DESIGN AND CONSTRUCTION OF A SOLAR INVERTER SYSTEM

BY

MACAULAY GREAT
ND/ELECT/21/058

EBIOWEI ANGELIC JOEL
ND/ELECT/21/057

AMABEBE JAMES WOYENGIKURO
ND/ELECT/21/059

FARKA EMMANUEL
ND/ELECT/21/055

ALAOEWEI OBANI
ND/ELECT/21/056

DEPARTMENT OF ELECTRICAL/ELECTRONICS

ENGINEERING

SCHOOL OF ENGINEERING TECHNOLOGY

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CERTIFICATION

This project has been approved and certified by the department of Electrical Electronics Engineering Technology as part of the requirement for the award of national diploma [ND] in

Electrical/Electronics Engineering Technology of Bayelsa State polytechnic Aleibiri, Bayelsa State.

PROJECT SUPERVISORS. Engr Okosi Festus/Mr Faowei

Signature …………………. ……………………

Date ……………………………………………

Head of department. Engr Okosi Festus

Signature …………………………………….

Date ……………………………………………

Dean, School of Engineering. Engr Ebimobowei .T. Yabefa

Signature …………………………………….

Date ……………………………………………

External Examiner ……………………….

Signature ………………………………….

Date………………………………………….

DEDICATION

I dedicate this project to God Almighty for His provision and Wisdom. And to my Spiritual Father, Mentor, and my Prophet PST DAVID IBIYEOMIE. PAPA thank you for all the prayers

and prophecies over my life, and to my supportive wife, MRS ENDUTIMI MACAULAY and my lovely children, thank you for been a great support to me, to my parents and loved once who supported me in one way or the other for the success of this program, I appreciate you all for your guidance and prayers.

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ENGR OKOSI FESTUS, for giving me guidance on how to carry out this project effectively. To my Dean. ENGR EBIMOBOWEI .T. YABEFA who also stood by me to succeed, thank you Sir, and thank you friends and family who also stood by me, I am grateful. TO MY HEAVENLY FATHER-I AM FOREVER THANKFUL

ABSTRACT

This work is on solar inverter converts direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical

grid or used by a local, off-grid electrical network. It is a critical balance of system (BOS)–component in a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar power inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection.

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CHAPTER ONE

INTRODUCTION

1.1 Background

The solar inverter is a vital component in a solar energy system. It performs the conversion of the variable DC output of the Photovoltaic (PV) module(s) into a clean sinusoidal 50 or 60 Hz AC current that is then applied directly to the commercial electrical grid or to a local, off-grid electrical network. A solar cell (also called photovoltaic cell) is the smallest solid-state device that converts the energy of sunlight directly into electricity through the photovoltaic effect. A Photovoltaic (PV) module is an assembly of cells in series or parallel to increase voltage and/or current. A Panel is an assembly of modules on a structure. An Array is an assembly of panels at a site. Typically, communication support scheme is included so users can monitor the inverter and report on power and operating conditions, provide firmware updates and control the inverter grid connection.

At the heart of the inverter is a real-time microcontroller. The controller executes the very precise algorithms required to invert the DC voltage generated by the solar module into AC. This controller is programmed to perform the control loops necessary for all the power management functions necessary including DC/DC and DC/AC. The controller also maximizes the power output from the PV through complex algorithms called maximum power point tracking (MPPT). The PV maximum output power is dependent on the operating conditions and varies from moment to moment due to temperature, shading, cloud cover, and time of day so adjusting for this maximum power point is a continuous process. For systems with battery energy storage, the two controller can control the charging as well as switch over to battery power once the sun sets or cloud cover reduces the PV output power. (Aditee P. Bapat*et al* 2

1.2 Statement of Problem

If there is one factor that has perpetually maintained the status of Nigeria as a less developed country, it is its electricity sector. Till date, many households and industrial businesses cannot be guaranteed of 24 hours supply of electricity from the National grid. At this stage of Nigeria's social and economic development, the country cannot deliver sufficient energy to the citizens despite huge financial resources that have been expended in the sector.

Rather, Nigerians have continued to rely on electricity generators for their power supply, fuel marketers are taking significant portion of households, institutions of learning and businesses' incomes to supply power, noise pollution from regular humming generators have become integral part of living for many Nigerians with imaginable consequences on their health. The Bayelsa State Polytechnic Aleibiri is not immune to the aforementioned problems of Nigeria's power sector, which has led to increase in day to day running cost of the Polytechnic. Because of this problems, there is a need to design and construct the hybrid solar panel inverter for the

department of electrical and electronics engineering technology, Bayelsa State Polytechnic Aleibiri to complement or augment the electricity supply from the National grid, reduce cost of energy consumed and eliminate noise and environmental pollution that is associated with running of generator.

1.3 Aim and Objectives

The aim of this project is to design and construct an efficient and economical 500 Watt solar Inverter that will utilize the appropriate use of office electrical appliances in the department

The objectives are as follows: -

(i) To provide efficiency, steadiness in the use of power appliances, by ensuring continuous availability of power supply in the cause of main outage during an execution of an important or urgent assignment. Thereby enabling the department meet up with its office duties even when central power is not available.

(ii) Reduce load on the National grid that turn to be reduce the overall energy consumption dependency on the main energy supply in the Polytechnic

(iii) Decrease customer utility bill on energy utilization because of its non-fuel consumption, low price and maintenance cost as compared to the convectional sources of power supplies within International and Local market.

(iv) Again, reduce carbon discharges and subsequently reduce global warming particularly in a period when poor climatic change has become a threat to human survival and life in general to all living creatures hence an ever increasing concern to control it.

1.4 Scope of Study

Basically, solar power source makes it possible to provide a clean reliable and quality supply of alternative electricity free of surges usages which could be found in the line voltage frequency (50Hz). This project design aims at creating a 500 watts power source which can be utilized as a regular power source for private individuals in the office or at home. This project involves the design and construction of a 500Watt hybrid Solar PV (photovoltaic) system which involves a solar panel, 12 volt battery and an inverter. Furthermore, as a consumer is generating his or her own electricity they also will benefit from a reduction in their electricity bills.

1.5 Significance of the Project

The solar inverter is the second most significant (and second most expensive) component of a solar PV system. It's important because it converts the raw Direct Current (DC) solar power that is produced by the solar panels into Alternating Current (AC) power that comes out of the wall sockets outlet. Inverters also have technology that maximizes the power output of that DC energy.

The use of solar power has many advantages. Firstly, the energy from the sun is free and readily accessible in most parts of the world. Moreover, the sun will keep shining until the world's end. Also, silicon from which most photovoltaic cells are made is an abundant and nontoxic element (the second most abundant material in the earth's crust).

Secondly, the whole energy conversion process is environmentally friendly. It produces no noise, harmful emissions or polluting gases. The burning of natural resources for energy can create smoke, cause acid rain and pollute water and air. Carbon dioxide, CO_2, a leading greenhouse gas, is also produced in the case of burning fuels. Solar power uses only the power of the sun as its fuel. It creates no harmful by-product and contributes actively to the reduction of global warming

1.6 Inverters

The inverter takes direct current DC power from the charged battery bank and converts it to sinusoidal alternating current AC power for the typical household or office lights and appliances. Once the number of watt-hours required for a day is determined, the peak loads need to be ascertained to properly size the inverter. This is the amount of watts used based on all appliances and loads that will be running at one time. A slit star air conditioner is an example of what may be the peak load requirement for office as case study. A 1/5 watt LED bulb, 32'' TV, 4 Phone charging and decoder will use about 30 (adjusted) watts per hour. If this represents the total peak loads for an office as the case study, an inverter that will be able to supply at least 30 watts of continuous power from the battery bank; let's assume one in the 5 watt range will be required. It is a smart idea to begin the system with the size of inverter you plan to develop into, as upgrading to newer, larger models is expensive. (Pure Energies 2014)

There are two basic types of inverters.

1.6.1 Central Inverters

Central inverters are well-tested and reliable systems that have been around for decades. These are the most common types of inverters. With central inverters, every solar panel is wired in a "string" to the inverter box. The conversion from DC to AC occurs at one central location, such as a garage. Because the solar panels are wired in "series," each panel's power output depends on all of the panels working. For example, In a string of Christmas tree lights. If one bulb goes out, the whole string of lights goes out until the bad bulb is replaced. So, if shade from a tree covers one panel, it can seriously diminish the power produced by the whole solar system until the shade clears. This is reason accurate shade analysis is so important.

1.6.2 Micro Inverters

Micro inverters are relatively new to solar. Instead of converting the DC to AC power at a central location, micro inverters are installed right under each solar panel. The main advantage to micro inverters is the ability for each solar panel to transmit power into the house independently. In other words, each panel produces its own solar power and keeps producing out solar watts regardless of what happening to the panel beside it. The down side of micro inverters is that they can be more expensive and take more labor cost to replace each inverter. Also, because they are so new, micro inverter reliability is unproven outside of laboratory testing. (Pure Energies 2014)

1.7 The Balance of System (BOS)

There are many other less well known and less expensive parts to a solar system. Installers typically wrap these up into "Balance of System" or "The BOS"

The balance of system

Includes components such as wiring, emergency DC disconnects, system monitoring hardware, the frames or "racking" that holds your panels to the roof and at the right angle, nuts, bolts, roof "flashing" to prevent leaks, and more. (Pure Energies 2014)

1.8 Solar Panels

Generally, Solar Panels are used for charging batteries. They provide a good solution for those that want to be self-sufficient and go on long camping missions through remote areas. They are available in various voltage and power ratings. More than one solar panel can be used in parallel to combine their power output. Solar panels joined in parallel work most efficiently if they are the same. If they are the same, you can design it so that they both generate power at their optimal Operating points. Mixing different panels together gives a compromised operating point. It will work but the panels will not operate as efficiently.

1.8.1 Solar Panel Mono or Poly

Silicon solar panels have two basic construction methods – polycrystalline or mono crystalline. There are slight differences between poly and mono cells. Mono are slightly more expensive, require more energy to make, and are slightly more efficient. Poly are slightly cheaper, use less energy to make so are better for the environment, are slightly less efficient but have a slightly better temperature coefficient. That means at elevated temperatures the poly cells become more efficient.

The differences are only slight. It is largely irrelevant. A solar panel with good efficiency and good temperature coefficient is to be used whether it is poly or mono, it does not matter.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The use of the sun's energy is nothing new and dates back to the beginning of time. In recent years however, the focus on energy consumption worldwide rapidly encourages the research and development of an alternative fuel source including the sun, wind, hydro, wave, geothermal, biomass and other forms of energy. And today, because of that focus, the use of solar energy is expanding by leaps and bounds especially since sunlight is free, unlimited, readily available, clean and reliable.

A solar power system is one which is capable of converting the absorbed sun energy; store it in a lead acid cell to be used on the electrical load. In this part of the world, where power supply is not effective and efficient, the use of solar power supply is of immense value and advantage considering the fact that we are blessed or rich in sun light that is high degrees of temperatures which is the integral that feeds a solar power supply unit for uses. It is low cost compared to other alternative sources of power supply in this society for example the use of generators which consume fuel or diesel and are really expensive, and its life span is better and reliable when used under or within or above the stipulated rating of the solar power device. (Ezugwu 2012)

Swagatam Majumdar, 2012 did a homemade 2000 VA power inverter circuit. He explained that making a power inverter rated above 500 VA is always difficult, mainly because of the involved transformer dimension which becomes quite huge, unmanageable and difficult to configure correctly.

Power inverters in the range of KVA, requires huge current transferring capabilities for implementing the required operations as per the desired specifications of the unit. Transformer being the main power making component of such an inverter, requires high handling secondary if battery voltage is at the lower side, for example 12V or 24V volts. In order to optimize the transformer at lower currents, the voltage needs to be pushed at higher levels which again becomes a problem, because higher voltage means connecting batteries in series. The above problems can definitely demoralize any new electronic hobbyists or anybody who might be planning to make a rather big inverter design, may be for controlling the whole house electrical. An innovative approach for making things simpler even with huge power inverter designs has been discussed which uses smaller discrete transformers with individual drivers for implementing a 3000 VA inverter circuit. He studied the circuit diagram below and its operations with the following points: Basically the idea is to divide the power into many different smaller transformers whose outputs can be fed to individual sockets for operating the relevant electrical appliances. This method helped him to avoid the need of hefty and complicated transformers, and the proposed design becomes feasible even for an electronic novice to understand and construct. Four IC4049s have been employed in this design. A single 4049 consists of 6 NOT gates or inverters, so in all 24 of them have been used here. Two of gates are wired up for generating the basic required square wave pulses and the rest of the gates are simply held as buffers for driving the next relevant stages. Each transformer utilizes a couple of gates and the respective high current Darlington transistors which function as the driver transistors. The associated gates conduct alternately and drive the transistors in accordance.

The MOSFETs which are connected to the driver transistors respond to the above high current signals and start pumping the battery voltage directly into the winding of the respective transformers. Due to this an induced high voltage AC starts flowing through the complementary output winding of all the involved transformers, generating the required AC 230 V or 120 V at the respective outputs. These voltages become available in small sockets, so only the relevant magnitude of power can be expected from each of the transformers. The 555 section takes care of the square wave output generated from the oscillator stage such that these are broken into

Sections and optimized for replicating a modified sine wave output. All the parts after POINT X in the circuit diagram below should be repeated for acquiring discrete power output sections, the common input of all these stages must be joined to POINT X. Each of the transformer may be rated at 200 VA, so together, 11 stages (after point X) would provide roughly outputs up to 1500 VA. Though using many transformers instead of a single transformer might look like a small drawback, the actual need of deriving 1500 VA using ordinary parts and concepts finally becomes easily achievable from the above design. (Swaga amMajumdar2012)

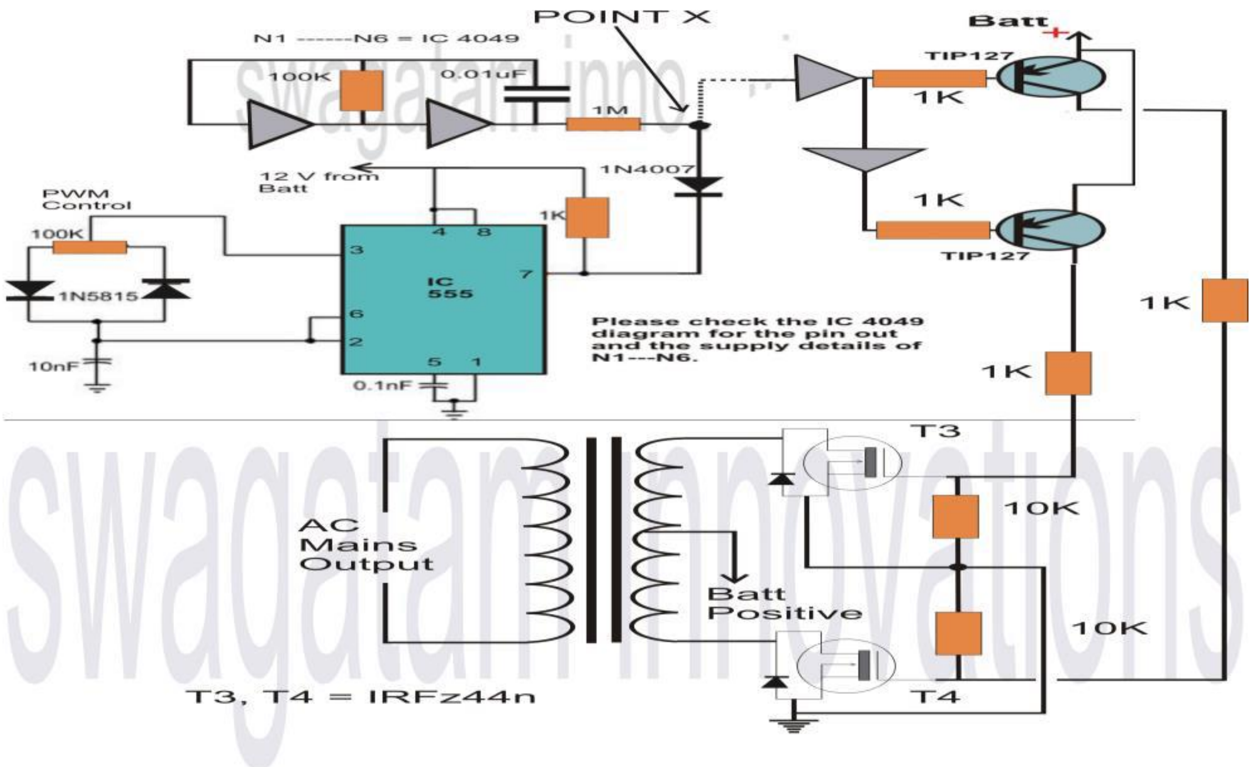

Figure 2.1 shows the circuit diagram designed by Swagatam Majumdar (2012)

Ezugwu (2012) designed and constructed a 200W solar system. The 200W solar system was determined by load assessment, solar panel number determination, battery requirement and then inverter sizing. A complete solar panel rated at 200W was however purchased, together with 2 number 150A solar battery, 3000W inverter and also 10A charge controller. These were assembled together with necessary protective gadgets like cut out switches; to give the 200W expected. The solar panel was mounted outside a building to allow for maximum collection of sun energy. It is expected that the system will help her department meet up with its office duties even when central power is not available.

2.2 Components used for the design

For this project to be completed there is a need to know the components used for the design. These include:

2.2.1 IC SG3524

2.2.1.1 Description

The SG3524 and SG2524 devices incorporate all the functions required in the construction of a regulating power supply, inverter, or switching regulator on a single chip. They can also be used as the control element for high-power-output applications. The SG3524 and SG2524 were designed for switching regulators of polarity, transformer-coupled dc-to-dc converters, transformer less voltage doublers, and polarity-converter applications employing fixed-frequency, pulse-width modulation (PWM) techniques. The complementary output allows either single-ended or push-pull application. Each device includes an on-chip regulator, error amplifier, programmable oscillator, pulse-steering flip-flop, two uncommitted pass transistors, a high-gain comparator, and current-limiting and shutdown circuitry. (Texas instrument 2014)

2.2.1.2 Features

1. Complete Pulse-Width Modulation (PWM) Power-Control Circuitry.

2. Uncommitted Outputs for Single-Ended or Push- Pull Applications.

3. 8A Standby Current.

2.2.1.3 Overview

SG3524 is a fixed-frequency pulse-width-modulation (PWM) voltage-regulator control circuit. The regulator operates at a fixed frequency that is programmed by one timing resistor, RT, and one timing capacitor, CT (capacitor terminal). RT (resistor terminal) establishes a constant charging current for CT. This results in a linear voltage ramp at CT, which is fed to the comparator, providing linear control of the output pulse duration (width) by the error amplifier.

The SG3524 contains an onboard 5-V regulator that serves as a reference, as well as supplying the SG3524 internal regulator control circuitry. The internal reference voltage is divided externally by a resistor ladder network to provide a reference within the common-mode range of the error amplifier as or an external reference can be used.

The output is sensed by a second resistor divider network and the error signal is amplified. This voltage is then compared to the linear voltage ramp at CT. The resulting modulated pulse out of the high-gain comparator then is steered to the appropriate output pass transistor (Q1 or Q2) by the pulse-steering flip-flop, which is synchronously toggled by the oscillator output. The oscillator output pulse also serves as a blanking pulse to ensure both outputs are never on simultaneously during the transition times. The duration of the blanking pulse is controlled by the value of CT.

Figure 2.2 shows the IC SG3524

2.2.2 IC 4066

2.2.2.1 General Description

The CD4066BC is a quad bilateral switch intended for the transmission or multiplexing of analog or digital signals. It is pin-for-pin compatible with CD4016BC, but has a much lower “ON” resistance, and “ON” resistance is relatively constant over the input-signal range.

2.2.2.2 Features

1. Wide supply voltage range 3V to 15V.

2. High noise immunity 0.45 VDD.

3. Wide range of digital and ±7.5 *V*PEAK analog switching.

4. “ON” resistance for 15V operation 80Ω.

5. Matched “ON” resistance ΔRON =5Ω over 15V signal input.

6. “ON” resistance flat over peak-to-peak signal range.

7. High “ON”/ “OFF” 65 dB output voltage ratio at F=10 kHz, RL=10 kΩ.

8. Control Line Biasing: Switch On (Logic 1), VC=VDD; Switch Off (Logic 0), VC=VSS.

9. High degree linearity 0.1% distortion.

10. Extremely low “OFF” 0.1 nA switch leakage.

11. Extremely high control input impedance 1012Ω.

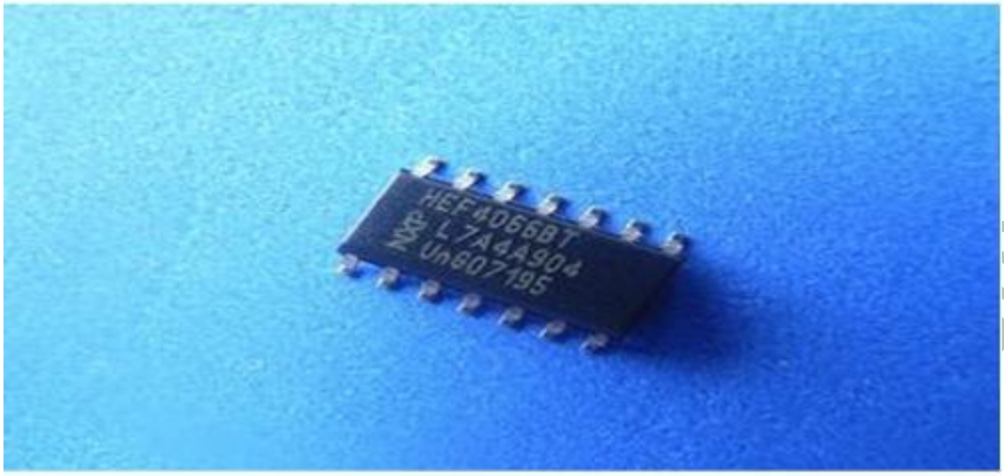

Figure 2.3shows the IC 4066

2.2.3 Variable Resistor

Variable Resistor is an electronic component. It is applied in an electronic circuit for adjusting circuit resistance to control voltage or current of that circuit or part of that circuit. The electrical resistance is varied by sliding a wiper contact along a resistance track. Sometimes the resistance is adjusted at present value as required at the time of circuit building by adjusting screw attached to it and sometimes resistance can be adjusted as when required by controlling knob connected to it. The active resistance value of the variable resistor depends upon the position of the slider contact on the resistance track.

It mainly consists of a resistance track and a wiper contact. The wiper contact moves along the resistance track when adjustable component is adjusted. There are mainly three different types of resistance track used in this resistor they are carbon track, cermet (ceramic and metal mixture) track and wire wound track. Carbon track and cermet track are used for high resistance application whereas wire wound track is used for low resistance variable resistor. The resistance tracks generally are of circular shape but straight track is also used in many cases. (Electrical4u 2014

2.2.3.1 Variable Resistor Connection

It is used as a rheostat when one end of the resistance track and wiper terminal is connected to the circuit and other terminal of resistance track remains open. In this case the electrical resistance between connected terminal and wiper terminal depends upon the position of the wiper (slider) on the resistance track. A variable resistor can also be used as a potentiometer when both ends of the resistance track are connected to the input circuit and one of the said ends of resistance track and wiper terminal is connected to the output circuit. In this case all three terminals are in use. Sometimes in electronics circuit there may be requirement of adjustable resistance but this adjustment is required only once or very often. This is done by connecting preset resistors in the circuit. Preset resistor is one kind of variable resistor whose electrical resistance value can be adjusted by adjusting an adjustable screw attached to it. (John 2010)

2.2.3.2 Types of Variable Resistor

Resistance track wise there are mainly two types of resistance track available one is linear track and other is logarithmic track. In linear track the resistance value varies linearly with changing slider position on the track. That means the resistance and the position of slider, form a straight line characteristics curve. When the resistance of variable resistor, varies logarithmically with position of the slider contact on the resistance track, the track is referred as logarithmic track.

The resistance value and type of track are marked on the resistor itself. For example, when a variable resistor is marked as 5K9 LIN means it has maximum 5.9 kilo Ω resistance and has a linear resistance track. Again when a resistor is marked as 2M LOG, it will have maximum 2megaΩ resistance and it has logarithmic track. Preset resistors are linear track type.

But the variable resistor used for volume in sound system are mainly LOG types as our ears have logarithmic response to the loudness. In GOL resistor, the resistance changes slowly at beginning and rapidly at towards end of the track. (John 2010)

2.2.3.3 Preset Variable Resistor

This is micro version of variable resistor. Preset resistors are directly mounted on circuit board and adjusted only when the circuit is built. There is an adjustable screw attached to the resistor and a small screwdriver is required to adjust this screw for desired resistance value. These resistors are quite cheaper than standard variable resistor available in the market.

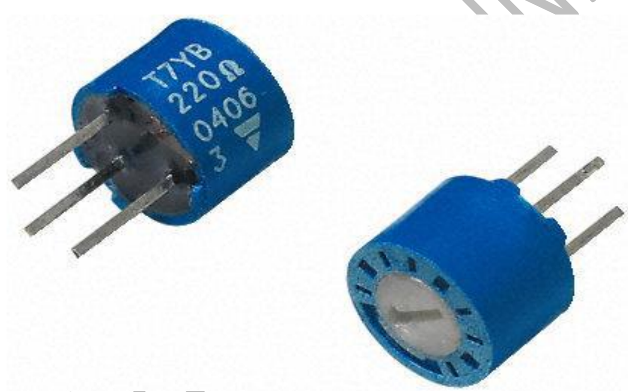

Figure 2.4 shows the variable resistor

2.2.4 Fixed Resistor

A fixed resistor is part of an electric circuit and is used to reduce the flow of electricity. Resistance is measured in Ohms and is typically shown as the number and then the units; for example, a 750 Ohm resistor would be written as 750-Ohm. The size of the resistor is based on the number of Ohms, and it can range from pin to book size.

Resistors come in two classes: fixed and variable. A fixed resistor is set at a specific value and cannot be changed. A variable resistor is able to manage flows at a specific level and below. This is an important distinction and determines when and where a resistor should be used. When selecting a resistor, it is important for a person to consider three things: the value of the resistor, its tolerance, and its power rating. The value is measured in Ohms. The tolerance indicates the upper and lower bounds of actual performance, which is measured in plus and minus percentage. For example, a tolerance of 10% means that the resistor performs within a 10% range of the resistance value listed in the specifications. Power rating shows the upper limit of power that can be managed by the resistor and is measured in watts. To calculate the power, a person can multiply the resistance value of the resistor by the square root of the current. If the power rating is exceeded, the resistor will fail. A rule of thumb is to use a resistor with a power rating two times higher than the actual power needed.

There are two kinds of fixed resistors: carbon and metal film. Carbon film resistors are designed for general use and are fairly cheap to produce and purchase. These units have a tolerance of 5%, with power ratings of 1/8 Watts (W), 1/4W, and 1/2W. The primary issue with this type of resistor is the fact they generate electrical noise.

A metal film resistor is best used when a higher tolerance is required. These units have a greater level of accuracy than carbon film resistors, due to the nature of the materials used. There is a corresponding increase in price, but it may be well worth the incremental cost to protect the other components of the circuitry. When reviewing the different types of resistors, individuals should think about the intended use of the circuit. They should select a manufacturer with a good reputation for quality and consistency, and take the time to test the resistor and the circuit before installation to ensure all the specifications are correct. (Carol Francois, 2015)

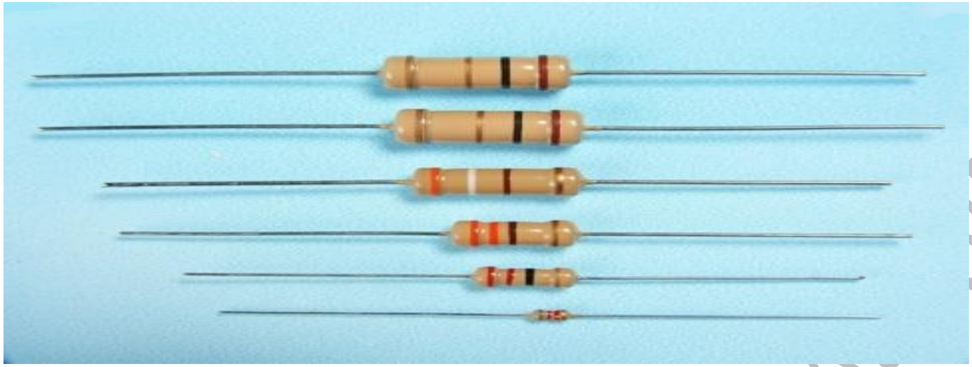

Figure 2.5 shows the fixed resistor

2.2.5 Diode IN4007

A diode is an electronic component with two electrodes (connectors). It acts like a gate or a valve, allowing electricity to go in one direction, but eventually some of the current will flow in the opposite direction, at the initial level of operation.

Diodes can be used to convert alternating current to direct current (Diode bridge). They are often used in power supplies and sometimes to decode amplitude modulation radio signals (like in a crystal radio). Light-emitting diodes (LEDs) are a type of diode that produce light and are used in many places. Today, the most common diodes are made from semiconductor materials such as silicon or sometimes germanium. (Diodes incorporated, 2015)

2.2.5.1 Features

1. Diffused Junction.

2. Surge Overload Rating to 30A Peak.

3. Low Reverse Leakage Current.

4. Low forward voltage drop.

5. High forward surge capability.

2.2.5.2 Typical applications

For use in general purpose rectification of power supplies, inverters, converters and freewheeling diodes application.

Figure 2.6 shows the diode IN4007

2.2.6 Capacitor (47uf/50v, 10uf/50v)

Capacitor is a device for the storage of electric charge. Simple capacitors consist of two plates made of an electrically conducting material (e.g., a metal) and separated by a non-conducting material or dielectric (e.g., glass, paraffin, mica, oil, paper, tantalum, or air). The Leyden jar is a simple capacitor. If an electrical potential (voltage) is applied to the plates of a capacitor (e.g., by connecting one plate to the positive and the other to the negative terminal of a storage battery), the plates will become charged, one positively and one negatively. If the externally applied voltage is then removed, the plates of the capacitor remain charged, and the presence of the electric charge induces an electrical potential between the plates. This phenomenon is called electrostatic induction. The capacity of the device for storing electric charge (i.e., its capacitance) can be increased by increasing the area of the plates, by decreasing their separation, or by changing the dielectric. The dielectric constant of a particular dielectric is the measure of the dielectric's unit capacitance. It describes the ratio of the capacitance of a dielectric-filled capacitor to a capacitor of the same size with a vacuum between the plates. Capacitors are used in many electrical and electronic devices. The main capacitor classifications are non-polarized (used for AC circuits) and polarized (used for DC circuits). Capacitors can also be classified as fixed or variable. One type of variable capacitor, formerly used in radio and television tuning circuits, consisted of two sets of semicircular plates, one fixed and the other mounted on a movable shaft. By rotating the shaft, the area of overlap of the two plates increases or decreases, thus increasing or decreasing the capacitance. These devices have largely been replaced by frequency synthesizers and a special type of solid-state diode, known as a varactor, whose capacitance changes with the reverse-biased voltage across it.

Figure 2.7 shows the capacitor

2.2.7 Transistor (BD139, C1815, A1015)

2.2.7.1 Description (BD139)

These epitaxial planar transistors are mounted in the SOT-32 plastic package. They are designed for audio amplifiers and drivers utilizing complementary or quasi-complementary circuits.

The NPN types are the BD135 and BD139, and the complementary PNP types are the BD136 and BD140. (Elite Enterprises H.K, 2015)

2.2.7.2 Features (BD139)

1. It is a complement to BD136, BD138 and BD140 respectively.

2. Products are pre-selected in DC current gain

2.2.7.3 Features (C1815)

1. It has a power dissipation of 0.2W

2. It has a collector current 0.15A

3. It has a collector-base voltage 60V

2.2.7.4 Features (A1015)

1. It has high voltage and high current.

2. Excellent Linearity.

3. Low noise.

4. It is complementary to C1815

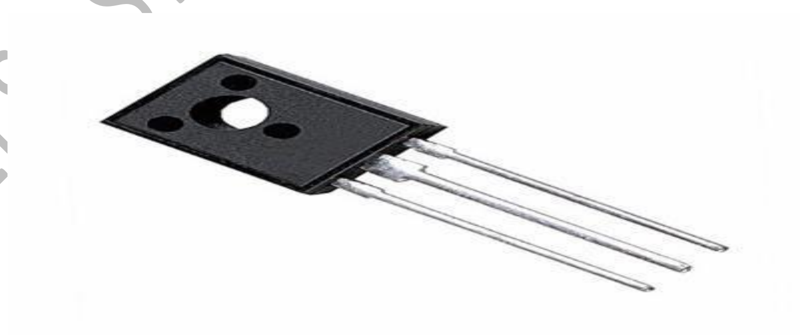

Figure 2.8 shows the Transistor

2.2.8 Timer (NE555)

2.2.8.1 Description

The NE555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200 mA. (Texas Instrument 2014)

2.2.8.2 Features

1. Timing from microseconds to hours.

2. Astable or monostable operation.

3. Adjustable duty cycle.

4. Compatible output can sink or source up to 200 mA.

2.2.8.3 Application Information

The NE555 timer devices use resistor and capacitor charging delay to provide a programmable time delay or operating frequency.

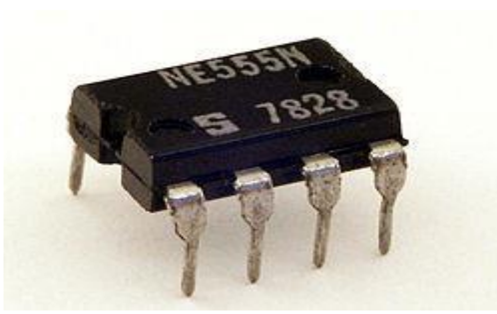

Figure 2.9 shows the NE555 Timer

2.2.9 Comparator (LM393)

Low Offset Voltage Dual Comparators

The LM393 series are dual independent precision voltage comparators capable of single or split supply operation. These devices are designed to permit a common mode range to ground level with single supply operation. Input offset voltage specifications as low as 2.0 mV make this device an excellent selection for many applications in consumer, automotive, and industrial electronics.

2.2.9.1 Description

The LM393 series consists of two independent precision voltage comparators with an offset voltage specification as low as 2.0mV max. For two comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.The LM393 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM393 series will directly interface with MOS logic where their low power drain is a distinct advantage over standard comparators.

2.2.9.2 Features

1. Wide Single−Supply Range: 2.0Vdc to 36Vdc.

2. Split−Supply Range: 1.0Vdc to 18Vdc.

3. Very Low Current Drain Independent of Supply Voltage: 0.4 mA.

4. Low Input Bias Current: 25 nA.

5. Low Input Offset Current: 5.0 nA.

6. Low Input Offset Voltage: 5.0 mV (max) LM293/393.

7. Input Common Mode Range to Ground Level.

8. Differential Input Voltage Range Equal to Power Supply Voltage.

9. These Devices are Lead Free, Halogen Free

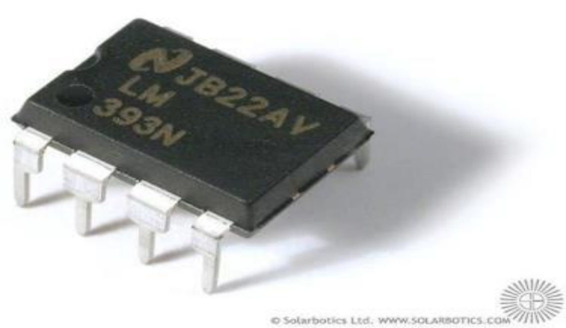

Figure 2.10 shows the LM393 Comparator

2.2.10 Regulator (LM117/LM317)

2.2.10.1 Description

The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 1.5A over a 1.2V to 37V output range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulations are better than standard fixed regulators. Also, the LM117 is packaged in standard transistor packages which are easily mounted and handled. In addition to higher performance than fixed regulators, the LM117 series offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators. Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is “floating” and sees only the input-to- output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

Also, it makes an especially simple adjustable regulator, a programmable output regulator or by connecting a fixed resistor between the adjustment pin and output, the LM117 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current. (Texas Instrument, 2014) 25

2.2.10.2 Features

1. Output-currentin excess of 1.5A.

2. Output-Adjustable between 1.2v and 37v.

3. Internal thermal overload protection.

4. Internal short-circuit current limiting.

5. Output-transistor safe operating area compensation.

Figure 2.11 Shows the LM317 Regulator

2.2.11 MOSFET

Discrete power MOSFETs employ semiconductor processing techniques that are similar to those of today's VLSI circuits, although the device geometry, voltage and current levels are significantly different from the design used in VLSI devices. The metal oxide semiconductor field effect transistor (MOSFET) is based on the original field-effect transistor introduced in the 70s. The invention of the power MOSFET was partly driven by the limitations of bipolar power junction transistors (BJTs) which, until recently was the device of choice in power electronics applications. Although it is not possible to define absolutely the operating boundaries of a power device, we will loosely refer to the power device as any device that can switch at least 1A. The bipolar power transistor is a current controlled device. A large base drive current as high as one-fifth of the collector current is required to keep the device in the ON state. Also, higher reverse base drive currents are required to obtain fast turn-off. Despite the very advanced state of manufacturability and lower costs of BJTs, these limitations have made the base drive circuit design more complicated and hence more expensive than the power MOSFET.

Another BJT limitation is that both electrons and holes contribute to conduction. Presence of holes with their higher carrier lifetime causes the switching speed to be several orders of magnitude slower than for a power MOSFET of similar size and voltage rating. Also, BJTs suffer from thermal runaway. Their forward voltage drops decreases with increasing temperature causing diversion of current to a single device when several devices are paralleled. Power MOSFETs, on the other hand, are majority carrier devices with no minority carrier injection. They are superior to the BJTs in high frequency applications where switching power losses are important. Plus, they can withstand simultaneous application of high current and voltage without undergoing destructive failure due to second breakdown. Power MOSFETs can also be paralleled easily because the forward voltage drops increases with increasing temperature, ensuring an even distribution of current among all components. (Duncan A. Grant, 2015)

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 INTRODUCTION

In this Chapter, the design steps, calculations of required components and implementation procedures along with the programming for the project are presented. The functional block diagram that represents the stages of the 3KVA solar inverter is as shown in Fig 3.1.

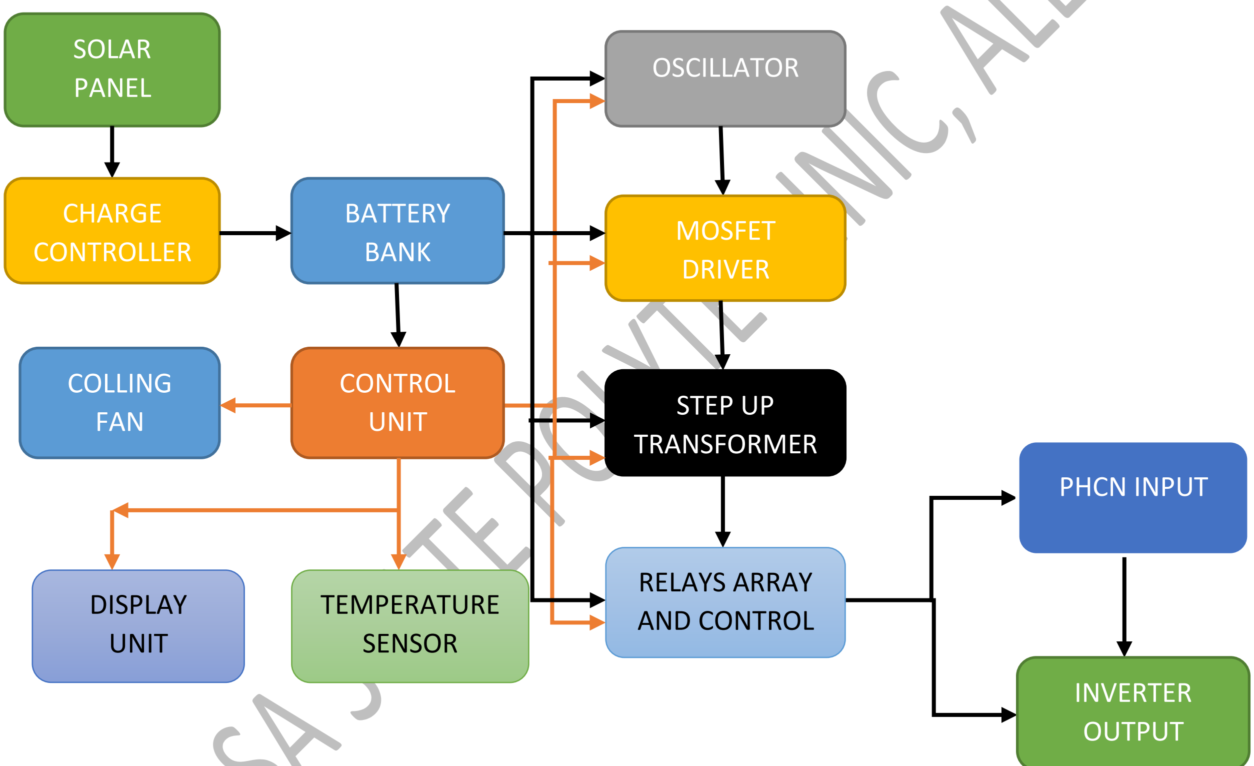

Fig. 3.1 Functional Block Diagram of the 3KVA Solar Inverter

The block diagram in Fig 3.1 comprises the oscillator stage which is responsible for generating the sine wave, the MOSFET driver for driving the required current through the transformer, relay unit for switching between the inverter output and PHCN supply, the control unit that does all the control process for the project, the display unit that display the activities of the inverter, the temperature sensor that does the temperature measurement for both the transformer and the power mosfet. The charge controller controls the charging rate from the solar panel to the battery bank. In what follows, the design calculation and specification leading to the final circuit are presented.

3.2 DESIGN SPECIFICATIONS

The proposed solar inverter herewith was designed based on the following specifications: it has an output power capacity of 3kVA, with a pure sine wave output. The sine wave operates at a frequency of 50Hz, which is the requirement for appliances in Nigeria. The output voltage is at 230V AC, while the solar charging approach uses the pulse width modulation (PWM). Generally, the capacity of an inverter is a function of the type and number of power MOSFETS used as well as the size and capacity of the power transformer.

3.3 POWER SUPPLY UNIT

The power supply unit is needed to power the electronics component used that operate on 5V DC. It basically consists of a 7805 voltage regulator, a 3 pin fixed positive output type monolithic voltage regulators with built-in overcurrent limit circuit and built-in thermal overload protection circuit. It regulate the 12V battery to a steady 5V with the ability to drive 1000mA which was used to power the microcontroller, the temperature sensors and the LCD display. A 470uF electrolytic capacitor was connected to the output of the regulator so as to smoothen the signal and remove any noise that may be caused by the regulator due to the process of regulation. A 100kΩ variable resistor was connected between the 12V battery and the ground so as to measure the battery voltage, the wiper of the 100KΩ variable resistor was connected to the ADC input of the microcontroller which convert the analog signal into a digital signal. The circuit diagram of the power supply unit is presented in figure 3.2

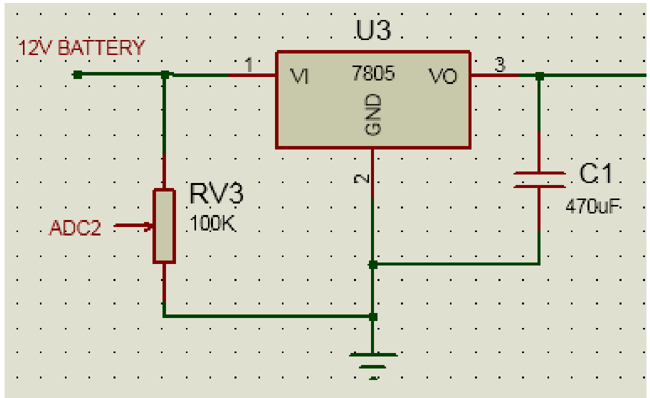

Figure 3.2: The power supply unit

3.4 THE RELAY UNIT

Array of relays were used as shown in figure 3.3, A 12V 10A relay was used for the switching of oscillator and the cooling fan i.e. RL1 and RL2, 12V 30A relay was used for switching the input and output device i.e. RL3-8. An electro mechanical relay was used, all the relays are in normally close mode. The output relay(RL7) is normally close at the inverter ON i.e. it used to supply source to the inverter through the battery when the mains AC supply is OFF. On the event of power supply from the mains, it switches OFF the inverter. Input relays is use to control the charging circuit and AC output voltage. Immediately there is supply of the voltage from the mains, the normally closed one of the relay depending on the level of the input voltage. At the same time it makes 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 (center tap/primary coil when AC is not used). The 12V AC supply to the MOSFETs serves as the rectifier that charges the battery.

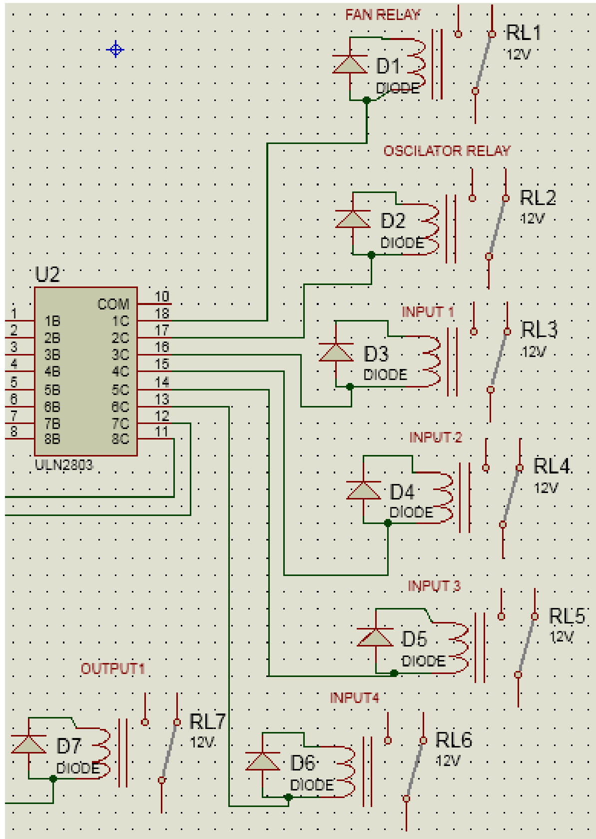

Figure 3.3: The Relay unit

3.3.1 The relay driver unit

A ULN2803 relay driver was employed to drive the arrays of relay since the microcontroller can only drive 5V and the relays requires a 12V DC to function, this driver contain eight darlington transistors with common emitters and integral suppression diodes for inductive loads. The driver features a peak load current rating of600mA (500mA continuous) and can withstand up to 50V. The microcontroller switches the driver from it input which is 5V and the driver switches each relay from its output which is 12V as shown in figure 3.3.

3.5 BATTERY UNIT

Battery is an imperative piece for an inverter operation. The presentation and life of an inverter to a great extent relies upon its battery used. There are a few orders of inverter batteries and the most widely used is the deep cycle battery. The type selected for this project is the GEL LEAD ACID BATTERY, is a deep cycle 200AH battery. Lead acid batteries are the most well-known inverter batteries. These are batteries that produce enormous measure of current. They are maintenance free batteries and are sealed that do not require electrolyte level check and topping up. They are fit and safer compared to normal lead acid batteries. But they are costlier compared to normal lead acid batteries and have a shorter life. They additionally discharge hurtful gases during charging and discharging.

A 200AH battery has ability to deliver 200A in one hour, with3000VA, assuming a power factor of 0.8, will give 3000 * 0.8 which is 2400W, the maximum current required at 12V is 2400/12 which gives 200A, it shows the inverter can last 2 hours on full load and last more if not fully loaded.

3.6 BATTERY CHARGING UNIT

This section discusses the battery charging circuit using the connected solar panel. For a 3KVA inverter to operate for one hour at maximum load, the required current is given in equation (3.1).

$$I = \frac{ratedpower}{batteryvoltage} \qquad (3.1)$$

Assuming a power factor of 0.8

Thus $\frac{3000*0.8}{12}$ $Therefore,\ I = 200A$(since the battery is 12V)

Hence, using a battery of 200AH, the time duration will be 200/200 x 1hr

= 1 hours

This means the battery can last for 2 hours on full load and last more if not on full load. The connected batteries can be charge from PHCN supply or through the solar panel. The solar panel requires charge controller which controls the rate of charging to avoid over charging the battery. The charge controller was implemented using PWM.

3.7 SOLAR PANNEL

Solar panel is one of the most commonly used renewable energy, this project is making use of two pieces of 150W solar panel which gives the sum of 300W, converting the battery power to a watt hour(Wh). Since the battery is rated 200Ah,multiplying 200Ah by 12volt will give 2400Wh. With the 300W solar panel operating at its full capacity means that it will take 2400Wh/300W=8 hours to fully charge the battery. But will need more hours to charge in a cloudy days.

3.8 OSCILLATOR STAGE

The conversion of DC energy from the battery to AC energy of a specified frequency is been done in this stage. It is an electronic source of alternating current or voltage having sine, square, saw tooth or pulse width. According to the definition/explanation above, it can be deduced that the oscillating stage is where the main idea of inverter lies. The oscillator used in this design was pulse width modulation regulator control (SG3524). This was chosen because of some reliability and availability of some essential components in its circuitry, to implement single ended or push-pull switching regulator. Included on the circuit is oscillator, voltage reference, a pulse width modulator, error amplifier, overload protection circuitry and output drivers.

TheSG3524 IC has 16pin dual-in-line-dip as shown in Figure 3.4, dual alternating out-put switches, current limiting and shut down circuitry, voltage stability.

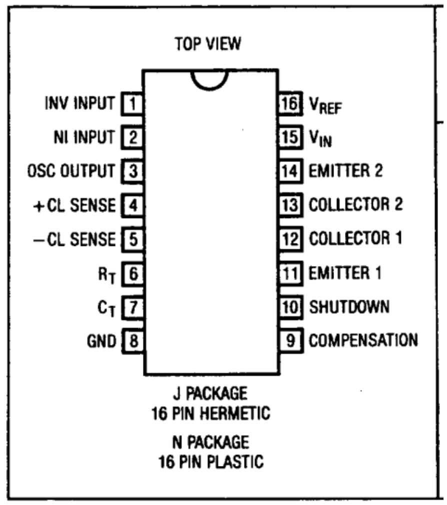

Fig. 3.4. Snapshot showing the SG3524 IC pin out

In the design, the IC is supplied with 12V DC at pin 15. However, the internal circuitry of the device required 5V DC. The excess voltage is being fed to both inverting and non-inverting pins 1 and 2 error amplifier respectively via pin 16 voltage reference pin. The voltage output of the comparator sunk to the ground through pin 4 and pin 5 which are clock sense pin. The major functional unit of the IC (SG3524) is oscillator circuitry. The oscillating frequency is varied through the resistor and capacitor connected to pin 6 and pin 7 respectively. The output of oscillator is pin 3 which is a single ended pulse fed directly into a flip flop. The flip flop divides the single ended output into two and fed to NOR gate, then to transistors each attached to a NOR gate at pin 12, 11, 13 and 14, pin 14 and 11 of each transistor is grounded (emitter) while pin 12 and 13 are the output pin used for push pull application. The internal circuitry of SG3524 is as shown in Fig. 3.5.

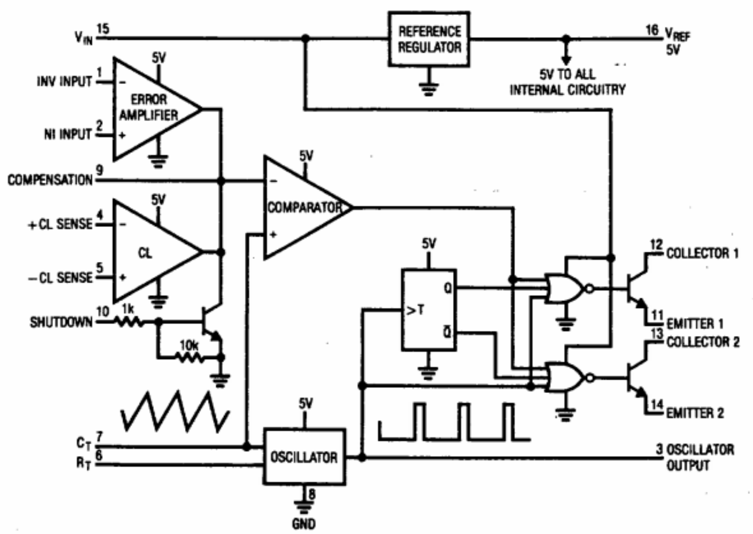

Figure. 3.5. Snapshot showing the internal circuitry of SG3524 IC

3.8.1 Frequency Configuration of the Oscillator

As stated above, SG3524 requires external synchronization for the designer to vary the pulse duration derived and consequently the frequency. The formula generated from the manufacturer of SG3524 for pulse duration is given as:

T = 1.1 RC(where T is in microsecond.) (3.4)

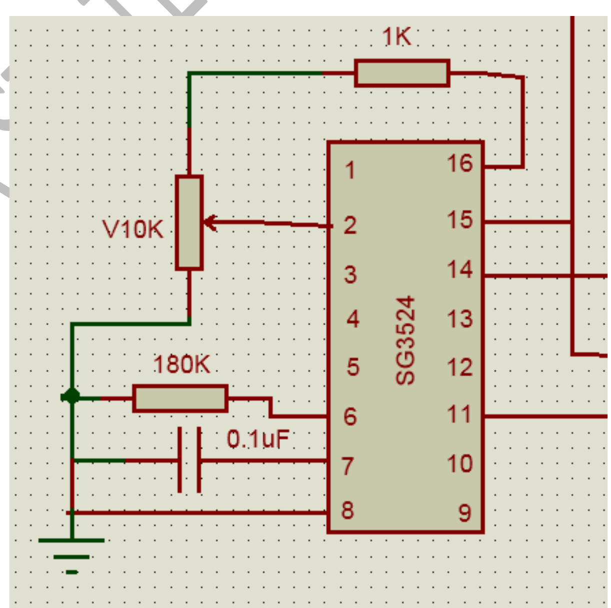

Fig. 3.6 Circuit diagram of the oscillator

Thus assuming R is chosen to be 180kΩ, which is a ready available resistance value, with capacitance value of 0.1uF, also readily available, the goal is to achieve an oscillating frequency of 50Hz which is the standard required for appliances in Nigeria.

Therefore $T = 1.1 \times 180 \times 10^{3} \times 0.1 \times 10^{-6}$

$T = 0.018$secs.which can be approximated to 0.02sec

However, frequency (f) can be obtained using (3.5).

$$f = {}^{1}\!/\!_{T} \qquad (3.5)$$

f = 1/0.02

= 50Hz.

The flip-flop divides the frequency into two i.e. F = 50Hz = 25Hz (half cycle) which will later summed at the output transformer. Resistor 10kΩ was used to drop voltage that feeds the inverting and non-inverting error amplifier at pin 1 and 2 and finally sink into the ground via pin 4 and pin 5. Pin 9 is a compensation pin and function in the case where there is error amplification.

3.9 POWER SWITCHING MOSFET

MOSFETs are metallic oxide semiconductors in which the gate is completely insulated from the channel by a thin (about 1dm) layer of silicon oxide. This permit operation with gate source or gate channel voltage above and below zero. The insulated gate of the MOSFET further reduces substantially the gate current, in which the gate current is less than one Pico ampere (pA).On the design, the MOSFET received 5V alternating voltage. Therefore, to OFF the MOSFET completely, the MOSFET gate was negatively biased to avoid the damage of the component, because without the negative bias, the MOSFET will not completely OFF before the arrival of the other pulses which might damage the MOSFET. In addition, 22KΩ resistor connected between the gate and the source to completely turn OFF the MOSFET. Diodes were connected across the drain of the MOSFET to avoid surge at reverse direction, which might also damage the MOSFET.

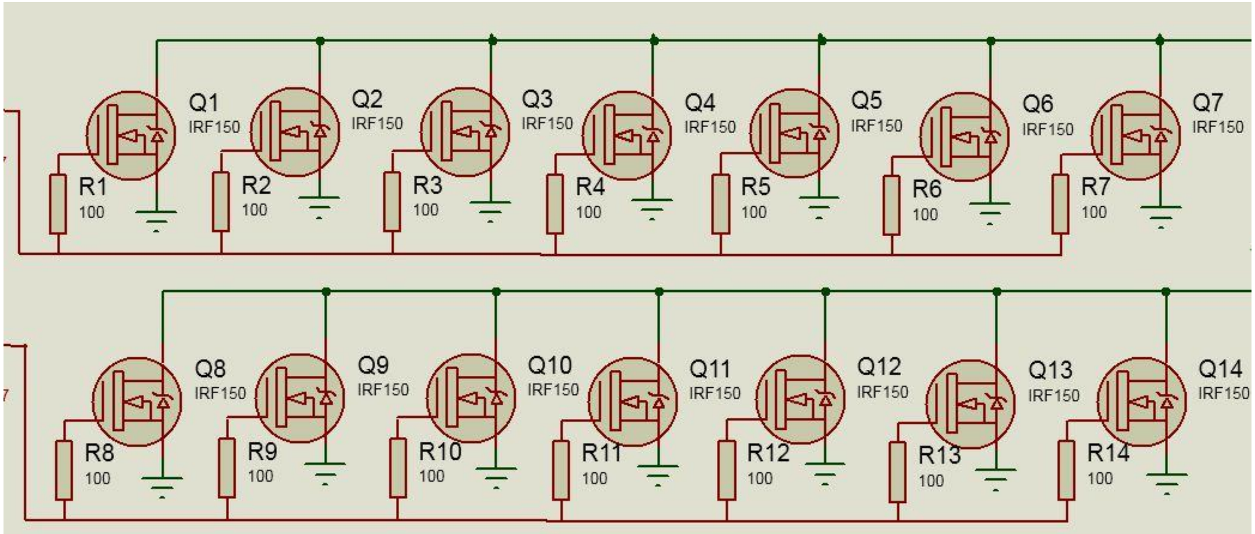

Fig 3.7.Circuit configuration of the MOSFET

3.9.1 MOSFET Design Calculation

A voltage level of 5V was fed from preamplifier to the switching MOSFET that makes $V_{GS} = 0$ at self-bias. Thus, the gate current can be obtained as:

$$I_G = \frac{V_H - V_{GS}}{R_b} \quad (3.6)$$

Where, V_{GS} is the gate to source voltage, V_H is the preamplifier voltage level, and R_b is the gate resistor. Thus,

$$I_G = \frac{5-0}{100} = \frac{5}{100}$$

$$= 0.05Amp$$

If $V_G = 5V$ at V_H

Therefore: Drain Current = D_i

Since drain current = $\frac{V_{DD}}{R_D}$

R_D = the reactance of the coil of the transformer.

Therefore, the reactance of the coil must be known.

Since L (inductance) is not noted

:. $X_L = \frac{V}{I}$, V = 12 and I =?

Targeted power rating = 3KW = P = IV

3000 = 12 x I

Assuming 0.8 power factor

$\frac{3000*0.8}{12}$ $There\ for\ I = 200A$

The IRF150 has capacity of 40Amp, therefore the MOSFET should be arranged in parallel to compensate for the current.

If $X_L = \frac{V}{I} = \frac{12}{100} = 0.12\Omega$

At 50Hz the reactance of the coil was noted to be 0.12Ω . Hence, R_D = 0.12Ω

Drain current = Di = $\frac{V_{DD}}{R_D} = \frac{12}{0.12} = 100Amps$

The arrangement of three IRF150in parallel will give total of 200A and the full load actually require 200A which is the reason why three MOSFET are connected in parallel to form the push pull configuration.

3.10TRANSFORMER DESIGN

A transformer is a static (stationary) piece of apparatus by means of which electric power in one circuit transformed into electric power of the same frequency in another circuit. It can raise or low the voltage in a circuit in response to ratio of the coil at the primary and secondary winding but with a corresponding decrease or increase in current. The transformer used here is a step-up transformer from 12V to 230 V AC. The physical basis of a transformer is mutual induction between two circuit linked by a common magnetic flux generated corresponding to the input power to the transformer. The bidirectional transformer was used at the output stage of the entire design of 3KVA inverter, to be able to realized 230V from the input of transformer of 12V AC signal at the MOSFET end. This step-up center tapped transformer steps up 12V AC from the output of the inverter unit to the desired 230 V AC.

3.10.1 Transformer Design Calculation

The transformer calculation was carried out on the assumption that there is no power loss. This however applies to an ideal case. Assuming no power loss, the rated power of the inverter is equal to the output power. Thus recall that input current = 200A,

Let E_s = Emf of secondary side of the transformer = 220V

E_p = Emf of primary side of the transformer = 12V

N_s = number of turns in secondary side of the transformer = 580turns

N_p = number of turns in primary side of the transformer =?

Also, transformer ratio (K) is given as in (3.7).

$$K = \frac{E_s}{E_p} = \frac{N_s}{N_P} \tag{3.7}$$

$$\frac{230}{12} = 19.2 = K$$

Given that the number of turns of the secondary side (N_S) =580 turns

To find N_p i.e. number of turns in primary side

Given E_p = 12V, E_s = 230V

$$\frac{Ep}{Es} = \frac{Np}{Ns}$$

$$N_p = \frac{Ep}{Es} \times N_s = \frac{12}{230} \times 580 = 30 \text{ turns}$$

To achieve the impedance of the coil the parameters are noted:

Secondary coil turns = 580 turns

Primary coil turns = 30 turns

Secondary Voltage = 230V

Primary Voltage =12V

Secondary current = ?

Primary current = 200A

The secondary current obtained by the current that runs through the source to the drain of the MOSFET. This help in powering the transformer, because the transformer is the R_L (Load resistor of the MOSFET).

:. I_s (primary current) is given by transformer ratio:

$$\frac{I_p}{I_s} = \frac{V_s}{V_p} = I_p = \frac{12 \times 200}{230} = 10.4A$$

:. Secondary current = 10.4A

Power efficiency = power input = power output

Power efficiency = 12 x 100 = 230 x 10.4

= 2392W

Which is the same as 2400 / 0.8 = 3000VA

If primary reactance $X_{sr} = \frac{V}{I} = \frac{12}{200}$

= 0.06

:. Inductance of the primary coil

X_L = 2πfL

= 0.12

= 2 x 3.142 x 50 x L

$L = \frac{X_L}{2\pi f} = \frac{0.12}{2 \times 3.142 \times 50}$

$L = 0.382 \times 10^{-3} H$

Inductance of the primary coil

$X_L = \frac{230}{10.4} = 22.11\Omega$

$X_L = 2\pi fL$

$X_L = 2 \times 3.142 \times 50 \times L$

$L = \frac{42.20}{2 \times 3.142 \times 50}$

$L = 0.134H$

Therefore, the resonant factor (Q) = $\frac{\omega L}{R_{dc}}$

Where R_{dc} = dc pure resistivity

DC resistivity for secondary coil is 1.6Ω

DC resistivity for primary coil = 2.5Ω

$\frac{2\pi fL}{R_{dc}}$ = Q – for primary coil

$\frac{2 \times 3.142 \times 50 \times 0.382 \times 10^{-3}}{1.6}$

= 0.075

Q factor for secondary coil

$$\frac{2 \times 3.142 \times 0.134 \times 50}{2.5}$$

= 16.84

Hence, impedance for secondary coils,

$R = Q \times X_L$

$R = 0.075 \times 0.072$

R = 0.0054Ω

Impedance for primary coil

= $Q \times X_L$

= 16.84 x 0.12

= $2.02\ \Omega$

3.11 CONTROL UNIT

This unit is made up of AVR microcontroller ATMEGA16 which performs the control function of the solar inverter. It also monitors the two temperature sensors, AC and DC voltage level, switching of the relays, control the cooling fan, oscillator and display all necessary information on the LCD. ATMEGA16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATMEGA16 achieves through puts approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed. ATMEGA16 has 131 powerful instructions most single-clock cycle execution, 32 × 8 general purpose working Registers, fully static operation, up to 16 MIPS throughput at 16 MHz,16 Kbytes of In-System self-programmable flash program memory, 512 bytes EEPROM, 8-channel 10-bit ADC, 1 Kbyte Internal SRAM, Byte-oriented Two-wire serial interface, programmable serial USART, Master/Slave SPI Serial Interface, programmable watchdog timer with separate on-chip oscillator, on-chip analog comparator. The internal block diagram of the microcontroller is presented in figure 3.

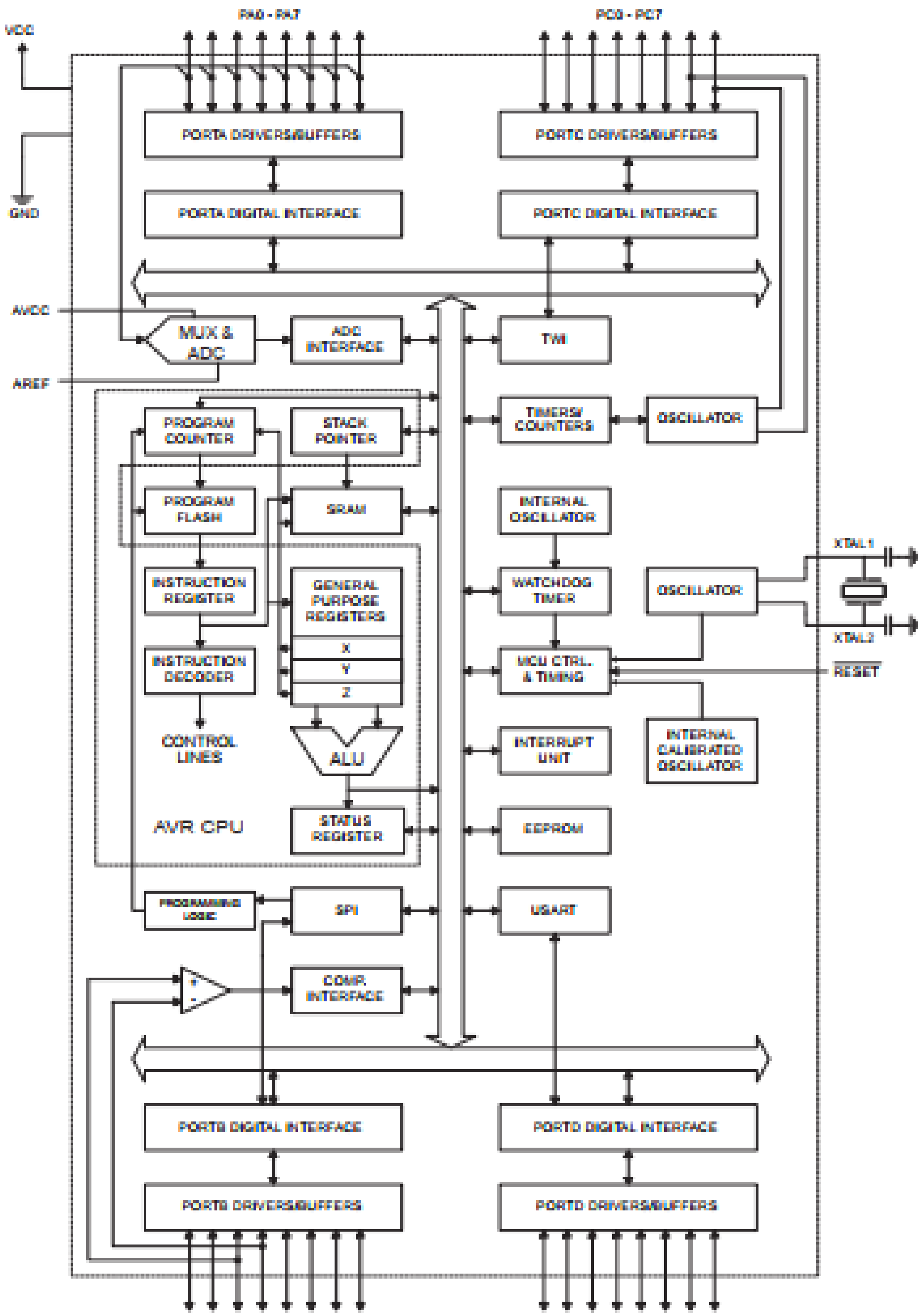

Figure 3.8: The internal block diagram for ATMEGA16

3.12 SOFTWARE PART

The software that drives the control unit was written in C/C++ language and was written with the help of the Atmel Studio which was used to debug and simulate the code to be free from syntax and logic error, an HEX file was generated which was burn on the microcontroller chip and the control process was complete, fig 3.9 shows the flow chat for the code.

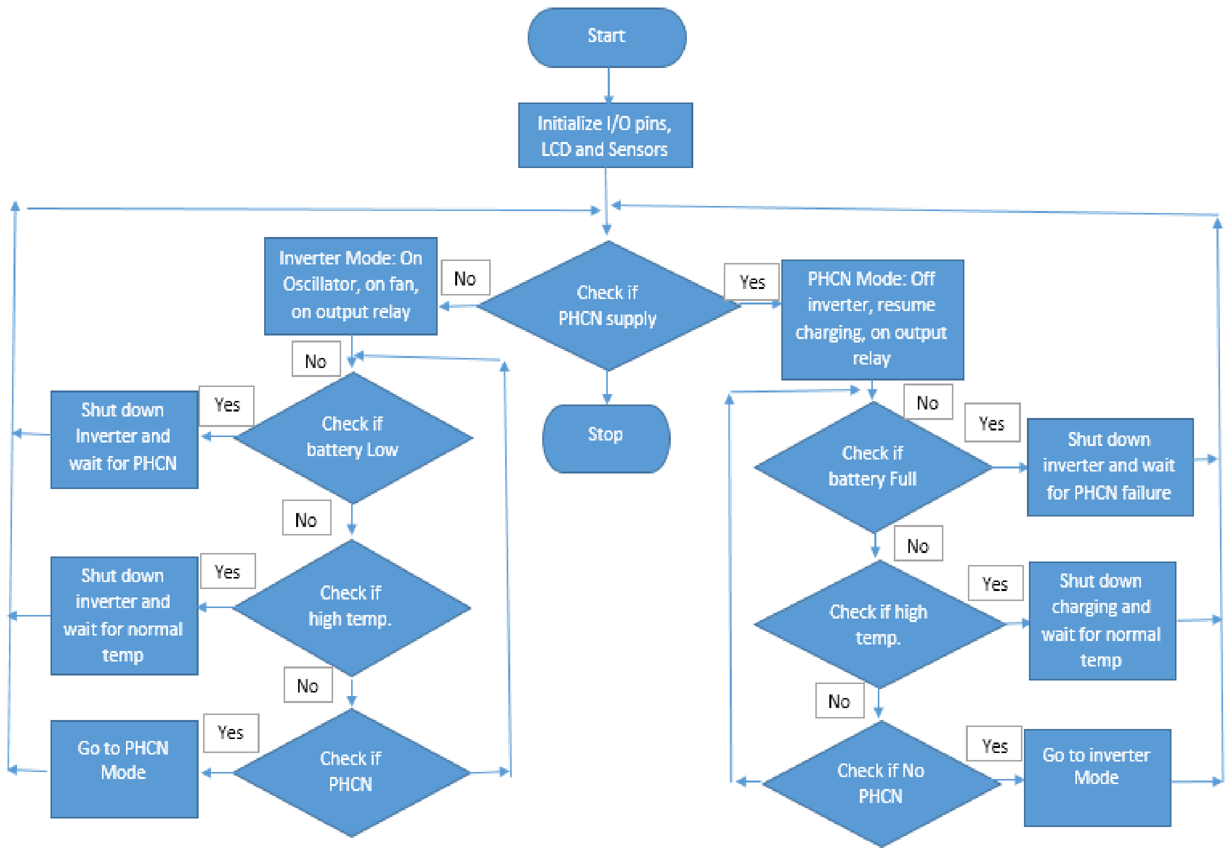

Fig 3.9: Program flow chat

3.13 DISPLAY UNIT

This unit is made of a 16 × 2 liquid crystal Display (LCD), this is a basic 16 character by 2-line display. Black text on Green/Blue background. It functions as an interface between the user and the inverter system and utilizes the extremely common HD44780 parallel interface chipset. This unit shows the output of all activities of the inverter and the LCD is responsible for this display. Figure 3.9 shows the LCD connection to the microcontroller.

Figure 3.9: Liquid Crystal Display (LCD)

3.14 TEMPERATURE SENSOR

Two temperature sensor was used in this project to serve as protection for the inverter, one is mounted on the MOSFETs and the other mounted on the transformer so as to detect fault or unwanted power loss. LM35 was used in this project because of its compact size and its ability to interface with the microcontroller ADC directly.LM35 is a precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4˚Cat room temperature and ±3⁄4˚C over a full -55 to +150˚Ctemperature range. Low cost is assured by trimming and calibrating at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration makes interface readout or control circuitry easy. It can be used with single power supply, or with plus and minus supply. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a -55˚ to +150˚C temperature range, while the LM35C is rated for a -40˚ to +110˚C range (-10˚with improved accuracy).

3.15 COMPLETE INVERTER CIRCUIT AND MODE OF OPERATION

This construction consist of different stages coupled together to perform a specific purpose and the circuit MOSFETs when in parallel are properly isolated from each other even if they are driven from the same source which is the Pin 11 and pin 14 of the SG3524N IC. The MOSFET is driven by the signal output of the driving stage thus controlling the voltage at the gate of the MOSFETs which result in the MOSFETs channel being alternatively switching on and off. That is, when one set MOSFETs channel switches on, the first set of MOSFET channel switches off. The switching action of the MOSFET channel which is a crucial process in the outlet section is done repeatedly for about 80 cycles per second, that is, at frequency of 80Hz. In the forward direction - that is, supply from the battery to the load receives the oscillated DC voltage signal, boost the power and conducts in positive and negative half cycles thereby producing an AC output same at high voltage and frequency. On the other hand when used in the reverse direction, this unit can be used to charge the battery from the main supply through the switching circuit (relay) in the control unit, in case of failure from the charge controller or the solar panel, this follows the normal rectification process, during the positive half cycle of the input AC signal, the first set of six(3) number MOSFETs conducts acting as diode but in the reverse direction (cathode to anode), a 12V DC voltage is presented at the center tap of the choke which serves as a positive input to the battery, since the negative terminal of the battery has been connected to the source of the MOSFETs. During the negative half cycle of the input signal, the second sets of the MOSFETs conducts and the same process occurs. What this means is that the oscillator (SG3524N) generates two separate signals from pins 11 and 14 which switches the MOSFETs gates on either sides (positive and negative). The supply from the battery to the load receives the oscillated DC voltage signal; boost the power and conducts in the positive and negative half cycles thereby producing an AC output voltage of 220v. The complete circuit of the inverter is as shown in Fig. 3.10.

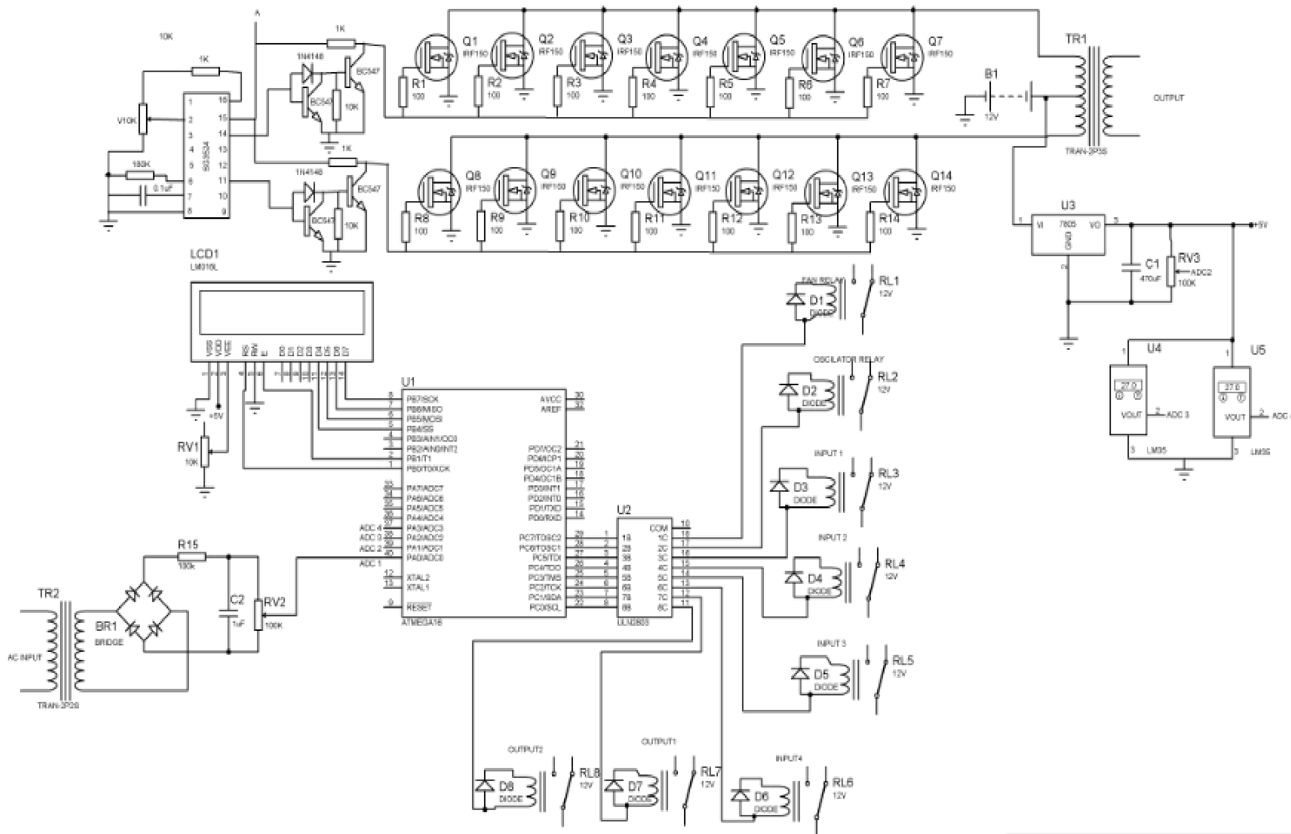

Fig. 3.10. Complete circuit diagram of 1.5KVA solar power inverter

CHAPTER FOUR

RESULTAND DISCUSSION

4.1CONSTRUCTION AND TESTING

The realization of this project involved theoretical (Project design and component selection) and practical (Implementation and coupling) exercise of converting the designed circuit diagram on the paper into a real, workable electrical device. The modular methods of construction were introduced to verifying the workability of each stage of the design on breadboard, which is the temporary circuit connection and to be able to determine the stage(s) that requires some amendment.

The final construction was implements on printed circuit board(PCB). All the electronic components involved were carefully selected and studied, connected together under the guide of the circuit diagram and datasheet that provides detailed information on the connection of each component. The design analysis of the whole circuit diagram in previous chapter was of great benefit in the construction, because it predicted the expected output of each stage, though with little variation. Each unit circuit was executed one after the other. After which all the units were joined together as a single working hardware. The circuit's construction involves the following materials and tools:

- Jumper wires
- Integrated circuit sockets
- Razor blade
- Cutting knife
- Soldering iron
- Soldering lead
- Vero board
- Pliers
- Digital multimeter

4.2 TESTING AND WORKABILITY OF THE INVERTER

The work at this stage is not just on paper, but also as a finished hardware system (product). After carrying out all paper design and analysis, the design was implemented and tested to be sure of its workability. Finally, it was constructed to meet the desired specification. The test was carryout as follow:

- Multimeter: The specified and expected input and output of the device found correct. Continuity, resistance, voltage and current of components were also tested and found to comply with the calculations in chapter three.
- The entire system output test was carried out on no load and on full load over time and the output was found to be stable in both voltage and frequency.

4.3 RESULTS FROM TESTING

Figure 4.1: Complete Fully packaged work

4.4 ASSEMBLING AND PACKAGING

The different units of the inverter were constructed in modules, then assembled to form the inverter system. These units include, transformer, MOSFET driver, oscillator, changeover, charge controller and battery bank.

The charge controller unit takes its input from the connected solar panel and provides a pulse width output for charging the batteries. Thus it was housed separately from the inverter, while its output goes to the batteries.

4.5SUMMARY OF RESULTS

The result obtained from the constructed inverter was very satisfactory. The primary aim of obtaining a 3kVA output capacity from the inverter was achieve and the uninterrupted constant supply of power achieved. Dual charging source was also achieved via solar panel and PHCN supply. Some of the challenges faced include MOSFETs overheating, hence, the idea of heat sink to reduce the heating and the introduction of temperature sensor also help. Noise in the output transformer was also reduced to the barest minimum. So vanish was applied to hold the coils more compactly to clear the noise. Filter capacitor was also connected to the output to filter the AC ripples.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This thesis was designed and constructed to provide an alternative means of power supply for domestic and commercial uses. In addition, it aimed to provide solution to the epileptic nature of power supply in this country.This inverter can supply power to most household appliances for a period of time that is directly proportional to the ampere-hour rating of the battery. Finally, to achieve a longer time of power supply, battery banks and wider solar modules are recommended.

5.2 RECOMMENDATION

1. The inverter should be design to use more than two batteries at a time connected in parallel.
2. The charging unit should be designed to be able to deliver a high charging current, so that batteries could be charged on time.
3. The device should be incorporated with alarm, to call the attention of the user when battery discharged.
4. The device should be design to automatically switch OFF when battery charges are below the useable capacity.

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