DESIGN AND CONSTRUCTION OF 500VA INVERTER WITH AUTOMATIC SHUT DOWN TIMER

(U. P. S.)

BY

OPARANDU CHUKWUMA E.
(98/7751EE)

DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY MI

SEPTEMBER 2003

CERTIFICATION

This is to certify that this project titled 'design and construction of a 500VA inverter (U. P. S) with automatic shut down timer' was carried out by Oparandu Chukwuma E. for the award of a bachelor degree in engineering (B. Eng.) in the department of Electrical and Computer Engineering , Federal University of Technology Minna, Niger State.

Engr. M. S. Ahmed
(Project Supervisor)

17-10-2003
Sign and Date

Engr. M. N. Nwohu
(Head of Department)

29/4/04
Sign and Date

External Examiner

Sign and Date

ACKNOWLEDGEMENT

I am grateful to almighty God for his infinite mercy and strength that kept me throughout my stay in the university. Also the contributions of my guardians especially Mr. & Mrs. *EDMUND OPARANDU.* to the success of this work, and also acknowledge the moral and financial support from my sister Nkeiru Oparandu.

I am also grateful to all members and staff of the department of Electrical/Computer Engineering, Federal University of Technology Minna, Niger State.

Finally, my regards to my supervisor Engr. M. S. Ahmed for his devoted supervision and direction throughout my construction and write up.

Thank you sir.

DEDICATION

This project work is dedicated to the glory of God Almighty for his strength, guidance and protection over me.

ABSTRACT

This report is a concise and explicit documentation on the stage-by stage design, analysis and construction of a 500VA inverter powered by a 12V d.c battery to provide back up power for uninterrupted power supply to consumer equipments. The inverter converts the 12V d.c source into alternating current and as well amplifies the output to 240V a.c.
The 12V d.c battery is an external power source, which is automatically charged by a charging circuit incorporated into the design of the system. The overall system design is therefore a compact assembly that can provide back up power automatically, to commensurate for system power interruption or outages.

TABLE OF CONTENTS

CHAPTER ONE

GENERAL INTRODUCTION

1.0 INTRODUCTION

In recent years, the field of power electronics has experienced a large growth due to the advancement of microelectronic application technology. These advances has led to the development of linear integrated circuits and digital signal processors in power electronics systems, thereby providing the most effective means of achieving efficient energy utilization. One of such application is the uninterrupted power supply system.

However, the distribution of electrical energy to consumer premises is such that there is no guaranty of continuous power supply to consumer equipment. Situations that lead to interruption in mains power supply or total system failure arise, such as;

(a) Over voltages and under voltage condition

(b) Spikes and surges

(c) Complete power outages due to various types of associated faults on the system, etc.

It is therefore, necessary to design a system that will provide efficient backup power with utmost reliability to consumer electronic services, especially in areas such as information storage and processing using computers; emergency and highly sensitive environments requiring power such as the hospitals, airports etc. such a system is designed to have the capability of monitoring the mains voltage in case of the situation listed above arising by switching control automatically or when needed. The system will tolerate varieties from nominal voltage within safe levels ensuring that there is no violation of this margin by thee mains voltage supply system. This therefore will adequately provide perfection for various critical electronic applications where uninterrupted power supply is of primary concern.

Summarily, the UPS system is composed of three major parts namely:

- INVERTER
- SWITCHING CONTROL SYSTEM
- BATTERY CHARGING SYSTEM

1.1. LITERATURE REVIEW.

The uninterrupted power supply systems are built to improve the quality and availability of a.c powered equipment.

In other to achieve this, the system must accept input a.c power and provide an output, which has three basic enhancements:

a) Power quality improvement

b) Power supply speculation

c) Backup power source.

The power quality effects, which may be improved by the U.P.S system, include noise, spikes and sags etc.

An uninterrupted power supply system provides redundant power by supplying the load with a primary source and then provides a backup power source in case of failure of the primary source.

The above can be achieved through a circuit that is known as the INVERTER. Several discrete semiconductor devices such as transistors (BJT), MOSFETs, silicon controlled rectifiers etc. which are capable of switching two outputs from stable (free-running) multivibrator, which are used to implement the inverter circuit. The output of the multivibrator is usually of a square wave pulse. These pulses are amplified; transformed and passed through a step-up transformer, which steps up the voltage to the required 220V.

The battery charger incorporated in the design charges the battery and maintains the battery at Trickle charge level thereby preventing the battery from self-discharge if left idle for a long period.

Several control and switching circuits were also incorporated into the system to carry out live monitoring function and carry out automatic switching.

Most uninterrupted power supply units/systems found in the market today provide uninterrupted power to consumer products, hospitals and areas where power supply need not be interrupted. But the world we live in does not usually accommodate ideal situations. Hence, situations are bound to occur such that the time lapse for the backup source to provide backup power expires, without an available a.c power to recharge the battery. In this case, the backup source can fail without warning to the user of electrical power. This can be in periods where such failure without warning could be dangerous.

Hence, we have come up with an additional sub-unit of system as an enhancement to existing uninterrupted power supply system. This circuit, which we coined 'the automatic shutdown timer circuit' gives the user a pre-shutdown alarm, with an added digital display which is calibrated electronically to count down for 5 minutes. During this time the user can take time to prepare for power failure.

1.2 PROJECT OUTLINE

The inverter (UPS) unit described in this project is subdivided into four sections.

The report opens with general introduction as chapter one. Chapter two and three deal with design, analysis and construction, testing and results. Chapter four finally, is discussion recommendation and conclusion.

1.3. PROJECT OBJECTIVE AND MOTIVATION

The design and construction of the 500va inverter was done with one aim in mind: being to ensure security of supply to consumer equipment.

Since backup systems were seen to fail with time prior to the restoration of original power supply, it is therefore necessary that the user of such backup system is not taken unawares. Hence the project is designed such that the user is warned prior to shutdown and by so doing ensuring the protection of the backup source, consumer equipment and supply.

CHAPTER TWO

ANALYSIS AND DESIGN

2.0. PRINCIPLE OF OPERATION

The 500VA inverter (UPS) with automatic shutdown timer has a simple but unique mode of operation, which involves a series of monitoring control logic circuits. The system uses the switching action of relays to achieve alternate and simultaneous switching operation.

When there is power supply from the utility supply system, the system through a bypass is directly connected to the output of the supply load. In this case, the system is placed on STANDBY. Using a manual ON/OFF switch, the standby state could be a 'HOT' standby that enables the system to switch automatically to UPS (inverter) mode or a 'COLD' standby which allows the user to manually switch over to inverter in the event of a power outage from the utility power supply.

The monitoring control logic unit senses the line voltage via the relay coil RLA1, connected in series to the input a.c. line voltage, this same relay switches four points simultaneously: RLA1A (Normally Closed) switch connected to the inverter and RLA1B (Normally Open) switch connecting to the charging unit to the winding to the output transformer. The system works such that when RLA1 coil in the power supply monitoring control senses current, it becomes energized, closing the Normally Open RLA1C connecting the utility power supply directly to the output of the system, which feeds the load, Closing RLA1B which connects the charging units secondary winding to the winding of the output transformer supply primary to it begins charging the battery;

and opening RLA1A Normally Closed switch connecting the inverter stage oscillator circuit to the battery.

On the failure of the power supply or under voltage, the sensing coil of the RLA1 becomes de-energized. A reverse switching occurs, hence RLA1B and RLA1C opens while RLA1A closes, thereby initiating inverter operations which converts the d.c supply from the battery to a square wave sinusoidal a.c supply which is amplified and sent to the output through a 12V/240V transformer.

A control logic unit also monitors the charging unit in order to prevent over charging of the battery. This circuit employs the use of a comparator to compare the battery minimum charge voltage which a preset value which is at the inverting input of the operational amplifier. When the batter voltage at the non-inverting input of the operational amplifier exceeds the preset value, a HIGH output from the operational amplifier will fire the gate of the thyristor which latches on produce a current in the anode that energizes the coil of a relay RLA2.this relay coil controls the Normally Closed switch connected in series with the lead from the charging unit to the positive terminal of the battery. The thyristor latch remains in this state until there is a change in anode current.

The automatic shutdown timer circuit was integrated into the design to monitor the battery discharge and voltage level. This is to avoid the placing of unnecessary load on the battery below its rated minimum battery supply voltage. The timeout display also helps to warn the user of the system before it shuts down the supply as a safe guard. The system functions such that a drop in battery voltage below the minimum will activate a BUZZER alerting the user that the battery voltage is low. Almost simultaneously, the timer is calibrated using counters and set to count down sixty seconds for each count for 5 minutes. It counts from five down to one and at the zero count; it automatically shuts off the battery supply to the oscillator, by supplying current to a relay coil RLA3 that switches off a normally closed switch (N/C) RLA3 along the supply line to the battery.

The design concept adopted consists of the various units or sub-unit of the inverter (UPS) that are designed, constructed and tested separately on their own.

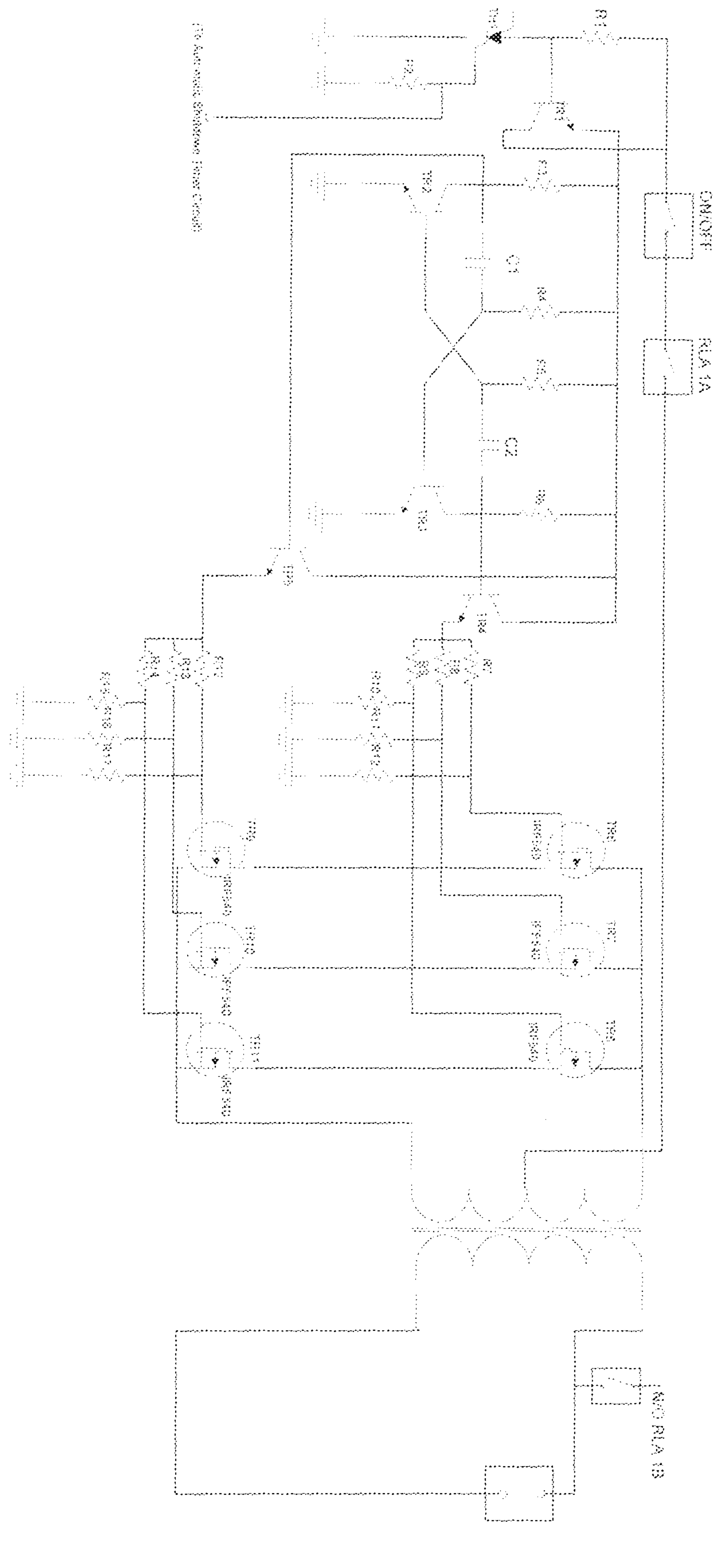
2.1 INVERTER UNIT

This is the sub-unit that converts direct current (D.C) voltage to alternating current (A.C) voltage, which determines the magnitude and frequency of the output voltage, frequency of fluctuations transients present on the utility power system.

The inverter unit incorporates the use of an oscillator, which generates the required ac output frequently constructed with components that exhibit negative resistance characteristics.

The metal oxide semi-conductor field effect transistors (MOSFETs) were used for the design due to some of its advantages over other transistorized circuits. The MOSFETs was operated in its ON and OFF mode to amplify and switch the primary side of the step-up transformer. It is equally important to note that the model of MOSFETs chosen was able to source out the right quantity of current from the battery that the load actually requires.

The problem of stability was dealt with by using enough MOSFETs so that the power equation or power law (Pin=Pout) will always be maintained. Once this law is obeyed, the output voltage will always be maintained constant at 240V at any point in time. The diagram in Fig.2.1 illustrates an inverter.


R1
R2
R3
R4
C1
C2
ON/OFF
RLA 1A
N/O RLA 1B

2.11 MULTIVIBRATOR FUNDAMENTALS

These devices are very useful as pulse generating, storing and counting circuits. It is a two-stage amplifier with positive feedback from the output of one amplifier to the input of the other. This feedback is supplied in such a manner that one transistor is driven to saturation and the other to cut-off.

There are various uses of the multivibrator which includes, as square wave and pulse generators; as frequency dividers; as saw tooth generators; as memory elements in computers and in radar and TV circuits.

2.12 TYPES OF MULTIVIBRATORS

There are three basic types of multivibrators distinguished by the type of coupling network employed.

i. Astable multivibrator
ii. Monostable multivibrator
iii. Bistable multivibrator

The first type is the non-driven type and was used in the design of the oscillator circuit. It is also called the free-running relation oscillator. The astable multivibrator has no stable state but it keeps oscillating continuously on its own without any external excitation. In this circuit, neither of the two transistors reaches a stable state such that when one is ON, the other is OFF and continues as such at a rate depending on the RC time constant in the circuit.

2.13 PARALLELING POWER MOSFETS IN SWITCHING APPLICATIONS

In most applications, the most beneficial characteristics of the power MOSFETs is its ability to be paralleled to increase current condition and power switching capabilities. Current sharing among devices is important in all of the models in which MOSFETs may conduct current. These models are:

i. Fully "ON" during static conditions.
ii. Switching applications including transient (turn ON and turn OFF) and pulsed conditions
iii. Applications in which Drain Source diode will conduct current.
iv. Linear Applications.

2.14 STATIC CURRENT SHARING DESIGN CONSIDERATION

Although increasing junction temperature raises the ON resistance and the condition losses of the power MOSFETs, definite benefits are attributed to the positive temperature coefficient of the ON resistance r_{DS} (ON). If a portion of the chip begins to log current, the localized temperature will increase, causing a corresponding increase the r_{DS} (ON) of that portion of the chip, and current will shift away from the device (less active portion dies). The increase in r_{DS} (ON) influences on the degree of current sharing which should not be over estimated.

In the power MOSFETs, the current sharing mechanism is not triggered simply by high temperature, but by difference between the low and high r_{DS} (ON) devices. Due to the generally small thermal coefficient of r_{DS} (ON), the difference in junction temperature sometimes must be sustained to attain a high degree of current sharing.

Unless devices are matched for identical ON-resistances, there will be at least a slight mismatch in their individual drain currents. The worst situation is obviously the paralleling of devices with the widest variation in r_{DS} (ON).

2.15 COMPARISON OF POWER MOSFET AND BIPOLAR POWER TRANSISTORS

It is highly predictable that in near future power MOSFETs will, in many applications gradually replace power bipolar devices due to numerous advantages it offers.

The table below lists the differences between power MOSFET and bipolar transistors.

METAL OXIDE SEMICONDUCTOR <u>MOSFET</u>	**BIPOLAR JUNCTION TRANSISTOR** <u>BJT</u>
Majority carrier device	Minority carrier device
High switching speeds, less temperature sensitive	Low switching speed, less temperature sensitive
Drift current (Fast)	Diffusion current (Slow)
Voltage driven	Current driven
Pure capacitive input impedance; no direct current required	Low input impedance; direct current required
Simple device circuitry	Complex device circuitry resulting from high base requirement
No thermal running	There is thermal running
Negative temperature coefficient on	Positive temperature coefficient on

resistance	collector current
Devices can be paralleled with some precautions	Devices cannot be easily paralleled because of matching problems
Low transconductance	High transconductance

2.20 BATTERY CHARGING SYSTEM

The battery charger is the next sub-system of the inverter (UPS). It consists of the utility monitoring control circuit, the battery charging control circuit and the charging unit. This section actually supplies power to the load when the main power has failed. It equally functions in such a way that when power is restored, it then replaces the lost energy from the battery. The battery charger also has incorporated in it a logic that actually monitors the battery voltage at any point in time. This logic takes care of over-voltage protection, under voltage protection and lastly the trickle charging capabilities.

The operation of the battery charger is as follows with the full-labeled diagram as shown in Fig.2.20.

The system works in such a way that, RLA1 coil in the power supplying monitoring control unit senses current and becomes energized thereby closing RLA1B which connects the charging units winding to the winding of the output transformer which begins to charge the battery. This is accomplished as the winding of the charging unit shares the same magnetic core with the output transformer thereby causing an electromagnetic field, which induces emf to the winding of the charging unit. During the failure of power supply or under voltage, the battery charger maintains a trickle charge from the initiated inverter operation via the center tap of the 12V/240V output transformer. The trickle charge is maintained indefinitely once the battery reaches full charge and is not supplying any load.

The charging unit is also monitored by a control logic unit, in order to prevent overcharging of the battery. The circuit employed the use of a voltage comparator to compare the battery maximum charge voltage which is calibrated using two series connected diodes (0.6V + 0.6V drop) to achieve a preset value for the inverting input (1.2V) of the voltage comparator. This voltage is a regulated value from the NEPA monitoring control unit. When the battery voltage at the non-inverting input of the voltage comparator exceeds the preset value, a HIGH output will be obtained from the operational amplifier. The high output will trigger the gate of the thyristor (TH1), which latches on producing a current in the anode that energizes the coil of the relay RLA2. This relay coil controls the Normally Closed switch connected in series with the positive terminal of the battery and the lead of the charger. The thyristor latch remains in this state until there is a change in anode current.

2.21 COMPARATOR

It is the simplest operational amplifier circuit often used as non-linear devices to compare the amplitude of one voltage with another. In this application, the operational amplifier was used in the open loop configuration, with the input voltage on one input and a reference voltage on one input and a reference voltage on the other.

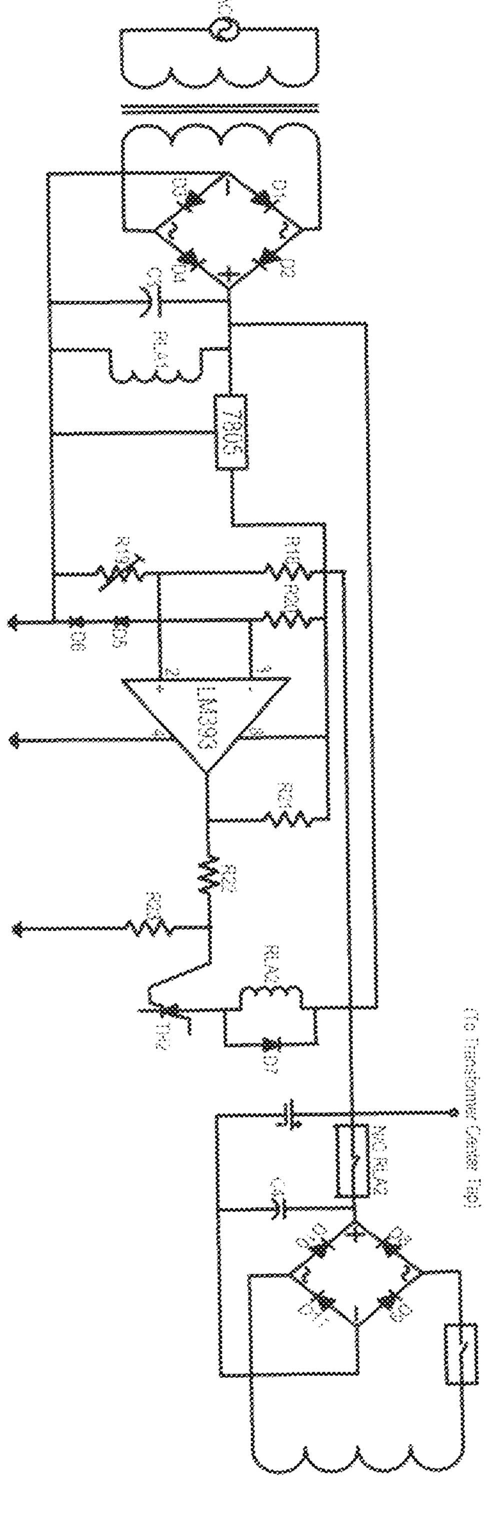
A simple comparator compares the voltage level of one input to the voltage level of the other inputs. Input voltage level may also be compared to zero (ground) or some fixed positive or negative voltage reference. The output condition for a given input condition is dependent upon which input (+ or -) is used as the reference.

2.30 SWITCHING-TRANSFER SYSTEM

The switching system is one of the sub-system of the uninterruptible power supply. This sub-system makes the inverter (UPS) to bear the name UNINTERRUPTIBLE. It is so versatile and so fast that visually no delay time is noticed during the transfer period. It is fully responsible in ensuring that the load at the output does not notice mains power failure. This is the uninterruptible nature of the power supply system. The primary and secondary supply of power come from mains supply and the inverter supply respectively. The transfer system makes sure that either of the two sources of power is supplying to the load at any point in time. This unit actually makes use of the relay (Electromechanical relays) to select the mains supply or inverter supply. This is possible by the logic circuitry incorporated in the system. The power source selected, usually depend on the mode of connection to the relay system.

The mains power supply is usually tagged the primary source of power in that it is connected to the normally open switch of the relay. This implies that anytime the mains supply is within the acceptable range (180V- 240V), it will then supply current to the external load. On the other hand, if the mains supply fails, it is no more within the acceptable range and the supply to the load will be transferred to the inverter, as the back-up source (Secondary source). The primary source will then remain inactive until the power is restored. During the period of power failure, the inverter will be supplying to the load. The supply time of the battery/inverter will be shown in subsequent sections.

Once the supply from the mains is restored, the change-over relay will automatically be changed from the inverter to the mains supply. This will equally initiate the battery charger to restore the lost energy from the battery. The charging process will continue until the battery is fully charged and the supply of current to the battery will be cut off and then maintained constant at its TRICKLE CHARGING current which is very minimal.


7805
LM393
NC RLA2
(To Transformer Center Tap)

2.40 THE AUTOMATIC SHUTDOWN TIMER UNIT

The diagram in Fig. 2.40 shows the circuit diagram of the automatic shutdown timer circuit stage that is used for "low battery" monitoring. This circuit is designed to give a warning sound on sensing a low battery condition, and displays a digital time for the user for a period of five minutes which is displayed on a digital read out. It automatically switches off d.c. supply to the oscillator circuit of the inverter stage to stop inverter system operation.

The battery terminals\are monitored by this circuit. The input to the stage consists of a 10V Zener diode ZD1, since the minimum working voltage of the battery for normal operation is 10V. When the battery voltage goes below 10V, say 9.5V, the Zener diode, ZD1, drops 9.5V i.e. 10V-9.5V=0.5V (HIGH)

The HIGH output of the Zener diode drives the base of the transistor. The two cascaded transistors TR13 and TR14 act as NOT gates. Each base input to either transistor produces an inverted output at the collector-emitter region. In this case, a "HIGH" in the base of TR13 produces a low in the collector region which drives the base of TR14 to produce a high which is sent to trigger IC3NE555 configured in the MONOSTABLE MODE.

The IC3 acts as a delay timer IC. A buzzer powered through IC9 which is an exclusive OR-gate is connected between the input and output of the NE555 (IC3). This means that one input to the IC9 gets the HIGH from the transistor TR14. The other input to the IC9 which is tapped from Pin 3 (the NE555 IC3 output) is a LOW. This is because there is a time delay determined by the time constant the input RC circuit to IC3 at the Trigger and Threshold pins (Pin 2 and Pin 6) respectively. So, the monostable multivibrator does not change state immediately on sensing a clock input except at the expiration of the time lag as represented in the diagram below.

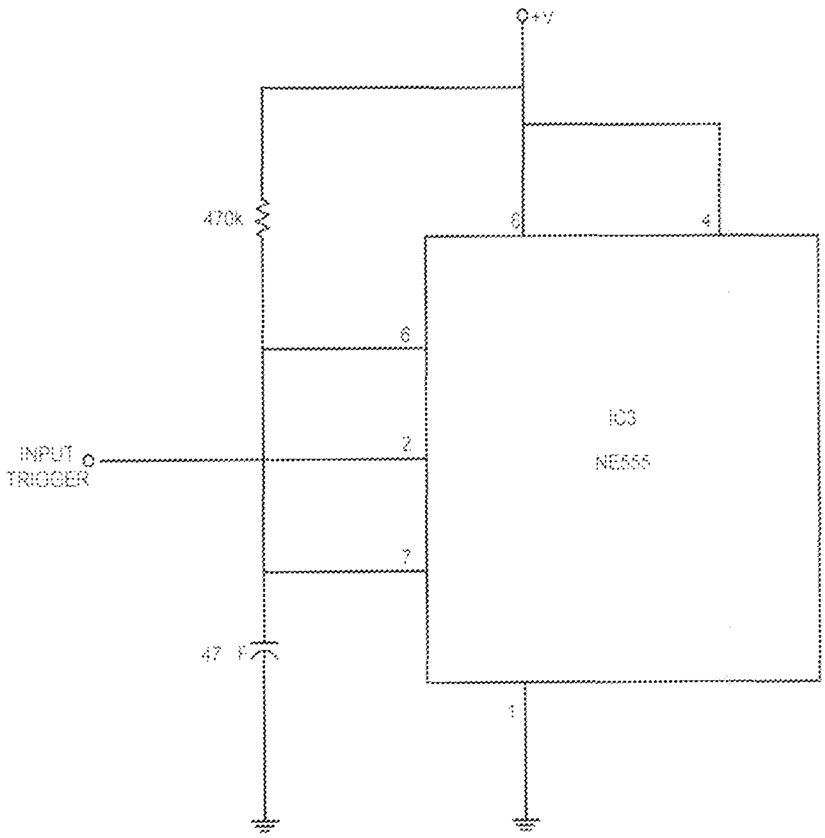


Fig.2.40a Monostable Mode

In this application, the duration of the output pulse in seconds is approximately equal to:

T=1.1 x R x C (in seconds)

Where R=470KΩ and C=47μF

=> $T = 1.1 \times 470 \times 10^3 \times 47 \times 10^{-6}$

= 24.299secs (≈ 24msec)

During this time delay, the buzzer beeps for the period until the IC3 changes state momentarily producing a "high" output at Pin 3, knocking off the buzzer.

The 74192 IC in the fig. 2.50 is an asynchronous presettable BCD decade up/down counter that provide asynchronous master reset (clear), parallel load and synchronous count up/count down operations. The count may be preset by the asynchronous parallel load capability of the circuit. Information present on the parallel data inputs (D_0-D_3) are loaded into the counter and appears on the outputs, regardless of the conditions of the clock inputs when the parallel load () is low. In this case, the parallel data input to the 74192 is 5 (binary 0101). This number is produced directly at the output.

The 7447IC is a decoder/driver which drives a seven segment display. This implies that the moment there is an output "HIGH" from transistor TRI4, the parallel load is HIGH and so a 5 is displayed on the digital read out (display). The buzzer beeps for 24msecs, after which a HIGH output of the monostable NE555IC disables it.

The output pulse is sent to trigger another NE555IC now configured as an ASTABLE multivibrator whose oscillations produce the clock pulses that provide sixty seconds counts to the counters 7490IC. The fig.2.40b shows the configuration of an astable mode.

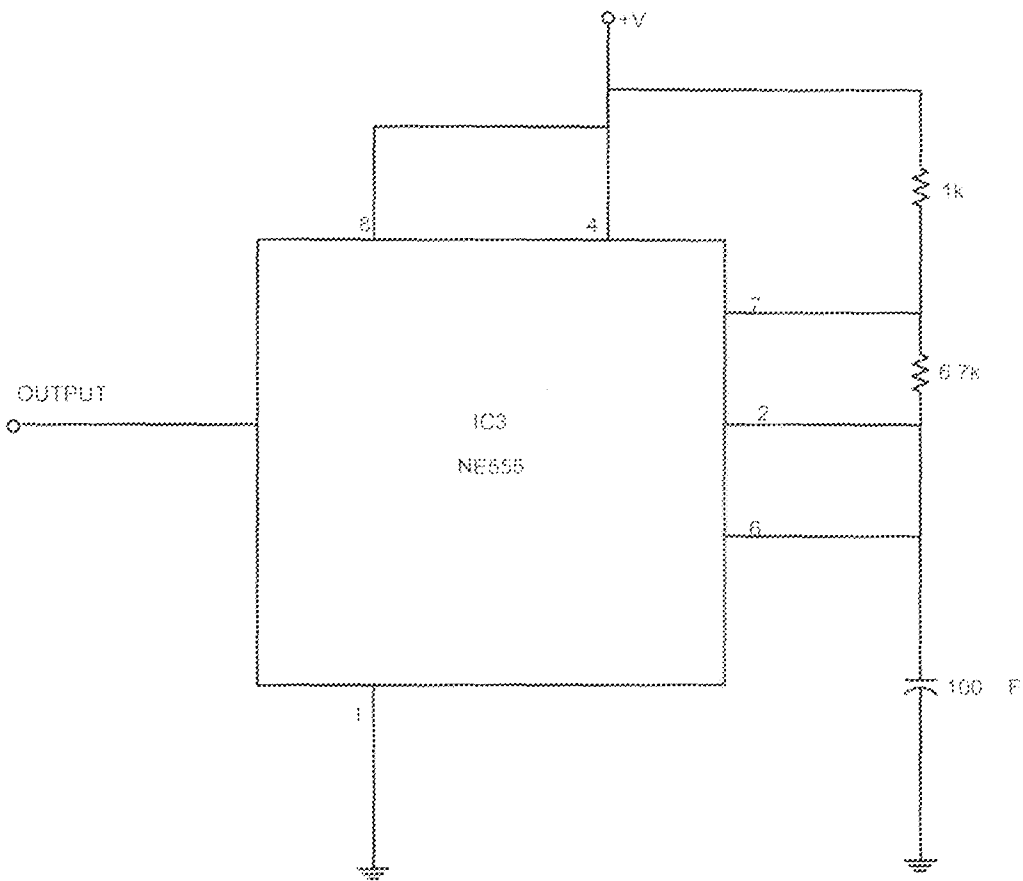
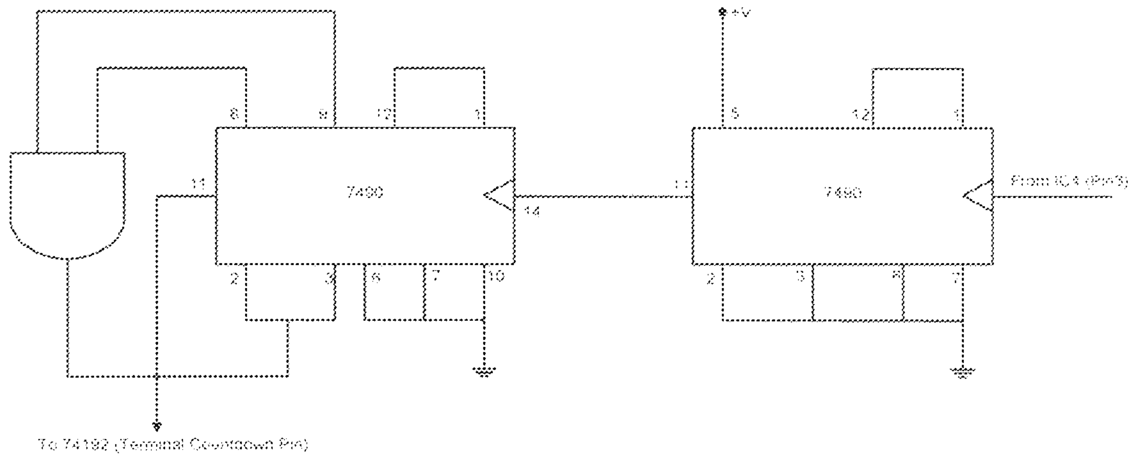
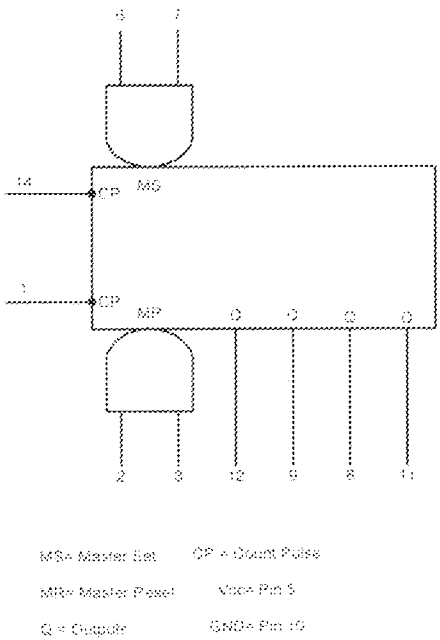


Fig.2.40b Astable Mode

Two 7490 decode counters were used. In order to achieve 60seconds count for (one minute) this is used to decrease the count of the 74192 countdown counter in the sequence 5-4-3-2-1-0. One of the 7490IC directly connected to the Astable multivibrator counts 10 while the second 7490IC cascaded to it counts 1 to 6 for every 10 counts of the first counter. This was achieved by the connections as described below:



PIN CONFIGURATION OF 7490



Count	OUTPUT			
	Q	Q	Q	Q
0	L	L	L	L
1	H	L	L	L
2	L	H	L	L
3	H	H	L	L
4	L	L	H	L
5	H	L	H	L
6	L	H	H	L
7	H	H	H	L
8	L	L	L	H
9	H	L	L	H

For 7490b, the output Q_0. Q_3 are connected such that on counting from 1-6 , at the sixth count (0110) the pins 8 and 9 respectively having clock pulse 1s, a gated AND asynchronous master reset MR (i.e. $MR_1.MR_2$) at pins 2 and 3 is provided. This overrides both clock and resets (clears) all the flip-flops. The output of 7490b is connected to the terminal countdown input of the 74192. So, for every 60secs, this corresponds to a minute and the counter decrements its count by 1.

The magnitude comparator, 7485IC is used to monitor the count output of the 74192 and hence, irritate shutdown by switching off the oscillator stage. This IC has a set of its inputs in parallel with the output of the 74192IC. The second set of inputs is preset at a value (0000).

2.50 SYSTEM DESIGN CALCULATIONS

This section gives the whole calculations carried out during the project. It covers the design calculation of the frequency of operation of the system being constructed. It equally covers the maximum rating of the automobile battery used for the back up source of energy. Again, it covers the assertion that the design is for a system within 500W capacity.

2.51 OSCILLATOR FREQUENCY

The oscillator was used to fix the frequency of the inverter. The frequency which is given as:

$$\text{Frequency, } F = \frac{1}{T}$$

Where T is period.

It can be proved that for an astable multivibrator, the off-time for Q_1 is $T_1=0.69R_1C_1$ and that for Q_2 is $T_2=0.69R_2C_2$. Hence, total time-period of wave is:

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

If $R_1 = R_2 = R$ and $C_1 = C_2 = C$ i.e. the two stages are symmetrical, then

$T = 1.38RC$

So that for $R = 470\Omega$ and $C = 220nF$

=> $T = 1.38 \times 470 \times 220 \times 10^{-9}$

$= 1.42692 \times 10^{-4}$ sec

∴ Frequency of oscillation which is given by the reciprocal of time period is;

$f = 1/T = 1/(1.42692 \times 10^{-4}) = 7008.10Hz\ (\approx 7\ KHz)$

2.52 HEAT DISSIPATION TO THE SYSTEM (HEAT SINKING)

Depending on the amount of power required from the inverter, adequate heat sinking of the IRF540 MOSFETs must be assured. The parameters applicable to the IRF540 MOSFETs are:-

i) Drain some voltage (V_{DS}) =60V max

ii) Drain Current (I_D)=39A max

iii) Drain source ON resistance (R_{ON})=0.08Ω

iv) Power dissipation (P_D)=150 Watts

Voltage drop across device= $I_D R_{ON}$

$= 39 \times 0.08 = 3.12$ V

Power dissipated across device = $I_D V$

$= 39 \times 3.12 = 121.68$ Watts

The maximum heat that will be dissipated to the system when it is at maximum load will be equal to 121.68Watts.

2.53 SYSTEM POWER AND POWER LOSS

At maximum condition, the following parameters would be obtained from the system:-

i) Maximum voltage from the battery =12V

ii) Maximum supply current to the system = 42A

iii) No load current = 0.12A

iv) Full load current when MOSFETs are paralleled = 60A

Therefore, maximum power at no load = 0.12 x 12 = 1.44 Watts

Also, maximum power delivered by the system = 42 x 12 = 504W at full load. The maximum power chosen for this inverter (UPS) design is therefore 500VA.

2.54 BATTERY LIFE CAPACITY

The type, nature and parameter of the battery used for the system can be obtained by the following:-

(1) Required backup time

(2) Power demand of the consumer equipment, respective discharge expected from the battery under maximum load.

(3) The battery to be used should be of excellent condition.

For a 500VA inverter to operate for one hour at maximum load, the required current is given by:

$$I = \frac{500}{12}$$

for a 12V battery

= 41.67A

hence, using a 12V battery of 200 AH, the time duration will be:

$$\frac{200}{104} \times 1hr$$

= 4.8hrs

= 4hrs 48mins (≈ 5hrs)

Hence, on maximum load and full charge on battery the operation time of the inverter will not exceed five hours.

Also, capacity (Ampere-Hour) AH = $\frac{\text{Power (Watt)}}{6.72}$ x Time (h)

Where h is the duration of the back-up time in hours

∴ Time duration for back-up = $\frac{\text{Battery capacity x 6.72}}{\text{Power rating (Watts)}}$

So that for a maximum power of 500VA and battery capacity of 200AH

=> Time duration of back-up = $\frac{200 \times 6.72}{500}$

= 2.688hrs

=2hrs 41mins of back-up

2.55 SYSTEM MAXIMUM POWER RATING

The system designed is expected to operate at a maximum power rate of 500VA, 240V a.c. at 50Hz frequency. The specified power rating is for a system that is 100% efficient. The following assumptions were made;

ASSUMPTION

1. Let the transformer used for the design be 90% efficient
2. The use of resistive loads was used for testing. (Power factor of resistive load is 1).

Power equation = Current x Voltage (in VA)

i.e. $P = VI$ (VA)

Also; $P = VICos\Theta$

Power into the system (Pin) = Power out of the system (P_{out})

$P_{in} = P_{out}$, for an ideal situation

but for a 90% efficient system

$P_{in} = 90\% P_{out} = 500W$ or 500VA at power factor of 1

$$P_{in} = \frac{90}{100} \times 500 = 450W$$

but at the output, V = 240V ac.

$\Rightarrow \quad IVCos\Theta = 450$

$\Rightarrow$ $I_{out} V_{out} = 450 \therefore I_{out} = \frac{450}{230} = 1.96A$

Maximum output current = 1.96A

The power law states that the total power into the system must also be the total power out of the system.

Total power into the system = 500VA.

$\Rightarrow$ Pin = 500

$\Rightarrow$ $I_{in} V_{in} = 500$

where V_{in} = 12V from battery

Therefore, $I_{in} = \frac{500}{12} = 41.67A$

The maximum current into the system is 41.67A. This then implies that the MOFSETs should be able to source out about 42A of current.

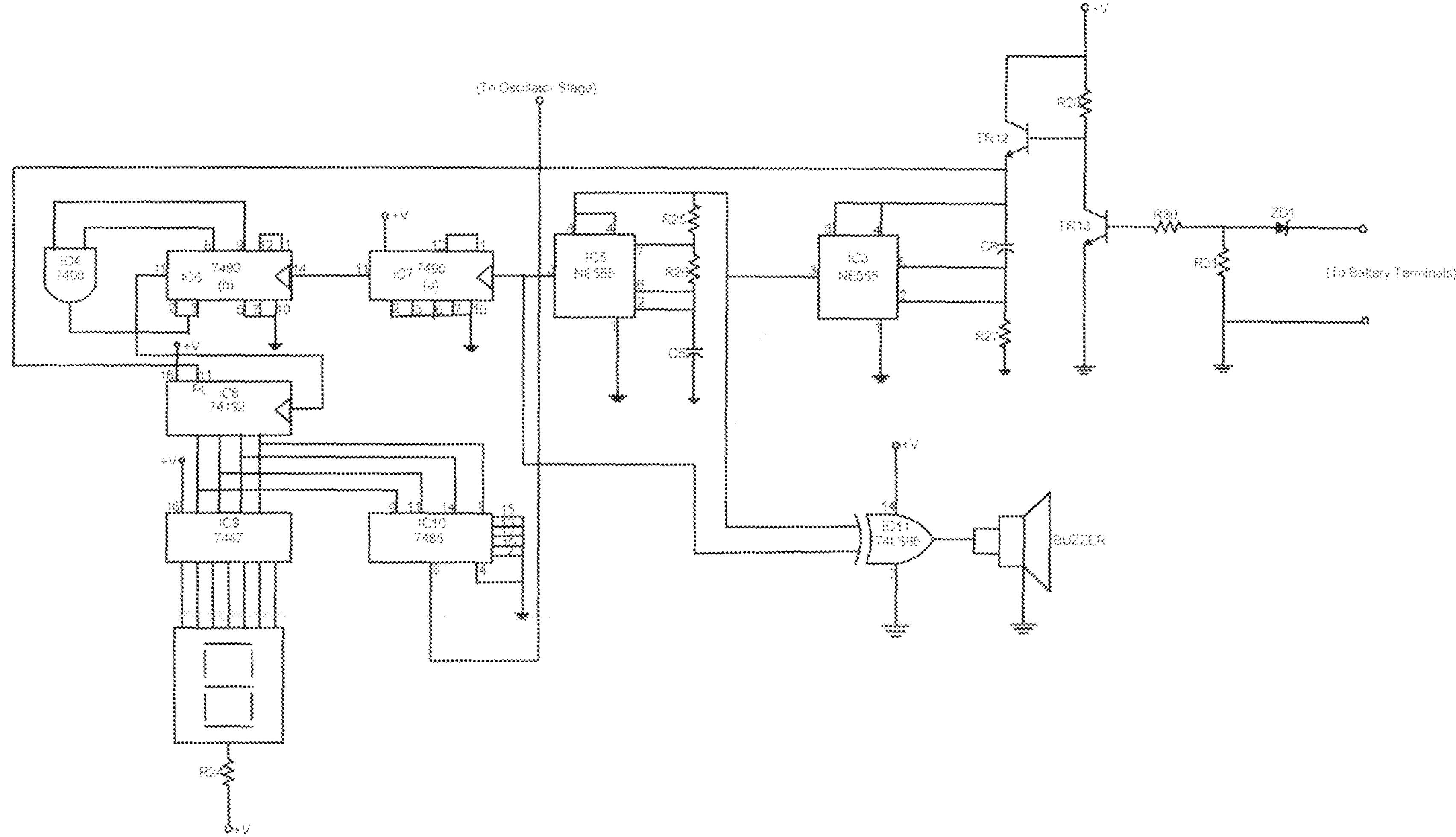


Fig 2.40 Automatic Shutdown Timer Circuit

CHAPTER 3

3.0 CONSTRUCTION

The construction of the project was done in two stages: the soldering of the circuits and the coupling of the entire project to the casing. The modules of the design were securely held to the body of the package. The heat sinks were equally well placed so as to allow proper ventilation in form of forced cooling.

The inverter transformer was included inside the package and this gives the package the heavy nature. The 12V battery source for the inverter is external.

3.1 IMPLEMENTATION:

The implementation of this project was done on the breadboard. The power supply was first derived from a bench power supply in the laboratory to confirm the workability of the circuits before the power supply stage was soldered to the Vero board. Stage-by-Stage testing was done according to the block representation on the breadboard before soldering of the circuit commenced on the Vero board. The oscillator and driver stage were also bread boarded. The class B amplifier was not bread boarded due to the high current that passes this stage. The charger and changeover stages were also bread boarded.

3.2 TESTING: The physical realization of the project is very vital. This is where the fantasy of the whole idea meets reality. The designer sees the work not just on paper but as a finished hardware product.

After carrying o… signs on paper and carrying out calculations and analysis, the project was imp… and tested to ensure the proper functioning of the whole system; its reliability a… the construction so as to meet the required specification. The process of testing … lementation involves the use of some –equipments stated below:

i) BENCH POWE…PPLY: This was used to supply voltage to the various stage of the circu…ing the breadboard test before the power supply in the circuit was built a…uring the soldering of the project. The bench power supply was used to…ed and calibrate the charger and low battery sensing circuit since the pow supply is of a variable type.

ii) OSCILLOSCOPE: The oscilloscope was used to observe the ripples in the power supply waveform an also to observe the waveform of the oscillator stage in the inverter circuit and in the timing circuit.

iii) DIGITAL MULTIMETER: The digital multimeter basically measures voltage, resistance, continuity, current, frequency, temperature, and transistor hfe. The process of implementation of the design on the breadboard required the measurement of parameters like voltage, continuity, current, and resistance values of components to test their status. Frequency measurement was used to check the frequency of the oscillator stage to confirm functionality, and the current measurement to test the charging current of the charger.

3.3 PROBLEMS ENCOUNTERED

Series of problems were encountered during the implementation, testing and construction of this project. They are as listed below:

i) One of the problems encountered in the execution of this project is the successive closure of the school, making it difficult to coordinate my activities with my project supervisor.

ii) The unavailability of laboratory equipments made it a Herculean task , since I had to seek out private owned laboratory where I could use oscilloscopes, bench power supplies etc.

CHAPTER 4

CONCLUSION AND RECOMMENDATION

4.0 CONCLUSION

The project was designed considering some factors such a economy, availability of components and research materials, efficiency, compatibility and portability, and also durability.

The performance of the project after test met design specifications and hence can be said to be satisfactory.

The general operation of the project and performance is dependent on the user who is prone to make human error such as battery polarity change or tendency to overload the system, and other conditions such as low battery level, which are prevalent to such battery- powered equipments.

In addition the construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user.

The project has really exposed me to power and digital electronics and practical electronics generally which is one of the major challenges I shall meet in my field now and in the nearest future.

The design of the 500 VA INVERTER-UPS (uninterruptible power supply) with low battery shutdown timer was quite challenging and tedious, compared to other designs without the timer.

Designing the timer circuit stage to work synchronously with the whole system was no easy task.

Although the job was quite tedious and challenging, it turned out to be a success at last. I wish to thank the department, my supervisor and the project co-coordinator for giving us the opportunity to carry out this project. However, like every aspect of engineering design there is room for improvement and further research on the project as suggested in the recommendations below.

4.1 RECOMMENDATIONS

i) I would recommend that further work be done in the area of determining the actual discharge rate of the battery with time.

ii) I also recommend that more research should be done on providing efficient power over long periods with the back up power provided internally.

REFERENCES

(1) Charles L. Alley and in Kenneth at Wood

'Micro electronics',

published by Prentice- Hall international edition, 1986.

(2) Douglas V. Hall

'Digital circuits and systems',

McCrano-Hill international editions, Electronic Engineering Series, 1989.

(3) Floyd Thomas L

'Electronic Device', 3rd edition, Published by Maxwell MacMillian

Canada, 1983.

4) Forrest M. Mims III

'103 projects for electronics experimenters',1st edition

Published by Tab-Book Inc. June 1991.