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Application Note 151 CO2100C Module for MP160/MP150 System

Technical Use Notes

The CO2100C Carbon Dioxide Measurement Module records quickly-varying carbon dioxide concentration levels. The CO2100C module is equipped with a variable speed pump to adjust the flow over a wide range of sampling conditions. Sampling line connections for input and output flow are accessible on the front panel of the module.

This application note discusses setup and calibration of the CO2100C module.

Hardware Setup

Snap the CO2100C module together with the UIM100C (MP150), HLT100C or AMI100D (MP160), (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.

Turn on the MP150 unit and start up the Acq*Knowledge* software. Please consult your Acq*Knowledge* manual for more information about running Acq*Knowledge*.

The CO2100C module is supplied with a 12 VDC @ 1 amp wall adapter. Do not use other wall adapters with the CO2100C module. Plug the adapter into the main power supply and insert the adapter plug into the back of the CO2100C module.

NOTE: Do not use other wall adapters with the CO2100C module

Power on the module and confirm the CO2100C's green POWER LED is on. If not, check the adapter mains 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 rating is: Instrumentation Type, Fast Blow @ 2 amps.

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. You generally will not have to adjust the PUMP SPEED control.

If the pump does not come on or comes on for a brief period and then shuts off, it may be because the PUMP SPEED control was set to minimum (zero speed). To change the pump speed, use a small straight blade screwdriver to turn the recessed potentiometer in the PUMP SPEED control. Keep the PUMP switch in the ON position as you change 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.

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, it is OK to leave the GAIN at the minimum setting of 1% carbon dioxide per volt (bottom position).

The GAIN ranges imply the following:

Gain	1V output = % gas concentration	Voltage output range
10% / V	10% CO_2	0 to 1 volt
5% / V	5% CO_2	0 to 2 volts
2% / V	2% CO_2	0 to 5 volts
1% / V	1% CO_2	0 to 10 volts

For example, if the 1% / V setting is used, then 4% carbon dioxide (approximate concentration of expired breath) will be out put as: 4 volts or 4000 mV.

Gas Sampling Setup

IMPORTANT: Prior to actual sampling any gas and attempting a calibration, it's very important to stabilize your measurement setup. Pump speed, filters and sampling lines all affect the carbon dioxide measurement of the CO2100C module. All these elements should be stable prior to attempting a CO2100C module calibration.

The sample input port is a male Luer fitting on the front of the CO2100C module. Be sure to attach a 5 micron filter (or better) on the sample input port prior to sampling any gases. The CO2100C module incorporates an internal particulate filter, however the addition of this external filter will extend the life of the internal filter and improve the long term performance of the CO2100C module.

Adjacent to the sample input port (on the right, facing the front panel of the module) is the sample output port. The sample output port is a bulkhead fitting with a 10/32 internal thread. To vent away undesirable gases from the site of the CO2100C module, simply screw a 10/32 Luer adapter into the bulkhead fitting and attach the venting line to the Luer adapter. Generally, it is not necessary to vent exhaust gases away from 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 air borne particulate matter and other contaminants.

IMPORTANT: Sample only dry gases. All water vapor, above ambient levels, should be removed from the sampling stream prior to being monitored by the CO2100C module. Water vapor permeable tubing (i.e. NAFION®) is recommended to dry the sampling stream to ambient. The AFT20 Gas Sampling Interface Kit includes all the items necessary (including NAFION® tubing) to efficiently connect the CO2100C module to a variety of setups, including BIOPAC mixing chambers, facemasks, and non-rebreathing T-valves.

Before attaching the input sampling line tubing to the CO2100C:

1. Allow the CO2100C to warm up fully (15 minutes).
2. Blow out the input sampling line tubing with compressed (dry) air or calibration gas prior to attaching tubing to CO2100C input sampling port.

In case of humidity condensation in sampling line, it's recommended to disconnect the sampling line tubing from the CO2100C and blow out the tubing with compressed (dry) air or calibration gas prior to use of CO2100C.

Calibration of the CO2100C Module

The CO2100C module comes factory calibrated to ± 1% carbon dioxide concentration accuracy. Depending upon sampling line configuration and pump speed (flow rate), the calibration may veer from 1% accuracy. Generally, you should perform a gas calibration prior to all exacting measurements.

> **NOTE: 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* once the measurement setup is in place. The calibration gases should be chosen to bracket your expected measurements.

For example, when performing end tidal CO_2 measurements, use normal air as the first calibration gas because you know the carbon dioxide concentration is 0.04%. However, a second calibration gas will need to be introduced into the chamber. For the second calibration gas, use 4% carbon dioxide, 16% oxygen, 80% nitrogen (such as BIOPAC's GASCAL). In this case, your measurements will be most accurate for the range of 0.04% to 4% carbon dioxide.

When calibrating the CO2100C module, the calibration must be performed at ambient pressure otherwise distortion may result. This is because the CO2100C is sensitive to the partial pressure of the gas being sensed. If pressurized gas is supplied directly to the input of the CO2100C module, without ambient venting, the readings will be distorted (usually they will be too high) and it's possible to damage the module. Instead, simply supply a slow stream of gas to the module's sampling line through a vented arrangement, so pressure can't build up inside the CO2100C. To craft a suitable calibration sampling line, use the "Y" connector that's part of the Gas Sampling Interface Kit (AFT20). Connect the gas calibration source through a pressure regulator and flow controller (GASREG) to one port of the "Y" connector. Then connect another port of the "Y" connector to the sampling line connected to the CO2100C sample input. Set the CO2100C sampling pump to ON. Slowly increase the flow of gas to the "Y" connector and make sure there is a gentle outflow of calibration gas leaving the third port of the "Y" connector. Do not cap this third port, as this gentle outflow of gas will insure that the gas is being sampled at ambient pressure.

1. Launch Acq*Knowledge.*
2. Confirm all gas sampling lines are in place between the CO2100C and the sampling chamber.
3. Run the CO2100C and adjust the PUMP SPEED control (if required).

In Acq*Knowledge* 4.0 and earlier:

4. Choose **MP150 > Set Up Channels > Scaling**.
5. Click on the CAL1 button once the first calibration gas (i.e. 0.03% CO_2 [AIR]) is introduced into the chamber.
6. Click on CAL2 once the second calibration gas (i.e. 4% CO_2 [GASCAL]) is introduced into the chamber.

In AcqKnowledge 4.1 and higher: You may use the Module Setup feature to closely match the software settings to the CO2100C module:

- Choose **MP150 > Set Up Data Acquisition > Channels > Add New Module**.
- Select CO2100C from the list of available modules and click OK.
- Match the channel switch position to the switch position on the CO2100C module and click OK.
- Match the gain and pump settings to those selected on the CO2100C module and click OK.
- Select "View by Channels > Setup" and click "Yes" to the subsequent module configuration dialog.
- Perform calibration steps 5 and 6 from above.

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 will affect an accurate calibration.

Pump Speed Control

The pump speed is factory preset to result in a sampling rate of approximately 150 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 2.5 seconds. This is because the pump will move 150 ml/min and the internal volume of the sampling line, dryer and internal tubing is about 6.3 ml.

The Gas Sampling Interface Kit volume is calculated using:

PVC Sample Line:	182.9 cm long at 0.165 cm ID	ID Volume = 3.92 ml
NAFION® Dryer:	30.5 cm long at 0.127 cm ID	ID Volume = 0.386 ml
Misc Tubing/Junctions:	Internal to module	ID Volume = 2 ml

Volume in ml is defined as: (Pi) • (radius in cm) ^{2} • (length in cm)

If the sample rate is 150 ml/min, then the pump will pull 6.3 ml in 2.5 seconds:

(60 sec/min) • (6.3 ml) / (150 ml/min) = 2.5 seconds

To check the flow rate, breathe at the free end of the sampling line at the moment you mark the recording using the marker function in Acq*Knowledge*. You should see a change in the carbon dioxide concentration level at around 2.5 seconds.

Specifications

Range:	0-10% CO_2
Repeatability:	±0.3%
Resolution:	±0.1%
Linearity:	±0.1%
Zero Stability:	±0.01% CO_2/hr
Response Time: *Factory Preset:*	150 msec (T20-T80) @ 200 ml/min 250 msec (T20-T80) @ 150 ml/min 350 msec (T20-T80) @ 50 ml/min
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
Humidity Range:	0-90% non-condensing

- Gas sampled must be free of liquids or any condensable vapors.
- Gas sampled should be filtered to 5 microns or better.
- The module measures the partial pressure of CO_2. Furthermore, the module is proportional to ambient pressure changes to the 3/2 power.

For example, the partial pressure of 4% concentration of CO_2 at sea level (760 torr) is:

760 torr * 0.04 = 30.4 torr

So at 700 torr and 4% CO_2, the module output will be:

(700 torr / 760 torr) ** 1.5] * 30.4 = 26.87 torr

Accordingly, when operating at an ambient pressure of 700 torr, the module scaling needs to be multiplied by a factor of (700/760) ** 1.5 or 0.884 (original scaling).