

Sensors

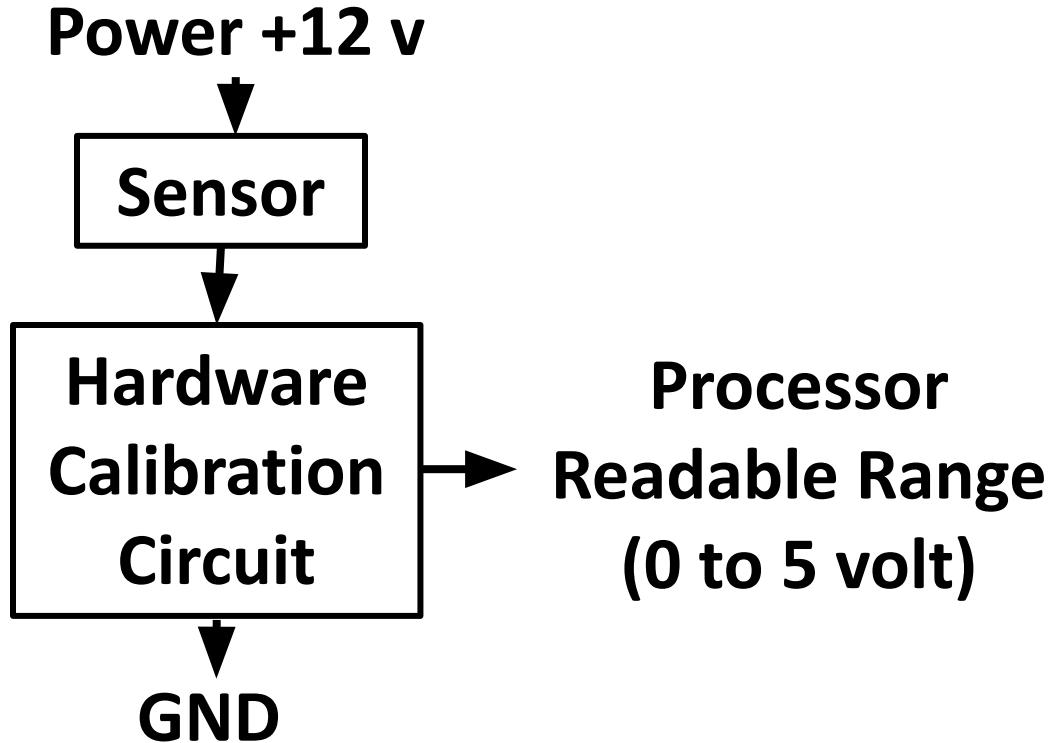
to perceive the environment

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CSE Department
BRAC University

Hardware Calibration

- Processor can read either digital or Analog value
 - Digital should be “0” (Gnd) or “1” (>3.5 Volt)
 - Analog should be in a range according to the analog reference voltage (Usually 0 volt to 5 volt).
 - Analog Voltage ADC Numerical Value (Usually 0 to 255 (8 bit Binary Number))
- **So, a sensor input must be calibrated into a readable range of Processor with a circuit.**

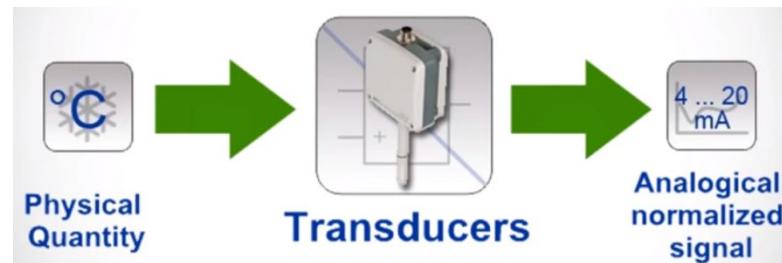
Hardware Calibration Block Diagram



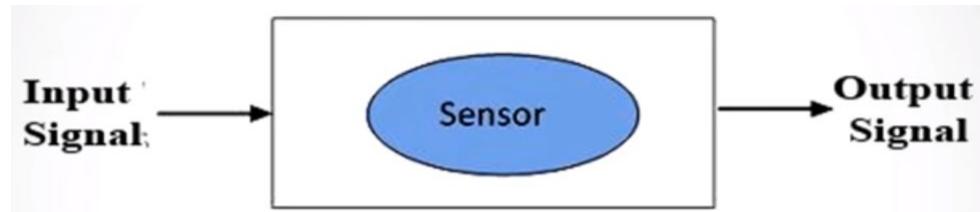
To get efficient result, hardware Calibration should be in the way so that the lower value goes to lower range and upper value goes to upper range.

Transducer & Sensor

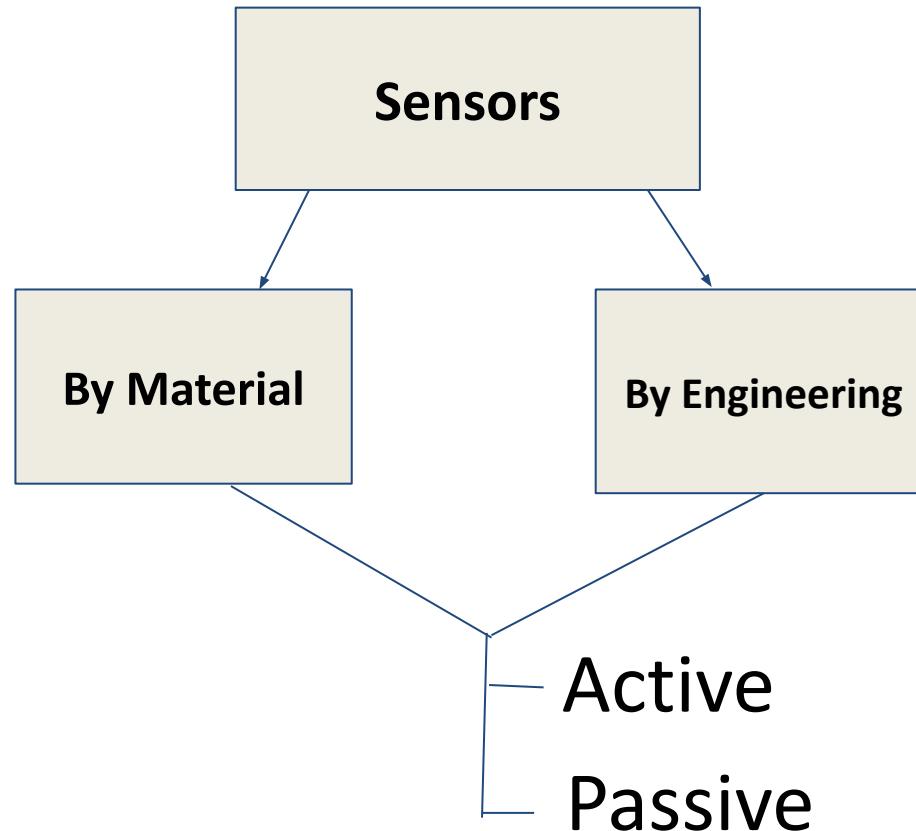
- Transducer: Convert energy from one form to another
 - Pressure, Piezoelectric, Ultra-sound, Temperature



- Sensor: Detect physical quantity and convert into electrical Signal



Types



Sensors

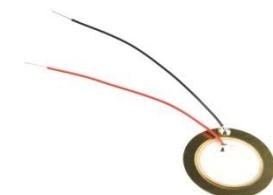
- By Material
 - Thermistor
 - Piezoelectric
 - Pyro electric material (IR)
 - Electromagnetic
 - Semiconductor
 - Radio active material
 - Capacitive
 - Resistive
 - Conductive
- By Engineering
 - Gyroscope
 - Microphone
 - Camera
 - LiDAR
 - Pulse Oximeter
 - Level Sensor
 - Hall-effect
 - Break-Beam
 - Vibrator
 - Accelarometer

Sensors

- Active Sensor:
 - Requires emitter
- Passive Sensor:
 - Sense environment directly. No need to emit any signal.

Transducer

- Pressure (Refrigerator and AC)
- Piezoelectric (Buzzer or lighter)
- Ultra-sound (Ultrasonography, Sonar)
- Temperature (Engines and boilers)



Sensors

- Light based Sensors
- Magnetic & Electro-Magnetic sensor
- Sound based Sensors
- Some Modern Sensors
- Water conductivity based sensors
- Underwater Sensors

Sensors

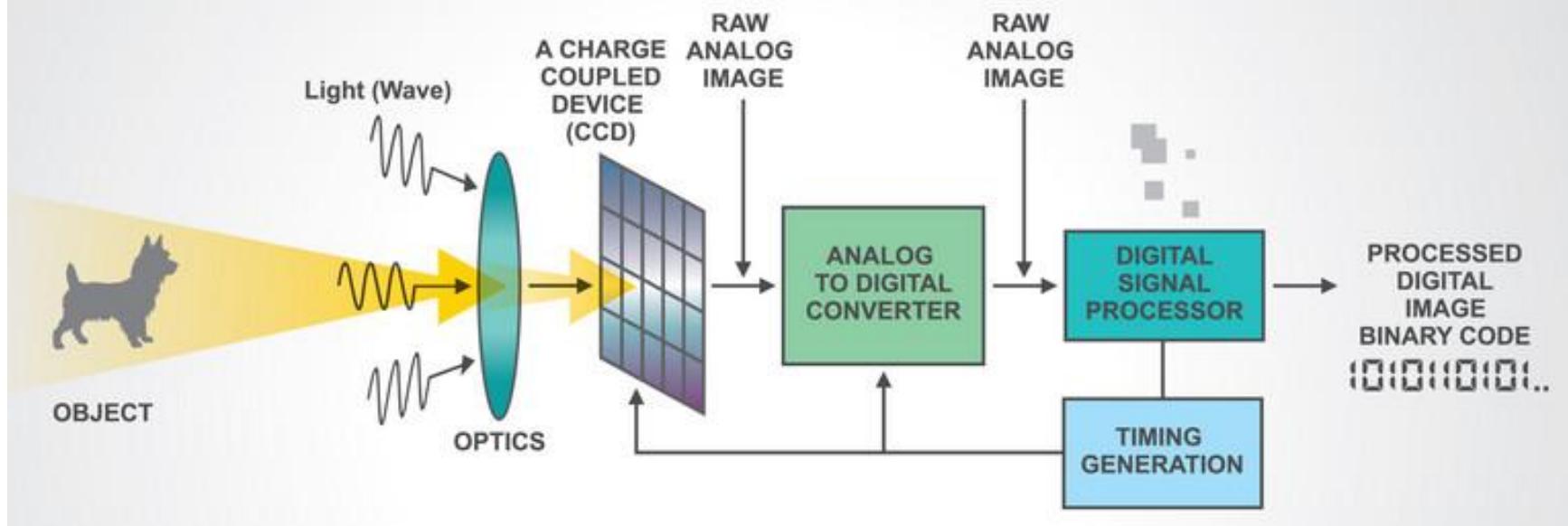
- Light based Sensors
 - Camera
 - Infrared
 - LDR
 - X-Ray
 - UV Ray
 - Heartbeat Sensor
 - Laser Sensor
- Sound based Sensors (using transducer or Piezoelectricity)
 - Microphone
 - Ultra-Sonic
 - Pressure
 - Vibration
- Magnetic & Electro-Magnetic sensor
 - Reed Switch
 - Hall-Effect based Sensors
 - Electromagnetic

Light based Sensors

- Camera
- Infrared
- LDR
- X-Ray
- UV Ray
- Heartbeat Sensor
- Laser Sensor

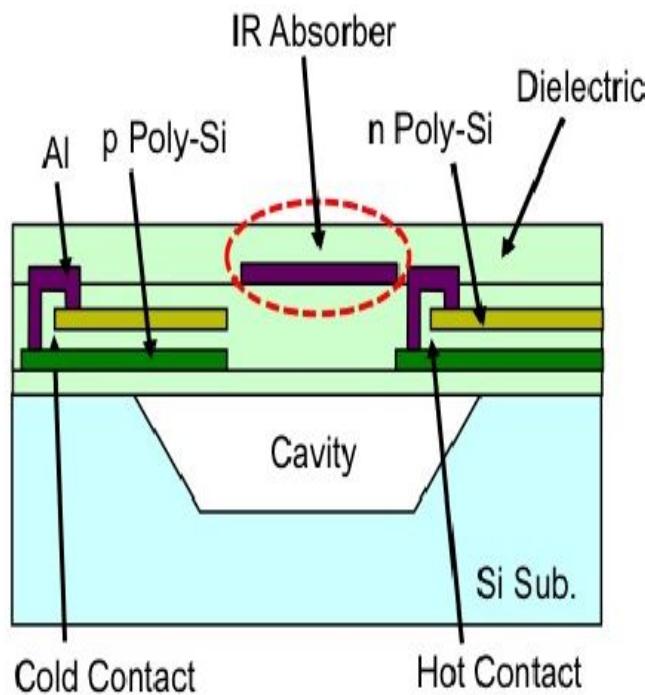
Camera

Working with Diagrams

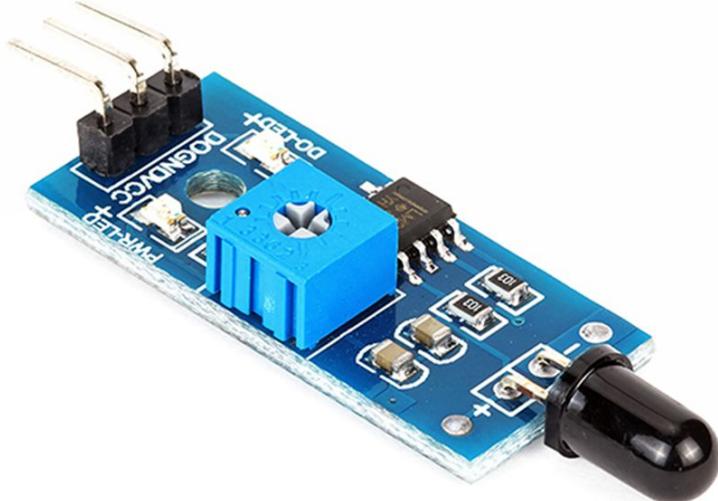


IR Sensor

Composed of Pyro electric material:
Pyro electricity can be described as
the ability of certain materials to
generate a temporary voltage when
they are heated or cooled.)



IR detector & Flame Sensor Module

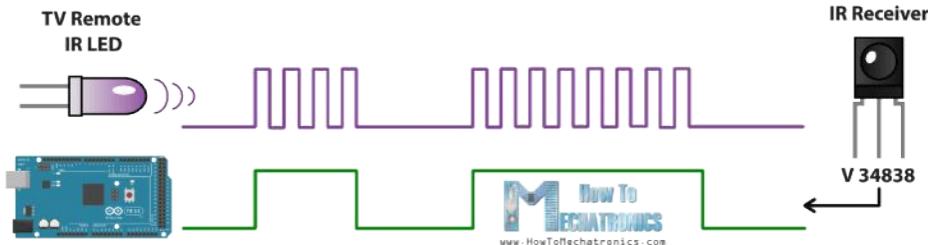


PIR

- Passive InfraRed sensor
 - Fresnel lenses used to focus the heat onto the material.
 - PIR need stabilizing period to adjust the room temperature
 - When human or animal passes heat increased and stabilized again.

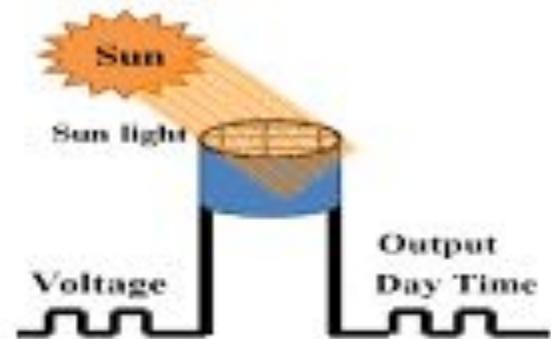
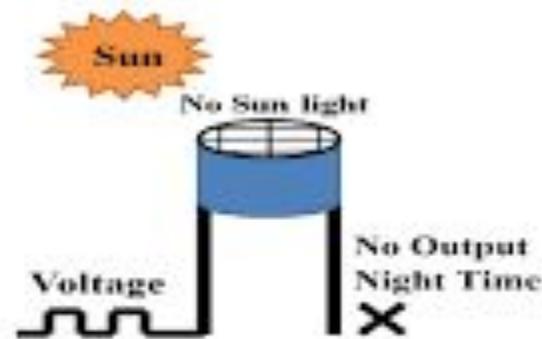
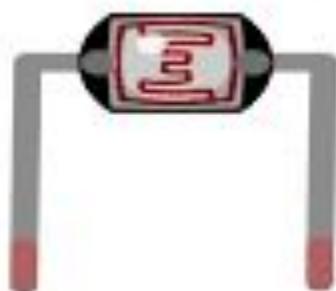


Infrared in Temperature Sensor and TV Remote

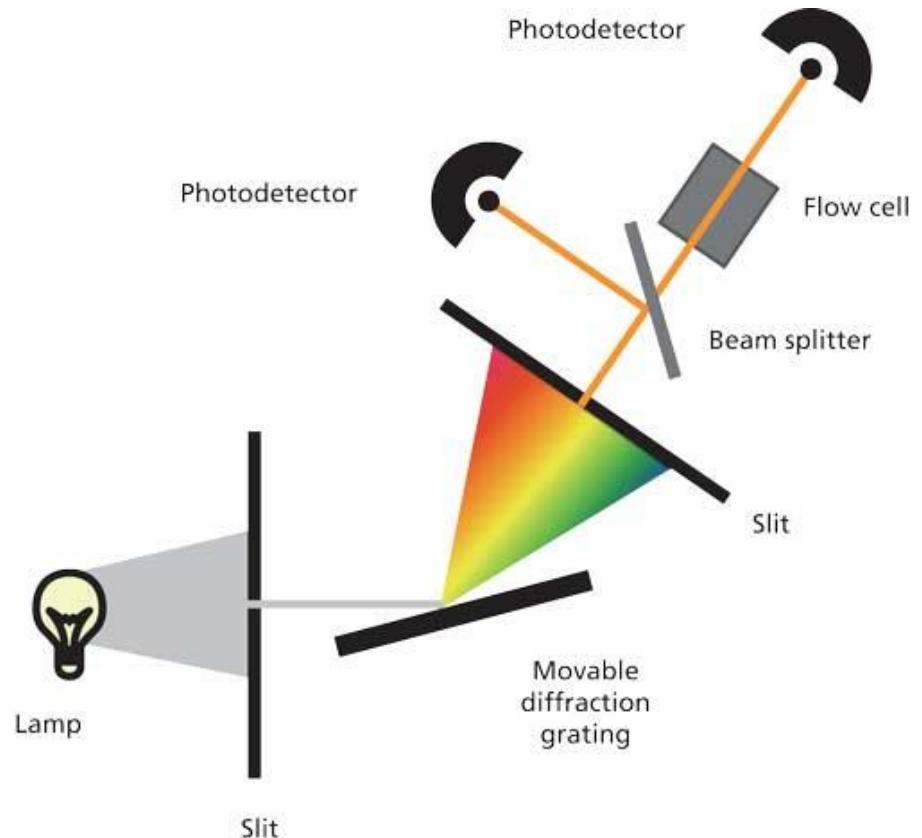


LDR

- Use Photo Sensitive Semi-conductor material



UV Sensor Module

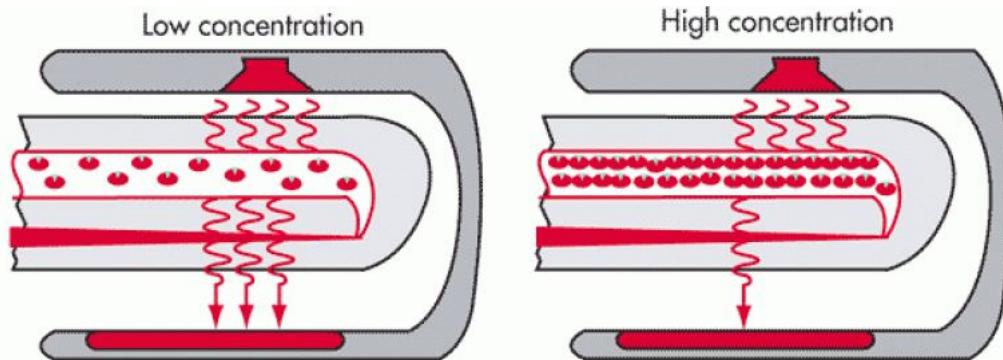


Response wavelength: 200~370nm

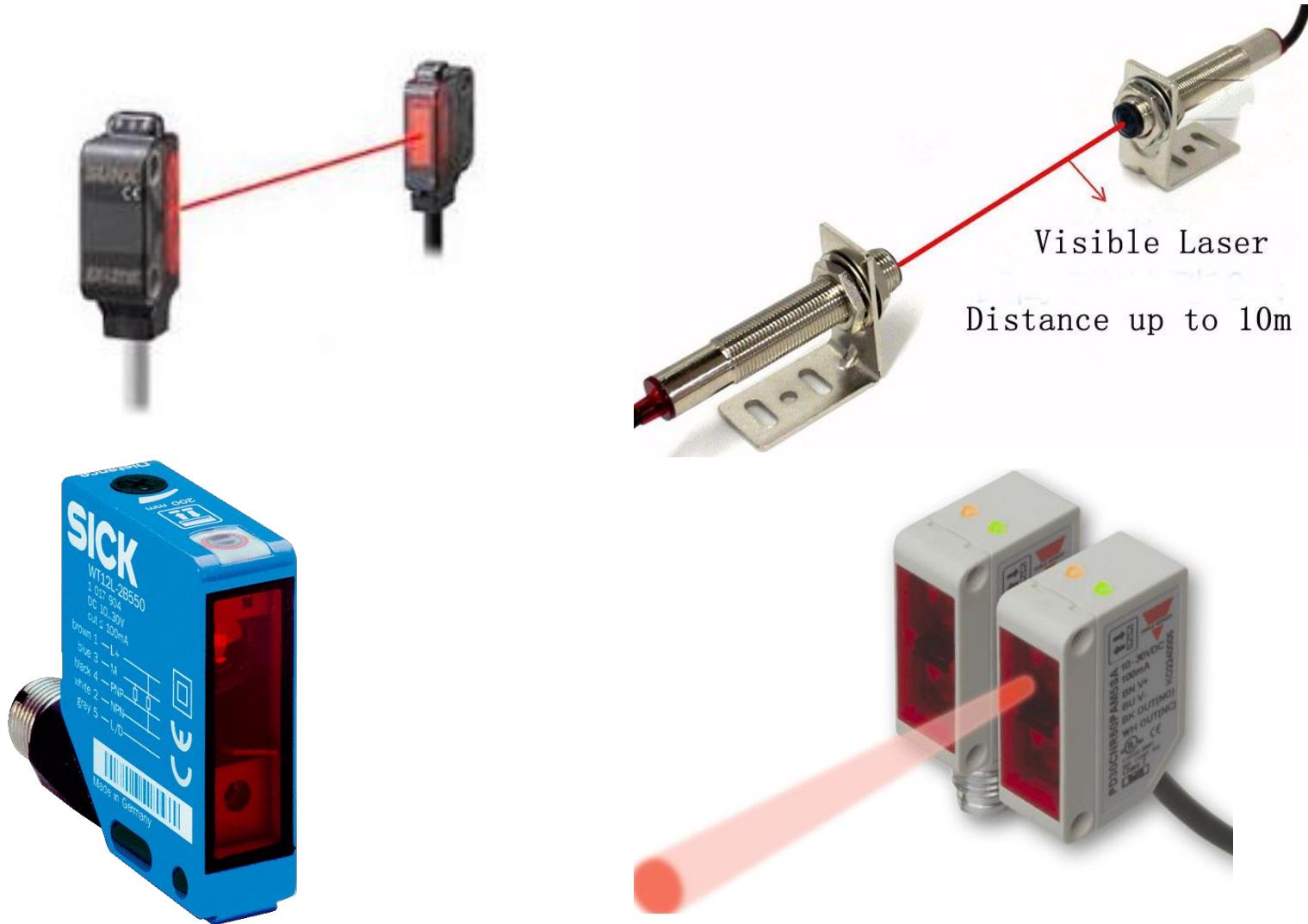
X-Ray Sensor



Pulse Oximeter using light and IR



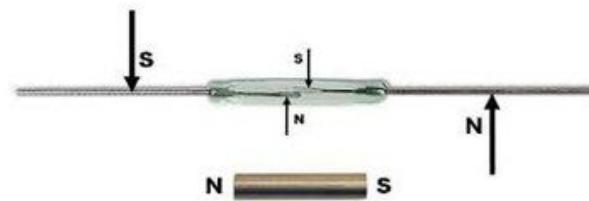
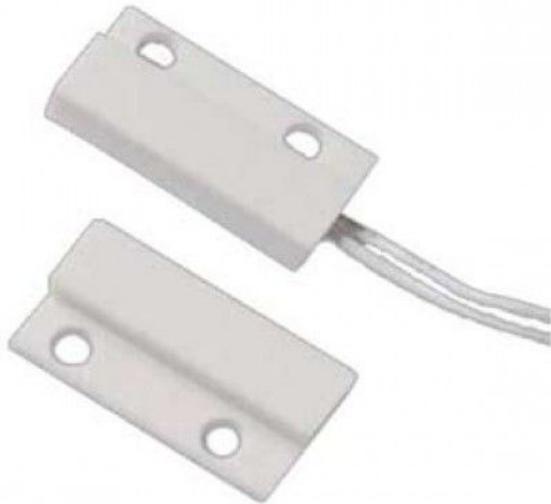
Laser Sensor



Magnetic & Electro-Magnetic sensor

- Reed Switch
- Hall-Effect based Sensors
- Electro-Magnetic Sensor

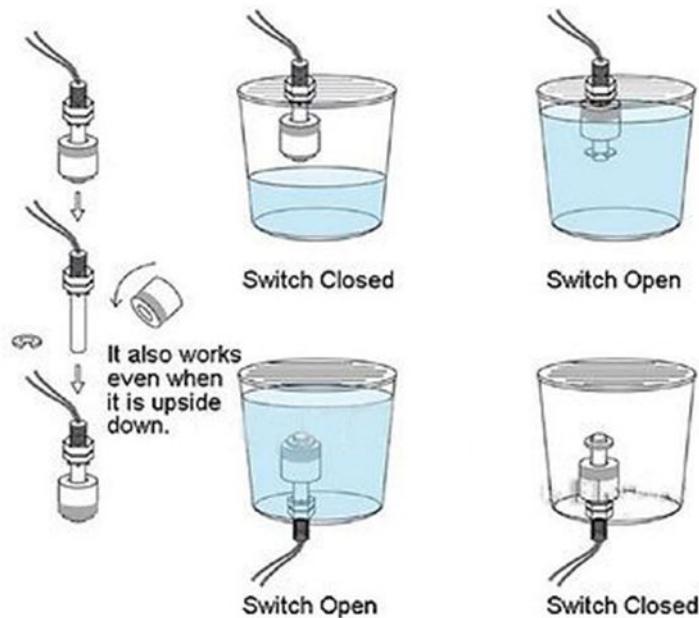
Magnetic Type Sensor (Mini Magnetic or Reed Switch)



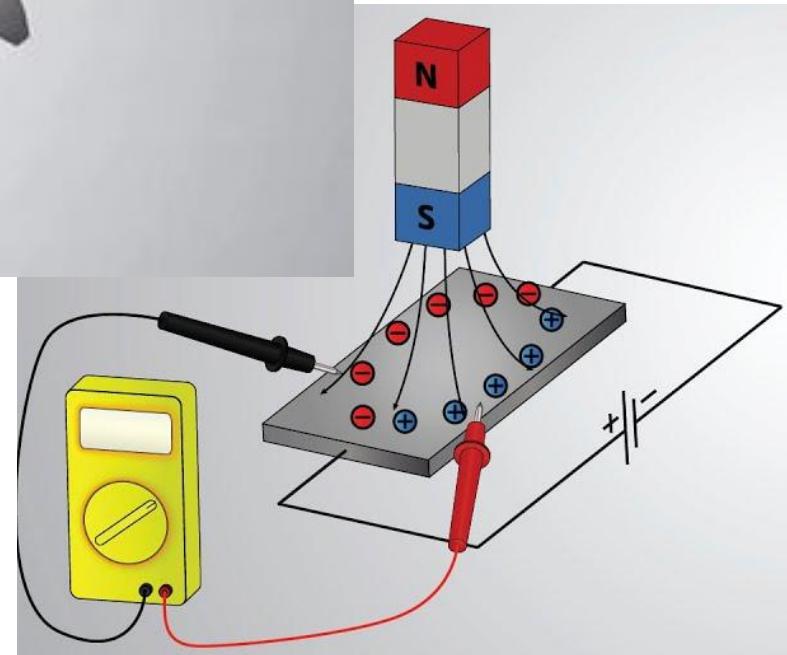
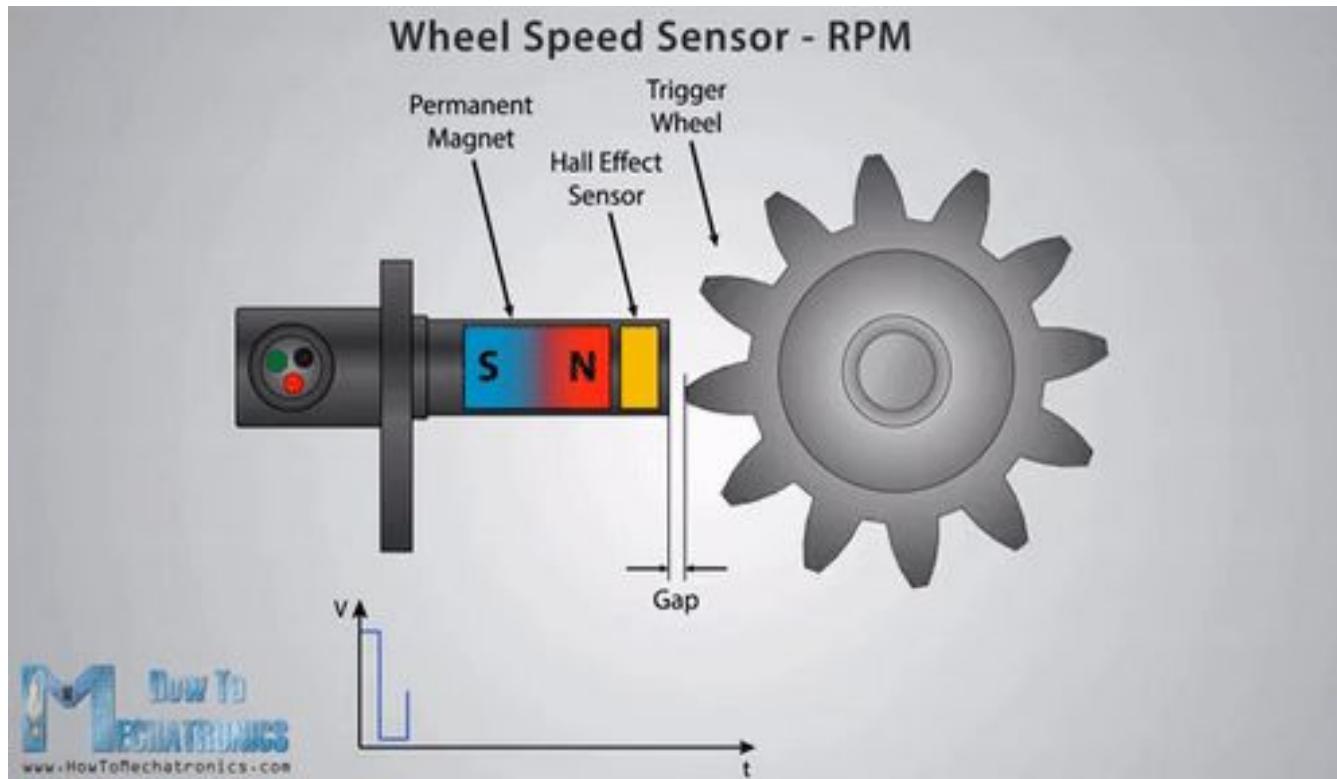
Liquid Level Sensor using reed switch



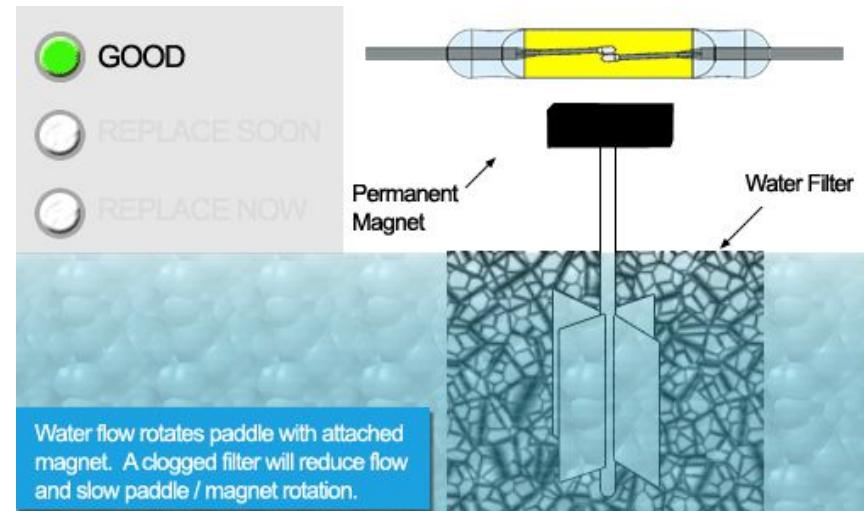
Water Level Sensor Horizontal Float Switch



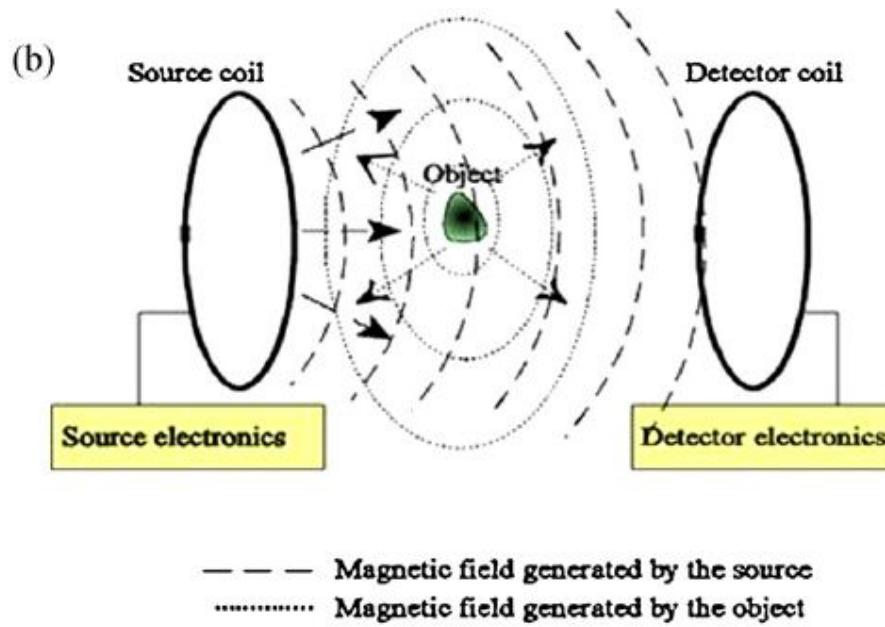
Hall Effect



Water Flow Sensor using both reed switch and Hall effect



Metal Detector using Hall-effect



Sound based Sensor

- By using Transducer or Magnetic Flux
- By using Piezoelectric
- Microphone
- Ultra-Sonic
- Pressure
- Vibration

Piezoelectric Materials

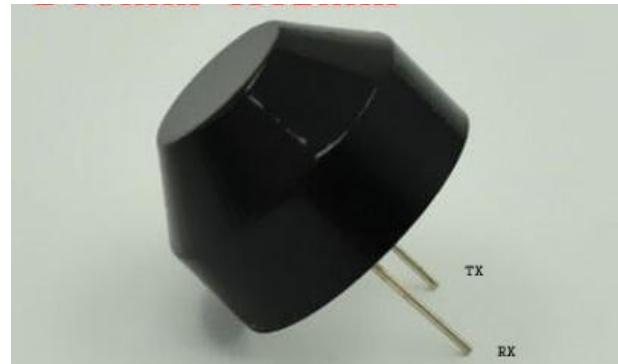
- Natural piezoelectric occurring materials:
 - Berlinit (structurally identical to quartz)
 - Cane sugar
 - Quartz (SiO_2)
 - Rochelle salt
 - Topaz
 - Tourmalin
 - Dry bone
- Man-made piezoelectric materials:
 - Barium titanate
 - Lead zirconate titanate.

Ultrasonic

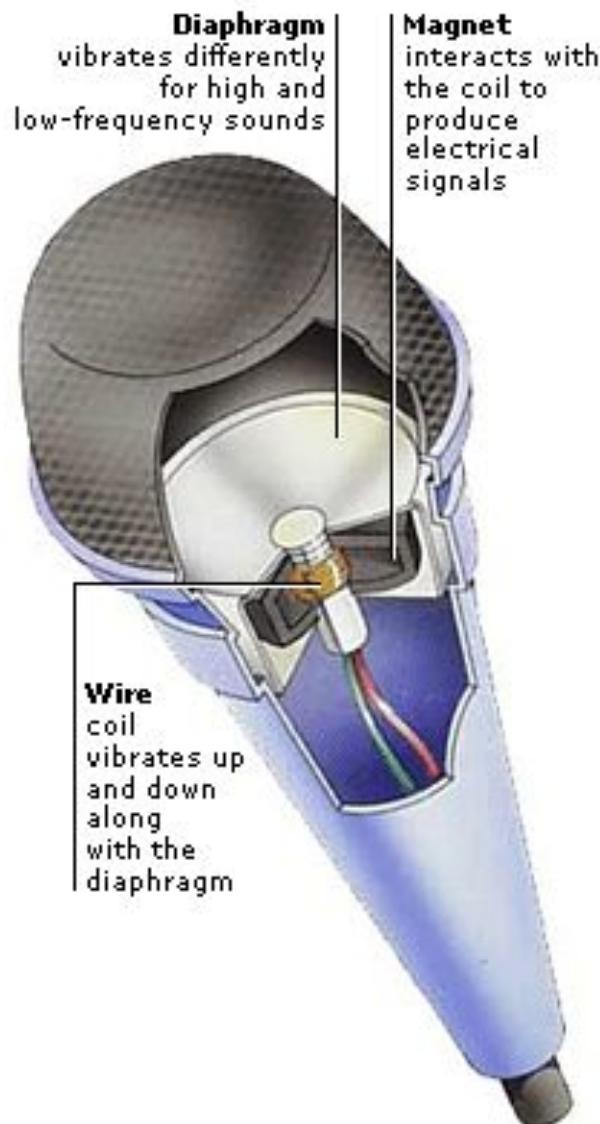
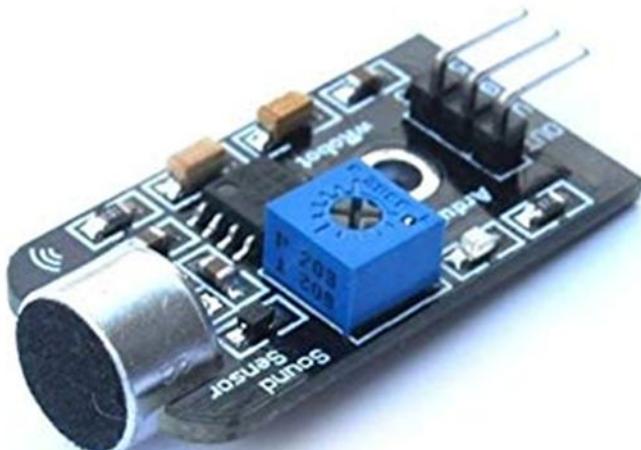
- By using travelling time of a ultrasonic wave with frequency of 40khz

- $\text{Distance} = (\text{Speed} \times \text{Time})/2$

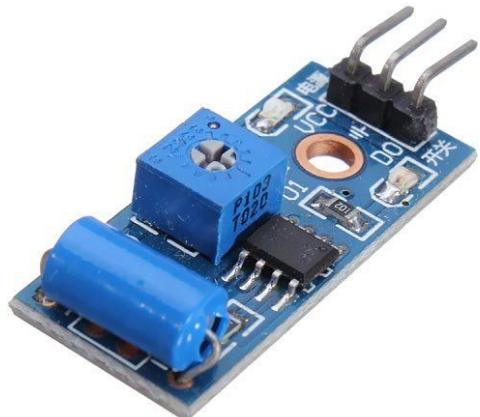
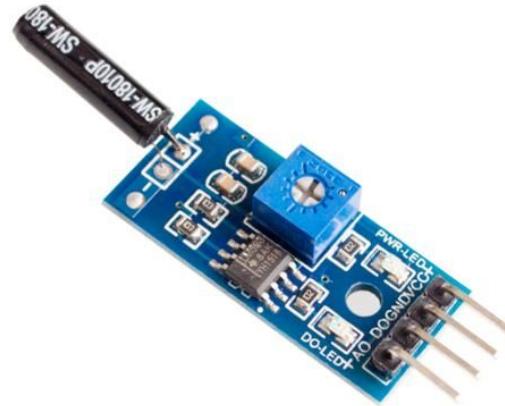
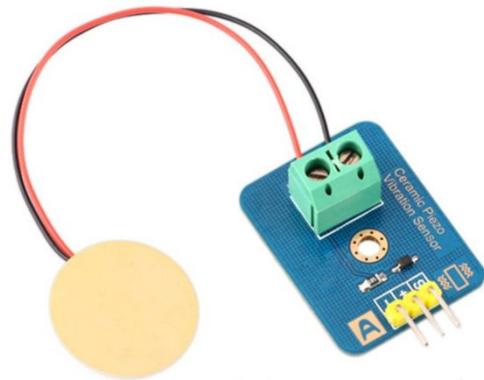
- Speed of ultrasonic wave is:
340meter/second in air



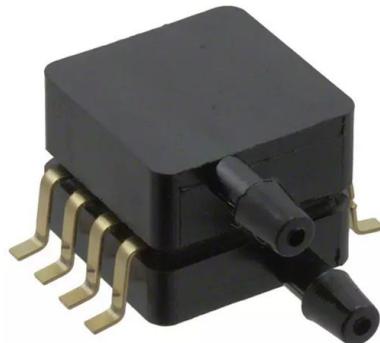
SOUND SENSOR (microphone)



Vibration Sensor (Using Piezo)



Pressure Sensor



- Pressure of gas and liquid.



Modern Sensors

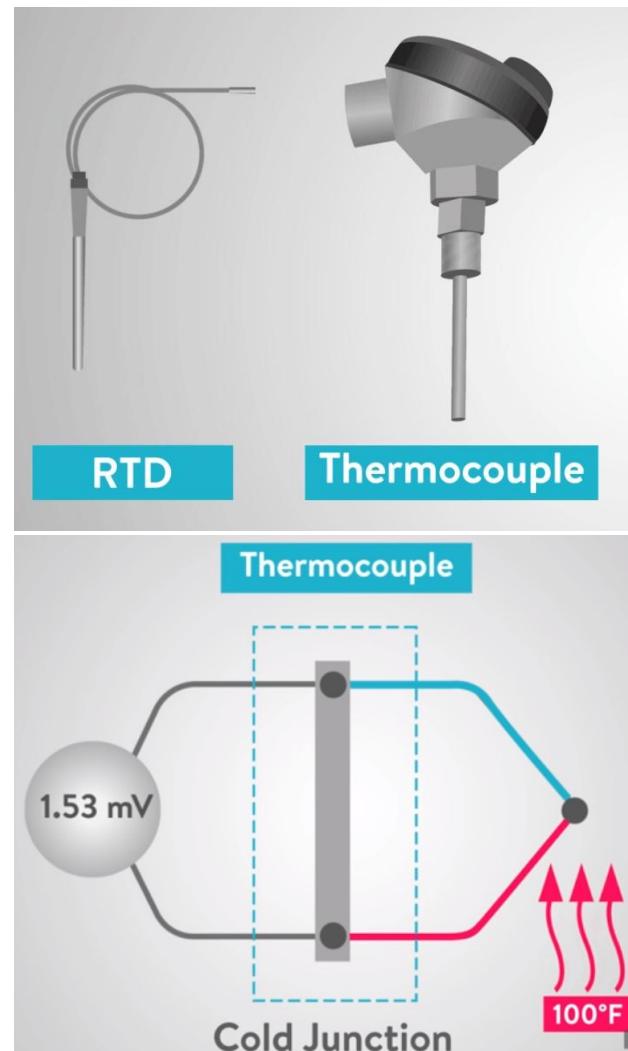
- Temperature
- Proximity
- Smoke & Gas
- Voltage Sensor
- Humidity Sensor
- Touch Sensor
- Gyroscope
- Accelerometer
- Break-Beam
- LiDAR



- <https://www.youtube.com/watch?v=xvF8b3eKeIU>
- <https://youtu.be/4mQ3o1t4Ssg>
- https://www.youtube.com/watch?time_continue=2&v=4mQ3o1t4Ssg&feature=emb_logo

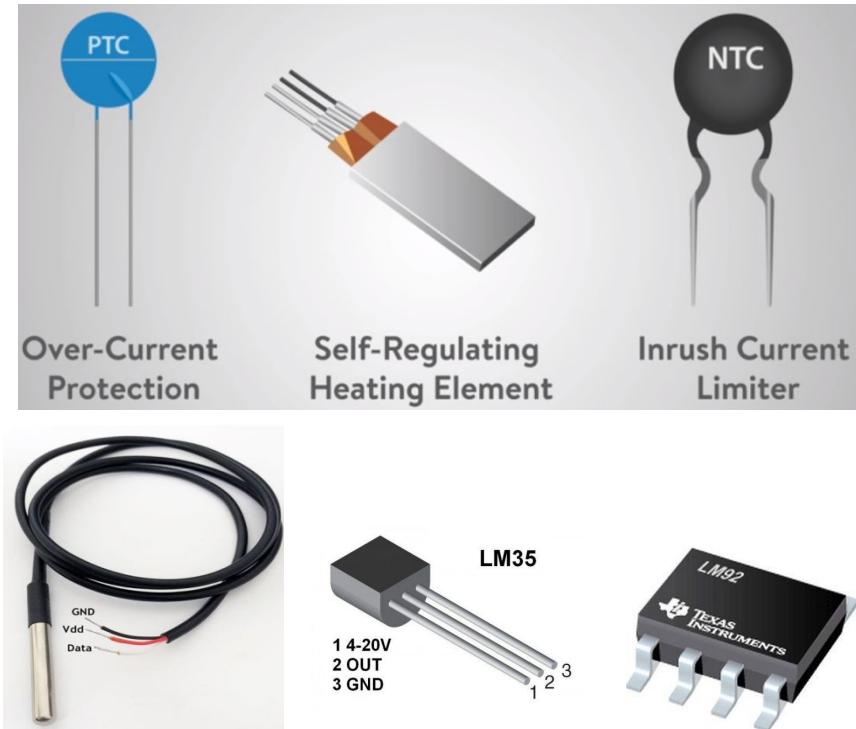
Temperature Sensing

- Resistance Temperature Detector (RTD):
Platinum, Copper, Nickel, Nickel-Ion
- Thermocouple (TC):
Junction of two materials
(Iron-constantan, Cromel-Alimel)



Temperature Sensing

- Thermistor are temperature dependent resistor
 - PTC (Positive Temperature Coefficient)
 - Self regulating Heating Element
 - Negative Temperature Coefficient NTC
- Semiconductor based temperature sensor used inside IC



RTD resistors are pure metal and thermistors are made with polymer or ceramic materials

Types of Proximity Sensors

1. Inductive Sensors



2. Capacitive Sensors



3. Photoelectric Sensor



4. Magnetic Sensors

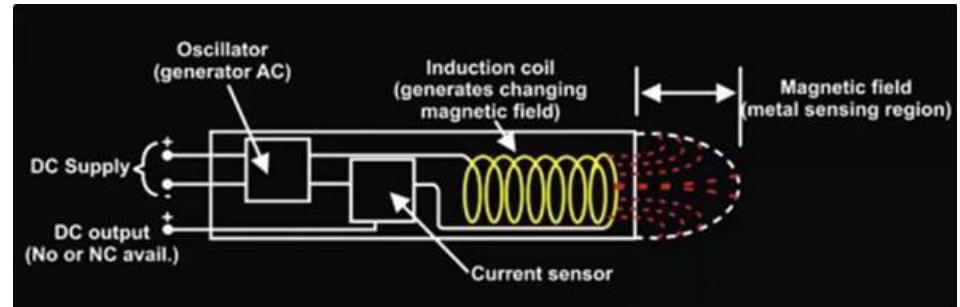


<https://www.youtube.com/watch?v=xAiSuQK22IM>

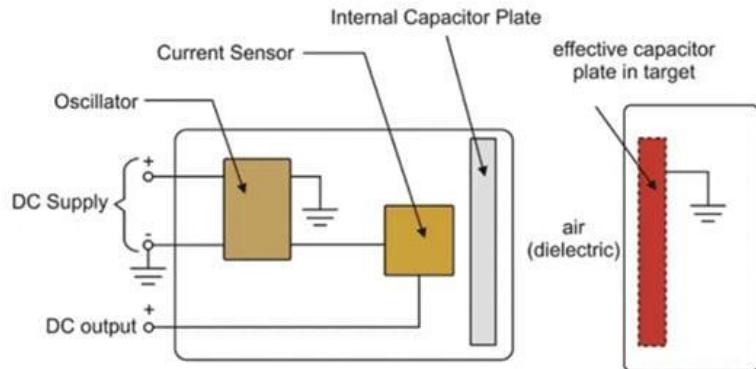
Activate Windows
Go to PC settings to activate Windows

Proximity Sensors

- Inductive:
 - Measure metal magnetic field from induction coil

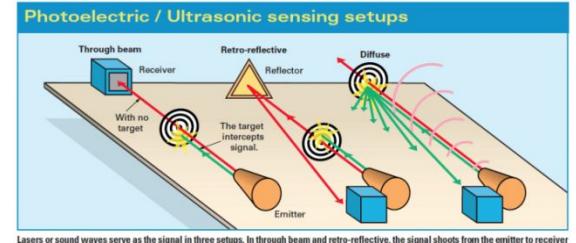


- Capacitive:
 - Measures metallic and non-metallic objects (Liquids, plastics, woods etc.)

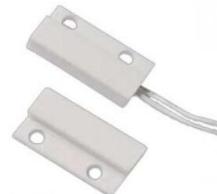


Other ways of proximity sensing

- Photoelectric:



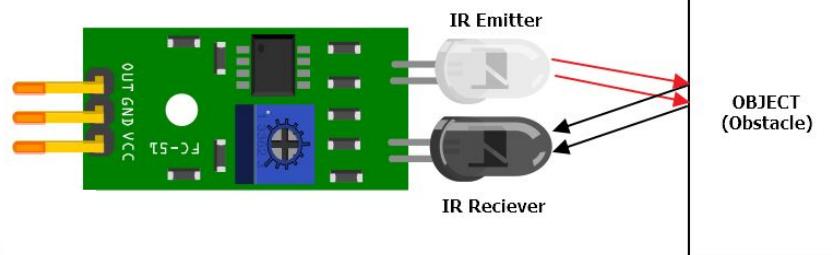
- Magnetic:



- Inductive:



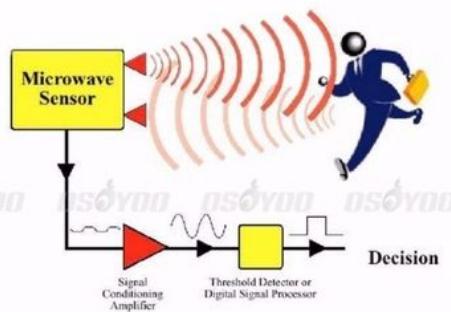
- IR



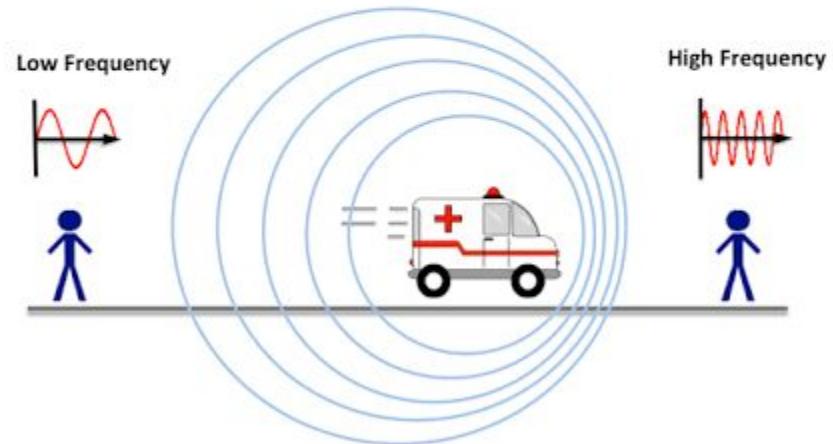
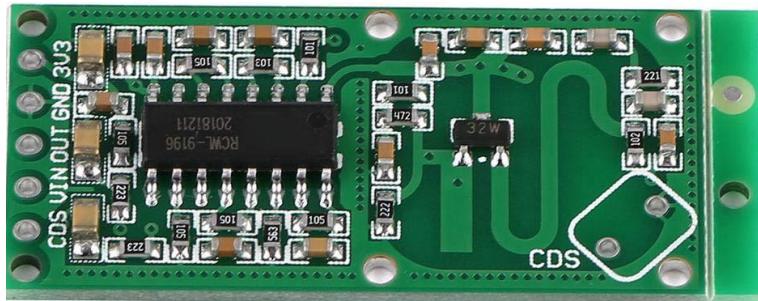
- Laser



Microwave Proximity Sensor (for moving object)

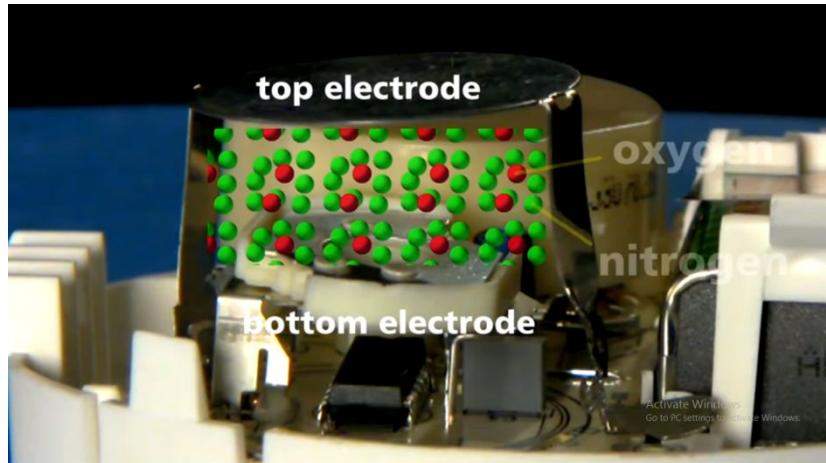


- Using “Doppler Effect” of moving object



Smoke Detector

- Radio active material:
Americium-241



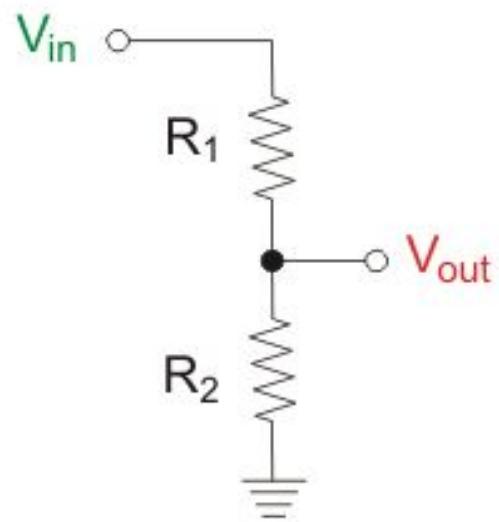
Smoke and Gas Sensor

Materials: metal oxides, semiconductors, carbon-based materials, and conducting polymers etc. Example: (Cami resistance / Carbon nano-tube)

1. Gas Sensor (MQ-9)
2. Smoke Sensor (MQ-5)
3. MQ135 Air Quality Sensor module
4. MQ6 LPG, LNG, iso-butane, propane gas
5. MQ8 Hydrogen gas sensor Module

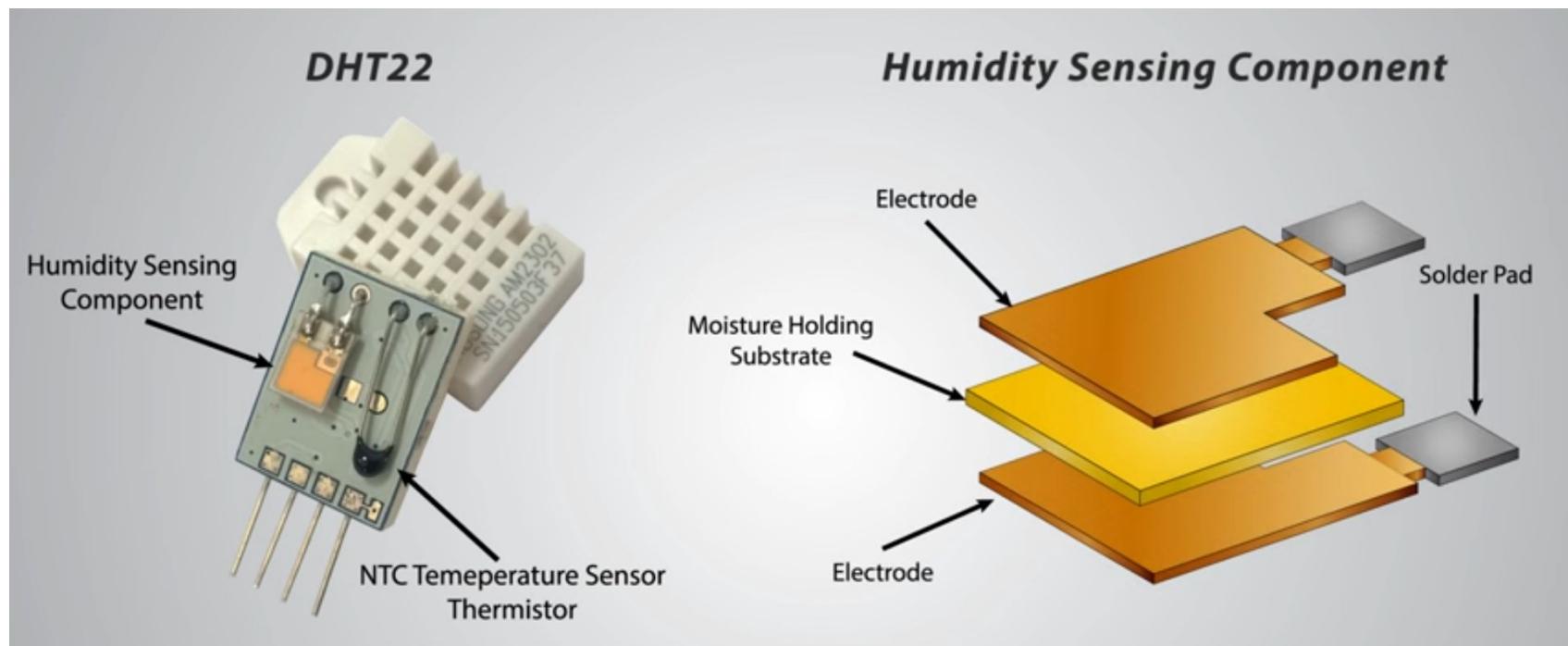
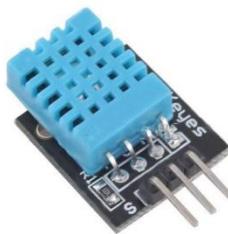


Voltage Sensor

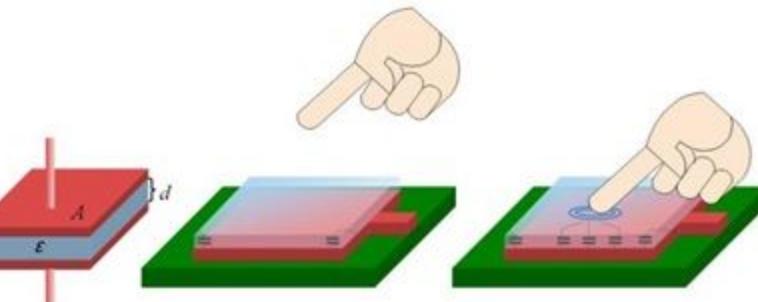
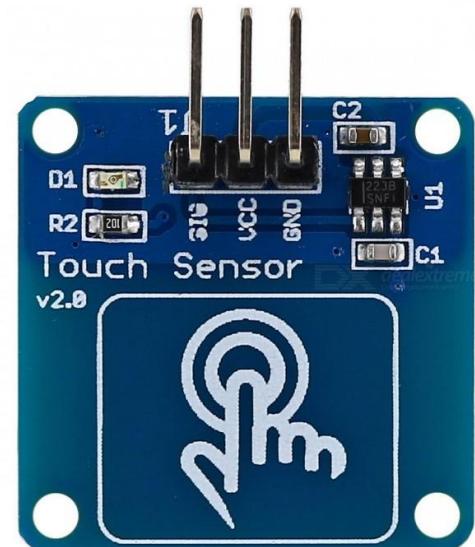
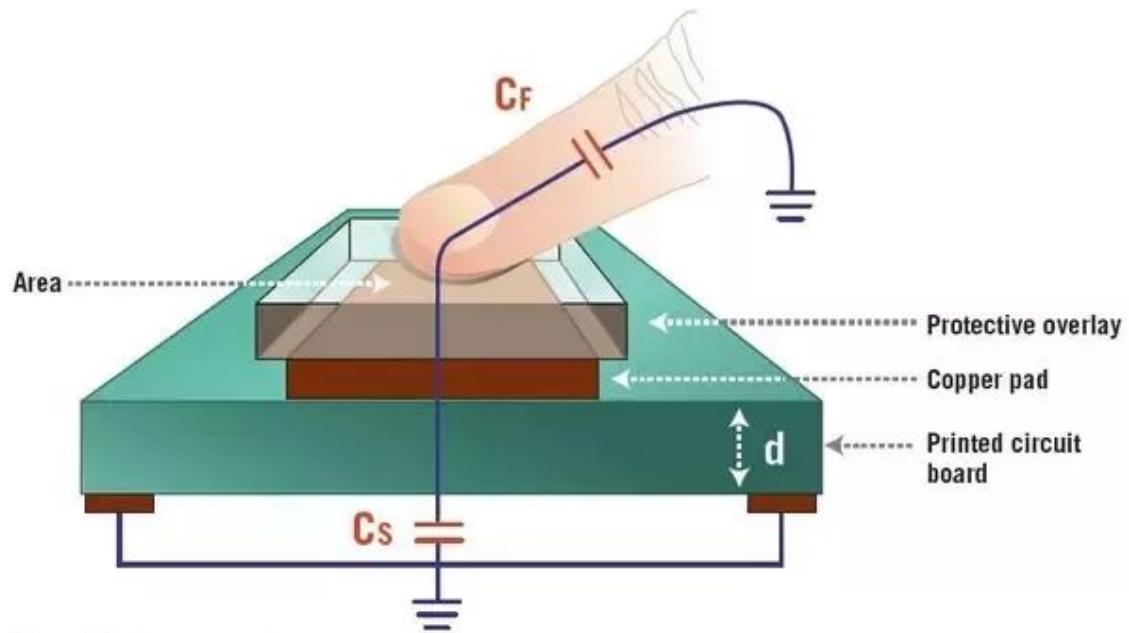


$$V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$$

Humidity Sensor



Touch Sensor

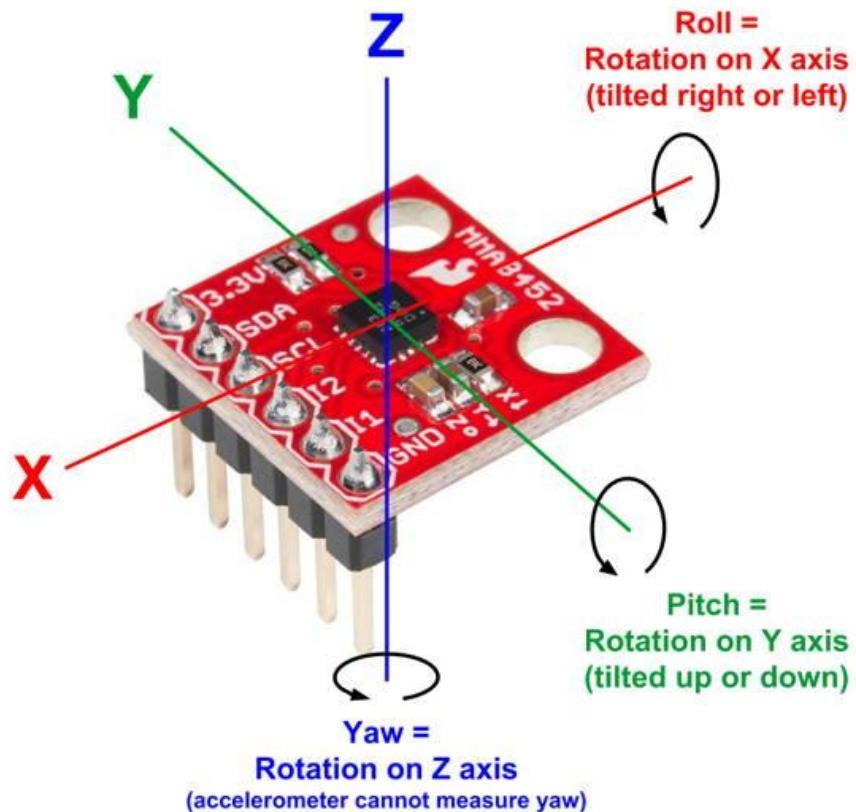


$$C = \epsilon \frac{A}{d}$$

$$\frac{1}{C_0}$$

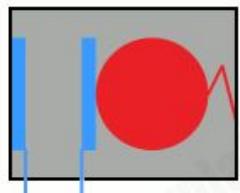
$$\frac{1}{C_0} \parallel \frac{1}{C_T}$$

Accelerometer

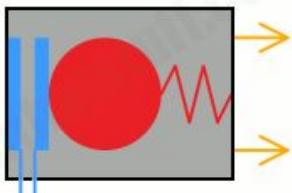


Accelerometer

Capacitive accelerometer



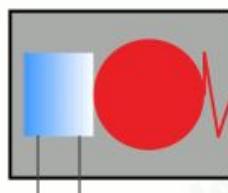
1. Mass presses capacitor plate



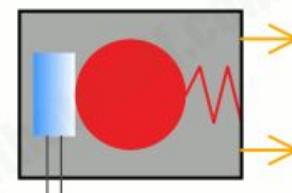
2. Mass closes plates, changing capacitance

www.explainthatstuff.com

Piezoelectric accelerometer



1. Mass presses against crystal



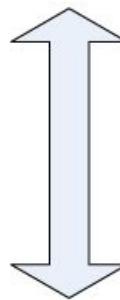
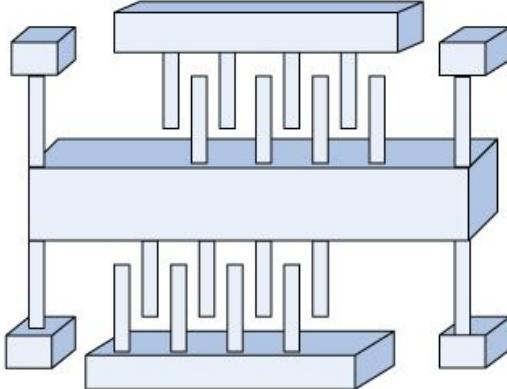
2. Mass squeezes crystal

3. Squeezed crystal generates voltage

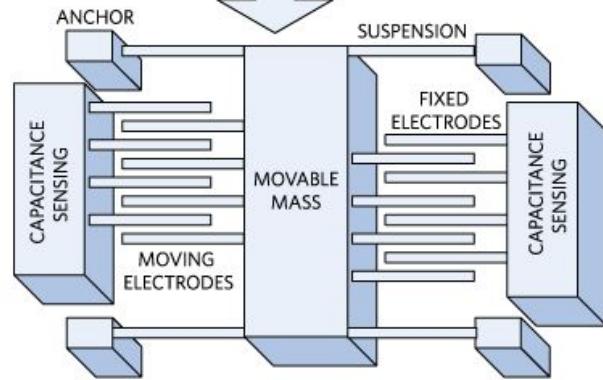
www.explainthatstuff.com

SILICON SUBSTRATE

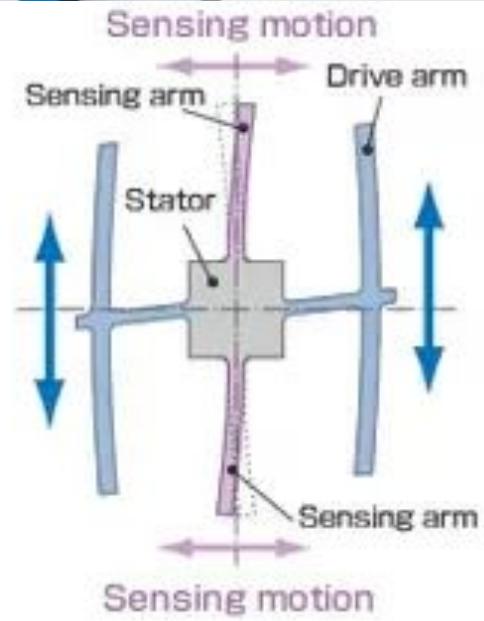
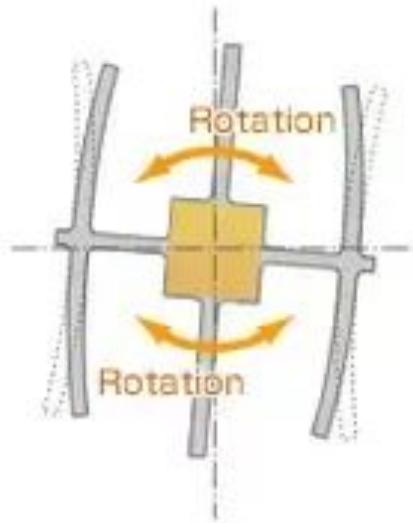
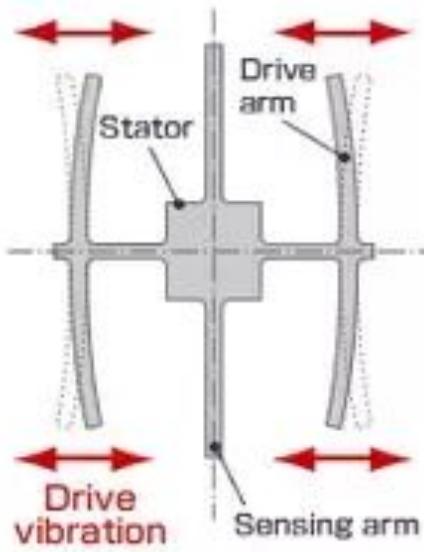
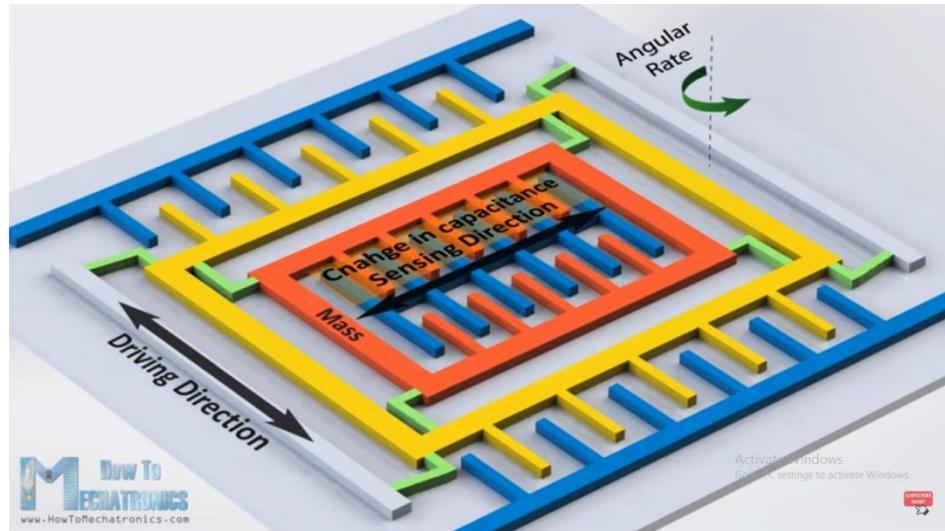
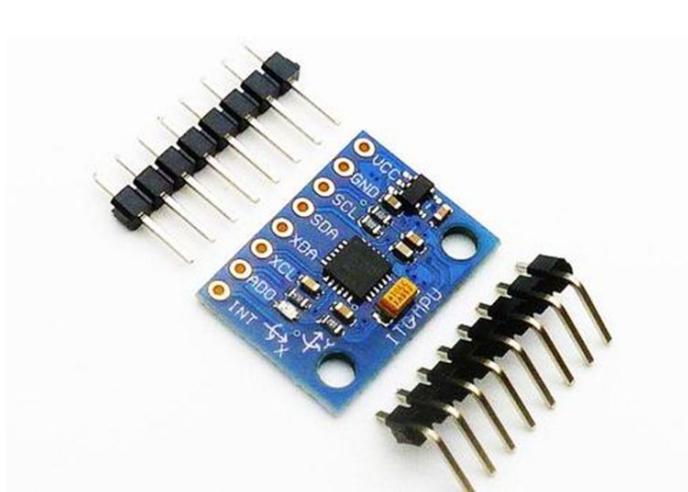
HORIZONTAL
MOTION
DETECTION



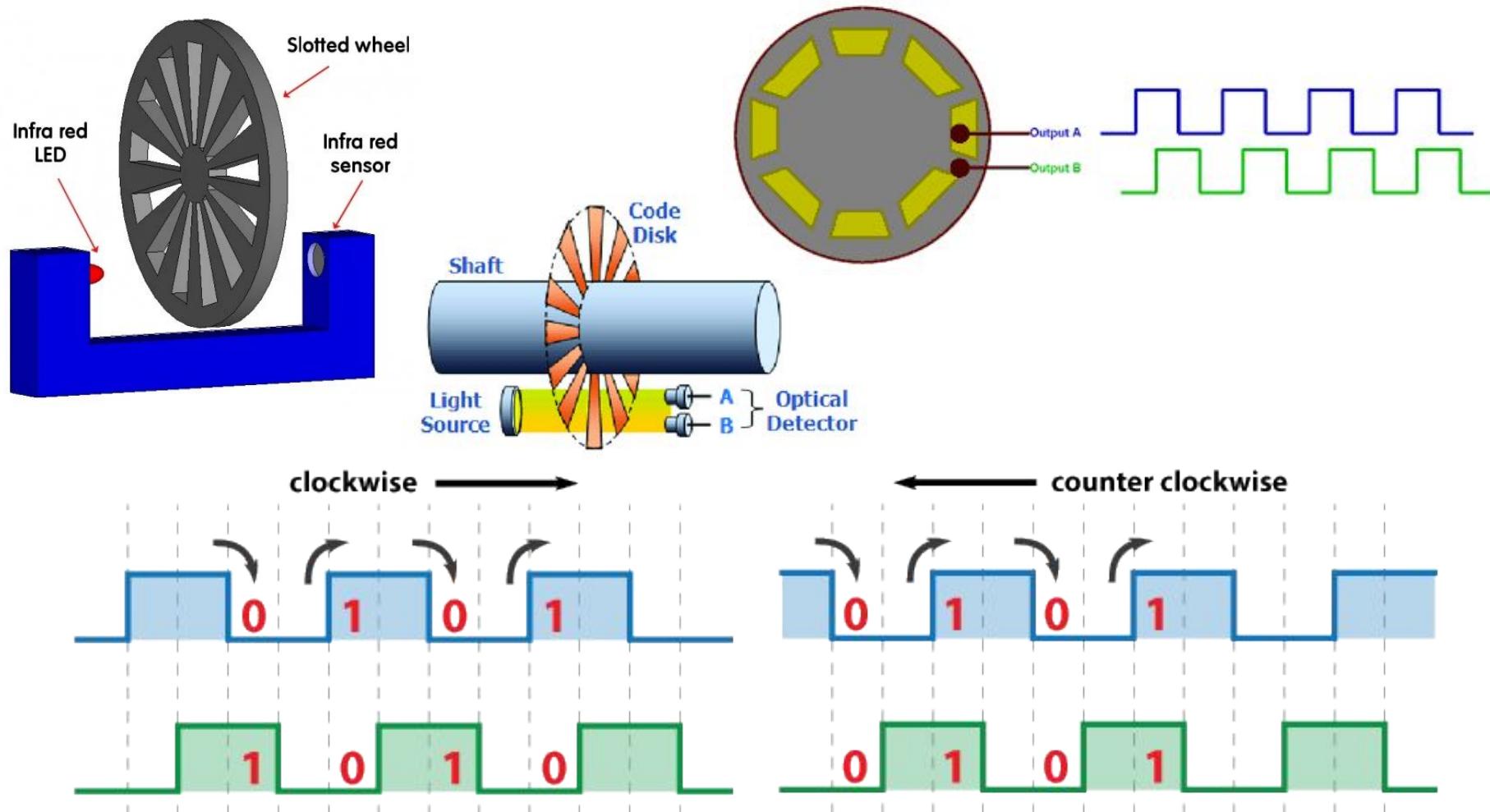
VERTICAL MOTION
DETECTION



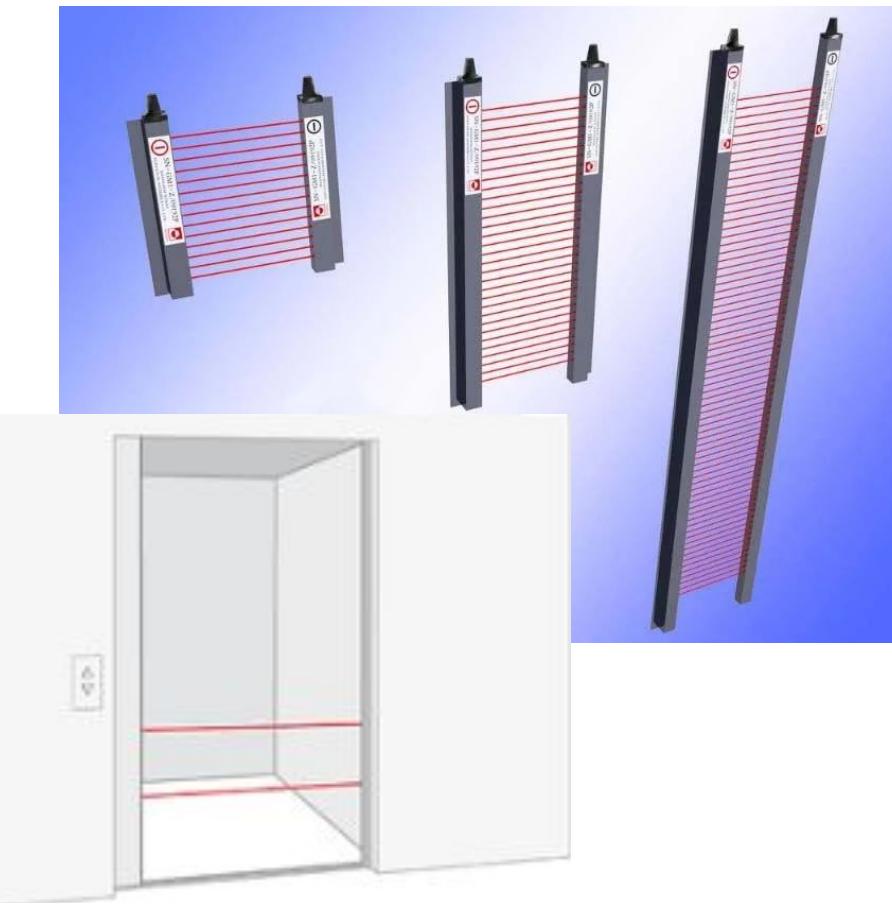
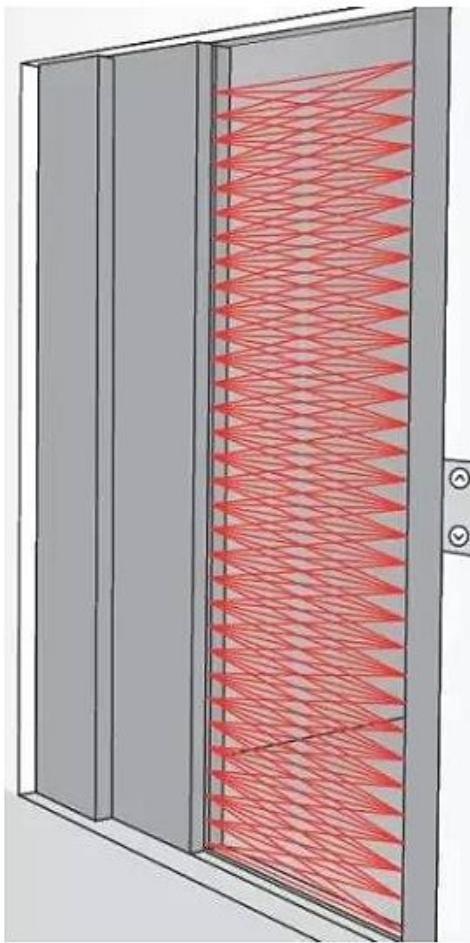
Gyroscope



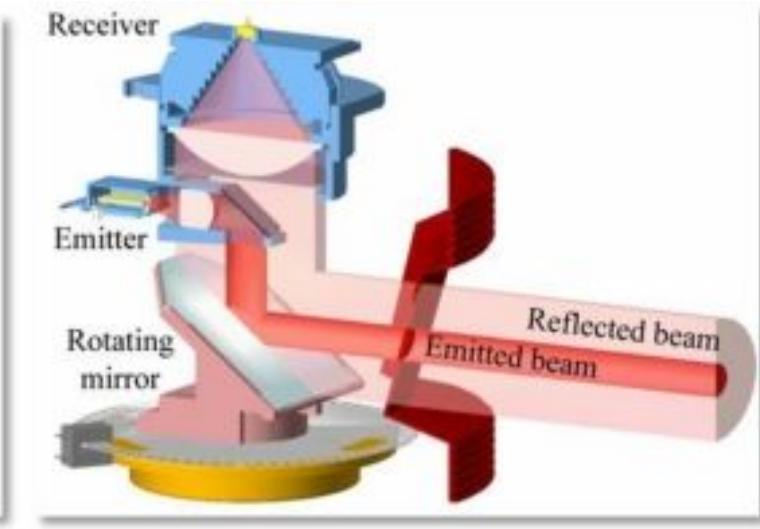
Break beam sensor (Shaft/Rotary encoder)



Break beam sensor (Light curtain (Lift door))



LiDAR (Light Detection And Ranging)



Velodyne LiDAR®



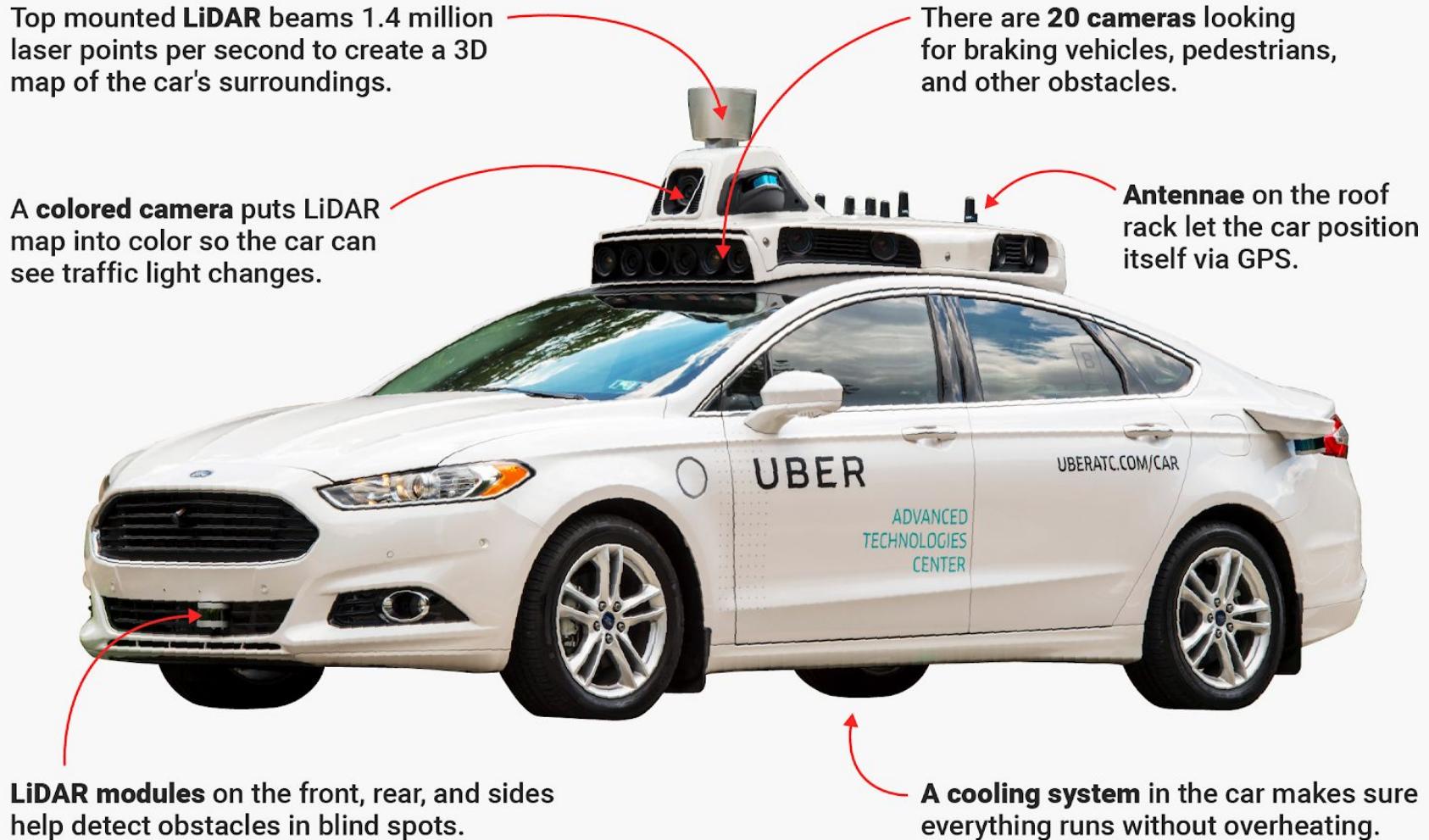
Laser Scanner or Lidar

Top mounted LiDAR beams 1.4 million laser points per second to create a 3D map of the car's surroundings.

A colored camera puts LiDAR map into color so the car can see traffic light changes.

There are 20 cameras looking for braking vehicles, pedestrians, and other obstacles.

Antennae on the roof rack let the car position itself via GPS.



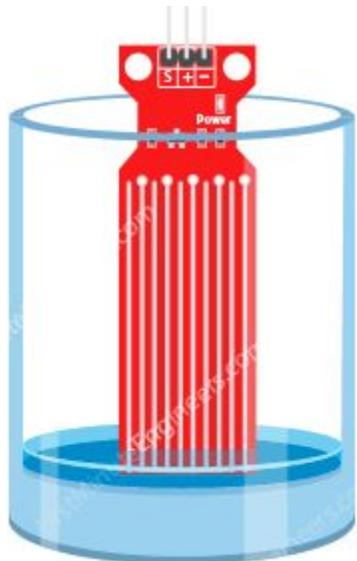
LiDAR modules on the front, rear, and sides help detect obstacles in blind spots.

A cooling system in the car makes sure everything runs without overheating.

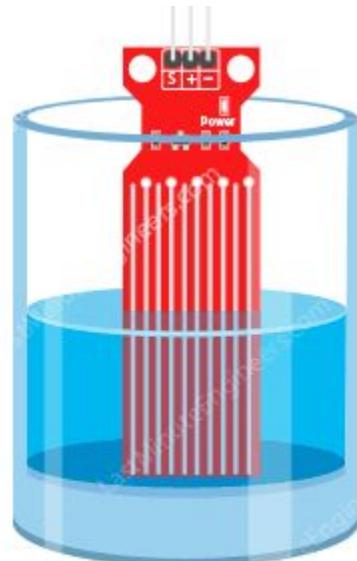
Water and Underwater Sensors

- Water Conductivity based sensor
 - Steam
 - Rain
 - water level
 - Soil Moisture Sensor
- Underwater Sensor:
 - Ph and Alkalinity
 - Dissolved Oxygen Sensor (DO)
 - Biochemical Oxygen Demand (BOD)
 - BOD, COD, TSS
 - Total Dissolved Solids S and Turbidity
 - Chlorine
 - Electrical Conductivity sensor water

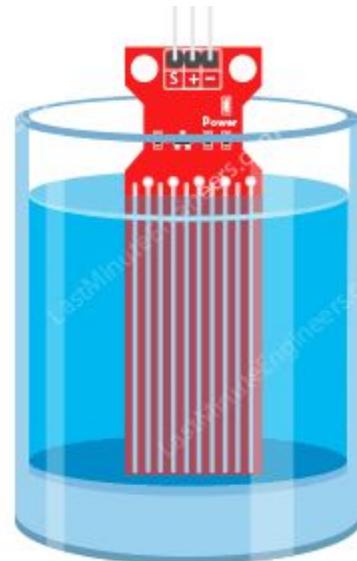
Water Level sensor



Status: Dry
Test Reading: ~0

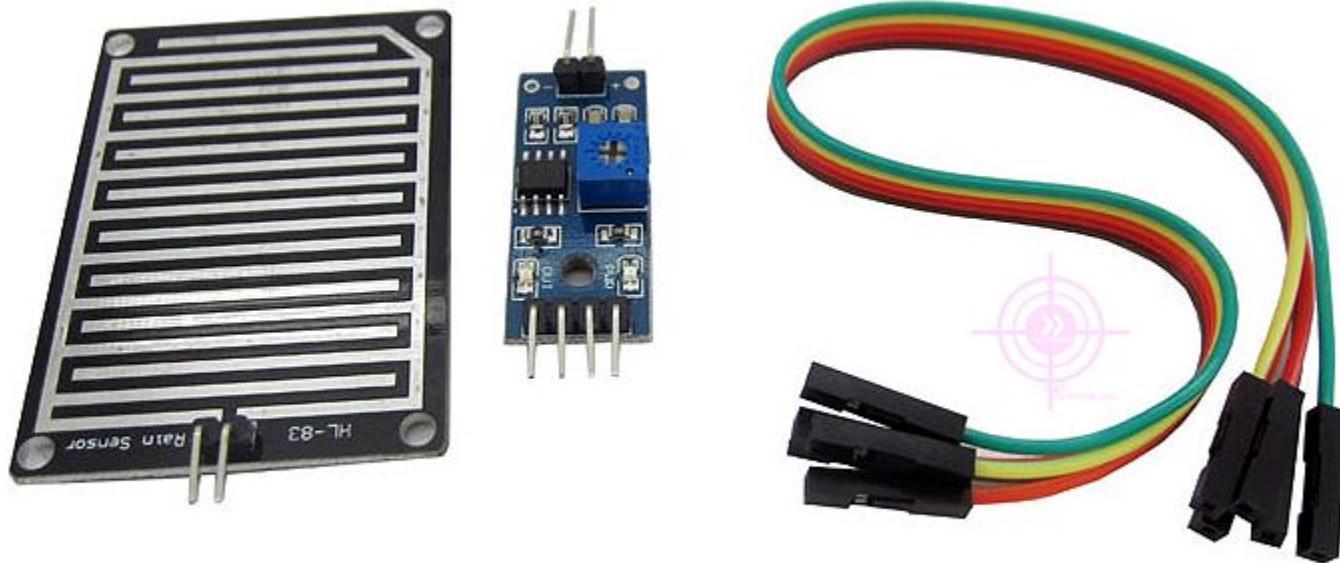


Status: Partially submerged
Test Reading: ~420



Status: Fully submerged
Test Reading: ~520

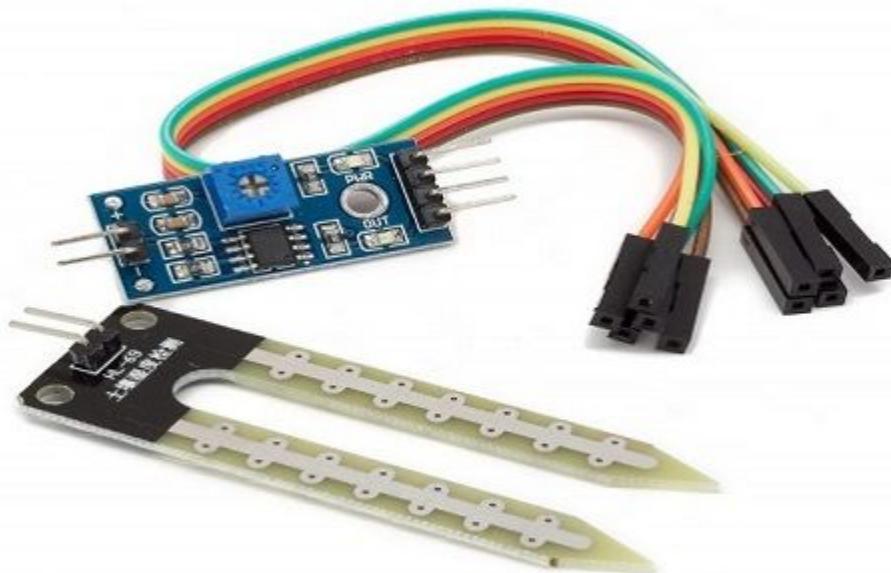
Rain Sensor



Steam Sensor



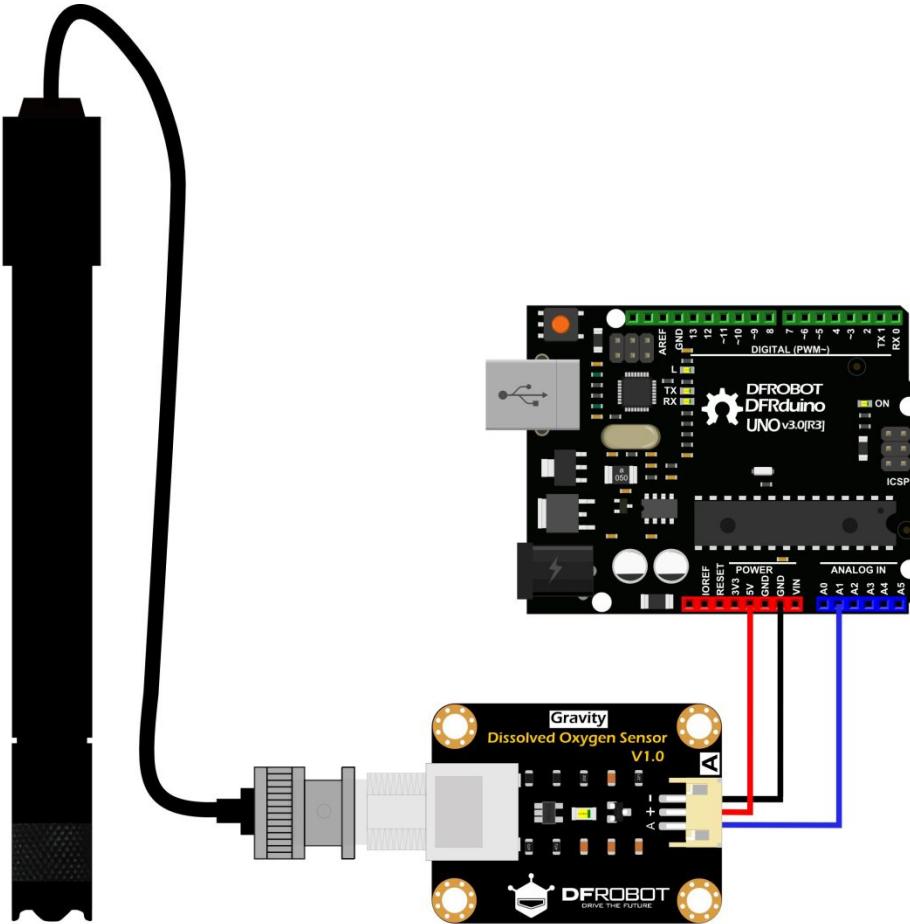
Soil Moisture Sensor



Ph and Alkalinity



Dissolved Oxygen Sensor (DO)



Biochemical Oxygen Demand (BOD)



BOD, COD, TSS

BOD: Biochemical Oxygen Demand

COD: Chemical Oxygen Demand

TSS: Turbidity And Total Suspended Solids



<http://onlineeffluentmonitoring.com/bodcodtss/>

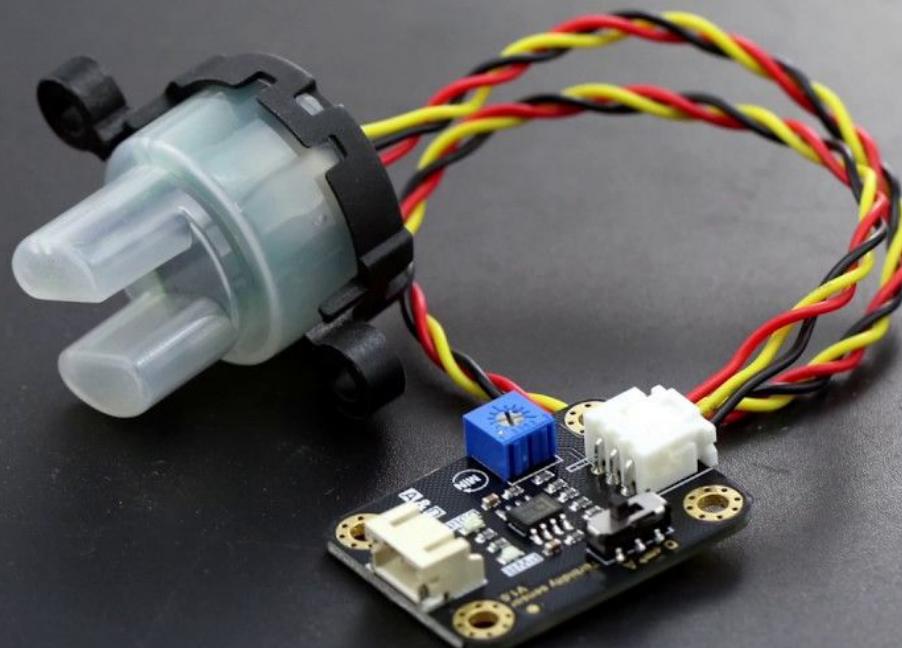
Total Dissolved Solids S and Turbidity

GRAVITY: ANALOG TURBIDITY SENSOR

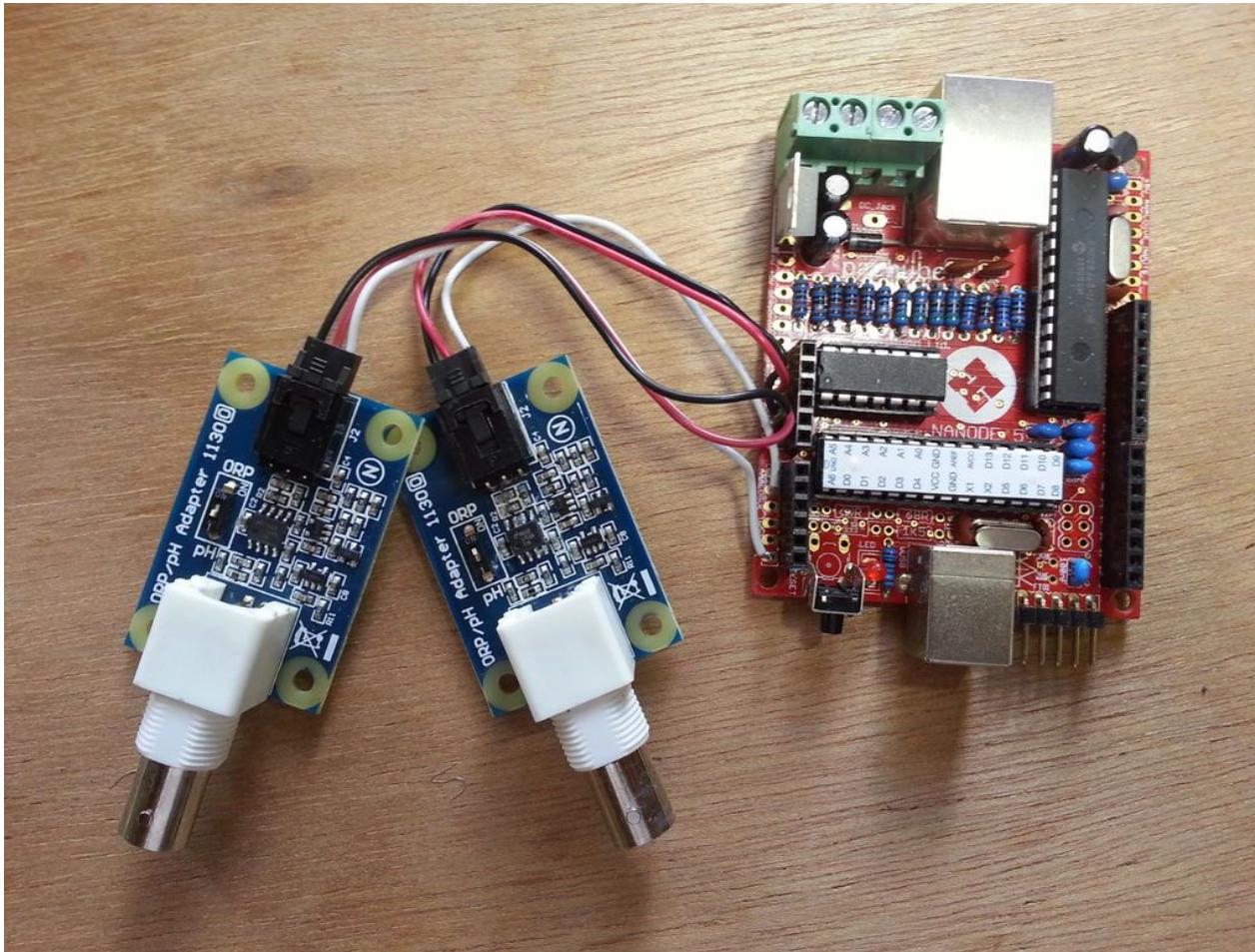
SKU: SEN0189

- OPERATING VOLTAGE: 5V DC
- RESPONSE TIME: <500MS
- INSULATION RESISTANCE: 100M (MIN)
- ANALOG OUTPUT: 0-4.5V
- DIGITAL OUTPUT: HIGH/LOW LEVEL SIGNAL
- SIZE: 1.5IN*1.1IN*0.4IN

DIFFICULTY 



Chlorine



Electrical Conductivity sensor water

