DESIGN, CONSRUCTION AND TESTING OF 500VA SOLAR INVERTER

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DEDICATION

I dedicate this work to God Almighty. My Parents and the entire member of my family.

DECLARATION

I Chukwu Matthew Udo, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

The design and construction of 500VA solar inverter is to provide alternative power supply to home electronics.

The system also serves as a main supply to those living where there is no power source from the mains.

The solar inverter designed and constructed make use of sunlight energy striking on the surface of the solar panel to provide DC current that charges a 112V battery. Having received full energy (fully charged) it can run the inverter and provide an AC electricity for home electronics and other lighter loads rated at 500VA which is the designed specification.

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

The energy problem is a serious case all over world. Inadequate supply of energy has paralyzed almost all the sector of the economy especially in the developing country of the globe. The problem of energy should not be allowed to continue. Engineers are particularly concerned toward providing solution as our professional ethic charged us with the task of providing engineering solution to problems facing humanity.

Down steamed to my field of Endeavour "Electrical/Computer engineering". Engineers are challenged toward designing a system that would utilize abundant gift of nature (sun light energy) to provide useful energy for powering home electronics gadget. Energy from the sun is raw in nature and if converted and processed could be useful for man. Some of these useful forms found application in the following area of life.

Solar refrigerators

Solar driers

Solar voltaic cells

Etc.

For the purpose of this project, the combination of solar system with inverter to generate electricity for home electronics is my primary concern.

1.1 AIMS AND OBJECTIVES

The project is aimed at providing electricity through solar source to homes in the rural areas/places where the PHCN source of electricity is not reliable. The system can also serve as backup power system in homes especially when there is power outage. The system due to design limitation can provide electricity for powering home electronics gadgets with total power rating of 400VA, which is 80% of 500VA(i.e. desired designed power rating) for efficiency. The system is to powering a TV set, a video, a fan and a lighting point and other lighter load..

1.2 Scope of the Project

The project is limited to the use solar panel to charge battery and at full charge, the powers an inverter to generate an AC electricity of 500VA basically for home electronics use. For efficient utilization of generated power and for protection of the designed system about 80% loading is tolerated.

1.3 Methodology

The solar voltaic cell panels are used in conjunction with an inverter circuit for the design. The use of inverter to convert DC electricity from the solar system to AC electricity is the method used for the design. The solar energy is used to charge up the battery to full capacity especially during the day when there is abundant sun light energy. The battery having accumulated full charge, have the capacity of to run an inverter to generate 500wats of ac electricity as output for home electronics' use. The design also incorporates a rectified power circuit as a minor/backup to enable user's choice. The are higher power rating voltaic cell panel are used to charge up battery and run the inverter circuit at the sometime. However due to the low power rating of the solar voltaic cell panel used in this project, the method is dropped. High power rating can be achieved by acquiring more modulus of the cell and connecting in series.

1.4 Source of material

The materials used to implement this project are basically integrated circuits(ICs), transistors, resistors, transformers, solar tray. These were locally sourced from electronics shops in Minna and Lagos.

1.5 Project outline

The project consist of five chapters, these are:

Chapter one includes introduction, aims and objectives, scope of works, methodology and source of material.

Chapter two- these are, literature review,working principle, sola system terminologies, working principles of inverter.

Chapter three consist of design analysis and calculation.

Chapter four-includes construction, testing and discussion of results.

Chapter five give conclusion and recommendation of the project.

CHAPTER TWO

2.0 Literature Review

2.1 History of Photovoltaic

The term "photovoltaic" comes from the Greek meaning "light", and "voltaic", meaning electrical, from the name of the Italian physicist Volta, after whom the measurement unit volt is named[2]. The term "photo-voltaic" has been in use in English since 1849[2]. The photovoltaic effect was first recognized in 1839 by French physicist Alexander-Edmond_Becquerel. However, it was not until 1883 that the first solar cell was built, by Charles_Fritts, who coated the semiconductor selenium with an extremely thin layer of gold to form the junctions[5].

2.2 Theory

Simple explanation

Photons in sunlight hit the solar panel and are absorbed by semi conducting materials, such as silicon. Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity[3]. The complementary positive charges that are also created (like bubbles) are called holes and flow in the direction opposite of the electrons in a silicon solar panel. An array of solar panels converts solar energy into a usable amount of direct current (dc) electricity.

2.3 METHODOLOGY:

There are several way of designing a solar inverter system. Some of the method that can be used are: The use of high rating power solar panel to feed the inverter. This method has a limitation, considering the fact that power input is equal to power output, the solar panel needed to be same rating with the desired output hence increases in cost. The second limitation of this method is that at night (low luminance), the solar system deliver little energy[5].

Another method is the use of two separate high energy battery bank, in which as one battery bank is being charged by the solar system, the other is supplying to the inverter circuit for inversion. This method is the most efficient however, for it requires a lot of capital and hence cannot serve the low and middle income earners in the rural area who are considered to use the design.The method considered suitable for the purpose of this design is the use of solar panel voltage of 17V to charge a 12V battery (which serve as a back up in a situation where there is a power outage and AC power is needed, or in rural area where there is no electricity and AC power is needed for home electronics[1]. The battery having received full charge is feed to the inverter circuit for inversion. Three relay are used in the circuit to effect switching, either switching on or off of the inverter solar or the socket of the output of the AC source of the mains.

2.4 Working Principle of Solar System

A solar cell or photovoltaic cell is a device that converts solar energy into electricity by the photovoltaic effect. Photovoltaic is the field of technology and research related to the application of solar cells as solar energy. Assemblies of cells are used to make solar modules, which may in turn be linked in photovoltaic arrays[6]. Solar cells have many applications. Individual cells are used for powering small devices such as electronic calculators. Photovoltaic arrays generate a form of renewable electricity, particularly useful in situations where electrical power from the grid is unavailable such as in remote area power systems[7]. Earth-orbiting satellites and space probes, remote radiotelephones and water pumping applications. Photovoltaic electricity is also increasingly deployed in grid-tied electrical systems.

2.5 SOLAR SYSTEM TERMINOLOGIES.

2.5.1 Photo generation of charge carrier.

When a photon hits a piece of silicon, one of three things can happen. Photon can pass straight through the silicon this (generally) happens for lower energy photons, the photon can reflect off the surfaces. The photon can be absorbed by the silicon, if the photon energy is higher than the silicon band gap value, this generates an electron-hole pair and sometimes heat, depending on the band structure[4].

When a photon is absorbed, its energy is given to an electron in the crystal lattice. Usually this electron is in the valence band, and is tightly bound in covalent bonds between neighboring atoms, and hence unable to move far. The energy given to it by the photon "excites" it into the conduction band, where it is free to move around within the semiconductor. The covalent bond that the electron was previously a part of now has one fewer electron — this is known as a hole. The presence of a missing covalent bond allows the bonded electrons of neighboring atoms to move into the "hole," leaving another hole behind, and in this way a hole can move through the lattice. Thus, it can be said that photons absorbed in the semiconductor create mobile electron-hole pairs.

A photon need only have greater energy than that of the band gap in order to excite an electron from the valence band into the conduction band. However, the solar frequency spectrum approximates a black body spectrum at ~6000 K, and as such, much of the solar radiation reaching the Earth is composed of photons with energies greater than the band gap of silicon[10]. These higher energy photons will be absorbed by the solar cell, but the difference in energy between these photons and the silicon band gap is converted into heat (via lattice vibrations --- called phonons) rather than into usable electrical energy.

2.5.2 Charge Carrier Separation

There are two main modes for charge carrier separation in a solar cell: Drift of carriers, driven by an electrostatic field established across the device. Diffusion of carriers from zones of high carrier concentration to zones of low carrier concentration (following a gradient of electrochemical potential). In the widely used p-n junction solar cells, the dominant mode of charge carrier separation is by drift[5]. However, in non-p-n-junction solar cells (typical of the third generation of solar cell research such as dye and polymer thin-film solar cells), a general electrostatic field has been confirmed to be absent, and the dominant mode of separation is via charge carrier diffusion[4].

2.5.3 Thermodynamic Efficiency Limitation

Solar cells operate as quantum energy conversion devices, and are therefore subject to the "Thermodynamic Efficiency Limit". Photons with energy below the band gap of the absorber material cannot generate a hole-electron pair, and so their energy is not converted to useful output and only generates heat if absorbed[7]. For photons with energy above the band gap energy, only a fraction of the energy above the band gap can be converted to useful output. When a photon of greater energy is absorbed, the excess energy above the band gap is converted to kinetic energy of the carrier combination. The excess kinetic energy is converted to heat through phonon interactions as the kinetic energy of the carriers slows to equilibrium velocity [7].

Solar cells with multiple band gap absorber materials are able to more efficiently convert the solar spectrum. By using multiple band gaps, the solar spectrum may be broken down into smaller bins where the thermodynamic efficiency limit is higher for each bin.

2.5.4 Quantum efficiency

Quantum efficiency refers to the percentage of photons that are converted to electric current (i.e., collected carriers) when the cell is operated under short circuit conditions. External quantum efficiency is the fraction of incident photons that are converted to electrical current, while internal quantum efficiency is the fraction of absorbed photons that are converted to electrical current[3].

2.5.5 Maximum-power point

A solar cell may operate over a wide range of voltages (V) and currents[4]. By increasing the resistive load on an irradiated cell continuously from zero (a short circuit) to a very high value (an open circuit) one can determine the maximum-power point, the point that maximizes V×I; that is, the load for which the cell can deliver maximum electrical power at that level of irradiation. (The output power is zero in both the short circuit and open circuit extremes)[4].

All solar cells require a light absorbing material contained within the cell structure to absorb photons and generate electrons via the photovoltaic effect. The materials used in solar cells tend to have the property of preferentially absorbing the wavelengths of solar light that reach the earth surface; however, some solar cells are optimized for light absorption beyond Earth's atmosphere as well[2]. Light absorbing materials can often be used in multiple physical configurations to take advantage of different light absorption and charge separation mechanisms. Many currently available solar cells are configured as bulk materials that are subsequently cut into wafers and treated in a "top-down" method of synthesis (silicon being the most prevalent bulk material). Other materials are configured as thin-films (inorganic layers, organic dyes, and organic polymers) that are deposited on supporting substrates, while a third group are configured as nanocrystals and used as quantum dots (electron-confined nanoparticles) embedded in a supporting matrix in a "bottom-up" approach. Silicon remains the only material that is well-researched in both bulk and thin-film configurations.

2.5.6 Summery of Research on Solar Energy

Photovoltaic solar power is one of the most promising renewable energy sources in the world[7]. Compared to nonrenewable sources such as coal, gas, oil, and nuclear, the advantages are clear: it's totally non-polluting, has no moving parts to break down, and does not require much maintenance. A very important characteristic of photovoltaic power generation is that it does not require a large scale installation to operate, as different from conventional power generation stations. Power generators can be installed in a DISTRIBUTED fashion, on each house or business or school, using area that is already developed, and allowing individual users to generate their own power, quietly and safely. Solar panels collect solar radiation from the sun and actively convert that energy to electricity. Solar panels are comprised of several individual solar cells. These solar cells function similarly to large semiconductors and utilize a large-area p-n junction diode. When the solar cells are exposed to sunlight, the p-n junction diodes convert the energy from sunlight into usable electrical energy. The energy generated from photons striking the surface of the solar panel allows electrons to be knocked out of their orbits and released, and electric fields in the solar cells pull these free electrons in a directional current, from which metal contacts in the solar cell can generate electricity. The more solar cells in a solar panel and the higher the quality of the solar cells, the more total electrical output the solar panel can produce. The conversion of sunlight to usable electrical energy has been dubbed the Photovoltaic Effect.

2.6 Working Principle of an Inverter

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[3]. In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits[3]. The most widely used type of tube was the thyratron. Since early transistors were not available with sufficient voltage and current ratings for most inverter applications, it was the 1957 introduction of the thyristor or silicon-controlled rectifier (SCR) that initiated the transition to solid state inverter circuits[2]. As they have become available, transistors and various other types of semiconductor switches have been incorporated into inverter circuit designs.

For the purpose of this project, mosfet is used. Mosfet has the following characteristics:

- No gate current
- High input impedance > $10^{14}\Omega$
- Used as analogue switch amplifier
- Use very low current
- Gate region is separated from conducting channel by thin layer of SiO_2 (glass)
- With high characteristics impedance >$10^{14}\Omega$ affect channel conduction purely by its electric field
- Gate can withstand up to ±20V
- Gate can swing either polarity relatively to the source without gate current flowing.
- Can be damaged by static electricity literally by touching

TYPES OF INVERTER

(1) Single phase inverter

(2) Three phase inverter

The design of 500VA is a single phase inverter. Types of single phase inverter are.

(i) Serial inverter

(ii) Parallel inverter

(iii) Bridge inverter

PARALLEL INVERTER: this is also called centre tapped of a single phase inverter. The output voltage is connected between the centre tap of the wave variable frequency up to 100HZ. The DC source is connected between the centre tap of the output transformer and common cathode point of the Mosfet. An inductor L is connected between the source and centre tap. This is the commutating inductance. The load is connected across the secondary of the transformer. The drain of the Mosfets are connected to the end point of the primary winding and between the drain of the Mosfets.The oscillator is connected by alternating turning ON and OFF of the Mosfet. DC source is made available across the two halves of the primary winding which in turn is available across the secondary winding as an AC voltage by transformer action. The oscillator is effectively in parallel with the load and hence the name Parallel Inverter.

2.6.1 Working Sequence of an Inverter.

The DC current enters an inverter. The inverter turns DC electricity into 240-volt AC (alternating current) electricity needed for home appliances. The AC power enters the utility panel in the house. The electricity is then distributed to appliances. There are three types of inverter which are classified according to the shape of output waveform.

1. Square wave inverter.

2. modified sine wave inverter.

3. Pure sine wave inverter.

The use of modified square wave oscillating IC (generator) is used for this project due to the fact that, it is efficient in designs, it is cheap and it is readily available in the market.

2.7 Solar and Inverter Combination

Having been exposed to the working principle solar system and inverter as separate system, combining the two system would yield a unique functional system that can proffers solution to energy problem. The solar and the inverter are combined together to form solar inverter. Projects on solar are mostly limited to the use very small wattage of solar cell to power calculators and other pet projects. This has not really contributed much progress in solving energy problem. Inverters of several (VA) have been designer with no consideration on the energy source to charge the battery. Solar inverter as specified in this design takes care of all these limitation by combining solar system and inverter system. The solar panel makes use of direct energy from the sun and converts it to direct current/voltage. The direct current is then used to charge the battery. The battery having received full charge is used to run an inverter. In the inverter system, voltage signal are oscillated, amplified and switch on and off to give an output through the transformer which is sufficient enough to run home electronics.

It is worthy to note that many student project design has not considered solar inverter due to its initial cost of design of which the solar panel account for about 60% of the total cost. However inverters of different capacity have been designed with the use of mosfet, thyristor, transistor and IC based oscillator. IC is designed with the analogue components. In this design SG3524 IC which is basically used as regulating power IC. SG3524 IC has a unique feature of complete PWM, single ended or push-pull output, line and load regulation of 0.25%, total supply current is less than 10mA and operation is beyond 100KHz[9]. The use of IRFP150N is another unique combination in the choose of component used[8]. The IRFP150N is a mosfet and has the advantage of switching very fast(nanoseconds). secondly mosfet is also used as rectifier. which is the advantage it has over other switching components[9]. The limitation of this project is classified in two major categories.

-The natural cause of limitation.

-The Physical limitation

The natural limitation is as a result of nature itself. The project source energy is the sun light energy which is only active during the day and inactive during the night. However. this limitation can be overcome by use deep cycle battery of several amperes rating that can drive the inverter thought the night. Recall power input equals power output, this means that the higher the battery rating the higher the duration at which it dissipates power. The physical limitation is as the result of low power rating of the solar panel. This limitation can be improved on by acquiring solar panel of higher power rating that charge the battery at a very faster rate. Acquiring a solar panel of higher power cannot render the already procured solar panel useless: rather connecting the new acquired solar panel in series with the existing one would lead to saving cost and improvement in efficiency.

CHAPTER THREE

3.0 Theory and Design

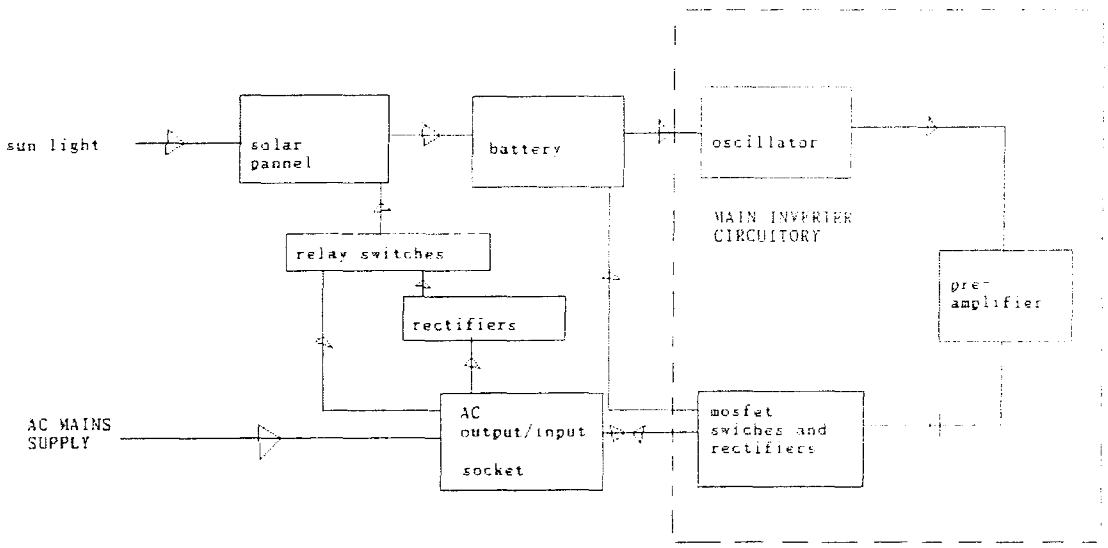

Fig 3.1 Block diagram of 500VA solar inverter

3.1 Power Block:

The block consists of the following components following:

Rectified block

Solar block

Regulatory block

3.1.1 Rectified Block

The rectified block consists of the input transformer, bridge rectifier, filtering capacitor, diode and fuses. The transformer rating is 230/12v. The input of the transformer is supplied with voltage from the mains and the output is connected to the bridge rectifier junction of opposite polarity. Rectification takes place at the diode arrangments. The output from bridge rectifier is filtered by a polarized capacitor connected across the output of the bridge rectifier at the forward bias junction (i.e. cathode to cathode or anode to anode junction). Diodes are used to prevent backflow of current at any point where backflow is not desired. Full wave rectification involves four diodes. Two of the diode conducts during the positive half cycle and the remaining two conducts during the negative half cycle. The output from the diode junctions is taken from the forward bias (same polarity) junction. The output is protected by a 5A fuse and a shunt capacitor is carefully chose for filtering the ripple and hence a DC output.

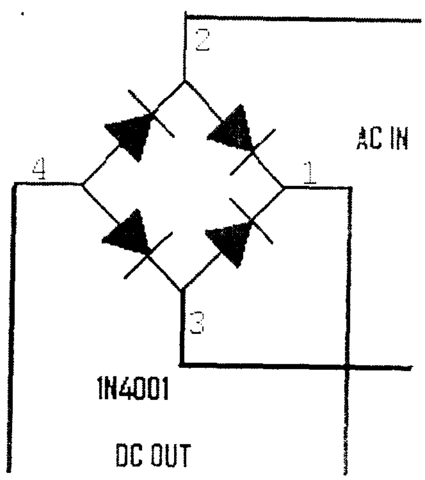

Fig 3.2 bridge rectifier

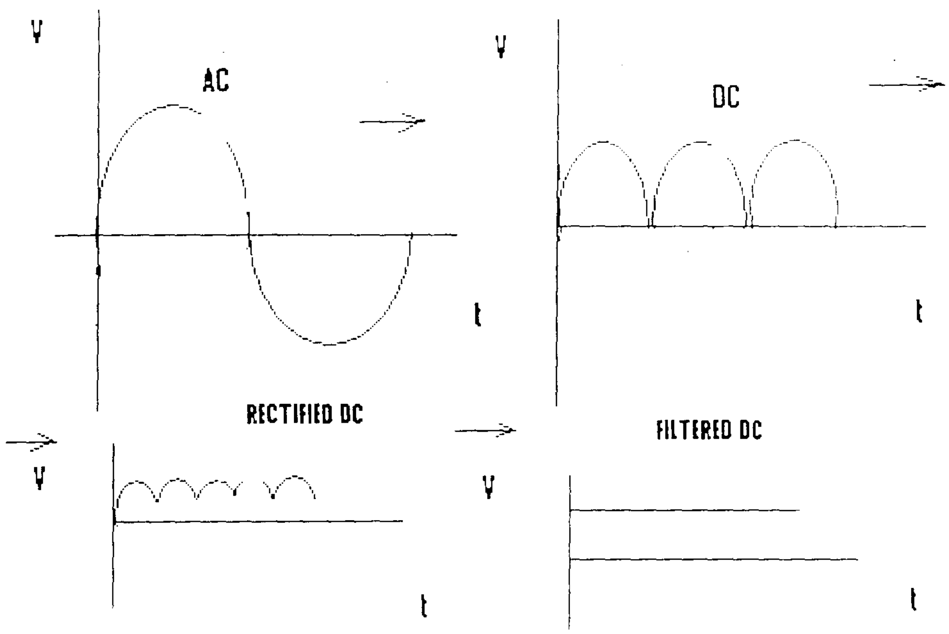

Fig 3.3 full wave form

3.1.2 Solar block

The solar panel used for this project is a product of Sollatek Technology with the rating of 1000w/sqm solar irradiance and 25 degree Celsius temperature, power rating of 5.0wP, current rating of: short circuit current:450mA, rated current :350mA, maximum system open circuited voltage of 30V, open circuited voltage of between 21V to 22V and rated voltage of 17V, fuse protection of 1.6A. The interpretation means that the solar panel is capable of conducting at temperature between (25 to 90) degree Celsius. The minimum voltage to is 17V and minimum current of 350mA. At abnormal temperature of about 90 degree Celsius, the panel is highly insulated. However temperature above 90 would damage the cells of the panel. The specification also shows that the panel maintains a voltage of between (21-22)V when unloaded. The solar cells in the solar panel is internally linked in series to form the solar modules .The figure below gives clear explanations of internal link of solar structure.

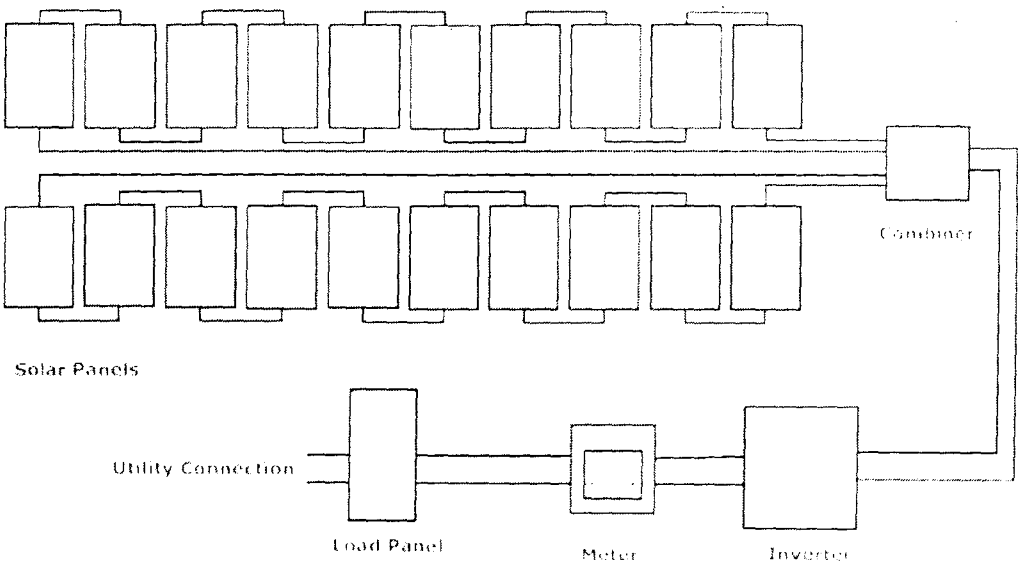

Fig 3.4 Solar panel showing internally linked cells

3.2 CHARGING CIRCUIT FROM AC

The 12V battery in the circuit is charged from AC mains through the arrangement of mosfet. Coupled to the transformer. Diagram below shows the charging circuit of the design.

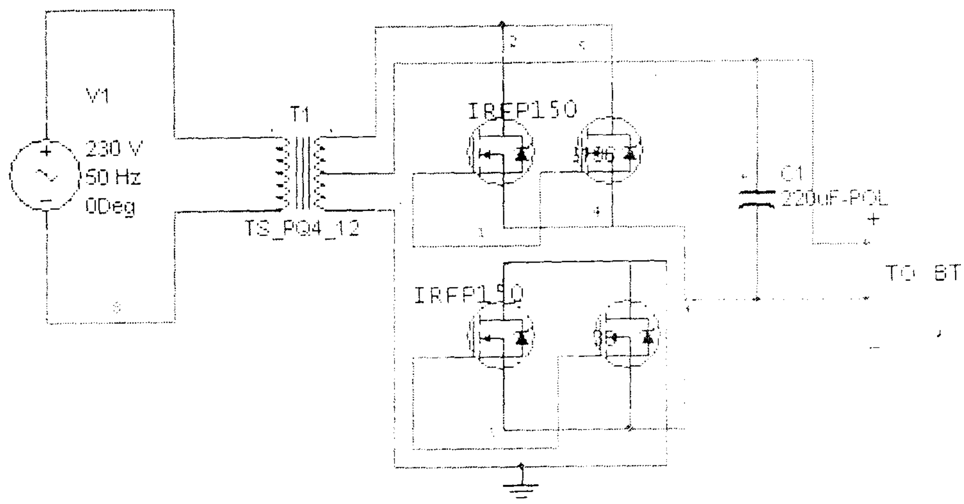

Fig 3.5 charging circuit

Whenever there is AC mains supply, the relay B is energized and switch to NO of the normal collect relay. The secondary coil of transformer now turns to be the primary by stepping down the 230V to 12V. The 12V AC is fed into the IRFP150 which contain a zener diode. Through the arrangement of four zener diode as shown in the fig above, voltage is rectified to DC. The rectified DC voltage is then filtered through a polarized capacitor before used to charging the 12V battery.

Mosfet switching is bidirectional device

3.3 Design calculations:

The overall design of 500VA solar inverter s designed using solar panel for charging a12V battery. Rating parameters are as follows

--Photovoltaic modulus specification at 1000w/sqm. solar irradiance and 25C cell temperature.

-- Max power = 5.0wp

-- Current - short circuit current = 450m

- -rated current = 350mA

-- Max system open circuited voltage= 30V

-- Open circuited voltage = 21-22V

-- Rated voltage = 17V

The rating specified above means that the solar panel is to supply a voltage of 21-22V and a current of 450mA when there is no load connected to it. It also means specified that the panel can supply a voltage of 17V and current of 350mA when a load is connected to it. The 17V supplied to the 12V, 60AH battery can charge the battery very well.

Energy stored in a battery = $12\times60\times60\times60$

= 2592000J

Power of the solar delivered by the solar panel :

$P_s = IV = 0.350\times 17 = 5.95w$

$E = PT$

Power delivered to the battery through solar = power received by the battery.

However energy of the battery = 2592000J

If the whole energy discharges, time required to fill the battery

Power of solar tray × time required to fill the battery energy = energy of the battery

$P_s T_r = E_{battery}$ where P_s= power of the solar tray

T_r= time required to fill the energy of the battery

E_b= energy of the battery at full.

$T_r = E_b/P_s$

= 2592000J/ 5.95

T_r = 43563.03 sec

Therefore T_r (H) = 43563.03/ 60×60 = 12.1 hrs.

For 60AH battery, it means that 60A is discharged in 1 hour. It then means that 60A can be filled into the battery in one hour for full charging when discharged under the same voltage. In a real situation, no battery is allowed to drop up to 30% of the total rated energy.

Therefore, the solar panel can be used to charge the 12V battery.

3.4 Arrangement of the relay circuits

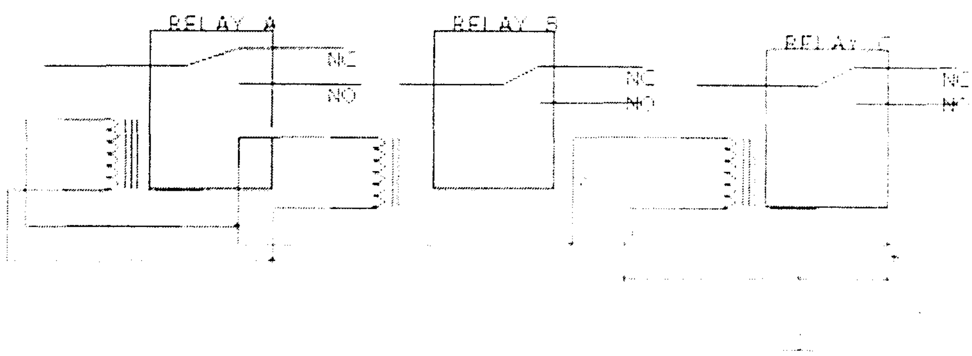

Fig 3.6 relay switches

Three relays: relay A. B.and C are used for switch in the design. The relay are connected in series and controlled by a rectified voltage from the mains. All the relays are normally close mode relay. Relay A is normally close at the inverter on i.e. it is used to supply source to the inverter through the battery when the main AC supply is off. On the application of power from the main. it switches off the inverter.

Relay B: control the charging circuit and AC output voltage. On the application of voltage from the main. the normally closed relay B is energized and switches on the output socket. At the same time it make the circuit with the output transformer winding which now turn to be the primary coil through transformation. drop the voltage to 12V at the secondary (centre tap/primary coil when AC is not used). The 12V AC is then feed to the mosfet and mosfet serves as the rectifier. that charges the battery.

Relay C: is used to switch off the source from solar when AC main is available. The relay is normally closed at the positive battery terminal. The solar panel can also be switched off through the manual switch.

3.4.1 THE RELAY AS SWITCHING CIRCUIT

The 18V step down transformer is used to step down 220V through the mains. The bridge rectifier is connected to the secondary coil of the transformer. The rectifier converts AC 18V into DC equivalent to 18V. The diode type of rectifier used is IN4001 which take 0.7V to conduct.

The arrangement of the diode in bridge rectifier enable 2 diode to conduct during the positive half circle and the remaining diode to conduct during the negative half circle..The rectified voltage is then filtered by 47μF-35V polarized capacitor before feeding to the input of the voltage regulator.

The voltage regulator used is 7812 which takes in approximately 18V and drop it to 12V. The 12V DC is finally feed to the relay A.B. and C for switching control. The 7812 voltage regulator is a plastic with a metal body build chip. The Vin dip is noted by using the left dip as the input. and the right as the output and the centre as the ground. The internal circuitry of the 7812 is shown below

3.5 THE MAIN INVERTER CIRCUIT

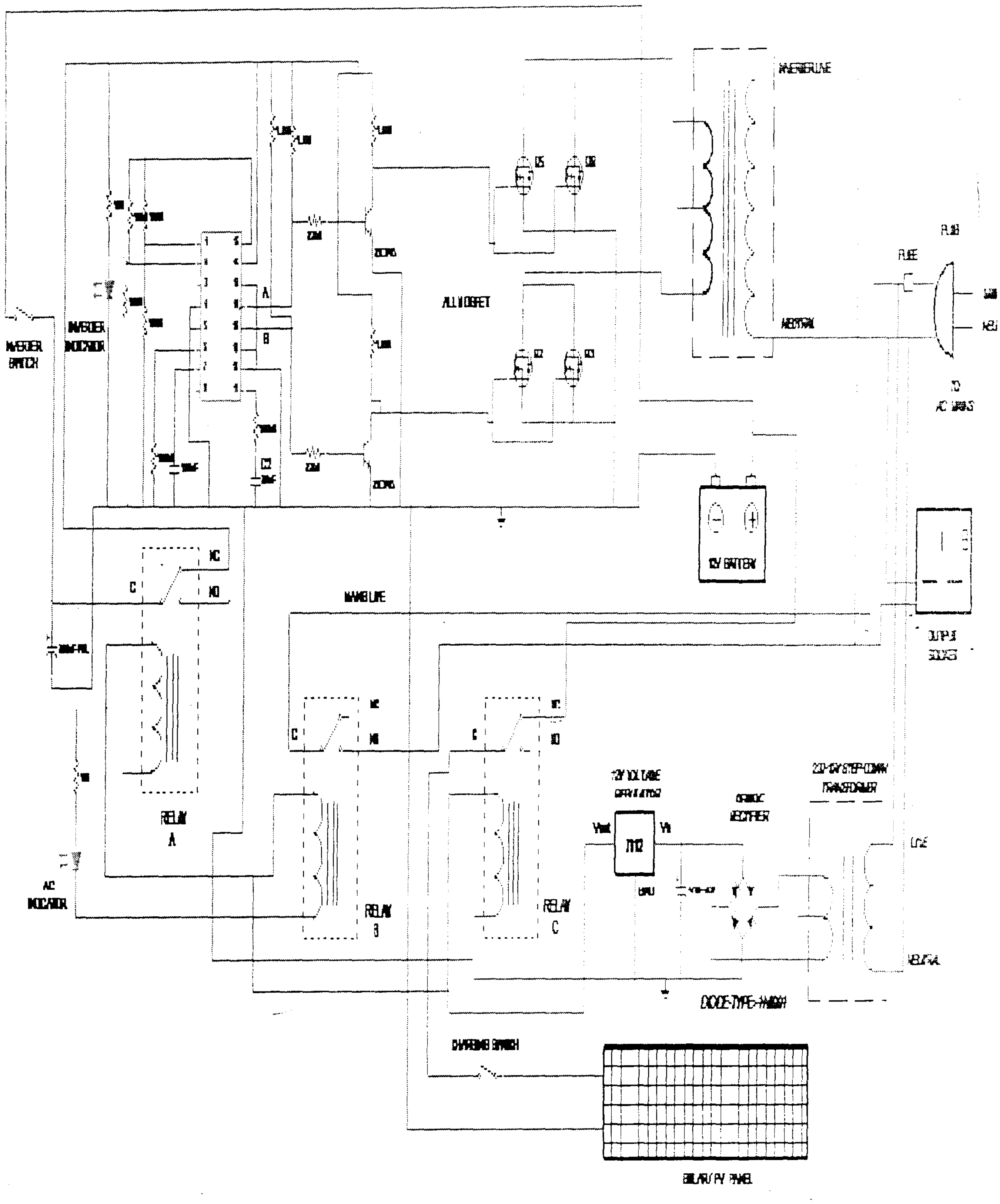

Fig 3.7 Complete circuit diagram of 500VA solar inverter system

3.5.1 OSCILLATOR CIRCUIT

The oscillator used is SG3524

SG3524 is chosen because of its property of regulating power supply inverter (switching regulator). The IC have 16 pin dual-in-line-dip used for voltage referencing , error amplifier, oscillator, pulse width modulating pulse, flip flop, dual alternating out-put switches, current limiting and shut down circuitry. Voltage stability .

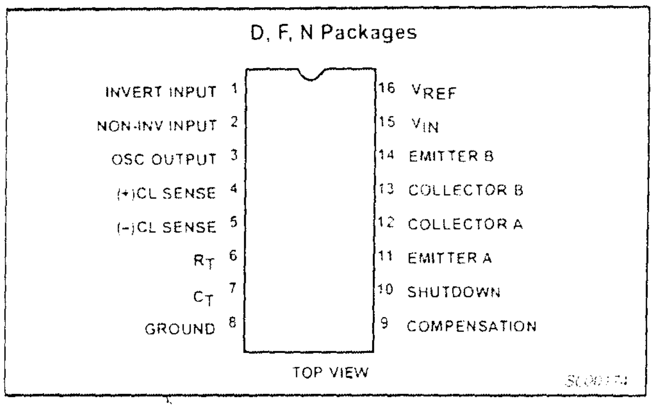

Fig 3.8 SG3524 IC

In the design, the IC is supplied with 12V DC at 15; however the internal circuitry of the design required 5V DC. The excess voltage is being fed to both inverting and non inverting pin 1 and pin error amplifier respectively via pin 16th voltage reference pin. The voltage output of the comparator is being slinked to the ground through pin 4 and pin 5.which

The major functional unit of the IC (SG3524) is oscillator circuitry of the oscillator is varied through pin 6 and pin 7 for resistor and capacitor respectively. The output of oscillator is pin 3 which is a single ended pulse fed directly into a flip flop.

The flip flop divide the single ended output into two and fed to NOR gate, then to a transistors each attached to a NOR gate at pin 12, 11, 13, and 14. Pin 14 and 11 of each transistor are grounded (emitter) while pin 12 and 13 are the output pin used for push pull application and fed to the preamplifier transistor: 2SC945.

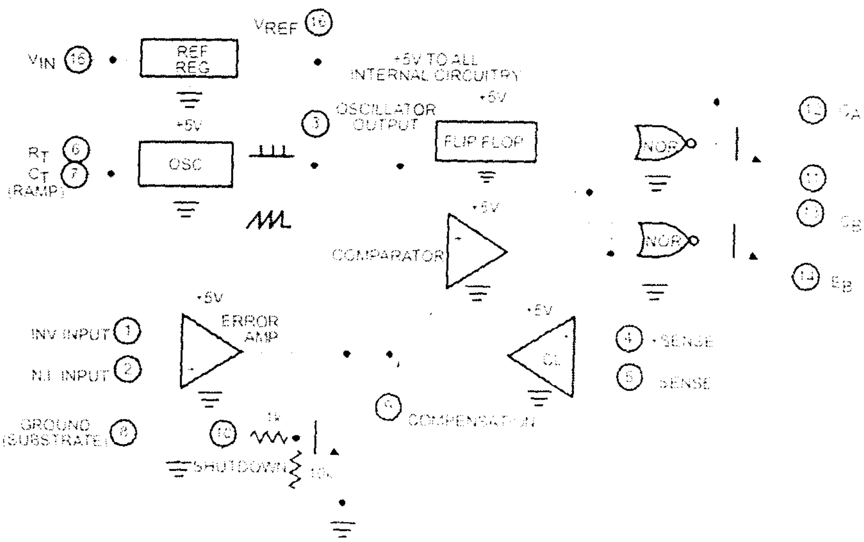

Fig 3.9 internal circuitry of SG3524 IC

From the data sheet of the manufacturer of SG3524, external synchronization is needed to allow designer to vary the pulse duration derived and consequently the frequency. The formula generated from the manufacturer of pulse duration:

$$(t) = R_t C_t \quad \text{where t is in micro seconds.}$$

However for push pull application, the outputs are separated and flip flop divide the frequency into two[9]. Below is the characteristic time/output graph of charging capacitor.

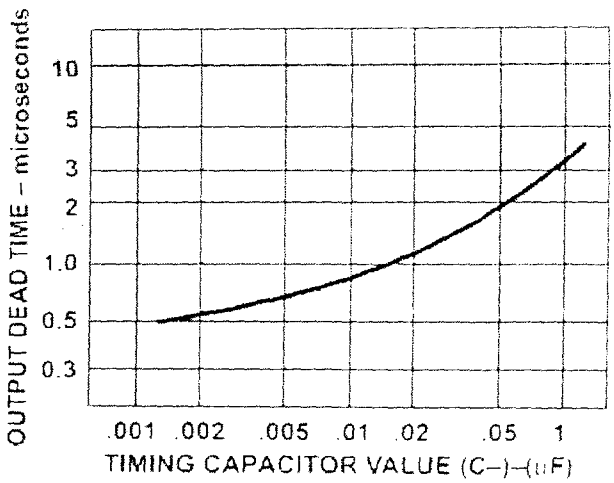

Fig 3.10 a plot of output dead time/ timing capacitor value

Thus $T=R_tC_t$ R_t is chosen to be 100KΩ

C_t is also chosen to be 100nf

Therefore $T = 100 \times 10^3 \times 100 \times 10^{-9}$

T = 0.01secs

However T = 0.01secs

$F = \frac{1}{0.01}$

F = 100Hz

The flip flop divides the frequency into two

I.e. $F = \frac{100Hz}{2}$ = 50 Hz (duty cycle)

10KΩ is used to drop voltage that feeds the inverting and non- inverting error amplifier at pin 1 and 2 and which is finally sink into the ground through pin 4 and pin 5. Pin 9 is a compensation pin and function in the case where there is error amplification. The voltage is sinked through 100KΩ in series with 22nf

Charging current = $\frac{3.6}{100\times10^{-3}}$ = 3.6×10^{-5} i.e. 36μA

3.5.2 Preamplifier

The preamplifier used is 2SC945 : 2SC945 is an NPN silicon transistor with an excellent

I_{out} of oscillator = 36μA however, current of the base to 2SC945 of transistor is calculated from

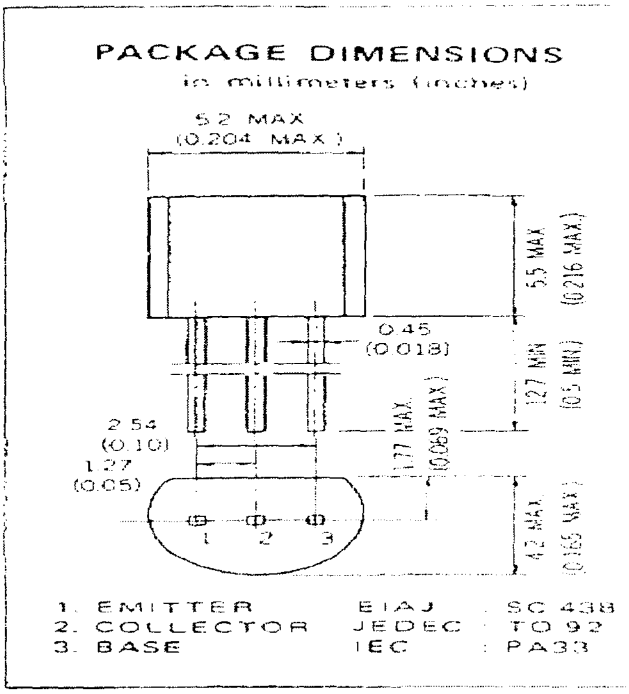

Fig 3.11 SC945 IC

By current divider theorem, the current that flow through 2.2KΩ resistor to the base as shown in the diagram is thus

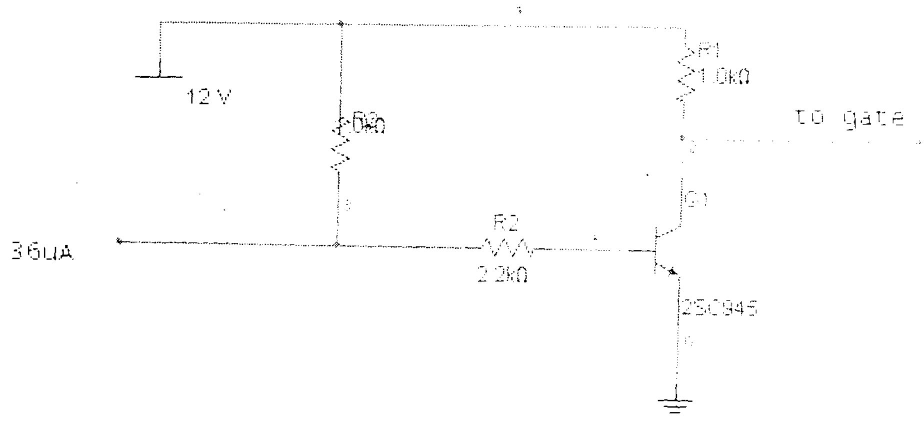

Fig 3.12 Arrangement of resistors to pre amplified circuit

$$I_b = I_1 + I_2$$

$$= 36\mu A + \frac{12}{1000}$$

$$= 0.012036\text{A}$$

$$= 12.036\text{mA}$$

From the datasheet, when I_b is between 10mA to 20mA, I_c 100mA, V_{CE} 6.0V,

$V_{GS} = (12 + 6)$V

= 16V (superimposition theorem)

From datasheet, when V_{GS} is between 10V to 20V, 22A is flown through I_D of each Mosfet

3.5.3 Mosfet Switching circuit

The switch circuit used is mosfet IRFP150 with the following electrical characteristics from the data sheet of the manufacturer under the condition[9].

MOSFET SWITCHING ANALYSIS: Their combination of low ON resistance (all the way to zero volts). extremely high off resistance . low leakage current and low capacitance makes the ideal as voltage controlled switch elements for analog signal. An ideal switch is its ON state. passes signal to the load without attenuation/non linearity. In off state it is open circuited. Negligible capacitance to ground and negligible coupling its signal of switch level. Typically between 25 to 100Ω (R_{ON}) in Mosfets intended for use in analogue switches. Gate signal level is not at all critical. as long as it is sufficiently more positive than the largest signal (to maintain R_{ON} low). Gate breakdown voltage in voltage in mosfet are typically 2 or as more. Mosfet switching is bidirectional device and Swing to either polarity. With Mosfet switching, it is important to provide a load resistance in the range of 1k to 100k in order to reduce capacitive feedback of the input signal that would otherwise cause off state. The output current of the 2SC945. which is 100mA causes a voltage of 6V. 6V + 12V =16V which is enough to operate the Gate of IRFP150N

As soon as the gate receives 16V. I_D current becomes 22A for each of the mosfet. For two mosfets are connected in parallel. the total current will be two times the current of each of the mosfets. This is the current that flow during each half cycle. Below is the characteristic drain to source on resistance/ drain current plot.

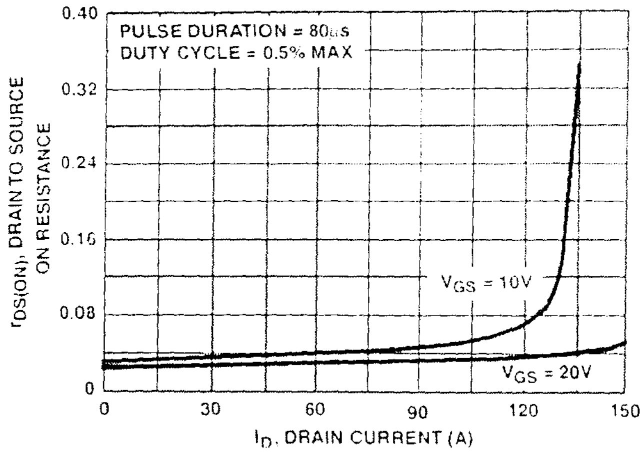

Fig 3.13 A plot of drain to source/ drain current

Thus $I_{half\ cycle} = 2I_D = 2\times 22 = 44$ A which is the out-put current which is multiplied by 12V that passes through the transformer coil to generate 528VA. Thus $P_O = I_{half\ cycle} \times 12V$ (voltage through the transformer winding) Where P_O is the power output. The inductor is connected in series with the transformer primary coil to enhance the sinusoidal wave required by AC gadgets. Fig3.16 is the characteristic wave form of the output

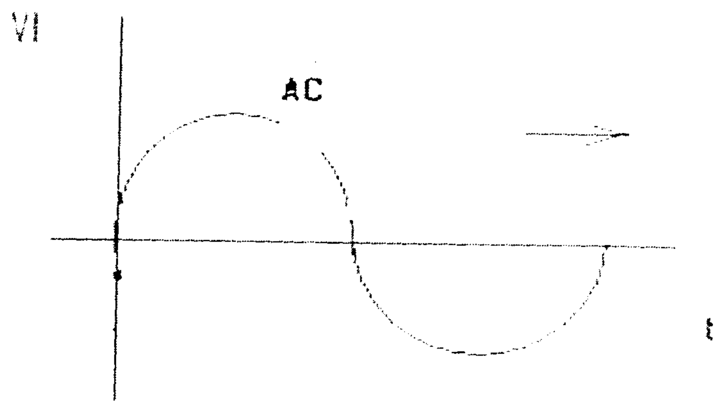

fig 3.14 output waveform

CHAPTER FOUR

4.0 CONSTRUCTION, TESTING AND DISCUSSION OF RESULTS

4.1 CIRCUIT CONSTRUCTION

Project involved practical exercise of converting the designed circuit diagram on the paper into a real working hardware. The first step involves verifying the workability of some parts and components of the circuit on the bread board. which is the temporary circuit connection.

The main construction was done on a Vero board. The involved electronic components were carefully connected together under the guide of the circuit diagram. The breaking down of the complete circuit during the design analysis. in the early chapter. was of great importance in the construction. Each unit circuit was executed one after the other. After which all the units were joined together as a single working construction.

The power supply unit was quite delicate during the construction- it was made with great care. After the complete construction. the power units were properly checked for short circuit and unwanted bridges. The circuit's construction involves the following materials and tools:-

- Soldering iron
- Soldering lead
- Jumper wires
- Integrated circuit sockets
- Cutting knife
- Razor blade

- Pliers
- Pair of Scissor
- Digital multimeter

4.1.1 Casing Construction

The consideration given before choosing the casing is based on the type of project. For a power project, the casing must be rugged enough to house all the components.

In the case of the project metal casing of gauze 16 was chosen. The metal was bent into handle shape, transparent plastic handle attached in other to ease view and carriage respectively. The case is also perforated linearly in other to allow exchange of heat hence improvement in heat skin. The fig4.1 below shows the casing construction for the project.

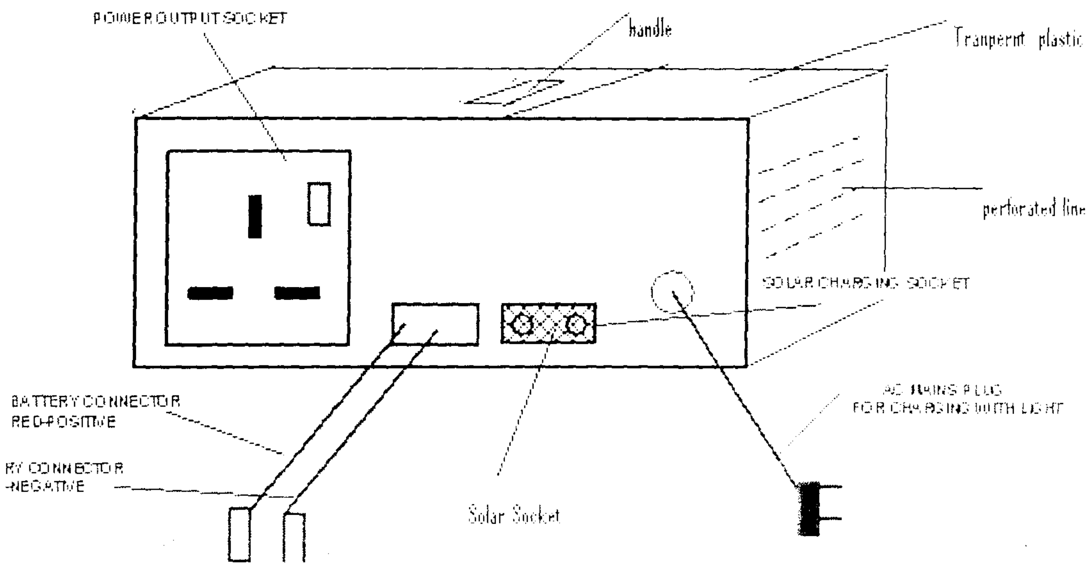

Fig 4.1 Casing Construction

4.2 TESTING

In test solar inverter system, adequate precaution should be taken. The first thing to do is to check the terminals of the battery, solar tray. The red cable as indicated is for the positive while the black is for the negative terminal. The fig4.2 below gives a vivid explanation of the connections.

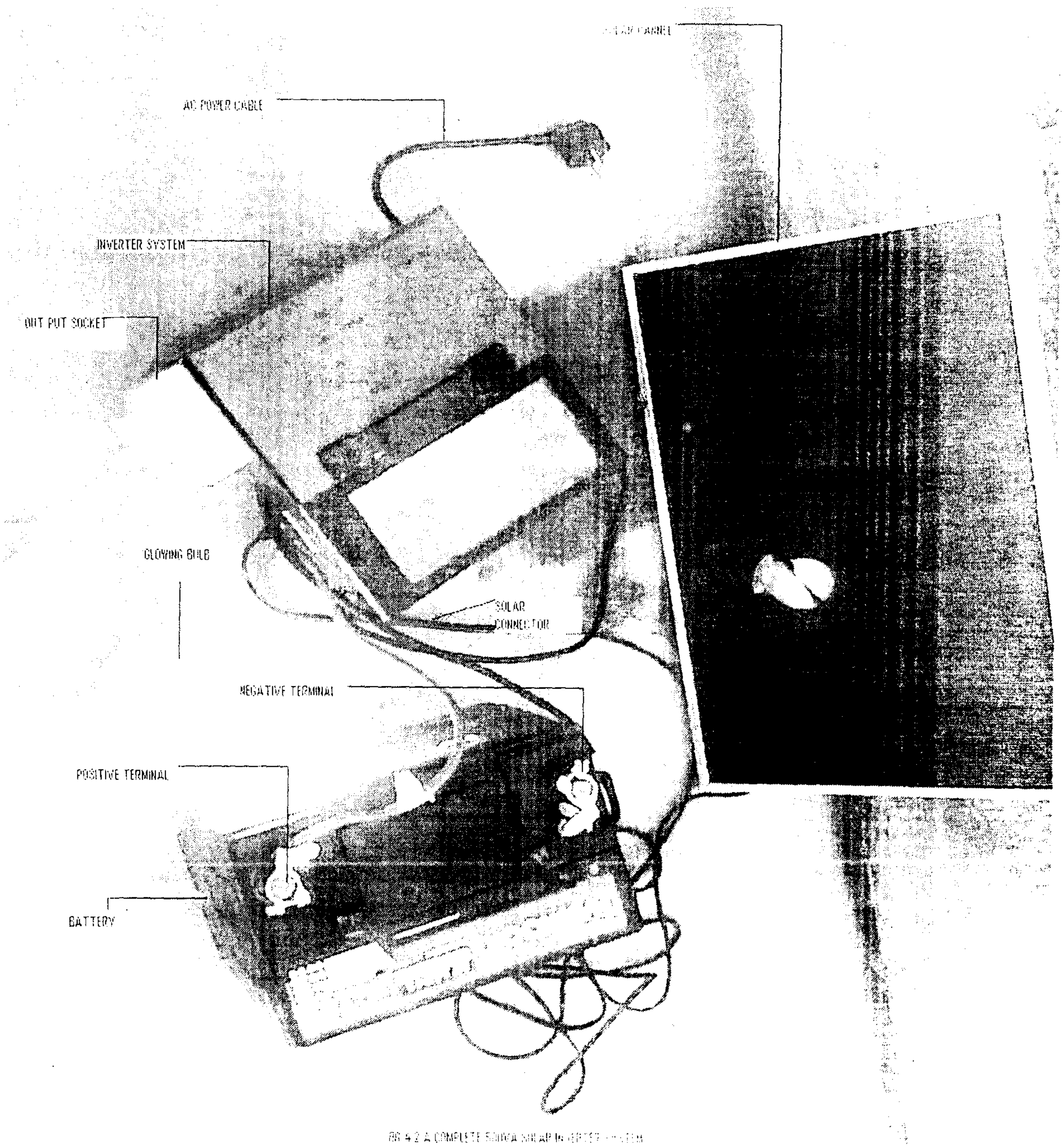

Fig 4.2 the overall construction layout

The steps involved are as follows. the inverter and the solar panel switch are off to brake the circuit. The red cable from the solar inverter system is firmly connected to the positive terminal of the battery and the black is also connected to the negative terminal.

The next step is the connection of solar panel. connecting red to positive and black to the negative terminal is done and expose to sunlight source. The output socket is ensured off and the connection cord is connected to the AC mains.

To test from the system assuming there is no AC main supply. the solar charger switch is off to avoid damaging of the solar panel and the inverter switch is on which is confirmed by the LED indicator. A 60W bulb or load less than 400W can be connected and it would be observed that the system comfortably powers it. In a situation where there is supply from the mains. the relay would off the inverter and AC from main now powers the load.

4.3 RESULT DISCUSSION

The result of the testing has now confirmed with the theory by supplying power using the system to power the load. In the design. 528VA was obtained as the output which is very close to the intended output.

A great precaution such as proper soldering. proper insulating. proper grounding and proper fusing is done to ensure the reality of the design.

CHAPTER FIVE

5.1 CONCLUSION

The project achieves its aim and objective by the use of integrated IC and power regulator for inversion. This is aimed at creating awareness on the use of abundant natural resources "the sun" to generate energy useful for home electronics.

Therefore the demonstration of these projects should make people who spend lots of money to run and maintain generator on daily basis, to consider solar inverter system in order to save their money on the long run. In addition, solar inverter does not make noise, pollute the environment and also is not associated with mechanical fear and wear whereas compared with generator machine counterpart.

5.2 RECOMMENDATION

1. The system should design using a more power rated solar panel of which is the limitation of this design.
2. The future designer should incorporate two battery bank to be Controlled by a switching circuit.
3. University curriculum should embark more on practical to aid Understanding of the theoretical postulates.
4. Government should encourage university by building more sophisticated laboratory for universities in order to improve on our technology.

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