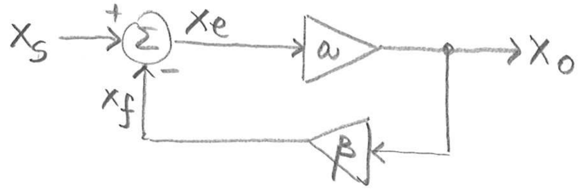
Negative feedback reference

→ General structure of a feedback amplifier:



→ Closed-loop gain is: or amplification

$$A \triangleq \frac{x_o}{x_s} = \frac{1}{\beta} \cdot \frac{a \cdot \beta}{1 + a\beta} = \frac{1}{\beta} \cdot \frac{T}{1+T} \quad (1)$$

(2) $T = a\beta$: loop gain.

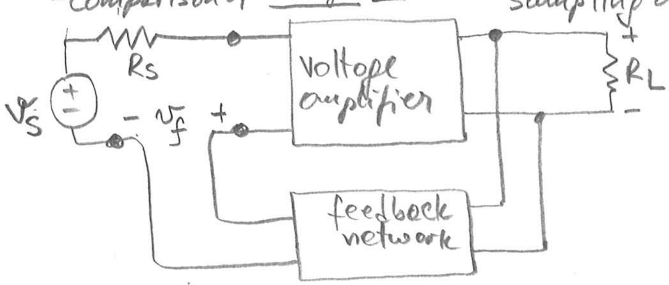
→ Based on the type of negative feedback topology (or configuration) the open-loop amplification a and the feedback factor β are "best" analyzed and computed as amplifications with meaning of transimpedance, transconductance, voltage-to-voltage, or current-to-current.

→ a and β can be easily computed using the so called "a" circuit and "β" circuit.

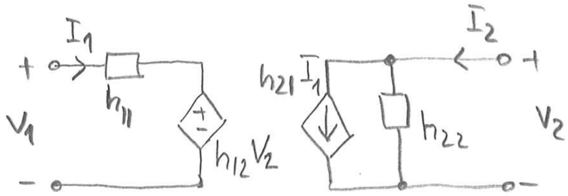
→ The four types of negative feedback topology are:

1 - series at input
- comparison of voltage v

- shunt at output (parallel out)
- sampling of voltage v



→ Feedback network must be studied with h parameters:



$$\begin{cases} V_1 = h_{11} I_1 + h_{12} V_2 \\ V_2 = h_{21} I_1 + h_{22} V_2 \end{cases}$$

$$\beta_v = h_{12} = \left. \frac{V_1}{V_2} \right|_{I_1 = 0}$$

open circuit.

voltage to voltage (or simply voltage) amplification:

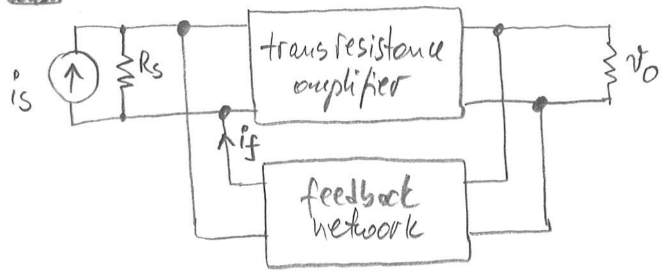
$$A_v = \frac{v_o}{v_s} = \frac{1}{\beta_v} \cdot \frac{a_v \cdot \beta_v}{1 + a_v \cdot \beta_v}$$

a_v: voltage amplification; β_v: voltage feedback factor

2

- shunt at input
- comparison of i

- shunt at out
- sampling of v

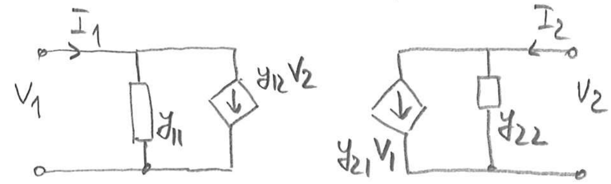


Current to voltage ⇒ transresistance amplifier (or converter).

$$A_r = \frac{v_o}{i_s} = \frac{1}{\beta_g} \cdot \frac{a_r \cdot \beta_g}{1 + a_r \cdot \beta_g}$$

(a_r: transresistance amplification; β_g: transconductance feedback factor)

→ Feedback network must be studied with y parameters:



$$\begin{cases} I_1 = y_{11} \cdot V_1 + y_{12} V_2 \\ I_2 = y_{21} V_1 + y_{22} V_2 \end{cases}$$

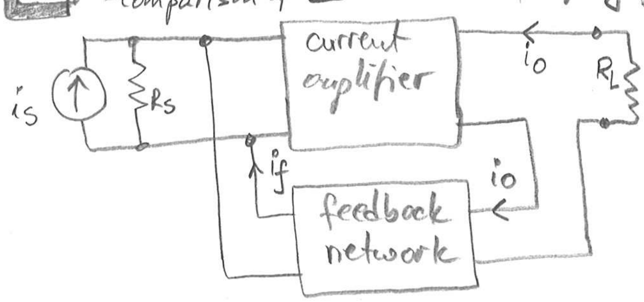
$$\beta_g = y_{12} = \left. \frac{I_1}{V_2} \right|_{V_1 = 0}$$

($V_1 = 0$: short circuit.)

3

- shunt/parallel at in
- comparison of i

- series at out
- sampling of i

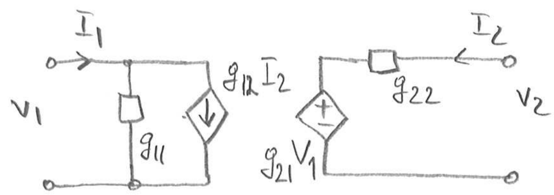


Current to current (or simply current) amplification:

$$A_i = \frac{i_o}{i_i} = \frac{1}{\beta_i} \cdot \frac{a_i \cdot \beta_i}{1 + a_i \cdot \beta_i}$$

(a_i: current amplification; β_i: current feedback factor.)

→ feedback network must be studied with g parameters:



$$\begin{cases} I_1 = g_{11} V_1 + g_{12} I_2 \\ V_2 = g_{21} V_1 + g_{22} I_2 \end{cases}$$

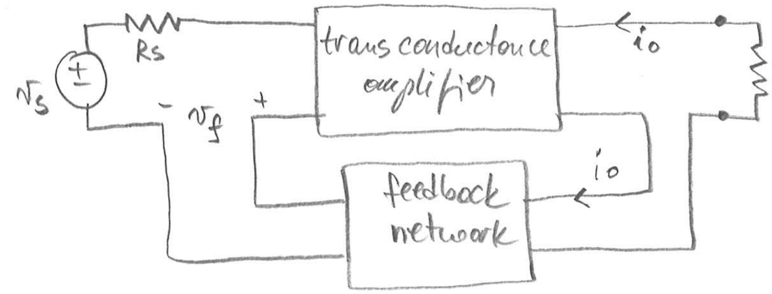
$$\beta_i = g_{12} = \left. \frac{I_1}{I_2} \right|_{V_1 = 0}$$

($V_1 = 0$: short circuit.)

4

- series at input
- compare voltage [v]

- series at output
- sampling current [i]



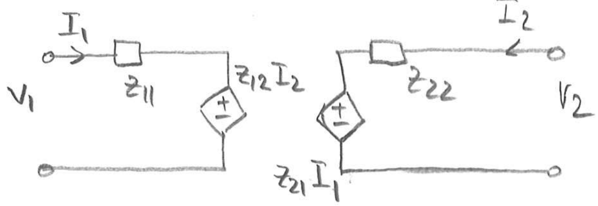
Voltage to current (or transconductance) amplifier (or converter).

$$A_g = \frac{i_o}{v_s} = \frac{1}{\beta_r} \cdot \frac{a_g \cdot \beta_r}{1 + a_g \cdot \beta_r}$$

a_g – transconductance amplification

β_r – transresistance feedback factor

→ Feedback network must be studied with [z] parameters:



$$\begin{cases} V_1 = z_{11} I_1 + z_{12} I_2 \\ V_2 = z_{21} I_1 + z_{22} I_2 \end{cases}$$

$$\beta_r = z_{12} = \left. \frac{V_1}{I_2} \right|_{I_1 = 0}$$

$I_1 = 0$ – open circuit