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The Book of 555 Timer Projects

Over 45 Builds for the Legendary 555 Chip (and the 556, 558)

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Preface

The 555 timer IC, originally introduced by the Signetics Corporation around 1971, is perhaps one of the most popular analog integrated circuits ever produced. Originally called the *IC Time Machine*, this chip has been used in many timer related and oscillator projects by countless people over decades. The chip provides a very low-cost design of monostable, astable, and bistable circuits using only a few external passive components such as resistors and a capacitor. Additional terminals are provided for external triggering or resetting the chip.

Since it became commercially available, many novel and unique commercial, industrial, and domestic circuits have been developed using this chip. The 555 timer chip was originally designed using the bipolar junction transistor technology. It is interesting to note that after about 50 years, the 555 chip is still very popular and used in many applications, although the CMOS versions seem to be more popular in portable low-power applications.

Over the years, derivations of the basic 555 timer chip has been produced. The 556 incorporates two timer circuits, while the 558 provides four of these in one package. In 2017, it was reported that over a billion 555 timer chips were produced annually. As a result of this, it is known as the most popular IC ever produced. The chip has been manufactured by many popular chip manufacturers, such as Intel, Texas Instruments, Signetics, Raytheon, STMicroelectronics, and others.

It was initially thought that the part name “555” came from the fact that there are three 5 kΩ resistors used inside the chip. It was however stated by the original manufacturers that the part number 555 was arbitrary and the fact that the chip had three 5 kΩ internal resistors was a coincidence.

This book is about the design of 555 timer IC based projects. Over 45 fully tested and documented projects are given in the book. All the projects given in the book have been tested fully by the author by constructing them individually on a small breadboard. Readers are not required to have any programming experiences for constructing or using the projects given in the book. However, it will be useful if some knowledge is available of basic electronics and the use of a breadboard for constructing and testing electronic circuits. The following subheadings are given for each project in the book:

- Title of the project
- Block diagram
- Design
- Circuit diagram
- Fritzing diagram (where possible)
- Construction details
- Testing procedure

The projects given in the book can be modified or expanded by the readers for their own applications. Electronic engineering students should find the projects useful, especially during the development of their final year projects and in their laboratory work. Additionally, people engaged in designing small electronic circuits and electronic hobbyists should find the projects fun, educational, interesting, and useful.

The author hopes that the readers find the projects in the book motivating and beneficial and hopes that they use a 555 timer IC in their future projects.

Dr Dogan Ibrahim
London, 2024

Chapter 1 • Introduction

1.1 Overview

The 555 timer IC, originally introduced by the Signetics Corporation around 1971, is sure to rank high among the most popular analog integrated circuits ever produced. Originally called the *IC Time Machine*, this chip has been used in many timer-related projects by countless people over decades. The chip provides a very low-cost design of monostable, astable, and bistable circuits using only a few external passive components such as resistors and a capacitor. Additional terminals are provided for triggering or resetting. Since it became commercially available, many novel and unique commercial, industrial, and domestic circuits have been developed using this chip. It is interesting to note that after about 50 years, the 555 chip is still very popular and used in lots of applications, although the CMOS versions seem to be more popular in portable low-power applications.

1.2 Types of 555 timer chips

As shown in Table 1.1, the 555 chip is available from many manufacturers under different type codes with prefixed letters, usually to identify the manufacturer. Although all of these chips seem to have different names, their operation is identical, while the packaging and some electrical and thermal specifications may differ slightly.

Manufacturer	Type number	Technology
Fairchild	NE555	Bipolar
Harris Semiconductor	ICM7555IPA	CMOS
Intersil	NE555 / SE555	Bipolar
National	LM555C / LM1455	Bipolar / CMOS
RCA	CA555CE	Bipolar
Texas Instruments	NE555P / NE555Y / SA555 / SE555 / SE555C	Bipolar
Texas Instruments	LMC555	CMOS
Motorola	MC1455 / MC1555	Bipolar / military
STMicroelectronics	TS555	CMOS

Table 1.1: Type 555 chips from different manufacturers.

1.3 555 timer chip specifications

This book covers the popular NE555P bipolar chip, whose specifications are given in this section for reference.

1.3.1 The NE555P chip

Please refer to the following Internet website for further information:

https://www.ti.com/product/NE555/part-details/NE555P

Features

- Timing from microseconds to hours
- Astable, monostable, or bistable operation
- Adjustable duty cycle
- Output can sink or source large currents
- Excellent temperature stability
- 8-pin package

Specifications

The basic specifications of the NE555P timer chip are:

- Operating voltage: 4.5 V to 16 V
- Output TTL compatible with 5 V supply voltage
- Supply current: typical 3 mA at 5V
- Output can sink or source 200 mA at 15 V supply
- Monostable accuracy: 1%
- Monostable drift with temperature: 50 ppm/ºC
- Astable accuracy: 2.25%
- Astable drift with temperature: 150 ppm/ºC
- Reset voltage: 1 V maximum
- Trigger voltage: 1.67 V typical at 5 V supply voltage
- Output low voltage: 200 mV maximum at 4.5 V supply, 180 mV at 15 V supply voltage
- Output high voltage: [supply voltage – 2.5 V] at 200 mA sink current and 15 V supply voltage; [supply voltage – 0.25 V] at 5 mA sink current and 5 V supply voltage.

Pinout

The 555 chip usually comes in an 8-pin plastic DIP (Dual-In-Line Package). Depending on the manufacturer, it consists of 23 transistors, 2 diodes, and 16 resistors. A 14-pin dual version of the chip aptly named “556” is also available that combines two 555s on a single chip. Figure 1.1 shows the internal structure of the 555 chip. The pinout is shown in Figure 1.2.

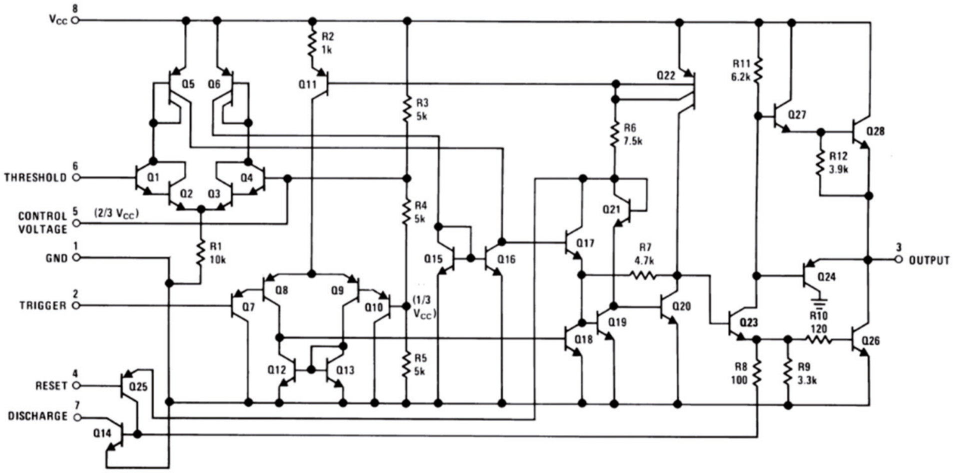

Figure 1.1: Internal structure of the NE555P timer chip.

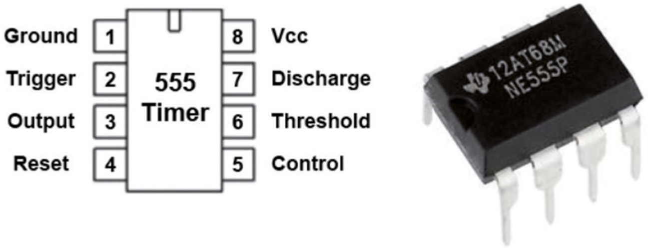

Figure 1.2: NE555P timer chip pinout.

The pins names are:

Pin	**Name**	**Function**
1	GND	Input
2	Trigger	Input
3	Output	Output
4	Reset	Input
5	Control	Input
6	Threshold	Input
7	Discharge	Input
8	VCC	Input

Chapter 2 • Operation of the 555 Timer Chip

2.1 Block Diagram

In order to understand the operation of the 555 timer chip, it is necessary to analyze its block diagram as shown in Figure 2.1.

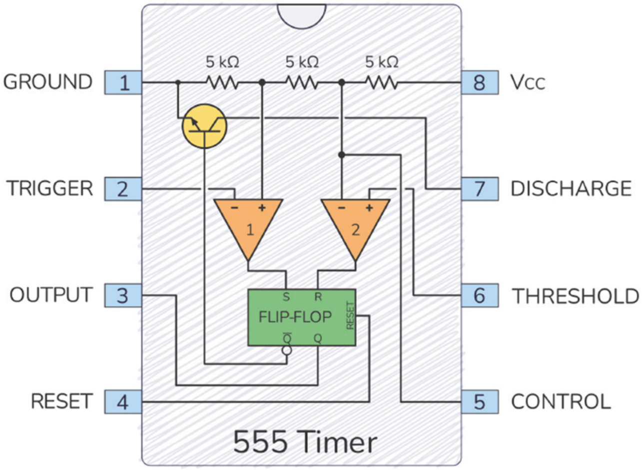

Figure 2.1: 555 timer chip internal block diagram. Source: build-electronic-circuits.com

The block diagram consists of two comparator circuits, an SR flip flop, a transistor, and three resistors.

2.2 Astable Circuit Operation

An astable circuit outputs squarewave signals at the frequency set by external two resistors and a capacitor. Perhaps the easiest way to understand the operation of an astable circuit is to insert the external components into Figure 2.1 and then analyze the circuit.

Figure 2.2 shows an astable circuit. Because of the three identical resistors, the voltage at the positive input of comparator 1 is at 1/3 Vcc, and the voltage at the negative input of comparator 2 is at 2/3 Vcc. When power is applied to the circuit, the capacitor is discharged and because the output of comparator 1 is positive, the flip-flop sets and its Q output (pin 3) goes High. The capacitor charges through resistors R1+R2 and the voltage across it increases. When it reaches 2/3 Vcc, the output of comparator 2 goes positive and resets the flip-flop. As a result, the output voltage at Q goes Low. This turns On the transistor and the capacitor discharges through R2. As soon as the voltage across the capacitor falls to 1/3 Vcc, comparator 1 is triggered. This again causes the flip-flop to set and the output goes High. The transistor cuts off and the cycle repeats with the capacitor charging through R1+R2. As a result, a squarewave voltage is output from the circuit.

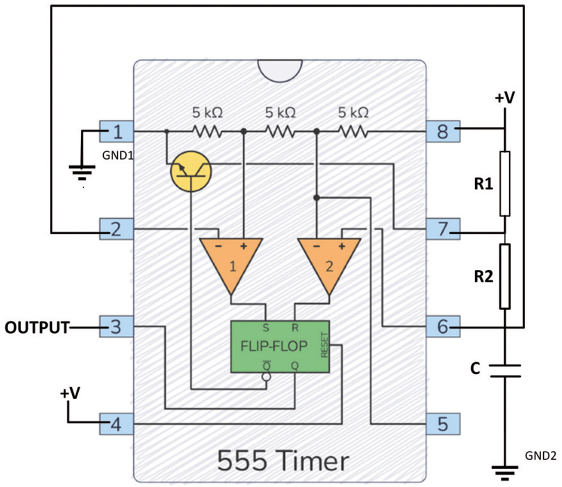

Figure 2.2: Basic astable circuit.

Figure 2.3 shows the output waveforms and the voltage across the capacitor which sets and resets the flip-flop.

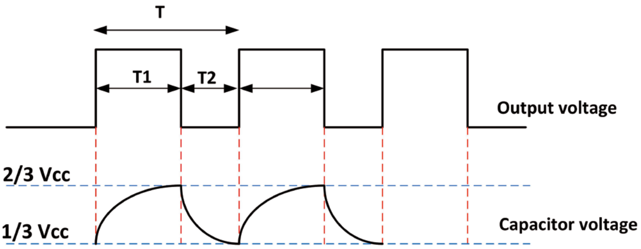

Figure 2.3: Output voltage and voltage across the capacitor.

The period (and hence the frequency) of the output voltage can be calculated as follows. Assuming zero initial conditions, the voltage across a capacitor in an RC circuit rises exponentially, given by the equation:

$$Vc = Vcc\left(1 - e^{-t/CR}\right)$$

Where V_c is the voltage across the capacitor and V_{cc} is the applied voltage. *CR* is known as the time constant of the circuit, and *t* is the time. However, in our astable circuit the initial voltage across the capacitor is not zero, but it is 1/3 Vcc. The equation describing the voltage across the capacitor with non-zero initial condition is given by:

$$Vc = Vcc\left(1 - e^{-t/CR}\right) + Voe^{-t/CR}$$

Where V_o is the initial voltage across the capacitor. In our astable circuit, the voltage rises from 1/3 Vcc to 2/3 Vcc. The equation for the voltage across the capacitor then reduces to: