

# Design, Build & Test of a 555 Timer Circuit

*by* Ben Palmer-Drury

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# Design, Build & Test of a 555 Timer Circuit.

Ben Palmer-Drury - 2212937

**Fundamentals of Electronics ACDA4018**



OME Level 4 Year 2

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Section 1 – Assignment Purpose

To design a circuit, using an astable 555 timer, capable of flashing 2 different coloured LED’s alternately. Firstly, it will be designed using Proteus software to simulate the operation, then built, physically, using a breadboard and the required components. A common example of this type of circuit would be a simple emergency vehicle beacon. Therefore, this example will be referred to throughout this report.

Section 2 – Circuit Description and Operation

Figure 1 is a schematic of the required circuit as given in the brief;

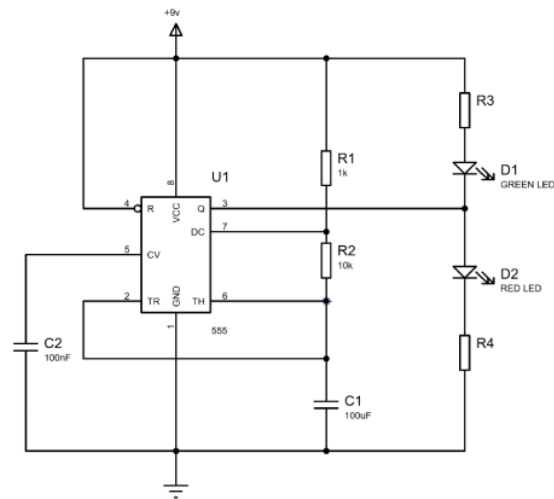


Figure 1 

The following table details the required components;

| Component                                                                           | Details                                                                                   |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| R1 – Resistor 1                                                                     | 1 kiloohm (kOhm)                                                                          |
| R2 – Resistor 2                                                                     | 10 kiloohm (KOhm)                                                                         |
| R3 – Resistor 3                                                                     | To calculate                                                                              |
| R4 – Resistor 4                                                                     | To calculate                                                                              |
| D1 – Green LED                                                                      | Coloured Light Emitting Diode                                                             |
| D2 – Red LED                                                                        | Coloured Light Emitting Diode                                                             |
| U1 - 555                                                                            | Integrated Circuit, programmable chip                                                     |
| C1 – Capacitor                                                                      | 100 microfarad (uF)                                                                       |
| C2 – Capacitor                                                                      | 100 nanofarad (nF)                                                                        |
|  | Ground – In this instance the frame of the lamp, where it is earthed to the vehicle frame |
|  | Electrical Power Supply – In this instance the vehicle power supply, a DC battery supply. |

Table 1 – Component details

NB - Most emergency vehicles use a 12v electrical system, unless on an HGV, which uses a 24v system. For safety the light bars can be stepped down in voltage, particularly for smaller applications like motorcycles.

To appreciate the operation of this circuit, a few underlying principles must be understood.

2.1 – Electricity. In context, this is the flow of negatively charged particles, from the negative terminal of a battery to the positive. These particles are called electrons and orbit the nucleus of all atoms. The nucleus contains Protons and Neutrons. Protons being positively charged, neutrons having no charge/neutral charge. Normally, the number of electrons is equal to the number of protons, however, when this balance is upset by an external force, atoms may lose or gain electrons. This movement or loss of electrons is considered to be electric current [1]. Each electron carries a small negative charge ( $1.602 \times 10^{-19}$  coulombs) [2]. When millions flow, this is measurable using various tools.

2.2 – Resistance. This property is the measure of opposition to the flow of current-carrying charged particles. This is observed as the emission of heat from a wire or component, however it is a characteristic of all electrical parts [3]. It is summed up in figure 2, a humorous cartoon;

2.3 – Ohms Law. Ohm is the unit of resistance. It is intrinsically linked to voltage and current. Voltage being the difference of potential across a circuit, or electromotive force [4]. Current, measured in amperes (amps), being the flow of electrons [5]. Ohms Law is expressed as;

$$V = IR \quad \text{or} \quad I = \frac{V}{R} \quad \text{or} \quad R = \frac{V}{I}$$

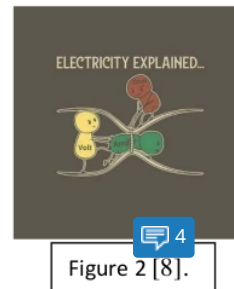


Figure 2 [8].

This means that resistance is the ratio or applied voltage to current does not vary with the current strength, at a constant temperature [2].

2.4 – Resistors. Materials vary in their ability to allow conductivity of electricity. Copper is highly conductive, often used in wiring for this purpose. Mica, quartz, polythene and porcelain have very little (to no) conductivity, therefore are considered to be non-conductive, or, an insulator. There is an intermediate layer of materials called semi-conductors. Elements such as germanium and silicon are considered so. Generic, or fixed (where the value cannot change), resistors are generally of a carbon composition. Should the resistors rating be exceeded it will over heat and become useless. The resistor is in operation when heat is being generated. Resistors are identified by coloured bands, but, should a user be unfamiliar with this system, then a more practical means of identification would be to use a multimeter [2]. There are two methods for calculating total equivalent resistance, shown below;

Parallel 
$$R_T = \frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \text{etc...}\right)}$$

Series 
$$R_T = R_1 + R_2 + R_3 + \text{etc...}$$

2.5 – Capacitor. These are electrical components that have the ability to temporarily store and release charge. When voltage is established across the insulator component, called the dielectric, connecting the two conductors, a charge is stored. This stored charge is proportional to the voltage; double the voltage, double the charge. If the voltage is tripled, the charge is also,

and so on. From this we see that the ratio of voltage to charge is constant. This constant is called capacitance and is measured in farad [2].

2.6 – 555 Integrated Circuit. “The invention of integrated circuits is perhaps the most important advance ever made in electronics.” [2]. And it is plain to see why. IC ‘chips’ have miniaturised circuits enabling devices to become smaller and more complex, not only in their construction but the tasks they are capable of. They have moved a lot of individual components to within the chip for extra functionality. In the astable mode, they are widely used in a variety of timer delay, pulse generation and oscillator applications. They are also capable of generating sounds when connected to speakers. In the context for this report, they are used as an oscillator that generates a square waveform. The wave’s frequency is adjustable by varying resistor and capacitor values, that are connected to the IC. The following equations shows LED on/off cycles when resistor and capacitor values are altered;

$$t_{on} = 0.69 \times C1 \times (R1 + R2)$$

$$t_{off} = 0.69 \times C1 \times R2$$

$t_{on}$  : Length of high output pulse in seconds  
 $t_{off}$  : Length of low output pulse in seconds  
 $R1$  : Resistance of  $R1$  in Ohms  
 $R2$  : Resistance of  $R2$  in Ohms  
 $C1$  : Capacitance of  $C1$  in Farads

If the values of  $C1$  or  $R2$  are increased, both the output on and off times also increase. If  $R1$  is the only variable that is increased, then only on time is increased [6].

### Section 3 – Proteus

Proteus is a design suite to enable the design, test and layout of printed circuit boards. Using the brief, the author laid out the virtual breadboard after finding and labelling the required components. The virtual breadboard is shown below;

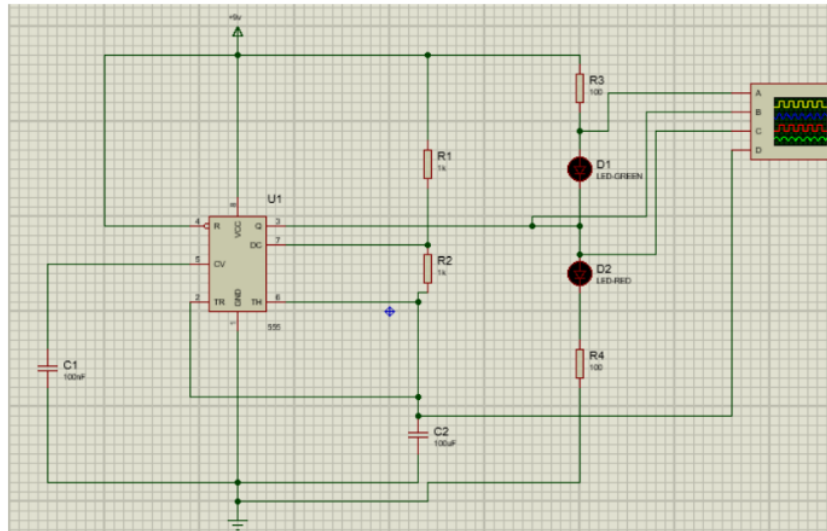


Figure 3 – Virtual Breadboard

For reasons that were unfathomable at the time of writing, the simulation does not run as intended. Resistor values have been adjusted ad nauseam, to no avail. Both LED's illuminate, but do not flash. This is the second iteration. On the first, it failed to simulate at all. The second iteration was started from scratch.

As of 12/01/2024 the simulation now runs! The author missed an errant wire that ran *under* a capacitor, which was not connecting as it should. For a fresh perspective, he enlisted the help of a Proteus user at FHD on the same team, GH. GH and the author took a systematic approach to checking each component and each wire, eventually discovering the issue.

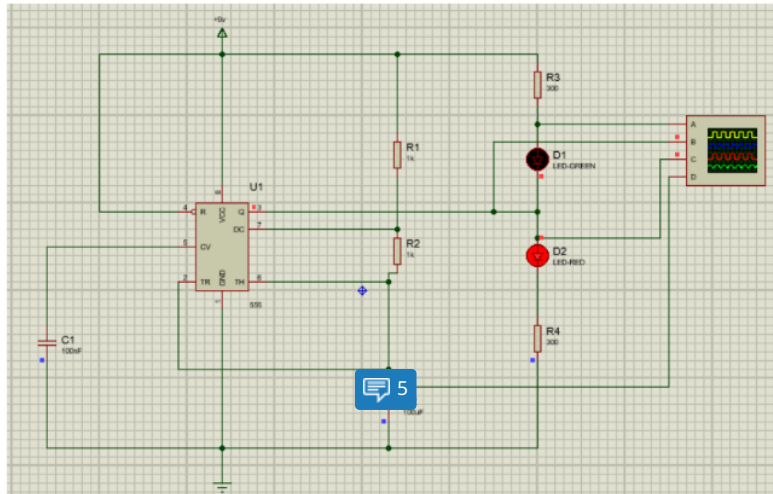


Figure 4 – Working simulation.



#### Section 4 – Calculations

Calculating resistances for R3 and R4.

Given that R1 and R2 are known, as well as voltage, we can calculate R3 & R4. Using the data gathered from the Proteus components, it was first necessary to know the forward volt drop for the LEDs ( $V_f$ ). Looking at the max recommended current, about 20mA, it's generally accepted to run at 50-75% of the maximum rating. The simulation was run at 10mA. Next, it is required to work out what voltage is across the current limiting resistors (R3 & R4). The circuit power supply is 9v ( $V_s$ ).

Voltage across the resistor would be;  $V_s - V_f = \text{Resistor voltage}$

$$9v - 2.2v = 6.8v$$

Next calculate the resistor using Ohms Law;  $R = \text{Voltage} / \text{Current (I)}$

$$= 6.8v / 0.01A$$

$$= 680 \text{ ohm}$$

This results in the complete equation;  $R = (V_s - V_f) / I$

Therefore, the resistances for R3&4 will both be 680 ohms.

To revisit the following equation from Section 2, we can work out the LED on/off times;

$$t_{on} = 0.69 \times C1 \times (R1 + R2)$$

$$t_{off} = 0.69 \times C1 \times R2$$

$t_{on}$  : Length of high output pulse in seconds

$t_{off}$  : Length of low output pulse in seconds

R1 : Resistance of R1 in Ohms

R2 : Resistance of R2 in Ohms

C1 : Capacitance of C1 in Farads

$$t_{on} = 0.69 \times 0.0001 \text{ F} \times (R3 + R4)$$

$$t_{on} = 0.09s$$

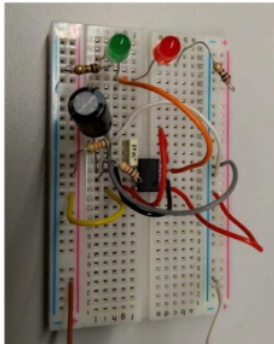
$$t_{off} = 0.69 \times 0.0001 \text{ F} \times R4$$

$$t_{off} = 0.05s$$

R3 & 4 substituted as they are the direct load limiting resistors. The 100uF capacitor is used for this calculation.

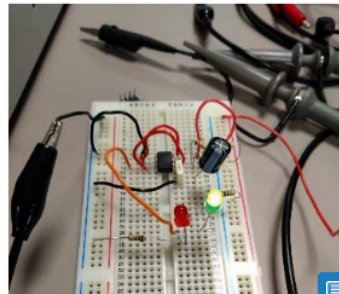
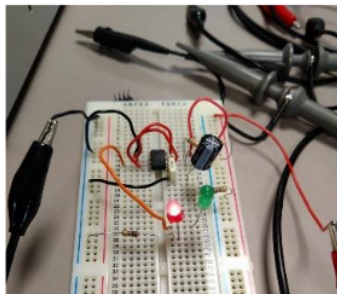
These results would apply to both LEDs as they are of comparable spec.

## Section 5 – Breadboard



Iteration 1 – The circuit initially failed to operate. The author carried out some basic troubleshooting diagnostics ruling out the resistors and power supply, using a multi meter. Initially, there was a case of operator error on the part of the author being unfamiliar with the voltage generator. Through like-for-like replacement it was discovered that both the IC and the breadboard were defective.

Figure 5 – Breadboard 1



Figures 6&7 - Breadboard 2

Iteration 2 – Once the IC and breadboard were changed the system operated as intended. Although, at first the green LED failed to function, but it was quickly realised that it was in backwards. This iteration was also much

operationally simpler, eliminating excess wiring, using the board to facilitate this. The author was initially thinking like a (former) mechanic rather than with an electronics mind-set. Once these issues were resolved, the system fully functioned as per the brief, enabling gathering the following data.

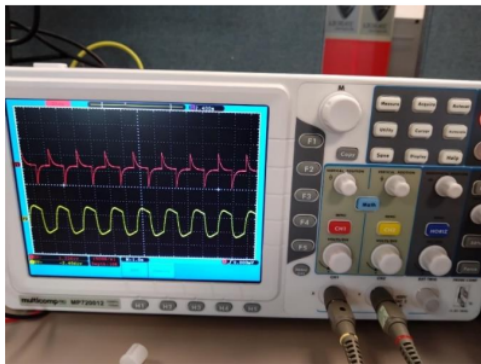


Figure 8 – Oscilloscope data

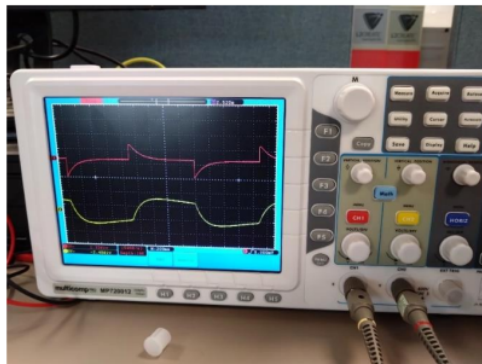


Figure 9 – Oscilloscope data

From these readings the author was able to calculate that the on/off time was 0.8 seconds. The frequency being derived from the formula;

$$Frequency = 1/Time$$

Using an appropriate calculator [7], using the extracted data, it was possible to calculate that the frequency of our LEDs was 1.25Hz.

#### Section 6 – Conclusions

From what started as a complete disaster with faulty simulations, and then faulty components in making the physical circuit the author has learnt (and remembered) a lot, with regard to electronic circuits.

Learnings included more in-depth theory to integrated circuit design and build, whilst building on 17 years as a professional mechanic.

Lessons learned include, testing of all equipment and components, *before* commencing a build. Historically the author would have done this, but took it at face value that the equipment provided was viable.

## Section 7 References

- [1] C. Platt, *Make: Electronics*, Canada: Maker Media, 2009.
- [2] G. H. Olsen, *Electronics*, Bungay: Heineman, 1986.
- [3] Britannica, "Resistance," 21 11 2023. [Online]. Available:  
<https://www.britannica.com/technology/resistance-electronics>. [Accessed 15 12 2023].
- [4] E. Hughes, *Electrical Technology*, vol. 4th, Bungay: Longman, 1969.
- [5] J. C. Morris, *Applied Electronics*, Loddon: Preston Press, 1997.
- [6] S. Campbell, "555 Timer Basics - Astable Mode," *Circuit Basics*, [Online]. Available:  
<https://www.circuitbasics.com/555-timer-basics-astable-mode/>. [Accessed 15 12 2023].
- [7] R. Rain, "Frequency Calculator," [Online]. Available:  
<https://www.omnicalculator.com/physics/frequency>. [Accessed 12 01 2024].
- [8] Facebook, *Electricity Explained*.

# Design, Build & Test of a 555 Timer Circuit

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## GRADEMARK REPORT

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FINAL GRADE

GENERAL COMMENTS

78/100

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PAGE 1



### Comment 1

Fundamentals of Electrical and Electronic Systems

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PAGE 2



### Comment 2

It is better to have Table  
of figures

Table  
of tables in a new page.

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PAGE 3



### Comment 3

It is better to add  
figure title for each figure Eg: Figure 1: [Brief Description of the figure] is  
appropriate and effectively communicates the content and purpose of the figure.

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PAGE 4



#### Comment 4

It is better to add figure title for each figure Eg: Figure 1: [Brief Description of the figure] is appropriate and effectively communicates the content and purpose of the figure

PAGE 5

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PAGE 6

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#### Comment 5

Good Work



#### Comment 6

It would have been better if oscilloscope outputs were included.

PAGE 7

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PAGE 8

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#### Comment 7

Good Work

PAGE 9

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PAGE 10

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GRADING FORM: GRADING

**BEN PALMER-DRURY**

**78**

#### ENGAGEMENT WITH LITERATURE

*Marks for engagement with literature skills will be gained through the use of information collected from appropriate reference material embedded in mainly the circuit description, but also in the testing*

*sections of your report. This reference material should be used to explain concepts and to support arguments in the discussion of your results.*



Engagement with an appropriate range of literature, including sources retrieved independently. Some over-reliance on texts rather than other sources. Referencing shows minor inaccuracies or inconsistencies. Citations and referencing require improvement.

**3**

## **KNOWLEDGE AND UNDERSTANDING**

*Marks for knowledge and understanding skills will be given for the accuracy of your description of the concepts and principles of the circuit and how this relates to the experimental setup used.*



Excellent knowledge and understanding of the basic underlying concepts and principles of electrical and Electronic systems. which is evident through the description on the experimental setups, calculations and theoretical explanation.

**25**

## **COGNITIVE AND INTELLECTUAL**

*Marks for cognitive and intellectual skills will be given for the quality and validity of your interpretation of the experimental results gathered.*



Excellent evaluation of the underlying concepts and principles of electrical and Electronic systems. Can interpret data accurately and with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements is evident from the description.

**22**

## PRACTICAL SKILLS

*Marks for practical skills will be given for your use of the available tools, models and techniques to explain your results and their relationship to the theory of the concepts.*



A very good application of a range of taught, basic methods, materials, tools and/or techniques in circuit design. The context of the application is well considered, and insightful. Excellent evidence of different approaches to problem-solving in Electrical and Electronic circuits and proposes appropriate solutions, which is evident in circuit design and the generated output.

**24**

## TRANSFERABLE SKILLS FOR LIFE

*Marks for transferable skills for life and professional practice will be given for the structure, coherence, presentation and overall quality of your report.*



The report exhibits a high level of structure and coherence. Presentation is clear, contributing to a very good overall quality. Demonstrates strong transferable skills for life and professional practice.

**4**