Weather Sensors

-let's Sense our Surrounding!!

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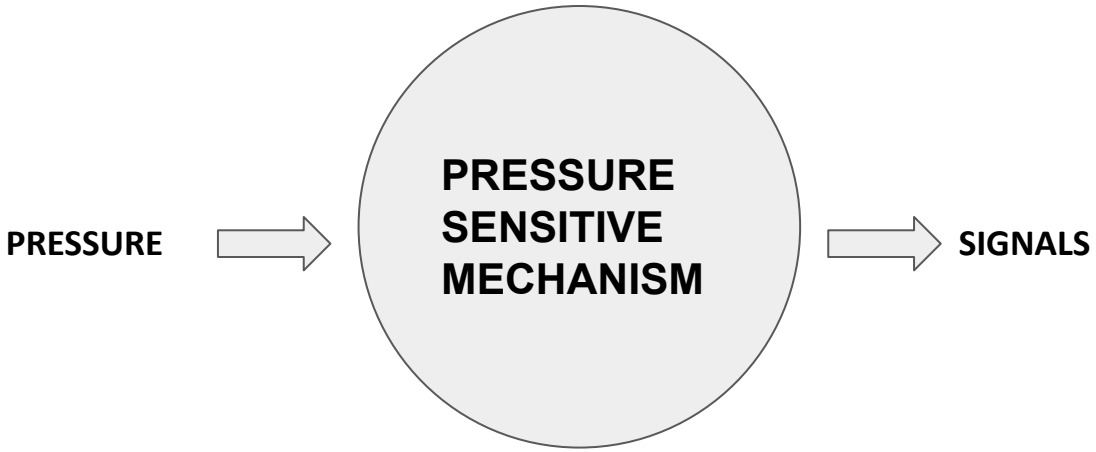
Inception

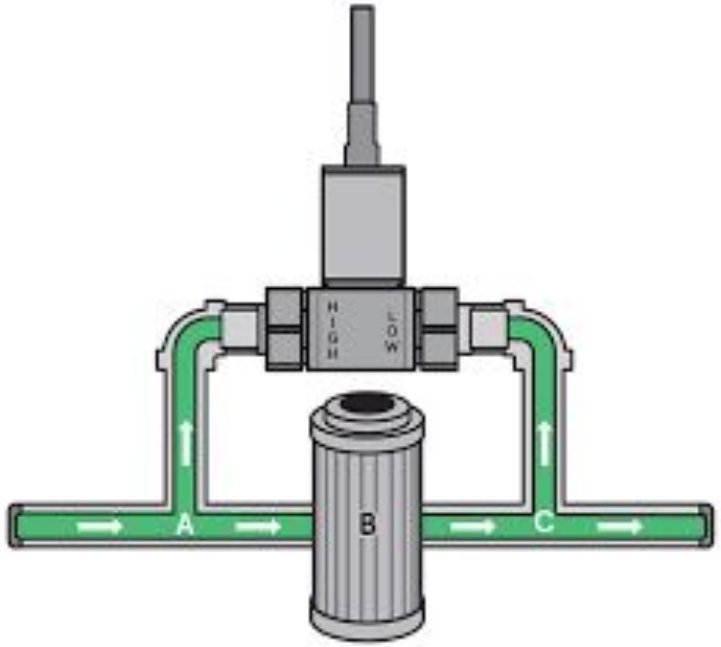
- Sensors convert **Physical signals to Electrical signals**
- Sensors are pervasive in all electrical devices.
  - We encounter them countless number of time in our oblivion..

- **We choose to “sense our surrounding”**

- **The key parameter of the climate around us are:**
  1)Pressure
  2)Temperature
  3)Relative humidity
  4)Wind speed
  5)Radiation

PRESSURE SENSOR





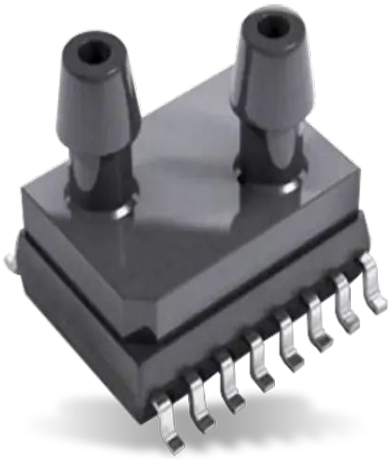
Broadly there are 2 types of **Pressure sensing Mechanism**:

1)**Force collector type**: It involves direct measurement of strains to evaluate force

- strain gauge
- Piezoelectric
- Capacitive pressure sensors
- force balancing etc.

2)**Others**: These mechanism use properties other than direct measurement of force to deduce pressure.

- Resonant frequency
- Thermal conductivity
- measuring flow of charged particles...



SM 933x differential pressure sensor

USES of pressure sensors:
for pressure sensing and measuring parameters which are related to pressure.

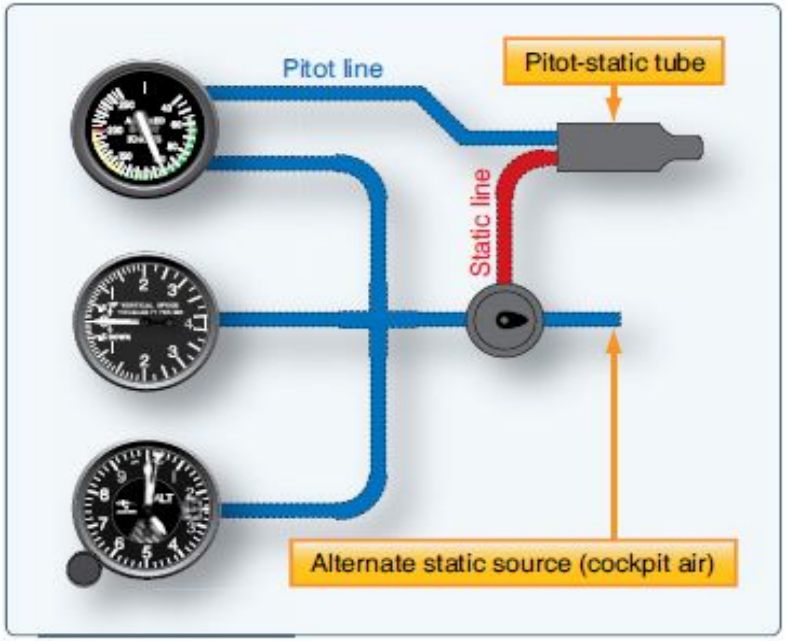
- **Altitude sensing:** by using relation of pressure with height
- **Flow Sensing**
- **Level/depth sensing:** by using simple relations p=(rho)*g*h
- **Leak sensing:**by observing pressure decay

Industrial Wireless pressure sensor

Air Speed Indicator

Vertical speed indicator

Altimeter



ELECTRICAL AIR TEMPERATURE SENSOR

- These are electrical devices which can be used to measure temperature of air.
- There are four types of these sensors.

a.) **Thermistor** –

It is a thermal resistor whose resistance change with temperature.

Material used – Ceramic or polymer.

Optimal range – (223- 423) K

A Thermistor

b.) **Thermocouple** –

It consists of two electric conductors of different materials combined to form a junction and junction voltage is used to find temperature.

Accuracy- low

Range- wide

c.) **Resistance Thermometer/ RTD** –

It is similar to thermistor with some differences.

Material used is pure metal such as platinum etc.

Range and precision both are better than thermistor.

d.) **Silicon Bandgap Temperature sensor** –

It consists of resistors, transistors and silicon diode.

Forward voltage of diode is calibrated to calculate temperature.

A Silicon Temperature Sensor

PT1000- A Platinum Resistance Thermometer(PRT)

- It is a commonly used RTD which gives accurate temperature readings over a wide range.
- It’s wire is made up of platinum.
- It also consists of inner conductors, insulation material and the thermowell
- Principle is to measure resistance of wire which varies almost linearly with temperature.
- Resistance at 0° C – 1000 ohms
- Resistance at 100° C- 1384.9 ohms
- Pico signal conditioners are used for linearising the equation between resistance and temperatures.
- Four / three wires are used in the sensor instead to two to get precise results
- It is used in REMS.

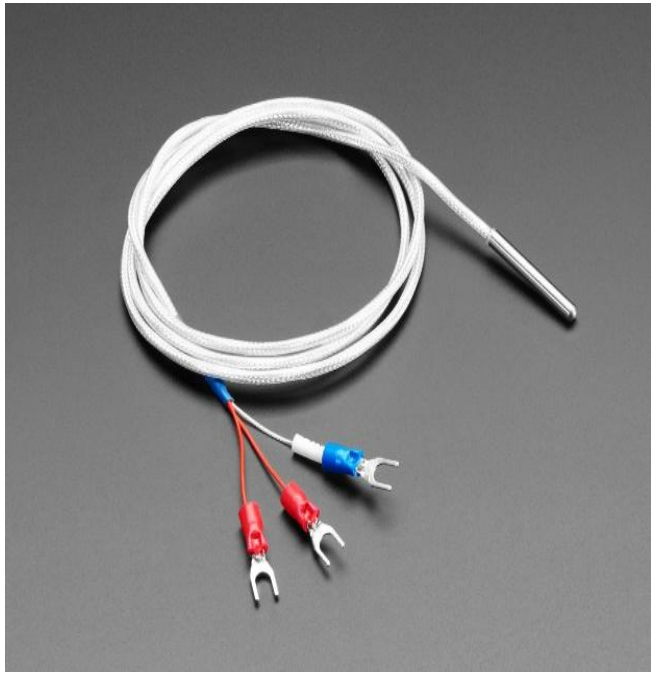
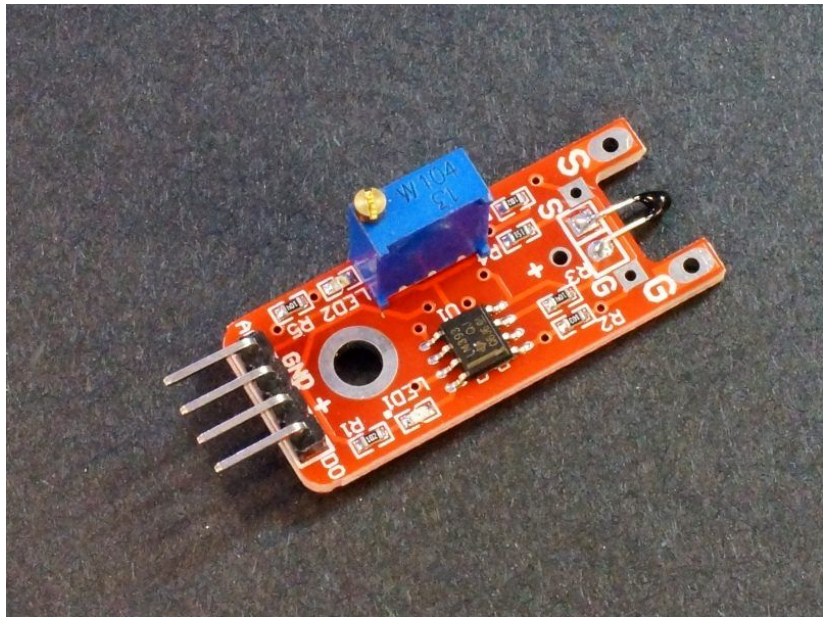


Image courtesy:-
https://www.electan.com

GROUND TEMPERATURE SENSOR

- Ground temperature sensors are used to **measure temperature of various surfaces**.
- Depending upon the mechanism they are primarily of two types:
  - Sensors which require physical contact with the surface (exp. **Thermistor**)
  - Sensors which do not require physical contact with the surface (exp. **Thermopile**)

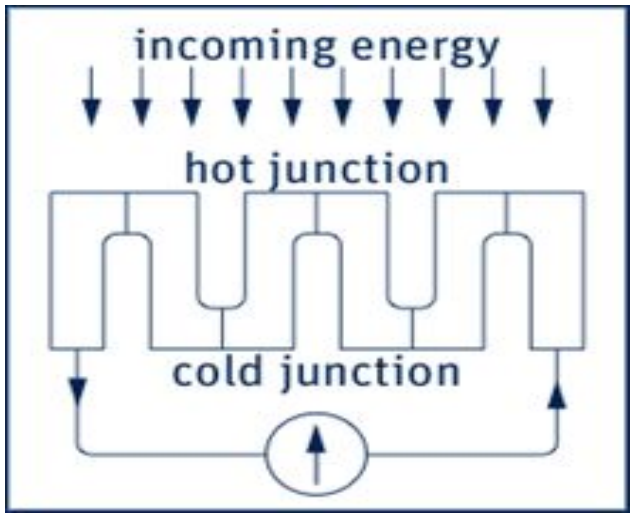


DIGITAL Thermistor temperature sensor module

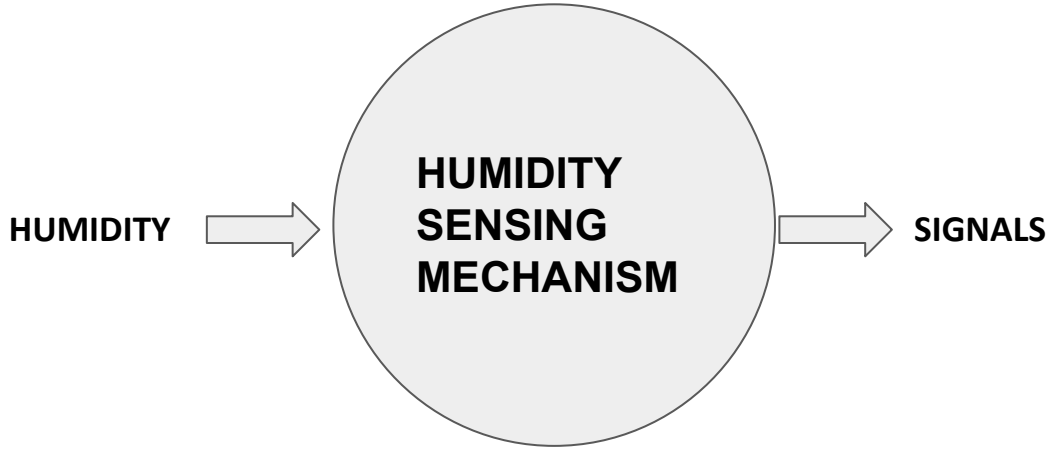
Thermopile

- Thermopile is a serially-interconnected array of thermocouples, each of which consists of two dissimilar materials with a large thermo-electric power and opposite polarities.
- When infrared radiation falls on it, it leads to the the **development of a potential difference** between the hot and the cold surface and with the relation between voltage induced temperature is estimated.

High Sensitive Thermopiles



HUMIDITY SENSOR



Two types of humidity sensor based on the principle used for measuring humidity :-

a) **Relative humidity sensor**-

- is used to measure live humidity in the environment at a given temperature **with respect to maximum humidity that can be there in the same environment at the same temperature.**
- It also includes measurement of temperature.
- RH sensors has 2 types.
  i. **Capacitive Relative Humidity Sensor**
  ii. Resistive Relative Humidity Sensor

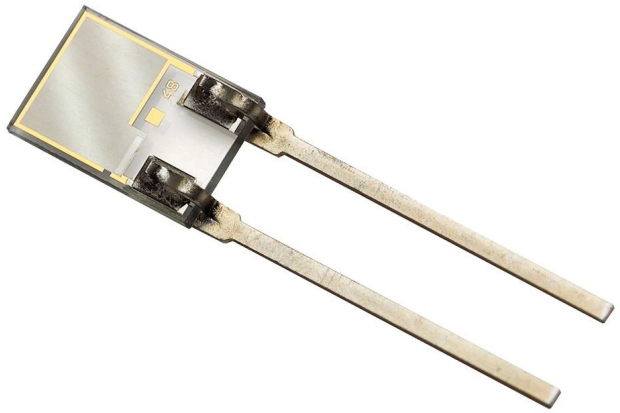
b) **Absolute humidity sensor**-

- is used to measure humidity at a given state of pressure and temperature.
- It does not measure temperature.
  i. Thermal absolute humidity sensor

TELAIRE HS20- Relative Humidity Sensor

Capacitive Relative Humidity Sensor

- It consists of a substrate on which a plastic or polymer is deposited between two conductive electrodes.
- The dielectric - constant of the material between the electrodes is much less than the dielectric constant of water i.e., around 80 at room temperature. So, **as humidity increases, net dielectric constant increases, hence capacitance increase**.
- This direct relation between amount of moisture in the sensor, relative humidity in the sensor and capacitance of the sensor is calibrated to calculate relative humidity.



E+E HC201- Capacitive Relative Humidity Sensor

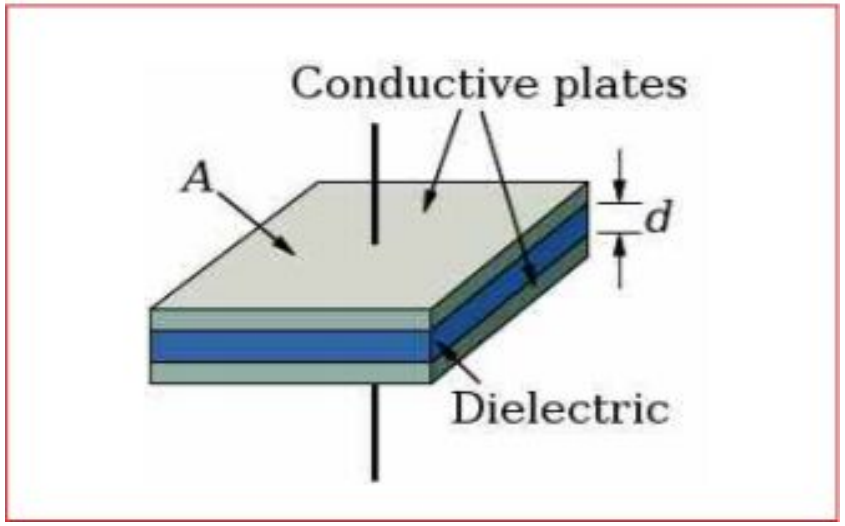


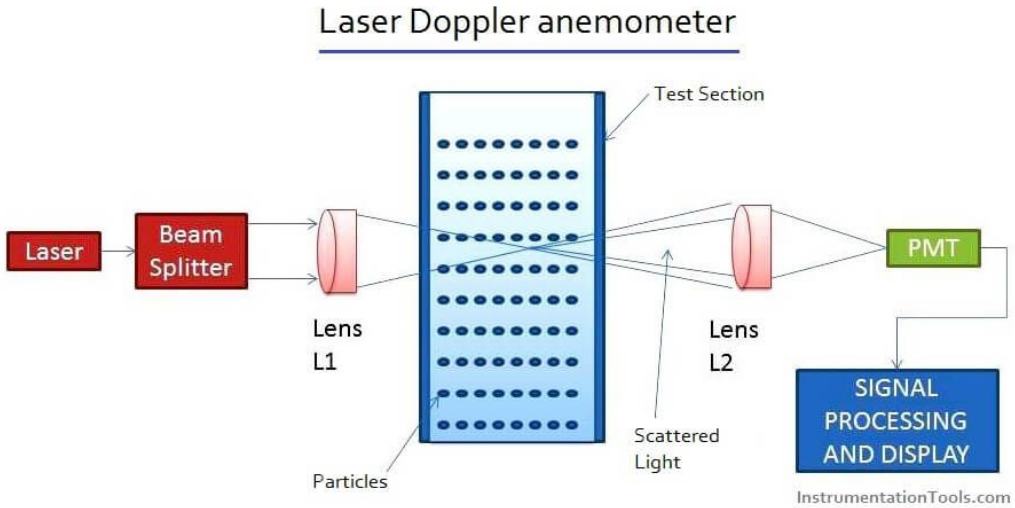
Image courtesy - https://www.rotronic.com

ANEMOMETER

- **It is a device used for measuring wind speed and direction and is used in collaboration with other sensors in an environment sensors.**
- There are three broad categories of anemometers
  - Mechanical anemometers (exp: vane and cup anemometers)
  - Electrical anemometers (exp: **Hot wire anemometers**,Laser Doppler anemometer)
  - Pressure anemometer (exp: Plate and Tube anemometers)

VANE anemometers

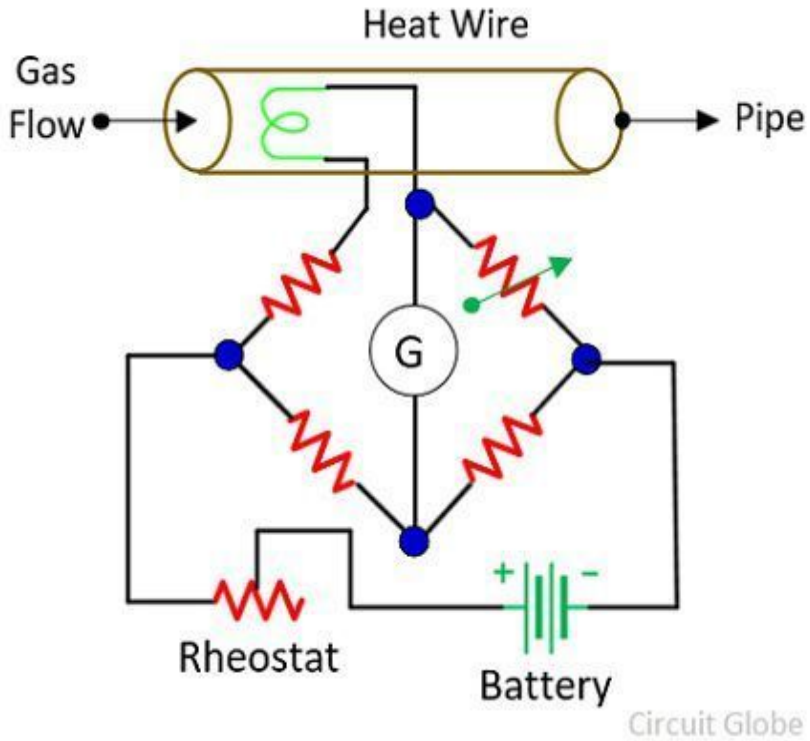
CUP anemometers



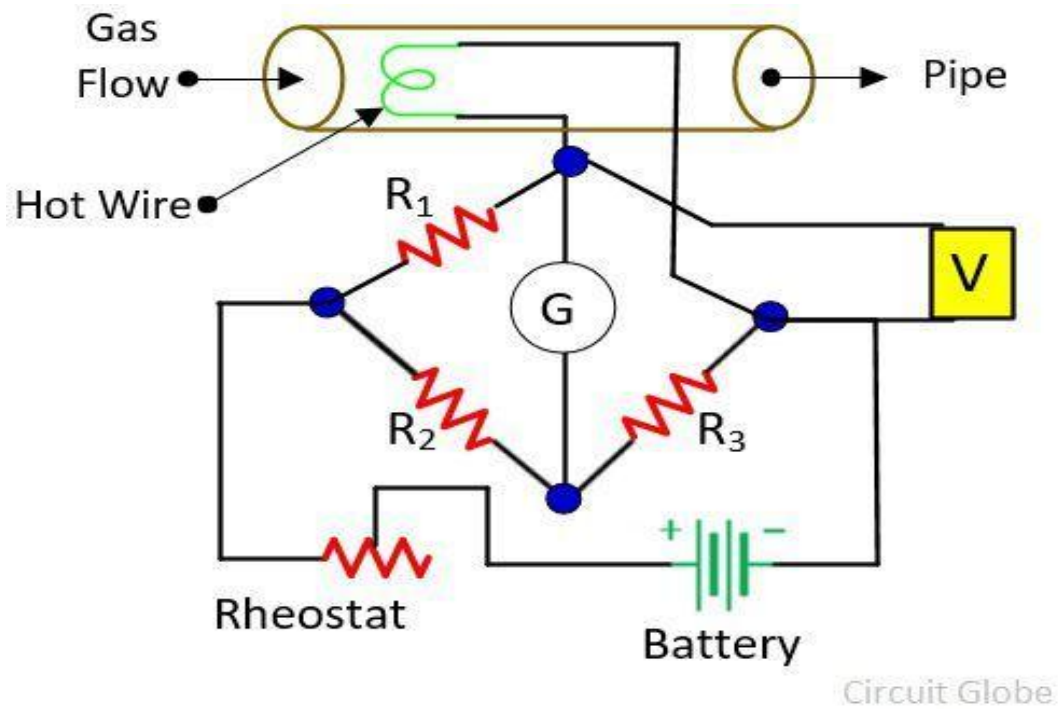
Hot Wire Anemometer

- The Hot wire anemometer consists of conducting wires in a ceramic tube and leads from the conducting wire is then connected to one of the limbs of the **wheatstone bridge**.
- The wire gets heated due to the current and transfers heat to the fluid in which it is placed.
- Since **resistance of the conducting wire depends upon its temperature**, as heat is transferred to the fluid its temperature drops which changes its resistance.
- This change is the used to measure the flow rate of the fluid.

Digital Hot wire anemometer



Constant current anemometer

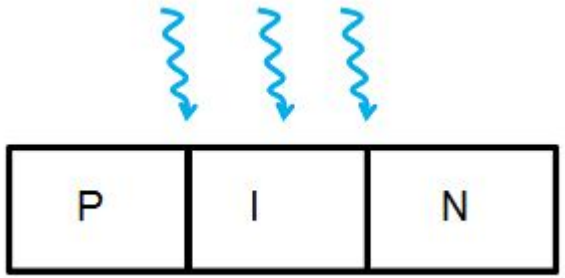


Constant temperature anemometer

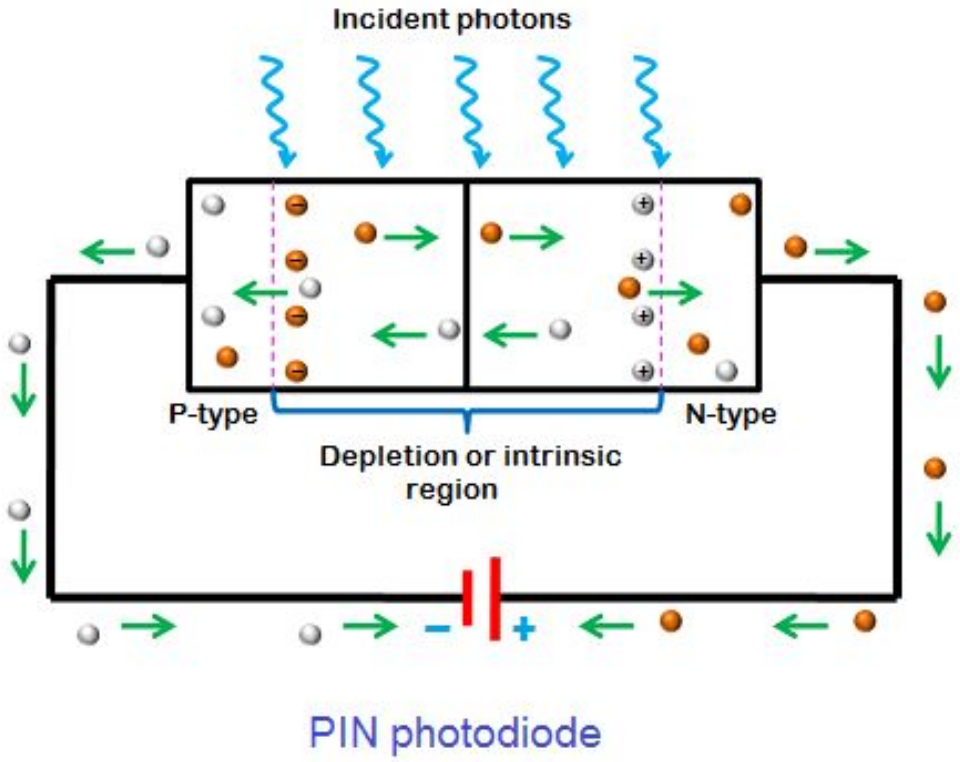
PHOTODIODE

- A semiconducting device that takes outputs electric current as a Function of intensity of light.
- Simply it is a PN junction diode designed to be **operated in reverse biased mode.**
- Based upon construction there are mainly 3 types of Photodiodes:
    1)PN junction photodiode
    2)PIN Photodiode
    3)Avalanche Photodiode

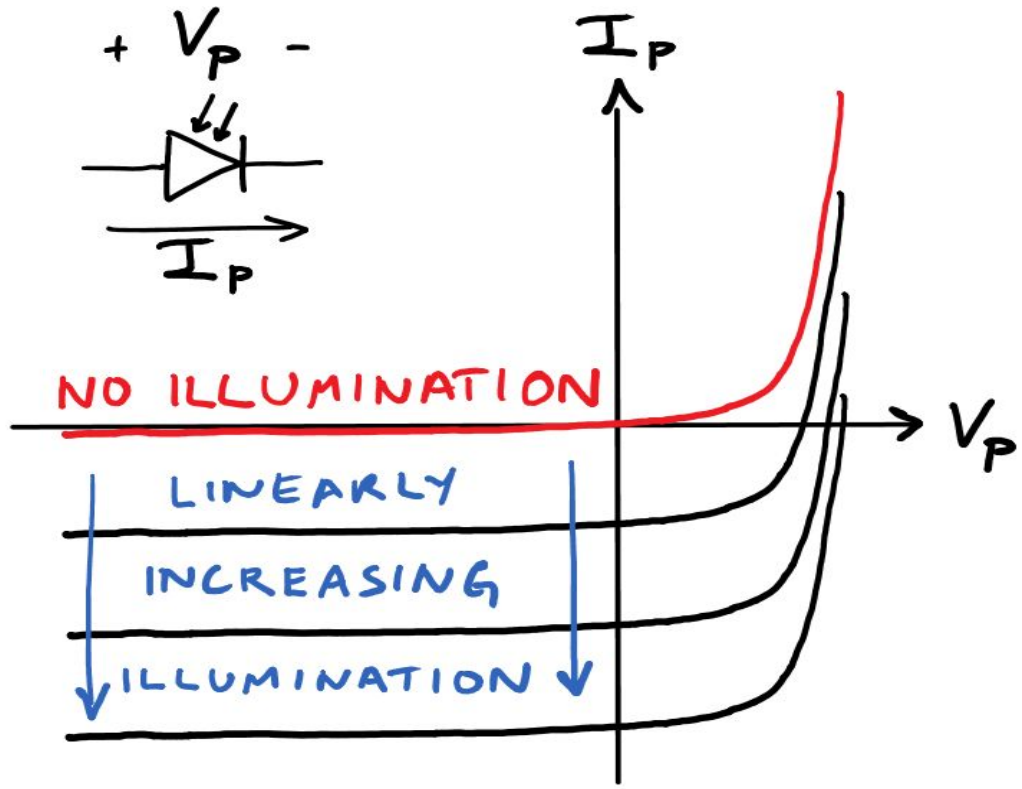
- PIN Junction photodiode is an advancement of PN junction photodiode.
- PIN Junction has an additional layer of pure semiconductor.



- When light falls on the Intrinsic semiconductor layer new electron holes pair are created which adds on to the concentration of holes and electrons thereby **increasing the reverse current !!** which was largely absent in ordinary PN junction photodiodes.
- **inner photoelectric effect**



V-I Characteristics of the photodiode



Key objectives of the photodiodes:

1) High sensitivity to light
2) Generate low noise
3) Low cost,Small size,**Long lifetime!!**

advantages of PIN photodiodes are:

1. Wide bandwidth
2. High quantum efficiency
3. High response speed

Use of Photodiodes:

- Smoke detectors, Medical devices
- Infrared remote control devices.
- Optical communications and in lighting regulations
- Basically in all light sensitive devices…

The six sensors we discussed so far are very discrete in nature...

Wind sensor measures only wind speed

Photodiode detects only light and so on..

A combination of all these SIX sensor can be used to measure weather parameters of any place in a *Hyper-local* fashion !!

Weather Forecasting Drone

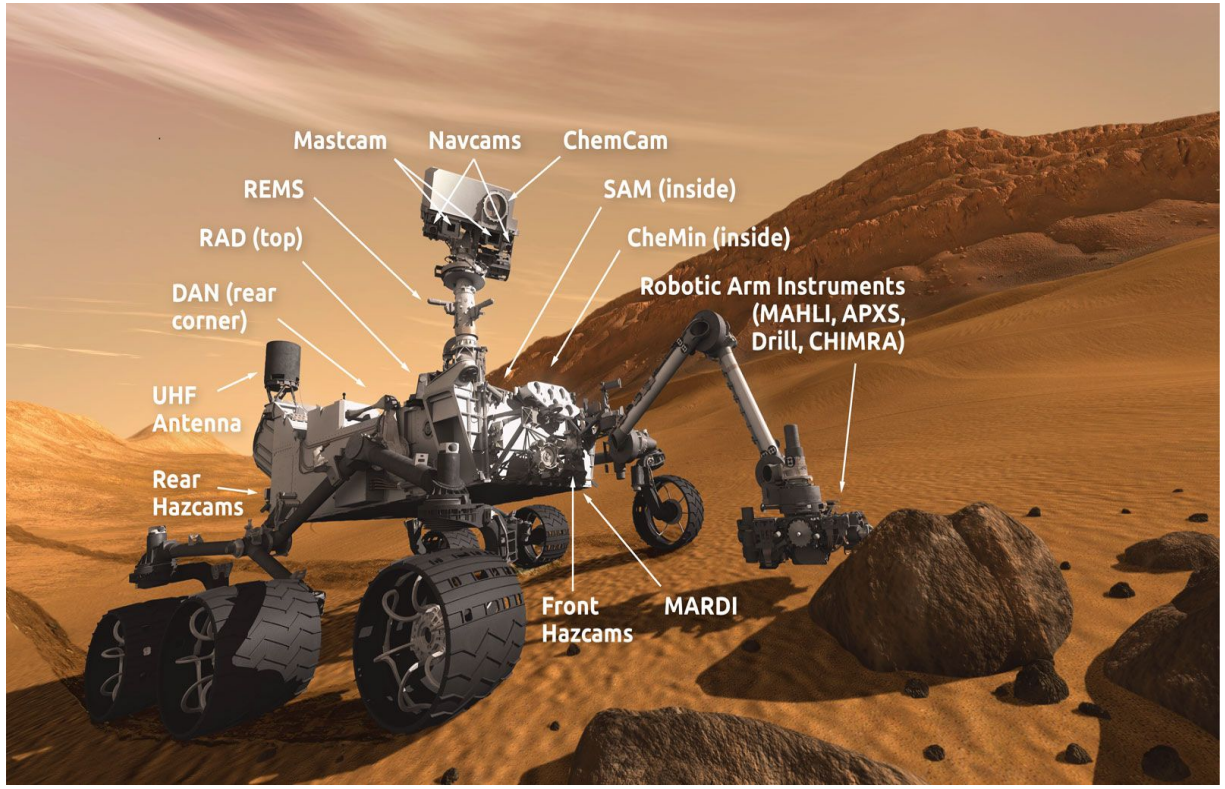
Weather data helps to optimize various function of Car

FUN FACT:

- The **Maximum Temperature shows the strongest effect on *stock and index prices***, when compared with other Weather parameters...

CASE STUDY : ROVER ENVIRONMENTAL MONITORING STATION (REMS)

- **REMS records six parameters:**
  1)wind speed/direction
  (Measured by **Anemometer**)
  2) pressure
  (Measured by **Pressure sensor**)
  3) relative humidity
  (Measured by **Humidity sensor**)
  4) air temperature
  (Measured by **Electrical Air temperature sensor**)
  5) ground temperature
  (Measured by **Thermopile**)
  6)ultraviolet radiation
  (measured by **photodiodes**)



MARS CURIOSITY ROVER

Rover_3d Boom_video

Bits and pieces about CURIOSITY ROVER...

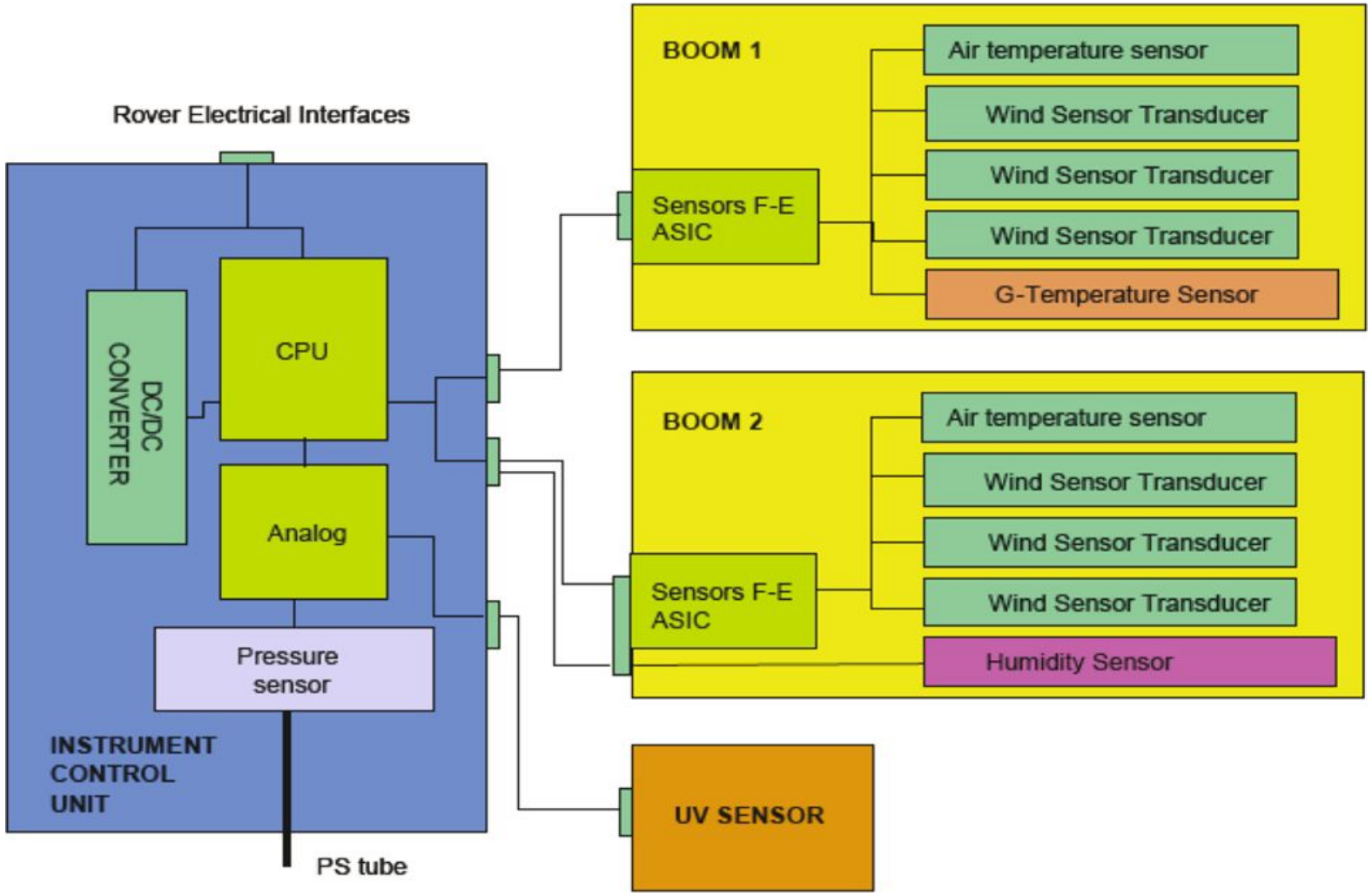
- ***Curiosity*** is a car-sized Mars rover **designed to explore the Gale crater on Mars** as part of NASA's Mars Science Laboratory (MSL) mission.
- Launched from Cape Canaveral on 26 NOV,2011.
- Landed on Mars on 6 AUG,2012.
- The ***Curiosity*** **Project Team** was ***awarded*** the 2012 ***Robert J. Collier Trophy*** by the National Aeronautic Association-

    - "*In recognition of the **extraordinary achievements** of successfully landing Curiosity on Mars, **advancing the nation's technological and engineering capabilities**, and significantly improving **humanity's understanding** of ancient Martian habitable environments*"

A selfie taken by the Curiosity Rover

- A suite of **infrared sensors** is on Boom 1 measuring the intensity of infrared radiation emitted by the ground, which provides an **estimate of ground temperature.**
- A sensor on Boom 2 tracks **atmospheric humidity**
- Both booms carry sensors for measuring **air temperature and wind sensors .**
- The **UV sensor** is located on the rover deck
    - It is composed of six photodiodes in the following ranges:
        - 315-370 nm (UVA)
        - 280-320 nm (UVB)
        - 220-280 nm (UVC)
        - 200-370 nm (total dose)
        - 230-290 nm (UVD)
        - 300-350 nm (UVE)
- The **pressure sensor** is located inside the rover body and is connected to the external atmosphere via a tube.
    - The tube exits the rover body through a small opening with protection against dust deposition.
    - can measure pressure ranging from 1 to 1150 Pa with an end-of-life accuracy of 20 Pa (calibration tests give values around 3 Pa) and a resolution of 0.5 Pa.

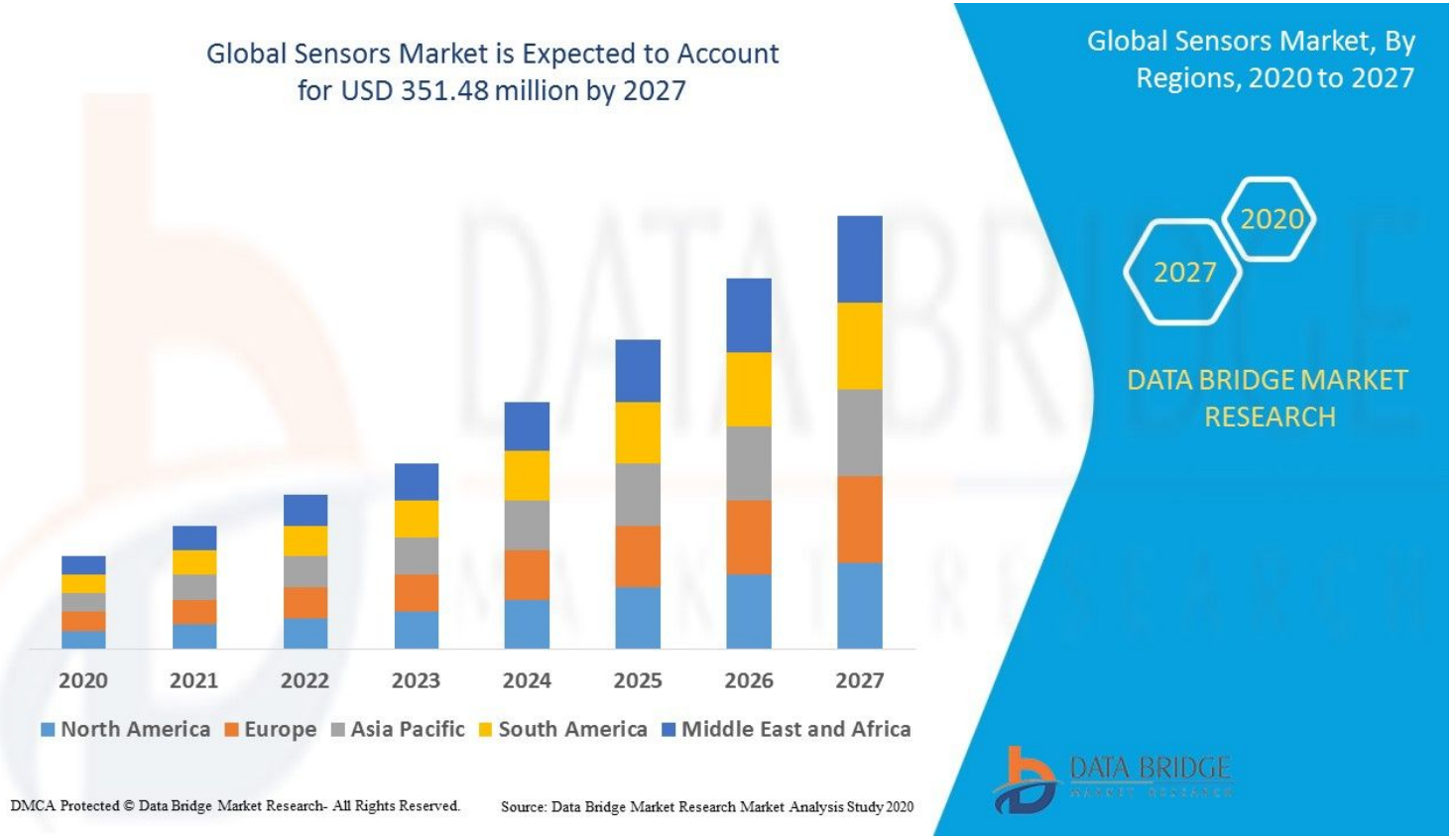
- Each hour in every **sol**, REMS records 5 minutes of data at 1 Hz for all sensors.
  - This strategy has been implemented based on a **high degree of autonomy** in REMS operations.
- The instrument wakes itself up each hour and after recording and storing data,it goes to sleep independently of rover operations.
  - **REMS records data independent of the operation of rover.**



BLOCK DIAGRAM of the REMS

Epilogue

- Sensors are **stepping to electrical domain**.
- Sensors have **Infinite potential** which is yet to unleashed..
- Expected **CAGR** of the sensor market is **9.5%** from 2019-2025
- IoTs,Fully autonomous and integrated Sensors will disrupt our existing lifestyle...



The "SENS-ational" future!!! is near

THANK YOU!!!