A NOVEL DESIGN OF HYBRID RENEWABLE ENERGY INVERTER

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Abstract

In this paper we propose the design of a sine wave inverter that is compatible with residential hybrid renewable power generation systems. The proposed designed inverter is based on three level pulse width modulation technique in combination with cascaded H bridge. In this system we are using N channel MOSFETS only for driving the H Bridge which minimize power loss and provides higher switching speed. Automatic power line selection using arduino is employed which helps in effective usage of generated energy from multiple sources without any lose. The simulation results using Multisim 14.1.0 show good quality performance for low power renewable energy applications.

Keywords: cascaded H Bridge, multilevel inverter, renewable energy, hybrid system

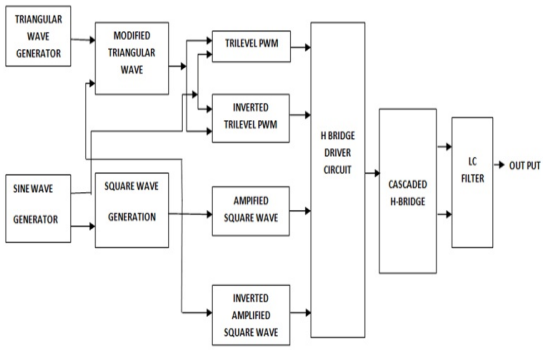
I. INTRODUCTION

Most of the present energy demand is met by fossil fuels and nuclear power plants. A small part is met by renewable energy sources such as wind, solar, biomass, geothermal etc. There will soon be a time when we will face a severe fuel shortage. This energy crisis forces the development of alternative methods of electricity generation. Hybrid energy systems from various renewable sources like sun, wind and hydro are the most extensively used technique. In this paper we propose a new cascaded H Bridge multilevel inverter which is compatible with hybrid renewable energy systems. There are mainly three topologies for multilevel inverters. They include diode clamped multilevel inverters, flying capacitor multilevel inverters and cascaded H-bridge multilevel inverters. Among the three, Cascaded H bridge multiple inverter topology has more advantages over a conventional inverter system. It requires the least number of components than all multilevel converters to convert direct current to an alternating current. The major advantage is to eliminate the use of a bulky transformer to boost the output signal which in turn reduces heating problems. It has the capability to produce a least distorted output waveform with reduced electromagnetic compatibility problems. Multilevel converters produce a small common mode voltage, reducing associated stress of the connected load. Increased number of voltage levels in the network leads to better voltage waveforms. It can be utilized for charging low voltages which provide utility interface with renewable energy systems.

II. PROPOSED INVERTER STRATEGY

Hybrid energy system is the combination of various energy sources for transmitting power to the load. Consider a trio-hybrid system, say solar, wind and hydro, is used for power generation. Arduino board is utilized for selecting the maximum power production line among the three sources automatically and the energy extracted from them are charged to two 6V batteries.

In this paper, we propose an inexpensive Cascaded H Bridge multilevel inverter topology with a pure sine wave output. It is chosen so as to eliminate the bulky transformer required in case of conventional inverter topologies. The major circuits are shown in the block diagram in figure (a).



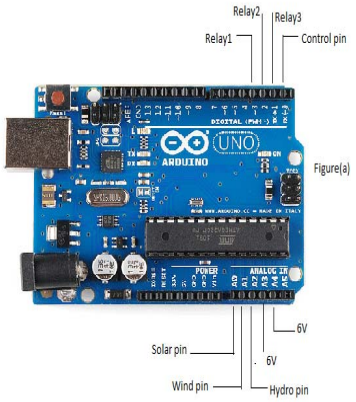
fig(a)

The control circuit is comprised of two basic blocks; sine wave generator and triangular wave generator. An oscillator is needed to produce a stable 50Hz sine wave that has less distortion so as to produce an accurate output. A Bubba oscillator was chosen as the means to produce this signal because of its potential to produce a stable sine wave that contains very little distortion. The output of this oscillator is passed to a non- inverting amplifier for further amplification before it is used in the circuitry. Amplified sine wave and a reference signal are fed to the inputs of a comparator to produce a square wave. The circuit for the construction of triangular wave consists of a Schmitt Trigger and an integrator. Schmitt Trigger produces the square wave which is fed to the integrator to produce triangular wave. It must then be modified such that it switches between a mid to high triangular wave, to a midtolow triangular wave by clamping the square and triangular waves. This modified triangular and previously generated amplified sine waves are supplied to two voltage summer circuits to produce a trilevel PWM wave and an inverted trilevel PWM wave. Similarly, another two voltage summer circuits are utilized in producing an amplified square wave and an inverted amplified square wave. These four waves are routed to the cascaded two-level H Bridge circuit comprising of N-MOS switches through MOSFET driver ICs to optimize efficiency. Output of the H Bridge circuit is passed through an LC filter circuit to get a sine wave output.

III. METHODOLOGY

A. Automatic Power Selection Using Arduino

The available three renewable energy sources are linked to the input pins of the Arduino board through a voltage divider network. Arduino selects the maximum power line from the three sources of energy. Two battery sources of 6 Volts are connected to the analog pins and the lower charged battery is identified. This identified battery is charged with a relay connected to the power line using digital pins of Arduino. Figure (b) shows the Arduino board.



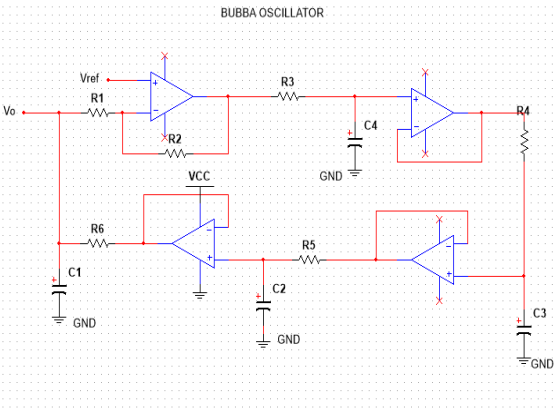
fig(b)

B. Sine Wave Generation

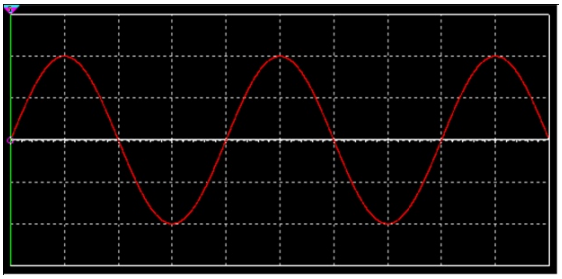
Bubba oscillator is a circuit to produce a filtered sine wave of desired frequency. It is indeed a phase shift oscillator that produces a phase shift of 45°from all the four opamps associated with the circuit. It dispenses high frequency stability and a least distorted output but produces an attenuated wave which is further amplified in the circuitry. This oscillator is opted for generating a sine wave of 50Hz and is connected to the 6V battery. A 4/4 TLV2474 op-amp IC is employed for construction of sine wave. The basic equation that unveils the math behind a bubba oscillator is given below.

$$V_{out} = V_{in}$$

Multisim 14.1.0 simulation tool is utilized in generating the sine wave. The circuit of bubba oscillator and the simulated sinusoidal waveform of 1.2V output voltage and a frequency of 50.1Hz are shown in fig(1) and fig(2) respectively.



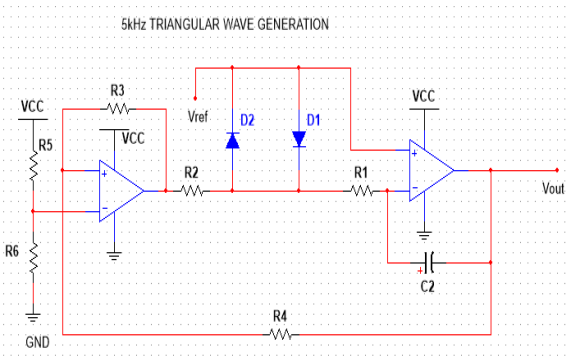
fig(1)



fig(2)

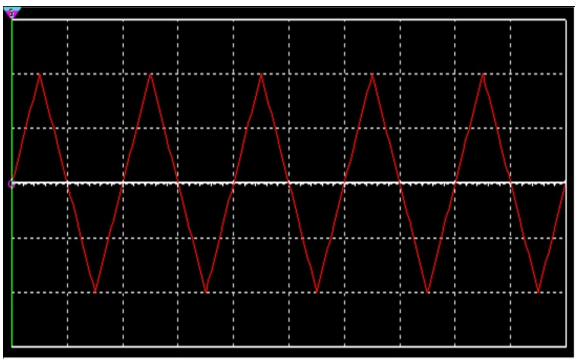
C. *Triangular Wave Generation*

A square wave generator and integrator circuits are combined together to produce a triangular wave of 5 KHz.



fig(3)

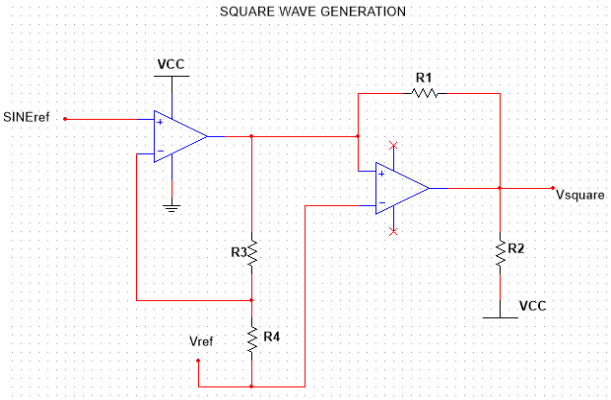
Schmitt trigger is utilized for square wave generation. The square wave output from the TL084D schmitt trigger IC is fed to the TL084D integrator IC and a triangular waveform is generated. The circuit and simulated waveform for 5KHz triangular wave of output voltage 2.6V are depicted in figures (3) and (4) respectively.



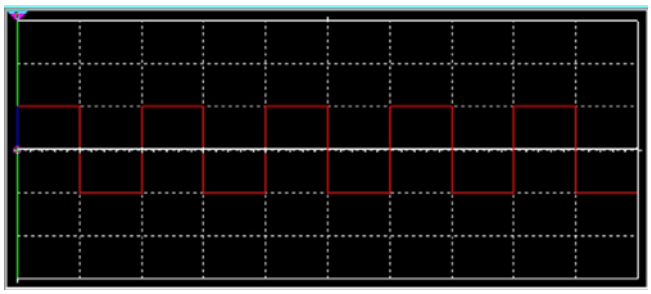
fig(4)

D. *Square Wave Generation*

50.1Hz sine wave generated by the bubba oscillator is amplified by a non-inverting amplifier. The so produced amplified sine wave is routed to a MC3302D Schmitt/comparator circuit along with a reference signal. As a result a 50Hz square wave with 2.8V output voltage is generated. The wave generator circuit is shown in figure (5) and the waveform in figure (6).



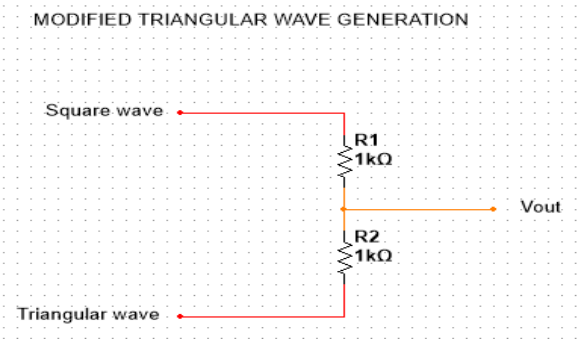
fig(5)



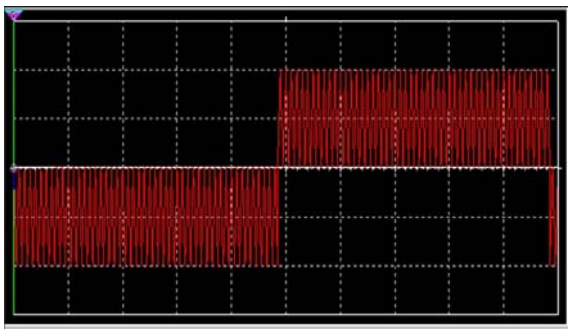
fig(6)

E. *Modified Triangular Wave Generation*

The generated triangular wave must then be modified such that it switches between a midtohigh triangular wave, to a midtolow triangular wave.



fig(7)

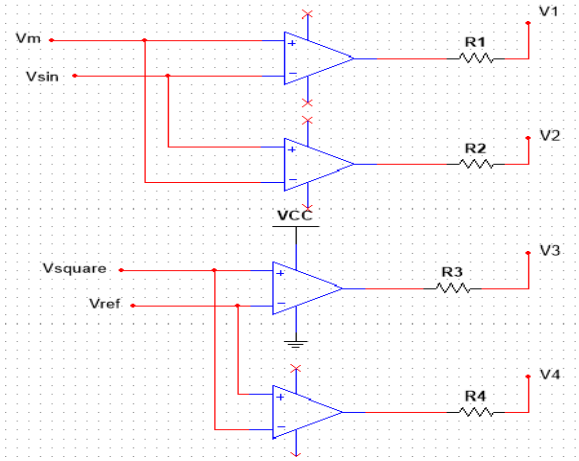


fig(8)

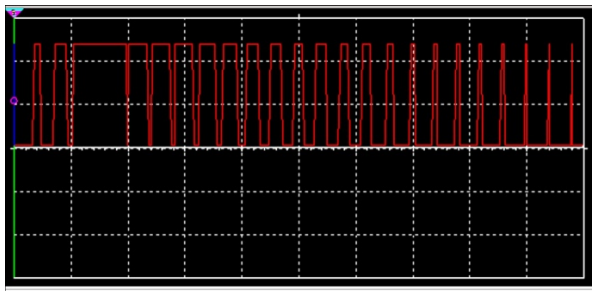
The 50Hz square wave generated from sine wave and the 5KHz triangular wave developed from the above mentioned circuits are clamped together to form a 6V modified triangular wave. The circuit and the corresponding waveform is depicted in figures (7) and (8) respectively.

F. PWM and Square Wave Generation:

Amplified sine wave of 50.1Hz and the 5KHz modified triangular waves are fed to the inverting and non-inverting terminals of two MC3302D voltage summer circuits to generate an inverted trilevel PWM and a trilevel PWM wave. Similarly, the 50Hz amplified square wave and the reference signal are fed to the inverting and non-inverting terminals of another two MC3302D voltage summer circuits to generate a square wave and an inverted square wave. The figure (9) and (10) resembles the circuit input to the cascaded H Bridge circuit and the generated 5.5V PWM waveform respectively.



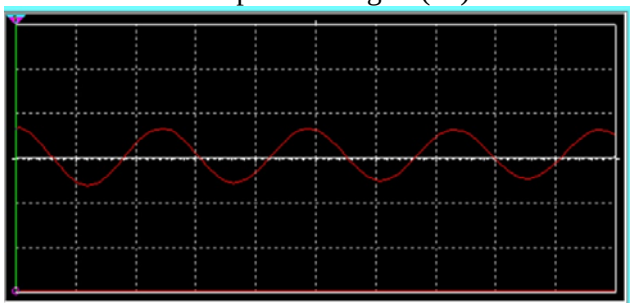
Fig(9)



fig(10)

G. Cascaded H Bridge and Filter Output:

The so produced inverted and non-inverted PWM and square waves are routed to a two-level cascaded H Bridge configuration through a driver IC IR2110. Eight IRFb20n5 N-MOSFETs are utilized in the circuitry and as a result, a 12V square and PWM waves are obtained. The concept of the inverter is based on connecting H-bridge circuits in series. Output of the Cascaded H-Bridge is boosted to 220V, then it can be passed through a LC Filter to get a pure sine wave output. The so produced sine wave output from the filter is depicted in figure(11).



Fig(11)

IV. CONCLUSION

In this paper, a new cascaded H Bridge inverter topology with a pure sine wave output, compatible with any hybrid energy system is proposed. Switches used in the proposed inverter are N-MOS due to its low ON time resistance. This topology stands out to be a more effective method in generating a sine wave with less harmonics enhancing efficiency cost effectively. The circuit is simulated using MULTISIM 14.1.0 and the simulation results have been demonstrated in the paper. Automatic power selection technique from the renewable sources using Arduino is also included. For further innovation, the cascaded H Bridge inverter topology can be implemented using Arduino.

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