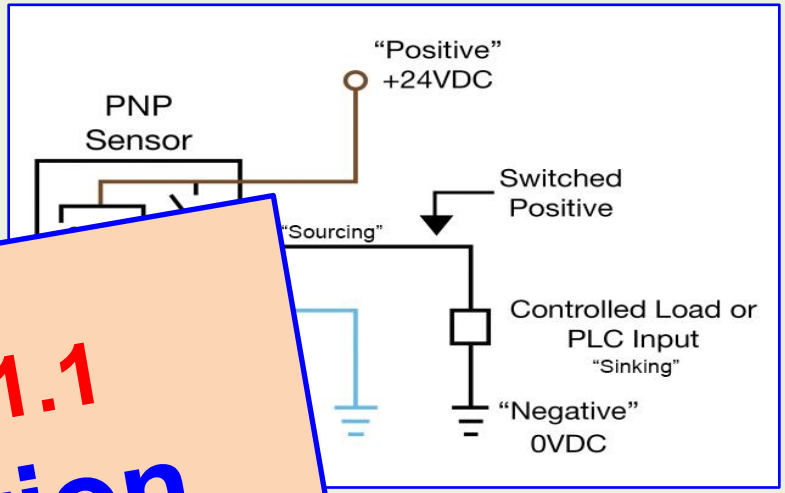
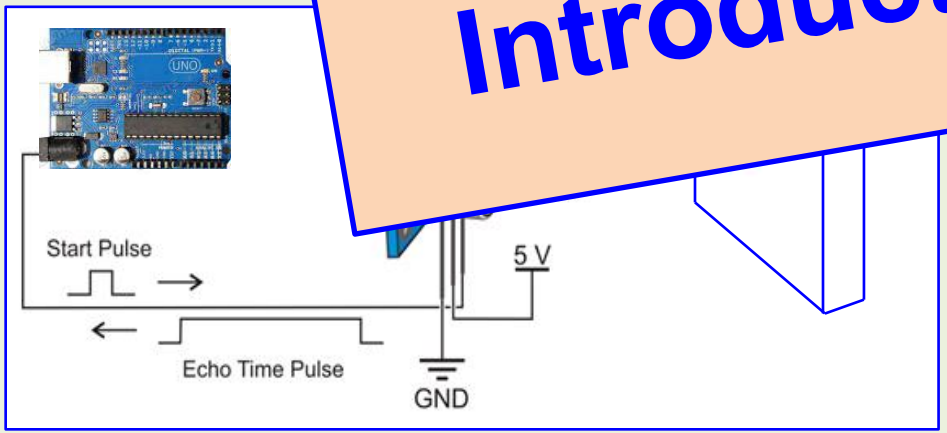
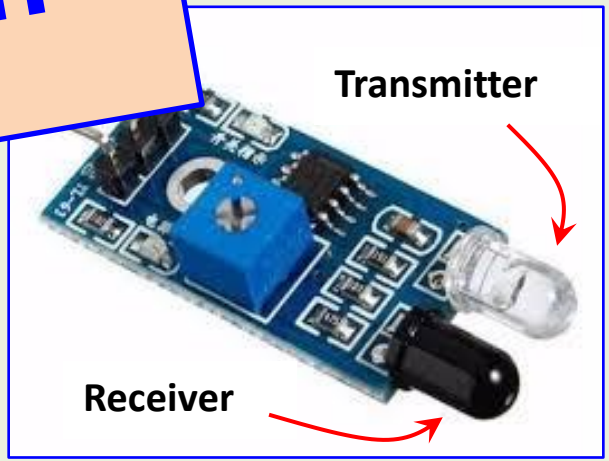


Sensors – 1.1
Introduction





Why Robots need Sensors ?

Where is the Obstacle ?

Obstacle detection and Avoidance

The grass cutter vehicle should understand the obstacle of golf pole

Where is the cropline?

Path planning

Why Robots need Sensors ?

Operator can see the task to be performed with his eyes as sensors.

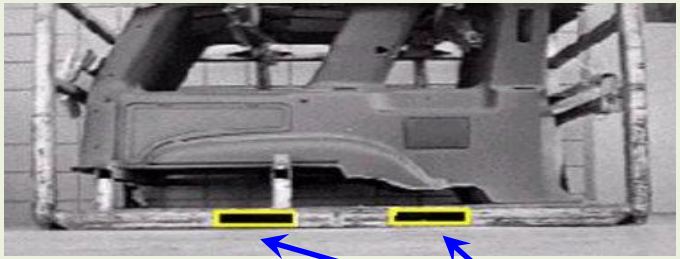
Sensing for specific tasks –
Fork Lift Trucks

When there is a manless Fork Lift Truck, sensors are required.

Why Robots need Sensors ?

Sensing for specific tasks –
Fork Lift Trucks

Where are the forkholes?



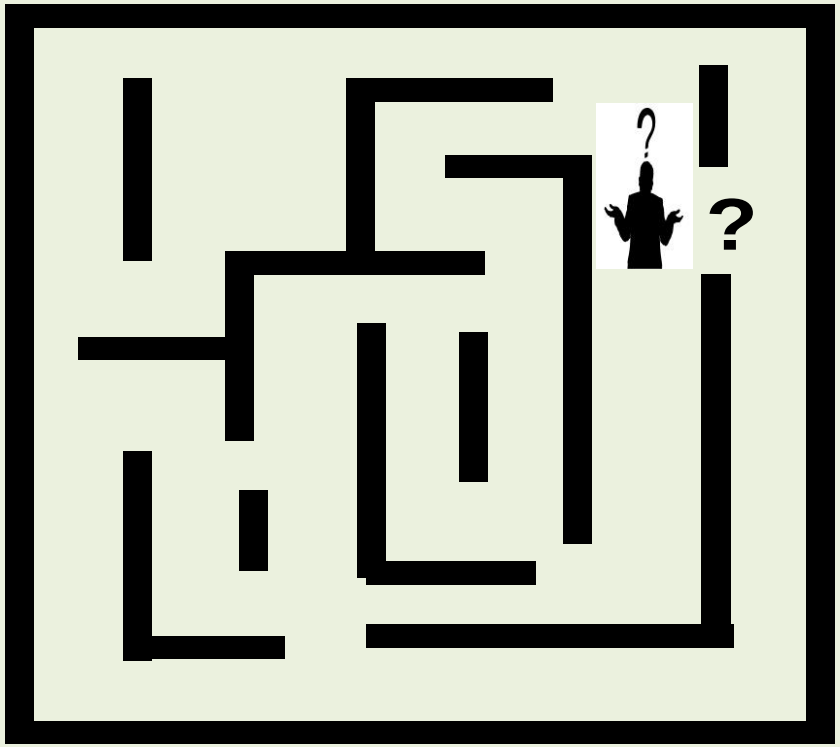
Autonomous material handling system

Why Robots need Sensors ?

Where is the face?

Face detection & tracking

Where am I ?



Find Location

Why are sensors important for Robots ?

1) They allow the robot to become more autonomous.
2) Robot can understand / perceive its own environment.
3) Decision making becomes easy through programming.
4) Continuous Feedback from sensors keeps the system updating easy.

Types of Sensors: Active and Passive

- Active sensors : Require an external source of power (excitation voltage) that provides most of the output power of the signal.
- Passive sensors : The output power is almost entirely provided by the measured signal without an excitation voltage.

Examples:

- Active Sensors : Radar, GPS, IR sensor, Blood Pressure Sensor
- Passive Sensors : Metal Detector, Thermocouple

Types of Sensors: Exteroceptive and Interoceptive

Exteroceptive: Measure parameters external to Robot system.

e.g. Pressure, Force, Torque, Image, Distance, Nearness, Active ranging, (Radar, Sonar, Lidar) etc.

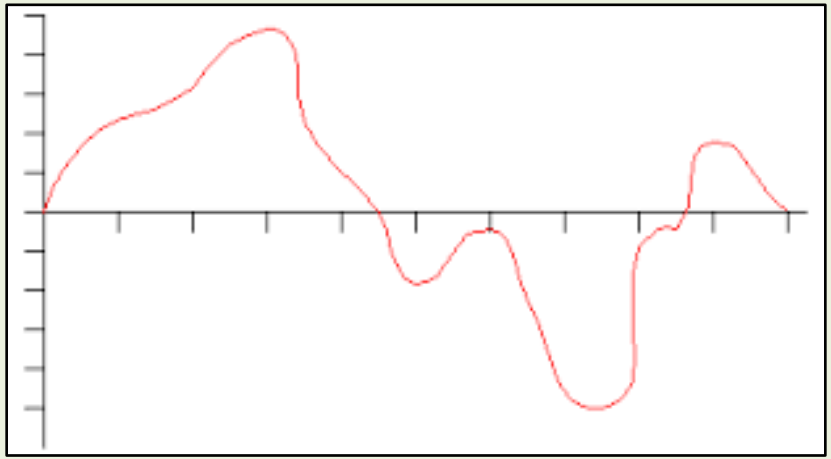
Interoceptive: Measures internal data of the Robot itself - engineering quantities

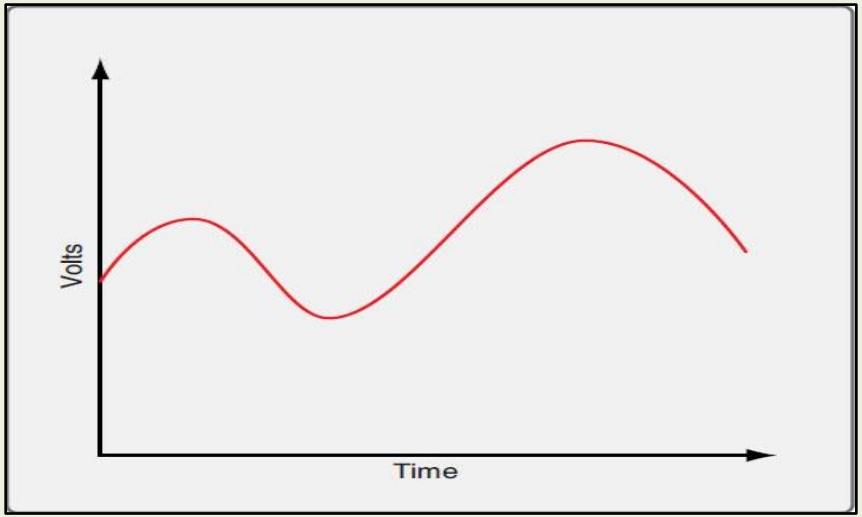
e.g. Position, Orientation, Speed, Temperature, Electrical (voltage, current), Battery charge status, Stress / Strain (strain gauges), Sound etc.

Types of Sensors : Analog and Digital

- **Analog sensors:** The signal produced by the sensor is continuous and proportional to the quantity to be measured.
- Produce ***continuous*** analog output signal

example : LDR, Sound Sensor, Current Sensor, temperature sensor, Velocity sensor, Rotation sensor etc.

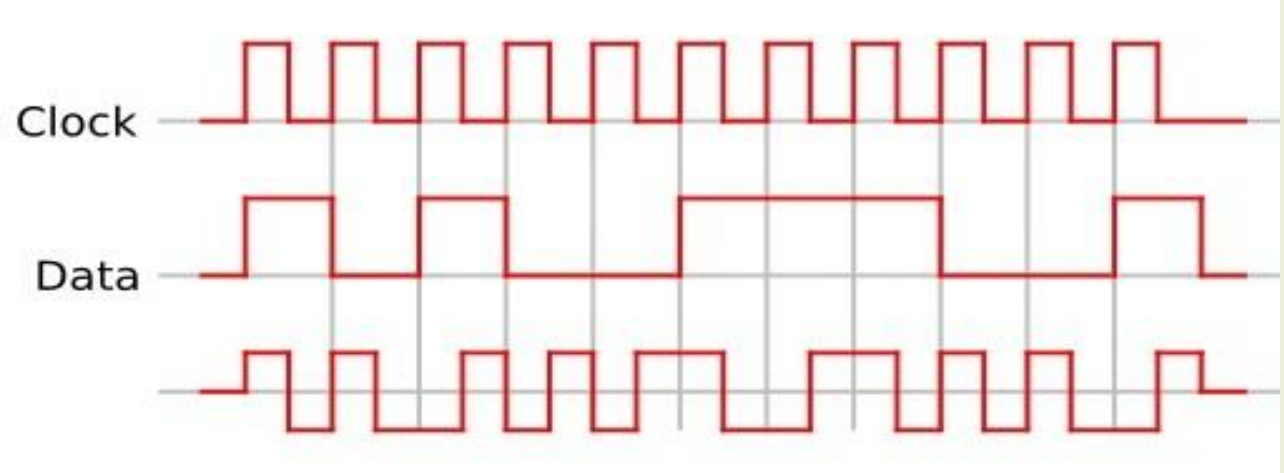




Types of Sensors: Digital Sensors

- **Digital sensors:** The signal produced or reflected by the sensor is ***binary*** in nature.
- The digital sensor consists of majorly three components: sensor itself, a cable, and a transmitter.

examples : IR Sensor, Touch (Tactile) sensor, Proximity sensor



Measurement in real world environment is always error prone.

Error can not be avoided ! It can be minimised and controlled.

Sensor performance ratings : (Features)

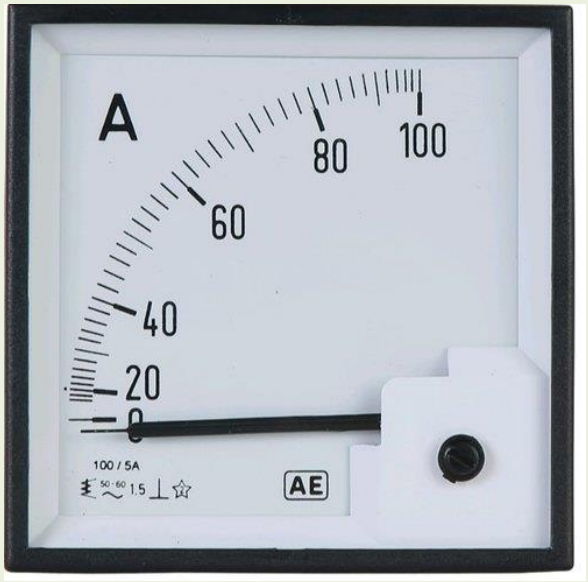
1) **Dynamic range :** Ratio of lower and upper limits. Measure of how wide the range of measurement is.
2) **Range :** Difference between minimum and maximum limits. Also termed as span.
3) **Resolution :** Smallest change that can be understood and detected by the sensor.
4) **Linearity / Non-Linearity :** Variation of o/p signal as function of the i/p signal.
5) **Drift :** It is the deviation from the actual reading when the reading is constant for a long duration.
6) **Response time :** The time required for the o/p to appear at the display.
7) **Bandwidth or frequency :** The speed with which a sensor can provide a stream of readings. The range of frequencies over which the o/p has uniform accuracy.
8) **Sensitivity :** Ratio of change in output to change in input. (ability to understand change in the input)

Sensor performance ratings :

9) **Cross-Sensitivity :** Sensitivity to environmental parameters that are independent to the target parameters.
10) **Error/Accuracy :** Difference between the sensor's output and the true value.
11) **Systematic/Deterministic Error :** Caused by factors that can be modeled, e.g. calibration of a sensor.
12) **Random Error :** for e.g. Colour instability of camera due to change in the surrounding light intensity. (beyond control)
13) **Reproducibility / Repeatability :** Reproducibility of the results again and again for the same input.

What difference can you see in these two meters ?

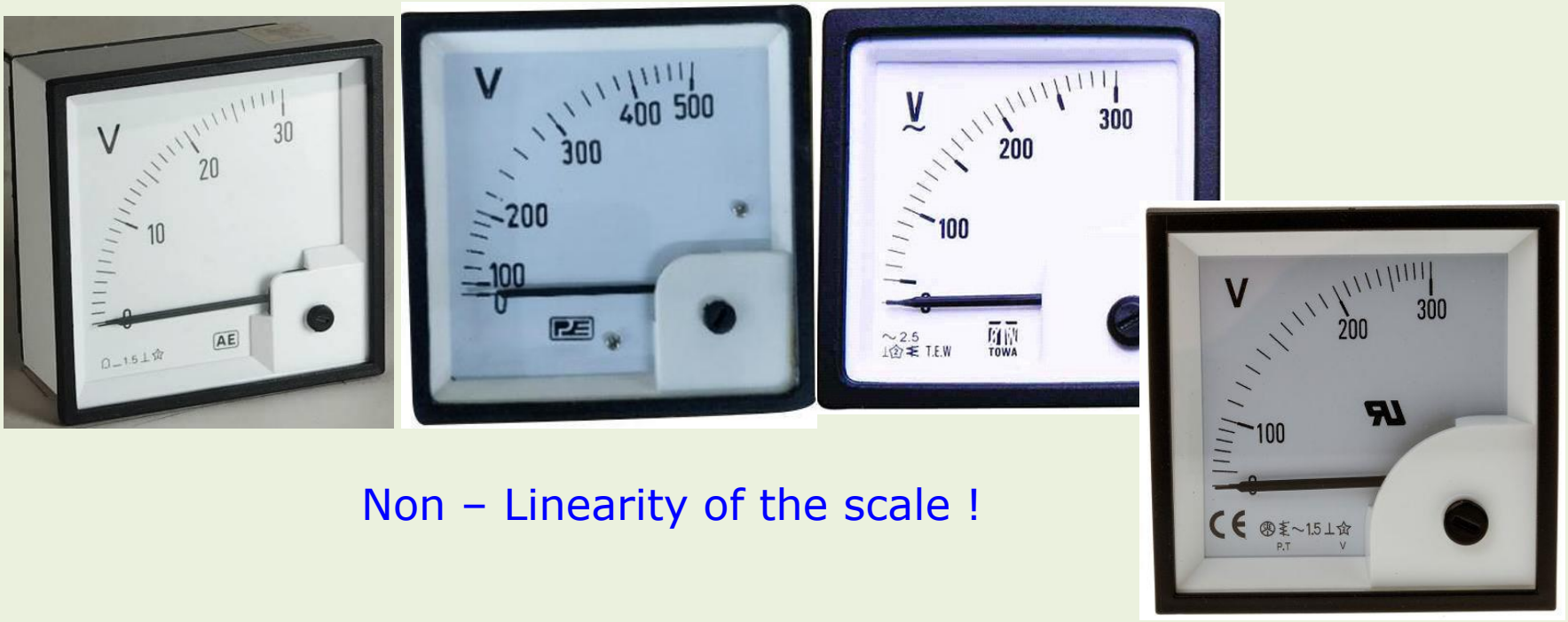
(….. of course not the range !)



Resolution …!

What difference can you see in these four meters ?

(….. of course not the range !)



Non – Linearity of the scale !

What is a smart sensor ?

- It is a combination of sensor and actuator both.

sensor + interfacing circuit = smart sensor

- Capable of logic functions, two-way communication and making decisions.
- IEEE 1451 standards - Sensors with some memory and standardized physical connection to enable the communication with processor and data network.

✓Features of a smart sensor -

- **Self calibration**: Adjust deviation of output of sensor from desired value.
- **Communication**: Broadcast information about its own status.
- **Computation**: Allows one to obtain the average, variance and standard deviation for the set of measurements.
- **Multi-sensing**: A single smart sensor can measure pressure, temperature, humidity, gas flow and infrared chemical reaction surface acoustic vapour etc.
- **Cost improvement**: less hardware and reduction of repetitive testing make smart sensor cost effective.

Different types of Sensors : Based on principle of working and parameter to be measured

- Proximity sensor (Range sensor)
- Tactile sensor (Contact sensor)
- Current sensor
- Tilt sensors (Angle sensor)
- Gyroscope (Angular velocity)
- Encoders (Speed sensor)
- Hall effect sensors (Magnetism sensor)
- Temperature sensor
- Acceleration sensor
- Image sensor

Proximity Sensor – Inductive

- Proximity sensor (Range sensor)
  - ✓ Inductive type (proximity switch)
  - ✓ Capacitive type

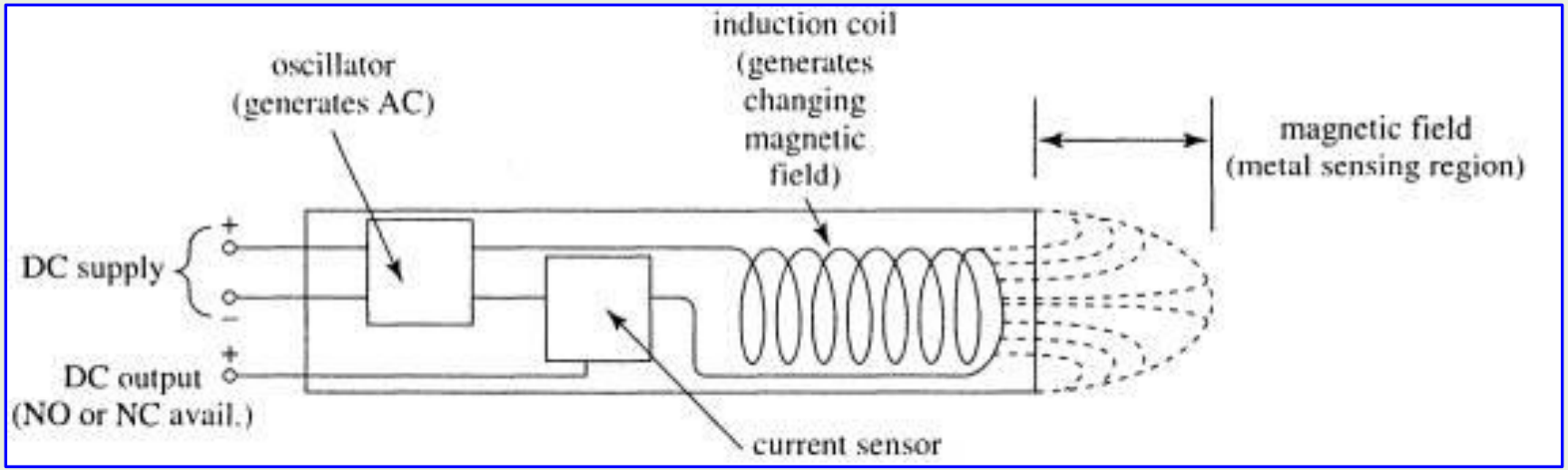
Inductive type – Works on the principle of electromagnetic induction. The sensor develops a magnetic field around it. When a metallic object comes in the vicinity, the magnetic field changes and this change is detected.

Non metallic objects do not change the field. Thus, can not be detected. e.g. Plastic, Rubber, Wood, Water, Dust etc.

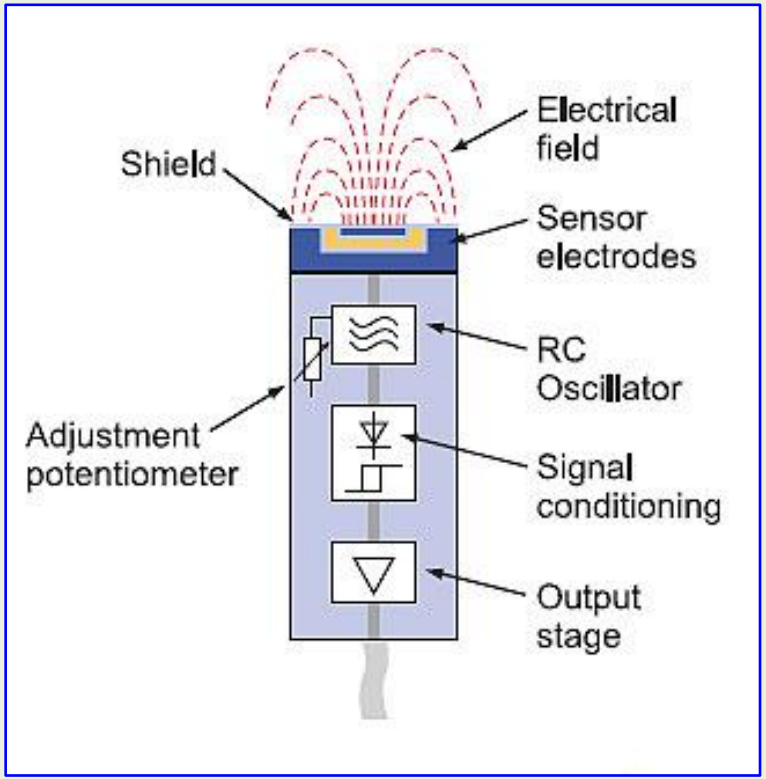
Proximity Sensor – Capacitive

Capacitive type – Works on the principle of Capacitance between two surfaces. One surface is inside the sensor and the other is the object itself which creates an electric field. When the object comes within the working zone, the capacitance value changes which can be detected. Thus any material like Plastic, Rubber, Wood, Dust (except air) can be detected.

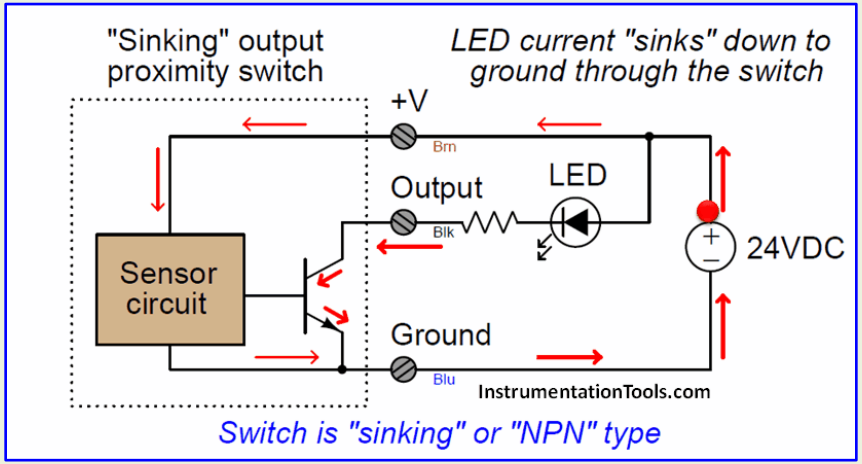
Proximity Sensor - Inductive

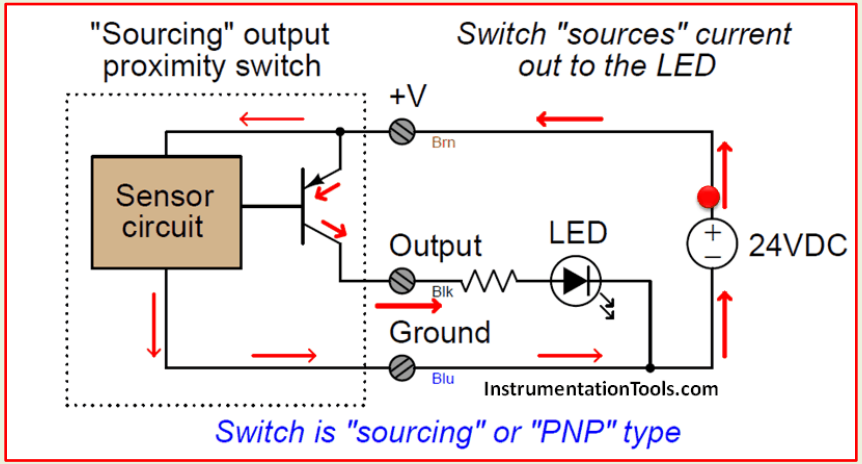


Proximity Sensor - Capacitive

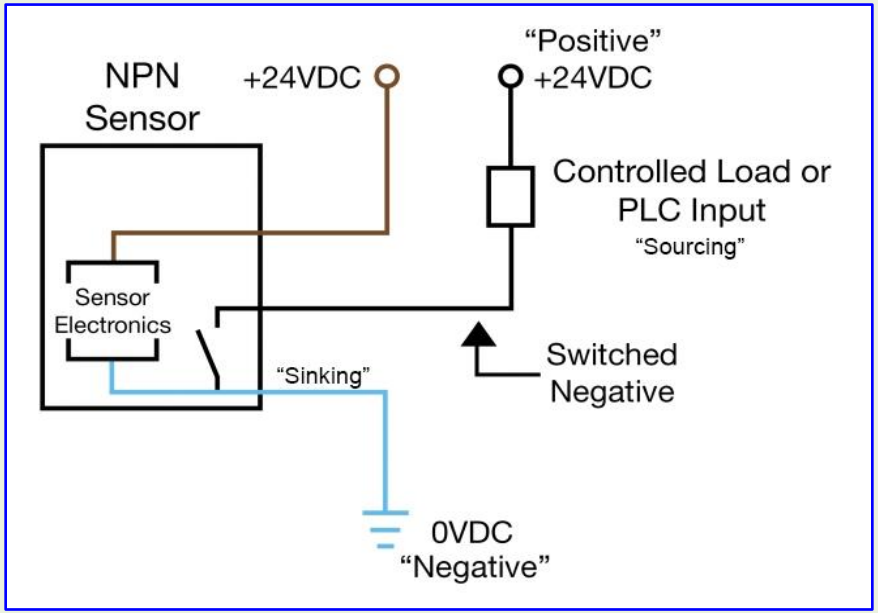


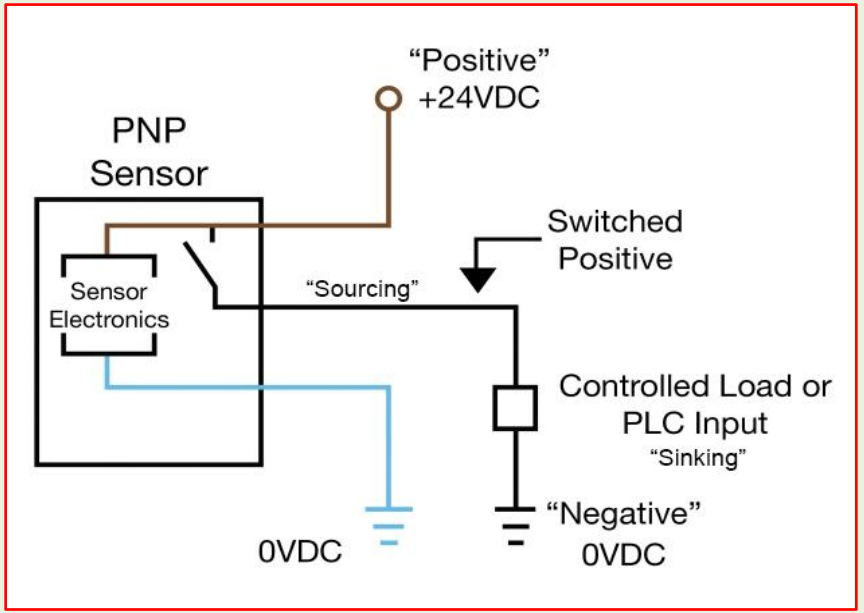
Proximity Sensor – NPN and PNP type





Proximity Sensor – NPN and PNP type





Proximity Sensor – Comparison

Capacitive type –

Advantages:

1) They can detect both metallic and non metallic objects.
2) Good stability.
3) High Speed.
4) Moderate Resolution.
5) Low power usage.

Disadvantages:

1) They are affected by temperature and humidity.
2) Could be triggered by dust, moisture etc.
3) Sensitive to noise.
4) Linearity is not good.
5) Less accurate compared to inductive.

Inductive type –

Advantages:

1) They are more accurate than Capacitive.
2) Have high switching rate.
3) Can work in harsh environment condition

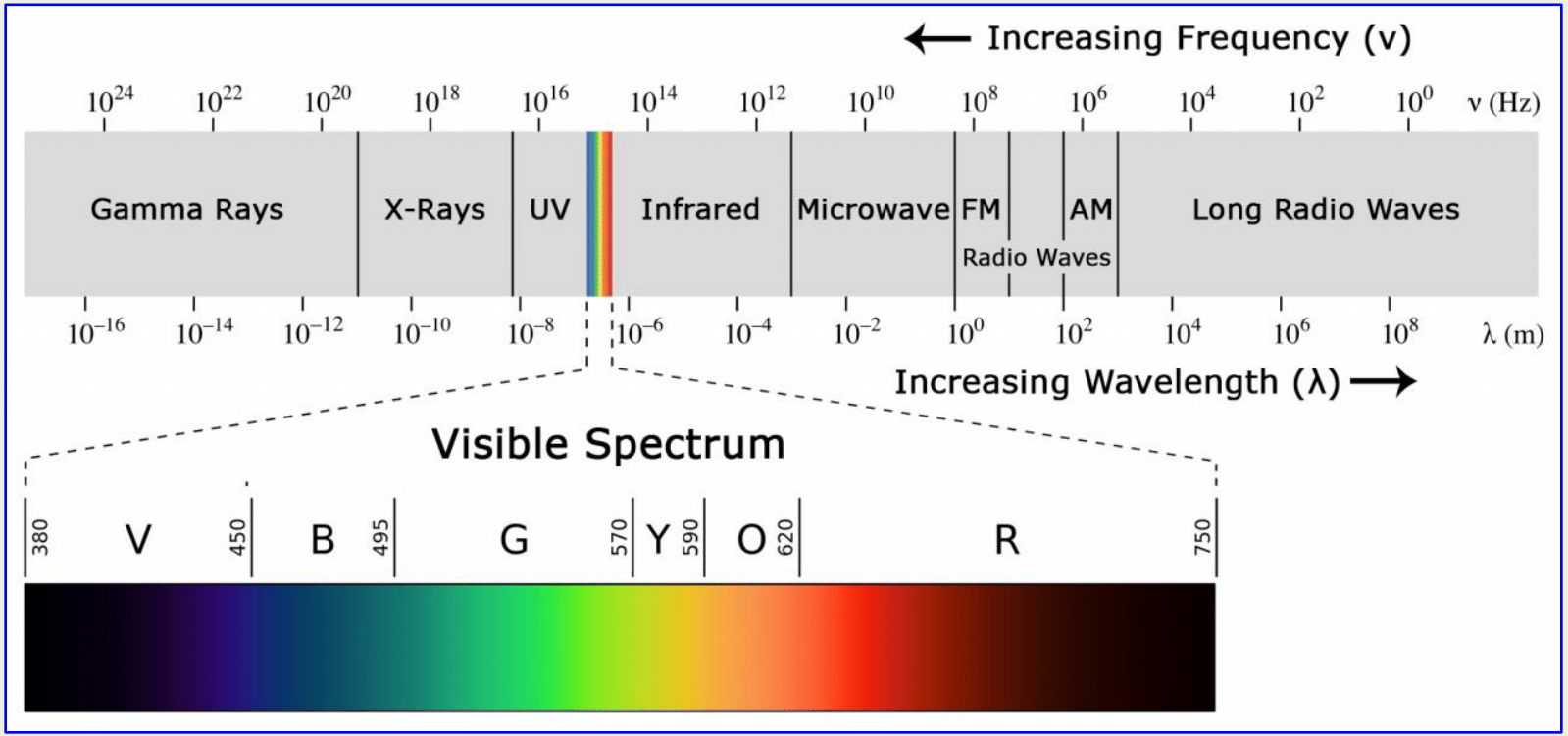
Disadvantages:

1) They can detect only metallic objects.
2) Operating range is limited.

Specifications : both types

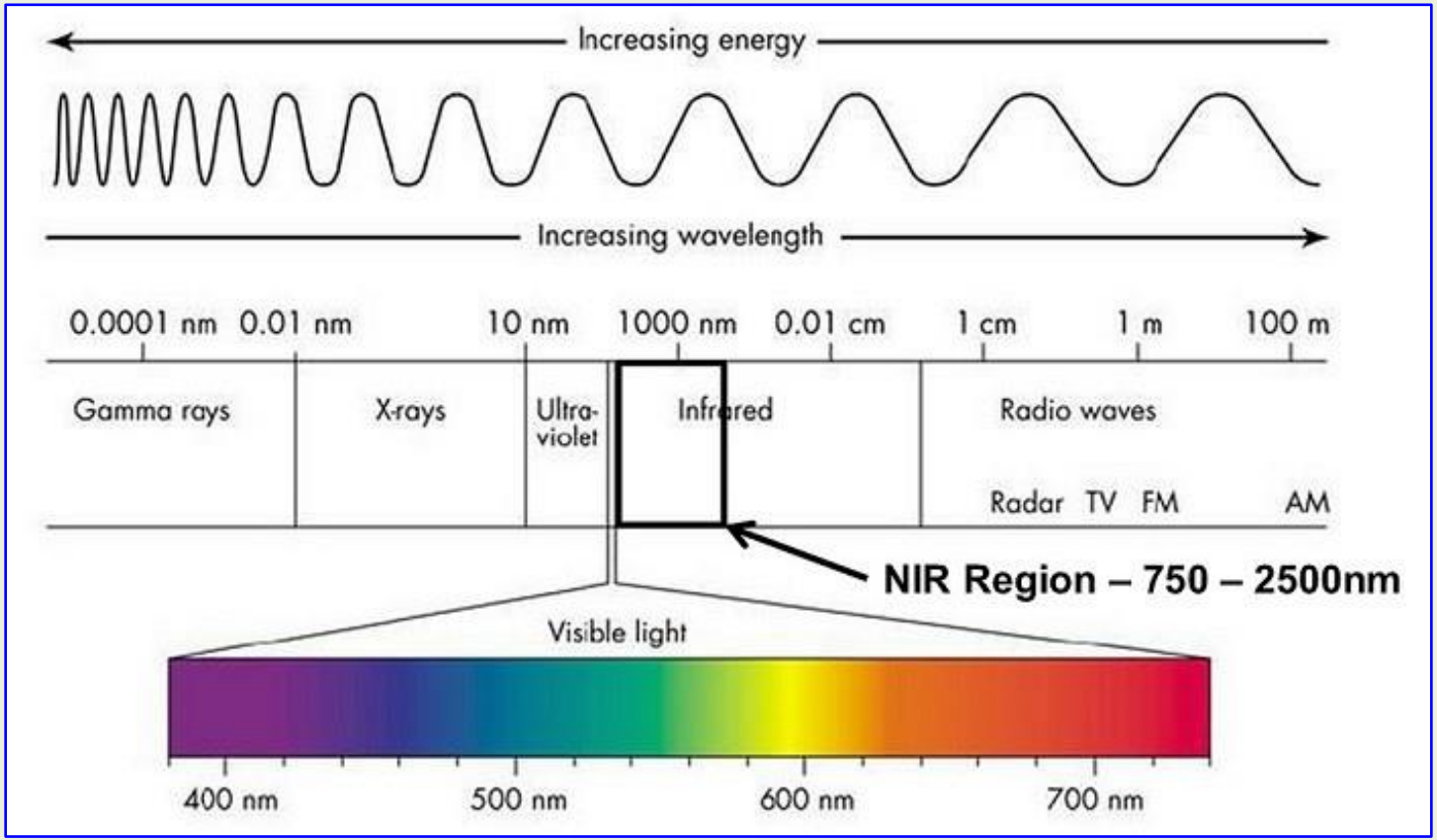
Working Voltage: DC 3 V – 36 V (variable)
Current loading : 20 to 300 mA (max.)
Response Frequency: 500 Hz
Detect Range: 0 – 50 mm (variable)
Pin-out :
Brown - VCC (+) **Blue** - Ground (–)
Black - Trigger Signal

Proximity sensor – Infra-Red Sensor

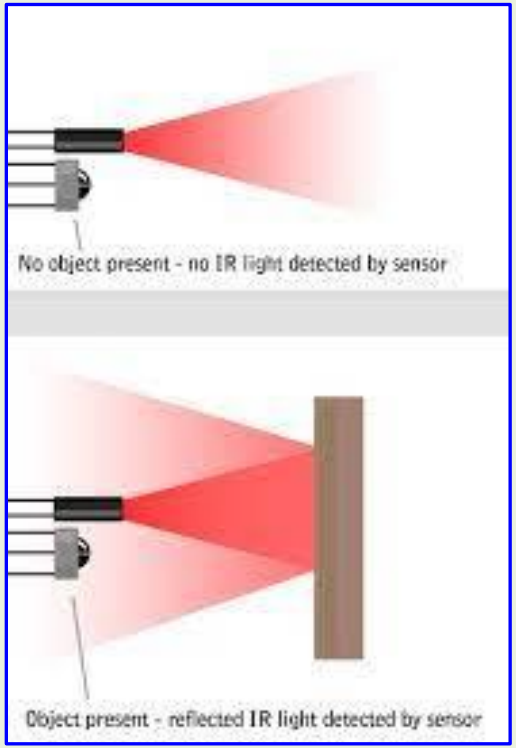


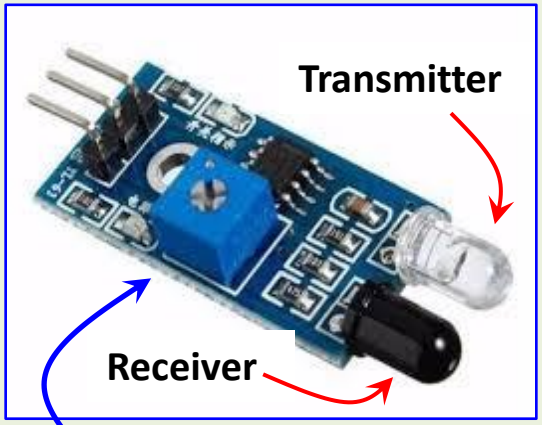
Proximity sensor – Infra-Red Sensor

Wavelength = 750 nm to 2500 nm



Proximity sensor – Infra-Red Sensor

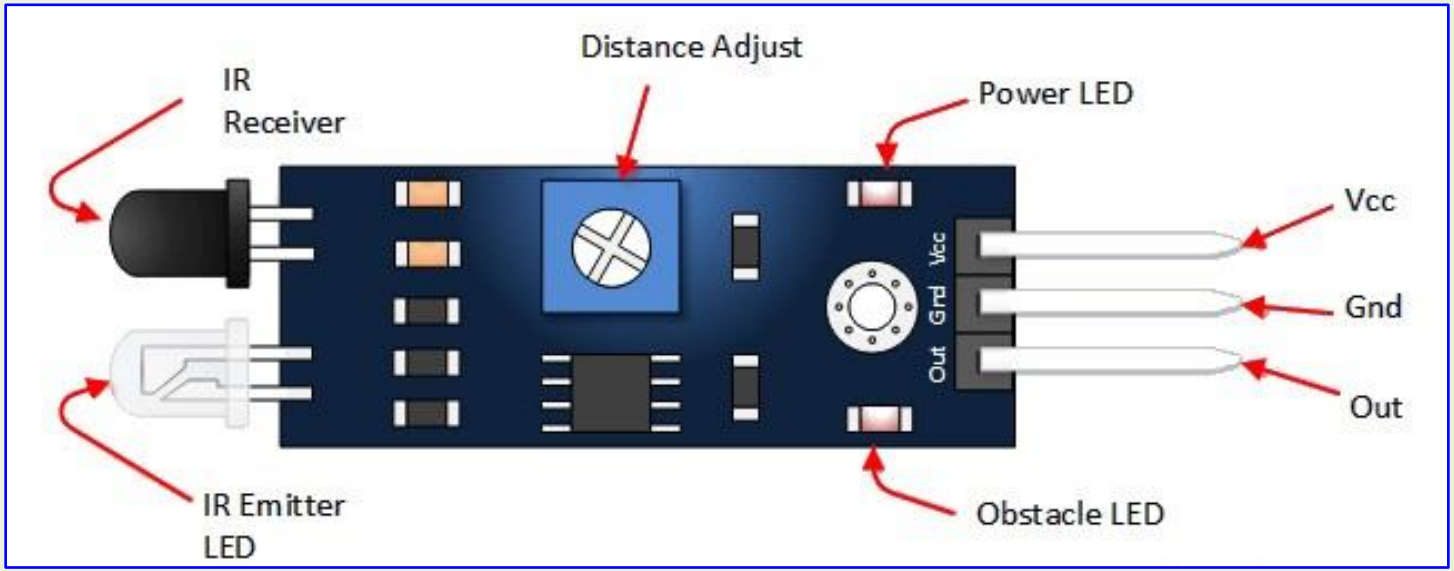




Trim Pot. for setting the range

Infra – Red sensor : IR sensor has 1) a Transmitter and 2) a Receiver in it. The transmitter emits out IR rays which are reflected from the object in the path and are received back by the Receiver.

Proximity sensor – Infra-Red Sensor



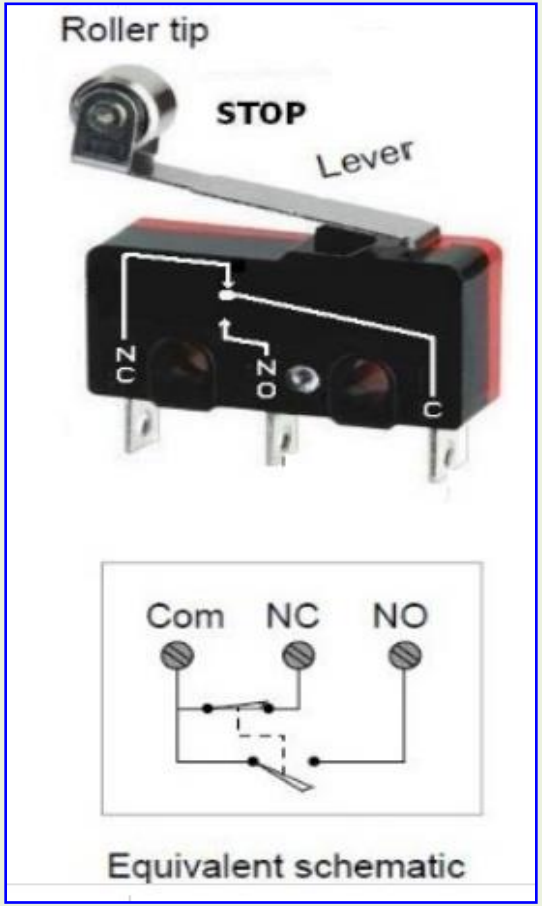
Tactile sensor – contact sensor

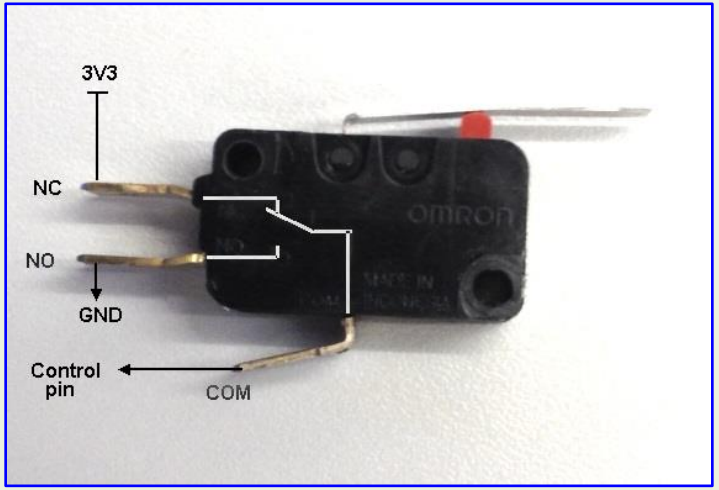
Hinge Lever type Switch

Roller type Switch

Plunger type Switch

Tactile sensor – contact sensor

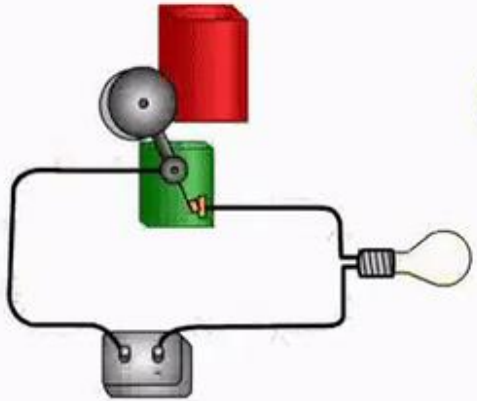




Hinge Lever type Switch

Tactile sensor – contact sensor

When the moving object touches and moves the lever, a set of electrical contacts is forced either open or closed.



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Tactile sensor – contact sensor