TÉCNICO LISBOA

SENSORS AND ACTUATORS

2022/2023 – 4th Quarter

1ST WRITTEN EXAM

June 28th, 2023

U LISBOA UNIVERSIDADE DE LISBOA

Number	Name	Room

Written Exam (closed book) with the duration of 2 hours. You can only turn in this sheet.

Part A

Part A is worth 10 points. Each answer in part A is worth 5 points. Justifications are important.

1. Consider a Stepper Motor.

a) (2 points) Describe the internal operation of a stepper motor.

There are several coils around the perimeter of the motor: the stator. When current is applied to one of those coils, it creates a magnetic field which attracts the rotor which becomes aligned with it. By changing the stator coil where current is applied, the rotor rotates to align itself with this new coil.

b) (2 points) In which applications is a stepper motor more suitable to be used?

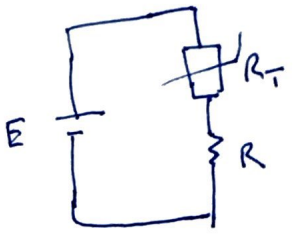
In applications where the goal is to position a load at some angle. For example, it can be used to pull the paper out of the tray of a printer.

c) (1 point) What is the meaning of "residual torque" and in which types of stepper motors have one?

The torque exerted by the motor on the load even when there is no current applied to any of the stator coils.

2. Consider a voltage divider consisting of a thermistor and a fixed resistance of 4 kΩ. Thermistor characteristics: Electrical resistance at 200 ºC: 1 kΩ, Thermal resistance: 0.2 ºC/W.

a) (2 points) What is the maximum dissipated power so that the self-heating is no more than 0.1ºC @ 200ºC?



$$0{,}2\,^\circ C/W \times P_{max} \leq 0{,}1\,^\circ C$$

$$\downarrow$$

$$P_{max} \leq 0{,}5\ W$$

b) (2 points) What is the maximum voltage that can be used in the voltage divider in the previous conditions?

$$P = R_T \cdot I^2 \qquad P < 0{,}5\ W \Rightarrow I < \sqrt{\frac{0{,}5}{1000}} = 22{,}3\ mA$$

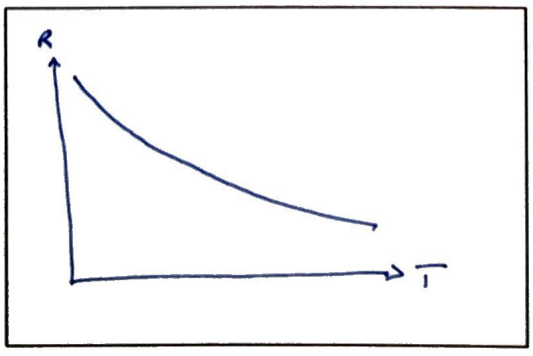
$$I = \frac{E}{R+R_T} \rightarrow E = I(R+R_T) \qquad E_{max} = I_{max}(R+R_T)$$

$$E_{max} = 22{,}3 \cdot 10^{-3} \cdot (4000 + 1000)$$

$$= 2{,}3 \cdot 5$$

$$= 111{,}5\ V$$

c) (1 point) Sketch the transfer function (Resistance versus Temperature) of a NTC thermistor.

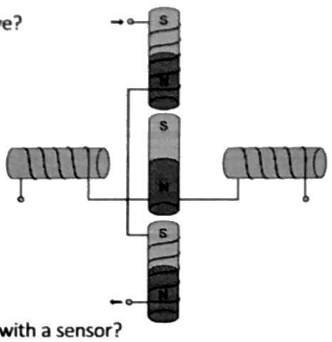


Part B

Part B is worth 10 points. Each answer in part B is worth 0.5 points if correct, -0.125 points if wrong and 0 points if not given.

The total minimum of part B is 0. Circle the correct choice. No justifications are needed.

1. Which type of sensor, actuator or system does not use electromagnetic waves?
   a. GPS system
   b. Pyrometer.
   c. Stepper motor.
   a. Magnetic resonance imaging.
   d. None of the above.
2. Consider a Peltier module. Which of the following statements is true?
   a. A Peltier module only transfers heat from one side to the other.
   b. The more current flowing through the module (within its specifications), the lower the temperature on the cold side.
   c. The temperature of the cold side for a given current depends on the heatsink used on the hot side.
   d. The temperature on the cold side is independent of temperature.
   e. None of the others.
3. In a capacitive microphone, what electrical parameter is directly affected by the acoustic wave?
   a. Charge.
   b. Resistance.
   c. Voltage.
   d. Capacity.
   e. None of the others.
4. The step-by-step motor of the figure has how many phases?
   a. One.
   b. Two.
   c. Four.
   d. Eight.
   e. None of the others.

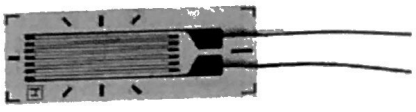


5. Which term describes the maximum expected error associated with the measurement made with a sensor?
   a. Resolution.
   b. Accuracy.
   c. Reach.
   d. Precision.
   e. None of the others.
6. Which of the following temperature sensors has high sensitivity but is not linear?
   a. A platinum RTD.
   b. A thermistor.
   c. An integrated sensor based on a PN junction.
   d. Thermocouple.
   e. None of the others.

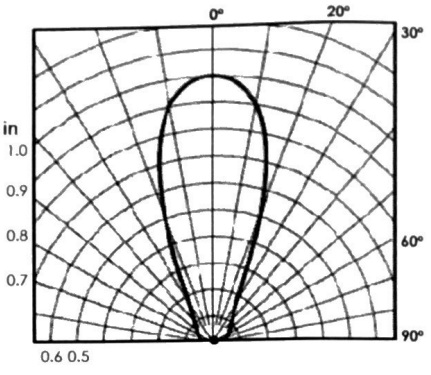
also ok →

7. What feature of a PWM signal determines the speed of rotation of a DC Motor?
   a. The amplitude.
   b. The offset.
   c. The frequency.
   d. The duty-cycle.
   e. None of the others.
8. In which mode of operation is the current in a photodiode directly proportional to the light intensity?
   a. It is never directly proportional.
   b. Photovoltaic.
   c. Photoconductive.
   d. In both photoconductive and photovoltaic modes.
   e. None of the others.
9. Consider that you have a speaker based on the piezoelectric effect. Should the system be sized to operate in which zone of the frequency response curve of the piezoelectric crystal?
   a. Resonance.
   b. Close to DC.
   c. In the flat part.
   d. In any zone.
   e. None of the others.
10. In the case of a permanent magnet stepper motor in which the rotor is aligned with one of the stator poles which of the following statements is true?
    a. The force between the rotor and this pole is zero and the torque is maximum.
    b. The force between the rotor and this pole is zero and the torque is zero.
    c. The force between the rotor and this pole is maximum and the torque is zero.
    d. The force between the rotor and this pole is maximum and the torque is maximum.
    e. None of the others.

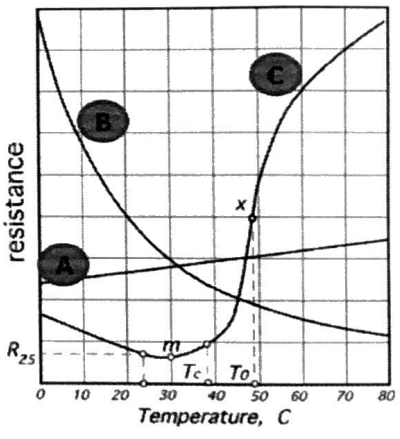
11. Ultrasound waves travel in which mediums?
    b. Vacuum.
    c. Just solids.
    d. Just air.
    e. Solids, liquids and gases.
    f. None of the others.
12. With a strain gauge oriented according to the figure in which direction (relative to the page) is it most sensitive?
    a. Horizontal.
    b. Vertical.
    c. Diagonal.
    d. Equally sensitive in all directions.
    e. None of the others.



13. What does a hot wire anemometer measure?
    a. Water temperature.
    b. Water velocity.
    c. Water density.
    d. Water acceleration.
    e. None of the others.
14. What are the typical values of distance that you can measure with ultrasound sensors?
    a. Tens of meters.
    b. Centimeters.
    c. Nanometers.
    d. Kilometers.
    e. None of the others.
15. What is the directivity of the photodiode whose datasheet extract is shown in the image?
    a. 20º.
    b. 40º
    c. 60º
    d. 90º
    e. None of the others.



16. What is the main advantage of measuring temperature with a pyrometer?
    a. Very accurate.
    b. Very fast.
    c. Can measure high temperatures.
    d. It also measures humidity.
    e. None of the others.
17. Consider the figure that shows the resistance variation of 3 temperature sensors. Which ones are RTDs?
    a. A.
    b. B.
    c. C.
    d. All of them.
    e. None of the others.
18. Which of the following temperature sensors works at higher temperatures?
    a. Thermocouple.
    b. Resistive temperature detector.
    c. Integrated temperature sensor.
    d. Thermistor.
    e. None of the others.
19. What physical phenomenon makes it possible for a stepper motor to rotate smoothly at high enough speeds?
    a. Air resistance.
    b. Temperature.
    c. Drag.
    d. Inertia.
    e. None of the others.



20. Why should an amplifier be used with a sensor that uses a photodiode?
    a. Because the current that comes out of the photodiode is very small.
    b. Because the cables that connect to the photodiode add too much capacity.
    c. Because the voltage that comes out of the photodiode has a small bandwidth.
    d. Because all sensors need to have an output voltage.
    e. None of the others.