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An Improved Topology for Symmetric, Asymmetric and Cascade Switched-Diode Multilevel Converter

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Abstract: Multilevel converters have been used for several applications such as static reactive power compensation, adjustable speed drives, renewable energy sources, and so on. The principal function of multilevel converter is to synthesize a desired ac voltage from several separate dc sources. Many kinds of topologies for multilevel converters have been proposed. In symmetric cascaded multilevel converter; dc voltage sources values of similar cells are equal. For the same number of power devices, asymmetric cascade multilevel topology significantly increases the number of output voltage levels. In these topologies, the values of dc voltage sources of different cells are non equal. However, the symmetric and asymmetric CHB converter requires a large number of switches and dc voltage sources. The current work proposes a improved H-bridge inverter whose topology is advantageous over other topologies.

Keywords: Inverters, Converters, H-Bridge inverter, Capacitor, Bidirectional switch.

I. INTRODUCTION

The term "Converters" is used to refer a system which transforms one form of electrical energy into another form of electrical energy for example AC into DC or DC into AC. Here conversion of ac into dc is called as "rectification" and conversion of dc into ac is known as "inversion". Depending on the type of source and the type of load, the power electronics converter circuit comes into the following categories:

- AC to DC = Rectifiers
- DC to DC = Choppers
- DC to AC = Inverters
- AC to AC = AC Voltage Controllers

A. AC to DC Converters (Diode Rectifiers): A diode rectifier circuit converts ac input voltage into a fixed dc voltage. The input voltage may be single phase or three-phase. Following are the types of rectifiers:

- When the bridge rectifier circuit consists of only diodes it is called as Uncontrolled Bridge Rectifier because the output of the circuit cannot be varied.
- When the bridge rectifier circuit consists of two diodes and two SCRs it is called as Semi-controlled Bridge Rectifier.

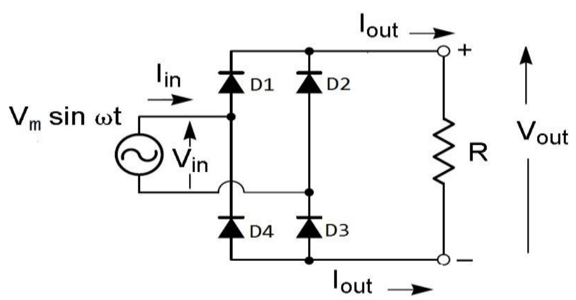

Figure: A Bridge Rectifier

- When the bridge rectifier circuit consists of four SCRs it is called as fully controlled Bridge Rectifier.

B. AC to DC Converters (Phase Controlled Rectifiers): These circuits convert constant ac voltage to variable dc output voltage. These rectifiers use line voltage for their commutation. These are used in dc drives, chemical industries, and synchronous machines. Phase controlled converters may be fed from single phase and three-phase source.

C. DC to DC Converters (DC Choppers):A dc chopper converts fixed dc input voltage to a controllable dc output voltage. The chopper circuits require forced, or load commutation to turn-off the SCR. For low power circuits we can use Power BJTs. Choppers are used in dc drives, battery driven vehicles etc.

D. DC to AC Converters (Inverters): An Inverter converts fixed dc voltage to a variable ac voltage. The output may be a variable voltage and variable frequency. Inverters find wide use in induction motors and synchronous motor drives, Induction heating, Uninterruptible Power Supply (UPS), and High Voltage DC (HVDC) Transmission etc.

E. AC to AC Converters: These circuits convert fixed ac input voltage into variable ac output voltage. These are of two types of AC to AC converters namely AC Voltage Controllers and Cycloconverters.

F. AC Voltage Controllers: These converter circuits convert fixed ac voltage directly to a variable ac voltage at the same frequency. These circuits employ two BJTs in antiparallel or a triac. Output voltage is controlled by varying the firing angle delay.

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G. Cycloconverters: These circuits convert input power at one frequency to output power at a different frequency through one stage conversion. These are mainly used for slow-speed large ac drives like rotary kiln etc.

II. RELATED WORK

An In [1] a voltage control algorithm for a hybrid multilevel inverter based on a staged-perception of the inverter voltage vector diagram is shown. The algorithm is applied to control a three-stage eighteen-level hybrid inverter, which has been designed with a maximum number of symmetrical levels. The inverter has a two-level main stage built using a conventional six-switch inverter and medium- and low- voltage three-level stages constructed using cascaded H-bridge cells. The distinctive feature of the proposed algorithm is its ability to avoid the undesirable high switching frequency for high- and medium- voltage stages despite the fact that the inverter's dc sources voltages are selected to maximize the number of levels by state redundancy elimination.

In [2] a study presents a three-stage 18-level inverter design and its innovative control method. The inverter consists of a series-connected main high-, medium- and low-voltage stages. The high-voltage stage is made of a three-phase, six-switch inverter. The medium- and low-voltage stages are made of three-level inverters constructed by H-bridge units. The proposed control strategy assumes a reference input voltage vector and aims to operate the inverter in one state per sampling time to produce the nearest vector to that reference. The controller operates to reach the desired state with minimum switching actions, giving the priority in switching reduction to the higher voltage stage.

A novel topologies for symmetric, asymmetric, and cascade switched-diode multilevel converter are proposed [3], which can produce many levels with minimum number of power electronic switches, gate driver circuits, power diodes, and dc voltage sources. The number of required power electronic switches against required voltage levels is a very important factor in designing of multilevel converter, because switches define the reliability, circuit size, cost, installation area, and control complexity.

In [4] a new structure for multilevel voltage source inverter is introduced, which produces more number of levels at output voltage waveform with reduced number of IGBTs and gate drivers. The number of required IGBTs and drivers against voltage levels is very important factors in designing of multilevel inverter, because IGBTs and drivers define the cost, reliability, circuit size, installation area and control complexity.

In [5] Application of multilevel inverters for higher voltage goals in industries has become more popular. In this study, new structures for symmetric, asymmetric and hybrid multilevel inverter are recommended. The proposed hybrid structure is used in high-voltage levels. The proposed structures can generate a great number of output voltage levels with minimum number of power electronic components such as insulated gate bipolar transistors (IGBTs) and gate drivers.

III.METHODOLOGY

A novel topology for symmetric, asymmetric and cascade switched-diode multilevel converter are proposed. The number of required power electronic switches against required voltage levels is a very important factor in designing of multilevel converter, because switches define the reliability, circuit size, cost, installation area, and control complexity. To produce maximum number of levels at the output voltage, the proposed cascade topology is optimized for different goals, such as the minimization of the number of power electronic switches, gate driver circuits, power diodes, dc voltage sources, and blocking voltage on switches. The proposed topologies can produce many levels with fewer components.

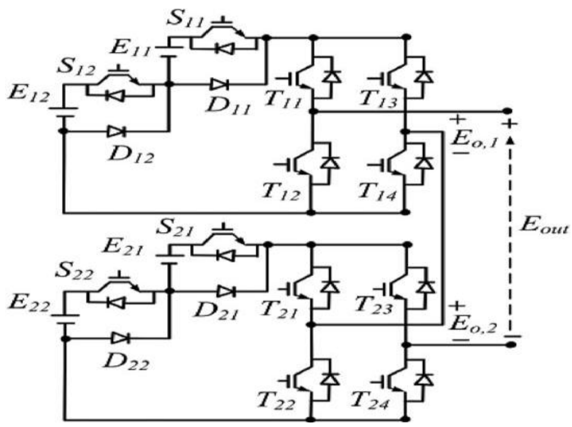

Figure: Circuit Diagram

A block diagram is also presented below for representing Novel Topologies for Symmetric, Asymmetric, and Cascade Switched-Diode Multilevel Converter with Minimum Number of Power Electronic Components.

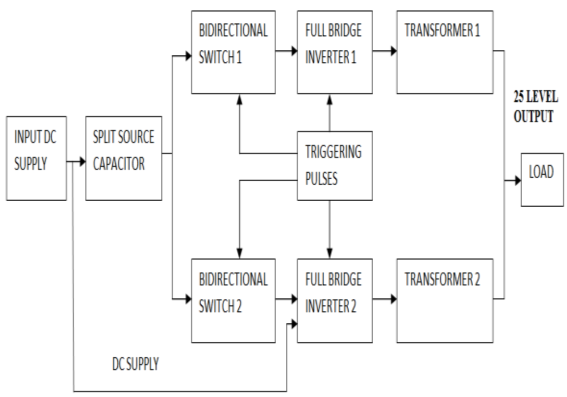

Figure: Block Diagram

IV.METHODOLOGY

The proposed method comprises a H-bridge inverter, two bidirectional switches, and a capacitor voltage divider

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formed by C1, C2. The H-bridge topology is significantly advantageous over other topologies, i.e., less power switch, power diodes, and less capacitor for inverters of the same number of levels. The advantages are:-

- Harmonic Reduction
- Single Dc Source
- No Grounding Problem
- Less Number Of Switches
- Higher Output
- Less Transformer Ratio

Below given figure shows the circuit diagram of a proposed Nineteen Level Inverter.

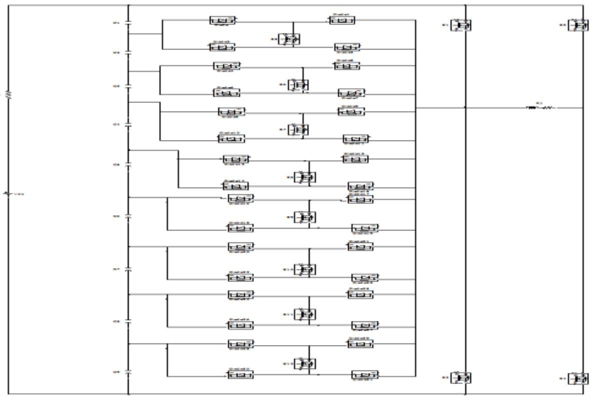

Figure: Circuit Diagram Nineteen Level Inverter.

Below given figure shows the simulation circuit diagram of a proposed Nineteen Level Inverter.

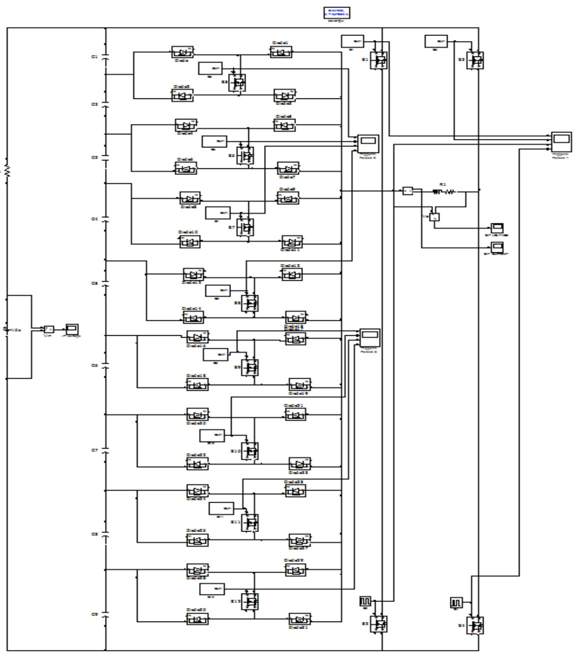

Figure: Simulation Circuit Diagram Nineteen Level Inverter.

Below given figure shows the simulated waveform of Input voltages of a proposed Nineteen Level Inverter.

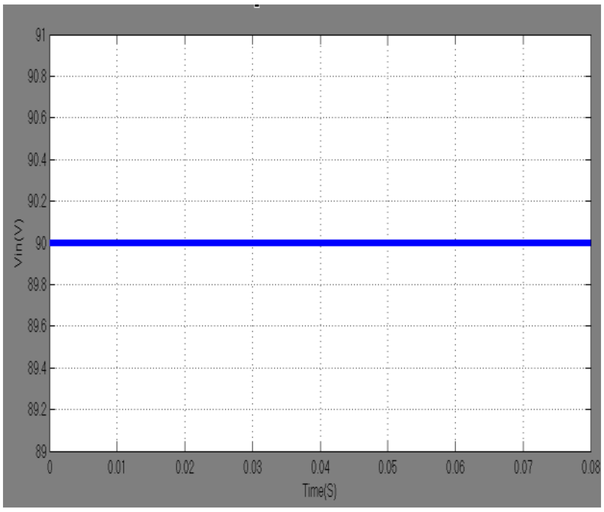

Figure: Input voltage waveform of Nineteen Level Inverter.

Below given figure shows the simulated waveform of triggering pulse of a proposed Nineteen Level Inverter.

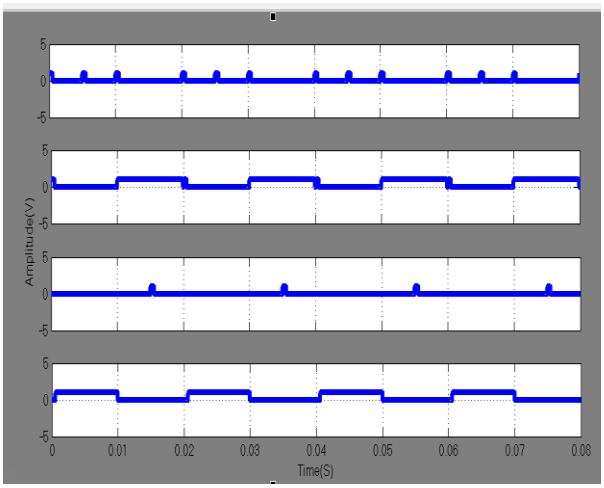

Figure: Waveform of triggering pulse.

Below given figure shows the Output voltage of a proposed Nineteen Level Inverter.

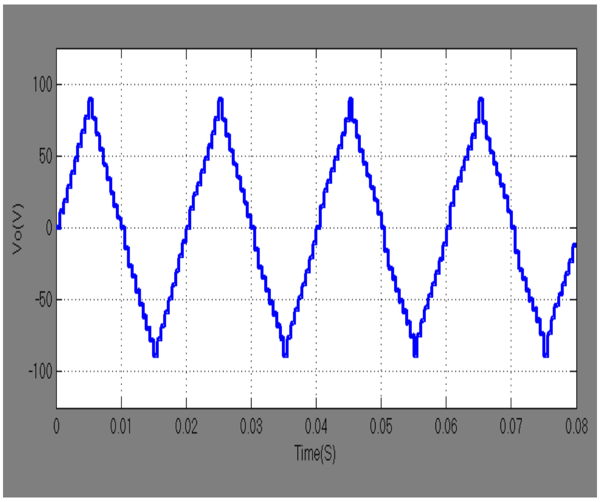

Figure: Output voltage.

Below given figure shows the Output Current of a proposed Nineteen Level Inverter.

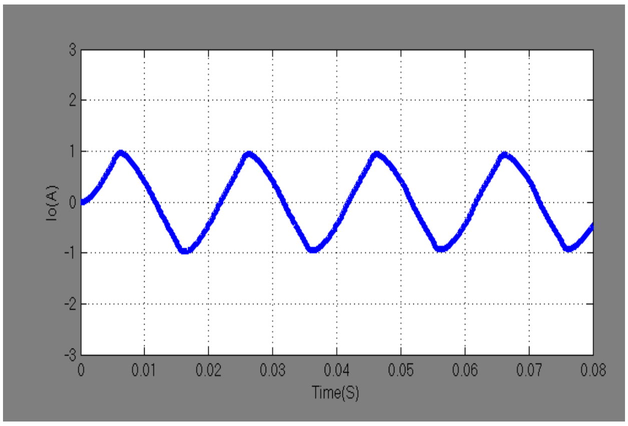

Figure: Output current.

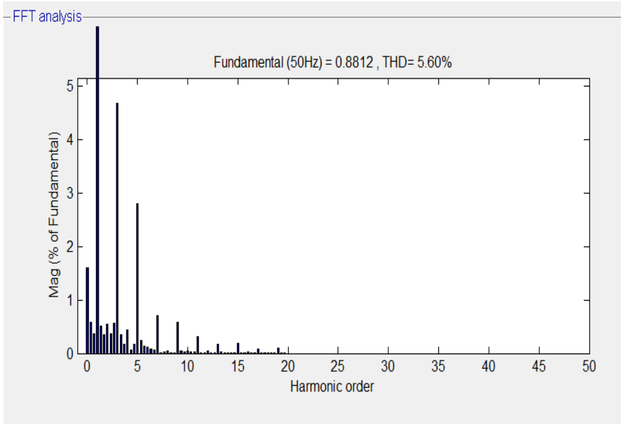

Figure: Total Harmonic Distortion

V. CONCLUSION

Multilevel power conversion was first presented over 30 years ago. Multilevel converters can produce a large number of output voltage levels, which results in high voltage capability, lower harmonic contents, lower switching losses, better electromagnetic compatibility, and high power quality. The number of required power electronic switches against required voltage levels is a very important factor in designing of multilevel converter, because switches define the reliability, circuit size, cost, installation area, and control complexity. To produce maximum number of levels at the output voltage, the proposed cascade topology is optimized for different goals, such as the minimization of the number of power electronic switches, gate driver circuits, power diodes, dc voltage sources, and blocking voltage on switches. The proposed topologies can produce many levels with fewer components.

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