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LI-840

CO_2/H_2O GAS ANALYZER

Instruction Manual

LI-COR®

Biosciences

LI-840

CO_2/H_2O Analyzer

Instruction Manual

LI-COR®

Biosciences

Federal Communications Commission
Radio Frequency Interference Statement

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC rules, which are designed to provide a reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

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Biosciences

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Declaration of Conformity

Manufacturer's Name: LI-COR Inc.

Manufacturer's Address: 4421 Superior Street
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declares that the product

Product Name: CO_2/H_2O Analyzer

Model Number(s): LI-840

Product Options: None

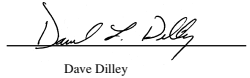
conforms to the following Product Specifications:

FCC CFR Part 15.109 Radiated Emissions, Class A
FCC CFR Part 15.107 Conducted Emissions, Class A

IEC 61326 : 1997/A2:2001 Radiated Emissions, Class A
IEC 61326 : 1997/A2:2001 Conducted Emissions, Class A
IEC 61000-4-2 : 1995/A2:2000: ESD, 4KV/8KV Contact/Air
IEC 61000-4-3 : 1995/A2:2000: Radiated RF Immunity, 10V/m
IEC 61000-4-4 : 1995/A2:2000: EFT/Burst
IEC 61000-4-5 : 1995/A2:2000: Surge
IEC 61000-4-6 : 1996/A1:2000: Conducted RF Immunity
IEC 61000-4-8 : 1993/A2:2000: H-Field Immunity, 30A/m
IEC 61000-4-11 : 1994/A2:2000: Voltage Dips

Supplementary Information:

The product herewith complies with the requirements of the EMC Directive 89/336/EEC.



Dave Dilley
Director of Engineering

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December 1, 2003

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1 General Description

What's What

This procedure should be followed if you have just taken delivery of your LI-840. Check the packing list to verify that you have received everything that was ordered and that you have also received the following items:

- **RS-232 Cable** - (Part #392-04993), used to connect the LI-840 to your computer.
- **840-500 Data Communications Software -** This Windows® 95/98/NT/2000/XP/ME compatible software is used for communication between the LI-840 and a computer. The software is provided on CD. A complete description of this software can be found in Section 3, *Operation*.

- **Standard Spare Parts Kit (9980-012)** - This kit contains replacement parts for the LI-840. As you become familiar with the analyzer you will learn which items to keep close at hand and which items can be stored away. The spare parts kit contains these items:

Description	Qty.	LI-COR Part No.
Polyurethane Mounting Feet	4	234-02268
Mounting Screws	4	149-02610
Terminal Block	1	331-05273
Bev-a-line Tubing	12'	222-01824
Gelman Air Filter	2	9967-008
Quick Connect Unions	2	300-03123
Rapid Tube Fitting Nut	2	9861-036
2.0A Fuse	2	439-03952
Cleaning Kit, includes:	1	9980-013
3" Cleaning Swabs	5	610-05314
5" Cleaning Swabs	5	610-05315
O-Rings	4	192-00226
Pre-formed Optical Bench Tubing	4	6580-010

Features

The LI-840 is an economical, high performance, non-dispersive infrared gas analyzer designed to be used for a wide variety of applications. Some of the LI-840's important features include:

- A 14 cm (5.5") optical bench is used to obtain a CO_2 measurement range of 0-3000 ppm (parts per million, or µmol/mol) and an H_2O measurement range of 0-80 ppt (parts per thousand, or mmol/mol).
- The optical bench is fully serviceable by the user; cleaning the optical bench is a simple process, and does not affect the instrument's factory calibration.
- Simple Windows® software provides for easy user calibration and data output.

Precautions

- The optical bench is maintained at a constant temperature of about 50 °C. Avoid direct exposure to sunlight or extremely high temperatures that may elevate the temperature inside the LI-840 case.
- The optical source is sensitive to vibration, and can be damaged by strong vibrations or jarring. Do not drop the LI-840, or expose it to severe mechanical shock.
- Do not use abrasive cleansers when cleaning the optical bench, as damage to the gold plating may result. Instructions for cleaning the optical bench can be found in Section 5.

- Always filter air entering the LI-840. Two Gelman filters are included in the spares kit.

Getting Started Tutorial

The following section briefly covers the basic steps you might follow to set up the LI-840 to collect and record data. Many of these steps are described in greater detail throughout this manual.

1 Install the 840-500 PC Communications Software.

This software is used to set the zero and span of the LI-840, and to set up data communication and data transfer parameters for viewing and logging data. Installation instructions can be found in Section 3, *Installing the Software on Your Computer*.

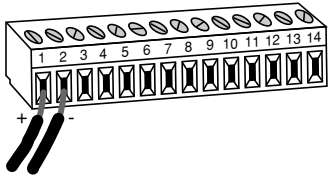
2 Determine your jumper settings for high and low alarm output, if required.

There are 2 jumpers inside the LI-840 case (on the main circuit board) which toggle the high and low alarm output between 0-5V (TTL levels) and an open drain condition.

The default jumper positions are set for 0-5V output for both high and low alarms. This alarm configuration is suitable for logic devices such as dataloggers. To use the high and/or low alarms to operate a relay switch, the jumpers should be reconfigured for open drain output. See Section 2, *Alarms*, for a description of how to change the alarm jumper settings.

If the default jumper positions are suitable for your application, or if you do not intend to use the alarms, proceed to Step 3.

3 Connect a power source to the LI-840.



The LI-840 requires an input voltage of 12-30 VDC. The power supply must be able to source a maximum current drain of 1.2A (at 12 VDC). After the instrument has warmed up it will draw about 0.3A (at 12 VDC) with the heaters on. Bare wire leads are connected to the terminal strip at positions 1 and 2. Connect the positive lead (usually red) to position #1 (12-30VDC), and the negative lead to position #2 (GND).

NOTE: Pull straight out on the face of the terminal strip to remove it; this can make it easier to connect the wires.

4 Connect the RS-232 cable.

Connect one end of the serial cable to the 9-pin Serial I/O port on the LI-840 front panel, and the other end to a serial port on your computer. If you want to interface to a device with a 25-pin serial port, a 9-pin to 25-pin adapter must be used; a gender changer may be required in some cases, also. Tighten the two screws on the ends of the serial cable.

5 Connect other output device(s) if desired.

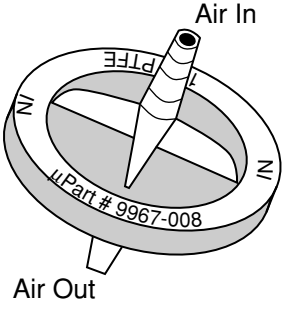
Output devices such as dataloggers and relay switches for high and low alarms are connected via the terminal strip. A complete description of the terminals can be found in Section 3, *Using the Terminal Strip*.

6 Hook up the input air stream and external filter.

Remove the nut from the **FLOW IN** fitting and connect a short (12" or so) piece of Bev-a-line tubing (in the spares kit). Tighten the nut. Place a Gelman filter (also in the spares kit) in the sample airstream before it enters the **FLOW IN** port on the LI-840. A user-supplied pump is required to force air through the LI-840.

> **IMPORTANT:** *Always install the external air filter before operating the LI-840.* Insert filter into the input airstream before it enters the LI-840. *Failure to do this will lead to contamination of the optical path.*

When using the LI-840 for applications where sample air is particularly dirty, you may consider stacking two filters in series. For maintenance, replace the filter furthest upstream from the analyzer with the filter closest to the analyzer and replace the filter closest to the analyzer with a new filter.



Install the new filter(s) with the blue lettering facing ***away from*** *the* ***FLOW IN*** *port.*

The air inlet and outlet ports should be covered with the dust caps provided or attached to an air line when the instrument is not in use. This will prevent dust from entering the instrument downstream from the filters where it can enter the optical path.

Replacement Gelman Acro 50 filters can be obtained from LI-COR (part #9967-008).

7 Start the 840-500 PC Communications Software.

Click on the program icon to start the 840-500 program. The 840-500 Main window appears. Select **Connect** from the File menu. Choose the serial port to which the LI-840 is connected, and the data output interval. Click the **Connect** button. If the analyzer is connected properly, data will appear in the main window.

8 Configure the analyzer.

Select **Settings** from the View menu. The Settings window appears. Choose a value for signal averaging (the Filter field), between 0 and 20 seconds. Set values for high and low alarms and corresponding dead bands, if desired. See Section 2 for a complete description of the alarms. If you are using an output device to collect data, choose the value to be output at DAC 1 and/or DAC 2. Make sure the Enable Heater and Pressure Compensation buttons are enabled (checked), and click **OK**.

9 Set the analyzer zero.

NOTE: The LI-840 is calibrated at the factory before shipping. It is recommended, however, that you verify the calibration by connecting a gas with known concentration and reading the displayed value. If the instrument needs to be calibrated, follow the steps below.

Connect a dry, CO_2-free gas to the input air stream. Select **Calibration** from the View menu. Select the CO_2 channel radio button. Click on **Zero CO_2**. After several seconds, a message will appear that indicates the IRGA is zeroed. Click on the H_2O channel radio button to select the H_2O channel. Click the **Zero H_2O** button.

10 Set the analyzer span.

Select the CO_2 channel radio button. Connect a span gas with known concentration of CO_2 to the input air stream. *Note that your span gas concentration must not exceed the span range chosen in the Settings dialog from Step 8 above*. Enter the value of the span gas. Click on **Span CO_2**. A message will appear indicating when the span calibration is completed.

Connect an airstream with a known water vapor concentration (such as may be generated by the LI-610 Portable Dew Point Generator) and repeat for the H_2O channel. Select the H_2O channel radio button. Enter the dew point value of the H_2O span gas, in degrees C, and click on **Span H_2O**. Click **Close**.

11 Set up the logging parameters.

Select **Options** from the Logging menu. Choose the File Header(s) to be output with the data, the values to be logged, the field delimiter, and log frequency. Click **OK**. Choose **Start** from the Logging menu. Enter a file name for the data file. Click **Save**.

12 Set up the charting parameters, if desired.

Select **Charting** from the View menu. Enter the value to be plotted, the Y-Axis min and max values, X-Axis max, and time units to be displayed on each plot. Click **Start** to begin recording data. Graphs with data will appear in the window and data will be logged to the file designated in Step 11 above.

13 Choose *Stop* from the Logging menu to close the data file and stop recording when you are done collecting data.

2 Power On

Power On

The LI-840 can be connected to a constant source of AC power using a transformer that provides 12-30VDC (14W maximum) to the LI-840. If the LI-840 is powered On with a voltage below 10.5 volts, the analyzer will not power up, and the Low Battery LED on the top panel will illuminate. The LI-840 will continue to operate with a low battery; there will, however, be a corresponding reduction in performance.

Alarms

The LI-840 is equipped with high and low alarms, which can be configured as open collector or 0-5V output (TTL levels) using jumpers on the main PC board (Figure 2-1). The default configuration is 0-5V output. Figure 2-2 shows the position of the jumpers for each of the two alarm conditions.

> The alarms can be used for either CO_2 or H_2O concentrations; only one can be chosen at a time, however.

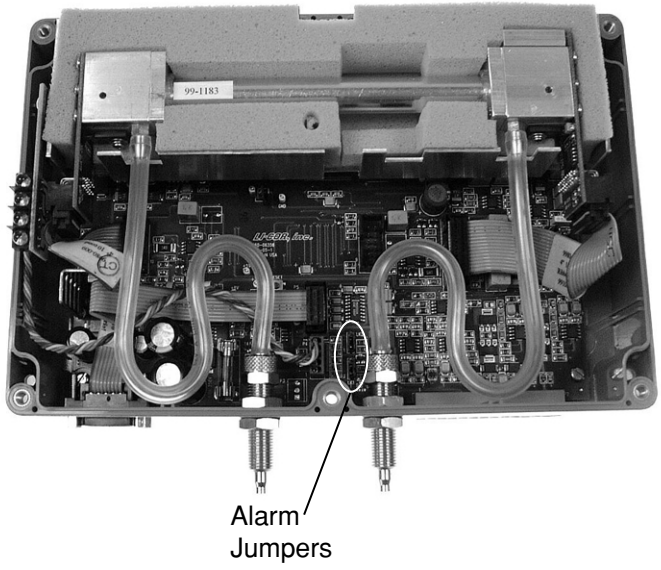


Figure 2-1. Location of alarm jumpers LK1 and LK2.

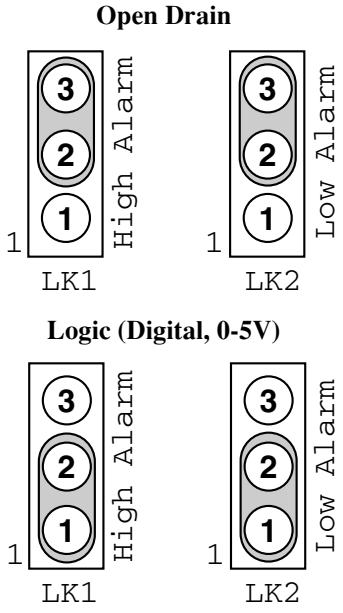
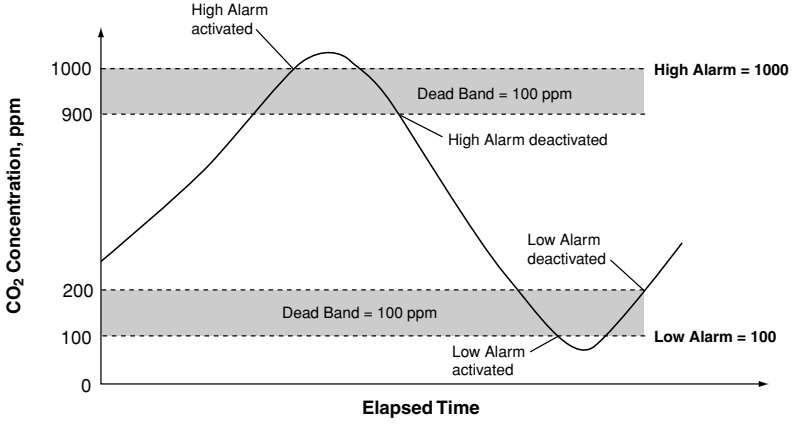


Figure 2-2. Position of jumpers for open drain and 0-5V output.

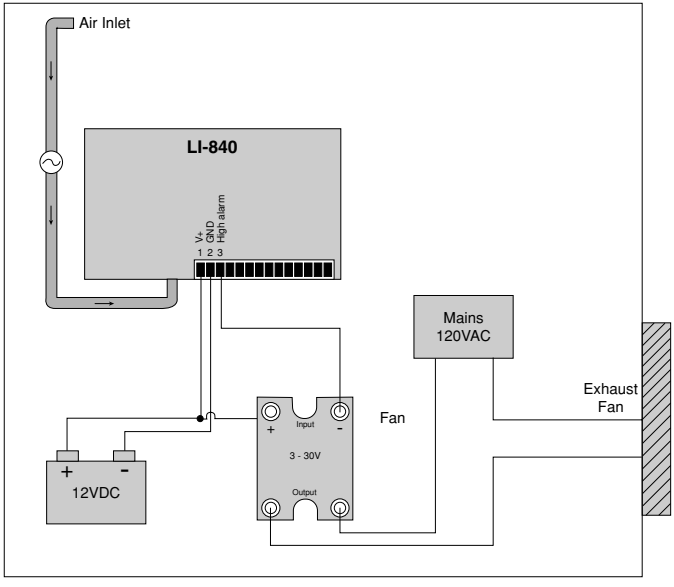
In addition, a "dead band" value can be set in software for both high and low alarms. To understand how the alarms and dead band values work, look at the diagram below.



In this chart, the low and high alarm values are set to 100 ppm and 1000 ppm, respectively. The dead band value in both alarms is set to 100 ppm. When the CO_2 concentration reaches 1000 ppm, the high alarm is activated, and remains active until the concentration drops below 900 ppm. When the CO_2 concentration falls below 100 ppm, the low alarm is activated, and remains active until the concentration rises above 200 ppm. Your choice for the dead band value(s) depends on your application, and the fluctuation in CO_2 concentrations over time.

Note: Increasing the signal average value in software (see *Settings Window; Options; Filter* in Section 3) can help reduce fluctuations in readings.

Alarm LEDs can be viewed on the top panel of the LI-840. Terminals 3 and 5 on the terminal strip are also connected to the High and Low alarms, respectively. This is useful in cases where you want to connect an audible alarm, for example, or a relay switch to operate another device that will raise or lower the CO_2 concentration to the desired level. The schematic diagram below shows how the high alarm could be connected to a relay switch that triggers an exhaust fan in a greenhouse environment. These relays could also be used to trigger devices such as automatic dialers, alarms, pumps, and valves in industrial and other environments.



A list of suppliers of electronic relay switches can be found in Appendix D.

NOTE: Consult your local electrical codes before wiring, and/or have a professional electrician wire your application.

3 Operation

Installing the PC Communications Software on Your Computer



The 840-500 software is shipped on CD. It requires that your computer have an RS-232 serial (COM) interface, and Windows® 95/98/NT/2000/XP/ME. The program runs on any true PC-compatible computer.

An installation menu starts when you insert the CD into your CD-ROM drive. Select *Install Software* from the menu and follow the instructions. If installation does not start, select **Run** from the Windows *Start* menu, and select the `LI840Setup.exe` file on the CD. When the software has finished the installation procedure, a program icon will be placed in the Programs menu.

NOTE: To remove the software, go to the Control Panel and select *Add/Remove Programs*. Choose LI840 from the list of programs and click the Add/Remove button.

Setting the Communication Parameters

LI-840 communication parameters are set automatically when the program is run.

Cabling

The serial cable included has 9-pin connectors on both ends; either end plugs into the 9-pin connector (Serial I/O) on the front panel of the LI-840. Use this cable to interface with your computer's 9-pin serial port. If you want to interface to a computer with a 25-pin serial port, a 9-pin to 25-pin adapter must be used. To connect to a computer with a USB port, a 9-pin serial to USB adapter must be used.

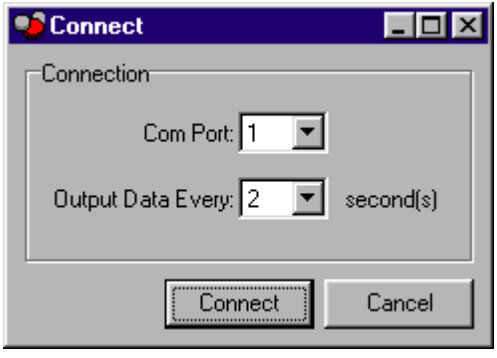
RS-232 Output

Data from the LI-840 can be transferred to a computer for analysis, printing or storage using the RS-232 interface. The LI-840 RS-232 port is configured as Data Terminal Equipment (DTE) with no hardware handshaking, and is bi-directional, meaning information can be transferred both into and out of the LI-840.

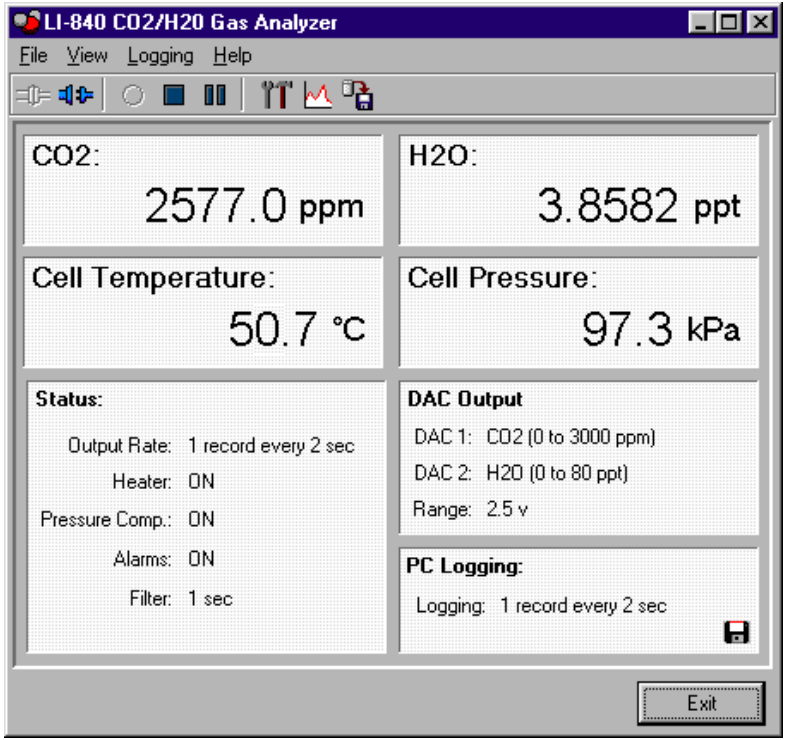
The 840-500 PC Communication Software that comes with the LI-840 is used to transfer data and setup files between the LI-840 and the PC.

Initial Setup

Click on the LI-840 program icon to start the program. The LI-840 Main Window appears. Select **Connect** from the File menu, or click on the connect icon on the toolbar, beneath the File menu. You are asked to select the serial port to which the LI-840 is connected, and the output interval at which data are output (0.5 to 20 seconds, in 0.5 second increments).



Choose a COM port and the output interval and click **Connect**. If the instrument is connected properly, data will begin to appear in the Main window (below):


LI-840 CO2/H2O Gas Analyzer
File View Logging Help
CO2:
2577.0 ppm
H2O:
3.8582 ppt
Cell Temperature:
50.7 °C
Cell Pressure:
97.3 kPa
Status:
Output Rate: 1 record every 2 sec
Heater: ON
Pressure Comp.: ON
Alarms: ON
Filter: 1 sec
DAC Output
DAC 1: CO2 (0 to 3000 ppm)
DAC 2: H2O (0 to 80 ppt)
Range: 2.5 v
PC Logging:
Logging: 1 record every 2 sec
Exit

The Main window displays the CO_2 concentration (ppm) and H_2O concentration (°C or ppt), cell temperature and pressure, and the status of various LI-840 parameters. There are also three menus used to configure the LI-840, perform zero and span calibrations, and set up the parameters for recording data.

Note that you can view H_2O concentrations in units of degrees C or parts per thousand (1 ppt = 1 mmol/mol). To change the units in the Main window, go to the View menu and toggle the **H2O in ppt** menu item on and off. Alternatively, you can click the mouse on the H_2O units being displayed in the Main window to change the display.

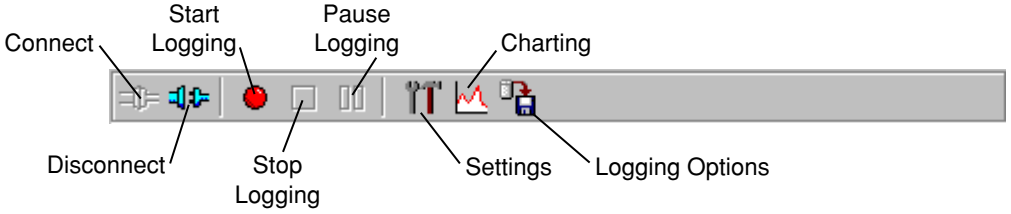
The LI-840 parameters displayed in the Main window are as follows:

Parameter	Description
Cell Temperature	Temperature (°C) in the LI-840 optical cell. This value should remain near 50 °C when the heater is turned ON.
Cell Pressure	Barometric pressure (kPa) measured in the LI-840 optical cell. This value can be used to correct measurements for the effects of pressure fluctuations on gas density and band broadening.
Output Rate	Displays data output rate chosen at connection.
Heater	Shows status of heater (ON/OFF), which is used to maintain the optical cell at a constant 50 °C. The heater is turned ON/OFF in the Settings window.

Parameter	Description
Pressure Comp.	Shows whether pressure compensation is ON/OFF. When ON, measurements are corrected for the effects of pressure fluctuations on gas density and band broadening.
Alarms	Shows status of High and Low alarms, whose values are set in the Settings window. Alarms are enabled (ON), or disabled (OFF).
Filter	Shows the current value for software signal averaging, set in the Settings window. The filter can be set from 0 (no signal averaging) to 20 seconds.
DAC Output	Displays source channels for DAC1 and DAC2, and the voltage output range (0-2.5V or 0-5V).
PC Logging	Shows "Off" if data are not being logged to a file, or "Logging" when data are being logged to a file.

Using the Toolbar

The toolbar in the Main window contains shortcuts for some of the commonly used menu items:



Settings Window - Setting Operational Parameters

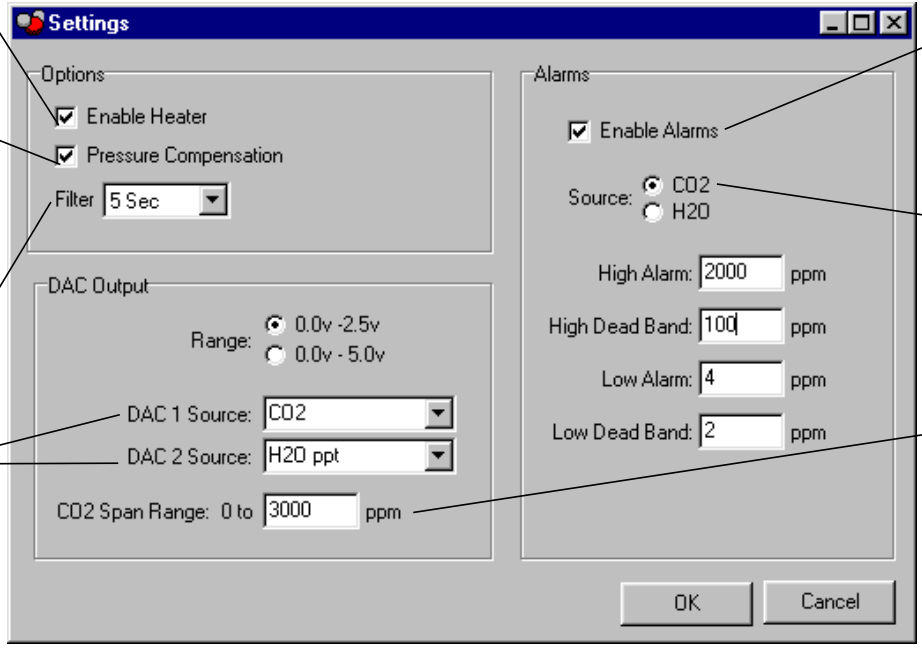
The Settings window contains parameters related to initial setup of the LI-840, including the resolution of the optical bench, signal filtering, high and low alarm setup, heater and pressure compensation options, and DAC output sources. Choose **Settings** from the View menu (or click on the toolbar icon) to open the Settings window:

The heater should be enabled to maintain the optical bench at a constant 50 °C.

Pressure compensation should be enabled to compensate for gas density changes caused by variations in pressure.

Software signal filtering is available from 0-20 seconds.

DAC output sources. Choose source to be output to DAC 1 and/or DAC 2



Disable the alarms here, set high and low alarm values, and high and low dead band values.

Use these radio buttons to choose CO_2 or H_2O as the alarm source.

CO_2 span range. This can be scaled between 0 and 99999 ppm. The measurement range for CO_2 on the LI-840 is 0-3000 ppm.

Options

Enable Heater

The Heater should be enabled to maintain the optical bench at a constant 50 °C.

Pressure Compensation

Enable the Pressure Compensation check box to automatically correct gas concentration values for changes in cell pressure. In most cases this should be turned on; disabling this feature means that no pressure correction is desired in the gas concentration calculations, which can lead to erroneous measurements.

Filter

Shows the current value for software signal averaging. The filter can be set from 0 (no signal averaging) to 20 seconds. Note that increasing the filter decreases instrument noise but reduces the response time.

DAC Output

Analyzer output for up to 2 values (None, CO_2, H_2O ppt, H_2O °C, Cell Temperature, or Cell Pressure) can be recorded by connecting a logging device to the terminal strip on the front of the analyzer. Output is linear, and is selectable at 0-5V or 0-2.5V. Choose the DAC output range and the source for DAC 1 and/or DAC 2.

The DACs in the LI-840 are bipolar, and will go slightly negative (~-0.100V). This can happen, for example, if the cell becomes contaminated or just from small random

perturbations when the gas concentration is near zero. See Section 5, *Cleaning the Optical Bench* for instructions on cleaning the optical cell, should it become contaminated.

Voltage output is measured by attaching the positive lead from the logging device to terminal 9 (V Out 1), or terminal 7 (V Out 2) on the LI-840 terminal strip. Connect the negative lead to position 10, (GND), or position 8.

The CO_2 concentration can be calculated from the DAC output voltage as follows:

$$CO_2 = V\left(\frac{C_{range}}{V_{range}}\right) \qquad 3\text{-}1$$

where V is the measured voltage, C_{range} is the maximum value of the CO_2 range selected (0 to 1000 ppm, 0 to 2000 ppm, etc.), and V_{range} is the maximum DAC output for the selected range (0-5V or 0-2.5V).

Example: The voltage output is set for 0-5V output (V_{range}), the maximum CO_2 range chosen is 2000 ppm (C_{range}), and the measured output voltage (V) is 2.9V. To calculate the CO_2 concentration (no offset) from Equation 3-1 above,

$$CO_2 = 2.9V\left(\frac{2000\ ppm}{5V}\right) \qquad 3\text{-}2$$

$$= \mathbf{1160\ ppm}.$$

The H_2O concentration (ppt) can be calculated from the DAC output voltage as follows:

$$H_2O = V\left(\frac{H_{range}}{V_{range}}\right) \qquad 3\text{-}3$$

where V is the measured voltage, H_{range} is the maximum value of the H_2O channel (80 ppt), and V_{range} is the maximum DAC output for the selected range (5.0 or 2.5 volts).

Example: The voltage output is set for 0-5V output (V_{range}), the H_2O range is fixed at 80 ppt (H_{range}), and the measured output voltage (V) is 2.9V. To calculate the H_2O concentration (no offset) from Equation 3-3 above,

$$H_2O = 2.9V\left(\frac{80\ ppt}{5V}\right) \qquad 3\text{-}4$$

= 46.4 ppt.

The H_2O concentration (dewpoint, °C) can be calculated from the DAC output voltage as follows:

$$DP = V\left(\frac{100\ °C}{V_{range}}\right) - 50°C \qquad 3\text{-}5$$

where V is the measured voltage and V_{range} is the maximum DAC output for the selected range (5.0 or 2.5 volts).

Example: The voltage output is set for 0-5V output (V_{range}) and the measured output voltage (V) is 2.9V. To calculate the H_2O dewpoint from Equation 3-5 above,

$$DP = 2.9V\left(\frac{100\ °C}{5V}\right) - 50°C \qquad 3\text{-}6$$

= 8 °C.

Converting Voltage Output to Cell Temperature

Cell temperature can be calculated from the DAC output voltage as follows:

$$Temp. = V\left(\frac{100\ °C}{V_{range}}\right) \qquad 3\text{-}7$$

where V is the measured voltage output and V_{range} is the maximum DAC output for the selected range (5.0 or 2.5 volts).

Converting Voltage Output to Cell Pressure

Cell pressure can be calculated from the DAC output voltage as follows:

$$\text{Pressure} = V\left(\frac{115\ \text{kPa}}{V_{range}}\right) \qquad 3\text{-}8$$

where V is the measured voltage output and V_{range} is the maximum DAC output for the selected range (5.0 or 2.5 volts).

Converting Current Output to ppm CO_2 or ppt H_2O

Current output can be measured by connecting the positive input of the data logging device to positions 11 or 13 (4-20 mA 1 or 4-20 mA 2), and the negative input to position 12 or 14 (GND). The current output at positions 11 and 13 is non-isolated, and is rated to drive a 250 ohm load.

> Note that these channels mirror their respective voltage output channels; current output channel 1 uses the variable chosen for the DAC 1 source, and current output channel 2 uses the variable chosen for the DAC 2 source. Similarly, a voltage output of 0 volts corresponds to a current output of 4 mA, and when the voltage outputs are at full scale (2.5 or 5 V), the current output will be 20 mA.

To convert current output (I) to units of ppm CO_2 or ppt H_2O in your computer or other output device, the following equation can be used:

$$CO_2 = \frac{C_{range}}{16}(I - 4) \quad 3\text{-}9$$

where C_{range} is the maximum available resolution (3000 ppm CO_2 or 80 ppt H_2O), and I is the measured current output in mA.

Example: You have chosen 3000 for the CO_2 range of the LI-840. The measured current output is 16.25 mA. To convert to ppm CO_2 or ppt H_2O:

$$CO_2 = \frac{3000}{16}(16.25 - 4) \quad 3\text{-}10$$

$$= \mathbf{2296.875\ ppm}.$$

$$H_2O = \frac{80}{16}(16.25 - 4) \quad 3\text{-}11$$

$$= \mathbf{61.25\ ppt.}$$

CO_2 Span Range

The span range entry field determines the maximum CO_2 range over which the LI-840 will make measurements. The factory calibration range for the LI-840 is 0-3000 ppm. Note that there is a benefit to selecting a narrower range if that range is adequate for your experiment.

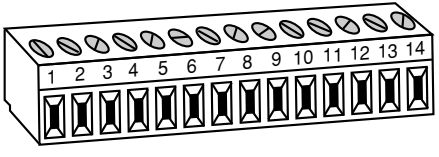
The narrower range provides better resolution in terms of the digital-to-analog converter (DAC). For example, if you choose a range of 0-1500 ppm, each step of the DAC is able to resolve twice as many data points as compared to the 0-3000 ppm range, which results in better resolution.

Alarms

Allows you to enable/disable the alarms, and enter high, low, and dead band values. A complete discussion can be found in *Section 2, Alarms*.

Using the Terminal Strip

The terminal strip is located on the front panel of the LI-840. To connect the wires, insert the bare wire end into the appropriate terminal and tighten the screw above that terminal using the small flat head screwdriver in the spare parts kit. The front face of the terminal strip can be removed to aid in connecting the wires by pulling straight out on the face.

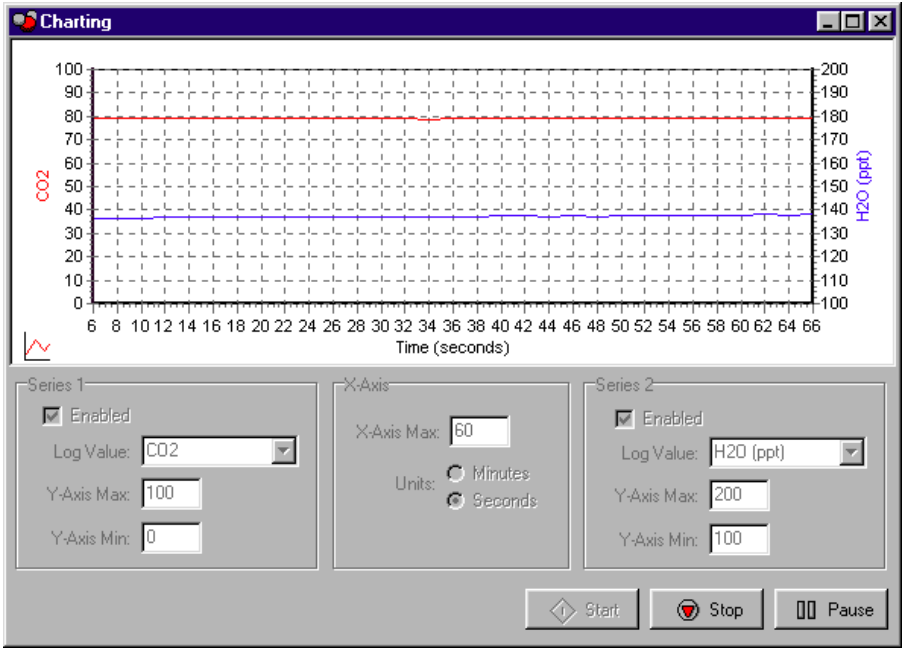


The terminal positions are as follows, reading left to right:

Terminal	Label	Description
1	12-30 VDC	Voltage In, 12-30 VDC
2	GND	Ground
3	High Alarm	High Alarm
4	GND	Ground
5	Low Alarm	Low Alarm
6	GND	Ground
7	V OUT 2	Voltage output channel 2
8	GND	Ground
9	V OUT 1	Voltage output channel 1
10	GND	Ground
11	4-20 mA 2	Current output channel 2
12	GND	Ground
13	4-20 mA 1	Current output channel 1
14	GND	Ground

Charting Window

Select **Charting** from the View menu to open the Charting window (below). This is the window in which you can set up the parameters for plotting your data. Two charts can be plotted simultaneously, using Y axes on either side of the chart.



Series 1

The Series 1 options are used to plot a chart with the Y axis on the left side of the chart. Choose the value to be logged, and set the maximum and minimum values for the Y axis.

Series 2

The Series 2 options are used to plot a chart with the Y axis on the right side of the chart. Choose the value to be logged, and set the maximum and minimum values for the Y axis.

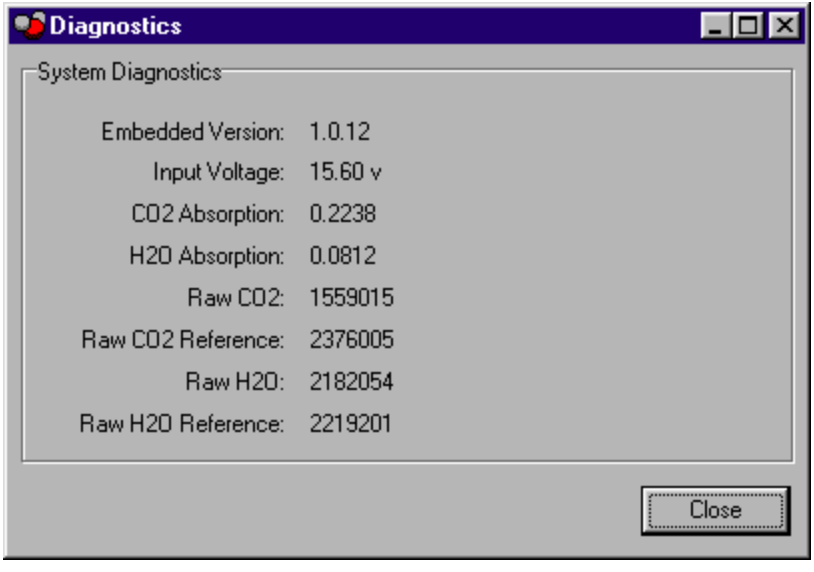
X-Axis Max

Sets the maximum value for the X axis (Time). The units for the X axis can be seconds or minutes.

Press **Start** at any time to view the chart layout and begin displaying data. Note that you must press **Stop** to make changes to the chart parameters, and then press **Start** again to resume data display.

Diagnostics Window

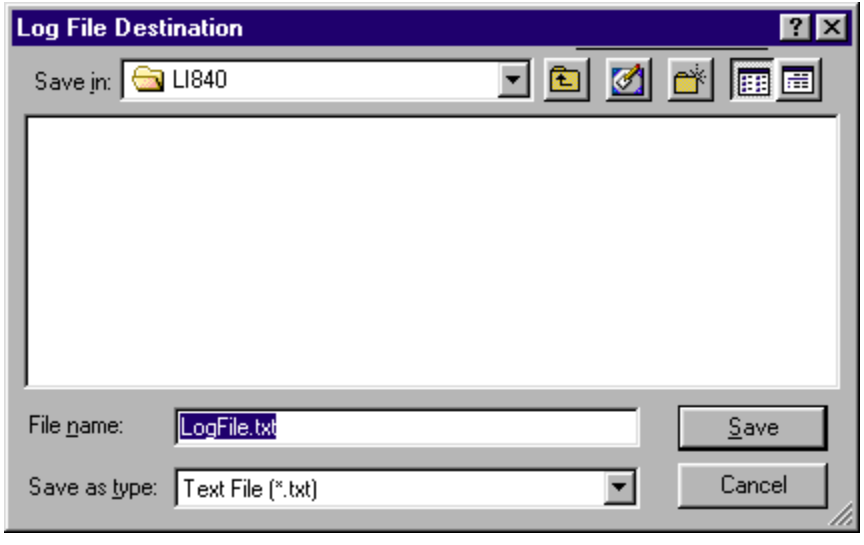
Select **Diagnostics** from the View menu to open the Diagnostics window (below). This window displays the current LI-840 internal software version number, the input voltage, and raw absorption values.



Logging Data

Start Logging

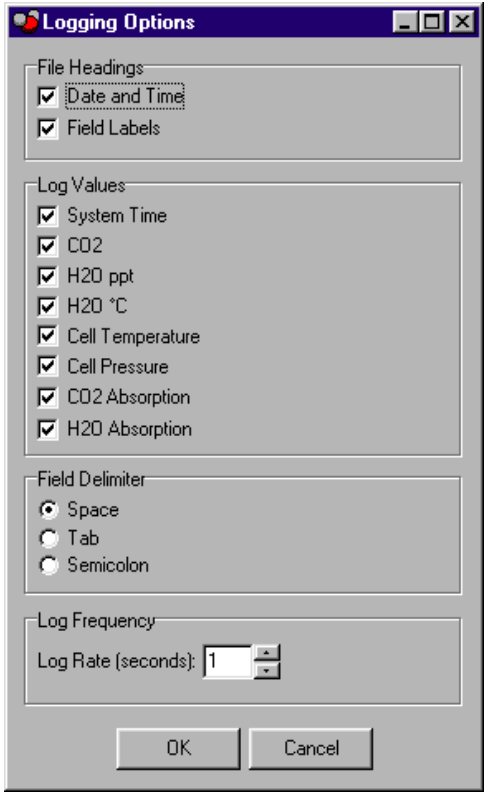
Opens the Log File Destination dialog, where you enter a file name for the data file. The file extension .txt is added automatically.



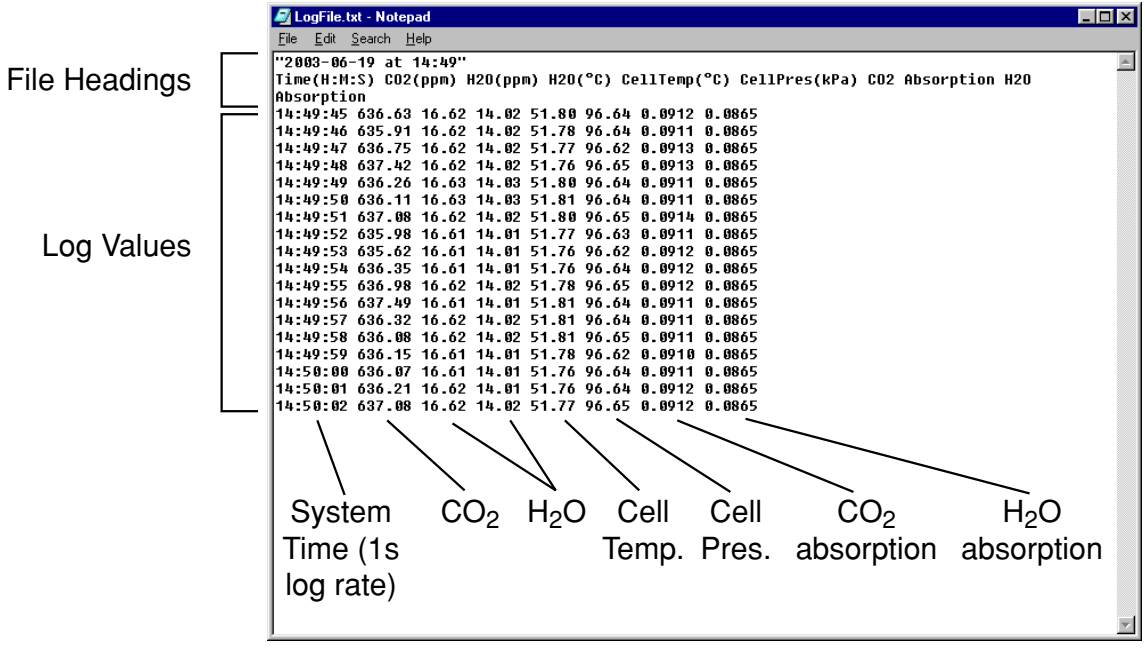
Stop Logging
Stops data logging.

Pause Logging
Pauses logging of data until **Start** is chosen from the Logging menu again, or the Start button on the toolbar is pressed.

Options
Opens the Logging Options window, where you can configure the data output options.

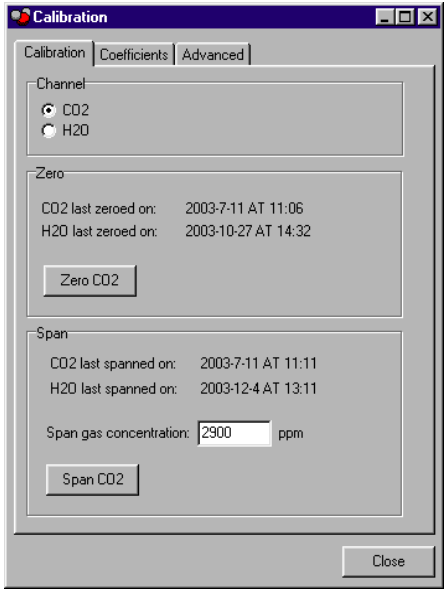

Logging Options
File Headings
Date and Time
Field Labels
Log Values
System Time
CO2
H2O ppt
H2O °C
Cell Temperature
Cell Pressure
CO2 Absorption
H2O Absorption
Field Delimiter
Space
Tab
Semicolon
Log Frequency
Log Rate (seconds):
1
OK
Cancel

As configured above, the data output would appear similar to that shown below.



Calibration Window - Setting the Zero and Span

Select **Calibration** from the View menu to open the Calibration window. This is the area in which you set the zero and span of the LI-840.



It is recommended that you perform the zero calibrations first, followed by the span calibrations. To zero, flow a dry, CO_2-free gas through the LI-840, and make sure the optical cell is completely purged. Press the **Zero CO_2** button.

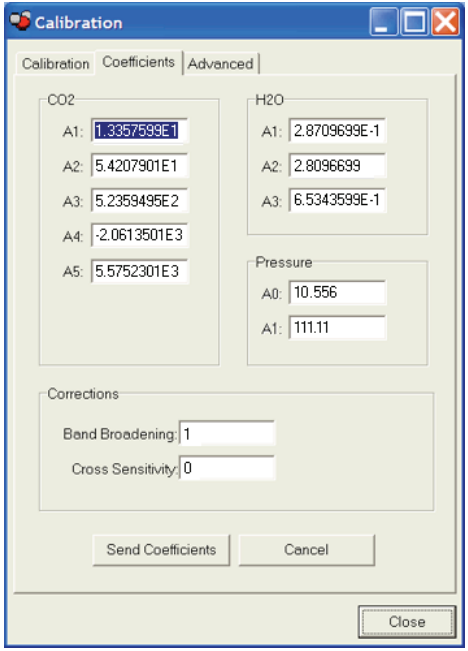
The display will show ZERO, and the text in the Calibration window is greyed out. The zero will be set electronically, and the current date will be entered in the "Last zeroed on" field when completed. Repeat for the H_2O channel.

To span, connect a span gas of known concentration to the input air stream. Make sure the cell is purged, enter the value of the span gas, and click on **Span CO_2**.

The display will show SPAN, and the text in the Calibration window is greyed out. The span will be set electronically, and the current date will be entered in the "Last spanned on" field when completed. Repeat for the H_2O channel using an airstream of known dew point.

Coefficients Page

The LI-840 uses a fifth order polynomial for the CO_2 calibration, and a third order polynomial for H_2O calibration. The Coefficients page displays these factory-determined calibration coefficients, as well as those for band broadening and cross sensitivity, and coefficients for the internal pressure transducer. These coefficients are fixed at the factory.



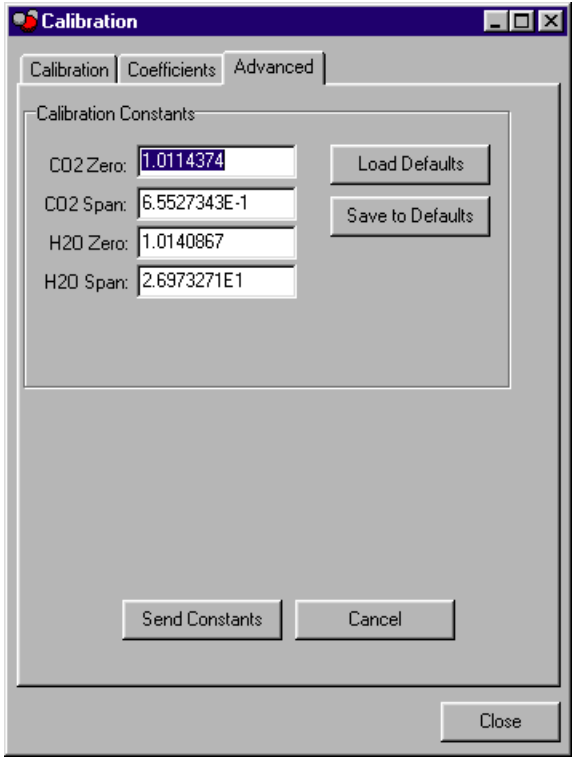
The calibration coefficients are unique to each instrument, and may be found on the calibration sheet shipped from the factory. In most cases you will not want to alter any of these values.

A description of the band broadening and cross sensitivity corrections can be found in Appendix B, *Equation Summary*.

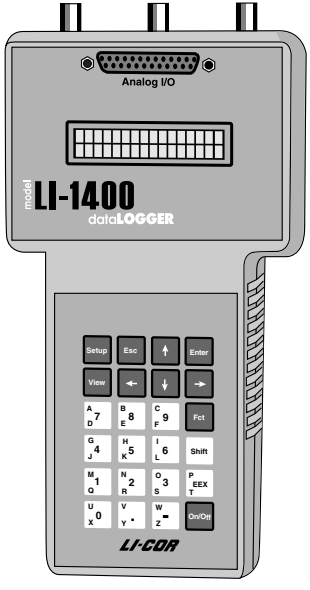
Advanced Page

The calibration constants for CO_2 and H_2O zero and span calibrations are found on the Advanced calibration page. These constants are stored to a file on the computer by clicking on **Save to Defaults**. Click **Load Defaults** to restore the values in this window using the file on the PC. If new constants are entered in this window, click **Send Constants** to send the values to the LI-840 for implementation.

In most cases you should not change the values in this window; see Appendix B, *Equation Summary* for a description of the terms used in this window.


Calibration
Calibration
Coefficients
Advanced
Calibration Constants
CO2 Zero:
1.0114374
CO2 Span:
6.5527343E-1
H2O Zero:
1.0140867
H2O Span:
2.6973271E1
Load Defaults
Save to Defaults
Send Constants
Cancel
Close

Connecting the LI-840 to the LI-1400 Datalogger



The following example shows how you can connect the LI-840 to a datalogging device such as the LI-COR Model LI-1400 DataLogger to collect analog data and convert to meaningful CO_2 and/or H_2O values. As mentioned earlier, voltage output from the LI-840 is linear; converting analog data into ppm CO_2 simply requires multiplying the raw mV output by a conversion factor, which is dependent upon the selected voltage output range, and the maximum CO_2 resolution available (set in software between 0-3000 ppm). In general, the conversion takes the form

$$CO_2 = V\left(\frac{C_{range}}{V_{range}}\right) \qquad 3\text{-}7$$

where V is the measured voltage, C_{range} is the maximum value of the CO_2 range selected (0 to 1000 ppm, 0 to 3000 ppm, etc.), and V_{range} is the maximum DAC output for the selected range (0-5V or 0-2.5V).

For example, if the voltage output is set for 0-5V output, the scaled CO_2 range is 2000 ppm, and the measured voltage output is 2.9V, the equation would take the form

$$CO_2 = 2.9V\left(\frac{2000\ ppm}{5V}\right) \qquad 3\text{-}8$$

= **1160 ppm**.

This general equation can be converted into simple multipliers, based on the two known voltage output ranges, and the value for maximum CO_2 resolution (0-3000). This multiplier can then be entered in the data logging device to convert raw voltage to CO_2 values. Table 3-1 lists the appropriate values for this multiplier; simply choose your DAC output range in the second row, and then select the LI-840 maximum CO_2 range in the first column; follow across to find the appropriate multiplier.

Table 3-1. Multipliers for Converting Voltage Output to CO_2 Readings

	DAC Output Range	
	0-5V	0-2.5V
C_{range}	**Multiplier (ppm/volt)**	
0-1000 ppm	200	400
0-2000 ppm	400	800
0-3000 ppm	600	1200

The LI-1400 can be used to monitor voltage signals up to 2.5 volts with 76 microvolt resolution in real time and convert them into meaningful engineering units shown on the

display. Alternatively, the LI-1400 can be configured to automatically log these data over extended periods of time and later dump the results to a computer for further analysis.

Access to the voltage channels require the 1400-301 Terminal block. Voltage channels are designated by the letter "V" and sequentially numbered V1-4. The lead from LI-840 terminal #7 or #9 should be attached to one of the LI-1400 terminals labeled V1, V2, V3, or V4, while the lead from terminal #8 or #10 should be attached to one of the LI-1400 terminals labeled ↓.

The following example shows how you can set up the LI-1400 Data Logger to collect raw voltage output from the LI-840 and convert to CO_2 values.

1. Set the voltage output of the LI-840 for 2.5V output as described in Section 3, *Analog Output*.

2. In the LI-1400, configure V1 channel as *General* for CO_2.

3. Enter a description, such as *CO2*.

4. Set Math = *Poly(nomial)* and press *Ent(er).*

5. Set description as desired, *a1 = multiplier from Table 3-2 above, a0, a2-a5 = 0*. When finished, press *Esc* to return to the main configuration list.

6. Set *Oper(ator) = none*.

7. Enter a *Label* such as *ppm* for the units.

8. Set *Average=1 sec* or as desired. CO_2 will now be displayed on channel V1.

   To log CO_2 automatically, follow the remaining steps:

9. Set *Log Routine* to the desired log routine.

10. Set *Calc=Mean*.

11. To capture the minimum and maximum CO_2 values, set *MinMax* accordingly.

12. *TCoef* has no effect when *Calc=Mean*. It is used only when integrating.

4 Theory of Operation

System Overview

The LI-840 CO_2/H_2O Gas Analyzer is an absolute, non-dispersive, infrared (NDIR) gas analyzer based upon a single path, dual wavelength, infrared detection subsystem. The CO_2 and H_2O measurements are a function of the absorption of IR energy as it travels through the optical path. Concentration measurements are based on the difference ratio in the IR absorption between a reference and sample signal. Reference and sample channels measure infrared gas absorption in a single path through the use of narrow band optical filters with appropriately selected bands. The CO_2 sample channel uses an optical filter centered at 4.26 micrometers, corresponding to the absorption band for CO_2. The reference channel for CO_2 has an optical filter centered at 3.95 micrometers, which has no absorption due to CO_2. The H_2O sample channel uses an optical filter centered at 2.595 micrometers, corresponding to the absorption band of H_2O. The reference channel for H_2O has an optical filter centered at 2.35 micrometers, which is outside the absorption band of H_2O.

The instrument uses digital signal processing techniques to determine the temperature and pressure corrected CO_2 concentration based on the optical bench signals using a ratiometric computation. The data are passed through a 6th order polynomial (CO_2) or 4th order polynomial (H_2O) that performs linearization of the detector signal to a mole fraction in air given in µmol CO_2 per mole of air, and mmol H_2O per mole of air (ppt).

Data output is provided in a digital format through an RS-232 interface that supports connection to an external computer. The instrument comes with a Windows® 95/98/NT/2000/XP/ME compatible application for instrument configuration, control, data collection and display. Analog signals are available through a terminal block for collection by a data logger or similar means.

Optical Bench System

The LI-840 CO_2/H_2O Gas Analyzer optical path is a thermostatically controlled IR detection system. The optical bench operation is based upon a broad band IR source and a pyroelectric detector. The source is mounted in a parabolic reflector to collimate the light and increase energy throughput down the optical path to the detector. The reflector and optical path are gold plated to further increase energy transmission. The detector is a pyroelectric device that operates based on thermal energy received. The narrow band optical filters allow only the two wavelengths of interest to illuminate the detector, allowing for the determination of CO_2 and H_2O concentrations in the presence of other infrared absorbing gases.

The detector responds to thermal energy, so it is necessary to precisely regulate the detector temperature. This allows for differentiation of thermal gradient noise from the received signals from the optical path. The detection subsystem is shown in Figure 4-1.

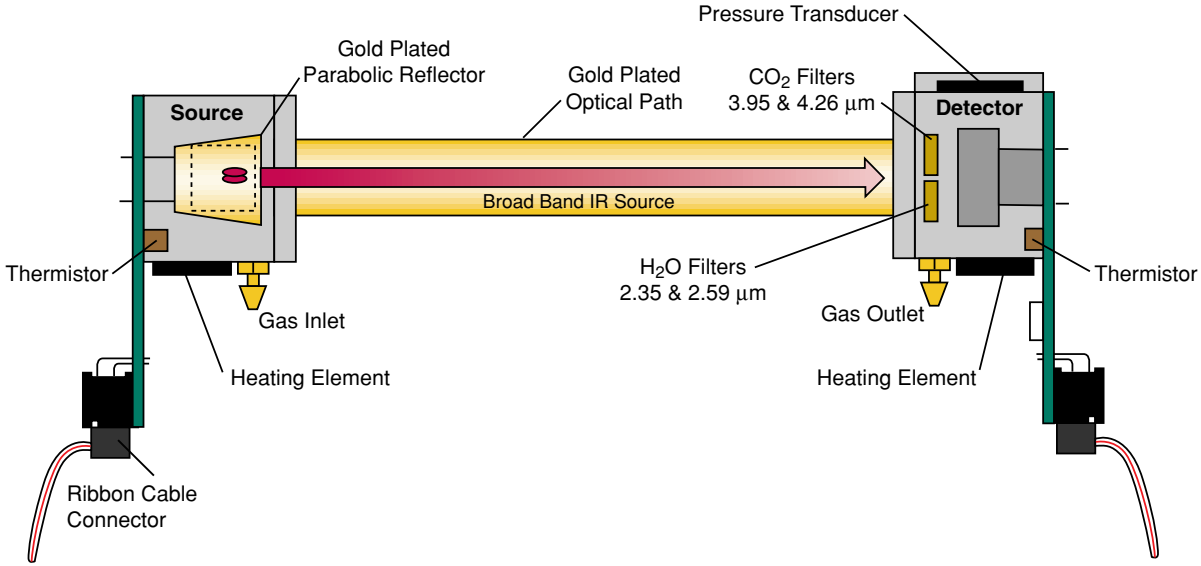


Figure 4-1. Schematic diagram of LI-840 optical bench.

The optical bench has a thermostat that maintains a constant operating temperature of 50 °C. A feedback loop is used to regulate the optical bench temperature. As shown in Figure 4-1, two thermistors, located in the source and detector housings, measure the present temperature. The thermistors are monitored as part of the control loop to determine corrections necessary in the thermal balance. Two heating elements are the sources of thermal energy into the source and detector housing. The optical path is in mechanical contact with the source and detector housing and thereby achieves thermal equilibrium.

The bench requires approximately 10 minutes to achieve the specified thermal temperature. A longer period of approximately 20 minutes is required to bring the performance of the detection system to within 1 to 2% of reading. As shown in Figure 4-1, the detector housing has a pressure transducer integrated into the housing design. Part of the CO_2 concentration calculation depends on the pressure observed in the optical path, measured with an in-line pressure transducer. Many parameters can affect the pressure and thus the concentration reading. The processing center in the analyzer reads the pressure reading as part of its data collection task and uses this information in the concentration calculation. The gas flow enters the source housing, passes down the optical path and exits at the detector housing. The maximum flow rate for the analyzer is approximately 1 liter/min.

Another key parameter in the concentration calculation is the gas temperature in the optical path. It is assumed in the analyzer operation that the gas temperature will equilibrate to the optical bench temperature (50 °C) by the time it enters the optical path. Since the instrument performs temperature and pressure corrections as part of the concentration calculation, this assumption is very important. To cause the sample air to equilibrate to the optical bench temperature, an airflow pattern is created with sufficient eddy currents to cause thermal equilibration.

The optical bench is mounted in a foam enclosure to accomplish two purposes. The first is to assist in maintaining the controlled thermal environment required for the optical bench as described above. The second function of the foam enclosure is to protect the optical bench from mechanical shock and vibration that might damage the mechanically sensitive components. The foam enclosure is supported by a optical bench "tray" which is in turn attached to the main circuit board (PCB). The optical bench is mechanically de-coupled from the case by creating the s-bend in the Bev-a-line tubing from the external fittings to the optical bench gas inlet and outlet connectors. The electronic interface to the source and detector is achieved through printed circuit boards mounted directly to the source and detector housings, respectively. The PCBs connect the main PCB to the source and detector PCBs via a ribbon cable. This achieves the mechanical isolation desired for the optical bench.

A 14 cm (5.5") optical bench provides a CO_2 measurement range of 0 – 3000 µmol/mol (ppm), and an H_2O measurement range of 0-80 mmol/mol (ppt).

5 Maintenance

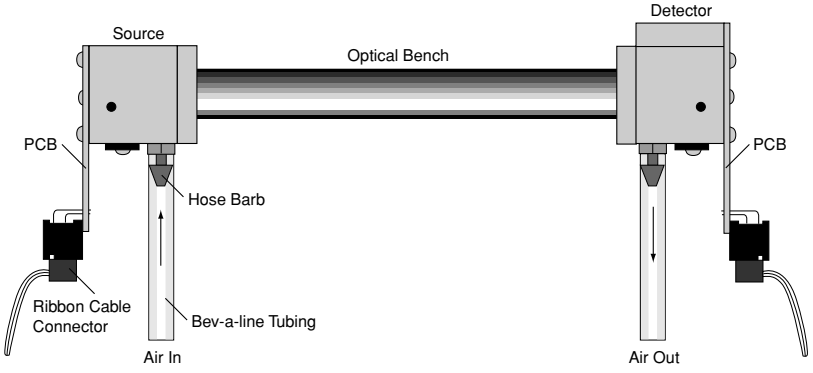
Cleaning the Optical Bench

The LI-840 optical bench can be removed and cleaned if necessary. If the optical path becomes dirty it may become difficult to span the analyzer. Excessive zero drift may also be observed if the optical path becomes dirty. Follow these steps to clean the optical bench:

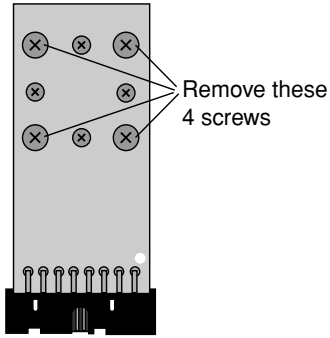
1. Turn the LI-840 off. Remove the six screws on the LI-840 top panel and remove the cover. Note that these screws are not molded into the case and may fall out.

2. Unscrew the tube retaining nuts on the inner air port fittings. Remove the tubing from both air ports. Leave the tubing connected to the source and detector housings.

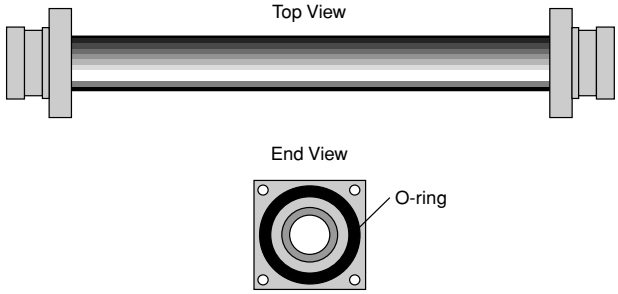
3. There are ribbon cables connected to the circuit boards on the source and detector housings, as shown below. Pull straight out on the connector that is attached to each ribbon cable. The optical bench can now be removed from the foam casing.

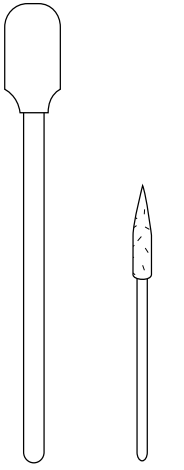


4. There are four screws on the source and detector circuit boards that must be removed. Remove the four screws in the corners of the boards, as shown below (they are slightly larger than the other four screws). Do not remove the remaining four screws.



5. The source and detector housings (with attached circuit boards) can now be removed. The bench will appear as shown below. It is a good practice to replace the O-rings when cleaning or replacing the optical path.





6. There are a number of swabs in the spare parts kit (see at left). Dip one end of the swab into a 50:50 ethanol/water solution and carefully swab both ends of the optical bench, until there is no more visible residue. A mild solution of dish washing type soap and water will also work. ***Do not use abrasive cleansers, as they can irreparably damage the gold plating on the optical bench.***

7. Use a reflector swab and carefully swab the gold-plated concave surface of the source housing, if necessary.

8. If you need to clean out the hose barbs and/or replace the tubing connected to the source and detector housings, use a small pair of diagonal cutters to remove the tubing from the hose barbs. Use the cutters to pinch the tubing parallel to the hose barb axis, and then pivot the cutters over the hose barb tip; the tubing will pull off of the hose barb. *Be very careful not to cut the tubing or scratch the hose barb with the cutters, as subsequent tubing connections may leak.*

9. Let the optical bench dry. Re-assemble the bench, making sure the O-rings are in place on both ends of the bench. Note that the orientation of the cylinder is not important; either end can be inserted into the source or detector housing.

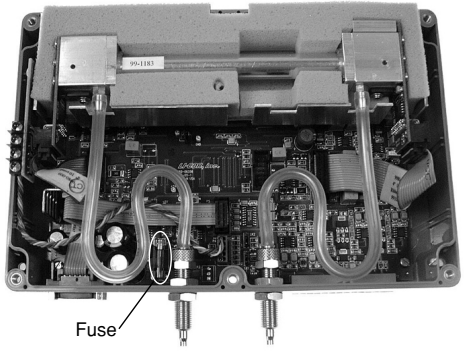
10. Re-assemble the LI-840 case. Make sure that the foam insulation on the inside top cover is positioned over the optical bench; it is required for thermal stability.

11. Perform zero and span calibrations as described in Section 3, *Calibration Window*.

Changing the Fuse

The LI-840 power supply is protected by a 2.0A 250V, 5 × 20 mm fast-blow type fuse located inside the case. If the battery fails to power the LI-840, and will not light the Power LED on the top panel, check to see if the fuse has blown.

To check the fuse, remove the six screws on the top of the LI-840. The fuse is located on the main circuit board, near the **Flow In** port, as shown below. Replacement fuses (part #439-03952, in the spares kit) plug into the fuse holder; no soldering is required. Replace the fuse and reassemble the LI-840 case.



Note on Infrared Source Replacement

The infrared source in the LI-840 is rated for more than 18,000 hours of life. Should the source fail, a replacement can be obtained from LI-COR. The source can be replaced in the field; however, it should be noted that changing a source has the potential of degrading the accuracy specification for CO_2 to as much as 3% of reading. The H_2O channel should remain within the published specification.

If the source fails, the instrument can be returned to LI-COR for replacement and factory recalibration. LI-COR has also developed a simple field recalibration procedure that requires only two verified non-zero concentrations of CO_2. A simple software application and instructions for replacing the source and performing this field calibration can be obtained free of charge from LI-COR.

A Specifications*

CO_2

Measurement Range: 0-3000 ppm
Accuracy: Better than 1.5% of reading
Calibration Drift
Zero Drift: <0.15 ppm/°C
Span Drift: < 0.03 %/°C
Total Drift at 370 ppm: <0.4 ppm/°C
RMS Noise at 370 ppm with 1 sec signal filtering: <1 ppm
Sensitivity to water vapor: < 0.1 ppm CO_2/ppt H_2O

H_2O

Measurement Range: 0-80 ppt
Accuracy: Better than 1.5% of reading
Calibration Drift
Drift at 0 ppt: <0.003 ppt/°C[1]

Span Drift at 10 ppt: <0.06 %/°C[2]
Total Drift at 10 ppt: <0.009 ppt/°C[3]
RMS Noise at 10 ppt with 1 sec signal filtering: <0.01 ppt
Sensitivity to CO_2: <0.0001 ppt H_2O/ppm CO_2

Measurement Principle: Non-Dispersive Infrared
Traceability: Traceable gases to WMO standards for CO_2. NIST traceable LI-610 Portable Dew Point Generator for H_2O
Pressure Compensation Range: 15 kPa-115 kPa
Maximum Gas Flow Rate: 1 liter/min
Output Signals: Two analog voltage (0-2.5V or 0-5V) and two current (4-20mA)
Digital: TTL (0-5V) or Open Collector
DAC Resolution: 14-bits across user-specified range
Source Life: ~18,000 Hours
Power Requirements: Input Voltage 12-30 VDC
1.2A @ 12V (14W) maximum during warm-up with heaters on
0.3A @ 12V (3.6W) average after warm-up with heaters on
Operating Temperature Range: –20°C to +45°C
Relative Humidity Range: 0 to 95% RH, Non-Condensing
Dimensions: 8.75" × 6" × 3" (22.23 × 15.25 × 7.62 cm)
Weight: 2.2 lbs (1 kg)

[1] Zero drift is the change with temperature at 0 concentration.
[2] Span drift is the residual error after re-zeroing following a temperature change.
[3] Total drift is the change with temperature without re-zeroing or re-spanning.

* Specifications subject to change without notice

B Equation Summary

General Form

The LI-840 computes CO_2 and H_2O concentrations using an equation of the form

$$c = f(\alpha g(\alpha, P))(T + 273) \quad (1)$$

where c is concentration, $f()$ is the calibration polynomial, α is the absorptance, $g(\alpha,P)$ is the pressure correction, and T is absolute temperature of the gas in the cell. Absorptance is computed from

$$\alpha = \left(1 - \frac{V}{V_o} Z\right) S \quad (2)$$

where V and V_o are the raw detector sample and reference readings. Z is the zeroing parameter, and S is the spanning parameter.

H_2O Equations

Absorptance α_w for water vapor is computed from

$$\alpha_w = \left(1 - \frac{V_w}{V_{wo}} Z_w\right) S_w \tag{3}$$

where V_W and V_{WO} are the sample and reference raw detector readings, Z_W is the zero parameter, and S_W is the span parameter. The pressure correction for water vapor is an empirical function $g_W()$ of absorptance and pressure P:

$$g_W(\alpha_w, P) = \frac{P_o}{P\left(1 + 0.8\alpha_w\left(\frac{P_o}{P} - 1\right)\right)} \tag{4}$$

The value of P_O is 99 kPa. When the pressure correction is not enabled, $g_W()$ is simply 1.0. The value of water absorptance that is output by the LI-840 is the product of absorptance and the pressure correction: $\alpha_W g_W(\alpha_W, P)$.

Water vapor concentration W (mmol mol^{-1}) is computed from

$$W = f_w(\alpha_w g W(\alpha_w, P))(T + 273) \tag{5}$$

where $f_W(x)$ is a third order polynomial whose coefficients are given on the calibration sheet.

$$f_w(x) = a_{w1}x + a_{w2}x^2 + a_{w3}x^3 \quad (6)$$

T is the temperature of the LI-840 optical bench, typically 51.5 °C.

CO_2 Equations

The measurement of CO_2 is a bit more complicated than for H_2O, because of the influence of water vapor. There is a slight direct cross sensitivity in the CO_2 signal to H_2O that is measured at the factory and accounted for in the computation of absorptance (Equation 7). There is also a band broadening effect that is accounted for in the computation of concentration (Equation 10).

CO_2 absorptance α_c is computed from

$$\alpha_c = \left(1 - \left(\frac{V_c}{V_{co}} + X_{wc}\left(1 - \frac{V_w}{V_{wo}}\right)\right)Z_c\right)S_c \quad (7)$$

where V_c and V_{co} are the raw detector signals for sample and reference, Z_c and S_c are zero and span parameters, and X_{wc} is a cross sensitivity parameter for the effect of water vapor on CO_2. Its value is reported on the calibration sheet as "XS=".

The empirical pressure correction function $g_c()$ is a function of CO_2 absorptance and pressure:

When $P = P_o$, $g_c() = 1$.

When $P < P_o$

$$g_c(\alpha_c, P) = \frac{1}{A + B\left(\frac{1}{z-\alpha_c} - \frac{1}{z}\right)} + 1$$

$$A = \frac{1}{a(p-1)} \tag{8}$$

$$B = \frac{1}{\frac{1}{b+cp} + d}$$

$$p = \frac{P_o}{P}$$

where a = 1.10158, b = -6.1217×10^{-3}, c=-0.266278, d=3.69895, and z=0.5.

When $P > P_o$

$$g_c(\alpha_c, P) = \frac{A + B\left(\frac{1}{z-\alpha_c} - \frac{1}{z}\right)}{1 + A + B\left(\frac{1}{z-\alpha_c} - \frac{1}{z}\right)} \tag{9}$$

$$p = \frac{P_o}{P}$$

CO_2 concentration C (µmol mol^{-1}) is computed from

$$C = f_c\left(\frac{\alpha_c g_c(\alpha_c, P)}{\psi(W)}\right)\psi(W)(T + 273) \tag{10}$$

where $f_c(x)$ is a 5th order polynomial whose coefficients are given on the calibration sheet.

$$f_c(x) = a_{c1}x + a_{c2}x^2 + a_{c3}x^3 + a_{c4}x^4 + a_{c5}x^5 \tag{11}$$

ψ(W) is the band broadening correction for water vapor.

$$\psi(W) = 1 + (b_w - 1)\frac{W}{1000} \tag{12}$$

The band broadening coefficient b_W has been determined to be 1.45 for the LI-840.

Symbol Summary

Many of the quantities described in the above section are available from the LI-840. Table 1 summarizes.

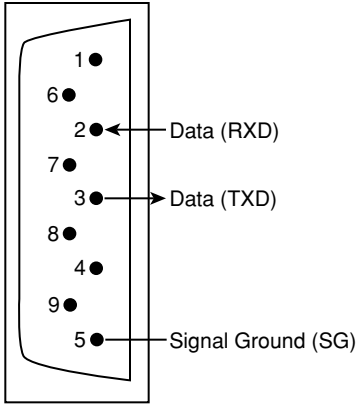
Table 1: Symbols

Symbol	XML Tag: <LI840>+	Description
α_w		H_2O absorptance
$\alpha_w\ g_W(\alpha_w,P)$	<DATA><H2OABS>	Pressure corrected absorptance of H_2O
W	<DATA><H2O>	H_2O (mmol mol^{-1})
P	<DATA><CELLPRESS>	Pressure (kPa)
T	<DATA><CELLTEMP>	Temp (C)
α_c		CO_2 absorptance
$\alpha_c g_c(\alpha_c,P)$	<DATA><CO2ABS>	Pressure corrected absorptance of CO_2
C	<DATA><CO2>	CO_2 (µmol mol^{-1})
V_w	<DATA><RAW><H2O>	Raw detector readings
V_{wo}	<DATA><RAW><H2OREF>	
V_c	<DATA><RAW><CO2>	
V_{co}	<DATA><RAW><CO2REF>	
$a_{w1}...a_{w3}$	<POLY><H2O>	Calibration coefficients

$a_{c1}...a_{c5}$	<POLY><CO2>	Calibration coefficients
Z_w	<CAL><H2OKZERO>	Zero and Span values
S_w	<CAL><H2OKSPAN>	
Z_c	<CAL><CO2KZERO>	
S_c	<CAL><CO2KSPAN>	
x_{wc}	<POLY><XS>	Cross sensitivity coefficient
b_w	<POLY><BB>	Band broadening coefficient

C Pin Assignments

DB-9 Connector



D Suppliers

Although the LI-840 has no internal chemicals to replace, the following suppliers may be useful for obtaining chemicals for generating a chemical zero gas. The company names, addresses, and phone numbers are the most current we have at the time of this printing. In some cases the information may change without notice.

Soda Lime (6-12 mesh) and Magnesium Perchlorate (Anhydrous) $Mg(ClO_4)_2$

GFS Chemicals
www.gfschemicals.com
P.O. Box 245
Powell, OH 43065
Phone: 614-881-5501
FAX: 614-881-5989
Toll free: 800-858-9682

Soda Lime: Part #66352

$Mg(ClO_4)_2$: Part #49001 (500g, <8% water)

Fisher Scientific
www.fishersci.com
711 Forbes Avenue
Pittsburgh, PA 15219-4785
Phone: 201-467-6400
FAX: 201-379-7415
Toll free: 800-776-7000
Toll free FAX: 800-926-1166

Soda Lime: Part #S201-212
(LI-COR Part #9960-071)

$Mg(ClO_4)_2$: Part #M54-500 (500g)

Thomas Scientific
www.thomassci.com
P.O. Box 99
Swedesboro, NJ 08085-6099
Phone: 609-467-2000
FAX: 609-467-3087
Toll free: 800-345-2100
Toll free FAX: 800-345-5232

Soda Lime: Part #C703-B76

$Mg(ClO_4)_2$: Part #C260-M61
(Dehydrite, 500g)

Ascarite II

GFS Chemicals
www.gfschemicals.com
P.O. Box 245
Powell, OH 43065
Phone: 614-881-5501
FAX: 614-881-5989
Toll free: 800-858-9682

P.W. Perkins Co., Inc.
www.pwperkins.com
856-769-3525

Thomas Scientific
www.thomassci.com
P.O. Box 99
Swedesboro, NJ 08085-6099
Phone: 609-467-2000
FAX: 609-467-3087
Toll free: 800-345-2100
Toll free FAX: 800-345-5232

Fisher Scientific
www.fishersci.com
711 Forbes Avenue
Pittsburgh, PA 15219-4785
Phone: 201-467-6400
FAX: 201-379-7415
Toll free: 800-776-7000
Toll free FAX: 800-926-1166

Electronic Relay Switches

Crydom Inc.
9525 Chesapeake Dr.
San Diego, CA 92123
800-827-9366
FAX: 619-715-7280

Potter & Brumfield Products Div.
Siemens Electromechanical
Components, Inc.
200 S. Richland Creek Dr.
Princeton, IN 47671-0001
info@ae.sec.siemens.com

E Configuration Grammar

Introduction

The LI-840 communicates exclusively through a serial interface. The following discussion describes how to implement a synchronized communication protocol.

LI-840 Communications and XML

The configuration grammar used to communicate with the LI-840 is based upon a subset of the e**X**tensible **M**arkup **L**anguage (XML). XML relies on the use of tags to "Markup", or give structural rules to a set of data.

A *tag* is a descriptive identifier, enclosed between a less than (<) and a greater than (>) symbol, used in part to describe a piece of data. For example, <NAME> is a tag that describes a person's name. Each tag must have a corresponding end tag, denoted by '/'. Extending the example above, the end tag of `<NAME>` is `</NAME>`.

Elements are the basic unit of XML content. An element consists of a start tag and an end tag, and everything in between. For example, consider the following element:

```
<NAME>George</NAME>.
```

In this example, <NAME> (start tag) and </NAME> (end tag) comprise the markup, and "George" comprises the data. Because XML is extensible, tags can be defined specifically for the data they are meant to describe.

Elements can also contain other elements other than data.

```
<NAME>
        <FIRST>George</FIRST>
        <LAST>Smith</LAST>
</NAME>
```

In this example, the outermost element <NAME> emcompasses two other elements that contain data. All elements combined make up the XML document.

Connecting and Configuring Data Output

The LI-840 communicates through a serial port on the front of the instrument. This port is configured as follows:

Baud Rate: 9600 bps
Data Bits: 8
Parity: None
Stop Bits: 1
Flow Control: None

After a serial connection is established, the LI-840 will immediately send data out the serial port in the manner in which it was configured previously. In order to reconfigure the LI-840 to output specific data values, you must send the RS-232 portion of the XML grammar to the instrument with the desired values "turned on". To "turn on" the data value, set the value of the element to TRUE. As an example, the following string is sent to the instrument after a connection has been made between the computer (using the Windows® application software) and the LI-840:

```
<LI840>
        <CFG>
                <OUTRATE>1</OUTRATE>
        </CFG>
        <RS232>
                <STRIP>FALSE</STRIP>
                <ECHO>FALSE</ECHO>
                <CELL TEMP>TRUE</CELL TEMP>
```

```
                    <CO2>TRUE</CO2>
                    <CO2ABS>FALSE</CO2ABS>
                    <CELLPRES>TRUE</CELLPRES>
                    <IVOLT>TRUE</IVOLT>
            </RS232>
</LI840>
```

Sending Data to the LI-840

To send data to the LI-840, each string must end with a '\n' to ensure that the LI-840 can parse consecutive commands.

After data have been sent to the LI-840, the instrument replies with:

```
<LI840><ACK>TRUE</ACK></LI840>
```

if the XML was received and parsed correctly. If there was an error in the XML, the following is sent:

```
<LI840><ACK>FALSE</ACK></LI840>.
```

For example, suppose that you would like to reconfigure the LI-840 to stop outputting cell temperature. Here is the command to send to the LI-840:

```
<LI840><RS232><CELLTEMP>FALSE</CELLTEMP></RS232></LI840>
```

If the command was received correctly, the LI-840 replies with

```
<LI840><ACK>TRUE</ACK></LI840>.
```

Reading Data From the LI-840

The LI-840 can send data continuously. To determine where one message ends and the next begins, each XML document sent from the LI-840 is delimited with a '\n' (0x10) character.

Polling the Current State of the LI-840

The LI-840 can be polled for individual sets of data by sending an XML document with a '?' in place of the set of elements requested. The element sets that can be requested include the data set, the current configuration, and the entire state of the instrument.

Sending this command:

```
<LI840><DATA>?</DATA></LI840>
```

instructs the LI-840 to send the most recent set of data values (as configured) as an XML document.

Sending this command:

```
<LI840><CFG>?</CFG></LI840>
```

instructs the LI-840 to send an XML document containing all of the configuration information, including heater status, filter settings, DACs, and alarms.

To receive the entire state of the instrument as an XML document, send this command:

```
<LI840>?</LI840>.
```

Calibration

The LI-840 calibration (zero and span) can be performed using XML grammar. This is accomplished in three steps:

1. Send the calibration command to the LI-840.

```
<LI840>
        <CAL>
                <DATE>{iso date}</DATE>
                <CO2ZERO>{bool}</CO2ZERO>
                <CO2SPAN>{int}</CO2SPAN>
        </CAL>
</LI840>
```

2. An acknowledgement is returned from the LI-840 if the command was accepted.

```
<LI840><ACK>TRUE</ACK></LI840>
```

3. After a few seconds, all of the calibration information is returned from the LI-840, indicating that it has finished the zero and/or span.

```
<LI840>
        <CAL>
                <CO2LASTSPAN>{iso date}</CO2LASTSPAN>
                <CO2LASTZERO>{iso date}</CO2LASTZERO>
                <CO2KZERO>{float}</CO2KZERO>
                <CO2KSPAN>{float}</CO2KSPAN>
        </CAL>
</LI840>
```

If the calibration can not be performed, an ERROR is sent:

```
<LI840><ERROR>{Error Text}</ERROR></LI840>.
```

To Zero the LI-840

1. Send the XML command to initiate the zero.

```
<LI840>
        <CAL>
                <DATE>YYYY-MM-DD</DATE>
                <CO2ZERO>TRUE</CO2ZERO>
        </CAL>
</LI840>
```

2. Wait for the acknowledgement.

3. Wait for the date to be returned to verify the zero operation succeeded. If the operation fails an <ERROR> will be sent.

To Span the LI-840

1. Send the XML command to initiate the span.

```
<LI840>
        <CAL>
                <DATE>YYYY-MM-DD</DATE>
                <CO2SPAN>Gas Concentration</CO2SPAN>
        </CAL>
</LI840>
```

2. Wait for the acknowledgement.

3. Wait for the date to be returned to verify the span operation succeeded. If the operation fails an <ERROR> will be sent.

LI-840 XML Grammar and Element Description

Data Types in the XML Grammar

{val | val |...}

The value will be a member of the specified set. | = or.

{bool}
: Boolean values, TRUE | FALSE.

{float}
: Floating point values in decimal or exponential notation.

{int}
: Integers.

{iso date}
: A date in the ISO format. 4 digit year - 2 digit month - 2 digit day. **Example**: 2002-04-27.

XML Grammar

```
<LI840>
        <ACK>{bool}</ACK>
        <VER>{string}</VER>
        <DATA>
                <CO2>{float}</CO2>
                <CO2ABS>{float}</CO2ABS>
                <H2O>{float}</H2O>
                <H2ODEWPOINT>{float}</H2ODEWPOINT>
                <H2OABS>{float}</H2OABS>
                <CELLTEMP>{float}</CELLTEMP>
                <CELLPRES>{float}</CELLPRES>
                <IVOLT>{float}</IVOLT>
                <RAW>
                        <CO2>{int}</CO2>
                        <CO2REF>{int}</CO2REF>
                        <H2O>{int}</H2O>
```

```
                <H2OREF>{int}</H2OREF>
        </RAW>
</DATA>
<RS232>
        <CO2>{bool}</CO2>
        <CO2ABS>{bool}</CO2ABS>
        <H2O>{float}</H2O>
        <H2ODEWPOINT>{bool}</H2ODEWPOINT>
        <H2OABS>{bool}</H2OABS>
        <CELLTEMP>{bool}</CELLTEMP>
        <CELLPRES>{bool}</CELLPRES>
        <IVOLT>{bool}</IVOLT>
        <STRIP>{bool}</STRIP>
        <ECHO>{bool}</ECHO>
        <RAW>
                <CO2>{bool}</CO2>
                <CO2REF>{bool}</CO2REF>
                <H2O>{bool}</H2O>
                <H2OREF>{bool}</H2OREF>
        </RAW>
</RS232>
<CFG>
        <OUTRATE>{float}</OUTRATE>
        <HEATER>{bool}</HEATER>
        <PCOMP>{bool}</PCOMP>
        <FILTER>{int}</FILTER>
        <ALARMS>
                <ENABLED>{bool}</ENABLED>
                <SOURCE>H2O | CO2<SOURCE>
```

```
                        <HIGH>{float}</HIGH>
                        <HDEAD>{float}</HDEAD>
                        <LOW>{float}</LOW>
                        <LDEAD>{float}</LDEAD>
                </ALARMS>
                <BENCH>{5|14}</BENCH>
                <SPAN>{int}</SPAN>
                <DACS>
                        <RANGE>{2.5|5.0}</RANGE>
                        <SET1>{float}</SET1>
                        <SET2>{float}</SET2>
                        <D1>{NONE|CO2|H2O|H2ODP|CELLTEMP|CELLPRES}</D1>
                        <D2>{NONE|CO2|H2O|H2ODP|CELLTEMP|CELLPRES}</D2>
                </DACS>
</CFG>
<CAL>
                <DATE>{iso date}</DATE>
                <CO2ZERO>{bool}</CO2ZERO>
                <CO2SPAN>{int}</CO2SPAN>
                <H2OZERO>{bool}</H2OZERO>
                <H2OSPAN>{float}</H2OSPAN>

                <CO2KZERO>{float}</CO2KZERO>
                <CO2KSPAN>{float}</CO2KSPAN>
                <H2OZERO>{float}</H2OZERO>
                <H2OKSPAN>{float}</H2OKSPAN>

                or
```

```
                <CO2LASTZERO>{iso date}</CO2LASTZERO>
                <CO2LASTSPAN>{iso date}</CO2LASTSPAN>

                <H2OLASTZERO>{iso date}</H2OLASTZERO>
                <H2OLASTSPAN>{iso date}</H2OLASTSPAN>
        </CAL>
        <POLY>
                <DATE>{string}</DATE>
                <BB>{float}</BB>
                <XS>{float}</XS>
                <RESET>{bool}</RESET>
                <CO2>
                        <A1>{float}</A1>
                        <A2>{float}</A2>
                        <A3>{float}</A3>
                        <A4>{float}</A4>
                        <A5>{float}</A5>
                </CO2>
                <H2O>
                        <A1>{float}</A1>
                        <A2>{float}</A2>
                        <A3>{float}</A3>
                </H2O>
        </POLY>
        <ERROR>{string}</ERROR>
</LI840>
```

Element Description

Tag	Parent	Value(s)	R/W	Comments
<LI840>	N/A (root)	<ACK> <VER> <ERROR> <DATA> <RS232> <CFG> <CAL> ?		<LI840> is the root tag for all XML statements. A ? outputs entire XML document.

Examples:
<LI840>?</LI840>
<LI840><ACK>TRUE</ACK></LI840>

Tag	Parent	Value(s)	R/W	Comments
<DATA>	<LI840>	<CO2> <CO2ABS> <H2O> <H2ODEWPOINT> <H2OABS> <CELLTEMP> <CELLPRES> <IVOLT> <RAW> ?		<DATA> contains all data values sent from the LI-840. All of the elements within the DATA tag are readable only. A ? requests all data values to be output.

Examples:
<LI840><DATA><CO2>2.34e2</CO2><IVOLT>1.5e2</IVOLT></DATA></LI840>
<LI840><DATA>?</DATA></LI840>

Tag	Parent	Value(s)	R/W	Comments
<CO2>	<DATA>	Float	R	CO_2 in ppm
<CO2ABS>	<DATA>	Float	R	CO_2 absorption
<H2O>	<DATA>	Float	R	H_2O in ppt (mmol/mol)
<H2ODEWPOINT>	<DATA>	Float	R	H_2O in °C
<H2OABS>	<DATA>	Float	R	H_2O absorption
<CELLTEMP>	<DATA>	Float	R	Cell temperature
<CELLPRES>	<DATA>	Float	R	Cell pressure
<IVOLT>	<DATA>	Float	R	Input voltage
<RAW>	<DATA>	<CO2>		Raw detector readings
		<CO2REF>		
		<H2O>		
		<H2OREF>		

Examples:
<LI840><DATA><CELLTEMP>5.16E1</CELLTEMP><CELLPRES>9.742E1</CELLPRES>
<CO2>6.17E2</CO2><CO2ABS>8.94E2</CO2ABS>DATA></LI840>

Tag	Parent	Value(s)	R/W	Comments
<CO2>	<RAW>	Integer	R	
<CO2REF>	<RAW>	Integer	R	
<H2O>	<RAW>	Integer	R	
<H2OREF>	<RAW>	Integer	R	

Tag	Parent	Value(s)	R/W	Comments
<RS232>	<LI840>	<CO2> <CO2ABS> <H2O> <H2ODEWPOINT> <H2OABS> <CELLTEMP> <CELLPRES> <IVOLT> <RAW> <ECHO> <STRIP>		Setting <RS232> values will determine what values are output in <DATA>

Tag	Parent	Value(s)	R/W	Comments
<CO2>	<RS232>	TRUE | FALSE	R/W	CO_2 in ppm
<CO2ABS>	<RS232>	TRUE | FALSE	R/W	CO_2 absorption
<H2O>	<RS232>	TRUE | FALSE	R/W	H_2O in ppt
<H2ODEWPOINT>	<RS232>	TRUE | FALSE	R/W	H_2O dew point
<H2OABS>	<RS232>	TRUE | FALSE	R/W	H_2O absorption
<CELLTEMP>	<RS232>	TRUE | FALSE	R/W	Cell temperature
<CELLPRES>	<RS232>	TRUE | FALSE	R/W	Cell pressure
<IVOLT>	<RS232>	TRUE | FALSE	R/W	Input voltage
<RAW>	<RS232>	<CO2>		Raw detector readings
		<CO2REF>		
		<H2O>		
		<H2OREF>		
<ECHO>	<RS232>	TRUE | FALSE	R/W	Echo commands sent to LI-840
<STRIP>	<RS232>	TRUE | FALSE	R/W	Strip XML from all data sent

Example:

<LI840><CFG><OUTRATE>0.5</OUTRATE></CFG><RS232><STRIP>FALSE</STRIP>
<ECHO>FALSE</ECHO><CELLTEMP>TRUE</CELLTEMP><CO2ABS>TRUE</CO2ABS>
<CO2>TRUE</CO2><CELLPRES>TRUE</CELLPRES><IVOLT>TRUE</IVOLT><RAW>TRUE
</RAW></RS232></LI840>

Tag	Parent	Value(s)	R/W	Comments
<CO2>	<RAW>	TRUE | FALSE	R/W	
<CO2REF>	<RAW>	TRUE | FALSE	R/W	
<H2O>	<RAW>	TRUE | FALSE	R/W	
<H2OREF>	<RAW>	TRUE | FALSE	R/W	

Tag	Parent	Value(s)	R/W	Comments
<CFG>	<LI840>	<OUTRATE> <HEATER> <PCOMP> <DOFFSET> <FILTER> <ALARMS> <DACS> <BENCH> <SPAN> ?		Elements within the <CFG> tag control system settings.

Example:
<LI840><CFG><HEATER>TRUE</HEATER><PCOMP>TRUE</PCOMP></CFG></LI840>

Tag	Parent	Value(s)	R/W	Comments
<OUTRATE>	<CFG>	0.5 to 20	R/W	Output data every N seconds (0.5 s increments).
<HEATER>	<CFG>	TRUE | FALSE	R/W	Turn heater on/off.
<PCOMP>	<CFG>	TRUE | FALSE	R/W	Pressure compensation on/off.
<FILTER>	<CFG>	0 to 20	R/W	Set a 0 to 20 second filter.
<ALARMS>	<CFG>	<ENABLED> <HIGH> <HDEAD> <LOW> <LDEAD>		High and low alarm settings.
<DACS>	<CFG>	<RANGE> <SET1> <SET2> <D1> <D2>		DAC outputs.
<BENCH>	<CFG>	14	R	Optical bench length (cm).
<SPAN>	<CFG>	Integer	R/W	Span range setting (0-3000).

Tag	Parent	Value(s)	R/W	Comments
<ENABLED>	<ALARMS>	TRUE | FALSE	R/W	Enable alarms.
<SOURCE>	<ALARMS>	CO2 | H2O	R/W	Channel (CO_2:ppm, H_2O:ppt)
<HIGH>	<ALARMS>	Float	R/W	High alarm on at this value.
<HDEAD>	<ALARMS>	Float	R/W	High alarm off at this value.
<LOW>	<ALARMS>	Float	R/W	Low alarm on at this value.
<LDEAD>	<ALARMS>	Float	R/W	Low alarm off at this value.

Example:

<LI840<LI840><CFG><ALARMS><ENABLED>TRUE</ENABLED><SOURCE>H2O</SOURCE>
<HIGH>1600</HIGH><HDEAD>1500</HDEAD><LOW>200</LOW><LDEAD>300</LDEAD>
</ALARMS></CFG></LI840>

Tag	Parent	Value(s)	R/W	Comments
<RANGE>	<DACS>	2.5 | 5.0	R/W	Output voltage. 2.5V or 5.0V.
<SET1>	<DACS>	Float	R/W	Set DAC output to value (DACS must be NONE)
<SET2>	<DACS>	Float	R/W	Set DAC output to value (DACS must be NONE)
<D1>	<DACS>	CO2 | H2O | H2ODEWPOINT | CELLPRES | CELLTEMP | NONE	R/W	DAC1
<D2>	<DACS>	CO2 | H2O | H2ODEWPOINT | CELLPRES | CELLTEMP | NONE	R/W	DAC2
Example: <LI840><CFG><DACS><RANGE>2.5</RANGE><D1>CO2</D1><D2>CELLTEMP</D2></DACS></CFG></LI840>				

Tag	Parent	Value(s)	R/W	Comments
<CAL>	<LI840>	<DATE> <H2OZERO> <H2OSPAN> <H2OLASTZERO> <H2OLASTSPAN> <H2OKZERO> <H2OKSPAN> <CO2ZERO> <CO2SPAN> <CO2LASTZERO> <CO2LASTSPAN> <CO2KZERO> <CO2KSPAN> <POLY>		Calibration parameters. When calibrating, <DATE> must be paired with a <CO2ZERO> or a <CO2SPAN>, or a <H2OZERO> or <H2OSPAN>.

Tag	Parent	Value(s)	R/W	Comments
<DATE>	<CAL>	20 character date	W	The date the calibration is taking place.
<H2OZERO>	<CAL>	TRUE | FALSE	W	Start H_2O zero.
<H2OSPAN>	<CAL>	Float (H_2O °C)	W	Start H_2O span.
<H2OLASTZERO>	<CAL>	20 character date	R	Date the LI-840 was last zeroed.
<H2OLASTSPAN>	<CAL>	20 character date	R	Date the LI-840 was last spanned.
<H2OKZERO>	<CAL>	Float	R/W	Calibration constant.
<H2OKSPAN>	<CAL>	Float	R/W	Calibration constant.
<CO2ZERO>	<CAL>	TRUE | FALSE	W	Start a CO_2 zero.
<CO2SPAN>	<CAL>	Float (CO2 ppm)	W	Start a CO_2 span.
<CO2LASTZERO>	<CAL>	20 character date	R	The date the LI-840 was last zeroed.
<CO2LASTSPAN>	<CAL>	20 character date	R	The date the LI-840 was last spanned.
<CO2KZERO>	<CAL>	Float	R/W	Calibration constant.
<CO2KSPAN>	<CAL>	Float	R/W	Calibration constant.
<POLY>	<CAL>	<DATE>	R/W	Factory calibration date.
		<BB>	R/W	Band broadening.
		<XS>	R/W	Cross sensitivity.
		<CO2>	R/W	CO_2 coefficients.
		<H2O>	R/W	H_2O coefficients.

Examples:
To Zero:
<LI840><CAL><DATE>2001-02-07</DATE><CO2ZERO>TRUE</CO2ZERO></CAL></LI840>
To Span:
<LI840><CAL><DATE>2001-02-07</DATE><CO2SPAN>1000</CO2SPAN></CAL></LI840>
Possible LI-840 Replies
<LI840><ACK>TRUE</ACK></LI840>
<LI840><ERROR>{ErrorText}</ERROR></LI840>
<LI840><CAL><CO2LASTSPAN>
{isodate}</CO2LASTSPAN><CO2LASTZERO>{isodate}</CO2LASTZERO><CO2KZERO>{float}
</CO2KZERO> <CO2KSPAN>{float}</CO2KSPAN> </CAL></LI840>

Tag	Parent	Value(s)	R/W	Comments
<DATE>	<POLY>	20 character date	R/W	Factory calibration date.
<BB>	<POLY>	Float	R/W	Band broadening value.
<XS>	<POLY>	Float	R/W	Cross sensitivity value.
<CO2>	<POLY>	<A1> <A2> <A3> <A4> <A5>	R/W	Floating point coefficients for the CO_2 calibration polynomial.
<H2O>	<POLY>	<A1> <A2> <A3>	R/W	Floating point coefficients for the H_2O calibration polynomial.

Tag	Parent	Value(s)	R/W	Comments
<ACK>	<LI840>	TRUE | FALSE	R	Acknowledgement to a send command.
<VER>	<LI840>	Text	R	Embedded software version.
<ERROR>	<LI840>	Text	R	Error. Includes a message.

Warranty

Each LI-COR, inc. instrument is warranted by LI-COR, inc. to be free from defects in material and workmanship; however, LI-COR, inc.'s sole obligation under this warranty shall be to repair or replace any part of the instrument which LI-COR, inc.'s examination discloses to have been defective in material or workmanship without charge and only under the following conditions, which are:

1. The defects are called to the attention of LI-COR, inc. in Lincoln, Nebraska, in writing within one year after the shipping date of the instrument.
2. The instrument has not been maintained, repaired, or altered by anyone who was not approved by LI-COR, inc.
3. The instrument was used in the normal, proper, and ordinary manner and has not been abused, altered, misused, neglected, involved in and accident or damaged by act of God or other casualty.
4. The purchaser, whether it is a DISTRIBUTOR or direct customer of LI-COR or a DISTRIBUTOR'S customer, packs and ships or delivers the instrument to LI-COR, inc. at LI-COR inc.'s factory in Lincoln, Nebraska, U.S.A. within 30 days after LI-COR, inc. has received written notice of the defect. Unless other arrangements have been made in writing, transportation to LI-COR, inc. (by air unless otherwise authorized by LI-COR, inc.) is at customer expense.
5. No-charge repair parts may be sent at LI-COR, inc.'s sole discretion to the purchaser for installation by purchaser.
6. LI-COR, inc.'s liability is limited to repair or replace any part of the instrument without charge if LI-COR, inc.'s examination disclosed that part to have been defective in material or workmanship.

There are no warranties, express or implied, including but not limited to any implied warranty of merchantability of fitness for a particular purpose on underwater cables or on expendables such as batteries, lamps, thermocouples and calibrations.

Other than the obligation of LI-COR, inc. expressly set forth herein, LI-COR, inc. disclaims all warranties of merchantability or fitness for a particular purpose. The foregoing constitutes LI-COR, inc.'s sole obligation and liability with respect to damages resulting from the use or performance of the instrument and in no event shall LI-COR, inc. or its representatives be liable for damages beyond the price paid for the instrument, or for direct, incidental or consequential damages.

The laws of some locations may not allow the exclusion or limitation on implied warranties or on incidental or consequential damages, so the limitations herein may not apply directly. This warranty gives you specific legal rights, and you may already have other rights which vary from state to state. All warranties that apply, whether included by this contract or by law, are limited to the time period of this warranty which is a twelve-month period commencing from the date the instrument is shipped to a user who is a customer or eighteen months from the date of shipment to LI-COR, inc.'s authorized distributor, whichever is earlier.

This warranty supersedes all warranties for products purchased prior to June 1, 1984, unless this warranty is later superseded.

DISTRIBUTOR or the DISTRIBUTOR'S customers may ship the instruments directly to LI-COR if they are unable to repair the instrument themselves even though the DISTRIBUTOR has been approved for making such repairs and has agreed with the customer to make such repairs as covered by this limited warranty.

Further information concerning this warranty may be obtained by writing or telephoning Warranty manager at LI-COR, inc.

IMPORTANT: Please return the User Registration Card enclosed with your shipment so that we have an accurate record of your address. Thank you.



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