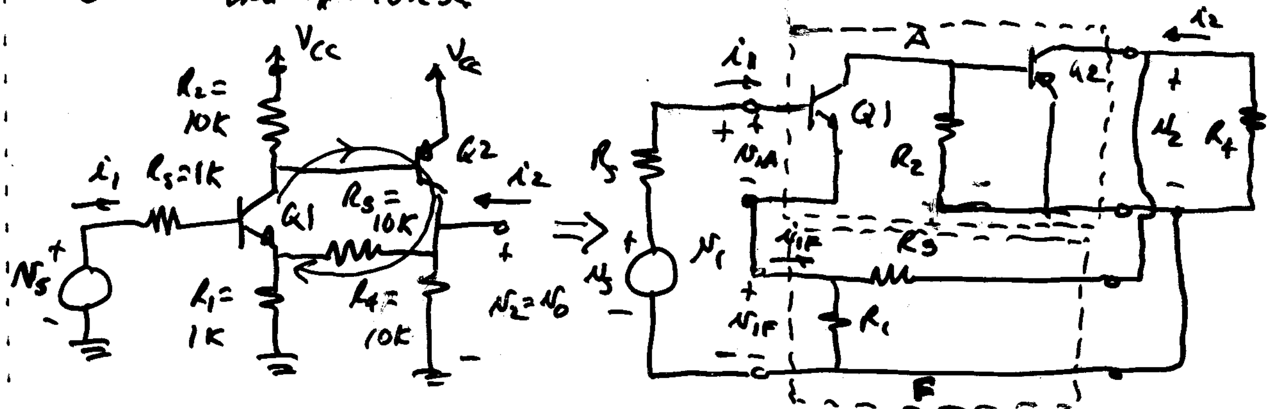
Quiz #10 - High Frequency Response
Vote results: 21 Yes 7 No

Example of Series-Shunt

Find $\frac{v_o}{v_s}$, $\frac{v_s}{i_1}$, and $\frac{v_o}{i_2}$ for the following circuit where $\beta = 100$ and $r_\pi = 10k\Omega$

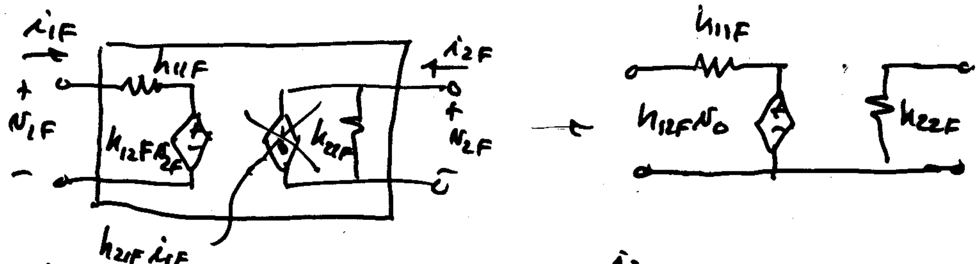


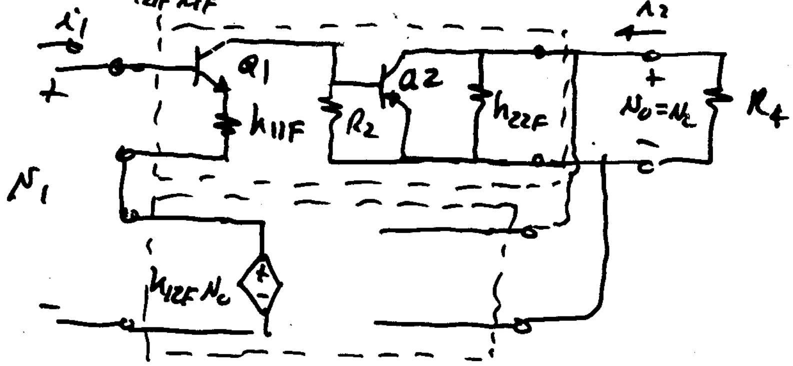
$h_{11T} = h_{11A} + h_{11F}$ $\quad h_{22T} = h_{22A} + h_{22F}$ $\quad h_{12F} = \left.\frac{v_{1F}}{v_{2F}}\right|_{i_{1F}=0} = \frac{R_1}{R_1+R_3} = \frac{1}{11}$

$$h_{11F} = \left.\frac{v_{1F}}{i_{1F}}\right|_{v_2=0} = R_1 \| R_3 = 0.91k\Omega$$

$$h_{22F} = \left.\frac{i_{2F}}{v_{2F}}\right|_{i_{1F}=0} = \frac{1}{R_1+R_3} = \frac{1}{11k}$$

F network:

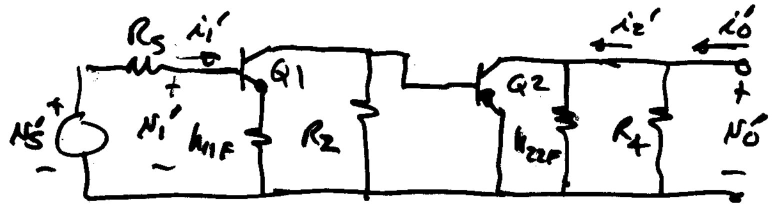




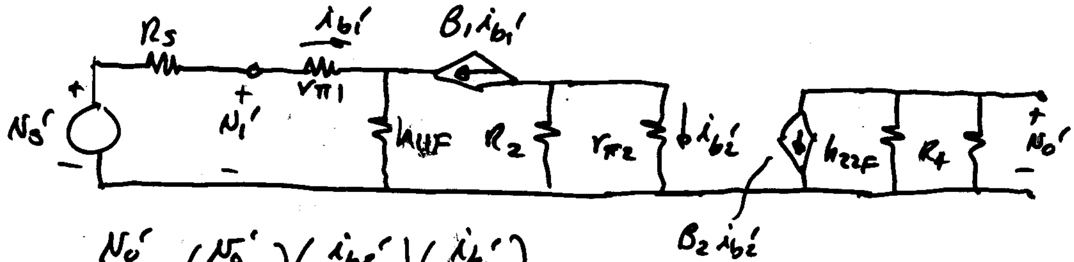
Continuing —

Prime variables

Next find A, the open-loop amplifier gain ($\underline{h_{RF}=0}$)



$$A = \frac{v_o'}{v_s'}$$



$$\frac{v_o'}{v_s'} = \left(\frac{v_o'}{i_{b2}'}\right)\left(\frac{i_{b2}'}{i_{b1}'}\right)\left(\frac{i_{b1}'}{v_s'}\right)$$

$$= \left(-\beta_2 \, R_4 \| \frac{1}{h_{22F}}\right)\left(\frac{-\beta_1 R_2}{r_{\pi 2}+R_2}\right)\left(\frac{1}{R_S + r_{\pi 1} + (1+\beta_1)h_{11F}}\right)$$

$$= \left(-100 \cdot 10K \| 11k\right)\left(-\frac{100 \cdot 10k}{20K}\right)\left(\frac{1}{1K + 10K + (101)(0.91k)}\right) = +255\ V/V$$

$$A_F = \frac{v_o}{v_s} = \frac{A}{1+AF} = \frac{255}{1+255\left(\frac{1}{11}\right)} = \frac{255}{1+23.17} = \underline{\underline{10.54 \tfrac{V}{V}}}$$

$\frac{v_s}{i_1}$ = Input resistance = ?

$$\frac{v_s'}{i_1'} = R_S + r_{\pi 1} + (1+\beta_1)h_{11F} = 102.8 k\Omega$$

$$\frac{v_s}{i_s} = \frac{v_s'}{i_1'}(1+AF) \qquad (R_S + h_{11T})\left[1 + \overbrace{\frac{-h_{21A} h_{12F}}{(R_S + h_{11T})(G_L + h_{22T})}}^{1+AF}\right]$$

Input resistance $= \frac{v_s}{i_1} = (102.8 k\Omega)(1+23.17) = \underline{\underline{2.485 M\Omega}}$

Output Resistance $= \frac{v_o}{i_o} = \frac{v_o'/i_o'}{1+AF}$

$$\frac{v_o'}{i_o'} = \frac{1}{h_{22F} + \frac{1}{R_4}} = 11K \| 10K = 5.23K$$

∴ output resistance $= \frac{5.23K}{1+23.17} = \underline{\underline{216\Omega}}$

Generalize the Feedback Analysis of Transistors Fb Amplifiers

All four forms of fb can be analyzed in exactly the same way as done previously.

Let $x = h, g, y,$ or z

1.) Find x_{11F}

2.) Find x_{22F}

3.) Find $x_{12F} = F$ (B)

4.) Find A (the open-loop amplifier gain) incorporating x_{11F} and x_{22F} and the correct x_{21} variables.

5.) $A_F = \dfrac{A}{1+AF}$

6.) $R_{inF} = \begin{cases} (R_s + x_{11T})(1+AF) & \text{if series} \\ \dfrac{1}{(G_s + x_{11T})(1+AF)} & \text{if shunt} \end{cases}$

$R_{outF} = \begin{cases} \dfrac{1}{(G_L + x_{22T})(1+AF)} & \text{if shunt} \\ (R_L + x_{22T})(1+AF) & \text{if series} \end{cases}$

Feedback Topology	Two-Port Parameters
Shunt-shunt (Transresistance amplifier)	$i_1 = y_{11}v_1 + y_{12}v_2$ $i_2 = y_{21}v_1 + y_{22}v_2$
Shunt-series (current amplifier)	$i_1 = g_{11}v_1 + g_{12}i_2$ $v_2 = g_{21}v_1 + g_{22}i_2$
Series-series (Transconductance amplifier)	$v_1 = z_{11}i_1 + z_{12}i_2$ $v_2 = z_{21}i_1 + z_{22}i_2$
Series-shunt (Voltage Amplifier)	$v_1 = h_{11}i_1 + h_{12}v_2$ $i_2 = h_{21}i_1 + h_{22}v_2$