

# Abbes Laghrour university

## L3 Automatique

### Capteurs et chaîne de mesure

#### Final Exam and key answer

1- What is the difference between active sensors and passive sensors?  
Specify the type (active or passive) for the following sensors: thermocouple, piezoresistive strain gauges, and Pt100.

2- Explain the following concepts: "sensor calibration" and "sensor sensitivity".

- Suggest a pressure sensor with high sensitivity.
- Suggest a non-contact temperature sensor.

3- Classify the following sensors in the table below:  
Piezoresistive gauges, Thermistors, incremental encoders, float sensors, pyrometers.

Level sensors	Temperature sensors	Pressure sensor	Position sensors

4- Briefly describe the operating principle of piezoresistive strain gauge sensors.

5- A vertical cylindrical tank has a total height of 6 meters and an internal diameter of 2 meters. An ultrasonic sensor is placed at the top. The speed of sound in air depends on the temperature (T) (in °C) according to the simplified formula:

$$V \text{ (m/s)} = 331.5 + 0.6T$$

- Recall the operating principle of this level sensor.
- Calculate the speed of sound if the temperature inside the tank is 30 °C.

- The sensor receives the echo after a time delay of 12 ms. Calculate the distance (d) between the sensor and the liquid.
- Calculate the height of the liquid (l) remaining in the tank.

**Key answer :**

### 1-Active sensor vs Passive sensor

**Active sensor:** Operating as a generator, an active sensor is generally based on a physical effect that ensures the conversion of the measurand's specific energy into electrical energy.

**Passive sensor:** This refers to an impedance where one of the determining parameters is sensitive to the measurand. The impedance of a passive sensor and its variations can only be measured by integrating the sensor into an energized electrical circuit, which acts as its conditioner.

**Active sensor:** thermocouple

**Passive sensor:** piezoresistive strain gauges, and Pt100.

2-

-**Sensor Calibration :** Calibrating a sensor consists in determining the relationship between the value of the measurand  $m$  and the value of the output electrical quantity  $s$ , as a function of additional parameters.

- **Sensitivity(S):** is the ratio of the change in the output signal ( $s$ ) to the corresponding change in the quantity being measured ( $m$ );  $S=ds/dm$ .

- **a pressure sensor with high sensitivity :** Semiconductor strain gauges
- **a non-contact temperature sensor :** Pyrometer

3-

Level sensors	Temperature sensors	Pressure sensor	Position sensors
float sensors	thermistors, pyrometer	piezoresistive gauges	incremental encoders

4- Piezoresistive strain gauge sensors operate by converting mechanical strain (deformation) into a change in electrical resistance, utilizing the piezoresistive effect. When external force/pressure causes a diaphragm to deform, the strain alters the resistivity and geometric structure of the sensor, changing its resistance proportionally to the applied stress.

5-

1. An ultrasonic level sensor is a transducer that functions alternately as a transmitter and a receiver. This transducer placed at the top of the tank, emits acoustic wave trains within a narrow cone. After reflection from the liquid surface, these waves return to the transducer, which converts them into an electrical signal. The time interval  $t$  between the emission and reception of the reflected wave train is proportional to the distance of the transducer from the liquid surface; it is therefore a function of the level.

$$h = (1/2) * C * t$$

With  $C$  being the speed of sound and  $t$  the round-trip time of the ultrasonic signal. The transducer converts this time into a direct level reading.

**2. Speed of sound at 30 °C:**

$$V=331.5+(0.6*30)=331.5+18=349.5 \text{ m/s}$$

**3. Measured distance  $d$  :**

$$d=V*t/2=349.5*0.012/2=2.097\text{m}$$

**4. Liquid height  $l$ :**

$$l=\text{Total height}-d=6-2.097=3.903\text{m}$$