Chapter 5 Gas Concentration Measurement Modules

CO2100C Carbon Dioxide Measurement Module

O2100C and CO2100C

The CO2100C module measures the partial pressure of CO_2 and thus the module output is proportional to the pressure in the sample cell.

- Gas sampled must be free of liquids or any condensable vapors.
- Gas should be filtered to 5 microns or better.

Technical Use Notes

1. Snap the CO2100C module together with the UIM100C (or other BIOPAC modules). Be sure to select an unused channel on the channel selector switch on top of the module. If two or more BIOPAC modules are set to the same channel, the outputs will conflict, resulting in erroneous readings.
2. Turn on the MP150/MP100 unit and start up the Acq*Knowledge* software. Please consult the "MP System Guide" for more information about running Acq*Knowledge*.
3. Plug the adapter into the main power and insert the adapter plug into the back of the CO2100Cmodule. The CO2100C module is supplied with a 12 vdc @ 1 amp wall adapter**—do not use other wall adapters with the CO2100Cmodule.**
4. The green POWER LED should light up. If it doesn't, check the adapter main power and the connection to the CO2100C module. If all looks OK, then check the FUSE on the back of the CO2100C module. [The FUSE ratings are: Instrumentation Type, Fast Blow @ 2 amps.]

5. The CO2100C module has a warm-up time of approximately 5 minutes. Output readings during this warm-up period will be very erratic.

   If the green POWER LED comes on, check for pump operation by turning the PUMP switch ON. You should hear a humming from the box, indicating that the pump is working. Generally, you will never have to adjust the PUMP SPEED control.

   The PUMP will start fast, then slow down and stabilize on a speed after a few seconds. This is a perfectly normal process, designed to overcome the pump's initial mechanical hysteresis.

   If the pump does not come on or comes on for a brief period and then shuts off, the PUMP SPEED control is set to a very low value (i.e., zero speed). To change the pump speed, use a small straight blade screwdriver to turn the recessed potentiometer in the PUMP SPEED control.

   To increase PUMP speed: Turn trim POT clockwise.

   To decrease PUMP speed: Turn trim POT counter-clockwise.

   Keep the PUMP switch in the ON position as you change the PUMP SPEED control.

6. If everything is OK so far, adjust the GAIN switch on the front of the CO2100C module. Set the GAIN for the range desired. Generally, you should have no trouble if you leave the GAIN at the minimum setting of 10% carbon dioxide per volt (top position).

   The GAIN ranges imply the following:

10% / V	One volt output equals 10% carbon dioxide concentration
	Voltage output range is from 0 to 1 volt
5% / V	One volt output equals 5% carbon dioxide concentration
	Voltage output range is from 0 to 2 volts
2% / V	One volt output equals 2% carbon dioxide concentration
	Voltage output range is from 0 to 5 volts
1% / V	One volt output equals 1% carbon dioxide concentration
	Voltage output range is from 0 to 10 volts

   For example, if the **10% / V** setting is used, then 4% carbon dioxide (approximate concentration in expired breath) will be output as: 0.40 volts or 400 mV.

Gas Sampling Setup

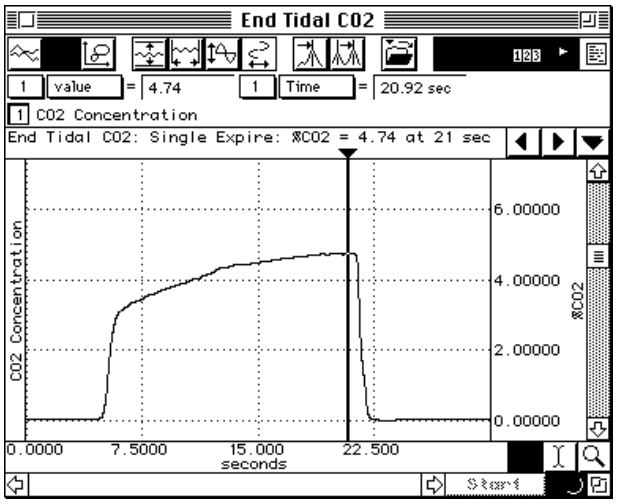
1. Stabilize the measurement setup prior to sampling any gases.
   Pump speed, filters and sampling lines all affect the oxygen measurement of the CO2100C module. Everything should be stable prior to attempting a CO2100C module calibration.
2. Attach a 5 micron filter (or better) on the sample input port prior to sampling any gases.
   The sample input port is a male Luer fitting on the front of the CO2100C module. The CO2100C module incorporates an internal particulate filter, however the addition of this external filter will extend the life of the internal filter and otherwise improve the long-term performance of the CO2100C module. Always use a 5 micron hydrophobic sampling filter (or better) at the sampling input of the CO2100C module. One is included with each CO2100C module and each Gas Sampling Interface Kit (AFT20). The 5-micron hydrophobic filter will help to protect the CO2100C module from airborne particulate matter and other contaminants.
3. Screw a 10/32 Luer adapter into the bulkhead fitting and attach the venting line to the Luer adapter to vent undesirable gases away from the site of the CO2100C module.
   The sample output port is adjacent to the sample input port (on the right, facing the front panel of the module) and is a bulkhead fitting with a 10/32 internal thread.

Important

Sample dry gases only. All water vapor needs to be removed from the sampling stream prior to being monitored by the CO2100C module. To dry the sampling stream, use water vapor permeable tubing (i.e. NAFION®). The AFT20 Gas Sampling Interface Kit includes all the items necessary (including NAFION® tubing) to efficiently connect the CO2100C module to the sampling chamber.

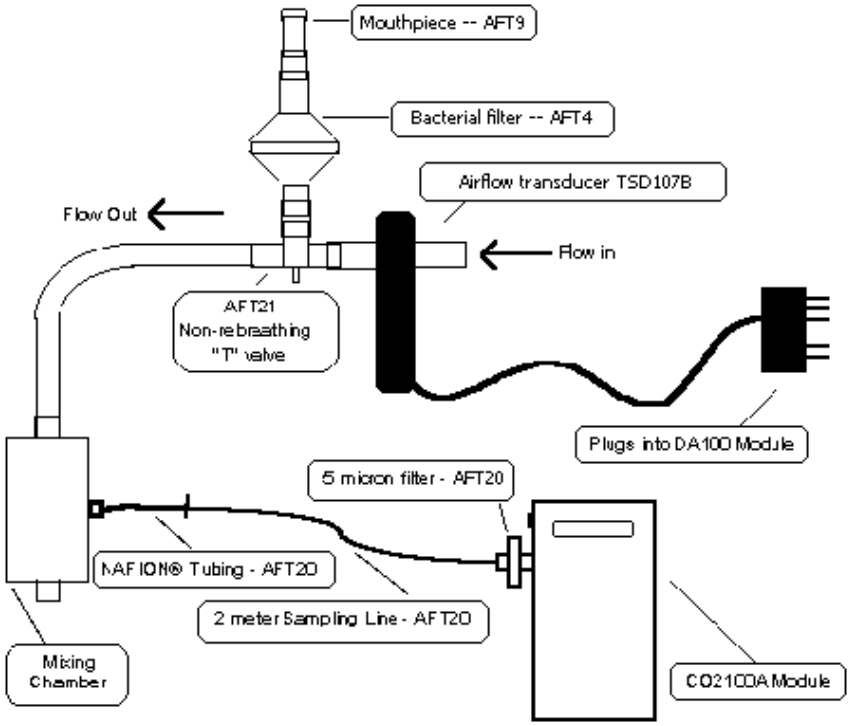
This waveform above shows the output of the CO2100C module recorded during a subject's single expiration.

It would be possible to monitor the total flow (via the TSD107B) and then multiply the flow by the concentration change. The result would be the precise amount of carbon dioxide expired by the subject. In the graph shown, note that the CO_2 concentration peaks out just prior to the Subject's inspiration.



End Tidal CO_2 Measurement

The following diagram illustrates a typical connection for the CO2100C module to a mixing chamber, AFT21 and TSD107B.



The subject breathes through the mouthpiece (AFT9), which attaches to the non-rebreathing "T" valve (AFT21) via a bacteria filter (AFT4). When the subject inspires, air is drawn into the AFT21 through the TSD107B, as shown by the "Flow In" arrow. When the subject expires, air is forced out through the mixing chamber, as shown by the "Flow Out" arrow.

CO2100C Calibration

The CO2100C module comes factory-calibrated to ± 1% carbon dioxide concentration accuracy. If you run at increased flow rates, the calibration may veer further from ±1% accuracy. Generally, **you should perform a gas calibration prior to all exacting measurements**. This may also be required if you are running at increased pump speeds and thus increased flow rate.

Initial (Factory) carbon dioxide accuracy calibration is usually inadequate for varying setup protocols. Proper calibration of the CO2100C module should be performed after the specific measurement setup is in place.

Exact calibration is typically performed in Acq*Knowledge*, using the **Scaling** function under **Setup Channels**, once the measurement setup is in place.

1. Set up your measurement so that all gas sampling lines are in place between the CO2100C module and the sampling chamber.
2. Adjust the PUMP SPEED control (if required) on the CO2100C module.
3. Run the CO2100C module and click on the CAL1 button when the first calibration gas is introduced into the sampling chamber.
4. Click on CAL2 when the second calibration gas is introduced into the sampling chamber. The calibration gases should be chosen to bracket your expected measurements. For example, when performing End Tidal CO_2 measurements, you can use normal air as the first calibration gas because you know the carbon dioxide concentration is 0.04%.
5. Introduce a second calibration gas into the chamber. For the second gas, it might be best to use a calibration gas of 4% carbon dioxide and 96% nitrogen. In this case, your measurements will be most accurate for the range of 0.04% to 4% carbon dioxide.

Note: Do not change the pump speed, the sampling filter or the sampling line length/configuration during or after a calibration. Changing any of these elements may reduce the accuracy of the calibration.

Pump Speed Control

The pump speed is factory preset to result in a sampling flow rate of approximately 100 ml/min, when used with the AFT20 Gas Sampling Interface Kit. The time delay between change of carbon dioxide concentration at the sampling end of the Gas Sampling Interface Kit (AFT20) to measurement at the CO2100C module is approximately 2.4 seconds. This is because the pump will move 100 ml/min and the internal volume of the Gas Sampling Interface Kit is about 4.0 ml.

$$\text{Volume in ml} = (\pi) \bullet (\text{radius in cm})^2 \bullet (\text{length in cm})$$

The Gas Sampling Interface Kit volume is calculated using:

PVC Sample Line:	72" long at 0.060" ID	Volume = 3.336 ml
NAFION® Dryer:	12" long at 0.050" ID	Volume = 0.386 ml
Misc. Tubing/Junctions:	6" long at 0.060" ID	Volume = 0.278 ml

If the sample rate is 100 ml/min, then the pump will pull 4 ml in 2.4 seconds:

$$(60 \text{ min/sec}) \bullet (4 \text{ ml}) / (100 \text{ ml/min}) = 2.4 \text{ sec}$$

To check the flow rate, breathe into the free end of the sampling line at the moment you mark the recording (using the marker function in Acq*Knowledge*). You should see no change in the carbon dioxide concentration level until after 2.4 seconds. Please note that you can change the pump speed to a relatively fast level. It's quite possible to exceed the maximum acceptable flow rate to the module, depending on the sampling line type and conditions. You won't harm the module by setting a fast flow rate, but erroneous readings may occur.

To achieve the best results, run the pump speed so the flow rate to the module does not exceed 200 ml/min. The CO2100C module output will be relatively insensitive to flow changes between 50 and 200 ml/min. However, above 200 ml/min, the CO2100C module output may start to behave very erratically.

Run at higher flow rates when you wish to improve the response time of the CO2100C module. Response times can often be boosted 10% over the nominal response times of 100ms at 100 ml/min. This particular increase is not exactly specified, as it is somewhat module dependent.

CO2100C Specifications

CO_2 Range:	0-10% CO_2
Gain	1, 2, 5, 10 (%CO_2/Volt)
Output Range:	0-10 volts
Repeatability:	0.03% CO_2
Resolution:	0.1% CO_2
Linearity:	0.1% CO_2
Zero Stability:	0.1% CO_2/24 hours
Response Time:	
@ 50 ml/min	130msec (T10-T90)
@ 100 ml/min	100msec (T10-T90) — factory preset
@ 200 ml/min	90msec (T10-T90)
Flow Range:	50-200 ml/min
Temp Range:	10-45°C
Zero Drift:	0.01% CO_2/°C
Span Drift:	0.02% CO_2/°C
Warm Up Time:	5 minutes @ 25°C
Sampling Port:	Male Luer
Weight:	740 grams
Dimensions:	7cm (wide) x 11cm (deep) x 19cm (high)
Power Source:	12VDC @ 1 amp (uses AC100A transformer)
Note:	The module measures the partial pressure of CO_2 so the module output is a function of the pressure in the sample cell. Gas sampled must be free of any liquid or condensable vapors. Gas should be filtered to 5 microns or better. The module utilizes Servomex, Inc. technology for CO_2 concentration signal processing.
See also:	AFT Series Air Flow & Gas Analysis Accessories, page 131. Application Note # AH151 — CO2100C Module Application Note # AH152 — CO2100C Module: Sample Application