CAPSTONE II Presentation

Gas Sensor Analysis

By: Alejandro Moore

What’s the purpose?

Sensor

- Device that has the capability to detect change in its surrounding environment and provides output in the form of analog or digital signal.
- Sends its data through transmitter to the microcontroller/microprocessor.

Single Gas Detector

- Hand-held, portable devices used to monitor one target gas.
- Commonly part of PPE for identification of a hazardous gas.

Multi-Gas Detector

- Ability to monitor multiple target gases.
- Used in industrial and residential settings to locate the presence of a variety of dangerous gases.

Did you know?

There are 4 main types of gas sensors?

- Infrared Sensors
- Photoionization Sensors
- Catalytic Sensors
- Electrochemical Sensors

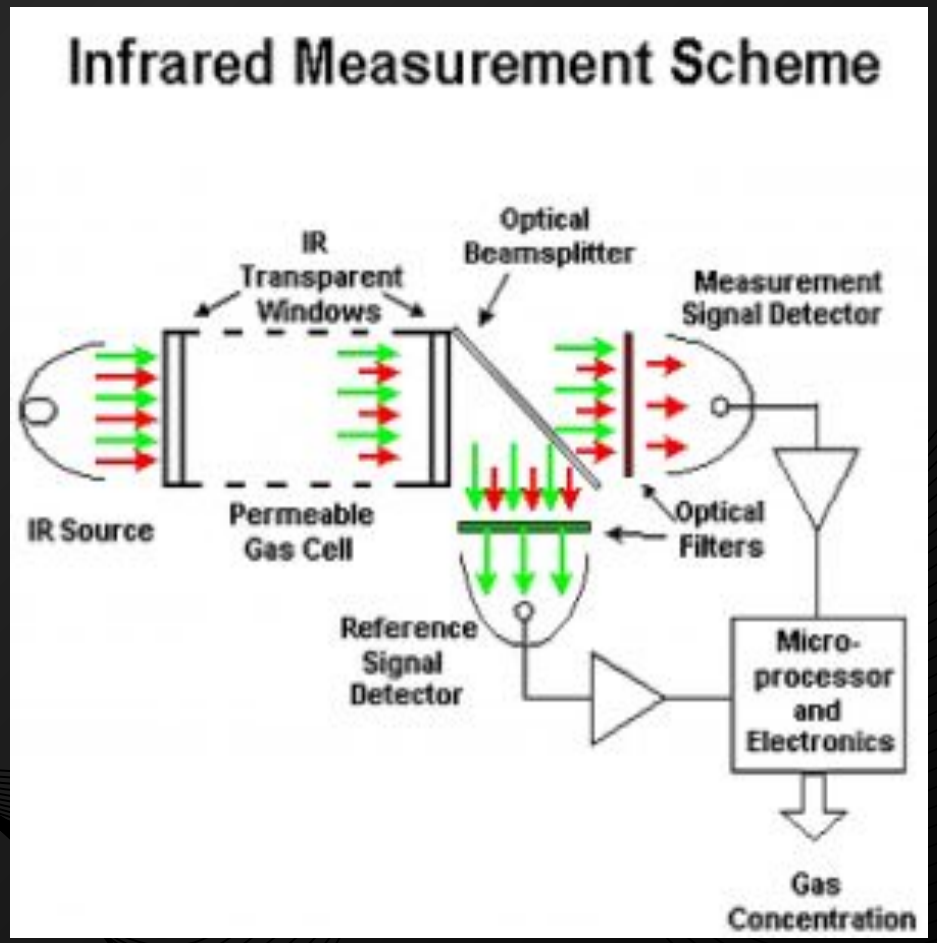
01

We will talk about this first.

Infrared Sensors

Infrared Sensors

- a method for detecting combustible hydrocarbon gas with infrared light.
- Used when there is no oxygen present, or in situations where you measure high carbon dioxide concentrations.
- Infrared source illuminates a volume of gas that has entered inside the measurement chamber.
- Gas absorbs some of the infrared wavelengths as the light passes through it, while others pass through it completely unattenuated.
- A change in the intensity of the absorbed light is measured relative to the intensity of light at a non-absorbed wavelength.
- Infrared gas detection devices may be classified as open path detection or point detection.



Pros & Cons

Advantages

- Speed of response is very quick, typically less than 10 seconds.
- Immune to contamination and "poisoning".
- Practically fail-safe, since any failure of the source or detector, or blockage of the signal by dirt, is immediately detected as a malfunction.
- Able to operate reliable in oxygen-rich or oxygen-poor environments.
- Virtually maintenance free and good for inaccessible areas.

Disadvantages

- Higher initial cost.
- Unable to detect gases that do not absorb infrared energy (ex. Hydrogen).
- Infrared emitting source can not be repaired in the field and must be returned to factory.

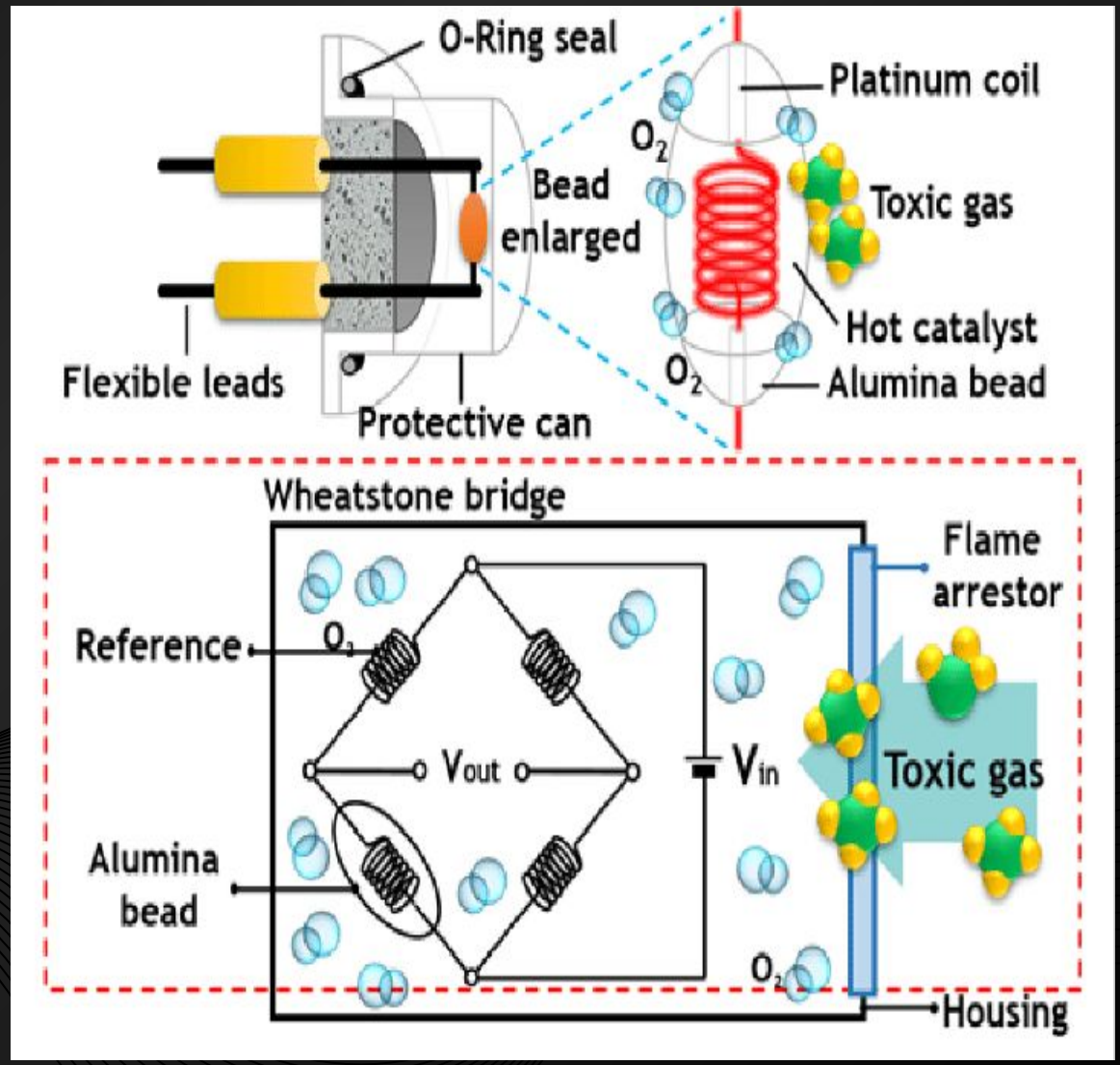
02

We will talk about this next.

Catalytic Sensors

Catalytic Sensors

- Typically used to measure combustible gases that come with an explosion hazard when concentrations are between the lower explosion limit (LEL) and the upper explosion limit (UEL).
- 2 basic elements: a detector which contains a catalytic material sensitive to flammable gases, and a compensator element which is inert.
- Combustible gases will burn in the presence of oxygen only on the detector, causing a rise in temperature and a corresponding rise in electrical resistance, and the sensor will convert the temperature change via a Wheatstone bridge-type circuit.
- When combustible gases raise the temperature of the detector and a rise in its resistance, it causes an imbalance in the circuit and produces an output voltage signal.



Pros & Cons

Advantages

- Easy to install, use, and calibrate.
- Economical, with a long life and low replacement cost.
- Very reliable.
- Can be calibrated to gases such as hydrogen.
- Not sensitive to optics and perform more reliable in dusty environments.
- More reliable in high temperature
- Less sensitive to humidity and changes in air

Disadvantages

- Can become inactive through contamination by chemicals containing chlorine and silicone compounds, as well as sulfuric and other corrosive chemicals.
- The only means of testing sensors is to expose them to known quantities of gas and calibrate them as needed.
- Requires oxygen to operate.
- Long exposure to concentrated hydrocarbons may degrade performance.
- If subjected to extreme gas concentration, the sensor may become damaged and show low or no signal.

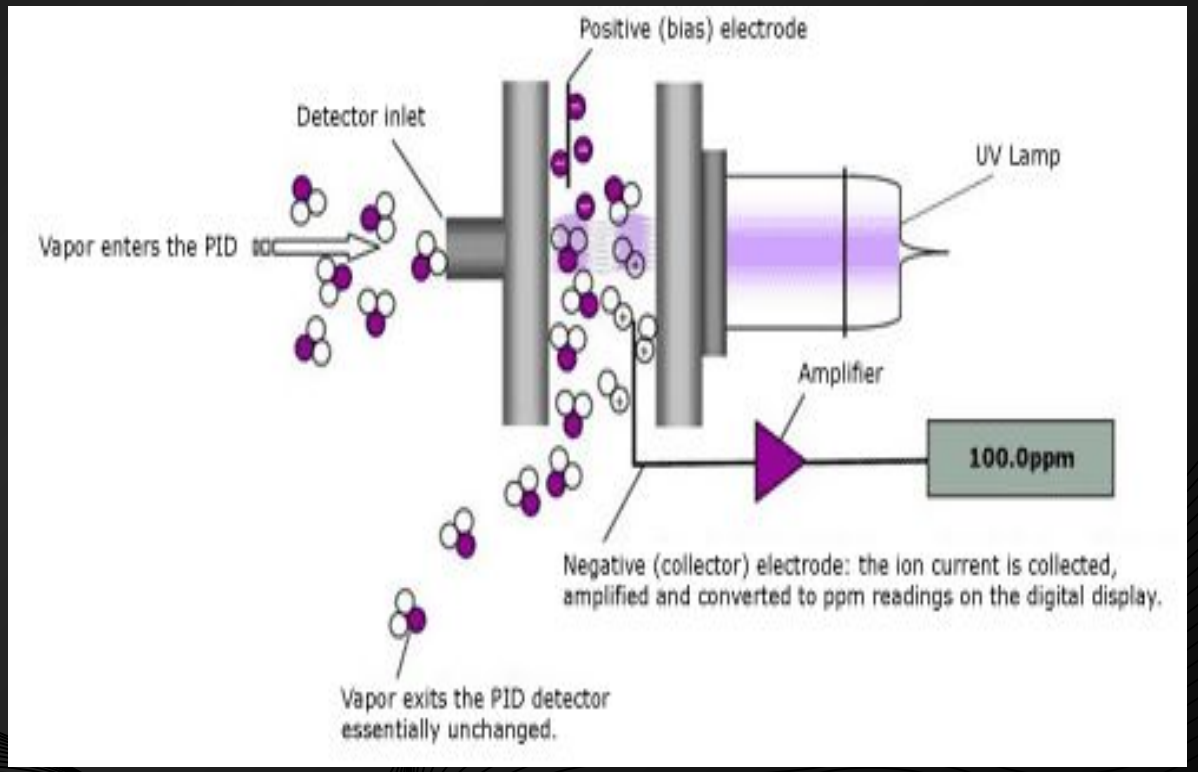
03

We will talk about this next.

Photoionization Sensors

Photoionization Sensors

- Uses an ultraviolet light source to ionise gases to positive and negative ions that can easily be identified with a detector.
- Charge of the ionized gas functions as the concentration of volatile organic compounds (VOC) in the air.
- Most VOCs are detected by these sensors, expect for low molecular weight hydrocarbons.
- UV lamp generates high-energy photons that pass through these lamps into the central chamber of the sensor.
- The gas sample in the atmosphere passes over into the sensor chamber and one percent of it diffuses through a membrane filter.
- Device then generates a current that's proportional to a gas concentration displayed as a ppm or ppb (Parts Per Billion).



Pros & Cons

Advantages

- Cost-effective.
- Simple to use and easy to install.
- Able to provide almost instantaneous results.
- Able to detect low concentrations of VOCs.

Disadvantages

- Not suitable for the detection of semi-volatile compounds.
- May give false positive readings for water vapor and rain. Also, high humidity can cause lamp fogging and decreased sensitivity.
- High concentrations of methane can hinder performance.
- Rapid variations in temperature at the detector, strong electrical fields, and naturally occurring compounds may affect instrument response.
- Must be re-calibrated frequently.

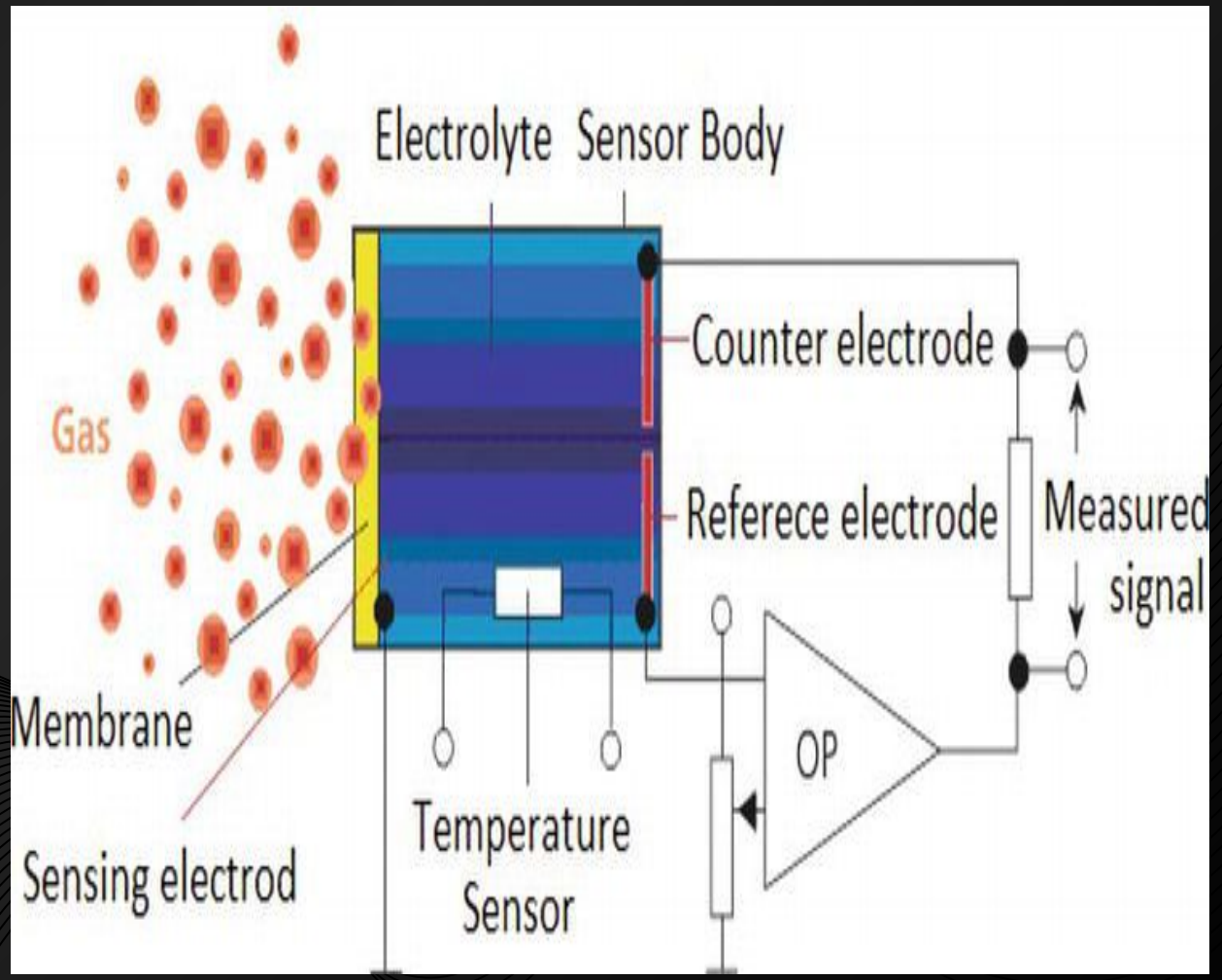
04

Lastly, we will talk about this.

Electrochemical Sensors

Electrochemical Sensors

- Measure a specific gas concentration by oxidising or reducing the gas to an electrode, generating a positive or negative current flow.
- Membrane allows gas to pass into the sensor, which in turn can either create oxidation or reduction.
- The electrical current generated is proportional to the concentration of the target gas.
- Current is then amplified and processed according to the calibration to give the user a reading in either parts per million (PPM) or percentage volume.
- To avoid cross-sensitivity, it is important to use filters and biasing voltage during operations to minimize the effect on the accuracy.



Pros & Cons

Advantages

- Linear output, low power requirements and good resolution.
- Excellent repeatability and accuracy.
- Does not get poisoned by other gases.
- Less expensive than most other gas detection technologies.

Disadvantages

- Narrow or limited temperature range.
- Short or limited shelf life.
- Cross-sensitivity of other gases.
- The greater the exposure to the target gas, the shorter the life-span.

Overview

- Each sensor has its own strength and weakness.
- User must take into account cost, accuracy, resolution, life-span, and many other factors before knowing which sensor will complete the task successfully.
- For the Citizen Air Quality Sensor, we will use Electrochemical Gas Sensors to meet the requirements in our Project Proposal.

Thank You!

References

- NewCastle Saftey Servicing https://newcastlesafetyservicing.com/types-of-gas-detectors/#:~:text=In%20this%20article%2C%20we'll,infrared%20sensors%20and%20photoionization%20sensors.
- Gas and Flame Detection https://www.gdscorp.com/infrared-gas-detectors/#:~:text=Infrared%20gas%20detection%20is%20a,and%20an%20optical%20infrared%20receiver.
- EnggCyclopedia https://enggcyclopedia.com/2011/11/infrared-gas-detectors/
- Technical Services https://www.buygasmonitors.com/blog/a-comprehensive-overview-to-photoionization-detectors/
- Photo Ionization Detector http://www.cpeo.org/techtree/ttdescript/photion.htm#:~:text=Limitations%20and%20Concerns&text=The%20PID%20may%20give%20false,lamp%20fogging%20and%20decreased%20sensitivity
- RC Systems https://www.rcsystemsco.com/photoionization-detectors#:~:text=Advantages%20of%20Photoionization%20Detectors,and%20other%20emergency%20leak%20situations.
- Safety+Health https://www.safetyandhealthmagazine.com/articles/the-pros-and-cons-of-electrochemical-sensors-2