IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN (P): 2347-4599; ISSN (E): 2321-8843
Vol. 5, Issue 9, Sep 2017, 1-16

DEVELOPMENT OF A 3KVA DC TO AC POWER INVERTER USING DC TO DC CONVERTER

IJAROTIMI OLUMIDE[1], IDOWU A, KAYODE[2] & OLAWALE J. BABATUNDE[3]

[1,2]Electrical and Electronics Engineering Department Faculty of Engineering Technology Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria.

[3]Computer Engineering Department Faculty of Engineering Technology Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria.

ABSTRACT

In this paper, a construction of 3kVA inverter based on Boost converter and Half-bridge inverter topology is presented. The boost converter steps the low voltage supply to a higher voltage supply, this is achieved with the use of appropriate electrical and electronics devices. The stepped up DC voltage is converted into an AC voltage which can be used by electrical appliances and it is also similar to the voltage that comes out of an electrical outlet. The essence of stepping up the voltage before converting is to reduce the size of the inverter using a high frequency transformer.

KEYWORDS: Inverter, Converter, PWM, Modulation frequency

INTRODUCTION

At the early stage, sun was the source of energy for generating power. Due to the inadequacy of the power generated through this source, there was a need to find other ways to improve the power supply when the generating station could not meet the demand of the people. As the technology advances, the hydroelectric generation was developed, gas firing generating station, and wired tubing methods of generating power supply were developed. In spite of all these developments, there was still failure in electrical power generation as a result of obsolete equipment at the generating stations. There was still need to find alternative for solving the problem. As a result of this, some options like alternators, inverters and others were developed. The electrical inverter is a high power electronic oscillator. It is so named because early mechanical AC to DC converters was made to work in reverse, and thus was “inverted”, to convert DC to AC. Inverters are used for many applications, as in situations where low voltage DC source such as batteries, solar panels or fuel cells must be converted so that devices can run off AC power. One example of such a situation would be converting electrical power from car battery to run a laptop, TV or cell phone (Doucet 2007 et al). There are three basic types of DC-DC converter circuits, termed buck, boost and buck-boost in all of these circuits a power device is used as a switch.

This paper focuses on the first method described and specifically the transformation of a high voltage DC source into an AC output. Of the different DC-AC inverters in the market today, there are essentially two different forms of AC output generated: modified sine wave, and pure sine wave. A modified sine wave can be seen as more of a square wave than a sine wave; it passes the high DC voltage for specified amounts of time so that the average power and rms voltage are the same as if it were a sine wave. These types of inverters are much cheaper than pure sine wave and therefore are attractive alternatives. Pure sine wave inverters, on the other hand, produce a sine wave output identical to the power coming out of an electrical outlet. These devices are able to run more sensitive devices that a modified sine wave may cause damage to as: laser printers, laptop computers, power tools, digital clocks and medical equipment.

This form of AC power also reduces audible noise in the device such as fluorescent lights and runs inductive loads, like motors, faster and quieter due to the low harmonic distortion.

Problem Statement

In the market of power inverters, there are many choices. They range from
expensive to very inexpensive, with varying degrees of quality, efficiency, and power output capability along the way.

High quality combined with high efficiency exists, though it is often at a high monetary cost. The high end pure sine wave inverter tends to incorporate very expensive, high power capable digital components. The modified sine wave can be very efficient, as there is not much processing being performed on the output waveform, but this results in a waveform with a high number of harmonics, which can affect sensitive equipment's such as medical monitors. Many of the very cheap devices output a square wave, perhaps a slightly modified square wave, with the proper RMS voltage, and close to the right frequency. Our goal is to fill a niche which seems to be lacking in the power inverters market, one for a fairly efficient, inexpensive inverter with a pure sine wave output. Utilizing PWM and analog components, the output will be a clean sinusoid, with very little switching noise, combined with the inexpensive manufacturing that comes with an analog approach, (Doucet, 2007 et al).

Scope of the Study

In many applications, it is important for an inverter to be relatively of small size and light weight. This can be achieved by using a high frequency (HF) link inverter topology. A popular HF link inverter is the so called DC-DC converter type. In this scheme, a bridge inverter is used to convert the direct input voltage into an HF square wave, which in turn, is rectified and filtered. The low pass filter output is a high-level direct voltage that is converted into a low frequency wave by sinusoidal pulse-width modulation inverter. In an alternative version, the HF bridge inverter produces on HF pulse width modulation wave, thus reducing the transformer losses (Chatzakis, 1996).

LITERATURE REVIEW

In this section we will discuss different types of boost converters and their typical applications as well as their strengths and weaknesses. During the course of this research, the various types of dc-dc boost converters in literature to better understand the theory behind dc-dc conversion and to get a grasp on the number and types of converters available.

Types of DC-DC Converters

DC-DC Boost Converter

The most basic type of boost converter consists of very few parts and is very straightforward.

This type of converter charges an inductor with current flow while the switch is closed, and uses that current when the switch is opened to produce a voltage across the load that is higher than the initial voltage applied to the inductor. A filter capacitor across the output keeps the voltage from dipping too low across the load while the inductor is charging, and a diode ensures that the capacitor does not discharge itself across the switch when it is closed. The theory is that if one can open and close the switch fast enough, the load will see a seemingly constant voltage that is boosted to some degree compared to the original voltage applied to the circuit. The ratio of output to input voltage depends on the duty cycle of the switch opening and closing, with higher ratios occurring with higher duty cycles.

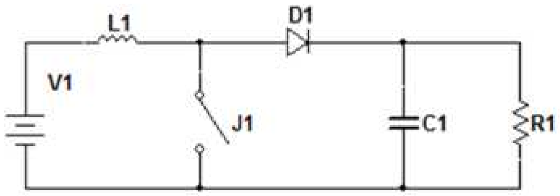

Figure 1: Basic Boost Converter Schematic Diagram

To analyze this circuit, we must first assume that the inductor current is continuous and always positive value, the capacitor is very large and holds the output constant, and the parts are ideal. We start with the switch closed, which allows current to flow through the inductor from the voltage source with no path resistance. This causes a steady increase in current over time, whose maximum value depends on the inductance of the coil, the voltage of the source, and the amount of time the switch is closed. Assuming that T is the period of oscillation and D is the percentage of time that the switch is closed, we can put this relation into equation form as follows:

$$\frac{\Delta i}{DT} = \frac{V_s}{L}$$

Equation 1: Current, Voltage, Inductance & time relation of a DC-DC boost converter closed switch condition

$$\Delta i = \frac{V_s * DT}{L}$$

Equation 2: Equation 1rearranged to solve for current change in time

When the switch is open, the inductor current decreases linearly while the inductor pushes its current through the diode and into the output capacitor and load. The rate of change is dependent upon the same factors as the closed switch case, with the addition of the output voltage of the circuit impeding current flow. For this case, the governing equation is as follows:

$$\Delta i = \frac{(V_s - V_o)(1 - D)T}{L}$$

Equation 3: Current, Voltage, Inductance & time relation of a DC-DC boost converter open switch condition

For steady state operation, the net change of current between the on state and off states must be zero. Therefore, the two equation is set up as follows:

$$\frac{V_s * DT}{L} + \frac{(V_s - V_o)(1 - D)T}{L} = 0$$

Equation 4: open &closed circuit conditions averaged for one period

Solving for V out,

$$V_o = \frac{V_s}{1 - D}$$

Equation 5: output voltage equation for a DC-DC boost converter

There is a minimum value of inductance required so that the current doesn't drop to zero when the switch is open. This minimum inductance value may be computed by:

$$L_{min} = \frac{D(1 - D)^2 R}{2f}$$

Equation 6: Calculating minimum required inductance for a DC-DC boost converter

There will be an output ripple since the capacitor cannot be infinitely large. The amount of ripple present is governed as follows:

$$\frac{\Delta V_o}{V_o} = \frac{D}{RCf}$$

Equation 7: Calculating output ripple for a DC-DC boost converter

Buck-Boost Converter

This type of dc-dc converter is extremely similar to the dc-dc boost converter in that it requires the same number of parts, but rearranged slightly. The inductor and switch have their positions reversed, and the diode is turned backwards. This configuration supposedly allows the output to be either higher or lower than the input source.

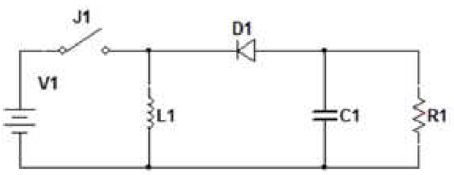

Figure 2: Buck Boost Converter Schematic Diagram

The equation and analysis that held true for the DC-DC boost converter is exactly the same forthis circuit while the switch is closed. When the switch is opened, there is a polarity reversal, and thesource voltage from the battery does not help the inductor supply voltage to the load. The outputvoltage for this circuit is:

$$V_o = -V_s(\frac{D}{1 - D})$$

Equation 8: Calculating output voltage of a Buck-Boost converter

The other equation that changes from the original boost converter diagram is the minimum inductance required. That equation is:

$$L_{min} = \frac{(1 - D)^2 R}{2f}$$

Equation 9: Calculating minimum inductance required for a Buck-Boost converter

Overview of the Research work from the late nineteenth century through the middle of the twentieth century, dc-to-ac power conversion was accomplished using rotary converters or motor generator sets (M-G sets). In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits- Rakesh Kumar (2002).

But today Inverters are designed using semiconductor switching element to complement the use of vacuum tubes and gas filled tubes as the inverter circuit.

Several Researchers have embarked on the research work and discover new technology to improve on the old existing method old design of Inverters from the ancient times up till dates. Further discoveries from the research work resulted to the design of Hybrid Bridge Inverter topology. The half bridge inverter topology has lower number of switches and simple control.

In this paper, the authors designed and constructed 3KVA, 50Hz, single-phase arc welding machine using locally available materials. To solve the problem of weight and size of conventional arc welding machine an inverter circuit was also designed. The inverter provides much higher frequency than 50Hz or 60Hz for transformer used in welding. The locally constructed electric arc welding machine capable of withstanding 150A, when subjected to insulation test, short circuit and open circuit test to as certain performance characteristic were very satisfactory, Engr. Ovbiagele U; Engr. Obaitan B (2015).

In this paper 5kVA power inverter was designed and simulated base on two topologies. A 555 timer IC was used as the control at fixed frequencies of 25 kHz and 50 Hz for the two stages. The results of the simulation were obtained. The graphs for both stages were plotted and the results show a significant increase in the voltage and duty cycle. The wave form of the output gives a square wave form, Musa, A. and G.S.M. Galadanci (2009).

The duration of dead band should be large enough to allow the switch that is turned off to close before the other switch, to start conducting. The advantage of H-bridge inverter topology has lower number of switches and simple, (Emadi and Stoyan, 1992).

This paper is to design and construct a 1000Watts (1KW) 220 Volts Inverter at a frequency of50Hz. This device is constructed with locally sourced components and materials of regulated standards. The basic principle of its operation is a simple conversion of 12V DC from a battery using integrated circuits and semiconductors at a frequency of 50Hz, to a 220V AC across the windings of a transformer, Olusegun O. Omitolaet al (2014).

More so, an inverter which is a device designed to change direct current D.C input to alternating current (A.C) output does not create or make electricity, but just changes it from one form to another D.C in is change to A.C out, (Sona Singh, 1999 and Kehua, 2007).

MATERIALS AND METHODOLOGY

A step-up DC-DC converter comprises of a direct current power source, an inductor, a first switching element, a second switching element, a smoothing capacitor, a driver controller for controlling switching ON or OFF the first switching element and the second switching element, and a control charging unit for charging a control operation of the driver controller according to a load current. A frequently used method for a power device to convert an input voltage to a desired output voltage induces power conversion at high efficiency by using a switching DC-DC converter (Harikrishnan & Raniya, 2012).

Block Diagram

Analog circuitry, as well as discrete components, a MOSFET drive integrated circuit and a low pass filter is all that is necessary to generate a 60Hz, 120V AC sine wave across a load. The block diagram showed below shows the varying parts of the project that will be addressed. The control circuit is comprised of three basic blocks, six volt reference, sine wave generator and triangle wave generator: when these blocks are implemented with comparators and other small analog circuitry they control the PWM signals that the two MOSFET drivers will send. The PWM signals are fed into these drivers that perform level translation to drive four NChannel configurations. From here the signal is sent through a low pass LC filter so that the output delivers a pure sine wave.

The Basic Equations of an Ideal DC-DC Converter are given as (Erickson, 1998)

$$P_{in} = P_{out} \quad (1)$$

$$P = VI \quad (2)$$

$$V = M(D)\,V_g \quad (3)$$

$$I_g = M(D)\,I \quad (4)$$

Where Pin and Pout Input and Output Powers Respectively

Vg	-	input voltage
V	-	Output Voltage
Ig	-	Input Current
I	-	Output Current
M	-	Conversion Ratio
D	-	Duty Cycle

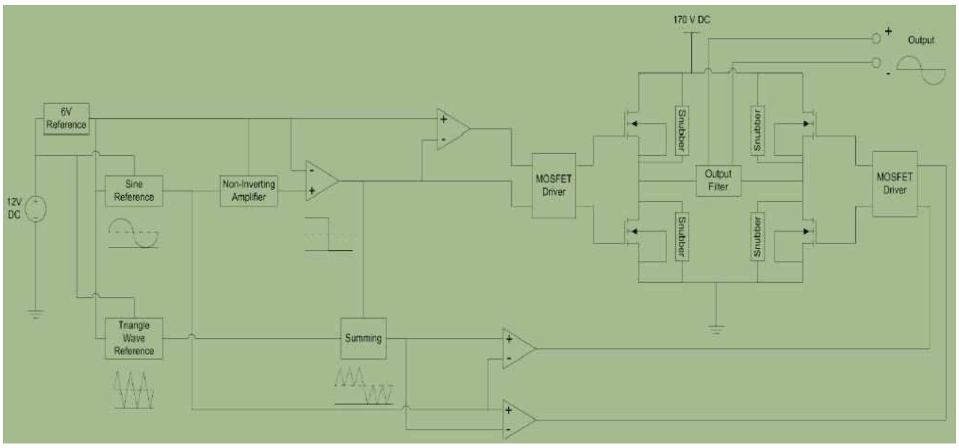

Figure 3: Basic Block Diagram of an Inverter Circuit

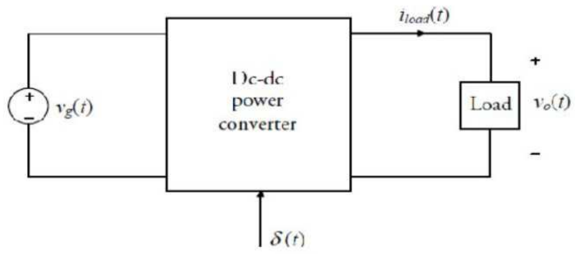

Figure 4: Dc/Dc Power Converter (Erickson, 1998)

The design of a switched mode DC/DC inverter is a complex procedure; however, when broken down into stages, it becomes much easier to manage. The circuit chosen is categorized into four main stages (Ijoga & Kwaha, 2013):

- Control Circuitry
- Driver Amplifier and Power Switch
- Rectifier and Filtering Capacitor

Control Circuitry

The SG3524 is a monolithic integrated circuit which incorporates all the function required for the construction of regulating SMPS (datasheet catalog, 2010). The rationales behind these choices are:

- It is a low cost device
- It has complete pulse width modulation (PWN) control circuitry
- Wire and load regulation of 0.2% (datasheet catalog, 2010)
- Frequency of operation up to 300KHZ (datasheet catalog, 2010)

The Oscillating Frequency of the PWM Circuit can be Determined with the Equation (Datasheet catalog, 2010)

Fs= 1.18 ---------- SRTG

Where RT and CT are timing resistor and capacitor respectively the range of practical values specified in the manufacturer data sheet; RT is between 1.8 and 100kn, while CT falls between 1nF and 0.1NF by choosing RT to be 24kn and CT to be 0.1 NF,

Fs= 1.18 = 492HZ

24,000X (0.1X10^{-6})

The period of oscillation, T of the PWN can be obtained from:

T=RTG (5)

Therefore,

T=24,000X (0.1X10^{-6})= 2.4ms (6)

Driver Amplifier and Power Switch

Digital ICs are low power devices because they can supply only small load current (Malvino& Bates, 2007). Therefore, there was need to amplify the pulse width train generated by the SG3524 IC. The C1815 NPN Epitaxial silicon transistor is the selected transistor for the driver amplifier stage due to its high DC current gain (HFE) linearity, high frequency oscillation, and because it's a general purpose transistor. The common-emitter configuration is the chosen connection for operating the circuit. This is because it has got high current gain, Bdc (50-300), very high voltage gain (up to 1500) and power gain (up to 10,000 or 40 dB) (Akande, 2007 et al,)

In addition, the voltage divider bias (VDB) technique is preferred for operating the transistor. This is because it requires only a dc power supply provides good bias stability operation point is almost independent of Bdc variation (Akande, 2007 et al). The supply voltage, Vcc chosen for the design is 12v DC with $\pm$ 10% tolerance. This was determined by picking an approximate and availability of 12v DC battery. The C1815 electrical characteristic table specified collector emitter voltage, VCE=6.0 v, minimum HFE or Bdc = 130 and collector current, Ic = 2.0mA. Let the load resistance of Rr=3kn. The dc load line for the driver stage amplifier is obtained using the equation (Akande, 2007 et al):

$$VCe=VCC-ICRC \quad (7)$$

At short circuit, VCE=O, then equation (7) becomes

$$Ic\ (sat) = \frac{12v}{3kn} = 4mA$$

At open circuit, Ic=O, then equation (7) becomes

$$Vcc = VCE=12v$$

Hence, at midpoint, ICQ=1Ic (sat) = 1mA and VCEQ=6v2

Where VCEQ is the collector-emitter voltage and ICQ collector current at Q-point. The DC current gain is expressed as (Akande, 2007 et al):

$$IB=\frac{IC}{IB} \quad (8)$$

$$IB = \frac{2mA}{130} = 15NA$$

The emitter voltage, VE can be obtained as (Malvino and Bates, 2007)

$$VE=0.1Vcc$$

$$VE=0.1X12V=1.2v \quad (9)$$

The emitter resistor, RE can be found using the expression

$$RE=\frac{VE}{IE} \quad (10)$$

IC=IE

RE=$\frac{1.2V}{2mA}$ = 600n (1kn preferred)

The base voltage, VBB can be obtained from the relation given by (Malvino and Bates, 2007):

VE=VBB-Vbe (11)

VBB=1.2v+0.7v=1.7v

Where, the base-emitter voltage for silicon transistor is,

Vbe=0.7v

A well deserved VDB circuit satisfies the shift voltage source condition given by (Malvino and Bates, 2007):

R2 $\leq$ 0.01 Bdc RE (12)

Therefore,

R2 $\leq$ 0.01X(130)X(1000n)=1.3kn (1.3kn preferred)

The output of a VDB circuit is expressed as (Malvino and Bates, 2007):

R1=$\frac{R2(VCC-VBB)}{VBB}$ (13)

R1=$\frac{1.3\ KN\ (12V-1.9V)}{1.9v}$ = 6910N (6.8KN preferred)

The choice of the semi-conductor technology utilized for this power switch function was influenced by factors such as low cost, peak voltage and current frequency of operation and heat sinking. Hence the IRH1010E power FET was chosen for this design due to its ultra low on resistance (ROSCOW) of about 12mn. Other benefits includes: fast switching and rugged zed device, low thermal resistance, provides high power capability, and good switching capability (SMPSRM, 2007).

Rectifier Circuit and Filtering Capacitor

There are four choices of rectifier technology: the standard recovery diodes, fast recovery diodes, the ultrafast diode and schottery rectifier (SMPSRM, 2007). The two rectifier technologies utilized in this design are the full wav rectification using MUR120 ultrafast rectifier. This was chosen due to its fast turn off and high reverse voltage capability of up to 1000v (SMPRSM, 2007).

The other rectifier technology utilized is the GBPC1508W bridge rectifier. This was chosen due to its suitability for high voltage application. The cut off frequency, tc of a filter is given by (Malvino and Bates, 2007).

FC = $\frac{1}{2\pi RC}$ (14)

Where C is capacitance and R resistance.

$$R = \frac{1}{2X3.143X492X4400NF} = 0.07n \text{ (80n Preferred for convenience)}$$

Power Transformer Stage

The overall power Pts for the DC converter given as 190W. The voltage across the primary winding of a centre tap transformer is twice the input dc voltage (bxeal, 2011).

Thus, Vp = 24 vac and efficiency, 17=0.95. The current through the primary winding Ip is given by (Mclyman, 2004)

$$Ip = \frac{Pcs}{Nvp} \tag{15}$$

$$AIp = \frac{190W}{0.95X24} = 8.3\ A$$

And the transformer input power; Pin is calculated as (MCLyman, 2004):

$$Pin = IpVp \tag{16}$$

Pin = 8.3AX24= 199.2W

The apparent power, Pt is calculated as (Ijoga and Kwaha, 2013)

$$Pt = Pin+Pts \tag{17}$$

Pt = 199.2W+190W = 389.2W

The transformer operating frequency, FT is determined from the switching frequency, fs (datasheetcatalog, 2010):

$$FT = \frac{1}{2} fs \tag{18}$$

FT = 1 X 492 = 246HZ 2

The value of FT and the design parameters can be used to compute the windings. The number of herns, Np at the primary winding can be computed by (Gottlieb, 1998):

$$Np = \frac{E10^8}{4FBsA} \tag{19}$$

Where E is the voltage, F is the transformer frequency, Bs is the flux density and A is the core area.

Np = $\underline{24X10^8}$ = 47.2 (48 turns preferred value)

4X246X15000X3.448

The current density, J is given by

$$J = \frac{Pc\ 10^8}{KBsKuFTAcWc} \quad (19)$$

Where winding fill factor, Ku = 0.25 (for multiple output transformer (Erickson, 1998)), Bs= 15000 GQuss. Using the E1-750 core parameters for core area, Ac and window area, WC.

$$J = \frac{389.2X10^8}{4X0.25X15000X246X3.448X2.723} = 1123ACM^2 \quad (1.123X10^7Am^{-2})$$

The primary wire area Awp is given by (MCLyman, 2004):

$$Aw = \frac{1}{j} \quad (20)$$

Where I is current. All windings operate at the same current density, j. therefore.

$$Awp = \frac{8.3}{1.123X10^7} = 7.39X10^{-7}m^{-2}\ (0.00739cm^2)$$

Power Inverter Stage Design

In this part H-bridge inverter topology was adopted.

An H-Bridge or full-bridge converter is a switching configuration composed of four switches in an arrangement th at resembles an H.

By controlling different switches in the bridge, a positive, negative, or zero-potential voltage can be placed across a load (Doucet, 2007 et al). The half bridge inverter in the simplest form. H-bridge inverter topology has lower number of switches and simple control. The duration of the dead band should be large enough to allow the switch that.

$\underline{Ldi\ (t)\ +Ri}\ (e) = VS\ dt$

Its general solution is of the form

$i(t) = \underline{Vs} + Ae^{-t/t}R$

Where T, the time constant for R-L load; is T = $\underline{L}$ R

Applying the initial condition, that is

I(o) = Imin = -Imanc when t=0, we get

$A= -\ \underline{VS}-\ I\ max\ R$

Hence, the expression for the current in the circuit during t=o and t=T/2 is

$I\ (t) = \underline{VS}\ [i\text{-}e^{-t/}{}_{T}] - I\ max^{\ e\text{-}t/}{}_{T}$

R

The current attains its maximum value at t=T/2 and obtained from

$I\ max = \underline{VS}\ (i\text{-}e^{-T/}{}_{2T}) - I\ max\ e^{-T/}{}_{2T}$

R

Re-arranging the tern we get

$I\ max = \underline{VS} \qquad \underline{i\text{-}e^{-T/}{}_{2T}}$

$\qquad\qquad R \qquad\qquad i\text{+}e^{-T/}{}_{2T}$

Hence the current in the circuit during t=o and t=T/2 is

$I\ (t) = \underline{VS}\ (i\text{-}e^{-t/T}) - \qquad \underline{VS} \qquad \underline{i\text{-}e^{-T/}{}_{2T}}$

$R \qquad\qquad\qquad\qquad R \qquad i\text{+}e^{-T/}{}_{2T}$

An H-bridge is a set of four switches that are assembled is such a way that arbitrary load impedance is decoupled from DC power fall and ground. This circuit architecture is utilized to control the direction of current across an arbitrary load by manipulating the four switches in the bridge. Each of the four switches in the H-bridge is independently controlled and works to divert current across the load at a frequency of 60Hz. An example of a simple H-bridge with four switches and single load impedance is shown in figure 3.3 (Benard, et al).

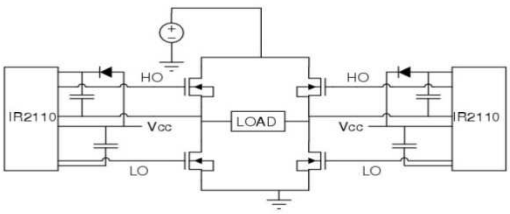

Figure 6: Diagram of an H-Bridge

Each of the switches shown in figure 3.3 has different roles for typical operation of an H-bridge. The first important distinction between the top two switches within the circuit is that the top two switches are referred to as high side and the bottom two switches are referred to as the low side. The high side switches are reversible for controlling the availability of the DC rail voltage across the load impedance while the low side switches are responsible for controlling the connection between the load impedance and ground.

N-channel MOSFET where chosen as switches in the bridge level translation between PWM signals and voltages required to forward bias high side N-channel MOSFETS. The IR2110 MOSFET driver integrated circuit was chosen. (Doucet, 2007 et al).

The IR2110 high and low side drive device exceeds all requirements for driving the MOSFETs in the bridge. It is capable of up to 500v at a current rating of 2A at a fast switching speed. The device is required to drive the high side MOSFETS in the circuit designated HO, due to the fact that the drain to source voltage, which is the highest voltage. With a full bridge configuration, two of these devices are utilized (Doucet, 2007 et al).

Operation of the IR2110 devices will be controlled through generated PWM signals; the PWM signal will be fed to the Hin and Lin pin simultaneously. If the internal logic detects logic high, the HO pin will be driven; if a logic low is detected, the Ho pin will be driven. The SD pin controls shutdown of the device and will be unused and load to good. Additional pins that require external connections are the Vss pin which will be led ground, the Vcc pin boots trapping components and output to MOSFETS.

Bootstrapping capacitors and diodes will be connected as designated. The values for these components are calculated from international rectifier's AN-978 application note HV floating MOS. Gate drivers ICS. The formulary for minimum bootstrap capacitor value obtained from this document is shown below.

$$C \geq R \quad \frac{\frac{Iqbs(max)}{F} + \frac{Icbs(leak)}{F} \; I6}{VCC\text{-}VF\text{-}VLS\text{-}Vmin}$$

$$[\, 2Q_{g+} QI_{s+}]$$

Minimum capacitor values were calculated to be 2NF for the 60Hz side of the bridge and 5inF for the 50 KHz side of the bridge. The elements of the equation above were determined from datasheets as follows:

Qg=Gate charge of high side FET = 110nC

Iqbs = Quiescieant current for high side driver circuitry = 230NA

QIs = Level shift charge required per cycle = 5nC

(Given in application note)

Icbs (leak) = Boot strip capacitor leakage current = 250 NA

F= Frequency = 60Hz for left side of bridge, 50KHz for right side of bridge

Vcc = Supply voltage = 12v

VF = forward voltages drop across bootstrap diode=15

VIs = Voltage drop across low side FET = 1.5 V

Components to be used according to the calculations above are the 2.2 uf+/-20%, 50v kemet c330c563k2R5CA capacitor. The diode to be used is the international Rectifier 8ETuo4-ND 8Amp 400v Ultrafast Rectifier.

Driving four MOSFETs in an H-Bridge configuration allows +170,-170, 06 O volts across the load at any time to utilize PWM signals and this technology, the left and right sides of the bridge will be driven by different signals. The MOSFET driver on the left side of the bridge will receive a square wave at 60Hz and the right side will receive the 50KHz PWM signal. The 60Hz square wave will control the polarity of the output. Sine wave, while the PWM signal will control the amplitude. The MOSFETS to be used in the design are the IRFB20N50KP5F Hexfet power MOSFET, rated for 500v at 20A with an Rds of 0.21ohm.

Filter

In other to optimize the efficiency, a switching frequency must be chosen which is low enough to keep the switches in line, but high enough to make sure the filter inductor is not unnecessarily large. Many engineering tools will assist with this decision, but here we choose to utilize mathlab. Using this, it is possible to mode the switching losses in the MOSFETS, based on their capacitance and switching rise times (which depends on the frequency), as well as their resistive losses in the filter induction (dependent on the inductor value/size, the requirement for which is dependent on frequency).

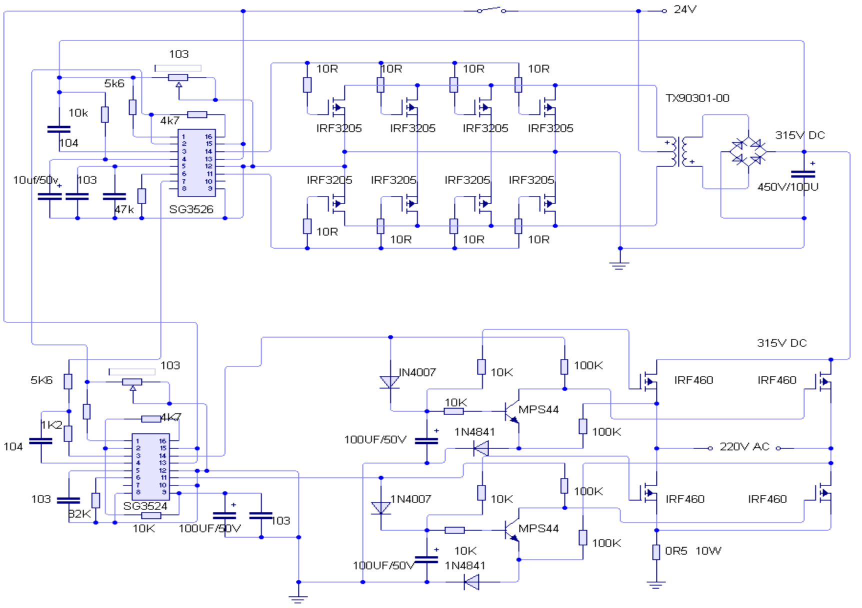

Figure 7: Schematic Diagram of DC/DC to AC Inverter.

Performance Evaluation and Result

The inverter was tested on a section by section basis. The output voltage of the oscillator was obtained on each side with frequency set to approximately 50Hz. The battery overcharging protection unit, low battery cut-off unit, low and high voltage surge protection as well as the time delay units, feedback unit were all tested by varying the protection meter associated with each of them and observing the response through the displays. The list of various settings that were made is listed overleaf;

Table: 1

Inverter output voltage	220 volts
Inverter frequency	50Hz
Maximum battery voltage	100 volts
Maximum loading capacity	700 watts
Minimum A.C input voltage	180v
Maximum A.C input voltage	250v

Figure 8: Diagram of Inner part of the Inverter

After all the setting was done, the effect of loading was carried out on the inverter system and the load test result are as follows;

Table: 2

Power (watt)	Voltage (v)
300	225
400	220
500	220
600	220
700	220
800	220
900	0

CONCLUSIONS

The successful completion of this work will provide job opportunities and improve the standard of living of most people in the third world countries like Nigeria. It will also reduce the dependence of third world countries on imported commodities. The construction of 3000watts (3KVA), 220 volt inverter at a 50Hz frequency was a gradual process of gathering of materials for testing of components. It is to be noted that the efficiency of this project depends on the input and on the total power of the load connected to its output terminals. Thus, the inverter could deliver constant power for a calculated number of hours.

In view of the inconsistence and unreliable public power supply and high cost of electric power generators coupled with the high cost of maintenance, the inverter is found to offer a better constant additional power supply for a sustainable duration; it is noiseless, harmless and cost effective. It is also a preferred power pack up to a computer and other appliance because it switches automatically to the battery when the AC mains are not available. Thus reduce system breakdown, prevent hard disk damages and data loss. In addition, the life span of the computers and other devices connected to either a standby or a continuous inverter is prolonged.

REFERENCES

1. Application Report Understanding Boost Power Stages in Switch mode Power Supplies, TI Literature Number SLVA061, 1999.
2. R. W. Erickson, Fundamentals of Power Electronics, New York: Chapman and Hall, 1997.
3. Musa,A. and G.S.M. Galadanci 5kva Power Inverter Design And Simulation Based On Boost Converter And H-Bridge Inverter Topology.Bayero Journal of Pure and Applied Sciences, 2(1): 6 – 13,*Bajopas Vol. 2 Number 1 June, 2009*.
4. http://Guru/PEInverters/introduction/pdf/inv.pdf ‘’24th February, 2006. PC Sen. (2002), Power Electronics. Tata McGraw-Hill publishing company limited, New Delhi, India, 726p.
5. Mukund R. Patel (2006).Wind and Solar PowerSystem: Design, Analysis, and Operation (2edition). CRC press, Taylor & Francis, U.S.A221-224pp

6. Simon ANG and Alejandro Oliva (2005). Power Switching Converters, (2 edition) CRC press, Taylor & Francis, 32-38pp
7. http://supertex.com/pdf/app-note/AN-36.pdf “23th January, 2008.
8. http://Guru/PEInverte rs/Half-bridge/pdf/inv.pdf‘’24th February, 2006
9. Ali EmadiAbdolhoseinNasiriand Stoyan B Bekiarou (1992).Uninterruptable Power Supplies& Active Filter.53p
10. https://web.wpi.edu/Pubs/E-project/Available/E-project-042507 092653/ unrestricted/ MQP_D_1_2.pdf
11. https://www.tuc.gr/fileadmin/users_data/elci/Kalaitzakis/J.19.pdf