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R-C phase shift oscillator: The phase shift network consists of three section R_1C_1, R_2C_2 and R_3C_3. To introduce a phase change of 180°. This phase shift of 180° is obtained with three section C_1R_1, C_2R_2, C_3R_3 (each section consists of a series coupling capacitor and a shunt resistor) each shifting the signal by 60°. The phase shift comes about because R and C provides a current which leads the applied voltage by certain angle. The smaller is the capacitance more will be current lead the voltage for a given resistance. With a proper choice of R and C, a phase shift of 60° per section is achieved.

To problem of a phase shift network for a transistor is some what complicated in comperision to vacuum tube because of low input impedance of the transistor. The last resistance in RC combination is not simply R_3 but the transistor input resistance is parallel with R_3.

Now the frequency determining resistors are equal and similarly the frequency determining capacitors are equal i.e

$$R_1 = R_2 = R_3 = R \text{ (say)}$$

$$\text{and} \quad C_1 = C_2 = C_3 = C \text{ (say)}$$

Consider the frequency of osillation and attenuation of the network, we proceed as follows, Fig (2) shows the equivalent circuit in which I_1 is the signal current from the oscillator circuit and I_4 is the signal current into the base circuit.

Applying Kirchhoff's law, we have

$$I_1R = I_2\left(2R - \frac{j}{\omega C}\right) - I_3R \text{ — (1)}$$

$$I_2R = I_3\left(2R - \frac{j}{\omega C}\right) - I_4R \text{ — (2)}$$

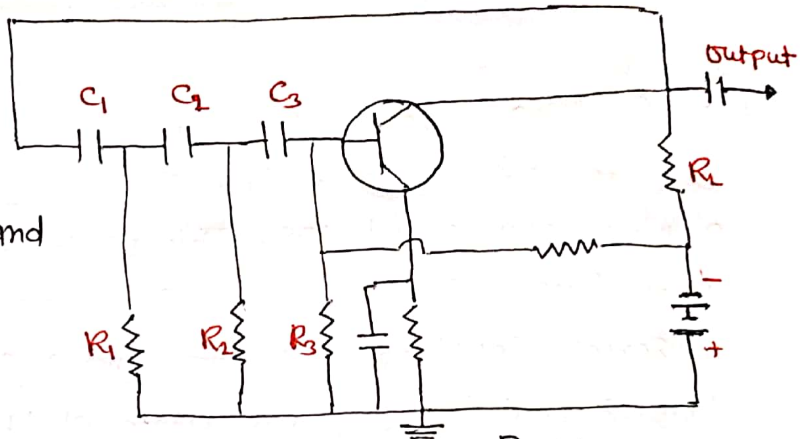

Fig.(1)

Eliminating I_2 from eqn (1) and (2) i.e. Substituting the value of I_2 from eqn (2) into eqn (1) we have

$$I_1R = \left\{\frac{I_3\left(2R - \frac{j}{\omega C}\right)}{R} - I_4\right\}\left(2R - \frac{j}{\omega C}\right) - I_3R \text{ — (3)}$$

or $$I_1R = \frac{\left(2R - \frac{j}{\omega C}\right)^2}{R} - I_3 - \left(2R - \frac{j}{\omega C}\right)I_4 - I_3R \text{ — (4)}$$

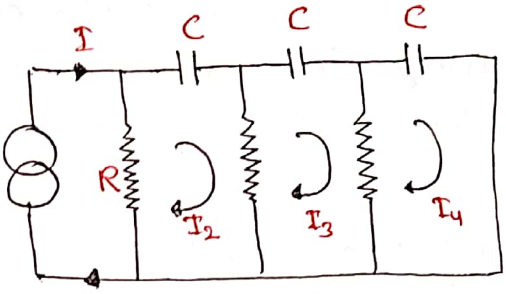

Fig.(2)

Substituting the value of I_3 from eqn (3) in eqn (4), we get

$$I_1R = \left\{\frac{(2R - j/\omega C)^2 (R - j/\omega C)}{R^2}\right\} I_4 - \left(2R - \frac{j}{\omega C}\right) I_4 - I_4\left(R - \frac{j}{\omega C}\right)$$

$$\therefore \frac{I_4}{I_1} = \frac{R^3}{\left(2R - \frac{j}{\omega C}\right)^2\left(R - \frac{j}{\omega C}\right) - \left(3R - \frac{2j}{\omega C}\right)R^2}$$

$$= \frac{R^3}{R^3 - j\frac{6R^2}{\omega C} - \frac{5R}{\omega^2 C^2} + \frac{j}{\omega^3 C^3}} \text{ — (5)}$$

For a phase shift of 180° between I_4 and I_1, the terms containing j should vanish and we have

$$\frac{j}{\omega^3 C^3} - \frac{j6R^2}{\omega C} = 0$$

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

$$\therefore \quad \omega = \frac{1}{\sqrt{6} \cdot RC} \quad \text{—— (6)}$$

The frequency of oscillations is given by

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

At this frequency, from equ^n (5), we have

$$\frac{I_4}{I_1} = \frac{R^3}{R^3 - \frac{5R}{C^2} \times 6R^2C^2} = -\frac{1}{29} \quad \text{—— (7)}$$

From equ^n (7) it is clear that transistor must give a current gain of at least 29 to achieve oscillations. This a is a transistor with high value of feed back is selected to give oscillations. For sinusoidal out put the transistor must not oscillate too strongly and the gain should be adjusted a give only a small amplitudes of oscillations.

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Teacher's Signature: ________