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O2100C AND CO2100C GAS CONCENTRATION MEASUREMENT MODULES

BIOPAC offers two fast-response analyzers for gas analysis. Each module measures partial pressure (of O_2 or CO_2, respectively) and thus module output is proportional to the pressure in the sample cell. Gas sampled must be free of liquids or any condensable vapors and should be filtered to 5 microns or better.

O2100C Records quickly varying oxygen concentration levels.

Ideal for monitoring time-averaged O_2 levels using mixing chambers or real-time O_2 levels for breath-by-breath measurements.

Employs an analysis technique based on the parametric oxygen measurement principle.

The O2100C is a paramagnetic-based oxygen measurement module designed to provide accurate measurement of the oxygen content in ambient air, expired breath and in breathing gas mixtures. The module provides a selectable range of analog outputs that map voltages to 0-100% oxygen concentration levels.

The module is a lightweight, and rugged unit that offers a number of advanced features, such as fast response and user-adjustable sampling flow rate.

The O2100C paramagnetic technology is non-depleting. This means there are no consumable parts and insures consistent performance over time. The selectivity of the paramagnetic measurement for oxygen means there is no interference from other respiratory gases. The O2100C small volume chamber allows a rapid gas exchange, giving the capability for fast response oxygen measurement.

The O2100C offers a stable and inherently linear measurement of oxygen. The excellent linearity of the O2100C makes it possible to calibrate the module by checking two optimally separated points in the desired measurement range.

CO2100C Records quickly varying carbon dioxide concentration levels.

Ideal for monitoring time-averaged CO_2 levels using mixing chambers or real-time CO_2 levels for breath-by-breath measurements.

Employs a single beam infrared, single wavelength, measurement technique.

The CO2100C is an infrared-based carbon dioxide measurement module designed to provide accurate measurement of the carbon dioxide content in ambient air, expired breath and in breathing gas mixtures. The module provides a selectable range of analog outputs that map voltages to 0-10% carbon dioxide concentration levels.

The module is a lightweight, and rugged unit that offers a number of advanced features, such as fast response and user-adjustable sampling flow rate.

The CO2100C is calibrated to measure carbon dioxide in the range 0 to 10%.

The CO2100C module measurement is based upon the single beam, single wavelength technique (SBSW), where wavelength selection is implemented via a carefully specified narrow-band optical filter. The speed of response is obtained by generating a fast infrared carrier signal, which is attenuated by the infrared absorption of carbon dioxide present, and a detection system that converts fast changes of this attenuation into an electrical output.

The CO2100C offers a stable and inherently linear measurement of carbon dioxide. The excellent linearity of the CO2100C makes it possible to calibrate the module by checking two optimally separated points in the desired measurement range.

Both modules are 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 readily accessible on the front panel of either module.

Each module can interface with the AFT15A and AFT15B mixing chambers (via the AFT20 or AFT31-MRI gas sampling interface kit), the AFT21 and AFT22 non-rebreathing T valves or the AFT25 mask with integral non-rebreathing T valve.

TECHNICAL USE NOTES

1. Snap the module together with the AMI100D, HLT100C, or UIM100C unit.
2. 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.
3. Turn the MP160/MP150 unit on and start the Acq*Knowledge* software.
   - Please consult the "Acq*Knowledge* Software Guide" for information about Acq*Knowledge*.
4. Plug the adapter into the main power and insert the adapter plug into the back of the module.
   - The module is supplied with a 12 vdc @ 1 amp wall adapter—**do not use other wall adapters with a gas analysis module.**
   - The green POWER LED should light up. If it doesn't, check the adapter main power and the connection to the O2100C module and then, if necessary, check the FUSE on the back of the O2100C/CO2100C module. [The FUSE ratings are: Instrumentation Type, Fast Blow @ 2 amps.]
   - The O2100C module has a warm-up time of approximately 1 minute. The CO2100C module has a warm-up time of approximately 15 minutes. Output readings during this warm-up period may be erratic.
5. Check for pump operation by turning the PUMP switch ON (after the green POWER LED comes on).
   - The module should emit a hum, indicating that the pump is working. Generally, the PUMP SPEED control will not have to be adjusted. However, it may be helpful to control sampling flow in the range of 50 to 200 ml/min depending upon measurement requirements.
   - 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., close to zero speed). To change the pump speed, keep the PUMP switch in the ON position and use a small straight blade screwdriver to turn the recessed potentiometer in the PUMP SPEED control. Turn trim POT clockwise to increase PUMP speed or counter-clockwise to decrease PUMP speed
6. Adjust the GAIN switch on the front of the module after proper startup.

Module	Gain	1V output = % gas concentration	Voltage output range
O_2	**100% / V**	100% O_2	0 to 1 volt
O_2	**50% / V**	50% O_2	0 to 2 volts
O_2	**20% / V**	20% O_2	0 to 5 volts
O_2	**10% / V**	10% O_2	0 to 10 volts

CO_2	**10% / V**	10% CO_2	0 to 1 volt
CO_2	**5% / V**	5% CO_2	0 to 2 volts
CO_2	**2% / V**	2% CO_2	0 to 5 volts
CO_2	**1% / V**	1% CO_2	0 to 10 volts

O_2 example: If the **100% / V** setting is used, then 20.93% oxygen (atmospheric level) will be output as 0.2093 volts or 209.3 mV. Generally, GAIN can be left at the setting of 10% oxygen per volt (bottom position).

CO_2 example: If the **10% / V** setting is used, then 4% carbon dioxide (approximate concentration in expired breath) will be output as 0.40 V or 400 mV. Generally, GAIN can be left at the setting of 1% carbon dioxide per volt (bottom position).

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 module. Everything should be stable prior to attempting 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 module. The 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 module. Always use a 5 micron hydrophobic sampling filter (or better) at the sampling input of the module. One is included with each module and each Gas Sampling Interface Kit (AFT20 or AFT31-MRI). The 5-micron hydrophobic filter will help to protect the module from airborne particulate matter and other contaminants.
3. If required, screw a 10/32 threaded Luer adapter into the sample output port bulkhead fitting and attach the venting line to the Luer adapter to vent undesirable gases away from the site of the 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 excess water vapor above ambient levels should be removed from the sampling stream prior to being monitored by the module. To dry the sampling stream, use water vapor permeable tubing (i.e., NAFION®).

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.

The AFT20 or AFT31-MRI Gas Sampling Interface Kit includes all the items necessary (including NAFION® tubing) to efficiently connect the module to a variety of setups, including BIOPAC mixing chambers, facemasks and non-rebreathing T-valves.

CALIBRATION

Each gas concentration module comes factory-calibrated to ± 1% concentration accuracy. Depending upon sampling line configuration and pump speed (flow rate,) the calibration may veer further from ±1% accuracy. Generally, **a gas calibration should be performed prior to all exacting measurements**. This may also be required when running at increased pump speeds and thus increased flow rate. Initial (Factory) oxygen accuracy calibration is usually inadequate for varying setup protocols. Proper calibration of the module should be performed after the specific measurement setup is in place.

The CO2100C and O2100C gas sampling modules are designed so that the gas sensors are held at ambient pressure, due to construction design which directs exhaust sampling direct to the ambient environment. In this regard, the modules are relatively insensitive to variations in sampling line pressure. However, it remains good practice to use setup configurations which will minimize any pressure variation in the sampling line.

Choose the calibration gases to bracket the expected measurements. For example:

- When performing End Tidal O_2 measurements, normal air can be used as the first calibration gas because the oxygen concentration is known as 20.93%. For the second gas, it might be best to use a calibration gas of 16% oxygen, 4% carbon dioxide and 80% nitrogen (such as BIOPAC's GASCAL). In this case, the measurements will be most accurate for the range of 16.00% to 20.93% oxygen.
- When performing End Tidal CO_2 measurements, normal air can be used as the first calibration gas because the carbon dioxide concentration is known as 0.04%. For the second gas, it might be best to use a calibration gas of 4% carbon dioxide, 16% oxygen and 80% nitrogen. In this case, the measurements will be most accurate for the range of 0.04% to 4% carbon dioxide.

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 the measurement so that all gas sampling lines are in place between the module and the sampling chamber.
2. Adjust the PUMP SPEED control (if required) on the module.
3. Run the module and click on the CAL1 button when the first calibration gas is introduced into the sampling chamber.
4. Introduce a second calibration gas into the chamber and click on CAL2 when the second calibration gas is introduced into the sampling chamber.

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 or AFT31-MRI Gas Sampling Interface Kit. The time delay between change of oxygen concentration at the sampling end of the Gas Sampling Interface Kit (AFT20 or AFT31-MRI)) to measurement at the 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" D	Volume = 3.336 ml
NAFION® Dryer:	12" long at 0.050" D	Volume = 0.386 ml
Misc. Tubing/Junctions:	6" long at 0.060" D	Volume = 0.278 ml

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

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

To check the flow rate, expire into the free end of the sampling line (30 cm Naflon tubing + 1.8 meters polyethylene tubing from AFT20 or AFT31-MRI Gas Sampling Kit) and simultaneously mark the recording (using the marker function in Acq*Knowledge*). The measured gas concentration level should show a change at approximately 2.5 seconds.

SPECIFICATIONS

O2100C Module measures the partial pressure of O_2.

CO2100C Module measures the partial pressure of CO_2.

Thus the module output is proportional to 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.

	O2100C	**CO2100C**
Range:	0-100% O2	0-10% CO2
Repeatability:	±0.1% O2	0.03% CO2
Resolution:	±0.1% O2	0.1% CO2
Linearity:	±0.2% O2	0.1% CO2
Zero Stability:	±0.01% O2/hr	0.1% CO2/24 hours
Response Time: *Factory Preset:*	200 msec (T20-T80) @ 200 ml/min 500 msec (T20-T80) @ 100 ml/min 1000 msec (T20-T80) @ 50 ml/min	150 msec (T20-T80) @ 200 ml/min 250 msec (T20-T80) @ 100 ml/min 350 msec (T20-T80) @ 50 ml/min
Delay: (at 4 ml sampling line volume)	Flow (ml/min) = 240/Delay (sec) *Example:* If Delay is 2 sec; Flow = 120 ml/min	
Gain:	10, 20, 50, 100 (%O2/Volt)	1, 2, 5, 10 (%CO2/Volt)
Output Range:	0-10 volts	
Flow Range:	5-200 ml/min (50/150 ml/min recommended, increasing flow rate decreases response time)	
Temp Range:	5-50° C	10-45° C
Zero Drift:	±0.05% O2/°C	±0.01% CO2/°C
Span Drift:	±0.25% O2/°C	±0.02% CO2/°C
Warm Up Time:	About 1 minute	About 5 minutes
Humidity Range: (non-condensing)	0-95% non-condensing	0-90% non-condensing
Sampling Input Port:	Male Luer	
Sampling Output Port:	Bulkhead fitting, 10/32 internal thread	
Weight:	990 grams	740 grams
Dimensions:	7 cm (wide) x 11 cm (deep) x 19 cm (high)	
Power Source:	12 VDC @ 1 amp (uses AC100A transformer, included)	

- Gas sampled must be free of liquids or any condensable vapors.
- Gas sampled should be filtered to 5 microns or better.
- The O2 module measures the partial pressure of O2 and thus the module output is proportional to the partial pressure of O2 in the sample cell.

For example, the partial pressure of 21% concentration of O2 at sea level (760 torr) is:

760 torr * 0.21 = 159.60 torr

So at 700 torr and 21% O2, the module output will be:

(700 torr / 760 torr) * 159.6 torr = 147 torr

Accordingly, when operating at an ambient pressure of 700 torr, the module scaling needs to be multiplied by a factor of (700/760) or 0.921 * (original scaling).

- The CO2 module measures the partial pressure of CO2 and thus the module output is proportional to the ambient pressure changes to the 3/2 power.

For example, the partial pressure of 4% concentration of CO2 at sea level (760 torr) is:

760 torr * 0.04 = 30.4 torr

So at 700 torr and 4% CO2, the module output will be:

(700 torr / 760 torr) ** 1.5] * 30.4 torr = 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) or ** 1.5 OR 0.884 (original scaling).

See also: AFT Series Airflow & Gas Analysis Accessories
Application Note # AH149 — O2100C Module Setup
Application Note # AH151 — CO2100C Module Setup