Analog and Digital Systems (UEE505)

Lecture # 11
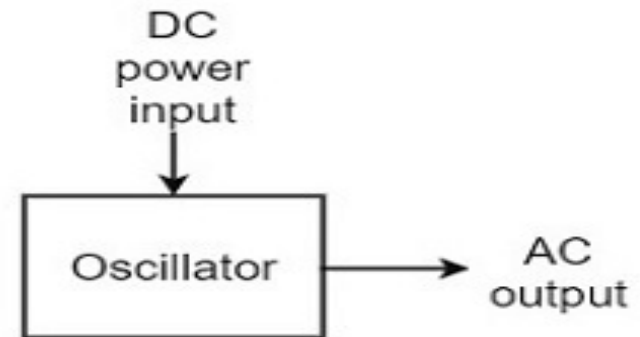## Oscillator Introduction & Hartley Oscillator

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

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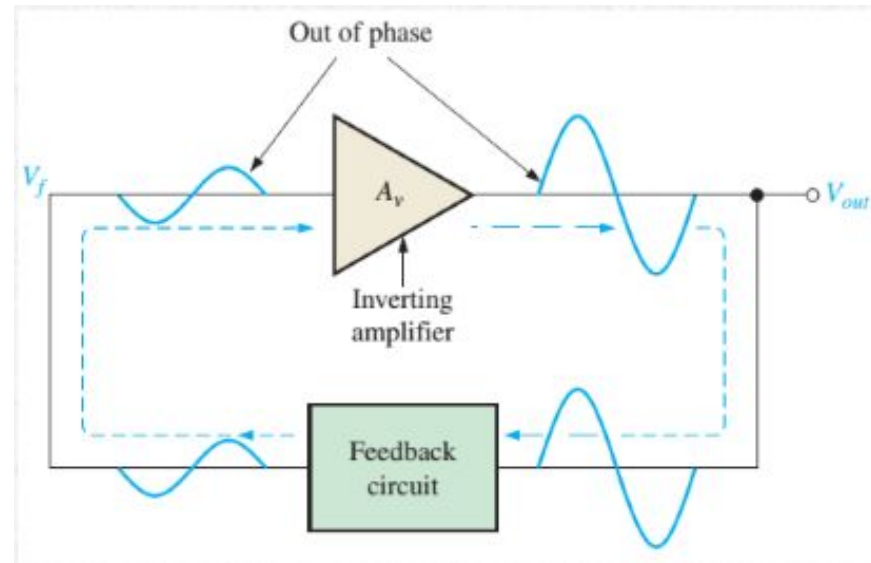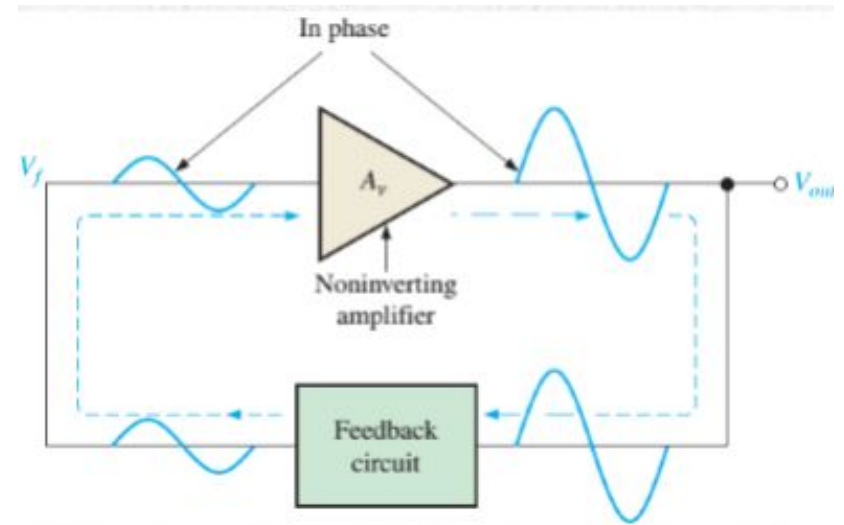Thapar Institute of Engineering & Technology Patiala, India

Oscillator

❖ Oscillators are electronic circuits that generate an output signal without the necessity of an input signal.

❖ It produces a periodic waveform on its output with only the DC supply voltage as an input.

❖ The starting ac voltage signal for an oscillator is noise voltage which appears across resistors used in the amplifier circuit (due to random motion of free electrons in different directions at ambient temperature).

❖ An **oscillator** generates output without any ac input signal.

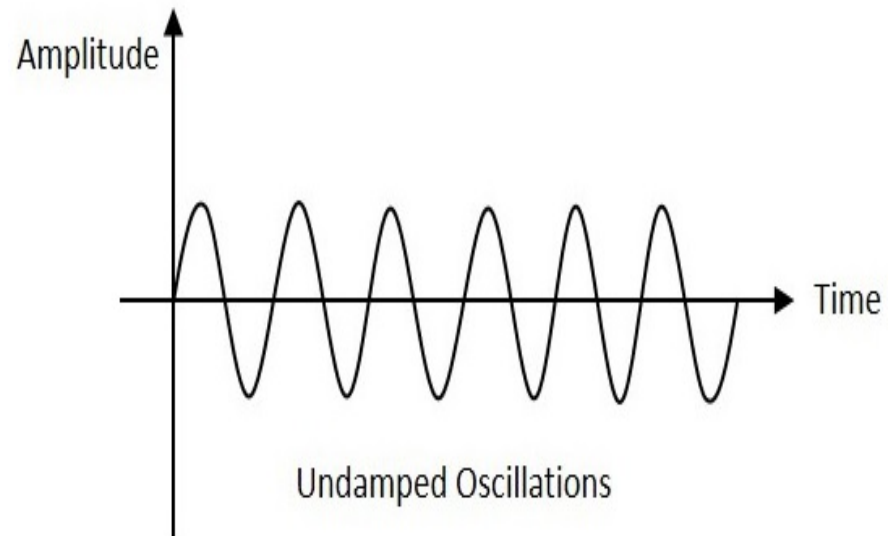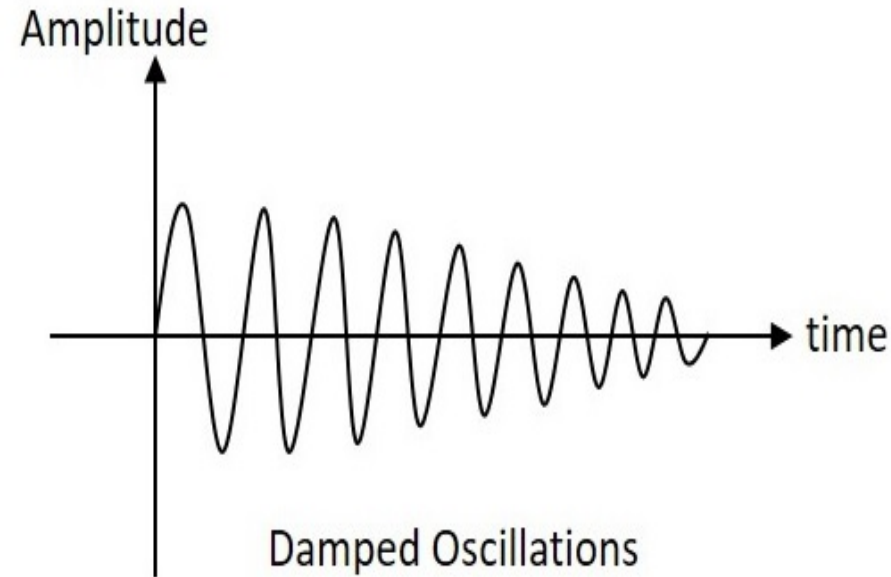❖ The output voltage can be either sinusoidal or non sinusoidal, depending on the type of oscillator.

DC power input

Oscillator → AC output

Feedback in Oscillator

- In Oscillators positive feedback is used to sustain the oscillation.
- In this , a portion of the output voltage of an amplifier is fed back to the input with no net phase shift, and increases the strength of the signal.
- Positive feedback is also called as **degenerative feedback** or **direct feedback**. This kind of feedback makes a feedback amplifier, an oscillator.
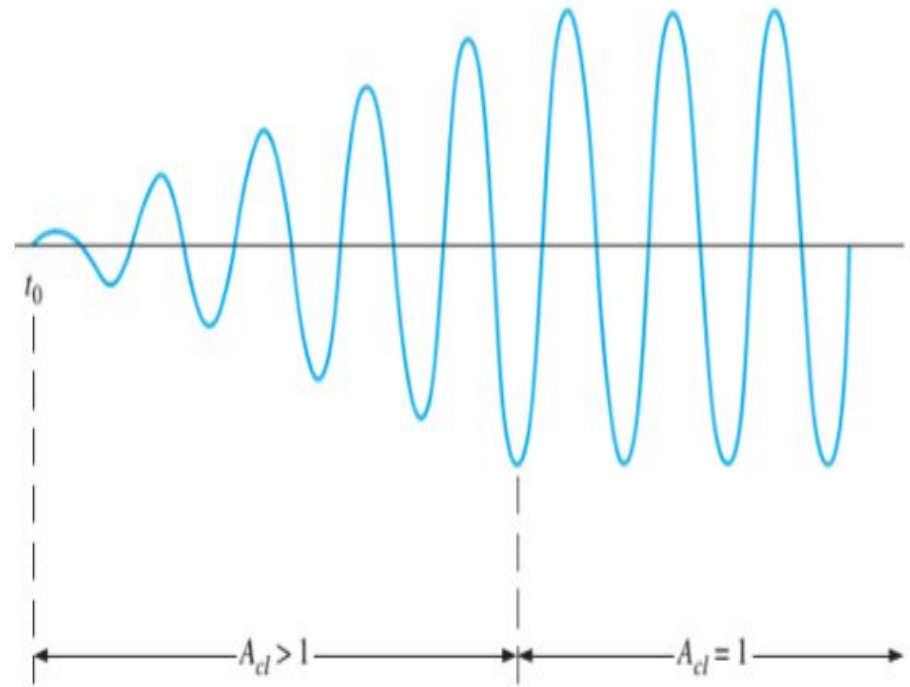
Nature of Sinusoidal Oscillations

- The nature of oscillations in a sinusoidal wave are generally of two types :

❖ **Damped Oscillations:**

- The electrical oscillations whose amplitude goes on decreasing with time.

❖ **Undamped Oscillations:**

- The electrical oscillations whose amplitude remains constant with time.

Amplitude

time

Damped Oscillations

Amplitude

Time

Undamped Oscillations

Start Up Condition

- For oscillation to begin, the voltage gain around the positive feedback loop must be greater than 1 so that the amplitude of the output can build up to a desired level.

- The gain must then decrease to 1 so that the output stays at the desired level and oscillation is sustained.
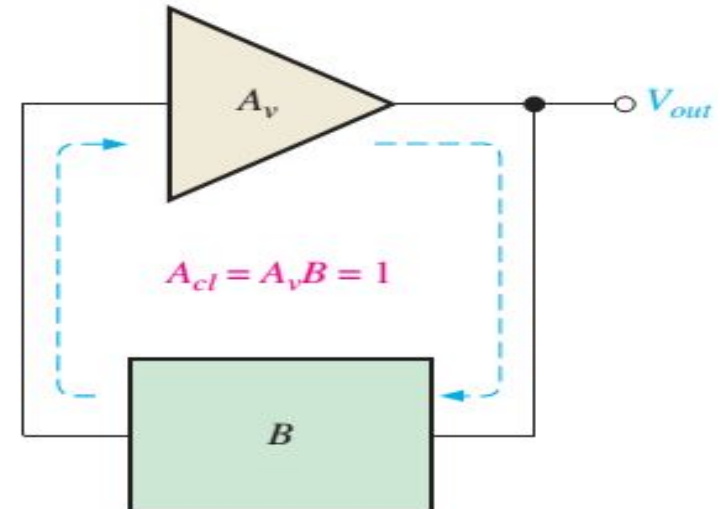
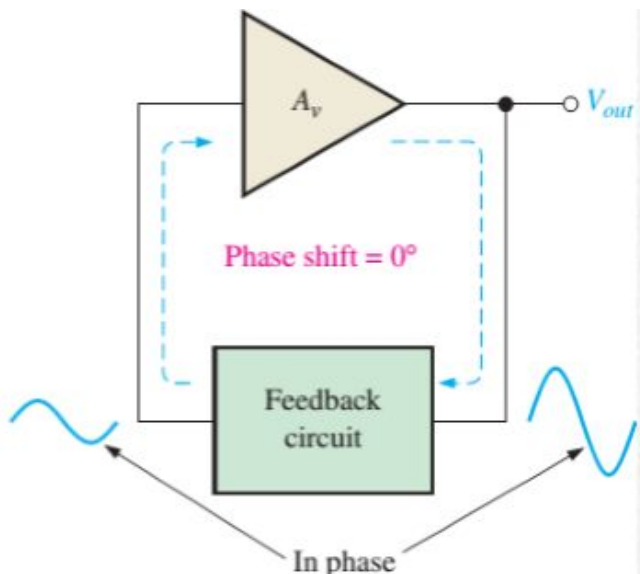# Conditions for Sustained Oscillation

Two conditions are required for a sustained oscillation:

1. The phase shift around the feedback loop must be 0°.

2. The voltage gain around the closed feedback loop (loop gain) must equal 1 (unity).

❖ These are known as BARKHAUSEN CRITERION of oscillations

A_v
V_{out}
Phase shift = 0°
Feedback circuit
In phase

A_v
V_{out}
$A_{cl} = A_v B = 1$
B

Oscillator Clssifications

1. LC oscillator (resonant circuit oscillators or **tank circuit oscillators) :**

- These oscillators are used to produce an output with frequencies in the **R.F. range** . Because of the frequency limitation (lower unity gain frequency) of most op-amps, BJT or a FET is used as an amplifier with these oscillators.

2. RC Oscillator:

- Used for generating oscillations within audio frequency range.
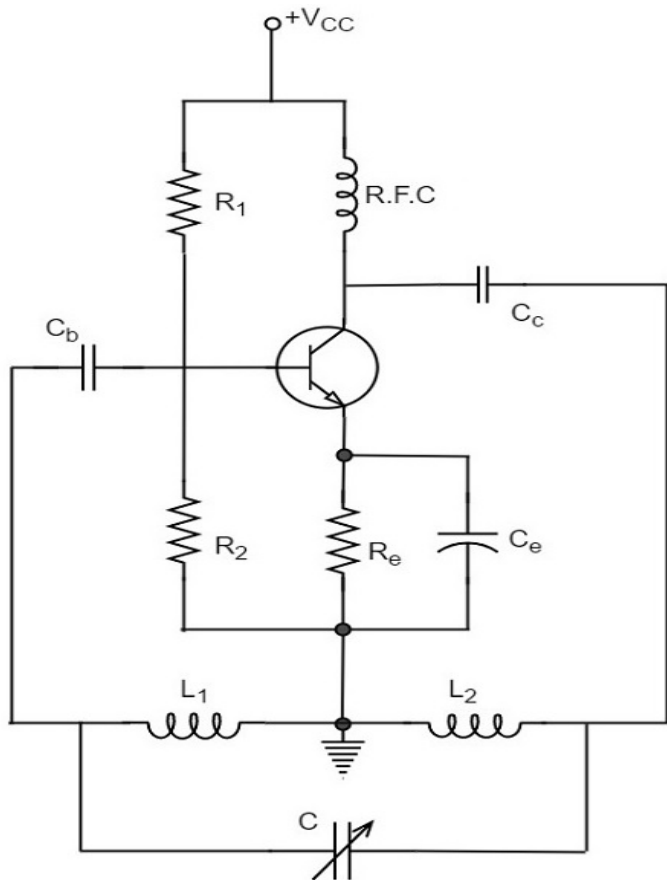
3. Crystal Oscillator:

- Used in applications where higher frequency stability of frequency is required.

- Used for generating high frequency oscillations upto hundred of MHz.

LC Oscillator

There are two common types:

- **Hartley Oscillator** – It uses inductive feedback.
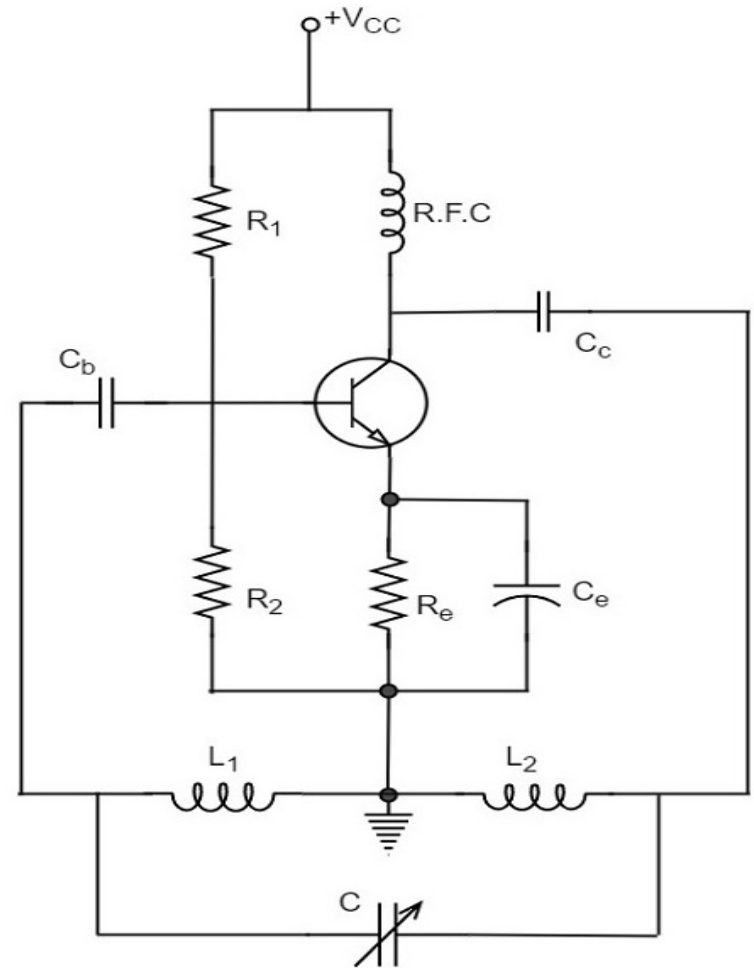- **Colpitts Oscillator** – It uses capacitive feedback.

Hartley Oscillator

- Resistors R_1, R_2 and R_e provide necessary bias condition for the circuit.
- The capacitor C_e provides a.c. ground thereby providing any signal degeneration.
- The capacitors C_c and C_b are employed to block d.c. and to provide an a.c. path.
- The radio frequency choke (R.F.C) offers very high impedance to high frequency currents which means it shorts for d.c. and opens for a.c

Hartley Oscillator
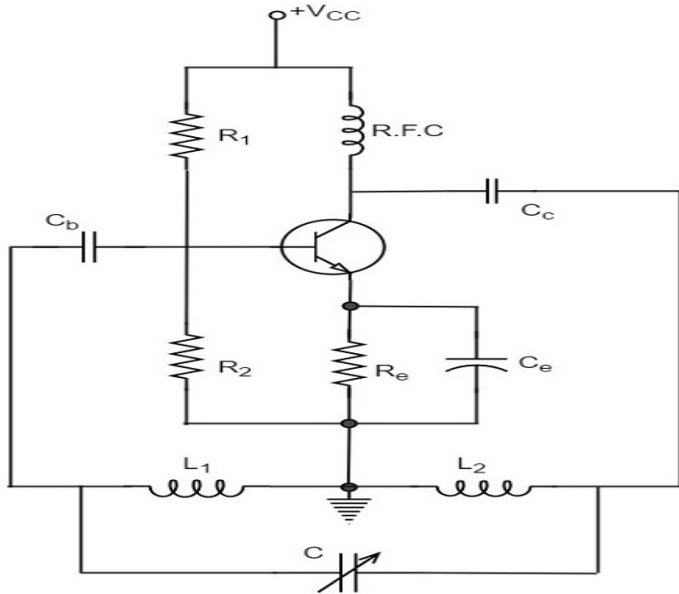
- The frequency determining network is a parallel resonant circuit which consists of the inductors L_1 and L_2 along with a variable capacitor C.

- The junction of L_1 and L_2 are earthed.

- The coil L_1 has its one end connected to base via C_b and the other to emitter via C_e.

- L_2 is in the output circuit.

- Both the coils L_1 and L_2 are inductively coupled.

Hartley Oscillator Operation

■   When the collector supply is given, a transient current is produced in the oscillatory or tank circuit. The oscillatory current in the tank circuit produces a.c. voltage across L_1.

■ The **Feedback network** consisting of two series inductors and parallel capacitor helps in determining the frequency and establishes the feedback.

■ As the CE configured transistor provides 180° phase shift, another 180° phase shift is provided by the this feedback network, which makes 360° phase shift between the input and output voltages.

■ This makes the feedback positive which is essential for the condition of oscillations.

■ To start up oscillations, loop gain |βA| of the amplifier is greater than one. To sustain the oscillations, loop gain |βA| of the amplifier must be equal to unity.

Frequency of Oscillation

- The equation for **frequency of Hartley oscillator** is given as:

$$F = 1/2\pi\sqrt{L_T C}$$

where $L_T = \mathbf{L_1} + \mathbf{L_2}$

- Here, $\mathbf{L_T}$ is the total cumulatively coupled inductance; $\mathbf{L_1}$ and $\mathbf{L_2}$ represent inductances of 1st and 2nd coils.

Hartley Oscillator

Advantages:

- Frequency can be varied by employing either a variable capacitor or a variable inductor.
- Less number of components are sufficient.
- The amplitude of the output remains constant over a fixed frequency range.

Disadvantages:

- The disadvantages of Hartley oscillator are
- It cannot be a low frequency oscillator.
- Harmonic distortions are present.

Applications:

- The applications of Hartley oscillator are
- It is used to produce a sine wave of desired frequency.
- Mostly used as a local oscillator in radio receivers.
- It is also used as R.F. Oscillator.

Example

In a Hartley Oscillator circuit, if L_1 = 0.1mH , L_2 = 10µH and Mutual Inductance between L_1 and L_2 coils is 20 µH then calculate the value of capacitor of oscillatory circuit for operating frequency of 4110kHz.

Answer : C = 10pF

References

❖ For more details, refer to:

- *Boylestad R. L., Electronic Devices and Circuit Theory, Pearson Education*

- *Neamen, Donald A., Electronic Circuit Analysis and Design, McGraw Hill*

- Thomas L. Floyd, Electronic Devices, *Pearson Education*