ECE594I Notes set 1: Motivation

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Why Study Noise ?

Not a secondary "add - on" subject.

Noise determines :

      range of communicat ions links

      resolution of measuremen ts

      precision of control systems.

Noise involves several disciplines

math (probabili ty theory)

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physics (statistic al thermodyn amics)

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semiconduc tor device physics

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circuit analysis and design

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communicat ion systems & instrument s (specific system analysis)

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Information theory (generaliz ed system design)

    (informati on theory is closely related to statistica l thermodyn amics

      & broadens our understand ing of probabilit y.)

Agenda

Enough math to serve our needs

Quick coverage of noise physics (stat thermo).

Transistor & passive element noise models

Circuit noise analysis : component level, 2 - port level

Noise metrics

Instruments

Communications systems :Microwave digital radio, optical links

Summary of information theory

We will then quickly cover * missing * circuits material

    broadband analog circuits : used in fiber ICs

    digital gate delay analysis : communications, instruments

    nonlinearity analysis : interference in radio receivers

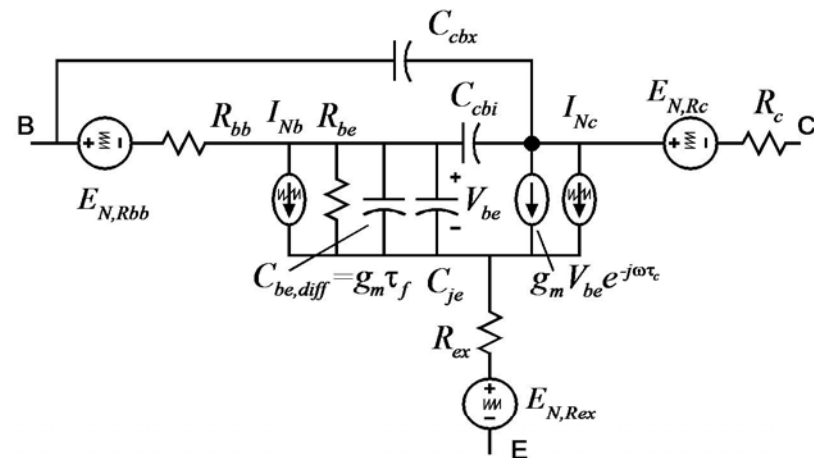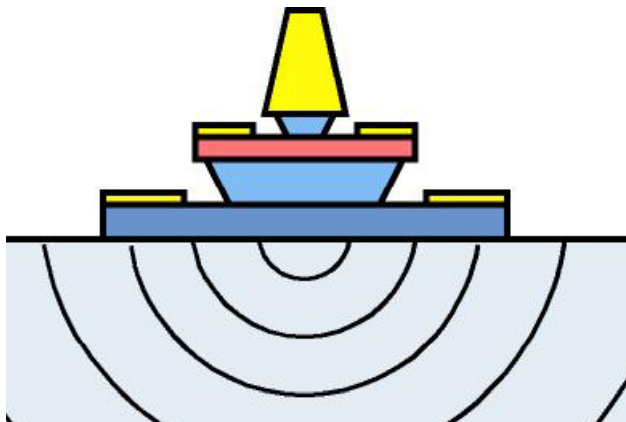# Problems to solve: (bipolar) transistor noise

How does noise vary with :

...device physical parameters ?

...bias conditions ?

...the impedance - match with the generator ?

How would we design the BJT and the circuit

for lowest added noise ?

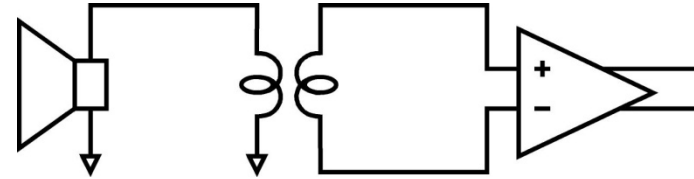(same questions for FETs)

Problems to solve: broadband preamplifiers

Microphone preamps :

    Why use a transformer ?

    What ratio ?

    What signal levels could we
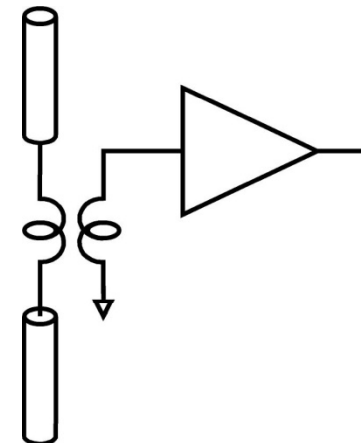
      expect to detect ?

Broadband radio receiver :

    Electrically short antenna $l << \lambda$
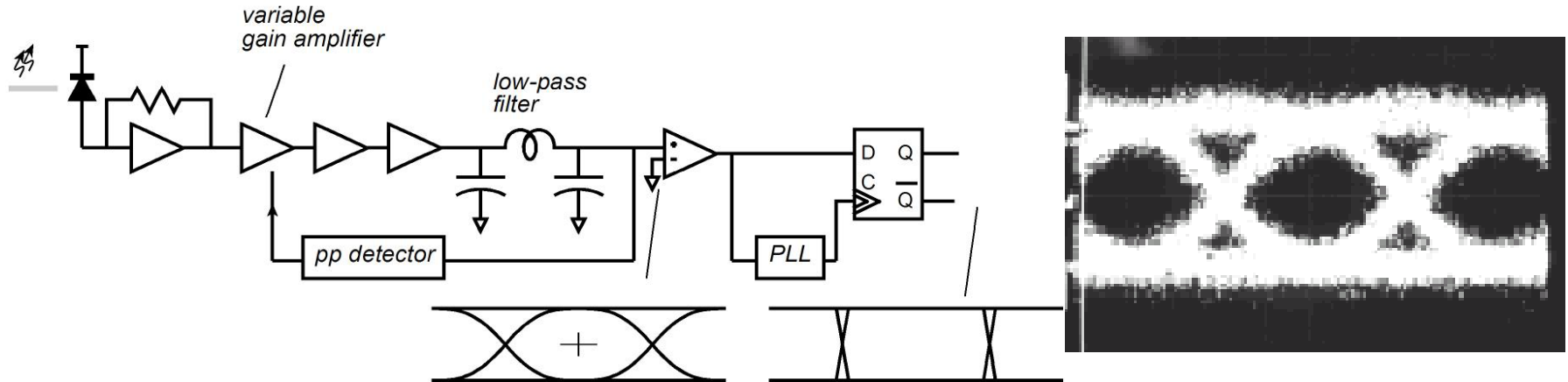
    How sensitive can the receiver be ?

    What are the design challenges ?

    What device, what circuit should we use ?

Problems to solve: optical receiver

What is the minimum detectable power ?

How does error rate change with received power ?

What preamp design gives best sensitivity ?

What are the filter, comparator, and latch for ?

What response should the filter have ?
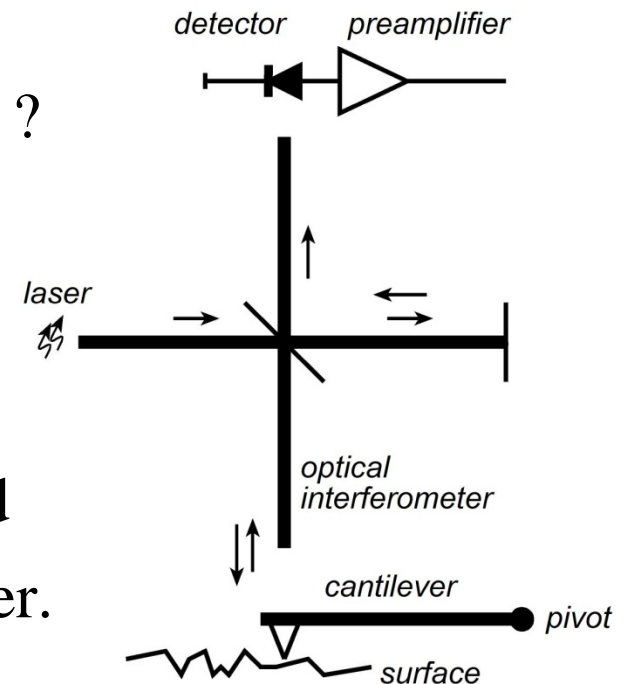
Problems to solve: atomic force microscope

What is the minimum observable displacement ?

Why might the laser 1/f noise matter ?

Why might we want to

(a) modulate the experiment at e.g. 1 kHz and

(b) detect the signal with a "lock-in" amplifier.

detector   preamplifier

laser

optical
interferometer

cantilever   pivot

surface

References and Citations:

Sources / Citations :

Kittel and Kroemer : Thermal Physics

Van der Ziel : Noise in Solid - State Devices

Papoulis : Probability and Random Variables (hard, comprehensive)

Peyton Z. Peebles : Probability, Random Variables, Random Signal Principles (introductory)

Wozencraft & Jacobs : Principles of Communications Engineering.

Motchenbaker : Low Noise Electronic Design

Information theory lecture notes : Thomas Cover, Stanford, circa 1982

Probability lecture notes : Martin Hellman, Stanford, circa 1982

National Semiconductor Linear Applications Notes : Noise in circuits.

Suggested references for study.

Van der Ziel, Wozencraft & Jacobs, Peebles, Kittel and Kroemer

Papers by Fukui (device noise), Smith & Personik (optical receiver design)

National Semi. App. Notes (!)

Cover and Williams : Elements of Information Theory

Possible Textbooks:

Van der Ziel ...and...

Gabriel Vasilescu :

Electronic noise and interfering signals : principles and applications