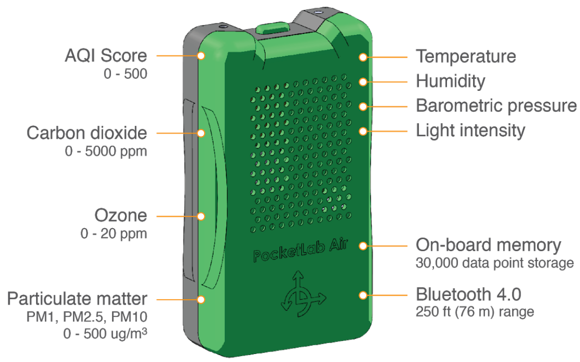
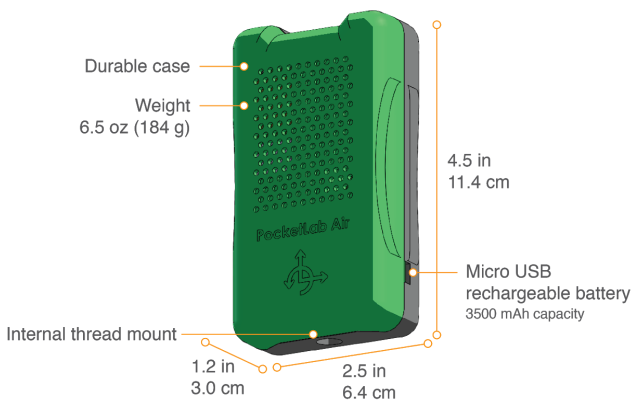
PocketLab Air Getting Started Guide





Power Button		
Short button press	Fast red and green flash	Start Bluetooth advertising
Long button hold (5 seconds)	Solid red	Power off PocketLab

LED Flashing Codes	
Alternating fast red and green flash	PocketLab Air is advertising to connect to Bluetooth
3 blue flashes	PocketLab Air initiated Bluetooth connection to the app
1 violet flash every 5 seconds	PocketLab Air is connected to the app
Alternating slow red and green flash	PocketLab has disconnected from the app and is powered on
3 red flashes every 5 seconds	PocketLab battery is low
3 red flashes every 10 seconds	PocketLab battery is charging when connected to micro USB
Orange flashes	PocketLab is downloading stored memory data to the app

App Icon Functionality	
	Settings, help, and battery meter
	Select sensor graph views
	Memory Data Logging set up
	Select sensor data rate
	Select the graph units
	Select camera mode (iOS only)
	View more options

App Requirements	
iOS	iPhone 4s, and newer iPads all except the iPad 1 and iPad 2 iPod Touch 5th gen and newer
Android	Android OS 5.0 and newer Most phones and tablets made since 2013
Windows 10	Native Bluetooth 4.0 support required. Most PCs made since 2013. Updated Chrome browser.
Mac OS	Macbook, Macbook Pro, Macbook Air with OSX 10.11 or later. Updated Chrome browser.
Chromebook	Bluetooth 4.0 support required. Most Chromebooks made since 2013.

App Installation and Setup

1. The PocketLab App is supported on the latest operating system and app versions. Please make sure your OS version and PocketLab App are up to date.
2. Before connecting, go to your device settings and turn Bluetooth ON.
3. For iPhones, iPads, and Android phones, download the PocketLab App from the Apple App Store or Google Play Store.
4. For MacOS, Chromebooks, and Windows 10 devices there is no need to download anything. Make sure you are using the latest version of a Google Chrome web browser and go to www.thepocketlab.com/app to connect to the PocketLab Web App.

Battery Charging

1. To charge the battery, connect a micro USB cable to the connector on the PocketLab. Plug the USB cable into a USB charger or computer port.
2. The LED will blink red every 10 seconds while charging and stop blinking when fully changed.

Connecting to PocketLab - iPhone, iPad, or Android Phone

1. Launch the PocketLab app.
2. Press the power button on the PocketLab sensor. The LED will flash alternating red and green.
3. If the PocketLab sensor is in close range to your device, the sensor will connect automatically, and the LED will flash blue. If the sensor does not connect, tap on the serial number on the connection screen.
4. When connected to the app, the LED will flash violet every 5 seconds.

Connecting to PocketLab - MacOS, Chromebook, or Windows 10 Device

1. Open a Chrome browser and go to www.thepocketlab.com/app.
2. Click “Connect to PocketLab.”
3. A connection window will appear listing PocketLabs available for Bluetooth connection.
4. Press the top button on the PocketLab sensor. The LED will flash alternating red and green.
5. The name of the PocketLab will appear in the connection window. Click on the name of the PocketLab and then click “Pair.”
6. When connected to the app, the LED will flash violet every 5 seconds.

Displaying and Recording Sensor Data

1. To record data, press the **Record** button on the graph screen. The current data will clear and the app will record new sensor data.
2. To stop the data recording, press the **Stop** button.
3. When the data recording has stopped, you can scroll through the graph, zoom in and out, and select graph points to view the data values.
4. Press the **Share** button to save or export the recorded sensor data.
5. When you are done reviewing or saving your data, press the **Clear** button to start streaming real-time sensor data gain.

Disconnecting the Sensor

1. To disconnect, press and hold the top button on the PocketLab sensor for 5 seconds. The LED indicator will flash red then stop.
2. Exit the PocketLab App.

Air Quality Index

Background Information

The Air Quality Index (AQI) is a scale for reporting the level of pollution in the ambient air in a particular location over a certain time period. The AQI helps people understand the health risks of the air they are breathing. The lower the AQI number, the less pollution and the healthier the air, and the higher the AQI number, the more pollution and higher risk of adverse health effects.

AQI is calculated differently depending on the agency that measures and reports the data. For example, the United States Environmental Protection Agency (EPA) uses an AQI scale from 0 to 500, and the Canadian Air Quality Health Index uses a scale from 1 to 10. For the US EPA scale the values 0 to 500 correspond to six health levels

Good	**0 to 50**	**Air quality is considered satisfactory, and air pollution poses little or no risk.**
Moderate	**51 to 100**	**Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.**
Unhealthy for Sensitive Groups	**101 to 150**	**Members of sensitive groups may experience health effects. The general public is not likely to be affected.**
Unhealthy	**151 to 200**	**Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.**
Very Unhealthy	**201 to 300**	**Health alert: everyone may experience more serious health effects.**
Hazardous	**301 to 500**	**Health warnings of emergency conditions. The entire population is more likely to be affected.**

The EPA bases the AQI on the concentration of five pollutants:

1. Ozone (O3)
2. Particulate Matter 2.5 um and 10 um in size (PM2.5 and PM10)
3. Carbon Monoxide (CO)
4. Sulfur Dioxide (SO2)
5. Nitrogen Oxides (NOX)

The AQI is calculated based on the following procedure

- AQI value is based on the unhealthiest level of the five pollutants. For example, if ozone is at an Unhealthy level of 180 and all the other pollutants are at Good level of 50 or below, the AQI will be equal to 180.
- The pollutant levels are averaged over a time period of 1 to 24 hours to do calculation.
- If a measurement device cannot measure all five pollutants, the AQI is calculated just from the pollutants that can be measured.

How does the sensor work?

PocketLab Air calculates the AQI based on the U.S. EPA scale from 0 to 500. The AQI is calculated from particulate matter (PM2.5 and PM10) and ozone measurements. Carbon dioxide is not a pollutant measured for AQI.

On the app display, the instantaneous AQI measurement and a 10-minute running average is displayed.

When you turn on PocketLab Air and first start collecting data, the sensors may take 10 minutes to warm up and provide an accurate measurement. Especially if you just take PocketLab Air out of a backpack or somewhere with lint or fine dust, the device will take some time to circulate ambient air through the sensors and make an accurate measurement.

Lab Investigation

Investigate this research question: Is the air quality in my location better, worse, or the same inside versus outside?

Setup the PocketLab Air inside your house, school, or office building on a desk or shelf where the device will not be disturbed. Connect PocketLab Air to the PocketLab app and collect data for 1 hour. Next, move the PocketLab outside to a secure and convenient location and record data for 1 hour. Continue to record data on the app.

After one hour stop the data recording and analyze the graph. Think about these questions to help guide your analysis:

- Did the AQI data change over the hour that you collected data inside? Did the graph level off and reach a consistent value or was it still significantly changing?
- When you moved the PocketLab Air from inside to outside, did you see a change?
- Did the AQI data stay at a consistent value or fluctuate while outside?
- What was the average AQI value inside? What was the average AQI value outside?
- Do you think there’s a part of the graph that has more accurate or reliable data than another part of the graph?
- Did the experimental data agree or disagree with your hypothesis?

Citizen Science Investigation

Compare the measurement of your local air quality with publicly available databases. The PocketLab app will display nearby AQI data and you can also explore resources like AirNow from the U.S. EPA available online. The EPA uses equipment that costs hundreds of thousands of dollars and can be the size of a trailer. These stations are very accurate, but they are sparsely distributed. Questions to investigate:

- How does the PocketLab Air AQI measurement compare to the nearest monitoring station?
- How can we use portable measurement equipment like PocketLab Air in conjunction with government monitoring stations?
- What are the limitations by only having a few government monitoring stations covering a large geographical area?

From: http://www.dnrec.delaware.gov/Air/Pages/Air-Quality-Monitoring-Homepage.aspx

Particulate Matter (PM)

Background Information

Particulate matter consists of small particles suspended in the atmosphere. Dust, pollen, sea salt, soil particles, mold, soot, smoke, and other fine substances create a mixture of particulate matter that we inhale with every breath. According to the EPA, particulate matter greater than 10 micrometers is generally filtered away in our nose and throat. Particulates less than 10 micrometers can often pass into the lungs. The smaller the particle size, the further it can move into the cardiovascular system and cause serious health concerns.

Inhalable coarse particles (PM 10)
Diameter: 2.5 micrometers - 10 micrometers
Emission sources: fossil fuel combustion, dust from construction and other industrial sites, larger particles from wildfires and brush burning, and pollen.

Fine Particles (PM 2.5 and PM 1.0)
Diameter: 2.5 micrometers and smaller
Emission sources: fossil fuel combustion (gasoline, oil, diesel fuel), particles in smoke from wildfires, particles formed when pollutants from industries and cars react in the atmosphere.

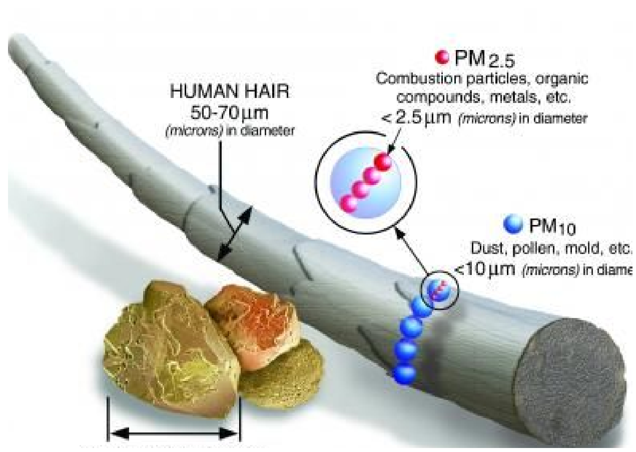
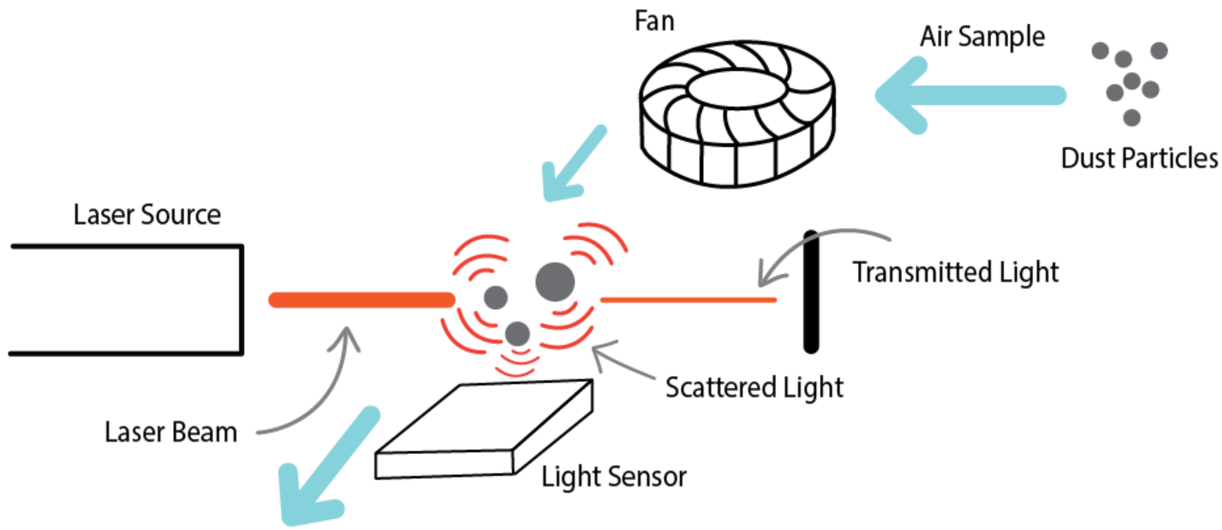


Diagram from the U.S. EPA

How Does the Sensor Work?

The PM sensor uses the principle of laser scattering to count the particles in the air. The PM sensor operates through the following method:

- A laser diode shines a light beam through a cavity.
- A fan draws air into the cavity with fine dust particles suspended in the air.
- As the laser beam shines through the air, the dust particles deflect or scatter some of the laser light.
- A light sensor, called a photodiode, measures how much laser light is transmitted through the cavity and how much is scattered by the dust particles.
- The microprocessor in the sensor converts the light measurements into dust concentration measurements, using a process called Mie scattering theory (named after German physicist Gustav Mie).



Lab Investigation

You can generate and measure changes in PM concentration to better understand how the PM sensor works and responds to environmental conditions. Example activities:

1. Burn a match, candle, or incense near the PocketLab Air and observe changes in the measurement. Try blowing out the candle or match and see what happens.
2. Record data in your kitchen before, during, and after you cook something on the stove. What happens when you start a strip of bacon sizzling?!

Citizen Science Investigation

No Idling Zones: There are many places in neighborhoods were automobiles sit while their engines idle. Examples where idling vehicles could be unhealthy for nearby people:

1. School buses and parents in their cars during pick-up and drop-off time at school
2. City busses at a transit station
3. Dump trucks and other equipment at a construction site

Set up your PocketLab Air to record PM 10, PM 2.5, and PM 1.0 data during times when the vehicles are idling and in the same location when there are no idling vehicles.
What do you notice? Can you find evidence to support more “No Idling Zones” in your community?

Carbon Dioxide

Background Information

Carbon dioxide circulates naturally in Earth's atmosphere as part of the carbon cycle (the process in which carbon dioxide is exchanged between the atmosphere, oceans, soil, plants, and animals). According to the EPA, since the industrial revolution humans have altered the carbon cycle through activities like burning fossil fuels, which adds CO_2 to the cycle, and deforestation which reduces natural ways in which CO_2 is removed.

The increase in greenhouse gases, like CO_2, trap heat in the atmosphere and contribute to global climate change. The pie-chart from the EPA shows a breakdown of the sources of carbon emissions in the United States. Other major greenhouse gases are methane and nitrous oxide.

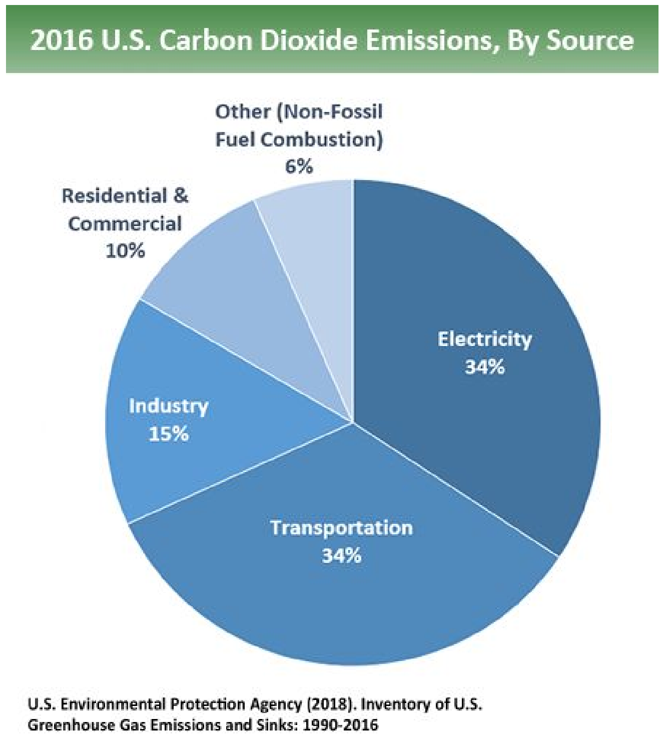
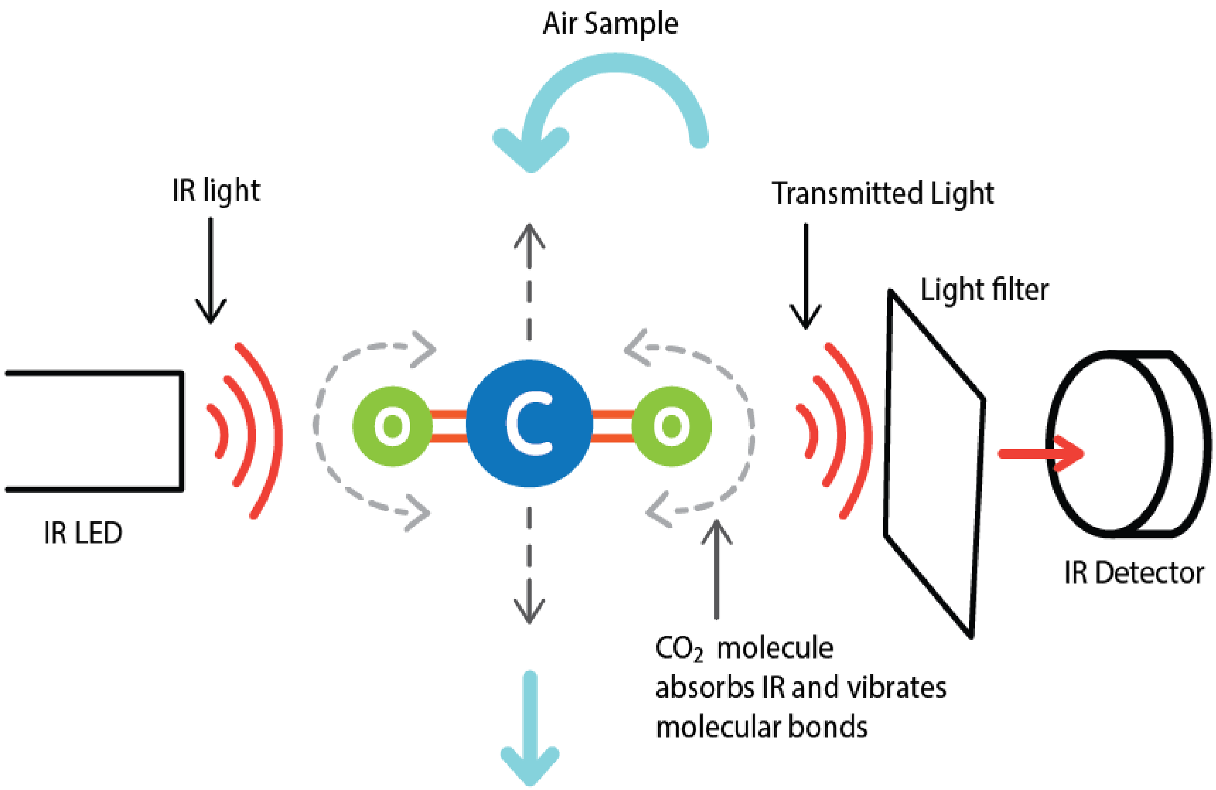


Diagram from the U.S. EPA

How does the sensor work?

The carbon dioxide (CO_2) sensor uses non-dispersive infrared (NDIR) radiation to measure the concentration of CO_2 in the air. The sensor operates through the following method:

- An infrared light emitting diode (IR LED) emits light at a wavelength of 4.26 um.
- The IR light passes through the air and hits CO_2 molecules which absorb that specific wavelength of light.
- The light absorption causes vibrations of the CO_2 molecular bonds and reduces the amount of IR light that passes through the air.
- An infrared (IR) detector, also called a photodiode, detects how much IR light passed through the air sample.
- An optical filter covers the detector to only allow light with 4.26 um wavelength to pass through.
- The IR detector is calibrated to a known CO_2 concentration in a laboratory and the data is stored in the sensor memory.



Lab Investigation

Measure your own respiration:
Exhale your breath toward the front of your PocketLab Air while measuring Carbon Dioxide. What do you notice?

Inside the cells in your body, when glucose (from the food you eat) reacts with oxygen (from the air you breathe), carbon dioxide, water, and energy are produced. You use the energy and exhale the carbon dioxide.

Cellular respiration in yeast:
Yeast, a common fungus, is an ingredient often used in baking. When yeast is active in warm water, it can convert sugar into carbon dioxide through cellular respiration.

1. Place a bowl of warm water with a tablespoon of yeast in a small dish.
2. Inside a larger container place the dish and the PocketLab Air.
3. Add a tablespoon of sugar to the yeast mixture and seal the large container.
4. Record CO_2 measurements and observe the yeast and sugar mixture.

As the yeast consumes the sugar the mixture will react and foam. What do you notice in the CO_2 graph? Why?

Citizen Science Investigation

There are many ways in which humans have added CO_2 to the carbon cycle. Using your PocketLab Air, investigate what areas in your neighborhood emit high amounts of CO_2.

Hint: Transportation accounts for 34% of carbon emissions in the US. A highway or high traffic road could be a good place to start. Record CO_2 data for 30 minutes near a highway and compare it with 30 minutes of recorded CO_2 data from a low traffic area. Make sure you are being safe in areas of high traffic and always staying on sidewalks.

A **Carbon Sink** is a natural or human-made reservoir that can accumulate carbon from the atmosphere and store it for a period of time. Trees and other plants are natural carbon sinks through the process of photosynthesis.

Thinking about what areas in your neighborhood emit high amounts of CO_2, how could Carbon Sinks be better implemented in your community to combat climate change?

Ozone

Background Information

Ozone (O_3) in our atmosphere is both good and bad. There is a helpful saying to remember "ozone: good up high, bad nearby." Good ozone is ozone high in our atmosphere that is part of the ozone layer. The ozone layer protects us from the sun's ultraviolet rays. Bad ozone is ozone that occurs at ground level, where it can be inhaled. Ground level ozone is a pollutant and creates smog.

Ground level ozone is not directly emitted. It is the result of sunlight causing a chemical reaction between nitrogen oxide (NOx) and volatile organic compounds (VOC). NOx and VOCs are emitted directly from sources like chemical plants, refineries, cars, and more. Ground level ozone can cause a variety of health problems and can weaken plants and ecosystems.

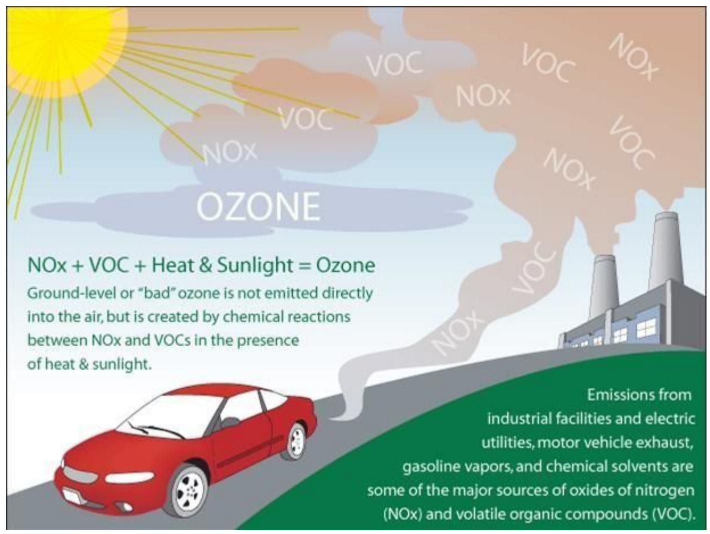
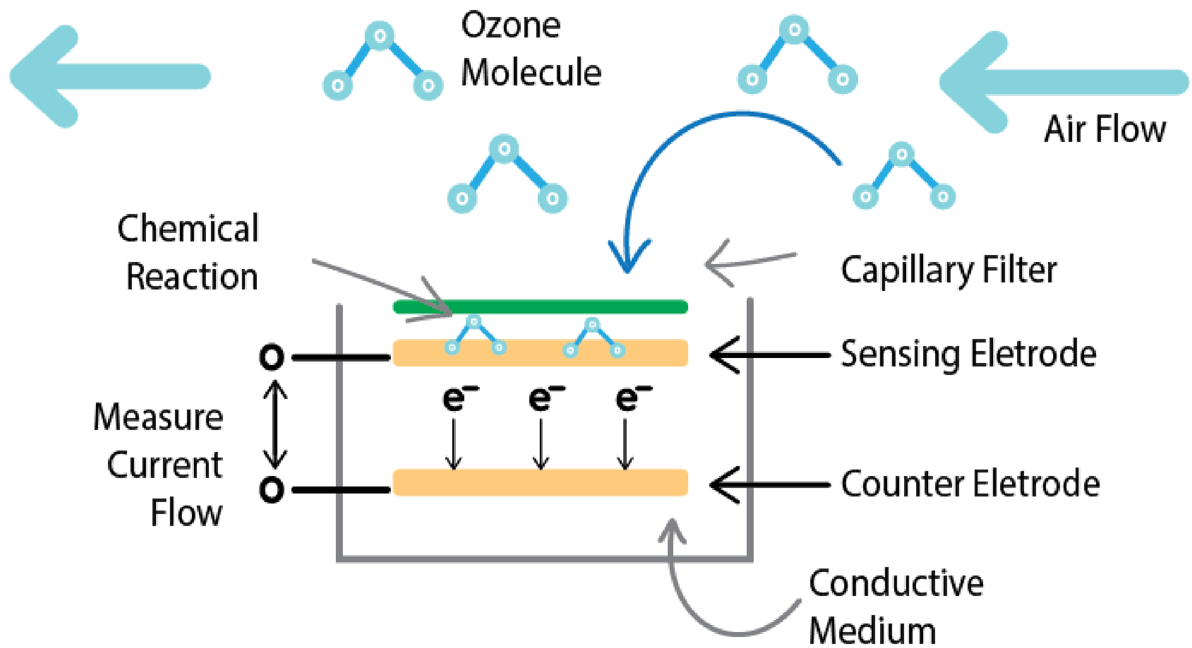


Diagram from the U.S. EPA

How Does the Sensor Work?

The ozone sensor measures ozone concentration through an electrochemical reaction. Typical electrochemical sensors are large industrial sensors that use a liquid electrolyte. The PocketLab Air uses a new type of sensor with a solid state electrolyte to enable PocketLab to be small and portable. The electrochemical ozone sensor operates through the following method:

- Ozone in the air passes through a filter to screen out particles and moisture.
- The ozone molecules undergo a chemical reaction with the sensing electrode that generates free electrons.
- The electrons flow through a conductive medium to the counter electrode.
- The flow of electrons creates an electric current that is proportional to the concentration of ozone gas.
- The electrodes are connected to a circuit to measure and amplify the current signal.



Lab Investigation

The PocketLab Air ozone measurements are strictly for educational purposes and should not be used for safety monitoring.

Ozone is a harmful gas to humans even in small amounts. Typical levels of ozone in the environment are at concentrations less than 50 parts per billion or 0.000005% of the molecules in the air. Unhealthy levels of ozone begin above 165 ppb concentration for an exposure time of one hour.

We do not recommend trying to generate ozone gas for experiments without appropriate training and in a controlled laboratory environment. Unintentional sources of ozone generation can come from electric arcing or sparking in electric motors. Industrial ozone generators are commonly used to deodorize air and to disinfect water.

Citizen Science Investigation

When is your community most sensitive to ozone pollution? Measure ozone levels and weather conditions on a variety of days and in a number of locations. Some things to consider:

1. Sunny days compared to cloudy days (use with light intensity data).
2. Warm days compared to cold days (use with temperature data).
3. Near known pollutant sources like highways and factories (use with geo location data).
4. Windy days compared to calm days (wind can carry ozone pollution to areas far away).