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ANALYSIS AND PERFORMANCE EVALUATION OF A FIVE-LEVEL SINGLE-PHASE FLYING CAPACITOR MULTILEVEL INVERTER

#1**B. SANTHOSH,** ***Associate Professor,***
#2**BANOTH NIKHITHA,** ***B.Tech Student,***
#3**RAMAGIRI POOJA SRI,** ***B.Tech Student,***
#4**DANDE SANTHOSH,** ***B.Tech Student,***
Department of Electrical and Electronics Engineering,
TRINITY COLLEGE OF ENGINEERING AND TECHNOLOGY, PEDDAPALLY, TG.

ABSTRACT- The inverter in question is a multilayer device that operates on a single phase and has five distinct operational levels. This article introduces a switching mechanism that utilizes switching angles. This mechanism is designed to produce a diverse array of output voltage waveforms in order to accomplish its objective. The matrix below illustrates the voltage waveform testing and modeling outcomes for five distinct material layers. Additionally, the matrix demonstrates the repercussions that are linked to those discoveries. This paper will conduct a comprehensive analysis of the five-level Flying Capacitor Multilevel Inverter's ability to generate single-phase and five-level limb voltages. The objective of this paper is to present this analysis. This process will involve an examination of the circuit's triggering and modeling block diagrams.

Keywords: Flying capacitor, multilevel inverter. Matlab/Simulink.

1.INTRODUCTION

The utilization of high-power medium-voltage propulsion in industrial applications has increased as a result of advancements in power electronics. It is imperative to enhance the efficiency of medium voltage, high power electric generators by simultaneously reducing the dv/dt and harmonics and increasing the output voltage. The concept of stacked inverters was devised by experts to address the common issues associated with industrial motors. The output voltage of a multilayer inverter is generated at a high frequency and fluctuates at a low frequency. This process ensures a low margin for error due to its increased generation frequency. This category of apparatus encompasses high-voltage direct current pumps, compressors, fans, static VAR compensators, and laminators. Substantial power and medium voltage are necessary for these devices. In the electronics industry, multilevel inverters are highly regarded. They are frequently utilized in industrial and renewable energy applications to convert direct current (DC) into alternating current (AC). Renewable energy sources account for a substantial portion of its energy consumption. There are numerous methods for the fabrication of multilayer transformers.

1. It is possible to see a multilayer inverter with a diode that stops power transfer.
2. This combination consists of a multi-layered inverter and a capacitor clamp.

Several layered H-bridge inverters make up the third part of the system.

A floating capacitor multilayer inverter can produce direct current voltage by attaching an extra capacitor to the power switch's phase rail. To guarantee that the inverter runs at its peak power in situations where power is absent, the clamping capacitor's available switching states might be limited.

2 . FIVE LEVEL FLYING CAPACITOR MULTILEVEL INVERTER

The innovative application of capacitors is the fundamental principle of this transformer. Capacitor clamps are utilized to sequentially attach switching cells. Capacitors supply electrical equipment with a modest amount of electricity. This inverter has switching phases that are identical to those of a diode-clamped inverter.

This form of multilayer inverter does not require clamping diodes. The output is equivalent to fifty percent of the DC power input. Damage has been sustained by the capacitors of the multilayer inverter. An internal switching redundancy is incorporated to regulate the discharge of the capacitor. It is capable of transporting both reactive and active electricity. However, switching losses are unavoidable when operating at high frequencies.

BASIC FEATURES:

The architecture is composed of capacitors, diodes, and switchable components. Although this design has the potential to accommodate an infinite number of voltage levels, there are actually only six.Every organ contains transistors and other electronic components. The voltage across capacitors decreases when they are in close proximity to a load.The voltage increases as the capacitors approach the source voltage (Vdc).The number of levels is determined by the number of valves in each limb that are capable of transmitting power.

CALCULATION:

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The following formula should be employed to ascertain the quantity of devices required for the construction of a five-level multilevel inverter:

- An "n"-level inverter is required to:
- Number of voltage sources Ndc = (n-1)
- Number of switching devices Nsd = 2(n-1)
- Number of balancing capacitors Nbc = (n-1) (n2)/2
- Number of DC bus capacitors Nc = (n-1)
- In a five level flying capacitor inverter: N = 5

Therefore: Ndc = (5-1) = 4 Nsd = 2(5-1) = 8 Nbc = (5-1) (5-2)/2 = 6 Nc = (5-1) = 4

The image below illustrates the subsequent phase leg of a five-level flying capacitor multilevel inverter that generates a staircase output voltage.

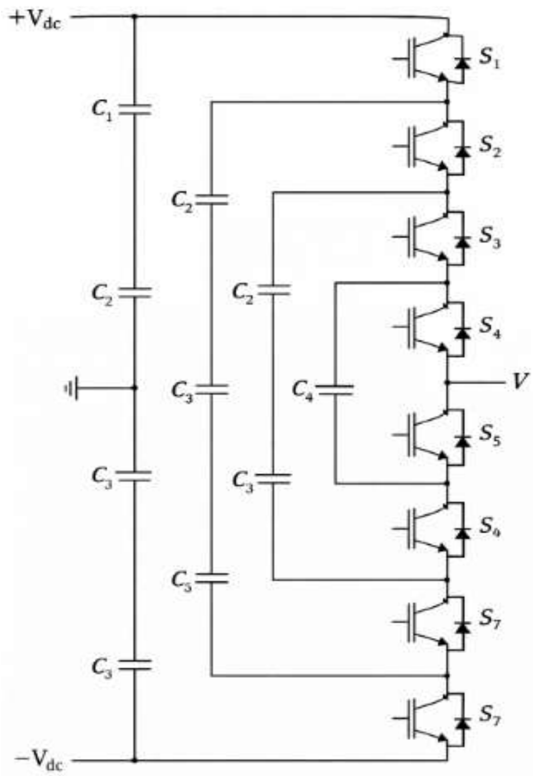

Fig (1): One Phase of A Five Level Flying Capacitor Multilevel Inverter

OPERATION:

Set the output voltage to V0 = Vdc by pressing the top-mounted switches S1–S4.In order to achieve the output voltage level V0 = Vdc/2, three of the upper switches (S1–S3) and one of the lower switches (S5) must be activated.To initiate, press the two switches located at the bottom (S5 and S6). The subsequent step involves pressing the S1 and S2 controls, which are located at the top of the device. The voltage that results, V0 = 0, will be negative.An output

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voltage of V0 = -Vdc/2 can be achieved by activating one upper switch (S1) and three lower switches (S5-S7). By activating all eight buttons on the bottom side, the output voltage, V0 = -Vdc, is attained.

Table 1 illustrates the voltage values and their respective switch states. To activate the device, turn the switch to position one. The device is rendered inoperable when the switch is set to position 0.

V_0	S1	S2	S3	S4	S5	S5	S5	S8
V_{dc}	1	1	1	1	0	0	0	0
$V_{dc/2}$	1	1	1	0	1	1	1	0
0	1	1	0	0	1	1	1	0
$-V_{dc/2}$	1	0	0	0	1	1	1	0
$-V_{dc}$	1	0	0	0	1	1	1	1

Table 1: The Switching State of Five Level Flying Capacitor Multilevel Inverter

3.SIMULATION

The efficacy of a single-phase, five-level multilevel inverter was comprehensively assessed using MATLAB/SIMULINK modeling tools. It is feasible to simulate, analyze, and model using the Matlab/Simulink software suite. It is capable of accommodating systems of varying complexity and is compatible with both continuous time models and sampled time models. The IDEAL and IGBT switches must be integrated into a circuit with two independent switches in order to comply with the modeling approach.Both of these switch varieties are functionally equivalent.

SIMULINK MODEL USING IDEAL SWITCH

The Ideal Switch block is not interoperable with all devices. The inner workings of basic semiconductor devices, such as MOSFETs and GTOs, can be illustrated through the use of appropriate switching logic.The Ideal Switch block is entirely controlled by the gate signal, regardless of whether g is equal to zero or greater than zero. The voltage remains constant regardless of the direction of flow when g>0. When g=0, the forward and backward voltage flows terminate as a result of the absence of current. When it is activated, it transitions instantly between the on and off phases.

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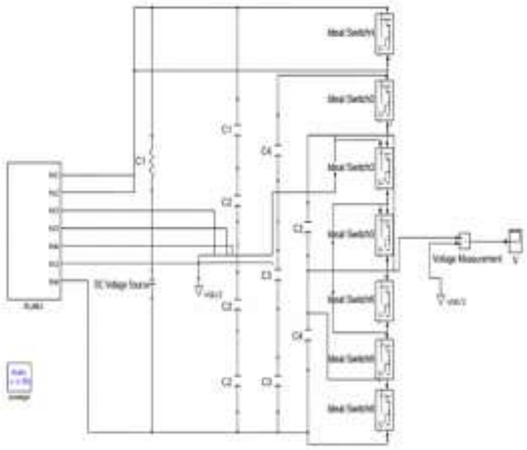

Fig (2): Simulink Model Using Ideal Switch

SIMULINK MODEL USING IGBT SWITCH

Subsequently, an IGBT switch regulates the game.IGBTs are superior to other transistor varieties due to their high capacity and voltage, rapid switching speed, minimal driver requirements, and absence of gate drive current. Additionally, they have a low on-resistance. Integrated gate bipolar transistors (IGBTs) are well-suited for high-voltage applications, including solar-powered AC-to-DC converters, speed control systems, frequency converters operating at hundreds of kHz, PWM and SMPS devices, and other systems. The faster on/off duration of BJTs in comparison to power MOSFETs is a significant concern.

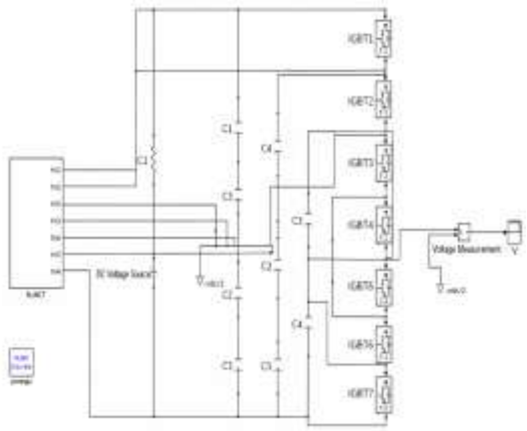

Fig (3): Simulink Model Using Igbt Switch

TRIGGERING OF SWITCHES:

The OR GATE circuitry in the initial circuit generates pulses.Eight OR gates comprise the initial circuit. Four are established on the positive half of the cycle, and four are established on the negative half.

The incoming signal with the values 8, 6, 3, and 1 must be generated by activating the first, second, third, and fourth OR gates in the correct sequence. Nine pulse generators are included in the initiating circuit. Follow these procedures to configure a half-cycle phase angle delay. For pulse generators 1, 2, and 3, a voltage output of zero (V=0) must be achieved promptly, phase delays of 0°, 180°, and 360° are necessary. PPGs 1 and 2 can instantaneously generate an output voltage of V=Vd/2 by employing phase delays of 450 ms and 1350 ms. The instant pulse generator 1 implements a phase delay of 900 to generate an output voltage of V=Vd [2, 4]. An image of the block architecture of the initiating simulation is provided below.

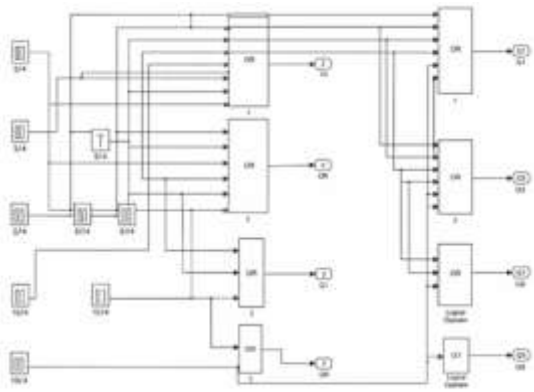

Fig (4): Simulink Model of Triggering Circuit

Figure 4 and Table 1, which were generated using the MATLAB software, illustrate the correlation between the voltage stress reduction on the layered inverter and the IGBT switching length.When supplied with 460 V DC, it generates a single-phase output pattern at 50 Hz and an almost flawless sine wave.

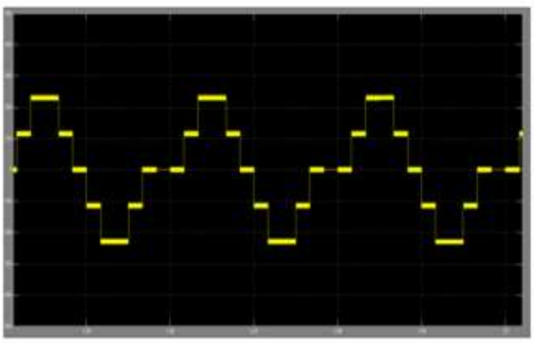

Fig (5): Waveform Obtained After Triggering of The IGBT Switches

An output pattern similar to this is produced when an IGBT switch is employed as a layered inverter.

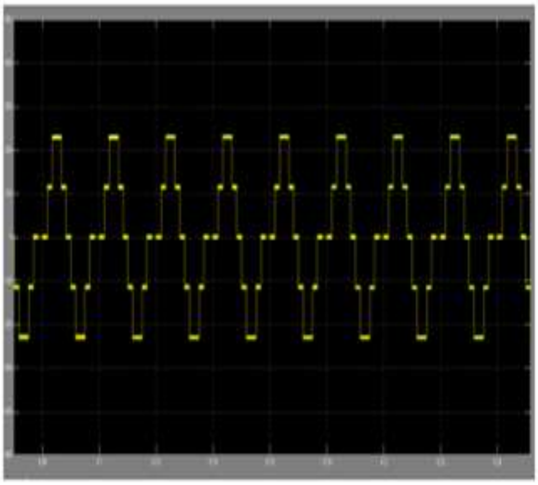

Fig (5): Waveform of Output Voltage Against Time (S)

4.CONCLUSION

An evaluation of each of the five inverter components will be carried out. This investigation will make use of the findings from the previous research in order to carry out the evaluation. When each and every one of their advantages is taken into account, they are an excellent choice for applications that require power that ranges from medium to high wattage. Through the utilization of a straightforward control technique and Matlab/Simulink throughout the process, we were able to correctly show five separate stages. The work of programming the switches to activate at specific angles and timings was accomplished by implementing a control system that was rather basic. This was done in order to accomplish the task. Both IDEAL switches and IGBT switches have output patterns that are quite like to one another, and there are a number of surprising parallels between the two types of switches. These similarities are something that I find to be really interesting. There is a possibility that a resistance load was put into the design of a converter that has five levels. There is a chance that this will occur.

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