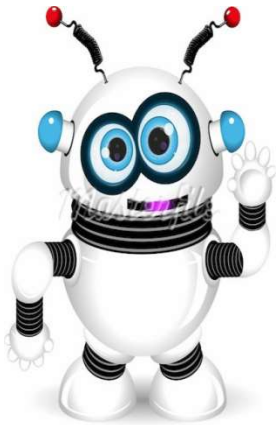
SENSORS for Robotics



What is sense?

Why sense?

What is sensor?

- Ability to perceives an external stimulus.
- Collect the information about the surrounding

Uncertainty
Detection
correction

Human Vs Robot

Human		Robot
• Eyes	⟷	• Light sensor, Ultrasonic sensor
• Ear	⟷	• Microphones
• Skin	⟷	• Touch sensor
• Nose	⟷	
• tongue	⟷	

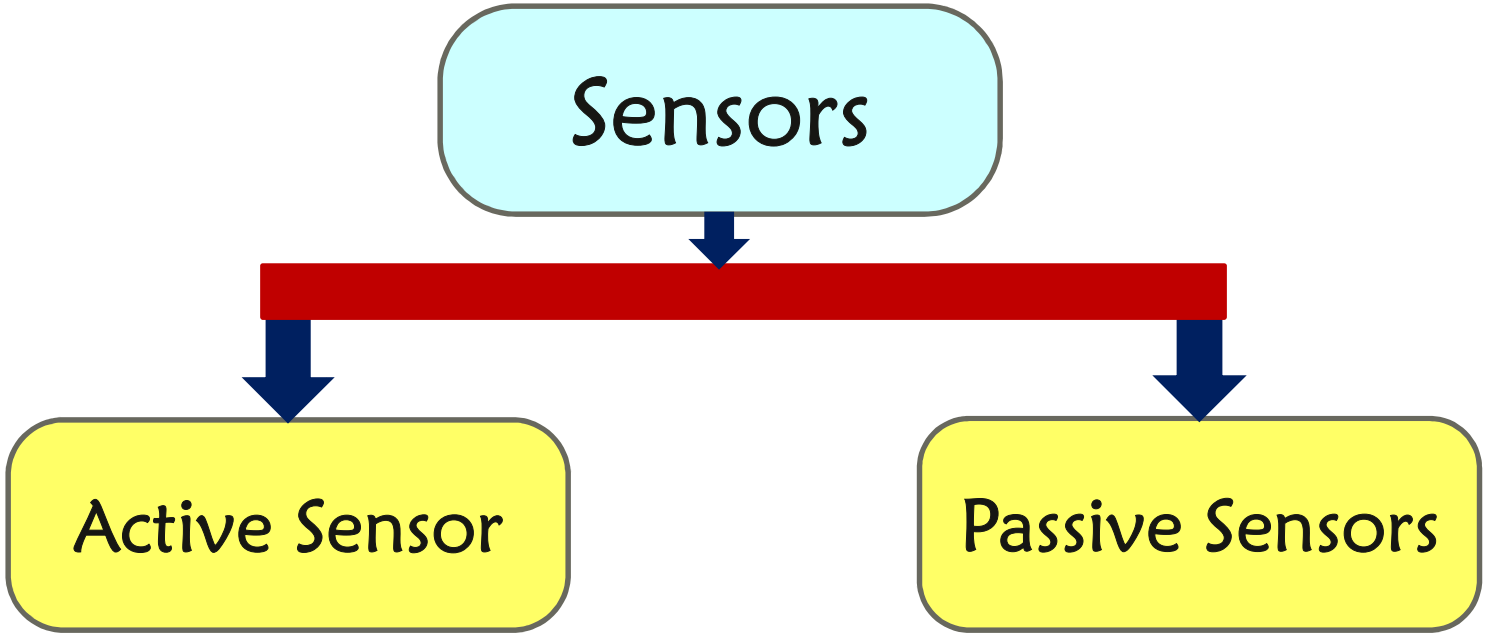
What is robot sensor?

The interaction of robot with the environment needs device known as SENSORS.

Functions performed by Sensor:

- Motion control variables, detection
- Robot guidance without obstruction
- Object identification tasks
- Handling the objects

Sensor Classification

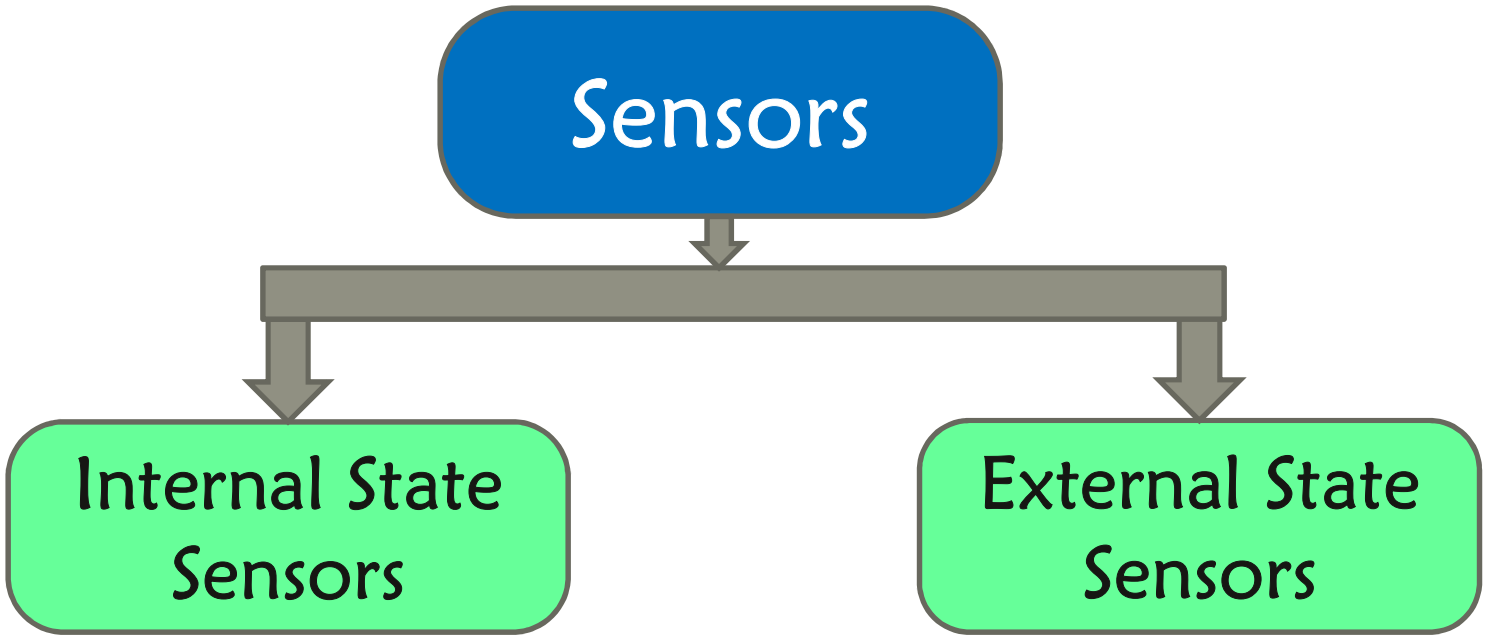


emitting energy into the environment,

e.g., radar, sonar

passively receive energy to make observation,

e.g., camera,
Piezoelectric sensor

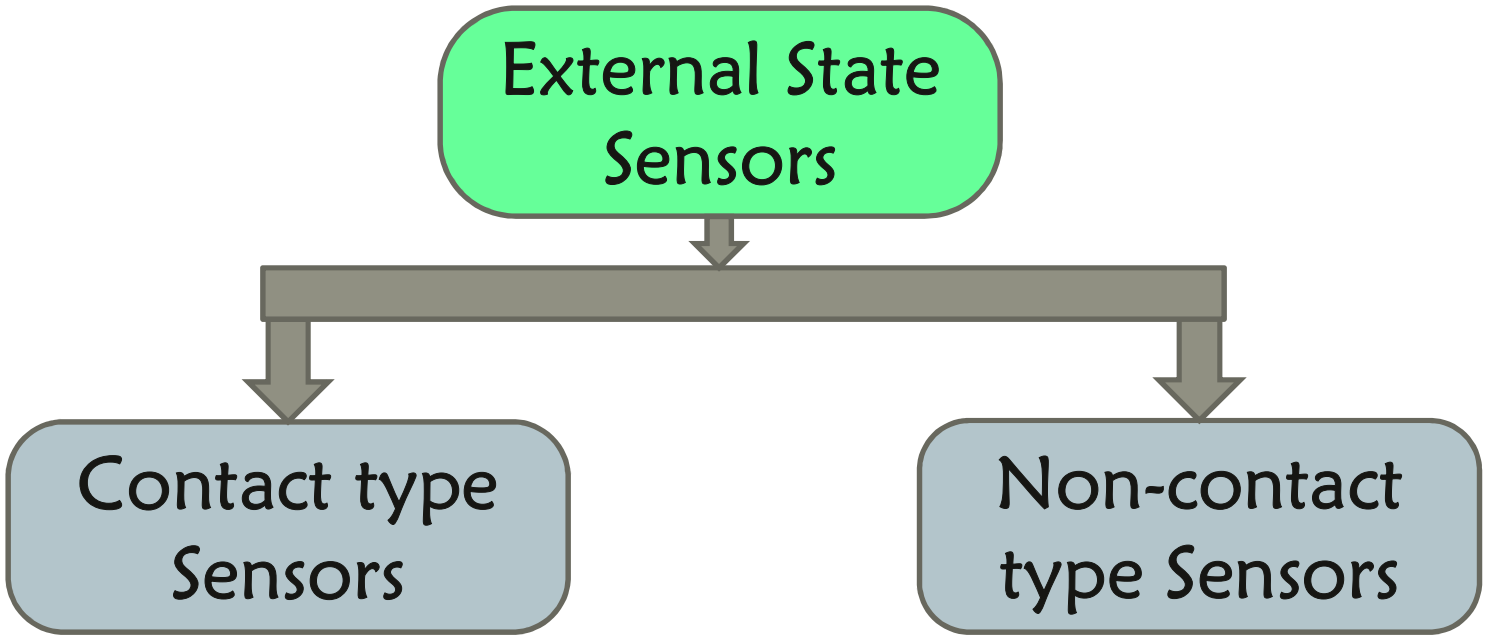


Information about robot joint, velocity & acceleration

Handling of objects using force sensor

Object identification.

Robot guidance



Object identification using Touch & Proximity sensor.

Robot guidance using range & vision sensor

Touch Sensor:

- Presence/absence
- Presence/absence + size & shape

Force Sensor:

- force in single axes
- Force in two/multiple axis.

Proximity Sensor:

- Non-contact detection

Vision Sensor:

- Detection of edge, corner etc.
- Determination of shape

Position sensor

Position sensor

Position sensors are used to measure the position/displacements, both angular and linear, as well as movements of robot joint.

Common position sensors:

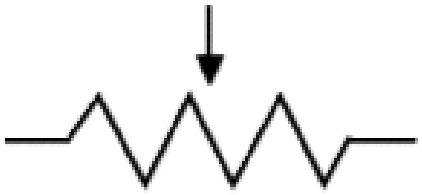
- Potentiometer
- Encoder
- LVDT

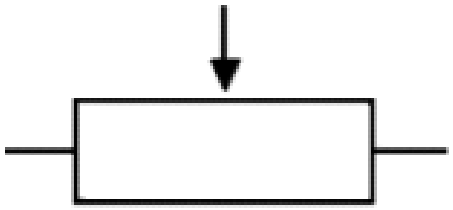
Potentiometer

Potentiometer

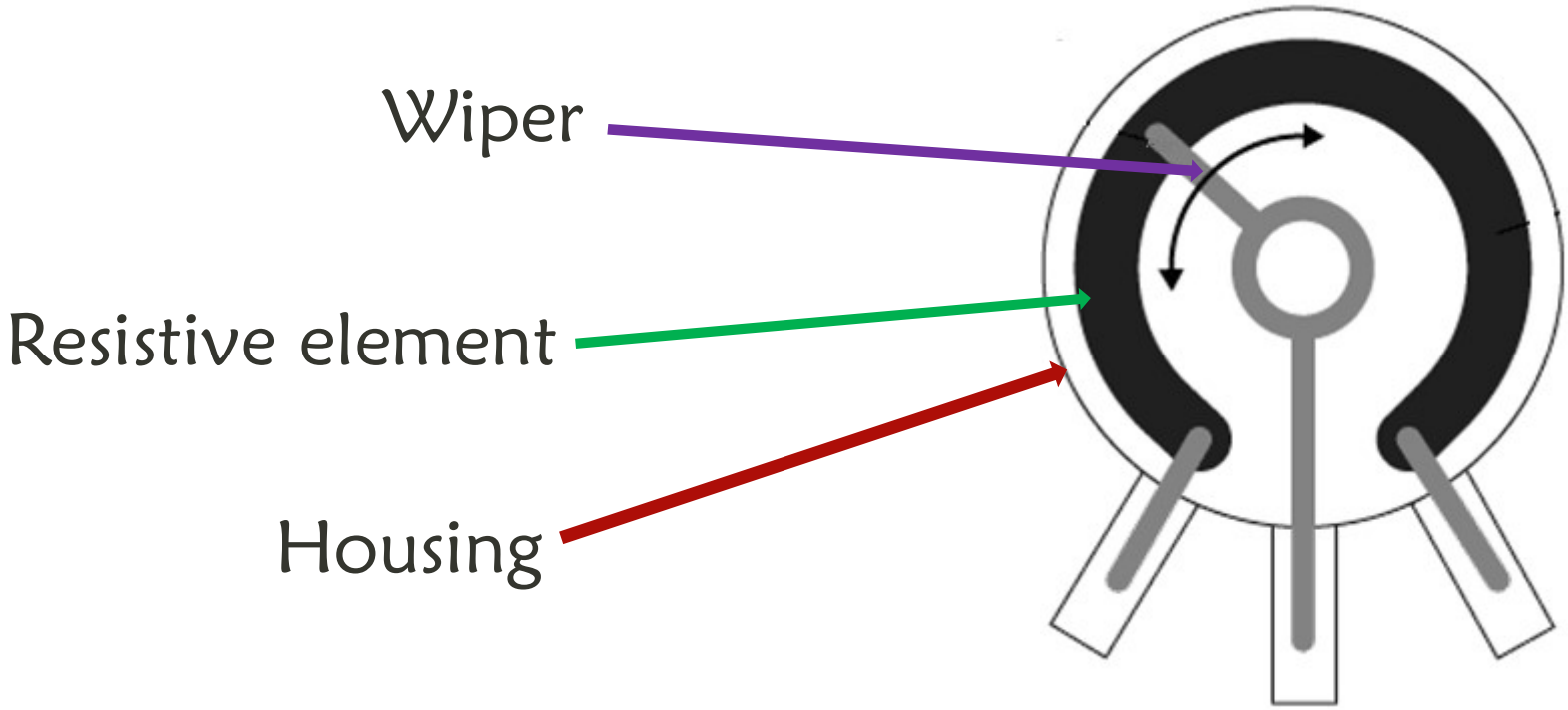
"Potentiometer is manually adjustable, variable resistor with three terminals"

- Two terminals are connected to resistive element.
- Third terminal is connected to adjustable wiper.
- Wiper position determines the output voltage.



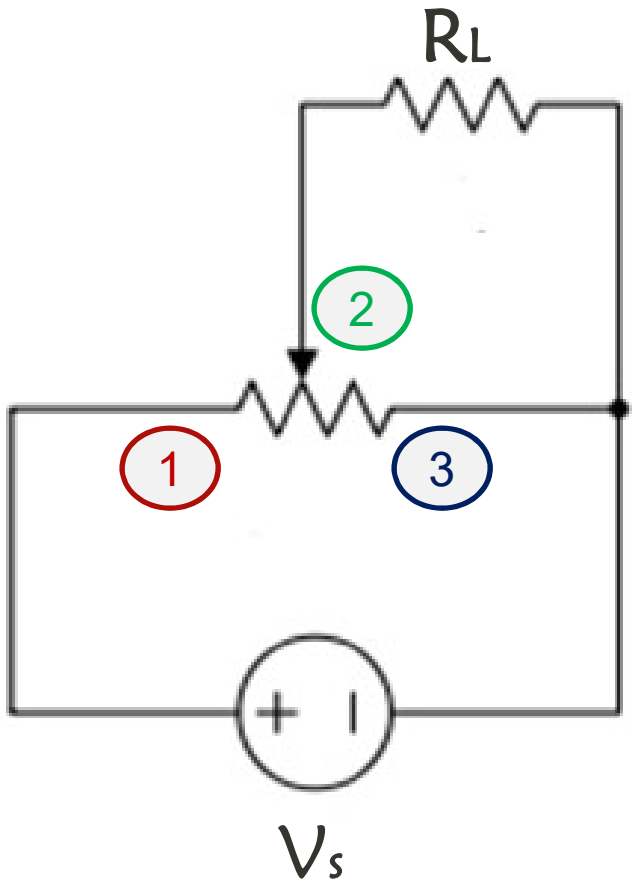


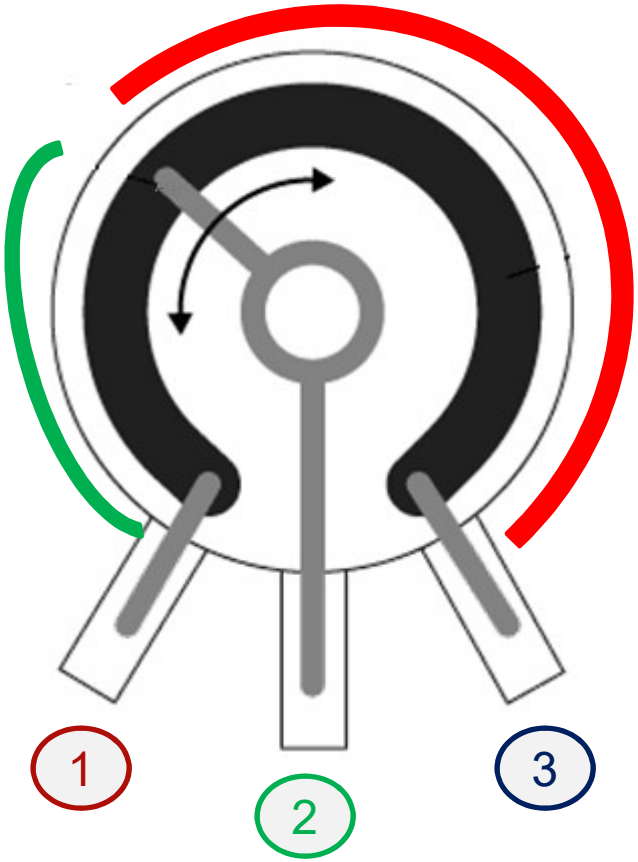
Potentiometer



3 elements

Potentiometer



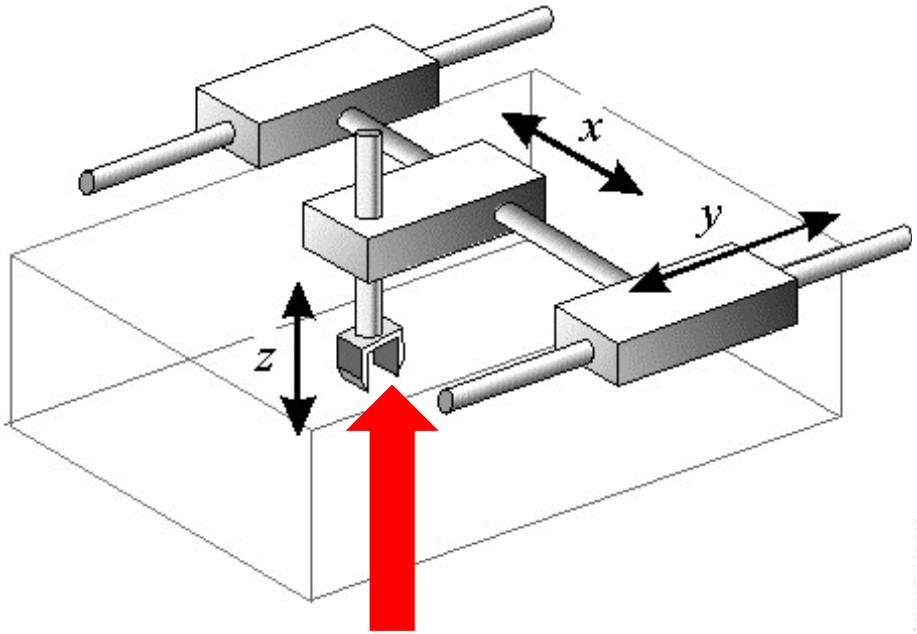


Potentiometer

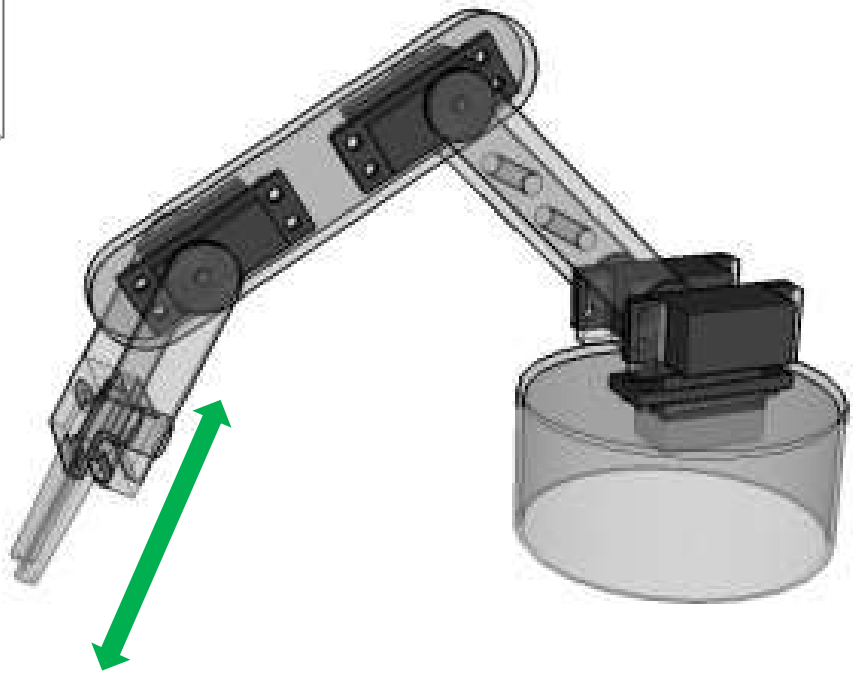
Two Types:

- Linear Potentiometer.
- Rotary Potentiometer.

Linear Potentiometer



Linear Potentiometer



Potentiometer

ENCODER

ENCODER

- Non contact optical devices used for converting the angular position of rotating shaft into analogue or digital data code.

i.e.
Converts mechanical movement to electrical signal (preferably digital)

Basic principle

Light from an LED or infra-red light source is passed through a rotating high-resolution encoded disk that contains the required code patterns, either binary, grey code.

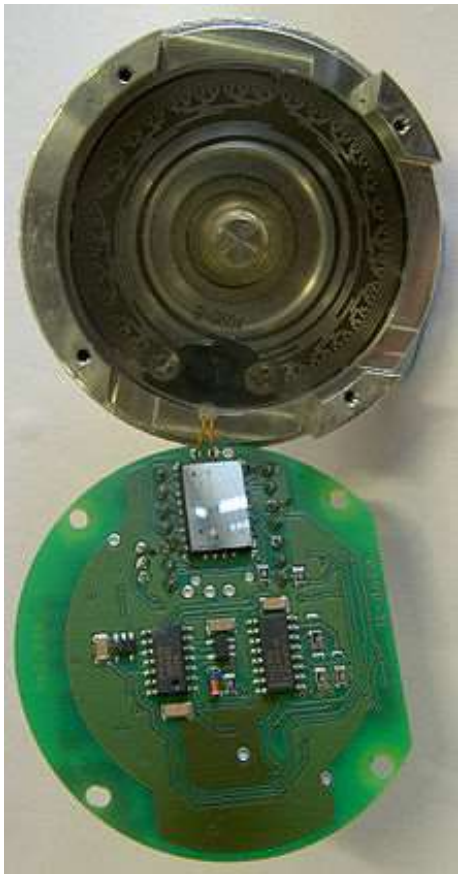
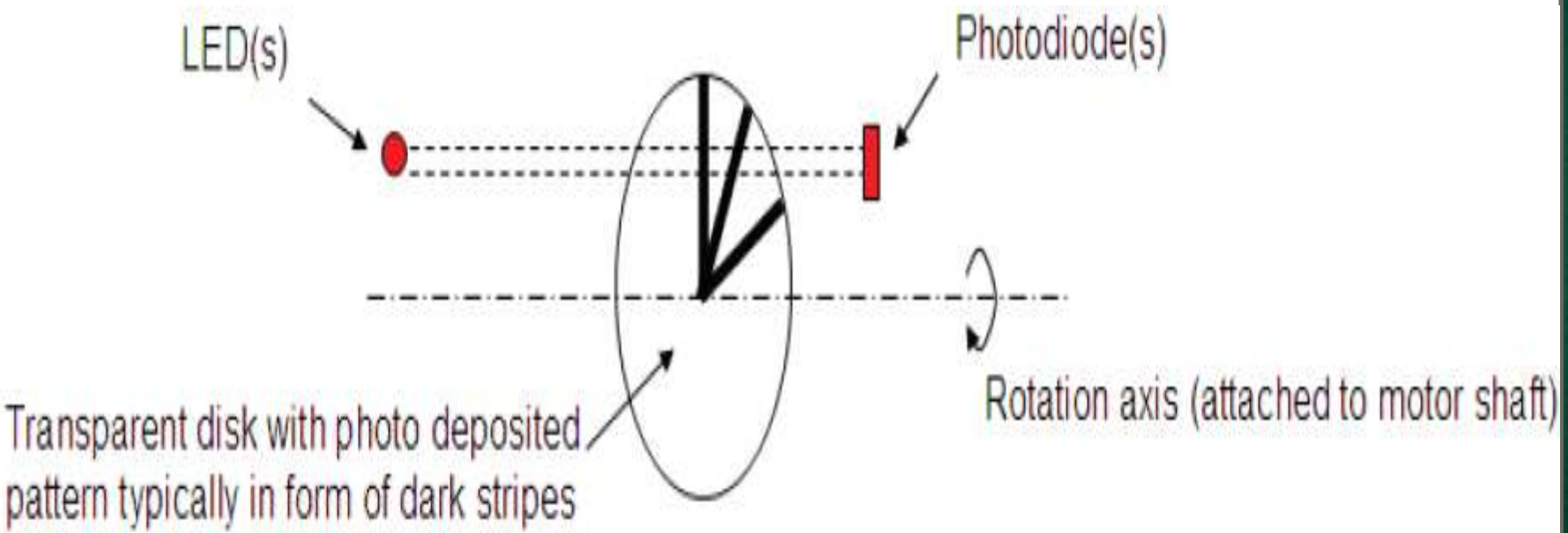
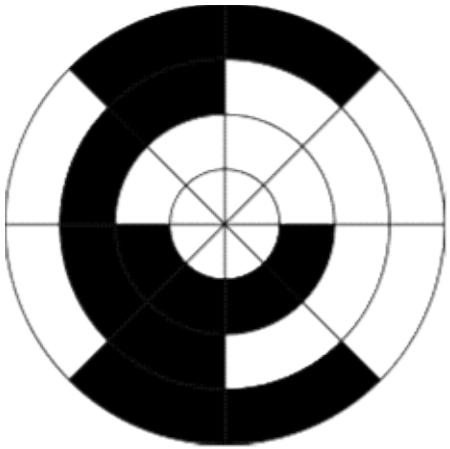
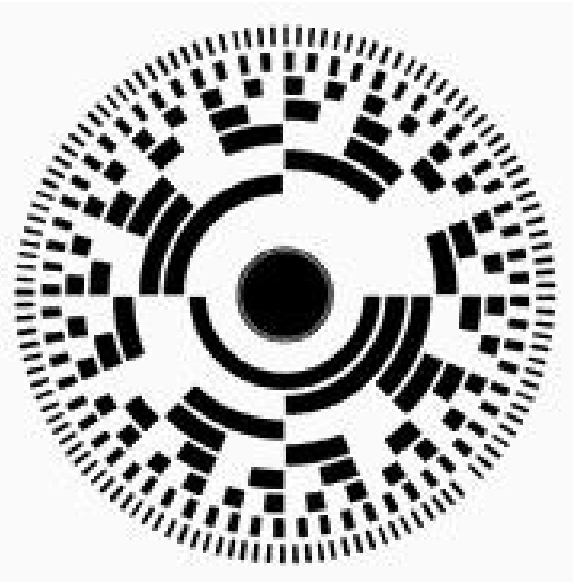


Photo detectors scan the disk as it rotates and an electronic circuit processes the information into a digital form as a stream of binary output pulses that are fed to counters or controllers which determine the actual angular position of the shaft.


LED(s)
Photodiode(s)
Rotation axis (attached to motor shaft)
Transparent disk with photo deposited pattern typically in form of dark stripes



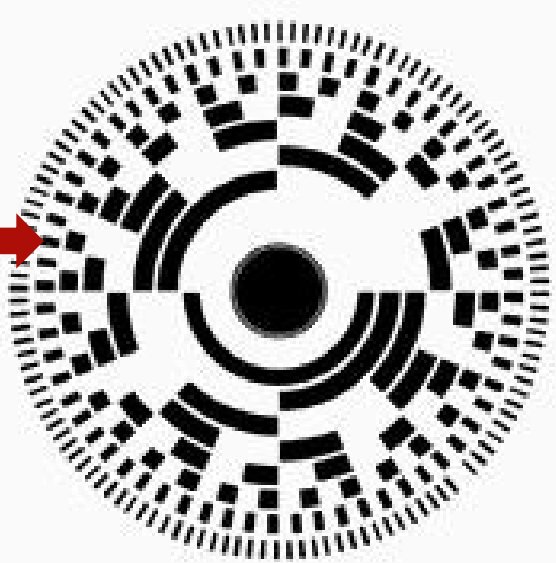
3-bit tracking



Encoder disk

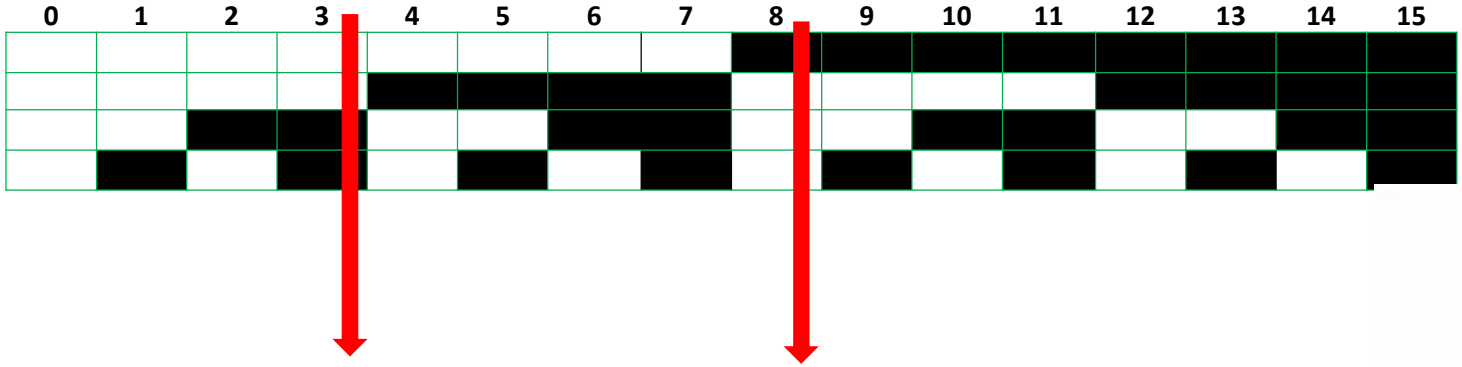
Code pattern

(binary code/ gray code)



Encoder disk

Encoder



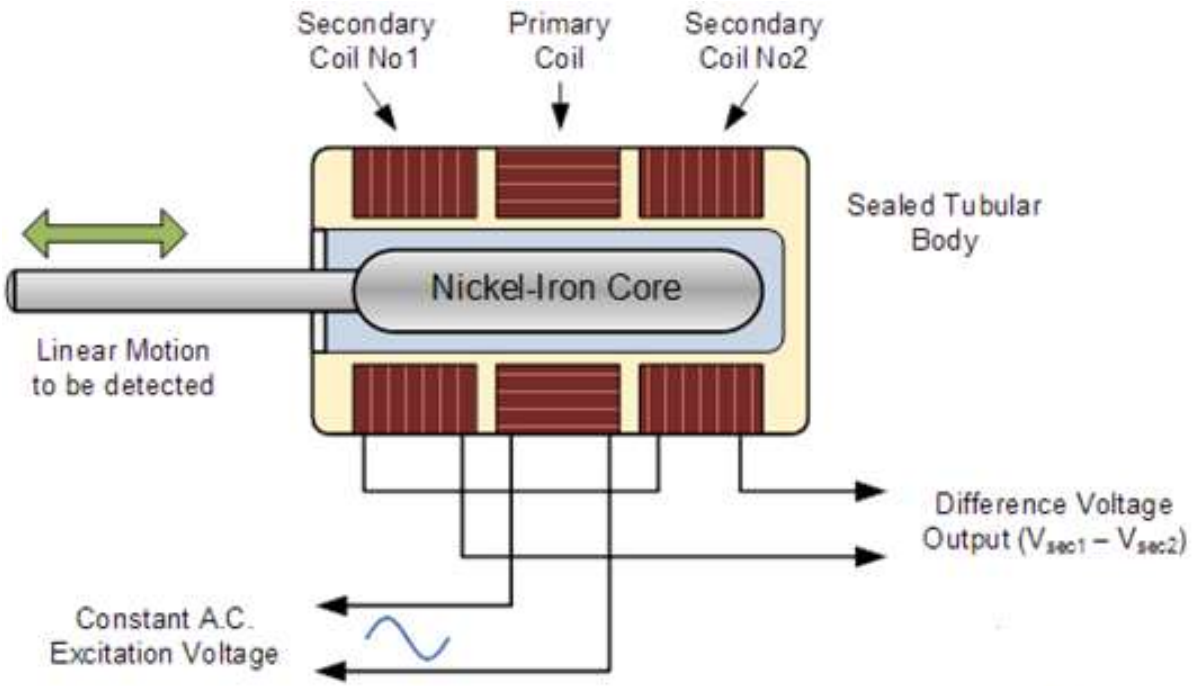
0	0
0	0
1	2
1	1

3

1	8
0	0
0	0
0	0

8

LVDT


Secondary Coil No1
Primary Coil
Secondary Coil No2
Sealed Tubular Body
Nickel-Iron Core
Linear Motion to be detected
Difference Voltage Output ($V_{sec1} - V_{sec2}$)
Constant A.C. Excitation Voltage

LVDT

Consist of 3 coils & a armature core

One primary coils
Two secondary coils

V_{out} (secondary coils) = difference of individual voltages of secondary coils

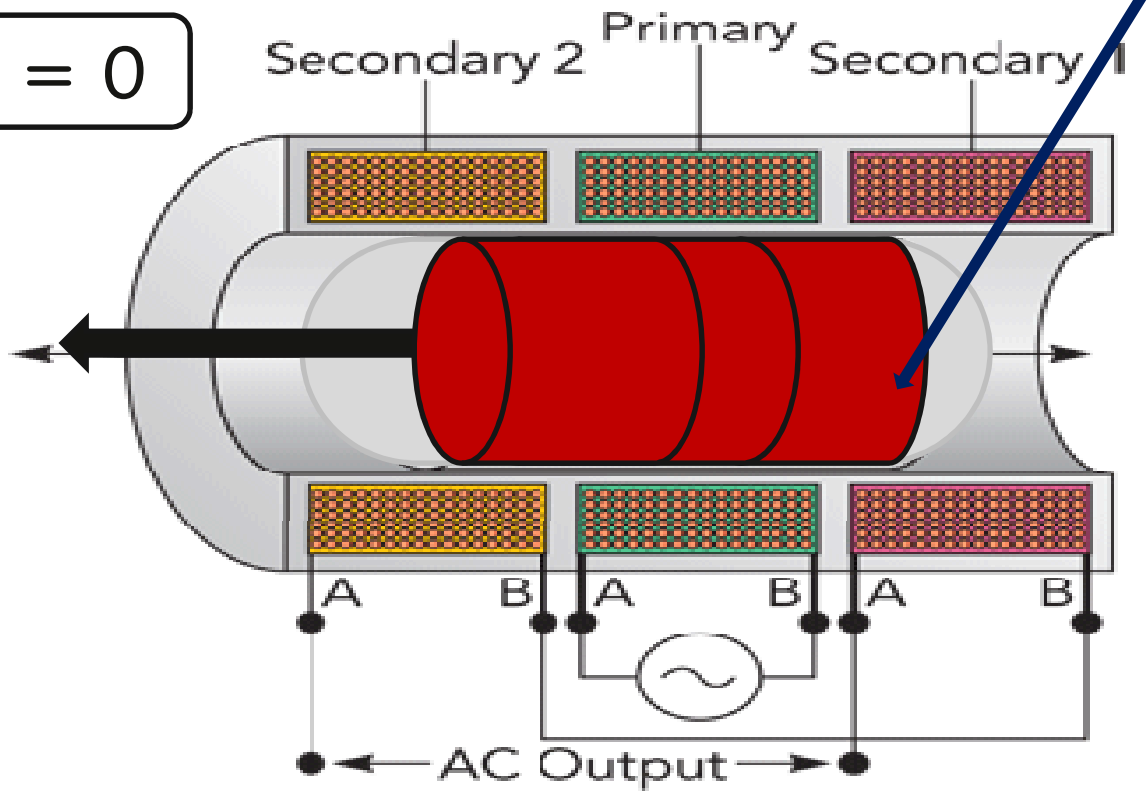
At centre: ($V_{out} = 0$)

$V_{out} \alpha$ distance travel by armature.

LVDT

armature core

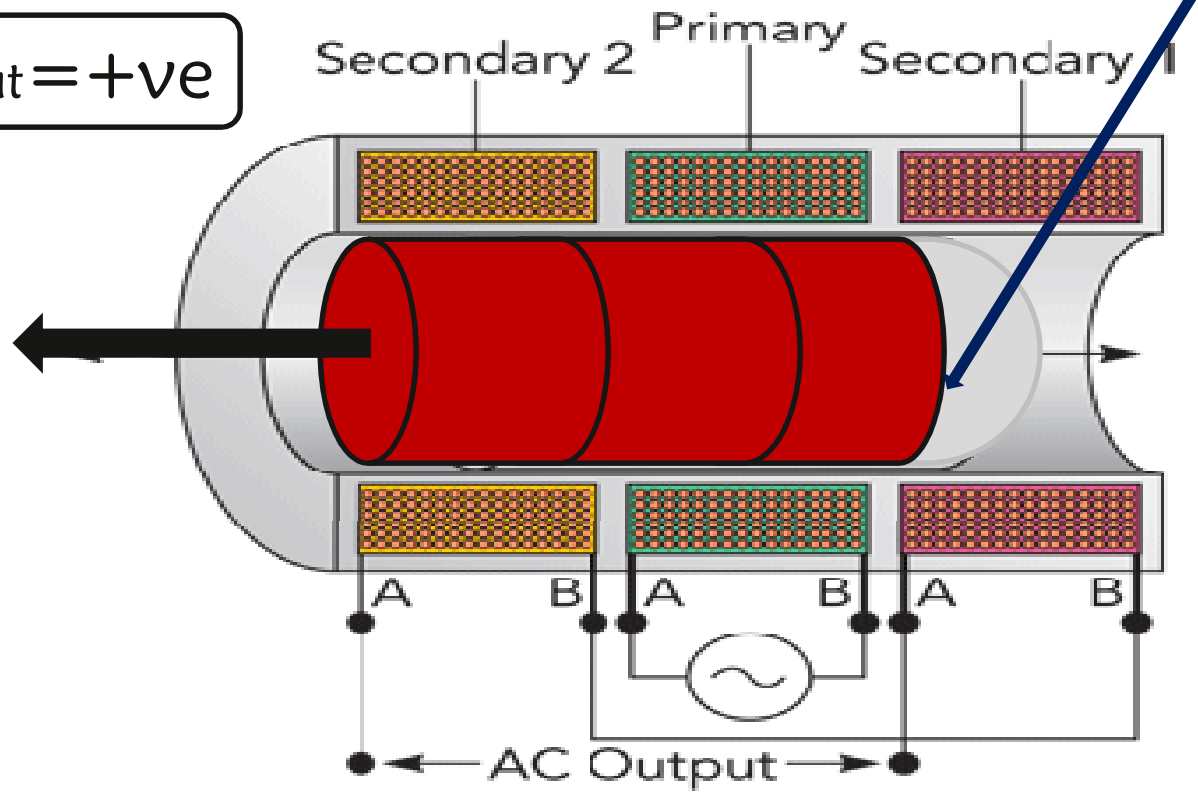
$V_{out} = 0$



LVDT

armature core

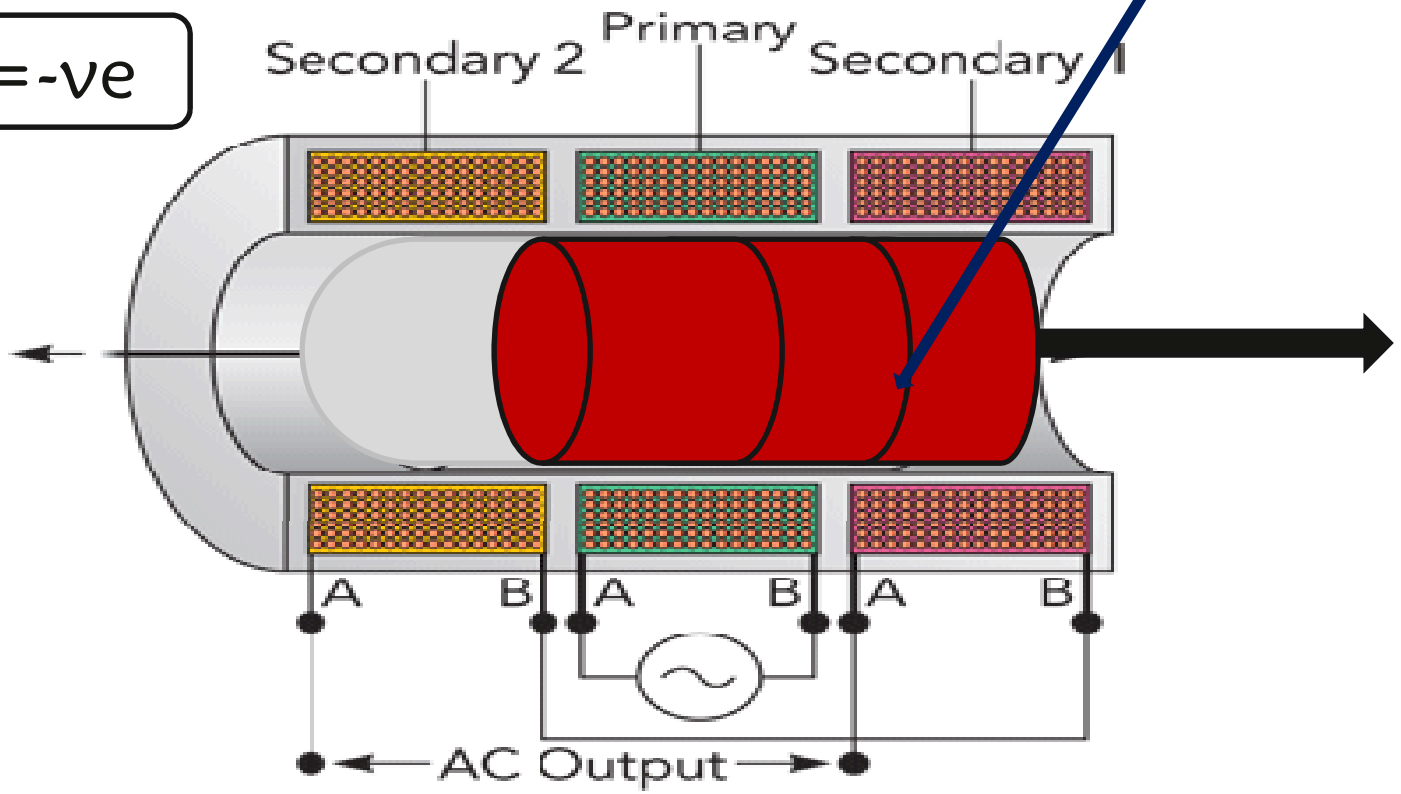
V_{out} = +ve



LVDT

armature core

V_{out} = -ve



Touch sensor

Touch sensor

Give sense of touch.

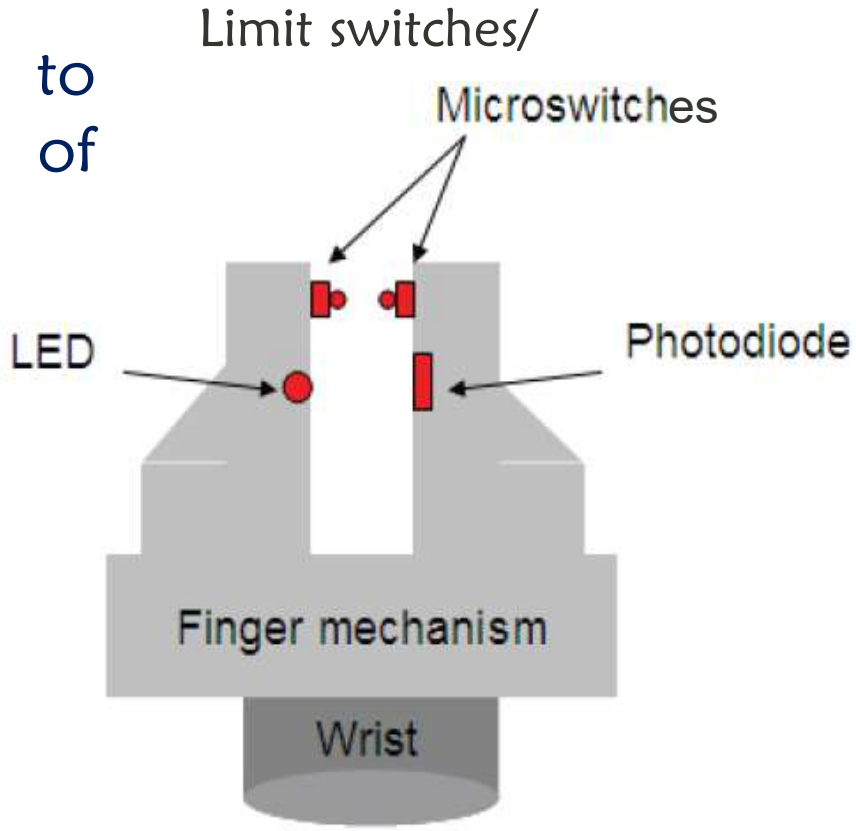
Touch sensor gather the information established by contact between the parts to be handled and the fingers in manipulator end effectors.

recognizing the object type.

Binary sensor

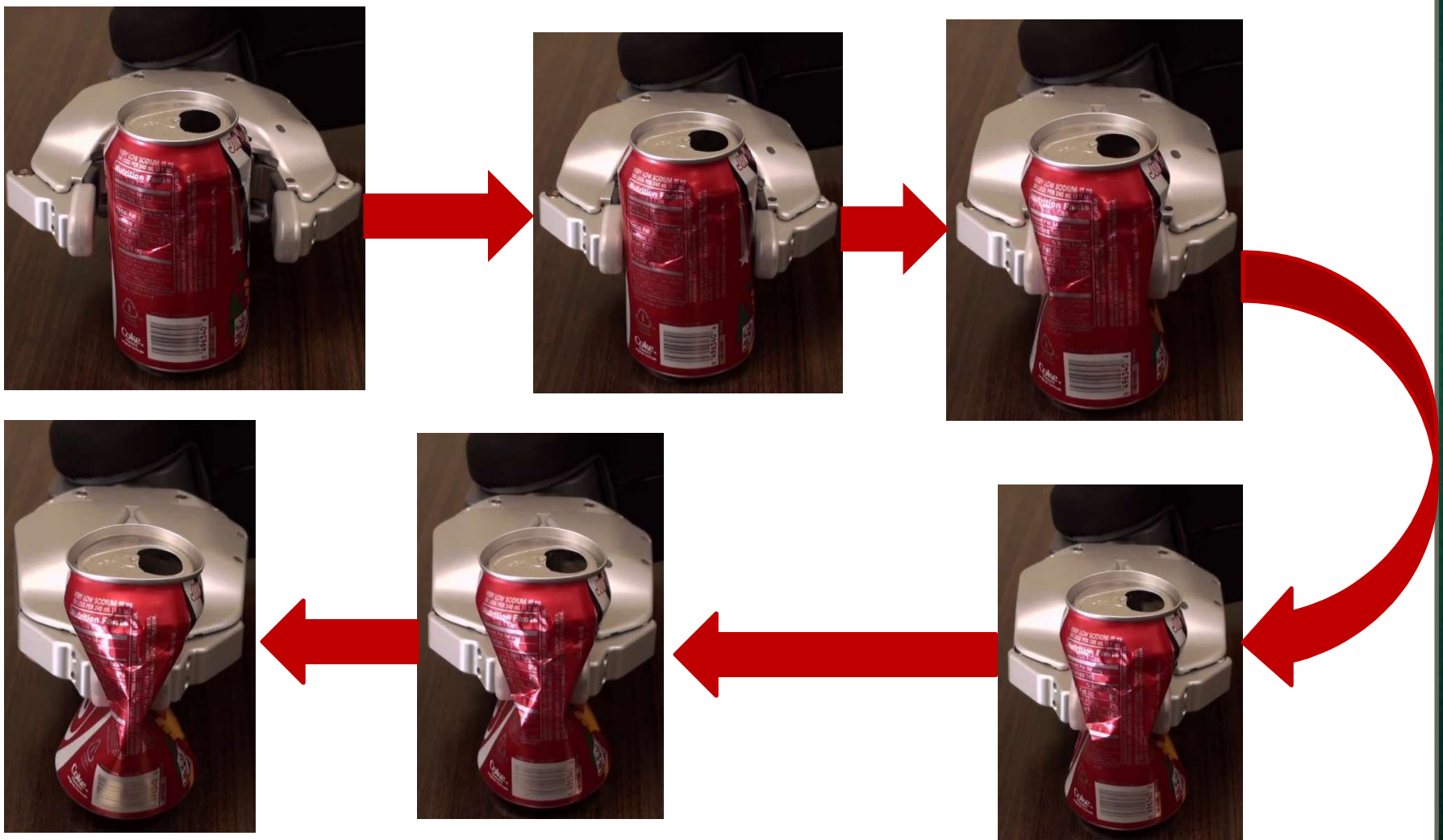
LED-Photo-diode pair used to detect presence / absence of object to be grasped.

- Micro-switches / Limit switches to detect touch.

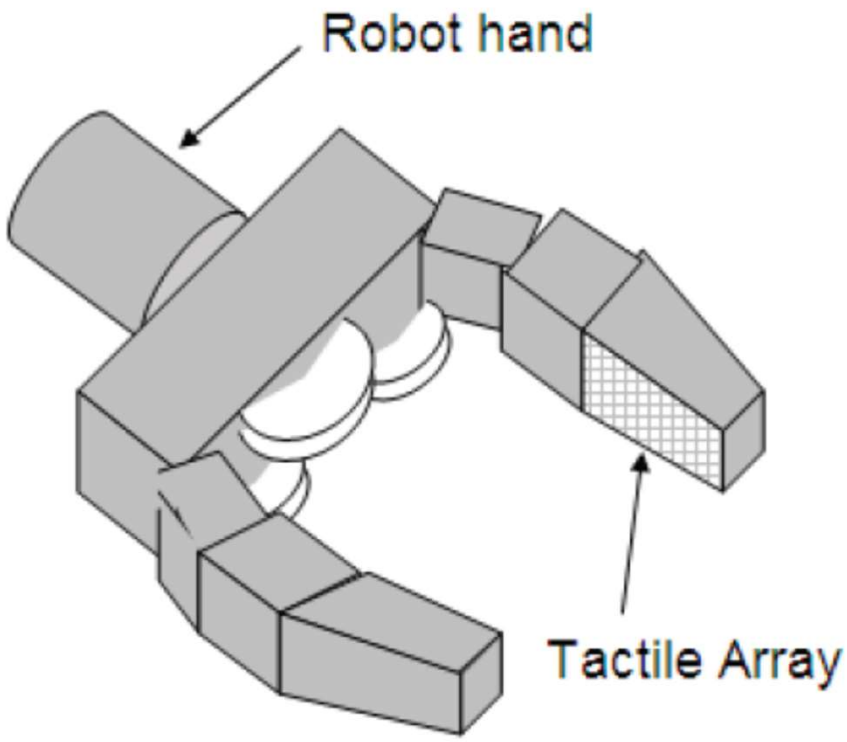


Tactile sensor

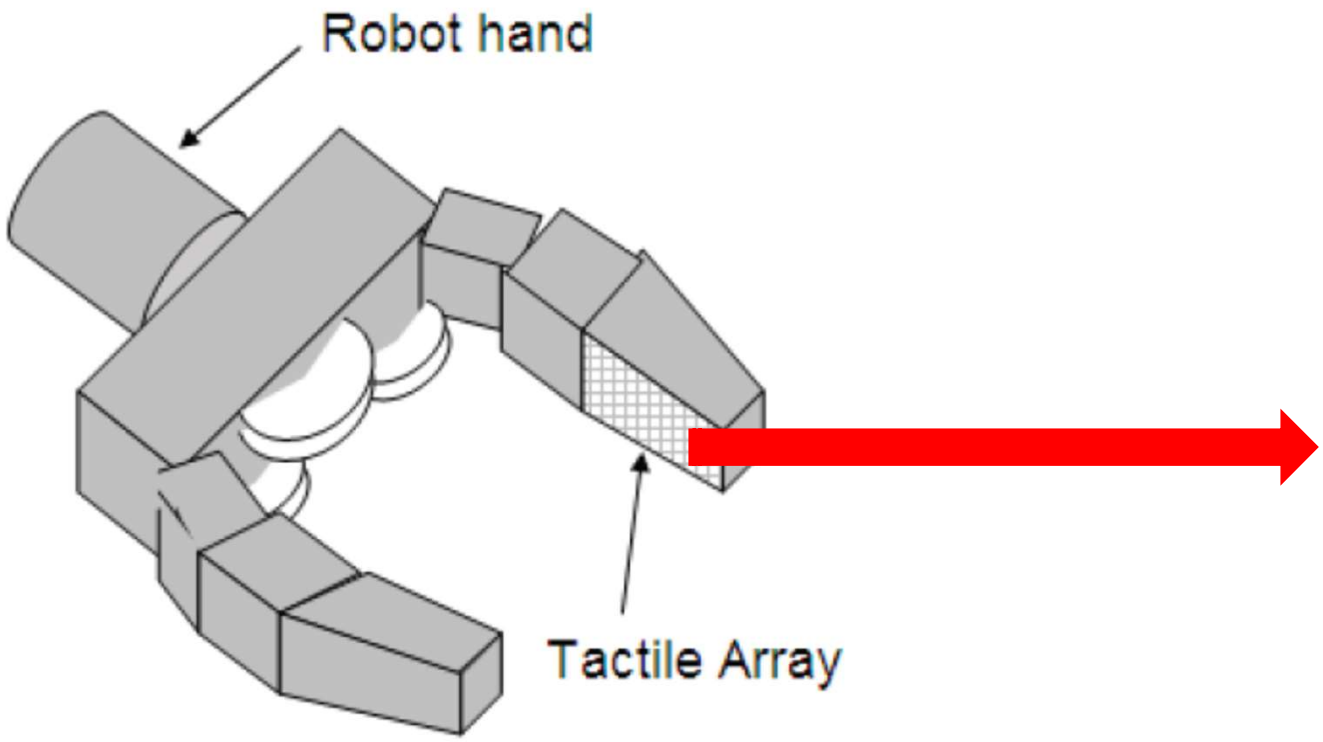
Without Tactile sensor



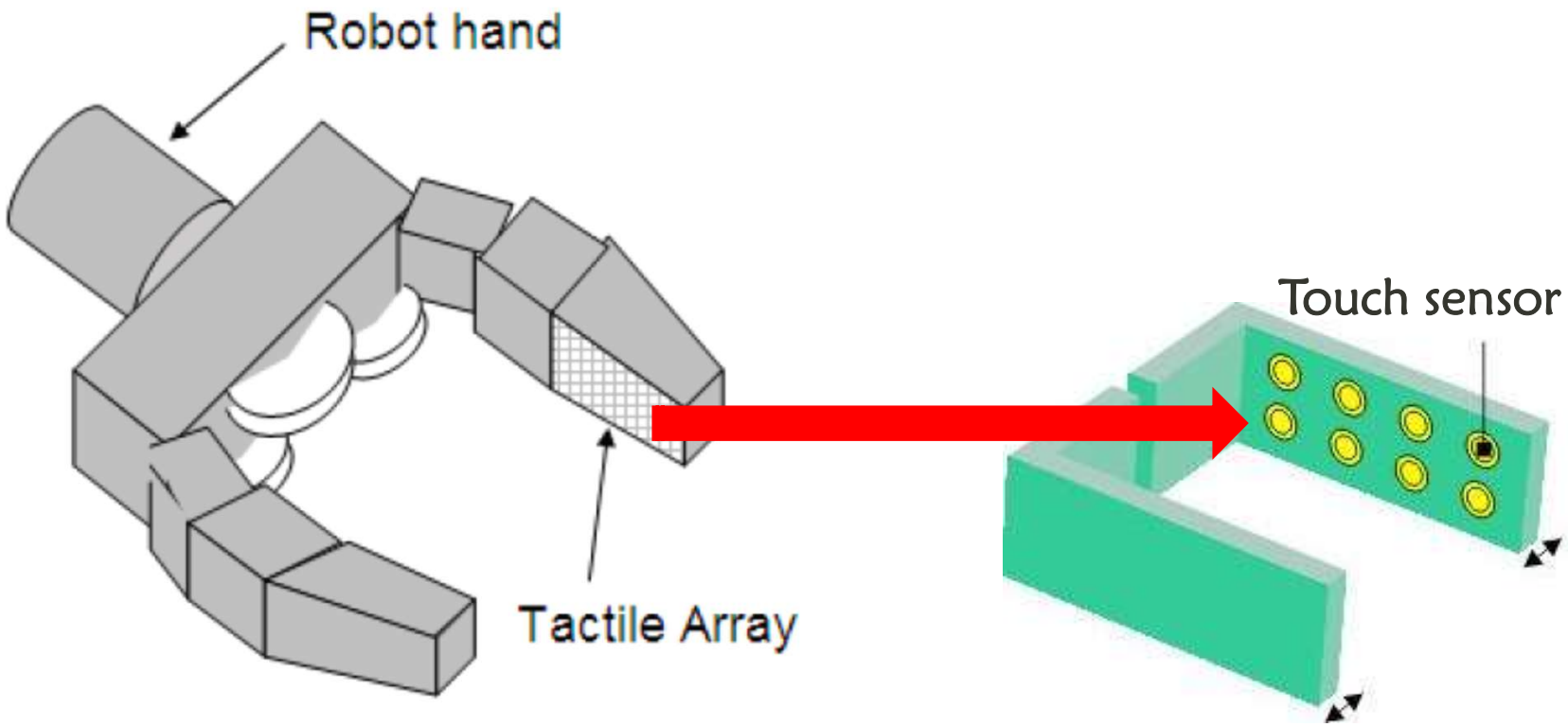
Tactile sensor



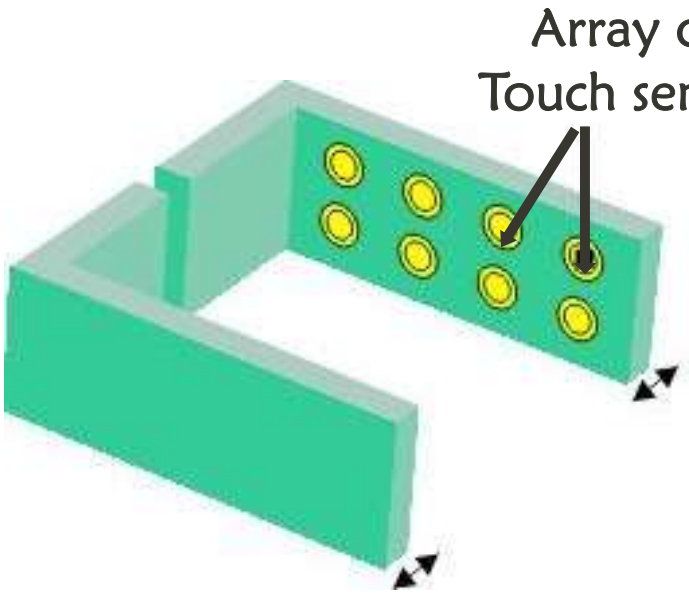
Tactile sensor



Tactile sensor



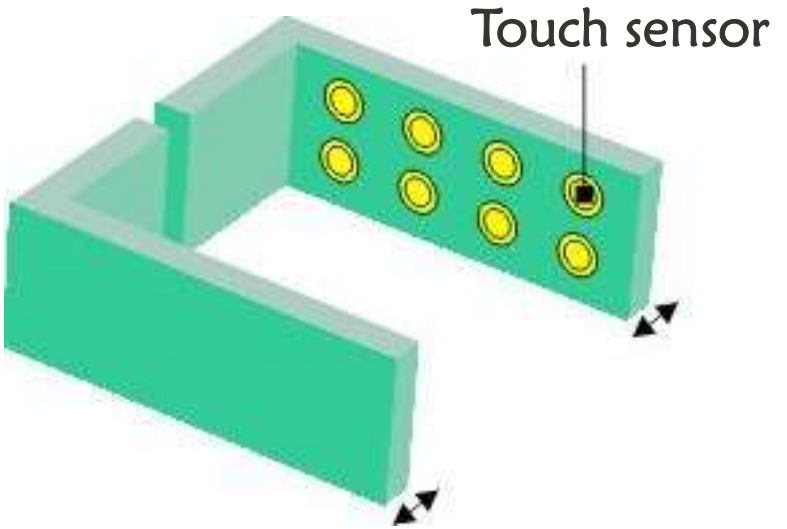
Tactile sensor



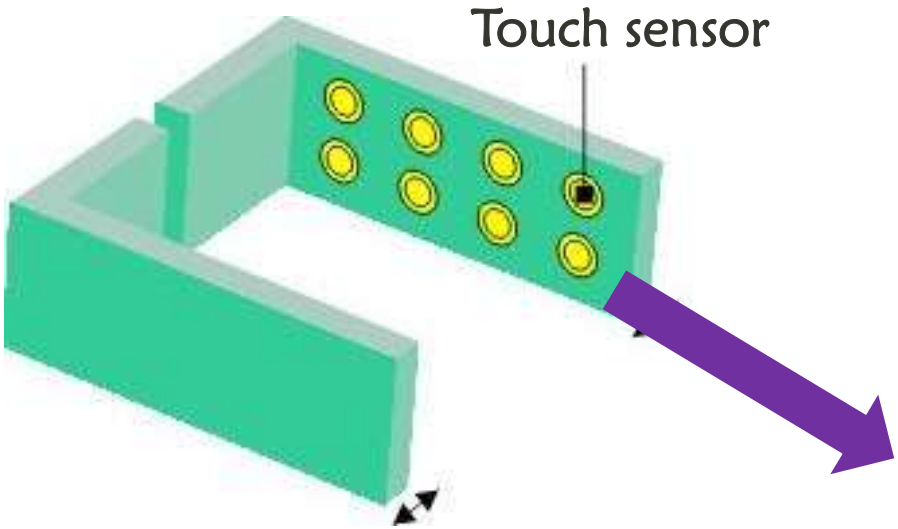
3 functional parts:

- Plunger
- LED
- Light sensor

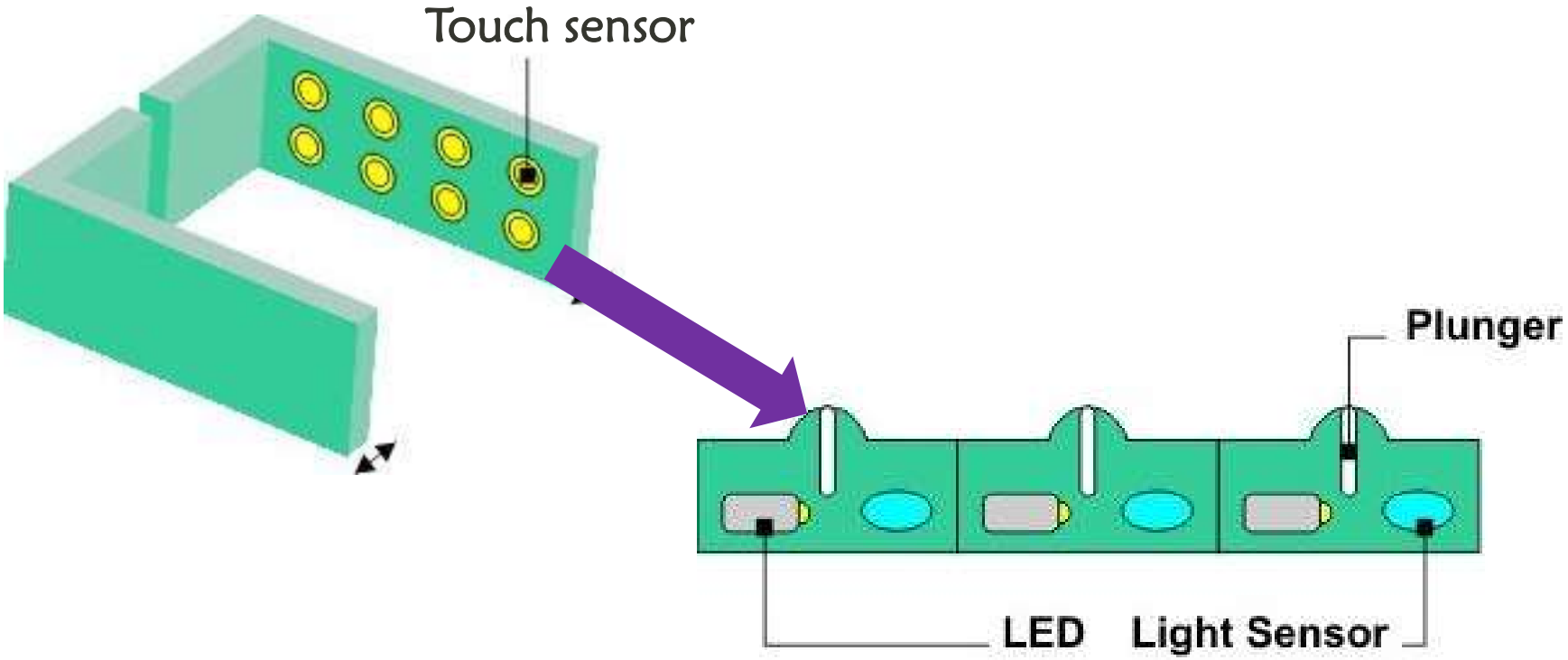
Tactile sensor



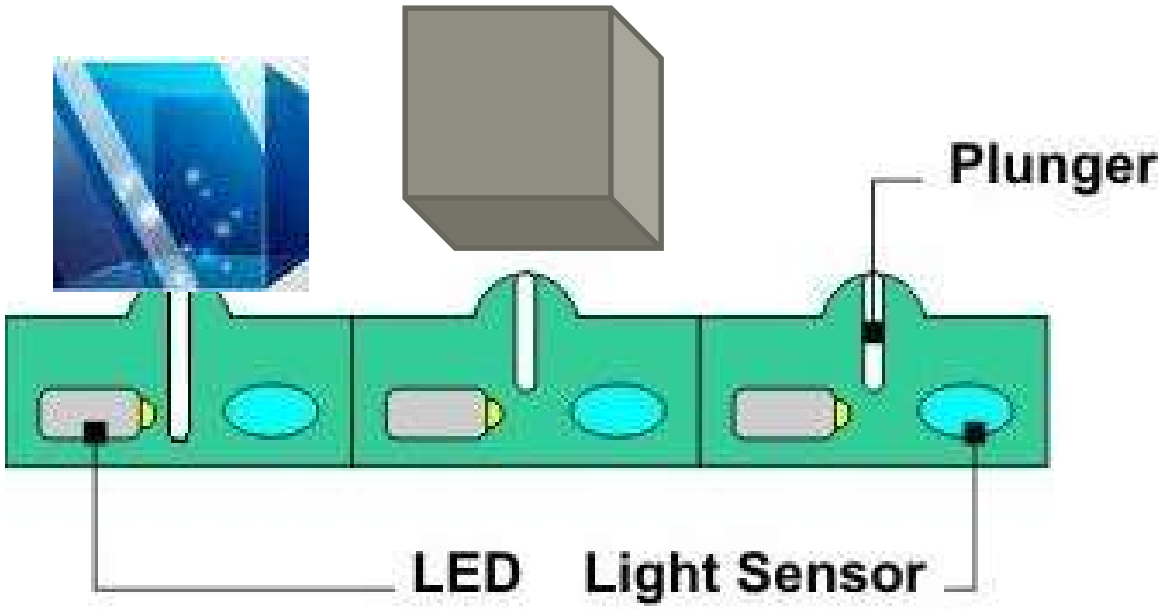
Tactile sensor



Tactile sensor



Tactile sensor



Tactile sensor

PROXIMITY SENSOR

Proximity sensor

Technique of detecting the presence or absence of an object with electronic non-contact sensor.

Application:

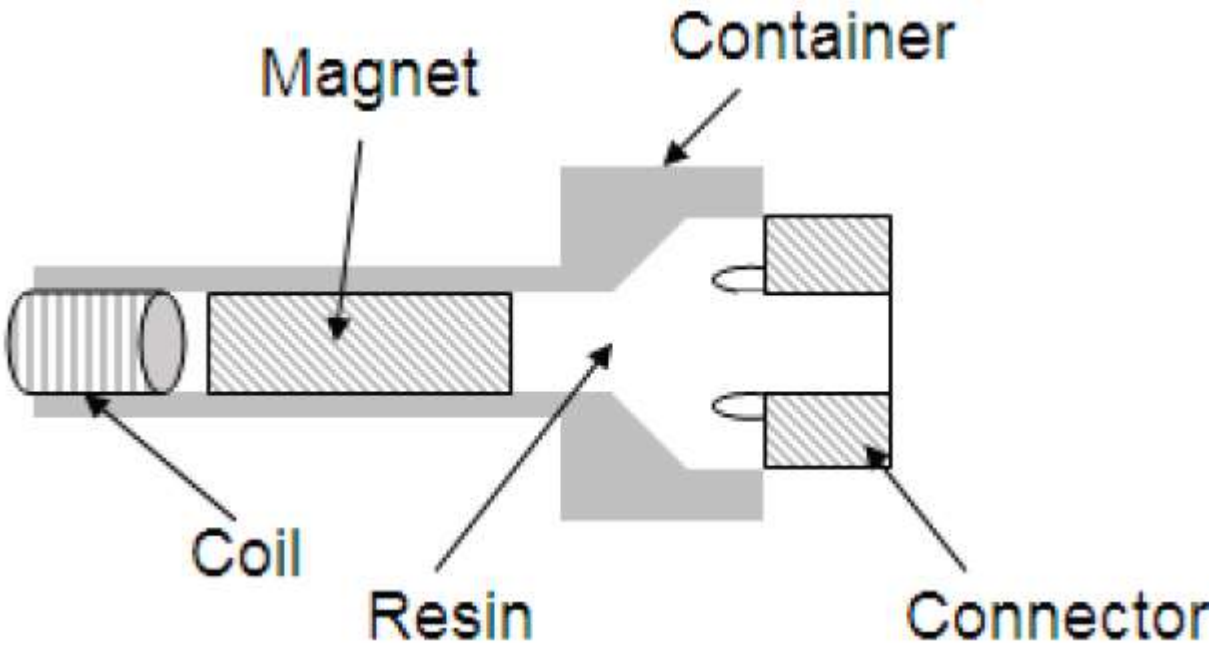
- object detection
- avoid collision
- object verification

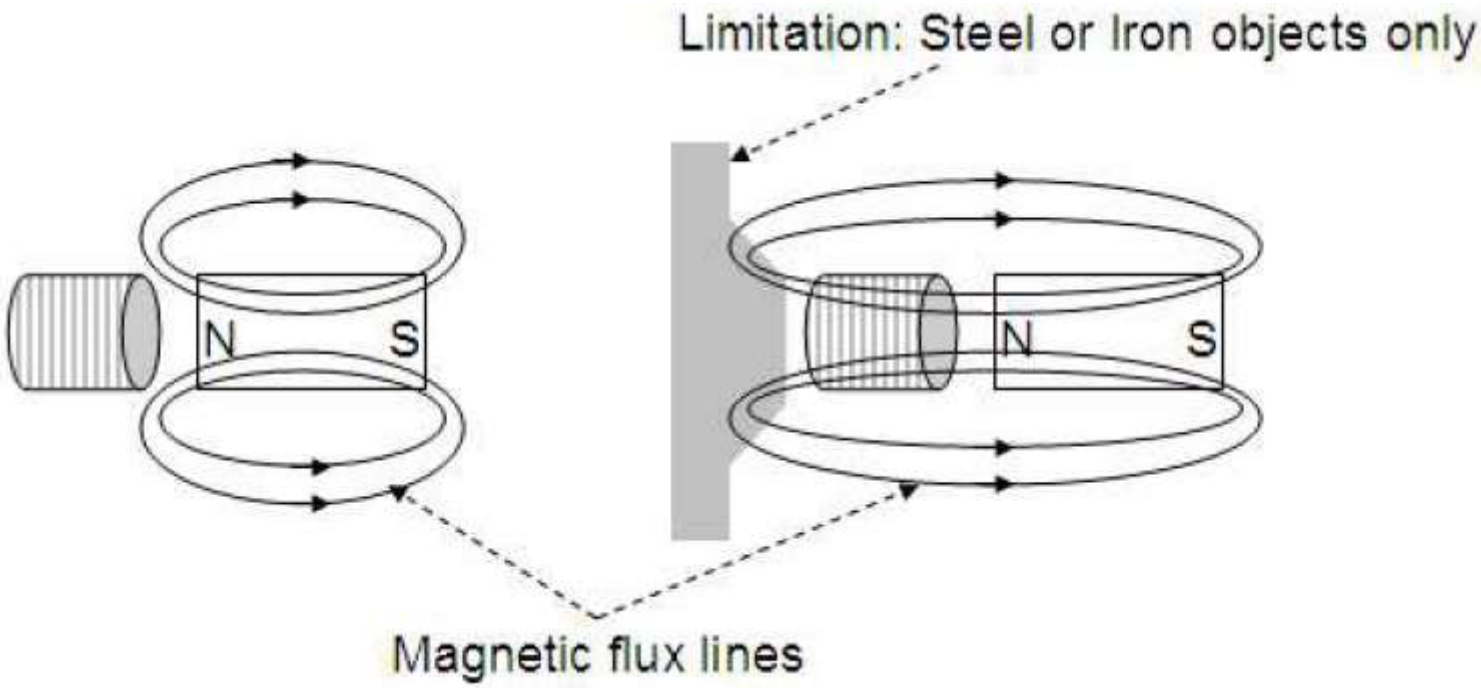
Some proximity sensor:

- Photoelectric/optical sensor
- Ultrasonic proximity sensor
- Inductive proximity sensor
- Hall-effect proximity sensor

INDUCTIVE PROXIMITY SENSOR

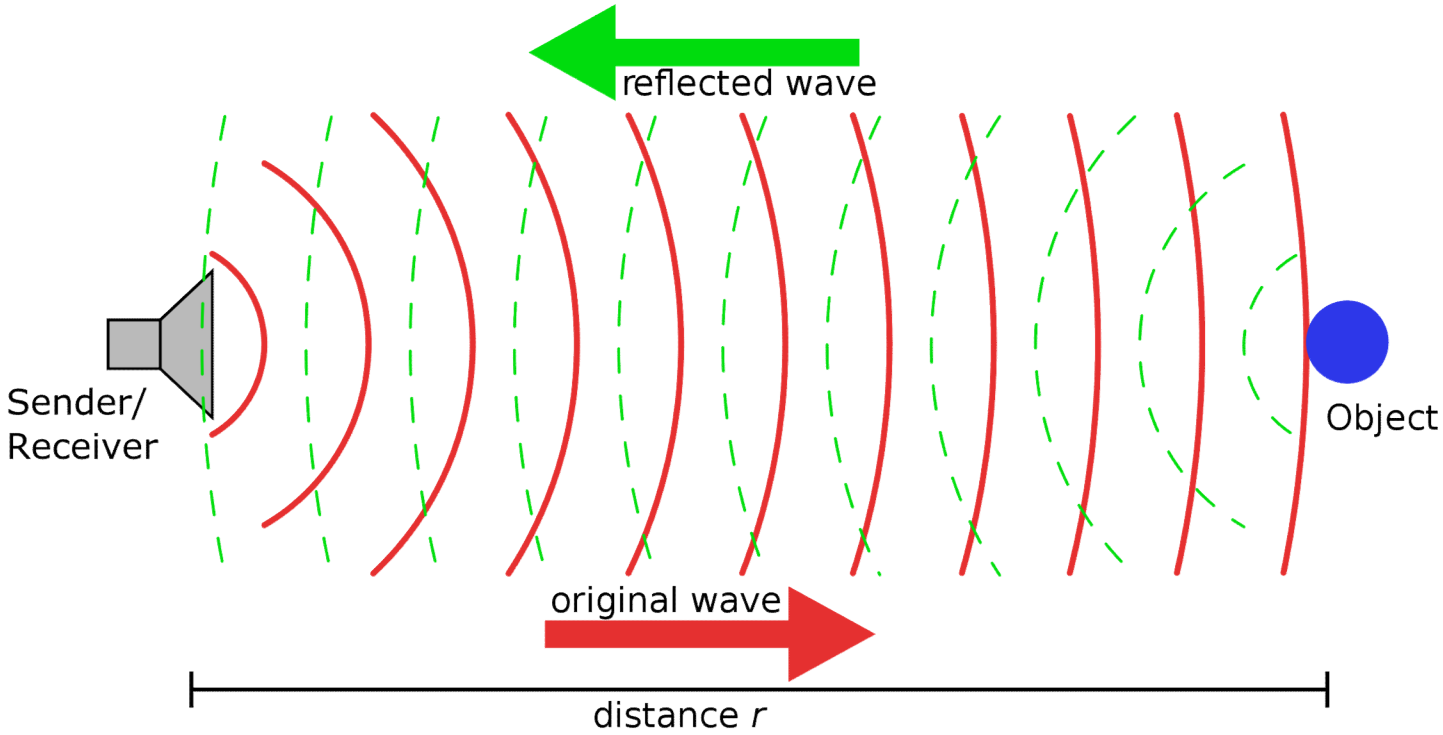
Inductive Proximity sensor



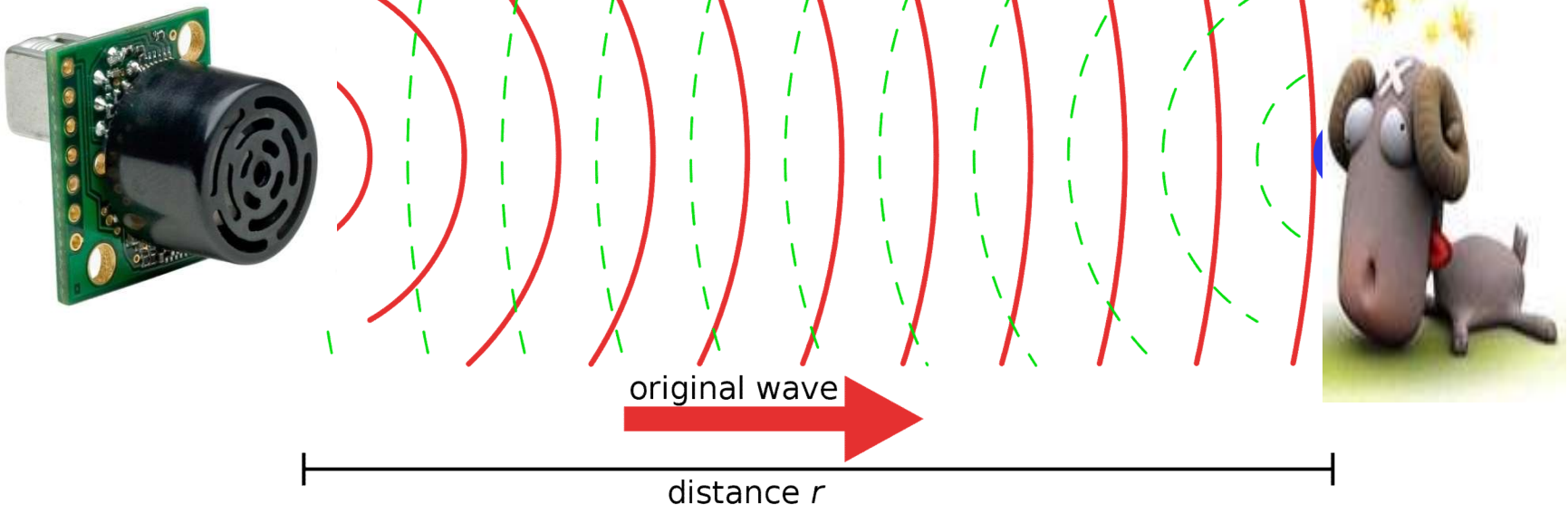

Limitation: Steel or Iron objects only
N
S
N
S
Magnetic flux lines

ULTRASONIC PROXIMITY SENSOR

Ultrasonic Proximity sensor

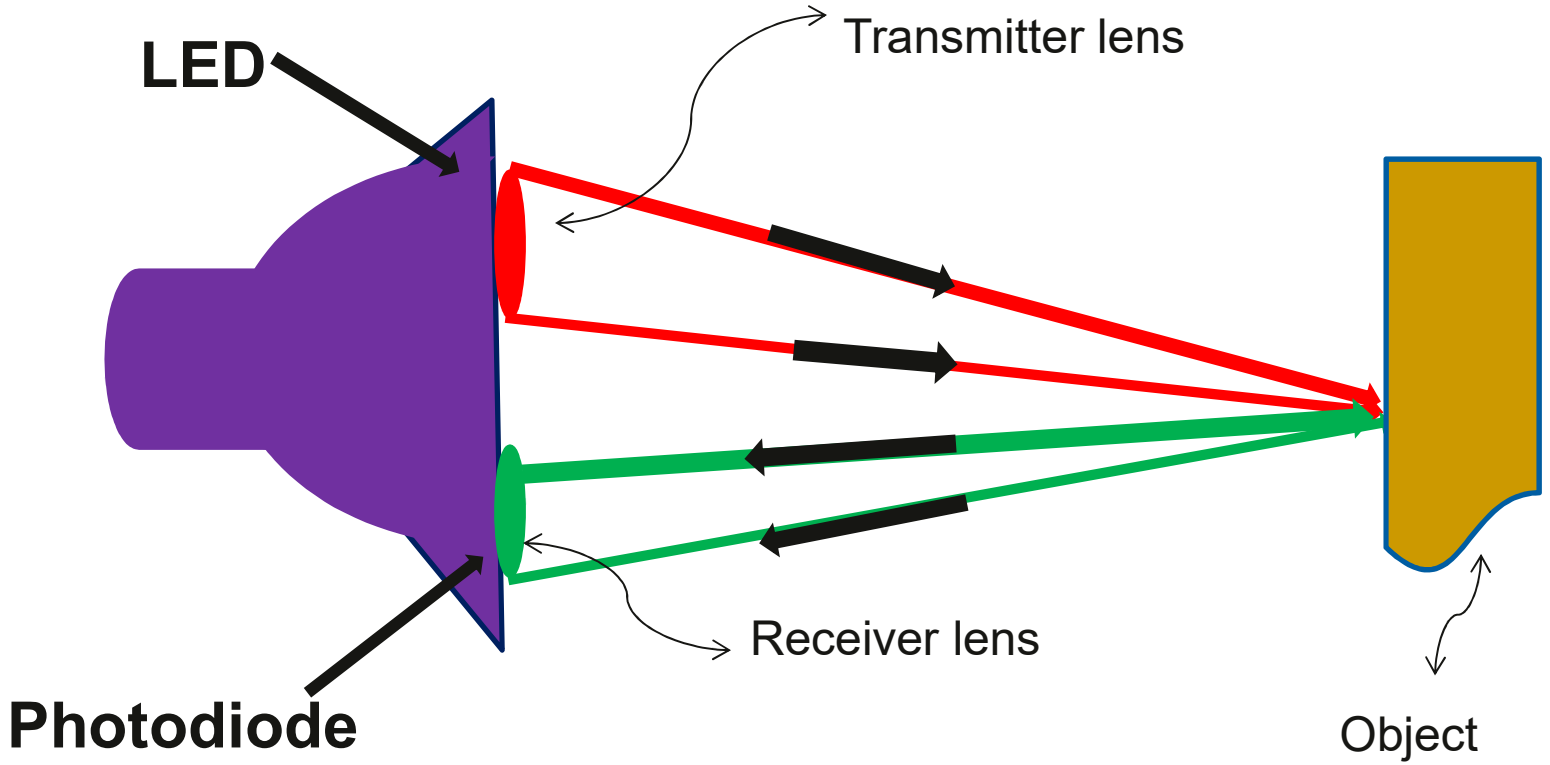


Ultrasonic Proximity sensor



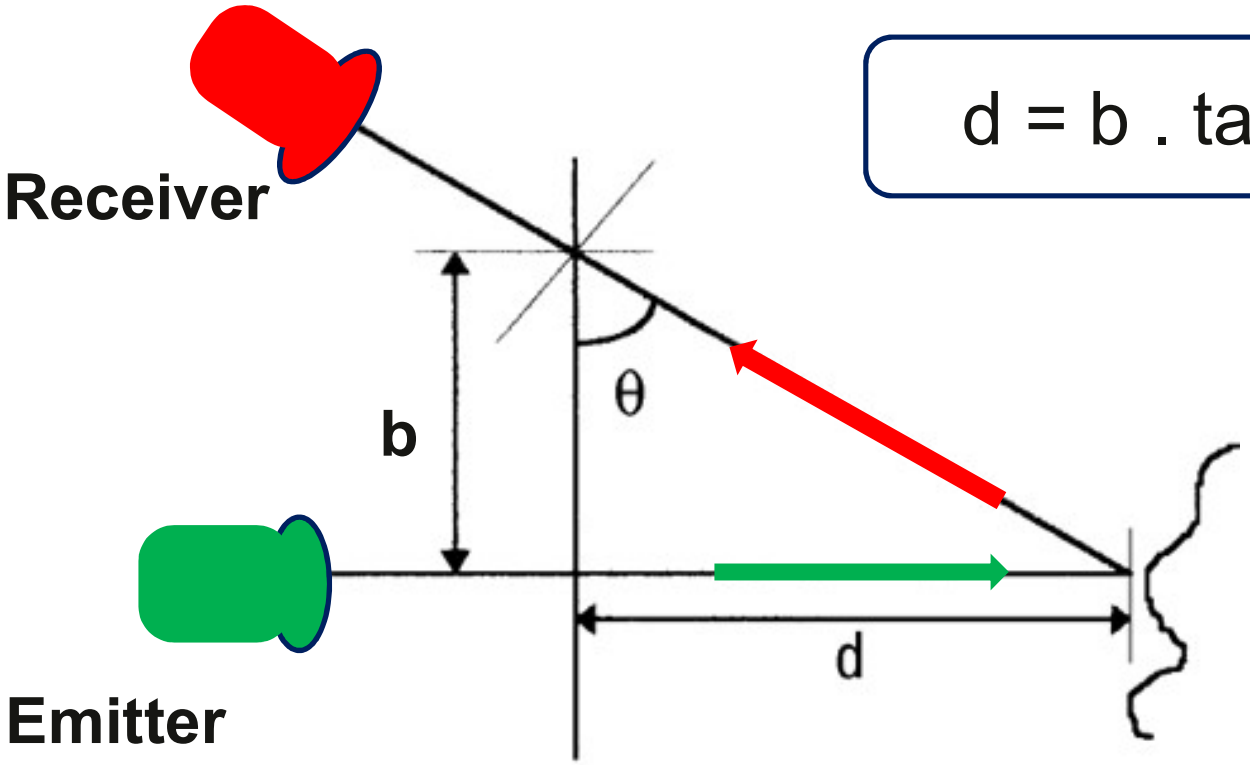
OPTICAL SENSOR

Optical sensor



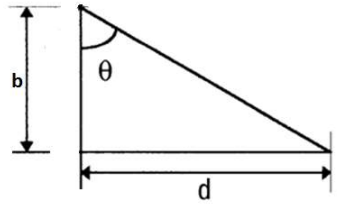
RANGE SENSOR

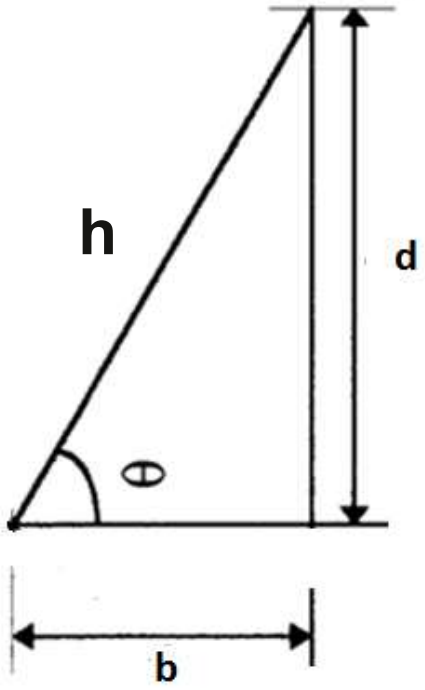
Range Sensor



$$d = b \cdot \tan \Theta$$

Range Sensor





$$b = h \cos\theta$$

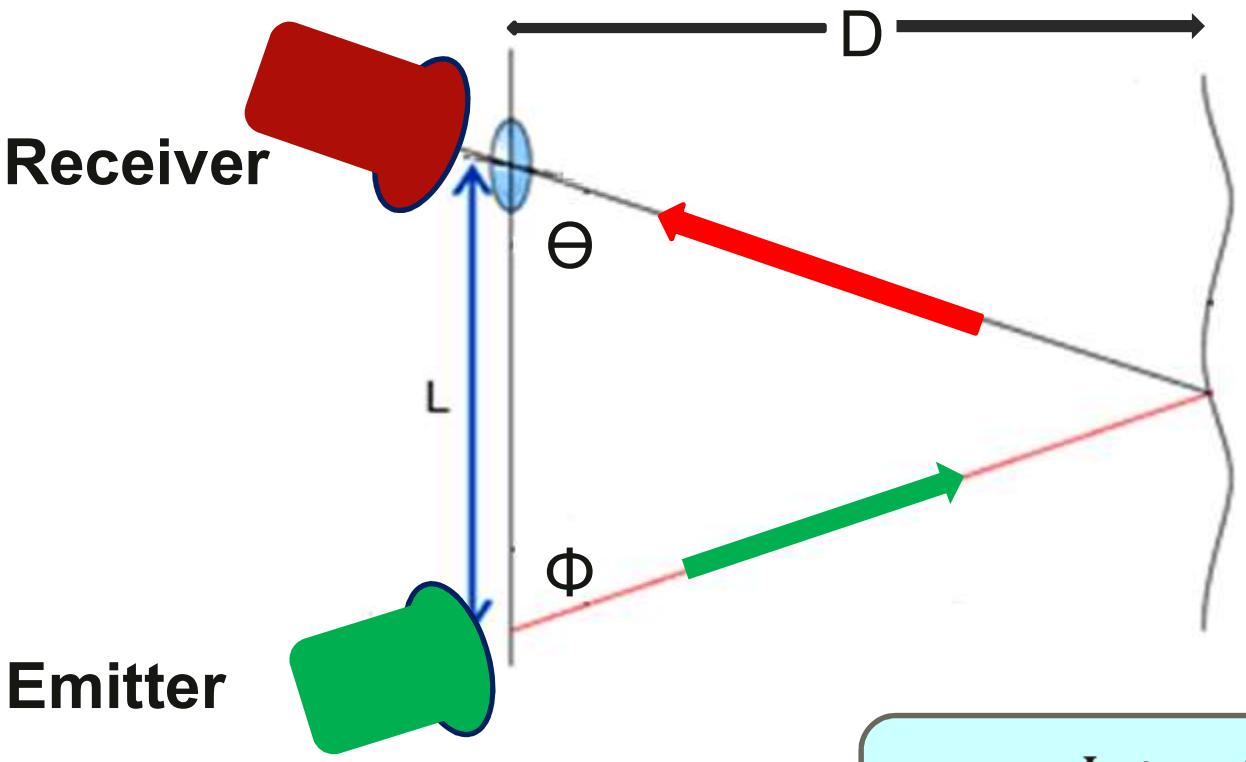
$$d = h \sin\theta$$

$$h = \frac{b}{\cos\theta}$$

$$d = \frac{b}{\cos\Theta} \sin\Theta$$

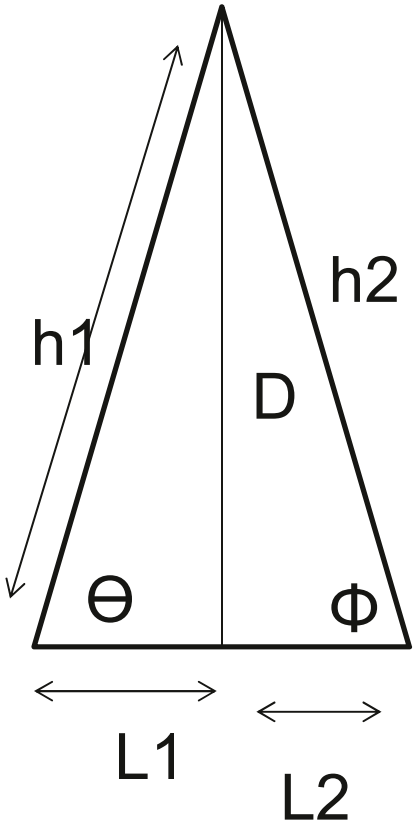
$$d = b \cdot \tan\theta$$

Range Sensor



$$D = \frac{\mathrm{L}.\tan\Theta.\tan\Phi}{tan\Theta + \tan\Phi}$$

Range Sensor



$L1 = h1 \cos\Theta$

$D = h1 \sin\Theta$

$h1 = \frac{L1}{\cos\theta}$

$L2 = h2 \cos\Phi$

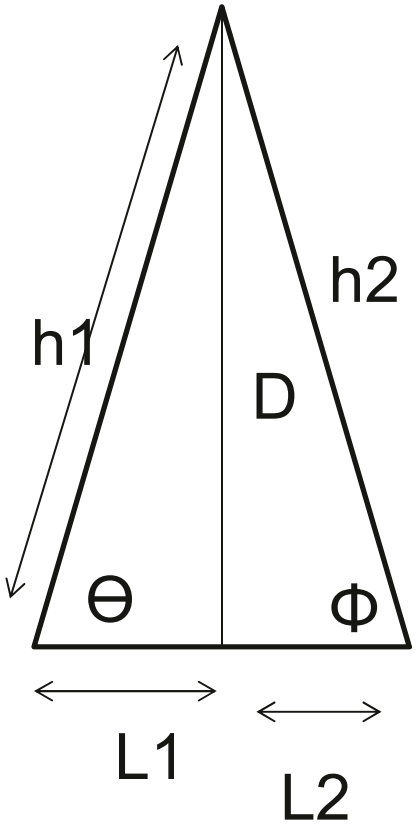
$D = h2 \sin\Phi$

$h2 = \frac{L2}{\cos\Phi}$

$D = L1.\frac{\sin\theta}{\cos\theta} = L1 \tan\Theta$

$D = L2.\frac{\sin\Phi}{\cos\Phi} = L2 \tan\Phi$

Range Sensor



$$L = L1 + L2 = \frac{D}{tan\theta} + \frac{D}{tan\Phi}$$

$$L = D\left(\frac{1}{tan\theta} + \frac{1}{tan\Phi}\right)$$

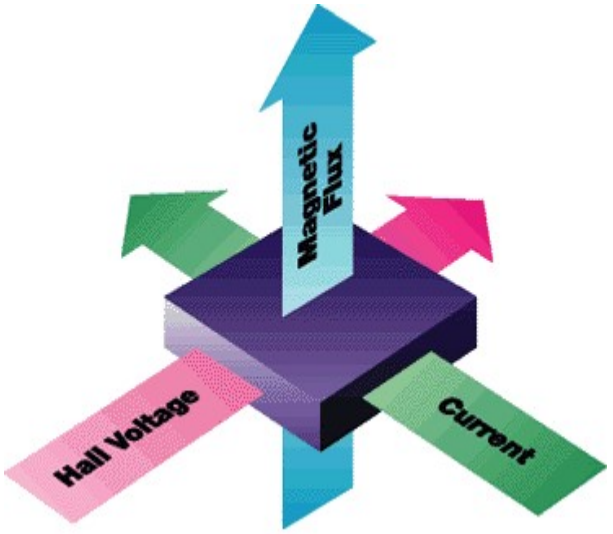
$$L = D.\frac{(tan\theta + tan\Phi)}{tan\theta.tan\Phi}$$

$$D = L.\frac{tan\theta.tan\Phi}{(tan\theta + tan\Phi)}$$

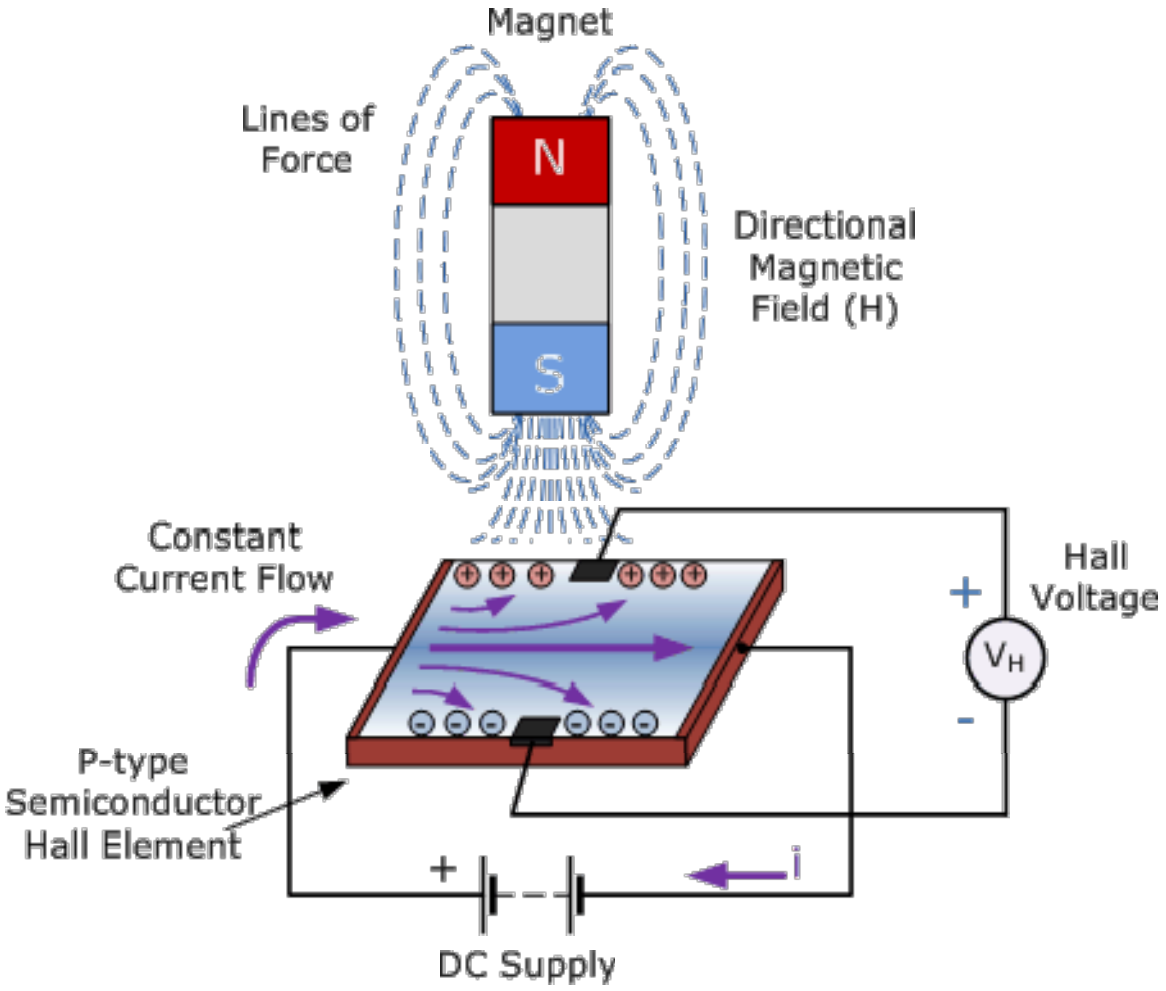
HALL EFFECT SENSOR

Hall effect Sensor

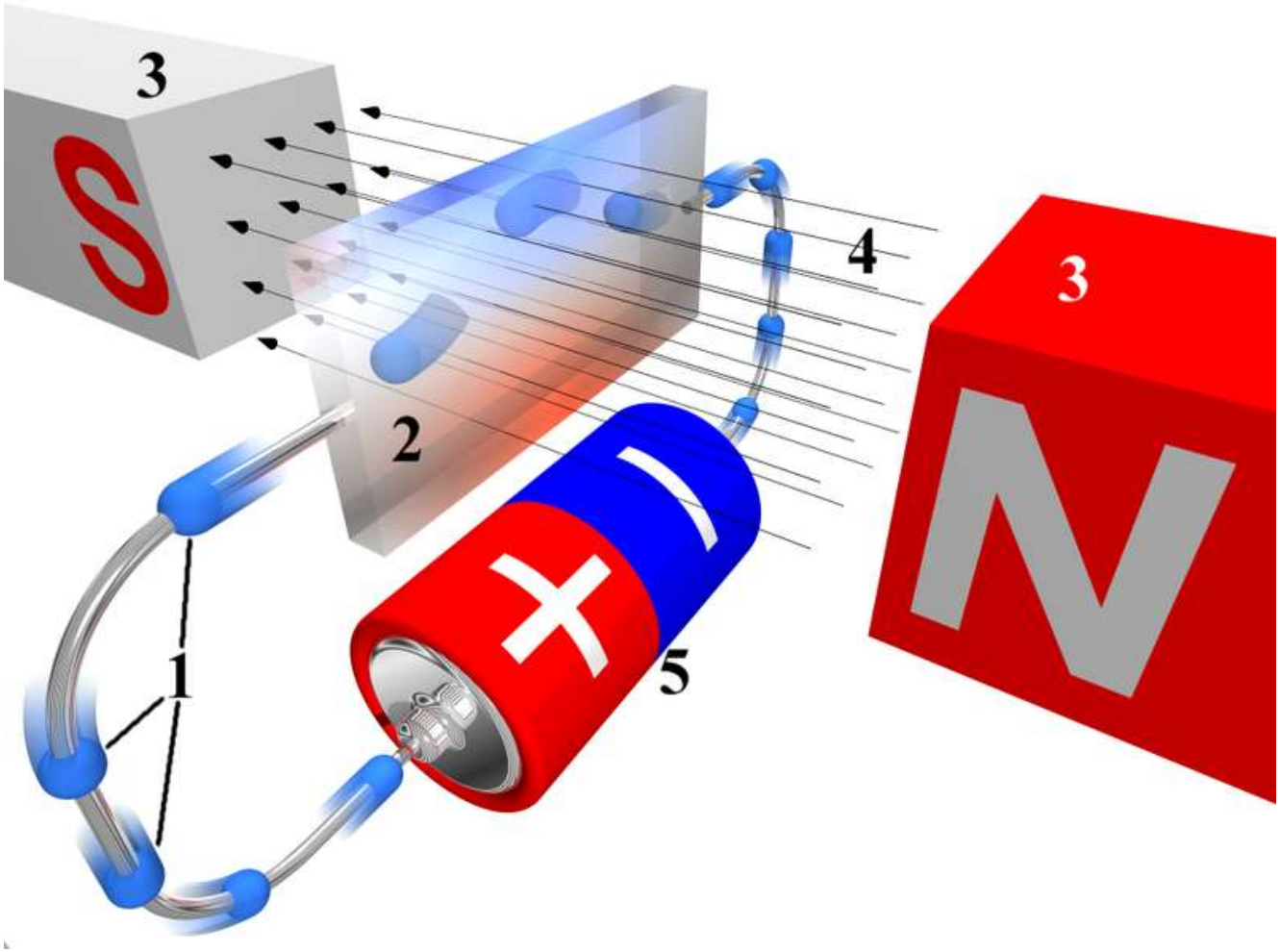
The Hall effect is the production of a voltage difference (the Hall voltage) across a current carrying conductor (in presence of magnetic field), perpendicular to both current and the magnetic field.



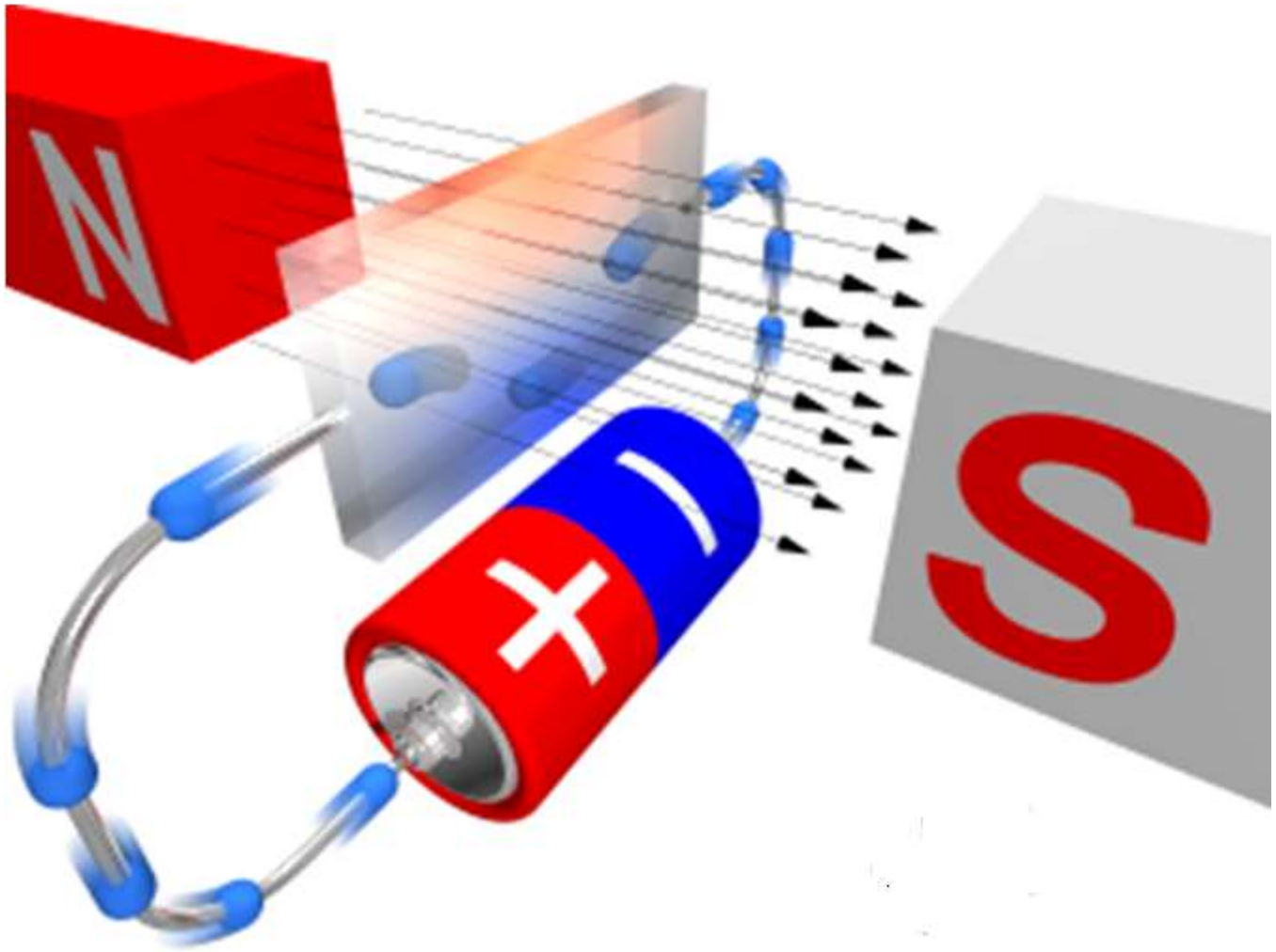
Hall effect Sensor



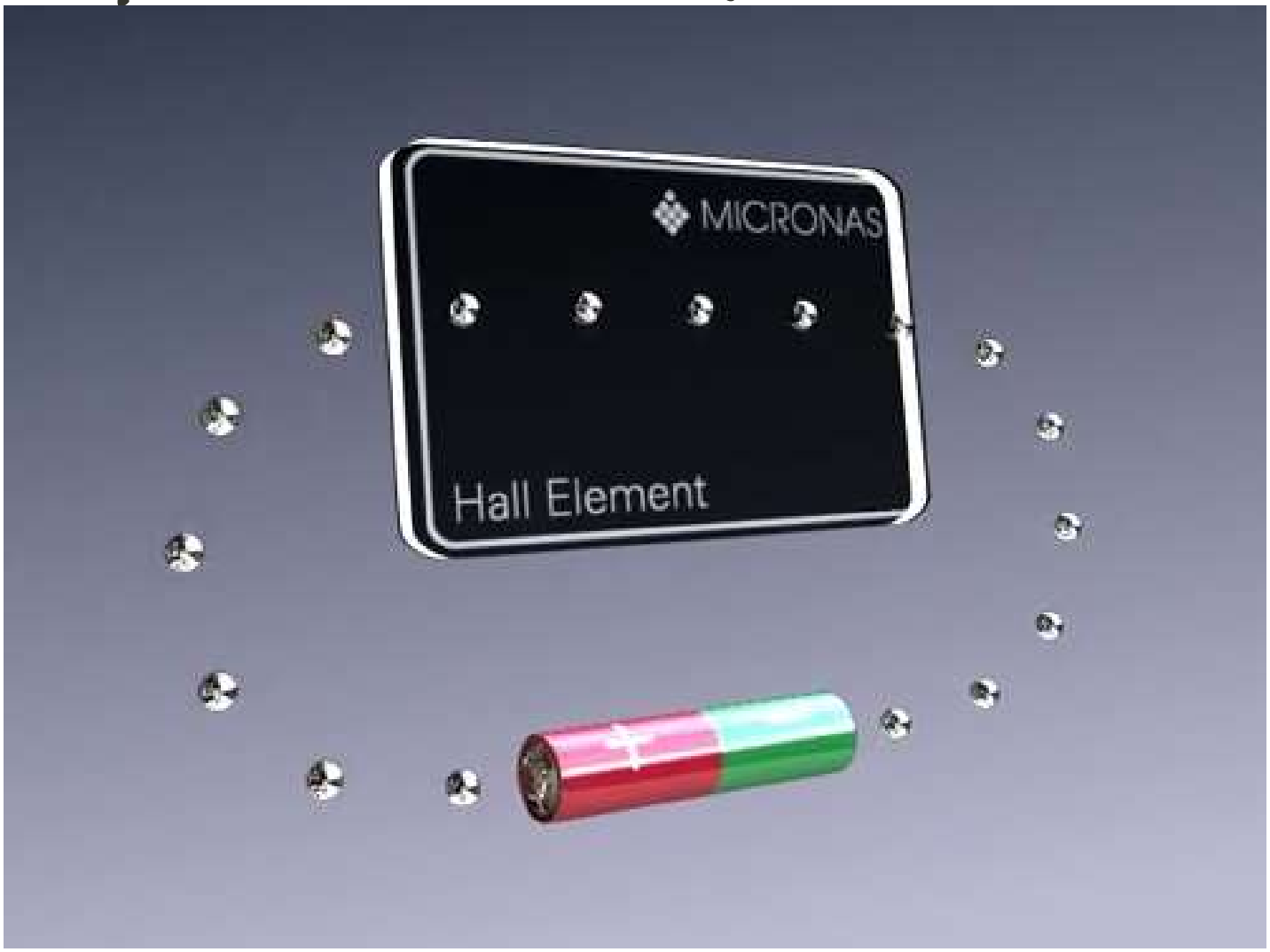
Hall effect Sensor



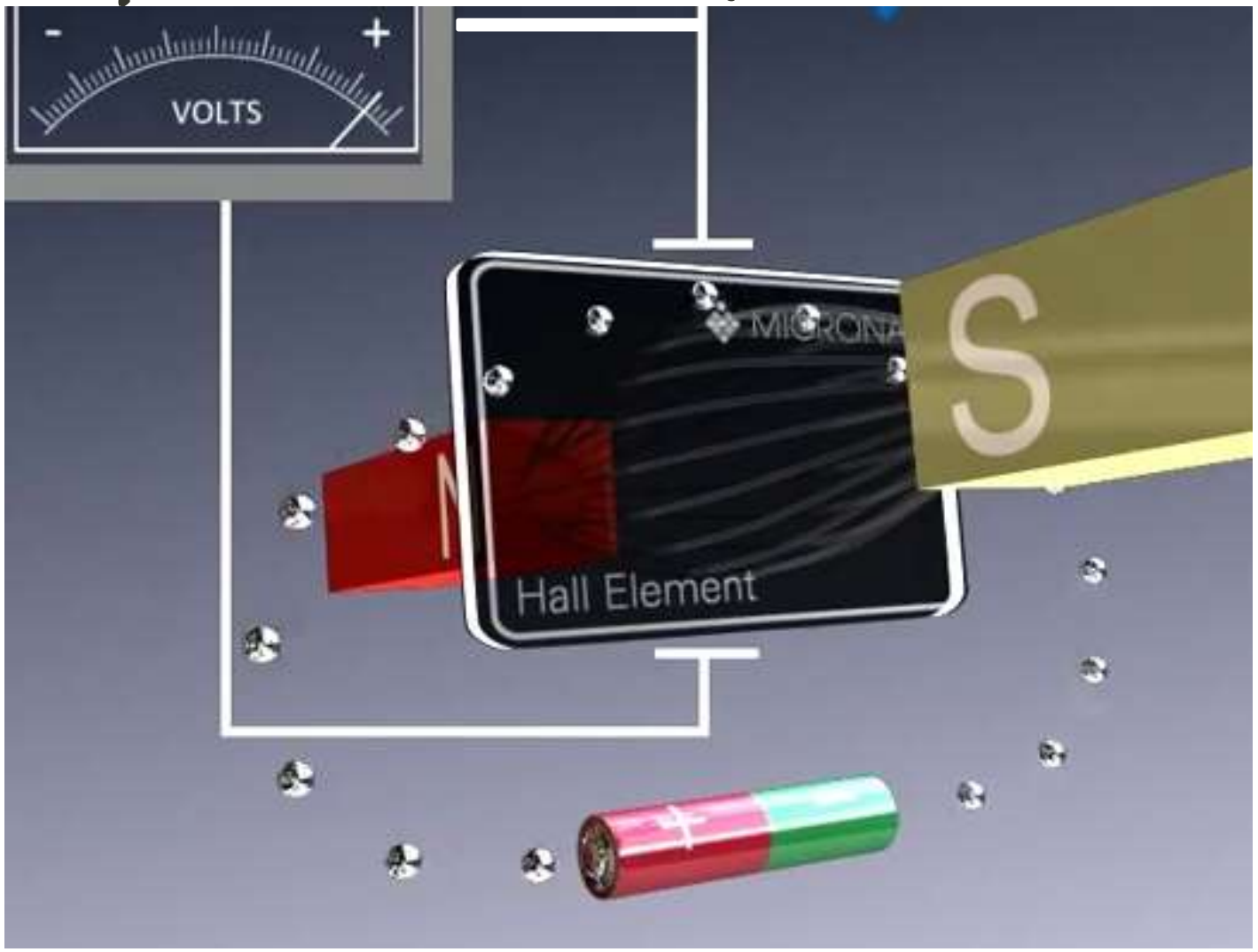
Hall effect Sensor



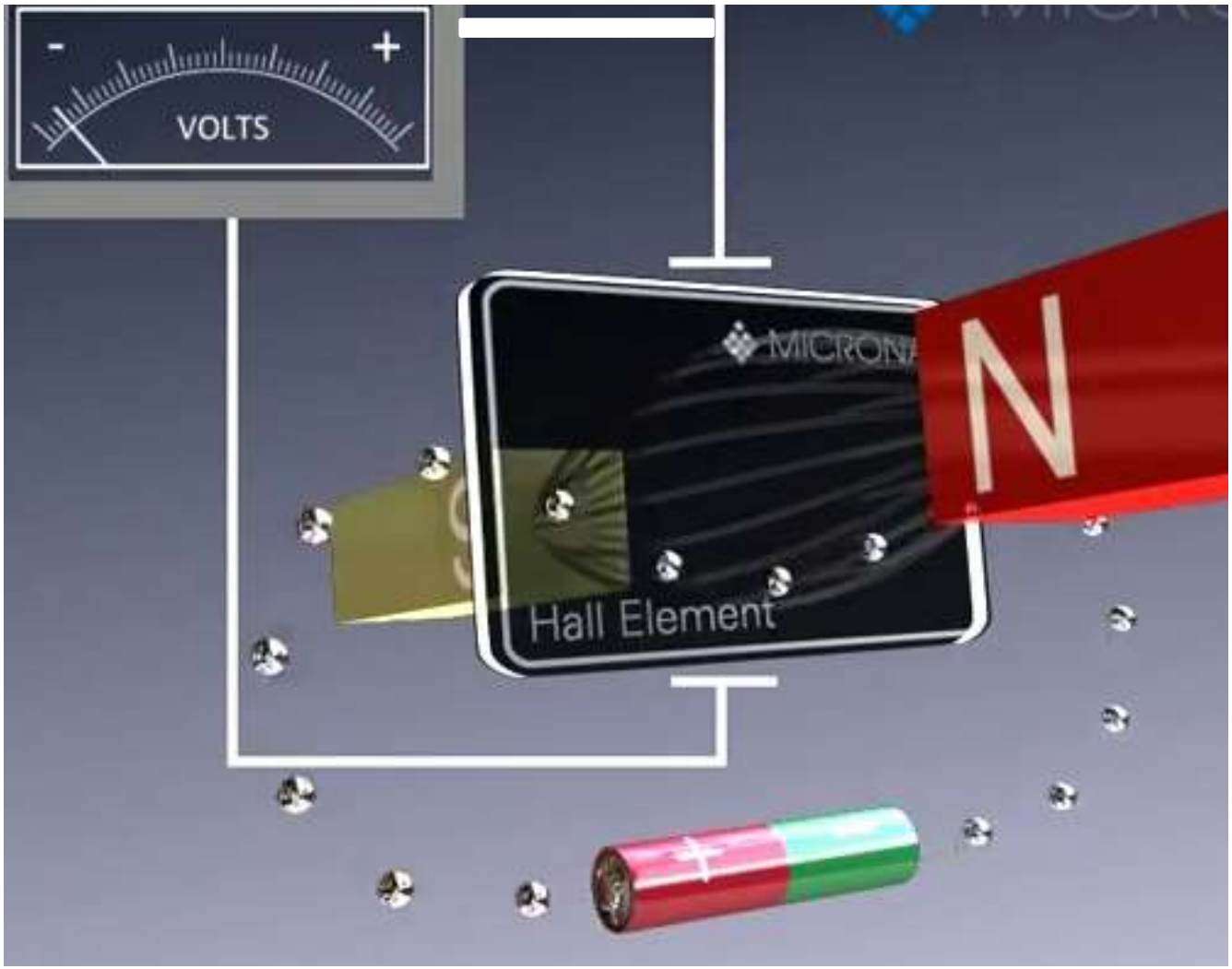
Hall effect Sensor



Hall effect Sensor



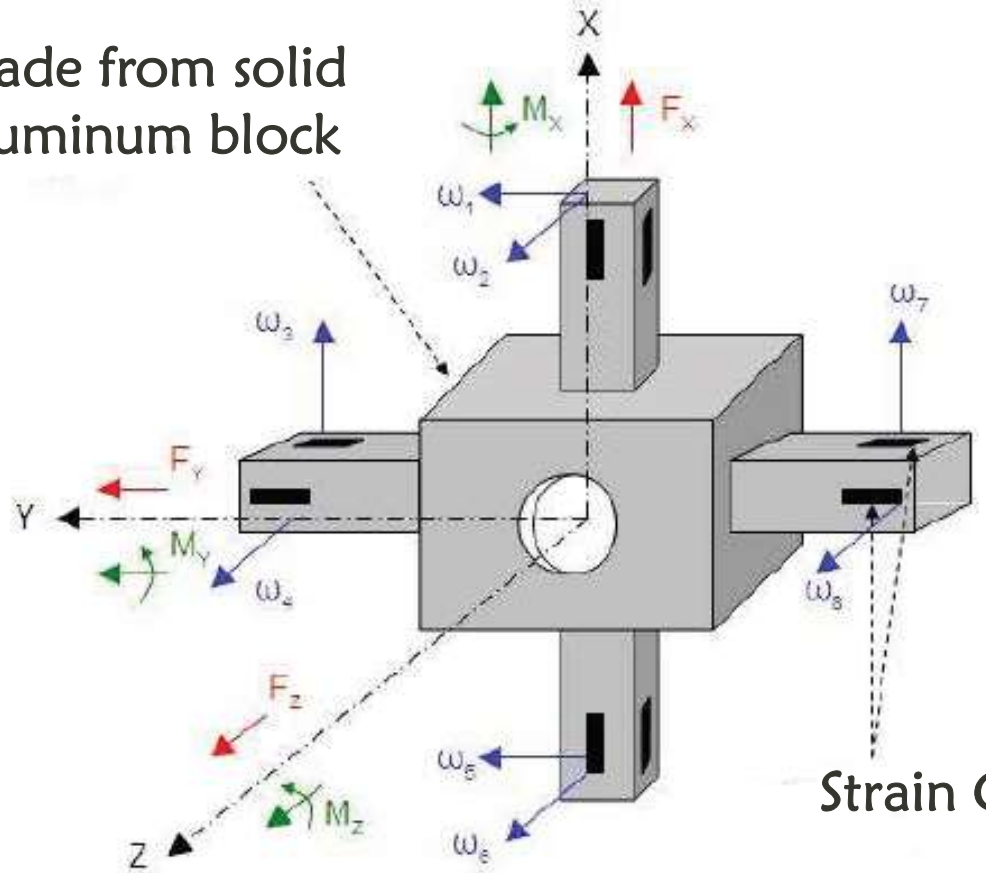
Hall effect Sensor



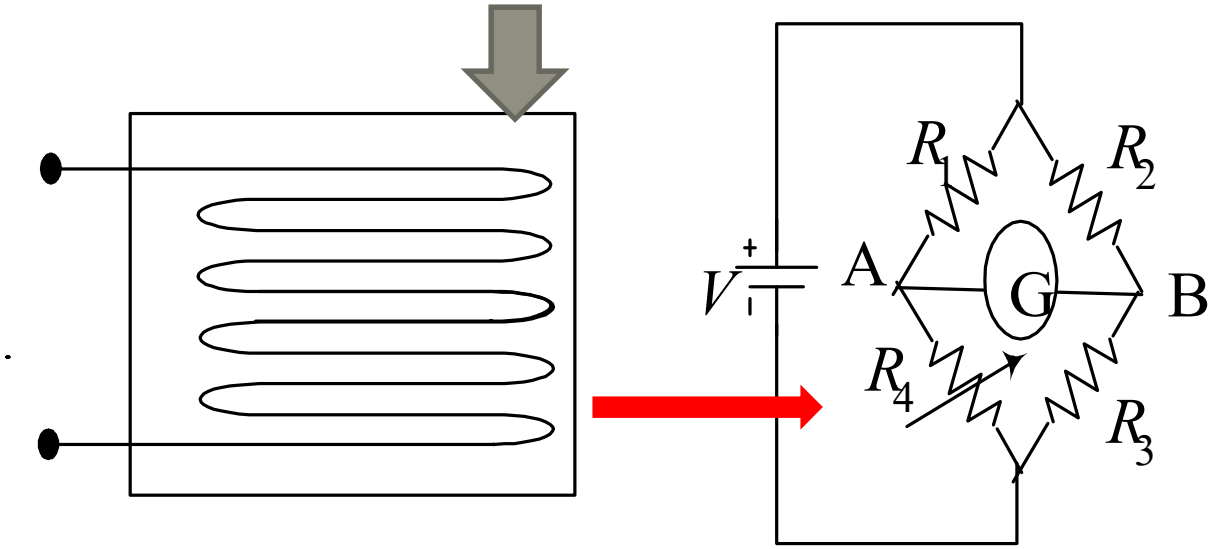
FORCE &TORQUE SENSOR

Six axis Force /Torque Sensors at wrist

Made from solid aluminum block

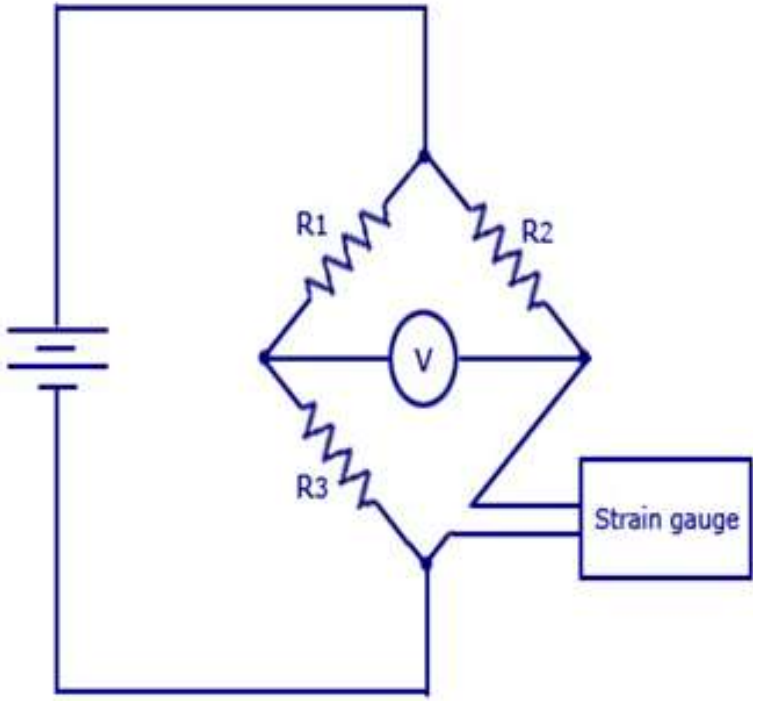


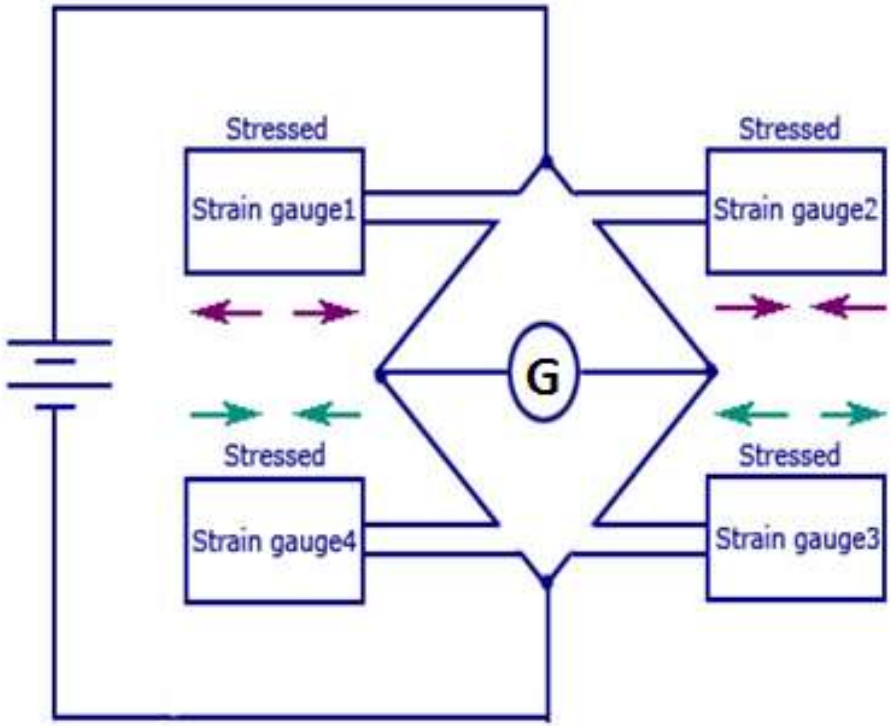
Wheatstone Bridge



R1. R3 = R2. R4 ⇒ $\frac{R_1}{R_4} = \frac{R_2}{R_3}$

Wheatstone Bridge






NEC

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