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ECEN 3730 Lab 2
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1. Objective

The objective of this lab is to build a 555 astable vibrator circuit on a solderless breadboard, aiming for approximately a frequency of 500 Hz and a duty cycle of 50%, and to compare the performances of two different 555 timers (LMC555 and NE555) in terms of rise time and output current.

2. Materials

i. Solderless breadboard (course kit)
ii. LMC555 (course kit)
iii. NE555 (course kit)
iv. Capacitors/Resistors/Wires (course kit)
v. Arduino Uno + Power Supply (course kit)
vi. LEDs (course kit)

3. Circuit

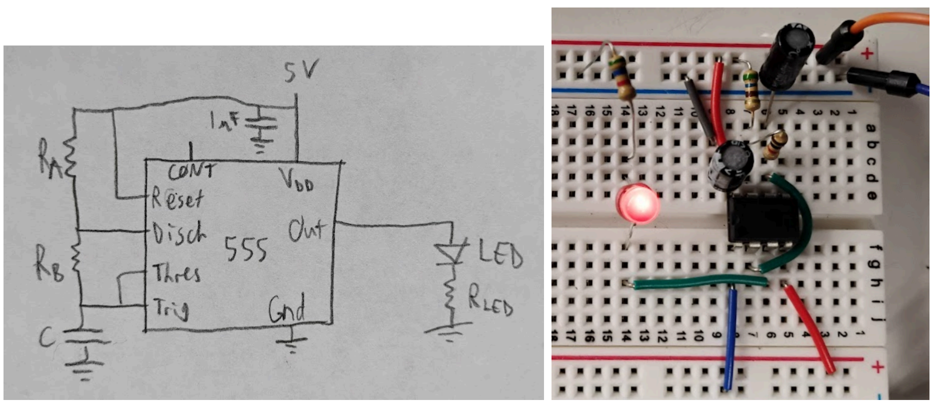

Figure 1: Circuit schematic based on TLC555 datasheet astable operation (left) and circuit built on solderless breadboard (right). We experiment with various values for R_{LED}, the other parameters are calculated in the next section.

4. Calculations

With the circuit chosen above, we are given $t_{on} = 0.693(R_A+R_B)C$ and $t_{off} = 0.693(R_B)C$ from the 555 timer datasheet. To achieve a 50% duty cycle, this means that we would need $R_A+R_B = R_B$, or $R_A = 0$. Instead, we will strive for a 60% duty cycle, which requires that $R_B = 2R_A$.

$$f = 500\,Hz$$

$$T = (500\,Hz)^{-1} = 2\,ms$$

$$t_{on} = 0.6 * 2\,ms = 1.2\,ms$$

$$t_{off} = 0.4 * 2\,ms = 0.8\,ms$$

Let C = 1 uF

$$0.693(1uF)R_B = 0.8\,ms$$

$$R_B = 1150\ \Omega$$

Let $R_B = 1\ k\Omega$ (value in kit)

$$R_B = 2R_A$$

Let $R_A = 560\ \Omega$ (value in kit)

With our selected values, we expect the actual frequency to be $f = \frac{1.44}{C(R_A+2R_B)} = 560\ Hz$ and the duty cycle to be $d = 1 - \frac{R_B}{(R_A+2R_B)} = 61\%$.

5. Results

For both 555 timers, we measured the rise time and the output current when driving the red LED with a current limiting resistance of 5.6 kΩ, 1 kΩ, and 50 Ω. In all cases, we also found that the frequency was about 560 Hz and the duty cycle was about 59%. Our results are summarized in Table 1.

NE555				LMC555			
R_LED (Ω)	V_R_LED (V)	I_LED (mA)	Rise Time (ns)	R_LED (Ω)	V_R_LED (V)	I_LED (mA)	Rise Time (ns)
-	-	-	80	-	-	-	19
50	2.13	42.6	65	50	0.56	11.14	13
1000	3.07	3.07	70	1000	2.71	2.71	19
5600	3.19	0.57	70	5600	3.15	0.563	20

Table 1: Measurements of the voltage across and current through R_{LED} and rise time for each timer and each value of R_{LED}. The first row is with no LED (555 output open). In general, LMC555 has a faster rise time, but is unable to supply as much current as NE555. We found that a larger resistor R_{LED} also increased the rise time.

Figure 2: Scope display with probe across R_{LED} for $R_{LED} = 5.6\ k\Omega$ (left) and $R_{LED} = 1\ k\Omega$ (right), both driven by LMC555. We observed the LED get dimmer for higher values of R_{LED} because there was less current through it, but there was also a greater voltage across R_{LED}.

Figure 3: Scope display showing rise time for R_{LED} = 50 Ω (left) and nothing connected to the 555 output (right), both for the NE555. The rise time was 15 ns greater with the LED connected than without.

6. Conclusions

In this lab, we learned to design a 555 timer astable vibrator circuit with a given frequency and duty cycle and observed the functional differences between two 555 timers. The LMC555 is much faster, but is not able to supply as much output current as the NE555, meaning that each timer is better suited for different applications. For our board, since we are more concerned about the current available than the speed, we will choose the NE555.

We also observed the impact of the load on the rise time of the timer. We found that when the voltage across R_{LED} went down, so did the rise time, because there was less change required for each transition (lower amplitude of the square wave).

From completing this lab, I learned that the datasheet was very helpful in calculating the values for the resistors and capacitors and for wiring up the 555 timer. The values for frequency and duty cycle that I predicted from the datasheet's equations were extremely close. I also learned that it is important to look closely at the display on the oscilloscope and to check how the measurement tool is measuring values (and to potentially make measurements manually instead). Because I took all of my rise/fall time measurements with the scope's measurement tool, it is likely that many of them are underestimated due to the overshoot seen in Figure 3.