DESIGN AND CONSTRUCTION OF A VOLTAGE LEVEL MONITORING DEVICE OF A BATTERY

BY

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(2006/24415EE)

A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NOVEMBER, 2011.

DECLARATION

I Njeakor Uzochukwu Basil, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I hereby relinquish the copyright to the Federal University of Technology, Minna.

Njeakor Uzochukwu Basil
(Student)

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CERTIFICATION

This is to certify that this project titled "Design and Construction of a Voltage Level Monitoring Device of a Battery" was carried out by Njeakor Uzochukwu Basil with matriculation number 2006/24415EE, and submitted to the Department of Electrical and Electronics Engineering, Federal University of Technology Minna in partial fulfillment of the requirements for the award of Bachelor in Engineering (B.Eng).

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DEDICATION

I dedicate this work first to the Lord Almighty who through His Spirit has given me strength to carry on this project and to my ever supportive father Chief H. N. Njeakor and my loving mother Mrs. Ebele Njeakor.

ACKNOWLEDGEMENTS

I sincerely thank the Lord God for His infinite mercy, blessings, guidance and sustenance over my life. My special thanks go to my mother, Mrs. Ebele Njeakor and also to my caring and loving father, Chief H. N. Njeakor for their unrelenting support and fervent prayers towards my academic advancement.

My special appreciation goes to my supervisor, Engr. Dr. M. N. Nwohu for his advice, corrections and guidance throughout my project work. Much thanks go to the entire staff of Electrical Engineering Department of the Federal University of Technology Minna, who in one way or the other have contributed to my success. Finally, I appreciate all members of Anglican Students' Fellowship especially the prayer and music units for their love and moral contribution.

ABSTRACT

This project is a monitoring device which indicates the present voltage level of a battery in order to conserve the battery life span. Furthermore this project helps to protect a battery from excessive usage by any system which may have destructive effect on the battery.

A 12V rechargeable lead-acid battery, for instance, should be operated not lower than 50%. Anything below 50%, it can be said to be deeply discharged and a single event of further discharge can cause a lot of negative effects.

Therefore the voltage monitoring circuit here specifically provides a visual output display of the voltage level of the battery. When the voltage of the battery falls below the set point, the speaker will give a sound of warning for the impending loss of power and initiate an automatic shut down of the system once the particular set voltage level is reached.

The project was able to monitor the voltage level of a 12 volt battery under observation and shut down the system once the battery voltage dropped to a set voltage, 7.3V.

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CHAPTER ONE

1.1 INTRODUCTION

Since the discovery of electrical energy, most systems in the world make use of electrical energy as their source of power. However, frequent power failure has led to having a stand-by source of power via battery. Therefore it is expedient to monitor the voltage level of the batteries continuously, although in practice, many of the battery users are unable to do so because of non availability of monitoring equipment, amongst other reasons. This project work will be able to solve this problem with a view to monitor the voltage level of a battery, continuously and initiate an automatic shut down of the system once the particular set voltage level is reached.

The voltage level monitoring device of a battery acts like an interface between the battery and the load/system connected to it and checks continuously the voltage level of the battery at all time.

A 12V rechargeable lead-acid battery, for instance, should be operated not lower than 50%. Anything below 50%, it can be said to be deeply discharged and a single event of further discharge can cause a lot of negative effects. A very common effect can be deduced from this scenario where a battery slated to last for nine months on optimum performance of four hours before exhaustion/discharging could suddenly be found to have an optimum performance of one and a half hours before discharging, just after three month of usage. This phenomenon is very common to portable devices such as laptops, mobile phones and common household appliances like rechargeable lamp. In general, it is virtually common to all devices, machines and systems, whether small or large, that run on battery.

1.2 AIMS AND OBJECTIVES OF THE PROJECT

The aims and objectives of the project are to design and construct a device that is:

- Capable of showing / indicating the voltage level of a battery [12V], thereby showing the strength level of the battery.
- Capable of protecting the battery from excessive usage by any system and initiate an automatic shut down of the system once the particular set voltage level is reached.
- Able to preserve the life span of the battery. Due to the fact that an uncontrollable discharge of a battery can cause a disastrous effect on the battery, which has the ability to reduce the life span of the battery. So this device has the ability to control and preserve the life span of the battery.
- Simple enough to use and relatively inexpensive: this device should be simple to use and relatively inexpensive because a large percentage of battery consumers are common and ordinary household users with little knowledge on how to go about caring for their battery

One of the things to keep in mind along side with objective is to first of all design a simple and compact circuit that reduces the requirement of the human attention by 85 percent and secondly to make a design that is accurate and sophisticated using inexpensive method so as to provide reliable indication of the voltage level of a battery and initiate an automatic shut down of the system once the particular set voltage level is reached.

1.3 PROJECT JUSTIFICATION

The need of a monitoring device which indicates the present voltage level of the battery using practical means to conserve the battery life span brought an idea of working on this project.

Furthermore, the need to protect a battery from excessive usage by any system with the fact that an uncontrollable discharge of a battery can cause a disastrous effect on the battery, which has the ability to reduce the life span of the battery.

1.4 PROJECT OUTLINE

Chapter one is composed of the introduction, objective and motivations of this project.

While Chapter two discussed the literature review which comprised a brief historical background and theoretical background of the project work.

Chapter three dealt with how the project design and construction was accomplished.

Chapter four dealt with the testing of the circuit, results obtained and discussion of those results.

Chapter five dealt with the conclusion and recommendation of the project work. Finally, consulted materials were cited in the references.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND

Batteries have been in existence since early 1800 after the invention of voltaic pile by Alessandro volt. According to a 2005 estimate, the worldwide battery industry generates US$48 billion in sales each year with 6% annual growth [2]. Batteries have become the vital element of any battery-backed system. In many cases the battery is even more expensive than the system it is backing. So it is important that Battery Management System is understood.

Battery Management System (BMS) is a system which involves care for batteries. It has been in existence for long but it meant different things to people. To many people, it simply meant battery monitoring. For the power or plant engineers responsible for standby power whose battery is the last line of defense against power blackout or telecommunications network outage, BMS means a system that encompass methods for keeping ready a back-up battery to deliver full power in addition to monitoring and protecting the battery. A battery monitoring circuit was first patented in the United States of America, on February 1979[2]. Ever since, a lot of inventions involving battery monitoring have been patented. A quick search on the web reveals a whole lot of companies that have ventured into the battery monitoring business products with so many variations. Shaanxi Aitelong Technology, in Mainland China has a battery online monitor system that the company produced, where with an internet connection, your device or system will among other functions, be put on watch, and alert will be made when it's found that the battery of the system on watch has fallen to a particular set point[3]. Individual designers are not left out, with the likes of Domie James, a freelance circuit engineering designer, who has designed and constructed a lot of functional and electronics circuits designed a low battery indicator whereby he employed the use of LM741 op-Amp, few resistors, Zener diode 5.1V and LED, around 2003[5].

This project does not differ much from all the inventions listed above in that it is also a voltage monitoring circuit but it specifically provides a visual output display of the voltage level of the battery. When the voltage of the battery falls below the set point, the speaker will give a sound of warning for the impending loss of power and initiate an automatic shut down of the system once the particular set voltage level is reached.

2.2 THEORETICAL BACKGROUND

This section discussed the theoretical background of discrete electronic components which have been put into use in various modules of this project work.

2.2.1 BATTERY

Battery is a multiple of electrochemical cells of the same chemistry. Electrochemical energy storage in a cell is based on the conversion of chemical energy into electrical energy and vice versa. Each battery is characterized by a chemical reaction, which includes the exchange of electrical charges between ions. Electrical energy is gained through two separate electrode reactions; one electrode releases ions, the other electron absorbs them and current flows through the connected device [3].

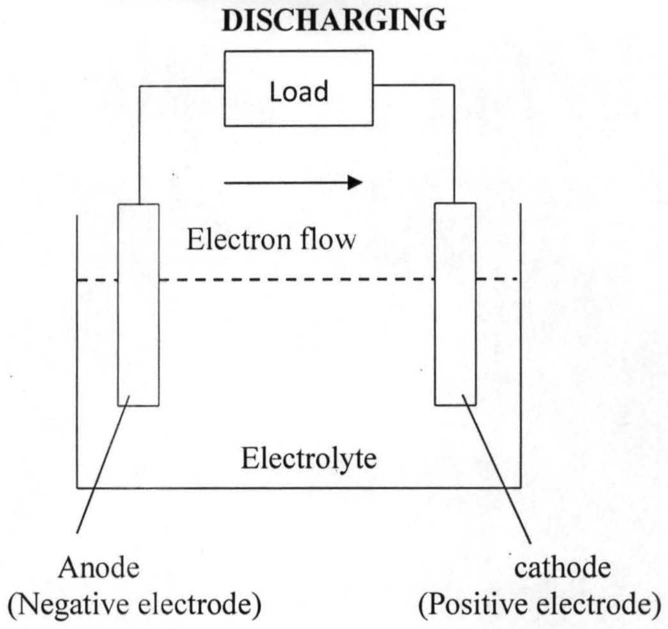


Figure 2.1: The schematic operation of an electrochemical cell.

The basic components of a cell are the positive electrode, the negative electrode and the electrolyte. The electrodes consist of active materials that take part in the electrochemical reactions. During discharging, the negative electrode (e.g. a metal or an alloy) is called anode and is capable of being oxidized while the positive electrode (e.g. an oxide or a sulfide) is called cathode and is reduced. During charging, the positive electrode is oxidized and turns into the anode whereas the negative electrode is reduced and is turned into the cathode. The electrolyte must be a non-conductor for electrons in order to avoid self-discharge of the cell.

A battery consists of one or more cells that are electrically connected in series. The voltage of the battery is the individual cell voltage multiply by the number of the connected cells. When the battery is fully charged and in no-load condition, this voltage is called open-circuit voltage and is higher than the typical voltage during discharge (working voltage). The battery voltage at which the discharge is terminated is called end or cutoff voltage. Battery can be either primary or secondary.

PRIMARY CELL: A primary battery is one that can convert its chemicals into electricity only once and then must be discarded. The most common form of the primary cell is the Leclanche cell, invented by the French chemist, Georges Leclanche in the 1860s. It is popularly called a dry cell or flashlight battery. The Leclanche cell produced about 1.5V. Another widely used primary cell is the Zinc-mercuric oxide cell, more commonly called a mercury battery [3].

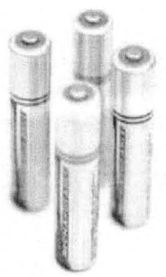


Plate I: Primary Cell Battery

SECONDARY CELL: A secondary battery has electrodes that can be reconstituted by passing electricity back through it; also called a storage or rechargeable battery, it can be reused many times. The storage battery or secondary cell, which can be recharged by reversing the chemical reaction was invented in 1859 by the French physicist, Gaston Plante. Plante's cell was a lead-acid battery, the type widely used today. The lead-acid battery, which consists of three or six cells connected in series, is used in automobiles, trucks, aircraft, and other vehicles. Its chief advantage is that it can deliver a strong current of electricity for starting an engine. However, it runs down quickly. A lead-acid battery has a useful life of about four years; it produces about 2V per cell [3].

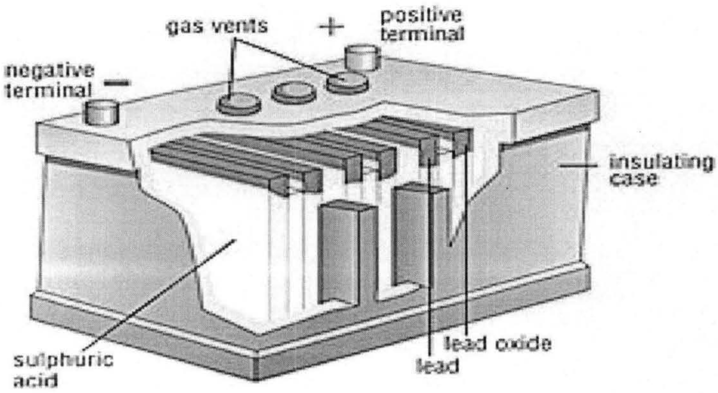


Plate II: Secondary Cell Battery

TYPES OF BATTERY

- THE LEAD-ACID BATTERY
- NICKEL- CADMIUM BATTERY
- NICKEL-HYDROGEN BATTERY
- SODIUM- NICKEL CHLORIDE

2.2.2OPERATIONAL AMPLIFIER (LM741 / LM3914N)

"Operational Amplifier," is a word used in the computing field to describe amplifiers that performed various mathematical operations. It was found that the application of negative feedback around a high gain DC amplifier would produce a circuit with a precise gain characteristic that depended only on the feedback used. By the proper selection of feedback components, operational amplifier circuits could be used to add, subtract average, integrate, and differentiate [6].

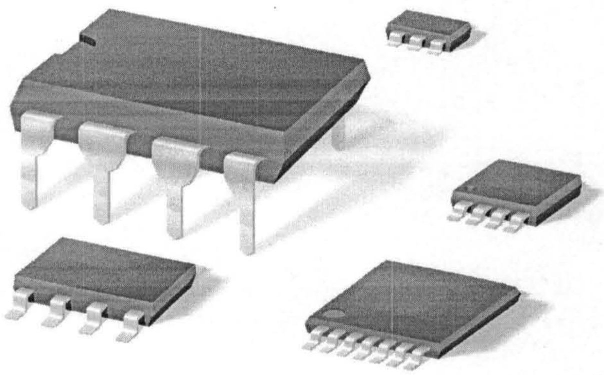
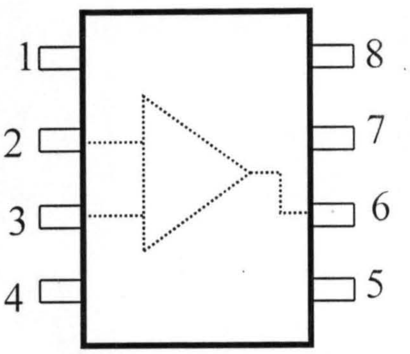


Plate III: Op-Amp Package

The UA741 operational amplifier used in this project is a high performance monolithic operational amplifier constructed on a single silicon chip. It is intended for a wide range of analog uses. The high gain and wide range of operating voltages provide superior performances in integrator, summing amplifier and general feedback applications [6]. They are also used as voltage comparators. When the signal voltage differs from the reference voltage, the output of the comparator becomes low or high. The signal input is connected to the inverting inputV_1, when V_1 is greater than V_{ref} the output voltage goes high, but when V_1 is less than V_{ref} the output goes low.



- 1 - Offset null 1
- 2 - Inverting input
- 3 - Non-inverting input
- 4 - VCC-
- 5 - Offset null 2
- 6 - Output
- 7 - VCC+
- 8 - N.C.

Figure 2.2: The internal structures of UA741

2.2.3 DRIVER IC LM3914N

Also LM3914N was used majorly in this project as a driver IC to display the present voltage level of the battery with the LEDs connected at the output. The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V [6].

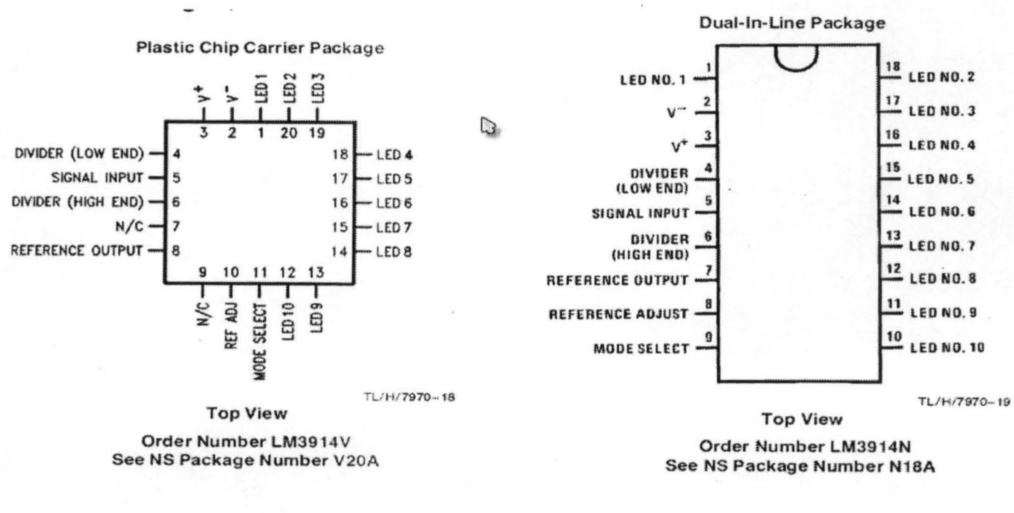


Figure 2.3: Connection Diagrams of IC LM3914N

2.2.4 LIGHT EMITTING DIODE

Light-Emitting Diode (LED) is a device that emits visible light or infrared radiation when an electric current passes through it. LEDs are made of semiconductors, or electrical conductors, mixed with phosphors, substances that absorb electromagnetic radiation and re-emit it as visible light. The visible emission is useful for indicator lamps and alphanumeric displays in various electronic devices and appliances. Devices such as remote controls and cameras that focus automatically use infrared LEDs, which emit infrared radiation instead of visible light.

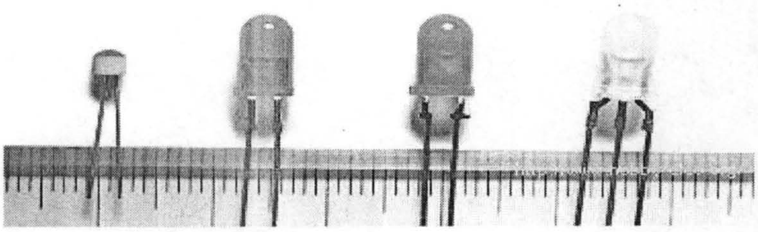


Plate IV: Types of Light Emitting Diodes

Light emitting diodes must be chosen according to how they will be used, because there are various kinds. The diodes are available in several colors. The most common colors are red and green, but there are even blue ones. The diode on the far right in the photograph combines a red LED and green LED in one package. The component lead in the middle is common to both LEDs. As for the reaming two leads, one side is for the green, the other for the red LED. When both are turned on simultaneously, it becomes orange. When an LED is new out of the package, the polarity of the device can be determined by looking at the leads. The longer lead is the anode side, and the short one is the cathode side. The polarity of an LED can also be determined using a resistance meter, or even a 1.5 battery [8].

2.2.5 RESISTORS AND POTENTIOMETER

Resistor is a component of an electric circuit that resists the flow of direct or alternating electric current. Resistors can limit or divide the current, reduce the voltage, protect an electric circuit, or provide large amounts of heat or light. Resistors are designed to have a specific value of resistance. Resistors are often color coded by three or four color bands that indicate the specific value of resistance. Some resistors obey Ohm's law, which states that the current density is directly proportional to the electrical field when the temperature is constant. The resistance of a material that follows Ohm's law is constant, or independent of voltage or current, and the relationship between current and voltage is linear [8]. And potentiometer is a three-terminal resistor with a sliding contact that forms an adjustable voltage divider. If only two terminals are used, it acts as a variable resistor. It is used to adjust the level of analog signals and as control inputs for electronic circuits. For this project it is used to get a reference voltage for the op-amp.

Figure 2.4: Electric symbol of a Resistor

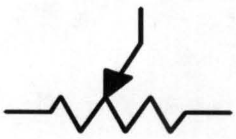


Figure 2.5: Electric symbol of a Potentiometer

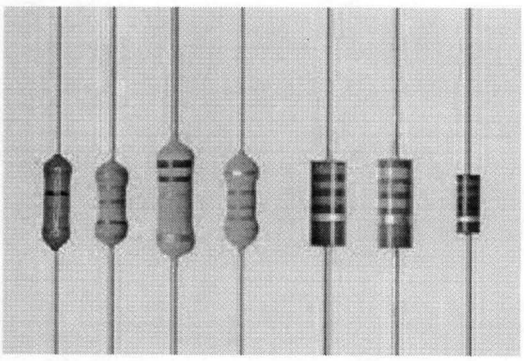


Plate V: Pictorial diagram of Resistors

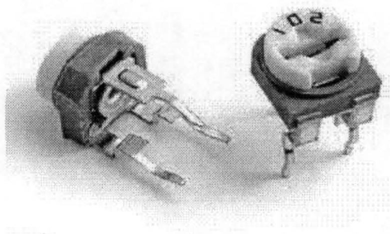


Plate VI: Pictorial diagram of a Potentiometer

2.2.6 CAPACITOR

Capacitors store electric charge. They are used with resistors in timing circuits because it takes time for a capacitor to fill with charge. They are used to smooth varying DC supplies by acting as a reservoir of charge. They are also used in filter circuits because capacitors easily pass AC (changing) signals but they block DC (constant) signals. It consists of two conducting surfaces separated by a layer of an insulating medium called a dielectric. It is represented as shown below. There are many types of capacitor but they can be split into two groups, polarized and unpolarised [6].

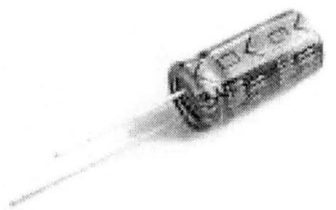


Plate VII: Pictorial diagram of a capacitor

Figure 2.6: Electric symbol of a capacitor

2.2.7 TRANSISTOR

Transistor is a small low-powered solid-state electronic device consisting of a semiconductor and at least three electrodes, used as an amplifier and rectifier and frequently incorporated into integrated circuit chips. In the transistor, a combination of two junctions may be used to achieve amplification. One type, called the n-p-n junction transistor, consists of a very thin layer of p-type material between two sections of n-type material, arranged in a circuit.

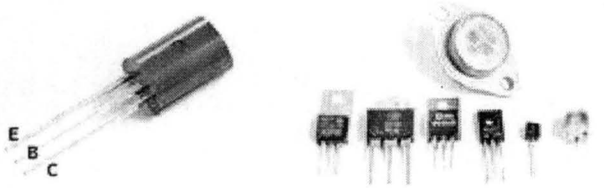


Plate VIII: Pictorial diagram of Transistors

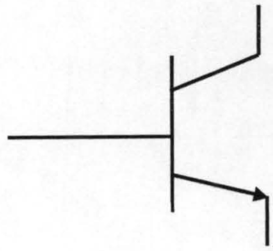


Figure 2.7: Symbol of a transistor

The n-type material is made of the emitter element of the transistor, constituting the electron source. To permit the forward flow of current across the n-p junction, the emitter has a small negative voltage with respect to the p-type layer, or base component that controls the electron flow. The n-type material in the output circuit serves as the collector element, which has a large positive voltage with respect to the base to prevent reverse current flow. Electrons moving from the emitter to the base are attracted to the positively charged collector, and flow through the output circuit. The input impedance or resistance to current flow between the emitter and the base is low, whereas the output impedance between collector and base is high. Therefore, small changes in the voltage of the base cause large changes in the voltage drop across the collector resistance, making this type of transistor an effective amplifier [8].

2.2.8 RELAY

Relay is an electromagnetic device consisting of a solenoid (usually a cylindrical coil of insulated wire wound in the form of a helix), in which an iron core is placed. An electric current passed through the coil induces a strong magnetic field along the axis of the helix. When the iron core is placed in this field, microscopic domains that can be considered small permanent magnets in the iron align themselves in the direction of the field, thus increasing greatly the strength of the magnetic field produced by the solenoid. The magnetization of the core reaches saturation once all the domains are completely aligned, and an increase of the current in the solenoid has little further effect. When the current is switched off, the core retains only a weak residual magnetism. Thus, relays are used as protective and control devices for switching and for transmission of signals. However, in this project work, relay is being used as a switching device [6].

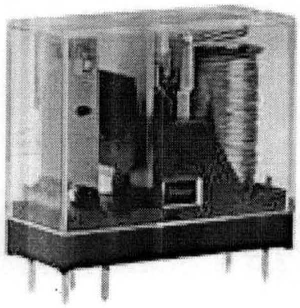


Plate IX: Pictorial diagram of Relay

2.2.9 BUZZER

Buzzer is an electronic device that makes a humming or buzzing sound when activated.

CHAPTER THREE

3.1 DESIGN AND CONSTRUCTION

In this section, the design analysis of this project "Voltage level monitoring device of a battery" was actualized and the procedures followed, step by step to construct the circuit of the project was also highlighted here.

3.2 METHODOLOGY

The circuit diagram of the project was first simulated on the multism (which is an electronic workbench application software) to make sure that the circuit work, and to get the desired output before implementation and construction are done. The workspace of the computer simulation is shown below:

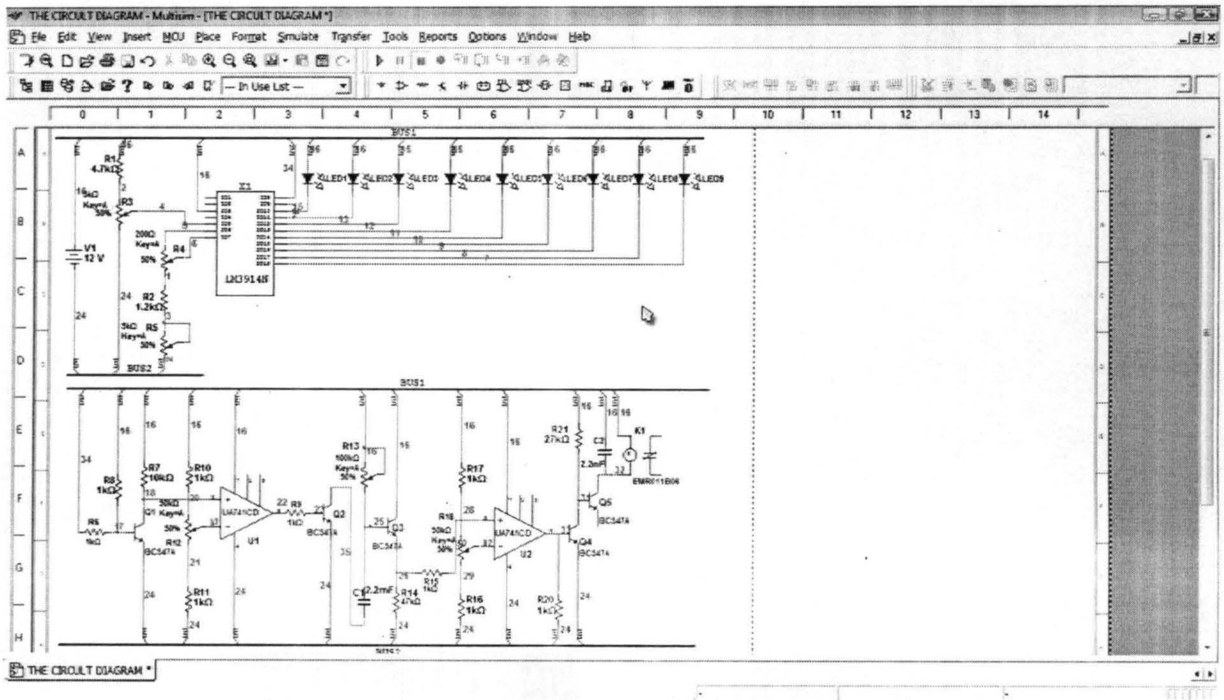


Figure 3.1: The circuit diagram of my project being simulated.

The methodology used in this project works with the principle of comparing the immediate voltage level of a battery with regard to the load applied to the battery so that when the voltage of the battery falls below the set point, there will be a warning for the impending loss of power. This design initiates an automatic shut down of the system once the particular voltage set point is reached. The input of the battery under observation is applied to the driver IC LM3914N, which displays the present voltage level of the battery.

3.3 DESIGN ANALYSIS:

This project "Monitoring device of the voltage level of the battery" consists of the following basic unit:

- The Power supply and switch unit
- The Monitoring and Display unit
- The Timer and Alarm unit
- The Output / Load unit

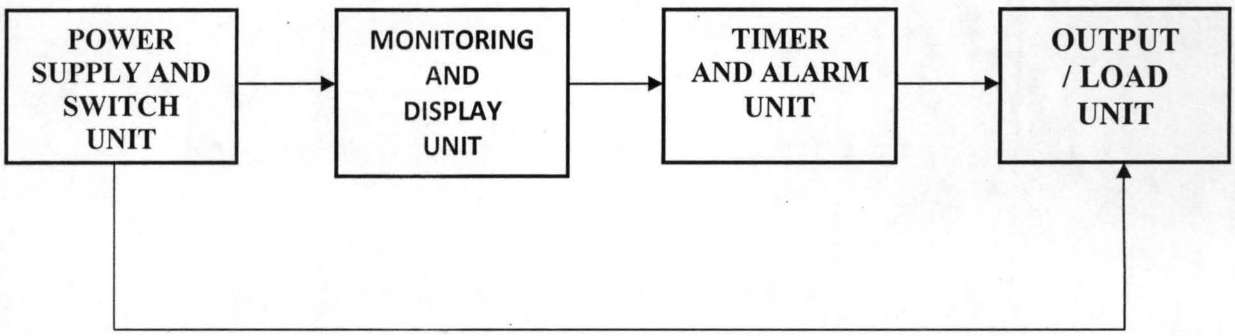


Figure 3.2: Circuit block diagram

3.3.1 POWER SUPPLY AND SWITCH UNIT:

The power source for the entire monitoring device is the battery. The battery here is a secondary battery (rechargeable battery) which can be recharged after usage. The monitoring device is a low power circuit which can be expanded to indicate small voltage steps over the range of 7V to 13V. The power consumption of the monitoring device is as low as 20mW, when operated with a 12V. So the power consumed by the device is relatively small when compared to the load applied to the battery.

A reset switch is used to start the system. The reset switch is connected to shunt the battery across the relay. The battery energy flows across the switch into the system which is activated for a few seconds before the reset switch returns to its function. The capacitor, which is connected across the relay, charges up to hold the relay closed for energy to remain constant at the relay, until the voltage of the battery falls below the set point, which causes the system initiates an automatic shut down of the system.

3.3.2 THE MONITORING AND DISPLAY UNIT

This unit is concerned with detailed analysis and operation of the components that make up the monitoring and display Unit.

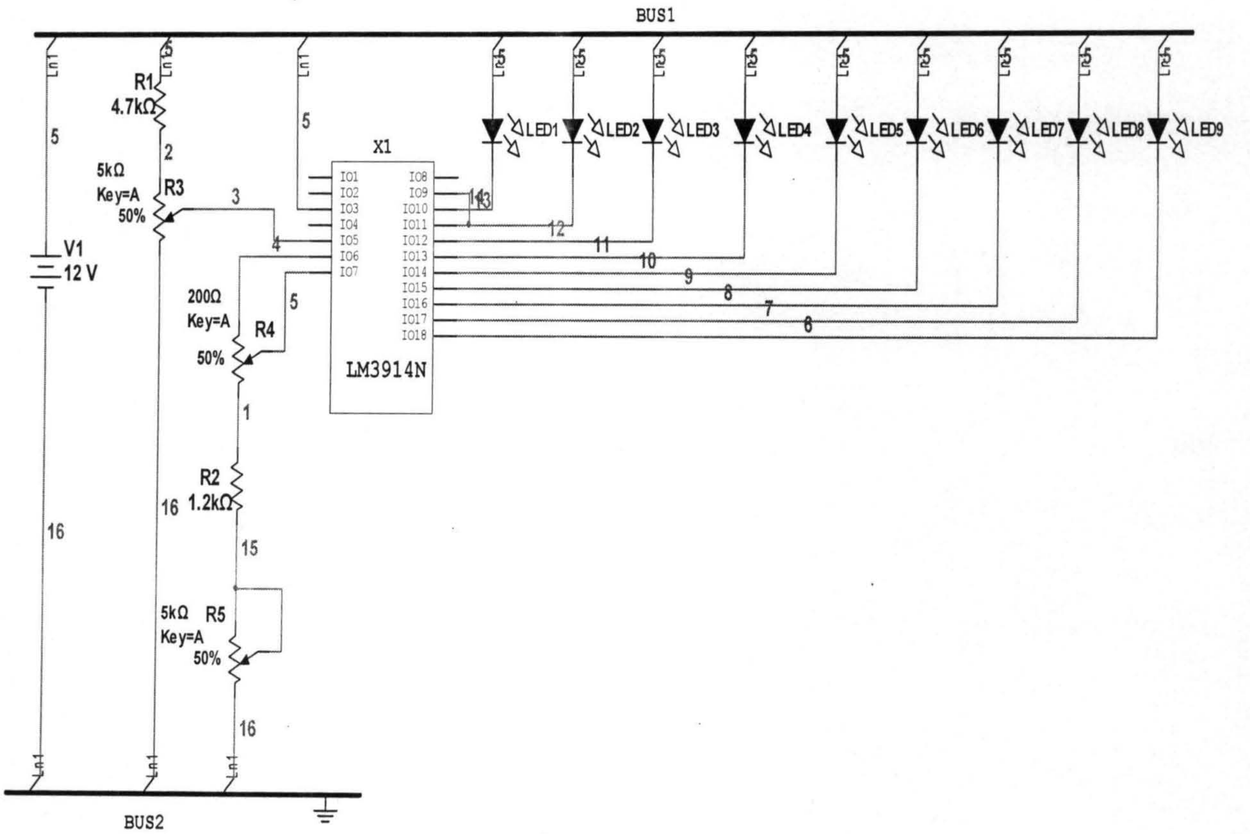


Figure 3.3: Monitoring and display Unit.

The core of this circuit is the LM3914N dot-bar voltmeter IC, which is also called LED Driver. The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system at less than 4V. The circuit contains its own adjustable reference and accurate 10-step voltage divider. The buffer drives 10 individual comparators referenced to the precision divider.

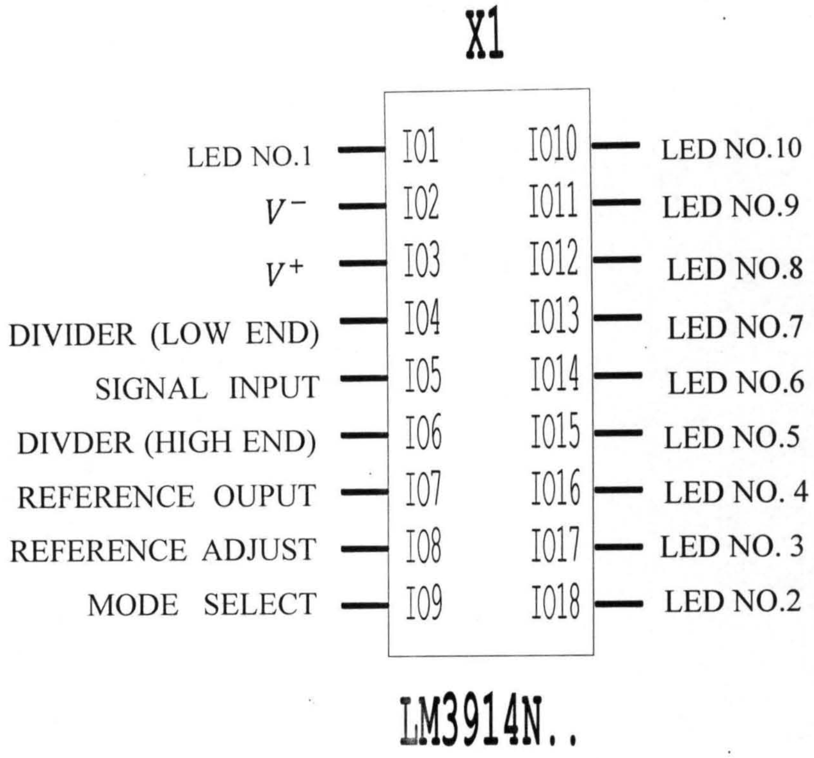


Figure 3.4: A simplified block diagram illustrating the simple external circuitry.

The circuit can drive LEDs of many colors, or low-current incandescent lamps. Many LM3914s can be ``chained" to form displays of 20 to over 100 segments. Both ends of the voltage divider are externally available so that 2 drivers can be made into a zero-center meter. The LM3914 is very easy to apply as an analog meter circuit. A 1.2V full-scale meter requires only 1 resistor and a single 3V to 15V supply in addition to the 10 display LEDs. If the 1 resistor is a pot, it becomes the LED brightness control. Much of the display flexibility derives from the fact that all outputs are individual, DC regulated currents. Various effects can be achieved by modulating these currents. The individual outputs can drive a transistor as well as a LED at the same time, so controller functions including ``staging" control can be performed. The LM3914 can also act as a programmer, or sequencer [6].

The reference is designed to be adjustable and develops a nominal 1.25V between the REF OUT (pin 7) and REF ADJ (pin 8) terminals. The reference voltage is impressed across program resistor R_1 and, since the voltage is constant, a constant current then flows through the output set resistor R_2 giving an output voltage of:

$$V_{ref(out)} = 1.25\left(1 + \frac{R_2}{R_1}\right) \quad (1)$$

$$V_{drop(LED)} = \frac{12.5}{R_1}$$

When voltage is applied to the LM3914N from the battery being monitored, the LM3914N displays outputs on the LEDs according to the voltage applied to it. This display is continuous and is in proportion to the voltage drop of the battery as it is being discharged. That is, as the battery is being discharged the LM3194N shows the present voltage level of the battery, with its LEDs being displayed in order of the voltage discharged. When the voltage drop to 7.3V the last LED will display which will trigger up the transistor.

3.3.3 BJT TRANSISTOR CALCULATIONS:

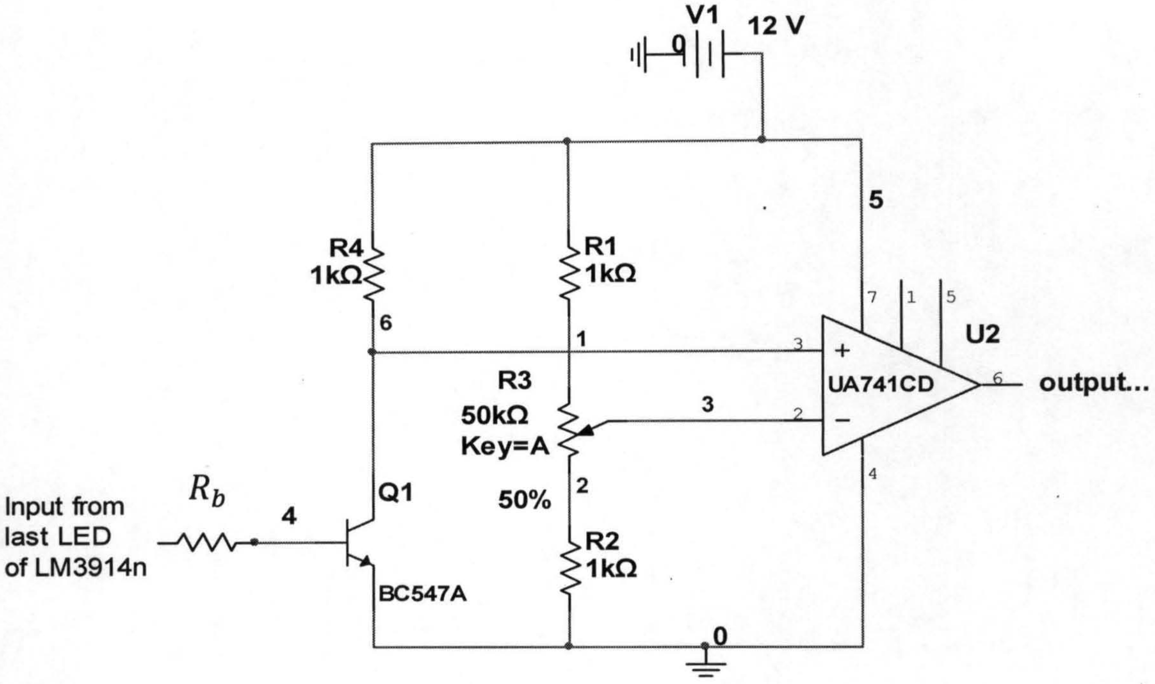


Figure 3.5: Comparator.

The transistor chosen is from a batch with variation in h_{fe} from 100-500, with the switching configuration for common emitter. To find a value for R_b that works with any transistor in the same gain group, the following must be done:

As the transistor chosen may have any h_{fe} between 100 and 500 then the minimum current gain is chosen (100). The collector current is 20mA from the transistor datasheet [6], then the required base current is therefore:

$$h_{fe} = \frac{I_c}{I_b} \quad (2)$$

$$I_B = \frac{I_c}{h_{fe(\min)}} = \frac{20}{100} = 0.2mA$$

Therefore the switching input for the transistor is,

$$Voltage\ base = \frac{7.3V \times 1k\Omega}{1k\Omega + 2.7k\Omega} = 1.97V$$

So the 1.97V was used to trigger up the transistor and transistors with gain equal or greater than 100 could easily work. The collector-emitter voltage of the transistor is as low as 0.1V from the transistor datasheet [6]. The power dissipated in the transistor is also low.

3.3.4 THE COMPARATOR LM741 CALCULATION:

Comparators are useful in triggering events based on a signal reaching a certain threshold. Comparators are a key crossover function between the analog and digital worlds. The job is to assert its output when the input rises above a certain threshold and reassert its output when the input falls below a threshold. If an op-amp is operated in an open-loop topology, it can be adapted to serve as a comparator [6].

Here LM741 is used as the comparator. The transistor delivers its output voltage of 7V to switch on the comparator LM741. The comparator compares the input voltage at the non-inverting terminal with the rail voltage at the inverting input.

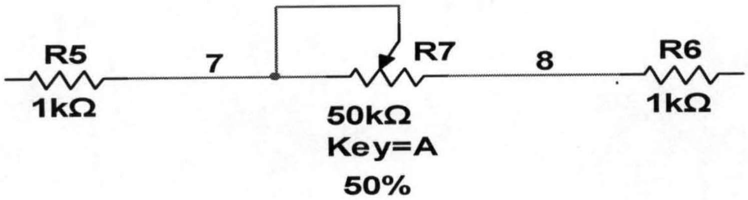


Figure 3.6: The Rail Voltage

The 50kΩ was varied to make the positive side more pronounced in this form.

Assuming the variable resistor is set to 7:3 ratio

That is, 1kΩ + 35kΩ on one side while 15kΩ + 1kΩ on the other side.

$$V_{ref} = \frac{12V \times 16k\Omega}{36k\Omega + 16k\Omega} = 3.69V$$

Therefore 3.69V of the rail voltage was compared with the 7V from the output of the transistor.

That is 3.69V was inverted to -3.69V. i.e.

$$7 - 3.69 = 3.31V$$

So 3.31V of the input voltage which was used to ON the by-pass transistor and the by-pass transistor at the response of its input voltage delivered up 12V to the timer.

3.3.5 THE TIMER AND ALARM UNIT

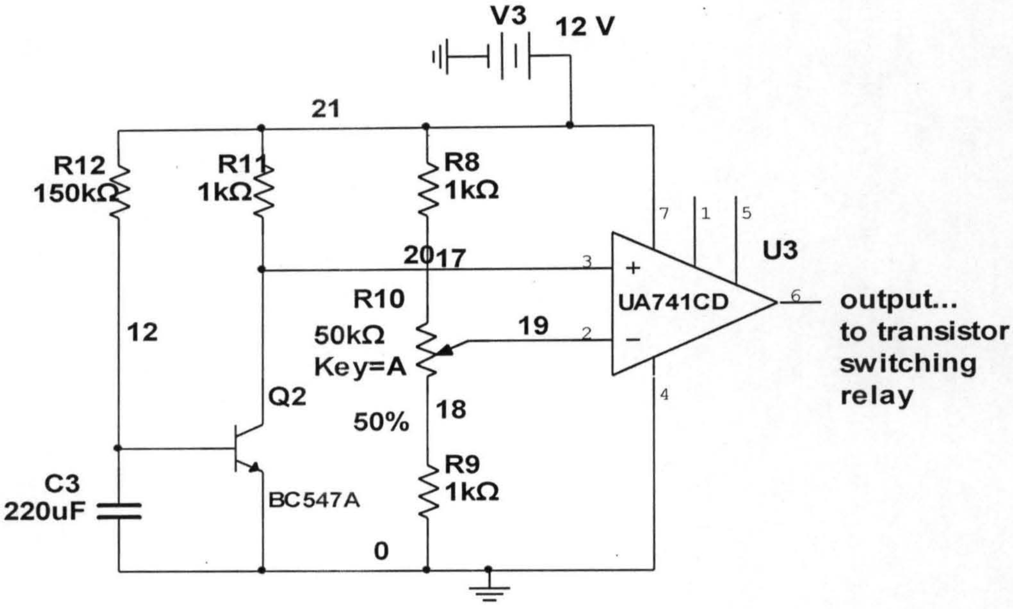


Figure 3.7: The Timer unit

As the voltage of the battery under observation drops below the set point 7.3V, the voltage is delivered to the BJT transistor unit which is compared with the comparator unit. The output delivered by the comparator unit in Figure 3.5 is passed to the Timer circuit unit above. The capacitor at the circuit acts like a shunt. With time, the capacitor begins to charge up which delivers positive voltage to the transistor gradually. This voltage is connected to the non-inverting terminal of the comparator. When the voltage delivered becomes more than the reference voltage at the inverting terminal of the comparator, the comparator delivers an output which shuts down the system. The timer works with the charging time capacity of the capacitor. The equation for the charging time capacity of a capacitor is written in section 3.3.6.

3.3.6 CALCULATIONS ON ALARM UNIT

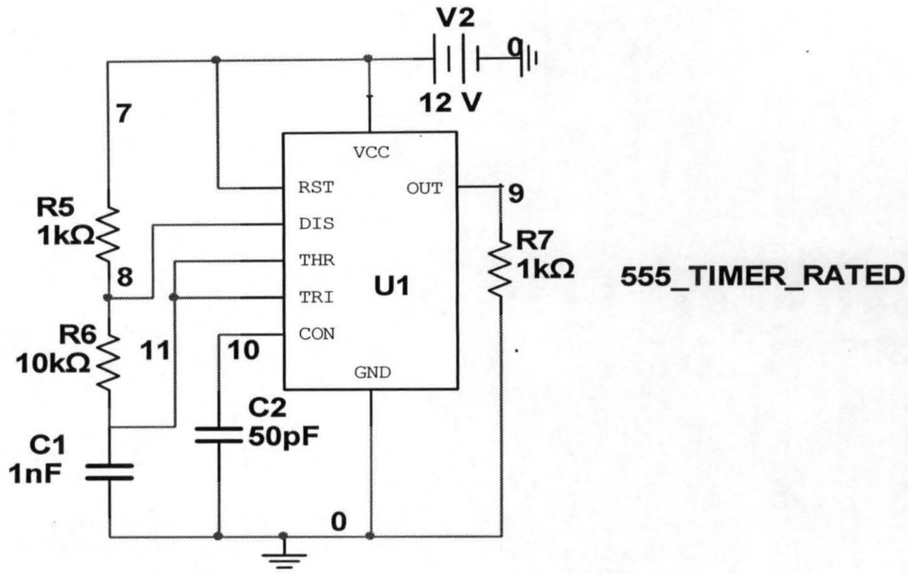


Figure 3.8: The Alarm unit.

The 555Timer IC is an integrated circuit (chip) implementing a variety of timer and multi-vibrator applications, designed by Hans R. Camenzind. The 555 Timer has three operating modes: monostable mode, astable mode and bistable mode. Here the timer has a single stable which is OFF state. Whenever it is trigged by an input pulse, the monostable switches to its temporary state. It remains in that state for a period of time determined by $t = R \times C$ [7]

In this project 555Timer was used to generate pulse which is called a tone generator (alarm system).

For the alarm unit, frequency of operation of the astable circuit is dependent upon the values of R1, R2 and C and can thus be calculated;

$$f = \frac{1}{[0.693 \times c \times (R_1 + 2 + \times R_2)]} \quad (3)$$

The time interval is related to the frequency by

$$t = \frac{1}{f}, \tag{4}$$

where the duty cycle,

$$D = \frac{t_1}{t} = \quad (R_1 + R_2) + (R_1 + 2R_2) \tag{5}$$

$$f = \frac{1}{0.693 \times 1\eta F \times (1k\Omega + 2 \times 10k\Omega)} = \quad 68.7KHz$$

Therefore sound for the alarm is generated at 68.7 KHz, which is fed to the loud speaker (transducer)

$$t = \frac{1}{68.7KHz} = 0.0000145 \sec onds$$

$$t_1 = 0.693(1k\Omega + 10k\Omega)1\eta F = 0.00007623$$

$$t_2 = 0.693 \times 10k\Omega \times 1\eta F = 0.00000693$$

$$Duty\ cycle = \frac{0.000007623}{0.000014553} = 0.52 = 52\%$$

This duty cycle means the pulse of the timer alarm is high for 52%

Capacitor is added to pin5 for noise immunity.

3.4 PRECAUTIONS TAKEN

1. Various tests were carried out at every stage of the project to ensure continuity from one stage to another.
2. The various parts for power connections were properly insulated to prevent open circuit in the entire system.
3. Low resistance wires were used majorly in the system to prevent large loss on the wire connections.
4. The components were firmly soldered to the vero board to prevent partial contacts in the system.
5. The circuit was firmly screwed to the casing.

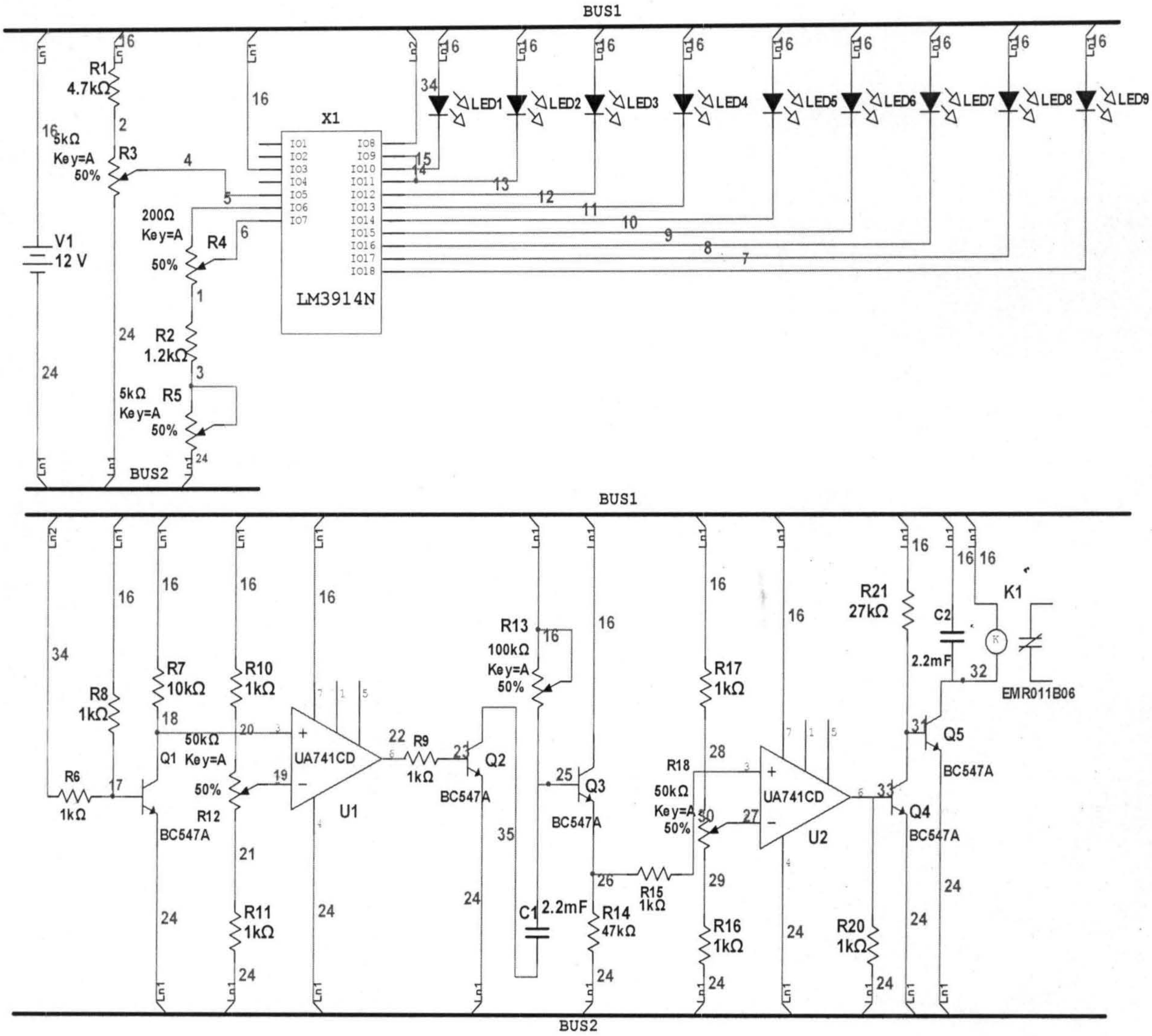


Figure 3.9: Complete circuit diagram

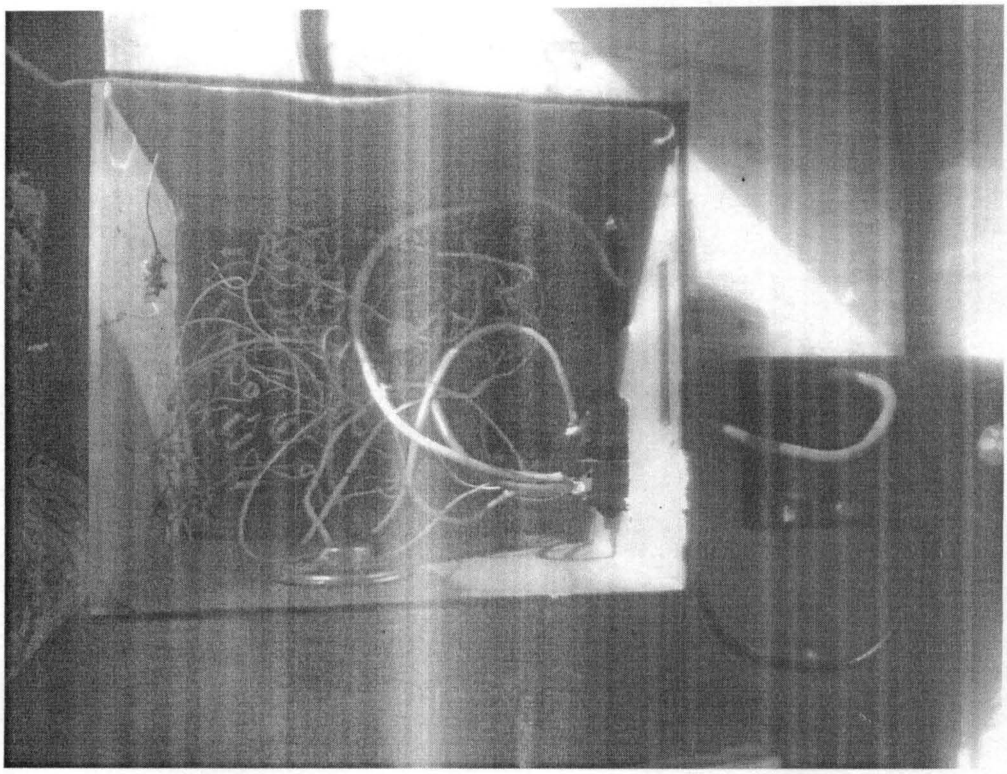


Plate X: The picture of the Vero board with circuit of project on it.

CHAPTER FOUR

TESTS, RESULTS AND DISCUSSION OF RESULTS

4.1 TESTING

In the process of realizing this project, the connection of the circuit was initially done on a computer software application (MULTISIM) before being constructed on a bread board to allow for testing and to ascertain that it is functioning effectively. But before the final design and construction stage was reached, all irregularities were checked and then tested and found to have a satisfactory output. The components were subsequently removed and transferred to a Vero board.

4.2 TEST AND RESULT

With the knowledge of the system operation, the system was tested step by step to the relay output and the wave form of each module was obtained as shown below.

Loads of 100W AC bulb and 60W AC bulb were used with the help of an inverter to test the system which discharged the battery power at a very fast rate. And the graph for the rate of discharge with time was computed and plotted, as shown in Figure 4.1.

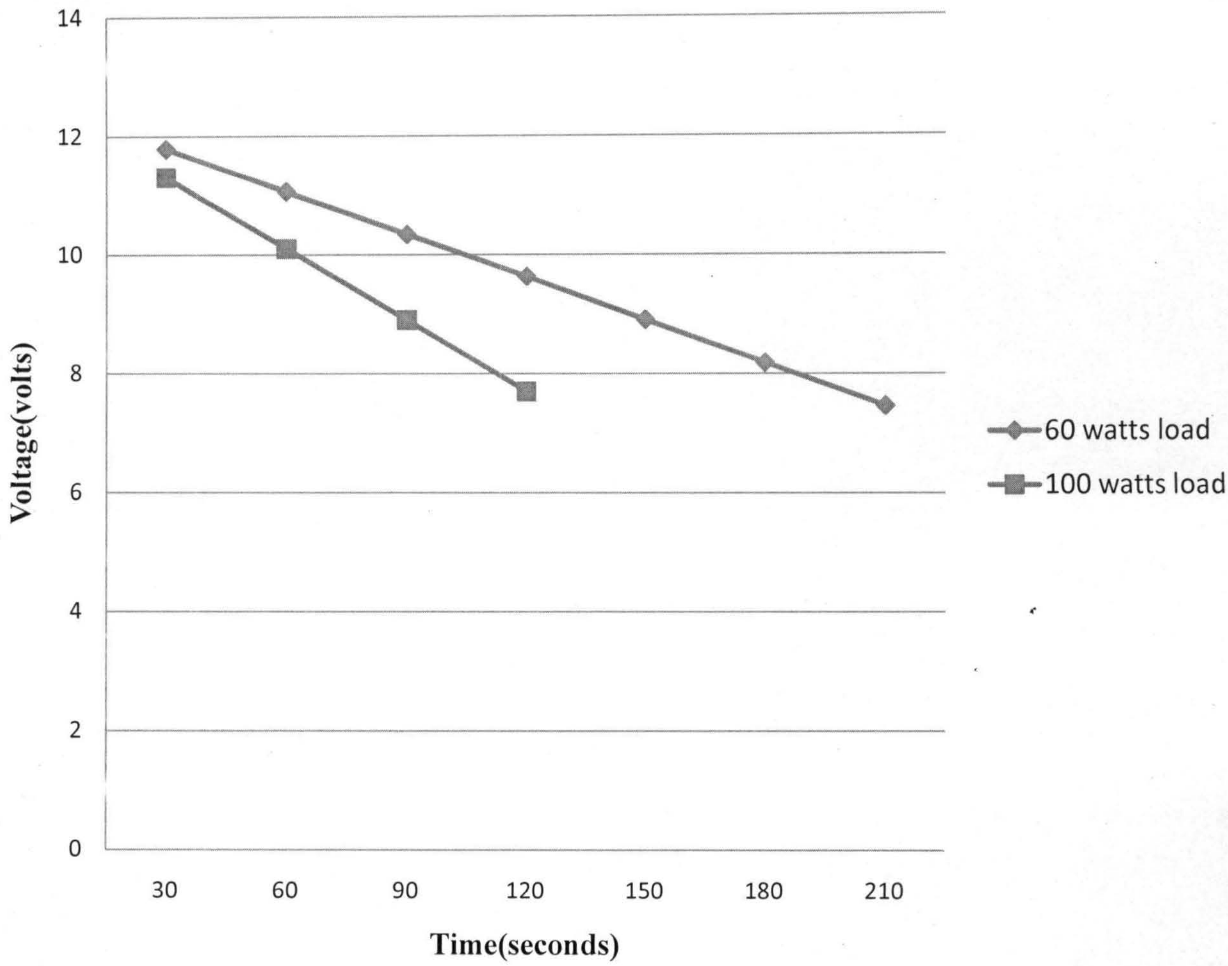


Figure 4.1: Graph for the rate of discharge with time.

Table 1: The rate of discharge with time

Time (seconds)	Voltage value with 60Watts Load (volts)	Voltage value with 100Watts Load (volts)
30	11.78	11.30
60	11.06	10.10
90	10.34	8.90
120	9.63	7.7
150	8.90	_
180	8.18	_
210	7.46	_

4.2.1 SIMULATION RESULTS

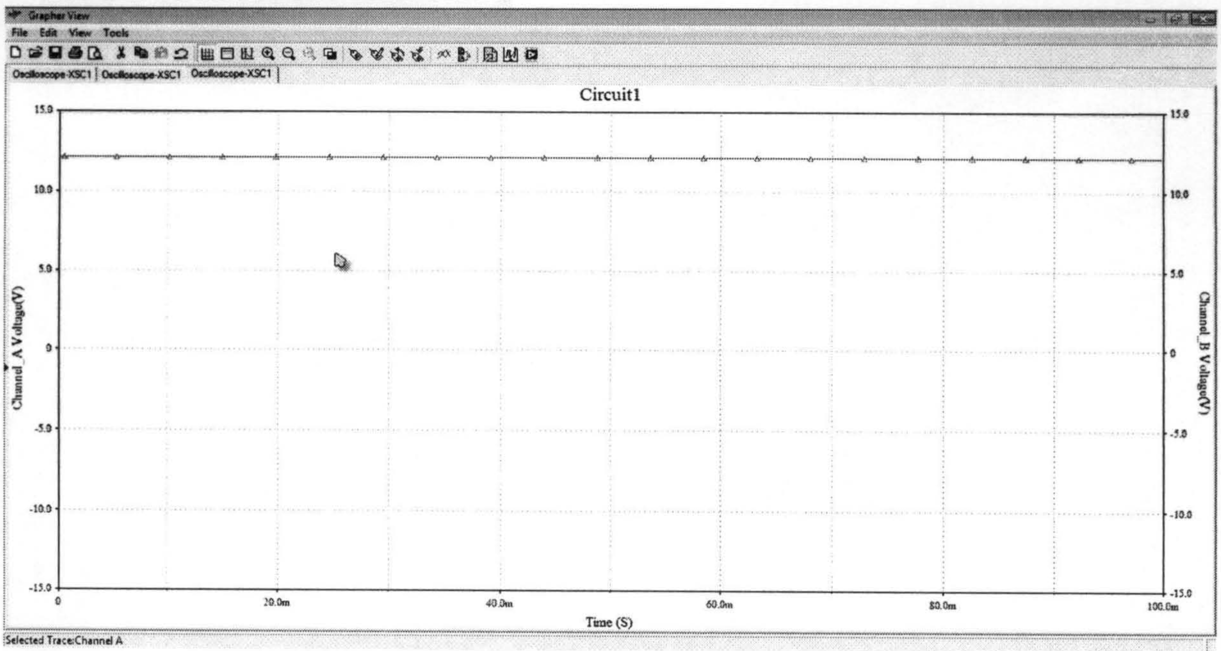


Figure 4.2: The wave form of the voltage supply unit.

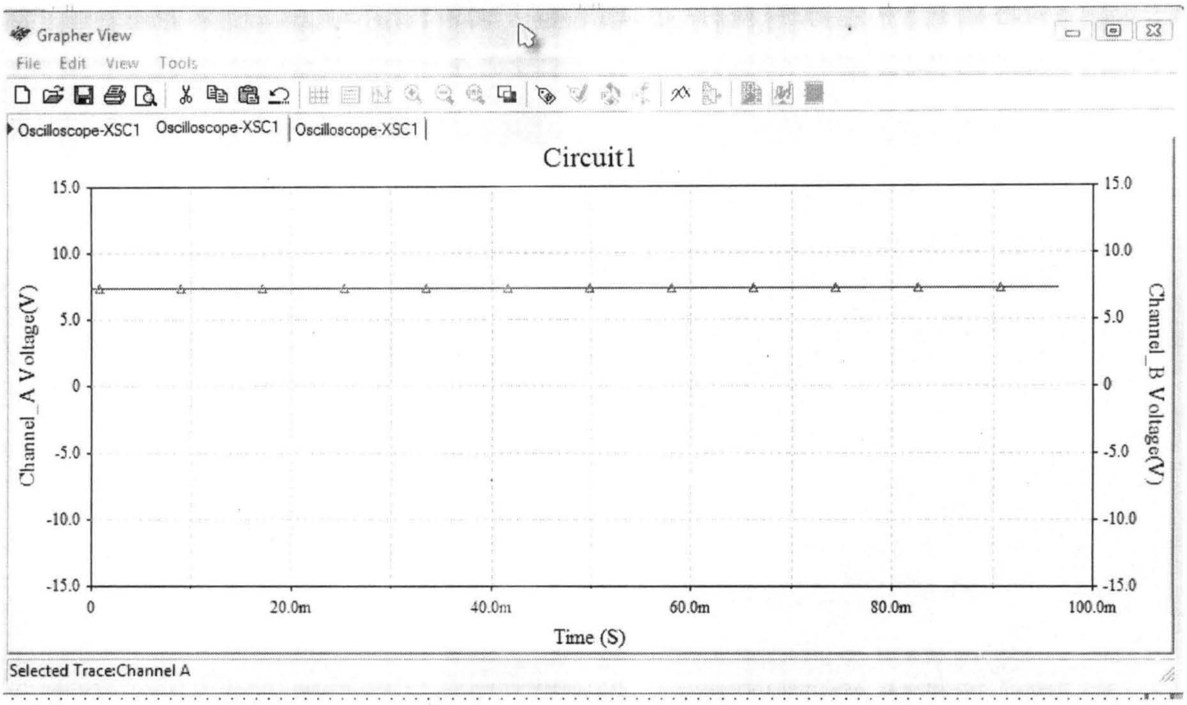


Figure 4.3: The wave form of the set point voltage.

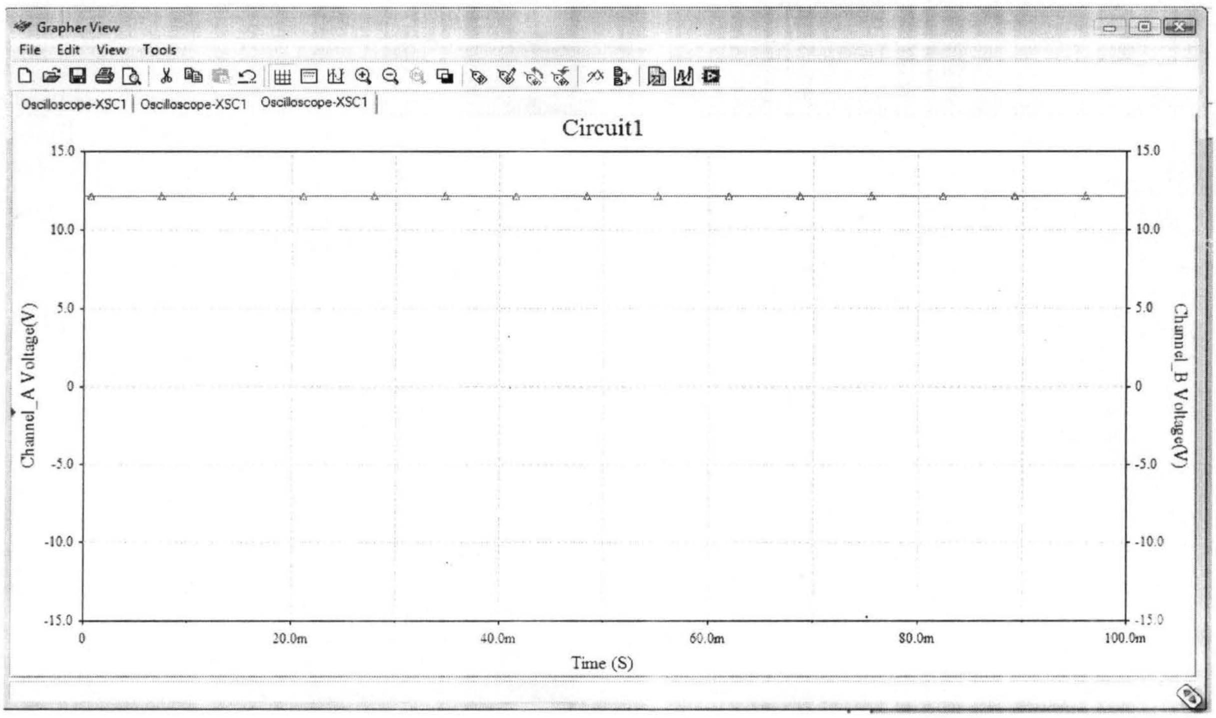


Figure 4.4: The output wave form of the monitoring device.

4.3 ASSEMBLING

The components were placed on a Vero board and soldered and all the connecting positive and negative terminals were cut out to avoid short-circuiting. The whole system was assembled in a plastic casing and provision was made for the switch from the outside. Also, LED indicators which glow Red, white, blue and Green were mounted in the ascending order of voltage drop with the last white LED indicating that the system has gotten to its set point, while the first green LED indicates that there is power in the system.

4.4 DISCUSSION OF RESULT

Figure 4.2 shows the wave form of the supply voltage from the battery, which was measured to be 12.5volts. Figure 4.3 shows the wave form of the set point voltage from the comparator unit in section 3.3.3, which was measured to be 7.3volts. Figure 4.4 shows the wave form of the output voltage from the output terminals, which was measured to be 12.1volts.

The wave forms in Figures 4.2, 4.3, and 4.4 are straight lines on a constant voltage level. This is because they are DC voltages.

From Figure 4.1, the rate of discharge of the battery with time when a load of 100W bulb was used is more than when a load of 60W bulb was used.

From the result obtained, the average time for the batteries to discharge to the set point is a factor that depends on the amount of load connected to the battery. Ordinarily, the circuit takes about 0.6A from 12V battery, so depending on what the battery is powering, that determines the time it takes to reach the set point where it gives out an alert.

4.5 LIMITATIONS

The limitation of this circuit is that it cannot measure batteries below 7volts and above 13volts, owing to the fact that a fixed voltage range for the circuit is from 7.3V to 12.5V and the set voltage is only for 12volts battery.

CHAPTER FIVE

5.1 CONCLUSION

The need of a monitoring device which indicates the present voltage level of the battery, and thereby reduces the requirement of the human attention by 85 percent, using practical means to conserve the battery life span and to protect a battery from excessive usage by any system with the fact that an uncontrollable discharge of a battery can causes a disastrous effect on the battery, which has the ability to reduce the life span of the battery brought an idea of working on this project. The objective of this project was achieved, as soon as the battery voltage level drops to the set point, the system initiates an automatic shut down. The project was also tested and the wave form of each module was obtained.

5.2 RECOMMENDATION

This project construction was designed for 12volts battery, therefore I would recommend that the Driver IC LM3914N be increased in the circuit to increase the voltage range that this circuit can measure. And that different set points can be arranged for different batteries like 15V battery, 9V battery, etc.

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