# MKT 1121
# Chapter-10

# Mechatronics Technology Sensors

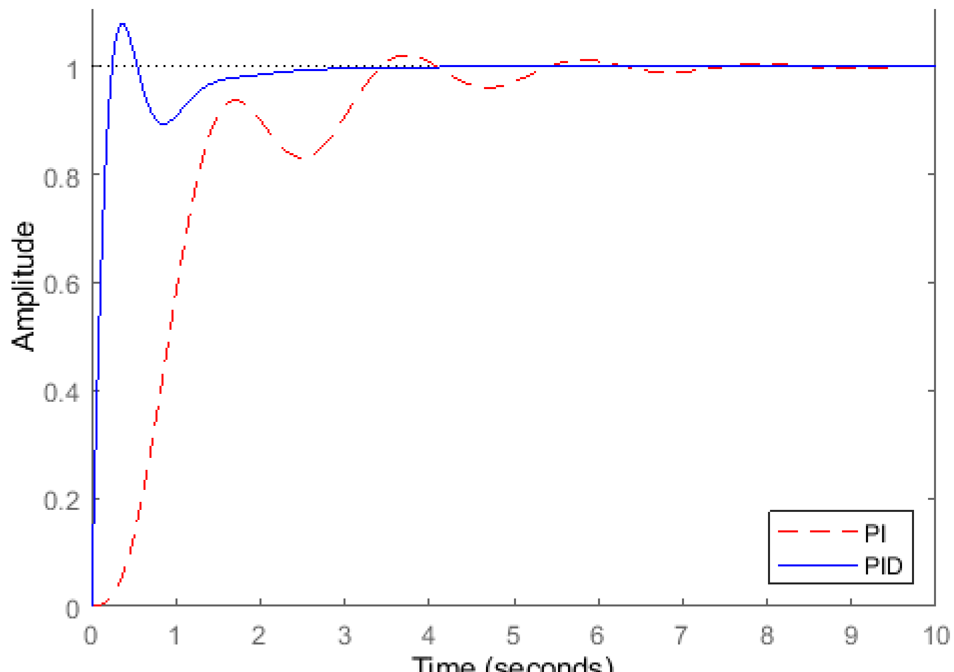
# Response time

• Response time: indicates the time needed forthe output to reach steady state for a stepchange in input.

• Typically the response time will be given as the time needed to reach 90% of steady state output upon exposure to a unit step change in input.

• The response time of the device is due to the inertia of the device (both mechanical and electrical).

• Fast response time is usually desirable• Slow response times tend to average readings



## Repeatability

• Also called reproducibility: failure of the sensor to represent the same value under identical conditions when measured at different times.

– usually associated with calibration

– given as percentage of input full scale of the maximum difference between two readings taken at different times under identical input conditions.

# Sensitivity

- **Sensitivity** of a sensor is defined as the change in output for a given change in input, usually a unit change in input. Sensitivity represents the slope of the transfer function.
- Also is used to indicate sensitivity to other environment that is not measured.
- Example: sensitivity of resistance measurement to temperature change

# Resolution

- **Resolution:** the minimum increment in stimulus to which the sensor can respond. It is the magnitude of the input change which results in the smallest observable output.

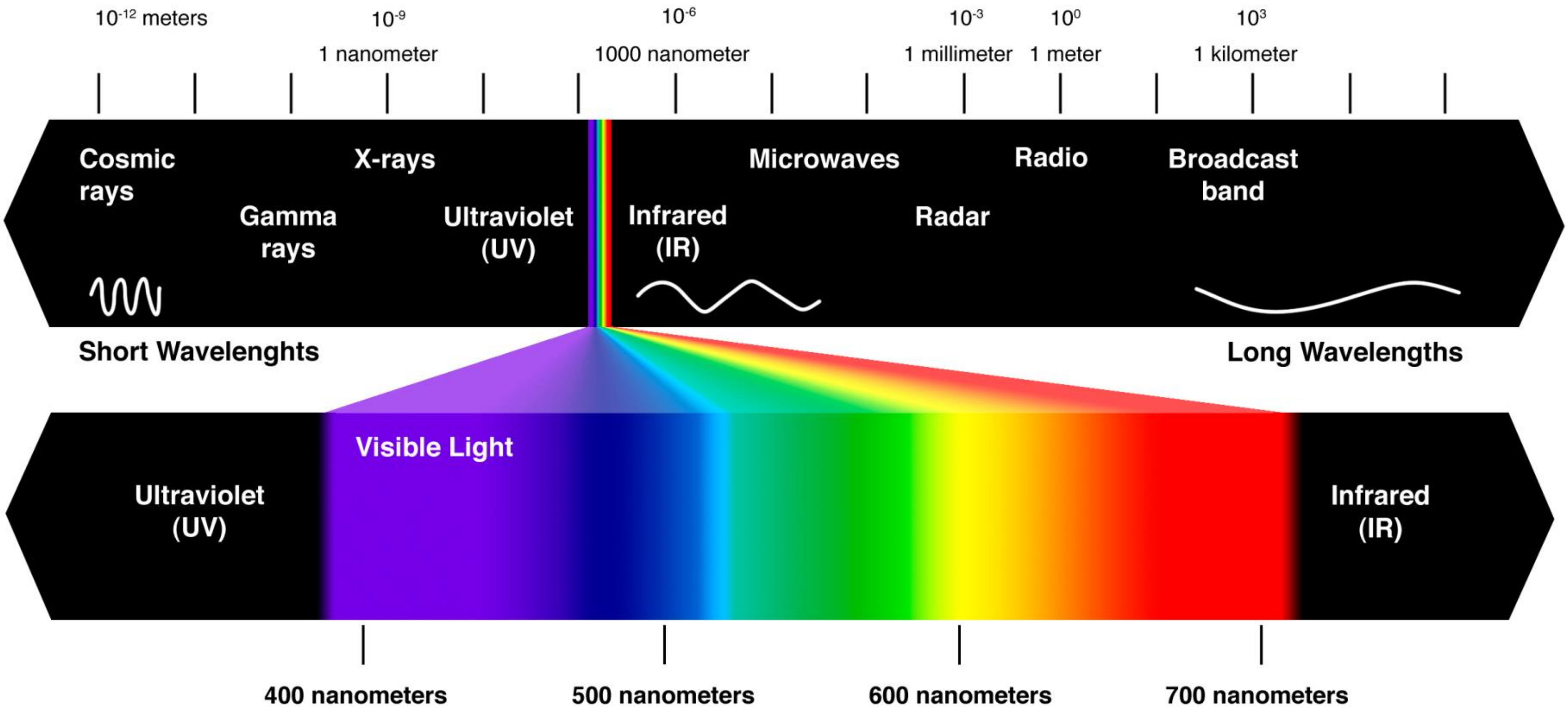
- Example: a digital voltmeter with resolution of
0.1V is used to measure the output of a sensor. The change in input temperature, pressure, etc.) that will provide a change of 0.1V on the voltmeter is the resolution of the sensor/voltmeter system.

- In digital systems generally, resolution may be specified as 1/ 2N (N is the number of bit.)

# *optical mouse*

Developed by Agilent Technologies and introduced to the world in late 1999, the optical mouse actually uses a tiny camera to take 1,500 pictures every second.

Able to work on almost any surface, the mouse has a small, red light-emitting diode (LED) that bounces light off that surface onto a complimentary metal-oxide semiconductor (CMOS) sensor. The CMOS sensor sends each image to a digital signal processor (DSP) for analysis. The DSP, operating at 18 MIPS (million instructions per second), is able to detect patterns in the images and see how those patterns have moved since the previous image. Based on the change in patterns over a sequence of images, the DSP determines how far the mouse has moved and sends the corresponding coordinates to the computer. The computer moves the cursor on the screen based on the coordinates received from the mouse. This happens hundreds of times each second, making the cursor appear to move very smoothly.

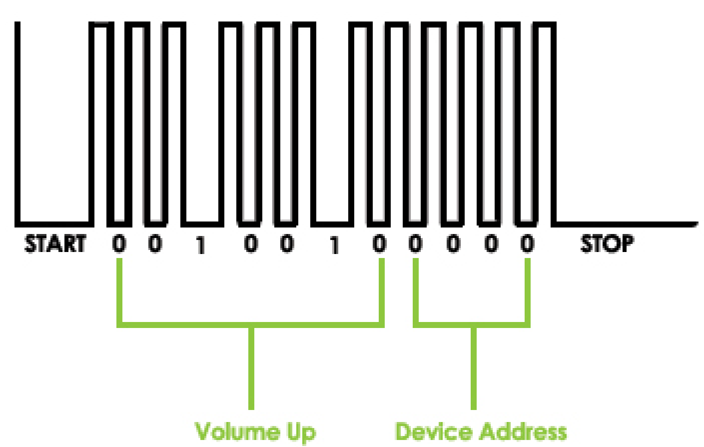


$10^{-12}$ meters
$10^{-9}$
1 nanometer
$10^{-6}$
1000 nanometer
$10^{-3}$
1 millimeter
$10^{0}$
1 meter
$10^{3}$
1 kilometer
Cosmic rays
Gamma rays
X-rays
Ultraviolet (UV)
Infrared (IR)
Microwaves
Radar
Radio
Broadcast band
Short Wavelenghts
Long Wavelengths
Visible Light
Ultraviolet (UV)
Infrared (IR)
400 nanometers
500 nanometers
600 nanometers
700 nanometers


# Selection

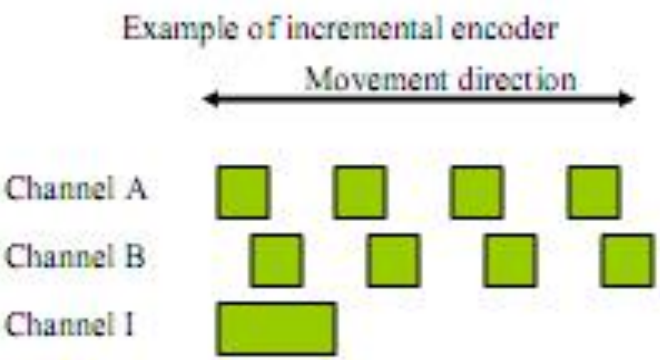
| Button | Code |
|---|---|
| 1 | 000 0000 |
| 2 | 000 0001 |
| 3 | 000 0010 |
| 4 | 000 0011 |
| Channel up | 001 0000 |
| Channel down | 001 0001 |
| Power on | 001 0101 |
| Power off | 010 1111 |
| **Volume up** | **001 0010** |
| Volume down | 001 0011 |
| Source: ARRLWeb | |

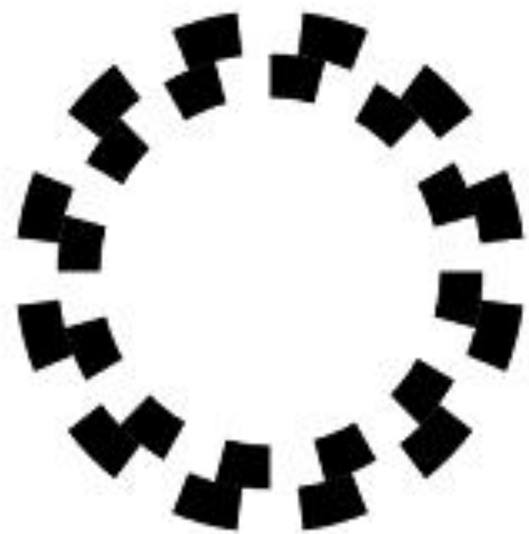
When the infrared receiver on the TV picks up the signal from the remote and verifies from the address code that it's supposed to carry out this command, it converts the light pulses back into the electrical signal for 001 0010. It then passes this signal to the microprocessor, which goes about increasing the volume. The "stop" command tells the microprocessor it can stop increasing the volume.



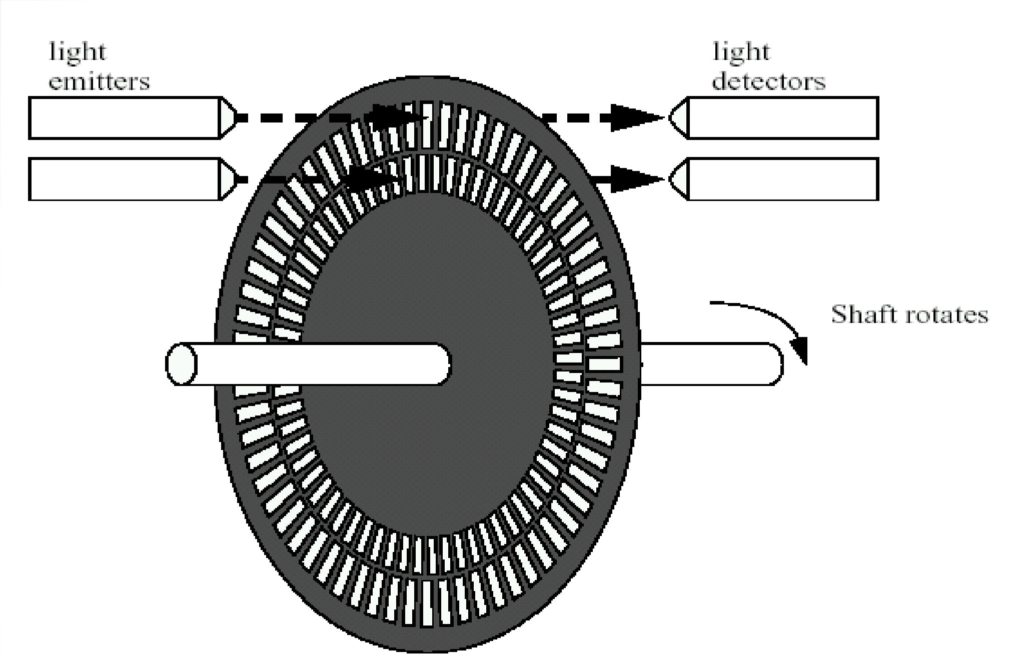
# Optical encoders – Pulse sensors

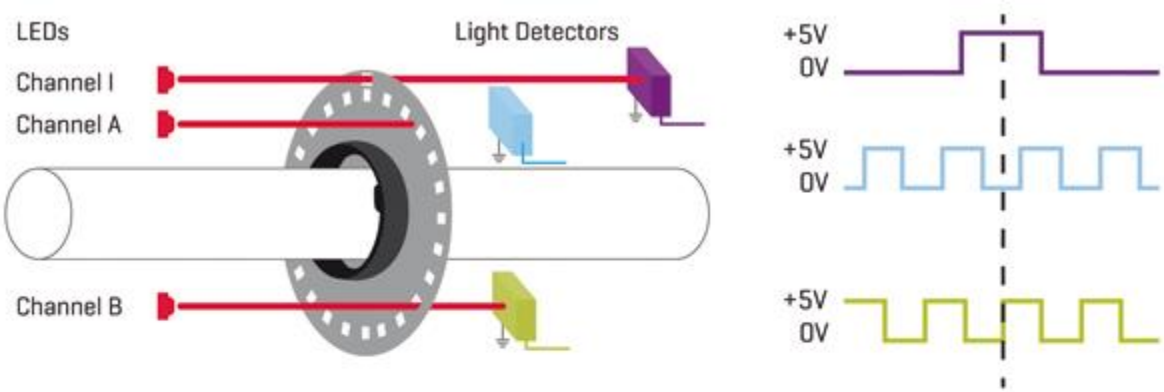
- An encoder is a device that provides a digital output as a result of a linear or angular displacement. There are incremental and absolute encoder types. Absolute encoders are normally using Gray-code.



# Incremental Encoders

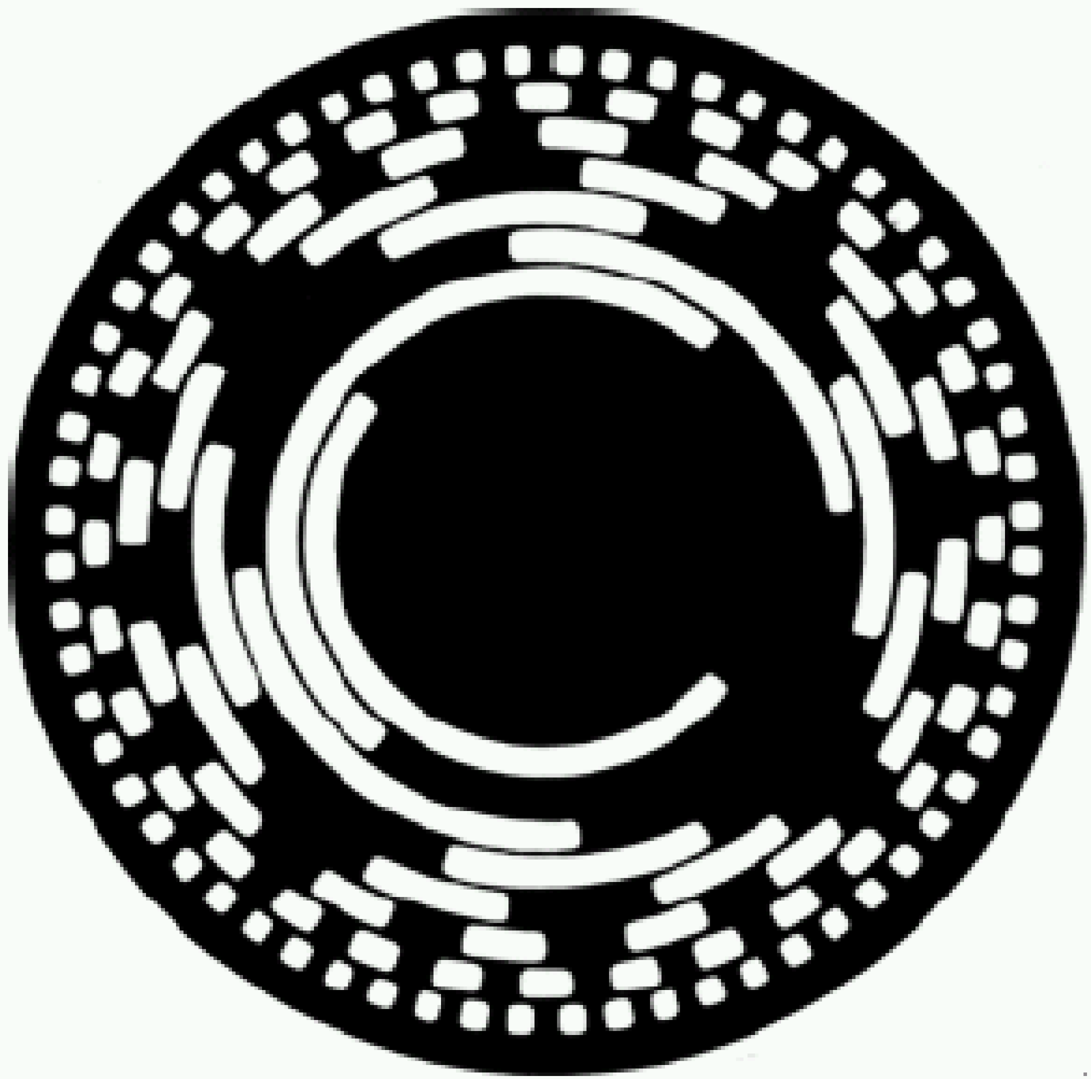


# Absolute Encoders

- Some form of encoding the absolute position is required

- The resolution of the encoder determines how many sensors will be needed



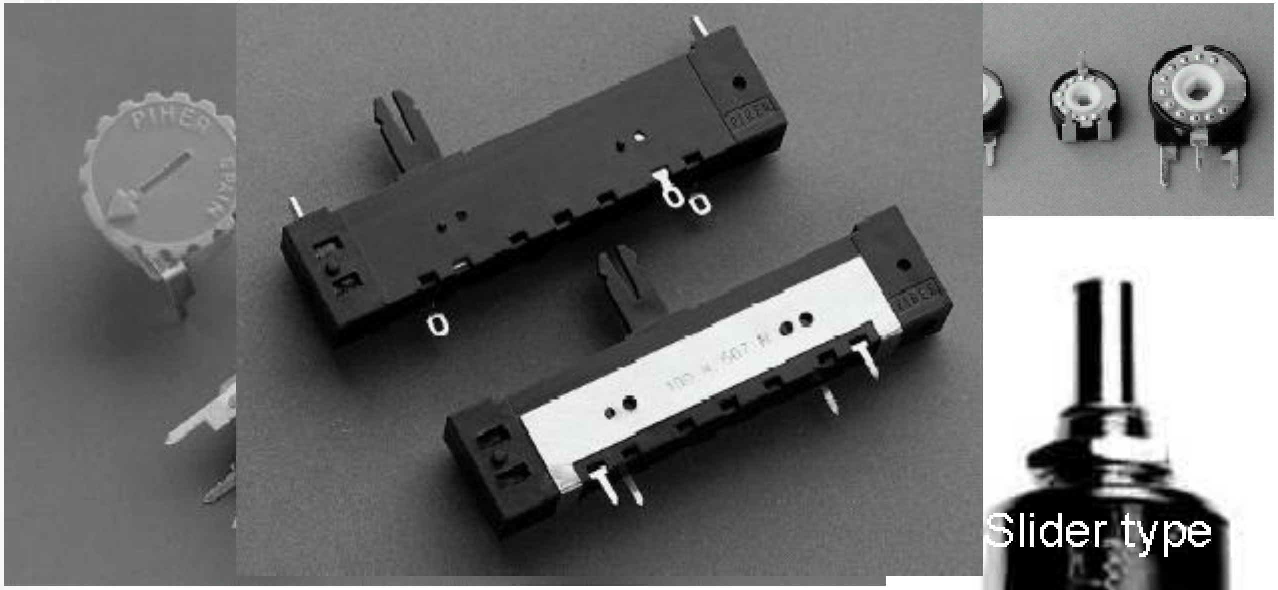
# Absolute
VS
# Incremental Encoder

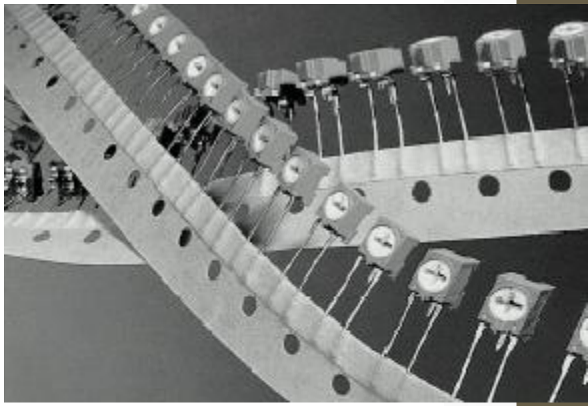
Comparison Chart

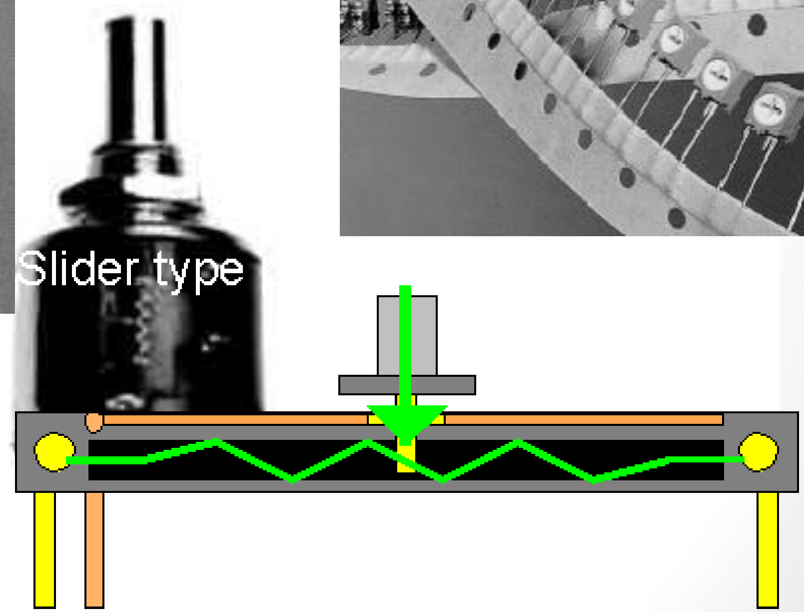
| Absolute Encoder | Incremental Encoder |
|---|---|
| An absolute encoder has a unique code for each shaft position which represents the absolute position of the encoder. | An incremental encoder generates an output signal each time the shaft rotates at a certain angle. |
| Absolute encoders only need power when a reading is taken. | It needs to be powered on throughout the operation of the device. |
| An absolute encoder typically costs twice as much as an incremental encoder. | These are less complex than their absolute counterparts, thus typically less expensive. |
| It doesn't lose the position information when the power is lost. | Each time the power is lost, the reading must be reinitialized or the system shows an error. |

# Potentiometers

- Rotary
  - Single turn or multi-turn



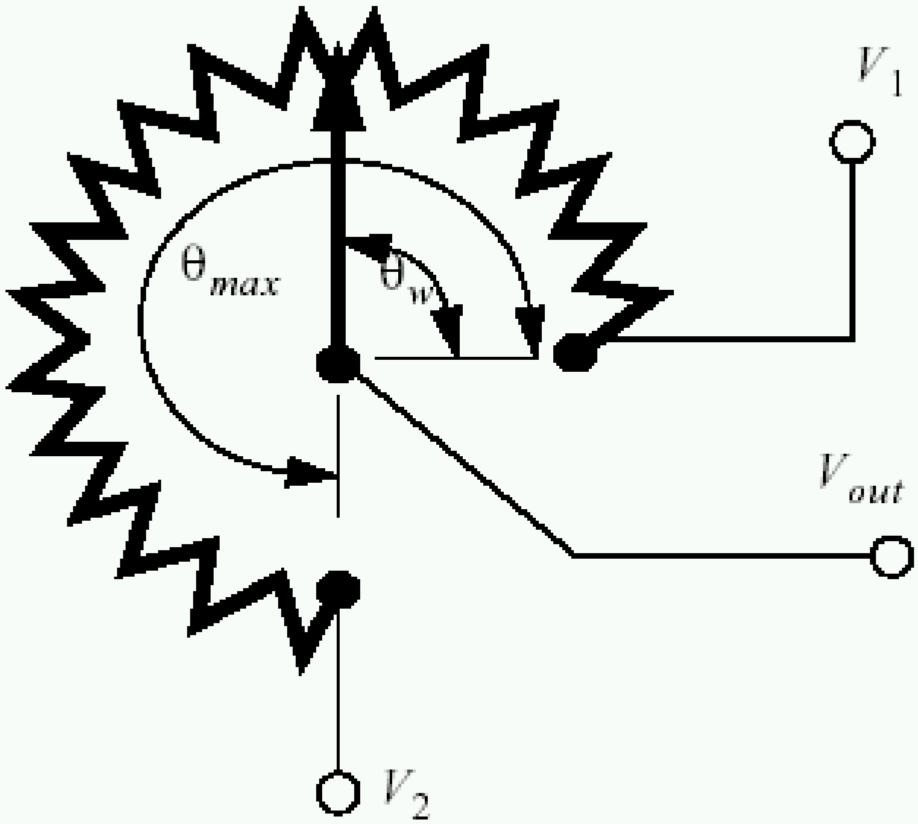





Overlay of schematic symbol on drawing of potentiometer

- Linear

# Potentiometer – voltage divider

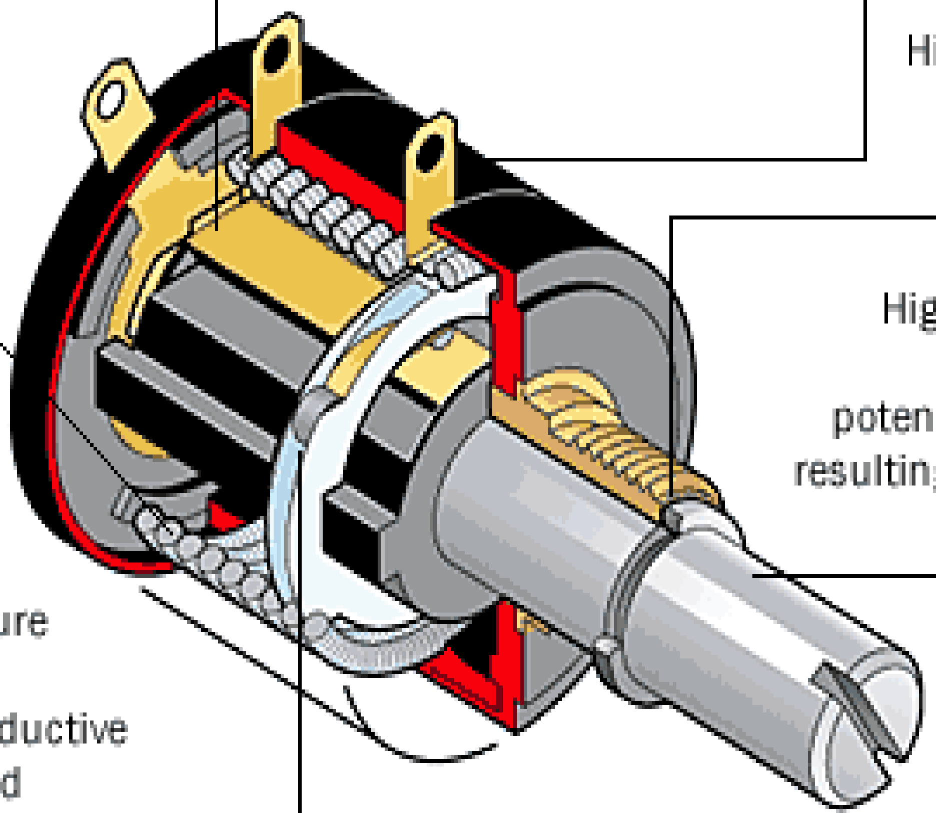



$$V_{out} = (V_2 - V_1)\left(\frac{\theta_w}{\theta_{max}}\right) + V_1$$

**GOLD PLATED TERMINALS AND CONTINUITY BAR:**
Do not corrode or tarnish.

**HOUSING:**
High temp. plastic
Durable in harsh environments.

**BRASS BUSHINGS:**
Hign quality brass bushings. Provde better support for potentiometer shaft side loads, resulting in long life expectancies

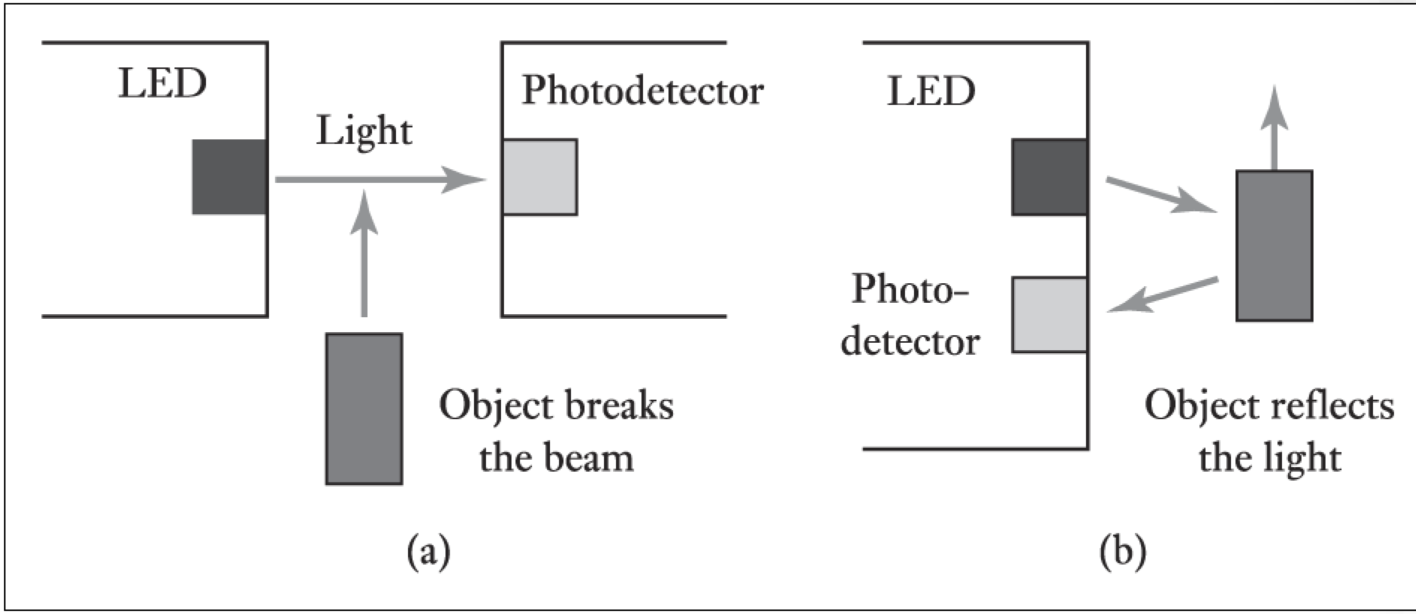


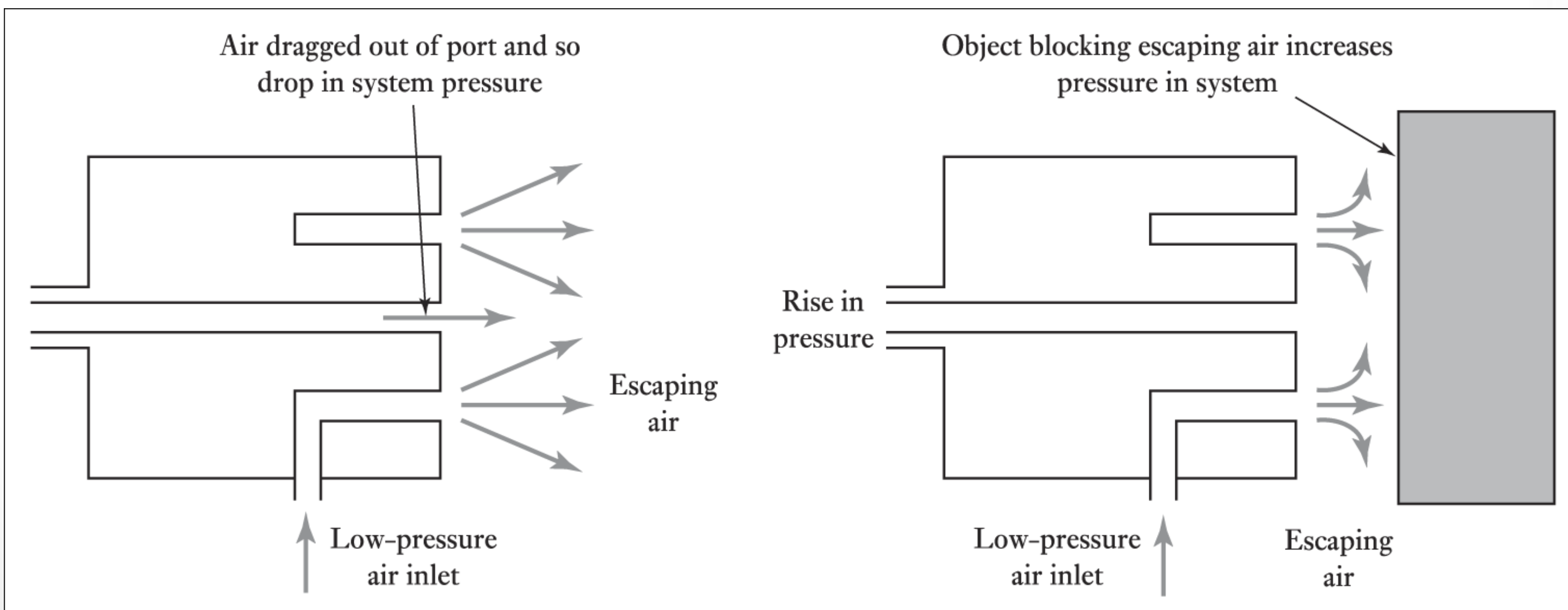
**ELEMENT:**
**Wirewound (shown):** Most commonly used in multi-turns. Offers better stability and linearity. Low temperature coefficient.
**Hybrid:** Made with conductive plastic over a wirewound element. Lower inductance, better resolution, and longer life

**STAINLESS STEEL SHAFT:**
Non-corrosive. Many modifications available for ease of linking to your system

**PRECIOUS METAL WIPER:**
Platinum alloy ensures long life and low noise.

# Proximity sensors



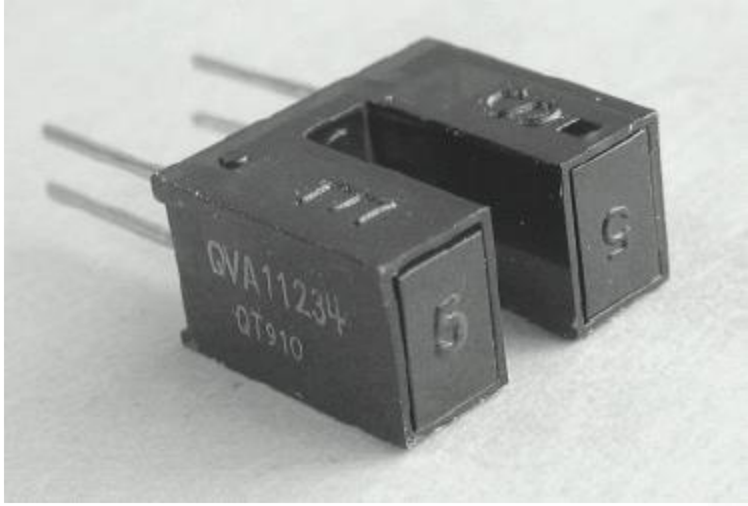



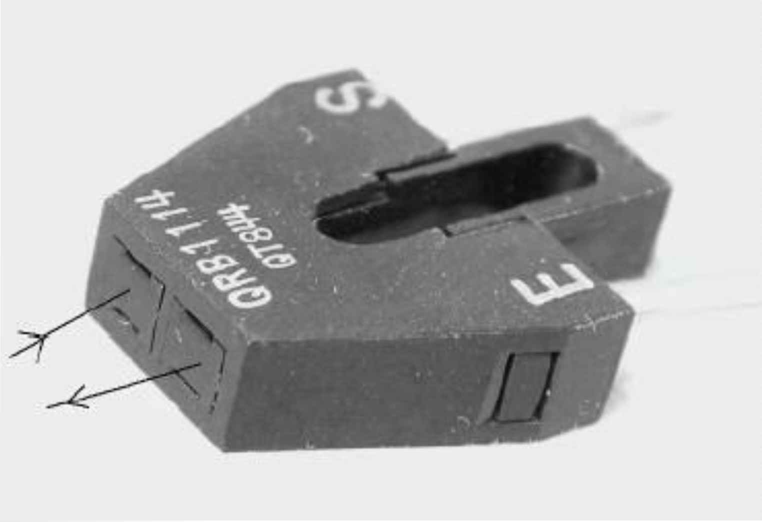
# Emitter / Receiver Pairs

- IR emitter and detectors

–Detection of objects (binary: present vs. not present)

–Beam breaking or photointerrupter

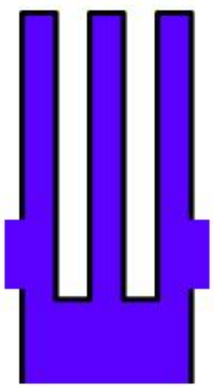




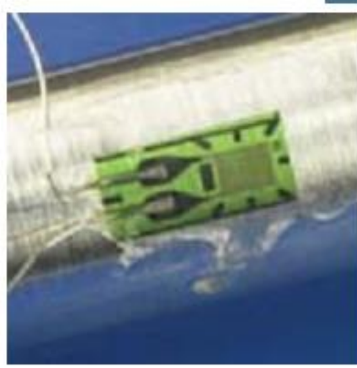
– Continuous output range and color measurement

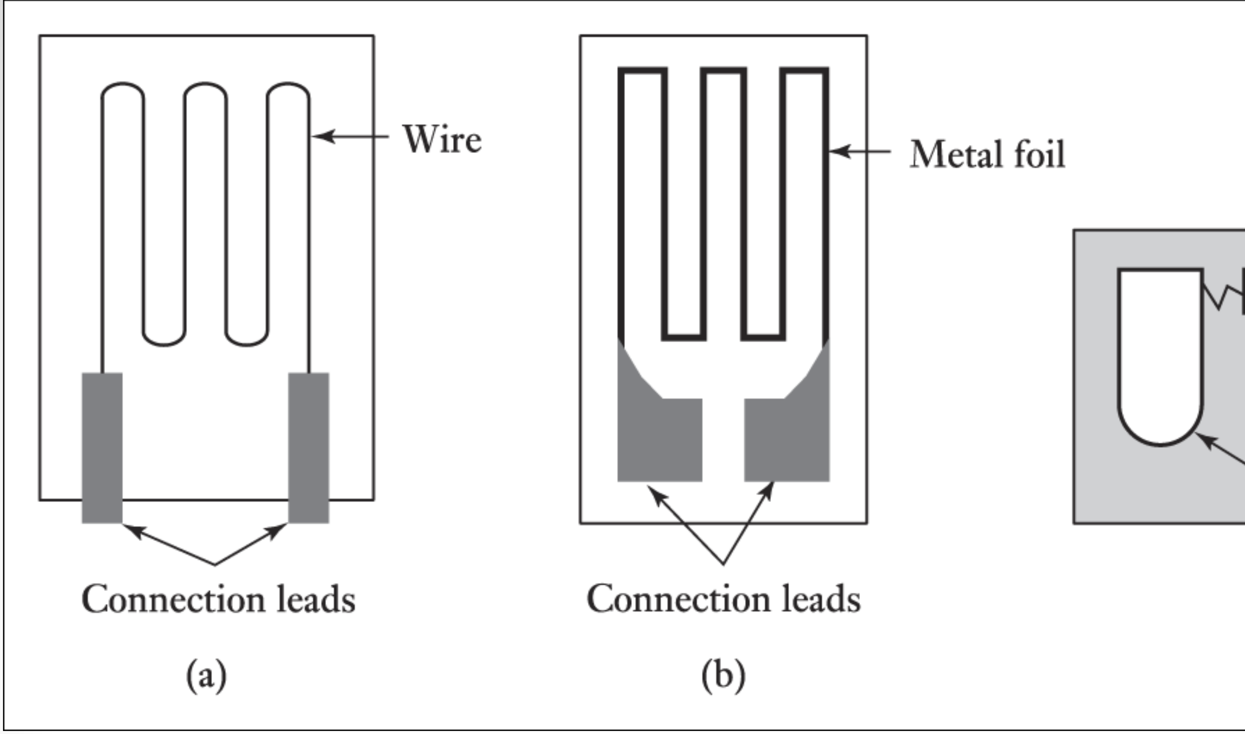
# Strain gauge sensors for measurements of force, pressure and torque

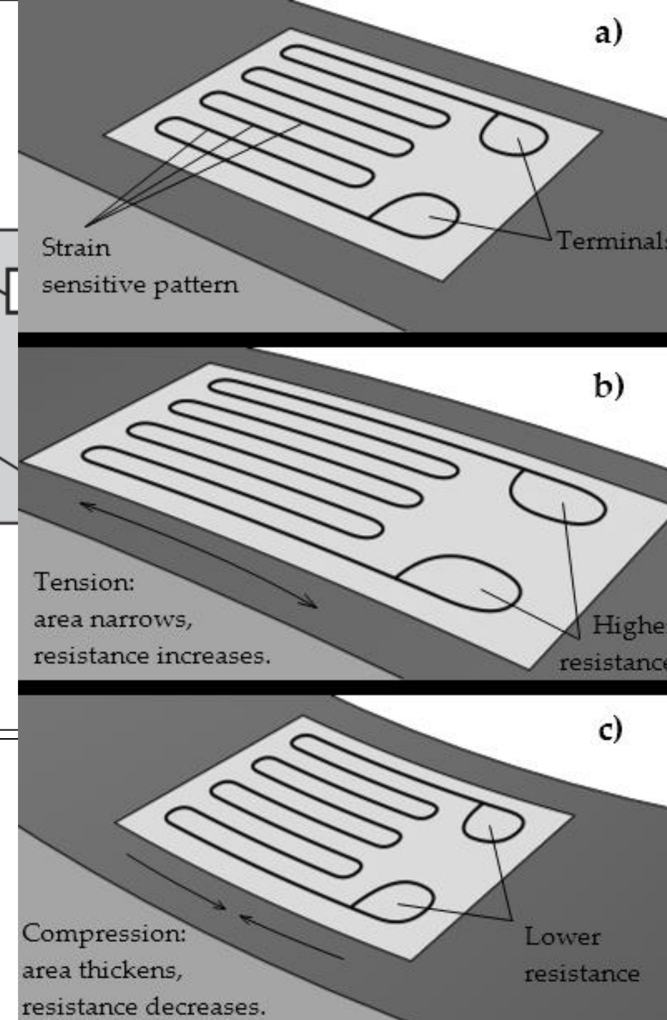
- The electrical resistance strain gauge is a metal wire, metal foil or a configuration of semiconductor material that changes its relative resistance ΔR/R proportional to the strain ε.

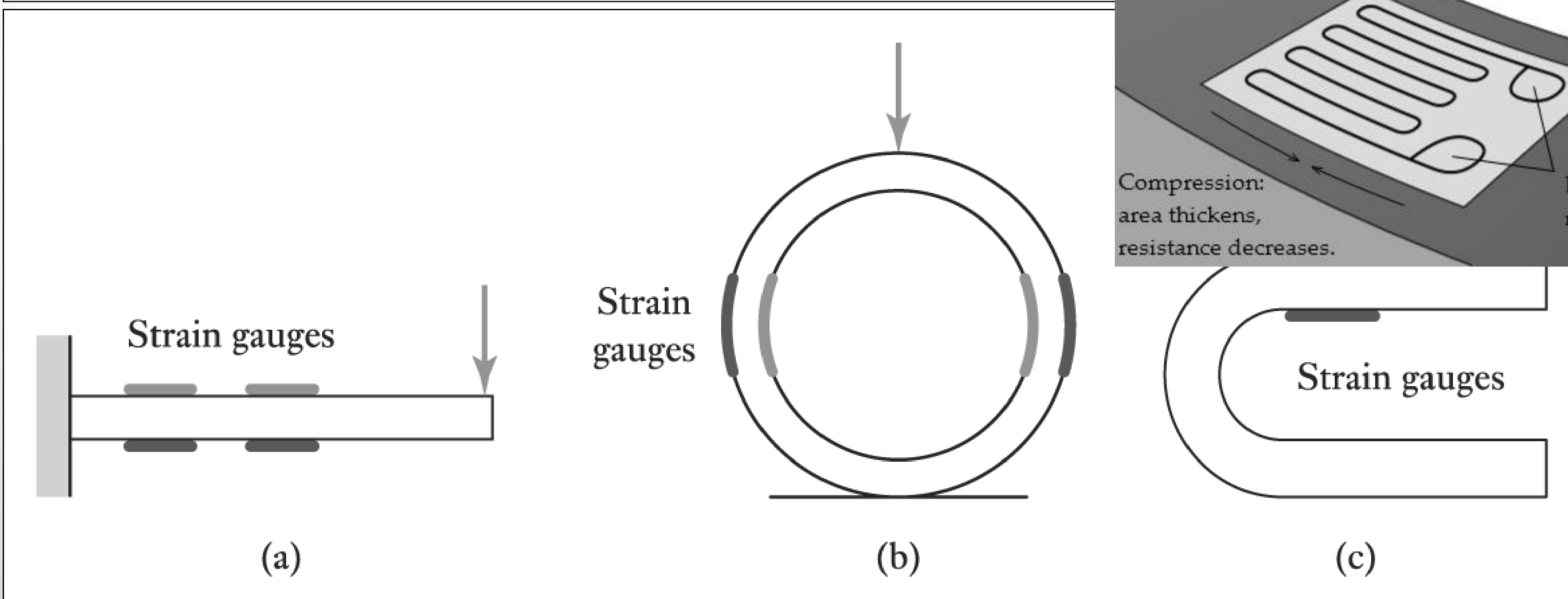


$$\frac{\Delta R}{R} = G\varepsilon$$

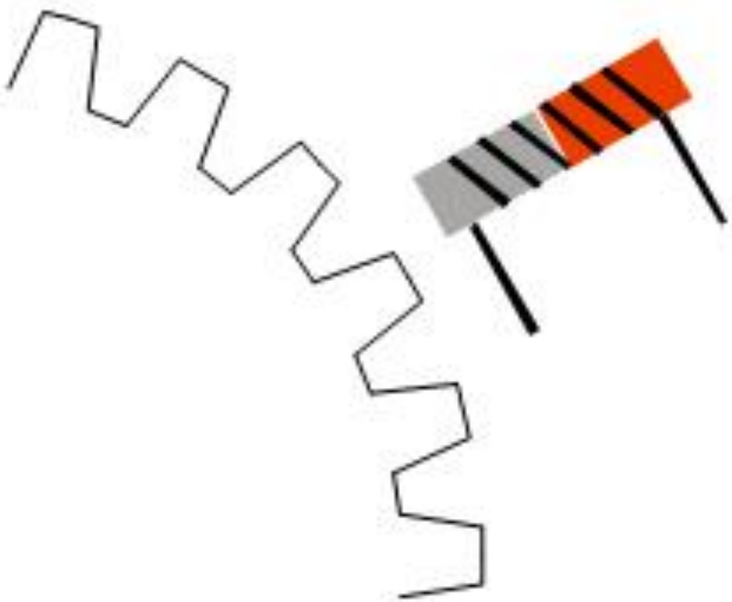

Wire
Connection leads
(a)
Metal foil
Connection leads
(b)


a)
Strain
sensitive pattern
Terminals
b)
Tension:
area narrows,
resistance increases.
Higher
resistance
c)
Compression:
area thickens,
resistance decreases.
Lower
resistance


Strain gauges
(a)
Strain
gauges
(b)
Strain gauges
(c)

# Tacho-generator – Speed sensor

- The tacho-generator is used to measure angular velocity. A pick-up coil is wound on a permanent magnet and placed close to a toothed wheel. The generated change in magnetic flux will result in an output proportional to the angular velocity.



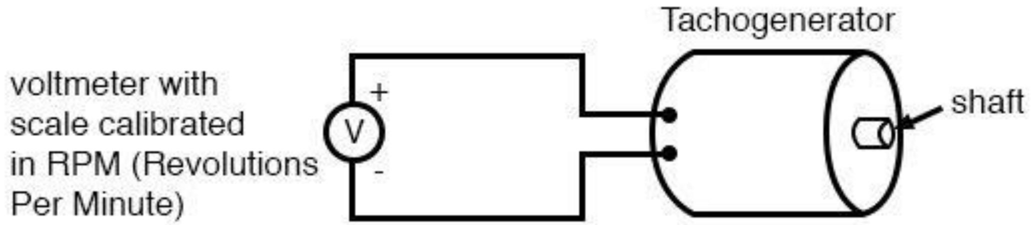
A tachogenerator, or tachometer generator, is an electromechanical device used to accurately measure the speed of engines and motors.

In fact, a tachogenerator will output a voltage proportional to the rotation around its own shaft.

In other words, a tachogenerator can convert mechanical energy into electrical energy.

A tachogenerator is commonly used to handle voltages between 0 and 10 volts and is classed as a precision instrument

Tachogenerators can also indicate the direction of rotation by the polarity of the output voltage. When a permanent-magnet style DC generator's rotational direction is reversed, the polarity of its output voltage will switch.



**References:**


- W. Bolton, Mechatronics: A Multidisciplinary Approach, Prentice Hall; 4th Ed., 2009.
- D. Alciatore, Introduction to Mechatronics and Measurement Systems, 4. bs., McGraw-Hill, Mart 2011.
- C. W. De Silva, Mechatronics: An Integrated Approach, CRC Press, 2004.
- AB Koku, Lecture Notes, METU
- P Hsu, W Du, K Youssefi, Lecture Notes, Un. Calgary
- eetimes.eu/designers-guide-to-industrial-iot-sensor-systems/
- www.thebetweendifference.net
- https://www.allaboutcircuits.com/textbook/direct-current/chpt-9/tachogenerators/



**Slides Prepared by:**

Haydar Livatyalı

M. Selçuk Arslan

Muhammet Garip