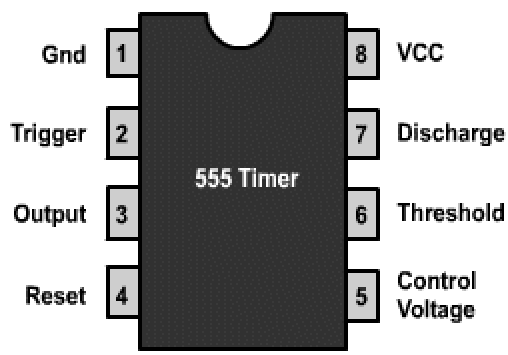
Lesson 3: The 555 Timer Chip

Movement of information inside a computer (or any electronic device) must be timed. A "timer" is an electronic device that controls when basic operations - such as the movement of data, and the calculations involving data - will take place, and how much time is allotted for each event.

The 555 timer chip is an IC chip that provides a basic timing mechanism that can be used in simple circuits. Whenever you see a flashing light on any electronic appliance or toy, it is probably due to the presence of a 555 timer chip. Inside the chip, there are 25 transistors, 16 resistors and 2 diodes, which allows the chip to vary it's functionality depending on the application.

The pin layout of the 555 timer chip is as follows:



The chip can operate in one of two modes, depending on how the pins are connected.

Monostable Mode

In monostable mode, the output is normally low. When triggering "event" occurs, it causes the output to go high for a certain amount of time (which is controlled by attaching a certain resistor / capacitor combination). When the time elapses, the output returns to it's original (low) state.

For example, a motion detector may cause a security light to stay on for 30 seconds when motion is detected. After 30 seconds, the light goes off.

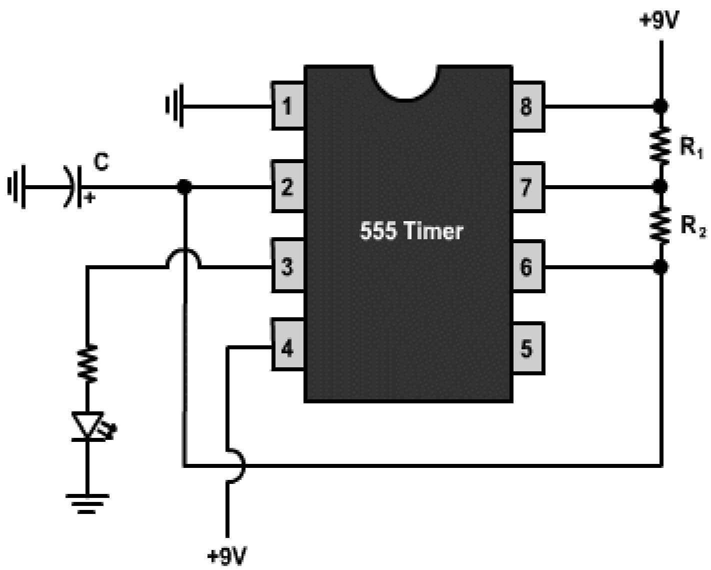
Astable Mode

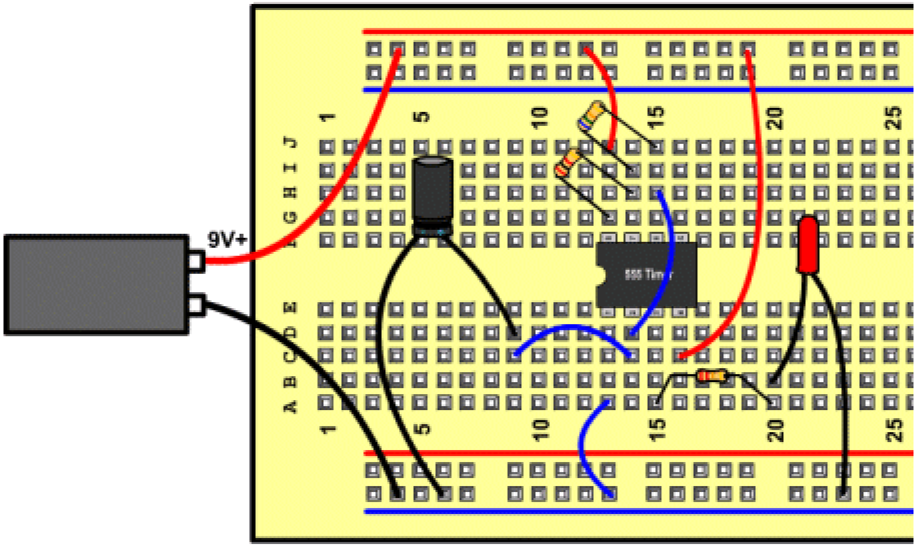
In astable mode, the output constantly switches between high and low. A blinking light on an electronic device is an example of astable mode. If the chip is attached to a speaker, then a continuous tone can be generated if there is a high rate of change (frequency) between high and low output.

To set up the 555 timer chip for astable mode,

- connect pins 4 (reset) and 8 to a 5V power source.
- connect pin 1 to ground.
- connect pin 3 to an output source (eg, to an LED through a 220Ω resistor).
- connect pin 7 to pin 8 through a resistor (R_1).
- connect pin 7 to pins 6 and 2 through a second resistor (R_2).
- connect pins 6 and 2 to the positive side of a capacitor (connect the negative end of the capacitor to ground).

This configuration can be shown by the following circuit diagram, and the actual breadboard wiring, as follows:





The capacitor charges through both resistors (R_1 and R_2) and discharges through R_2 only. Therefore, if you want the on / off frequencies to be about the same, then a relatively small value for R_2 (typically 1KΩ - 2KΩ) is used. The value of resistor R_2 will determine the overall frequency of the timer. The timer frequency will decrease (get slower) as R_2 increases ... therefore, if the timer output is an LED, a 65KΩ resistor will cause the LED to blink on and off about five times per second, whereas a 330KΩ resistor will decrease the blinking rate to about once per second.

The capacitor is what actually causes the oscillation in the output state. Remember that a capacitor "charges" when voltage is applied, and "discharges" when voltage is removed. When the charging capacitor reaches a certain voltage (about 2/3 Vcc), it is detected by pin 6 (threshold). This causes 0V to be sent to pin 3 (output - causing the LED to turn off) and pin 7 (discharge - which cuts off the voltage to the capacitor, causing it to discharge). When a discharging capacitor reaches a certain voltage (about 1/3 Vcc), it is detected by pin 2 (trigger). This causes 9V to be sent to pin 3 (output - causing the LED to turn on) and pin 7 (discharge - which again supplies voltage to the capacitor, causing it to charge). This process repeats indefinitely.

The relationship between the resistor and capacitor values and the timer frequency is given by the following formula:

$$F = 0.693 \times (R_1 + 2R_2) \times C$$

For example, if the circuit uses R_1 = 2KΩ, R_2 = 65KΩ and C = 2.2μF, then the timer frequency will be

$$F = 0.693 \times (2000 + 2(65{,}000)) \times 0.0000022 = 0.2012$$ *(about 5 times per second)*

If the value of R_2 is increased to 330KΩ, then the timer frequency changes to

F = 0.693 x (2000 + 2(330,000)) x 0.0000022 = 1.0093 (about once per second)