Elektronik II

Series-Series, Shunt-Shunt Feedback and Worked Examples

Original notes: Ders12.pdf

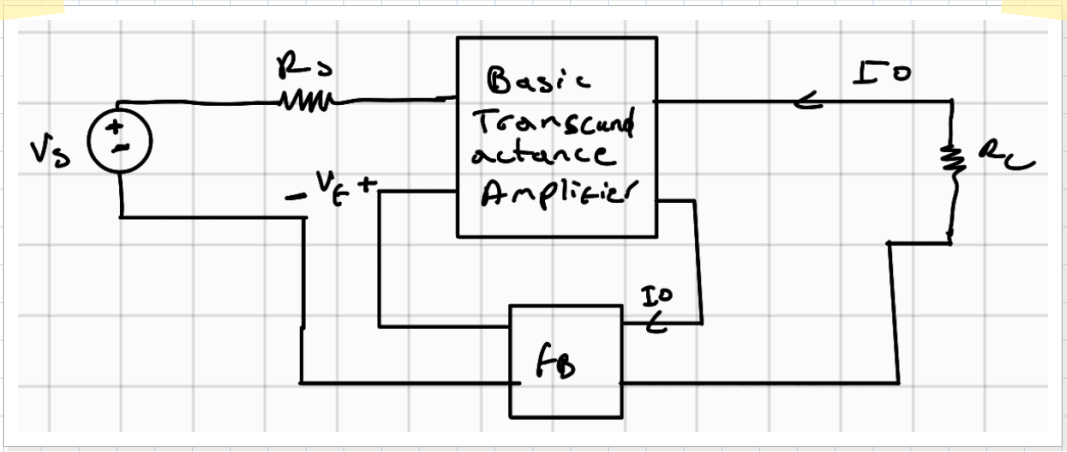
UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

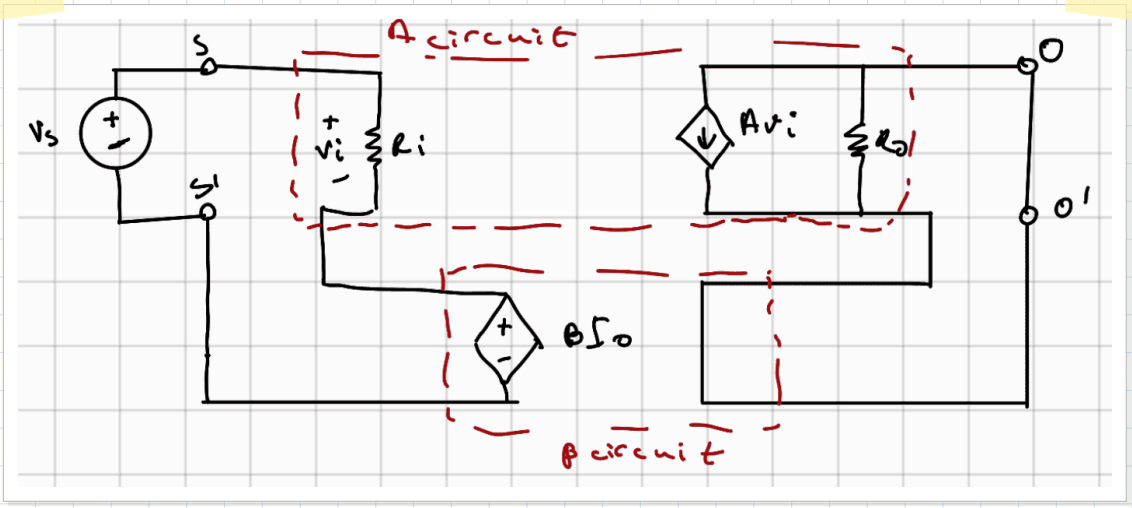
orig. p. 1

Series (o) – Series (I) Feedback Topology

- Suitable for transconductance Amplifier

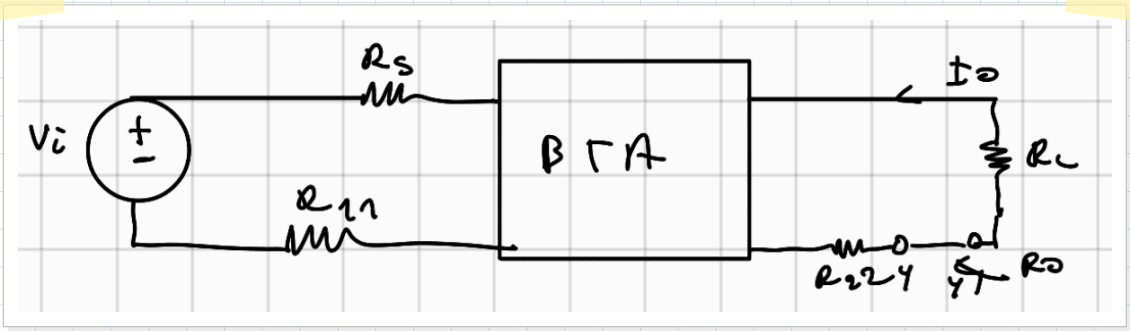


original drawing, p. 1

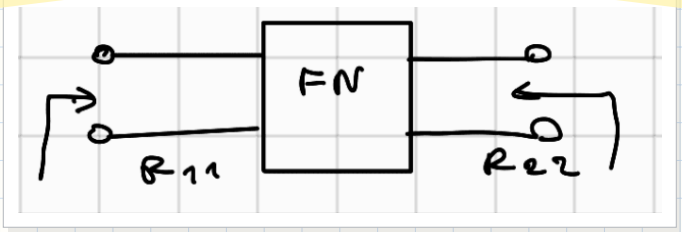


original drawing, p. 1

Two-port equivalent circuit

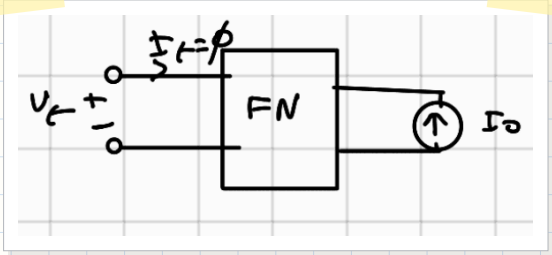


original drawing, p. 1



original drawing, p. 1

$$\frac{I_o}{V_1} = A$$



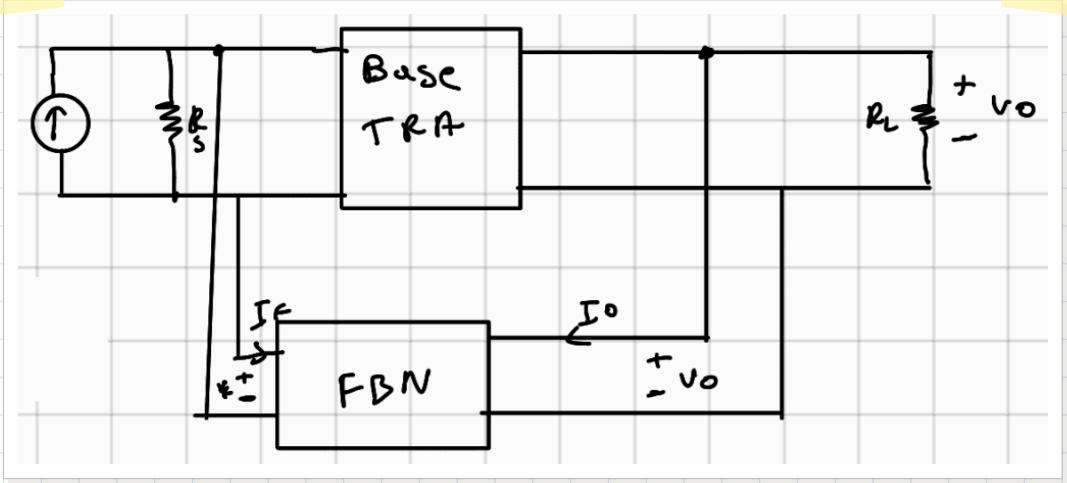
original drawing, p. 1

$$\beta = \frac{V_f}{I_o}$$

$$R_{if} = R_i\,(1 + A\beta)$$
$$R_{of} = R_o\,(1 + A\beta)$$
$$A_f = \frac{A}{1 + A\beta}$$

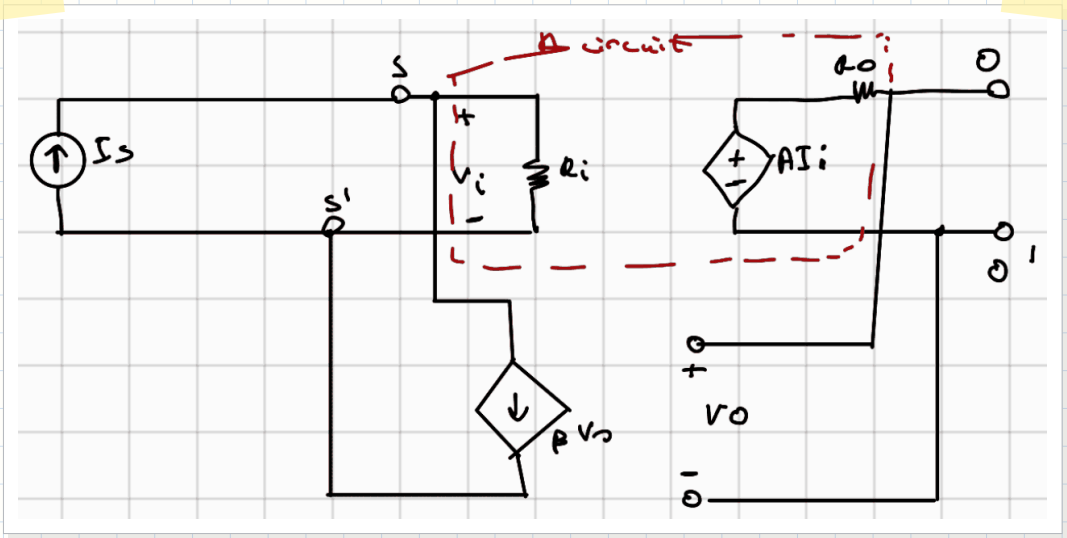
orig. p. 2

Shunt – Shunt feedback topology (Transresistance amplifier)

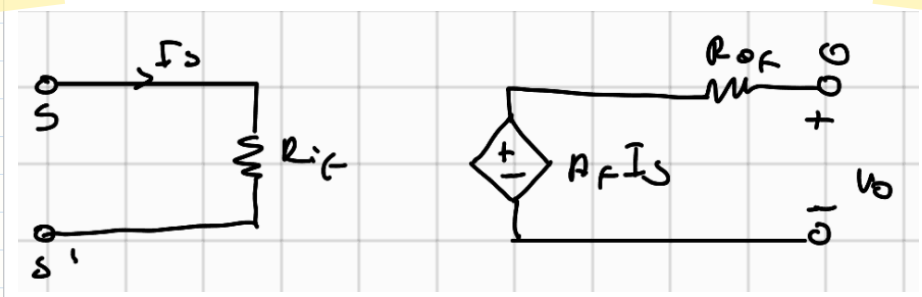


original drawing, p. 2

$$A_o = \frac{V_{out}}{I_{in}}$$

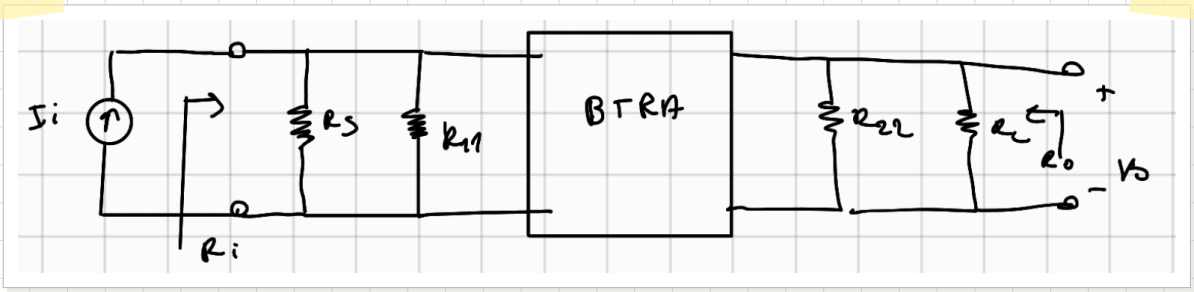


original drawing, p. 2



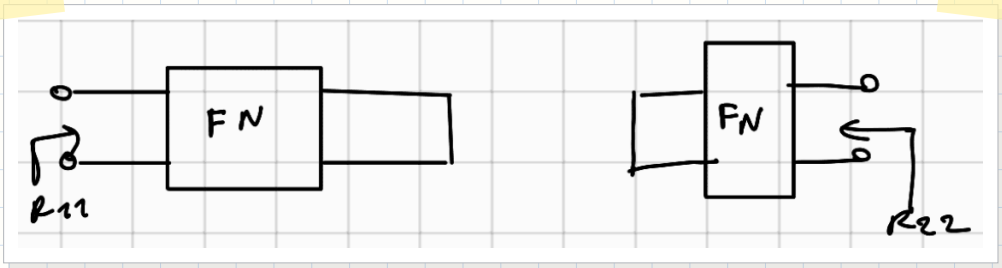
original drawing, p. 2

Close loop equivalent circuit model

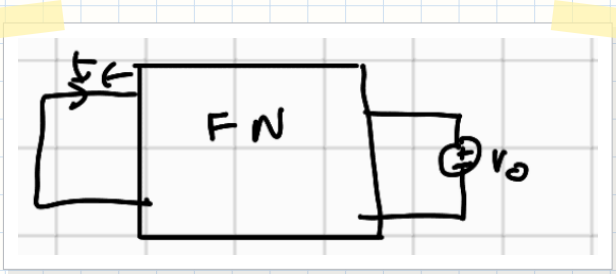


original drawing, p. 2

orig. p. 3



original drawing, p. 3



original drawing, p. 3

$$\beta = \frac{I_f}{V_o}$$

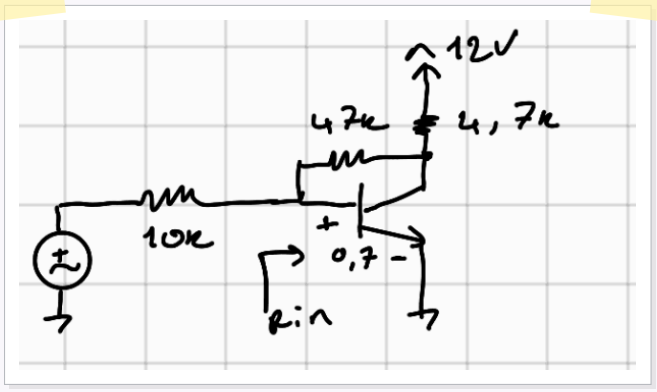
$$R_{if} = \frac{R_i}{1 + A\beta}$$

$$R_{of} = \frac{R_o}{1 + A\beta}$$

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

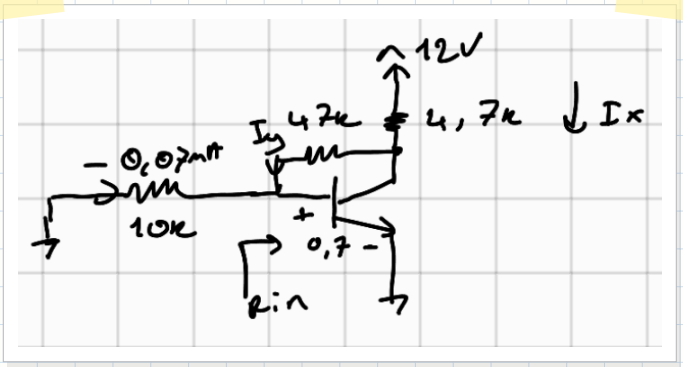
Example 2

Analyze the circuit below and calculate $\frac{v_o}{v_s}$, R_{in}, and R_{out}



original drawing, p. 3

ignore r_o! ($V_A = \infty$) $\beta = 100$



original drawing, p. 3

$$I_x = \frac{12 - V_C}{4{,}7\,k\Omega} \qquad I_B = I_y - 0{,}07\,mA$$

$$I_C = 100\,I_B \Rightarrow 100\,I_y - 7\,mA = I_C$$

$$I_y = \frac{V_C - 0{,}7}{47k} \qquad I_C = I_x - I_y = \frac{12 - V_C}{4{,}7k} - \left(\frac{V_C - 0{,}7}{47k}\right)$$

$$100\left(\frac{V_C - 0{,}7}{(47k)}\right) - 7\,mA = \frac{12 - V_C}{4{,}7k} - \left(\frac{V_C - 0{,}7}{47k}\right)$$

orig. p. 4

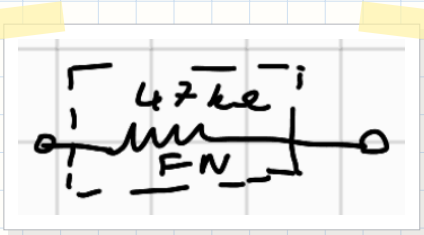
$V_C = 4{,}95\,V$

$I_B = 0{,}015\,mA$ $\qquad g_m = \frac{I_C}{V_T} = 60\,mS$

$I_C = 1{,}5\,mA$ $\qquad r_\pi = (\beta + 1) \cdot \frac{1}{g_m} = 1{,}66\,k\Omega$

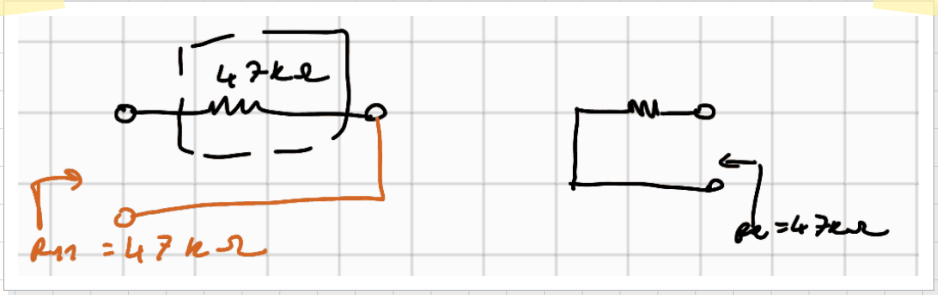
a) Feedback type: Shunt (o) – Shunt (I) (Transresistance)

b) Feedback Network:

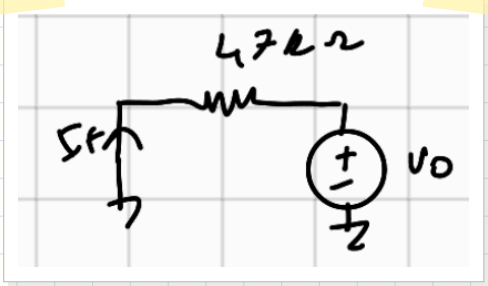


original drawing, p. 4

c) Calculate R_{11}, R_{22}, and β



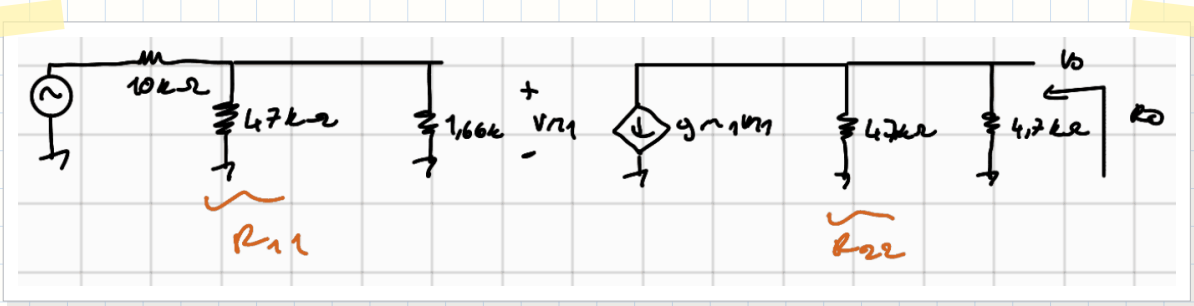
original drawing, p. 4



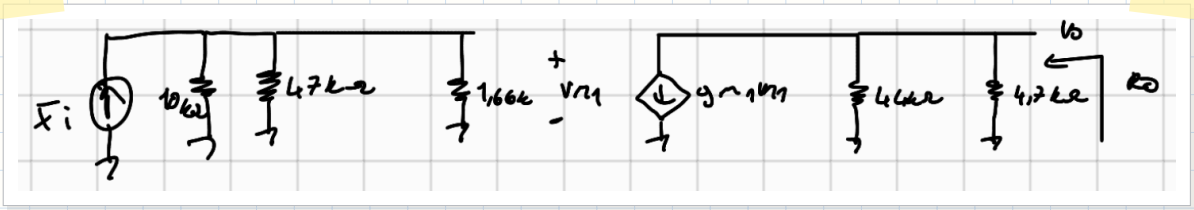
original drawing, p. 4

$$\frac{I_f}{V_o} = -\frac{1}{47k\Omega} = \beta$$

d)



original drawing, p. 4



original drawing, p. 4

$$A = \frac{v_o}{I_i} \Rightarrow \begin{cases} v_o = -g_{m1}\, v_{\pi 1}\,(4{,}27k) \\ v_o = -256{,}2\, v_{\pi 1} \\ v_{\pi 1} = I_i\,(10k \parallel 47k \parallel 1{,}66k) \\ v_{\pi 1} = I_i \cdot 1{,}38k \end{cases}$$

$g_{m1} = 60\,mS$

orig. p. 5

$$v_o = -256{,}2 \cdot I_i \cdot 1{,}38k$$

$$A = \frac{v_o}{I_i} = -353{,}6\,k\Omega$$

$$R_i = 1{,}38k$$
$$R_o = 4{,}27k$$

$$A_f = \frac{A}{1 + A\beta} = \frac{-353{,}6k}{1 + 353{,}6k \cdot \frac{1}{47k}} = \frac{-353{,}6\,k\Omega}{8{,}52}$$

$$A_f = -41{,}4\,k\Omega$$

$$R_{if} = \frac{1{,}38k}{8{,}52} \Rightarrow R_{if} = 162\,\Omega$$

$$R_{of} = \frac{4{,}27}{8{,}52} = 501{,}2\,\Omega$$

$$R_{in} = \left(\frac{1}{162} - \frac{1}{10k}\right)^{-1} \approx 165\,\Omega$$

$$R_{out} = R_{of}$$

$$\frac{v_o}{I_i} = -353{,}6\,k\Omega$$

$$\frac{v_o}{v_s} = \frac{A_f}{R_s} = -4{,}14\ [V/V]$$

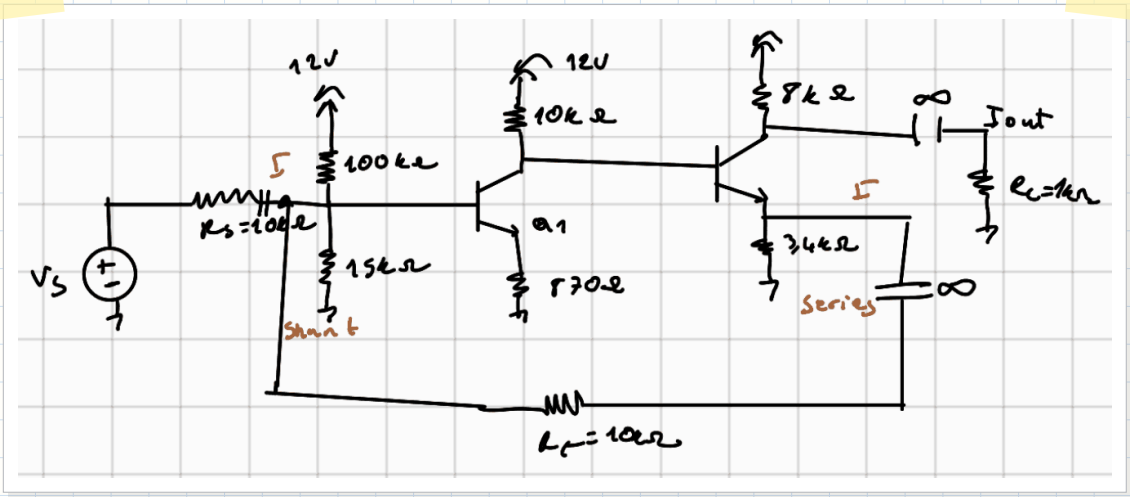
Example

Analyze the current amplifier given below and calculate: $\frac{v_o}{v_{in}}$, $\frac{I_{out}}{I_{in}}$, R_{in} and R_{out}

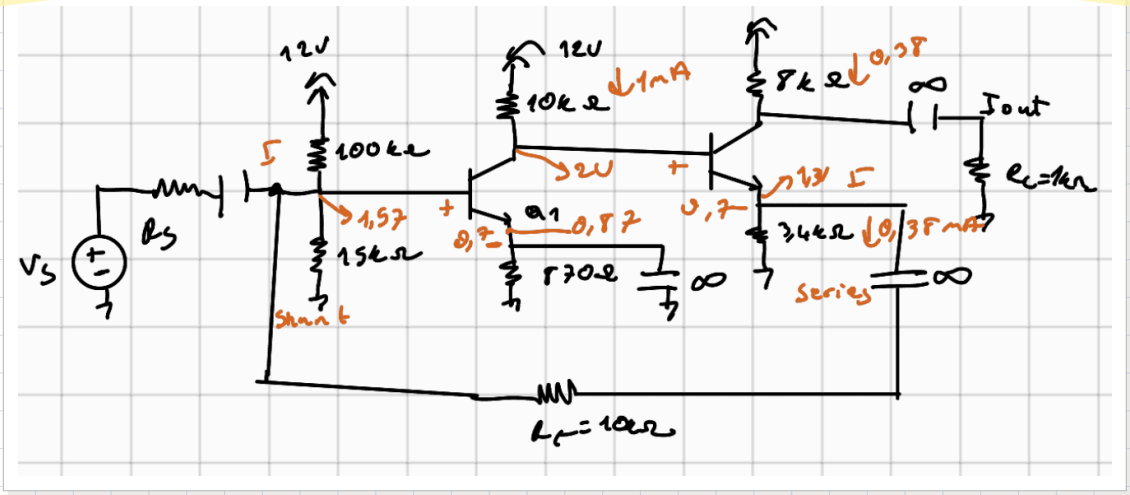
Assume β = 100 for small signal, ∞ for DC

orig. p. 6

$V_A = 75\,V$



original drawing, p. 6



original drawing, p. 6

$I_{C1} = 1\,mA$ $\quad I_{C2} = 0{,}38\,mA$ $\quad r_o = \frac{V_A}{I_C}$

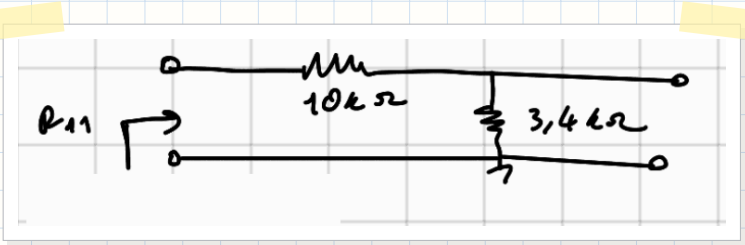
$g_{m1} = 40\,mS$ $\quad g_{m2} = 15{,}2\,mS$

$r_{\pi 1} = 2{,}5\,k\Omega$ $\quad r_{\pi 2} \approx 6{,}6\,k\Omega$

$r_{o1} = 75\,k\Omega$ $\quad r_{o2} = \frac{75}{0{,}38} \approx 197\,k\Omega$

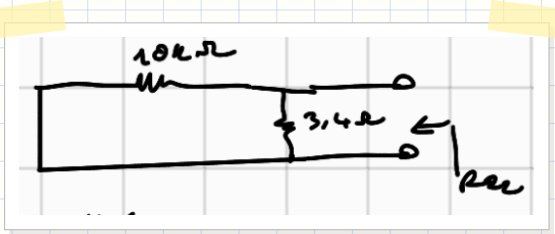
a) Feedback type : Series-Shunt

b) Feedback network out two port parameters



original drawing, p. 6

$$R_{11} = 13{,}4\,\text{k}\Omega$$

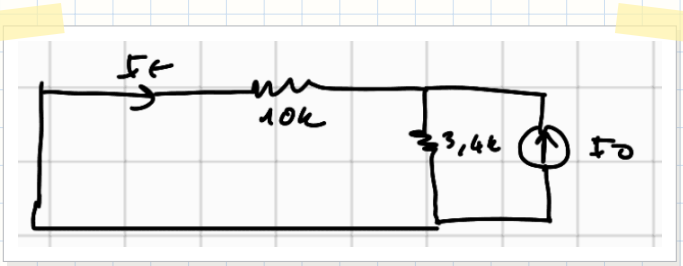


original drawing, p. 6

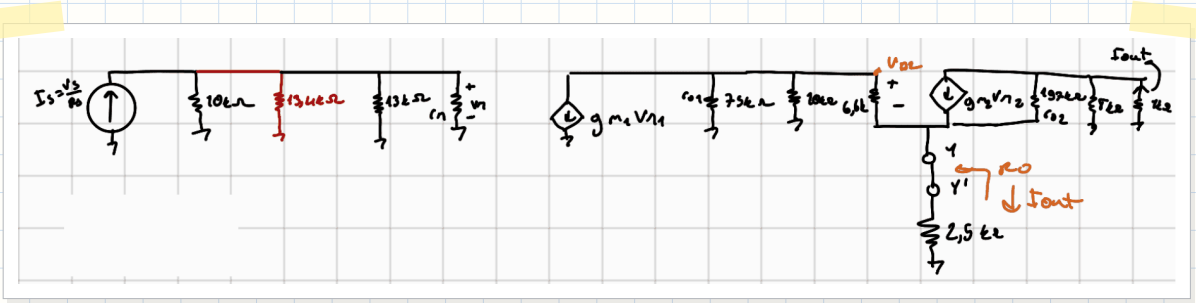
$$R_{22} = 10\text{k} \parallel 3{,}4\text{k}\Omega \Rightarrow R_{22} = 2{,}5\,\text{k}\Omega$$

orig. p. 7

$$\beta = \frac{I_f}{I_o} = \frac{-3{,}4\text{k}}{13{,}4\text{k}} \approx -0{,}25\ [\text{A/A}]$$



original drawing, p. 7



original drawing, p. 7

$$A = \frac{I_{out}}{I_s}$$

$$v_{\pi 1} = I_s\,(10k \parallel 13{,}4k \parallel 13k \parallel 2{,}5k) = 1{,}55k\,I_s$$

$$v_{be2} = -g_{m1}\,v_{\pi 1}\left(75k \parallel 10k \parallel \left(6{,}6k + \underbrace{250k}_{(\beta+1)(2{,}5k)}\right)\right) \approx -320\,v_{\pi 1}$$

$$I_{out} \approx \frac{v_{be2}}{\underbrace{\frac{6{,}6k\Omega}{100} + 2{,}5k}_{2{,}57k\Omega}} \cdot \frac{8}{9}$$

$$\frac{I_{out}}{I_s} = -192{,}4\ [A/A]$$

$$R_i = 1{,}55\,k\Omega$$

$$R_o = 2{,}5k\Omega + \underbrace{\frac{6{,}6k\Omega}{\beta+1}}_{101} + \underbrace{\frac{10k \parallel 75k}{\beta+1}}_{101}$$

$$= 2{,}7\,k\Omega$$

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

$$1 + A\beta = 1 + (-0{,}25 \times -192{,}4)$$

$$\boxed{1 + A\beta = 49{,}1}$$

$$A_f = \frac{-192{,}4}{49{,}1} \approx -3{,}92\ [A/A]$$

orig. p. 8

$$R_{if} = \frac{R_i}{1 + A\beta} = \frac{1{,}55k}{49{,}1} \approx 31{,}5\,\Omega$$

$$R_{of} = R_o\,(1 + A\beta) = 2{,}7k \times 49{,}1 \approx 132\,k\Omega$$