EPC module 3 B&C

Electronic principles and circuits (Visvesvaraya Technological University)

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Oscillators:

Theory of Sinusoidal Oscillation:

* use an amplifier with positive feedback, to build sinusoidal oscillations

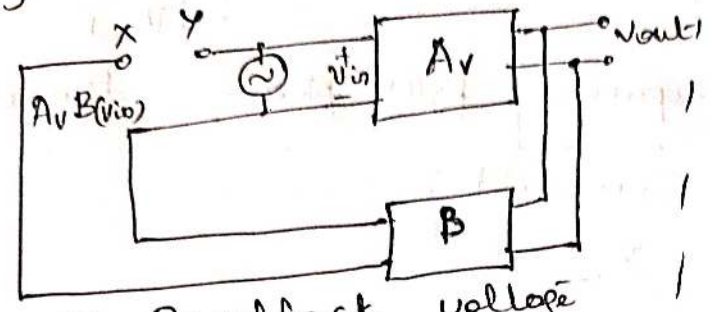


fig @ Feedback voltage relates to point 'x'

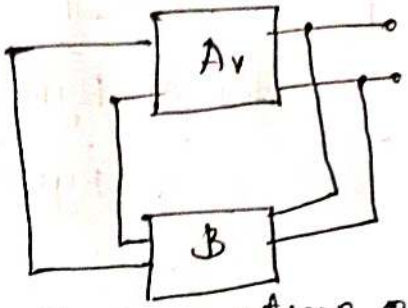
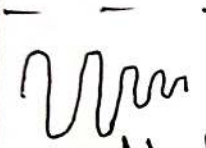
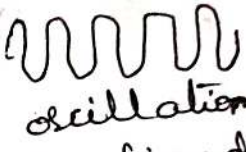


fig (b) connecting points x and y



(c) oscillations die out

(d) oscillations increase



(e) oscillations are fixed in amplitude

The fig @ shows an ac voltage source driving the input terminals of amplifier. The amplified o/p voltage is

$$V_{out} = A_v.(V_{in})$$

This voltage drives a feedback circuit ie usually resonant circuit. The feedback voltage returning to point 'x' is given by:

$$V_f = A_v.B(V_{in})$$

B - feedback fraction.

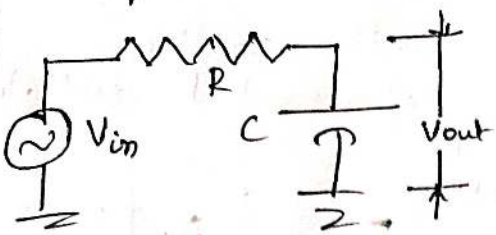
$A_vB\,V_{in} < V_{in} \rightarrow$ o/p signal will die out - (c) fig

$A_vB\,V_{in} > V_{in} \rightarrow$ o/p signal builds up - fig (d)

$A_vB\,V_{in} = V_{in} \rightarrow$ o/p signal is steady sine wave fig (e)

Wein Bridge oscillator :

Lag circuit :



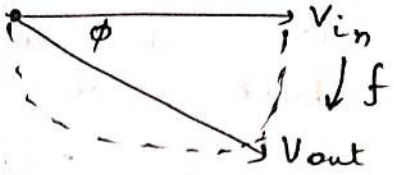


fig @ Bypass capacitor fig ⓑ phasor diagram

Gain of Bypass circuit :

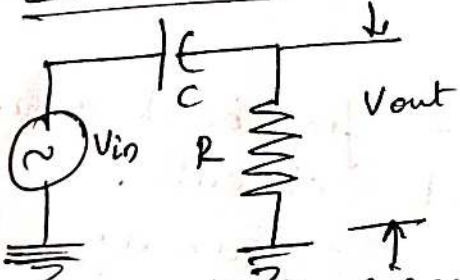
$$\frac{V_{out}}{V_{in}} = \frac{X_C}{\sqrt{R^2+X_C^2}}$$

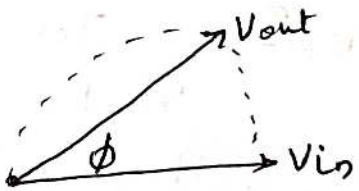
phase angle is :

$$\phi = -\arctan \frac{R}{X_C}$$

ϕ is the phase angle b/w o/p & i/p. - sign, indicates the output voltage lags the input voltage.

Lead circuit :





ⓑ phasor diagram

@ coupling circuit

voltage gain of the circuit is :

$$\frac{V_{out}}{V_{in}} = \frac{R}{\sqrt{R^2+X_C^2}}$$

phase angle is :

$$\phi = \arctan \frac{X_C}{R}$$

The phase angle is positive, the o/p voltage leads the i/p voltage.

Lead - lag circuit :

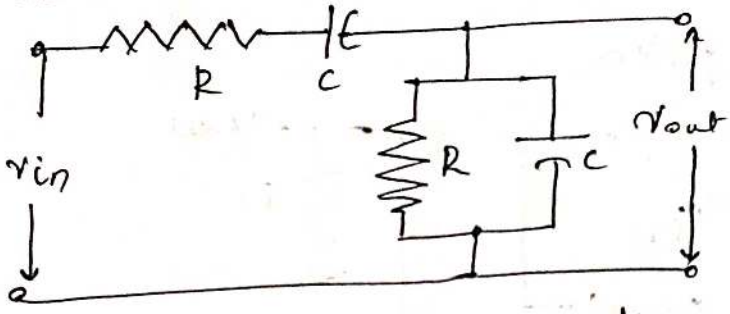


fig ⓐ circuit

The frequency where the output is maximum is the resonant frequency fr. At this frequency, the feedback fraction 'B' reaches a maximum value of 1/3.

fig ⓑ voltage gain

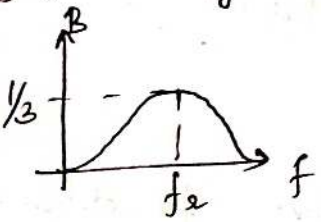


fig ⓒ phase response

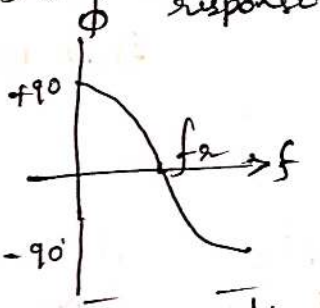
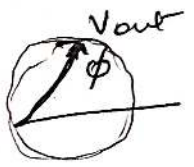


fig ⓓ phasor diagram



The fig ⓒ shows the phase angle of output voltage verses input voltage. At low frequencies, the phase angle is positive (leading), At very high frequencies, the phase angle is negative (lagging).

At resonant frequency, the phase shift is 0°.

The phase angle may vary from +90° to -90°

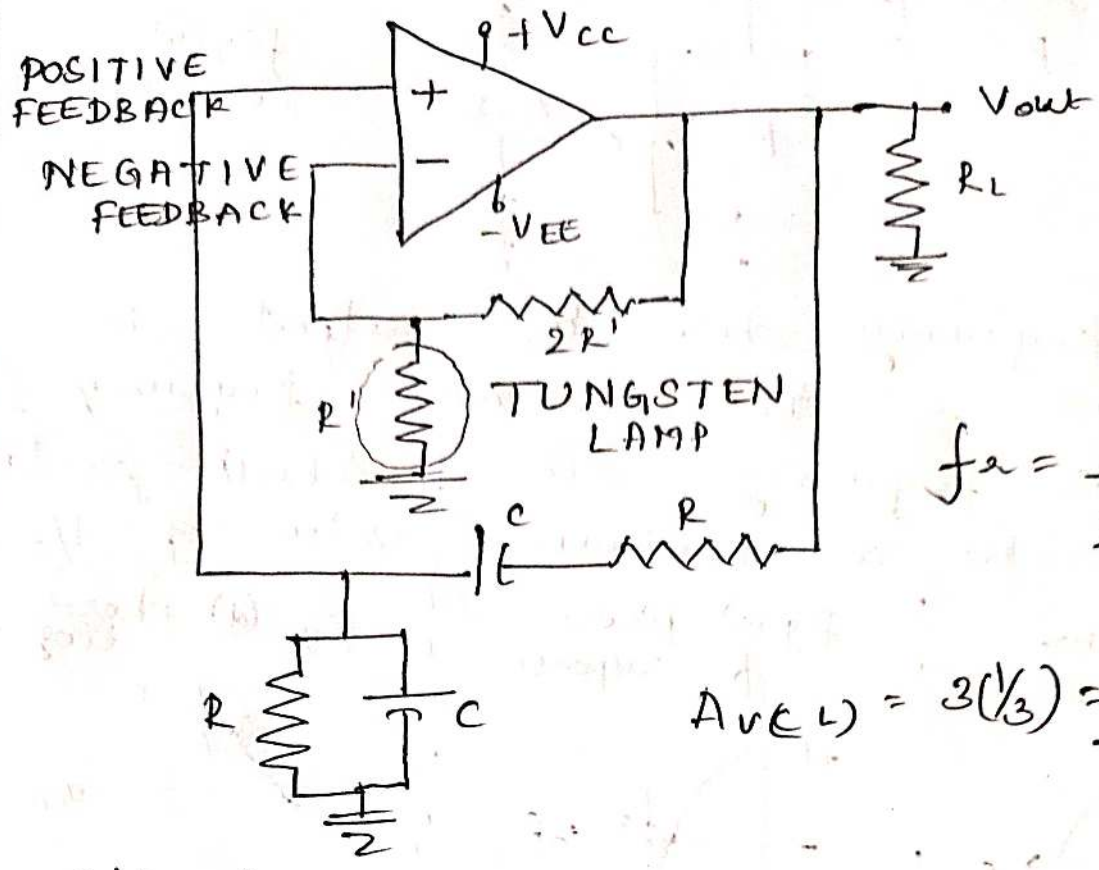
Formulas:

$$B = \frac{1}{\sqrt{9 - (X_C/R - R/X_C)^2}}$$

$$\phi = \text{arctan}\ \frac{X_C/R - R/X_C}{3}$$

$$f_r = \frac{1}{2\pi RC}$$

Wein Bridge oscillator:



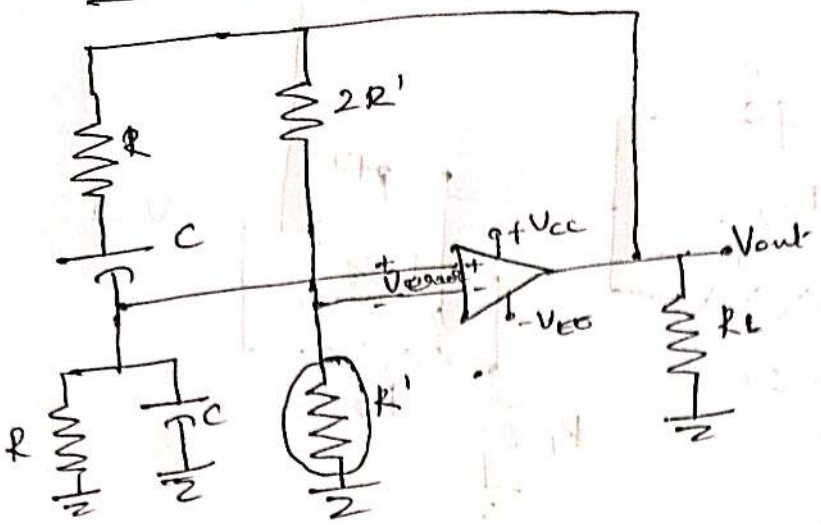
$$f_r = \frac{1}{2\pi RC}$$

$$A_{V(CL)} = 3(1/3) = \underline{1}$$

Working:

* It uses positive and negative feedback because there are two paths for feedback.
* A path for +ve feedback from output through lead-lag circuit to non-inverting input.
* A path for -ve feedback from output through voltage divider to inverting input.
* Initially the circuit is biased ON, ie more positive feedback than negative feedback → produces oscillations.
* After desired level, the negative feedback becomes large enough to reduce loop gain $A_V\beta$ to 1.
* Tungsten lamp heats slightly & its resistance increases.

Notch Filter :— Wein Bridge.

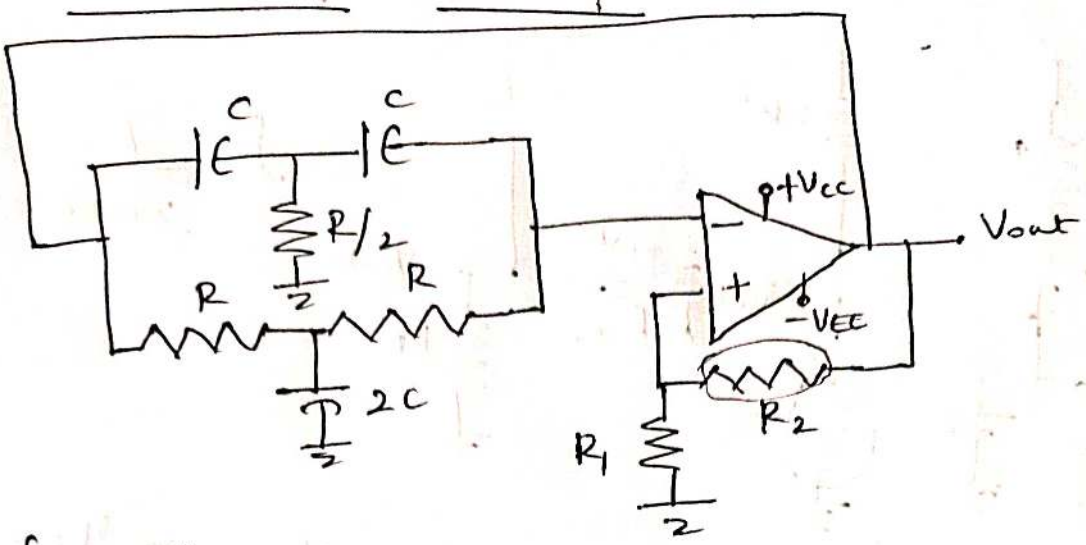


$$f_r = \frac{1}{2\pi RC}$$

* The lead-lag circuit is in the left side of bridge & voltage divider is at the right side.
* The error voltage is the output of the bridge.
* when the bridge approaches balance, the error voltage approaches zero.
* The wein bridge acts like a Notch filter, a circuit with zero output at one particular frequency.

$$f_r = \frac{1}{2\pi RC}$$

Twin - T oscillator:



$$f_r = \frac{1}{2\pi RC}$$

* The positive feedback to non-inverting i/p is through a voltage divider.
* The negative feedback is through Twin-T filter.
* When power is ON, the lamp resistance R_2 is low, +ve feedback is maximum & oscillations build up
* Now the lamp resistance increases, positive feedback decreases, the oscillations tend off & become constant & lamp stabilizes the o/p voltage.

* In Twin - T, the resistance R/2 is adjusted. This is necessary because the circuit oscillates at a frequency, slightly different from ideal resonant frequency.

RC phase shift oscillator :

fig (A) RC phase shift with 3-lead circuits :

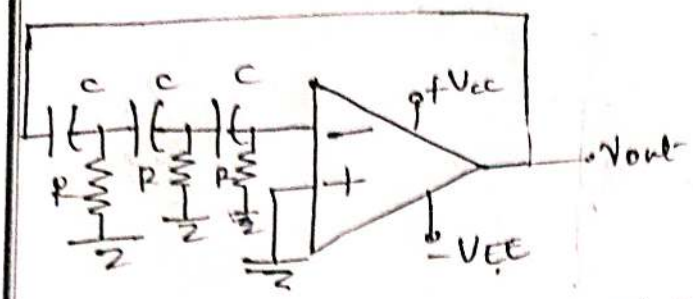
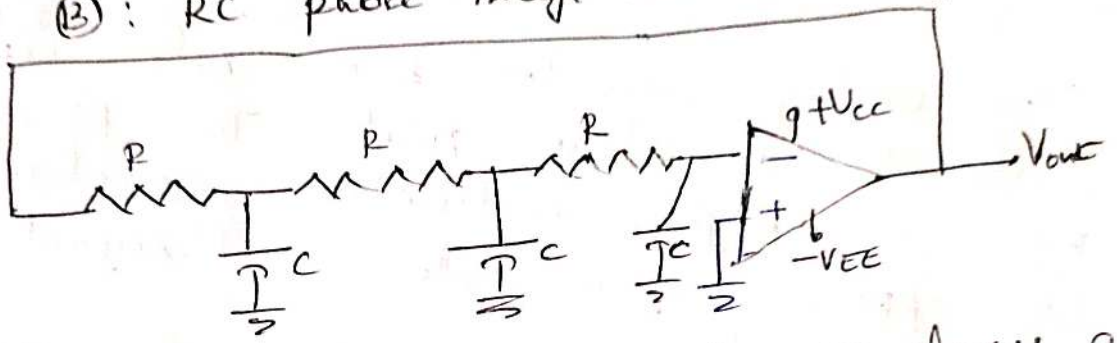
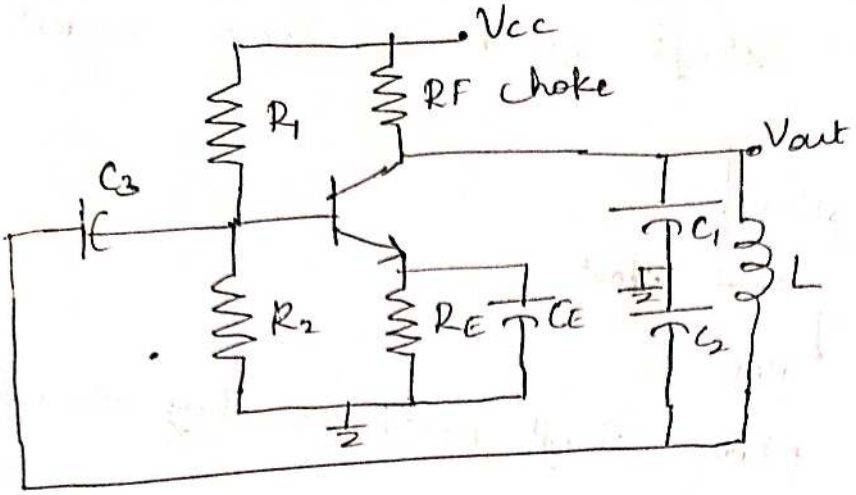


fig (B) : RC phase shift with 3-lag circuits :



* A lead or lag circuit produces a phase shift of (0° to 90°) depending on the frequency.
* At some frequency, the total phase shift of 3 lead circuits equals 180° (upper 60° each)
* The amplifier has an additional 180° of phase shift because the signal drives the inverting input.
* The phase shift around the loop is 360° (or) 0°
* $A_V B$ is greater than 1, then oscillations can start.

Colpitts oscillator:

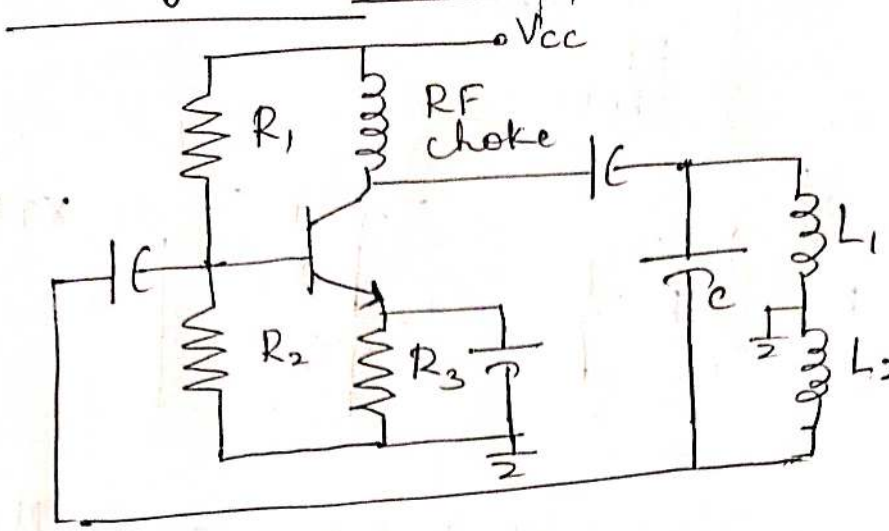


$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{C_1 C_2}{C_1 + C_2}$$

* The voltage divider bias sets up a quiescent operating point. The RF choke has a high inductive reactance, so it appears open to ac signal.
* The circuit has a low-frequency voltage gain of $\frac{r_c}{r_e'}$
* The RF choke appears open to ac signal, the ac collector resistance is primarily the ac resistance of resonant tank circuit. The ac resistance has a maximum value at resonance.
* The required starting condition for any oscillation is $A_V B > 1$ at resonant frequency of tank circuit.
* Feedback fraction $B = \frac{C_1}{C_2}$
* voltage gain $A_{V(min)} = \frac{C_2}{C_1}$

Hartley Oscillator:



$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$L = L_1 + L_2$$

$$B = \frac{L_2}{L_1}$$

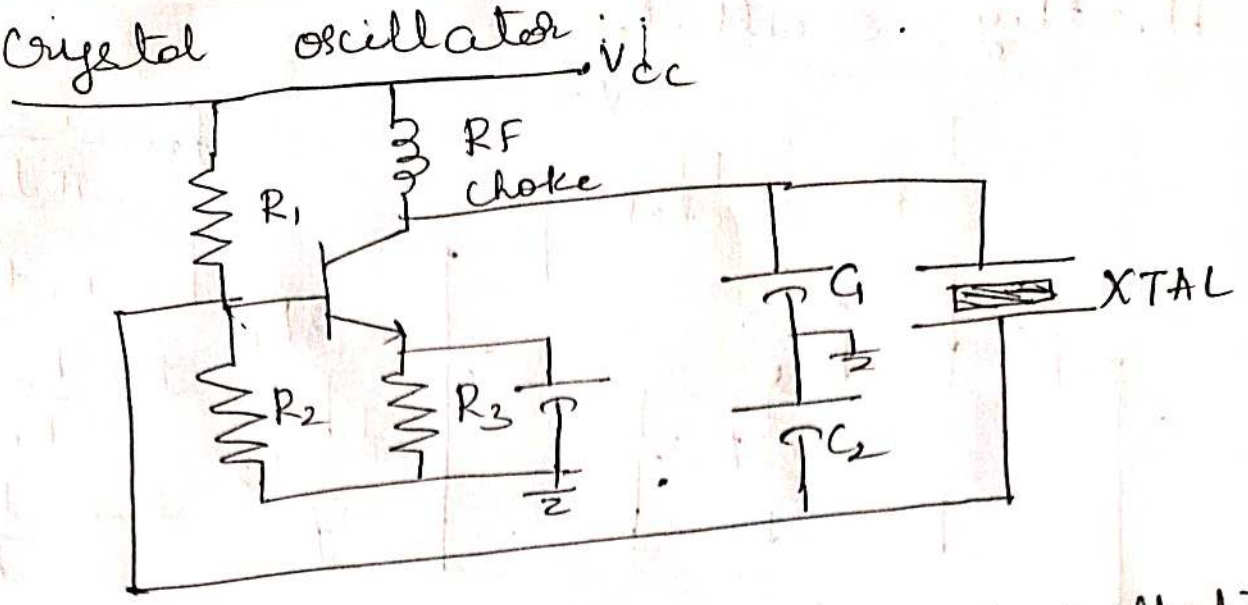
$$A_{V(min)} = \frac{L_1}{L_2}$$

* Fig shows an Hartley oscillator.
* When the LC tank is resonant, the circulating current flows through L_1 in series with L_2.

$$\therefore L = L_1 + L_2$$

* The feedback voltage is developed by inductive voltage divider L_1 & L_2.
* O/P voltage across L_1.
* Feedback voltage across L_2.
* Hartley oscillator use a single tapped inductor instead of two seperate inductors.

Crystal oscillator



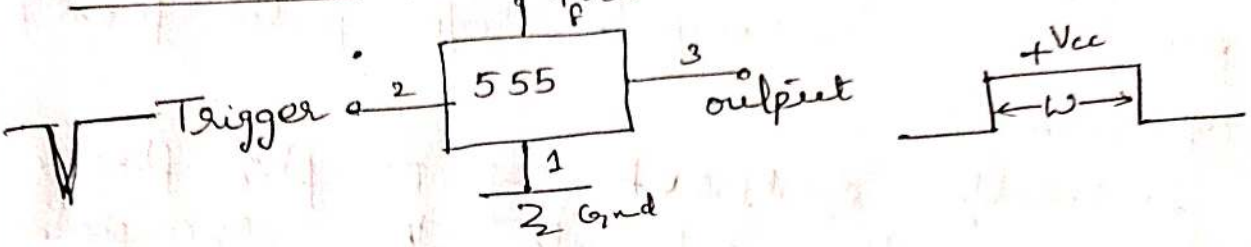
* Accuracy & stability of oscillators are obtained from quartz-crystal oscillator.
* The feedback signal comes from capacitive tap.
* The crystal (XTAL) acts like a a large inductor in series with capacitor.
* The resonant frequency is totally unaffected by transistor and stray capacitances.

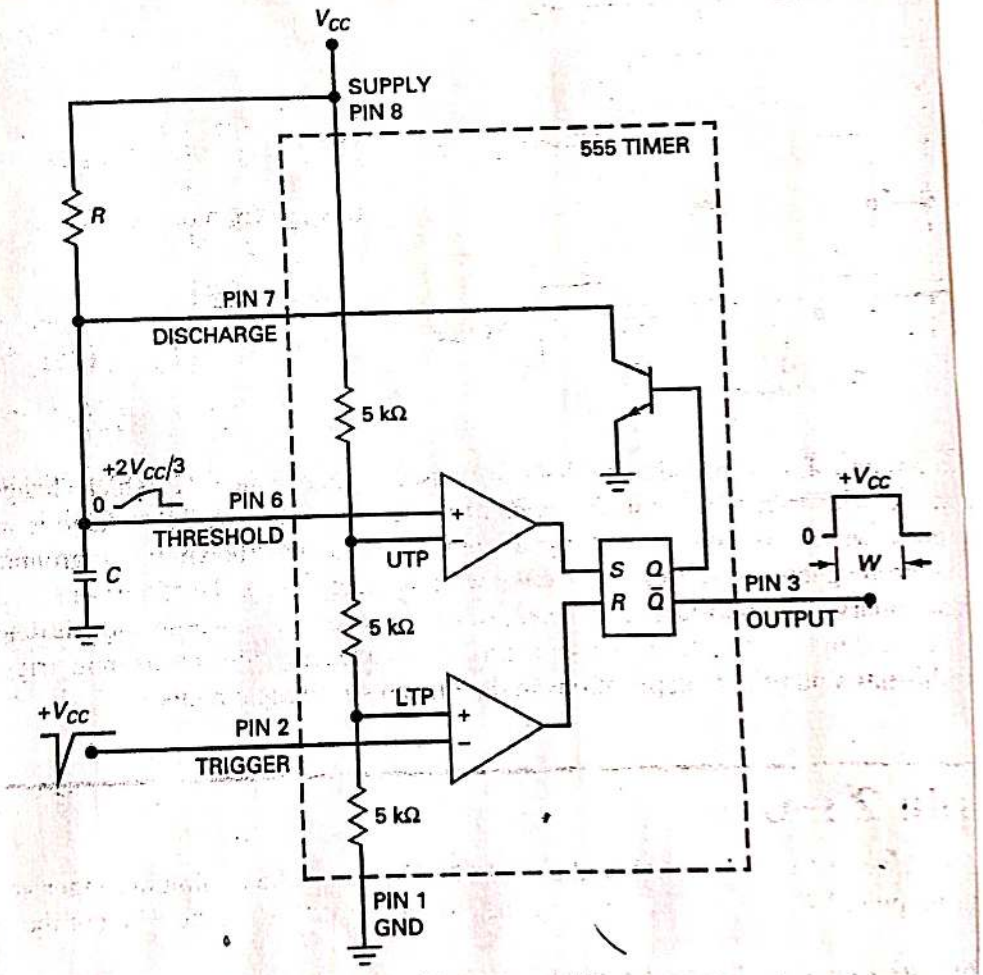
$$f = \frac{1}{2\pi\sqrt{LC_p}}$$

555 Timer: (LM555, CA555)

* It is a widely used IC timer, a circuit that runs in either 2 modes
  * Monostable state
  * Astable state

Monostable operation:

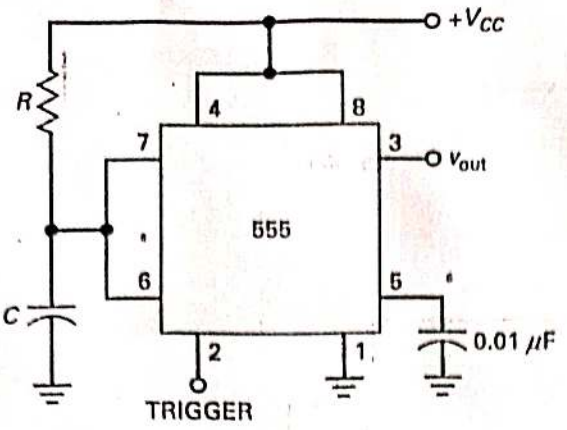




* The fig shows 555 timer connected for monostable operation. The circuit has an external resistor 'R' and capacitor C
* The voltage across capacitor is used for threshold voltage to pin 6. when the trigger arrives at pin 2, the circuit produces rectangular o/p pulse from pin 3.

Operation:

* Initially output of RS flip flop is high, this saturates the transistor and clamps the capacitor voltage to ground. The circuit will remain in this state until a trigger arrives,
* Because of voltage divider, the trip points are UTP = 2/3 Vcc & LTP = 1/3 Vcc
* The trigger i/p falls to slightly less than 1/3 Vcc, the lower comparator resets flip flop Q is changed to low, the transistor goes into cutoff, allows the capacitor to charge.
& $\overline{Q}$ is high
* The capacitor voltage is greater than 2/3 Vcc, the upper comparator sets the flip flop. Q is ON the Transistor which discharges the capacitor & $\overline{Q}$ is low & it remains same until i/p trigger arrives.
* The width of rectangular pulse depends on how long it takes the capacitor 'C' to charge through resistance 'R'.

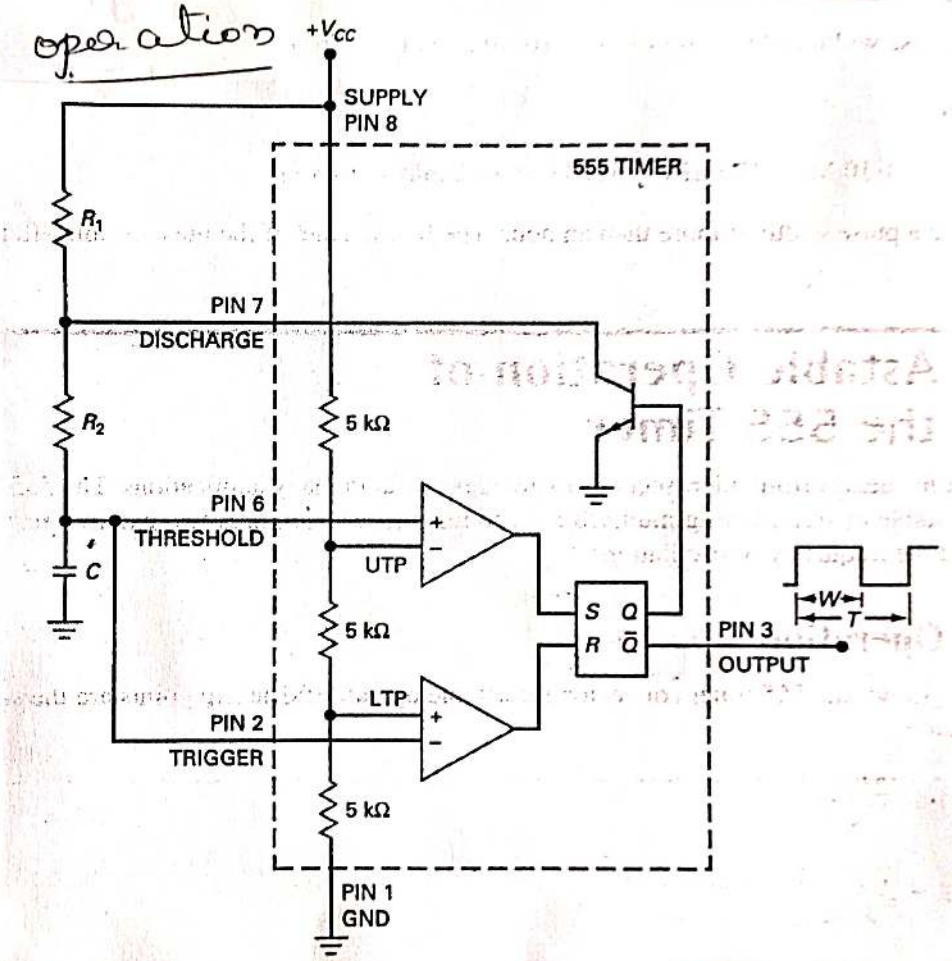


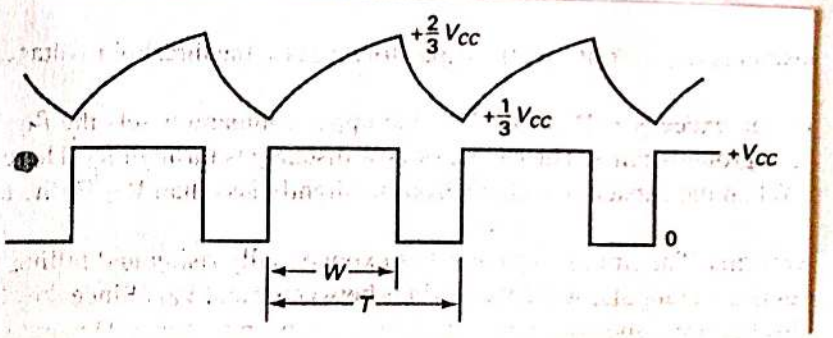
$UTP = \frac{2V_{CC}}{3}$

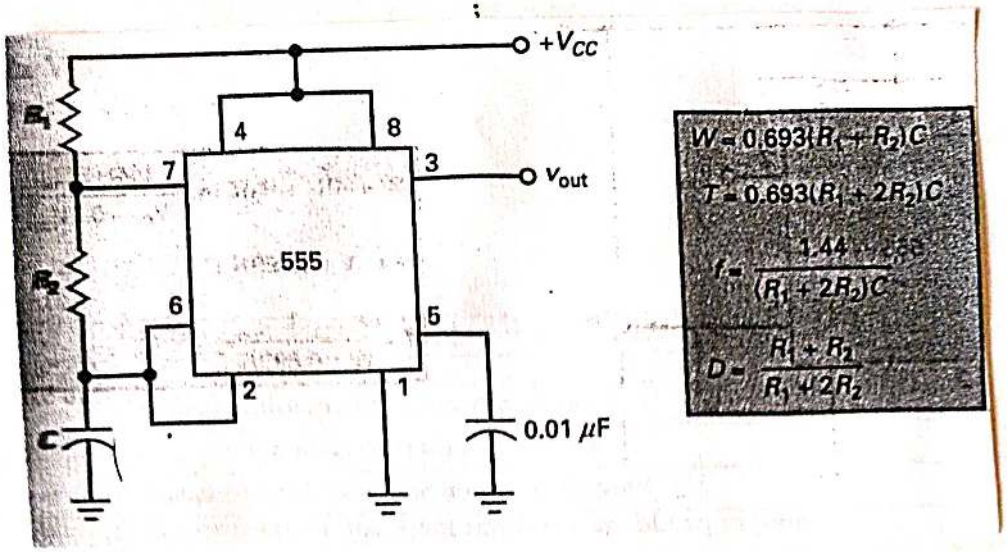
$LTP = \frac{V_{CC}}{3}$

$W = 1.1RC$

Astable operation







* The trip points for astable operation are:
  $UTP = \frac{2}{3} V_{cc}$ & $LTP = \frac{1}{3} V_{cc}$
* Q is low, the transistor is cutoff & capacitor is charging through resistance
  $R = R_1 + R_2$
* Charging time constant is $(R_1 + R_2)\,C$.
* The threshold voltage exceeds $2/3 V_{cc}$, the upper comparator sets flip flop. Q is high, the transistor saturates and grounds pin 7.
* The capacitor now discharges through R_2, the discharge time constant is $R_2 C$.
* Now, the capacitor voltage drops slightly less than $1/3 V_{cc}$, the lower comparator resets the flip flop