DESIGN AND CONSTTRUCTION

OF A 0.5.KVA DC-AC INVERTER

BY

ADEOYE ENIOLA JOHN ADEWALE

(Reg. No. 93/3491)

OF THE DEPARTMENT OF

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CERTIFICATION

This project report has been read and approved as having met the requirement of the Department of Electrical and Computer Engineering in the School of Engineering and Engineering Technology, Federal University of Technology Minna, for the award of Bachelor of Engineering (Hons) degree (B.Eng.) in Electrical and Computer Engineering.

Mr. Paul Obafemi Attah
(Project Supervisor)

Date: 24/03/2000

Dr. Y. A. Adediran
Head of Department Electrical and Computer Engineering.

Date: 6/4/00

External Examiner

Date: 6/4

DECLARATION

I declare that this project is the result of my personal effort and that it has never been presented in any seminar, symposium or elsewhere in any form for the award of Diploma or Degree.

All information from published work used in this project have been duely acknowledged.

Adeoye E.J.A.   DATE.

29:03:2001

DEDICATION

I dedicate this work to the almighty God who is solely responsible for the good and glorious things in my life.

I also dedicate this work to the memory of my late dad, Mr. Matthew Adeniyi Adeoye, who arose the passion to learn in me. I love you daddy and I will miss you till I set my eyes on you again.

"We give back to you, O God, those whom you gave to us. You did not lose them when you gave them to us, and we do not lose them by their return to you.

Your dear Son has taught us that life is eternal and love cannot die. So death is only an horizon and an horizon is only the limit of our sight "

- William Penn

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My profound gratitude goes to God almighty through my Lord Jesus Christ whose grace is my prime effort in succeeding

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I appreciate the concern of Miss. Adenike Adeoye and Miss. Adebola Adeoye. They were there to encourage and advice me as need demands through my journey to obtain a degree.

I remember here my ten nices and nephews who are to me the epitome of joy and happiness - I love you all.

I say thank you a million times for your prayers, love, moral and financial support.

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Omachonu Abu, Shola Olarewaju, Micheal Ogundele, Seun Sonaike, Femi Daodu, Femi Adegbola, Tosin Ogundipe, Aiyatu Takaya, and many more; all Rhemites, lecturers and colleagues in class; well wishers and admirers, for their contributions in making my success at Federal unversity of Technology Minna a reality.

The race is not for the swifit, nor the battle for the strong, neither riches for men of skill, all is by the grace of God.

May God continue to work out His best plans in the lives of all of you in Jesus name. Amen.

Adeoye E.J.A.

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ABSTRACT

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

The purpose of this work is to develop the dc - ac inverter/charger unit as an alternative to the use of generating sets because of its low cost and its maintenance free nature.

The inverter/charger was designed using power mosfets as the main inverter switching components and the switching signals were generated by a 555 timer astable multivibrator. It is essnetially a square wave interner. The inverter/charger can power loads up to 500VA from an ordinary 12Volts car battery.

LIST OF FIGURES AND TABLES

CHAPTER ONE

INTRODUCTION

INVERTER/CHARGER

Conventional electricity supply has failed to meet the needs of many business and residential homes. For much longer than can be remembered, the National Electric Power Authority has lost it shine. It is now associated more with darkness than electric light. The customers' ears are full with regular announcements of their need of some bullion of Naira to be able to put their humpty dumpty selves together again.

Many have long turned to generating sets, but those have been discredibted, for their high noise emission, high cost of maintenance, high atmospheric pollution and in the last few years, high cost of diesel and fuel or scarcity of both.

In the face of persistent power failure, solar energy products present a ready alternative.

Solar energy products includes:

Modular panels which generate energy from day light and sunlight (direct current or DC)

Inverter the DC is then transformed to alternating current (AC) by inverter which is more or less the transformer.

Heavy-duty batteries, they play a supportive role in the system, they are used as back up so that in the night when the solar panel has stopped charging, the battery takes over.

The batteries do not need charging. As the modules generate power in the daytime, they also charge the batteries for work at night when itself will be off duty.

The inverter seems to be the heart of the solar energy system.

An inverter could be designed to be with a charger and powered by a battery, which can be used to serve the following purposes:

(1) To provide freedom from noise, vibration and fumes of a generator ,it allows you to enjoy silent AC power.

(2) To provide adequate power to operate household appliances like TV, VCR, stereo, blender, personal computer and most small appliances independently of NEPA.

(3) To provide an inexpensive means of generating AC power.

1.1 AIMS AND OBJECTIVES

The aims of this work is to produce an alternating current from a direct current source, such as car battery, modular panels (solar cells) e.t.c. The device that makes this possible by converting ac-to-dc is the subject matter of this work.. The device is known as an inverter.

The choice to designs a 0.5kVA capacity inverter was due to the fact that most voltage regulators used for electronic appliances in homes are rated at 0.5KVA. thus the design is to produce an inverter that will be able to power electronic appliance such as television, video, and tape player in homes.

This capacity of an inverter is believed to be highly marketable and affordable just as its voltage regulator counterpart.

This work is also expected to reveal all that is involved in dc-to-ac conversion and thus serves as prototype of more complex designs which perhaps are having higher output power rating.

1.2. METHODOLOGY

Inverter and charger system

Inverter unit

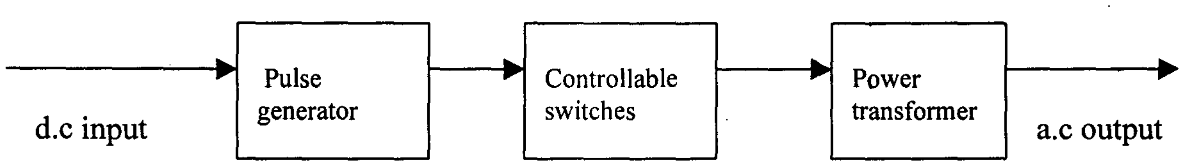

Figure 1.1 Block diagram of a D.C – A.C Inverter.

A d.c input from the d.c source is fed to the pulse generator which converts

it to pulses. The realized pulses are used to turn a set of power mosfets on- and-off. Mosfets are controllable switches, and other controllable switches such as bipolar junction transistor (BJT), or thyristor (silicon controlled rectifier), could have been used to achieve the same end.

At the output of the inverter is a step-up power transformer from where the output voltage is tapped to supply the load.

Battery Charging Unit

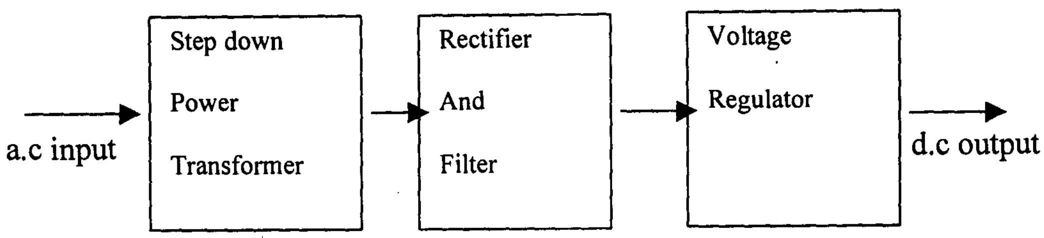

Figure 1.2 Block of a battery charging unit.

An ac input from the mains is stepped down by a step-down power transformer and is rectified by a full wave bridge rectifier. The voltage output of the rectifier is filtered and is passed through a voltage regulator, and thus giving rise to a regulated voltage which is fed to the batteries for charging.

1.3 LITERATURE REVIEW

Before the development of the dc – ac inverter, there was no other way to obtain AC power other than from the mains supply or from standby generator sets. The mains supply in Nigeria is quite unreliable and generating sets are quite expensive to procure.

The development of the dc – ac inverter has therefore made it possible to obtain AC from batteries which are readily available.

The world's first high performance inverteer was introduced in 1983 by Heart interface who has been a leader in inverter/charger technology. It was the first reasonably prices commercially marketed DC – AC power inverter.

In 1984 Heart interface patented and introduced inverters utilizing field effect transistors (i.e. Mosfets – metal oxide semi conductors field effect transistor) for the main power output devices. The use of mosfets made the design smaller because they are much smaller than bipolar junction transistors.

1.4. PROJECT OUTLINE

The write up is a detail report on the design and construction of a 0.5KVA DC -AC inverter/charger. It gives a total breakdown and analysis of all the steps and stages involved in the design and construction of the system.

Chapter one a is comprehensive introduction to the concept of DC-AC conversion.

Chapter two consist of the system design i.e process of designing the inverter/charger system and comprehensive highlight of all sub-systems, device and components that make up the complete system.

Chapter three outlines the construction, testing and analysis of results obtained from testing.

Chapter four contains the conclusion, recommendation and references made.

CHAPTER TWO

SYSTEM DESIGN

2.10 COMPONENTS SELECTION

The inverter/charger system is made up of various sub- systems in which electronic components will be required to implement.

The main components selected in implementing these sub-systems and consequently the entire system are as follow;

- Bipolar junction transistor
- Metal oxide semiconductor field effect transistors (MOSFET)
- 555 Timer integrated circuit (Ic)
- Voltage regulator integrated circuits (Ics)
- Capacitors
- Resistors
- And diodes

2.1.1 THE POWER MOSTETS

At the switching stage of the inverter, the power mostet if used for switching purposes. The mostet has high speed. High power, and high gain.

It has almost no storage time, no thermal runaway and inhibited breakdown characteristics.

The n+ source and drain regions are diffused or implanted into the relatively lightly doped P-type substrate and a their silicon dioxide layer insulates the aluminum gate from the silicon surface. No lateral current flows from the drain to source without a conducting n. channel between them since the drain - to- source path comprises two series, oppositely- directed pn- junctions.

When a positive gate voltage is applied with respect to the source, positive charges are created on the metal gate. In response, negative charges are induced in the underlying silicon, by the formation of a depletion region and a thin surface region containing mobile electrons. Effectively the positive gate potential inverts the p- channel allowing current to flow fready between and source.

An important parameter in mos transistor is the threshold voltage VTH, which is the minimum positive gate voltage to undue the n- conducting channel. With zero gate voltage the structure is normally off. The device is considered to operate in the enhancement mode since the application of a positive gate voltage in excess of VTH induces an conducting channel.

The typical output characteristics and the load line of the power mosfet are shown in figures 2.1a and 2.7b.

A gate- source voltage pulse is needed to deliver sufficient current to charge the input capacitor in the desired time in order to turn the mosfet on. The input capacitor is the sum of capacitor formed by metal oxide gate structure from gate to drain.

Turning off the mosfet is done by removing the gate voltage. Since it is a majority carrier semi-conductor device, it begins to turn off immediately upon the removal of the gate voltage and presents a very high impedance between drain and source, thus inhibiting current flow.

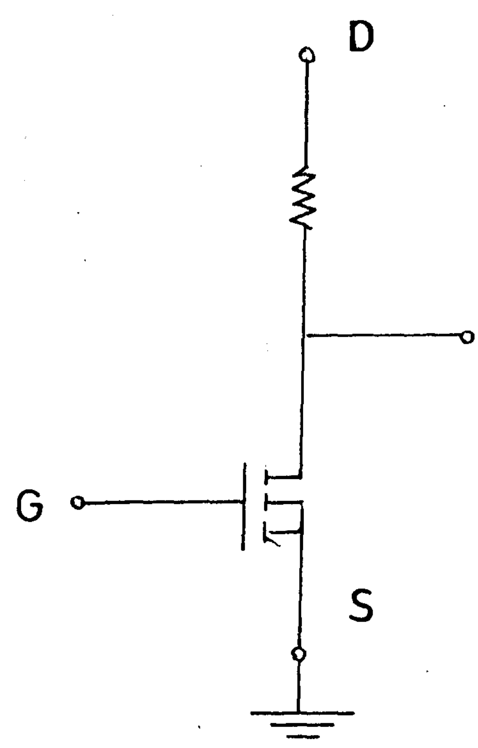

Fig 2.1a N-Channel Mode Mosfet Switch

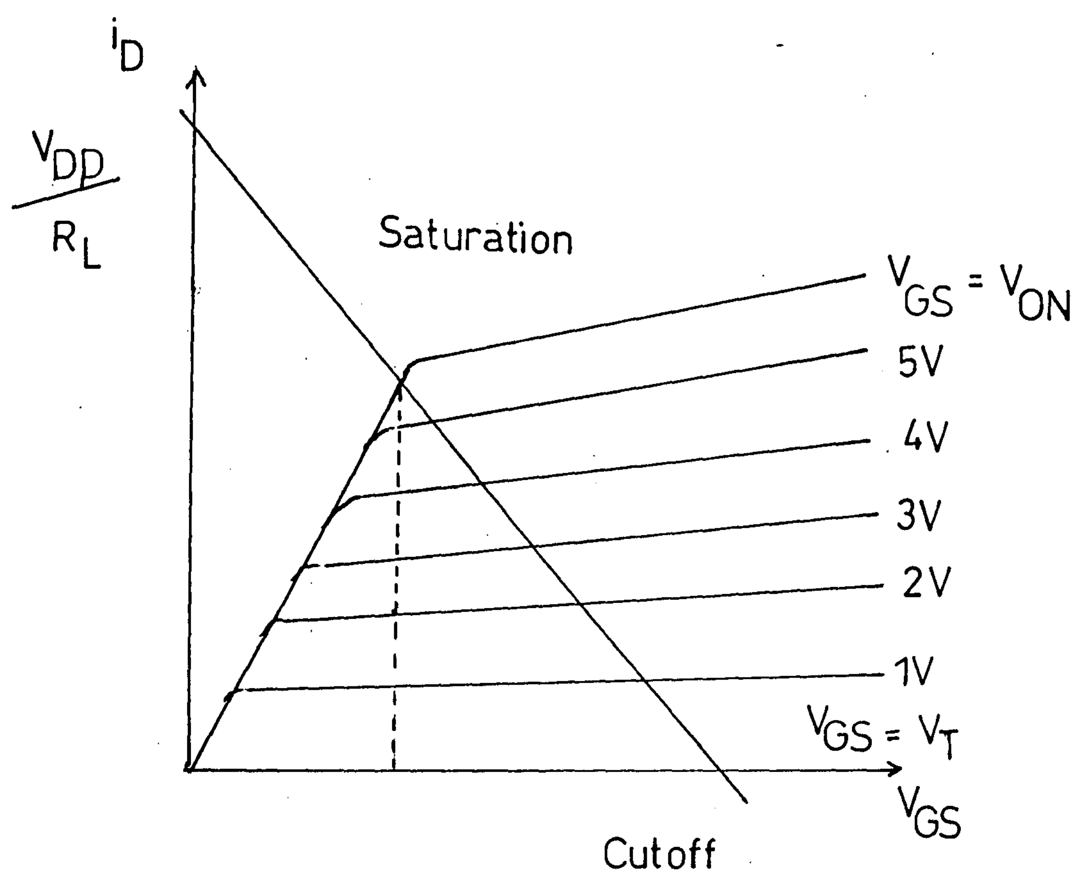

Fig 2.1b Terminal Characteristics And Load Line Of Mosfet

2.1.2 TLC 555 TIMER

The 555 timer is a highly stable device for generating accurate time delay or oscillation. Signetic corporation first introduced this device as the SE 555/NE 555 and it is available in two package style, 9-pin circular style, To-99 can or 8.pin mini DIP or as 14-pin DIP. There is also available counter timer such as Exar's XR - 2240 which contains a 555 timer plus a programmable binary counter in a single 16pin package. A single 555 timer can provide time delay ranging from miroseconds to hours whereas counter timer can have a maximum timing range of days

The 555 times can be used with supply voltage in the range of +5V to 18V and can drive load up 200mA. It is compatible with both TTL and COMS logic circuits. Because of the wide range of supply voltage, the 555 timer is verstile and easy to use in various applications. Various applications such as oscillator,pulse generator, mono-shot, multivibrator, burglar alarm, traffic light control and voltage monitor e.tc.

2.2.0 DETAILED SYSTEM DESIGN

The inverter/charger cpmprises of two parts viz:

1) The battery charging medule
2) The inverter medule

2.2.1 THE BATTRY CHARGING MODULE

Basically there are two methods 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:

3) Booster/high rate charging
4) Trickle or slow rate charging
5) Floating system.

Assume that battery is at 11.5V when down charger output voltage = 14V

Current to flow in circuit = 8A

$14-11.5= 2.5V$ (potential difference between charger and battery)

value of limiting resistor = $2.5/8 = 0.3\Omega$

power dissipated by resistor

$P=I^2 R$

$= 8^2 \times 0.3\Omega = 19.2W$

Thus, a resisitor rated at 0.3Ω, 20w, which is closest in value to what we need was used.

Figure 2.2 shows that circuit diagram of the charger

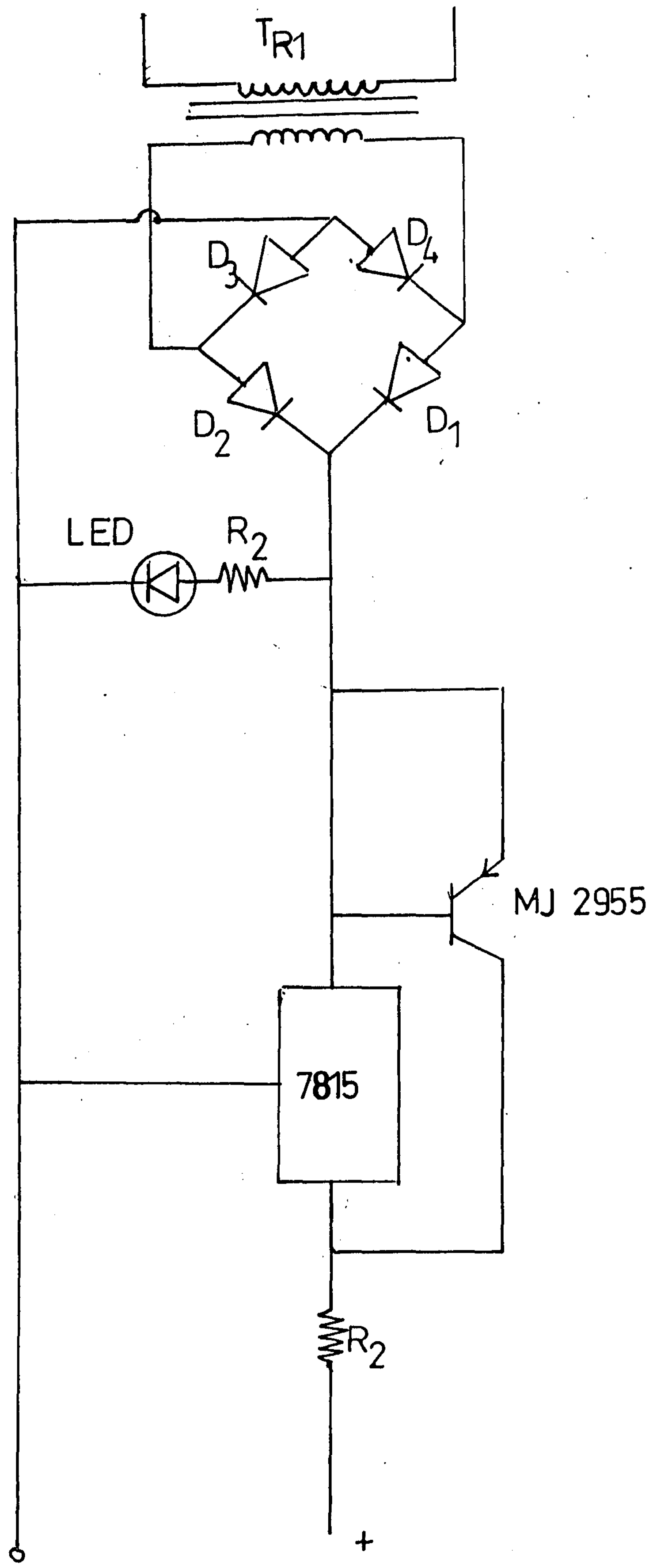

Fig 2.2 Battery Charger Circuit

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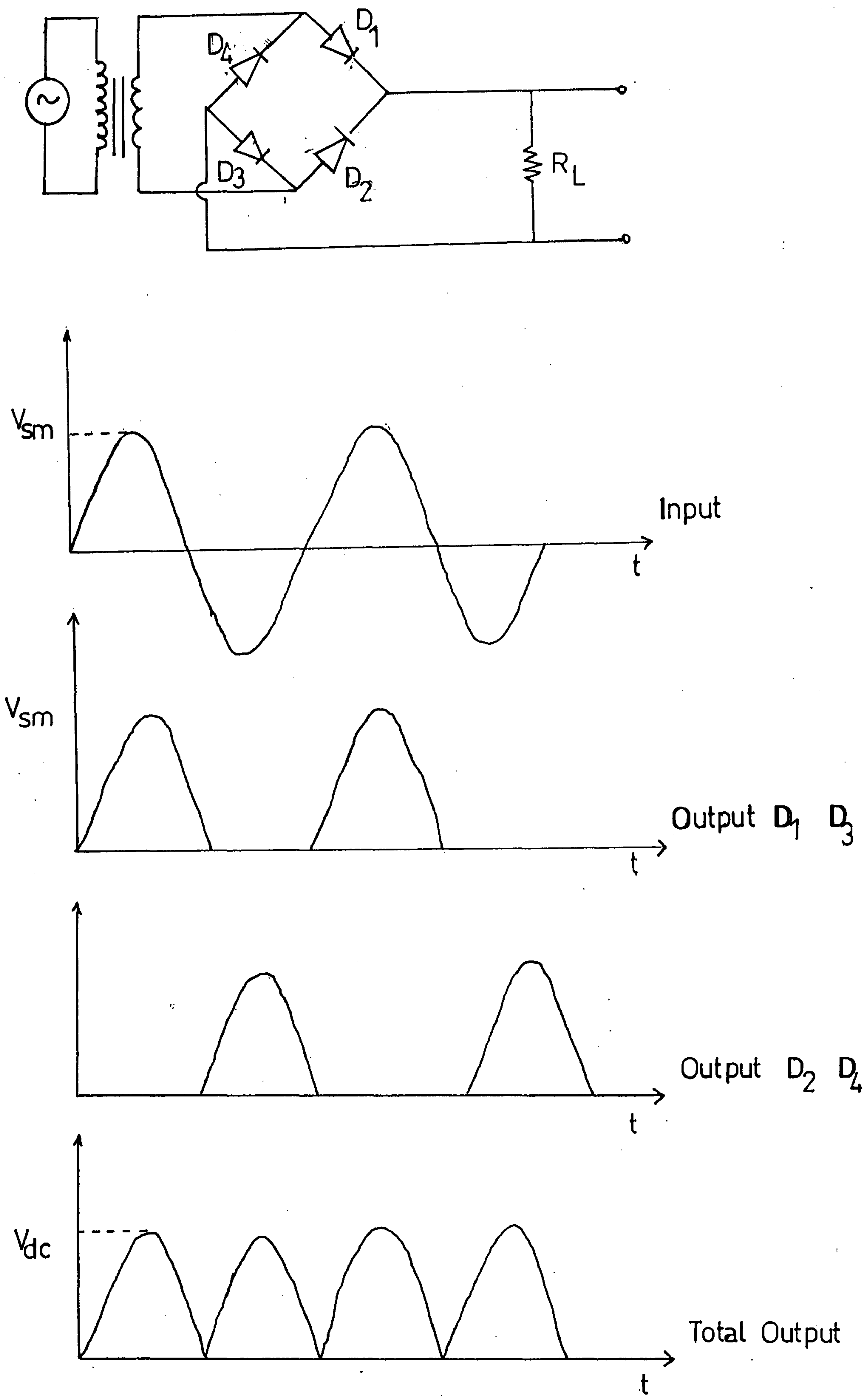

Fig 2.3 Fullwave Bridge Rectifier

2.4.0 THE INVERTER MODULE

The inverter unit is divide into the following subunits:

1. Transistor switching unit
2. Pulse generator
3. Inverter switching
4. Power transformer

2.4.1. TRANSISTOR SWITCHING UNIT

This is made up of two npn trasistors and one pnp transistors used as switches. By this design the need to achieve switching between inverter and charger modes by the use of a relay is eleminated

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

Figure 2.4a A typical BJT switch

The collector current at saturation point is given by:

$$I_{c\,sat} = \frac{V_{cc} - V_{sat}}{R_C}$$

$$\approx V_{cc} / R_c$$

i_B must be greater than or eual to 50µA for the transistor to be in saturation

$$i_c = B\, i_b + I_{CEO}$$

$$I_B = \frac{V_i - V_T}{R_B} \geq I_{B\,sat}.$$

Where

V_i = input voltage

V_T = Threahold voltage (usually 0.7v)

$$R_B \leq \frac{V_i - V_T}{I_{B\,sat}}$$

Input at D1 goes to the base of transistor Q1 and a base current flows causing Q1 to conduct and thus shutting out base current to the base of Q2 by putting its base at a zero potential. Q2 is turned off by this and since current cannot flow of Q3, Q3 is also turned off.

This implies that there is no input to the pulse generator, thus the inverter is off.

On removing the input to D1 Vcc is dropped across R1, and current flows to the base of Q2 which turns it on . Q3 is also on since base current can now flow out. This make current to flow into the pulse generator and the inverter comes on.

The input to D1 is available when the inverter/charger is plugged to the mains and acts as a battery charger.

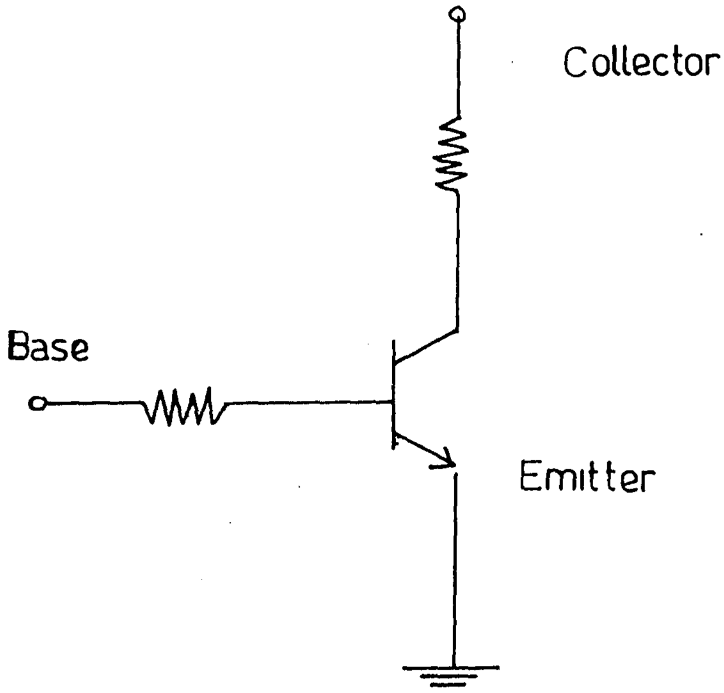

Fig 2.4a Typical BJT Switch

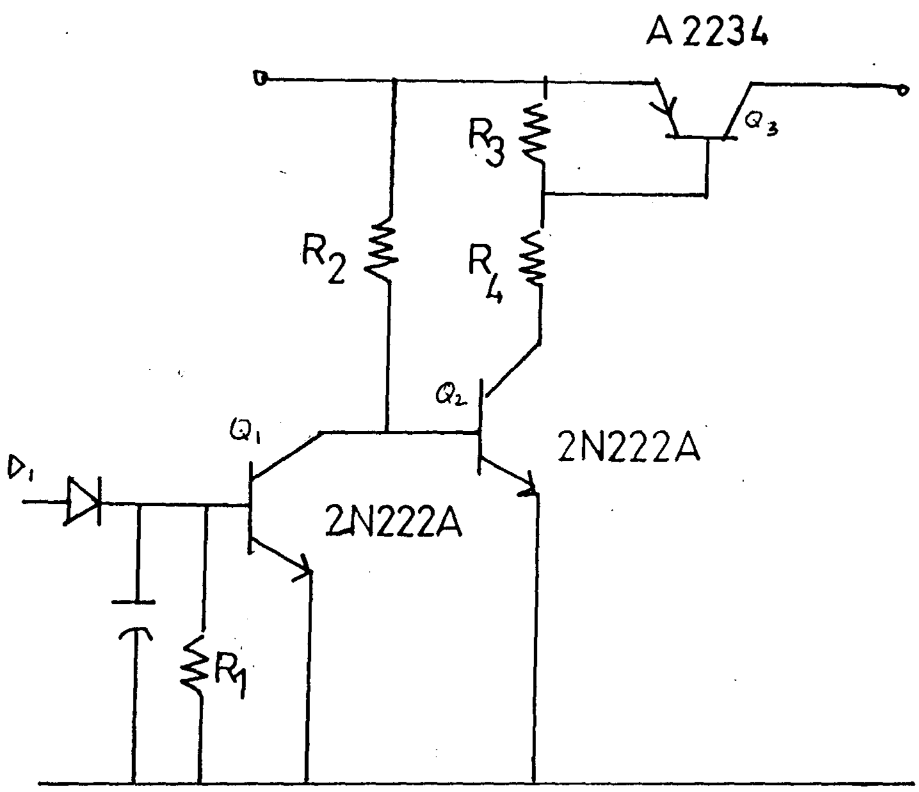

Fig 2.4b Inverter Mode Switch

2.4.2. PULSE GENERATOR.

A 555 timer connected as an astable multivibrator was used to design the pulse generator. Figures 2.4. a and b shows the disgram of a 555 timer connected in an astable mode and the on and off nature of its output waveform.

The frequency of oscillation of the 555 timer is calculated as follows;-

Let t on (the on time of the timer) = 0.693 (R1+R2) C

Let t off (the off time of the timer) = 0.693 (R2) C

It is apparent that on time must always exceed the off time in this configuration unless R1 has a very low resistance conpared with R2

To make t on = t off , equal values were chosen for R1 and R2 and a diode was connected across R2.

This now gives:

T on= 0.693R1 C

T off = 0.693R2 C

Therefore, T = ton + toff

But R1 = R2

T= (0.693+0.693)RC

T= 1.386

T≈1.4RC

But f =1/T

f = 0.7/RC

Assuming R = 10KΩ, f =50Hz

$C = 0.7/10 \times 10^3 \times 50 = 1.4\mu f$

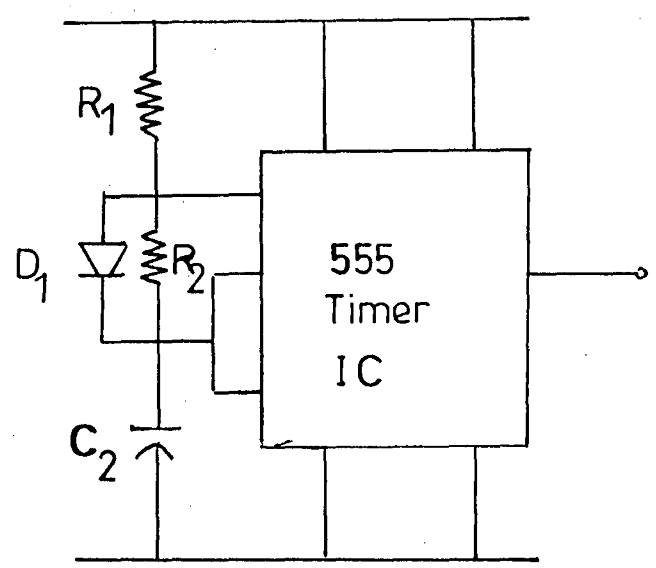

Fig 2.5a **555** Timer IC Astable Multivibrator

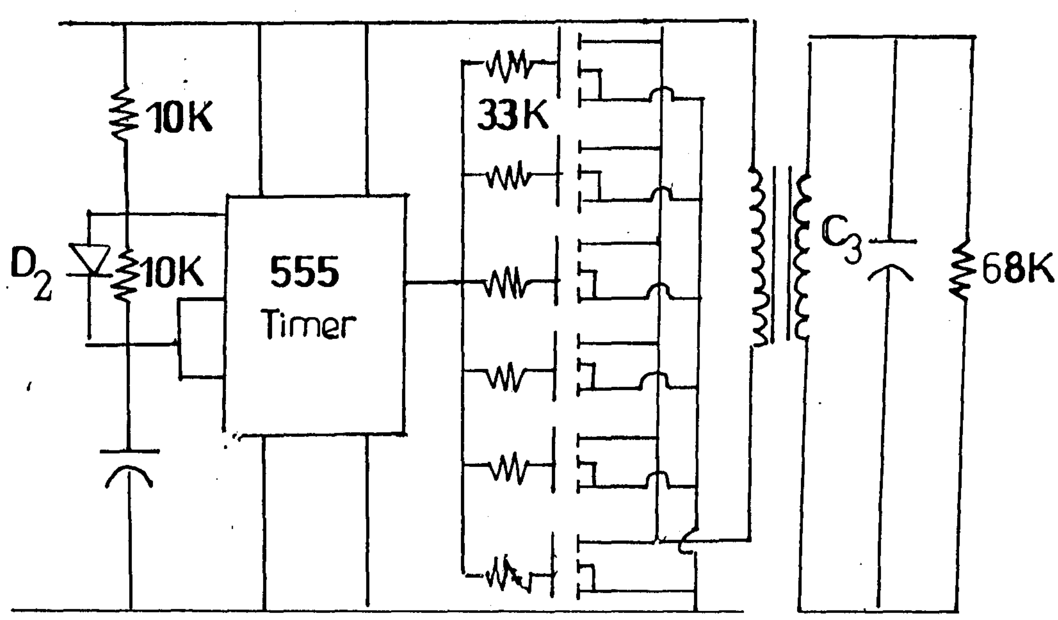

Fig 2.5b Inverter Circuit

2.4.3 INVERTER SWITCHING CIRCUIT

This circuit employs six IRF 540 mosfets connected in parallel. This permits a sharing of local current and provides more efficiency in power handling.

The power stage was made by connecting the mosfset directly to the power transformers

2.4.4 POWER TRANSFORMER

A transformer is an electrical machine which takes in power at one voltage and sends it put at another. The voltage is raised or lowered but with a considerable drop in current. The transformer has two windings secondary and primary windings. A step up transformer was used for the inverter.

The E.M.F equation for a transformer is given below.

Let N1 = Number of turn in primary

N2 = Number of turns in secondary

ϕm = maximum flux in core in vebers

= Bm X A

Bm = Maximum flux desity in the core

A= area of the core

F= frequency of ac input in hertz

Flux increases from zero value to maximum value ϕm in one quarter of the cycle i.e. 1/4 of second

Therefore, the average rate of change of flux.

= ϕm /1/4f = 4fϕm wb / s or volt

The rate of change of flux per turn means induced e.m.f. in volts.

If ϕ varies sinusoidally, then r.m.s value of induced e.m.f. is obtained by multiplying the average value with form factor.

Form factor = r.m.s value / Average value = 1.11

R.m.s value of e.m.f / trurn = 1.11 x 47Q volt.

Now r.m.s value of the induced e.m.ef. in the whole of primary winding.

= (induced e.m.f/turn) x No. of primary turns

E1 = 4.44FN1 ϕm = 4.447N1 Bm A............(1)

Similarly r.m.s. value of the e.m.f induced in secondary is:

$E2 = 4.44 FNz \phi m = 4.44FN2S Bm A$ ....(2)

From equations 1 and 2, it can be seen that:

$E1/N1 = E2/N2 = 4.44f\phi m$

This means that the ratio of the e.mf. to turns ratio is the same in both the primary and secondary windings.

From equations 1 and 2

$E2/E1 = N2/N1 = k$

Where K is the voltage transformation ratio.

Neglecting losses:

Input power = output power

$V1I1 = V2 I2$ or $I2/I1 = V1/V2 = 1/K$

Output of inverter/charger = 500VA

Output voltage = 220V

$$I2 \text{ (secondary current)} = \frac{\text{output power (VA)}}{\text{outout voltage}}$$

$= 500/220$

$=2.27A$

$I1$ (primary current) $= I2\ V2/V1$

$= 500/12 \qquad = 41.67A$

It is taken into consideration that due to losses, peak voltage obtained during oscillation is less than the maximum of 12volts, a 9 volts to 220 volts transformer was used instead.

2.4.5 COOLING SYSTEM

The power mosfets were mounted on an aluminium heat sink due to the large amount of heat generated by the inverter. A 12V brushless fan was installed in the system to draw out the heat produced and in the process draw in cool air through the opening on the top of the casing.

2.4.6 STATUS INDICATOR LEDS

Made up of two light emitting diodes connected to the inverter and charge circuits to indicate the mode in which the inverter/charger is in. The green LED indicates a battery charging mode, while the orange LED indicates an inverter mode.

2.4.7 BATTERY

Serves as the source of D.C input to the inverter. The quantity of electrolyte which a 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 expressed 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 ampre-hour rating. When this parallel connection is made, the voltage of all the batteries in the bank is the same, but the AH rating becomes the sum of the AH ratings of all the batteries in the bank.

To calculate typical power requirement for a device of say 175 watt.

Assuming efficiency of 75%

Efficiency factor = 100/75 = 1.33

$$\text{DC amps} = \frac{\text{power}}{\text{Battery voltage}} = 175W/12V = 14.58A$$

Actual D.C. amp = DC amps x efficiency factor

= 14.58x1.33

= 19.39A

Taken that the device is to be used for 2 hours, Amp hours consumed

= 2hrs x 19.39

= 38.78

Thus, a 60AH battery is suitable for the inverter/charger.

The circuit diagram for the inverter is shown in figure 2.6

CHAPTER THREE

CONSTRUCTION : BUILDING AND IMPLEMENTING THE CIRCUIT.

The circuit components were initially connected on a breadboard temporarily as stipulated by the circuit diagrams. The battery charger was the first to be built on the bread board and tested. The output voltage was measured and it was found that the performance of the device is in accordance to expectation before the components were disconnected and transferred to the vero board.

The circiut components of the inverter module was also first implemented on a bread board, the output waveform of the 555 timer was observed on the oscilloscope. It was also found that the performance of the inverter module is according to expectation before it was transferred to the vero board.

The inverter/charger mode switch components, the pulse generator, excluding the power mosfet were then soldered onto the vero board.

Holes were made on the prefabricated metal casing to accommodate the cooling fan, transformers, indicator and all other components that could only be accommodated by screwing.

Strong metal casing became necessary because of the heavy components of the inverter/charger.

The power mosfets were mounted on an aluminium heat sink and screwed down. The heat sink was necessary because of the large amount of heat dissipated by the mosfets.

Cables were connected to link every point in line with the circuit diagram. Finally, the components were all assenbled in the metal casing and all the cables were linked correctly. A visual inspection was done to all connections.

The components used and their respective costs are as follow:

Component	Quantity	unit	=N=
555 Timer Ic	1	30	30.00
7815 voltage regulator Ic	1	50	50.00
10KΩ variable resistor	1	20	20.00
IRF540 power mosfets	6	150	900.00
Power Transformer	1	1,500	1,500.00
Bridge rectifier 25A	1	100	100.00
Signal diodes	3	10	30.00
1/8 watt resistors	14	5	70.00
1.5μf electrolytic capacitor	1	5	5.00
0.66μf capacitor	1	5	5.00
LM 31 7T adjustable voltage	1	70	70.00
N.P.N transistor	2	30	60.00
P.N.P. transistor	1	20	20.00
Aluminium heat sink	1	200	200.00
Metal case	1	500	500.00
12V brushless cooling fan with metal grille	1	250	250.00
MJ2955 n-p-n power transistor	1	150	150.00

3.1. TESTING

After proper inspection was done to the system, and it became clear that it could be tested. The system was connected to a 12V 60 AH car battery.

The output voltage was made 220V by adjusting the variable resistor.

The system was used to power various electronic/electrical appliances as shown below:

APPLIANCE	POWER CONSUMPTION (WATTS)
21" Colour Television	100
Video cassette recorder	50
Electric lamp	100
14" colour television	70
personal computer and HP DeskJet printer	300

Table 4.1 shows the power consumption of appliances

The power drained on the battery should be considered, since the battery serves as a power source to the inverter.

The table 4.2 below shows the power consumed by some appliances from the battery over a period of time.

			Appliance run times/amp hours	
Appliance	Typical wattage	1 hrs	2hrs	3hrs
VCR	50w	6	12	35
21" Television	100w	12	23	-
stereo	50w	6	12	35
PC & printer	300w	35	-	-
Lamp	100w	12	23	-

Typical power consumption of appliance over 3hours period in amp hours.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

In concluding it is obvious that there is a realistic solution to energy crisis in the country. The cost of on inverter system that has the same power output with a generator is far lower than that of the generator, which means it is a device that common man could afford.

That art and technology involved is not too complex and above all, it is in existence.

Harnessing this techology by indigenous firm will bring about the popularity of the inverter in the country and since it is able to serve the need of the people they will buy it and the companies producing it will make good money.

4.1 RECOMMENDATION

Solar energy: time to act

At a time, the University of Ife was the seat of a solar energy research centre. For decades, the centre had operated but we have not been told of any concrete results at least, one that has culminated result in the conversion of energy from the sun to the use of the ordinary Nigerians. I do not talk of unapplied research finding.

If we had frittered and continue to ftitter away this gift of God, now is the time to return to the drawing board to ensure that we do not continue to suffer in the midst of plenty. For. If we have so much energy conserved in the sun, and sun continues to shine on our land 'ad infinitum', we have nobody to blame but ourselves for throwing away an inexhaustible gift of nature.

Necessity is the mother of invention. Solar energy had been 'invented' for centuries. Therefore, ours is not the burden of invention but of adaptation. We should call experts in solar energy generation from any part of the world and give them an assignment to build the necessary infrastructure here.

This will definately result to the production of module panels (solar cells) locally which will to a great extent make solar energy products available to Nigerians.

4.2 REFERENCES

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