UNIT-V

Special ICs

Introduction to 555-IC

- The 555 timer is an integrated circuit specifically designed to perform signal generation and timing functions.
- One of the most versatile linear integrated circuits is the 555 timer.
- The 555 is a monolithic timing circuit that can produce accurate and highly stable time delays or oscillation.
- The timer basically operates in one of the two modes: either as monostable(one-shot) multivibrator or as an astable (free running) multivibrator.
- The device is available as an 8-pin metal can, an 8-pin mini DIP, or a 14-pin DIP.

- The SE555 is designed for the operating temperature range from - 55°Cto + 125°C, while the NE555 operates over a temperature range of 0° to +70°C.
- The important features of the 555 timer are these: it operates on +5 to + 18 V supply voltage in both free-running (astable) and one- shot (monostable) modes; it has an adjustable duty cycle; timing is from microseconds through hours; it has a high current output; it can source or sink 200 mA.
- The output can drive TTL and has a temperature stability of 50 parts per million (ppm) per degree Celsius change in temperature, or equivalently 0.005%/°C.
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Applications-

- Mono-stable and astable multivibrators
- DC-DC converters
- Digital logic probes
- Waveform generators
- Analog frequency meters and tachometers
- Temperature measurement and control
- Infrared transmitters
- Burglar and toxic gas alarms
- Voltage regulators
- Electric eyes
- Missing pulse detector
- Linear ramp generator
- Frequency divider
- Pulse width modulation
- FSK generator
- Pulse position modulator
- Schmitt trigger

Pin diagram of 555-IC

- **Pin 1:** Ground.

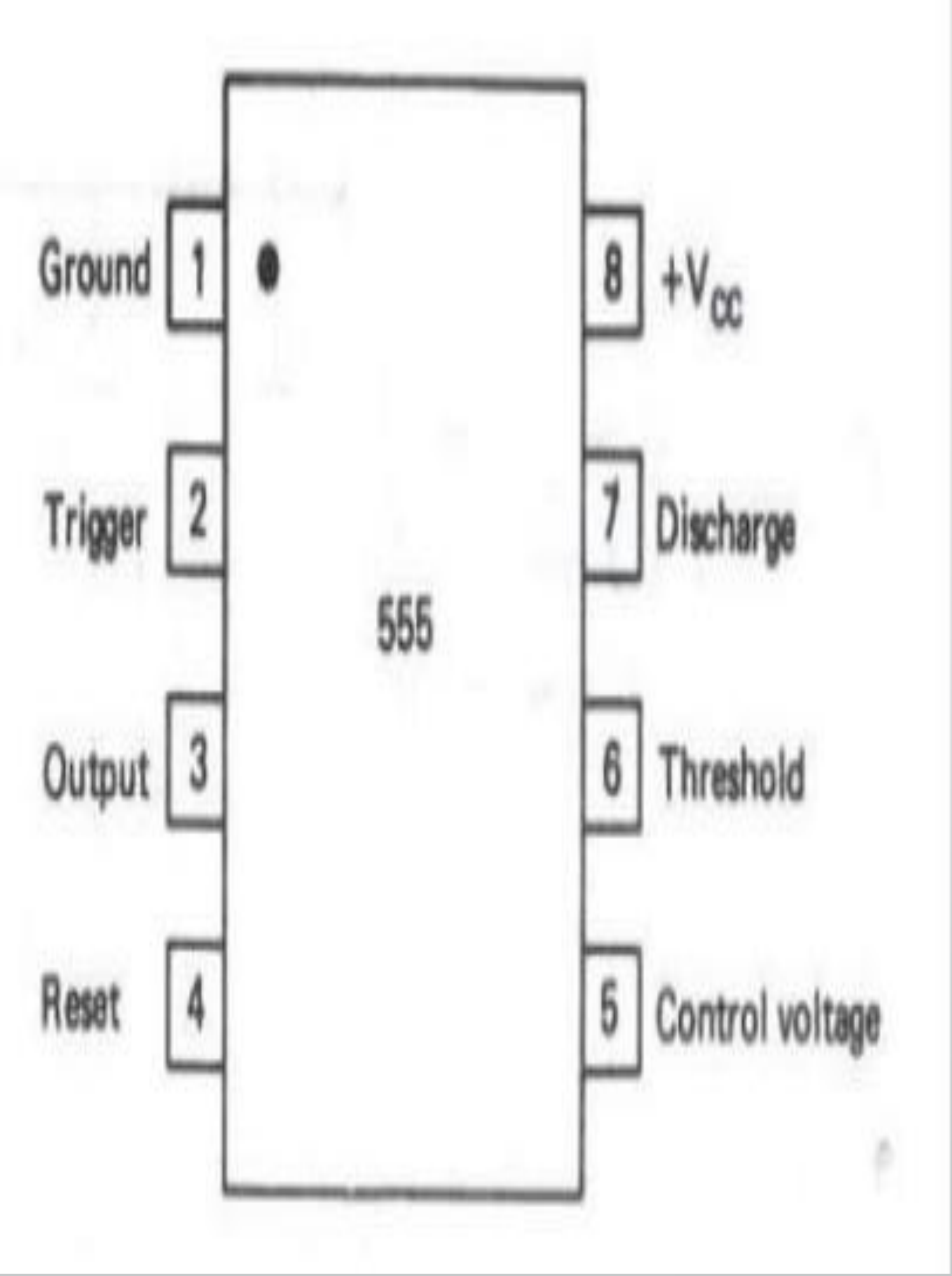
All voltages are measured with respect to this terminal.

- **Pin 2:** Trigger.

The output of the timer depends on the amplitude of the external trigger pulse applied to this pin. The output is low if the voltage at this pin is greater than 2/3 VCC. However, when a negative-going pulse of amplitude larger than 1/3 VCC is applied to this pin, the comparator 2 output goes low, which in turn switches the output of the timer high. The output remains high as long as the trigger terminal is held at a low voltage.

- **Pin 3:** Output.

There are two ways a load can be connected to the output terminal: either between pin 3 and ground (pin 1) or between pin 3 and supply voltage + VCC (pin 8). When the output is low, the load current flows through the load connected between pin 3 and + VCC into the output terminal and is called the sink current.



- However, the current through the grounded load is zero when the output is low. For this reason, the load connected between pin 3 and + VCC is called the normally on load and that connected between pin 3 and ground is called the normally off load.
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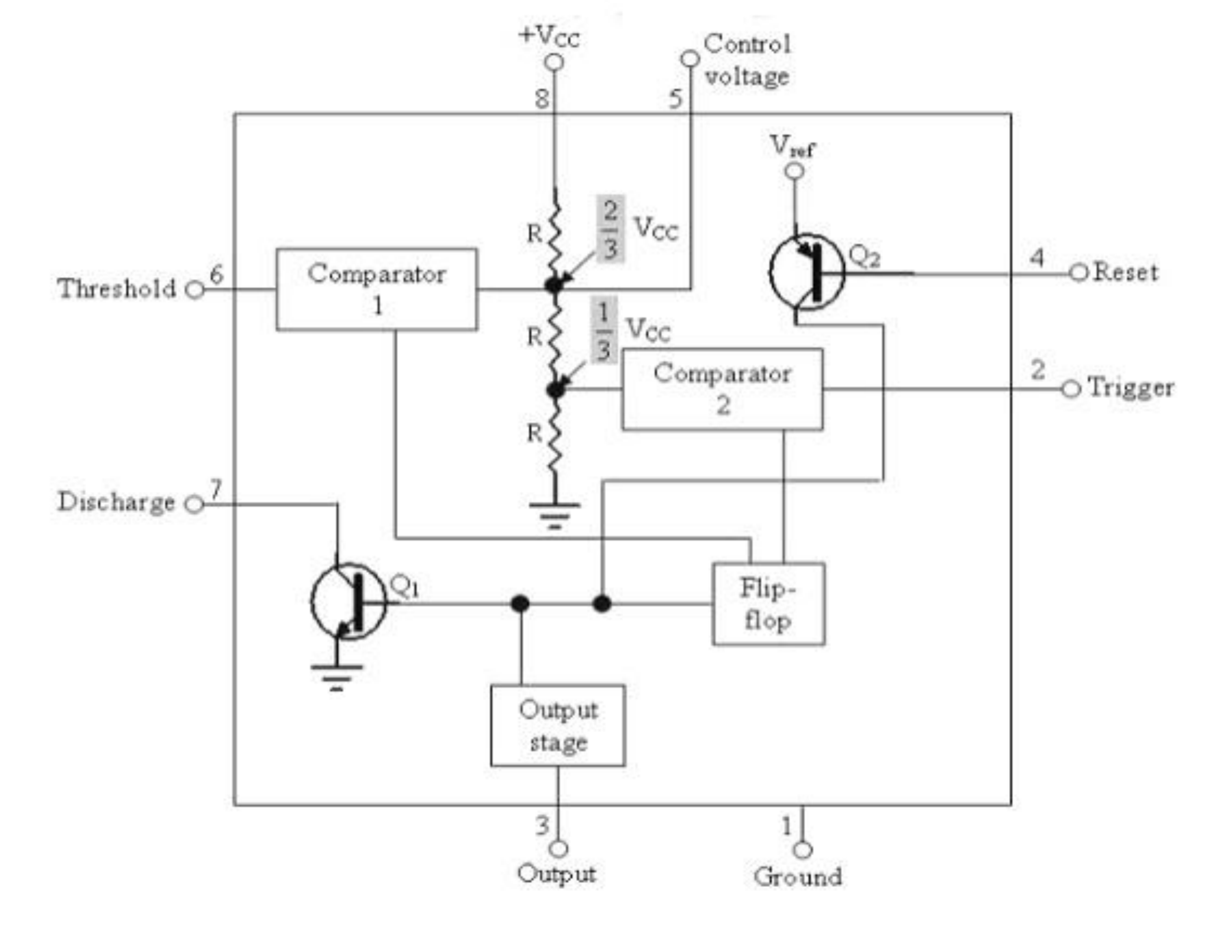
- **Pin 4:** Reset.

The 555 timer can be reset (disabled) by applying a negative pulse to this pin. When the reset function is not in use, the reset terminal should be connected to + VCC to avoid any possibility of false triggering.



- **Pin 5:** Control voltage.

An external voltage applied to this terminal changes the threshold as well as the trigger voltage . In other words, by imposing a voltage on this pin or by connecting a pot between this pin and ground, the pulse width of the output waveform can be varied. When not used, the control pin should be bypassed to ground with a 0.01-**µF capacitor to prevent any** noise problems.

- **Pin 6:** Threshold.

This is the non-inverting input terminal of comparator 1, which monitors the voltage across the external capacitor. When the voltage at this pin is threshold voltage 2/3 V, the output of comparator 1 goes high, which in turn switches the output of the timer low.

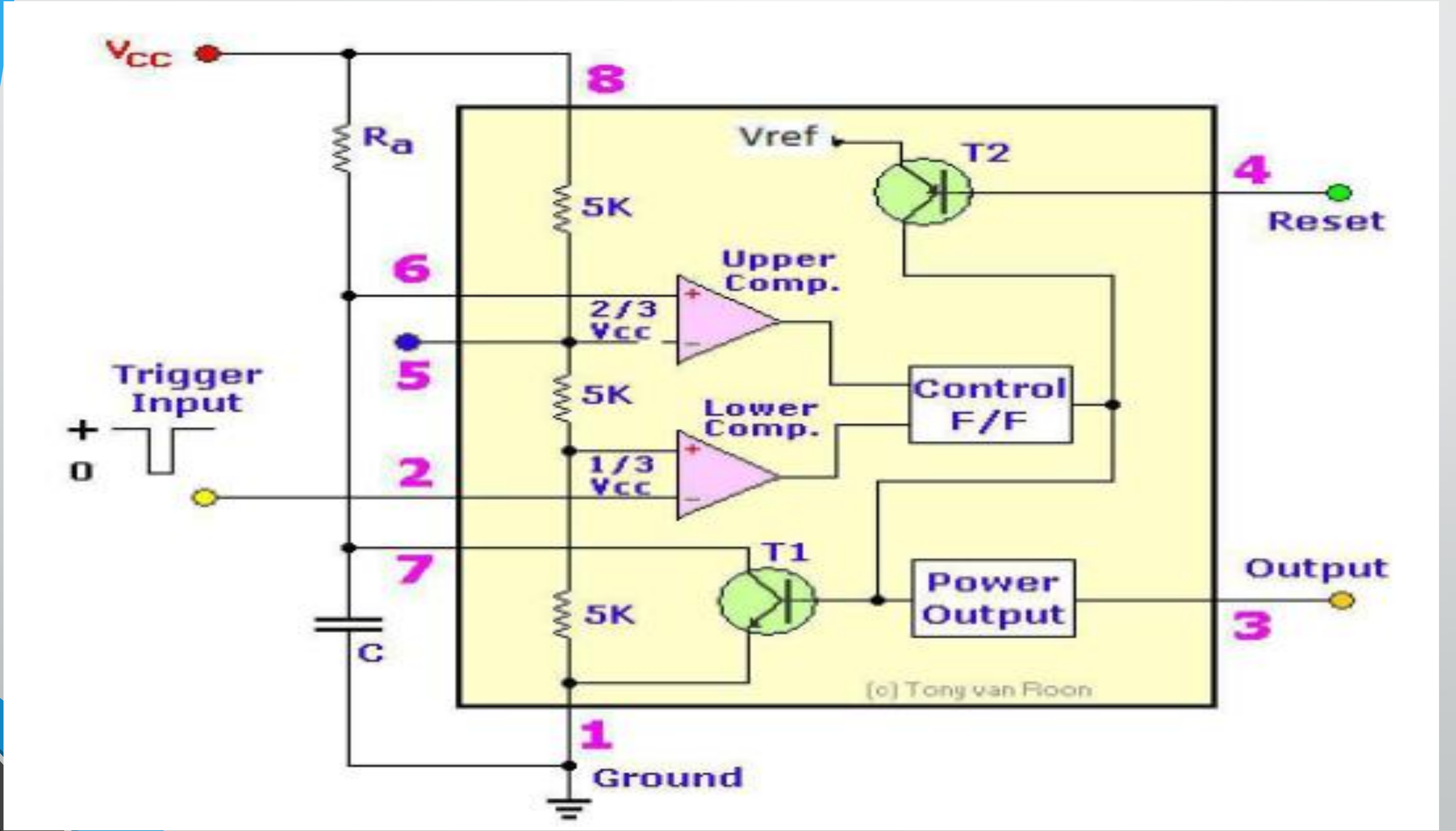
- **Pin 7:** Discharge.

This pin is connected internally to the collector of transistor Q1, as shown in Figure 2.1(b). When the output is high, Q1 is off and acts as an open circuit to the external capacitor C connected across it. On the other hand, when the output is low, Q1 is saturated and acts as a short circuit, shorting out the external capacitor C to ground.

- **Pin 8:** + VCC.

The supply voltage of +5 V to +18 is applied to this pin with respect to ground (pin1).

FUNCTIONAL BLOCK DIAGRAM OF 555 TIMER-



THE 555 AS AN ASTABLE MULTIVIBRATOR-

- The 555 as an Astable Multivibrator, often called a free-running multivibrator, is a rectangular- wave-generating circuit. Unlike the monostable multivibrator, this circuit does not require an external trigger to change the state of the output, hence the name free running.
- However, the time during which the output is either high or low is determined by the two resistors and a capacitor, which are externally connected to the 555 timer. Fig 4-6(a) shows the 555 timer connected as an astable multivibrator.
- Initially, when the output is high, capacitor C starts charging toward V through RA and R8. However as soon as voltage across the capacitor equals 2/3 Vcc, comparator I triggers the flip flop, and the output switches low. Now capacitor C starts discharging through R8 and transistor Q.
- When the voltage across C **equals 1/3 comparator 2's output triggers the flip**-flop, and the output goes high.
- Then the cycle repeats.

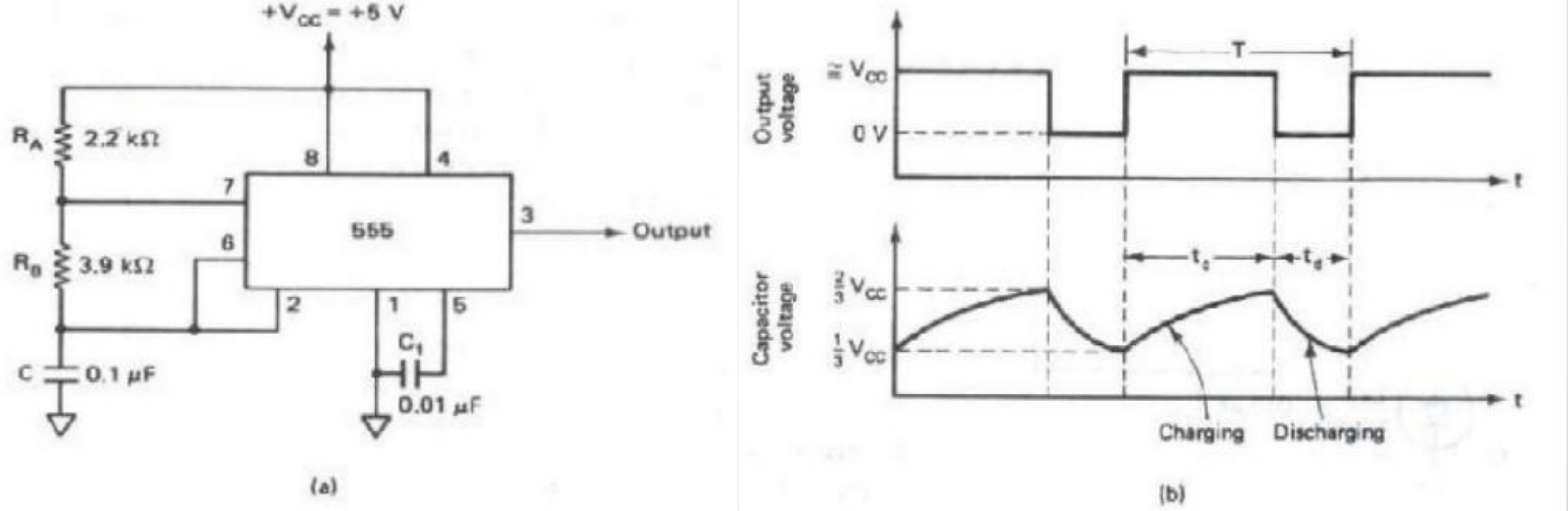


Fig 2.9: The 555 as a Astable Multivibrator (a)Circuit(b)Voltage across Capacitor and O/P waveforms.

- The output voltage and capacitor voltage waveforms are shown in Figure 2.6(b). As shown in this figure, the capacitor is periodically charged and discharged between 2/3 Vcc and 1/3 V, respectively. The time during which the capacitor charges from 1/3 V to 2/3 V. is equal to the time the output is high and is given by

$$t_C = 0.69(R_A + R_B)C$$

- Where, RA and R3 are in ohms and C is in farads.

- Similarly, the time during which the capacitor discharges from 2/3 V to 1/3 V is equal to the time the output is low and is given by

$$t_d = 0.69(R_B)C$$

- where RB is in ohms and C is in farads. Thus the total period of the output waveform is

$$T = t_c + t_d = 0.69(R_A + 2R_B)C$$

- This, in turn, gives the frequency of oscillation as

$$f_o = \frac{1}{T} = \frac{1.45}{(R_A + 2R_B)C}$$

- Above equation indicates that the frequency fo is independent of the supply voltage V. Often the term duty cycle is used in conjunction with the astable multivibrator . The duty cycle is the ratio of the time t during which the output is high to the total time period T. It is generally expressed as a percentage. In equation form, $\% \, duty\,cycle = \frac{t_c}{T} \times 100$ $= \frac{R_A + R_B}{R_A + 2R_B}$

Astable Multivibrator Applications-

- **Square-wave oscillator:** Without reducing RA = 0 , the astable multivibrator can be used to produce a square wave output simply by connecting diode D across resistor RB, as shown in Figure 4-7.
- The capacitor C charges through RA and diode D to approximately 2/3 Vcc and discharges through RB and terminal 7 until the capacitor voltage equals approximately 1/3 Vcc; then the cycle repeats.
- To obtain a square wave output (50% duty cycle), RA must be a combination of a fixed resistor and potentiometer so that the potentiometer can be adjusted for exact square wave.

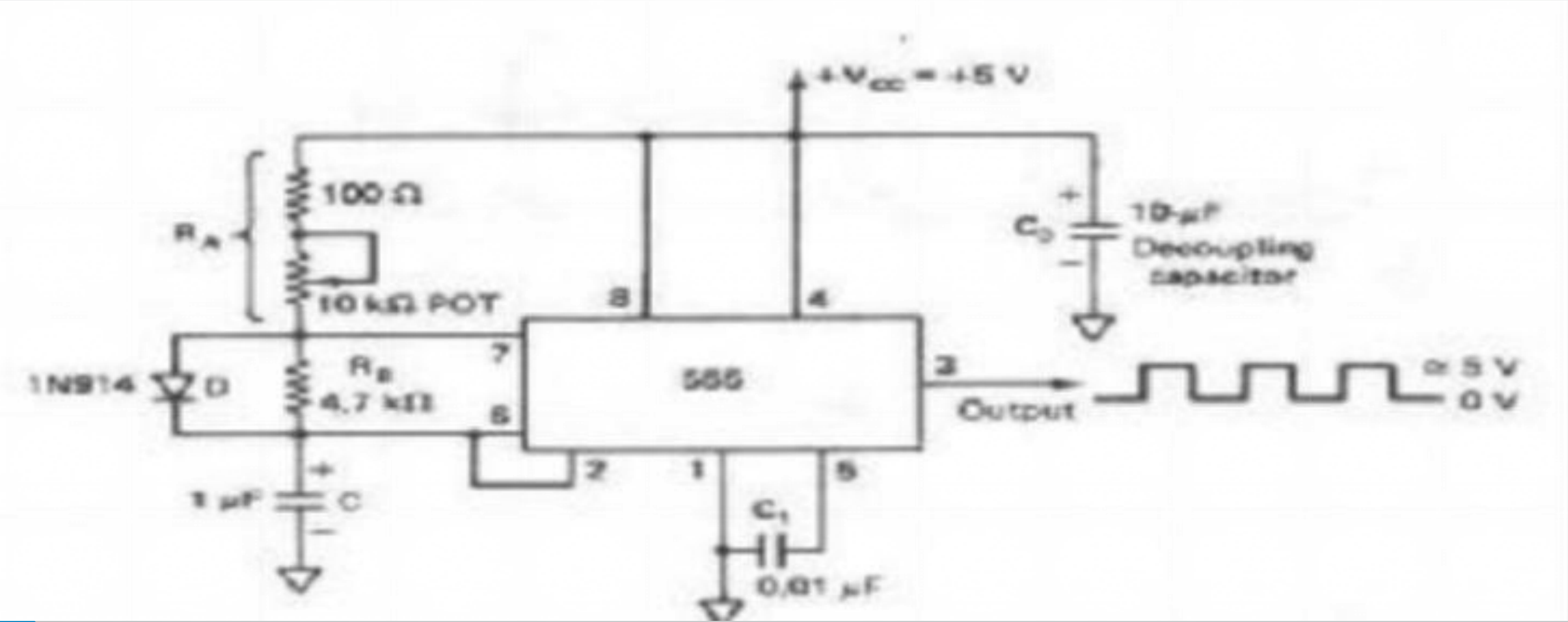
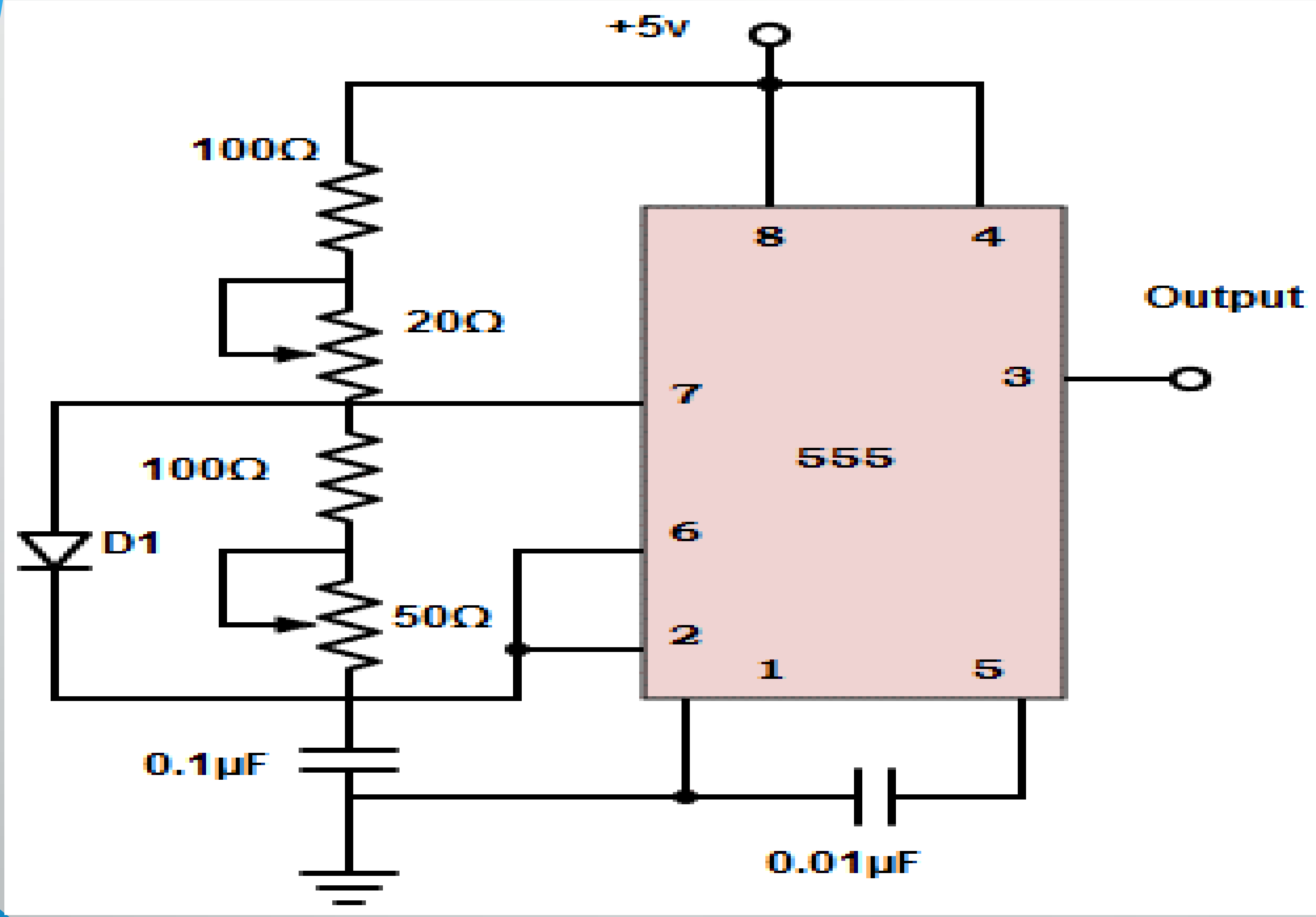


Fig: Astable Multivibrator as a Square wave generator Free-running ramp

Problem: Determine the frequency and duty cycle of a rectangular wave generator.



Options are:

A) Frequency=63.7kHz; Duty cycle=50%

B) Frequency=53.7kHz; Duty cycle=55%

C) Frequency=43.7kHz; Duty cycle=50%

D) Frequency=60 kHz; Duty cycle=55%

MCQ :Q1) Astable multivibrator operating at 150Hz has a discharge time of 2.5m. Find the duty cycle of the circuit.

Options are: A) 50 % B) 75 % C) 95% D) 37.5 %

Q2) Free running frequency of Astable multivibrator?

A) $f = 1.45/(R_A+2R_B)C$
B) $f = 1.45. (R_A+2R_B).C$
C) $f = 1.45.Ra /(R_A+2R_B)$
D) $f=1.45. C/(R_A+2R_B)$

- **Generator:** The astable multivibrator can be used as a free-running ramp generator when resistors RA and R3 are replaced by a current mirror. Figure 2.8(a) shows an astable multivibrator configured to perform this function. The current mirror starts charging capacitor C toward Vcc at a constant ra When voltage across C equals 2/3 Vcc, comparator 1 turns transistor Q on, and C rapidly discharges through transistor Q. However, when the discharge voltage across C is
- Approximately equal to 1/3 Vcc, comparator 2 switches transistor Q off, and then capacitor C starts charging up again. Thus the charge— discharge cycle keeps repeating. The discharging time of the capacitor is relatively negligible compared to its charging time; hence, for all practical purposes, the time period of the ramp waveform is equal to the charging time and is approximately given by

$$T = \frac{V_{cc} C}{3 I_C}$$

- Where I = (Vcc — VBE)/R = constant current in amperes and C is in farads. Therefore, the free running frequency of the ramp generator is

$$f_o = \frac{3 I_C}{V_{cc} C}$$

$$f_o = \frac{3I_C}{V_{cc}C}$$

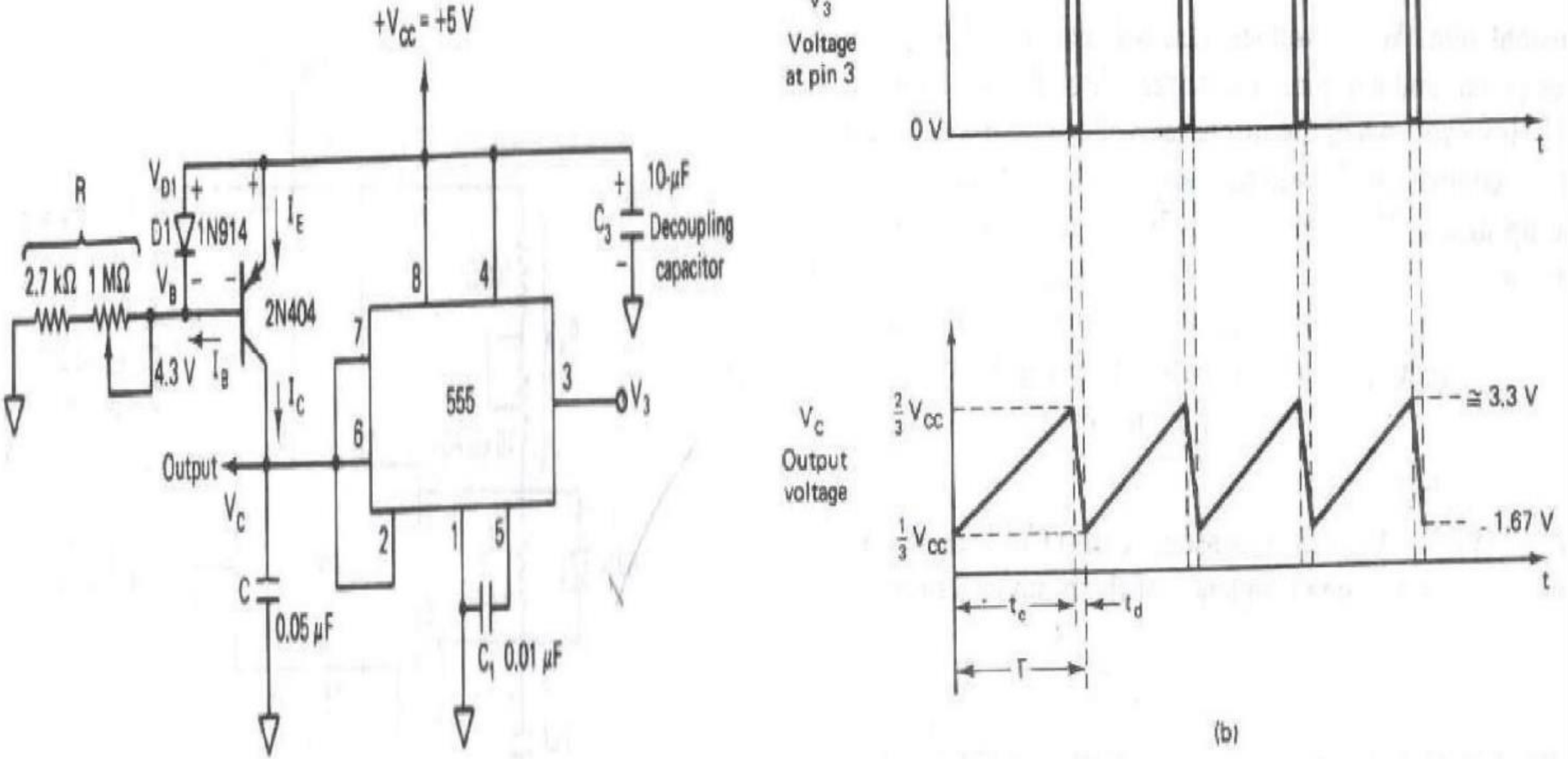


Fig 2.11: (a) Free Running ramp generator (b) Output waveform.

THE 555 AS A MONOSTABLE MULTIVIBRATOR-

- A monostable multivibrator, often called a one-shot multivibrator, is a pulse-generating circuit in which the duration of the pulse is determined by the RC network connected externally to the 555 timer.

- In a stable or standby state the output of the circuit is approximately zero or at logic-**low level. When an external trigger pulse is applied, the output is forced to go high (≈VCC).**

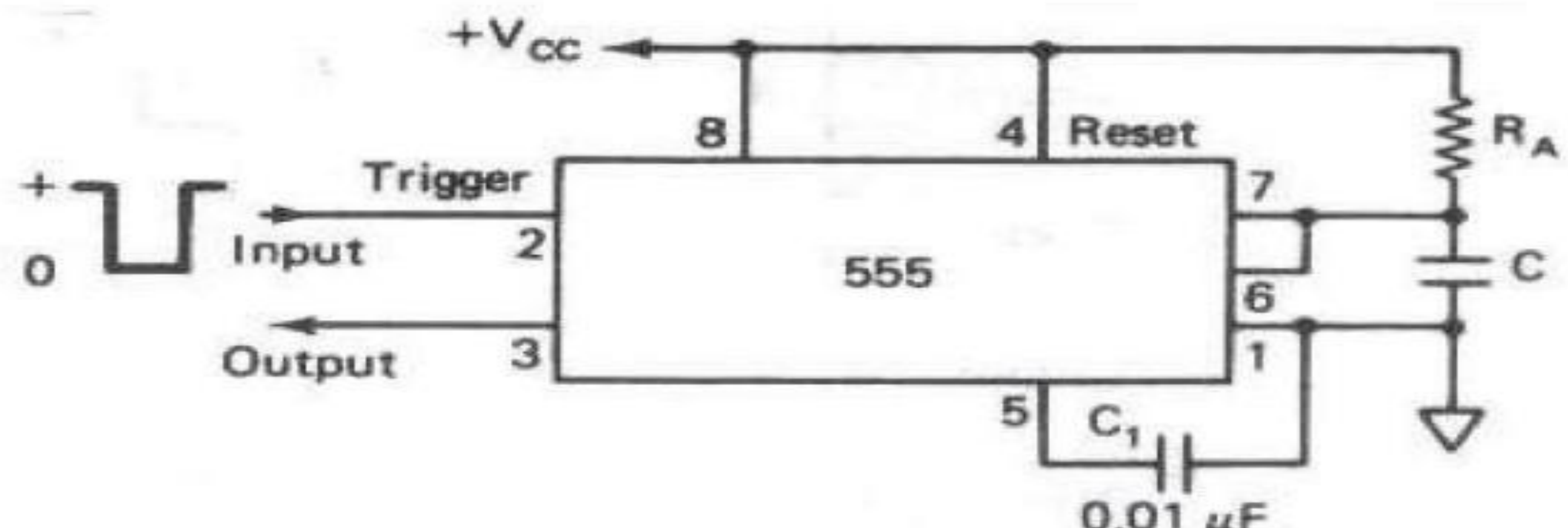
- The time the output remains high is determined by the external RC network connected to the timer. At the end of the timing interval, the output automatically reverts back to its logic-low stable state. The output stays low until the trigger pulse is again applied. Then the cycle repeats.

- The monostable circuit has only one stable state (output low), hence the name mono-stable. Normally, the output of the mono- stable multivibrator is low. Fig 2.2 (a) shows the **555 configured for monostable operation. To better explain the circuit's operation, the** internal block diagram is included in Fig 2.2(b).

Mono-stable operation:

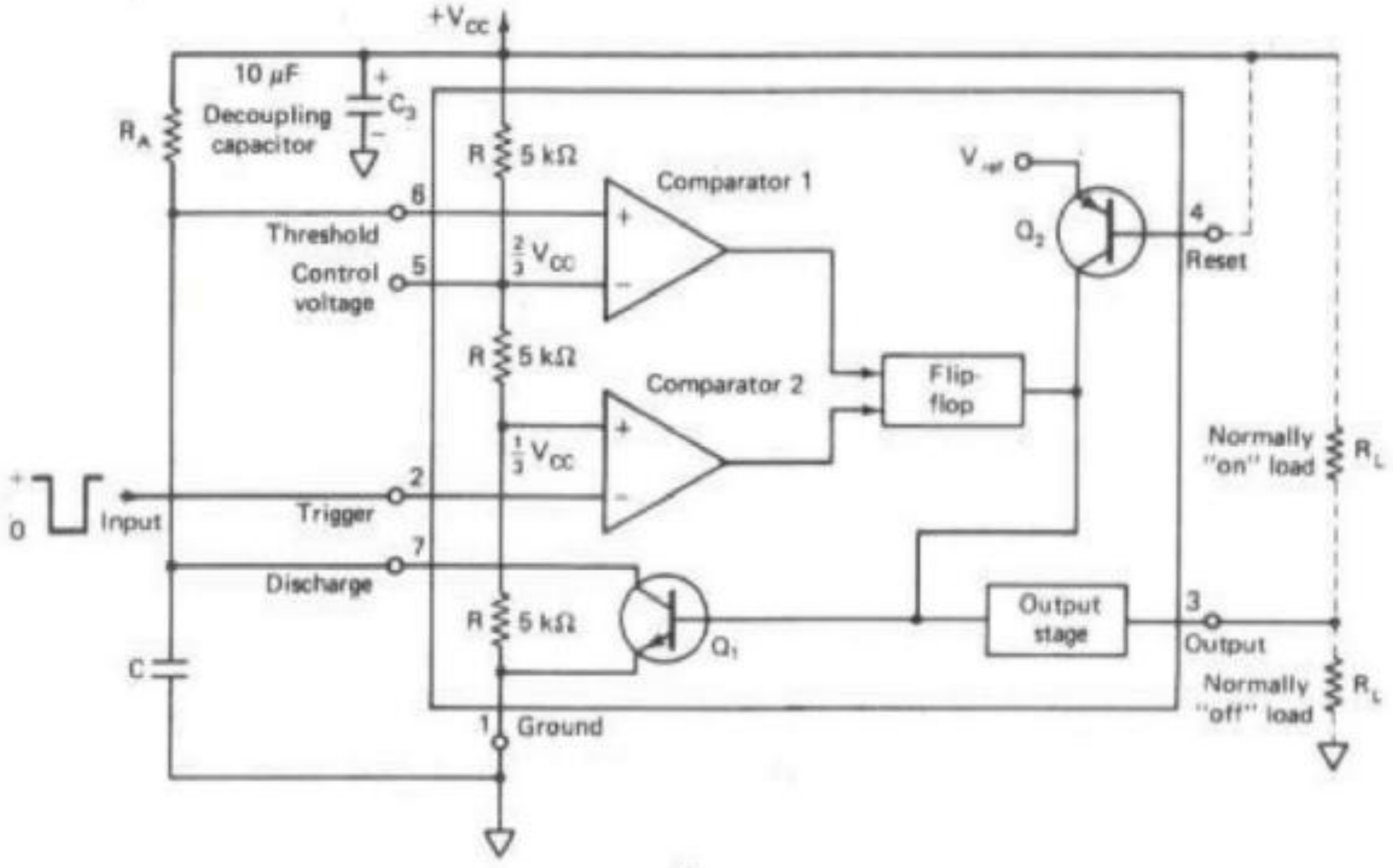
- According to Fig 2.2(b), initially when the output is low, that is, the circuit is in a stable state, transistor Q is on and capacitor C is shorted out to ground. However, upon application of a negative trigger pulse to pin 2, transistor Q is turned off, which releases the short circuit across the external capacitor C and drives the output high. The capacitor C now starts charging up toward Vcc through RA.

- However, when the voltage across the capacitor equals 2/3 Va., comparator **I 's output** switches from low to high, which in turn drives the output to its low state via the output of the flip-flop. At the same time, the output of the flip-flop turns transistor Q on, and hence capacitor C rapidly discharges through the transistor.

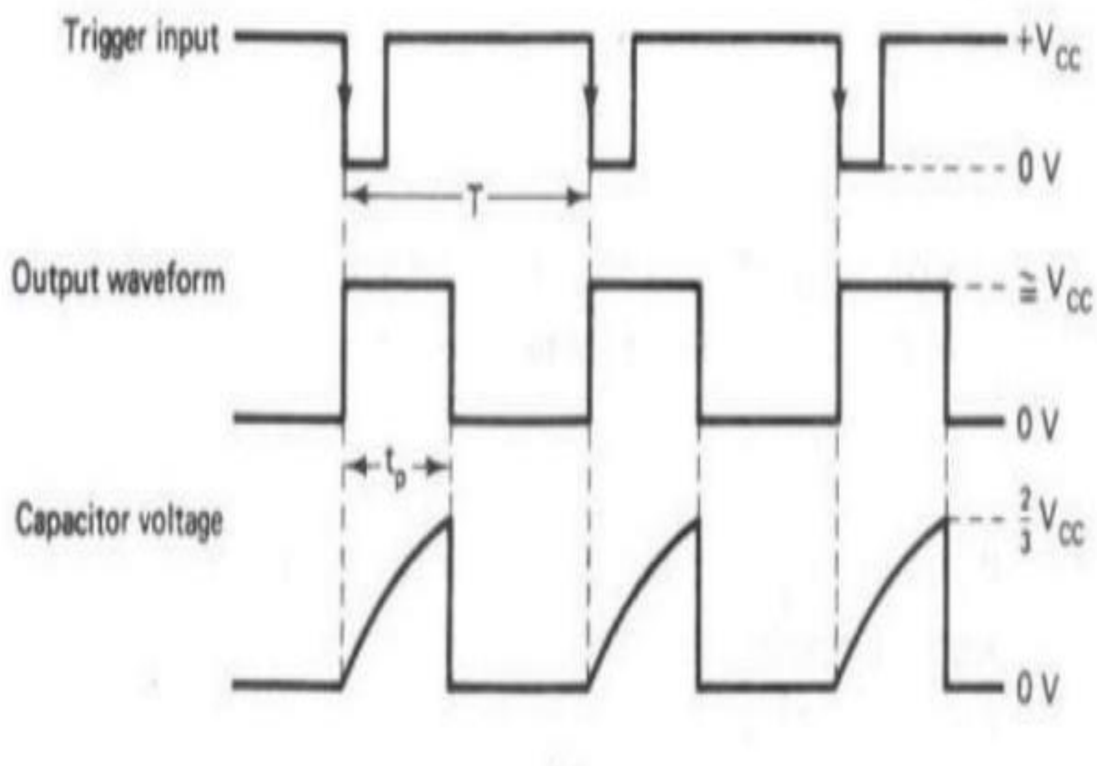


(a)

- The output of the monostable remains low until a trigger pulse is again applied. Then the cycle repeats. Figure 4-2(c) shows the trigger input, output voltage, and capacitor voltage waveforms.
- As shown here, the pulse width of the trigger input must be smaller than the expected pulse width of the output waveform.
- Also, the trigger pulse must be a negative-going input signal with amplitude larger than 1/3 the time during which the output remains high is given by where Fig.2.5 (b) 555 connected as a Monostable Multivibrator (c) input and output waveforms Where RA is in ohms and C is in farads. Figure 2.2(c) shows a graph of the various combinations of RA and C necessary to produce desired time delay.
- **tp = pulse period = Ton = 1.1 RA * C**



(b)



(c)

MCQ : Q1). A 555 timer in Monostable application mode can be used for....

options are: A) Pulse position modulation

B) Frequency shift keying

C) Speed control and measurement

D) Digital phase detector

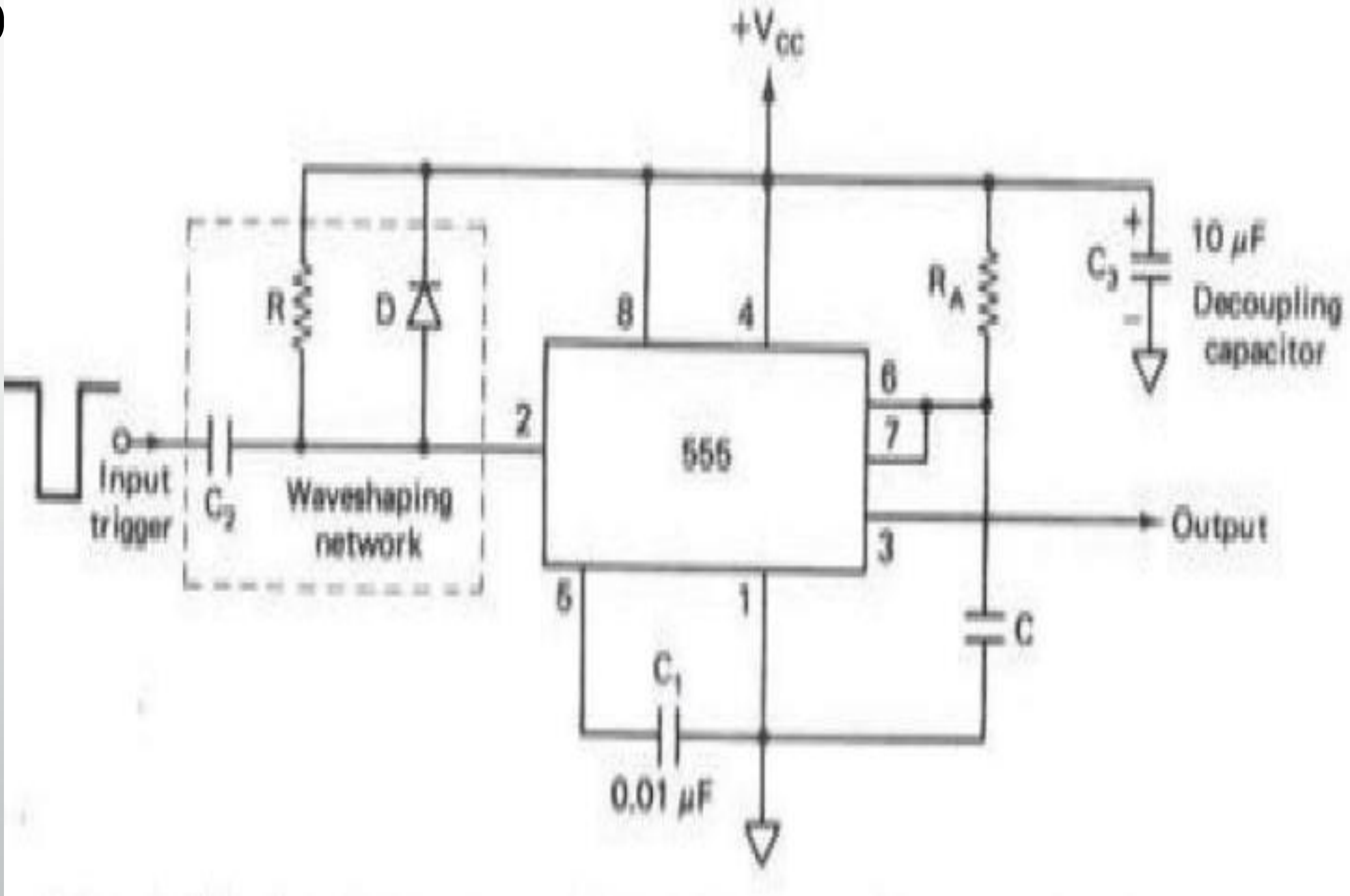
Q2). A monostable multivibrator has R = 120kΩ and the time delay T = 1000ms, calculate the value of C?

A) 0.9 uF, B) 1.32u F, C) 7.5u F, D) 2.54uF

- Note that this graph can only be used as a guideline and gives only the approximate value of RA and C for a given **time delay. Once triggered, the circuit's output will remain in the high state until the set time**1, elapses.
- The output will not change its state even if an input trigger is applied again during this time interval T. However, the circuit can be reset during the timing cycle by applying a negative pulse to the reset terminal. The output will then remain in the low state until a trigger is again applied.
- Often in practice a decoupling capacitor (10 F)

unwanted voltage spikes in the output waveform.

Sometimes, to prevent any possibility of mistriggering the monostable multivibrator on positive pulse edges, a wave shaping circuit consisting of R, C2, and diode D is connected between the trigger input pin 2 and pin 8, as shown in Figure 4-3. The values of R and C2 should be selected so that the time constant RC2 is smaller than the output pulse width.



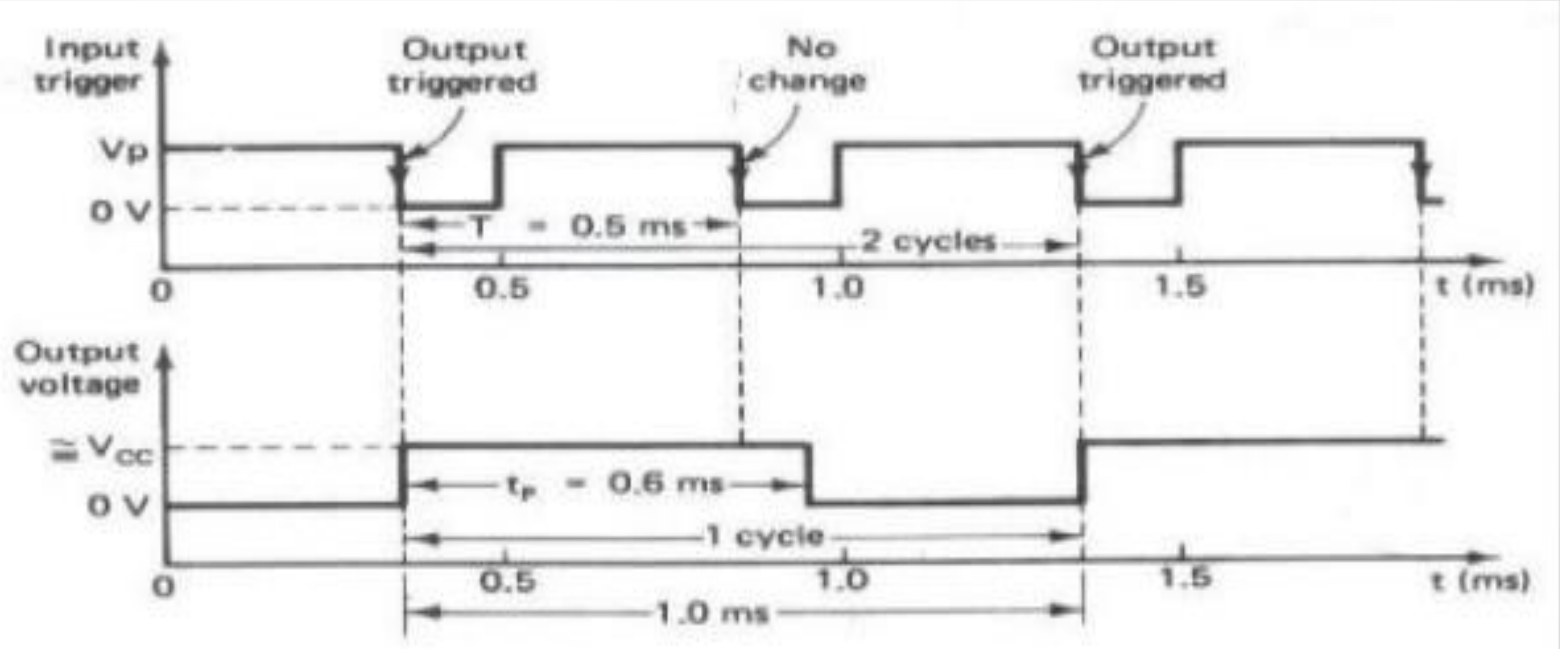
Monostable Multivibrator Applications-

- **Frequency divider:** The monostable multivibrator of Figure 2.2(a) can be used as a frequency divider by adjusting the length of the timing cycle tp, with respect to the tine period T of the trigger input signal applied to pin 2.

✓ To use monostable multivibrator as a divide-by-2 circuit, the timing interval tp must be slightly larger than the time period T of the trigger input signal, as shown in Figure 2.4.

✓ By the same concept, to use the monostable multivibrator as a divide-by-3 circuit, tp must be slightly larger than twice the period of the input trigger signal, and so on.

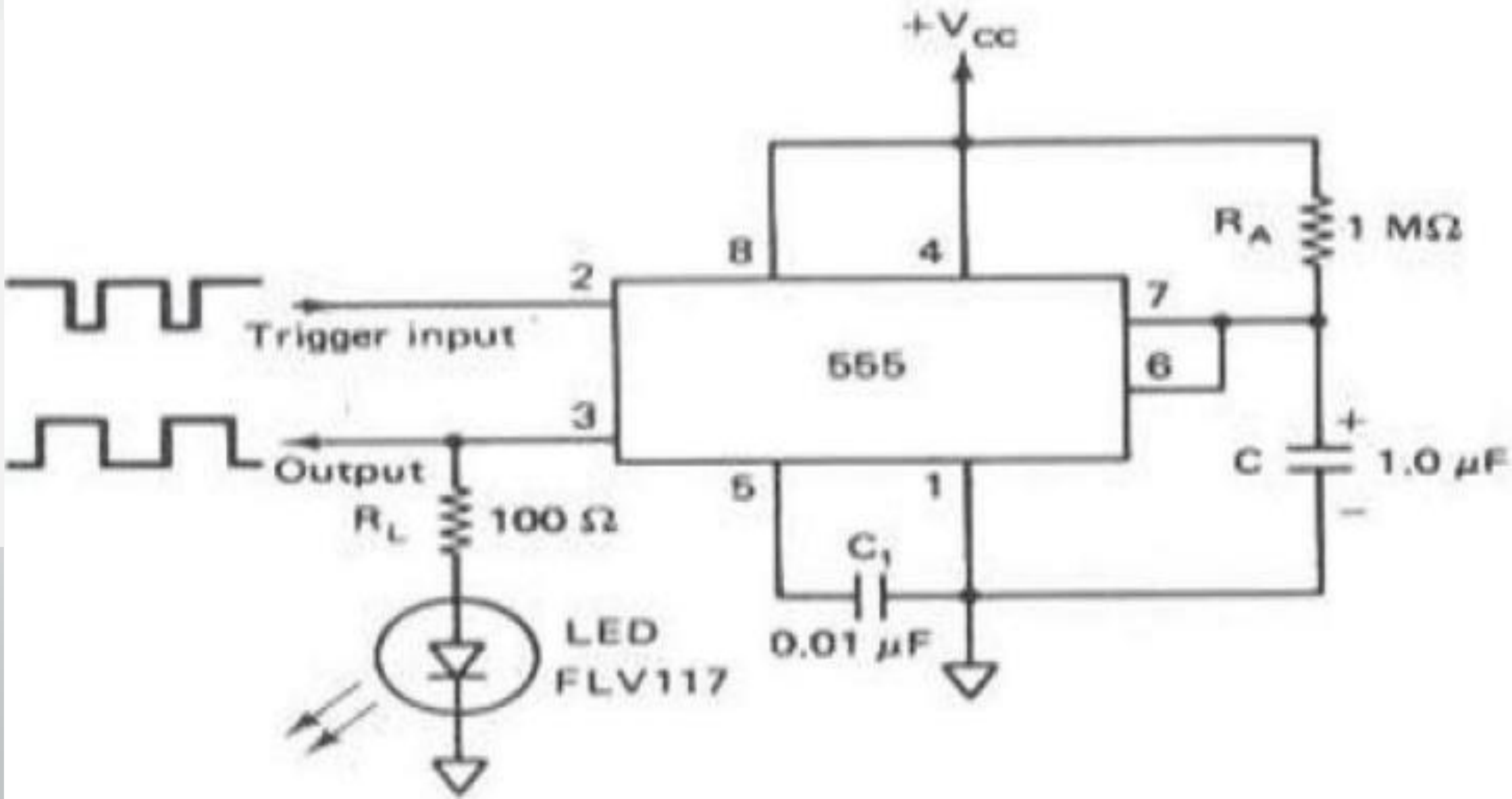
✓ The frequency-divider application is possible because the monostable multivibrator cannot be triggered during the timing cycle.



(b) Pulse stretcher: This application makes use of the fact that the output pulse width (timing interval) of the monostable multivibrator is of longer duration than the negative pulse width of the input trigger. As such, the output pulse width of the monostable multivibrator can be viewed as a stretched version of the narrow input pulse, hence the name pulse stretcher. Often, narrow-pulse- width signals are not suitable for driving an LED display, mainly because of their very narrow pulse widths. In other words, the LED may be flashing but is not visible to the eye because its on time is infinitesimally small compared to its off time. The 555 pulse stretcher can be used to remedy this problem.

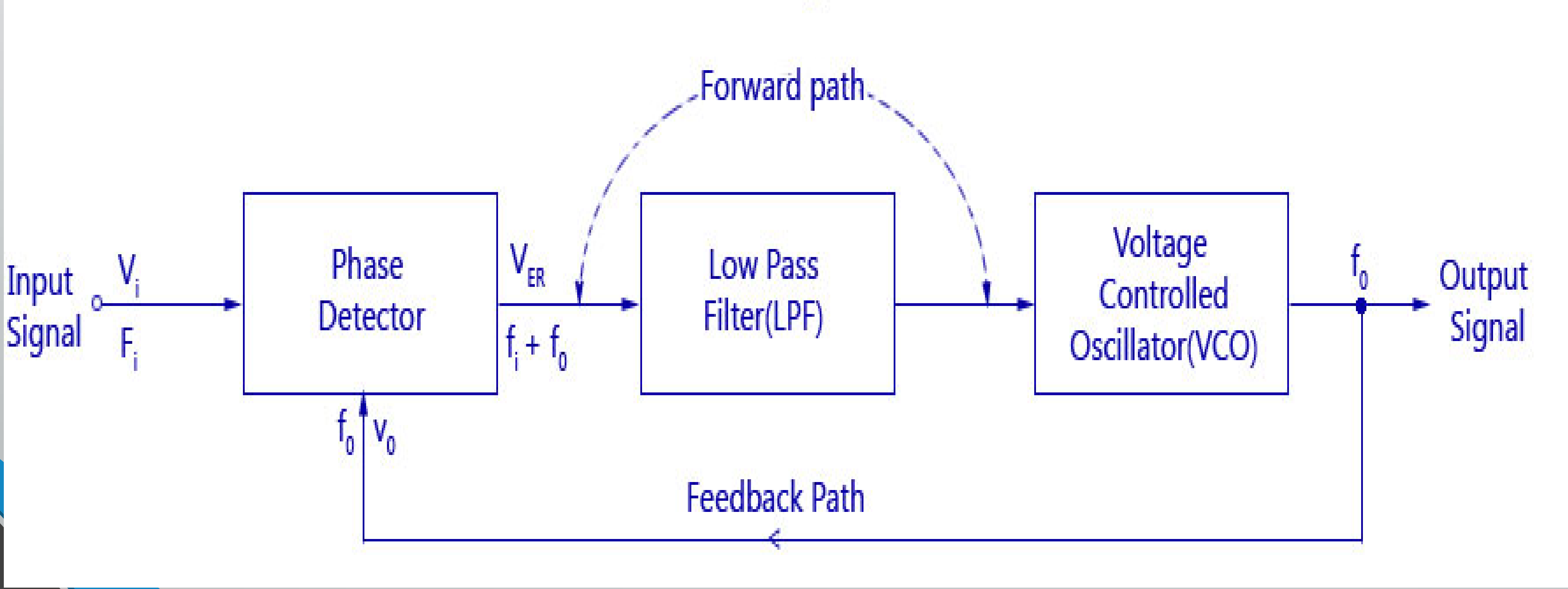
Figure 2.8 shows a basic monostable used as a pulse stretcher with an LED indicator at the output.

- ***The LED will be on during the timing interval tp = 1.1RAC, which can be varied by changing the value of RA and/or C.***



Phase Locked Loop: PLL

- A PLL is a basically a closed loop system designed to lock output frequency and phase to the frequency and phase of an input signal
- The phase detectors or comparator compares the input frequency f_{IN} with the feedback frequency f_{OUT}. The output voltage of the phase detector is a dc voltage and therefore is often referred to as the error voltage. The output of the phase is then applied to the low-pass filter, which removes the high-frequency noise and produces a dc level.



Applications of 565 PLL: **The phase-locked loop principle has been used in applications such as : 1. Frequency Multiplier**

2. FM (frequency modulation) stereo decoders,

3. Motor speed controls,

4. Tracking filters,

5. Frequency synthesized transmitters and receivers,

6. FM demodulators,

7. Frequency shift keying (FSK) decoders, and a

8. Generation of local oscillator frequencies in TV and in FM tuners.

MCQ: Q1. What is the function of low pass filter in phase-locked loop?

A) Improves low frequency noise **B)Removes high frequency noise**

C) Tracks the voltage changes **D) Changes the input frequency**

VOLTAGE CONTROLLED OSCILLATOR-

- A voltage controlled oscillator is an oscillator circuit in which the frequency of oscillations can be controlled by an externally applied voltage

The features of 566 VCO-

1. Wide supply voltage range(10- 24V)
2. Very linear modulation characteristics
3. High temperature stability