• Notes Set 1: Motivation

- scope of topics, from physics, devices, circuits, to systems

ECE 594, Lecture Notes set 1

Motivation Lecture: Agenda of Course.

Noise is not a secondary topic

the fundamental factor 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

system: analytical perspective.

Information theory.

Our agenda in the course will be as below:

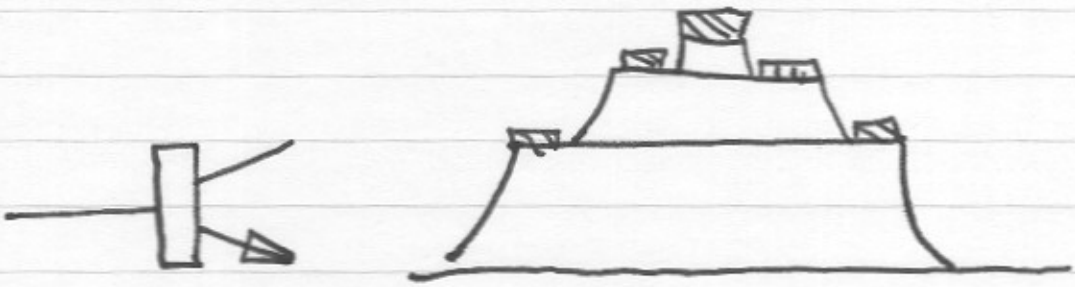
* Enough math to be competent.
* A quick skim-through of physics of noise.
* Noise models of semiconductor devices.
* Heavy emphasis on circuits.
* Heavy emphasis on systems' hardware.
  Comm systems, instrumentation
* Re-visiting noise models of $\frac{1}{f}$ and noise in physics later in term.
* In 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:

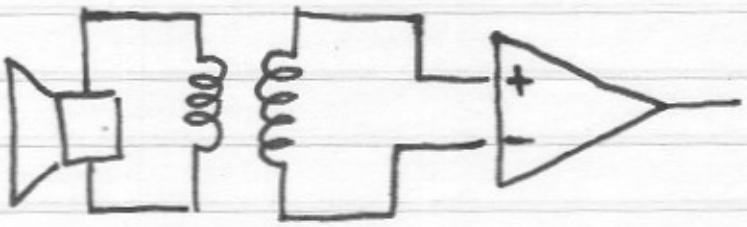
First Problem:

bipolar transistor:



- how does impedance-matching network on input change S/N ratio?
- how does base resistance, transit times?
- how would we design for least noise?

Microphone preamplifier

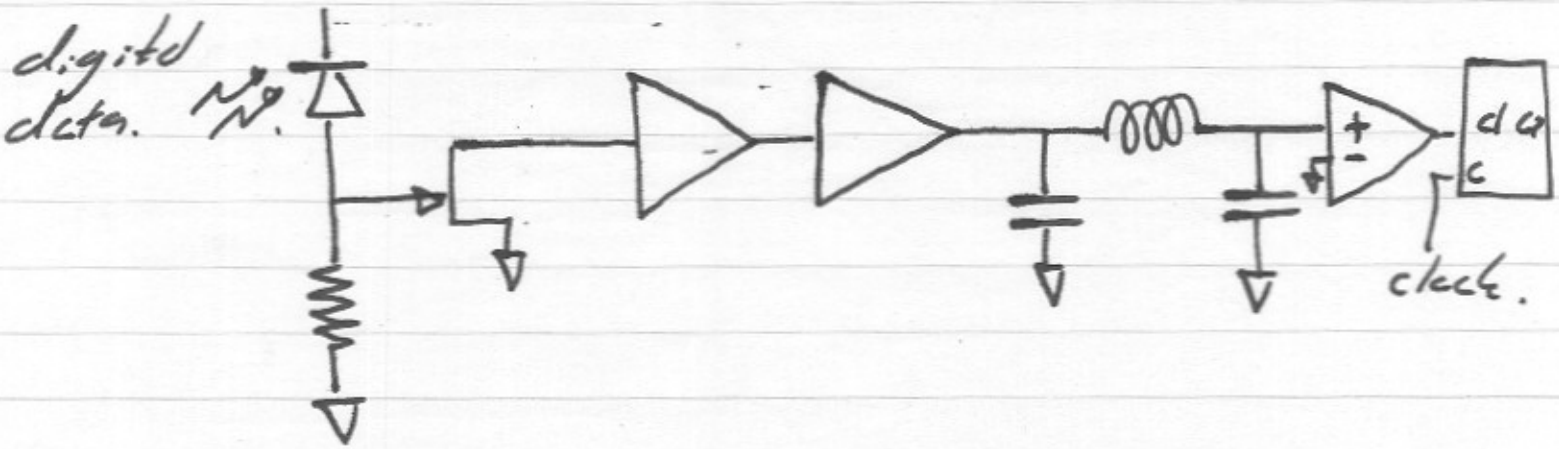


why is a transformer used?

which ratio?

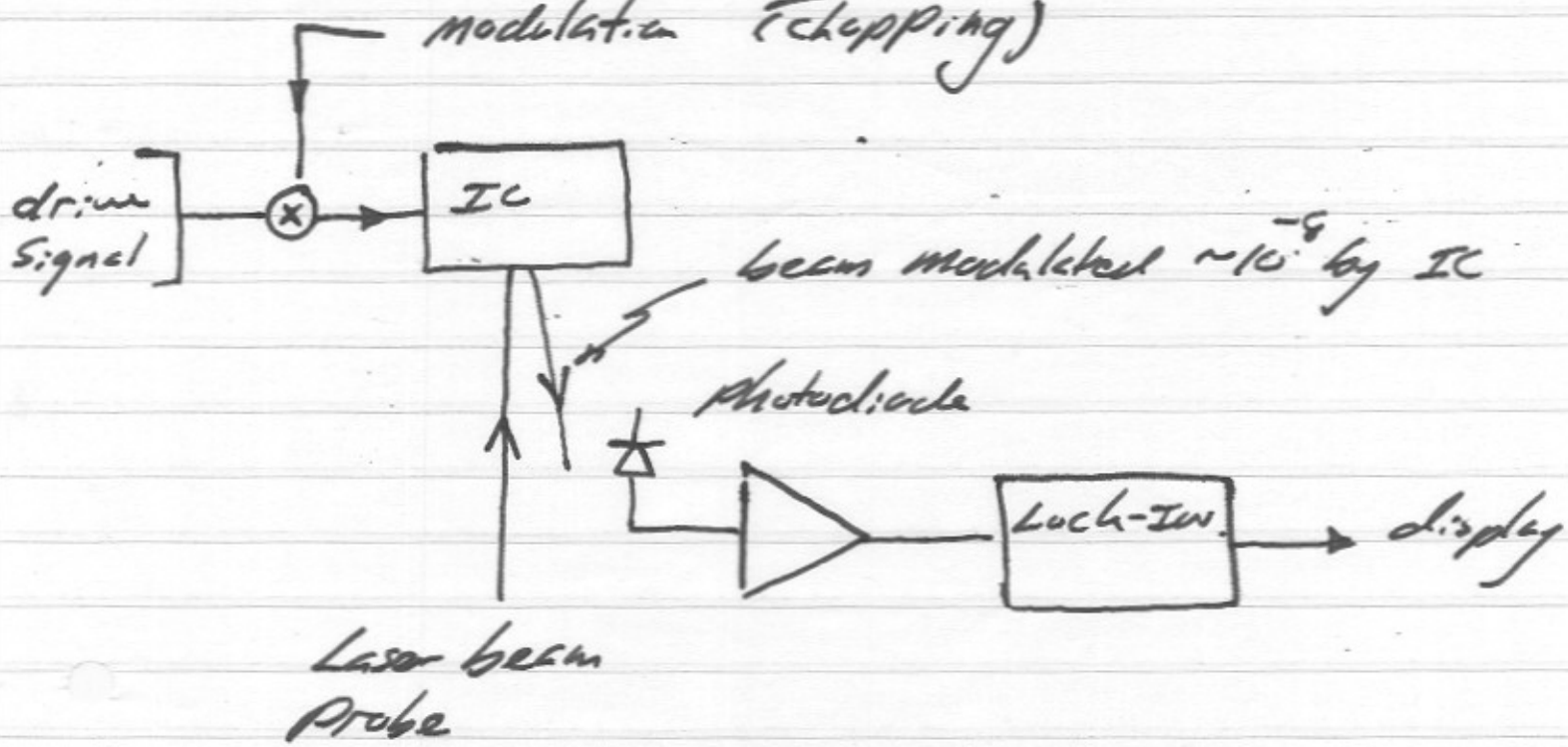
what signal levels from microphone might we reasonably detect?

Optical receiver:



- what is the minimum detectable power?
- How does error rate change with power?
- How to design preamplifier for best sensitivity?
- what are the filter, comparator, & flip-flop for?

Electro-optic Sampling:

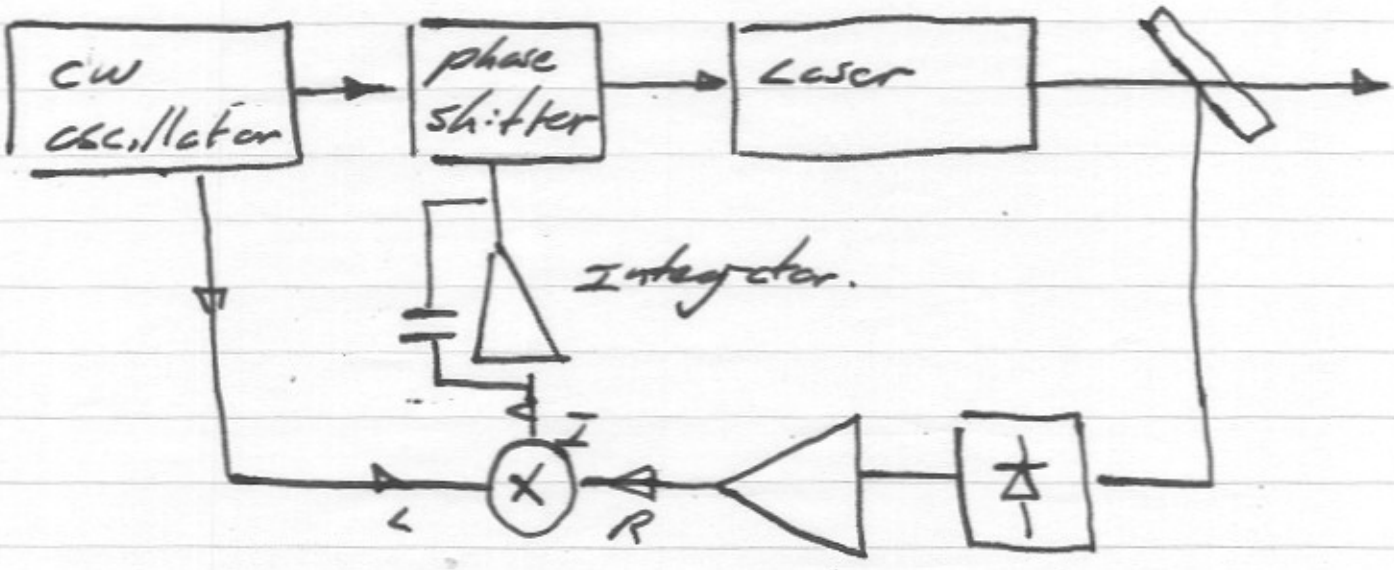


why are we modulating the signal?

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.

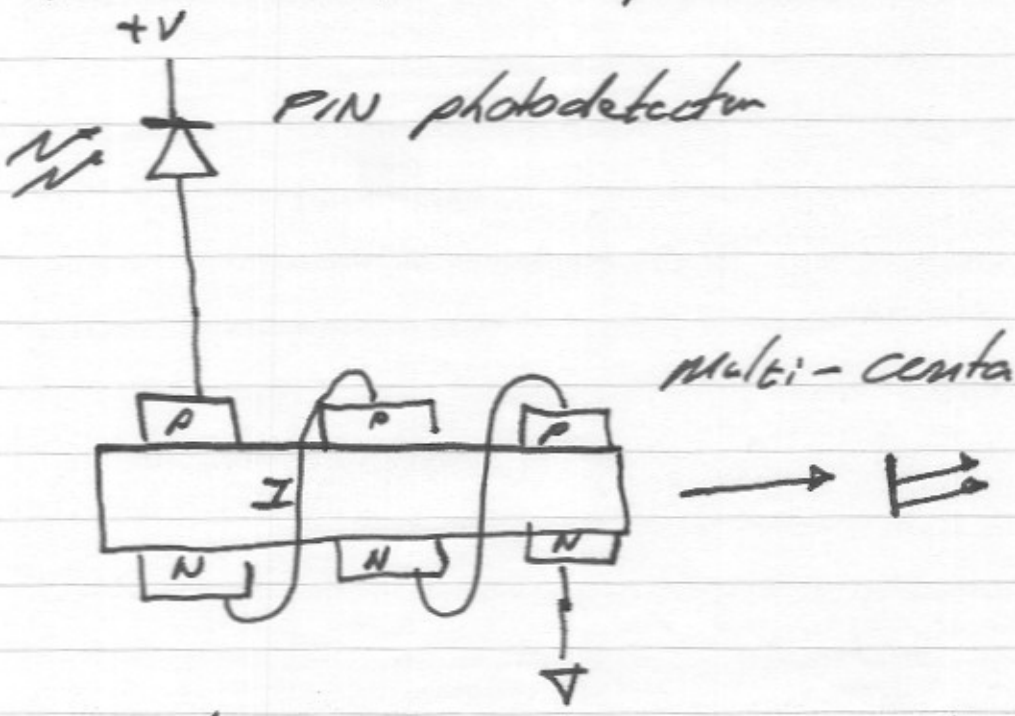
How do we measure / describe "jitter"

How much does loop suppress it?

How does Mixer & amplifier noise figure

impact system?

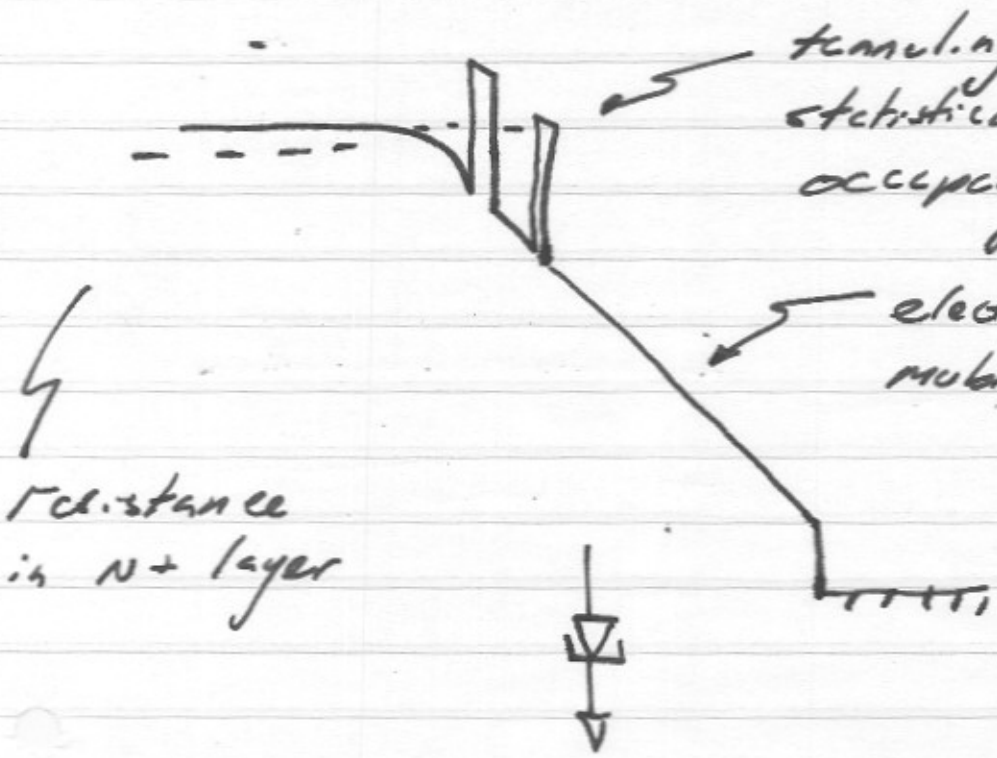
Photon Number Amplifier



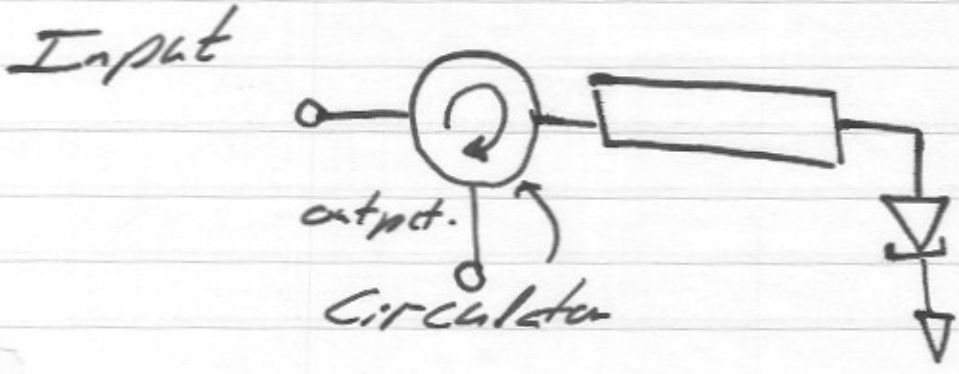
how does optical S/N ratio change from input to output?

Is this a noiseless amplifier?

Resonant-tunnel-diode:



How do we predict the noise contribution of this device?

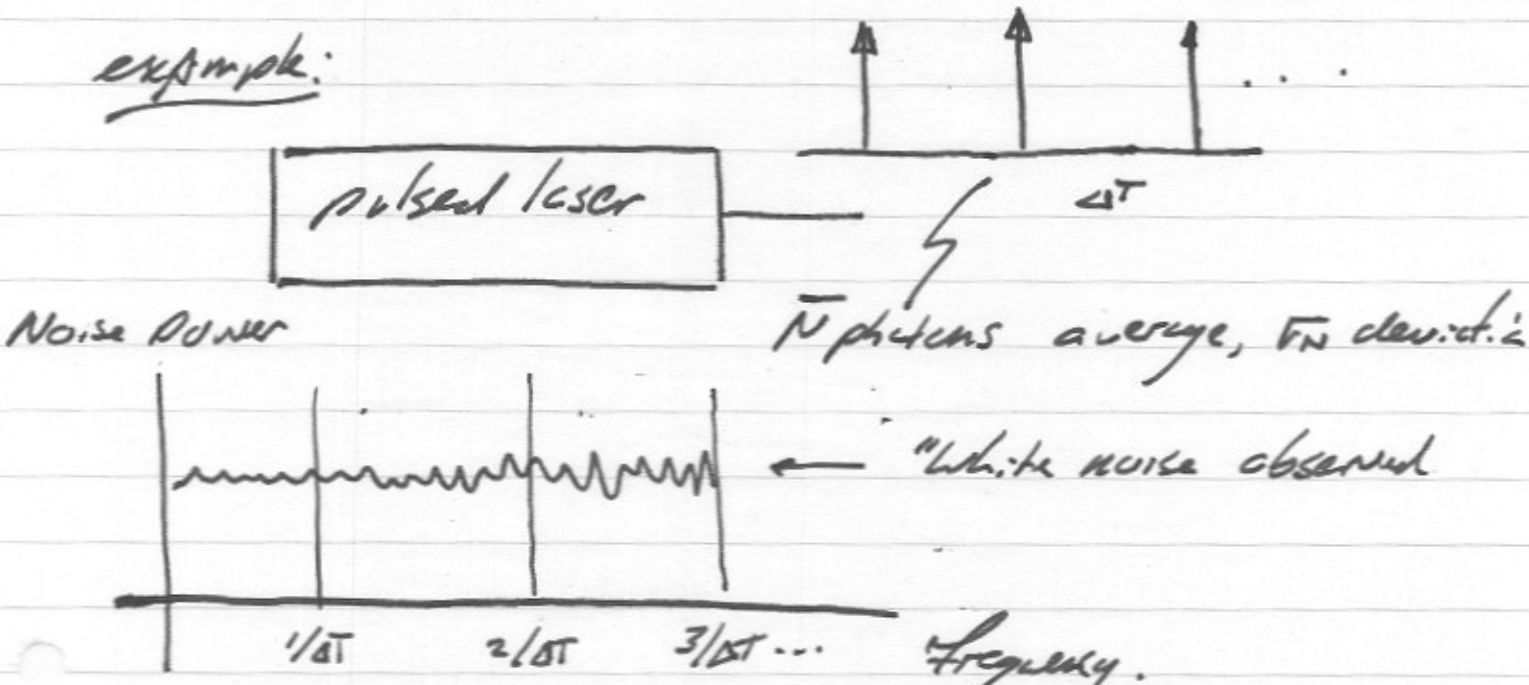


what are the noise properties of this amplifier?

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:



should receiver bandlimit to 1/ΔT ??

References we will use cautiously:

Van Der Ziel: Noise in Solid State Devices

Motchenbacher: Low Noise Electronic Design.

Vendelin: Microwave Circuit Design.

Bell Labs: Transmission systems for communication.

IEEE Reprint collections:

Pucel: MMICs

Fukui: Low Noise transistors.

⋮ Microwave Digital Radio.

Smith & Personick: Optical Recvrs.

Wozencraft & Jacobs:

Principles of communication engineering.

National semiconductor - Linear Applications

Gray & Meyer: Analog IC des. gn.

Papoulis: Probability - random variables.