Controlling Three Level Diode Clamp Inverter With DC-DC Converter In Standalone Application

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Abstract: Electricity may be produced using fuel cells or photovoltaics. As a result, high gain converters are needed in microgrids to match the DC bus voltage. Switching capacitors are used by these high gain converters to produce the necessary DC bus voltage. Switched capacitors work in parallel and series to limit reverse voltage and create high static gain. One switch, minimal component stress, high voltage gain, and low ripple current are all requirements that a special converter is proposed to meet. The input voltage to a diode-clamped multilevel inverter is controlled by this DC-DC converter. The output of the dc-dc converter is fed into a diode clamped inverter, and MATLAB/SIMULINK tracks the functioning of the converter.

Keywords: DC-DC Converter, Average current control, voltage gain, multilevel inverter

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1. Introduction:

Over the course of the last decade, there has been a considerable increase in the use of solar panels. Increasing the voltage level of PV generation often requires using a technique that involves connecting the PV panels in a series of connections. However, because to partial shade and module mismatches, the PV panels' output power is reduced by a significant amount [1]. When this is the case, the configuration of the PV panels in which they are linked in parallel is superior to the configuration in which they are connected in series [2]. Despite this, the PV output voltage of the panels that are linked in parallel is not very high. In order to increase the PV voltage to high levels, therefore, DC-DC converters with significant voltage gains are necessary. A standard DC-DC boost converter has the potential to deliver a large voltage gain; but, in order to do so, it requires operation with an extremely high duty cycle that is quite near to unity. Operating under a high duty cycle will cause an increase in the voltage and current stresses that are placed on the components. Additionally, the converter will suffer from high conduction losses due to the fact that the power switch will conduct for a significant amount of time in the immediate vicinity of the switching period. In addition, the output diode will only conduct for a very little amount of time, which will result in the diode having a major difficulty with its ability to recover from reverse current [3]. Adjusting the turns-ratio of the transformer is the typical method that isolated converters use to attain high-voltage gains. However, they have a high cost, huge voltage spikes on the switches as a result of the leakage inductance of the transformers, and the power dissipation would affect the overall efficiency [4]. In addition, the transformers' leakage inductance can cause enormous voltage spikes. In contrast, non-isolated high step-up DC-DC converters are becoming suitable solutions for improving system efficiency and reducing the cost of the system in PV applications due to the elimination of galvanic isolation transformers. This is possible because these converters do not require an isolation transformer. The following is a list of the most important requirements that must be met by DC-DC converters for use in photovoltaic (PV) applications: the ability to draw a continuous input current while maintaining a low ripple in order to accurately perform the maximum power point tracking (MPPT) function; the accomplishment of a high-voltage gain while maintaining a low or medium duty cycle; the presence of low voltage stresses on the switches; a simple structure with a low number of components and high efficiency; and finally, For applications requiring high step-up, a great number of non-isolated DC-DC converters have been proposed.

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For applications requiring high step-up, a great number of non-isolated DC-DC converters have been proposed. These converters make use of voltage boosting methods such as switched-capacitor (SC) cells, coupled inductors, and switched-inductor (SL)/voltage-lift (VL) cells [5-6]. In addition to this, high step-up DCDC converters that are developed from their isolated counterparts may be found [7].

In this article, a converter [9] with improved voltage gain was built out of switched capacitor cells, as can be seen in Figure 1. This high gain converter incorporates switching capacitors into its design so that it can achieve the required DC bus voltage for use in applications involving renewable energy. Switched capacitor circuits act in series and parallel during switching operation, which results in a high static gain and a limitation on the reverse voltage that appears across the components. These benefits are achieved by combining series and parallel operations. The diode-clamped inverter is connected in cascade with this Converter. The output of the high gain converters is fed into the multilayer inverters so that the quality of the voltage that is produced may be improved. This is done in order to make the voltage more stable. The diode-clamped Cascade topology and the flying capacitor topology are the two multilevel inverter topologies that are utilized the majority of the time. Previous studies have shed light on a number of different modulation techniques that may be applied in order to switch between different topologies. The two methods that are utilized the great majority of the time are known as carrier-based modulation and space vector modulation. Because of the simplicity with which they may be implemented and the low amount of computing power that is required, carrier-based approaches will most certainly continue to be widely used in the foreseeable future. When developing carrier-based modulation algorithms for use in diode-clamped inverters, the carrier disposal strategy is frequently employed as the basis for the construction of the foundational algorithms. The performance of a converter that uses a diode clamped multilevel inverter is discussed, along with the converter's steady-state analysis, the mechanism that it uses to manage current, and the results of its simulation in MATLAB/SIMULINK.

2. DC-DC Converter

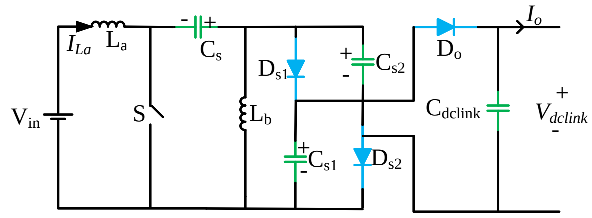

Figure.1 Modified sepic converter

The circuit diagram of dc-dc converter is shown in Figure 2. When the switch S is ON, the inductors L_a and L_b store energy from the supply and capacitor Cs respectively. The series connected switched capacitor cells C_{s1} and C_{s2} supply energy to the load. When switch 'S' is OFF switched capacitors C_{s1} and C_{s2} are charged by both the inductors La and Lb. The voltages across the capacitors C_{s1} and C_{s2} are equal. Let the voltage across the capacitor Cs and C_{s1} be Vcs, and Vceq, respectively, voltage across the switch 'S' be VQ , the current through the inductor L_a be IL_a and load current be Io.

3. 1-phase 3 level multilevel inverter:

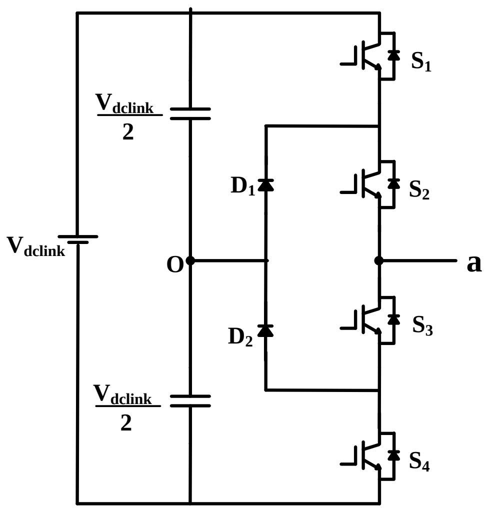

Fig.2. single phase 3 level Diode clamp MLI

As part of the process of analysis, the node with a potential of 0 V, denoted by the letter "o," will serve as the reference point. The difference in potential energy that is present in the circuit between point "a" and point "o" is the load voltage, and it is represented by the symbol vao. This difference is designated as the load voltage (t). As shown in figure 2, the value of vao(t) is equal to $V_{dclink}/2$ when both S1 and S2 are active at the same time. The voltage stress that is present across the devices while they are in the OFF state is equal to $V_{dclink}/2$, which is the same as saying that it is half of the DC link Voltage. When the devices are in the OFF state. The load voltage is 0 volts whenever switches S2 and S3 are both activated at the same time. If the load current is positive at this moment, then the current will conclude its travel through S2 and D1 and arrive at its destination. If the load current is negative, then the current will not complete its journey. If the direction of the load current is negative, then it will complete its circuit by going via S3 and D2 before reaching its destination. Once more, the component that can be found in the OFF block possesses a voltage that is the same as V_{dclink} divided by two. The load voltage that is attained is $-V_{dclink}/2$ whenever switches S3 and S4 are both turned ON at the same time. The voltage stress that is placed across the devices that are OFF in this scenario is also equal to $V_{dclink}/2$. This is the case in the previous scenario as well. Consequently, the utilization of these three states will result in the manufacture of three levels, which are as follows: $+V_{dclink}/2$, $-V_{dclink}/2$, and 0.

4. Current mode controller:

It is feasible to regulate both the output voltage and the output current of a switch mode power supply using the current control approach. It is commonly used for boost mode converters. During each power switch on-time, the voltage error signal is employed to manage the peak current within the magnetic components. Current mode control provides a very fast input and output reaction time, as well as built-in over-current safety. It is frequently used in forward mode converters. [8] In comparison to voltage-mode control, current-mode control adds an inner control loop control. The duty cycle is controlled by sensing the inductor current. When the output voltage Vo is compared to the reference voltage Vref, an error signal is generated. This error signal generates control signal ic. The inductor current is then measured and compared to the control signal ic in order to create the duty cycle of the switch and operate the converter's switch. When the feedback loop is closed, the inductor current is proportional to the control signal ic, and the output voltage equals the reference voltage Vref.

5. Simulation Results:

The above discussed dc-dc converter, multilevel inverter and its closed loop control is carried out in MATLAB/SIMULINK. The dc-dc converter was supplied with a dc value of 30 V. The input voltage 30 V is stepped upto 150 V with the help of converter shown in figure.1. The obtained 150 V from the converter is applied to the 1-phase 3 level diode clamped multi level inverter. The average current control method is implemented to the dc converter to obtain the steady state response from the dc converter. The results are obtained are discussed as follows.

Figure.3 shows the inductor current ILa with input voltage of 30V. The value of current is 8 A. Figure.4. shows the output voltage of a dc converter. Its value is 150V. Figure.5. is the 1-phase 3 level output voltage from a diode clamped multilevel inverter. This voltage is obtained with the Vdclink voltage of 150V. Figure.6. shows the output voltage of a dc converter. Its value is 200V. Figure.7. is the 1-phase 3 level output voltage from a diode clamped multilevel inverter. This voltage is obtained with the Vdclink voltage of 200V.

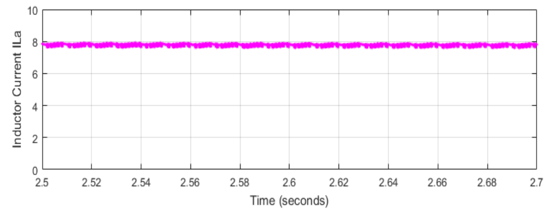

Figure.3. Inductor current ILa in dc converter

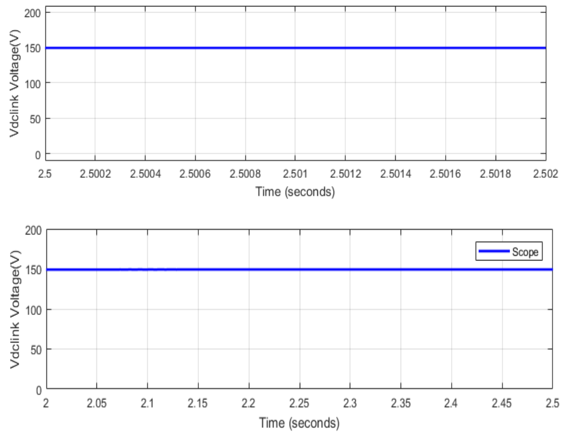

Figure.4. Vdclink voltage of dc converter

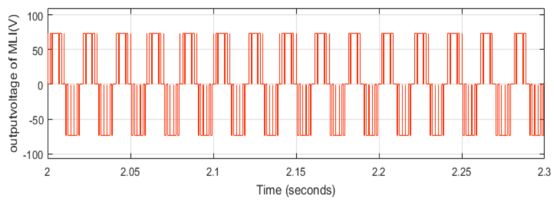

Figure.5. Single phase output voltage of MLI

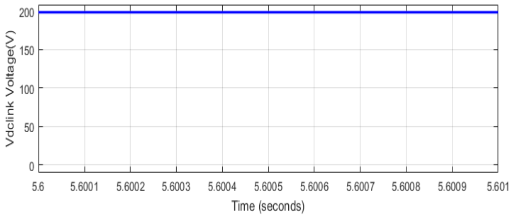

Figure.6. Vdc link voltage of dc converter with change in the reference value

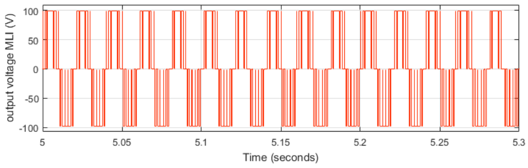

Figure.7. Single phase output voltage of a MLI

6. Conclusion:

The high gain dc converter increases the voltage with a lower duty ratio and reduces the reverse voltage that arises across the components. This Converter is linked in series with a diode-clamped inverter. The steady-state performance of a converter using a diode clamped multilevel inverter is examined using the average current control approach.

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