



Joseph Nelhams (2416858)

Circuit Design

School of Applied Computing
ACDA4018 Fundamentals of Electrical and Electronic Systems

Academic Year: 2024 - 2025

Lecturer: Olubenga Olubodun

July 2025

Table of Contents

List of Figures.....	iii
List of Tables.....	iii
List of Equations.....	iv
1 Introduction.....	1
1.1 Document Outline	1
1.2 555 Timer.....	1
1.2.1 Functions of the 8-pins	1
1.2.2 The 3 modes of operation	2
2 Simulation and Breadboard Prototype.....	4
2.1 Circuit Design and Calculations	4
2.1.1 Further Calculations	5
2.2 Proteus Simulation.....	6
2.3 Breadboard Prototype.....	7
3 Results and Observations	9
3.1 Simulation Measurements	10
3.1.1 C1.....	10
3.1.2 Output Voltage (Pin 3).....	10
3.2 Breadboard Measurements	11
3.2.1 C1.....	11
3.2.2 Output Voltage (Pin 3).....	12
3.3 Data Comparison.....	12
3.3.1 C1 Comparison	13
3.3.2 Pin 3 Comparison.....	14
4 Summary	15
References	16
Appendix A : Usage of generative AI	17

List of Figures

Figure 1 – Diagram of a 555 timer.....	1
Figure 2 - A diagram of a 555 timer in astable configuration as provided in the assignment brief.	4
Figure 3 - A screenshot of the diagram being simulated in Proteus.	7
Figure 4 - The completed breadboard for a 555 timer in an astable configuration, with the red LED currently lit up.	8
Figure 5 - A graph showing the voltage of C1 against time, taken from the Proteus simulation	10
Figure 6 - A graph showing the output voltage from pin 3 of the 555 timer.	10
Figure 7 – A graph showing the voltage across C1, taken from the breadboard.	11
Figure 8 – A graph showing the output voltage against time, taken from the breadboard.	12
Figure 9 – A graph overlaying the measurements from C1 of the simulation and the breadboard	13
Figure 10 – A graph overlaying the measurements taken from pin 3 of the simulation and the breadboard.	14

List of Tables

Table 1 - List of the 8 pins of a 555 timer and their functions	1
Table 2 - Chosen Values for D1 and D2.....	5
Table 3 - Table of values for the 555 timer.	6

List of Equations

$R = V_{cc} - V_{fI}$ Equation 1	4
$R_3 = 9V - 2.2V0.015A = 453.33\Omega$ Equation 2	5
$R_4 = 9V - 2.0V0.015A = 466.66\Omega$ Equation 3	5
$T_{on} = 0.693 \times (R_1 + R_2) \times C_1$ Equation 4.....	5
$T_{off} = 0.693 \times R_2 \times C_1$ Equation 5	6
$T = T_{on} + T_{off}$ Equation 6	6
$f = 1/T$ Equation 7	6

1 Introduction

1.1 Document Outline

This document explains what a '555 timer' is and what different applications it is used in. The 555 timer is designed as a prototype on a breadboard and then created using Proteus, a PCB (printed circuit board) design and circuit simulation tool. Measurements are taken from the physical circuit and the simulation, then compared.

1.2 555 Timer

[1,2,3] The 555 timer (figure 1 [4]) is an 8-pin IC (Integrated Circuit) first produced in 1972 and designed in 1971 by Hans Camenzind of Signetics. It is primarily used in timers, delays, and pulse generation applications and is widely used in circuits today. The 555 timer has 3 main modes: Monostable, Astable and Bistable. It is called a 555 timer due to the three 5kΩ resistors, which act as a voltage divider within the circuit.

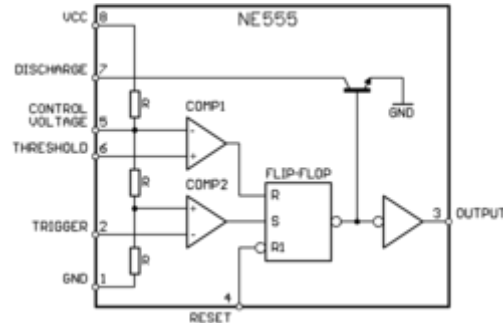


Figure 1 – Diagram of a 555 timer.

1.2.1 Functions of the 8-pins

Table 1 - List of the 8 pins of a 555 timer and their functions

Pin	Name	Function
1	GND	Ground (0V)

2	Trigger	Starts timing when the input voltage drops below $1/3V_{CC}$
3	Output	Delivers the output signal
4	Reset	Resets the timer
5	Control	Controls the threshold voltage
6	Threshold	Ends timing when the voltage exceeds $2/3V_{CC}$
7	Discharge	Discharge timing capacitor
8	V_{CC}	Supply Voltage

1.2.2 The 3 modes of operation

1.2.2.1 Monostable Mode

The Monostable mode, or one-shot pulse mode, has the IC act as a pulse generator. This is useful for applications such as timers, touch switches, frequency dividers and more. In monostable mode, an output pulse is produced when the trigger signal drops below $1/3 V_{CC}$, where V_{CC} is the input power to the circuit. The output pulse duration is equivalent to the time it takes in seconds to charge the capacitor to $2/3V_{CC}$.

1.2.2.2 Astable Mode

In Astable mode, or free-running mode, the 555 timer acts as an oscillator. Applications for this include, but are not limited to, LEDs (Light Emitting Diodes), pulse generation, logic clocks and more. In this mode, the circuit puts out a stream of rectangular pulses, making it an effective tool for converting analogue inputs into digital outputs. This circuit outputs a repeated signal as the capacitor charges and discharges; there is no stable state, causing the varying high and low voltage output as represented by the rectangular digital signal output from the IC.

1.2.2.3 Bistable Mode

In Bistable mode, also known as flip-flop mode, the IC is stable in both states and changes states once triggered. Applications include toggle switches and SR (Set-Reset) latches.

2 Simulation and Breadboard Prototype

2.1 Circuit Design and Calculations

The assignment brief specifies to construct a 555 timer in astable configuration according to the following diagram (figure 2).

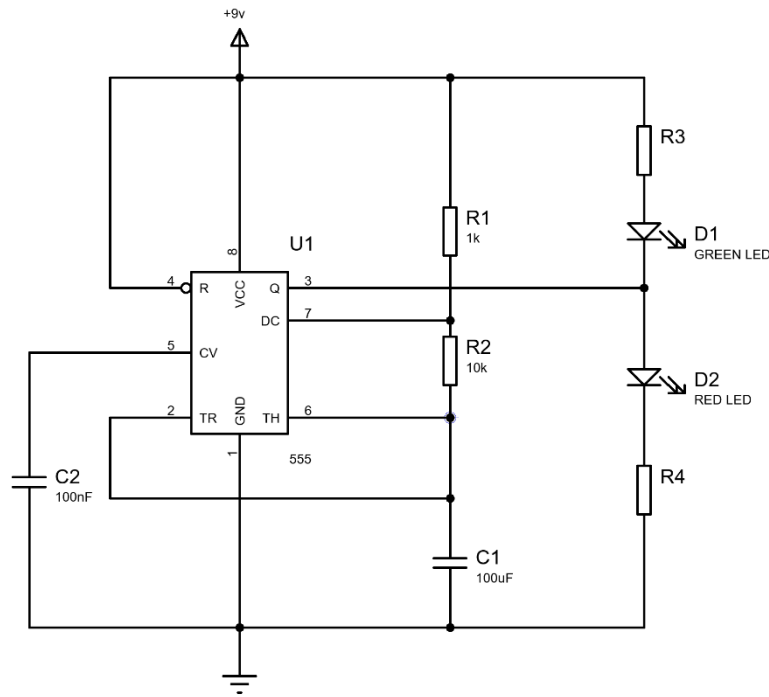


Figure 2 - A diagram of a 555 timer in astable configuration as provided in the assignment brief.

The circuit diagram specifies 4 resistors, with R3 and R4 having no defined values. Within the circuit, R3 and R4 act as current-limiting resistors for the diodes. The values of R3 and R4 must be calculated; to do so, the forward voltage (V_f) of the LEDs and the current (I) supplied to the LEDs should be known so that the resistance can be calculated using Ohm's law (eq. 1)

$$R = \frac{V_{cc} - V_f}{I}$$

Equation 1

The values of V_f (Table 2) for the green (D1) and red (D2) LEDs are assumed based on typical values for these components; this is due to not knowing the specifications of said components.

Table 2 - Chosen Values for D1 and D2

	Forward Voltage (V_f)	Desired Current (I)
D1 - Green LED	2.2V	15mA
D2 - Red LED	2.0V	15mA

Using the values provided in Table 2 along with Ohm's law (eq. 1), the resistance values for R3 and R4 can be calculated (values given to 2 d.p.):

$$R3 = \frac{9V - 2.2V}{0.015A} = 453.33\Omega$$

Equation 2

$$R4 = \frac{9V - 2.0V}{0.015A} = 466.66\Omega$$

Equation 3

Due to the answers given by equations 2 and 3, the ideal resistor values would be $\approx 470\Omega$. However, due to the equipment available, the resistor values used for the breadboard, and therefore the simulation, are 1k Ω ; This was the closest value resistor available for use.

2.1.1 Further Calculations

As well as calculating the values of R3 and R4, the values of the On time, Off time, Total Period, and Frequency have also been calculated using the following equations:

On time (T_{on}):

$$T_{on} = 0.693 \times (R1 + R2) \times C1$$

Equation 4

Off time (T_{off}):

$$T_{off} = 0.693 \times R2 \times C1$$

Equation 5

Total Period (T):

$$T = T_{on} + T_{off}$$

Equation 6

Frequency (f):

$$f = \frac{1}{T}$$

Equation 7

The values from these formulas for the 555 circuit are given in Table 3 to 2 d.p.

Table 3 - Table of values for the 555 timer.

R3	R4	T_{on}	T_{off}	T	f
453.33Ω	466.66Ω	0.76s	0.69s	1.46s	0.69Hz

2.2 Proteus Simulation

The circuit diagram provided in Figure 2 was closely replicated in Proteus, with the values of R3 and R4 set to what was available to hand at the time. A screenshot of the circuit being simulated is provided in Figure 3.

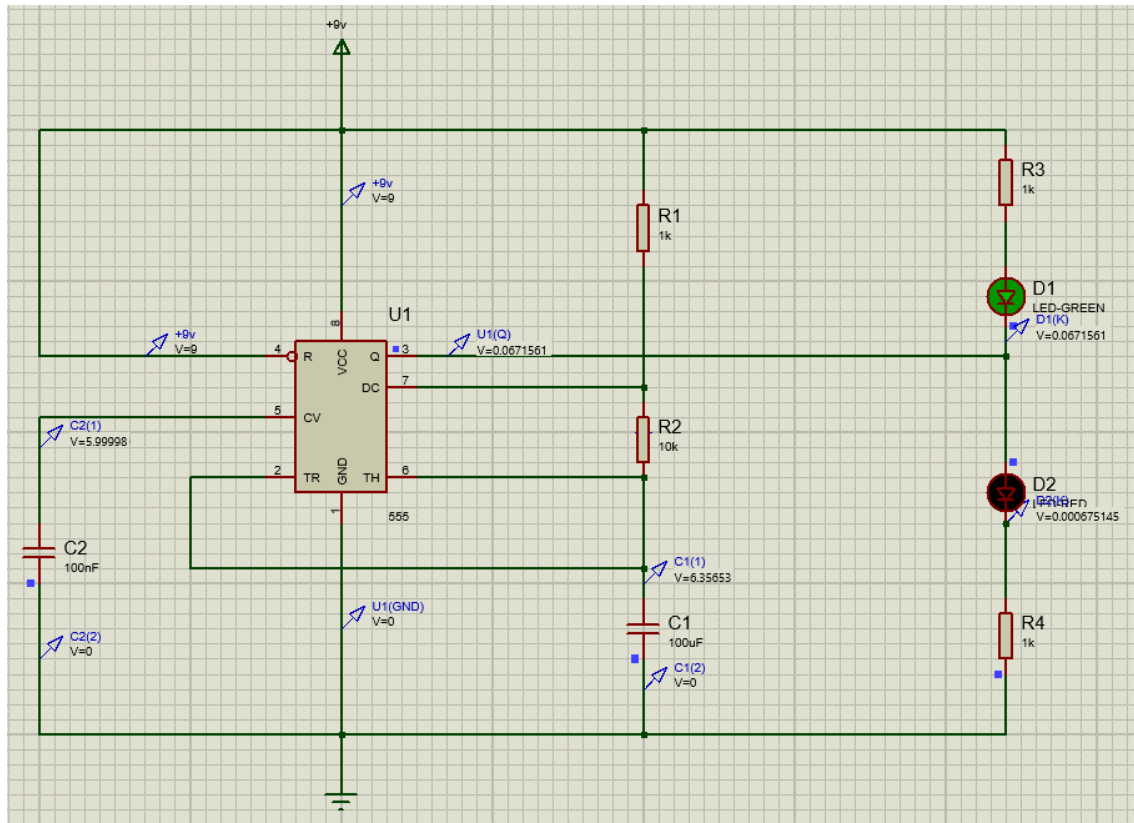


Figure 3 - A screenshot of the diagram being simulated in Proteus.

Probes measuring the voltage across a component or length of wire have been added throughout the circuit. This demonstrates that the circuit is functioning correctly. The probes connected to the ground of the circuit read 0V, which provides proof of Kirchhoff's Voltage Law and further justification for the circuit's intended operation.

2.3 Breadboard Prototype

The breadboard circuit, as shown in Figure 4, was built from the IC chip first, then each component was added to the breadboard following the ordering of the pins. To start with, pin 1 of the chip was connected to the ground (0V rail), then the 100 μ F capacitor was connected to pin 2. The red diode and a 1k Ω resistor were connected to pin 3, and pin 4 was connected to the supply voltage positive rail. A 100nF capacitor was connected to pin 5 and the ground, and a wire connected pin 6 to C1, a 10k Ω resistor was connected to pin 7 and C1, and a wire connected pin 8 to the power rail. Finally, R3 and the green LED were connected to the

power supply and to D2 to complete the circuit. The breadboard was hooked up to a variable power supply to be tested.

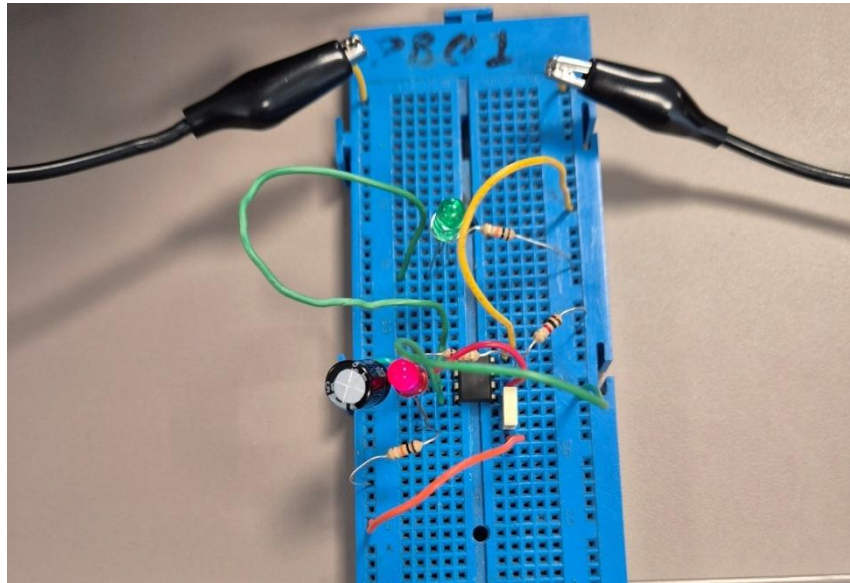


Figure 4 - The completed breadboard for a 555 timer in an astable configuration, with the red LED currently lit up.

A multimeter was connected to the breadboard across specific components to collect measurements, which are further explored in section 3.

3 Results and Observations

The measurements taken for both the Proteus simulation and the breadboard include the voltage across C1 and the output voltage from pin 3.

3.1 Simulation Measurements

3.1.1 C1

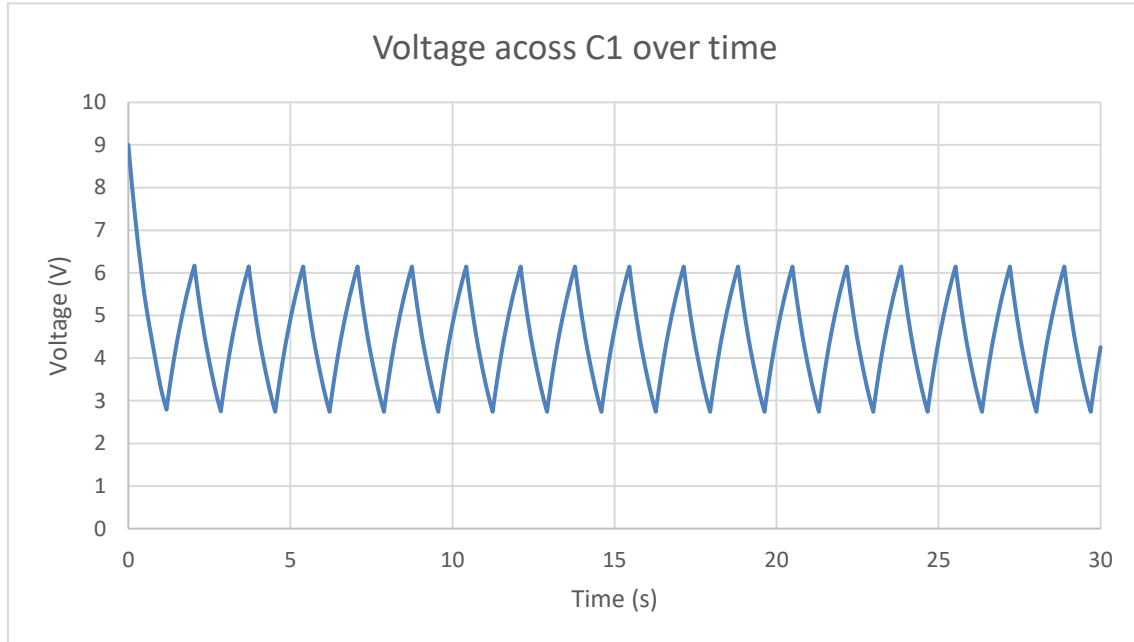


Figure 5 - A graph showing the voltage of C1 against time, taken from the Proteus simulation

3.1.2 Output Voltage (Pin 3)

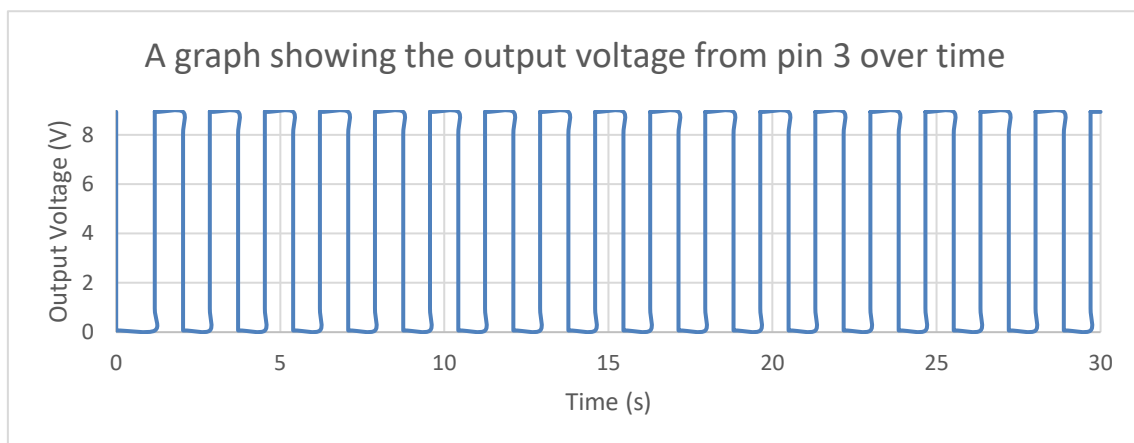


Figure 6 - A graph showing the output voltage from pin 3 of the 555 timer.

3.2 Breadboard Measurements

3.2.1 C1

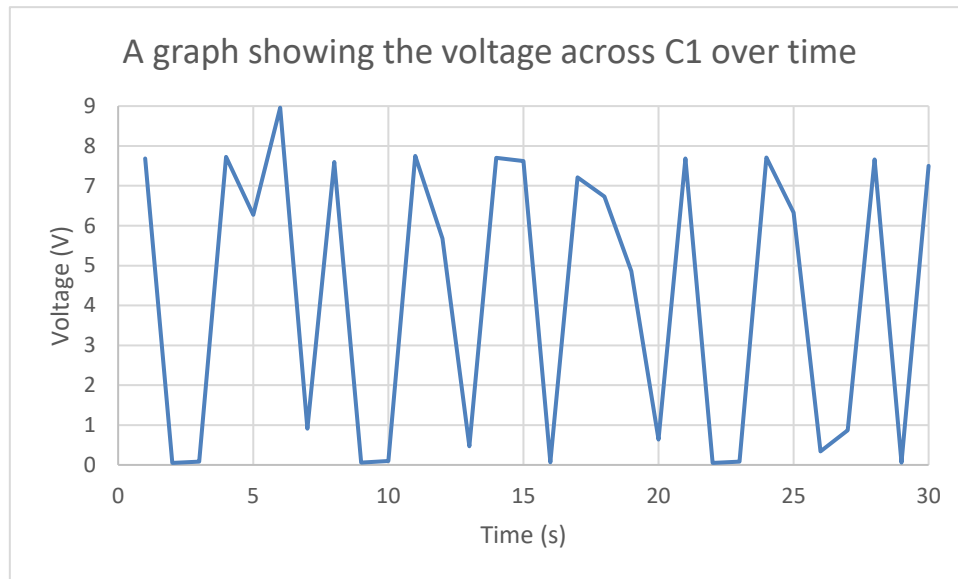


Figure 7 – A graph showing the voltage across C1, taken from the breadboard.

The refresh rate from the multimeter limited the amount of data that could be gathered from the circuit. This is the reason for the major dissimilarities between the breadboard and the simulation.

3.2.2 Output Voltage (Pin 3)

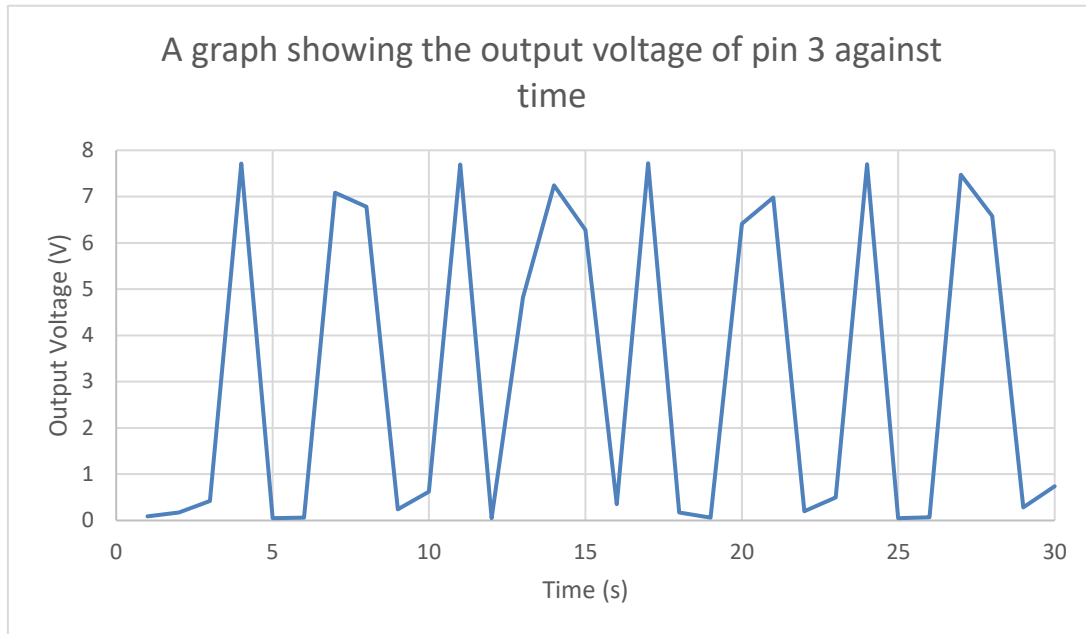


Figure 8 – A graph showing the output voltage against time, taken from the breadboard.

3.3 Data Comparison

The graphs from both the simulation and the breadboard have been combined to try to compare the two. Ideally the two graphs should be close to identical however the limitations with the diagnostics present will make the data be more diverse than they realistically are.

3.3.1 C1 Comparison

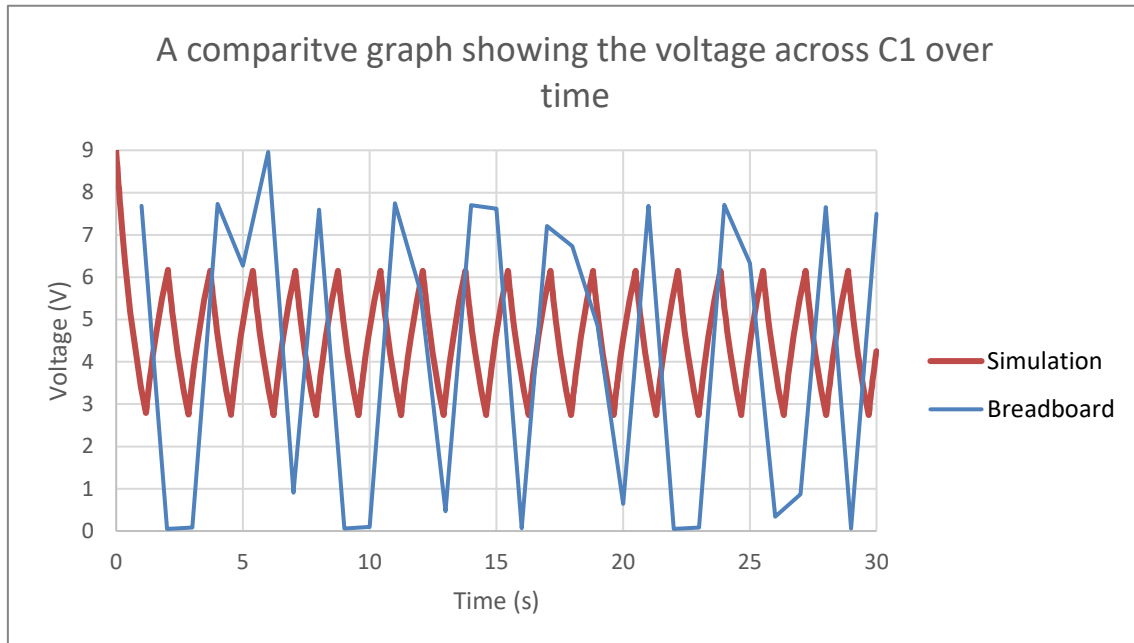


Figure 9 – A graph overlaying the measurements from C1 of the simulation and the breadboard

The two graphs are quite difficult to compare due to the comparatively infrequent measurements taken from the breadboard. The simulation has 631 points of measurement in comparison to only 30 from the breadboard. The minimum and maximum voltages of C1 from the breadboard are notably higher than those of the simulation; this could be due to differences in the component properties from the simulation in comparison to the components used with the breadboard.

3.3.2 Pin 3 Comparison

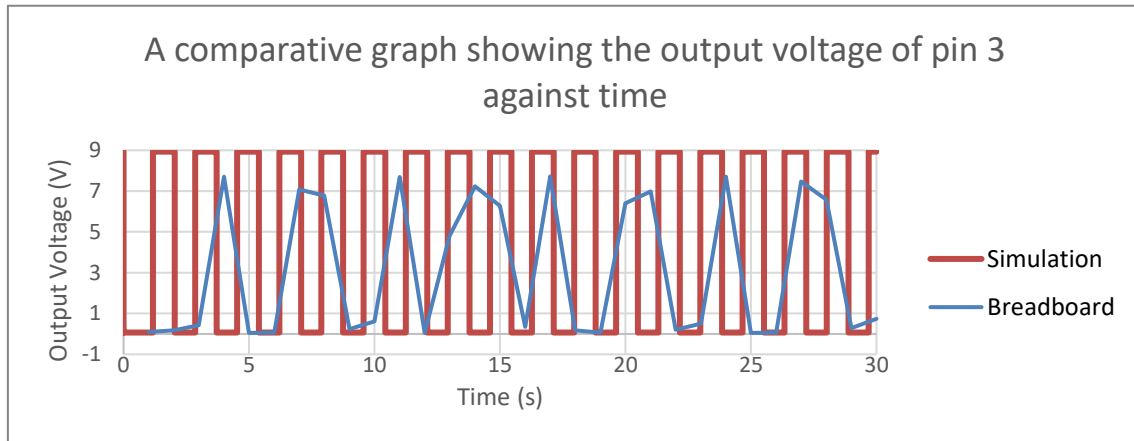


Figure 10 – A graph overlaying the measurements taken from pin 3 of the simulation and the breadboard.

Once again, due to the limitations of the diagnostics, it is difficult to objectively compare the two graphs. It is worth noting that the peak voltages differ quite a lot between the two graphs. For the simulation, the peak voltage is 9V, which is equal to the supply; however, the breadboard peaks only at 7.7V. This shows that either the power supply was not supplying enough voltage, or that the total circuit resistance of the breadboard was substantially higher than that of the simulation.

4 Summary

To summarise, an Astable 555 timer circuit was designed and prototyped on Proteus and a breadboard. Measurements of these circuits were taken from the output voltage (pin 3) and Capacitor 1. Due to the limitations of the multimeter, it is very difficult to make objective comparisons between the two. It is noteworthy that the maximum voltage readings from the breadboard were lower than the simulation; this is either due to the power supply unit providing less voltage than intended or due to a greater total circuit resistance in the breadboard.

References

1. P. Horowitz and W. Hill, *The art of electronics*. Cambridge University Press, 2015.
2. P. Scherz and S. Monk, *Practical Electronics for Inventors, Fourth edition*. McGraw-Hill Education TAB, 2016.
3. "555 Timer Monostable Circuit Calculator," *Allaboutcircuits*.
<https://www.allaboutcircuits.com/tools/555-timer-monostable-circuit/>
(accessed Jul. 20, 2025).
4. Texas Instruments Incorporated, "Precision Timers," Feb. 2025. [Online].
Available: <https://www.ti.com/lit/ds/symlink/ne555.pdf>

Appendix A : Usage of generative AI

This is a statement to confirm that generative AI was used as an aid for this assignment. AI was used to help with the research portion of the assignment, but was not used for writing, proofreading, programming or anything else. This was done according to what was laid out in the “Usage of Generative AI in Assessment” section of the assignment brief. All research and references were verified and fact-checked by me before inclusion in the assignment.