Reduction of Harmonics using Seven Level Cascaded Multilevel Inverter

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Abstract- **Multilevel inverter technology has emerged in recent times as a very important different in the area of high-power medium-voltage energy control. In this paper, cascaded multilevel inverter is used to reduce the total harmonic distortion. A cascaded multilevel inverter consists of series H-bridge (single-phase, full-bridge) inverter units. By reducing the number of switches, the multilevel topology has been improved for high power applications. To improve the multilevel inverter topologies for high quality and high power applications by reducing the number of switches. Therefore an identical H-bridge module is used to improve manufacturability and modularity. Proposed method not only reduces the number of switches, besides it produces the variable AC voltage waveform without harmonics. The simulation is done by MATLAB Simulink software.**

Keywords-Cascaded Multilevel Inverter, H-Bridge, Seven Level, Total Harmonic Distortion

I. INTRODUCTION

Now a day's application of inverter plays a major role. Most of the sources producing electricity in DC manner. To convert DC to AC we need of inverters. Inverter is a power electronics based device which converts dc to ac. During conversion harmonics will produce. To avoid or to reduce the harmonics multilevel inverter is used [11]. To get a continuous power supply we using renewable sources. Most of renewable sources produce a DC power. In order to connect this power to grid we are in need of inverters. To get AC power with low harmonics multilevel inverter concept is used. In power industry, multilevel inverters have achieved tremendous interest. It presents a new set of features that are well suited for use in power industry. It is easier to produce high power, high-voltage inverter with a multilevel inverter structure. Multilevel inverter increases the voltage level without requiring the higher rating on individual devices can increases the power rating. The structure of the multilevel inverter allows the system to reach high voltage without increases in harmonics. Multilevel inverter does not use transformers; series connected synchronized switching devices [1]. The harmonic content of output voltage waveform decreases significantly if the number of voltage levels increases. The topology structure of multilevel inverter must have less switching devices as far as possible; have lower switching frequency for each switching device. It should be capable of withstanding very high input voltage for high power applications. In multilevel concept for each node it requires a bidirectional switches. Three types of inverters are available. In this paper, Cascaded multilevel inverter is described [2]-[4].

This paper presents state-of-the-art multilevel technology, considering well-established and emerging topologies as well as their modulation and control techniques. Special attention is dedicated to the latest and more relevant industrial applications of these converters. Finally, the possibilities for future development are addressed.

In high power applications, harmonic content of the output waveform has to be reduced as much as possible. In order to avoid distortion in the grid and to reach the maximum energy efficiency multilevel inverters are preferred. By using the proposed topology number of switch will reduce significantly and hence the efficiency will improve. The multilevel inverter mainly utilized to synthesis a desired single or three phase voltage waveform.

II. HARMONICS AND ITS CAUSES

One of the biggest problems in power quality aspects is the harmonic contents in the electrical system. Generally, harmonics may be divided into two types are Voltage Harmonics, and Current Harmonics. Current harmonics is usually generated by harmonics contained in voltage supply and depends on the type of load such as resistive load, capacitive load, and inductive load. Both harmonics can be generated by either the source or the load side. Harmonics generated by load are caused by nonlinear operation of devices, including power converters, arc-furnaces, gas discharge lighting devices, etc. Load harmonics can cause the overheating of the magnetic cores of transformer and motors. On the other hand, source harmonics are mainly generated by power supply with non-sinusoidal voltage waveform. Voltage and current source harmonics imply power losses, Electromagnetic Interference (EMI) and pulsating torque in AC motor drives.

A. Total Harmonics Distortion (Thd)

Any periodic waveform can be shown to be the superposition of a fundamental and a set of harmonic components. By applying Fourier transformation, these components can be extracted. The frequency of each harmonic component is an integral multiple of its fundamental. There are several methods to indicate of the quantity of harmonics contents. The total harmonics distortion (THD), which is defined in terms of the amplitudes of the

harmonics, *Hn*, at frequency *nw0*, where *w0* is frequency of the fundamental component whose amplitude of *H1* and *n* is integer. The THD is mathematically given by,

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} H_{(n)}^{2}}}{H_1}$$

III. MULTILEVEL INVERTER AN OVERVIEW

A. General

Multilevel inverter is divide the main dc supply voltage into several smaller dc sources which are used to synthesize an ac voltage into staircase, or stepped, approximation of the desired sinusoidal waveform. A waveform generated with five dc-sources each with one-volt magnitude approximates the desired sinusoid, as shown in figure 1. The five dc sources (five steps) produce a peak to peak voltage of 10 volts using 11 discrete levels [5]-[6].

Figure 1 illustrates an example multilevel waveform. Using multiple levels, the multilevel inverter can yield operating characteristics such a high voltages, high power levels, and high efficiency without the use of transformers.

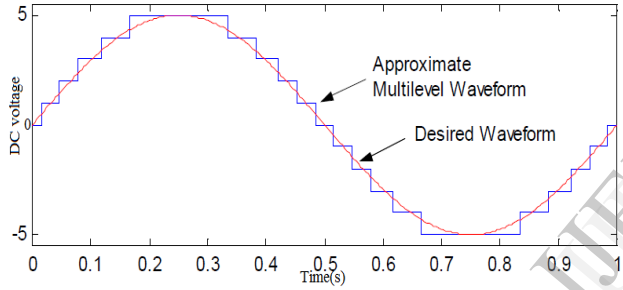

Fig 1: Example multilevel sinusoidal approximation using 11-Levels

The multilevel inverter combines individual dc sources at specified times to yield a sinusoidal resemblance; by using more steps to synthesize the sinusoidal waveform, the waveform approaches the desired sinusoid and the total harmonic distortion approaches zero.

B. Types Of Multilevel Inverter

There are three main types of multilevel inverter: (1) diode-clamped inverter, (2) capacitor-clamped inverter, and (3) Cascaded inverter. The multilevel inverter may be implemented at the discrete component level dividing the main dc supply voltage into smaller voltages.

C. Cascade H-Bridge Inverter

The cascade H-bridge inverter is a cascade of H-bridge, or H-bridges in a series configuration. The three phase inverter has the same configuration as a single phase full bridge inverter used in unipolar PWM. A single phase H-bridge is shown in figure 2. Cascaded of H-bridge is shown in figure 3. The four switches S1, S2, S3 and S4 controlled to generate three discrete outputs Vab with levels of –Vdc, 0, +Vdc. When S2 and S3 are on the output is –Vdc; When either pair S1 and S2 or S3 and S4 are on the output is 0; when S1 and S4 are turned on the output is +Vdc [7]-[9].

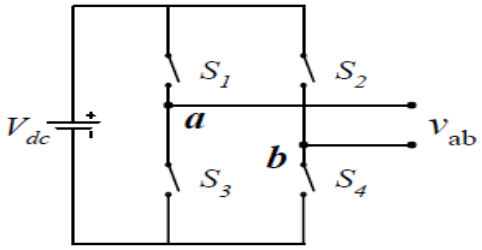

Fig 2: Single H-bridge configuration

The cascade H-bridge multilevel inverter uses separate dc source for each H-bridge, as shown by the single phase structure figure 3. The output of each H-bridge can have three discrete levels, which when combined at specified times result in a staircase waveform, Van as shown in figure 3. The number of output voltage levels m in a cascade inverter with separate dc source is m=2s+1 possible levels.

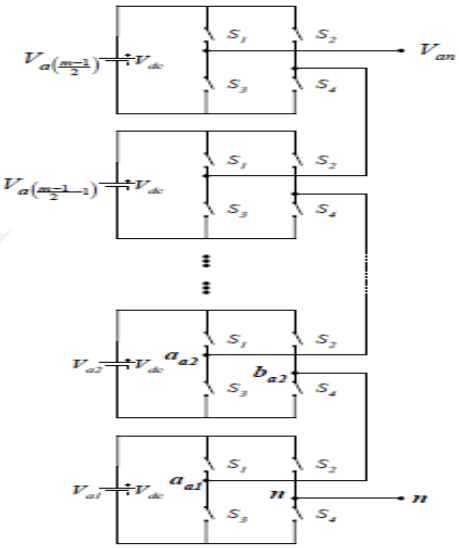

Fig 3. Cascaded H-bridge multilevel inverter

The advantages of cascade multilevel H-bridge inverter with s separate dc source per phase are as follows;

- The series structure allows a scalable, modularized circuit layout and packaging since each bridge has the same structure.
- Switching redundancy for inner voltage levels is possible because the phase voltage output is sum of each bridge‘s output.
- Potential of electrical shock is reduced due to the separate dc sources or voltage balancing capacitors
- Requires the least number of components considering there are no extra clamping diodes are voltages balancing

Optimized circuit layout and packaging are possible because each level has the same structure and there are no extra clamping diodes or voltage- power conversions, thereby limiting its applications balancing capacitors. It needs separate dc sources for real.

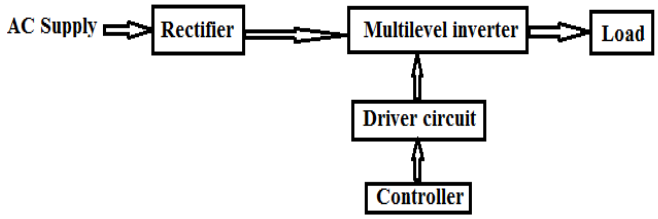

Fig 4. Proposed block diagram

IV. SIMULATION AND RESULTS

The following models have been created using SIMULINK. Fig shows MATLAB model of CMLI. This model contains three phase programmable voltage source ,rectifier bridge, CMLI circuit, with upper and lower triggering circuit and three phase V-I measurement.

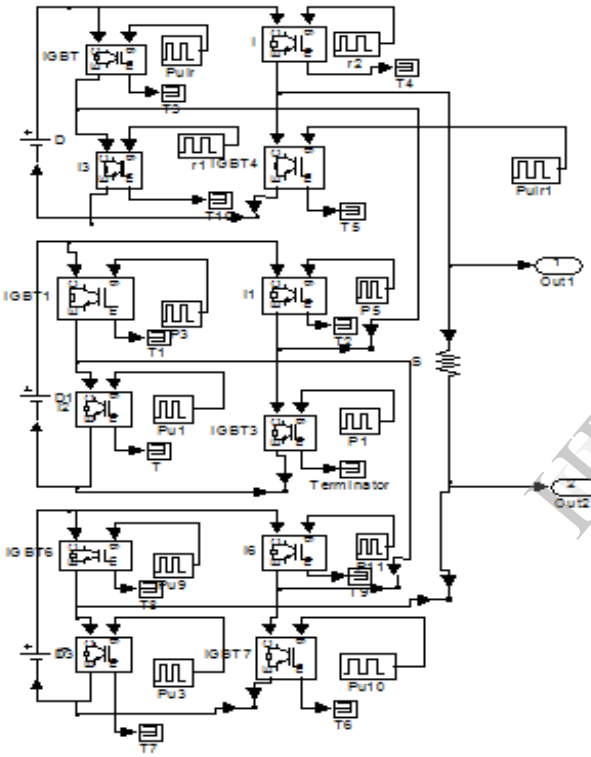

Fig 5. Simulink model for overall system

A. Pulses To Mosfet Switches

The Fig. 4.2 shows the pulse pattern for the MOSFET switches of the seven level cascaded MLI. The pulse duration for switches T1, T2, T3 and T4 is 83.4%. The pulse duration for switches T5, T6, T7 and T8 is 66.6%. The pulse duration for switches T9, T10, T11 and T12 is 50%

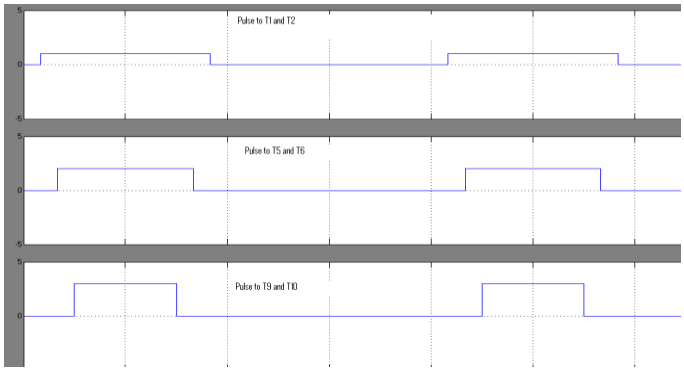

Fig 6. Pulses for positive group of switches

The Fig 4.3 shows the output voltage of the simulated cascaded MLI for the input battery voltage of 100V. The output voltage of each level consists of 100V. The total peak voltage of 300V.

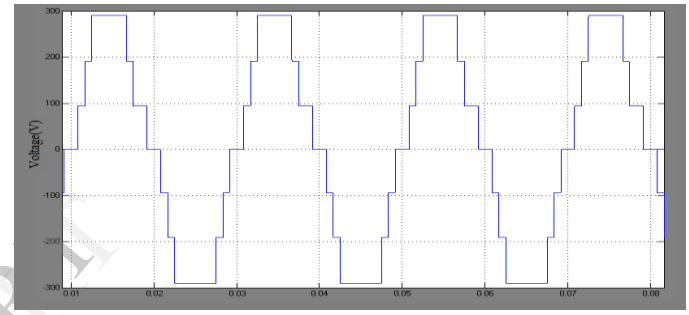

Fig 7. Output voltage for seven level output

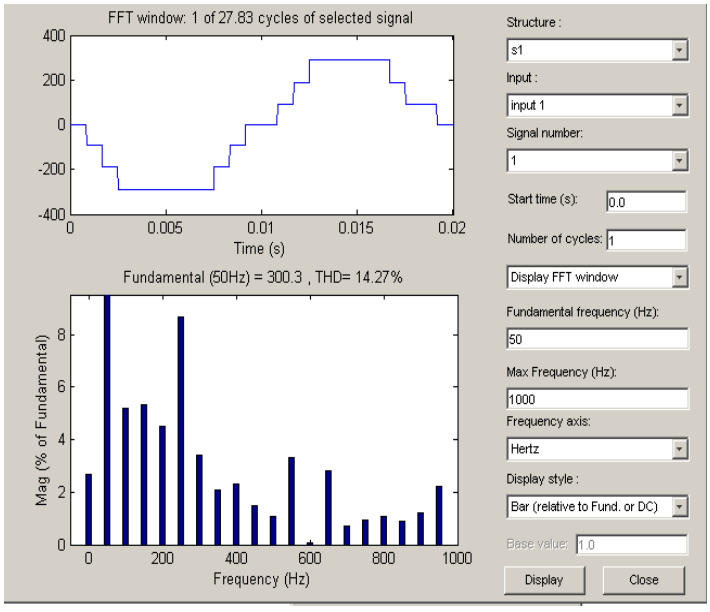

Fig 8. Frequency spectrum for seven level inverter

IV. CONCLUSION

In this Paper cascaded H-bridge Seven level inverter using low frequency transformers with single DC source is planned. The proposed structure is a compound of both bidirectional and unidirectional switches which have the advantage of using fewer IGBTs and driver circuits. It produces required seven level output voltage with low harmonics and reduced number of components compared to conventional methods. Harmonic spectrum for seven level output voltage is analyzed to prove its efficiency in reducing output harmonic components. Simulated and experimental output waveforms were shown to prove the consistency and possibility of the circuit.

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