EE 240B – Spring 2018

Advanced Analog Integrated Circuits

Lecture 6: Noise- and SNR-Limited Amplifier Design Methodology

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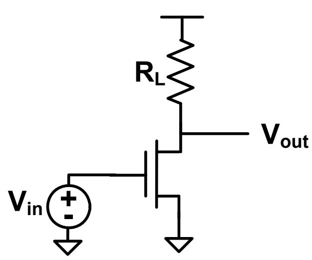
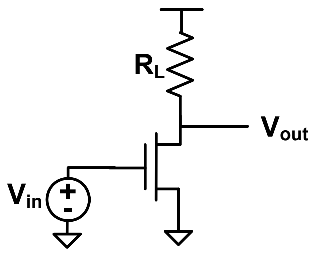
Noise Density Limited Amplifier Design Methodology



- **Input specifications:**
  - Minimum small signal gain A_v
  - Supply voltage V_{dd}
  - Fixed V*
  - Maximum input-referred noise spectral density $v_{i,n}^2/\Delta f$
- **Goal: minimize power**

Small Signal Model and Noise Analysis



Resulting Design

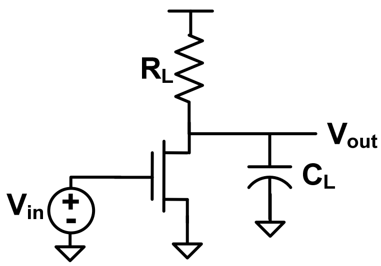
Discussion (1)

- Why did we not even specify the capacitive load?

Discussion (2)

- If you could exactly set a_{v0}, what value would you pick?

Integrated Noise-Limited Amplifier



- **Input specifications:**
  - Minimum small signal gain A_v
  - Minimum 3dB bandwidth ω_{bw}
  - Supply voltage V_{dd}
  - Fixed V*
  - Maximum noise variance $v_{o,n}^2$
- **Goal: minimize power**

Required C_L, g_m, and I_D

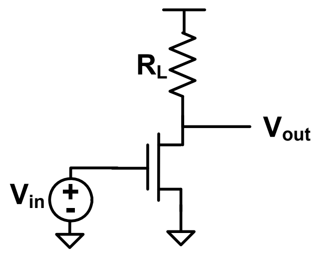
Discussion (1)

- **For both noise-density and integrated noise-limited amplifiers, what V* should you pick?**

Discussion (2)

- **How would one know the $v_{i,n}^2/\Delta f$ or $v_{o,n}^2$ spec?**

Signal Swing Limitations



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Why Linearity Matters

- **Option 1: Retaining the original shape of the input inherently matters**
  - E.g., oscilloscope, spectrum analyzer
  - (Actually also often matters in communication systems)
- **Option 2: Need to be able to discern a (small) signal out of the combination of many others**
  - E.g., RF, neural front-ends
  - “Other” signals could
- **Precise linearity metric depends on usage scenario**
  - More next time – will use simplified metric for now

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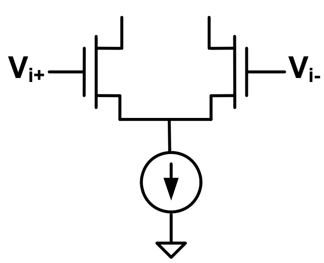
Sources of Non-Linearity

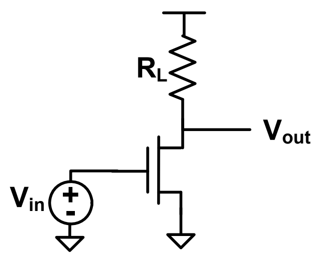
- **Output limited: Non-linear Z_{out} (r_o)**

- **Input limited: Non-linear g_m**

Input Non-Linearity with a Diff. Pair



Full Circle: SNR-Limited Design (noise density)



- **Input specifications:**
  - Minimum small signal gain A_v
  - Supply voltage V_{dd}
  - Input-referred maximum linear amplitude $V_{i,max}$
  - Signal shape (usually sinusoid) and amplitude V_{sig}
  - Externally determined bandwidth f_{bw}
  - Minimum signal-to-noise ratio SNR_{min}
- **Goal: minimize power**

Required $v_{i,n}/\Delta f$

Required V*

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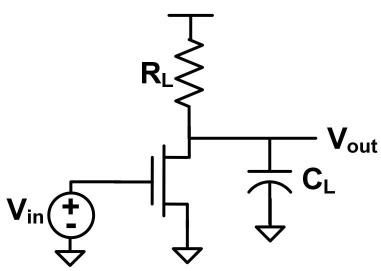
SNR-Limited Design (total noise)



- **Input specifications:**
  - Minimum small signal gain A_v
  - Minimum 3dB bandwidth ω_{bw}
  - Supply voltage V_{dd}
  - Input-referred maximum linear amplitude $V_{i,max}$
  - Signal shape (usually sinusoid) and amplitude V_{sig}
  - Minimum signal-to-noise ratio SNR_{min}
- **Goal: minimize power**

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Discussion