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Carrier Based Multilevel Inverter With Different Reference Waveforms

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ABSTRACT

In this paper a recent topology, the multilevel carrier based inverter topology has been presented with its advantages over conventional inverter schemes. A comparative study has been done within the topology used between pure sinusoidal reference waveform and the modified sinusoidal reference waveform which constitutes harmonics. The entire simulation has been done in MATLAB Simulink and the outputs have been shown for comparison purpose.

Keywords – multilevel inverter, carrier-based inverter, five level inverter

I. INTRODUCTION

Traditional inverter schemes though providing satisfactory results are found to be outdated with new inverter topologies and new controlling strategies over the period of time. Carrier based multilevel inverter topology has come into the limelight a few years back and it has pretty much changed the way things were before. It is advantageous in various aspects and it provides lesser number of switching devices as compared to the conventional five-level inverter scheme. And, lesser isolated power supplies are required. In this paper we suggest a circuit configuration for the 5-level inverter, which is formed by four 2-level inverters cascaded. The DC link capacitors in this topology do not carry load currents and hence the voltage fluctuations in the neutral point are also absent when compared to the cascaded H-bridge topology.

II. THE PROPOSED SCHEME – 5 LEVEL INVERTER CONFIGURATION

The Fig.2.1 shows the inverter scheme topology used. The cascaded inverters are fed by the DC voltage source equivalent to ¼ of the total DC voltage required i.e. each inverter is supplied by a DC voltage source of $V_{dc}/4$.

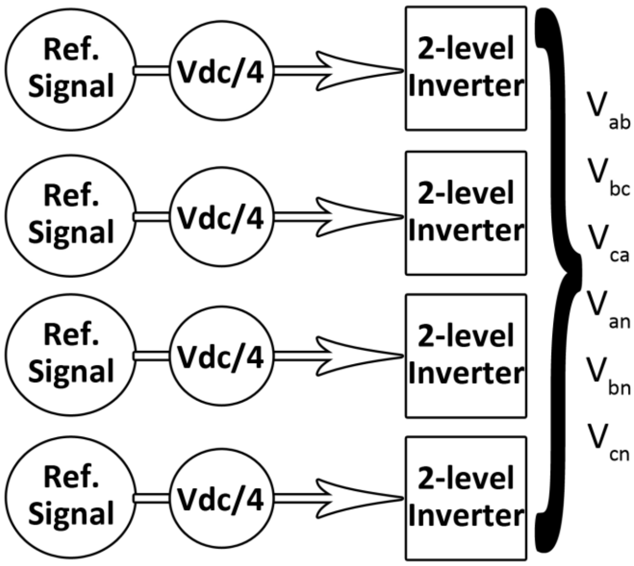

Fig.2.1. Proposed 5-level inverter topology

The outputs of the four 2-level inverters can be fed to the desired appliance. We have taken an induction motor in this case for observing the characteristics. In MATLAB Simulink, the phase and line voltages are obtained which are observed in the scope, which are provided latter in this paper.

III. GOVERNING EQUATIONS

Multilevel carrier based Pulse Width Modulation is used for the 5-level inverter scheme. This multilevel carrier based PWM for an N-level inverter uses a set of N-1 adjacent level shifted triangular carrier waves. If the reference wave has peak amplitude V_m* and frequency f_m, the modulation index is defined with reference to a triangular wave of peak-to -peak amplitude of V_c (N-1) as

$$Ma = 2 V_m^* / V_c (N-1) \quad (1)$$

For the 5-level inverter scheme, four triangular waves with peak-to-peak amplitude of V_c are used.

The reference waveforms used in the multilevel carrier based inverter are governed by the equations shown below:

$V_a^* = V_m \ \mathrm{Sin}(\omega t) + 0.2V_m \ \mathrm{Sin}(3\omega t) + nV_c/2$ (2)

$V_b^* = V_m \ \mathrm{Sin}(\omega t - 2\pi/3) + 0.2V_m \ \mathrm{Sin}(3\omega t) + nV_c/2$ (3)

$V_c^* = V_m \ \mathrm{Sin}(\omega t - 4\pi/3) + 0.2V_m \ \mathrm{Sin}(3\omega t) + nV_c/2$ (4)

These reference waveforms constitute a third harmonic content which is found to improve the inverter's performance similar to space vector modulation scheme. Control signals for the four inverters are generated such that the appropriate devices are switched to realize the particular level in a particular phase depending upon the region of operation required. The reference wave set for 2-level operation requires single triangular waveform and it increases one by one for 3-level, 4-level and 5-level as two, three and four.

In this particular inverter scheme used, we are using two types of reference signals. One reference signal is a modified sinusoidal reference waveform which has harmonics in it and the other is a pure sine wave which is of null harmonics and perfectly sinusoidal.

IV. SIMULINK BLOCKS & OUTPUTS

The line voltages of the carrier based multilevel inverter topology using modified sinusoidal reference waveform is as shown below for a DC voltage of 300V.

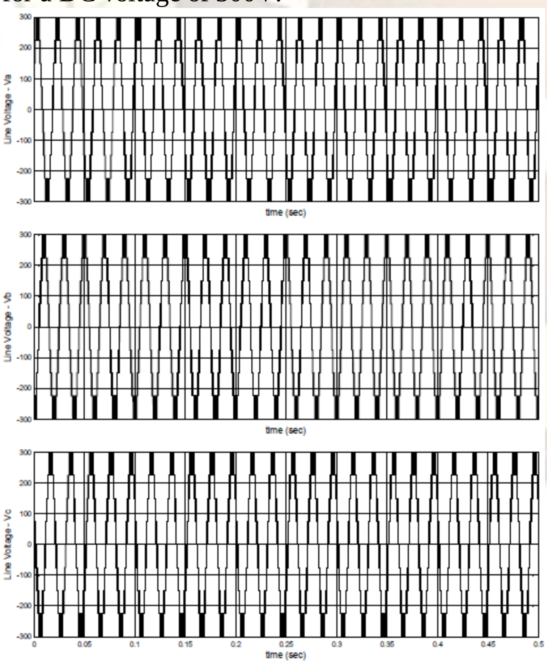

Fig.4.1. Line voltages-modified sine wave

And the phase voltages are obtained as shown below:

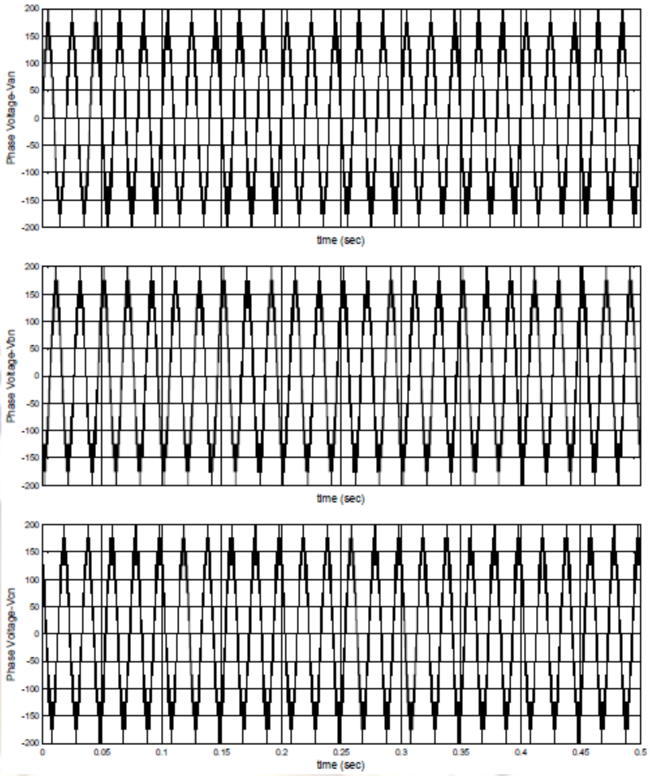

Fig.4.2. Phase voltages-modified sine wave

The carrier signals and reference signals are obtained as:

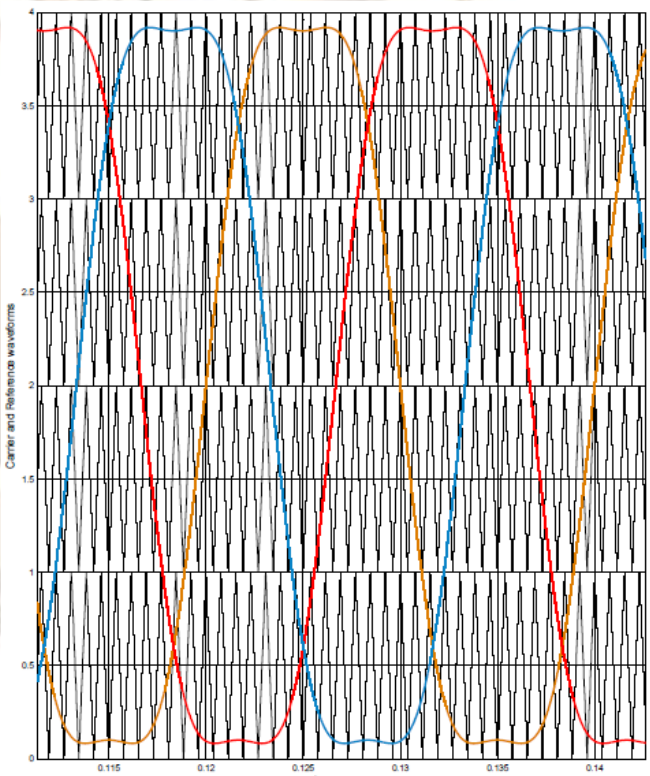

Fig.4.3. Zoomed Carrier & reference signals-modified sine wave

The line voltages of the carrier based multilevel inverter topology using pure sinusoidal reference waveform is as shown below for a DC voltage of 300V.

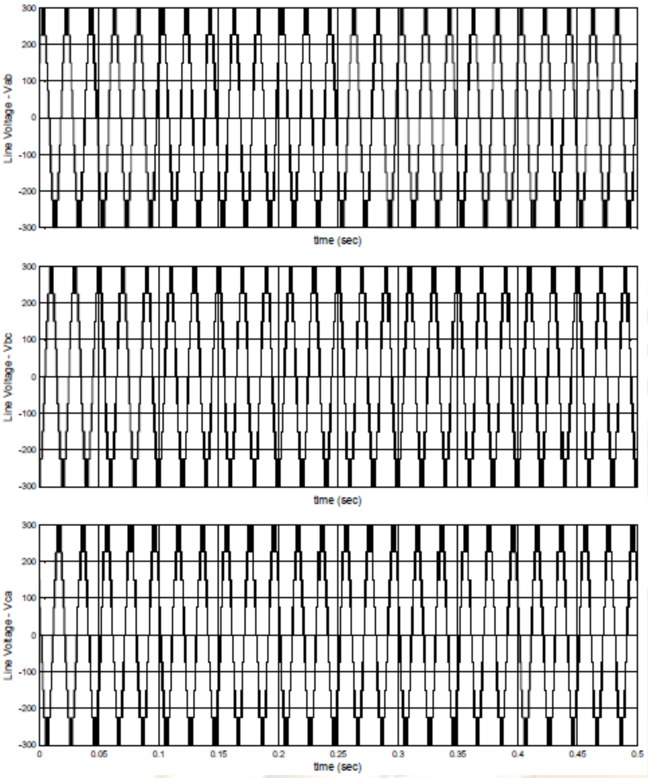

Fig.4.4. Line Voltages-pure sine wave

And the phase voltages are obtained as shown below:

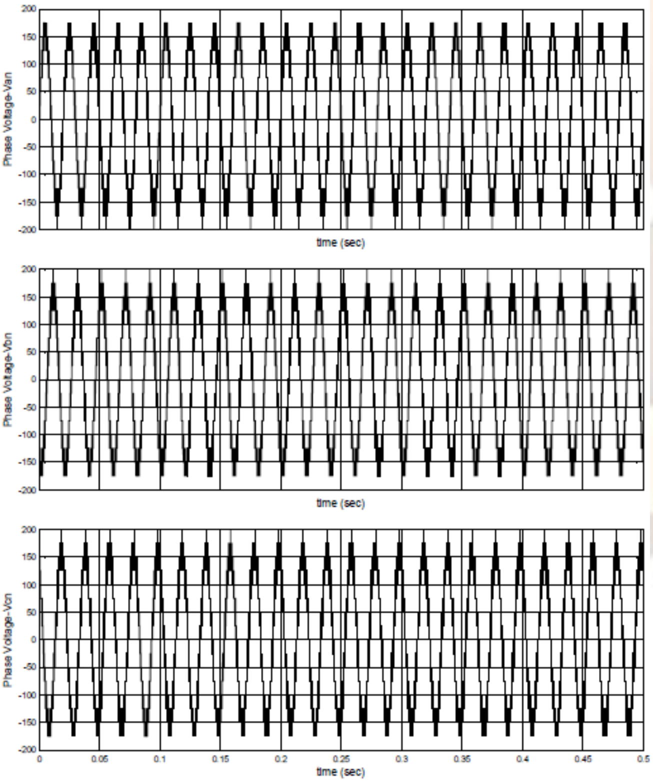

Fig.4.5. Phase Voltages-pure sine wave

The carrier signals and reference signals for pure sine wave are obtained as:

Fig.4.6. Carrier & reference signals-pure sine wave

Now we compare the waveforms of the induction motor response which is given a step change in torque connected to the two types of topologies differing in reference waveform. For modified sinusoidal reference, we obtain the Speed Vs Time plot as:

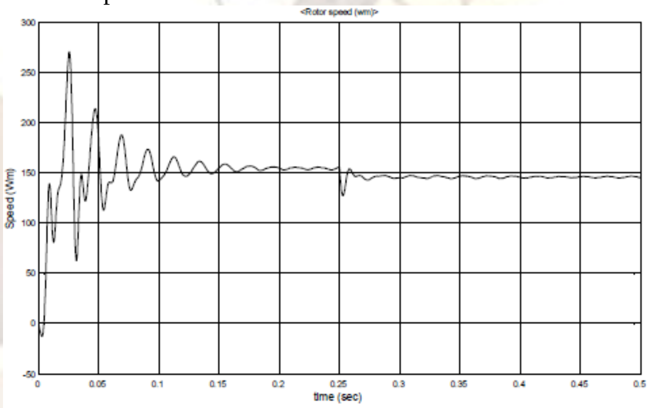

Fig.4.7. Speed Vs Time-modified sine wave

From the above graph it can be observed that the oscillations almost got suppressed at 0.4 sec.

Now, when we consider the pure sinusoidal waveform as the reference, we can see that it's not settling even after 0.5 sec, which is why we can give the modified sinusoidal reference signal a higher score for better performance. This can be observed if we observe the waveform in Fig.4.8.

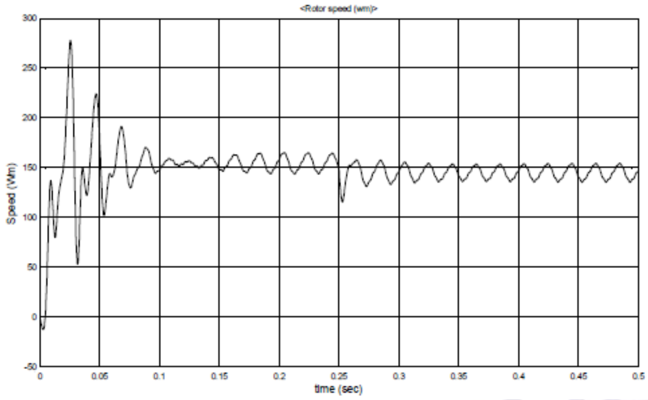

Fig.4.8. Speed Vs Time-pure sine wave

Now, considering the Torque Vs Time graph, for the modified sinusoidal reference waveform, we obtain the graph as shown below:

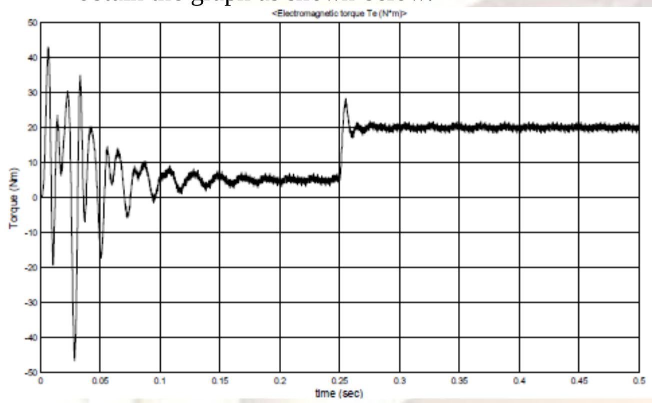

Fig.4.9. Torque Vs Time-modified sine wave

From the above graph we can observe that the oscillations almost got minimized at 0.4 sec, and now when we consider the case of pure sinusoidal waveform, we observe the waveform as:

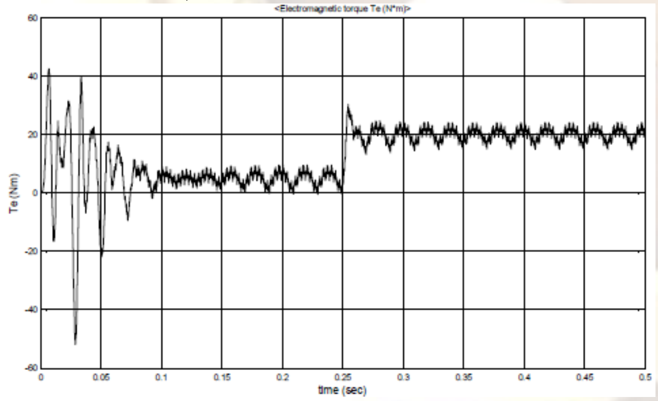

Fig.4.10. Torque Vs Time-pure sine wave

From this, we can observe that the oscillations couldn't be suppressed even after 0.5 sec, hence proving that the modified sinusoidal reference waveform is the better alternative among the two reference signals experimented.

V. CONCLUSION

From the experimental results of MATLAB Simulink, we can clearly state that the multilevel carrier based inverter topology employing the modified sinusoidal reference waveform with harmonics in it is a better alternative compared to the purely sinusoidal reference signal; as the output waveforms observed are showing that. Also, lesser-isolated power supplies are required when compared to the cascaded H-bridge configuration & most importantly this inverter scheme also does not experience neutral-point fluctuations. The multi-level -level carrier based PWM does not require the look-up tables to realize the switching sequences as in case of space vector modulation which makes its operation and use simplified for a better understanding.

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