

Fakulta strojní VŠB – TUO

Katedra automatizační techniky a řízení

Control Instrumentation

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Katedra automatizační techniky a řízení

Lecture No. 4
Division of sensors and examples for measuring quantities in engineering and their evaluation

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Katedra automatizační techniky a řízení

What do you find out?

- Division of sensors
- Conversion of the measured value to the measurable
- The essence of transfers
- Examples of sensors
- Ways of evaluation
- ...

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Katedra automatizační techniky a řízení

Principles of measurement

The measured quantity **changes the electrical**

- Direct measurement methods –
- Indirect measurement methods –

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Principles of sensors

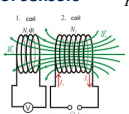
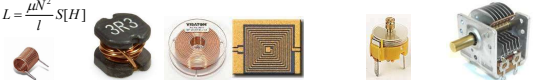
$R = \rho \cdot \frac{l}{S} [\Omega]$ $R = R_0(1 + \alpha\Delta t) [\Omega]$

$C = \frac{Q}{U} [F]$ $C = \epsilon_0 \epsilon_r \frac{S}{d} [F]$

$L = \frac{\Phi}{I} [H]$

$U_i = -L \frac{dI}{dt} [V]$

$L = \frac{\mu N^2}{l} S [H]$

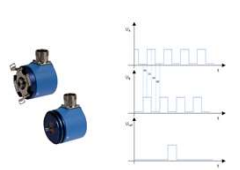
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Criterion I –

- for measuring
- ...



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Criterion I - according to the measured quantity

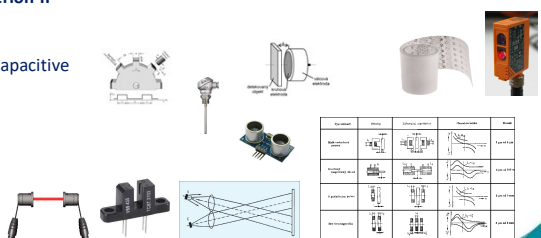
This is one of the basic criteria used by the designer

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Criterion II –

- Capacitive



| Typ senzoru | Princip činnosti | Charakteristika | Aplicace |
|--------------|------------------|-----------------------------|-----------------------------------|
| Induktivní | Indukční | Velká vzdálenost, odolnost | Průmysl, zemědělství |
| Kapacitní | Kapacitní | Malá vzdálenost, citlivost | Automobilový průmysl, zemědělství |
| Ultrazvukový | Ultrazvukový | Velká vzdálenost, odolnost | Průmysl, zemědělství |
| Teplotní | Teplotní | Malá vzdálenost, citlivost | Průmysl, zemědělství |
| Optický | Optický | Velká vzdálenost, citlivost | Průmysl, zemědělství |

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Criterion II –


Not all methods of evaluation may be suitable for measuring in the conditions of technology.

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Criterion IV – according to the method of

Values from sensors can be




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Requirements

- Principle of sensor
 - measurement of dimensions, length, presence of objects, position, level height of liquids and loose materials
 - measurement of flows and pressures of gases, liquids and bulk materials
 - temperature and heat measure
 - measuring speed, shaft speed, weight, forces, torques and vibrations
 - ...




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Position, dimension, displacement - resistiv sensors

- Angle of rotation



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Evaluation of resistance sensors

$U = IR$

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Evaluation of capacitive sensors

$U = IR$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

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Evaluation of induction sensors

$U = IR$

$X_L = \omega L = 2\pi f L$

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Measurement of acceleration

The diagram shows the internal structure of an ICP sensor, including the Acoustic Shield, Seismic Mass, Piezoelectric Material, Electrical Connector, Preload Stud, Mounting Stud, and Receptacle. It also displays a block diagram of the sensor's internal circuitry, which includes a Charge Amplifier, Temperature Sensor, and Signal Processor. The output is shown as a mass m with displacement $\pm b y$.

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Position measurement - linear

The diagram illustrates the principle of a linear displacement transducer using a differential transformer. It shows the conductive plates, dielectric, primary winding, and secondary windings (VS1, VS2). The displacement x is measured relative to the zero position. The output voltage U_{out} is proportional to the displacement x .

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Measurement of water level, presence of an object

The diagram shows the principle of ultrasonic level measurement. It includes a diagram of the sensor's operation, a photo of the sensor module, and a diagram of the sensor's internal components. The sensor measures the distance D from the fluid level to the measurement point. The output is a digital signal.

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Level measurement

The slide illustrates various level measurement methods. On the left, a float valve mechanism is shown with labels for 'Vessel', 'Pressure liquid', 'Nozzle', 'Weight decreasing mechanism', 'Displace "tag"', 'Nozzle', and 'Open valve'. In the center, a 'Bubbler type level measurement device' is depicted with a 'Tank' containing 'Process liquid', a 'Bip tube', and a 'Pressure transmitter for weight'. On the right, a 'Pressure transmitter for weight' is shown with a 'Signal out' and 'Air supply' connection. A photograph of a float valve is also included.

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Measurement of dimensions

sliding scale

The slide shows several precision measuring instruments. It includes a 'sliding scale' (vernier caliper), a digital depth gauge with a software interface, a vernier caliper, and a micrometer.

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Displacement measurement

The slide details displacement measurement techniques. It features a diagram of a probe with force vectors F_1 and $F_2 = f(x)$. Another diagram shows a probe with force vectors F_1 and $F_2 = f(x)$. A photograph shows a dial indicator measuring a cylindrical part. A diagram of a laser interferometer is also present.

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Measurement speed

Operating principle of MEMS Linear Acceleration Sensor

Static Acceleration

Displacement (mm)

Acceleration sensor angle (deg)

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Measurement of acceleration

Fig. 1 Basic Configuration of Strain-gage Acceleration Transducer

Internal structure of an acceleration sensor

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Strength measurement

Strength measurement

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Pressure measurement

A tubular device for measuring pressure differences is called a manometer.

$$\Delta P = P_2 - P_1 = \rho g h$$

Pressure at top is less Fluid density

1 atmosphere = 760 mmHg
 = 29.92 inches Hg
 = 407 inches H₂O
 = 33.9 ft H₂O
 Hg = mercury

Stationary plate Solid frame

Pressure Pressure

Isolating diaphragm Silicone fill fluid Sensing diaphragm (moving plate) Isolating diaphragm

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Pressure measurement

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Pressure measurement

Dynamic force

Electrode

Quartz crystal

Piezoelectric Pressure Transducer

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Flow measurement

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Flow measurement

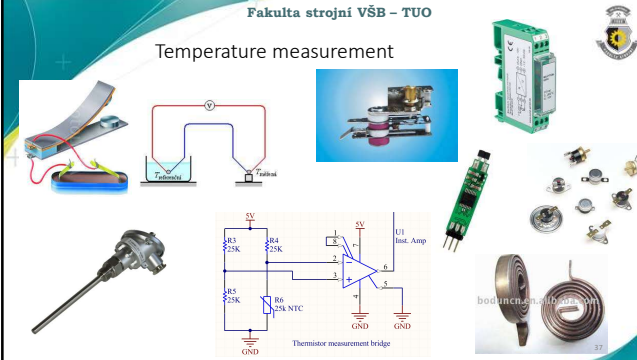
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Temperature measurement

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Temperature measurement



The slide displays various temperature measurement components and a circuit diagram. On the left, there is a photo of a sensor assembly with a thermocouple and a thermistor. In the center, a schematic diagram shows a Wheatstone bridge circuit for a thermistor measurement. The bridge consists of a 5V supply, a 25kΩ resistor, a 25kΩ resistor, a 25kΩ resistor, and a 25kΩ NTC thermistor. The output is connected to a 5V supply and a 1kΩ resistor, which is then connected to a U1 micro-ampere meter. On the right, there are photos of a green PCB module, a thermocouple, and a thermistor.

Thermistor measurement bridge

U1
micro. Amp

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Katedra automatizační techniky a řízení

What was the content of the lecture?

- Division of sensors
- Conversion of the measured value to the measurable
- The essence of transfers
- Examples of sensors
- Ways of evaluation
-

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