The Fundamentals of 555 Timers

An Explanation and Practical Applications
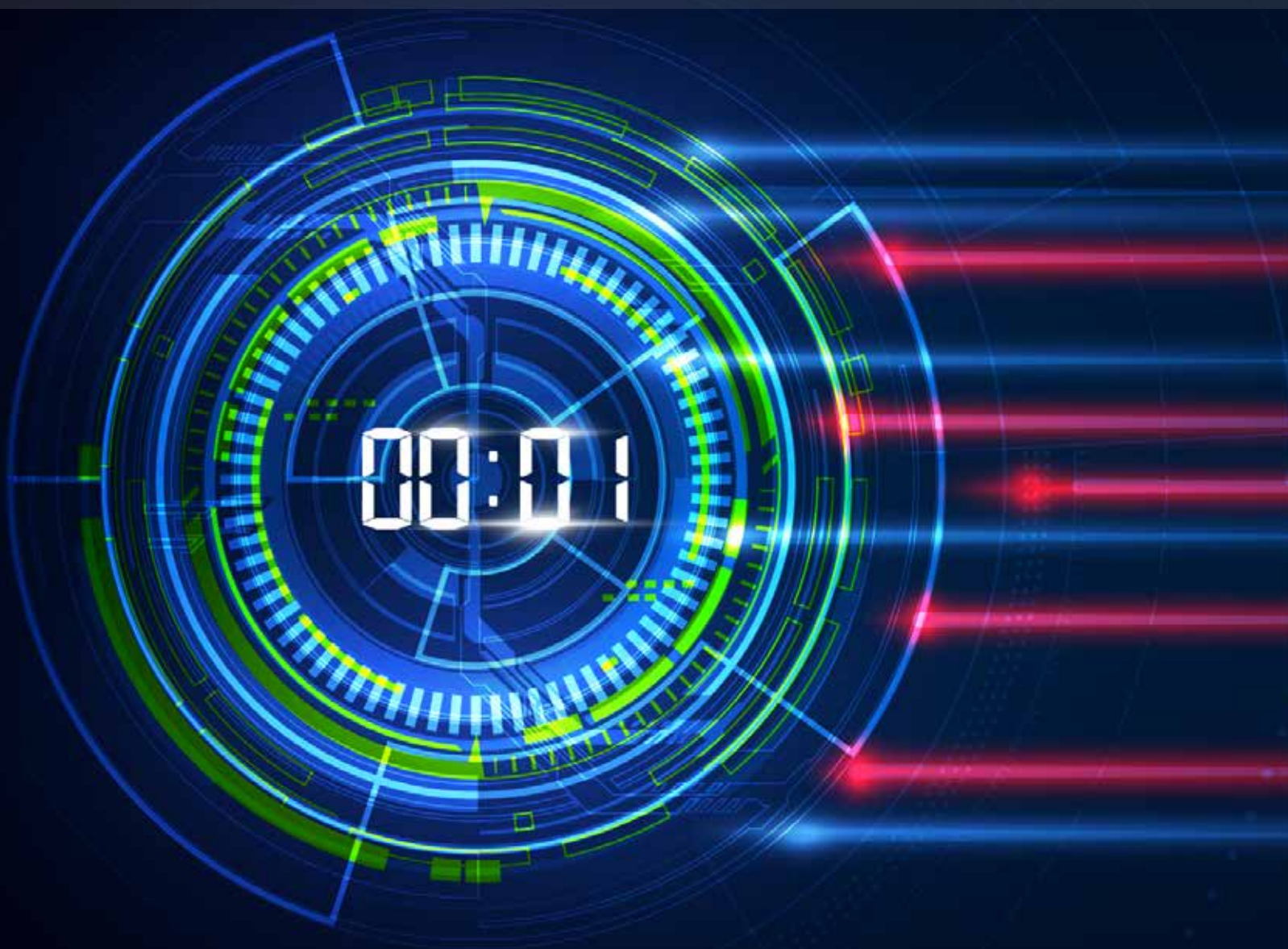
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555 timers are all around us. Since their invention in the 1970s, they've made their way into billions of electronic devices, from DIY hobbyist projects to sophisticated lab equipment. In this eBook, we will discuss the history of 555 timers, how they function, their internal circuitry, and more.

element14 Community Team

(Image source: Flickr)

555 timers are everywhere in the world of electronics. Billions of them have been made, and they are still being manufactured. They can be used in flashing lights or beeping prank devices, security trip alarms, making the Knight Rider sweeping light, music synthesizers, and even traffic light control systems. All of these are demonstrated in my tutorial book, "Essential 555 IC: Design, Configure, and Create Clever Circuits." Make those projects in the book, and you'll have a grasp of just how versatile that integrated circuit can be. But first, let's go over the very basics of the 555 timer IC.

A 555 timer IC or 555 oscillator is a cheap and helpful precision timing device that can act as a simple timer to generate single pulses or long-time delays, or as a relaxation oscillator producing a string of stabilized string waveforms of varying duty cycles, ranging from 50 to 100%. The timer is so named because it packs a trio of internally connected 5 kΩ resistors to generate two comparative reference voltages. It's also an incredibly robust 8-pin chip that can act as a

monostable, bistable, or astable (the output voltage rises and falls in a stable pattern) multivibrator, making it suitable for a myriad of applications, including delay timers, pulse generators, LED and lamp flashers, alarms, tone generators, logic clocks, frequency division, power supplies, and more.

The 555 timer hasn't changed much since its inception in 1971. The first prototypes were released as the NE555V (plastic DIP) and SE555T (metal TO-5), which were differentiated by a dual in-line package and a metal-semiconductor package, respectively. By 1972, the timer was being produced by 12 companies and quickly became a best-selling product for electronics manufacturers. There are two different types of 555 timers, both being eight-pin chips. The most common offers a rectangular 'V' package, denoted by four pins placed down each side. The other version, which was previously the most common but has now fallen from favor somewhat, is the circular 'T' package that looks similar to a capacitor.

To better understand how a 555 timer works, let's take a look at its internal circuitry and pin assignments, as outlined in the figure to the right. Watch the video on *How 555 Timers Work* for more in-depth information, complete with working circuit examples.

Pin 1 – Ground The ground pin connects the timer to the negative (0 V) supply rail.

Pin 2 – Trigger This functions like a starter's pistol to start the 555 timer running. The trigger is an active low trigger, meaning the timer starts when the voltage on pin 2 drops to below 1/3 of the supply voltage. When the 555 is triggered via pin 2, the output on pin 3 goes high.

Pin 3 – Output The output is either low, which is very close to 0 V, or high, which is close to the supply voltage placed on pin 8. The exact shape of the output (how long it's high and low) depends on the connections to the remaining five pins. By itself, the pin can drive small speakers, LEDs, or motors.

Pin 4 – Reset As its name implies, this pin is used to reset the 555's timing operation. As with the trigger input, reset is an active low input, meaning pin 4 must be connected to the supply voltage for the timer to operate. If pin 4 is momentarily grounded, the timer's operation is interrupted and won't start again until it's triggered via pin 2.

Pin 5 – Control Voltage This pin controls the timing of the 555 by overriding the level of the voltage divider network within the circuit. When not in use, it
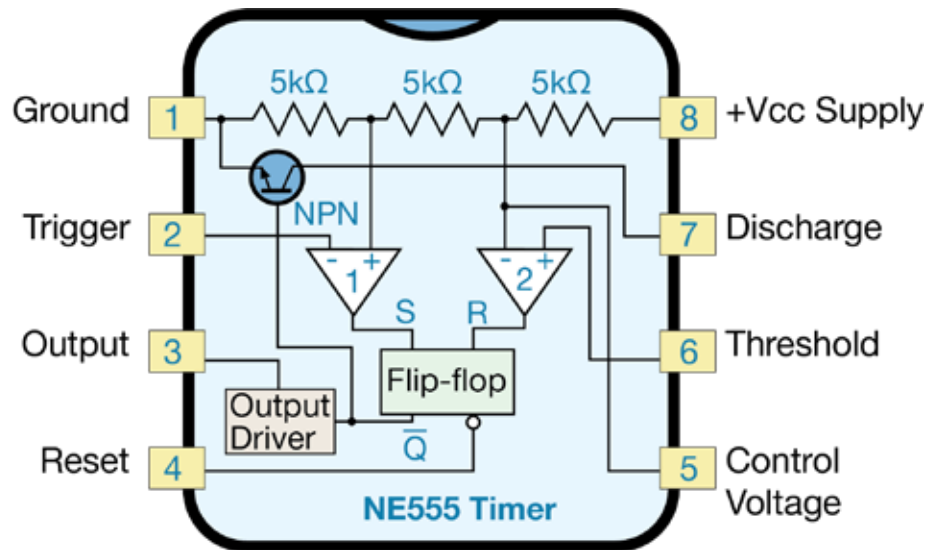
NE555 timer block diagram detailing the internal circuitry and pin assignments. (Image source: Radinpirouz)

is connected to Ground via a small 0.01 µF capacitor, which is used to level out any fluctuations in the supply voltage that could negatively affect the operation of the timer.

Pin 6 – Threshold This pin is used to monitor the voltage across the capacitor that's discharged by pin 7. When the voltage reaches 2/3 of the supply voltage (Vcc), the timing cycle ends, and the output on pin 3 drops low.

Pin 7 – Discharge This pin is used to discharge an external capacitor that works in conjunction with a resistor to control the timing interval. In most common circuits, pin 7 is connected to the supply voltage through a resistor and to ground through a capacitor.

Pin 8 – +Vcc Supply This is the power supply pin, which for general purpose 555 timers is between 4.5 V and 15 V.

Next, let's take a look at the 555 timer's internal circuitry denoted in the block diagram schematic. In the middle are a pair of comparators which are indicated by their upside-down triangle symbols. These are used to compare two voltages or currents, and they output a digital signal indicating which is larger. There is also a flip-flop, symbolized by a rectangle, which is a circuit that has two stable states and can be used to store information. The timer also packs a voltage divider, a discharge transistor, and an output stage.

The voltage divider features three 5 kΩ resistors connected together. It provides reference voltages at 1/3 and 2/3 of the supplied voltage, which can range from 5 to 15 V.

This is where those comparators come into play, as they compare two analog input voltages at their positive (non-inverting) and negative (inverting) input terminal. So, for example, if the input voltage at the positive terminal is higher than the input voltage at the negative terminal, the comparator will output 1. Conversely, if the voltage at the negative input terminal is higher than that at the positive terminal, the comparator will output 0.

The first comparator negative input terminal is connected to the 2/3 reference voltage at the voltage divider and the external "control" pin (Pin 5), while the positive input terminal is connected to the external "Threshold" pin (Pin 6). Moreover, the second comparator negative input terminal is connected to the "Trigger" pin (Pin 2), while the positive input terminal is connected to the 1/3 reference voltage at the voltage divider.

By using those three pins, we can control the output of the two comparators, which is then piped to the R and S inputs of the flip-flop. The flip-flop will then output 1 when R is 0 and S is 1, and, inversely, it will output 0 when R is 1 and S is 0. What's more, the flip-flop can be reset via the Reset pin (Pin 4), which can then override the two inputs, resetting the entire timer at any time.

The Q-bar output of the flip-flop (denoted below the flip-flop symbol) goes to the output stage or the output drivers, allowing it to either source or sink a current of 200 mA to the load. The output of the flip-flop is also connected to a transistor that connects the Discharge pin (Pin 7) to the Ground.

CHAPTER - 3 — 555 Timer Modes

Monostable Mode

When the 555 timer is set to monostable mode, it outputs a single pulse. The duration of the pulse can be adjusted by a resistor and capacitor connected to the timer; larger resistors or capacitors increase the duration, while smaller ones decrease it. An example of the 555 timer in monostable mode would be pressing a button and illuminating an LED, which would turn off after a preset time.

Bistable Mode

In bistable mode, the pulse from the 555 timer can be manually turned on and off. The OFF state is triggered by sending a signal to Pin 2 (trigger), while the OFF state is triggered by sending a signal to Pin 4. No time circuits are necessary because ON and OFF states are manually triggered. In the LED and button example, the button would be connected to both pins 2 and 4. Pushing the button would turn the LED on and pushing it again would turn it off.

Astable Mode

In astable mode, the 555 timer acts as an oscillator, generating a square wave. The frequency is adjusted by changing the values of two resistors and a capacitor, ranging from a low of 500 kHz to a maximum of 2 MHz. An LED connected to a 555 timer in astable mode would flash on and off. A potentiometer could be added to allow the speed of the flashing to be adjusted.

555 timers can be found in a myriad of different electronics, including traffic lights and crosswalk signs.
(Image source: Pexels)

As mentioned earlier, 555 timers can often be found in everyday electronics devices, including traffic signals, home automation systems, vehicles, and more. Scientists and engineers are no strangers to the timer and its applications, and 555 timers can be found in a variety of lab equipment, including DC-DC converters and digital logic probes, waveform generators, analog frequency meters, and tachometers.

They are also used for debounce switches, PWM (Pulse Width Modulation) and PPM (Pulse Position Modulation) circuits, and devices that require accurate clock signals. You'll also find them in motion detectors, sound-operated timers, PWM audio amplifiers, and linear and touch-free timers.

It has been 50 years since 555 timers hit the market, and while they have evolved to produce dual and quad timers, their CMOS and Bipolar processes have remained relatively unchanged. That said, they are still used in next-gen technology, and it will be interesting to see what the next 50 years will bring for 555 timer innovation.
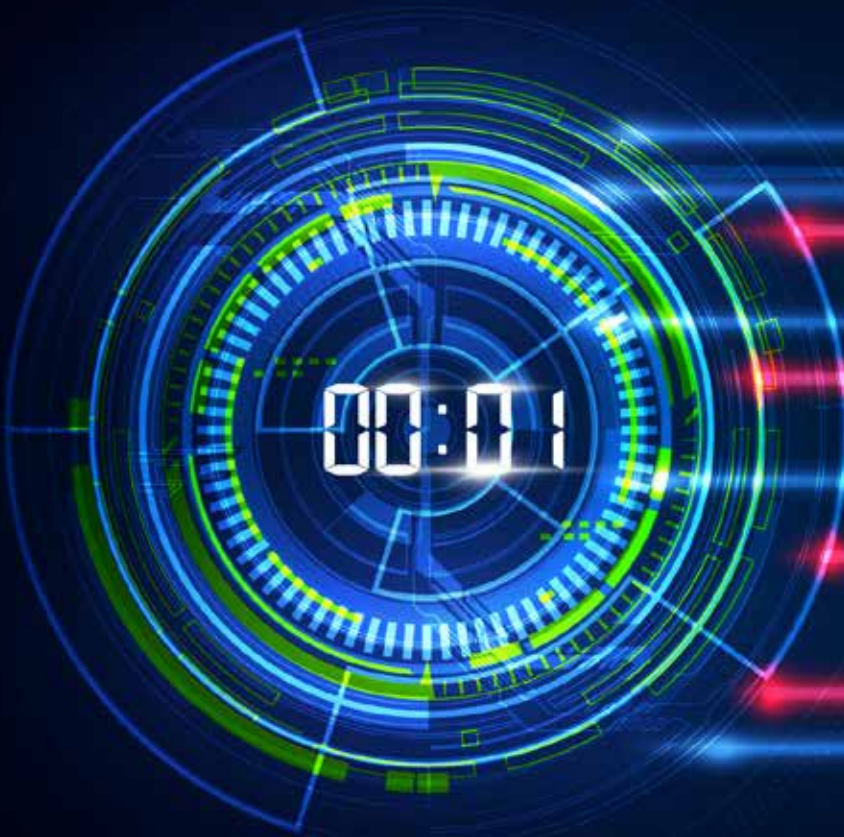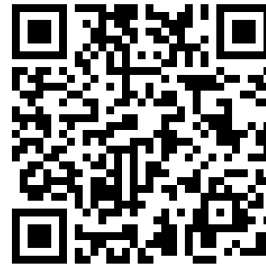
Reference: **Essential 555 IC: Design, Configure, and Create Clever Circuits, 1st Edition**
        by Cabe Force Satalic Atwell

For more information, check out our dedicated

[web page for 555 timers](#) on the element14 community.

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