January 23, 2012

- Thanks for all of the emails – still waiting on a couple . . . nudge, nudge . . .
- ***Office Hours™***
  - **Wed:** 3:00-4:30 pm
  - **Thurs:** 9:00-10:00 am

    Beginning NEXT week – or by appointment
- New Stuff on Website!

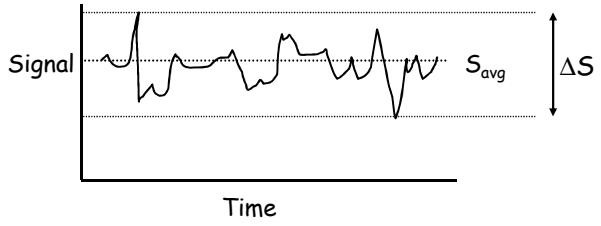
1

Calculating S/N

- For a set of data (replicate measurements):

$$S/N = \mathbf{S_{avg}} / \sigma_s = (RSD)^{-1}$$

- For a temporally-varying signal:



$\Delta S \approx 5\sigma = 5N$

So: $N \approx \Delta S/5$

Thus:

$S/N \approx 5S_{avg}/\Delta S$

2

Noise Sources

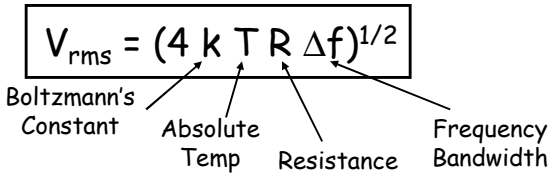
- We'll characterize by their *frequency response*

1. **White Noise** - *amplitude invariant with respect to frequency*

   Two types:

   - **Johnson (Thermal) Noise**

     -voltage fluctuations due to random e^- motion in resistive devices

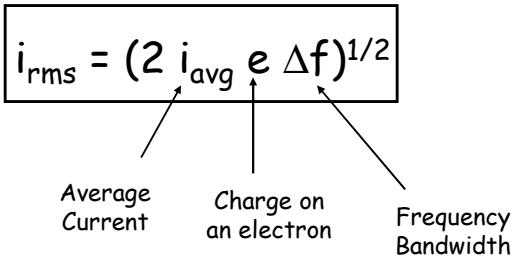


3

More White Noise

- **Shot Noise**

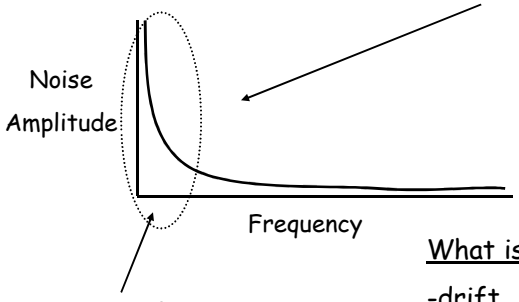
  -current fluctuations due to random motion of e^- across a junction



4

More Noise

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



What is it?

-drift

-*low freq.* signal fluctuations

5

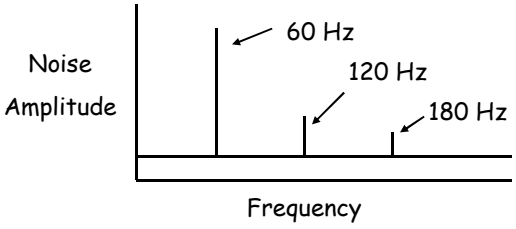
Still More Noise!

3. **Environmental Noise**

Two types:

- Interference Noise

  -predictable; occurs at *known* discreet frequencies



Example:

AC "hum" from power-line

6

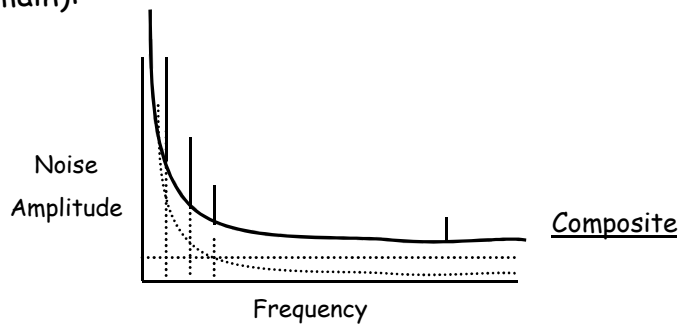
More Environmental Noise

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

7

Composite Noise Spectrum

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



8

Strategies for Increasing S/N

- White Noise: *reduce* Δf, temp, resistance, i_{avg}
- Flicker Noise: *make measurements at frequencies >100 Hz*

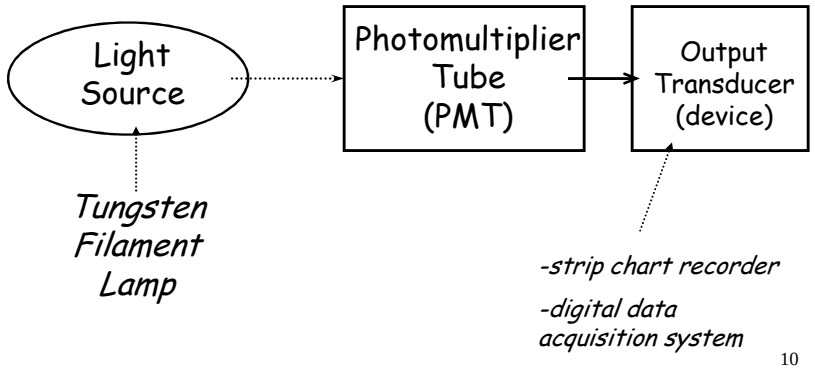
BUT:

- 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

9

Hypothetical Instrument

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



10