PEASE'S 1993 QUALS QUESTION

1. Define the Ampere.

2. How do you measure current (absolutely)?

3. Given that charge is quantized (in integral multiples of q) should not a low current have appreciable fluctuations? How big would these fluctuations be if we measured a current of 0.1pA (1 electron /μs) with a bandwidth of 10 KHz (i.e. integration times of about 100μs)?

4. If we measured current by observing (say, with a scanning tunneling microscope) the deposition of silver atoms at the cathode in an electrolytic cell would we see fluctuations corresponding to the Poisson distribution, i.e. a mean deposition rate of 100 electrons/100μs (corresponding to the 10 KHz bandwidth) and a standard deviation of √100 or 10% of the mean?

5. If we measured current by measuring the force between two wires carrying the current (fig. 1) would the force fluctuations be averaged out over the huge number of electrons in the wires (note the small dimensions to allow a bandwidth of 10KHz)? How many electrons are there?

6. If we introduced a pn junction diode into the circuit (fig. 2) would this change the fluctuations observed? Give reasons.

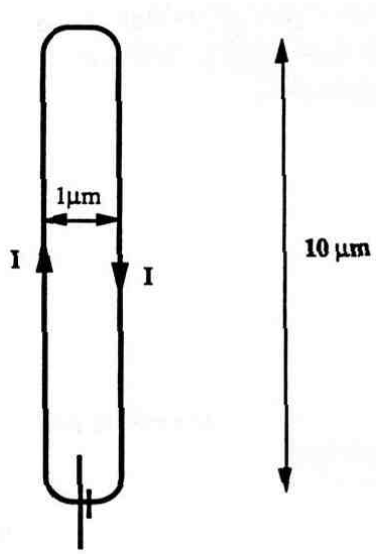


fig. 1

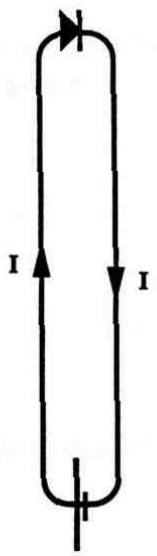


fig. 2

In each case the wire diamter is 0.1μm and the current is measured by measuring the force between the long arms of the wire with a very sensitive sensor (e.g. AFM).

Fabian

1995 Quals Questions - Pease

physics

1. Define Inductance.
2. Write down the expression for the impedance of an inductor (phase or notation).
3. Why is a coil a suitable shape for an inductor?

   Bring out a moving - coil loudspeaker
4. How does this loudspeaker work?
5. Over what range of frequencies?
6. What is printed on the loudspeaker ("8 ohms, 0.5W")?
7. Why does it say '8 ohms' without reference to frequency (given that the electrical component is a coil)?
8. Why does it say '0.5W' when you cannot dissipate power in an inductor?
9. How would you relate the mechanical work done by the cone to the electrical characteristics of the loudspeaker?

Fabian pease

Pease's '96 QUals questions:

- What are commonest types of transistors and what are they used for?

- What are the desirable properties of a transistor used in digital logic?

- What are the limits of those properties as set by physics, and by technology?

- Suppose micromachining was developed so we could make electromechanical structures to 100nm, 10nm or even 1nm. Could we make a relay that would be as good, or even better, than a silicon transistor? In particular could we get a better on/off ratio for a given switching energy?

Fabian

Quals Question 2000, Pease

1. Why is the semiconductor industry spending $B's on shrinking the features of IC's?
2. How do the speed and energy dissipated per clock cycle vary with linear dimensions (vertical and horizontal) when the speed is limited by the interconnect load (in a CMOS inverter ckt.)?
3. Why does the energy dissipated per clock cycle not depend upon the resistance when it is only in the resistance that energy is dissipated?
4. By driving the interconnect with a slow ramp instead of a step function can we lower the energy dissipated/clock cycle below CV^2?
5. What fundamental factors (i.e. NOT lithography) limit how far we scale down dimensions of IC's?

From: "Fabian Pease" <pease@cis.Stanford.EDU>
To: "Diane Shankle" <shankle@ee.stanford.edu>
Subject: Re: Quals Meeting Today!
Date: Mon, 29 Jan 2001 13:59:21 -0800
X-Priority: 3

Thanks Diane:
Here's my Question(s):

1. During the last 30 years digital circuitry has been increasingly doing tasks previously done with analog circuitry. Why?

2. List some of the parameters used to describe the technical performance of an analog-to-digital converter (ADC).

3. Outline how an ADC works. What happens when the 2 inputs to a comparator are the same?

4. What are some of the fundamental limits to ADC performance; for example does the Heisenberg uncertainly principle set a limit to the combination of high speed and high resolution? How might the various forms of noise limit speed and resolution?

Fabian
-----Original Message-----

From: "Fabian Pease" <pease@cis.stanford.edu>
To: "Diane Shankle" <shankle@ee.Stanford.EDU>
Cc: <group@jumpjibe.stanford.edu>
Subject: Quals question
Date: Tue, 22 Jan 2002 10:33:02 -0800
X-Priority: 3

Pease's Question(s):

1. Draw the circuit diagram of a CMOS inverter. Add a capacitive load C.
2. If you apply a square-wave clock to the input how much energy is dissipated in 1 clock cycle (and where and when) ?
3. Do you think chips will draw more or less power in the future ? Explain.
4. Why have batteries progressed so little in the last 100 years?

fp

Date: Sat, 15 Jan 2005 16:29:19 -0800
From: Fabian Pease <pease@cis.stanford.edu>
X-Accept-Language: en-us, en
To: Diane Shankle <shankle@ee.Stanford.EDU>
Subject: Re: Quals Questions 2005

Pease's question(s):

1. Define 1 volt
2. How do you measure voltage (several ways are possible)?
3. Have you ever heard of a Kelvin Generator? (no one had)
4. Here is one. When the water flows a voltage is generated. How does it work?
5. Try using this multimeter to measure the voltage (get a transient indication of voltage, then nothing). Why doesn't the meter work?
6. Devise a voltmeter with infinite (>1e14 ohms) resistance.

Date: Wed, 01 Mar 2006 16:09:02 -0800
From: Fabian Pease <pease@cis.stanford.edu>
X-Accept-Language: en-us, en
To: Diane Shankle <shankle@ee.Stanford.EDU>
Subject: Re: Reminder Quals Question 2006

Diane Shankle wrote:

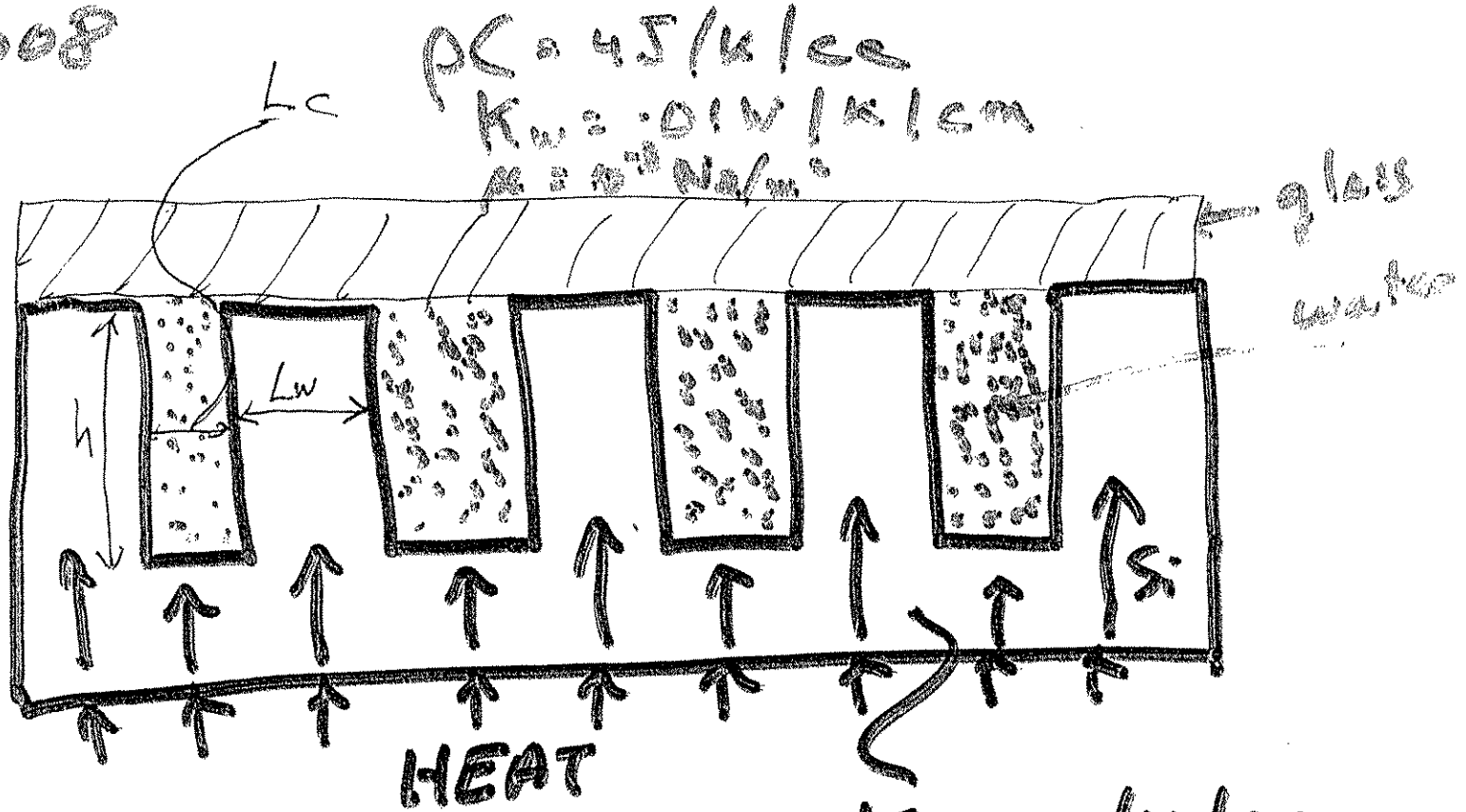
> Hi,
>
> Reminder!
>
> Please send me your Quals question.
>
> Thanks and Enjoy Your Day,
> Diane

Peases's Question:
Here is a pair of Bose sound-cancelling headphones. Try them on.
How would you design a sound-cancelling headphone?
fp

Fabian Pease

A cathode-ray oscilloscope (CRO) operates by focusing and deflecting a beam of free electrons onto a screen. Outline the limitations to the sensitivity, resolution and speed. You may assume the electron lens is free of aberrations.

Pease' Question
2008



Length (into board) 1 cm
Water Pressure 1 atm

- Why do heat sinks have fins?
- Express the area advantage of the above finned structure over an un-finned structure terms of h, Lc, Lw.
- Choose h, Lc, Lw.

Fabian Pease

For what was the most recent Nobel Prize in Physics awarded?

a) How does the image sensor in your digital camera work? (if you don't know, invent one)
b) Why, do you think, the CCD won the prize when other devices (Solar cell, DRAM, SRAM, Flash memory, CPU-chip) did not?
c) Why, do you think, has the CMOS sensor largely replaced the CCD in digital cameras?

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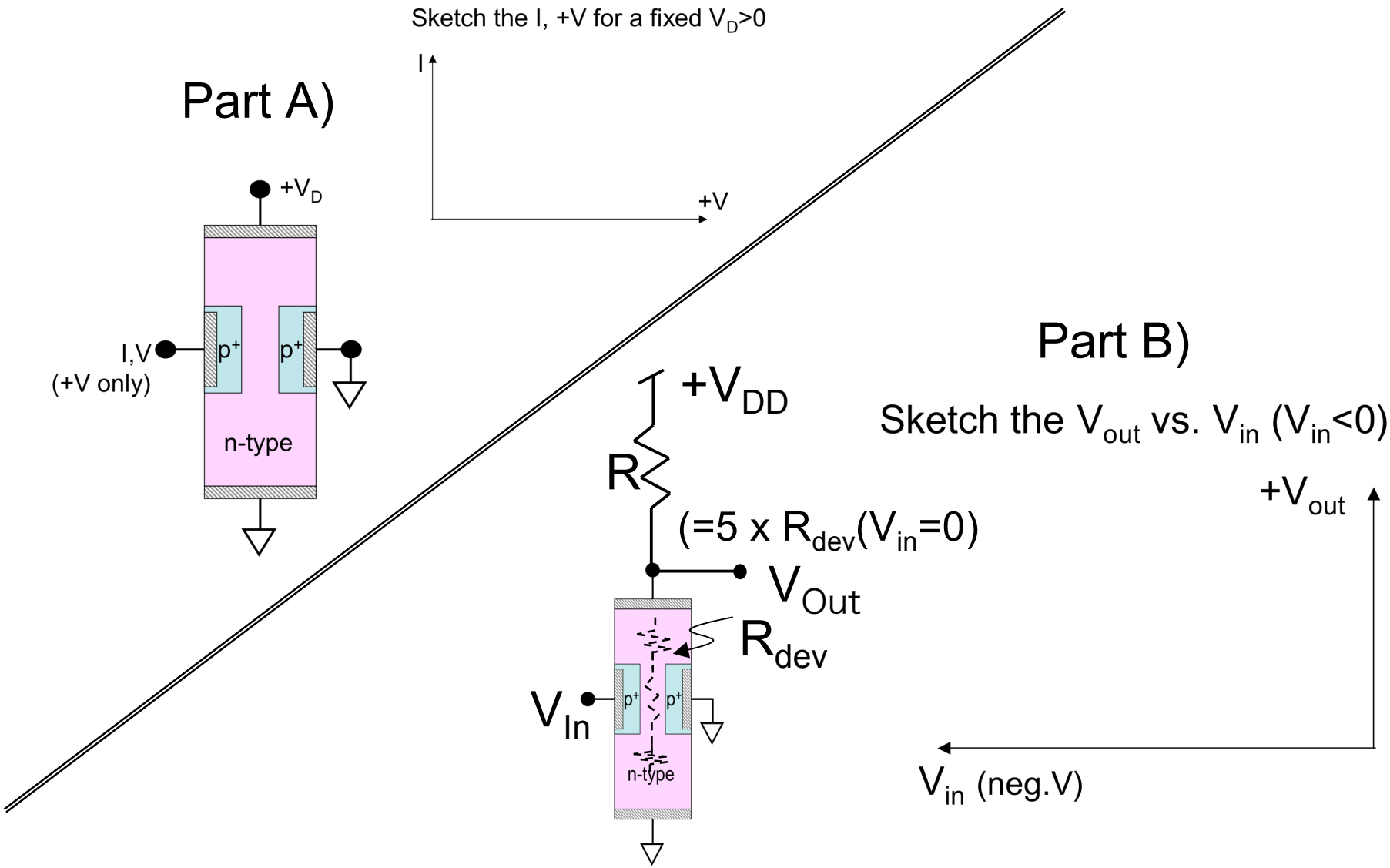

After discussion of Parts A) and B) there were follow-on questions (not included here) dealing with different terminal connections and bias conditions for Part A) and how to “optimized” the device performance in Part B)

Pease's Quals question 2012

When troubleshooting electrical equipment containing voltages 100 to 300 we are advised to stand on an insulating sheet. Why?

BUT when the equipment has voltages about 50,000V we are advised to be sure we are grounded. Why?

How much energy do we store when we are charged to 50,000V?

Estimate your capacitance. Either isolated or standing on a 1cm thick insulator.

How would you measure your capacitance?

2013 Quals Questions
Fabian Pease

What do you mean by the term 'active device'; give examples of active and passive devices.
What do you think was the earliest active device?
Here is a vacuum tube. Hot filament down the center emits electrons that are attracted to the anode. In between is a grid electrode that modulates the electron current between anode and cathode.
Now using the board show me how a MOSFET works. Why is the substrate silicon (or other single crystal semiconductor)? Why not graphite (or other cheap amorphous or polycrystalline material)? i.e. how is it that the gate voltage affects the conductance of a silicon layer but not of a graphite one?