EE97 Spring 2025
Thursday 1:30-4:15 PM
Lab #9: LM555 Oscillators, and Digital Counter
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Station #9
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EXPERIMENT 1:

When using the LM555 as an oscillator, its control circuit has a hysteresis character: it turns on the switch if the input voltage is above ⅔ of the supply voltage and turns it off if the input voltage is below ⅓ of the supply voltage. We built a circuit with a timing capacitor C, several resistors, and the LM555.

$$f = \frac{1}{T_d + T_c} = \frac{1}{0.693(R_1 + R_2)C + 0.693R_2C} \cong \frac{1.44}{(R_1 + 2R_2)C}$$

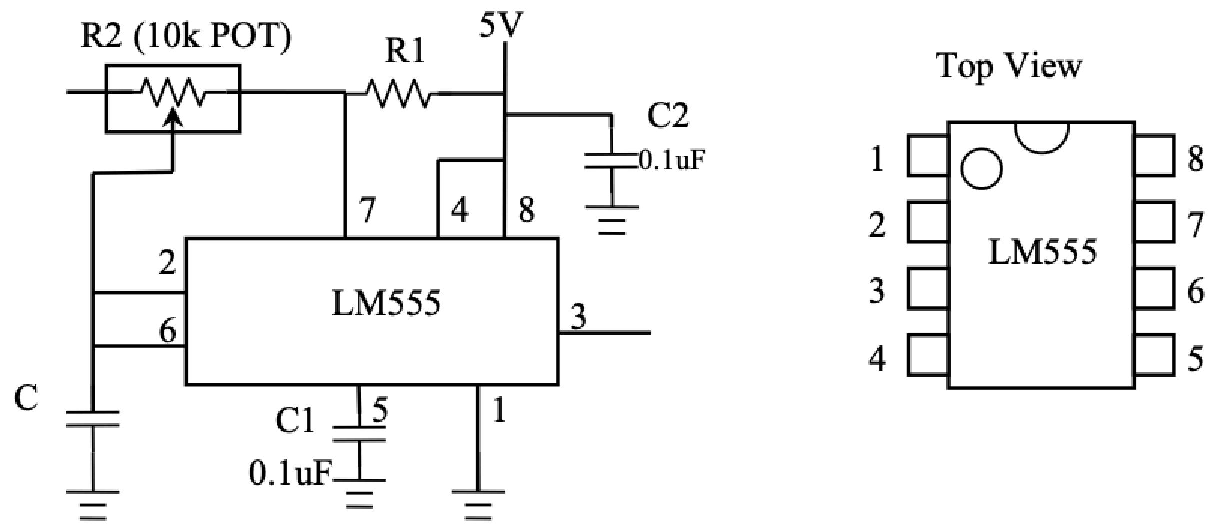



Figure 4

PART 1 & 2: Construct the circuit in Figure 4, letting C=0.1 microF, R1=1k ohm, and determining the value of R2 on the 10k POT so that the oscillation frequency is 823 Hz according to the above equation for f. Build the circuit on one end of the breadboard and leave the rest of the space for the next experiment. Capacitors C1 and C2 are filtering capacitors used to filter out unwanted high-frequency voltage fluctuations, but they don't have a role in determining oscillation frequency.

Value of R2 on 10k POT: (R1 = 1k, C = 0.1*10^-6, f = 823)
f = 1.44/ [(R1+2*R2)*C]
823 = 1.44/ (1000*10^-7 + 2*R2*10^-7)

10^-4 + 2*10^-8*R2 = 1.44/ 823
R2 =  [(1.44/ 823) - 10^-4]/ (2*10^-7) = 8248 → about 8.25k ohms

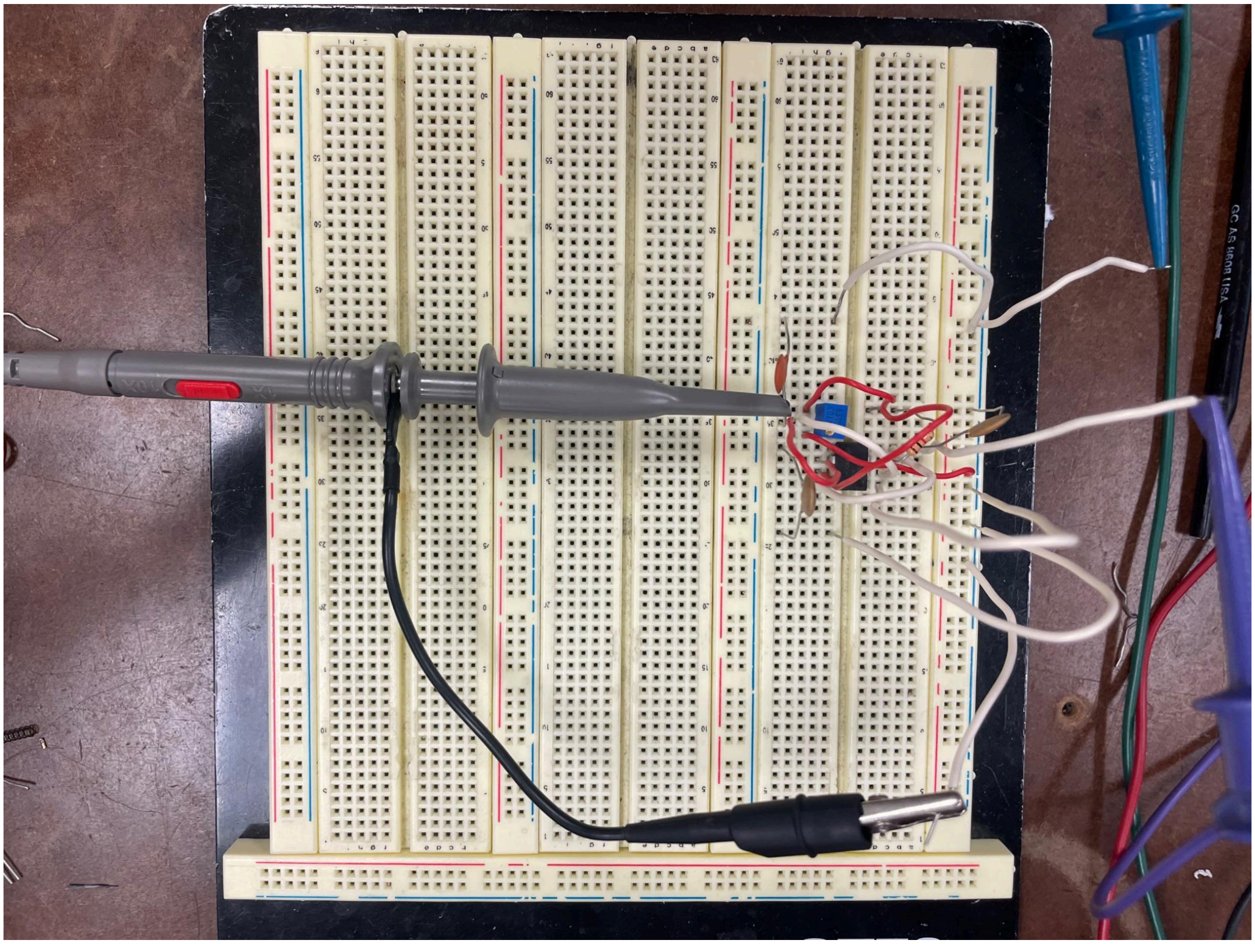


*Figure 1.2.1: Circuit*

PART 3: Observe the voltage across capacitor C (pin 2 or pin 6 to G) and verify the frequency and waveform shape. The actual frequency won't be exactly 823 Hz due to the tolerance (error) of the capacitor. Using the scope, fine-tune the frequency to exactly 823 Hz by turning the POT.

Vc = 1.66 - 3.34 V (delta = 1.68 V)

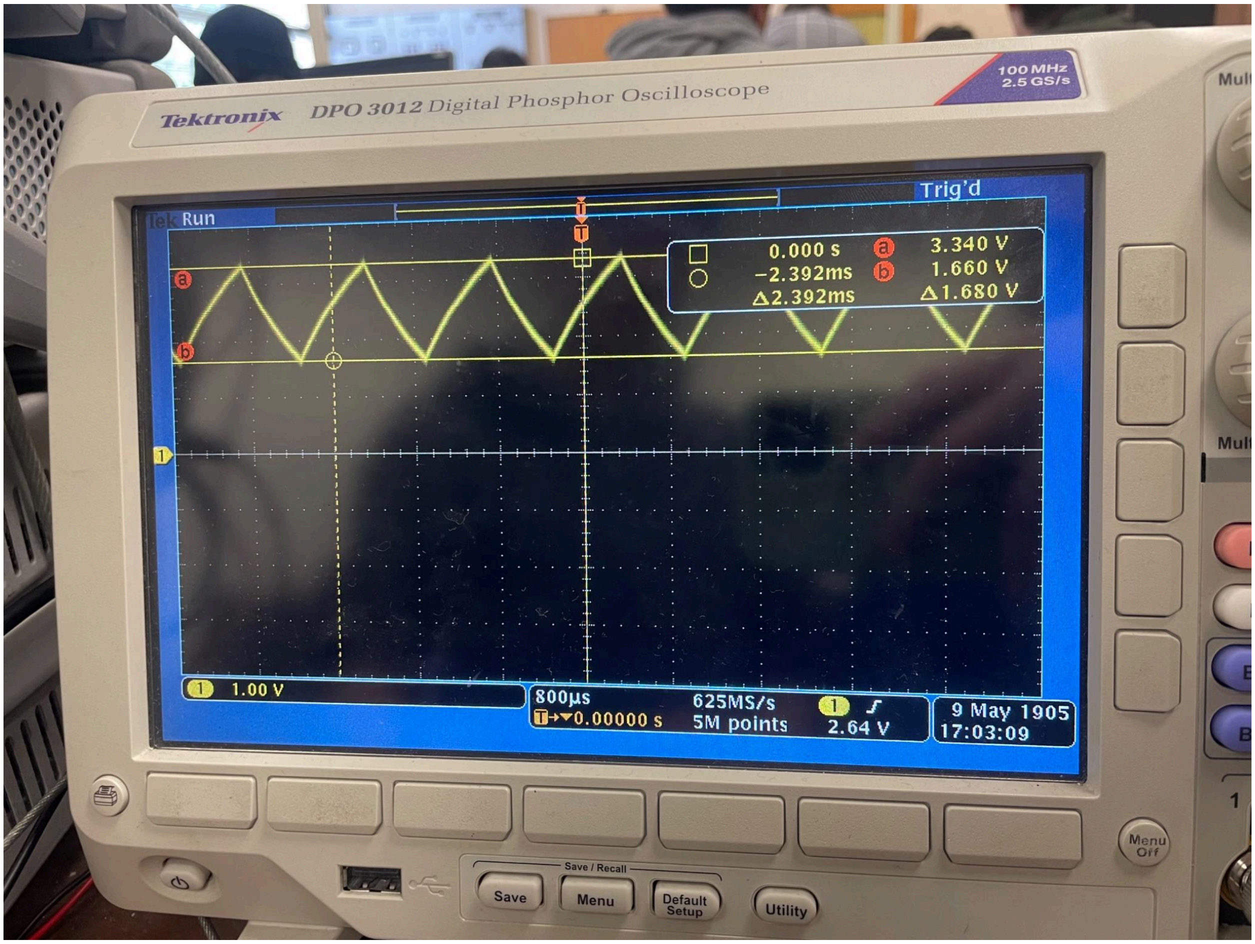



*Figure 1.3.1: Oscilloscope Screen Shot*

PART 4: Is the waveform's lower limit ⅓ of the supply voltage and its upper limit ⅔ of the supply voltage as shown in Figure 3?

| |
|---|
| Yes |

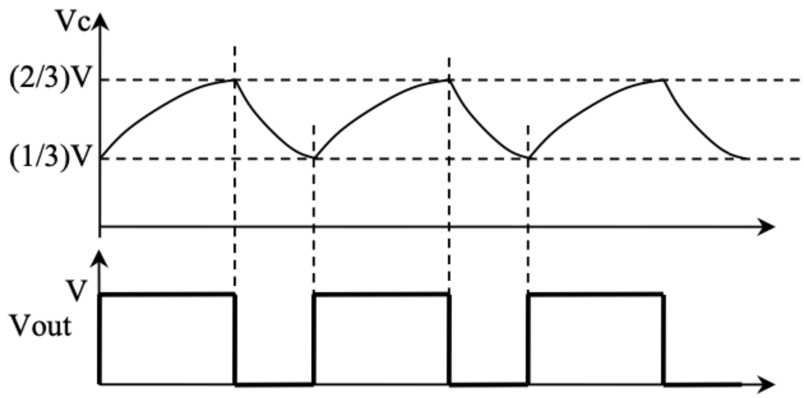



Figure 3

PART 5: Pin 3 is the output of the LM555 timer. Simultaneously display the signal from pin 3 and the voltage waveform across C on the scope.

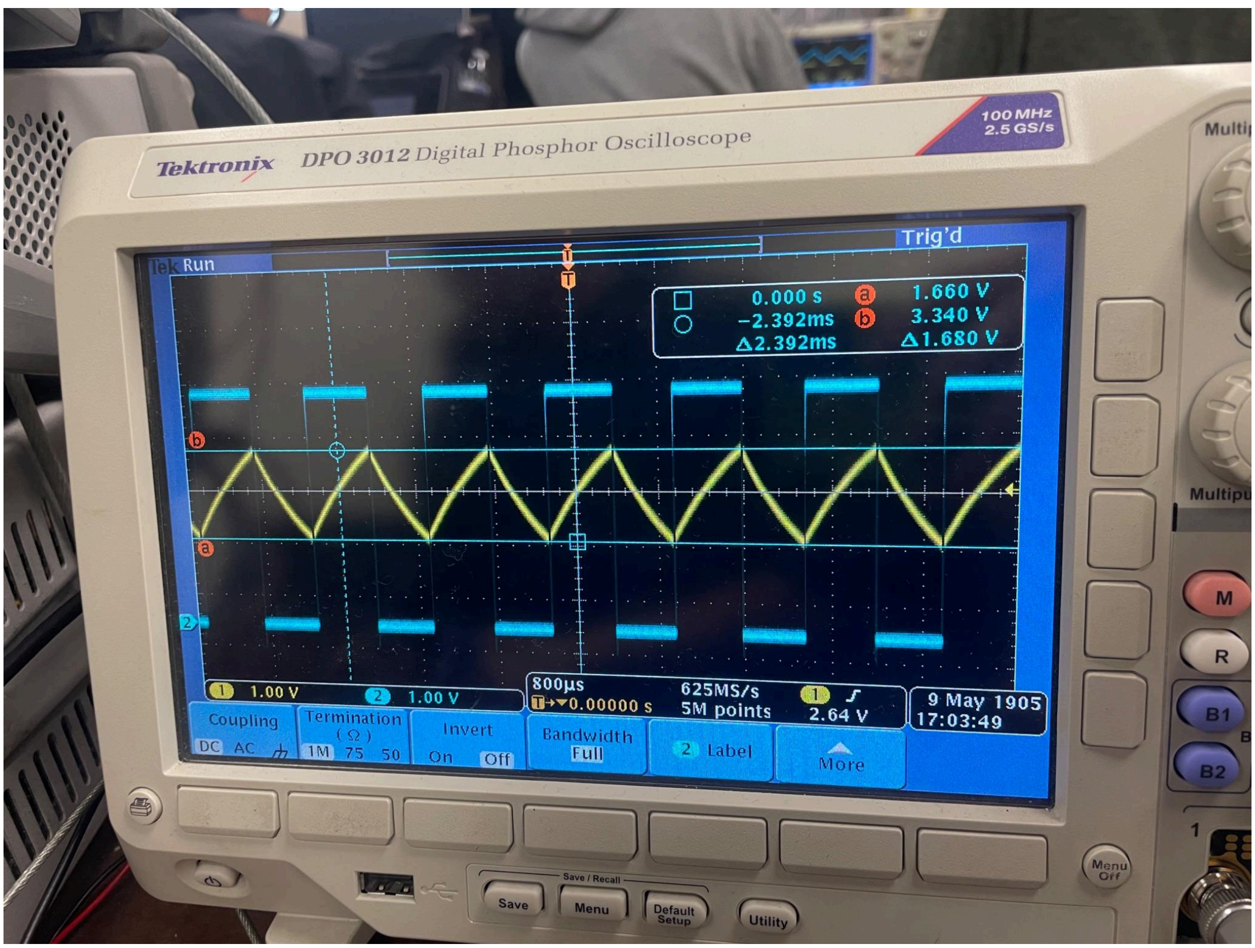



*Figure 1.5.1: Oscilloscope Screenshot*

Does the output voltage state correspond to the charge/ discharge period of C as shown in Figure 3?:
Yes

EXPERIMENT 2:

Our circuit this time is similar to that used in the previous experiment, with a couple of alterations so that the oscillation frequency is 1 Hz, which we are able to visually observe with LED lights.

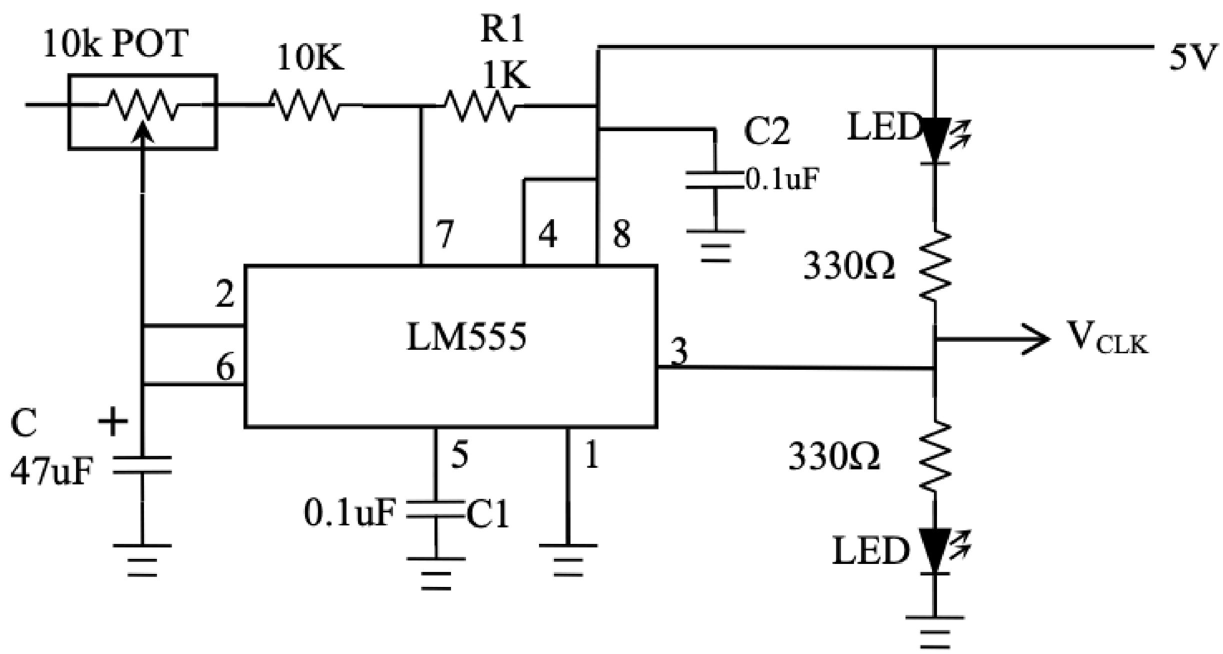



Figure 5

PART 1, 2, & 3: Build the circuit in Figure 5, which is the circuit from Experiment 1 but with a 10k resistor connected in series with the POT and 2 LEDs connected at output pin 3.
The 330 ohm resistors limit the current flow through the LEDs so that the lower LED is turned on when the output from pin 3 is high and the upper LED is turned on when the output is low.
*Note for this circuit, R2=10k + POT.

| |
|---|
| Rpot Calculations:<br>Value of R2 connected to 10k POT: (R1 = 1k, C = 47*10^-6, f = 1)<br>f = 1.44/ [(C*R1+2C*(10000+Rpot)]<br>1 = 1.44/ (47*10^-6*10^3 + 2*47*10^-6*10000 + 2*47*10^-6*Rpot)<br>1.44 = 47*10^-3 + 94*10^-2 + 94*10^-6*Rpot<br>Rpot = (1.44 - 47*10^-3 - 94*10^-2)/ (94*10^-6) = 4819 → about 4.8k ohms |

PART 4: The LEDs should be flashing alternately at about 1 Hz period. *Note when you set the scope time scale to < 0.1s/div and the trigger to AUTO, the trigger mode turns into a “roll”

mode, in which the input voltage is shown on the right edge of the screen in real-time and the history of the voltage is recorded across the screen.
You can stop the rolling motion by pressing the “Run/Stop” button on the right. If in Normal mode, wait a few seconds before the effect is shown on the scope screen after adjusting hte scope setting or changing the input signal.

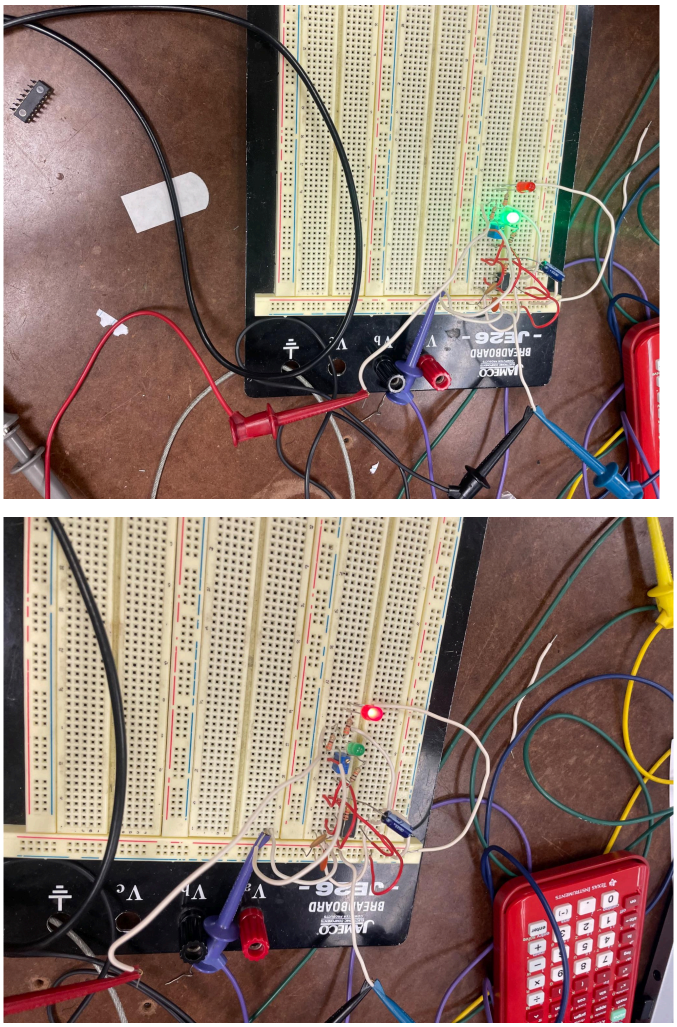


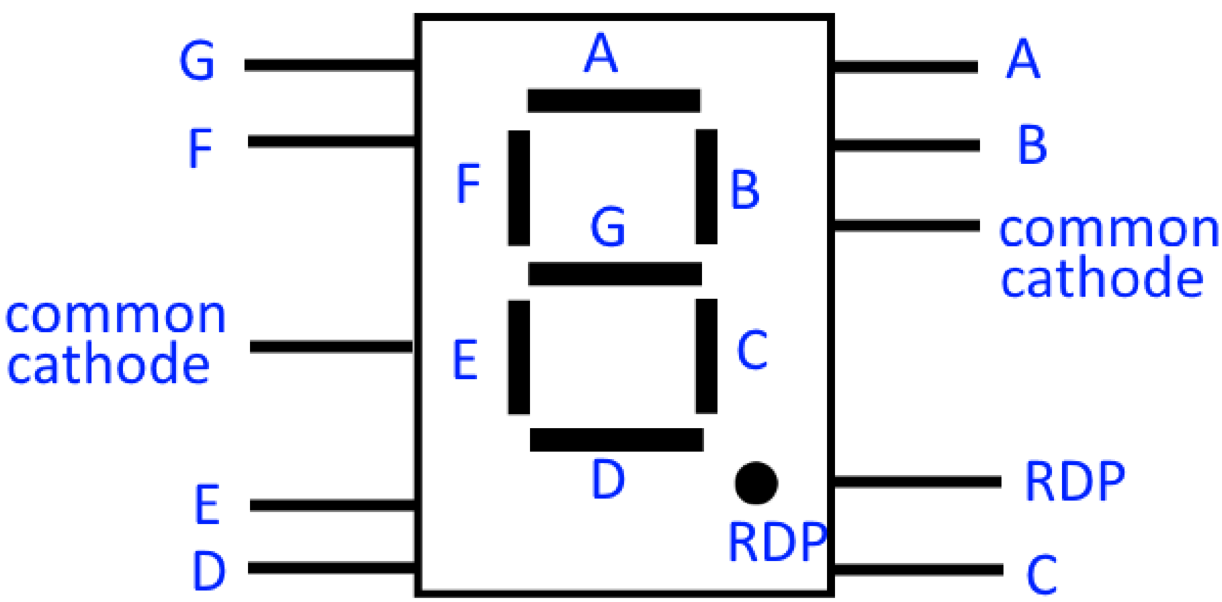
*Figure 2.4.1: 1 Hz Flashing Circuit & Breadboard Picture*

EXPERIMENT 3:

Unlike analog signals, the exact voltage value of a digital signal doesn't matter, and any voltage below 1.5V is a low (logic '0') and any value above 3.5V is a high (logic '1'). In this experiment, we use a digital counter IC (CD4026( to count the number of pulses generated by the LM555 circuit in Experiment 2.

| | | OUTPUT | | | | | | |
|---|---|---|---|---|---|---|---|---|
| State | Q3~Q0 | a | b | c | d | e | f | g |
| **0** | 0000 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| **1** | 0001 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| **2** | 0010 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| **3** | 0011 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| **4** | 0100 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| **5** | 0101 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| **6** | 0110 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| **7** | 0111 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| **8** | 1000 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **9** | 1001 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |

**Table 1**



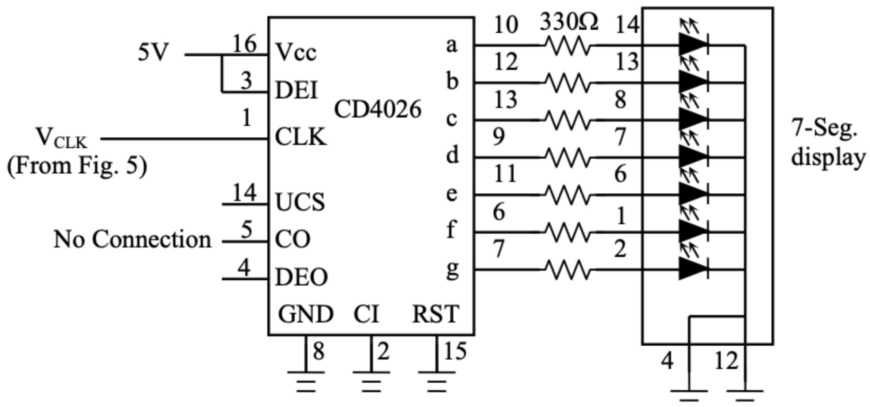



Figure 9

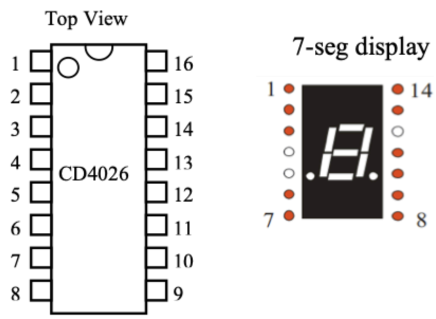



Figure 10

PART 1: Build the circuit in Figure 9, where all the resistors are 330 ohm, and are used to limit the current flow through the LEDs. The CLK pin (pin 1) of CD4026 connects to pin 3 of LM555 from the circuit of Experiment 2. Figure 10 shows the pin numbers of CD4026 and the 7-segment display. The circuit should produce a number on the 7-segment display, counting up every second.

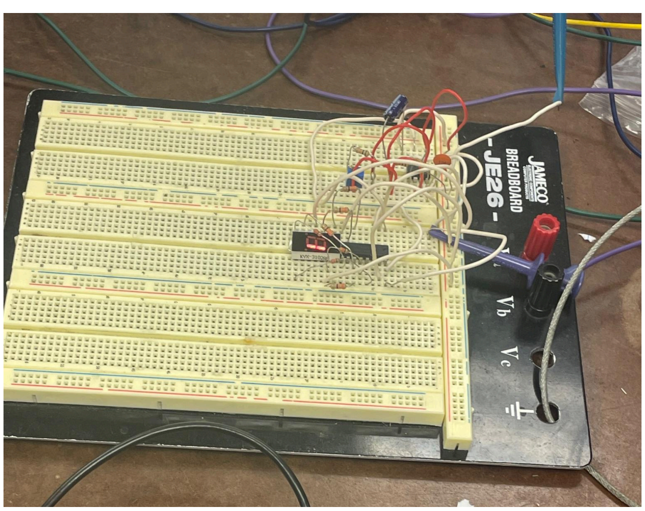


*Figure 3.1.2: Picture of State 1*

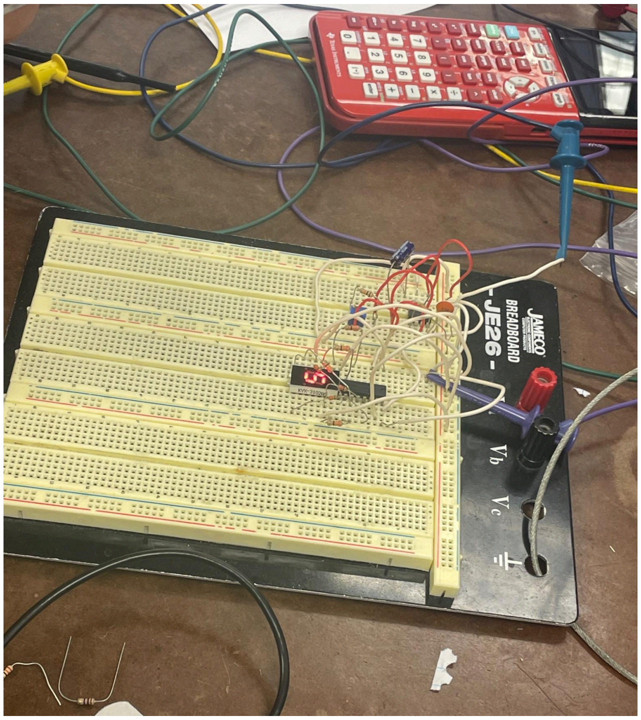



*Figure 3.1.3: Picture of State 5*

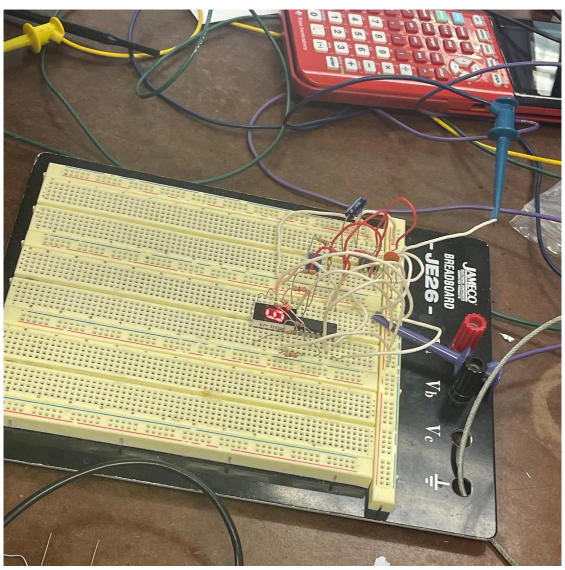



*Figure 3.1.4: Picture of State 9*

PART 2: Connect pin 2 of CD4026 to 5V instead of G to see how it affects the counting process.