Fundamentals of Electrical and Electronic Systems

William Critchley

Student number: 2309517
Fundamentals of Electrical and Electronic Systems (ACDA4018)

Ordnance, Munitions and Explosives

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Introduction

In this module, we were asked to construct a circuit from the diagram seen below in Figure 1. Resistors 3 and 4 had unknown values, and we were tasked with calculating their resistance. The next part of the task was running a simulation to calculate the on and off times for each LED as it flashed, along with the total time period and the frequency.

The task then asked for the construction of the circuits on a breadboard. The breadboard we created was then to be tested against the simulated results to assess their accuracy.

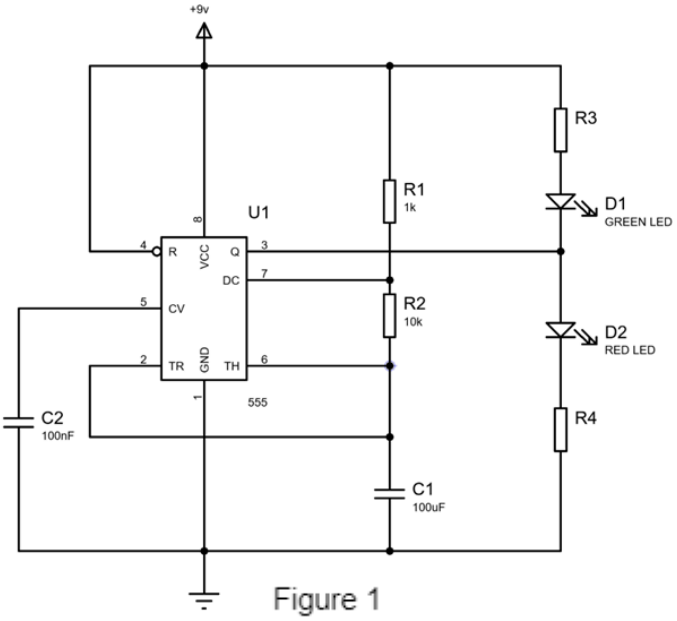


Figure 1

The Circuit

This circuit is centred around a 555 timer Integrated Circuit (IC) outlined in red in Figure 2. This IC has 8 pins, each having a different role in its operation:

1. Ground - Connects to ground
2. Trigger - starts the timing cycle
3. Output - Outputs the signal
4. Reset - Resets the timer
5. Control Voltage - changes the threshold voltage.
6. Threshold - Ends the timer in monostable mode or controls the on off timing in astable mode.
7. Discharge - Discharges the timing capacitor.
8. Vcc - Connects to the power supply[1]

In this circuit, the 555 timer is in astable mode. This is a mode of operation in which the timer outputs a continuous consistent on and off pulse. These pulses create an oscilloscope sketch which resembles a very flat AC signal, changing from off to fully on nearly instantly[2].

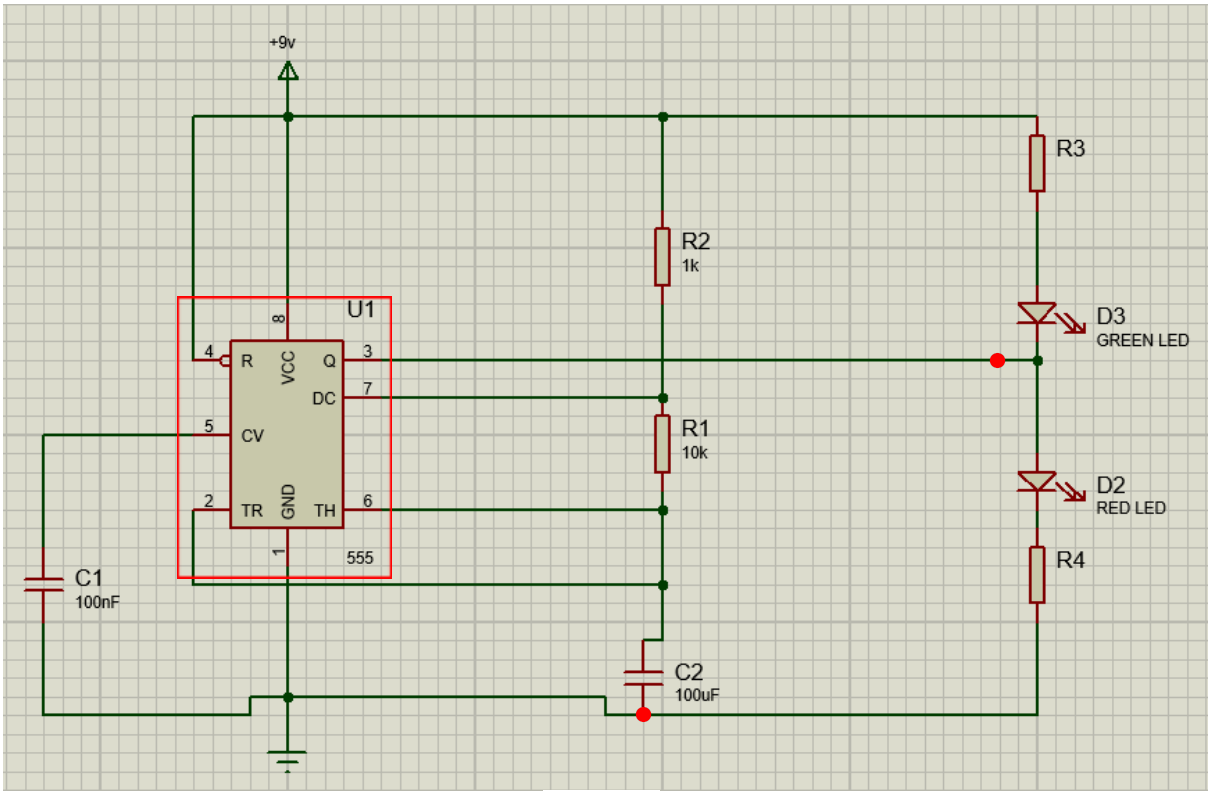


Figure 2

Figure 2 shows the circuit specified in the task description. The circuit was recreated in Proteus. When simulated, the LEDs flash on and off at regular intervals.

Calculations:

Resistor 3 and 4:

To calculate the resistance of R3, I used Proteus to find how much voltage and current was passing through the resistor. I then substituted these values into Equation 1 [2]; Vtotal = 9 Vcomponent = 2.2 and Icomponent = 10mA, giving $R_3 = \frac{9-2.2}{0.01}$ R3 = 680 Ω .

$$R_3 = \frac{V_{total} - V_{component}}{I_{component}}$$

Equation 1

R4 had the exact same values for Vt, Vc and Ic, resulting in the same resistance of 680 Ω, as calculated above.

The On & Off time:

The on and off time of a circuit can be calculated by measuring the on and off pulse on an oscilloscope. The output for Proteus's virtual oscilloscope can be seen in Figure 3. This shows that the On pulse had a length of 76ms or 0.76s and the Off pulse had a length of 700ms or 0.7s.

On Time	0.76s
Off Time	0.7s

The Time Period:

The time period can be calculated by adding the time for one full off and on pulse in this case the time period is 1.46s

The Frequency:

The frequency can be calculated as $F = \frac{1}{T}$, where T corresponds to the time period. Substituting into the above formula, the frequency for this circuit is $F = \frac{1}{1.46}$ = 0.68 Hz

on time (ms)	off time (ms)	time period (s)	frequency (Hz)
760	700	1.46	0.68

Simulation Graphs

These outputs were gained by attaching the digital oscilloscope at two points, denoted as red dots in Figure 2.

This graph shows the output voltage from leg 3 of the 555 timer. The time period is 1.46 s, with an on pulse of 0.76 s and off pulse of 0.7 s as calculated above.

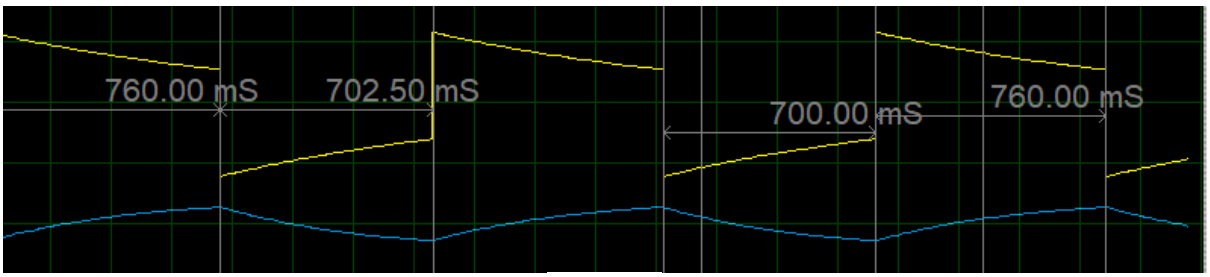


Figure 3

This oscilloscope output in Figure 4 shows the capacitor voltage of capacitor C2 increasing and decreasing as it charges and discharges.

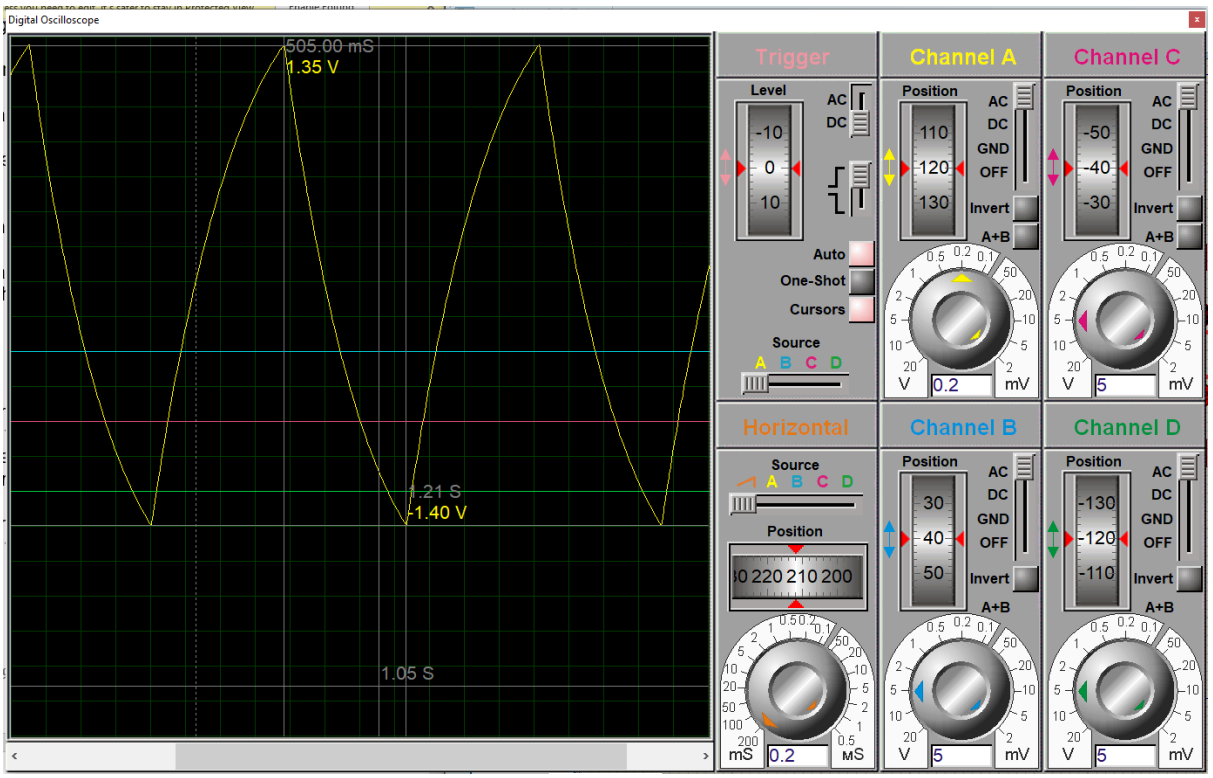


Figure 4

Breadboards

We were then instructed to recreate our simulated circuit on a breadboard so the simulation could be validated with real world results. My method for constructing my circuit was initially placing the 555 IC and the parallel sections that would need to be connected. I then ran the wires from the IC to the other components. The final circuit can be seen in Figure 5 (below).

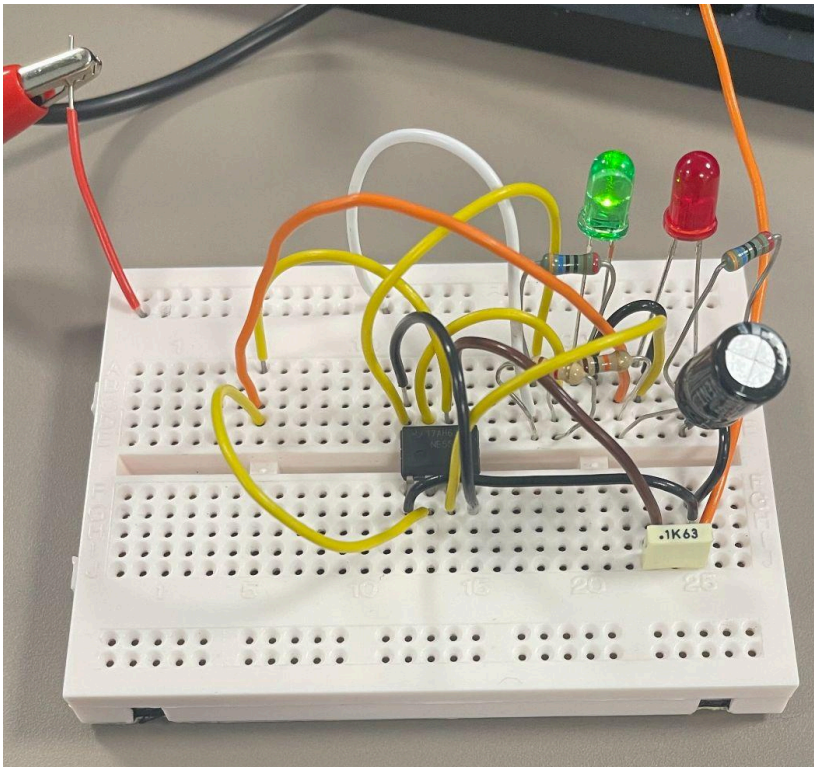
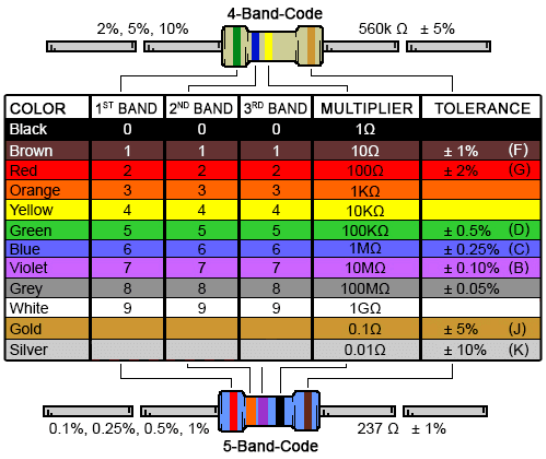


Figure 5

One aspect of my work which I identified for improvement was the aesthetics of my circuit. Although the circuit functions as intended and replicates the desired functionality, its presentation could be neater. The importance of focusing on not only the functionality, but also the appearance of my work became particularly apparent when I was asked to help a classmate with their work, as it was difficult to convey how I had put mine together.

The actual values of the resistors R3 and R4 were not identical to those of the simulation, but the small difference in value had no effect on the results. As calculated previously, the resistance of both simulated resistors was 680 Ω. The resistance of both real resistors was 460 Ω. I calculated the resistance using a resistor chart which shows the values relating to the coloured bands on the component. The table used can be seen in Figure 6 [3].



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

Figure 6

On the green resistor in my circuit the bands are yellow, blue, black, black, brown and red, in that order as seen in Figure 5.

Substituting the values found in the tables for this order of colours gives

Yellow	Blue	Black	Black	Brown	Red
4	6	0	x10^0	±1%	50 ppm/°C

460 x 1 = 460 Ω ±1% with a temperature coefficient of 50 ppm/°C

Collecting Breadboard Data

The breadboard circuit was constructed using:

- 2 x 460 Ω resistors
- 1 x 1k Ω resistor
- 1 x 10k Ω resistor
- 1 x 555 timer IC
- 1 x red LED
- 1 x green LED
- 1 x 100nF Capacitor
- 1 x 100μF Capacitor
- 13 x insulated wires

To collect the relevant data i attached the probes of an oscilloscope to the circuit in equivalent locations to those used in the simulation. As mentioned previously, the location of the problem is shown in Figure 2 by red dots - the replicated configuration can be seen below in Figure 7. The probes are attached to the output of capacitor C2 and to pin 3 of the 555 timer.

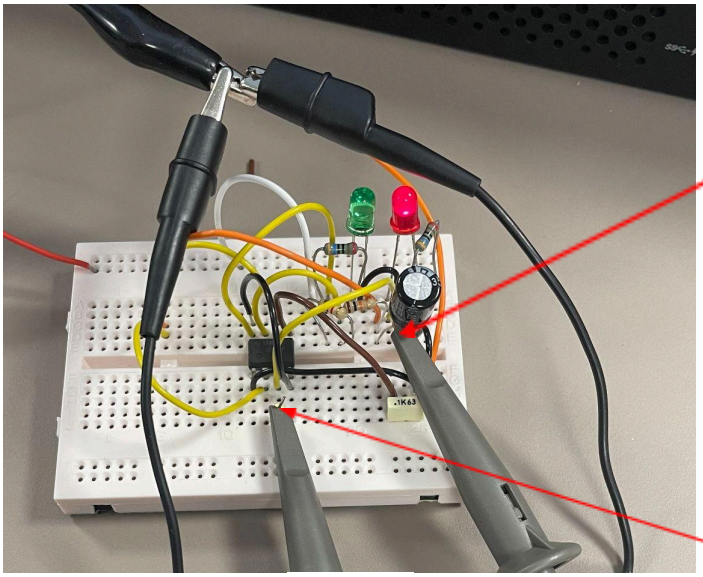


Figure 7

Attachment point for capacitor reading

Attachment point for output voltage

The outputs from these probes were displayed on the oscilloscope. I was then able to assess them and take measurements to compare with the simulated results

Breadboard Results

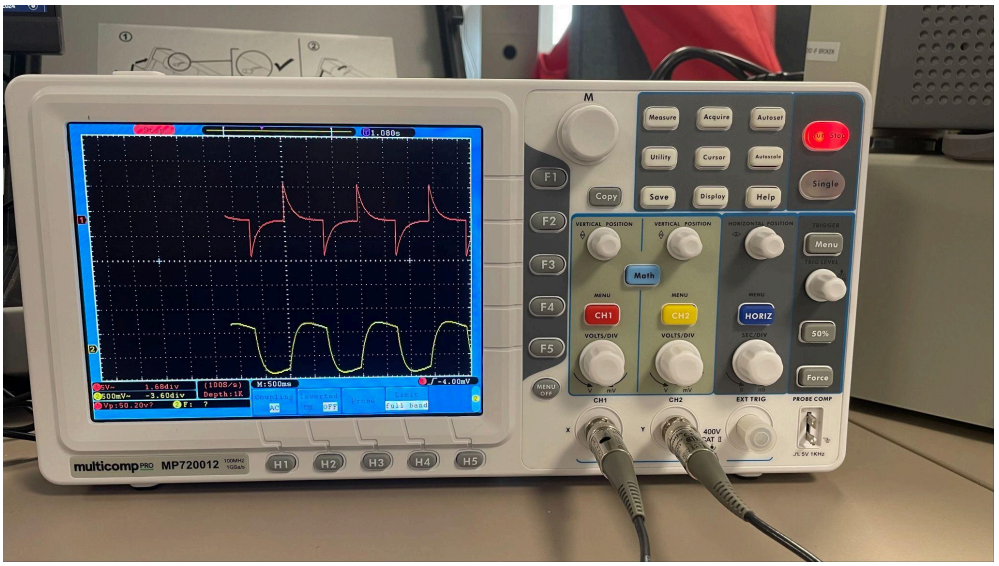


Figure 8

Figure 9

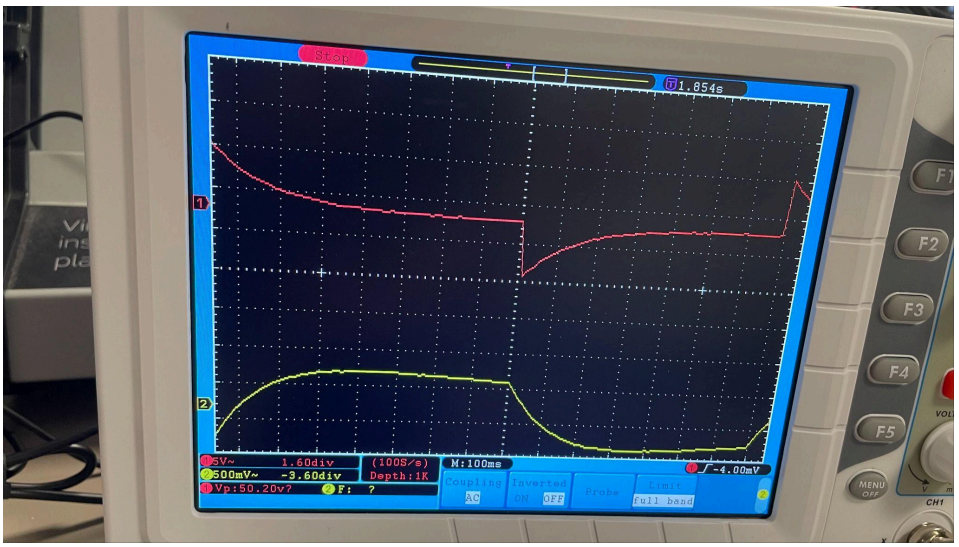


Figure 8 shows the full oscilloscope output with the top (red) trace showing the pin 3 output voltage and the bottom (yellow) trace showing the capacitor charging and discharging. Each division in the x axis is 100 ms, and as such, the off pulse in Figure 9 can be seen to be approximately 700 ms. The full results measured are given in the below table.

on time (ms)	off time (ms)	time period (s)	frequency (Hz)
760	700	1.46	0.68

Conclusions

Overall, the findings of this report exemplify how Proteus can very accurately simulate physical circuits, as the set of results from the simulation correspond exactly to those of the real circuit. Future works could look into other uses of 555 timers, for example, the flashing lights in police light bars as they flash in a regular pattern. Another potential area of research is possible defence applications, such as a delay fuse in a munition to achieve enhanced structure penetration. This could work by initiating the timer upon initial impact, then setting the timer to detonate the warhead after a set time e.g. half a second. Or in Navigation lights for example on ships or the tips of aeroplane wings .

References

[1] The Pennsylvania State University, “The 555 Timer IC” Dept. Mech. Eng., Pen state, pennsylvania 2023

[2] A. Beddoe, D Price, 28 January 2017, “GCSE Electronics ebook” [online], Available: https://resources.eduqas.co.uk/Pages/ResourceSingle.aspx?rlid=938

[3] Digi-Key Electronics.(Accessed: 16/07/2024) "Resistor Color Code Calculator" [Online]. Available: https://www.digikey.com/en/resources/conversion-calculators/conversion-calculator-resistor-color-code.