Example of Series-Shunt Feedback using an Op Amp

Consider the following series-shunt feedback circuit:

\[
\begin{align*}
N_0 &= 25K \\
R_1 &= 10K \\
R_2 &= 91K \\
L_{out} &= \frac{A}{1+AF}
\end{align*}
\]

Find \( \frac{N_0}{N_0} \), \( h_{11F} \) \& \( h_{out} \)

From previous work we know that,

\[
\frac{N_0}{N_0} = \frac{h_{21A}}{h_{12A} h_{21A} - (h_{e} h_{in})(h_{22} h_{21})}
\]

where \( A = \frac{-h_{21A}}{(h_{e} h_{in})(h_{22} h_{21})} \) and \( F = h_{12F} \)

\[
\begin{align*}
h_{11F} &= \frac{N_{1F}}{N_0} \bigg|_{N_{1F} = 0} = \frac{R_1 R_2}{R_1 + R_2} = 0.01K \\
h_{22F} &= \frac{N_{2F}}{N_0} \bigg|_{N_{2F} = 0} = \frac{1}{R_1 + R_2} = \frac{1}{100K} \\
h_{12F} &= \frac{N_{1F}}{N_0} \bigg|_{N_{1F} = 0} = R_1 R_2 = 0.01K
\end{align*}
\]

\[ A = ? \]

Use the following model for \( A \)

\[
A = \frac{N_0'}{N_0} = \left( \frac{25K}{1K+25K+901K} \right) \left( \frac{2K}{1K+2K} \right) = 4730 V/V
\]

\[ \beta = h_{12F} = 0.099 \]

\[ \frac{N_0}{1+AB} = \frac{A}{1+\beta} = \frac{4730}{1+4730(0.099)} = 10.08V/V \]
\[ R_{\text{inf}} = \frac{R_5 + k_{11T}}{N_1} + h_{22T} N_2 \]

\[ N_5 = N_1 = h_{11T} i_1 + h_{12T} N_2 \]

\[ N_2 = -R_L i_2 \]

\[ i_2 = h_{21T} N_1 + h_{22T} N_2 \]

\[ \frac{N_5}{N_1} = \frac{R_{\text{inf}}}{N_1} = R_5 + k_{11T} + \frac{-h_{21A} h_{12F}}{h_{22T} + G_L} \]

\[ N_5 = (R_5 + k_{11T}) i_1 + h_{12F} N_2 \]

\[ N_1 = h_{11T} i_1 + h_{12F} N_2 \]

\[ R_{\text{inf}} = 16.1 \Omega \]

\[ \text{Output} = \frac{662 \Omega}{1 + (4730)(0.08)} = 1.41 \Omega \]
The general approach to analyzing series-shunt F networks is to:

1. Find $h_{11F}$ (input resistance of the F network with the output short-circuited).
2. Find $h_{22F}$ (output conductance of the F network with the input open-circuited).
3. Find $h_{12F} = 0 = F$ (voltage gain from output to input with input open-circuited).
4. Use the $A$ circuit including the loading of the F circuit ($h_{11F}$ $h_{22F}$) to find $A$.
5. $A_F = \frac{A}{1 + AF} = \frac{A}{1 + AB}$
6. $h_{MF} = (h_{st}h_{HT})(1 + AF) = (h_{st}h_{HT})(1 + AF)$
7. $h_{outF} = \frac{(h_{22F} + G_2)}{1 + AF} = \frac{h_{22F} + G_2}{1 + AB}$

Example:

If $B_1 = B_2 = 100 \Omega$, find $V_{R2}$ = 10k, find $\frac{N_2}{N_1}$, $\frac{N_2}{N_1}$ and $\frac{N_2}{N_2}$

To be continued ...