Board 1 Report: 555 Timer Circuit

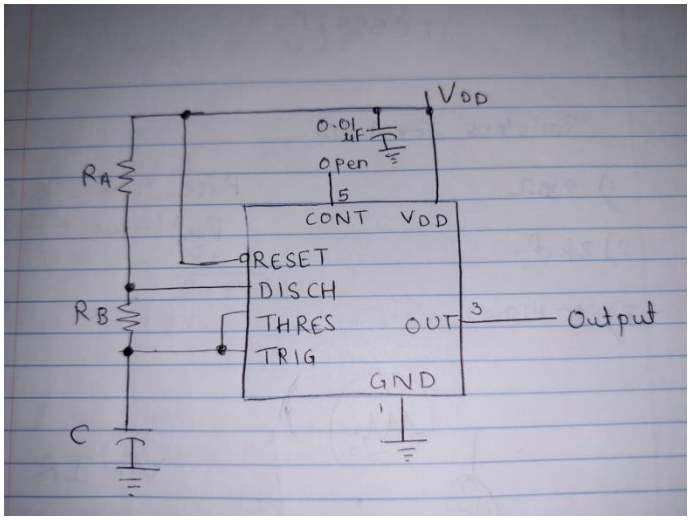
Objective:

This project aimed to design and test a PCB using the 555 Timer in an astable configuration to generate a square wave signal with a controlled frequency and duty cycle. The board was designed in Altium Designer**,** ensuring best PCB design practices and using 1206 components for easy manual soldering**.** The circuit was tested under both load and no-load conditions, **measuring** key electrical parameters such as output voltage, LED current, rise and fall times**.** These measurements validated circuit performance and provided insights for future PCB designs.

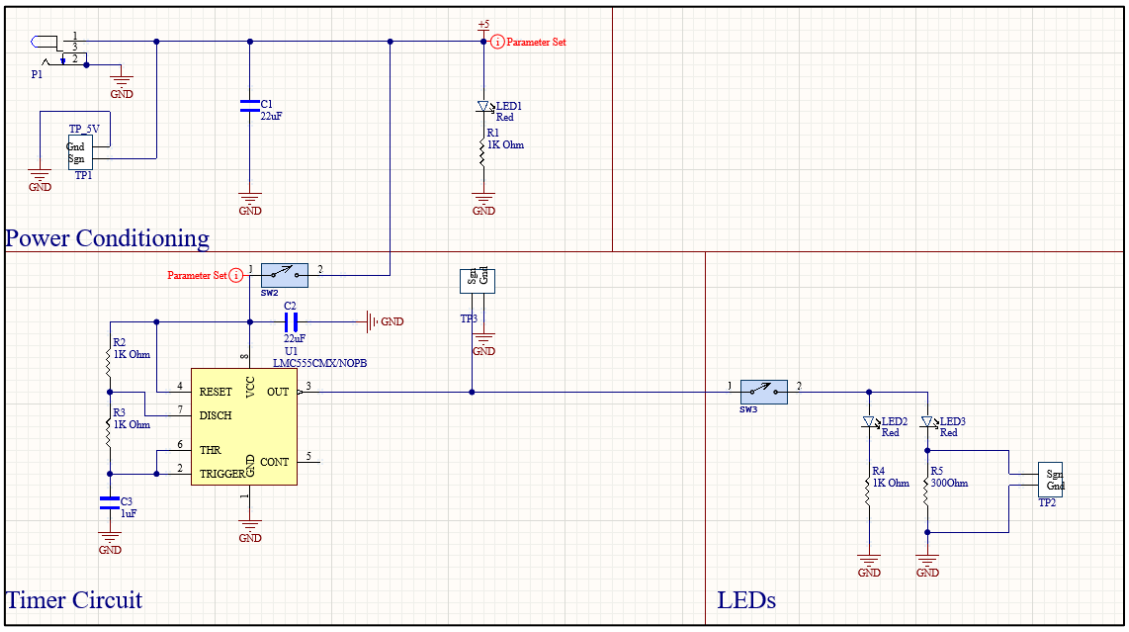
Bill of Materials:

	Line #	Name	Description	Designator	Quantity
1		22uF	22uF ±10% 25V X5...	C1, C2	2
2		1uF	MULTILAYER CERA...	C3	1
3		Red	Red 621~631nm 12...	LED1, LED2, LED3	3
4		Power Jack	Power Barrel Connec...	P1	1
5		1k	CHIP RESISTOR - SU...	R1, R2, R3, R4	4
6		300 Ohm	CHIP RESISTOR - SU...	R5	1
7		SW_2Pin_100mil_Switch	2Pin Header	SW2, SW3	2
8		TP_5V	Test Point 300 mil ce...	TP1	1
9		10x Probe TP	Test Point 300 mil ce...	TP2, TP3	2
10		LMC555CMX/NOPB	555 Type, Timer/Osc...	U1	1

Napkin sketch:

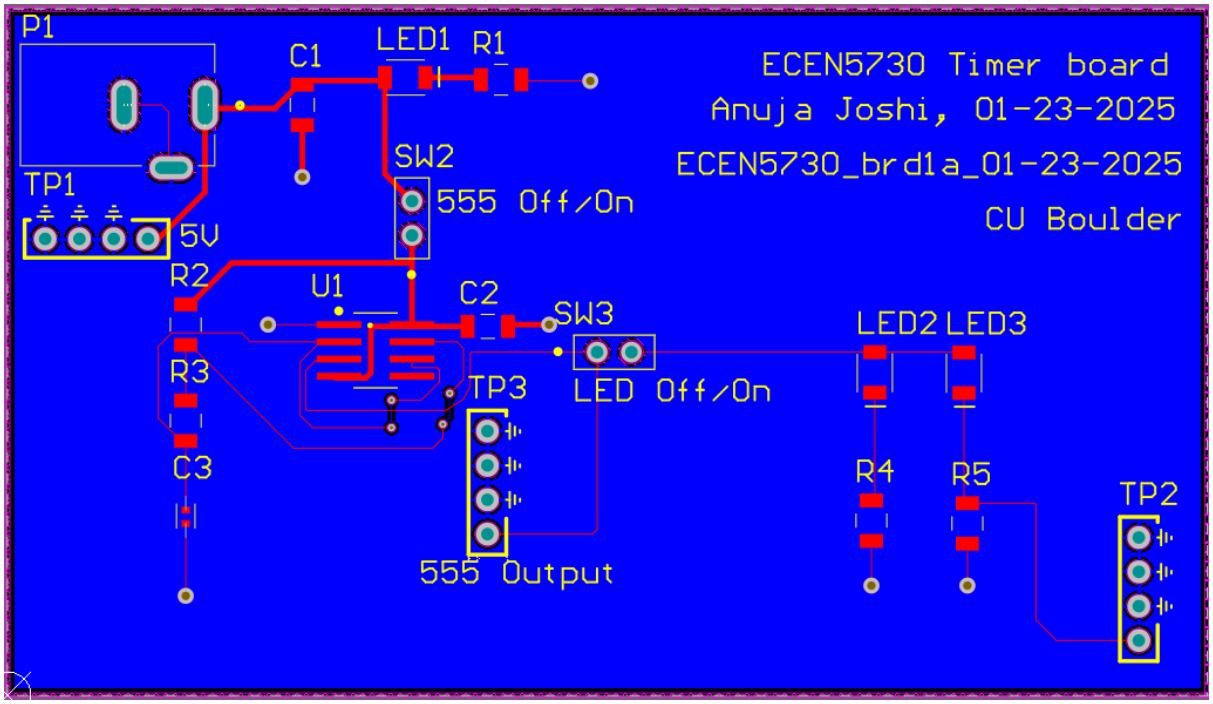


Altium Schematics:



Board layout:

1. Ground plane (polygon pour) was added for better signal integrity and noise reduction.
2. Test points were placed for voltage and current measurements, though more could have been added for better debugging.
3. Component placement was optimized for ease of assembly and measurement.



Board picture:

1. The 555 timer was configured in astable mode, generating a square wave at around 500 Hz with a duty cycle of 66%.
2. The circuit included two LEDs with different series resistors (1kΩ, 300Ω) to observe brightness variation.
3. Power input (5V DC) was provided via a power jack, with test points placed for measurement.

Working and testing:

1. Verified 5V power supply **at** Test Point 1 (TP1)**.**

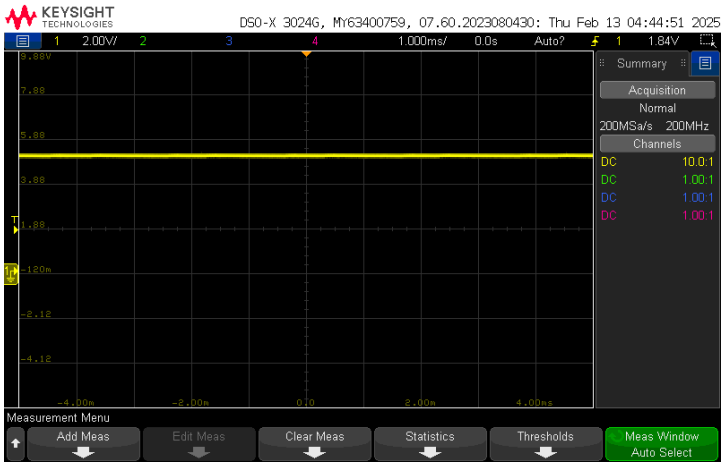
2. Measured the 555 timer's output signal at TP2 without any LEDs connected.

3. Re-measured the 555 timer's output after connecting LEDs.

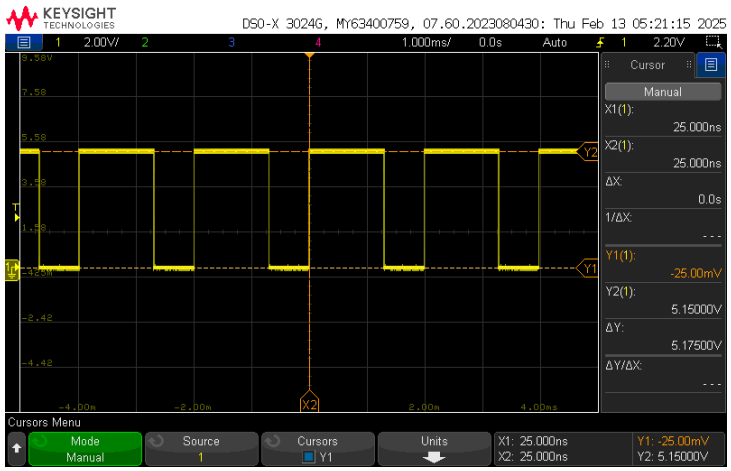
4. Observed a drop in output voltage, indicating some current draw impact on the 555 timer output**.**

Scope shots:

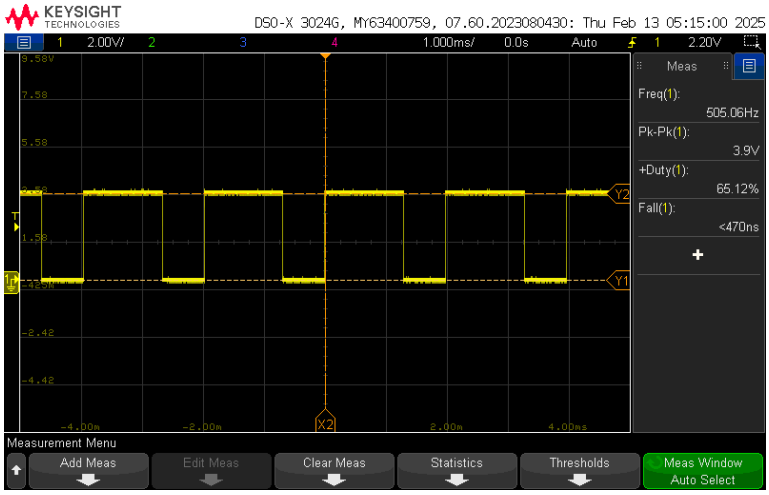
1. Power at TP1: The test point TP1 is used to measure the input power to the circuit.



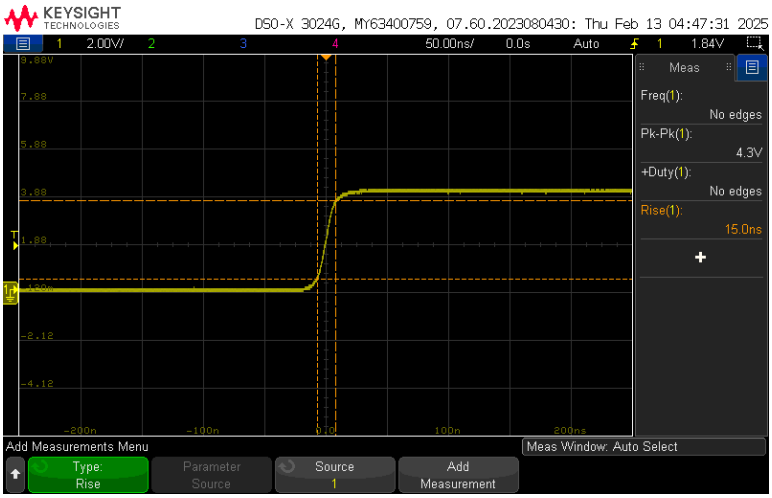
2. Output at TP2(without load)



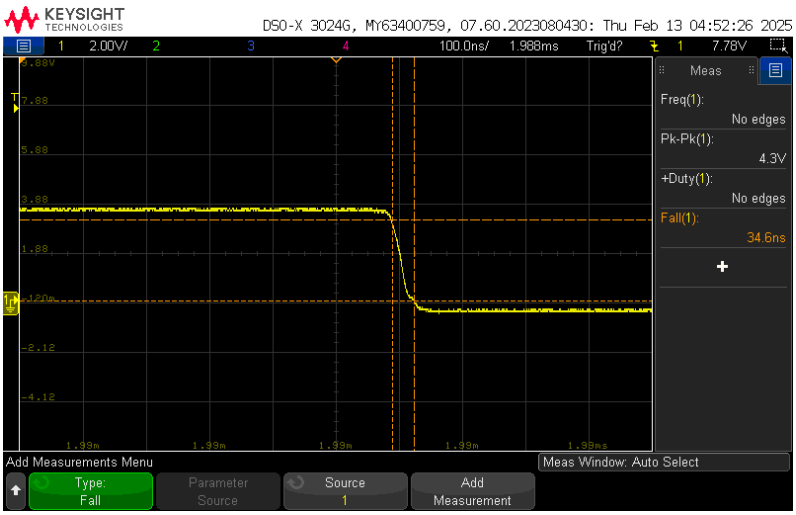
3. Output at TP2(with load)



4. Rise time and fall time



Rise time



Fall time

The fall time decreased when the load was connected, due to the BJT (Bipolar Junction Transistor) logic inside the 555 timer**.**

What Did Not Work & Challenges Faced:

1. **Altium GND Net Label Issue**
   - Problem**:** Initially, power was not reaching the circuit beyond TP1 due to a ground net label issue in Altium Designer.
   - Fix**:** Connected an external wire from TP1 ground to the power jack's ground**,** which resolved the issue.
   - Lesson Learned: Always double-check net labels in the schematic to ensure all ground connections are properly linked.
2. **Lack of Test Points Across Resistors**

- Problem: Difficulty in measuring the voltage across each resistor due to the absence of dedicated test points.
- Fix: Future designs should include test points across all critical resistors for easier debugging and accurate measurements.
- Lesson Learned: Proper test point placement is crucial for effective troubleshooting.

Calculations:

Current calculations: at TP3

R = 330ohm

V = 1.18V

I = V/R

= 1.18/330

= 3.5mA

Thevenins resisteance

V_{th} = 5.4V

V_L = 3.9V

R_L = 1(1/1k ohm + 1/330 ohm) = 248ohm

R_L = 248((5.4 – 3.9)/3.9)

= 95.38 ohm

Conclusion:

1. The 555 timer successfully generated a square wave at the expected frequency.

2. LED brightness varied as expected, confirming proper current flow through different resistor values.
3. Test points provided useful debugging access, but additional ones across every resistor would have improved voltage measurements.

Key learnings:

1. Proper test point placement allowed for easy measurement of power, output signals, and LED currents.

2. Ensure all ground connections are correctly labelled before finalizing the design.

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4. 90-degree bends can cause signal integrity issues and etching problems; always use 45-degree bends for better routing.

5. Minimize the number of vias in a 2-layer PCB.

6. Always use spring connectors for probes when taking measurements on the PCB.

7. The internal BJT switching behavior of the 555 timer causes a reduction in fall time when additional current is drawn.

8. A simple power LED helps quickly verify that the board is powered and eliminates confusion during debugging.

9. Isolation switches allowed for separate testing of different circuit blocks, making it easier to debug issues.

10. Ensuring correct footprint dimensions prevents issues during assembly, especially for connectors and test points.