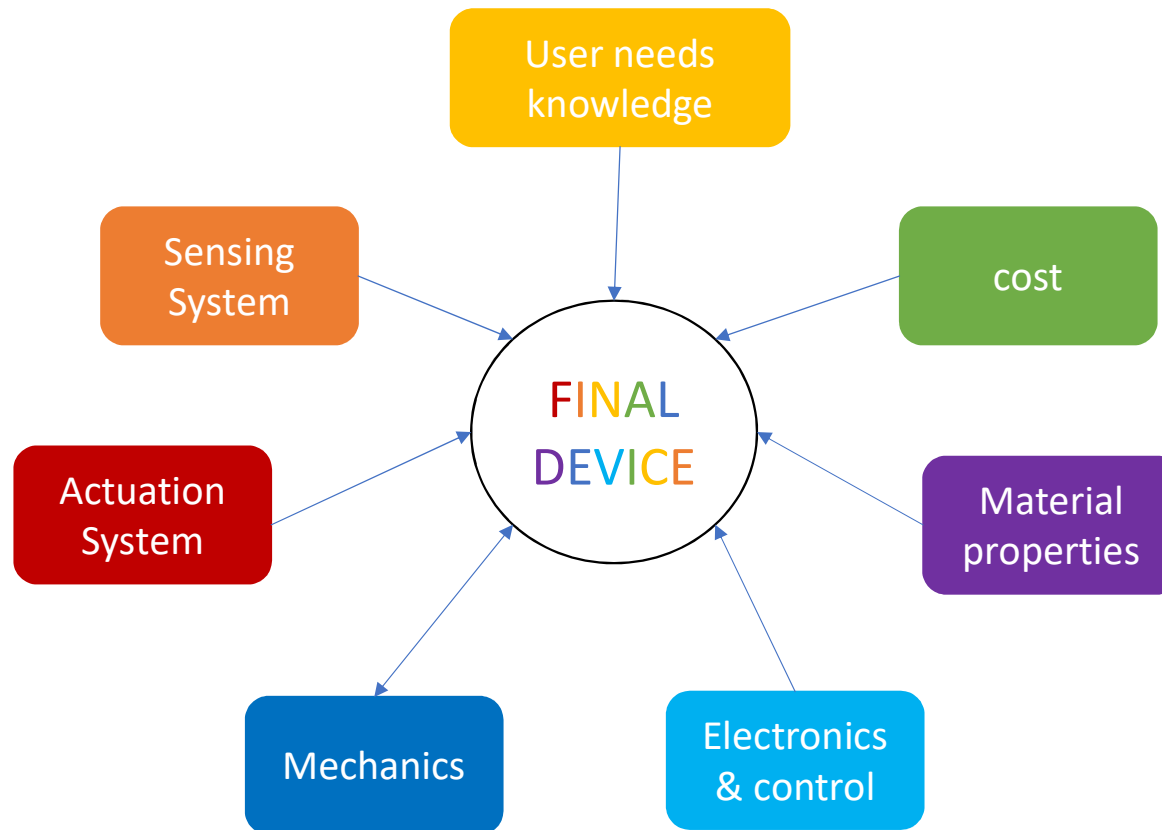# Design Lab: Introduction & Sensing Systems

Corso Materiali intelligenti e Biomimetici
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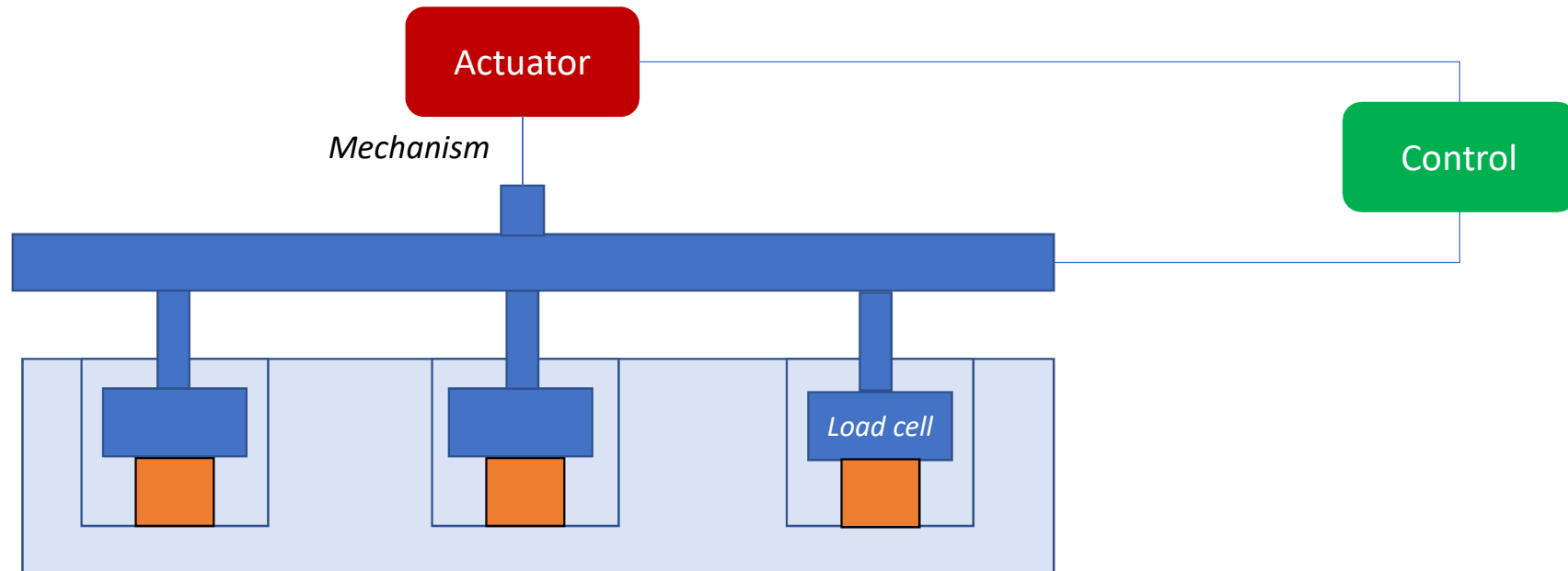# Design of innovative testing systems

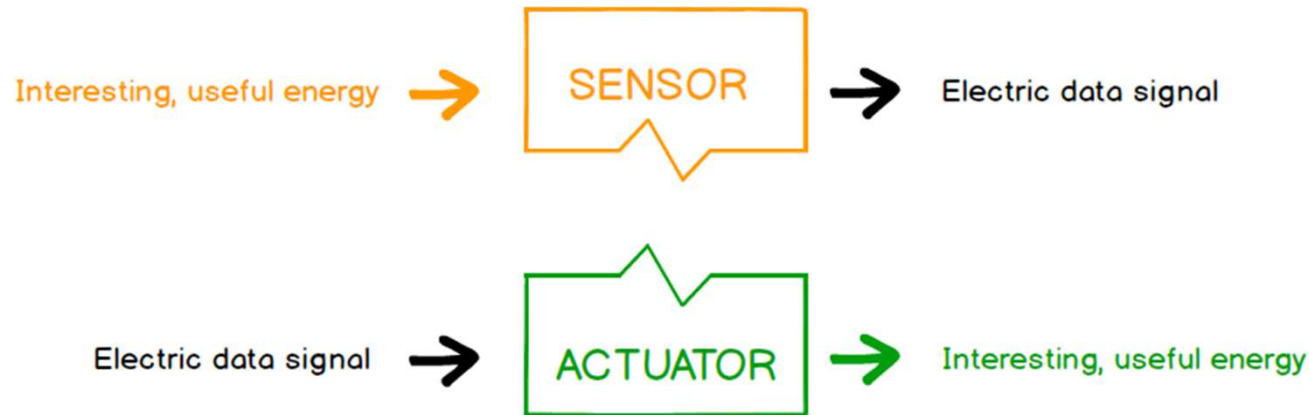*The importance of being a Biomedical Engineer*

Project: multi-tester

Specifications:

- Test multiple samples, minimizing costs

Sensors vs. Actuators

The word "**Transducer**" is the collective term used for both Sensors and Actuators.
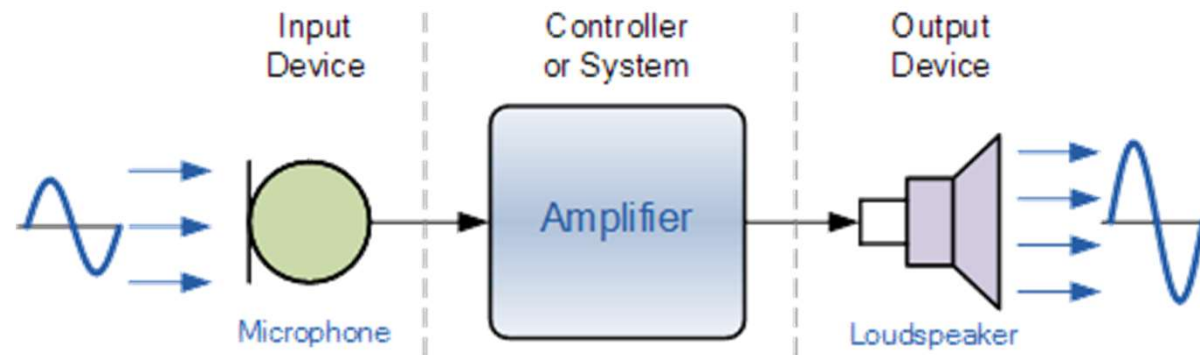
Devices which perform an **"Input" function** are commonly called **Sensors** because they "*sense" a physical change* in some characteristic and covert that into an electrical signal.

Devices which perform an **"Output" function** are generally called **Actuators** and are used to *control some external device,* for example movement or sound.
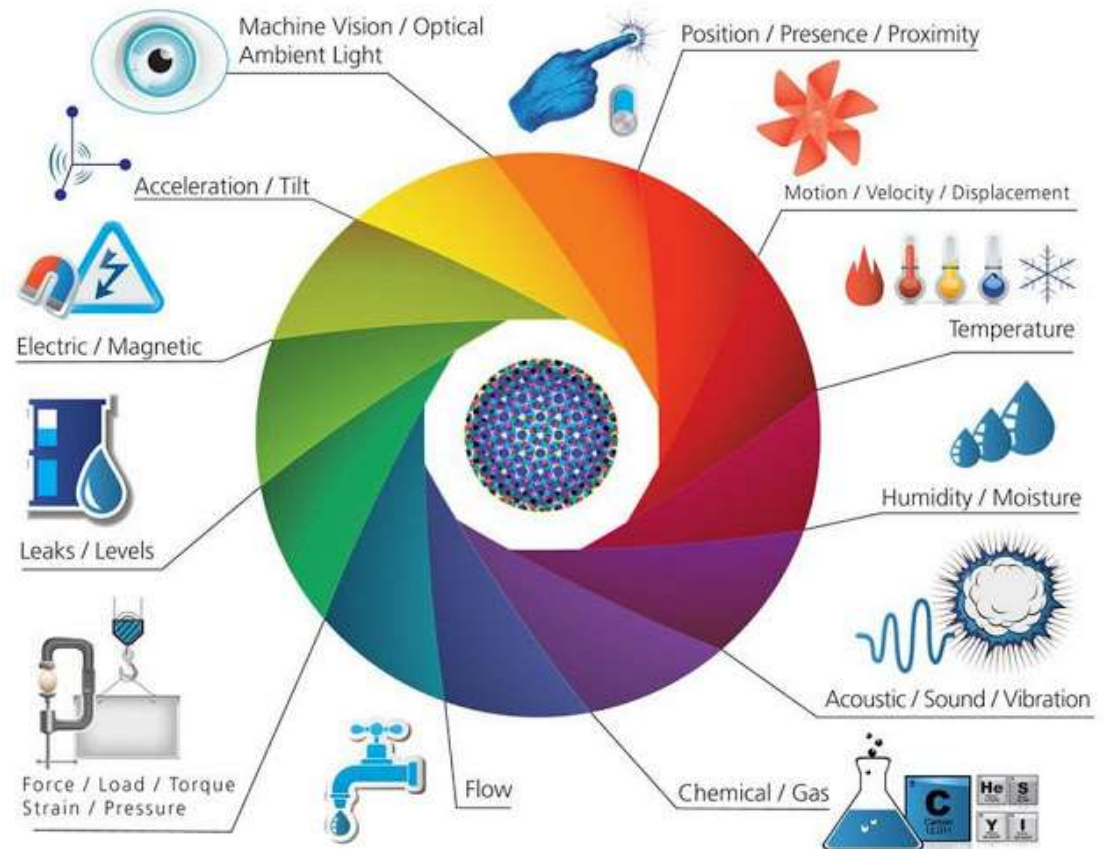
Transducers

Electrical Transducers are used to **convert energy of one kind into energy of another kind.**

For example, *a microphone (input device) converts sound waves into electrical signals* for the amplifier, and *a loudspeaker (output device) converts these electrical signals* back into sound waves and an example of this type of simple Input/Output (I/O) system is given below

Transducer – types

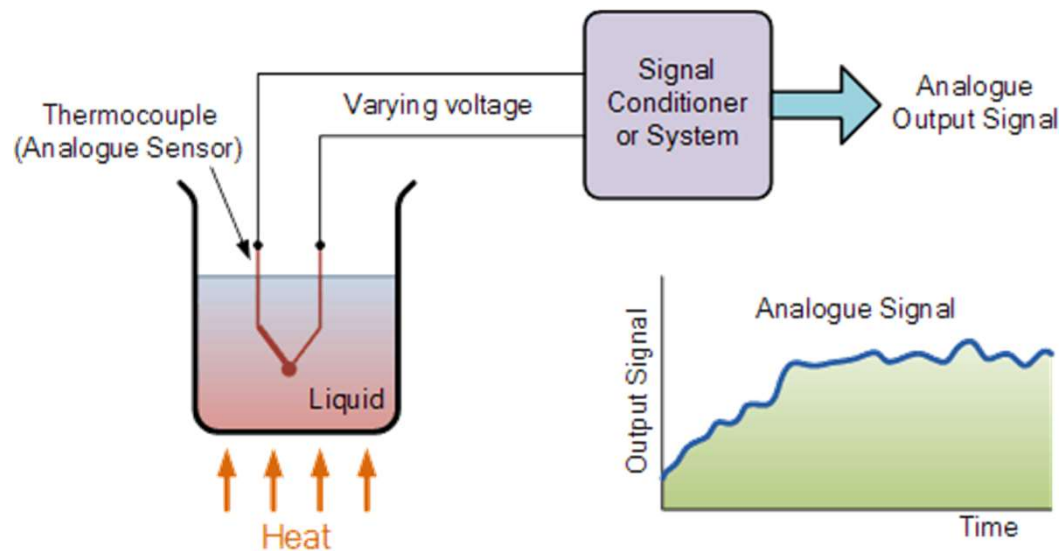| Quantity being Measured	Input Device (Sensor)	Output Device (Actuator)
Light Level	Light Dependant Resistor (LDR) Photodiode Photo-transistor Solar Cell	Lights & Lamps LED's & Displays Fibre Optics
Temperature	Thermocouple Thermistor Thermostat Resistive Temperature Detectors	Heater Fan
Force/Pressure	Strain Gauge Pressure Switch Load Cells	Lifts & Jacks Electromagnet Vibration
Position	Potentiometer Encoders Reflective/Slotted Opto-switch LVDT	Motor Solenoid Panel Meters
Speed	Tacho-generator Reflective/Slotted Opto-coupler Doppler Effect Sensors	AC and DC Motors Stepper Motor Brake
Sound	Carbon Microphone Piezo-electric Crystal	Bell Buzzer Loudspeaker

Sensors

Input type transducers or sensors, produce a **voltage or signal output response which is proportional to the change in the quantity that they are measuring** (the stimulus). The type or amount of the output signal depends upon the type of sensor being used.

- **active sensors** require an **external power supply to operate,** called an excitation signal which is used by the sensor to produce the output signal. Active sensors can also produce signal amplification. A good example of an active sensor is an LVDT sensor or a *strain gauge*. Strain gauges are pressure-sensitive resistive bridge networks that are external biased (excitation signal) in such a way as to produce an output voltage in proportion to the amount of force and/or strain being applied to the sensor.

- A **passive sensor** does **not need any additional power source** or excitation voltage. Instead a passive sensor generates an output signal in response to some external stimulus. For example, a *thermocouple* which generates its own voltage output when exposed to heat.

Analogue Sensors

Analogue Sensors produce a **continuous output signal** or voltage which is generally *proportional to the quantity being measured*.

Physical quantities such as Temperature, Speed, Pressure, Displacement, Strain etc are all analogue quantities as they tend to be continuous in nature. For example, the temperature of a liquid can be measured using a thermometer or thermocouple which continuously responds to temperature changes as the liquid is heated up or cooled down.
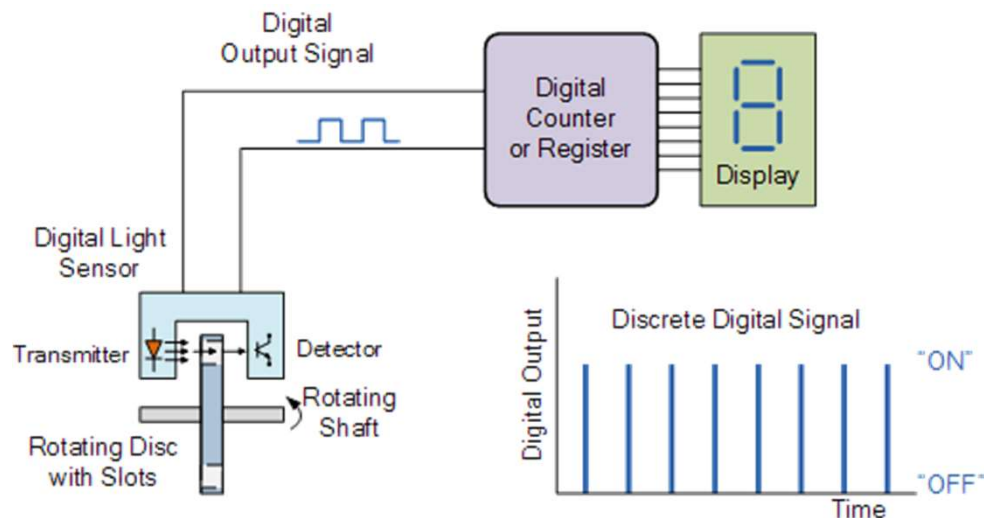

Also **analogue signals can be easily converted into digital type** signals for use in micro-controller systems by the use of **analogue-to-digital converters** (ADC).

Digital Sensors

Digital Sensors produce a **discrete digital output signals** or voltages that are a *digital representation of the quantity being measured*.

Digital sensors produce a **Binary output signal** in the form of a logic "1" or a logic "0", ("ON" or "OFF"). This means then that a digital signal *only produces discrete (non-continuous) values* which may be outputted as a single "bit", (serial transmission) or by combining the bits to produce a single "byte" output (parallel transmission).

For example, the speed of the rotating shaft can measured by using a digital LED/Opto-detector sensor.

The disc which is fixed to a rotating shaft has a number of transparent slots within its design. As the disc rotates with the speed of the shaft, each slot passes by the sensor in turn producing an output pulse representing a logic "1" or logic "0" level.
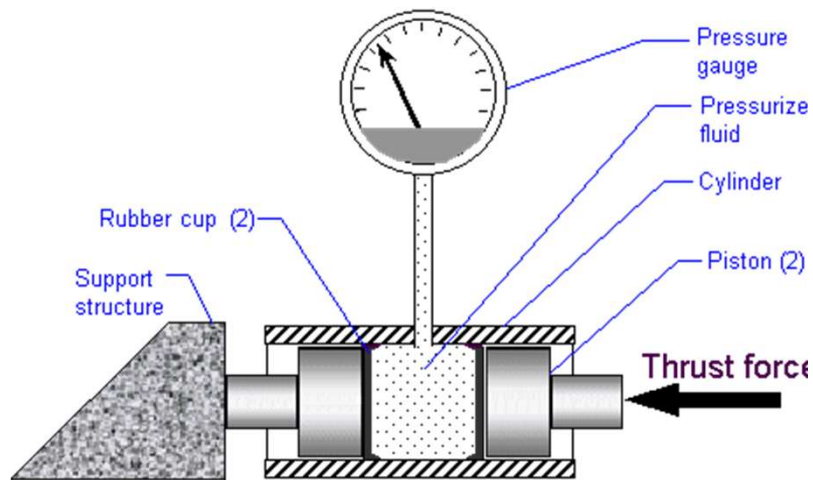
These pulses are sent to a register of counter and finally to an output display to show the speed or revolutions of the shaft. By increasing the number of slots or "windows" within the disc more output pulses can be produced for each revolution of the shaft
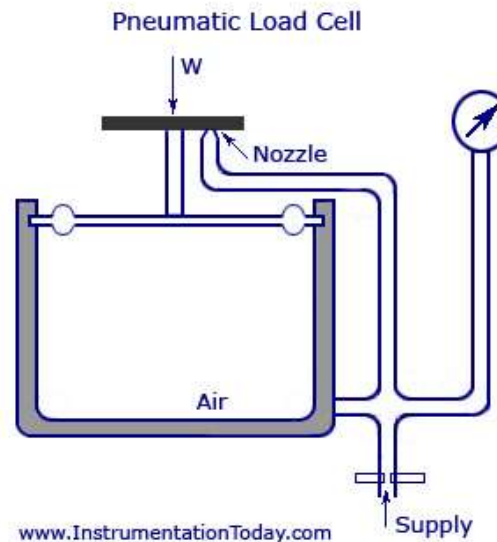
Load cells

A load cell is a **transducer that tranforms pressure (force) into an electrical signal**.
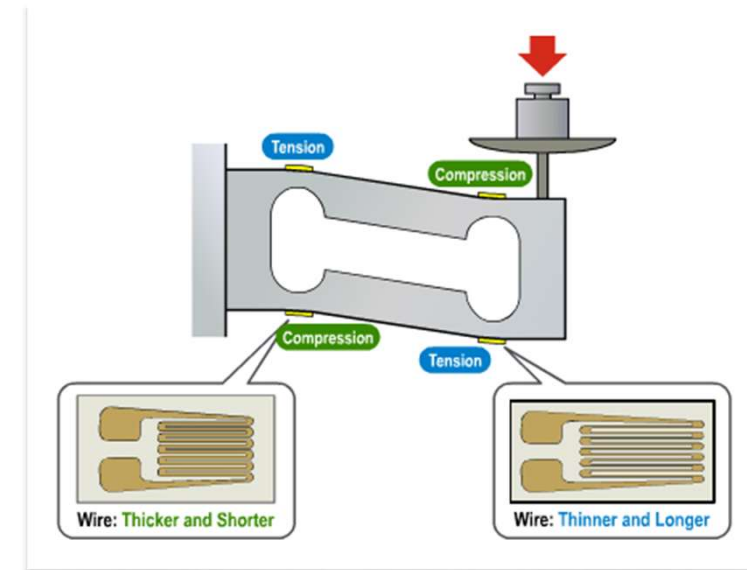
Types:

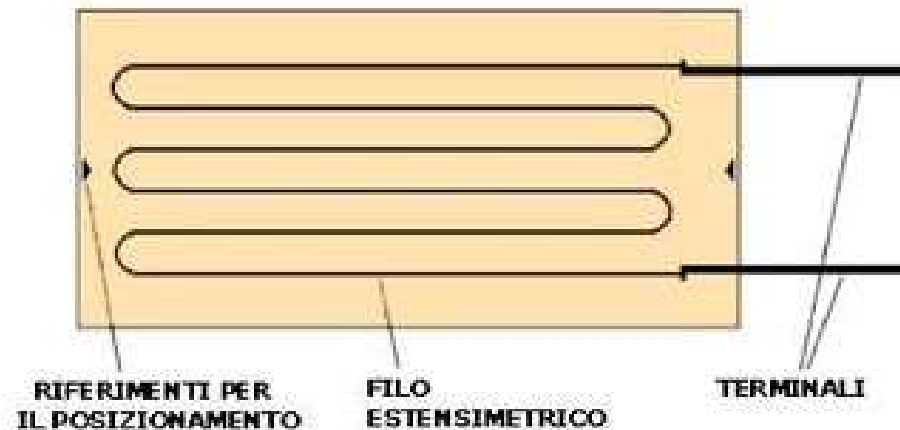Hydraulic Load Cells

Pneumatic Load Cells

Strain Gauge Load Cells

Strain Gauge (1)

A strain gauge is a device that measures electrical **resistance changes in response to strain** (indirectly pressure/force) applied to the device.

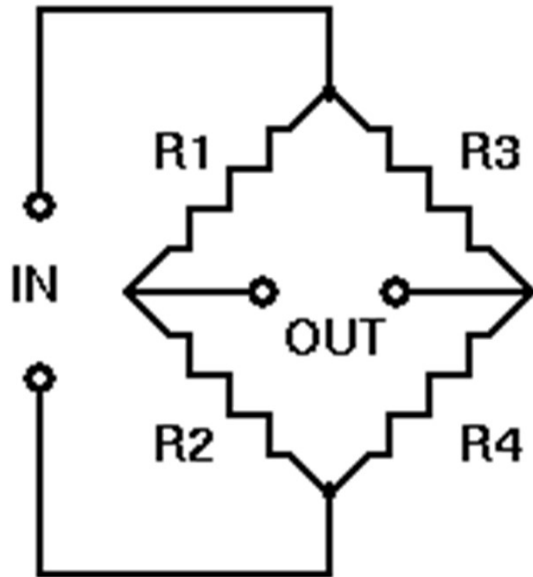RIFERIMENTI PER IL POSIZIONAMENTO   FILO ESTENSIMETRICO   TERMINALI

The sensitivity to strain is expressed quantitatively as the **gauge factor (GF)**, defined as the *ratio of fractional change in electrical resistance to the fractional change in strain.*

Typically resistance variation are very small (i.e. small electrical signal, difficult to detect), so we need to turn it into something that we can measure accurately.

Strain Gauge (2)

wheatstone bridge:

when $R1/R2 = R3/R4$ ➡ Vout=0

but if there is a change to the value of one of the resistors:

$$Vout = [(R3/(R3 + R4) - R2/(R1 + R2))] * Vin$$

Esercitazione 1

- Ricerca caratteristiche celle di carico idonee per l'applicazione: evidenziare 2-3 celle (marca & modello, fornitore & codice fornitore) allegando i relativi datasheet e riassumento in una tabella le proprietà rilevanti (range carico, risoluzione, ingombro, costo, disponibilità - altro)

- Cercare un adeguato sistema amplificazione

- Indicare possibili alternative alle celle di carico (se risultano una soluzione migliore) per l'applicazione (es. Sensori forza a film sottile): indicare brevemente come implementereste l'applicazione