VIETNAM NATIONAL UNIVERSITY, HO CHI MINH CITY
UNIVERSITY OF TECHNOLOGY
FACULTY OF COMPUTER SCIENCE AND ENGINEERING

ELECTRICAL ELECTRONIC CIRCUITS
REPORT

ASSIGNMENT

Topic:

Music Rhythm LEDs

Instructor:	Nguyen Thien An
Student name:	Nguyen Bui Tuan Anh
Student ID:	2352038
Class:	CC03

HO CHI MINH CITY, 2024

Contents

1 Introduction

In this assignment, I am working on a PCB project that is the Music Rhythm LEDs circuit. It uses a microphone to detect sound and flashes LEDs in sync with the rhythm of the music.

2 Schematic and Conceptual Design

2.1 Schematic Design

This is the Schematic Design for my circuit.

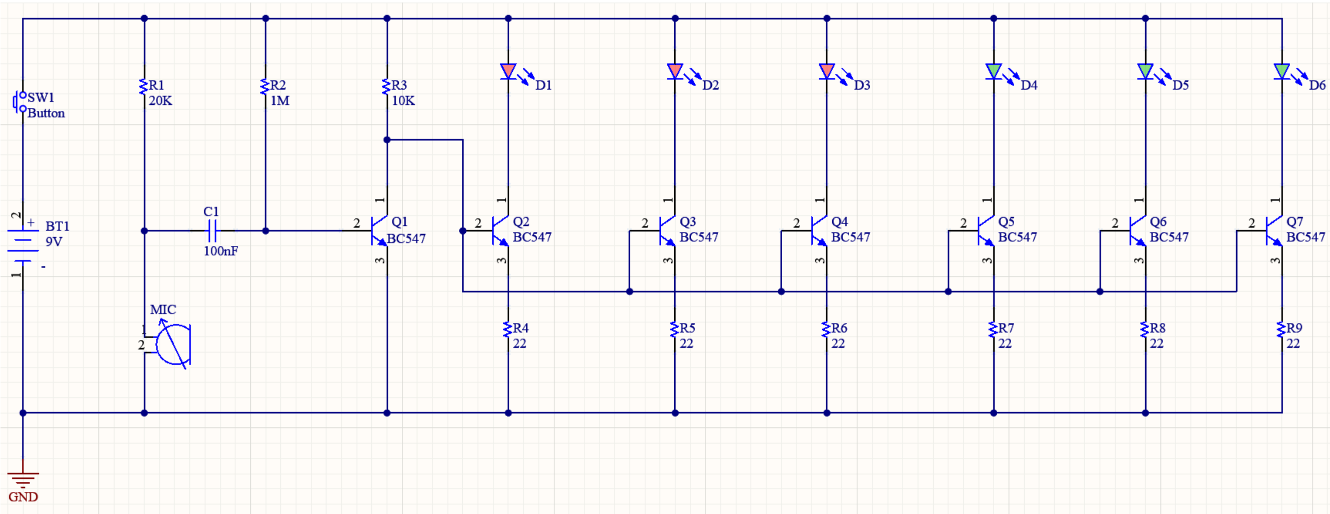

Figure 2.1: Schematic Design

2.2 Conceptual Design

2.2.1 Form Factor with Hardware Interface

Sketching the form factor in Altium Designer

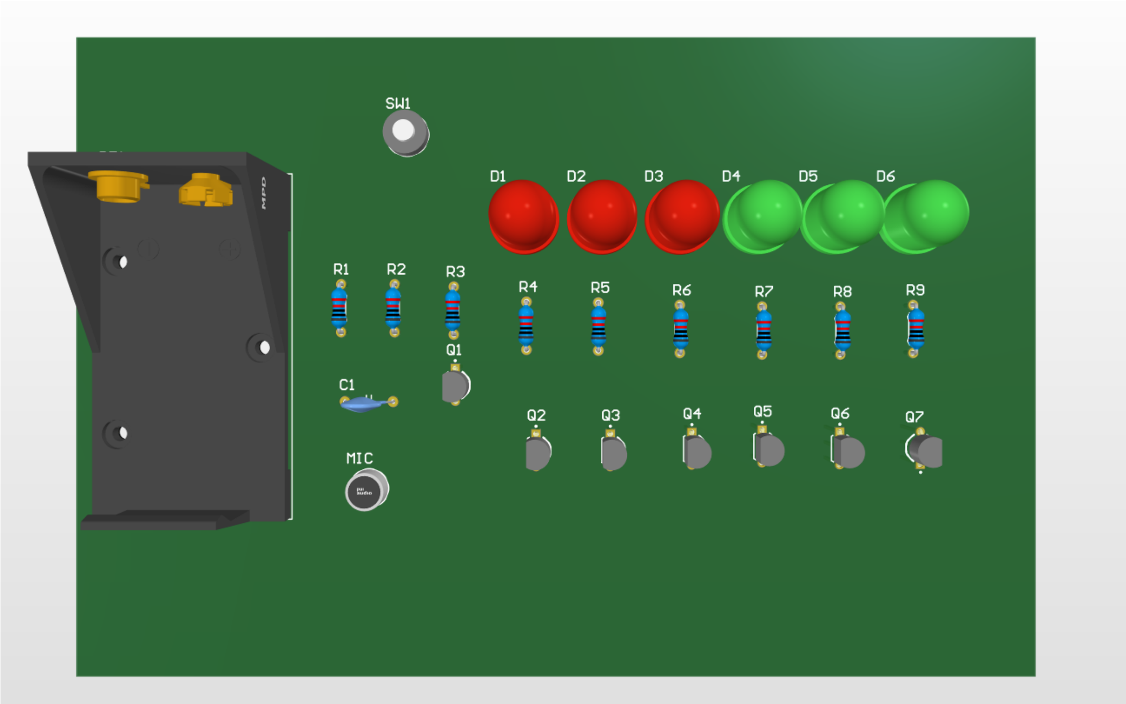

Figure 2.2: Form Factor

I will explain the interface of the form factor above:

- R1 to R9: Resistors R_1 to R_9
- C1: Capacitor C_1
- Q1 to Q7: Transistors Q_1 to Q_7
- D1 to D6: 6 LEDs
- MIC: the Microphone to detect sound
- SW1: Switch
- The 9V battery holder.

The main working principle of this circuit is:

1. Sound Detection and Amplification

- The microphone picks up sound, converting it into an AC signal. This AC signal is coupled through C1 to the base of Q1.
- Transistor Q1 amplifies the signal from the microphone. As the sound intensity changes, the amplified signal at the collector of Q1 will fluctuate accordingly.

2. LED Flashing Circuit

- The amplified signal is then used to drive the base of each of the transistors Q2 to Q7.
- Each of these transistors controls one LED, and when the base voltage is high enough, the corresponding transistor conducts, allowing current to flow through the LED, causing it to light up.
- The resistors R4 to R9 limit the current and voltage apply to each LED, preventing damage.

3. Synchronization with Music Rhythm:

- As the sound signal changes in intensity with the rhythm, the amplified output changes, causing different transistors to switch on and off.
- This synchronized flashing effect creates a light show in rhythm with the music.

2.3 Functional Blocks

According to the schematic and conceptual above, this device can be defined to have 3 main blocks:

- Power Supply: the 9V DC source (Battery).
- Function: flashing LEDs syncing with the input Music.
- Human Interface: Switch to turn on/off, the Microphone and the LEDs dancing.

3 Hardware Specification

In this section, I will explain the components in details by some attributes and calculations.

1. Electret condenser Microphone 56DB DIP

Detects sound and converts it into a small electrical signal – steady DC voltage (idle bias), with the AC audio signal superimposed

- Omnidirectional
- Operating voltage: 3 - 5V. We can choose typically as 4V
- Frequency Range: 50 – 16kHz
- Current consumption: Max 0.5mA
- Sentivity: $-56 \pm 2\,dB$

56DB DIP Datasheet

2. Capacitor C_1 (100 nF)

Blocks the DC bias voltage and allows only the AC (audio) signal from the microphone to pass through. This capacitor C_1 and resistor R_2 also form a high-pass filter that blocks all the frequency that $< f_c$ (cut-off frequency)

Therefore, we need the frequency f_c to be lower than or equal to the range of 50 – 16kHz (frequency range of the Mic). We will now choose appropriate the value for R_2 right after this.

$$f_c = \frac{1}{2\pi R_2 C_1} = \frac{1}{2\pi R_2 \times 100 \times 10^{-9}}$$

The capacitor is non-polar, so I choose a ceramic one
Capacitor C_1

3. Resistors R_1, R_2, R_3

- **R_1 (10 kΩ):** Pull-up resistor, modify the appropriate voltage bias (2V), and current consumption (0.5mA) apply to the microphone.

The capacitor C_1 blocks DC, so we can calculate the current through the mic (which is the current through R_1), and has to be $\leq 0.5\,\text{mA}$

$$I_{mic} = \frac{V_{DC} - V_{mic}}{R_1} = \frac{9-4}{10} = 0.5\,\text{mA}$$

- **R_2 (1 MΩ):** Connect with the capacitor C_1 to form a high-pass filter, define a low cut-off frequency f_c which should be less than the range 50 - 16kHz of the Mic, allow full audio signal to pass through

$$f_c = \frac{1}{2\pi R_2 C_1} = \frac{1}{2\pi \times 10^6 \times 100 \times 10^{-9}} = 1.6\,\text{Hz} < \text{frequency range of the Mic}$$

- **R_3 (10 kΩ):** Bias resistor for the transistor Q_1.

Resistor 10 kΩ
Resistor 1 MΩ

4. Transistors

- Transistor Q_1 (BC547): Amplifies the audio signal from the microphone.
- Transistors Q_2 to Q_7 (BC547): Each drives one LED in response to the amplified signal.

BC547 Datasheet.

5. LEDs (LED_1 to LED_6)

Flash in response to music rhythm. Size: 10 mm

Red LEDs:

- Operating voltage: max 2.3V (typical 2.2V)
- Current drive: 20mA

Green LEDs:

- Operating voltage: max 3 - 3.3V (typical 3.2V)
- Current drive: 20mA

Red LEDs
Green LEDs

6. Resistors R_4 to R_9

Limit the current and voltage apply to each LED, protecting them from excessive current.

$R_{4\to6}$:

- We choose typical V = 2.2V for Red LEDs
- The max value of V_{CE} is 45 for the BC547 transistor.
- The current through Red LEDs is 20mA

So, we need the resistors to satisfy those values. I choose a common resistor value of $22\,\Omega$ for $R_{4\to6}$

$$V_{CE} = V_{DC} - V_{LED} - I_{LED} \times R_{4\to6} = 9 - 2.2 - 20 \times 10^{-3} \times 22 = 6.36\,\text{V} < 45\,\text{V}$$

$\boldsymbol{R_{7\to9}}$ **:**

- We choose typical V = 3.2V for Green LEDs
- The max value of V_{CE} is 45 for the BC547 transistor.
- The current through Green LEDs is 20mA

So, we need the resistors to satisfy those values. I choose a common resistor value of $22\,\Omega$ for $R_{7\to9}$

$$V_{CE} = V_{DC} - V_{LED} - I_{LED} \times R_{7\to9} = 9 - 3.2 - 20 \times 10^{-3} \times 22 = 5.36\,\text{V} < 45\,\text{V}$$

Resistor $22\,\Omega$

7. Battery 9V:

The battery supplies constant DC voltage source for the device. As shown in some calculations above, 9V is suitable for this device.

9V Battery
Battery Holder

8. Switch:

Turn on or off the device. For the final PCB device, I will use a rocker switch and connect its wire to the PCB board for better appearance and convenience.

Rocker Switch

4 PCB Layout

The PCB Layout of this device is made in Altium Designer. My PCB device has 1 layer so the only layer we need is the bottom layer.

4.1 2D Layout:

This is the bottom layout after everything have been done (including polygon pour, mounting holes, etc)

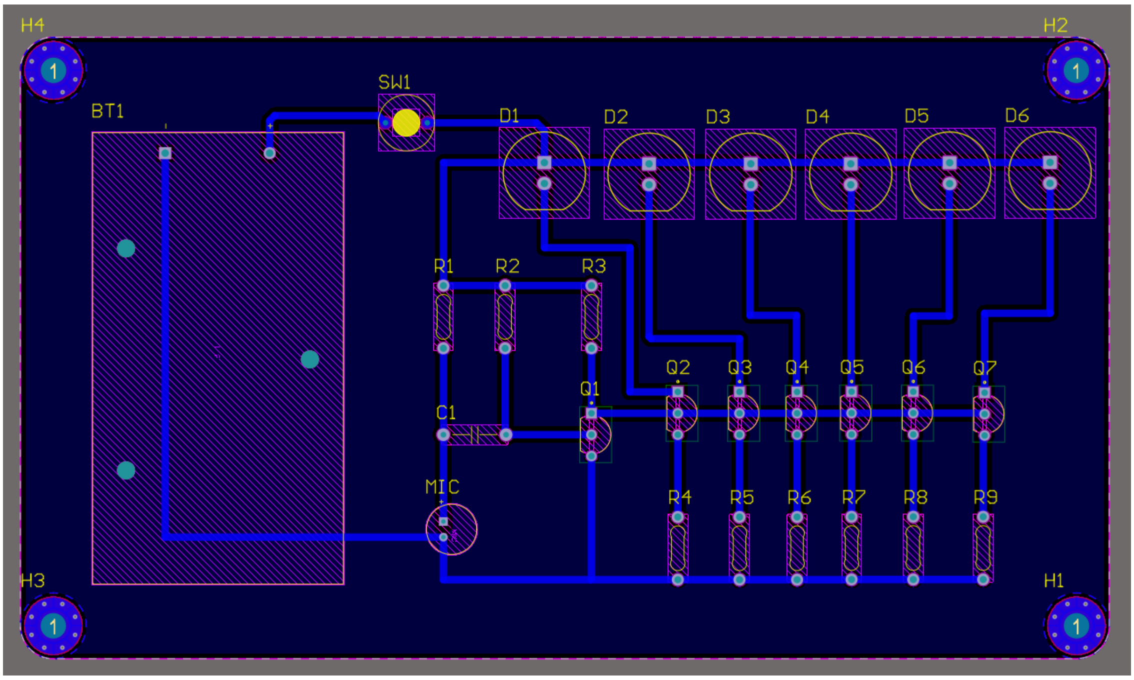

Figure 4.1: Bottom Layer

4.2 3D Layout

Here are some 3D view of the project

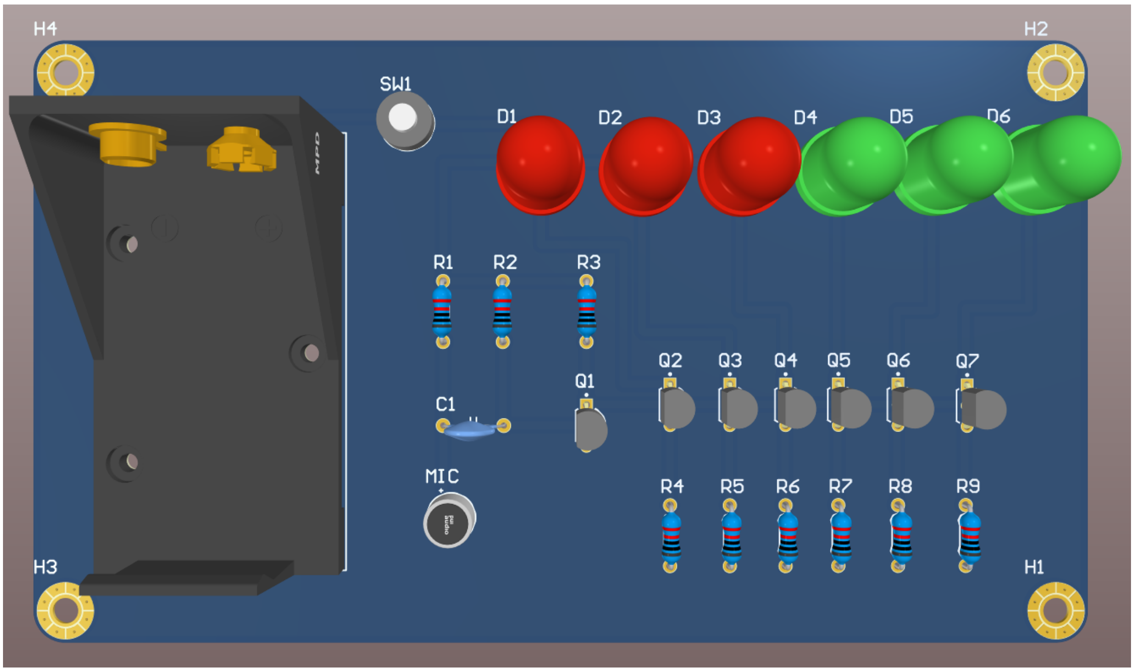

Figure 4.2: 3D Layout

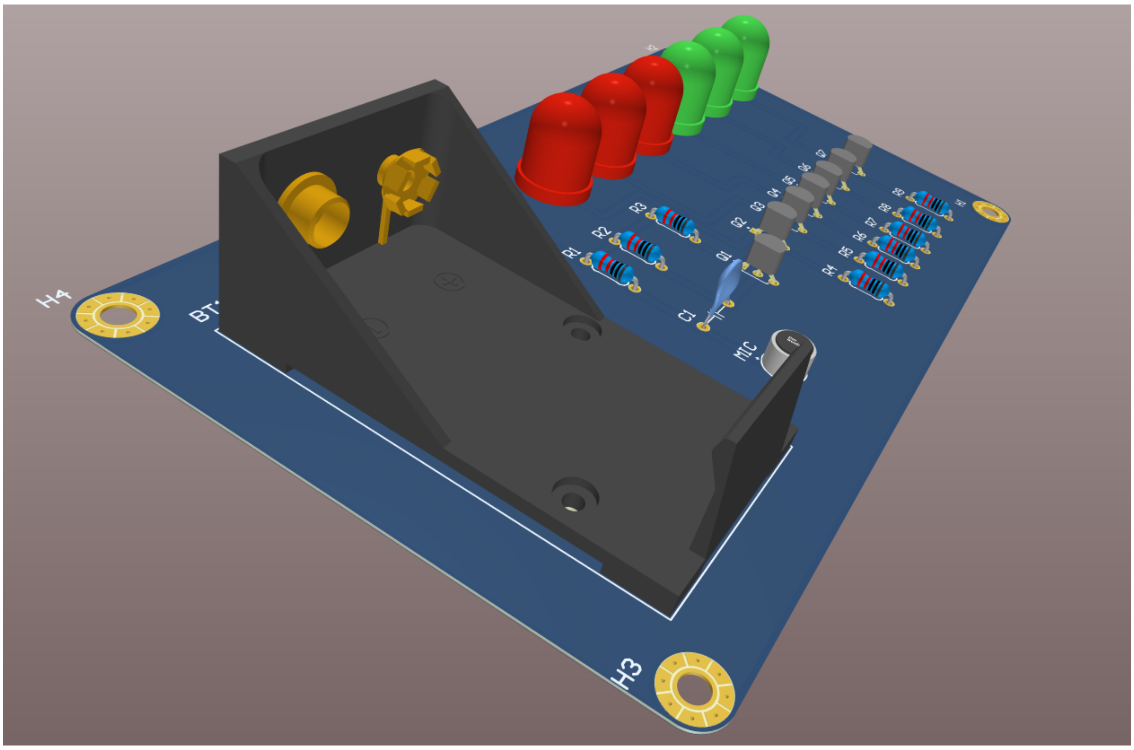

Figure 4.3: 3D Layout

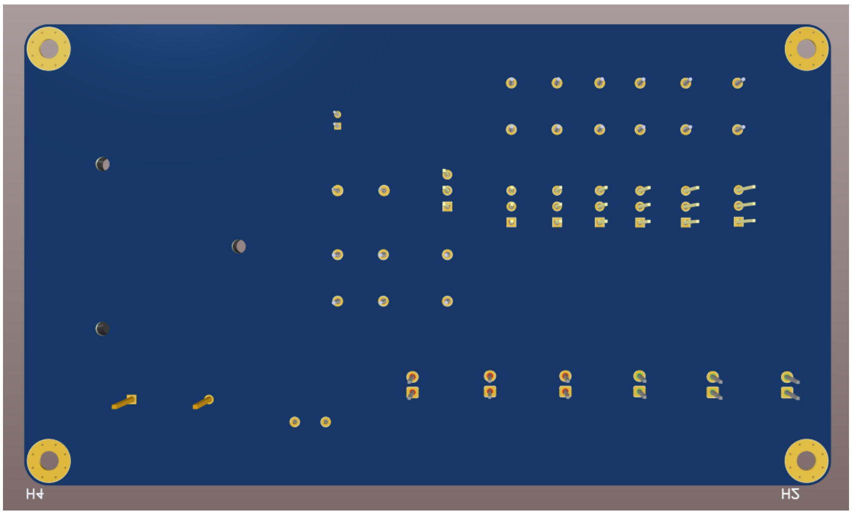

Figure 4.4: 3D Layout

4.3 Final PCB Device Layout

This is my One-Layer PCB Rhythm Music LEDs device

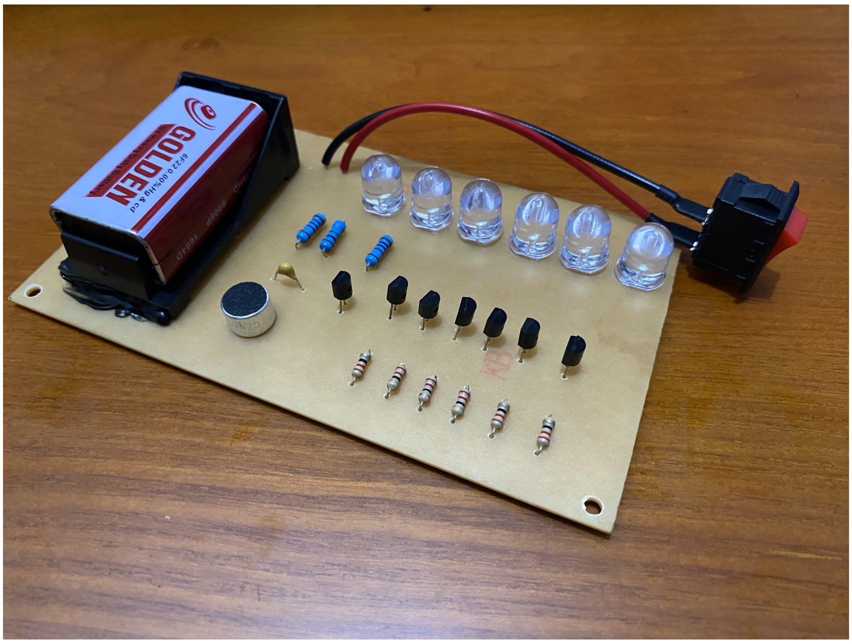

Figure 4.5: PCB Device

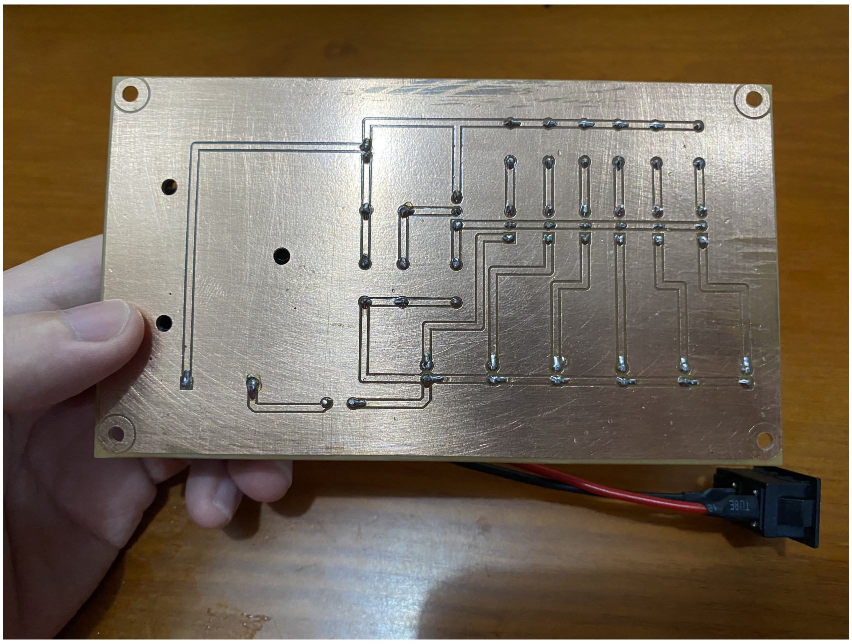

Figure 4.6: PCB Device

5 Device Demonstration

This is a video I recorded to show how the device works: Rhythm Music LEDs device Demo

Thank you for watching.

6 Altium Education Certificate

Figure 6.1: Altium Certificate