

CO₂ Gas Sensor

(Order Code CO2-BTA or CO2-DIN)



The Vernier CO₂ Gas Sensor is used to monitor gaseous carbon dioxide levels in a variety of biology and chemistry experiments. It can measure small changes in carbon dioxide concentration in photosynthesis and respiration experiments. It measures gaseous carbon dioxide levels in the range of 0 to 5000 ppm by recording the amount of infrared radiation absorbed by carbon dioxide molecules. The CO₂ Gas Sensor allows students to:

- Measure increases in carbon dioxide levels from small animals and insects, such as crickets or worms.
- Monitor the changes in carbon dioxide concentration in a plant terrarium during photorespiration and photosynthesis cycles.
- Measure CO₂ levels during cell respiration of peas or beans.
- Measure changing carbon dioxide levels in a classroom.
- Monitor the rate at which carbon dioxide is removed from an enclosed atmosphere using sodium hydroxide or potassium hydroxide.
- Measure the rate of production of carbon dioxide in a chemical reaction between hydrochloric acid and sodium bicarbonate.
- Determine the rate at which carbon dioxide gas diffuses through a gas diffusion tube.
- Monitor production of carbon dioxide during fermentation or respiration of sugars.

NOTE: This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

Inventory of Items Included with the CO₂ Gas Sensor

Check to be sure that each of these items is included with your CO₂ Gas Sensor:

- 250 mL gas sampling bottle (Nalgene bottle with lid)
- Split rubber stopper to attach the gas sampling bottle to the sensor tube of the CO₂ Gas Sensor
- CO₂ Gas Sensor booklet

Using the CO₂ Gas Sensor with a Computer

This sensor can be used with a Macintosh® or Windows® computer and any of the following lab interfaces: Vernier LabPro®, Universal Lab Interface, or Serial Box Interface. Here is the general procedure to follow when using the CO₂ Gas Sensor with a computer:

1. Connect the CO₂ Gas Sensor to the appropriate port on the interface.
2. Start the Logger Pro® data-collection software on the computer.
3. The program will automatically identify the CO₂ Gas Sensor and you are ready to collect data.¹

Using the CO₂ Gas Sensor with Graphing Calculators

This sensor can be used with a TI graphing calculator and any of the following lab interfaces: LabPro, CBL 2, or CBL. Here is the general procedure to follow when using the CO₂ Gas Sensor with a graphing calculator:

1. Load a data-collection program onto your calculator:
 - LabPro or CBL 2—Use the DataMate program. This program can be transferred directly from LabPro or CBL 2 to the TI graphing calculator. Use the calculator-to-calculator link cable to connect the two devices. Put the calculator into the Receive mode, and then press the Transfer button on the interface.
 - Original CBL—Use the CHEMBIO program. This program is available free on our web site at www.vernier.com. Load the program into a calculator using TI-GGRAPH LINK™ or TI Connect™.
2. Use the calculator-to-calculator link cable to connect the interface to the TI graphing calculator using the I/O ports located on each unit. Be sure to push both plugs in firmly.
3. Connect the CO₂ Gas Sensor to any of the analog ports on the interface. In most cases, Channel 1 is used. Start DataMate, and the CO₂ Gas Sensor will be identified automatically.²

Using the CO₂ Gas Sensor with Palm OS® Handhelds

This sensor can be used with a Palm OS handheld and the LabPro. Use the following general setup procedure:

1. Connect the Palm OS handheld, LabPro, and the CO₂ Gas Sensor.
2. Start Data Pro.
3. Tap New, or choose New from the Data Pro menu. Tap New again. The CO₂ Gas Sensor will be identified automatically.³ You are ready to collect data.

¹ If your system does not support auto-ID, open an experiment file in Logger Pro, and you are ready to collect data.

² If your system does not support auto-ID, choose SETUP and set up an experiment.

³ If your sensor does not auto-ID, tap Setup and set up an experiment.

Taking Measurements

Follow these steps to collect data using the CO₂ Gas Sensor:

1. Allow the CO₂ Gas Sensor to warm up for about 90 seconds,⁴ then start collecting data. **Note:** Since the CO₂ Gas Sensor updates its reading every second, do not set the data rate faster than 1 reading per second. Once you have started collecting data, you should see the red LED on the sensor box turn on each time the sensor takes a new reading—about once every second.
2. When you have finished collecting data, simply remove the sensor from the gas sampling bottle. We recommend that you leave the slit rubber stopper on the sensor tube. Store the sensor in the box in which it was shipped.

Additional Information

- Whenever possible, we recommend that you connect the AC Adapter to the computer or handheld interface when using the CO₂ Gas Sensor. The large current required by the CO₂ Gas Sensor results in a significant decrease in battery life.
- Only one CO₂ Gas Sensor can be used at a time with the interface.
- The sensor cannot take readings at a CO₂ concentration higher than 5000 ppm. Once the CO₂ concentration reaches this level, the computer or handheld will continue to display a reading of ~5000 ppm until the actual level drops below 5000 ppm again.
- Even though the sensor responds rather quickly to changes in CO₂ concentration, remember that gas has to diffuse through the holes in the sensor tube before any changes in concentration can be detected. Since diffusion of gases is a fairly slow process, there is a resulting delay in the readings. Likewise, if you expose the sensor to higher levels of CO₂ (such as exhaled breath, which can be > 50,000 ppm of CO₂), then it may take a minute or more for the CO₂ chamber to exchange the higher concentration of CO₂ for lower concentrations in its surroundings. Fanning air toward the sensor tube can speed up this process.
- To collect data in a controlled environment, we recommend that you use the slit rubber stopper and the 250 mL Nalgene collection bottle that is included with your sensor.
- **Very important:** Do not place the sensor tube directly into any liquid. The sensor is intended only for measuring gaseous, not aqueous, CO₂ concentration.
- **Important Tips for Original CBL Users:** The CO₂ Gas Sensor needs to warm up for 90 seconds any time power is interrupted. Even if the sensor has been plugged into the interface continuously, the CBL Automatic Power Down feature (ADP) results in a power interrupt each time you advance to a new part of the CHEMBIO program, and the sensor will need to go through a 90-second warm-up period again.

⁴While the CO₂ Gas Sensor is warming up, you will see readings increase to ~5000 ppm and then slowly decrease back to the CO₂ level to which the sensor is exposed.

Specifications

Measurement range of CO₂ Gas Sensor: 0–5000 ppm CO₂

Accuracy (at standard pressure, 1 atm):

±100 ppm in the range of 0–1000 ppm

±10% of reading in the range of 1000–5000 ppm range

Typical Resolution: 20 ppm

Response time: 95% of full-scale reading in 120 seconds (faster when air currents are provided)

Warm-up time (connected to powered interface): 90 seconds (maximum)

Pressure effect: 0.19% of reading/mm of Hg from standard pressure

Output signal range: 0–2.5 V

Output impedance: 1 kΩ

Input potential: 5 V (±0.25 V)

Gas sampling mode: diffusion

Normal operating temperature range: 25°C (±5°C)

Operating humidity range: 5–95%, non-condensing

Storage temperature range: -40 to 65°C

Calibration information:

slope (gain): 2000 ppm/V

intercept (offset): 0 ppm

live calibration: performed by push button in outdoor ambient air (~400 ppm)

This sensor is equipped with circuitry that supports auto-ID. When used with LabPro or CBL 2, the data-collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor. This greatly simplifies the setup procedures for many experiments. Auto-ID is required for the Quick Setup feature of LabPro and CBL 2 when the unit operates remotely from the computer or calculator. If you purchased a CO₂-DIN to connect to the sensor to a ULI or Serial Box Interface, the auto-ID feature is not supported in these interfaces.

How the CO₂ Gas Sensor Works

The Vernier CO₂ Gas Sensor measures gaseous carbon dioxide levels in the range of 0 to 5000 ppm by monitoring the amount of infrared radiation absorbed by carbon dioxide molecules. The sensor uses a hot metal filament as an infrared source to generate infrared radiation (IR). The IR source is located at one end of the sensor's shaft. At the other end of the shaft is an infrared sensor that measures how much radiation gets through the sample without being absorbed by the carbon dioxide molecules. The detector measures infrared radiation absorbed in the narrow band

centered at 4260 nm. The greater the concentration of the absorbing gas in the sampling tube, the less radiation will make it from the source through the sensor tube to the IR detector. The temperature increase in the infrared sensor produces a voltage that is amplified and read by a Vernier interface or the CBL 2. Carbon dioxide gas moves in and out of the sensor tube by diffusion through the eight vent holes in the sensor tube. When the sensor is collecting data, you can see the IR source blinking on and off. It takes a new reading about once every second.

The CO₂ Gas Sensor typically measures gaseous carbon dioxide concentration in units of parts per million, or ppm. In gaseous mixtures, 1 part per million refers to 1 part by volume in 1 million volume units of the whole. A concentration of 600 ppm for CO₂ would simply mean that there is 600 L of CO₂ gas for every 1,000,000 L of air (or 0.6 mL of CO₂ per 1 L of air). As a comparison, the level of carbon dioxide in the Earth's troposphere has gradually increased from 317 ppm in 1960 to current levels of nearly 370 ppm. Exhaled human breath has a carbon dioxide concentration of about 50,000 ppm.

Do I Need to Calibrate the CO₂ Gas Sensor? "No"

We feel that you should not have to perform a new calibration when using the CO₂ Gas Sensor in the classroom. We have set the sensor to match our stored calibration before shipping it. You can simply use the appropriate calibration file that is stored in your data-collection program from Vernier in any of these ways:

1. If you are using the Logger *Pro* software (version 2.0 or newer), open an experiment file for the CO₂ Gas Sensor, and its stored calibration will be loaded at the same time. Note: If you have an earlier version of Logger *Pro*, a free upgrade to version 2.2.1 is available from our web site.
2. Any version of the DataMate program (with LabPro or CBL 2) has stored calibrations for this sensor.
3. All versions of the CHEMBIO, PHYSICS, or PHYSCI programs (for CBL), version 4/1/00 or newer, have stored calibrations for this sensor. Go to our web site, www.vernier.com, to download a current version.
4. Any version of Data Pro has stored calibrations for this sensor.

If you do find that you need to calibrate your CO₂ Gas Sensor, it can be calibrated using one known CO₂ level. **Note:** This calibration method is different than the usual two-point calibration performed using other Vernier sensors. To calibrate the CO₂ Gas Sensor in units of parts per million (ppm):

- Place the 250 mL collection bottle (included with your sensor) in the air outside your building long enough to ensure that its contents are replaced with fresh air. The calibration will be based on this sample having a carbon dioxide concentration of about 400 ppm.⁵ While still outdoors (with the slit rubber stopper on the sensor tube of the CO₂ Gas Sensor), insert the stopper into the

gas sampling bottle containing fresh outside air. Do this by holding the stopper, not the probe box. You can now take the bottle and sensor to the location where the calibration is to be done (either outside or back in the classroom).

- Connect the CO₂ Gas Sensor to Channel 1 of the Vernier interface, TI CBL or CBL 2. Load (or select) an experiment file for the CO₂ Gas Sensor. Let the sensor warm up by collecting data for at least 90 seconds. You can monitor the CO₂ reading by simply observing the live display on the computer data-collection software, or by selecting Monitor Input in the CBL data-collection program, CHEMBIO.
- When the CO₂ Gas Sensor has warmed up (readings should have stabilized), use a paper clip or the point of a mechanical pencil to press down the calibration button. Release the button immediately after the Red LED blinks rapidly three times. After about 30 seconds, the reading should stabilize at a value of approximately 400 ppm (± 50 ppm). If the reading is significantly lower or higher than 400 ppm, simply press the button again to repeat the process.



Temperature Considerations

Your Vernier CO₂ Gas Sensor is designed to operate between 20°C and 30°C. The CO₂ Gas Sensor can be used outside of this temperature range; however, you should be aware that there will be a loss in accuracy of readings, even if you do the 1-point calibration at the lower or higher temperature. This does not prohibit taking readings using incubation temperatures or outdoor readings at temperatures warmer or colder than the 20 to 30°C range. Allow enough time for your CO₂ Gas Sensor to stabilize at the desired operating temperatures.

⁵The carbon dioxide concentration in the Earth's atmosphere has steadily increased throughout the 20th century to an average level of just below 370 ppm in 1997. Levels in your area may be slightly higher due to localized influences such as automobile or industrial emissions of carbon dioxide.

More about Carbon Dioxide Concentration

The average increase in the concentration of carbon dioxide in the Earth's atmosphere has been well documented. The graph below shows that the concentration increased from about 320 to over 360 ppm during the past 40 years.⁶ Locally, especially in urban areas, it is not uncommon for this concentration to be above 380 ppm due to emissions from fossil fuel combustion. The calibration value of 400 ppm for ambient outside air used with the CO₂ Gas Sensor is very close to these values. The ability of carbon dioxide to act as a greenhouse gas by absorbing increasing amounts of infrared radiation is a growing environmental concern.

You can use the CO₂ Gas Sensor within your classroom or other parts of your school building to demonstrate to students the increased levels of carbon dioxide that occur in confined spaces. We often find that carbon dioxide levels within offices with several people will reach as high as 1000 to 1200 ppm CO₂. You can even use the sensor to show that levels are generally higher in lower regions of a room than in the upper reaches. It is also possible to show the effect of turning on air conditioning, room ventilation, or simply opening a car window.

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.

⁶Cecie Starr and Ralph Taggart, *Biology: The Unity and Diversity of Life*, 6th ed., Belmont, CA; Wadsworth, 1992



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