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Pure Sine Wave Inverter with Charge Controller

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ABSTRACT:

Inverters find extensive applications in various industrial and commercial settings, particularly in DC-AC motor drive systems and uninterruptible power supplies. A DC-AC converter, commonly referred to as an inverter, is responsible for transforming DC voltage input into AC voltage output. The essential components for testing and operation include operational amplifiers, gate drivers, power MOSFETs, and controllers integrated into the gate driver circuit. This paper presents the design and assembly of a 10kVA pure sine wave inverter system equipped with a charge controller, operating on the principle of PWM modulation. The inverter employs the IC SG3524 and a set of twelve MOSFETs for driving the load. The project initiates with the power supply, and electronic data books aid in component selection, streamlining design and calculations. Notably, the 13inverter features a monitoring system and a battery charging section seamlessly integrated into the circuit."

Keywords: Inverter, Sine, Controller, PWM, Charge, MOSFET

Introduction

In present-day society, instability of power supply has been a common phenomenon; this is because there is poor generation of power supply in most parts of the nation. The increasing power demand in homes, hospitals, and industries has led consumers to explore alternative power sources to meet their daily energy requirements. The quest for alternative power supply brought about the[1] invention of Gasoline and diesel Generators. These generators come with their own set of advantages and disadvantages. While they partially satisfy consumers' electricity needs, they also pose health hazards and may not be entirely safe for human use. In response to the environmental pollution caused by gasoline generators, inverters have emerged as an alternative. Inverters are devices that convert[2]Direct Current (DC) into Alternating Current (AC), generating electricity through an inversion process, the reverse of rectification, where AC is converted into [3] DC power. Typically, an inverter comprises an invert circuit, charger circuit, and a battery. The charger circuit keeps the battery charged when mains AC supply is available and can power various electrical and electronic equipment. Given the unreliable electricity distribution in Nigeria and the growing demand for power in industries, homes, and hospitals, the invention of inverters offers a potential solution to these pressing issues in the country.

Introducing an inverter system as an alternative power supply can effectively mitigate environmental pollution associated with diesel or gasoline generators. Inverters are indispensable for hospitals, ensuring uninterrupted power supply during critical operations to save lives. Moreover, the invention of inverter systems contributes to fuel savings and a reduction in the overall cost of living. In recent years, Nigeria's industries have suffered from low productivity and efficiency due to inadequate electricity distribution. The advent of inverters addresses these challenges, promoting increased productivity to meet the demands of the population.

The 10KVA pure sine wave inverter, in particular, offers seamless power backup for both office and home use, featuring advanced technology for trouble-free performance and high efficiency. Its durability makes it suitable for Nigeria's challenging power supply environment. This IGBT-based PWM technology[4] inverter incorporates smart-charge technology for faster charging and extended battery life.

Compared to traditional power supply systems like generators, inverters offer several advantages. They operate silently, preventing noise pollution, and can be charged using the main utility power source or solar panels, eliminating the need for fuel storage. Inverters are lightweight, have lower running costs, and require minimal maintenance. The primary objective of this project is to design an electrical device that converts DC to AC, producing a 10kW sine waveform of mains/utility voltage. This can be powered from a 12V battery source.

From the late nineteenth century to the mid-twentieth century, the conversion of DC to AC power was achieved using rotary converters or motor-generator sets [5](M-G sets). During the early twentieth century, vacuum tubes and gas-filled tubes emerged as switches in inverter circuits, with the thyratron[6] being the most commonly used type of tube. The term "inverter" finds its origin in the history of electromechanical inverters. Early AC to DC converters utilized an induction or synchronous AC motor[7] directly linked to a generator (dynamo). In this setup, the generator's commutator[8] reversed its connections precisely at the right moments to produce DC power. A later development in this technology is the synchronous converter, where motor and generator windings are combined into a single armature. This armature features slip rings at one end and a commutator at the other, along with just one field frame. Both setups result in AC input and DC output. In the case of an M-G set[9], it's as if the DC is generated separately from the AC. With the approp8riate auxiliary and control equipment, an M-G set or rotary converter can be operated in reverse, effectively converting DC back into AC. Therefore, the term "inverter" is derived from the concept of an inverted converter, as it performs the reverse process.

Effective utilization of DC power sources often requires having a high voltage gain, ensuring linearity in voltage control, minimizing the amplitude of low-order harmonics in the output voltage to reduce harmonic content in output currents, minimizing switching losses in inverter switches, and allowing sufficient time for the proper operation of inverter switches and control systems. Various pulse-width modulation (PWM) techniques are employed in sine wave inverters, with one of the most used methods being single or two-level PWM. This approach involves comparing a low-power reference sine wave with a triangular wave, resulting in a two-level PWM signal. Single or two-level PWM is widely recognized and widely used for pulse-width modulation in inverters.

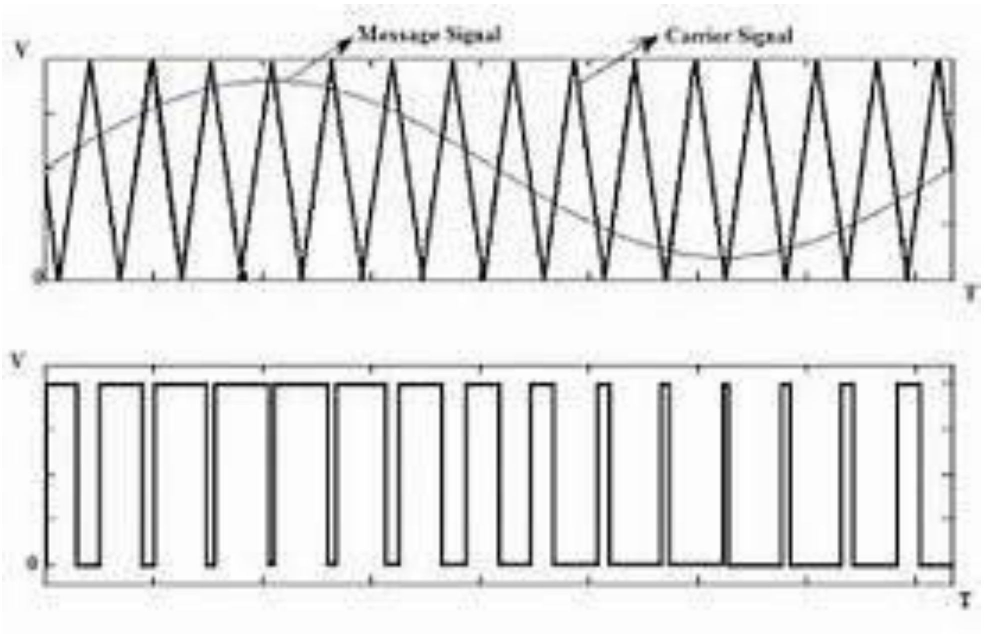


Figure1:Two level PWM

Multi-level pulse-width modulation(PWM) is employed to significantly reduce harmonic content in the output voltage. Different levels of multiphase PWM can be used to improve the output quality, including 3-level PWM, 5-level PWM, 7-level PWM, and 9-level PWM. The choice of which level of PWM to use depends on the inverter's cost and desired output quality. To strike a balance between cost-effectiveness and output quality, 3-level PWM is commonly utilized. In comparison to 2-level PWM, the harmonics plot of 3-level PWM shows no higher-level harmonics of significant magnitude, closely approximating the desired sine wave. However, the primary frequency in 3-level PWM has a much lower voltage magnitude than that of the 2-level design due to the presence of other frequencies caused by switching the signal polarity.

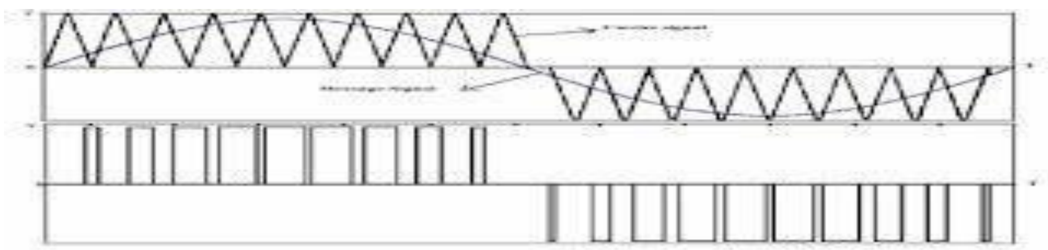


Figure 2:Three Levels PWM

PWM (Pulse-Width Modulation) is widely utilized in electronic power converters and motors to convert available direct current (DC) into alternating current (AC) for powering AC devices. By varying the duty cycle of the PWM signal, a specific pattern of DC voltage is generated across the load, which appears as an AC signal to the load. The speed of the PWM signal can be controlled through various means, including simple analog components, digital microcontrollers, or dedicated PWM integrated circuits. This technique allows for efficient and precise control of AC devices using a DC power source.
In analog PWM control, two signals - a sinusoidal reference signal[10] at the desired output frequency and a carrier signal, typically a high-frequency triangular[11] wave - are generated. These signals feed into a comparator, which produces output signals based on their difference. When the carrier signal exceeds the reference signal, the comparator output is in one state, and when the reference signal is higher, it's in the second state. This process allows modulation and demodulation of sine pulses.
On the other hand, digital microcontroller-based PWM[12] requires a sinusoidal reference signal (modulating signal) and a triangular carrier signal[13] to control switching frequency. Microcontroller modules are employed to compare these signals and generate the PWM signal.PWM finds a wide range of applications, from measurement and communications to power control and conversion. It produces harmonics at much higher frequencies than a square wave, simplifying filtering.
The advantages of PWM include the ability to control the output voltage amplitude with modulating waveforms and reduced filter requirements to decrease harmonics. However, it comes with the drawback of more complex control circuits for switches and increased losses due to more frequent switching. In the H-Bridge configuration[14], four switches are arranged like the letter "H," allowing the application of positive, negative, or zero-potential voltage across a load. This configuration is often used to drive motors, enabling forward, reverse, and off states for motor control.

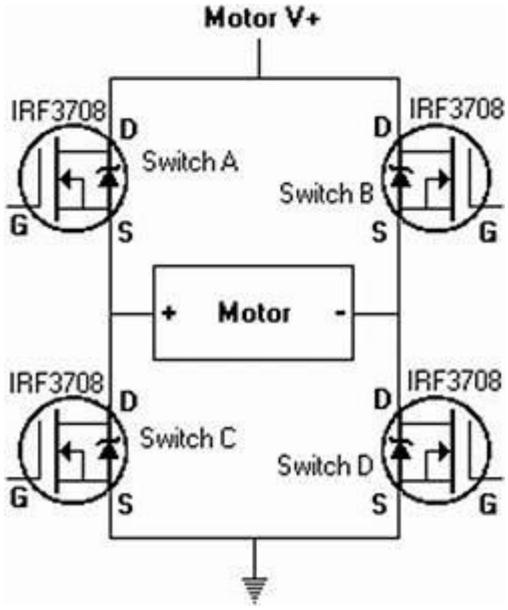


Figure 3:H-Bridge Configuration Using N-Channel MOSFETS

In Figure 3, the H-Bridge circuit is composed of four switches, each corresponding to a specific position: high side left, high side right, low side left, and low side right. These positions allow for four possible switch configurations to achieve different voltage outputs across the load. Table 1 outlines these positions.
It's important to note that all other switch configurations, not mentioned in Table 1, have been omitted deliberately. This omission is because those configurations could lead to a short circuit of power to ground, which might result in damage to the device or rapid depletion of the power supply.

2. Materials and Methods

This chapter provides an overview of the materials and methods employed in designing this project. While many of the components used in this solar-supported inverter system are like those found in electronic gadgets, their functions and designs differ. The following section briefly describes the materials to be used in this project.

Materials

This CMOS IC[15] integrates various functions, including an SPWM sinusoid generator, dead-timecontrol circuit, range divider, soft-start circuit, circuit protection features, RS232 serial communication, a 12832 serial LCD unit, and more.

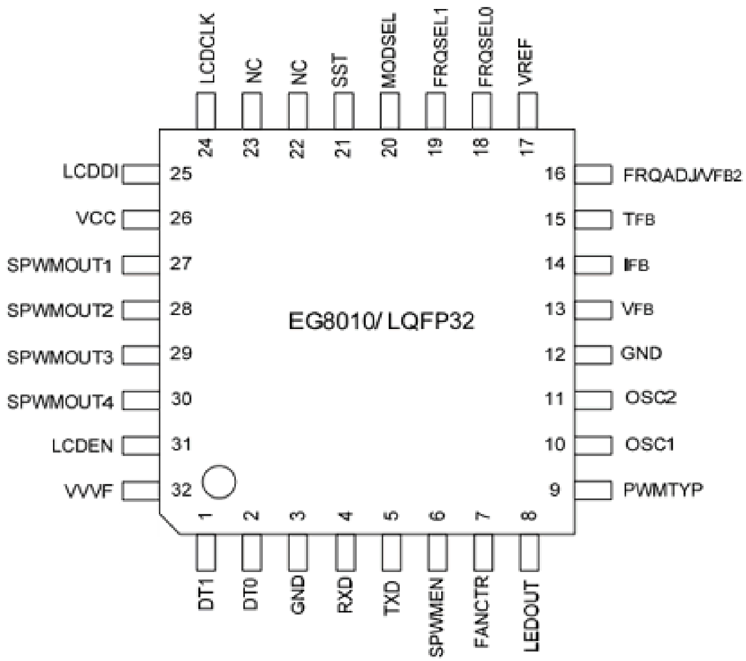


Figure 4: EG8010Pinout

This dual differential comparator accepts two voltage inputs for comparison and determines which one is greater, making it a valuable component for circuits that require decision-making based on input levels relative to a specified threshold. In this project, it is employed to compare and regulate the inverter's output voltage to maintain a consistent level.

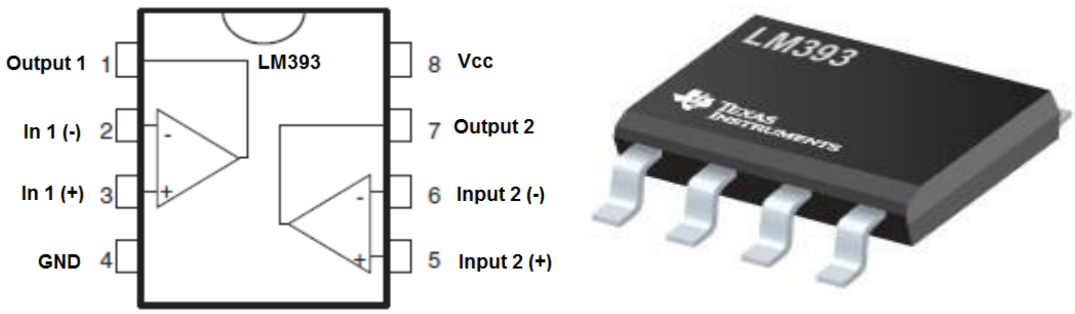


Figure 5:PinConfigurationofLM393

The Bipolar Junction Transistor (BJT)[16]is a semiconductor device composed of three doped semiconductor regions: Base, Collector, and Emitter, separated by two p-n junctions. It serves as both a switching and amplification component. The p-n junction between the Base and Emitter has a critical Barrier Voltage (V) of approximately 0.6V, a vital parameter for BJTs. There are two main types of BJTs: NPN and PNP transistors. The NPN type requires a base voltage greater than 0.6V (for silicon transistors) to turn ON, while the PNP type necessitates a base voltage lower than 0.6V.
In this project, BJT transistors are employed to control the cooling fan, enabling the regulation of the inverter's temperature. Figure 3.2.3 depicts the symbols for the two types of BJTs.

Metal Oxide Semiconductor Field Effect Transistor;

Metal Oxide Semiconductor Field Effect Transistor (MOSFET)is a three terminal device such as source, gate, and drain. It is widely used for switching and amplifying electronic signals in the electronic devices. The MOSFET[17] is a high voltage and the most common transistor and can be used in both analog and digital circuits. It has an extremely high input gate resistance with the current flowing through the channel between the source and drain being controlled by the gate voltage. The MOSFET is the main component of the H-bridge circuit used in this project for switching purposes. The circuit symbol of a MOSFET is as shown below.

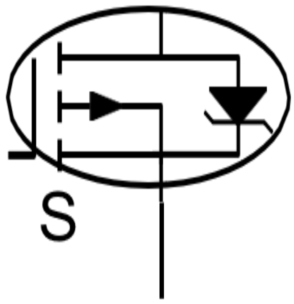


Figure 6:Symbol of a MOSFET.

Resistor

A resistor is a passive two-terminal electrical component[18] that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and other uses. Resistors are used in this project to limit the flow of electric current. Figure 11 shows the circuit symbol and picture of a fixed and variable resistor respectively.

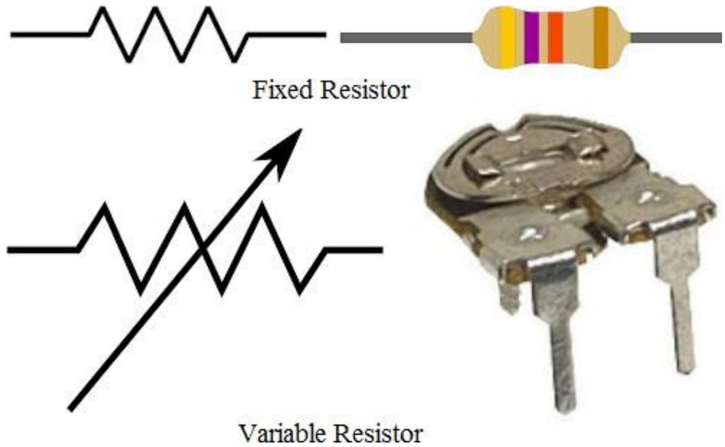


Figure 7:Symbols and Pictures of Resistors.

Capacitor

The Capacitor, sometimes referred to as a Condenser[19], is a basic passive device designed to "store electricity." It possesses the capacity to store energy in the form of an electrical charge, resulting in a potential difference (Static Voltage) across its plates, resembling a miniature rechargeable battery. Capacitors serve as filters and timing components in this project, determining the resonant frequency of the oscillator. Figure 3.2.6 illustrates an assortment of capacitor variations.

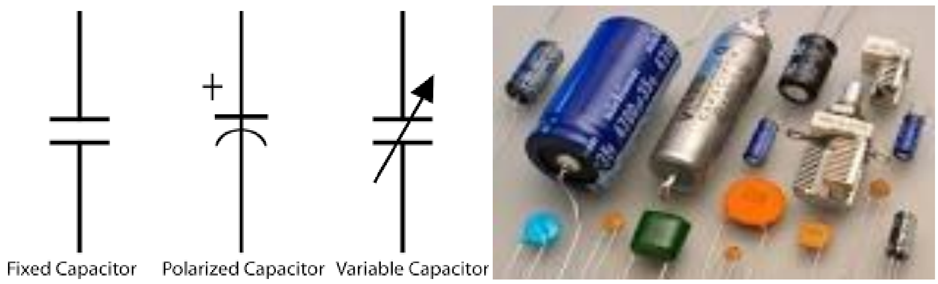


Figure 8:Symbols and Picture of capacitors.

Diodes

A diode is an electronic component[20] that permits the flow of current in only one direction, as long as it operates within a specified voltage range. It functions as a one-way valve within electronic and electrical circuits. In the reverse direction, a diode restricts current flow unless the reverse voltage surpasses a specific threshold, known as the reverse breakdown voltage.Diodes are used as rectifiers in this project. The symbol and picture of a diode is asshown.

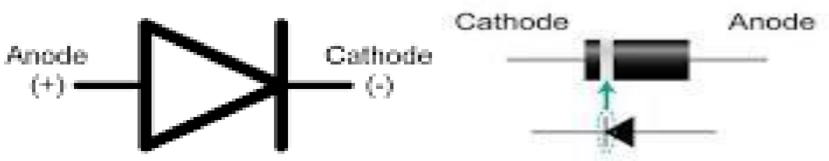


Figure 9:Symbol and picture of a diode.

Light Emitting Diode

A light-emitting diode (LED) is a semiconductor light source with two leads. It operates as a p–n junction diode that emits light when activated. When an appropriate voltage is applied to its leads, electrons recombine with electron holes inside the device, resulting in the release of energy in the form of photons. This phenomenon is known as electroluminescence, and the color of the emitted light corresponds to the energy band gap of the semiconductor material. In this project, yellow, green, and red LEDs are utilized as indicators. Figure 10 displays the symbol and images of a light-emitting diode.

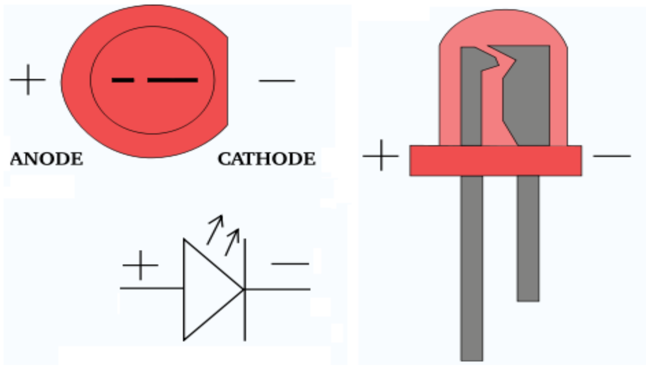


Figure 10:Symbol and picture of light emitting diode.

Photo-Sensitive Copper Clad Board:

Copper Clad Laminate Board, often abbreviated as CCLB, is a foundational material used in the production of Printed Circuit Boards (PCBs). It is made by laminating copper onto one or both sides of a reinforcing material, typically consisting of glass fiber or wood pulp paper, which has been impregnated with resin. In this project, the photosensitive variety of copper clad board is employed for PCB fabrication. Figure 15 provides a visual representation of a copper clad board.

Figure 11:Copper Clad Board.

Connectors

Electrical connector is any device for joining electrical circuits together (sometime known as ports, plugs, orinter faces).

Figure 12: Picture of a Connector.

ZenerDiode

A Zener diode is a silicon semiconductor device that permits current to flow in either a forward or reverse direction. The diode consists of a special, heavily doped p-n junction, designed to conduct in the reverse direction when a certain specified voltage is reached. The Zener diode has a well-defined reverse-breakdown voltage, at which it starts conducting current, and continues operating continuously in there verse-bias mode without getting damaged. Additionally, the voltage drop across the diode remains constant over a wide range of voltages, a feature that makes it suitable for use in voltage regulation. The symbol is shown below in Figure 13

Figure 13:Zener Diode

Relay

A Relay is an electrically operated switch. Many Relays use an electromagnet to mechanically operate a switch. Relays controls one electrical circuit by opening and closing contacts in another circuits. Relays are generally used to switch smaller currents in a control circuit. The picture is shown below in Figure 12.

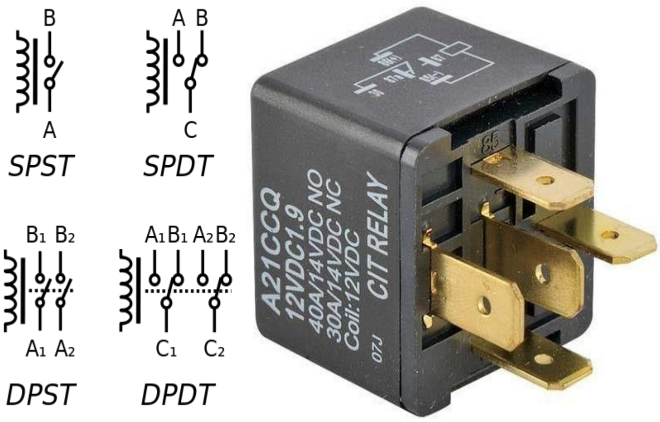


Figure14: Relay

LM2576HV

Is a step down buck voltage regulator .It is used in this project to step down the 48vdc battery output to 12vdc.

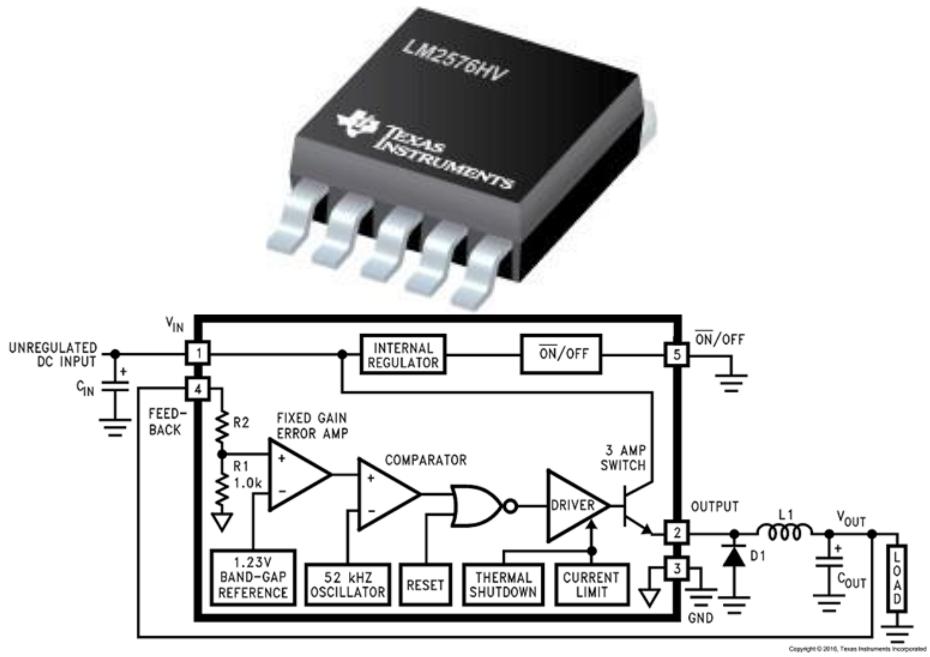


Figure15:LM2576HV

LM7805;

This is also a step-down voltage regulator. It is used in this project to step down the 12 v dc output of LM2576HV to5vdc.

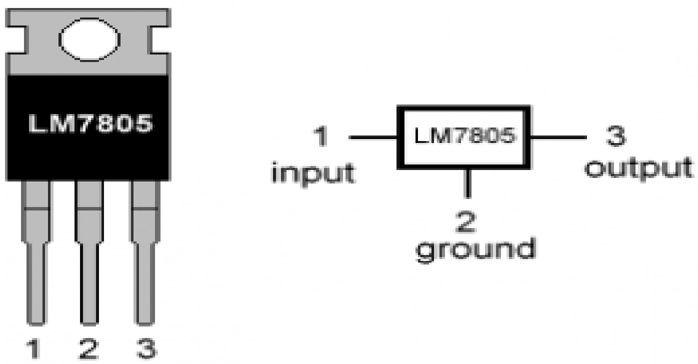
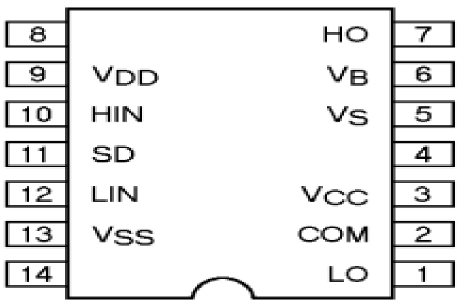


Figure 16:LM7805

IR2110

This is a gate driver IC. It is used in this project to drive the H-bridge transistors in the H bridge circuit.



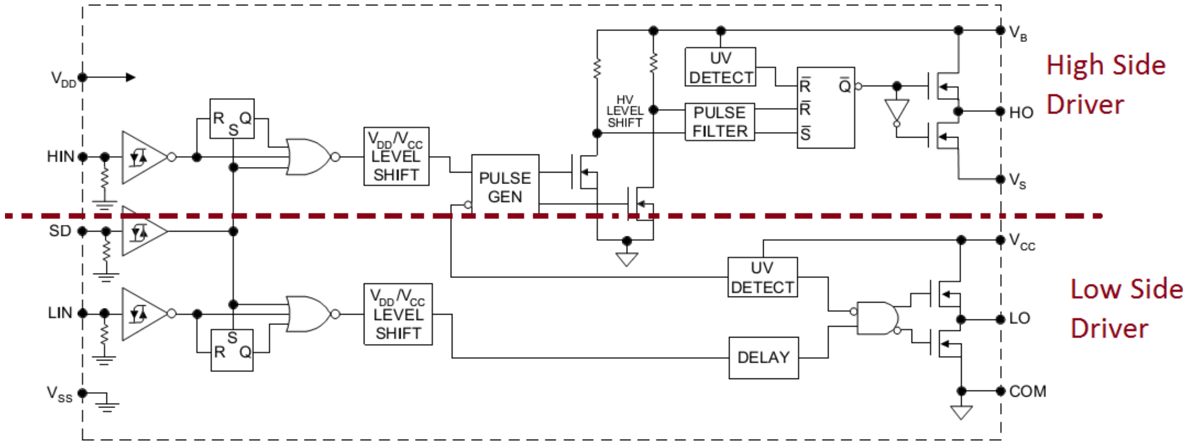


Figure 17:IR2110

Voltage Transformer:

This is a static device that transforms electricity from one voltage level to another without any direct electrical contact (that is through electromagnetic induction) and without change in frequency. A step-up transformer is used in this project to step up the 48vac inverted output to 220vac.

Figure 18: Voltage Transformer

DeepCycleLeadAcidBattery

A Lead Acid Battery is a secondary cell, meaning that it is rechargeable. Deep Cycle Lead Acid Battery is used in this project as an energy storage device and also supply the input voltage of48vneeded to power the inverter in the absence of utility power.

Figure 19:Deep Cycle Lead Acid Battery

DC Circuit Breaker

This is a dc electrical protective device. It is used in this project as a protective device between the battery and the inverter.

Figure 20:DC Circuit Breaker

AC Circuit Breaker

This is an ac electrical protective device. It is used in this project as a protective device between the inverter and the supply so that limited current can only be drawn from the inverter.

Figure 21:AC Circuit Breaker

Solar Panel

This contents photovoltaic cells that converts solar energy to electrical energy. It is used in this project to convert direct sunlight to electricity that is needed to chargethe48vbattery.

Figure22:Solar Panel

MetalCase;

The Metal Case is used in this project to package the inverter. It serves as a protective cover for the inverter circuits.

Figure23:MetalCase

Cables:

Cables are conductors that allow the passage of electric current through them. Various cables were used in this work.

Figure24:Cables

Fan

This is a cooling device. It is used in this project to regulate the temperature of the inverter.

Figure25:Fan

PV Frame

This is the aluminum material used in this project for mounting the solar panels on the roof.

Figure24:PVFrame

MC4 Connectors

This is the device used in this project for connecting the outputs of the solar panels together.

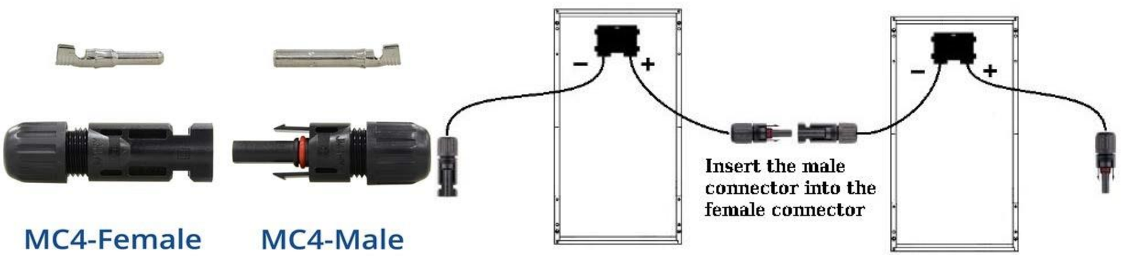


Figure 26:MC4Connectors

Battery Rack

This is a metal structure used in this project for storing battery packs.

Figure27:Battery Rack

Transfer Switch (Change Over Switch)

This is used in this project for selecting between the inverter output and the utility output.

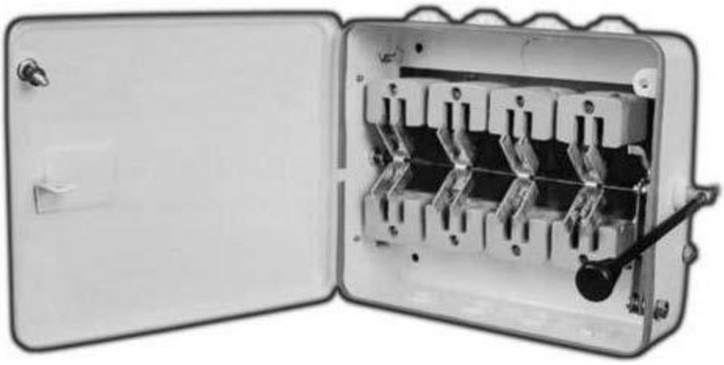


Figure 28:Transfer Switch

Panel Clamp

This is a clamping device used in this project for holding the solar panel to the frame.

Figure 29:PanelClamp

Methods

Inverters are built with specific maximum loading capacity. Proper load power estimation is necessary to decide which inverter rating is suitable for the department.

Load Estimation of the Department of EEE in Imo State University

This load forecast was done based on the present load need in the department. The building has six offices, one classroom and one simulation laboratory. Table. 2Below shows the estimated loads of the department.

Table2: Load estimation of the department of Electrical and Electronic Engineering in Imo State University.

Load description	**Number of Points**	**Power Rating(W)**	**Load(W)**
Ceiling Fan	10	120	1200
Lighting Points	22	60	1320
13ASocketOutle	12	300	1440
15ASocketOutle	4	1500	6000
Total			**9960**

After

System architecture

The architectural block diagram of the solar powered inverter system is shown in Figure 32 It consists of a variety of components integrated to form an inverter system.

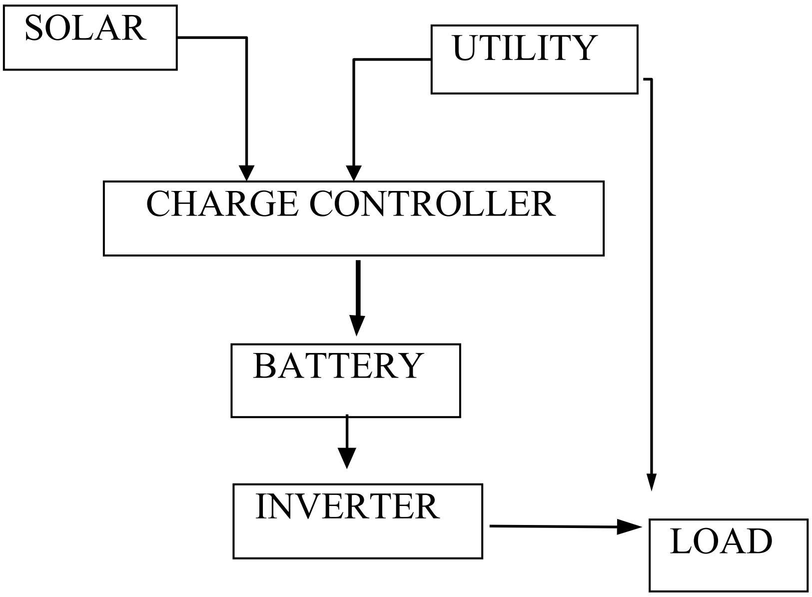


Figure 30: Architectural Block Diagram of the Inverter System with Charge Controller.

- **Solar**: This block defines the function of the solar panel. Here, the silicon cells of the solar panel convert the radiated solar energy directly to electricity. Charge Controller: This block defines the function of the charge controller. The charge controller is connected between the solar panel and the battery to regulate the charging of the battery. It has a switch and a sensor. The sensor dictates when the battery is fully charged and when the battery is discharged. Hence, when the battery is fully charged, it opens the switch so that current will not enter the battery and when the battery is discharged, it closes the switch so that current will enter the battery and get it recharged.
- **Battery**: The battery stores charged chemical energy which is converted to electrical energy. When the sun is down, the energy stored by the battery is used to power the inverter.
- **Inverter**: The inverter converts the direct current from the battery output into alternating current of the same frequency as that of the utility grid which is desirable and most suitable to power our electrical appliances.
- **Load**: This denotes the electrical appliances that consume the electrical energy produced from the output of the inverter.
- **Utility**: The energy from the utility grid can optionally also be used to charge the battery while supplying power to the appliances.

DESIGN AND IMPLIMENTATION

Inverter Design

This section presents a design of an inverter system whose specifications are as follows.

Single phase 10KVA output power,220V output, Sine-wave output, PV array input, Utility input.

Oscillator

From the system specifications, the objective of this project is to generate electric power with sine wave output. The EG8010 pulse width modulator integrated circuit is adopted as the main oscillatory component. By default, application, when a few discreet components are added to this integrated circuit(IC), a pure sinewave is generated. The Block and circuit diagrams are shown in Figure 31

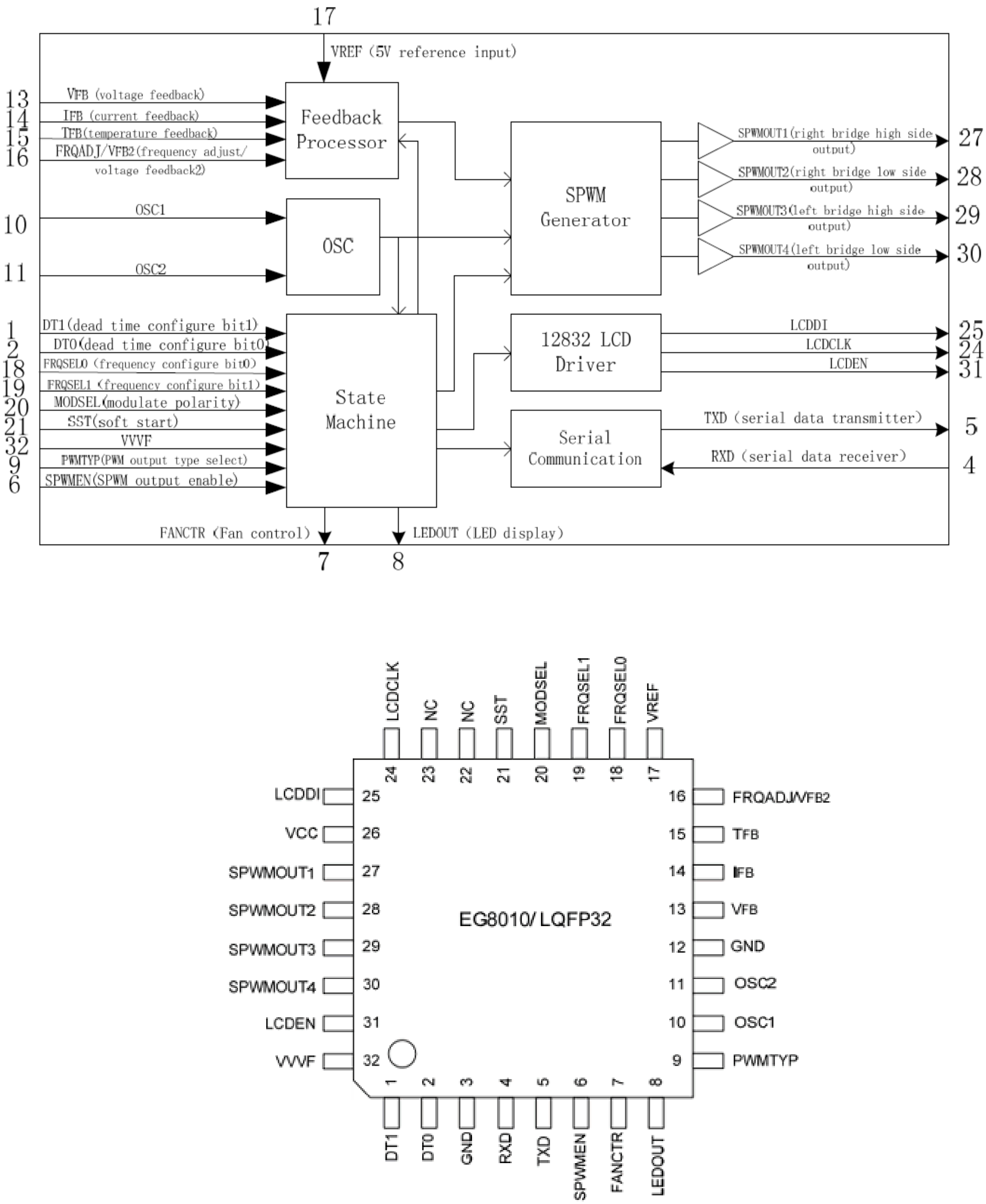


Figure 31: Block and circuit diagram of the Pulse Width Modulated IC

Drivers:

In this project work, the H bridge switching circuit is used. H bridge circuit contains MOSFETs. 2 MOSFETs are used as high side MOSFETs and the other 2 MOSFETs are used as low side MOSFETs. International rectifiers (IR2110) MOSFET drivers are used as high side and low side MOSFET driver. It has a floating circuit to handle two bootstrapoperations. IR2110 can withstand voltage up to 500v (offset voltage) and its output pins can provide peak current up to 2A. The circuit diagram is shown in Figure 32.

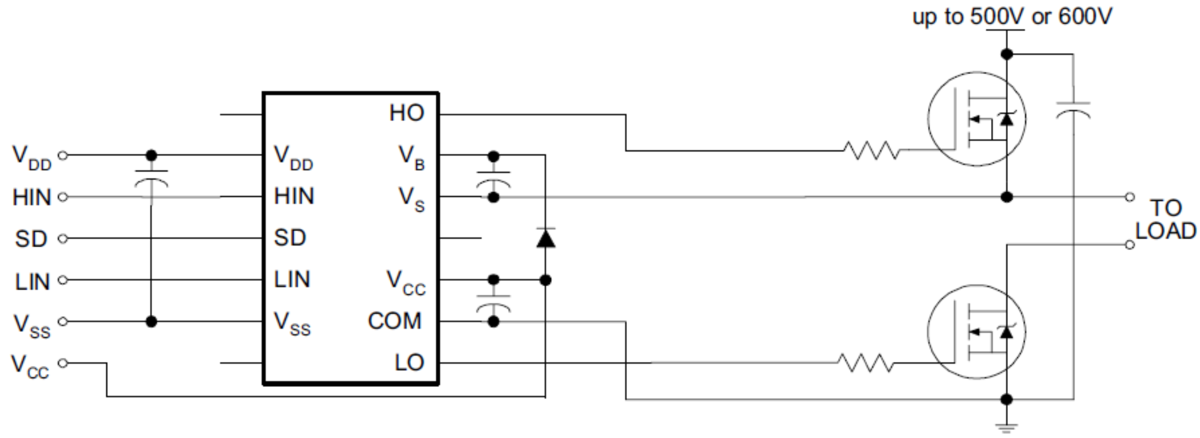


Figure32:MOSFET Driver connection diagram

Switches

Normally, the output from the oscillator is not enough to drive the loads. There is need to amplify the signal so that it can power the loads. In this regard, semi-conductor devices are often employed. Following the fact that MOSFETs require no or little current in order to switch on heavy loads, they are employed for switching purposes. The circuit diagram of the power switches is shown in Figure 33.

TT

Figure 33:Switching Circuit diagram.

Transformer Design

The size of the core of a transformer is related to its power handling capacity. This relationship is represented mathematically in the equation below.

C.A= $1.152\sqrt{V.A}$

Where C.A is the core-area and

V.A. is the power handling capacity (10KVA) C.A = $1.152\sqrt{10000}$

C.A = $115.2cm^2$

C.A = $0.01152m^2$

$$v = \frac{1}{4.44 * B * F * C.A}$$

B is Flux density (1.2tesla) f is frequency (50Hz) Where v is Turn per volts

$$v = \frac{1}{4.44 * 1.2 * 50 * 0.0115}$$

T=0.3V

i.e.0.3v=1

Primary windings

$V_P = 48v$

hence,

0.3v=1T

48v=48/0.3

Number of turns, N_p=160

Secondary windings

V_s=220v, $V_P = 48v$

$f = 160N$

Using transformer emf equation,

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

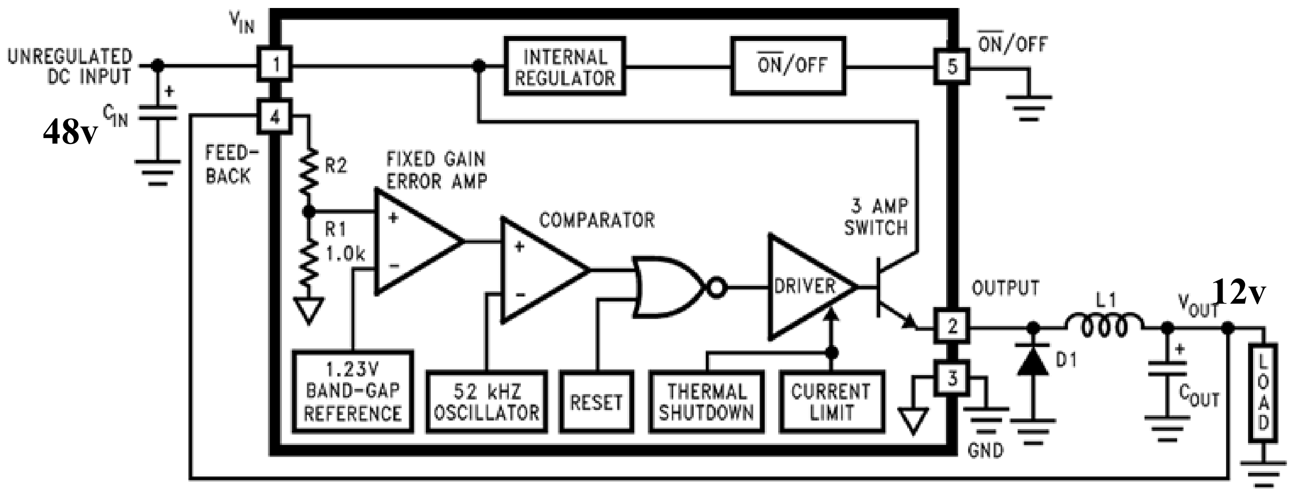
$$N_S = N_P \times \frac{V_S}{V_P}$$

Number of turns ,N_s=160220/48

N_s=733

Power Supply Unit

This converts DC battery voltage to low voltage regulated DC power for the internal components of the inverter. In this project, LM2576HV and LM7805 was used as power supply. The LM2576HV was used to step the 48v dc from the battery to 12v while the LM7805 was used to step down the 12v from LM2576HV output to 5v.



Their circuit diagrams are shown below in Figure 34.

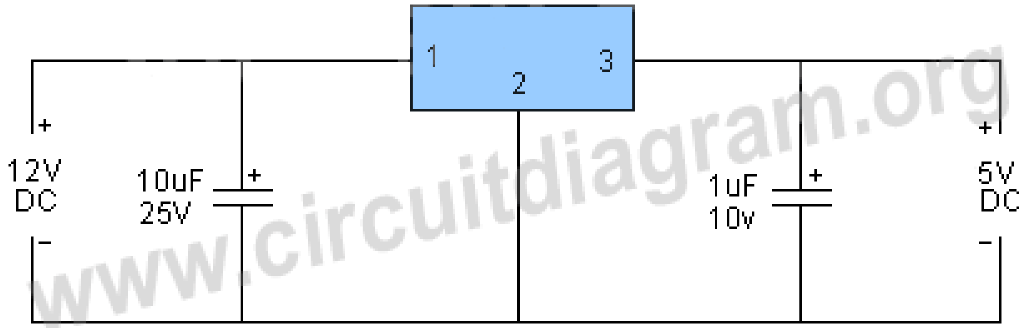
LM2576HV

From the datasheet,

To get33voutput,R2=1.7kToget5voutput,R2= 3.1kToget12voutput,R2=8.84k

To get 15v output,R2=11.3k

For adjust able version,R1 is open and R2=0

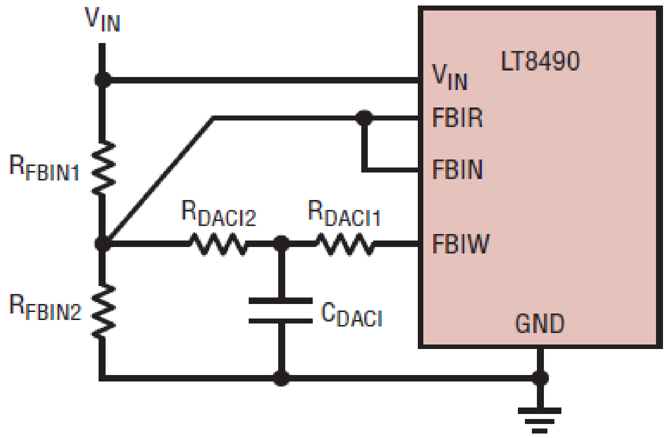


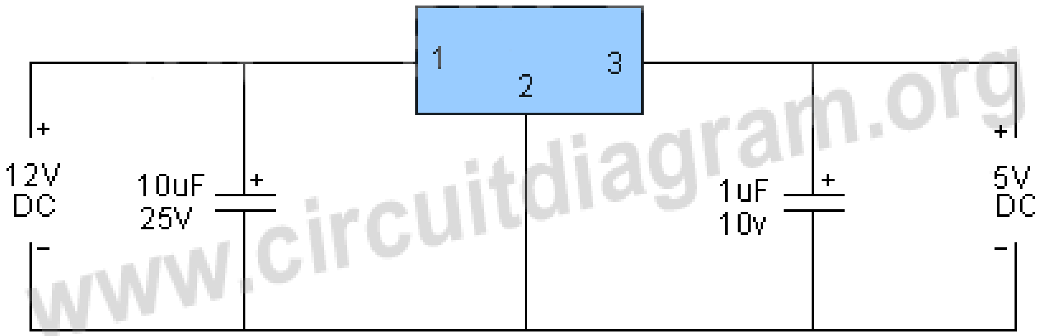
LM7805IC

Figure38:Power Supply Unit circuit diagrams

The Charge Controller

The charge controller in this context prevents the battery from being over charged. The circuit diagram of the charge controller is shown in Figure.39





LM7805IC

Figure38:Power Supply Unit circuit diagrams

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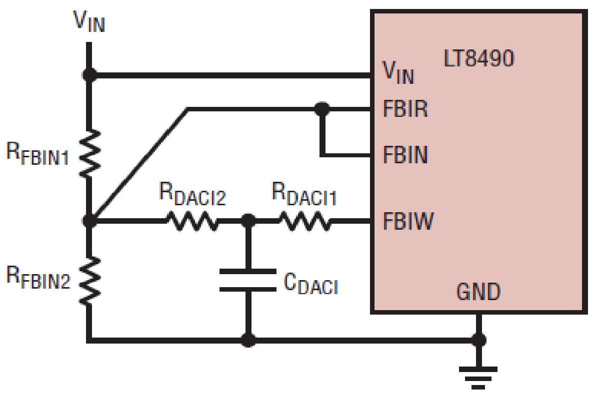


The resistors can be calculated from the formula below:

$$R_{FBIN1} = 100\left[\frac{1+\left(\frac{4.470V}{V_{MAX}-6V}\right)}{1+\left(\frac{5.593}{V_{MAX}-6V}\right)}\right]OHMS \quad , R_{DAC12} = 2.75\left(\frac{R_{FBIN1}}{V_{MAX}-8V}\right)OHMS \quad ,$$

$$R_{DACI1} = 0.2(R_{DACI2})OHMS$$

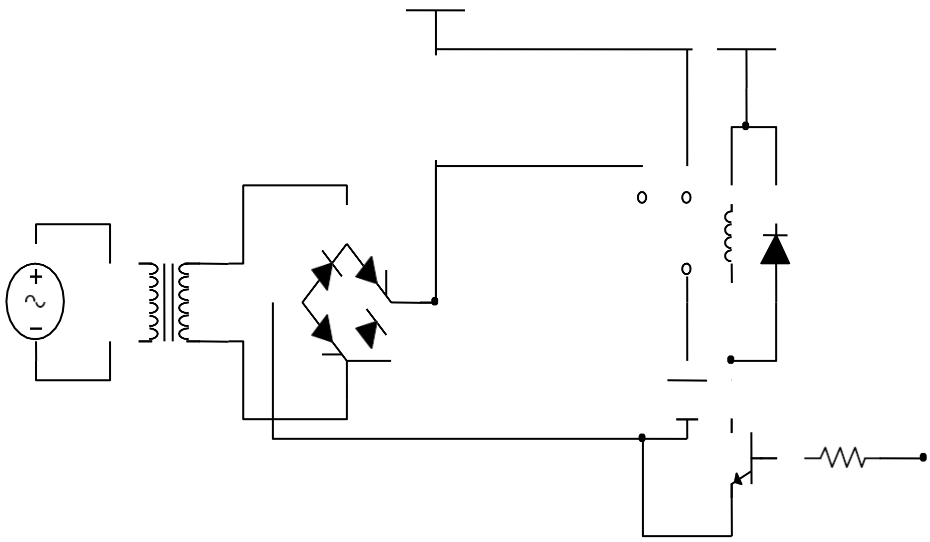
$$C_{DACI} = \frac{1}{1000\left(R_{DACI2}\right)}F$$ Applying the formula above with V_{MAX} = 48v:

R_{FBIN1}=98KΩ ,R_{DACI2} = 6KΩR_{FBIN2} = 3KΩR_{DACI1} = 1KΩC_{DACI}=1µF

The system is designed in a way that it can charge the battery from a solar system or from the utility supply. See the circuit diagram below:

Photovoltaic Cells

VCC



2
AC
4 1
Input3100kΩ
From
Battery Charge Monitor

Figure40:Charge Controller circuit diagram

The Monitors

The voltage of the battery is constantly monitored to determine when it is low orwhen it is charged. When the battery is low, the monitor shuts down the inverter. When the battery is charged, the battery is disconnected from the supply to prevent it from being over charged.

Also the AC input is monitored to know when there is power. When there is power,the monitor shuts down the inverter and begins to charge the battery. The circuit diagrams of the three monitors mentioned above are shown in Figure 41 below.

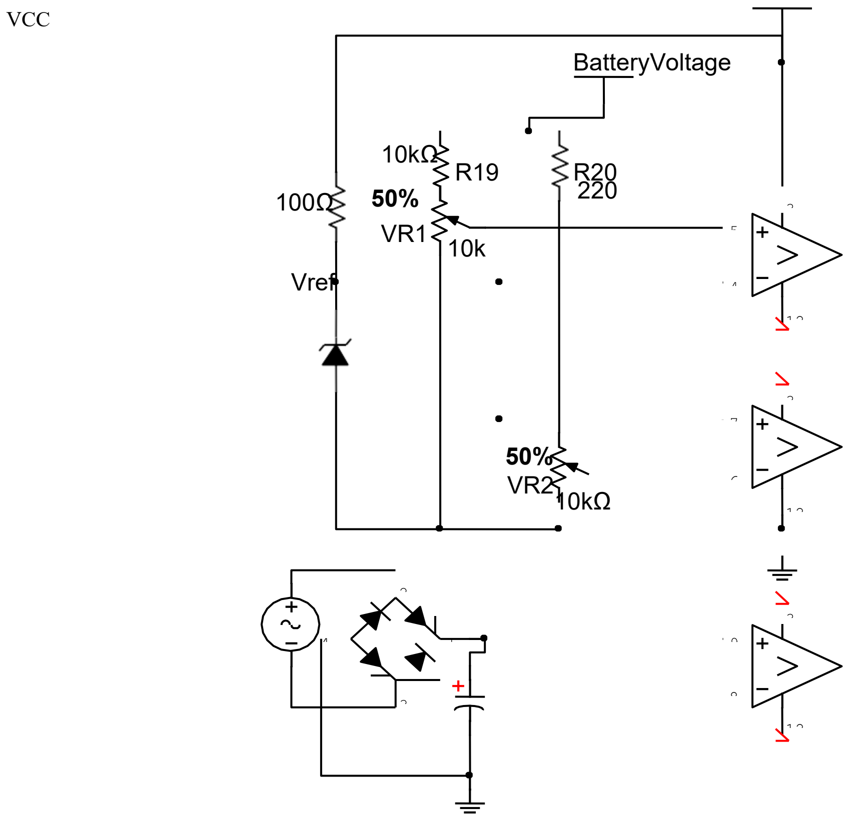


Figure 42:TheMonitors

System Construction

Construction in this context has to do with the transformation of the design into a working/functional device. For the sake of durability and reliability, the system was constructed using a Printed Circuit Board (PCB). A Printed Circuit Board (PCB) is used mechanically to support and electrically to connect electronic components using conductive pathways to achieve a desired aim/objective. Printed Circuit Board can be done with ordinary copper clad board through direct transfer from a mesh done by an artist. It can also be done with a photo-resist board with the use of the UV Exposure unit for photo transfer. We used special PCB software:(PC Bartist by Advanced Circuit to be specific) for the production of the artwork. The PCB used in this work was made using the pre-sensitized copper clad board. Below are the steps involved in making the Printed Circuit Board(PCB

Artwork Production

To make a Printed Circuit Board (PCB), there must be a circuit that is ready to be implemented. After we successfully designed the device (developed a circuit); the first step under taken was to draw the schematic diagram of the system in the schematic window of the PCB Artist. After this, the schematic diagram was transferred to the PCB window and the desired connection was routed. After routing the desired connection tracks, the layout was printed out on a laser film using a laser-jet printer. When printed out, the hardcopy is called the artwork.

Photo Transfer

The tracks on the artwork were transferred to the photosensitive copper clad board with the help of the UV exposure unit.

Development

After the transfer process, a weak solution of Sodium Hydroxide (NaOH) was used to develop the board so that the track scan be visible.

Etching

Etching is the process whereby metals are removed from a substance. Since we are talking about copper, we are confining this discussion to the removal of unwanted copper. That is to say that etching is the slight opposite of plating (plating is a process whereby metals are used to cover other substance(s)). We used a strong solution of Ferric Chloride($FeCl_3$)as the etching chemical(etchant).It took about 12minutes for the board to be completely etched. It should be noted that: The greater the concentration of the solution, the faster the rate of etching. When the power of the etching solution gets reduced ,its color changes from the normal brown color to dull green. Agitation by shaking the solution gently increases the rate of the etching process.

Drilling:

The drilling process was done with the help of a drilling machine, to create holes on the etched board where the electronic components are to be placed.

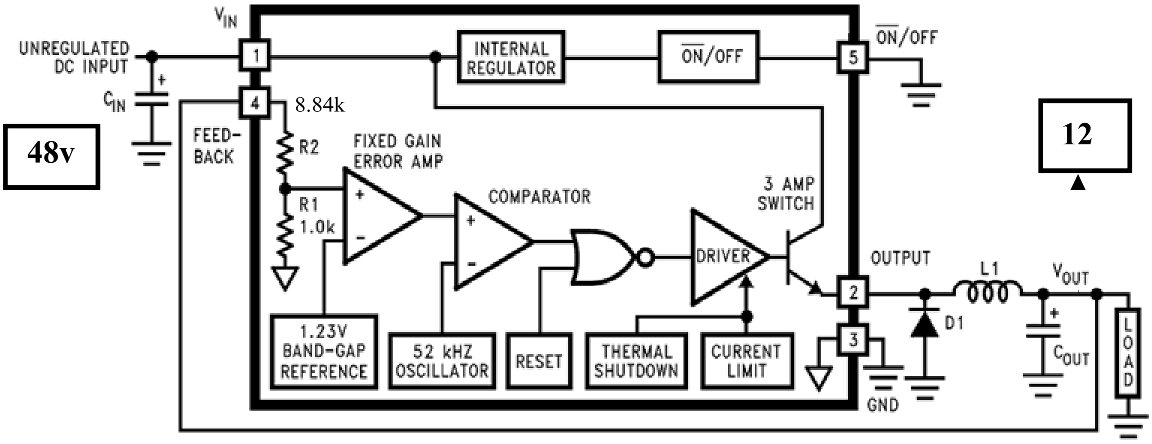
Placing of Components on PCB and Soldering:

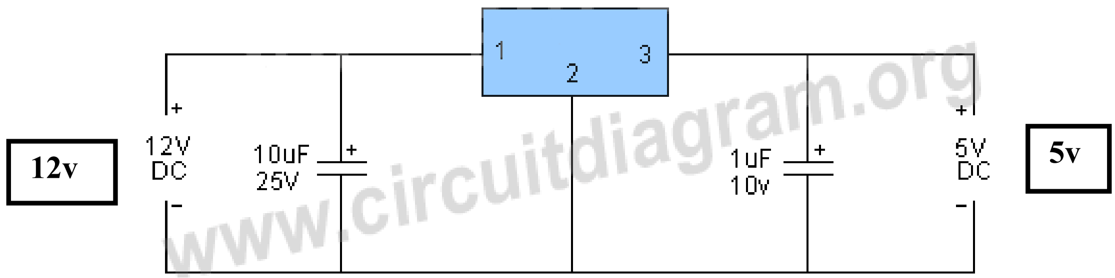
Electrically, soldering is the process by which electronic components are connected together .Soldering was done with a30watts soldering iron, to prevent the electronic components from being heated up and possibly damaged. An alloy of Lead and Tin in the ratio of 60/40 (for good flow) was used. This is the last process in the production of a printed circuit board. The precautions in the construction of the device are listed below: The designed art work was checked to see if it actually corresponded with the schematic diagram of the design before printing the work out on a laser film.The board was washed with plenty of water after the etching processes to prevent further reaction on the board by the solutions.All the components were confirmed to have been firmly and neatly soldered to prevent the formation of dry joint and partial contact.

System Integration

The entire system of the description gives rise to solar supported inverter system with charge controller. This section discusses the integration and implementation of the major blocks to actualize this project. It also involves testing the system and the results of the testing. This 10KVA solar supported inverter with charge controller system comprises of the following devices;Inverter, Solar panels or Photo-voltaic Modules, Batteries

The circuit diagram below shows the integration of inverter system.





System Implementation

The implementation process started with the inverter. The inverter sessions are the oscillator and driver circuit, the power switching circuit, the transformer, the power supply unit, charge controller circuit and the monitor circuit.

Inverter Implementation

The components for each of the sessions of the inverter were specified in their circuit diagrams. After the PCB implementation on a copper clad board, the components with their required ratings were rightly placed on the printed circuit board (PCB) and soldered. The oscillator, power supply unit, monitors and charge controller components were brought together and implemented on a PCB. The picture below shows the implementation.

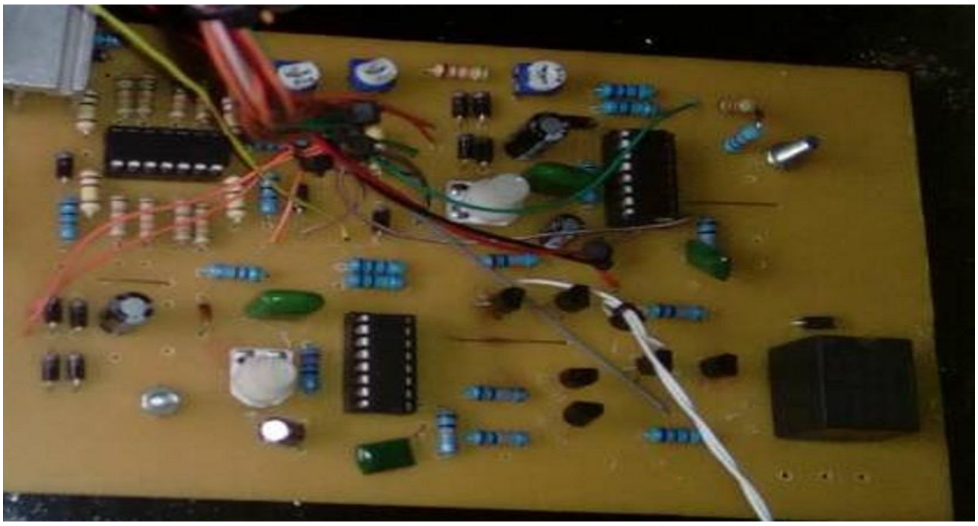


Figure44:Oscillator ,power supply unit ,monitors and charge controller

MOSFET and other components of power switching circuit were brought together and implemented on a PCB.

Figure 45:Power Switching Circuit Implementation.

The primary coil of gauge 10AWG and secondary coil of gauge 15AWG were brought and wound on a former. The diagram is shown below;

.x

Figure46:Transformer Implementation.

Two cooling fans were also provided to suck away the heat dissipated by the components, thereby maintaining a cool temperature. The diagram of the cooling fans is shown below;

Figure47:Cooling Fans Implementation.

All the inverter circuits were integrated and coupled into an inverter casingwithdimensionof15×17×12inchesasshownbelow;

Figure48:Inverter Implementation.

Solar Panels or Photo-Voltaic Modules Implementation

The solar panels are connected together in series to give a maximum output. We chose Mono-crystalline amorphous silicon photovoltaic module. This type generates a higher voltage with less sun shine than the polycrystalline type. It is also more effective n and more durable than polycrystalline type. And also we made sure that the solar panel was facing the south.

Battery Implementation

Deep cycle lead-acid battery was used in the implementation. This is more preferable because it maintained the maximum efficiency. They are 12V output connected in series of eight (8) to give out96V.

Figure49:Battery Implementation.

Installation

Finally, the solar panel is mounted on the house roof with the photo voltaic surfaces facing the longitude. Inverter is connected to the solar panel and the batteries to form a solar system. The output of the system is connected to the department to power the loads.

Testing and Results

The testing was done at the completion of each session after a prior test of all the individual components. Then the entire installation was tested by loading the inverter system with some appliances like bulbs, printers, fans, laptops etc. The steps and results are tabulated below:

Testing of Photovoltaic Modules

Each of the solar panels was tested with digital multi-meter under sun hours to determine if the rating is complete. The value of the ratings was also recorded.

Testing of Deep Cycle Lead Acid Battery

The batteries also were brought together and tested with digital multi-meter under room temperature to as certain the output.The output value of each of them was recorded. The picture is shown below.

Figure50:Battery Testing

Testing of the Inverter

The solar panel and the Battery were connected to the battery and the output of the inverter was also read with a multi-meter. The output of the inverter was recorded.Then the entire installation was tested by loading the inverter system with some appliances like bulbs, printers, fans, laptops etc. The steps and results are tabulated below:

Table 2: Tests and Results

TEST	RESULTS	
	OUTPUTVOLTAGE	OUTPUTCURRENT
Solar Panels	155.81	11.1
Batteries	56.5	200
Inverter	220	42.53

Discussion

In the inverter circuit, when Vcc of 48V is applied, the regulator will regulate it to 12v and5v which is sent to the EG8010 board. The EG8010 now controls the IR2110 Drivers that drives the switching circuit in order to convert the dc voltage to ac. The ac voltage is then fed to the primary coil of the transformer, which is induced on the secondary coil and transformed to 220V,ready to be used.

CHAPTERFIVE RECOMMENDATION AND CONCLUSION

S/N	ITEM	QUANTITY	UNITPRICE(₦)	COST(₦)
1	Step-up Transformer	1	82,000	82,000
2	Presensitized Copper Clad Board	3	5400	16200
3	Resistors	26	10	260
4	Capacitors	18	50	900
5	Diodes	15	20	300
6	Power Connectors	8	1600	12800
7	Cooling Fans	2	1500	3000
8	Heat sink	3	800	2400
9	Integrated Circuits	3	400	1200
10	IntegratedCircuitsSockets	3	50	150
11	100ADCCircuit Breaker	1	4600	4600
12	DCvoltmeterModule	1	3200	3200
13	ACvoltmeter Module	1	3500	3500
14	(15x17x12)"MetalCase	1	14500	14500
15	Switch	1	100	100
16	Metal Oxide Semiconductor Field Effect Transistor	8	2200	17600
17	Bipolar Junction Transistor	6	100	600

18	LightEmittingDiode	3	20	60
19	1Litreof Strong Solution of Ferric Chloride	1	2100	2100
20	1LitreofWeakSolutionof Sodium Hydroxide	1	2100	2100
21	Cables	1	8000	8000
22	Battery Bank	8	100000	800000
23	Photo voltaic Array	8	50000	400000
24	Battery Connectors			
25	Cable Logs			
	Total			**1375570**

CONCLUSION

Due to unstable power supply in Nigeria, The 10kva pure sine wave inverter with charge controller is highly recommended for household use , industrial use and other facilities that are in of power supply. it is efficient, reliable and economical as the inverters are charged using solar and little of external power supply ie (generator). In conclusion, we have been able to design an efficient device which is highly useful.

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