EEM 451 Industrial Control Systems
Sensors and Actuators-I

Hakkı Ulaş Ünal
Dept. of Electrical-Electronics Eng.
Anadolu University, Turkey
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**: are used to measure various quantities utilizing the characteristics of light. Some of the typical optic sensors are color and scan sensors.

- **Industrial physical sensors**: are used to measure the variations in physical properties of the samples, such as temperature, stiffness, elastic modulus, presence of irregularities. Temperature and distance sensors are widely used sensors in industry.

- **Industrial measurement sensors**
Color sensors detects the color of the object based on measuring the intensity of the reflected radiation from the object whenever a light is casted to it. These sensors often used to detect primary colors (red, green, blue) and secondary colors (magenta, cyan, yellow) and black and white.
Industrial optical sensors: color sensors

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Industrial optical sensors: color sensors

- The color sensors generally composed of three LDR systems and a chip.
- Each of these LDR systems consists of a different color filter and a convex lens.
- These color filters are red, blue, and green.
- Whenever the light is reflected from the object, which is in front of the sensor, the lens cause to the light rays to converge.
- Then, the filters determine which LDR will be triggered and the corresponding gate output will light.
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Selection factors:
- Operating, rated, output voltages
- Spectral sensitivity
- Color temperature.
- ...
Industrial optical sensors: scan sensors

Scan sensors, are called image or vision sensors, converts analog information into an electronic image in a digital format that can be used by the computer. They are widely used in industrial control for alignment, matrix code reading, color recognition, edge detection, scanning, dimensioning applications.
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In scanning, a white light strikes the image and then its reflected onto a photosensitive surface on the sensor. Each pixel of the reflected light transfers a gray value such that image ranging from 0 (black) to 255 (white). The software interprets the value in terms of 0 (black) or 1 (white) as a percentage then a monochrome image of the scanned item is formed. As the sensor moves forward, it scans the image in tiny strips and the sensor stores the information in a sequential fashion.
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 measuring the radiant power that is assumed to be emitted.
Industrial physical sensors: Temperature sensors

Thermocouples are widely used in industry and there exists several types of thermocouples. They produce a voltage as a function of temperature of the object which is in contact with the sensor.
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Thermoelectric

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Industrial physical sensors: Temperature sensors

- Metal A
- Metal B

$T_s$  $T_e$

$+ e_{ab} -$
Industrial physical sensors: Temperature sensors

- $V_B = S_B \Delta T$, $V_A = S_A \Delta T$
- $e_{ab} = V_A - V_B$
- $S_{AB} = S_A - S_B$
Industrial physical sensors: Temperature sensors

<table>
<thead>
<tr>
<th>Standard Calibration</th>
<th>Material</th>
<th>Temp Range</th>
<th>Accuracy</th>
<th>Premium Grade</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;J&quot;</td>
<td>Iron</td>
<td>32 F to 1400 F</td>
<td>+/- 4 F or 0.75%</td>
<td>&quot;JJ&quot;</td>
<td>+/- 2 F or 0.4%</td>
</tr>
<tr>
<td>&quot;K&quot;</td>
<td>Chromel</td>
<td>32 F to 2300 F</td>
<td>+/- 4 F or 0.75%</td>
<td>&quot;KK&quot;</td>
<td>+/- 2 F or 0.4%</td>
</tr>
<tr>
<td>&quot;T&quot;</td>
<td>Copper</td>
<td>-320 F to 700 F</td>
<td>+/- 2 F or 0.75%</td>
<td>&quot;TT&quot;</td>
<td>+/- 1 F or 0.4%</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>Chromel</td>
<td>32 F to 1600 F</td>
<td>+/- 3 F or 0.75%</td>
<td>&quot;EE&quot;</td>
<td>+/- 1.8 F or 0.4%</td>
</tr>
<tr>
<td>&quot;N&quot;</td>
<td>Nicrosil</td>
<td>32 F to 2300 F</td>
<td>+/- 4 F or 0.75%</td>
<td>&quot;NN&quot;</td>
<td>+/- 4 F or 0.4%</td>
</tr>
</tbody>
</table>