



A New Hybrid 27 Level Single Phase Multi Level Inverter for Induction Motor Loads

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ABSTRACT: This paper proposes a New Hybrid 27 Level Multi Level Inverter with Cascaded H Bridges which can drive a Single phase Induction motor. It uses an asymmetrical voltage source topology and it produces different voltage levels from separate dc sources. This hybrid topology has got more applications in the industrial world. In conventional multi-level inverters, the use of converters for providing asymmetrical voltage sources increases its losses and cost. The proposed inverter provides a 27 level voltage output with a THD less than 5%. With this method we can reduce the harmonics and increase the efficiency.

KEYWORDS: Single Phase Induction Motor Drive, Multi-Level Inverter, Asymmetrical Voltage Sources, Total Harmonic Distortion (THD).

I.INTRODUCTION

Multi level Inverters are the new trend in the area of DC-AC Conversion. A lot of research works are being done in this area for better DC to Sine Wave conversion in both single phase and Three Phase. In all these researches, the main emphasis is given on the reduction of Total Harmonic Distortion (THD) and the efficiency of the output voltage waveform. Total Harmonic Distortion is the resemblance of the corresponding wave to a pure sinusoidal waveform. Closer the resemblance is lesser the THD will be.

There are many topologies which are proposed over years in multi level inverters. Few of them are Neutral Point Clamped or Diode Clamped (NPC), the Flying Capacitor (FC), Cascaded H-Bridge type (CHB) and the very recent series switch connected reduced switch topology multi-level inverters [1]. The Diode Clamped type and super capacitor type are less used because of the complexity involved in their circuits for generating more level of output voltage waveform. The recent trend is using the topologies in which switches are connected in series with the dc voltage sources and with an H bridge polarity changing circuit in the output side. Even though this topology can create more number of levels with reduced number of switches, the stress on each switch and the circuit complexity will be very high.

This paper proposes a new Hybrid topology with 3 cascaded H bridges with asymmetrical Voltage sources to obtain a 27 level single phase output voltage waveform [2]. The single phase output is fed into a single phase Induction Motor and the results were verified in MATLAB/SIMULINK software. The THD and the motor performance was found to be satisfactory.

II.PROPOSED TOPOLOGY

The Fig.1 shows the circuit diagram of the proposed topology. It contains 3 cascaded H Bridges with asymmetrical voltage sources feeding each H Bridge. The Voltage source magnitudes are in the ratio 1:3:9. Empirically if we provide each voltage source as 1V, 3V, 9V then we will be able to get a 27 level output voltage waveform ranging from +13V to -13V including zero level.

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Harmonic Elimination Methods etc are widely used. Among these, the popular methods are Sinusoidal PWM and Space Vector PWM in high frequency switching. In Low switching frequency, space vector modulation and Selective Harmonic Elimination is popular.

In this paper, Selective Harmonic Elimination technique which uses fundamental frequency switching is used[5]. This method makes use of many mathematical equations to eliminate harmonics like 5th, 7th, 11th and 13th harmonics. This method is also called fundamental switching frequency with harmonics elimination theory.

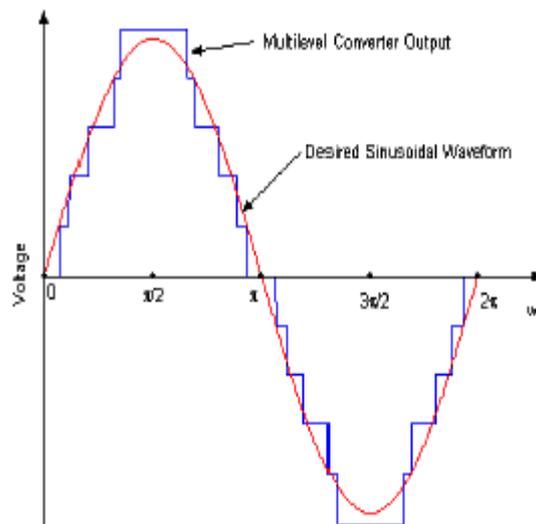


Fig.2 Desired Sinusoidal Waveform and Multi Level Inverter Output

The Harmonic Elimination Theory is based upon identifying the proper switching angles such that they eliminate desired harmonics from the Fourier function of the output voltage waveform. For achieving a wide modulation index with minimum THD for the output waveforms, a generalized SHE method is proposed. The method is called Virtual Stage PWM. Out of the total degrees available in a multi level inverter, one degree is used to control the magnitude of the inverter voltage and rest are used to eliminate the harmonics in SHE method. The Selective harmonic elimination is done using solving the transcendental equations for the unknown angle values. The equations given below shows a set of transcendental equations for 4 variables.

$$\begin{aligned} \cos(\theta_1) + \cos(\theta_2) + \dots + \cos(\theta_s) &= 4m_1 \\ \cos(5\theta_1) + \cos(5\theta_2) + \dots + \cos(5\theta_s) &= 0 \\ \cos(7\theta_1) + \cos(7\theta_2) + \dots + \cos(7\theta_s) &= 0 \\ \cos(11\theta_1) + \cos(11\theta_2) + \dots + \cos(11\theta_s) &= 0 \end{aligned}$$

IV.SIMULATION CIRCUITS AND RESULTS

The Simulation circuit of the multi level inverter with both resistive load and induction motor load are given in figure 3 and 4 respectively.

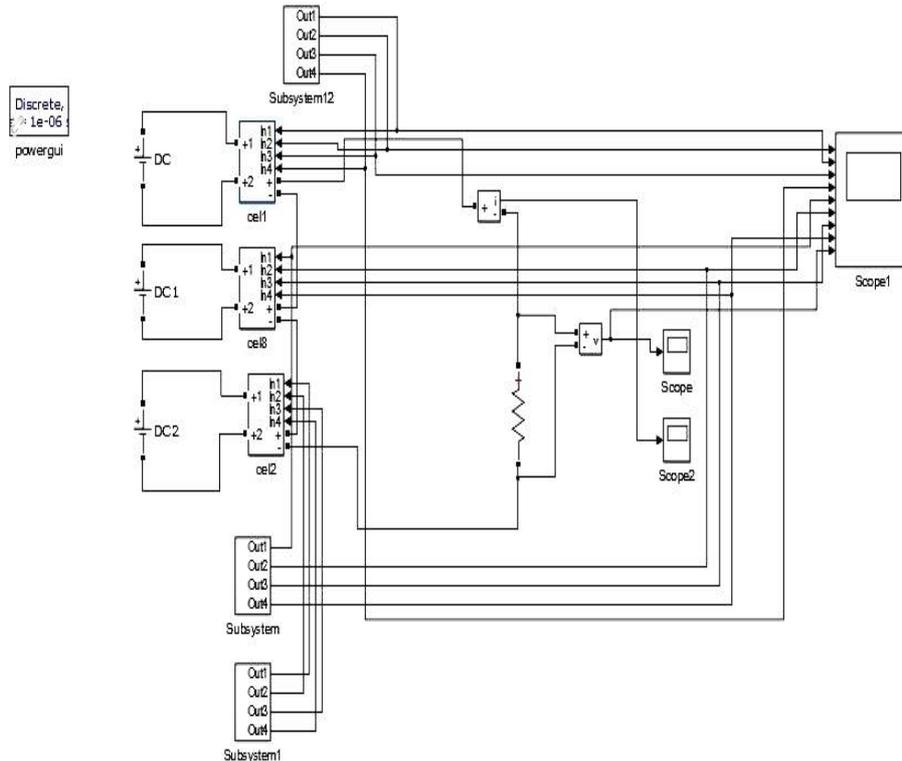


Fig.3 Simulation Circuit with Resistive Load

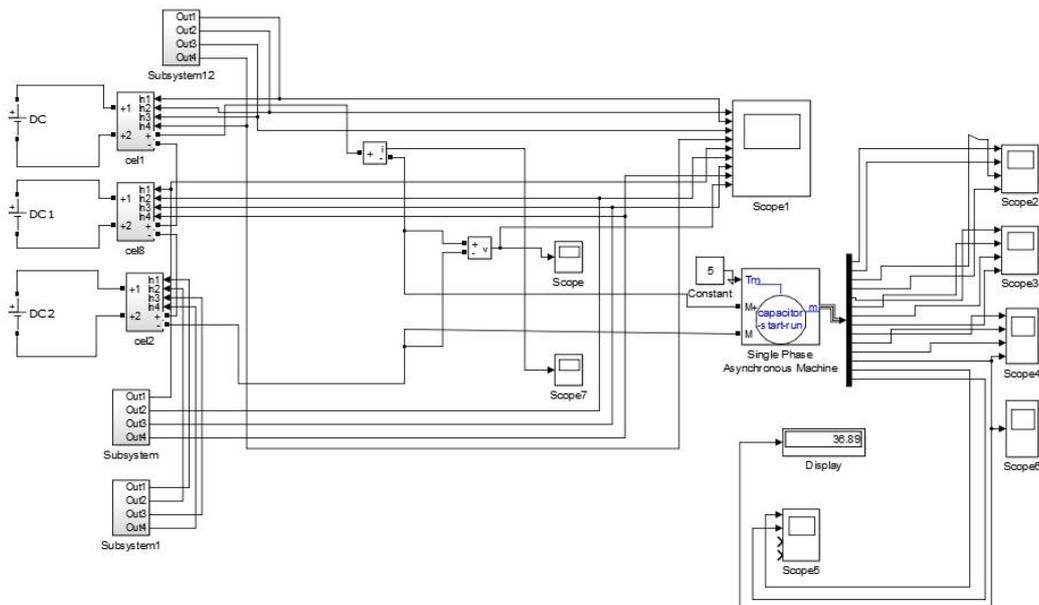


Fig.4 Simulation Circuit with Induction Motor Load

The Total Harmonic Distortion (THD) of the output voltage of the New 27 Level Hybrid Multi level inverter with resistive load was found to be 4.16% and with the induction motor load was found to be 4.93% which are within the IEEE standards.

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The output voltage waveforms with Resistive load and their corresponding FFT Spectrum are given in figures 5 and 6 respectively.

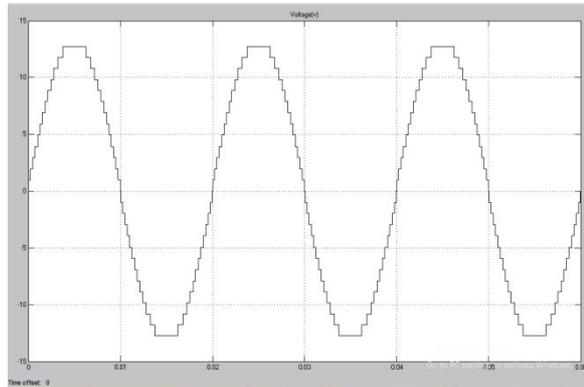


Fig.5 Output Voltage Waveform with Resistive Load

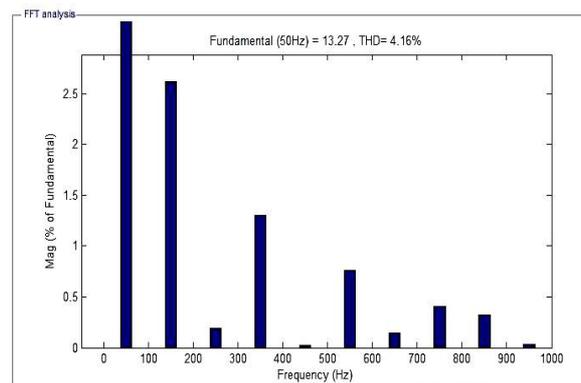


Fig.6 FFT Spectrum of the Output voltage Waveform with Resistive Load

The output voltage waveforms with Induction Motor load and their corresponding FFT Spectrum are given in figures 7 and 8 respectively. It can be seen that there is no much increase in the THD even with an induction motor load. The spikes happening in each transition level of voltage is also negligible for this kind of load. The input Voltage to the stator of the Induction Motor can be considered as almost sinusoidal.

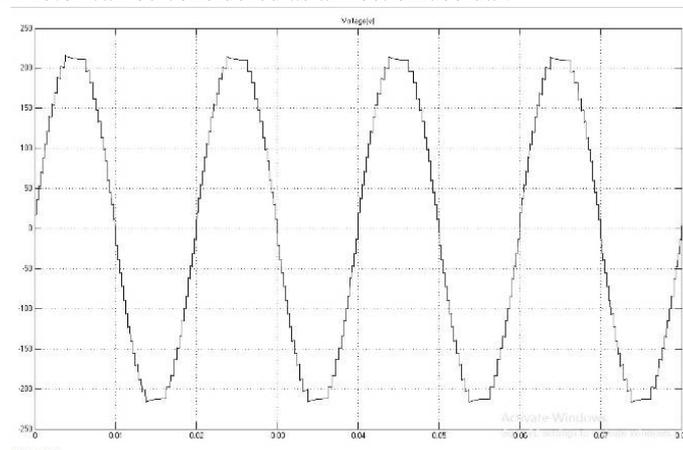


Fig.7 Input Voltage Waveform to the Stator of Induction Motor

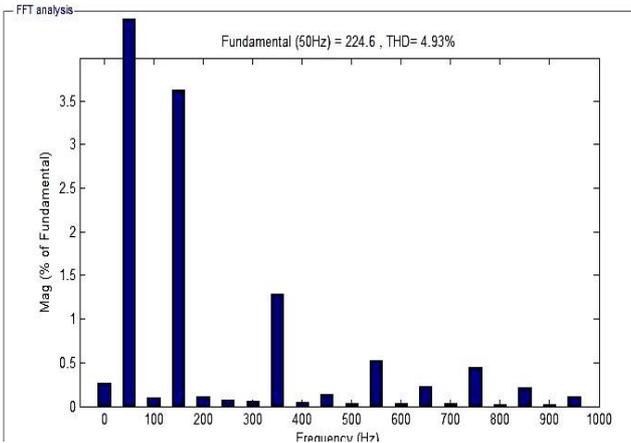


Fig.8 FFT Spectrum of the Output voltage Waveform with Induction Motor Load

The motor performance was found to be satisfactory after running a 0.25 HP single phase induction motor with a constant load torque of 5 Nm. The motor speed is acquiring a constant speed of 140 rad/s with a tolerance range of 3 rad/s within 0.35 seconds after switching on. The parameters of the motor was selected on the basis of a typical 0.25 HP single phase induction motor. The inrush current was found to be under the tolerance limits.

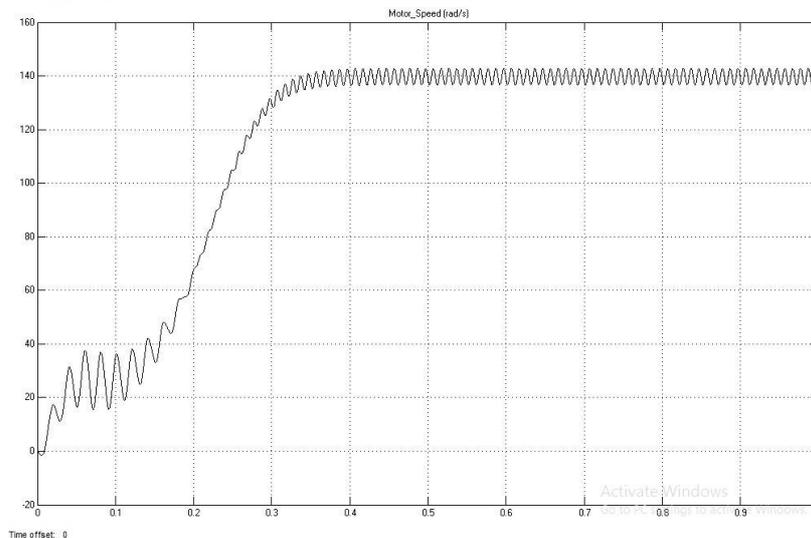


Fig.9 Speed of the Induction Motor

The input current to the stator of the Induction motor was also found to be sinusoidal with a THD less than 5% even without the use of filters. That shows the advantage of this multi level inverter topology and its ability to drive induction motors. The motor speed and the input current to the stator are given in figures 9 and 10.

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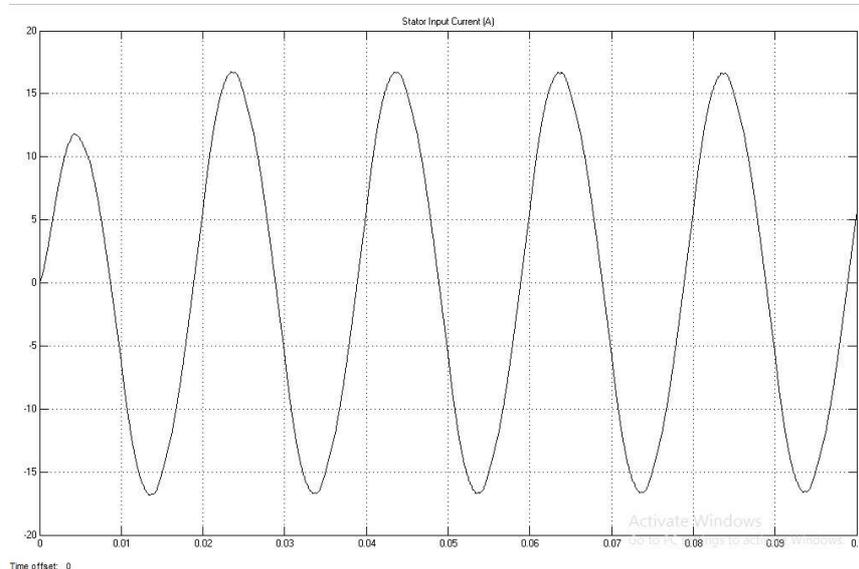


Fig.10 Stator Input current to the Induction Motor

V.CONCLUSION

A new hybrid single phase 27 level multi level inverter which feeds a single phase induction motor was proposed. The motor performance with this multi level inverter was found to be satisfactory even without the use of a filter. The proposed topology consists of 3 cascaded H Bridges and the stresses on the switches were found to be considerably less when compared to other topologies. The switching and controlling technique used was simple and efficient which gives less THD and maximum efficiency with less circuit complexity. The hardware of the circuit can be easily achieved and a Microcontroller level intelligence can easily serve the purpose for implementing the switching technique.

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