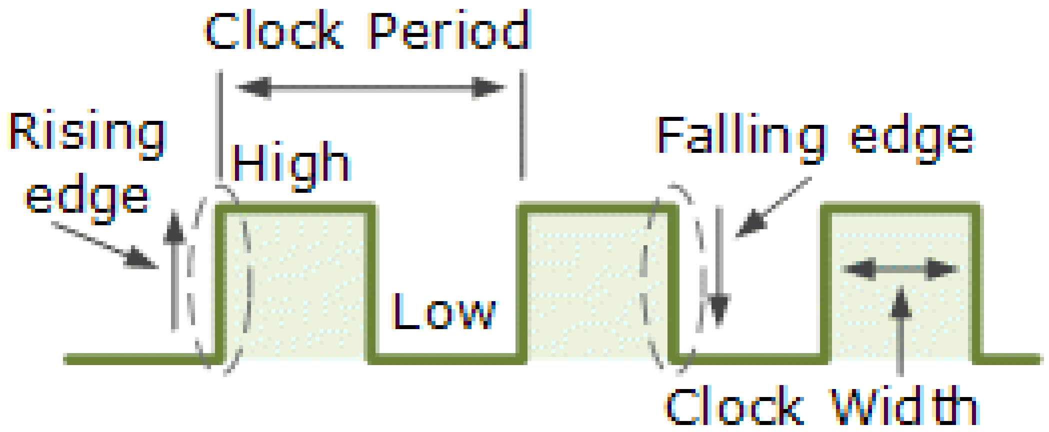
LIC: LECTURE
Signal Generators

- **Multivibrator: Need and Different Types**
  - **Astable Multivibrator**
  - **Monostable Multivibrator**
  - **Bistable Multivibrator**
- **Astable Multivibrator**
  - **Working Principal**
  - **Calculation of Time Period**
  - **Design Example**

Multivibrator

- **The Multivibrator is the electronic circuit which is used to implement two state devices like oscillator, timer and flip-flops.**
- **Here, the two states refer to the two voltage levels of the Multivibrators.**
- **Depending upon the number of stages, the multivibrator can be divided into three types.**



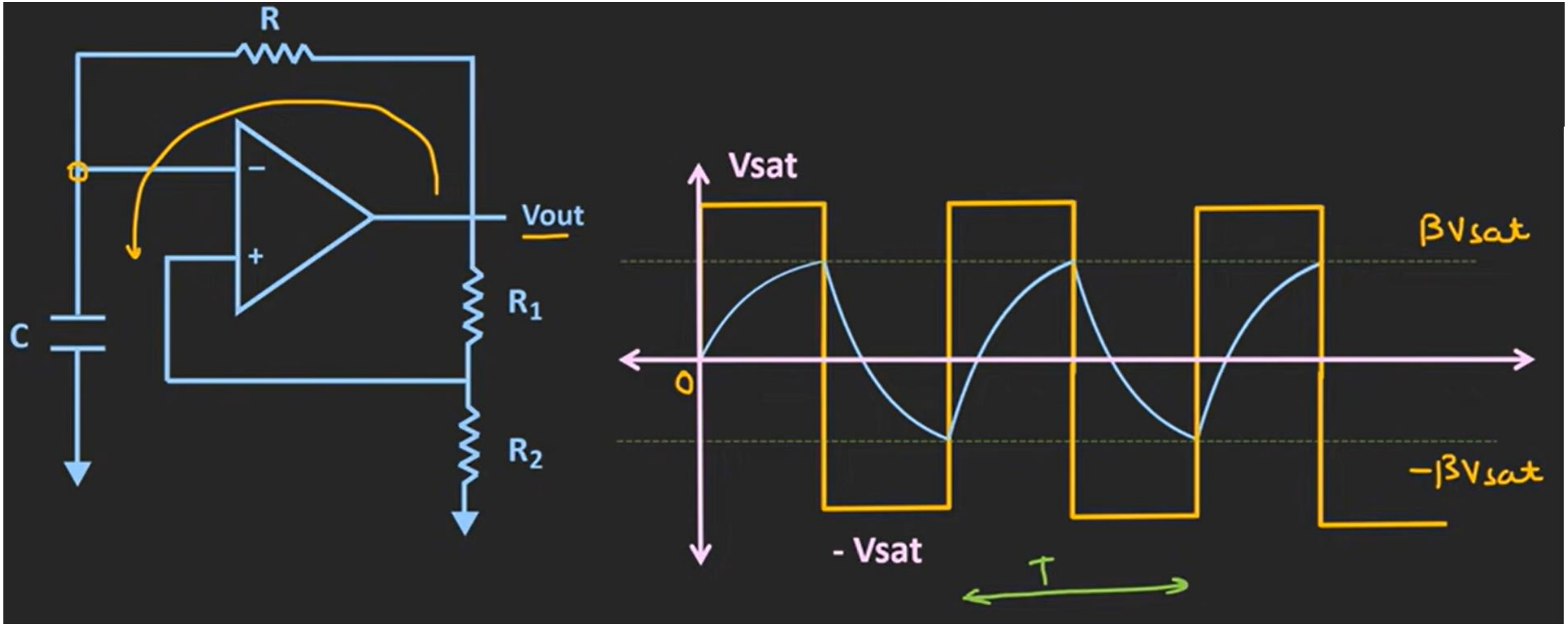
Multivibrator

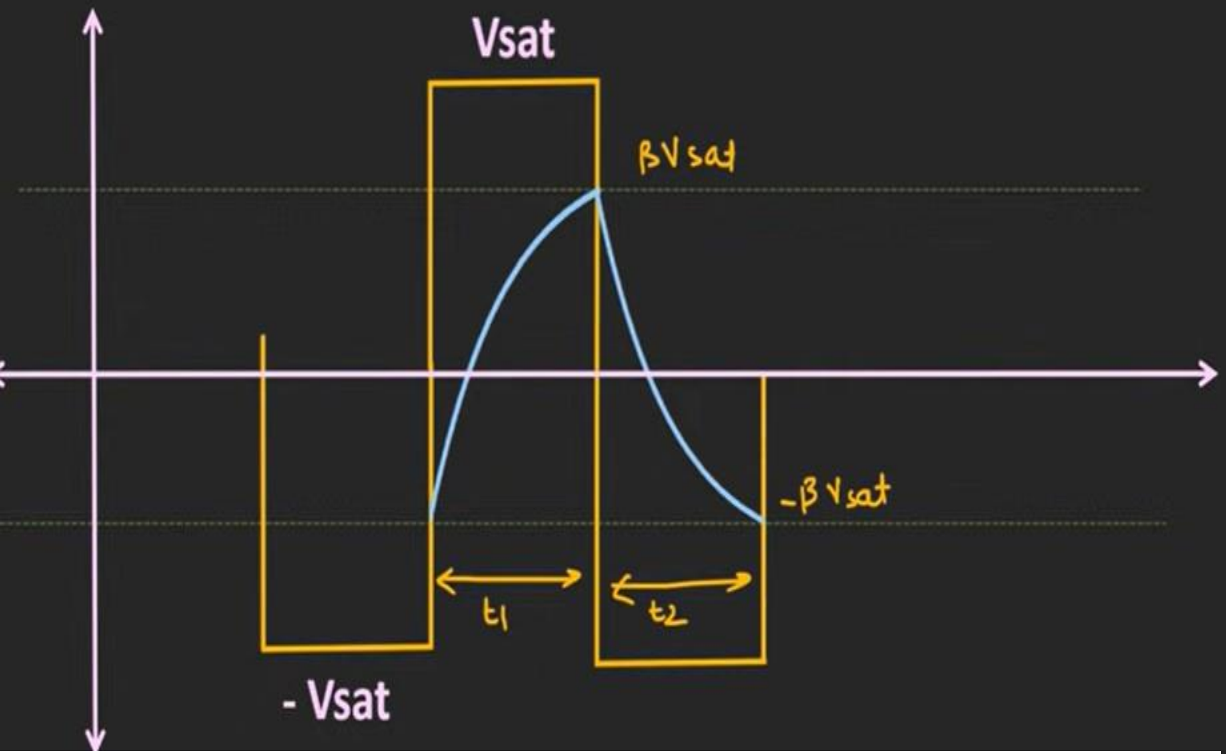
Astable – A *free-running multivibrator* that has NO stable states but switches continuously between two states this action produces a train of square wave pulses at a fixed frequency. (Eg. Relaxation Oscillator)

Monostable – A *one-shot multivibrator* that has only ONE stable state and is triggered externally with it returning back to its first stable state. (Eg. Timer applications)

Bistable – A *flip-flop* that has TWO stable states that produces a single pulse either positive or negative in value. (Eg.-Sequential Circuits)

ASTABLE MULTIVIBRATOR
(Free Running Multivibrator)





ASTABLE MULTIVIBRATOR

Derivation of Time Period (T=t1+t2)

Calculation of charging time-t_1

$$V_C(t) = V_{Final} + [V_{initial} - V_{Final}]e^{-t/RC}$$

$$V_{Final} = V_{sat}$$

$$V_{in} = -\beta V_{sat}$$

$$V_C(t_1) = V_{sat} + [-\beta V_{sat} - V_{sat}]e^{-t_1/RC}$$

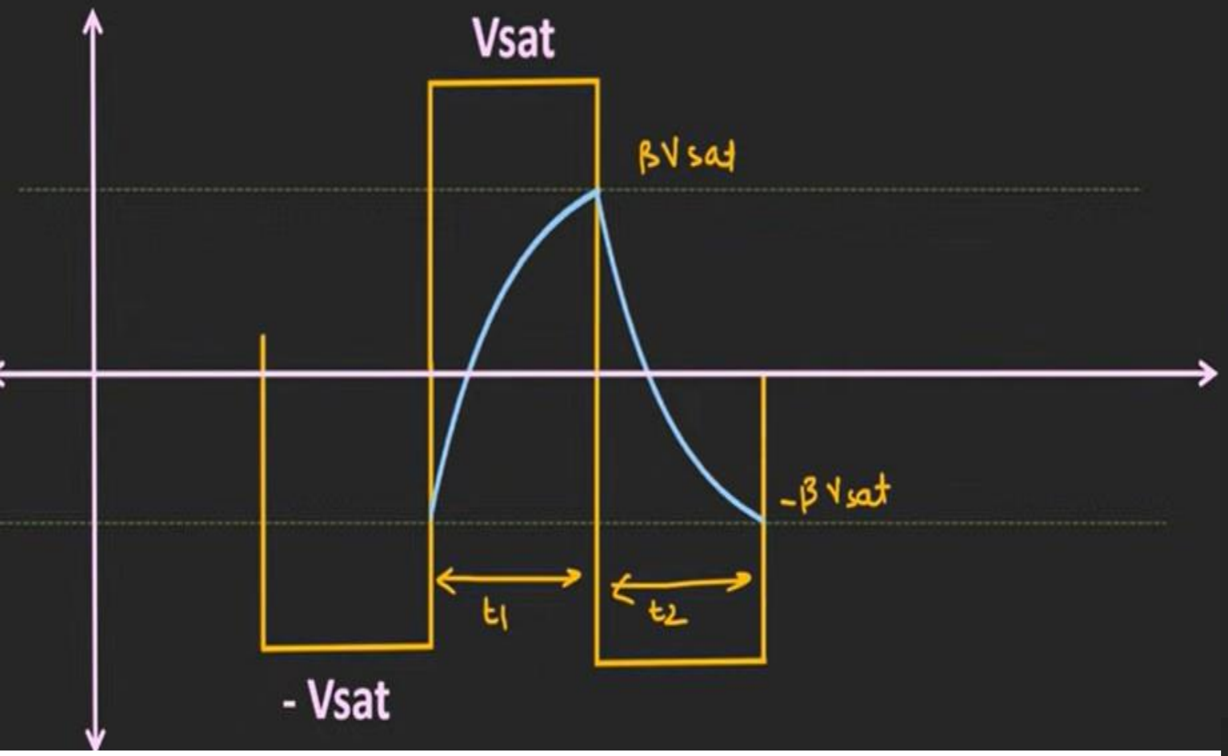
$$\beta V_{sat} = V_{sat} - [1+\beta]V_{sat}\, e^{-t_1/RC}$$

$$\beta - 1 = -[1+\beta]e^{-t_1/RC}.$$

$$\left[\frac{1-\beta}{1+\beta}\right] = e^{-t_1/RC}$$

$$\Rightarrow t_1 = -RC \ln\left[\frac{1-\beta}{1+\beta}\right]$$

$$t_1 = RC \ln\left[\frac{1+\beta}{1-\beta}\right]$$



$$V_c(t) = V_{Final} + [V_{initial} - V_{Final}]\, e^{-t/RC}$$

$$V_{initial} = \beta V_{sat} \rightarrow -\beta V_{sat}$$

$$V_{Final} = -V_{sat}$$

$$V_c(t_2) = -V_{sat} + [\beta V_{sat} - (-V_{sat})]\, e^{-t_2/RC}$$

$$-\beta V_{sat} = -V_{sat} + V_{sat} \times (1+\beta) \times e^{-t_2/RC}$$

$$\frac{1-\beta}{1+\beta} = e^{-t_2/RC}$$

$$\Rightarrow t_2 = RC \times \ln\left(\frac{1+\beta}{1-\beta}\right)$$

$$T = t_1 + t_2 = 2t_1 = 2RC \ln\left(\frac{1+\beta}{1-\beta}\right)$$

ASTABLE MULTIVIBRATOR

Derivation of Time Period (T=t1+t2)

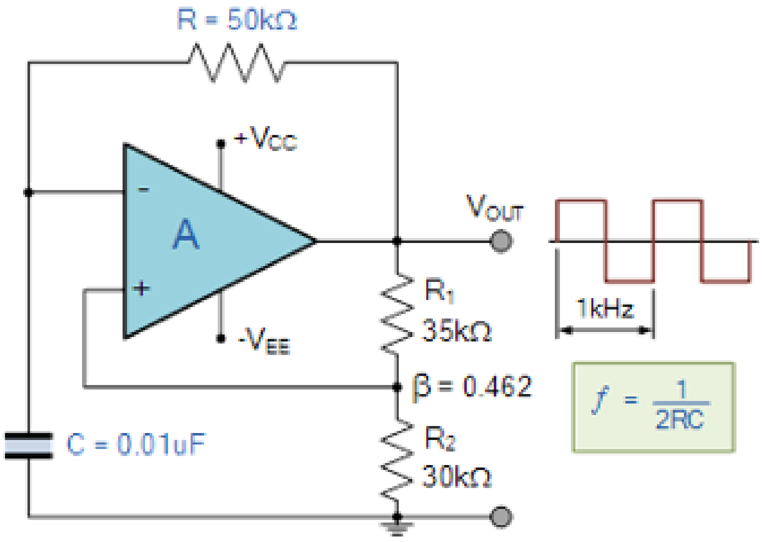
Calculation of discharging time-t_2

Design Problem-1

An op-amp multivibrator circuit is constructed using the following components.
R1 = 35 kΩ, R2 = 30 kΩ, R = 50 kΩ and C = 0.01 uF and powered with Vcc = 11V, V_{EE} = -11V DC supply.
Calculate the circuits frequency of oscillation.

Design Problem-1

An **op-amp multivibrator circuit** is constructed using the following components. R1 = 35kΩ, R2 = 30kΩ, R = 50kΩ and C = 0.01uF and powered with Vcc=11V, VEE=-11V DC supply. Calculate the circuits frequency of oscillation.



$$\beta = \frac{R2}{R1 + R2} = \frac{30k\Omega}{35k\Omega + 30k\Omega} = 0.462$$

$$T = 2RC\ln\left(\frac{1+\beta}{1-\beta}\right) = 2RC\ln\left(\frac{1+0.462}{1-0.462}\right)$$

$$T = 2\times(50k\Omega\times 0.01uF)\times\ln(2.717)$$

$$\therefore T = 0.001\times 1 = 0.001\,\text{Sec} \quad \text{or} \quad 1\text{mS}$$

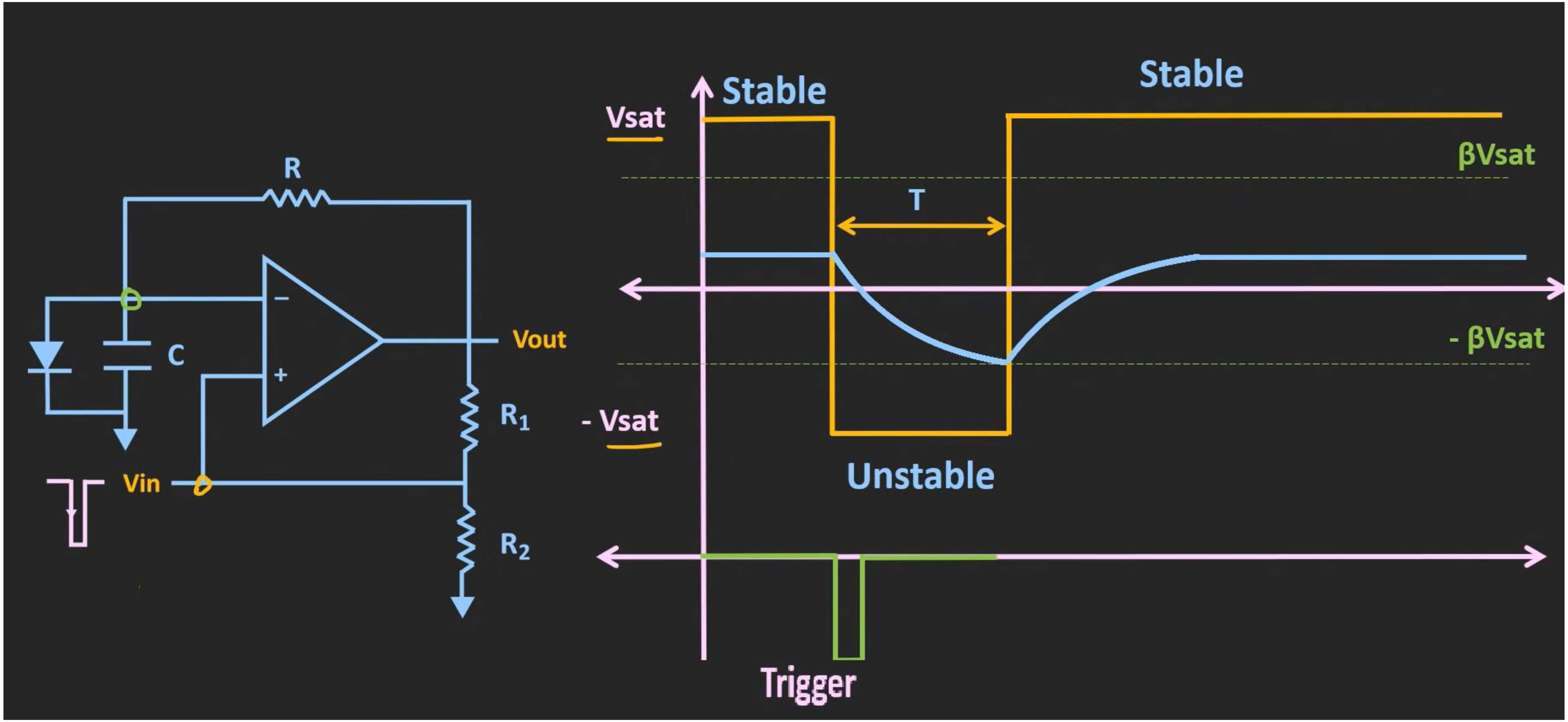
$$\therefore\ f = \frac{1}{T} = \frac{1}{0.001} = 1{,}000\text{Hz} \quad \text{or} \quad 1\text{kHz}$$

LIC: LECTURE
Signal Generators

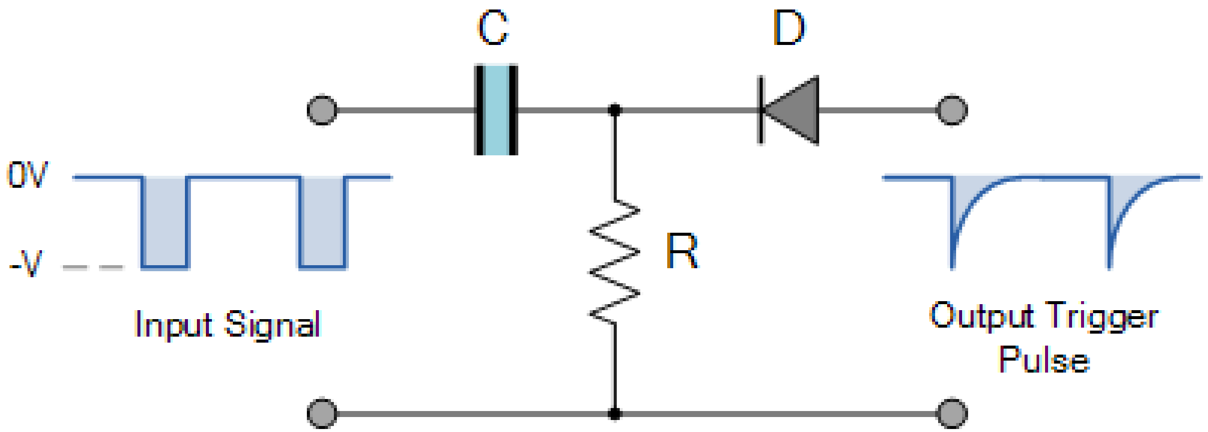
- ✓ Astable Multivibrator
  - ✓ Working Principal
  - ✓ Calculation of Time Period
  - ✓ Design Example
- **Monostable Multivibrator**
  - Working Principal
  - Calculation of Time Period and Recovery Time
  - Design Example

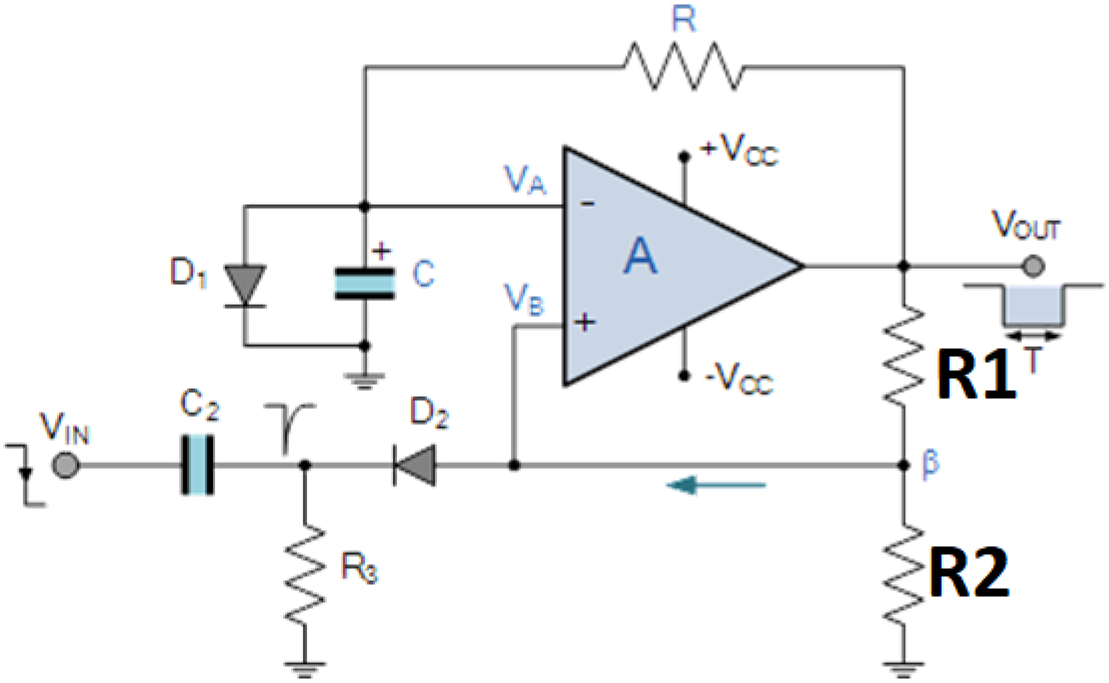
MONOSTABLE MULTIVIBRATOR

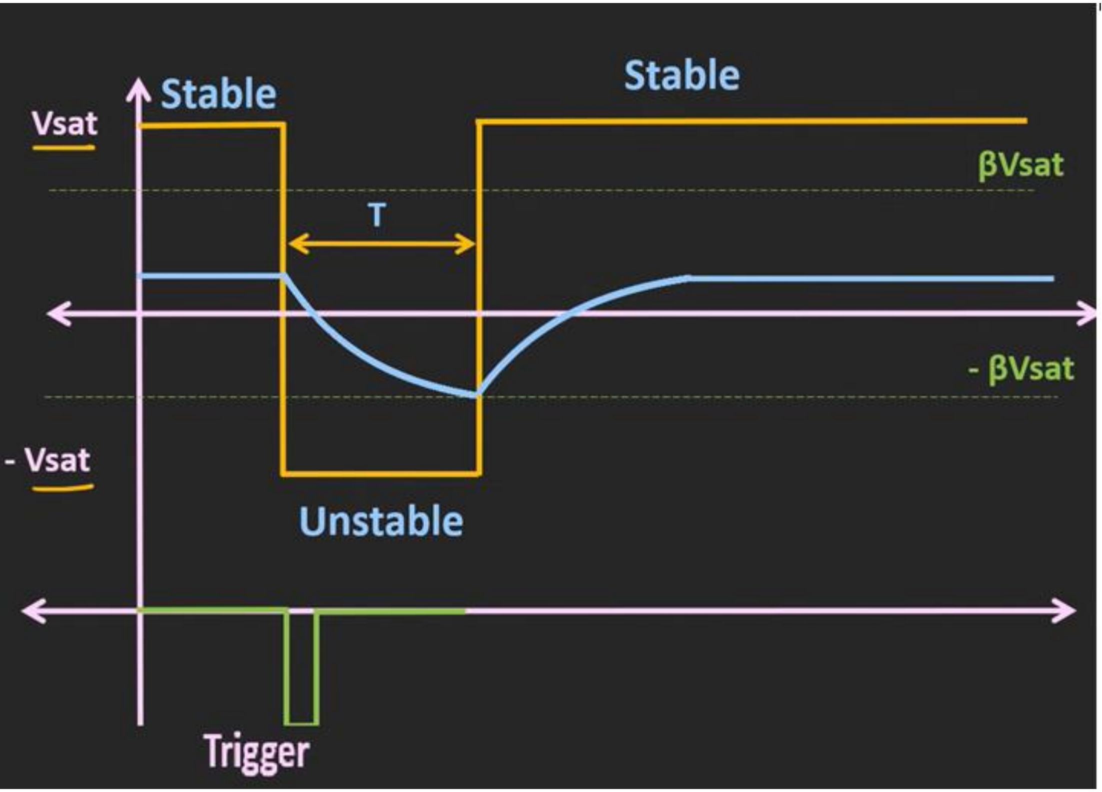
(1 STABLE & 1 QUASI-STABLE STATE-One Shot Multivibrator)



RC Differentiator Circuit







MONOSTABLE MULTIVIBRATOR

Derivation of Time Period (T) for unstable state (Pulse Width)

$$V_C(t) = V_{FINAL} + (V_{initial} - V_{FINAL})\, e^{-t/RC}$$

$$\left.\begin{aligned} V_{FINAL} &= -V_{SAT} \\ V_{INITIAL} &= V_D \\ V_C(t) &= -\beta V_{SAT} \end{aligned}\right\}$$

$$-\beta V_{SAT} = -V_{SAT} + (V_D - (-V_{SAT}))\, e^{-t/RC}$$

$$-\beta V_{SAT} = -V_{SAT} + (V_D + V_{SAT})\, e^{-t/RC}$$

$$V_{SAT} - \beta V_{SAT} = (V_D + V_{SAT})\, e^{-t/RC}$$

$$e^{-t/RC} = \frac{V_{SAT}[1-\beta]}{V_{SAT} - \beta V_{SAT}}$$

$$e^{-t/RC} = \frac{V_{SAT}[1-\beta]}{V_D + V_{SAT}} = \frac{V_{SAT}}{V_{SAT}}\left[\frac{1-\beta}{1+V_D/V_{SAT}}\right]$$

$$e^{-t/RC} = \frac{1-\beta}{1+\frac{V_D}{V_{SAT}}}$$ taking natural log

$$-\frac{t}{RC} = \ln\left[\frac{1-\beta}{1+V_D/V_{SAT}}\right]$$

$$\boxed{t = RC \ln\left[\frac{1+V_D/V_{SAT}}{1-\beta}\right]}\ *$$

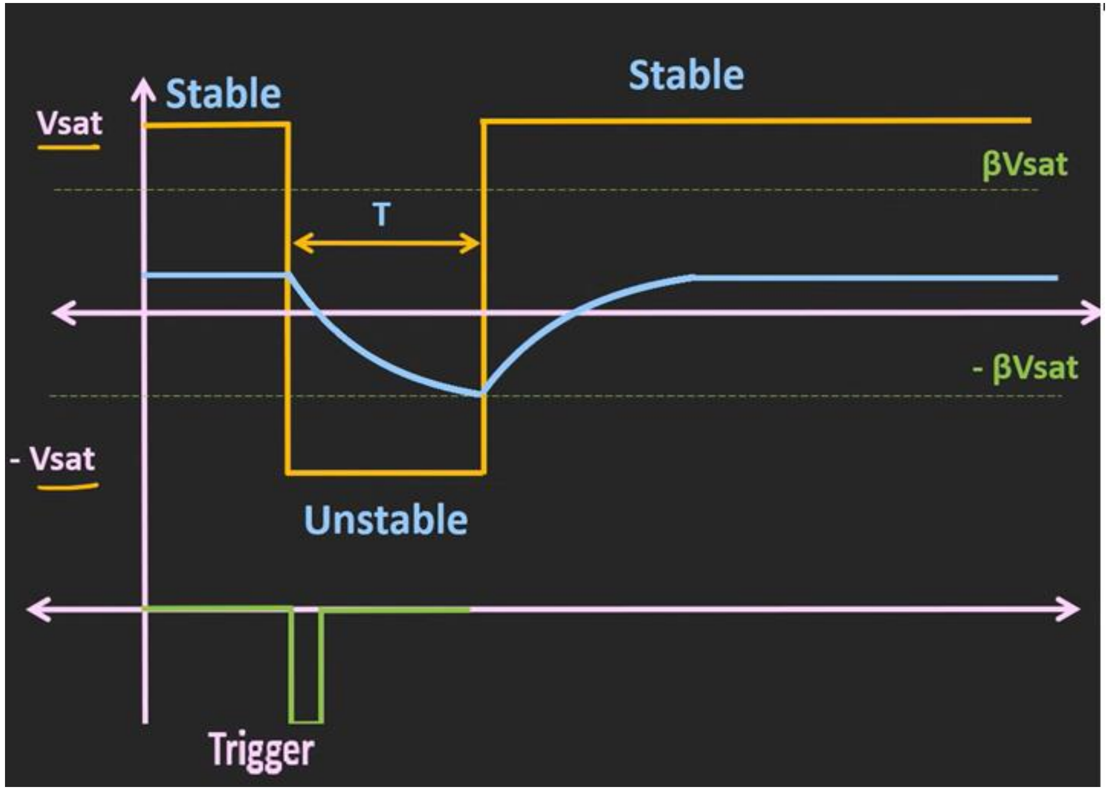
DISCHARGING time

$V_D \ll |-V_{SAT}|$

If $V_D = 0$ & $\beta = R_2/(R_1+R_2)$

$$t = RC \ln\left[\frac{1+0}{1 - R_2/(R_1+R_2)}\right]$$

$$\boxed{t = RC \ln(1 + R_2/R_1)}\ *$$



MONOSTABLE MULTIVIBRATOR

Derivation of Charging Time/Capacitor Recovery Time - Stable State

$$V_c(t) = V_{final} + (V_{initial} - V_{final})\, e^{-t/RC}$$

$$V_{FINAL} = V_{SAT}$$

$$V_{initial} = -\beta V_{SAT}$$

$$V_c(t) = V_D$$

$$V_D = V_{SAT} + (-\beta V_{SAT} - V_{SAT})\, e^{-t/RC}$$

$$V_D - V_{SAT} = -V_{SAT}[1+\beta]\, e^{-t/RC}$$

$$e^{-t/RC} = \frac{-(V_D - V_{SAT})}{V_{SAT}[1+\beta]}$$

taking natural log

$$-\frac{t}{RC} = \ln \frac{V_{SAT} - V_D}{V_{SAT}[1+\beta]}$$

$$t = -RC \ln \frac{1 - V_D/V_{SAT}}{1+\beta}$$

$$\boxed{t = RC \ln \frac{1+\beta}{1-(V_D/V_{SAT})}}$$

An op-amp monostable circuit is constructed using the following components. R1 = 30kΩ, R2 = 30kΩ, R = 150kΩ and C = 1.0uF. If the op-amp monostable is supplied from a ±12V supply and the timing period is initiated with a 10ms pulse. Calculate the circuits timing period, capacitor recovery time, total time between trigger pulses and the differentiator network values. Draw the completed circuit.

Data given: R1 = R2 = 30kΩ, R = 150kΩ, C = 1.0uF and pulse width equals ten milliseconds, (10ms).

$$\beta = \frac{R_1}{R_1 + R_2} = \frac{30k\Omega}{30k\Omega + 30k\Omega} = 0.5$$

$$T = RC.\ln\left(1 + \frac{R_1}{R_2}\right)$$

$$= RC \times \ln\left(1 + \frac{30k\Omega}{30k\Omega}\right)$$

$$= 150k\Omega \times 1.0uF \times 0.693$$

$$T = 0.104\,\text{secs or } \underline{104ms}$$

$$T_{(charging)} = RC \times \ln\left(\frac{1+\beta}{1 - \frac{V_D}{V_{CC}}}\right)$$

$$T_{(charging)} = RC \times \ln\left(\frac{1+0.5}{1 - \frac{0.7}{12}}\right)$$

$$\therefore T_{(ch.)} = 150k\Omega \times 1.0uF \times 0.465 = \underline{70ms}$$

$$T_{(total)} = T_{(delay)} + T_{(charging)}$$

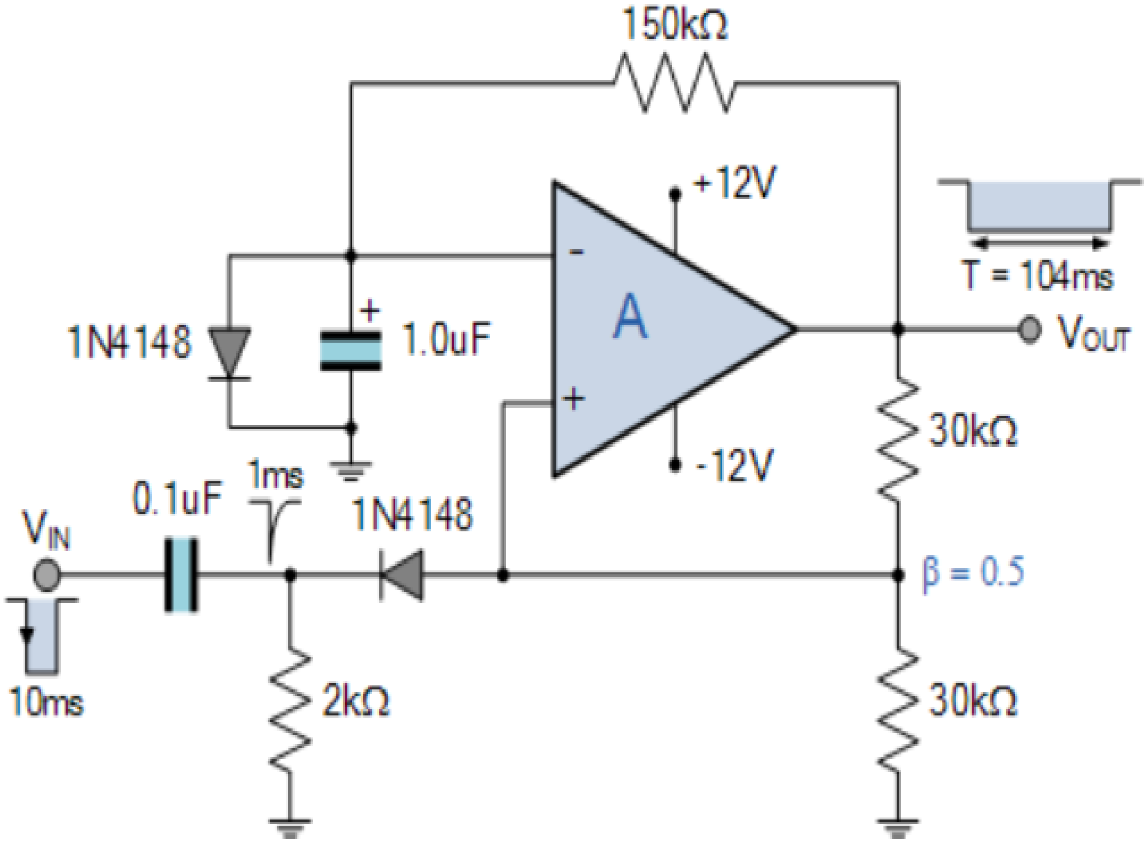
$$\therefore T_{(total)} = 104ms + 70ms = 174ms$$

The input pulse is given as 10ms, therefore the negative spike duration will be 1m (10%). If we assume a capacitance value of 0.1uF, then the differentiator RC values calculated as :

$$\text{Pulse width} = 1\text{ms} = 5RC$$

$$\text{If } C = 0.1\text{uF}$$

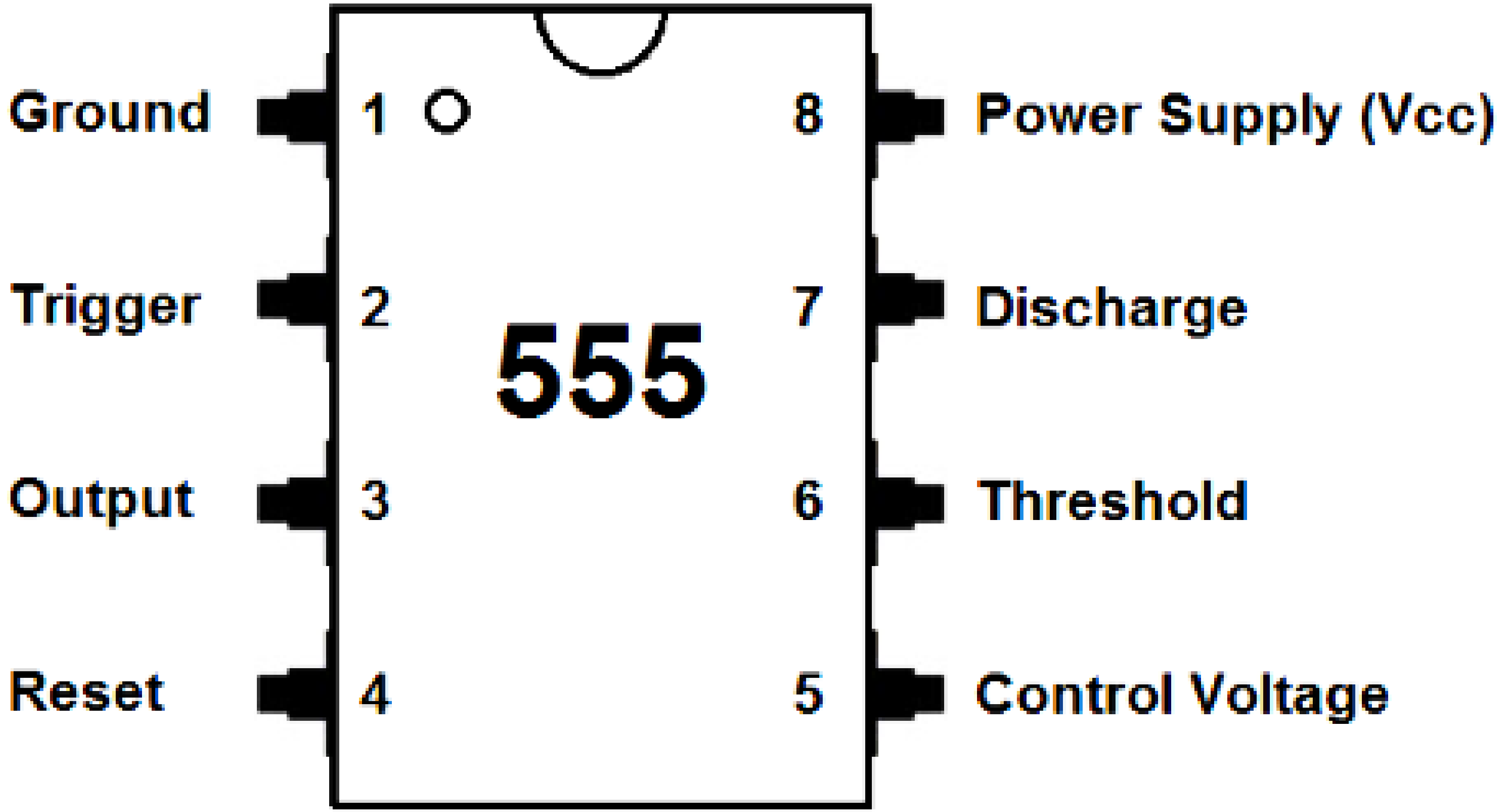
$$R = \frac{1\text{ms}}{5 \times 0.1\text{uF}} = 2000\Omega \text{ or } 2\text{k}\Omega$$



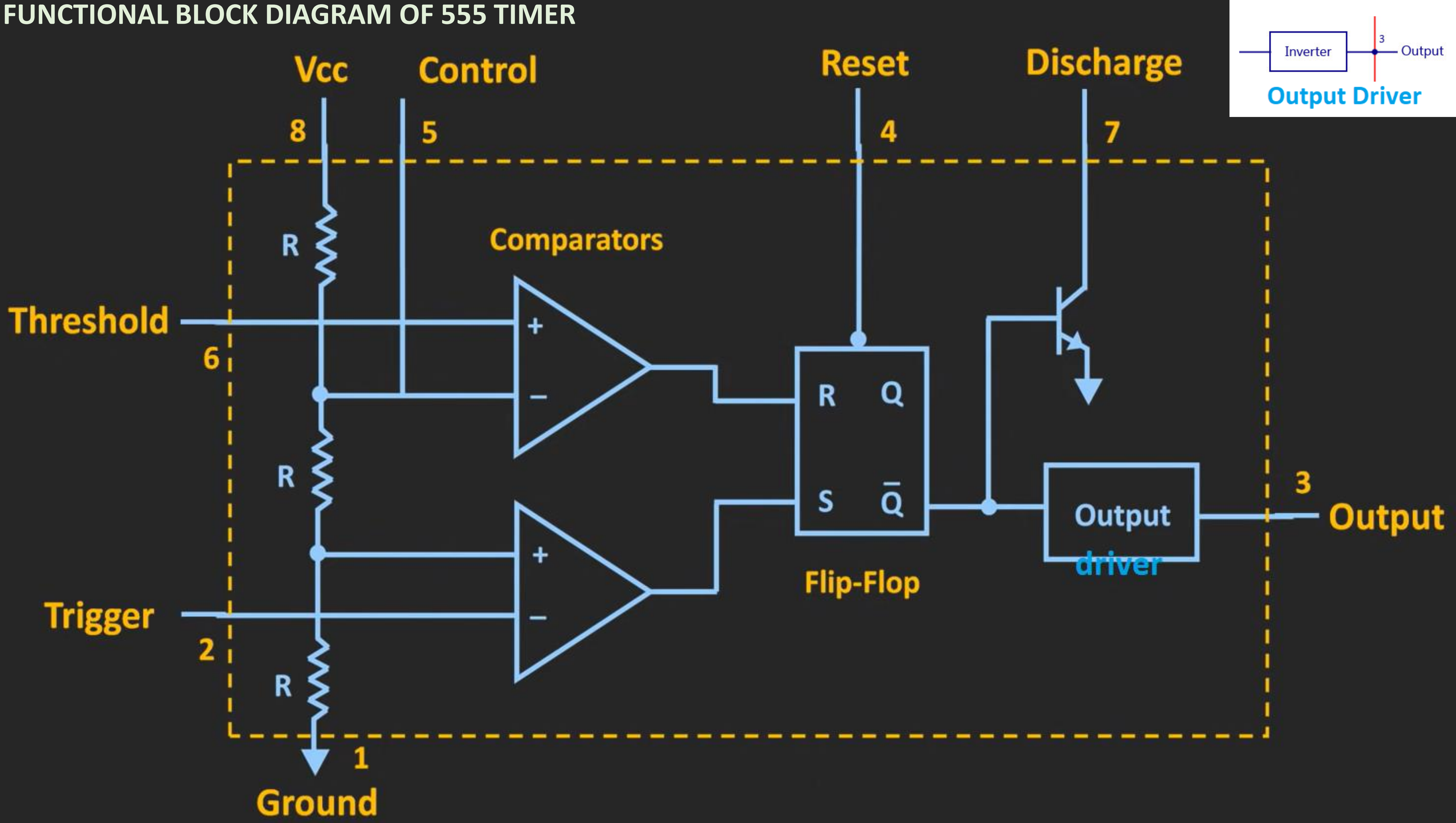
LIC: LECTURE
Signal Generators

- ✓ Monostable Multivibrator using op-Amp
  - ✓ Working Principal
  - ✓ Calculation of Time Period and Recovery Time
  - ✓ Design Example
- 555 Time IC
  - Pin Configuration
  - Internal Block Diagram
- Astable Multivibrator using Timer IC

PIN DIAGRAM


Ground
1
Trigger
2
Output
3
Reset
4
555
8
Power Supply (Vcc)
7
Discharge
6
Threshold
5
Control Voltage

FUNCTIONAL BLOCK DIAGRAM OF 555 TIMER



ASTABLE MULTIVIBRATOR USING 555 TIMER

1 - Ground

2 - Trigger

3 - Output

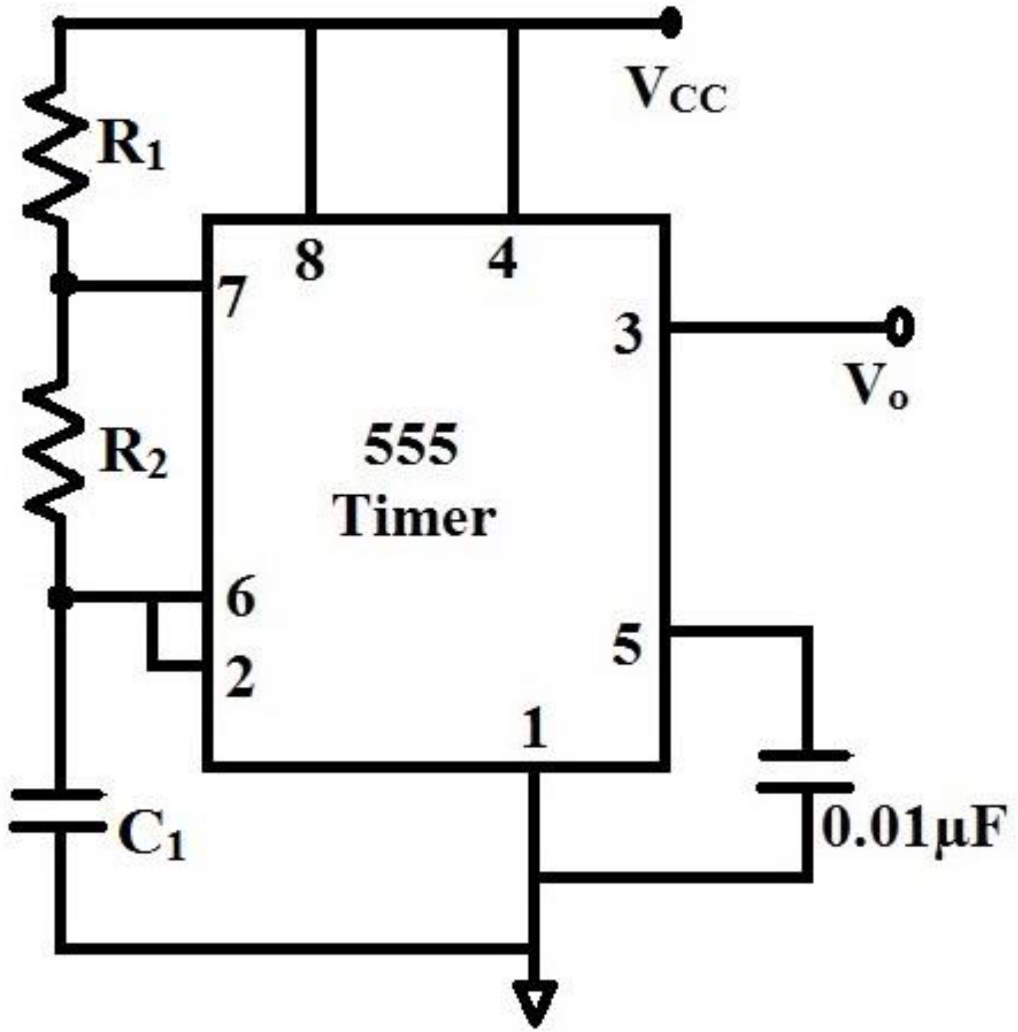
4 - Reset

5 - Control

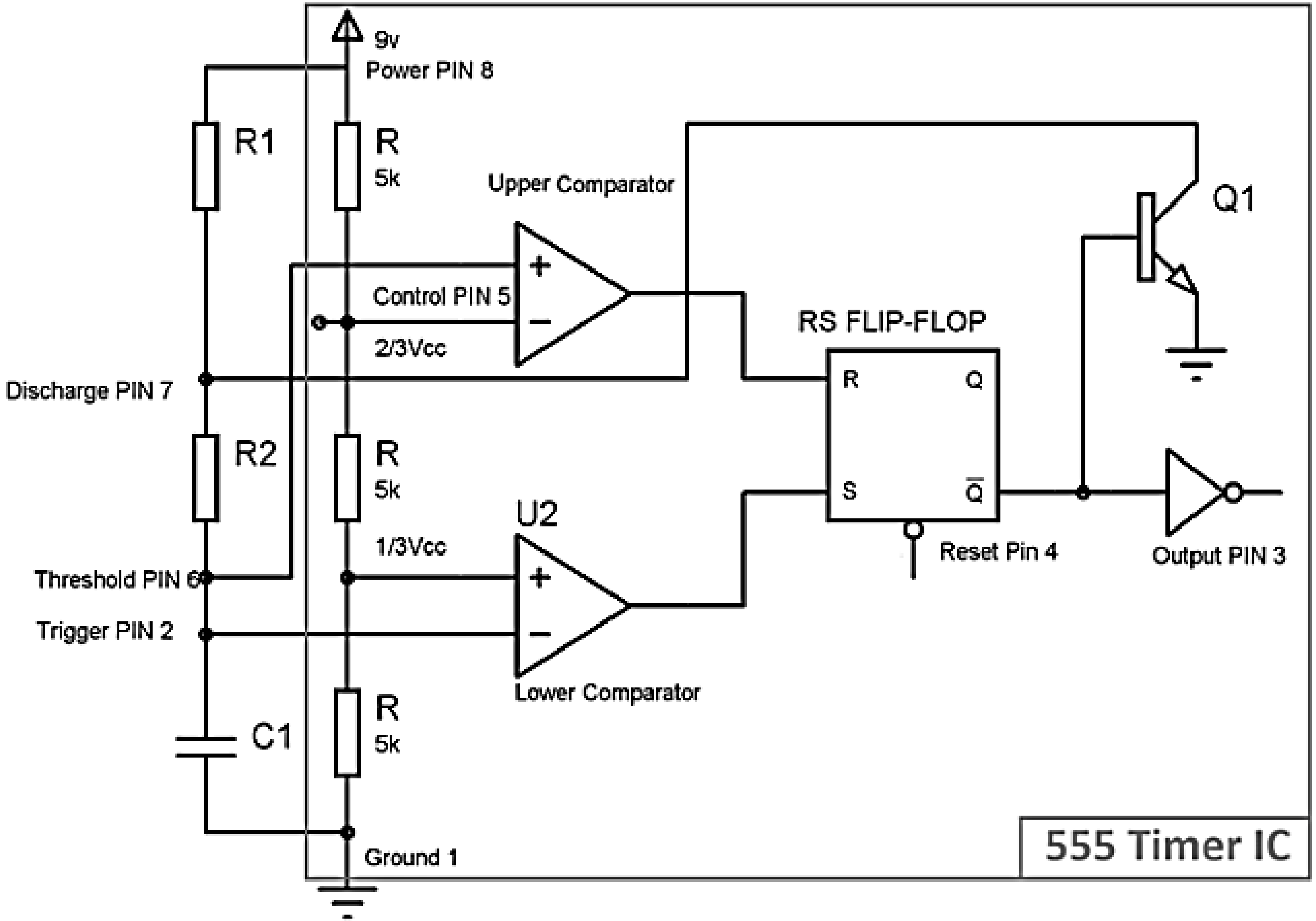
6 - Threshold

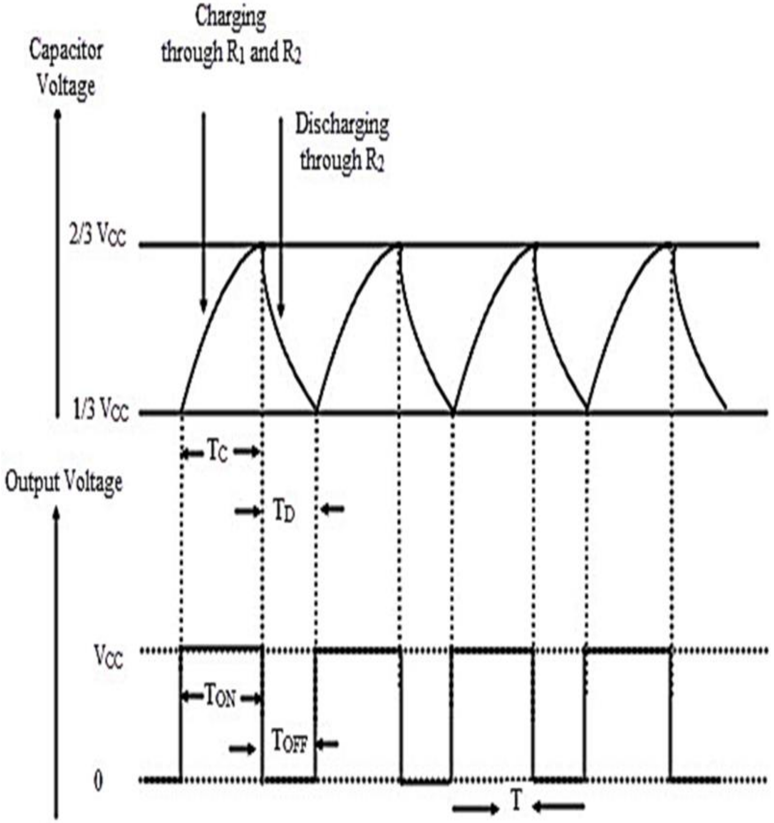
7 - Discharge

8 - Vcc

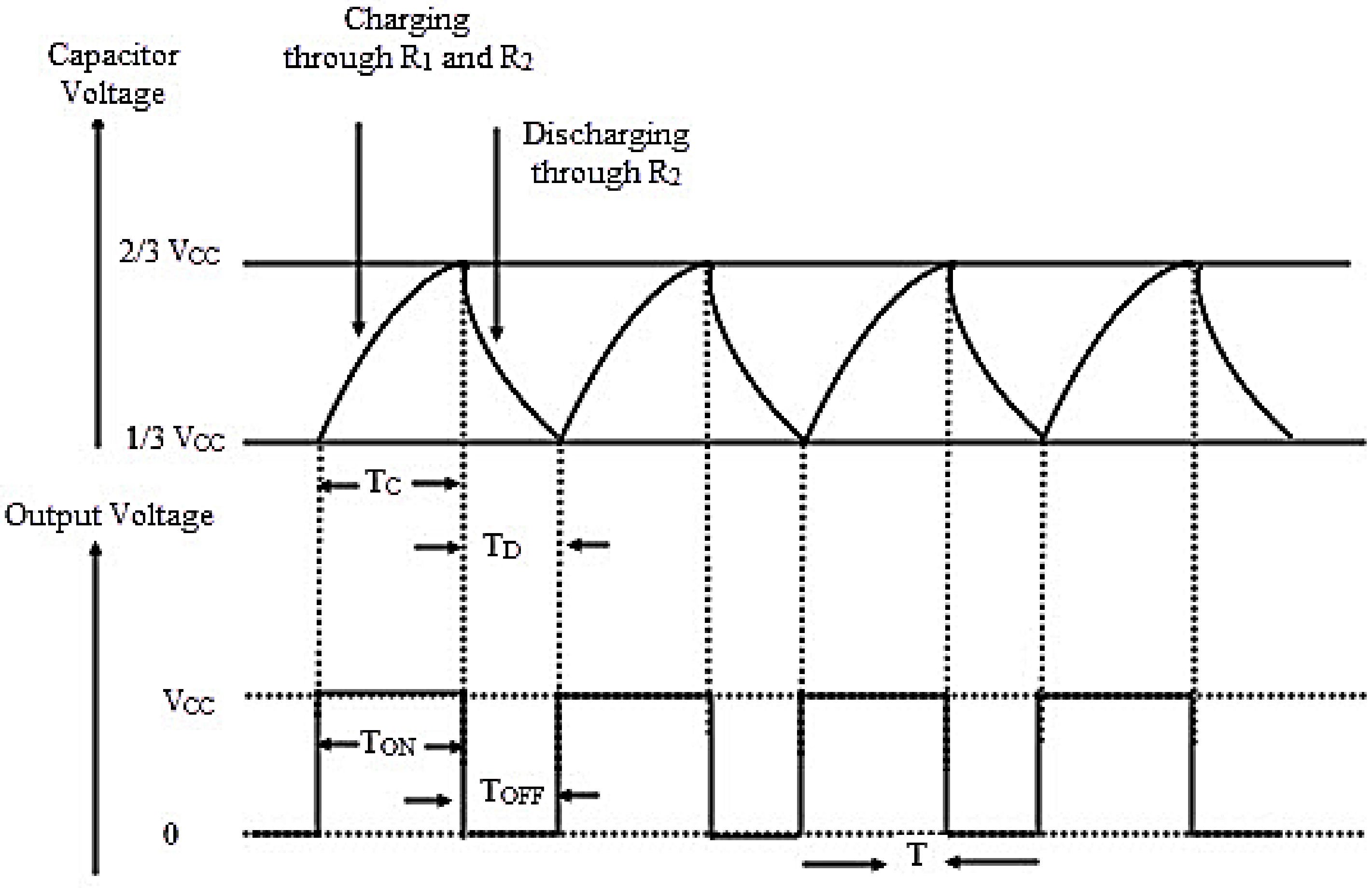


FUNCTIONAL BLOCK DIAGRAM OF ASTABLE MULTIVIBRATOR





TIMING PULSES



DERIVATION FOR THE EXPRESSION OF DUTY CYCLE

$$V_C = V_{CC}\left(1 - e^{-t/RC}\right)$$

- Time taken, t_1 by the circuit to charge from 0 - $\frac{2}{3}V_{CC}$,

$$\frac{2}{3}V_{CC} = V_{CC}\left(1 - e^{-t_1/RC}\right)$$

$\Rightarrow$

$$\boxed{t_1 = 1.099RC}$$

- Time taken, t_2 by the circuit to charge from 0 - $\frac{1}{3}V_{CC}$,

$$\frac{1}{3}V_{CC} = V_{CC}\left(1 - e^{-t_2/RC}\right)$$

$$\boxed{t_2 = 0.405RC}$$

- Time to charge from $\frac{1}{3}V_{CC}$ to $\frac{2}{3}V_{CC}$,

$$T_C = t_1 - t_2$$

$$\boxed{T_C = 0.69(R_1 + R_2)C}$$

- Capacitor discharges from $\frac{2}{3}V_{CC}$ to $\frac{1}{3}V_{CC}$.

$$\frac{1}{3}V_{CC} = \frac{2}{3}V_{CC}e^{-t/_{RC}}$$

- Solving the equation we get ,

t = 0.69 $T_D = 0.69\ R_2C$

- Total time,

$$T = T_C + T_D$$

$$T = 0.69\ (R_1 + 2R_2)C$$

$$f = \frac{1.45}{(R_1+2R_2)C}$$

- Duty cycle,

$$D\% = \frac{T_C}{T} \times 100\%$$

$$\Rightarrow D\% = \left(\frac{R_1 + R_2}{R_1 + 2\,R_2}\right) \times 100\%$$

T = 0.69 $(R_1 + 2R_2)C$

f = $\frac{1.45}{(R_1+2R_2)C}$

EXAMPLE 10.3. In the circuit of Fig. 10.16 specify suitable components for $f_0 = 50$ kHz and $D(\%) = 75\%$.

Solution. Let $C = 1$ nF, so that $R_A + 2R_B = 1.44/(f_0 C) = 28.85$ kΩ. Imposing $(R_A + R_B)/(R_A + 2R_B) = 0.75$ gives $R_A = 2R_B$. Solving gives $R_A = 14.4$ kΩ (use 14.3 kΩ) and $R_B = 7.21$ kΩ (use 7.15 kΩ).

Q1) For a astable multivibrator using 555 timer, R_1= 6.8kΩ, R_2 = 3.3kΩ and C = 0.1µF. Calculate (a) t_{HIGH}, (b) t_{LOW}, (c) free running frequency and (d) duty cycle, D.

Ans :-

(a) t_{HIGH} = 0.7ms

(b) t_{LOW} = 0.23ms

(c) f = 1.07kHz

(d) D = 0.75 or 75%

LIC: LECTURE
Signal Generators

- ✓ 555 Time IC
  - ✓ Pin Configuration
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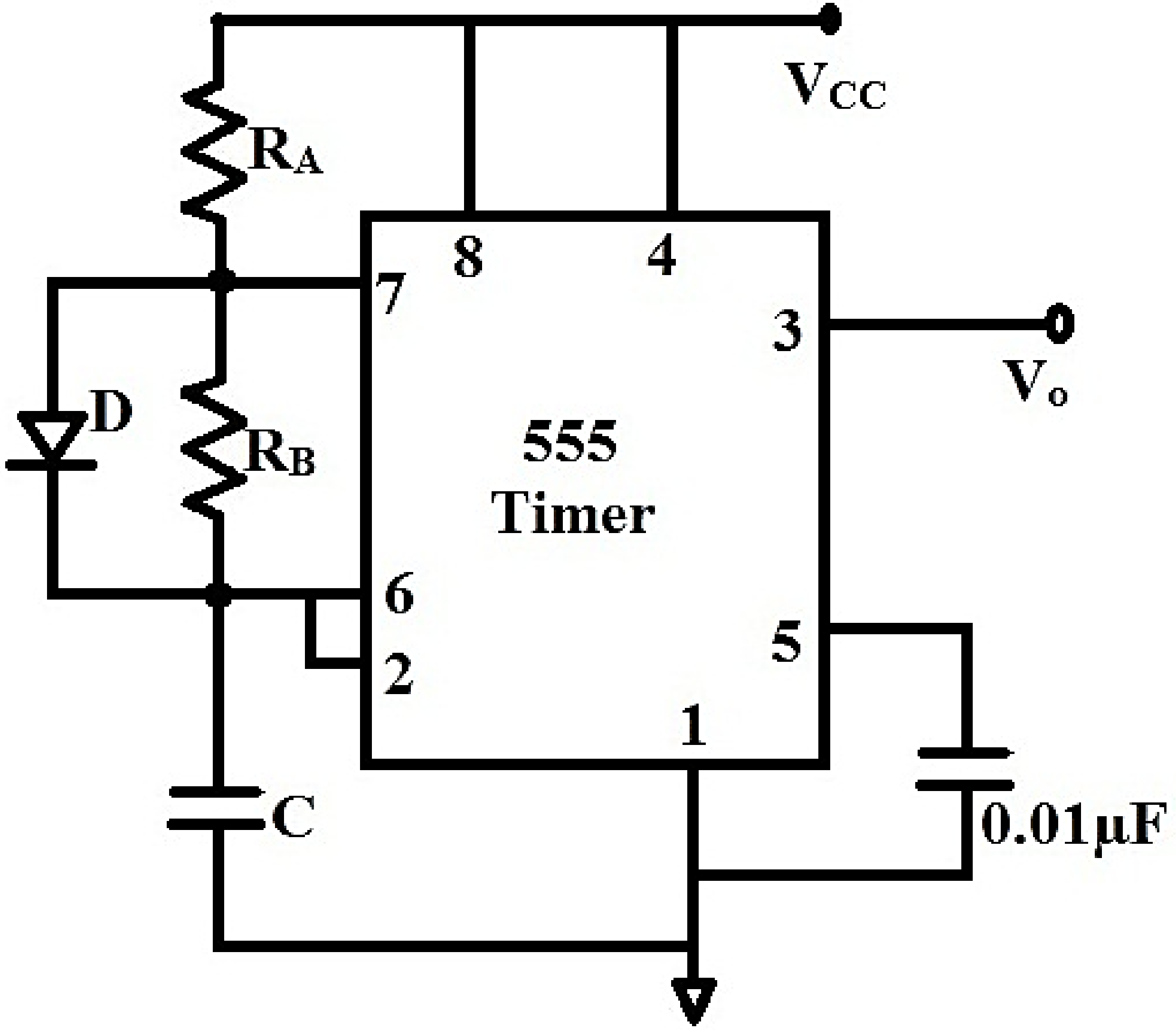
- ✓ Astable Multivibrator using Timer IC
  - Design Example
- Bistable Multivibrator using Timer IC
  - Applications

ADJUSTABLE DUTY CYCLE MULTIVIBRATOR



DUTY CYCLE DERIVATION

- During charging,

$$T_C = 0.69\, R_A\, C$$

- During discharge,

$$T_D = 0.69\, R_B\, C$$

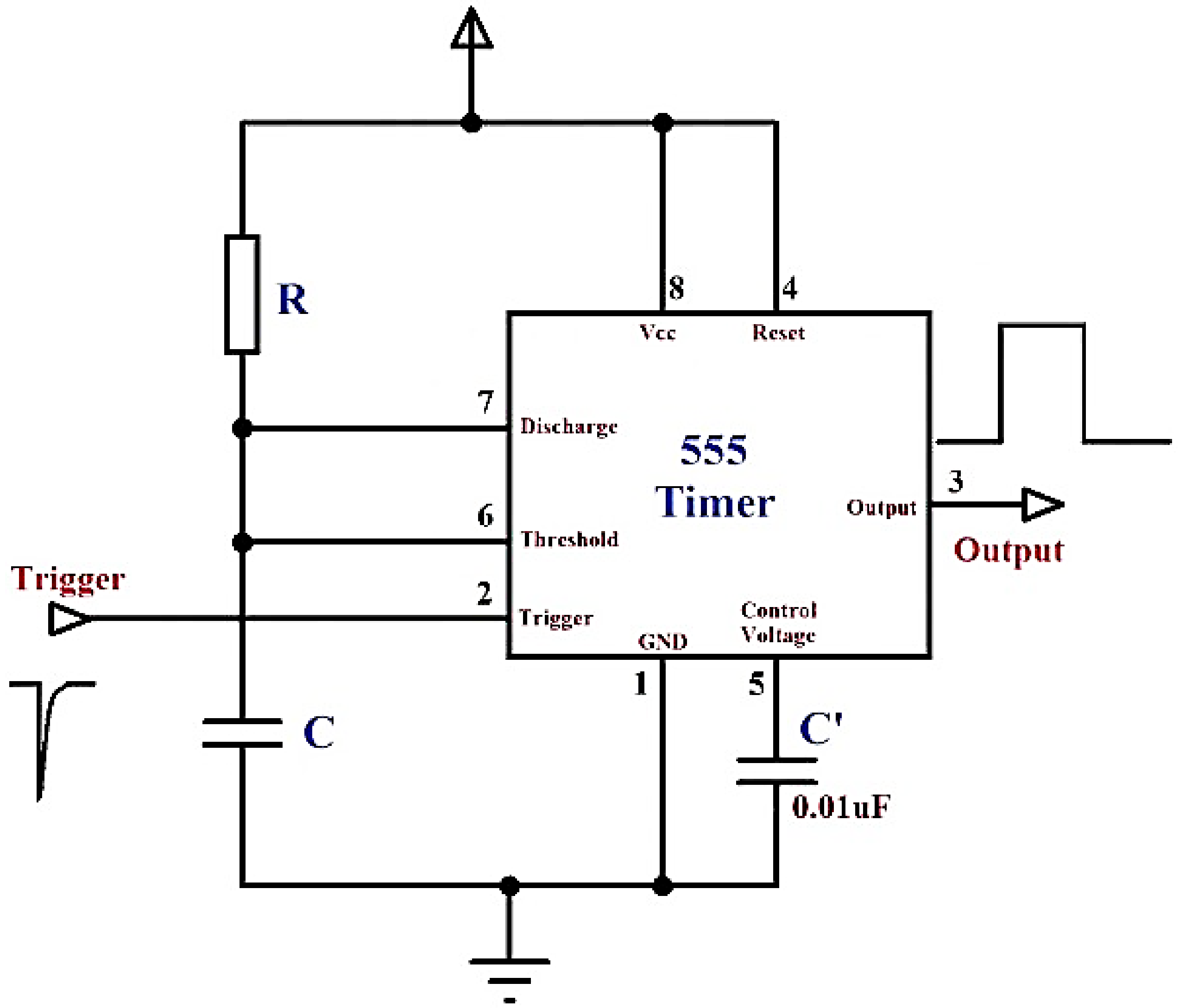
- Therefore, total time period T is,

$$T = 0.69\,(R_A + R_B)C$$

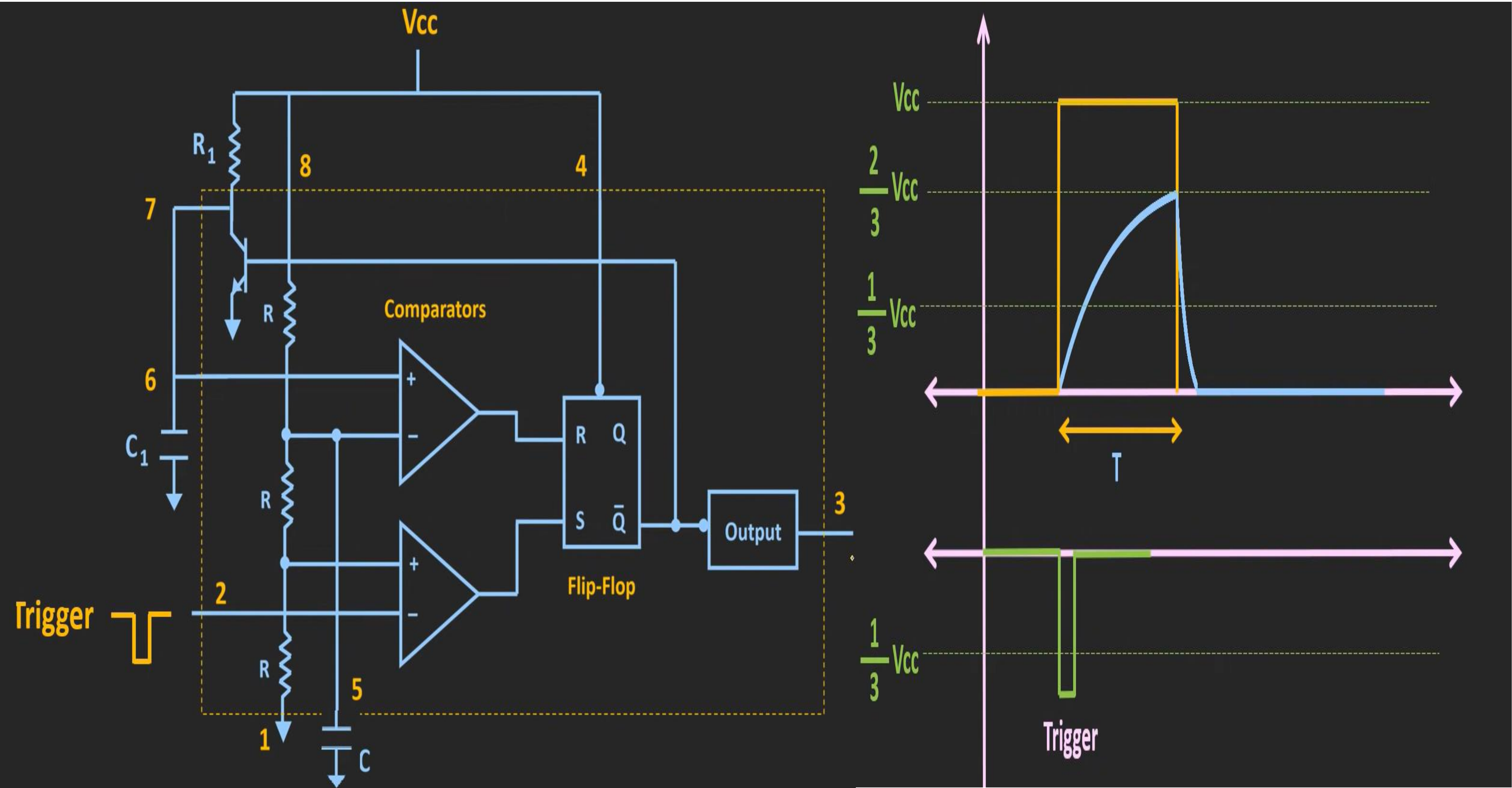
$$\boxed{f = \frac{1.45}{(R_A + R_B)C}}$$

$$\boxed{D = \frac{R_A}{R_A + R_B}}$$

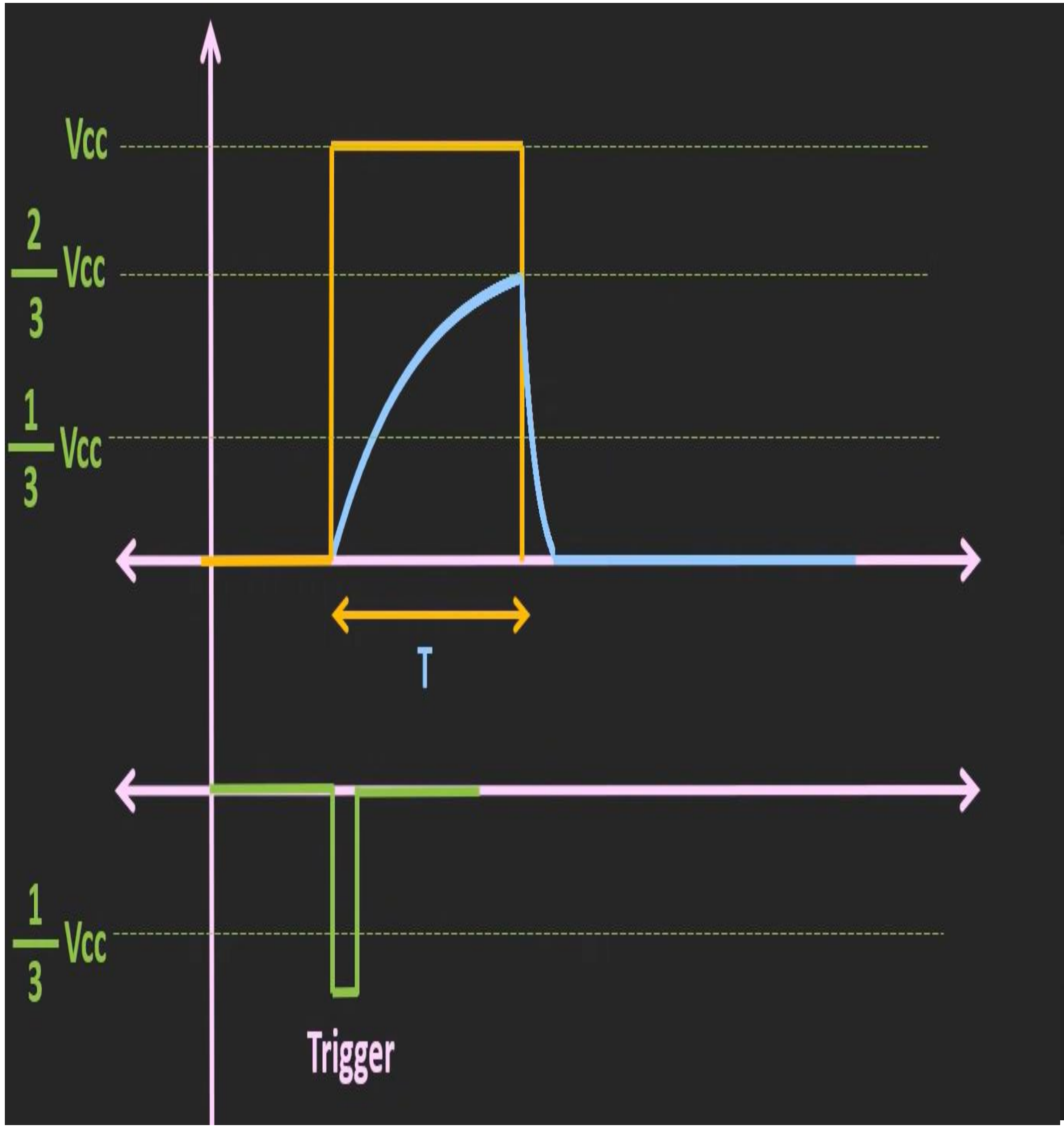
MONOSTABLE MULTIVIBRATOR USING 555 TIMER



FUNCTIONAL BLOCK DIAGRAM OF MONOSTABLE MULTIVIBRATOR



TIME PERIOD DERIVATION



$$V_c(t) = V_0(1 - e^{-t/RC})$$

$$V_c(t) = V_F + (V_I - V_F)e^{-t/RC}$$

$$= V_{cc} + (0 - V_{cc})e^{-t/RC}$$

$$V_c(t) = V_{cc} \times (1 - e^{-t/RC})$$

$$\frac{1}{3} = e^{-t_1/RC}$$

$$\ln\left(\frac{1}{3}\right) = -\frac{t_1}{RC}$$

$$\Rightarrow t_1 = RC \times \ln(3)$$

$$t_1 \simeq 1.1\,RC$$

Q2) Design a monostable multivibrator using 555 timer to produce a pulse width of 100ms. Calculate the value of R by assuming the values of $C = 0.47\mu F$.

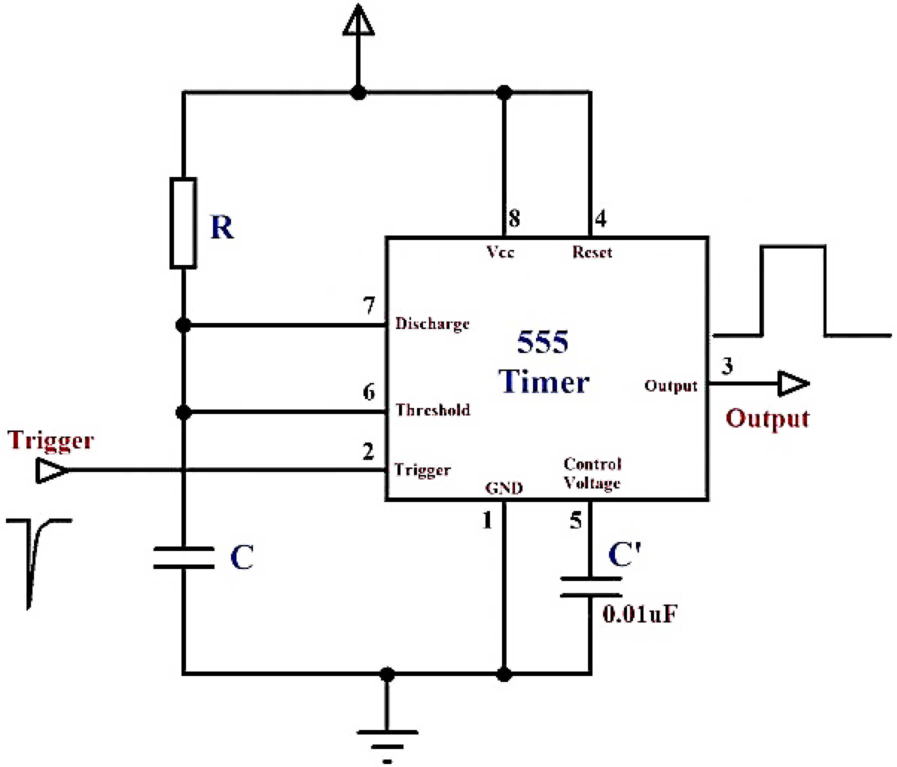
Ans: -

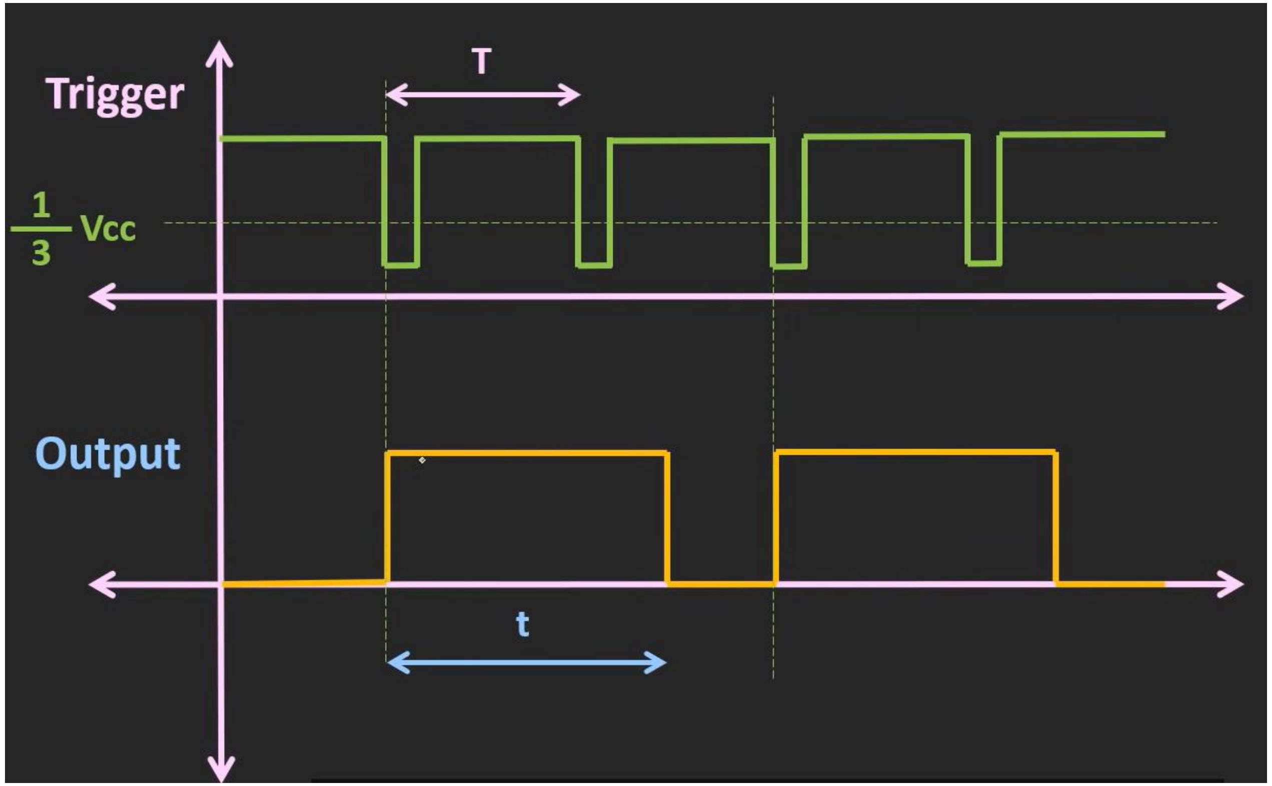
$$T = 1.1\ RC$$

$$R = 193.423 k\Omega$$

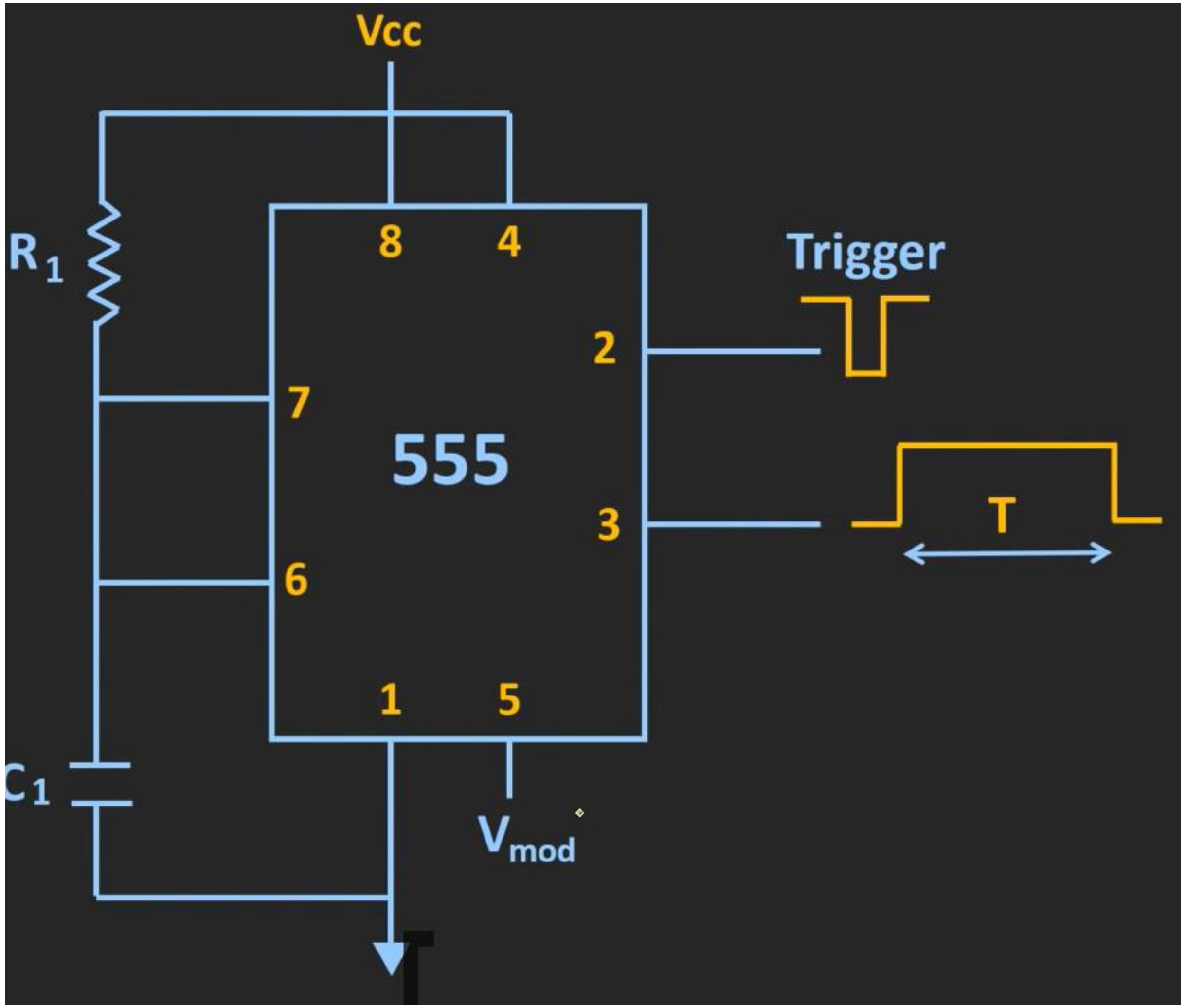
APPLICATION OF MONOSTABLE MULTIVIBRATOR

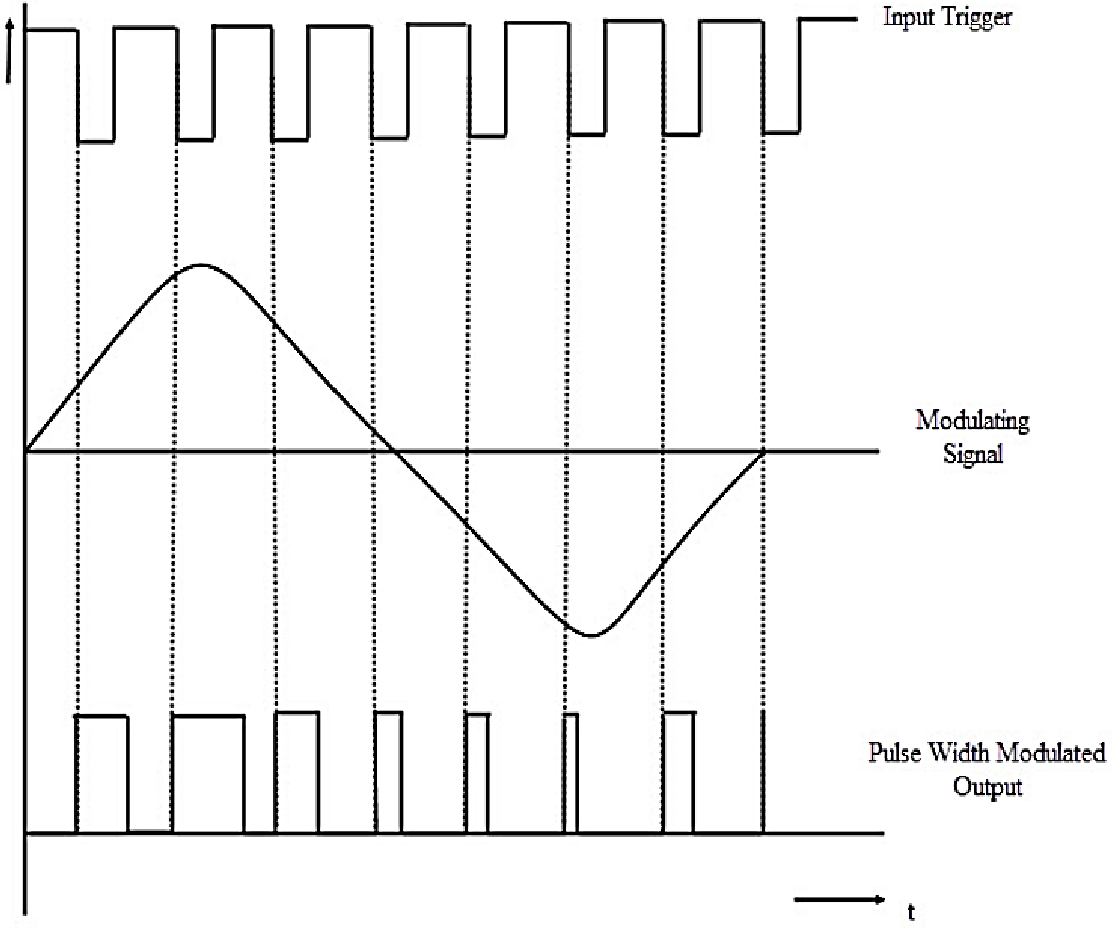
Frequency Divider



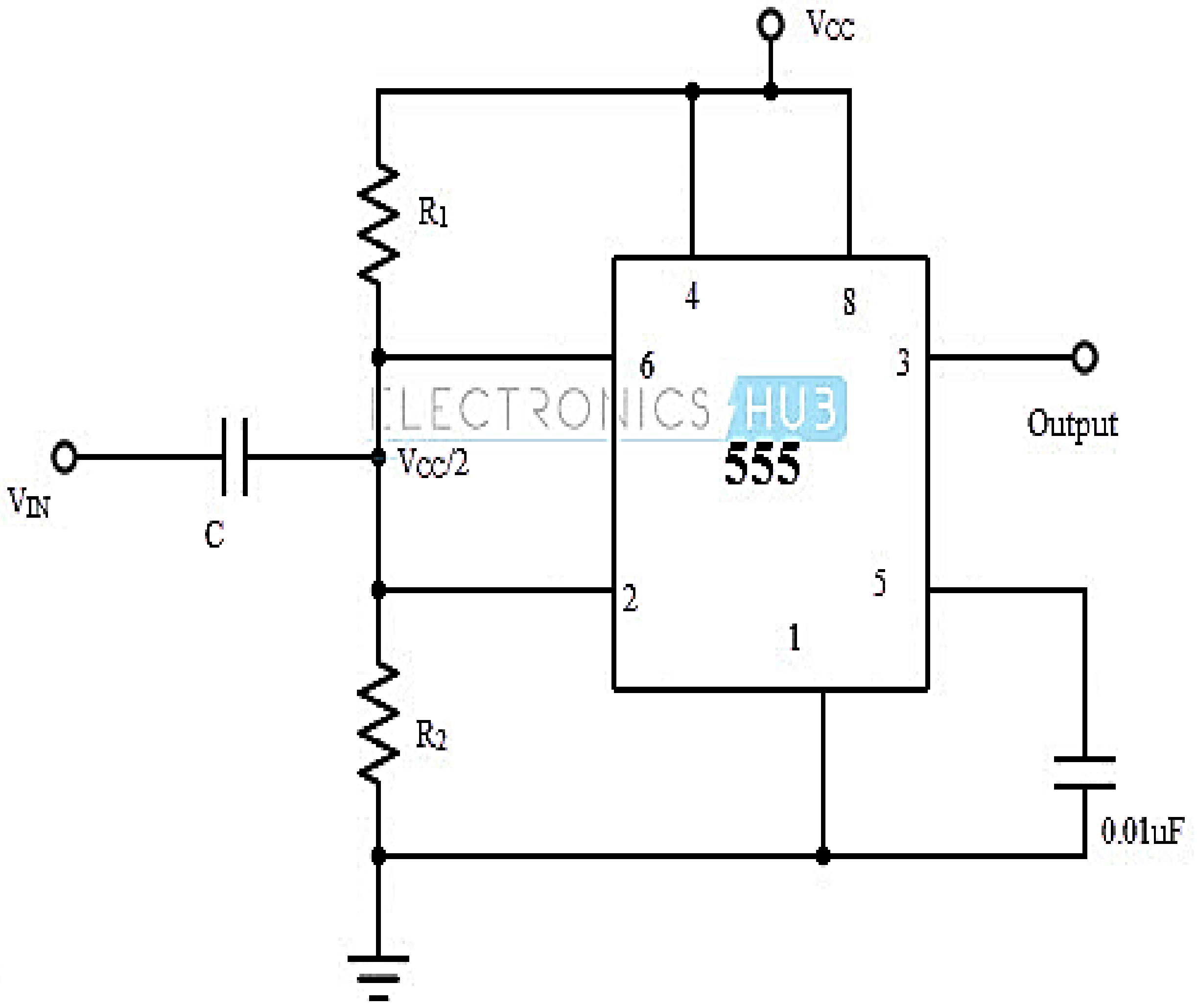


Pulse Width Modulation

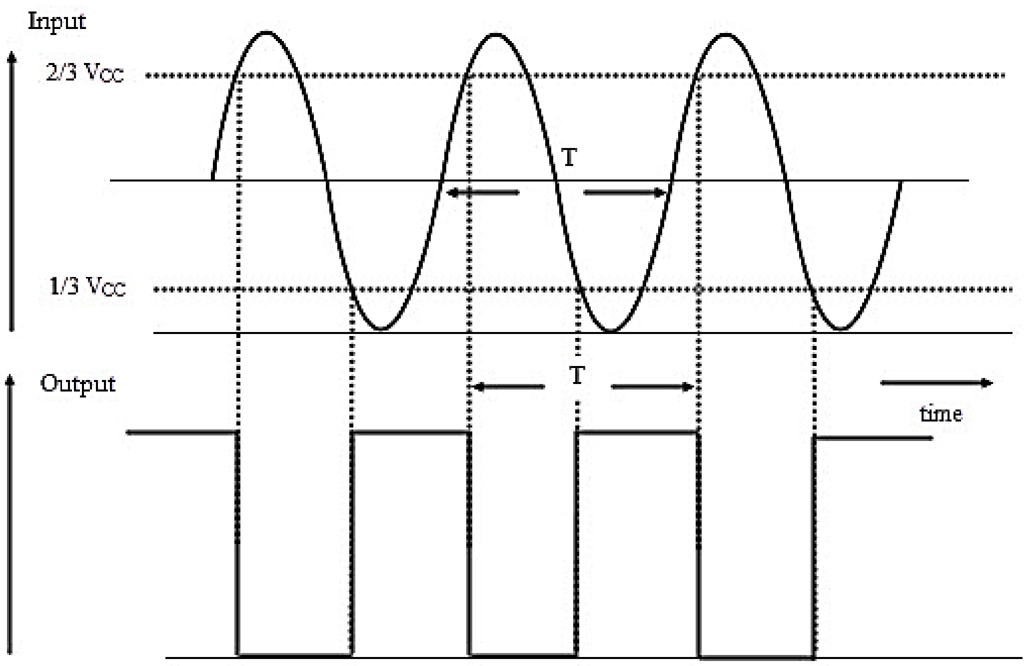




SCHMITT TRIGGER



TIMING PULSES



LIC: LECTURE
Signal Generators

- ✓ **Design of Multivibrators using Timer IC**
  - ✓ **Different Applications**

- **Sine Wave Generation Using Op-Amp**
  - **Circuit**
  - **Derivation of frequency of operation**
- **Triangular Wave Generation Using Op-Amp**
  - **Circuit**
  - **Derivation of frequency of operation**

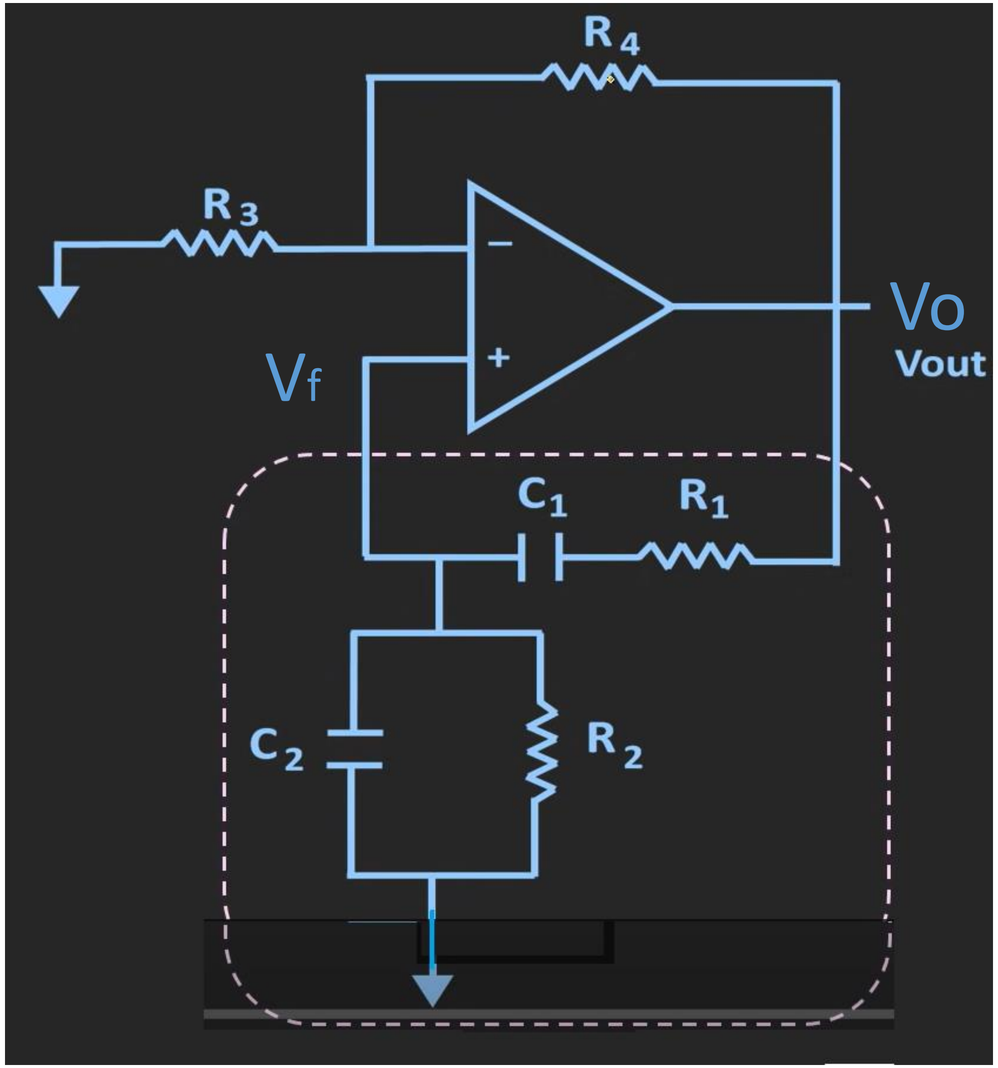
Sine Wave Generation

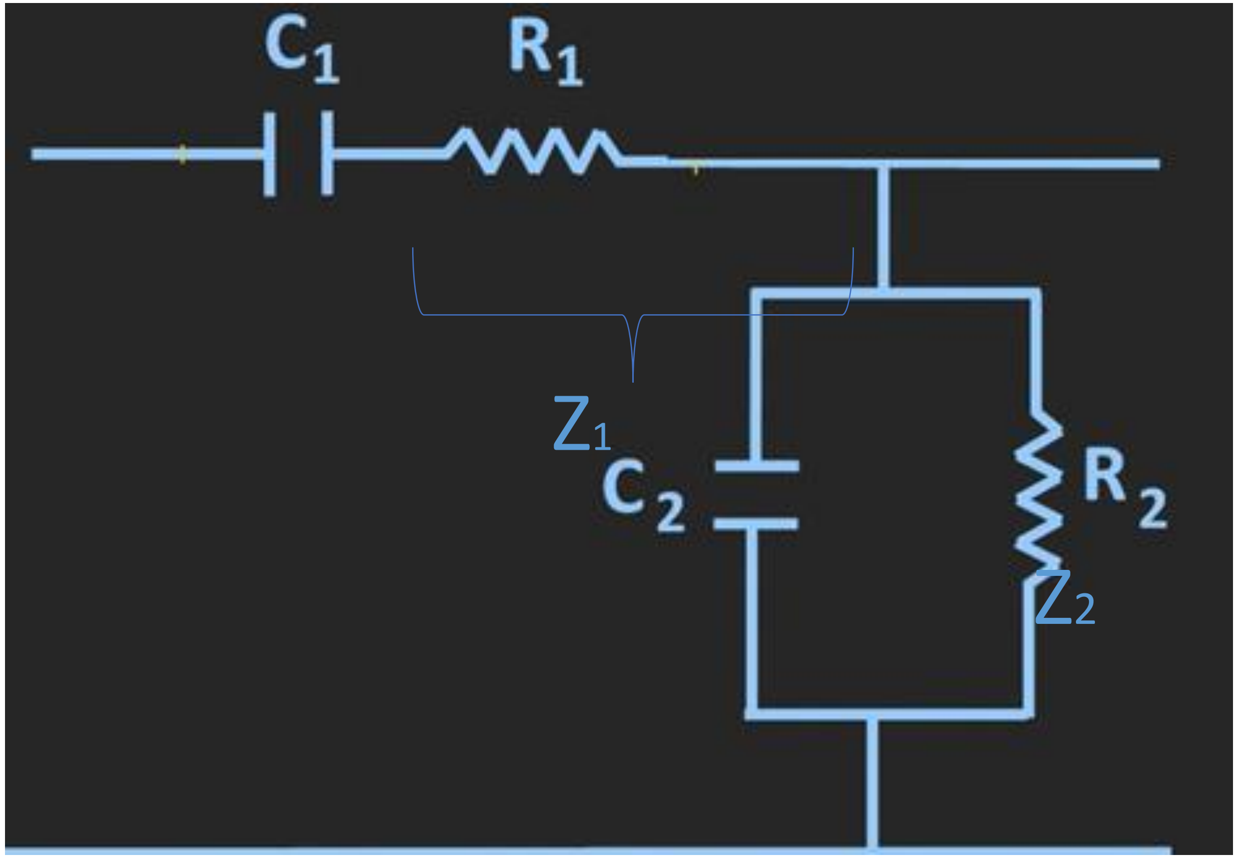
- One of the simplest sine wave oscillators which uses a RC network in place of the conventional LC tuned tank circuit to produce a sinusoidal output waveform, is called a **Wien Bridge Oscillator**.

- The **Wien Bridge Oscillator** is so called because the circuit is based on a frequency-selective form of the Wheatstone bridge circuit.

- The Wien Bridge oscillator is a two-stage RC coupled amplifier circuit that has good stability at its resonant frequency, low distortion and is very easy to tune making it a popular circuit as an audio frequency oscillator but the phase shift of the output signal is considerably different from the previous phase shift **RC Oscillator**.

WEIN’S BRIDGE OSCILLATOR





$$ß=V_f/V_o$$

The loop gain must be unity or greater. The feedback signal feeding back at the input must be phase-shifted by 360° (which is the same as zero degrees).

$$\frac{V_o}{V_{in}} = \frac{Z_2}{Z_1+Z_2} \qquad Z_2 = R_2 \parallel \left(\frac{1}{j\omega C_2}\right)$$

$$= \frac{R_2}{1+j\omega R_2 C_2}$$

$$\frac{V_o}{V_{in}} = \frac{\dfrac{R_2}{1+j\omega R_2 C_2}}{R_1 + \dfrac{1}{j\omega C_1} + \dfrac{R_2}{1+j\omega C_2 R_2}}$$

$$\frac{V_o}{V_{in}} = \frac{R_2 (j\omega C_1)}{R_1 (j\omega C_1)(1+j\omega C_2 R_2) + 1 + j\omega C_2 R_2 + j\omega R_2 C_1}$$

$$\frac{V_o}{V_{in}} = \frac{j\omega R_2 C_1}{\underbrace{1-\omega^2 R_1 R_2 C_1 C_2}_{0} + j\omega \left[R_1 C_1 + R_2 C_2 + R_2 C_1\right]}$$

$$\omega^2 R_1 R_2 C_1 C_2 = 1$$

$$\Rightarrow \omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}} \qquad \Rightarrow f = \frac{1}{2\pi \times \sqrt{R_1 R_2 C_1 C_2}} \qquad \Rightarrow f = \frac{1}{2\pi RC}$$

$$\frac{V_o}{V_{in}} = \frac{R_2 C_1}{R_1 C_1 + R_2 C_2 + R_2 C_1} = \beta \qquad \beta = \frac{1}{3}$$

$$A\beta = 1$$

$$A = \frac{1}{\beta} = \frac{R_1 C_1 + R_2 C_2 + R_2 C_1}{R_2 C_1} = \frac{R_1}{R_2} + \frac{C_2}{C_1} + 1$$

$$A = \frac{1}{\beta} = \frac{R_1 C_1 + R_2 C_2 + R_2 C_1}{R_2 C_1} = \frac{R_1}{R_2} + \frac{C_2}{C_1} + 1$$

$$A = 1 + \frac{R_4}{R_3} = \frac{R_1}{R_2} + \frac{C_2}{C_1} + 1$$

$$\Rightarrow \underbrace{\frac{R_4}{R_3} = \frac{R_1}{R_2} + \frac{C_2}{C_1}}$$

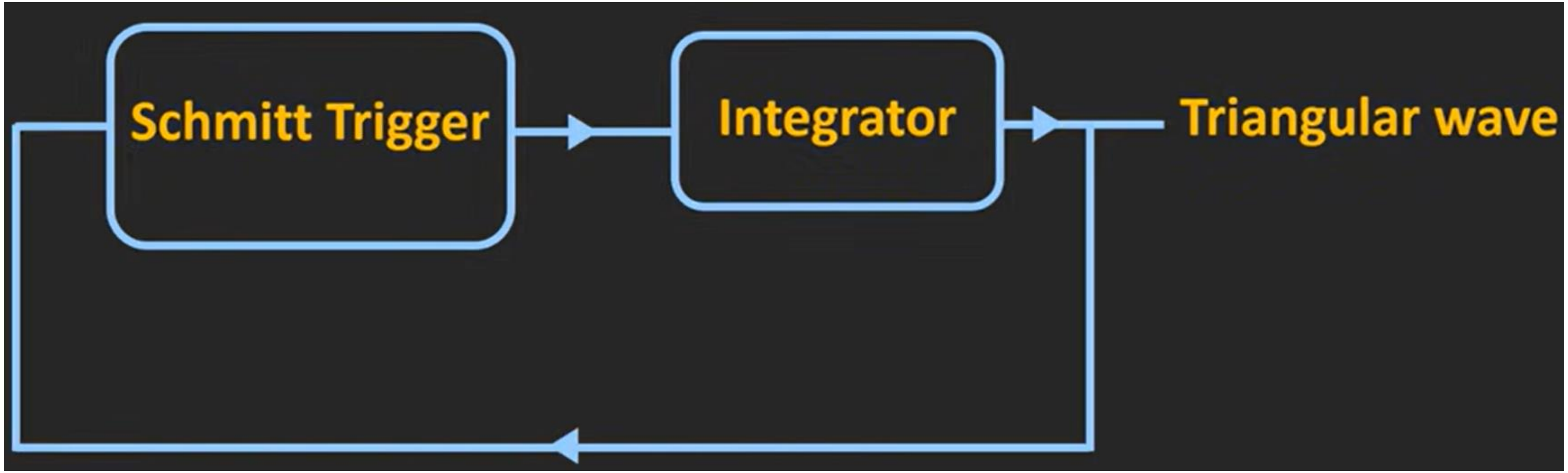
$$R_1 = R_2$$

$$C_1 = C_2$$

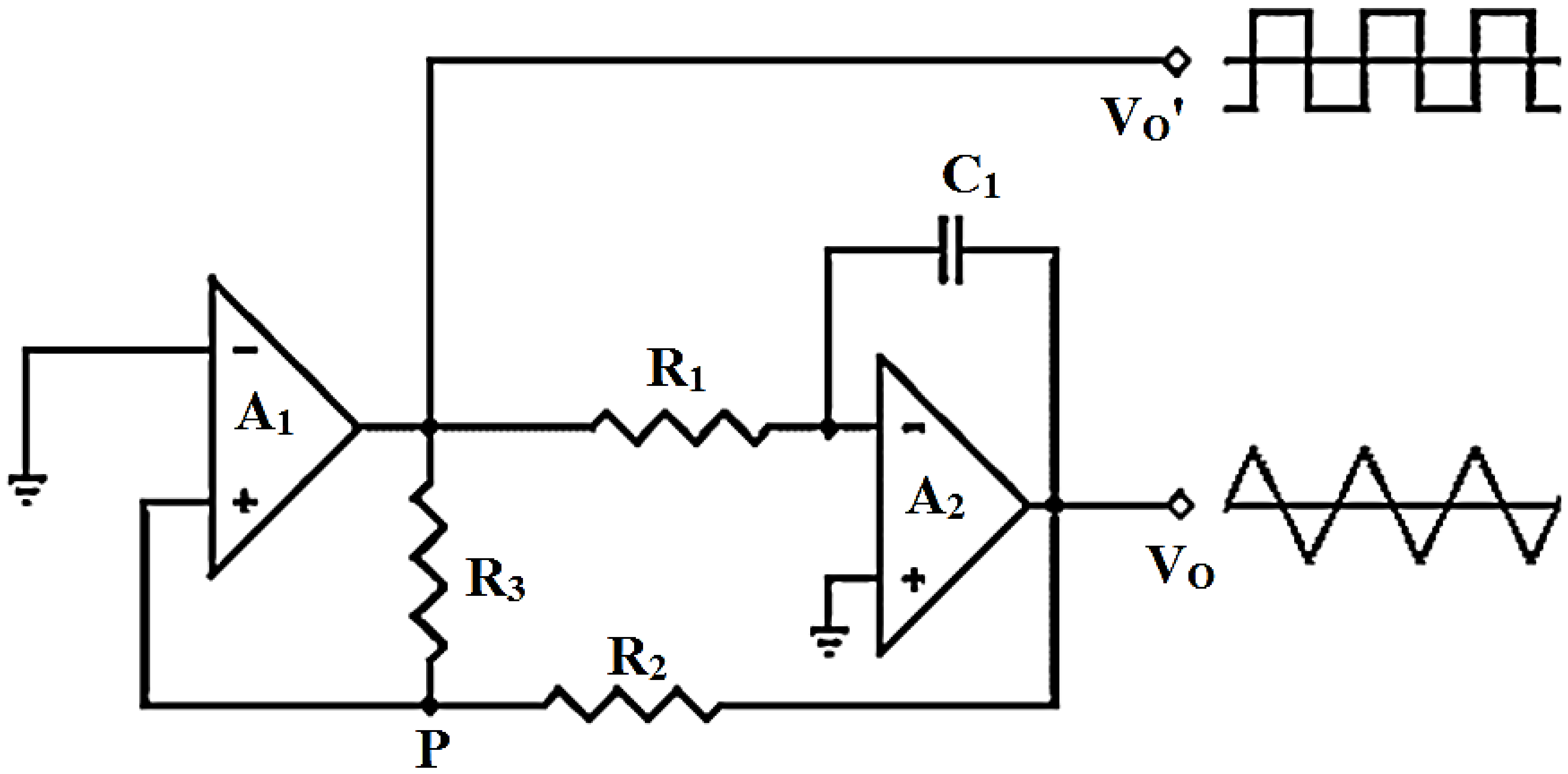
$$\Rightarrow \underbrace{\frac{R_4}{R_3} = 2}$$

TRIANGULAR WAVE GENERATOR ????

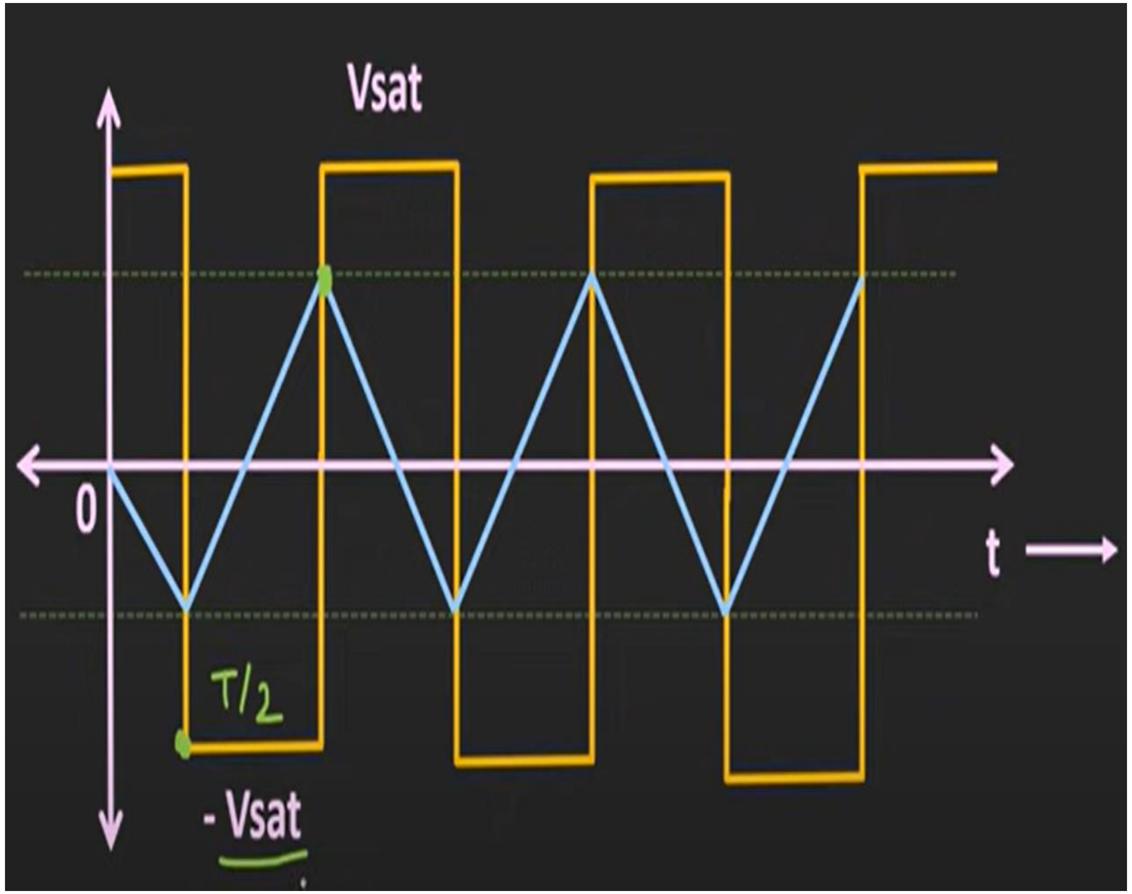
TRIANGULAR WAVE GENERATOR



TRIANGULAR WAVE GENERATOR using Schmitt Trigger



OUTPUT WAVEFORMS

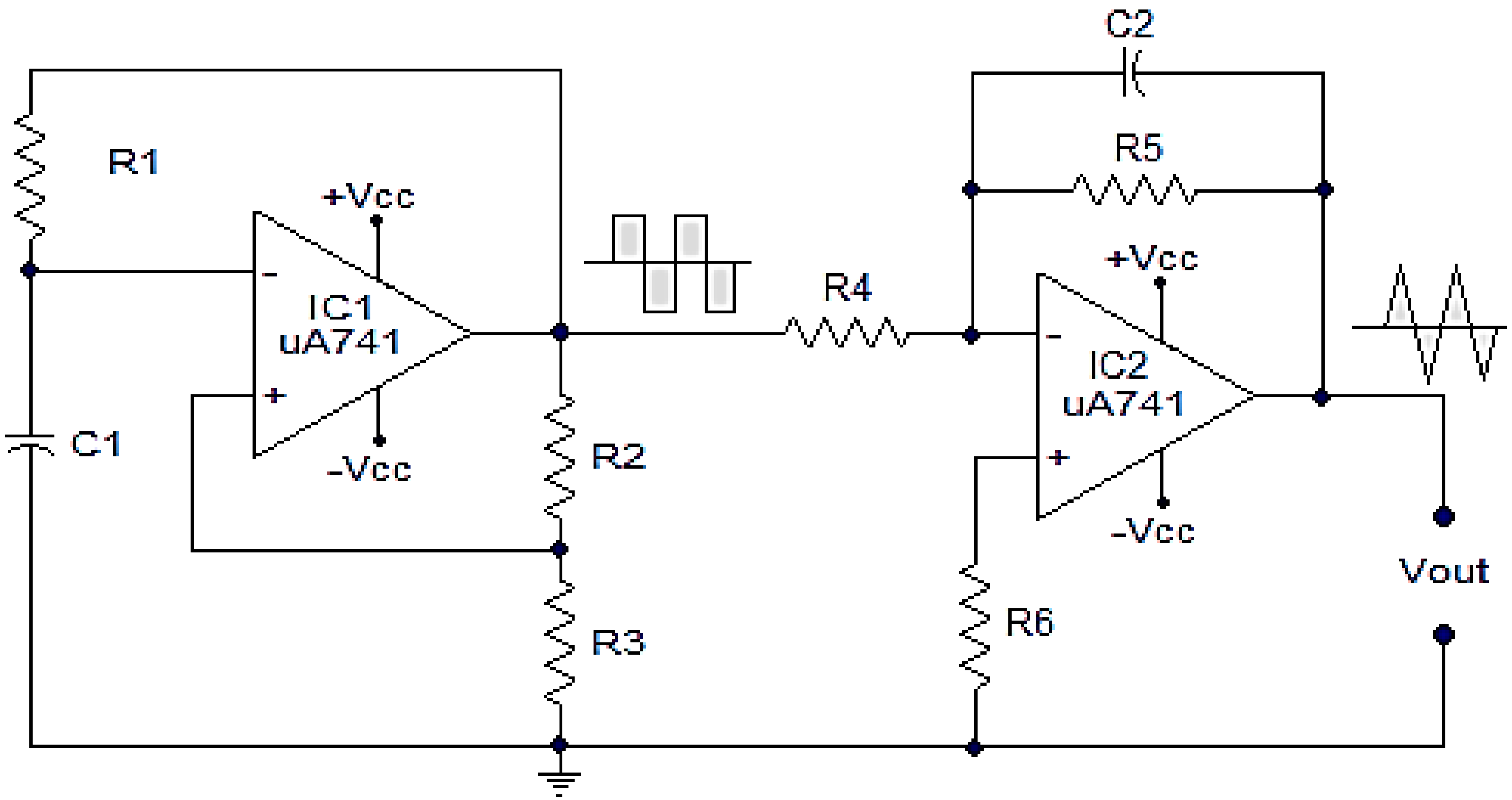


$$V_O = -\frac{1}{RC}\int_0^t v_{in}(t)\,dt$$

$$V(P\text{-}P) = -\frac{1}{R_3 C_2} \times (-V_{sat}) \times \frac{T}{2}$$

$$V_{P-P} = \frac{V_{sat} \times T}{2 R_3 C_2}$$

TRIANGULAR WAVE GENERATOR using Astable Multivibrator

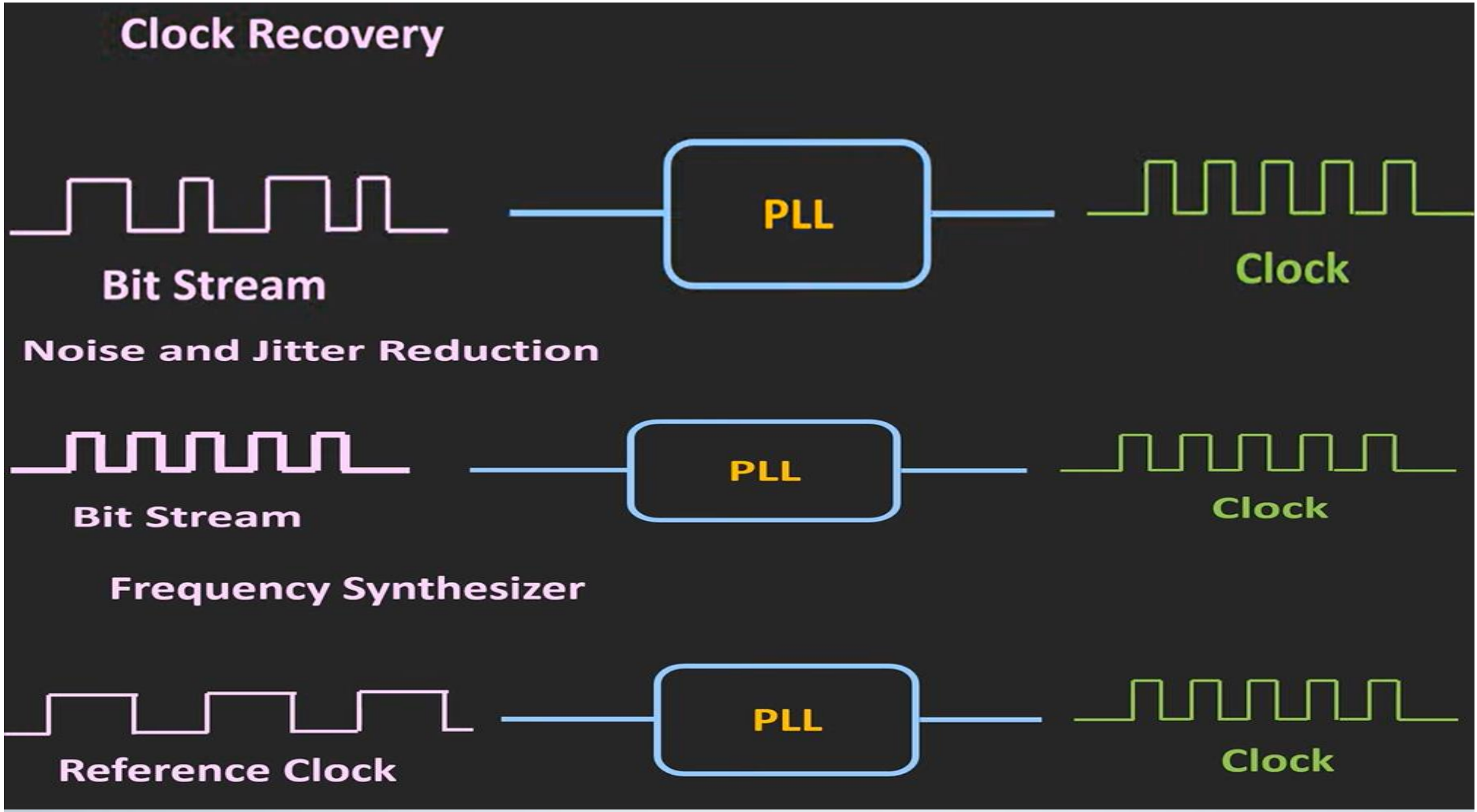


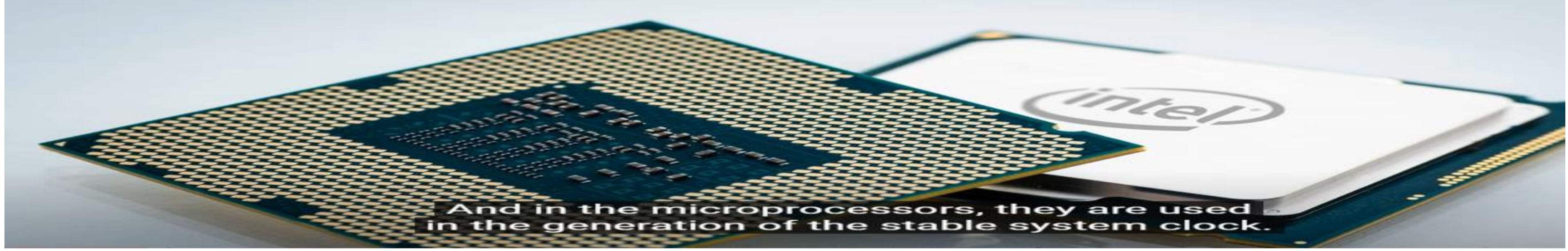
LIC: LECTURE
PHASE LOCKED LOOP (PLL)

- **PLL Circuit**
  - **Need and Requirements**
  - **Circuit**
  - **Working Principal**
  - **Phase Detector Design**
  - **Voltage Controlled Oscillator**
  - **Application as Frequency Synthesizer ($f.N$ or f/N)**

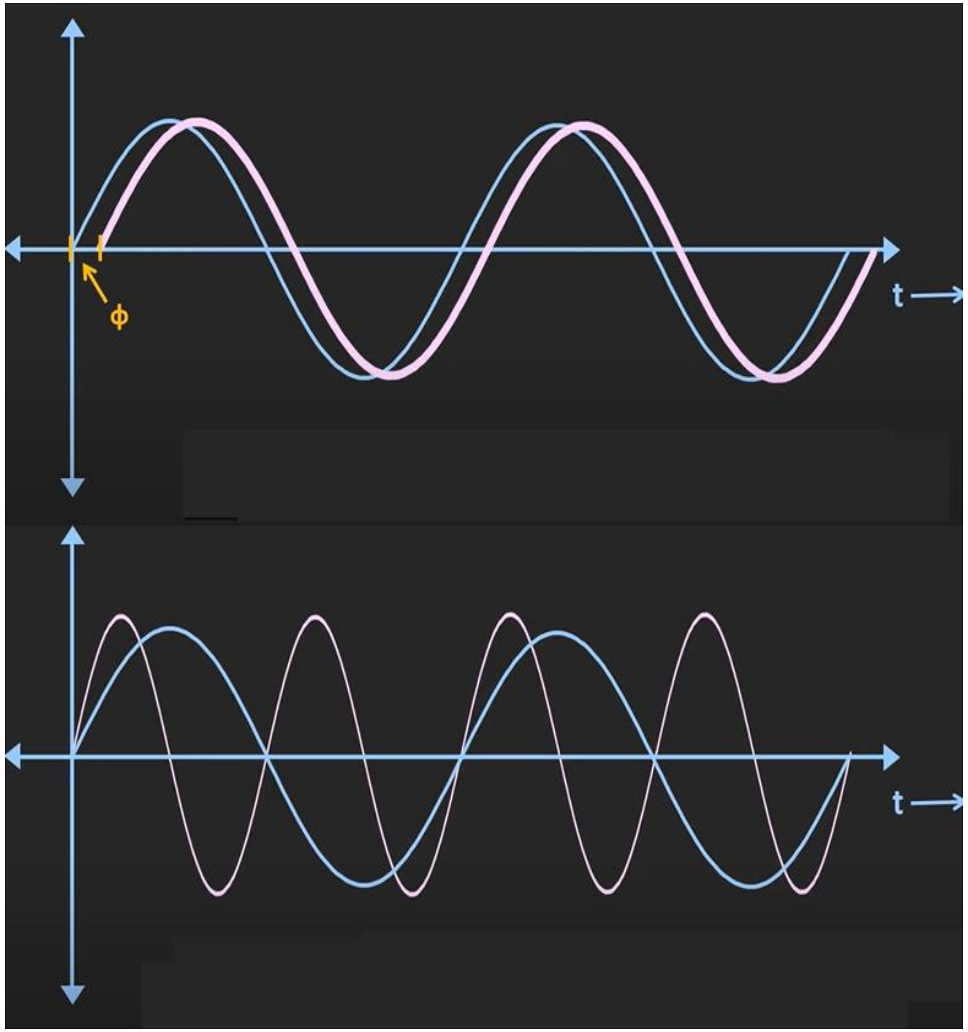
PHASE LOCKED LOOP (PLL)

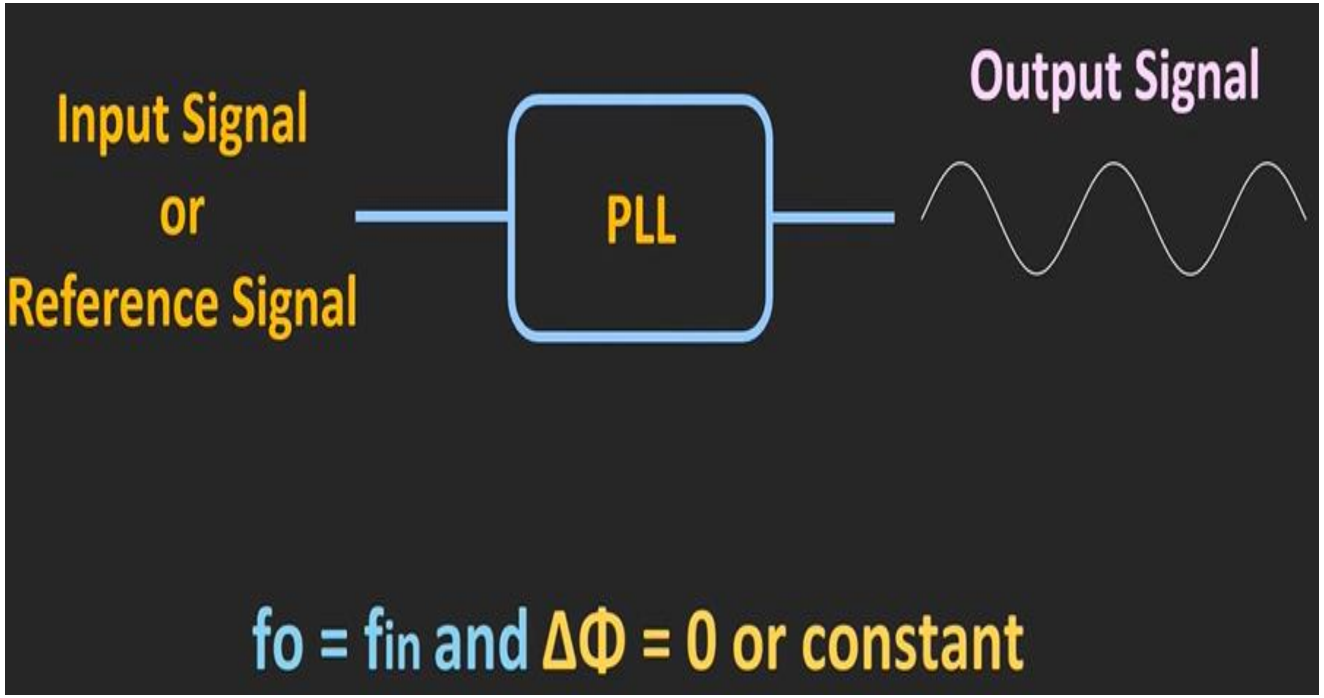
- Frequency Demodulation
- Clock Recovery
- Noise and Jitter Reduction
- Frequency Synthesizer
- Stable System Clock in Microprocessors



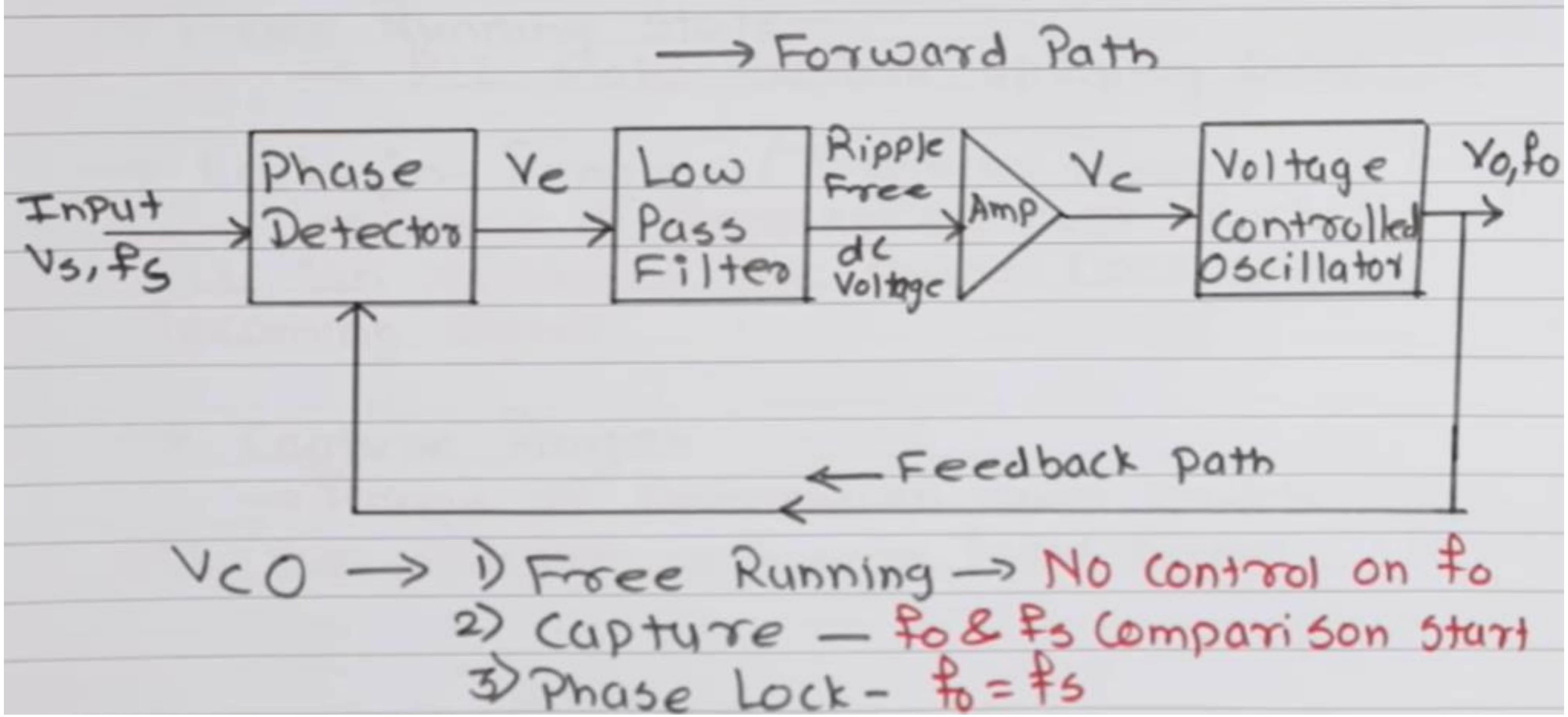


PHASE LOCKED LOOP (PLL)



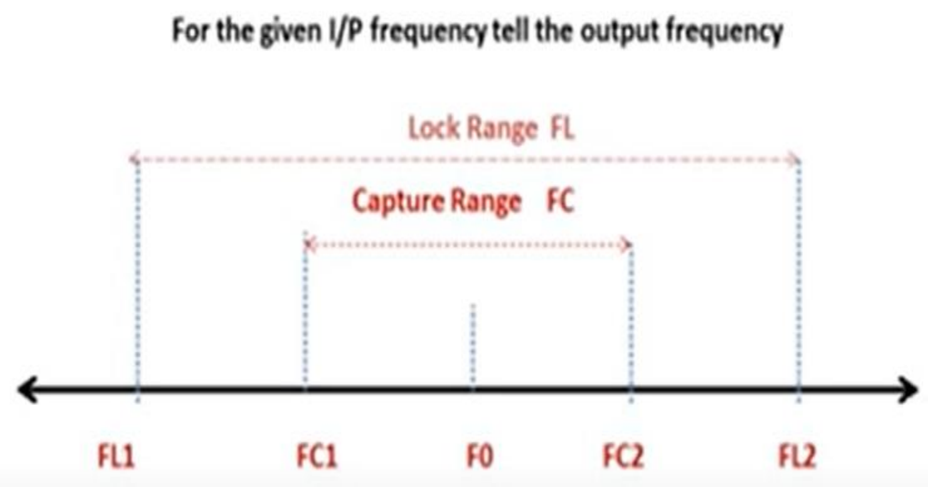


PLL Working Principal

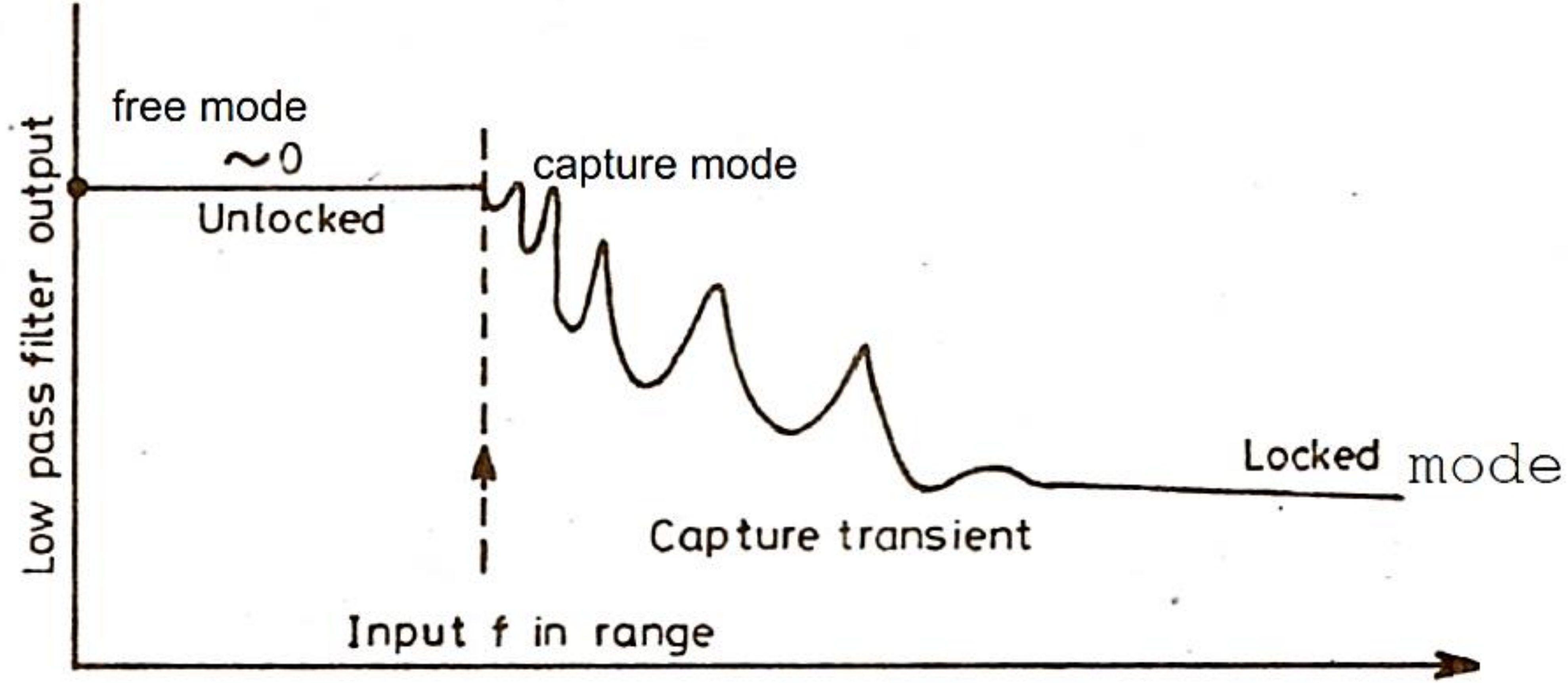


PLL Working Principal

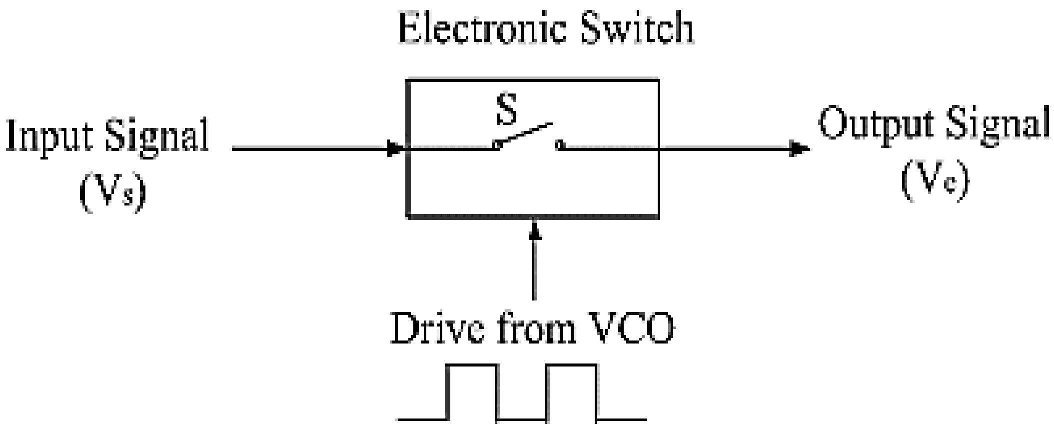
- Lock range: The range of frequencies over which the PLL maintains lock with the incoming signal is called the lock range of PLL.
- Capture range: The range of frequencies over which the PLL can acquire lock with an i/p signal is called the capture range.
- PULL In Time: The capture of an i/p signal does not take place as soon as the signal is applied, But it takes finite time. The total time taken by the PLL to establish lock is called pull-in time.

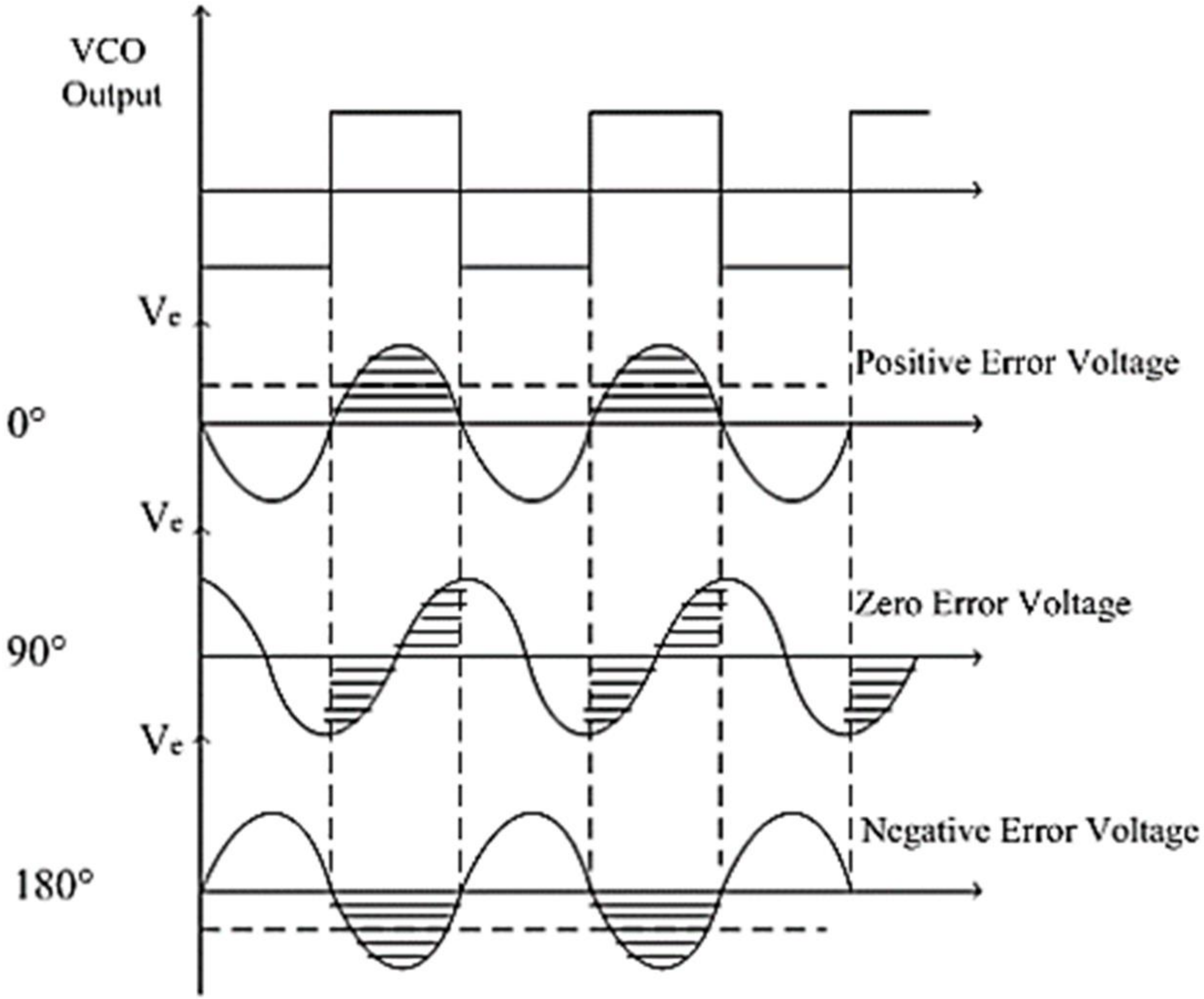


Capture transient



ANALOG PHASE DETECTOR





Analysis

❖Phase detector is a multiplier which multiplies the input signal ($V_{in} = V_s\, sin(2\pi f_{in} t)$) by the VCO signal ($V_{out} = V_o sin(2\pi f_{out} t + \varphi)$)

❖Therefore, Phase detector output,

$$V_e = kV_s V_o sin(2\pi f_{in} t) sin(2\pi f_{out} t + \varphi)$$

where k → phase comparator gain

φ → phase shift between the input signal and the VCO output.

➔$V_e = \frac{kV_s V_o}{2}\left(cos\left(2\pi f_{in} t - (2\pi f_{out} t + \varphi)\right) - cos(2\pi f_{in} t + 2\pi f_{out} t + \varphi)\right)$

❖ Above expression indicates that output contains a double frequency term and a DC component.

- Double frequency term is eliminated by the LPF and the DC signal is applied to the modulating input signal of the VCO.
- When at lock, $f_{in} = f_{out}$,

➔ $V_e = \frac{kV_sV_o}{2}\left(cos(-\varphi) - cos(2\pi * 2f_{out}t + \varphi)\right)$

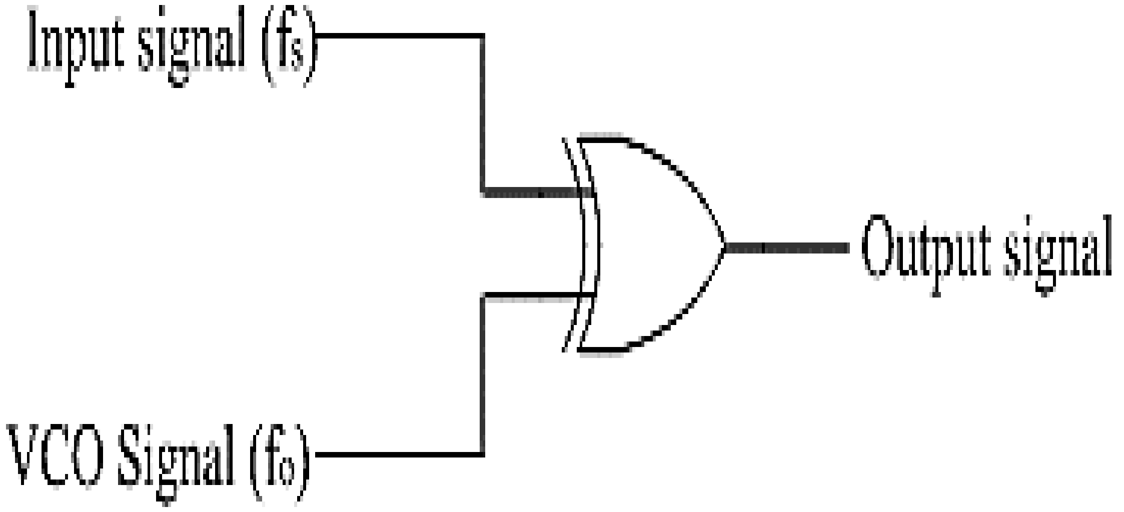
- For a perfect locked state, the phase shift should be 90°, in order to get zero error signal, i.e. $V_e = 0$.

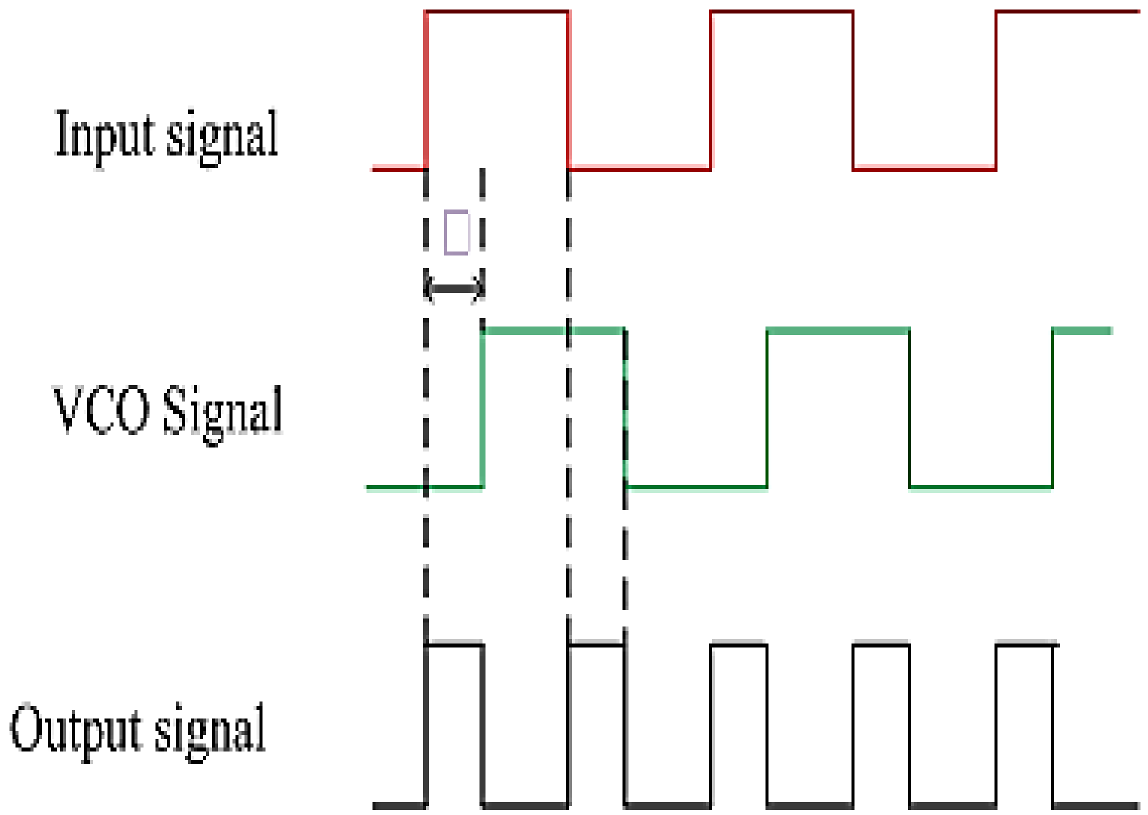
Drawbacks of Switch Type Phase Detector

1. Output voltage V_e is proportional to the input signal amplitude making the phase detector gain and the loop gain dependent on the input signal amplitude.
2. Output is proportional to cos φ and not φ making it non-linear.

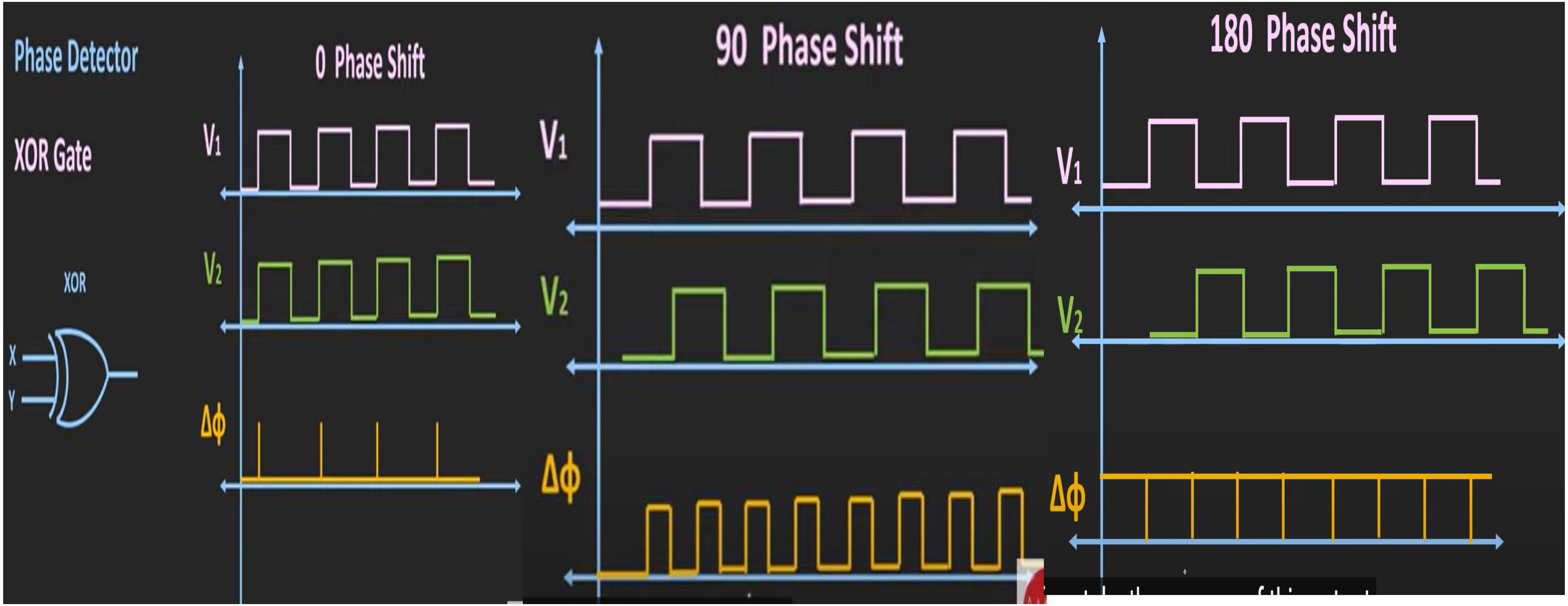
- Both drawbacks can be eliminated by limiting the amplitude of the input signal i.e. converting the input to a constant amplitude square wave.

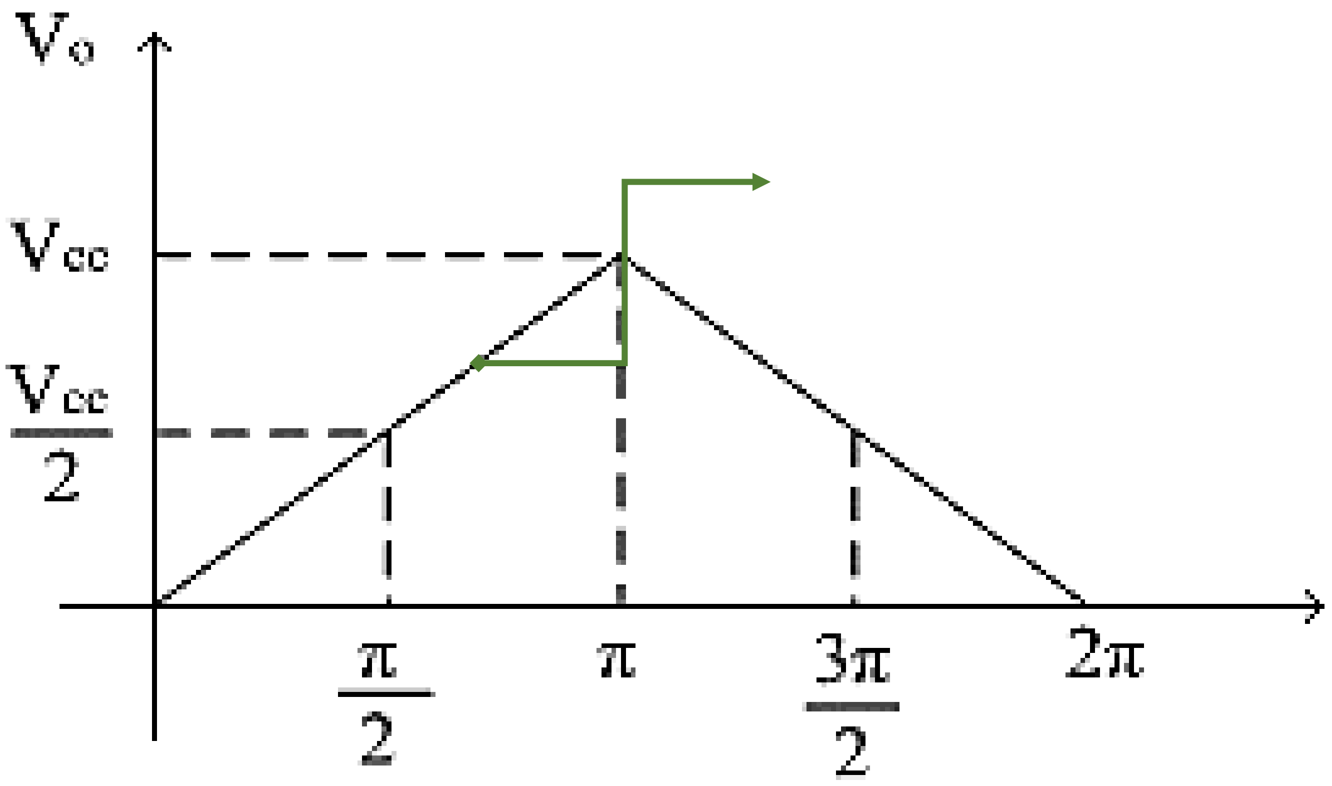
DIGITAL Phase Detector





DIGITAL Phase Detector





DC Output voltage Vs phase difference ϕ curve

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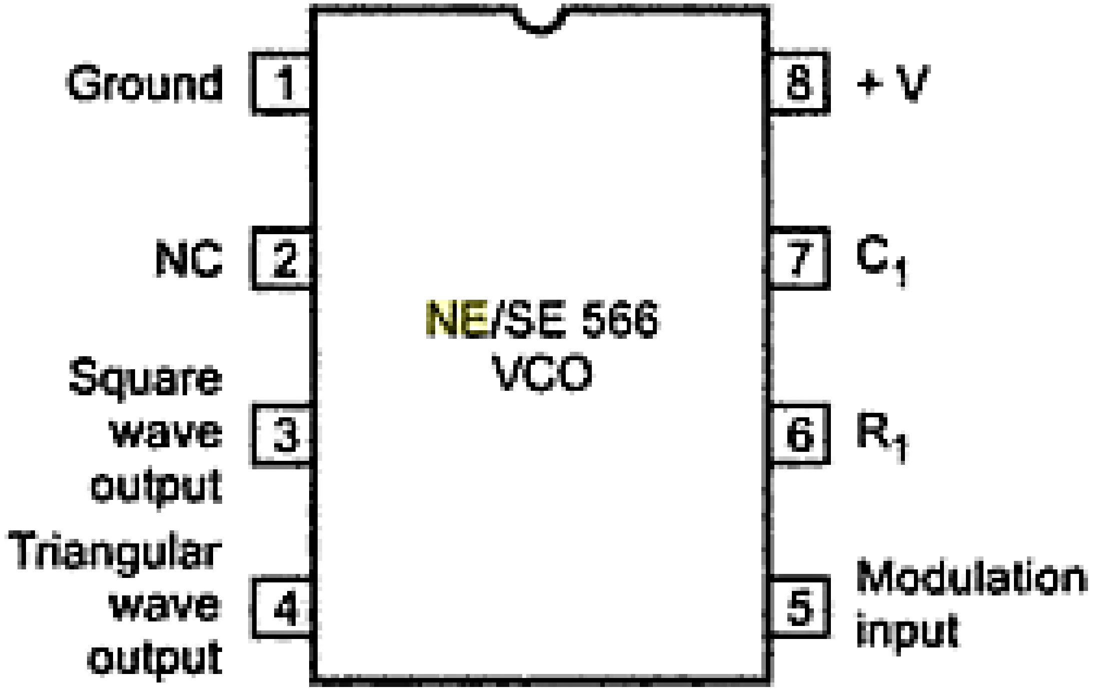
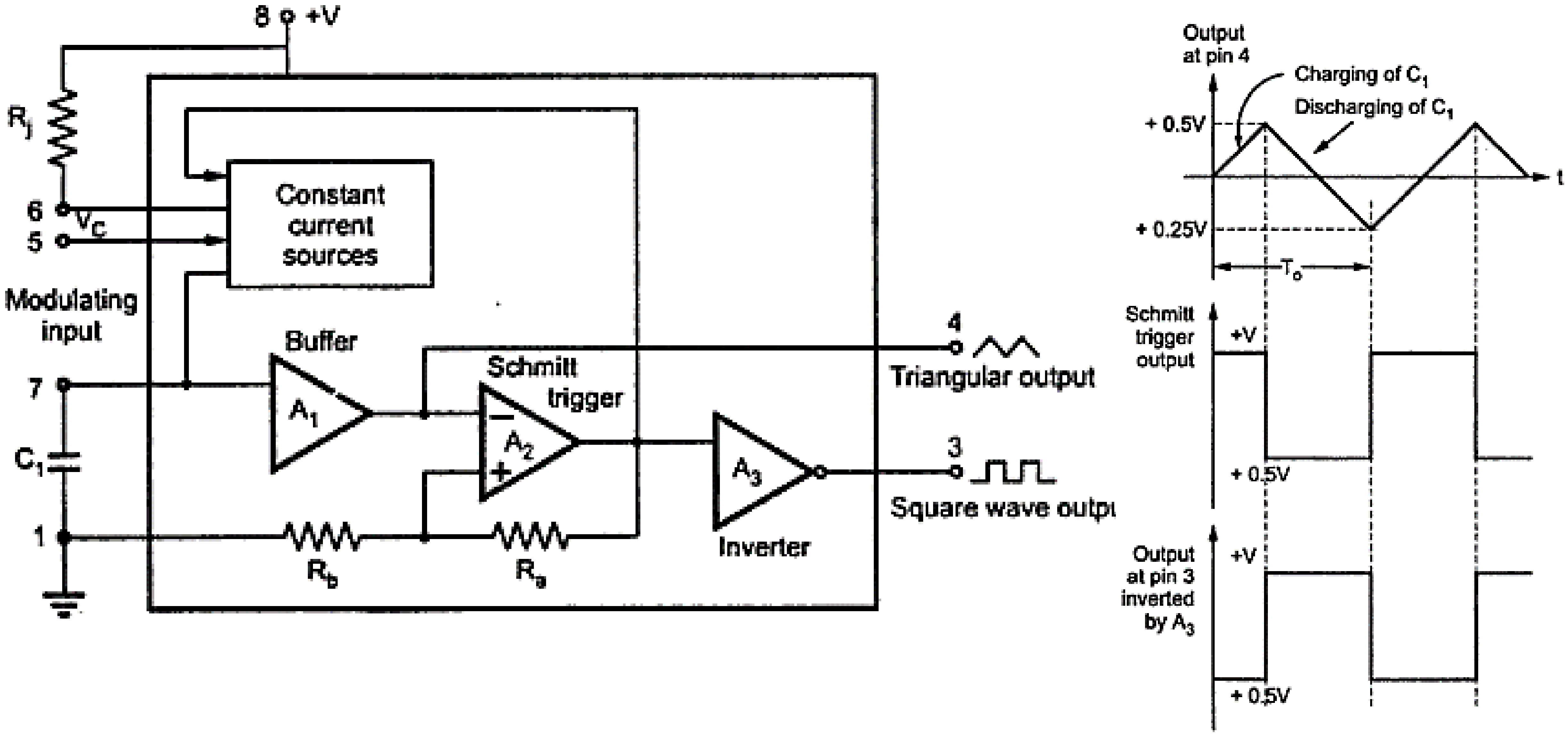
VOLTAGE Controlled Oscillator (VCO)



Pin Configuration

BLOCK DIAGRAM



Output Frequency Calculation

- Total voltage on the capacitor changes from 0.25 V_{CC} to 0.5 V_{CC}.

$$\therefore\ \Delta V = 0.25\, V_{CC}$$

- Capacitor charges with a constant current source.

$$\frac{\Delta V}{\Delta t} = \frac{i}{C_1}$$

$$\Delta t = \frac{0.25\, V_{CC} C_1}{i}$$

- Time period of triangular waveform = $2\Delta t$

- Frequency, f_o is

$$f_o = \frac{1}{T}$$

- But,

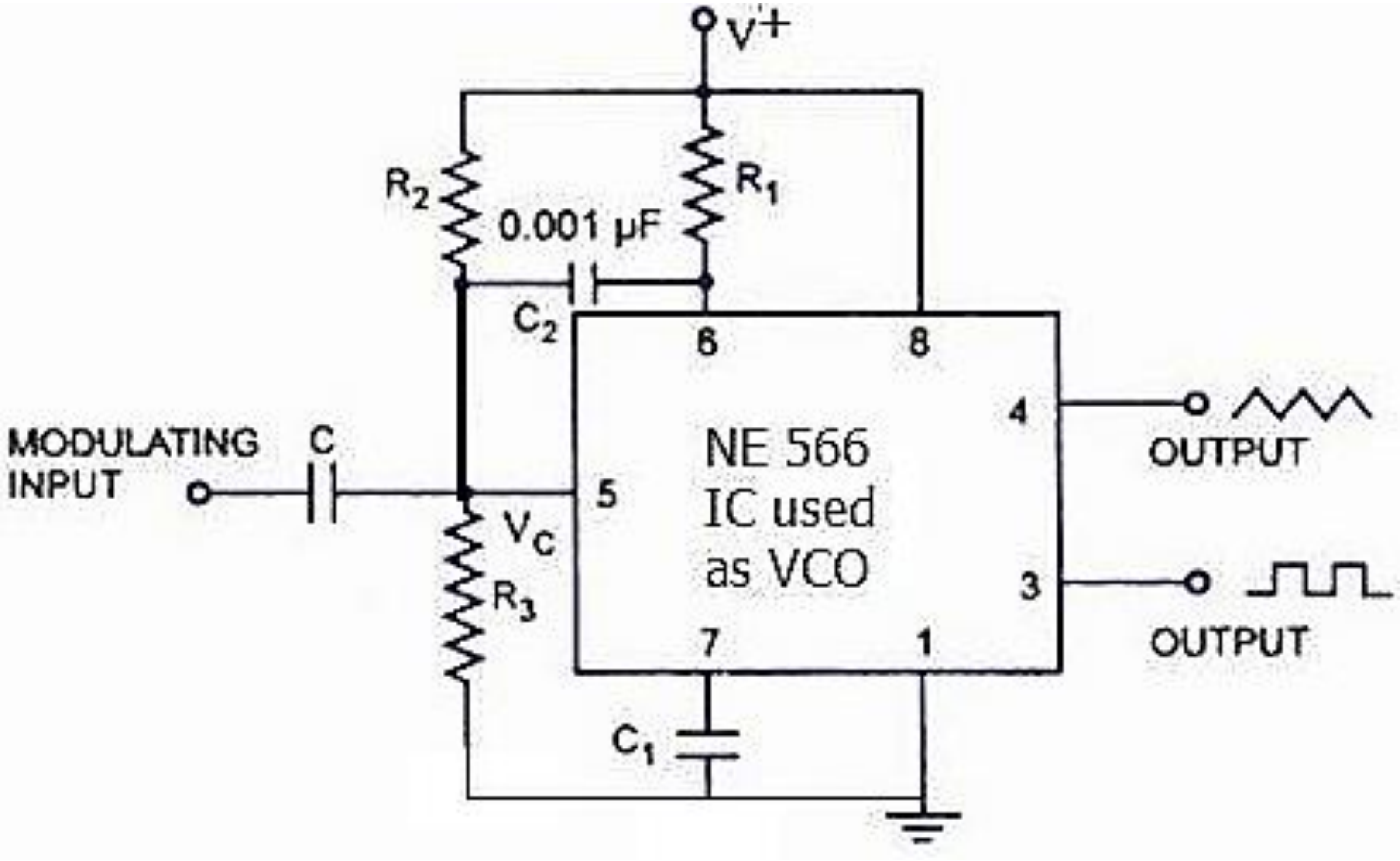
$$i = \frac{V_{CC} - V_C}{R_1}$$

- where V_C = voltage at pin 5.

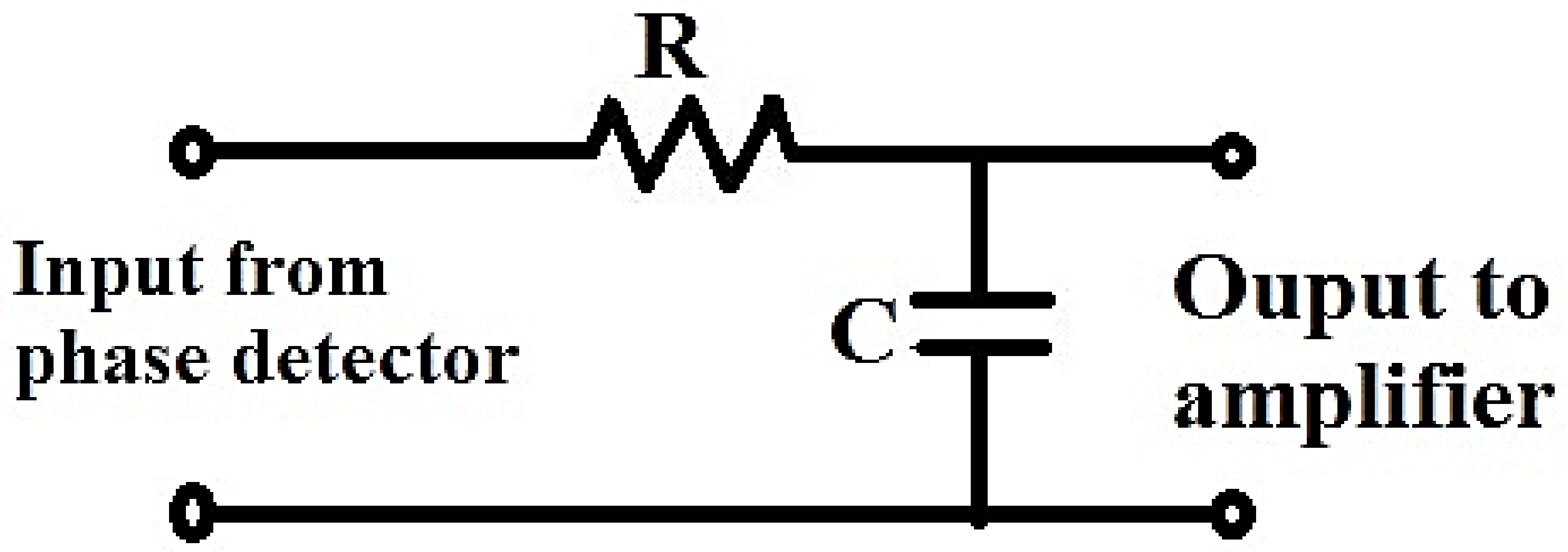
$$f_o = \frac{2(V_{CC} - V_C)}{C_1 R_1 V_{CC}}$$

Outcomes

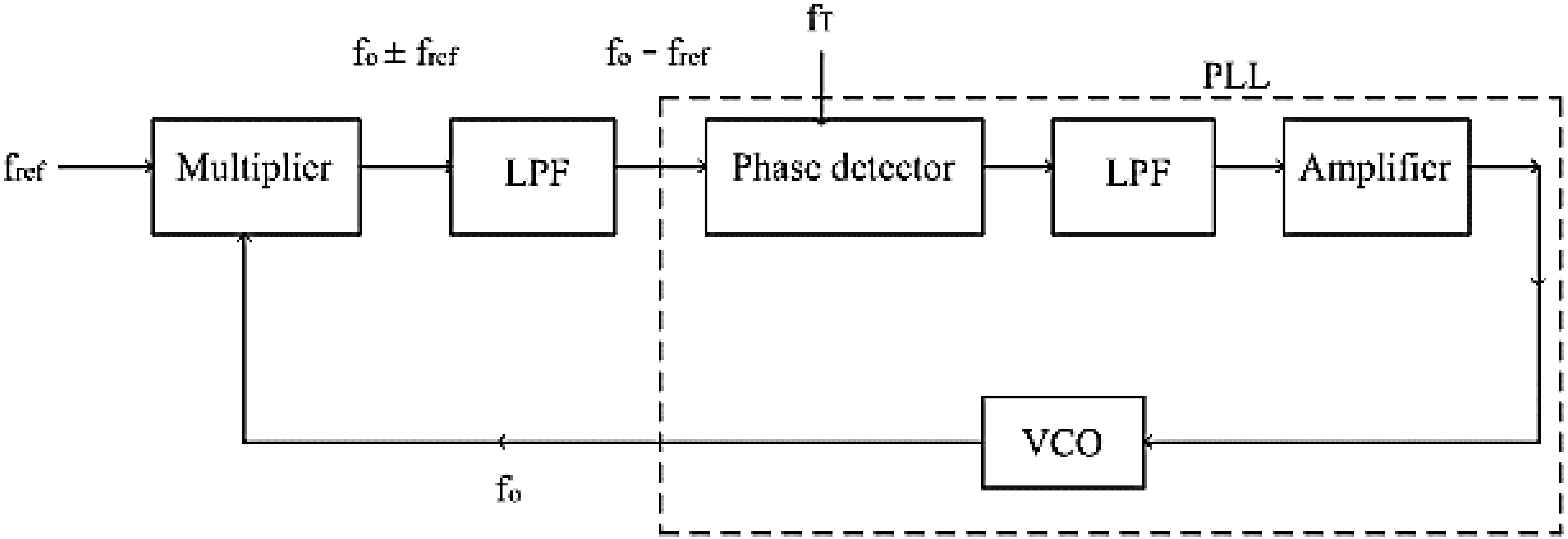
- Output freq. of VCO can be changed by –
  a) R_1
  b) C_1
  c) Modulating input V_C
- V_C can be varied by connecting a R_2 - R_3 circuit as shown in the circuit.



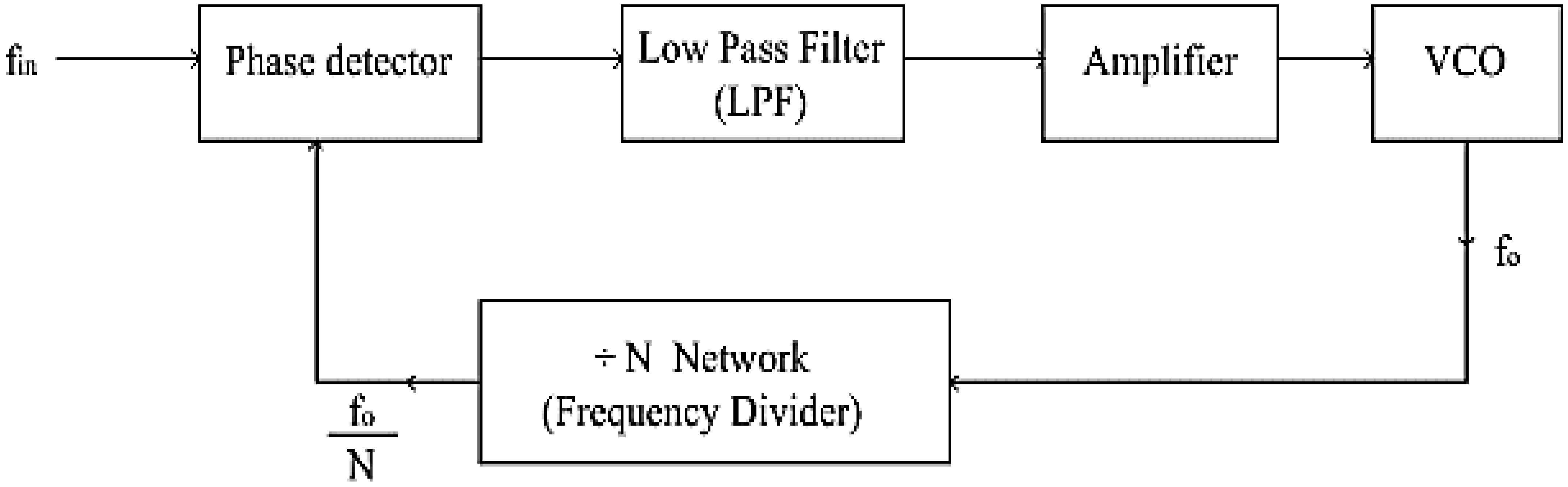
Low Pass Filter



Frequency Translation

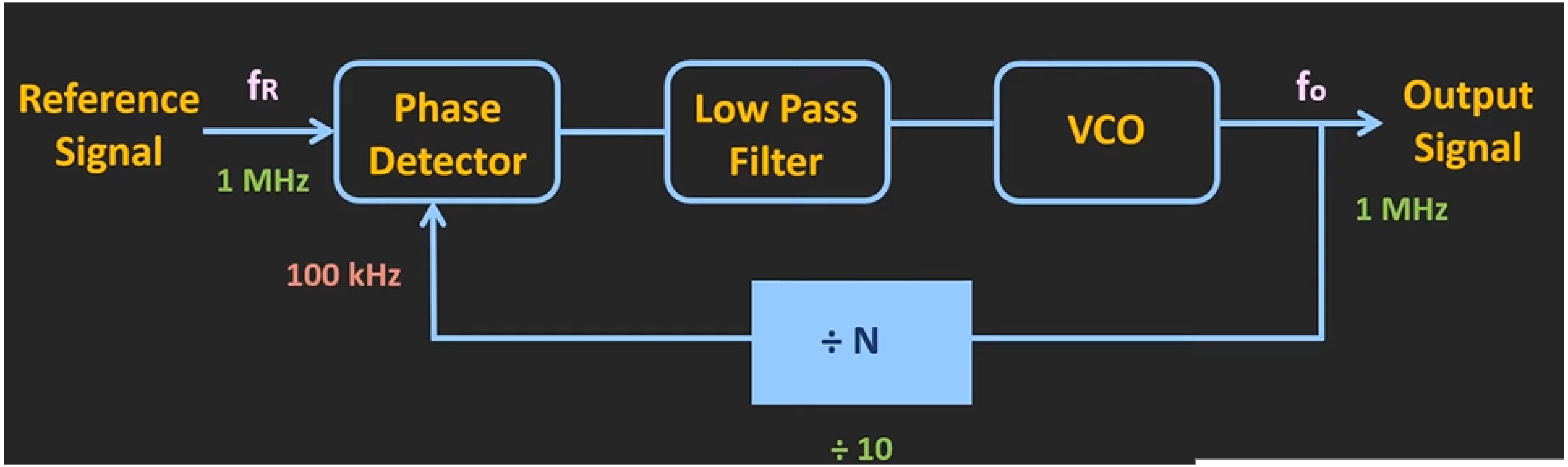


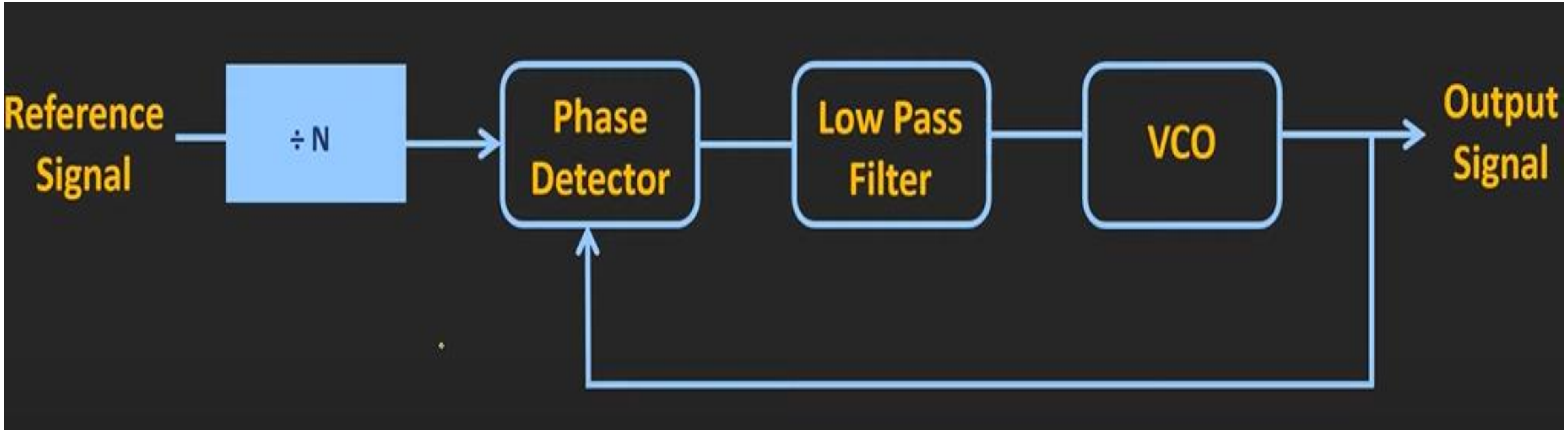
Frequency multiplier/ divider

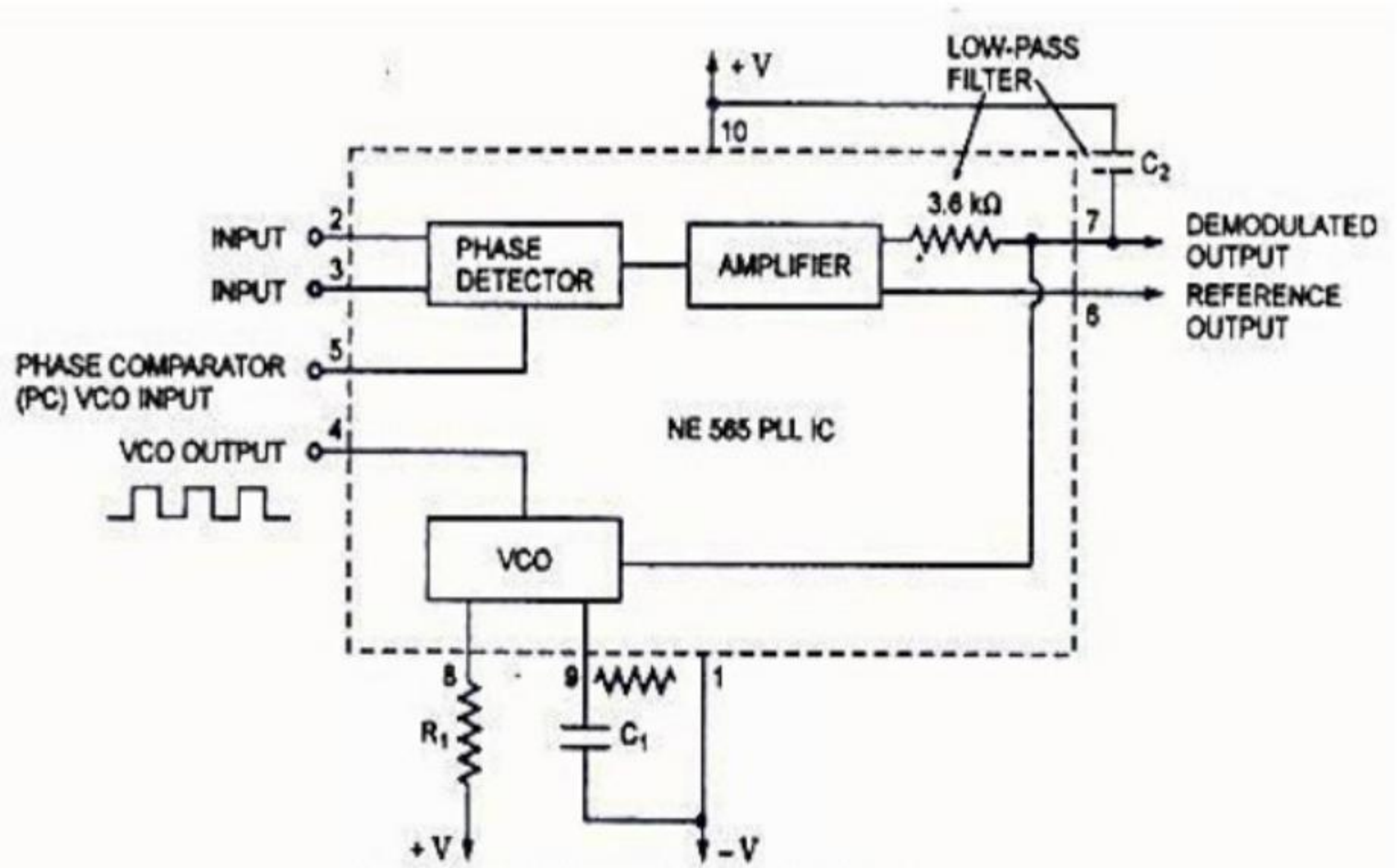


FREQUENCY MULTIPLIER

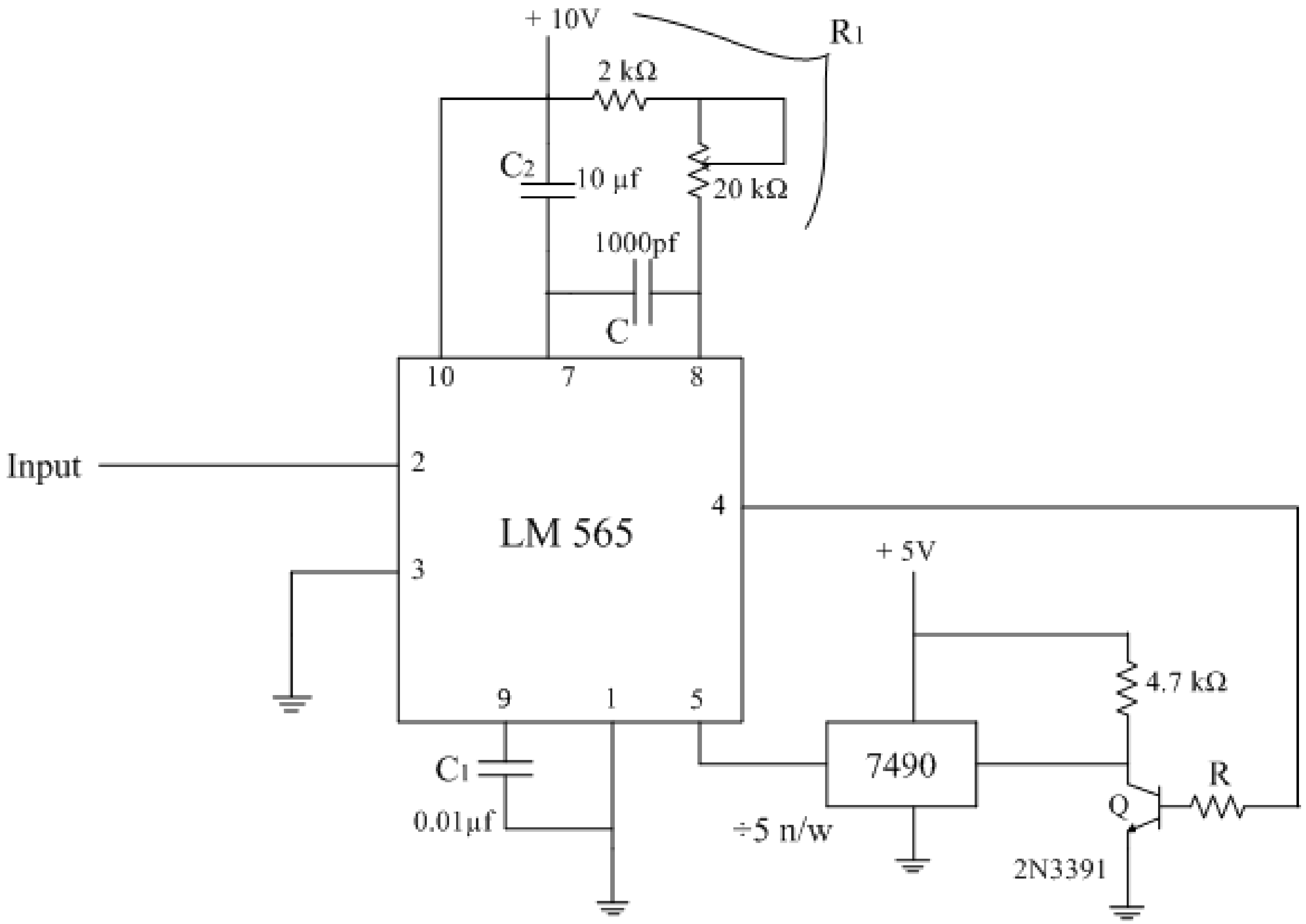
Frequency Synthesizer







Monolithic Phase Locked loop (NE/SE 565)


+ 10V
R1
2 kΩ
C2
10 μf
20 kΩ
1000pf
C
10
7
8
Input
2
LM 565
4
3
+ 5V
4.7 kΩ
9
1
5
7490
C1
0.01μf
÷5 n/w
R
Q
2N3391