UNIT: 5 SINUSOIDAL OSCILLATORS — 4 Lectures

Sinusoidal Oscillators:
- Output waveform is a SINE wave
- Also called 'Harmonic Oscillators'
- Output freq.s 20Hz – 1GHz

Non-sinusoidal Oscillators:
- Output waveform is Square, Triangular, Sawtooth etc.
- Also called 'Relaxation Oscillators'
- Output freq.s – upto 20MHz.

Sinusoidal Oscillators

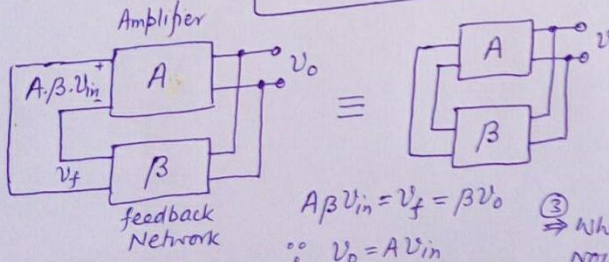
- **Tuned Circuit Oscillators** (LC Tank ckt)
  - called R.F. (Radio freq.) Oscillators
  - Hartley, Colpitt etc.
- **RC Oscillators**
  - Audio freq. Oscs
  - Phase Shift & Wein-Bridge
- **Crystal Oscillators** – used Quartz Crystals
- **Negative-Resistance Osc.** – use tunnel devices

BARKHAUSEN Criterion for Self-Sustained Oscillations

- Feedback must be "POSITIVE" (Phase shift of 0°/360°)
- Loop Gain ($= A\beta$) must be ≥ 1
  - $\Rightarrow A\beta > 1$ initially for starting Oscillations → By either Reducing A or β
  - $\Rightarrow A\beta = 1$ Afterward for sustaining Oscillations.

$$A\beta = 1 \angle 0^\circ \text{ or } 360^\circ$$

β = Feedback Fraction



$A\beta V_{in} = V_f = \beta V_o$

$\because V_o = A V_{in}$

① ⇒ Starting Voltage is "THERMAL NOISE"

② ⇒ Random movement of Free electrons in a Resistor generates a Noise voltage across that resistor.

③ ⇒ When power is first Turned ON, these Noise voltages gets amplified & appear at the output. – It contains all frequencies upto 1000 GHz.

④ ⇒ Above & Below Resonant frequency Phase shift ≠ 0° or 360°

⑤ ⇒ Hence Oscillations are sustained only at the Resonant frequency of the Feedback Network.

Advantages / Disadvantages of LC & RC Networks in Oscillator Circuits

- Frequencies < 1 MHz : RC Oscillators are used to produce almost perfect Sine waves (Op-Amps & BJT are suitable)
- Frequencies > 1 MHz : LC Resonant circuits are used (BJT & FET are used (Op-Amp Not suitable)

Disadvantages of LC circuits :
- Frequency instability
- Unsuitable for low frequencies
- Inductors (Bulky, Expensive)
- Waveform quality not good.

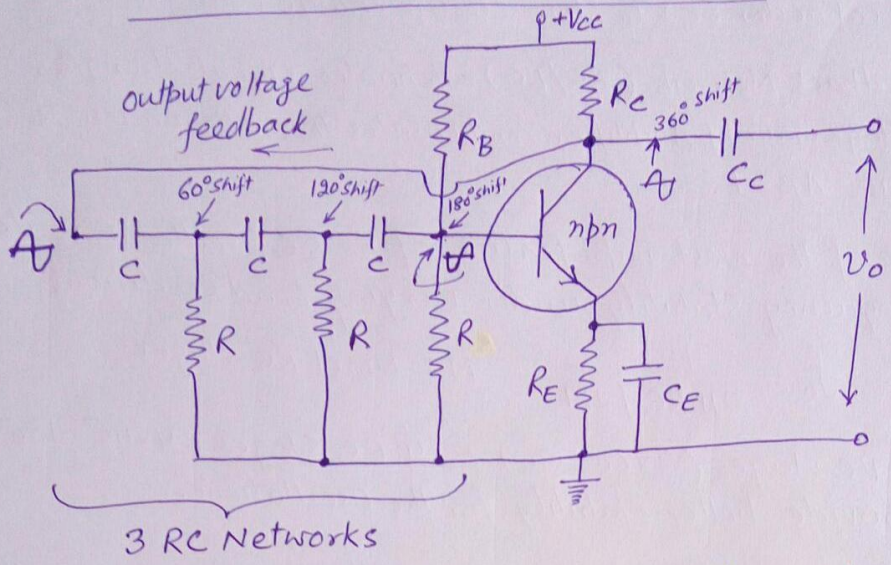
Advantages of LC Circuits :
- Can produce High freq. Oscillations (1 - 500 MHz)

Advantages of RC Network :
- All drawbacks of LC Osc. ckts are eliminated
- Less bulky & expensive
- Can produce low frequencies
- Waveform stability is very good & output is distortion free

- Commonly used for generating Audio frequencies.

Disadvantages of RC Network :
- Due to small feedback, starting Oscillations becomes difficult.
- Output signal is small.
- To increase feedback, High value of V_{cc} is required.

RC PHASE SHIFT OSCILLATOR



- This type of Oscillator uses an Amplifier configuration in combination with 3 RC-Networks.
- Each RC Network produces a 60° phase shift between the input and output signal. So 3 RC networks produce a combined phase shift of 180°.
- A further 180° phase shift is produced by the Amplifier configuration, resulting in a total 360° phase shift or "Positive Feedback"
- With sufficient biasing & hence adequate amplification Sustained Oscillations can be maintained.

RC Phase Angle: Since $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

Total Impedance of a Single RC Network is

$$Z = \sqrt{R^2 + X_C^2} \quad \text{and} \quad \phi = \tan^{-1}\left(\frac{X_C}{R}\right)$$

⇒ Properly chosen X_C (i.e value of C) and R can make $\phi = 60°$

⇒ **Frequency of Oscillations:** $\boxed{f_o = \frac{1}{2\pi\sqrt{6}\,(RC)}}$

Feedback Fraction: $\boxed{|\beta| = \frac{1}{29}}$ so $(A_v)_{min} = 29$ ⇒ Applicable for FET Amplifier configuration

✱ For a Transistor (small signal CE Config) Short circuit Current Gain h_{fe} should be equal to or more than 44.5 for sustained Oscillations.

$h_{fe} > \frac{29}{k} + 4k + 23 \Rightarrow (h_{fe})_{min} = 44.5$ for $k = 2.7 \Rightarrow \beta = -\frac{1}{120} \Rightarrow |A| = \left|\frac{1}{\beta}\right| = 120$ for BJT config.