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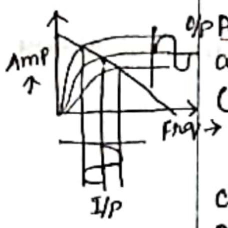
ADDITIONAL BOOK

ELECTRONIC CIRCUITS

SIGNATURE OF HALL INVIGILATOR

* An electronic circuit is a complete course of conductors through which current can travel.
* circuits provide a path for current to flow.
* In other words, a circuit must form a loop.

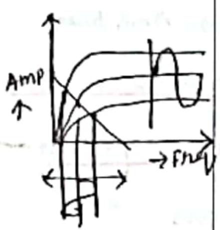
SMALL SIGNAL:-



A small signal model takes a circuit and based on an operating point (bias) and linearizes all the components. Nothing changes because the assumption is that the signal is so small that the operating point (gain, capacitance, etc..) doesn't change.

"Large signal" is the opposite of "small signal", which means that the circuit can be reduced to a linearized equivalent circuit around its operating point with sufficient accuracy.

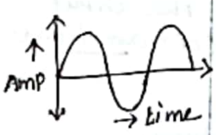
LARGE SIGNAL:-



A large signal model, on the other hand, takes into account the fact that the large signal actually affects the operating point, as well as that elements are non-linear and circuits can be limited by power supply values.

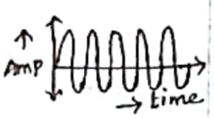
Large-signal modeling is a common analysis method used in electronics engineering to describe nonlinear devices in terms of the underlying non-linear equations. In circuits containing nonlinear elements such as transistors, diodes and vacuum tubes, under "large signal conditions", AC signals have high enough magnitude that non linear effects must be considered.

Low Frequency Models:-



Low frequency the portion of the electromagnetic spectrum b/w 30KHz and 300KHz. This range of frequencies is used for several types of radio communication, including the longwave broadcast band in Europe and Asia.

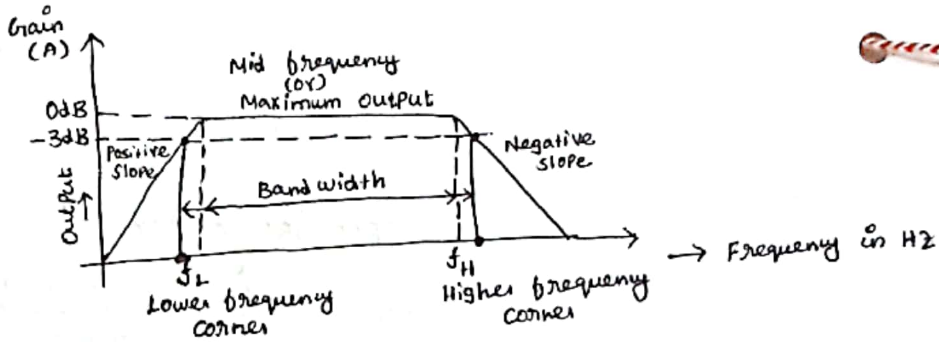
High frequency Models:-



High frequency the portion of the electromagnetic spectrum b/w 3 and 30MHz

what is frequency response of an amplifier:-

Frequency response is the quantitative measure of the output spectrum of a system (or) device in response to a stimulus, and is used to characterize the dynamics of the system. It is a measure of magnitude and phase of the output as a function of frequency, in comparision to the input.

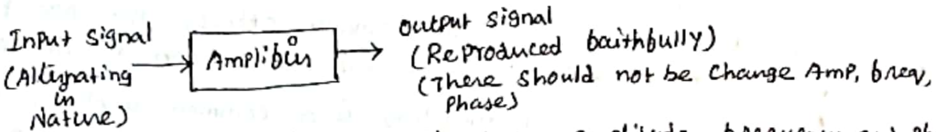


Frequency Response

Audio amplifiers:-
These can handle frequency in the range of 20HZ to 15KHZ (this is the frequency spectrum of an audio signal)

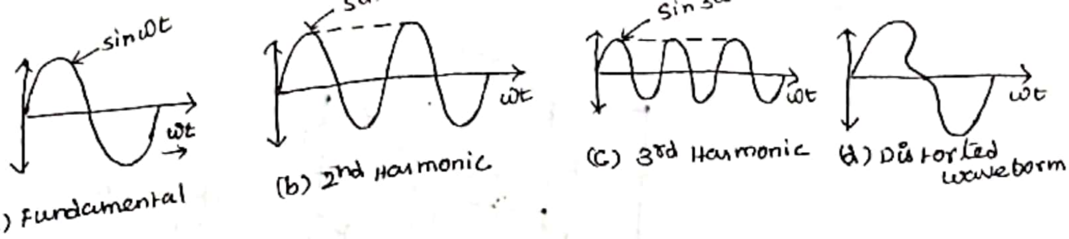
Video amplifiers:-
These are wide band amplifiers designed to amplify frequency from 30HZ to 40MHZ of video signals.

Distortion in Amplifiers:-



* The basic features of any alternating signal are amplitude, frequency and phase
* Hence the possible distortion in any amplifier are amplitude distortion, phase distortion and frequency distortion.
* But the phase distortion are not detectable by human ears.
* while the change in gain of the amplifier with respect to the frequency is called frequency distortion.
* Due to such nonlinearity in the dynamic characteristics ~~is~~ the wave form of the output voltage differs from that of the input signal. Such a distortion is called nonlinear distortion (or) amplitude distortion (or) harmonic distortion.
* harmonic distortion plays an important role in the analysis.

Harmonic Distortion:-
* Harmonic distortion means the presence of the frequency components in the output wave form, which are not present in the input signal.
* The component with frequency same as the input signal is called as fundamental frequency component.
* The additional frequency components present in the output signal are having frequency components. These components are called harmonic components (or) harmonics.
* For example if the fundamental frequency is "f" HZ then the output signal contains fundamental frequency component at "f" HZ and additional frequency components at 2f HZ, 3f HZ, 4f HZ and so on.
* The 2f component is called second harmonic
* The 3f " " " Third harmonic
* The order of the harmonic increases, its amplitude decreases. As the second harmonic amplitude is largest.



* The above figure shows distorted waveform can be obtained by adding the fundamental and the harmonic components.

* The percentage of harmonic distortion due to each order comparing the amplitude of each order (2nd, 3rd & so on) can be calculated by comparing the amplitude.

$$\% \text{ nth harmonic distortion} = \% D_n = \frac{|B_n|}{|B_1|} \times 100$$

$$\% D_2 = \frac{|B_2|}{|B_1|}, \quad \% D_3 = \frac{|B_3|}{|B_1|} \text{ and so on.}$$

where
B_1 - fundamental frequency component
B_n - nth harmonic component has an amplitude

Total Harmonic Distortion:-

Total harmonic distortion, which is the effective distortion due to all the individual components is given by

$$\% D = \sqrt{D_2^2 + D_3^2 + D_4^2 + \cdots} \times 100$$

where 'D' - Total Harmonic Distortion.

RC Coupled Amplifier:-

What is amplifier:-

* Amplification is a process of increasing the signal strength by increasing the Amplitude of a given signal without changing its characteristics input signal may be a current signal, voltage signal (or) a power signal

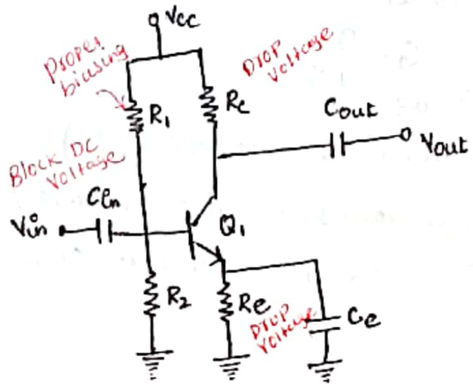
* Amplifier will amplify the signal without changing its characteristics

* Application of amplifier are of wide range, they are mainly used in communication, controllers, audio and video instruments etc..

Single Stage Common Emitter Amplifier:-

* A single stage common emitter RC coupled amplifier is a simple and elementary amplifier circuit.

* The main purpose of this circuit is pre-amplification that is to make weak signals to be stronger signal for further amplification.



* The capacitor Cin at the input acts as a filter which is used to block the DC voltage and allow only AC voltage to the transistor.

* R_1 & R_2 resistance are used for providing proper biasing to the bipolar transistor.

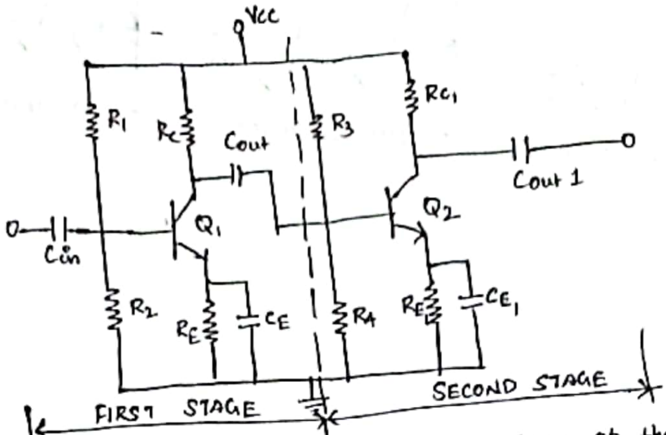
* R_1 & R_2 biasing voltage to drive the transistor in active region.

* Transistor having three region:-
  (i) cut-off Region
  (ii) Active Region.
  (iii) Saturation Region

* R_C & R_E are used to drop voltage of Vcc by 50%

* R_E & C_E makes a negative feedback for making the circuit operation more stable

Two Stage Common Emitter Amplifier:-



* when input AC signal is applied to the base of the transistor of the 1st stage of RC coupled amplifier. from the function generator.

* 1st stage amplifier output applied to next stage of amplifier through the coupling capacitor Cout

* Thus the successive stages amplify the signal and the overall gain is raised to the desired level.

* Much higher gain can be obtained by connecting a number of amplifier stages in succession.

* RC coupling is most Popular because it is cheap and provides a constant amplification over a wide range of frequencies.

Basic Parameters of A Transistor Amplifier:-

A good amplifier must have all the following specification:-

1) It should have high input impedance
2) " " " high stability
3) It must have high linearity
4) It should have high gain & bandwidth
5) It must have high efficiency.

B.W

$B.W = f_U - f_L$ Hz

* Normally good audio amplifier must have B.W from 20Hz to 20KHz

Gain

Gain of an amplifier is defined as the ratio of output Power to the input Power

$$G = \frac{P_{out}}{P_{in}}$$

"Gain in dB"

$$\text{Gain in dB} = 10 \log\left(\frac{P_{out}}{P_{in}}\right)$$

" Gain in voltage = output voltage / Input voltage

" Gain in current = output current / Input current,

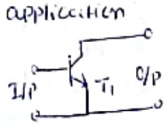
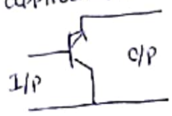
Efficiency:-

$$\text{Efficiency} = (P_{out}/P_{in}) \times 100$$

Conclusion:-

Amplification increasing signal strength using Rc coupled Amplifier using multistage amplifier using a combination of R & C.

Comparison Between the three transistor configuration:-

Sl.No	Characteristics	Common Base	Common Emitter	Common Collector
1.	Input Dynamic Resistance	Very Low (less than 100 Ω)	Low (less than 1k)	Very high (750k)
2.	Output Dynamic Resistance	Very high (less than 1M)	High (less than 45k)	Low (50 ohm)
3.	Current gain	Less than 1	High (100)	Very high (greater than 100)
4.	Leakage current	Very Small	Very Large	Very Large
5.	Voltage gain	About 150	About 500	Less than 1
6.	Power gain	Medium	Highest	Medium
7.	Phase relation b/w I/P and O/P	In Phase	out of Phase (180°)	In Phase
8.	Applications	For high freq application	For audio freq application	For impedence Matching application.
9.	Configuration			

Amplifiers classification:-

An amplifier circuit is one which strengthens the signal. The amplifier action and the important considerations for the Practical circuit of transistor amplifier were also detailed in Previous chapters.

Amplifiers are classified according to many considerations.

1) Based on number of stages

Depending upon the number of stages of Amplification,

* Single-stage Amplifiers :- This has only one transistor circuit, which is a singlestage amplification.

* Multi-Stage Amplifiers :- This has multiple transistor circuit which provides multi-stage amplification

2) Based on its output:-

Depending upon the Parameters that is amplified at the output,

* Voltage Amplifiers: The amplifier circuit that increases the voltage level of the input signal, is called as Voltage amplifier

* Power Amplifiers :- The amplifier circuit that increases the power level of the input signal, is called as power amplifier.

3) Based on the input signals:-

Depending upon the magnitude of the input signal

* Small signal Amplifiers :- when the input signal is so weak so as to produce small fluctuations in the collector current compared to its quiescent value.

* Large signal Amplifiers :- when the fluctuations in collector current are large is known as Large signal Amplifiers

4) Based on the frequency range:-

Depending upon the freq range of the signals being used,

* Audio Amplifiers - The amplifier circuit that amplifies the signal that lie in the audio frequency range (ie) from 20Hz to 20kHz frequency range.

* Power Amplifiers - The amplifier circuit that amplifies the signals that lie in a very high freq range.

5) Based on Biasing conditions :-

Depending upon their mode of operation,

* Class A Amplifiers :- The biasing conditions in class A power amplifier are such that the collector current flows for the entire AC signal applied

* Class B amplifier :- Collector current flows for half-cycle of input AC signal applied

* Class C amplifier :- Collector current flows for less than half-cycle input AC signal applied.

* Class AB amplifier :- combining both class A & class B to minimize the problems they have.

6) Based on the coupling Method :-

Depending upon the Method of coupling one stage to the other,

* RC coupled amplifier :-

  coupled to the next stage using Resistor and capacitor (RC)

* Transformer coupled amplifier :-

  coupled to the next stage using transformer

* Direct coupled Amplifier :-

  coupled to the next stage directly

7) Based on the transistor configuration :-

Depending upon the type of transistor configuration,

* CE amplifier :-

  CE configured transistor

* CB amplifier :-

  CB configured transistor

* CC amplifier :-

  CC configured transistor

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Feedback amplifiers:-

* Feedback plays an important role in almost all electronic circuits.
* It is almost invariably used in the amplifier to improve its performance and to make it more ideal.
* In the process of feedback, a part of output is sampled and fed back to the input of the amplifier.
* Therefore, at input we have two signals: Input signal, and part of the output which is fed back to the input.
* Both these signals may be in phase (or) out of phase.
* When input signal and part of output signal are in phase, the feedback is called positive feedback
* When they are in out of phase, the feedback is called negative feedback.

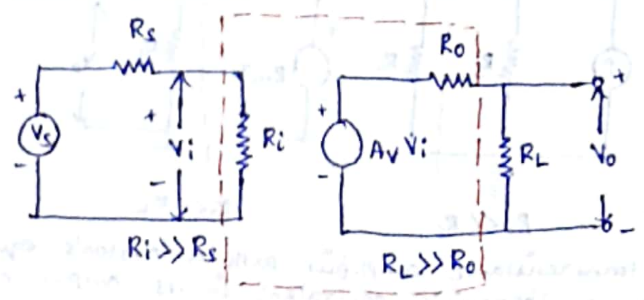
The concept of feedback and show how to modify the characteristics of an amplifier by combining a portion or part of the output signal with the input signal. We also study the analysis of various feedback amplifiers.

Classification of amplifiers:-

* Classification of amplifiers based on the magnitudes of the input and output impedances of an amplifier relative to the source and load impedances respectively.
* Amplifiers can be classified into four broad categories:-

1) Voltage
2) Current
3) Transconductance - Differential input voltage produces an output current.
4) Trans resistance - converts an input of current to an output of voltage.

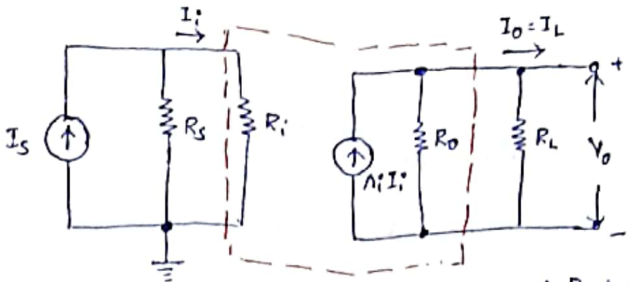
1) Voltage amplifier:-



* Fig. shows Thevenin's equivalent circuit of an amplifier.
* If the amplifier input resistance R_i is large compared with the source resistance R_s then $V_i \approx V_s$
* If the External load resistance R_L is large compared with the output resistance R_o of the amplifier, then $V_o \approx A_V V_i \approx A_V V_s$

* Such amplifier circuit provides a voltage output proportional to the voltage input, the factors does not depend magnitudes of the source and load resistance
* Hence, this amplifier is called voltage amplifier

Current Amplifier:-

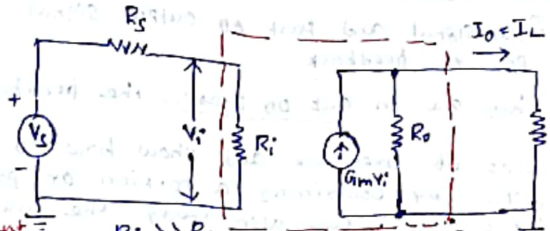


$R_i \to 0$ (or) $R_i << R_s$ $R_L << R_o$ (or) $R_o \to \infty$

Norton's equivalent circuits of a current amplifier

* Fig. shows Norton's equivalent circuit of a current amplifier.
* If amplifier input resistance $R_i \to 0$, then $I_i = I_s$
* If amplifier output resistance $R_o \to \infty$, then $I_L = A_i I_i$
* Such amplifier provides a current output proportional to the signal current, and the proportionality factor is independent of source and load resistance
* This amplifier is called current amplifier.

Transconductance Amplifier:-



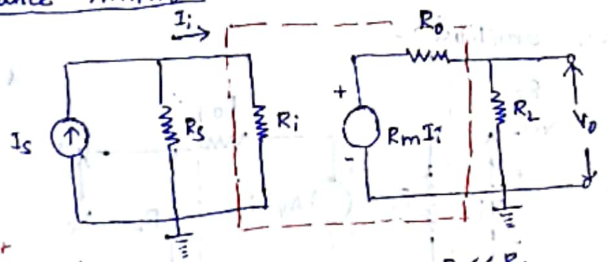
$R_i >> R_s$ $R_o >> R_L$

Note:-
* I/p circuit → Thevenin's equivalent
o/p circuit → Norton's equivalent
* O/p current ∝ I/p voltage
* Independent of the magnitudes of the source and load resistance.

Transconductance Amplifier

* Fig. shows transconductance amplifier with a Thevenin's equivalent in its input circuit and Norton's equivalent in its output circuit.
* In this amplifier, an output current is proportional to the input signal voltage and the proportionality factor is independent of the magnitudes of the source and load resistance.
* Ideally, this amplifier must have an infinite input resistance R_i and infinite output resistance R_o.

Transresistance Amplifier:-



I/p circuit → Norton's equivalent
O/p circuit → Thevenin's equivalent

$R_i << R_s$ $R_o << R_L$

* Fig. shows transresistance amplifier with a Norton's equivalent in its input circuit and a Thevenin's equivalent in its output circuit

Note
→ O/p voltage ∝ I/p signal current
→ Independent on the source and load resistance

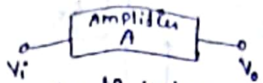
* In this amplifier an output voltage is proportional to the input signal current and the proportionality factor is independent. On the source and load resistance
* Ideally, this amplifier must have zero input resistance R_i and zero output resistance R_o.

TYPES OF FEEDBACK

1) Positive feedback
2) Negative feedback

- If the original input signal and the feedback signal are in phase, the feedback is called as positive feedback.
- However if these two signals are out of phase then the feedback is called as negative feedback.

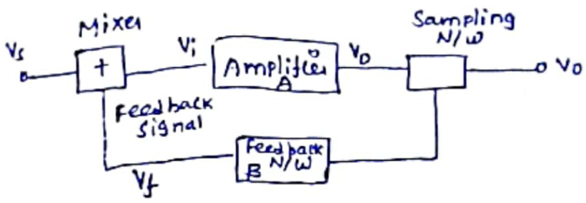
Amplifier without Feedback:-



* The most important thing to understand from Fig. is that the output and input terminals of this amplifier are not connected to each other in any way
* Therefore the amplifier of Fig. is an amplifier without any feedback

Gain without feed back :- $A = \frac{V_o}{V_i}$

Amplifier with Feedback:-

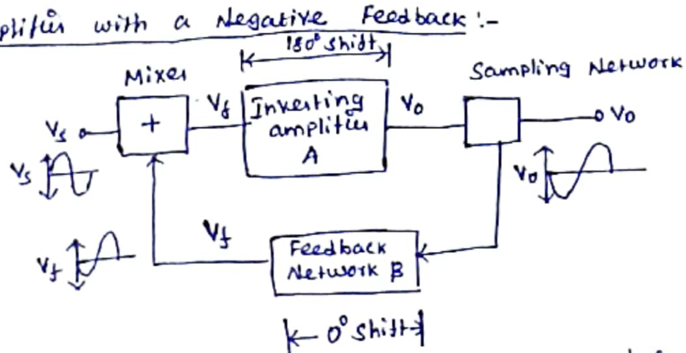


Refer to Fig. Here the same amplifier with a gain A is being used along with a mixer network, sampling network and a feed back network.

The voltage gain of the feedback amplifier is given by,

Gain with feedback $A_f = \frac{V_o}{V_s}$

Amplifier with a Negative Feedback:-



The block diagram of an amplifier with a Negative feedback Fig.

$V_f = \beta V_o$

where V_f = Feedback signal (output of the feedback Network)

Feedback factor $\beta = \frac{V_f}{V_o}$

Types of Negative feedback:-

Depending on the type of sampling and mixing network, the feedback amplifier are classified into four categories.

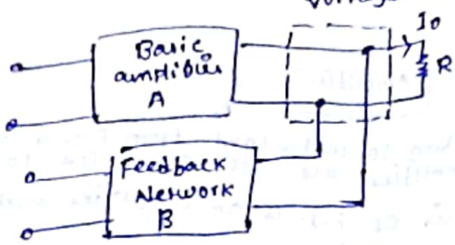
Voltage series feedback
Current " "
Current Shunt "
Voltage Shunt "

Sampling Network

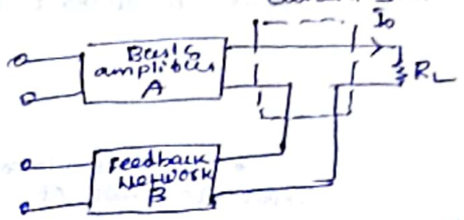
* There are two ways to sample the output, according to the sampling parameter, either voltage (or) current.

* The output voltage is sampled by connecting the feedback network in shunt across the output

* The output current is sampled by connecting the feedback network in series with the output.



(a) Voltage sampling



(b) current (or) loop sampling

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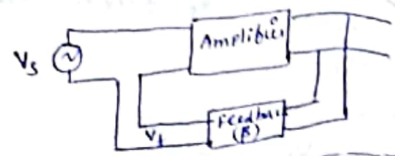
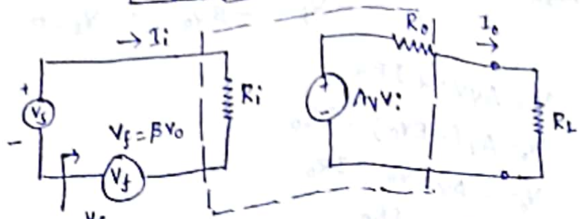
Voltage Series Feedback:-





$R_{if} = \frac{V_s}{I_i}$

Thevenin's Model

Input Resistance

Input Resistance with feedback is given as

$$R_{if} = \frac{V_s}{I_i}$$

Applying KVL to the I/P side we get:-

$$V_s - I_i R_i - V_f = 0$$

$$V_s = V_f + I_i R_i$$

$$V_s = \beta V_o + I_i R_i$$

$$\boxed{V_f = \beta V_o}$$

The output voltage V_o is given as

$$V_o = \frac{A_V V_i R_L}{R_o + R_L}$$

$A_V \rightarrow$ open loop gain

$A_V \rightarrow$ with load

$$\boxed{A_V = \frac{A_V R_L}{R_o + R_L}}$$

$$V_s = \beta V_o + I_i R_i$$

$$= \beta \cdot \frac{A_V V_i R_L}{R_o + R_L} + I_i R_i$$

$$V_s = \beta A_V V_i + I_i R_i$$

$I = V/R$

$V = IR$

$\boxed{V_i = I_i R_i}$

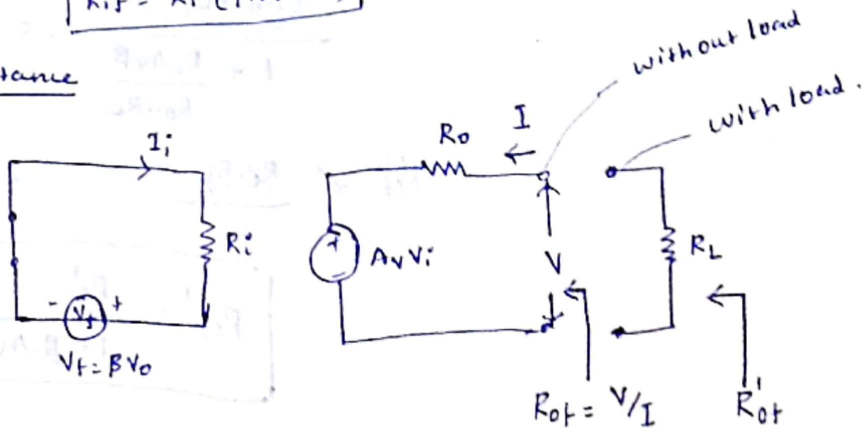
$$V_s = \beta A_V I_i R_i + I_i R_i$$

$$\frac{V_s}{I_i} = \beta A_V R_i + R_i$$

$$\frac{V_s}{I_i} = R_{if}$$

$$\boxed{R_{if} = R_i (\beta A_V + 1)}$$

O/P Resistance



Applying KVL to the output side we get

$$A_V V_i + I R_o - V_o = 0 \Rightarrow V_o = + A_V V_i + I R_o$$

$$I = \frac{V - A_V V_i}{R_o}$$

The I/P voltage is given as $\therefore V_s = 0$

$$V_i = -V_f = -\beta V_o$$

$$V_o = A_V V_i + I R_o$$

$$V_o = A_V(-\beta V_o) + I R_o$$

$$V_o = -A_V \beta V_o + I R_o$$

$$V_o + A_V \beta V_o = I R_o$$

$$V_o(1 + A_V \beta) = I R_o$$

without load

$$\Rightarrow \boxed{R_{of} = \frac{V_o}{I} = \frac{R_o}{1 + A_V \beta}}$$

with load

$$R_{of}' = R_{of} \parallel^{el} R_L$$

$$R_{of}' = \frac{\frac{R_o}{1+A_V\beta} \times R_L}{\frac{R_o}{1+A_V\beta} + R_L} \Rightarrow \frac{\frac{R_o R_L}{1+A_V\beta}}{\frac{R_o + R_L(1+A_V\beta)}{1+A_V\beta}}$$

$$\Rightarrow \frac{R_o R_L}{R_o + R_L(1 + A_V\beta)}$$

$$\Rightarrow \frac{R_o R_L}{R_o + R_L + R_L A_V \beta}$$

Dividing numerator and denominator by $(R_o + R_L)$ we get

$$R_{of}' = \frac{\frac{R_o \cdot R_L}{R_o + R_L}}{\frac{R_o + R_L + R_L A_V \beta}{R_o + R_L}}$$

$$R_{of}' = \frac{\frac{R_o \cdot R_L}{R_o + R_L}}{1 + \frac{R_L A_V \beta}{R_o + R_L}} = \frac{R_o \parallel R_L}{1 + \frac{R_L A_V \beta}{R_o + R_L}}$$

$$R_{of}' = \frac{R_o \parallel R_L}{1 + \beta A_V}$$

$$\boxed{R_{of}' = \frac{R_o'}{1 + \beta \cdot A_V}}$$

where $\therefore A_V = \frac{A_V R_L}{R_o + R_L}$

$\therefore R_o' = \frac{R_o R_L}{R_o + R_L}$

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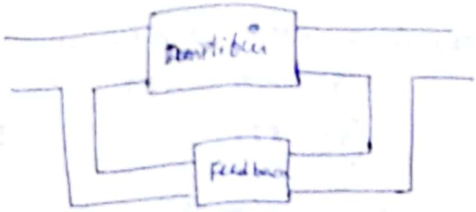
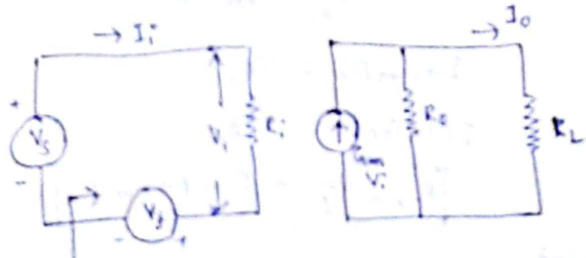
Current Series F/B





$V_f = \beta I_o$

$R_{if} = \frac{V_s}{I_i}$

Applying KVL to the input side we get.

$$V_s - I_i R_i - V_f = 0$$

$$V_s = I_i R_i + V_f$$

$$V_s = I_i R_i + \beta I_o \rightarrow ①$$

$V_f = \beta I_o$

The output current I_o is given as

$$I_o = \frac{G_m V_i R_o}{R_o + R_L} = G_M V_i \rightarrow ②$$

$G_M = \frac{G_m R_o}{R_o + R_L}$

I_o - Value Sub. eq ①

$$V_s = I_i R_i + \beta I_o$$

$$V_s = I_i R_i + \beta G_M V_i$$

$V_i = I_i R_i$

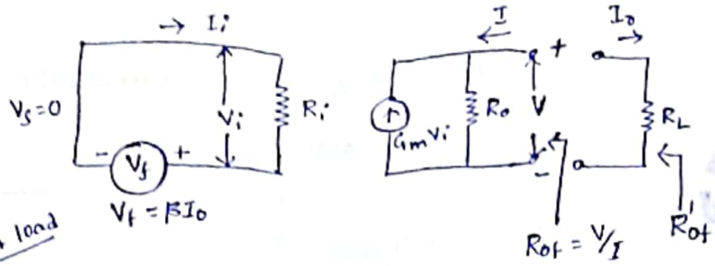
$$V_s = I_i R_i + \beta G_M I_i R_i$$

$$V_s = I_i (R_i + \beta G_M R_i)$$

$$\frac{V_s}{I_i} = R_i + \beta G_M R_i$$

$$R_{if} = \frac{V_s}{I_i} = R_i (1 + \beta G_M)$$

Output Resistance



Without load

Apply KCL to the o/p node

$$I = \frac{V}{R_o} - G_m V_i$$

The input voltage is given as

$$V_i = -V_f = -\beta I_o \qquad \therefore I_o = -I$$

$$\boxed{V_i = \beta I}$$

$$I = V/R_o - G_m \beta I$$

$$I + G_m \beta I = V/R_o$$

$$I(1 + G_M \beta) = V/R_o$$

$$\boxed{R_{of} = V/I = R_o(1 + G_m \beta)}$$

With load

$$R'_{of} = R_{of} \,//\, R_L$$

$$= \frac{R_o(1+G_m\beta)R_L}{R_o(1+G_m\beta)+R_L} = \frac{R_oR_L(1+\beta G_m)}{R_o + R_L + \beta G_m R_o}$$

Dividing numerator and denominator by $R_o + R_L$.

$$R'_{of} = \frac{\dfrac{R_oR_L(1+\beta G_m)}{R_o+R_L}}{\dfrac{R_o+R_L+\beta G_m R_o}{R_o+R_L}}$$

$$= \frac{\dfrac{R_oR_L(1+\beta G_m)}{R_o+R_L}}{1 + \dfrac{\beta G_m R_o}{R_o+R_L}} \qquad \therefore R'_o = \frac{R_oR_L}{R_o+R_L}$$

$$G_M = \frac{G_m R_o}{R_o + R_L}$$

$$\boxed{R'_{of} = \frac{R'_o(1+\beta G_m)}{1+\beta G_M}}$$

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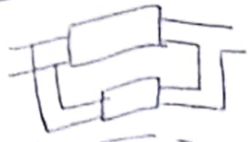
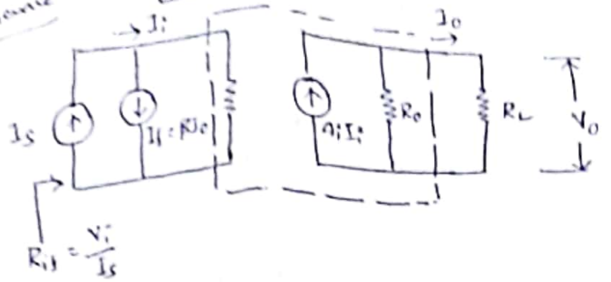
Current Shunt feedback



I/P resistance



Applying KCL to the input node we get

$$I_s = I_i + I_f \qquad \boxed{I_f = \beta I_o}$$
$$= I_i + \beta I_o$$

The output current I_o is given as

$$I_o = \frac{A_i I_i R_o}{R_o + R_L} \qquad \boxed{A_I = \frac{A_i R_o}{R_o + R_L}}$$

$$I_o = A_I I_i$$

I_o value sub in I_s eq

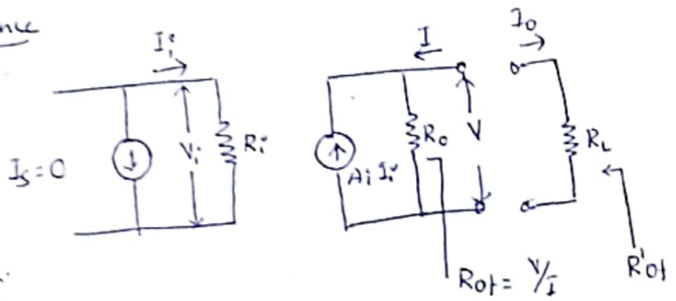
$$I_s = I_i + \beta I_o$$
$$I_s = I_i + \beta A_I I_i$$
$$I_s = I_i (1 + \beta A_I)$$

The input resistance with feedback is given as

$$R_{if} = \frac{V_i}{I_s} = \frac{V_i}{I_i (1 + \beta A_I)} \qquad \boxed{R_i = \frac{V_i}{I_i}}$$

$$\boxed{R_{if} = \frac{R_i}{1 + \beta A_I}}$$

O/P resistance



without load.

Applying the KCL to the output node we get,

$$I = V/R_o - A_i I_i$$

The input current is given as

$$I_i = -I_f = -\beta I_o \qquad \boxed{\because I_s = 0,\ I = -I_o}$$
$$= \beta I$$

I_i value sub/ above eq

$$I = V/R_o - A_i I_i$$
$$= V/R_o - A_i \beta I$$

$$I + A_i \beta I = V/R_o$$

$$I(1 + A_i \beta) = V/R_o$$

$$\boxed{R_{of} = V/I = R_o (1 + A_i \beta)}$$

with Load

$$R'_{of} = R_{of} \,//\, R_L$$

$$= \frac{R_{of} \times R_L}{R_{of} + R_L}$$

$$= \frac{R_o(1+\beta A_i)R_L}{R_o(1+\beta A_i)+R_L} = \frac{R_o R_L(1+\beta A_i)}{R_o + R_L + \beta A_i R_o}$$

Dividing num/. and deno/. by $R_o + R_L$ we get,

$$R'_{of} = \frac{\frac{R_o R_L(1+\beta A_i)}{R_o + R_L}}{1 + \frac{\beta A_i R_o}{R_o + R_L}}$$

$$\therefore \quad R'_o = \frac{R_o R_L}{R_o + R_L}$$

$$A_I = \frac{A_i R_o}{R_o + R_L}$$

$$R'_{of} = \frac{R'_o(1+\beta A_i)}{1+\beta A_I}$$

$$\boxed{R'_{of} = \frac{R'_o(1+\beta A_i)}{1+\beta A_I}}$$

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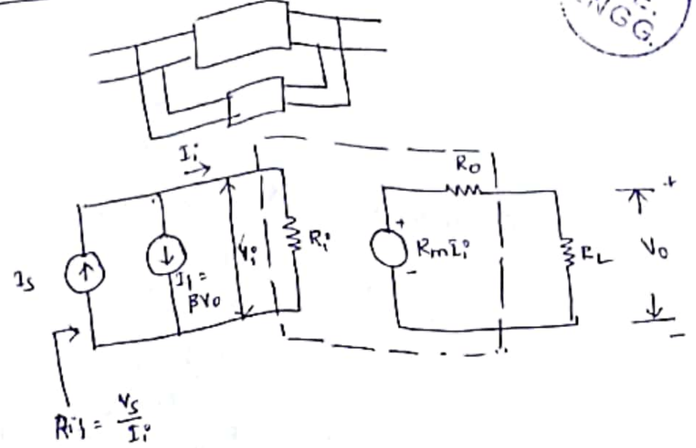
Voltage Shunt Feedback :-



Applying KCL at input node we get,

$$I_s = I_i + I_f$$

$$= I_i + \beta V_o$$

$$\boxed{I_f = \beta V_o}$$

The output voltage V_o is given as

$$V_o = \frac{R_m I_i R_o}{R_o + R_L}$$

$$= R_M I_i$$

$$\boxed{R_M = \frac{R_m R_o}{R_o + R_L}}$$

V_o value sub/. I_s eq

$$I_s = I_i + \beta V_o$$

$$= I_i + \beta R_M I_i$$

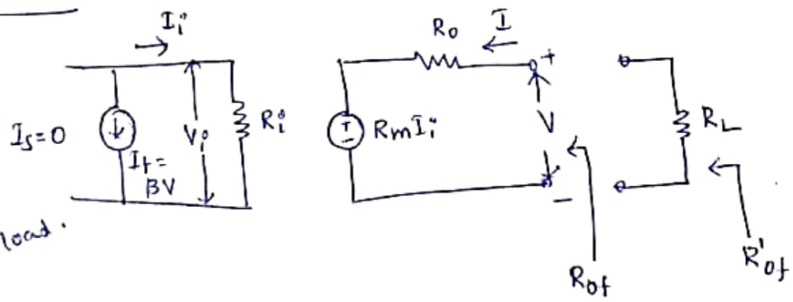
$$I_s = I_i (1 + \beta R_M)$$

$$R_{if} = \frac{V_i}{I_s} = \frac{V_i}{I_i (1 + \beta R_M)}$$

$$\boxed{R_i = \frac{V_i}{I_i}}$$

$$\boxed{R_{if} = \frac{R_i}{(1 + \beta R_M)}}$$

O/p feedback



without load.

Applying KVL to the output side we get,

$$R_m I_i + I R_o - V = 0$$

$$I = \frac{V - R_m I_i}{R_o}$$

The input current is given as

$$I_i = -I_f = -\beta V$$

I_i value sub I eq

$$I = \frac{V - R_m I_i}{R_o} = \frac{V + \beta V R_m}{R_o} = \frac{V(1 + \beta R_m)}{R_o}$$

$$\boxed{R_{of} = V/I = \frac{R_o}{1 + \beta R_m}}$$

With load

$$R_{of}' = R_{of} \parallel R_L = \frac{R_{of} \times R_L}{R_{of} + R_L}$$

$$= \frac{\frac{R_{of} \times R_L}{1 + R_m\beta}}{\frac{R_o}{1 + R_m\beta} + R_L} = \frac{R_o R_L}{R_o + R_L(1 + R_m\beta)}$$

Dividing num. & deno. by $R_o + R_L$ we get,

$$R_{of}' = \frac{\frac{R_o R_L}{R_o + R_L}}{1 + \frac{\beta R_m R_L}{R_o + R_L}}$$

$\therefore$

$$R_{of}' = \frac{R_o'}{1 + \beta R_M}$$

$$R_o' = \frac{R_o R_L}{R_o + R_L}$$

$$R_M = \frac{R_m R_L}{R_o + R_L}$$

Properties of Negative Feedback :-

1. The voltage gain is more stable
2. Higher input impedance and lower output impedance
3. Frequency response is better
4. Output is more resilient to noise
5. Distortion is reduced.

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Gain with Feedback

* Symbol 'A' is used to represent transfer gain of the basic amplifier without feedback
* Symbol 'A_f' is used to represent transfer gain of the basic amplifier with feedback

$$A = \frac{x_o}{x_i} \quad \text{and} \quad A_f = \frac{x_o}{x_s}$$

x_o = o/p voltage (or) o/p current
x_i = I/p voltage (or) I/p current
x_s = source voltage (or) source current

(2)

As it is negative feedback the relation b/w x_i and x_s is given as

$$x_i = x_s + (-x_f)$$

x_f = Feed back voltage (or) Feedback current

$$\boxed{A_f = \frac{x_o}{x_s} = \frac{x_o}{x_i + x_f}}$$

Dividing by x_i to numr. and Denomi we get,

$$A_f = \frac{x_o/x_i}{\frac{x_i + x_f}{x_i}} \qquad \therefore \boxed{A = \frac{x_o}{x_i}}$$

$$= \frac{A}{1 + \frac{x_f}{x_i}}$$

$$= \frac{A}{1 + \left(\frac{x_f}{x_i} \times \frac{x_o}{x_o}\right)}$$

$$= \frac{A}{1 + \left(\frac{x_f}{x_o} \times \frac{x_o}{x_i}\right)}$$

$$= \frac{A}{1 + \left(\frac{x_f}{x_o} \times \frac{x_o}{x_i}\right)}$$

$$= \frac{A}{1 + (\beta A)} \qquad \therefore \boxed{\beta = \frac{x_f}{x_o}}$$

$$\boxed{A_f = \frac{A}{1 + \beta A}}$$

Distortion with Feedback :-

Feedback N/w does not contain reactive elements, the overall gain is not a function of frequency. under such conditions frequency and phase distortion is substantially reduced.

Noise and Nonlinear Distortion:- amount of noise signal and non-linear distortion. The factor $(1+\beta A)$ reduces both I/P noise and resulting nonlinear distortion for considerable improvement, Thus, noise and non-linear distortion also reduced by same factor as the gain.

Signal feedback reduced the

Effects of Feedback

Feedback Type	x_s	x_o	Gain stabilized	Input Impedance	Output Impedance
Series voltage	V_s	V_o	$A_{vf} = \frac{A_v}{1+A_v\beta}$	$R_i(1+A_v\beta)$	$\frac{R_o}{1+\beta A_{voc}}$
Series current	V_s	i_o	$G_{mf} = \frac{G_m}{1+G_m\beta}$	$R_i(1+G_m\beta)$	$R_o(1+\beta G_{msc})$
Parallel voltage	i_s	V_o	$R_{mf} = \frac{R_m}{1+R_m\beta}$	$\frac{R_i}{1+R_m\beta}$	$\frac{R_o}{1+\beta R_{moc}}$
Parallel current	i_s	i_o	$A_{if} = \frac{A_i}{1+A_i\beta}$	$\frac{R_i}{1+A_i\beta}$	$R_o(1+\beta A_{isc})$

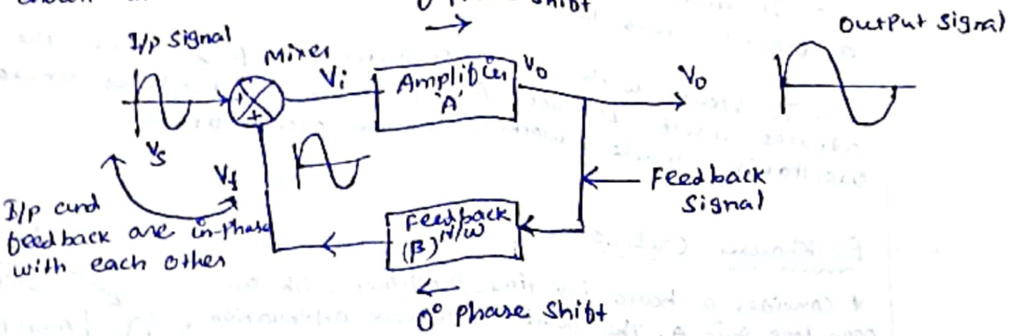
2-

OSCILLATORS

K. Danny
9976965897

Basic Theory of oscillators:-

* The feedback is a property which allows to feedback the part of the output, to the same circuit as its input.
* Such a feedback is said to be Positive feedback (in-Phase)
* Consider a non-inverting amplifier with the voltage gain 'A' as shown in the figure.



②

* The amplifier gain is 'A' in open loop gain

$$A = \frac{V_o}{V_i}$$

* The amplifier gain is 'Af' in closed loop gain

$$A_f = \frac{V_o}{V_s}$$

* The feedback is positive and voltage V_f is added to V_s to generate input of amplifier V_i, so,

$$V_i = V_s + V_f \rightarrow ①$$

The feedback voltage V_f depends on the feedback element gain β. So we can write,

$$V_f = \beta V_o \rightarrow ②$$

Sub/. eq ② in eq ①.

$$V_i = V_s + V_f$$
$$V_i = V_s + \beta V_o$$
$$V_s = V_i - \beta V_o \rightarrow ③$$

Sub/. in Expression for A_f,

$$A_f = \frac{V_o}{V_i - \beta V_o}$$

Dividing both num/. and denom/. by V_i,

$$A_f = \frac{(V_o/V_i)}{1 - \beta(V_o/V_i)}$$

$$\boxed{A_f = \frac{A}{1 - A\beta}} \qquad \therefore A = \frac{V_o}{V_i}$$

Now consider the various values of β and the corresponding value of A_f for constant amplifier gain of $A = 20$

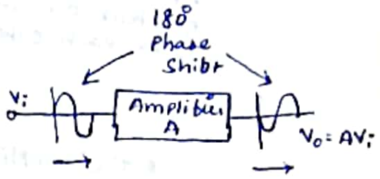
A	β	A_f
20	0.005	22.22
20	0.04	100
20	0.045	200
20	0.05	∞

- It must be noted that β the feedback n/w gain is always a fraction and hence $\beta < 1$

- To start with the oscillations $A\beta > 1$ but the circuit adjusts itself to get $A\beta = 1$, when it produces sinusoidal oscillations while working as an oscillator.

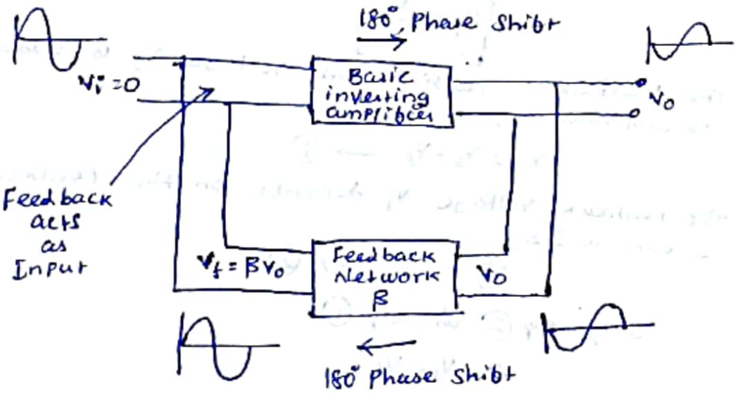
Barkhausen Criterion:-

* Consider a basic inverting amplifier with an open loop gain A. The feedback network attenuation factor β is less than unity.



* Inverting amplifier produces a phase shift of 180° b/w I/P and O/P

* The feedback n/w must introduce a phase shift of 180° while feeding back the voltage from output to input.



* V_i applied at the input of the amplifier. Hence we get,

$$V_o = AV_i \longrightarrow (1)$$

* Feedback to be given to input

$$V_f = -\beta V_o \longrightarrow (2)$$

Subs. eq (2) into eq (1) we get,

$$V_f = -\beta A V_i \longrightarrow (3)$$

* V_f must act as V_i

Now if V_f has to be equal to V_i,

$$V_i = -\beta A V_i$$

This will get satisfied only when,

$$\boxed{-A\beta = 1}$$

The $-A\beta = 1$ condition is called Barkhausen criterion

$$\boxed{A\beta = -1 + j0}$$

Equating magnitudes of both sides,

$$|A\beta| = |-1 + j0|$$

$$\boxed{|A\beta| = 1}$$

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ADDITIONAL BOOK

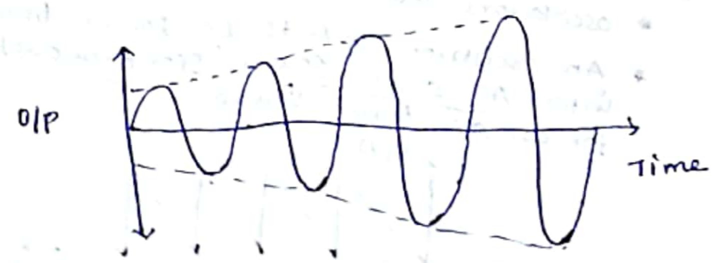
AU ELE. ENGG.

SIGNATURE OF HALL INVIGILATOR

(i) $|A\beta| > 1$

* when the total phase shift around a loop is 0° (or) 360° and $|A\beta| > 1$, then the output oscillates but the oscillations are of growing type.

* The amplitude of oscillations goes on increasing as shown in figure. 2

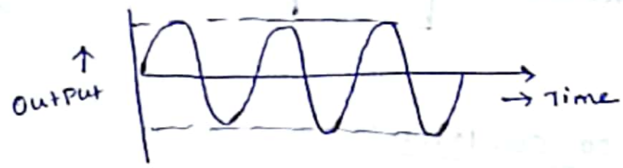


Growing type of oscillations.

(ii) $|A\beta| = 1$

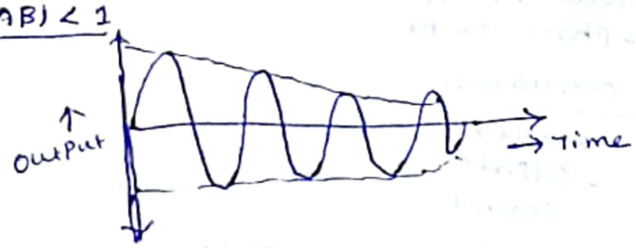
* when total phase shift around a loop is 0° or 360° ensuring positive feedback and $|A\beta| = 1$

* oscillations are with constant frequency and amplitude called sustained oscillations.



Sustained oscillations

(iii) $|A\beta| < 1$



* when total phase shift around a loop is 0° (or) 360° decaying type. but $|A\beta| < 1$ then the oscillations are of decaying type.

* Such as amplitude oscillation decreased

Introduction:-

* oscillator is an electronic circuit that generates a periodic waveform on its output without an external signal source. It is used to convert dc to Ac

* oscillators are circuits that produce a continuous signal of some type without the need of an input.
* These signals serve a variety of purposes.

Application of oscillators.

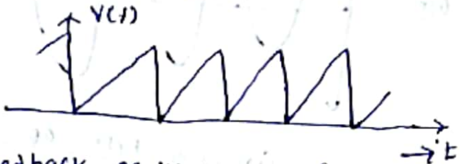
* oscillators are used to generate signals

Example

- used as a local oscillator to transform the RF signals to IF signals in a receiver.
- used to generate RF carrier in a transmitter
- generate clocks in digital systems

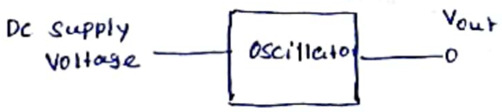
Oscillators

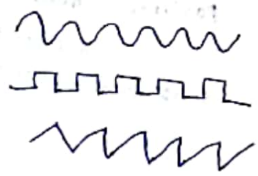
* oscillators are circuits that generate periodic signals
* An oscillator converts DC power from the power supply into AC signal power spontaneously - without the need for an AC input source



* The feedback oscillator relies on a positive feedback of the output to maintain the oscillations.

* The relaxation oscillator makes use of an RC timing circuit to generate a nonsinusoidal signal such as square.





Types of oscillators:-

1. RC oscillators
   - wien Bridge
   - Phase-shift
2. LC oscillators
   - Hartley
   - colpitts
   - crystal
3. unijunction / relaxation oscillators

OSCILLATION PRINCIPLE

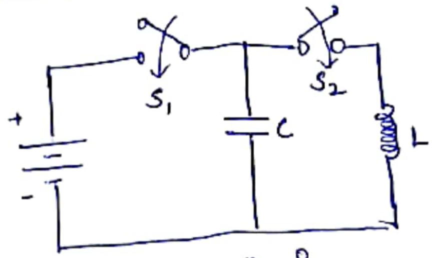
- without I/P to produces Oscillation using RC Oscillator.

* Every resistance has some free electrons under room temperature
* The Free electrons move randomly in various directions. Such a movement of the free electrons generates a voltage called noise voltage across resistance
* Such voltage across the resistance are amplified. Hence, to amplify such small noise voltage to start the oscillations.
* The part of the output voltage is sufficient to drive the input of amplifier circuit. Then circuit adjusts itself to get $|A\beta| = 1$ and with phase shift of 360°, we get sustained oscillations.

(2)

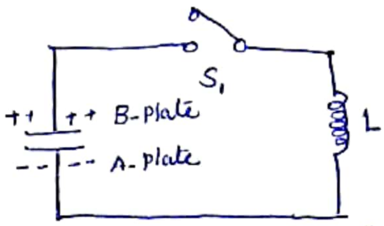
LC Oscillator and tank circuit Principle:-

(a)



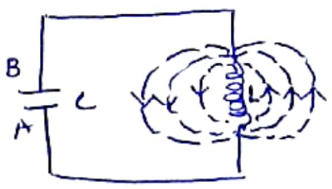
Tank circuit

(b)



(b) when switch S_1 is closed

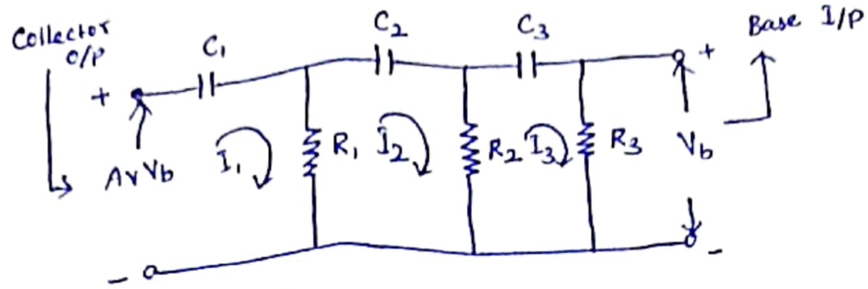
(c)



Due to this flow of current, magnetic field is setup in inductor and stores the energy given out by the electric field this due to S_2 is closed condition.

RC - Phase Shift Circuit

Derivation of Condition for Sustained Oscillations and Expression for Frequency of oscillations



From the above circuit,

First loop, $A_V V_b = I_1\left(R_1 + \frac{1}{j\omega C_1}\right) - I_2 R_1 \rightarrow (1)$

Second loop, $0 = -I_1 R_1 + I_2\left(R_1 + R_2 + \frac{1}{j\omega C_2}\right) - I_3 R_2 \rightarrow (2)$

Third loop, $0 = -I_2 R_2 + I_3\left(R_2 + R_3 + \frac{1}{j\omega C_3}\right) \rightarrow (3)$

On arranging the above three equations in matrix form, we get.

$$\begin{bmatrix} R_1 + \frac{1}{j\omega C_1} & -R_1 & 0 \\ -R_1 & \left(R_1 + R_2 + \frac{1}{j\omega C_2}\right) & -R_2 \\ 0 & -R_2 & R_2 + R_3 + \frac{1}{j\omega C_3} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} A_V V_b \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} R + \frac{1}{j\omega C_1} & -R & 0 \\ -R & 2R + \frac{1}{j\omega C_2} & -R \\ 0 & -R & 2R + \frac{1}{j\omega C_2} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} A_V V_b \\ 0 \\ 0 \end{bmatrix}$$

By using crammer rule, we can find Δ_2 and ΔI_3

$$\Delta_2 = \left[R + \frac{1}{j\omega C}\right]\left[\left\{\left(2R + \frac{1}{j\omega C}\right)^2 - R^2\right\}\right] + R\left(-R\left(2R + \frac{1}{j\omega C}\right)\right)$$

$$\Delta_2 = \left(R + \frac{1}{j\omega C}\right)\left(2R + \frac{1}{j\omega C}\right)^2 - R^2\left(R + \frac{1}{j\omega C}\right) - R^2\left(2R + \frac{1}{j\omega C}\right)$$

Then,

$$\Delta I_3 = \begin{bmatrix} R + \frac{1}{j\omega C} & -R & A_V V_b \\ -R & 2R + \frac{1}{j\omega C} & 0 \\ 0 & -R & 0 \end{bmatrix}$$

Unit – IV

K. Devmugam. AP/ECE

Class 'A' Amplifier

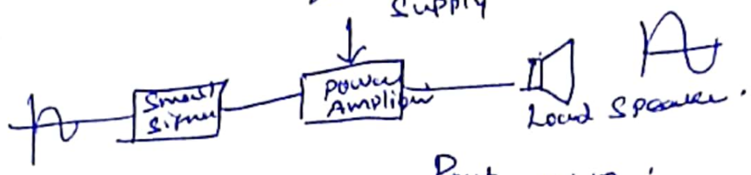
Common emitter amplifier are the most commonly used.

→ Common emitter amplifier.

→ very large voltage gain.

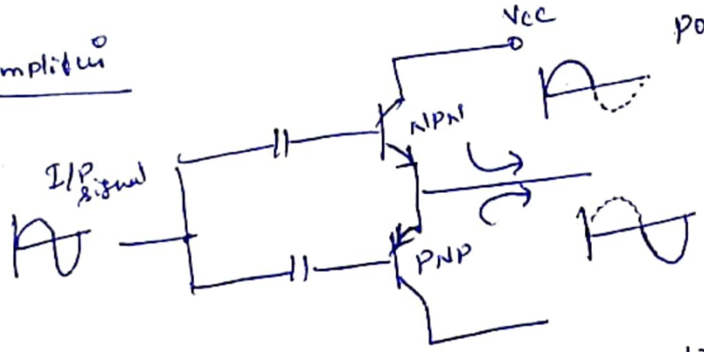
→ Some times an amplifier is required to drive large resistive Load such as Loud Speaker, to drive motor in the robot. these types of amplification where high switching current are needed Power amplifier are required.

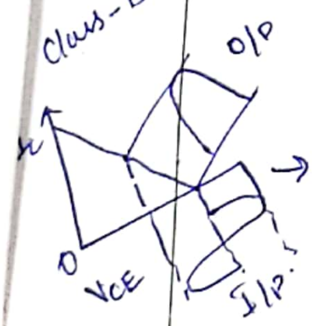
→ The main function of power amplifier → Large signal. Amplifier (delivered Power ∴ high current & high voltage).



$$\eta\% = \frac{P_{out}}{P_{DC}} \times 100$$

Class B Amplifier





→ Class 'B' – Amplifier use two or more transistor biased in such a way so that each transistor only conducts during one half cycle of the input waveform.

→ To improve the full power efficiency of the previous class 'A' amplifier. by reducing the wasted power in the form of heat.

→ It is possible to design the power amplifier circuit with two transistor in its output stage producing termed as a class 'B' Amplifier. also known as Push-Pull amplifier. configuration.

→ Push-Pull amplifier use two complementary, one being an NPN type & other PNP type. with both power transistor to receive the I/P signal.