DESIGN, CONSTRUCTION AND TESTING OF AN AUTOMATIC CHANGEOVER 900VA DC - AC INVERTER WITH CHARGER AND USED AS A U.P.S.

By

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SEPTEMBER 2003

DECLARATION

I VITUS PAUL NWAKEZE do hereby solemnly declare that this project *'DESIGN CONSTRUCTION AND TESTING OF 900VA DIRECT CURRENT TO ALTERNATING CURRENT (DC-TO-AC) INVERTER WITH AUTOMATIC CHANGEOVER AND USED AS AN UNINTERRUPTIBLE POWER SUPPLY'* is as a result of my personal effort. It has therefore never been presented elsewhere either wholly or partly for either a degree or diploma. And therefore, all the information that is gotten from past-published work and made use of in this project is been acknowledged.

VITUS PAUL NWAKEZE.

10-10-08

DATE

DEDICATION

I wish to dedicate this project and its report first to God Almighty through his Son Jesus Christ and the Holy Spirit who saw me through thick and thin and who gave me His love and life to come to the end of my academic pursuit. Also my special dedication goes to my parents CHIEF LINUS OBINOKWARA and MRS FELICIA OBINOKWARA who gave me all the encouragement and support, who stood by me all through my studies who even when they lack, they get something out of nothing to sponsor my academic pursuit. God will surely bless them in Jesus name. They shall live to reap the fruit they planted in me and of their labour as well.

CERTIFICATION.

This is to verify that this project titled "DESIGN, CONSTRUCTION AND TESTING OF AN AUTOMATIC CHANGEOVER **D.C-A.C** INVERTER AND USED AS A U.P.S was carried out by **VITUS PAUL NWAKEZE** for the award of B-Eng degree in the ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT **FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.**

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ABSTRACT

Due to the no confidence that the teeming populace has passed on the electricity supply given to them by NEPA because of the continuous load shedding and the irregularities in the electricity power supply in Nigeria, which is so hazardous to various electronic equipment and electronic gadgets, it became very important to develop a DC – AC inverter system and used as an uninterruptible power supply so as to protect this sensitive equipment. It is automatically and highly protective to the electronic equipment in this project, the components used in this design involves the use of a push – pull amplifier which is been driven by an astable multivibrator, automatic relay switching system. The output of this inverter is rated at 0.9kVA sinusoidal after passing it through filters.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

It is undoubtedly that electricity is the bedrock of development and the beginning of urbanization with the inclusion of good road, portable water and good health facilities and hospitals. It is rather unfortunate that the national electric power authority (NEPA) has failed to meet the demands of the teeming populace and therefore got the name Never Expect Power Always for its acronyms (NEPA).

The supply people get from NEPA is as a result of load shedding and so due to this load shedding which is constant and continuous, it leads to damage of vital and sensitive equipment both in the offices and at homes such equipment includes television, computers and etc.

The economy is not helping matters either as the prices of generating sets which is an alternative has beyond the reach of an ordinary man and even the people buoyant enough to purchase one cannot tolerate the noise generated by this sets which is highly unbearable and the cost of maintenance and fuelling of this generating sets is not an easy not to crack either and lastly, the smokes given out from the exhaust pipes of the generating sets leads to some illnesses.

Considering the above problems stated, the idea of this of this project at hand was conceived, that is the DESIGN, CONSTRUCTION AND TESTING OF A 900VA DC – TO-AC INVERTER AND CHARGER WITH USE AS A U.P.S with an automatic change of power source from the mains (NEPA).

This project will give an output of 220-240v which could drive virtually all equipment both at home and offices, it will be very cheap for a common man producing no noise and without fuelling and having low cost of maintenance and giving out no smokes.

There are two main circuit this includes the inverting circuit and the controllable charging circuit which actually does the charging of the car battery which will later discharge its direct current (DC) to be inverted for use by the electronic equipment and gadgets.

1.2 LITERATURE REVIEW

A world-renowned computer guru once said "SCIENCE AND TECHNOLOGY IS MEANINGLESS UNLESS IT IS USED FOR THE DEVELOPMENT AND BETTERMENT OF MANKIND". This saying is loud and clear here as the first worlds inverter circuit was developed or introduced by an American company called the HEART INTERFACE in the year (1983) a known and acknowledged leader in the manufacturing of inverter and charger technology based in America.

As the year passes by, and to be precise in the year (1994) there was an improvement in the inverter technology as the power MOSFET was then introduced for the main power output of the inverter circuit. The power MOSFET was used so that it could make the design smaller, and to switch larger currents which is better off the use of Bipolar Junction Transistors (BJT).

However in the early (1990s) this was used to develop the Uninterruptible Power Supply (U.P.S), which can be used to drive computer systems and other electronic gadgets at homes and offices when there is sudden power failure. In a nutshell, the uninterruptible power supply (U.P.S) is the most economical, useful and also stress less inverters circuit designed for the generation of power to complement the NEPA mains supply meant for today's technology. Today, different inverters and chargers are in the market.

This mode of power generation is cheap, noiseless, very reliable and with a very low failure rate, and so worth having one at home or offices so as to prevent damage of computer systems hard disk and some electronic gadgets due to unsteady power supply from NEPA.

1.3 PROJECT AIMS AND OBJECTIVES

As it is with the usual sayings that the major aims and objectives of every project undergone will be to solve a problem and ofcourse to better the life of the people or populace with a less cost for construction. Consequently, it is not different with this project s its major aims and objectives is targeted at achieving an output of 900VA or 0.9KVA of 220V-240V which could at least drive most of the equipments and electronic gadgets at homes or in the offices examples is such as televisions, radios and a full multimedia computer system.

It is also aimed at achieving certain level of energy conservation from the mains supply (NEPA) so that it will enable us to restore the potential energy of the battery after using it power the circuit.

This project at hand will also enable to achieve an automatic change of power from a car battery of about 12V to a public mains of about 220V-to-240V and then vice versa. Finally, it will also dwell on the process of using the same step – transformer used in the inverting mode, as a step – down transformer to charge the car battery during and in the charging mode.

1.4 PROJECT OUTLINE

This project is specially based on the design, construction and testing of a 900VA or 0.9KVA Direct Current to Alternating Current (DC-to-AC) inverter and charger with special application as an Uninterruptible Power Supply (U.P.S). The step-by-step analysis of the stages of the design is given as shown below in the chapters:

CHAPTER ONE:

This particular chapter talks more on the general introduction of what the project at hand does, what their advantages are, how they makes life easier and improves the life of the teeming populace. The detailed literature review about the project, and then the aims and objectives of why the project was undertaken.

CHAPTER TWO:

This chapter two deals more concisively on each unit or module that makes up the entire working System, the operation of this module and their circuit diagrams. This includes the charging module, the inverting module, the inverters in general terms, the transistors and also outlines the design and modes of operation of each modules and finally on the design and operation of the entire system and also the calculations used to get the values of the components used.

CHAPTER THREE:

This particular chapter deals in details the construction process involved into the design, the testing while the construction was on, the modifications made after the construction was preliminarily made, then the final construction made and then the complete circuit diagram of the entire system coupled together. Also included here is the construction of the casing for the project and why such material was used for the casing and finally the major calculations that are involved.

This chapter also deals wholly on the major testing conducted on the entire circuit and then using the finished work to power some electronic gadgets, and also on the result that was obtained from using the system for the testing and talked also on the precautions that was taken or followed in achieving the positive result.

CHAPTER FOUR:

This chapter dwells specifically on the recommendations for the improvement on this project for any up coming student who wants to embark on the same project. The problem that was encountered in accomplishing the project, the summary on this project that was undertaken, the final conclusions made it also talks on the references that was made so as to accomplish this report that was written.

CHAPTER TWO

2.1 SYSTEM DESIGN

This chapter as was earlier stated in the project outline of chapter one deals wholly on the actual breakdown of the entire circuit system into modules (units), the operation and detailed explanation of each of the modules, which makes the complete working system. This modules or units will include the astable multivibrator unit, the charger unit, the transistor unit, the battery voltage level indicator unit, the relay switching unit, the inverting transformer unit and of course the inverting unit which is the heart of the whole system. All of the above units, each has their own characteristics and modes of operation which is backed-up with diagrams and sketches are been written on. They are then been interconnected to form a complete operating and functional system, which we now refer to as a DC-to-AC inverter and charger system.

2.2 ASTABLE MULTIVIBRATOR MODULE

This is otherwise called a free running relaxation oscillator, it has no stable state at all, but only two quasi-stable (half stable) states between which it keeps oscillating continuously of its own accord without any external excitation. In this circuit, neither of the two transistors reaches a stable state. When one is ON, the other is OFF and then continuously switch back and forth at a rate depending on the RC time constant in the circuit, hence it oscillates and produces pulses of mark-to-space ratio and moreover, two outputs that is 180° out of phase with each other is available, it should be noted here that the transistors do not work on the linear region of the characteristics.

MODE OF OPERATION OF THE ASTABLE MULTIVIBRATOR

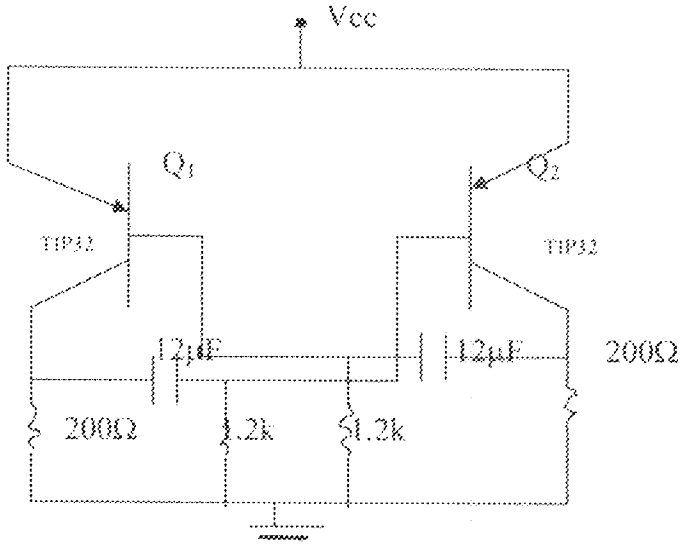


Fig 2.01: *The circuit diagram of the astable multivibrator.*

The circuit operation would easily be understood if it is remembered that due to the feedback, when Q_1 is ON, then Q_2 is OFF and when Q_2 is ON, Q_1 is OFF. The feedback system is such that Q_1 willl be rapidly driven to saturation and Q_2 to cut-off.

Since Q_1 is in saturation, the voltage drop across R_{L1} is the V_{CC}, so the capacitor C_1 will start charging through R_2. This charging process will then forward bias Q_2 setting it to cut OFF and the voltage at R_{L2} will be zero.

The voltage across R_2 at the beginning of the process is V_{CC} and it will continue to drop until the potential difference is below (V_{CC} -0.7V) which will eventually reverse bias Q_2 and then drive Q_2 to saturation.

When Q_2 is saturated, the potential at point B is V_{CC} and capacitor C_2 will start charging through R_1. The potential head of R_1 at the beginning of the charging of C_2 is V_{CC}, which will set Q_1 OFF by forward biasing Q_1. C_1 will start discharging at that point.

The voltage across R_2 will continue to drop until it is below (V_{CC}- 0.7V) as can be seen in the figure above, the time in each state depends on the RC values.

It can be proved from the sketch below that the OFF-time for Q_1 is $T_1 = 0.69\ R_1C_1$, and that for Q_2 is $T_2 = 0.69R_2C_2$.

Hence the total period of the wave is

$$T = T_1 + T_2 = 0.69\ (R_1C_1 + R_2C_2)$$

$$R_1 = R_2 = R \quad \text{and} \quad C_1 = C_2 = C$$

This therefore means that the two stages are symmetrical that is to say

$$T = 1.38RC.$$

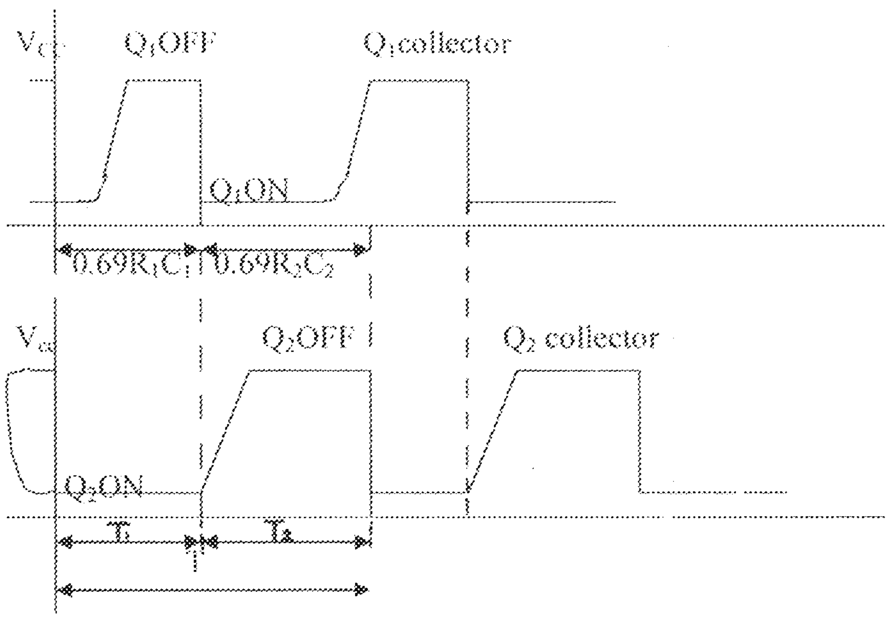


Fig 2.02: *Graphical sketch of an astable multivibrator circuit.*

The frequency of oscillation is given by the reciprocal of the time period

$$F = 1/T = 1/1.38RC.$$

2.3 THE INVERTING MODULE

THE INVERTERS

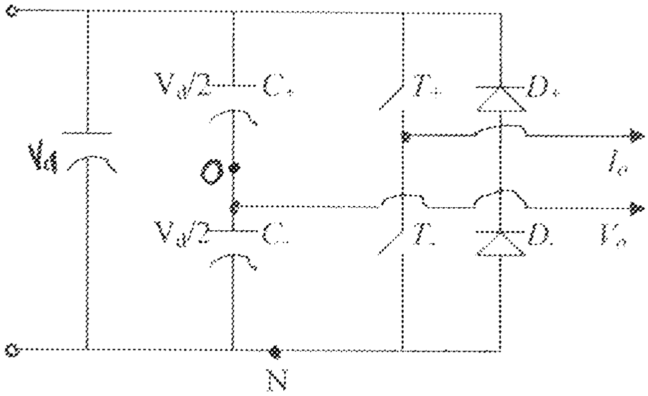
The switch mode direct current to alternating current inverters are applied where the objective is to produce a sinusoidal alternating current output whose magnitude and frequency can both be controlled. The switch mode inverter is a converter through which the power flow is reversible. There are inverters with single-phase and three-phase alternating current output.

Voltage source inverters can further be divided into the pulse width modulated inverters. In this type, the magnitude and frequency of the output is been controlled while the input direct current is essentially constant. The next one is the square wave inverters, in which case, the inverters controls only the frequency of the output, while the magnitude remains constant. The last one is the single phase inverters with voltage cancellation, this particular type, combines or possesses characteristics of pulse width modulated, and the square wave inverters.

SINGLE PHASE INVERTERS

HALF BRIDGE INVERTERS

Here two equal capacitors are connected in series across the direct current inputs, and their junction is at a mid potential with a voltage across each capacitor. Sufficiently, large capacitance must be used such that is reasonable to assume the potential at point "O" remains essentially constant with respect to the direct current (dc) bus N as seen in the diagram of figure 2.03 shown below.



T_+ & T_- = *Switches*

D_+ & D_- = *Diodes*

C_+ & C_- = *capacitors*

I_o = *Output current.*

V_o = *Output voltage*

Fig 2.03: *A half bridge inverter.*

The current between the two capacitor C_+ and capacitor C_- having equal and very large values must divide equally.

When T_+ is ON, either T_+ or D_+ conducts depending on the direction of the output current I_o, and I_o splits equally between the two capacitors. Similarly, when T_- is in the ON state, either T_- or D_- conducts depending also on the direction of the output current I_o, and I_o splits equally between the two capacitors and so capacitors C_+ and C_- are connected in parallel where it will now be acting as a direct current blocking capacitors.

FULL BRIDGE INVERTERS

There is also the full bridge inverters, their modes of operations are the same only that in this case, there are four (4) diodes and four (4) switches in the full wave bridge inverters types as could be seen from the diagram shown below in figure 2.04. The diodes in this case are reverse biased.

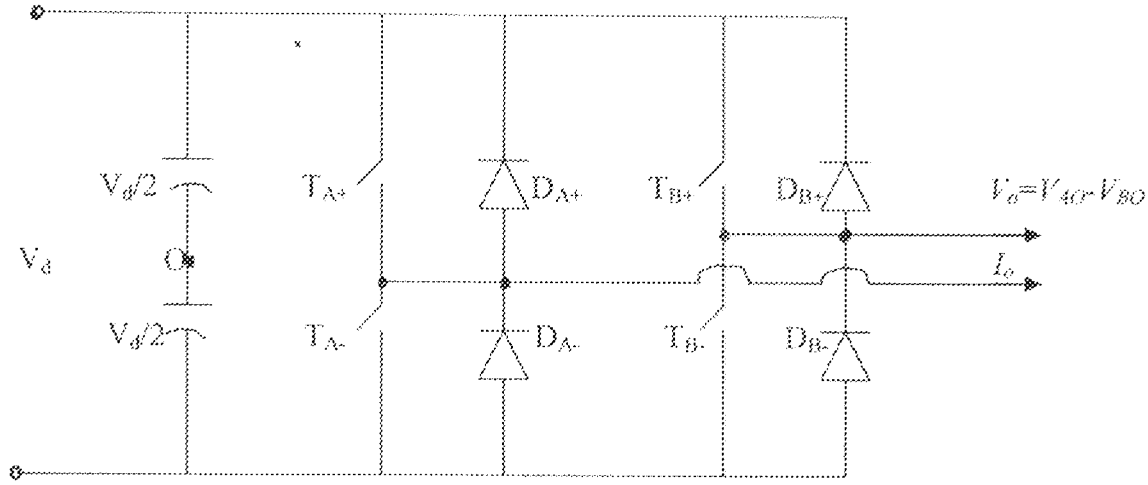


Fig 2.04: *A full bridge inverters.*

They consist of two one (1) leg inverters and preferred over the half bridge inverters arrangement for higher power ratings. The output of inverter leg B is negative of the inverter leg A output. When T_{a+} is ON, and Vao is equal to $+V_d/2$, T_{b-} is also ON and $V_bo = -V_d/2$.

For half bridge inverters

$$V_t = V_{d\ (max)}$$

$$V_{ol(max)} = 4/(\pi\sqrt{2})[V_{d(max)}/2]$$

$$I_t = \sqrt{2}\ I_{omax} \qquad q = 2$$

The maximum switch utilization ratio is given by

$$= (V_{ol}I_{omax)/(}qV_t\ I_t) = 1/(2\pi)$$

$$\approx 0.16$$

For the full bridge inverters

$$V_t = V_{dmax}$$

$I_t = \sqrt{2}I_{omax}$

$4(V_{dmax})/\pi\sqrt{2}$ $\qquad$ $q = 4$

The maximum switch utilization ratio

$= 1/2\pi$

≈ 0.16

THREE PHASE INVERTERS

For the project at hand, this is the type that I actually made use of in this project. They have six (6) switches. They consists of three (3) legs one for each phase and so each inverter leg is similar to the one used for describing the basic one leg inverter and so the output of one leg that is VAN (with respect to the negative direct current bus) depends only on V_d and the switch states. At any instant, one of the two switches in a leg is always ON. The inverters output voltage is independent of the direction of the load current as shown in the diagram of figure 2.05 below.

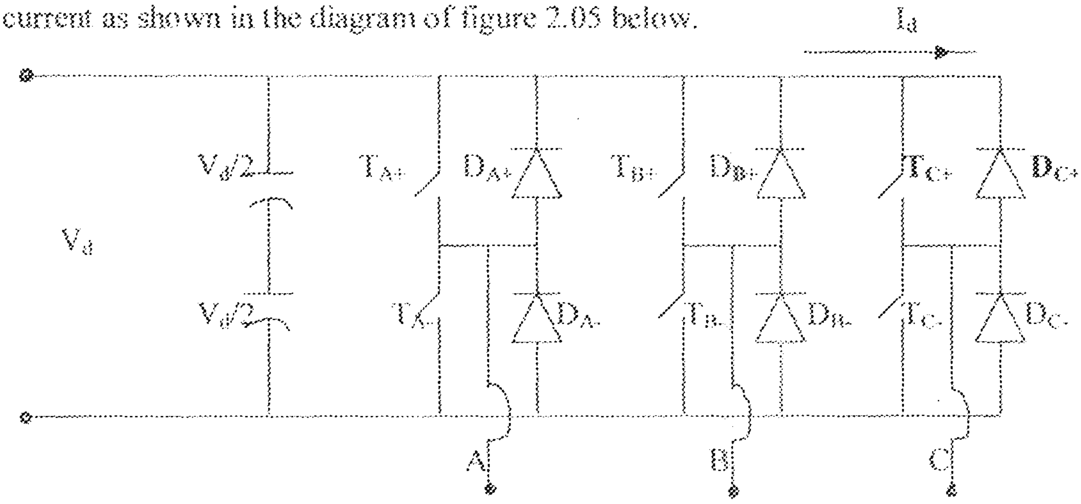


Fig 2.05: *Three-phase inverter*

V_{LL} = Line – to – Line voltage

$= \sqrt{3}(VAN)/\sqrt{2} \qquad = \sqrt{3}(VAN)/\sqrt{2}$

$= \sqrt{3}(M_a.V_d)/2\sqrt{2}$

$\approx 0.612\ M_a.V_d$

THE INVERTING CIRCUIT

From the knowledge that we have about inverters, we can now conveniently apply our study of the inverters to the inverting circuit, which is of course the main part of this project in that it actually performs the real transformation or inversion from the direct current to the alternating current (DC- to AC), beginning with the block diagram of figure 2.06 below.

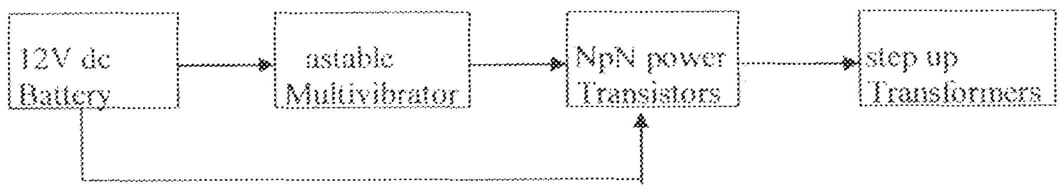


Fig 2.06: *Block diagram of the inverting circuit.*

As was earlier stated, the inverting circuits,the most important part of this project since it does the actual conversion from DC - to – AC. It involves an astable multivibrator, which generates the pulses at 50Hz which is been used to fire the Bipolar Junction Transistors (BJT) which are of the NpN types connected in the Push – Pull configuration so that it would be able to power the step – up transformer. The 12V dc power output will the through the step up power transformer, be stepped up to about 220V - 240V alternating current at the output.

The generated and final 220V – 240V alternating current, will then pass through a filter for the pulse wave output power signal to be shapened to its sinusoidal equivalent. This is now the signal been used to run the electronic gadgets.

MODES OF OPERATION OF THE INVERTER CIRCUIT

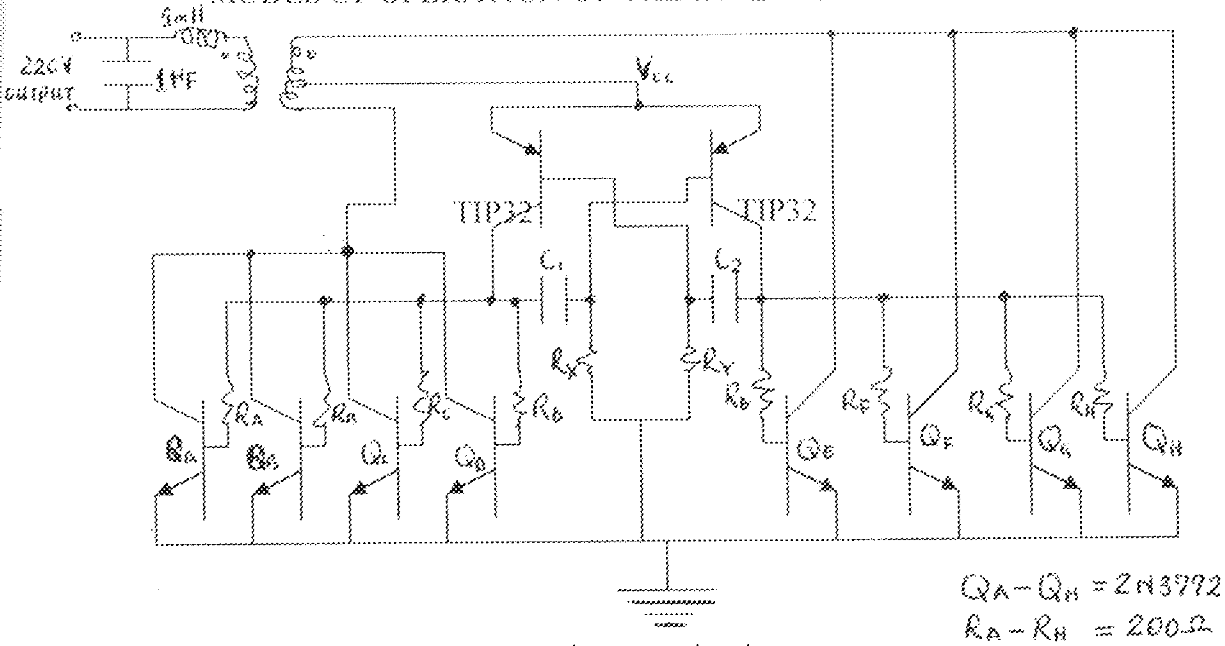


Fig 2.07: The DC – to – AC inverter circuit.

$Q_A - Q_H$ = 2N3772
$R_A - R_H$ = 200Ω
$R_X = R_Y$ = 1.2kΩ
$C_1 = C_2$ = 12μF

The operation or working principle of this transistorized power inverter circuit will be best understood if the circuit diagram of figure 2.07 above is critically studied. The output of one side of the astable multivibrator is connected to the base of four power Bipolar Junction Transistors all connected in parallel in a Push – Pull configuration.

Each of the four (4) power transistors has each, a 200 ohms (Ω) resistor connected to their base, this is responsible for the current limitations and also for the prevention and protection in case of the breakdown of any one of the power transistors so that it will not directly affect the adjacent transistor. The power transistors will then develop a very high gain by the summation of the individual current output.

To achieve a full wave maximum power amplification, the transistors are connected in the Push and Pull configuration order, the output from the transformer is in the form of pulse wave signal and the filter placed at the output is meant to change the pulse wave signal to a sinusoidal signal which is what is actually needed to drive the electronic gadgets that are been connected to it.

It is very important to note here that the filter is actually acting as a surge protector so as to prevent the overshoot of the output voltage from the transformer most especially at the point where there is a change of power source or supply from the use of a direct current battery to the use of the public main supply (NEPA) and vice versa.

2.4 THE TRANSISTOR MODULE

The need to write on transistors in this report is due to the simple fact that transistors were made use of extensively in the project and so the need to discuss about and their switching characteristics.

A power Bipolar Junction Transistor (BJT) has a vertically oriented four (4) layer of alternating P- type and N- type doping such as the NpN transistors and the PnP transistors. The have three (3) terminals as indicated in the diagram sketched below in figure 2.08, they are labeled as collector, base, and the emitter.

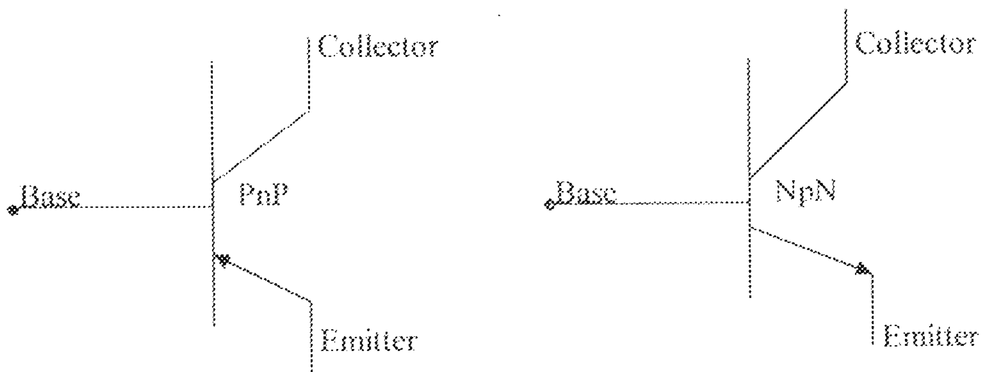


Fig 2.08: *Circuit symbol of Bipolar Junction Transistors (BJT).*

The base is the input terminal in power amplification; the output terminal is the collector while the emitter is the common between the input and the output but the PnP transistors has the opposite type of doping in each of the layers. The Bipolar Junction Transistors (BJT) are current controlled devices and base current must be supplied continuously to keep them in the ON state. The direct current gain (hFE) is usually only 5- 10 in high power transistors and so this devices is connected sometimes in a Darlington or triple Darlington configuration so that one could achieve a very large current gain.

In the active region, the base – emitter junction (B - E) is forward biased and the collector - base (C – B) is reverse biased; electrons are injected into the base from the emitter.

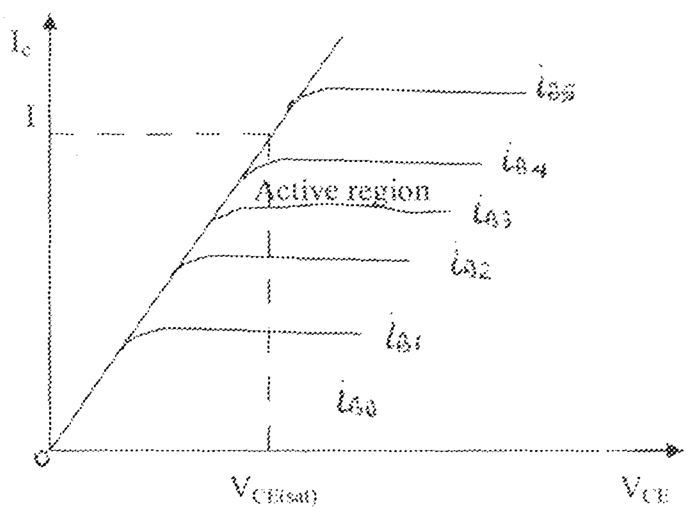


Fig 2.09: *I-V characteristics of a BJT.*

And holes are injected from the base into the emitter.

For the switching characteristics of the Bipolar Junction Transistors. To switch from the OFF state to the ON state, charge must be supplied to the transistor so that a stored charge distribution are established and maintained in the transistor. However, the turn-ON of the transistors involves removing all of the stored charge in the transistor.

This is merely achieved by reducing the base current to zero (0) and relying on the internal recombination process in the transistor to remove the charge.

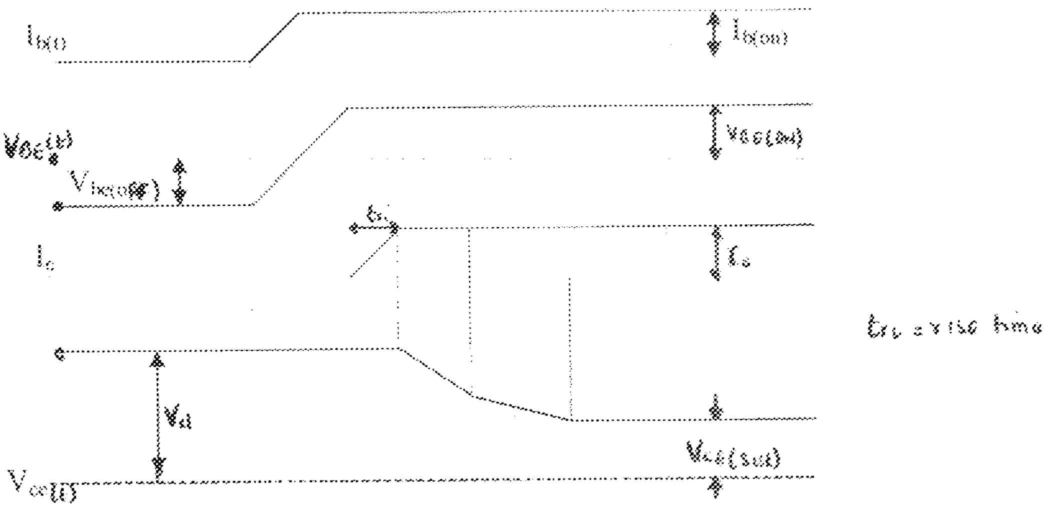


Fig 2.10: *Current and voltage waveforms of the BJT on its ON – state.*

The sketch above labeled figure 2.10, depicts the current and the voltage waveforms of the Bipolar Junction Transistor (BJT) when the transistor is on the ON – state.

It is of great importance to know also that voltages and current can destroy transistors. And so this transistors needs to be protected and therefore, it is worth knowing that *SNUBBER CIRCUITS* are specially used to protect the transistors by improving their *SWITCHING TRAJECTORY.* They are of three (3) types, this includes;

1. *Turn OFF snubbers*
2. *Turn ON snubbers*
3. *Over Voltage snubbers*: This normally comes into play when over voltage is generated due to stray inductances in the circuit.

2.5 THE INVERTING STEP – UP TRANSFORMER

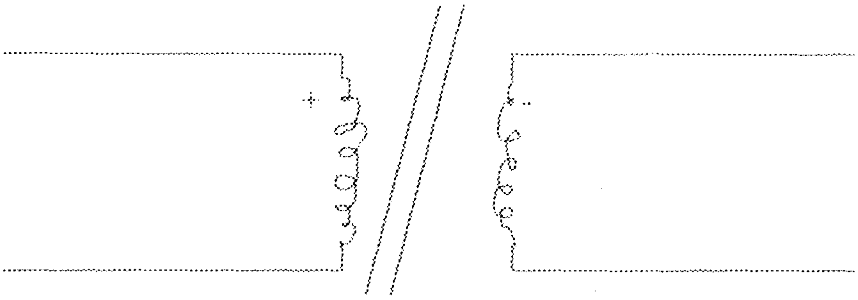


Fig 2.11: *The inverting step – up transformer.*

The inverter step – up transformer made use of in this project is a core type of transformer rated at 1000VA or 1kVA (transient power). This was specially designed at that rate so that it would able to withstand the power transformation and also to be able to take care of the minimum losses that are surely going to take place.

This transformer been made use of in this project, can also be used as a step – down transformer when there is power supply from the mains source (NEPA). And in this mode, it is actually used to charge the *DC* car battery. It will also automatically turn a step – up transformer whenever there is no supply from the mains (NEPA).

In this transformer and like every other transformer in the market, there is the primary winding and secondary winding. The primary winding with respect to the secondary winding is ofcourse rated in the turns ratio of *1: 18*.

The primary winding of this power transformer used is the center-tapped type of transformer configuration and of core type too. The center-tapped transformer was chosen so that it could enhance the *push and pull* function of the power inverting transistors that was used in constructing the inverter circuit.

2.6 THE RELAY SWITCHING SYSTEM MODULE

The relay switching system been used here is the normally open type of relay. The operations of these relays that are actually functioning in a synchronous mode could be understood better with careful study of the block diagram of figure 2.12 below.

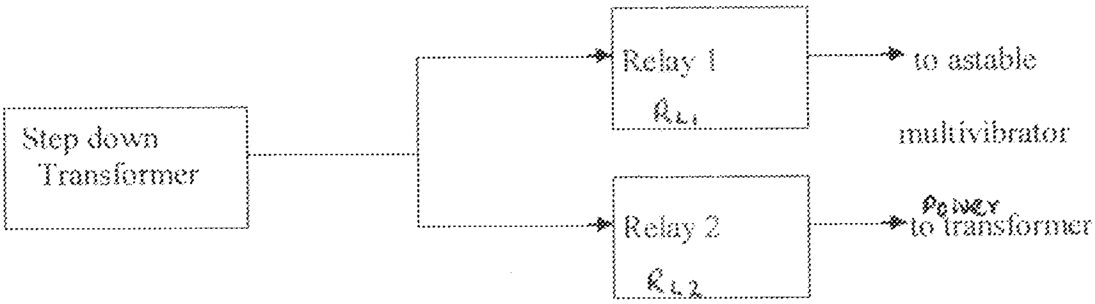


Fig 2.12: The block diagram of the relay switching system

The synchronous switching action of this two relays is to enable the transformer been used as a step – up transformer in the absence of the mains supply that is during the inverting mode and to as well be used as a step – down transformer when the power from the mains supply is fully restored to charge the DC car battery.

A 12V, 500mA step – down transformer is connected permanently to the alternating current (AC) mains and then the output is fed into a bridge rectifier for rectification before they then power the two relays labeled R_{L1} and R_{L2}. This is normally meant for the changing of state.

The first relay R_{L1} connects the battery to the astable multivibrator circuit when there is no power supply coming from the public mains supply (NEPA) and this also disconnects automatically, immediately the supply from the AC mains is restored from the public mains supply.

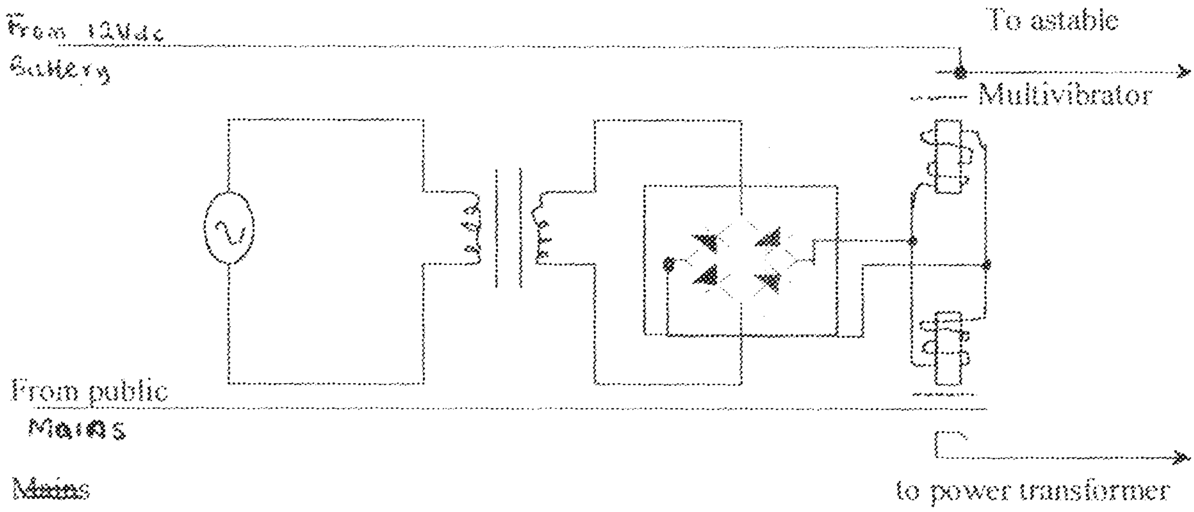


Fig 2.13: *The internal circuit of the relay switching system.*

The second relay R_{L2} also function in such a way that when there is power supply from the mains, the second relay R_{L2} is connected to the primary of the step – up inverting power transformer but when there is no supply from the mains, it will disconnect for the R_{L1} to be connected.

From the action of the two relays, it is clear then that they both functions synchronously in that both of them cannot be connected at the same time. As one is connected due to no supply from the AC mains, the other is disconnected. And as the R_{L2} is connected due to supply from the mains, then R_{L1} is disconnected.

The circuit above describes the connection as R_{L1} is connected to the astable multivibrator; the R_{L2} is connected to the output of the inverting power transformer.

2.7 THE CHARGER SYSTEM MODULE

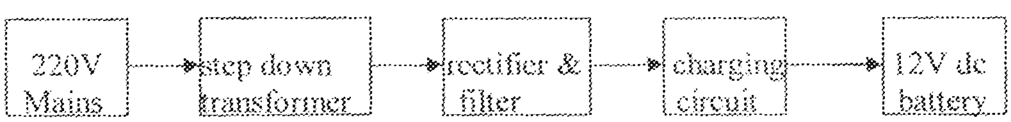


Fig 2.14:*Block diagram of the charging system module*

It is to be noted keenly here that one very interesting aspect or part of the charging section of this DC – to – AC converter is that the same power transformer that was used for the stepping up of the voltage in the inverting mode is still the same transformer that is been used so as to power the charging unit that is it is still been used to charge the 12V dc car battery whenever there is power supply from the mains.

The output is then converted to DC after it has been passed through the rectifiers circuit and through a low pass filter, and it should be carefully noted that the output would be 15V direct current (dc) because since it will charge a battery of about 12V, the output voltage must be a bit greater than the voltage of the battery so that it will be able to contain it.

The direct current (DC) output, which is 15V dc, is then used to charge the battery by connecting it through the controllable charger circuit.

The controllable charger circuit is a special switching device that stops the charging current from flowing into the battery whenever the battery is fully charged to its maximum capacity.

It is of great importance to remember here also that the controllable charging system of this project can be set to any charging level that has to be within the limit or range of the DC supply gotten from the step – down transformer.

The controllable charger circuit system has another important advantage in that it helps in the protection of the battery`s life span that is helping the DC car battery last longer.

MODE OF OPERATION OF THE CHARGER SYSTEM.

The mode of operation of this all important charger system goes thus but first of all, let me state here that the controllable charger is a very special control unit system which is entrusted with the task of regulating the rate or amount of the charging of the direct current (DC) car battery. Now the sensitive component that is saddled with the responsibility of the detection of the car battery voltage level is the zener diode, which is connected across a resistor that is been denoted as V_{R1} of rating 10kΩ which is specially used to select the amount of maximum charging voltage of the car battery before tripping OFF would occur as the voltage level exceeds it.

The resistor been labeled as R_1 in this circuit, will be acting as a current limiter. This is specially put there so that it will protect the zener diode from been destroyed by the very large current coming from the *DC* car battery as could be seen from the circuit diagram below labeled figure 2.15.

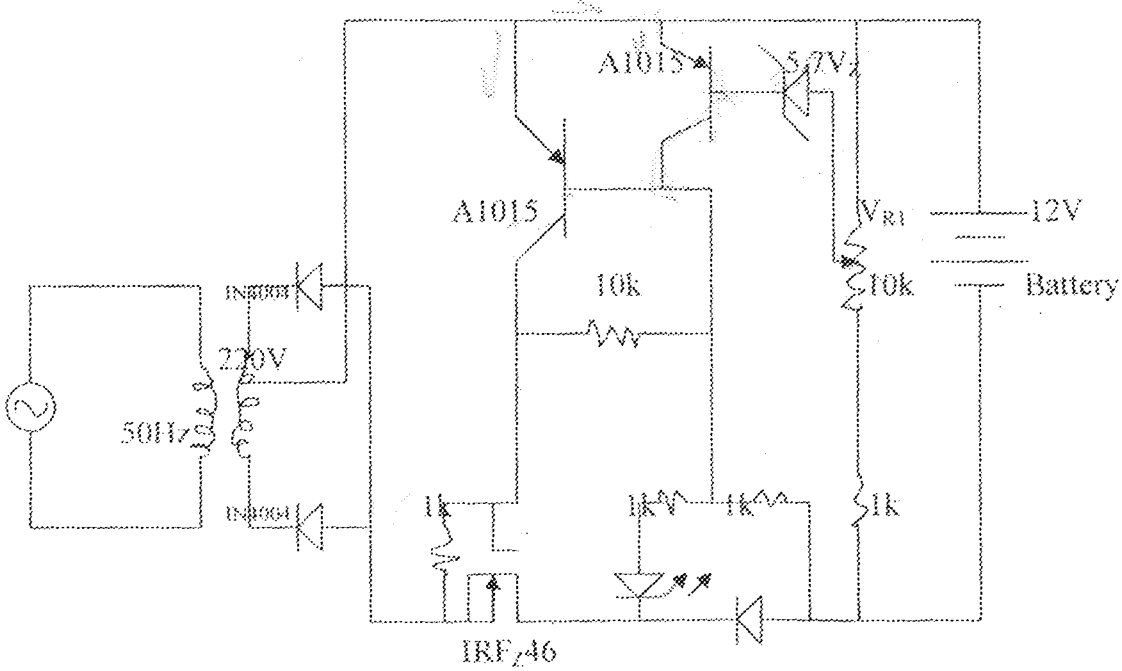


Fig 2.15: *The charger system circuit diagram.*

Taking a close look of the circuit diagram of figure 2.15 above it will be noticed that the zener diode is connected in the reverse bias polarity in such a way that when the voltage of the battery charges up to the required voltage that corresponds to the zener diode through the potential divider, then the zener diode will breakdown allowing current to flow out of the base of Q_1 (where Q_1 is the first A1015 transistor). Q_1 will then becomes saturated and the output collector current of Q_1 will flow into the base of Q_2 setting Q_2 OFF since the are connected in the Darlington pair method, as can easily be noticed from the circuit diagram of figure 2.15 above.

Going further, the output Q_2 (where Q_2 is the second A1015 transistor) will then becomes grounded because current is not flowing since it has been set OFF. This will then set the power MOSFET that is connected in series with the 15V dc source to switch OFF the charging unit. Any moment the voltage drops below the setting ON of the variable resistor by the resistor labeled R_4 (10kΩ) connected to Q_2 in reverse bias mode, this biasing process drives the Q_2 to saturation and current flows through Q_2 to fire the gate of the MOSFET which will then close the circuit and then the charging process will begin or continue again. The resistor R_5 (1kΩ) that is connecting the gate of the power MOSFET (IRFz 46) to the negative terminal of the source discharges the gate when there is no enable input.

Then the resistor labeled R_1 (1kΩ) is connected to the *LED*, which is actually acting as a current to this diode serving as an indicator. This is understood better with the diagram labeled figure 2.15.

2.8 THE BATTERY VOLTAGE LEVEL INDICATOR MODULE.

Considering critically the circuit diagram sketched below as could be seen in figure 2.16, the circuit diagram is actually meant to know when the battery voltage level drops to its bearest minimum so that the battery charging would the commence again and while doing this, the life span of the battery is saved from damage in as much as the inverter is ON. It will enable one to adjust the charger system setting so that the car battery is not been over charged.

The circuit consists of three light emitting diode (LED) indicators with the colours of yellow, green, and red with each been connected in series with a reverse bias polarity zener diode of voltage ratings 10V, 11V, and 12V respectively. In each also is connected a 100Ω resistor in series where each of the zener diodes connected is actually acting as a current limiter.

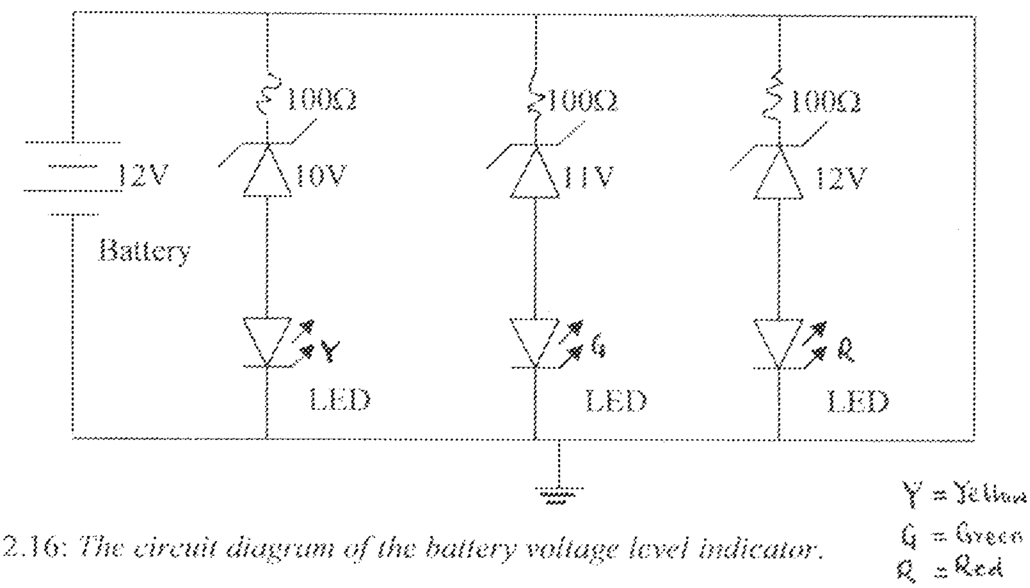


Fig 2.16: *The circuit diagram of the battery voltage level indicator.*

Whenever the battery voltage is just above the zener diode rating, the zener diode will just breakdown allowing current to flow so as to enable the light emitting diode (LED) to come ON and it goes OFF again when it is in the reverse or vice – versa. It is to be noted clearly and very well too here that this simple circuit had to be incorporated into this project in that it performs the task, which a digital multimeter will perform which is actually meant to monitor the behaviour of the DC car battery.

2.9 THE GENERAL MODE OF OPERATION OF THE ENTIRE CIRCUIT DESIGN.

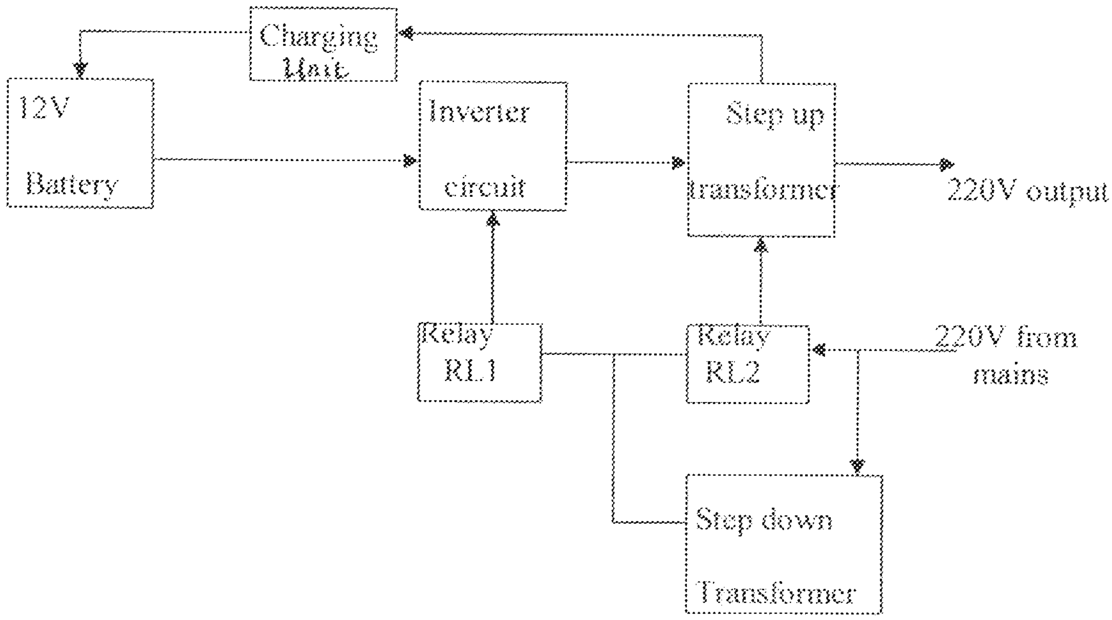


Fig 2.17: *Block diagram of the entire DC – to – AC inverter system/charger.*

The mode of operation of the entire system would be easier to understand by considering the block diagram sketched above of figure 2.17.

There are so many types and designs of the direct current to alternating current (DC – AC) inverter, but the type of design made use of in this project is the simple type designed with the use of power transistors. The astable multivibrator circuit is specially assigned with the task of generating the pulse signal at a frequency of 50Hz.

The pulse signal been generated by the astable multivibrator circuit is then used to drive the Bipolar Junction Transistors which are been connected in parallel and also of the push and pull configuration and this connection is so as to be able to get a large power output amplification so that it could drive the step – up transformer which is a center tapped type. Two relays are also used; the relays labeled R_{L1} and R_{L2} are been powered by a different transformer, which is connected to the public mains.

It is of great important to note here that this inverter is the OFF LINE type which means that when the public electric supply is in the OFF state, the relay labeled R_{L1} will connect the astable multivibrator and then the inverter circuit and already the 12V battery had begun to supply a DC voltage of about 12V dc. This then goes through the 1kVA power step-up transformer, which will then step up the voltage to about 220V ac and then the electronic gadgets to be powered will be connected at the output. Note also that the second relay labeled R_{L2} will disconnect the public mains from the output of the inverter immediately R_{L1} connects the astable multivibrator.

Then when power from the public mains is ON or restored, the relay R_{L1} will immediately disconnects the battery from the astable multivibrator as the second relay R_{L2} connects the mains directly to the output of the inverter continuity. Now while this was done, the same step-up transformer used for the inversion from 12Vdc to 220V ac will then be used as a step down transformer and steps down the voltage from 220V ac to about 15V dc. The output at the primary winding which now serves as the input due to the inverting mode, will then pass through a centre tap full wave rectifier and then the DC output will be used to charge the battery through the charging unit as could be seen from the block diagram of figure 2.17.

CHAPTER THREE

CONSTRUCTION AND TESTING

3.1 CONSTRUCTION PROCESS.

Before the construction of the project proper began, I carried out a simulation of the entire circuit in a computer with the use of an electronic work bench (EWB) to first of all ascertain the uniqueness of the circuit and if the system would be functional and of course it did.

So when all the buy lines have been made, it was time to build the required prototype of the project at hand. This began with the astable multivibrator circuit. The astable multivibrator circuit was first developed on the breadboard so as to avoid damaging the component as a result of removal if when placed on the Vero board permanently and about been removed. The output was grounded through the light emitting diode (LED) so as to view the behaviour of the astable multivibrator. The output frequency was tested using a digital multimeter to ascertain if it actually gave 50Hz.

The LED on the breadboard was later removed and then the output of the multivibrator was connected to the base of the power transistors, which were already mounted on the heat sink. The signal of the output was also tested using the digital multimeter. The 12V dc relays were then mounted on the breadboard along with the inverter and the charger circuit combined to form the expected operation. The LED of the battery voltage level indicator was also designed on the breadboard and then it was tested with a potential divider, which is been connected across a battery source so as to see that it is actually responding to the variations of the voltage level from the battery when the potential divider is been varied.

Now after the actions and responses of the relays, that is, the ability of the two relays to change from the AC mains to the battery and vice versa was tested and it was realized that the relays will come ON at the same time but will not go OFF at the same time, and this posed a big problem. This has to be corrected or modified.

3.2 MODIFICATION.

Because of the abnormalities that was noticed from the result of the preliminary test been carried out during the construction it became obvious that modifications has to be made so as to achieve the aim and objectives of the project and also make working of the project possible and to eliminate some damages which of course was imminent.

When it was clear that the two relays do not go OFF at the same time, because if this does not go OFF at the same time then whenever there is power change over, it will be noticed by the equipment since there will be delay in the change over from the public mains to car battery. This was corrected or modified when the capacitor rating was change to a lower rated type, and so this problem was solved. The rated value was changed from 2200μF; 50V to 220μF; 25V and so when it was tested in the circuit, it worked perfectly since the change over that is the response of the relays come ON and OFF at the same time and the electronic gadget used for the testing did not notice the change of power supply from the public mains to the use of car battery and vice versa.

The problem of overcharging of the 12V dc car battery was eliminated when a charger circuit was introduced in between and then the charging level was consequently controlled and the over charging of the battery was stopped. The heating up and forming of the battery electrolyte stopped and the battery started charging at normal voltage level. Also, the heating up of the LED voltage level indicator also instantly stopped when the 100Ω resistor was introduced which actually acted as a current limiting resistor to the LEDs.

Now the power transistors mounted on the heat sink was later doubled by the addition of two power transistors also connected in parallel along with the one already in the circuit. This of course improved the power output and also minimized the heat losses the whole system was re – tested again from the bread board and it worked perfectly.

3.3 FINAL CONSTRUCTION.

Since it has been cleared and confirmed that the circuit was working perfectly well on the breadboard after the due and corrective modifications that was been made to the circuit, then the whole circuit cannot remain on the breadboard since the breadboard was meant for prototyping, it has to be transferred to the veroboard permanently, therefore, the entire circuit was transferred to a very large veroboard. But before that, the final component layout was sketched on paper so as to view the appearance of the component on the veroboard for compatibility and simplicity in other not to make a mistake during the transfer and soldering on the veroboard.

Jumper wires were also used to connect in some cases where necessary and then step by step soldering was done following the sketch on paper and special care was taken to prevent short circuiting and wrong polarity of the various soldered point on the veroboard.

Now as the soldering of the inverter circuit was completed, it was tested to confirm if there was any problem using the multimeter and also to ensure there was no short circuit and that all the conductor current was properly terminated. When it was realized that it was in order, the other module that is the charger module, the charger level indicator module, was transferred too and soldered accordingly. After soldering, the final circuit was transferred to the wooding casing along with the battery and the transformer. Some perforations were made on the wooding casing so as to be enabling ventilation for the heat dissipated by the power transistors mounted on the heat sink and those from the transformer.

3.4 CONSTRUCTION OF THE CASING.

Considering the fact that this project cannot remain open, due to severe shock and so to prevent this severe electric shock which could be dangerous, the need to construct its casing.

The casing of this project has similarities with the design of conventional power DC – to – AC inverters, plywood was actually chosen and carefully designed to conform to the features of the conventional power inverters. The size of the Veroboard determined the dimension of the casing.

Allowance was also made for opening where fresh air could enter the system so as to aid proper ventilation of the power transistors, which were already mounted on the heat sink. And also to make the system accessible for easy maintenance. Space was also provided for the power transformers.

Lastly, the main reason why plywood was used for the casing was because of its light weight since the power transistors and the transformer made it heavy and so wood was chosen so that weight will be seriously reduced and in case there is any partial contact since dry wood does not shock, then the danger of electric shock was averted. Also, it allowed the veroboard to be screwed approximately on the internal section of the constructed casing so as to avoid short-circuiting. The veroboard was first drilled through appropriate points before screwing was done. They were firmly tightened at various appropriate points on the casing. It was then covered using screw to aid maintenance

3.5 CALCULATIONS.

This is the calculation that will enable one to know the value of the base resistor and feedback capacitor on the multivibrator (astable type) circuit that is needed to produce the expected power by the inverting module.

V_1=current gain of Q_1=75

V_2=current gain of Q_2 =100

Ns=secondary number of turns =1

N_p=primary number of turns =18

I_s=secondary winding current =?

I_p=primary winding current =?

Now the output power been expected in this project is 900VA at 220V, since we made use of ideal transformer.

I_s= P/V = 900/220 = 4.09A

The turns ratio of transformer $N_p:N_s$ = 1:18

We made from transformer (ideal) formular that

$I_p N_p = I_s N_s$

$I_p = I_sN_s/N_p$ = 18x4.09/1

$I_p = 73.64$

$I_p = 74A$

$I_{c2} = 74A$

$I_{b2} = I_{c2}/V2 = 74/100 = 0.74A$

$I_{b2} = 740mA.$

$I_{b1} = Ic_1/V_1 = 0.74/75$

$I_b = 0.0099$

$I_B = 9.9mA$

$R_1 = Vcc - 0.6/I_{B1} = 12\text{-}0.6/0.0099 = 1.15k\Omega$

$R_1 = 1.15k\Omega$

Now the value of the feedback capacitor that is required to generate an output signal at 50Hz is given by the formular below

$F=1/0.69(R_1C_1+R_2C2)$

But $R_1 = R_2=R$

$C_1 = C_2 = C$

So that we now have

$50 = 1/1.38(RC)$

Making C the subject we then have

$C = 1/1.38x50xR$

$C = 1/1.38x50x1150$

$C=12.6\mu F$

Since I could not get the above values of the components due to it unavailability in the market, I now replaced the calculated values of the component with its closest value of the component that will produce the required power output. The nearest value preferred wereC_1 replaced with 12.0µf and R_1 replaced with 1.2k ohms, so we then have

$F = 1/1.38x1200x12.1x10^{-6}$

$F = 49.9Hz$

$F = 50Hz$

CALCULATIONS TO DETERMINE THE CHARGING CURRENT

The charging of the battery is a very important aspect of this project, this is so that the life span of the battery can be projected and extended too. And so this part of the project write up is to calculate and therefore determine the charging current used in charging the battery. Let us consider the diagram below

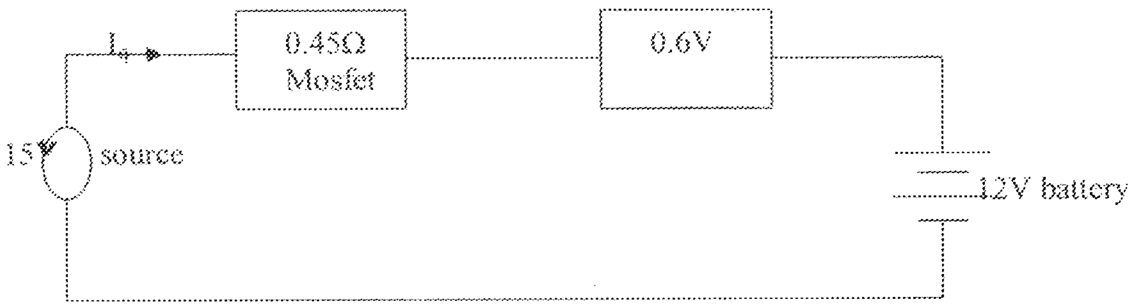


Fig: 3.02: *The charging circuit*

Before the controllable charging system trips OFF, the minimum amount of the charging current that must be attained or achieved when the car battery rated at 12V Dc is given by the calculations stated below,

$I_{min} = V_s - (V_b + V_m)/R_m$ where V_s = source voltage =15V

V_b = Battery voltage = 12V

R_m = Resistance of MOSFET = 0.45Ω

V_m = Voltage of MOSFET = 0.6V

$I_{min} = 15-(10+0.6)/0.45$

$=5.33A$

Now, if the battery runs down after usage to a voltage of 10V. All parameter remaining the same while V_B change to 10v, which the voltage of the battery dropped to we, now have using the I_{min} formular above

$I_{min} = 15-(10+0.6)/0.45 = 9.78A$

Therefore, we can conclude from here that the large value of the charging current enable the battery to charge faster while the controllable charger automatically switches the circuit OFF immediately the battery voltage returns to normal level which is actually 12v in this project.

3.6 TESTING

The testing of this project although was done intermittently during the process of construction so that double works would not be done and also to reduce the amount of stress. For the first case, while this simulation was carried out on the computer it was clear that the circuit would work conveniently with all things been equal. Now while each of the components was tested and found okay with the use of digital multimeter, the inverter circuit was first built and after building it on the veroboard and modifications made, it was tested with 6V rechargeable lantern battery and was used to power a radio cassette recorder and it worked perfectly well. The charger circuit was also built on the veroboard and the charging level indicator, and were tested independently and in each case, they worked perfectly well after the modifications were carried out as this was used to charge the rechargeable lantern battery.

When the whole system was coupled together since each was working independently, it was connected to a personal computer with the use of a car battery of 12V. This was used perfectly well to drive the computer.

As the inverting mode was working, the system (inverter and charger) was connected to an AC mains socket on the wall and switched ON and immediately, the inverting circuit was cut OFF and charging of the battery began as the system began to use the public AC mains and vice versa was also done later.

All this happened without the computer system going off which implies that the change over system was done in microseconds without the knowledge of the equipment and so the objective of the project was achieved.

The system was used to RUN the following electronic gadgets and time of working stated below

Personal computer with scanner and printer---------------------------------- 50mins

6 pieces of 60W electric bulbs-- 8hrs

Audio cassette recorder--- 6hrs.

Fluorescent tube-- 12hrs 30mins.

Television --- 2hrs 45mins.

3.7 RESULTS OBTAINED AND DISCUSSION

After whole system that is the DC – AC inverter and charger system was coupled and tested, the result obtained from the testing of this project was so amazing that the output voltage that was supposed to at a voltage of 220V, it was realized that when it was connected by R_{L1} that is in the inverting mode a very quick measurement with my digital multimeter gave about 225V and later at about 5 – 10 minutes, the voltage stabilized at

220V, and did not drop again. Infact, it was preferred to the public AC mains supply from NEPA which was actually measured also and the public mains supply was fluctuating between 180V – 200V.

And so the inverter was even supplying more than the public mains AC power supply and so the inverter was used to power the electronic gadgets without the use of voltage regulator.

3.8 PRECAUTIONS TAKEN.

Several precautions were taken in putting together this project. This was done to ensure that the system was working well with the components not damaged in the process of construction so as to maintain a low cost of production.

SOME OF THE PRECAUTIONS INCLUDES:

1. The circuit diagram was followed during the breadboard and veroboard stages of the construction.
2. The values of the circuit components though not exactly were ensured to be closed to their calculated values.
3. The correct polarity of the component used were correctly ascertained before soldering so as to prevent internal damages been done to them.
4. Proper soldering techniques were applied, stray solder were carefully removed to avoid short circuit. High grade soldering lead was used also.
5. The output voltage from the system was 220V and so before connecting any equipment I put off the system to avoid serve electric shock.
6. I made sure that all connections were tight and socket was fitting.

CHAPTER FOUR

4.1 RECOMMENDATIONS FOR IMPROVEMENT

For further improvement on this work, I wish to recommend to any student that wishes to embark on this project with the following; The student should use a larger battery voltage source so as to reduce the number of turns ratio of the step up transformer because the lower the turns ratio, the higher the efficiency and then the lower the input current and copper loss in the transformer. The student should also use integrated circuit example 555 timer since they are easier to handle. The student should also make space for the use of solar to charge the battery. The student should use automatic charge circuit instead of the controllable charger used here.

4.2 PROBLEMS ENCOUNTERED

It is undoubtedly that for such a complex project and as applied to of course all projects, that there were so many problems encountered at the course of putting this project together. Example Minna, which is where I actually carried out this project, is a poor commercial area and so getting some of these components were not really easy. Example of such component is the 1000VA step up transformer, which I had to travel to Kaduna state to purchase and the power transistors too had to be bought in Kaduna state since they were not available in Minna. And unfortunately, the 1000VA step-up transformer when brought back to Minna and tested, was not working properly and so had to return to Kaduna again for a change.

Another problem encountered mostly was that since this project has to deal with power, many of the component like LEDs and the zener diodes got spoilt or burnt at one time or the other of great concern was the same 1kva power transformer which got burnt after 8 weeks of purchase, it really got me off balance as I had to leave everything again for Kaduna to buy another one.

One other big problem was from the almighty NEPA that seizes power supply at will and so this really affected my work while doing the soldering work and of course this led me to working mid-nights when there is possibility of two or three hours of power supply daily.

4.3 SUMMARY

Electricity and power are two things that are a necessity to life since electricity is one of the backbones of development and it is central to the human experience. It is an essential element and aspect of our society and development as well, due to the ever-increasing demand for it since life would have been completely uncomfortable with out it, and therefore, working on this project was really challenging, however, it actually turned out to be interesting and very much enlightening because it exposed me so much to the generation and transmission of power and brought the course EEE 514 power electronics to my door step of understanding making it easier and therefore, drove the course home.

It was noted however, that the difference between the theoretical values and those practical values measured were partly due to human errors and approximations made in the values of the component. These errors are practically inevitable.

4.4 CONCLUSIONS.

To say that this project was concluded successfully is of course an understatement infact, if there is a better word than success; this is what should be used to qualify the outcome of this project. The design, construction and testing of a 900VA DC – AC inverter and charger and as an uninterruptible power supply (UPS) is the cheapest and most economical, to protection of electronic gadgets and equipment both at homes and in the offices. It is very cheap to maintain compared to other power generating systems or sets. It does not produce smokes since it does not involve the burning of fuels and so does not need fuelling as is been used by power generating sets. It does not produce noise and distractions, which is associated with a generating set of the same capacity. The generated noise from generating sets could be very disturbing and unbearable; this project takes care of those disadvantages and distractions.

The cost of producing this system is about #9000 naira, which is cheaper than APC 650AV, which currently sells in the market for about #25000 naira to #30000 naira or an equivalent power-rating generator, which currently sells in the market for #35000 naira or even more.

Conclusively, this project was a very interesting aspect of my academic life and worth going through by every graduating student. Infact, it met the aims and objectives of the project since it reduced cost and made life easier and as well as solve the problems associated with generating sets. In a nutshell, it was a very huge success and a project worth undergoing and ofcourse investing into.

4.5 REFERENCES.

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