KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

PROJECT REPORT

BATTERY LEVEL INDICATOR

A **first-year project report** submitted in partial fulfilment
of the requirements for the degree of
Bachelor of Engineering

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CERTIFICATION

FIRST YEAR PROJECT REPORT

on

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ABSTRACT

The project intends to design and fabricate a device for battery level indicator. A battery level indicator is a device that indicates battery level using voltage comparator and displays analogue percentage with reference LEDs. This project consists of two prototype designs varying in the types and quantity of the components used. The first device's circuit consists of Zener diodes ranging from 8-12 volts, resistors and 5 LEDs. The second device's circuit consists of an additional component BJT-NPN (Bipolar Junction Transistor). Each LED indicates 20% of the battery level accordingly. The second device maintains constant brightness of the LED indicators for minimum and maximum percentage of battery due to the use of transistor.

ACKNOWLEDGEMENT

We would like to extend a very warm thanks to our supervisor Dr. Shailendra Kumar Jha and our Project Coordinator Dr. Anup Thapa for approving us to build a battery level indicator as our academic project for the duration of this semester. We would also like to thank our entire faculty and the Department of Electrical & Electronics engineering for their help and support for the completion of this project. We expect similar support in the future too. And finally, we would like to extend the warmest of thanks to Mr. Sandesh Banjara, a final year student for extensively helping us to understand the concepts behind our project.

ABBREVIATIONS

Abbreviation	Full Form
LED	Light Emitting Diode
IC	Integrated Circuit
PCB	Printed Circuit Board
BJT	Bipolar Junction Transistor
NPN	Negative Positive Negative

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1 Introduction

Building a device that can detect and notify the battery level of any 12-volts power source can help assist end-users to be aware of the battery levels on their batteries to prevent older models of batteries like Lead-Acid batteries from dying due to complete discharging.

1.1 Background

This is an era of portable technology. Lightweight and portable devices such as smartphones, tablets, laptops all run on batteries, mostly rechargeable ones and battery level information is a necessity more so than it seems to be fun. A battery level indicator indicates the amount of charge left in a battery. The use of batteries, however, requires the user to take definite safety measures. Overcharging and over discharging are the biggest causes of a damaged battery. Before, battery level indicators were not as accurate as it is now, and it was hard to keep track of the charge level through mere assumption instead of an approximate percentage. Thus, an indicator which will facilitate checking the charge level of the battery at any instance and prevent a user from over draining their batteries to the level where the battery gets non-operational, is a must.

1.2 Motivation

Though a battery level indicator seems to be everywhere, in phones, large electrolytic cells, laptops, etc. it really is not available everywhere. If it was made available in every device that used a battery, then we would be able to check the battery percentage in any device and charge our devices accordingly before the battery is over- drained. Some batteries in use have high tolerance limit for overcharging while some may rupture after a certain limit of overcharging. So, this project focuses on designing and constructing such an indicator that is re-attachable to several devices and which gives the visual indication of SoC of a battery allowing the user to disconnect it before overcharging.

1.3 Problem Description

The use of batteries in today's world is extensive. They are used in almost every electronic devices. Thus it is imperative to take good care while handling batteries as it doesn’t take much to damage a battery. The most common causes of battery damage are overcharging and over draining of a battery. Hence to avoid such problems, a battery level indicator in every battery is a must.

1.4 Objectives

- Develop an indicator that shows the remaining battery level with a max permissible error of 20%
- Display the battery level using LEDs. The number of glowing LEDs will indicate the battery level.

1.5 Methodology

Firstly, detailed literature and technological survey is carried out. Then essential required components to do the project are distinguished. The prototype circuits are first tested on the breadboard. After successful work completion in breadboard, further work is carried out in prototype matrix board. The matrix board circuits are provided with a protective casing. The two different circuits can be made into two different battery level indicators and thus the project is completed.

1.6 Limitations

- This project works only for a 12 volts battery and requires further modification for bigger or smaller batteries.
- Specific resistance is used by doing calculation as random resistance cannot be used.
- The battery level cannot be shown in difference level of less than 20% in the circuits completed without the use of ICs.

1.7 Organization of Report

The first chapter of the report comprises of Introduction which consists of sub-topics like background, motivation, problem description, methodology, objectives, limitations, etc. The second chapter gives the detailed literature survey and the technological survey. The third chapter of the report deals with the system analysis and the final result of the project. The last part concludes the report and gives a short summary of the project. Then the references taken from external texts are given.

1.8 Summary

In this introduction chapter, the main theme of the project is discussed. The purpose and its implementation in our daily life is included in this section. The first chapter of this report mainly deals with the introduction part of the project. A basic background of battery level indicators is given. Then the problems descriptions and the motivation behind the project is given. The main objectives of the project is outlisted. There are a few limitations of the project that are mentioned. The overall methodology of the project is also summarized.

2 Technology and Literature Survey

This topic discusses about the use of battery level indicators throughout history. It gives a summary of its early use since the 18th century to recent times. Then the different types of components that are used in fabrication of the circuits used in the devices are given.

2.1 Prior and Recent Developments

The first use of batteries can be dated to the 18th century when Benjamin Franklin described multiple Leyden jars as battery of a cannon. Volta developed the voltaic pile in 1800 which employs electrolytes and electrodes to create flow of electrons through a wire to light up a bulb connected to the wire. It is still taught all around the world in introductory courses of science, so we know that it is the foundation for modern batteries. Despite Volta's findings, the first use of a battery as a practical source of energy by industry standards came around 36 years later when John Frederic Daniel, a British chemist invented the Daniel Cell which utilized earthen pots to manipulate electrolytes. Through constant innovations throughout the next two centuries, a battery has now come to be a highly preferred energy source especially after their potential was demonstrated by the fuel cell powered Honda Clarity FCX and the Lithium-ion battery packed Tesla Roadster in 2008, both of which could go 480+ kilometres on full charge. Since its first commercial use in 1959 as an energy pack in tractors, today's battery technologies such as lithium-ion also known as smart batteries are now as prominent and promising as ever as the world shifts towards green energy.

A lot of advancements have been seen in the battery level indicating technology and it is already a saturated piece of universal component. Battery level indicators today are purely software based and digital, controlled by a single microcontroller chip. They are most commonly seen in mobile phones and laptops and show the remaining charge, charging/discharging cycles, output voltage and battery health with dismissible errors.

Battery level indicators are needed in simple terms, to keep track of the SOC of batteries used in any electronic devices. Analog battery level indicators used decades ago did not suffice as they didn't give the information regarding critical battery level. A paper on 'how to prolong Lithium-based batteries' by Battery University shows how discharging of a battery at high temperatures and high voltages reduce its DoD, which is SoC in other terms (Cadex Electronics Inc., 2010). So, in our daily random use of batteries, it is necessary to know what amount of charge is left in order to prolong the battery life because in common practice, factors like voltage and temperature are not measured. A battery level indicator can be developed using a voltage divider circuit using diodes and resistors as well as by using a set of Comparator ICs for to achieve a compact device.

2.2 Components

The following components were used in the process of developing this device:

1. Resistor
2. Transistor
3. LEDs
4. Zener Diodes

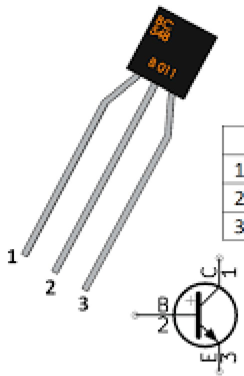
2.2.1 Resistor

A resistor is a device which resists the passage of electrical current. It is an electrical component which implements electrical resistance as a circuit element. Resistors are used in electrical circuits for various purposes such as adjusting signal levels, dividing voltages, reducing current flow, terminating transmission lines, etc among other uses. The values of resistors used so far in this project are of 470 ohm, 49 ohm, 44 ohm, 22 ohm and 820 ohm.

Figure 1 : Resistor

2.2.2 Transistor

A transistor is an electrical device which can be used to switch electrical power and electrical signals or amplify them. A transistor is generally composed of semiconductor material with an external circuit connected to at least three terminals. The transistors used in this project, BC548 transistors are general purpose silicon NPN-BJT (Negative Positive Negative Bipolar Junction Transistor). It is used for amplification and switching purposes.



BC-548	
1	Collector
2	Base
3	Emitter

Figure 2: BC-548 Model Transistor

2.2.3 LEDs

An LED is a semiconductor light source that emits light when a current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. Red(5V, 20 mA) LEDs have been used in this project.

Figure 3: LED

2.2.4 Zener Diode

A zener diode allows current to flow in the reverse direction when the zener voltage is reached. The zener diodes used in this project so far have a biasing voltage of 8.2V, 9V, 10V, 11V and 12V.

Figure 4 : Zener diodes

2.3 Summary

From multiple Leyden jars used as battery in the early 18th century we have come a long way. Nowadays the most commonly used batteries are lithium-ion and lithium-polymer based. Lithium-ion and Li-Polymer batteries are outstanding in every aspect so they are used from remotes of TV to space missions.

3 Methodology and Results

3.1 System Overview

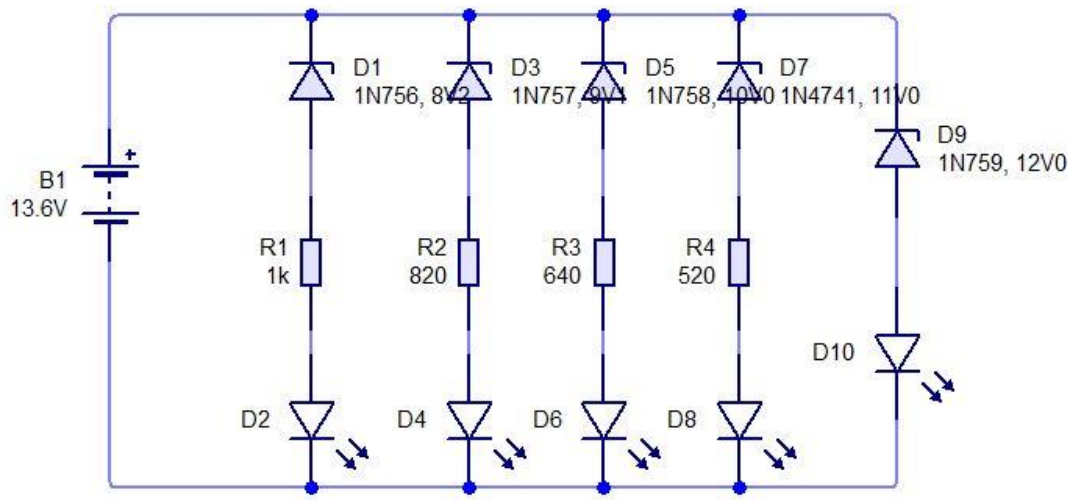


Figure 5 : Compact Circuit using Zener, Resistor & LEDs

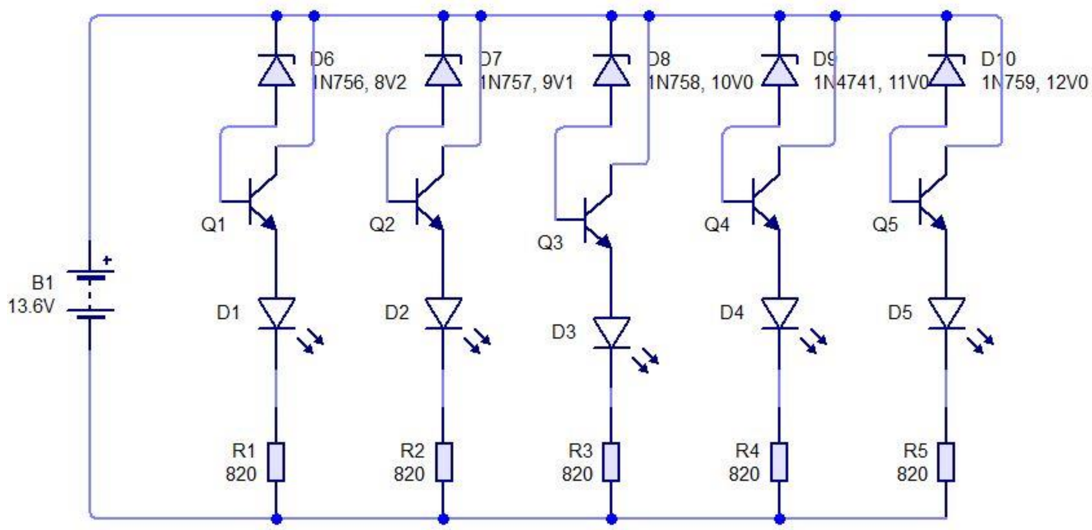


Figure 6 : Stable Brightness circuit with additional BJT-NPN Transistors

3.2 Project Activity

We completed our tasks in the following order:

1. Completed design and simulation of prototypes of 12 volts battery level indicator in simulation platform (Circuit Wizard) using 5 LEDs.
2. Simplification of the design.
3. Collection of necessary components and conduction of their test on breadboard.
4. Implementation of the tested circuit on matrix board.

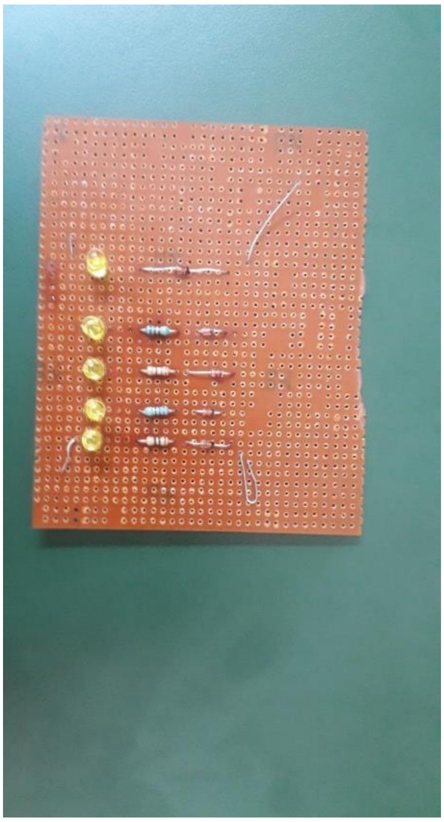


Figure 7 : 1st Circuit

The circuit using resistors & diodes

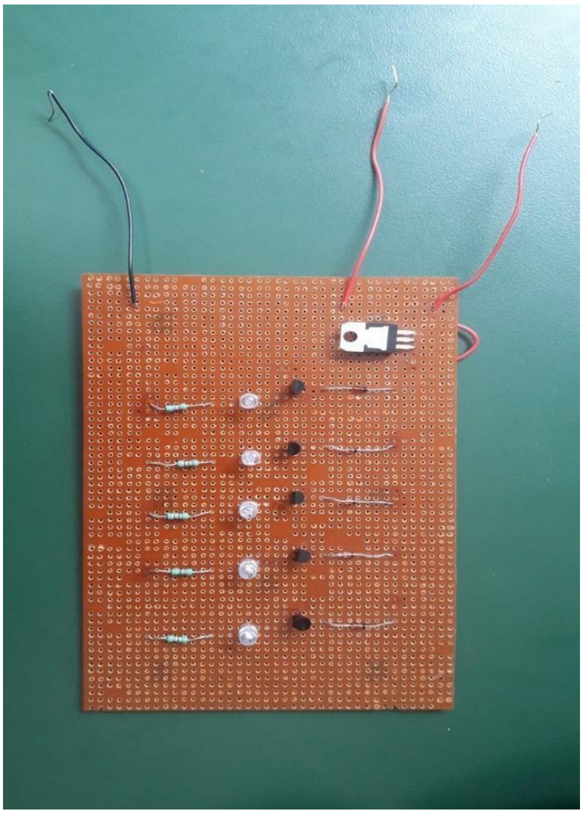


Figure 8 : 2nd Circuit

The circuit with the addition of the transistors

1. Implementation of final circuit using 10 LEDs on breadboard and matrix board.
2. Completion of PCB design.
3. Implementation of design on PCB.
4. Testing and troubleshooting of final product.

3.3 Comparative Analysis

Technical

Since the first device is based on only zener diodes, the first device does not maintain constant brightness among the LEDs but the use of transistors as switches in second device makes it able to maintain constant brightness. The zeners are used to ON the second circuit (transistors) at its base in the second device.

Economic

The first device is more economical compared to the second device. The first device consists of lesser components which inevitably makes it cheaper than the second one. This can be illustrated more clearly from the table below:

<table>
<tr><th>Device with only Zener Diode and Resistors</th><th>Device with Transistor added to the preceding circuit</th></tr>
<tr><td>
<table>
<tr><th>Component</th><th>Quantity</th><th>Cost</th><th>Total</th></tr>
<tr><td>Resistors</td><td>5</td><td>3</td><td>15</td></tr>
<tr><td>Zener diode</td><td>5</td><td>3</td><td>15</td></tr>
<tr><td>LED</td><td>5</td><td>5</td><td>25</td></tr>
<tr><td>Matrix Board</td><td>1</td><td>30</td><td>30</td></tr>
</table>
</td><td>
<table>
<tr><th>Component</th><th>Quantity</th><th>Cost</th><th>Total</th></tr>
<tr><td>Resistor</td><td>5</td><td>3</td><td>15</td></tr>
<tr><td>Transistor</td><td>5</td><td>5</td><td>25</td></tr>
<tr><td>LED</td><td>5</td><td>5</td><td>25</td></tr>
<tr><td>Zener diode</td><td>5</td><td>3</td><td>15</td></tr>
<tr><td>Matrix Board</td><td>1</td><td>30</td><td>30</td></tr>
</table>
</td></tr>
<tr><td>Total Cost: 85</td><td>110</td></tr>
</table>

**All values are in NRs.*

Application

The first device is more portable than the second one due to its smaller size. For example, campers prefer the first device compared to the second as it occupies less space.

3.4 Summary

This chapter gives a detailed explanation of the working system of the battery level indicators. A system overview of the two circuits used is provided. Then a detailed explanation of the components used and the circuit setup of both circuits is given. The project activities done in sequential order is specified. Then a comparative analysis of two circuits is done.

4 CONCLUSION AND FUTURE WORKS

This project comprises of designation and fabrication of two different devices as battery level indicators. The battery level indicator is indicated with the use of zener diodes, resistors and LEDs in the first device.The first device's circuit consists of zener diodes ranging from 8-12 volts, resistors and 5 LEDs. For the second device, additional components such as BJT-NPN transistors are used where they act as switches to turn on the circuit and display the battery level as analogue percentage with reference LEDs. Each LED indicates 20% of the battery level accordingly. The second device maintains constant brightness of the LEDs for minimum to maximum percentage of battery due to the use of BJT-NPN transistor. These two devices can only be used to display the battery level for a 12V battery. Battery level of any battery deviating from that value needs further modification of the circuits.

The battery level can also be indicated with the use of ICs in the circuits for better accuracy, efficiency and compactness. ICs are used to operate displays that visually show the magnitude of an analog signal. The use of LM3914 in the circuit would be more accurate as upto 10 LEDs can be implemented in the circuit design. Therefore, each LED would have the capacity to indicate the battery level at a difference of 10% thus achieving precision.

5 BIBLIOGRAPHY

http://www.mcmanis.com/chuck/robotics/tutorial/h-bridge/bjt_theory.html

https://www.digikey.com/en/maker/blogs/zener-diode-basic-operation-and-applications

https://www.khanacademy.org/science/electrical-engineering/ee-circuit-analysis-topic/ee-resistor-circuits/a/ee-voltage-divider

Robert L. Boylestad, *"Introductory Circuit Analysis"*, 13th Edition, Pearson, 2019

https://www.electronics-tutorials.ws/opamp/opamp_1.html

https://www.allaboutcircuits.com/textbook/experiments/chpt-6/voltage-comparator/

https://www.electronics-tutorials.ws/transistor/tran_4.html

6 REFERENCES

Cadex Electronics Inc. (2010, 10). *How to Prolong Lithium Based Batteries - Battery University*. Retrieved from Basic to Advanced Battery Information from Battery University: https://batteryuniversity.com/learn/article/how_to_prolong_lithium_based_batteries

7 GANTT CHART

Tasks	**March**	**April**	**May**	**June**	**July**
Literature survey					
Proposal Submission					
Prototype Designing					
Mid-term report submission					
Circuit designing and testing					
Product Assembling					
Final report submission					

Tasks Completed

Tasks Remaining

8 APPENDIX

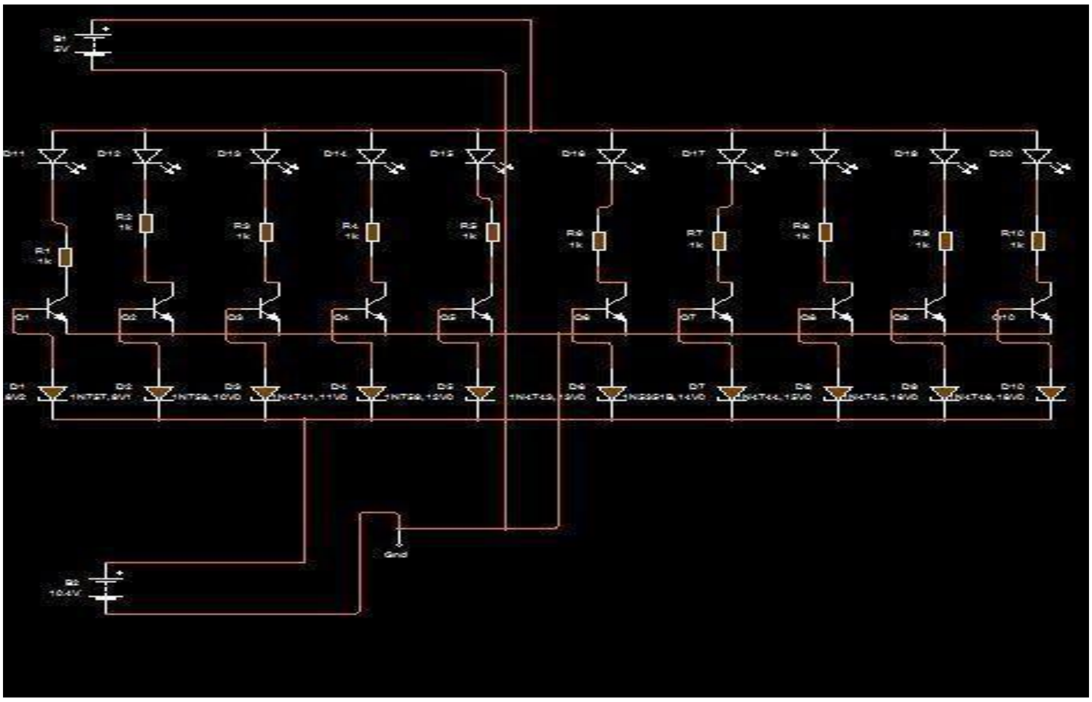


Figure 9 : Extended Circuit with 10 LEDs