S101 Oxygen Sensor
Manual

Manufactured and Distributed by:

QUBIT SYSTEMS INC.
700 Gardiners Road, Unit 105
Kingston, Ontario
Canada K7M 3X9

Phone: (613) 384-1977
                1-888-262-2219 (North America)
Fax: (613) 384-9118
Email: info@qubitsystems.com

Web Site: www.qubitsystems.com

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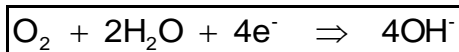
Principle of Operation

The O$_2$ sensor is a galvanic cell (a lead-oxygen battery) consisting of a lead anode, an O$_2$ cathode, and an acid electrolyte. It also incorporates an O$_2$-permeable Teflon FEP membrane with a gold electrode bonded to its surface. Oxygen diffusing through this membrane is reduced electrochemically at the gold electrode. Within the sensor, the following reactions occur:

Cathode:

$$O_2 + 2H_2O + 4e^- \Rightarrow 4OH^-$$

Anode:

$$2Pb + 4OH^- \Rightarrow 2PbO + 2H_2O + 4e^-$$

Overall:

$$O_2 + 2Pb \Rightarrow 2PbO$$
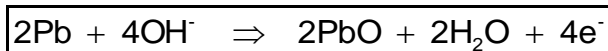
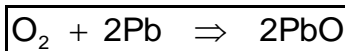A resistor and a thermistor (for temperature compensation) are connected between the anode and the cathode, so that the battery is always discharged. The output of the instrument is proportional to the current flowing through the resistor and thermistor. This is, in turn, proportional to the partial pressure of O_2 in contact with the Teflon FEP membrane. The signal from the oxygen sensor is transmitted to the computer via the LabPro. It is then displayed in "percentage O_2" using Logger Pro 3 software.

> ***Note: The expected life of the O_2 sensor's galvanic cell is 3 – 5 years. If you are no longer able to adjust the O_2 sensor's signal amplitude by adjusting the gain, you will need to order a new sensor. The part number for the O_2 sensor supplied with this package is S101.***

It is advised to keep the S101 Oxygen sensor stable during use. Keep the unit upright as shown in the diagram above. There are Velcro strips attached to both the sensor and the amplifier to assist in proper mounting to the Qubit Systems Lab Stand and accessories bracket.

Calibration of the S101 O_2 Sensor

The O_2 sensor is permanently attached to an amplification box incorporating a gain control. The sensor output range is 0 to 4.5 volts. The gain control can be used to set the maximum voltage to correspond to any pO_2 between 15% and 100%. The output of the sensor is linear across all pO_2 ranges. The O_2 sensor may therefore be calibrated using a single pO_2 standard. For use in the range incorporating atmospheric pO_2, the simplest way to calibrate the sensor is to expose it to standard air (20.95% O_2) and to set an appropriate voltage output using the gain control. For example, if a range from 0% to 40% O_2 was required, the gain control would be used to set 20.95% O_2 at approximately 2.20 volts. For high-resolution use, the O_2 sensor should be calibrated with an analyzed standard O_2 mixture and zero O_2 should be measured in an O_2-free atmosphere (typically N_2 gas).

DATA ACQUISITION USING THE LABPRO™ INTERFACE

LabPro™ Interface

The LabPro interface has 6 independent channels: 4 analog and 2 digital. The digital channels can be used with motion detectors, photogates and radiation monitors. LabPro collects data faster than the SBI and supports analog output. LabPro can be used with a PC or Macintosh computer (running Logger Pro 3 software), with a Palm or Visor Handheld (running DataPro software), or for stand-alone data collection and storage. LabPro can be connected to a computer via a serial or USB port. LabPro stores 12,000 data points internally and has sampling rates from 1/day to 50,000/s.

The LabPro interface works in conjunction with the Logger Pro software that is provided with your package. Vernier Software of Portland, Oregon manufactures both LabPro and Logger Pro. The complete guides to the use of LabPro and Logger Pro are included with your package. This manual only provides a general guide to the uses and capabilities of LabPro and Logger Pro. If you ordered the LabPro interface, your package should include the interface, a PC serial cable and adapter or a Macintosh serial cable, a USB cable, a power supply, a calculator cradle and a short calculator link cable.

To conduct the experiments described in QUBIT'S packages, you will usually connect LabPro to a computer. The minimum requirements are a Power Mac running OS 9.2 or later with an unused modem, printer or USB port, or a Pentium® running Windows 95/98/2000/NT/ME/XP with an unused serial or USB port. (Note that a USB port cannot be used with Windows 95.). LabPro can be powered by batteries or by AC power. We recommend that you connect the AC power adapter by plugging the round plug on the 6 V power supply into the left side of the interface. If you hear 6 beeps and observe the LEDs blinking, the unit has been powered up successfully.

Connect the sensors to the appropriate channels as specified in the experiment that you are running. In QUBIT'S experiments, you will mainly be using the analog channels on the side of the interface. The Digital/Sonic channels are on the opposite side of the interface.   In QUBIT'S old manuals, the "ports" on the SBI are equivalent to the "channels" on the LabPro. If instructed to connect a sensor to Port 2 of the SBI, simply connect it to CH 2 of LabPro.
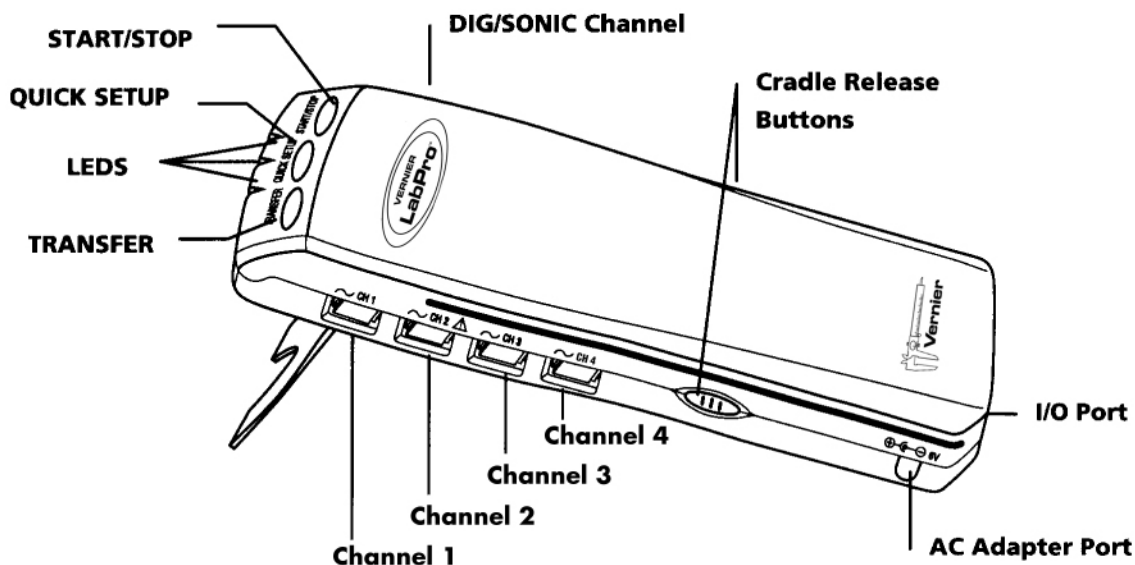
START/STOP

QUICK SETUP

LEDS

TRANSFER

DIG/SONIC Channel

Cradle Release Buttons

I/O Port

AC Adapter Port

Channel 4

Channel 3

Channel 2

Channel 1

Diagram modified with permission from *Vernier Software*.

There are 3 buttons on top of the LabPro. DO NOT use the buttons if LabPro is connected to a computer running Logger Pro. When LabPro is connected to a computer, its operation is controlled via the Logger Pro software. The "Transfer" button begins the transfer of calculator programs or applications between LabPro and a TI graphing calculator. The "Quick Setup" button clears any data stored in LabPro's memory, scans all channels for auto-ID sensors and sets them up to collect data when LabPro is in the stand-alone mode. The "Start/Stop" button begins sampling for Quick Setup. Sampling continues until Start/Stop is pressed again.

There are 3 LEDs on top of the LabPro. The red LED indicates an error condition. The yellow LED indicates that LabPro is ready to collect data samples and the green LED indicates that LabPro is collecting data. LabPro also has a sophisticated diagnostic beep code system. Please refer to your LabPro manual for a complete description of the beep codes.

Logger Pro 3

Installing and Running Logger Pro 3

PC Users:

(1) To start, you will need to have a complete copy of Logger Pro 3 installed on the computer. Before starting the installation, make sure that all USB cables are disconnected from your computer. Failure to do so may cause an error in the installation of the USB drivers.

(2)   Run the installation and DO NOT CHANGE the default destination directory. Logger Pro 3 will be installed in C:/Program Files/Vernier Software/Logger Pro 3.

(3)   The setup process will automatically load the USB drivers for connecting the LabPro to your computer (unless you do not have a USB port).

(4)   If you do not have QuickTime 6 (or greater) installed on your computer, it is advised that you do so when prompted. QuickTime will allow you to use the picture and movie features of Logger Pro 3.

(5)   You will be prompted to connect the LabPro to the computer via the USB connection, if you plan on using such a connection during your experiments. Ensure that the LabPro is powered before you connect the USB cable (QUBIT SYSTEMS sensors do not need to be connected).

(6)   Once the USB is connected, you will be prompted to install the software for LabPro. Choose to automatically install this software and follow the on-screen directions.

(7)   Click 'Finish' to complete the installation process.

(8)   Use the USB cable to connect LabPro to the USB port of the computer (or use the serial cable to connect LabPro to the modem or printer port).

(Note: Logger Pro 3 CANNOT be used with a ULI or Serial Box Interface)

(9)   Connect the power supply to LabPro via the AC adapter port. Plug in the power supply.

(10)   Double click the Logger Pro 3 icon on your desktop to start Logger Pro. If Logger Pro detects the LabPro Interface, the main Logger Pro screen will appear. If Logger Pro cannot detect the LabPro Interface, the "Connect to LabPro" dialog box will appear. Select the port that LabPro is connected to (USB or COM 1-4) in the dialog box and click the "OK" button. Once the LabPro has been identified, the connection will be displayed (in text) at the top left of the main screen. If the LabPro Interface cannot be identified, secure all cable connections and ensure that it has power. If you used a USB connection, check that you are running Logger Pro 3 and Windows 98 or later.

(11)   To use the LabPro Interface with Logger Pro 3, the LabPro Operating System must be at least version 6.26. If an older version is installed on the LabPro Interface, you will be prompted to upgrade to version 6.26 when Logger Pro 3 is started. Ensure that you close all other running programs before starting the update process. In the **Update OS** window, click on 'Update OS Now' and then 'OK' in the next **Update OS** window. When the update is finished (approximately 7 minutes), LabPro will beep several times.

Macintosh Users:

(1)   To start, you will need to have a complete copy of Logger Pro 3 installed on the computer (You must be using at least OS 9.2). Run the "Complete Installation" and make sure that you have disconnected all TI GRAPH_LINK and USB cables. The most recent version of Logger Pro (3) is included with this package.

(2)   When the installation has completed, use the serial cable to connect LabPro to the modem or printer port of the computer or use the USB cable to connect LabPro to the USB port of the computer.

(3)   Connect the power supply to LabPro via the AC adapter port. Plug in the power supply.

(4)   If the installation process does not automatically place a Logger Pro 3 icon on your desktop, you should create one. Locate the Logger Pro 3 file in the Applications folder on your hard drive. You should click on the file and choose "Make alias", so the program can be accessed easily from your desktop.

(5)   Double click the Logger Pro 3 icon on your desktop to start Logger Pro. If Logger Pro finds LabPro the main Logger Pro screen will appear. If Logger Pro cannot find an Interface, the "Connect to LabPro" dialog box will appear. Select the port that LabPro is connected to (USB or other) in the dialog box and click the "OK" button. Once the LabPro has been identified, the connection will be displayed (in text) at the top left of the main screen. If the Interface cannot be identified, secure all cable connections and ensure that the Interface has power. If you used a USB connection, check that you are running Logger Pro 3 and OS 9.2 or later.

(6)   To use the LabPro Interface with Logger Pro 3, the Operating System in LabPro must be version 6.26. If an older version is installed on the LabPro Interface, you will be prompted to upgrade to version 6.26 when Logger Pro 3 is started. Close all running programs before starting the update process. In the **Update OS** window, click on '**Update OS Now**' and then 'OK' in the next **Update OS** window. When the update is finished (approximately 7 minutes), LabPro will beep several times.

Installing Q̲ᴜʙɪᴛ's Setup Files to your Hard Drive

C404 Automatic Installation CD

Qubit Systems's C404 Automatic Installation CD is designed to install the setup files (designed by Qubit Systems) for Logger Pro 2.2.1 and Logger Pro 3. These setup files contain experiment files (described in the manuals accompanying your package) and the required calibration files for all of Qubit Systems's sensors.

Please see the accompanying C404 Installation Manual for complete instructions.

O$_2$ Setup File Selection for PC or Macintosh Users

(1)   Attach the O$_2$ sensor to the appropriate channel as specified in your experimental procedure. Note: Channels on the LabPro are equivalent to ports on the SBI. QUBIT's setup and calibration files assume that sensors are assigned to channels in accordance with the setup file for the experiment that you will be running.

(2)   Select "Open" on the file menu. Click on the appropriate folder and setup file as specified in your experiment manual.

The setup files on the CD that we have supplied to you are 'Read-only'. Any copies that you may make of the setup files will not be 'Read-only'. Users should therefore be warned not to write over the setup files. To make a setup file 'Read-only', first select the file then choose 'Properties' from the 'File' menu. Click on 'Read only', then 'OK'. This will prevent users from writing over the setup file when saving their data.

Creating your own Custom Setup File

After your setup file loads, a graph or combination of graphs will appear on the screen. Each custom setup file will show the output from one or more of the instruments supplied with the package. You may create your own custom setup file by changing the sensor inputs, calibration files, graph ranges, running time and data collection rate as described below.

Data Collection with Logger Pro 3

Please see the Logger Pro manual for more detailed data collection and analysis instructions.

Graph Displays

When the **S101_O2.cmbl** setup file loads, a graph will appear on the screen showing output from Oxygen sensor.

You can customize most of the options of any graph to your liking by double clicking on the graph and selecting the options in the dialog box that is displayed.

Selecting Sensor Inputs and Calibration Files

You should ensure that each sensor is connected to an appropriate channel on the LabPro. The default setting for the **S101_O2.cmbl** setup file assigns the Oxygen sensor to CH1 of the LabPro Interface. To alter the arrangement of sensors in the setup file, or to use other sensors, you must change the settings within Logger Pro. To do this, select "Show Sensors" from the "Experiment" menu. You can change the sensor

assignment by scrolling through the Analog Sensor options and dragging the desired sensor to the appropriate channel (CH1-4), or scroll through the Digital Sensor options and drag the desired sensor to the appropriate channel (DIG/SONIC1-2). A 'Setup Changed' dialog box will appear to confirm sensor replacement.

You should ensure that the sensor's calibration file is loaded. To do this, select "Show Sensors" from the "Experiment" menu and then click on the image of the appropriate sensor. At the bottom of the menu appear the current calibrations to choose from. If you wish to recalibrate, then select 'Calibrate' at the top of the menu and proceed as described.

Graph Ranges, Run Time and Data Collection Rate

To modify the range of the x and y-axes, click on the maximum and/or minimum values and type in the new values.

If you wish to alter the maximum time allotted to your experiment or the rate of data sampling, select "Experiment", then "Data Collection". Type in the run time of your experiment in the box labelled "Length". **Note that the maximum value you select for the Time-axis limits the time over which you can collect data for a particular run.** If your experiment exceeds the allotted time, select "Experiment", then "Store Latest Run". You may then restart data collection. Data from the first part of your experiment will remain on the screen as a faint trace and new data will be plotted in a bolded shade of the same colour. You can collect numerous runs in this way. Each run will be collected to a separate data table. When you save your data, all of the runs will be saved under the same file name.

You may also alter the rate at which you collect data. The default rate is 1 point/s. For long experiments this may be too fast, resulting in very large data files. For shorter experiments with important transient conditions, you may wish to sample at a faster rate.

Data Collection and File Saving

To start data collection, click on the "Collect" icon above the graphs. This will change to a "Stop" icon. Click on the "Stop" icon to stop data collection.

If you wish to save your data or any changes to your Logger Pro setup, select "File" from the main menu, then "Save As…". The default path is to save your file as **S101_O2.cmbl** in the 'S101 & S102 Oxygen Sensor' folder. If you save the file without changing its name, the original setup file will be over-written! You should save your data files under a new name and store them in an appropriate location on your hard drive, or on a 3.5" disk in drive A.   You may open your stored file by selecting "File" then "Open" from the main menu and navigating to the file via the "Look In" dialog box.

Data Analysis with Logger Pro 3

- Position the cursor at the beginning of the data set that you wish to analyze, then click and hold with the mouse.

- Drag the cursor across the data set and unclick. A greyed box will appear on the screen to show the data range to be analyzed.

- Select "Analyze", and then choose from a wide variety of analysis options. For example, use:

  - "Examine" to scroll through the data points at specific time intervals.
  - "Integral" to integrate the selected data.
  - "Statistics" to automatically perform a variety of statistical analyses.

You can also fit curves and tangents to the selected data by choosing the appropriate menu option.

SPECIFICATIONS

Principle	Acid Electrolyte, Teflon Diffusion Membrane
Detection Range	0-100 %O$_2$ (Linear)
Resolution	±50 ppm
Accuracy	± 0.21% of Full Scale
Response Time (90%)	12 Seconds
Life Expectancy (in air at 20%)	4-5 years (Replacement cells are available)
Influence by Other Gases	Ammonia and Ozone
Required Sample Volume	Minimum of 2-3mL/min
Operating Temperature	5 to 40°C (Effective range)
Compensation	Built-in Temperature Compensation
Pressure Range	0.5 atm to 1.5 atm
Pressure Effect	Output voltage changes proportionally
Shock	Resistant to 2.7 G
Vibration	Avoid strong vibration
Orientation	Upright with gas port facing down
Weight	125 gm Total
Specifications	0-5 volt output
Power Supply	5 Volts (Provided by computer interface)

The sensor gives a Partial Pressure Oxygen reading in kPa Oxygen. The following equation calculates Oxygen percentage by measuring gas pressure at the sensor.

O$_2$ (%) = O$_2$ (kPa) * Absolute Pressure (kPa) / 100

Water Vapour in gas stream will not damage the cell but condensation on internal diffusion membrane will cause false readings. We recommend drying the gas before passing it through the sensor because water vapour dilutes the oxygen concentration.

The S101 Sensor is fitted with 1/8 inch Nylon NPT Union.

Sensor is fitted with a standard British Telecom Analog connector (suitable for the LabPro Interface) and may also be fitted with a five-pin DIN connector (suitable for the Serial Box Interface or Universal Lab Interface). Alternatively, we can provide bare wires and a description of the wires, for use in your own data logging system.

LIMITED WARRANTY

This QUBIT SYSTEMS product has been examined and tested for proper operation. Please operate this product only in accordance with the instructions. QUBIT SYSTEMS INC. warrants this product against defects in workmanship and materials for a period of 2 years from the date of purchase by the original owner. If the product should become defective within this warranty period, we will repair or exchange it. A return authorization number must be obtained from QUBIT SYSTEMS INC. prior to returning equipment. Items received without a return authorization number will be refused. Products to be serviced under this warranty should be sent to **QUBIT SYSTEMS INC., 700 Gardiners Road, Unit 105, Kingston, Ontario, Canada K7M 3X9**. Shipment must be prepaid, properly packed and insured.

QUBIT SYSTEMS INC. is not and will not be liable for any consequential loss or damages of any category or description that may occur by reason of purchase and use of this product. The responsibility of QUBIT SYSTEMS INC., in any event, is strictly limited to the replacement/repair of the product.