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Voltage Balancing In Diode Clamped Multilevel Inverter Using Multilevel Boost Converter

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ABSTRACT:Without using multilevel boost converter voltage balance cannot be made because the number of level increases in diode clamped multilevel inverter the control method gets complexity. So that voltage unbalance problems are occurred in diode clamped multilevel inverter. The voltage unbalance problems are midpoint unbalance and the central capacitor discharge. This paper proposes a multilevel boost converter integrated with renewable source to balance the dc link voltage of the five level diode clamped multilevel inverter. . Therefore, in this case voltage unbalance problems are determined and the efficiency of the motor is improved. The hardware setup of the proposed system is designed to balance the voltage of capacitor in multilevel boost converter. By implementing this technique, high conversion efficiency can be provided.

KEYWORDS: Multilevel Boost Converter (MBC), voltage unbalance problem, Diode Clamped Multilevel Inverter (DCMLI), high efficiency, midpoint unbalance.

I.INTRODUCTION

Multilevel inverter is one of the latest advancements in power electronics. Nowadays the multilevel inverters are used for medium voltage and high power applications. The synthesize output voltage have more steps, because the number of level increases in multilevel inverter the staircase waveform will be generate and it reduces the total harmonic distortion. The number of level increases in multilevel inverter the control method gets complexity, so voltage unbalance problems are occurred in diode clamped multilevel inverter.

The voltage unbalance problems are midpoint unbalance and central capacitor discharge. Multilevel inverters have some advantages, its provides (i) low switching frequency (ii) low harmonic distortion, (iii) low voltage stress, (iv) high efficiency (v) ability to operate without magnetic components. 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].

Diodes are mostly used in diode clamped multilevel inverter. This inverter will provides a several voltage levels during different phases to the capacitor banks. Fundamental frequency is used for all the switching devices, so that the diode clamped multilevel inverter provides high efficiency. The applications of diode clamped multilevel inverters are: (i) High voltage DC and High voltage AC transmission lines (ii) static var compensator (SVC) and (iii) variable speed motor drives. The number of level increases in multilevel inverter, the control of the inverter should be complex. So those voltage unbalance problems are introduced in diode clamped multilevel inverter [4-6].

There are two types of voltage unbalance problems. The problems are: (i) Midpoint unbalance and (ii) Central capacitors 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 multilevel boost converter to boost the dc voltage from N levels. The multilevel boost converter is based on one inductor, one switch, 2N-1 diodes and 2N-1 capacitors for an Nx converter [7-10]. This project will propose a multilevel boost converter integrated with renewable energy source to balance the voltage of dc link capacitor in diode clamped multilevel inverter.

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II. PROPOSED TOPOLOGY

Solar panel absorbs the maximum solar radiation at constant temperature thereby giving its voltage and current. The solar panel voltage is given to the multilevel boost converter. PWM control method is used to generate the gate pulse for the switch of multilevel boost converter. The multilevel boost converter to boost the dc voltage from the solar panel, then the boosted dc voltage to have given the 3phase 5level diode clamped multilevel inverter. The SPWM method is used to trigger the switch of DCMLI. The ATmega8 microcontroller is used to control the switch of both MBC and DCMLI and then the inverter voltage is given to the AC load. The block diagram of the proposed model is shown in Figure 1.

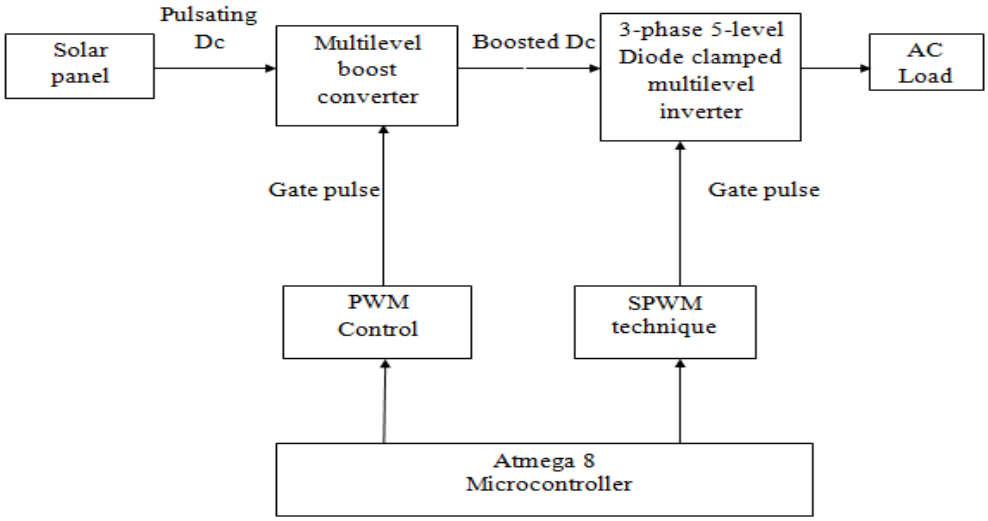

Figure 1. Block Diagram of the Proposed Model

(i) Multilevel boost converter

The multilevel boost converter is based on one inductor, one switch, 2N-1 diodes and 2N-1 capacitors for an Nx converter. The operation of multilevel boost converter depends upon the gate pulse is given to the switch for triggering. The multilevel boost converter is to boost the input voltage from the solar panel. The Modeling of Multilevel Boost Converter is shown in Figure 2.

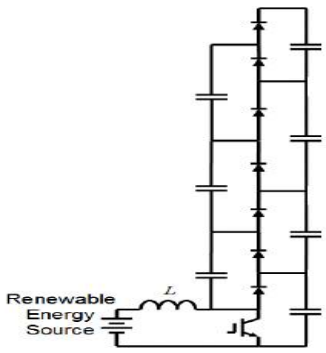

Figure 2.Modeling of Multilevel Boost Converter

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(ii) Diode Clamped Multilevel Inverter

In diode clamped five level converter dc link is made by four capacitors and the capacitors are connected in series. The dc link capacitors consist of C_1, C2, C3, and C4. For a DC bus voltage across each capacitor is Vdc/4. The complimentary switch pairs in each phase will be i.e., Sa_1-Sa'_1, Sa_2-Sa'_2, and Sa_4-Sa'_4. The circuit diagram of Diode-clamped five level converters is shown in Figure 3.

The principle of operation of DCMLI is

1. For output voltage $V_{a0} = V_{dc}$, 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}.

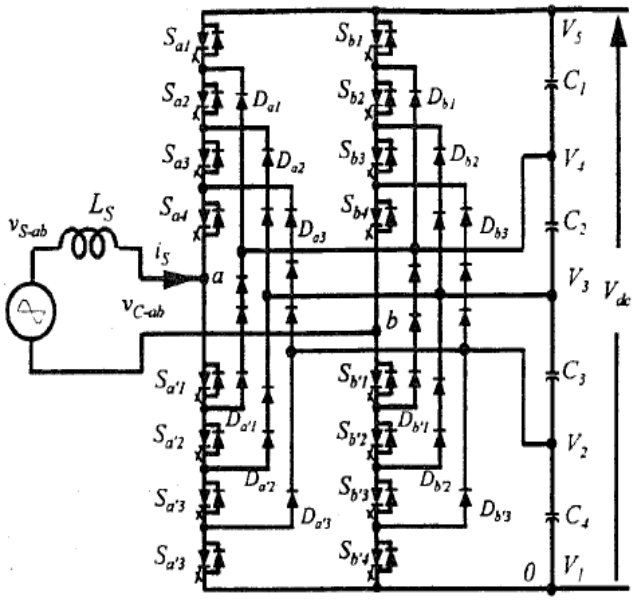

Figure 3. Circuit Diagram of Diode- Clamped 5- Level Converter

Table 1 shows the voltage levels and their corresponding switch states. State 1 means switch is on and state 0 means switch is off.

Table 1. Switching states

Output V_{a0}	**Switch state**							
	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

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III. HARDWARE RESULTS

The hardware setup of the proposed system is shown in Figures. Figure 4 shows Multilevel boost converter, Figure 5 shows Diode clamped multilevel inverter; Figure 6 shows Gate drive circuits and Figure 7 shows AT mega 8 microcontroller. Table 2 shows the components ratings.

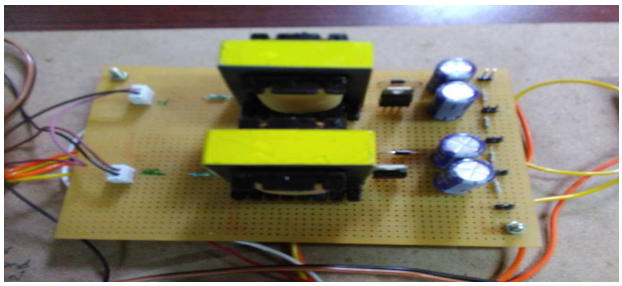

Figure 4. Multilevel boost converter

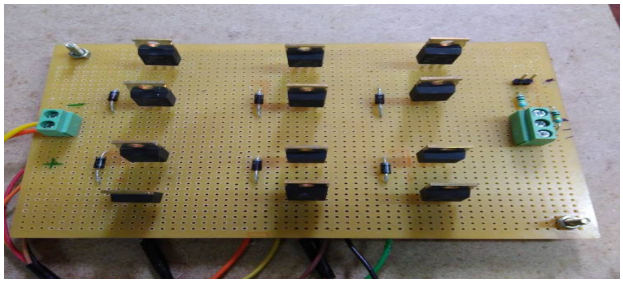

Figure 5. Diode clamped multilevel inverter

Table2. Components ratings

Components	Ratings
Inductor	222µH
MOSFET switch	IRF840,500V,8A
Diode	IN4007,1A
Capacitor	1000µf,25V
Resistor	1K
Driver IC	IR-2110

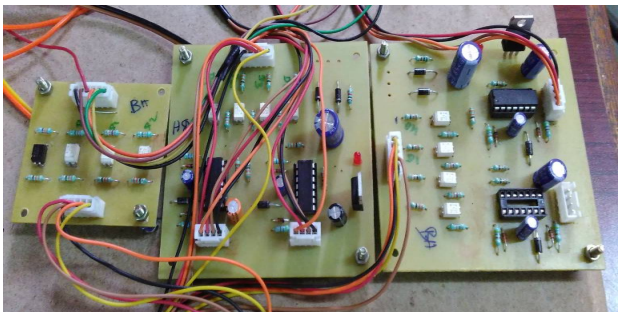

Figure 6. Gate drive circuits

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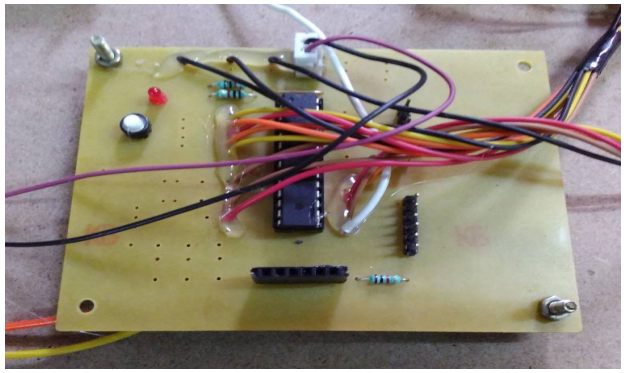

Figure 7. AT mega 8 microcontroller

The overall setup of the proposed system is shown in Figure 8. The solar panel absorbs the solar radiation from the sun to give the maximum voltage of 24V. Solar panel is connected to the battery; the battery stores the solar panel voltage. The input of solar panel voltage is given to the multilevel boost converter. This converter is utilized to boost the dc voltage from the solar panel. The current sensor is used to sense the current of the switch of multilevel boost converter, then the boosted dc voltage of 78.2 V is given to the input of single phase five level diode clamped multilevel inverter. Gate drive circuits are used to drive the MOSFET switch, and it's used to improve the current gain. The AT mega 8 microcontroller is used to trigger the gate pulse of MOSFET switch for both multilevel boost converter and diode clamped multilevel inverter. Thus the inverter output voltage of 142 V is obtained and it is given to the AC load.

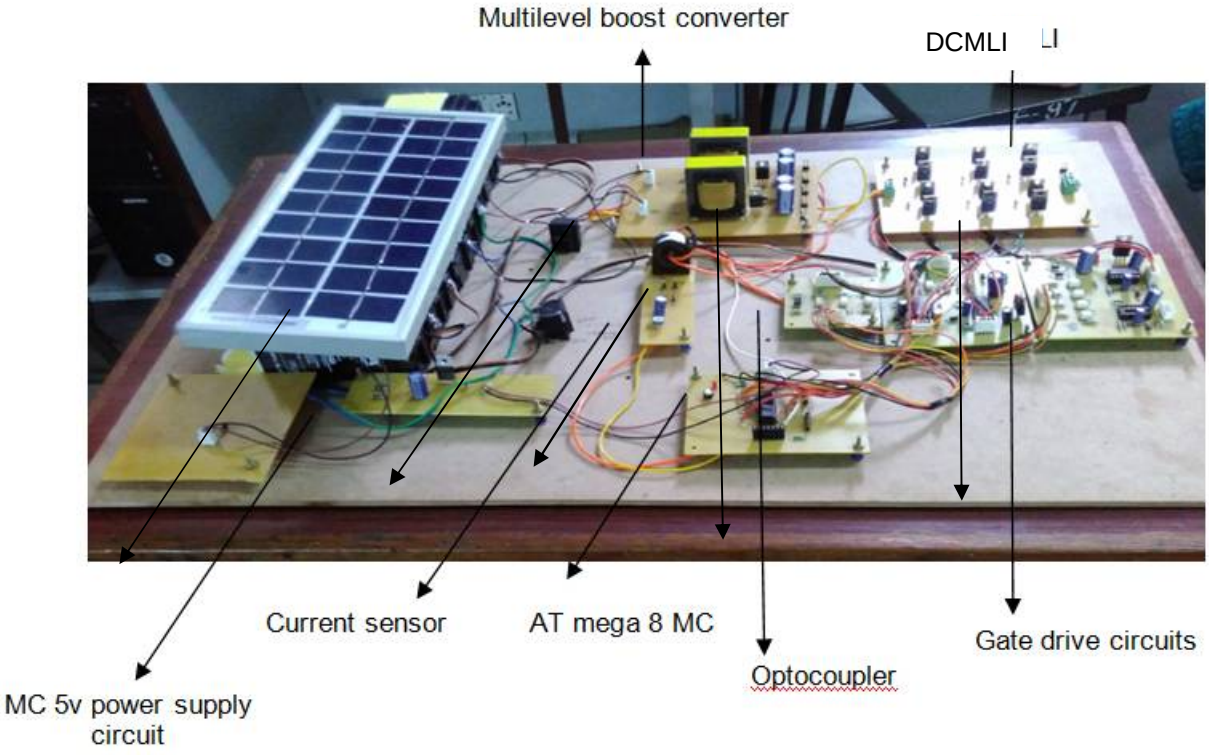

Figure 8. Overall setup of the proposed system

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IV. RESULTS AND DISCUSSION

The output voltage of multilevel boost converter is 78.2V, and then voltage across each capacitor is 11.1V. Figure 9 and Figure 10 shows output of MBC and output of voltage across each capacitor.

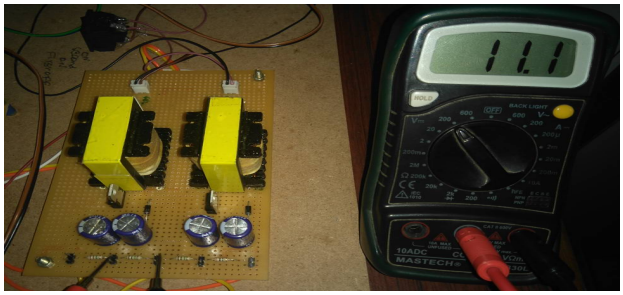
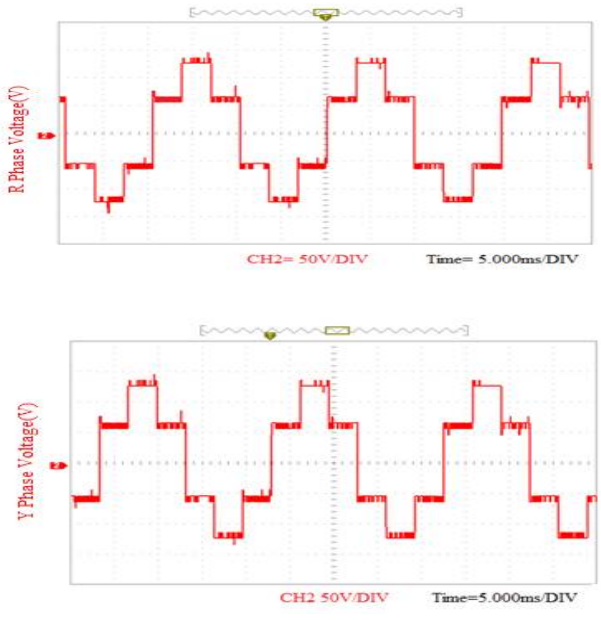


Figure 9. Output of MBC

Figure 10. Voltage across each capacitor

Figure 11 shows the output voltage of diode clamped multilevel inverter and the output voltage is 142 V.



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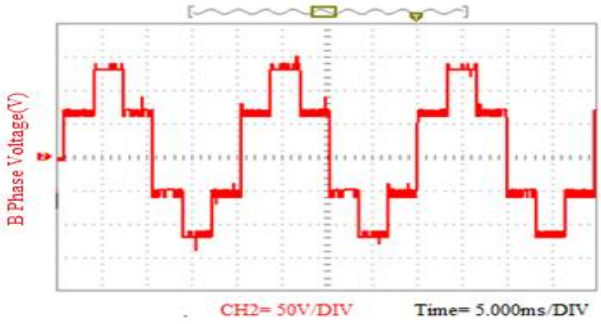

Figure 11. Output of DCMLI

V. CONCLUSION

This paper proposes the voltage balancing in diode clamped multilevel inverter using multilevel boost converter. To balance the voltage of dc link capacitor in diode clamped multilevel inverter using multilevel boost converter is achieved. The multilevel boost converter is based on one inductor, one switch, 2N-1 diodes and 2N-1 capacitors for an Nx converter. Therefore, in this case voltage unbalance problems are determined and the efficiency of the motor is improved. The hardware setup of the proposed system is designed to balance the voltage of capacitor in multilevel boost converter. By implementing this technique, high conversion efficiency is obtained.

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