A SOLUTION TO BALANCE THE VOLTAGE OF DC-LINK CAPACITOR USING BOOST CONVERTER IN DIODE CLAMPED MULTILEVEL INVERTER

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Abstract

This paper proposes a solution to balance the voltage of dc link capacitor using boost converter in diode clamped multilevel inverter. Employing multilevel inverter with renewable energy alone, voltage balance cannot be made because high number of level increases the control complexity and therefore voltage unbalance problems is being introduced. So then we introduce a new technique where the diode clamped multilevel inverter is being combined with switched inductor multilevel boost converter. Therefore, in this case voltage unbalance problem is reduced where the entire system is simulated and executed in PSIM software. By implementing this technique high conversion efficiency can be provided and it is used for industrial drive applications and integration of renewable energy sources.

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I. INTRODUCTION

Multilevel inverter was introduced in 1975. Multilevel inverter is one of the most recent advancements in power electronics. Nowadays the multilevel inverters are preferred for high voltage and high power applications. Multilevel inverter have many advantages such as (i) low switching frequency (ii) low EMI noise (iii) low harmonic distortion, (iv) low voltage stress. There are three types of multilevel inverters, namely Diode clamped which is also called neutral point; capacitor clamped which is also called Flying capacitors and Cascaded H- bridge multilevel inverter [1-3].The synthesize output voltage have more steps, because of increasing the number of levels in multilevel inverter and it generates a staircase waveform which reduces the harmonic distortion. Due to increasing the numbers of levels in multilevel inverter the control complexity are occurred and introduce the voltage unbalance problem. In diode clamped multilevel inverter, diodes are most commonly used. This inverter provides multiple

voltage levels through different phases to the capacitor banks, where the capacitor banks are connected in series. A diode which transfers a limited amount of voltage, so it will reduce the stress on the electrical devices. Diode clamped multilevel inverter provides high efficiency because fundamental frequency is being used for all the switching devices [4-7].

The applications of diode clamped multilevel inverters are: (i) static var compensator (SVC), (ii) HVDC and HVAC transmission lines and (iii) variable speed motor drives. In diode clamped multilevel inverter DC link is made by four capacitors which are connected in series. There are two types of voltage unbalance problems are occurred in diode clamped multilevel inverter. The problems are midpoint unbalance and the central capacitor discharge. The voltage unbalance problems are reducing the efficiency of output voltage in diode clamped multilevel inverter. The conventional boost converters are used to boost the dc voltage from one level. But switched inductor multilevel boost converter to boost the dc voltage from N levels. The Switched inductor multilevel boost converter is based on two inductor, one switch, 2N+2 diodes and 2N-1 capacitors for an Nx converter [8-10]. This project will propose a clamping converter named as switched inductor multilevel boost converter integrated with renewable energy source to balance the dc link voltage of the diode clamped multilevel inverter and to develop a simulation model in PSIM software of the proposed switched inductor multilevel boost converter.

II. PROPOSED TOPOLOGY

Solar radiation becoming the most important renewable energy source. Solar panel absorbs the solar radiation to the maximum at constant temperature thereby giving its voltage and current. The block diagram of the proposed model is shown in Figure 1.
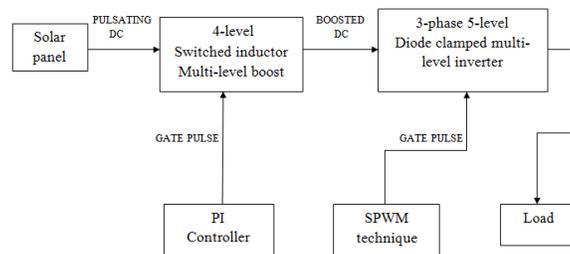

Figure 1. Block Diagram of the Proposed Model

The operation of switched inductor multilevel boost converter depends upon the gate pulse given to the switch for triggering. The switched inductor multilevel boost converter is to boost the input voltage from the solar panel. The boosted input voltage is sent to the three phase five level diode clamped multilevel inverter as input. Inverter thereby converts direct current to alternating current. Here sinusoidal pulse width modulation technique is used to generate square pulse in order to trigger the switches. Sine wave and Triangular wave is used to obtain square pulse that is ON and OFF switching process.

III. MODELING OF SWITCHED   INDUCTOR MULTILEVEL BOOST CONVERTER

Switched inductor Multilevel Boost Converter (SIMBC), based on two inductor, one switch, 2N+2 diodes and 2N-1 capacitor for N levels. The modeling of 4 level switched inductor multilevel boost converter is developed using the PSIM software shown in Figure 2. The switched inductor multilevel boost converter is to boost the input Voltage from the solar panel.
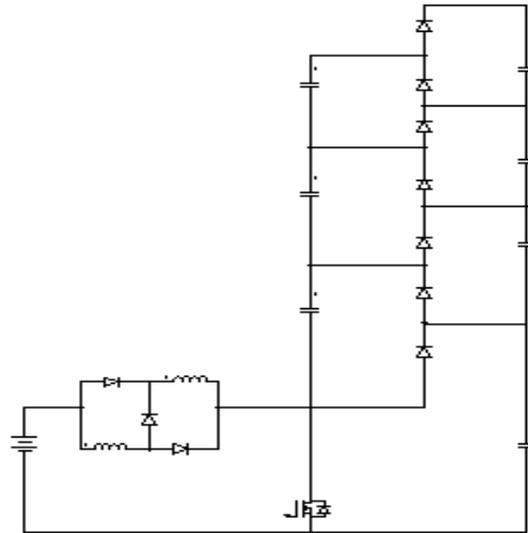

Figure 2. Modeling of switched inductor multilevel Boost Converter

IV. DIODE CLAMPED MULTI LEVEL INVERTER

In three phase 5-level diode clamped multilevel inverter the dc link is made by four capacitors are connected in series. A three-phase five-level diode-clamped inverter is shown in Figure 3. To produce an m level of the phase voltage, an m level diode-clamp inverter needs m-1 capacitors on the dc bus. The dc bus consists of four capacitors, i.e., C1, C2, C3, and C4. For a dc bus voltage Vdc, the voltage across each capacitor is Vdc/4. The four complimentary switch pairs in each phase will be i.e., Sa_1-Sa'_1, Sa_2-Sa'_2, and Sa_4-Sa'_4.

The principle of operation of DCMLI is

1. For output voltage V_{a0} =Vdc, turn on all upper switches S_{a1} through S_{a4}.
2. For output voltage v_{a0} =3V_{dc}/4, turn on three upper switches S_{a2} through S_{a4} and one lower switch S'_{a1}.
3. For output voltage v_{a0} =V_{dc}/2, turn on two upper switches S_{a3} through S_{a4} and two lower switches S'_{a1} and S'_{a2}.
4. For output voltage l v_{a0} =V_{dc}/4, turn on one upper switch S_{a4} and three lower switches S'_{a1} through S'_{a3}.
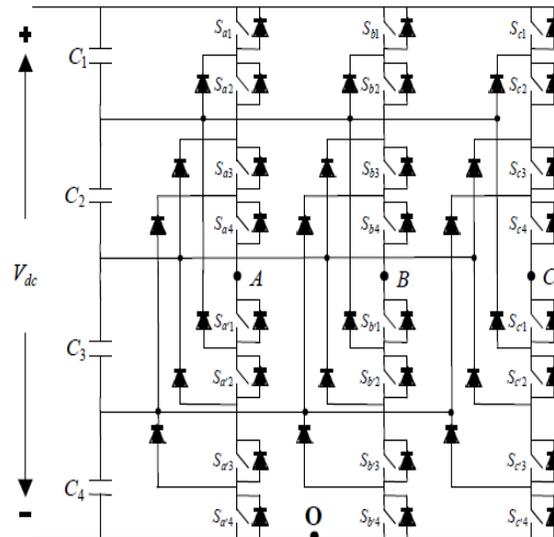5. For output voltage v_{a0} =0, turn on all lower switches S'_{a1} through S'_{a4}.

Figure 3.Three-Phase Five-Level Diode-Clamped Inverter

TABLE I. Shows the voltage levels and their corresponding switch states. State 1 means switch is on and state 0 means switch is off.

V.SIMULATION CIRCUITS

Output	Switch state							
V_{a0}	S_{a1}	S_{a2}	S_{a3}	S_{s4}	S'_{a1}	S'_{a2}	S'_{a3}	S'_{a4}
$V_5=V_{dc}$	1	1	1	1	0	0	0	0
$V_4=3V_{dc}/4$	0	1	1	1	1	0	0	0
$V_3=V_{dc}/2$	0	0	1	1	1	1	0	0
$V_2=V_{dc}/4$	0	0	0	1	1	1	1	0
$V_1=0$	0	0	0	0	1	1	1	1

In some cases two or more solar panels are being connected in series in order to obtain higher output voltage from the panel. And hereby two solar panels naming TITAN_S6_36 is being used which having their corresponding parameter values for each.

Irradiation of solar panel is 1000wb/m^2 is used as a constant value. The standard temperature of atmosphere 25°C is being applied incident on the panel. The simulation of PV panel in PSIM software is shown in Figure 4.
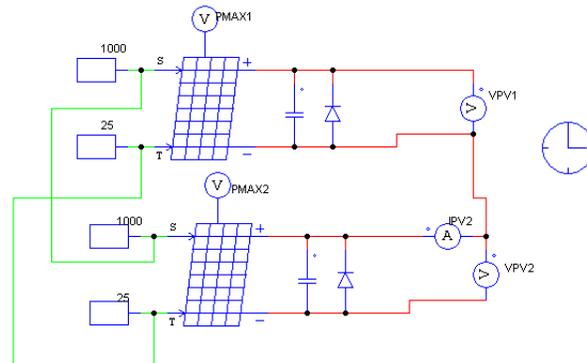
Figure 4. Simulation of PV panel

The Simulation of 4 level switched inductor multilevel boost converters is developed using the PSIM software shown in Figure 5. Switched inductor multi-level boost converter is being constructed in PSIM software using a switch IGBT, inductor, capacitor, and diode. To control the switch of the SIMBC, the PI controller gives the necessary control signal to the switch, and the PI controller gives the pulse of the switched inductor multi-level boost converter.

Switched inductor multilevel boost converter as a balancing converter for diode clamped multi-level inverter is shown in Figure 6. To use SIMBC to boost the DC voltage from the solar panel. The Switched inductor multilevel boost converter maintains the same voltage in all output capacitors.
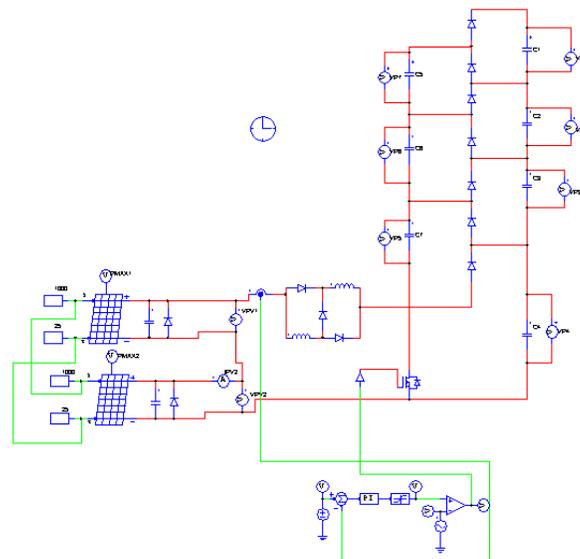

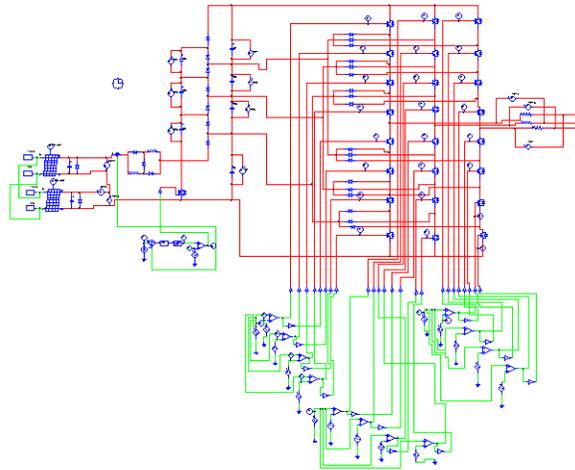Figure 5. Switched inductor multilevel Boost Converters in PSIM

Figure 6. SIMBC as a Balancing Converter for DCMLI

As we see in PSIM software circuit for an inverter we use again IGBT acting as switches which is being triggered by the use of SPWM technique which generates gate pulse. There by triggering the switches in order to produce the output which is been applied across a load probably in this case a three phase R load

A diode clamped multilevel inverter uses the sinusoidal pulse width modulation technique to achieve the desired voltage level. Since SPWM is used, it is easy to implement in the multilevel inverter circuit. The firing pulses for the switches are generated by sinusoidal pulse width modulation technique. The carrier signal is compared with reference signal for pulse generation. The subsystem block of SPWM is shown in Figure 7.
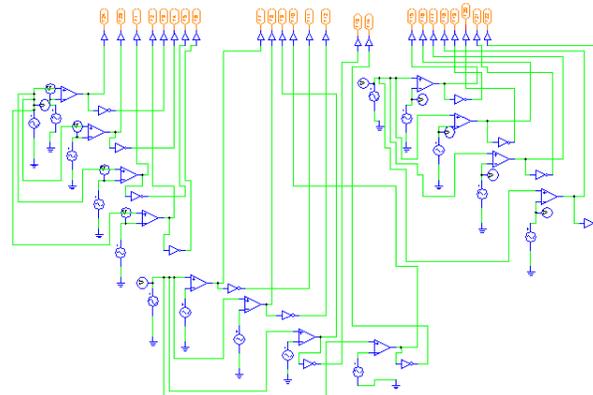

Figure 7.Subsystem Block of SPWM

VI. RESULTS AND DISCUSSIONS

The PV Panel output Voltage is shown in Figure 8. Two solar panels are being connected in series in order to obtain higher output voltage from the panel. It has been analyzed that the dc voltage is being obtained as output whose values being the same for both the panels as 20.51V for the input of solar irradiation = $1000Wb/m^2$, temperature = 25°C.

The switched inductor multilevel boost converter is used to boost the DC voltage from the solar panel. Then the

switched inductor multilevel boost converter maintains the same voltage in all output capacitors. Results Obtained from switched inductor multilevel boost converter is shown in Figure 9.
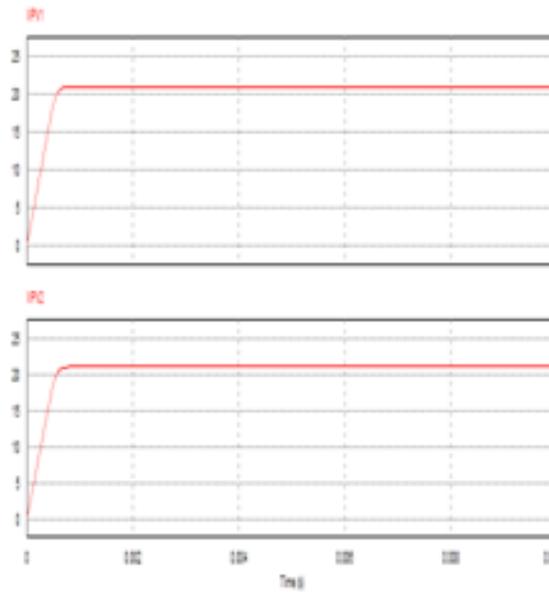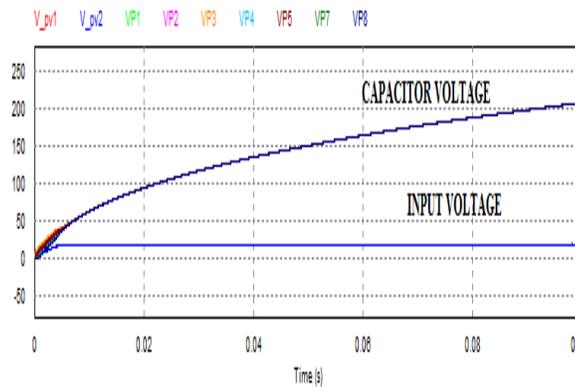

Figure 8. PV Panel Output Voltage

Figure 9. Results Obtained from Switched inductor multilevel Boost Converter

Output of R phase and three phase five level diode clamped multilevel inverter is shown in Figure 10 and

Figure 11. The line voltage consists of positive phase-leg voltage and negative phase-leg voltage.
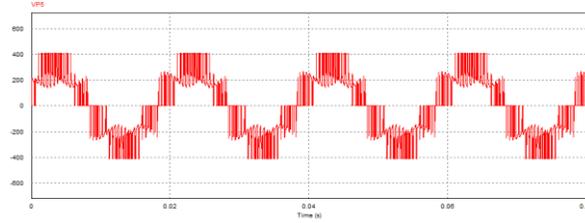

Figure 10.R phase voltage of 5 level DCMLI Waveform

Each phase-leg voltage tracks one-half of the sinusoidal wave. The resulting line voltage is a five-level staircase wave. The input, intermediate and output voltages of the proposed system are shown in Table 2.
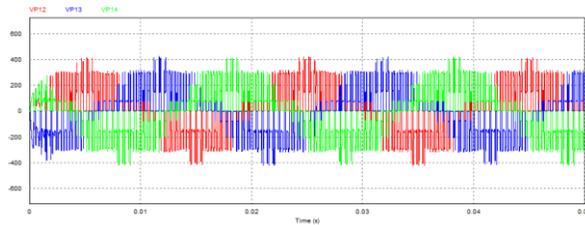

Figure 11.Output of Three Phase Five Level Diode Clamped Multilevel Inverter

TABLE II. Results of the Proposed   System

COMPONENTS	TYPE OF VOLTAGE	MAGNITUDE OF VOLTAGE
Solar Panel 1	Pulsating dc voltage	20.51V
Solar Panel 2	Pulsating dc voltage	20.51V
Voltage across each capacitor	DC voltage	136V
3 phase 5 level DCMLI	AC voltage	422V

VII. CONCLUSION

This paper proposes a solution to balance the voltage of dc link capacitor using boost converter in diode clamped multilevel inverter. The proposed Switched inductor multilevel Boost Converter (SIMBC) integrated with renewable energy source to balance the dc link voltage of the diode clamped multilevel inverter (DCMLI).A three phase five level diode clamped multilevel inverter uses the sinusoidal pulse width modulation technique to achieve the desired voltage level. Since SPWM is used, it is easy to implement in the multilevel inverter circuit. Therefore, in this case voltage unbalance problem is reduced where the entire system is simulated and executed in PSIM software. By implementing this technique, high conversion efficiency can be provided.

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