EECS240 – Spring 2010

Lecture 7: Noise and Feedback

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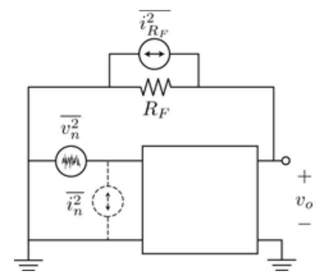
Noise and Feedback

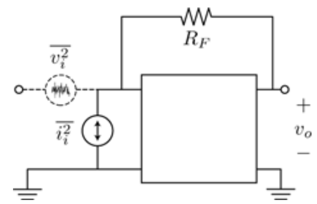
- Ideal feedback:
  - No increase of input referred noise
  - No decrease of SNR at output
- Practical feedback: increased noise
  - Noise from feedback network
  - Noise gain from elements outside feedback loop

Real Feedback

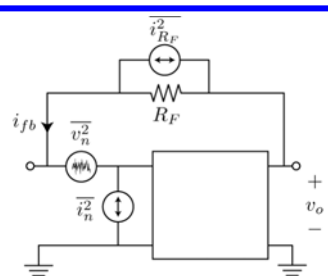
- **Conceptually identical to standard two port calculations**
  - **Use Rs = 0 to find $v_{i,eq}^2$**
    Rs = ∞ to find $i_{i,eq}^2$

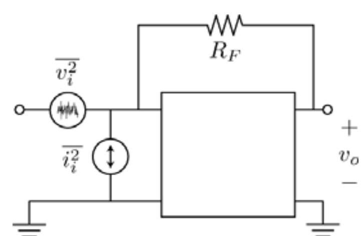


- **Calculations get tedious…**



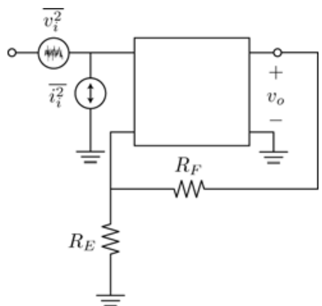
Practical Feedback Analysis





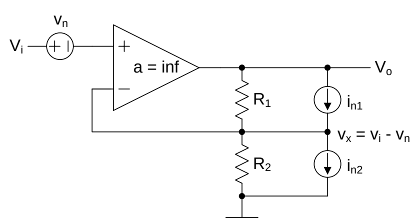
- **Quick approximation method:**
  - **Consider loading of feedback network on the input**
  - **Add a noise source associated with this element.**
- **Example: shunt feedback**
  - **Loading at input is R_F → $i_i^2 = i_n^2 + 4kT\Delta f/R_F$**

Example #2: Series-Shunt Feedback



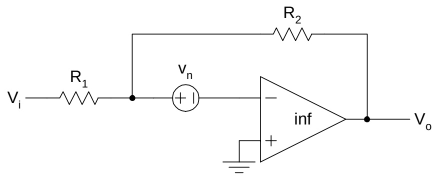
- **Loading is $R_F||R_E$**
- **So, noise voltage becomes:**
  - $v_i^2 = v_n^2 + 4kT(R_F||R_E)\Delta f$

Implications: Non-Inverting Amp



- **Minimum power from feedback → large R1+R2**
- **Example:**
  - **$A_v = 10$, R2 = 100kΩ, R1 = R2(A_{v0}-1) = 900kΩ**
  - **v_{nfb}^2 = 40nV/√Hz (very high)**
- **Only way to lower noise is increase power…**

Example: Inverting Amplifier



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

$$v_o = -v_i \underbrace{\frac{R_2}{R_1}}_{-A_{v0}} + v_n\left(1+\frac{R_2}{R_1}\right) = -v_i \underbrace{\frac{R_2}{R_1}}_{-A_{v0}} + v_n \frac{R_1+R_2}{R_1}$$

$$\overline{v_{ieq}^2} = \overline{v_n^2}\left(\frac{R_1+R_2}{R_1}\frac{R_1}{R_2}\right)^2 = \overline{v_n^2}\left(\frac{R_1+R_2}{R_2}\right)^2 = \overline{v_n^2}\left(1+\frac{1}{|A_{v0}|}\right)^2$$

- **"Ideal" feedback, why is $v_{i,eq}^2 > v_n^2$?**

Example

Example