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# MULTILEVEL BOOST INVERTER ANALYSIS AND DESIGN FOR INCREASED FREQUENCY WITH REDUCED COMPONENTS

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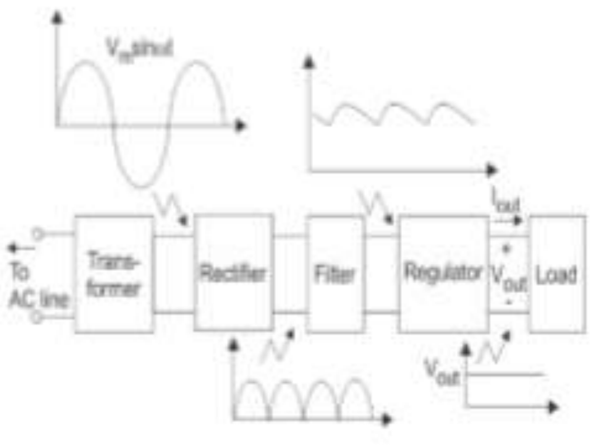
**ABSTRACT:** The flying-capacitor multilevel (FCML) architecture is used in this study to evaluate high step-up conversion. Unlike the two-level boost converter, high energy density capacitors assist inductors in storing and transporting energy during conversion in the FCML architecture. The switching node has a high effective switching frequency, the inductor and switches experience less voltage stress, and the overall voltage stress is reduced. As a result, the passive component bulk of the converter is minimized while maintaining excellent voltage gain efficiency. A hardware prototype transforms 100 V to 1 kV with an output power of 820 W to demonstrate excellent power density and efficiency. To achieve such high power density and efficiency goals, numerous converter regions must be optimized. The solutions used, the design process, and the comparison to other cutting-edge systems are all explained. The hardware prototype achieved a power density of 329 W/in3 (20 W/cm3) and a peak efficiency of 94.1%.

***Key words:*** High step-up converter, flying-capacitor multilevel,high voltage.

## 1.INTRODUCTION

Other electrical gadgets are powered by power supply. A power supply converts the electricity from a source into the voltage, current, and frequency required to power a load. As a result, the term "electric power converter" is sometimes used to describe these power supply. Some power supplies are integrated into the appliances they power, while others stand alone. Electronics and desktop power supplies are examples of the latter.Due to cost, most electrical power is produced, transferred, and distributed as alternating current (AC), yet most electronic circuits and devices require direct current (DC). Dry cells and batteries can be used for this. Although their portability and lack of ripple are benefits, their low voltages, frequent maintenance, and high cost make them more expensive than dc power sources. Almost every modern electronic equipment contains a circuit for converting alternating current to direct current. The device's DC power supply transforms alternating current to direct current voltage. A transformer is frequently used at the input of power supplies. Following that is a diode rectifier, smoothing filter, and voltage regulator circuit.

Figure 1 shows a block diagram of a DC power supply. A transformer, rectifier, filter, and regulator are all part of the basic power supply. The output of the DC power supply provides a constant DC voltage to the load. Let's go over each DC power supply component in detail.



Components of typical linear power supply

Figure 1. DC power circuit schematic

**Transformer**

Transformers reduce supply voltage in order to connect solid-state electronic devices and circuits. Separating the gadget from the supply line is critical for safety. Internal shielding can keep electrical noise out of the power supply and keep the load running smoothly.

**Rectifier**

Rectifiers convert sinusoidal alternating current (AC) to positive or negative pulsing direct current (DC). P-N junction diodes convert or rectify alternating current to direct current. The majority of rectifiers require one, two, or four diodes. There are half-wave and full-wave (bridge or center-tap) rectifiers. The output voltage of a rectifier circuit pulsates due to unwanted AC components (supply frequency f and associated harmonics). Most electronics perform well with DC voltage supplied by a rectifier. A filter circuit is required to remove AC components from the rectifier.

**Filter**

A filter sends the DC components of the rectifier output to the load while blocking the AC components. Reactive circuit components like as capacitors, inductors, and resistors are commonly used in filters. Load current and input AC voltage can both have an effect on output DC voltage. As a result, a voltage regulator at the output of the rectifier filter combination is required to provide a nearly constant DC voltage at the regulator's output. Voltage regulators can make use of discrete transistors, integrated circuits (ICs), Zener diodes, and other components. Its primary function is to steady the DC output voltage. It does, however, reject AC ripple voltage that the filter cannot eliminate. Overvoltage, thermal shutdown, current limiting, and short-circuit protection may also be included in the regulator.

**High-voltage power supply**

Hundreds or thousands of volts are generated by high-voltage power sources. Custom output connectors eliminate the possibility of inadvertent human contact, insulation failure, and arcing. Lower voltage connectors, such as SHV connectors, can be utilized; however, beyond 20 kV, Federal Standard connectors are needed. Some high-voltage power supplies provide analog or digital inputs for adjusting output voltage. Electron and ion beams are accelerated and controlled by high-voltage power sources in focused ion beam columns, electron microscopes, x-ray generators, electrophoresis, and electrostatics.

To create high voltage, high-voltage power supplies use a power inverter to power a voltage multiplier, high turns ratio, high-voltage transformer, or both (usually a transformer followed by a multiplier). The power source discharges high voltage via the unique connection. It is then fed into a voltage divider to generate a low-voltage metering signal for use with low-voltage devices. The metering signal is sent by the power supply to external circuitry that monitors the high-voltage output or to a closed-loop controller that adjusts the inverter input power and high voltage.

High step-up DC to DC converters generate high voltage DC output for DC power systems such as huge wind farms, photovoltaic grid-connected power systems, medical devices such as X-ray machines, satellite ion trusters, and pulse electric field applications. These applications require powerful step-up converters with rated power ranging from hundreds to a few kilowatts to generate DC voltage at kilovolts from sources at hundreds of volts.

Traditional boost converters have difficulty attaining high voltage gain, power density, and efficiency. High voltage stress on switches and diodes, large conduction and switching losses, and massive magnetic volume from low-frequency switching of high-voltage switches are some of the system's major drawbacks. High step-up ratios are also possible with the switched-capacitor (SC) converter. It achieves significantly higher power density than switched-inductor DC-DC buck or boost converters by utilizing capacitors' high energy density. Charge redistribution loss and output load regulation loss are two shortcomings of SC converters.

In this investigation, we advocate employing the FCML converter for high voltage step-up. The FCML topology allows for the use of smaller inductors, low voltage switches, and high energy density capacitors in the circuit design, resulting in a hardware prototype with a maximum output power of 820 W and a peak efficiency of 94.1%.

## 2. LITERATURE SURVEY

Serban and colleagues presented a solar inverter. Because of their low cost, efficiency, and simplicity, single-stage conversion photovoltaic (PV) inverters are increasingly being utilized to create solar plants. Existing PV facilities operate at less than 1000 V and experience significant dc-bus voltage changes due to PV cell temperature and maximum power point voltage. This study looks at 1500 V solar inverters that use power devices and innovative modulation to boost dc-bus voltage. A detailed comparison with 1000 V solar inverters demonstrates the advantages of the large dc-bus range of 1500 V systems.

LF Costa et al. developed a non-isolated multilayer step-up dc-dc converter for high power and output voltage applications. The suggested converter has low switching losses, a low semiconductor voltage, and a low input inductor volume. The primary issues of this research are the theory and explanation of the converter's five-level structure. To function, the four capacitors in the five-level DC-DC converter must be balanced.

A multilayer flying-capacitor boost converter was proposed by Lefevre and colleagues. Using different voltage class MOSFETs, asymmetric voltage functioning is investigated for loss optimization. Following that, a low-cost zero-voltage, zero-current switching snubber is built to reduce inductor size. With an emphasis on nonlinear MOSFET parasites, the proposed snubber is compared to diode boost for synchronous rectification.

"Experimental evaluation of capacitors for power buffering in single phase power converters" model proposed by Barth C. et al. In driving waveforms, varying speeds produce pulse width and rising times less than 100 nanoseconds. Inductive devices, such as random wound motors, may experience high turn-to-turn voltages as a result of these rapid transitions, resulting in partial discharge and early failure. Absorbing high-frequency energy from the drive electronics-motor interface is one solution. This research looks at cable optimization design considerations. You Y.R. and Lei. Pilawa-Podgurski [15] demonstrated that the resonant and soft-charging functionalities of SC converters are strongly connected. It also suggests that SC topologies use a single inductor to achieve either activity. Because most resonant or soft-charging SC converters were created on the fly, this paper presents an analytical method for determining whether the architecture of a conventional SC converter is compatible with the proposed methodology. Dickson, Fibonacci, ladder, series-parallel, and doubler topologies are examined. The approach is validated by the creation of a set of high-performance SC converters, as well as computational and experimental results.

Y designed and built a 2-kW, 60-Hz, 450-VDC-to-240-VAC power converter. Lei et al. participated in the Google/IEEE Little Box Challenge. The inverter's seven-level flying capacitor multilevel converter incorporates low-voltage GaN switches that operate at 120 kHz. With 8 times less capacitance than passive capacitors, the inverter's active buffer for twice-line-frequency power pulsation decoupling maintains efficiency above 99%. "A Single-Phase Cascaded Multilevel Inverter Based on a New Basic Unit With Reduced Number of Power Switches," by A. E. Babaei et al., offers a series-connected basic unit-based inverter that can only produce positive output levels. An H-bridge is now included in the suggested inverter. A cascaded multilayer inverter was constructed. Four ways for calculating dc voltage source magnitude to achieve even and odd output voltage levels are explained.

## 3.PROPOSED METHOD

PWM is the simplest method for controlling numerous inverters. For the power system, a nine-level inverter with two capacitors and one voltage source is recommended. In comparison to present architectures, the recommended inverter has more voltage levels and fewer components. THD of the output voltage is minimized, which reduces backstage power switch voltage stress. More crucially, the capacity of the two capacitors to balance their voltage simplifies modulation. The primary advantage of pulse width modulation (PWM) control is that it reduces output voltage THD. The inverter operates at the frequency of the carrier signal. PWM with multiple carriers is always employed in multilayer applications.

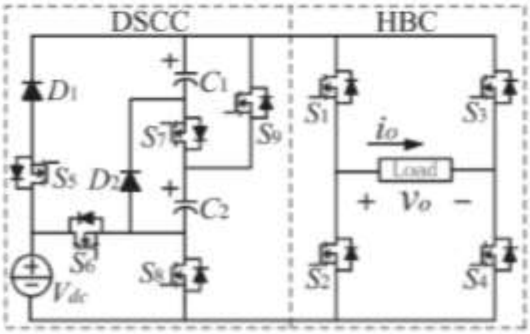


Figure 2. Inverter type with nine operational levels

### Functioning of the proposed model

The operational model of the proposed system is shown in Figure 2. This diagram depicts the specified two-stage nine-level inverter. Frontal switched capacitor circuits (DSCC) produce more voltage while using fewer components than basic SC cells.

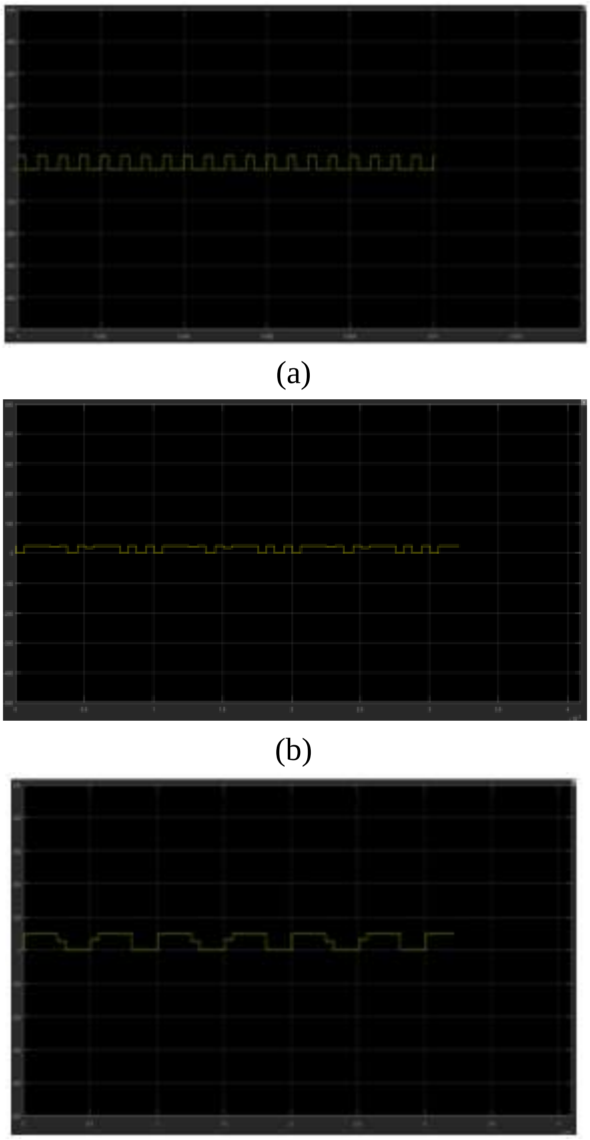
The backend uses an H-bridge circuit (HBC) to reverse the polarity of the frontend's output. The inverter should ideally have nine output voltage levels. It is necessary to use one dc voltage supply, two capacitors, two diodes, and nine power switches.

### Advantages and applications of the proposed system

- With only one voltage source and fewer components, the proposed HF inverter can produce nine output levels.
- Harmonics that have been reduced
- As a result, switching loss is considerably reduced.
- Applications such as high-power conversion.

## 4.SIMULATION RESULTS

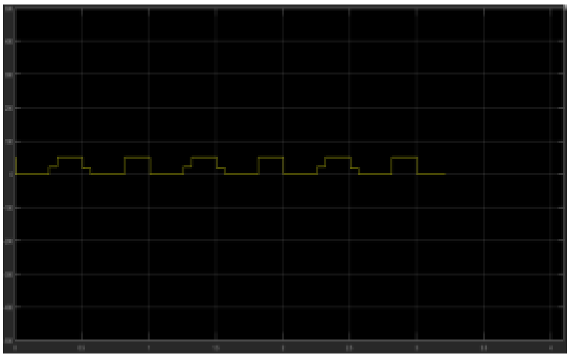
The performance of the nine-level inverter is tested using Matlab simulation, as shown below. The output frequency is set to 1 kHz. Figure 3 depicts simulated output voltage waveforms, whereas Figure 4 depicts load current waveforms for varied loads. The voltage waveform is depicted in Figure 5.



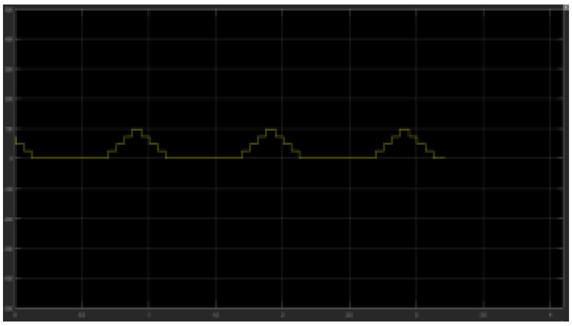
(a)

(b)

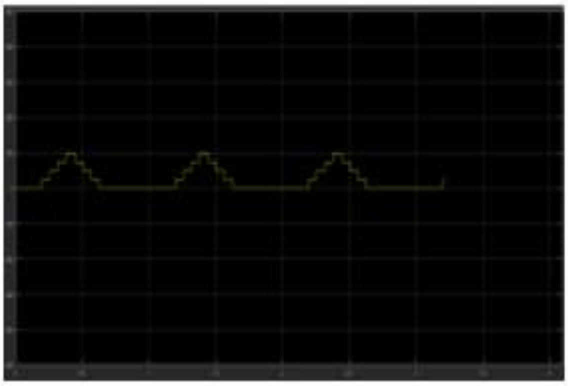
(c)



(d)

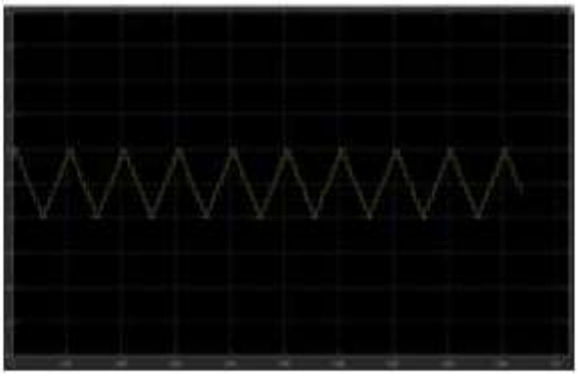


(e)

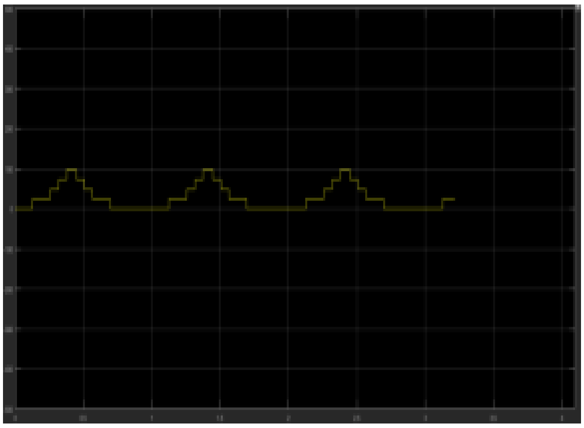


(f)

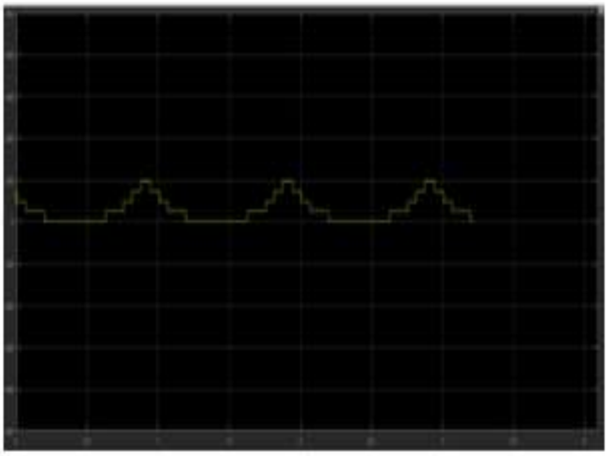
Waveform simulations at various voltages (a-f).



(a)



(b)



(c)

(a), (b), and (c) depict load current wave patterns at various voltages.

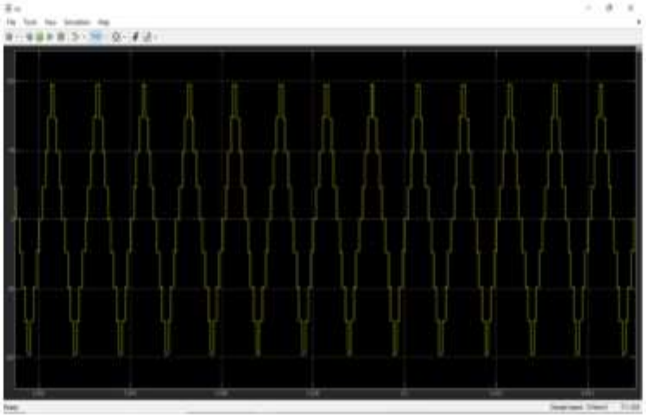


Figure 5 Wave form of the output voltage

## 5.CONCLUSION

This research proposes a multilevel inverter for high-frequency power distribution. In contrast to the current structure, the proposed architecture may generate a nine-level staircase output with a single voltage source, fewer power components, and less voltage stress. They have all broadened its applicability. To simplify modulation and eliminate voltage balancing, this capacitor multilayer inverter design employs pulse width modulation.

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