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Design and Construction of 1 KVA Power Inverter System

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Authors' contributions

This work was carried out in collaboration between all authors. Author AEA designed and simulated the circuit and wrote the first draft of the manuscript. Author MO. Ogbuatu, MO. Oluwe and BOE did the implementation and performance evaluation. Author KE proof read the draft and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The inverter system is a device that converts the Direct Current (DC) from a battery to an Alternating Current (AC) which can be used for appliances. It does not only convert the current but also steps the voltage of the battery up to the required value. The inverter system does not require fuel to make it function, that makes it cheap.
The circuit has seven (7) embedded circuits in it; namely the oscillator circuit, which comprises the 4047 Oscillator Integrated Circuit (IC), It converts the DC current signal to AC signal at the same frequency.
The current modification circuit, this comprises the switching transistors and the cascaded MOSFETs, which modifies the current to the desired input to the step up transformer which steps it up to the required voltage and current. The battery low circuit indicates when the inverter battery is low, while the battery full circuit indicates when the inverter battery is full. The change over circuit changes the source from AC main to battery automatically. The rectifying circuit charges the battery and lastly the inverter on circuit: this indicates when the inverter is on.
The inverter system also has the battery full indicator, which helps to safe – guard the life of the

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battery while charging and it automatically switches of charging mode once the battery is full. The inverter system has timer for delaying the incoming current surge to protect the inverter from the large surge current and increase the working life of the inverter. The inverter was tested and the result obtained showed that it was able to bear the load up to 870 VA.

Keywords: Inverter; direct current; alternating current; step up transformer; MOSFET; oscillator IC.

1. INTRODUCTION

1.1 Background

Power stability has been one of the major problems of Nigerian technological growth. The solution to power instability in Nigeria has been a major problem for Nigerian government. Other neighboring African nations also suffer the same problem. This has popped lots of thoughts to the minds African Electrical Engineers.

Following the intermittent electric power failure, the need for stable power supply to equipment such as computer, TV sets, theatre equipment in the hospitals and a host of others led to the development of the inverter systems with a different design based on the technology employed. The inverter is a means through which an Alternating Current (AC) is produced from a Direct Current (DC) power of a desired output voltage, current and frequency [1].

Thus an inverter compensates for the possibility of power failure. Frequent public power outages have led to the massive use of generators with its negative consequences which include; noise, fire outbreak and environmental pollution [2].

Inverters overcome these draw backs as it does not require fuelling, cheaper and environmentally friendly.

The output frequency for this design is 50Hz, and a peak voltage of 240 V is in agreement with the national standard. Its driving circuit incorporates Bipolar Junction Transistor (BJT) as the main switching component. In this case, BJTs were chosen as the high power output device due to their excellent power handling capability, fast switching action, high voltage and high current rating with low heat dissipation.

2. LITERATURE REVIEW

In the world today, there are currently two forms of electrical transmission, Direct Current (DC) and Alternating Current (AC), each with its own advantages and disadvantages. DC power is simply the application of a steady constant voltage across a circuit resulting in a constant current. A battery is the most common source of DC transmission as current flows from one end of a circuit to the other. Alternating current, unlike DC, oscillates between two voltage values at a specified frequency, and its ever changing current and voltage make it easy to step up or down the voltage. For high voltage and long distance transmission situations, all that is needed to step up or down the voltage is a transformer. AC current is more viable but less available. Conversion of DC current to AC is done by a device called INVERTER.

A lot of engineers had earlier conceptualized what they felt inverter system should look like. The incessant power outage in Nigeria has prompted the engineers to improve the inverter power system and this project is not an exception. The power system is a very paramount constituent of technological growth. A constant supply of power improves productivity of factories and companies. Computer rooms, as well as domestic homes, require continuous supply of electricity. All this has prompted the urgency to improve on the properties of the inverter power system in quality, durability, maintainability and capacity.

2.1 Review of Past Projects

The inverter system usually has different parts, with some parts compulsory and others necessary. Amongst these parts are the transistors for switching, the transformer and 555 Timer IC as an oscillator has been the basic constituent of power inverter system. According to [3], oscillator is a device that will accept direct input and give oscillating output. In this case, it takes direct current to give an oscillating current. This oscillating current is not a perfect sine wave current, so there is a need for current modification and filtering to achieve the sine wave as required for an oscillating current. Transistors are basically used for the current modification and in-combination with resistors for filtering to achieve the sine wave. This output is stepped up by a transformer of certain power rating. The power rating of this transformer gives is the power rating of the inverter system. The inverter system requires a battery to function. The Direct Current (DC) is obtained from a DC battery supply. The current rating of this DC battery must be of a high rating so as to carry the power required by the inverter. The battery supply is 12 V DC. Combination of any type of DC battery to achieve the 12V cannot be used because of current rating. Usually, a Lead Acid Accumulator battery or a dry cell battery of required current rating is used for the battery. When this battery is low, there will be a need for the battery to be charged. The charger is a rectifier and a step-down transformer. The rectifier converts the AC current to a DC current. The bank of transistors is used for current modification for the step up transformer input. The step up transformer has the secondary winding that is a couple of the primary winding in a number of turns, depending on the output voltage required and the current rating for which it is meant for. The core Area of the transformer is calculated based on the power rating to be achieved as well. The wire for the primary winding is made very thick so as to carry the power and bear the heat coming from the transistors. The wire to be used for the secondary winding is dependent on the type of load for which it is meant. For house hold appliances, a 2.5 mm laminated cable is used for the secondary winding. The inverter is commonly known as Uninterrupted Power Supply (UPS). Usually, heat sink is used to cool down the transistors. The heat sink is not sufficient to cool the transistors, so a DC fan can be incorporated to the circuit for better heat management.

2.2 Review Modification

The inverter works as enumerated above, but radiates lots of heat. In this project, IRF 150 MOSFET has been incorporated in place of the transistor which radiates less heat. Furthermore, the IRF 150 MOSFETs gives room for expansion.

Battery level indicator is also incorporated to show when the battery is low and when the batter is full.

In the circuit for battery full and battery low is the comparator. A comparator is a device that takes two inputs and gives output after comparing the two inputs [4].

The output is in form of the input of the either the inverting or the non-inverting, depending on what it is meant for. If the inverting input is higher than the non-inverting input, the output will be high after comparing the two, but if the inverting is less than the non-inverting, the output will be the reference value of the non-inverting. In this case, the reference value is the voltage supply, when the voltage at the inverting is less than the non-inverting, the output will be the input voltage. This is used to indicate battery low and battery full with the aid of a voltage fixing diode (zener diode). The room for future expansion is good for any electrical project. To supply 1kVA, a combination of six MOSFETs in cascade can serve the purpose, but for this project, there is an allowance in the number of MOSFETs used. Fourteen MOSFETs are incorporated in the design, these can supply five (5) times of 1 kVA, that is, it can supply up to 5 kVA with an increase in the number of battery to be used. It can go as far as supplying five (5) times the power that is used for in this project.

The power source switching has been made automatic by 555 timer IC which controls the switching from AC main and battery supply. The 555 timer IC is an integrated circuit that can function in either monostable or astable mode [5,6]. In the astable mode, the 555 timer can be used as a timer; it engages and dis-engages at certain time controlled by its clock. This timing is to delay the supply by some microseconds before the power comes up. The delay is to prevent transient current from the circuit. Transient current are the surge current which is higher than the normal current [7]. Surge current can damage electrical appliances. This surge current is imminent when the power is just supplied. With the combination of the timer and the capacitor, the surge will not have an influence on the appliances. The capacitor absorbs the surge and the delay does the function of delaying the time and allows every surge to be absorbed before the circuit is engaged with power. This will make the inverter safe to use.

In the inverter is also the charging circuit. When the battery goes down in voltage, the inverter will definitely go off. Then there will need to charge the battery and this has been incorporated in the inverter. The inverter battery charging circuit contains basically the step-down transformer and the rectifier.

The step-down transformer steps down the voltage from the mains to the required voltage needed to charge the battery. In this case, it will step down from 220V/AC to 15V/AC before the voltage is rectified. In the charging circuit, the voltage regulator maintains the amount of voltage coming out of the charging circuit to the required voltage. To show the voltage output of the inverter, a meter indicator is used, this increases the viability of the inverter as it tells the user when the battery is going low even before the indicator indicates that the battery is low.

3. METHODOLOGY

3.1 Transformer Design

3.1.1 1kVA step-up transformer

Starting with the 1kVA step-up transformer

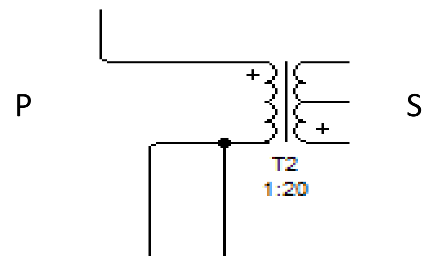

Fig. 1. KVA step-up transformer

P= transformer primary side (1)

S= transformer secondary side (2)

The transformer primary voltage = 12 volts

The transformer secondary voltage = 220 volts

$$\text{The transformer primary current } = \frac{1000 \text{ watts (power)}}{12 \text{ (volts)}} \quad (3)$$
$$= 83.3 \text{ Ampere}$$

$$\text{The transformer secondary current } = \frac{1000 \text{ watts (power)}}{220 \text{ volts(secondary voltage}} \quad (4)$$
$$= 4.5 \text{ Ampere}$$

The operating frequency = 50 Hz

3.1.2 Design of amplifying and current distribution circuit

IRF 150 (cascaded MOSFETs)

The IRF 150 is a metal oxide semiconductor with voltage divider combination of resistor at the gate [8].
From the data sheet, it has on-state resistance of 0.05X and a drain current of 38A.

$$\text{Power} = (38)^2 \times 0.055 \text{ watts} \quad (5)$$
$$= 1444 \times 0.055 \text{ watts}$$
$$= 79.42 \text{ watts}$$

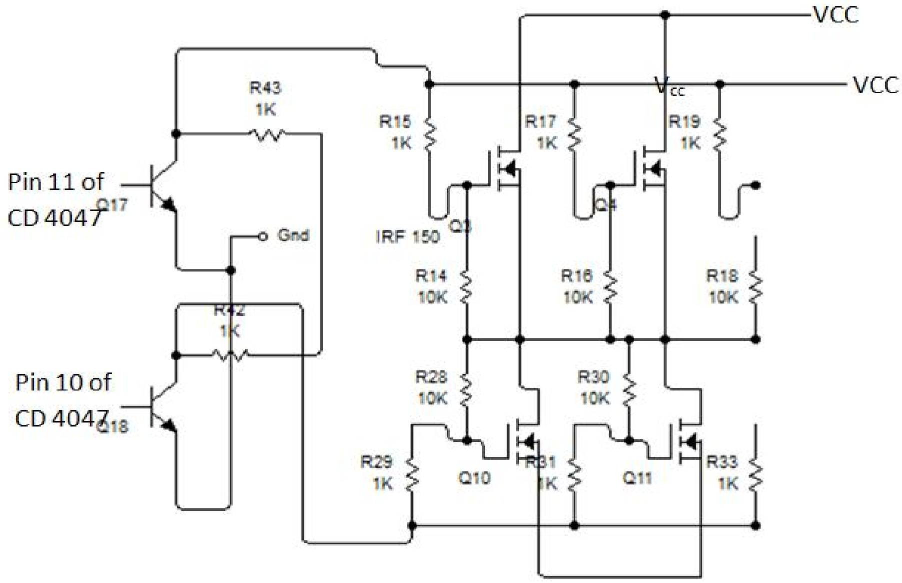

Fig. 2. Switching and a section of the current modification circuit

Now, using IRF 150 MOSFET (cascaded) for the power transmission and current modification,

$$\frac{1000\,watts}{79.42watts} = \text{number of IRF 150 MOSFETS required for the cascade} \quad (6)$$
$$=12.5912$$

14 MOSFETS will be used for even power distribution.

The IRF 150 from the data sheet has;

Capacitance of 1.1pF, Charge(Q) of 125nC

To obtain the rise time of the pulse

Frequency = 50Hz

BDX53 Transistor(Q17 and Q18) has been selected for switching

The transistor Q1 and Q2 can be used as a switch by driving them to saturation.

$$I_C = I_{CE} \quad (7)$$

To obtain the suitable current for the cascaded MOSFET, I have chosen 220X resistor for R_3 and R_4 so that,

$$\frac{\mathrm{Vcc}}{\mathrm{R3}}=13 \quad (8)$$
$$\frac{12}{220} = 0.06\mathrm{Amp}$$

To obtain the current rating for each MOSFET,

$$\text{the pusle period} = \frac{1}{\text{frequency}} = \frac{1}{50} = 0.02 \text{ seconds} \quad (9)$$

Pulse period = 20 msec

$$\text{the rise time} = \frac{20\text{msec}}{2} = 10\text{msec}$$

$$\text{the MOSFET gate current} = \frac{\text{CV}}{\text{t}} \tag{10}$$

C= capacitance (Farad), V= voltage (volts), t = time (seconds)

$\text{IG} = 1.1\text{pF x } \frac{12}{10}$msec

IG= 1.32 x 10^{-6} = 1.32µAmpere

For seven MOSFETS,
=1.32µA x 7
= 0.0092m

Ampere (the required current to drive the entire MOSFETS).

3.1.3 Design of the battery low circuit

From the circuit above, the diode D7 (IN4733A) is a zener diode used as a voltage regulator to fix a 5.1V voltage at the positive input of the operational amplifier(LM358N1) (non-inverting input). 470Ω resistor will be used as R_4, 49 mA is maximum input current from the op-Amp (LM358N) data sheet.

$$\frac{12\text{v}}{470} = 0.025319\text{Amp}$$

=25.5319mA

Any value other than 470Ω can be used but for the sake of allowance, we have chosen 470Ω

The voltage divider combination has been done to divide the supply voltage into fractions which will then be compared with the fixed voltage, which is the 5.1 volts.

10 kΩ has been chosen for R2 and R 3. They are just to divide voltage any equal combination of resistors could have divided the voltage.

So, inverting input

$$\text{The} V- = \left(\frac{10\text{k}\Omega}{(10\text{k}\Omega + 10\text{k}\Omega)}\right) \text{Vsupply} \tag{11}$$

Vsupply is the voltage from the battery.

V+ = 5.1 volts (fixed by zener diode (IN4733A)

When the supply voltage (battery voltage) is 14 volts (fully charged)

$$V- = \left(\frac{10\text{k}\Omega}{10\text{k}\Omega + 10\text{k}\Omega}\right) 14\text{volts} \tag{12}$$

$$= \left(\frac{1}{2}\right) 14 \text{ volts}$$

= 7 volts

V+ = 5.1 volts

V- > V+, the output voltage of the Op Amp is low no current drives through the external circuit.

When the supply voltage (battery voltage) is 11 volts,

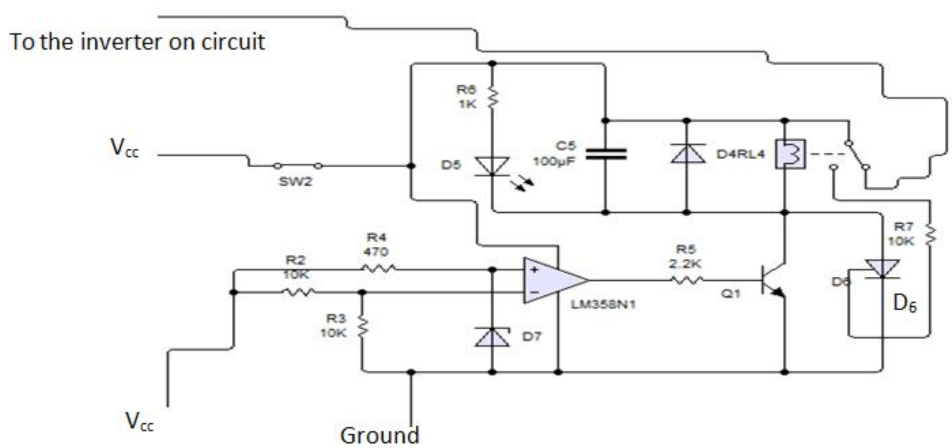

Fig. 3. The battery low circuit

$$V- = \left(\frac{10k\Omega}{10kv+10k\Omega}\right)11\text{volts}$$
$$= \left(\frac{1}{2}\right) 11 \text{ volts}$$
$$= 5.5 \text{ volts}$$

V+ = 5.5 volts.

V- > V+, the output voltage of Op-amp is low, and no current drives through the external circuit. When the supply voltage (Battery voltage) is 10 volts.

$$V- = \left(\frac{10k\Omega}{10k\Omega+10K\Omega}\right)\text{volts} = \frac{1}{2}(10) \text{ volts}$$

V- = 5 volts

V+= 5.1 volts

V+ > V-, the output voltage of the Op Amp is high and current drives through the external circuit.

At the external circuit, a transistor BC 547(Q1) has been selected for efficient switching.

When the output equals to the supply voltage, the transistor (Q1) switches on.

The transistor has current gain (hfe) of 270 and collector current of 100mA (from the data sheet).

$$\text{The base current } I_b = \frac{I_c}{h_{fe}} \tag{13}$$

I_b= 0.037mA

The base voltage is less than 12 volts

$$R_5 = \frac{\text{base voltage}}{\text{base current}} \tag{14}$$

$$R_5 = \frac{12V}{0.37} \times 10^{-3}$$

R_5 = 3.448MΩ

2.2kΩ has been chosen as it's the minimum value of resistance that will not blow up the transistor.

When the transistor is switched on, the relay (RL4) charges and closes up its switch (Electomagnetic induction) there by disconnecting the inverter circuit and putting on the main supply if the main supply is available.

The diode D4 (IN4007) has been connected across the relay to prevent any form of backward flow of current to the transistor (Q1).

The capacitor of capacitance 1000μF has been connected across LED (light emitting diode) to supply 2V and a resistor of 1kΩ has been connected to the LED to protect the LED from blowing up as the maximum current requirement for the LED is 10 mA.

The LED is an indicator, showing battery is low.

The thyristor (D6) in Fig. 3, has been installed also across the transistor Q1 to protect the transistor from the sudden charge from the relay.

$$R_6 = \frac{(Vs-Vi)}{i}\Omega \tag{15}$$

Vs is the source voltage = 12 V
Voltage required by LED = 2 V
i is LED current rating = 10 mA

$$R_6 = \frac{(12-2)}{10} = \frac{10}{10} \text{ mA}$$

R_6 = 1000 Ω

R_6 = 1kΩ

3.1.4 Design of the battery full circuit

From the circuit above, the diode D3 (IN4736A) is a zener diode to fix the voltage at the inverting input of 6.8 volts. R_9 and R_{10} are equal resistors, that is resistors of equal value to serve as a voltage divider, so that only half fraction is supplied to the non-inverting input.

R_8 keeps the current at the non-inverting to a value less than 49 mA (The maximum current allowable at Op – amp input).

A value of 470Ω is chosen for R_8 so that

$$\frac{12V}{470} = 0.0255319 \text{ Amp}$$

12V/470 = 0.0255319 Amp

= 25.5319mA (input current) which is smaller than the allowable current of the Op-Amp.
When the voltage from the battery is 11 volts

$$\left(\frac{R_8}{R_8+R_9}\right) \text{Vsupply} = V+; R_8 = R_9 \tag{16}$$

$$= \left(\frac{1}{2}\right) 11 \text{ VOlts} = 5.5 \text{ Volts}$$

The inverting input is 6.8 volts (fixed by the zener diode)

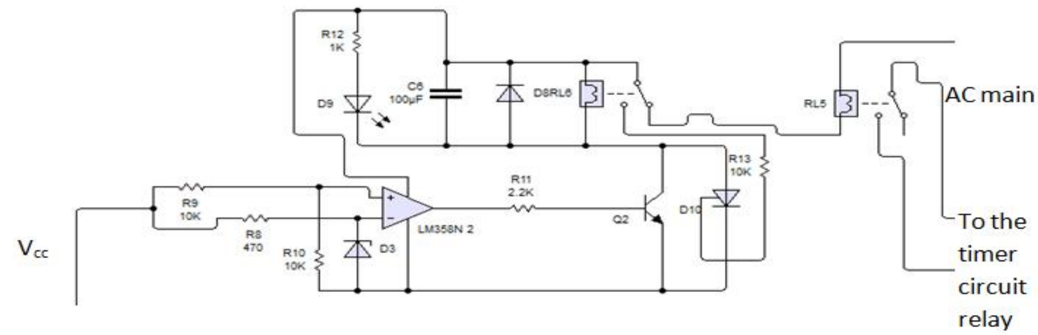

Fig. 4. The battery full circuit

The V- > V+, therefore the output voltage of the Op Amp will be low.

Again,

When the supply voltage is 12 volts

$$\left(\frac{R_8}{R_8 + R_9}\right) 12 \text{ Volts}$$

R8 = R9

$\left(\frac{1}{2}\right) 12 \text{ Volts}$ = V+ (non inverting input)

V+ = 6 volts

V- is still greater than V+ Output of the Op Amp still low.

When the supply voltage is at 13.5 volts,

$\left(\frac{1}{2}\right) 13.5 = 6.75 \text{ Volts}$, the output of the Op Amp is still low.

When supply is at 14 volts,

(R8/R8+R9) Vsupply = V+$\left(\frac{1}{2}\right) 14 = V$ +V+ = 7V

V+ > V- , the output voltage of the Op Amp is high which is 14 volts.14 volts is the battery full voltage.
This is used because of voltage drop across the circuit so that allowance of +2 volts will be there from the supply.

Transistor (Q2) BC547 has been connected at the Op-amp output for efficient switching.

The transistor has collector current of 100 mA and current gain (h_{fe}) of 270

$$\text{The base current } I_b = \frac{I_c}{h_{fe}} \tag{17}$$

$$= \frac{100\text{mA}}{270} = 0.037\text{mA}$$

$$\text{The base resistance } R_b = \frac{V_b}{I_b} \quad = \frac{14}{0.037}\text{mA}$$

I_b = 378.37kΩ

R_{11} = 3.78MΩ

2.2kΩ has been chosen as the minimum resistor value to drive the BC547 without blowing it up.

R_{11} = 2.2kΩ
When the transistor is switched on, current flow through the relay (RL3) and the relay closes, the inverter turns on and the inverter is ready to power the load.

Light emitting diode (LED) has been used as an indicator to show when the battery is full.

The LED has maximum input current of 10 mA so resistor R29 has been connected at the diode input to control the current to the value less than the maximum diode allowable current.

The capacitor C9 has been connected across the LED to keep the led on.

Diode D6 (IN4007) has been connected to prevent any current from flowing back to the transistor from the relay (RL3).

The thyristor has been connected across the transistor Q16 to prevent any current from flowing back to the transistor when the RELAY closes.

Resistor of resistance 10 kΩ (R28) has been connected at the gate of the thyristor because the thyristor maximum gate current is 1.2 mA.

Relay (RL5) receives pulse from the timer circuit(RL1)

$$R_{12} = \frac{(Vs-Vi)}{i} \tag{18}$$

R_{12} is the resistor connected to LED

$$R_{12} = \frac{12-2}{10}\text{mA} = 1000\Omega = 1\text{k}\Omega$$

Vs = 12 volts, V_{load} consumed by LED is 2v
Max current needed by LED is 10 mA

3.1.5 Design of the change-over circuit

The change-over circuit is a switching circuit that switches supply between MAINS or inverter. When the relay RL1 closes, the RL5 receives supply from the inverter battery full circuit and powers the load, inverter is on.

When its battery low, the inverter circuit is opened and charging and the load is connected to the MAINS if available. The inverter is OFF.

Diode D2 in Fig. 5 below, has been connected to prevent current from flowing to the ground from the 12 volts battery supply also isolates the MAINS and the battery.

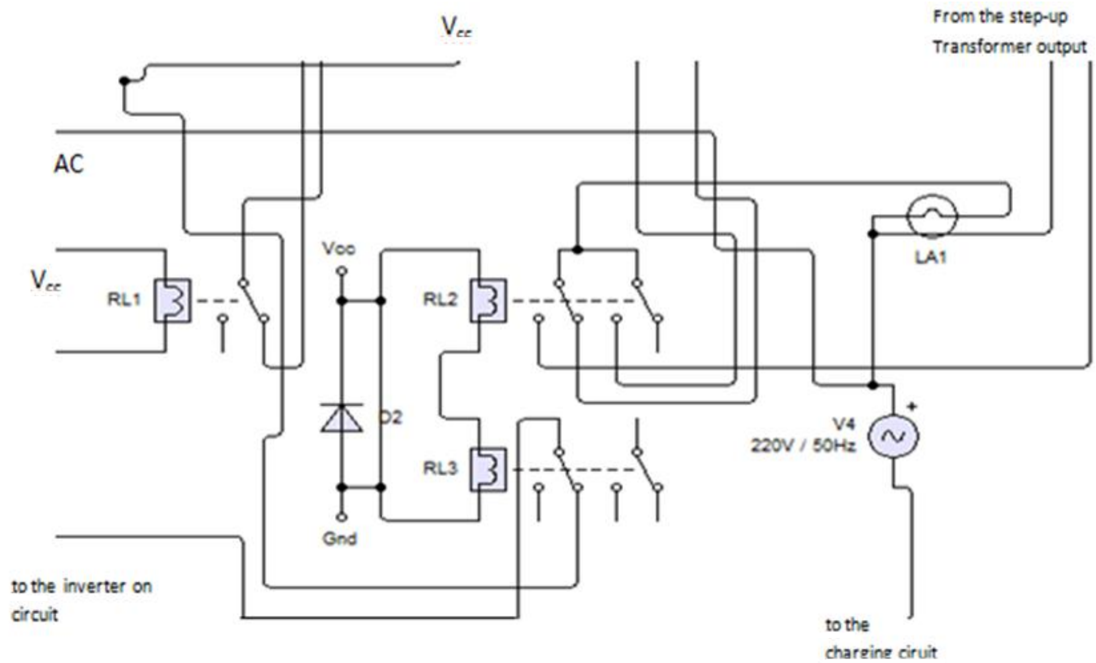

Fig. 5. Change-over circuit

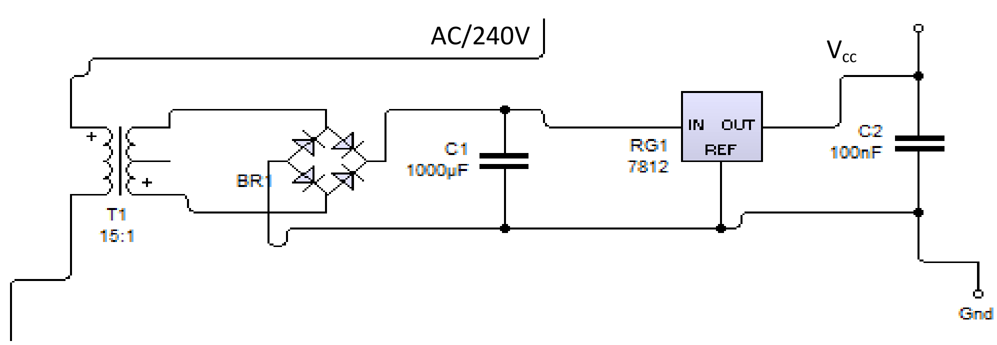

Fig. 6. The rectifying circuit (Battery charger)

3.1.6 Design of the battery charging circuit (Rectifying circuit)

Transformer (T1) is a 15V/2000mA step-down transformer. It steps down the 220 Volts from MAINS to 15V output secondary. 15V is required at the output because of the voltage drop in the bridge circuit (AC – DC converter circuit) and voltage requirement of LM7812 voltage regulator. The bridge rectifier selected is G25B80 bridge rectifier with four diodes. Each diode has a voltage drop of 1 volt (from the data sheet), the total voltage drop is 2 volts at the output.

Capacitor C1 has been connected across the input of the voltage regulator LM7812.

The voltage regulator LM7812 has a minimum input voltage of 14.7 volts, but the voltage at the output of the rectifier is 13 volts.

But 14.7 is the minimum input voltage for LM7812 voltage to obtain a capacitor to produce a stored voltage of 2v to augment the current of capacitor,

$$I = C_1 \frac{dv}{dt} \tag{19}$$

$Idt = C_1dv$
$I\int dt = C_1\int dv$
$It = C_1V$

$$C_1 = \frac{it}{v} \tag{20}$$

$$C_1 = \frac{10 \text{ msec x } 2000\text{mA}}{2 \text{ volts}}$$

C_1=10Mf =1000µF

The LM7812 voltage regulator produces an output voltage of 12 volts as indicated from the data sheet.

The capacitor C2 (100nF) is a bypass capacitor, ensuring no AC component at the output.

3.1.7 Monostable/astable multivibrator (OSCILLATOR)

Integrated Circuit (IC) 4047 has been selected to obtain the alternating pulse signal from the 12 volts DC source from the battery.

The Astable operation is enabled by a high level on the ASTABLE (AST) input. The period of the square wave at Q and Q is a function of the external component employed. Pulse on the MONOSTABLE or ASTABLE input allows the circuit to be used as a gatable Multivibrator. In the Monostable mode, positive edge – triggering is accomplished by applying a leading edge pulse to the +TRIGGER (+T) input. For –TRIGGER (-T) and a high level to the +TRIGGER [9].

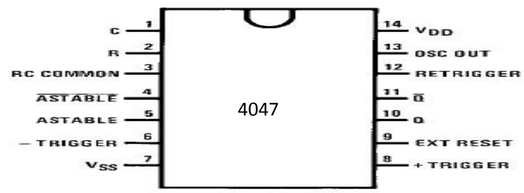

Fig. 7. 4047 Oscillator chip configuration

From the 4047 data sheet, the wave form obtainable for Astable mode is Astable Pulse from Pin 10 and Pin 11. The Integrated Circuit (IC 4047), used as the Oscillator also has a feedback action to regulate itself.

3.1.8 The Inverter Output and Indicator

The capacitor C7 in the circuit above augment the voltage regulator input voltage to the required value. The voltage regulator has an input minimum (threshold) voltage of 14.7 volts, but from the transformer input or battery, output is ≤ 14 volts.

From the step-down transformer,

The current at secondary of (TR2) is 2000 mA

$\text{Capacitance} = \frac{it}{v}$Farad

$$\text{Time (t)} = \frac{1}{\text{frequency}}\text{sec} \tag{21}$$

$$= \frac{1}{50} = \frac{20\text{msec}}{2} = 10\text{msec(for one half cycle)}$$

2 volts to be supplied by the capacitor to augment the input of the voltage regulator:

$$C_7 = \frac{10\text{msec X } 2000\text{mA}}{2}$$

C_7 = 10mF = 10000µF

For rise time of 1msec

$$C_7 = \frac{1\text{msec X } 200\text{mA}}{2}\text{F}$$

C_7= 1mF

C_7= 1000µF

C_8 is a bypass capacitor to prevent any form of ac component at the regulator output

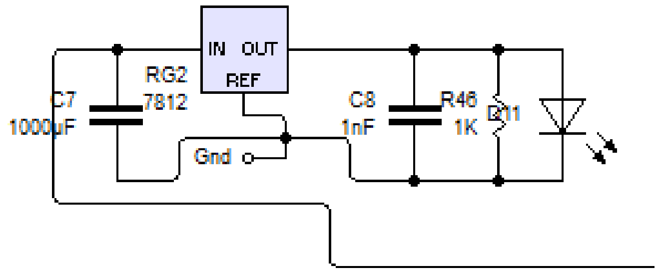

Fig. 8. The inverter on the indicator circuit

The LED (light emitting diode) has been connected to indicate inverter is powered only.

A 1 KΩ resistor prevents the current at the output from going directly to the LED as the LED maximum current rating is 10mA

The LED resistor $R46 = \frac{Vs - VL}{I}\Omega$ (22)

V_s= source voltage
V_L = Load voltage

$$R_{46} = \frac{12-2}{10mA}\Omega$$

$$R_{46} = \frac{10}{10mA}\Omega$$

R_{46} = 1000Ω

3.1.8 <u>The delay and timer circuit</u>

In the Monostable mode, the 555 functions is a "one – shot" pulse generator and application includes; timer, missing pulse detection, bounce free switches, touch switches, frequency divider, capacitance measurement and as pulse width modulation.

To be used as a one-shot generator, the pulse begins when timer receives a signal at trigger input falls below a third of voltage supply.

The width of the output is determined by the time constant $R_{17}C_6$ network which comprises a resistor (R) and capacitor (C).

The output is obtained when the voltage of the capacitor equals to 2/3 of the supply voltage.

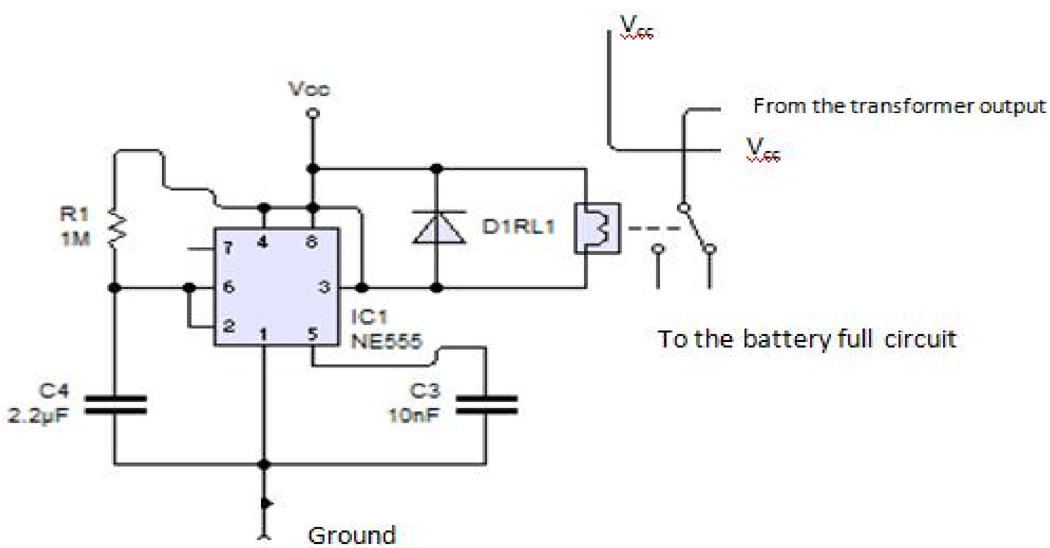

Fig. 9. Delay circuit

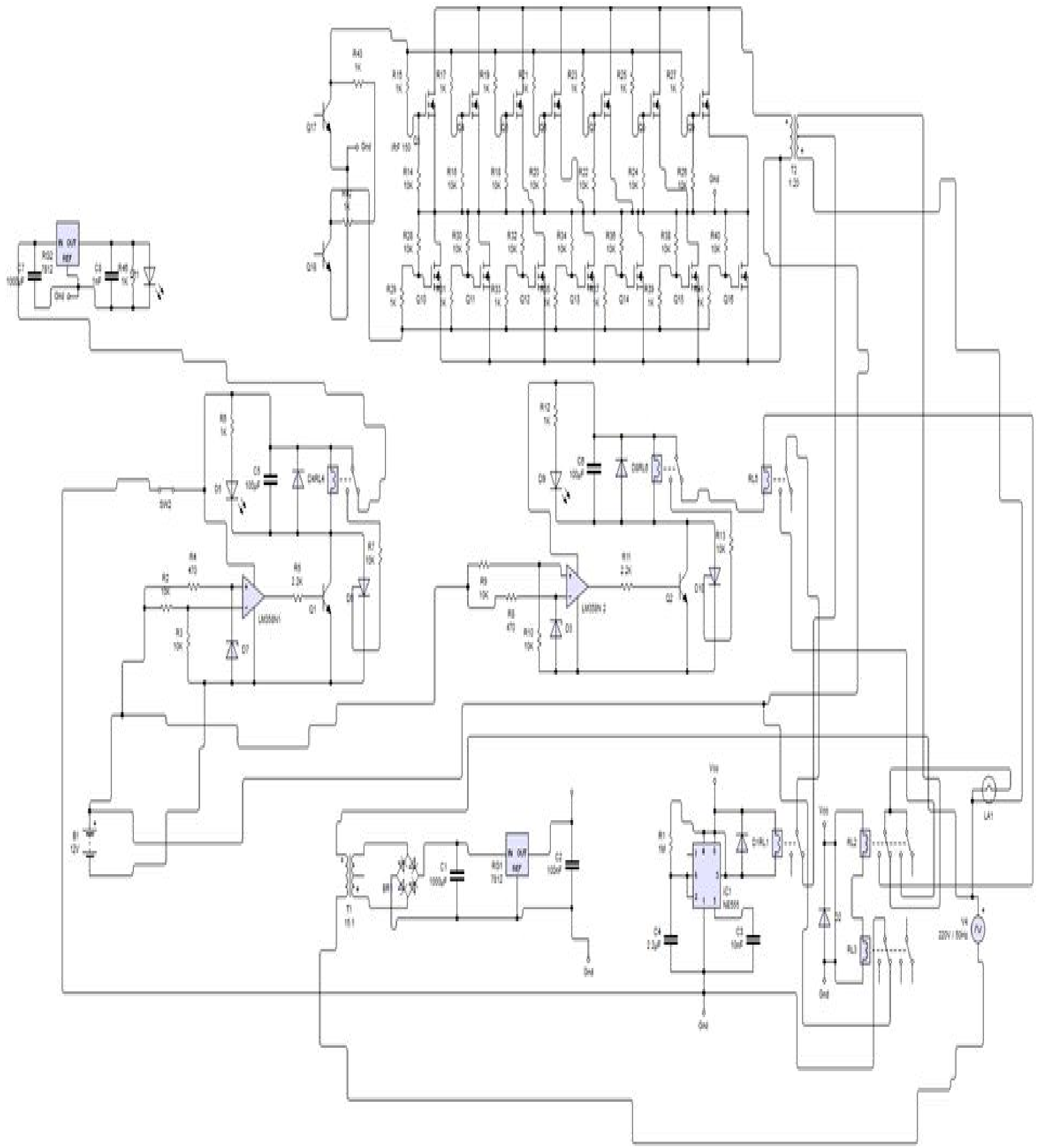

Fig. 10. Complete circuit diagram

4. Testing

In the course building the inverter, various tests are carried out amongst which are

1. Device testing
2. Continuity test
3. Short circuit test

4.1 Device Testing

To test the Inverter, a load of up to 900 VA was connected to the device to test if the device can carry up to the power stipulated for it to bear.

4.2 Continuity Test

The continuity test is carried out to avoid any form of an open circuit. The presence of an open circuit in any electrical system will create an open circuit fault in the system and the system will not function. The wires have to be continuous all the way from one terminal to another. The lead used in the soldering of the components must be well soldered and there should be no any form of partial contact as this might initiate an open circuit in the system.

4.3 Short Circuit Test

A short circuit occurs when the live and the neutral wires touch each other. When this happens, the current goes infinitely high and can blow up the entire system [10]. There should be no form of short circuit, be it on the legs of the integrated circuits or along the wires. Short circuit fault is a very costly fault as it can blow up the whole system and should be avoided as much as possible, so this test is very important prior to the powering of the inverter system. To determine the system failure rate, the part count analysis of the various components is required.

4.4 Result and Findings

The Inverter was tested on a section by section basis. The output voltage of the Oscillator was obtained to be 4.24Volts on each side with the frequency set to approximately 50Hz. The other unit could not be tested until the final coupling has been done. The lists of various parameters are found below:

Table 1. Specifications of the inverter

S/N	Parameters	Rating
1	Inverter Frequency	50 Hz
2	Inverter Output Voltage	220 Volts
3	Minimum battery voltage	10 Volts
4	Maximum loading capacity	800 watts
5	Minimum AC input Voltage	180 V
6	Maximum AC input Voltage	250

After using the above parameter, the effect of loading was carried out on the Inverter and the load test result is shown below.

Table 2. Load test result

S/N	Power (Watts)	Voltage (Volts)
1	250	230
2	300	225
3	400	220
4	500	220
5	600	220
6	700	220
7	800	220
8	900	0

4.5 Findings

The inverter was able to bear the load up to 870VA and after some time, the load began to malfunction as the battery voltage began to fall and later the battery low indicator came up before the inverter finally went off.

It was also discovered that when the Inverter was loaded, the output voltage initially drops and the regulated itself back to 220 Volts. This was due to the feedback action of the Integrated Circuit (IC 4047), used as the Oscillator.

5. CONCLUSION

Based on this research work, it can be deduced that an inverter system can be used to change direct current to alternating current. This can be used to supply power to house hold appliances and can be made to have a higher power rating which can be used in factories. This will help improve power stability and better the national economy.

6. RECOMMENDATION

This paper has shown how Inverter system can operate automatically; automatic in the sense that the supply changes from the mains to the battery and battery to main depending on when there is power supply from the Power Holding Company of Nigeria. It is therefore recommended that both the engineers that construct and the user of inverter system should adopt this mode of inverter system configuration for its flexibility, reliability, availability and high resistance to stress. Since various parts are in the different model, fault can easily be identified and repair can be carried out easily without affecting the other parts.

It is also recommended that the inverter should be suspended on a wood or a stand as placing it on the ground may allow it to come in contact with water and this can lead to rust or damage to some components in the inverter system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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