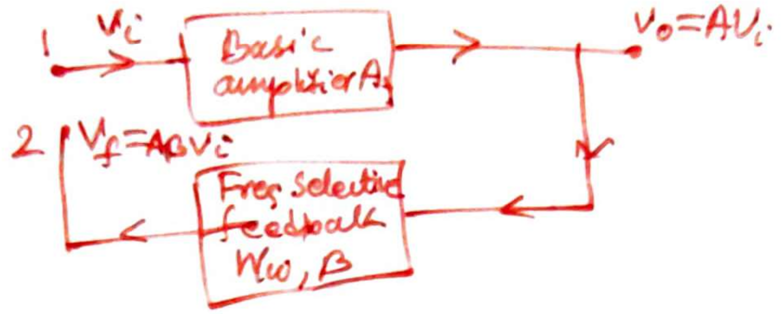
Basic Principle of Sine Wave Oscillators



$$V_o = AV_i$$
$$V_f = \beta V_o = A\beta V_i$$

∴ The quantity $A\beta$ represents loop gain of system

→ If A & β are adjusted so that $A\beta = 1$, the feedback signal V_f will be identically equal to externally applied signal V_i

→ Barkhausen criterion for oscillations

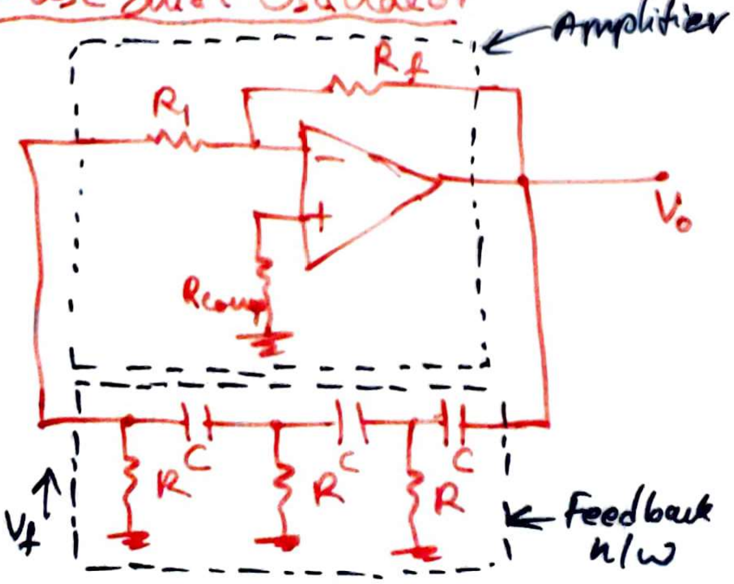
$$|A\beta| = 1$$
$$\angle A\beta = 0° \text{ or multiples of } 2\pi$$

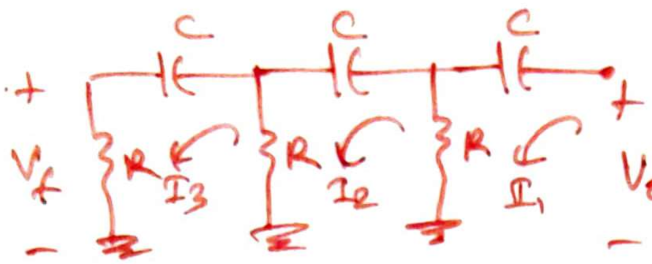
→ There are different types of sine wave oscillators

↳ RC-phase shift oscillators can provide freq's varying from a few Hz to several hundred kHz

↳ LC oscillators are suitable for high freq's up to hundreds of MHz.

RC-Phase Shift Oscillator





→ Op-amp is used in inverting mode therefore provides 180°.

→ Additional phase of 180° is provided by RC feedback n/w to obtain total phase shift of 360°.

→ Each of the RC stage provides a 60° phase shift so that the total phase shift due to feedback n/w is 180°.

$$I_1\left(R+\frac{1}{sC}\right)-I_2R=V_0 \quad \text{—— (1)}$$

$$-I_1R+I_2\left(2R+\frac{1}{sC}\right)-I_3R=0 \quad \text{—— (2)}$$

$$0-I_2R+I_3\left(2R+\frac{1}{sC}\right)=0 \quad \text{—— (3)}$$

$$\& \quad V_f=I_3R$$

→ Solving (1), (2) & (3) for I_3

$$I_3=\frac{V_0R^2s^3C^3}{1+5sRC+6s^2C^2R^2+s^3C^3R^3}$$

$$V_f=I_3R=\frac{V_0R^3s^3C^3}{1+5sRC+6s^2C^2R^2+s^3C^3R^3}$$

$$\Rightarrow \frac{V_f}{V_0}=\frac{1}{1+\frac{6}{sRC}+\frac{5}{s^2C^2R^2}+\frac{1}{s^3C^3R^3}}$$

→ Replacing $s=j\omega$, $s^2=-\omega^2$ & $s^3=-j\omega^3$

$$\beta=\frac{1}{1+\frac{6}{j\omega RC}-\frac{5}{\omega^2R^2C^2}-\frac{1}{j\omega^3R^3C^3}}$$

$$=\frac{1}{(1-5\alpha^2)-j\alpha(6-\alpha^2)}$$

where $\alpha=\frac{1}{\omega RC}$

→ for $A\beta = 1$, β should be real, so imaginary term must be zero

$$\alpha(6-\alpha^2) = 0$$
$$\Rightarrow \alpha^2 = 6$$
$$\Rightarrow \alpha = \sqrt{6}$$
$$\Rightarrow \frac{1}{\omega RC} = \sqrt{6}$$

→ The freq. of oscillation fo is $f_0 = \frac{1}{2\pi RC\sqrt{6}}$

→ for $\alpha^2 = 6$, $\beta = -\frac{1}{29}$ (−ve sign indicates feedback produces 180° phase shift)

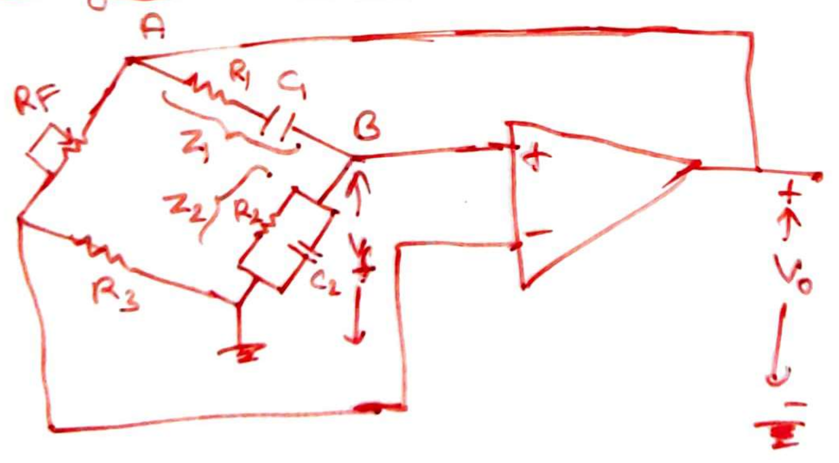
$$|\beta| = \frac{1}{29}$$

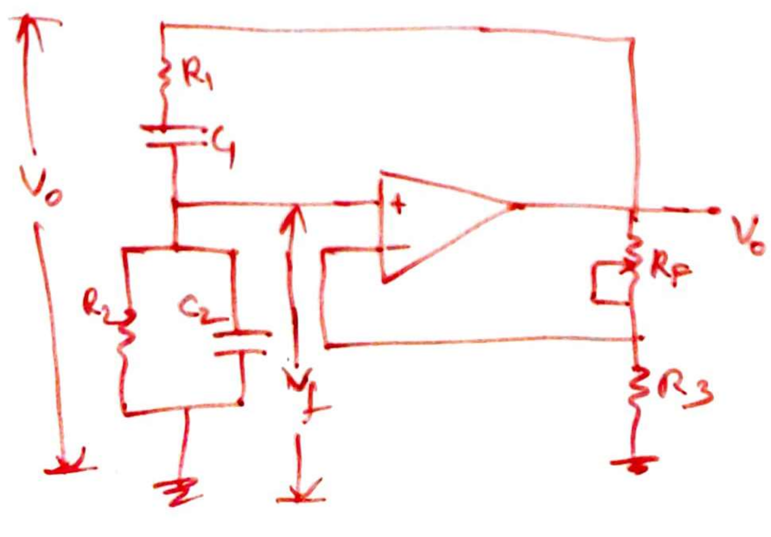
$$|A\beta| \geq 1$$

→ Therefore for sustained oscillations, $|A| \geq 29$

$$R_f = 29 R_1$$

Wein Bridge Oscillator





$$A = 1 + \frac{R_F}{R_3}$$

$$\beta = \frac{V_f}{V_0} = \frac{Z_2}{Z_1 + Z_2}$$

$$Z_1 = R_1 + \frac{1}{SC_1}$$
$$= \frac{SC_1R_1 + 1}{SC_1}$$

$$Z_2 = \frac{R_2}{1 + SR_2C_2}$$

$$\beta = \frac{R_2/(1+sR_2C_2)}{\frac{1+sR_1C_1}{sC_1} + \frac{R_2}{1+sR_2C_2}} = \frac{sR_2C_1}{1+s(R_1C_1+R_2C_2+R_2C_1)+s^2R_1R_2C_1C_2}$$

→ Put $s = j\omega$

$$\beta = \frac{j\omega R_2 C_1}{1+j\omega(R_1C_1+R_2C_2+R_2C_1) - \omega^2 R_1R_2C_1C_2}$$

→ For β to be a real quantity

$$1-\omega^2 R_1R_2C_1C_2 = 0$$

→ Freq. of oscillation

$$f_0 = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

$$\& \ \beta = \frac{R_2C_1}{R_1C_1+R_2C_2+R_2C_1}$$

→ For $R_1 = R_2 = R$ & $C_1 = C_2 = C$

$$f_0 = \frac{1}{2\pi RC}$$

$$\& \ \beta = \frac{1}{3}$$

→ Since $|A\beta| \geq 1$ for sustained oscillations

$$|A| \geq 3$$

→ Since $A = 1 + \frac{R_F}{R_3}$

$$3 = 1 + \frac{R_F}{R_3} \Rightarrow R_F = 2R_3$$