C BYREGOWDA INSTITUTE OF TECHNOLOGY

DEPARTMENT: ELECTRONICS & COMMUNICATION ENGINEERING

SUBJECT: ANALOG ELECTRONIC CIRCUIT
SUBJCET CODE: PCC21EC34

NOTES
MODULE-3

SYLLABUS	**Feedback Amplifier:** General feedback structure, Properties of negative feedback, The Four Basic Feedback Topologies, The series-shunt, series-series, shunt-shunt and shunt-series amplifiers (Qualitative Analysis). **Output Stages and Power Amplifiers:** Introduction, Classification of output stages, Class A output stage, Class B output stage: Transfer Characteristics, Power Dissipation, Power Conversion efficiency, Class AB output stage, Class C tuned Amplifier. [Text 1: 7.1, 7.2, 7.3, 7.4.1, 7.5.1, 7.6 (7.6.1 to 7.6.3), 13.1, 13.2, 13.3(13.3.1, 13.3.2, 13.3.3, 13.4, 13.7)]
Teaching-LearningProcess	Chalk and talk method, Power Point Presentation. **Self-study topics:**Class D power amplifier. **RBT Level:** L1, L2, L3

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Module 3: Chapter 1: FEEDBACK AMPLIFIERS

⇒ INTRODUCTION

(*) The amplifier in which a part of output is sampled and fed back to the Input of the amplifier is called Feedback Amplifier.

(*) Therefore, at Input we have two signals: Input signal and part of the Output which is fed back to Input/Feedback Signal.

(*) Feedback Signal can be either poisitive or Negative.

i) Positive Feedback: When Input signal and Feedback signal are Inphase, the feedback is called positive Feedback. Eg: It is used in Oscillators.

ii) Negative Feedback: When Input signal and the Feedback signal are out-of-phase, the feedback is called Negative Feedback. Eg: Used in Amplifiers.

(*) In Amplifier design, negative feedback is applied to effect one or more of the following properties:

1. Desensitize the Gain: i.e., make the value of the gain less sensitive to variations in the value of circuit components.

2. Reduce non-linear distortion: i.e., make the output proportional to the Input.

3. Reduce the effect of Noise: i.e., minimize the effect of unwanted electric signals generated by circuit components/by extranal Interference on Output.

4. Control the Input and output Impedances: i.e., Raise or lower the Input and output Impedances by the selection of an Appropriate feedback topology.

5. Extend the Bandwidth of the Amplifier.

(*) All of the desirable properties above are obtained at the expense of a reduction in gain.

(*) The basic Idea of Negative Feedback is to tradeoff gain for other desirable properties.

(*) Negative Feedback is employed in a number of applications.

(*) Almost all op-amp circuit employ negative feedback.

⇒ THE GENERAL FEEDBACK STRUCTURE

(*) Figure 1, shows the signal-flow diagram of the basic structure of a Feedback Amplifier, where 'x' represents either Voltage or a current signal.

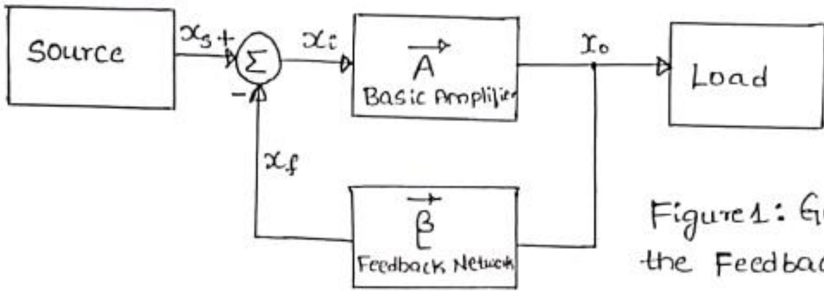


Figure 1: General Structure of the Feedback Amplifier.

(*) The open-loop amplifier has a gain 'A', thus its output x_o is related to Input x_i by,

$$x_o = A x_i \longrightarrow ①$$

(*) The output x_o is fed to the Load as well as to a feedback Network, which produces a sample of the output. This sample x_f is related to x_o by feedback factor β.

$$x_f = \beta x_o \longrightarrow ②$$

(*) The Input to the basic Amplifier, x_i is given by

$$x_i = x_s - x_f \longrightarrow ③$$ (*) Subtraction makes feedback Negative.

where $x_f \rightarrow$ Feedback signal
$x_s \rightarrow$ Source signal, which is the Input to complete feedback Amplifier.

(*) The gain of the feedback Amplifier can be obtained by combining eqⁿs ① through ③:

$$A_f = \frac{x_o}{x_s} = \frac{x_o}{x_i + x_f} = \frac{A x_i}{x_i + \beta x_o} = \frac{A x_i}{x_i + A\beta x_i} = \frac{A}{1 + A\beta} \longrightarrow ④$$

$$\therefore \boxed{A_f \equiv \frac{x_o}{x_s} = \frac{A}{1 + A\beta}}$$

(*) The quantity $A\beta$ is called loop gain.

(*) For the Feedback to be Negative, the loop gain $A\beta$ should be positive; i.e., Feedback signal x_f should have the same sign as x_s, thus resulting in a smaller difference signal, x_i.

(*) eqⁿ ④ ⇒ Gain with feedback will be smaller than open-loop gain A, by the quantity $(1 + A\beta)$ which is called Amount of Feedback.

(*) In many circuits, the loop gain $A\beta$ is large, $A\beta >> 1$, then eq^n (4) becomes, $A_f \simeq 1/\beta$: Thus the gain of the feedback Amplifier is entirely determined by the feedback network.

(*) Since feedback network usually consists of passive components, It can be chosen accurately. Thus, the negative feedback is used to obtain accurate, predictable and stable gain.

(*) The Feedback signal is given as

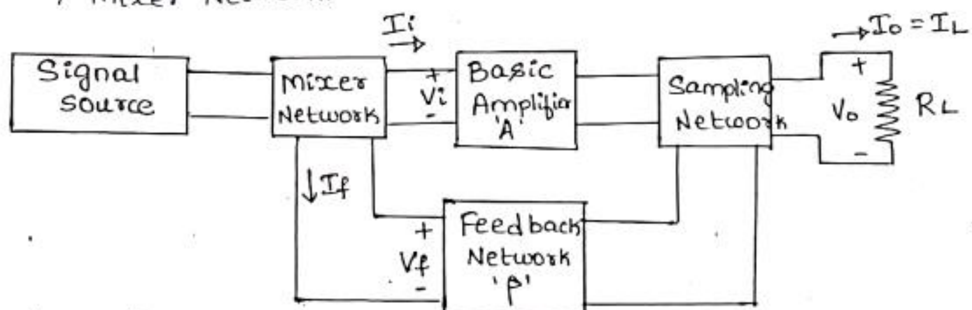
$$x_f = \beta x_o = \frac{A\beta \cdot x_s}{1+A\beta} \quad \Big| \quad \text{from eq}^n (4) \quad x_o = \frac{A \cdot x_s}{1+A\beta}.$$

$$\therefore \boxed{x_f = \frac{A\beta}{1+A\beta} \cdot x_s} \longrightarrow (5)$$

(*) Thus for $A\beta >> 1$, we see that $x_f \simeq x_s \Rightarrow$ the signal x_i at the Input of basic amplifier is reduced to almost zero.

NOTE: The Feedback connection has three Networks:

1) Sampling Network.
2) Feedback Network.
3) Mixer Network.



Block diagram of Amplifier With Feedback.

(*) The feedback Amplifier samples the output voltage/current by means of suitable sampling Network and applies this signal to the Input through a feedback Network.

(*) At the Input the feedback signal is combined with the Input signal through a mixer Network and is fed into the Amplifier.

Sampling Network:

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

Voltage Sampling

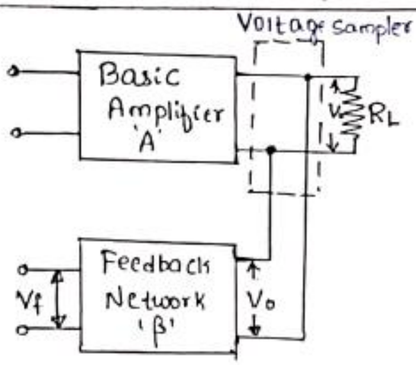
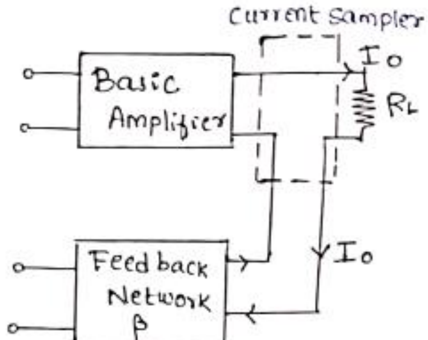


Fig: a) Voltage or node sampling

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

This type of connection is referred to as voltage sampling.

Current Sampling



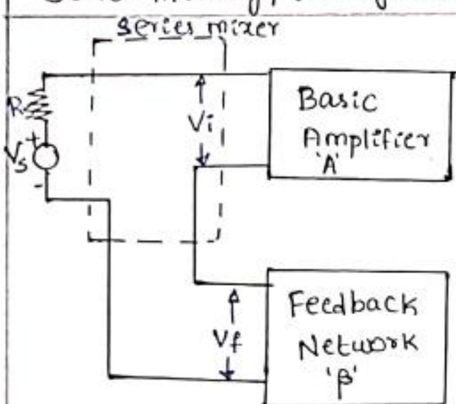
b) Current or loop sampling.

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

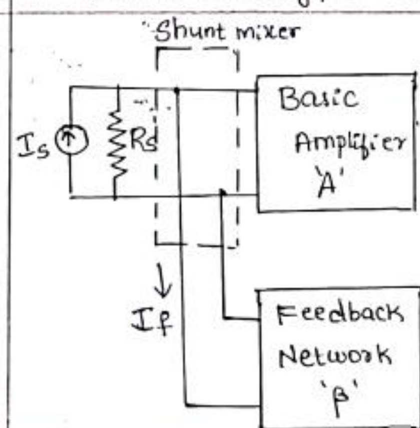
This type of connection is referred to as current sampling.

Mixer Network: It is used to Add/Subtract Feedback signal with Source signal.
(*) There are two ways of mixing Feedback signal with the Input signal. These are: Series Input connection and Shunt Input Connection.

Series Mixing / Voltage mixing



Shunt mixing / current mixing



⇒ **SOME PROPERTIES OF NEGATIVE FEEDBACK**

1) Gain Desensitivity.
2) Bandwidth Extension.
3) Noise Reduction.
4) Reduction in Nonlinear Distortion.

1) GAIN DESENSITIVITY

(*) The transfer gain of the amplifier is not constant as it depends on the factors such as operating point, temperature etc.

(*) This lack of stability in amplifiers can be reduced by introducing negative feedback.

(*) The closed loop voltage gain is given by,

$$A_F = \frac{A}{1+A\beta} \longrightarrow (1)$$

(*) Differentiating B.S wrt A, we get [Assume β as constant].

$$\frac{dA_F}{dA} = \frac{(1+A\beta)\cdot 1 - A\beta}{(1+A\beta)^2}$$

WKT. $\dfrac{du}{dv} = \dfrac{v.u' - uv'}{v^2}$

$$\frac{dA_F}{dA} = \frac{1+A\beta - A\beta}{(1+A\beta)^2} = \frac{1}{(1+A\beta)^2} \longrightarrow (2)$$

(*) Divide eqn (2) by (1)

$$\frac{dA_F}{A_F} = \frac{dA}{(1+A\beta)^2} \times \frac{(1+A\beta)}{A}$$

$$\Rightarrow \therefore \boxed{\frac{dA_F}{A_F} = \frac{dA}{A}\frac{1}{(1+A\beta)}} \longrightarrow (3)$$

where $\frac{dA_F}{A_F}$ → Fractional change in gain with feedback.

$\frac{dA}{A}$ → Fractional change in gain without feedback.

$$\therefore (3) \Rightarrow \frac{dA_F/A_F}{dA/A} = \frac{1}{1+A\beta} = S \longrightarrow (4)$$

∴ The fractional chain in gain with feedback divided by the fractional change in gain without feedback is called sensitivity of the transfer gain.

(*) The reciprocal of sensitivity is called Desensitivity factor.

$$D = (1+A\beta)$$

(*) Therefore, stability of the Amplifier increases with increase in desensitivity.

(*) If $A\beta >> 1$, then $A_f = \dfrac{A}{1+A\beta} = \dfrac{A}{A\beta} \simeq \dfrac{1}{\beta}$

and the gain is dependent only on the feedback network.

2) ## BANDWIDTH IMPROVEMENT

i) (*) Consider an Amplifier whose high frequency response is characterized by single pole. Its gain at midband frequencies can be expressed as,

$$A(s) = \frac{A_m}{1 + s/\omega_H} \longrightarrow ④$$

where $A_M \rightarrow$ Midband gain
$\omega_H \rightarrow$ upper 3-dB frequency.

(*) Application of negative feedback around this Amplifier results in a closed loop gain $A_f(s)$ given by.

$$A_f(s) = \frac{A(s)}{1 + \beta A(s)} \longrightarrow ⑤$$

(*) Substituting eqⁿ ④ in eqⁿ ⑤

$$A_f(s) = \frac{A_m/(1 + s/\omega_H)}{1 + \frac{A_m \cdot \beta}{1 + \frac{s}{\omega_H}}} = \frac{A_m/\cancel{(1+\frac{s}{\omega_H})}}{\frac{1 + \frac{s}{\omega_H} + A_m \cdot \beta}{\cancel{(1+\frac{s}{\omega_H})}}}$$

$$= \frac{A_m}{1 + \frac{s}{\omega_H} + A_m \cdot \beta} = \frac{A_m}{(1 + A_m\beta) + \frac{s}{\omega_H}}$$

$$\therefore A_f(s) = \frac{A_m/(1 + A_m\beta)}{1 + \frac{s}{\omega_H(1 + A_m\beta)}} \longrightarrow ⑥$$

(*) Thus, the feedback Amplifier will have a midband gain of $A_m/(1 + A_m\beta)$ and a upper 3-dB frequency ω_{fH} given by,

$$\omega_{Hf} = \omega_H (1 + A_m\beta) \longrightarrow ⑦$$

(*) Thus, the upper 3-dB frequency is increased by a factor equal to amount of feedback.

ii) The midband frequency of an amplifier whose low frequency response is characterized by a dominant lowfrequency pole is given as,

$$A(s) = \frac{A_m \cdot s}{s + \omega_L} \longrightarrow ⑧$$

(*) Substituting eqⁿ ⑧ in eqⁿ ⑤

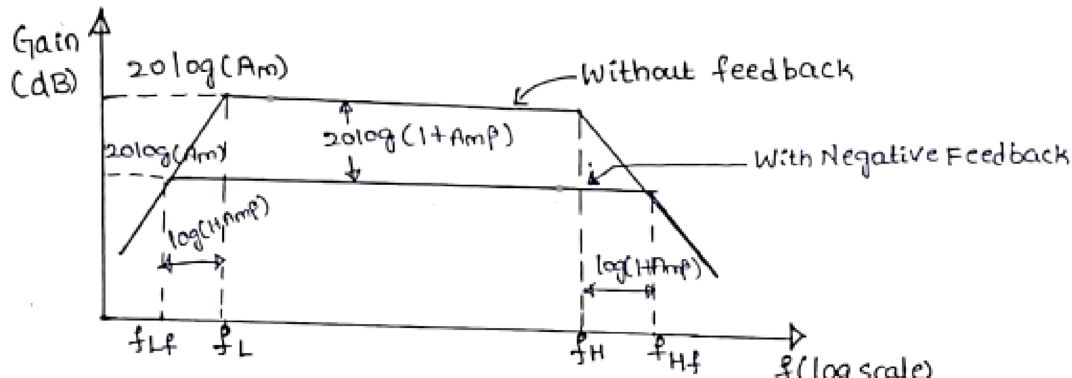
$$A_f(s) = \frac{A_m \cdot s/(s + \omega_L)}{1 + \frac{A_m\beta \cdot s}{s + \omega_L}} = \frac{A_m \cdot s/\cancel{(s+\omega_L)}}{\frac{(s + \omega_L) + A_m\beta s}{\cancel{(s+\omega_L)}}} = \frac{A_m \cdot s}{s + A_m s\beta + \omega_L}$$

$$\therefore A_f(s) = \frac{A_m \cdot s/1 + A_m\beta}{s + \frac{\omega_L}{1 + A_m\beta}} \longrightarrow ⑨$$

(*) Thus, lower 3-dB frequency ω_{Lf} is,

$$\omega_{Lf} = \frac{\omega_L}{1+A_m\beta} \longrightarrow (10)$$

(*) Thus, the amplifier Bandwidth is increased by a factor by which its mid-band gain is decreased, maintaining Gain-Bandwidth product constant.



$$f_{Lf} = \frac{f_L}{1+A_m\beta} \qquad A_{mf} = \frac{A_m}{1+A_m\beta} \qquad f_{Hf} = f_H(1+A_m\beta)$$

3. NOISE REDUCTION

(*) Almost all Amplifier circuits produce noise due to active and passive components present in it.

(*) During Amplification process this noise is also amplified along with the signal.

(*) Negative feedback can be employed to reduce the effect of Noise.

(*) Consider the situation illustrated in Fig a, It shows an amplifier with gain A_1, an input signal V_s and noise/interference V_n.

(*) If for some reason, this amplifier suffers from noise and this noise is assumed to be introduced at the input of the Amplifier.

(*) This signal-to-Noise ratio of the Amplifier is

$$\frac{S}{N} = \frac{V_s}{V_n} \longrightarrow (11)$$

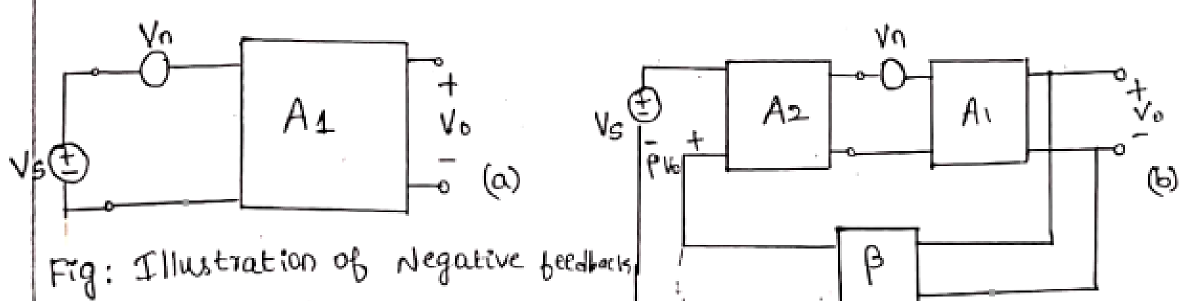


Fig: Illustration of Negative feedback to improve SNR in Amplifiers.

(*) Consider the circuit(b), Assume it is possible to build another Amplifier stage with gain A_2 that does not suffer from the noise problem.

(*) Output Voltage can be found by superposition:

$$V_o = V_s \cdot \frac{A_1 A_2}{1+A_1 A_2 \beta} + V_n \cdot \frac{A_1}{1+A_1 A_2 \beta} \longrightarrow (12)$$

(*) Thus the Signal-to-noise ratio at the output becomes

$$\frac{S}{N} = \frac{V_s \cdot A_2}{V_n} \longrightarrow (13)$$

Which is A_2 times higher than the original case.

(*) Improvement in SNR by the application of feedback is possible only if one can precede the noisy stage by a noise free stage.

(*) This situation is not uncommon in practice. Eg: Output power Amplifier stage of an Audio Amplifier.

(*) Such a stage usually suffers from a problem known as power-supply hum.

(*) This problem is mainly due to the large current that this stage draws from power supply. The power output stage is required to provide large power gain but little or no voltage gain.

(*) Therefore power-output stage can be preceded by a small-signal Amplifier with large voltage gain (Also referred as pre Amplifier).

4. REDUCTION IN NON-LINEAR DISTORTION

(*) Non-linear distortion occurs when an Amplifier has non-linear transfer characteristics.

(*) The amplifier transfer characteristics can be considerably linearized through the application of Negative feedback.

(*) This is Evident from the fact that the Negative feedback reduces the dependence of overall closed loop amplifier gain on the open-loop gain of the Basic Amplifier (i.e., $A_f \simeq 1/\beta$)

(*) Thus, large changes in open loop gain give rise to smaller change in closed-loop gain.

(*) For Eg:- With $\beta = 0.01$, let 'A' change from 1000 to 100 resulting in,

$$A_{f1} = \frac{1000}{1+(1000 \times 0.01)} = 90.9 \quad \& \quad A_{f2} = \frac{100}{1+(100\times 0.01)} = 50.$$

(*) Thus if the overall gain has to be restored, then a preamplifier should be added.

⇒ FEEDBACK TOPOLOGIES

Based on the quantity to be amplified (Voltage or Current) and on the desired form of output (voltage or current), amplifiers can be classified into four categories.

(Mixer Connection - Sampler Connection) / (Sampling Parameter - mixer Connection)

1) Voltage-mixing Voltage-Sampling / Series-Shunt / Voltage-Series Topology
2) Current-mixing Current-Sampling / Shunt-Series / Current-Shunt Topology
3) Voltage-mixing Current-Sampling / Series-Series / Current-Series Topology
4) Current-mixing Voltage-Sampling / Shunt-Shunt / Voltage-Shunt Topology.

→ Voltage Amplifier

(i) Voltage Amplifier are Intended to Amplify an Input voltage signal and provide an output voltage signal.

(ii) The voltage Amplifier is essentially a voltage-controlled voltage source.

(iii) The Input Impedance is required to be high & output Impedance required to be low.

(iv) Since signal source is essentially a voltage source, it is convenient to represent it in terms of a Thevenin equivalent circuit.

(v) Feedback Network should sample the output Voltage and the feedback signal x_f should be a voltage that can be mixed with the source voltage in series.

(vi) A Suitable feedback Topology for Voltage Amplifier is a Voltage-mixing Voltage sampling as shown in Fig1.

(vii) Because of the series connection at the Input and parallel or shunt connection at the output, this feedback topology is also known as Series-Shunt Feedback.

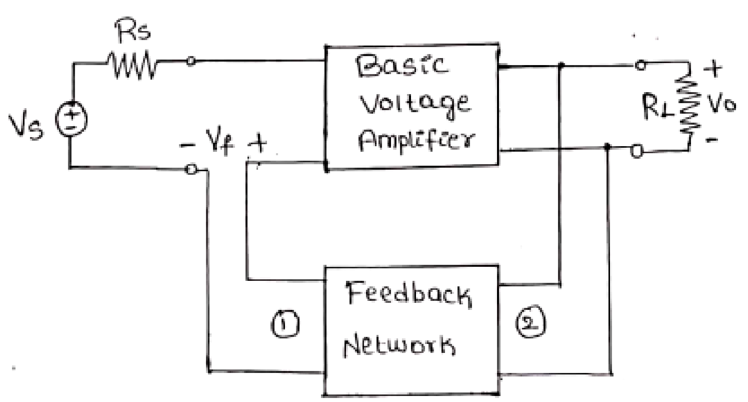


Fig 1: Voltage-mixing Voltage-sampling (Series-Shunt) Topology.

(*) This topology
- Stabilizes the voltage gain.
- Higher input resistance [∵ of the series connection at the input)
- A lower output resistance [∵ of the parallel connection at the output).

which are desirable properties of a voltage Amplifier.

Example 1: The feedback network is composed of voltage divider (R_1, R_2) as shown in fig a, develops a voltage V_f that is applied to the negative input terminal of the op-Amp

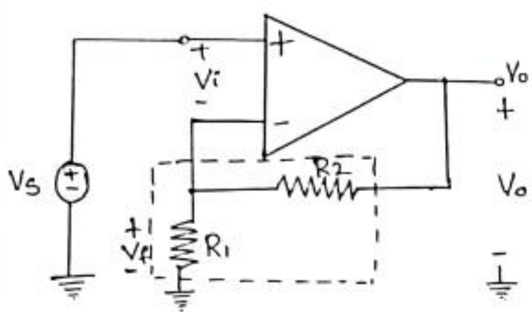


Fig a: Example of Series-Shunt Amplifier.

(*) Subtraction of V_f by V_s is achieved by utilizing the differencing action of the op-amp differential input.

(*) For Feedback to be negative, V_f must be of same polarity of V_s.

(*) As V_s increases, V_o increases and the Voltage divider causes V_f to increase.

(*) Thus V_f is of same polarity as V_s, making Feedback negative

EXAMPLE 2: Fig b, utilizes two MOSFET Amplifier stages in Cascade.

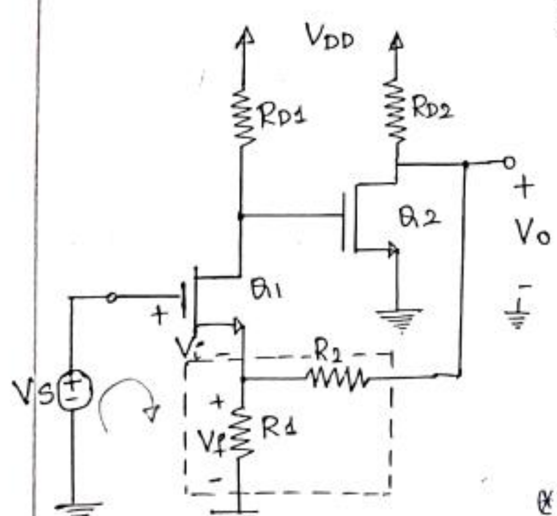


Fig (b): Example

(*) The output voltage is sampled by the feedback network composed of the voltage divider (R_1 & R_2) and the feedback signal is fed to the source terminal of Q1

(*) The subtraction is implemented by applying V_s to the gate of Q1 and V_f to its source.

KVL to Input loop, $V_s - V_i - V_f = 0$

$\therefore\ V_i = V_s - V_f$

(*) Let V_s increase, the drain voltage of Q1 will decrease and since it is applied to the gate of Q_2, its drain voltage V_o will increase.

(*) This will cause the feedback voltage V_f to increase, which has the same polarity as V_s. ∴ Feedback is Negative.

→ Current Amplifier

(*) The Input signal in a current Amplifier is current and thus signal source is most conveniently represented by its Norton equivalent.

(*) The output quantity of Interest is current, hence feedback nework should sample the output current.

(*) The feedback signal should be current so that it may be mixed in Shunt with the source current.

(*) Thus the feedback Topology suitable for a current Amplifier is the Current-mixing Current-Sampling Topology as shown in Fig2.

(*) Because of parallel-connection at the Input and the series connection at the output, this feedback Topology is known as Shunt-Series Feedback.

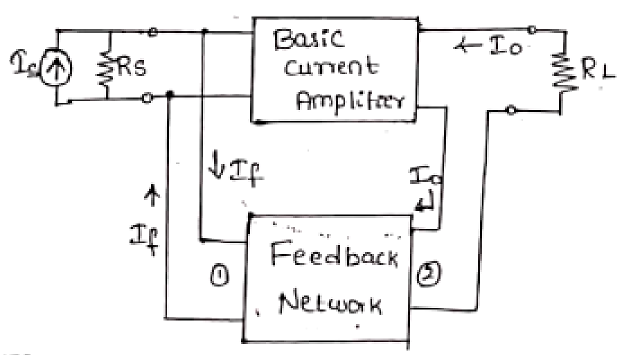


Fig 2: Current-mixing current-Sampling (shunt-series) Topology.

(*) This Topology
- → Stabilizes the current gain.
- → Lowers Input resistance and
- → Results in Higher output resistances.

(*) Both are desirable properties for a current Amplifier.

(*) An example is shown in fig a, It utilizes a CG stage Q_1 followed by a CS stage Q_2.

(*) The output current I_o is fed to a load R_L, A sample of I_o is obtained by Placing a small Resistance R_m in series with R_L.

(*) The feedback current I_f that flows through R_F is subtracted from I_s at Source node, resulting in Input current $I_i = I_s - I_F$.

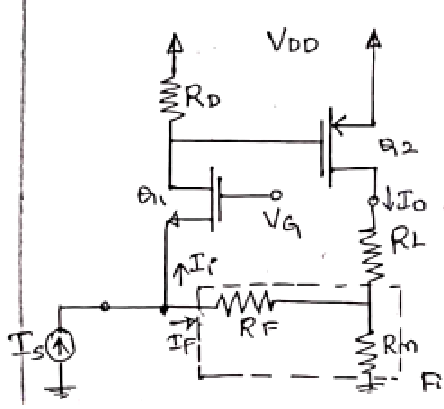


Fig a.

(*) An Increase in I_s causes I_i to increase & drain voltage of Q_1 Increases.

(*) This Voltage is applied to the gate of P-channel device Q_2, which cause I_o to decrease.

(*) Thus voltage across R_m will decrease, which cause I_F to Increase

(*) Thus I_s and I_F has same polarity, making feedback negative.

→ Transconductance Amplifier

- In transconductance Amplifier the Input Signal is a Voltage and the output signal is a current.
- The feedback Topology is the Voltage-mixing current-sampling Topology as illustrated in Fig 3.
- The presence of the series connection at both the Input and output gives this feedback Topology an alternative name Series-Series Feedback.

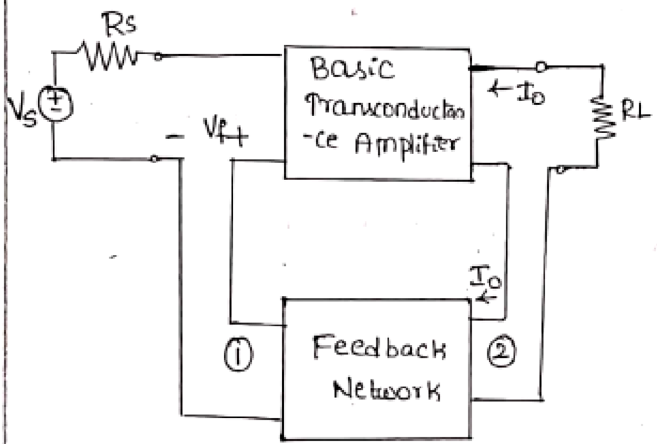


Fig 3: Voltage-mixing current-Sampling (Series-Series Topology).

- The Series connection at the Input results in an Increased Input resistance.
- The Series sampling at the output results in Increased Output resistance.
- Thus this topology provides the transconductance Amplifier with desirable properties of Increased Input and Output Impedances.

EXAMPLE 1: Fig a utilizes a differential Amplifier A_1 followed by a CS-stage Q_2.

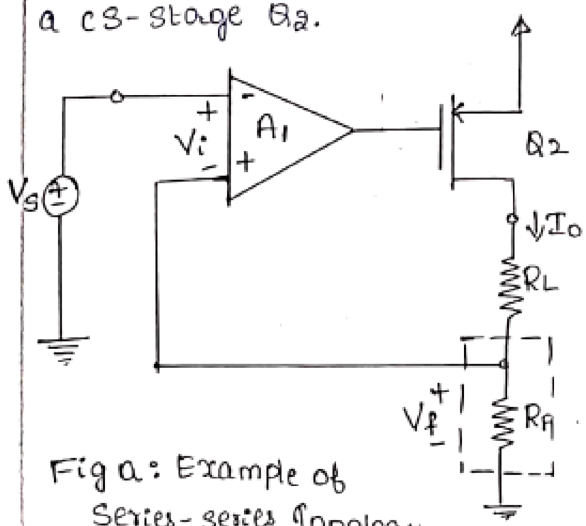


Fig a: Example of Series-series Topology.

- The output current I_o is fed to R_L and to a Series resistance R_F which develops a feedback voltage V_f
- The Subtraction of V_f from V_s is Performed by the differential Amplifier.
- If V_s Increases, the gate voltage at Q_2 decreases which will cause I_o to Increase.
- The Increase in I_o, increases the feedback Voltage V_f.
- Thus the Feedback is negative.

→ Transresistance Amplifier

(*) In transresistance Amplifiers the Input signal is current and output signal is voltage.

(*) Appropriate feedback Topology is current-mixing voltage-sampling as illustrated in Fig 4:

(*) The presence of the parallel (or shunt) connect at both the Input and output makes this feedback topology also known as Shunt-Shunt Feedback.

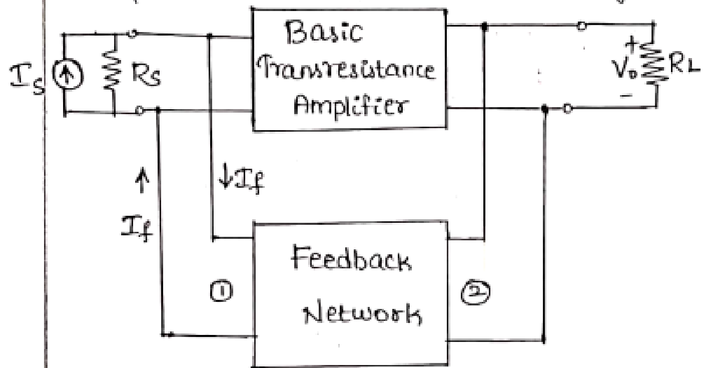


Figure 4: Current-mixing Voltage-sampling (Shunt-shunt) Topology

(*) The shunt-connection at the Input causes the Input resistance to be reduced.

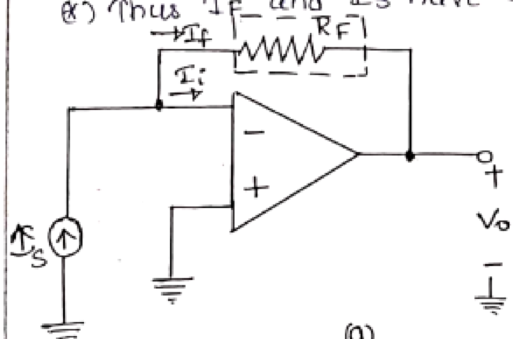
(*) The Shunt connection at the output stabilizes the output voltage and reduces the output resistance.

(*) Thus, the shunt-shunt Topology equips the transresistance Amplifier with desirable attributes.

EXAMPLE: The circuit in Fig a, utilizes op-amp with feedback resistance R_F, that senses V_o and provides a feedback current I_F that is subtracted from I_s at Input node.

(*) If I_i increases, the output voltage will decrease causing I_F to Increase.

(*) Thus I_F and I_s have Same polarity and feedback is negative.



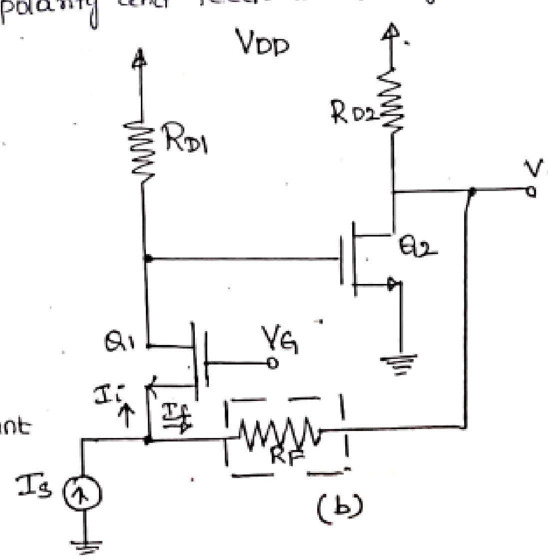


Fig (a) & (b) Examples of Shunt-Shunt Topology.

⇒ THE SERIES-SHUNT FEEDBACK AMPLIFIER

(*) The Ideal structure of the Series-Shunt Amplifier is shown in Fig 1a.

(*) It consists of

→ A unilateral open-loop amplifier (the A circuit) and

→ An Ideal voltage-mixing voltage-sampling feedback network (β circuit).

(*) The A circuit has an Input resistance R_i, a voltage gain A and an output resistance R_o. It is assumed that source & load resistances included inside A circuit.

(*) The β-circuit does not load the A circuit i.e., connecting β circuit does not change the value of A (i.e $A = \frac{V_o}{V_i}$)

1) Closed-loop gain.

$$A_f = \frac{V_o}{V_s} = \frac{A}{1+A\beta} \longrightarrow (1)$$

Note that. A & β have reciprocal units.

2) Input resistance.

(*) The equivalent circuit model of the Series-Shunt feedback Amplifier is shown in fig 1b.

(*) R_{if} and R_{of} denote input and output resistances with feedback.

The relationship between R_{if} and R_i is established by considering Fig 1a.

$$R_{if} = \frac{V_s}{I_i} = \frac{V_s}{V_i/R_i} = R_i \cdot \frac{V_s}{V_i}$$

$$R_{if} = R_i \cdot \frac{V_i + A\beta V_i}{V_i} = R_i(1+A\beta) \longrightarrow (2)$$

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

Apply KVL.

$V_s - V_i - V_f = 0$

$V_s = V_f + V_i$

$V_s = \beta V_o + V_i = A\beta V_i + V_i$

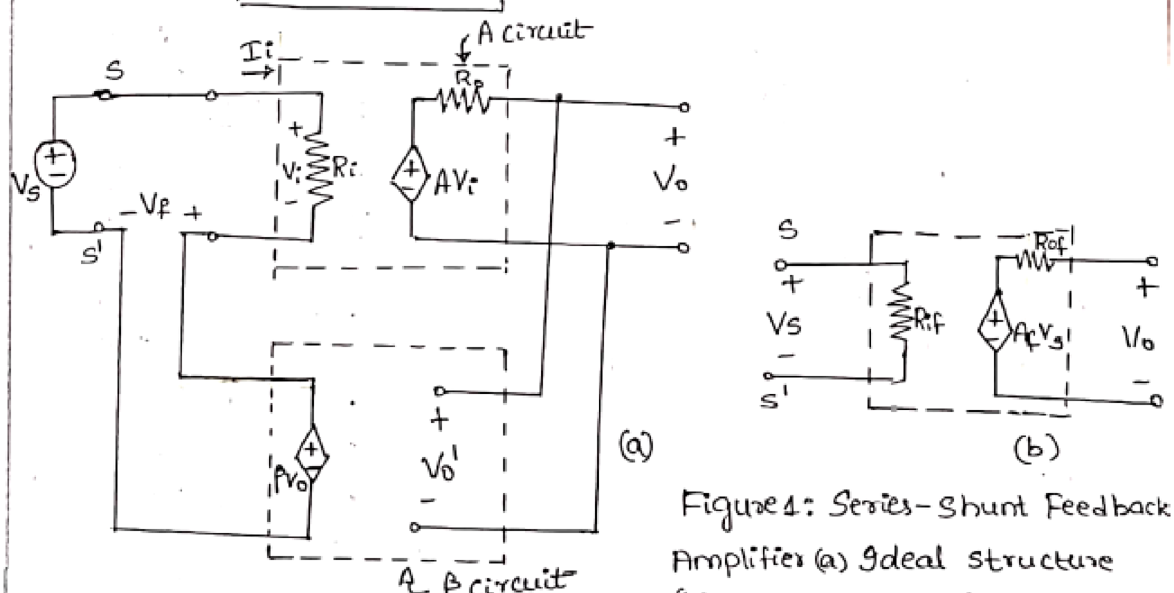


Figure 1: Series-Shunt Feedback Amplifier (a) Ideal structure (b) Equivalent circuit.

(x) Thus, negative feedback Increases the Input resistance by a factor equal to amount of feedback.

(x) Since the Feedback voltage V_f Subtracts from V_s, the voltage that appears across R_i, i.e., V_i becomes quite small.

(x) Thus, the Input current I_i becomes correspondingly small and hence the resistance seen by V_s becomes large.

(x) Eq^n ② can be Generalized as,

$$Z_{if}(s) = Z_i(s)\left[1 + A(s)\beta(s)\right] \longrightarrow ③$$

3) Output Resistance.

(x) To find the Output resistance R_{of}, of the feedback Amplifier, we reduce V_s to zero and apply a test Voltage V_t at the output as shown in fig 2.

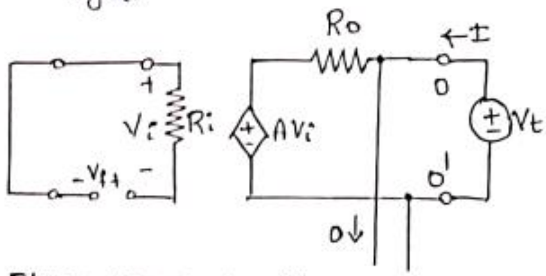


Fig 2: measuring the output resistance of the Feedback Amplifier Of fig 1a.

$$\rightarrow R_{of} = \frac{V_t}{I}$$

Where $I = \dfrac{V_t - AV_i}{R_o}$

(x) Since $V_s = 0$, it follows from fig 1a that.

$$V_i = -V_f = -\beta V_o = -\beta V_t \quad (V_o = V_t)$$

(x) Thus, $I = \dfrac{V_t + A\beta V_t}{R_o}$

Leading to. $\boxed{R_{of} = \dfrac{R_o}{1 + A\beta}} \longrightarrow ④$

(x) Thus, Negative feedback reduces the output resistance by a factor equal to the Amount of feedback.

(x) The relationship between R_{of} and R_o depends only on the method of sampling.

(x) Since the feedback samples the output voltage V_o, it acts to stabilize the value of V_o. i.e., to reduce changes in the value of V_o.

(x) This means that voltage-sampling feedback reduces the output resistance.

(x) Equation ④ can be generalized to

$$Z_{of}(s) = \frac{Z_o(s)}{1 + A(s)\beta(s)} \longrightarrow ⑤$$

⇒ THE SERIES-SERIES FEEDBACK AMPLIFIER

(*) The Series-Series Feedback topology stabilizes I_o/V_s and is therefore best suited for transconductance amplifier.

(*) Fig 3a, shows the Ideal Structure for the Series-Series feedback Amplifier. It consists of a unilateral open-loop amplifier (the A-circuit) and an Ideal feedback Network.

(*) In this case 'A' is a transconductance,

$$A = \frac{I_o}{V_i} \longrightarrow (a)$$

, while β is transresistance. Thus $A\beta$ is dimensionless quantity.

(*) The load and source resistances have been absorbed inside the A circuit and β-circuit does not load the A circuit.

1) Closed-loop gain,

$$A_f \equiv \frac{I_o}{V_s} = \frac{A}{1+A\beta} \longrightarrow (6)$$

2) Input resistance.

(*) Fig 3b, shows the equivalent circuit model of the feedback Amplifier shown in Fig 3a.

$$\therefore R_{if} \equiv \frac{V_s}{I_i} = \frac{V_s}{V_i/R_i} = R_i \cdot \frac{V_s}{V_i} = R_i \cdot \frac{V_i + \beta V_o}{V_i} = R_i \cdot \frac{V_i + A\beta V_i}{V_i}$$

$$\therefore \boxed{R_{if} = R_i(1+A\beta)} \longrightarrow (7)$$

(*) Thus Series-Series feedback Amplifier increases Input resistance by the factor equal to amount of Feedback.

(*) Eqn (7) can be Generalized as, $Z_{if}(s) = Z_i(s)\left[1 + A(s)\beta(s)\right] \rightarrow (8)$

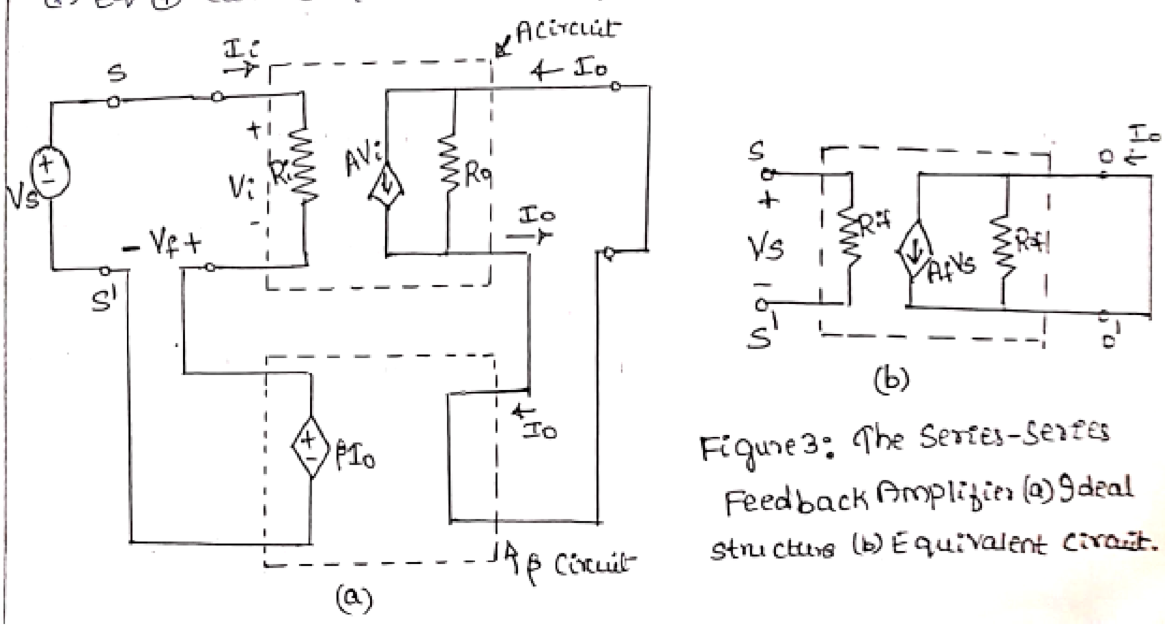


Figure 3: The Series-Series Feedback Amplifier (a) Ideal structure (b) Equivalent circuit.