Performance Analysis of Induction Motor Drive using Different Cascaded H-Bridge Multilevel Inverter Topology

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Abstract - *Huge electric drives need advanced power electronics converter to meet their power demands. Consequently, multilevel power inverter structure have been introduced .A multilevel converter has many advantages such as high power ratings, improvement in the performance of the system in terms of reduced harmonics and dv/dt stresses etc . There are so many topologies of multilevel inverter described in the literature; however we are using cascaded H-bridge multilevel inverters with reduced no. of switches as it is the most practicable topology to use as a power converter for medium & high power application. Induction motor drives are the most common used ac motors in industries because it is cheap, robust, efficient and reliable. This paper deals with the comparison of cascaded 7 level, 9 level and 11 level multilevel inverter for induction motor drive. Here sinusoidal pulse width modulation technique is used. THD and Motor parameters are analyzed. Simulation using MATLAB/ Simulink has been performed to verify the performance of multilevel inverters.*

Key Words: **Cascaded H-bridge multilevel inverters, THD, Parameters of Induction motor drive, MATLAB, Simulink**.

1. INTRODUCTION

Power electronic converters are widely used in various industrial drive applications in order to overcome the problems of the limited voltage and current ratings of power semiconductors devices, and therefore some kinds of series and/or parallel connections are required. Recently, the use of multilevel inverters has become popular due to their ability to synthesize waveforms with a better harmonic spectrum and to attain higher voltages as compared to conventional one. Cascade multilevel inverter is one of the power electronic devices used to synthesize a desired ac voltage from several levels of dc voltages. Induction motor drives are the mostly used ac drives in industries because of its low cost and reliability. And due to the increase use of power electronic drives with these motor drives has provided a way to replace the dc motor drives used in industries.

Multilevel Inverters are basically of 3 types [1]:

Diode Clamped multilevel inverter.

Flying Capacitor multilevel inverter.

Cascaded multilevel inverter.

But the cascaded H-bridge is the most efficient one because of many advantages such as use of less no. of components as compared to others, modular structure, provide higher power and output voltages and reduce switching losses. Multilevel Inverters increases the no. of levels in the output and reduces the no. of dc sources required [2].

1.1 Sinusoidal PWM:

Sinusoidal pulse width modulation technique of harmonic reduction is used here. In this case only pulse time (width) can be changed while pulse magnitude remain constant. A pure sin wave is compared with carrier wave and gate pulses are produced. In this particular modulation technique, two parameters i.e. Frequency ratio and modulation index are important 1) The ratio of reference frequency to carrier frequency is known as frequency ratio: $P= w_c/w_m$, 2) The ratio of reference signal amplitude and carrier signal amplitude is known as modulation index: $Ma=A_m/A_c$.

2. IMPLEMENTATION IN MATLAB:

The simulation circuit for 7, 9 and 11 level CMLI with induction motor drive is shown below:
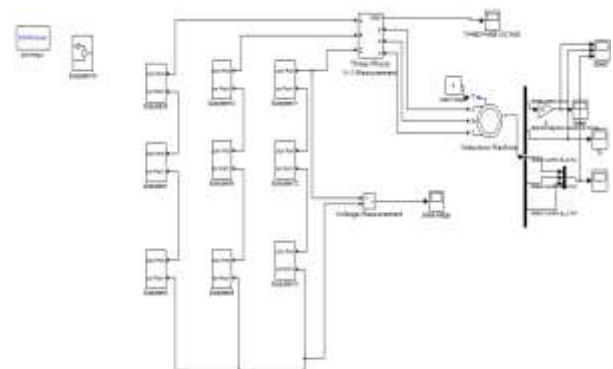

Fig-1: Simulation circuit of a three phase 7-level CMLI

Simulation circuit of three phase 7-level CMLI consists of three subsystems connected in cascaded in three phases each as shown in Fig-1.The resulting output ac voltage swings -3Vdc to +3Vdc with seven-level inverter i.e.-3V,-2V,-1V,0,1V,2V,3V.
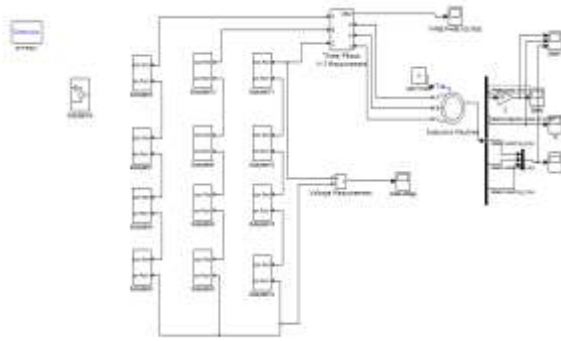
Fig-2: Simulation circuit of three phase 9 level CMLI

Simulation circuit of three phase 9-level CMLI consists of four subsystems connected in cascaded in three phases each as shown in Fig-2.The resulting output ac voltage swings -4Vdc to +4Vdc with nine-level inverter i.e.,-4V,-3V,-2V,-1V,0,1V,2V,3V ,4V.
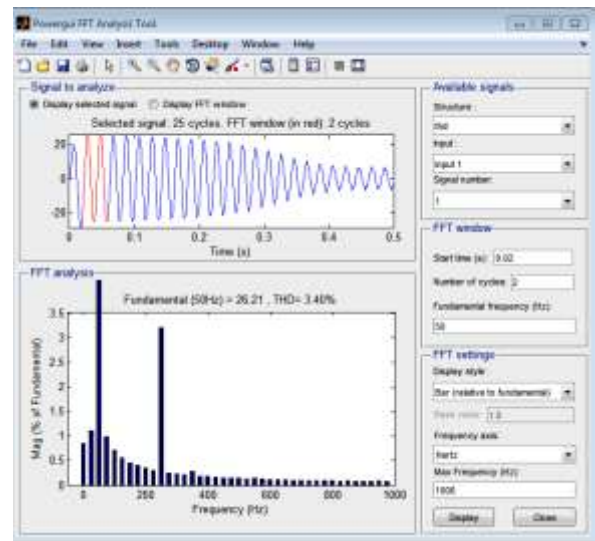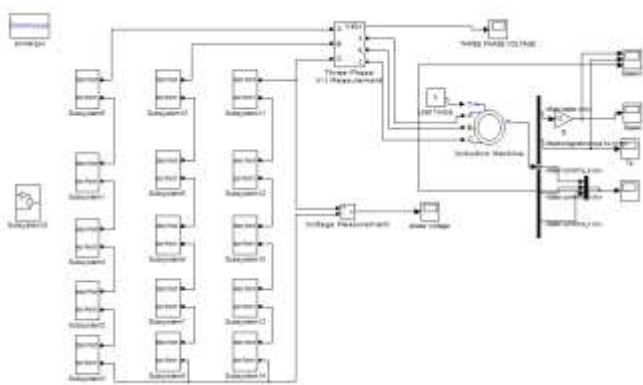

Fig-3: Simulation circuit of a three phase 11-level CMLI

Simulation circuit of three phase 11-level CMLI consists of four subsystems connected in cascaded in three phases each as shown in Fig-3.The resulting output ac voltage swings -5Vdc to +5Vdc with eleven-level inverter i.e.-5V,-4V,-3V,-2V,-1V,0,1V,2V,3V ,4V,5V.

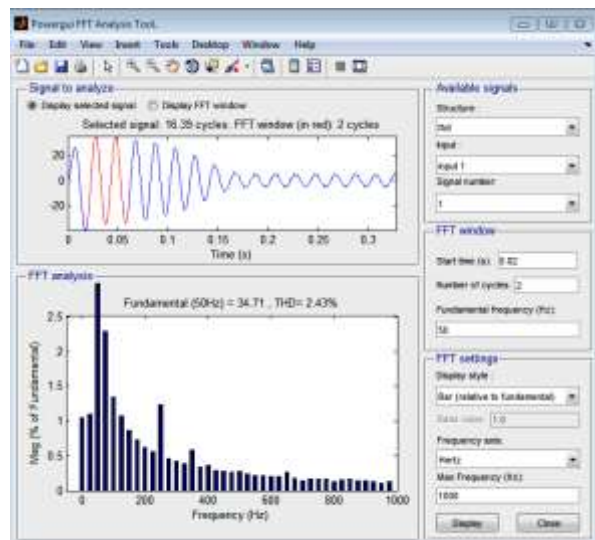### 3. Simulation Results:

The performance analysis has been carried for three phase induction motor and multilevel inverter used for analysis.

Table-1. Ratings of Three Phase Induction Motor

Voltage (L-L)	400V
Nominal Power of Motor	5.4HP (4KW)
Frequency	50 Hz
Rated speed	1430 rpm

Table 1 shows the rating of three phase induction motor used in circuit.

Fig-4:THD analysis of 7 level of CMLI
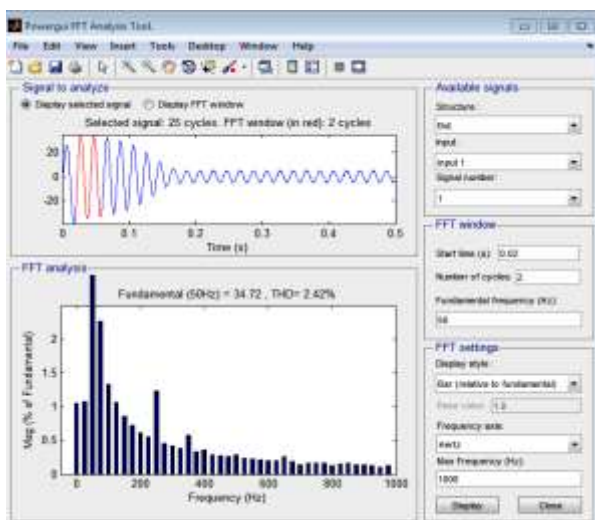

Fig-5:THD analysis of 9 level of CMLI

Fig-6:THD analysis of 11 level of CMLI

The speed, torque and stator current for 7 level, 9 level and 11 level is shown below:
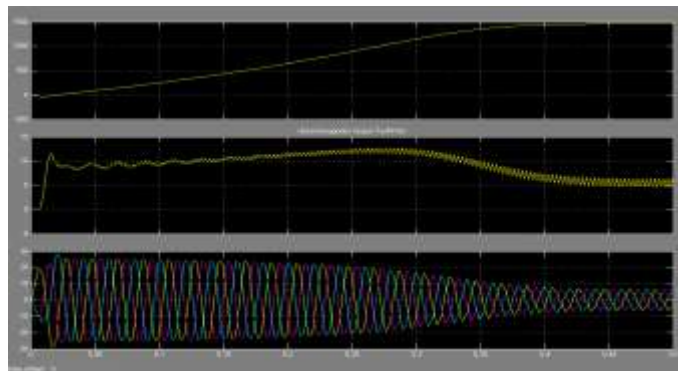

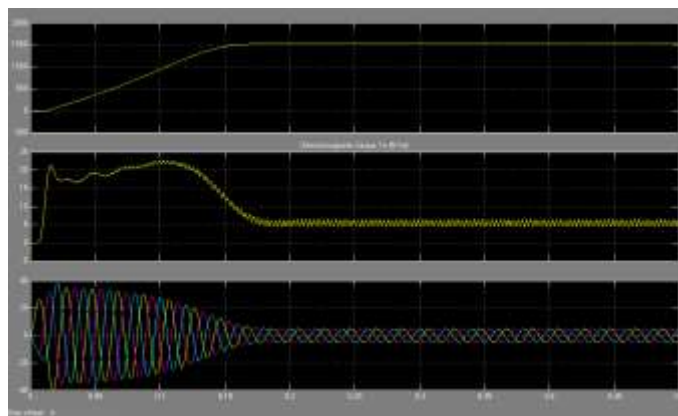**Fig-7**: Speed , Torque and Current motor output of 7 level CMLI.

Fig-8: Speed , Torque and Current motor output of 9 level CMLI.
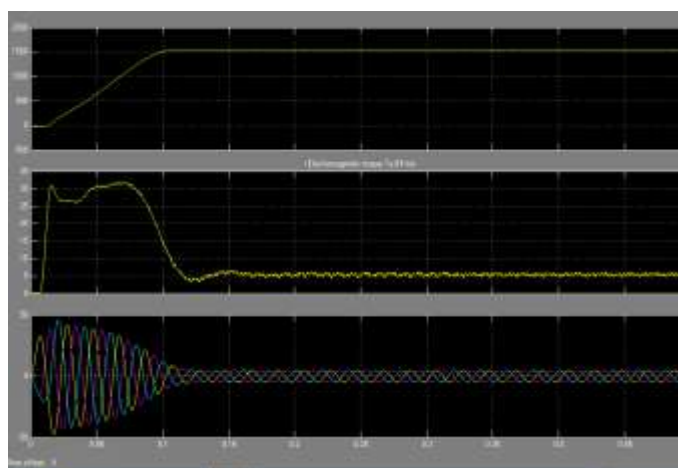

Fig -9: Speed, Torque and Current motor output of 11 level CMLI.

THD and the steady state values of output of 7 level, 9 level and 11 level are compared and shown in the table 2**.**

Table -2. Steady state value for induction motor:

CMLI	Stator Current	Rotor speed	Electromagnetic Torque	THD
7LEVEL	0.4 sec	0.38sec	0.425 sec	3.40%
9LEVEL	0.16 sec	0.17sec	0.19 sec	2.43%
11LEVEL	0.125sec	0.13sec	0.165 sec	2.42%

4. CONCLUSION

The paper shows the comparison of 7 level, 9 level and 11 level CMLI to show the advantage of increasing the no. of levels of CMLI .It is shown that the steady state values of current, speed and electromagnetic torque of motor have reached earlier in case of 11-level CMLI than 9-level and 7-level .THD analysis also show that as the no. of levels of CMLI increases, harmonic distortion reduced and therefore more optimized operation of induction motor obtained.

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