



## Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
E L O 4 1 A	T 2 0 1	2 0 1 8 - 0 4 - 0 5
Kursnamn	Elektronik AV, Sensorer och instrumentering	
Provnamn	Teori del 2: Skriftlig tentamen	
Ort	Sundsvall	
Termin	V18	
Ämne	Elektronik	



**Mittuniversitetet**  
MID SWEDEN UNIVERSITY

## Sensors and Instrumentation

Written re-examination on theory part 2, 3 hp  
The 5<sup>th</sup> of April 2018

All answers to the questions and solutions to the mathematical problems should be written in an “easy to read and easy to follow” fashion. Mention and motivate, if you make an assumption. Try to be precise and coherent in formulating your answers. Irrelevant and/or unnecessarily long text might cost you points. Figures and plots, if needed, should be drawn with proper labels, units and axes.

- Calculators are allowed.
- Only printed dictionary books are allowed, NOT the electronic ones.
- Time: 5 hours.
- Maximum points: 60.
- Minimum points to pass: 30.

**Grading scale:**

Points	Grade
54 - 60	A
48 - 53.5	B
42 - 47.5	C
36 - 41.5	D
30 - 35.5	E
28.5 - 29.5	Fx
0 - 28	F

Good luck!  
Dr. Reza Salim  
Phone: +46101428922

## Section A: $7 \times 6 = 42$ points

- (1) Explain photolithography process step by step with necessary figures.
- (2) Answer to the following questions:
  - (a) Describe the wet etching process and its types.
  - (b) Describe the dry etching process.
  - (c) Which special goal in sensor fabrication can be achieved by combining wet and dry etching?
- (3) Define p-type and n-type semiconductors, how they are created? How a pn-junction is formed? Explain forward biased and reverse biased conditions in a pn-junction.
- (4) One way to establish a good thermal coupling between a temperature sensor and an object of interest is to embed the sensor into the object. What are the problems/challenges in doing that? How can you overcome those challenges? Describe the operation of a temperature sensing system with your solution.
- (5) How do these sensors work?
  - (a) Fluoroptic temperature sensor.
  - (b) Chilled mirror based humidity sensor.
- (6) Answer to the following questions:
  - (a) How does a closed-loop accelerometer function?
  - (b) Describe the structure of a pressure sensitive piezoelectric cable. Where can it be useful?
- (7) How do these sensors work?
  - (a) Gas drag vacuum sensor.
  - (b) Optical dust sensor.

## Section B: 8 points

- (1) A photon with 0.248 nm of wavelength strikes on a piece of Si and is completely absorbed. As a result, an electron from the K-shell of a Si atom is liberated by the photoelectric effect. What is the kinetic energy of the liberated electron?

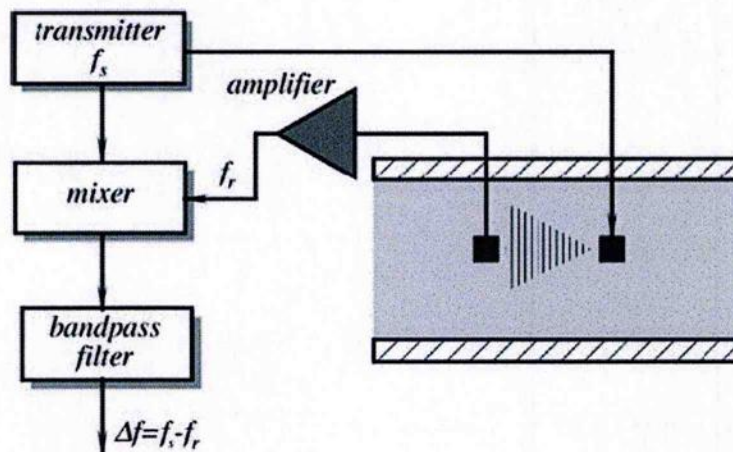
3 points

Help:

Photon energy,  $E = \frac{hc}{\lambda}$  Planck's constant,  $h = 4.13567 \times 10^{-15} \text{ eVs}$  Speed of light,  $c = 3.0 \times 10^8 \text{ ms}^{-1}$  Electron binding energy in the K-shell in Si is 1.839 keV

- (2) A transmitter-receiver assembly is positioned inside a flowing stream. If  $\Delta f = 0.4$  MHz,  $f_r = 2.6$  MHz and the velocity of sound in that medium in the given temperature is  $\approx 1480 \text{ ms}^{-1}$ , estimate the average fluid velocity,  $v$ .

3 points



Help:

$$\Delta f = f_s - f_r \approx \frac{2f_s v}{c}$$

- (3) If the speed of sound in dry air is  $343.33 \text{ ms}^{-1}$ , find out the temperature.

2 points

Help:

$$v \approx 331.5 \sqrt{\frac{T}{273.15}} \text{ ms}^{-1}$$

## Section C: $10 \times 1 = 10$ points

Write true or false for each statement below.

- (1) In a carbon nanotube (CNT) the length-to-diameter ratio is really low.
- (2) Both sputtering and chemical vapor deposition have to be performed in a vacuum chamber.
- (3) A photoresistor changes its resistance as the function of incident light.
- (4) When a bolometer is exposed to electromagnetic radiation, the radiation is absorbed by the resistor and converted into heat - the heat elevates the temperature of the resistor above the ambient - the temperature increase changes the ohmic resistance of the bolometer - resistance is converted into electric output.
- (5) When heat is transferred by means of radiation - thermal energy in the form of UV light is exchanged between the sensor and the object.
- (6) In soil moisture measurements using coil, eddy currents get stronger as the water content increases.
- (7) Moving a magnet through a coil of wire will induce a voltage in the coil.
- (8) There is no difference between force and pressure.
- (9) The SI unit of pressure is psi.
- (10) The electromagnetic flow sensors are useful for measuring the movement of conductive liquids.

*If you can't explain it simply, you don't understand it well enough.*

– Albert Einstein