

Lecture 25: Noise

- Announcements:
- Project Slide Set #3 due Friday, April 26
- HW#7 online and due Friday, 5/10, at 9 a.m.
- Module 16 on Sensing Circuit Non-Idealities & Integration online
- Module 17 is online (on Noise and MDS)
- First 15 minutes of class were for HKN to go over course evaluation procedures
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- Reading: Senturia Chpt. 14, 15
- Lecture Topics:
  - ↳ Ideal Op Amps
  - ↳ Op Amp Non-Idealities
  - ↳ MEMS-Transistor Integration
    - Mixed
    - MEMS-First
    - MEMS-Last
- Reading: Senturia Chpt. 16
- Lecture Topics:
  - ↳ Minimum Detectable Signal
  - ↳ Noise
    - Circuit Noise Calculations
    - Noise Sources
    - Equivalent Input-Referred Noise
  - ↳ Gyro MDS
    - Equivalent Noise Circuit
    - Example ARW Determination
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- Last Time:
- Going through MEMS/transistor integration ...

Circuit Noise Calculations

Inputs:  $N_i(j\omega)$ ,  $S_i(\omega)$

Block:  $H(j\omega)$

Outputs:  $N_o(j\omega)$ ,  $S_o(\omega)$

Annotations:
 

- Deterministic (red arrow from  $N_i$  to  $N_o$ )
- Random (red arrow from  $S_i$  to  $S_o$ )
- No  $j$  → noise has random phase,  $s$  "j" is pointless!

Deterministic Signals:

$N_o(j\omega) = H(j\omega)N_i(j\omega)$

Random Signals:

Mean-Square Spectral Density

$$S_o(\omega) = [H(j\omega)H^*(j\omega)] S_i(\omega) = |H(j\omega)|^2 S_i(\omega)$$

$\sqrt{S_o(\omega)} = |H(j\omega)| \sqrt{S_i(\omega)}$  → How is it we can do this?

↖ root-mean square amplitudes

Handling Noise Deterministically

$\frac{N_{ni}^2}{\Delta f} = S_i(f) \rightarrow N_{ni} = \sqrt{S_i(f) B}$  bandwidth

Can approximate this by a sinusoidal voltage generator (esp. when B is small, say 1Hz)

Why is this the case?

Neither the amplitude nor the phase of a signal can change appreciably within a time period  $\frac{1}{B}$ .