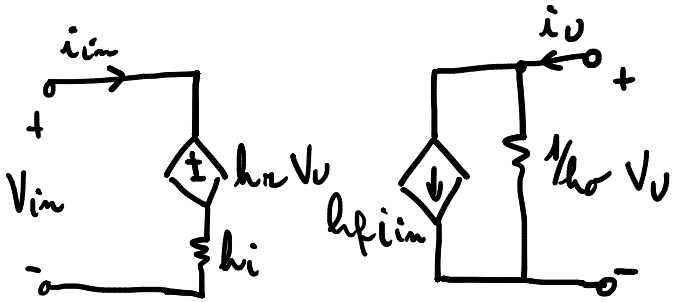
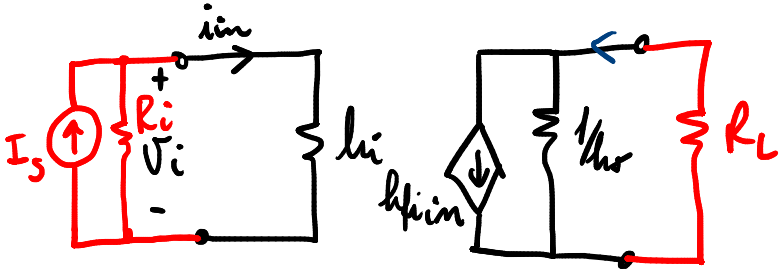


$$\begin{cases} i_U = h_f i_{in} + h_o V_U \\ V_{in} = h_r V_U + h_i i_{in} \end{cases}$$

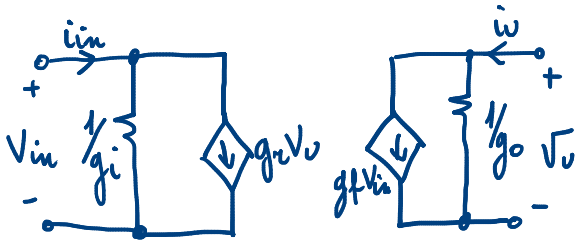


$$i_U = h_f i_{in} \cdot \frac{1/h_o}{1/h_o + R_L} \qquad i_{in} = \frac{R_i}{R_i + h_i} I_S$$

$$i_U = h_f \frac{1/h_o}{1/h_o + R_L} \cdot \frac{R_i}{R_i + h_i} I_S$$

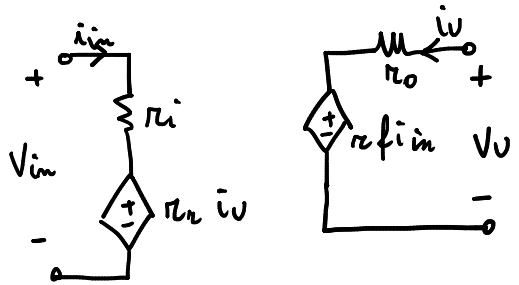
$$A_I$$

AMPL. TRANSCONDUTTIVO



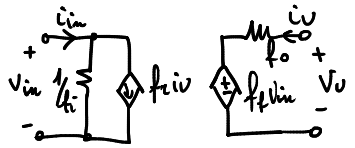
$$\begin{cases} i_U = g_f V_{in} + g_o V_U \\ i_{in} = g_i V_{in} + g_r V_U \end{cases}$$

AMPL. TRANSRESISTIVO



$$\begin{cases} V_U = r_o i_U + r_f i_{in} \\ V_{in} = r_i i_{in} + r_r i_U \end{cases}$$

$$\begin{cases} v_u = f_f v_{in} + f_o i_u \\ i_{in} = f_i v_{in} + f_r i_u \end{cases}$$



$$f_f = \left.\frac{v_u}{v_{in}}\right|_{i_u=0} ; \quad f_o = \left.\frac{v_u}{i_u}\right|_{v_{in}=0}$$

$$f_i = \left.\frac{i_{in}}{v_{in}}\right|_{i_u=0} ; \quad f_r = \left.\frac{i_{in}}{i_u}\right|_{v_{in}=0}$$

$$\begin{cases} i_u = h_f i_{in} + h_o v_u \\ v_{in} = h_i i_{in} + h_r v_u \end{cases}$$

$$h_f = \left.\frac{i_u}{i_{in}}\right|_{v_u=0} \qquad h_o = \left.\frac{i_u}{v_u}\right|_{i_{in}=0}$$

$$h_i = \left.\frac{v_{in}}{i_{in}}\right|_{v_u=0} \qquad h_r = \left.\frac{v_{in}}{v_u}\right|_{i_{in}=0}$$

$$\begin{cases} i_u = g_f v_{in} + g_o v_u \\ i_{in} = g_i v_{in} + g_r v_u \end{cases}$$

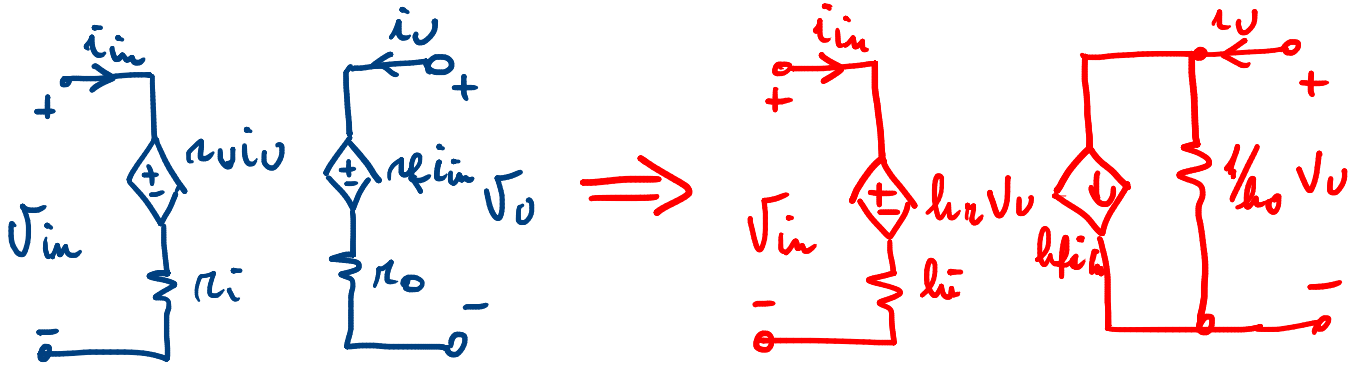
$$g_f = \left.\frac{i_u}{v_{in}}\right|_{v_u=0} \qquad g_o = \left.\frac{i_u}{v_u}\right|_{v_{in}=0}$$

$$g_i = \left.\frac{i_{in}}{v_{in}}\right|_{v_u=0} ; \quad g_r = \left.\frac{i_{in}}{v_u}\right|_{v_{in}=0}$$

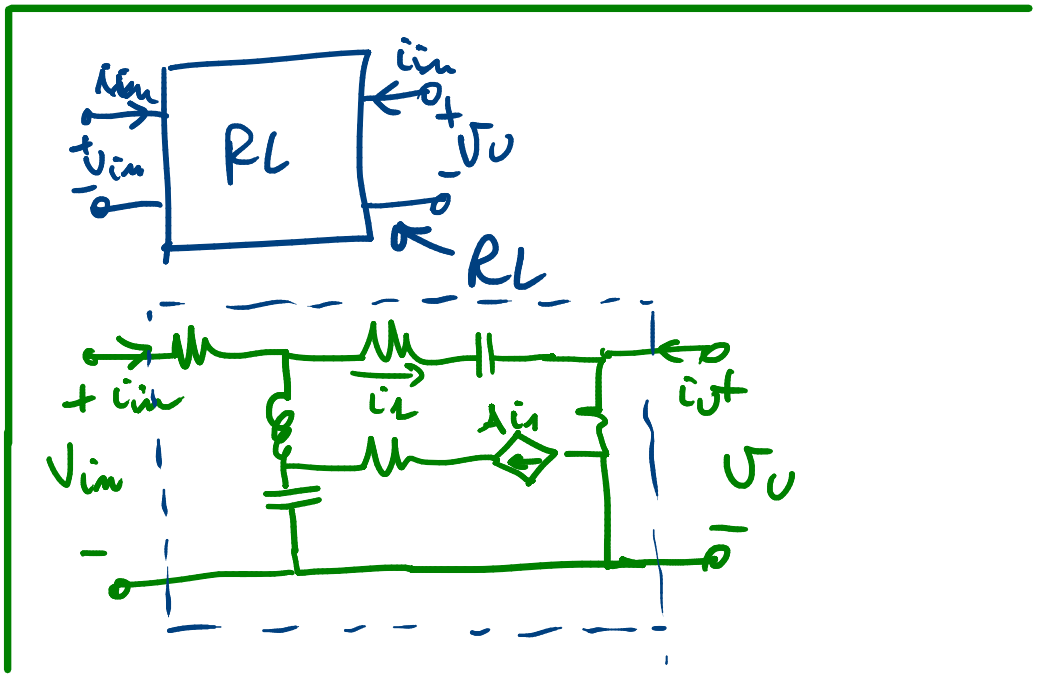
$$\begin{cases} v_u = r_f i_{in} + r_o i_u \\ v_{in} = r_i i_{in} + r_r i_u \end{cases}$$

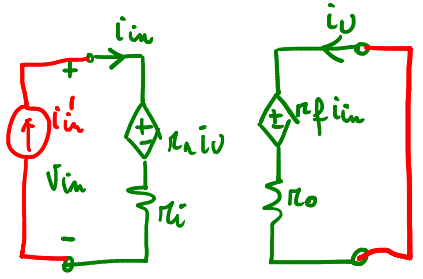
$$r_f = \left.\frac{v_u}{i_{in}}\right|_{i_u=0} ; \quad r_o = \left.\frac{v_u}{i_u}\right|_{i_{in}=0}$$

$$r_i = \left.\frac{v_{in}}{i_{in}}\right|_{i_u=0} ; \quad r_r = \left.\frac{v_{in}}{i_u}\right|_{i_{in}=0}$$



$$h_f = \left.\frac{i_v}{i_{in}}\right|_{v_v = 0}$$





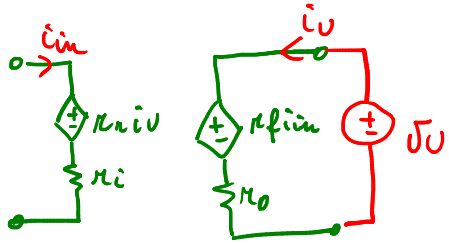
$$h_f = \left.\frac{i_U}{i_{in}}\right|_{V_U=0}$$

$$i_U = -\frac{r_f i_{in}'}{r_o}$$

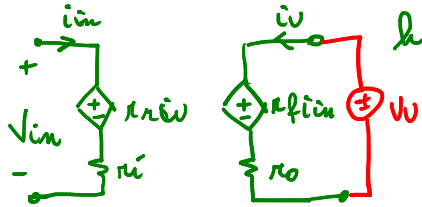
$$r_f i_{in}' + r_o i_U = 0 \qquad i_U = -\frac{r_f}{r_o} i_{in}'$$

$$h_f = -\frac{r_f}{r_o}$$

$$h_o = \left.\frac{i_U}{V_U}\right|_{i_{in}=0}$$



$$i_U = \frac{V_U}{r_o} \Rightarrow h_o = \frac{1}{r_o}$$



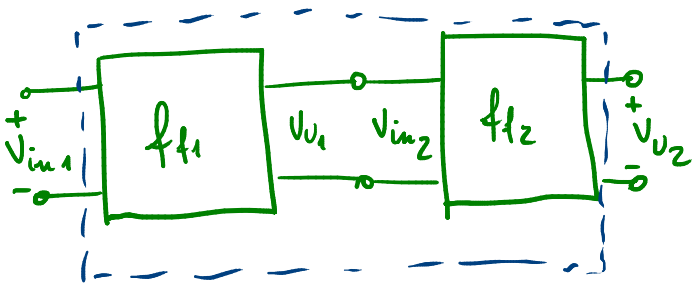
$$h_r = \left.\frac{V_{in}}{V_U}\right|_{i_{in}=0} =$$

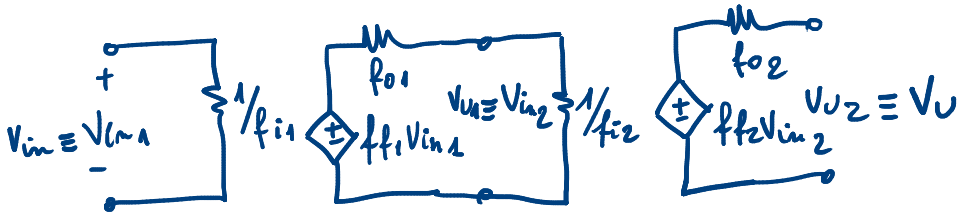
$$i_U = \frac{V_U}{r_o}$$

$$V_{in} = r_r i_U = \frac{r_r}{r_o} V_U$$

$$h_r = \frac{r_r}{r_o}$$

$$h_i = \left.\frac{V_{in}}{i_{in}}\right|_{V_U=0} = r_i - r_r \frac{r_f}{r_o}$$





$$V_U = f_{f2} V_{in2} \; ; \; V_{in2} = \frac{1/f_{i2}}{f_{o1} + 1/f_{i2}} f_{f1} V_{in1}$$

$$V_U = f_{f2} f_{f1} \frac{\frac{1}{f_{i2}}}{f_{o1} + 1/f_{i2}} V_{in}$$

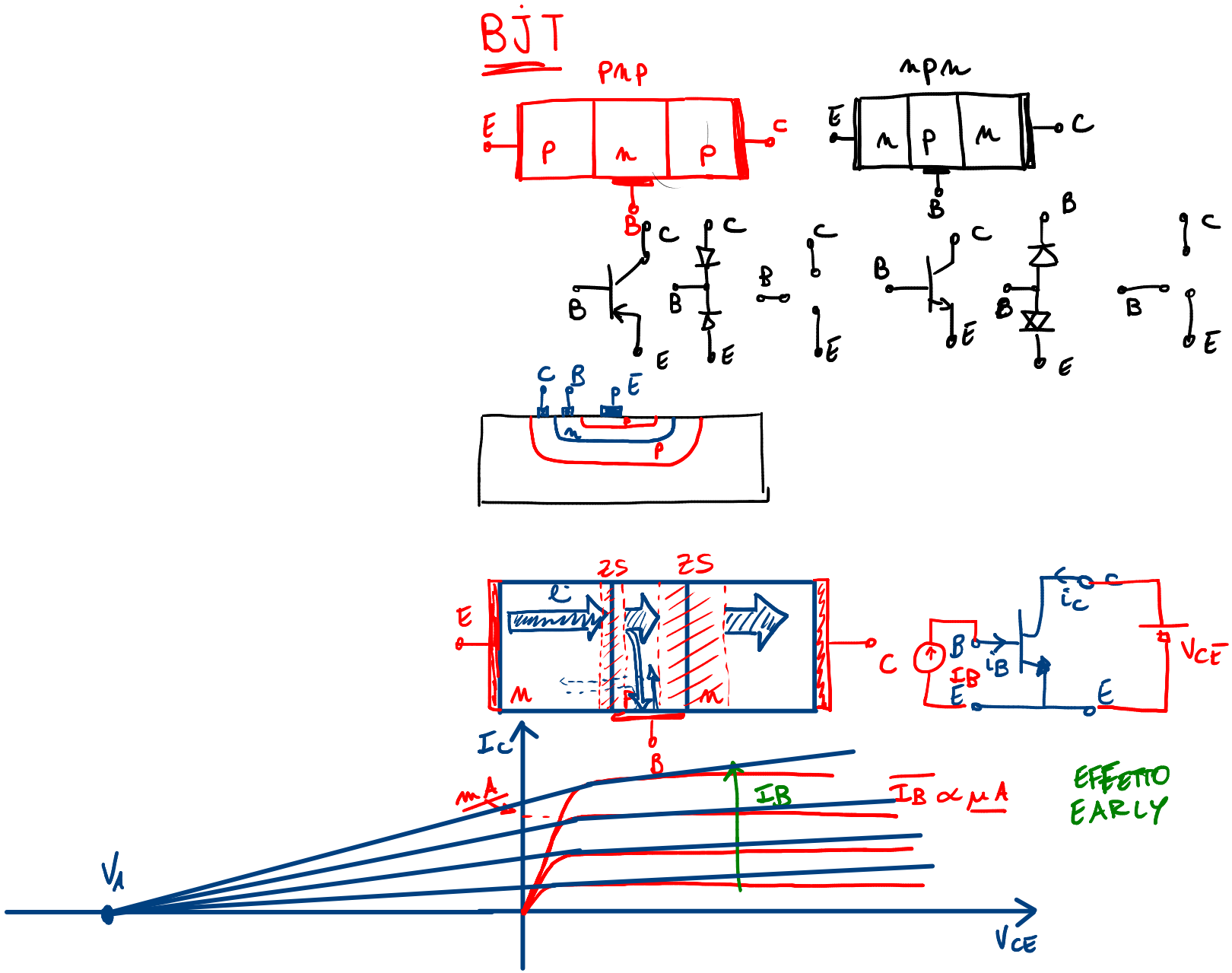
$f_{f\,tot}$

$$A(s) = k \frac{(s+\omega_{o1})(s+\omega_{o2}) \cdots (s+\omega_{om})}{(s+\omega_{p1})(s+\omega_{p2}) \cdots (s+\omega_{pn})} = \frac{V_U(s)}{V_S(s)}$$

Guadagno di potenza

- Potenza totale in ingresso e in uscita
  - $P_{IN} = i_{in} v_{in} + I_{in} V_{in} + i_{in} V_{in} + I_{in} v_{in}$
  - $P_U = i_u v_u + I_u V_u + i_u V_u + I_u v_u$
- Potenza media associata all'informazione
  - $P_{INm} = i_{in} v_{in}$
  - $P_{Um} = i_u v_u = A_I A_V i_{in} v_{in} = A_P P_{INm}$
- Il rapporto A_P tra le potenze medie associate all'informazione si definisce guadagno di potenza
  - Se $A_P < 1$, si parla di attenuatore

BJT


pnp
npn
E
B
C
P
n
ZS
ZS
i_C
i_B
I_B
V_{CE}
I_C
mA
I_B
$I_B \propto \mu A$
EFFETTO EARLY
V_A
V_{CE}