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5-Level inverter for a grid-connected PV system

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ABSTRACT:

Nowadays, investments in new renewable and sustainable energy sectors are being rapidly carried out to reduce CO2 emissions and address global warming caused by the use of fossil fuels. Advances in power electronics have contributed greatly to the advent of solar photovoltaic and wind energy-based power generation systems. This presents presents an overview of the research that has led to the creation of various switched-capacitor multilevel inverter topologies. An exhaustive assessment of the literature is presented with the goal of decreasing the number of devices required to support an increased number of output levels. In this section, the thesis objectives and structure are discussed in detail. Nowadays, investments in new renewable and sustainable energy sectors are being rapidly carried out to reduce CO2 emissions and address global warming caused by the use of fossil fuels. Advances in power electronics have contributed greatly to the advent of solar photovoltaic and wind energy-based power generation systems.

1. INTRODUCTION

Various types of power converter families have been developed. Inverters are among the most essential converters for converting direct current to high-quality alternating current. The inverters families are classified into two main categories: two-level inverters and MLIs.

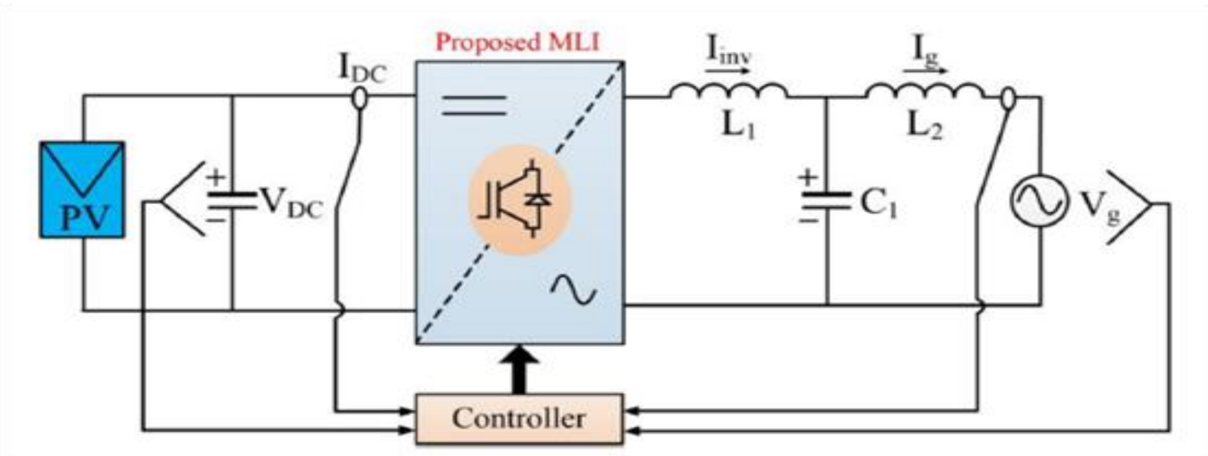

Figure 1: Simulink Model of the system

Until the late 1980s, traditional two-level inverters were the industry norm. The advancements in power electronic switches, such as IGBT and MOSFET and their associated cost reductions have accelerated research on MLI architectures. In order to connect these sources to the distribution grid and/or local loads. Basic application of proposed work shown in Figure 1. Various types of power converter families have been developed. Inverters are among the most essential converters for converting direct current to high-quality alternating current. The inverters families are classified into two main categories: two-level inverters and MLIs. Until the late 1980s, traditional two-level inverters were the industry norm. The advancements in power electronic switches, such as IGBT and MOSFET and their associated cost reductions have accelerated research on MLI architectures.

2. MODELLING OF SYSTEM MODEL

MLIs have a significant advantage over two-level inverters, including lower *dv/dt*, less electromagnetic interference, improved harmonic performance and reduced output filter size. NPC inverter, FC inverter and CHB inverters are three of the earliest well-established inverter topologies that have been around for a long time. These conventional topologies each have their own set of advantages and disadvantages. In the case of NPC and FC suffer the capacitor voltage balancing issues and require a complex control strategy to balance the capacitor voltage. The number of clamping diodes and capacitors required increases as the voltage levels increase. To synthesize a multistep voltage waveform, Separate dc sources are required for the CHB inverter and consequently, the voltage gain in all the classical topologies is limited to one. To address these difficulties, the concept of switched DC source and reduced device count to maximize the voltage level have been investigated, as they provide a compact architecture that reduces the systems cost and control complexity. Existing topologies have the problem of voltage boosting capabilities. Novel topologies based on a Switched Capacitor (SC) are being researched to improve boosting ability and significantly reduce the number of devices further.

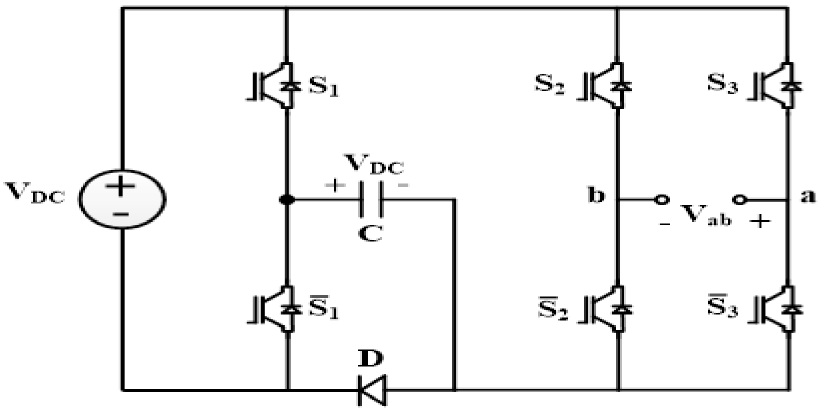

Figure 2 Five Level Boosting Inverter Topology

Figure 2 shows the proposed five-level boosting inverter topology. The circuit topology of the proposed 5-Level inverter for a grid-connected PV system is depicted in figure 2. Six unidirectional switches, one diode, and one capacitor with a PV source are used. In this topology, a leg of the switched capacitor is cascaded with the H-bridge structure. The capacitor (C) is charged to the DC input voltage of V_{DC}. The proposed inverter generates different output levels of 0, $\pm V_{DC}$, and $\pm 2V_{DC}$.

3. *OPERATION OF PROPOSED BOOST INVERTER*

Table 1 illustrates the charging and discharging operational modes as well as the parallel and series path of the capacitor for the suggested 5-Level inverter for grid-connected PV power generation. It is important to note that the power switches' ON

Table 1: Switching table of proposed boost inverter

Switching State	V_{ab}	Power Switches						Capacitors (C)
		S_1	$\overline{S}_1$	S_2	$\overline{S}_2$	S_3	$\overline{S}_3$	
μ_1	0	1	0	1	0	1	0	Δ
μ_2	$+V_{DC}$	1	0	0	1	1	0	Δ
μ_3	$+2V_{DC}$	0	1	0	1	1	0	∇
μ_4	0	1	0	0	1	0	1	Δ
μ_5	$-V_{DC}$	1	0	1	0	0	1	Δ
μ_6	$-2V_{DC}$	0	1	1	0	0	1	∇

and OFF states are represented by the numbers 1 and 0. "Δ" and "∇" denote the capacitor 'C's charging and discharging modes. The resistive load and inductive load current paths are displayed in blue and red, respectively, while the path via which capacitors are charged is depicted in green.

4. *DESIGNING OF PV WITH MPPT MODEL SELF-BALANCING MECHANISMS OF CAPACITOR*

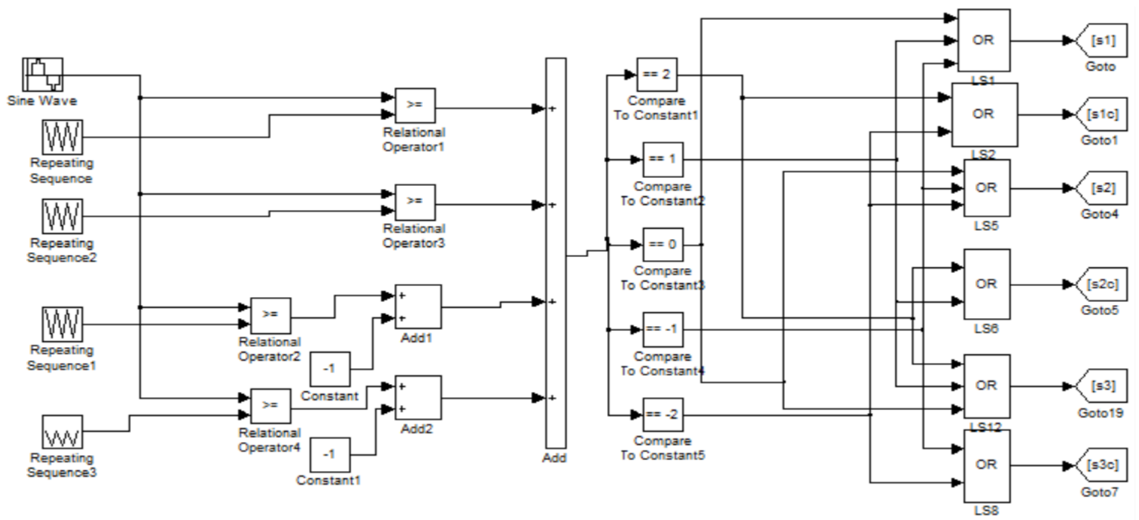

Figure 3 Simulation Model

Figure 3 shows the charging and releasing of the capacitor "*C*" at voltages level of 0, $\pm V_{DC}$ and $\pm 2V_{DC}$ respectively. Switches are used to charge the capacitor in parallel with the input supply voltage (*VDC*). When it is connected in series with the load, it releases its stored energy. Several charging durations of the capacitor occur during one cycle of the output voltage and capacitor voltages can dynamically maintain the source voltage, with some voltage ripples. This feature enables automatic balancing of the capacitor voltage. Capacitance discharge values are dependent on the load, the longest discharge time and the load power factor. Figure 3 shows the complete simulation of proposed boost multilevel inverter. The boost converter is a medium of power transmission to perform energy absorption and injection from solar panel to grid-tied inverter. The process of energy absorption and injection in boost converter is performed by a combination of four components which are inductor, electronic switch, diode and output capacitor. The process of energy absorption and injection will constitute a switching cycle. In other word, the average output voltage is controlled by the switching on and off time duration. At constant switching frequency, adjusting the on and off duration of the switch is called pulse-width-modulation (PWM) switching. The switching duty cycle, k is defined as the ratio of the on duration to the switching time period. The energy absorption and injection with the relative length of switching period will operate the converter in two different modes known as continuous conduction mode (CCM) and discontinuous conduction mode (DCM).

5. SIMULATION RESULTS

The results of proposed five-level structure are validated in MATLAB/Simulink environment. Table 2 displays the simulation parameters of the suggested work. The simulation result obtained under steady state and dynamic circumstances.

Table 2: Simulation parameters

Parameter	Specification
DC source (VDC)	100V
Output frequency	50Hz
switching frequency	10kHz
Capacitor	4200uF
R load	50 Ω
RL-Load	R=50Ω,L=100mH

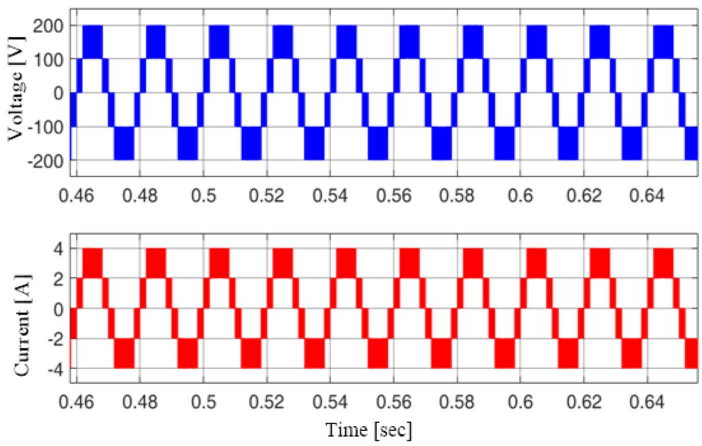

Figure 4: Output voltage and current with resistive load

Figure 4 shows the load voltage and load current with resistive load of 50 Ohm. It archives five-voltage level at the output terminal and generates boost output voltage with levels of +200V, +100V, 0, -100V and -200V.

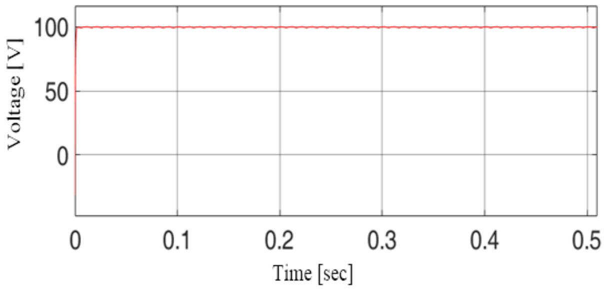

Figure 5: Capacitor voltage

Figure 5 shows the capacitor voltage with very less ripple voltage. Proposed five level inverter operates with boosting capabilities and balance the capacitor voltage at the input DC voltage 100V. Figure 6 shows the dynamic response of the proposed multilevel inverter. In this intense the resistive load change from 100 Ohm to 50 Ohm at the time of 0.5 sec. It can be clearly seen that the output voltage has not change at this time but output current has been doubled at this point. Its changes from 2A to the 4 A after doing half of the resistive load.

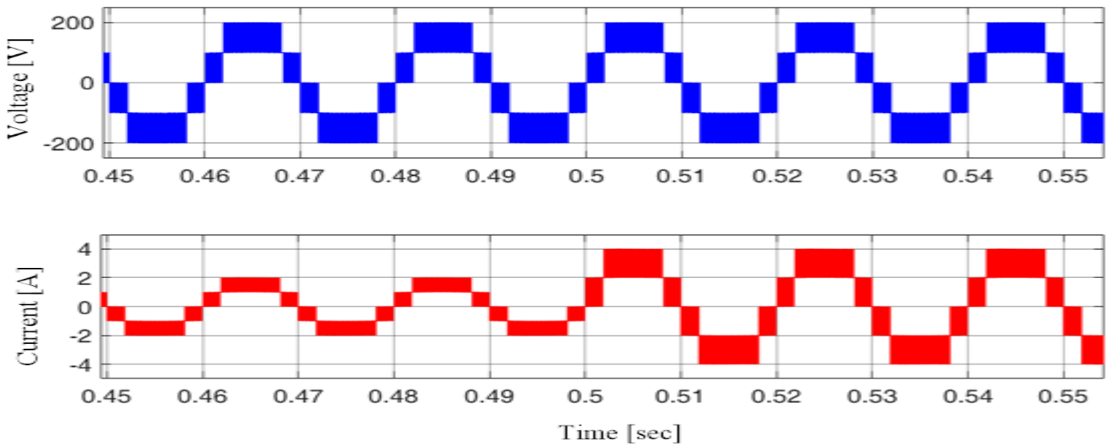

Figure 6: Output voltage and current

6. CONCLUSION

Compressors, conveyors, crushers, furnace blowers, grinding mills, pumps, rolling mills, mining hoists, and other modern industrial loads are operating with high voltages and power. Due to their drawbacks, which include the need for a greater number of power switches at higher di/dt and dv/dt ratings, conventional VSIs are no longer the preferred choice for high power applications. MLI's numerous advantages, including reduced THD, reduced EMI, and reduced switching device stresses, were recognized by a large number of power electronic researchers. As a result, MLI applications are expanding to include things like uninterrupted power supply (UPS), flexible AC transmission system (FACTS), the conversion of solar and wind energy, fuel cell and electric vehicles, and so on.

Over the past four decades, numerous MLI topologies that are suitable for various high power and voltage applications have been developed by researchers.

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