OSCILLATORS

Any circuit which is used to generate an a.c voltage without an a.c input signal is called oscillator.

To generate a.c voltage, the circuit is supplied energy from a d.c source.

positive feedback is used to generate oscillations of desired frequency.

classification of oscillators :

oscillators are classified in to the following different ways

① According to the waveform generated

a) sinusoidal oscillator : An electronic device that generate sinusoidal oscillations of desired frequency is known as a sinusoidal oscillator.

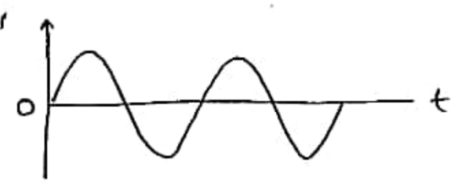


fig: sinusoidal wave form.

b) Relaxation (or) Non Sinusoidal oscillators : The oscillators which produce square waves, triangular waves, Sawtooth waves are known as Relaxation oscillators

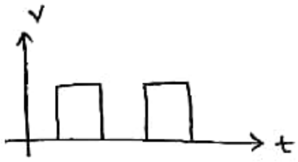


Fig: square

Fig: sawtooth

Fig: Triangular

② According to the fundamental mechanisms involved

a) Negative resistance oscillators: Negative resistance oscillators uses negative resistance of the amplifying device to neutralize the positive resistance of the oscillator.

b) Feedback oscillators: these oscillators uses positive feedback in the feedback amplifier to satisfy the barkhausen criterion.

③ According to the frequency generated

a) Audio frequency oscillators (upto 20 KHz)
b) Radio frequency oscillators (20 KHz to 30 MHz)
c) Very high frequency oscillator (30 MHz to 300 MHz)
d) ultra high frequency oscillator (300 MHz to 3 GHz)
e) Microwave frequency oscillator (above 3 GHz)

④ According to the type of circuit used

a) LC tuned oscillator

b) RC oscillators.

<u>Basic theory of oscillators</u>:

The feedback is a property which allows to connect the part of the output to the same circuit

As the phase of the feedback signal is same as that of the input applied, the feedback is called positive feedback.

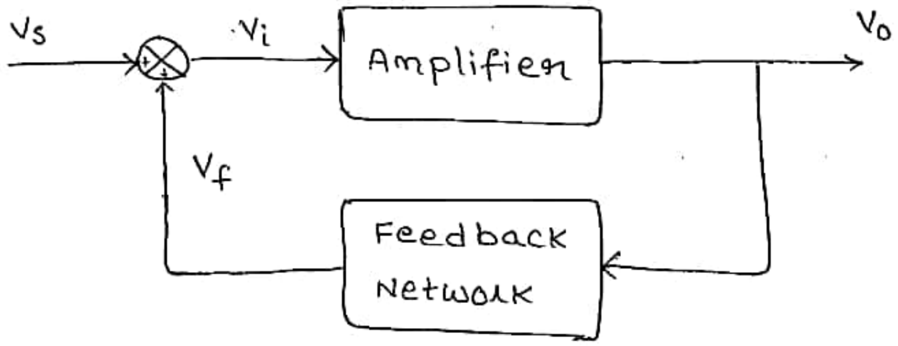


Fig: concept of positive feed back.

Here Amplifier gain called open loop gain (gain without feedback) given by

$$A = \frac{V_o}{V_i} \longrightarrow (1)$$

the gain with feedback (closed loop gain or over all gain) denoted by A_f

$$A_f = \frac{V_o}{V_s} \longrightarrow (2)$$

the feedback is positive and voltage V_f is added to V_s to generate V_i

$$\therefore \quad V_i = V_s + V_f \longrightarrow (3)$$

the feedback voltage V_f depends on the feedback gain β given by

$$\beta = \frac{V_f}{V_o} \longrightarrow (4)$$

$\therefore$ Eq (3) $\Rightarrow$ $V_i = V_s + \beta V_o$ $\quad [\because V_f = \beta V_o$ from (4)$]$

$$\Rightarrow V_i = V_s + \beta A V_i \quad [\because V_o = AV_i \text{ from } (1)]$$

$$\Rightarrow V_s = V_i(1 - A\beta)$$

But $$A_f = \frac{V_o}{V_s} = \frac{V_o}{V_i(1-A\beta)} = \frac{A}{1-A\beta} \quad \left[\because A = \frac{V_o}{V_i}\right]$$

Here $|A_f| > |A|$.

The product of open loop gain and feedback factor is called loop gain ($A\beta$)

If $|A\beta| = 1$ then $A_f = \infty = \frac{V_o}{V_s}$

$$\Rightarrow V_s = 0$$

Hence the gain of the amplifier with positive feedback is infinite and the amplifier gives an a.c output without a.c input signal. thus the amplifier acts as an oscillator.

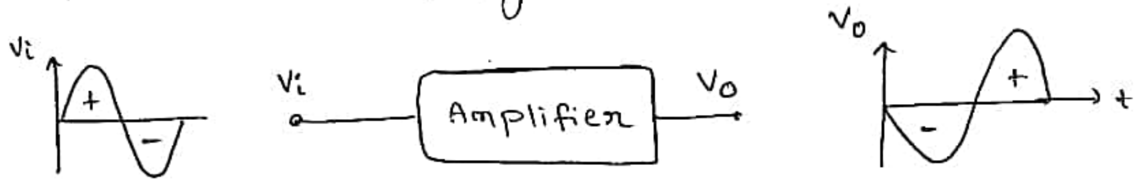
Barkhausen criterion (conditions for oscillations):

Mechanism for start of oscillations:

The oscillator circuit is set in to oscillations by a random variation caused in the base current due to noise component or a small variation in the dc power supply. the noise components ie small random electrical voltages and currents are always present in any conductor, tube or transistor. Even when no electrical signal is applied, the ever present noise will cause some small signal at the output of the amplifier.

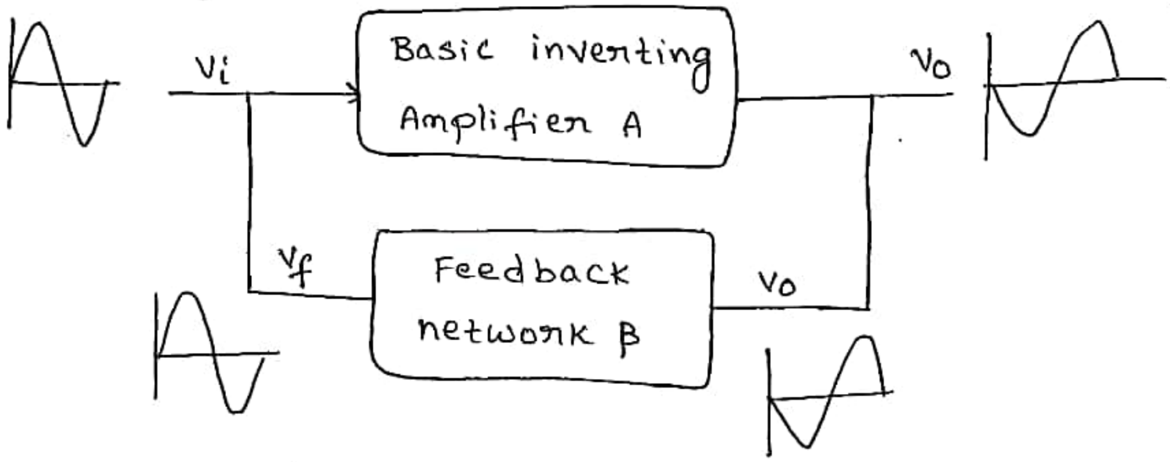
If a small fraction β of the output signal is fed back to the input with proper phase relation, then this feedback signal will be amplified by the amplifier. If $A > \frac{1}{\beta}$ (ie $A\beta > 1$), then the output increases and thereby the feedback signal becomes larger. This process continues and the output goes on increasing. But as the signal level increases, the gain of the amplifier decreases and at a particular value of output, the gain of the amplifier is reduced exactly equal to $1/\beta$ (ie $A = \frac{1}{\beta} \Rightarrow A\beta = 1$). Then the output voltage remains constant at frequency f_r called frequency of oscillation.

Consider a basic inverting amplifier with an open loop gain A. As basic amplifier is inverting, it produces a phase shift of 180° between input and output as shown in figure below.



Now the input Vi applied to the amplifier is to be derived from its output Vo using feedback n/w. But the feedback must be positive ie the voltage derived from output using feedback network must be inphase with Vi. Thus the feedback network must introduce a phase shift of 180° while feeding back the voltage from output to input. This ensures positive feedback.

The arrangement is shown in figure below



Here $A = \frac{V_o}{V_i} \Rightarrow V_o = A V_i \longrightarrow (1)$

$\beta = \frac{V_f}{V_o} \Rightarrow V_f = \beta V_o \longrightarrow (2)$

$\therefore \quad V_f = A\beta V_i \longrightarrow (3)$

For the oscillator, we want that feedback should drive the amplifier and hence V_f must act as V_i from Equation (3), we can write that, V_f is sufficient to act as V_i when $|A\beta| = 1$

And the phase of V_f is same as V_i ie feedback network should introduce $180°$ phase shift in addition to $180°$ phase shift introduced by inverting amplifier. This ensures positive feedback. So total phase shift around a loop is $360°$.

In this condition V_f drives the circuit and without external input, circuit works as an oscillator.

The two conditions which are required for the circuit to work as an oscillator are called

The Barkhausen criterion states that

1. The total phase shift around a loop, as the signal proceeds from input through amplifier, feedback network to input again, completing a loop is precisely 0° or 360°.

2. the magnitude of the product of the open loop gain of the amplifier and the magnitude of the feedback factor β is unity ie $|A\beta| = 1$

Differences between Alternator and oscillator:

Alternator	oscillator
1. It is a rotating device which has rotating parts	1. It is not a rotating device.
2. It creates Energy	2. It doesn't create energy. only converts dc energy to ac energy.
3. It has fixed frequency	3. The frequency of the oscillator ranges from few Hz to MHz.