Oscillators

In a feedback system, a part of the output is sampled and fed back into the input. If the phase of the feedback signal matches with the phase of the input signal applied to the amplifier, then such a feedback network is known as positive feedback. The positive feedback network improves the gain of the network.

If a positive feedback network is designed such that it generates oscillations or periodic output with zero or no input signal. Then such a network / circuit is known as oscillators.

Classification of Oscillators :-

Based on the output waveform, the oscillators can be categorized as

→ Sinusoidal or harmonic oscillators

Eg:- sine, cosine etc.

→ non-sinusoidal oscillators

Eg:- square, triangular, pulse etc.

Based on the components used to construct feedback ckt they can be categorized as,

→ RC phase shift oscillator [R&C components]

→ L and C components

Eg: Hartley oscillator, colpitt's oscillator.

Based on the range of operating frequency, they can be categorized as

→ Audio frequency oscillators [20 Hz to 20 KHz]
→ Radio frequency oscillators [20 KHz to 30 MHz]
→ very high frequency oscillator [30 MHz to 300 MHz]
→ ultra high frequency oscillator [300 MHz to 3 GHz]
→ microwave oscillators [3 GHz to 30 GHz]

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The oscillators generate sustained oscillations without an external input signal, here the DC power from the supply is converted to ac power in the load. The circuit consists of both active and passive components.

Sinusoidal oscillations can be produced using two different ways

1) Negative resistance oscillators :

An oscillator that works on negative resistance property is known as negative resistance oscillators. They are non feedback oscillators. The term negative resistance refers to a condition where an increase in voltage across two points causes a decrease in current.

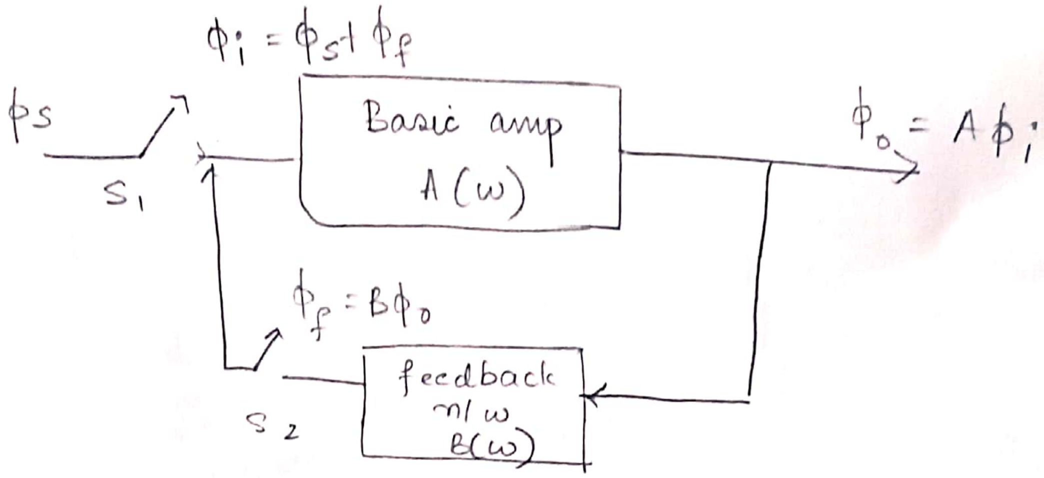
Eg: Tunnel Diode, UJT relaxation oscillator, Gunn oscillator.

2) Feedback Oscillators :

Oscillators in which the feedback is used to generate oscillations are known as feedback oscillators.

Sinusoidal Oscillations can be produced using
1) negative resistance osc
2) feed back oscillators

Principle of sinusoidal Osc.



$A(\omega)$ → amplifier gain

$B(\omega)$ → feedback factor $\omega = 2\pi f$

ϕ → either voltage or current

When S_1 is closed S_2 is open

$\phi_i = \phi_s$ and $\phi_f = \cancel{B\phi_o}\ B(\omega)\phi_o = B(\omega)\,A(\omega)\,\phi_i$

the ratio, $\dfrac{\phi_f}{\phi_i} = \dfrac{B(\omega)\,A(\omega)\,\cancel{\phi_i}}{\cancel{\phi_i}}$ → loop gain

$B(\omega)$ & $A(\omega)$ are functions of frequency,

If for a particular freq, $\omega = \omega_0$ we have,

$[B(\omega_0)\,A(\omega_0)] = 1$ we get

$$\phi_f = \phi_i = \phi_s$$

When S_1 is open and S_2 is closed at $w = w_0$ fB signal will have same magnitude as i/p signal and also in phase with i/p sig hence the system will sustain osc at particular freq $w_0 = 2\pi f_0$ even if $\phi_s = 0$

$$A(f) = \frac{A(w)}{1 - A(w)B(w)}$$

if $A(w)B(w) = 1$ then $A_f = \infty$

this indicates that ckt can produce o/p without external i/p ($V_s = 0$) just by feeding a part of the o/p as its own i/p

o/p cannot be infinite but gets driven into oscillation In other words, the ckt stops amplifying and starts oscillating.

Barkhausen Criterion :-

Criterion for generation of Oscillation

i) as $A(w)$ & $B(w)$ are complex 2 condns can be derived

1) $|A(w)B(w)| = 1 \rightarrow$

2) $\underline{|A(w)B(w)} = 0 \rightarrow$ total phase shift around a loop as the signal proceeds from Input through amplifier f/B n/w back to i/p again ~~completing~~ completing a loop $= 0$ or 360°

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for practice $A(\omega) B(\omega) > 1$ to start Osc

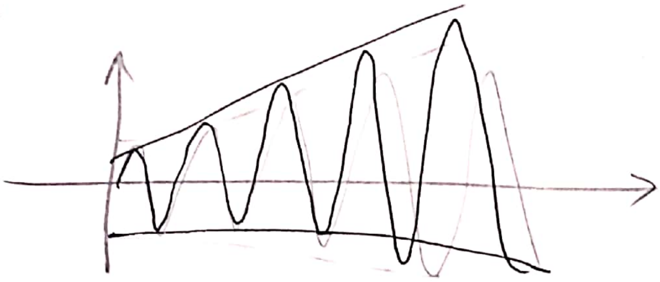
then ckt adjusts to $A(\omega) B(\omega) = 1$

finally leading to self sustained oscillations

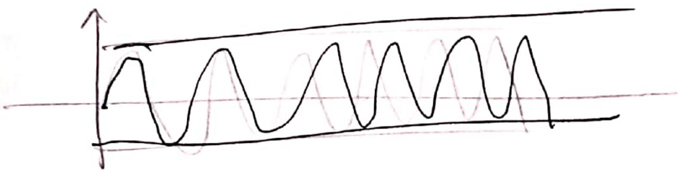
Nature of Osc can be decided based on $|A(\omega) B(\omega)|$

1) phase = 0° or 360° & $A(\omega) B(\omega) > 1$

o/p osc but oscillations goes on increasing

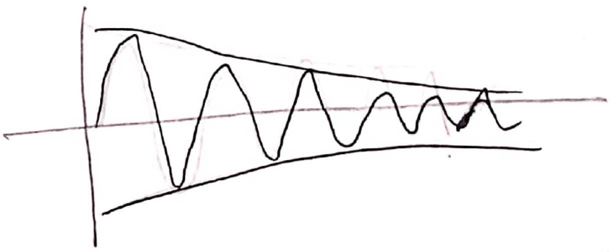


2) phase = 0 or 360 $A(\omega) B(\omega) = 1$



sustained Osc.

3) phase = 0° and 360° $|A(\omega) B(\omega)| < 1$ → decaying



4) $A(\omega) B(\omega) = 1$ by $A(\omega) B(\omega) \neq 0$

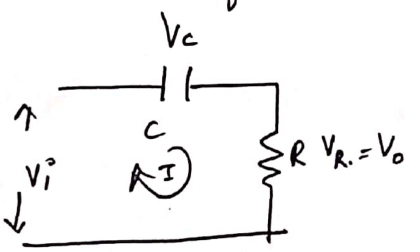
oscillations will die out as i/p signal will gradually decay due to phase cancellation

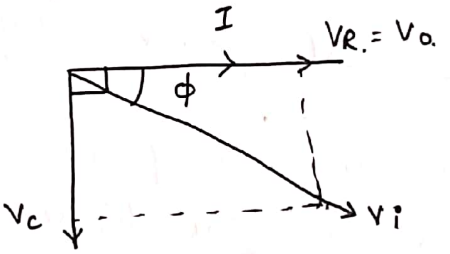
RC phase shift Oscillators

It consists of an amplifier and RC network in the feedback loop. Positive feedback networks are used for designing oscillators. Hence the total phase shift in the network must be equal to 360° or 0° in order to have positive feedback.

The CE amplifier provides a phase shift of 180°. Hence the RC network is used to provide an additional phase shift of 180° i.e., 180 + 180° = 360 to obtain positive feedback.

→ consider the RC network used in the feedback network of the oscillator,





→ The current I and V_R are in phase or they have the same phase angle.

→ The current I leads the capacitor voltage by 90°

→ the input voltage V_i is equal to the vector sum of V_c and V_o

→ hence there is a phase difference of ϕ b/w input and output voltage.

→ when $\phi = 0° \rightarrow$ resistive ckt
$\phi = 90° \rightarrow$ capacitive ckt

→

$\therefore$ from ckt $V_o = IR$

$V_c = IX_c$

from phasor diagram,

$$\tan\phi = \frac{V_c}{V_R} = \frac{\cancel{I}X_c}{\cancel{I}R} = \frac{1}{2\pi fCR}.$$

$$f = \frac{1}{2\pi CR\tan\phi}$$

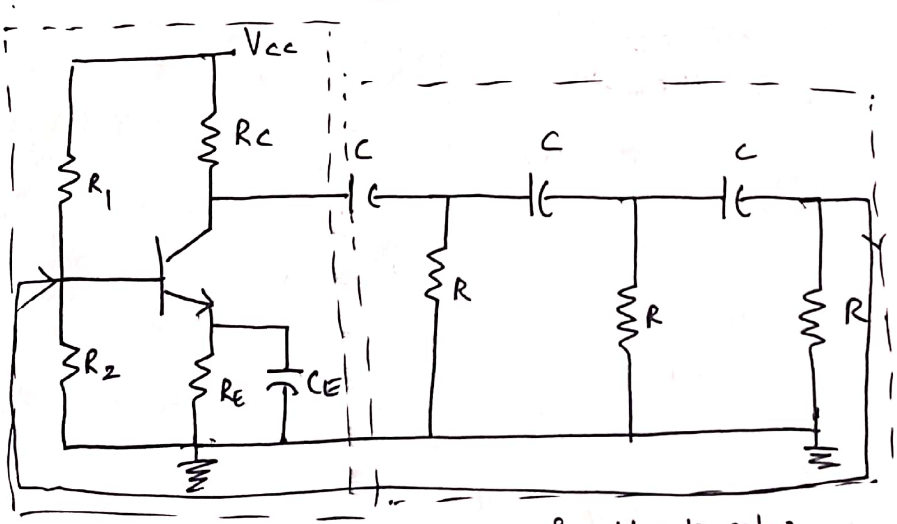
$$\therefore \phi = \tan^{-1}\left(\frac{1}{2\pi fCR}\right).$$

→ Hence in the RC phase shift oscillator, three identical RC networks are used.

→ The R and C values are selected such that each RC network provides a phase shift of $60°$ at osc frequency.

→ Hence the total phase shift $= 60° + 60° + 60° = 180°$.

The ckt diagram of a RC phase shift oscillator is as shown in the figure below,



Basic amplifier

feedback n/w.

$\therefore$ the frequency of oscillation for an RC phase shift oscillator is given by

$$f_o = \frac{1}{2\pi CR\sqrt{4\left(R_c/R\right) + 6}}$$

as $\frac{R_c}{R} << 1$

$$\therefore \boxed{f_o = \frac{1}{2\pi RC\sqrt{6}}}$$

The condition for sustained oscillations is given by.

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