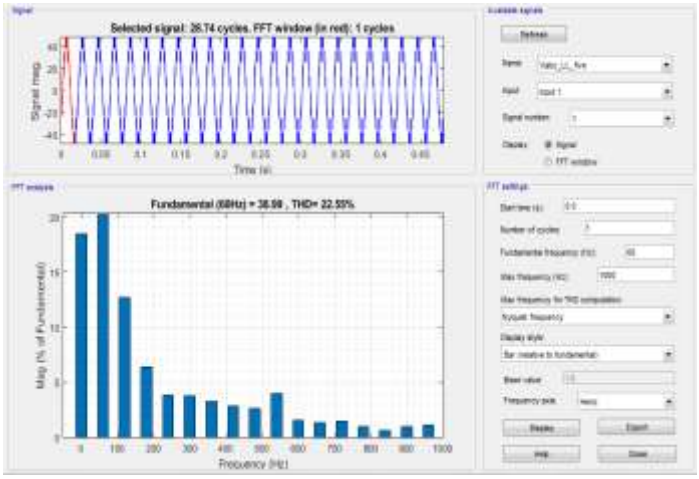


Fig -13: THD for five level diode clamped multilevel inverter voltage output.

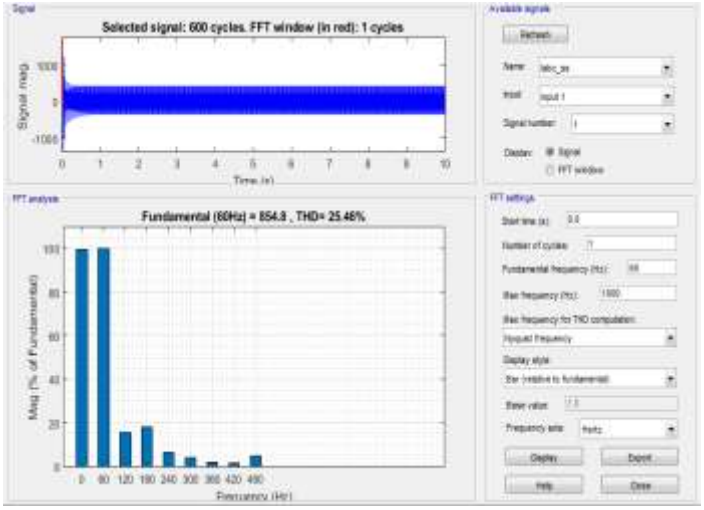


Fig -14: THD for conventional inverter Current output.

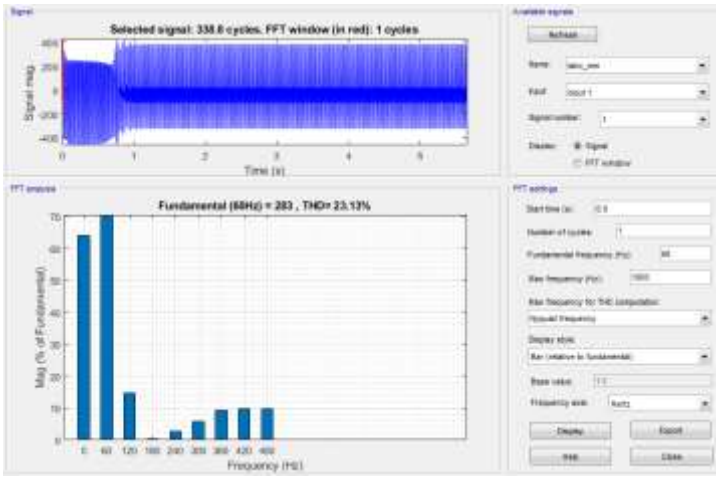


Fig -15: THD for Three level diode clamped multilevel inverter Current output.

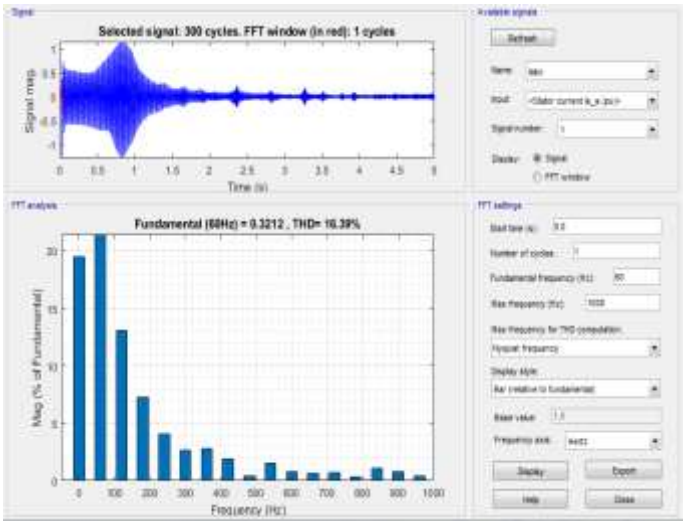


Fig -16: THD for Five level diode clamped multilevel inverter Current output.

THD data for various duty cycles:-

Duty	THD value in %		
	Single Level	Three Level Inverter	Five level Inverter
0.2	82.82	57.93	44.8
0.4	25.46	23.13	16
0.6	23	14.39	10.5

2.2 Torque and Speed output comparison.

Conventional Inverter:

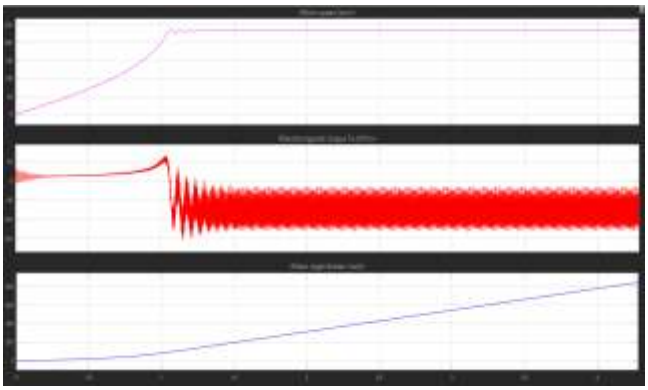


Fig -17: Output torque and Speed for Conventional Inverter.

Diode clamped multilevel inverter:

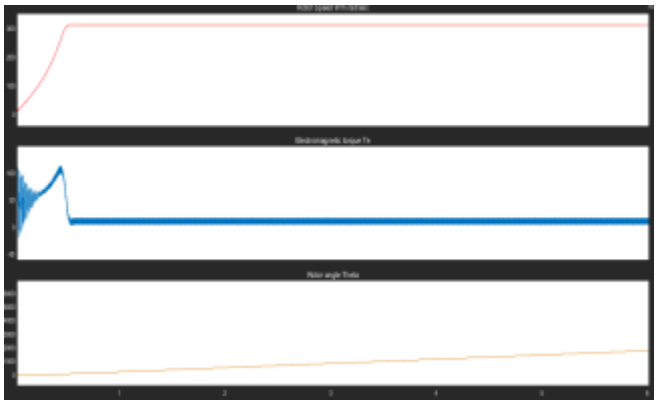


Fig -18: Output torque and Speed for Three level Diode clamped multilevel inverter.

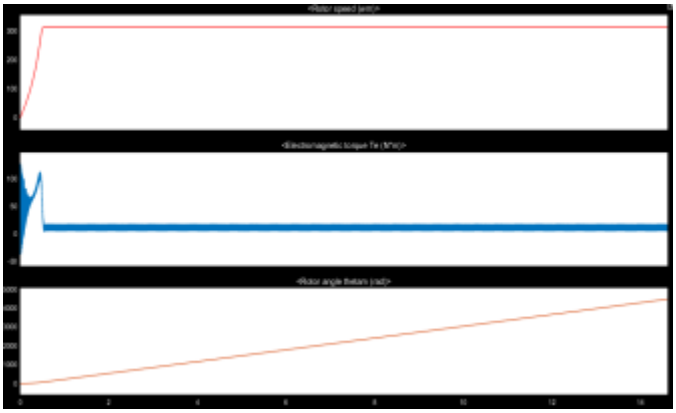


Fig -19: Output torque and Speed for Five level Diode clamped multilevel inverter.

3. CONCLUSION

Modelling of three level and five level multilevel inverter fed induction motor drive have been done in matlab Simulink. Simulation results for Induction motor drive fed by conventional (Two level) inverter, Three level diode clamped inverter & Five level diode clamped inverter are compared for Total Harmonic Distortion (THD).It is observed that as we go for higher voltage levels, Total harmonic contents gets reduced. This inverter system can be used in variable speed drive applications.

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