

January 26, 2005

➤ No Class: Monday, Jan 31st

➤ **Office Hours™**

⊕ 1:10 - 2:10 pm, Monday, A223 Cook

⊕ Not next week (no class Monday Jan 31st!)

⊕ 1-2 pm, Thursday, 300 Waterman

⊕ 3-4 pm, Friday, 300 Waterman

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More White Noise

▪ Shot Noise

-current fluctuations due to random motion of e^- across a junction

$$i_{rms} = (2 i_{avg} e \Delta f)^{1/2}$$

Average
Current

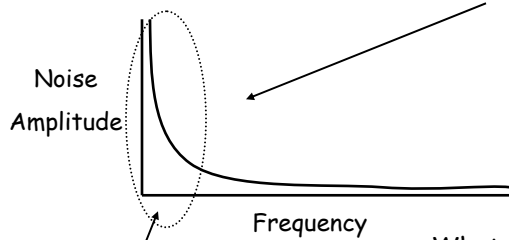
Charge on
an electron

Frequency
Bandwidth

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More Noise

2. Flicker (1/f) Noise - amplitude varies with 1/f



Most significant at low (<100 Hz) frequencies

What is it?

-drift

-low freq. signal fluctuations

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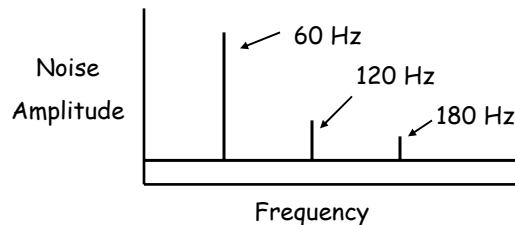
Still More Noise!

3. Environmental Noise

Two types:

■ Interference Noise

-predictable; occurs at *known* discrete frequencies



Example:
AC "hum"
from power-line

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More Environmental Noise

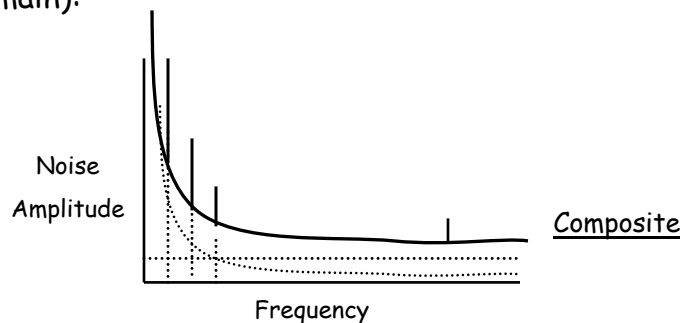
■ Impulse Noise

- erratic and unpredictable
- difficult to find source*
 - motors
 - solar flares
 - computers
 - temperature variations
- difficult to correct!**

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Composite Noise Spectrum

- In order to understand S/N enhancement, need to look at **ALL** noise sources together (in frequency domain):



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Strategies for Increasing S/N

■ White Noise: *reduce Δf , temp, resistance, i_{avg}*

■ Flicker Noise: *make measurements at frequencies >100 Hz*

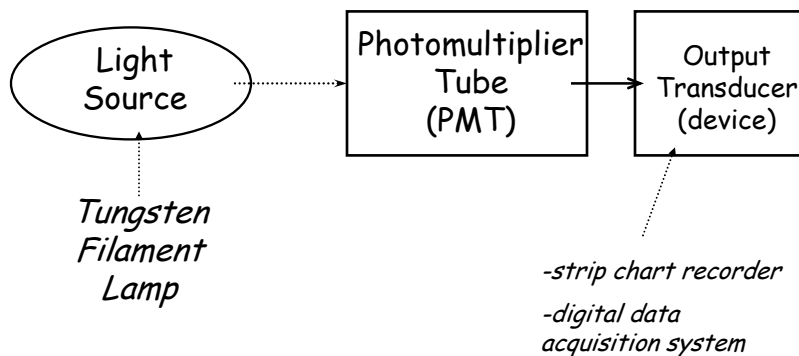
BUT:

■ Signal:
-often at or near dc (low freq.)
-often directly proportional to resistance
-often directly proportional to current
-often measured with transducers having very LARGE Δf

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Hypothetical Instrument

■ Let's explore the signal and noise behavior of a simple light measurement instrument:



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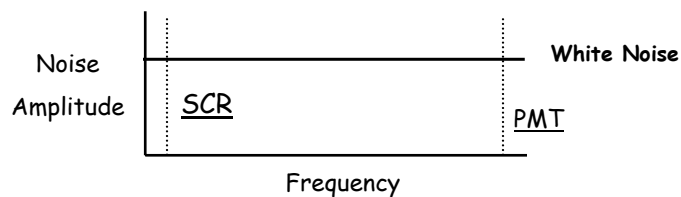
Reducing Δf

- Look at *frequency response* of instrument components:

PMT: 10^7 Hz

SCR: 10^0 Hz

DDA: $10^0 - 10^7$ Hz (variable)



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S/N Enhancement: Impact of Δf

- Output device/transducer limits Δf :

$$\frac{S/N (\Delta f = 10^0)}{S/N (\Delta f = 10^7)} \approx 10^3$$

- Δf can be easily adjusted using a *low-pass* frequency filter
- BUT: remember that Δf also affects ability to measure the signal (at f_o); $f_o > 0$

So, object is to keep Δf to a *minimum*,
without reducing the **SIGNAL**

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Reducing 1/f Noise

- We need to *move* f_0 to >100 Hz . . . *HOW?*

→ **MODULATE** the source

-analytical signal "encoded" at a freq.
where 1/f noise is negligible

