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ADVANCING POWER CONVERSION: A 5-LEVEL SINGLE PHASE FLYING CAPACITOR MULTILEVEL INVERTER

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ABSTRACT-It refers to a single-phase, five-level floating capacitor multilevel inverter. A switching approach is described that produces multilevel output voltage waveforms by calculating switching angles. The results of testing and simulations of voltage waveforms for five layers of materials are presented. This article describes in detail how to create the five level voltages and one phase leg of a five level Flying Capacitor Multilevel Inverter. It is discussed what the circuit's triggering and modeling block diagrams reveal.
Keyword–Flying capacitor, multilevel inverter. Matlab/Simulink.

1.INTRODUCTION

As power electronics advance, more high-power medium-voltage propulsion applications are being used in industry. Enhance the performance of high-power and medium-voltage electric drives by increasing output voltage while decreasing dv/dt and harmonic. To address these issues, researchers developed the layered inverter theory for industrial drives. A multilayer inverter's output voltage is generated at high frequency and changes at low frequency with minimal misunderstanding. About high-power and medium-voltage equipment such as laminators, compressors, fans, SVCs, and HVDC pumps. Multilevel inverters are extremely significant in electronics, and they are frequently used to convert DC to AC in industrial and renewable energy situations. In addition to its great power output, it makes extensive use of renewable energy sources. There are several approaches of building multilayer transformers.

1. A multilevel inverter with a diode cutoff.
2. A multi-layer inverter with a capacitor clamp.

The third component is a chain of H-bridge stacked inverters.

A flying capacitor multilayer inverter generates direct current voltage by adding an extra capacitor to the phase rail of the power switch. The arrangement allows the inverter to operate at high capacity, particularly while power is out, by restricting the amount of switching states that the clamping capacitor can provide.

2 .FIVE LEVEL FLYING CAPACITOR MULTILEVEL INVERTER

The primary idea behind this transformer is to make effective use of capacitors. Switching cells are connected in series using capacitor clamps. Capacitors are used to transfer restricted power to electrical equipment. When compared to a diode clamped inverter, this inverter has identical switching states.

This form of multilayer inverter eliminates the requirement for clamping diodes. The output is equivalent to half of the DC power fed in. The rising capacitors in the multilayer inverter have cracked. To maintain the capacitor discharge balanced, an internal switching redundancy is included. It can handle the transfer of both active and reactive power. Nonetheless, switching losses are unavoidable when high frequency switching is employed

BASIC FEATURES:

The architecture consists of diodes, capacitors, and switching devices. The theoretical architecture of this topology allows for an infinite number of different voltage levels, but in actuality, there are only six.On the other hand, each organ is composed of transistors or other switching devices. When capacitors are close to a load, their voltage decreases.The voltage increases as the capacitors get closer to the source voltage (Vdc).The number of levels depends on the number of conducting switches in each limb.

CALCULATION:

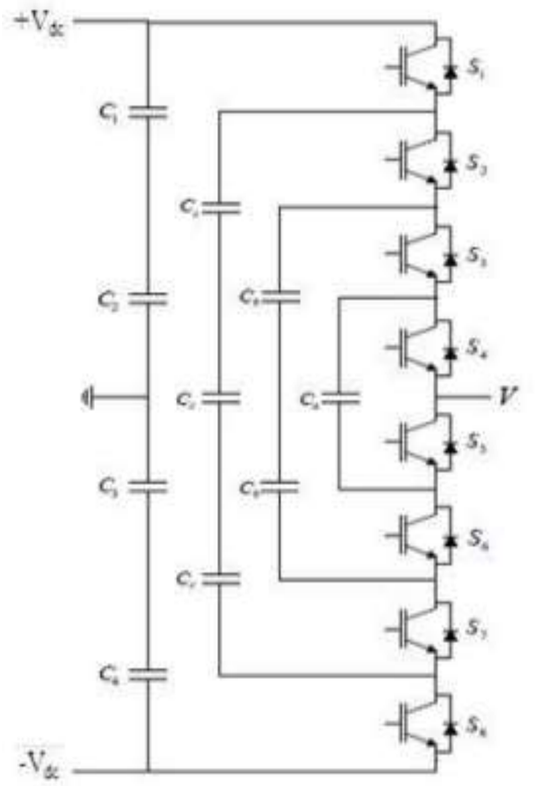
The formula to find number of devices needed for obtaining five level multilevel inverter is

An 'n' level inverter needs:

- 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 following one phase leg of a five level flying capacitor multilevel inverter to produce a staircase output voltage is shown below



FIG(1)ONE PHASE OF A FIVE LEVEL FLYING CAPACITOR MULTILEVEL INVERTER

OPERATION:

To get an output voltage level of V0 = Vdc, activate each of the upper half switches S1 through S4.To obtain the output voltage level V0 = Vdc/2, turn on one lower switch (S5) and three upper switches (S1-S3).First, hit the two bottom switches (S5 and S6). Next, hit the top two switches (S1 and S2). The voltage at the output will then be V0 = zero.Open three lower switches (S5–S7) and one higher switch (S1) to obtain an output voltage of V0 = -Vdc/2. Turning on all eight lower half switches results in an output voltage of V0 = -Vdc.

Table 1 displays the voltage values and the switch states that correspond to them. When the switch is in position 1, the device is operational. When the switch is in state 0, the device does not function.

TABLE 1: THE SWITCHING STATE OF FLYING LEVEL MULTILEVEL INVERTER

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

3.SIMULATION

The MATLAB/SIMULINK modeling software was used to thoroughly investigate the performance of a single-phase, five-level multilevel inverter. The Matlab/Simulink software suite is used for analysis, simulation, and modeling. It supports both sampling time and continuous time models for linear and complicated systems. For the modeling approach to function, a circuit with two independent switches—the IDEAL switch and the IGBT switch—is required.Both types of switches provide the same function.

SIMULINK MODEL USING IDEAL SWITCH

Certain gadgets cannot be utilized with the Ideal Switch block. Simple semiconductor devices, such as a GTO or MOSFET, can be demonstrated using appropriate switching logic.The gate signal (g>0 or g=0) provides full control of the Ideal Switch block. When g>0, it allows any two-way current flow with no voltage drop; when g=0, it prevents any forward or backward voltage flow with no current flow; and when turned on, it swiftly flips between on and off states.

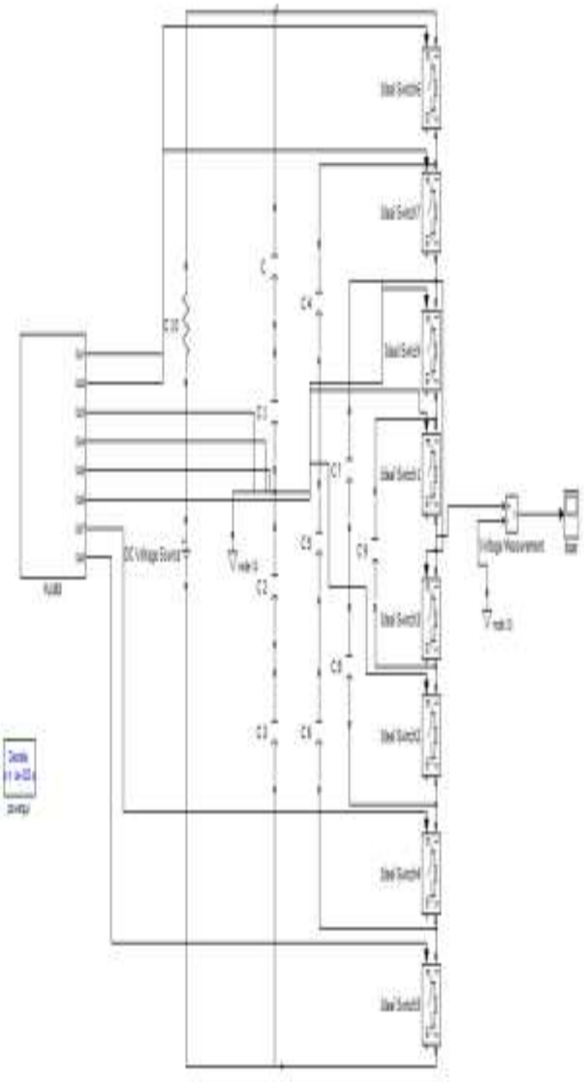


FIG (2) SIMULINK MODEL USING IDEAL SWITCH

SIMULINK MODEL USING IGBT SWITCH

The simulation is then executed via an IGBT switch.IGBTs outperform other types of transistors due to their low on-resistance, large capacity and voltage, fast switching speed, low driver friendliness, and no gate drive current. All of these qualities make IGBTs ideal for high-voltage applications such as frequency converters operating at hundreds of kHz, PWM and SMPS devices, variable speed control systems, and solar-powered AC to DC converters. Here are the primary issues: When compared to power MOSFETs, BJTs have faster switching times.

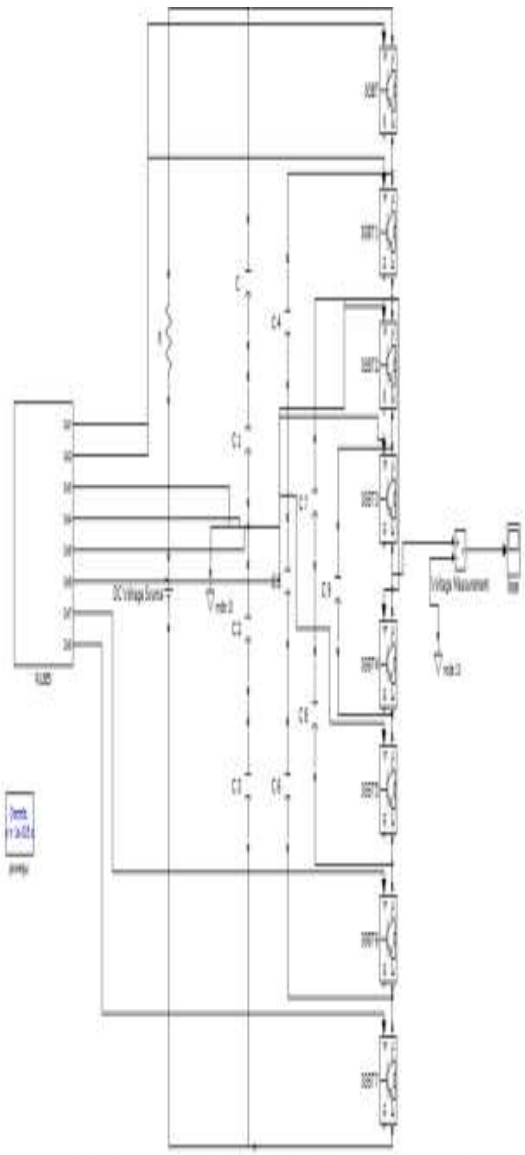


FIG (3) SIMULINK MODEL USING IGBT SWITCH

TRIGGERING OF SWITCHES:

The triggering circuit combines OR GATE circuitry to generate pulses.The starting circuit consists of eight OR gates, four for the positive half cycle and four for the negative half cycle.

To generate an incoming signal with 8, 6, 3, and 1, the first, second, third, and fourth OR gates must be activated in the proper order. The triggering circuit consists of nine pulse producers all together. This is how you define the phase angle delay across a half cycle.

So that V=0 has an immediate output voltage of zero, pulse generators 1, 2, and 3 require phase delays of 00, 1800, and 3600, respectively. PPGs 1 and 2 may generate an output voltage of V=Vd/2 instant using phase delays of 450 and 1350 ms, respectively. Instant pulse generator 1 uses a phase delay of 900 to produce an output voltage of V=Vd [2, 4]. The block plan for the triggering simulation is shown in the image below.

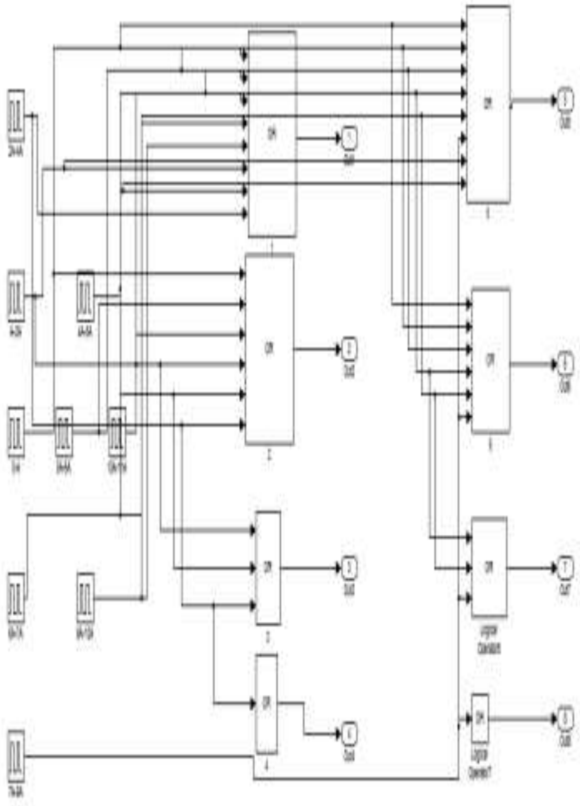


FIG (4)SIMULINK MODEL OF TRIGGERING CIRCUIT

Result:

Using MATLAB software, the timing diagram analysis in Figure 4 and Table 1 demonstrates a link between the time it takes for IGBT switching and the reduction in voltage stress on the multilayer inverter.The 460 V DC input power produces a 50Hz, 1ph output waveform, as well as a nearly perfect sine wave.

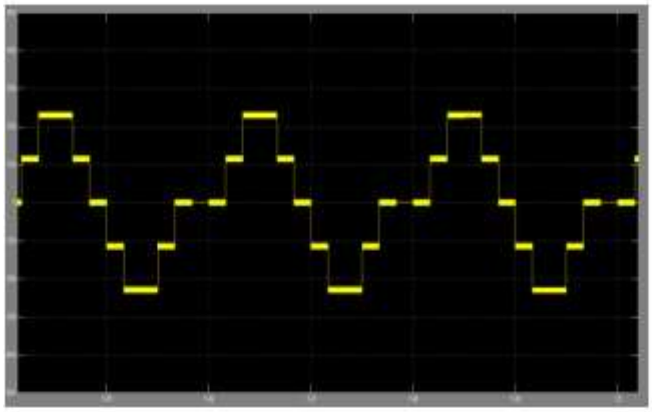


FIG (4) WAVEFORM OBTAINED AFTER TRIGGERING OF THE IGBT SWITCHES

When you pretend to be a multilayer inverter with an IGBT switch, you obtain the output pattern seen below.

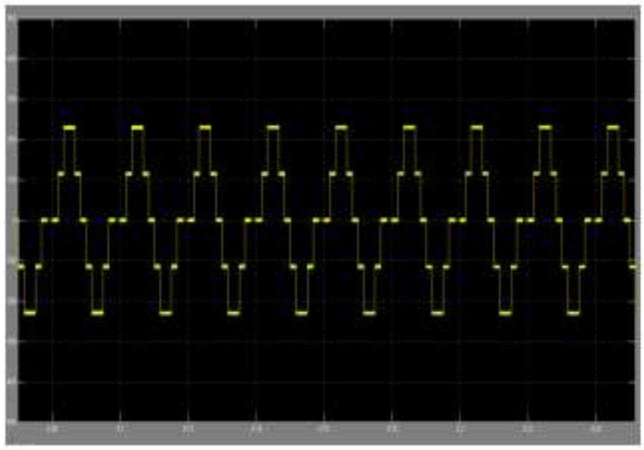


FIG (5) WAVEFORM OF OUTPUT VOLTAGE AGAINST TIME(S)

4.CONCLUSION

This probe looks at five inverter layers. Because of their numerous advantages, they have become quite popular for medium and high-wattage power applications. To simulate five phases, a basic control strategy was employed using Matlab/Simulink. The switches were programmed to open at the appropriate angle and time using a basic control system. It's interesting how much the output patterns of an IGBT switch and an IDEAL switch are similar. With the resistive load in mind, a five-level converter may have been designed.

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