Nepal Institute of Engineering

Nepal Engineering Council Registration Examination Preparation Class

Computer Engineering

1.5 Signal Generator

1. Concept of Basic Electrical and Electronics Engineering (AExE01)

1.1 Basic concept: Ohm´s law, electric voltage current, power and energy, conducting and insulating materials. Series and parallel electric circuits, start-delta and delta-star conversion, Kirchhoff's law, linear and non-linear circuit, bilateral and unilateral circuits, active and passive circuits.

1.2 Network theorems: concept of superposition theorem, Thevenin`s theorem, Norton`s theorem, maximum power transfer theorem. R-L, R-C, R-L-C circuits, resonance in AC series and parallel circuit, active and reactive power.

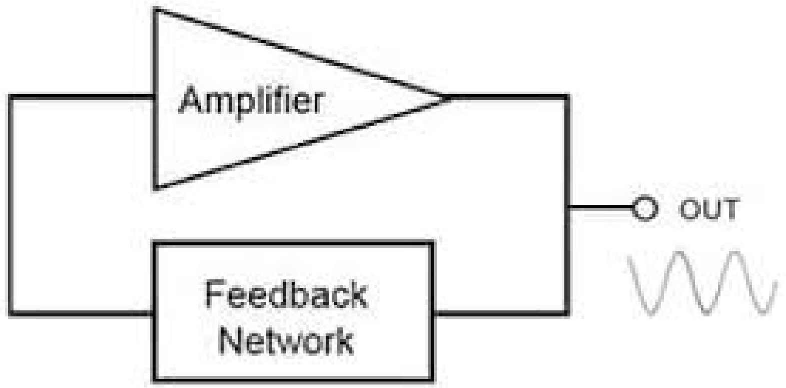
1.3 Alternating current fundamentals: Principle of generation of alternating voltages and currents and their equations and waveforms, average, peak and rms values. Three phase system.

1.4 Semiconductor devices: Semiconductor diode and its characteristics, BJT Configuration and biasing, small and large signal model, working principle and application of MOSFET and CMOS.

1.5 Signal generator: Basic Principles of Oscillator, RC, LC and Crystal Oscillators Circuits. Waveform generators.

1.6 Amplifiers: Classification of Output Stages, Class A Output Stage, Class B Output Stage, Class AB Output Stage, Biasing the Class AB Stage, Power BJTs, Transformer-Coupled Push-Pull Stages, and Tuned Amplifiers, op-amps.

Oscillators



- Oscillators are electric circuits that generate a continuous voltage output waveform at a required single frequency.
- For positive feedback

$A_f = A/(1-\beta A)$

1. Sinusoidal Oscillators – these are known as **Harmonic Oscillators** and are generally a "LC Tuned-feedback" or "RC tuned-feedback" type Oscillator that generates a purely sinusoidal waveform which is of constant amplitude and frequency.

2. Non-Sinusoidal Oscillators – these are known as **Relaxation Oscillators** and generate complex non-sinusoidal waveforms that changes very quickly from one condition of stability to another such as "Square-wave", "Triangular-wave" or "Sawtoothed-wave" type waveforms.

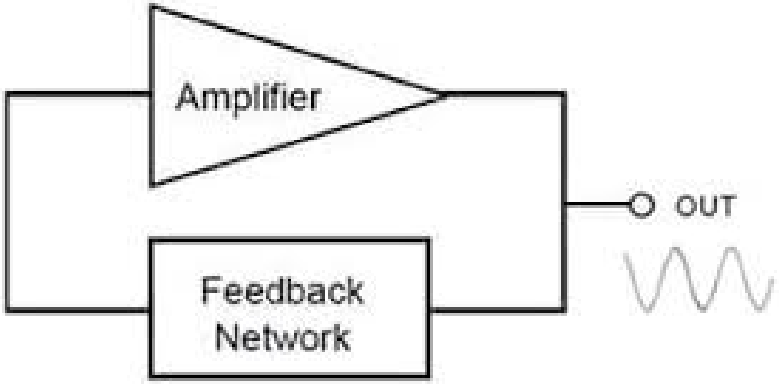
- **Essential condition for oscillation**

(Barkhausen’s Criteria for oscillation) :

1. The loop gain is equal to one in absolute magnitude, which means that

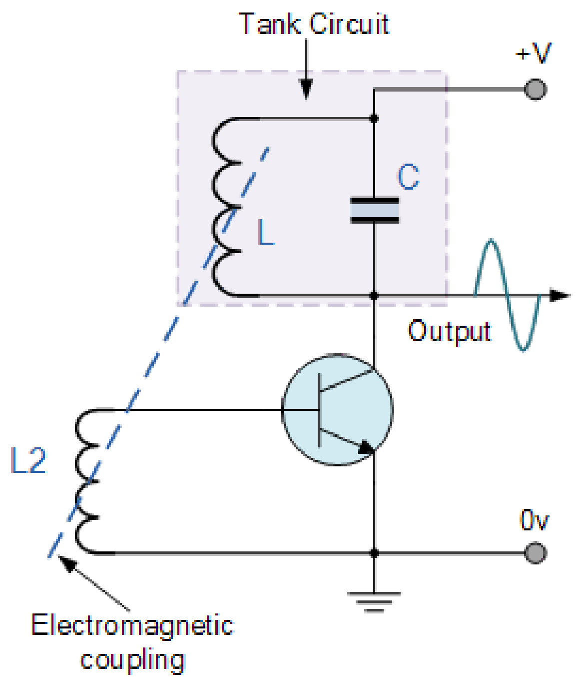
$\beta A = 1$

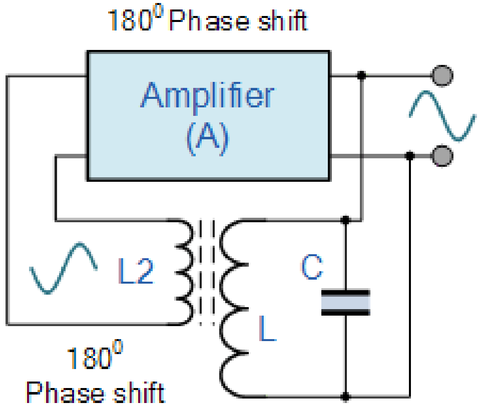
2. The phase shift through the loop is either zero or an integer multiple of 2π



• **LC Oscillator :**

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

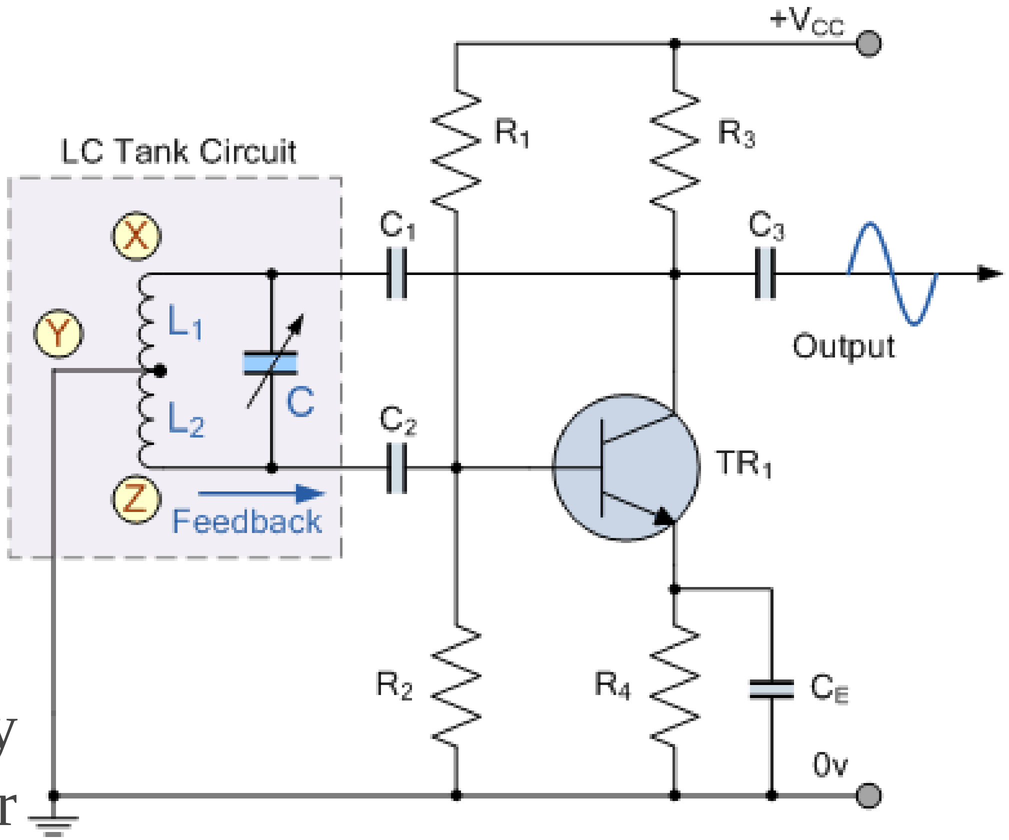




- **Hartley oscillator:**

$$f = \frac{1}{2\pi\sqrt{L_T C}}$$

$$\text{where: } L_T = L_1 + L_2 + 2M$$

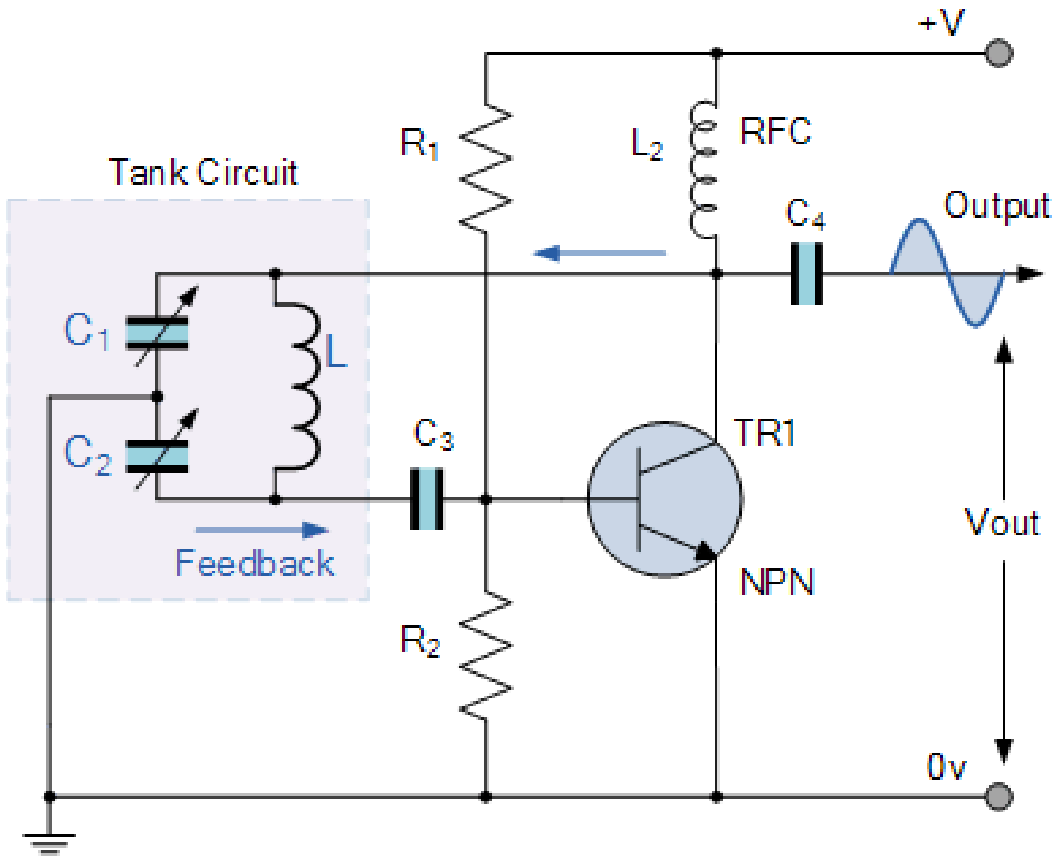


- Positive output feedback is inductively coupled by tank circuit consisting inductor coil with center tap.
- It is mainly used as radio receivers.
- It is suitable for oscillations in RF

- **Colpitts oscillator:**

$$f_r = \frac{1}{2\pi\sqrt{L\,C_T}}$$

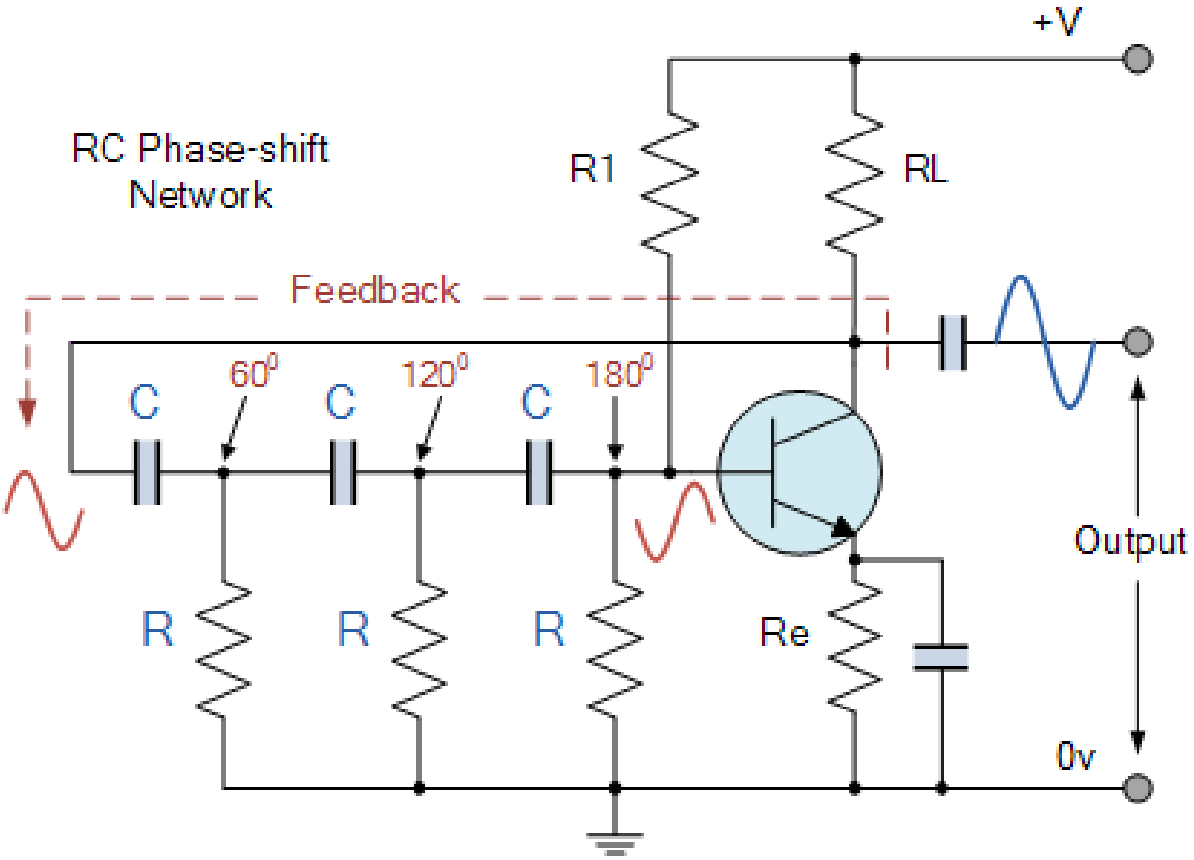
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} \quad \text{or} \quad C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$



- It consists of a parallel LC resonator tank circuit whose feedback is achieved by way of a capacitive divider
- Used for the generation of sinusoidal output signal with very high frequencies

- **RC Phase Shift oscillator:**

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

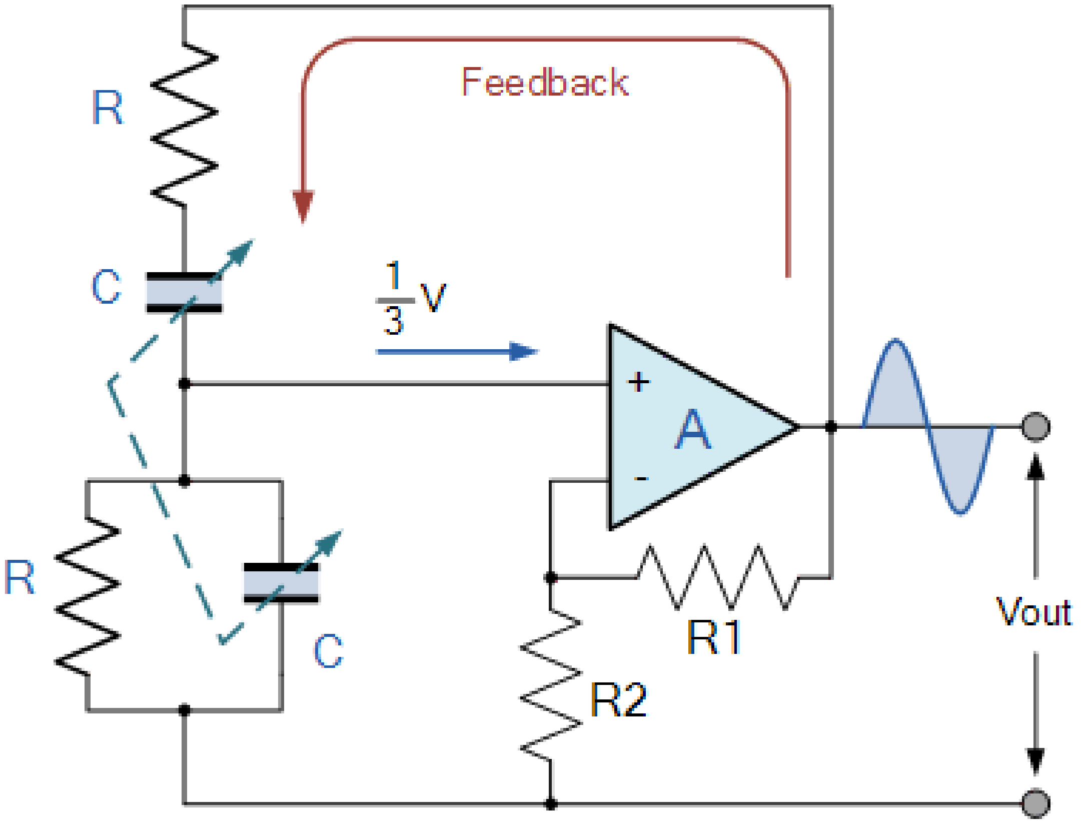


- It is used to generate low or audio frequency signal
- By changing the value of R and C, frequency of oscillator can be changed

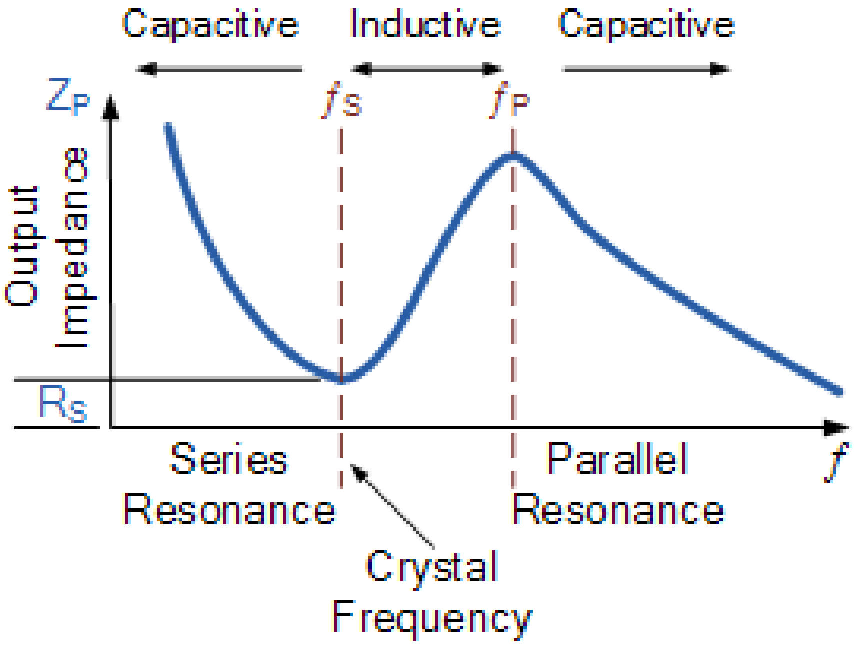
- **Wein bridge oscillator:**

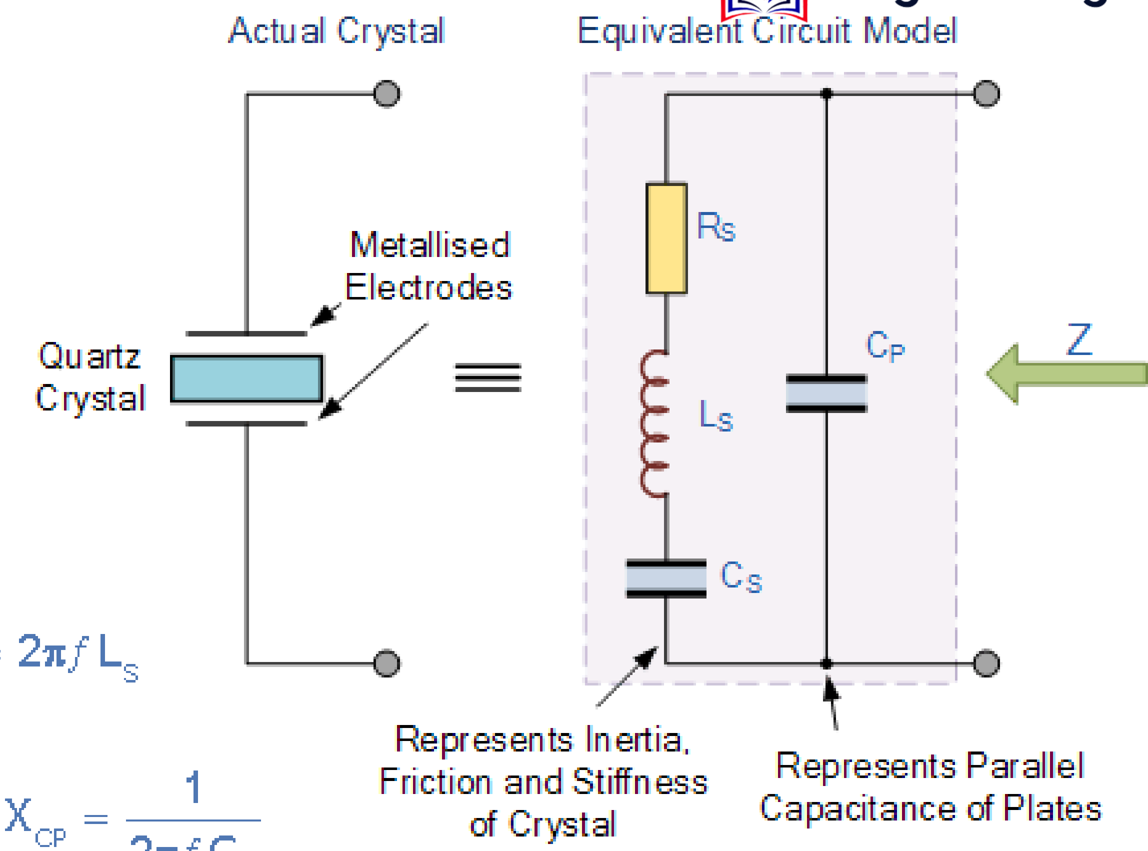
$$f_r = \frac{1}{2\pi RC}$$

- Frequency range: 100Hz to 100 KHz
- Accuracy= 0.1 to 0.5 percent can be achieved
- Used in distortion analyser



• Crystal oscillator:





$$R = R \quad \text{and} \quad X_{LS} = 2\pi f L_S$$

$$X_{CS} = \frac{1}{2\pi f C_S} \quad \text{and} \quad X_{CP} = \frac{1}{2\pi f C_P}$$

$$Z_S = \sqrt{R_S^2 + (X_{LS} - X_{CS})^2}$$

$$\therefore Z_P = \frac{Z_S \times X_{CP}}{Z_S + X_{CP}}$$

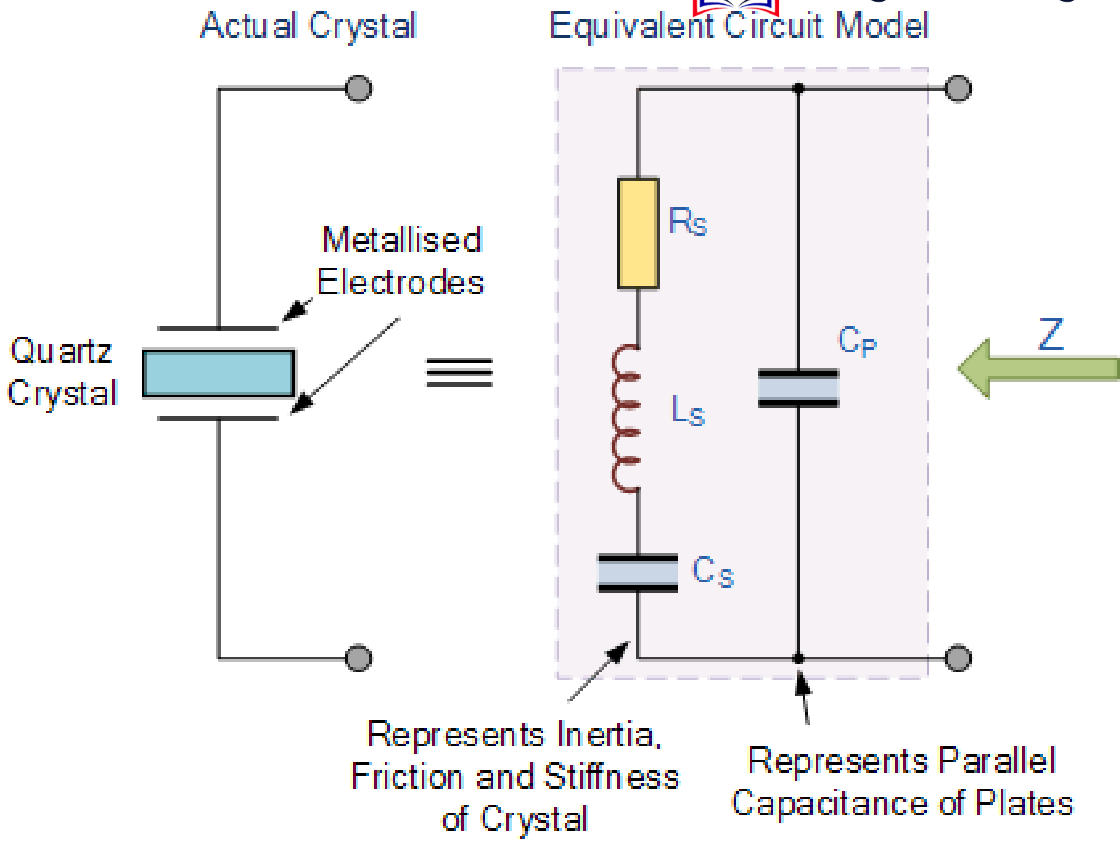
- **Crystal oscillator:**

Series resonant frequency

$$f_S = \frac{1}{2\pi\sqrt{L_S C_S}}$$

Parallel resonant frequency

$$f_P = \frac{1}{2\pi\sqrt{L_S\left(\frac{C_P C_S}{C_P + C_S}\right)}}$$



- Crystal oscillator is fixed frequency oscillator with a high Q-factor.
- Crystal oscillator operates on the principle of inverse piezoelectric effect in which alternating voltage applied across the crystal surfaces causes it to vibrate at its natural frequency.
- These vibrations get converted into oscillations
- Crystal like quartz have high Q factor which results in high frequency stability

Type of oscillator	*Approximate frequency range*
Crystal oscillator	Fixed frequency
Wien bridge oscillator	1 Hz to 1 MHz
Phase-shift oscillator	1 Hz to 10 MHz
Hartley oscillator	10 kHz to 100 MHz
Colpitts oscillator	10 kHz to 100 MHz

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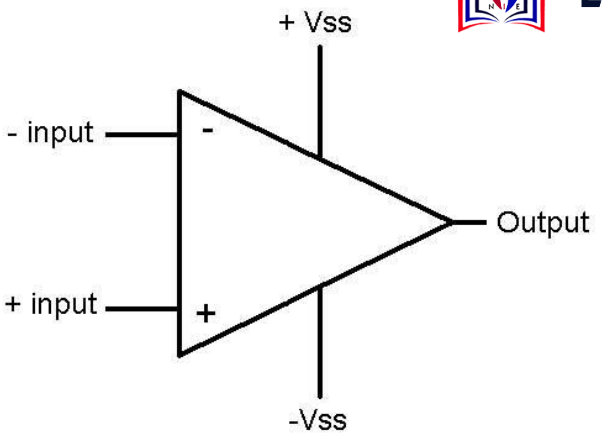
Op Amp



Parameter	Symbol	Ideal Op-Amp	Practical Op-Amp
DC Open loop gain	A_{OL}	∞	100 dB
Input Impedance	Z_{IN}	∞	2MΩ
Output Impedance	Z_{out}	0	75Ω
Input Offset Voltage	V_{IO}	0	1mV
Slew rate	SR	∞	Depends on input signal frequency
Bandwidth	BW	∞	Depends on input signal frequency
CMRR	ρ	∞	90 dB

Tuned Amplifier

- Tuned amplifiers are the amplifiers that are employed for the purpose of **tuning**. Tuning means selecting. Among a set of frequencies available, if there occurs a need to select a particular frequency, while rejecting all other frequencies, such a process is called **Selection**. This selection is done by using a circuit called as **Tuned circuit**.
- When an amplifier circuit has its load replaced by a tuned circuit, such an amplifier can be called as a **Tuned amplifier circuit**.