FEED BACK SYSTEM
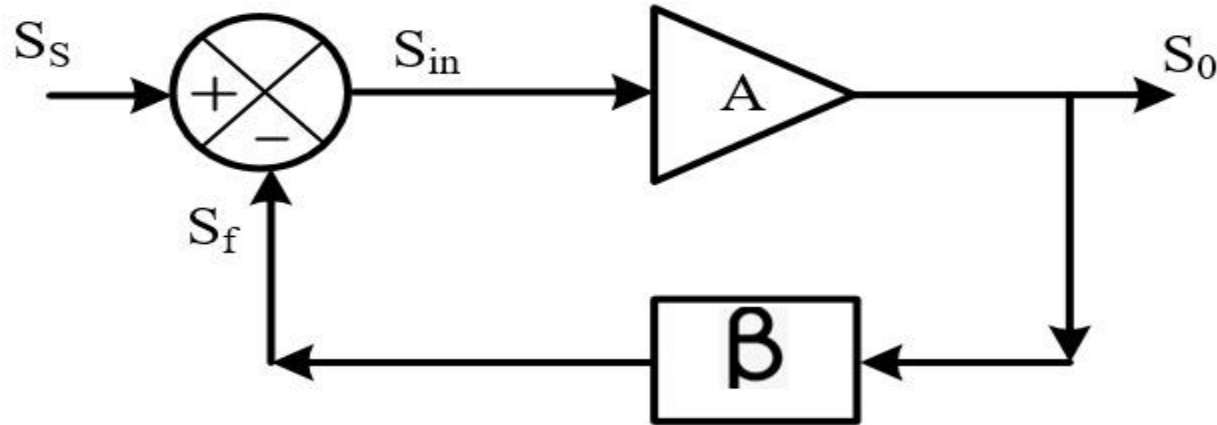
Basic model of feedback amplifier consist of


- Forward amplifier: The input signal to the forward amplifier is S_{in} and the output signal from the amplifier is S_o. The gain of the amplifier is A.
- Feedback network: The input signal to the feedback network is S_o and the output signal from the feedback network is the feedback signal S_f. The gain of the feedback network is β.
- Signal sampler: Signal sampler is taping the output signal for feedback.
- Signal mixer: Signal mixer is mixing the feedback signal S_f with the primary input signal S_s to generate the input signal to the amplifier S_{in}. The mixer is multiplying the input signals with +1 or -1 and then mix it.

Types of Feedback system:

1) Negative feedback system   2) Positive feedback system
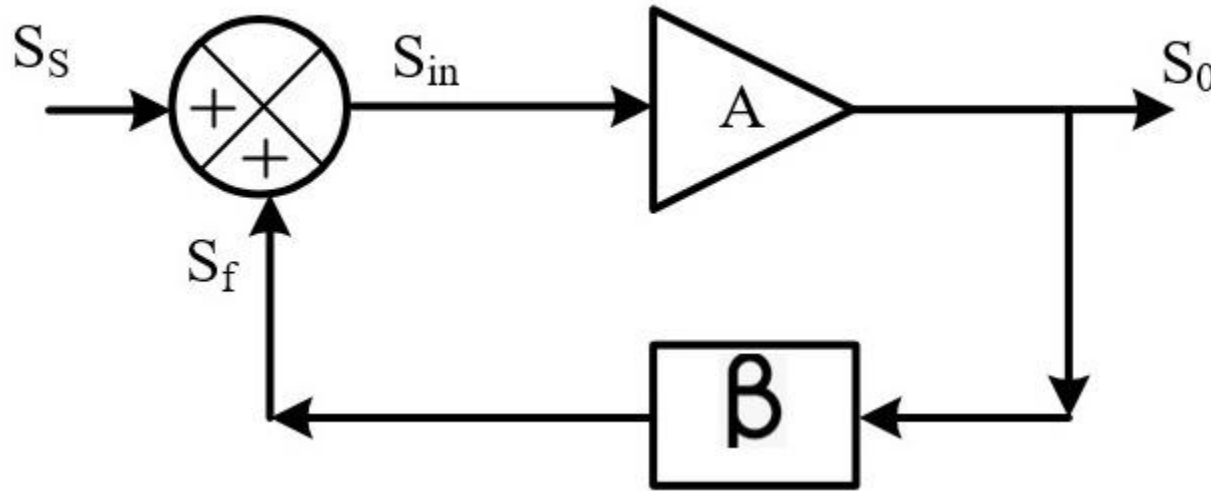
Negative Feedback System
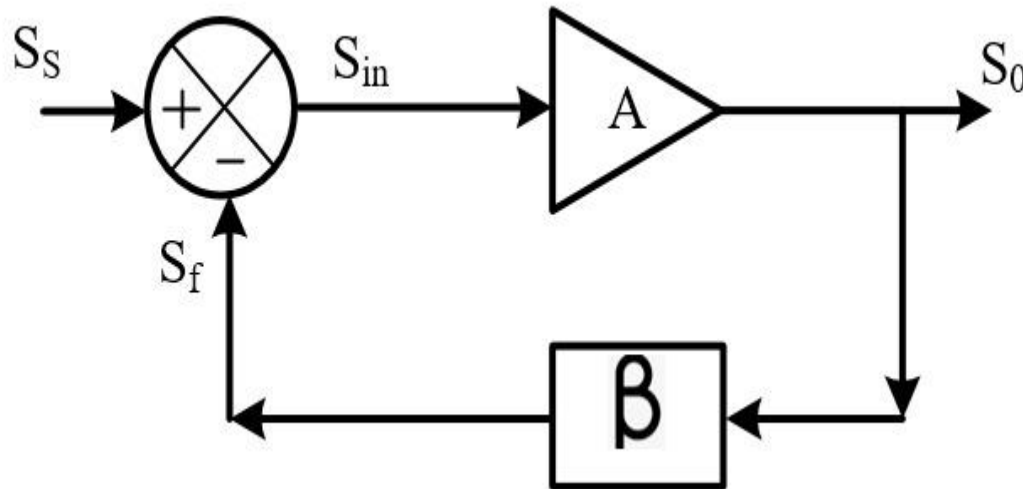
- For a change at a point in the system/ circuit if the created effect coming back to the point through the feedback path negate the original change then the feedback system is called negative feedback system.

- Assume S_{in} is increased. If A is positive S_o also increases. If β is positive S_f also increases. When the signal is going through the mixer, if it is negative the signal coming back to the input of the amplifier is in the opposite direction [negating the original change]. Hence it is called as the negative feedback system.

- Based on the sign of mixer, A and βwe will get negative feedback.

Positive Feedback System

- **For a change at a point in the system/circuit if the created effect coming back to the point through the feedback path aggravate the original change then the feedback system is called as positive feedback system.**

•Assume S_{in} is increased. If A is positive S_o also increases. If β is positive S_f also increases. When the signal is going through the mixer, if it is positive the signal coming back to the input of the amplifier is in the same direction or phase [aggravate the original change]. This is known as positive feedback system.

•Based on the sign of mixer, A and βwe will get positive feedback system.

Parameters of negative Feedback system
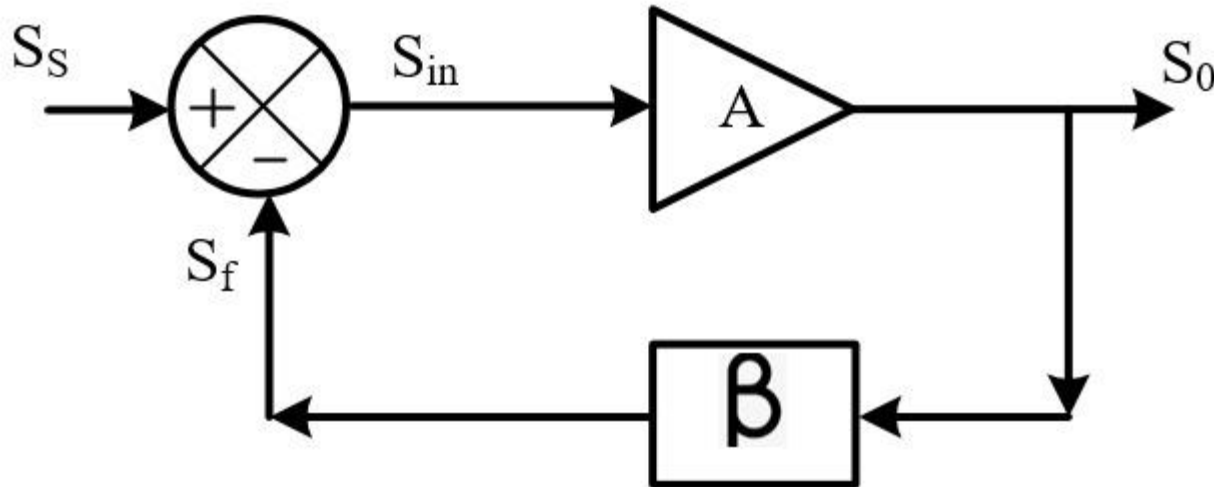
Gain with feedback $A_f = \dfrac{S_o}{S_s}$

$$S_o = AS_{in} = A(S_s - S_f) = A(S_s - \beta S_o) = AS_s - A\beta S_o$$

$$S_o(1 + A\beta) = AS_s$$

$$\frac{S_o}{S_s} = \frac{A}{1 + \beta A} = A_f$$

Loop gain $= -A\beta$

Without feedback gain is A

With feedback gain is reduced by $(1 + \beta A)$

$(1 + \beta A)$ is known as the Desensitivity factor.

Feedback Connection Types

❖ **Feedback can be connected in four basic ways.**

❖ **Both voltage and current can be feed back to the input either in series or parallel.**

1) **Voltage – series feedback.**

2) **Voltage – shunt feedback.**

3) **Current – series feedback.**

4) **Current – shunt feedback.**

o Series feedback connections increase the input resistance.

o Shunt feedback connections decrease the input resistance.

o Voltage feedback decrease the output impedance.

o Current feedback increase the output impedance.
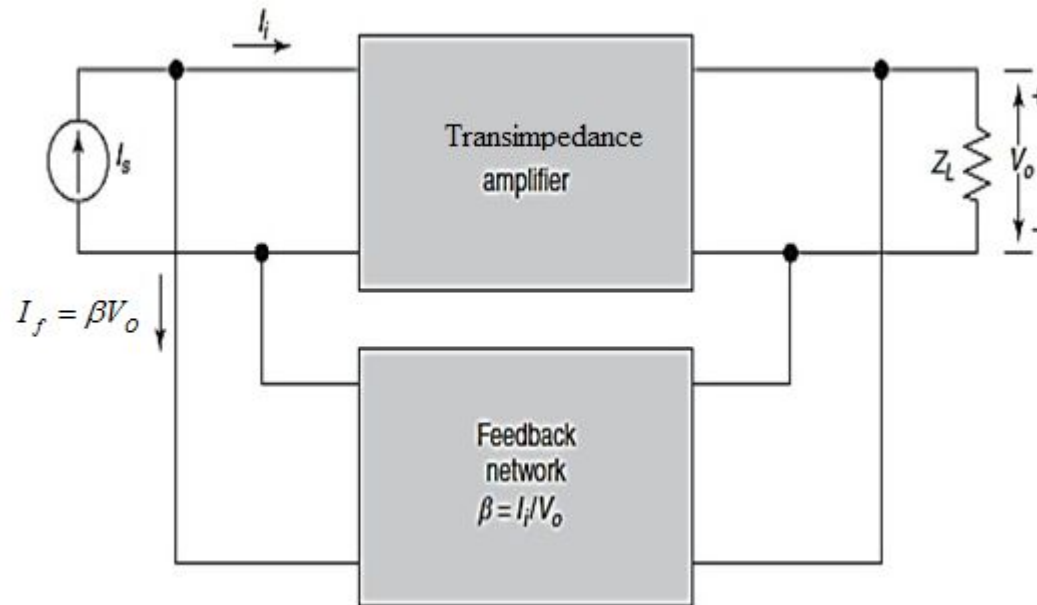
1) Voltage-series feedback:

- The input signal is voltage and the output signal is voltage. Voltage is sampled at the output and f*eedback in the form of voltage at the input. Forward amplifier converts voltage to voltage. So the gain of the amplifier is voltage gain Av. The feedback path converts voltage to voltage and its gain is β.*

- *The voltage gain with feedback is* $A_{vf} = \dfrac{A_v}{1 + \beta A_v}$

- *The voltage gain with feedback reduces the gain Av by the factor (1+β Av). When β Av>>1,* $A_{vf} \approx \dfrac{1}{\beta}$

- *The voltage gain is stabilized to* $A_{vf} \approx \dfrac{1}{\beta}$
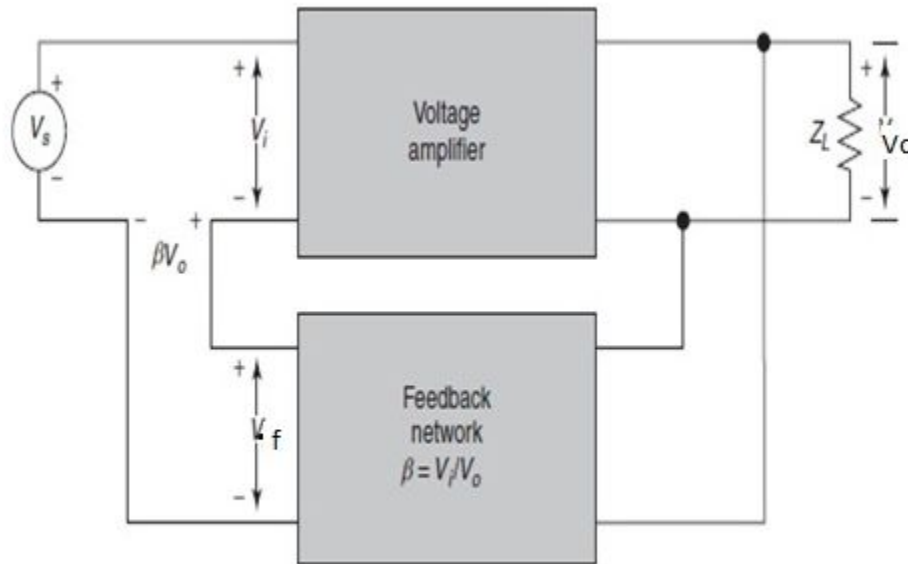
Voltage amplifiers with voltage-series feedback

2) Voltage-Shunt Feedback

- The input signal is current and the output signal is voltage. Voltage is sampled at the output and feedback in the form of current at the input. Forward amplifier converts current to voltage. So the gain of the amplifier is trans impedance **Z_m** . The feedback path converts voltage to current and its gain is β.

- *The trans impedance with feedback is* $Z_{mf} = \dfrac{Z_m}{1 + \beta Z_m}$

- *The gain with feedback reduces the gain Z_m by the factor* $(1 + \beta Z_m)$. *When* $\beta Z_m \gg 1,\ Z_{mf} \approx \dfrac{1}{\beta}$

- *The trans impedance with feedback is stabilized to* $Z_{mf} \approx \dfrac{1}{\beta}$
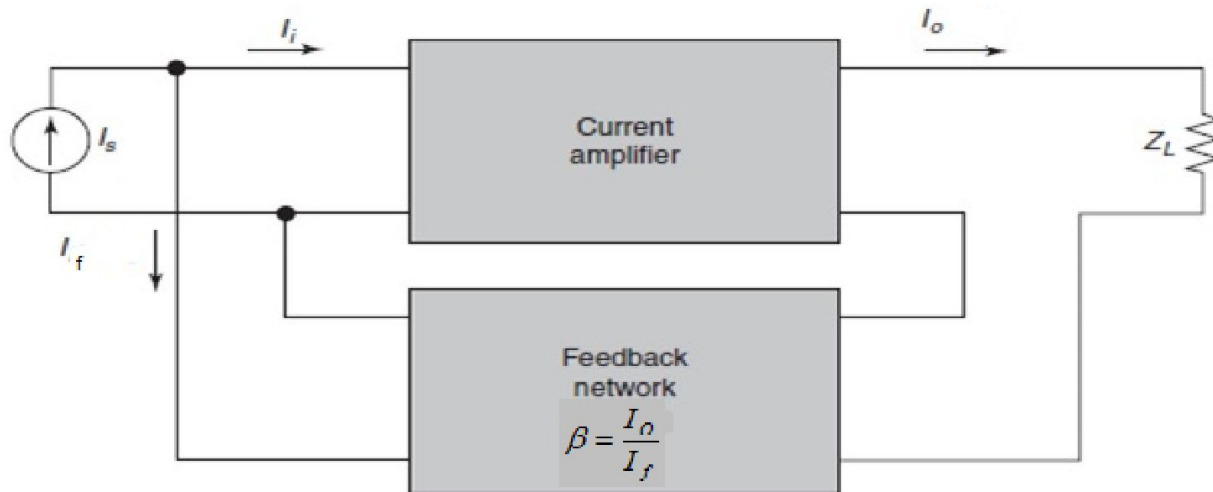
3)Current-shunt feedback

- The input signal is current and the output signal iscurrent. Current is sampled at the output and f*eedback in the form of current at the input. Forward amplifier converts current to current. So the gain of the amplifier is current gain* **A$_i$**. *The feedback path converts current to current and its gain is β.*

- The current gain with feedback

- *The current gain with feedback reduces the gain Av by the factor (1+β Av). When* >>1,

$$A_{if} = \frac{A_i}{1+\beta A_i}$$

$$\beta A_i \qquad A_{if} \approx \frac{1}{\beta}$$

- *The current gain with feedback is stabilized to*

$$A_{if} \approx \frac{1}{\beta}$$

Current amplifiers with current-shunt feedback

4) Current-Series Feedback:

- The input signal is voltage and the output signal is current. Current is sampled at the output and f*eedback in the form of voltage at the input. Forward amplifier converts voltage to current. So the gain of the amplifier is trans conductance. The feedback path converts current to voltage and its gain is β.*

- *The trans conductance with feedback* $G_{mf} = \dfrac{G_m}{1 + \beta G_m}$

- *The gain with feedback reduces the gain by the factor* $(1 + \beta G_m)$ *. When* $\beta G_m \gg 1,$ $G_{mf} \approx \dfrac{1}{\beta}$

- *The trans conductance with feedback is stabilized to* $G_{mf} \approx \dfrac{1}{\beta}$
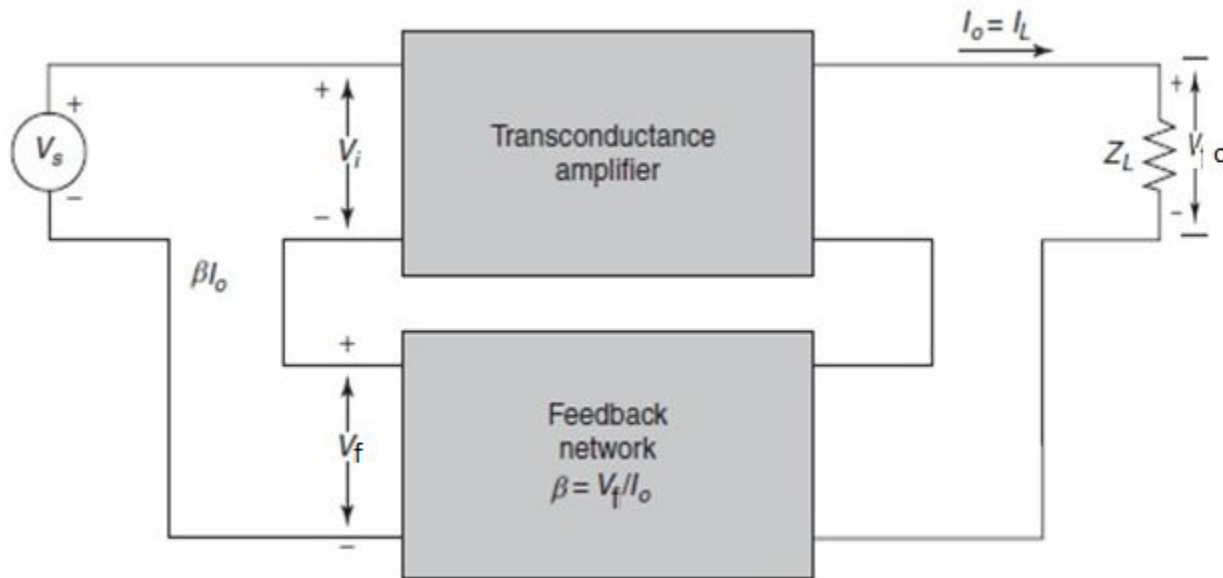
Transconductance amplifier with current-series feedback

Summary

TABLE ▢1 Summary of Gain, Feedback, and Gain with Feedback

		Voltage-Series	Voltage-Shunt	Current-Series	Current-Shunt
Gain without feedback	A	$\dfrac{V_o}{V_i}$	$\dfrac{V_o}{I_i}$	$\dfrac{I_o}{V_i}$	$\dfrac{I_o}{I_i}$
Feedback	β	$\dfrac{V_f}{V_o}$	$\dfrac{I_f}{V_o}$	$\dfrac{V_f}{I_o}$	$\dfrac{I_f}{I_o}$
Gain with feedback	A_f	$\dfrac{V_o}{V_s}$	$\dfrac{V_o}{I_s}$	$\dfrac{I_o}{V_s}$	$\dfrac{I_o}{I_s}$

Summary of effects of negative feedback

**TABLE ▢.2** Effect of Feedback Connection on Input and Output Impedance

Voltage-Series	Current-Series	Voltage-Shunt	Current-Shunt
$Z_{if} = Z_i(1 + \beta A)$	$Z_i(1 + \beta A)$	$\dfrac{Z_i}{1 + \beta A}$	$\dfrac{Z_i}{1 + \beta A}$
(increased)	(increased)	(decreased)	(decreased)
$Z_{of} = \dfrac{Z_o}{1 + \beta A}$	$Z_o(1 + \beta A)$	$\dfrac{Z_o}{1 + \beta A}$	$Z_o(1 + \beta A)$
(decreased)	(increased)	(decreased)	(increased)

# Effect of negative feedback on frequency response

- The gain of the forward amplifier is A.

- The gain of the feedback amplifier is $A_f = \dfrac{A}{1 + \beta A}$

- The reduction in gain of the amplifier is $(1 + A\beta)$

- The bandwidth increases by the same factor $(1 + A\beta)$

- Hence the gain bandwidth product remain the same.

- Unity gain frequency is remaining the same.

Frequency response of negative feedback amplifier
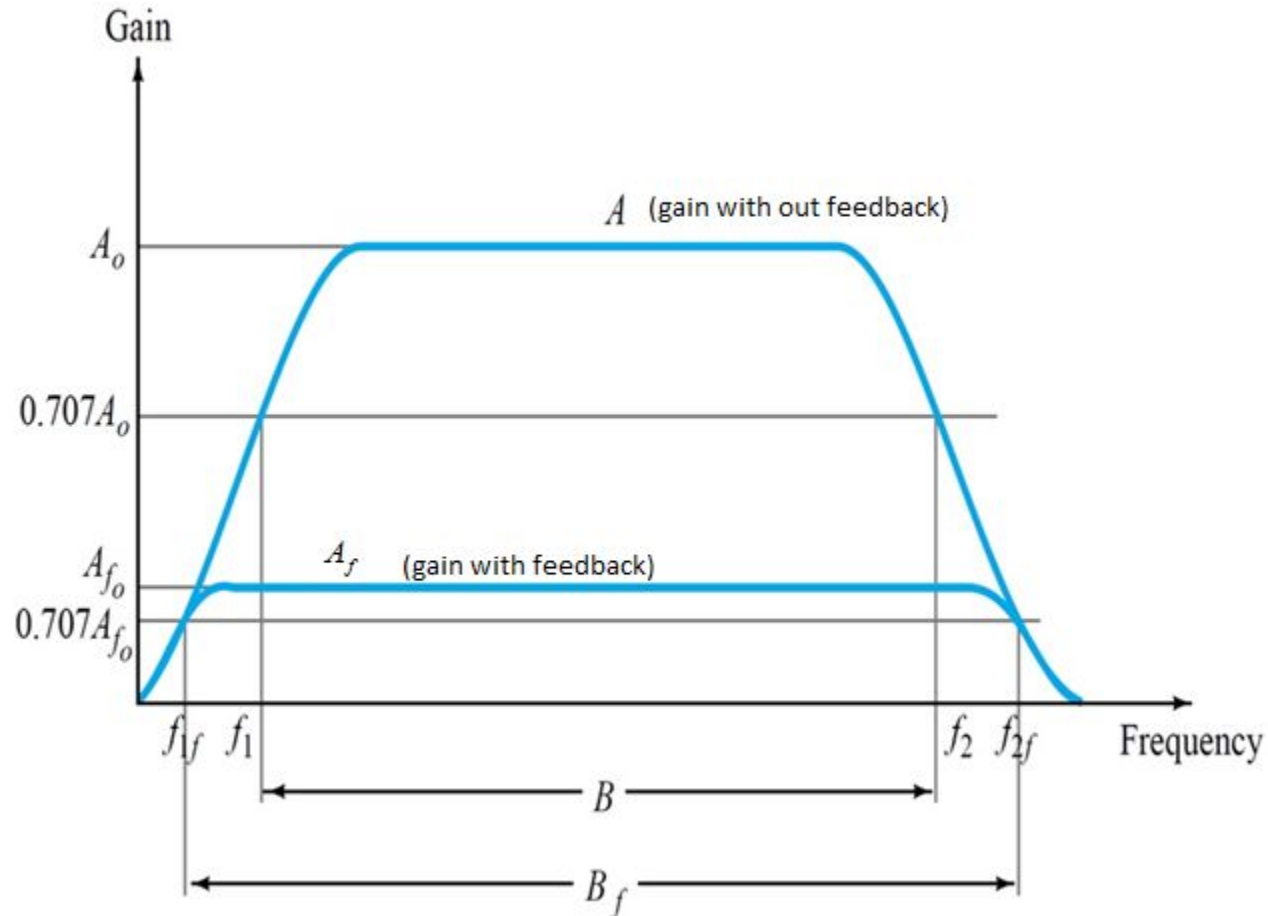
Practical Feedback Circuits (1/2)

❑ **Voltage series feedback:**
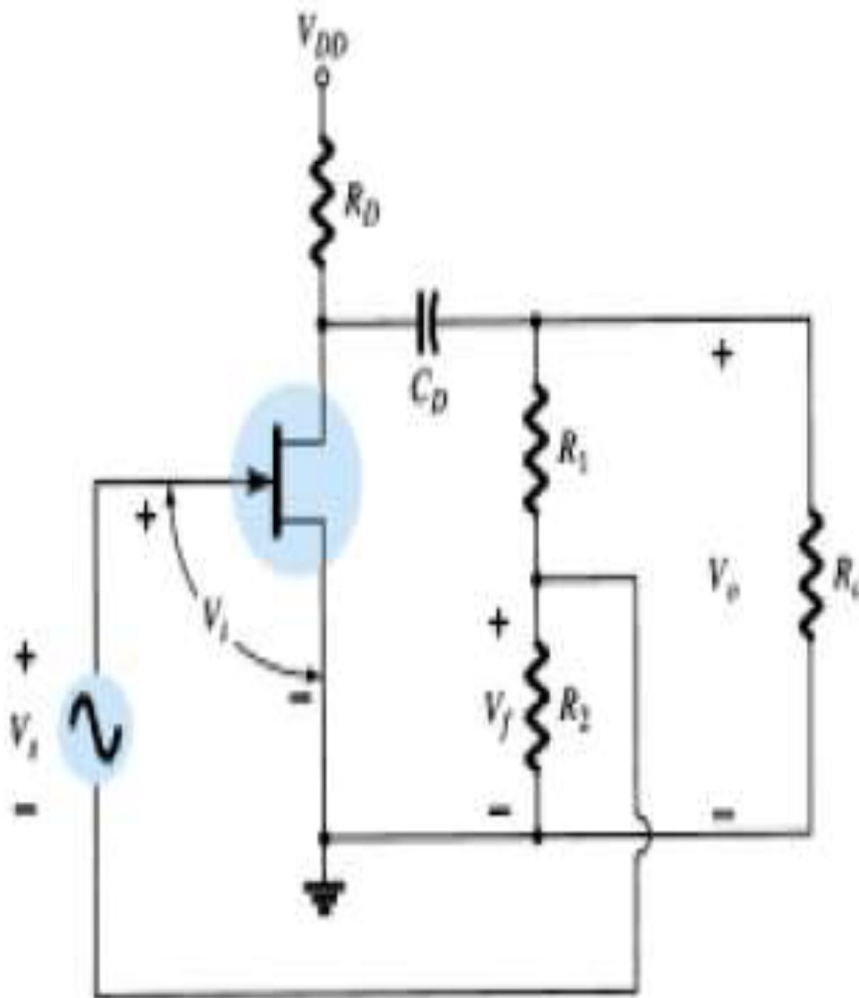
- Here, R_1 and R_2 resistors are used as a feedback network.

- **A part of output signal is obtained from R_2 to ground.**

- v_f is connected in series with the source signal v_s.

- **Without feedback the amplifier gain is:**

  $$A = v_o/v_i = -g_m R_L$$

- where R_L is the parallel combination of R_D, R_o and $(R_1 + R_2)$.

➤ **The feedback factor:**

$$\beta = \frac{v_f}{v_o} = \frac{-R_2}{R_1 + R_2}$$

➤ **We know the gain with negative feedback is:**

$$A_f = \frac{A}{1 + \beta A} = \frac{-g_m R_L}{1 + \dfrac{R_2}{R_1 + R_2} R_L g_m}$$

➤ **If $\beta A \gg 1$ we have:**

$$A_f \cong \frac{1}{\beta} = -\frac{R_1 + R_2}{R_2}$$