IC555 as Monostable multivibrator

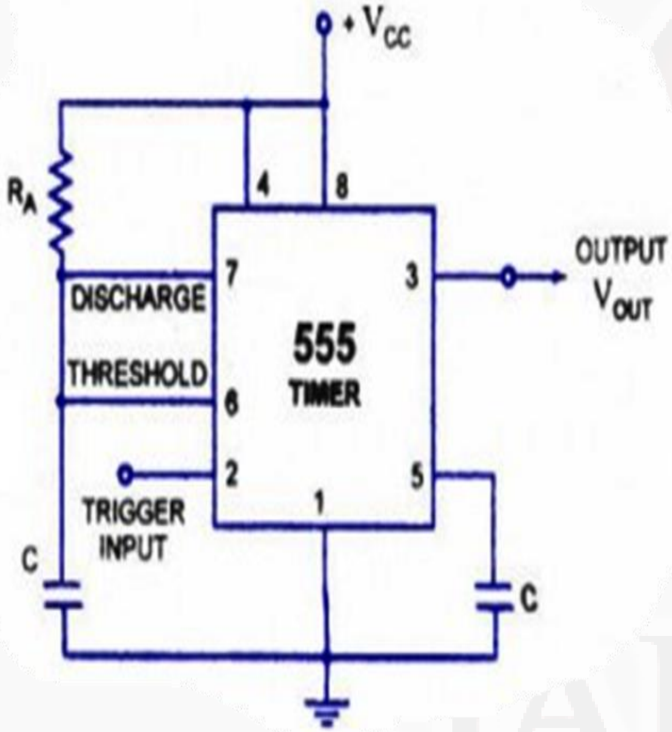
Contents:

Introduction

- A monostable multivibrator (MMV) often called a one-shot multivibrator, is a pulse generator circuit in which the duration of the pulse is determined by the R-C network connected externally to the 555 timer.
- In such a vibrator, one state of output is stable while the other is quasi-stable (unstable).
- For auto-triggering of output from quasi-stable state to stable state energy is stored by an externally connected capacitor C to a reference level.
- The time taken in storage determines the pulse width.
- The transition of output from stable state to quasi-stable state is accomplished by external triggering.

Circuit diagram

Figure shows an monostable circuit built using an external resistor and capacitor to set the timing interval of the output signal.



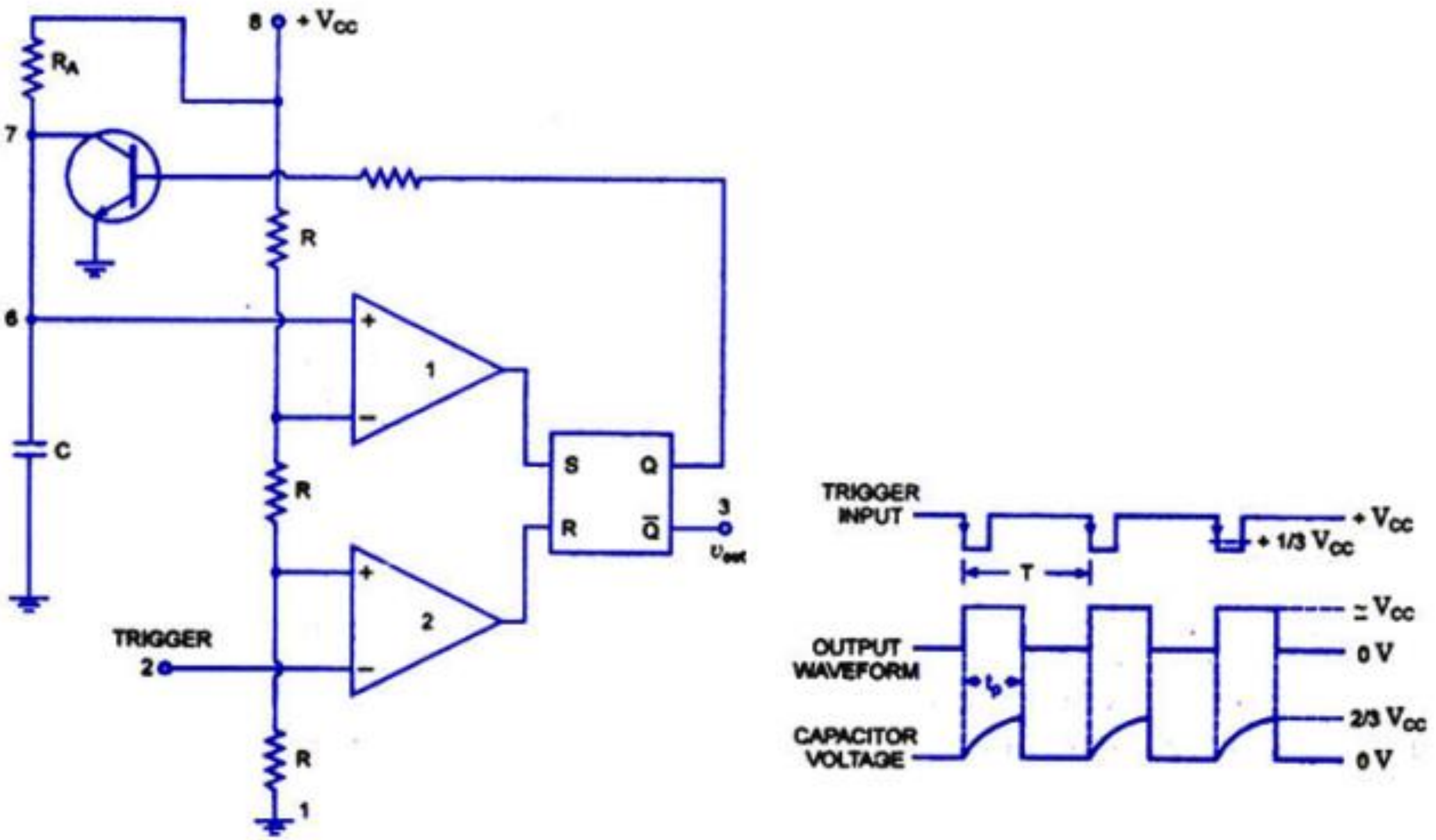
Pin 1 is grounded. Trigger input is applied to pin 2. In quiescent condition of output this input is kept at + V_{cc}.

To obtain transition of output from stable state to quasi-stable state, a negative-going pulse of narrow width (a width smaller than expected pulse width of output waveform) and amplitude of greater than + 2/3 V_{cc} is applied to pin 2.

Output is taken from pin 3. Pin 4 is usually connected to + V_{cc} to avoid accidental reset.

Pin 5 is grounded through a 0.01 u F capacitor to avoid noise problem. Pin 6 (threshold) is shorted to pin 7. A resistor RA is connected between pins 6 and 8. At pins 7 a discharge capacitor is connected while pin 8 is connected to supply *VCC*.

Circuit diagram



Internal Circuitry With External Connections

Trigger Input, Output and Capacitor Voltage Waveforms

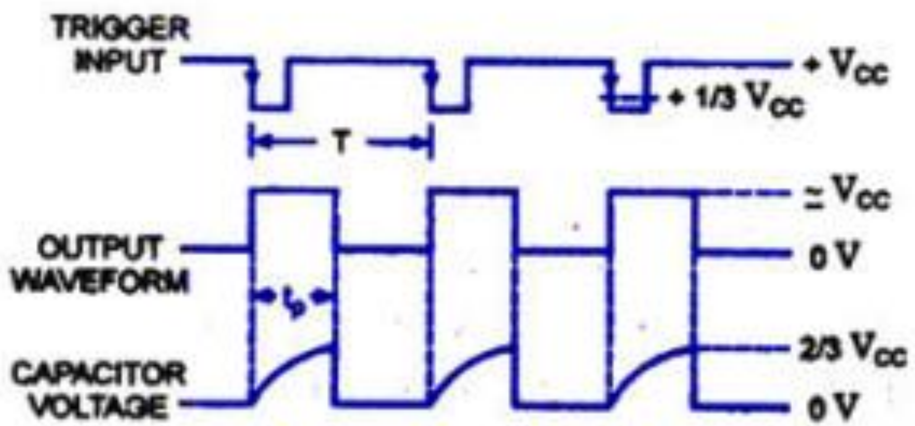
Monostable Operation

Working of Monostable multivibrator :

Initially, when the output at pin 3 is low i.e. the circuit is in a stable state, the transistor is on and capacitor C is shorted to ground.
When a negative pulse is applied to pin 2, the trigger input falls below +1/3 V_{CC}, the output of comparator 2 goes high which resets the flip-flop and consequently the transistor turns off and the output at pin 3 goes high.
This is the transition of the output from stable to quasi-stable state, as shown in figure.
As the discharge transistor is cutoff, the capacitor C begins charging toward +VCC through resistance R_A with a time constant equal to $R_A C$. When the increasing capacitor voltage becomes slightly greater than +2/3 V_{CC}, the output of comparator 1 goes high, which sets the flip-flop. The transistor goes to saturation, thereby discharging the capacitor C and the output of the timer goes low, as illustrated in figure.
The output of the Monostable Multivibrator remains low until a trigger pulse is again applied. Then the cycle repeats.

Working of Monostable multivibrator :

Trigger input, output voltage and capacitor voltage waveforms are shown in figure.



Trigger Input, Output and Capacitor Voltage Waveforms

Working of Monostable multivibrator :

The capacitor C has to charge through resistance R_A. The larger the time constant R_AC, the longer it takes for the capacitor voltage to reach $+2/3V_{cc}$.

In other words, the RC time constant controls the width of the output pulse. The time during which the timer output remains high is given as: $T_P = 1.0986\ R_AC$

where R_A is in ohms and C is in farads.

The above relation is derived as below. Voltage across the capacitor at any instant during charging period is given as: $V_c = V_{cc}(1 - exp(-t/R_AC))$

Substituting Vc = $2/3\ V_{cc}$ in above equation we get the time taken by the capacitor to charge from 0 to $+2/3V_{cc}$.

i.e. $+2/3V_{CC}. = V_{CC}.\ (1 - exp.^{-t/R_AC})$ or

$t = R_AC\ log_e3 = 1.0986\ R_AC$

So pulse width, $T_P = 1.0986\ R_AC = 1.1\ R_AC$.

The pulse width of the circuit may range from micro-seconds to many seconds. This circuit is widely used in industry for many different timing applications.

Application of Monostable multivibrator

Frequency divider

It can be used as a frequency divider by adjusting the length of timing signal T_P with respect to the time period T of the trigger input signal applied to pin 2.

eg. To use as monostable multivibrator as a divider-by-2 circuit, the timing interval T_P must be slightly larger than the time period T of the trigger input signal. -similarly, to use the monostable multivibrator as a divider-by-3 circuit, T_P must be slightly larger than twice the period of input trigger signal.

Pulse stretcher

The output pulse width (timing interval) of the monostable multivibrator is of longer duration than the negative pulse width of input trigger. Output pulse width of monostable multivibrator can be viewed as the stretched version of the narrow input pulse. Narrow pulse widths are not suitable for driving LED display (because its on time is infinitesimally small compared to off time. IC 555 pulse stretcher can be used toremedy this problem.

References:

- Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
- Digital Fundamentals, Thomas L. Floyd, 11th Ed., 2015, Pearson Education Limited
- Modern Digital Electronics, R P Jain, 4th Ed., 2010, Tata McGraw Hill