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**NeuLog CO$_2$ logger sensor**
**NUL-220**

The CO$_2$ Sensor can be used for any science experiment or activity where CO$_2$ levels are required.  Some fields of study include Chemistry, Physiology, Exercise Science, Biochemistry, Biology, Earth Science, Environmental Science, etc.

This sensor is practical for testing CO$_2$ levels both in laboratories and in the field.  An electromechanical cell in the sensor reacts with carbon dioxide to produce a voltage which is directly interpreted to give a CO$_2$ concentration reading.

Just a few of the thousands of possible experiments that can be done with the NUL-202 sensor are: Monitoring of ecological systems, combustion reactions, CO$_2$ consumption rates, studying photosynthesis, testing chemical solutions, hydrogen peroxide decomposition, and many more.

The NeuLog CO$_2$ sensor collects data in the following units of measurement:
- Parts per million (ppm): The total number of carbon dioxide molecules per million molecules sampled.

**Sensor calibration:**

Prior to each use the CO$_2$ needs to warm up for roughly half an hour.  To do this, plug the CO$_2$ sensor into a USB module or a battery pack and allow the sensor to sit for half an hour prior to collecting data for the best results.

**Open air mode:**

The CO$_2$ sensor needs to be calibrated before use.  Calibration of the probe assumes a standard atmospheric CO$_2$ concentration of 20.9% (assuming stable levels in the Earth's atmosphere at sea level).

**Materials Needed***:*

- NUL-220 CO$_2$ sensor
- 1 of the following (depending on experiment type)
  - USB-200 USB Module (*For On-line experiments)*
  - BAT-200 Battery (*For Off-line experiments)*
  - VIEW-101 Viewing Module and BAT-200 Battery *(For use with NeuLog Viewer)*
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**Procedure:**

1. The CO$_2$ sensor needs a power supply to properly calibrate so connect the CO$_2$ sensor to:
   a. ***For On-line experiments***: USB-200 USB Module.
   b. ***For Off-line experiments***:  BAT-200 Battery
   c. ***For use with the NeuLog Viewer****:*  VIEW-101 Viewing Module and BAT-200 Battery.
2. The sensor now needs to be calibrated:
   a. Connect the CO$_2$ sensor to the left side of a USB-200 Module (which is connected to a computer via the USB to mini USB cable).
   b. Open the NeuLog software.
   c. Once the CO$_2$ sensor is detected click the "Module setup" button.
   d. Hold the probe vertically so the opening is facing the ground.
   e. Press and hold the blue "Start/Stop" button the faceplate of the sensor for 3 seconds.
3. The CO$_2$ Sensor is now calibrated for use.

**Quick start procedure:**

*PC or Mac Computer*

**Materials needed:**

- NUL-220 CO$_2$ Sensor
- USB-200 USB Module
- A USB to mini USB cable (which comes with the USB-200)

Prior to initial use the NeuLog CO$_2$ sensor needs to be calibrated, please review the "Sensor calibration" section of this document on beginning on page 2 for detailed instructions.  Your CO$_2$ sensor needs to be connected to a USB-200 module.  The USB-200 module then connects to a computer via a USB to mini-USB cable.  Please note that you cannot plug the CO$_2$ sensor directly into the computer.

Resident PC software and browser based software can be downloaded for free at www.NeuLog.com/dowload as well as a full software user guide. **Note:** Make sure not to download and install both types of software, they will conflict on the computer.

**Procedure:**

1. Calibrate the $CO_2$ sensor. (Follow the 'Sensor Calibration" guide in this document)
2. Install the NeuLog software
3. Connect the USB-200 module to the PC or Mac
4. Connect the $CO_2$ sensor to the USB-200 module (they directly plug together).
5. Open the NeuLog software.
6. Once a $CO_2$ sensor logo appears on the left side of the screen the probe has been automatically identified and you can begin experimentation.
7. If the $CO_2$ sensor is not automatically identified then click the "Search for sensors" icon to find the sensor.
8. Select the "On-line experiment" button; this will open a graph below.
9. Click on the "Module setup" button located on the $CO_2$ sensor icon in the module window to change the sensor settings if need be.
10. Click on the experiment set up button to change the experiment settings if need be (experiment duration for example).
11. The $CO_2$ sensor will give a live reading in the box to the left of the screen while plugged in.
12. To run an experiment and collect data click "Run experiment".
13. To end data collection early, click "Stop experiment".

*Tablet, smart phone device*

**Materials needed:**

- NUL-220 $CO_2$ Sensor
- WIFI-201 WIFI module
- BAT-200 Battery

Prior to initial use the NeuLog $CO_2$ sensor needs to be calibrated, please review the "Sensor calibration" section of this document on beginning on page 2 for detailed instructions. Your $CO_2$ sensor needs to be connected to a WIFI-201 module. The WIFI-201 module will create a closed NeuLog wifi network which will stream the NeuLog data to a device of your choosing. Once your device is wirelessly connected to the NeuLog network you can run experiments and collect data through a browser of your choosing.

**Procedure:**

1. Calibrate the $CO_2$ sensor. (Follow the 'Sensor Calibration" guide in this document)
2. Connect the $CO_2$ sensor directly to the left side of a WIFI-201 module (no wires required).
3. Connect a BAT-200 module to the right side of the WIFI-201 module.
4. Although not required, we recommend plugging the BAT-200 to an outlet using a USB to micro USB charger (such as a typical cell phone charger). The WIFI-201 module will run for 15-75 minutes (depending on the sensor) without being plugged in.
5. For further WIFI-201 instructions or the WIFI-201 quick start guide please visit www.NeuLog.com/download.
6. The WIFI-201 indicator lights will flash; take no action until the LED to the far left turns blue.
7. Take your tablet or smart phone and go to the Wi-Fi settings and select the NeuLog network which matches the WIFI module ID found on the back of the WIFI-201 device. (NeuLogXXXX for example)
8. Give your device 1-2 minutes to connect to the WIFI-201 network.
9. Once the device is connected go to your browser and type in the website wifi201.com into the URL bar, then wait for 30-60 seconds.
10. You will see a "Control mode" icon in the browser, click on this icon.
11. The browser will then load a new screen and begin to auto detect the sensors, this can take a few minutes.
12. If the browser does not auto detect, select "Search for sensors"
13. Once the sensor is found you will see an icon on the left side of the screen for the $CO_2$ sensor. The icon will display data in real time.
14. To set the $CO_2$ sensor's settings click on "Module setup" button located on the $CO_2$ sensor icon on the left side of your screen.
15. To change the experimental settings click the "Experiment setup" button (experiment duration for example).
16. To run an experiment and collect data click "Run experiment".

### *Operation with NeuLog viewer*

**Materials needed:**

- NUL-220 CO2 Sensor
- VIEW-101 Viewing Module
- BAT-200 Battery

**Procedure:**

1. Calibrate the $CO_2$ sensor. (Follow the 'Sensor Calibration" guide in this document).

2. Connect the CO2 sensor to the left side of the viewer.
3. Connect the BAT-200 module to the right side of the viewer.
4. The VIEW-101 will auto detect the sensor and you will see it appear on the left side of the screen.
5. Once the sensor appears it will be monitoring data in real time.
6. To run an experiment and collect data click the run button (little green person).

### *Off-line experiments*

(Off-line experiments are for when you do not have a sensor connected directly to a computer, tablet, smartphone, or NeuLog viewer).

**Materials needed:**

- NUL-220 $CO_2$ Sensor
- BAT-200 Battery

**Materials needed to configure your offline experiment:**

- USB-200 USB Module or WIFI-201 WIFI module or VIEW-101 Viewing Module
- A USB to mini USB cable (which comes with the USB-200)

**Procedure:**

1. Calibrate the $CO_2$ sensor. (Follow the 'Sensor Calibration" guide in this document)
2. Connect the $CO_2$ sensor directly to the left side of a charged BAT-200 module.

3. When ready to collect data press the "Start/Stop" button on the $CO_2$ sensor, a red light will turn on for the duration of the experiment.
4. To change the experiment settings first connect to your chosen device (PC, Mac, tablet, smart device) and select the "Module setup" button. (For more information on how to change the experiment settings view quick start procedure section for your chosen device in this document.)
5. After the experiment has concluded (when the "Start/Stop" button is pressed again or the data collection period ends) connect the sensor to your chosen device. (full instructions in each device's quick start procedure section)
6. Open NeuLog software.
7. Click the "Off-line experiment" button.
8. Click the "Load data from sensors" button.
9. Select which experimental data to upload. (5 experimental runs can be stored at one time on the NUL-220 $CO_2$ sensor)

**Restoring sensor's factory default settings:**

**Procedure:**

1. Connect the USB-200 to a PC, Mac, tablet, or smart device.
2. Connect the $CO_2$ sensor to a USB-200 module (they directly plug together).
3. Open the NeuLog software.
4. Click the "Tools" icon.
5. Click "Restore sensor's factory defaults" icon.
6. If prompted to clear the graph, click either the "Off-line experiment" or "On-line experiment" (whichever you are using).
7. Click "Clear experiment results".
8. Resume from step 4.

**Included with sensor:**

- NeuLog $CO_2$ sensor probe which is attached to the sensor body by a durable rubber-coated wire.
- NeuLog NUL-220 $CO_2$ Sensor Guide (This Document)

| Sensor specifications: | |
|---|---|
| **Range and operation modes** | 350-10,000 ppm |
| **ADC resolution** | 10 bit |
| **Resolution** | 1 ppm |
| **Max sample rate (S/sec)** | 100 |

### Sensor features:

- Fully digital data
- Rugged plastic ergonomic case
- Push button switch for Start/Stop experiments in off line mode
- LED indicator of experiment status (blinks while collecting data)
- Attached probe cased in durable plastic
- *Note:* NeuLog products are intended for educational use.

### Videos and experiment examples:

- Videos, literature and other probes can be found at www.NeuLog.com
- http://www.NeuLog.com/Products/CO2loggerSensor.aspx
- **Photosynthesis -**
  http://www.neulog.com/Portals/3/Users/Experiment_B-10_Photosynthesis_Ver 3.2.5.pdf

### Technical background:

The philosophy behind NeuLog's plug and play technology is based on each sensor's ability to store its own data due to an internal flash memory chip and micro-controller in each plastic NeuLog body. This technology allows the sensor to collect and then store the digital data in the correct scientific units ($^o$C, $^o$F, Lux, %, ppm, for example).

The sensor needs to be calibrated prior to initial use, please review the "Sensor Calibration" guide in the beginning of this document for detailed instructions.

Inside the probe a small incandescent light bulb emits infrared radiation which interacts and is absorbed by carbon dioxide molecules. An infrared sensor detects how much infrared radiation was not affected by carbon dioxide molecules and in turn will heat up from the radiation it is collecting. This heat produced is inversely related to the amount of carbon dioxide present. More carbon dioxide present will produce less heat and vice versa. The heat acts as a resistor in the wires and based on how much electrical resistance there is a carbon dioxide reading can be determined through calculation.

### Maintenance and storage:

- Never submerge the NeuLog sensor's plastic body in any liquid.
- Do not allow liquid into the NeuLog sensor's plastic body.
- After using the probe wipe off all excess material, liquid or residue from the $CO_2$ probe body.
- Store in a box at room temperature out of direct sunlight.
- Do not put the plastic case, or cord of the $CO_2$ probe in an acids or bases.

### Warranty:

We promise to deliver our sensor free of defects in materials and workmanship for a period of 3 years from the date of purchase. Our warranty does not cover damage of the product caused by improper use, abuse, or incorrect storage. Sensors with a shelf life such as ion selective proves have a warranty of 1 year. Should you need to act upon the warranty please contact your distributor. Your sensor will be repaired or replaced.

**Thank you for using NeuLog!**

Flexible, simple, fast, forward thinking.
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