



# Study of Control Technique for 7-Level Cascaded H-Bridge Inverters

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**Abstract:** A multilevel inverter is a power electronic device that is used for high voltage and high power applications and has many advantages like high power quality waveform, reduced total harmonic distortion (THD). Hence, the size and bulkiness of passive filters can be reduced. In this paper, a new 7-level inverter based on developed H-bridge with reduced number of components is discussed. This inverter configuration requires only 6 unidirectional power switches and 2 DC voltage sources in comparison with conventional cascaded H-Bridge (CHB) 7-level inverter which requires 12 power switches and 3 isolated DC voltage sources. Hence, a new 7-level inverter based on developed H-bridge results in reduced complexity of the circuit and total cost of the inverter. The circuits are simulated using nearest level modulation technique and the effect of the harmonic spectrum is analyzed. The circuits are modeled and simulated using MATLAB/Simulink. A new 7-level inverter based on developed H-bridge with reduced number of switches can obtain desired output voltage levels in-line with the conventional CHB 7-level inverter.

**Keywords:** Developed H-bridge, Cascaded H-bridge, 7-level inverter, Nearest level modulation

## I. INTRODUCTION

The power electronics device which converts DC power to AC power at required output voltage and frequency level is known as inverter. [2] Multi-level inverters are used for high power and high voltage applications and have many advantages like high power quality waveform, reduced total harmonic distortion (THD). [3] Hence, the size and bulkiness of passive filters can be reduced. These inverters generate a stepped voltage waveform by proper arrangement of semiconductor devices and number of dc voltage sources as an input.

The multi-level inverters are primarily classified as Flying capacitor inverter, Diode clamped and Cascaded H- Bridge multilevel inverter. [1] Cascaded H-Bridge (CHB) multilevel inverter needs a number of isolated dc supplies, each of which feeds an individual H-bridge power cell. The number of H-bridge cells in a CHB inverter is mainly decided by the inverter operating voltage, harmonic requirements, and manufacturing cost.

In this paper, a new 7-level inverter based on developed H-bridge with reduced number of power switches is discussed. [1] This inverter configuration requires only 6 unidirectional power switches and 2 DC voltage sources in comparison with conventional CHB 7-level inverter which requires 12 power switches and 3 isolated DC voltage sources.

## II. CONVENTIONAL CASCADED H-BRIDGE 7-LEVEL INVERTER

Conventional cascaded multilevel inverter consists of a number of single-phase H-bridge inverters. [2] The CHB inverter with seven to eleven voltage levels has been widely used in high-power and medium-voltage applications. [14]

IGBTs are exclusively used as switching devices in these inverters. A stepped output voltage and current can be obtained in a cascaded multilevel inverter by cascading many H-bridge inverters. In conventional CHB7-level Inverter, three H-bridge inverters are to be cascaded to get a 7-level output. [3]

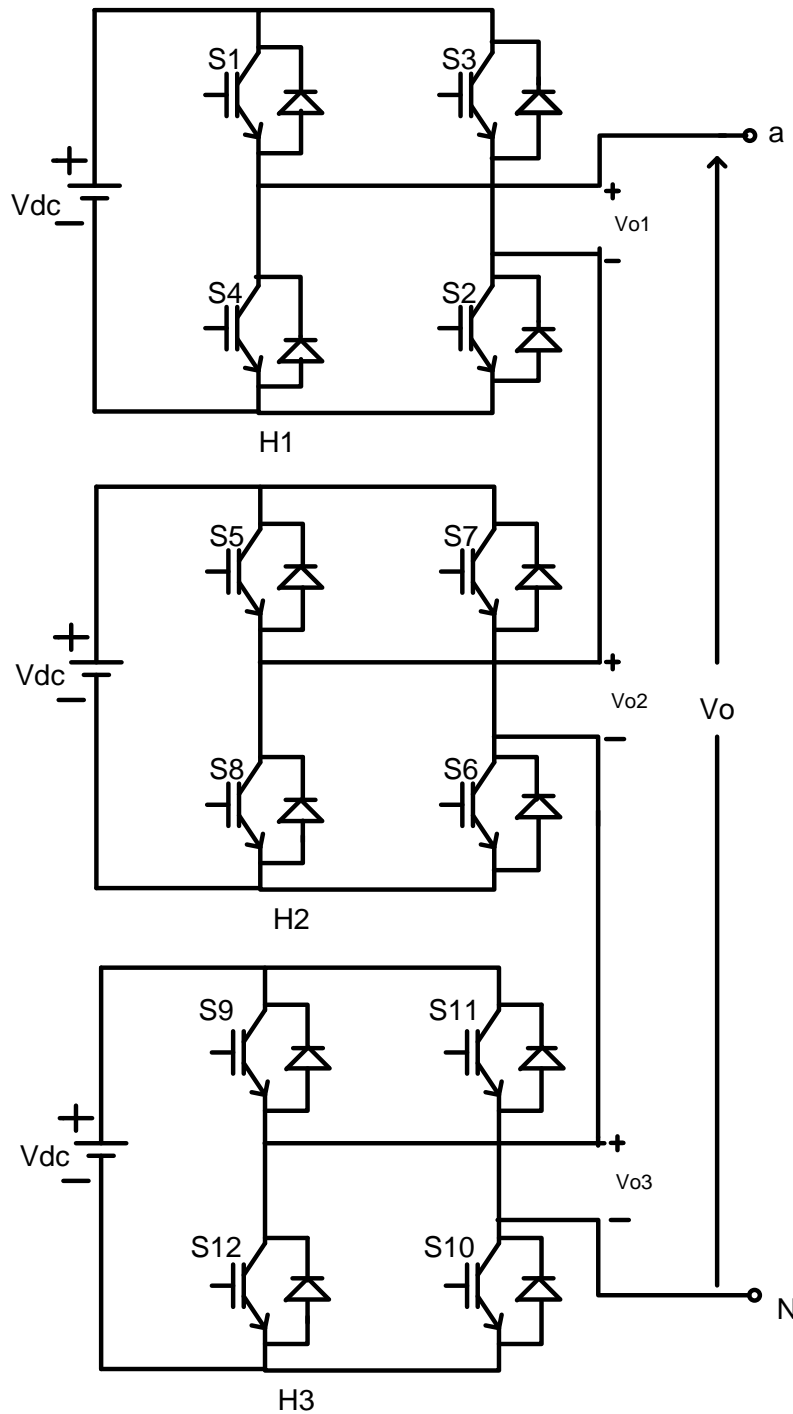


Fig. 1. Per phase diagram of conventional CHB 7-level inverter

### III. NEW 7-LEVEL INVERTER BASED ON DEVELOPED H-BRIDGE

A new 7-level inverter configuration based on developed H-bridge consists of six unidirectional power switches (IGBTs) and two dc voltage sources [13]. This circuit (Figure 2) is used to obtain desired level of output with less number of power switches, dc voltage sources and power diodes compared to conventional CHB 7-level inverter which results in decreased complexity and total cost of the inverter.

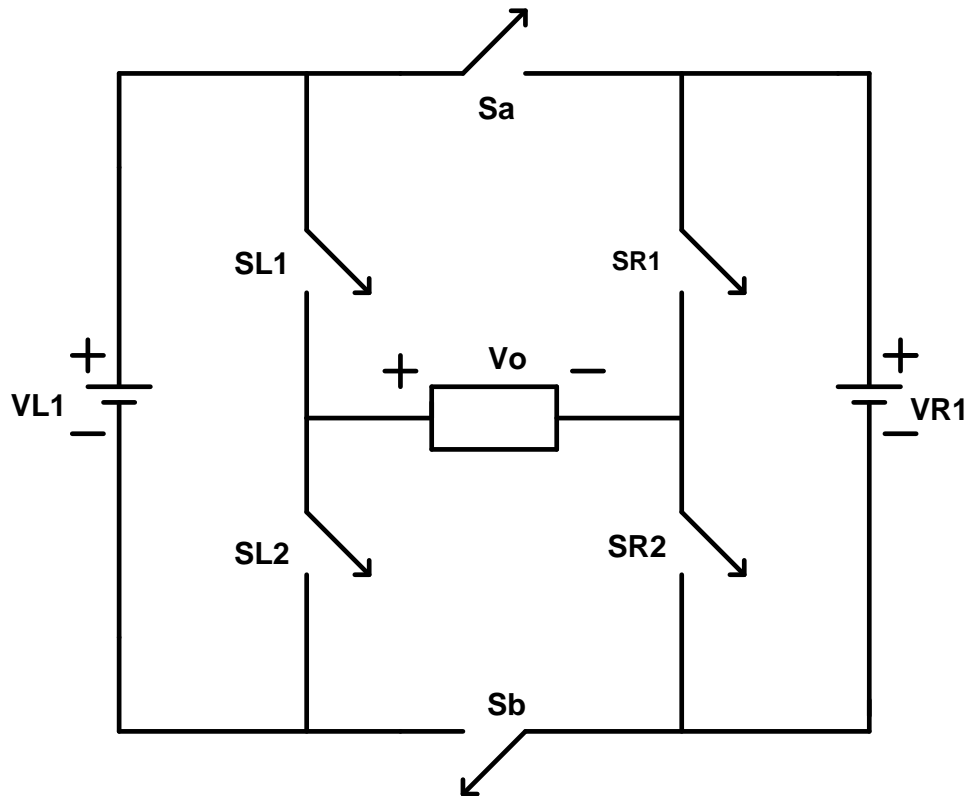


Fig. 2 - A new 7-level inverter based on developed H-bridge

As shown in Figure 2, a new 7-level inverter based on developed H-bridge is obtained by adding two unidirectional power switches and one dc voltage source to the H-bridge inverter i.e. the new inverter consists of six unidirectional power switches ( $S_a$ ,  $S_b$ ,  $S_{L,1}$ ,  $S_{L,2}$ ,  $S_{R,1}$ , and  $S_{R,2}$ ) and two dc voltage sources ( $V_{L,1}$  and  $V_{R,1}$ ). As shown in Figure 2, the simultaneous turn-on of  $S_{L,1}$  and  $S_{L,2}$  (or  $S_{R,1}$  and  $S_{R,2}$ ) causes the voltage sources to short-circuit. Similarly,  $S_a$  and  $S_b$  should not turn on, simultaneously. [1]

#### IV. METHODOLOGY

The nearest level control technique is used in the proposed work for the pulse generation for both 12 switch and 6 switch inverter configurations. This control method tends to generate a staircase voltage which minimizes the error with respect to the reference voltage and is known as nearest level (or round) control method [7].

In this method, the sinusoidal reference voltage is compared with the available dc voltage levels and the level is chosen that is nearest to the reference voltage [12]. Consequently, the proper switches are turned on to generate the desired voltage level. The output voltage ( $v_o$ ) will be staircase voltage with minimum possible error with respect to the reference voltage. The circuits are modeled and simulated using MATLAB/Simulink.

#### V. SIMULATION RESULTS

The simulation is done for the conventional CHB7-level inverter and a new 7-level inverter based on developed H-bridge. Simulations are done by using NLC (Nearest level control) technique by comparing the sinusoidal reference voltage with the available dc voltage levels. Harmonic spectrum analysis is done using FFT window in MATLAB/Simulink.

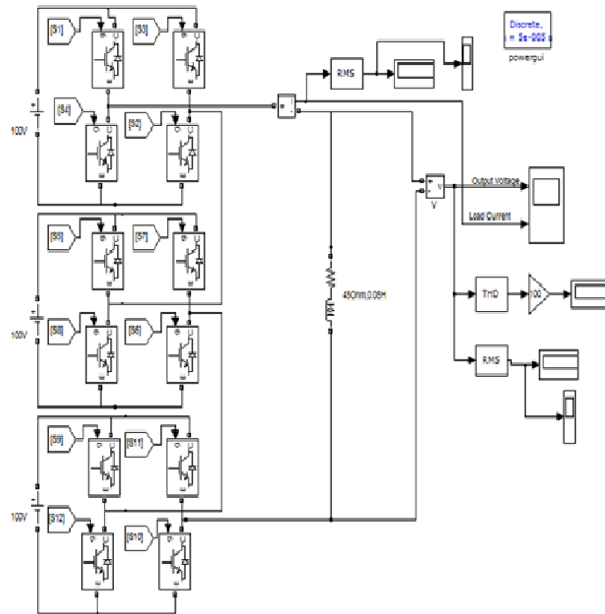


Fig 3 - MATLAB/Simulink model of conventional CHB 7-level inverter

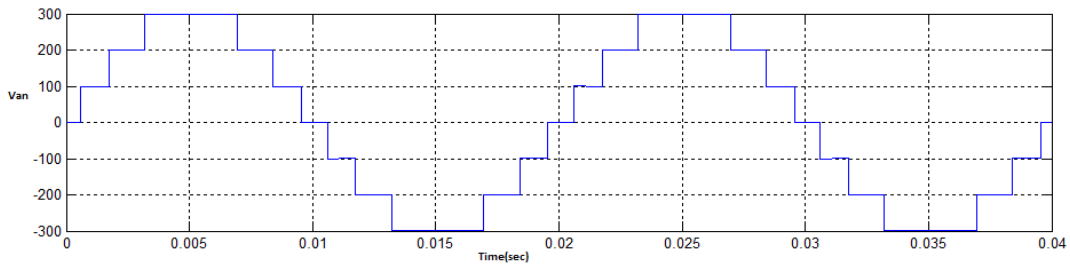


Fig. 4 - Output voltage waveform of conventional CHB 7-level inverter

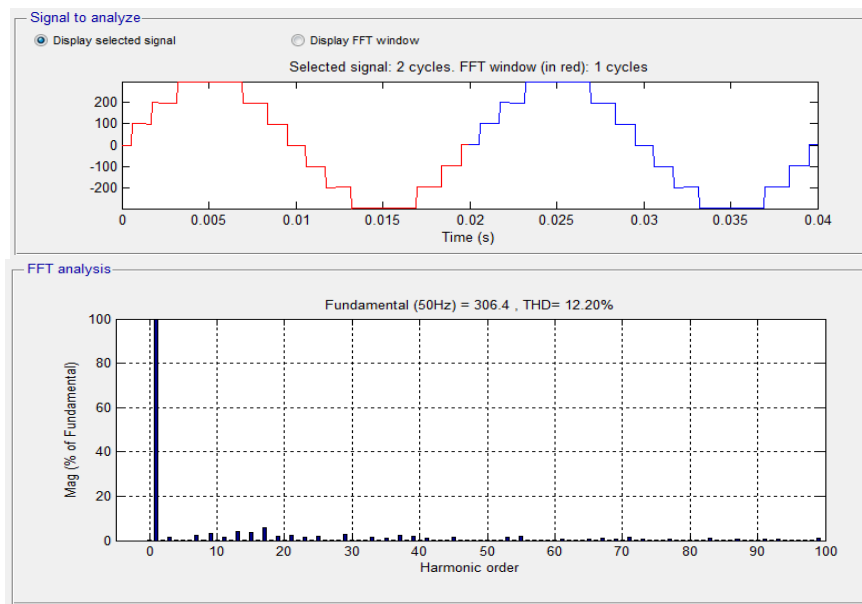


Fig. 5 - FFT analysis of conventional CHB 7-level inverter



Figure 4 shows the output voltage waveform of the conventional CHB 7-level inverter which is being produced by NLC. [8]. Total Harmonic Distortion is very low, but the low harmonic content is very high. Figure 5 shows output voltage waveform in FFT window in MATLAB/Simulink and harmonic spectrum of output voltage of conventional CHB 7-level inverter.

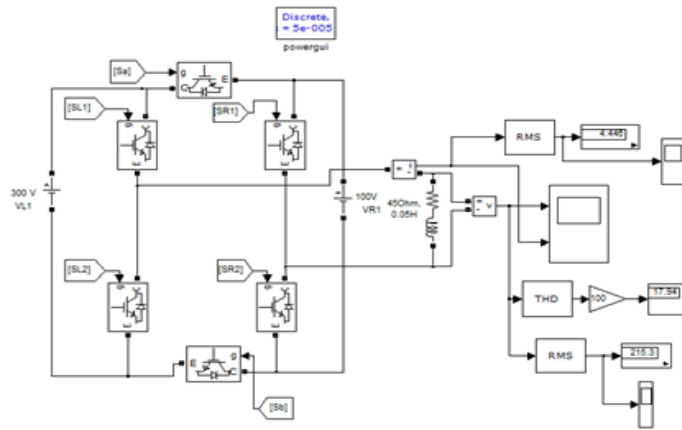


Fig. 6 - MATLAB/Simulink model of new 7-level inverter based on developed H-bridge

Figure 6 Shows the MATLAB/simulink model of a new 7 level inverter based on developed H-bridge. In this model, only six IGBT switches are used compared to the twelve switches in conventional CHB 7-level inverter. The pulses for the switches are being generated using NLC technique.

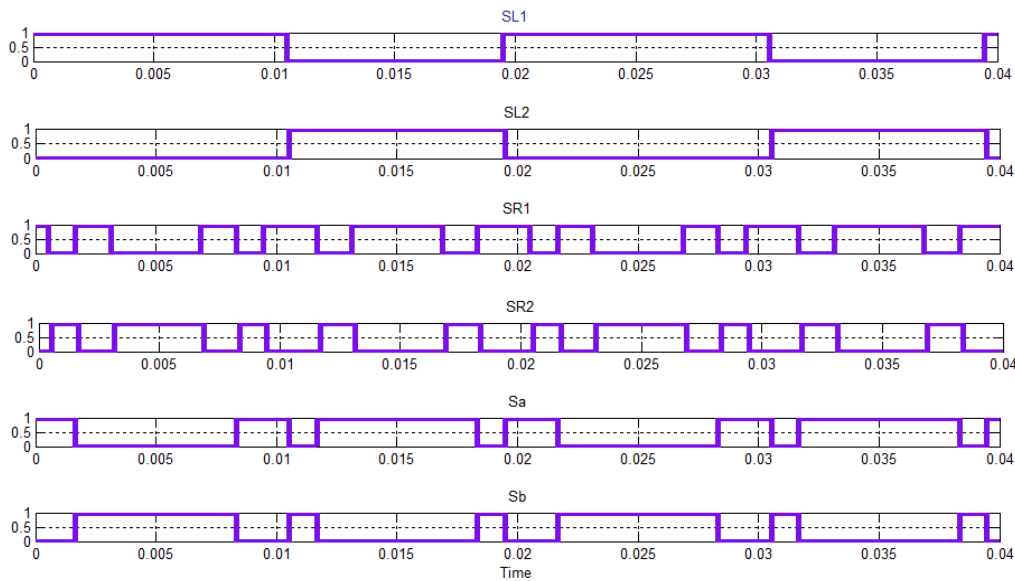


Fig. 7 - Pulse generation using NLC method for switches in new 7 level inverter configuration

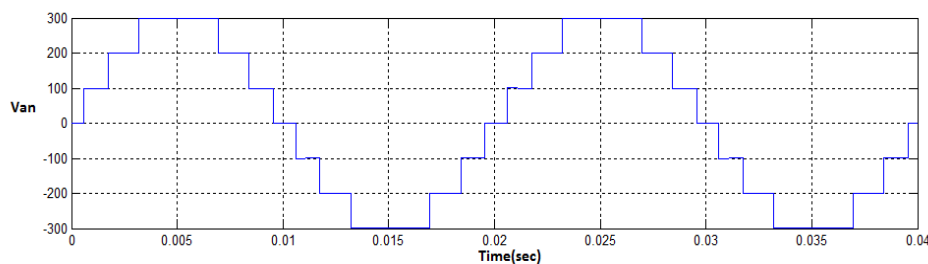


Fig. 8 - Output voltage waveform of a new 7-level inverter

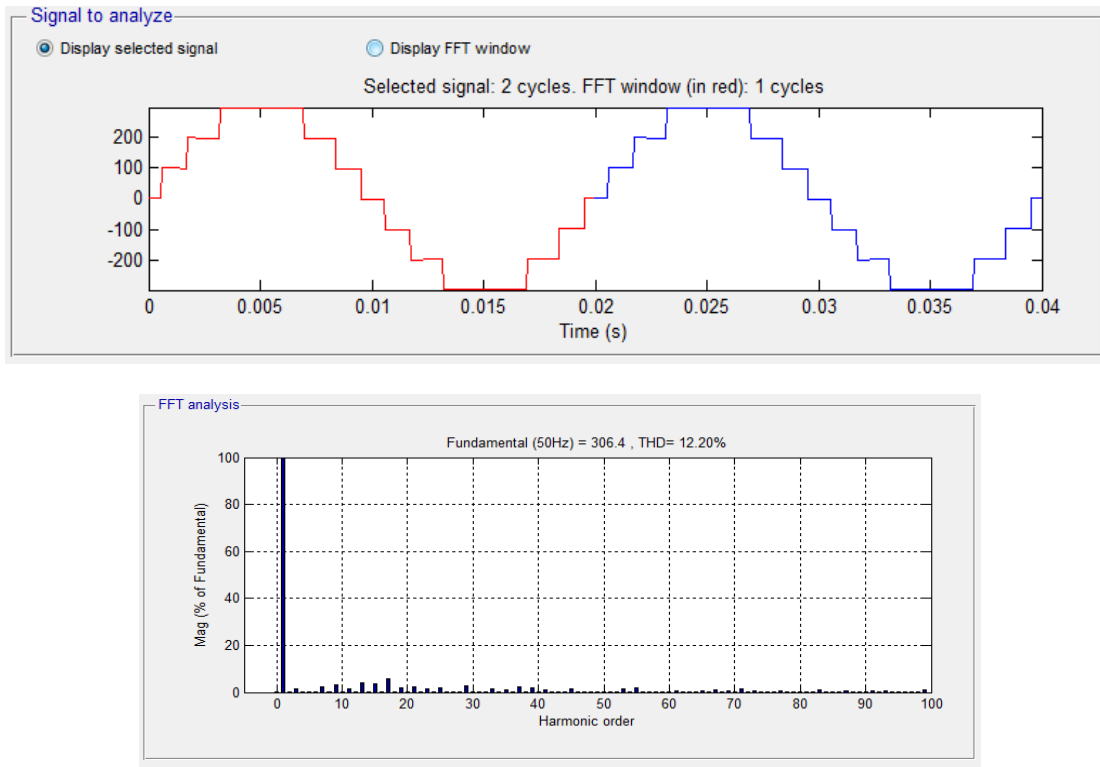


Fig. 9 - FFT analysis of a new 7-level inverter using 6 switches

Figure 8 shows the output voltage waveform of the new 7-level inverter which is being produced by NLC. [8] Total Harmonic Distortion is very low, but the low harmonic content is very high. Figure 9 shows output voltage waveform in FFT window in MATLAB/Simulink and harmonic spectrum of output voltage of new 7-level inverter.

From table 1, it is evident that a new 7-level inverter based on developed H-bridge requires 6 unidirectional power switches which are 50 percent lower than the conventional CHB 7-level inverter.

TABLE I COMPARISON OF TWO CONFIGURATIONS OF 7-LEVEL INVERTERS

	Power Switches	Voltage Supply
Conventional CHB 7-level inverter	12	03
New 7-level inverter based on developed H-bridge	06	02
% Reduction with respect to Conventional CHB 7-level inverter	50%	33%

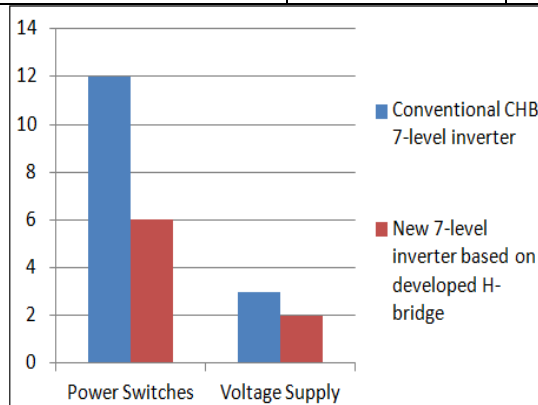


Fig. 10 – Comparison of two configurations of 7-level inverters



It is also evident that a new 7-level inverter based on developed H-bridge requires 2 DC voltage sources which are 33 percent lower than the conventional CHB 7-level inverter.

## VI. CONCLUSION

Conventional CHB 7-level inverter requires 12 power switches and 3 isolated DC voltage sources. A new 7-level inverter based on developed H-bridge requires only 6 unidirectional power switches and 2 DC voltage sources. The new 7-level inverter based on developed H-bridge requires least number of power switches and DC voltage sources as compared to conventional CHB 7-level inverter configuration. This also means the new 7-level inverter based on developed H-bridge requires least number of gate drive circuitry and power diodes. Simulation results show desired output voltage level of both the configurations. It can be seen that THD content for the new 7 level inverter with 6 switches and conventional CHB 7-level inverter configuration with 12 switches are comparable. Thus, the new 7-level inverter based on developed H-bridge reduces the complexity of the circuit and will have least cost with respect to conventional CHB 7-level inverter.

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