Terminology

- Transducers convert one form of energy into another
- Sensors/Actuators are input/output transducers
- Sensors can be passive (e.g. change in resistance) or active (output is a voltage or current level)
- Sensors can be analog (e.g. thermocouples) or digital (e.g. digital tachometer)
## Transducer types

<table>
<thead>
<tr>
<th>Quantity being Measured</th>
<th>Input Device (Sensor)</th>
<th>Output Device (Actuator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Level</td>
<td>Light Dependant Resistor (LDR), Photodiode, Phototransistor, Solar Cell</td>
<td>Lights &amp; Lamps, LED's &amp; Displays, Fiber Optics</td>
</tr>
<tr>
<td>Temperature</td>
<td>Thermocouple, Thermistor, Thermostat, Resistive temperature detectors (RTD)</td>
<td>Heater, Fan, Peltier Elements</td>
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<tr>
<td>Force/Pressure</td>
<td>Strain Gauge, Pressure Switch, Load Cells</td>
<td>Lifts &amp; Jacks, Electromagnetic, Vibration</td>
</tr>
<tr>
<td>Position</td>
<td>Potentiometer, Encoders, Reflective/Slotted Opto-switch, LVDT</td>
<td>Motor, Solenoid, Panel Meters</td>
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<tr>
<td>Speed</td>
<td>Tacho-generator, Reflective/Slotted Opto-coupler, Doppler Effect Sensors</td>
<td>AC and DC Motors, Stepper Motor, Brake</td>
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<tr>
<td>Sound</td>
<td>Carbon Microphone, Piezo-electric Crystal</td>
<td>Bell, Buzzer, Loudspeaker</td>
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</table>
Positional Sensors: potentiometer

Processing circuit

![Diagram of a potentiometer sensor and its associated circuitry.](image)
Positional Sensors: LVDT

Linear Variable Differential Transformer
Positional Sensors: Inductive Proximity Switch

- Detects the presence of metallic objects (non-contact) via changing inductance
- Sensor has 4 main parts: field producing Oscillator via a Coil; Detection Circuit which detects change in the field; and Output Circuit generating a signal (NO or NC)
Positional Sensors: Rotary Encoders

- Incremental and absolute types
- Incremental encoder needs a counter, loses absolute position between power glitches, must be re-homed
- Absolute encoders common in CD/DVD drives
Temperature Sensors

- **Bimetallic switch** (electro-mechanical) – used in thermostats. Can be “creep” or “snap” action.

- **Thermistors** (thermally sensitive resistors); **Platinum Resistance Thermometer** (PRT), very high accuracy.
Thermocouples

- Two dissimilar metals induce voltage difference (few mV per 10K) – electro-thermal or Seebeck effect

- Use op-amp to process/amplify the voltage
- Absolute accuracy of 1K is difficult
<table>
<thead>
<tr>
<th>Code Type</th>
<th>Conductors (+/-)</th>
<th>Sensitivity</th>
<th>British BS 1843:1952</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Nickel Chromium / Constantan</td>
<td>-200 to 900°C</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Iron / Constantan</td>
<td>0 to 750°C</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Nickel Chromium / Nickel Aluminium</td>
<td>-200 to 1250°C</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Nicrosil / Nisil</td>
<td>0 to 1250°C</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>Copper / Constantan</td>
<td>-200 to 350°C</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>Copper / Copper Nickel Compensating for &quot;S&quot; and &quot;R&quot;</td>
<td>0 to 1450°C</td>
<td></td>
</tr>
</tbody>
</table>
Light sensors: photoconductive cells

- Light dependent resistor (LDR) cell
Light level sensitive switch
Photojunction devices

photodiode

phototransistor
Photovoltaic Solar Cells

- Can convert about 20% of light power into electricity
- Voltage is low (diode drop, \(~0.6V\)
Photomultiplier tubes (PMT)

- Most sensitive of light sensors (can detect individual photons)
- Acts as a current source

![Diagram of Photomultiplier Tube](image)
Motion sensors/transducers

- Switches, solenoids, relays, motors, etc.
- Motors
  - DC
    - Brushed/brushless
  - Servo
  - Stepper motors
- AC
Sound transducers

- microphone

- speaker

• Note: voice coil can also be used to generate fast motion
Piezo transducers

- Detect motion (high and low frequency)
- Sound (lab this week), pressure, fast motion
- Cheap, reliable but has a very limited range of motion
Summary

• We’ve only briefly touched on most basic types
• Many other transducers are used/common, almost for any physical quantity one can think of
• Processing electronics is often essential: output of many sensors is not linear, needs impedance transform, filtering, etc.
• For additional references see
  • Handbook of Transducers by H.N. Norton