PH3204: Electronics Lab

Study of a 555 timer IC

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Contents

1 Aim

To study the use of a 555 timer as an astable multivibrator and to determine the time period of the output waveform.
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2 Theory

In this experiment, we will be using a 555 timer to make an astable multivibrator. An astable multivibrator is a circuit that continuously switches between its two unstable states, producing a square wave output. The 555 timer is a versatile integrated circuit that can be used in various configurations, including monostable and astable modes. The 555 timer consists of two voltage comparators, a flip-flop, a discharge transistor, and a resistor divider network. In astable mode, the timer oscillates between its high and low states, generating a square wave output. The frequency and duty cycle of the output waveform can be controlled by adjusting the values of external resistors and capacitors connected to the timer. We will also study these properties in this experiment.

3 Circuit Diagram

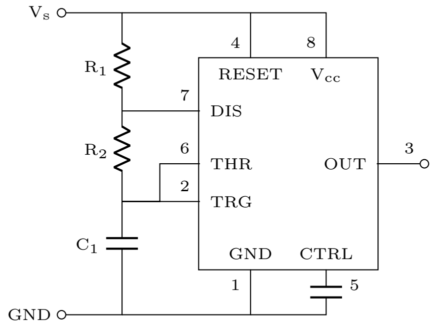

Figure 1: Circuit Diagram of 555 Timer IC

The pins of the 555 timer are as follows:

- Pin 1: Ground (GND): This pin is connected to the ground of the circuit.
- Pin 2: Trigger (TRIG) - This pin is used to trigger the timer.
- Pin 3: Output (OUT) - This pin provides the output of the timer.
- Pin 4: Reset (RESET) - This pin is used to reset the timer. A low signal on this pin resets the flip-flop, causing the output to go low.
- Pin 5: Control Voltage (CTRL) - This pin is used to control the timing of the timer, by changing the threshold voltage usually set at $2V_{cc}/3$. It is usually connected to a capacitor to filter noise.
- Pin 6: Threshold (THR) - This pin is used to monitor the voltage across the timing capacitor. When this voltage exceeds 2/3 of the supply voltage, the flip-flop is reset.
- Pin 7: Discharge (DISCH) - This pin is used to discharge the timing capacitor. When the flip-flop is reset, this pin is connected to ground, allowing the capacitor to discharge.
- Pin 8: Supply Voltage (VCC) - This pin is connected to the positive supply voltage.

The input and output waveforms of the 555 timer in astable mode are shown below.

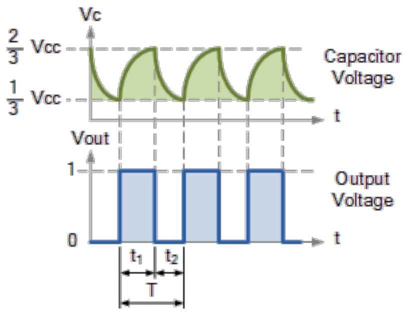

Figure 2: Input and Output Waveforms of 555 Timer in Astable Mode. (Source: The Internet)

The frequency of the output waveform can be altered by changing the values of the resistors and capacitors connected to the timer. The frequency of the output waveform is given by the formula:

$$f = \frac{1}{\ln(2)(R_1 + 2R_2)C_1} \tag{1}$$

The uptime and downtime of the output waveform can be calculated using the following formulae:

$$T_H = \ln(2)(R_1 + R_2)C_1 \qquad ; \qquad T_L = \ln(2)R_2C_1 \tag{2}$$

The duty cycle(D) is defined as the time the output is high divided by the total time period of the output waveform. The duty cycle, expressed as a percentage, can be calculated using the formula:

$$D = \frac{T_H}{T_H + T_L} \times 100 = \frac{R_1 + R_2}{R_1 + 2R_2} \times 100 \tag{3}$$

4 Data

The following data was obtained from the experiment. We calculate the up and down times using the oscilloscope.

C(μF)	$R_1(\Omega)$	$R_2(\Omega)$	f_T(Hz)	T_H (e) (s)	T_L(e)(s)	T(e)(s)	f_e(Hz)	Err(%)
0.001	10^3	10^4	6.87×10^4	7.2×10^{-6}	7.2×10^{-6}	1.44×10^{-5}	6.94×10^4	1.08
0.001	10^4	10^5	6.87×10^3	7.4×10^{-5}	6.6×10^{-5}	1.40×10^{-4}	7.14×10^3	3.97
0.001	10^5	10^6	6.87×10^2	7.3×10^{-4}	6.7×10^{-4}	1.40×10^{-3}	7.14×10^2	3.97
0.01	10^3	10^4	6.87×10^3	8.4×10^{-5}	7.6×10^{-5}	1.60×10^{-4}	6.25×10^3	9.02
0.01	10^4	10^5	6.87×10^2	8.7×10^{-4}	7.9×10^{-4}	1.66×10^{-3}	6.02×10^2	12.31
0.01	10^5	10^6	6.87×10^1	7.8×10^{-3}	8.1×10^{-3}	1.59×10^{-2}	6.29×10^1	8.45
0.1	10^3	10^4	6.87×10^2	4.4×10^{-4}	4.2×10^{-4}	8.60×10^{-4}	1.16×10^3	69.26
0.1	10^4	10^5	6.87×10^1	4.8×10^{-3}	4.8×10^{-3}	9.60×10^{-3}	1.04×10^2	51.63
0.1	10^5	10^6	6.87	5.0×10^{-2}	4.8×10^{-2}	9.80×10^{-2}	1.02×10^1	48.53
1	10^3	10^4	6.87×10^1	7.5×10^{-3}	7.0×10^{-3}	1.45×10^{-2}	6.90×10^1	0.39
1	10^4	10^5	6.87	7.7×10^{-2}	7.0×10^{-2}	1.47×10^{-1}	6.80	0.98
1	10^5	10^6	6.87×10^{-1}	7.8×10^{-1}	7.0×10^{-1}	1.48	6.76×10^{-1}	1.65
10	10^4	10^5	6.87×10^{-1}	7.9×10^{-1}	7.1×10^{-1}	1.50	6.67×10^{-1}	2.96
10	10^5	10^6	6.87×10^{-2}	8.4	6.9	1.53×10^1	6.54×10^{-2}	4.86
10	10^3	10^4	6.87	7.8×10^{-2}	7.0×10^{-2}	1.48×10^{-1}	6.76	1.65

Table 1: Data

The following data was obtained from the experiment. We calculate the duty cycle using the oscilloscope.

C (μF)	R1 (Ohm)	R2 (Ohm)	Expt. Duty Cycle(%)	Theo. Duty Cycle(%)
0.001	10^3	10^4	5.00×10^{-1}	5.24×10^{-1}
0.001	10^4	10^5	5.29×10^{-1}	5.24×10^{-1}
0.001	10^5	10^6	5.21×10^{-1}	5.24×10^{-1}
0.01	10^3	10^4	5.25×10^{-1}	5.24×10^{-1}
0.01	10^4	10^5	5.24×10^{-1}	5.24×10^{-1}
0.01	10^5	10^6	4.91×10^{-1}	5.24×10^{-1}
0.1	10^3	10^4	5.12×10^{-1}	5.24×10^{-1}
0.1	10^4	10^5	5.00×10^{-1}	5.24×10^{-1}
0.1	10^5	10^6	5.10×10^{-1}	5.24×10^{-1}
1	10^3	10^4	5.17×10^{-1}	5.24×10^{-1}
1	10^4	10^5	5.24×10^{-1}	5.24×10^{-1}
1	10^5	10^6	5.27×10^{-1}	5.24×10^{-1}
10	10^4	10^5	5.27×10^{-1}	5.24×10^{-1}
10	10^5	10^6	5.49×10^{-1}	5.24×10^{-1}
10	10^3	10^4	5.27×10^{-1}	5.24×10^{-1}

Table 2: Duty Cycles

5 Observations

We observe that the errors are quite small for most of the cases. The errors are less than 10% for most of the cases. The errors are quite large for the $1\mu F$ capacitor. We expect a linear fit between the experimental and theoretical frequencies. The loglog plot is given below,

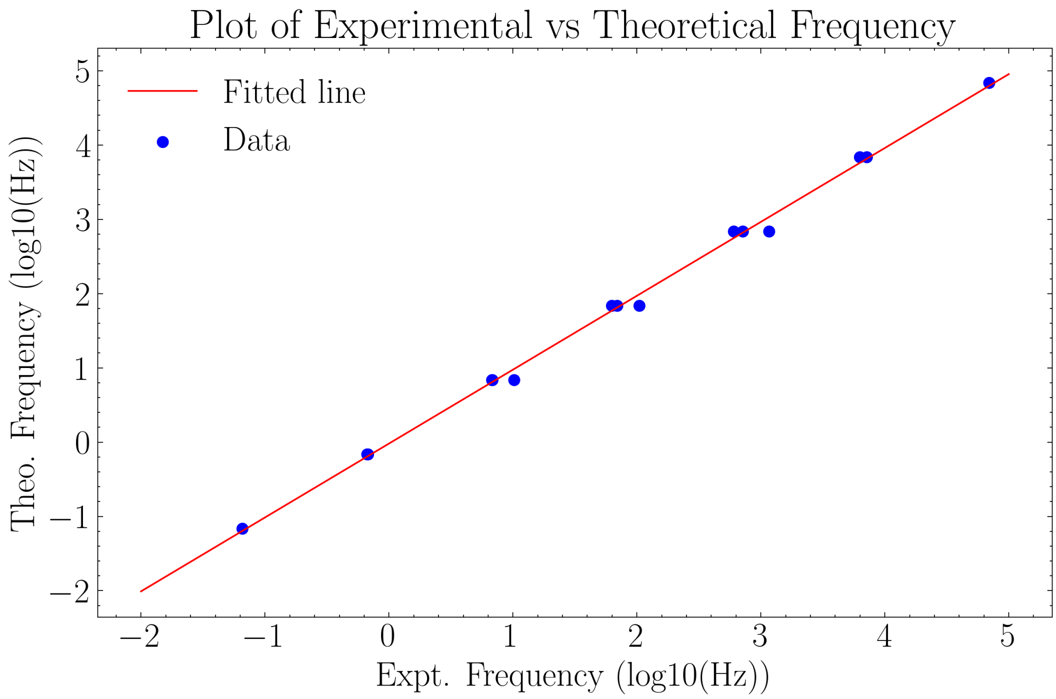

Figure 3: Loglog plot of the experimental and theoretical frequencies.

We expect a slope of 1. We obtain from the linear fit the slope to be 0.994 ± 0.014. We see that the experiment matches the data quite well.

6 Results

The experiment demonstrated the use of a 555 timer to run a astable multivibrator. We were able to calculate the frequency and duty cycle of the output waveform. The experimental values were in good agreement with the theoretical values. The errors were less than 10% for most of the cases. The errors were quite large for the $1\mu F$ capacitor.

7 Error Analysis

- There are errors in the provided values of the resistors and capacitors. The resistors and capacitors are not ideal and have some tolerance.
- The oscilloscope has some error in measuring the time period of the output waveform.
- The 555 timer is not ideal and can have internal variations in its characteristics.
- The power supply had some noise which can affect the output waveform.
- The breadboard connections can introduce errors to the output waveform.

8 Conclusion

We conclude the experiment by showing how the 555 timer can be used as an astable multivibrator. We were able to calculate the frequency and duty cycle of the output waveform. The experimental values were in good agreement with the theoretical values.