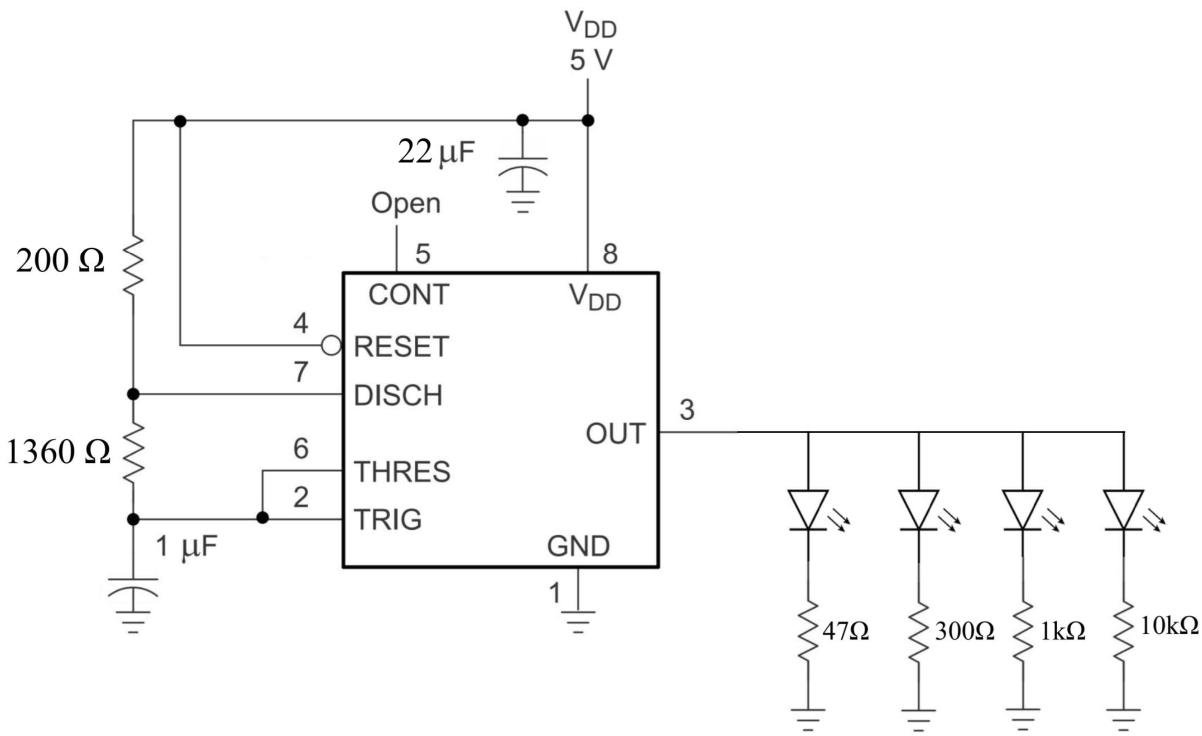
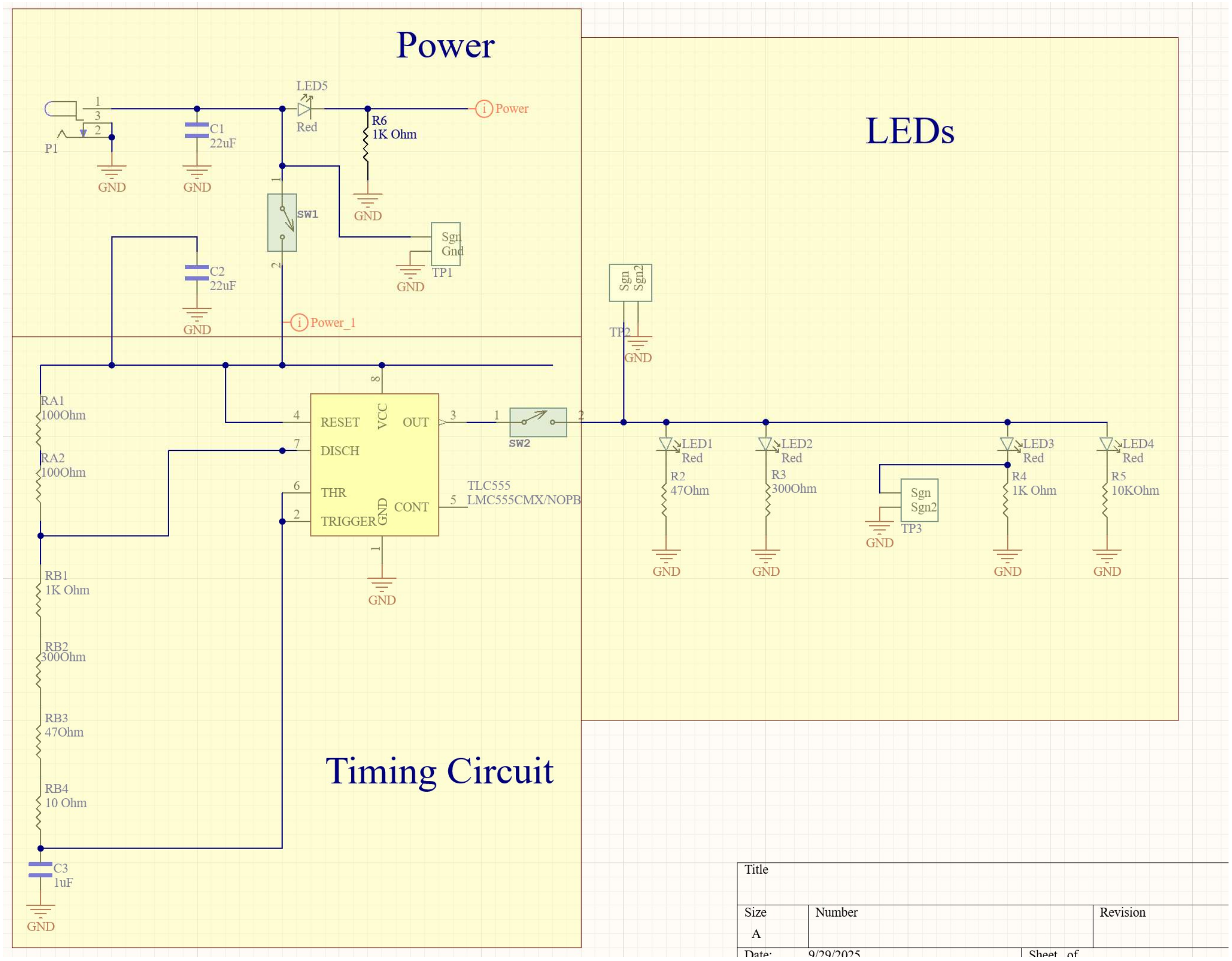
Board 1 Report

POR: The function of this board is to produce a 50% duty cycle 500 Hz wave whose output powers LEDs in series with various resistor values. Since this our first board and largely being used as practice, the baseline goal is to turn on the LEDs and view the output waveform at it's test point. For this board to "work", I would expect at least some of the LEDs connected to the output to turn on, indicating I was able to properly solder them onto my board. I would also expect to see a square wave output. Risk reduction includes adding switches and test points to make debugging any issues easier.

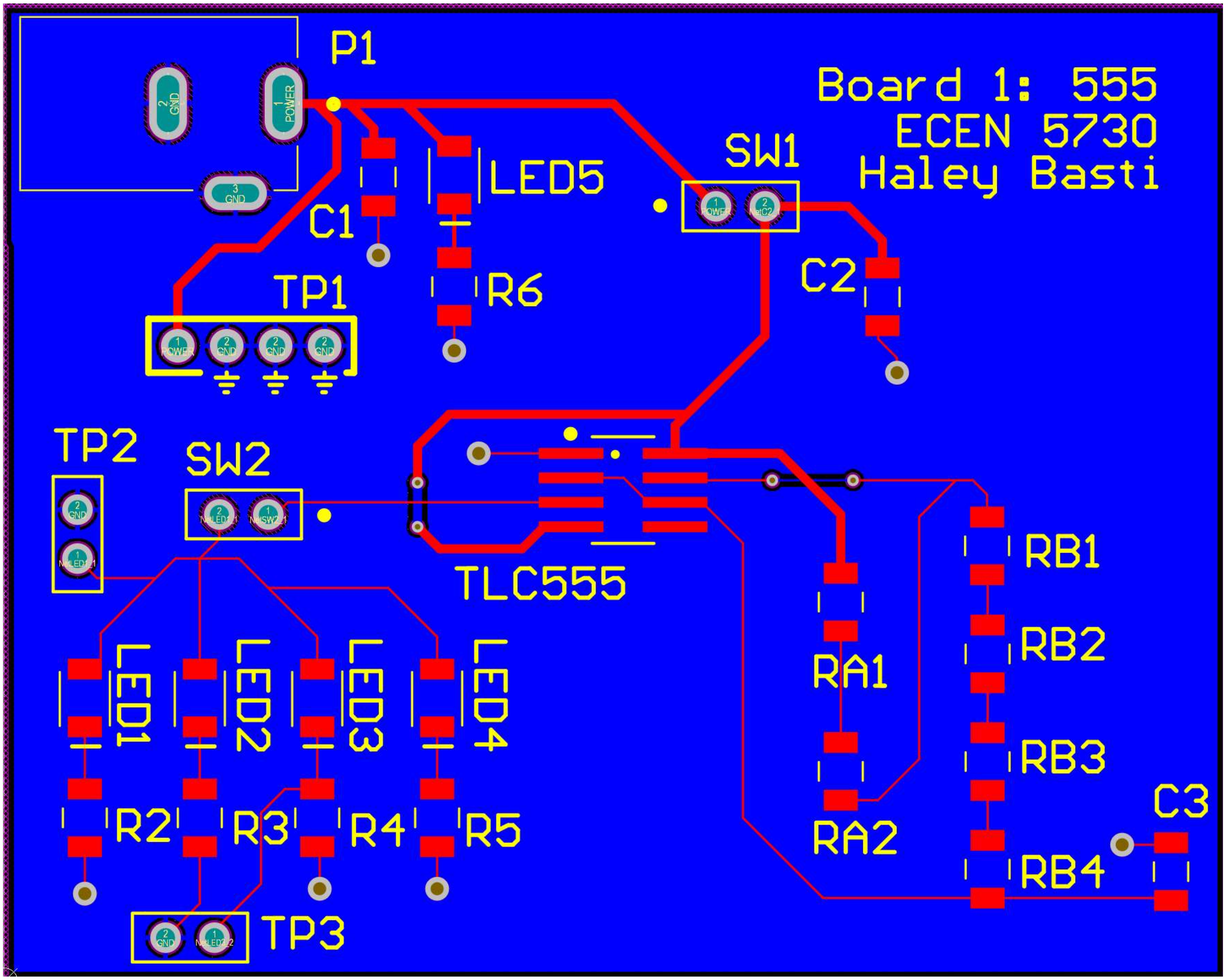
The schematic I began with was very similar to the one used in lab 2, with notable exceptions being the addition of the LEDs and swapping the 10 uF capacitor at the voltage rail to a 22 uF capacitor.



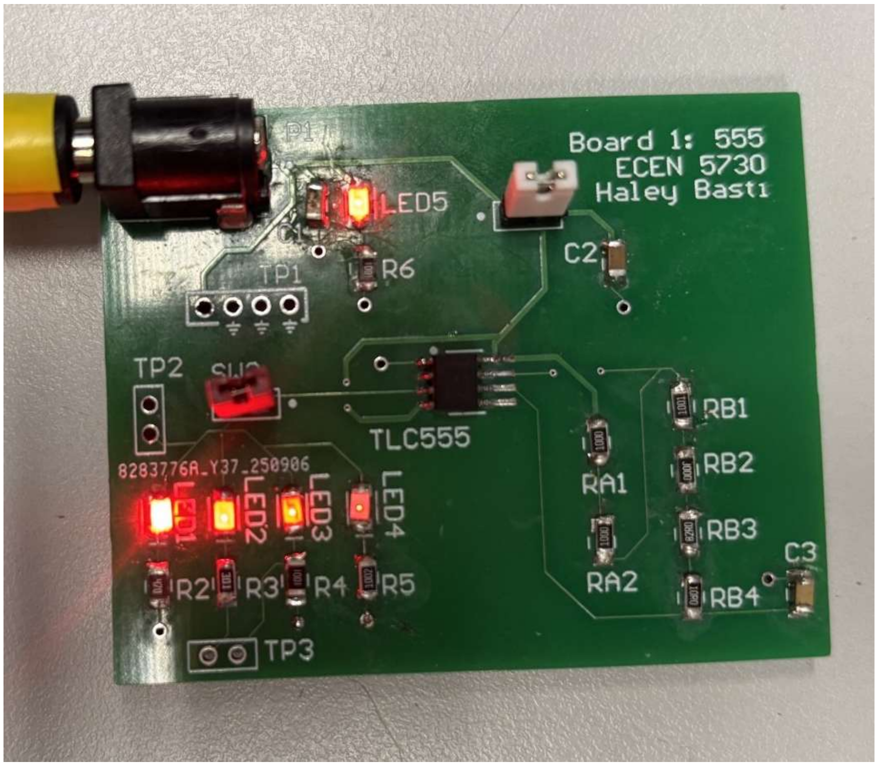
The schematic capture used in Altium Designer can be seen below. Some differences to note between the original layout and the realized design is an added switch between the power and the rest of the circuit. A test point was also added here to ensure the 5V Vcc power was going to reach the timing circuit. An LED was added here as well to show that the board is receiving power. A decoupling capacitor of 22 uF was also added here. Since a single "200" and "1360" Ohm resistor does not exist, multiple series resistors were used to realize these values. Another addition was the isolation jumper switch from the output of the timing circuit to the LEDs and a test point here as well, where the waveform seen below was taken. A test point across the 1k resistor was also added to determine current.



The 2-layer board layout can be seen below, with dimensions of 2500x2000 mils.



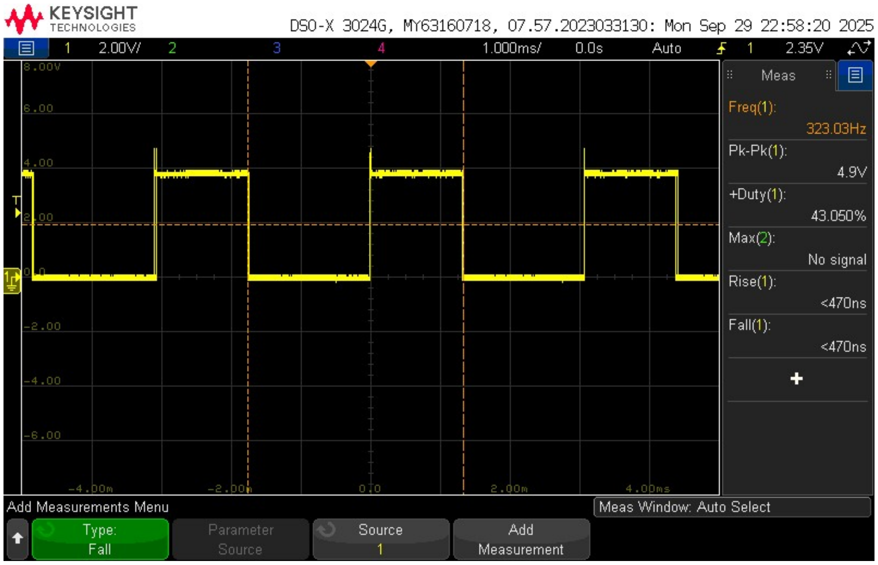
Below is the assembled board, showing all 5 LEDs working as expected, The furthest-left resistor before the LED was 47 Ohms, and moving right the resistor values increased to 300, 1k, and 10 kOhms. It is important to note the brightness of the LEDs weakens with increasing resistor values, as expected.



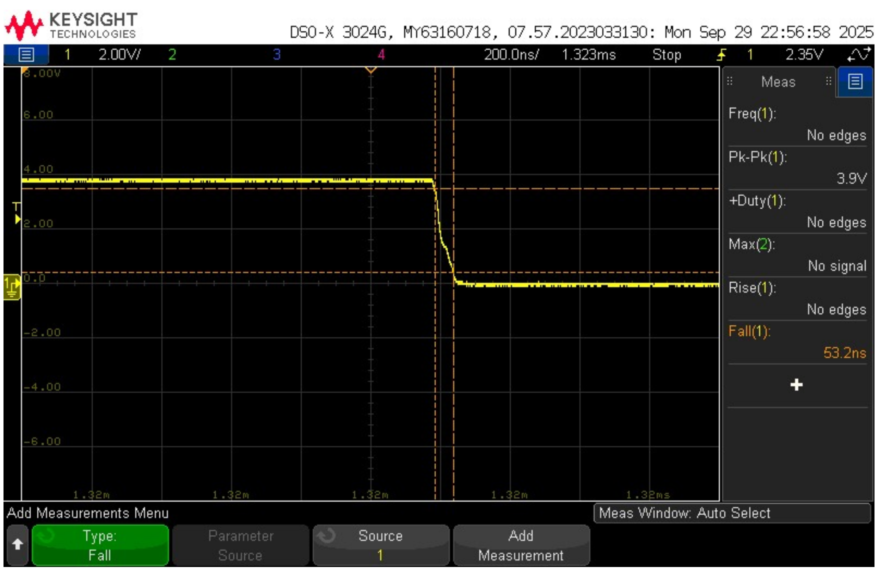
This board "worked" because the expected square wave output was visible at the designated test point, and all LEDs were lit. The jumper switches also positively isolated various parts of the board from one another when removed. My expectations for the performance features would have been to see a waveform fairly close to the SBB realized circuit. The analysis of my measurements produced a few findings. First, measuring across Resistor A and Resistor B indicated these values were 199 and 1360 Ohms respectively. That being said, the output waveform frequency was much lower than the expected value of 500 Hz. This could be due to tolerance of the capacitor, as even going from 1 uF to 1.5 uF could cause the frequency to drop to 327 Hz, according to the formula:

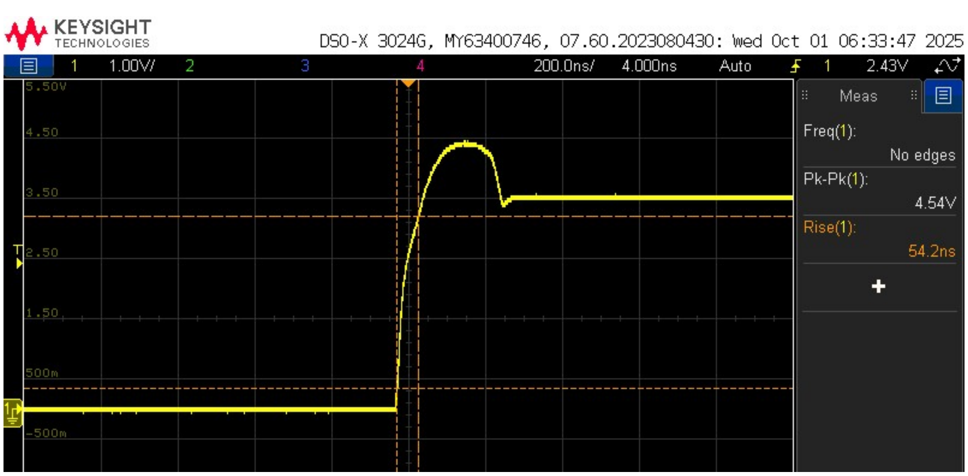
$$\frac{1.44}{(R_1 + 2R_2)} = f$$

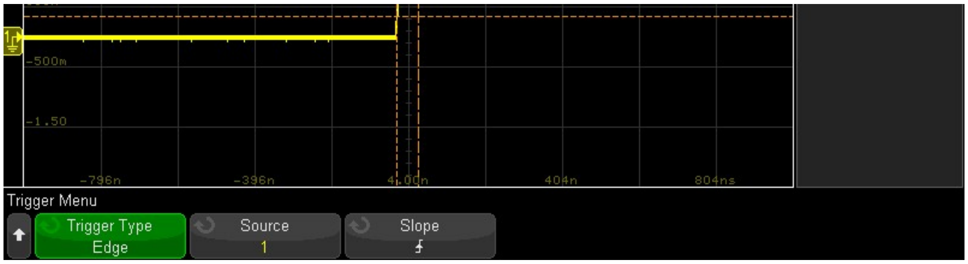
In future designs I would prioritize selecting resistor values that minimize the number of components needed to realize required values to further reduce risk. Minimizing signal traces that go to the bottom layer of the board was also a strength of this board. A soft error would be the discrepancy between the expected frequency and duty cycle and what was measured, which is further explained below. Thankfully, no hard errors were noted.



Above is the waveform generated by the output of the 555 timer, taken from the TP2 test point. It is interesting to note that both the duty cycle and frequency decreased from the SBB version of the circuit. When testing the SBB version, I measured a duty cycle of almost exactly 50% and 500 Hz. Due to tolerance of the surface mount components, the duty cycle and measured frequency decreased to about 320-390 Hz, and a 43% duty cycle.







The LMC555 timer used on our board's datasheet indicated an expected fall time of 15 ns. The measured value from the completed board showed a fall time of approximately 53 ns. This delay is likely due to an impedance mismatch and reflections (as seen in the notch in the middle of the falling edge). The screen capture of the rise time is contains a similar response on the rising edge, which also lists the rise time as 15 ns, but is longer for the same reasons listed previously.