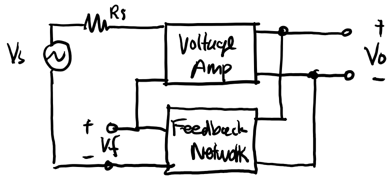
Practical Feedback Cases

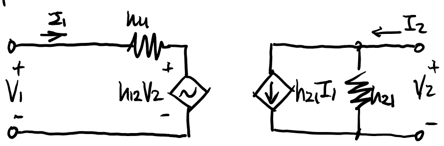
November 23, 2017 10:55

(Two Port Networks)

Recall Feedback network in series-shunt topology:



We represent this using h-parameters:



$$H = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$$

h_{11}: Ω; h_{12}: unitless; h_{21}: unitless; h_{22}: Ω

$V_1 = h_{11} I_1 + h_{12} V_2$

$I_2 = h_{21} I_1 + h_{22} V_2$

We can solve for each of the parameters by superposition.

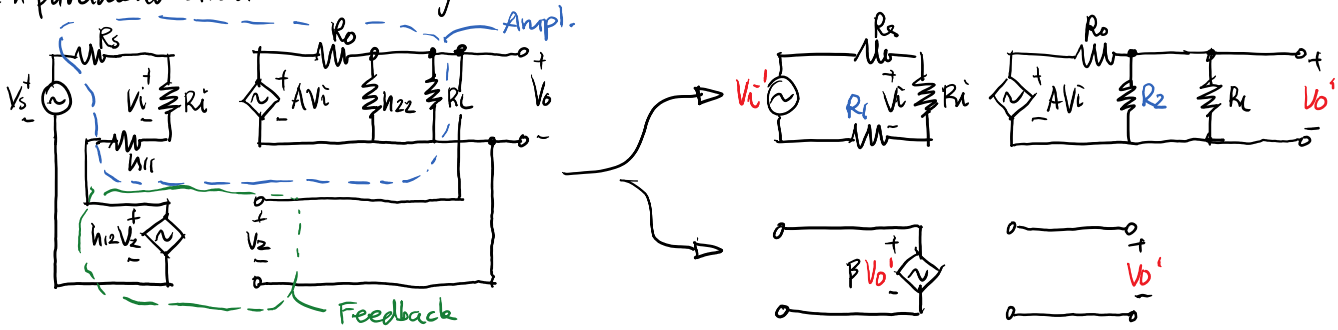
When $V_2 = 0$, $V_1 = h_{11} I_1 \Rightarrow$ $h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0}$

Carrying out similar tests $\Rightarrow$ $h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$

$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0}$

$h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$

The h-parameter circuit can be arranged into:



↳ $R_1 = h_{11}$

↳ $R_2 = \frac{1}{h_{22}}$

↳ $\beta = h_{12}$

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

Parameters For Various Feedback Topologies

Series-Shunt (Voltage Amp)

h-parameters

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

Shunt-Shunt (Transresist. Amp)

y-parameters

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

Series-Series (Transconduct. Amp)

z-parameters

$\begin{bmatrix} V_1 \end{bmatrix} \; \begin{bmatrix} z_{11} & z_{12} \end{bmatrix} \begin{bmatrix} I_1 \end{bmatrix}$

Shunt-Series (Current Amp)

g-parameters

$I_1 \Big] = \begin{bmatrix} g_{11} & g_{12} \end{bmatrix} \begin{bmatrix} V_1 \end{bmatrix}$

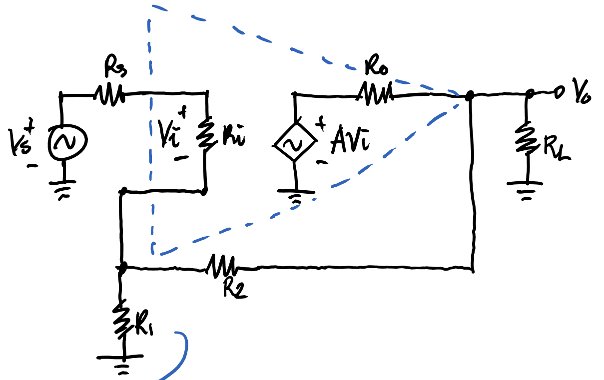
Series-Series (Transconductance Amp)
z-parameters

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

Shunt-series (Current Amp)
g-parameters

$$\begin{bmatrix} I_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ I_2 \end{bmatrix}$$

Ex

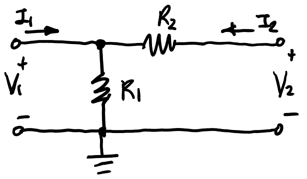


$R_i = 10k\Omega$
$R_o = 100\Omega$
$A = 10^4$

$R_1 = 1k\Omega$
$R_2 = 9k\Omega$

$R_s = 1k\Omega$ (Relatively high)
$R_L = 1k\Omega$ (Relatively low)

the feedback network



Using Series-shunt topology
→ use h-parameters.
Using feedback network,
→ find h-parameters

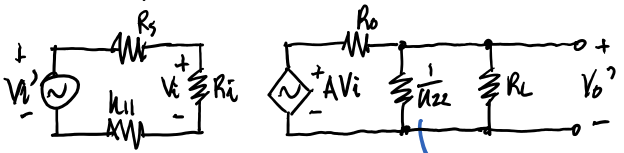
$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} = R_1 \,//\, R_2 = 900\Omega$$

$$h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0} = \frac{R_1}{R_1+R_2} = 0.100$$

$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} \ \dots \text{ (don't need to be calculated)}$$

$$h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0} = \frac{1}{R_1+R_2} = \frac{1}{10k}$$

Redraw the amplifier circuit with all the resistances "absorbed"



conductance in series ≡ resistance in parallel

Now we find the gain A':

$$A' = \frac{V_o'}{V_i'}$$

$$V_o' = AV_i\left(\frac{\frac{1}{h_{22}} // R_L}{(\frac{1}{h_{22}} // R_L) + R_o}\right) \quad \text{(voltage divider)}$$

$$= 9009\,V_i$$

$$V_i = \frac{R_i}{R_i + h_{11} + R_s} V_i' \quad \text{(voltage divider)}$$

$$= 0.84\,V_i'$$

$$\rightarrow A' = \boxed{7571}$$

Given that $\beta = h_{12} = 0.100$

Then gain w/ feedback is:

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Then gain w/ feedback is:

$$A_f = \frac{A'}{1+A'\beta} = \frac{7571}{1+(7571)(0.1)} = \boxed{9.99}$$

Impedance with feedback:

$$\rightarrow R_{if} = R_i'(1+A'\beta) = (11.9K)(1+7571 \cdot 0.10) = \boxed{9.02M\Omega}$$

$R_i' = R_i + R_s + h_{11} = 11.9k\Omega$

Since we included source impedance in our calculation, we subtract it out

$$R_{in} = R_{if} - R_s$$
$$= 9.02M - 1k$$
$$= \boxed{9.02M\Omega}$$

$$\rightarrow R_{of} = R_o'\left(\frac{1}{1+A'\beta}\right) = (90.1)\left(\frac{1}{1+(7571)(0.10)}\right) = \boxed{0.119\Omega}$$

$R_o' = R_o \,//\, R_L \,//\, \frac{1}{h_{22}}$
$= 90.1$

Since we included load impedance in our calculation, we need to take it out

$$R_{of} = R_{out} \,//\, R_L$$

$$\rightarrow R_{out} = \frac{R_{of} R_L}{R_L - R_{of}} = \frac{(0.119)(1k)}{(1k)-(0.119)} = \boxed{0.119\Omega}$$