



## Försättsblad Prov Original

Kurskod	EL041A	Provkod	T101	Tentamensdatum	2019 - 01 - 07
Kursnamn	Elektronik AV, Sensorer och instrumentering				
Provnamn	Teori del 1: Skriftlig tentamen				
Ort	Sundsvall				
Termin					
Ämne					

# Sensors and Instrumentation

Written examination on theory part 1, 1.5 hp

The 7<sup>th</sup> of January 2019, HT 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.

- Course codes
  - EL041A, EL046A
- Aid:
  - Calculator,
  - If relevant, a dictionary or electronic dictionary between English and the students home language.
- Time: 2 hours.
- Maximum points: 30.
- Minimum points to pass: 15.

Grading scale:

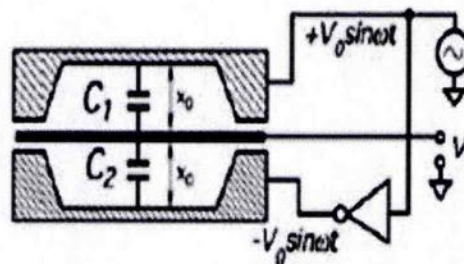
30	Max
27	A
24	B
21	C
18	D
15	E
14	Fx
0-13	F

Section A:  $5 \times 3 = 15$  points

- (1) Sensor characterization is usually described using a graph showing sensor output versus stimulus. Draw such graphs to exemplify the concepts of hysteresis in sensor characteristics.
- (2) Design a liquid level detector using a prism. Describe the working principle of your liquid level detector.
- (3) What is the photoelectric effect? Describe. Also describe and discuss two similar physical effects.
- (4) Design a sensor to detect tiny displacements of an object using piezoresistive material. Explain the operating principle of your sensor.
- (5) Explain how Eddy currents are utilized in a dual-coil metal detector.

Section B: 10 points

- (1) You have three equally spaced plates (each with 2.5 cm in length and 1.5 cm in width) as shown in the figure below, where  $x_0 = 5$  mm. The plates form two capacitors  $C_1$  and  $C_2$ . The upper plate is supplied with a sinewave signal, where  $V_0 = 4.5$  V. The same signal is inverted and supplied to the lower plate.
  - a) Calculate the voltage  $V$  and explain. 4 points
  - b) You have attached the central plate to an object without disturbing the arrangement and the object just moved 1.5 mm straight upward. Calculate the new  $C_1$  and  $C_2$ .



Help:

$$C = \frac{\epsilon_0 A}{d} \quad \epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$$

- (2) You have a gamma radiation source with the photon energy 5,0 keV and the intensity 20 kBq. You have two different detectors, one in Ge (cooled) and one in GaAs (room temperature). Calculate the rate of electron-hole-pair-creation in the two respective detectors for this photon beam. You can assume that the absorption rate in the detectors are 100%. Recalculate this rate to current using the electron charge  $q = 1.602 \cdot 10^{-19}$  C. (Use the material table below).

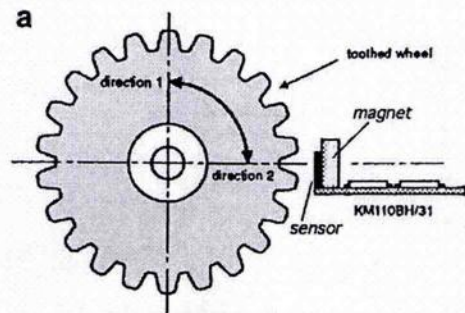
4 points

**Table 16.2** Detecting properties of some semiconductive materials (adapted from ref. [2])

Material (operating temperature in K)	Z	Band gap, eV	Energy per electron-hole pair, eV
Si (300)	14	1.12	3.61
Ge (77)	32	0.74	2.98
CdTe (300)	48–52	1.47	4.43
HgI <sub>2</sub> (300)	80–53	2.13	6.5
GaAs (300)	31–33	1.43	4.2

- (3) A magnetoresistive sensor mounted in line with a permanent magnet close to a rotating wheel generate a square wave signal with frequency 1.3 kHz. The no of teeth of the wheel is 22. Calculate the angular velocity.

2 points



Section C: 5 x 1 = 5 points

Find the most correct answer.

(1) A pyroelectric device is a

- (a) Heat flow detector.
- (b) Force detector.
- (c) Heat detector.
- (d) Both (a) and (c).

(2) When polarized light strikes a metallic object, the rejected light usually

- (a) Retain its polarization.
- (b) Has different polarization angle.
- (c) Becomes non-polarized.
- (d) None of the above.

(3) What does it mean if a detector has a dead band

- (a) There is a band on the detector that block the signal for part of the surface area.
- (b) For some values of the stimulus, no change in output is detected.
- (c) The surface layer of the detector does not react to stimulus.
- (d) None of the above.

(4) In general, all sensors are transducers, but not all transducers are sensors.

- (a) True.
- (b) False.

(5) Heat can not be contained, which means that it flows spontaneously from warmer to cooler part of the system and there is no method known to modern science to stop the heat flow entirely

- (a) True
- (b) False
- (c) Heat flow is mainly a quantum mechanical property that needs relativistic corrections to be understood since the flow approaches the speed of light.