Al-Mustaqbal University
Department of Medical Instrumentation Techniques Engineering
Class: four
Subject: Advanced logic design
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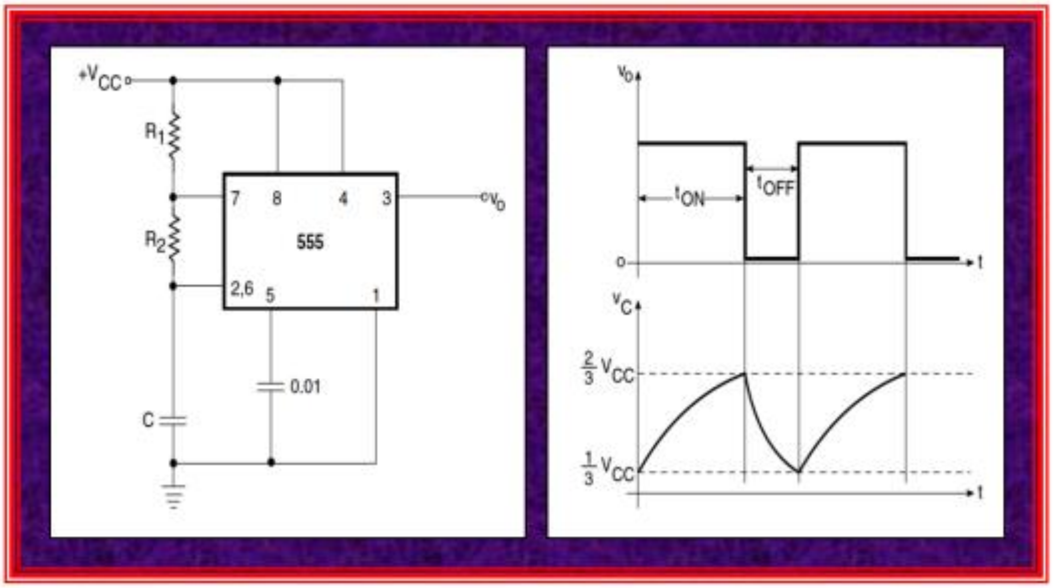
Second term / Lec.-8: Astable Multivibrators

Astable Multivibrators



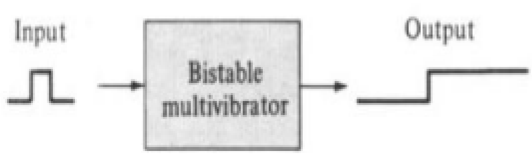
1-Multivibrator

Multivibrators, like the familiar sinusoidal oscillators, are circuits with regenerative feedback, with the difference that they produce pulsed output. There are three basic types of multivibrator, namely

as:-

a-Bistable multivibrator.

A bistable multivibrator circuit is one in which both LOW and HIGH output states are stable.



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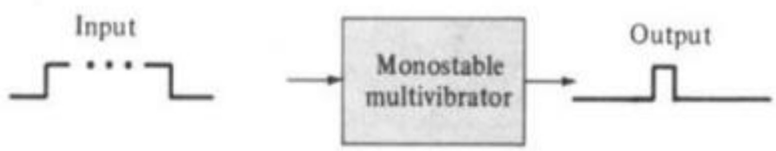
b- Monostable multivibrator.

A monostable multivibrator, also known as a monoshot, is one in which one of the states is stable and the other is quasi-stable. The circuit is initially in the stable state. It goes to the quasi-stable state when appropriately triggered. It stays in the quasi-stable state for a certain time period, after which it comes back to the stable state.



c-Astable multivibrator.

In the case of an astable multivibrator, neither of the two states is stable. Both output states are quasistable.

The output switches from one state to the other and the circuit functions like a freerunning square-wave oscillator Figure (1) shows the basic astable multivibrator circuit. It can be proved that, in this type of circuit, neither of the output states is stable. Both states, LOW as well as HIGH, are quasi-stable. The time periods for which the output remains LOW and HIGH depends upon R2C2 and R1C1 time constants respectively. For R1C1 = R2C2, the output is a symmetrical square waveform.The circuit functions as follows. Let us assume that transistor Q2 is initially conducting, that is, the output is LOW. Capacitor C2 in this case charges through R2 and the conducting transistor from VCC, and, the moment the Q1 base potential exceeds its cut in voltage, it is turned ON. A fall in Q1 collector potential manifests itself at the Q2 base as voltage across a capacitor cannot change instantaneously. The output goes to the HIGH state as Q2 is driven to cut-off. However, C1 has now started charging through R1 and the conducting transistor Q1 from VCC. The moment the Q2 base potential exceeds the cut-in voltage, it is again turned ON, with the result that the output goes to the LOW state. This process continues and, owing to both the couplings (Q1 collector to Q2 base and Q2 collector to Q1 base) being capacitive, neither of the states is stable. The circuit produces a squarewave output.

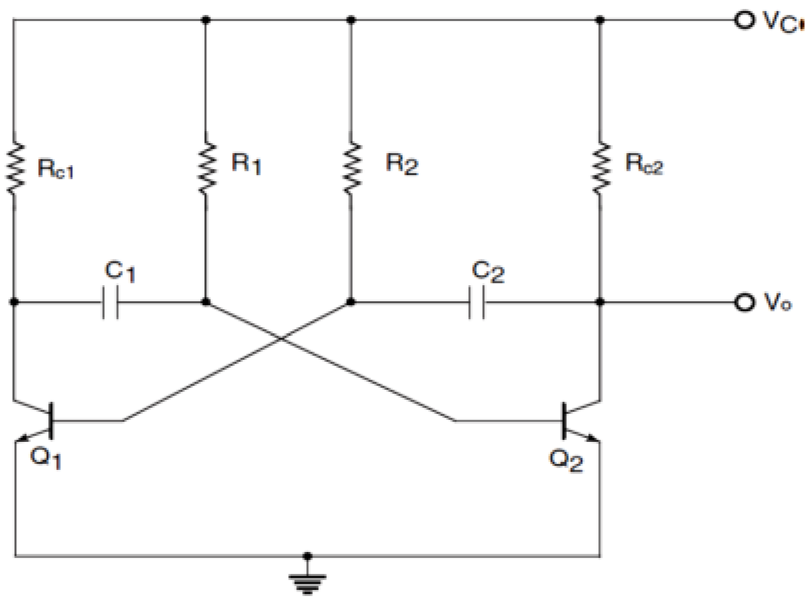


Fig.1. Astable multivibrator.

2-IC Timer-Based Multivibrators

IC timer 555 is one of the most commonly used general-purpose linear integrated circuits. The simplicity with which monostable and astable multivibrator circuits can be configured around this IC is one of the main reasons for its wide use.

Figure (2) shows the internal schematic of timer IC 555. It comprises two op-amp comparators, a flip-flop, a discharge transistor, three identical resistors and an output stage. The resistors set the reference voltage levels at the non-inverting input of the lower comparator and the inverting input of the upper comparator at (+VCC/3) and (+2VCC/3). The outputs of the two comparators feed the SET and RESET inputs of the flip-flop and thus decide the logic status of its output and subsequently the final output. The flip-flop complementary outputs feed the output stage and the base of the discharge transistor. This ensures that when the output is HIGH the discharge transistor is OFF, and when the output is LOW the discharge transistor is ON.

Different terminals of timer 555 are designated as ground (terminal 1), trigger (terminal 2), output (terminal 3), reset (terminal 4), control (terminal 5), threshold (terminal 6), discharge (terminal 7) and +VCC (terminal 8). With this background, we will now describe the astable circuits configured around timer 555.

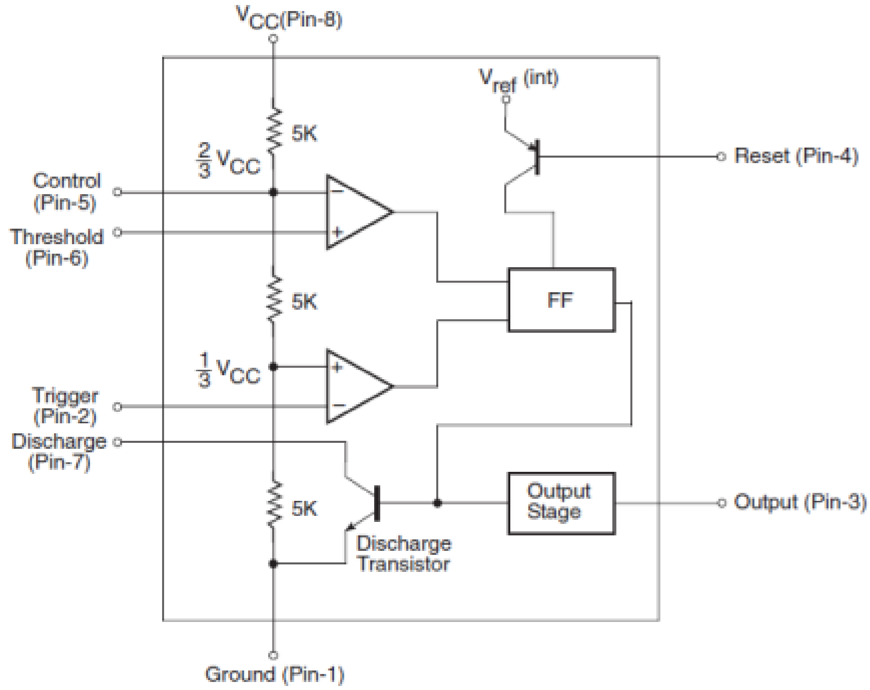


Fig.2. Internal schematic of timer IC 555.

3-Astable Multivibrator Using Timer IC 555

Figure(3-a) shows the basic 555 timer based astable multivibrator circuit. Initially, capacitor C is fully discharged, which forces the output to go to the HIGH state. An open discharge transistor allows the capacitor C to charge from +VCC through R1 and R2. When the voltage across C exceeds 2VCC/3, the output goes to the LOW state and the discharge transistor is switched ON at the same time.

Capacitor C begins to discharge through R2 and the discharge transistor inside the IC. When the voltage across C falls below +VCC/3, the output goes back to the HIGH state. The charge and discharge cycles repeat and the circuit behaves like a free-running multivibrator. Terminal 4 of the IC is the RESET terminal. usually, it is connected to

+VCC. If the voltage at this terminal is driven below 0.4 V, the output is forced to the LOW state, overriding command pulses at terminal 2 of the IC. The HIGH-state and LOW-state time periods are governed by the charge (+VCC/3 to +2VCC/3) and discharge (+2VCC/3 to +VCC/3) timings. These are given by the equations:-

$$\text{HIGH-state time period } T_{\text{HIGH}} = 0.69(R_1 + R_2).C \qquad (1)$$

$$\text{LOW-state time period } T_{\text{LOW}} = 0.69R_2.C \qquad (2)$$

The relevant waveforms are shown in Fig. (3-b). The time period T and frequency f of the output waveform are respectively given by the equations:-

$$\text{Time period } T = 0.69(R_1 + 2R_2).C \qquad (3)$$

$$\text{Frequency } F = 1/[0.69(R_1 + 2R_2).C] \qquad (4)$$

Remember that, when the astable multivibrator is powered, the first-cycle HIGH-state time period is about 30% longer, as the capacitor is initially discharged and it charges from 0 (rather than +VCC/3) to +2VCC/3. In the case of the astable multivibrator circuit in Fig. 3(a), the HIGH-state time period is always greater than the LOW-state time period.

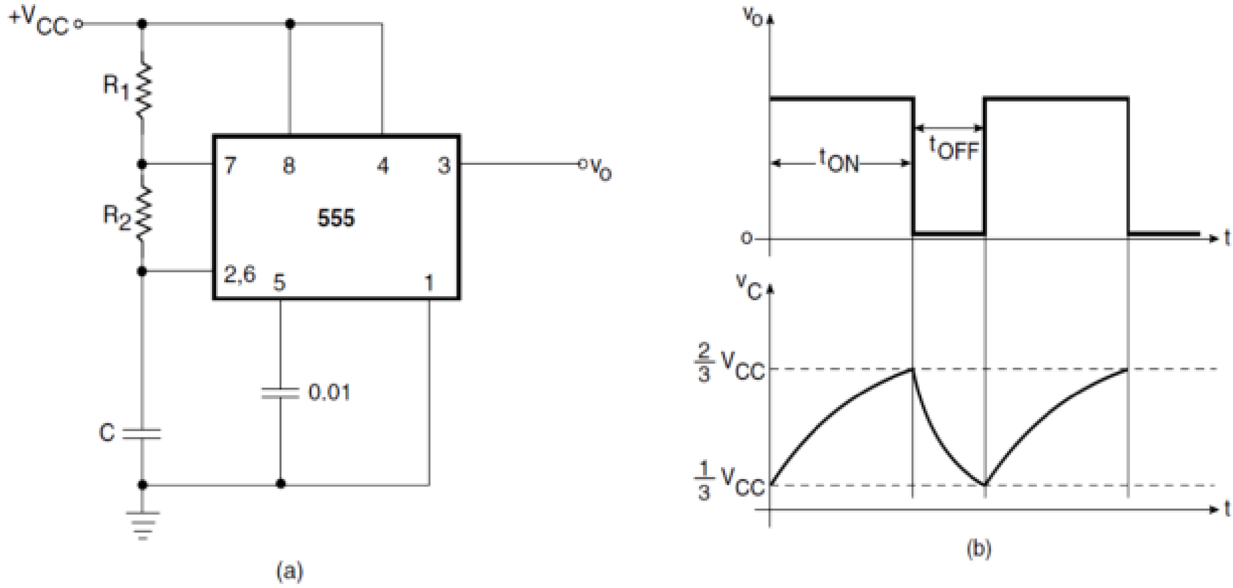


Fig.3.(a) Astable multivibrator using timer IC 555, (b) astable multivibrator relevant waveforms.

Figures 4(a) and (b) show two modified circuits where the HIGH-state and LOW-state time periods can be chosen independently. For the astable multivibrator circuits in Fig.4(a) and (b), the two time periods are given by the equations:-

$$\text{HIGH-state time period} = 0.69R_1.C \quad (5)$$

$$\text{LOW-state time period} = 0.69R_2.C \quad (6)$$

For $R_1 = R_2 = R$

$$T = 1.38RC \text{ and } f = 1/1.38RC \quad (7)$$

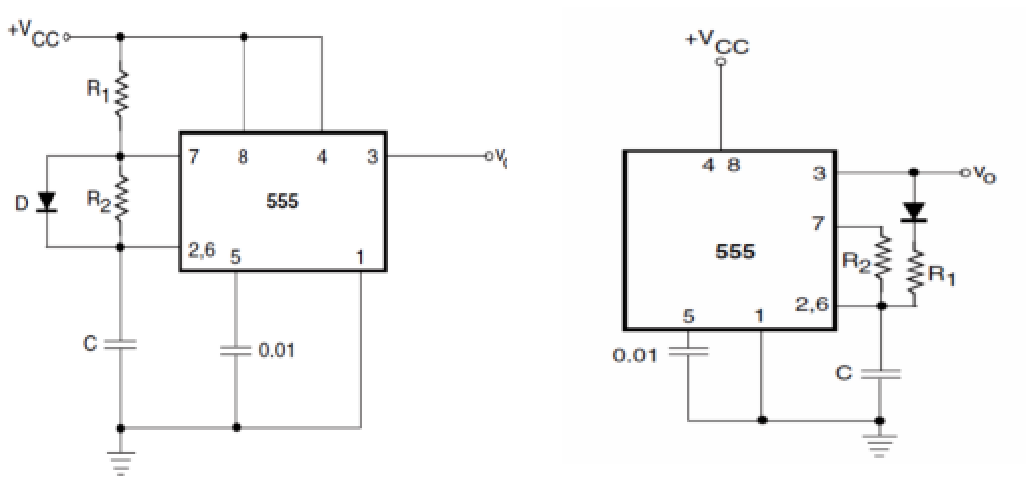


Fig.4. modified circuits of Astable multivibrator using timer IC 555.

1. Astable Multivibrator:

- Waveform: It generates a continuous square wave output.

- Operation: It oscillates between two states (high and low) without any external triggering.

- Timing: The high and low states have different durations, determined by the values of the timing components.

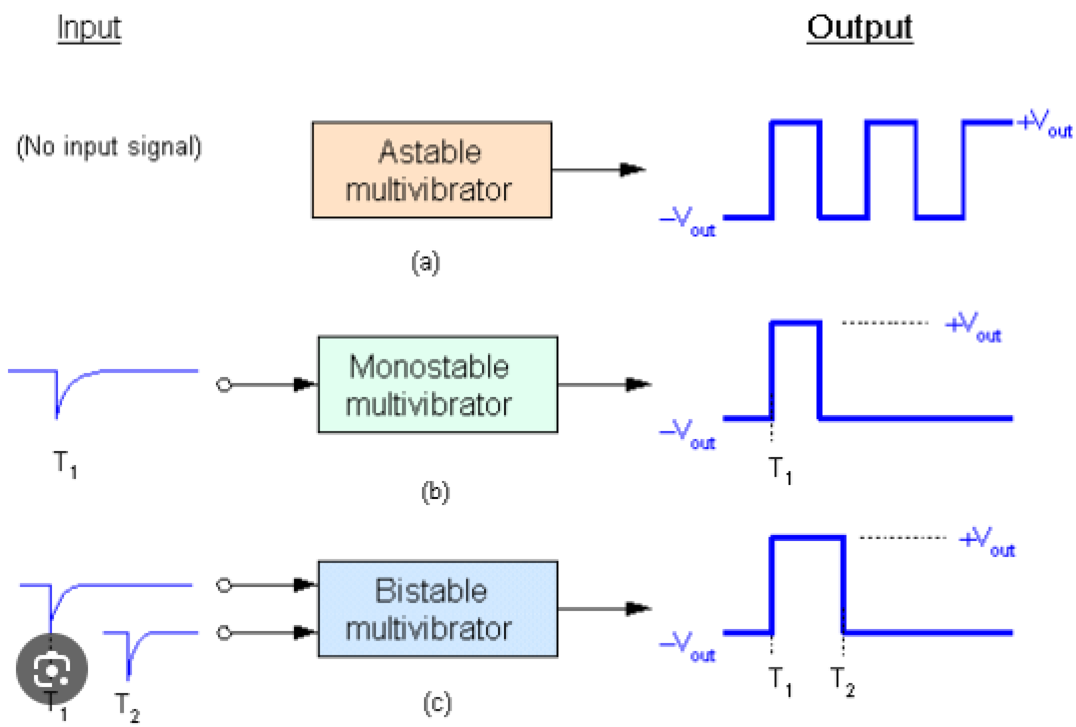
- Application: Widely used in applications requiring continuous square wave generation, such as oscillators and clock circuits.

2. Monostable Multivibrator:

- Waveform: Produces a single output pulse in response to an external trigger.
- Operation: Returns to a stable state after the pulse, remaining there until the next trigger.
- Timing: The duration of the output pulse is determined by the timing components.
- Application: Useful in pulse shaping, timing circuits, and debounce circuits.

3. Bistable Multivibrator:

- Waveform: It has two stable states (high and low).
- Operation: Remains in one state until triggered to switch to the other state.
- Timing: The duration of each state is not determined by timing components but by the applied trigger.
- Application: Essential in digital electronics for storing binary information and sequential logic circuits.



Application

1. Timing Circuits: They are extensively used in timing circuits to generate precise square wave pulses for controlling the timing of operations in digital systems, such as clock signals in microprocessors.

2. Pulse Generation: Multivibrators are utilized for generating pulses of specific durations, frequencies, and shapes required in applications like pulse-width modulation (PWM), pulse-position modulation (PPM), and frequency modulation (FM).

3. Digital Counters and Dividers: Bistable multivibrators, particularly flip-flops, are fundamental building blocks in digital counters and dividers used in frequency synthesis, frequency division, and digital frequency meters.

4. Signal Conditioning: They are employed for conditioning signals, such as signal shaping, signal regeneration, and signal synchronization, to prepare signals for further processing in electronic circuits.

5. Clock Synchronization: Multivibrators are used in clock synchronization circuits to ensure that different components of a system operate in synchrony, preventing timing conflicts and data corruption in digital systems.

6. Alarm Systems: Monostable multivibrators are utilized in alarm systems for generating a brief output pulse in response to an input trigger, enabling applications like burglar alarms, doorbells, and automotive security systems.

7. Waveform Generation: Astable multivibrators are employed in waveform generation applications, such as function generators, tone generators, and pulse generators, for producing periodic square wave signals with adjustable frequency and duty cycle.

8. Digital Logic Circuits: Bistable multivibrators, specifically flip-flops, serve as basic storage elements in digital logic circuits, including registers, latches, shift registers, and memory cells, for storing and manipulating binary data.