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B.Sc. part-2 physics (Hons)
paper-iv Lecture no- 46

Topic: RC Phase Shift Oscillator

RC phase-shift oscillators use resistor-capacitor (RC) network (Figure 1) to provide the phase-shift required by the feedback signal. They have excellent frequency stability and can yield a pure sine wave for a wide range of loads.

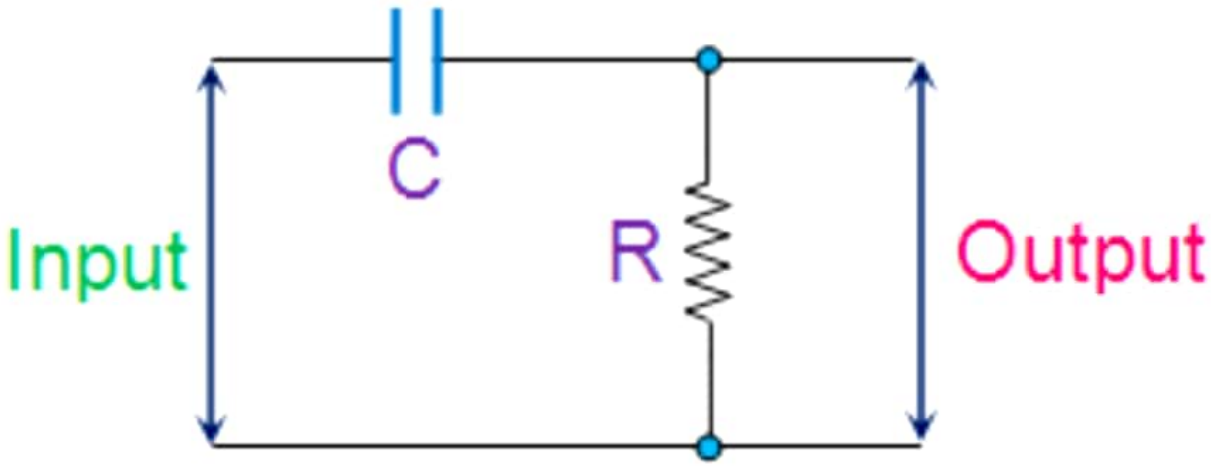

Figure 1 RC Phase-Shift Network

Ideally a simple RC network is expected to have an output which leads the input by 90^{o}.

However, in reality, the phase-difference will be less than this as the capacitor used in the circuit cannot be ideal. Mathematically the phase angle of the RC network is expressed as

$$\varphi = tan^{-1}\frac{X_C}{R}$$

Where, $X_C = 1/(2\pi fC)$ is the reactance of the capacitor C and R is the resistor. In oscillators, these kind of RC phase-shift networks, each offering a definite phase-shift can be cascaded so as to satisfy the phase-shift condition led by the Barkhausen Criterion.

One such example is the case in which **RC phase-shift oscillator** is formed by cascading three RC phase-shift networks, each offering a phase-shift of 60^{o}, as shown by Figure 2.

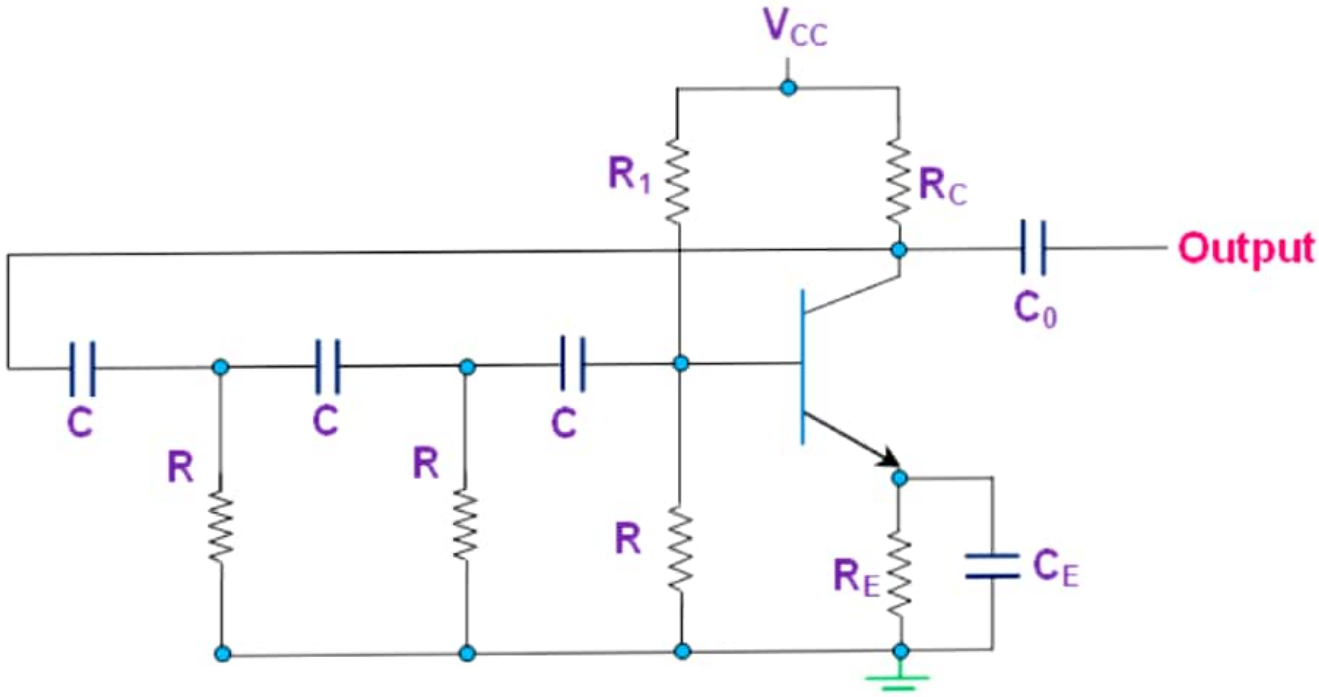

Figure 2 RC Phase-Shift Oscillator Using BJT

Here the collector resistor RC limits

the collector current of the transistor, resistors R_1 and R (nearest to the transistor) form the voltage divider network while the emitter resistor R_E improves the stability. Next, the capacitors C_E and C_o are the emitter by-pass capacitor and the output DC decoupling capacitor, respectively. Further, the circuit also shows three RC networks employed in the feedback path.

This arrangement causes the output waveform to shift by 180^o during its course of travel from output terminal to the base of the

transistor. Next, this signal will be shifted again by 180^{o} by the transistor in the circuit due to the fact that the phase-difference between the input and the output will be 180^{o} in the case of common emitter configuration. This makes the net phase-difference to be 360^{o}, satisfying the phase-difference condition.

One more way of satisfying the phase-difference condition is to use four RC networks, each offering a phase-shift of 45^{o}. Hence it can be concluded that the **RC phase-shift**

oscillators can be designed in many ways as the number of RC networks in them is not fixed. However it is to be noted that, although an increase in the number of stages increases the frequency stability of the circuit, it also adversely affects the output frequency of the oscillator due to the loading effect.

The generalized expression for the frequency of oscillations produced by a **RC phase-shift oscillator** is given by

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

Where, N is the number of RC stages formed by the resistors R and the capacitors C.