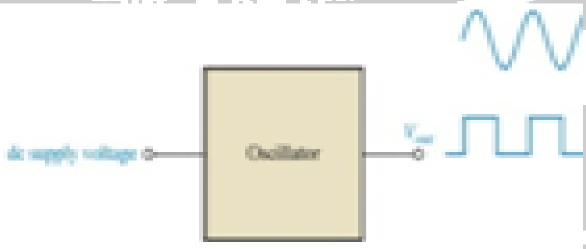
UNIT II OSCILLATORS

Barkhausen criterion for oscillation - Phase shift, Wien bridge - Hartley and Colpitts oscillators - Clapp oscillator - Ring oscillators and crystal oscillators - Oscillator amplitude stabilization.

2.1.Need of an Oscillator

- An oscillator circuit is capable of producing ac voltage of desired frequency and wave shape.
- To test performance of electronic circuits, it is called signal generator.
- It can produce square, pulse, triangular, or saw tooth wave shape.
- High frequency oscillator are used in broadcasting.
- Microwave oven uses an oscillator.
- Used for induction heating and dielectric heating.
- Oscillators are circuits that produce a continuous signal of some type without the need o an input.
- These signals serve a purpose for a variety of purposes. Communications systems, digital systems (including computers), and test equipment make use of oscillators.
- The feedback type oscillator which rely on a positive feedback of the output to maintain the oscillations.
- The relaxation oscillator makes use of an RC timing circuit to generate a non-sinusoidal signal such as square wave.



An oscillator is a circuit that produces a repetitive signal from a dc voltage.

Types of Oscillators:

- There are many types of oscillators, but can broadly be classified into two main categories
- Harmonic Oscillators (also known as Linear Oscillators) and
- Relaxation Oscillators.

- In a harmonic oscillator, the energy flow is always from the active components to the passive components and the frequency of oscillations is decided by the feedback path.
- Whereas in a relaxation oscillator, the energy is exchanged between the active and the passive components and the frequency of oscillations is determined by the charging and discharging time-constants involved in the process.
- Further, harmonic oscillators produce low-distorted sine-wave outputs
- while the relaxation oscillators generate non-sinusoidal (saw- tooth, triangular or square) wave-forms.

  Sinusoidal or non-sinusoidal.

- An oscillator generating square wave or a pulse train is called multivibrator :
  1. Bistable multivibrator (Flip-Flop Circuit).
  2. Monostable multivibrator.
  3. Astable multivibrator (Free-running).
- Depending upon type of feedback, we have
  1. Tuned Circuit (LC) oscillators.
  2. RC oscillators, and
  3. Crystal oscillators.

<u>The main types of Oscillators include:</u>

1. RC Oscillators
   i. Wien Bridge Oscillator
   ii. RC Phase Shift Oscillator
2. LC Oscillators
   i. Hartley Oscillator
   ii. Colpitts Oscillator
   iii. Clapp Oscillator
3. Crystal Oscillators

2.1.2 Introduction to Feedback:

The phenomenon of feeding a portion of the output signal back to the input circuit is known as feedback. The effect results in a dependence between the output and the input and an effective control can be obtained in the working of the circuit. Feedback is of two types.

1)Negative Feedback 2) Positive Feedback

Negative or Degenerate feedback:

- In negative feedback, the feedback energy (voltage or current), is out of phase with the input signal and thus opposes it.
- Negative feedback reduces gain of the amplifier. It also reduce distortion, noise and instability.
- This feedback increases bandwidth and improves input and output impedances.
- Due to these advantages, the negative feedback is frequently used in amplifiers.

Positive or regenerate feedback:

- In positive feedback, the feedback energy (voltage or currents), is in phase with the input signal and thus aids it. Positive feedback increases gain of the amplifier also increases distortion, noise and instability.
- By making $1 - A\beta = 0$, or $A\beta = 1$, we get gain as infinity.
- This condition ($A\beta = 1$) is known as Barkhausen Criterion of oscillations.
- It means you get output without any input !
- Because of these disadvantages, positive feedback is seldom employed in amplifiers. But the positive feedback is used in oscillators.

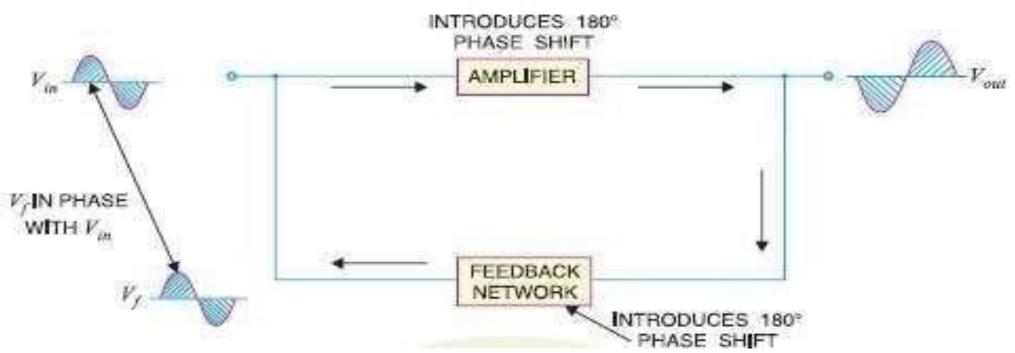


Fig -2.1.1

In the above figure, the gain of the amplifier is represented as A. The gain of the amplifier is the ratio of output voltage V_o to the input voltage V_i. The feedback network extracts a voltage $V_f = \beta V_o$ from the output V_o of the amplifier.

This voltage is subtracted for negative feedback, from the signal voltage V_s. Now,

$$Vi=Vs + V_f=Vs+\beta Vo$$

The quantity $\beta = V_f/V_o$ is called as feedback ratio or feedback fraction.

The output V_o must be equal to the input voltage $(V_s + \beta V_o)$ multiplied by the gain A of the amplifier.

Hence,

$(Vs+\beta Vo)A=Vo$ $AVs+A\beta Vo=Vo$ $AVs=Vo(1-A\beta)$

$$Vo/Vs=A/(1-A\beta)$$

Therefore, the gain of the amplifier with feedback is given by $A_f=A/(1-A\beta)$

How is it Possible ?

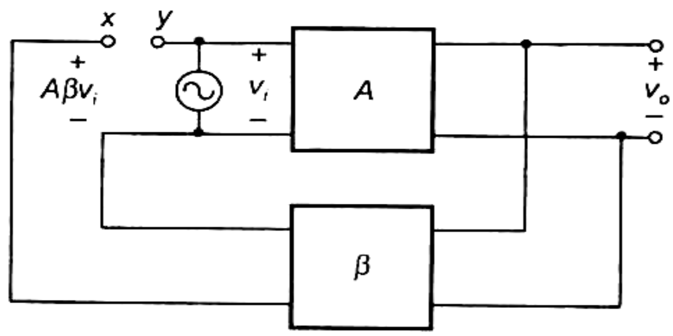


Fig 2.1.2

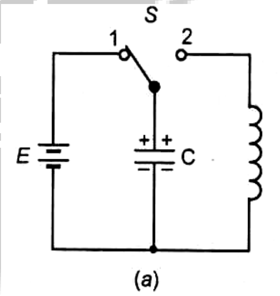
- Connecting point x to y, feedback voltage drives the amplifier. What happens to the output ?
- There are three possibilities.
  - (1) If $A\beta < 1$, we get decaying of damped oscillations.
  - (2) If $A\beta > 1$, we get growing oscillations.
  - (3) If $A\beta = 1$, we get sustained oscillations. In this case, the circuit supplies its own input signal.

Where from comes the starting voltage ?

- Each resistor is a noise generator.
- The feedback network is a resonant circuit giving maximum feedback voltage at frequency f_0, providing phase shift of 0° only at this frequency.
- The initial loop gain $A\beta > 1$.
- The oscillations build up only at this frequency.
- After the desired output is reached, $A\beta$ reduces to unity.

Tank Circuit

- LC parallel circuit is called tank circuit.



- Once excited, it oscillates at $$f_0 = \frac{1}{2\pi\sqrt{LC}}$$
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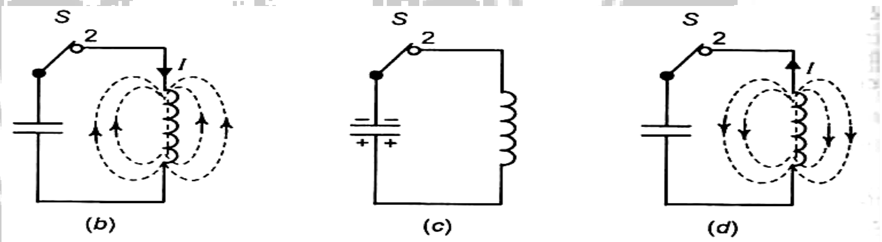

The energy keeps oscillating between electric potential energy and magnetic filed energy.

2.1.3 Comparison Between Positive and Negative Feed Back:

S.No.	Negative Feedback	Positive Feedback
1	Feedback energy is out phase with their input signal	Feedback energy is in phase with the input signal.
2	Gain of the amplifier decreases	Gain of the amplifier increases
3	Gain stability increases	Gain stability decreases
4	Noise and distortion decreases.	Noise and distribution increases.
5	Increase the band width	Decreases bandwidth
6	Used in amplifiers	Used in Oscillators

2.1.4 Barkhausen criterion for oscillation

- The condition $A\beta=1$ is known as Barkhausen criteria. It implies
- Magnitude of the loop gain $A\beta = 1$
- Phase shift over the loop = 0 0r 360 degrees.
- Frequency of the noise in the amplifier for which this criteria are satisfied, is the frequency of oscillations.
- By applying this criteria, we can even find the values of transistor parameters, like gain, required for setting in oscillations.