EEM 451 Industrial Control Systems
Sensors and Actuators-II

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In order to monitor, control the process variables, sensors are used. There exists numerous type of sensors in industry, some of them are:

- Industrial optical sensors
- Industrial physical sensors
- Industrial measurement sensors
Industrial physical sensors: Temperature sensors

These sensors can be classified into two groups: Contact and non-contact temperature sensors.

▶ Contact temperature sensors: the temperature of the sensor and the object, which is in contact to sensor, are in thermal equilibrium. They measure their own temperature

▶ Noncontact temperature sensors: there does not exist any contact with the object. The temperature of the object is determined by by measuring the radiant power that is assumed to be emitted.
Industrial physical sensors: Temperature sensors

Resistance temperature detectors, also called Resistance thermometers, can be classified as thin film RTDs and wound wire RTDs. In both, the principle in RTDs is the change of resistance due to the temperature change.
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Mounted wire

Thin film
A thermistor is a thermally sensitive resistor that exhibits a change in electrical resistance, more than the standard resistance, when a change happens in a temperature.
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Industrial physical sensors: Temperature sensors

Radiation Thermometer (Non-contact): The idea is the fact that materials with a temperature above absolute zero emit thermal radiation. Radiation Thermometer measures the temperature by using the radiated electromagnetic thermal.
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# How to choose Temperature sensors

<table>
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<tr>
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<th>Thermocouple</th>
<th>RTD</th>
<th>Thermistor</th>
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<tbody>
<tr>
<td>Temp. r Range</td>
<td>-450+4200F</td>
<td>-400+1200F</td>
<td>-100+500F</td>
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<tr>
<td>Long-term Stability</td>
<td>Poor to fair</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Acc.</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Sens. (output)</td>
<td>Low</td>
<td>Medium</td>
<td>Very high</td>
</tr>
<tr>
<td>Response</td>
<td>Medium to fast</td>
<td>Medium</td>
<td>Medium to fast</td>
</tr>
<tr>
<td>Linearity</td>
<td>Fair</td>
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<td>Poor</td>
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Advantages of Thermocouples
No resistance lead wire problems, Fastest resp., Simple, Inexpensive, High temperature operation

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Non-linear, Least stable, Least sensitive.
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Most stable, accurate, More linear than thermocouple, Area temperature sensing

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**Advantages of Thermistor**
High output, fast Two-wire ohms measurement, Economical

**Disadvantages of Thermistor**
Non-linear, Limited range, Fragile, Current source required
Industrial physical sensors: Distance sensors

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**Active sensor**
It is a sensor measures the change of a physical field around the sensor with emitting
Industrial physical sensors: Distance sensors

Ultrasonic distance sensors measure the distance to, or presence of target objects by sending a pulsed ultrasound wave at the object and then measuring the time for the sound echo to return. Knowing the speed of sound, the sensor can determine the distance of the target object.
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The ultrasonic distance sensor regularly emits a barely audible click by supplying a high voltage either to a piezoelectric crystal, or to the magnetic fields of ferromagnetic materials. Then, the crystal bends and sends out a sound wave. A timer within the sensor keeps track of exactly how long it takes the sound wave to bounce off a target and return. This delay is then converted into a voltage that corresponds to the distance from the sensed object.
The ultrasonic distance sensor can be operated in two different modes:

**Continuous mode:** the sensor continuously sending out sound waves at a rate determined by the manufacturer.
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Continuous mode: the sensor continuously sending out sound waves at a rate determined by the manufacturer.

Clock (or digital) mode: the sensor sending out signals at a rate determined by the user. This rate can be several signals per second with the use of a timing device, or it can be triggered intermittently by an event such as the press of a button.
Industrial physical sensors: Distance sensors

**Optical Distance sensors**

Optical distance sensors detect the decrease or change in transmission of light emitted from a laser or diode.
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**Inductive distance sensors**
Inductive sensors are non-contact devices that set up a radio frequency field with an oscillator and a coil. The presence of an object alters this field and the sensor is able to detect this alteration. This field is emitted at the sensing face of the sensor. If a metallic object (switching trigger) nears the sensing face, eddy currents are generated.
Industrial physical sensors: Distance sensors

Capacitive Distance sensors
Non-contact sensors. It is based on measuring changes in an electrical property called capacitance. Capacitance describes how two conductive objects with a space between them respond to a voltage difference applied to them.
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Photoelectric distance sensors
Photoelectric distance sensors emit irradiating light to the target, receive the reflected light from the target, and can make measurement of the target position.

- Phototransistor analyzes incoming light, verifies that it is from the light source, and triggers an output.
- Through beam photoelectric sensor, is configured with the emitter and detector opposite the path of the target and sense presence when the beam is broken.
- Retroreflective photoelectric sensor is configured with the emitter and detector and rely on a reflector to bounce the beam back across the path of the target.