ECE 1000 Final Report: My Magic Wand PCB Project

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***Abstract* - As an electrical engineering student, being able to understand how Printed Circuit Board (PCB) works is very important. Therefore, I have decided to make an intro project for my first PCB design ever. The expected outcomes from this project are: understanding the process of making a PCB, including designing schematic, finding an appropriate footprint for each component, modifying route appropriately, and exporting Gerber and Drill files, being able to solder components on the PCB, and getting used to digital IC chips, especially the 555 Timer. This report explains the design, functionality of the Magic Wand PCB Design.**

I. INTRODUCTION

For this project, I am designing a custom PCB for a "magic wand" that brings a touch of enchantment through a sequence of blinking LEDs. The goal of the project is to create a compact, handheld wand that lights up in a programmed pattern, simulating a magical effect. Using simple IC digital chips and a series of LEDs, this project will cover essential PCB design principles, including component layout, circuit routing, and power management. The wand will create dazzling light sequences, offering an interactive and visually engaging experience. This project not only combines electronics with creativity but also offers hands-on experience in designing a functional and aesthetic PCB.

II. BACKGROUND

To comprehend the "My Magic Wand PCB Project," it's essential to have a foundational understanding of several electronic components and concepts:

1. **555 Timer IC**: This versatile integrated circuit functions as a timer, pulse generator, or oscillator. In this project, it's configured to generate adjustable clock pulses that control the LED blinking sequence.
2. **Binary Counter (e.g., SN74HC393N)**: This digital device counts clock pulses from the 555 timer and outputs a binary number corresponding to the count. The project utilizes this counter to sequence the LEDs.
3. **Decoder/Demultiplexer (e.g., CD74HC138E)**: This component decodes binary inputs from the counter into individual outputs, each corresponding to a specific LED. It ensures that only one LED lights up at a time in the desired sequence.
4. **Potentiometers**: Variable resistors used to adjust the frequency of the 555 timer's output pulses, allowing control over the LED blinking speed.

III. PROJECT DESCRIPTION AND FORMULATION

Materials:

1. 1 TI CD74HC138E: IC DECODER/DEMUX 1X3:8 16DIP.
2. 1 TI SN74HC393N: IC BINARY COUNTER DL 4BIT 14DIP.
3. 1 LM 555 : 555 Timer.
4. 8 100 Ohm Resistors.
5. 2 100K Potentiometer.
6. 1 Switch.
7. 8 Green LEDs.
8. 1 47uF Electrolytic capacitor.
9. 4 0.1uF Ceramic capacitor.
10. 1 10uF Ceramic capacitor.
11. 3 AAA battery holder.

Diagram:

Figure 1 below shows the schematic of the circuit including the power supply, the IC chips, and the LED configuration. Furthermore, Figure 2 and Figure 3 show the PCB design of the top layer and bottom layer of the wand. Finally, Figure 4 shows the actual design and soldered board.

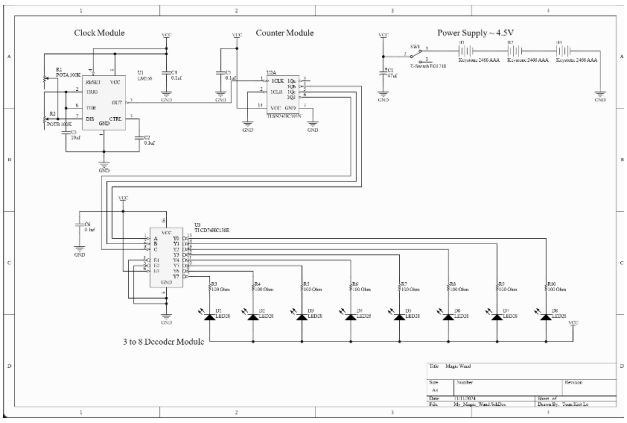

Figure 1: Schematic of the Magic Wand.

Figure 2: Top Layer View of the PCB Design

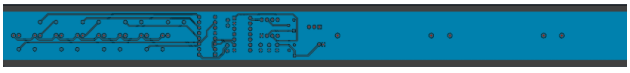

Figure 3: Bottom Layer View of the PCB Design

Figure 4: Completed Design and Soldered Product

Functionality:

When the switch is closed, all the IC chips are powered by the 4.5 V power supply. Initially, the 555 timer will take the value of the potentiometers R_1, R_2, and the capacitance C_3. The charge, discharge, and cycle time can be calculated using these equations:

$$t_{charge} = 0.693(R_1 + R_2).C_3,$$
$$t_{discharge} = 0.693 \times R_2 \times C_3,$$
$$T = t_1 + t_2 = 0.693(R_1 + 2R_2)C_3.$$

Using the clock pulse generated by the 555 Timer, the 4-BIT Binary Counter start counting, however, I only use 3 outputs pin to drive the 3:8 decoders. Finally, the output of the 3:8 decoder will emit the LEDs in sequence.

IV. DISCUSSION AND RESULTS

The "My Magic Wand PCB Project" demonstrates the interplay of foundational electronic components to achieve a functional and visually appealing outcome. The project effectively employs a 555 Timer IC to generate clock pulses, a binary counter to sequence outputs, and a decoder to control individual LEDs. These components, along with proper circuit design techniques, successfully achieve the desired sequential LED blinking pattern.

Throughout the development process, several key considerations were addressed:

1. **Component Selection**: Each component was chosen based on its compatibility with the circuit's requirements. The 555

Timer IC offered a flexible timing solution, while the SN74HC393N and CD74HC138E provided reliable counting and decoding functionalities.

2. **Timing Adjustments**: Using a potentiometer to vary the resistance in the 555 timer circuit allowed for precise control of the blinking speed. This feature added interactivity and highlighted the importance of understanding RC timing circuits.
3. **Power Supply Design**: The use of a 3 AAA battery configuration ensured sufficient power while maintaining portability. Proper current-limiting resistors were included to protect the LEDs from overcurrent damage.
4. **PCB Layout**: Designing a compact yet functional PCB posed challenges in routing connections and managing space constraints. However, the final PCB design achieved a balance between functionality and manufacturability.

Despite its success, the project encountered a few challenges, such as ensuring stable operation at higher blinking speeds and minimizing potential noise in the circuit. These issues were addressed through iterative testing and design refinements.

The project successfully met its objectives. The key results include:

- **Sequential LED Control**: The LEDs illuminated in a well-defined sequence, showcasing the effectiveness of the binary counter and decoder.
- **Adjustable Blinking Speed**: The potentiometer enabled smooth and responsive control over the LED timing, adding a customizable element to the circuit.
- **Compact and Functional PCB**: The final PCB design was compact, portable, and easy to assemble, making it user-friendly and visually appealing.
- **Educational Value**: The project provided an excellent learning experience in digital logic, analog timing circuits, and PCB design principles.

The "My Magic Wand PCB Project" not only achieved its technical and aesthetic goals but also served as a valuable learning tool for understanding electronic design fundamentals. The successful implementation of sequential LED control and timing adjustments highlights the project's potential for educational applications and further enhancement.

V. CONCLUSION

The **"My Magic Wand PCB Project"** successfully demonstrates the integration of fundamental electronics principles into a practical and visually engaging design. By leveraging components such as the 555 Timer IC, binary counters, and decoders, the project showcases how basic digital and analog circuits can work in harmony to create dynamic LED lighting effects.

This project not only serves as a functional and aesthetically pleasing outcome but also provides an excellent learning platform for understanding PCB design, timing circuits, and binary logic. The adjustable speed control adds a layer of user interactivity, making it a versatile tool for both educational and entertainment purposes.

REFERENCES

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