Abstract: Nine level inverter and converter which is used for solar powered utilities was proposed. The inverter has 7 switches in main circuit and 1 switch for high frequency switching for the generation of nine level output. The output in the inverter reduces overall THD, loss due to switching and improves the efficiency of the power in the output. In this paper the control circuit is simplified by using capacitors to balance the voltage automatically. Using MATLAB/Simulink simulation results are explained in detail.

Keywords: Converter, multilevel inverter, solar powered utilities and MATLAB/Simulink.

I. INTRODUCTION

In Multilevel inverter there are 3 types

1. Flying capacitor
2. Diode clamped and
3. Cascaded.

In first two types of multilevel inverter capacitor is used to build step voltage but not easy in capacitor voltage control. Power and output of voltage can be increase with increase in levels. For the proposed 9 level inverter there are 14 power electronic switches in both first two types but in cascaded type only 7 main switches are used. However in recent years, there are different type of techniques are used to develop a 9 level inverter. The switching devices in the multilevel inverter do not have any voltage shared in the circuit problems. Thus it has more advantages and the major application of this types are in large motor drives and utilities.

II. PROPOSED CIRCUIT CONFIGURATION & MODES OF OPERATION

The proposed multi level inverter with power converter shows in the configuration of Fig 1.

A solar cell utility is connected to power converter which transforms the power in the output into two voltage sources supplies to the inverter and the power converter which is a boost converter connected with a transformer turns ratio of 2:1. The proposed inverter consists of full bridge converter and the capacitor are in cascaded, the capacitor selection in the circuit which give four level DC output and the bridge converter convert this four level DC output to nine level AC output.

Fig 1. Multi Level Inverter with Power Converter

Fig 2a. Operation of Power Converter (SD1 is ON)

A power converter combines current fed converter with a boost converter shows in the Fig 2a.

It consists of a diode, a inductor, a switch which charges C2 & capacitor C1 is charged by the current fed converter consists of diode, inductor, transformer and the switches.

Fig 2b. Operation of Power Converter (SD1 is OFF)
From the Fig 2b, when the switch SD1 is OFF position and SD2 ON position, the C1, C2 capacitors are in parallel to transformer, therefore energy in the inductor flows in the capacitor through diode D3 and charge capacitor C1 through the transformer and diode D2 in the off state of switch SD1.

The capacitor voltage ratio C1: C2 is same as that of the turn ratio 2:1 of the transformer because capacitors are charged with the help of transformer in parallel. The boost converter in the circuit which the conduction is continuous mode of operation.

Voltage in the capacitor C2 is,

\[ V = S \]

And C1 is,

\[ V = S \]

The working of 9 level inverter is split into positive half cycle & negative half cycle. In analyzing, the ideal switches in the circuit and the diodes, C1, C2 constant which is equal to Vdc/4, Vdc/2, output is sinusoidal controlled and in phase voltage, the output current obtained in the 9 level inverter is also positive in first half cycle.

The working principle of the 9 level inverter in the first half cycle is divided into following modes in Fig 3.

**Mode 1:** Working principle is Switches S1 and S2 OFF, output is Vdc/4. S1 and S4 ON, then the voltage in the output of the inverter is Vdc/4.

**Mode 2:** S1 is OFF and S2 ON, the output is 3Vdc/4. S1 and S4 ON, then the output is 3Vdc/4.

**Mode 3:** D2 reverse bias so S1 is ON and S2 either ON or OFF because the S2 state cannot disturb flow of the current, C1, C2 is discharged in series in the output circuit output is Vdc/2. S1 and S4 ON, output is Vdc/2.

**Mode 4:** S1 and S2 OFF, the output is Vdc. S1 ON, the inverter output current is positive S1 to switch ON forcibly for continuous conduction of filter with inductor current.

**Mode 5:** S1 and S2 OFF, the output is Zero.
Inverter another half cycle, the current obtained in the output is also negative. It is divided into the above modes and it is shown in the Fig 4. Compared with positive cycle, the negative cycle has the difference is Switch \( S_2 \) and \( S_3 \) ON during 5, 6, 7, 8 modes and \( S_2 \) may ON or OFF during mode 9 of negative half cycle.

III. SIMULATION CIRCUITS AND RESULTS

MATLAB software is used for simulation to analyze and to verify the circuit operation, characteristics of the proposed system. The Fig 5a. shows the circuit diagram for nine level inverter consists of seven main switches and four balancing capacitors to balance the output of nine level.

The voltage given as input is from the solar power closed loop irradiance level and the output is then to the inverter.

It is generated for 20ms period by the pulse generating circuit and the phase delay is different for each switches to operate.


IV. CONCLUSION

The proposed inverter system consists of power converter with 9 level inverter. The existing 7 level inverter contains 6 switches and the 9 level inverter contains only 7 switch to create the stepped ac sinusoidal output waveform. The proposed inverter has reduced number of balancing capacitors to balance the voltage automatically. Simulation results in the proposed inverter generates the output of nine level and the output voltage, output current are in phase with voltage utility and also the THD reduces when increase in the number of levels.

REFERENCE


Fig 5e. Output 9 level Inverter voltage waveform

Fig5f. THD Analysis of Nine level Inverter

Fig5f. THD analysis of 1q 9 level inverter where the THD level in the 9 level inverter is 10.80%.

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