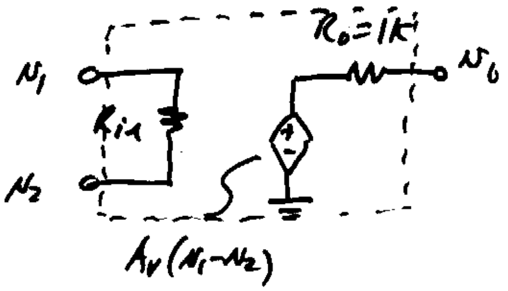
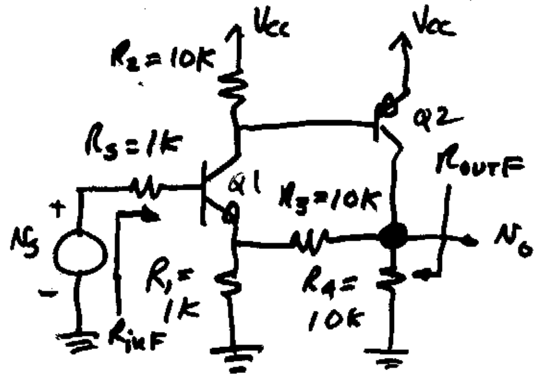
Small-Signal Model for the Voltage Amplifier (Op Amp)

$R_{in} = 25K\Omega$
$A_v = 10^4$ V/V
$R_o = 1K$



Back to Series-Shunt Transistor Feedback Example



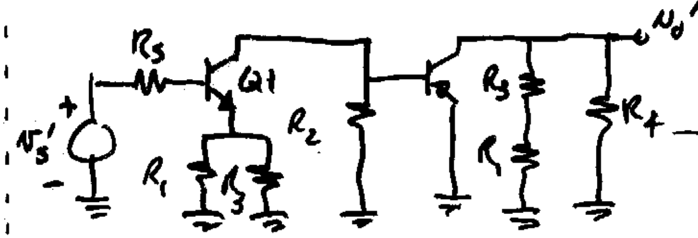
$\beta = 100 \quad r_\pi = 10K$

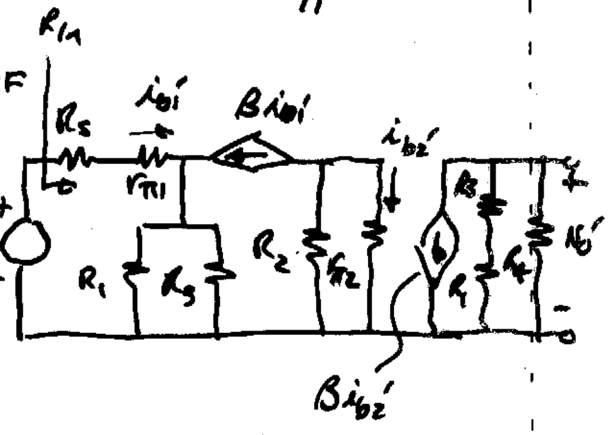
Find $\frac{v_o}{v_s}$, R_{inF}, & R_{outF} using feedback analysis methods.

$h_{11F} = R_1 \| R_3$, $h_{22F} = \frac{1}{R_1 + R_3}$, $h_{21F} = \frac{R_1}{R_1 + R_3}$

$B = \frac{1}{11}$

Step 4.) Find A when $B = 0 = h_{21F}$





$$\frac{v_o'}{v_s'} = A = \left(\frac{v_o'}{i_{b2}'}\right)\left(\frac{i_{b2}'}{i_{b1}'}\right)\left(\frac{i_{b1}'}{v_s'}\right) \quad \frac{1}{R_{in}}$$

$$= \left[-\beta\, R_4 \| (R_1 + R_3)\right]\left[\frac{-\beta R_2}{r_{\pi 2} + R_2}\right]\left[\frac{1}{R_S + r_\pi + (1+\beta) R_1 \| R_3}\right]$$

$$= \left[-100\,(5.24k)\right]\left[\frac{-100 \cdot 10k}{20k}\right]\left[\frac{1}{102.8k}\right] = 255 \text{ V/V}$$

5.) $$A_F = \frac{A}{1 + AB} = \frac{255}{1 + 255\left(\frac{1}{11}\right)} = \frac{255}{1 + 23.17} = \underline{\underline{10.54 \text{ V/V}}} \approx \frac{1}{B} \text{ if } AB > 1$$

6.) $R_{in}(B=0) = h_{11A} + h_{11F} + R_S = R_S + r_{\pi 1} + (1+B) R_1 \| R_3 = 102.8K\Omega$

$R_{inF} = R_{in}(1+AB) = 102.8K(24.17) = \underline{\underline{2.485 M\Omega}}$

7.) $R_{out}(B=0) = \dfrac{1}{h_{22T} + G_L} = R_4 \| (R_1 + R_3) = 5.24K\Omega$

$R_{outF} = \dfrac{R_{out}}{1+AB} = \dfrac{5240\Omega}{24.17} = \underline{\underline{216\Omega}}$

General Approach for Analyzing Feedback Amplifiers

All four forms of feedback amplifiers can be analyzed in exactly the same way. Let $x = h, g, y, z$

1.) Find x_{11F}

2.) Find x_{22F}

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

4.) Set $B = 0$, find A incorporating x_{11F} and x_{22F} into the amplifier circuit.

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

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

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

Feedback Topology	Two-Port Parameters
Shunt-Shunt (Transistance Amplifier) $\frac{V_{out}}{I_{in}}$	$i_1 = y_{11} v_1 + y_{12} v_2$ $i_2 = y_{21} v_1 + y_{22} v_2$
Shunt-Series (Current Amplifier) I_{out}/I_{in}	$i_1 = g_{11} v_1 + g_{12} i_2$ $v_2 = g_{21} v_1 + g_{22} i_2$
Series-Series (Transconductance Amp.) I_{out}/V_{in}	$v_1 = z_{11} i_1 + z_{12} i_2$ $v_2 = z_{21} i_1 + z_{22} i_2$
Series-Shunt (Voltage Amplifier) V_{out}/V_{in}	$v_1 = h_{11} i_1 + h_{12} v_2$ $i_2 = h_{21} i_1 + h_{22} v_2$

Next is Shunt-Shunt

$$y_{11F} = \left.\frac{i_{1F}}{v_{1F}}\right|_{v_{2F}=0} \qquad y_{22F} = \left.\frac{i_{2F}}{v_{2F}}\right|_{v_{1F}=0} \qquad y_{12F} = \left.\frac{i_{1F}}{v_{2F}}\right|_{v_{1F}=0}$$

Example next