Single Phase Thirteen Level Inverter using BI Directional Switches and reduced Switch Count for PV Systems

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Abstract - Renewable energies have advantages of zero fuel cost and reduced environmental impacts. This paper proposes an Asymmetrical Thirteen level H-Bridge inverter circuit. Two inputs from solar PV panels are given to the converter and maximum power is extracted by using maximum power point tracking method. Integrated converter is DC to DC Boost converter. The output is given to H- inverter which converts dc to ac and the thirteen level output voltage is applied to load. Operational analysis and simulation results are given for the proposed circuit.

Index Terms— Dc-Dc Boost converter, FPGA controller, H-Bridge inverter with bi-directional switch circuit, Total harmonic distortion (THD).

I. INTRODUCTION

With increasing concern in renewable energy systems with various sources becomes greater than before. Renewable energy sources such as photovoltaic (PV) and wind energy can be used to enhance the safety, Reliability and sustainability of a power system. Renewable energy resources will increasingly an important part of power generation in the new millennium. There is an enormous need for integrated power converters that are capable of interfacing and controlling several power terminals with low cost and compact structure. The utilization of natural energy is recognized as a new energy source which will eventually replace conventional energy sources. Renewable energy sources do not have the high external cost and social issues. Renewable energy sources such as wind, solar, fuel cell holds more potential to meet our energy demands. This proposal focuses on control of one major renewable-energy source PV and the output of the PV panel is converted to AC by using the thirteen level asymmetrical H-bridge Inveter configurations.

II. MULTILEVEL INVERTER

Multilevel inverter is the generation of high voltage using lower voltage rating devices connected in series. Also it has the potential to get a high quality output voltage by producing multi output voltage levels. However it increases the number of switching devices and other components, which result in an increase of complexity problems and systems cost.

Many multilevel inverter configurations have been researched to get sinusoidal like output voltage wave with minimum circuit components.

A Multilevel inverter has several advantages over a conventional two level converter that uses high switching frequency pulse width modulation (PWM). The attractive features of a multi level inverter can be briefly summarized as follows. Staircase waveform quality: Multilevel inverters not only can generate the output voltages with low distortion, but also can reduce the dv/dt stresses; therefore electromagnetic compatibility (EMC) problems can be reduced. Common mode voltage: Multilevel inverters produce small CM voltage, therefore the stress in the bearings of a motor connected to a multilevel motor drive can be reduced. Furthermore CM voltages can be eliminated by using advanced modulation technique. Input current: Multilevel inverters can draw input current with low distortion. Switching frequency: Multilevel inverters can operate at both fundamental frequency and high switching frequency PWM. It should be noted that lower switching frequency means lower switching loss and higher efficiency. There are several multilevel converters are commercialized for high power applications such as Flexible AC transmission systems (FACTS) Controllers, Train Traction, Automotive applications, renewable energy power conversion and transmission etc.

III. PROPOSED MULTILEVEL INVERTER TOPOLOGY

The proposed single-phase Thirteen - level inverter was developed from the seven - level inverter. It comprises two single-phase conventional H-bridge inverter, two bidirectional switches, and two capacitor voltage divider formed by $C1$, $C2$, $C3$ and $C4$ as shown in Fig. The modified H-bridge topology is significantly advantageous over other topologies, i.e., less power switch, power diodes, and less capacitors for inverters of the same number of levels.
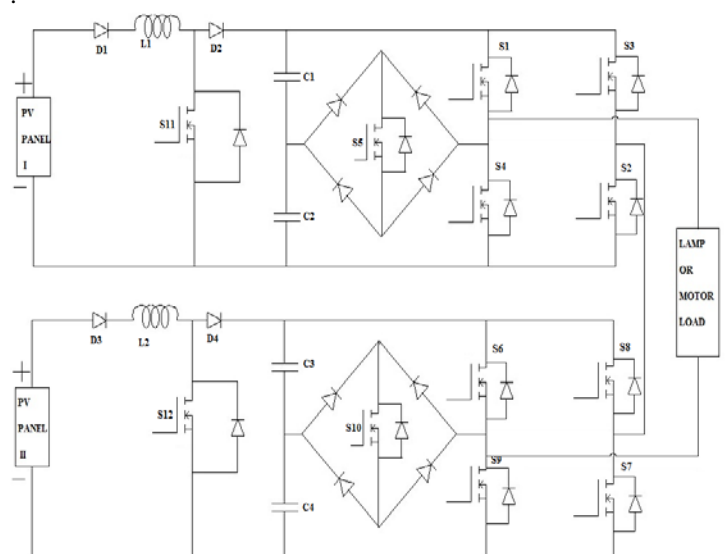

Fig 1.   Thirteen level Inverter Circuit diagram

Photovoltaic (PV) arrays were connected to the inverter via a dc–dc boost converter. The power generated by the inverter is to delivered was required because the PV to the load. The dc–dc boost converter arrays had a voltage that was lower than the load

voltage. High dc bus voltages are necessary to ensure that power flows from the PV arrays to the load. Proper switching of the inverter can produce thirteen output-voltage levels of (Vdc, 5/6Vdc, 4/6Vdc, 3/6Vdc, 2/6Vdc, 1/6Vdc, 0, -5/6Vdc, -4/6Vdc, -3/6Vdc, -2/6Vdc, -1/6Vdc,-Vdc) from the dc supply voltage.

The switching states are easily understood from the mat lab programs for both the H- bridge inverters.

PWM GENERATION

The PWM Signal was generated in this thirteen level inverter is a single reference sine wave frequency of 50 Hz is compared with a triangular carrier wave frequency of 10 KHz. The amplitude of the sine wave is taken in different offset values. There are three offset sine wave is compared with a triangular wave and the PWM.
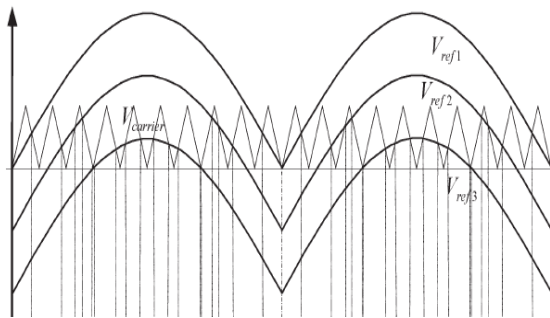
Fig 2.   PWM generation technique

IV. SIMULATION AND EXPERIMENTAL RESULTS

MATLAB SIMULINK simulated the proposed configuration before it was physically implemented in a prototype. The different amplitude of reference sine wave is compared with a triangular wave and the PWM signal is generated.

Here the switching device is MOSFET and the two bi directional devices are IGBT. The processor used here is FPGA (Field Programmable Gate Array). It's under the category of Very large scale integration system. In FPFA many of the pins are multiplexed pins. So we can use it as either input or output pins. The operating speed of the Spartan 3E controller operating speed is much greater than Digital signal processors. These controllers are used to generate the PWM pulses to the thirteen level inverter.

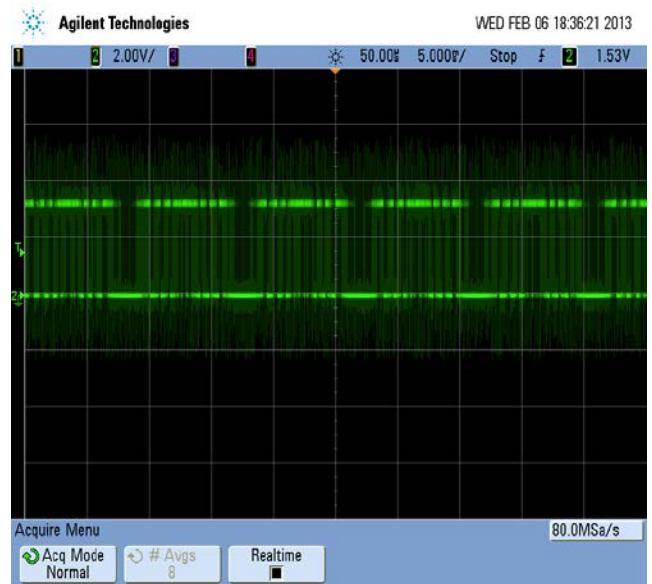Fig 3.   PWM pulses to the Inverter switch S1, S2, S3, S4

Fig 4.   PWM pulses to the Inverter switch S5

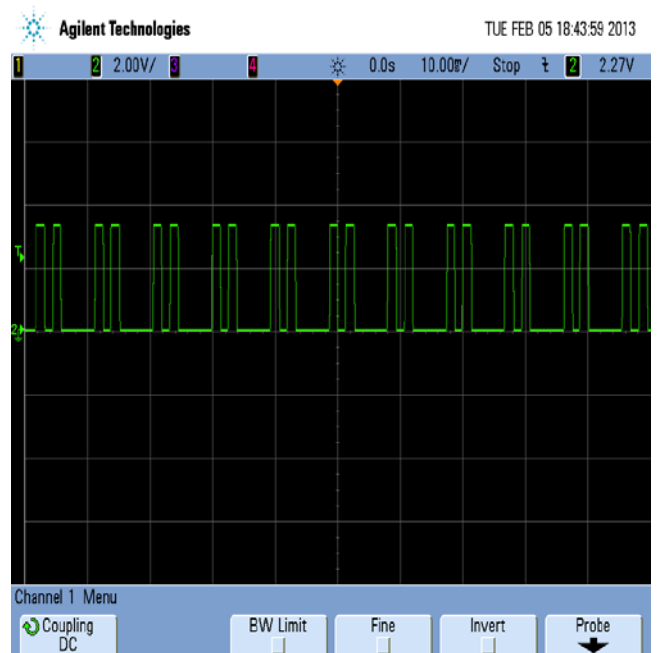Fig 5.   PWM pulses to the Inverter switches S6, S7, S8,S9

Fig 6.   PWM pulses to the Inverter switch S10

The figure shows the thirteen level inverter output voltage by using Mat lab simulation.
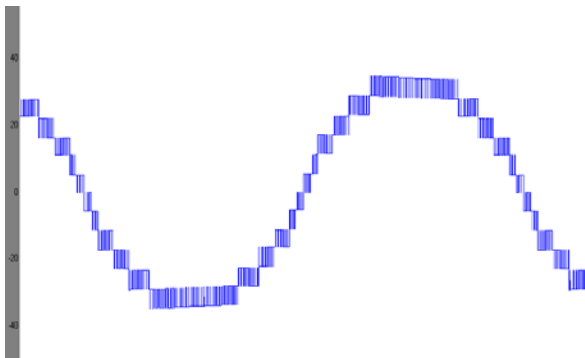

Fig 7. Thirteen level inverter simulation output voltage
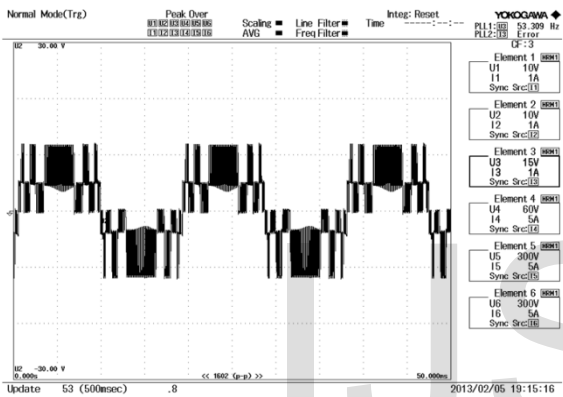

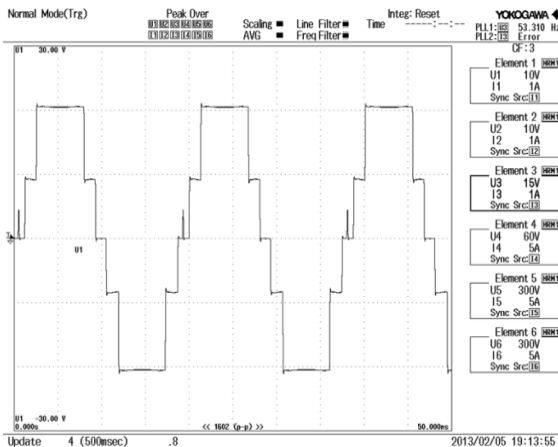Fig 8. Thirteen level inverter 1 output voltage

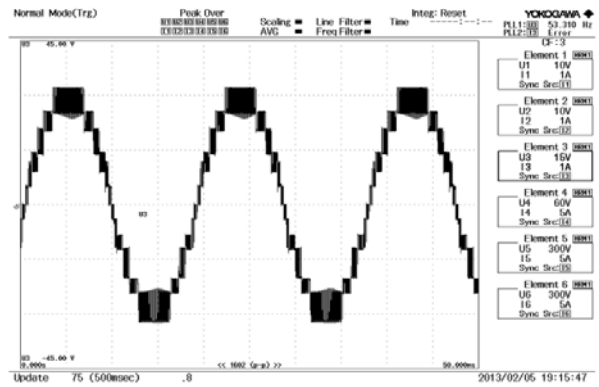Fig 9.   Thirteen level Inverter 2 output voltage

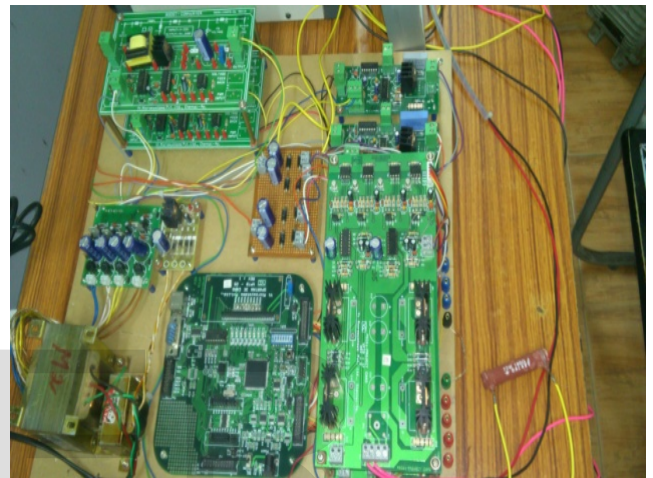Fig 10. Thirteen level inverter hardware output voltage

Fig 11. Experimental setup for the single phase thirteen levels PWM inverter.

IV.THD RESULT

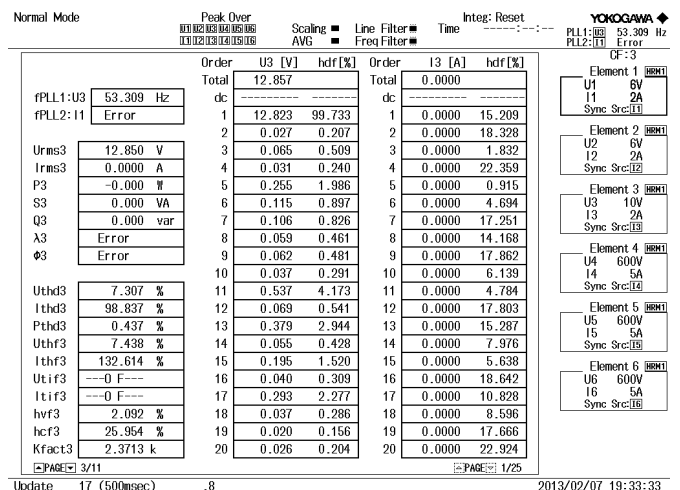By using YOKOGAWA the harmonics result is analysed.

Fig 12. THD Result.

Fig 13. THD bar chart.

V. CONCLUSIONS

Multilevel inverters offer improved output waveforms and lower THD. This paper has presented a novel PWM switching scheme for the proposed multilevel inverter. In this paper three reference signal and is compared with a triangular wave signal to generate the PWM signals. Here there are two different DC voltage levels are used for the two H-Bridge inverters. So this method of configuration is known as asymmetrical cascaded inverter. By controlling the modulation index and different levels of Dc voltages the thirteen levels of the output voltage's achieved. A FPGA XILINS SPARTAN 3E is optimized the performance of the inverter. The THD level of this thirteen level inverter is 7.307 %.

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