Electronic Instrumentation
Regular exam
3 February 2012, 16:30-19:30
(Duration: 3 hours)

Universidade do Algarve
MIEET

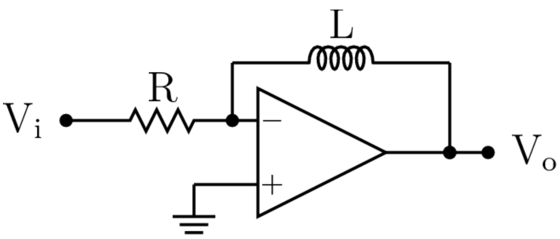
- Write your name, student number and course on all sheets you hand in.
- Talking is not allowed. If you do it, your exam will be canceled. Switch off your cellular telephone.
- If you give up, write “I Desist” on the exam sheet and hand it in.
- The exam has 5 questions and the maximum score for each is written in brackets.
- Write legible.
- Good luck!

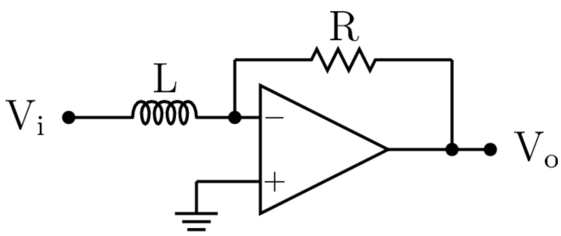
Question 1 (4)

The relation between voltage drop *V* and current *I* in an inductor *L* is given by:

$$V(t) = L\frac{dI(t)}{dt}$$

where *t* represents time. We can use an inductor in an opamp circuit. See the examples below. Consider the opamps ideal.



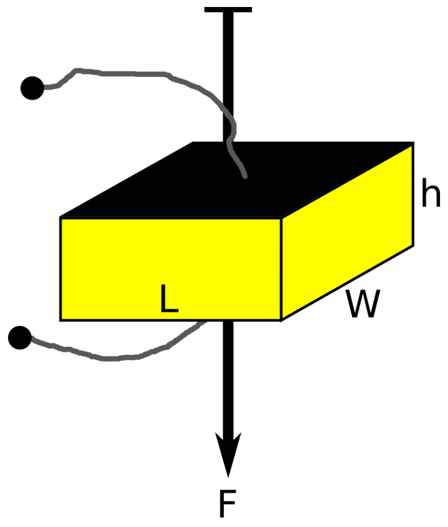


a) What means an 'ideal opamp'?

b) What is the relation between input and output of the above circuits.

Question 2 (8)

To weigh objects, we take a capacitor and let it be deformed when the weight is placed on top or hanging from it. Our capacitor exists of metal (thin) foil glued on two sides of a bar of material with dimensions *L*, *W* and *h*, see image below. For this calculation we will pull along direction h.



The capacitance of such a parallel-plates capacitor is given by

$$C = \frac{\epsilon_d A}{h}$$

with ε_d the permittivity of the material, *A* the area of the plates and *h* the distance between them.

a) Derive an expression for the gauge factor *k* of the capacitor,

$$k \equiv \frac{dC/C}{dh/h}$$

using the definition of Poisson's Ratio, ν

$$\nu \equiv -\frac{dL/L}{dh/h} = -\frac{dW/W}{dh/h}$$

b) What is the gauge factor for a material that has constant volume?

c) A constant-volume capacitor of nominal value of 1 μF is extended 1% in length h. What is the new value of the capacitance?

Young's Modulus *E* describes the deformation of a material when a force is acting upon it. It is the ratio between stress – pressure *P* (unit: Pa) – and relative deformation, strain ε (unitless),

$$E = P/\epsilon$$

$$\epsilon = dh/h$$

Note that the pressure P is the force per area, $P = F/WL$ in our case. The material we use for the capacitor is rubber which has the following properties:

Young's Modulus: $E = 0.05$ GPa

Permittivity: $\varepsilon_d = 7\varepsilon_0$ ($\varepsilon_0 = 8.85418 \times 10^{-12}$ F/m)

Poisson's Ratio: $\nu = 0.50$

The dimensions of our capacitor are

$L = 10$ cm

$W = 1$ cm

$h = 10$ μm

d) What is the nominal capacitance? (unit: F).

e) What is the sensitivity of the sensor? (unit: F/N).

The weight F and mass m of an object are related to $F = mg$, with $g = 9.81$ m/s^2.

f) What is the sensitivity of the sensor? (unit: F/kg).

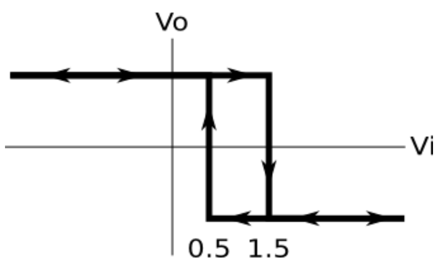
g) When measured with a multimeter with 4 decimal places at any scale, measuring directly the capacitance, what would be the resolution of the system? (unit: kg).

Question 3 (2)

What is a Wheatstone bridge and what is its advantage? Give a (numerical) example.

Question 4 (4)

Design a circuit that has hysteresis between 0.5 and 1.5 volt, as shown below



Question 5 (2)

Explain the following parameters of sensor systems

- Sensitivity
- Accuracy
- Resolution
- Selectivity

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