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Phy-M-203

Feedback

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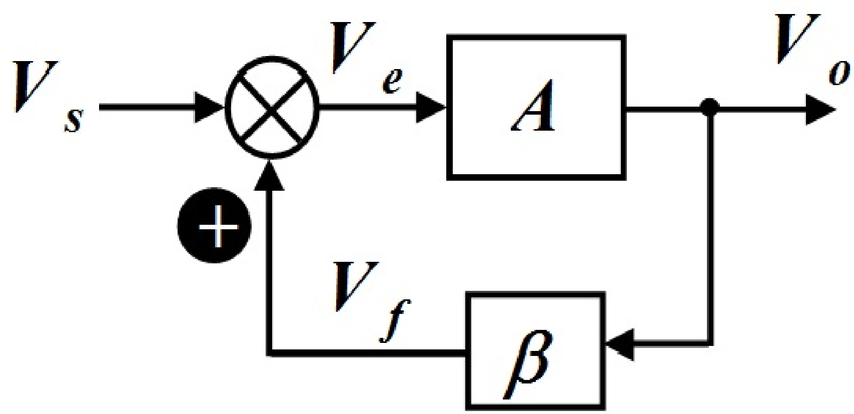
Feedback Amplifier

Feedback is defined as a process in which the output signal from an amplifier is sampled and a part of it is fed back together with the input signal so as to modify the behavior of that amplifier.

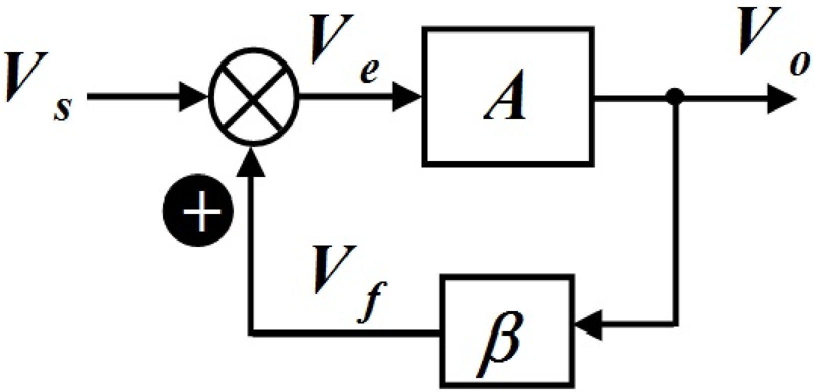


- The figure above is a schematic representation of a feedback amplifier. Here, V_s is the input signal voltage, V_e is the actual input to the amplifier, V_o is the output of the amplifier. ***A*** is the gain of the amplifier and $\boldsymbol{\beta}$ is the attenuation produced by the feedback network.

Gain in a Feedback Amplifier

- Feedback process modifies the amplitude as well as the phase of the input signal. Consider the feedback network shown below.

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



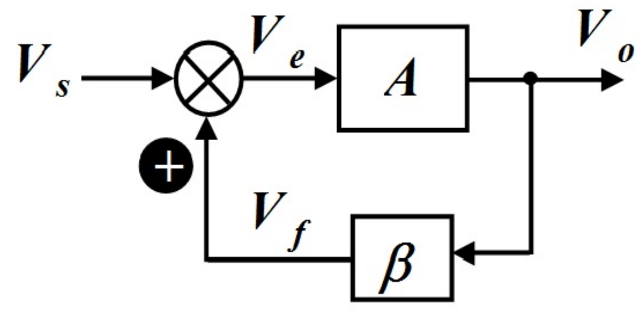
$$Since\ V_e = V_s + V_f = V_s + \beta V_o$$

$$V_o = AV_s + A\beta V_o$$

$$Thus\ V_o(1 - A\beta) = AV_s\ hence\ A_f = \frac{A}{1 - A\beta}$$ ¿

This is the expression of gain in a general Feedback amplifier.

Positive and Negative Feedback



- Positive Feedback represents the situation in which the feedback signal V_f is in phase with the input signal V_s.
- Negative Feedback represents the situation in which the feedback signal V_f is in phase with the input signal V_s.
- For negative feedback the feedback factor ß is negative.

$$Thus\ A_f = \frac{A}{1 + A\beta}\ for\ negative\ feedback.$$

We will be concerned with Negative feedback mainly in our discussion.

Effect of Negative Feedback on Gain of the Amplifier

$$A_f = \frac{A}{1 + A\beta} \; for\ negative\ feedback.$$

- The quantity ß is the magnitude of feedback factor.

  Thus the denominator (1+Aß) in the expression of A_f is always larger than 1. Which makes A_f smaller than A.

- We conclude that negative feedback reduces the overall gain of the amplifier.

Effect of Negative Feedback on Stability of the amplifier

- Due to various reasons, the gain of an amplifier can vary. The reason can be a change in ambient temperature, or fluctuations of supply voltage, or ageing or something else. Let us see the effect of negative feedback on the Stability of the amplifier against variation of gain.

- To see this, we obtain the differential of A_f.

$$dA_f = \frac{(1 - A\beta)\,dA - A\,d(1 - A\beta)}{(1 - A\beta)^2}$$

On rearranging the terms we obtain

$$\frac{dA_f}{A_f} = \left(\frac{1}{1 + A\beta}\right)\frac{dA}{A}$$

Thus relative change in gain with feedback is smaller than the relative change in gain without feedback by a factor of $(1+A\beta)$. We can conclude that Negative feedback improves stability of an amplifier.

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$$dA_f = \frac{(1-A\beta)dA - Ad(1-A\beta)}{(1-A\beta)^2}$$

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Effect of Negative Feedback on Bandwidth of the amplifier

- The bandwidth of an amplifier is defined as the difference between upper cutoff frequency and lower cutoff frequency. We will assume that the lower cutoff frequency is much smaller than the upper cutoff frequency. So in the following derivation we ignore the lower cutoff frequency and consider the upper cutoff frequency only. We will also assume that the frequency response of the amplifier is same as that of first order Low pass filter.
- We assume that the gain A is a function of frequency.

$$A(\omega)=\frac{1}{1+j\left(\frac{\omega}{\omega_o}\right)}$$

Effect of Negative Feedback on Bandwidth of the amplifier (contd.)

- We assume that the gain A is a function of frequency.

$$A_f(\omega)=\frac{A}{1+A\beta}=\frac{A_o/(1+j\omega/\omega_o)}{1+A_o\beta/(1+j\omega/\omega_o)}$$

- When we divide both the numerator and denominator by $(1+A\beta)$

  we get

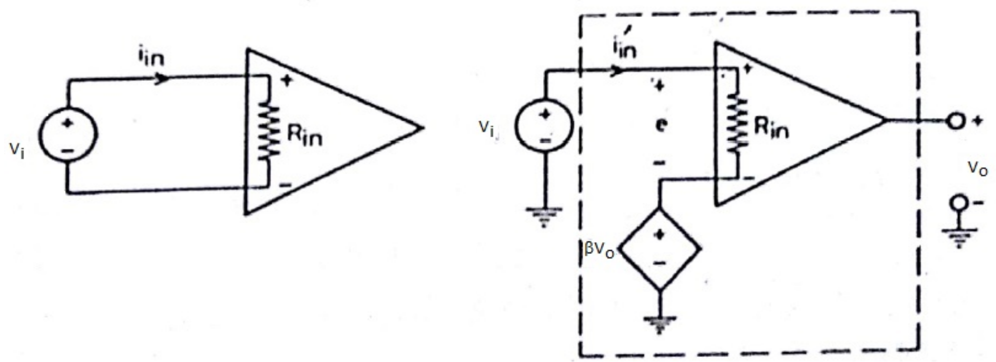
$$A_f(\omega)=\frac{A_{fo}}{1+j(\omega/\omega_{fo})}$$

  where $A_{fo} = A_o/(1+A_o\beta)$ and $\omega_{fo} = \omega_o(1+A_o\beta)$

- We notice that although Negative Feedback reduces gain (A_{fo}), the Bandwidth ω_{fo} increases by same factor. The Gain Bandwidth product remains independent of amount of feedback. This is an important result.

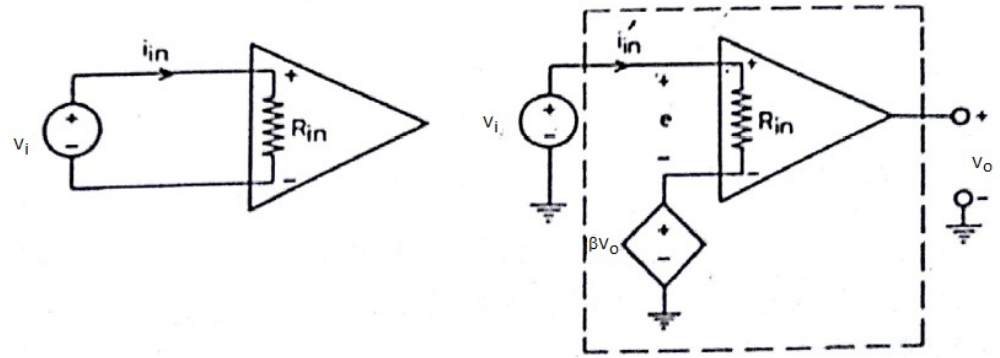
Effect of Negative Feedback on Input resistance

- We shall now examine the effect of negative feedback on input resistance of an amplifier. Let us assume that the feedback is voltage series type (Sampled quantity is voltage and fed back quantity is also voltage)



The figure above shows an amplifier without feedback (left) and another amplifier with feedback (right). Each amplifier is given an input signal V_i and has input resistance R_{in}. Input resistance is the resistance offered by the amplifier to the source of its input signal. The feedback signal is represented by a voltage source in series applying voltage βV_o with reversed polarity.

Effect of Negative Feedback on Input resistance (contd.)

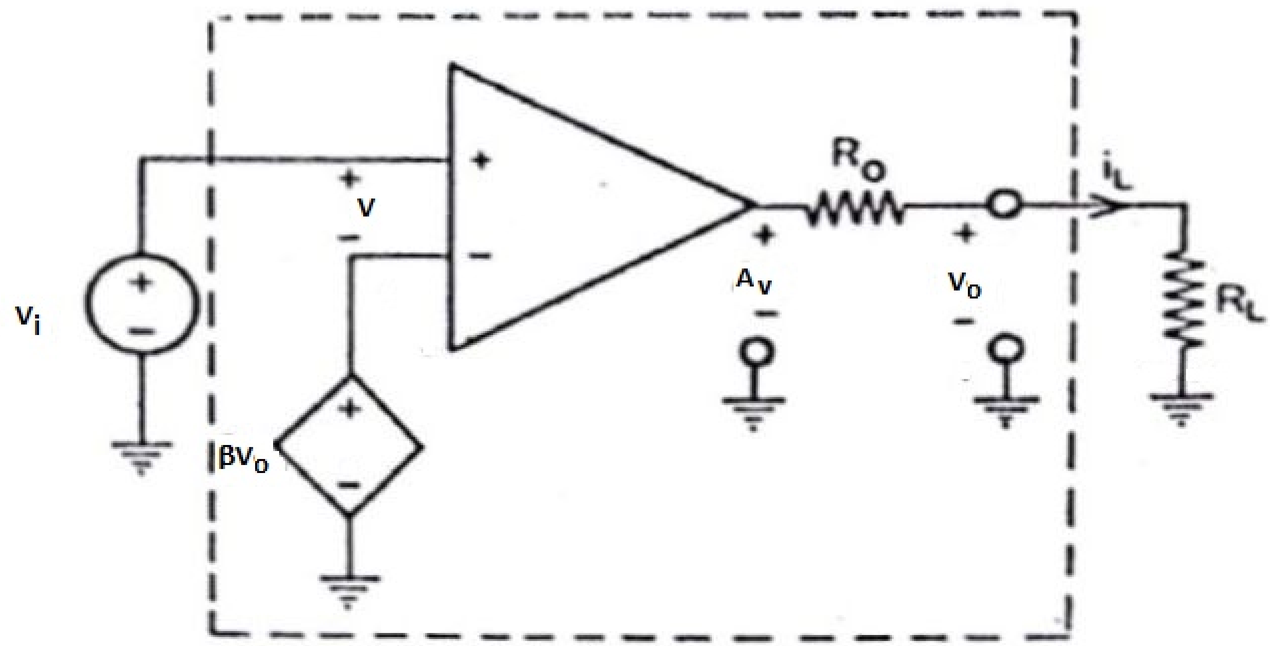


Suppose the input resistance of both amplifiers is R_{in}. In the case of no feedback, the input resistance will be same i.e. R_{in}. In the second case, the input current is now reduced to i'_{in} which is equal to $(V_i - \beta V_o)/R_{in}$

Thus the effective input resistance with feedback is

$$R_{inf} = V_i / i'_{in} = R_{in}\,(1 + A\beta)$$

Effect of Negative Feedback on Output resistance



In the figure above the output resistance is R_o which is in series with the Load resistance R_L. Because of the presence of R_o, the voltage V_o available for feedback gets modified when there is a finite load current i_L.

Effect of Negative Feedback on Output resistance (contd.)

Using KVL we can write for the output circuit,

$$V_o = A_v V - i_L R_o = A_v (v_i - \beta V_o) - i_L R_o$$

$$V_o (1 + A_v \beta) = A_v v_i - i_L R_o$$

$$V_o = [V_i A_v / (1 + A_v \beta)] - [i_L R_o / (1 + A_v \beta)]$$

We can write this as

$$V_o = V_i A_{vf} - i_L R_{of}$$

where A_{vf} is the gain with feedback. Then we can identify R_{of} as

$$R_{Of} = R_o / (1 + A_v \beta)$$

We conclude that Negative feedback decreases output resistance by a factor of $(1+A_V\,\beta)$.

Types of Feedback

In the discussion of feedback, we have assumed that the input, output and feedback signals are all voltages. But this need not be so.

Depending on whether the output and feedback signals are voltage or current signals, four types of feedback or feedback topologies have been defined. These are:

(1) Voltage series feedback

(2) Voltage shunt feedback

(3) Current series feedback

(4) Current shunt feedback.

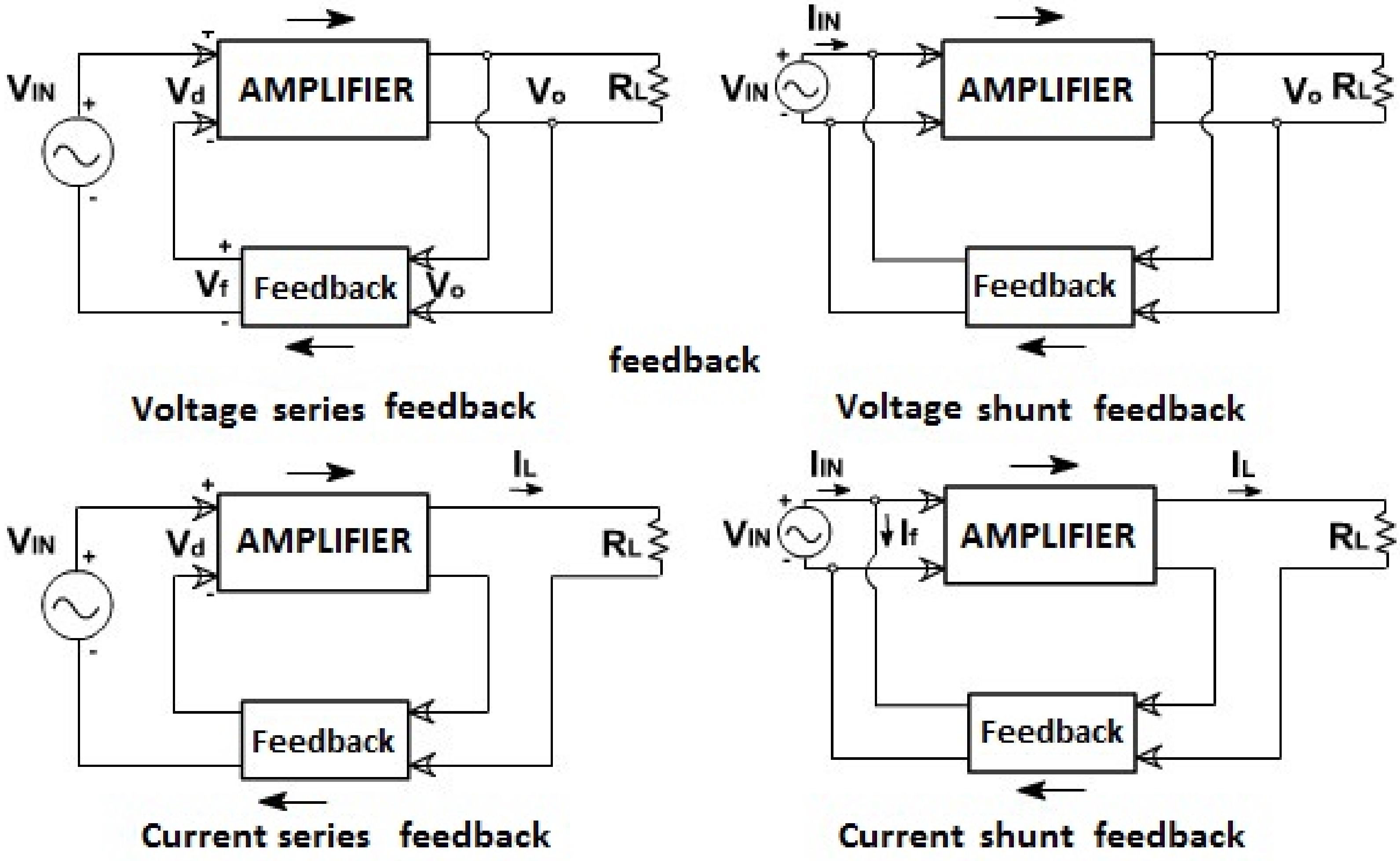
Types of Feedback (contd.)

Basis of this classification: In any feedback process, we have to deal with two quantities: First the sampled quantity, and second the feedback quantity.

Now, if you desire to sample or measure a voltage signal, you connect a voltmeter in parallel with the source. On the other hand, if you desire to sample a current signal, you connect an ammeter in series with the source. The first term thus tells us the sampled quantity – whether it is voltage or current.

The feedback quantity obtained after scaling by the feedback network is added to the input signal (or subtracted from it). If the feedback quantity is a voltage, then the output from the feedback network must be connected in series with the input signal. But if it is current, then it must be connected in parallel with the input (shunt). We use the terms series or shunt feedback to indicate the quantity fed back.

Types of Feedback (contd.)



The four feedback topologies

Feedback properties of different types

Characteristics	Voltage series	Voltage Shunt	Current series	Current Shunt
Voltage Gain	Decreases	Decreases	Decreases	Decreases
Bandwidth	Increases	Increases	Increases	Increases
Harmonic Distortion	Decreases	Decreases	Decreases	Decreases
Noise	Decreases	Decreases	Decreases	Decreases
Input Resistance	Increases	Decreases	Increases	Increases
Output Resistance	Decreases	Decreases	Increases	Decreases

THANKS!!!