DESIGN AND CONSTRUCTION OF LIGHTNING COUNTER

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DEDICATION

This project work is solely dedicated to GOD almighty, my parents and my family who looks forward to me achieving an optimal happiness in life.

DECLARATION

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

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With love to my family , my brothers Ransome and Andy Esor , my lovely sister Lynthia Esor , and to Mr and Mrs Fred Ayuk Esor ,I am saying a big thanks to you all.

ABSTRACT

This project presents the design and construction of a lighting counter that can be used to estimate the frequency of lighting in a particular area within a specific period of time. To know the level of protection needed before a high rising building is erected or a BT station. The design works on the principle of sensing and counting the lighting flash as it occurs. The features included are: the antenna, sensing and counting unit then the display unit.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE

GENERAL INTRODUCTION

1.0 Introduction

Lightning cause damage to property, structures, and can even be fatal to human life if not respected. Without a doubt, expenses from lightning damage can be substantial—especially for companies whose equipment is installed on tall structures (since lightning tends to strike taller objects). The wireless antenna industry is particularly at risk with its multitude of towers.

With antenna equipment leaning more toward sophisticated designs (many with integrated electronics), protecting the electronics adds another layer of costs to the overall expenditures for a wireless site. These extensive overheads can make or break a business opportunity in today's highly competitive arena. Antenna OEMs (Original Equipment Manufacturers) are faced with the importance to determine whether lightning protection is required and the level needed, when considering new business ventures. [1]

This project provides factors to consider, as well as recommendations.

1.1 Project Aims and Objective

1.1.1 Aim

The aim of this project is to Design and Construct a lightning counter to detect and count the number of times lightning occurs in a particular area of study over a specified time.

1.1.2 Objectives

1. To know the intensity of lightning.
2. To know the level of protection and what specific protection to use.

3. To know the lightning frequency and probability
4. To know the structure height of the antenna required.

1.2 Methodology

To achieve the aim of this project, the properties of lightning was studied. This allows the selection of a good sensor that can detect the occurrence of lightning. To achieve the counting of the lightning that occurred, a 555 timer was studied and configured in a mono-stable mode to trigger the counting unit whenever lightning occurs. The count is then displayed on a seven segment display unit.

1.3 Project outline

The project report is outlined thus; chapter one states the problem, the aim of the project, the methodology involved and the block diagram representation. Chapter two highlights the literature review, which talks about the historical background of Gsm and communications and other related materials used in the course of this project. Chapter three comprises the circuit design and analysis.

Chapter four constitutes construction and testing, the results obtained and some of the difficulties encountered. Chapter 5 concludes the project and states recommendations.

CHAPTER TWO

LITERATURE REVIEW

Cloud-to-ground lightning strikes usually originate from thunder clouds in the form of a leader, carrying negative charges traveling towards the Earth in a stepped fashion.

This negative downward leader provokes upward-moving positive streamers from objects protruding from the ground (objects from the ground form intensified electric fields beneath the negative downward leader). The upward streamers may form into a positive leader, which then connects to the downward negative leader. The connection acts as a huge *switch closure* and forges a path for the negative charges to drain to the Earth. This type of lightning is referred to as *negative lightning*. Positive lightning (a leader carrying positive charges from a thunder cloud down towards the Earth) occurs on a less frequent basis, but consists of a higher level of energy. Determining the most likely object to project the successful upward-bound leader will be crucial for the placement and protection of antenna towers. The physics of lightning show that upward streamers only occur when the local electric fields are very strong, and that curved conductive surfaces intensify any ambient electric fields. Elevated structures, such as antenna towers, provide these characteristics and produce the ideal environment to attract lightning. Therefore, it becomes apparent that proper lightning dissipation be designed into the towers, while considering factors that can diminish the probability of a direct lightning strike.[1]

In this project, an electronic device is designed to be used in the calculation of lightning frequency of a particular area over a specified period of time. This will assist in knowing the

In this project, an electronic device is designed to be used in the calculation of lightning frequency of a particular area over a specified period of time. This will assist in knowing the level of protection to be provided for the antenna to be installed in that area. The probability of lightning occurring can also be calculated from the obtained frequency by multiplying the flash density (number of discharges per square Kilometer per year) by attractive area of the structure, The attractive area of a structure reflects the ground area surrounding the structure that is susceptible to lightning. The attractive area is exponentially proportional to the structure's height. This indicates that the higher the structure, the more likelihood it will trigger lightning.

From the theories mentioned above, similar antenna towers installed in an area with low flash density will probably need little to no protection, while those in a high frequency area will require a higher level of protection. The level of protection is proportional to the need for protection.

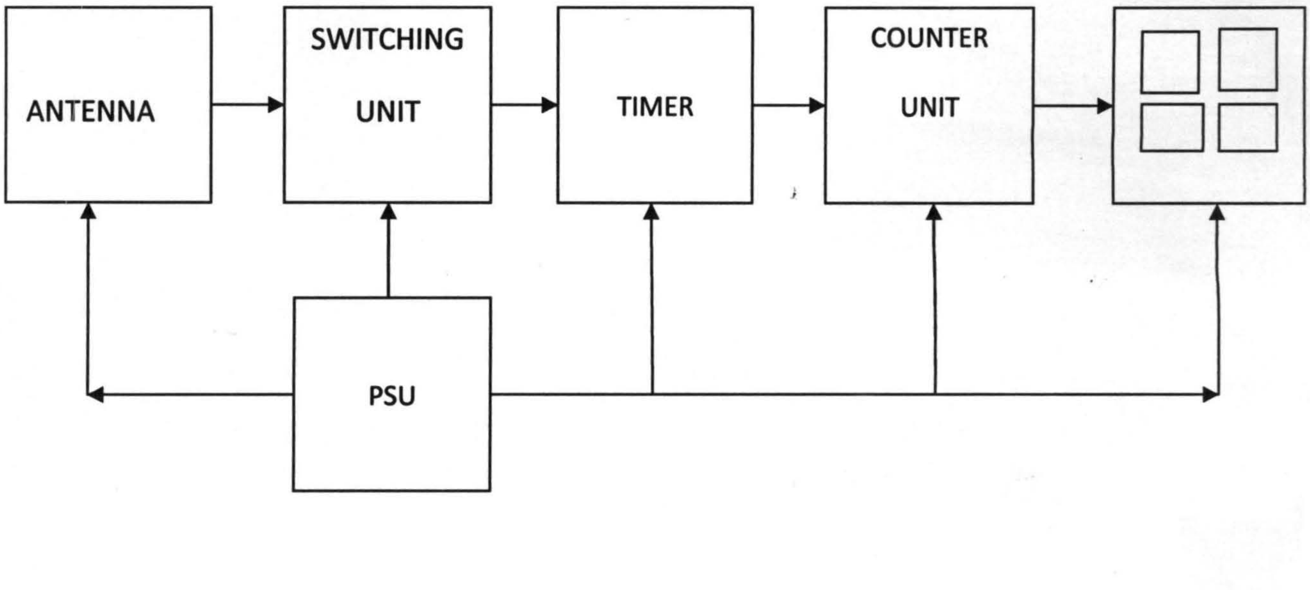

Figure2.1 Block diagram of the design.

Antenna Unit

The antenna detects the lightning, and current flows through it to the base of the transistor used as a switch. Whenever light flashes on the antenna, it senses it and the transistor turns on to trigger the timer which generates clock pulse the counter unit.

Switching Unit

The switching unit is made up of an NPN transistor configured as a simple switching device to trigger the timer whenever a base current flows through it. A variable resistor is connected between the antenna, the base of the transistor and ground. This allows varying the level of light that can trigger the transistor.[2]

Timer unit

A 555 timer configured in mono-stable mode is used to send a clock pulse to the counter unit whenever a lightning is detected. In the mono-stable mode, the timer functions as one shot. The circuit triggers on a negative-going input signal when the level reaches 1/3 of Vcc. Once triggered, the circuit remains in this state until the set time has elapsed, even if it is triggered again during this interval. The duration of the output high state is given by $t = 1.1RC$. Detail design of this unit comes up in chapter three of this project. [5]

Counter Unit

The counter unit was design using a decade counter which counts from 0 to 9 and back to zero. The output of the decade counter is connected to a seven segment display unit to display the count as the counter increment. The decade counter is cascaded to achieve counts greater than 9. Cascading two decade counter gives counts from 0 – 99 and cascading three of the counters gives a counts from 0 – 999. Detail design of this unit comes is contain in chapter three of this project.[3]

Display Unit

The display unit displays the counts of the detected lightning. A seven segment display is used in this unit. The seven segment display is connected to the output of the decade counter used in the counter unit.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

In this chapter, the detailed design of the individual block diagram in chapter two and criteria for component selection will be look into. This will be followed by the construction and assembling of various modules.

3.1 Design of Power Supply Unit

Most electronic devices and circuits required a dc source for their operation []. In dc power supply, the available 230V ac, 50Hz is converted to dc through rectifying circuit. The dc voltage produced by power supply is used to power all types of electronic circuits, such as television receivers, computers and laboratory equipment [2]. A dc source can also be obtained from electrolytic cells. A typical dc power supply consists of five stages as shown in fig. 3.1. But in this project, a battery is used to power the device to solve the issue of power failure. So transformer and rectifying unit are not part of the power supply unit in this project. ICs and other components used run on a power supply of 5V and 12V, hence the supply must be regulated to prevent fluctuation in voltage level. Fig 3.2 shows the block diagram of the power supply unit used.

Fig. 3.1 A typical dc power supply block diagram []

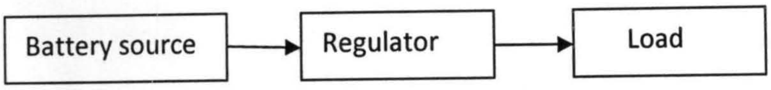

Fig 3.2 dc power supply unit

Thecomplete circuit diagram of the power supply is as shown below.

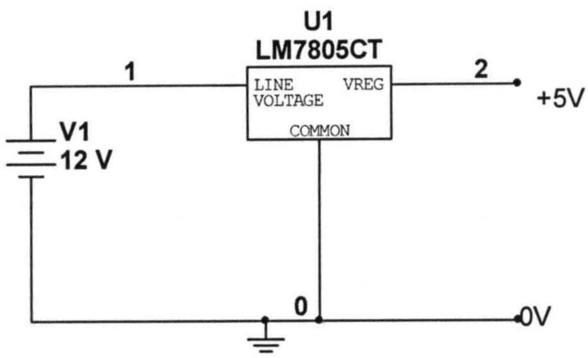

Fig 3.3 power supply circuit diagram

3.2 Sensing Unit

The sensing unit comprises of an antenna to sense the occurrence of lightning, a variable resistor to adjust the sensitivity, and a transistor to trigger the timer whenever a lightning occurs. The output from the antenna is coupled to the base of the transistor via a 1μF capacitor. A general purpose NPN transistor 2N2222 was used as a switch to trigger pin 2 of the 555 timer configured in mono-stable mode. The input to pin 2 of the 555 timer is held high using a pull up resistor calculated as shown below.

Pin 2 can sink current of about 1.6mA. Therefore, by taking the sinking current to be 0.5mA, the pull-up resistors can be calculated.

From the fig.3.4 below, V_{cc} = IR,

Where V_{cc} = +5V, I = 0.5mA, R = pull-up resistor.

Therefore, $R = \frac{Vcc}{I} = \frac{5V}{0.5mA} = 10k\,\Omega$

A resistor value of 100KΩ and a capacitor of 10μF were selected for the 555 timer in a monostable mode making the output to go high for time $T = \mathbf{1.1}RC$ whenever the timer is triggered. Hence the time is;

$$T = 1.1 \times 100 \times 10^{3} \times 10 \times 10^{-6} = 1.1 \text{ seconds } [5]$$

The pin three output triggers the counting unit. The complete circuit diagram of sensing unit is as shown below;

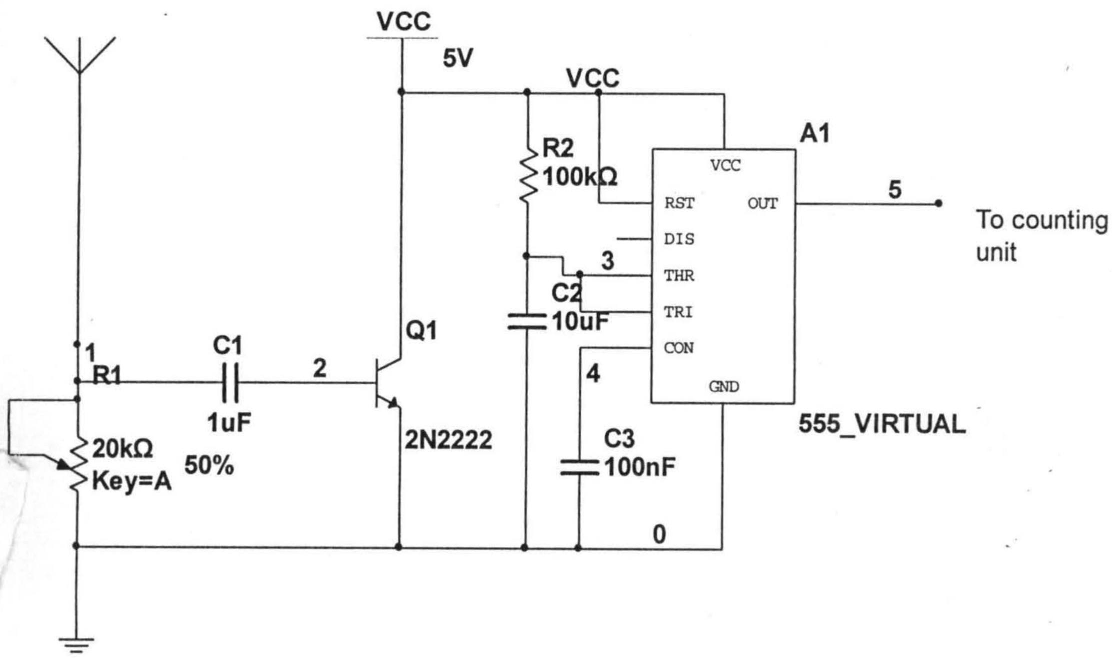

Fig 3.4 sensing unit circuit diagram

3.3 Design of Counter Unit

The counting unit was designed using a CD4518 dual up binary counter CMOS IC. It consists of two identical, internally synchronous 4-stage counters. The counter stages are D-type flip-flops having interchangeable clock and enable lines for incrementing on either positive going transition or negative-going transition. The counter was cascaded in the ripple mode the Q4 output of the counter to enable the next counter while clock input of the next counter is held low. Two CD4518 IC was used to achieve a three-digit counter. The outputs Q1, Q2, Q3, Q4, were connected to the decoding unit. The reset is active high, it is normally low. Whenever the reset input is high, the counter is reset to zero.

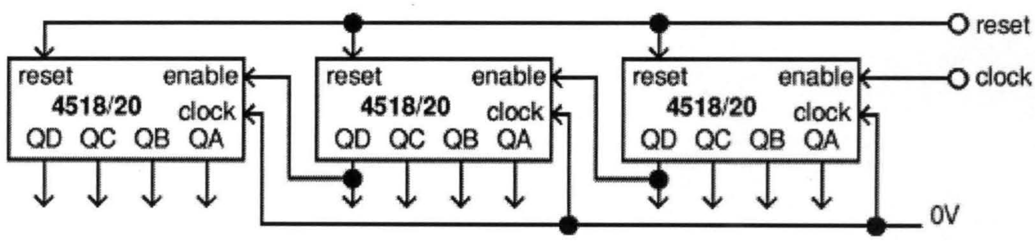

Fig 3.5 counting unit circuit diagram

The figure shows how the 4518 IC was link. The clock input was held low the enable input was used to trigger the counting. Counting advance as the enable input goes low (i.e falling edge). Output QD supplies a clock signal to the next counter. The CD4520 IC can also be used to achieve the counting.

3.4 Design of Decoder Unit.

To decode the output of the CD4518, a CMOS CD4511 type decoder was used. It is a BCD to seven segment latch decoder drivers constructed with CMOS logic and NPN bipolar transistor output devices on a single monolithic chip. The appropriate outputs a-g becomes high to display the BCD (binary coded decimal) number supplied on inputs A-D. The output is capable of sourcing up to 25mA [4]. A 330Ω resistor iss connected between the output and the seven-segment. This is to protect each of the segments from excessive current. Hence the current flowing in each segment on a 5V supply is given as;

$$I = \frac{V}{R}$$

$$I = \frac{5}{330} = 15mA$$

The figure below shows the pin configuration of the CD4511 CMOS IC;

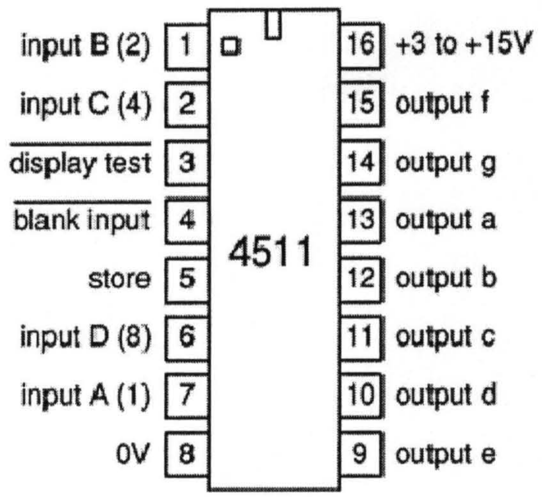

Fig 3.6 Pin configuration of CD4511

Display test and blank input are active-low so they were connected to V_{cc} for normal operation. When display test is low all the display segments should light (showing number 8) []. When blank input is low the display will be blank (all segments off). The store input was also connected to V_{cc} for normal operation of the IC. When store is high the displayed number is stored internally to give a constant display regardless of any changes which may occur to the inputs A-D.

3.5 Seven Segment Display Unit

Since the output of the decoder is active high, a common cathode seven segment is required. A 330Ω resistor was connected between the output of the decoder and each of the segments to protect them from excessive current. Three seven segment display was used giving a maximum count of 999.

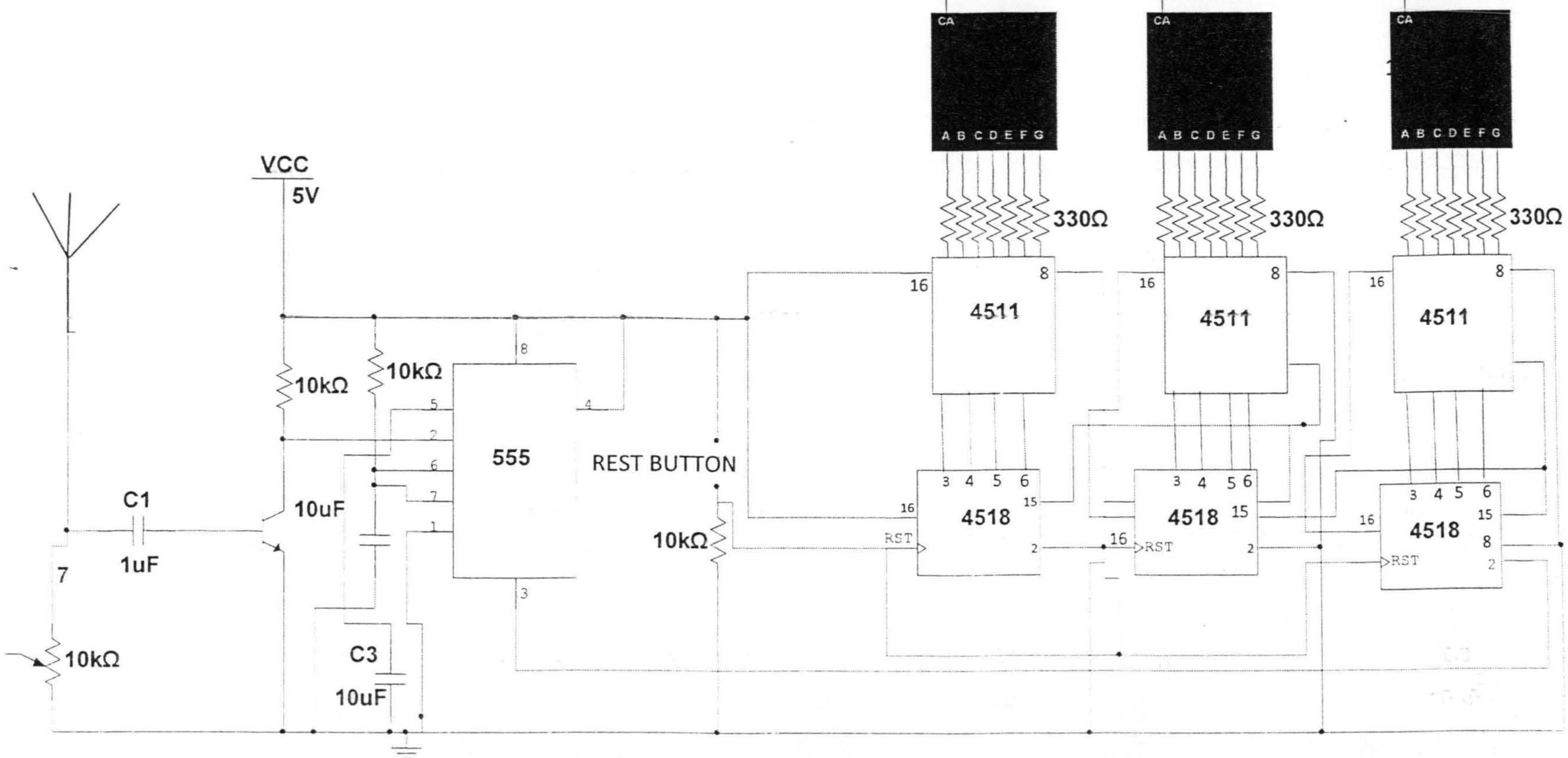

Fig 3.7: COMPLETE CIRCUIT DIAGRAM OF LIGHTNING COUNTER

3.7 Construction

The complete circuit was first constructed and tested on a breadboard. The various components used were tested using multimeter before connection. Finally the circuit was constructed on 10 by 5cm veroboard. The flow of the logic signal was noted and the different sections were laid out accordingly. The power is supplied to the main board by 7805 voltage regulator which feeds the driving circuit. As a precaution during construction, IC sockets were used for the various ICs used, so that excessive heat does not harm them. Also, the Vero board was checked carefully for continuity and any solder bridging. The following are the list of components used for the construction of the device.

i. Power supply unit
    - 9V battery
    - 7805 regulator
    - Battery cap

ii. Sensing Unit
    - Antenna
    - 10 KΩ Variable resistor
    - 1μF capacitor
    - 2N2222 NPN transistor
    - 10KΩ
    - 100KΩ resistor
    - 10μF capacitor
    - 100nF capacitor

- 555 timer IC
- IC socket

iii. Counting Unit

- Two CD4518 CMOS IC
- Reset button
- Connecting wire
- IC socket

iv. Decoding Unit

- Three CD4511 CMOS IC
- IC socket

v. Display unit

- Twenty – one 330Ω resistor
- Three seven segment display (common cathode)

CHAPTER FOUR

TESTING, RESULT AND DISCUSSION

4.1 Testing

After constructing the circuit on the veroboard, the soldering was tested using a multimeter to test for continuity and unwanted bridging in the circuit. The final work was tested using a fluorescent tube. The flickering effect of the fluorescent tube was used to simulate the occurrence of lightning,

4.2 Result

The result obtained whenever the fluorescent tube is switched on is the increment of the count. The counts indicate the total number of lightning that has occurred over a particular period of time in the area of installation. To start a fresh count, the reset button was pressed and the count reset back to zero. Maximum count that was obtained is 999 counts.

CHAPTER FIVE

CONCLUSION

5.1 Conclusion

The Lightning Counter was designed and constructed using a CD4518 BCD up-counter and a CD4511 BCD-seven segment latch decoder driver with common cathode seven-segment display connected. The device has the capability of counting up to nine thousand nine hundred and ninety-nine lightning occurrence (999 counts).

5.2 Recommendation

The aims of this project were purposely kept within what was believed to be attainable within the allotted timeline. As such, many improvements can be made upon this initial design. It is felt that this design represents a functioning miniature scale model (prototype) which could be replicated to a much larger scale. The following recommendations are provided as ideas for future expansion of this project:

- A microcontroller could be used to reduce the cost of components used in this initial design.
- The sensing unit could be improved to avoid interference from the environment.
- The seven segment-display could be increased to achieve larger count.

REFERENCES

[1] Lightning Protection for Cellular Tower Mounted Electronics by Andrew Corporation

[2] Electrical technology by B.L and A.K THERAJA

[3] Data sheet on CD4511 IC

[4] Data sheet on CD4518 IC

[5] Data sheet on 555 timer IC

[6] http://www.datasheetcatalog.com