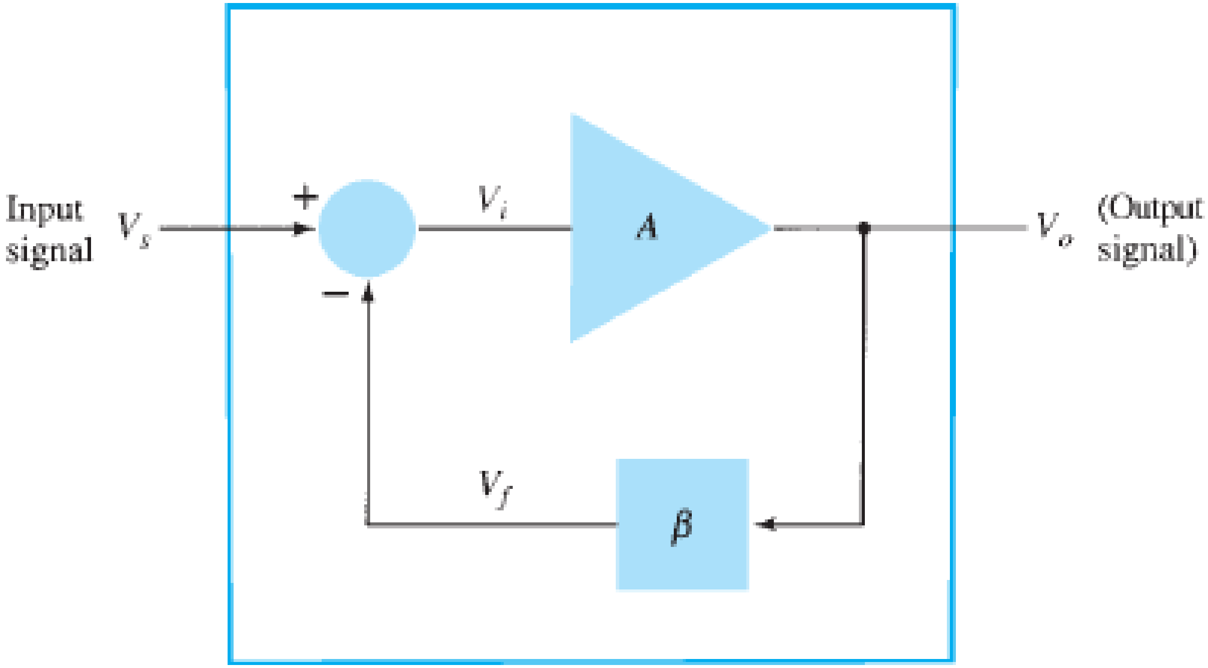
Feedback and Oscillator Circuits

Feedback



Feedback amplifier

- The input signal, *Vs,* is applied to a mixer network
- Here it is combined with a feedback signal V_f
- Difference (or sum) of signals, V_i, is then the input voltage to the amplifier
- Amplifier output, V_o, is connected to the feedback network (β), which provides a reduced portion of the output as feedback signal to the input mixer network

- If the feedback signal is of the opposite polarity compared to input, this is negative feedback
- If the feedback signal is of the same polarity with the input, this is positive feedback

Feedback

Negative Feedback:
Although negative feedback results in reduced overall voltage gain, a number of improvements are obtained, among them being:

1. Higher input impedance.
2. Better stabilized voltage gain.
3. Improved frequency response.
4. Lower output impedance.
5. Reduced noise.
6. More linear operation.

Feedback

Types of Feedback Connections:
There are four basic ways of connecting the feedback signal. Both *voltage* and *current* can
be fed back to the input either in *series* or *parallel.* Specifically, there can be:

1. Voltage-series feedback (Fig. 14.2 a).
2. Voltage-shunt feedback (Fig. 14.2 b).
3. Current-series feedback (Fig. 14.2 c).
4. Current-shunt feedback (Fig. 14.2 d).

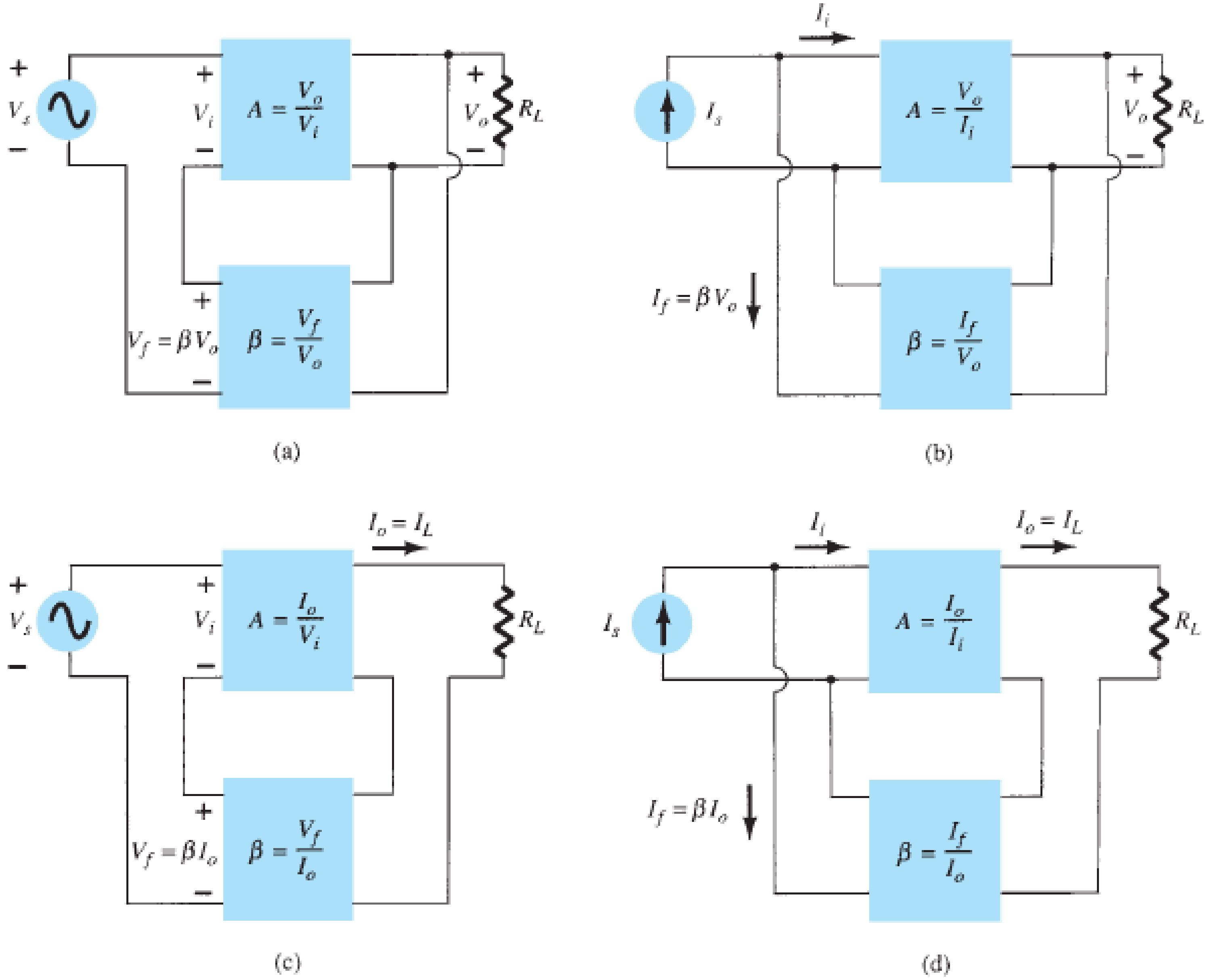


FIG. 14.2

Feedback

Types of Feedback Connections:

1. Voltage-series feedback (Fig. 14.2 a).
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4. Current-shunt feedback (Fig. 14.2 d).

In the list above,

- *Voltage* refers to connecting the output voltage as input to the feedback network
- *Current* refers to tapping off some output current through the feedback network.
- *Series* refers to connecting the feedback signal in series with the input signal voltage
- *Shunt* refers to connecting the feedback signal in shunt (parallel) with an input current source.

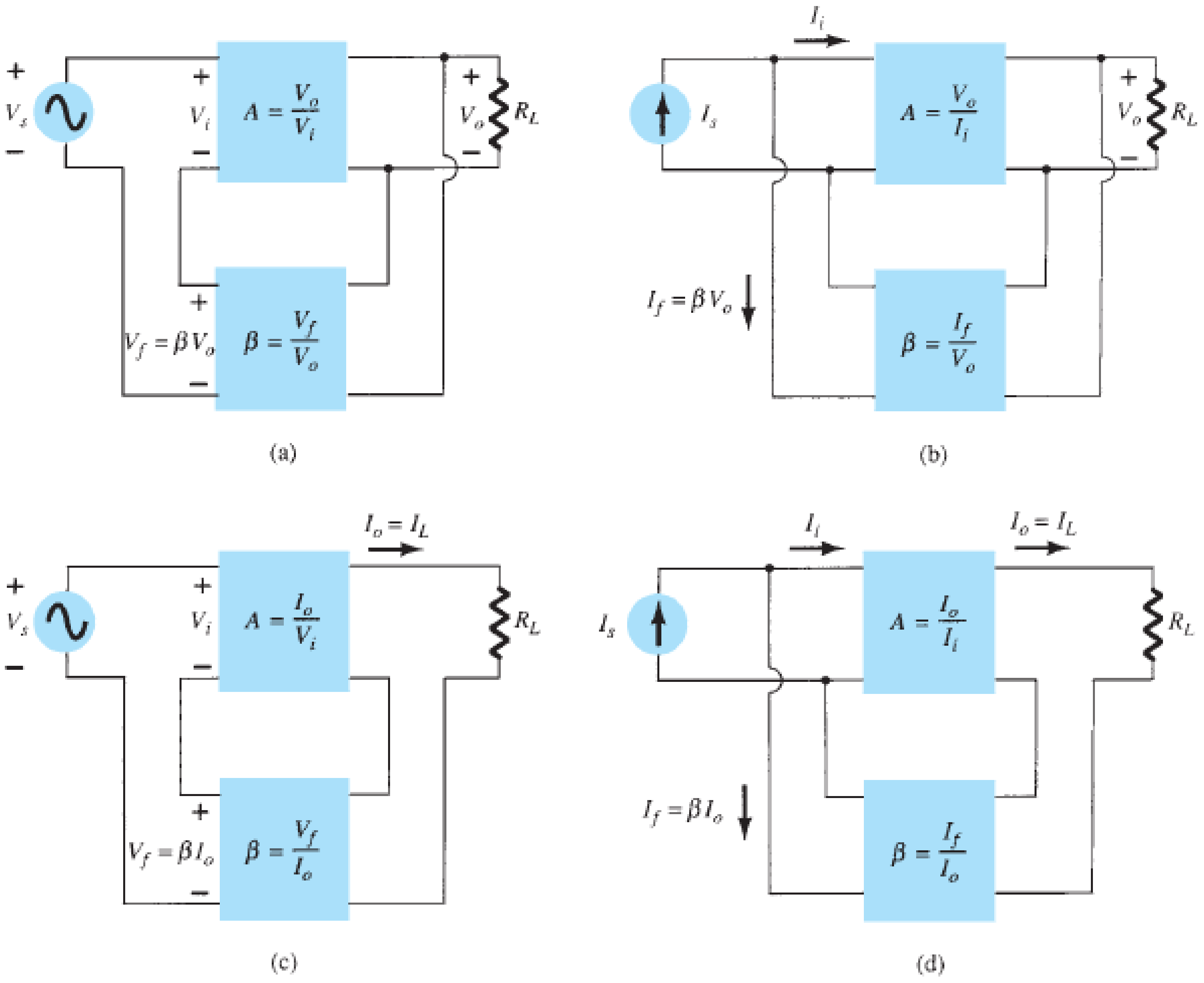


FIG. 14.2

Feedback

Voltage-series feedback :

If there is no feedback ($V_f = 0$), the voltage gain of the amplifier stage is

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

If V_f is connected in series with the input, then

$$Vi = Vs - Vf$$

$$Vo = AV_i = A(V_s - V_f) = AV_s - AV_f = AV_s - A(\beta V_o)$$

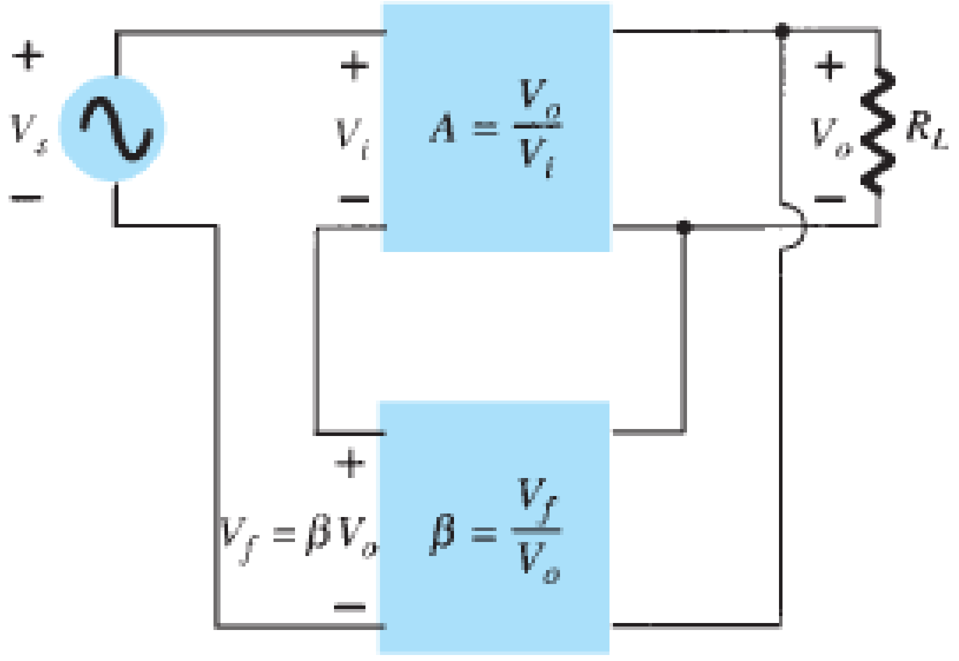
$$(1 + \beta A)V_o = AV_s$$

so that the overall voltage gain *with* feedback is

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

This shows that the gain *with* feedback is the amplifier gain reduced by the factor $(1 + \beta A)$

This factor will be seen also to affect input and output impedance among other circuit features.



Feedback

Voltage-series feedback – Input Impepance:

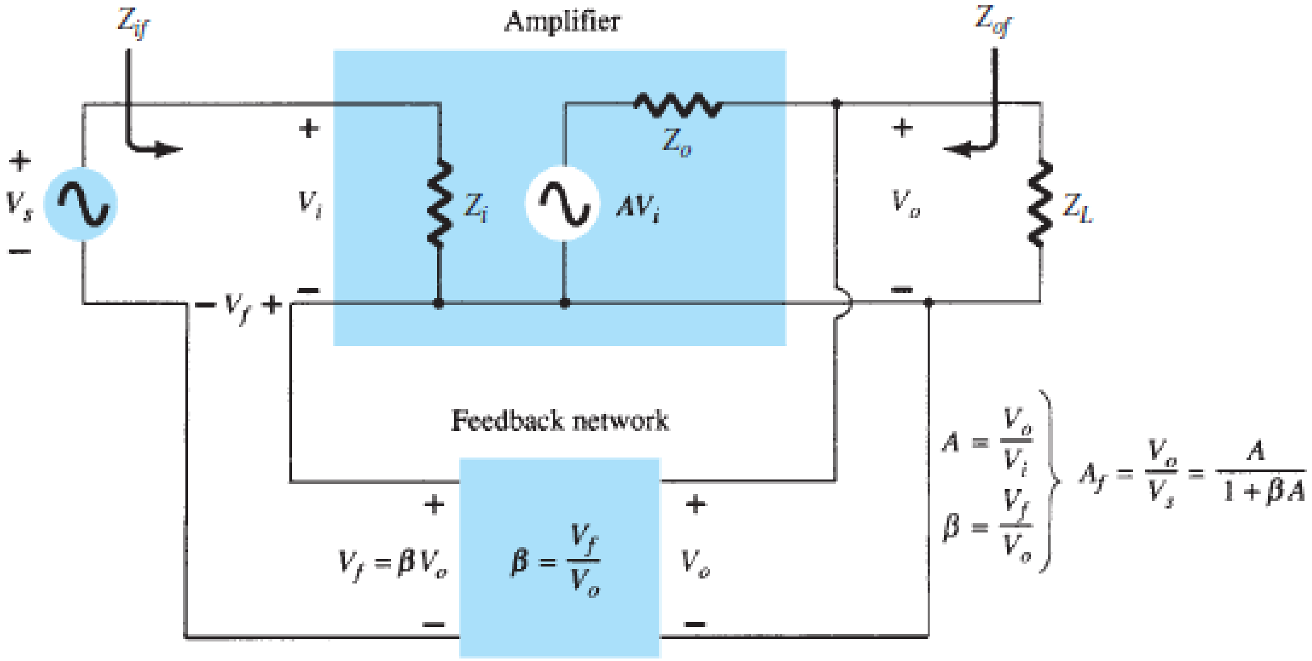
$$I_i = \frac{V_i}{Z_i} = \frac{V_s - V_f}{Z_i} = \frac{V_s - \beta V_o}{Z_i} = \frac{V_s - \beta A V_i}{Z_i}$$

$$I_i Z_i = V_s - \beta A\, V_i$$

$$V_s = I_i Z_i + \beta A V_i = I_i Z_i + \beta A I_i Z_i$$

$$Z_{if} = \frac{V_s}{I_i} = Z_i + (\beta A) Z_i = Z_i(1 + \beta A)$$

The input impedance with series feedback is the value of the input impedance without feedback multiplied by the factor $(1 + \beta A)$, and applies to both voltage-series and current-series configurations.



Feedback

Voltage-series feedback – Output Impepance:

The output impedance is determined by applying a voltage *V*, resulting in a current *I*, with V_s shorted out $(V_s = 0)$. The voltage *V* is then

$$V = IZ_o + AV_i$$

For $V_s = 0$,

$$V_i = -V_f$$

$$V = IZ_o - AV_f = IZ_o - A(\beta V)$$

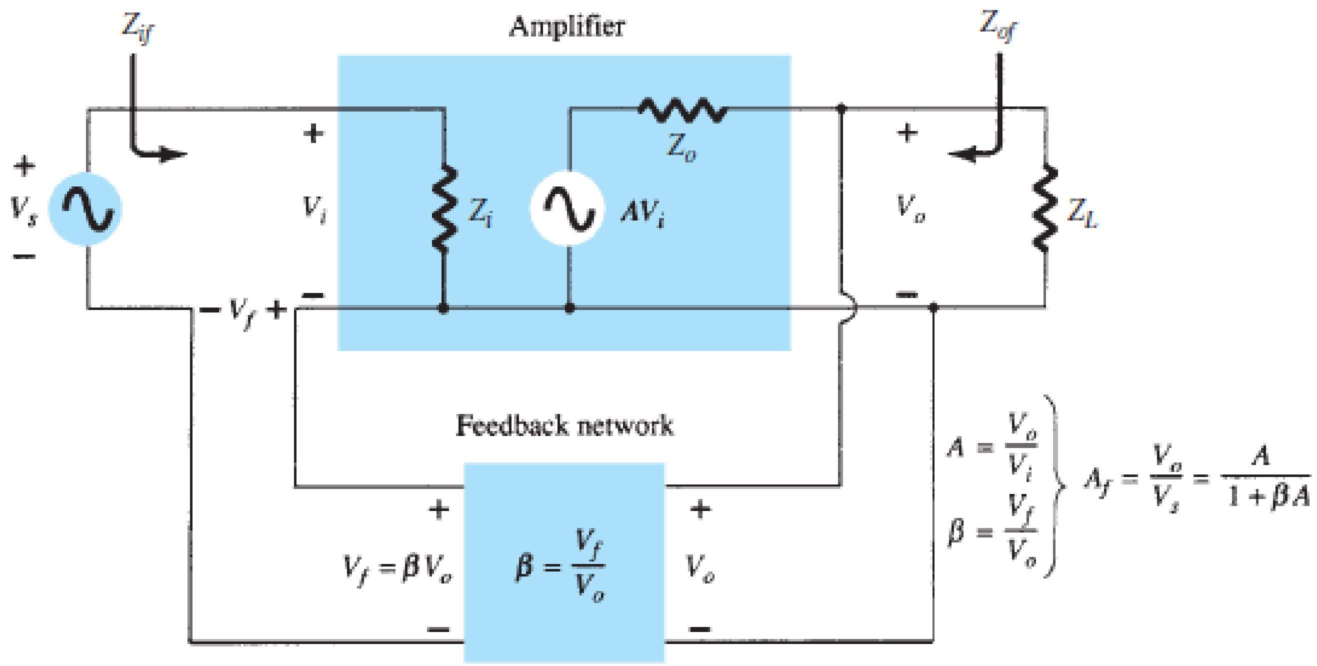
Rewriting the equation as

$$V + \beta AV = IZ_o$$

allows solving for the output impedance with feedback:

$$Z_{of} = \frac{V}{I} = \frac{Z_o}{1 + \beta A}$$

This shows that with voltage-series feedback the output impedance is reduced from that without feedback by the factor $(1 + \beta A)$



Feedback

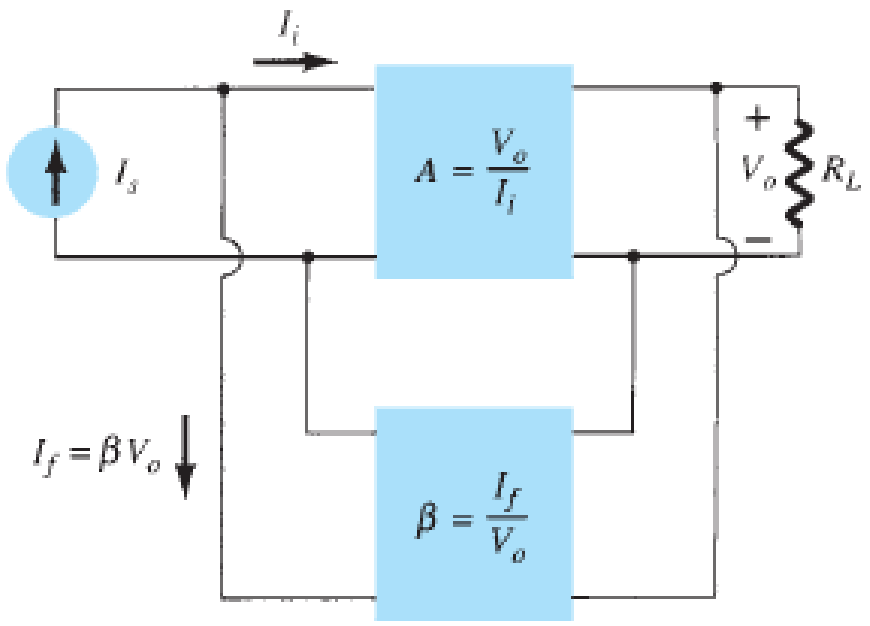
Voltage-shunt feedback :

The gain with feedback for the network shown in the figure is

$$A_f = \frac{V_o}{I_s} = \frac{AI_i}{I_i + I_f}$$

$$= \frac{(A\ I_i)}{I_i + \beta V_o} = \frac{AI_i}{I_i + \beta AI_i}$$

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



Feedback

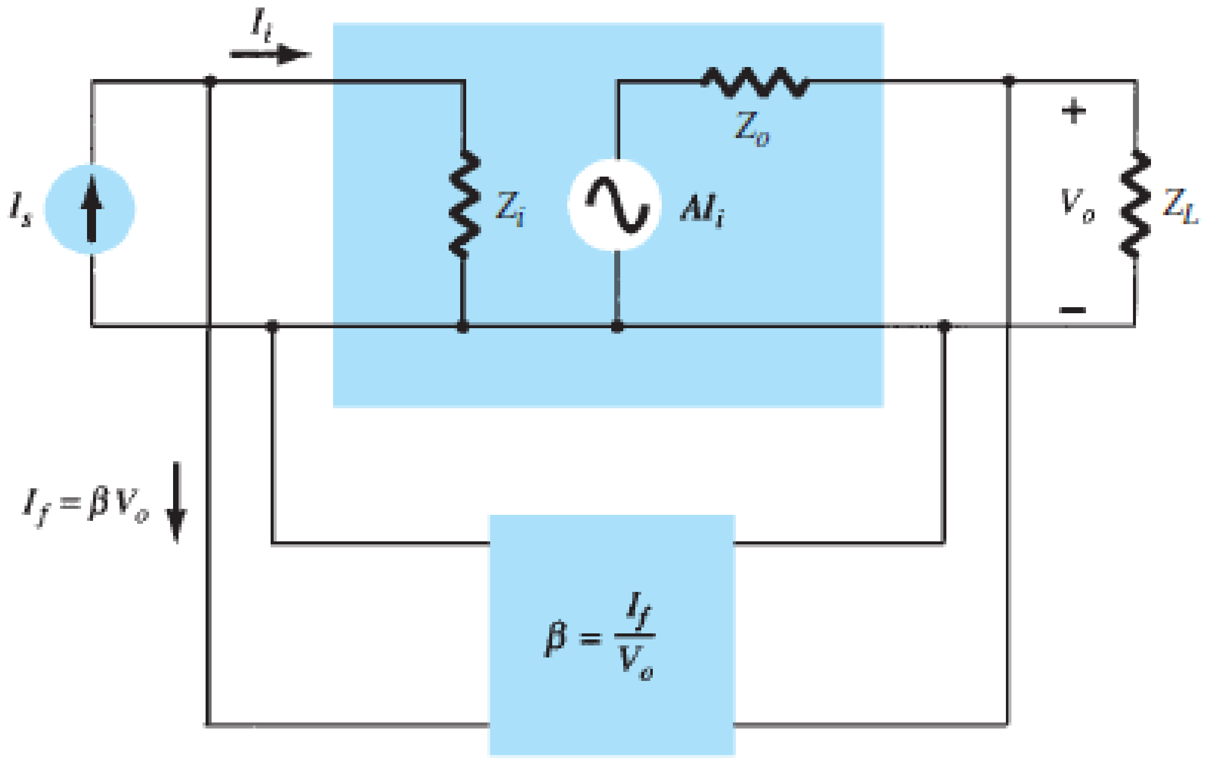
Voltage-shunt feedback – Input Impedance:

$$Z_{if} = \frac{V_i}{I_s} = \frac{V_i}{I_i + I_f}$$

$$= \frac{V_i}{I_i + \beta V_o}$$

$$= \frac{V_i/I_i}{I_i/I_i + \beta V_o/I_i}$$

$$Z_{if} = \frac{Z_i}{1 + \beta A}$$



This reduced input impedance applies to the voltage-series connection and the voltage-shunt connection

Feedback

Current-series feedback Output Impedance:
Output impedance can be determined by applying a signal *V* to the output, with V_s shorted out, resulting in a current *I*

Ratio of *V* to *I is* the output impedance

For the output part of a current-series feedback connection, the resulting output impedance is:

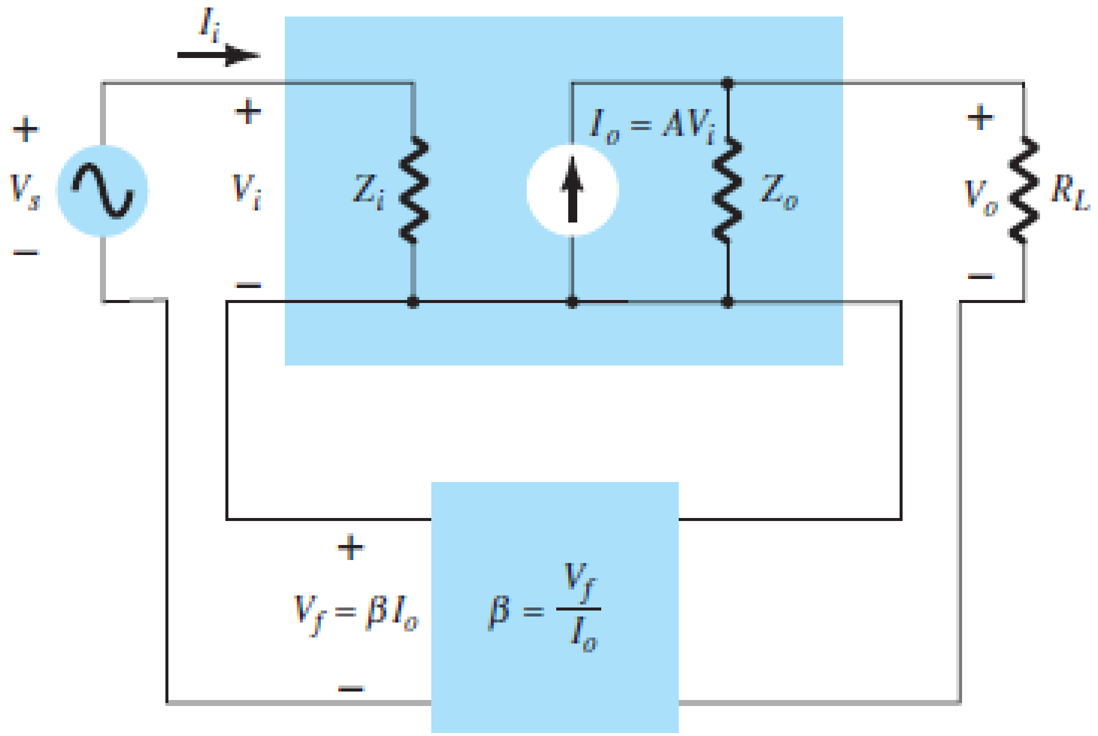
With $V_s = 0$,

$$V_i = V_f$$

$$I = \frac{V}{Z_o} - AV_i = \frac{V}{Z_o} - AV_f = \frac{V}{Z_o} - A\beta I$$

$$Z_o(1 + \beta A)I = V$$

$$Z_{of} = \frac{V}{I} = Z_o(1 + \beta A)$$



Feedback

Effect of Feedback Connection on Input and Output Impedance:

A summary of the effect of feedback on input and output impedance is provided in the table below

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