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Cascaded H Bridge Fifteen Level Inverter

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***Abstract*— There are different types of inverters classifieds based on output voltage waveform like stepped, sinusoidal, multi level etc. Inverters are mainly used for commercial and industrial purposes. The unique structure of the multilevel inverter is low harmonics in output voltage. There are different types of multilevel inverters. Among these Cascaded multilevel inverters drawn tremendous interest in power industry because it requires less number of components. As the number of level increases the harmonic content of output voltage waveform decreases. This paper presents a Cascaded H-Bridge fifteen level inverter with minimum number of switches. As the level increases the synthesized output waveform has more steps which produce staircase wave that approaches desired waveform. The problem of switching losses and power losses can be eliminated with minimum number of switches. For an existing fifteen level inverter it requires 28 numbers of switches and for the proposed inverter requires only 12 numbers of switches. So that the cost of the inverter can be reduced.**

Keywords—Inverter, Multi Level Inverter, Cascaded H Bridge, Fifteen level output voltage.

I. INTRODUCTION

Inverters are required for converting DC to AC at desired frequency. Inverters are required to control the speed of AC motors, to link renewable energy sources with grid etc. An ideal inverter will generate sinusoidal output voltage waveform at its output terminals. However it is very difficult to obtain sinusoidal voltage without sacrificing efficiency. Sinusoidal Pulse Width Modulation is a technique of control to obtain sinusoidal voltage. Recently researchers are interested in developing stepped voltage waveform at different levels resembling a staircase at the output of inverter. such inverters are called Multi Level Inverters. Level can be three, five, seven etc. One important application of multilevel converters is focused on medium and high-power conversion. Nowadays, there exist three commercial topologies of multilevel voltage source inverters [1]: neutral point clamped (NPC), cascaded H-bridge (CHB), and flying capacitors (FCs). Among these inverter topologies, cascaded multilevel inverter reaches the higher output voltage and power levels (13.8 kV, 30 MVA) and the higher reliability due to its modular topology.

II. MULTI LEVEL INVERTER

Diode clamped multi level converters are used in conventional high-power ac motor drive applications like conveyors, pumps, fans, and mills. They are also utilized in oil, gas, metals, power, mining, water, marine, and chemical industries[2]. They have also been reported to use in a back-to-back configuration for regenerative applications. For a five level it requires seven diodes, four capacitors and eight switches. The diode clamped inverter faces many problems such as dc link unbalance, indirect clamping of the inner devices, turn-on snubbing of the inner dc rails.etc. In addition to this the diode clamping inverter suffers from such problems as dc link unbalance, indirect clamping of the inner devices, turn-on snubbing of the inner dc rails as well as series association of the clamping diodes etc. Diodes in DCMLI are used for clamping the voltages.

Flying Capacitors MLI has more advantages than Diode Clamped MLI. Flying capacitor multilevel converters have been used in high-bandwidth high-switching frequency applications such as medium-voltage traction drives. In this MLI capacitors are used for clamping the voltages instead of diodes in Diode Clamped MLI. Every cell has a single capacitor and two power switches. Power switch is a combination of a transistor connected with an anti-parallel diode. An inverter with N cell will have 2N switches and N+1 different voltage levels including zero. The capacitors are used for balancing the voltages. The cell and capacitor voltage difference is maintained within a safe band and hence there is no chance of unbalancing the capacitor voltages. This is the problem in Diode clamped MLI. But this problem is solved in Flying capacitor MLI. The main advantage of using this MLI is that each branch can analyzed separately and individually. Pre charging of capacitors is necessary and difficult. That is the main disadvantage of flying capacitor type MLI. All the switching devices should be used equally. Every inverter limb consists of cells connected in inward nested series.

Cascaded H-Bridge MLI is another member of this family. These types of inverters are used to extract power from solar power[4]. Cascaded H-bridge multilevel converters have been applied where high power and power quality are essential, for example, static synchronous compensators active filter and reactive power compensation applications, photo voltaic power conversion, uninterruptible power supplies, and magnetic resonance imaging. The number of phase voltage levels at the converter terminals is 2N+1, where N is the number of cells or dc link voltages. In this type of inverter the diode and the capacitors are eliminated and DC sources or voltage cells are connected across each H-Bridge cells. So the precharging of the capacitor problem is eliminated. And the voltage balancing problem also eliminated. It is composed of multiple units of single-phase H-bridge power cells. The H bridge cells are normally connected in cascade on their ac side to achieve medium

voltage operation and low harmonic distortion. The cascaded H bridge multilevel inverter requires a number of isolated dc supplies, each of which feeds a H-bridge power cell. The main advantage of using these inverters is that the renewable energy source such as solar energy can be extracted by these inverters. So wastage of energy can be reduced. And more power can be utilized.

III. CASCADED H BRIDGE FIFTEEN LEVEL INVERTER

Cascaded H Bridge multi Level Inverter is one of the most important inverters in nowadays. Here fifteen level voltage is obtained in the case of fifteen level inverter. They can generate output voltages with extremely low distortion and lower order harmonics. They draw input current with very low distortion. In addition, using sophisticated modulation types of methods, CM voltages can be eliminated. They can operate with a less switching frequency. In this topology Cascaded H-Bridge fifteen level Inverter is used. For an existing topology it requires 2*(m-1) number of switches. That is for a fifteen level inverter 28 number of switches are needed. But the main advantage of this proposed topology is that these inverters requires only 12 number of switches and that is less than half number of switches than the existing. So the switching losses and the power losses can be reduced and the cost of the system also reduced. This is also possible for lower level to higher levels. For three levels to any higher level is possible[4]. As the level increases the harmonic distortion in the output waveform decreases. Because as the level increases the synthesized output waveform has more steps which produces staircase wave that approaches desired waveform.

Inverters are most commonly used converters. The inverter presented throughout this paper will give high output voltage which is broadly used in industries and for commercial purposes. The aim of this paper is to obtain Cascaded H-Bridge Fifteen Level inverter. The transformer divides the input voltage into three different levels and then the multilevel inverter produces the fifteen level output voltage. As the number of switches reduced the switching losses reduced. The voltage stress also reduced. The main advantage of using higher level is that the harmonics are reduced in the output waveform.

IV. CIRCUIT DIAGRAM

Figure below shows the circuit topology of the Cascaded H-Bridge MLI. This circuit contains 12 numbers of switches. These switches are connected in H-Bridge shape. Each H-bridge cell may have positive, negative or zero voltage. Final output voltage is the sum of all H-bridge cell voltages and is symmetric with respect to neutral point, so the number of voltage levels is odd. The cascaded H-bridges multi level inverter introduces the idea of using Separate DC Sources (SDCSs) to produce an AC voltage waveform.

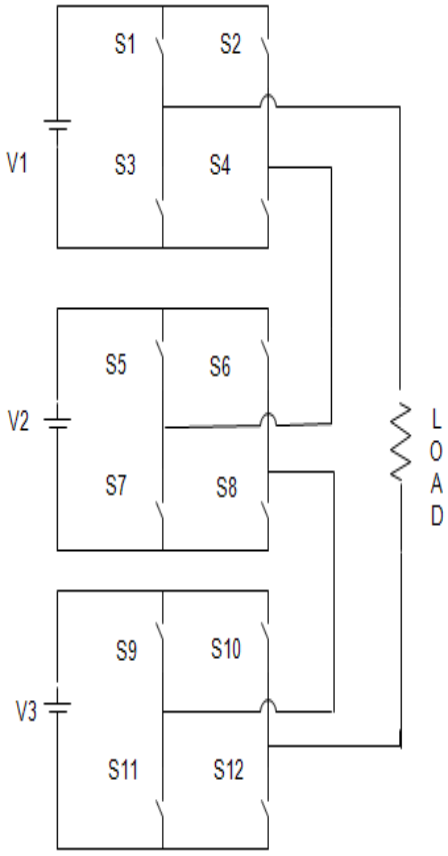

Fig. 1. Circuit Diagram of Fifteen Level Inverter

Each H-bridge inverter is connected to its own DC source Vdc. By cascading the AC outputs of each H-bridge inverter, an AC voltage waveform is produced. By closing the appropriate switches, each H-bridge inverter can produce three different voltages: Vdc, 0 and -Vdc. It is also possible to modularize circuit layout and packaging because each level has the same structure, and there are no extra clamping diodes or voltage balancing capacitors. The number of switches is reduced using the new topology.

Circuit consist of 12 number of switches, separate dc sources for each H bridges and the output is given to the load. The working of this CHBMLI is operated in different modes. Mainly 8 modes of operation only for the positive half cycle and eight modes of operation for the negative half cycle. Here shows the eight modes in the positive half cycle alone. The three voltage sources has three different low level voltages V1,V2,V3.These three voltages passes through the cascaded H bridge MLI. So the output will have fifteen voltage levels. ie –Vdc/7, -2Vdc/7, -3Vdc/7, -4Vdc/7, -5Vdc/7, -6Vdc/7, -Vdc, 0 , Vdc/7, 2Vdc/7, 3Vdc/7, 4Vdc/7, 5Vdc/7, 6Vdc/7, Vdc Because each H bridges can produce three different voltage levels. Here these three voltages passes through the CHBMLI and produces fifteen level voltage as output. Only 12 numbers of switches are used and no need of diodes and capacitors. So the voltage balancing problem and pre-charging of capacitor problem all are eliminated. The switching losses and power losses also reduced. Voltage stress to a particular switch can also be eliminated. These are the main advantages of using these inverters. Figure below shows the 15 Level Output Waveform.

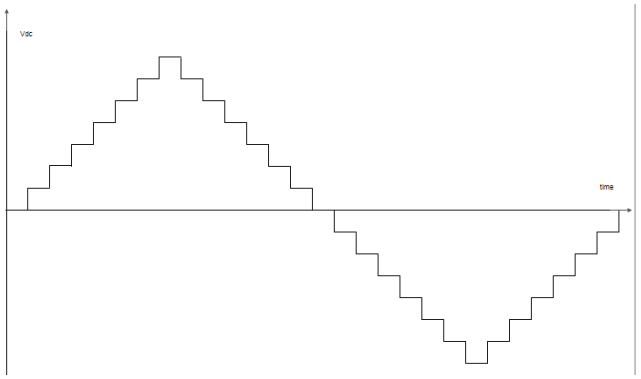

Fig. 2. Output Waveform of Fifteen Level Inverter

The main reason for selecting the Cascaded H Bridge fifteen level inverter is that with minimum level of voltages maximum number of output voltage level can be obtained. As the level increases the harmonic distortion in the output waveform decreases. For a sinusoidal output voltage it contains large amount of harmonics in the output waveform. So the distorted waveform is obtained. But in the case of the staircase waveform the distortion is less when compared to the sinusoidal waveform. As the level increases the output waveform will be in the staircase waveform and the harmonic distortion can be reduced in a great amount.

V. SIMULATION OF FIFTEEN LEVEL INVERTER

A prototype of Cascaded H bridge fifteen level inverter is simulated using Mat lab/ Simulink. The simulation is done in open loop. Here the input voltage can be selected as 10V, 20V and 40V to get an output voltage as 70V. The MATLAB/ Simulink model is as shown below. Figure below shows the simulation diagram of a Cascade H bridge fifteen level inverter. Three different input voltages are given as input. 10v, 20v and 40v. These voltages are given to the 12 different switches which are connected in Cascaded H Bridge shape. And an output voltage of 70v is obtained. The output voltages have different levels. About fifteen levels output is obtained.

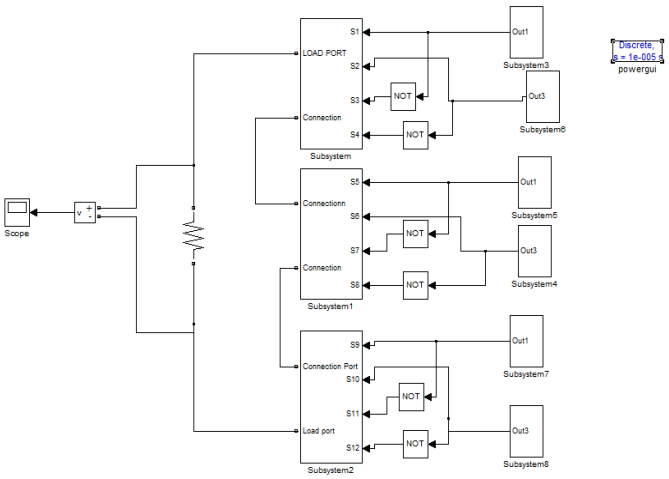

Fig. 3. Simulation of Fifteen Level Inverter

Simulation result Of Cascaded H Bridge Fifteen Level Inverter. An output of 70v is obtained with an input of 10v,20v,40v.

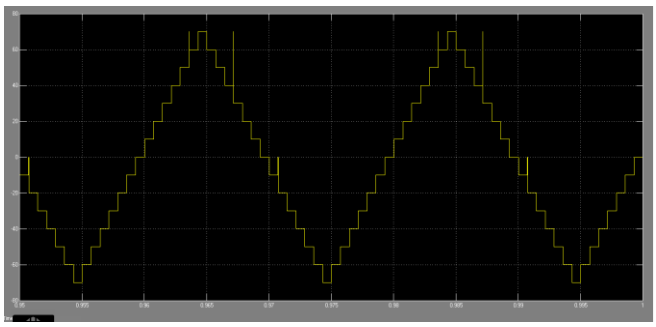

Fig. 4. Simulation Result of Fifteen Level Inverter

VI. HARDWARE OF CASCADED H BRIDGE FIFTEEN LEVEL INVERTER

Figure below shows the hardware setup of the Cascaded H Bridge Fifteen Level Inverter. It consists of a driver circuit, control circuit and power circuit. The power circuit consists of 3 single phase inverters. The switches are connected in cascaded H Bridge shape

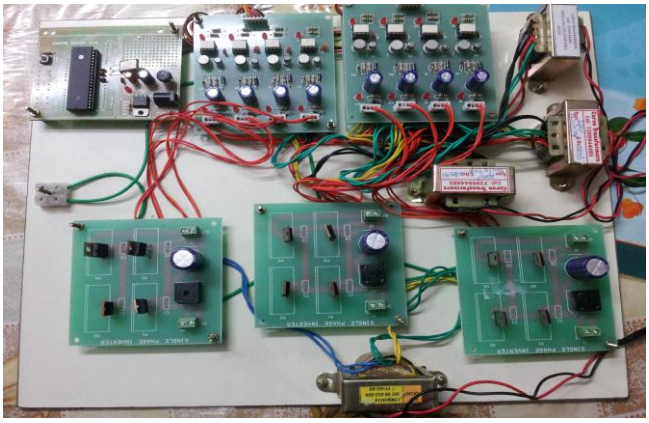

Fig. 5. Hardware set up of Cascaded H Bridge Fifteen Level Inverter

VII. EXPERIMENTAL SET UP OF FIFTEEN LEVEL INVERTER

The figure below shows the different pulses given to the different switches,experimental setup of the Cascaded H Bridge Fifteen Level Inverter. The experimental result of the hardware is also shown below.

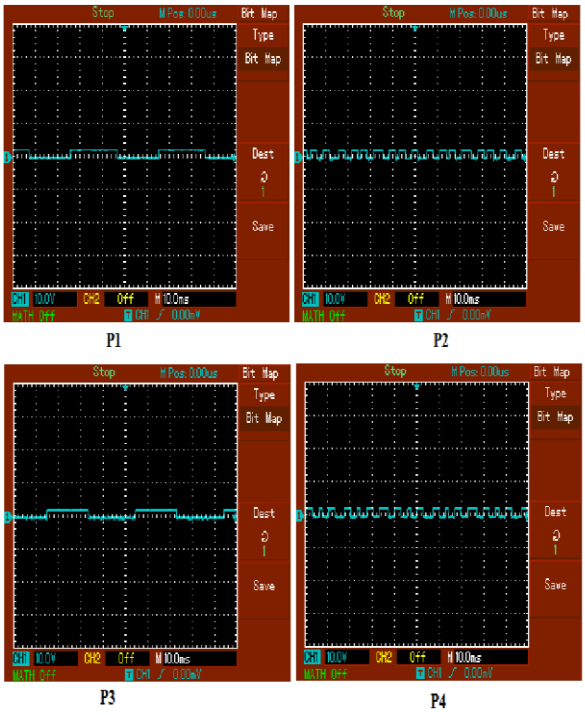

Fig. 6. Gate Pulses Given To The Different Switches

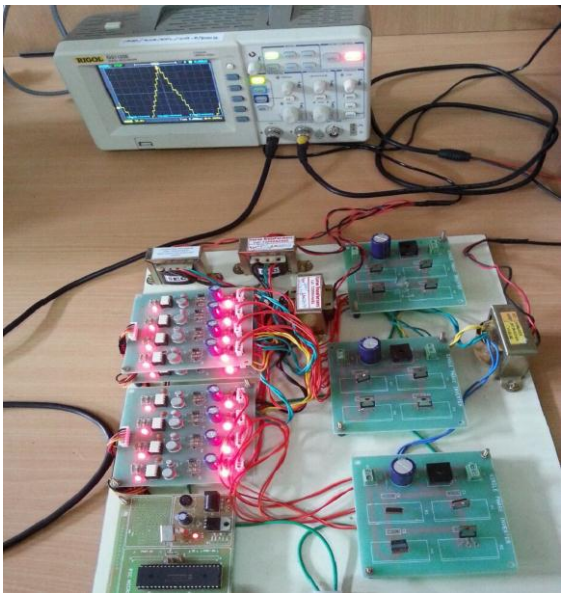

Fig. 7. Experimental set up of Cascaded H Bridge Fifteen Level Inverter

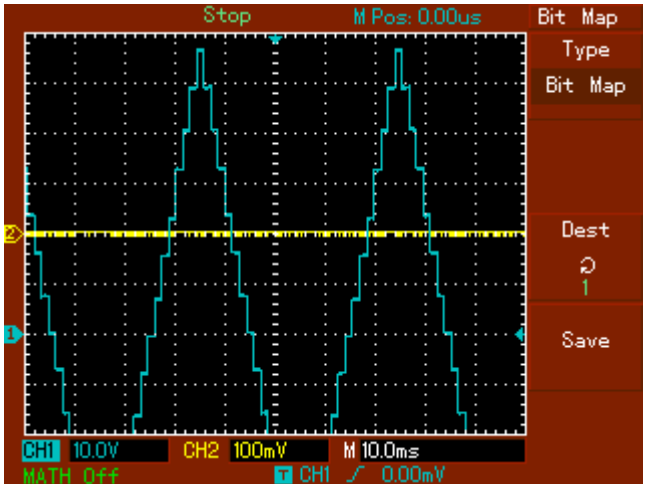

Fig. 8. Final Result of Cascaded H Bridge Fifteen Level Inverter

VIII. CONCLUSIONS

Multi Level Inverter is the most popularly used. It plays more and more important role in many industrial applications. In this paper a CASCADED H-BRIDGE FIFTEEN LEVEL INVERTER is introduced. An extremely large output voltage is obtained with the proposed converter and the voltage stress on the power devices is reduced. Moreover it requires 12 MOSFETs. 15 levels obtained with less harmonic distortion.

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