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EE C247B - ME C218 Introduction to MEMS Design Fall 2019

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Module 17: Noise & MDS

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Lecture Outline

- 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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Determining Sensor Resolution

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Minimum Detectable Signal (MDS)

- Minimum Detectable Signal (MDS): Input signal level when the signal-to-noise ratio (SNR) is equal to unity

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graph LR; S[ Sensed Signal ] --> Sensor; subgraph Sensor; direction TB; SSF[ Sensor Scale Factor ]; SN[ Sensor Noise ]; end; subgraph SCC[ Signal Conditioning Circuit ]; direction TB; CG[ Circuit Gain ]; CON[ Circuit Output Noise ]; end; Sensor --> SCC; SCC --> O[ Output ];
```

- The sensor scale factor is governed by the sensor type
- The effect of noise is best determined via analysis of the equivalent circuit for the system

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Noise

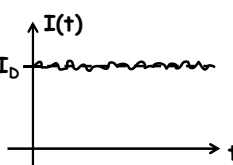
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Noise

- **Noise:** Random fluctuation of a given parameter $I(t)$
- In addition, a noise waveform has a zero average value

Avg. value (e.g. could be DC current)



- We can't handle noise at instantaneous times
- But we can handle some of the averaged effects of random fluctuations by giving noise a power spectral density representation
- Thus, represent noise by its mean-square value:

Let $i(t) = I(t) - I_D$

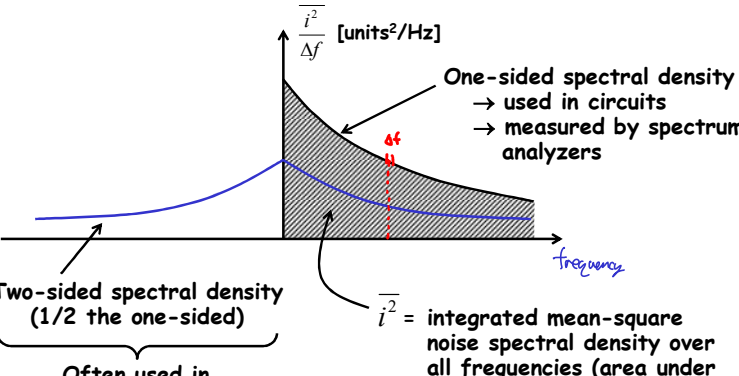
Then $\overline{i^2} = \overline{(I - I_D)^2} = \lim_{T \rightarrow \infty} \frac{1}{T} \int_0^T |I - I_D|^2 dt$

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Noise Spectral Density

- We can plot the spectral density of this mean-square value:



One-sided spectral density
 → used in circuits
 → measured by spectrum analyzers

Two-sided spectral density
 (1/2 the one-sided)
 Often used in systems courses

$\overline{i^2}$ = integrated mean-square noise spectral density over all frequencies (area under the curve)

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