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 $v_{i_{eq}}^2$
  - $R_s = \infty$ to find $i_{v_{eq}}^2$

- 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 $R_F \rightarrow \Delta i^2 = i_a^2 + 4kT\Delta f/R_F$
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 $R1+R2$
- Example:
  - $A_v = 10$, $R2 = 100k\Omega$, $R1 = R2(A_v0^{-1}) = 900k\Omega$
  - $v_{nfb}^2 = 40nV/\sqrt{Hz}$ (very high)
- Only way to lower noise is increase power…
Example: Inverting Amplifier

- Ignoring noise from $R_1$, $R_2$:

$$v_o = -v_i + v_n \cdot \frac{R_2}{R_1} \left(1 + \frac{R_2}{R_1}\right) = -v_i + v_n \cdot \frac{R_1 + R_2}{R_1}$$

$$v_{eq}^2 = v_n^2 \left(1 + \frac{R_1 + R_2}{R_1 R_2}\right)^2 = v_n^2 \left(1 + \frac{1}{|A_{\infty}|}\right)^2$$

- “Ideal” feedback, why is $v_{eq}^2 > v_n^2$?
Example