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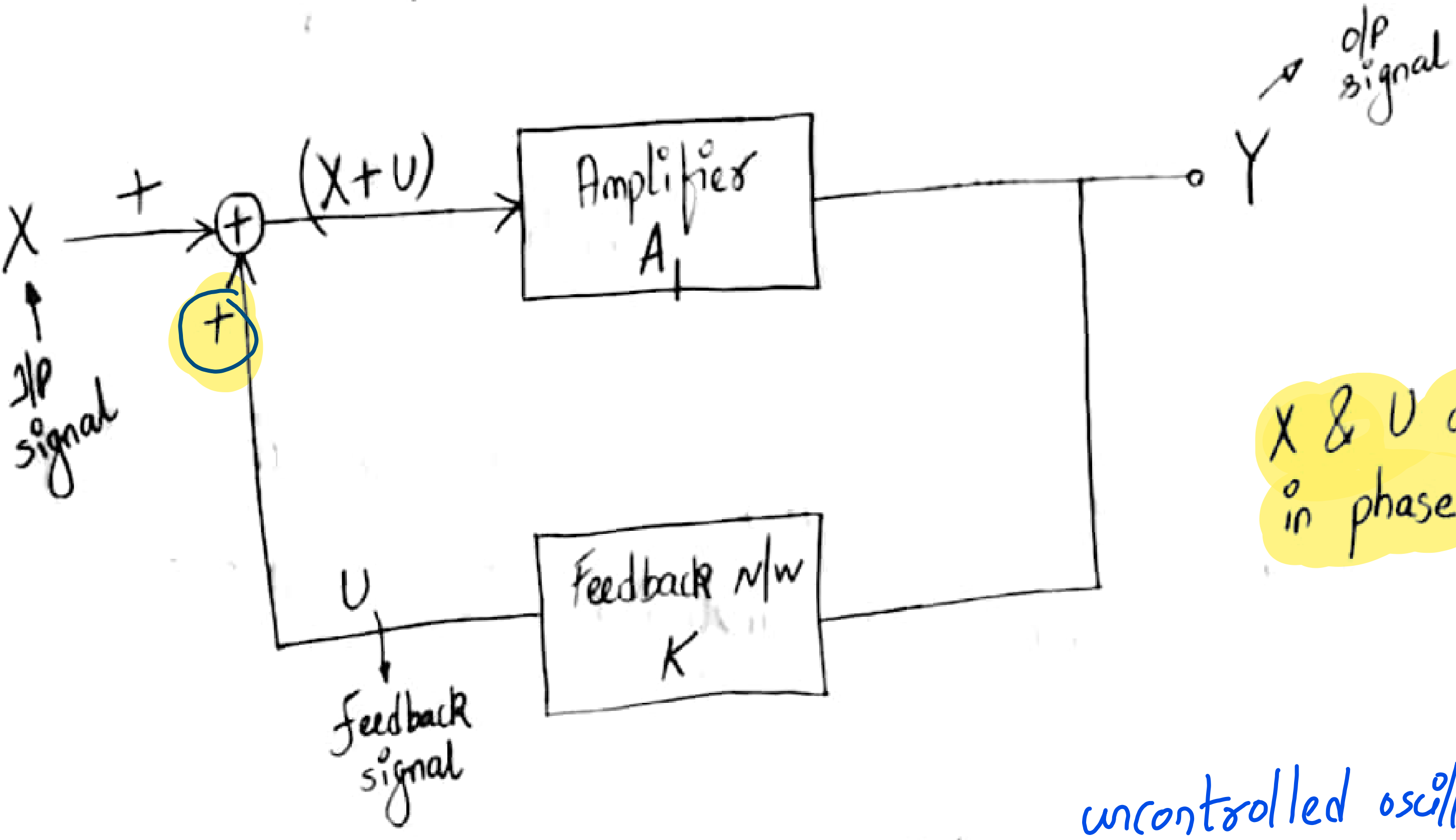
• Concept of positive feedback:



X & U are in phase.

→ Feedback signal $U = KY$

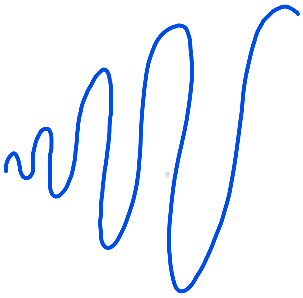
→ $Y = A_1 (X + U)$

→ $Y = A_1 (X + KY)$

→ $Y(1 - KA_1) = A_1 X$

$$\therefore \boxed{\frac{Y}{X} = \frac{A_1}{1 - KA_1}}$$

uncontrolled oscillations



$$\boxed{\begin{array}{l} KA_1 \to 1 \\ \hookrightarrow \frac{Y}{X} \to \infty \end{array}}$$

A_1 → open-loop gain

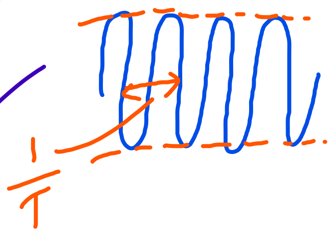
$\frac{Y}{X}$ → closed-loop gain

→ $\frac{Y}{X}$ (closed-loop gain) is greater than A_1 (open-loop gain)

Controlled Oscillator

– control ampl

– control freq



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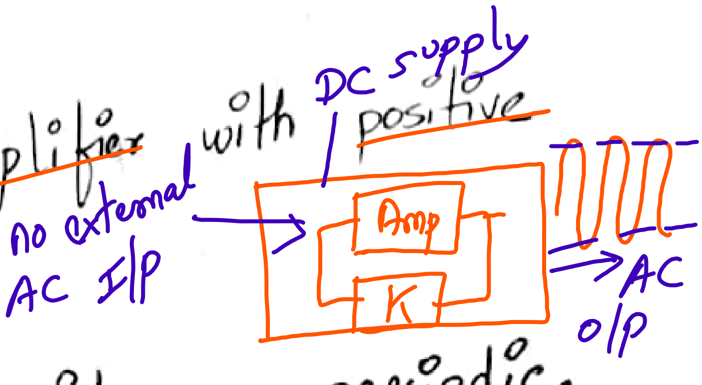
→ Now, if K ↑ses, A_1 being constant, $\frac{Y}{X}$ will increase and at a particular value of K, $\frac{Y}{X} \to \infty$.

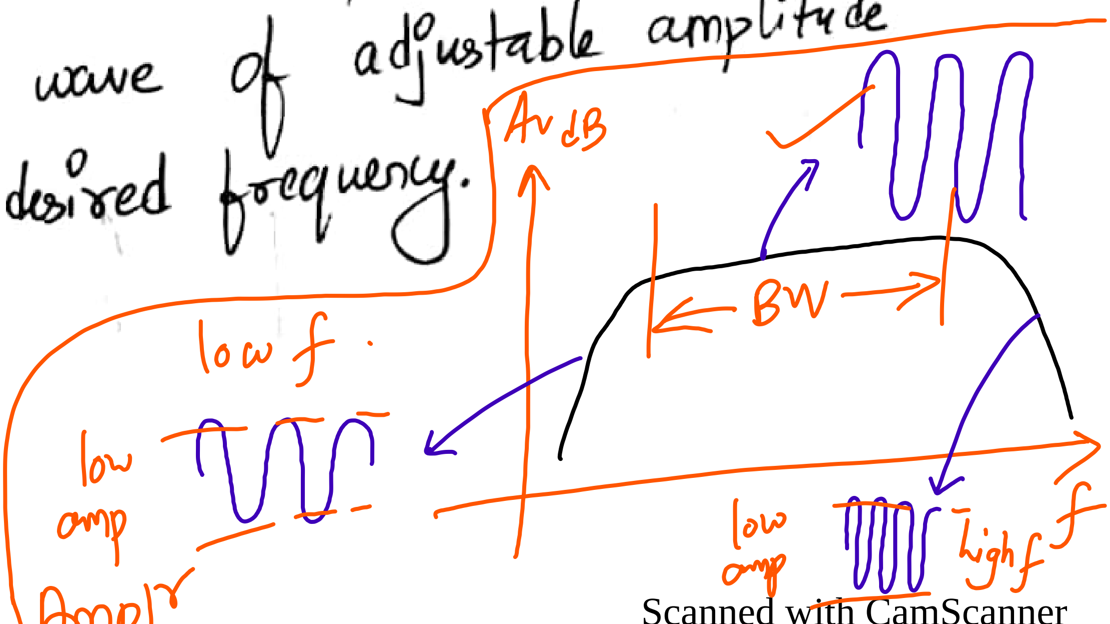
→ This means that even without the I/P X, the amplifier will keep producing o/p voltage with the help of f/b signal.

→ Since, $\frac{Y}{X}$ is very high, it results in instability and this is where the amplifier starts operating as an oscillator.

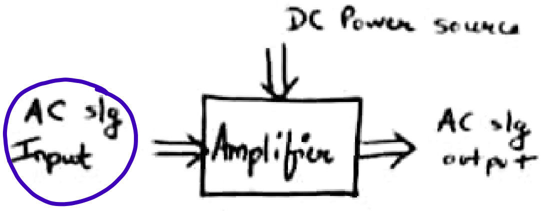
→ An oscillator is an amplifier with positive feedback.



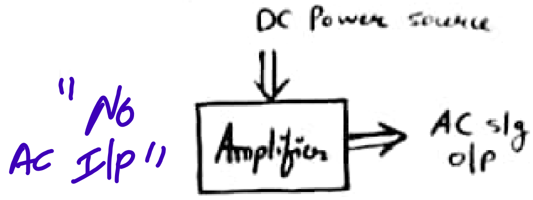
→ An oscillator circuit provides, a periodic, sinusoidal wave of adjustable amplitude of any desired frequency.



• Comparison between an Amplifier and an Oscillator :-



a) Amplifier



b) Oscillator

a) Amplifier	b) Oscillator
• An amplifier is a device, which produces an o/p signal with a similar waveform as that of the I/p. But its power level is generally high. This additional power is supplied by an external dc source.	• An oscillator is an 'amplifier' employing +ve feedback, which produces an o/p signal, without any ac I/p signal, of any desired frequency
• An amplifier is an energy conversion device ie it gets energy from dc source and converts it into an ac energy at the same frequency as that of the I/p signal.	• An oscillator keeps producing an o/p signal, as long as the dc power is applied. (ie An oscillator does not require any external slg to start or maintain energy conversion process)
• May or may not use -ve f/b, used only to improve Q-point stability.	• Always use +ve f/b betn o/p and I/p to generate sustained oscillations

• Frequency stability of an oscillator:

It is a measure of oscillator's ability to maintain a constant frequency over a long time interval. However, frequency of an oscillator changes slowly (or drifts away) from its initially set value.

Change in oscillating frequency may arise due to the following factors:-

a) **Q point of the active devices:-** The Q-pt of the active devices (ie BJT, FET) is selected such that its operation in non-linear region, changes device parameters values, which, in turn, affects the freqn stability of the oscillator

b) **Circuit components:** The values of the circuit components (R, L and C) changes with the variations in temperature. Since such changes takes place slowly, they also cause a drift in oscillator frequency

c) **O/P load:** A change in the o/p load may cause a change in Q-factor (quality factor) of the tank circuit, thereby causing a change in oscillator o/p frequency.

d) **Inter element and stray capacitances:** They affect the frequency stability of an oscillator.

e) **Supply voltage:** The changes in dc supply voltage applied to the active device, shift the oscillator frequency. This problem is avoided by using a highly regulated power supply

* Principle of oscillations :-

$\boxed{+ve \ f/b} + Ampl^r \rightarrow osc$

- An oscillator is an amplifier employing +ve f/b which does not require any ac I/P signal, but it generates an o/p signal.

But, positive feedback does not always guarantee's oscillations.

- An oscillator to produce sustained oscillations, it has to satisfy "Barkhausen's Criterion".

- **Barkhausen's criterion for sustained oscillation**

1] "The frequency of sinusoidal oscillator for which the total phase shift introduced, as a signal proceeds from the I/P, through the amplifier and feedback network, and back again to the I/P, is precisely 0 (or integral multiple of 2π)."

"$A_1 K$ = loop gain"

ie $\angle A_1 K = 0$ or $360°$

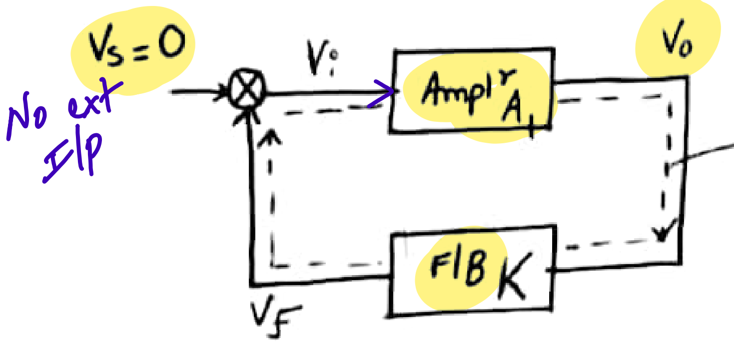


fig 1.2

① $\angle A_1 . K = 0°$ or $360°$

Total phase shift around the Loop is 0°.

② $|A_1 K| \geq 1$

2] "Oscillations will be sustained, at the oscillator frequency, if the magnitude of product of transfer gain of the amplifier (A) and the magnitude of the feedback gain (K) of the feedback Network is equal to unity. (slightly greater than)

ie $|A_1 K| \geq 1$

The above 2 statement's of Barkhausen's criterion can be concisely stated as,

1] The net phase shift through the amplifier and feedback network must be 0° or $2\pi n$ radians.

ie $\angle A_1 K = 0°$ or $360°$

2] The magnitude of the product of gain of the amplifier and feedback network must be unity (slightly greater than 1)

ie $|A_1 K| = 1$

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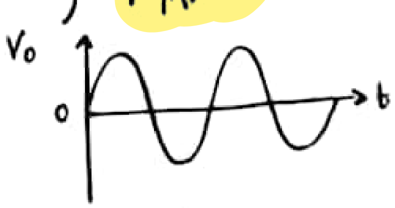
Please Note: If an oscillator circuit does not satisfy any one of these Barkhausen's criterion, then oscillations will not be produced.

- Frequency of oscillation is that frequency at which the given oscillator satisfies both conditions of Barkhaushen's criterion simultaneously.
  [ie $|A_1K| = 1$ and $\angle A_1K = 0°$ or $2\pi n$ radians]

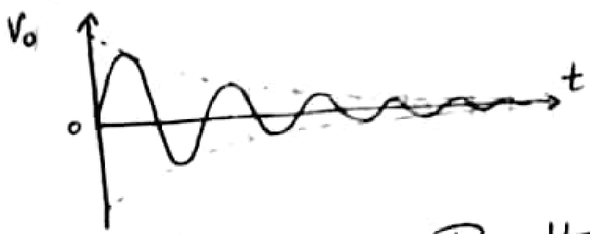
- Now let's see how the value of loop gain $|A_1K|$ affect the nature of oscillations:

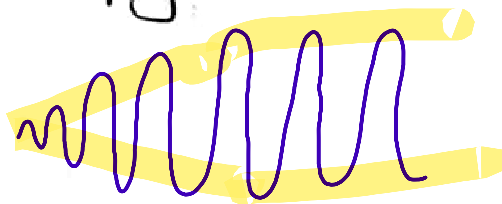
  $|A_1K| \geq 1$ slightly greater

a) $|A_1K| = 1$ → Results in sustained oscillations of constant amplitude.

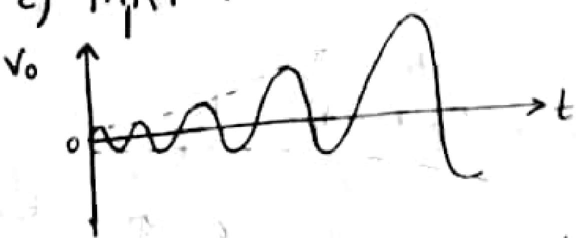


b) $|A_1K| < 1$ → Results in exponentially decaying oscillations.





c) $|A_1K| > 1$ → Results in exponentially ↑sing oscillations.



- From (a), (b) and (c), it is clear that the given oscillator circuit will oscillate only if $|A_1K| \geq 1$ ie In every practical oscillator, loop gain (A_1K) is slightly greater than unity. ---> in order to compensate for the "Non-Linearities" existing in the circuit.

* Why $|A_1K|$ must be slightly greater than 1 for Practical Oscillator?

- From fig 1.2, it appears that if $|A_1K|$ at oscillator frequency is unity, then, with f/b signal connected to i/p, removal of V_s will make no difference.
- If $|A_1K|$ is less than unity, the removal of external signal will results in cessation of oscillations
- If $|A_1K|$ is >1, then the amplitude of oscillations will continue to ↑se without limit.

- But of course, such an ↑se in the amplitude can continue only as long as it is not limited by the onset of nonlinearity of operation in the active devices (Like BJT, FET) associated with the amplifier in oscillator ckt. 05

→ This onset of nonLinearity to limit the amplitude of oscillation is an essential feature of the operation of all Practical oscillators.

- Now, Let us see how ?

Suppose initially it were possible to satisfy $|A_1K|=1$ condition. Then because circuit components and more importantly, transistor characteristics (drift) with age, temperature, voltage, etc, it is clear that "if the entire oscillator is left to itself, in a very short time $|A_1K|$ will become either less or larger than unity.

→ Therefore, an oscillator in which the loop gain $|A_1K|$ is exactly unity is completely unrealizable in practise.

∴ In a practical oscillator, it is accordingly necessary to arrange to have $|KA_1|$ somewhat larger (±10%) than unity ⇒ in order to ensure that, with incidental variations in transistor and circuit parameters $|A.\beta|$ shall not fall below unity.

$|A_1K| \geq 1.1$

* How does an Oscillator operate without an I/P signal?

- Initially, to start the oscillations, we need some I/P, so that o/p wave is produced. A, part of o/p is then Fedback & when it satisfies the condition $|A_1K|=1$, oscillation's are produced.
- But in practise, no I/P voltage is applied, still oscillator works, because this I/P voltage at the start is the noise which is due to random movement of electrons inside any electronic device.
- This small noise voltage is amplified by an amplifier and fedback to the I/P.
- Thus this noise voltage acts as the starting voltage to begin small oscillations, which are amplified and again Fedback to I/P, till the loop gain $|A_1K| \geq 1$, Only then sustained oscillations will be obtained at the O/P.
- In this way, oscillator operates without an I/P signal.

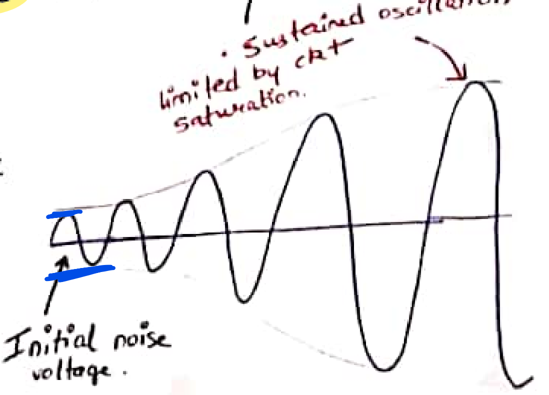
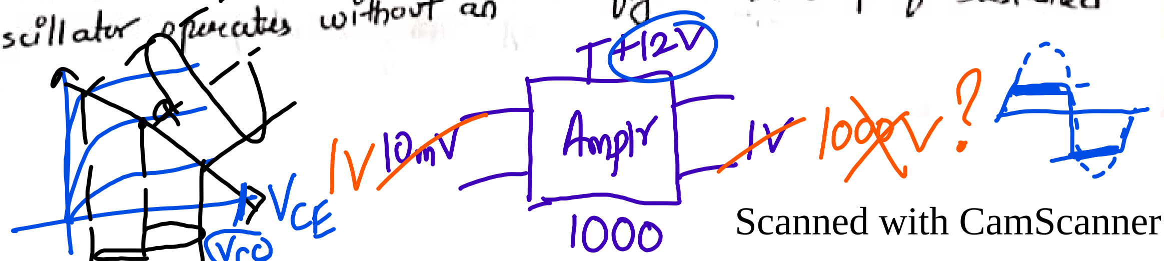
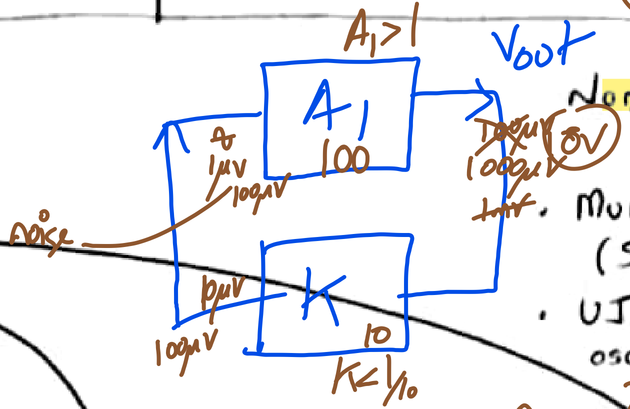


fig 1.3: Build-up of sustained



Classification of oscillators

$A_1 . K \geq 1$



Sinusoidal oscillators

RC or low-frequency oscillators

- These oscillators use R, C elements and are used to generate low (audio) frequency signals. They are also known as "Audio-Frequency" oscillators.

f_{osc} (20Hz - 20KHz)

Eg: 1) RC-Phase shift oscillators
2) Wien-bridge oscillators.

- Twin T oscillator.

LC (Tuned circuit oscillators)

- These oscillators use a tuned-ckt (tank ckt) and are used to generate high frequency signal.

$f_{osc} > 20KHz$

- They are also known as (Radio frequency) or RF oscillators.

Eg 1. Hartley oscillator
2. Colpitts oscillator
3. Clapp's oscillator.

- These are also called as High-Frequency oscillators.

4. Tuned oscillator (Armstrong oscillator).

Crystal oscillators

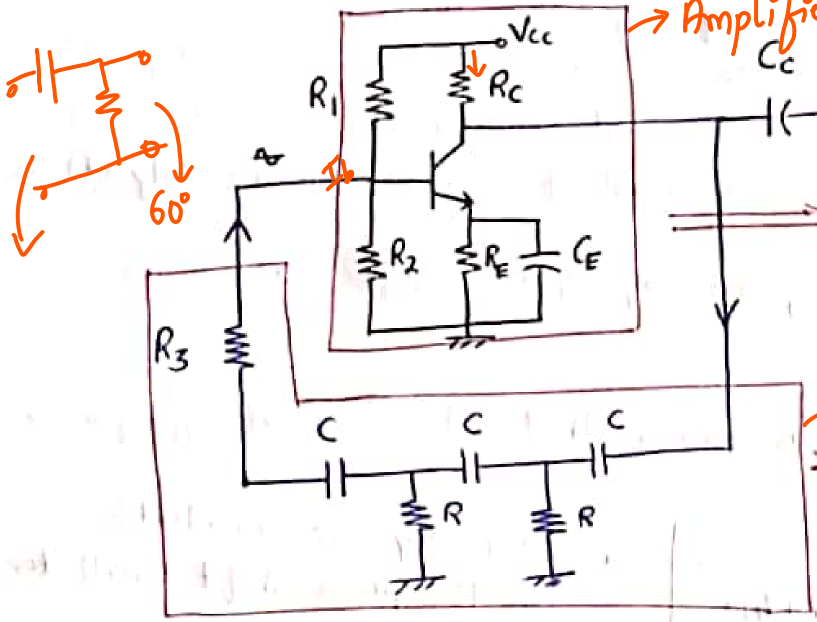
- These oscillator's use quartz crystals and are used to generate highly stabilised o/p signal with frequencies upto 10MHz and with a very high quality factor.

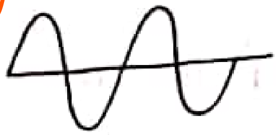
1.00000 MHz

Non-sinusoidal oscillators

- Multivibrators (Schmitt Trigger)
- UJT relaxation oscillator, etc

I] RC Phase-Shift Oscillator:





→ Amplifier (180°)

⇒ Single stage CE amplifier providing a phase shift of 180°.

→ f/b n/w (60°+60°+60°=180°)

→ Feedback Network consisting of 3 RC section's, providing total phase shift of 180°.

ckt ①: RC Phase-shift oscillator

- For producing oscillations, we must use a +ve feedback of sufficient magnitude. This occurs only when the fraction of o/p is f/b with the same phase as that of the I/p signal.
- In this ckt, a fraction of o/p of single-stage CE amplifier is passed through the RC Phase-shift network, before feeding back to the I/P.
- The RC phase-shift n/w consists of 3 RC section's which provides a total phase shift of 180° in addition to the phase-shift of 180° introduced by the amplifier. Thus, there is a total phase shift around the loop between the I/p and o/p ckt is 0° or 360°.
- It has been found that by using a transistor (BJT) as an active element of the amplifier stage, the o/p of f/b network is loaded by relatively low I/p impedance of the transistor.
- In above ckt, the f/b signal is coupled through the f/b resistor (R_3) in series with the amplifier's I/p resistance's, that's why we have $\boxed{R_3 = R - R_i}$, where R is the value of resistor in Phase-shift network, R_i is ampl's I/p resistance.

→ Note: R_1, R_2 and R_E ⇒ [biasing resistor to bias BJT in active region and does not play any role in getting oscillation's]