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## Application Example using the O2100A Module

The O2100A module can be used to perform real-time oxygen concentration monitoring. The O2100A module may be used to perform analysis of expired air during the course of a pulmonary function or exercise physiology test. This application note will focus on the use of the O2100A module for estimating oxygen consumption ( $VO_2$ ).

When performing a test of this kind, many factors exist to confound the measurement. For example, it may be reasonable to think that the volume of expired air is always the same as inspired air, but this is only true when the volume of carbon dioxide expired is equal to the amount of oxygen consumed. In other words, the inspired and expired volumes are equal only when the Respiratory Exchange Ratio (RER) equals one. The Respiratory Exchange Ratio is defined as  $VCO_2$  divided by  $VO_2$ . (V is Volume). For purposes of simplicity, this application note will assume that  $RER=1$ .

An additional factor affecting oxygen consumption measurement is the response time of the O2100A module. Nominally, the step response time of the O2100A module is 500 msec. For breathing rates exceeding 42 BPM (using the formula:  $Tr = 0.35 / Fh$ ), the O2100A module will slowly begin to attenuate its response to oxygen changes.

When measuring  $O_2$  concentration changes during the course of a breathing cycle without the use of a mixing chamber, the response time of the O2100A module is critical. It is possible, for certain applications (i.e. breath-by-breath analysis), to improve the response time by increasing the sampling flow rate of the O2100A module.

Naturally, when using a mixing chamber to average  $O_2$  concentration over a few breaths, there is no performance degradation when measuring  $O_2$  concentration changes for arbitrarily high breathing rates. Accordingly, a mixing chamber is typically recommended for quick, accurate and easy metabolic analysis.

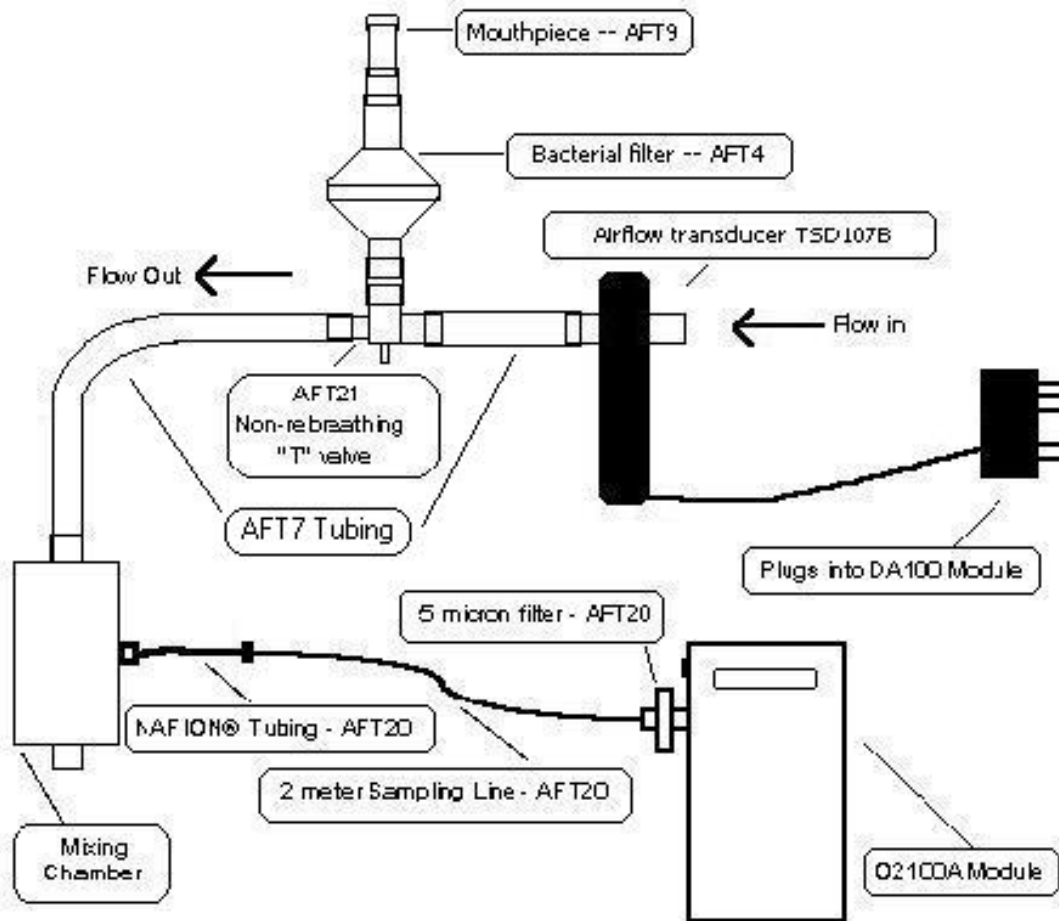
The O2100A module is normally used in conjunction with an MP100 system. The O2100A connects to the monitored gas flow via the AFT20 gas sampling interface kit. The AFT20 kit is used to connect the O2100A module to a mixing chamber (typically 5 liters) which is on the output end of a non-rebreathing "T" valve (like the AFT21). The input end of the "T" valve connects to a Pneumotach (airflow) transducer, like the TSD107B.

Because the O2100A module is connected to the mixing chamber, the module will sense the changes in oxygen concentration occurring as the subject breathes. Furthermore, because the TSD107B is placed in the "Flow In" line, the total volume of inspired air can be calculated on a breath-by-breath basis. Finally, because both the oxygen concentration and total volume of expired air is known (assuming RER = 1), it is possible to estimate the approximate amount of oxygen consumed by the subject during the course of breathing.

Like all gas sampling equipment, the module measures the partial pressure of oxygen in its internal sample cell and is, therefore, sensitive to changes in ambient pressure. When connecting the module sampling line to the mixing chamber, ambient pressure influences on the oxygen reading are minimal.

In certain cases, however, (such as connecting directly to the AFT21 non-rebreathing "T" valve), pressure effects may be problematic. To minimize the possible effects of pressure changes occurring inside the T valve from affecting the reading of the O2100A module, insert a small Venturi to scale down the pressure effects. A reasonably good Venturi can be implemented by employing the "Y" coupler included with the AFT20 Gas Sampling Interface Kit. To have the "Y" act like a Venturi, just leave the third port open to ambient pressure.

The following diagram illustrates a typical connection for the O2100A module to the 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 airflow transducer, as shown by the "Flow In" arrow. When the subject expires, air is forced out through the mixing chamber.



### O2100A Connection to Mixing Chamber, AFT21 and TSD107B

The following graph illustrates data collected using the previously defined setup procedure. The waveforms shown are calculated and derived by AcqKnowledge in real-time. The waveform descriptions are as follows:

#### *Waveform 1 – Expired O<sub>2</sub>*

This waveform is the O2100A module output. The O2100A module samples the O<sub>2</sub> concentration directly from the mixing chamber.

### ***Waveform 2 - Delta O2***

This waveform is the O<sub>2</sub> concentration in the mixing chamber subtracted from the O<sub>2</sub> concentration in the ambient environment (O<sub>2</sub> = 20.93%). This waveform is the O<sub>2</sub> concentration consumed.

### ***Waveform 3 – Inspired Flow***

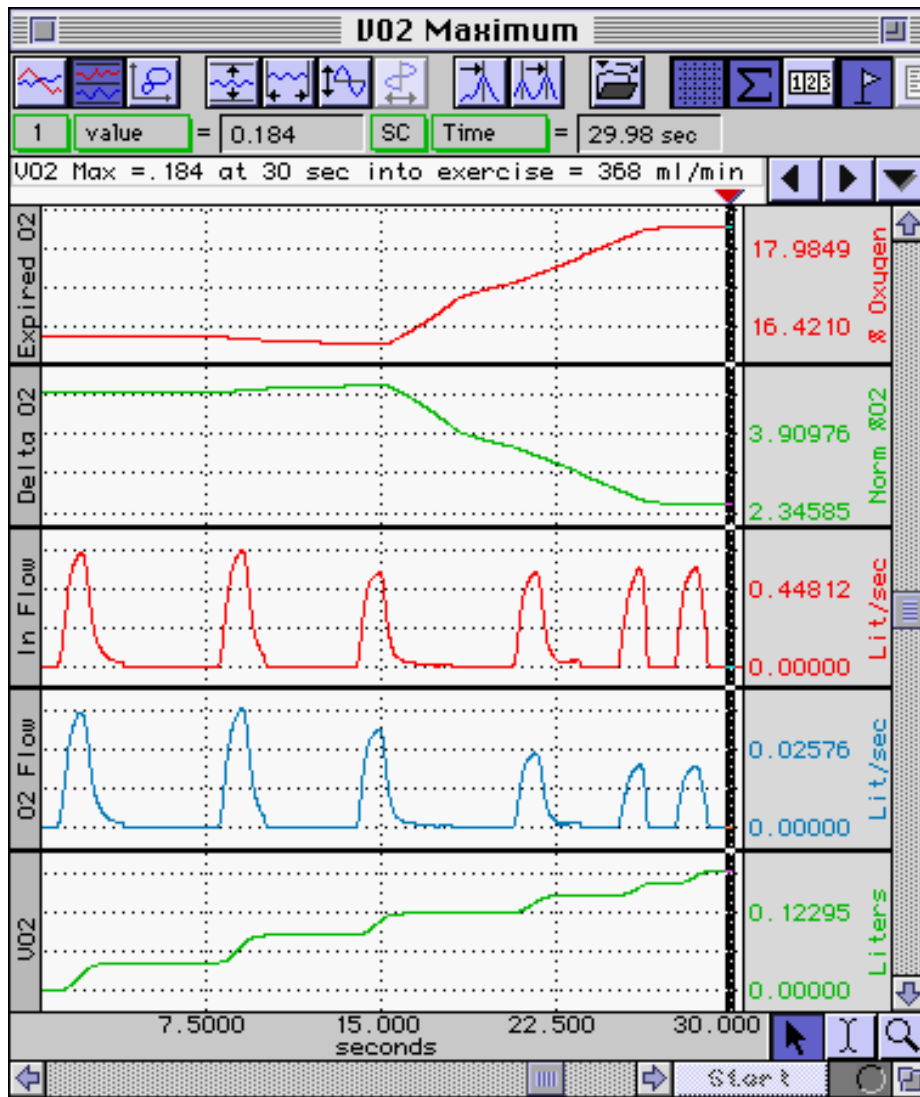
This waveform is generated by the TSD107B, which is connected to a DA100 module. This waveform is the total inspired air flow. Please note that this application note assumes inspired air flow to be equal to expired air flow (RER=1).

### ***Waveform 4 - O2 Flow***

This waveform is the mathematical result of multiplying the expired air flow measured by the TSD107B (waveform 3) by the consumed oxygen concentration (waveform 2). Accordingly, this waveform is the oxygen flow consumed by the subject. Note how the flow signal drops as the normalized oxygen concentration level drops.

### ***Waveform 5 - VO2***

This waveform is the integral of the oxygen flow consumed by the subject. The integral of the oxygen flow is the amount of oxygen consumed up to a particular point in time. In this case, VO<sub>2</sub> equaled 184 ml after 30 seconds of exercise, which extends to an estimate of 368 ml/min oxygen consumption.



*VO2 Measurement*

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