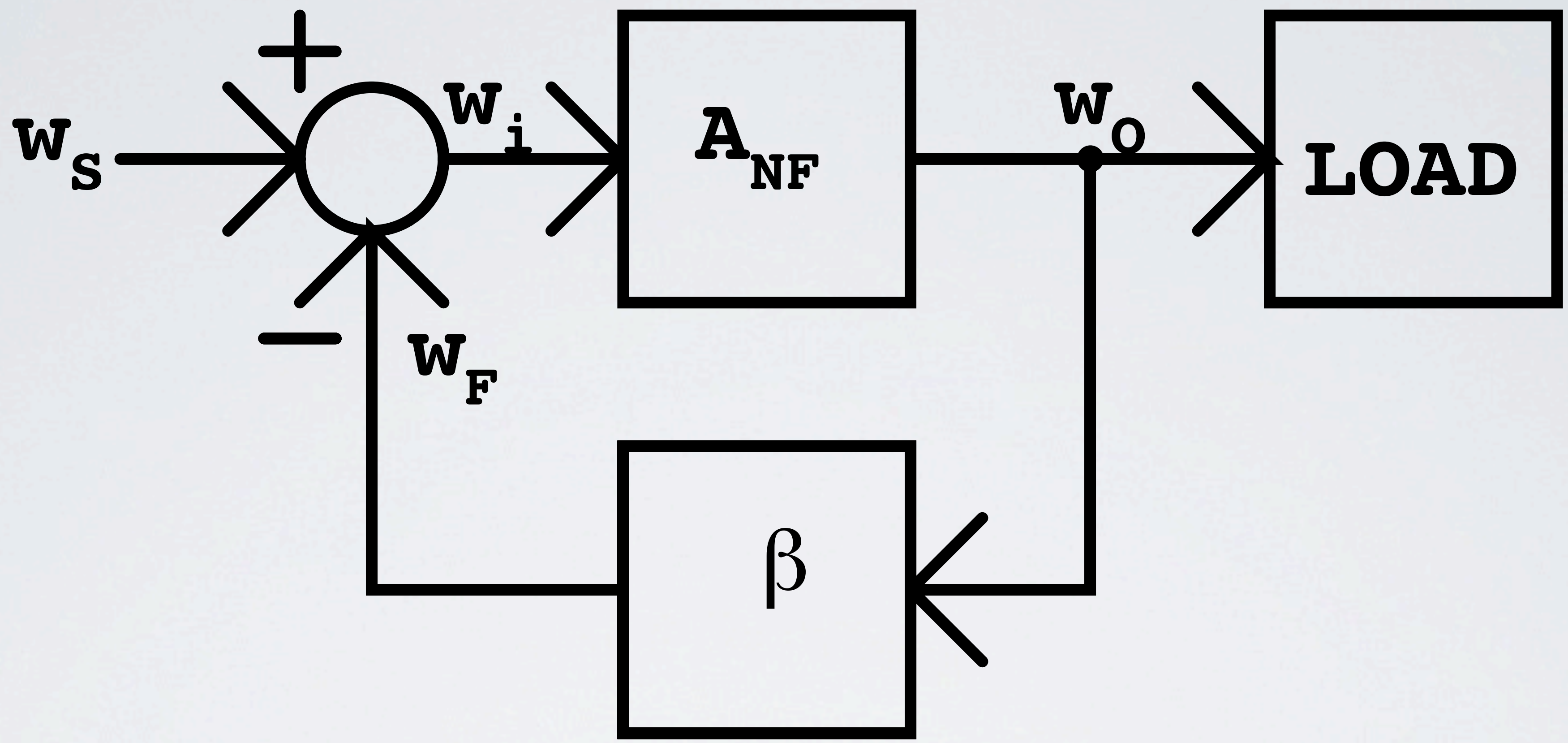
RETRO-ALIMENTACIÓN

Conceptos Básicos

INEL 5207 - Enero 2013

Sistema General



$$w_O = A_{NF} w_i = A_{NF}(w_S - \beta w_O)$$

$$w_O = \frac{A_{NF}}{1 + \beta A_{NF}} w_S = A_F w_S = \frac{A_{NF}}{D}$$

$$
\begin{aligned}
A_f &= \frac{A}{1+\beta A} \\
&= \frac{A}{T}\frac{1}{1+\frac{1}{T}} \\
&= A_{ideal}\frac{1}{1+\frac{1}{T}} \\
A_{ideal} &= \lim_{\beta A \to \infty} A_f = \frac{A}{T} = \frac{1}{\beta} \\
A_f &= \frac{1}{\beta}\frac{1}{1+\frac{1}{T}}
\end{aligned}
$$

La cantidad

$$\frac{1}{1+\frac{1}{T}}$$

expresa cuanto se aparta la ganancia de nuestro amplificador del caso ideal. Por esto es a veces denominada la *función de error*.

VENTAJAS

- Reduce la sensitividad a parámetros
- Aumenta el ancho de banda
- Reduce la distorción
- Majora la resistencia de entrada y salida
- Desventaja: reduce la ganancia.

SENSITIVIDAD

$$
\begin{aligned}
S_P^{A_F} &= \frac{P}{A_F}\frac{dA_F}{dP} = \frac{P}{A_F}\frac{d\frac{A_{NF}}{1+\beta A_{NF}}}{dP} \\
&= \frac{P}{A_F}\frac{d}{dA_{NF}}\frac{A_{NF}}{1+\beta A_{NF}}\frac{dA_{NF}}{dp} \\
&= \frac{P}{A_F}\frac{dA_{NF}}{dp}\left(\frac{1}{1+\beta A_{NF}} - \frac{\beta A_{NF}}{(1+\beta A_{NF})^2}\right) \\
&= \frac{P}{A_{NF}}\frac{dA_{NF}}{dp}\left(1 - \frac{\beta A_{NF}}{1+\beta A_{NF}}\right) \\
&= \frac{P}{A_{NF}}\frac{dA_{NF}}{dp}\frac{1}{1+\beta A_{NF}} \\
&= S_P^{A_{NF}}\frac{1}{1+\beta A_{NF}}
\end{aligned}
$$

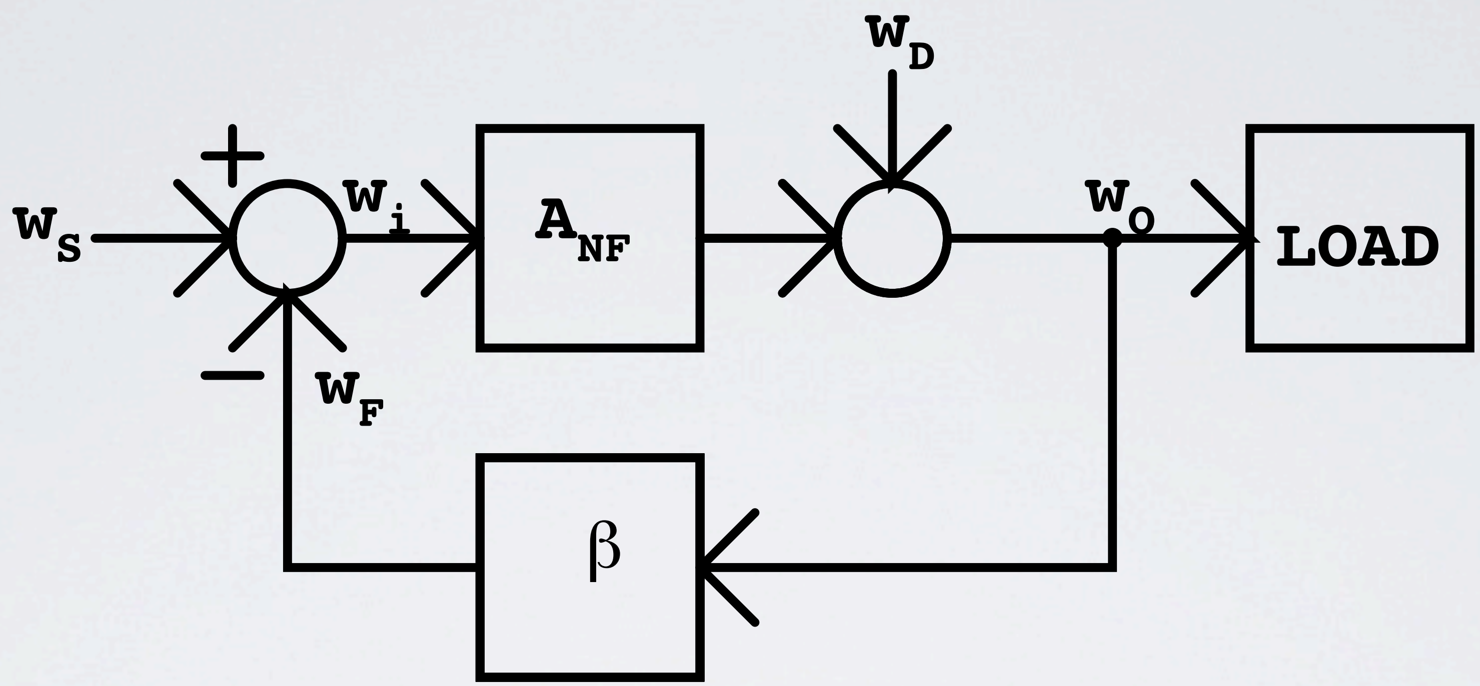
RESPUESTA DE BAJA FREC.

$$
\begin{aligned}
A_{NF}(s) &= A_{mid}\frac{s}{s+\omega_L} \\
A_F(s) &= \frac{A_{mid}\frac{s}{s++\omega_L}}{1+\beta A_{mid}\frac{s}{s+\omega_L}} \\
&= \frac{A_{mid}s}{s+\omega_L+\beta A_{mid}s} \\
&= \frac{A_{mid}s}{s(1+\beta A_{mid})+\omega_L+} \\
&= \frac{A_{mid}}{1+\beta A_{mid}}\frac{s}{s+\frac{\omega_L}{1+\beta A_{mid}}}
\end{aligned}
$$

RESPUESTA DE ALTA FREC.

$$
\begin{aligned}
A_{NF} &= A_{mid}\frac{\omega_H}{s+\omega_H} \\
A_F(s) &= \frac{A_{mid}\frac{\omega_H}{s+\omega_H}}{1+\beta A_{mid}\frac{\omega_H}{s+\omega_H}} \\
&= \frac{A_{mid}\omega_H}{s+\omega_H+\beta A_{mid}\omega_H} \\
&= \frac{A_{mid}\omega_H}{s+\omega_H(1+\beta A_{mid})} \\
&= \frac{A_{mid}}{1+\beta A_{mid}}\,\frac{\omega_H(1+\beta A_{mid})}{s+\omega_H(1+\beta A_{mid})}
\end{aligned}
$$

DISTORCIÓN



$$
\begin{aligned}
w_O &= w_D + A_{NF} w_i \\
&= w_D + A_{NF}(w_S - \beta w_O) \\
&= \frac{w_D}{1+\beta A_{NF}} + \frac{A_{NF}}{1+\beta A_{NF}}
\end{aligned}
$$

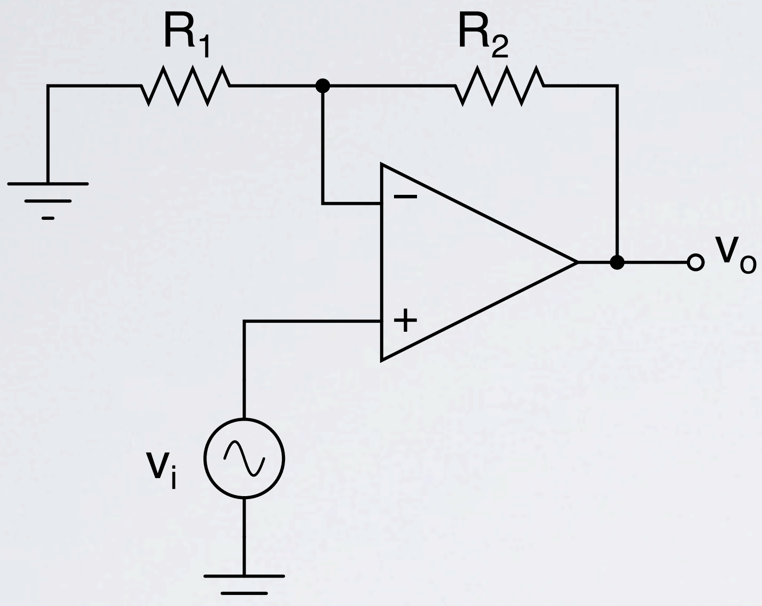
1.5 Negative feedback

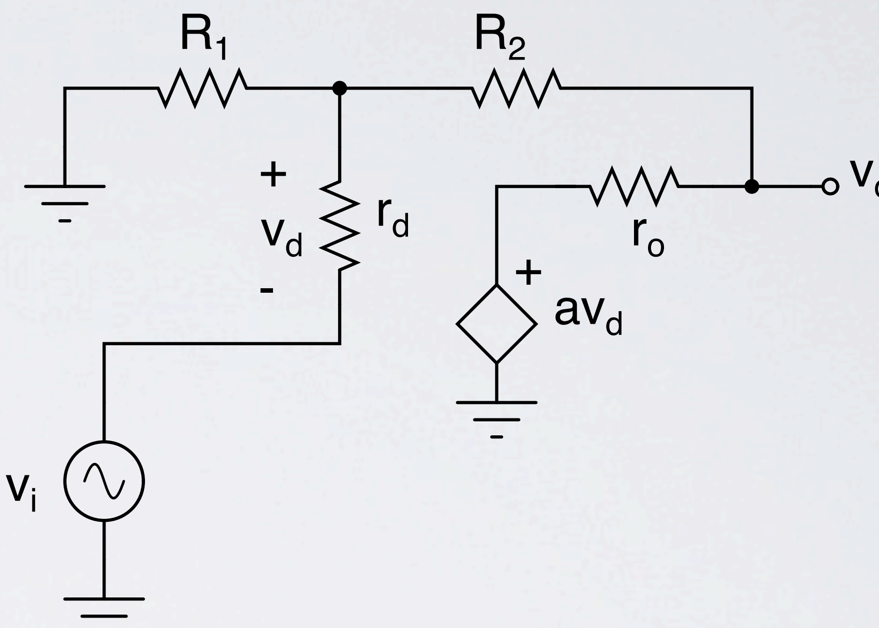
1.45 A voltage amplifier has $a = 10^5$ V/V and $v_i = 10$ mV. Find v_d, v_f, v_o, A, T, and the percentage deviation of A from A_{ideal} for $\beta = 10^{-3}$ V/V, 10^{-2} V/V, 10^{-1} V/V, and 1 V/V. Compare the various cases and comment.

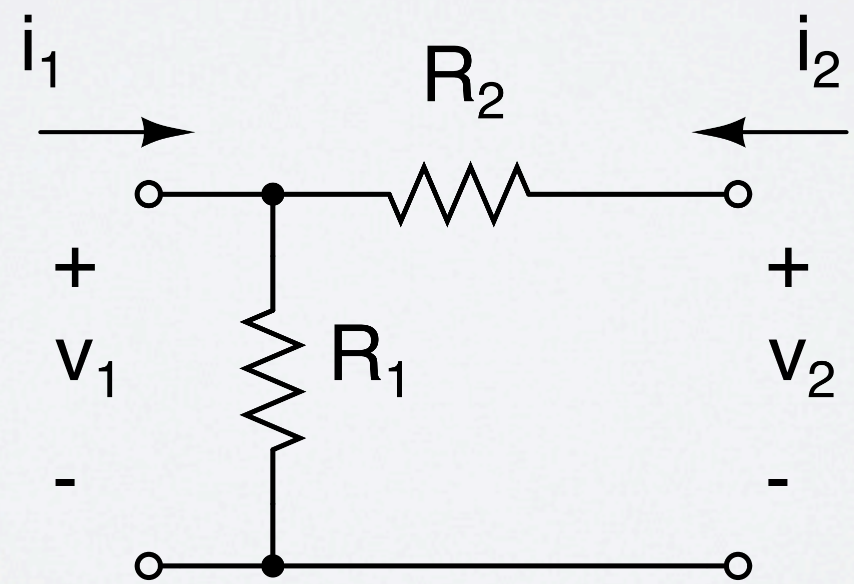
1.46 (*a*) Find the desensitivity factor of a negative-feedback system with $a = 10^3$ and $A = 10^2$. (*b*) Find A exactly via Eq. (1.40), and approximately via Eq. (1.49) if a drops by 10%. (*c*) Repeat (*b*) for a 50% drop in a; compare with (*b*) and comment.

1.47 You are asked to design an amplifier with a gain A of 10^2 V/V that is accurate to within ±0.1%, or $A = 10^2$ V/V ± 0.1%. All you have available are amplifier stages with $a = 10^4$ V/V ± 25% each. Your amplifier can be implemented using a cascade of basic stages, each employing a suitable amount of negative feedback. What is the minimum number of stages required? What is the β of each stage?

AMP. SIN INVERSIÓN







$$\beta = \frac{v_1}{v_2} \Big|_{i_1=0} = \frac{R_1}{R_1 + R_2}$$

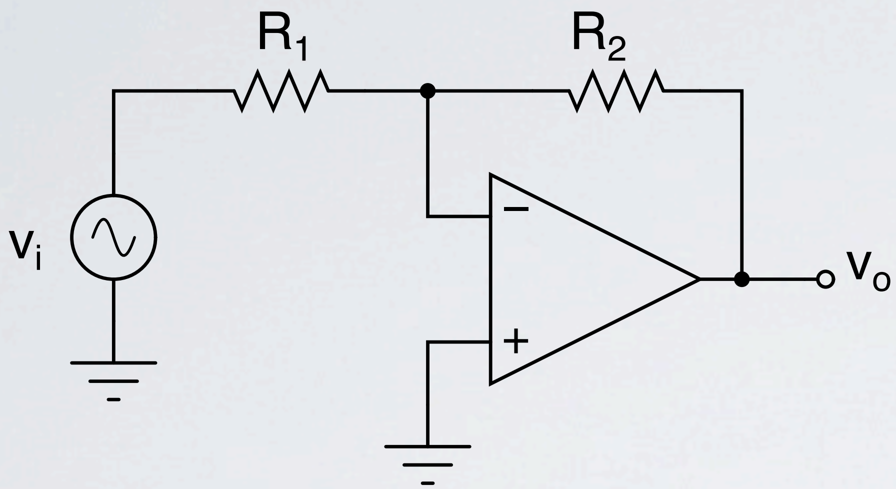
$$T = \frac{v_o}{v_i} = \frac{R_{22}}{r_o + R_{22}} a \frac{r_d}{r_d + R_{11}} \frac{R_1}{R_1 + R_2}$$

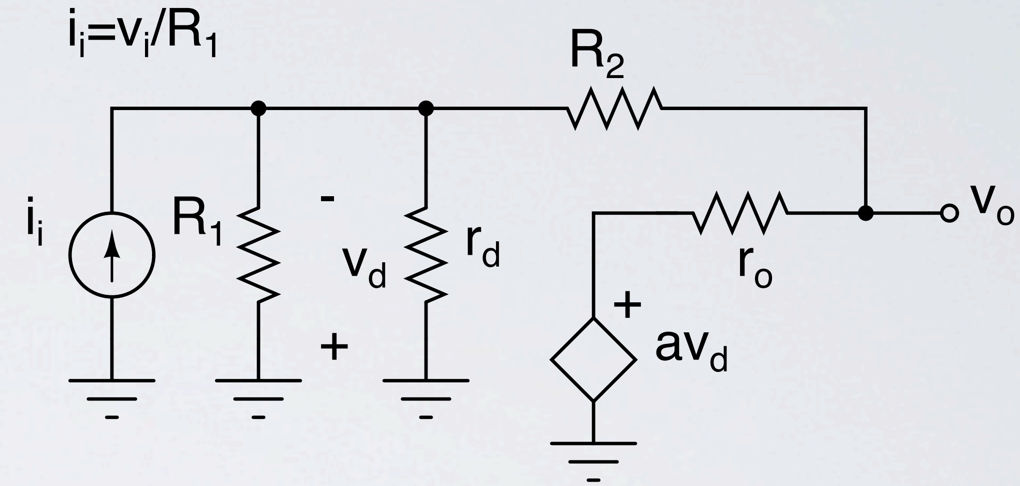
Para un diseño correcto, $r_d \gg R_{11}$ y $r_o \ll R_1 + R_2$, y.

$$T \approx \frac{aR_1}{R_1 + R_2} = a\beta$$

$$A_f = \frac{1}{\beta} \frac{1}{1 + \frac{1}{T}} = \left(1 + \frac{R_2}{R_1}\right) \frac{1}{1 + \frac{1}{T}}$$

AMP CON INVERSIÓN





$$T = a \frac{R_1 \mid\mid R_2 \mid\mid r_d}{r_o + R_2}$$

Usualmente, $r_d \gg (R_1 \mid\mid R_2)$ y $r_o \ll R_2$, así que

$$T \approx a \frac{R_1}{R_1 + R_2}$$

Esta es la misma expresión que obtuvimos para el amplificador sin inversión.

$$A_{vf} = \frac{v_O}{v_i} = -\frac{R_2}{R_1} \frac{1}{1 + \frac{1}{T}}$$

1.54 (*a*) Find A_{ideal} in the circuit of Fig. P1.54 if all resistances are equal. (*b*) Assuming $r_d \cong \infty$ and $r_o \cong 0$, find a_{min} such that the deviation of A from A_{ideal} is less than 0.1%.

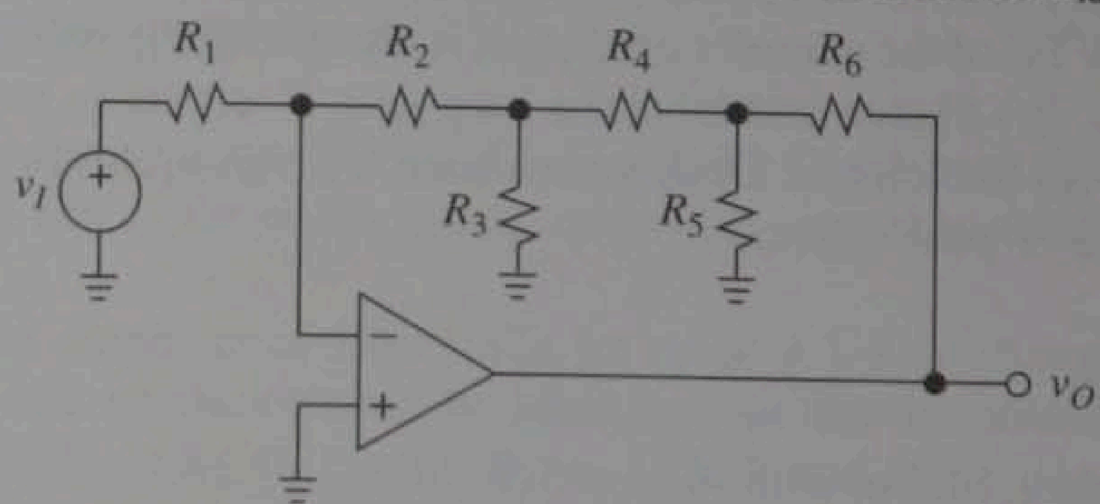


FIGURE P1.54