Notes Set 1: Motivation

- scope of topics, from physics, devices, circuits, to systems
Motivation: Lecture: Agenda of Course.

Noise is not a secondary topic in determining communication system, measurement system, control system performance.
Noise, as a topic, is too broad to consider in a single course:

- Math
- Physics
- Device theory
- Circuits
- Systems: hardware perspective
- Systems: analytical perspective
- Information theory
Our agenda in the course will be as below:

* Enough math to be competent.
* A quick skim through of physics of noise.
* Noise models of semiconductor devices.
* Heavy emphasis on circuits.
* Heavy emphasis on system hardware.
* Comin systems instrumentation.
* Re-visiting noise models of $kT$ and noise in physics later in term.
* In the last 1-2 lectures, skim other related topics.
What is the course really about?

Here are some examples of problems we would like to find easy to solve once the term is over:

**First Problem:**

bipolar transistor:

- how does impedance-matching network on input change $SIN$ ratio?
- how does base resistance, transit time?
- how could we design for best noise?
Microphone preamplifier

Why is a transformer used?
What ratio?
What signal levels from microphone might we reasonably detect?
Optical receiver:


1. What is the minimum detectable power?
2. How does error rate change with power?
3. How to design preamplifier for best sensitivity?
4. Which are the filter, comparator, & flip-flop for?
Electro-optic Sampling:

modulation (chopping)

IC

been modulated ~10^3 by IC

photodiode

Lock-In

display

Laser beam
Probe

why are we modulating the signal?

what is a lock-in amplifier?

how small a signal can we measure?
Phase locked loop

Laser has timing jitter, phase lock loop suppresses it.

How do we measure/describe "jitter"?
How much does loop suppress it?
How does mixer & amplifier noise figure impact system?
Photon Number Amplifier

PIN photodetector

multi-contact laser.

How does optical signal ratio change from input to output?

Is this a noiseless amplifier?
Resonant tunnel diode:

- Tunneling through a quantum well, statistically all W state acceptor levels.
- Electrons due to mobile charge.

Resistance in n+ layer

How do we predict the noise contribution of this device?

Input

Output

Circulator

What are the noise properties of this amplifier?
Our objective is to study underlying material with enough detail to be able to confidently give the right answer to these types of problems.

This requires more care than a "practical engineers" class.

**Example:**

- Pulsed laser
- Noise power
- "White noise observed"

Should receiver bandwidth be \( \frac{1}{\Delta t} \) ??
References we will use cautiously:

Van Der Ziel: Noise in Solid State Device

Matsenbaecher: Low Noise Electronic Design

Vendelin: Microwave Circuit Design

Bell Labs: Transmission Systems for Communication

IEEE Paper Collections:

Pacei: MMICs

Eckai: Low Noise Transistors

Microwave Digital Receiver

Smith & Peramiki: Optical Recei
Wozencraft & Jacobs:
Principles of Communications engineering.

Covey & Meyer: Analog IC design.

Papoulis: Probability - random variables.