Noise and Feedback

- **Ideal feedback:**
  - No increase of input referred noise
  - No decrease of SNR at output

- **Practical feedback: increased noise**
  - Noise from feedback network
  - Noise gain from elements outside feedback loop
Real Feedback

• Conceptually identical to standard two port calculations
  • Use $R_s = 0$ to find $v_{i,eq}$
  • $R_s = \infty$ to find $i_{i,eq}$

• Calculations get tedious…

Practical Feedback Analysis

• Quick approximation method:
  • Consider loading of feedback network on the input
  • Add a noise source associated with this element.

• Example: shunt feedback
  • Loading at input is $R_F \rightarrow i_i^2 = i_n^2 + 4kT\Delta f/R_F$
Example #2: Series-Shunt Feedback

- Loading is \( R_F \| R_E \)
- So, noise voltage becomes:
  \[ v_i^2 = v_n^2 + 4kT(R_F \| R_E)\Delta f \]

Implications: Non-Inverting Amp

- Minimum power from feedback \( \rightarrow \) large \( R_1 + R_2 \)
- Example:
  - \( A_v = 10, R_2 = 100k\Omega, R_1 = R_2(A_v0 - 1) = 900k\Omega \)
  - \( v_{n_{fb}}^2 = 40nV/\sqrt{\text{Hz}} \) (very high)
- Only way to lower noise is increase power…
Example: Inverting Amplifier

\[
\begin{aligned}
&v_o = -v_i + v_n \left(1 + \frac{R_2}{R_1}\right) = -v_i + v_n \left(1 + \frac{R_2}{R_1}\right) \\
&v_{\text{eq}}^2 = v_n^2 \left(1 + \frac{1}{|A_{\text{in}}|}\right)
\end{aligned}
\]

- Ignoring noise from \( R_1, R_2 \):

- “Ideal” feedback, why is \( v_{\text{eq}}^2 > v_n^2 \)?

Example
Example