



Design and Implementation of Solar inverter for Pure Sine Wave Inverter

AYE MYAT THU¹, KYAW SOE LWIN²

¹Dept of Electronic, Mandalay Technological University, Mandalay, Myanmar, E-mail: ayemyatthu.tu@gmail.com

²Dept of Electronic, Mandalay Technological University, Mandalay, Myanmar, E-mail: kyawsoelwin007@gmail.com.

Abstract: The dc-ac converter is a circuit that convert the dc voltage supply to ac voltage output and this converter also known as inverter. Inverter is used in many types at industrial and commercial applications especially in dc-ac conversion ac motor derives system controls and uninterruptible power supply. This thesis combined the knowledge at electrical. The main test of this paper is to construct a pure sine wave inverter system .The developed system used common electronic parts such as operational amplifier gate driver dc to dc converter and power MOSFETS .The MOSFET also use controller by gate driver circuits .This thesis is started with system design of inverter circuit by using the paper calculation to get the waveform of output and switching of MOSFETS .The hardware circuit is then constructed and the output waveform are shown by oscilloscope. This paper will include operation, analysis control strategy and experiment result based on the design calculation and hardware implementation.

Keywords: Boost Converter, MOSFET, Power Inverter, Converter Transformer.

I. INTRODUCTION

This paper is approach to DC to AC power inverter, which aims to efficiently transform a DC power source, similar to power that would be available at an electrical wall outlet. Inverters are used for many applications, like solar panels or fuels cells where low voltage DC sources must be converted to AC power, such as a situation would be converting electrical power from a car battery to run laptop, TV or cell phone. The method in which the low voltage DC power is inverted is completed in two steps. The first being the conversion of the high voltage DC source to an AC waveform using pulse width modulation. Another method to complete the desired outcome would be to first converter low voltage DC power to AC and then use a transformer to get desired output. This paper is focus on the first method described and specifically the transformation of high voltage DC source into an AC output. The input of DC voltage sources will be a battery, which is being supplied by photovoltaic (PV) panels and wind turbine. There are many types of inverter. These inverters differ in their outputs providing varying level of efficiency and distortion that can affect electronic devices in different ways. This system will use solar inverter is a key devices in a solar energy system. Solar inverter has high efficiency, high reliability and high cost than other inverter. This paper focuses on DC to AC pure sine wave inverter.

II. SYSTEM OVERVIEW

The block diagram showed the varying parts of the project that will be addressed. The control circuit is composed of three basic blocks, the six voltage reference,

sine wave generator and triangle wave generator. These block are implemented with comparator and other analog circuitry they control the PWM signals that two MOSFET drivers. The PWM signals are run into these MOSFET drivers that perform level translation to drive four N-channel MOSFETs in an H-Bridge configuration. The signal is sent through a low-pass LC filter so that the output delivers a pure sine wave. The specific operation, construction, and resulting output waveforms for each block will be discussed in detail in this paper.

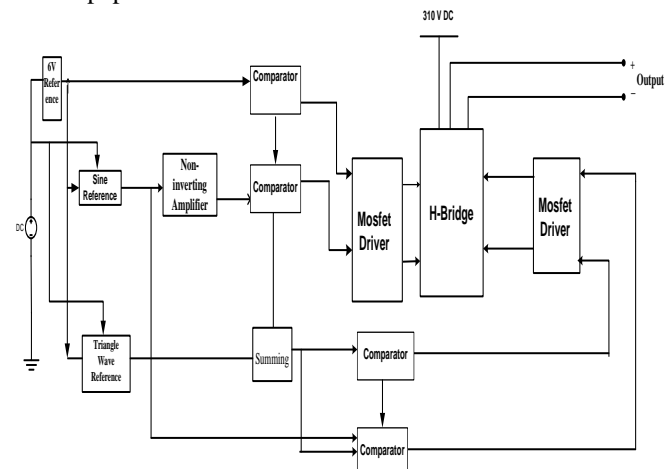


Fig.1.Block Diagram of the System

A. Sine Wave Generator

The circuit shown in figure is used to accurate pulse width modulation signal using analog circuitry. The pure sine wave inverter needed to build a 60 Hz sine wave output. To

produce a 60 Hz sine wave was needed an oscillator. The oscillator was being output was a 6 volt signal for all of the calculations and all of the components were correct. The frequency of the oscillator is controlled by 4 filters composed of a resistor and capacitor. To get the correct size signal, a potentiometer was put in place of one the resistors and adjusted while measuring the output on an oscilloscope to decide what size resistor should be used to oscillate at 60 Hz. So LM 348 op-amp was chosen to meets all the requirements of creating this sine wave which it is an inexpensive part.

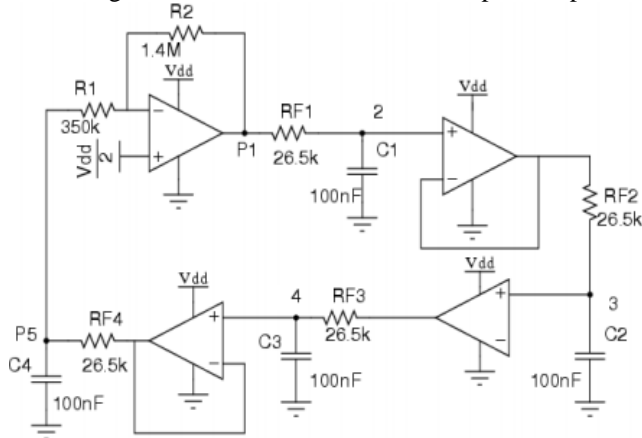


Fig2.Bubba Oscillator Circuit

The bubba oscillator has 4 differential output points (2-5).The output of point 2 has the largest amplitude, but it is also the most distorted. The output of point 5 is inverted with the point 2 output. The signal from point 5 is the best point to get the least distorted signal, the amplitude of the wave is not a factor as much because there is a non-inverting amplifier that this signal will run through before used in any of the control circuitry.

B. Triangle Wave Generator

The second part of the system is stable triangular wave generator. The reference sine wave and a carrier wave at the switching speed of the power supply are required for generating a sine wave at 60 Hz. Sawtooth signal or triangular signal can be used as carrier waves. Triangular waves will be used for these types of generator. The circuit also used the two op-amps. The op-amp of the one works as “the Schmitt circuit” and another op-amp works as “the integrating circuit”. By cascading the two op-amps, the desired triangle wave can be generated. The output of Schmitt circuit becomes the square waves. The output of the Schmitt circuit is inputted to the integration circuit. The output of the integration circuit becomes the triangular wave.

The oscillation frequency can be calculated by the equation of $F = 1/4RC (R_2/R_1)$. This circuit depends greatly on the slew rate of the operational amplifiers to generate the required frequencies. The output waves with frequencies of up to above 20K Hz can be generated by using the TL-084 op-amp. The power supply needs both of the positive power supply and negative power supply. Also, to work in the oscillation, the condition of $R_2 > R_1$ is necessary .When

making the value of R1 small compared with R2, the output voltage becomes small. The near value is good for R1 and R2.This may make opposite if not oscillating using the resistor with the same value.

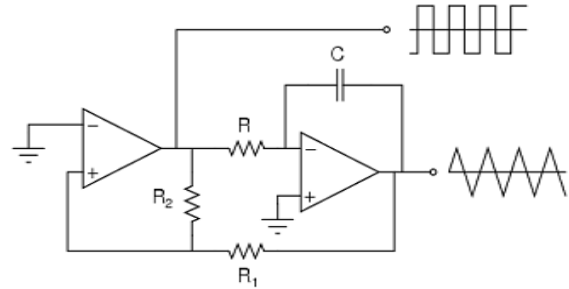


Fig. 3 Triangle Wave Generator

III. METHODOLOGY

A. Pulse Width Modulation

In electronic power converters and motors, PWM is used extensively as a means of powering alternating current (AC) devices with an available direct current (DC) for advanced DC/AC conversion. Variation of duty cycle in the PWM signal to provide a DC voltage across the load in a specific pattern will appear to the load as an AC signal, or can control the speed of motors that would otherwise run only at full speed or off. This is further explained in this section. The pattern at which the duty cycle of a PWM signal varies can be created through simple analog components, a digital microcontroller, or specific PWM integrated circuit.

Analog PWM control requires the generation of both reference and carrier signals that feed into a comparator which creates output signals based on the difference between the signals 1 and 0. The reference signal is sinusoidal and at the frequency of the desired output signals, while the carrier signal is often either a saw tooth or triangular wave at a frequency significantly greater than the reference. When the carrier signal is exceeds the reference, the comparator output signal is at one state, and when the reference is at higher voltage, the output is at its second state. The sinusoidal reference sine is blue, the carrier triangle wave is red and modulated and unmodulated sine pulse are shown in the following figure.

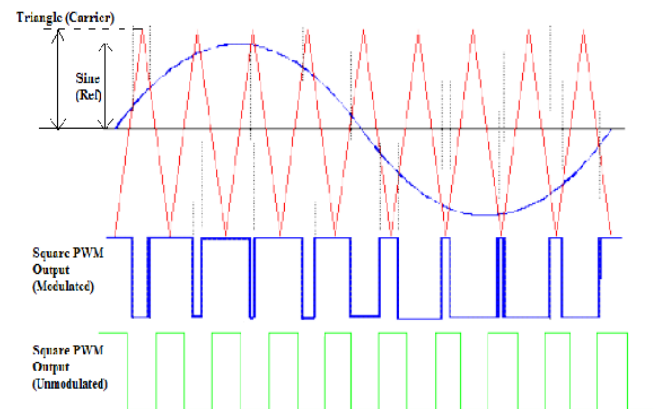


Fig4. Pulse Width Modulation.

Design and Implementation of Solar inverter for Pure Sine Wave Inverter

The average value of PWM wave in each carrier cycle is equal to the value of the modulating wave at the center of the carrier cycle. The spectrum of the PWM wave consists of components at the modulating frequency; pulse components clustered in sidebands around the carrier frequency and integer multiples of the carrier frequency. In order to source an output with a PWM signal, transistor or other technologies are used to connect the source to the load when the signal is high or low. Full Bridge configurations required the use of four switching devices and are often referred to as H-Bridge due to their orientation with respect to a load.

D. H-Bridge Configuration

An H-Bridge or full bridge converter switching configuration composed of four switches in an arrangement that resembles an H. By controlling different switches on the bridge, appositive, negative, or zero potential voltage can be placed across a load. When this loads a motor, these states correspond to forward, reverse, and off. The use of an H-Bridge configuration to drive a motor is shown in figure.

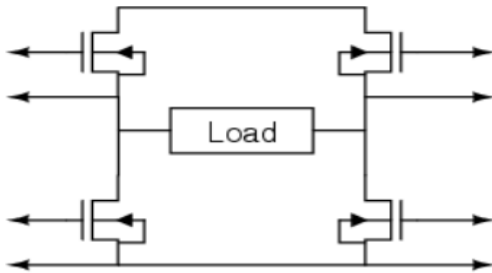


Fig5. H-Bridge configuration using N-channel MOSFETs

The H-Bridge circuit consists of four switches corresponding to high side left, high side right, low side left, and low side right. There are four possible switch positions that can be used to obtain voltages across the load. These positions are outlined in Table 1. Note that all other possibilities are omitted, as they would short circuit power to ground, potentially causing damage to the device or rapidly depleting the power supply.

TABLE1

High Side left	High Side Right	Low Side Right	Low Side Left	Voltage Across Load
On	Off	On	Off	Positive
Off	On	Off	On	Negative
On	On	Off	Off	Zero Potential
Off	Off	On	On	Zero Potential

The switch used to implement an H-Bridge can be mechanical or built from solid state transistors. Selection of the proper switches varies greatly. The use of P-channel MOSFETs on the high side and N-channel MOSFETs and a FET driver, lower "on" resistance can be obtained resulting in reduced power loss. The use of all N-channel MOSFETs required driver, since in order to return on a high than the switching voltage. This difficulty is often overcome by driver

circuits capable of charging an external capacitor to create additional potential. MOSFET drivers and discussion of how they achieve this higher potential are discussed.

B. Operations Of MOSFET Driver

The following figure show an H-bridge with cycle-by-cycle current control implemented with current sensing devices on the low-side in combination with the shutdown pin of the IR2113. Operation of the IR2113 device will be controlled through generated PWM signals. The PWM signal will be fed to the H_{IN} and L_{IN} pins simultaneously. If the internal logic detects a logic high, the H_O pin will be driven; if a logic low is detected, the L_O pin will be driven. The SD pin controls shut down of the device and will be unused and tied to ground. Additional pins that require external connections are the VSS pin which will be tied to the ground, the V_{CC} pin which will be tied to 12V, pins requiring connections to bootstrapping components and outputs to the MOSFETS.

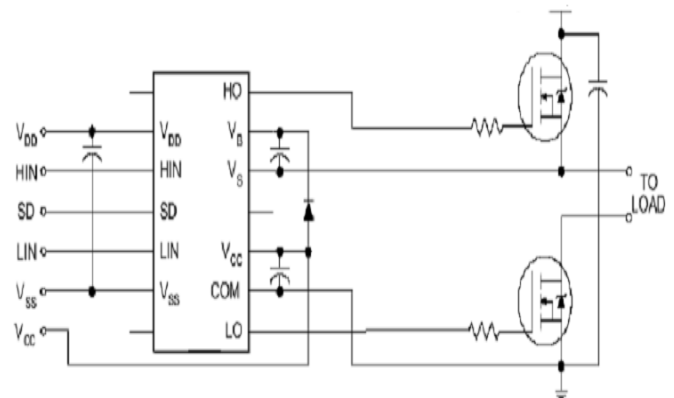


Fig6. The Operation IR2113 MOSFT Driver

As shown in figure 6 the bootstrap diode and capacitor are the only external components strictly required for the operation in a standard PWM application. The voltage seen by the bootstrap capacitor is the V_{CC} supply only .Its capacitance is determined by the following constraints:

- Gate voltage required to enhance MGT.
- IQBS –quiescent current for the high-side driver circuitry.
- MGT gate-source forward leakage current.
- Bootstrap capacitor leakage current

IV. RESULTS

The figure7 show the first part of the pure sine wave inverter is a stable source for sine wave source. This circuit is provided a filtered sine wave of any frequency the user desires based upon the configuration of resistor and capacitor. This circuit was fully task with four operational amplifier which can either buffer or amplify the signal. Four identical RC sections contributes 45 degree phase shift, so taking outputs from alternate sections yields low-impedance quartered outputs. When an output is taken from each op-amp, the circuit delivers four 45 degree phase shift sine waves. The equation for this oscillator is $\omega = 1/RC$.

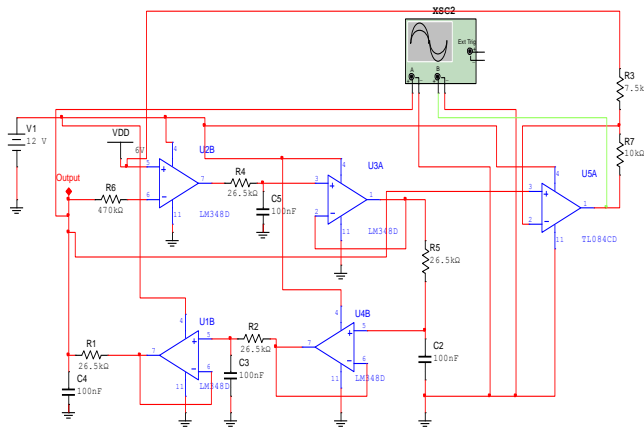


Fig7. Amplify Sine Wave inverter.

The figure 7 show the Simulation of amplifies sine wave output for pure sine wave inverter.

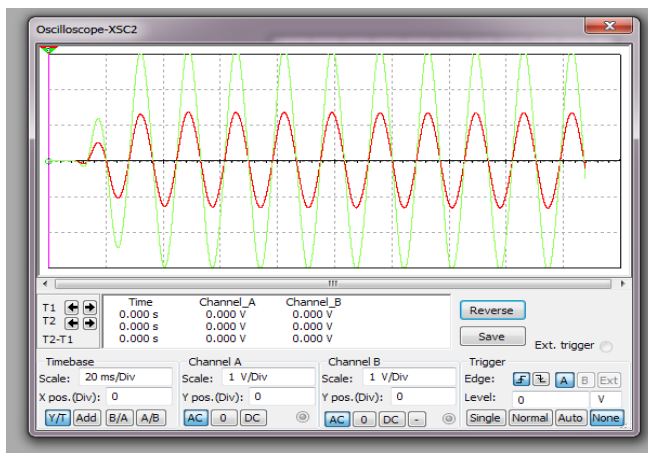


Fig8. Amplify Sine Wave Output.

The figure 8 show the Simulation result of amplifies sine wave output for pure sine wave inverter.

The figure shown in below the simulation circuit diagram of triangular wave output for the one part of sine wave inverter.

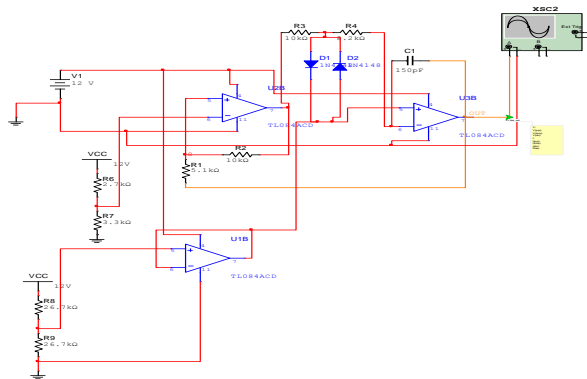


Fig9. Triangular wave circuits

The figure 10 is the result of the triangle wave output for the design of pure sine wave. The output will oscillate at a frequency and the amplitude can be controlled by the amplitude of R_1 and R_2 .

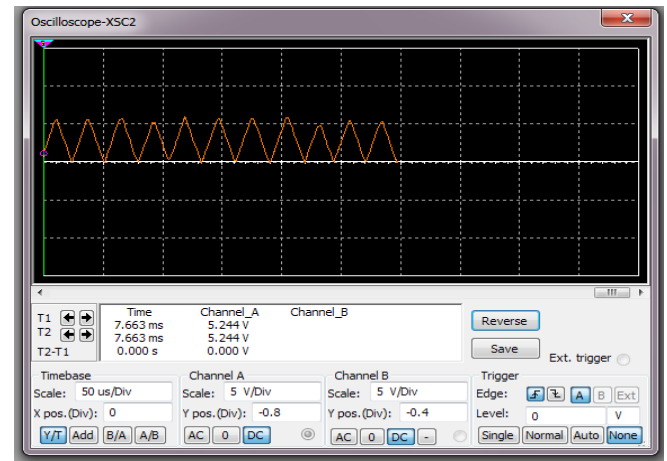


Fig10. Triangular wave Output.

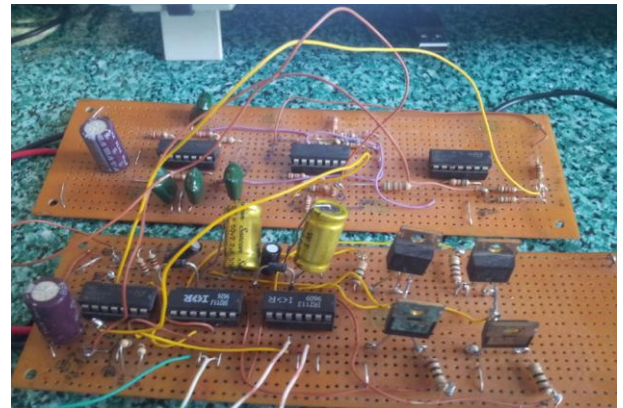


Fig11. Hardware implementation of Sine wave Inverter

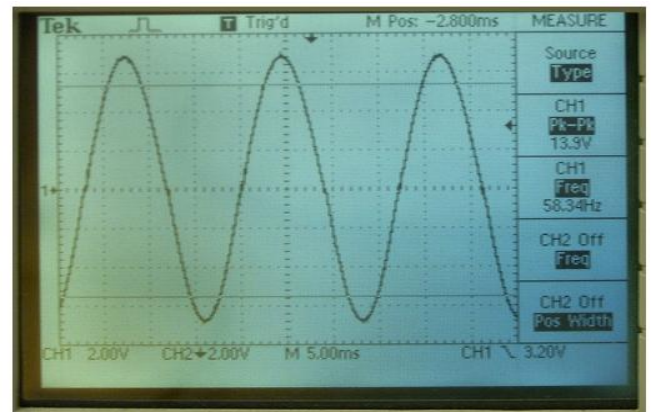


Fig11. Final Output of Sine wave Inverter.

V. SUMMARY

This paper is to implement of the pure sine wave inverter design had to be taken to ensure that individual circuit of the project functions correctly. In order to this research work was placed on a project board to ensure functionality and where any glitches or inaccuracies due to small uncalculated loss could be accounted for. The designed project had to be placed on the projected board in a specific order so that each part of circuits could be provided for reliable operation to acquire desired output precisely.

VI. CONCLUSION

In this paper were to produce a pure sine wave DC-AC inverter that would output at 60 Hz, would be cheap to manufacture, good efficient in this method. The DC to DC converter has been constructed by using SG 3524(Switch Mode Power Supply IC) and ferrite core transformer which has been designed according to the requirements. The PWM signal which generated signal for MOSFETs driver was constructed by using the TL 084 (OP-AMPs) and LM 339 (OP-AMP).The second goal to produce a $220 V_{RMS}$ sin wave with the capability of providing 2KW of power was not actually tested but the team is confident in its ability to produce this waveform. The purposed sine wave inverter produces very little harmonic distortion with specific frequency.

VII. REFERENCES

- [1] Sine-Wave Oscillator” – Application Report SLOA060, Texas Instruments http://www.ti.com/lit/an/sloa060/sloa_060.pdf.
- [2] ST Microelectronics: 1 kW dual stage DC-AC converter based on the STP160N75F3, Application Note AN2794, ST Electronics, Feb 2009.
- [3] Craig Danton, Nimit Mehta: POWER INVERTER, Final Project Report, Department of Electrical Engineering, Columbia University, December 11th, 2008.
- [4] [www.Thamid's .com](http://www.Thamid's.com).
- [5] “New High Voltage Bridge Driver Simplifiers PWM Inverter Design,” by D.Grant ,B. Pelly PCIM conference 1989.
- [6] Ledwich, G.1998). Pulse Width Modulation (PWM) Basics. Retrieved December. 1, 2006, from [http://www.powerdesigners.com /InfoWeb/design center/ articles/PWM /pwm.sh tm](http://www.powerdesigners.com/InfoWeb/design_center/articles/PWM/pwm.sh tm).