

Sensors of physical quantities

Sensor

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example, a mercury-in-glass thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube. A thermocouple converts temperature to an output voltage which can be read by a voltmeter. For accuracy, most sensors are calibrated against known standards.

Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware. Applications include cars, machines, aerospace, medicine, manufacturing and robotics.

A sensor is a device which receives and responds to a signal or stimulus. Here, the term “stimulus” means a property or a quantity that needs to be converted into electrical form. Hence, sensor can be defined as a device which receives a signal and converts it into electrical form which can be further used for electronic devices. A sensor differs from a transducer in the way that a transducer converts one form of energy into other form whereas a sensor converts the received signal into electrical form only.

A sensor's **sensitivity** indicates how much the sensor's output changes when the measured quantity changes. For instance, if the mercury in a thermometer moves 1 cm when the temperature changes by 1 °C, the sensitivity is 1 cm/°C. Sensors that measure very small changes must have very high sensitivities.

A good sensor obeys the following rules:

- Is sensitive to the measured property
- Is insensitive to any other property likely to be encountered in its application
- Does not influence the measured property

Ideal sensors are designed to be linear or linear to some simple mathematical function of the measurement, typically logarithmic. The output signal of such a sensor is linearly proportional to the value or simple function of the measured property. The sensitivity is then defined as the ratio between output signal and measured property. For example, if a sensor measures temperature and has a voltage output, the sensitivity is a constant with the unit [V/K]; this sensor is linear because the ratio is constant at all points of measurement.

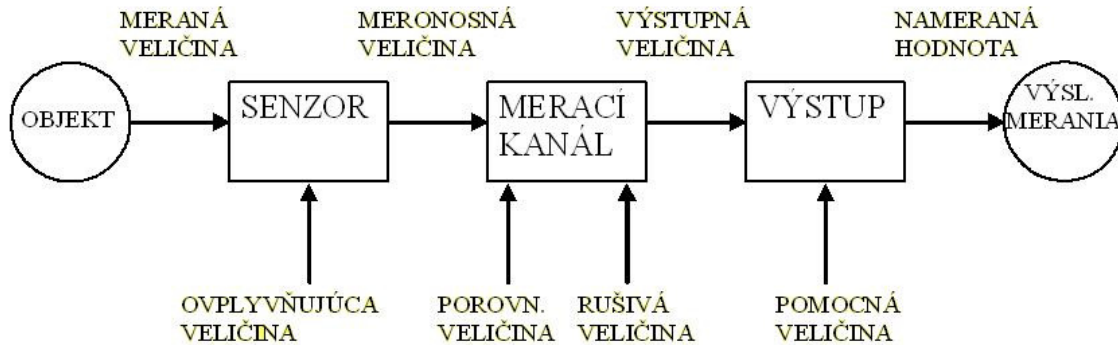
Note: All living organisms contain biological sensors with functions similar to those of the mechanical devices described. For example: light – eyes, smell - nose, sound – ears, and so on.

Electrical measuring circuit

Is composed of operating components such as amplifiers, filters, generators, counting circuits that can manipulate the amplitude and shape of an incoming signal from a sensor. Output is converted by decoding components into a human readable form.

Displaying measured quantities

Analog data are usually shown on a scale using a pointer. Numeric or digital data are shown as numbers on digital displays. In modern devices, memory is an important component that stores information about the measured quantity for further analysis.



Two basic groups of sensors:

Active

The effect of the measured physical quantity on the sensor does not change the sensor's electrical properties. The sensor does not need a power supply.

Passive

The effect of the measured physical quantity on the sensor changes the electric parameters (resistance, inductance, capacitance, frequency), therefore the sensor needs a power supply to function properly.

Types of physical quantity sensors:

Mechanical sensors

- *Pressure*
- *Movement*
- *Position*
- *Speed*
- *Acceleration*
- *Vibration*
- *Force*
- *Momentum*

Heat sensors

- *temperature*
- *heat*
- *heat flow*

Radiation sensors

- visible light
- infrared
- ultraviolet
- nuclear

Chemical sensors

- solution concentration
- polarographic sensors
- substance composition sensors/detectors

Other types of sensors:

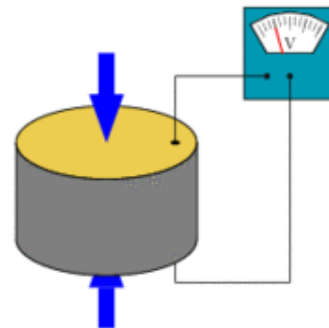
- touch
- contactless
- linear (analog)
- digital (numeric)
- compound
- integrated

Example of sensors

Piezoelectric pressure sensor

Piezoelectricity is the ability of some materials to generate an electric field or electric potential in response to applied mechanical stress.

Piezoelectric pressure sensors directly measure pressure. The measured pressure is applied onto a piezoelectric crystal which in turn creates electric polarization that produces electric voltage. When the mechanical pressure ceases, the dielectric returns to its original state. They are used to measure fast changing pressures up to 100 MPa.



Note: The word is derived from the Greek piezo, which means to squeeze or press.

Electronic temperature sensors

Resistance thermometers, also called resistance temperature detectors or resistive thermal devices (RTDs), are temperature sensors that exploit the predictable change in electrical resistance of some materials with changing temperature. As they are almost invariably made of platinum, they are often called platinum resistance thermometers (PRTs). They are slowly replacing the use of thermocouples in many industrial applications below 600 °C, due to higher accuracy and repeatability.

Electronic temperature sensors use the dependency of a certain electrical quantities such as electrical resistance from the temperature. Resistance based temperature sensors and thermoelectric sensors (thermocouples) belong to a group of electronic temperature sensors. Their main advantage is small size, accuracy, low cost and numerous design variations.

Semiconductor resistance temperature sensors – thermistors – use the relation between temperature and resistance. They are very sensitive to temperature changes. Based on how the resistance responds to temperature changes, we distinguish between two types of temperature coefficients:

1. NTC – Negative Temperature Coefficient (resistance decreases with an increase in temperature)
2. PTC – Positive Temperature Coefficient (resistance increases with an increase in temperature)

Thermocouple is an electric temperature detector that uses thermoelectric resistance created by heat (Seebeck's effect).

Liquid level sensors with an electrical output

Level sensors with an electrical output utilize mostly capacity, resistance and electromechanical principals.

RPM sensors

Electronic RPM sensors are specially designed electric devices such as dynamos or power generators. The amount of output voltage is directly proportional to the number of rotations.

VOCABULARY

sensor – snímač

observer – pozorovateľ

thermocouple – termočlánok

innumerable – nespčetné, nespočítateľné

aware – vedomý

responds – reaguje

logarithmic – logaritmický

mercury – ortuť

glass tube – sklenená trubica

tactile – hmatový

dim – matný

stimulus – podnet, impulz, popud

sensitivity – citlivosť

obeys – počúva na slovo