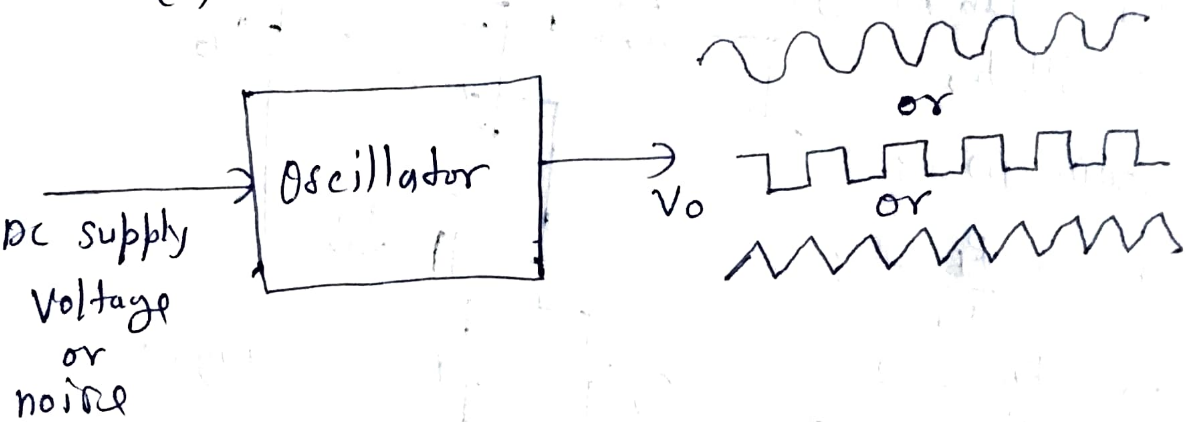
Oscillators

⇒ An oscillator is a circuit that produces a periodically oscillating waveform on its output with dc input. The output voltage can be either sinusoidal or nonsinusoidal, depending on the type of oscillator.

⇒ Basic classifications for oscillators are

(i) feedback oscillators

(ii) Relaxation oscillators.

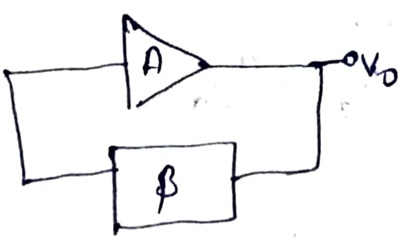


(*) Conditions of Oscillation:

their are two conditions for oscillation.

(i) The phase shift around the feedback loop must be 0° (2πn)

(ii) loop gain must be '1' i.e. $A\beta = 1$



phase shift = 1

loop gain $A\beta = 1$

⊗ Types of sinusoidal oscillators:

(i) Wien bridge oscillators.
(ii) RC phase-shift oscillators.
(iii) LC oscillator
(iv) crystal oscillator.

(i) Wien bridge oscillator:-

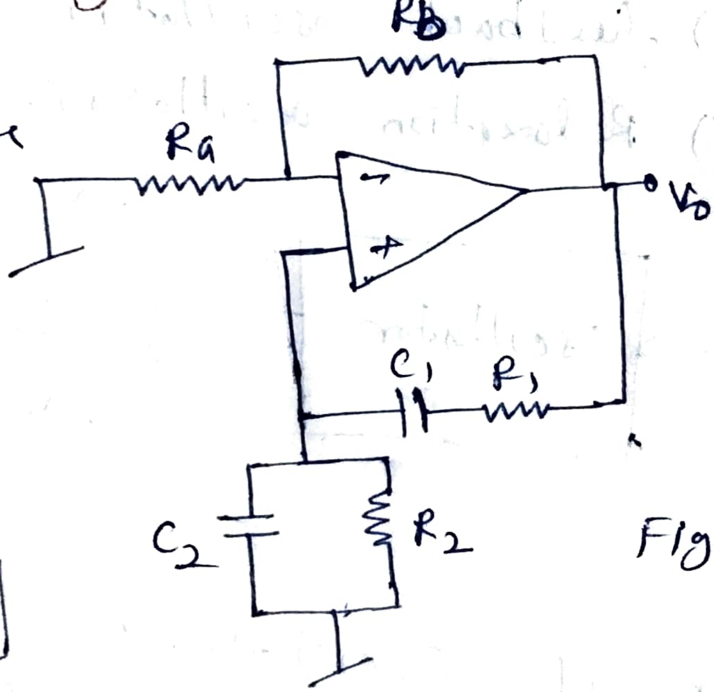


Fig. 1

For wien bridge oscillator

gain (A) = 3

or $1 + \frac{R_b}{R_a} = 3$

$\Rightarrow \frac{R_b}{R_a} = 2$

$\Rightarrow \boxed{R_B = 2R_a}$

↑ condition of oscillation.

We know that

$A \cdot \beta = 1$

$\Rightarrow 3 \cdot \beta = 1 \Rightarrow \boxed{\beta = \frac{1}{3}}$

$\Rightarrow$ For Fig (1) the feedback network can be ~~written as~~ drawn as.

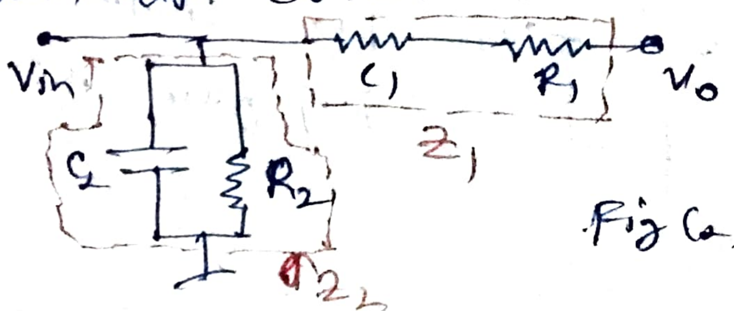


Fig (a)

From Fig (2)

$$\frac{V_o}{V_{in}} = \frac{Z_2}{Z_1 + Z_2} \quad \text{— (A)}$$

since $Z_1 = R_1 + \frac{1}{sC_1}$

$Z_2 = R_2 \parallel \frac{1}{sC_2}$

$$\Rightarrow \frac{V_o}{V_{in}} = \frac{R_2 \parallel \frac{1}{sC_2}}{R_1 + \frac{1}{sC_1} + \left\{ R_2 \parallel \frac{1}{sC_2} \right\}}$$

$$\Rightarrow \frac{V_o}{V_{in}} = \frac{\dfrac{R_2 \times \frac{1}{sC_2}}{R_2 + \frac{1}{sC_2}}}{R_1 + \frac{1}{sC_1} + \dfrac{R_2 \times \frac{1}{sC_2}}{R_2 + \frac{1}{sC_2}}}$$

$$\Rightarrow \frac{V_o}{V_{in}} = \frac{R_2 / sC_2}{R_1 R_2 + \frac{R_1}{sC_2} + \frac{R_2}{sC_1} + \frac{1}{s^2 C_1 C_2} + \frac{R_2}{sC_2}}$$

$$\Rightarrow \frac{V_o}{V_{in}} = \frac{s R_2 C_1}{1 + s^2 R_1 R_2 C_1 C_2 + s\left[R_1 C_1 + R_2 C_2 + R_2 C_1\right]}$$

put $s = j\omega$

$$\Rightarrow \frac{V_o}{V_{in}} = \frac{j\omega R_2 C_1}{1 - \omega^2 R_1 R_2 C_1 C_2 + j\omega\left[R_1 C_1 + R_2 C_2 + R_2 C_1\right]} \quad \text{— (B)}$$

for oscillation

phase shift $\left(\frac{V_o}{V_{in}}\right) = 0$

$$\Rightarrow \quad 1 - \omega^2 R_1 R_2 C_1 C_2 = 0$$

$$\Rightarrow \quad \omega^2 = \frac{1}{R_1 R_2 C_1 C_2}$$

$$\Rightarrow \quad \omega = \sqrt{\frac{1}{R_1 R_2 C_1 C_2}}$$

$$\Rightarrow \quad \boxed{f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}}$$

at this frequency eqn. (B) becomes.

$$\frac{V_o}{V_{in}} = \frac{R_2 C_1}{R_1 C_1 + R_2 C_2 + R_2 C_1}$$

$$\Rightarrow \quad \beta = \frac{R_2 C_1}{R_1 C_1 + R_2 C_2 + R_2 C_1}$$

Since $A \cdot \beta = 1$

$$\Rightarrow \quad A = \frac{1}{\beta}$$

$$\Rightarrow \quad A = \frac{R_1 C_1 + R_2 C_2 + R_2 C_1}{R_2 C_1}$$

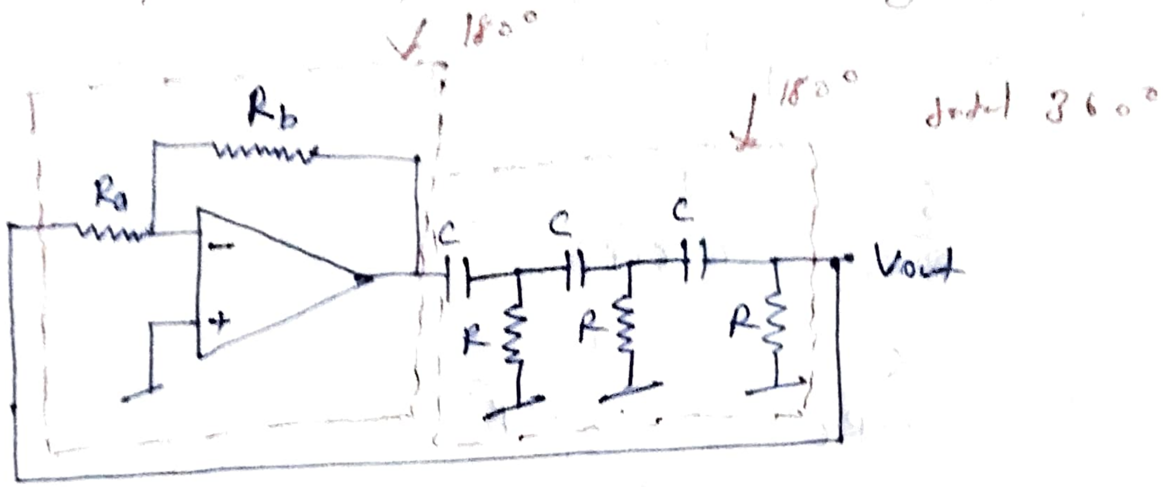
$$\Rightarrow \quad A = \frac{R_1}{R_2} + \frac{C_2}{C_1} + 1$$

$$\Rightarrow \quad 1 + \frac{R_b}{R_a} = \frac{R_1}{R_2} + \frac{C_2}{C_1} + 1$$

Condition for oscillation

$$\Rightarrow \quad \boxed{\frac{R_b}{R_a} = \frac{R_1}{R_2} + \frac{C_2}{C_1}}$$

* RC-phase shift Oscillator using op-amp:



Fig(1)

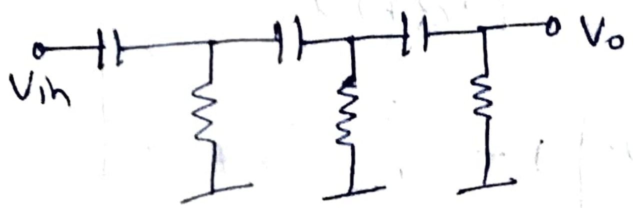
for oscillation total phase shift = 0° or 360°

for RC-phase shift oscillator

$A = 29$ & $\beta = \frac{1}{29}$

$\Rightarrow$ $\boxed{A \cdot \beta = 1}$

The feedback network is given as:



Fig(2)

From Fig (2)

$$V_{in} = V_o\left[1 + \frac{6}{sRC} + \frac{5}{s^2R^2C^2} + \frac{1}{s^3R^3C^3}\right]$$

$$\Rightarrow \frac{V_{in}}{V_o} = 1 + \frac{6}{sRC} + \frac{5}{s^2R^2C^2} + \frac{1}{s^3R^3C^3}$$

$$\Rightarrow \frac{V_{in}}{V_o} = 1 + \frac{6}{j\omega RC} - \frac{5}{\omega^2R^2C^2} - \frac{1}{j\omega^3R^3C^3} \quad \text{— (A)}$$

for oscillation frequency imaginary ~~pho~~ part of above equation is equal to zero

$$\Rightarrow \frac{6}{\omega RC} - \frac{1}{\omega^3 C^3 R^3} = 0$$

$$\Rightarrow \frac{6}{\omega RC} = \frac{1}{\omega^3 C^3 R^3}$$

$$\Rightarrow \omega^2 = \frac{1}{R^2 C^2 6}$$

$$\Rightarrow \omega = \frac{1}{RC\sqrt{6}}$$

$$\Rightarrow \boxed{f = \frac{1}{2\pi RC\sqrt{6}}}$$

at resonant frequency equ. (A) becomes.

$$V_{in} = V_o\left[1 - \frac{5}{\omega^2 C^2 R^2}\right]$$

$$\Rightarrow V_{in} = V_o\left[1 - \frac{5}{\frac{1}{R^2 C^2 6} \times R^2 C^2}\right]$$

$$\Rightarrow V_{in} = V_o\left[1 - 30\right]$$

$$\Rightarrow V_{in} = -29\, V_o$$

$$\Rightarrow \frac{V_o}{V_{in}} = -29$$

$$\Rightarrow \left|\frac{V_o}{V_{in}}\right| = 29 \quad \& \quad \angle\left[\frac{V_o}{V_{in}}\right] = -180^\circ$$