DESIGN AND CONSTRUCTION OF A LOW POWER FLUORESCENT LAMP INVERTER WITH CHARGER

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DECLARATION

I declare that this project is as a result of my personal effort and that it has never been presented in any seminal, symposium or elsewhere in any form for the award of diploma or degree.

All information from published and unpublished work used in this project is been duly acknowledged.

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EXTERNAL EXAMINER	DATE

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DEDICATION

I dedicate this project to Almighty Allah, and His noble prophet mohammed (SAW)

I also dedicate this work to the memory of those that lost their life in Tsunami disaster, Bellview Airplane crash of 22nd October, 2005. may Allah grant them Eternal life.

ABSTRACT

Due to the interruptive nature of electricity supply in Nigeria today and high cost of procuring stand by generating set it became necessary to look for alternative methods of generating electricity for domestic used.

The purpose of this work is to develop a DC-AC inverter and charge units as an alternative to the use of generating set because its low cost and its maintenance free nature.

The low power inverter and charger was design using Transistor as the main inverter switching components. It is purely a sine wave inverter. The inverter/charger can power fluorescent lamps from a 6v battery.

The method, procedure and the realization of the device to achieve the above set objective are contained in this project report.

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CHAPTER ONE

1.1 INTRODUCTION

Electricity is the most convenient source of Electrical Energy, for use in all aspect of economy. It can be quickly and efficiently transmitted over long distance, and can easily be converted from one form of energy to another form. It is also used to power residential equipment such as electric cookers, room heater, radio, TV set, air conditioners and some office equipments.

Some equipment and machine have greater need for quality and reliable power supply. Power interruption has ~~let~~ lead to delayed or stoppage of some industrial processes, death of people in hospitals. Vital and sensitive equipment both in offices and at home can also be damaged due to power outages.

However, some have tuned to generating sets, to provide alternative means of generating AC mains. The generating set has some disadvantages, such as noise pollutions, Air pollution and the need to be buying fuel which is quite expensive nowadays.

Therefore the better alternative means of power supply to electrically driven industrial machine, commercial and residential equipment is needed. The power inverter meets this need.

This is the reason why power inverter was developed to ensure reliable power supply.

In this project, the system design is the type that supplies power to the fluorescent lamp when there is a power failure from the mains. 6VDC battery is used to supply the inverter system, with the required energy which is then transformed in to AC mains, to light the fluorescent lamp.

The system that is to be designed in this project is the type of power inverter that invert 6VDC to 230 VAC when there is power failure. It is design to carry flourescent lamp conveniently since it is of low power rating. The complete inverter system is made up of battery charging unit, which use power from the main to charge the battery as long as the power remains on.

The other units is the inverter unit, which invert the DC (DIRECT CURRENT) from the battery to Alternating Current (AC), and in this design, it is to invert 6VDC to 230AC

1.2 STRUCTURE OF AN INVERTER

The figure below shows the block diagram of power inverter.

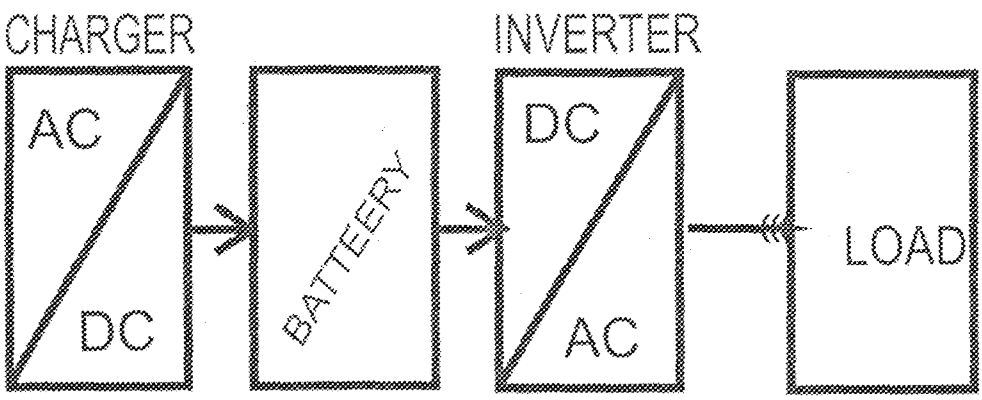


Fig 1 Block Diagram of Power Inverter

1.21 CHARGER

This section is very important to the duration (useful life) to which the battery being used in the project would work. It is activated as soon as there is supply at the mains. In this section, 220-230V AC is stepped down to 12V which is then rectified via full wave rectifier and voltage is then regulated to 6VDC.

1.2.2 BATTERY

The battery, this supplies the inverter the most needed power, for use by the load. The battery used in this work is a 6V, 45AH lead acid accumulator and is made up of two terminals, the positive and the negative terminals.

1.2.3 INVERTER

This is the heart of the whole design and it is the main determinant of the magnitude and frequency of the output voltage.

In case of power failure, the charged battery supplied sufficient power to the inverter to maintain its output for a specified time, until the battery has discharged to predetermined minimum voltage.

1.3 TRANSFORMER

Two transformers were used for the whole inverter system, one in the charging unit and the other at the inverter output.

1.3.1 STEP-UP TRANSFORMER

The step up transformer, step up 6V DC from the battery at the primary side to 230v AC at the secondary. The transformer is a centre tapped one, with feed back.

1.3.2 CHARGER TRANSFORMER

This is a small transformer of 230/12V for charging the battery used in the system. However, since 12VDC is used for the purpose of this work, a 12v transformer is appropriate.

1.4 CHANGE OVER SWICTH

These are the switches used to connect and disconnect the battery. It also connects the load to the inverter.

1.5 OUTPUT UNIT

This unit is where load are connected to the inverter system. Therefore, the low power inverter system can be used in places where adequate and constant power supply is essential for lightening.

1.6 SUMMARY

Chapter one is the general introduction to what the power inverter is all about. The literature review and other related work about inverter is found in chapter two. The broad discussion on various sections or unit of inverter is in chapter three. The construction and testing part is found in chapter four, while the result will be discussed in chapter five, conclusion recommendations and references in chapter six.

CHAPTER TWO

2.1 LITERATURE REVIEW

The role of modern electric power supply cannot be over-emphasized since there is need for a reliable power supply; research has been going on to device means whereby there will be no interruption in the power to our electronic equipments.

The fundamental of electrical power engineering was laid as far back as the middle of the 19^{th} century, when 1831, the English scientist Michael faraday discovered the phenomenon of electromagnetic induction. Further studies of interaction between electric current conductors and electromagnetic field led to the invention of an electric generator which converts the mechanical energy into electrical energy.

However, the definitive advantages of AC current over DC current were established by the three-phase AC system built by M.O DOLIBO-DOBROVOLSKY in 1888. The rotating magnetic field of the system allows the wide use of most simple, inexpensive dependable and compact inductive motors, Engineered by MO Dolivo Dobrovolsky.

The first inverter circuit was developed by an American company called the HEART INTERFACE in the year 1983.

In 1984, there was an improvement in the inverter technology as the MOSFET was introduced to make the design smaller, and to switch larger current.

Project Report of inverter design for 2001 future energy challenge by student team; Joy Mazumda, Duy biu, Manasi, Nancy Saidhana, Seve pugh, and Bassem Khury from college of engineering and computer science, university of central Florida, Orlando was carried out. In their report dated 15^{th} June, 2001, for a design of high power density, 10kw inverter circuit was presented for conversion of energy from DC fuels cells to AC power to be used mainly for domestic utilities. The configuration was achieved using a high frequency DC push pull converter at the input side followed by a full bridge inverter and a low power filter at the output side. Due to the simplified power stage and the application of the DSP based sinusoidal pulse width modulation technique, output voltage total harmonic distortion (THD) is reduced and a relatively smaller overall inverter size is achieved. The practical circuit operation from a 48VDC fuel cell input and output a regulated 120vAC, 60Hz sinusoidal voltage having 3-wire configuration. A low power inverter has been redesigned tested and prototypes to deliver a 1.5kw load.

There are also project work done by some of the students of this department on design and construction of 500VA, inverter. (Adeoye Eniola John, 2000). He used 555 timers in astable mode for signal generated and TTl dual JK flip-flop for pulse width modulation and frequency division. The deficiency of the work is the use of the TLL JK Flip-flop, which consumes much power with less efficiency. Also (Abachi Eugene 2004) use CD4047IC is a stable mode to deliver currents to the transistor.

The inverter/charger is a system that ensures continuous supply of electrical power when there is an outage, by conversion of DC which is drawn from secondary cell.

There are different kinds of inverter. Beside the input voltage, output voltage and power rating. There are inverters that output the power at different wave forms. The three most common outputs wave form for inverters are square wave, modified sine wave (some times called quasi sine wave) and sine wave output. Square wave is the simplest method that is widely used, in the cheap low power device. Many years ago this was the only wave form available as cheap inverters. Square wave formed inverters generally consists of an oscillation driven switching transistors, that switch incoming power to different sides of the center tapped transformer primary. The square wave mains voltage is outputted from the transformer secondary. The converter transformer can be pretty similar to normal 12v ~ 120v or 12v ~ 230v mains power transformer rated to inverter power rating. The square wave power at the output can cause problems in equipment originally designed for the sine wave. Most devices with the variable speeds such as electric drills, or cordless screw driver can behave irrationally when operating with modified sine or square waves inverters.

The modified "sine wave" form is becoming nowadays popular. Inexpensive inverters is quite easy to make with modern electronics. This type of inverter generally uses a switch mode power supply that generates 150 ~ 300VDC that is then switched to the output at right way using few high voltage power transistors/FETs controlled by output control timing electronics. Modified sine wave is made from two square wave waves out of phase. The phase is adjusted with load so that RMS voltage wave form is comparable with electronics but it may induce loud mechanical buzzing. Referenced www.epanorama.net, ups page

CHAPTER THREE

3.0 PROJECT DESIGN DETAILS

3.1 DESIGN DETAILS

The inverter was designed to invert direct current to alternating current. So therefore the whole system comprises of battery charging unit, the battery and the inverter unit. The direct current is obtained from the battery which is then used by the inverter to convert dc voltages to ac voltages. For continuous supply of the dc voltages to the inverter a battery charger is needed to constantly charge the battery.

However, this shows that the circuit has two main circuit units, the battery charging circuit and the inverting circuit. The inverter circuit has two main units, namely; the inverting unit and power amplification unit. The inverting unit converts the direct current to alternating current, while the power amplification unit amplifies the alternating current to the required power needed at the output.

3.2 THE BATTERY CHARGING MODULE

Basically, these are two method of charging batteries which are

1. constant-current charging method
2. Constant-voltage charging method.

Other methods which are also used but are modified forms of the above mentioned are;

1. Booster or high rate charging
2. trickle or slow rate charging

The circuit below shows the battery charging circuit.

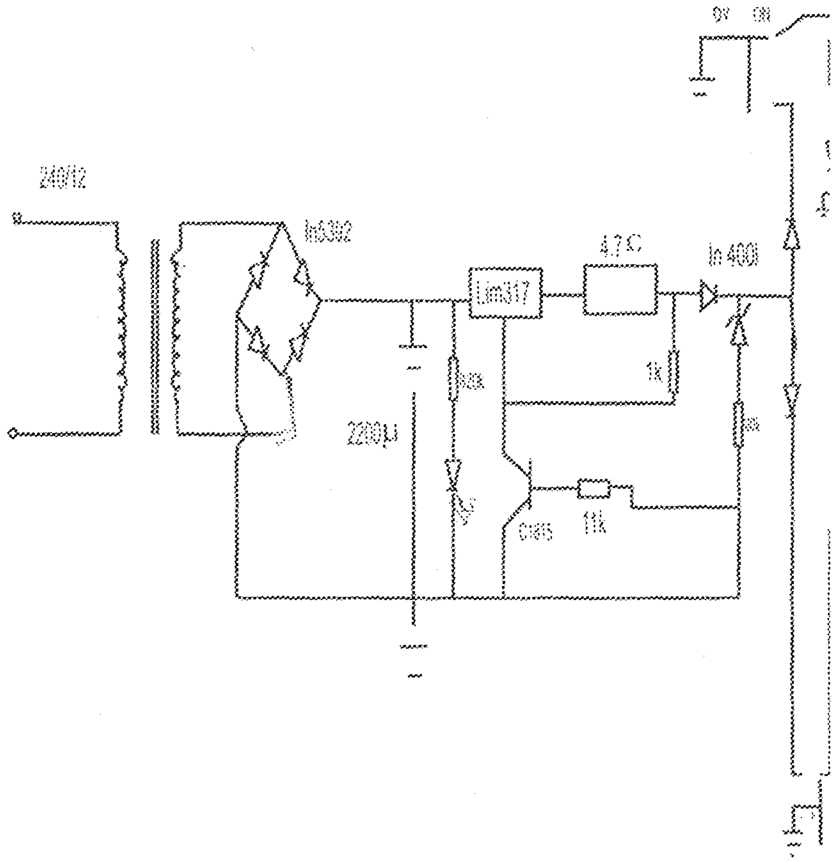


Fig. 2 Circuit Diagram of the Charger

3.2.1 THE RECTIFICATION DIODES

The battery can be recharge when its energy content has been used up. To charge the battery used in this project a charger is employed to recharge the battery system. The charging circuits started working when the there is AC mains supplied. The AC voltage from the mains is stepped down by the step down transformer from 240VAC to 12VDC. The AC voltage is then rectified to DC through full bridge rectifier. The figure below shows full bridge rectifier circuit.

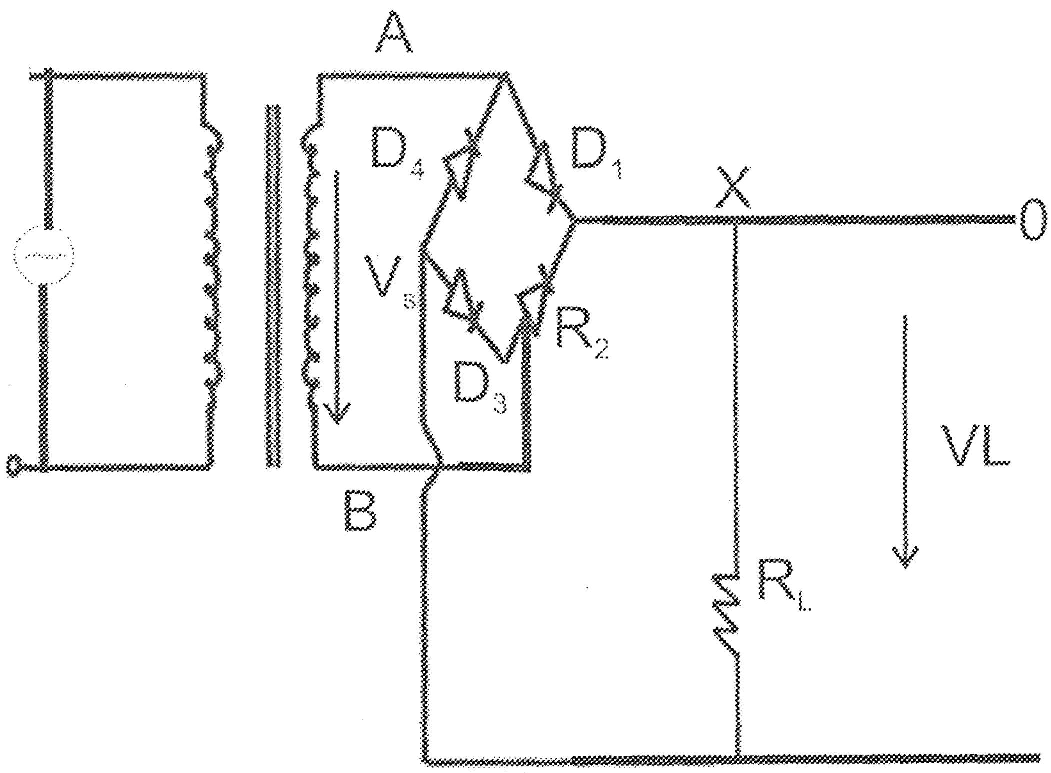
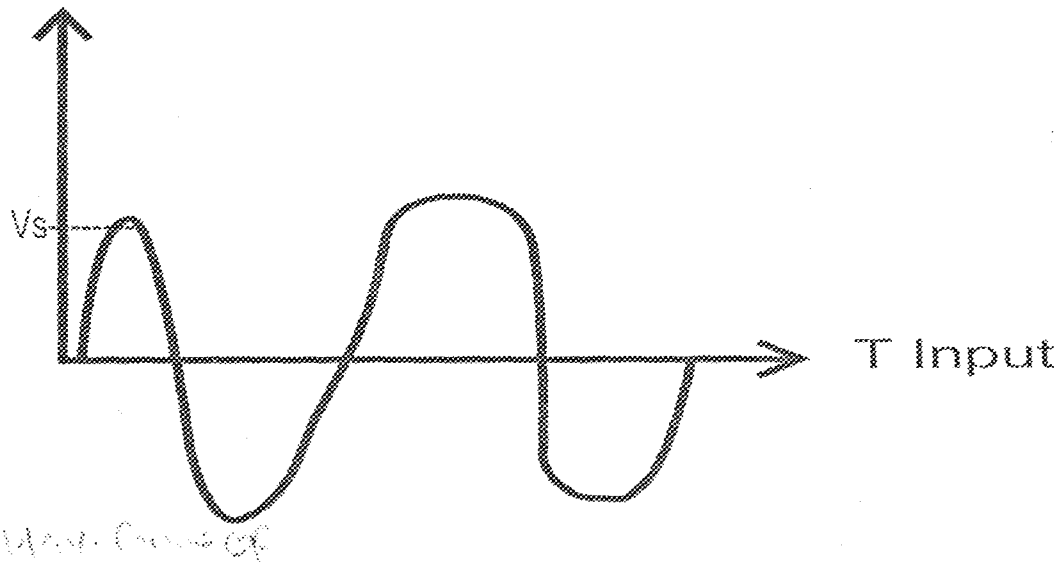


Fig 3: Bridge Rectifier Circuit

The circuit avoids the use of centre-tapped transformer though at the expense of two addition diodes. During the positive half-circle of the input AC signal Vs Diodes D1 and D3 conduct while diodes D2 and D4 are reversed biased. Hence a current I flows in the direction Ax and the output voltage VL drop across the load resistor RL as shown in the figure above

During the negative half circle when point A is at lower potential then point B, diodes D2 and D4 now conduct while diodes D1 and D3 are reverse biases. Hence current I_L flows in the direction BC that is current flows in the same direction through the load as before.

The figure below shows the output wave form.



g. 3a: Voltage input to the Diodes

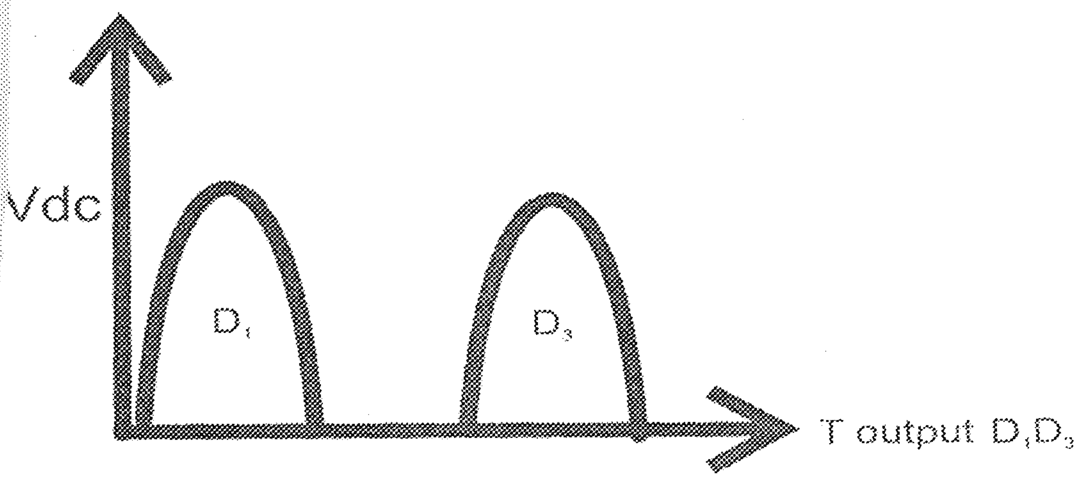


Fig: 3b

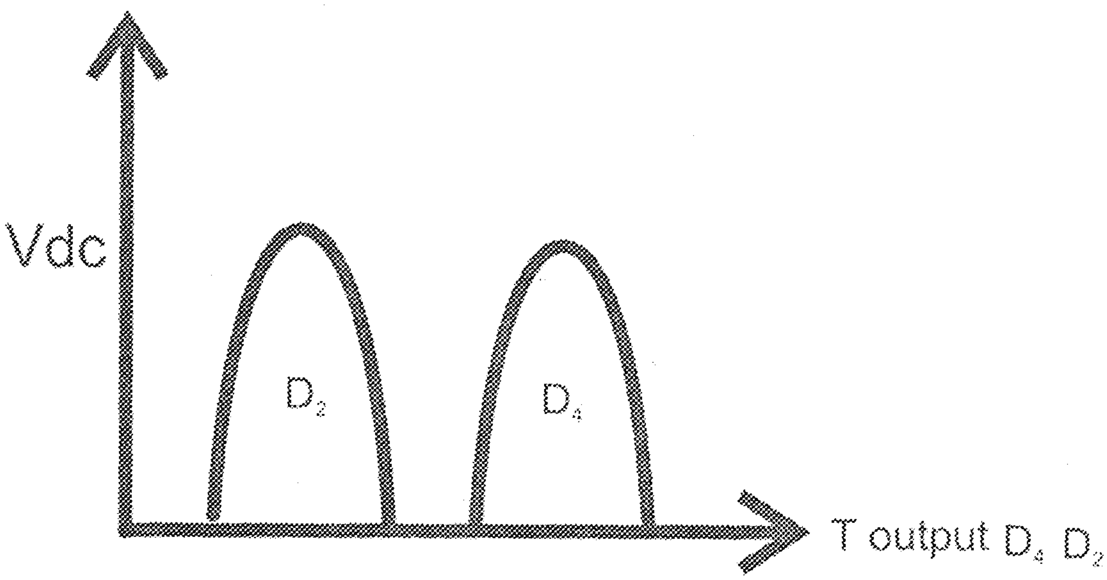


Fig: 3c

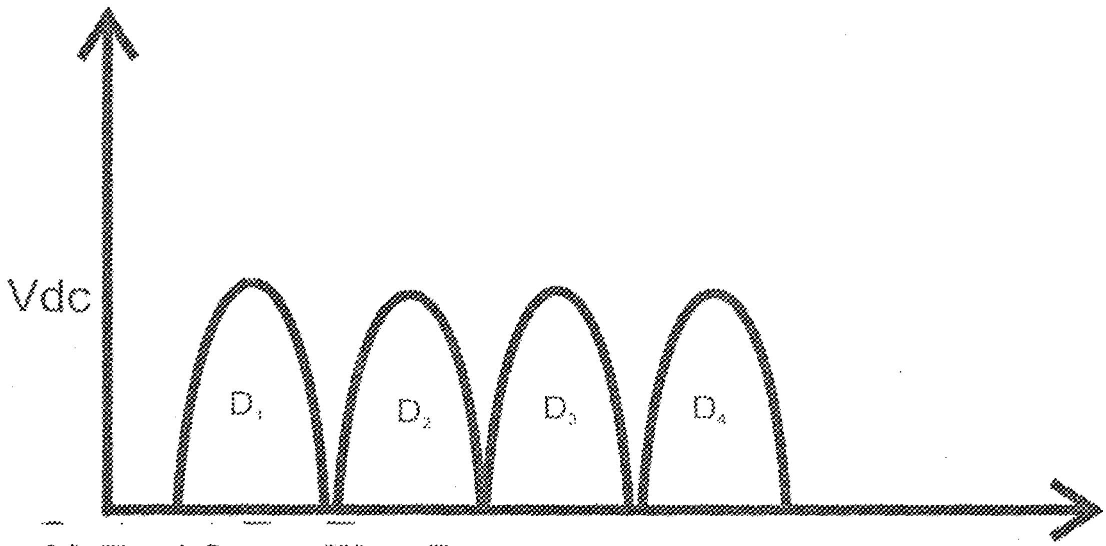
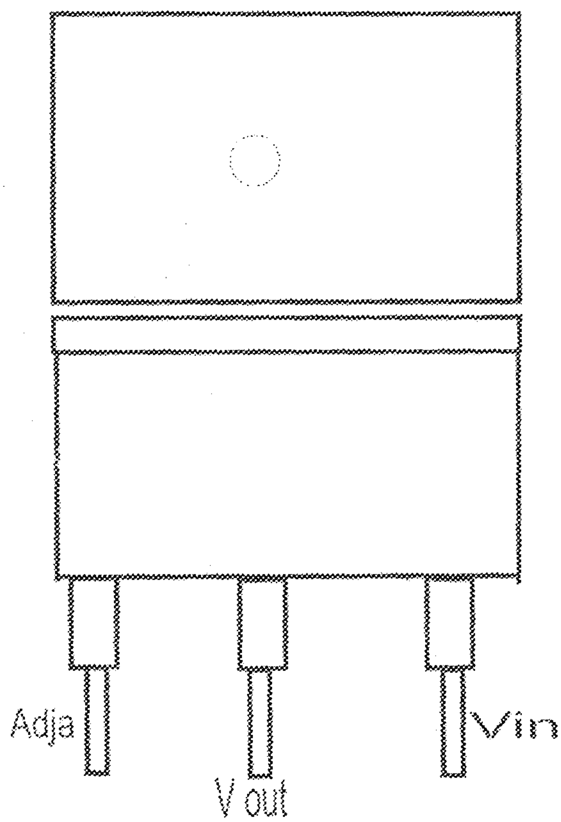


Fig. 3d: Total Output Wave Form

3.2.2 LM317

The LM317 adjustable is a 3-terminal positive voltage regulator, capable of supplying in excess 1.5A over a 1.2 to 37V output-voltage. The LM317 regulator is exceptionally easy to use and requires only external resistors to serve the output voltage. The Lm317 offers a full over load protection, current limit, Thermal overload protection and safe operating current (50A) protection.

Normally, an LM317 requires no capacitor unless, the regulator is situated more than six inches from the input filter capacitor. The LM317 can be used as a precision current regulator.



Fig, 4: LM 317 Pin Diagram

The application units for LM317, the regulator develops a nominal 1.25V reference voltage, Vref, between the output and adjustable terminal. The reference voltages impressed across the resistor R_1 and since the voltage is constant, a constant I flows through the out put resistors R_2, given an output voltages.

$Vout = VREF(1 + R2/R1) + IadjR_2$

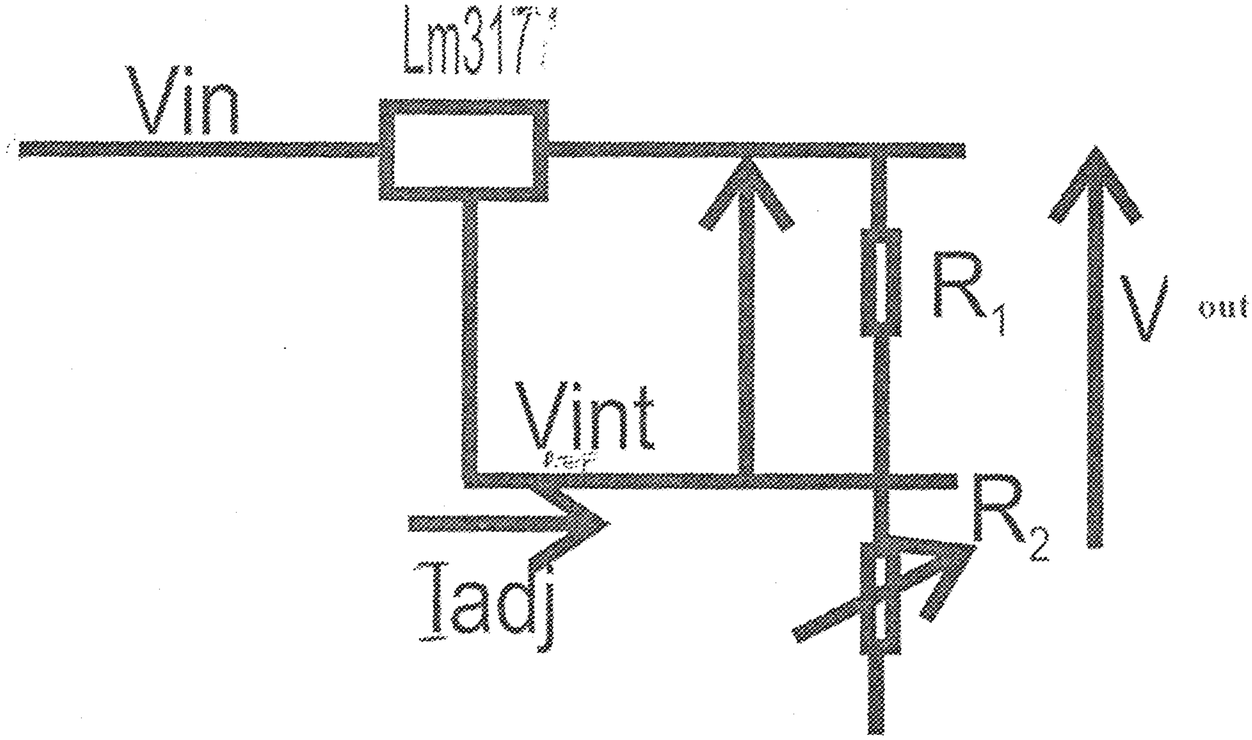


Fig. 5: Showing LM317 Voltage Application Units

The LM317 is configured as a constant current, constant voltage regulator to charge the two 6V, 4.5AH lead acid batteries that provide power to the inverter units. At the beginning of the charging cycle when the battery voltage is less. The base of the 2SC1815 Transistor Q_1 is off. This allows the adjustable voltage regulator to operate as a constant current source. The regulator therefore forces a constant 1.25V across R_{LIM}, thus generating a constant current of

$I_{LIM} = (1.25v/ R_{LIM})$ A

R_{LIM} was chosen as 1n to produce a charging current at 1.25A. As the batteries begin charging, their voltages Rise and is sensed at the output of the 6V zener diode. The 20Kohm trimmer resistor and V2, plus 0.6v needed to turn on Q1, Q1 starts controlling the adj pin of the LM317 which then starts to regulates the voltage across the battery and the constant voltage portion of the charging cycle starts. Immediately the charger is in the constant voltage mode, the charger maintains a regulated voltage across the battery and the charging current is dependent on the state of charged battery. As the cell approach fully charged condition, the charging current falls to a very low value.

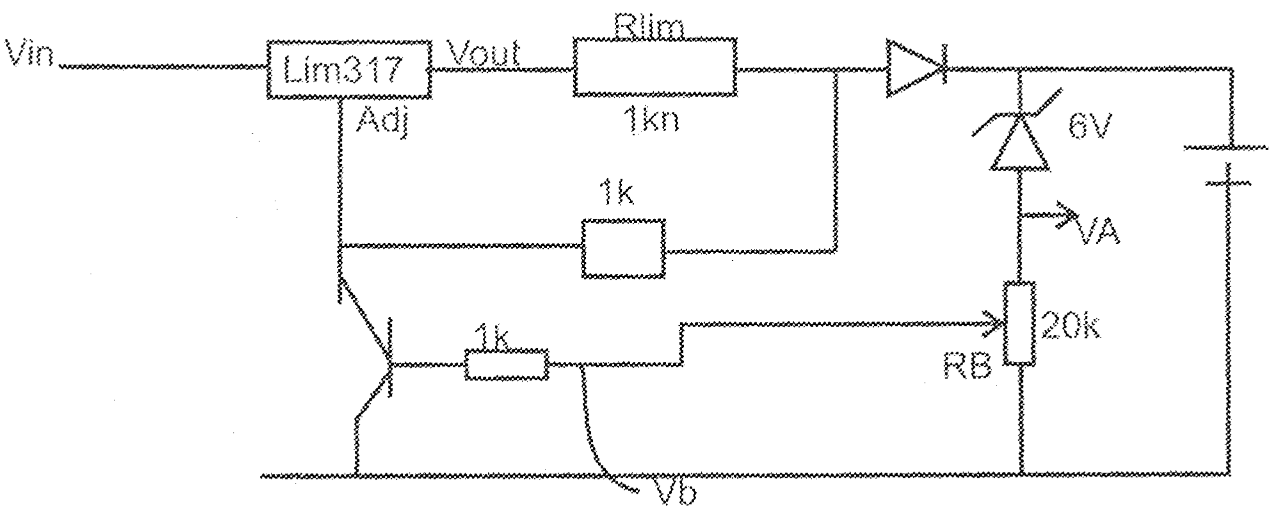


Fig. 6: Showing LM 317 with Load

The LM is configured to generate a constant voltage of 6v minimum; and (V_{in} – 1.25) V (maximum) across the two lead Acid batteries.

The out put voltage is determined from the expression

V_b = 0.6 V = Va Rb/(Ra+Rb)……………1

But Va=(Vbatt_V2)

=(Vbatt_6)…………………2

0.6RA+0.6RB=VARA………3

Substituting equation 2 in to equation 3

0.6RA+0.6RB= (Vbatt_6)*R_B…………4

0.6(RA+RB) =Vbatt X RB-6RB…………5

Vbatt X RB=0.6(RA+RB) +6RB

$$Vbatt=\frac{0.6RA+0.6RB+6RB}{RB}$$

$$Vbatt=\frac{(0.6RB+6.6RB)}{RB}$$

Vbatt=0.6(RA/RB) +6.6

Thus the battery voltage is programmable for any chosen value of Ra and Rb.

The In 4001 diodes is used to prevent the battery current from flowing through the LM317 regulator from the output to the input when the DC input voltage from the battery is removed.

The 25v 220nF by pass capacitor is used to stabilized the operation of the charging system.

3.2.3 THE ZENER DIODE

In normal power supply circuit, the input voltage to the rectifier may vary, probably due to fluctuation in the AC mains. This may result in variation of output signal.

The zener diode as a voltage regulator, its function in the charging circuit is to provide a steady value of the output voltage despite possible variation in input voltage or load. Zener diode operates in the reverse bias region and should therefore be so connected in the circuit. If the reverse voltage is increased from 0 volt, only the reverse saturation current flows. At the breakdown voltage Vz, however, the negative current starts to increase appreciably. Any voltage higher than Vz applied to the diode does not increase the output voltage despite the rapid increase in the reverse current.

The figure below shows zener diode V-I curve and circuit symbol.

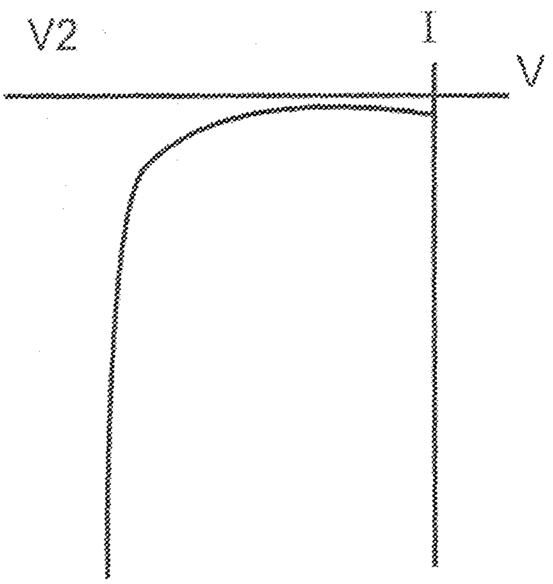
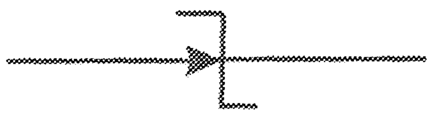


Fig 7 (a) V-I curve



(B) Circuit Symbol

3.3 THE INVERTER MODULE

There are different ways of achieving inversion form DC to AC base on the components used. Example of such components are transistors; integrated circuit. For this project work the BJTs (NPN) transistors is used since the aim is to achieve a low power output for lightening.

The inverter Unit is divided into the following subunits.

(1) Transistor switching unit

(2) Power transformer

3.3.1 TRANSISTOR SWITCHING UNIT

This is made up two npn transistors used as switches by the design the need to achieve switching between inverter and charger by the use of a relay is eliminated.

The transistor has to be operated in its saturation and cut off regions for it to serve as a switch.

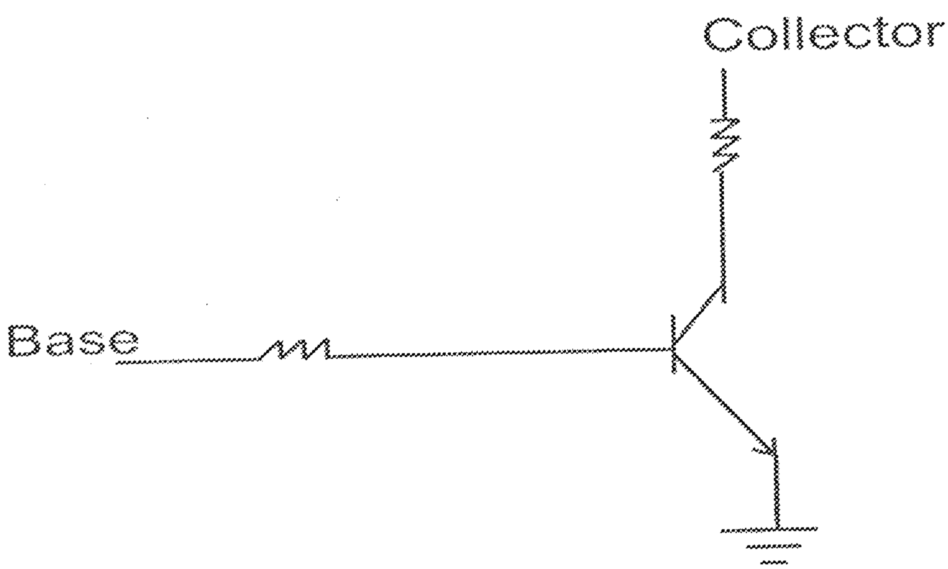


Fig. 8: A Typical BJT Switch

3.3.2 OPERATION OF BJT

In order to get the transistor ready for operation, the two PN junctions must be appropriately biased. The rule of biasing the Bipolar junction Transistor (BJT) is

Forward bias the Emitter-Base Junction

Reverse bias the collector-base Junction

The biasing rule is illustrated in the figure below for NPN transistor

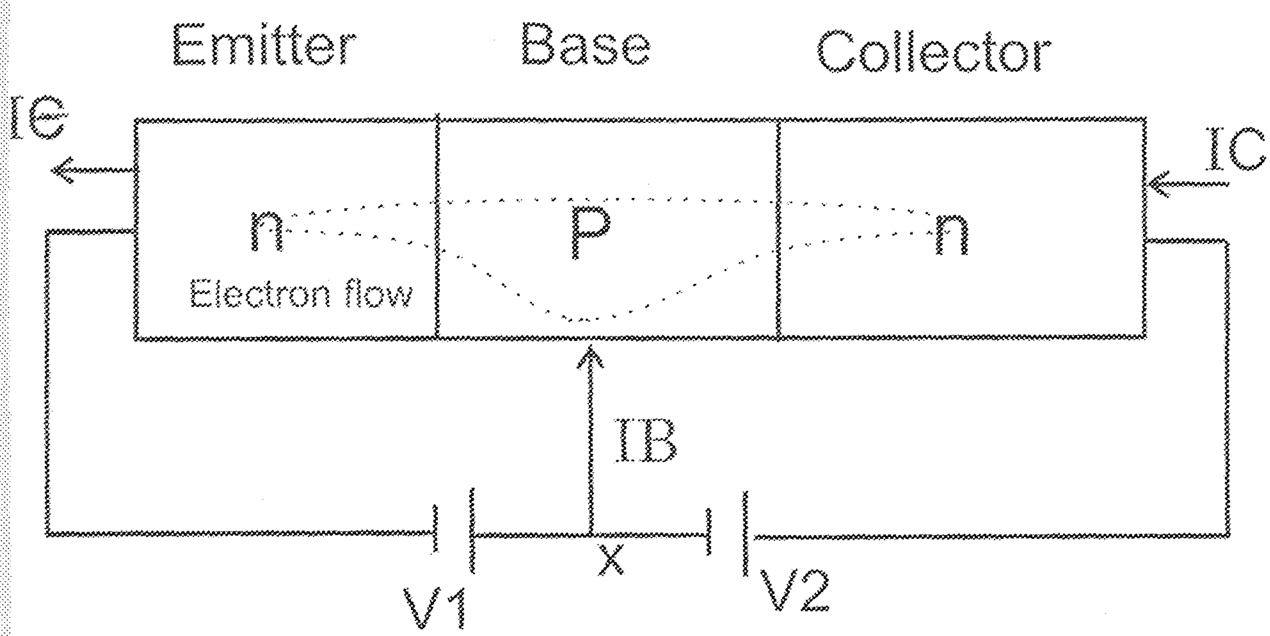


Fig. 9: Biasing and Operation of NPN Transistors

Under this biasing condition, a large number of electrons (majority carriers) in the emitter region are injected into the lightly doped and relatively thin base-region to become minority charge carriers. Some of these electrons recombine with holes in the base region. The replenishment of these holes forms the base currents Ib, in the external circuit. However most of the electrons (injected) are drifted to the collector region by positive potential of batteries V2 to form the collector current Ic. The injected electrons from the emitter form the emitter current.

3.3.3 CURRENT RELATIONSHIP IN BJT

The kirchoff's current law for node in figure above

IE=IC+IB

IC= α IE

α =IC/IE – ratio of collector current to the emitter current

IC= $(\alpha/1-\alpha)IB = \beta IB$

$\beta = IC/IB = 1/1-\alpha$

For this transistor to serve as a switch. It must be in saturation and cut off region, the figure below shows typical output characteristic curves of BJT

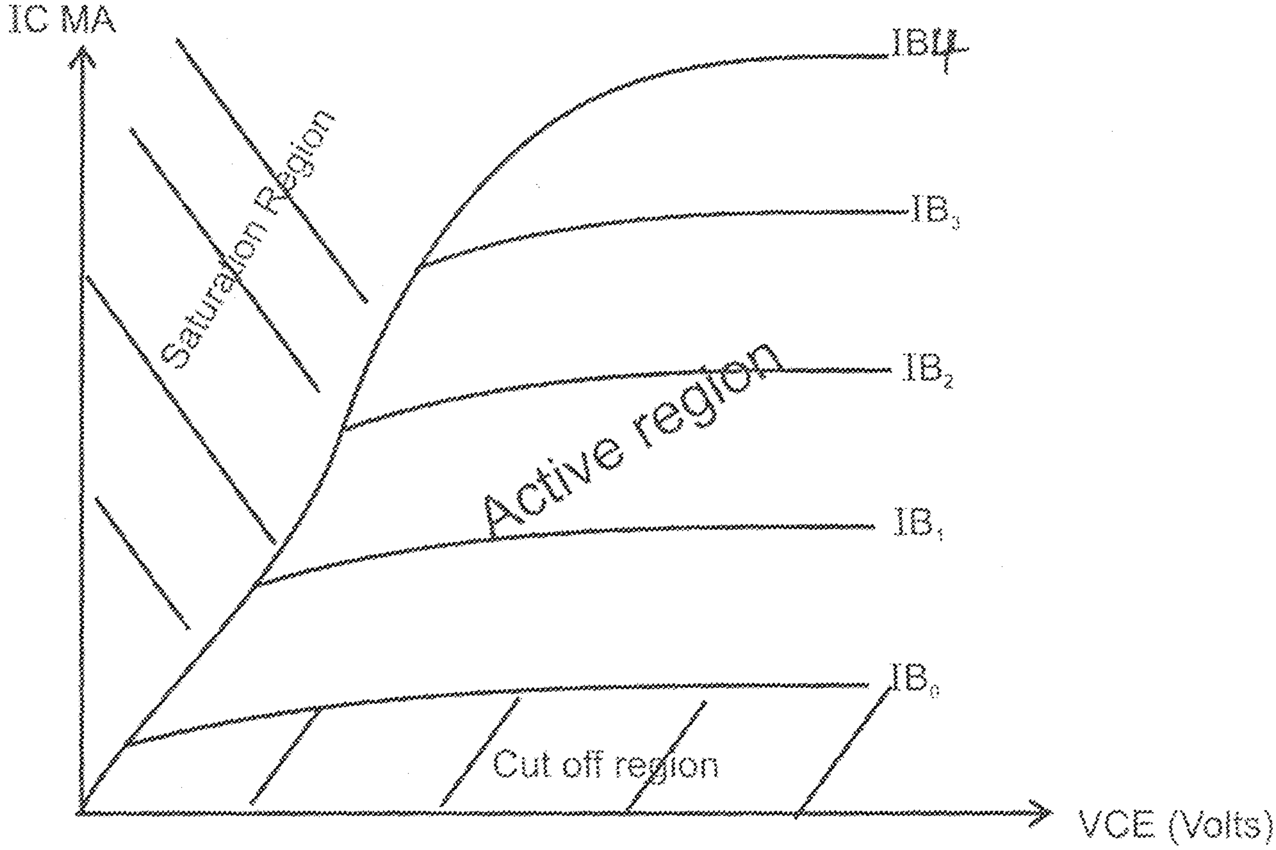


Fig. 10: Typical Output Characteristic Curves of BJT

1. Saturation region – Where Ic rise rapidly with increase in Vce
2. Cutt off region – where Ib is zero in this region only a small leakage current, Icbo flows, !cbo is the reverse saturation current flowing between this collector and the emitter when the base current is zero.

The collector current at saturation point is given by

$$Ic\ sat = \frac{Vcc - Vsat}{Rc}$$

$$= Vcc/Rc$$

Ib must be greater equal to 50 μA for the transistor to be in saturation

Ic= $\beta I + Icceo$

$$Ib = \frac{Vi - Vt \geq Ibsat}{RB}$$

Where

Vi=input voltage

Vt=Thresholdvoltage (usually 0.7v)

$$Rb \leq \frac{Vi-Vt}{IBsat}$$

Let RB=330n

Vi=6v

Vt=0.7

$$IB \leq \frac{6-0.7}{330} = 16mA$$

3.3.4 RESONANCE FREQUENCY CHOKE

This RF choke is an inductor to preset the circuit frequencies above the specified frequency without affecting the flow of 6V DC. The RF choke used in this project work is to adjust the frequency of the circuit, whereas the DC to the inverter circuit is unaffected.

The frequency of the inverter is 25KHZ since it is a low power supply

$C=0.1\,\mu F$

$F=1/2\Pi\sqrt{LC}$

$25 \times 10^3=1/2\Pi\sqrt{LC}$

$\sqrt{LC}=1/2\Pi X 25 X 10^3$

$LC=1/(2\Pi X 25 X 10^3)^2$

$LC=4.05 \times 10^{-11}$

$L=\frac{4.05 \times 10^{-11}}{0.1 \times 10^{-6}}=405\,\mu H$

3.3.5 POWER TRANSFORMER

A transformer is an electrical AC component which consists of two or more coils that are linked together by mutual inductance. It is used to transfer electrical power from one coil to another. It can also be used to change voltage, current or impedance from one value to another.

A step up transformer with a centre tap was used at the inverter output section. The circuit symbol of a step transformer is shown in the figure below. The transformer also has a feed back section which compares the output frequency with the input.

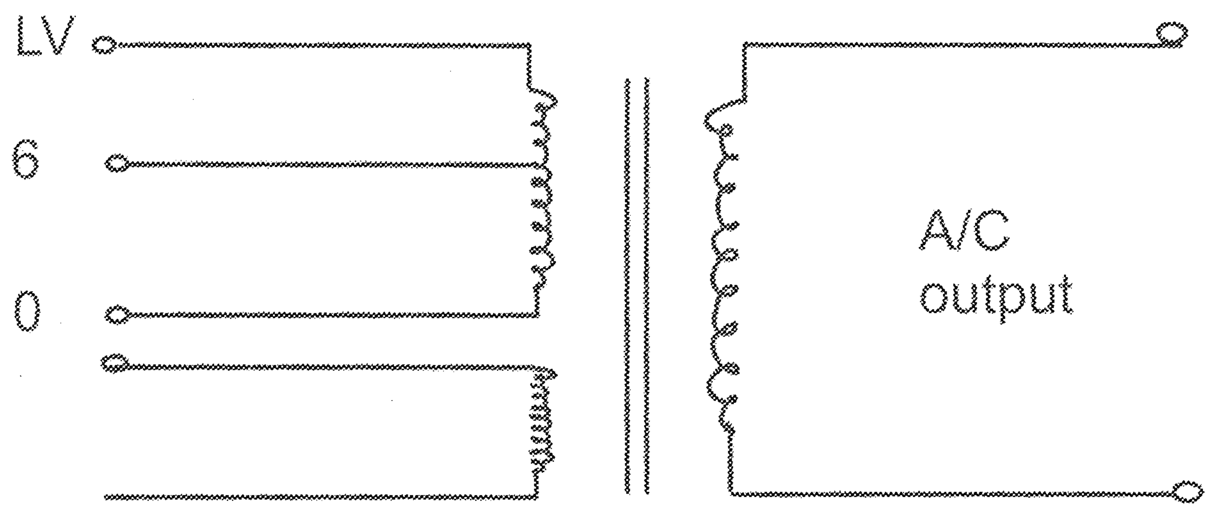


Fig 11 Showing center-Tapped transformer

The transformer voltages and windings is related by the equation.

V2/V1=N2/N1

V1 and V2 are the voltages in Primary and Secondary windings N1 and N2 is the number of terms in the primary and secondary winding.

The output voltage of the inverter is to be 240V, and the input voltage is 6V

The output power of each section is 60W

$I=60/240=0.25A$

$\therefore V2/V1 = N2/N1$

V2=240V
V1=6V

Number turn in primary is 8-8-3

3-turns is the feed back

Total number of turns =16-3=13

240/6=N2/13

N2=240 x 13/6

N2=3,120/6

N2=520

∴ The number of turn in secondary winding is 520 Turns so this number of turns was used for the desire power output in each see him of inverter Neglecting power losses

Input power = output power

$V_1I_1 = V_2I_2$

Or $I_2/I_1=V_1/V_2=K$

K is the transformation ratio

Output of inverter =60W

Output voltage =240V

$I_2=60/240=0.25A$

$I_1=I_2V_2/V_1$

=0.25 x 240/6

=60/6=10A

3.3.6 STATUS INDICATOR

This is made up of the three light emitting diodes, the two green LED is connected to each 60w section of the inverter circuits to indicated the mode in which inverter is, the red LED indicates the battery charging mode.

3.3.7 BATTERY

This serve as the source of DC input to the inverter. The quantity of electrolyte which the battery can give in a single discharge is its capacity. This means it is the product of the discharge current and discharge time. It is express in ampere –hour (AH). The AH is the amount of power the battery can discharge over a period of time.

The battery bank should have batteries connected to each other in parallel. This helps in increasing the Ampere-hour rating. When this parallel connection is made, the voltage of all the batteries in the bank is the same, but the AH ratings becomes the sum of the AH rating of all the batteries in the bank.

To calculate power requirement of a device say 50 WATT

Assuming efficiency of 75%

DC Amps =power/Battery voltage=50/6=8.33A

Actual DC Amps X efficiency factor

Efficiency factor 100/75=1.33

= 8.33 X 1.33

= 11A

Take the device is to be used for 2 hours Ampere hour consumed

= 2X 11A

=22AH

This battery of 60AH is suitable for the inverter.

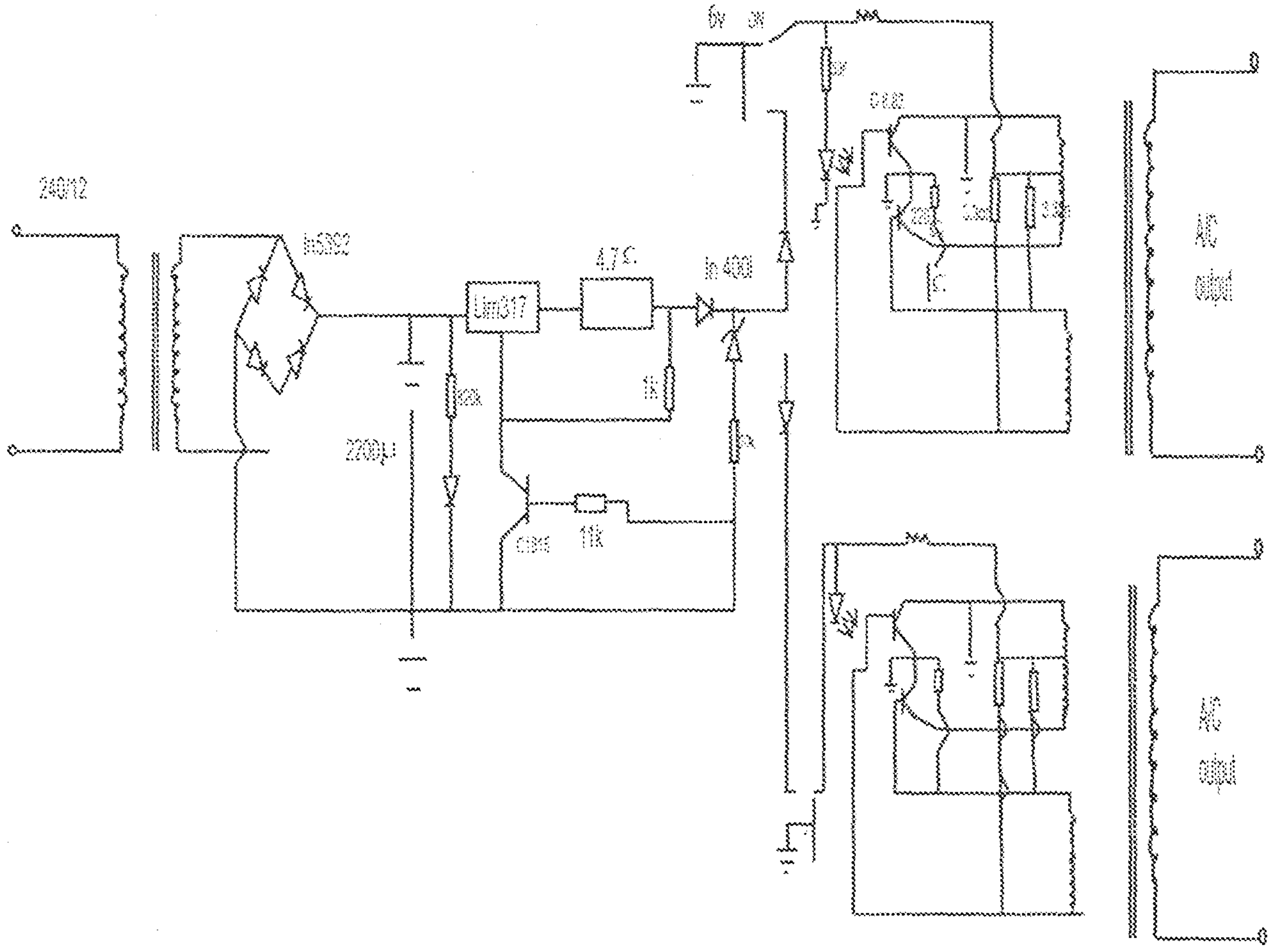


Fig. 12: Circuit Diagrams of Complete Inverter with Charger

CHAPTER FOUR

4.1 CONSTRUCTION TESTING AND RESULTS

4.1.1 CONSTRUCTION

The circuit was first design and simulated using multism. The circuit component was then connected on the bread board temporarily as per circuit design specification. The battery charger circuit was first implemented on the bread board and tested. Also the inverter system was also built on the breadboard and the output voltage measured, and it was found to be in accordance with the specification.

The whole system was then transferred to the Vero board, carefully, with construction of the diodes and transistors first followed by other units.

However various problem was encountered during the construction of the system on a Vero board. Among which include unprofessional handling of the components. Non availability of some used components in Minna.

4.1.2 SOLDERING PROCESS

The component that is to be soldered, a 60 watt soldering iron supplied the required heat needed with lead to hold the components permanently on the Vero board. The system was then ready for packaging.

4.1.3 PACKAGING

The complete constructed circuit on the Vero board was then housed in a plastic casing.

4.1.4 PRECAUTION

The entire designed construction would have been a failure if certain precaution were not taken.

Some of these precautions include.

1. Over heating of the component was put into consideration during soldering process.
2. All components were properly soldered into their appropriate place on the Vero board.
3. The values of the components though not exact, were ensured to be close to the required values.

4.2.1 TESTING

Each unit of the design was simulated first using multisim software on a computer. Then it was also tested on a breadboard, before it was transferred to the Vero board.

The output voltage of both inverter and charger unit was measured using digital millimeter.

4.3.1 RESULTS

The constructed low power inverter was used with fluorescent tubes and their power consumption is shown in the table below.

APPLIANCES	POWER CONSUMPTION
3 Fluorescent Tube (3)	20 Watt each

Table 1 Power Consumption of some electronic and Electrical Appliance

4.3.2 DISCUSSION OF RESULT

From the result obtain, on testing the low power inverter system, it was discovered that the results obtained was satisfactory.

The system was able to supply the tubes without the aid of any auto voltage regulator.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Conclusively it is obvious that there is a realistic solution to power outages in Nigeria. The cost of an inverter system that has the same power output with some generator is far lower than the cost of the generator, which implies it is a device that commons could afford.

The art and technology is not too complex and above all it is in existence. In addition, more knowledge and understanding of transformer winding, transistor as a switch and amplifier was acquired.

The inverter device is also very cheap to maintain compare to the generating sets that needs to be fuelled to maintain constant operation. The inverter does not produce any noise like other generating system of its capacity which produces unbearable noise when in use.

Finally, this project has been very interesting and worth going through by every graduating student in order to expose them to the practical of what is being learnt in class. This will also create confidence in students after graduation, when they go out to the practical fields of Electrical-engineering due to the practical experience gained in the design and construction of their project.

5.2 RECOMMENDATION

Since the field of electronics remains ever dynamic, it is always very possible with no limitations, to modify the designs for better performance. In view of this I recommended that any student who wish to embark on this type of projects should use.

- Power mosfet for switching large currents
- An IC can be incorporated in to the circuit such as SN740IC, 7404IC to oscillate the incoming DC signal, for transistors to amplified and then switch in to output transformer of the required power ratings
- The device should be incorporated with a thermistor to sense heating within the circuitry.
- The device is recommended for use as an alternative low power supply in homes and offices, for lightning.

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