DESIGN, CONSTRUCTION AND TESTING OF A 450VA DC TO AC INVERTER/UPS

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

OCTOBER 2006

DECLARATION

I, Afulike Nwabueze, declare that this work was done by me and has never been presented else where for the award of degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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(Signature & Date)

DEDICATION

To the Almighty God and the following departed souls; Mr. Solomon O. Afolike (My father) and Mr. Sylvanus O. Ekpechogu (My in-law).

ACKNOWLEDGEMENT

I thank God for sustaining me, creating and equipping the people that contributed to the success of my education.

I specially appreciate my parents; Mr. S.O Afulike and Mrs. Fanny A. Afulike for sensitizing me on the importance of education at the earliest time of my life.

I am indebted to the entire family of Mr. S.O. Ekpechogu (late) and my sister, Mrs. V.G. Ekpechogu. My profound gratitude goes to my sister, Mrs P.C .Ezigbo and her husband, Mr. F.U. Ezigbo for their supportive rolls.

I also appreciate the efforts of my brothers and sisters; Mrs. C.C. Ukachi, Mr. N.I. Afulike, Mr. A.U. Afulike, Miss Gloria N. Afulike and Mrs. Love O. Utomi. May God Bless and preserve my cousins, nephews and niece.

My special thanks goes to my supervisor, Mr. P.O. Attah, for his time in reading, scrutinizing and correcting this work. I also thank my H.O.D, Engr. M.D. Abdullahi, my level adviser, Mr. J. Kolo and all the staffs of Electrical/Computer Engineering Department.

I am grateful to the entire management and staff of News Engineering (Nig.) Ltd, Minna and Scientific Equipment Development Institute (SEDI), Enugu.

To my good friends and colleagues, God bless you as you proceed in life.

ABSTRACT

This project is aimed at producing an AC voltage from a DC voltage source(a12v dc battery). It is based on the ability of an oscillator to convert pure DC from a 12v battery, to Ac on its own with no external input signal being applied. This AC signal is modified and transformed (to increase the level).

The project is restricted to an output of 450VA, 220v AC at a frequency of 50HZ. This 450VA output can be increased by increasing the number of power MOSFET used and the transformer size and capacity. A modular design was employed in the work. the functional units were separately designed and implemented before the whole assembly. The work yielded the required result of 220v AC (at 50HZ frequency voltage) output.

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CHAPTER ONE

INTRODUCTION

This project is all about designing and constructing an a.c mains power supply back-up system (Inverter/UPS) for both homes and industries. It is basically an inveter circuit that employs automatic switching and delay circuitry.

An inverter converts a d.c input voltage to an a.c output voltage. Inverter find several applications, some of them are in variable AC motor drives, UPS, mobile AC power supplies, induction heating, e.t.c.[5]

1.1 AIMS AND OBJECTIVES

The present state of the Nigeria's power industry which ranges from voltage fluctuations, insecurity of supplies (incessant supplies) to unavailability in some areas is the primary motivator to this project. In addition, the project is aimed at:

i. Providing emergency lighting in homes, industries, e.t.c.

ii. Safeguarding sensitive equipment which may be damaged by very low/high voltages as well as voltage flunctuations

iii. Ensuring constant supply to life-saving equipment and devices in the hospitals/homes.

iv. Providing a reliable and mobile a.c power supplies in remote areas for emergency.[1]

1.2 METHODOLOGY

A modular method was employed in the design of the system. Each module was independently designed and tested before the total assembly on a breadboard. When the respective modules were tested and found okay, they were assembled on a breadboard, tested and found okay before permanently soldering on a veroboard.

The casing was designed to accommodate the transformers, the main circuit board, the switching circuit (with heat sink) and the relays. The positioning of the switch, socket, meter, light indicators was based on a standard inverter/UPS.

After the whole assembly, the system was again tested and found okay.

1.3 SCOPE OF THE PROJECT

This project is aimed at designing an inverter of any capacity ranging from 150VA, 250VA, 300VA….. to thousands of VA. The capacity is a function of:

i. The type and number of power MOSFETS used and

ii. The size and capacity of the power transformer used.

The higher the number and rating of the MOSFETS and the bigger the power transformer, the higher the capacity/rating of the inverter

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The higher the number and rating of the MOSFETS and the bigger the power transformer, the higher the capacity/rating of the inverter.

The system was also designed to operate in two modes (battery mode and mains mode) Such that when on a.c mains, the load gets its supply from a c mains. In addition, there is a charging system for the battery.

Due to some hindrances, the project was restricted to the following specifications:

i. Power output = 450VA

ii. Output voltage = 220V a.c

iii. Input voltage = 12V d c

iv. Frequency = 50HZ

1.4 SOURCES OF MATERIALS/EQUIPMENT

The materials used were sourced from the local electronic market in Minna. Most of the facilities used in designing the casing were in scientific equipment development institute. (SEDI) Enugu. Equipment for measuring and testing were from the same SEDI.

The good ideas of my colleagues should not be forgotten; the mechanical design and construction of the casing was done in assistance with some SEDI staffs.

CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

2.1 HISTORICAL BACKGROUND

As early as 1881 Marcel Deprez, inspired by experiments with arc light across d.c generator, published the first theoretical examination of HVDC (high voltage DC) power transmission. He soon put theory into practice and by 1882 he transmitted 1.5KW at 2KV over a distance of 35 miles.

The following decade witnessed the rising of alternating currents on account of the availability of transformers and the development of induction motors. This prompted the following warning by Thomas Edison in 1887; Take warning! Alternating current are dangerous, they are fit only for the electric chair.

From 1889, R. Thury continued the work of Deprez by using Dc generators in series to attain high transmission voltages. Among his many European installations, the best examples of a Dc transmission technology were that from Moutiers to Lyon with a final capacity of 20Mw at 125KV over a distance of 230km. This scheme operated at constant current and was as a reinforcement of an existing Ac system. It was probably the first recognition of Ac to Dc co-existence, as Thury himself put it. "The two systems shake hands fraternally in order to give each other help and assitance……"[8]

This A.c to D.c (or Dc to Ac) co-existence was extend by inverting dc voltage from batteries to Ac voltages for immediate powering of some household equipment and appliances.

2.2 BASIC INVERTER CIRCUIT

A basic inverter circuit should consist of the following: power supply, switching circuit, step-up transformer and oscillatory circuit.

The power supply could be solar or a battery of cells. The commonly used power supply is a battery (a dc battery). A battery of cells is a device for sroring energy, the energy stored being known as the capacity of the battery. This is usually measured in ampere hours (Ah). If, however, a battery is capable of providing current of 5A for 10 hours, it is said to have a capacity of 50Ah. Such a battery could not be expected to provide, say, a current of 10A for 5 hours[3]. The battery is a lead-acid accumulator that comes in different sizes, capacities and voltages e.g 6V 2Ah, 12V 7Ah,. e.t.c.[4]

The oscillator, which can be designed from a multivibrator, is the signal generator of an inverter. An oscillator is a special circuit that converts pure Dc to Ac or pulsating (varying) Dc on its own with no external input signal being applied. There are two major types of oscillators; sinusoidal oscillators and non sinusoidal oscillators. Sinusoidal oscillators produce a sine- shaped output signal. Non sinusoidal oscillators produce all other shaped waves, which include sawtooth, square wave and pulses[1][7].

To produce a sinusoidal waveform, an appropriate passive filter is inserted between the output transformer and the load resistor. This method of using electronic filter in inverter to produce sinusoidal wave form is acceptable for low power inverters but becomes technically less attractive for inverters with higher power ratings[1].

Many electronic systems rely heavily on the transistor's ability to act as a switch. Used as a switch, the transistor has the advantages of having no moving parts being able to operates ON and OFF at a very high rate of speed, and requiring very low driving voltages and currents in order to trigger the switching action[1].

The switching circuit of an inverter is designed from a power transistor, power MOSFETs or SCR, connected in parallel. The number determins the rating of the device.

The transformer is undaubtedly the most important of all electrical machines[3]. A transformer is a device that couples two Ac circuits magnetically rather than through any direct conductive connection and permits a "transformation" of the voltage and current between one circuit and the other[2]. In inverter design, a step-up transformer is used to increase the output of the switching circuit to the required level, mostly 12V ac to 110ac or 220ac.

2.3 BRIEF REVIEW OF PREVIOUS INVERTERS

Inverters were designed from transistors, SCR and tunnel diodes, e.t.c. Such inverters are used for low/medium outputs, high outputs and very low outputs, respectively[6]. Some of these inverters have advantage over the others, in application For example, transistorized inverters require complicated circuitry for triggering and commutation. Whereas transistors in addition to having simple control circuitry, have better switching speed, high efficiency and greater reliability[6].

All these inverters, no matter the switching device used (transistors or SCRs) make use of a basic principle as shown and explained

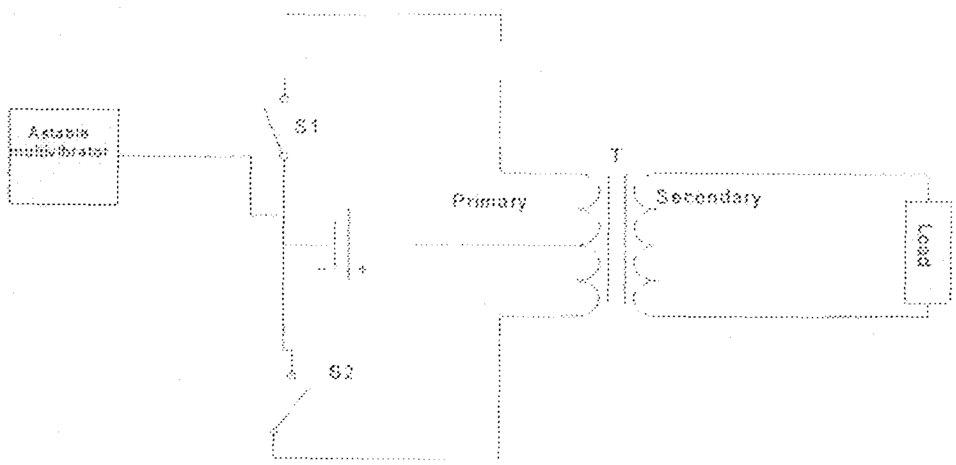


Fig 2.2 Basic inverter circuit diagram

S1 and S2 are switching devices (transistors, SCRs or tunnel diodes) which open and close alternately at regular intervals of time. The two switching devices are driven by an astable multivibrator operating at the desired frequency. When S1 is closed, the entire dc source voltage V is applied across points A and C of the transformer primary. S1 remains closed for a certain period of time after which it is cut off and S2 closes. It also remains closed for the same period of time during which the source voltage V is impressed across points B and C of the primary. S2 then opens out and S1 closes. In this way an alternating voltage is applied across the primary which induces an ac voltage in the secondary.

2.3.1 TUNNEL-DIODE INVERTER

The circuit diagram of this type of inverter is shown in fig 2.3.1. It uses germanium tunnel diode which is a two terminal negative resistance device and works on this principle without the need for any external feedback connection.

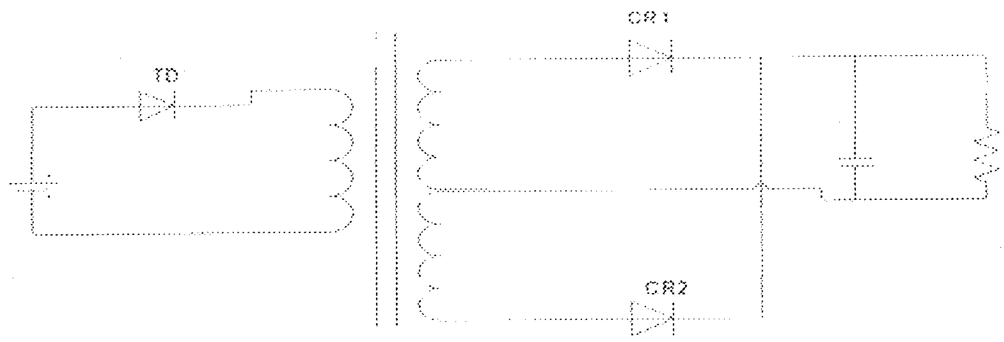


Fig 2.2.2, Single-Tunnel Diode Inverter.

2.3.2 DRIVEN TRANSISTOR INVERTERS

As the name implies these type of inverters are used for driving resistive loads. One of the common applications is driving the capacitive load of a rectifier filter circuit. When driven inverters are overloaded, they can drive loads within their power rating provided enough base drive is available so that the collector dissipation does not increase catastrophically during the starting phase. The formula used in designing the circuit for both the exciter must be matched with the drive needed at the output stage and supply the same power drive as needed by a self-excited inverter of similar output capacity. An example of a typical driven inverters using an exciter is shown in fig 2.3.2.

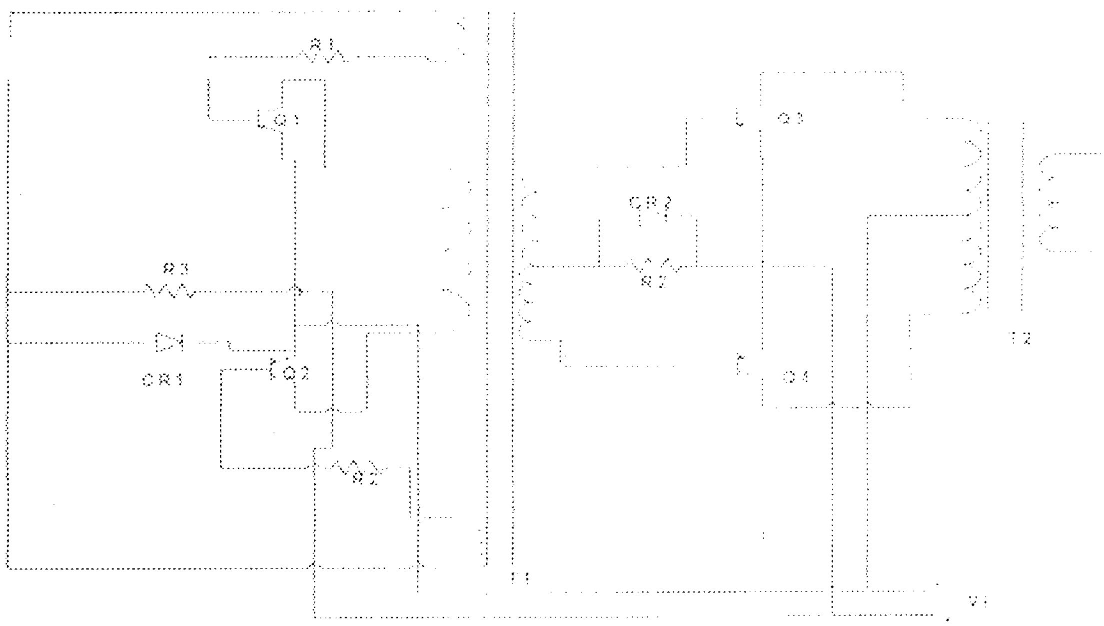


Fig 2.3.2 Typical Driven Transistor Inverter Using Saturating Transformer Exciter.

2.4 PROJECT PREVIEW

In line with the basic principle, the project is designed but with a power MOSFET as the switching device. MOSFET are good for high frequency operation, dissipates less heat unlike power transistors.

Unlike previous inverters, this design has an automatic switching circuit which switches between battery mode and mains mode operations. The project is made up of these modules described.

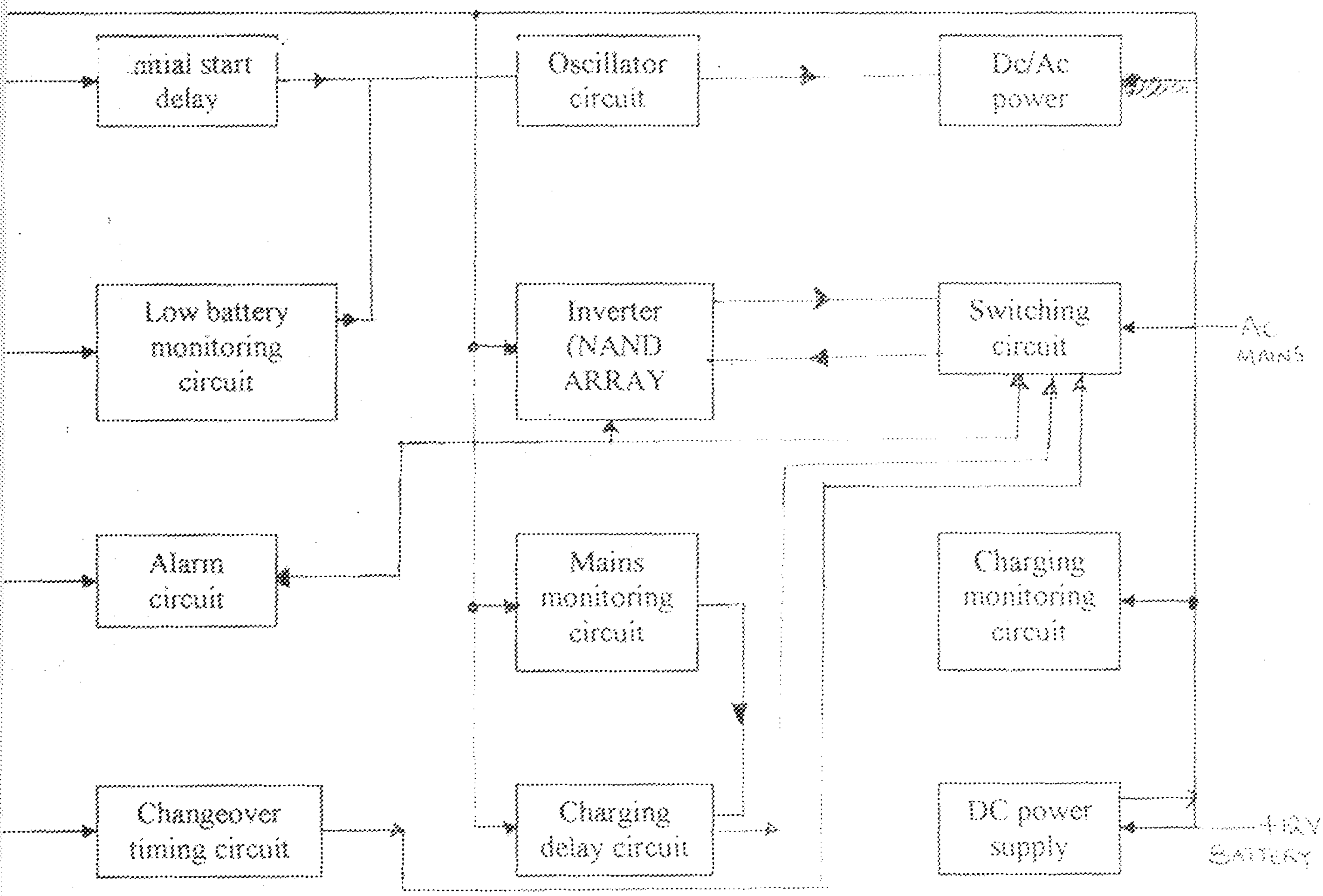


Fig 2.4: The block diagram of the 450VA DC to AC power inverter/ UPS

2.4.1 DC/AC POWER

This module consists of the power transformer, (12-0-12/220V), rectifying diodes (6A1 x 4), 12V dc battery, switching MOSFETs (IRFZ44 x 6).

The 12V d.c battery voltage which is initially converted by an a.c voltage by the oscillator is obtained at the output of the MOSFETs as 12V a.c. This voltage (12V ac) is fed to the (12-0-12V) primary of the power transformer which steps up the voltage to 220V a.c.

This module is also responsible for charging of the battery. When there is mains supply (i.e. when operating in mains mode), the power transformer steps down the 220V a.c supply to 12V a.c supply. This is rectified by the rectifying diodes and used in charging the battery.

2.4.2 INITIAL START DELAY CIRCUIT

This circuit protects the switching MOSFET from breakdown. It is designed from a 555 timer. It is designed in such a way that at initial turn, the output of the oscillator is not fed immediately to the power MOSFE.The timing is in such a way that the oscillator output is allowed to stabilize before the base voltage of the MOSFET is supplied.

2.4.3 LOW BATTERY MONITORING CIRCUIT

The design is based on an operational amplifier. It helps to monitor the level of the battery to avoid over-discharging. The operational amplifier serves as a voltage comparator. It senses the voltage of the battery and compares it with two reference voltages, (I) and II.

When the battery voltage falls below the reference voltage I, the output of the OP-Amp changes state and triggers the alarm circuit which gives an audio sound signifying "battery low". When the battery further falls to the second preset voltage (reference voltage II), the output of the second OP-Amp goes high and thus shuts down the gate voltage of the switching device (MOSFET).

This circuit in addition to prevent the battery from over-discharging also in a way helps to increase the lifespan of the battery.

2.4.4 ALARM CIRCUIT

The alarm circuit performs two operations.

i. It gives an audio sound whenever there is a blackout or on battery mode.This sounds once every 5 minutes provided the unit is on battery mode.

ii. It also sounds when the battery is low. In this case, it comes on once every second (i.e. at 1Hz).

2.4.5 CHANGEOVER TIMING CIRCUIT

This circuit was designed using 555 timer, and relays (for switching).It is a monostable circuit which delays the switching from battery to mains voltage.The circuit helps to eliminate the problem of chattering which is normally experienced due to fluctuations or partial contact on the mains voltage. This may cause the breakdown of the switching devices. With this circuit, the load is not switched to the mains until the mains voltage normalizes.

2.4.6 OSCILLATOR CIRCUIT

The oscillator circuit is a circuit with two outputs (Q and $\bar{Q}$) that switches ON and OFF (i.e. oscillates) at a particular preset frequency (in this case 50Hz). When one output is high, the other will be low, and vice versa. These outputs turn 'ON' and 'OFF" the switching devices (MOSFETS) in the 12V d.c voltage from the battery is converted to 12V a.c at the 12-0-12 turn of the power transformer. The oscillator circuit uses CD4047B as the base component.

2.4.7 INVERTER (NAND GATE) ARRAY

This circuit was designed using CD4093B, a quard 2 input NAND gate. It is just an array of NAND gates which helps in;

i. Smooth shutting down of the gate voltage of the switching devices in the Ac/Dc power.

ii. Smooth changeover from battery to mains and vice versa.

2.4.8 MAINS MONITORING CIRCUIT

This circuit was designed using an operational amplifier (LM358) as a voltage comparator.It monitors the mains voltage and compares it with a reference voltage (preset voltage). If the mains voltage is normal, it switches the load to it but if lower than the preset voltage, it remains on the battery mode (inverter).

This module takes care of all sorts of monitoring in this system: it makes sure that the line voltage does not go below or above the acceptable range of operation. The time duration from the period of switching is usually negligible such that the supply is seen as uninterruptible, hence the name UPS

2.4.9 CHARGING DELAY CIRCUIT

The circuit was designed using the 555 timer in the monostable mode. This circuit helps to delay the charging of the battery until a smooth switching from the battery to the mains is successful done.

The circuit was incorporated in the design to check and alleviate the problem associated with jamming of the mains a.c supply with the battery mode a.c supply.

CHAPTER THREE

3.0 SYSTEM DESIGN AND IMPLEMENTATION

The modular design of the inverter/UPS circuit is shown in this chapter. The circuit is broken down into six different (component) circuits namely:

i. Oscillator circuit Design

ii. Delay circuits Design (oscillator, mains and charging delay circuits).

iii. Battery condition monitoring circuit Design (Alarm and shutdown circuits)

iv. Mains monitoring circuit Design.

v. Power circuits Design

vi. Switching circuit Design

3.1 OSCILLATOR CIRCUIT DESIGN

The oscillator circuit was designed from an IC, CD4047B. This is CMOS (Complimentary Metal Oxide Semiconductor) IC. Other components of the oscillator circuit are: two transistors, four fixed resistors, one variable resistor and one ceramic capacitor.

The circuit is as shown.

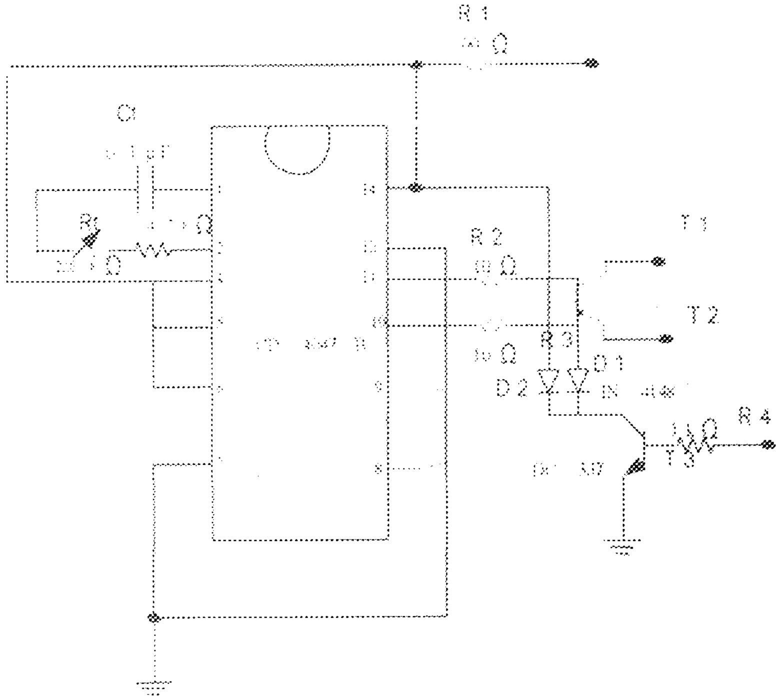


Fig 3.1 Oscillator Circuit Diagram

Resistor R_1 and capacitor Ct are the timing resistor and capacitor respectively. Their selection is such that, in conformity with the variable resistor (220K), an oscillation of frequency 50/60HZ can be obtained at the output.

Transistor T_3 and the diodes (D_1 and D_2) are used to shutdown the gate voltage of the FET when the battery voltage is very low and/or when switching from battery source to mains. The resistors R_2 and R_3 are current limiting resistors for the two transistors TR_1 and TR2. The transistors TR_1 and TR_2 are current source for the gate voltage of the FET.

Frequency of the oscillator,

$$Fosc = 1/(Rt \times Ct) \ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$Rt = (4.7k + V_{R1}),\ Ct = 0.1uF$$

The required frequency of the inverter output

$$F = Fosc/2 = 50Hz.$$

$$\longrightarrow Fosc = 100Hz.$$

Substituting for Fosc, Rt,Ct in the equation (1),

$$100Hz = 1/(4.7K + VR1)0.1uF$$

$$\underline{VR1 = 95.3k\Omega}$$

3.2 DELAY CIRCUITS

There are 3 delay circuits in the inverter/UPS circuits each serving different purpose as specified. Each delay circuit was designed from a NE555 (timer) IC. The circuits are:

i. Oscillator delay circuit

ii. Mains delay circuit and

iii. Charging delay circuit.

3.2.1 OSCILLATOR DELAY CIRCUIT

The oscillator delay circuit delays the gate voltage (turn-on voltage) of the MOSFET for a few seconds to protect the MOSFETs from surge and collision with the mains voltage at turn-on.

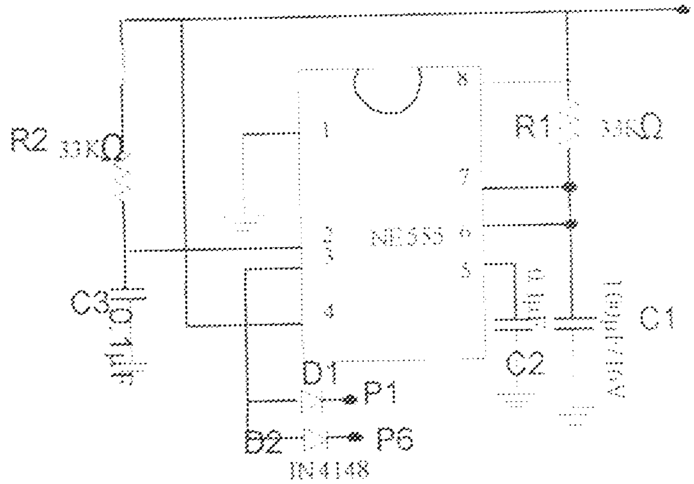


Fig 3.2 Oscillator Delay Circuit Diagram

The resistors R1 and capacitor C1 are the timing resistor and capacitor respectively.

The delay time is calculated thus:

$Td = R1C1$

$= 33 \times 10^3 \times 100 \times 10^{-6}$

$= 3.3$ seconds

R2 and C3 acts as a trigger for the circuit. At turn-on, the trigger input (i.e. Pin 2) of the IC is grounded through the capacitor C3 and then, timing cycle begins. The output of the delay circuit goes high for a period of 3.3 seconds after which there is a supply to the MOSFET.

3.2.2 MAINS DELAY CIRCUIT

This delays the changing over from battery to mains. The circuit diagram is as shown.

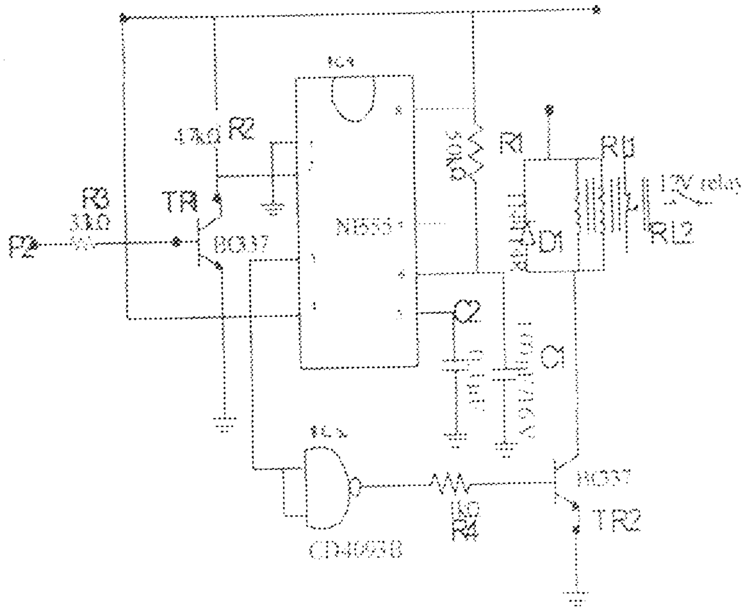


Fig 3.3 Mains Delay Circuit Diagram

The delay time of the above circuit was calculated as follows

td $= 50 \times 10^3 \times 100 \times 10^{-6}$

$= 5$ seconds.

The resister R2 is a pull-up resistor for the trigger pin of the IC1 the capacitor C2 is a voltage controlled capacitor. It prevents the monostable circuit from malfunctioning.

IC2 was used as an inverter (or a not gate) the resistor R4 is a limiting resistor for the transistor Tr2

The diode D1 serve as a feedback diode, it helps to redirect the feedback voltage from the inductor (coil) of the relay so as to prevent the transistor TR2 from breaking down as a result of the feedback voltage.

The relay RL1 switches between the mains voltage and the inverter voltage while RL2 switches ON/OFF the alarm circuit and also the not gates that helps to shut down the gate voltage of the MOSFET.

3.2.3 CHARGING DELAY CIRCUIT

This prevents the battery from charging immediately there is change over to mains. This helps to protect the power MOSFET from mains, which may result due to delay in switching of the relay. The circuit diagram is as shown.

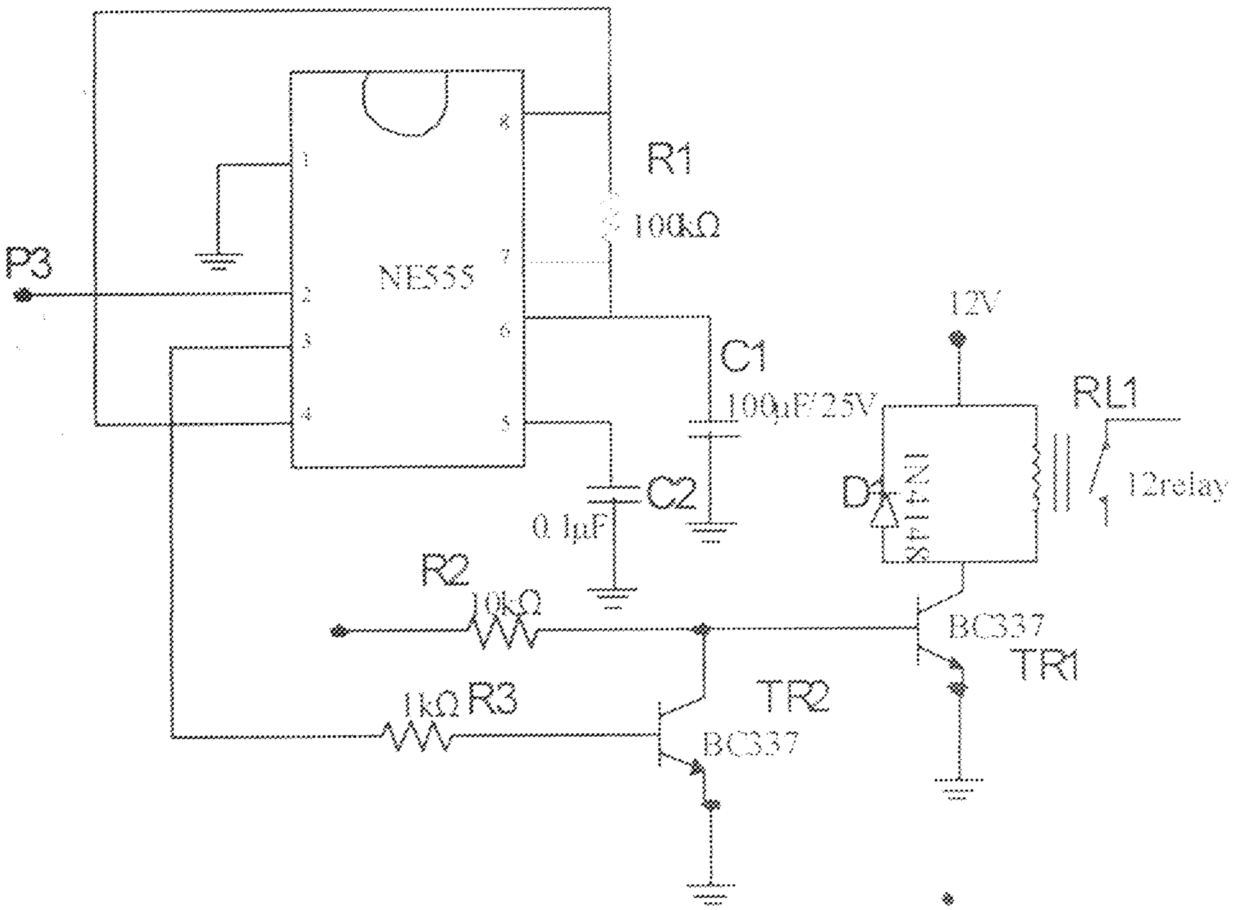


Fig 3.4 Charging Delay Circuit Diagram

The delay time of the circuit was calculated thus: $td = R_1C_1$

$= td = 100 \times 10^3 \times 100 \times 10^{-6}$

$= 10seconds$

The timing was chosen such that the gate voltage of the MOSFET is properly shut down before charging commences. From the calculation the charging commences 5 seconds after change over to mains. [td (charging) – td (mains) i.e. 10 – 5 = 5secs]

The capacitor C1 is a voltage controlled capacitor. The trigger input (i.e. pin2) of IC1 is connected to point P3

R2 and R3 are limiting resistors for the transistors TR1 and TR2 respectively.

D1 is a feedback diode. The relay RL1 switches the live terminals of the power transformer to the mains live terminal for charging to commence.

3.3 BATTERY CONDITION MONITORING CIRCUIT

The battery condition monitoring circuit can be broken into 4 parts:

i. Low battery alarm (warning) circuit

ii. Low battery shutdown circuit

iii. Charging monitoring circuit

iv. Mains monitoring circuit

3.3.1 LOW BATTERY ALARM WARNING CIRCUIT

This comprises an operational amplifier circuit and an alarm circuit The circuit diagram is as shown.

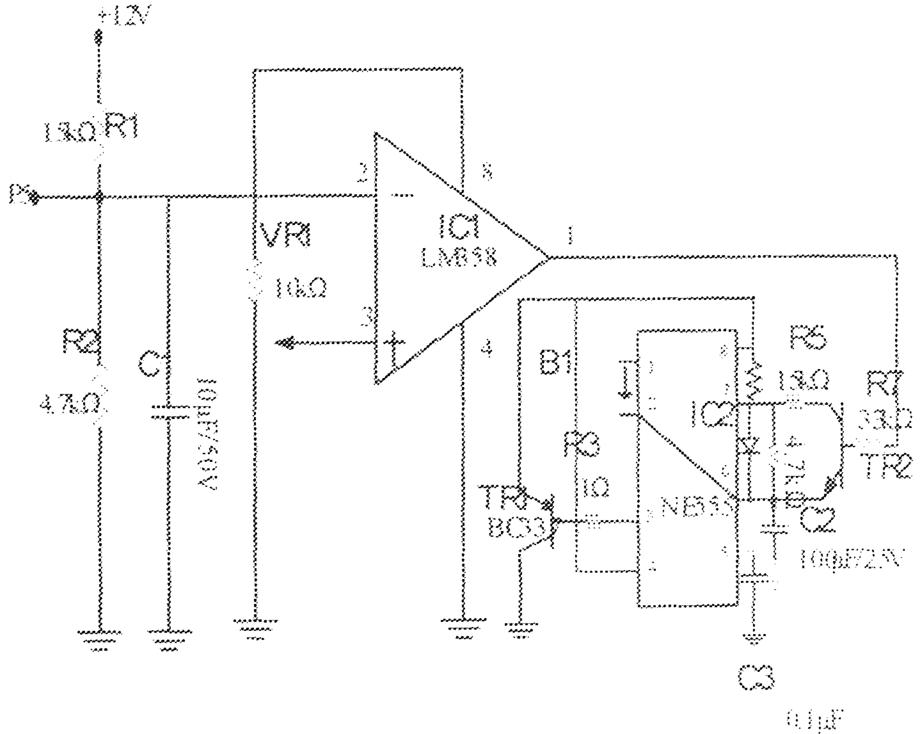


Fig 3.5 Low Battery Alarm Warning Circuit Diagram

The resistors R1 and R2 form the voltage divider network such that at a battery voltage of 10.0v a voltage of 10.00 – 0.6 = 9.4 appears across the 4.7k and 15k resistors. Where 0.6 is theforwardvoltage drop of the diode in the power circuit.

The voltage across the 4.7k is thus (9.4 x 4700) /(4700+15000)

= 2.244V

= 2.244V

Hence, the variable resistor at pin3 of the Op-Amp VR1 is set to a reference voltage o 2.24v. Thus below this voltage the output of the operational amplifier goes high therefore turning on TR2.

The alarm circuit timing was calculated thus:

Toff $= 0.693 \times 4.7 \times 106 \times 100 \times 10^{-6}$

$= 325.71$ seconds

$= 325.71$ $= 5.43$mins.

TOn $= 0.693 \times 15 \times 103 \times 100 \times 10^{-6}$

$= 1.04$seconds

From the calculations, the alarm beeps for 1 seconds in every 325.71seconds (i.e. 5.43 mins), but for a low battery voltage of about 10.0v, the transistor TR2 comes on making the beeping more frequent. The frequency of this beeping is;

$f = (1.44) / C2(R4+2R5)$

$= (1.44*1000000) / 100(15000+33000)$

$= 0.3Hz$

3.3.2 LOW BATTERY SHUTDOWN CIRCUIT

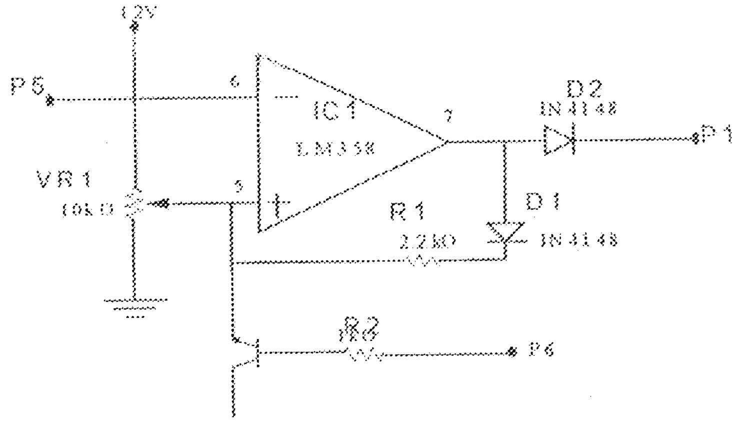


Fig 3.6 Low Battery Shut Down System

The circuit shuts down the gate voltage of the MOSFET at a battery voltage of 9.6v.The

Voltage across the resistor R1and R2 of fig 3.5 at a battery voltage of 9.6v is

$$9.6 - 0.6 = 9v$$

: voltage across R2 is

$$VR2 = (9 \times 47000) /(15000+4700)$$

$$= 2.15v.$$

The voltage at pin5 of IC1 is therefore set to a reference value of 2.15v such that below 9.6v the gate voltage is shutdown and there is no supply at the a.c output.

The resistor R1 is a feedback resistor which helps to hold the output in a high state once the battery voltage is low. This is to avoid chattering. The transistor Tr1 helps to reset the output of the op=amp at initial turn on.

3.3.3 CHARGING MONITORING CIRCUIT

This circuit monitors the level of the battery and steps its charging once 9 voltage of about 15v is attained. The circuit is shown below.

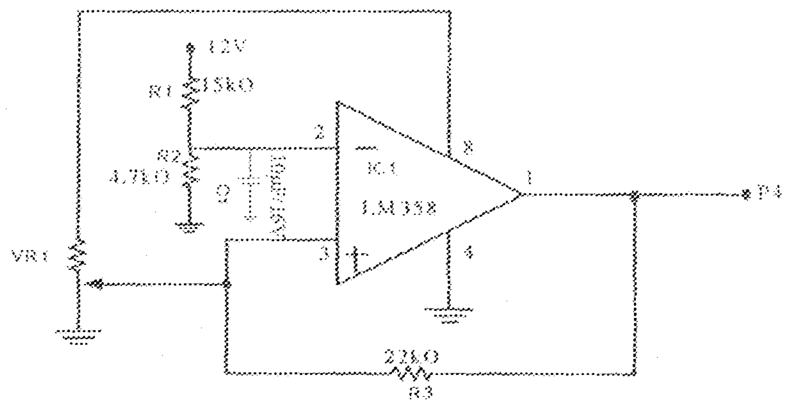


Fig 3.7 Charging Monitoring Circuit Diagram

At a battery voltage of about 15v, the voltage across 15k and 4.7k is

15 – 0.6 =14.4

Hence ,

VR2 = (4700 *14.4) /(4700+15000)

= 3.44v

Therefore, the voltage at pin3 of the IC is set to a reference value of 3.44v such that the output of the Op-Amp changes states, from high to low stopping the charging of the battery.

R3 is a feedback resistor.

3.4 MAINS MONITORING CIRCUIT

The mains monitoring circuit monitors the mains voltage and triggers the switching to mains if the mains voltage is high enough or remains on battery mode if the mains voltage is low. The circuit is as shown.

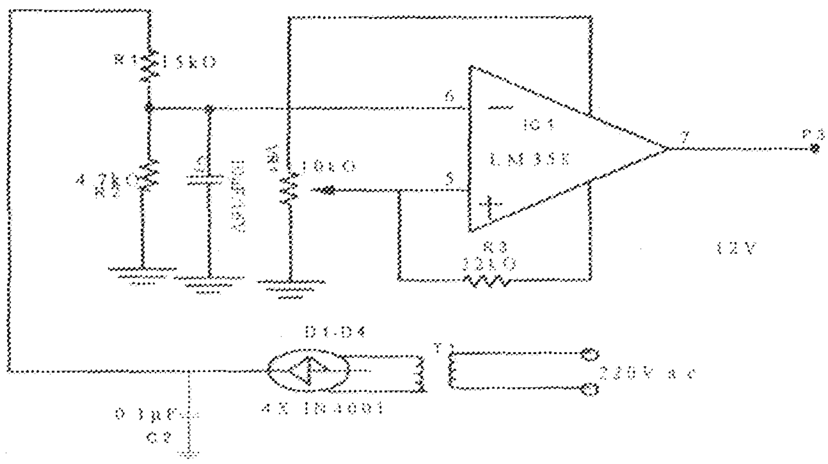


Fig 3.8 Mains Monitoring Circuit Diagram

The variable resistor VR1 was set to 2.6 such that at voltage below 170volts, the inverte remains on battery mode while at voltages higher that 170volts, the inverter output is switched t mains.

C1 and C2 are smoothing capacitors.

D1, D2, D3 and D4 are rectifying diodes, used for full wave bridge rectification.

The transformer TR1 is a step down transformer that steps the 220v ac mains supply to 12v a.c.

3.5 POWER CIRCUIT

This comprises

i. Power MOSFET and power transformer circuit

ii. Regulated power supply circuit.

3.5.1 POWER MOSFET AND POWER TRANSFORMER CIRCUIT

The circuit is as shown

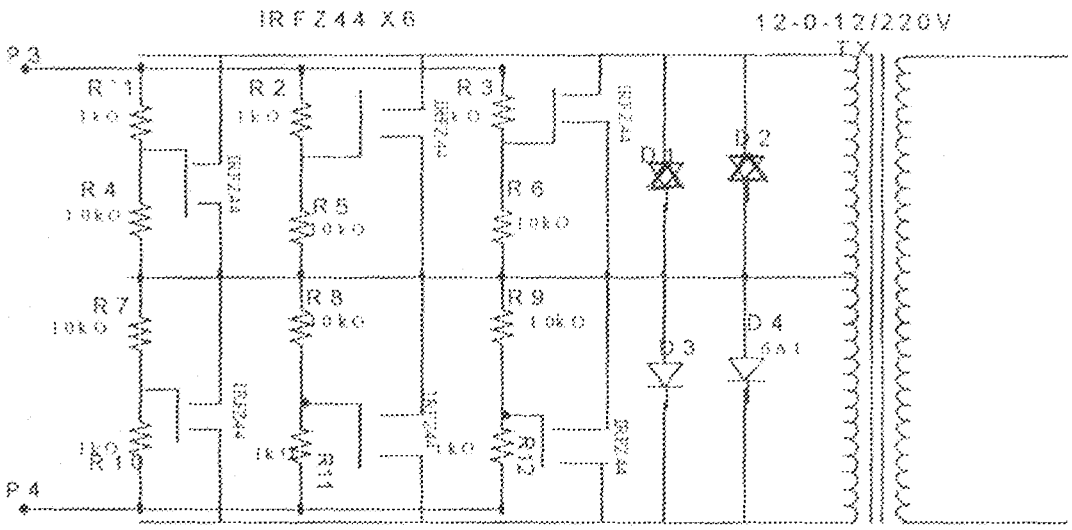


Fig 3.9 Power Circuit Diagram

Resistors R1 and R5, R2 and R6, R3 and R7, R4 and R8 and R5 and R9 are voltage dividers for the gate voltages if the power MOSFETs.

The transformer turns was calculated as follows.

Volt per turn = 0.6v

For the primary side (12 – 0 – 12v),

Number of turns = 12/0.6

= 20 turns.

For the secondary side (220v),

No. of turns = 220/0.6

= 366.7

= 367 turns.

D1 – D4 are feedback diodes. They also help in rectification for charging of the battery.

3.5.2 REGULATED POWER SUPPLY CIRCUIT

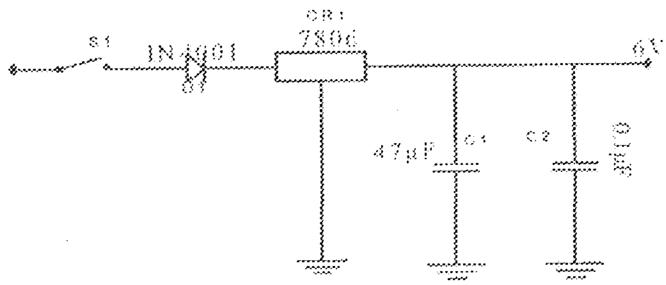


Fig 3.10 Regulated Power Supply Circuit Diagram

S1 is a power switch which when on allows power into the control board (circuit board). D1 is a rectifier diode which allows current to flow in one direction only the regulated power supply IC (CR1) ensures a 6v supply to the control board.

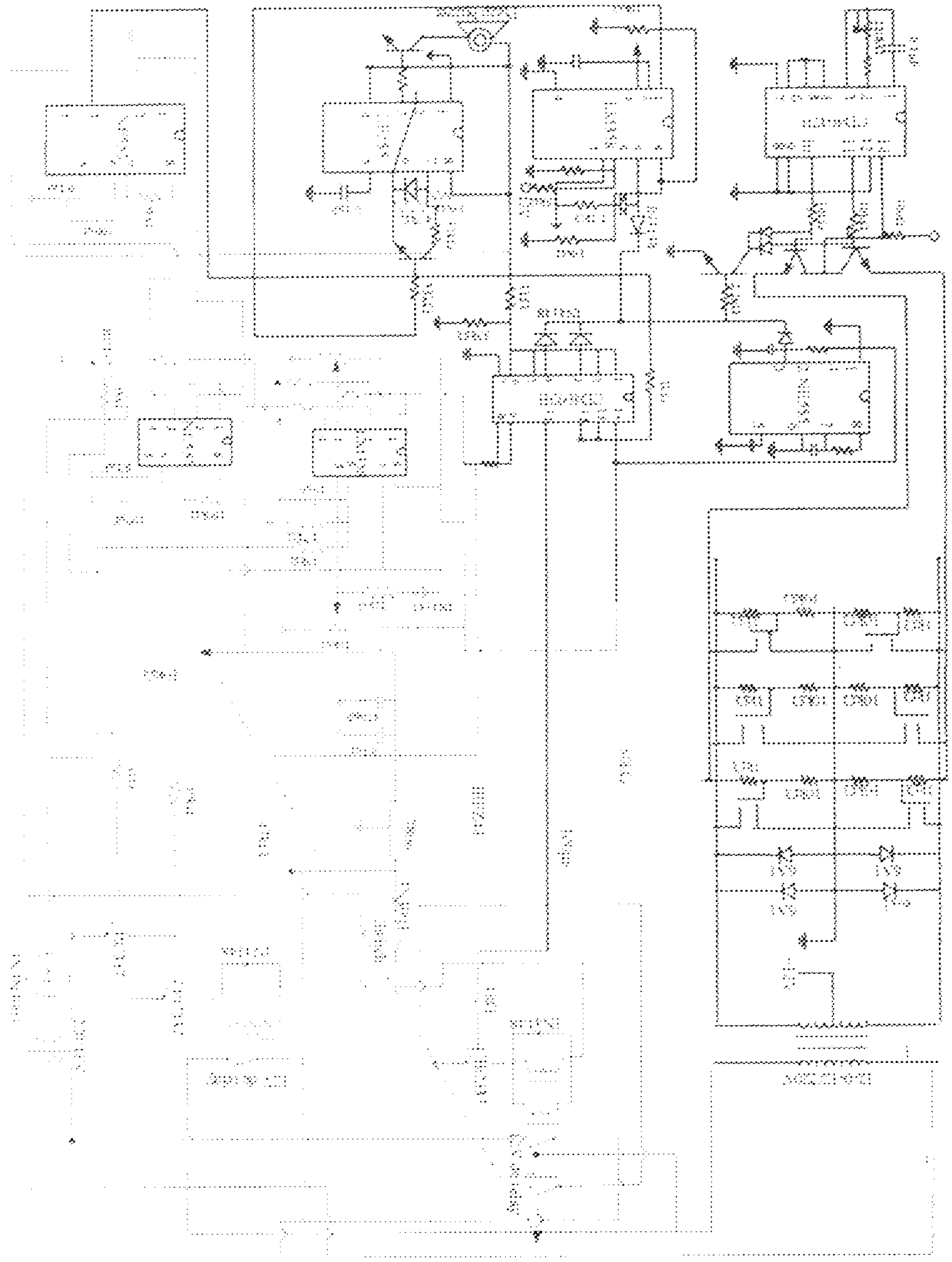
C1 and c2 are smoothing capacitors, they help to remove spikes whenever there is a fluctuation in voltage.

3.6 COMPLETE CIRCUIT DIAGRAM

The modular parts of the circuit are assembled to obtain the complete circuit diagram as shown below. Also inclusive in the complete circuit diagram is the power sources (a.c mains supply and the d.c (12v) battery).

With this, the relationship between the operational blocks (modules) can be easily seen.

Also inclusive in the complete circuit is the automatic changeover switching circuit, implemented using 3 12v dc relays.



CHAPTER FOUR

4.1 TESTING

The following tests were carried out on the project:

i. Continuity / short circuit tests using a multimeter.

ii. Oscillator output test using oscilloscope

iii. System output test on no load and on load.

These tests are summarized below.

- The circuit board was visually inspected after soldering.
- A multimeter was used to test for continuity and short circuit.
- The oscillator output was tested using an oscilloscope.
- After assembly of the components inside the casing, the system was once more inspected and tested for continuity.
- The casing was then closed. The system tested for any short circuit with the casing.
- The power supply cables (both 12vdc battery supply and 220v a.c power supply) were tested for continuity.
- The system was then supplied with a 12V d.c voltage from the battery and the output tested with an oscilloscope, as well as a voltmeter to confirm.
- smaller load (about 40w) was then connected to the system and later increased.

4.2 RESULTS

The tests' result can be summarized under the following headings:

i. Continuity / short circuit tests result.

ii. Oscillator output test result iii. System output test results

4.2.1 CONTINUITY / SHORT CIRCUIT TESTS RESULT

From the tests, non of the paths was found short-circuited and the conducting paths / lines were continuous.

4.2.2 OSCILLATOR OUTPUT TEST RESULT

A wave oscillating at a 50HZ frequency was observed on the oscilloscope. The peak values of the waveform were found to be +6v and -6v, on 12v d.c supply.

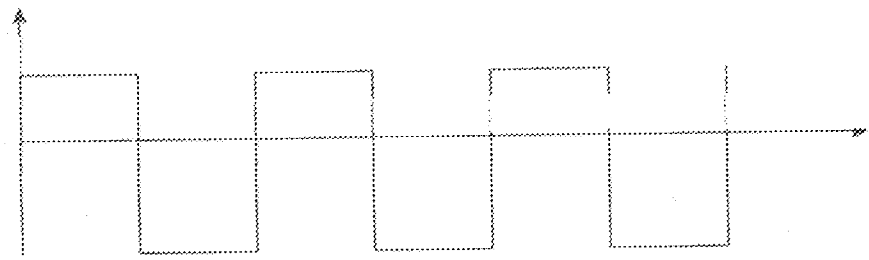


Fig 4.1 Oscillator Output Wave Form

4.2.3 SYSTEM OUTPUT TEST RESULT

The result can be summarized as thus :

- Voltage = 220v a.c
- Frequency = 50HZ
- The system also carried a substantial amount of load.

4.3 DISCUSSION OF RESULT

The result obtained from the project is very satisfactory. The primary aim of obtaining a 220v a.c from a 12v d.c battery was achieved. The carefulness during the soldering process made the system to be free from short circuits. Also the insulating wood used to mount the heating sink prevented short circuit between the circuit and the casing.

4.4 SHORTCOMINGS/LIMITATIONS

Although the project is a success,

(i) The hum from the step-up transformer constitutes a nuisance

(ii) Unavailability of some facilities to my disposal e.g. machinery for the casing design, affected the running cost.

(iii) Scarcity of the originals of electronic components in the local market also affected the cost as well as the execution time of the project.

Therefore, the laminations of the step-up transformer should be well and tightly packed to prevent the hum. The originals of the components should be sought as this would affect the performance of the circuit.

4.5 TROUBLE SHOOTING GUIDE

Although other faults may occur, the following major faults are listed and the troubleshooting guide outlined.

i. "No output" fault

ii. Battery not charging

iii. Alarm not sounding

iv. 'Output' only on mains mode

NO OUTPUT

i. When there is no output on battery and mains mode (i.e system total down), check the regulator.

ii. When on battery mode and there is no output, the following should be suspected and checked (in sequence).

- The fuse
- The power MOSFETS
- The oscillator circuit
- The oscillator delay circuit , NE555 timer
- The NAND gate, CD4093

BATTERY NOT CHARGING

- Check the mains monitoring circuit
- Check the charging delay circuit
- Check the relay, RL1

ALARM NOT SOUNDING

- Check the alarm circuit

OUTPUT 'ONLY' ON MAINS MODE

- Check the relay, RL2.
- Check the battery.

Faults may occur from other components associated with the 'key' circuits therefore, the person carrying out the troubleshooting should take time to test the components. The guide is just to narrow down the faults to a particular block.

CHAPTER FIVE

5.1 SUMMARY

An inverter can be designed and constructed with knowledge of its basic principle of operation. Selection of the components especially switching semiconductors should be based on their characteristics, reliability and expected performance. Hence, one should have good knowledge of the semiconductor to be used.

The switching semiconductor (MOSFETS) as well as the size (and capacity) of the transformer determines the wattage the inverter can supply

5.2 ACHIEVEMENTS

- After the whole assembly, a 12v d.c input voltage, from a battery, gave an output of 220v a.c at the output terminal.
- The frequency of the output was found to be 50HZ.
- The project was used to power a television set, CD player, lighting and fan points, comfortably for 30mins using a 7Ah capacity battery.

5.3 PROBLEMS ENCOUNTERED

Everything did not go smoothly in the course of this project. The following problems were encountered ;

- Constant burning of the oscillator (CD 4047B), until a current limiting resistor of 100 was to limit the VCC of the CD4047B IC..
- Inability to get the exact values of some components in the local market.

- The humming of the step-up transformer, which constitutes a nuisance.
- Unavailability of some facilities, equipment needed for the construction, especially the casing.

5.4 SUGGESTION/RECOMMENDATION

i. An improvement on the output power is suggested. This is simply by increasing the number of power MOSFETS and,the capacity and size of the output transformer

ii. A further work on solar powered inverter is also recommended to alleviate the problem of charging the battery as a result of outages.

iii. The device needs no fueling, is noiseless, has no environmental pollution, and also quick in starting. It is also environment friendly and requires no running cost I therefore recommend it as a supplement to the mains power supply.

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APPENDIX

Configuration of the ICS

[A] CD4047B → [redacted]

Description: IC- CMOS HV Monostable / Astable Multivibrator

V_{DD}= 3V to 15V

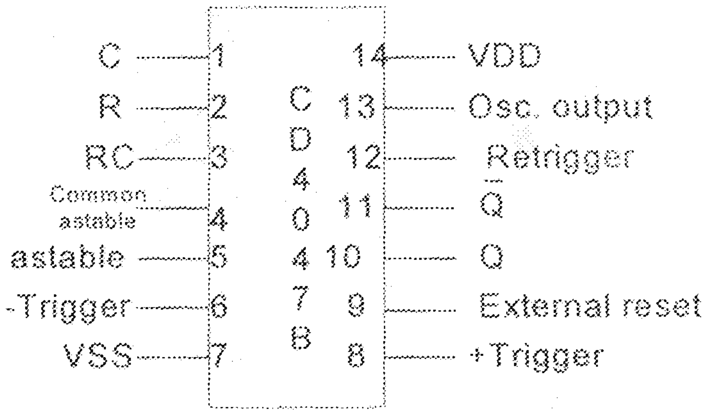

Fig. A: pin configuration of CD4047B IC

[B] LM358

Description: Dual low power operational Amplifier

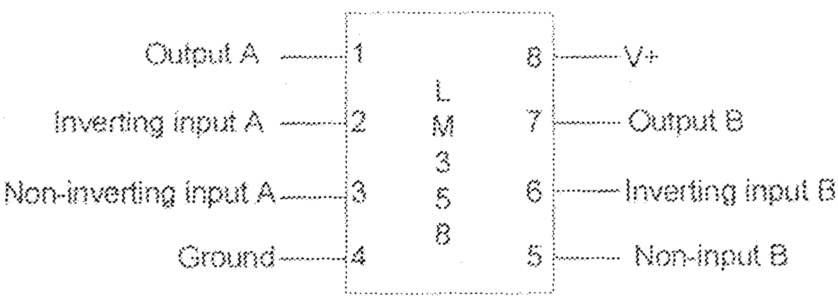

Fig B: pin configuration of LM358 IC

[C] NE555

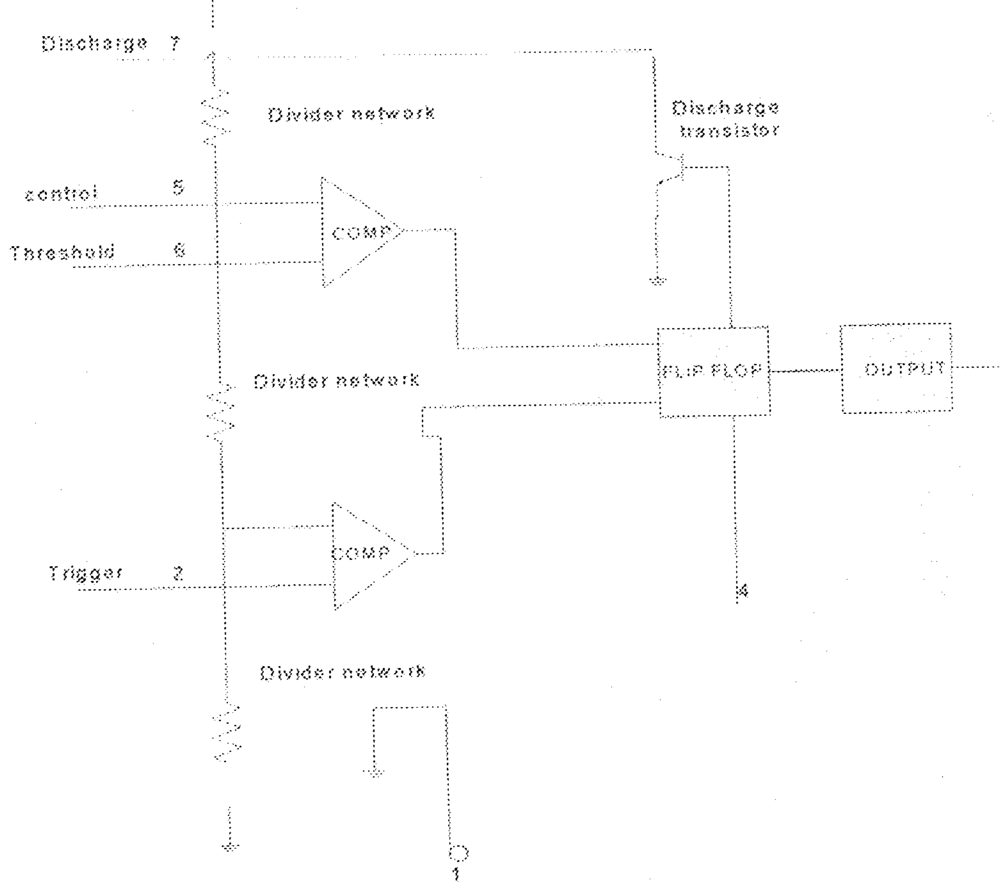

Fig c: Functional block diagram of the NE555 IC Timer

[D] CD 4093B

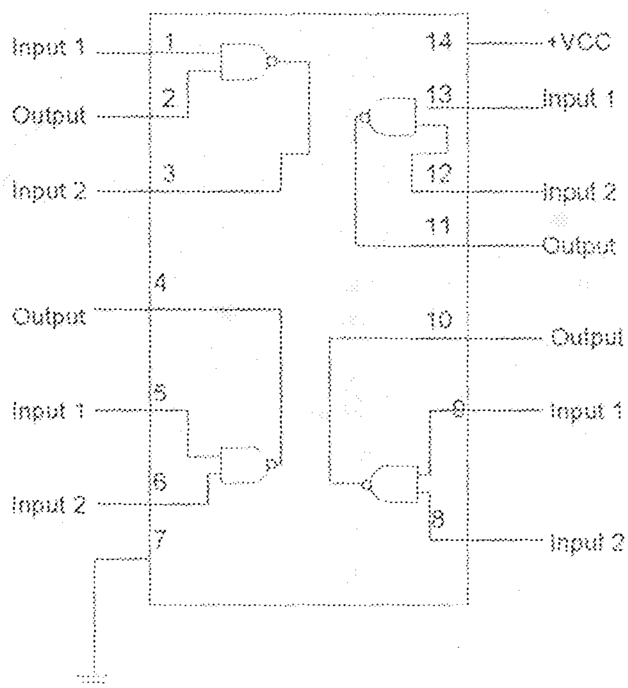

Fig D : pin configuration of CD 4093B IC

[9], [11]