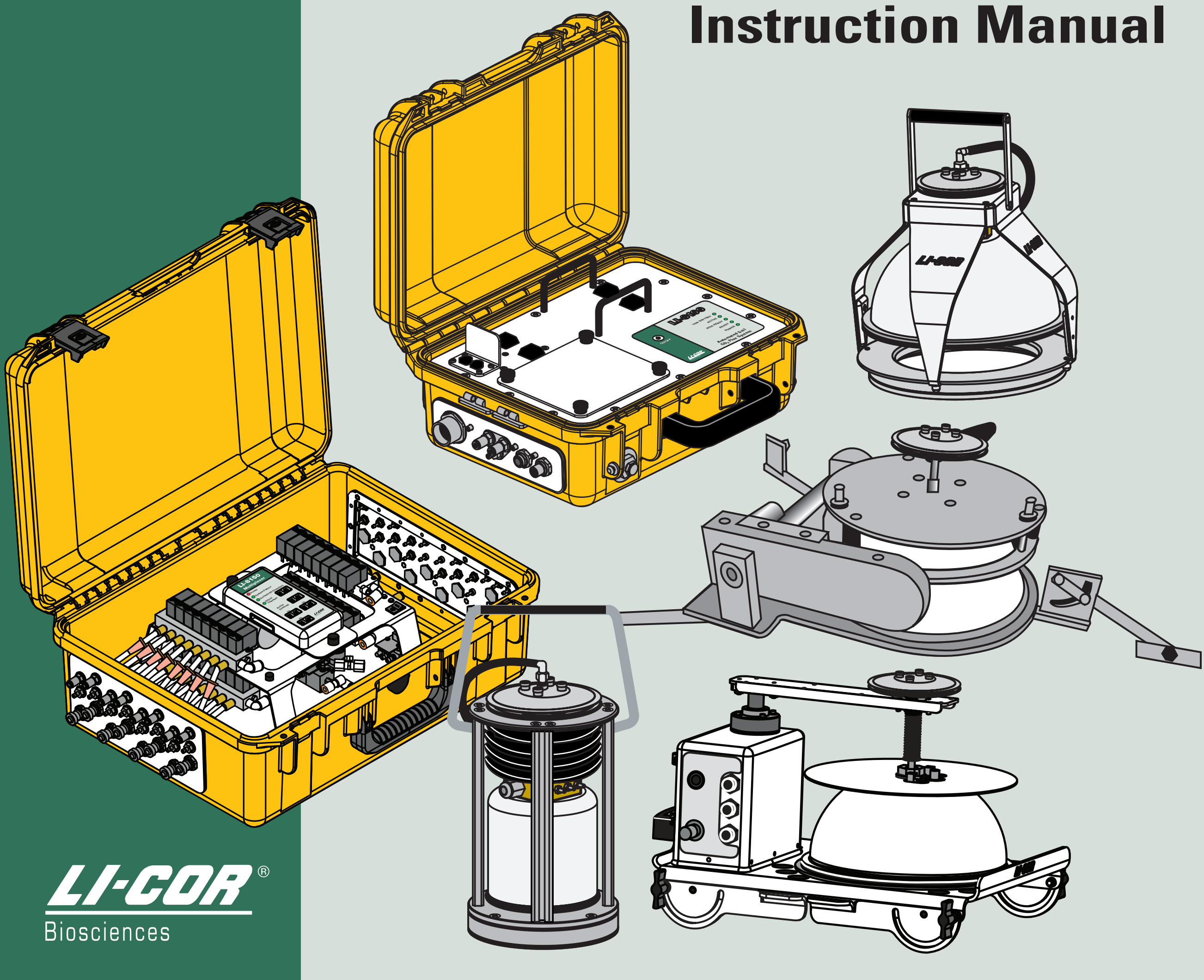
LI-8100

Automated Soil CO_2 Flux System

& LI-8150 Multiplexer

Instruction Manual



LI-COR®
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LI-8100

Automated Soil CO_2 Flux System & LI-8150 Multiplexer Instruction Manual

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NOTICE

The information contained in this document is subject to change without notice.

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Note on Safety

LI-COR products have been designed to be safe when operated in the manner described in this manual. The safety of this product can not be guaranteed if the product is used in any other way than is specified in this manual.

Equipment markings:

The product is marked with this symbol when it is necessary for you to refer to the manual or accompanying documents in order to protect against damage to the product.

The product is marked with this symbol when a hazardous voltage may be present.

The product is marked with this symbol when a crush hazard is present.

The product is marked with this symbol for a Chassis Ground connection.

WARNING **Warnings** must be followed carefully to avoid bodily injury.

CAUTION **Cautions** must be observed to avoid damage to your equipment.

Manual markings:

WARNING **Warnings** must be followed carefully to avoid bodily injury.

CAUTION **Cautions** must be observed to avoid damage to your equipment.

NOTE **Notes** contain important information and useful tips on the operation of your equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio fequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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Declaration of Conformity

Manufacturer's Name: LI-COR Inc.

Manufacturer's Address: 4421 Superior Street
Lincoln, Nebraska USA 68504

declares that the product

Product Name: Automated Soil CO_2 Flux System

Model Number(s): LI-8100

Product Options: LI-8150 Multiplexer
8100-101 Long-Term Chamber
8100-102 10 cm Survey Chamber
8100-103 20 cm Survey Chamber
8100-104 Long-Term Chamber
8150-770 AC Power Supply

conforms to the following Product Specifications:

Safety: UL 61010 B-1 : 2003
CAN/CSA-C22.2 #61010-1 : 2004
EN61010-1 : 2001

EMC: 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, 1KV
IEC 61000-4-6 : 1996/A1:2000: Conducted RF Immunity, 3V
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.

John Rada
Engineering Manager

Document #53-07671
September 7, 2006

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1 Getting Started

What is the LI-8100?

The LI-8100 is a fully automated system dedicated to making measurements of soil CO_2 flux. The Analyzer Control Unit powers either a Survey or Long-Term measurement chamber, and houses the system electronics and the infrared gas analyzer (IRGA) used to measure the change in CO_2 and H_2O concentrations in the soil chamber.

An Auxiliary Sensor Interface attaches to the Analyzer Control Unit to allow for connection of an external power source and your choice of sensors, such as soil temperature and/or soil moisture probes.

Data collected by the LI-8100 can be stored to the instrument's flash memory, to an internal compact flash (CF) card, or transferred to a personal computer.

Data collection protocols are defined in either Windows® software or interface software for Palm® OS on a Personal Digital Assistant (PDA). The LI-8100 is a Wi-Fi ("wireless fidelity") enabled device that allows for wireless communication with compatible PDAs or personal computers. Data collected by the LI-8100 can be output to your Windows® computer; data analysis software (FV8100) is also included to allow further examination and/or recomputation of your data.

What's What

If you have just taken delivery of your LI-8100 check the packing list to verify that you received everything ordered, including the following items:

Analyzer Control Unit

The Analyzer Control Unit is the yellow enclosure that houses the LI-8100 electronics and infrared gas analyzer. The interior of the Control Unit contains the indicator panel, brackets for the optional 6400-03 Rechargeable Battery, and an access panel for inserting or removing the wireless and compact flash cards. The left side of the Control Unit has a mount for the Auxiliary Sensor Interface (below), as well as connections for the soil flux chambers and RS-232 cable.

Figure 1-1. *Analyzer Control Unit, with 6400-03 Rechargeable Battery, Auxiliary Sensor Interface, and shoulder strap.*

Auxiliary Sensor Interface

The Auxiliary Sensor Interface attaches to the side of the Analyzer Control Unit, as shown at right, and allows for connection of your choice of sensors, or an alternative power source. The Auxiliary Sensor Interface is described in more detail in Section 2, *Initial Setup*.

The Auxiliary Sensor Interface uses "gland" type plugs to seal the wire connections against moisture and insects. As many as five different sensors, or four sensors and an external power supply can be connected to the Auxiliary Sensor Interface.

Serial Cable Interface (p/n 9981-018)

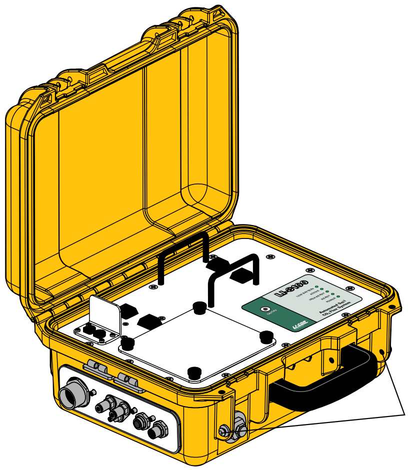
The Serial Cable Interface is a 1 meter cable with a round connector on one end that mates to the RS-232 port on the left side of the Analyzer Control Unit. The other end of the cable has a 9-pin male connector for attaching to the Standard RS-232 Serial Cable (below).

Standard RS-232 Cable (p/n 9975-016)
The Standard RS-232 Cable is a DTE to DTE cable with 9-pin connectors on both ends. This cable mates with the Serial Cable Interface (above); the other end should be used to connect to your computer's 9-pin serial port. If you want to interface to a computer with a 25-pin serial port, then the 9-pin to 25-pin adapter included (p/n 392-5688) must be used.

Compact Flash Memory Card (p/n 8100-554)
The compact flash memory card included is a Type I industrial grade card with adapter sleeve that is rated for high temperature use. Other commercially available cards are compatible with the LI-8100, however, we cannot guarantee their stability under high temperatures. Type II compact flash cards can also be used with the LI-8100, with the appropriate adapter sleeve.

NOTE: Type II Compact Flash cards are slightly thicker than Type I cards; as a result, the adapter sleeve is also thicker, and may be more difficult to remove from the LI-8100 Analyzer Control Unit case when inserted in tandem with a second wireless card adapter.

Shoulder Strap Kit (p/n 604-07467)
The shoulder strap can be attached to the Analyzer Control Unit, if you prefer to use it to carry the instrument case. Simply slide the strap ends over the two button heads attached to the Analyzer Control Unit, on either side of the handle, as shown below.



Software CD (p/n 8100-500)

Contains the LI-8100 Windows® and interface software for Palm® OS, the LI-8100 Data Analysis (File Viewer) software, this instruction manual, the Data Analysis, and Palm/LI-8100 Configuration manuals in PDF format.

NOTE: The latest version of the LI-8100 instrument (embedded) software is available on LI-COR's web site at http://www.licor.com.

8100-101 Long-Term Chamber

Contains the chamber, spares kit (p/n 8100-611), and a replacement gasket kit (p/n 8100-612).

8100-104 Long-Term Chamber

Contains the chamber, spares kit (p/n 8100-613), and a replacement gasket kit (p/n 8100-612).

8100-102 10 cm Survey Chamber

Contains the chamber, spares kit (p/n 8100-621), replacement gasket kit (p/n 8100-622), and the 8100-201 Soil Temperature Probe.

8100-103 20 cm Survey Chamber

Contains the chamber, spares kit (p/n 8100-631), replacement gasket kit (p/n 8100-632), and the 8100-201 Soil Temperature Probe.

Spare Parts Kit

This box contains replacement parts for your LI-8100. As you become familiar with the system you will learn which items to keep close at hand and which items can be stored away. Additional spares kits are packaged with their respective soil chambers, as well. An optional bellows kit (p/n 8100-623) is also available from LI-COR that can be used to replace damaged bellows on either the 10 cm or 20 cm Survey Chambers.

The spares kits include these commonly used items:

Description	Qty.	LI-COR Part No.
Analyzer Control Unit Spares Kit	1	9981-032
O-rings	20	192-02597
Bev-a-line Tubing	10'	222-01824
Balston Disposable Air Filters	2	300-01961
Quick Connect Straight Union	1	300-03123
Quick Connect Right Angle	2	300-03125
Quick Connect Plug	2	300-07124
Quick Connect Coupling	1	300-07125
Quick Connect Union “Y”	2	300-03367
Quick Connect Port Plug	1	9981-118
3 Amp Fuse	1	439-04215
Auxiliary Sensor Interface Spares Kit	1	9981-028
Strain Relief	5	198-07221
EPDM Plugs	10	610-08324
Santoprene	1′	222-08325
3 Amp Fuse	1	439-04215
Optical Bench Cleaning Kit	1	9981-029
O-rings	4	192-00226
Bev-a-line Tubing	1'	222-01824
Wrapped Point Cleaning Swabs	5	610-05314
Sock Tip Swab	5	610-05315

Description	Qty.	LI-COR Part No.
8100-102 Survey Chamber Spares Kit	1	8100-621
Cable Ties	10	218-08499
Bev-a-line Tubing	11'	222-01824
Thumb Nut	4	165-00140
10 cm Soil Collars	6	6581-157
8100-103 Survey Chamber Spares Kit	1	8100-631
Cable Ties	10	218-08499
Bev-a-line Tubing	11'	222-01824
Thumb Nut	4	165-00140
20 cm Soil Collars	6	6581-044
8100-101 Long-Term Chamber Spares Kit	1	8100-611
Cable Ties	10	218-08499
Bev-a-line Tubing	18'	222-01824
Thumb Nut	4	165-00140
20 cm Soil Collars	2	6581-044
10-32 x 3/4" screws	6	122-07715
8100-104 Long-Term Chamber Spares Kit	1	8100-613
Cable Ties	9	218-08499
Urethane Tubing	6'	222-00303
Thumb Nut	4	165-00140
20 cm Soil Collars	2	6581-044
Bumpers	4	191-08069
Cap Plugs	5	620-08297

Description	Qty.	LI-COR Part No.
10 cm Survey Chamber Gasket Kit	1	8100-622
Foam Seal Gaskets	20	6560-229
Survey Collar Gaskets	2	6581-065
Chamber Flange Gaskets	2	6581-066
Manifold Gaskets	2	6581-057
Seal Washer	4	167-07255
Chamber Gasket Trim	2.2'	226-07390
Loctite Adhesive	1	208-05786
10-32 x 1/2" screws	4	122-00014
4-40 x 3/8" screws	18	122-01578
8-32 x 1/2" screws	4	122-04328
20 cm Survey Chamber Gasket Kit	1	8100-632
Cap Nuts	4	163-02618
Foam Seal Gaskets	20	6581-107
Manifold Gaskets	2	6581-057
Soil Collar Gaskets	4	6581-108
Chamber Gasket Trim	6'	224-07606

Loctite Adhesive	1	208-05786
10-32 x 1/2" screws	4	122-00014
4-40 x 3/4" screws	2	158-07847
Flat washer, #10	4	167-00154
Seal washer, #10	4	167-07255
8100-101 Long-Term Chamber Gasket Kit	1	8100-612
Loctite Adhesive	1	208-05786
Collar Gasket	2	6581-060
Chamber Gasket Trim	6'	224-07606
6-32 x 3/8" screws	4	122-00009
4-40 x 3/8" screws	18	122-01578
8100-104 Long-Term Chamber Gasket Kit	1	8100-612
Loctite Adhesive	1	208-05786
Collar Gasket	2	6581-060
Chamber Gasket Trim	6'	224-07606
6-32 x 3/8" screws	4	122-00009
4-40 x 3/8" screws	18	122-01578

Description	Qty.	LI-COR Part No.
LI-8100 Bellows Kit (optional)	1	8100-623
Silicone Lubricant	1	210-01958-1
10-32 x 1/2" screws w/o-ring	4	138-07470
Manifold Gasket	1	6581-057
Bellows, 3" I.D. x 4.25" O.D.	1	254-7219

Calibration Sheet

This data sheet is a copy of the calibration information entered into the LI-8100 by LI-COR. Keep it in a safe place for future reference. LI-COR also retains copies of calibration information for your soil CO_2 flux system; contact us if yours is misplaced.

Optional Accessories

6400-03 Rechargeable Battery

(12VDC). The 6400-03 Rechargeable Batteries are tested and fully charged before they leave the factory, but may discharge during shipping. It is a good idea to test your batteries to make sure they are charged. See "*Recharging the 6400-03 Batteries*" in Section 14 for instructions about charging batteries. The 6400-03 batteries require the LI-6020 Battery Charger for recharging. One 6400-03 battery provides approximately 3-4 hours of battery life, depending on pump usage, wireless card usage, etc., at 25 °C. A mounting bracket and connectors are present in the LI-8100 Analyzer Control Unit case for use with the 6400-03.

NOTE: There are 2 battery connectors in the case; you can attach a second, fully charged battery before removing the discharged battery to provide uninterrupted operation.

LI-6020 Battery Charger (115/230VAC)
The LI-6020 can charge up to four 6400-03 batteries at a time.

Soil Temperature Probe (p/n 8100-201 & 8150-203)
The Omega soil temperature probe is a T-handled Type E thermocouple with 6.4 mm (0.25") diameter and 250 mm (10") immersion length. The probe contains a 2-wire adapter cable for connection to the Auxiliary Sensor Interface. Alternatively, the connector can be cut off or unscrewed for permanent installation via the resulting bare wire leads. The 8150-203 thermistor probe has a plug for direct connection to the 8100-104 Long Term Chamber, or to the Chamber Sensor Interface when used with the 8100-101 Long-Term Chamber; see Sections 8 and 9 for more information.

Soil Moisture Probe (p/n 8100-202 & 8150-202)
The ECH_2O Model EC-5 soil moisture probe (Decagon Devices, Inc., Pullman, WA) is a 5 cm (2") dielectric sensor that measures volumetric water content of the soil. The probe contains a 3-wire adapter cable for connection to the Auxiliary Sensor Interface (see Section 2, *Connecting the Soil Moisture Probe to the Auxiliary Sensor Interface*). The 8150-202 probe has a plug for direct connection to the 8100-104 Long Term chamber, or to the Chamber Sensor Interface when used with the 8100-101 Long-Term Chamber; see Sections 8 and 9 for more information.

Palm® Wireless Communications Package (p/n 8100-561)*
Includes 8100-557 Palm® LifeDrive Personal Digital Assistant (PDA), USB cable, serial cable for Palm (p/n 8100-558), wireless card (p/n 8100-552), and Palm Travel Charger (p/n 8100-559). The Palm Wireless Package allows for wireless communication between the LI-8100 and compatible PDAs. Separate instructions, entitled "Configuring the Palm® LifeDrive for Use with the LI-8100" are included as a PDF file on the LI-8100 CD.

* May not be available in all areas.

2 Initial Setup

Cable Connections

There is a panel for connecting the RS-232, chamber, and Auxiliary Sensor Interface cables on the left side of the Analyzer Control Unit. The panel appears as shown in Figure 2-1 below.

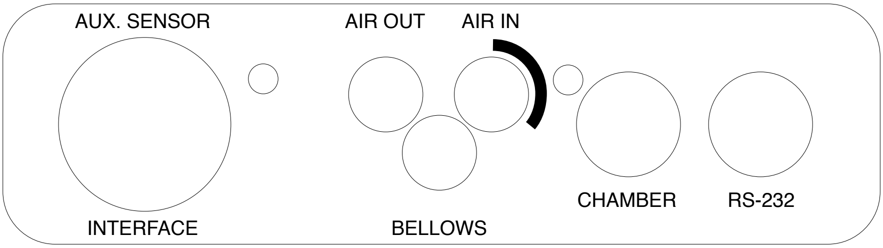


Figure 2-1. *Analyzer Control Unit cable connection panel.*

Locate and attach the Serial Cable Interface (p/n 9981-018), which is a 1 meter cable with a round connector on one end that mates to the RS-232 port on the left side of the Analyzer Control Unit. The other end of the cable has a 9-pin male connector for attaching to the Standard RS-232 Serial Cable (p/n 9875-016). Connect the Serial Cable Interface and Standard RS-232 Serial Cables together.

There are three hoses connected to the Survey Chambers: air to the chamber, air returning from the chamber to the Analyzer Control Unit, and air that drives the bellows. The Long-Term Chambers use only two hoses: air in and air out. These hoses are connected to the side panel of the Analyzer Control Unit, as shown below. The hose for Air In has a male fitting and the hose for Air Out has a female fitting. Note that one of the hoses has a piece of black shrink wrap; this hose attaches to the Air In fitting on the Analyzer Control Unit. The bellows hose has a male fitting, and attaches to the port marked Bellows on the Analyzer Control Unit. Insert the hoses until the fittings snap into place. To remove the hoses, slide the collar on the fittings; the collar on the bellows and Air In fittings slide toward the Analyzer Control Unit, and the collar on the Air Out fitting slides away from the Analyzer Control Unit.

Note that the fittings on the side panel have fine threads. Make sure there is no debris on the fittings before attaching the connectors, as the threads can be easily damaged. Cover the connectors with the attached connector dust caps whenever the connectors are not being used.

Figure 2-2. *Chamber hose connections.*

Note that the Bellows port is active only with the Survey Chambers. If you are using a Long-Term chamber, only the Air In and Air Out fittings are active. The Bellows port should be plugged with p/n 9981-118, found in the spare parts kit.

The yellow circular connector bundled with the air hoses is attached to the Chamber fitting. Note that this fitting is indexed; you may have to rotate it until it slips into place before tightening.

When all of the cables are connected, the side panel should appear similar to that shown below in Figure 2-3.

Figure 2-3. *Proper cable connections.*

> Note that if you swap between Survey and Long-Term chambers connected to the Analyzer Control Unit you must power the instrument off and then back on, as the type of chamber attached to the Analyzer Control Unit is recognized during system startup.

The Analyzer Control Unit

Using Batteries

The LI-8100 requires one 6400-03 battery to power the instrument; alternatively, an external power source (10.5-28 VDC, 3A max.) can be connected via the Auxiliary Sensor Interface. The 6400-03 fits inside the Analyzer Control Unit, and can be connected to either of the two battery connectors. You can attach a second, fully charged battery before removing the discharged battery to provide uninterrupted operation. The 6400-03 requires the LI-6020 Battery Charger, which can charge up to four 6400-03 batteries at once.

Using Compact Flash Cards

Only one compact flash and/or wireless card can be installed in the Analyzer Control Unit; it is not possible to install two compact flash or two wireless cards at the same time. ***NOTE**: Always eject the compact flash card (see File Manager in Section 11, "Using the Windows Software", or File Manager in Section 12, "Using a PDA") before removing the compact flash. Turn the instrument off before removing or installing the wireless PC card.*

About LI-8100 Data Records and Storage Options

The LI-8100 has 18 Megabytes of onboard flash available for data collection. The data stored in onboard flash is compressed at an approximate ratio of 3:1. Therefore, with compression*, about 50 MB of data can be stored on the instrument. If more space is required for data logging, a compact flash card can be used as well. Typical compact flash cards range from 128 MB to 1 GB. A 256 MB compact flash card is included with each instrument.

When logging all data values, the size of the record is approximately 190 bytes. Table 2-1 summarizes the amount of space required to log the largest data record at one second intervals.

Table 2-1. Storage space required to log largest data record at 1 second intervals.

Data Logging Period	Space Required
1 minute	11.1K
1 hour	667.9K
1 day	15.6MB

100% duty cycle logging all data fields at 1 Hz

Typical protocols would not require the instrument to be recording data 100% of the time (except when used with the LI-8150 Multiplexer). Table 2-2 illustrates some example observation configurations and their respective durations based on internal storage.

Table 2-2. Examples of observation lengths and duration that can be stored to internal memory.

Observation Length** (minutes)	Frequency (observations/hour)	Duration (hours)	Duration (days)
3	15	102	4.25
2	15	153	6.3
3	4	384	16
2	4	576	24
3	2	768	32
2	2	1153	48

Possible long term protocols, logging all data fields at 1 Hz

*The compression ratio depends on the redundancy of data items. The more redundant the data, the higher the compression ratio will be.
**The observation length is defined to be the amount of time the chamber is closed collecting data.

Using a Wireless Card

An optional wireless package is available from LI-COR for those users who want to control the LI-8100 via a wireless network. The wireless package includes a fixed networking Type II PC Card that can be inserted into either of the two PC card slots in the Analyzer Control Unit. *The wireless card included is the only card warranted for use with the LI-8100; while other cards could be used, LI-COR cannot guarantee the integrity of the data*. Separate instructions for wireless networking with a PDA are included with the LI-8100; see *"Configuration of the Palm LifeDrive with the LI-8100 Automated Soil CO_2 Flux System for Wireless Communication"*. ***NOTE**: Always turn the instrument off before removing the wireless and/or compact flash cards.*

Air Filters

There are two Balston air filters located inside the Analyzer Control Unit. One of the filters is on the flow path to the attached chamber, and the other is on the bellows air path, and is used only when a Survey Chamber is attached. The bellows air path draws air from outside of the Analyzer Control Unit through a port on the front panel.

The air filter on the flow path will need to be replaced after about 3 months of continuous use, depending upon the conditions under which the instrument is used. You can look at the clear Bev-a-line tubing to get a visual indication of how much dirt is present in the line, or alternatively, if the instrument zero and span settings are fluctuating widely (see Section 5, *User Calibration*), it may be time to change the filter. Instructions for replacing the air filters are given in Section 14, *Maintenance*.

Power On

When the LI-8100 is powered on using the ON/OFF button on the indicator panel inside the Analyzer Control Unit, a series of LEDs will light.

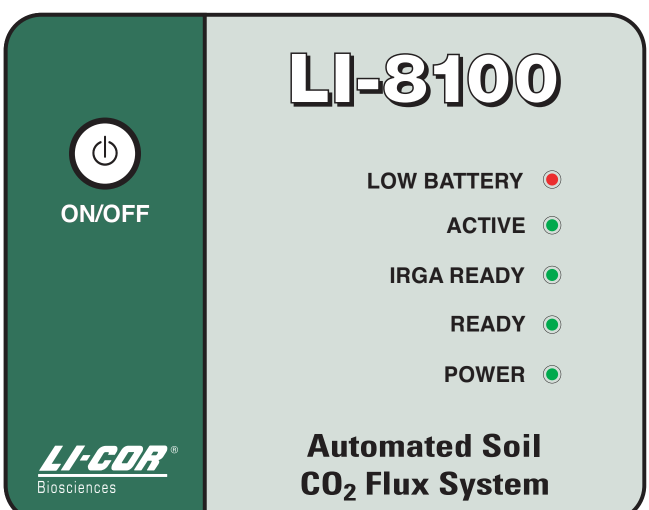


***Figure 2-6.** The indicator panel is located on the inside panel of the Analyzer Control Unit.*

Power - On when ON/OFF button is pushed, and indicates that power is applied to the instrument.

Ready - On when the instrument is ready to communicate with a computer or PDA.

IRGA Ready - On when the IRGA has reached its operating temperature. This may take about 10 minutes after the instrument is powered on. The instrument will function before the IRGA Ready light illuminates; however, measurements should not be made until the optical bench has reached its operating temperature.

Active - On when the LI-8100 is making a measurement.

Low Battery - On when the input voltage drops below a factory-determined threshold (approximately 10.94 volts). If the voltage drops below 10.5 volts, the instrument will turn off.

Automatic Restart Function

The LI-8100 has the capability to restart a measurement following a power interruption to the instrument. Enabling this feature requires the user to first reposition a small jumper in the Analyzer Control Unit housing. When the jumper is repositioned, power will be restored to the instrument when it becomes available; note that this function is available only when the LI-8100 is powered via the Auxiliary Sensor Interface, and is not available when powered by a battery inside the Analyzer Control Unit. Note, too, that in order to restart the measurement, this feature must be also be enabled in software, following the jumper placement.

The LI-8100 jumper is located on the underside of the circuit board located directly below the PC card slots in the Analyzer Control Unit. Remove the access panel to view the jumper. Note that there are three pins aligned horizontally on the underside of the circuit board, below the words “Power On” imprinted on the circuit board. When configured at the factory, the jumper covers the leftmost and center pins (Keypad position, Figure 2-7). In this position, if power is interrupted, the instrument can only be restarted by pressing the On/Off button on the keypad. By repositioning this jumper so that it covers the center and rightmost pins (Aux In position, Figure 2-8), power can be automatically restored when it becomes available.

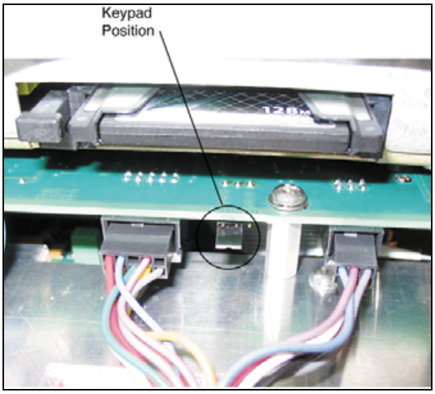


Figure 2-7. Keypad jumper position.

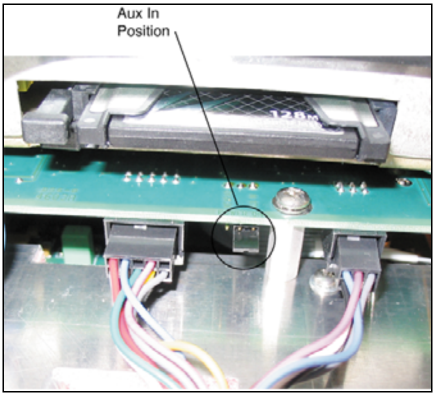


Figure 2-8. Aux In jumper position.

IMPORTANT: ***When the jumper is in the Aux In position, the LI-8100 presents a potential shock hazard.*** For example, if power is interrupted and the unit shuts off, it is possible to remove the access panel and make contact with electrical components; if the user is unaware that a power interruption caused the instrument to shut down, power could be automatically restored while the user is in contact with these internal components. ***For this reason, we recommend that you always disconnect the power supply from the instrument before servicing any internal components in the Analyzer Control Unit.***

If you want the LI-8100 to restart the current measurement following a power interruption, reposition the jumper to the Aux In position as described above, and enable the Auto Restart function in software; in the LI-8100 Windows software, choose **Instrument Settings** from the 8100 menu and enable the 'Resume measurement on instrument restart' check box, as shown in Figure 2-9 below. In the LI-8100 Interface Software for Palm OS, tap on **Instrument Settings** on the 8100 menu, and enable 'Automatic Restart', as shown in Figure 2-10 below.

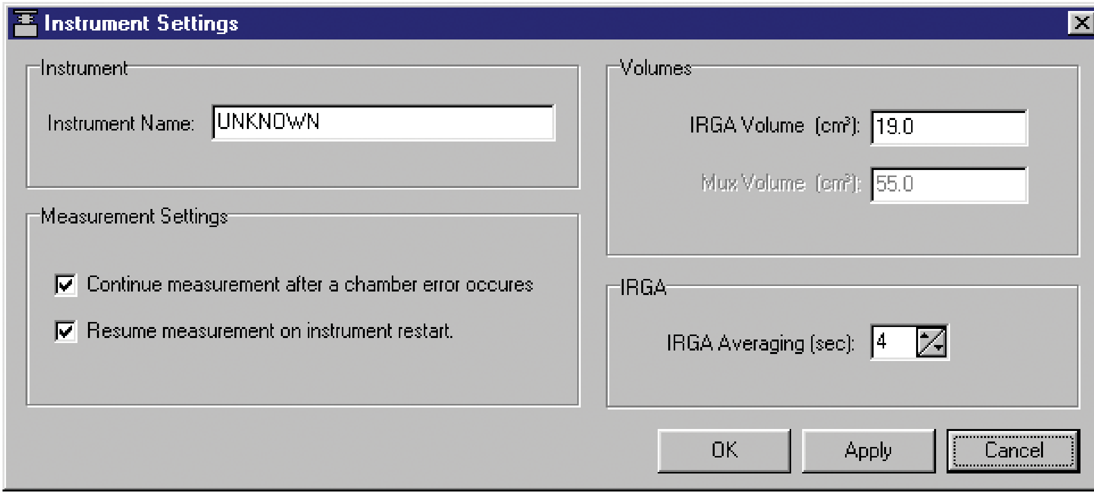


Figure 2-9. *Auto Restart function in Windows® software.*

Figure 2-10. *Auto Restart function in Palm® OS software.*

Using the Auxiliary Sensor Interface

The Auxiliary Sensor Interface attaches to the side of the Analyzer Control Unit and allows for connection of your choice of sensors, or an alternative power supply. The Auxiliary Sensor Interface is O-ring sealed, and has connections for up to 4 thermocouples (types E, J, or T, or raw), and 4 general purpose input voltage channels, any of which can be configured to measure a soil moisture probe. Sensors can be powered externally or by the LI-8100 with a constant 5 VDC source. The Auxiliary Sensor Interface also has a 12-28 VDC input (3A maximum) for use with external power. Note that on Type E, J, or T thermocouples, the red wire is negative. Note, too, that on the 8100-201 Thermocouple Probe, the red wire is negative, and the purple wire is positive.

Figure 2-11. *Auxiliary Sensor Interface and connector.*

Auxiliary Sensor Interface Terminals

Loosen the 4 philips head screws in each corner of the Auxiliary Sensor Interface module and remove the top cover. The interior of the interface appears as shown below.

Figure 2-12. Auxiliary Sensor Interface interior.

Note that there are 2 terminal strips, with connections as follows:

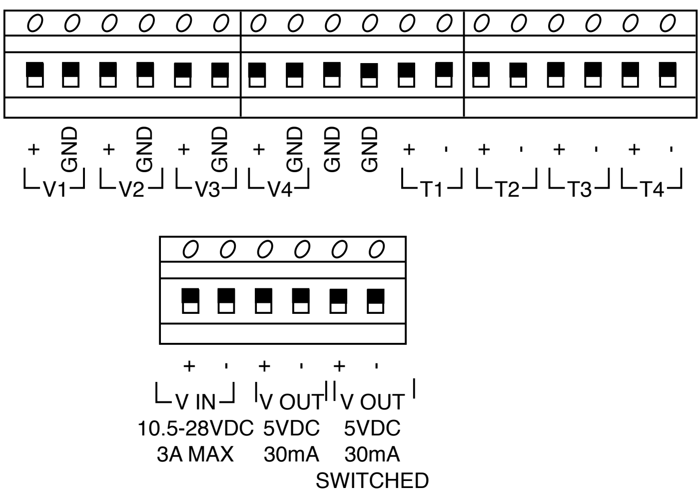


Figure 2-13. Graphical representation of terminal positions.

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

Terminal	Label	Description
1	V1 +	Voltage input 1 positive
2	V1 GND	Voltage input 1 ground
3	V2 +	Voltage input 2 positive
4	V2 GND	Voltage input 2 ground
5	V3 +	Voltage input 3 positive
6	V3 GND	Voltage input 3 ground
7	V4 +	Voltage input 4 positive
8	V4 GND	Voltage input 4 ground
9	GND	Ground
10	GND	Ground
11	T1 +	Thermocouple input 1 positive
12	T1 -	Thermocouple input 1 negative
13	T2 +	Thermocouple input 2 positive
14	T2 -	Thermocouple input 2 negative
15	T3 +	Thermocouple input 3 positive
16	T3 -	Thermocouple input 3 negative
17	T4 +	Thermocouple input 4 positive
18	T4 -	Thermocouple input 4 negative

Terminal	Label	Description
1	V IN +	Voltage input positive
2	V IN -	Voltage input negative
3	V OUT +	5 VDC output positive
4	V OUT -	5 VDC output negative
5	V OUT +	5 VDC output positive (switched)
6	V OUT -	5 VDC output negative (switched)

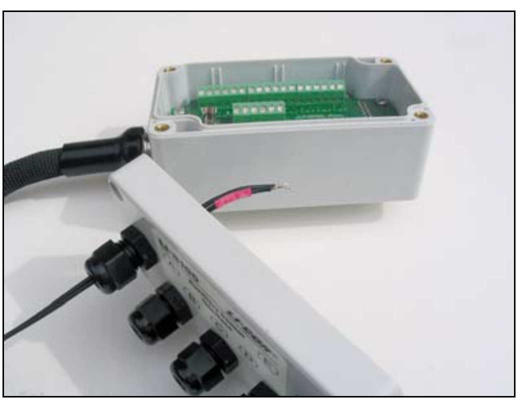
Connecting Sensors to the Auxiliary Sensor Interface

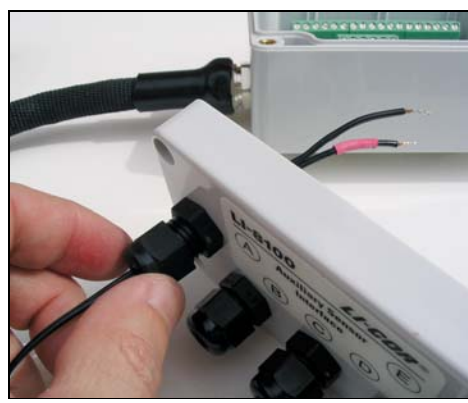
There are 5 strain relief “gland” type plugs on the Auxiliary Sensor Interface top cover, through which the sensor or power supply wires pass, after which the wires are connected to the appropriate screw terminals. To attach your sensor(s) or power supply to the Auxiliary Sensor Interface, follow these steps:

1. Remove the philips head screw in each of the 4 corners of the Auxiliary Sensor Interface module and remove the top cover.

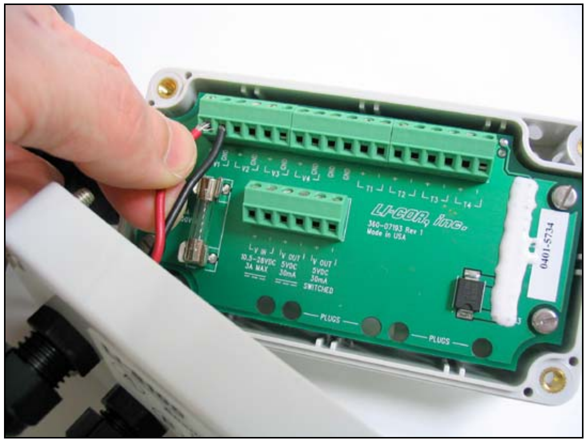
2. Remove the cap from any of the 5 gland plugs by turning counter-clockwise.

3. Pass the wires through the top of the plug cap first, and then through the gland plug. Screw the plug cap slightly, but don’t tighten yet.





4. Use a small flathead screwdriver to loosen the appropriate screw terminal, and insert the wire leads into the terminal strip. Tighten the screw terminals. Make a note of which plug the wires are passing through (e.g. A, B, C, D, or E), and to which terminal the wires are connected (e.g. A/T1, B/V3, etc.). This information will be needed later when you enter the sensor calibration coefficients into software.



5. Pull lightly on the wires to remove excess wire from inside the interface, re-attach the interface top cover, and tighten the gland plug cap.

6. When you have finished installing all of your sensors and/or a power supply, attach the Auxiliary Sensor Interface cable connector to the connector on the side panel of the Analyzer Control Unit labeled Aux. Sensor Interface. The Sensor Interface module has metal fittings on the back that snap into the brackets above the side panel connectors for transporting the unit, as shown below.

7. There are 10 EPDM type plugs that can be inserted into unused gland plugs on the Auxiliary Sensor Interface; the plugs prevent water, insects, dirt, etc. from entering the interface box. Remove the top cover and insert the narrow end of the plug through the back of the gland plug(s) and tighten the plug cap(s) (below). The plugs should always be inserted when there are gland plugs that do not have wires inserted through them.

8. Note too that there is a length of Santoprene tubing in the Auxiliary Sensor Interface spares kit. This tubing can be cut to length and used for small gauge wires that may not be able to be tightened sufficiently with the gland plugs. It can also be used for oddly shaped wires that can be difficult to seal with the gland plug caps.

Connecting the Soil Moisture Probe to the Auxiliary Sensor Interface

The ECHO Model EC-5 soil moisture probe (Decagon Devices, Inc., Pullman, WA) is a 5 cm (2") dielectric sensor that measures volumetric water content of the soil. The probe has a stereophone jack at its base; an adapter plug is included (p/n 436-08586) that contains a 3-wire cable for connection to the Auxiliary Sensor Interface.

Voltage channels 1-4 (V1-V4) can be used with the ECH$_2$O soil moisture probe; the soil probe must be set up in software. The 3-wire adapter cable has red, bare (ground, unshielded), and white wires that are connected to V4(+), V4(-), and V OUT 5VDC SWITCHED(+), respectively, as shown in Figure 2-14.

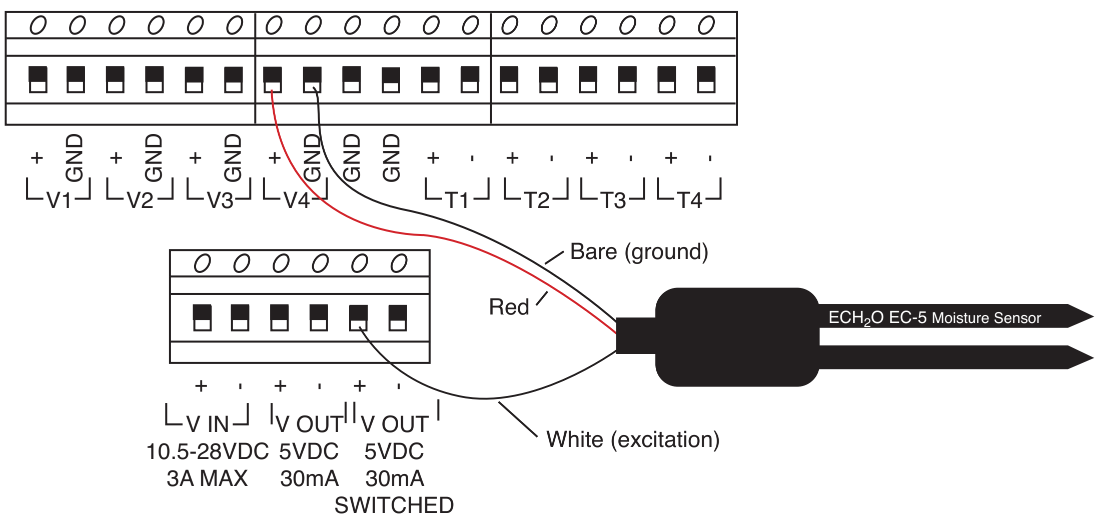


Figure 2-14. *ECH$_2$O EC-5 soil moisture probe connection to Auxiliary Sensor Interface.*

Important Note on Wire Insertion

When inserting wires through the gland plugs on the Auxiliary Sensor Interface, it is important that a water-tight seal is formed when the gland plug cap is tightened. Note that in the picture above at Step 6, the wire leads are encased in a round sheath, which provides a good seal with the bushing in the gland plug. Bare wires that are not sheathed do not seal tightly; moisture will travel along the bare wires, or in the groove of two attached wires, and could blow the fuse in the Auxiliary Sensor Interface, or cause corrosion to the connector and/or circuit board. If you are continuously blowing fuses, check to see if the wires are tightly sealed; if not, you may need to encase bare wires in a short piece of sheathing material.

Using Soil Collars

Both the Survey and Long-Term soil chambers for the LI-8100 require the use of a soil collar that is inserted (and usually left) in the soil before making measurements. Using soil chamber collars has several advantages over direct insertion into the soil, including:

- The disturbance effect of insertion will not affect measurements conducted several hours or days later.
- It is possible to make repeated measurements at one location.

Construction of Soil Collars

Soil collars for use with the 10 cm (4") survey chamber can be easily constructed from thin-walled polyvinyl chloride (PVC) pipe. The tubing must have an inside diameter of 10 cm (3.930″) minimum and an outside diameter of 11.4 cm (4.50") maximum. Cut a section approximately 8.9 cm (3.5″) long or longer, depending on your soil type and experiment. Bevel one edge with a grinding wheel so that it is easier to press into the soil. The 10 cm (4") soil collars are available from LI-COR under part #6581-157 (1 each).

Soil collars for use with the Long-Term chambers or 20 cm Survey Chamber require a bit more effort to construct; we use a thick-walled 20.3 cm (8") PVC sewer pipe (i.e., Schedule SDR35), and a large lathe to bevel the edge. If you have access to a machine shop and want to try to construct your own 20.3 cm (8") collars, we have provided the mechanical specifications below. You can bevel the edge as desired, but keep in mind that a sharper edge will aid in insertion of the collar, particularly in hard soils. The 20.3 cm (8") soil collars are also available from LI-COR under part #6581-044 (1 each).

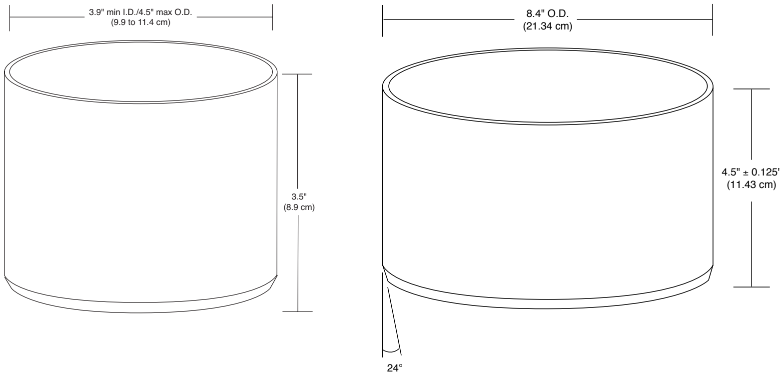


Figure 2-15. *Dimensions for 10 cm (4") and 20.3 cm (8") soil collars.*

Installing and Using Soil Collars

Soil collars should be installed several hours to one day before making a measurement. You can test to see if the flux has stabilized by making a measurement immediately after installing the collar, and then make subsequent measurements over time. Note, however, that the soil surface CO_2 flux depends on the time of day, and the diurnal cycle can be quite large.

In hard or compacted soils, it may be helpful to use a knife or sharp screwdriver blade to create a channel of appropriate depth around the circumference of the collar before insertion. For the larger 8" collars, you may need to lay a piece of wood across the collar and pound with a hammer.

Insertion Depth

The optimal collar height will vary with site conditions and the length of time the collars will be used at a given site. At a minimum, the collar should be inserted into the soil to a depth that gives a solid foundation so the collar does not move when moving the chamber on and off the collar. As insertion depth is increased, lateral diffusion of CO_2 in the soil column below the chamber will be reduced. The advantage of this is that lateral diffusion can be a source of error in the measurement (Healy et al., 1996), but the disadvantage is that as insertion depth increases, the possibility of root shearing increases. Collars may become loose over time and should be moved if this occurs.

Collars should extend a minimum of 2 cm above the soil surface for the 10 and 20 cm Survey chambers, and 3 cm or more for the Long-Term chamber, depending on the slope of the site. Collars can extend above the soil more than 2 or 3 cm, but with greater extension there is increased shading and perturbation of air movement. Over the long term, these perturbations could result in changes of evaporation rate, soil temperature and soil moisture.

Measuring the Chamber Offset

The chamber offset is used to determine the volume of air inside the soil collar, which is in turn used to calculate the total system volume. The total system volume is an important part of the flux calculation, so it should be determined as accurately as possible. Note that the chamber offset is measured differently for the Survey and Long-Term Chambers. With the Survey Chambers, the chamber offset is measured by the distance between the soil surface and the top of the soil collar. With the Long-Term Chamber, the chamber offset is measured by the distance between the soil surface and the upper edge of the chamber base plate, as shown below.

The chamber offset for the Survey Chambers is measured by the distance between the soil surface and the top of the soil collar.

The chamber offset for the Long-Term Chambers is measured by the distance between the soil surface and the upper edge of the chamber base plate. First measure the distance from the soil surface to the top of the soil collar,...

and then subtract the distance between the upper edge of the chamber base plate and the top of the soil collar to obtain the offset value.

This value should be as close to 1 cm as possible, since the default Long-Term chamber volume value in the software accounts for displacement by the collar. That displacement is estimated assuming that the collar is 7 mm thick and protrudes 1 cm above the chamber base plate.

Figure 2-16. *Chamber offset measurement using Survey and Long-Term Chambers.*

In uneven or sloping soil conditions, make measurements of the chamber offset at multiple points within the collar (i.e., North, South, East, and West), and then average these measurements to obtain the chamber offset that is entered into software.

When setting the 10 cm Survey chamber onto the collar, care must be taken not to let the bottom edge of the chamber disturb the soil within the collar (this will not occur if the collars extend more than 2 cm above the soil surface). Care should be taken, also, to make sure the collar is not disturbed when placing the chambers on or around them. The chamber edge should be as close to the soil surface as practical (within 1-2 cm) so that air flow within the chamber produces mixing near the soil surface. A foam gasket between the bottom of the Survey chambers and the top of the soil collar minimizes leaks between the collar and the chamber. The Long-Term chamber mounting plate uses a rubber flange that seals this space between the chamber and the collar.

Placement of Soil Temperature and Moisture Probes

There have been numerous reports showing a strong correlation between soil CO_2 flux and soil temperature (e.g., Hanson et al., 1993, Norman et al., 1992). Soil temperature and moisture may vary significantly with depth (Hillel, 1982), and is dependent on a number of site characteristics (e.g., exposure to light, shade, wind). In general, temperature and moisture measurements should be made in close proximity to the CO_2 flux measurement.

References

Norman, J.M., R.L. Garcia and S.B. Verma. 1992. Soil surface CO_2 fluxes and the carbon budget of a grassland. J. Geophys. Res. 97(D17):18845-18853.

Hanson, P.J., S.D. Wullschleger, S.A. Bohlman and D.E. Todd. 1993. Seasonal and topographical patterns of forest floor CO_2 efflux from an upland oak forest. Tree Physiology. 13:1-15

Hillel, D. Introduction to Soil Physics, 366 pp., Academic Press Inc.San Diego, 1982.

Healy, R.W., R.G. Striegl, T.F. Russell, G.L. Hutchinson, and G.P. Livingston. 1996. Numerical evaluation of static-chamber measurements of soil-atmosphere gas exchange: Identification of physical processes. Soil Sci. Soc. Am. J. 60:740-747.

3 Measurement Quick Start

This section is designed to quickly demonstrate a simple LI-8100 measurement. For the purposes of this discussion we will refer to the use of the LI-8100 Windows application software. Follow these steps to complete this tutorial:

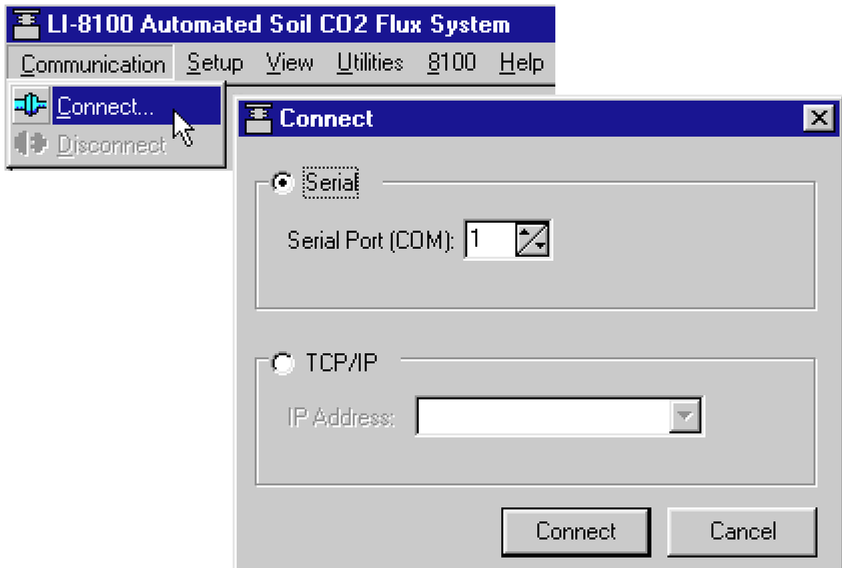
1. Connect the chamber cables, battery, and computer as described in Section 2, *Initial Setup*.

2. Install the Windows application software as described in Section 11, *Installing the PC Communications Software*.

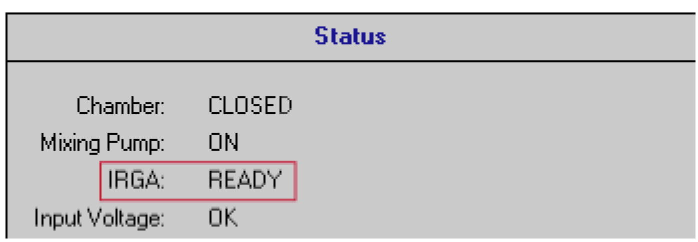
3. Place the chamber on a soil collar. Collar installation is discussed in detail in Section 2, *Initial Setup*. If you have not installed the soil collars yet, refer to Section 2, *Installing the Soil Collars*.

4. Turn the LI-8100 on using the ON/OFF button on the keypad on the inside panel of the Analyzer Control Unit. Wait for the "Ready" light to come on.

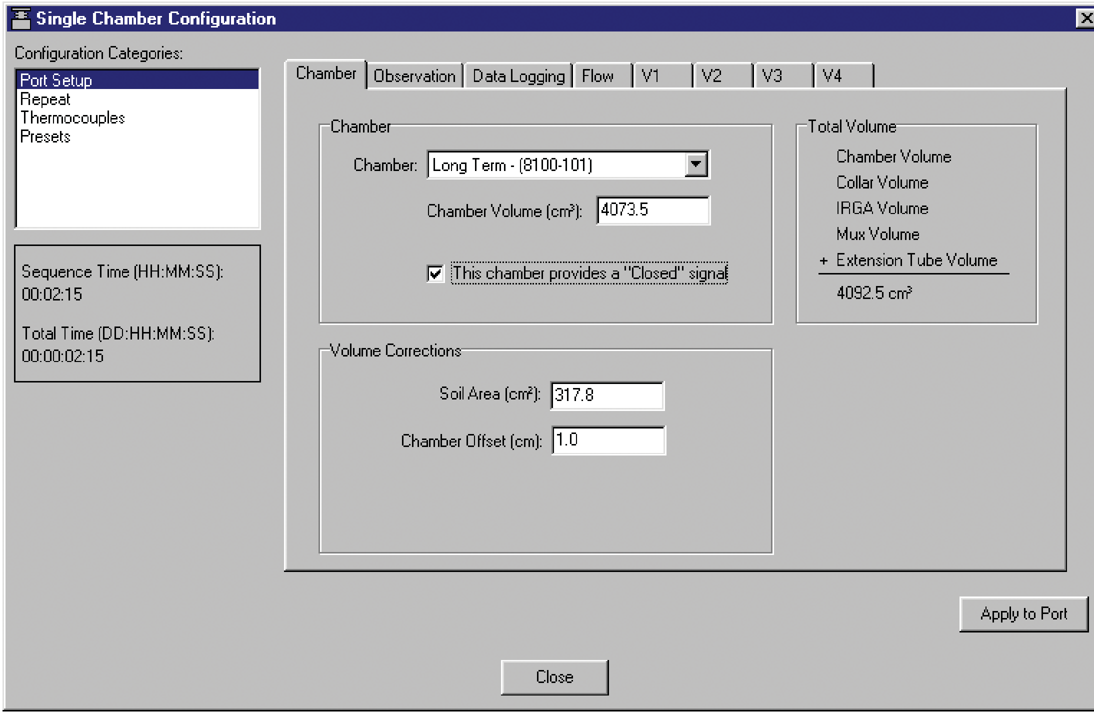
5. Open the LI-8100 Windows application software and click on the Connect icon, or choose **Connect** from the Communication menu. Choose the serial (COM) port on the computer to which the LI-8100 is connected.



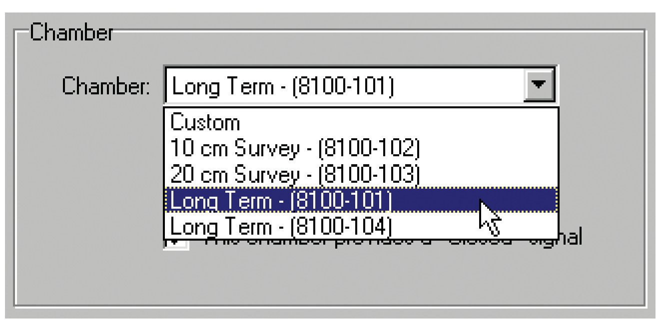
6. Observe the Status of the IRGA on the Main window of the LI-8100 software, or the LED of the LI-8100 keypad. After about 10 minutes, the IRGA Ready LED will illuminate, and the Status in the Main window will show "IRGA: READY".



7. Choose **Measurement Configuration** from the Setup menu. The Single Chamber Configuration dialog appears:



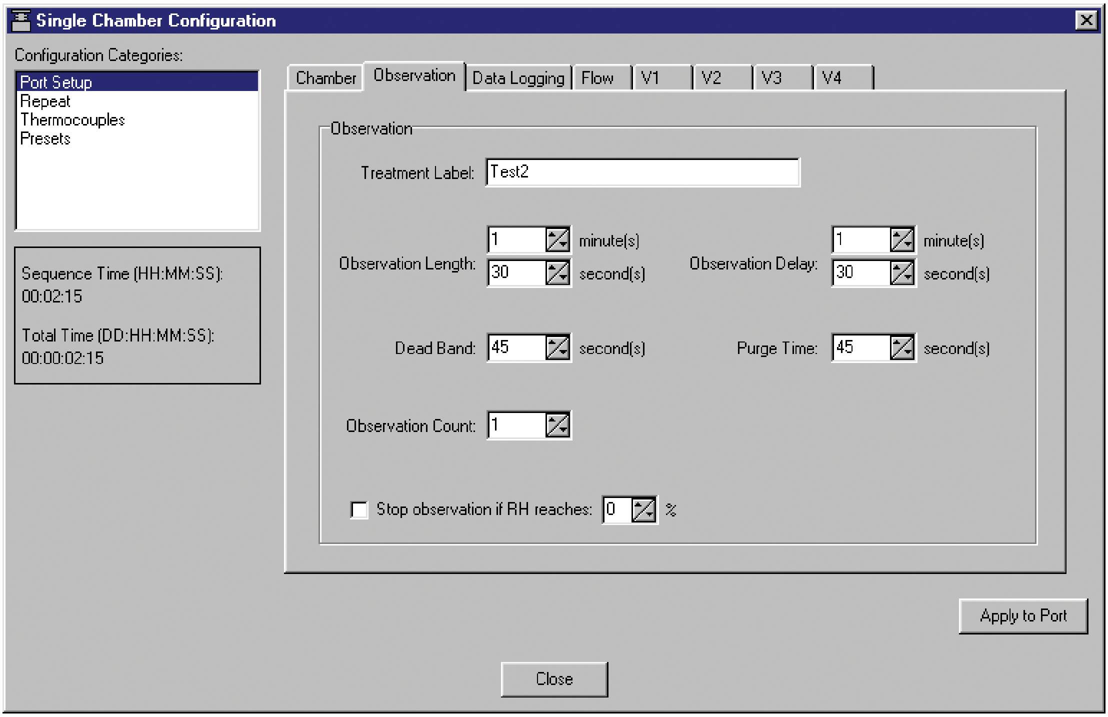
Use the Chamber pull-down menu to choose the type of chamber you are using. The choices are:



Custom – a user-built chamber, or tubing used for profiling studies.
10 cm Survey – LI-COR p/n 8100-102
20 cm Survey – LI-COR p/n 8100-103
Long Term – LI-COR p/n 8100-101
Long Term – LI-COR p/n 8100-104

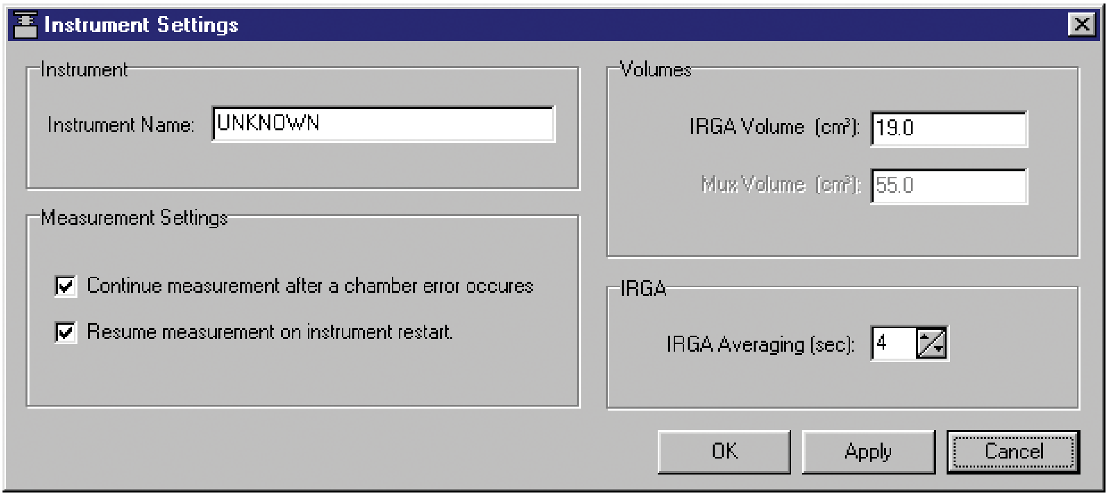
The Chamber Volume and Soil Area values are automatically entered. Enter a value for the Chamber Offset. The Chamber Offset is the distance (in cm) between the soil surface and the bottom of the soil chamber, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup*). Ultimately, this offset will affect the total volume of air in the chamber that is used to calculate flux.

8. Click on the **Observation** tab.



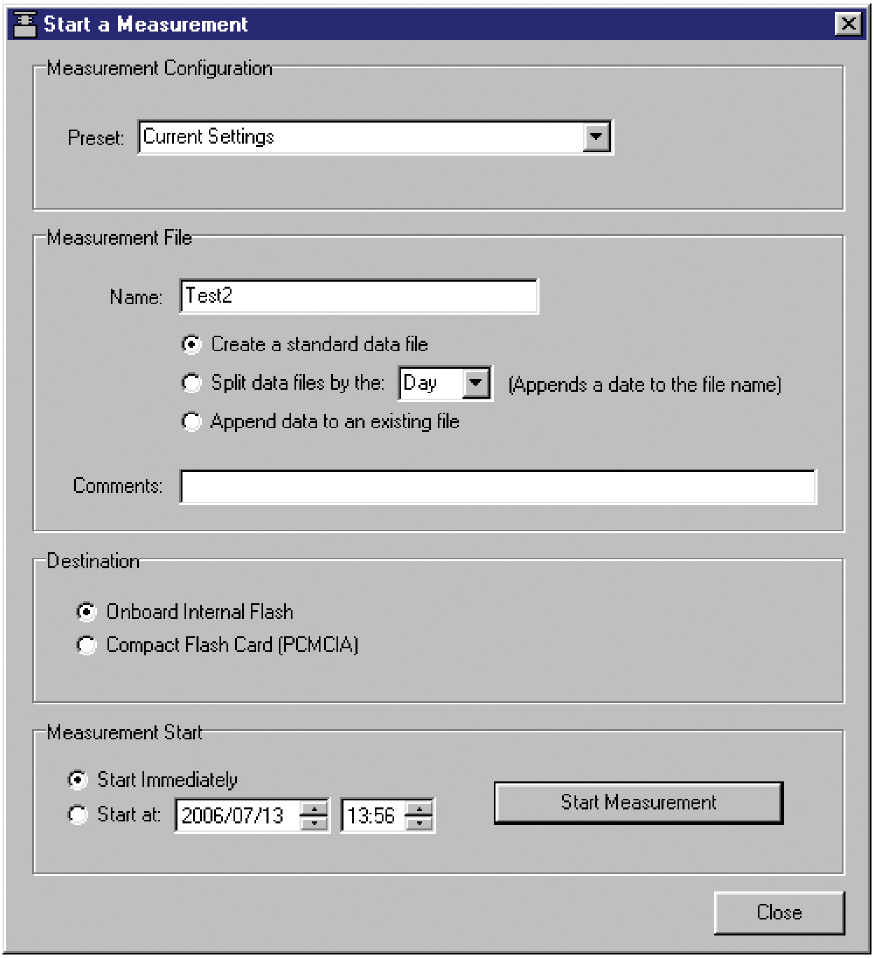
For this example, we'll simply use the default values that appear in the window. Enter a Treatment Label if desired.

9. Choose **Instrument Settings** from the 8100 menu.



Enter a name for the instrument at "Instrument Name" (i.e., Survey_System_1). The instrument name is sent to the LI-8100, where it is saved and becomes part of the data record. Click **Apply**. Click **OK**.

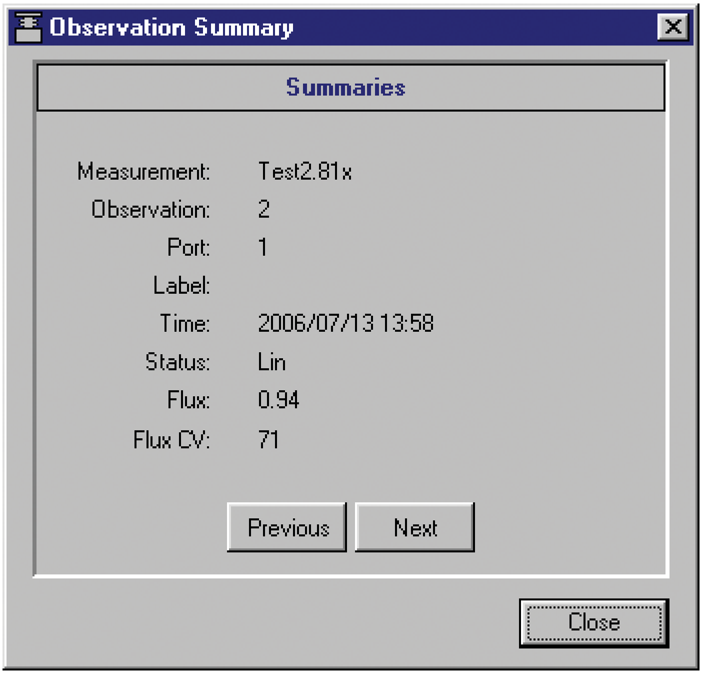
10. Click on the New Measurement icon () on the tool bar, or select **Start New Measurement** from the Setup menu. The Start a Measurement dialog appears:



Enter a File Name, and Comments if desired. Data can be logged to the LI-8100 internal flash memory, or to a Compact Flash Card (CF), if one is installed.

11. Click **Start Measurement**. The dialog box will close. As the chamber automatically closes, observe the progress of the measurement in the Main window. After the measurement is finished, the chamber will automatically open.

12. To view the data you have collected, select **Summary Records** from the View menu. The Observation Summary dialog box appears. Verify that the flux values are reasonable. Click Previous or Next to scroll through all Observations. When finished viewing the records, click **Close**.



Now you should experiment with the setup parameters to optimize your measurement protocols for the conditions in which you are conducting your experiments. To assist you, Section 4 describes the theory behind the LI-8100's equation derivation and flux calculation method. Sections 6 through 9 include measurement protocols and tips for using any of the four soil chambers.

About LI-8100 Data Files

An LI-8100 data file consists of lines of tab-delimited text with one or more **Observations**. An **Observation** is preceded by **Header** information, and also contains **Raw Records, Summary Records**, and **Footer** information as shown below.

```
LI-8100:        199        92        4593        23a        192
File Name:  test1
Instrument Name:MUX1
Serial Number:81A-0109
Software:   2.a.12
Comments:
Obs#:       1
            :          <several lines removed>
V4 Info:    0          M=1       B=0
Labels_01:  28
Type        Etime      Date      Tcham      Pressure   H2O      CO2      Cdry
```

Header

```
1           -1         2006-01-10 12:04:410  97.65     4.768    634.51   637.55
1           -1         2006-01-10 12:04:420  97.59     4.781    633.96   637
1           0          2006-01-10 12:04:430  97.52     4.75     627.32   630.31
            :          <several lines removed>
1           89         2006-01-10 12:06:120  97.47     4.616    634.87   637.82
```

Raw Records

```
2           0          2006-01-10 12:06:120  97.5      4.704    622.51   625.45
3           44.5       2006-01-10 12:06:120  97.48     4.621    632.48   635.42
4           89         2006-01-10 12:06:120  0.06      0.146    16.96    17.03
```

Summary Records

```
CrvFitStatus:Lin
Exp_Flux:   0.000000
Exp_FluxCV: 19.900000
Exp_dCdry/dt:0.048000
Exp_R2:     0.223300
            :          <several lines removed>
Lin_SSN:    5.3384
Lin_SE:     0.0090
Crv_Domain:90
Crv_#Smp:   90
Dead Band:  00:00
TimeClosing:2
```

Footer

Header - The lines from "LI-8100" through the labels line.

Type - The first item in each record is called the Type, and it identifies the type of record. The types are -1, 1, 2, 3, and 4.

Type	Description
-1	Warning Record
1	Raw Record
2	Initial Value (regressed from first 10 seconds of ETime≥0 data)
3	Mean Value (of ETime≥0 data)
4	Range Value (of ETime≥0 data)

Raw Records - A record of Type = 1. These records represent *measured* data from the time the chamber starts to close, to the time when it starts to open.

Summary Records - A record of Type 2, 3, or 4. An Observation always has one of each, for a total of three.

> Type 2 records for measured columns represent *initial* values based on a linear regression with E_{time} of the first 10 seconds of data.
>
> Type 3 records for measured columns are the *mean* values of all the data.
>
> Type 4 records for measured columns are the *ranges* (max - min) of all the data.

Footer – the results of the analysis, including flux values. The footer won't be present for files logged with the "Compute Flux" option turned off.

Observation – the Header + *n* Raw Records + 3 Summary Records + the Footer.

The **Summary Records** consist of a number of **Measured Variables**, some of which appear in all **Observations**, (i.e., Date, Pressure, CO_2, H_2O, etc.) and some of which are optional, and a number of **Final Variables** of Type 2, 3, or 4, as shown below. Summary statistics of **Measured Variables** are identified by the column label, and a prefix of "IV", "Mean", or "Range". Thus, for example, "IV Cdry" means the Type 2 value of the Cdry column, and "Range Etime" means the Type 4 value of the Etime column.

Raw (Type 1)

1	1	4A5X	0	2004-02-19 14:26:31	22.13	94.16	20.808	462.6	472.43
1	1	4A5X	1	2004-02-19 14:26:32	22.14	94.17	20.873	464.87	474.78
1	1	4A5X	2	2004-02-19 14:26:33	22.15	94.17	20.941	465.32	475.27
1	1	4A5X	3	2004-02-19 14:26:34	22.16	94.16	21.024	467.67	477.41
1	1	4A5X	4	2004-02-19 14:26:35	22.17	94.17	21.077	468.86	478.96
1	1	4A5X	5	2004-02-19 14:26:36	22.18	94.17	21.13	470.89	481.05
1	1	4A5X	6	2004-02-19 14:26:37	22.19	94.17	21.197	472.65	482.89
1	1	4A5X	7	2004-02-19 14:26:38	22.2	94.16	21.223	472.37	482.61
1	1	4A5X	8	2004-02-19 14:26:39	22.22	94.17	21.299	475.76	486.11
1	1	4A5X	9	2004-02-19 14:26:40	22.23	94.17	21.299	475.76	486.11
1	1	4A5X	10	2004-02-19 14:26:41	22.24	94.17	21.404	476.71	487.13
:									
2	1	4A5X	0	2004-02-19 14:26:31	22.14	94.17	20.897	464.75	474.67
3	1	4A5X	60	2004-02-19 14:28:32	22.43	94.17	22.559	550.77	563.51
4	1	4A5X	120	2004-02-19 14:28:32	0.37	0.03	2.49	166.17	171.35

Initial Value (Type 2)
Mean (Type 3)
Range (Type 4)

474.67	1.645	8.3	90	1.1	19	835.2	3.25	83.7	1126.22
563.51	1.412	7.13	0.0293	30	19	835.2	3.25	83.7	1126.22
171.35	0.005	1.2	1259.3	90	0	0	0	0	0

Final Variables

The table below lists the LI-8100 variables, including the Label that appears in the Header information, and a description of the variable. A summary of the method and equations used to compute the Measured Variables, including the appropriate slope of C_{dry}, is given in Appendix D.

Table 3-1. LI-8100 Variables

Label	**Description – Header Variables**
LI-8100	5 hexadecimal values giving the size of the header, label, raw data, summary data, and footer
File Name	File name stored on LI-8100
Instrument Name	User-entered instrument name
Serial Number	Instrument serial number
Software	Version of embedded code in the instrument
Comment	User-entered at time of data collection
Obs#	Observation number
Port#	Multiplexer port number (0 if not using multiplexer)
Label	User-entered at time of data collection, same value in all records
Type	The type of record
Observation Delay	Wait time between observations
Observation Length	Original observation length
Flow8100	Pump setting in LI-8100 Analyzer Control Unit
FlowMux	Pump setting in the LI-8150 Multiplexer
Tmux	Multiplexer temperature at start of observation
Virga	IRGA volume, in cm^3
Vmux	Volume of the multiplexer (if present), in cm^3
Vext	Volume of extension tubing, in cm^3
Vcham	Chamber and tubing volume, in cm^3
Offset	Collar offset dimension (cm)
Area	Exposed soil area (cm^2)
Vtotal	Total system volume, in cm^3
V1 Info	Information on how the voltage channel is configured; multiplexer channel, slope, offset, etc.
V2 Info	"
V3 Info	"
V4 Info	"
Labels_01	Number of columns in the raw data section

Label	Description – Footer Variables
CrvFitStatus	Curve fit solution. "Exp" means the exponential fit was better than the linear fit (Exp_SSN<Lin_SSN). "Lin" means the linear fit was still better after the maximum number of iterations, and the non-linear coefficients have therefore been derived from the linear fit
Exp Flux	Flux computed from Exponential Fit
Exp_FluxCV	Coefficient of variable (%) of Exp Flux
Exp_dCdry/dt	Slope of the Exponential Fit at time t_0 (Eq. 4-15)
Exp_R2	Correlation coefficient for Exponential Fit
Exp_SSN	Normalized sum of squares of residuals for Exponential Fit
Exp_SE	Standard error (%) of the Exponential Fit
Exp_a	The *a* term in the Exponential Fit
Exp_Cx	The C_∞ term in the Exponential Fit
Exp_Co	The C_o term in the Exponential Fit. Usually the IV value of Cdry, but if followed by *, indicates it has been manually set.
Exp_t0	The t_o term in the Exponential Fit
Exp_Iter	Number of iterations used in the Exponential Fit
Exp_MaxIter	Maximum number of iterations allowed for the Exponential Fit. This is fixed to 10 in the LI-8100 (but can be ajusted in the FV8100 program)
Lin Flux	Flux computed from Linear Fit
Lin_FluxCV	Coefficient of variable (%) of Lin Flux
Lin dCdry/dt	Slope of the Linear Fit
Lin_R2	Correlation coefficient for the Linear Fit
Lin_SSN	Normalized sum of squares of residuals for Linear Fit
Lin_SE	Standard error (%) of the Linear Fit
Crv_Domain	Time span (s) used in the curve fit
Crv_#Smp	Number of data points used for curve fitting
Dead Band	Time (s) after the chamber closes that are skipped by the analysis, in the latest (re-)computation
TimeClosing	Time, in seconds, it took the chamber to close

4 Theory of Operation

Measuring Carbon Dioxide Flux from the Soil

Carbon dioxide in the soil is produced by respiration from plant roots and microorganisms surrounding the roots, and from heterotrophic microorganisms that metabolize plant litter and soil organic matter. In some soils, CO_2 is also generated by the action of rainwater on calcareous substrates. Respiration and metabolism depend strongly on temperature, so it is not surprising to find that CO_2 efflux from the soil is also temperature dependent.

Carbon dioxide moves from the sites of production to the atmosphere primarily by diffusion through air-filled pores and cracks in the soil, but it can also be driven by local changes in pressure due to wind or volumetric displacement by rain. The air-filled porosity of the soil varies with soil type and moisture content, so these characteristics can have a significant effect on CO_2 movement in the soil.

The LI-8100 uses the rate of increase of CO_2 in a measurement chamber to estimate the rate at which CO_2 diffuses into free air outside the chamber. For such an estimate to be valid, conditions must be similar inside and outside the chamber; these conditions include the concentration gradients driving diffusion, barometric pressure, temperature and moisture of the soil.

The CO_2 gradient between the soil surface layer and air are not exactly the same inside and outside the chamber, because there is an *increase* in CO_2 mole fraction inside the chamber. The diffusion rate is estimated and corrected for using an analytical technique that takes into account the effects of increasing chamber CO_2 concentration on the diffusion gradient. This makes it possible to estimate the *initial* rate of CO_2 increase that occurred immediately after the chamber closed.

It is also important to consider the effect of the presence of the chamber on CO_2 gradients within the soil. Detailed diffusion model studies have shown that chambers can alter gas concentration gradients in the soil, leading to errors in CO_2 flux estimates (Healy, et al., 1996). We recommend limiting measurement times to about 1 1/2 to 3 minutes in order to keep chamber CO_2 concentration changes as small as possible, and minimize this effect.

Soil CO_2 flux varies substantially in both space and time. The LI-8100 can be used to sample both types of variability. The Survey chamber allows rapid measurements to be made at many sites, and the Long Term chamber supports automated, sequential measurements at a single site over time. Both chambers have carefully designed pressure vents to prevent pressure gradients and wind incursion from outside the chamber. Both chambers close automatically, minimizing mechanical disturbances during the measurement. The Long Term chamber moves away from the soil measurement area when a measurement is not in progress. For example, if a 2-minute measurement is made once every 30 minutes, the soil will be fully exposed to sun, wind and precipitation more than 93% of the time. This is an important consideration to ensure that the moisture and temperature of the soil within the measurement collar are similar to the surrounding soil.

Deriving the Flux Equation: The Model

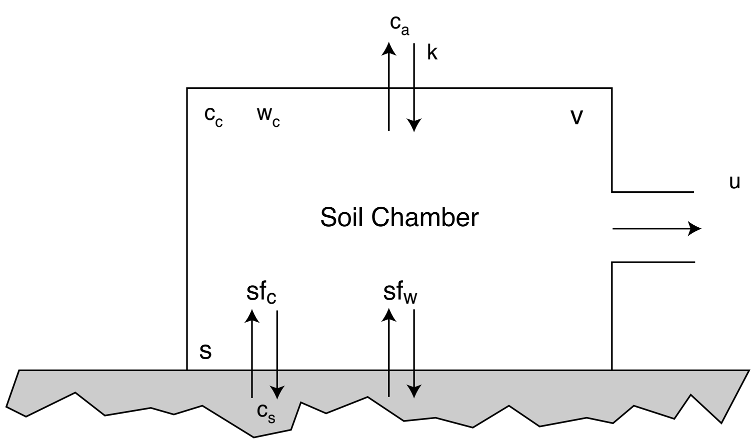


Figure 4-1. *Diagram depicting a chamber of volume v (m^3) and surface area S (m^2) sitting over the soil, which has CO_2 efflux rate f_c (mol m^{-2} s^{-1}) and water evaporation flux rate f_w (mol m^{-2} s^{-1}).*

At constant pressure, the total rate at which water evaporates into the chamber sf_w (mol s^{-1}) is balanced by a small flow rate of air out of the chamber u (mol s^{-1}). The CO_2 mole fraction of the air outside the chamber is c_a, inside the chamber is c_c, and in the soil is c_s, all in mol mol^{-1}. The chamber air water vapor mole fraction is w_c (mol mol^{-1}). The rate constant k (s^{-1}) characterizes leaks (if any) due to diffusion of CO_2 between the soil chamber and outside air. The chamber volume v includes the volume of the pump and measurement loop.

The mass balance equations for CO_2, water vapor and air take the form

storage = flux in - flux out.

We neglect the effects of leaks for now, but we will consider them later.

CO_2 Mass Balance

$$v\frac{\partial \rho_c^c}{\partial t} = sf_c - c_c u \tag{4-1}$$

H_2O Mass Balance

$$v\frac{\partial \rho_c^w}{\partial t} = sf_w - w_c u \tag{4-2}$$

Air Mass Balance

$$v\frac{\partial \rho_c}{\partial t} = sf_c + sf_w - u \tag{4-3}$$

ρ_c^c is the number density of CO_2 in the chamber, ρ_c^w is the number density of water vapor in the chamber, and ρ_c is the total number density of air in the chamber (all in mol m^{-3}); $\rho_c = \rho_c^a + \rho_c^c + \rho_c^w$, where ρ_c^a is the number density of dry air in the chamber.

The number density of air is given by the ideal gas law, $\rho_c = p\ (RT_K)^{-1}$, where R is the gas constant (8.314 Pa m^3 K^{-1} mol^{-1}), and T_K is the absolute temperature (K). From equation (4-3), with p and T_k constant, and $sf_w >> sf_c$,

$$u = sf_w \tag{4-4}$$

Combining equations (4-2) and (4-4), and noting that $\rho_c^w = \rho_c\ w_c$, we find

$$sf_w = \frac{v\rho_c}{1-w_c}\frac{\partial w_c}{\partial t} \tag{4-5}$$

Combining equations (4-1), (4-4) and (4-5) gives

$$f_c = \frac{v\rho_c}{s}\left(\frac{\partial c_c}{\partial t} + \frac{c_c}{1-w_c}\frac{\partial w_c}{\partial t}\right) \tag{4-6}$$

Equation (4-6) has the same form as that used in the LI-6400 Portable Photosynthesis System for soil respiration; however, it can be simplified by defining $c_c' = c_c\,(1 - w_c)^{-1}$, which is the chamber CO_2 mole fraction corrected for water vapor dilution. This is called Cdry (ppm) in the LI-8100 data output. Differentiating c_c' we find,

$$(1-w_c)\frac{\partial c_c{}'}{\partial t} = \frac{\partial c_c}{\partial t} + \frac{c_c}{1-w_c}\frac{\partial w_c}{\partial t}$$

Substituting this into equation (4-6) gives

$$f_c = \frac{v\rho_c}{s}(1-w_c)\frac{\partial c_c{}'}{\partial t} \qquad 4\text{-}7$$

Equation (4-7) has an important advantage over equation (4-6) because it is not necessary to estimate the rate of increase in water vapor mole fraction. In most measurements, the water vapor mole fraction increases in a highly non-linear fashion, and the rate is estimated with a linear function. Thus, in effect, equation (4-6) forces us to use average values for w_c/ t and w_c. But with equation (4-7), the dilution correction is made point-by-point, and estimates of the initial values at time zero are used to estimate f_c at the instant the chamber closed. This is both easier and more accurate than the procedure required to implement equation (4-6).

In order to use equation (4-7) the initial values must be known for p and T_K (to compute ρ_c), as well as the initial values for w_c and c_c'/ t. After the chamber closes, the LI-8100 performs a linear regression with time on the first 10 values of each measured variable. The initial values of p, T_K and w_c are obtained from the time zero intercepts of these regressions; however, finding the initial value for c_c'/ t requires a little more work.

To do this, f_c is defined in terms of the CO_2 mole fraction gradient across the soil-to-chamber interface and a transfer coefficient, to obtain

$$f_c = \rho_c g(c_s - c_c) \qquad 4\text{-}8$$

where c_s is the CO_2 mole fraction in the soil surface layer communicating with the chamber (mol mol^{-1}), g is conductance to CO_2 (m s^{-1}), and ρ_c is the density of air (mol m^{-3}). The soil and chamber must be isothermal for equation (4-8) to hold. A correction for non-isothermal conditions could be included if one is needed.

Combining equation (4-8) with equation (4-7), considering all variables except c_c' to be constant, and rearranging, gives

$$\frac{dc_c'}{dt} + \frac{sg}{v} c_c' = \frac{sg}{v} c_s' \qquad 4\text{-}9$$

where $c_s' = c_s(1\text{-}w_c)^{-1}$. When $w_c = w_s$, c_s' gives the dilution-corrected CO_2 mole fraction in the soil layer communicating with the chamber. We do not expect w_c to equal w_s exactly, but most of the time they will differ by less than 0.02 mol/mol or so, which introduces only a small uncertainty in c_s'. If c_s' is taken as a constant, then equation (4-9) can be integrated to give

$$c_c'(t) = c_s' + [c_c'(0) - c_s']e^{-At} \qquad 4\text{-}10$$

where $A = sg\ v^{-1}$ is a rate constant (s^{-1}) and $c_c'(0)$ is the initial value of the dilution-corrected CO_2 mole fraction when the chamber closes. The rate of change in $c_c'(t)$ at any time can be computed from the derivative of equation (4-10).

$$\frac{dc_c'}{dt} = A\left[c_s' - c_c(0)\right]e^{-At} \qquad 4\text{-}11$$

Calculating the Flux from Measured Data

In the LI-8100, equations (4-7), (4-10) and (4-11) are implemented in a form that presents the variables in more familiar and intuitive units. Equation (4-7) is computed as

$$F_c = \frac{10VP_0\left(1 - \frac{W_0}{1000}\right)}{RS(T_0 + 273.15)} \frac{\partial C'}{\partial t} \qquad 4\text{-}12$$

where F_c is the soil CO_2 efflux rate (µmol m^{-2} s^{-1}), V is volume (cm^3), P_0 is the initial pressure (kPa), W_0 is the initial water vapor mole fraction (mmol mol^{-1}), S is soil surface area (cm^2), T_0 is initial air temperature (°C), and $\partial C'/ t$ is the initial rate of change in water-corrected CO_2 mole fraction (µmol^{-1} mol s^{-1}).

Figure 4-2 shows $C'(t)$ *vs* t data that were obtained from a soil CO_2 flux measurement with two observations. The data are marked to show when the chamber closed and when it opened.

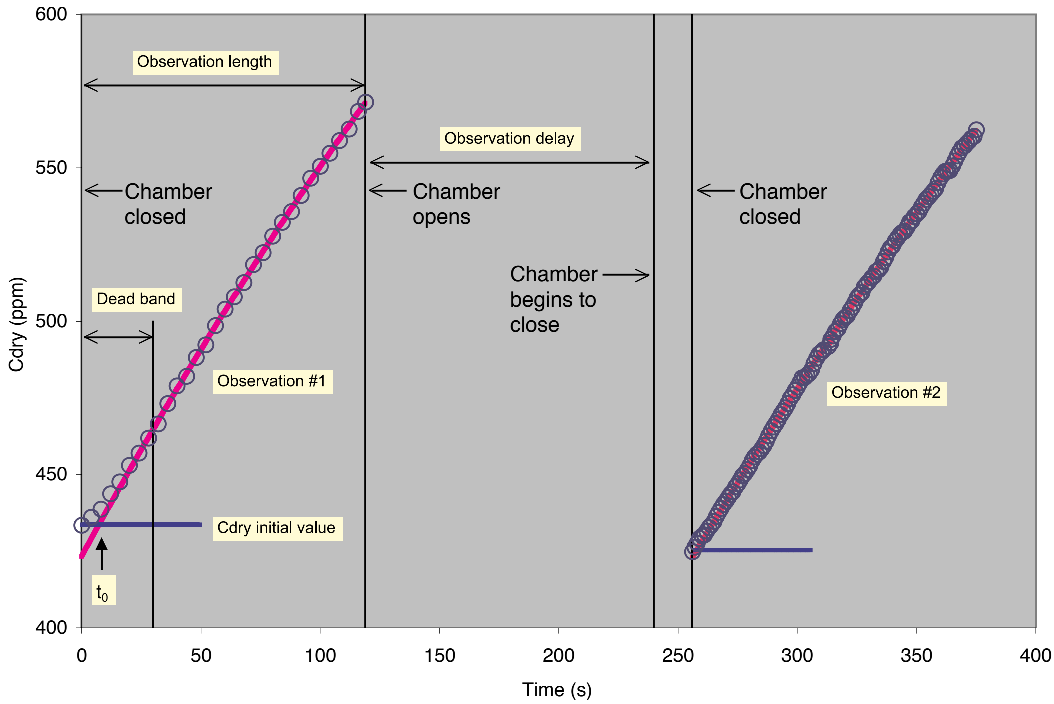


Figure 4-2. *Soil CO_2 flux data were collected on bare soil in a tropical greenhouse near Lincoln, NE in February 2004. Two Observations are shown. About 60% of the data from the first Observation have been removed for clarity. For both Observations, the Observation length was 120s, Dead band was 30s, and Observation delay was 120s. The chamber begins to close at the end of the Observation delay and the first data point used in the analysis is collected after the chamber touches down; the difference represents the time required for the chamber to close. Observation #1: t_0 =7.3s, C_0' = 434 ppm, C_x' = 1016 ppm, Flux = 6.4 µmol m^{-2} s^{-1}; Observation #2: t_0 = 2.0s, C_0' = 425 ppm, C_x' = 1145 ppm, Flux = 6.0 µmol m^{-2} s^{-1}.*

The Dead Band is the time until steady chamber mixing is established, and typically lasts 20s to 30s. After mixing is stable, the data are fit with an empirical equation that has a form similar to equation (4-10):

$$C'(t) = C_x{}' + (C_0{}' - C_x{}')e^{-a(t-t_0)} \qquad \text{4-13}$$

where $C'(t)$ is the instantaneous water-corrected chamber CO_2 mole fraction, C_0' is the value of C'(t) when the chamber closed, and C_x' is a parameter that defines the asymptote, all in µmol CO_2/mol air (ppm); a is a parameter that defines the curvature of the fit (s^{-1}).

The initial value of $C'(t)$, called C_0' in equation (4-13), is computed from the intercept of a linear regression of the first 10 points after the chamber closes. This is used as a parameter in the non-linear regression that fits equation (4-12) to the $C'(t)$ *vs* t data between the end of the Dead Band and the end of the observation. This regression yields values for the parameters C_x', a and t_0. $t = t_0$ represents the time when $C'(t)$ in equation (4-13) equals its initial value when the chamber closes, or $C'(t_0) = C_0'$. The delay between the instant the chamber closed and t_0 gives the time required to establish steady mixing. CO_2 offsets or time delays can occur when the chamber closes, and these events can cause t_0 to be positive or negative in value.

All the initial values needed to obtain the soil CO_2 efflux rate, F_c, in equation (4-12) can now be computed. The initial values P_0, T_0 and W_0 are all obtained from the intercepts of linear regressions of the first 10 measurements of P, T and W after the chamber closes. The rate of change of dilution-corrected chamber CO_2 mole fraction can be computed at any time from

$$\frac{dC'}{dt} = a(C_x' - C_0')e^{-a(t-t_0)} \qquad \text{4-14}$$

When $t = t_0$,

$$\left.\frac{dC'}{dt}\right|_{t=t_0} = a(C_x' - C_0') \qquad \text{4-15}$$

Equation (4-15) gives an estimate of the rate of change in C' at the instant the chamber closed. This value must be estimated mathematically. It cannot be measured directly at any time during the measurement because imperfect mixing prevents an accurate estimate early in the measurement cycle, and later in the cycle, the increasing chamber CO_2 concentration continuously reduces the gradient between soil and chamber. This suppresses the rate, as can be seen from equation (4-14) and also in Figure 4-2.

Relationship Between the Model Equation (4-10) and Empirical Equation (4-13)

The diffusion model provides an equation with a form that allows correction for the effect of changing gradients on the rate, which in turn, makes it possible to estimate the initial rate. It is worthwhile to distinguish between the model function given in equation (4-10) and the empirical function in equation (4-13). As just described, the units are different in the two expressions; but more important, for the parameters c_s and A in equation (4-10) to have their defined meaning, the assumptions underlying the derivation must be true. By contrast, equations (4-13) through (4-15) are treated as empirical functions and are used only to estimate the CO_2 rate of change, dC'/dt. The parameters C_x', a and t_0 do not depend upon a specific theoretical interpretation, and may or may not provide reliable estimates of soil parameters.

Correcting for Initial CO_2 Concentrations That Differ Between Measurements

Different measurements may begin at different CO_2 concentrations, which introduces variation into the data, because the flux rate changes with chamber CO_2 concentration. Correcting the measurements to a common target CO_2 concentration may reduce such variation. For a given curve fit, the CO_2 rate of change can be computed at any CO_2 concentration according to

$$\frac{dC'}{dt} = a(C_x{}' - C_{\text{target}}{}') \qquad \text{4-16}$$

This calculation is supported in the Data Analysis software (FV8100) included with the LI-8100.

Evaluation of Other Methods for Computing Soil CO_2 Efflux

Other approaches have been used for computing CO_2 flux in transient measurements. One commonly used method is to fit a linear function to what is sometimes referred to as "the linear portion" of the curve. Unfortunately, there is no linear portion, as can be seen from careful inspection of Figure 4-2. The slope is meaningless in the initial phase before steady mixing is established, and after steady mixing is established, the extent of the non-linearity depends upon the soil surface-to-chamber volume ratio and the flux rate. During this time, CO_2 vs time curves are always concave in a downward direction, meaning that linear regression over this portion of the data set will give an underestimate of the rate of change. In every case we have tested so far, the average rate measured by linear regression is less than the initial rate measured by non-linear regression. Nevertheless, linear regression is a robust numerical approach and the mean values for the CO_2 efflux rate reported by the LI-8100 in Type 3 records are computed by this method. We recommend you use these only for comparison to the initial values, which are obtained by fitting equation (4-13) to the data using a non-linear regression method.

Another approach that has been used to estimate the initial rate is to fit a polynomial to the CO_2 concentration vs time data. This approach is theoretically sound inasmuch as a power series can be generated from a Taylor series approximation to equation (4-13). Usually, the data are fit with a quadratic equation. We tested this approach and found that while it can be justified on theoretical grounds, it does not work very well in practice. The shape of even a second order polynomial is sensitive to small perturbations in the data. This makes initial rate calculations subject to much larger variations than when the same data are analyzed by nonlinear regression using equation (4-13).

Effects of High Chamber CO_2 Concentrations

Finally, we consider the importance of choosing appropriate **observation times** and **observation delays**. We do not have experience on enough soil types to give absolute recommendations for the best observation length in all situations. Nevertheless, our experience so far suggests that 60s to 120s will often work well. This prevents large build-ups in chamber CO_2 concentration at typical change rates such as 0.5 ppm s^{-1}. We have found that optimal **dead band** length can vary from about 10s to 60s, with 30s being a good value to use as a first estimate.

Dead bands and **observation times** can be adjusted after the fact, using the LI-8100 Data Analysis software (FV8100). This program allows you to recalculate data easily, using subsets of data selected to give optimal dead bands and observation lengths. Therefore, it is not critical to choose the right dead band and observation length in the field; as long as the observation lengths are long enough, they can be optimized later, if necessary.

Long observations can have the effect of capping the soil and causing the CO_2 concentration to build up in the soil under the chamber. This phenomenon can be observed by performing a sequence of observations in which the chamber concentration is allowed to increase several hundred ppm during each observation. When the **observation delay** is set to be just long enough to allow the chamber atmosphere to come back to the ambient CO_2 concentration, the initial rates in sequential observations can often be observed to increase as the soil CO_2 concentration increases. This is expected according to equation (4-15), $dC_c'/dt = a(C_x' - C_{ambient}')$, if it is assumed that $C_x' = C_{soil}'$. Thus, one effect of long observation lengths may be to perturb the very process we wish to measure.

Another effect of high chamber CO_2 concentrations is to promote leaks between the chamber and atmosphere. Leaks can be ignored when the gradient between the chamber atmosphere and ambient atmosphere are small. But when the gradient is not small, leaks cannot be neglected and it can be shown that the parameters in equation (4-10) are altered to become,

$$a = (k + gs/v) \text{ and } c_x' = [(gs/v)c_s' + kc_a'] (gs/v + k)^{-1}, \qquad 4\text{-}17$$

where k and c_a' are the leak rate time constant and water-corrected ambient CO_2 concentration, respectively, and the expression for c_x' replaces c_s' in equation (4-10). Thus, when chamber CO_2 concentrations are high, the rate constant and asymptote will reflect leaks from the system.

Table 4-1. Definitions of the variables used in the derivations and implemented in the LI-8100.

Variable	Description (units)	LI-8100 Data File Column
v	Total Volume (m^3)	
V	Total Volume (cm^3)	"Vtotal"
s	Total Surface Area (m^2)	
S	Total Surface Area (cm^2)	"Area"
f_w	Water Evaporation rate (mol $m^{-2}s^{-1}$)	
p	Pressure (Pa)	
P	Pressure (kPa)	"Pressure"
P_o	Initial value of P	Type 1 "Pressure"
T_K	Absolute temperature ((K)	
T	Temperature (°C)	"Tcham"
T_o	Initial value of T (°C)	Type 1 "T_{cham}"
R	Gas Constant (8.314 Pa m^3 (K^{-1} mol^{-1})	
f_c	CO_2 Flux (mol m^{-2} s^{-1})	Type 2 Exponential Fit "Flux" Type 3 Linear Fit "Flux"
F_c	CO_2 Flux (μmol m^{-2} s^{-1})	
dC'/dt	Rate of change in water corrected CO_2 (μmol mol^{-1} s^{-1} or ppm s^{-1})	Type 2 Exponential Fit "dCdry/dt" Type 3 Linear Fit "dCdry/dt"
RH	Relative Humidity (%)	"RH"
w_c	Water Vapor Mole Fraction (mol mol^{-1})	
W	Water Vapor Mole Fraction (mmol mol^{-1})	"H2O"
W_o	Initial value of W	Type 1 "H2O"
k	Rate constant (s^{-1})	
u	Air flow rate out of the chamber (mol s^{-1})	
c_a	CO_2 mole fraction of air outside the chamber (mol mol^{-1})	
c_s'	Dilution-corrected CO_2 mole fraction of air in the soil (mol mol^{-1})	

Variable	Description (units)	LI-8100 Data File Column
c_c'	Dilution-corrected CO_2 mole fraction of air inside the chamber (mol mol^{-1})	
c_a'	Dilution-corrected ambient CO_2 concentration	
ρc_c	The number density of CO_2 in the chamber (mol m^{-3})	
ρc_w	The number density of water vapor in the chamber (mol m^{-3})	
ρc	The total number density of air in the chamber (mol m^{-3})	
ρc_a	The number density of dry air in the chamber (mol m^{-3})	
g	Conductance to CO_2 (m s^{-1})	
a	Rate Constant (s^{-1}) Exponential Coefficient	Type 3 "CrvFit"
t_0	Time Zero	Type 2 "CrvTime"
$C'(t)$	Dilution-corrected CO_2 (μmol mol^{-1})	"Cdry"
C'_o	Initial dilution-corrected CO_2 (μmol mol^{-1})	Type 1 "Cdry"
C_x'	Asymptote parameter from exponential fit (μmol mol^{-1})	Type 4 "CrvFit"

Reference

Healy, R.W., R.G. Striegle, T.F. Russell, G.L. Hutchinson, G.P. Livingston. 1996. *Numerical evaluation of static-chamber measurements of soil-atmosphere gas exchange: Identification of physical processes*. Soil Sci. Soc. Am. J. 60:740-747.

5 User Calibration

Introduction

The gas analyzer in the LI-8100 is calibrated at the factory using precision gases at controlled temperatures. The calibration function for CO_2 uses a fifth order polynomial and also corrects for temperature and pressure, as well as band broadening and cross-sensitivity to water vapor. The calibration function for water vapor uses a third order polynomial and also corrects for pressure and temperature. The Coefficients pages of the Windows and Palm software display the factory-determined calibration coefficients, and they are also recorded on a calibration sheet that comes with the instrument.

Like all infrared gas analyzers, the LI-8100 optical bench zero and span may drift over time with changes in temperature, cleanliness of the optical bench, and other factors. The zero and span procedure discussed in this section is used to correct for any drift that may occur. Setting zero and span makes the instrument output conform to expected values.

Zero and Span should be checked periodically, the frequency depending upon accuracy requirements and the variability of the environment in which the LI-8100 is used. The majority of the analyzer drift is corrected by setting the zero, so this should be the highest priority. It is also a good idea to verify analyzer performance by periodically checking the span. If you begin checking these on a daily basis and keep a log of zero and span adjustments, you will learn how much your analyzer drifts and how frequently you need to zero and span.

The calibration of the instrument shifts if the optical path gets dirty. Most of this shift is corrected by setting the zero and span, but the calibration curve linearity may also change if the optical path becomes extremely dirty. Linearity can be tested using two span gases and a zero gas. Set the zero and span as usual, and then measure a known intermediate gas concentration. The concentration measured should be within the instrument specification, taking into account the known accuracy of the intermediate gas. If that is not the case, clean the optical path as described in Section 14. Linearity changes are small even when the cell becomes quite dirty, so frequent cleaning of the optical path should not be necessary, especially if the filters are kept clean.

CO_2 and H_2O Gas Standards

Tanks of compressed air with known CO_2 concentration and specified accuracy are readily available from commercial suppliers. Such tanks can provide convenient standards for checking the CO_2 span of the LI-8100; however, tanks are not available that contain a known water vapor concentration for checking the span of the water vapor channel. The LI-610 Portable Dew Point Generator can be used to provide air with a known dew point for the primary calibration of new analyzers. The span of the analyzer in the LI-8100 is stable when the zero is set on a regular basis, and soil CO_2 flux measurements are not very sensitive to errors in the water vapor measurement. For these reasons, it is recommended not to alter the span of the water vapor channel unless an LI-610 or similar equipment is used to produce an accurate span gas.

CO_2 and H_2O Zero

Either CO_2-free air or CO_2-free nitrogen can be used as a zero gas. It is best to use a column filled with a chemical CO_2 scrubbing agent downstream of the tank, however, as even "CO_2-free" gases at times contain a trace of CO_2. Note that the scrubber may add significant H_2O vapor, so you may want to use a water vapor scrubber downstream from the CO_2 scrubber.

A suitable CO_2 zero scrub is soda lime (LI-COR part number 9964-090) and an H_2O scrub is Drierite (LI-COR part number 622-04299). When using chemical scrubbers, it is important to make sure that the chemicals are fresh. Always be sure to have a particulate filter installed in the air flow path between the chemicals and the instrument.

Compressed cylinders may be at pressures of several thousand pounds per square inch; before using them for calibration, they should be fitted with a regulator to reduce the pressure down to a range of around fifteen pounds per square inch.

CO_2 Span

To set the CO_2 span, a cylinder of CO_2 in air, verified to be accurate to within at least 1%, would be a suitable choice. Be cautious with a new cylinder, as the stated value of the calibration cylinder may be significantly different from the actual gas concentration (i.e., mislabeled). Choose a gas with a CO_2 concentration slightly greater than the highest concentration encountered during measurements.

H_2O Span

For known water vapor concentrations, a convenient standard to use is a dew point generator such as the LI-COR LI-610 Portable Dew Point Generator. To avoid condensation problems, choose a dew point temperature that is about 3 to 5 °C below the ambient temperature. Also, since water vapor sorbs and desorbs from surfaces, minimize the sorbing surface area (minimize tubing lengths), and allow plenty of time for the reading to stabilize. It is important not to rush through water vapor calibrations; give the surfaces plenty of time to equilibrate to large changes in water vapor concentration.

Plumbing and Pressure Considerations

Air flow through the LI-8100 is achieved with a rotary pump, which cannot be bypassed during the zero and span-setting processes. The in-line pump can cause pressure changes in the optical bench when a flow of gas is introduced, which must be taken into account when setting the span in the instrument. There are two approaches that can be used: Pump on or pump off. If you calibrate with the pump off, you need to make sure the pump has stopped in a non-blocking position. This is done by flowing calibration air into the IRGA at about 0.5 to 1.0 liter/min., and noting the LI-8100 pressure reading. If the pump is blocking the flow, the pressure will be several kPa above ambient. If this is the case, start and stop the pump and note the new pressure. In most cases, starting and stopping the pump once or twice is sufficient to get the pump into a non-blocking state.

The alternative method is to leave the pump on, and use a T-fitting to equalize the pressure, while maintaining a flow of calibration gas through the optical bench. This method may consume more calibration gas and is best used with a rotameter to ensure there is a positive flow from the vent tube. If the H_2O span is to be set, this method must be used.

Setting Zero: CO_2 and H_2O

Using a Calibrated Tank of Zero Gas

1. Verify that the LI-8100 pump is turned on and set the pump speed:

   Windows Software
   A. Select **Manual Controls** from the Utilities Menu. Click on the Flow tab.
   B. Click on **8100 Flow ON**.
   C. Move the slider bar to set the flow rate to **low**.
   D. Click **Set**.
   E. Click **Close**.

   Software for Palm OS
   A. Select **Manual Controls** from the Utilities Menu.
   B. Select **Flow On**.
   C. Tap on the Setup Menu.
   D. Select **Area, Volumes, & Flow Rate**.
   E. Tap on the Flow Rate field. Set the flow rate to **low**.
   F. Tap **Send**.

2. Note cell pressure.
   Found on the main page of the Windows interface, and Monitor page of the Palm interface. Make note of the cell pressure.

3. Plumb the LI-8100.
   A. Attach a tank of dry, CO_2-free gas to the LI-8100 air inlet.
   B. Vent the instrument outlet to the atmosphere.
   C. Turn off the pump, and set flow from tank at 0.5 l/min.
   D. Note LI-8100 pressure. If it is > 1 kPa above Step 2, turn the pump on and back off.

4. Monitor CO_2 and H_2O concentrations.
   When concentrations are stable, proceed to step 5. Allow 1-2 minutes for the CO_2 concentrations to stabilize and 15-20 minutes for the H_2O concentration to stabilize near zero.

5. Calibrate.
   Windows Software
   A. Select **Calibration** from the Utilities menu.
   B. Click on the CO_2 tab.
      i. Verify that the CO_2 concentration in the main window is still stable.
      ii. Click on the **Zero CO_2** button.
      iii. Click **Yes** to perform the calibration.
   C. Click on the H_2O tab.
      i. Verify that the H_2O concentration in the main window is stable.
      ii. Click on the **Zero H_2O** button.
      iii. Click **Yes** to perform the calibration.
   D. Click on **Close** to exit the calibration screen.

   Software for Palm OS
   A. Select Calibration from the Utilities pull down menu.
   B. Click the Zero button.
      i. Enable the CO_2 check box.
      ii. Verify that the CO_2 concentration is stable.
      iii. Click on the **Send** button.
   C. Click the Zero button.
      i. Enable the H_2O check box.
      ii. Verify that the H_2O concentration is stable.
      iii. Click on the **Send** button.

Using Chemical Scrubbers

1. Prepare Chemical Tubes.
   Fill each tube with the proper chemical. Ensure that air flows freely through the tube.

2. Verify that the LI-8100 pump is turned on and set the pump speed to low. Follow step #1 from *"Setting Zero: CO_2 and H_2O, Using a Calibrated Tank of Zero Gas."*

3. Plumb the LI-8100.
   A. Attach a chemical tube containing either Soda Lime or Drierite to the air inlet.
   B. Vent the instrument outlet to the atmosphere.

4. Calibrate
   Follow step #5 from "*Setting Zero: CO_2 and H_2O, Using a Calibrated Tank of Zero Gas.*"

Setting the Span: CO_2

Note: Set the span *only* after setting the zero.

1. Verify that the LI-8100 pump is turned on and set the pump speed to low. Follow step #1 from "*Setting Zero: CO_2 and H_2O, Using a Calibrated Tank of Zero Gas.*"

2. Note cell pressure.
   Found on the main page of the Windows interface, and the Monitor page of the Palm interface. Make note of the cell pressure before you plumb the instrument for calibration.

3. Plumb the LI-8100
   A. Attach a tank containing a known concentration of CO_2 to the LI-8100 air inlet.
   B. Vent the instrument outlet to the atmosphere.
   C. Turn off the pump, and set flow from tank at 0.5 l/min.
   D. Note LI-8100 pressure. If it is > 1 kPa above Step 2, turn the pump on and back off.

4. Monitor CO_2 concentration.
   When CO_2 concentration is stable proceed to the next step. Allow 1-2 minutes for the CO_2 concentrations to stabilize.

5. Calibrate
   Windows Software
   A. Select **Calibration** from the Utilities menu.
   B. Click on the CO_2 tab.
      i. Enter the span gas concentration (ppm).
      ii. Verify that the CO_2 concentration is stable.
      iii. Click on the **Span CO_2** button.
      iv. Click **Yes** to perform the calibration.
   C. Click **Close** to exit the calibration screen.

   Software for Palm OS
   A. Select **Calibration** from the Utilities menu.
   B. Click the **Span** button.
      i. Enable the CO_2 check box.
      ii. Verify that the CO_2 concentration is stable.

iii. Enter concentration of the span gas (ppm).
iv. Click **Send**.

Setting the Span: H_2O

Note: Always set the zero before setting the span. To set the H_2O span, use an air stream containing a known, stable H_2O concentration. This is best achieved by using an instrument such as the LI-610 Dew Point Generator. If the proper equipment is not available, we strongly recommend that you do not adjust the span of the H_2O channel.

1. Verify that the LI-8100 pump is turned on and set the pump speed to low. Follow step #1 from *"Setting Zero: CO_2 and H_2O, Using a Calibrated Tank of Zero Gas."*

2. Plumb the LI-8100.
   A. Connect the output of the LI-610 to the air inlet on the LI-8100, using a "Y" fitting.
   B. Connect a short piece of tubing (a few inches) to the other end of the "Y" and allow it to vent to the atmosphere.
   C. Set up the LI-610 to provide your air stream with a known dew point and set the LI-610 flow rate as high as possible (usually between 1.5 and 2.0 L/min.). This will provide extra calibration air that will vent out the "Y" connector, thus providing adequate air flow to the LI-8100 while eliminating pressure changes within the optical bench.

3. Calibrate
   Windows Software
   A. Monitor the H_2O concentration in the main window of the LI-8100 Windows interface software. When the concentration is stable proceed to the calibration window.
   B. Select **Calibration** from the Utilities menu.
   C. Click on the H_2O tab.
      i. Enter the span gas dew point (°C).
      ii. Verify that the H_2O concentration in the main window is still stable. Allow 15-20 minutes for the H_2O vapor concentration to stabilize near your span point.
      iii. Click on the **Span H_2O** button.
      iv. Click **Yes** to perform the calibration.
   D. Click **Close** to exit the calibration screen.
   Software for Palm OS
   A. Select **Calibration** from the Utilities menu.
   B. Click the Span button.
      i. Enable the H_2O check box.

ii. Verify that the H_2O concentration is stable. Allow 15-20 minutes for the H_2O vapor concentration to stabilize near your span point.
iii. Enter the span gas dew point (°C).
iv. Click **Send**.

Linearity Adjustment

The gas analyzer's calibration polynomial relates absorptance to concentration. Ideally, this polynomial linearizes the instrument, so that if you zero and span, the instrument will then not only read correctly at zero and at the span value, but also at all other concentrations across the range.

The linearity of the gas analyzer can be checked following zeroing and spanning by flowing another known concentration (for example, half of the value used for spanning) through the analyzer and seeing if it reads within 1.5% (the specification).

Factory calibrations, which determine the coefficients of the polynomial, are quite stable with time. However, if the analyzer's source or detector is replaced, or if significant dirt accumulates in the optical bench, then linearity errors that exceed specifications can result. If you determine that your gas analyzer's linearity error for CO_2 or H_2O is excessive, then you can make adjustments to the coefficients with the help of a utility program (CalAdjust.exe) that is on the LI-8100 CD. You will also need two span gasses for CO_2, or an LI-610 to generate two known dewpoints for H_2O.

1. *Zero the instrument*
The instrument needs to be well zeroed for this correction.

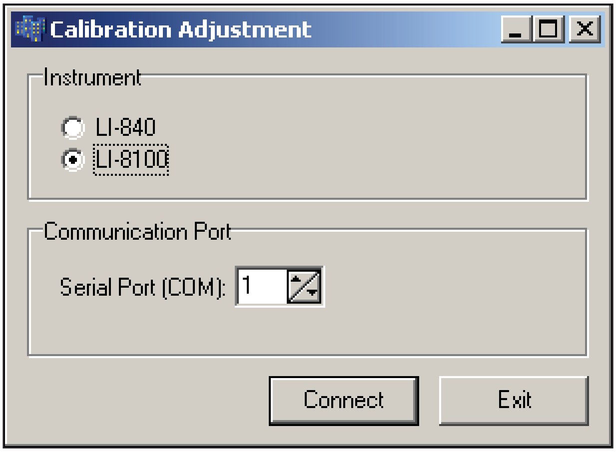
SPAN OPTION: Before doing the next two steps, you may wish to manually set the span value to 1.0000. This is especially true if you've noticed the span values getting progressively worse (0.9, 0.8, etc.). Whatever the span value is when you perform this calibration adjustment will be the new "normal" value. (To view and/or adjust the span values in the LI-8100, navigate to (Palm) **Utilities - Calibration**, or (Windows) **Utilities - Calibration**, then click the **Manual** tab.)

2. *Measure the first concentration (or dewpoint)*
Make a note of the measured and true values, and also the bench temperature, and (if doing water) the bench pressure reading.

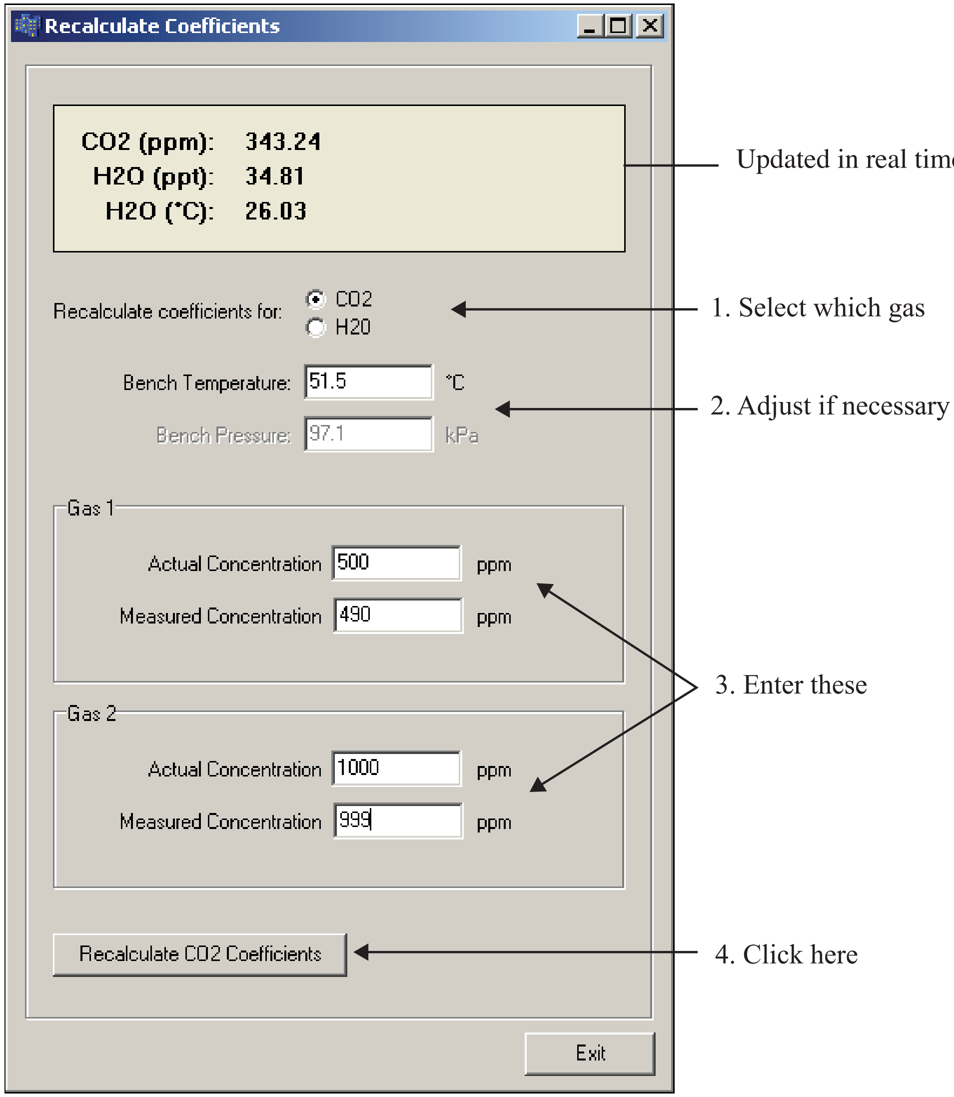
3. *Measure the second concentration (or dewpoint)*
   Note the measured and true values. Presumably, the pressure and temperature will be essentially the same.

4. *Run CalAdjust.exe*
   The program can be found on the LI-8100 CD, or downloaded from www.licor.com.

5. *Connect the PC to the LI-8100*
   Set the LI-8100 radio button, choose the serial (COM) port, and click **Connect**.

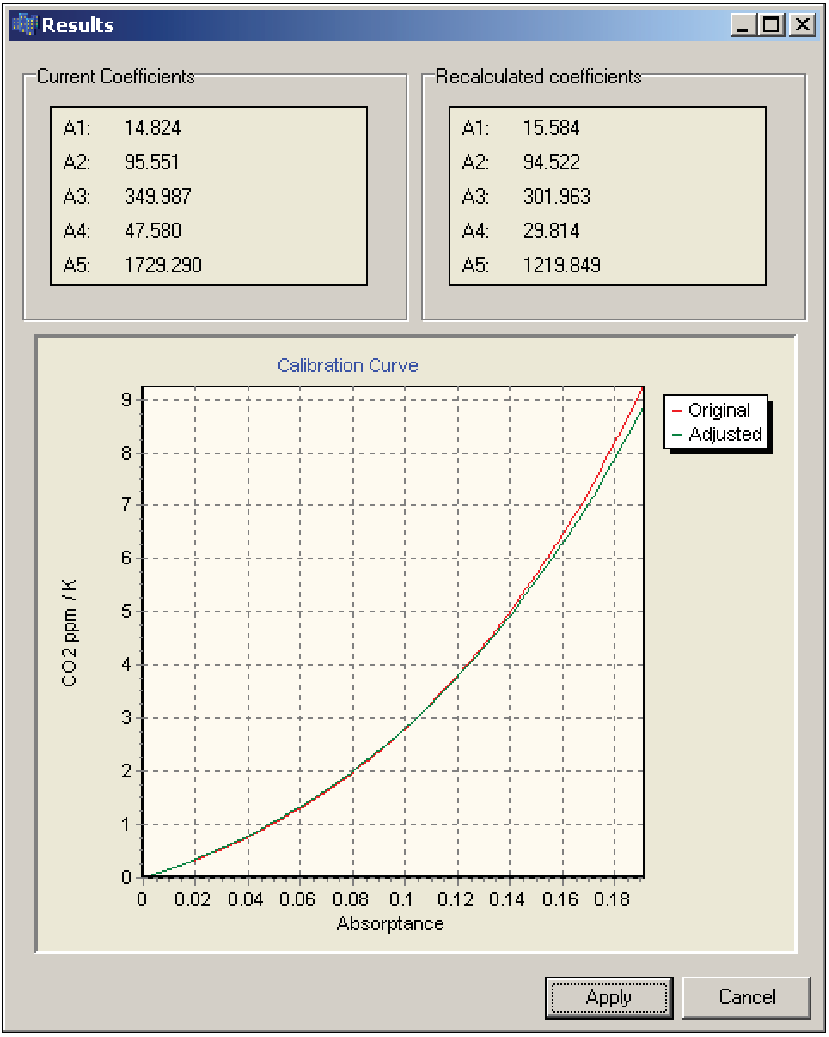


6. *Enter the measured data*
   "Actual" (concentration or dew point) is the true value. "Measured" is what the analyzer indicated. Gas 1 can be either the higher or lower concentration.



When done, click the **Recalculate** button.

7. *View the results*
   You will be shown the old and new curves and coefficients, based on the two points you entered.



8. *Click **Apply***
If you want to udate the instrument with the new coefficients, click Apply. Otherwise, **Cancel** will leave the instrument unchanged.

6 Using the 10 cm Survey Chamber

General Description

The LI-8100 10 cm Survey Chamber is designed to make rapid measurements of soil CO_2 flux that can be repeated over a number of locations to get an accurate measure of spatial variability.

A pressure/vacuum air flow system expands and contracts a bellows to raise and lower the chamber over a soil collar to make the flux measurement. This chamber design minimizes perturbations of the microclimate inside the chamber for accurate, repeatable measurements, and eliminates the need for chemical scrubbers.

A double-sealed gasket system seals the chamber both inside and outside of the soil collar to minimize CO_2 leaks and wind effects. A pressure vent at the top of the chamber prevents pressure spikes when the chamber closes, and maintains the chamber pressure at the ambient level under calm and windy conditions.

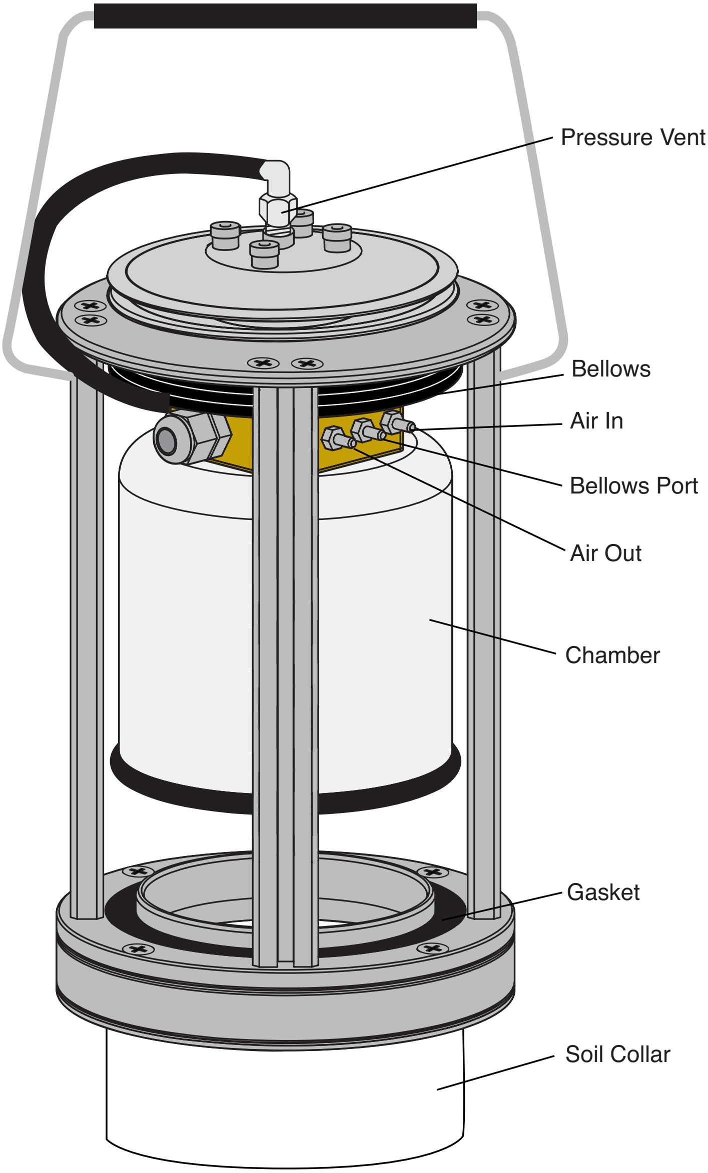


Figure 6-1. *The 10 cm Survey Chamber.*

The Measurement Flow Path

Air flow generated by a rotary pump inside the Analyzer Control Unit provides a steady flow of air to the Survey Chamber, with minimal pulsations. Air flow to the chamber provides mixing without using fans that can cause pressure gradients. Air returning from the chamber passes through a filter before it enters the optical bench of the infrared gas analyzer in the Analyzer Control Unit. The analyzer optical bench measures CO_2 and H_2O concentrations simultaneously; these concentrations are then used to calculate flux rate.

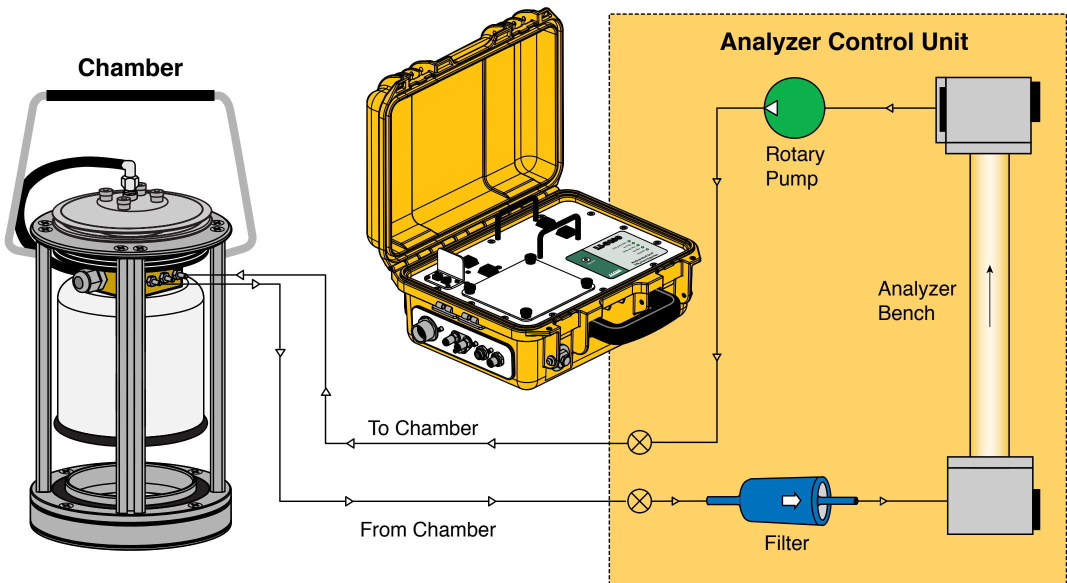


Figure 6-2. *The measurement flow path to the Survey Chamber.*

The Bellows Flow Path

A separate pressure/vacuum air flow system is used to drive the bellows to raise and lower the chamber. A diaphragm pump provides air flow to a series of valves controlled by a pressure transducer. Pressurized air fills the bellows and drives the chamber closed; a vacuum raises the chamber and vents excess air out of the Analyzer Control Unit.

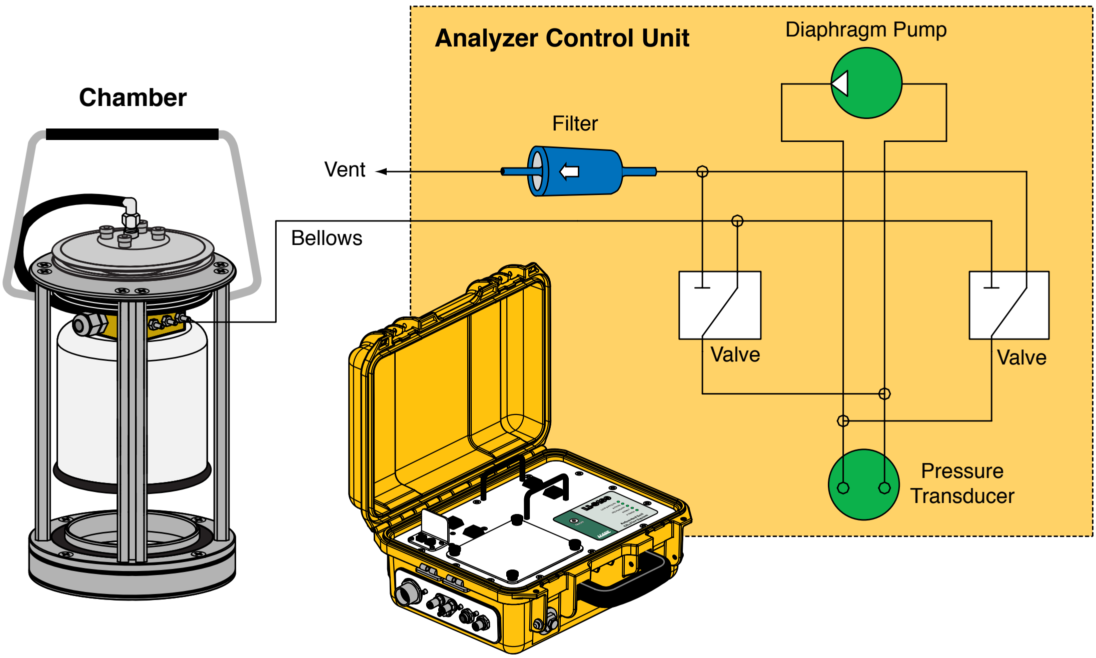


Figure 6-3. The bellows flow path to the 10 cm Survey Chamber.

Connecting the Chamber to the Analyzer Control Unit

There are three hoses connected to the 10 cm Survey Chamber; air to the chamber, air returning from the chamber to the Analyzer Control Unit, and air that drives the bellows. These hoses are connected to the side panel of the Analyzer Control Unit, as shown in Figure 6-4. The **Air In** hose has a male fitting, and the **Air Out** hose has a female fitting. Note that one of the hoses has a piece of black shrink wrap; this hose attaches to the **Air In** fitting on the Analyzer Control Unit. The bellows hose has a male fitting, and attaches to the port marked **Bellows** on the Analyzer Control Unit. Insert the hoses until the fittings snap into place. To remove the hoses, slide the collar on the fittings and pull straight out.

Figure 6-4. *10 cm Survey Chamber hose connections.*

Making Measurements

The following discussion assumes that you have already connected the Survey Chamber, installed soil collars several hours or more before making a measurement (see page 2-17), and have installed the Windows® and/or software for the Palm OS. This discussion also assumes that you have connected your external sensors, including soil moisture and/or soil temperature probes, to the Auxiliary Sensor Interface as described in Section 2, *Initial Setup*. Although they are similar, measurement protocols for both the LI-8100 Windows application software and the software for Palm OS are detailed below.

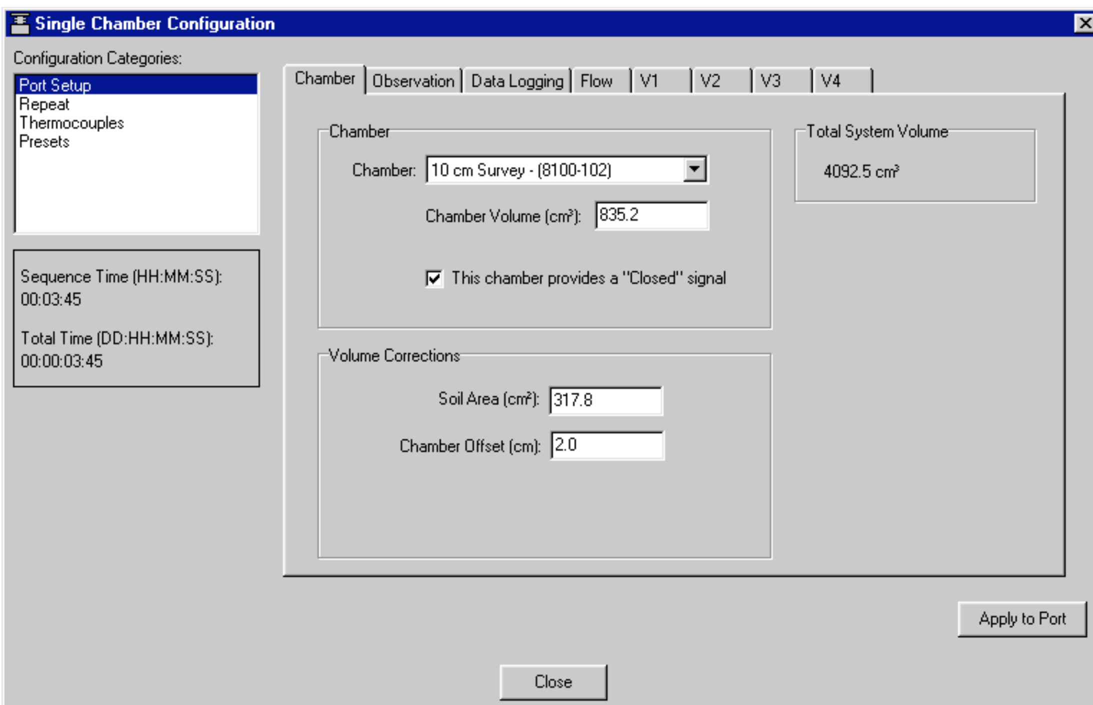
- Connect the cables, battery, and chamber as described in Section 2, *Initial Setup*.
- Connect the LI-8100 to your computer or PDA using the appropriate serial cables, as described in Section 2, *Initial Setup*.
- Turn the LI-8100 on using the ON/OFF button on the inside panel of the Analyzer Control Unit. Wait for the IRGA Ready light to illuminate. Note that the chamber moves to its open (up) position at system startup.
- Measure and record the height of the soil collar that extends above the soil surface. Place the chamber on the soil collar.
- Insert the soil temperature probe and/or soil moisture probes at the desired depths and distances from the chamber.

Software Setup Using the LI-8100 Windows Application Software

The following discussion assumes that you have installed the LI-8100 application software on your PC, and are connected via the serial cables provided, or have configured the LI-8100 and your computer to communicate via a wireless network, as described in Section 11, *Using the Windows Software*. The measurement protocol is identical, regardless of how the PC is connected to the LI-8100.

1. Open the LI-8100 Windows application software and click on the **Connect** icon, or choose **Connect** from the Communication menu. Choose the serial (COM) port on the computer to which the LI-8100 is connected, and click Connect. Alternatively, click on **TCP/IP** and enter the IP address of the wireless card in the LI-8100 and click **Connect**. After a few moments, data will begin to appear in the Main window.

2. Choose **Measurement Configuration** from the Setup menu. The Single Chamber Configuration window appears.

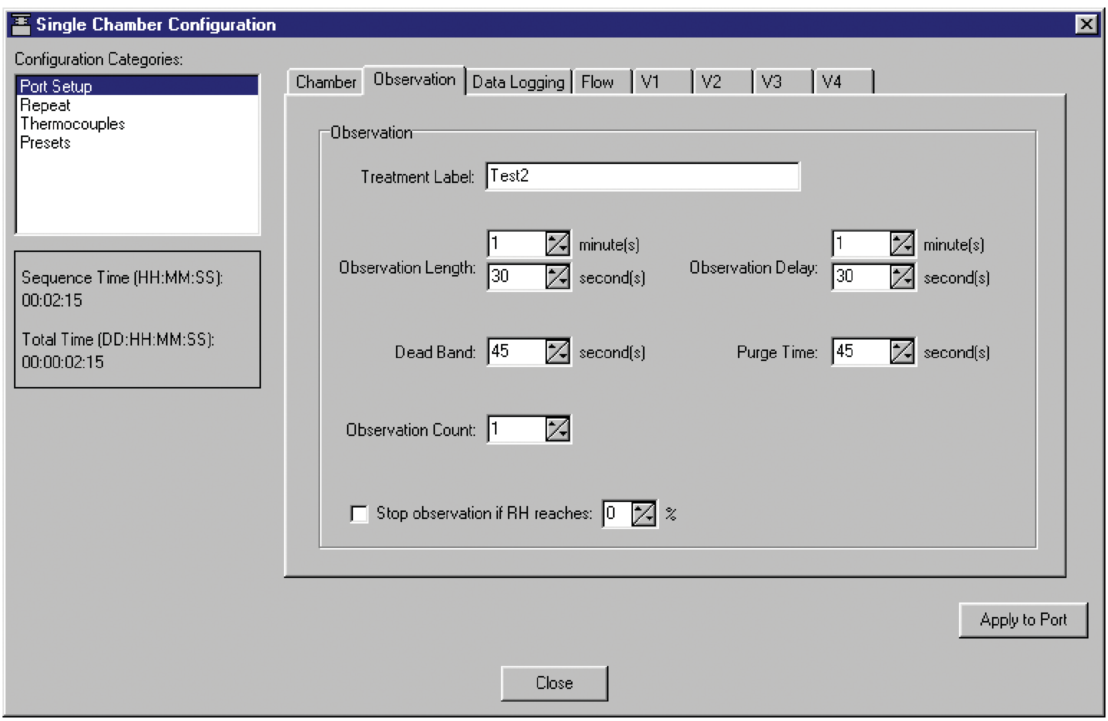


Use the Chamber pull-down menu to choose 10 cm Survey (8100-102). The Chamber Volume value is automatically entered.

Enter the **Soil Area** (83.7 cm^2 for 8100-102) and **Chamber Offset** (cm). The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the **Total Volume**. Measuring the Chamber Offset is described in Section 2, *Using Soil Collars*.

Click on **Apply to Port** to send these values to the LI-8100 for implementation.

3. Click on the **Observation** tab to open the Observation window.



Treatment Label

The **Treatment Label** is embedded as a separate column in the resulting data records.

Observation Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At moderate to low CO_2 fluxes an Observation Length of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *Etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *Etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 Data Analysis (File Viewer) program, if Raw records are collected.

Observation Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Observation Delay

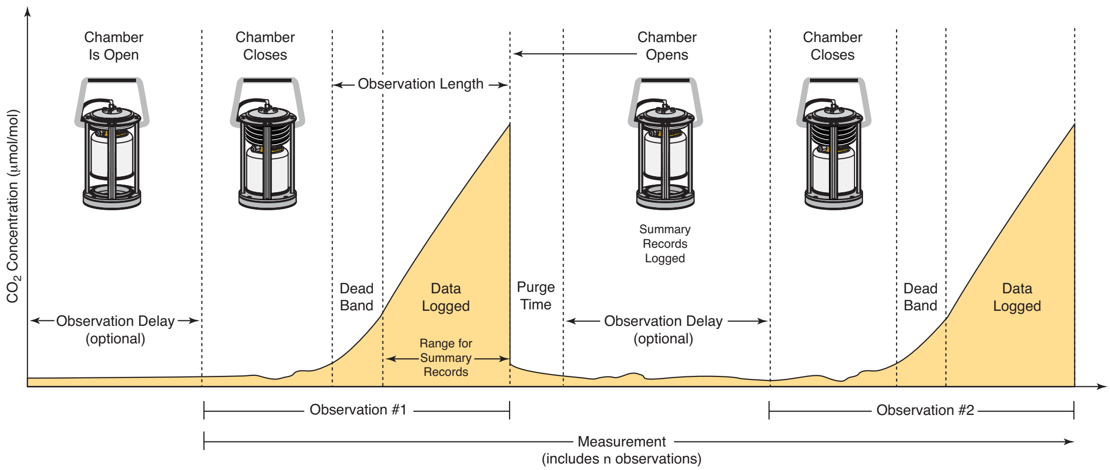
When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber CO_2 concentration may return to ambient levels in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the **Purge Time** to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a **Purge Time** of about 45 seconds is adequate.

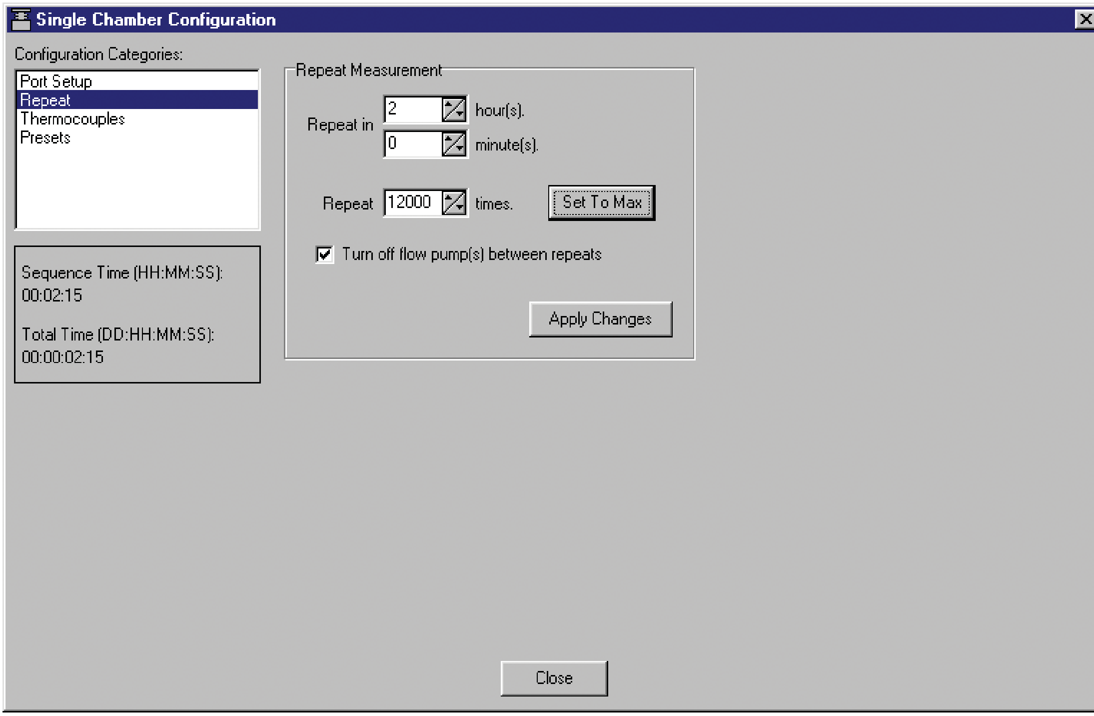
IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below, after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at “Observation Delay”.



Stop Observation if RH reaches...

Enable the 'Stop Observatio if RH reaches' check box and enter a relative humidity value (if humidity is a concern at the measurement site). The Observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the Observation. If the Observation is aborted, a message is placed in the log file, and the measurement will continue at the next Observation.

4. Click on **Repeat** under the Configuration Categories list to view the Repeat window.

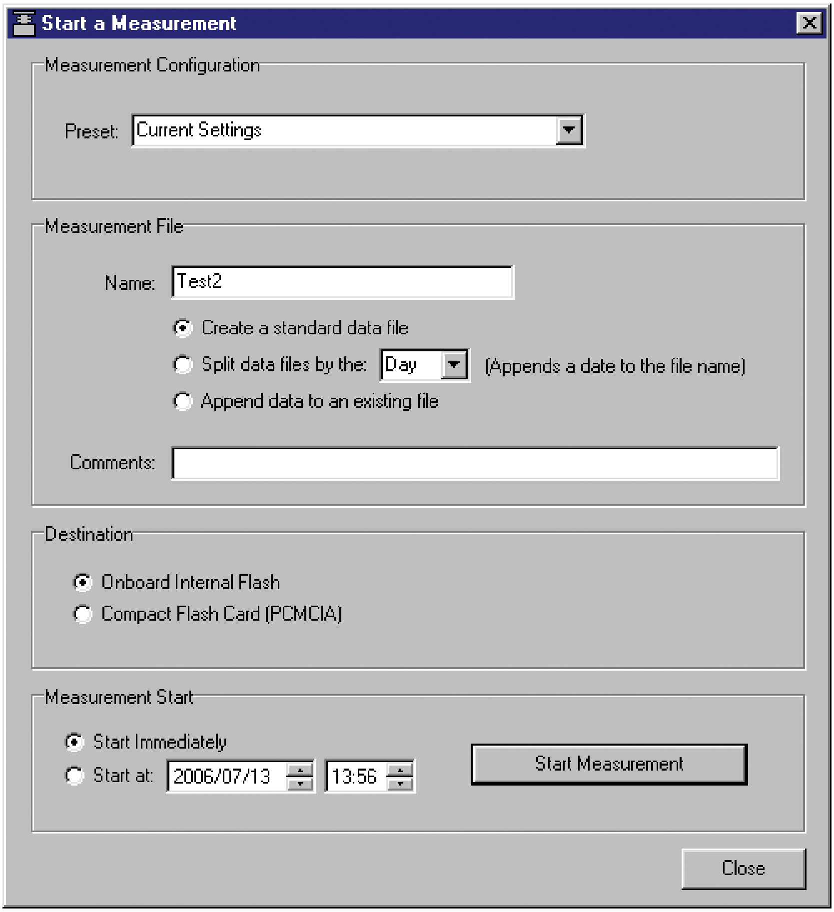


The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.

For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Set To Max** button).

You can elect to turn off the flow pump between repeated measurements to conserve battery life and extend the life of the pump by enabling the check box.

5. Choose **Start Measurement** from the Setup menu to open the Start a Measurement dialog.



Measurement Configuration

You can choose a defined set of measurement parameters from the Preset pull-down menu, or use the configuration as currently defined.

Measurement File

Enter a **File Name** and optional **Comments**. The **Comments** appear only in the header information. Files can be created in the standard data file format, where the entire data set is placed in a single file, as defined by the measurement configuration. Large files can be split into smaller files, in increments of 1 day, or 1 week. Files split by the day are appended with a date, beginning at 12:01 a.m. each day; files split by the week are appended with a date, beginning at a period 7 days after the first measurement is taken. Click the 'Append data to an existing file' button to add new measurement data at the end of the currently defined file.

Destination

Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time. Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Measurement Start

Enter a **Start** time. You can start the measurement immediately or choose to begin the measurement at a specified date and time.

6. Click **Start Measurement** to begin the measurement.

Software Setup Using the LI-8100 Application Software for Palm OS

The following discussion assumes that you have installed the LI-8100 application software on your PDA, and are connected via the serial cables provided, or have configured the LI-8100 and your PDA to communicate via a wireless network, as described in Section 12, *Using a PDA*. The measurement protocol is identical, regardless of how the PDA is connected to the LI-8100.

1. Open the LI-8100 Application software for Palm OS. Click on **Connect by Serial** if you are connected via serial cables, or **Connect by TCPIP** if you are using a wireless configuration.

2. Click on the Setup menu and choose **Measurement Protocol**. The Measurement Protocol screen appears (below).

Obs. Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At low to moderate CO_2 fluxes an **Observation Length** of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI8100 File Viewer program.

Obs. Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Obs. Delay

When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

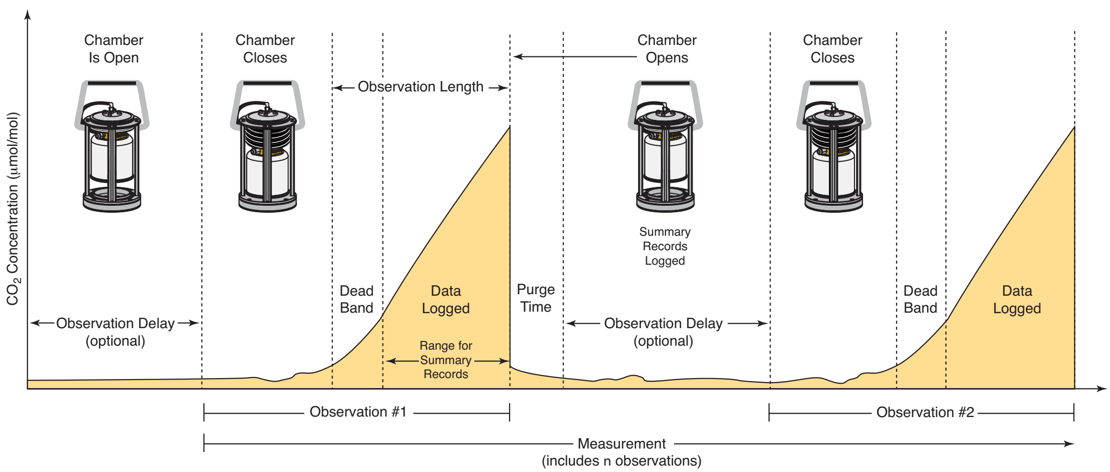
When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber air may return to ambient in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below, after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation**

Delay has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at “Observation Delay”.

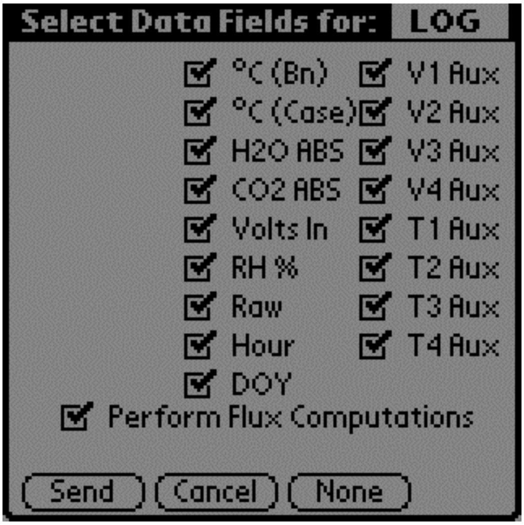


Additional Log Fields

Tap on Additional Log Fields to choose the values to be logged to memory. Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card.

Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Enable the Perform Flux Computations check box to automatically compute the flux rate after each measurement.



Tap **Send** to send the selected data fields to the LI-8100 for implementation.

Tap **Cancel** to close the page without sending the data fields.

Tap **None** to disable (uncheck) all data fields. None button changes to **All** when the fields are disabled.

The additional data values that can be logged are as follows:

Label	***Description***
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
Hour	Time of day.
DOY	Day of the year.
V1 Aux	Input at voltage channel 1 (soil moisture).
V2 Aux	Input at voltage channel 2 (soil moisture).
V3 Aux	Input at voltage channel 3 (soil moisture).
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

3. Click on the Setup menu and choose **Areas and Volumes.** The Areas, Volumes, & Flow Rate screen appears (below).

The Total Volume value is computed and displayed after the Chamber Offset, Soil Area, and Chamber Volume values are entered. IRGA Volume is set under "Instrument Settings" and is displayed here.

Chamber Offset

The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the Total System Volume. Measuring the **Chamber Offset** is described in Section 2, *Using Soil Collars*.

Soil Area

The area of soil encompassed by the soil collar, in cm^2. Calculate the Soil Area from the inside diameter of the soil collar. The default values in the LI-8100 software are given for the 10 cm and 20 cm soil collars provided by LI-COR.

Chamber Volume

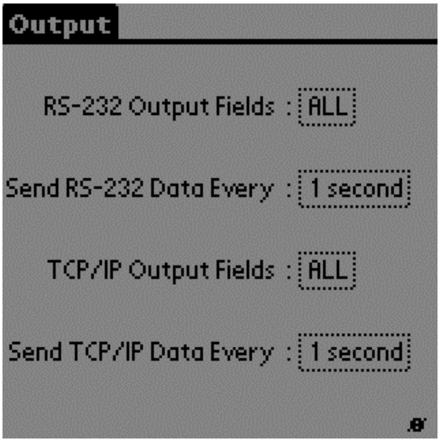
The **Chamber Volume** value includes the air inside the chamber, as well as from the tubing attached to the chamber. This volume is entered automatically when you choose the Survey or Long-Term chamber in software, but can be adjusted manually by the user if the chamber volume changes for any reason (i.e., the tubing length changes).

Flow Rate
The rotary pump in the LI-8100 Analyzer Control Unit provides a flow rate of 0.5 to 1.5 liter/minute to the chamber. In most cases you should operate the Survey and Long-Term chambers at the highest flow rate.

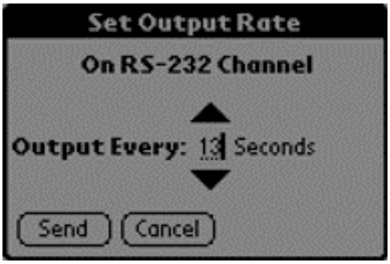
IRGA Volume
This is a factory-defined value that includes the volume of the optical bench and associated plumbing inside the Analyzer Control Unit. The default IRGA volume is 19 cm^3.

Total Volume
The total system volume, which is computed from the sum of the **Chamber Volume**, **IRGA Volume**, **Chamber Offset**, and **Soil Area**.

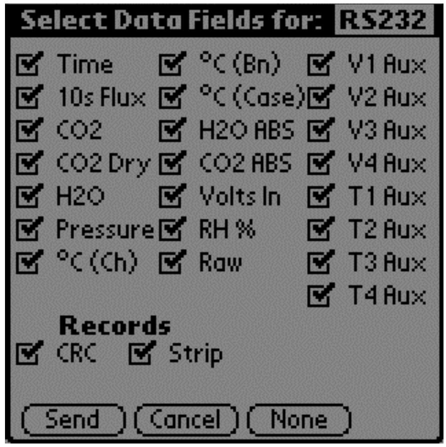
4. Click on the 8100 menu and choose **Outputs**. The Output screen appears (below), where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included. You can also choose the output frequency for both RS-232 and/or TCP/IP data.



Data can be output via RS-232 or TCP/IP at intervals between 1 and 20 seconds.



RS-232 Output Fields
Choose the data values to be sent to the RS-232 port.



The data values that can be output are as follows:

Label	***Description***
Time	Instrument time.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
CO2	Chamber CO_2 concentration in µmol/mol.
CO2 Dry	Chamber CO_2 concentration, corrected for water vapor dilution, in µmol/mol.
H2O	Chamber water vapor concentration, in mmol/mol.
Pressure	Atmospheric pressure in the optical bench (kPa).
°C (Ch)	Air temperature inside the soil chamber.
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
V1 Aux	Input at voltage channel 1.
V2 Aux	Input at voltage channel 2.
V3 Aux	Input at voltage channel 3.
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

Note that when the LI-8100 outputs data, each field is "marked up" using e**X**tensible **M**arkup **L**anguage (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the 'Strip' check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

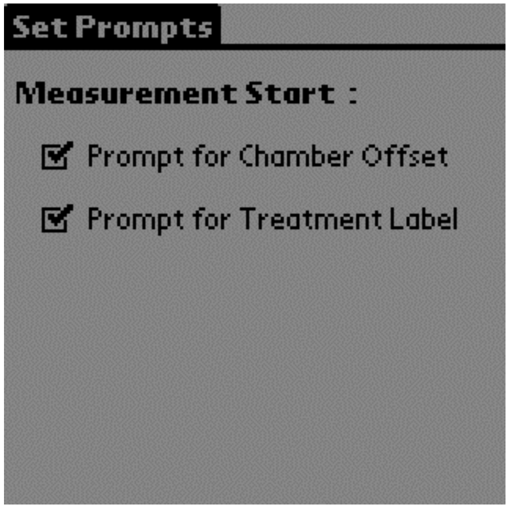
Disable the 'CRC' check box to remove CRC from the data. Note that the LI-8100 Palm OS application itself does *not* use CRC checking.

TCP/IP Output Fields

Tap on the TCP/IP field to configure the data values to be sent via the wireless card, if desired. Note that you can configure the TCP/IP (wireless) and/or RS-232 options while the other is enabled; changes will not take effect until data logging is stopped and restarted, however. For example, if you are currently logging data to the PC, you can configure the wireless output, but you must first stop logging data to the PC before beginning wireless output with the new configuration.

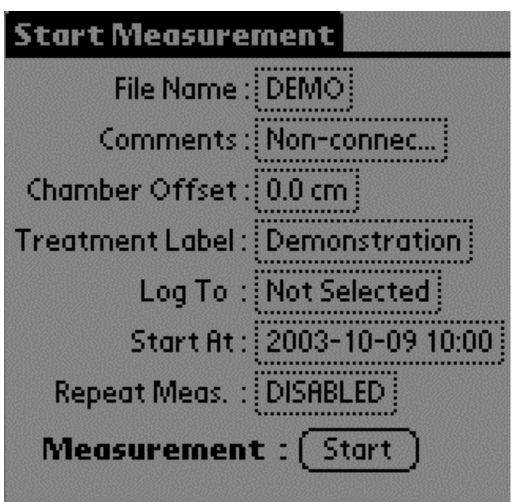
The data values that can be output are as shown above at RS-232 Output.

5. Click on the Utilities menu and choose **Prompts**. The Prompts screen appears (below).



This screen allows you to turn system prompts on or off. By default, a prompt appears whenever a new measurement is started, to enter the **Chamber Offset** (Collar Height) and **Treatment Label**. You can turn off these prompts by unchecking the appropriate boxes.

6. Click on the Setup menu and choose **Start Measurement**. The Start Measurement screen appears (below).



The Treatment Label is embedded as a separate column in the data records.

Enter a **File Name** and optional **Comments**. Enter the **Chamber Offset** and **Treatment Label.**

Note that if the **Chamber Offset** and **Treatment Label** prompts are enabled (see #5 above), you will be prompted for these values if they are not already entered on this screen when the **Start** button is pressed.

Log To
Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time.

Repeat Measurement and Start At:
The **Repeat Measurement** and **Start At** functions allow you to repeat the defined protocol at a regular clock interval. The **Start At:** parameter functions independent of the **Repeat Measurement** parameter; the **Repeat Measurement** function can be disabled, but you must still enter a valid **Start At:** time to intiate a measurement.

These functions are particularly useful when making long term, unattended measurements. For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations.

7. Tap **Start** to begin the measurement.

7 Using the 20 cm Survey Chamber

General Description

The LI-8100 20 cm Survey Chamber is designed to make rapid measurements of soil CO_2 flux that can be repeated over a number of locations to get an accurate measure of spatial variability.

The 20 cm Survey Chamber uses the same pressure/vacuum air flow system used in the 10 cm Survey Chamber to raise and lower the chamber over the soil collar. Its larger size, however, allows the chamber to be placed on the 20 cm soil collars used with the LI-8100 Long-Term Chamber. This allows for measurements of spatial variability on the same soil collars as are used for temporal measurements, using a large exposed soil area.

The chamber design minimizes perturbations of the microclimate inside the chamber for accurate, repeatable measurements, and eliminates the need for chemical scrubbers.

A double-sealed gasket system seals the chamber both inside and outside of the soil collar to minimize CO_2 leaks and wind effects. A pressure vent at the top of the chamber prevents pressure spikes when the chamber closes, and maintains a pressure equilibrium between the inside of the chamber and ambient air in all conditions (e.g. wind).

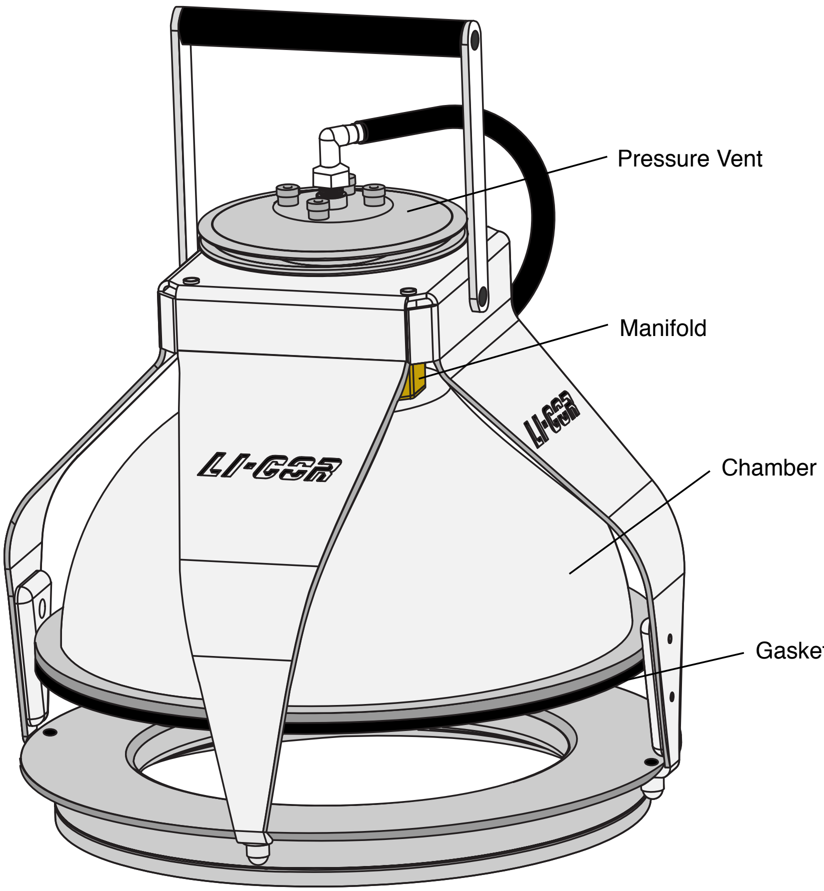


Figure 7-1. The 20 cm Survey Chamber.

The Measurement Flow Path

Air flow generated by a rotary pump inside the Analyzer Control Unit provides a steady flow of air to the 20 cm Survey Chamber, with minimal pulsations. Air flow to the chamber provides mixing without using fans that can cause pressure gradients. Air returning from the chamber passes through a filter before it enters the optical bench of the infrared gas analyzer in the Analyzer Control Unit. The analyzer optical bench measures CO_2 and H_2O concentrations simultaneously; these concentrations are then used to calculate flux rate.

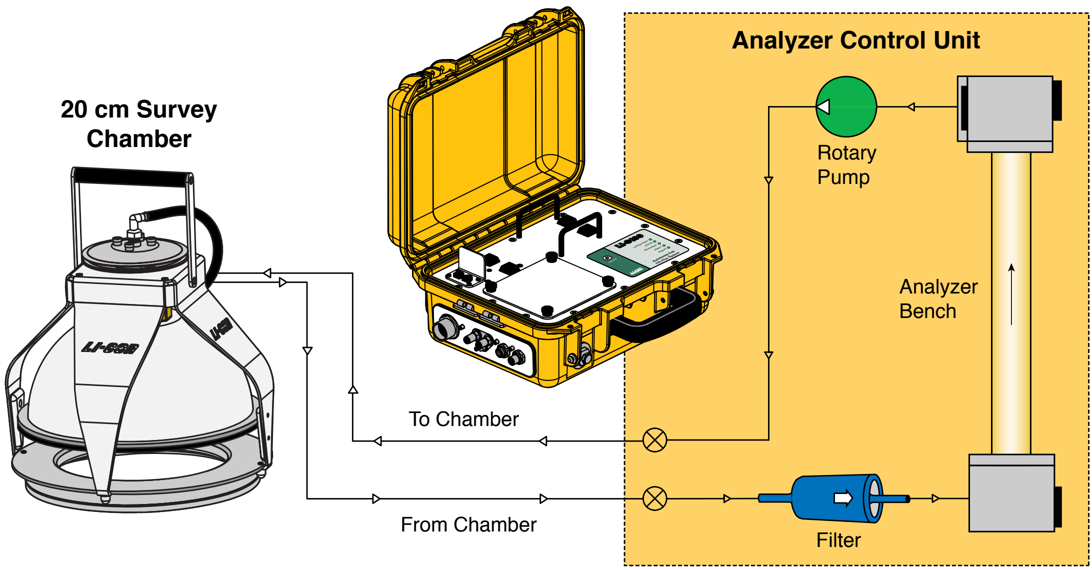


Figure 7-2. The measurement flow path to the 20 cm Survey Chamber.

The Bellows Flow Path

A separate pressure/vacuum air flow system is used to drive the bellows to raise and lower the chamber. A diaphragm pump provides air flow to a series of valves controlled by a pressure transducer. Pressurized air fills the bellows and drives the chamber closed; a vacuum raises the chamber and vents excess air out of the Analyzer Control Unit.

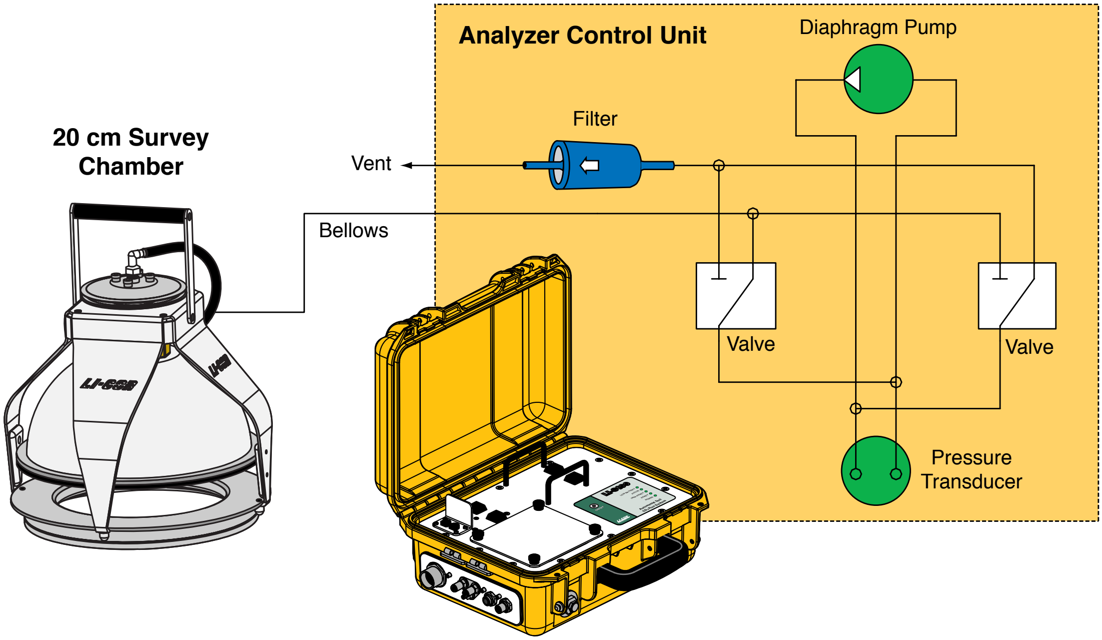


Figure 7-3. *The bellows flow path to the 20 cm Survey Chamber.*

Connecting the Chamber to the Analyzer Control Unit

There are three hoses connected to the 20 cm Survey Chamber; air to the chamber, air returning from the chamber to the Analyzer Control Unit, and air that drives the bellows. These hoses are connected to the side panel of the Analyzer Control Unit, as shown in Figure 7-4. The **Air In** hose has a male fitting, and the **Air Out** hose has a female fitting. Note that one of the hoses has a piece of black shrink wrap; this hose attaches to the **Air In** fitting on the Analyzer Control Unit. The bellows hose has a male fitting, and attaches to the port marked **Bellows** on the Analyzer Control Unit. Insert the hoses until the fittings snap into place. To remove the hoses, slide the collar on the fittings and pull straight out.

Figure 7-4. *Chamber hose connections.*

Making Measurements

The following discussion assumes that you have already connected the Survey Chamber, installed soil collars several hours or more before making a measurement (see page 2-17), and have installed the Windows® and/or software for the Palm OS. This discussion also assumes that you have connected your external sensors, including soil moisture and/or soil temperature probes, to the Auxiliary Sensor Interface as described in Section 2, *Initial Setup*. Although they are similar, measurement protocols for both the LI-8100 Windows application software and the software for Palm OS are detailed below.

- Connect the cables, battery, and chamber as described in Section 2, *Initial Setup*.

- Connect the LI-8100 and your computer or PDA using the appropriate serial cables, as described in Section 2, *Initial Setup*.

- Turn the LI-8100 on using the ON/OFF button on the inside panel of the Analyzer Control Unit. Wait for the IRGA Ready light to illuminate. Note that the chamber moves to its open (up) position at system startup.

- Measure and record the height of the soil collar that extends above the soil surface. Place the chamber on the soil collar.

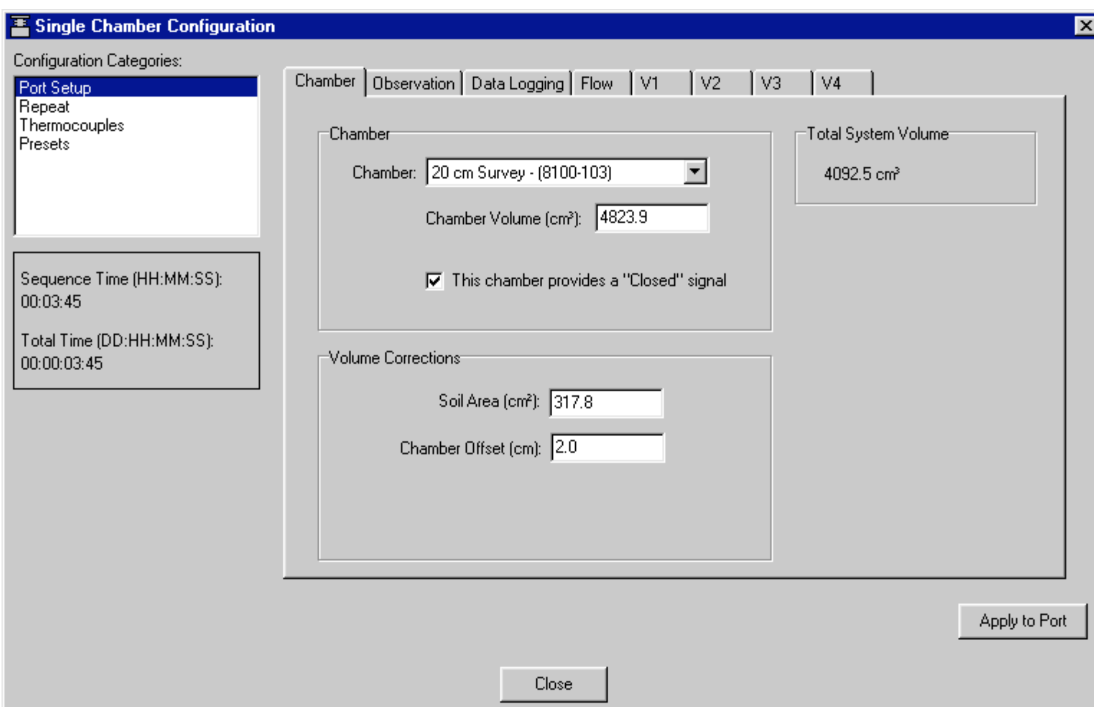
- Insert the soil temperature probe and/or soil moisture probes at the desired depths and distances from the chamber.

Software Setup Using the LI-8100 Windows Application Software

The following discussion assumes that you have installed the LI-8100 application software on your PC, and are connected via the serial cables provided, or have configured the LI-8100 and your computer to communicate via a wireless network, as described in Section 11, *Using the Windows Software*. The measurement protocol is identical, regardless of how the PC is connected to the LI-8100.

1. Open the LI-8100 Windows application software and click on the **Connect** icon, or choose **Connect** from the Communication menu. Choose the serial (COM) port on the computer to which the LI-8100 is connected, and click Connect. Alternatively, click on **TCP/IP** and enter the IP address of the wireless card in the LI-8100 and click **Connect**. After a few moments, data will begin to appear in the Main window.

2. Choose **Measurement Configuration** from the Setup menu. The Single Chamber Configuration window appears.

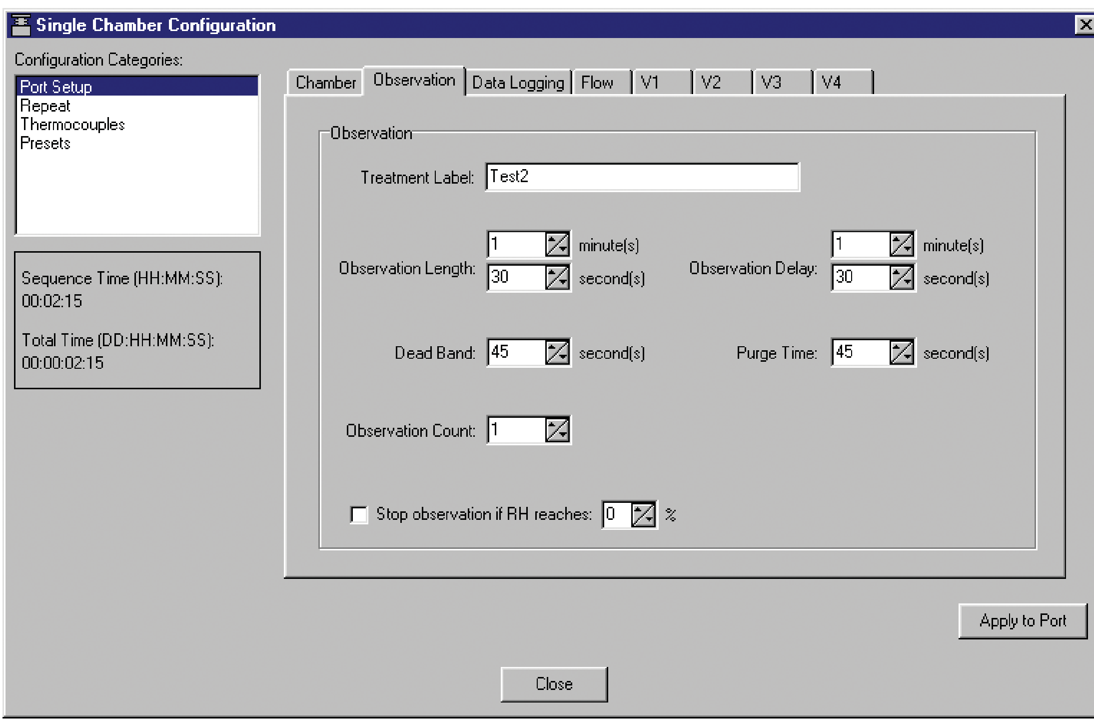


Use the Chamber pull-down menu to choose 20 cm Survey (8100-103). The Chamber Volume value is automatically entered.

Enter the **Soil Area** (317.8 cm^2 for 8100-103) and **Chamber Offset** (cm). The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the **Total Volume**. Measuring the Chamber Offset is described in Section 2, *Using Soil Collars*.

Click on **Apply to Port** to send these values to the LI-8100 for implementation.

3. Click on the **Observation** tab to open the Observation window.



Treatment Label

The **Treatment Label** is embedded as a separate column in the resulting data records.

Observation Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At moderate to low CO_2 fluxes an Observation Length of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *Etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *Etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 Data Analysis (File Viewer) program, if Raw records are collected.

Observation Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Observation Delay

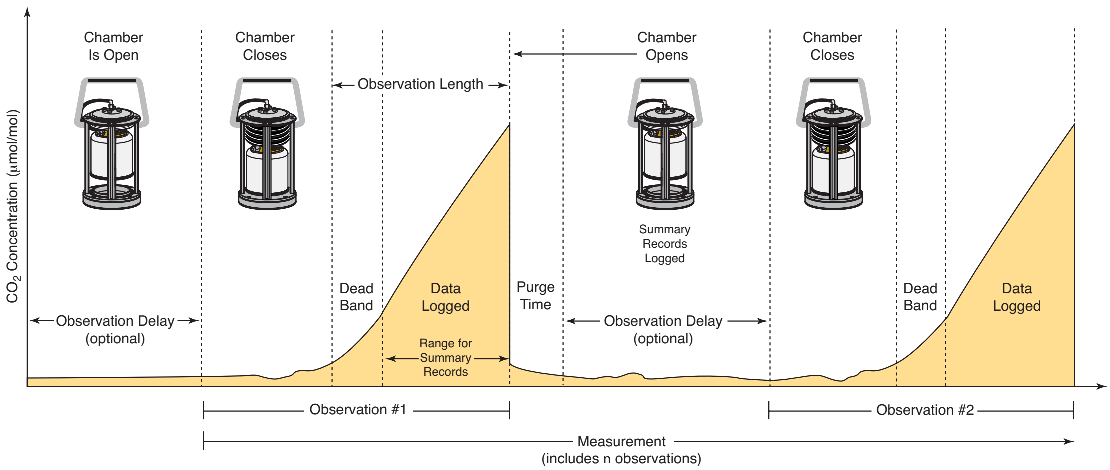
When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber CO_2 concentration may return to ambient levels in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture, for example, that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

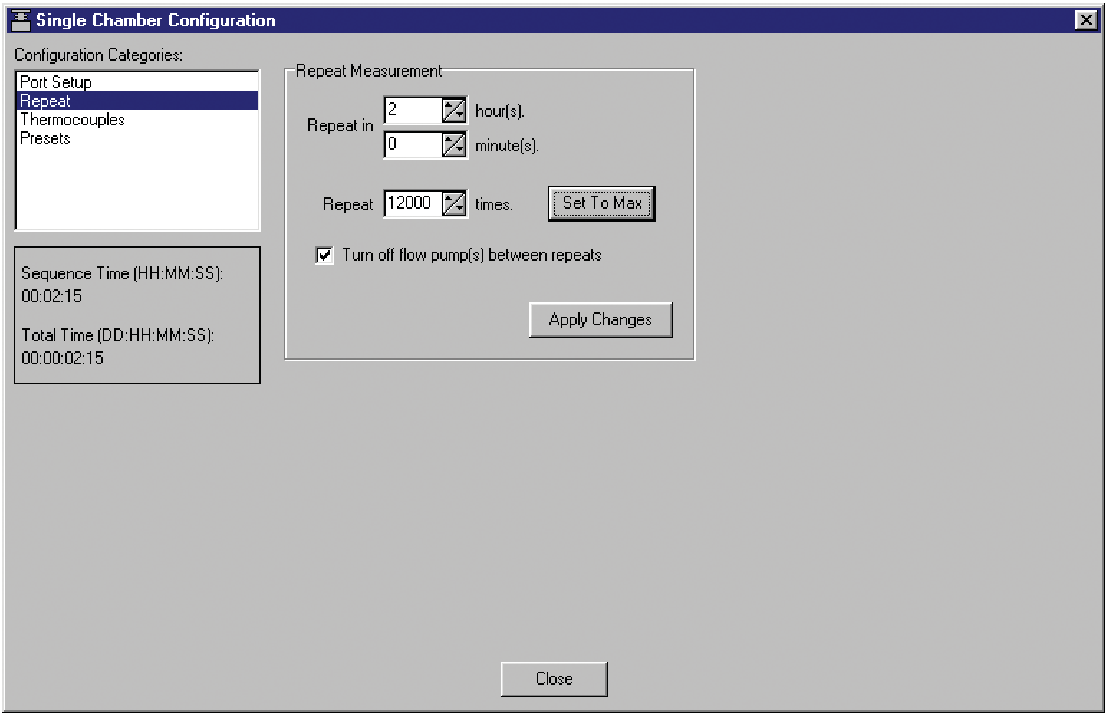
IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below (10 cm chamber shown), after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at “Observation Delay”.



Stop Observation if RH reaches...

Enable the 'Stop Observatio if RH reaches' check box and enter a relative humidity value (if humidity is a concern at the measurement site). The Observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the Observation. If the Observation is aborted, a message is placed in the log file, and the measurement will continue at the next Observation.

4. Click on **Repeat** under the Configuration Categories list to view the Repeat window.

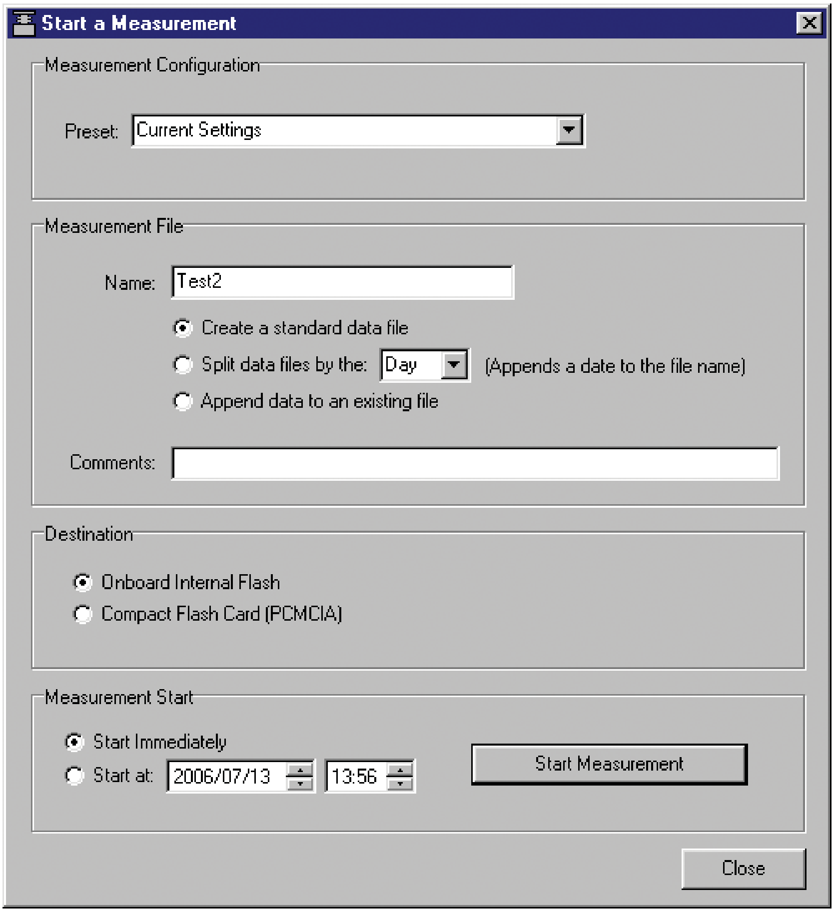


The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.

For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Set To Max** button).

You can elect to turn off the flow pump between repeated measurements to conserve battery life and extend the life of the pump by enabling the check box.

5. Choose **Start Measurement** from the Setup menu to open the Start a Measurement dialog.



Measurement Configuration

You can choose a defined set of measurement parameters from the Preset pull-down menu, or use the configuration as currently defined.

Measurement File

Enter a **File Name** and optional **Comments**. The **Comments** appear only in the header information. Files can be created in the standard data file format, where the entire data set is placed in a single file, as defined by the measurement configuration. Large files can be split into smaller files, in increments of 1 day, or 1 week. Files split by the day are appended with a date, beginning at 12:01 a.m. each day; files split by the week are appended with a date, beginning at a period 7 days after the first measurement is taken. Click the 'Append data to an existing file' button to add new measurement data at the end of the currently defined file.

Destination

Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time. Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Measurement Start

Enter a **Start** time. You can start the measurement immediately or choose to begin the measurement at a specified date and time.

6. Click **Start Measurement** to begin the measurement.

Software Setup Using the LI-8100 Application Software for Palm OS

The following discussion assumes that you have installed the LI-8100 application software on your PDA, and are connected via the serial cables provided, or have configured the LI-8100 and your PDA to communicate via a wireless network, as described in Section 12, *Using a PDA*. The measurement protocol is identical, regardless of how the PDA is connected to the LI-8100.

1. Open the LI-8100 Application software for Palm OS. Click on **Connect by Serial** if you are connected via serial cables, or **Connect by TCPIP** if you are using a wireless configuration.

2. Click on the Setup menu and choose **Measurement Protocol**. The Measurement Protocol screen appears (below).

Obs. Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At low to moderate CO_2 fluxes an **Observation Length** of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI8100 File Viewer program.

Obs. Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Obs. Delay

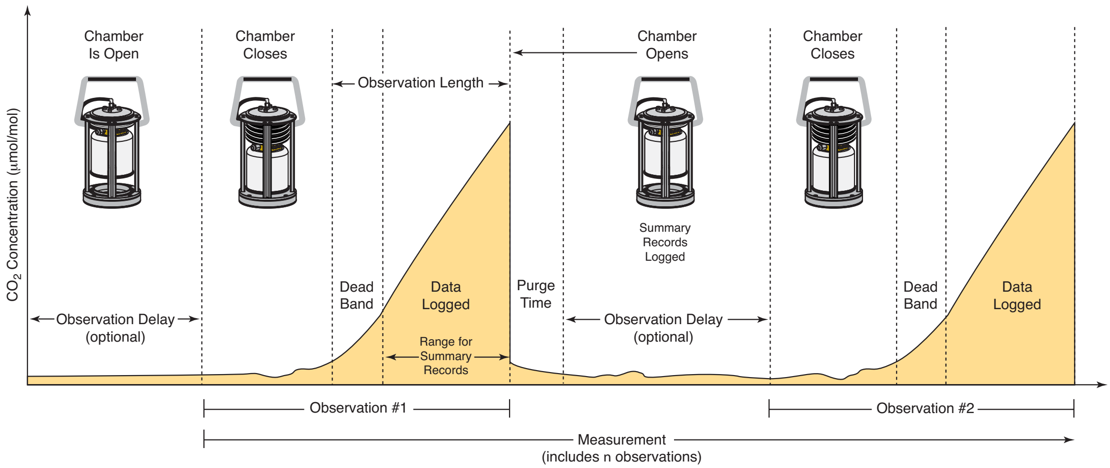
When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber air may return to ambient in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture, for example, that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below (10cm chamber shown), after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at "Observation Delay".

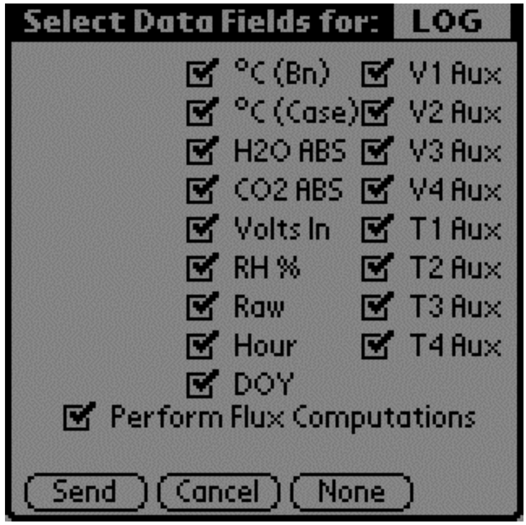


Additional Log Fields

Tap on Additional Log Fields to choose the values to be logged to memory. Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card.

Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Enable the Perform Flux Computations check box to automatically compute the flux rate after each measurement.



Tap **Send** to send the selected data fields to the LI-8100 for implementation.

Tap **Cancel** to close the page without sending the data fields.

Tap **None** to disable (uncheck) all data fields. None button changes to **All** when the fields are disabled.

The additional data values that can be logged are as follows:

Label	***Description***
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
Hour	Time of day.
DOY	Day of the year.
V1 Aux	Input at voltage channel 1 (soil moisture).
V2 Aux	Input at voltage channel 2 (soil moisture).
V3 Aux	Input at voltage channel 3 (soil moisture).
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

3. Click on the Setup menu and choose **Areas and Volumes.** The Areas, Volumes, & Flow Rate screen appears (below).

The Total Volume value is computed and displayed after the Chamber Offset, Soil Area, and Chamber Volume values are entered. IRGA Volume is set under "Instrument Settings" and is displayed here.

Chamber Offset

The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the Total System Volume. Measuring the **Chamber Offset** is described in Section 2, *Using Soil Collars*.

Soil Area

The area of soil encompassed by the soil collar, in cm^2. Calculate the Soil Area from the inside diameter of the soil collar. The default values in the LI-8100 software are given for the 10 cm and 20 cm soil collars provided by LI-COR.

Chamber Volume

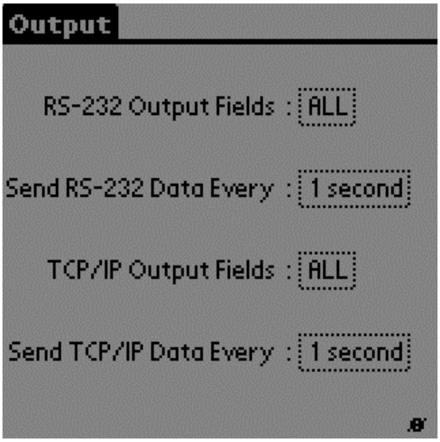
The **Chamber Volume** value includes the air inside the chamber, as well as from the tubing attached to the chamber. This volume is entered automatically when you choose the Survey or Long-Term chamber in software, but can be adjusted manually by the user if the chamber volume changes for any reason (i.e., the tubing length changes).

Flow Rate
The rotary pump in the LI-8100 Analyzer Control Unit provides a flow rate of 0.5 to 1.5 liter/minute to the chamber. In most cases you should operate the Survey and Long-Term chambers at the highest flow rate.

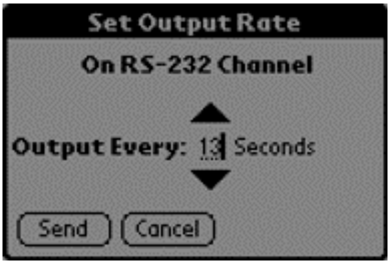
IRGA Volume
This is a factory-defined value that includes the volume of the optical bench and associated plumbing inside the Analyzer Control Unit. The default IRGA volume is 19 cm^3.

Total Volume
The total system volume, which is computed from the sum of the **Chamber Volume**, **IRGA Volume**, **Chamber Offset**, and **Soil Area**.

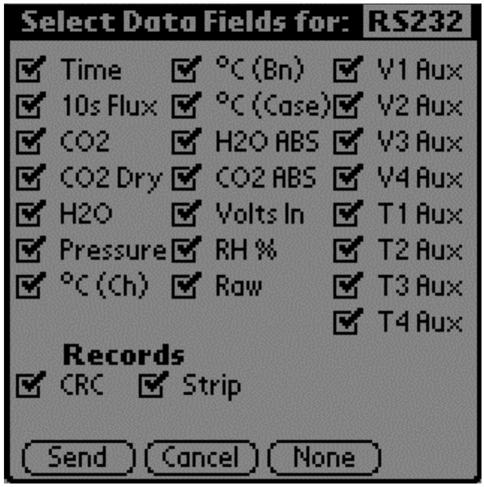
4. Click on the 8100 menu and choose **Outputs**. The Output screen appears (below), where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included. You can also choose the output frequency for both RS-232 and/or TCP/IP data.



Data can be output via RS-232 or TCP/IP at intervals between 1 and 20 seconds.



RS-232 Output Fields
Choose the data values to be sent to the RS-232 port.



The data values that can be output are as follows:

Label	***Description***
Time	Instrument time.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
CO2	Chamber CO_2 concentration in µmol/mol.
CO2 Dry	Chamber CO_2 concentration, corrected for water vapor dilution, in µmol/mol.
H2O	Chamber water vapor concentration, in mmol/mol.
Pressure	Atmospheric pressure in the optical bench (kPa).
°C (Ch)	Air temperature inside the soil chamber.
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
V1 Aux	Input at voltage channel 1.
V2 Aux	Input at voltage channel 2.
V3 Aux	Input at voltage channel 3.
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

Note that when the LI-8100 outputs data, each field is "marked up" using e**X**tensible **M**arkup **L**anguage (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the 'Strip' check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

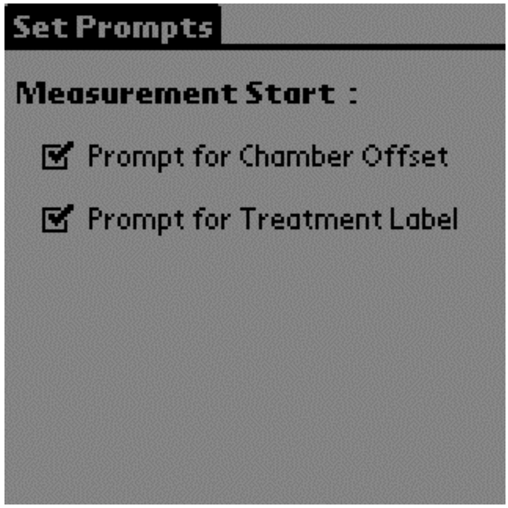
Disable the 'CRC' check box to remove CRC from the data. Note that the LI-8100 Palm OS application itself does *not* use CRC checking.

TCP/IP Output Fields

Tap on the TCP/IP field to configure the data values to be sent via the wireless card, if desired. Note that you can configure the TCP/IP (wireless) and/or RS-232 options while the other is enabled; changes will not take effect until data logging is stopped and restarted, however. For example, if you are currently logging data to the PC, you can configure the wireless output, but you must first stop logging data to the PC before beginning wireless output with the new configuration.

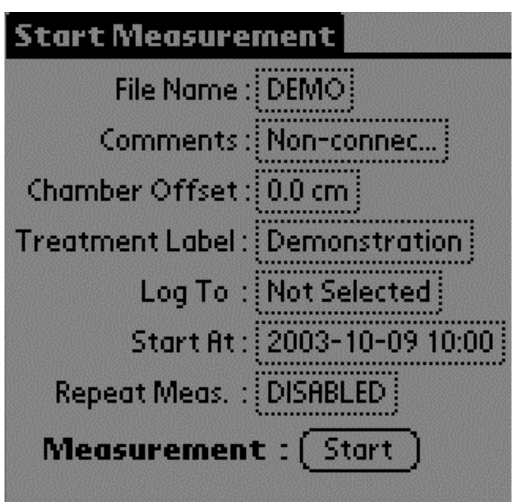
The data values that can be output are as shown above at RS-232 Output.

5. Click on the Utilities menu and choose **Prompts**. The Prompts screen appears (below).



This screen allows you to turn system prompts on or off. By default, a prompt appears whenever a new measurement is started, to enter the **Chamber Offset** (Collar Height) and **Treatment Label**. You can turn off these prompts by unchecking the appropriate boxes.

6. Click on the Setup menu and choose **Start Measurement**. The Start Measurement screen appears (below).



The Treatment Label is embedded as a separate column in the data records.

Enter a **File Name** and optional **Comments**. Enter the **Chamber Offset** and **Treatment Label.**

Note that if the **Chamber Offset** and **Treatment Label** prompts are enabled (see #5 above), you will be prompted for these values if they are not already entered on this screen when the **Start** button is pressed.

Log To
Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time.

Repeat Measurement and Start At:
The **Repeat Measurement** and **Start At** functions allow you to repeat the defined protocol at a regular clock interval. The **Start At:** parameter functions independent of the **Repeat Measurement** parameter; the **Repeat Measurement** function can be disabled, but you must still enter a valid **Start At:** time to intiate a measurement.

These functions are particularly useful when making long term, unattended measurements. For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations.

7. Tap **Start** to begin the measurement.

8 Using the 8100-101 Long-Term Chamber

General Description

The 8100-101 Long-Term Chamber is designed to make long term, diurnal measurements of soil CO_2 flux at a single location for weeks or months at a time.

A unique, moveable design minimizes the effects of the chamber on the natural soil conditions to give reliable results over long periods of time. A motor-driven strut system moves the chamber away from the soil area to be measured, ensuring that the area of interest is subjected to normal, undisturbed precipitation, temperature, and shading effects. The low profile chamber design minimizes wind effects over the measurement location.

A double gasket system seals the chamber outside of the soil collar, and between the chamber and mounting plate, to minimize CO_2 leaks and wind effects. A pressure vent at the top of the chamber prevents pressure spikes when the chamber closes, and maintains the chamber pressure at the ambient level under calm and windy conditions.

The Measurement Flow Path

Air flow generated by a rotary pump inside the Analyzer Control Unit provides a steady flow of air to the Long-Term Chamber, with minimal pulsations. Air flow to the chamber provides mixing without using fans that can cause pressure gradients. Air returning from the chamber passes through a filter before it enters the optical bench of the infrared gas analyzer in the Analyzer Control Unit. The analyzer optical bench measures CO_2 and H_2O concentrations simultaneously; these concentrations are then used to calculate flux rate.

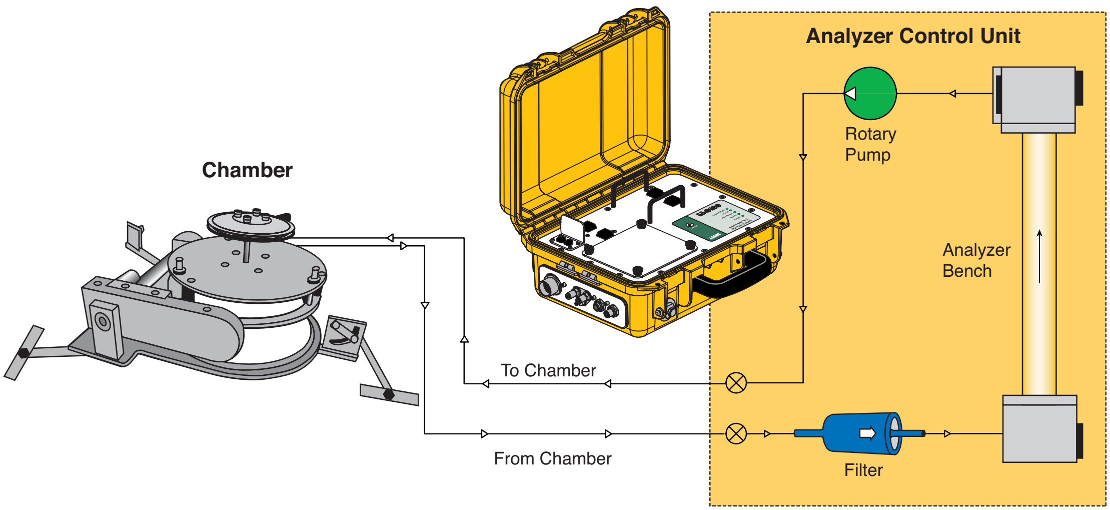


Figure 8-1. *The measurement flow path to the 8100-101 Long-Term Chamber.*

Assembling the Long-Term Chamber

To facilitate shipping, the Long-Term Chamber is partially disassembled. You will need to attach the three legs and the pressure vent to the chamber before using.

Make sure the O-ring is in the proper groove, and screw the pressure vent and tube into the top of the chamber. Tighten hand tight.

Note that there are two legs with a 22.9 cm (9") attachment arm, and one shorter leg with a 10.2 cm (4") attachment arm, as shown below in Figure 8-2. Two 10-32 × 3/4" phillips head screws are used to attach each leg to the Long-Term chamber base plate.

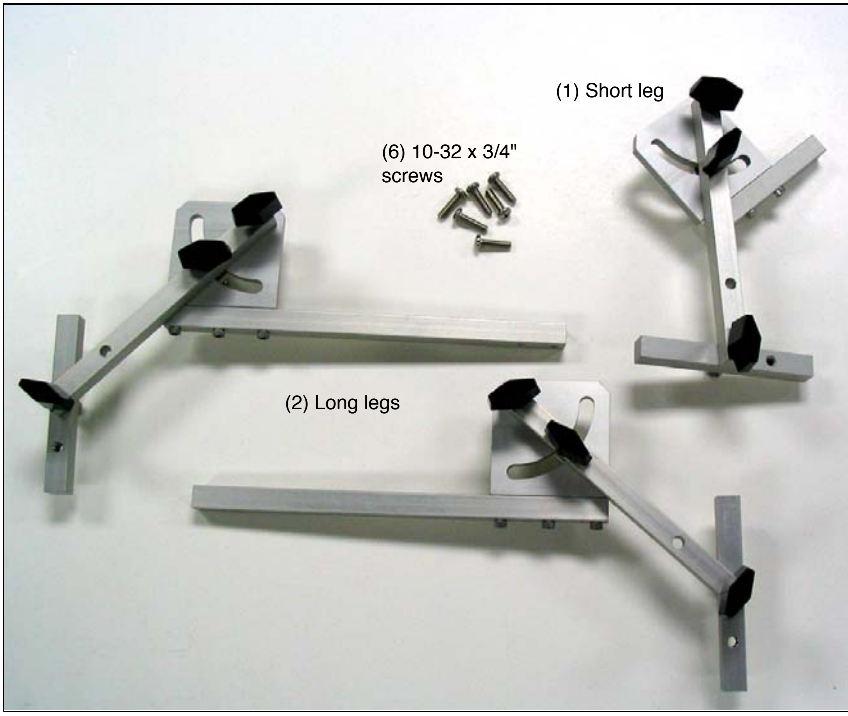


Figure 8-2. *Two long legs and a single short leg attach to the Long-Term chamber base plate.*

The short leg attaches to the rounded front end of the base plate. The leg mounts below the base plate. The two screws are inserted through the leg and then into the bottom of the base plate, as shown below in Figure 8-3.

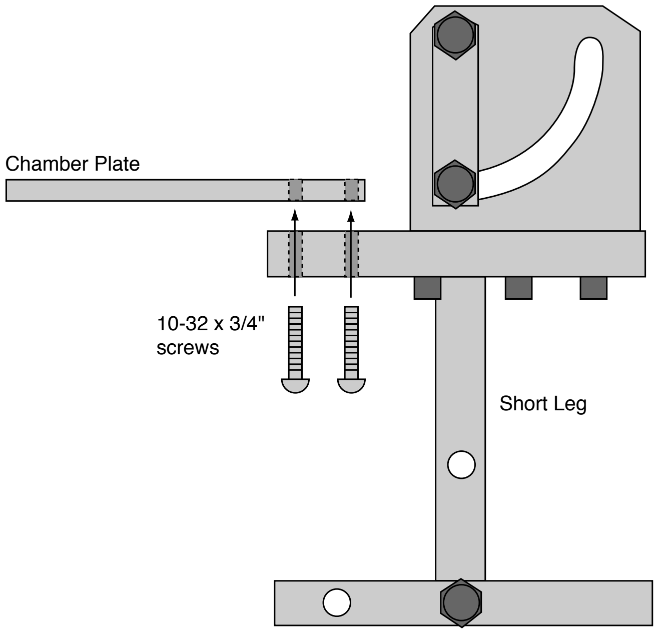


Figure 8-3. *Insert the screws through the short leg and up into the bottom of the base plate.*

The two long legs attach at opposite ends of the rear of the base plate. Note that there are three holes on each corner of the base plate; the two legs can be mounted perpindicular to the plate, or at an angle to provide a wider base when additional support is needed, as shown below in Figure 8-4.

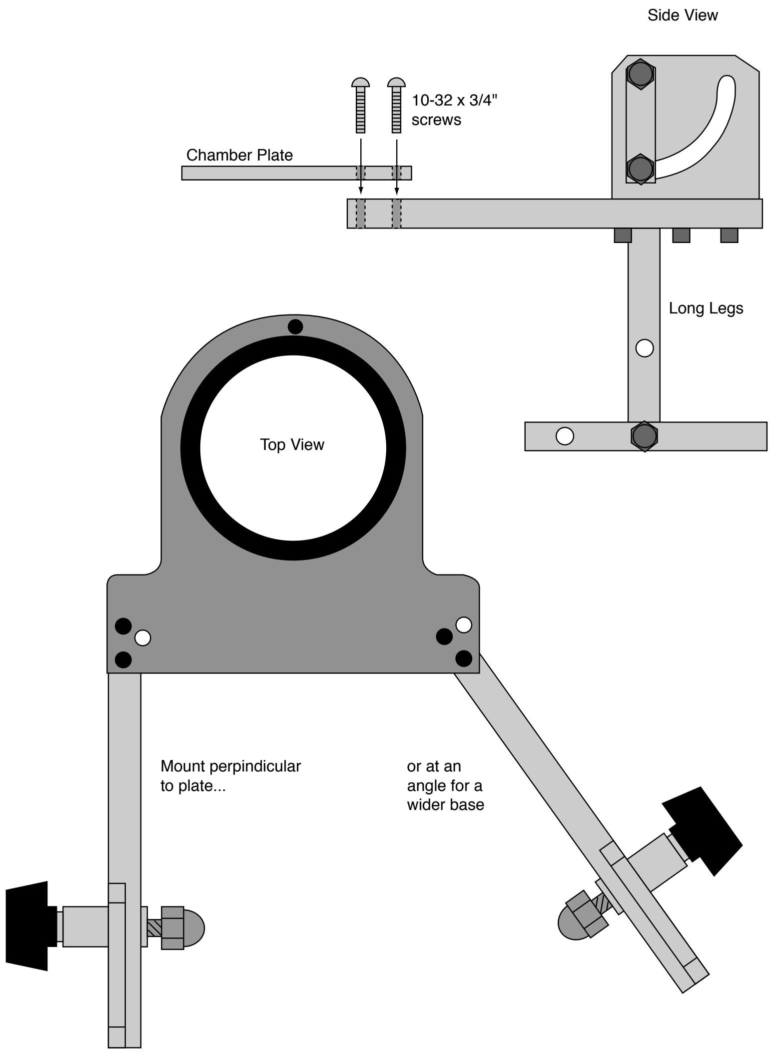


Figure 8-4. *The legs with long attachment arms can be mounted in line with the base plate, or at an angle to provide a broader base for additional support.*

The long legs are mounted beneath the base plate. The two screws for each leg are inserted through the base plate and into the leg, as shown in Figure 8-4.

The height and angle of the supports on each leg can be adjusted by loosening the black knobs. The bottom support on each leg can be angled and inserted into the ground, if desired. A hole is provided on the bottom support as well, which can be used to stake the legs, if desired. When fully assembled, the Long-Term Chamber will appear as shown below in Figure 8-5.

Figure 8-5. *Assembled 8100-101 Long-Term Chamber.*

Connecting the Long-Term Chamber to the Analyzer Control Unit

There are two hoses connected to the Long-Term Chamber; air to the chamber and air returning from the chamber to the Analyzer Control Unit. These hoses are connected to the side panel of the Analyzer Control Unit, as shown in Figure 2-2. The **Air In** hose has a male fitting, and the **Air Out** hose has a female fitting. To remove the hoses, slide the collar on the fittings and pull straight out. A small plug (p/n 9981-118, in the spares kit) is used to plug the Bellows port.

IMPORTANT NOTE: The base plate of the 8100-101 chamber should not rest directly on the soil. Although the plate is anodized, it can corrode, particularly under moist conditions, and after fertilization. In addition, placing the chamber base directly on the soil will block natural diffusion of CO_2 out of the soil, and will also create a continuously moist environment under the chamber. For these reasons, we recommend that the legs always be used to elevate the chamber base slightly.

Making Measurements

The following discussion assumes that you have already connected the Long-Term Chamber, installed soil collars several hours or more before making a measurement (see page 2-17), and have installed the Windows® and/or software for the Palm OS. This discussion also assumes that you have connected your external sensors, including soil moisture and/or soil temperature probes, to the Auxiliary Sensor Interface as described in Section 2, *Initial Setup*. Although they are similar, measurement protocols for both the LI-8100 Windows application software and the software for Palm OS are detailed below.

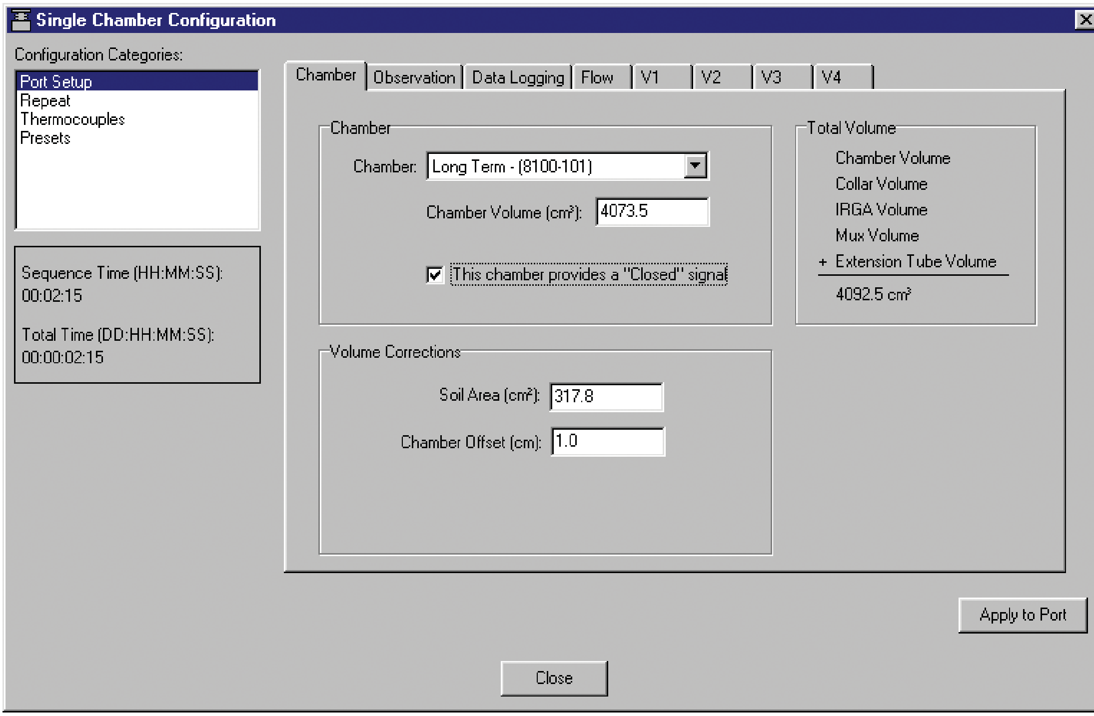
- Connect the cables, battery, and chamber as described in Section 2, *Initial Setup*.
- Connect the LI-8100 and your computer or PDA using the appropriate serial cables, as described in Section 2, *Initial Setup*.
- Turn the LI-8100 on using the ON/OFF button on the inside panel of the Analyzer Control Unit. Wait for the IRGA Ready light to illuminate. Note that the chamber moves to its open position at system startup.
- Measure the chamber offset as described in Section 2. Place the chamber over the soil collar.
- Insert the soil temperature probe and/or soil moisture probes at the desired depths and distances from the chamber.

Software Setup Using the LI-8100 Windows Application Software

The following discussion assumes that you have installed the LI-8100 application software on your PC, and are connected via the serial cables provided, or have configured the LI-8100 and your computer to communicate via a wireless network, as described in Section 11, *Using the Windows Software*. The measurement protocol is identical, regardless of how the PC is connected to the LI-8100.

1. Open the LI-8100 Windows application software and click on the **Connect** icon, or choose **Connect** from the Communication menu. Choose the serial (COM) port on the computer to which the LI-8100 is connected, and click Connect. Alternatively, click on **TCP/IP** and enter the IP address of the wireless card in the LI-8100 and click **Connect**. After a few moments, data will begin to appear in the Main window.

2. Choose **Measurement Configuration** from the Setup menu. The Single Chamber Configuration window appears.

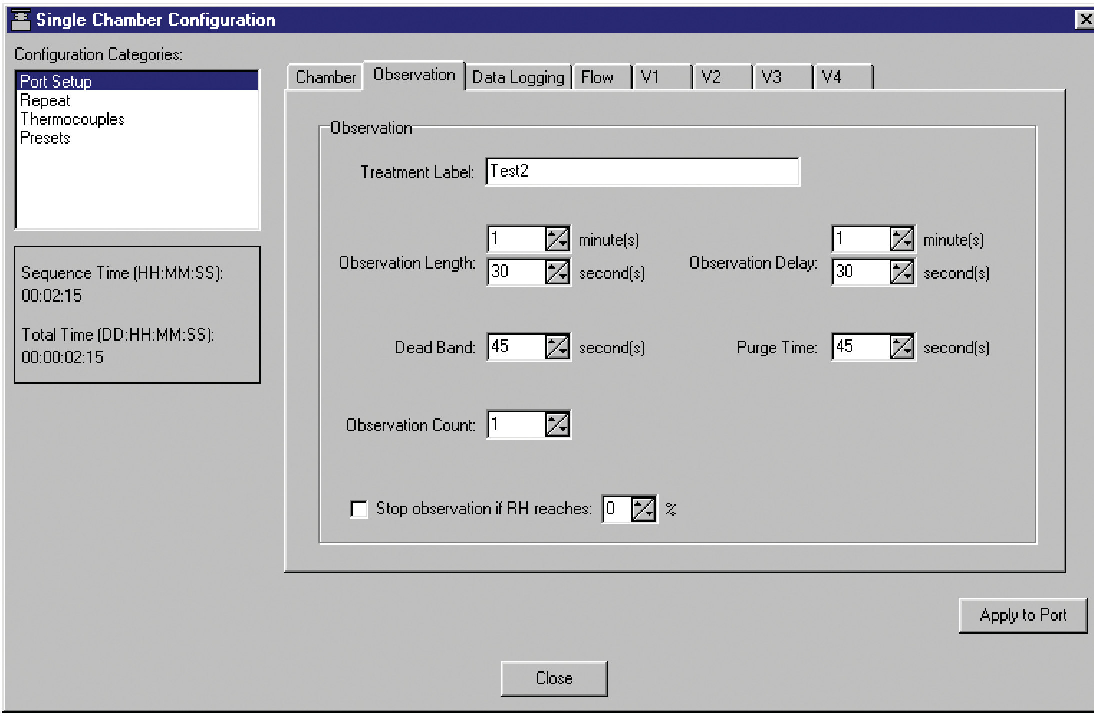


Use the Chamber pull-down menu to choose Long Term (8100-101). The Soil Area value and Chamber Volume values are automatically entered.

Enter the **Chamber Offset** (cm). The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the **Total Volume**. Measuring the Chamber Offset is described in Section 2, *Using Soil Collars*.

Click on **Apply to Port** to send these values to the LI-8100 for implementation.

3. Click on the **Observation** tab to open the Observation window.



Treatment Label

The **Treatment Label** is embedded as a separate column in the resulting data records.

Observation Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified* ***Dead Band*** *period*. At moderate to low CO_2 fluxes an Observation Length of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *Etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *Etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between

10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 Data Analysis (File Viewer) program, if Raw records are collected.

Observation Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Observation Delay

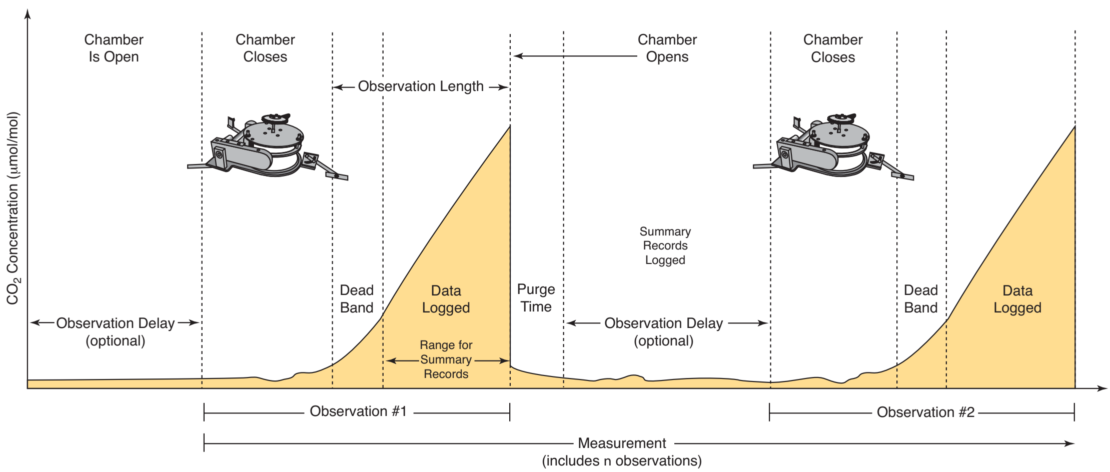
When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber CO_2 concentration may return to ambient levels in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture, for example, that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

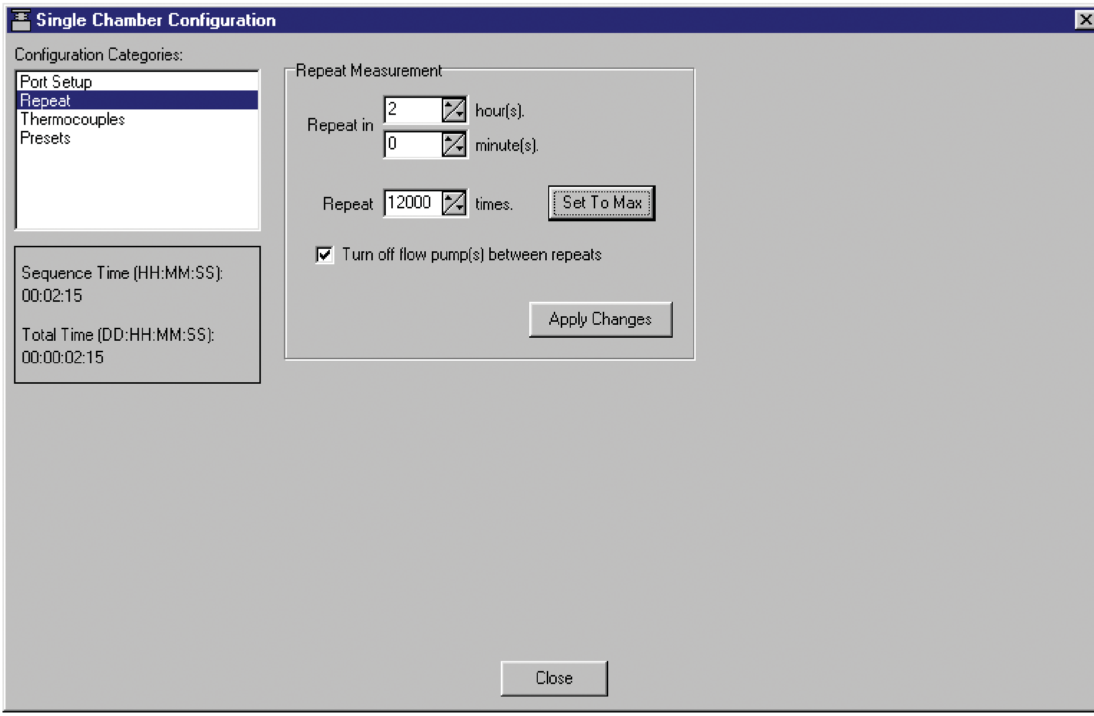
IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below, after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at "Observation Delay".



Stop Observation if RH reaches...

Enable the 'Stop Observatio if RH reaches' check box and enter a relative humidity value (if humidity is a concern at the measurement site). The Observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the Observation. If the Observation is aborted, a message is placed in the log file, and the measurement will continue at the next Observation.

4. Click on **Repeat** under the Configuration Categories list to view the Repeat window.

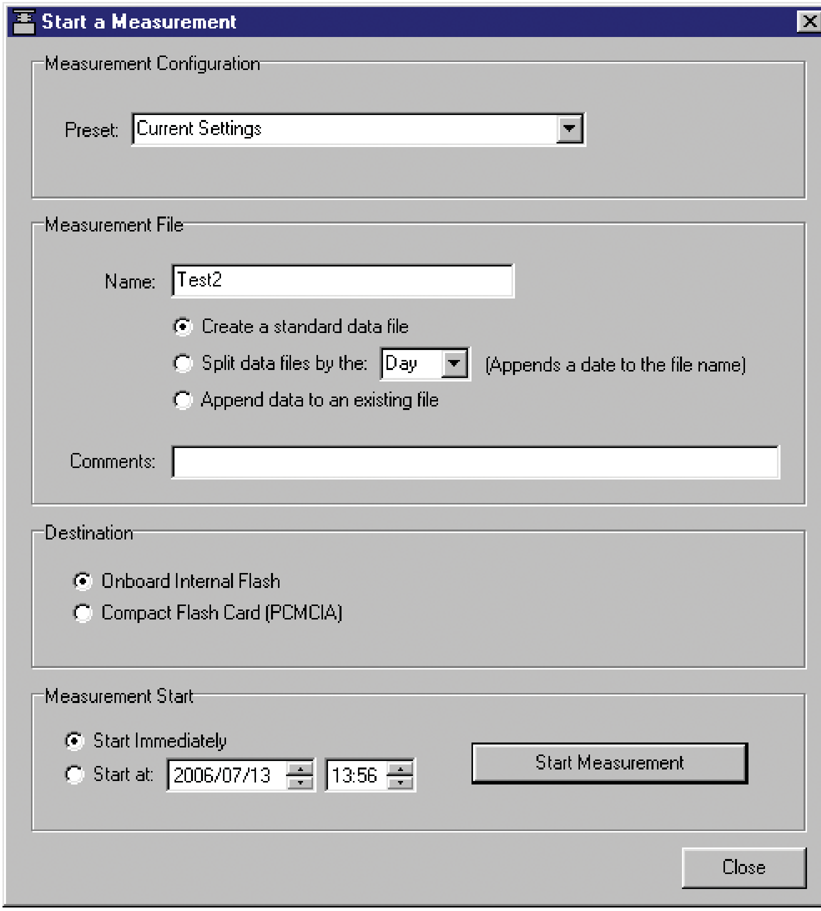


The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.

For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Set To Max** button).

You can elect to turn off the flow pump between repeated measurements to conserve battery life and extend the life of the pump by enabling the check box.

5. Choose **Start Measurement** from the Setup menu to open the Start a Measurement dialog.



Measurement Configuration

You can choose a defined set of measurement parameters from the Preset pull-down menu, or use the configuration as currently defined.

Measurement File

Enter a **File Name** and optional **Comments**. The **Comments** appear only in the header information. Files can be created in the standard data file format, where the entire data set is placed in a single file, as defined by the measurement configuration. Large files can be split into smaller files, in increments of 1 day, or 1 week. Files split by the day are appended with a date, beginning at 12:01 a.m. each day; files split by the week are appended with a date, beginning at a period 7 days after the first measurement is taken. Click the ‘Append data to an existing file’ button to add new measurement data at the end of the currently defined file.

Destination

Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time. Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Measurement Start

Enter a **Start** time. You can start the measurement immediately or choose to begin the measurement at a specified date and time.

6. Click **Start Measurement** to begin the measurement.

Software Setup Using the LI-8100 Application Software for Palm OS

The following discussion assumes that you have installed the LI-8100 application software on your PDA, and are connected via the serial cables provided, or have configured the LI-8100 and your PDA to communicate via a wireless network, as described in Section 12, *Using a PDA*. The measurement protocol is identical, regardless of how the PDA is connected to the LI-8100.

1. Open the LI-8100 Application software for Palm OS. Click on **Connect by Serial** if you are connected via serial cables, or **Connect by TCPIP** if you are using a wireless configuration.

2. Click on the Setup menu and choose **Measurement Protocol**. The Measurement Protocol screen appears (below).

Obs. Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At low to moderate CO_2 fluxes an **Observation Length** of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI8100 File Viewer program.

Obs. Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Obs. Delay

When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

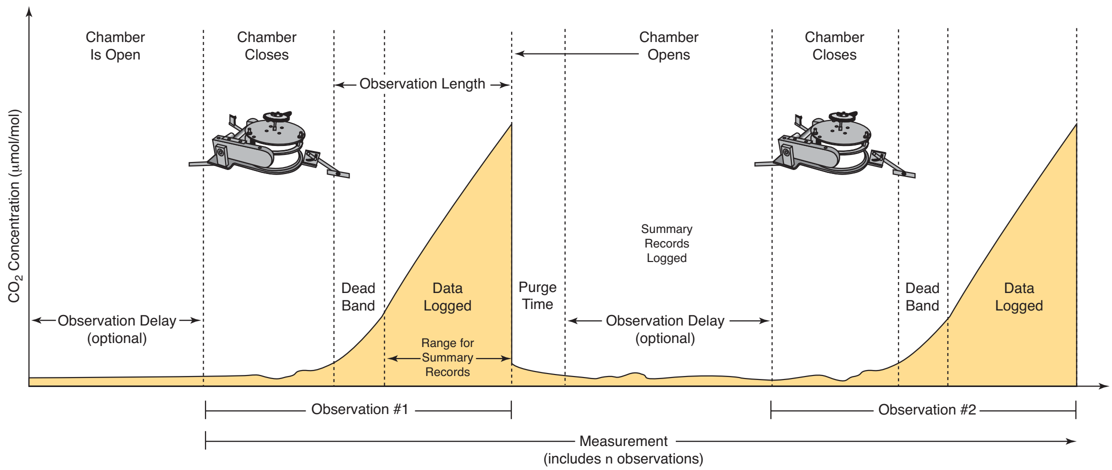
When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber air may return to ambient in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture, for example, that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below, after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation**

Delay has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at “Observation Delay”.

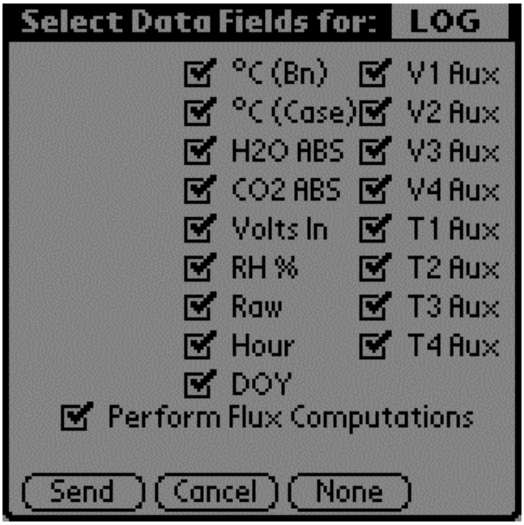


Additional Log Fields

Tap on Additional Log Fields to choose the values to be logged to memory. Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card.

Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Enable the Perform Flux Computations check box to automatically compute the flux rate after each measurement.



Tap **Send** to send the selected data fields to the LI-8100 for implementation.

Tap **Cancel** to close the page without sending the data fields.

Tap **None** to disable (uncheck) all data fields. None button changes to **All** when the fields are disabled.

The additional data values that can be logged are as follows:

Label	***Description***
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
Hour	Time of day.
DOY	Day of the year.
V1 Aux	Input at voltage channel 1 (soil moisture).
V2 Aux	Input at voltage channel 2 (soil moisture).
V3 Aux	Input at voltage channel 3 (soil moisture).
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

3. Click on the Setup menu and choose **Areas and Volumes.** The Areas, Volumes, & Flow Rate screen appears (below).

The Total Volume value is computed and displayed after the Chamber Offset, Soil Area, and Chamber Volume values are entered. IRGA Volume is set under "Instrument Settings" and is displayed here.

Chamber Offset

The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the Total System Volume. Measuring the **Chamber Offset** is described in Section 2, *Using Soil Collars*.

Soil Area

The area of soil encompassed by the soil collar, in cm^2. Calculate the Soil Area from the inside diameter of the soil collar. The default values in the LI-8100 software are given for the 10 cm and 20 cm soil collars provided by LI-COR.

Chamber Volume

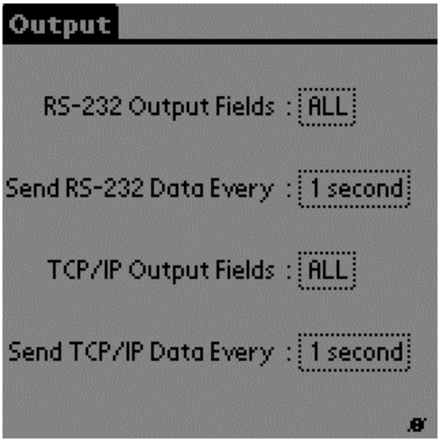
The **Chamber Volume** value includes the air inside the chamber, as well as from the tubing attached to the chamber. This volume is entered automatically when you choose the Survey or Long-Term chamber in software, but can be adjusted manually by the user if the chamber volume changes for any reason (i.e., the tubing length changes).

Flow Rate
The rotary pump in the LI-8100 Analyzer Control Unit provides a flow rate of 0.5 to 1.5 liter/minute to the chamber. In most cases you should operate the Survey and Long-Term chambers at the highest flow rate.

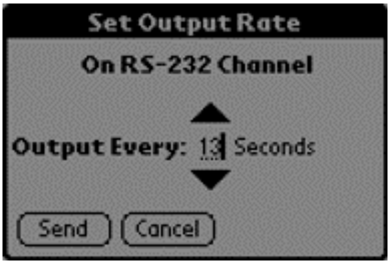
IRGA Volume
This is a factory-defined value that includes the volume of the optical bench and associated plumbing inside the Analyzer Control Unit. The default IRGA volume is 19 cm^3.

Total Volume
The total system volume, which is computed from the sum of the **Chamber Volume**, **IRGA Volume**, **Chamber Offset**, and **Soil Area**.

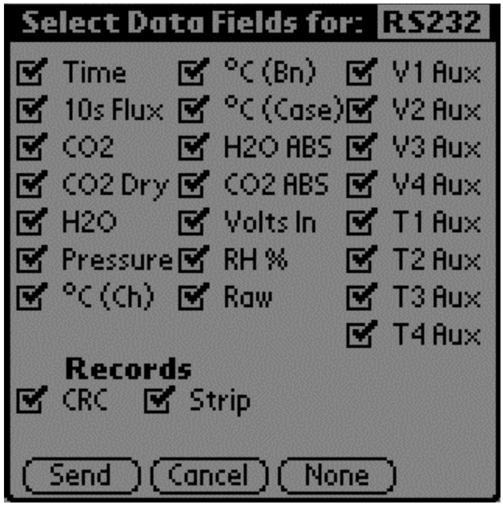
4. Click on the 8100 menu and choose **Outputs**. The Output screen appears (below), where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included. You can also choose the output frequency for both RS-232 and/or TCP/IP data.



Data can be output via RS-232 or TCP/IP at intervals between 1 and 20 seconds.



RS-232 Output Fields
Choose the data values to be sent to the RS-232 port.



The data values that can be output are as follows:

Label	***Description***
Time	Instrument time.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
CO2	Chamber CO_2 concentration in µmol/mol.
CO2 Dry	Chamber CO_2 concentration, corrected for water vapor dilution, in µmol/mol.
H2O	Chamber water vapor concentration, in mmol/mol.
Pressure	Atmospheric pressure in the optical bench (kPa).
°C (Ch)	Air temperature inside the soil chamber.
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
V1 Aux	Input at voltage channel 1.
V2 Aux	Input at voltage channel 2.
V3 Aux	Input at voltage channel 3.
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

Note that when the LI-8100 outputs data, each field is "marked up" using e**X**tensible **M**arkup **L**anguage (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the 'Strip' check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

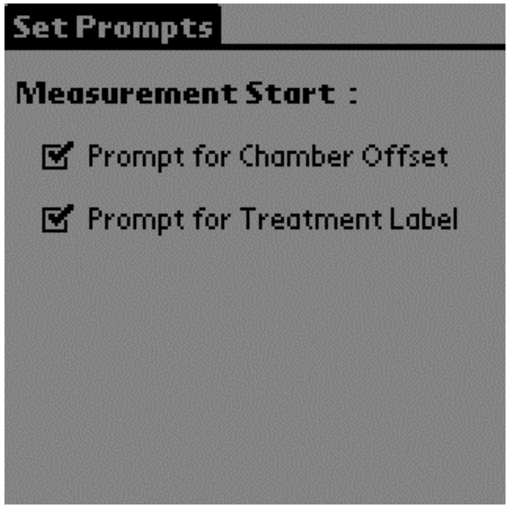
Disable the 'CRC' check box to remove CRC from the data. Note that the LI-8100 Palm OS application itself does *not* use CRC checking.

TCP/IP Output Fields

Tap on the TCP/IP field to configure the data values to be sent via the wireless card, if desired. Note that you can configure the TCP/IP (wireless) and/or RS-232 options while the other is enabled; changes will not take effect until data logging is stopped and restarted, however. For example, if you are currently logging data to the PC, you can configure the wireless output, but you must first stop logging data to the PC before beginning wireless output with the new configuration.

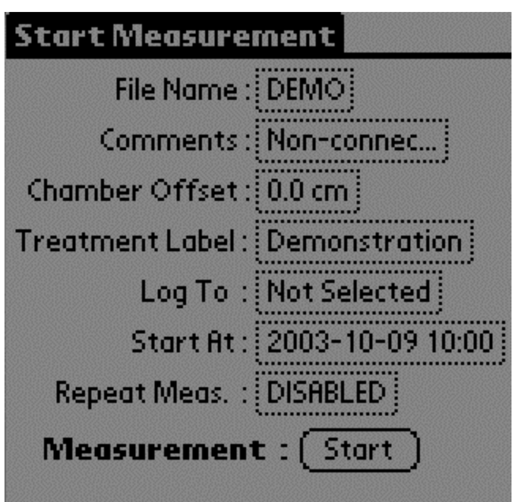
The data values that can be output are as shown above at RS-232 Output.

5. Click on the Utilities menu and choose **Prompts**. The Prompts screen appears (below).



This screen allows you to turn system prompts on or off. By default, a prompt appears whenever a new measurement is started, to enter the **Chamber Offset** (Collar Height) and **Treatment Label**. You can turn off these prompts by unchecking the appropriate boxes.

6. Click on the Setup menu and choose **Start Measurement**. The Start Measurement screen appears (below).



The Treatment Label is embedded as a separate column in the data records.

Enter a **File Name** and optional **Comments**. Enter the **Chamber Offset** and **Treatment Label.**

Note that if the **Chamber Offset** and **Treatment Label** prompts are enabled (see #5 above), you will be prompted for these values if they are not already entered on this screen when the **Start** button is pressed.

Log To
Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time.

Repeat Measurement and Start At:
The **Repeat Measurement** and **Start At** functions allow you to repeat the defined protocol at a regular clock interval. The **Start At:** parameter functions independent of the **Repeat Measurement** parameter; the **Repeat Measurement** function can be disabled, but you must still enter a valid **Start At:** time to intiate a measurement.

These functions are particularly useful when making long term, unattended measurements. For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations.

7. Tap **Start** to begin the measurement.

9 Using the 8100-104 Long-Term Chamber

General Description

The 8100-104 Long-Term Chamber is designed to make long term, diurnal measurements of soil CO_2 flux at a single location for weeks or months at a time.

A unique, moveable design minimizes the effects of the chamber on the natural soil conditions to give reliable results over long periods of time. A motor-driven "arm" moves the chamber away from the soil area to be measured, ensuring that the area of interest is subjected to normal, undisturbed precipitation, temperature, and shading effects. The low profile chamber design minimizes wind effects over the measurement location.

A double gasket system seals the chamber outside of the soil collar, and between the chamber and mounting plate, to minimize CO_2 leaks and wind effects. A pressure vent at the top of the chamber prevents pressure spikes when the chamber closes, and maintains the chamber pressure at the ambient level under calm and windy conditions.

The 8100-104 Long-Term Chamber is designed primarily for use with the LI-8150 Multiplexer. The 8100-104 has three integrated sensor inputs; sensors attached to these inputs can only be monitored when the chamber is connected to the Multiplexer. If the 8100-104 is used in single chamber mode with the LI-8100, auxiliary sensors must be connected to the Auxiliary Sensor Interface, not the chamber itself.

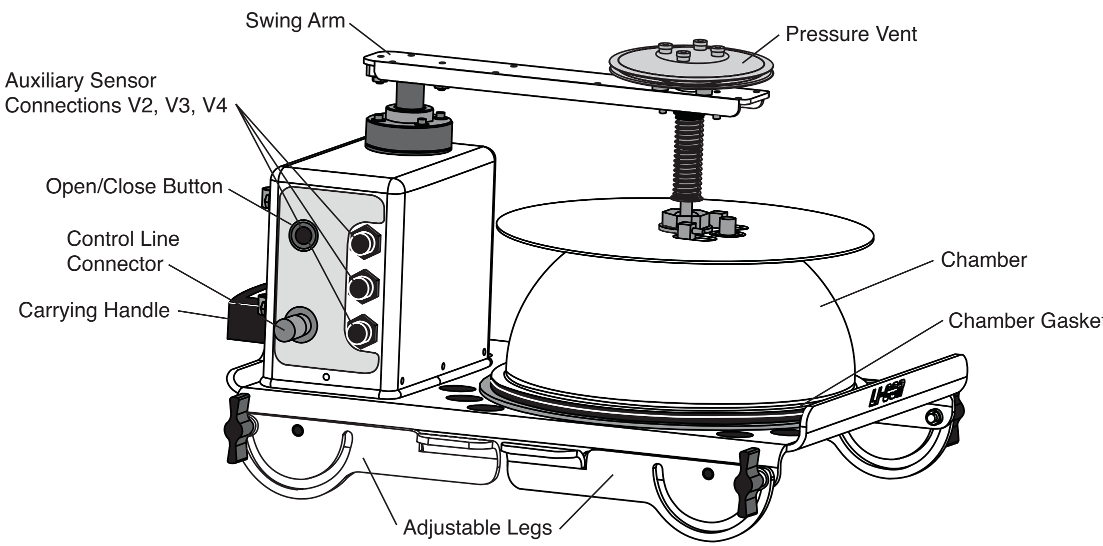


Figure 9-1. *8100-104 Long-Term Chamber.*

The 8100-104 differs from the 8100-101 Long-Term Chamber primarily in the way that the chamber moves away from the soil collar when the measurement is complete. The 8100-101 raises in a 180° arc straight up and back away from the soil collar. The 8100-104 chamber raises slightly before it swings outward in a 180° arc around the perimeter of the raised control panel (Fig. 9-2). This outward movement can have implications as to the placement of the chamber; the 8100-104 may not be appropriate for use in obstructed areas (e.g. within rows of crops), where the swing arm does not have complete freedom of movement. Note, however, that the open position can be changed, as described below.

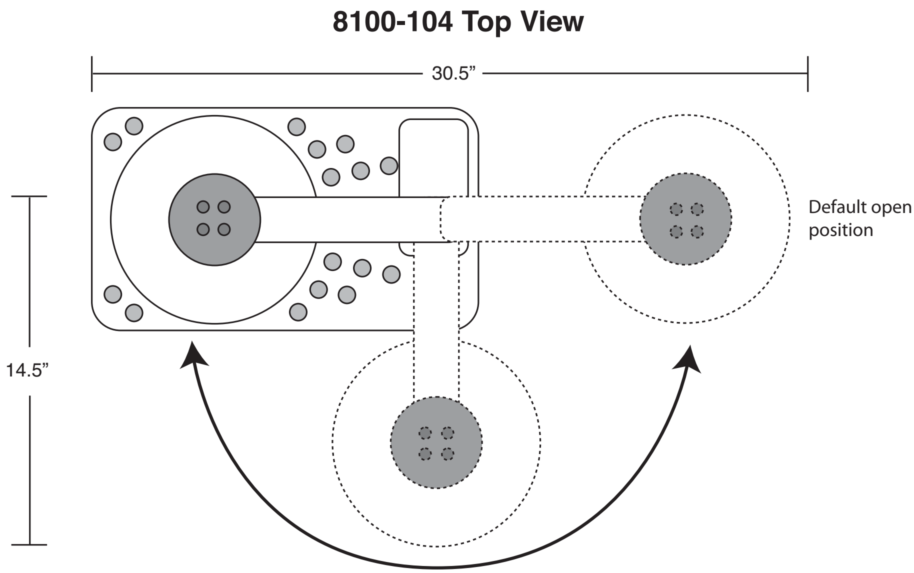


Figure 9-2. The 8100-104 Long-Term Chamber rotates in an ~180° arc via the swing arm.

Changing the Chamber Open Position

The default open position is approximately 180° from the closed position, as shown in Figure 9-2. There are, however, five additional open positions (Fig. 9-3) that can be programmed using the Open/Close button on the chamber control panel. This can be useful for areas where the terrain, or obstructions, don't permit the full 180° of movement. To change the open position:

1. Press and hold the Open/Close button for 5 seconds. Wait a few moments while the chamber positions itself.
2. Press the Open/Close button one time to move the chamber to its first open position (#5 in the diagram below). Continue to press the button one time to move the chamber to each of the other five open positions.
3. When the chamber is in the desired open position, hold the Open/Close button for 5 seconds again; the chamber will "remember" this position until it is reprogrammed.

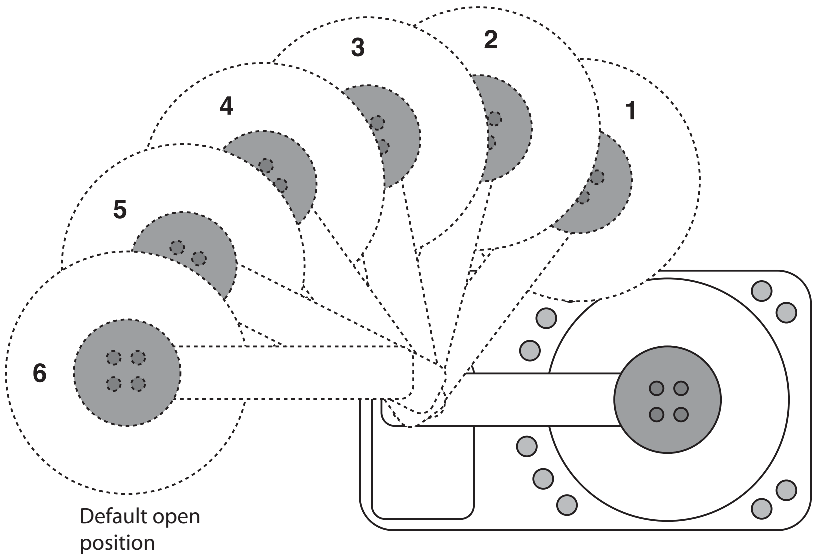


Figure 9-3. *The 8100-104 Long-Term Chamber has six programmable open positions.*

Press the Open/Close button twice in quick succession to "park" the chamber; the chamber raises slightly to prevent compression of the chamber gasket.

IMPORTANT! We recommend that you "park" the chamber before transport or long-term storage of the chamber.

Using Auxiliary Sensors with the 8100-104

The 8100-104 chamber differs from the 8100-101 in the way in which auxiliary sensors are attached, as well. As mentioned earlier, the 8100-104 has built-in sensor connectors; these connectors are active only when the chamber is connected to the LI-8150 Multiplexer. Soil moisture (p/n 8150-202) and soil temperature (p/n 8150-203) probes for use with the 8100-104 are fitted with 8-pin connectors that mate with the connectors on the control panel of the chamber. If the 8100-104 is to be used in single-chamber mode with the LI-8100, any auxiliary sensors must be wired into the Auxiliary Sensor Interface, as described in Section 2, "*Using the Auxiliary Sensor Interface*"; in this instance, the 8100-201 Soil Temperature and 8100-202 Soil Moisture probes are used.

NOTE: Install the sensor connector dust caps when not in use to prevent water ingress and connector corrosion.

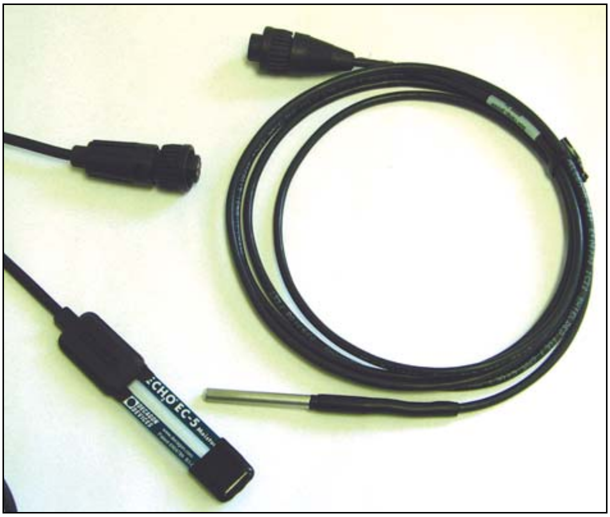


Figure 9-4. *The 8100-104 uses dedicated soil moisture (left) and soil temperature (right) probes which have 8-pin connectors for direct attachment to the chamber. These probes are active* ***only*** *when the 8100-104 is used in conjunction with the LI-8150 Multiplexer.*

The Measurement Flow Path

Air flow generated by a rotary pump inside the Analyzer Control Unit provides a steady flow of air to the Long-Term Chamber, with minimal pulsations. Air flow to the chamber provides mixing without using fans that can cause pressure gradients. Air returning from the chamber passes through a filter before it enters the optical bench of the infrared gas analyzer in the Analyzer Control Unit. The analyzer optical bench measures CO_2 and H_2O concentrations simultaneously; these concentrations are then used to calculate flux rate.

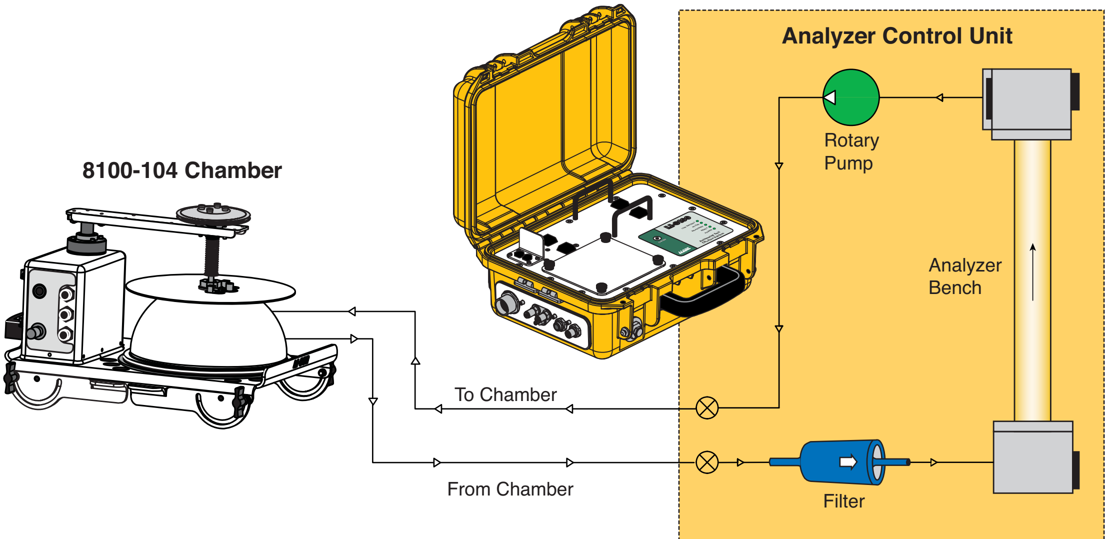


Figure 9-5. *The measurement flow path to the 8100-104 Long-Term Chamber.*

Connecting the Long-Term Chamber to the Analyzer Control Unit or Multiplexer

There are two short hoses connected to the 8100-104 Long-Term Chamber; air to the chamber and air returning from the chamber to the Analyzer Control Unit. The 8100-104 requires the use of an additional cable to connect to the Analyzer Control Unit or the LI-8150 Multiplexer; the 8100-704 is a 2m accessory cable, and the 8150-705 is a 15m accessory cable. These cables are connected to the side panel of the Analyzer Control Unit, as shown in Figure 2-2, or the LI-8150 Multiplexer side panel, as shown in Figure 10-8. The **Air In** hose has a male fitting, and the **Air Out** hose has a female fitting. To remove the hoses, slide the collar on the fittings and pull straight out. A small plug (p/n 9981-118, in the spares kit) is used to plug the Bellows port. Connect the control cable to the port labeled Control Line on the chamber control panel.

Making Measurements

The following discussion assumes that you have already connected the Long-Term Chamber, installed soil collars several hours or more before making a measurement (see page 2-17), and have installed the Windows® and/or software for the Palm OS. This discussion also assumes that you have connected your external sensors, including soil moisture and/or soil temperature probes, to the Auxiliary Sensor Interface as described in Section 2, *Initial Setup,* or directly to the chamber itself (Multiplexer present).

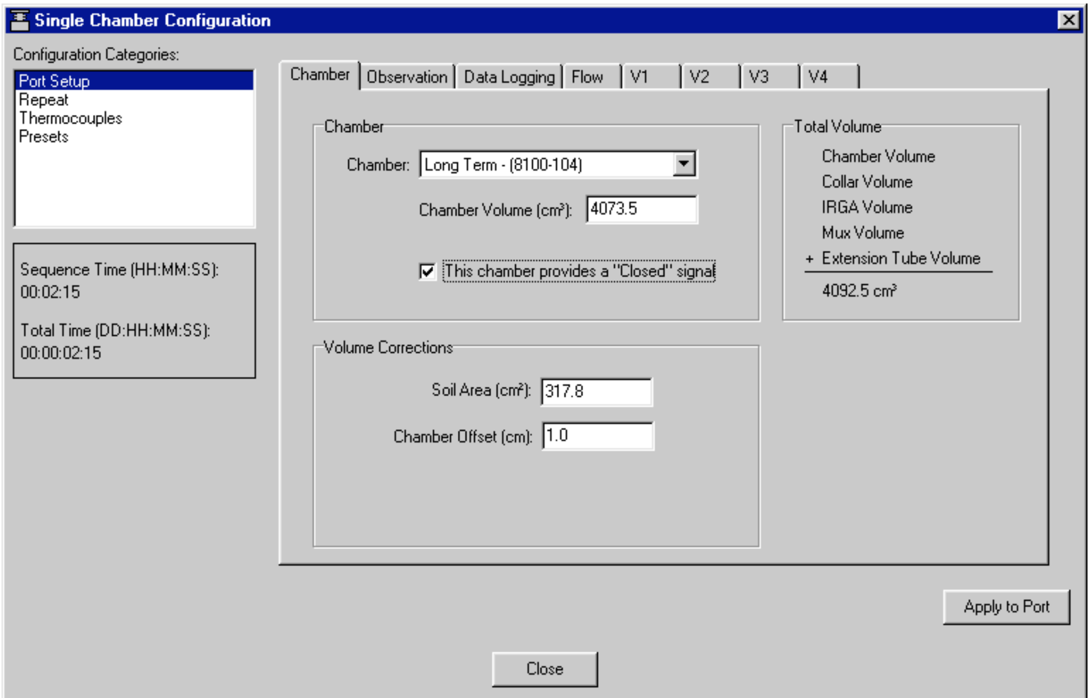
Although they are similar, measurement protocols for both the LI-8100 Windows application software and the software for Palm OS are detailed below.

- Connect the cables, battery, and chamber as described in Section 2, *Initial Setup*.
- Connect the LI-8100 and your computer or PDA using the appropriate serial cables, as described in Section 2, *Initial Setup*.
- Turn the LI-8100 on using the ON/OFF button on the inside panel of the Analyzer Control Unit. Wait for the IRGA Ready light to illuminate. Note that the chamber moves to its open position at system startup.
- Measure the distance between the soil surface and the upper edge of the chamber base plate. Place the chamber over the soil collar. Adjust the legs, if necessary so that the chamber is approximately level over the soil collar.
- Insert the soil temperature probe and/or soil moisture probes at the desired depths and distances from the chamber.

Software Setup Using the LI-8100 Windows Application Software

The following discussion assumes that you have installed the LI-8100 application software on your PC, and are connected via the serial cables provided, or have configured the LI-8100 and your computer to communicate via a wireless network, as described in Section 11, *Using the Windows Software*. The measurement protocol is identical, regardless of how the PC is connected to the LI-8100.

1. Open the LI-8100 Windows application software and click on the **Connect** icon, or choose **Connect** from the Communication menu. Choose the serial (COM) port on the computer to which the LI-8100 is connected, and click Connect. Alternatively, click on **TCP/IP** and enter the IP address of the wireless card in the LI-8100 and click **Connect**. After a few moments, data will begin to appear in the Main window.
2. Choose **Measurement Configuration** from the Setup menu. The Single Chamber Configuration window appears.

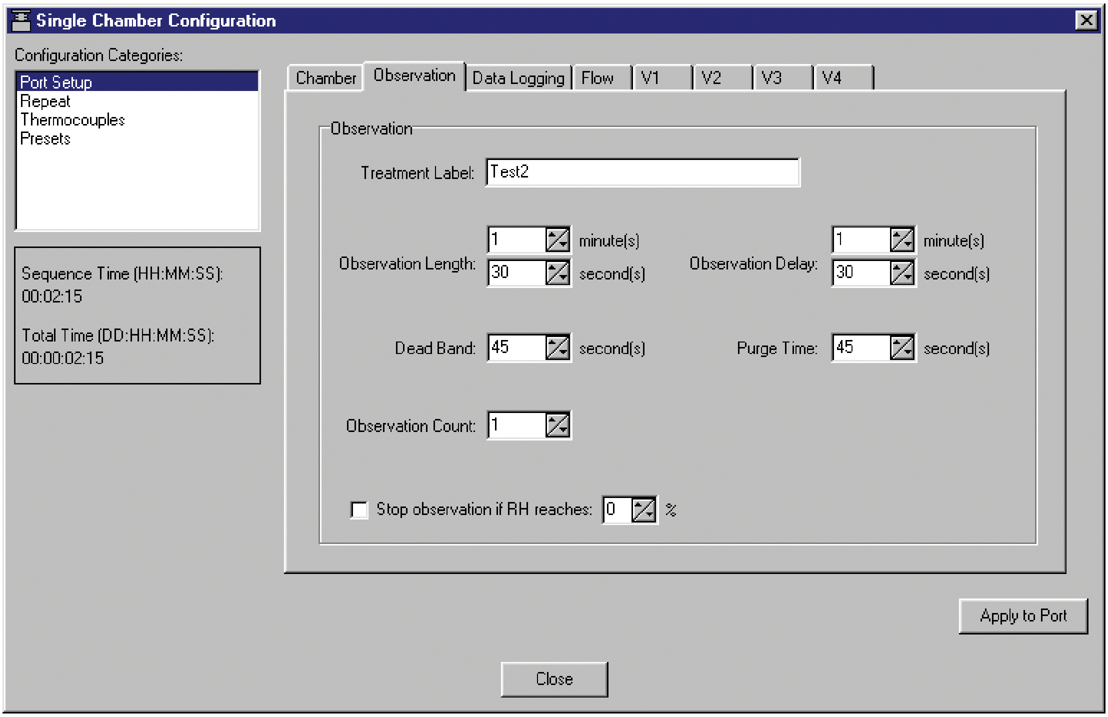


Use the Chamber pull-down menu to choose Long Term (8100-104). The Soil Area value and Chamber Volume values are automatically entered.

Enter the **Chamber Offset** (cm). The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the **Total Volume**. Measuring the Chamber Offset is described in Section 2, *Using Soil Collars*.

Click on **Apply to Port** to send these values to the LI-8100 for implementation.

3. Click on the **Observation** tab to open the Observation window.



Treatment Label

The **Treatment Label** is embedded as a separate column in the resulting data records.

Observation Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At moderate to low CO_2 fluxes an Observation Length of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *Etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *Etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 Data Analysis (File Viewer) program, if Raw records are collected.

Observation Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Observation Delay

When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

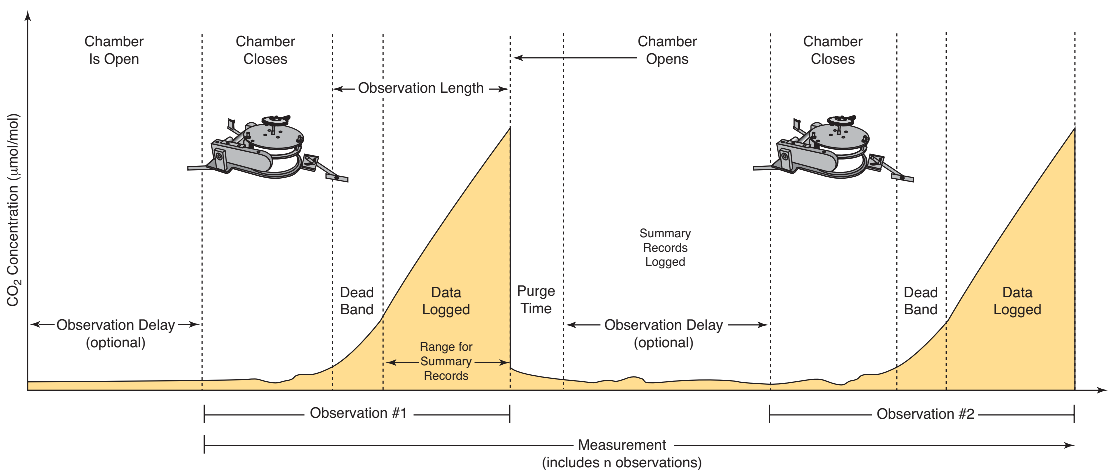
When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber CO_2 concentration may return to ambient levels in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture, for example, that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber.

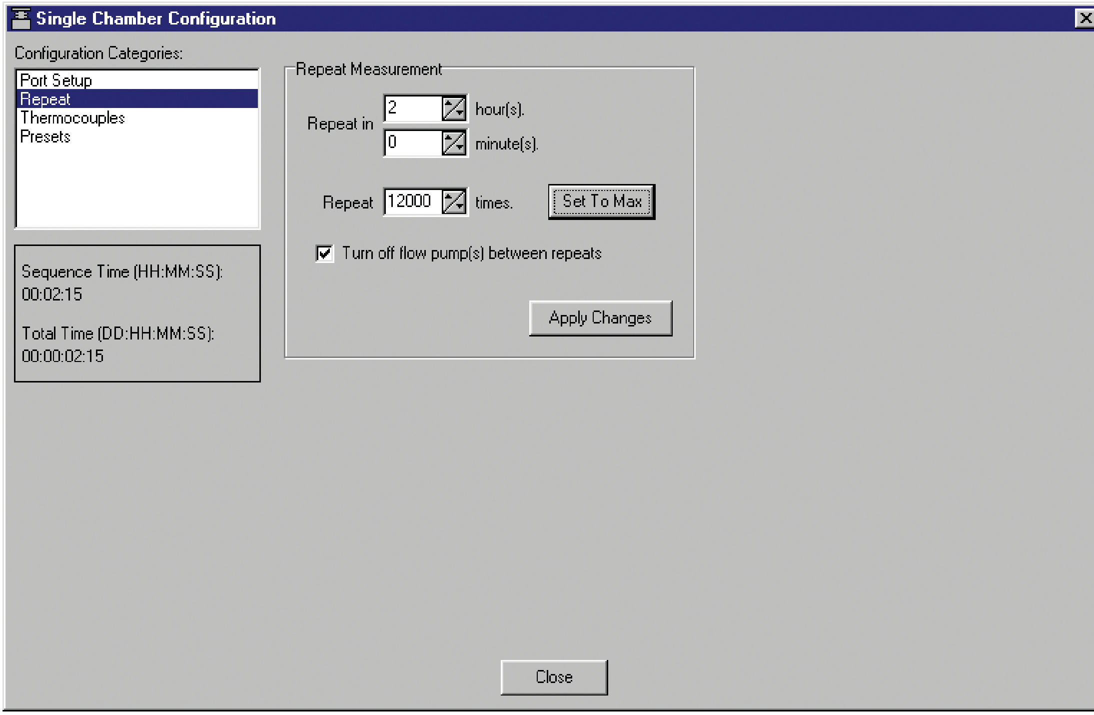
Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below (8100-101 shown for illustrative purposes), after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at "Observation Delay".



Stop Observation if RH reaches...

Enable the 'Stop Observatio if RH reaches' check box and enter a relative humidity value (if humidity is a concern at the measurement site). The Observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the Observation. If the Observation is aborted, a message is placed in the log file, and the measurement will continue at the next Observation.

4. Click on **Repeat** under the Configuration Categories list to view the Repeat window.

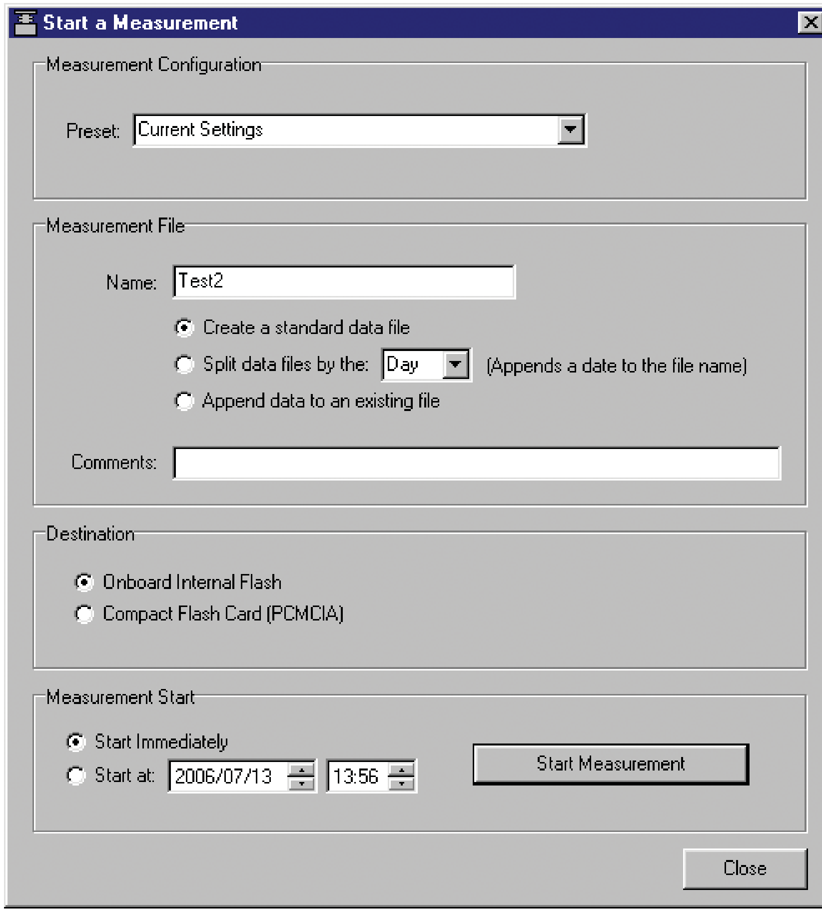


The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.

For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Set To Max** button).

You can elect to turn off the flow pump between repeated measurements to conserve battery life and extend the life of the pump by enabling the check box.

5. Choose **Start Measurement** from the Setup menu to open the Start a Measurement dialog.



Measurement Configuration

You can choose a defined set of measurement parameters from the Preset pull-down menu, or use the configuration as currently defined.

Measurement File

Enter a **File Name** and optional **Comments**. The **Comments** appear only in the header information. Files can be created in the standard data file format, where the entire data set is placed in a single file, as defined by the measurement configuration. Large files can be split into smaller files, in increments of 1 day, or 1 week. Files split by the day are appended with a date, beginning at 12:01 a.m. each day; files split by the week are appended with a date, beginning at a period 7 days after the first measurement is taken. Click the 'Append data to an existing file' button to add new measurement data at the end of the currently defined file.

Destination
Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time. Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Measurement Start
Enter a **Start** time. You can start the measurement immediately or choose to begin the measurement at a specified date and time.

6. Click **Start Measurement** to begin the measurement.

Software Setup Using the LI-8100 Application Software for Palm OS

The following discussion assumes that you have installed the LI-8100 application software on your PDA, and are connected via the serial cables provided, or have configured the LI-8100 and your PDA to communicate via a wireless network, as described in Section 12, *Using a PDA*. The measurement protocol is identical, regardless of how the PDA is connected to the LI-8100.

1. Open the LI-8100 Application software for Palm OS. Click on **Connect by Serial** if you are connected via serial cables, or **Connect by TCPIP** if you are using a wireless configuration.

2. Click on the Setup menu and choose **Measurement Protocol**. The Measurement Protocol screen appears (below).

Obs. Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At low to moderate CO_2 fluxes an **Observation Length** of 90 to 120 seconds is usually adequate.

Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *etime* will register -1.

Dead Band

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI8100 File Viewer program.

Obs. Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (below).

Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

Obs. Delay

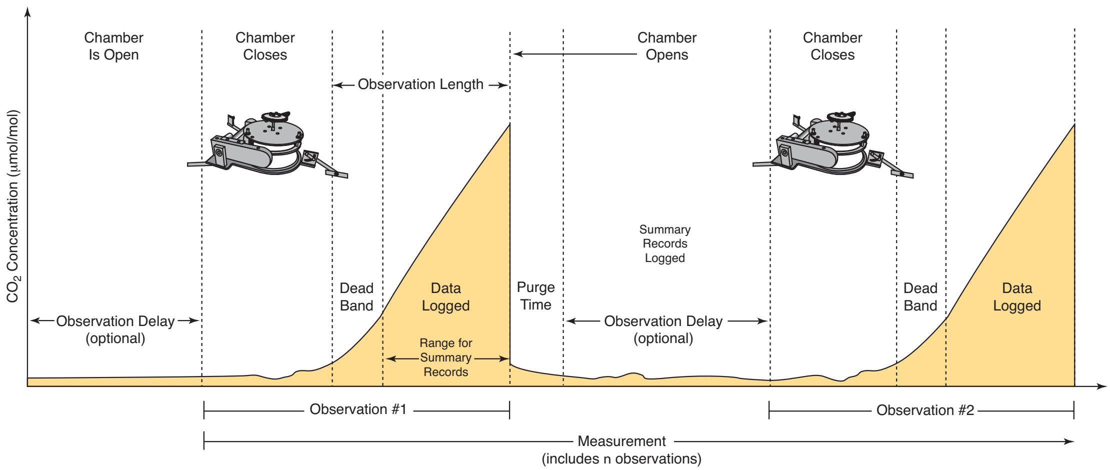
When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber air may return to ambient in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture, for example, that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below (8100-101 shown for illustrative purposes), after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at "Observation Delay".

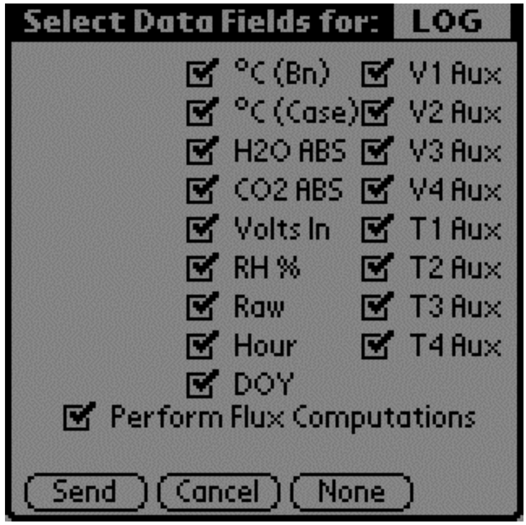


Additional Log Fields

Tap on Additional Log Fields to choose the values to be logged to memory. Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card.

Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Enable the Perform Flux Computations check box to automatically compute the flux rate after each measurement.



Tap **Send** to send the selected data fields to the LI-8100 for implementation.

Tap **Cancel** to close the page without sending the data fields.

Tap **None** to disable (uncheck) all data fields. None button changes to **All** when the fields are disabled.

The additional data values that can be logged are as follows:

Label	***Description***
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
Hour	Time of day.
DOY	Day of the year.
V1 Aux	Input at voltage channel 1 (soil moisture).
V2 Aux	Input at voltage channel 2 (soil moisture).
V3 Aux	Input at voltage channel 3 (soil moisture).
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

3. Click on the Setup menu and choose **Areas and Volumes.** The Areas, Volumes, & Flow Rate screen appears (below).

The Total Volume value is computed and displayed after the Chamber Offset, Soil Area, and Chamber Volume values are entered. IRGA Volume is set under "Instrument Settings" and is displayed here.

Chamber Offset

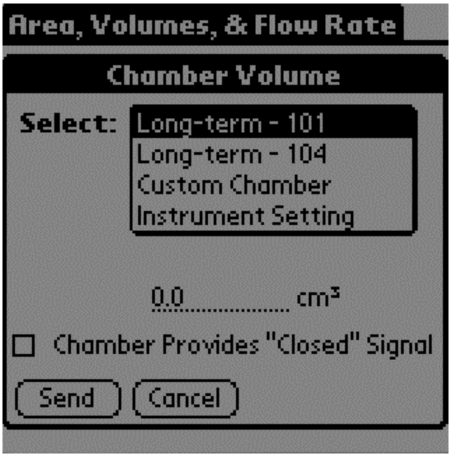
The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the Total System Volume. Measuring the **Chamber Offset** is described in Section 2, *Using Soil Collars*.

Soil Area

The area of soil encompassed by the soil collar, in cm^2. Calculate the Soil Area from the inside diameter of the soil collar. The default values in the LI-8100 software are given for the 10 cm and 20 cm soil collars provided by LI-COR.

Chamber Volume

The **Chamber Volume** value includes the air inside the chamber, as well as from the tubing attached to the chamber. This volume is entered automatically when you choose the Survey or Long-Term chamber in software, but can be adjusted manually by the user if the chamber volume changes for any reason (i.e., the tubing length changes).



Choose Long-term – 104; the Chamber Volume is automatically entered.

Flow Rate

The rotary pump in the LI-8100 Analyzer Control Unit provides a flow rate of 0.5 to 1.5 liter/minute to the chamber. In most cases you should operate the Survey and Long-Term chambers at the highest flow rate.

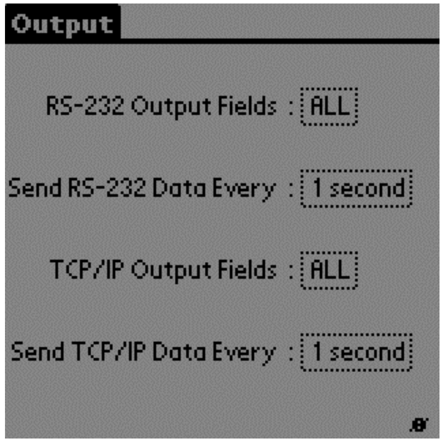
IRGA Volume

This is a factory-defined value that includes the volume of the optical bench and associated plumbing inside the Analyzer Control Unit. The default IRGA volume is 19 cm^3.

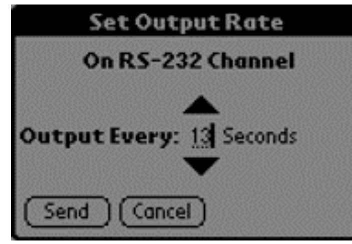
Total Volume

The total system volume, which is computed from the sum of the **Chamber Volume**, **IRGA Volume**, **Chamber Offset**, and **Soil Area**.

4. Click on the 8100 menu and choose **Outputs**. The Output screen appears (below), where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included. You can also choose the output frequency for both RS-232 and/or TCP/IP data.

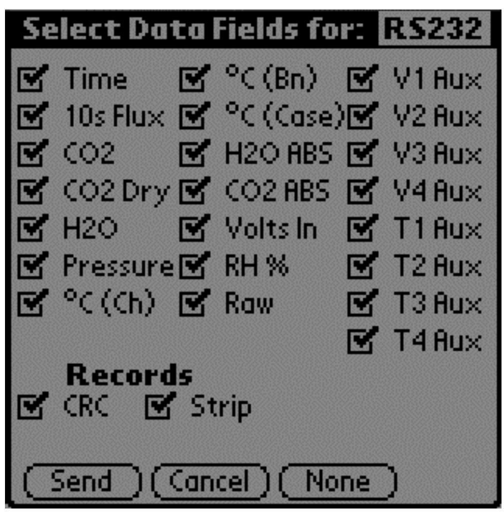


Data can be output via RS-232 or TCP/IP at intervals between 1 and 20 seconds.



RS-232 Output Fields

Choose the data values to be sent to the RS-232 port.



The data values that can be output are as follows:

Label	***Description***
Time	Instrument time.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
CO2	Chamber CO_2 concentration in µmol/mol.
CO2 Dry	Chamber CO_2 concentration, corrected for water vapor dilution, in µmol/mol.
H2O	Chamber water vapor concentration, in mmol/mol.
Pressure	Atmospheric pressure in the optical bench (kPa).

°C (Ch)	Air temperature inside the soil chamber.
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
V1 Aux	Input at voltage channel 1.
V2 Aux	Input at voltage channel 2.
V3 Aux	Input at voltage channel 3.
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

Note that when the LI-8100 outputs data, each field is "marked up" using e**X**tensible **M**arkup **L**anguage (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the 'Strip' check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

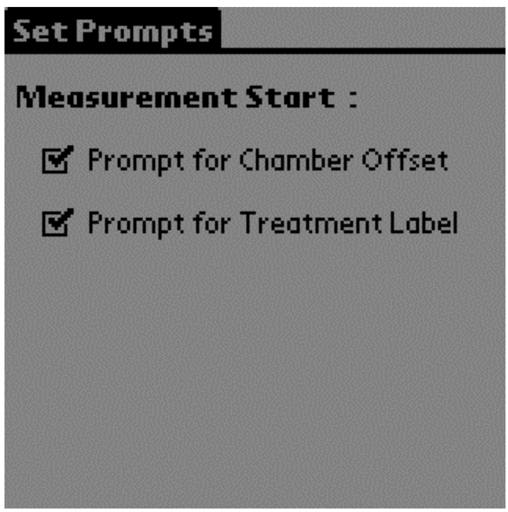
Disable the 'CRC' check box to remove CRC from the data. Note that the LI-8100 Palm OS application itself does *not* use CRC checking.

TCP/IP Output Fields

Tap on the TCP/IP field to configure the data values to be sent via the wireless card, if desired. Note that you can configure the TCP/IP (wireless) and/or RS-232 options while the other is enabled; changes will not take effect until data logging is stopped and restarted, however. For example, if you are currently logging data to the PC, you can configure the wireless output, but you must first stop logging data to the PC before beginning wireless output with the new configuration.

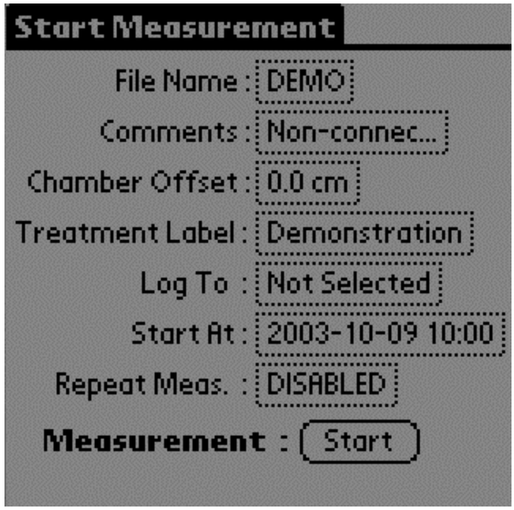
The data values that can be output are as shown above at RS-232 Output.

5. Click on the Utilities menu and choose **Prompts**. The Prompts screen appears (below).



This screen allows you to turn system prompts on or off. By default, a prompt appears whenever a new measurement is started, to enter the **Chamber Offset** (Collar Height) and **Treatment Label**. You can turn off these prompts by unchecking the appropriate boxes.

6. Click on the Setup menu and choose **Start Measurement**. The Start Measurement screen appears (below).



The Treatment Label is embedded as a separate column in the data records.

Enter a **File Name** and optional **Comments**. Enter the **Chamber Offset** and **Treatment Label.**

Note that if the **Chamber Offset** and **Treatment Label** prompts are enabled (see #5 above), you will be prompted for these values if they are not already entered on this screen when the **Start** button is pressed.

Log To

Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time.

Repeat Measurement and Start At:

The **Repeat Measurement** and **Start At** functions allow you to repeat the defined protocol at a regular clock interval. The **Start At:** parameter functions independent of the **Repeat Measurement** parameter; the **Repeat Measurement** function can be disabled, but you must still enter a valid **Start At:** time to intiate a measurement.

These functions are particularly useful when making long term, unattended measurements. For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations.

7. Tap **Start** to begin the measurement.

10 Using the LI-8150 Multiplexer

About the LI-8150

The LI-8150 Multiplexer is an accessory for the LI-8100 that makes it possible to connect as many as 16 individual soil chambers at one time, which are sampled and controlled by the LI-8100 Analyzer Control Unit.

The LI-8150 expands the capabilities of the LI-8100 and provides a simple solution for spatial and temporal sampling. The LI-8150 allows the researcher to control the number of chambers needed for his/her study and offers the flexibility of adding more chambers as needed. The LI-8150 is constructed with the same attention to detail as the LI-8100, and features a number of innovative design details:

- Choose from 8 or 16 port configurations – 8-port system can be easily upgraded to 16-port system
- Durable, weatherproof connectors and case
- High flow, low power, long-life solenoid valves
- Filter assemblies clean incoming air
- LED indicator panel provides Multiplexer diagnostic information
- System software for leak testing without the need for additional hardware

The LI-8150 can also be connected to ordinary gas sampling lines for vertical profiling or other studies. A 15m extension cable can be connected to each soil chamber to provide a measurement diameter of 30m.

Figure 10-1. *As many as 16 chambers can be connected at one time, with a measurement diameter of 30 m.*

What's What

If you have just taken delivery of your LI-8150 check the packing list to verify that you received everything ordered, including the following items:

Cable/Hose Assembly

Contains all cables and hoses for connection to the LI-8100 Analyzer Control Unit. Setup instructions are given later in this section.

Spare Parts Kit

This box contains replacement parts for your LI-8150. As you become familiar with the system you will learn which items to keep close at hand and which items can be stored away. Additional spares kits are packaged with the soil chambers, as well.

The spares kits include these commonly used items:

Description	Qty.	LI-COR Part No.
Multiplexer Spares Kit	1	9981-130
Urethane Tubing, 1/8″ ID x ¼″ OD	3 ft.	222-00303
Hose Barb T-Fitting	2	300-02627
¼″ Quick Connect Plug	2	300-08151
3 Amp Fuse	1	439-04215
4 Amp Fuse	1	439-08516
Jumper Tube Assembly	1	9981-142
Filter Replacement Kit (set of 8)	1 or 2*	8150-909

* Two kits are included with the LI-8150-16 Multiplexer configuration.

Optional Accessories

DC Power Cable (8150-706)

A 3 m cable with bare wire leads for connection to a user-supplied DC power source (10.5-14.5 VDC). An optional AC power supply (below) is also available.

8150-770 AC Power Supply

When used with the LI-8150 Multiplexer, the 8150-770 AC Power Supply is used to provide power to both the Multiplexer and the LI-8100. The 8100-770 provides a constant 12VDC source (4.5A maximum) to the Multiplexer and LI-8100. The Power Supply is weather resistant, O-ring sealed, and is designed for long-term outdoor deployment.

Figure 10-2. *8150-770 AC Power Supply.*

The 8150-770 has an input voltage range of 115-120 or 230-240VAC; ***the range is switch-selectable, and must be configured before applying power.*** Loosen the 4 screws in each corner on the top panel of the power supply. Slide the top cover away from the supply; note that the cover is attached via a grounding wire and cannot be fully removed. Verify that the switch is in the correct position for your mains power supply (choose 115 for 115-120VAC, or 230 for 230-240VAC).

Note that the voltage switch is pre-configured at the factory; if you need to move the voltage switch, it is likely that you will need to change the fuse, as well. Use a flathead screwdriver to loosen the cap on the fuse holder (see below) and check to see that the proper fuse is installed. A 1A fuse (p/n 439-08924) is used when the voltage selector switch is set to 230VAC, and a 2A fuse (p/n 439-08923) is used when the voltage selector switch is in the 115VAC position. Spare fuses can be found in the 8150-770 spares kit.

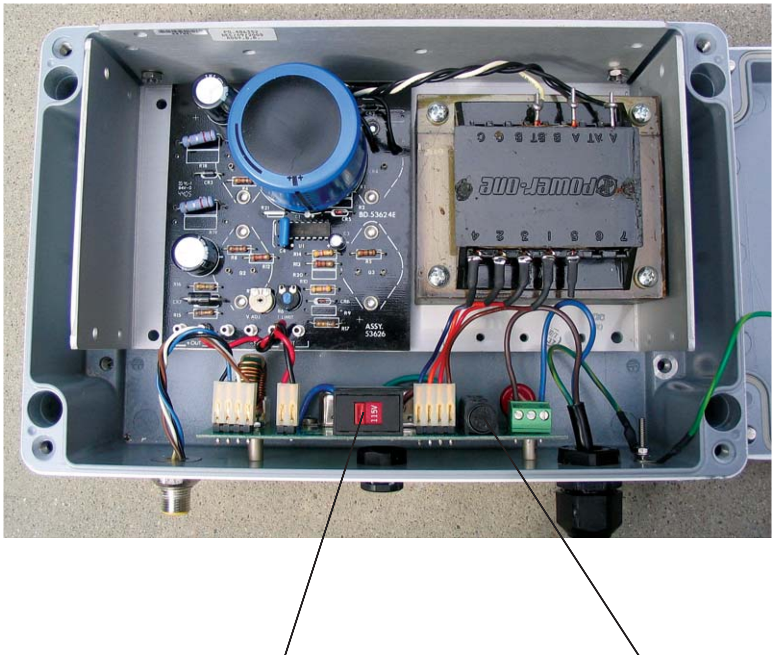


Figure 10-3. *Location of voltage selector switch and fuse holder.*

The 8150-770 includes a 2m power cord that is used to connect the power supply to the LI-8150 Multiplexer (p/n 9981-140). Note that the cord can be used in any orientation; either end can connect to the Power Supply or Multiplexer. The system is also supplied with an attached AC power cord. To protect against electrical shock, the Power Supply must be connected to a properly grounded AC mains receptacle; we recommend that the mains power to the instrument be supplied by a ground-fault circuit interrupter (GFCI). If an extension cord is to be used with the Power Supply, make sure that it is rated for outdoor use. Connect the power cord between the Power Supply and Multiplexer; plug the AC cord into mains power, and then power the LI-8150 and LI-8100 on.

The 8150-770 AC Power Supply can rest on the ground, or be mounted off of the ground using holes in the 8150-770 box. If the 8150-770 is allowed to rest on the ground, and there is a possibility of water pooling around, or immersing the unit, it is recommended that the Power Supply be placed on a platform, or sheltered, to reduce the possibility of shock hazard. Care must be taken when installing and operating the 8150-770 to insure that the power supply cord remains accessible, as this is the only means to completely remove power from the instrument.

Note, too, that if the Power Supply is deployed outdoors for an extended period of time, it may be subject to damage from weather and/or rodents. We recommend that you periodically inspect the power supply and power cord(s) for damage. In addition, check the gland connector where the power cord passes through the power supply case to make sure it is tight, so that water cannot leak into the case; tighten if necessary.

The AC Power Supply can be used in combination with the batteries located inside the LI-8100 Analyzer Control Unit; if AC power is interrupted, the batteries will continue to power the LI-8100. When AC power is restored, the measurement will continue at the point in which it was interrupted.

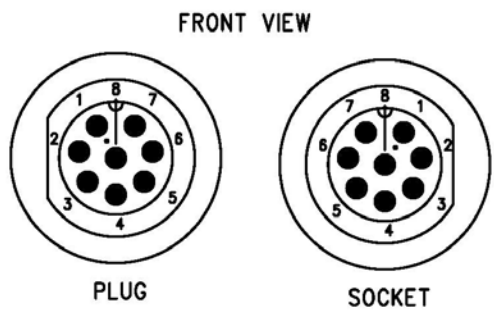
Chamber Sensor Interface (8150-661)

A Chamber Sensor Interface is required for each 8100-101 Long Term Chamber where auxiliary sensors are to be connected. The Chamber Sensor Interface allows for connection of up to three auxiliary sensors. The 8150-661 has 3 sealed connectors, each of which is wired internally to 0-5V inputs, as well as a variety of output voltage channels. Bare wire leads with a mating connector (p/n 392-08577) are also provided so that the user can connect sensors from other manufacturers to any of the three connectors. Soil temperature and soil moisture probes can be purchased from LI-COR that are pre-wired for direct connection to the Chamber Sensor Interface.

Figure 10-4. *Chamber Sensor Interface.*

The connectors on the Chamber Sensor Interface are wired as follows:

Pin Number	Signal	Wire Color
1	0v – 5v In +	Brown
2	5V_Ref Out (4mA)	Pink
3	+5v Out (100mA)	Blue
4	N/C	Grey
5	Unreg Out (50mA)	Red
6	Switched +5V Out (30mA)	Yellow
7	0v – 5v In -	Green
8	Gnd	White



Plug = Chamber Sensor Interface Box
Socket = Cable end

The Chamber Sensor Interface has a pass-through connector that allows it to be placed near the LI-8150 Multiplexer, or near the soil chamber. When placed near the Multiplexer, the Chamber Sensor Interface cable is attached directly to a chamber port labeled CHBR; the soil chamber control cable (or the optional extension cable/hose assembly) then attaches to the port on the left side of the Sensor Interface box, as shown in Figure 9-3, as well as Figures 9-10 to 9-12.

Cable/Hose Extension Assembly (8150-705)

Extends the distance at which each chamber can be placed from the Multiplexer. Assembly is 15 m in length; only one extension can be used for each chamber.

Soil Moisture Probe (p/n 8150-202)

The ECH$_2$O Model EC-5 soil moisture probe (Decagon Devices, Inc., Pullman, WA) is a 5 cm (2") dielectric sensor that measures volumetric water content of the soil. The probe is wired at the factory with a plug for direct connection to the Chamber Sensor Interface, or directly to the 8100—104 Long-Term Chamber.

Soil Temperature Thermistor (8150-203)
6 foot cable, connects to the Chamber Sensor Interface or 8100-104 Long-Term Chamber. Accuracy: ±1.0 °C from –20 to 50 °C.

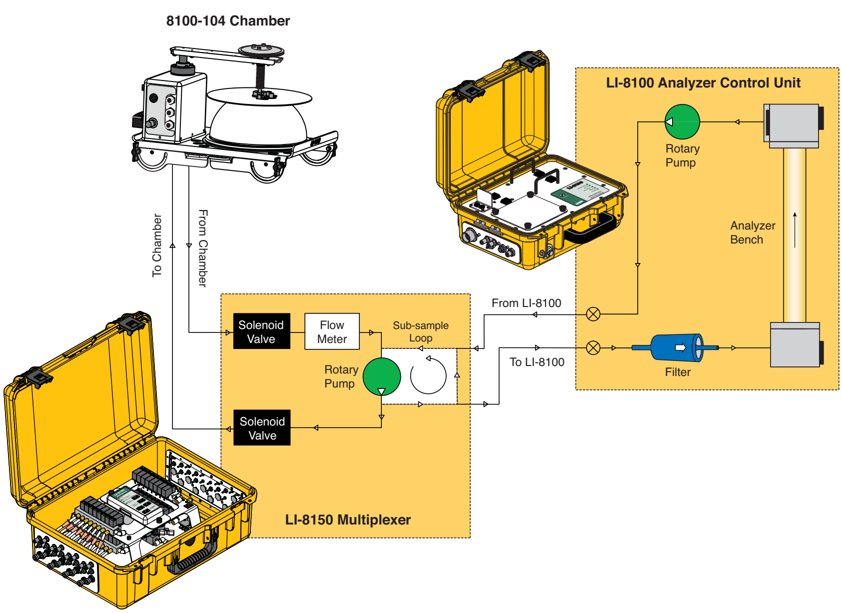
DC Power Cable (8150-706)
3 m cable, bare lead termination. For user-supplied DC power source.

Eight to Sixteen Port Upgrade Factory Installation (8150-916)
Factory upgrade of an eight port Multiplexer to sixteen ports.

Eight to Sixteen Port Upgrade Field Installation (8150-916-1)
Field installation kit includes control panel assembly, solenoid/valve bank assemblies, Multiplexer module PCA boards, filter assemblies, necessary hardware, and installation instructions.

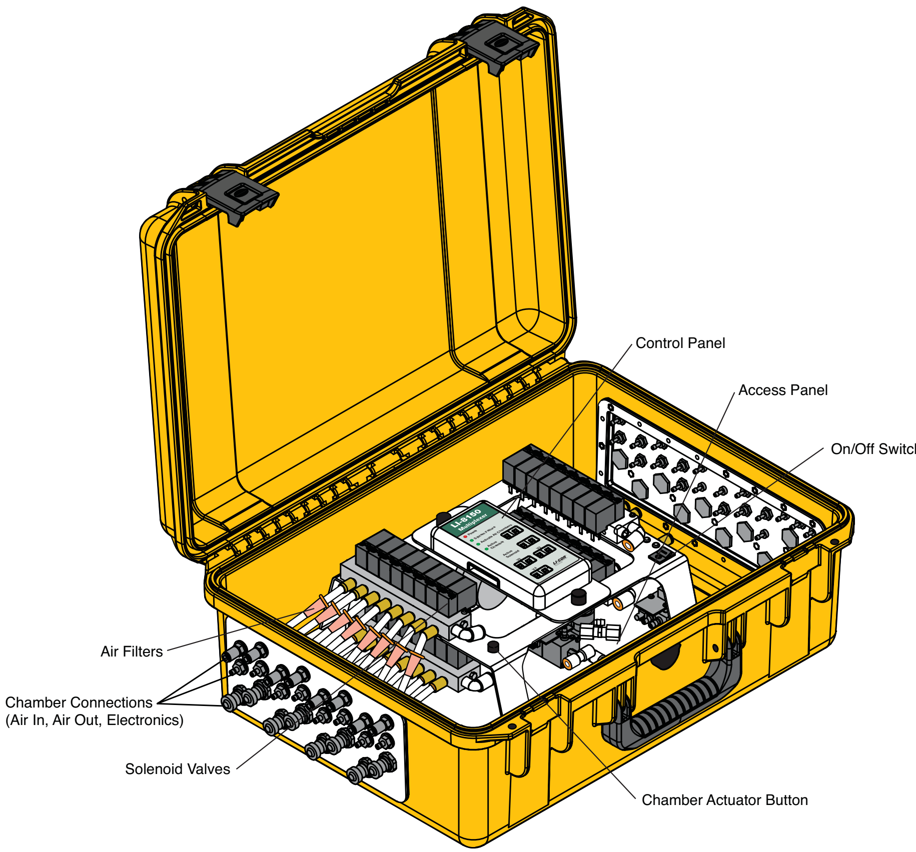
How It Works

The LI-8150 Multiplexer contains a pump-driven (pneumatic) circuit that transports the sample gas from one of 8 (or 16) chambers (or gas lines) at a time to the IRGA in the LI-8100. This circuit provides air flow to and from the chamber while maintaining the pressure in the IRGA at the ambient level. This pneumatic circuit also monitors the approximate flow rate to and from the chamber(s), and provides a method to test for leaks throughout the system.

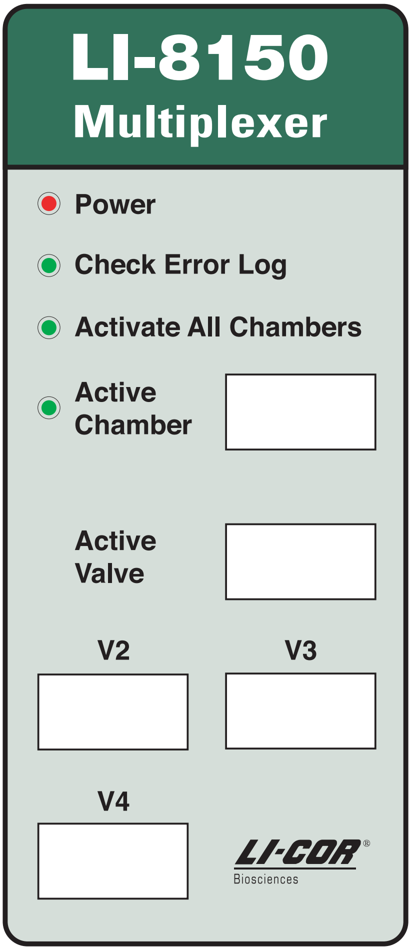


The above block diagram shows the direction of flow, and the major components contained in the pneumatic circuit. Solenoid valves are used to control flow to and from one chamber at a time (there is a separate valve for inlet and outlet). Thus, the 8-port multiplexer has 16 solenoids, and the 16-port multiplexer has 32 solenoids. Sample gas from the chamber is filtered as it enters the pneumatic circuit; it is filtered again in the LI-8100 before it is measured by the IRGA.

A rotary vane pump is used to circulate the sample gas to and from the multiplexer and the selected chamber. A flow sensor measures the approximate flow rate in the 'chamber loop' (between 1.5 and 3.5 lpm in normal operating conditions). The flow rate is adjustable in software. The pump also circulates flow in a 'sub-sampling loop', as it is in-line with both parallel loops. Flow restrictors in the 'sub-sampling loop' restrict flow in comparison to the 'chamber loop' to control the pressure in the LI-8100 IRGA. The LI-8100, in turn, samples air from the 'sub-sampling loop' using its own pump. The LI-8100 bellows pump circuit is used to pressurize each chamber to test for leaks.



On either side of the LI-8150 case are connections for up to 8 chambers. The left side shown above (optional) has only chamber connections; the right side (not pictured) also has power and LI-8100 connections. The raised platform in the case contains the On/Off switch and central Control Panel (below), which provides a display of the active chamber and valve. A Chamber Actuator Button is also located on the raised platform; pressing this button closes all attached chambers (4 at a time), which is useful when preparing the chamber(s) for transport. The plate under the raised panel has a small access panel that can be removed to access the fuses.



Power – Illuminates when power is applied to the instrument, and the power switch is turned On.

Check Error Log – illuminates when an error condition is detected (e.g. a chamber failed to close, flow rate is too low, etc.). The Error Log can be viewed in the Windows application software, under the View Menu, and in the Palm software, by pressing the “E” indicator when present.

Activate All Chambers – illuminates when Chamber Actuator Button is pressed. All connected chambers will close in series (4 at a time); (1-4), (5-8), (9-12), and (13-16).

Active Chamber – displays chamber that is currently performing a measurement.

Active Valve – displays currently active (open) solenoid valve. When a measurement is being performed, this will always match the Active Chamber. When the instrument is idle, however, a valve can be operated independent of the chamber(s).

V2-V4 – shows the port from which the indicated voltage output is coming.

Cable Connections

LI-8100

There is a panel for connecting the RS-232, chamber, and Auxiliary Sensor Interface cables on the left side of the LI-8100 Analyzer Control Unit. These connectors have slightly different uses when the LI-8150 Multiplexer is connected to the Analyzer Control Unit. The LI-8100 side panel appears as shown in Figure 10-5 below.

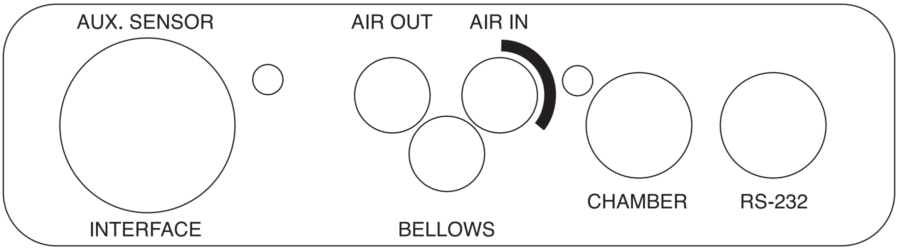


Figure 10-5. *LI-8100 Analyzer Control Unit cable connection panel.*

There are two hose/cable bundles included with the LI-8150; the yellow cable with large bulkhead connectors on either end connects to the port labeled Aux. Sensor Interface on the LI-8100, and to the port labeled LI-8100 on the LI-8150. The second hose bundle has three air hoses and an electronic cable. These hoses are connected to the side panel of the Analyzer Control Unit, as shown below. The hose for Air In has a male fitting and the hose for Air Out has a female fitting. Note that one of the hoses has a piece of black shrink wrap; this hose attaches to the Air In fitting on the Analyzer Control Unit. The bellows hose has a male fitting, and attaches to the port marked Bellows on the Analyzer Control Unit. Insert the hoses until the fittings snap into place. To remove the hoses, slide the collar on the fittings; the collar on the bellows and Air In fittings slide toward the Analyzer Control Unit, and the collar on the Air Out fitting slides away from the Analyzer Control Unit.

Note that the fittings on the side panel have fine threads. Make sure there is no debris on the fittings before attaching the connectors, as the threads can be damaged. Cover the connectors with the attached connector dust caps whenever the connectors are not being used.

Figure 10-6. *Chamber hose connections.*

The yellow circular connector bundled with the air hoses is attached to the Chamber fitting. Note that this fitting is indexed; you may have to rotate it until it slips into place before tightening.

LI-8150

Attach the large bulkhead connector to the port labeled LI-8100. Attach one end of the power cable to the connector labeled PWR (Figure 10-6).

Figure 10-7. *Attach the bulkhead connector and power cable.*

The hose for the pump (labeled P) has a male fitting. The hose for Air Out (labeled O) also has a female fitting; this hose has a piece of black shrink wrap.

The Air In hose has a female fitting, and attaches to the port marked I. Insert the hoses until the fittings snap into place. To remove the hoses, slide the collar on the fittings. Lastly, attach the round control cable to the connector labeled CTRL.

Figure 10-8. *Attach the air hoses and control cable.*

Chambers

Each LI-8150 side panel has connectors for up to 8 soil chambers (Long-Term Chambers only); the right panel shown above has connectors labeled 1-8, and the optional left panel (if present) has connectors labeled 9-16. Note that it is not necessary to connect the chambers in sequential order; they can be connected to any port(s) of your choosing. The port numbers are important to note, however, as they are used in software during measurement setup.

Each chamber has air hoses with a male and female fitting that attach to the Air In and Air Out connectors for each corresponding chamber connectors; the bundled electronic cable connects to the fitting labeled CHBR. The photo below shows some typical LI-8150 connections, including soil chambers and gas sampling (vertical profiling) lines.

Figure 10-9. *Cable connections for LI-8150 and a single soil chamber.*

Chamber Sensor Interface (p/n 8150-661)

The optional Chamber Sensor Interface box allows for connection and monitoring of up to three auxiliary sensors for each multiplexed 8100-101 chamber. Each of the three sensor connections can be configured as a General Purpose Input, a dedicated input for the Decagon EcH_2O or Delta-T Theta soil moisture probes, or a Thermistor input that can be monitored on any of the V2, V3, or V4 voltage channels (V1 is dedicated for measuring flow from the Multiplexer to the chamber). This interface box is not used with the 8100-104 Long-Term Chamber, as the sensor connectors are built into the side of the 8100-104.

Figure 10-10. *Chamber Sensor Interface.*

The Chamber Sensor Interface has a pass-through connector, so that it can be attached in-line between the Multiplexer and the soil chamber, or between the Multiplexer and either end of an optional cable/hose extension assembly. Thus, the Chamber Sensor Interface can be deployed near the Multiplexer, or near the chamber, as desired, to provide maximum flexibility in positioning auxiliary sensors (Figures 10-11 to 10-13 below). **Important Note**: the cable can be disconnected from the 8100-101 chamber; in this instance, it is possible to physically connect the short cable from the Chamber Sensor Interface directly to the chamber (Figure 10-11). ***This will not work, however, as the electrical connections between the chamber and the sensor interface will be reversed***.

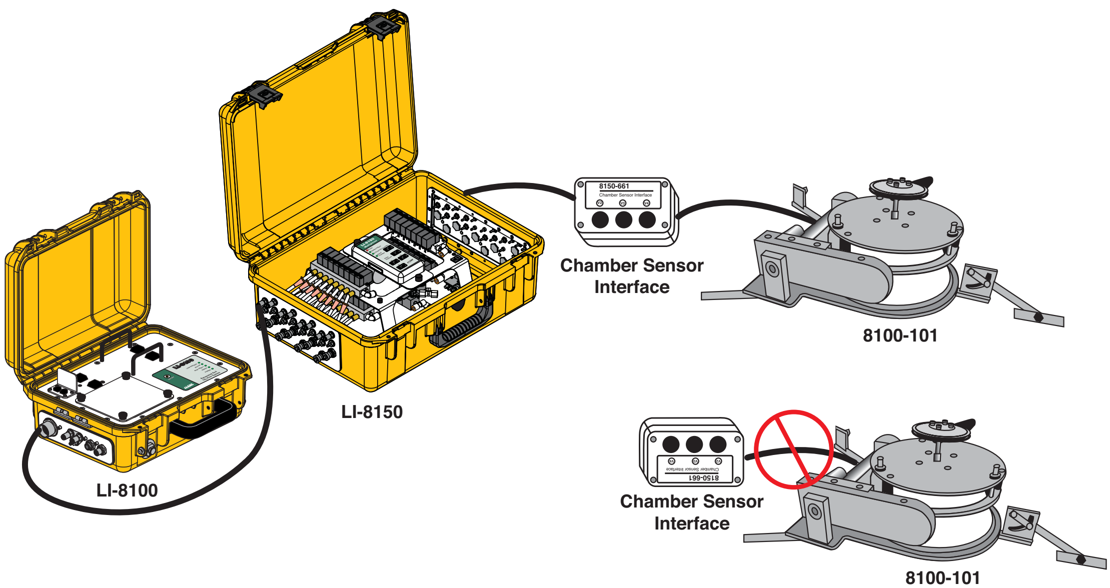


Figure 10-11. *The Chamber Sensor Interface can be placed in-line between the LI-8150 and the Long-Term Chamber.*

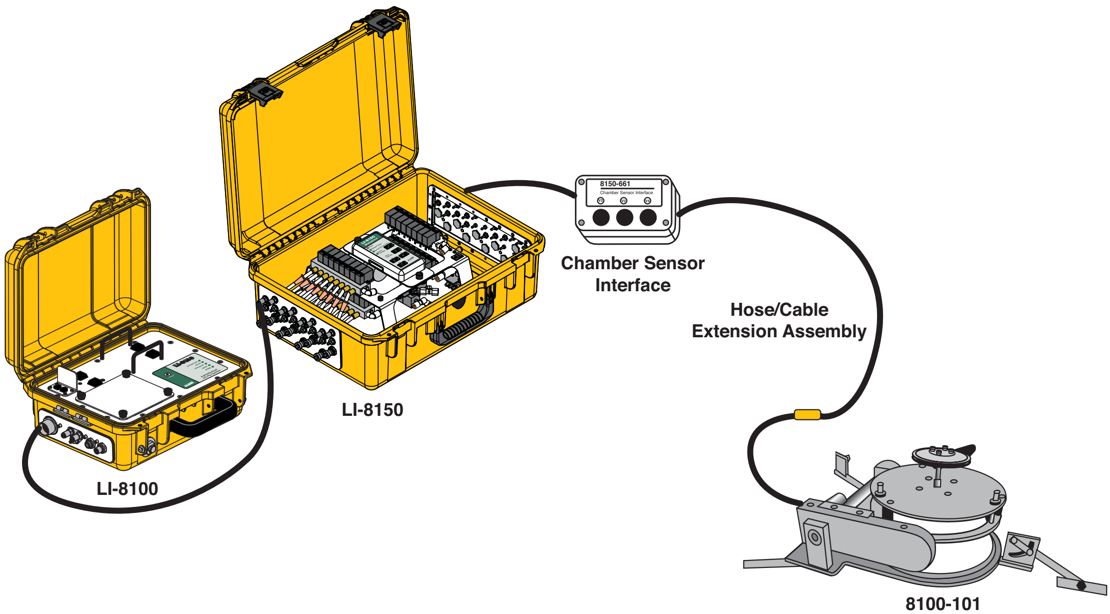


Figure 10-12. When used with the Chamber/Hose Extension Assembly, the Chamber Sensor Interface can be placed near the LI-8150…

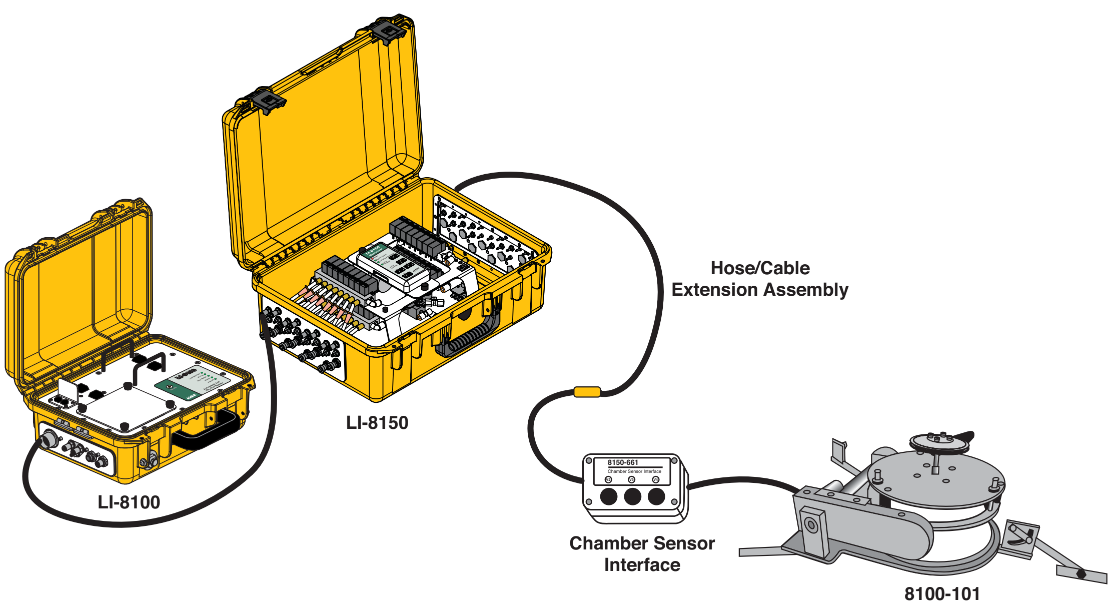


Figure 10-13. or near the Long-Term Chamber.

Unlike the Auxiliary Sensor Interface that is used with the LI-8100, the Chamber Sensor Interface is pre-wired with plugs on the exterior of the box; when soil temperature or soil moisture probes are purchased from LI-COR for use with the Multiplexer, they are fitted with plugs as well, which snap onto the mated connectors on the interface box. For sensors from other manufacturers, a plug with bare wire leads (p/n 392-08577) is provided that can be attached to the sensor's wire leads; a wiring diagram with pin numbers and wire colors is given earlier in this section. The 8100-104 Long-Term chamber also has pre-wired plugs built into the side of the chamber; this chamber uses the same probes as are used with the Chamber Sensor Interface.

***Figure 10-14**. A plug with bare wire leads (p/n 392-08577) can be used to attach sensors from other manufacturers to the Chamber Sensor Interface.*

Note that when the Multiplexer is attached to the LI-8100, the Auxiliary Sensor Interface cannot be attached to the LI-8100; thus, thermocouples cannot be measured without an external measurement device, as all measurement channels are dedicated for use with sensors attached to the Chamber Sensor Interface(s).

Measurement Quick Start

This section is designed to quickly demonstrate a simple LI-8100 measurement using the LI-8150 Multiplexer. For the purposes of this discussion we will refer to the use of the LI-8100 Windows application software, rather than the optional interface software for Palm OS. Follow these steps to complete this tutorial:

1. Connect the cables, power supply, and computer as described above, and in Section 2, *Initial Setup*.

2. Install the Windows application software as described in Section 11, *Installing the PC Communications Software*.

3. Connect as many soil chambers as desired. Optionally, install extension cables and/or Chamber Sensor Interfaces as described above. If you are using one or more Chamber Sensor Interfaces, you may want to connect soil temperature, soil moisture probes, etc. at this time.

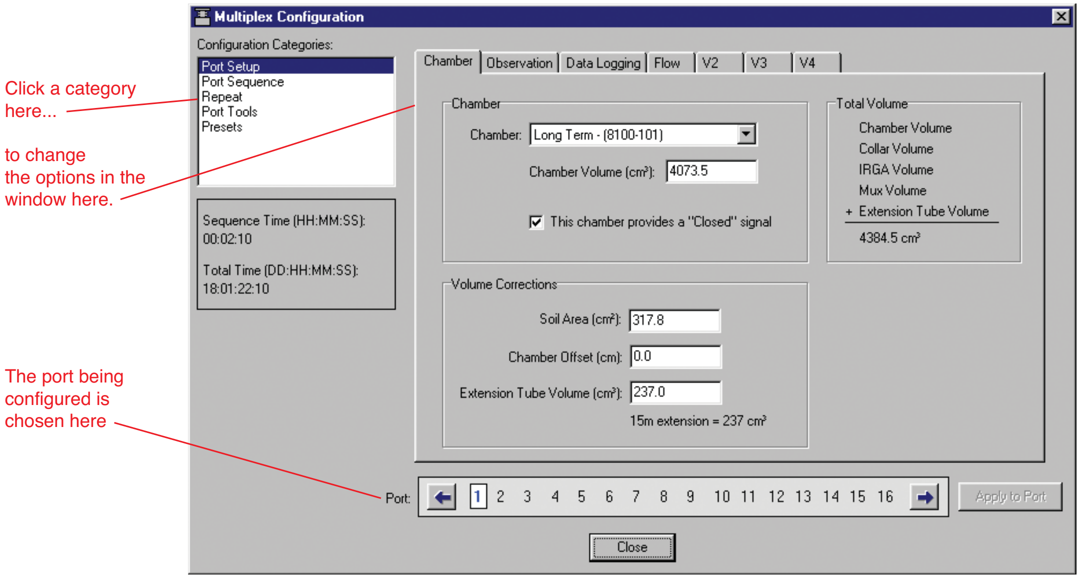
4. Place the chamber(s) on a soil collar. Collar installation is discussed in detail in Section 2, *Initial Setup*. If you have not installed the soil collars yet, refer to Section 2, *Installing the Soil Collars*.

5. Turn the Multiplexer on ***first*** using the power switch on the inside panel, and then turn the LI-8100 on using the ON/OFF button on the keypad on the inside panel of the Analyzer Control Unit. If everything is connected properly, all chambers connected will automatically open in series (4 at a time). Wait for the "Ready" light to come on.

6. Open the LI-8100 Windows application software and click on the Connect icon, or choose **Connect** from the Communication menu. Choose the serial (COM) port on the computer to which the LI-8100 is connected. When the LI-8150 and LI-8100 are powered on in the proper sequence, the software will automatically sense the presence of the Multiplexer; the available functions change accordingly.

7. **Optional**: The Multiplexer is tested before shipping from the factory; you may, however, wish to perform a leak test to ensure the integrity of all tubing connections. The LI-8100 bellows pump circuit is used to pressurize each chamber port to test for leaks; the air hoses and solenoids for each port are tested – the chamber itself is isolated from the circuit and is not part of the leak test. See *Performing a Leak Test* below if you want to perform a leak test, or want more information.

8. Choose **Measurement Configuration** from the Setup menu. The Multiplex Configuration dialog appears.



Note that there are 5 configuration categories at the top lefthand part of the dialog; clicking on any of these categories changes the options available in the tabbed portion of the dialog box. Note, too, the port number string at the bottom of the dialog; the port to be configured is chosen here. You can choose to configure each port individually, or configure a single port, and then copy that configuration to as many other ports as desired. For the purpose of this exercise, we'll simply configure a single port, and copy that configuration to all other connected chambers.

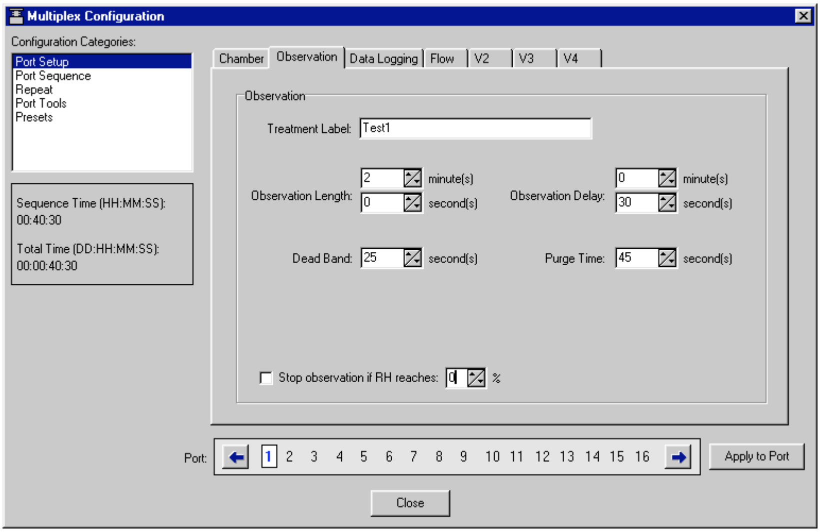
8a) Click on the port to which your first chamber is connected (#1 in the example above).

8b) In the **Port Setup:Chamber** page (shown above), select the type of chamber connected to the chosen port (Long Term 8100-101 in the example above). The default value for Chamber Volume is automatically entered. Enter the Soil Area (317.8 cm^2 for 8100-101 or 8100-104), Chamber Offset value (see Section 2, Measuring the Chamber Offset), and Extension Tube Volume values (237 cm^3 for 15 m Extension Tube from LI-COR). If you are not using an extension tube, enter '0' for the Extension Tube Volume.

8c) Click on the **Observation** tab. Enter a Treatment Label, and set the Observation parameters as shown below.

Observation Length: 2 minutes

Dead Band: 25 seconds
Observation Delay: 30 seconds
Purge Time: 45 seconds

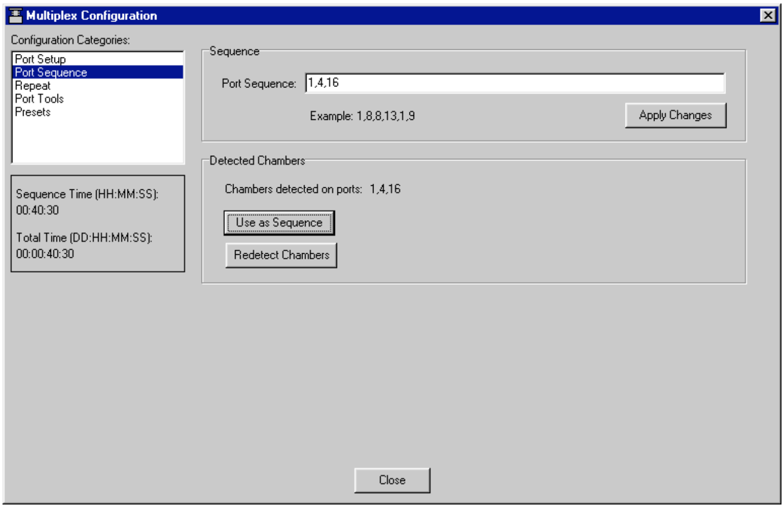


8d) Click on the **Data Logging** tab. Click on the Select All button, if the Optional Data Fields are not all selected.

8e) Click on the **Flow** tab. Make sure the flow rate is set to Low. If it isn't, move the slider all the way to the left.

8f) Optionally, you can click on the **V2, V3,** or **V4** tabs to choose the type of probe (or thermistor) for each input on the Chamber Sensor Interface. The factory-derived calibration coefficients for each probe are entered here, also.

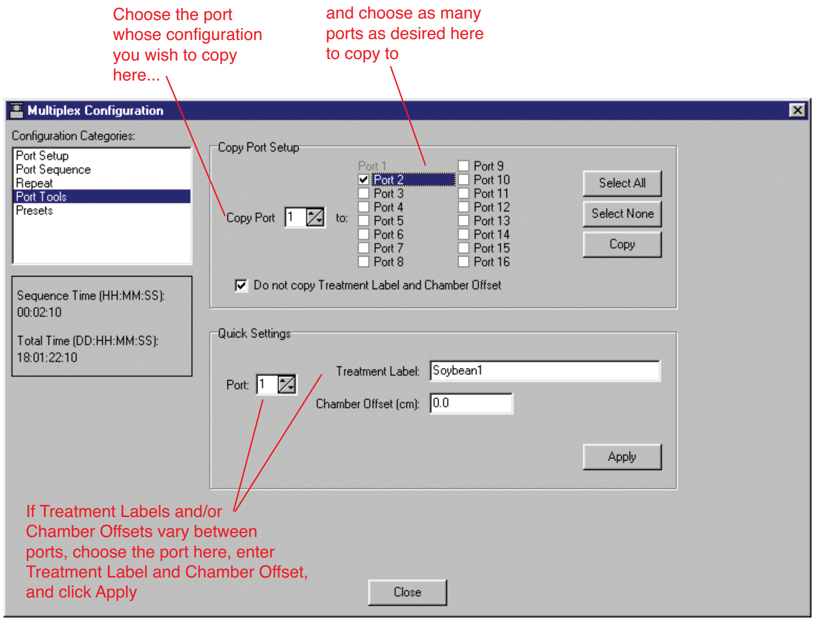
8g) Click on **Port Sequence** under Configuration Categories. The dialog will change to show the current measurement sequence, and the chambers detected, as shown below.



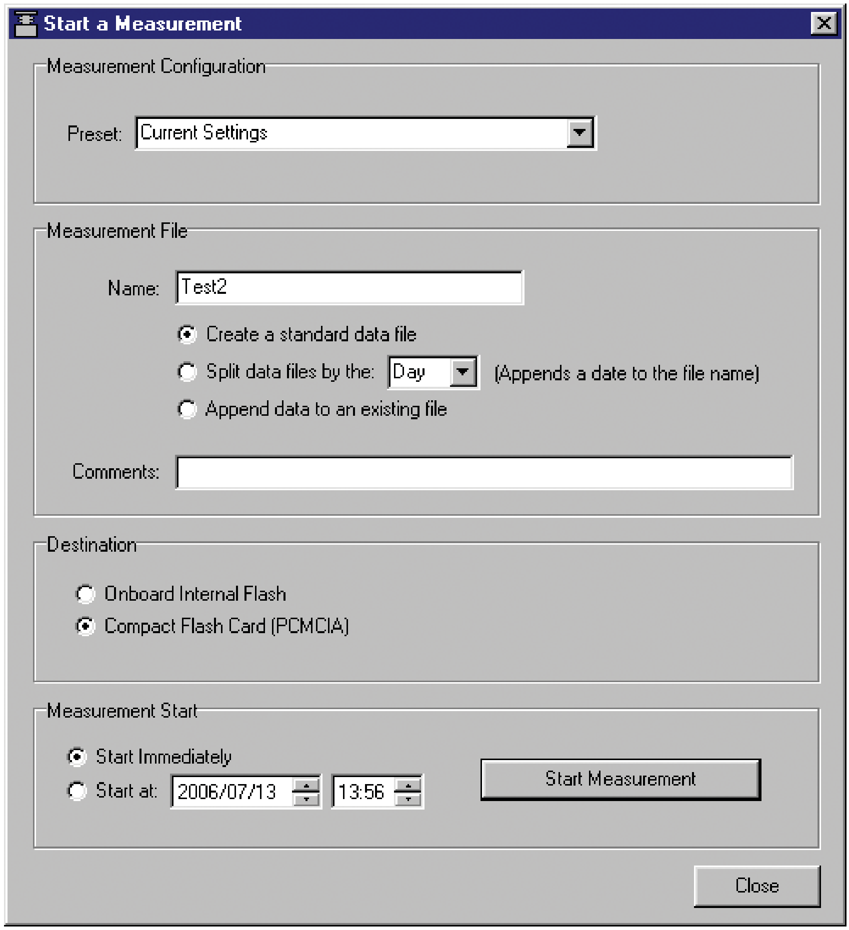
When the chambers are connected properly, they will be detected in software, and shown here. In the example above, chambers were detected on ports 1, 4, and 16. Chambers can be measured in any desired sequence, using the Port Sequence entry field. In the example above, if we wanted to measure the chambers in the order in which they were detected, we can simply click the 'Use as Sequence' button; the Port Sequence field will be filled in automatically. If, however, you want to measure in a different order (e.g. 4, 16, 1), simply enter the desired order in the Port Sequence field manually (ports separated by commas). Click **Apply Changes**, if necessary.

8h) Click on **Repeat** under Configuration Categories. The dialog will change to show the Repeat measurement configuration. You can choose to repeat the measurement protocol at a chosen number of hours and minutes, and for a chosen number of times. Set the repeat time to 1 hour, and for as many repeats as you want.

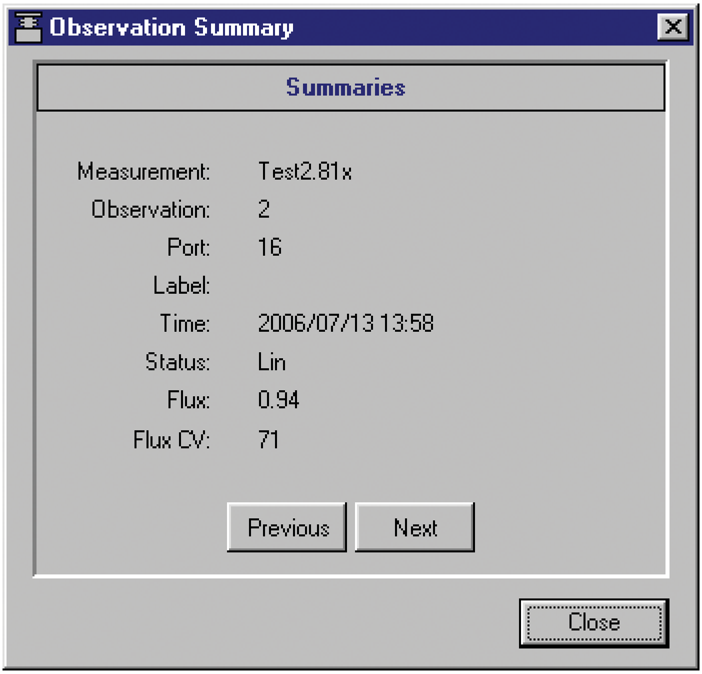
8i) Click on **Port Tools** under Configuration Categories. After you have defined a measurement protocol for a single port, you can copy that configuration to as many other ports as desired. Choose the 'Copy Port' (just defined, #1 in the example above), and then enable the other ports to which you want to copy that definition. Note that if the Chamber Offsets and/or Treatment Labels vary between soil collars, you will need to enter them individually; this can be done in the Quick Settings part of this dialog. Simply choose the port, and then enter Treatment Label and Chamber Offset for each port. Click **Apply** after entering the Treatment Label and/or Chamber Offset for each port. When you are finished, click on the **Copy** button.



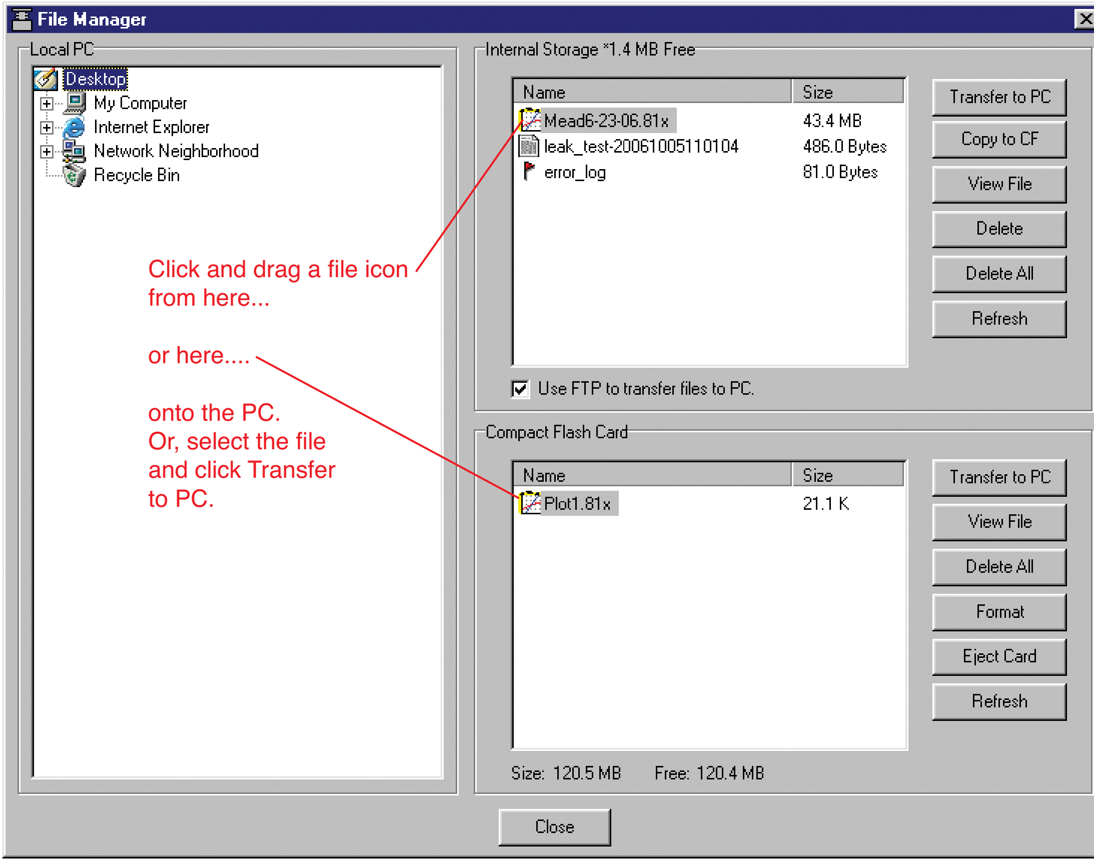
9. Click **Start Measurement** from the Setup menu. Use the Current Settings preset, and choose the Start time (immediately, or at a defined date and time). Click the **Start Measurement** button.



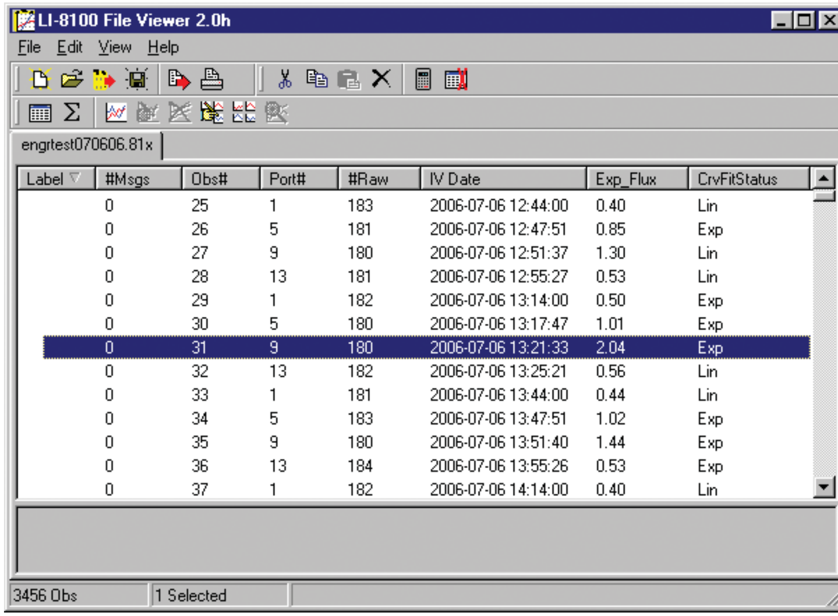
10. Choose **Summary Records** from the View menu. You can view a brief summary of each observation, in series, including flux values, by clicking **Previous** or **Next**. Click **Close** when finished reviewing the records.



11. Choose **File Manager** from the Utilities menu. We can use this dialog to perform basic file management functions, including copying files from the LI-8100 internal memory and/or from the compact flash card to the computer. We'll move the file just created to the computer, where we can open it in the LI-8100 File Viewer program for further analysis. Locate the newly created file in the Internal Storage list box (Test1 in the example above). Click and drag the file icon into the Local PC list box, to the desired location (i.e., onto the Desktop, or into a file folder).

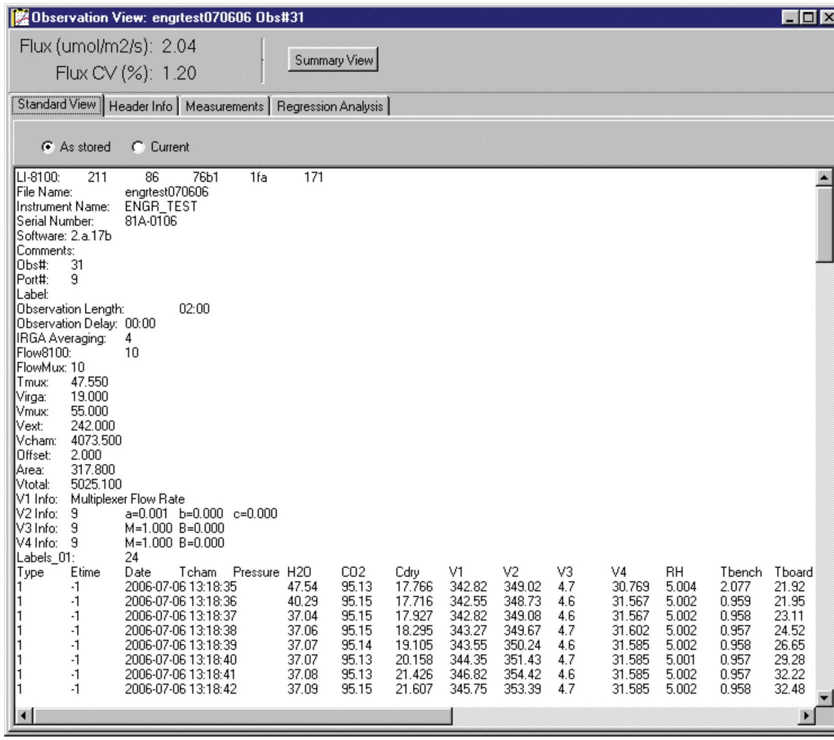


12. Locate the file transferred above and double-click on the file icon; LI-8100 data files are associated, and automatically open with, the LI-8100 File Viewer program (they have a .81x file extension). The File Viewer program will open, and will display a summary view of all observations in the file.

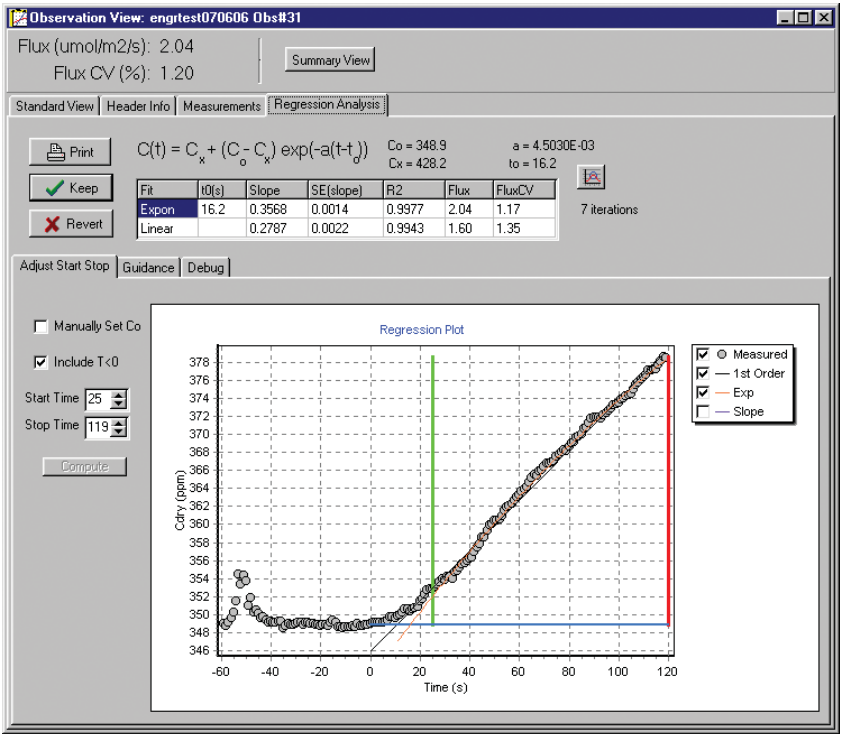


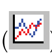
Label	#Msgs	Obs#	Port#	#Raw	IV Date	Exp_Flux	CrvFitStatus
	0	25	1	183	2006-07-06 12:44:00	0.40	Lin
	0	26	5	181	2006-07-06 12:47:51	0.85	Exp
	0	27	9	180	2006-07-06 12:51:37	1.30	Lin
	0	28	13	181	2006-07-06 12:55:27	0.53	Lin
	0	29	1	182	2006-07-06 13:14:00	0.50	Exp
	0	30	5	180	2006-07-06 13:17:47	1.01	Exp
	0	31	9	180	2006-07-06 13:21:33	2.04	Exp
	0	32	13	182	2006-07-06 13:25:21	0.56	Lin
	0	33	1	181	2006-07-06 13:44:00	0.44	Lin
	0	34	5	183	2006-07-06 13:47:51	1.02	Exp
	0	35	9	180	2006-07-06 13:51:40	1.44	Exp
	0	36	13	184	2006-07-06 13:55:26	0.53	Exp
	0	37	1	182	2006-07-06 14:14:00	0.40	Lin

Select an observation by double-clicking on it (Obs. 31 in the example above). An Observation View appears, where you can view all final variables collected, as well as view and/or perform additional regression analyses, if desired.



Click on the Regression Analysis tab to view a regression plot of the chosen observation.



Click on the chart () icon on the toolbar. You can define additional plots to be displayed in the main window (flux vs. chamber temperature is the default). Click **OK**. A plot appears below the summary records in the main window.

> An on-line manual that describes the File Viewer functions can be found in the Help menu at 'FV8100 Manual'.

Performing a Leak Test

The LI-8150 Multiplexer utilizes a large amount of tubing, particularly when extension tubes are used between the Multiplexer and the soil chambers. A routine has been developed that allows the user to test for leaks in the system. Each port can be tested individually; the soil chamber is isolated and is not a part of the leak test. To perform the leak test, the bellows circuit in the LI-8100 (not used during normal operation for the Long-Term chambers) is used to evacuate the system. The IRGA pressure is then monitored to determine the leak rate of the system. Upon completion of the leak check on each port, the system is purged to allow the next port to be evacuated.

The leak test requires that; a) each multiplexer port is sealed to form a closed loop, usually by disconnecting the extension tubing at the chamber end and mating the male and female connectors to each other, and b) one port is left open to allow the system purge.

Note that the Multiplexer can be tested for system leaks independent of any extension tubing; the leak test will test for integrity of the solenoids and internal tubing only, as well as the connection between the LI-8100 and the Multiplexer. A small fixture (p/n 9981-142) consisting of a short piece of tubing, and a male and female connector, is included in the spares kit, which forms a closed loop between the air input and output ports (Figure 10-15 below). The fixture is connected to each port before performing the leak test on that port; only one port can be tested at a time.

Figure 10-15. *In the absence of extension tubing, the leak test fixture is attached between the air inlet and outlet ports (port #14 shown).*

■ Follow these steps to perform a leak test:

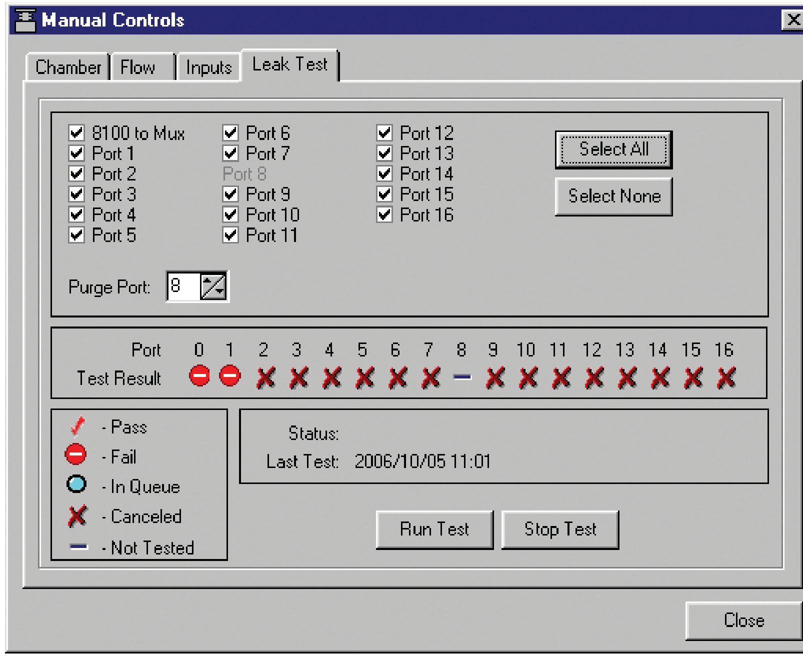
1. For each port to be tested, disconnect the extension tubing at the chamber end, and mate the male and female connectors together to form a closed loop. Alternatively, connect the tubing fixture (p/n 9981-142) between the air inlet and air outlet ports on the Multiplexer side panel, in the absence of the optional cable/hose extension tube assembly.

Mate the male and female connectors at the chamber end of the extension tubing.

2. Make sure that at least one port is left open; you can disconnect the tubing at the chamber end, without mating the connectors, or simply disconnect at the Multiplexer side panel. Thus, the greatest number of ports that can be checked at one time is 7, with an 8-port system, or 15, with a 16-port system. The open port will need to be checked for leaks after completion of the other ports' test.

3. Choose **Manual Controls** from the Utilities menu in Windows or Palm software.

   Windows:
   a. Click on the Leak Test tab in the Manual Controls dialog.

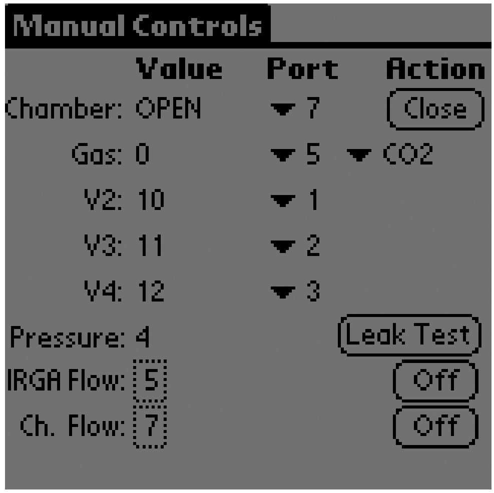


b. Enable the check boxes next to the ports to be tested. Choose a purge port to be left open. Enable the '8100 to Mux' check box to test the air lines between the LI-8100 and the Multiplexer (Port 0).

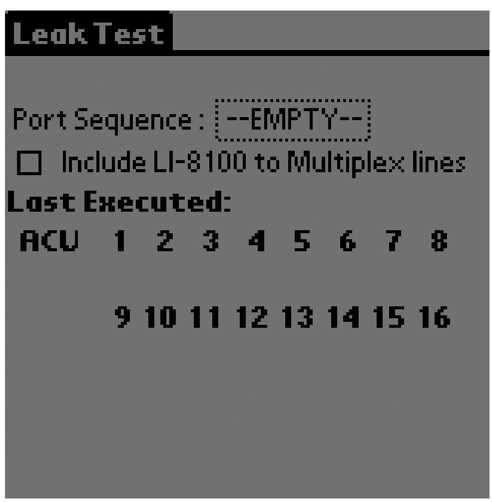
c. Click on the **Run Test** button. Each selected port will be tested in sequence. The results of each test are displayed after the port check is completed.

Palm:

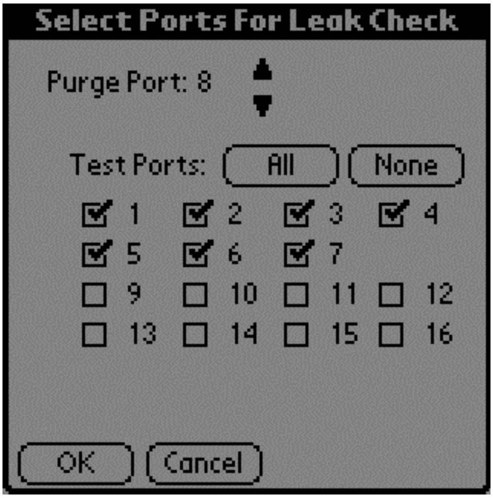
a. Tap on **Leak Test** in the Manual Controls page.



b. Enable the 'Include LI-8100 to Multiplex lines' box to test the air lines between the LI-8100 and the Multiplexer. Tap on the **Port Sequence** field.



c. Enable the check boxes next to the ports to be tested. Choose a purge port to be left open. Tap **OK**. The results of the test are shown in the Leak Test page.



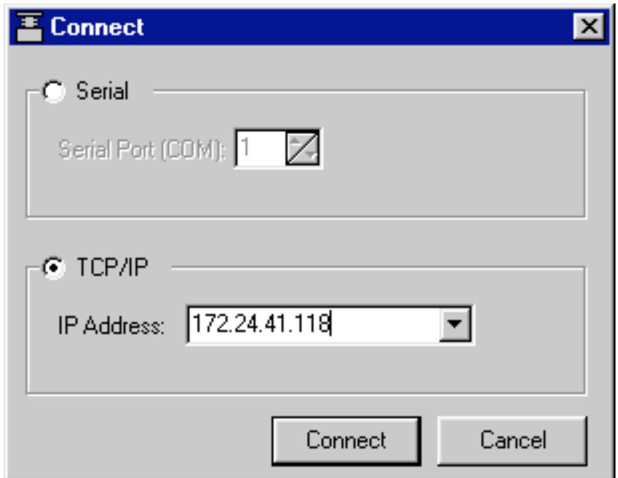
Using the Windows Interface Software with the Multiplexer

Data from the LI-8100 can be transferred to a computer for analysis, printing or storage using the RS-232 interface. Section 11 contains instructions for using the Windows software with the LI-8100 and a single soil chamber; this section details how to use the Windows software when the Multiplexer is connected to the LI-8100. Many of the software functions are identical, or very similar to, those present when the LI-8100 is used in single-chamber mode; when the LI-8150 Multiplexer is connected, some of the functionality of the software changes to allow data collection from as many as 16 chambers at a time.

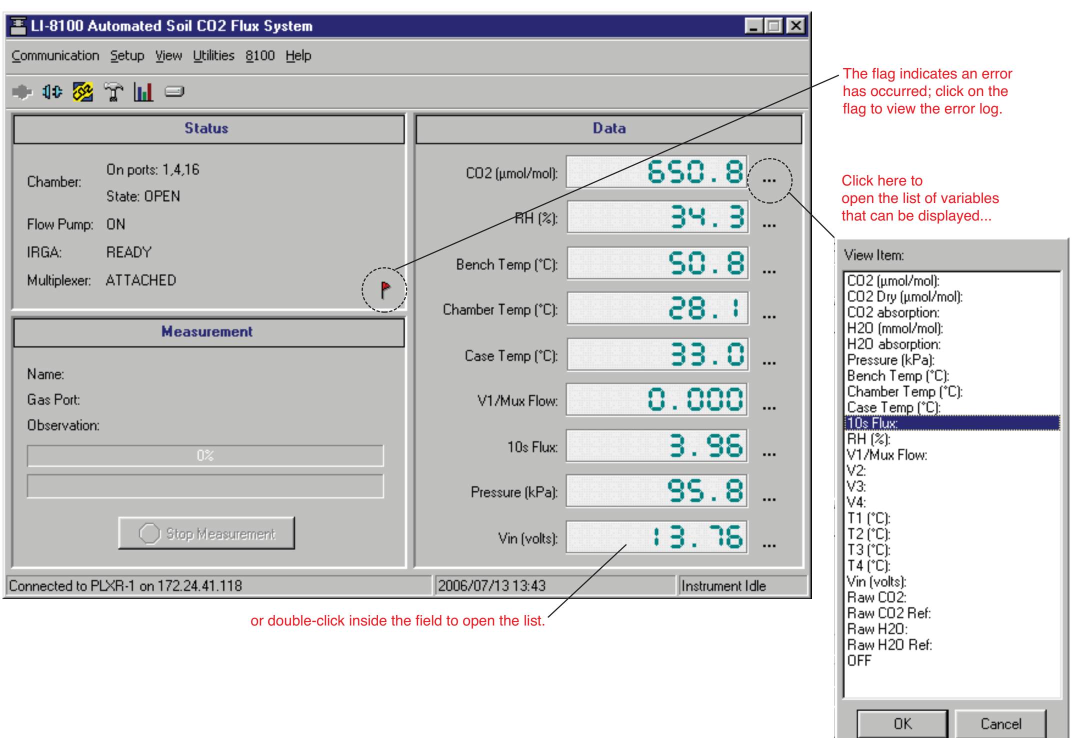
Turn on the Multiplexer, and then the LI-8100. Double-click on the LI-8100 program icon to launch the program; the Main Window appears. If the Multiplexer is turned on, the software will detect its presence, and will load those functions applicable to its use.

Connecting

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-8100 is connected, or the IP address of the LI-8100, if the instrument is connected to a wireless network (see *Remote Networking* below).



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

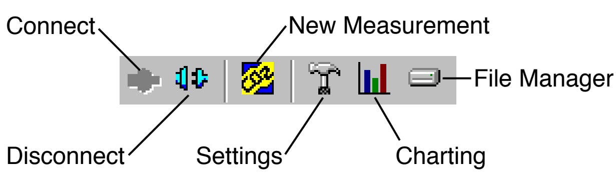


The Main window displays selected data variables on the right side of the window, as well as the progress of the current measurement and the status of various LI-8100 and LI-8150 parameters. If the Multiplexer is detected, the status window will display ATTACHED; detected chambers will also be displayed on their corresponding ports. You can change the variables that you want to monitor, displayed on the right side of the window by clicking on the dots next to any variable and selecting a different one from the pop-up menu (above). There are also five menus used to configure the LI-8100, perform zero and span calibrations, and set up the parameters for recording data.

NOTE: You can also double-click inside the data fields to open the pop-up menu, and then double-click on the desired variable to make it active.

Using the Toolbar

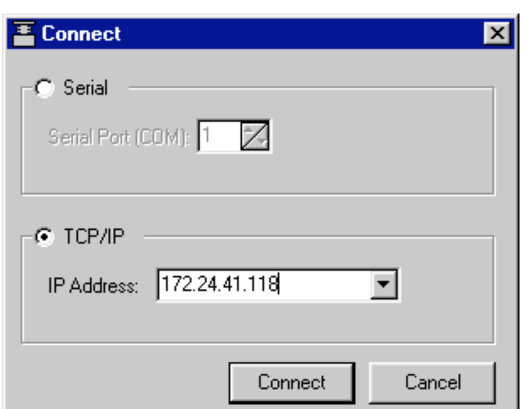
The toolbar in the Main window contains shortcuts for some of the commonly used menu items:



Communication Menu

Connect

Opens the Connect dialog, where you can choose the serial (COM) port on the computer to which the LI-8100 is connected, or enter the IP address of the LI-8100, if the instrument is connected to a wireless network.



The Internet Protocol (IP) address is a unique number that identifies a host (in this case, the LI-8100) connected to a network. The address is composed of a set of four numbers (called octets), where each octet ranges in value from 0 to 255. When entering an IP address, the octets are separated with a period. For example, 192.168.100.2 is a valid IP address.

Disconnect

Terminates communication between the Windows application software and the LI-8100.

Setup Menu

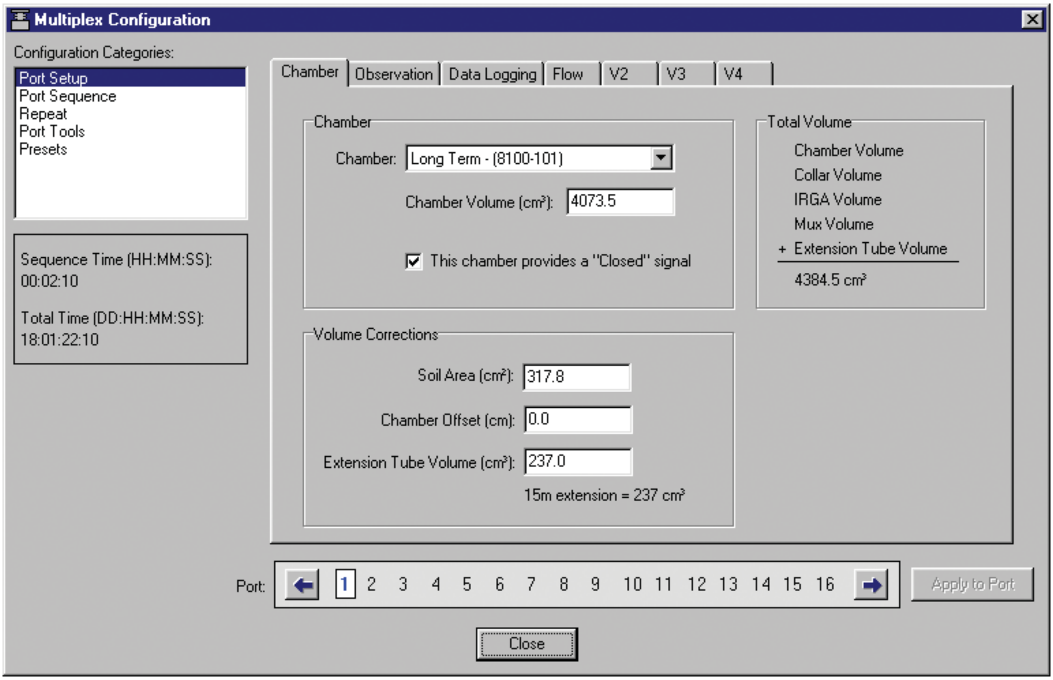
Measurement Configuration

Opens the Multiplex Configuration window, where you can define the measurement protocol, data logging options, flow rate, voltage inputs, and chamber offset values. There are a number of tabbed pages associated with the Chamber Configuration window; click on the tabs to open the other pages.

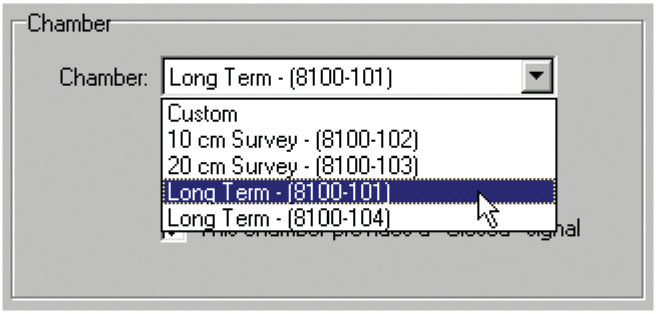
Note that there are 5 Configuration Categories in the upper lefthand corner of the window; clicking on any of the categories changes the options in the main part of the window. Note, too, that there is a string of port numbers at the bottom of the window; click on any port number to define the measurement configuration ***for that port***. After a single port has been configured, that configuration can be copied to as many other ports as desired; see *Port Tools* below. After you have finished defining a ports' configuration, be sure to click the **Apply to Port** button.

Port Setup: Chamber

The Chamber tab contains options for choosing the type of chamber that is connected to the port being defined (port #1 in the example below), as well as entering any Volume Corrections, including chamber offset, and whether or not an extension tube is connected to the chamber.



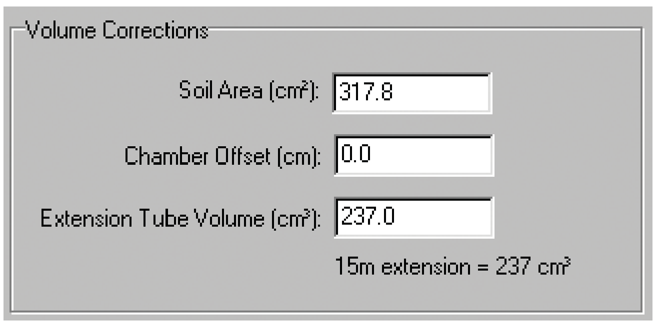
Choose the type of chamber that is connected to the active port from the Chamber pull-down menu. The choices are:



Custom – a user-built chamber, or tubing used for profiling studies.
10 cm Survey – LI-COR p/n 8100-102
20 cm Survey – LI-COR p/n 8100-103
Long Term – LI-COR p/n 8100-101
Long Term – LI-COR p/n 8100-104

Chambers sold by LI-COR provide an electronic signal when they are closed; this signal is used during various operations (e.g. during calibration) to indicate when the chamber is fully closed. Thus, when a LI-COR chamber is chosen from the menu, the "This chamber provides a "Closed" signal" check box is automatically enabled. If a custom chamber is attached, this check box should be enabled only if the chamber provides this electronic signal. The Chamber Volume (cm^3) is automatically entered for LI-COR chambers; this value will need to manually entered when using custom chambers.

The Volume Corrections allow you to enter the exposed Soil Area (cm^2) within the soil collar, as well as the Chamber Offset and extension tube volume (if present).

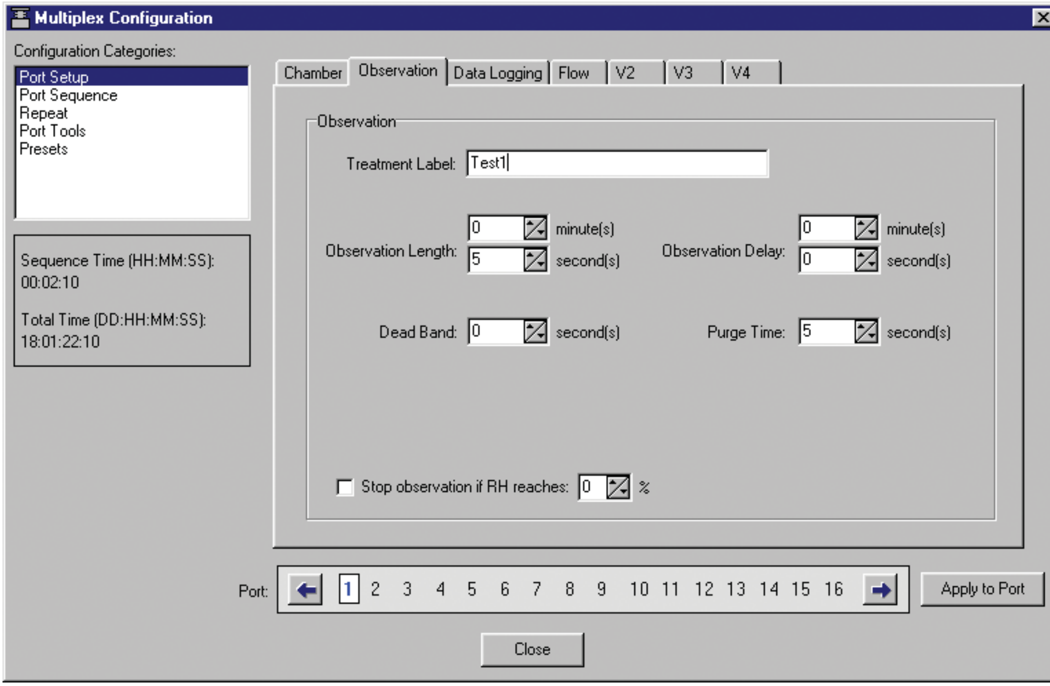


The **Soil Area** is the area encompassed by the chamber collar. The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar (Collar Volume). This value is, in turn, added to the **Chamber Volume, IRGA Volume, Multiplexer (Mux) Volume,** and **Extension Tube Volume** to obtain the **Total Volume**. Measuring the Chamber Offset is described in Section 2, *Using Soil Collars*.

The Chamber Volume value is entered automatically when a LI-COR chamber is chosen from the Chamber pull-down menu. Enter the Soil Area value (317.8 cm^2 for the 8100-101 or 8100-104), Chamber Offset, and Extension Tube Volume (237 cm^3 for 15 m Extension Tube from LI-COR). If you are not using a chamber extension tube, enter zero for the Extension Tube Volume value.

Port Setup: Observation

Click on the Observation tab to open the Observation page, where you can define the Observation Length, including delay times, Dead Band value, and Purge Time values.



The **Treament Label** is user-entered information which is included in a data record (maximum 30 characters).

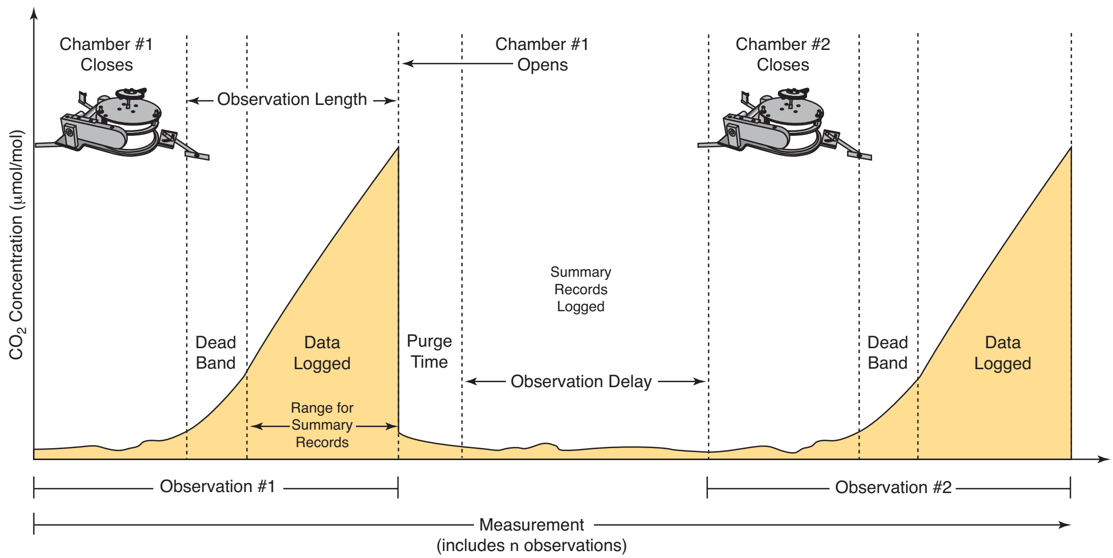
The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At moderate to low CO_2 fluxes an Observation Length of 90 to 120 seconds is usually adequate.

When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing (30 seconds is a good starting point if you are new to the system). There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 Data Analysis (File Viewer) program.

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the **Observation** is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

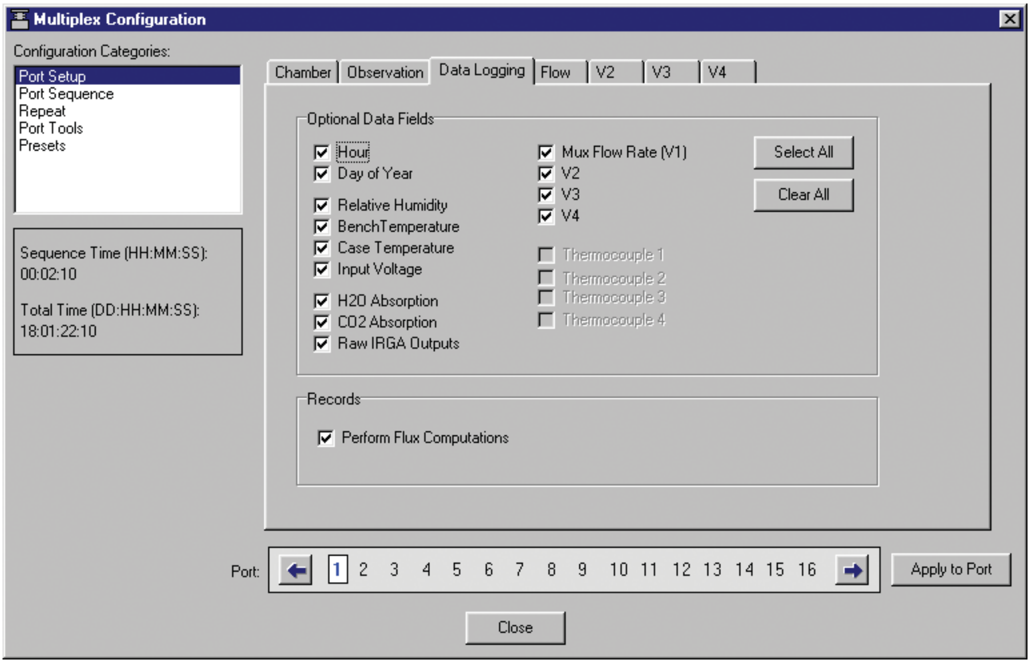
When an observation is complete, the chamber will automatically rise up off of the soil collar. If a **Purge Time** is designated, air will continue to flow through the port whose **Observation** has just completed (post-purge). After the Purge Time has finished, air flow switches to the next port in the sequence for the **Observation Delay** (pre-purge).



Enable the 'Stop observation if RH reaches' check box and enter a relative humidity value (if humidity is a concern at the measurement site). The Observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the Observation. If the Observation is aborted, a message is placed in the log file, and the measurement will continue at the next Observation.

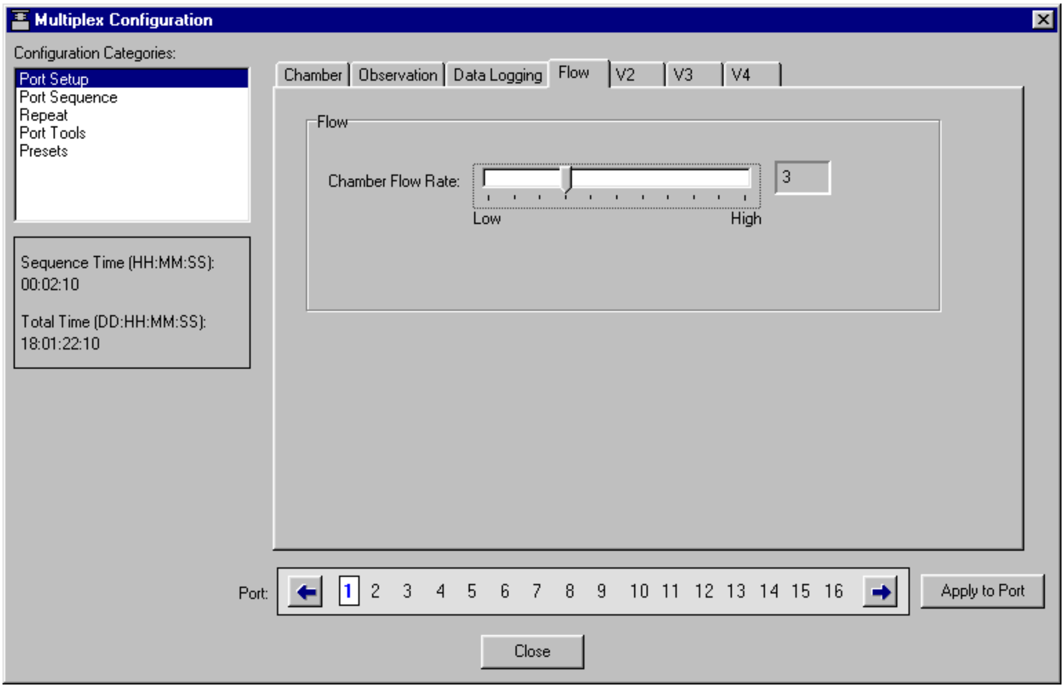
Port Setup: Data Logging

The Data Logging page contains a number of Optional Data Fields that can be logged with each Observation. These fields are not used in any calculations. Choose **Select All** to enable all records, or **Clear All** to disable these records. If you want to perform flux calculations after each Measurement is completed, enable the 'Perform Flux Computations' check box.



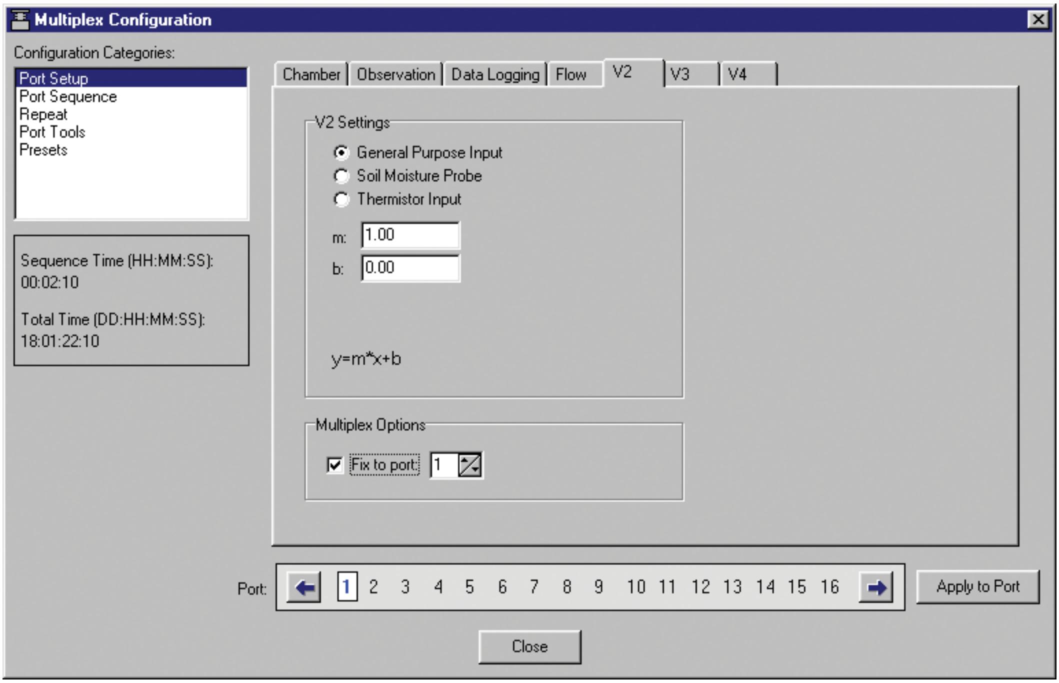
Port Setup: Flow

Click on the Flow tab to set the chamber flow rate. When a Multiplexer is attached, the LI-8100 pump's flow rate is automatically set to High when a measurement is active.



Port Setup: V2 (V3, V4)

The V2, V3, and V4 windows are the areas in which you can input the coefficients for linear external input devices connected to the Chamber Sensor Interface (V1 is dedicated for measuring Multiplexer flow rate). There is a General Purpose Input, a dedicated input for the Decagon EcH_2O or Delta-T Theta soil moisture probes, and a Thermistor input that can be monitored on any of V2, V3, or V4 voltage channels.



Enter the slope and offset values (obtained from the manufacturer) for each device attached to the voltage inputs. If Thermistor Input is selected, the page changes to show input fields A, B, and C, for thermistor calibration coefficients; the thermistor temperature calculation is of the form

$$T\ (^\circ C) = 1/[A + B^*(\ln R) + C^*(\ln R)^3] - 273.15$$

NOTE: If a soil moisture probe is connected, the probe is automatically powered for about 10 seconds to allow it to stabilize, before it is sampled.

The voltage ouput from the input devices connected to the Chamber Sensor Interface can be viewed in the Main Window, or on the control panel inside the Multiplexer case. During normal operation, the value observed is dependent upon which port is currently active; for example, if a Chamber Sensor Inferface is attached to port #1, the voltage output observed is that which is present when a measurement is taking place on port #1. Then, when a measurement starts on port #2, the observed voltage output changes to reflect a device connected to port #2's Chamber Sensor Interface, and so on. In some cases, however, you may want this value to reflect the output from a single device at all times.

For example, if a sonic anemometer is connected to a Chamber Sensor Interface near chamber #7, you might want to view the voltage output from the anemometer on channel V2 at all times, regardless of what might be attached to channel V2 on other ports. To accomplish this, you can 'fix' the output from a voltage channel to a given port. Thus, in the example above, you would select 'Fix to port:7' to monitor the output voltage of the sonic anemometer for all ports on Voltage channel 2. Note that you will not be able to use Voltage channel 2 for any other ports until this function is disabled.

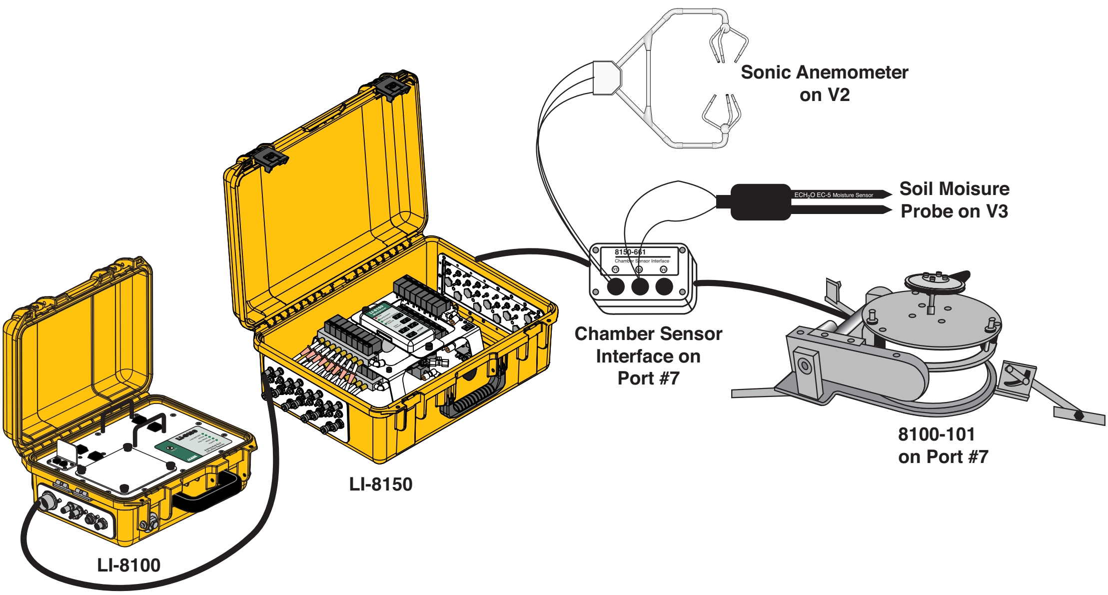
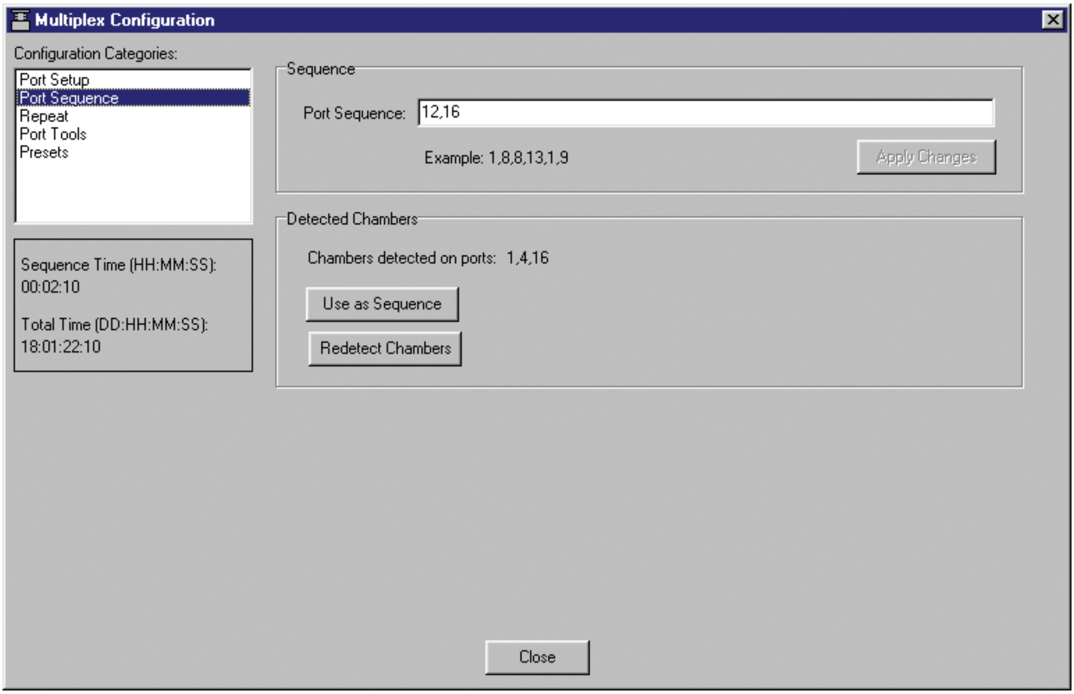


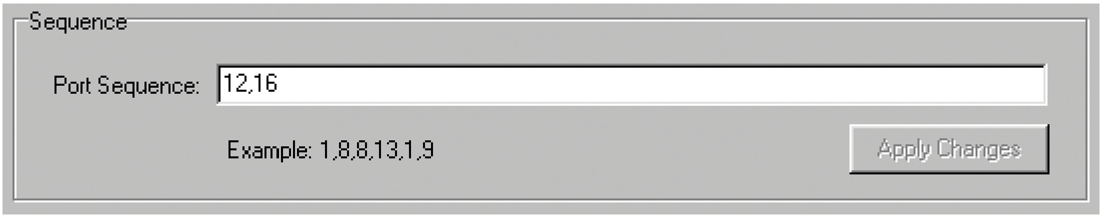
Figure 10-16. *Sensor output can be fixed to a specific port for constant monitoring.*

Port Sequence

The Port Sequence page defines the order in which ports (chambers) are sampled.

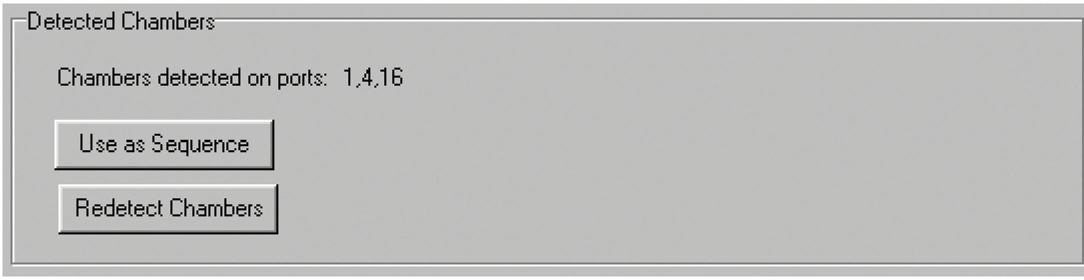


In most instances the ports are measured in sequential order (e.g. 1, 2, 3, 4, …16). They can, however, be measured in any desired sequence by entering the order at Port Sequence. Enter the port sequence, separated by commas (e.g. 1,8,8,13,1,9).



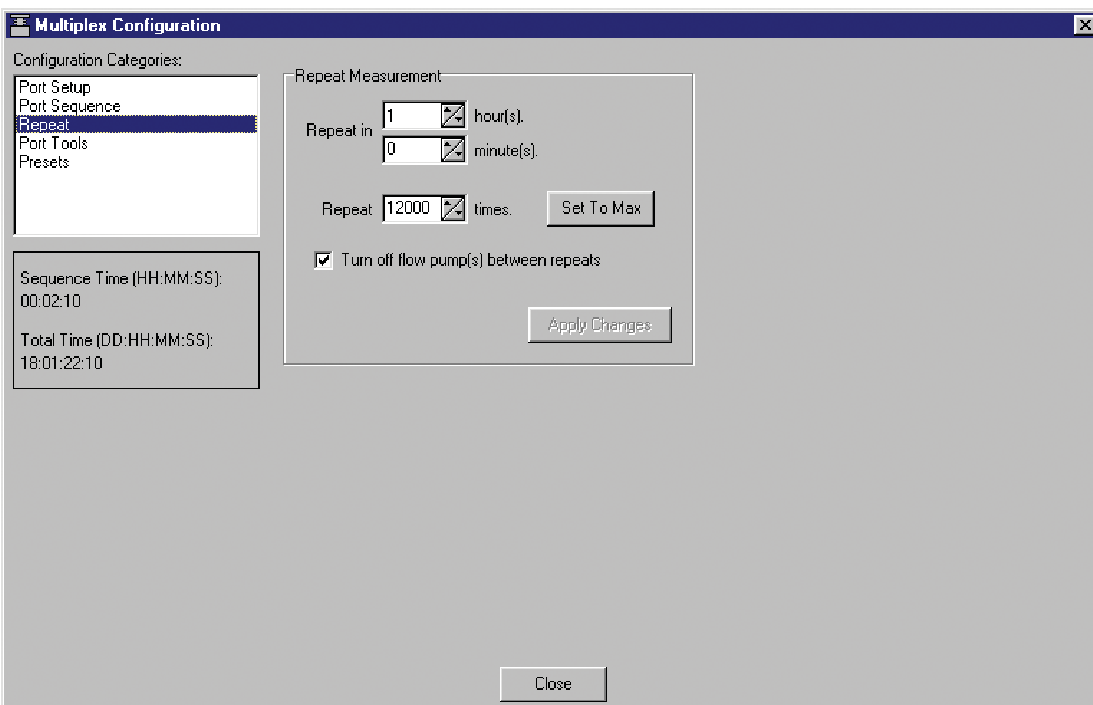
When LI-COR chambers are attached to the Multiplexer, they are automatically detected, and displayed at Detected Chambers. If you want to measure the chambers in the order they were detected, click on **Use as Sequence**. The order will be automatically entered in the Port Sequence field. Click **Redetect Chambers** to query the system again; this is useful if a chamber was added, and you want to system to 'find' the added chamber.

You can also sample ports where there are no chambers (or custom chambers) attached; make sure the 'This chamber provides a "Closed" signal' check box in the Port Setup:Chamber window is unchecked.



Repeat

The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.

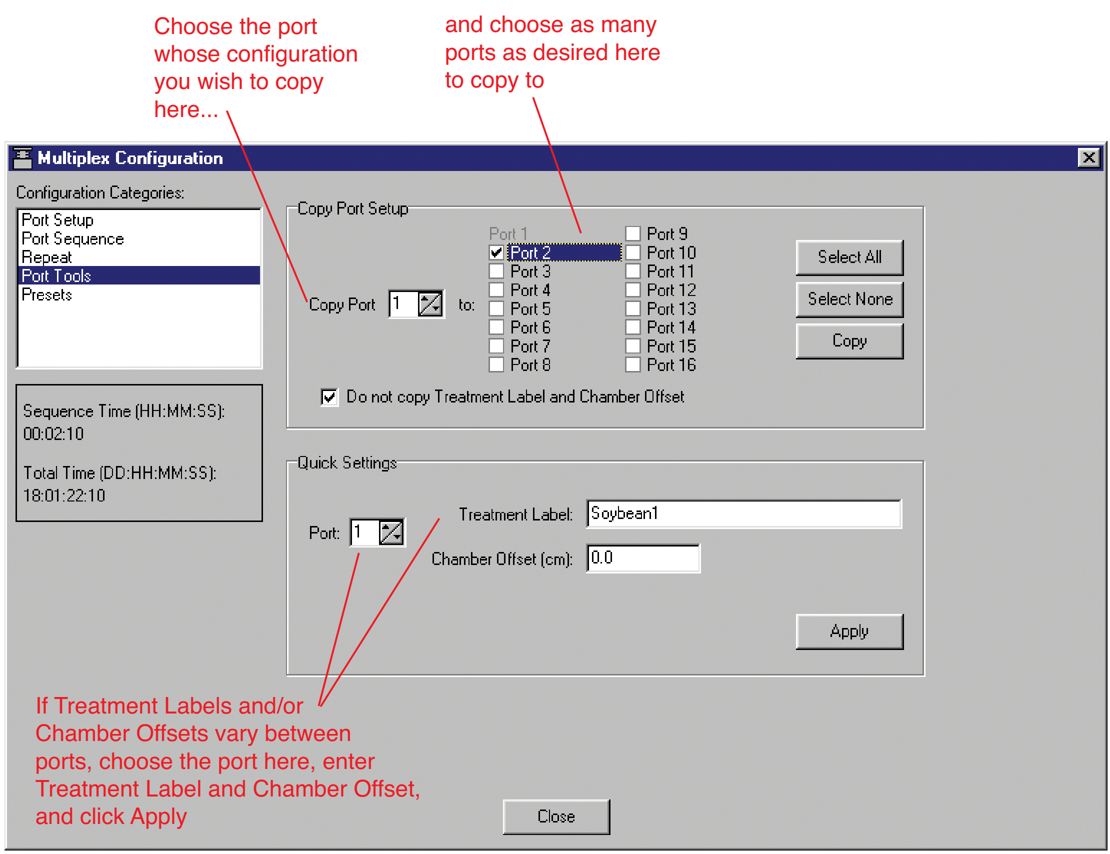


For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 times (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Set To Max** button).

You can elect to turn off the flow pump between repeated measurements to conserve power and extend the life of the pump by enabling the check box.

Port Tools

In many instances, the measurement protocol defined for a port (chamber) will be used for all ports. Or, in other instances, you may want to define a specific protocol for one set of chambers (e.g. between row), and a second protocol for another set of chambers (e.g. in-row). It is not necessary to define each port individually; simply define the protocol for one port, and then copy its definition over to as many other ports as desired.



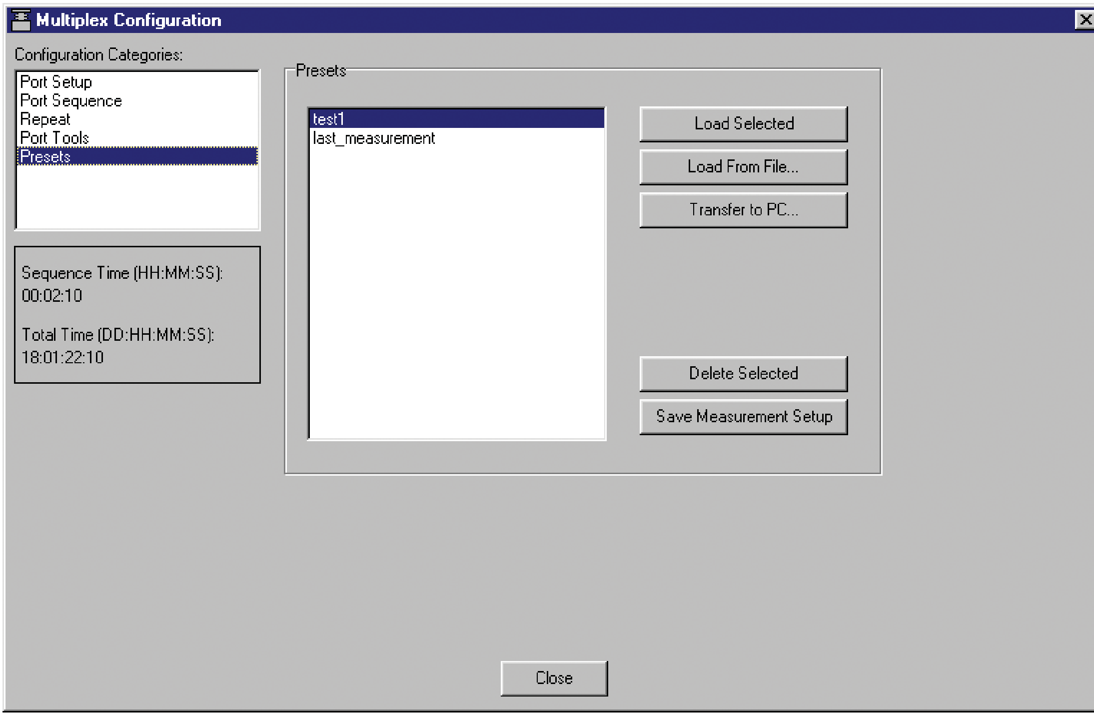
Choose the port whose protocol has been previously defined (#1 in the example above), and then choose the ports to which you want to copy this protocol (#2 in the example above). Click **Select All** to choose all ports, or **Select None** to disable all check boxes. Click **Copy** when finished.

Note that in most instances you will not want to copy the Treatment Label and Chamber Offset values to other ports; they generally vary between chambers. Enable the 'Do not copy Treatment Label and Chamber Offset' check box to prevent the Copy Port's Treatment Label and Offset values from being copied to the other ports.

The Quick Settings area functions as a shortcut for entering Treatment Labels and Chamber Offset values for each port, when you do not copy them as described above. Use the Port up/down arrow selector to choose the port, enter a Treatment Label and Chamber Offset value, and then click **Apply**. Repeat for additional ports. This simply prevents you from having to return to the Observation tab and enter Treatment Labels and Chamber Offsets for each port.

Presets

After you have finished defining a set of measurement protocols, you can save the definition as a **Preset**, which can then be recalled and applied globally, rather than re-defining the protocol each time it is to be used. For example, you might have a series of measurement protocols for daytime, nighttime, and diurnal measurements. Any or all of these protocols can be saved individually for later recall.

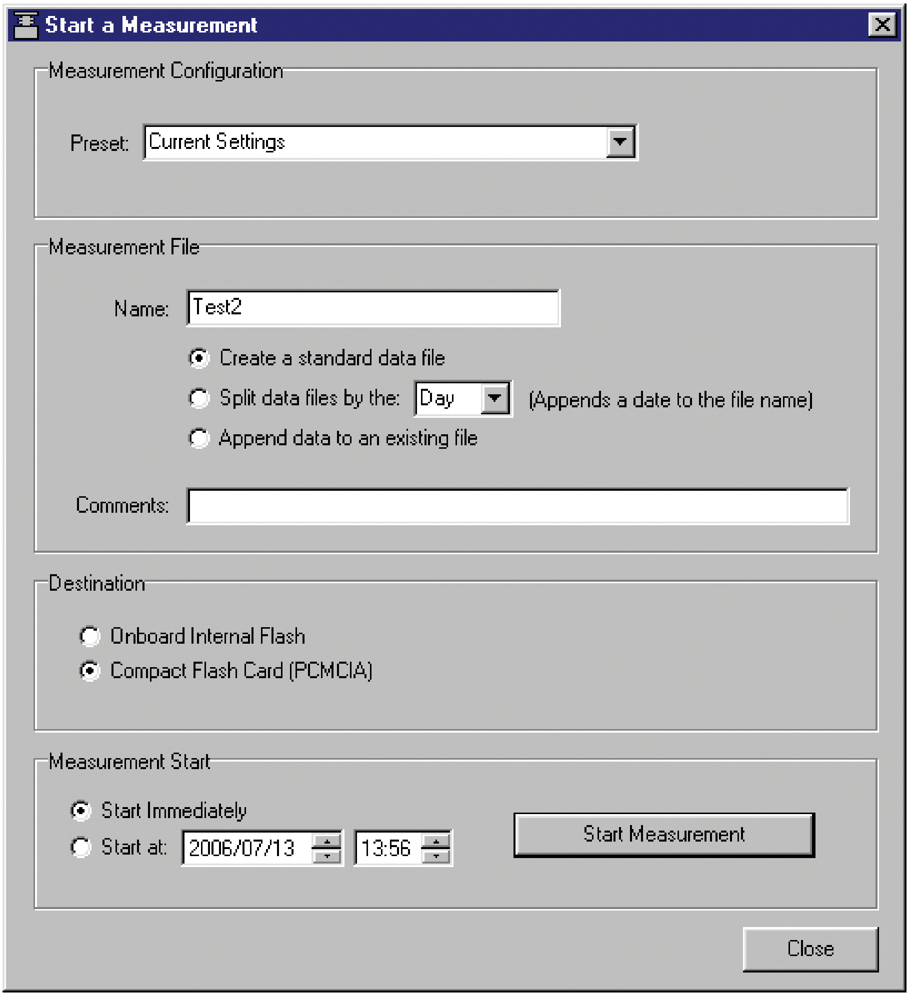


Click **Save Measurement Setup** to save the configuration as currently defined to a measurement Preset. You are prompted for a filename for the Preset. After the Preset is saved, you can save it to the computer by clicking **Transfer to PC**, and choosing a destination for the file (by default, they are saved in a folder named Presets in the LI-8100 Program Files folder). Preset files are appended with a .81p file extension.

To load a Preset, choose a Preset from the list, and click **Load Selected**, or click **Load From File** and locate the file on the computer.

Click **Delete Selected** to remove a Preset from the list.

Start Measurement



Measurement Configuration

You can choose a defined set of measurement parameters from the Preset pull-down menu, or use the configuration as currently defined (see **Measurement Configuration:Presets** above).

Measurement File

Enter a **File Name** and optional **Comments**. The **Comments** appear only in the header information. Files can be created in the standard data file format, where the entire data set is placed in a single file, as defined by the measurement configuration. Large files can be split into smaller files, in increments of 1 day, or 1 week. Files split by the day are appended with a date, beginning at 12:00 a.m. each day; files split by the week are appended with a date, and are also split at 12:00 a.m each day. Click the ‘Append data to an existing file’ button to add new measurement data at the end of the currently defined file.

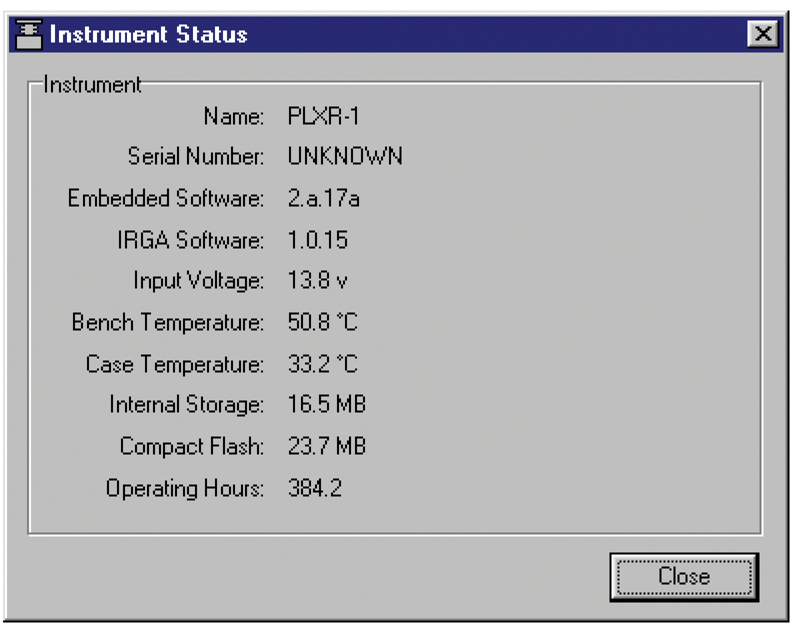
Destination
Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time. Data stored to the internal memory can be transferred to a Compact Flash card or to the PC when a measurement is not active. Note that data files can be large, and the internal memory is limited; in most cases it is recommended that you log to a Compact Flash card.

Measurement Start
Enter a **Start** time. You can start the measurement immediately or choose to begin the measurement at a specified date and time.

View Menu

Instrument Status

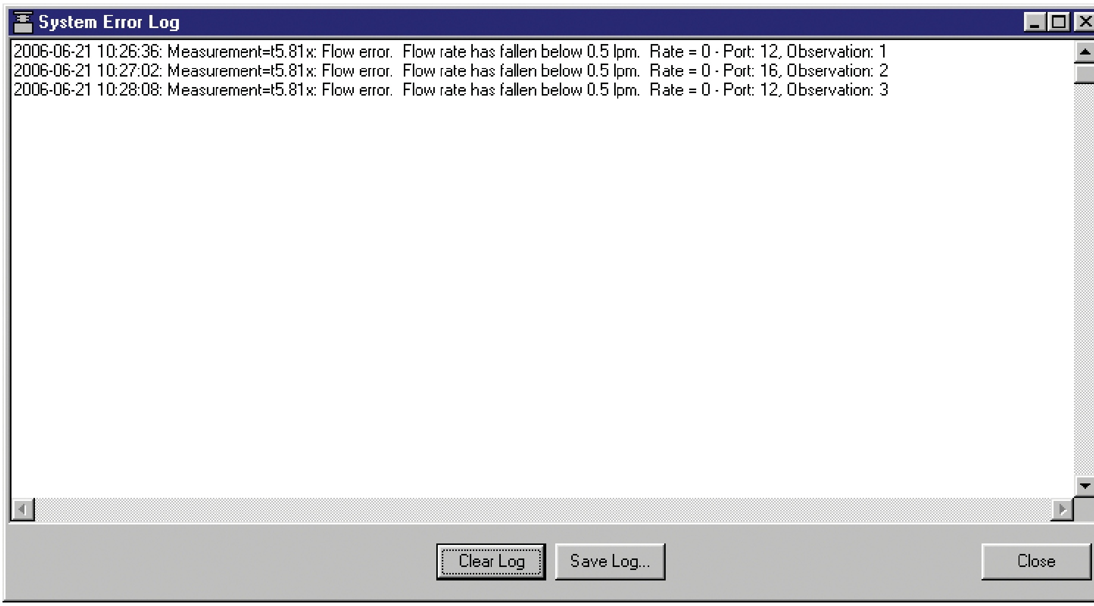
Opens a window that displays the current operating state of the LI-8100.



Click **Close** to close the window.

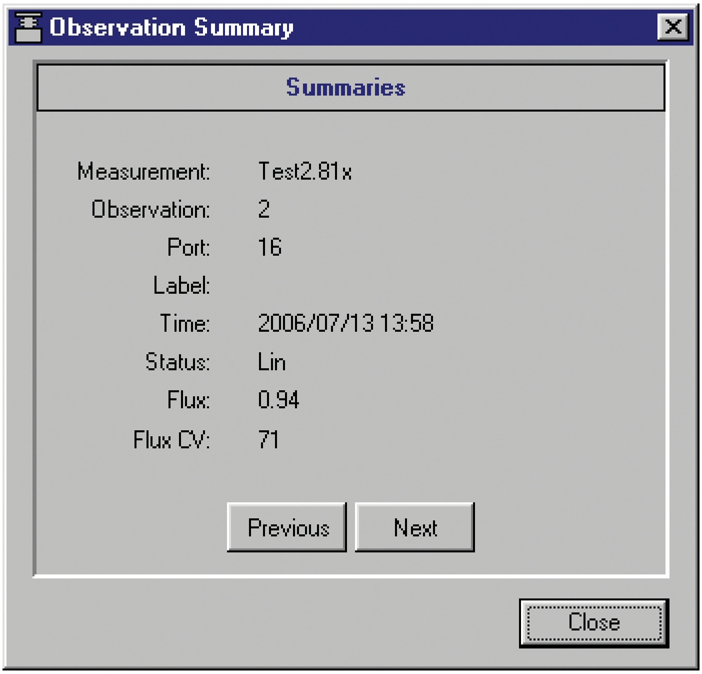
Error Log

Opens a window that displays any logged errors that occurred during a measurement cycle. Click **Clear Log** to delete all messages, or **Save Log** to enter a filename and save the Error Log to a text file.



Summary Records

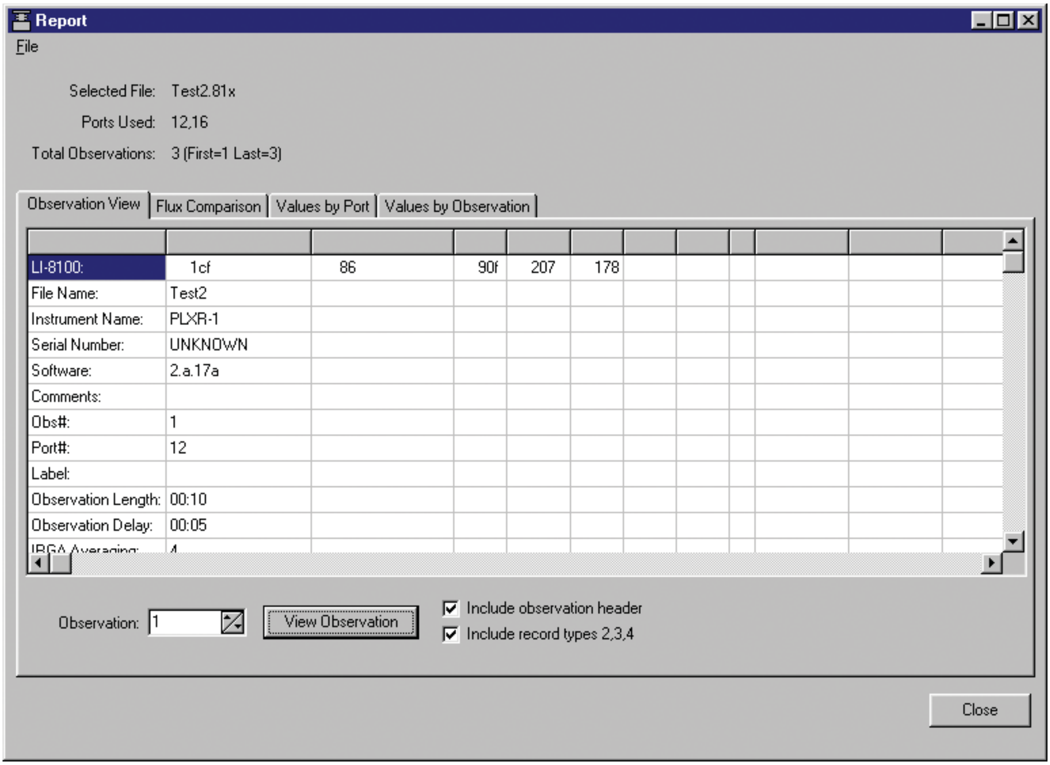
Opens a window that displays select records, including Curve Fit Status (linear or exponential flux calculation), Flux values and Flux CV for each observation. Click **Previous** or **Next** to scroll through all Summary Records.



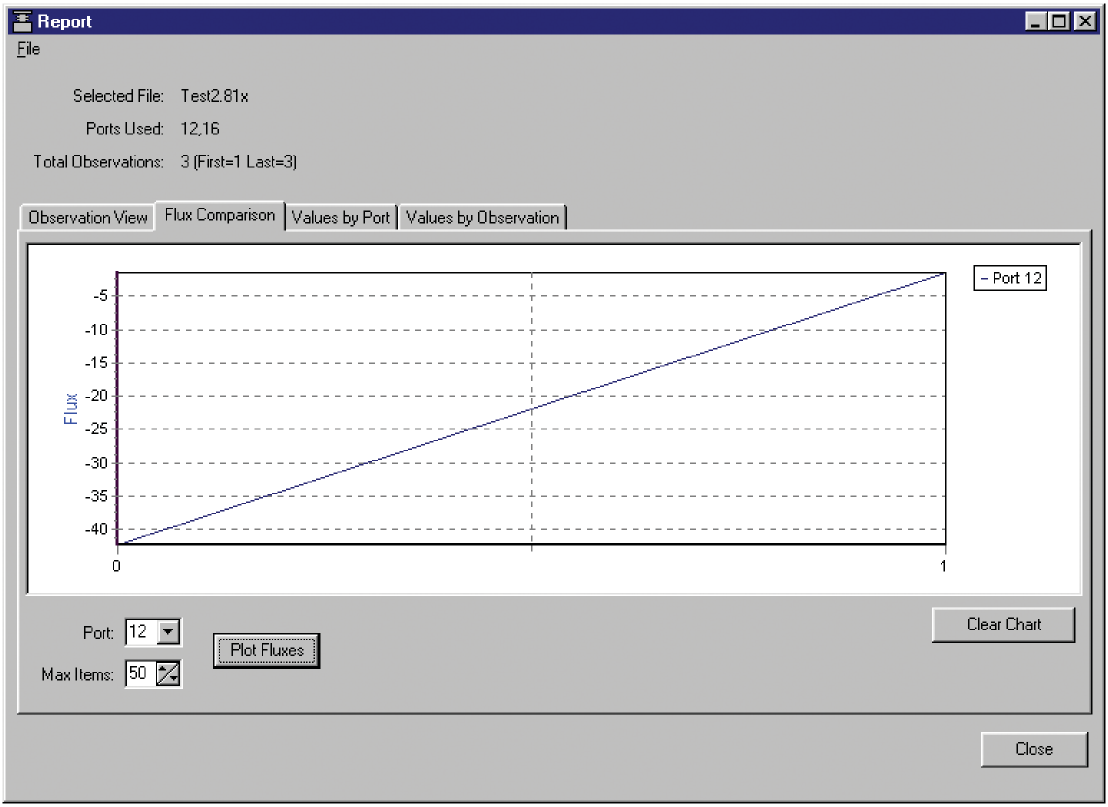
Reports

Opens the Report window, which provides a variety of ways to view selected Observations. Choose **Select Data File** from the File menu, and choose the file whose Observations you want to view.

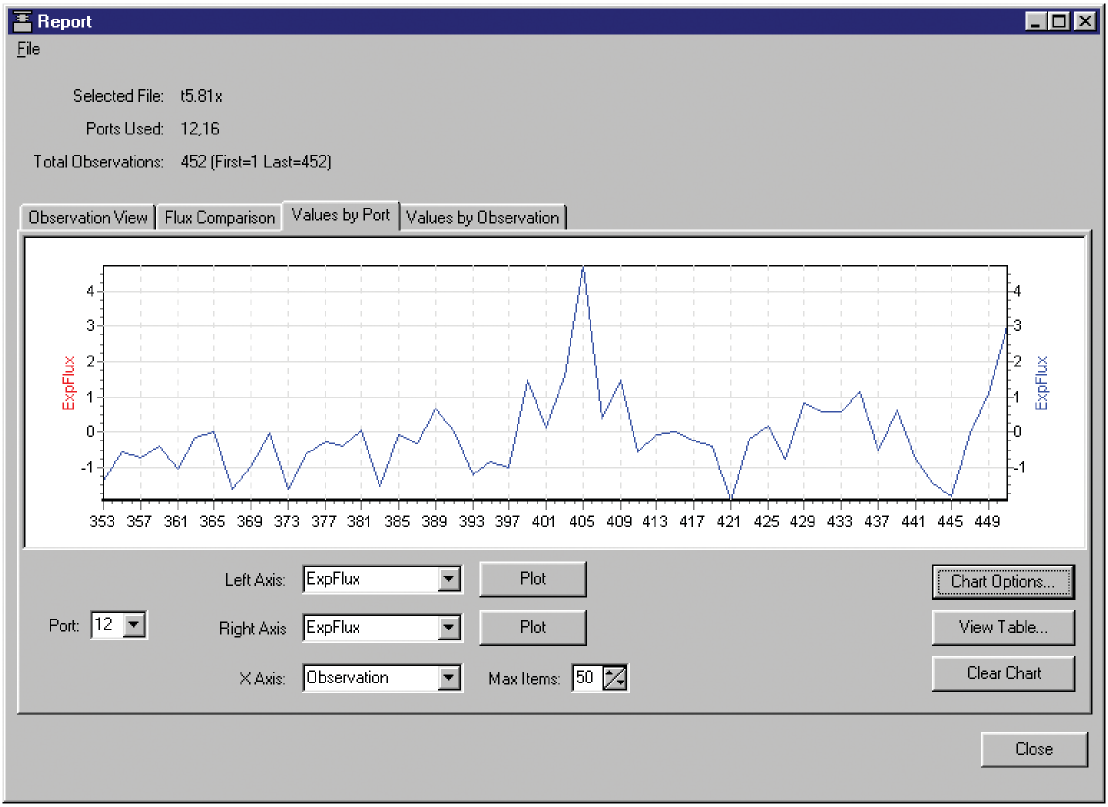
The **Observation tab** displays the Observation's data in tabular format. Choose the Observation number using the scroll arrows (or just type it), and click **View Observation**. If you do not want to view the observation header and/or the summary records (Type 2, 3, and 4 records), disable the check box(es).



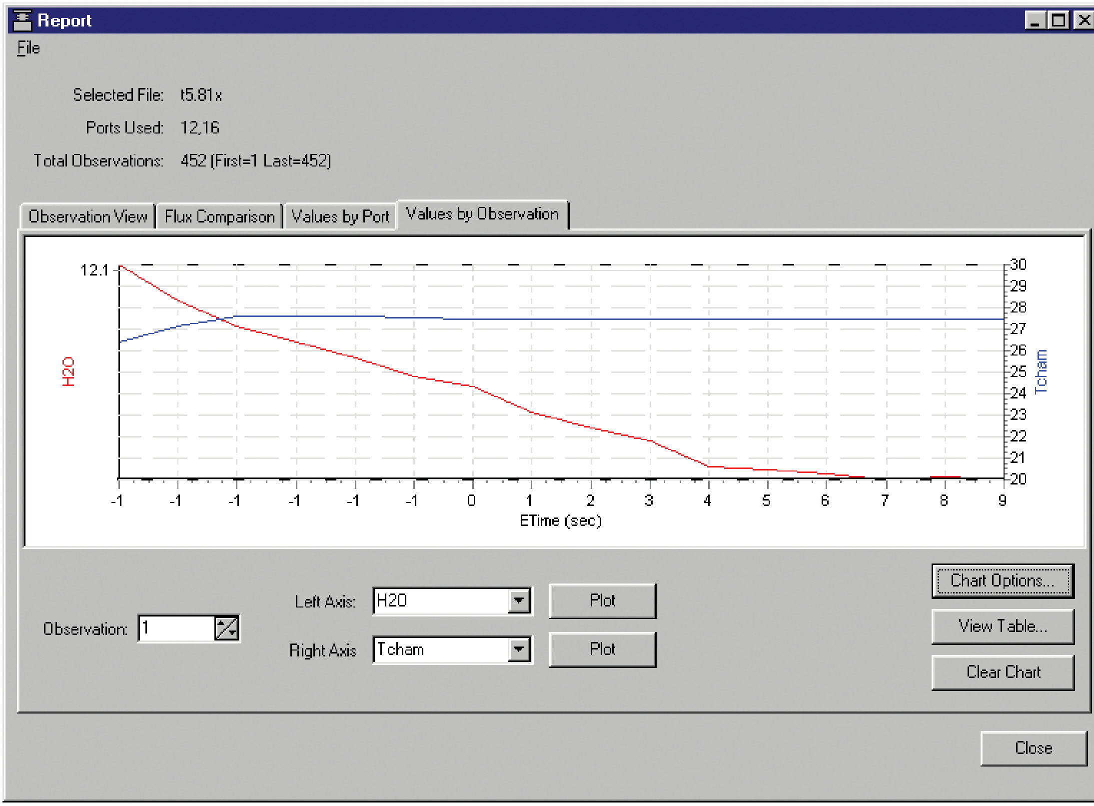
The **Flux Comparison tab** allows you to plot flux values on a chart. The flux values can be plotted for each port; e.g. you can plot fluxes of all ports concurrently. Choose the number of flux data points to be plotted, and click **Plot Fluxes**. The **Max Items** denotes the number of points to plot. The data plotted on the graph are always the most recent in the file. Click **Clear Chart** to remove all plots from the chart.



Click on **Values by Port** to plot records *by port*, on left, right, and X axes. Choose the Port (Chamber) whose records you want to plot, and then select the variable to plot on each axis. Click **Plot**. To automatically scale the left and/or right axes, click on **Chart Options**. Enable automatic scaling, and set the maximum and minimum values for the axes, if desired. To view the selected Observations in tabular format, click on **View Table**. Click **Clear Chart** to remove all data from the chart.



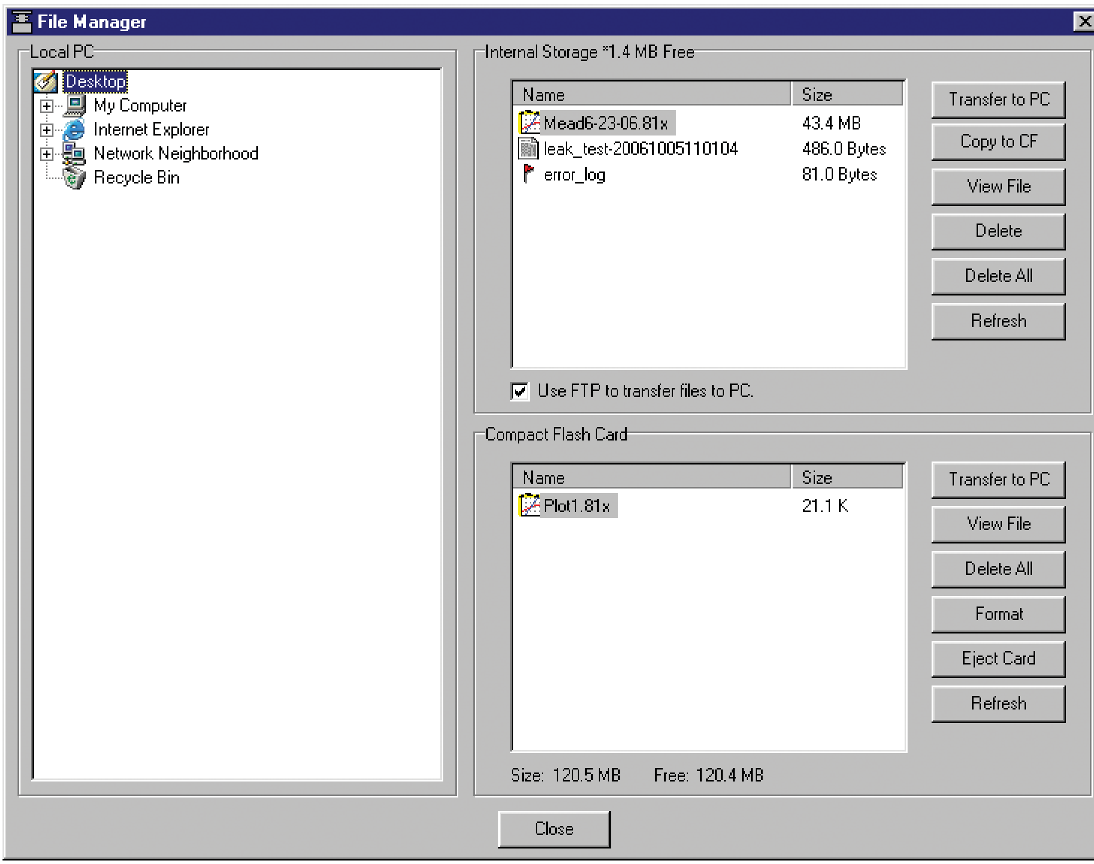
Click on **Values by Observation** to plot records *by obseration*, on left and right axes, against elapsed time (ETime). Choose the Observation whose records you want to plot, and then select the variable to plot on each axis. Click **Plot**. To automatically scale the left and/or right axes, click on **Chart Options**. Enable automatic scaling, and set the maximum and minimum values for the axes, if desired. To view the selected Observations in tabular format, click on **View Table**. Click **Clear Chart** to remove all data from the chart.


Report
File
Selected File: t5.81x
Ports Used: 12,16
Total Observations: 452 (First=1 Last=452)
Observation View
Flux Comparison
Values by Port
Values by Observation
12.1
H2O
Tcham
30
29
28
27
26
25
24
23
22
21
20
-1
-1
-1
-1
-1
-1
0
1
2
3
4
5
6
7
8
9
ETime (sec)
Chart Options...
Left Axis: H2O
Plot
Observation: 1
Right Axis Tcham
Plot
View Table...
Clear Chart
Close

Utilities Menu

File Manager

Opens the File Manager dialog, where you can move files from the LI-8100 to your computer or optional compact flash card.



The Local PC window displays a directory tree of the files on your computer. The Internal Storage window displays the LI-8100 data files currently stored on the LI-8100 internal flash memory, and the amount of free memory available. Note that there is an asterisk by the free memory available shown; this is a reminder that data files stored on the LI-8100 are compressed. Therefore, the free memory available on the LI-8100 may not be indicative of how many files can be stored there. Files are compressed at a ratio of roughly 3:1, meaning if 15 MB of free space are indicated, approximately 45 MB of LI-8100 data files may be stored. The file sizes listed in the directory list are actual size, however.

If a compact flash card is present, the Compact Flash window also shows the amount of available memory on the card. To move files from the LI-8100:

1. Select the file you want to transfer and select **Transfer to PC** or **Copy to CF**. When **Transfer to PC** is selected, the file(s) will be transferred to the selected destination in the Local PC area.

2. Click, drag and drop the file(s) you want to transfer.

Some useful keyboard shortcuts: Most of the common keyboard shortcuts can be used when selecting and/or moving files in the LI-8100 directory list. For example, press CTRL + A to select all files, Shift + click to select a range of files, or CTRL + click to select multiple files individually. You can also "drag and drop" selected files to the PC destination of choice, or to the Compact Flash card.

From Internal Storage...

Click the **Transfer to PC** button to move the highlighted file(s). When you are finished moving files, you can delete selected files, or all files, by clicking **Delete**, or **Delete All**, respectively. Click on **Refresh** to update the file list. Click **Copy to CF** to move the selected files to the compact flash card. Click **View File** to open the entire file in a new text window.

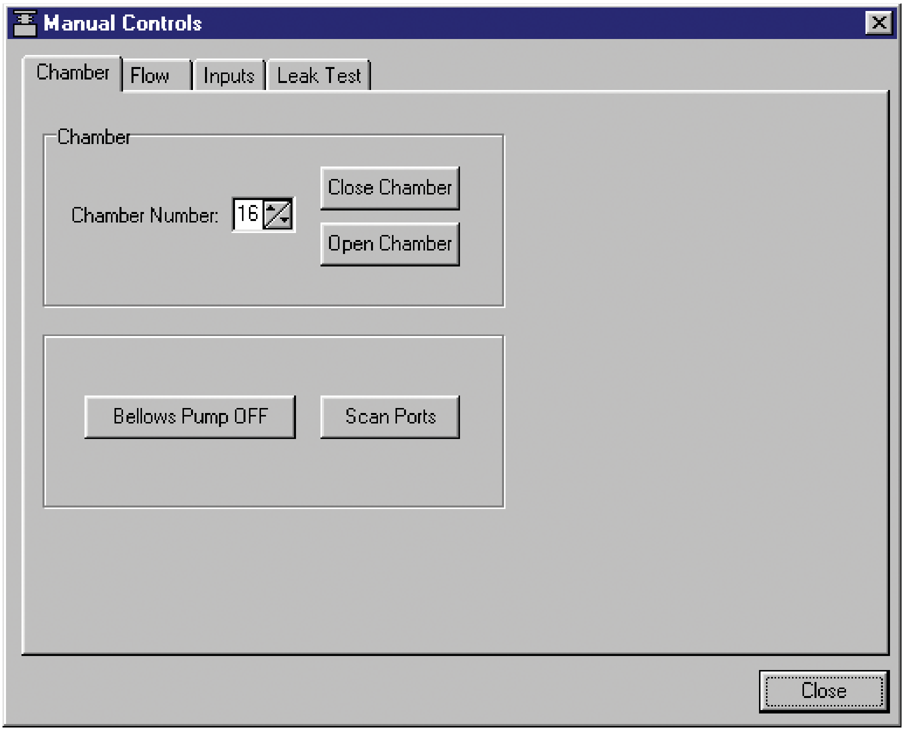
Files generated by the LI-8100 are denoted with a .81x file extension, and contain all of the raw data records and summaries.

From the Compact Flash Card...

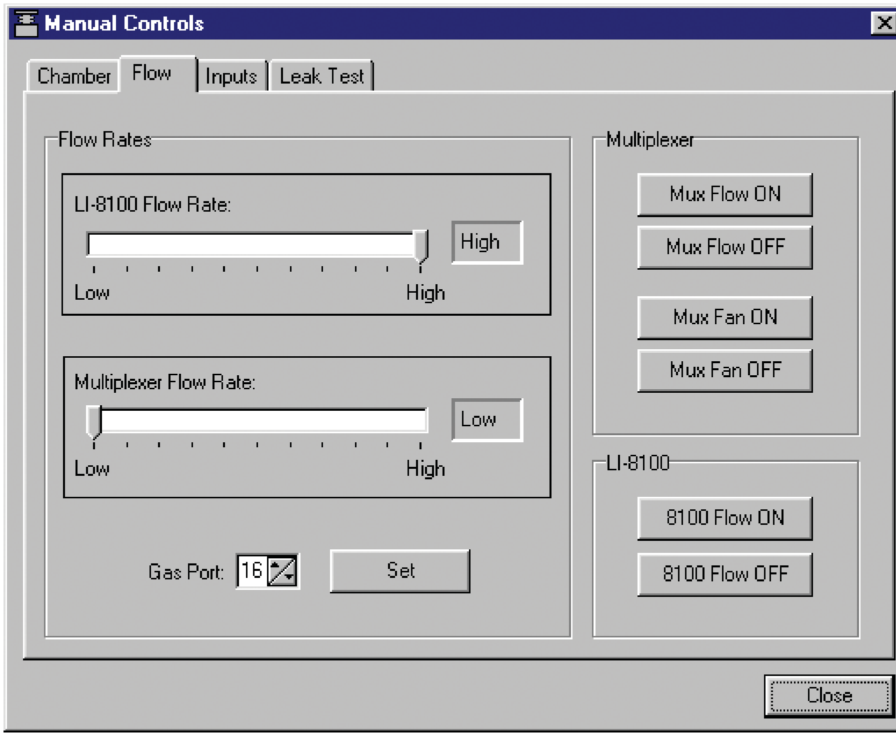
Click on **Format** to format the compact flash card. ***Note that all files on the card will be deleted.*** Click the **Transfer to PC** button to move the highlighted file(s). When you are finished moving files, you can delete all files by clicking **Delete All**. Click **View File** to open the entire file in a new text window. Click **Eject Card** to unmount the compact flash card, and facilitate safe removal from the instrument. Click on **Refresh** to update the file list.

Manual Controls

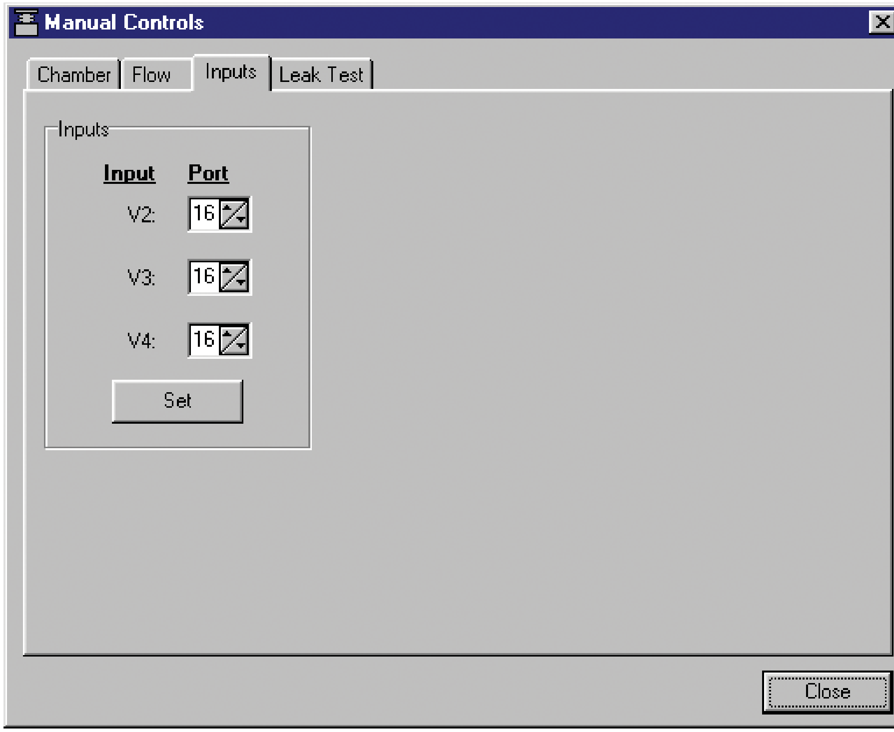
Opens the Manual Controls dialog, where you can use manual chamber controls to open or close the chambers, turn the LI-8100 or Multiplexer flow on or off, turn the bellows pump off, set voltage inputs to specified ports, and perform a leak test on the Multiplexer. Controlling the chamber flow manually is useful when performing user calibration of the infrared gas analyzer, as described in Section 5. In general, the Manual Controls are used for diagnostic purposes, and are not used when making typical measurements.



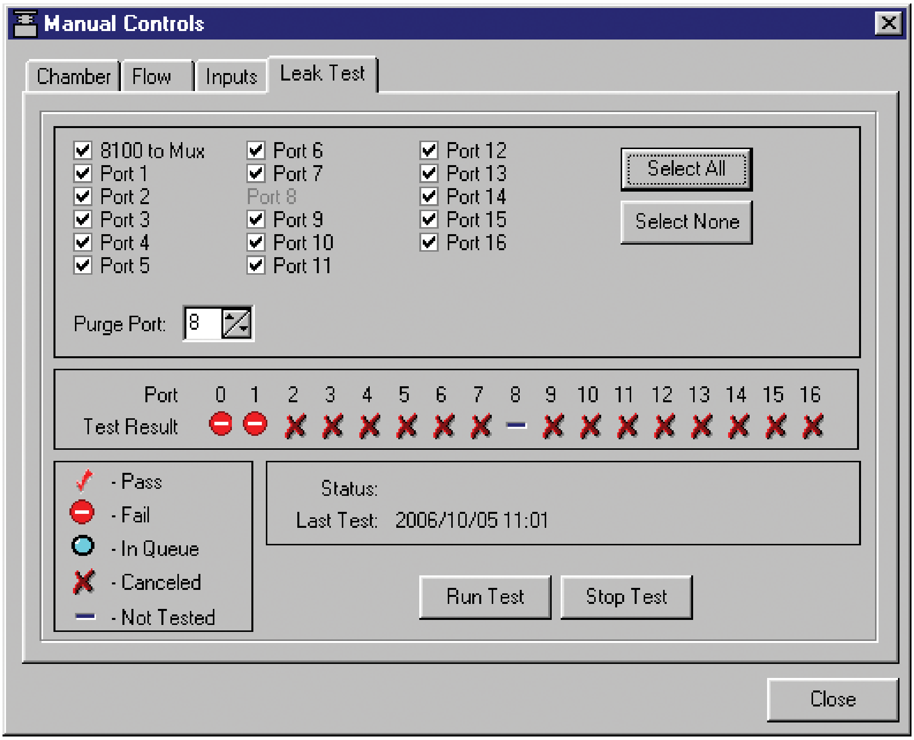
Choose the chamber number that you want to manually open or close, and click the **Close Chamber** or **Open Chamber** button. Click **Scan Ports** to force the system to detect chambers connected to the system. The detected chambers are shown in the Main window.



The Flow tab contains a variety of controls for adjusting the flow rate of both the LI-8100 and LI-8150. Choose the Gas Port whose flow you want to adjust, and click **Set**. The LI-8100 and/or LI-8150 flow rates can be adjusted, from Low to High as desired, as well as turned Off and back On. Note that when a measurement is started, the LI-8100 flow rate is automatically set to High, regardless of how it might be set in the Manual Controls dialog.



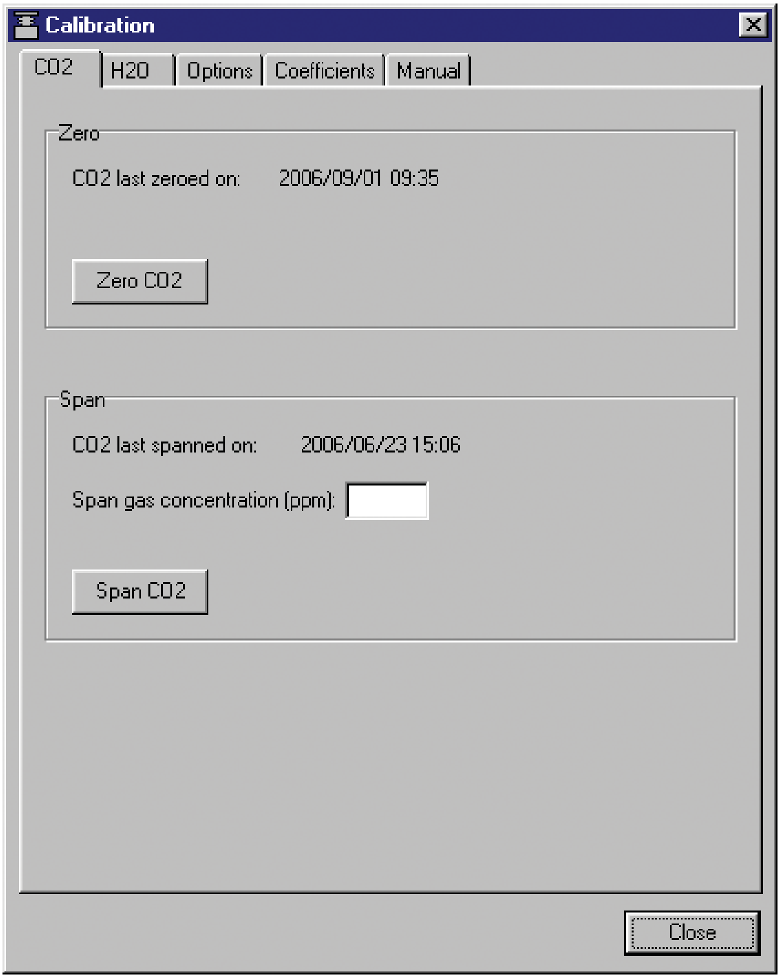
The Inputs tab allows you to manually set the voltage input that is displayed on the Main page, and on the LI-8150 control panel. Choose the voltage input (V2, V3, or V4) and the gas port containing the sensor whose voltage output you want to monitor, and click Set. For example, if you have a soil temperature probe connected to a Chamber Sensor Interface at Port 9, and it is connected to voltage input V3, choose Port 9 at Input V3; the voltage output from that probe is displayed in the Main window (if V3 is defined as one of the variables displayed there) and on the LI-8150 control panel at V3.



Information on how to perform a Leak Test can be found earlier in this section at *Performing a Leak Test*.

Calibration

Select **Calibration** to open the Calibration window. This is the area in which you set the zero and span of the infrared gas analyzer in LI-8100 Analyzer Control Unit. Step-by-step instructions for performing user calibrations are given in Section 5.



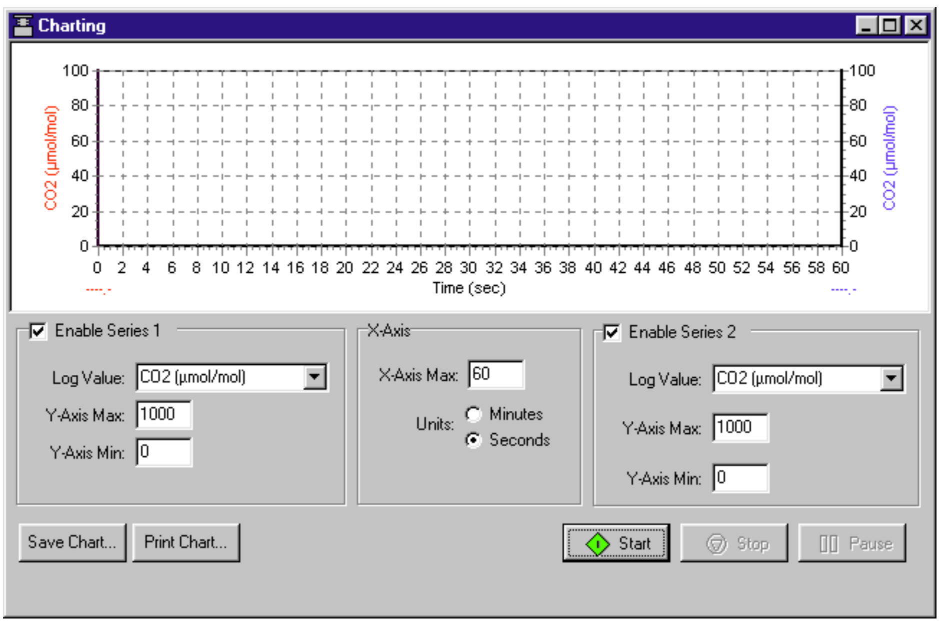
The calibration functions for both CO_2 and H_2O correct for pressure fluctuations that may be present. To disable this correction, click on the Options tab and uncheck the 'Enable Pressure Compensation' check box.

The LI-8100 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. These coefficients are fixed at the factory, and are present on the calibration sheet included with the instrument.

The calibration constants for CO_2 and H_2O zero and span calibrations are found on the Manual page. These constants are stored to a file on the computer by clicking on **Save Values**. Click **Load Values** to restore the values in this window using the file on the PC. If new constants are entered in this window, click **Apply** to send the values to the LI-8100 for implementation; the constants are not automatically saved to the computer until you choose **Save Constants**.

Charting

Select **Charting** to open the Charting window (below). This is the window in which you can set up the parameters for plotting your real-time 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.

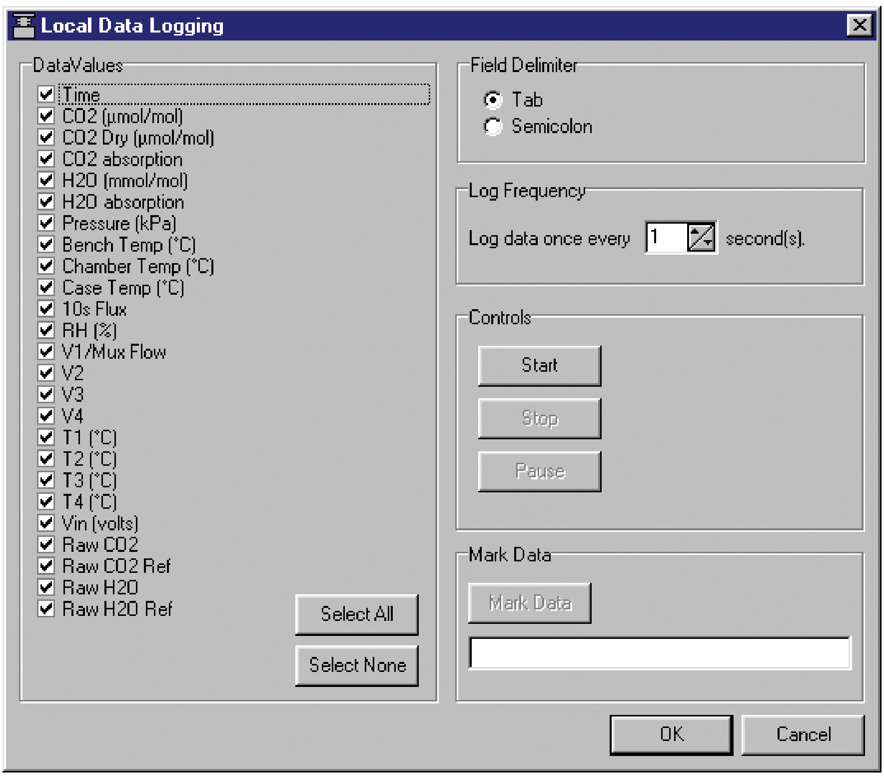
X-Axis Max

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. Click on **Save Chart** to save the plot as currently displayed in the window to a .bmp file. Click **Print Chart** to print the currently displayed plot to your printer.

PC Data Logging

Opens the Local Data Logging dialog, where you can configure the real-time data output options for collecting selected data records on your computer. By default, log files are denoted with a .txt file extension.



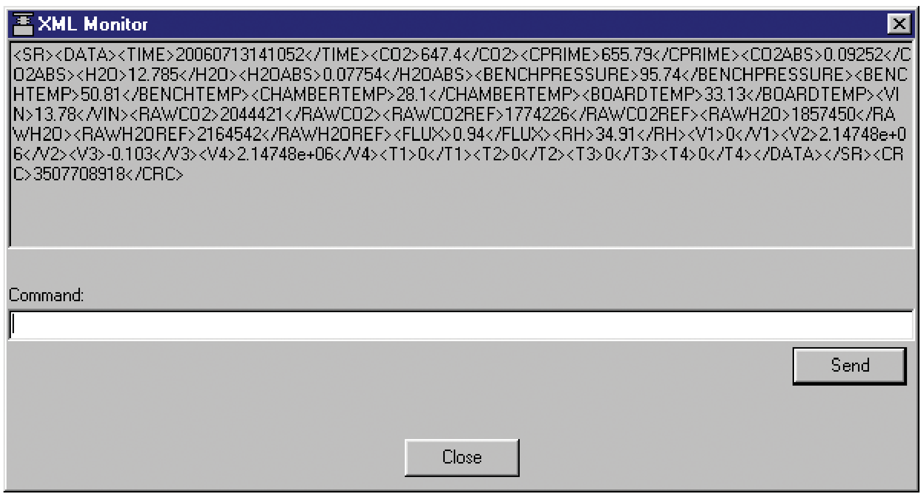
Choose the frequency at which to log data (seconds), and the delimiter for the data fields (tab or semicolon character). Use the **Controls** buttons to manually start or stop data logging, independent of any measurement protocol that is currently defined. You are prompted for a file name and destination for the log file. After the **Start** button is pressed and data logging begins, you can enter comments in the Mark Data field and click the **Mark Data** button to insert the comment into the data file. For example, if you observed an anomaly while logging data and want to make note of the time of its occurrence, you could enter a comment and insert it into the log file for later reference.

The data values that can be output are as follows:

Label	***Description***
Time	Instrument time.
CO2 (µmol/mol)	Chamber CO_2 concentration in µmol/mol.
CO2 Dry (µmol/mol)	Chamber CO_2 concentration, corrected for water vapor dilution.
CO2 absorption	Absorption of photons in the optical bench due to the presence of CO_2.
H2O (mmol/mol)	Chamber water vapor concentration, in mmol/mol.
H2O absorption	Absorption of photons in the optical bench due to the presence of water vapor.
Pressure (kPa)	Atmospheric pressure in the optical bench.
Bench Temp (°C)	Temperature of the optical bench.
Chamber Temp (°C)	Air temperature inside the soil chamber during an active measurement (if no measurement is active, displays Multiplexer case temperature).
Case Temp (°C)	Air temperature inside the Analyzer Control Unit case.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
RH (%)	Relative humidity inside the soil chamber.
V1/Mux Flow	Output at voltage channel 1 (multiplexer flow to LI-8100 when attached).
V2	Output at voltage channel 2.
V3	Output at voltage channel 3.
V4	Output at voltage channel 4.
Vin (volts)	Input (battery) voltage.
Raw CO2	CO_2 raw signal.
Raw CO2 Ref	A measure of the optical amplitude of the CO_2 channel, primarily for diagnostic purposes.
Raw H2O	H_2O raw signal.
Raw H2O Ref	A measure of the optical amplitude of the H_2O channel, primarily for diagnostic purposes.

XML Monitor

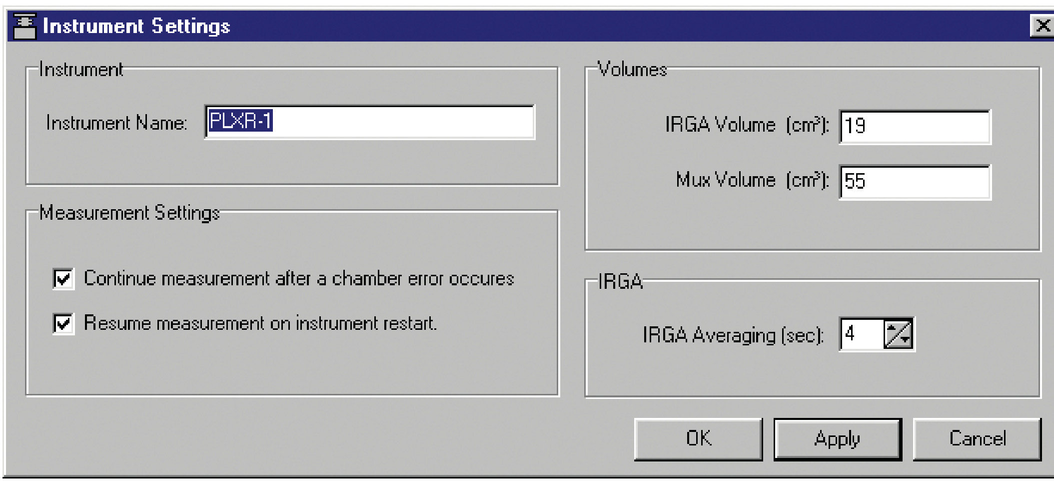
The configuration grammar used to communicate with the LI-8100 is based upon a subset of XML (eXtensible Markup Language). XML relies on the use of tags to "Markup" or give structural rules to a set of data. The XML Monitor window is primarily a diagnostic tool that displays real-time XML communication; a command line field is present that allows the user to send an XML command to the LI-8100 for implemenation. This can be useful for diagnosing problems, as a LI-COR technician can gauge the instrument's response to given commands, and determine if the instrument is functioning properly.



8100 Menu

Instrument Settings

You can enter a name for the instrument, decide how to proceed after a chamber error or instrument restart occurs, choose default values for IRGA and Multiplexer volumes, and choose the time interval (in seconds) over which to average the IRGA readings in this window.



The instrument name is a user-entered name; enter a maximum of 30 characters. The instrument name is used to identify data from multiple instruments; when logging data to a compact flash card, a directory is created with the instrument name under which to store the data.

The Measurement Settings determine whether or not the measurement will continue after a chamber error (e.g. the chamber fails to close because of an obstruction) occurs, and whether to resume a measurement after an instrument restart, as can occur from a power failure or a low battery condition.

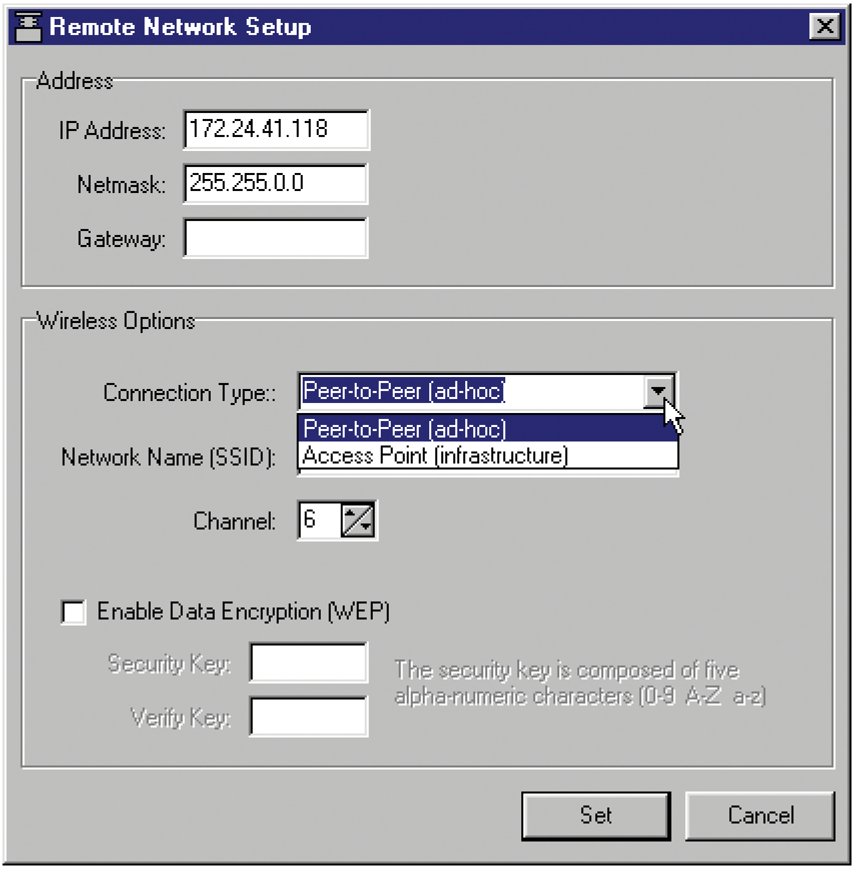
The Volumes are used as default values for the IRGA in the LI-8100, and the tubing in the LI-8150 Multiplexer. In most cases these values should not be changed. Default values are 19 cm^3 for the IRGA volume, and 55 cm^3 for the Multiplexer volume.

The IRGA Averaging setting controls the amount of averaging that is done to CO_2 and H_2O signals from the IRGA. The IRGA is sampled at 2Hz. With 4 second IRGA Averaging (the default recommended setting) 8 data points will go into any value of CO_2 or H_2O. As data stream in, earlier data are dropped from the average. The minimum is 1 second and the maximum is 20 seconds.

Click on **Apply** to send these values to the LI-8100 for implementation.

Networking

The LI-8100 can be connected to a PC or PDA via a wireless network if desired. The Remote Network Setup window allows you to configure wireless options for the LI-8100.



Connection Type

The LI-8100 is preconfigured for a **peer-to-peer** (ad-hoc) wireless 802.11b network. An ad-hoc, or peer-to-peer wireless network consists of a number of devices, each equipped with a wireless networking interface card. Each device can communicate directly with all of the other wireless enabled devices. These devices can share information, but may not be able to access wired LAN resources, unless an **access point** (below) is used. A peer-to-peer network allows the LI-8100 to connect other devices (e.g. the computer or Palm PDA) without a separate server running on that network.

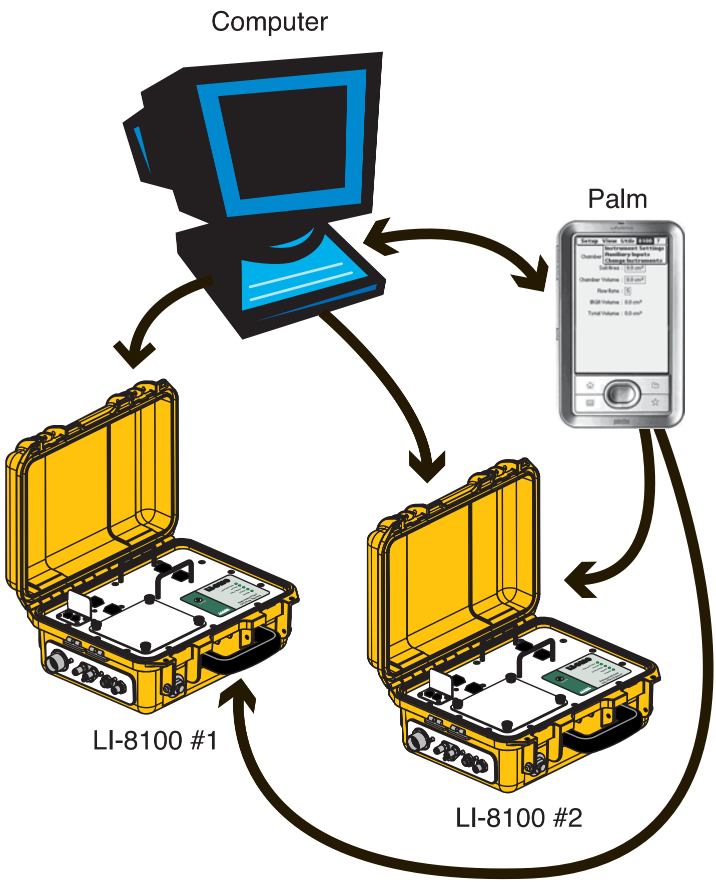


Figure 10-17. *On an Ad-hoc network, each device can communicate with other wireless enabled devices.*

The LI-8100 can also be connected to a specific hardware **access point**; this can be a dedicated hardware access point (HAP) such as a linksys wireless router/access point, or it can be a Software Access Point that runs on a computer equipped with a wireless network interface card. The access point acts as a hub to provide connectivity for the wireless devices. Note that even with an access point present, only one client (PC or PDA) can talk to an LI-8100 at a time.

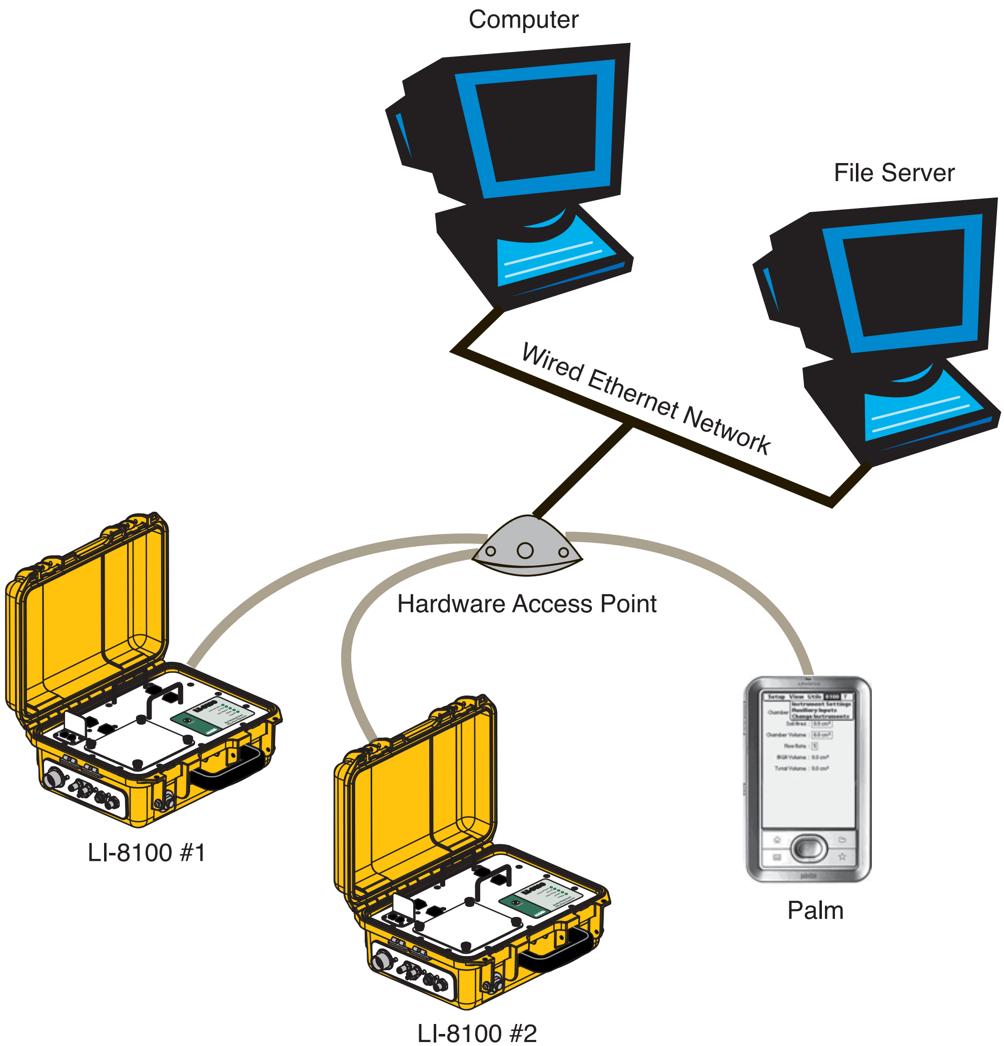


Figure 10-18. *A hardware access point can be used to bridge wireless and wired network devices.*

In order to communicate with other devices, the LI-8100 must be given a unique IP address, netmask, network name, and channel. Optionally, data encryption can be enabled.

The **IP address** is a number that uniquely identifies each node on the network. The address is composed of a set of four numbers called "octets", where each octet ranges in value from 0 to 255. When entering an IP address, the octets are separated with a period. For example, 192.168.100.2 is a valid IP address.

Some IP address ranges have been set aside for private use, and are typically used by organizations for internal networks. LI-COR recommends choosing an IP address from the private range 192.168.100.0 to 192.168.100.255. In this range, the first 3 octets, which represent the network address, are fixed at 192.168.100. The last octet, which represents the host address, must be different for each node on the network. For simplicity, you can number your first device 192.168.100.1, your second device 192.168.100.2, and so on.

For example, suppose you have two LI-8100s, a computer, and a Palm handheld device (Figure 9-17). You could assign the following IP addresses to each device (ad-hoc):

LI-8100 #1:192.168.100.1
LI-8100 #2:192.168.100.2
Computer:192.168.100.3
PDA:192.168.100.4

For an access point, you will need to know the network addresses for the access point and assign an IP address in that range.

The **netmask** is a set of 4 octets used to separate an IP address into two parts; the network address and the host address. If you are using LI-COR's recommended IP address range, the netmask should be set to 255.255.255.0.

The **Gateway** is a node that routes traffic to another network (for ad-hoc configurations, leave this blank).

The **Wireless Options** are inherent to 802.11 networks. The network is given a name, a frequency, and optional encryption keys.

The **network name**, or **SSID** (Service Set Identifier), is a name given to a wireless local-area network (WLAN). Each device that needs to communicate must have the same SSID. The LI-8100 supports a network name of up to 30 characters.

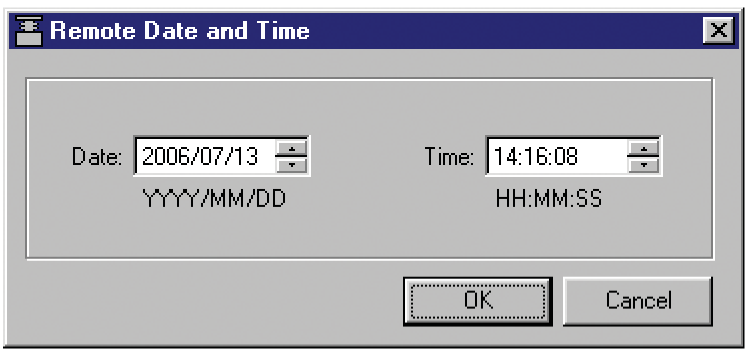
A range of radio frequencies between 2.4 and 2.5 GHz have been designated for public use in most countries. The **channel** refers to a specific portion of the total frequency range that is given to a device for communication. The LI-8100 supports channels 1 to 11. Choose an appropriate channel for the country where the instrument will be located.

Country	Channels
Europe	1-13
USA	1-11
France	10-13
Japan	1-14

WEP (Wired Equivalent Policy) is an encryption standard built into 802.11b, and is supported by the LI-8100. If data encryption is enabled, the same 40-bit (5 character) key must be entered on all devices of the WLAN. The key is used for data encryption and decryption.

Date and Time

Sets the clock in the LI-8100.



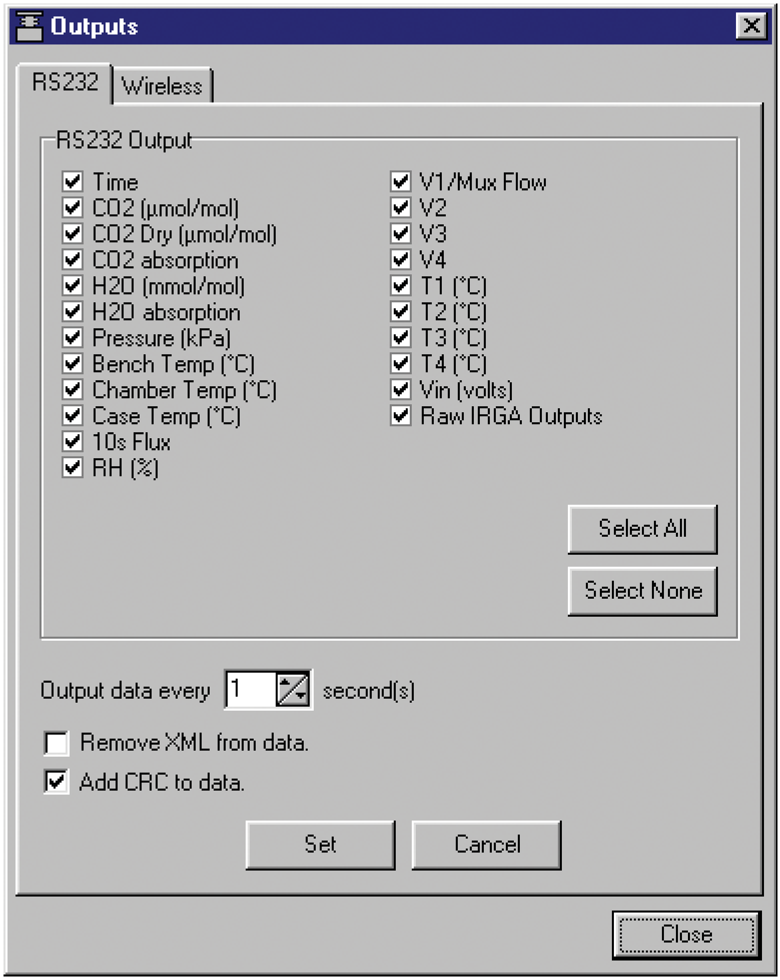
Click on year, month, or day field to highlight the text, and use the up or down arrow buttons to increase or decrease the numbers. Alternatively, highlight the desired field and type in the new number.

Click on the hour, minutes, or seconds field and use the up or down arrow buttons to adjust the time. The clock is a 24-hour clock; i.e., 13:00:00 is 1:00 p.m.

Click **OK** to dismiss the dialog and accept the change(s).

Outputs

Opens the Outputs dialog, where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included, as when using the PC Data Logging options.



Choose the raw data values to be sent to the RS-232 port and output frequency (seconds). Note that when the LI-8100 outputs data, each field is "marked up" using e**X**tensible **M**arkup **L**anguage (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the **'Remove XML from data'** check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

Disable the 'Add CRC to data' check box to remove CRC from the data.

Click on the RS-232 or Wireless tabs to configure data values to be output over that channel. You can configure either channel while connected to that channel; however, changes will not take effect until you disconnect.

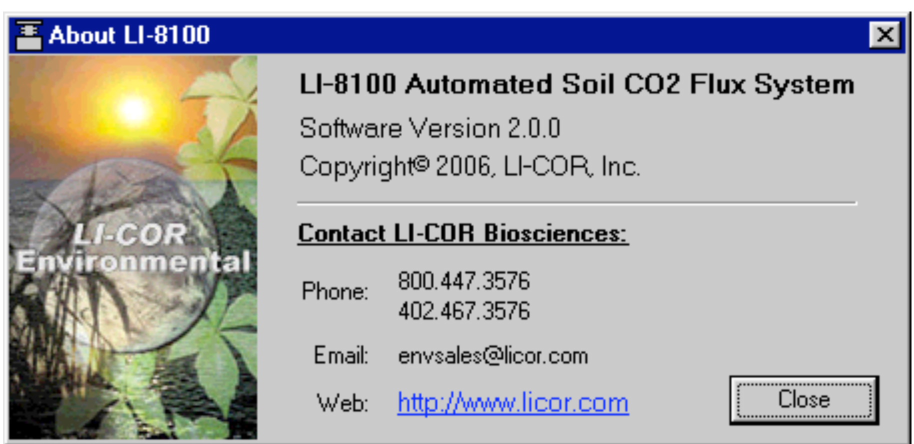
Help Menu

Help

Opens the on-line help index, where you can choose help topics related to the Windows application software.

About

Displays the current LI-8100 Windows software version number and contact information for LI-COR.

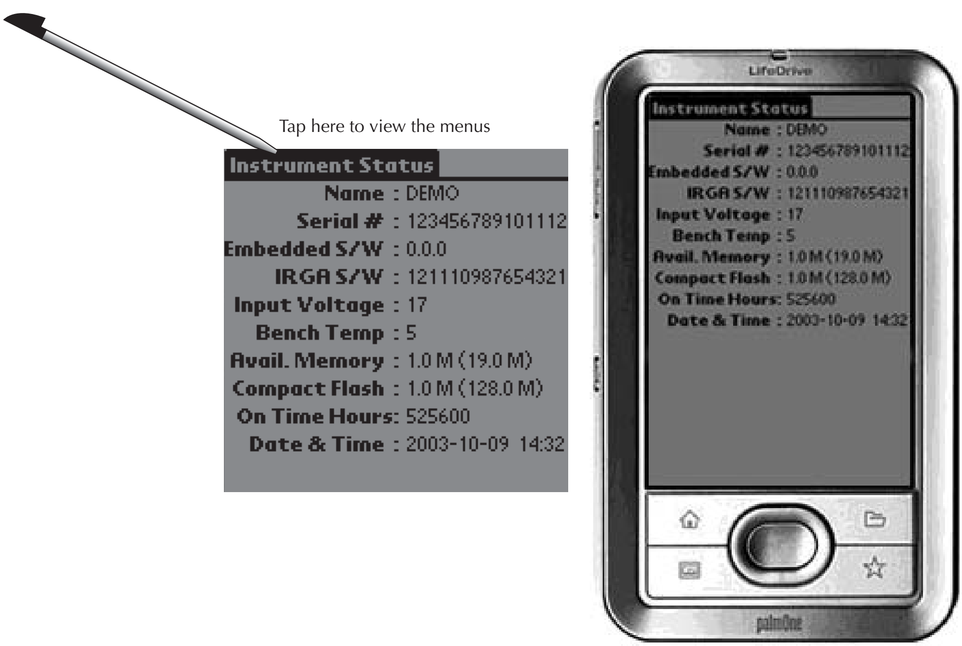


Using the LI-8100 Interface Software for Palm OS

Locate the LI-8100 program icon. It may initially be located in an Unfiled category, until you move it into a different location (i.e., All, or Main). Tap the LI-8100 program icon to start the program. Tap the **Connect by Serial** or **Connect by TCPIP** button, depending on whether you are connected to the LI-8100 via a serial cable or via a wireless network, respectively.

In the Palm Interface Software, fields surrounded by a dashed line are editable fields that can be modified by tapping inside the field.

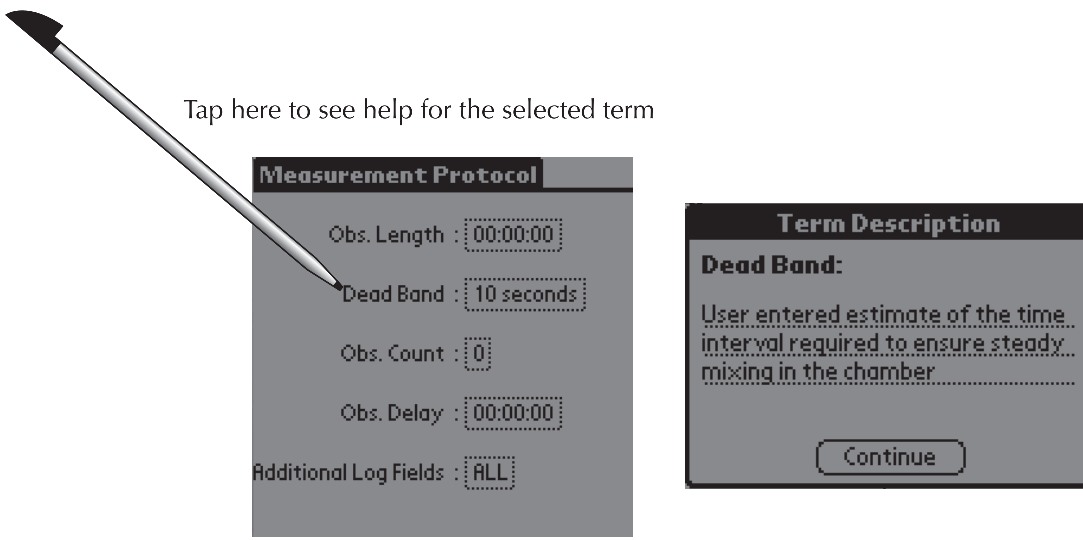
There are 5 menus on the LI-8100 menu bar; Setup, View, Utils, 8100, and Help? Tap the menu bar at the top of the page to view the menus. Note that you can set the default page that appears when the program is started (see *Set Start Page* in the Utils menu, below). In the example below, the Start Page is set to display the Instrument Status page.



Accessing On-line Help

There are two ways to obtain on-line help in the Palm OS application. Tap the Help menu and choose **Indicators** to see a list of the indicators that may appear on the PDA screen when using the LI-8100 application. For example, if the @ indicator is visible on-screen, it indicates that an active measurement is in progress. You can also tap on the indicator itself to bring up a description.

Descriptions of most terms used in the LI-8100 application can be viewed by tapping on the text of the term for which you want to view help. For example, tapping the Dead Band term in the Measurement Protocol screen brings up the following term description:

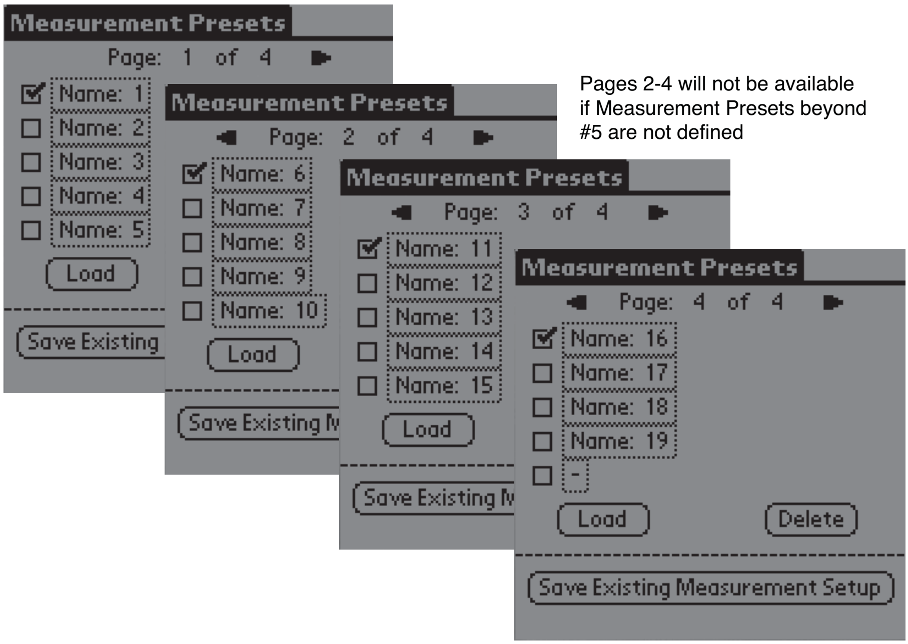


The Setup Menu

Measurement Presets

Opens the Measurement Presets page, where you can define up to 19 different configurations containing measurement setup parameters. These parameters can be saved and recalled for later use, without the need to redefine experimental parameters before each experiment. For example, individual parameters for different types of soil chambers can be defined (e.g. 10 cm and 20 cm survey chambers), and saved as unique measurement presets; switching between chambers can then be easily done by simply loading the appropriate preset and starting the measurement.

Each preset contains the experimental parameters defined on the Measurement Protocol page, as well as the Area, Volumes and Flow Rate, Start Measurement, and Instrument Settings pages.



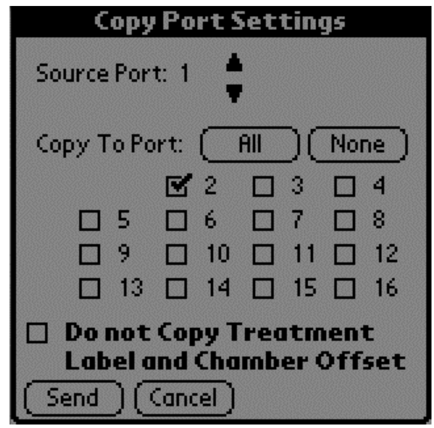
By default, the presets are unnamed until they are saved with a new name. When the experimental parameters have been defined, tap **Save Existing Measurement Setup** to name the preset; the name will apear next to the box that is enabled (checked). Select a different preset by enabling the checkbox next to the preset name, and tap **Load** to activate that preset's predefined parameters. Tap **Delete** to remove the active preset.

Measurement Preset pages are added as more Presets are defined (4 in the example above); tap the arrow keys to scroll between the Preset pages.

Measurement Protocol

Opens the Measurement Protocol page, where you can set the parameters for making a soil CO_2 flux measurement.

After you have defined a measurement protocol for a single port, you can copy that configuration to as many other ports as desired. After you have defined the parameters in this window, tap **Copy**, and then enable the other ports to which you want to copy that definition.



Choose the Source Port whose definition you want to copy. Enable the ports to copy to individually, or tap All to enable all other ports. Note that if the Chamber Offsets and/or Treatment Labels vary between soil collars, you will need to enter them individually. Tap **Send** to copy the port settings.

Chamber Offset

The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume, Multiplex Volume** and **Extension Tube Volume** (if present) to obtain the **Total Volume**. Measuring the **Chamber Offset** is described in Section 2, *Using Soil Collars*.

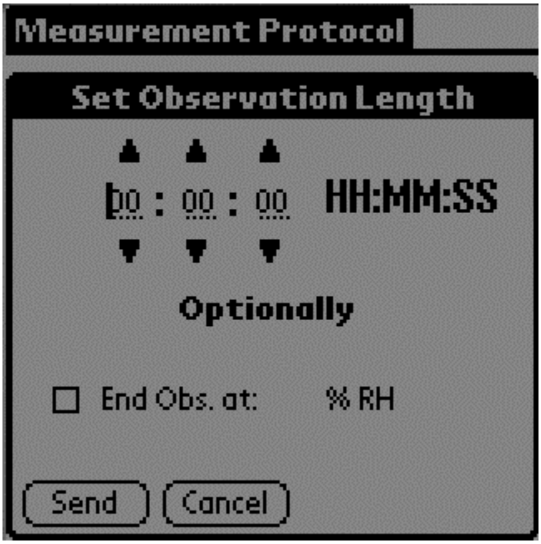
Treatment Label

The Treatment Label can be up to 30 characters in length; it can be prompted for and is included in the data record.

Observation Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, and includes the specified **Dead**

Band period. At low to moderate CO_2 fluxes an **Observation Length** of 90 to 120 seconds is usually adequate.

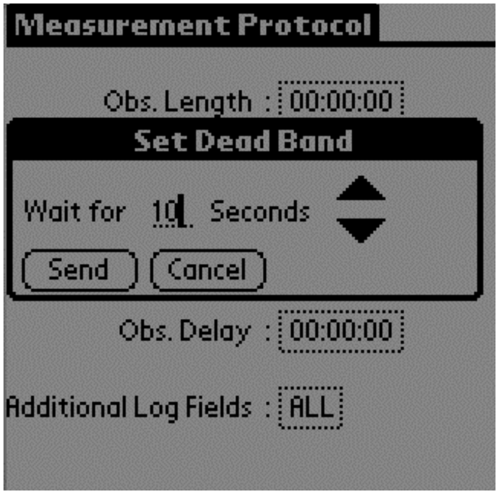


Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *etime* is set to -1 for all records collected.

Enable the 'End Obs. at' check box and enter a relative humidity value, if desired. The observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the measurement. If the observation is aborted, a message is placed in the log file, and the measurement will continue at the next observation.

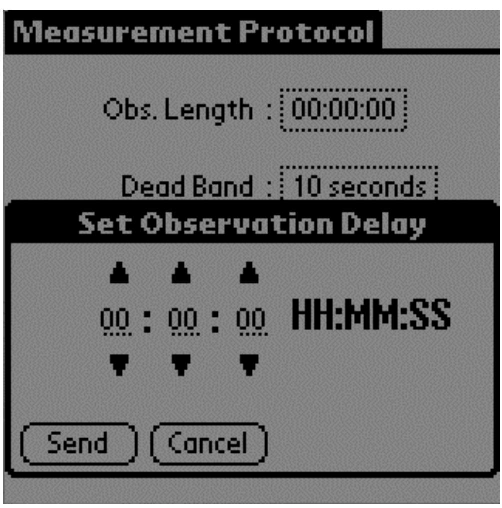
Dead Band

The **Dead Band** is the time period that starts when the chamber closes and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides for adequate mixing (30 seconds is a good starting point if you are new to the system). There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 File Viewer program (if Raw records are collected).



Observation Delay

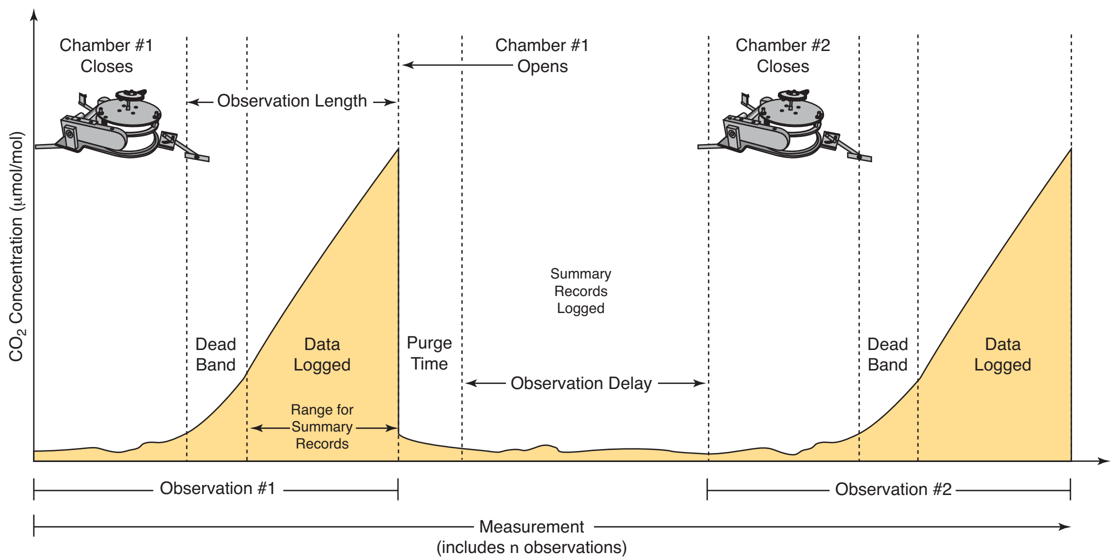
When making repeated observations, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.



Purge Time

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the **Observation** is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

When an observation is complete, the chamber will automatically rise up off of the soil collar. If a **Purge Time** is designated, air will continue to flow through the port whose **Observation** has just completed (post-purge). After the Purge Time has finished, air flow switches to the next port in the sequence for the **Observation Delay** (pre-purge).

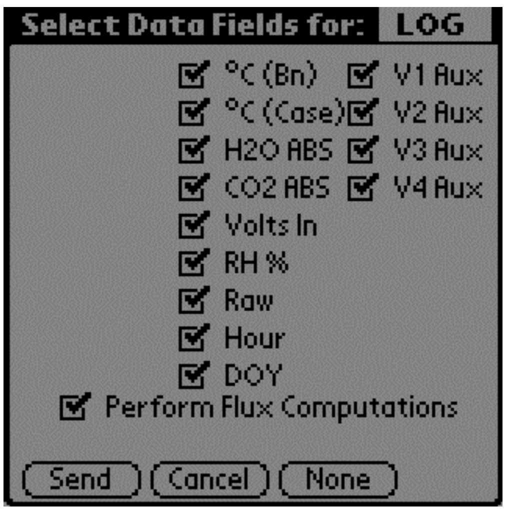


Additional Log Fields

Tap on **Additional Log Fields** to choose the values to be logged to memory. Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card.

Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Enable the Perform Flux Computations check box to automatically compute the flux rate after each measurement.



Tap **Send** to send the selected data fields to the LI-8100 for implementation.

Tap **Cancel** to close the page without sending the data fields.

Tap **None** to disable (uncheck) all data fields. None button changes to **All** when the fields are disabled.

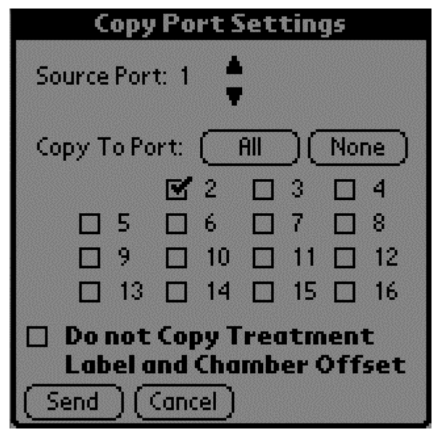
The additional data values that can be logged are as follows:

Label	***Description***
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
Hour	Time of day.
DOY	Day of the year.
V1 Aux	Input at voltage channel 1 (soil moisture).
V2 Aux	Input at voltage channel 2 (soil moisture).
V3 Aux	Input at voltage channel 3 (soil moisture).
V4 Aux	Input at voltage channel 4 (soil moisture).

Area, Volumes, and Flow Rate

Opens the Area, Volumes, and Flow Rate page, where you can set the chamber offset and flow rate, and choose the default soil area and chamber volume values, which determine the total system volume of air.

The IRGA Volume and Total Volume values are computed and displayed after the Chamber Offset, Soil Area, Chamber Volume, and Extension Tube Volume values are entered.

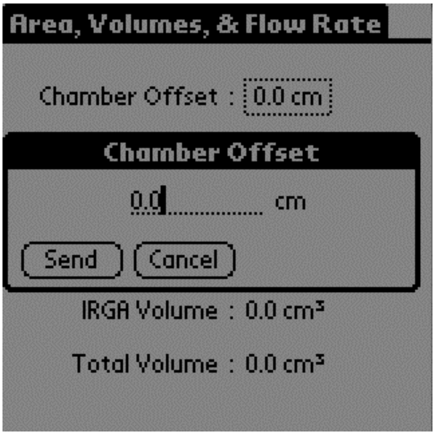


After you have defined a measurement protocol for a single port, you can copy that configuration to as many other ports as desired. After you have defined the parameters in this window, tap **Copy**, and then enable the other ports to which you want to copy that definition.

Choose the Source Port whose definition you want to copy. Enable the ports to copy to individually, or tap All to enable all other ports. Note that if the Chamber Offsets and/or Treatment Labels vary between soil collars, you will need to enter them individually. Tap **Send** to copy the port settings.

Chamber Offset

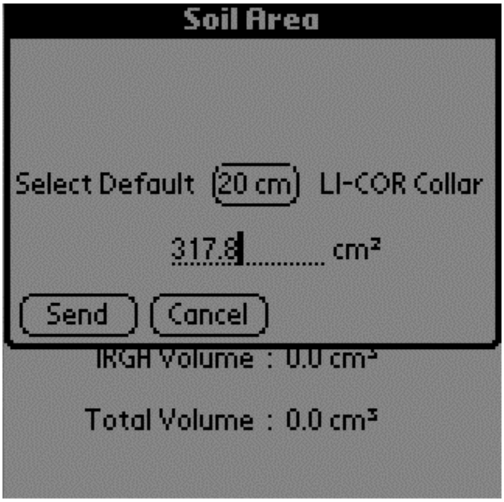
The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume, Multiplex Volume** and **Extension Tube Volume** (if present) to obtain the **Total Volume**. Measuring the **Chamber Offset** is described in Section 2, *Using Soil Collars*.



If you measured the Chamber Offset in inches, remember to multiply by 2.54 to convert the value to cm.

Soil Area

The **Soil Area** is the surface area of soil encompassed by the soil collar. Tap on the 20 cm button; the soil area is calculated automatically and is shown in the window.

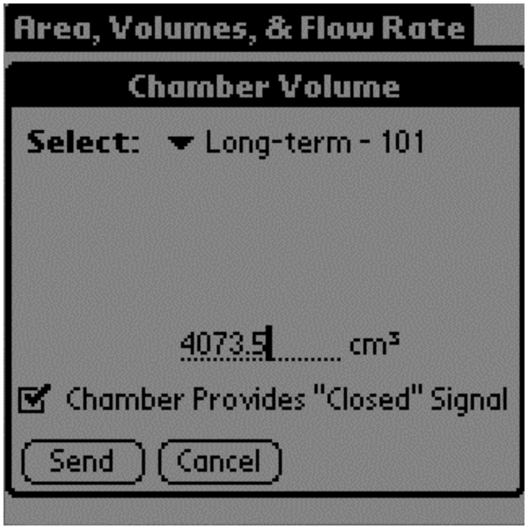


Alternatively, if you are using a collar of your own making, you can enter the soil area (in cm^2) manually.

Chamber Volume

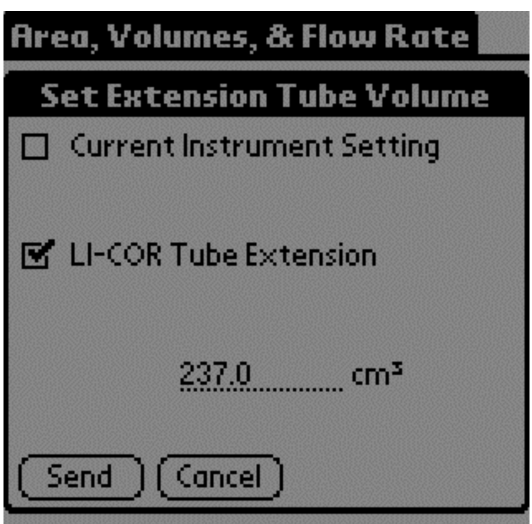
The **Chamber Volume** is the volume of air within the soil chamber. Tap on the arrow next to Select and choose the chamber connected to the instrument. Choose Long-term 101 for the 8100-101 Long-Term Chamber, or Long-term 104 for the 8100-104 Long-Term chamber; the chamber volume (cm^3) is calculated automatically and is shown in the window. If you choose Custom Chamber, you will be required to manually enter the chamber volume. Choose Instrument Setting to view the volume currently active in the intrument.

Note that all LI-COR soil chambers provide an electronic signal when the chamber is closed; if you have constructed a custom chamber for use with the LI-8100 that does not provide an electronic “closed” signal, make sure that the ‘Chamber Provides “Closed” Signal’ is not selected. This is important, for example, when calibrating the instrument.

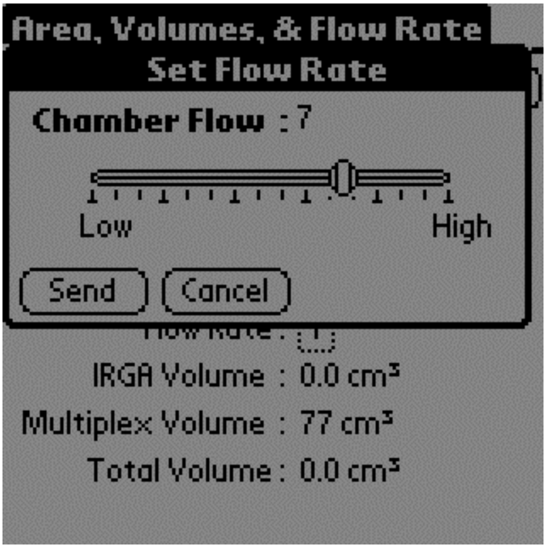


Extension Tube Volume

The Chamber Volume value is entered automatically when a LI-COR chamber is chosen from the Chamber pull-down menu. Enter the Soil Area and Extension Tube Volumes. If you are not using a chamber extension tube, enter zero for the Extension Tube Volume value.

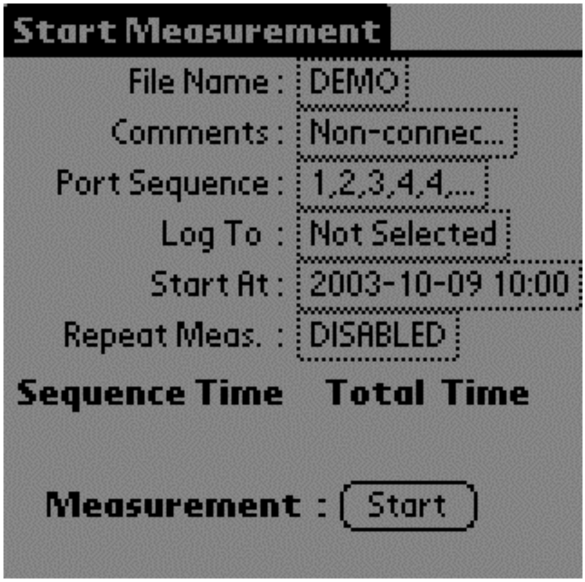


Chamber Flow
Drag the slider bar to set the flow rate to the chamber. The Low flow rate is equivalent to approximately 1.5 liters/minute, and the High flow rate is equivalent to approximately 3.5 liters/minute.



In most cases it is recommended that you use the highest flow rate when making measurements, to ensure adequate mixing of the air within the chamber.

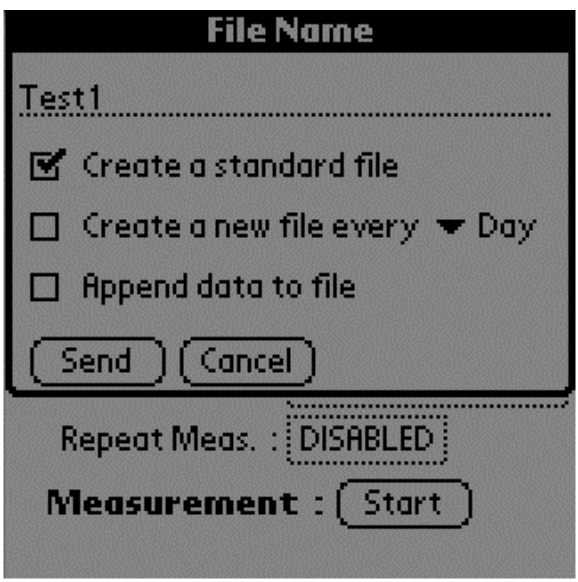
Start Measurement
Opens the Start Measurement page, where you can enter the **File Name** and optional **Comments**, as well as the **Port Sequence**, location at which the data are stored, **Start Time**, and number of times to repeat the measurement.



The File Name can be up to 30 characters in length. The Comments can be up to 100 characters in length.

Comments are included in the data file header.

Enter a File Name (below) and optional Comments.



Enable the 'Create a standard file' to create a single file that is not split and/or appended.

You can create a new file every Day or Week; note that you must first enable the Repeat Measurement field (below) to use this function.

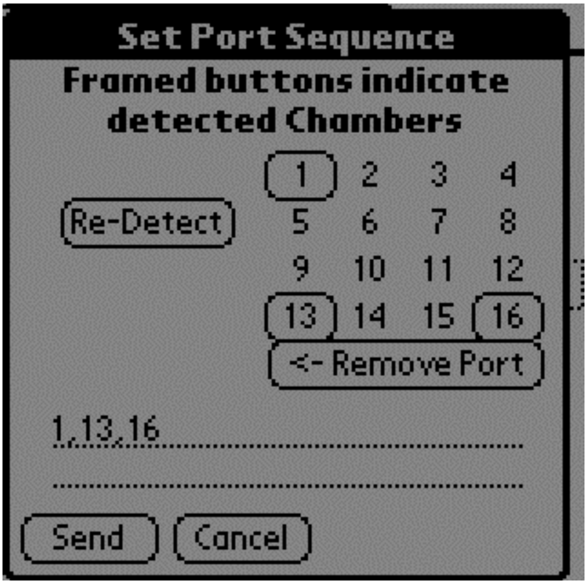
Enable the 'Append Data To File' check box to add new data at the end of an existing file.

Choose a location (Internal Flash or Compact Flash Card) to which to log data; note that data files created with the Multiplexer can become quite large. For this reason, we recommend that you log to Compact Flash, as the internal memory is limited.

Enter the Start Time; you can choose to start the measurement immediately ('now'), or at a defined date and time.

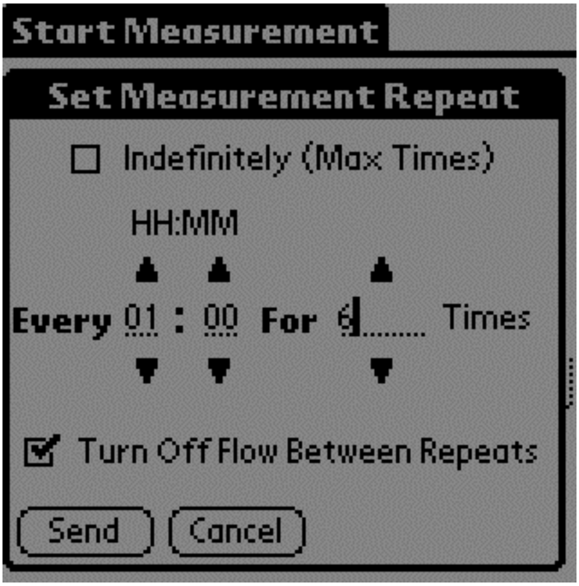
Port Sequence

When the chambers are connected properly, they will be detected in software, and shown here.



In the example above, chambers were detected on ports 1, 13, and 16. Chambers can be sampled in any desired sequence, using the Port Sequence entry field. Enter the desired order in the Port Sequence field manually (ports separated by commas, no spaces). Tap **Remove Port** to remove the port number at the cursor location. Tap **Send** when finished.

The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.



For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Indefinitely (Max Times)** button).

You can elect to turn off the flow pump between repeated measurements to conserve power and extend the life of the pump by enabling the check box.

Tap **Start** to begin the measurement.

The View Menu

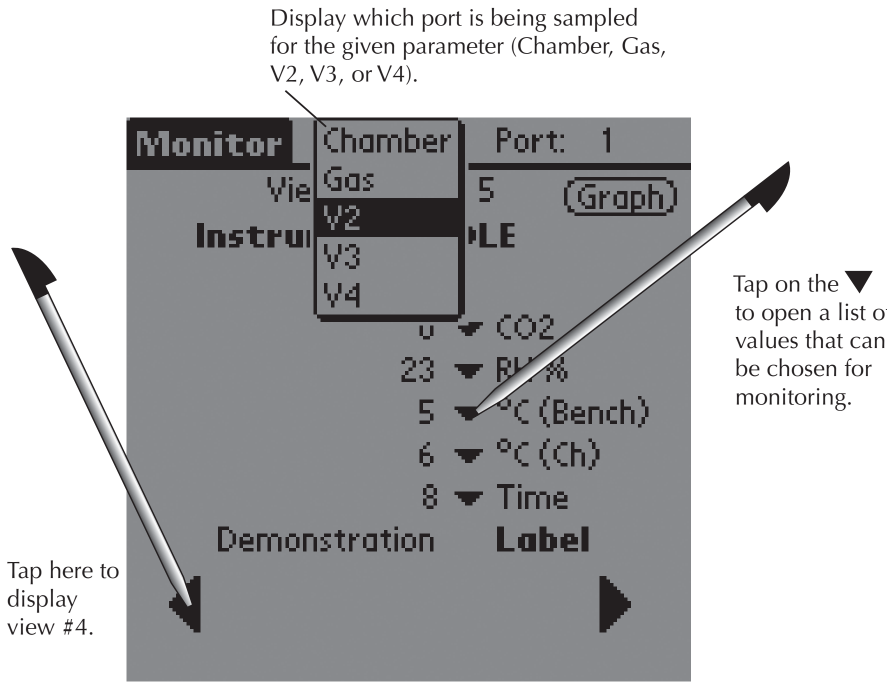
Instrument Status

Opens the Instrument Status page, where you can view the current operating state of the LI-8100.

The Instrument Status page displays the user-entered instrument name and serial number, the instrument software versions, input (battery) voltage, IRGA bench temperature, available memory in the instrument and optional compact flash card, the log file destination (internal memory or compact flash card), the number of accumulated hours of instrument operation, and the current date and time.

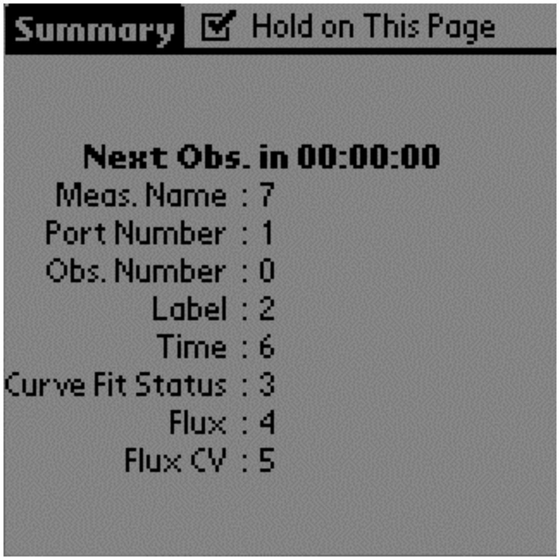
Monitor Page

Opens a page where you can view real-time values of selected instrument outputs. You can define as many as five "views" that contain up to five values each; tap on the right or left arrow to scroll the views. Select Chamber, Gas, V2, V3, or V4 from the pull-down menu to display the port that is being sampled for that parameter. Tap on **Graph** to display a chart showing the top value on the page (CO_2 in the example below) against the number of samples graphed in chronological order.



Summary Page

Opens a page where you can view the summary records for the most recent measurement. Note that in normal operation the Summary Page will toggle to the Monitor page when a new measurement is started; enable the 'Hold on This Page' box to retain the Summary Page on the display when a new measurement starts.

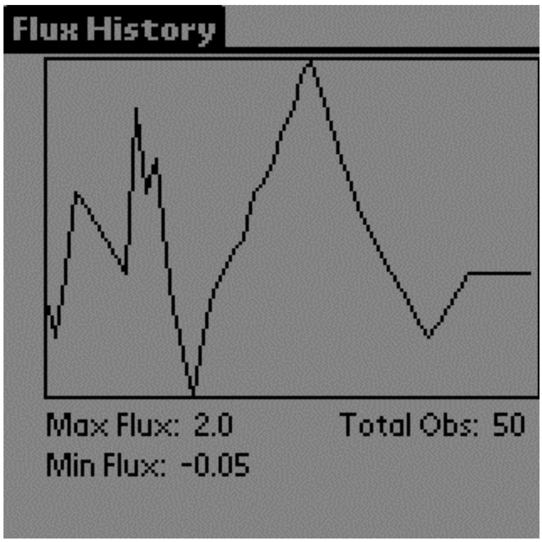


A timer that displays the time remaining until the next defined measurement is also shown on the Summary Page. The Summary Values that can be monitored on this page are as follows:

Label	***Description***
Meas. Name	Measurement name.
Port Number	Gas port from which the Summary Record was generated.
Obs. #	Current observation number.
Label	Treatment label for current observation.
Time	Time in HH:MM:SS.
Curve Fit Status	Linear or exponential flux calculation
Flux	Ten second running estimate of soil CO_2 flux rate.
Flux CV	CV of flux (Exponential fit).

Flux History

Displays a running chart of the last 50 observed flux values by gas port. Choose the Port from the pull-down menu at the top of the page to view flux values from a different port.

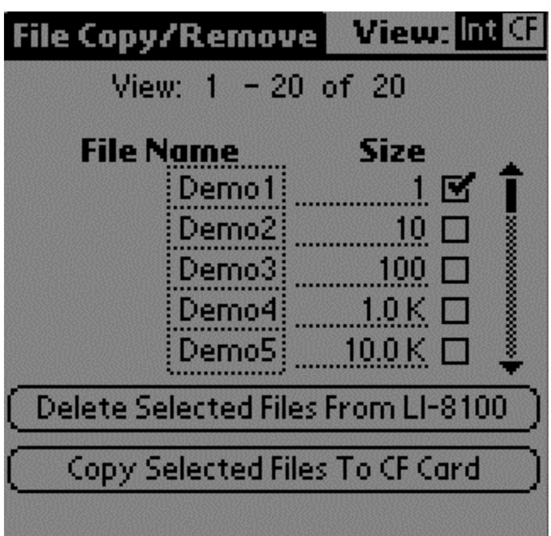


The Utilities Menu

File Manager

Opens the File Manager page, where you can perform file and/or storage operations on existing data files. The first File Manager page displays the amount of available memory on the LI-8100 and on the optional compact flash card.

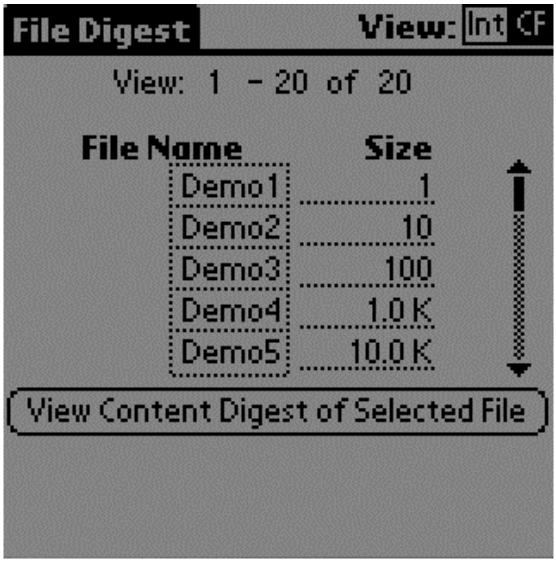
Tap **File Copy/Removal** to delete selected files from the LI-8100 internal memory, or to format the compact flash card.



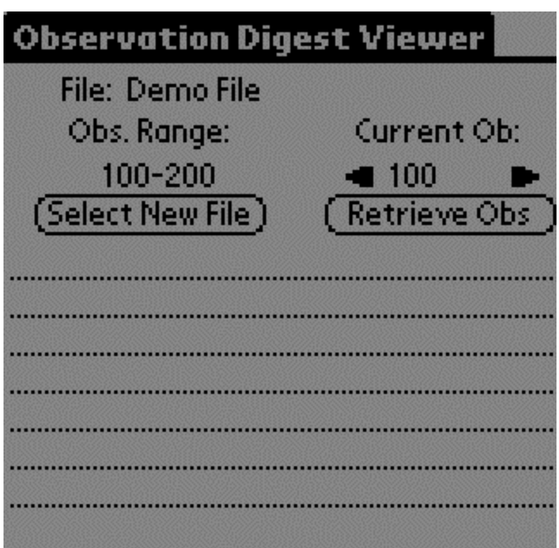
Tap Int or CF to view files on the LI-8100 internal memory, or compact flash card, respectively.

Files stored in internal memory can be selected for deletion, or for copying to the compact flash card.

Tap **File Digest Viewing** to display a notepad containing data from the observations within the chosen file.

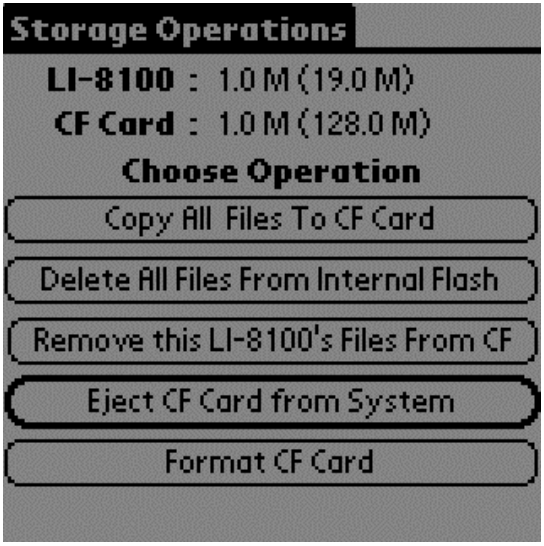


Tap on **View Content Digest of Selected File** to open the selected file. The Observation Digest Viewer appears.



The range of Observations is shown; tap the right or left arrow to scroll through observations within this range. *Note that if data scrolls off the bottom of the window, you must use the Palm navigation button to scroll the window.*

Tap **Storage Operations** to delete all files from the LI-8100 internal memory or compact flash card, or to move all files to the compact flash card.



Copy All Files to CF Card: Copies all files from the LI-8100 internal memory to the optional compact flash card.

Delete All Files From Internal Flash: Removes all files from the LI-8100 internal memory.

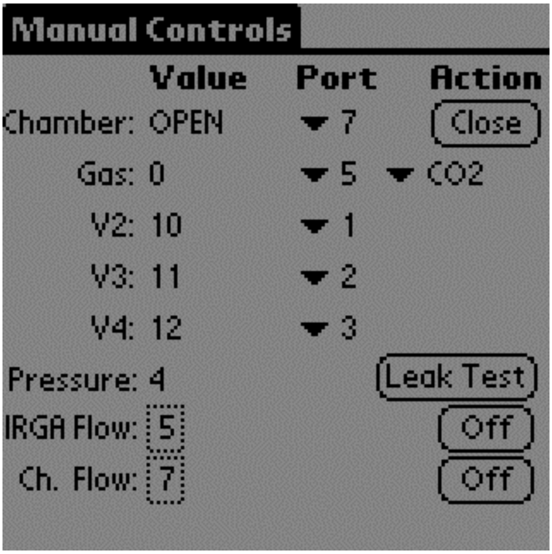
Remove this LI-8100's Files From CF: When files are copied to the compact flash card, the LI-8100 creates a directory on the card with the instrument name. This operation removes that directory and its contents from the card.

Eject CF Card from System: Unmounts the compact flash card safely; you should always eject the card before removing it from the PC card slot to ensure the integrity of the data.

Format CF Card: Deletes ***all files*** from the compact flash card.

Manual Controls

Opens the Manual Controls dialog, where you can manually open or close the chambers, turn the LI-8100 or Multiplexer flow on or off, set voltage inputs to specified ports, and perform a leak test on the Multiplexer. Controlling the chamber flow manually is useful when performing user calibration of the infrared gas analyzer, as described in Section 5. In general, the Manual Controls are used for diagnostic purposes, and are not used when making typical measurements.



Choose the chamber number that you want to manually open or close, and tap **Close** or **Open**.

When using the gas ports for applications other than soil CO_2 flux measurements with chambers (e.g. vertical profiling), the gas ports can be set to display CO2, CO2 ABS, H2O, H2O ABS, or Pressure, depending on the way in which the experiment is configured.

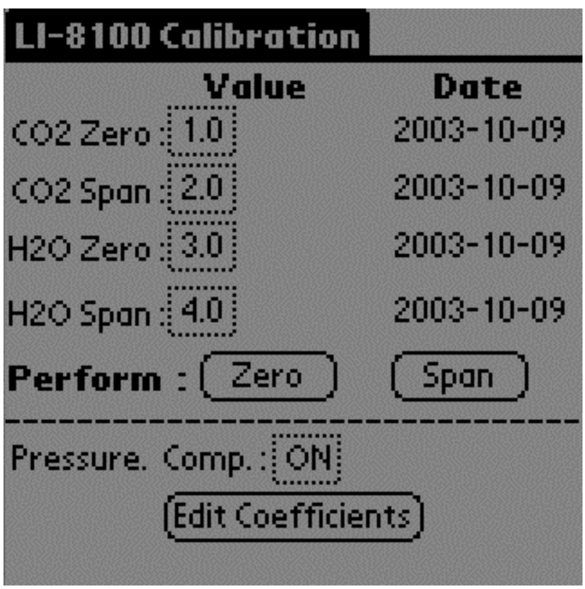
The voltage fields (V2, V3, V4) allow you to manually set the voltage input that is displayed on the Main page, and on the LI-8150 control panel. Choose the voltage input (V2, V3, or V4) and the gas port containing the sensor whose voltage output you want to monitor. For example, if you have a soil temperature probe connected to a Chamber Sensor Interface at Port 9, and it is connected to voltage input V3, choose Port 9 at Input V3; the voltage output from that probe is displayed in the Main window (if V3 is defined as one of the variables displayed there) and on the LI-8150 control panel at V3.

The IRGA Flow and Ch. Flow fields open controls for adjusting the flow rate of both the LI-8100 (IRGA Flow) and LI-8150 (Ch. Flow). The LI-8100 and/or LI-8150 flow rates can be adjusted, from Low (0) to High (10) as desired, as well as turned Off and back On. Note that when a measurement is started, the LI-8100 flow rate is automatically set to High, regardless of how it might be set in the Manual Controls page. Choose the Gas Port whose flow you want to adjust, and tap **Off** or **On**.

Information on how to perform a Leak Test can be found earlier in this section at *Performing a Leak Test*.

Calibration

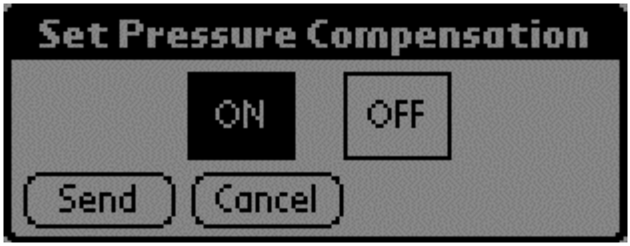
Opens the Calibration page, where you set the zero and span of the infrared gas analyzer in LI-8100 Analyzer Control Unit. Step-by-step instructions for performing user calibrations are given in Section 5.



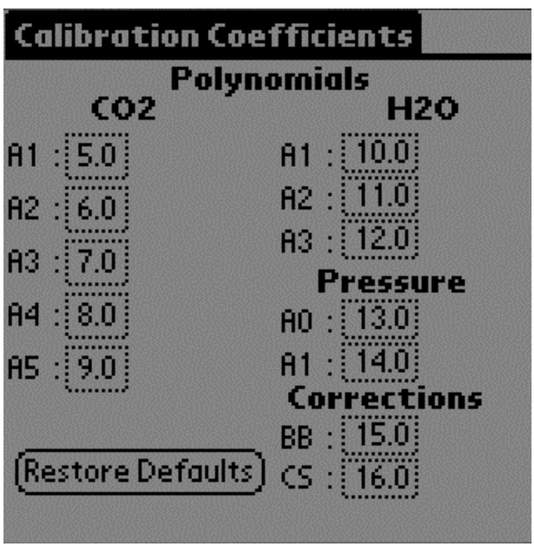
The calibration constants displayed here are updated each time you perform a zero or span. In most cases there is no need to edit these values manually. If you do edit the values, the dates will not change. The dates reflect the last time the instrument was zeroed and/or spanned.

The calibration constants for CO_2 and H_2O zero and span calibrations are found on the Calibration page. If new constants are entered in this page, tap **Send** to send the values to the LI-8100 for implementation (note that the dates will not change).

The calibration functions for both CO_2 and H_2O correct for pressure fluctuations that may be present. To disable this correction, tap the 'Pressure Comp.' field and then tap **Off**.

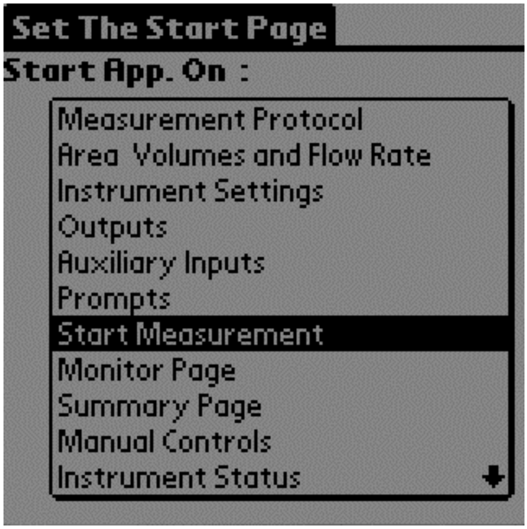


The LI-8100 uses a fifth order polynomial for the CO_2 calibration, and a third order polynomial for H_2O calibration. Tap the 'Edit Coefficients' field to view the Coefficients page. This page displays these factory-determined calibration coefficients, as well as those for band broadening (BB) and cross sensitivity (CS). These coefficients are fixed at the factory, and are present on the calibration sheet included with the instrument.



Set Start Page

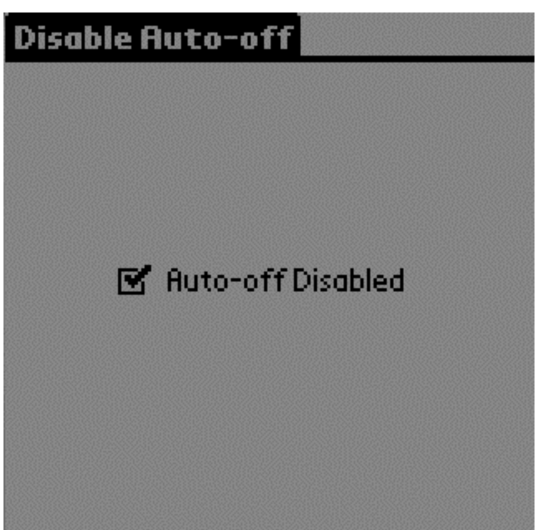
Allows you to choose the application page that is displayed when the LI-8100 Application for Palm OS is started.



Choose the start page from the pull-down menu, and tap the menu bar to exit. The selected page will be displayed the next time the LI-8100 application is started.

Disable Auto-Off

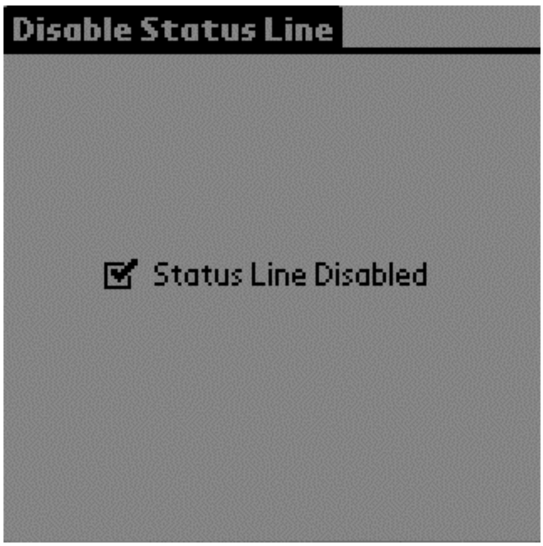
Many PDAs have an energy-saving feature that turns the handheld off after a certain period of inactivity. This can be an inconvenience when using the PDA with the LI-8100. Use this page to disable the auto-off feature while the LI-8100 application is running.



When Auto-off is disabled, a ø symbol appears in the lower righthand corner of the screen.

Disable Status Line

When a measurement is being made, a status line appears at the bottom of the page that indicates the activity that is occurring on the PDA (e.g., "querying config"). Use this page to disable the status line, if desired.



The 8100 Menu

Instrument Settings

Opens the Instrument Settings page, where you can view and/or edit the current operating state of the LI-8100.

Name: The instrument name to which the PDA is connected. The instrument name is limited to 30 characters. Files copied to a Compact Flash card are put into a directory with this name.

Date: Current date, in YYYYMMDD.

Time: Current time, in HHMM.

Network Parameters: The IP address of the wireless card in the LI-8100.

Automatic Restart: When enabled, allows the measurement to restart following a power interruption to the instrument. This is not the default option, as it requires that a hardware jumper be installed; see Section 2, *"Automatic Restart Function"* for more information.

Chamber Error: Determines how an error condition affects the measurement; you can choose to log the chamber error and continue the measurement, or log the error and stop the measurement. Tap **Send** to enable this function.

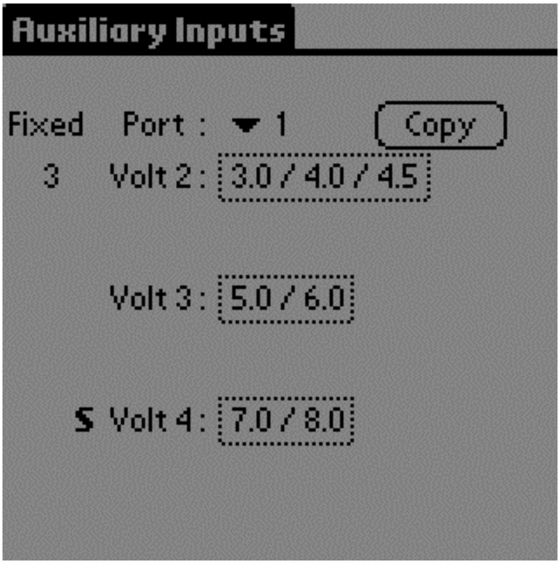
IRGA Averaging: The amount of averaging of the CO_2 and H_2O signals from the IRGA. The IRGA in the LI-8100 is sampled at 2 Hz. With 4 second signal averaging (the default), 8 data points are averaged for each CO_2 or H_2O value. As more data are received, previous data are dropped from the average. The minimum value is 1 second, and the maximum value is 20 seconds.

IRGA Volume: Volume of air (cm^3) in the optical bench and associated tubing inside the Analyzer Control Unit case. In most cases this number should not be changed.

Multiplex Volume: Volume of air (cm^3) in the tubing and solenoids in the LI-8150 Multiplexer case. In most cases this number should not be changed.

Auxiliary Inputs

The Auxiliary Inputs window is the area in which you can input the coefficients for linear external input devices connected to the Chamber Sensor Interface (V1 is dedicated for measuring Multiplexer flow rate). There is a General Purpose Input, a dedicated input for the Decagon EcH_2O or Delta-T Theta soil moisture probes, and a Thermistor input that can be monitored on any of V2, V3, or V4 voltage channels.

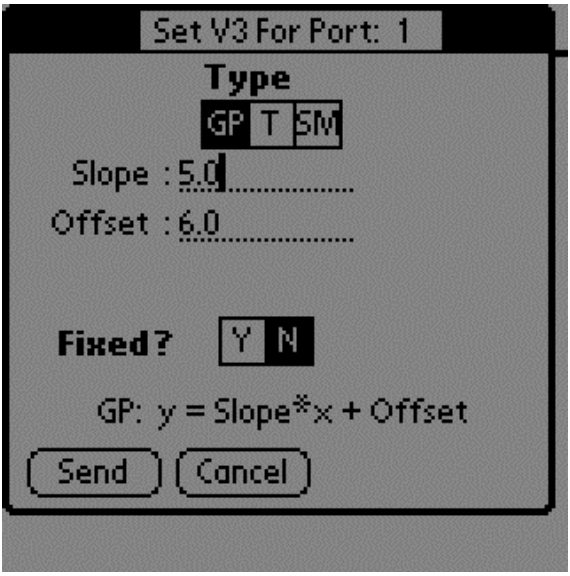


The 'S' indicates that Voltage Channel 4 is currently configured for a soil moisture sensor. There are 3 calibration coefficients displayed at voltage channel #2, indicating that a thermistor is connected there; its output is fixed to Port #3.

Choose the Port to which the Chamber Sensor Interface is attached from the Port pull-down. Tap on any of the voltage coefficient fields to enter the slope and offset values (obtained from the manufacturer) for each device attached to the voltage inputs. If Thermistor Input is selected, the page changes to show input fields a, b, and c, for thermistor calibration coefficients; the thermistor temperature calculation is of the form

$$T\ (°C) = 1/[A + B*(\ln R) + C*(\ln R)^3] – 273.15$$

NOTE: If a soil moisture probe is connected, the probe is automatically powered for about 10 seconds to allow it to stabilize, before it is then sampled. Soil probes can be configured under either the General Purpose (GP) or Soil Moisture (SM) inputs; in most cases they should be configured as Soil Moisture inputs to be sampled correctly.



GP = General Purpose
T = Thermistor
SM = Soil Moisture Probe

If Thermistor (T) is chosen, the page changes to allow entry of calibration coefficients A, B, and C.

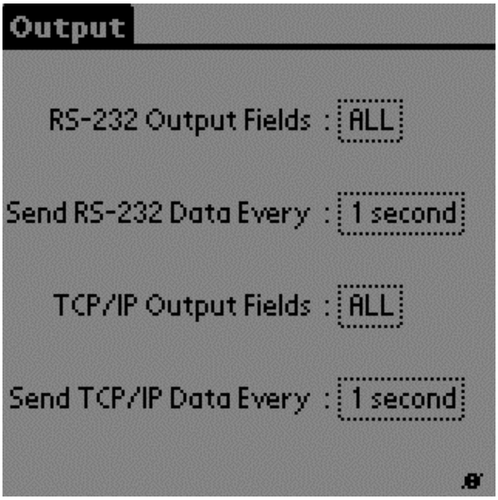
The voltage ouput from the devices connected to the Chamber Sensor Interface can be viewed in the Main Window. During normal operation, the value observed is dependent upon which port is currently active; for example, if a Chamber Sensor Inferface is attached to port #1, the voltage output observed is that which is present when a measurement is taking place on port #1. Then, when a measurement starts on port #2, the observed voltage output changes to reflect a device connected to port #2's Chamber Sensor Interface, and so on. In some cases, however, you may want this value to reflect the output from a single device at all times.

For example, if a sonic anemometer is connected to a Chamber Sensor Interface near chamber #7, you might want to view the voltage output from the anemometer on channel V2 at all times, regardless of what might be attached to channel V2 on other ports. To accomplish this, you can 'fix' the output from a voltage channel to a given port. Thus, in the example above, you would select

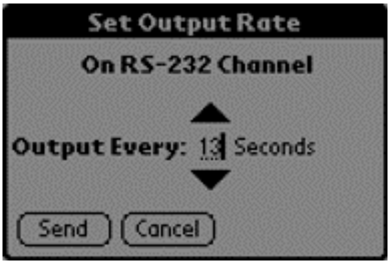
'Fixed?Y', and then choose Port 7 to monitor the output voltage of the sonic anemometer on Voltage channel 2.

Outputs

Opens the Outputs page, where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included. You can also choose the output frequency for both RS-232 and/or TCP/IP data.

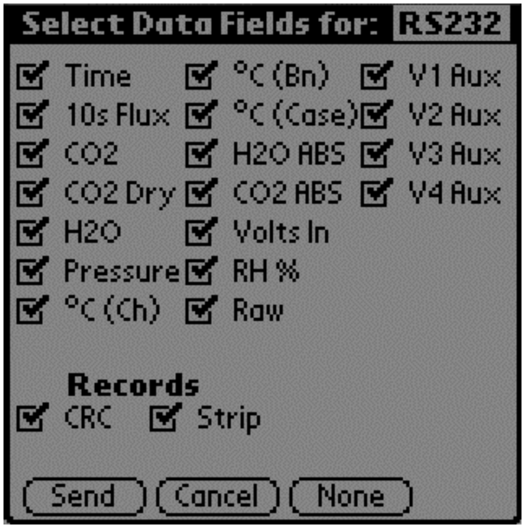


Data can be output via RS-232 or TCP/IP at intervals between 1 and 20 seconds.



RS-232

Choose the data values to be sent to the RS-232 port.



The data values that can be output are as follows:

Label	***Description***
Time	PDA time.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
CO2	Chamber CO_2 concentration in µmol/mol.
CO2 Dry	Chamber CO_2 concentration, corrected for water vapor dilution, in µmol/mol.
H2O	Chamber water vapor concentration, in mmol/mol.
Pressure	Atmospheric pressure in the optical bench (kPa).
°C (Ch)	Air temperature inside the soil chamber.
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
V1 Aux	Input at voltage channel 1.
V2 Aux	Input at voltage channel 2.
V3 Aux	Input at voltage channel 3.
V4 Aux	Input at voltage channel 4 (soil moisture).

Note that when the LI-8100 outputs data, each field is "marked up" using eXtensible Markup Language (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the 'Strip' check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

Disable the 'CRC' check box to remove CRC from the data. Note that the LI-8100 Palm OS application itself does *not* use CRC checking.

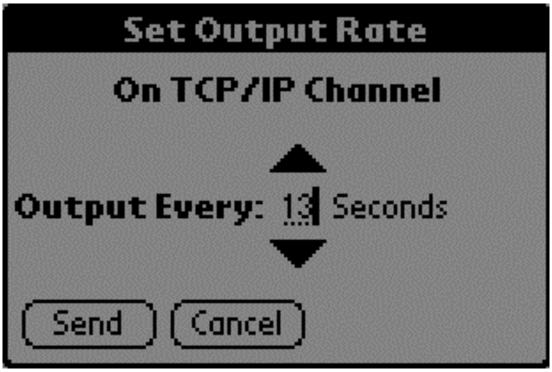
TCP/IP

Tap on the TCP/IP field to configure the data values to be sent via the wireless card, if desired. Note that you can configure the TCP/IP (wireless) and/or RS-232 options while the other is enabled; changes will not take effect until data logging is stopped and restarted, however. For example, if you are currently logging data to the PC, you can configure the wireless output, but you must first stop logging data to the PC before beginning wireless output with the new configuration.

The data values that can be output are as shown above at RS-232 Output.

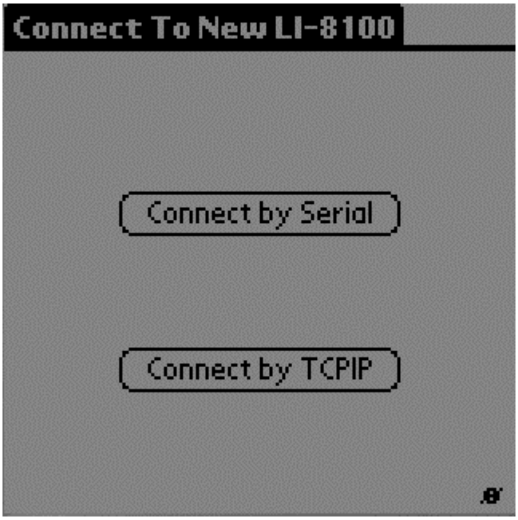
Log Every

Sets the frequency at which to log data (seconds).



Change Instruments

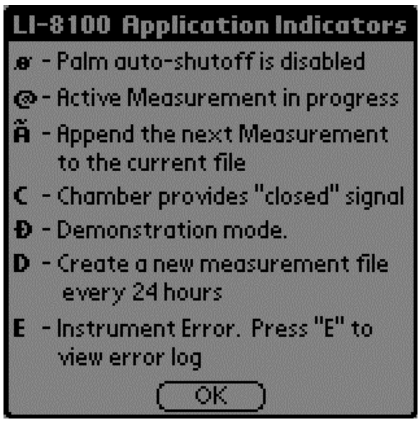
The Connect to New LI-8100 page allows you to connect to a different LI-8100 without requiring you to close the program. Tap 'Connect by Serial' if you are connecting to the new instrument via the serial cable, or 'Connect by TCPIP' if you are connecting via the wireless card. You are then prompted to enter the IP address of the instrument to which you want to connect.

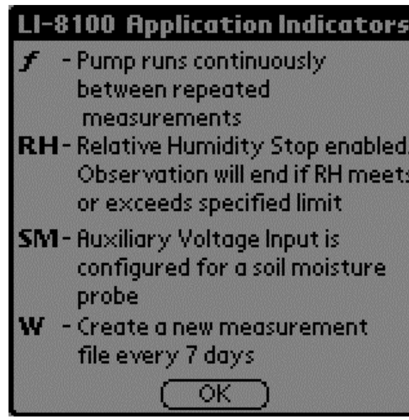


The Help Menu

Indicators 1 and 2

Opens the Indicators page(s), where you can view the definitions of indicators that can appear on the screen.





About LI-8100

Displays a screen that shows the LI-8100 Application Software for Palm OS version number and contact information for LI-COR.

LI-8150 Maintenance and Repair

The LI-8150 Multiplexer is designed to require little or no routine maintenance. Most of the LI-8150 components are modular, and are designed to be easily replaced should the need arise. The discussion below describes basic maintenance and repair of user-replaceable items; contact LI-COR for information on repair of items not described below.

Fuses

There are two fuses on the LI-8150 main circuit board that protect the LI-8100 and LI-8150 power supplies. Spare fuses can be found in the LI-8150 spares kit. The fuses are located under the access panel at front edge of the white lower plate assembly, as shown in Figure 10-19 below. The proper fuse sizes are labeled on the circuit board; the leftmost fuse protects the LI-8100 power supply (3A Fast 250V 5x20, p/n 439-04215), and the rightmost fuse protects the LI-8150 power supply (4A Fast 125V 5x20, p/n 439-08516). If the LI-8150 and/or LI-8100 fail to power up, check to see if either of these fuses has blown. Loosen the thumbnuts on the access panel and lift off to access the fuses.

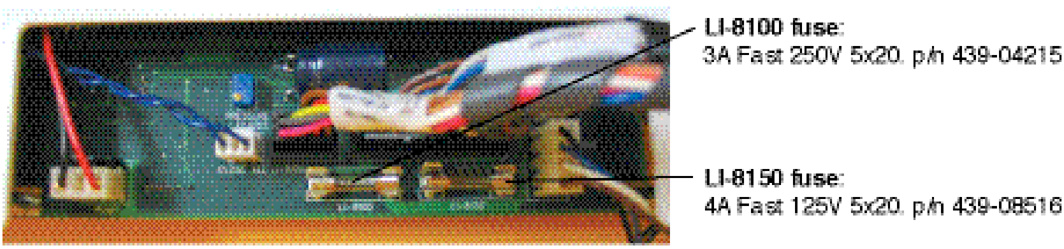


***Figure 10-19**. Remove the access panel to replace the fuse(s).*

Tubing

The urethane tubing used for air connections within the LI-8150 is 1/8″ ID x ¼″ OD; a 3′ length of this tubing can be found in the spare parts kit under p/n 222-00303. If any of the internal tubing should become clogged or otherwise damaged, simply remove it by pressing in on the orange quick-connect fittings, cut a new piece of the same length, and replace.

Air Filters

The air filters are located on the air lines connected to each of the eight (or sixteen) air input ports. The filters are translucent to more easily see dust and dirt buildup. Check the filters periodically (yearly or more often, depending on operating environment). Replace the filters when they become dirty, or if low, or no, flow rates are present on the associated chamber. A filter kit (8 each) can be found in the spares kit under p/n 8150-909; additional kits can be ordered from LI-COR.

Remove dirty or damaged filters by pressing on the quick-connect fittings and pulling the tubing straight out; discard the tubing and old filter. Note the orientation of the new filter; the arrow pointing toward the wider end of the filter should point toward the solenoids. Attach the tubing near the solenoid first. The tubing on the other end of the filter is longer than is required; route the tubing toward the connector on the Multiplexer case, leaving a bit of slack, and cut to length.

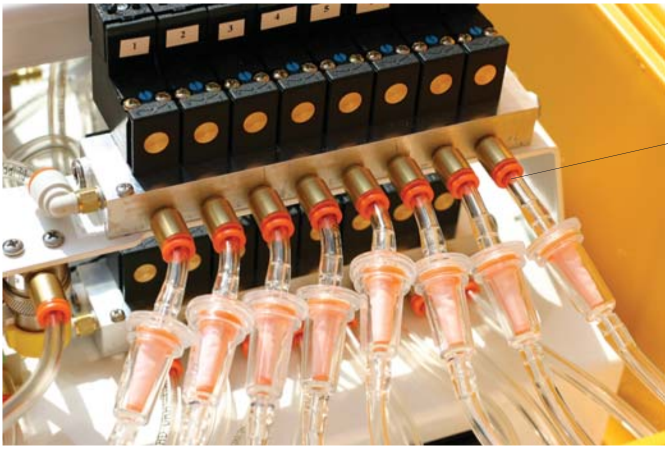


Figure 10-20. *Note orientation of filters. Attach nearest the solenoids first, and cut the tubing at the other end to length.*

Air Pump

The rotary air pump is designed for long life; if the pump should fail, however, it can be easily replaced as a complete unit, by following these steps:

1. Power the LI-8150 off and open the lid.

2. Loosen the two thumbnuts on the top and bottom of the control panel, and move the control panel off to the side; it is not necessary to remove the ribbon cable connector from the control panel.

3. Note the orientation of the old pump; *the red arrow on the pump's left side should point toward the leftmost connector when properly inserted into the mounting bracket*. Press in on the quick-connect fittings and remove the two air hoses. Slide the pump forward and lift it out of the mounting bracket.

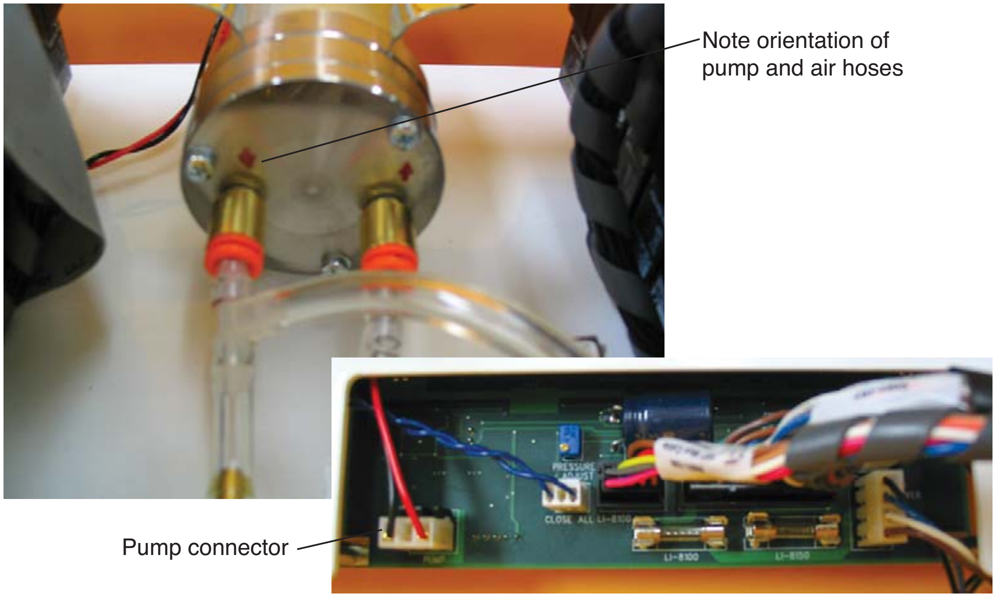


***Figure 10-21**. Note orientation of pump; the red arrow on the lefthand side of the pump should point toward the leftmost connector.*

4. Loosen the two thumbnuts on the lower access panel and remove. Disconnect the pump connector (Figure 10-21) and remove the old pump.

5. Insert the new pump onto the mounting bracket in the proper orientation, as described in step 3 above. Reconnect the air hoses in the proper orienation, also. The hose that connects to the left side of the pump (air out) connects in a straight line to the flow meter directly in front of it.

6. Thread the wire harness down through the hole behind the front left strut, and attach the connector to the circuit board.

7. Reattach the access panel cover and control panel.

Solenoid Valves

Under normal operation the solenoid valves should not need to be replaced. If however, a solenoid fails to open, it can be easily replaced. Note that each solenoid has a manual override that can be used to test the mechanical opening of each solenoid (they are normally closed). If it appears that a solenoid is not opening (no flow), turn the blue screw on the top of the solenoid valve with a small flathead screwdriver a quarter turn in either direction to manually open the solenoid. If the solenoid does not open manually, it should be replaced. Solenoid valves are available from LI-COR under p/n 300-08249 (1 ea.). Follow these steps to replace a solenoid:

1. Power the LI-8150 off and open the lid.

2. Remove the single screw on the wired valve connector, pinch the top of the connector, and remove.

3. Remove the two screws on the top of the solenoid valve, remove the solenoid, and discard.

4. Make sure the manifold gasket is in place, and install the new solenoid valve.

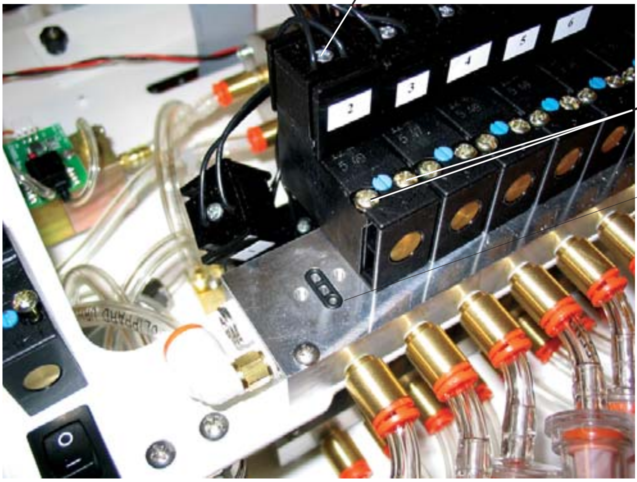


Figure 10-22. *Remove the electrical connector, remove the valve, and make sure the manifold gasket is in place before installing new valve.*

11 Using the Windows® Software (Single Chamber Mode)

Installing the PC Communications Software on Your Computer

The PC Communications Software that comes with the LI-8100 is used to transfer data and setup files between the LI-8100 and the PC.

The software is shipped on CD, and requires your computer to have an RS-232 serial (COM) interface, and Windows® 2000/XP.

Insert the CD into your CD-ROM drive. If installation does not automatically start, select **Run** from the Windows *Start* menu, and select the `Setup.exe` file on the CD. When the software has finished the installation procedure, the LI-8100 program icon will be placed on your desktop and in the Programs menu.

> **NOTE:** To remove the software, go to the Control Panel and select *Add/Remove Programs*. Choose LI8100 from the list of programs and click the Add/Remove button.

Operation - Using the LI-8100 Software

Data from the LI-8100 can be transferred to a computer for analysis, printing or storage using the RS-232 interface. The LI-8100 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-8100. The LI-8100 communication parameters are as follows:

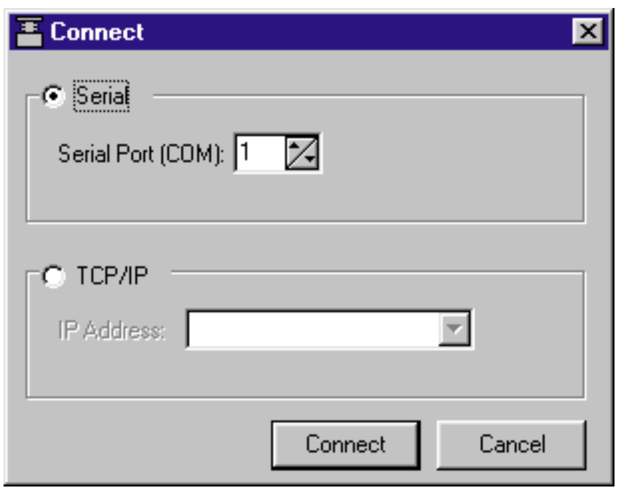
Baud Rate: 57600 bps
Data Bits: 8
Parity: None

Stop Bits: 1
Flow Control: None

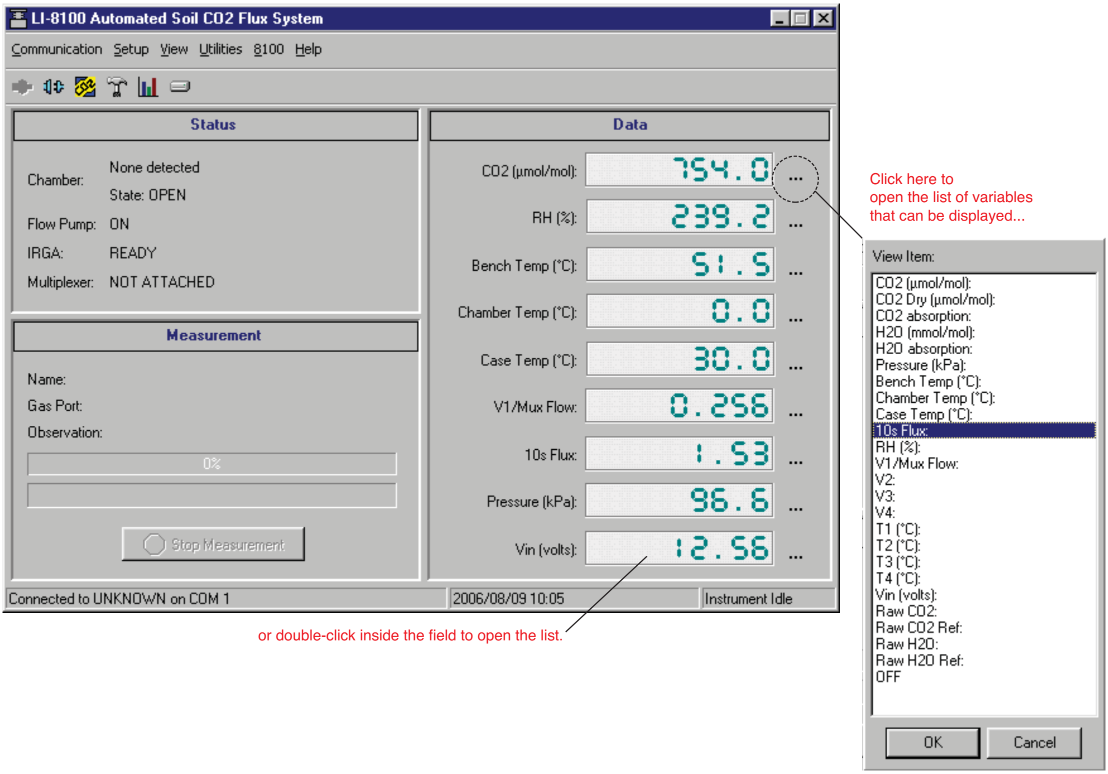
Double-click on the LI-8100 program icon to launch the program; the Main Window appears.

Connecting

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-8100 is connected, or the IP address of the LI-8100, if the LI-8100 is connected to a wireless network (see *Remote Networking* below).



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

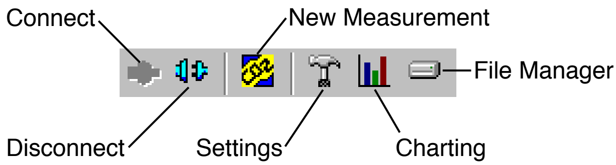


The Main window displays selected data variables on the right side of the window, as well as the progress of the current measurement and the status of various LI-8100 parameters. You can change the variables that you want to monitor, displayed on the right side of the window, by clicking on the dots next to any variable and selecting a different one from the pop-up menu (above). There are also five menus used to configure the LI-8100, perform zero and span calibrations, and set up the parameters for recording data.

NOTE: You can also double-click inside the data fields to open the pop-up menu, and then double-click on the desired variable to make it active.

Using the Toolbar

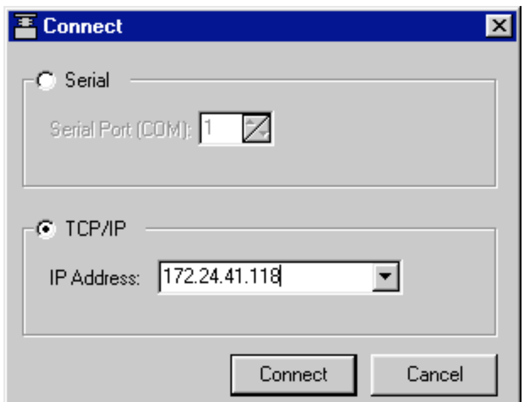
The toolbar in the Main window contains shortcuts for some of the commonly used menu items:



Communication Menu

Connect

Opens the Connect dialog, where you can choose the serial (COM) port on the computer to which the LI-8100 is connected, or enter the IP address of the LI-8100, if it is connected to a network.



The Internet Protocol (IP) address is a unique number that identifies a host (in this case, the LI-8100) connected to a network. The address is composed of a set of four numbers (called octets), where each octet ranges in value from 0 to 255. When entering an IP address, the octets are separated with a period. For example, 192.168.100.2 is a valid IP address.

Disconnect

Terminates communication between the Windows application software and the LI-8100.

Setup Menu

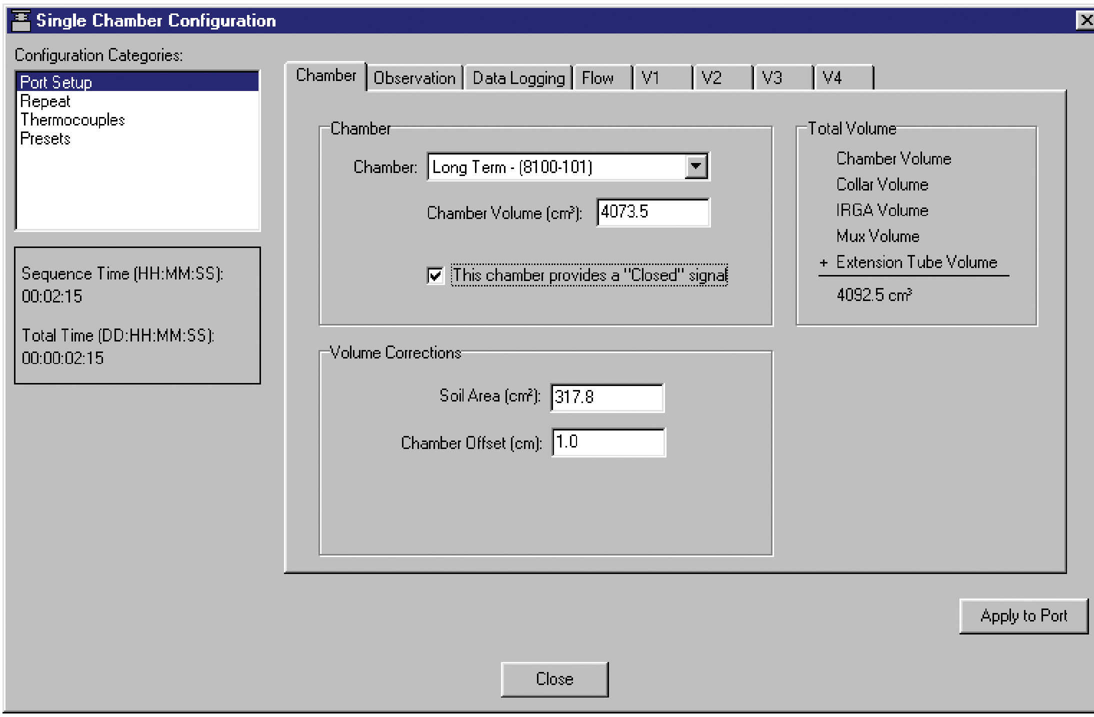
Measurement Configuration

Opens the Single Chamber Configuration window, where you can define the measurement protocol, data logging options, flow rate, voltage inputs, and chamber offset values. There are a number of tabbed pages associated with the Chamber Configuration window; click on the tabs to open the other pages.

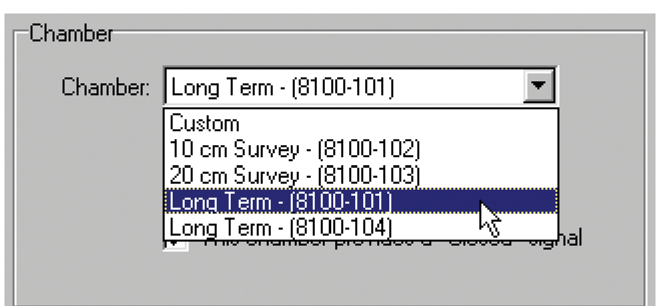
Note that there are 4 Configuration Categories in the upper lefthand corner of the window; clicking on any of the categories changes the options in the main part of the window. After you have finished defining the chamber's configuration, be sure to click the **Apply to Port** button.

Port Setup: Chamber

The Chamber tab contains options for choosing the type of chamber that is connected to the LI-8100, as well as entering any Volume Corrections, including chamber offset and soil area.



Choose the type of chamber that is connected from the Chamber pull-down menu. The choices are:



Custom – a user-built chamber, or tubing used for profiling studies.
10 cm Survey – LI-COR p/n 8100-102

20 cm Survey – LI-COR p/n 8100-103
Long Term – LI-COR p/n 8100-101
Long Term – LI-COR p/n 8100-104

Chambers sold by LI-COR provide an electronic signal when they are closed; this signal is used during various operations (e.g. during calibration) to indicate when the chamber is fully closed. Thus, when a LI-COR chamber is chosen from the menu, the "This chamber provides a "Closed" signal" check box is automatically enabled. If a custom chamber is attached, this check box should be enabled only if the chamber provides this electronic signal. The Chamber Volume (cm^3) is automatically entered for LI-COR chambers; this value will need to manually entered when using custom chambers.

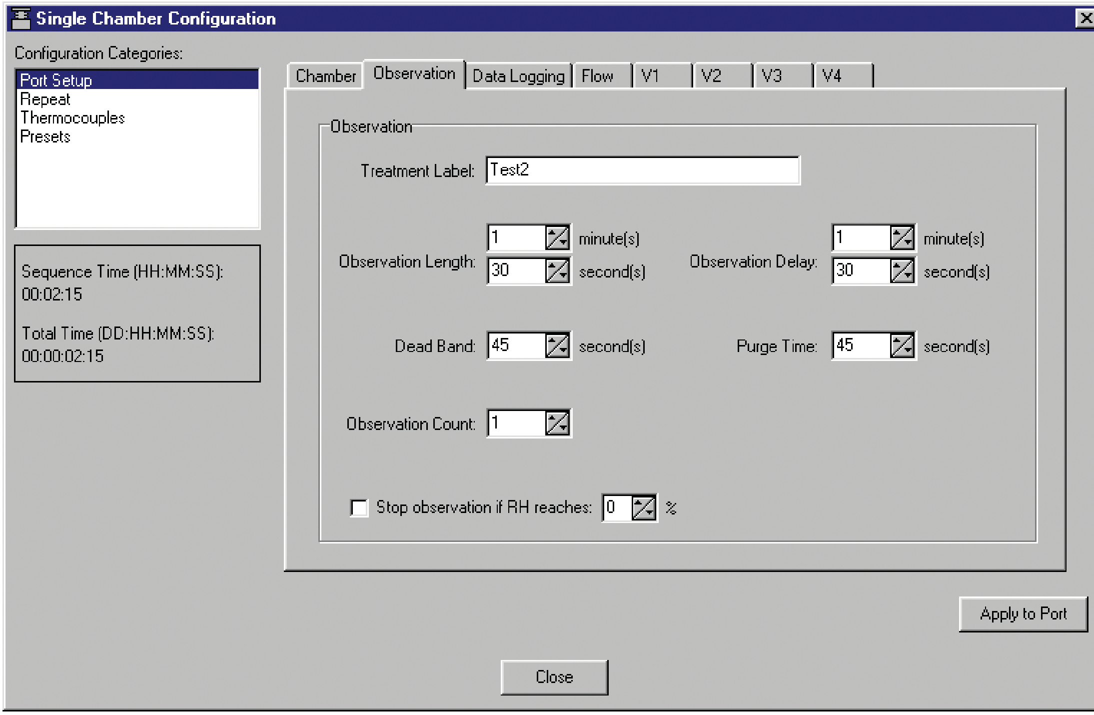
The Volume Corrections allow you to enter the exposed Soil Area (cm^2) within the soil collar, as well as the Chamber Offset value.

The **Soil Area** is the area encompassed by the chamber collar. The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar (Collar Volume). This value is, in turn, added to the **Chamber Volume** and **IRGA Volume** to obtain the **Total Volume**. Measuring the Chamber Offset is described in Section 2, *Using Soil Collars*.

The Chamber Volume and Soil Area values are entered automatically when a LI-COR chamber is chosen from the Chamber pull-down menu.

Port Setup: Observation

Click on the Observation tab to open the Observation page, where you can define the Observation Length, including delay times, Dead Band value, and Purge Time values.



The **Treament Label** is user-entered information which is included in a data record (maximum 30 characters).

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, *and includes the specified **Dead Band** period*. At moderate to low CO_2 fluxes an Observation Length of 90 to 120 seconds is usually adequate.

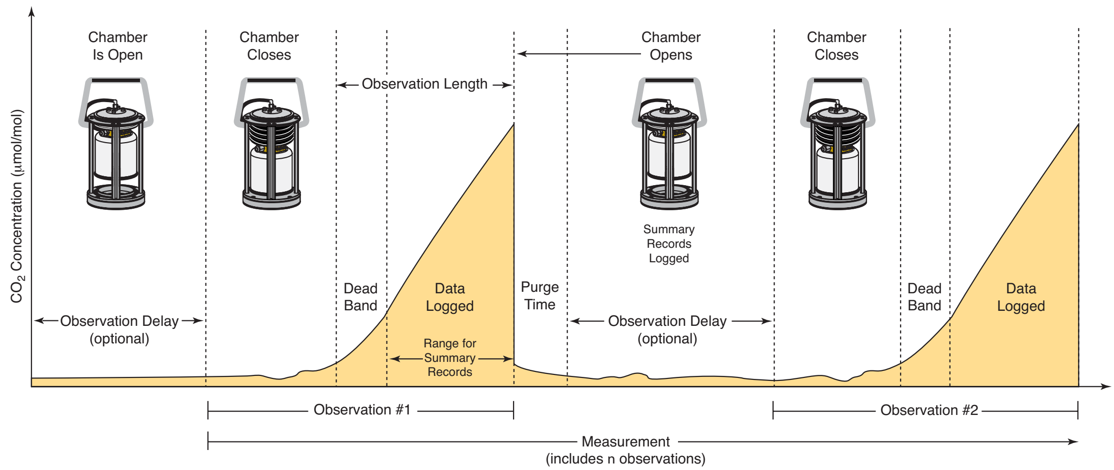
When making repeated measurements, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.

The **Dead Band** is the time period that starts when the chamber closes completely, and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 Data Analysis (File Viewer) program.

The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next observation using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

When an observation is complete, the chamber will automatically rise up off of the soil collar. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber CO_2 concentration may return to ambient levels in as little as 20 or 30 seconds. In back-to-back observations, the **Observation Delay** follows the **Purge Time** (below).

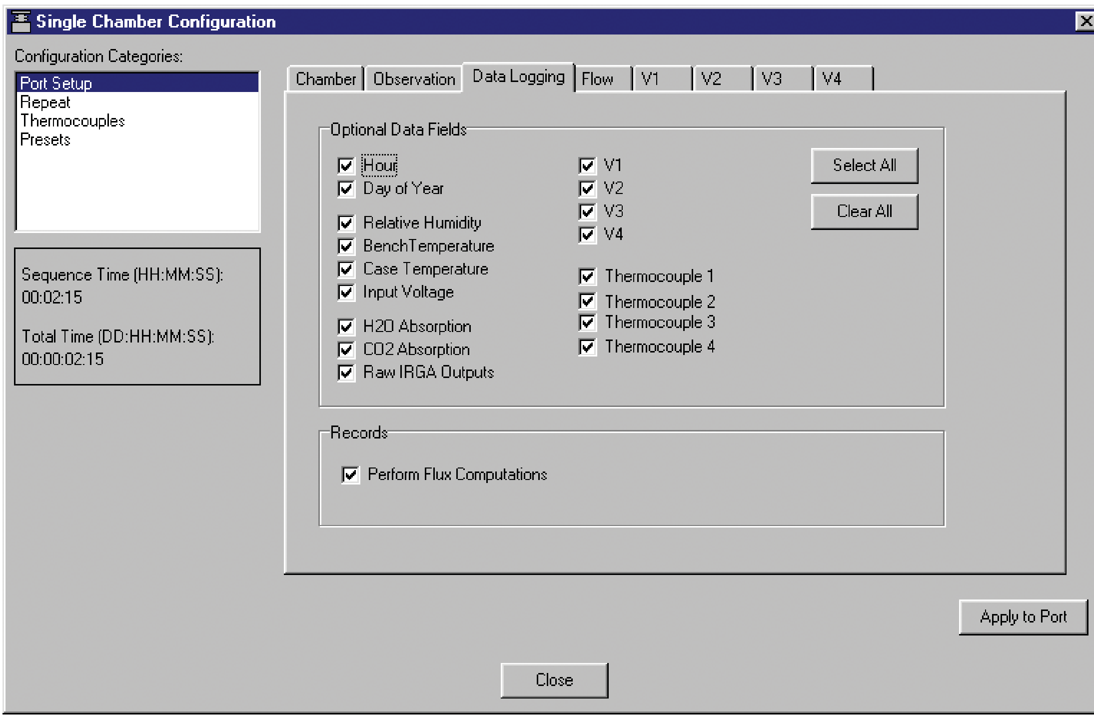
IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below, after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at “Observation Delay”.



Enable the 'Stop observation if RH reaches' check box and enter a relative humidity value (if humidity is a concern at the measurement site). The Observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the Observation. If the Observation is aborted, a message is placed in the log file, and the measurement will continue at the next Observation.

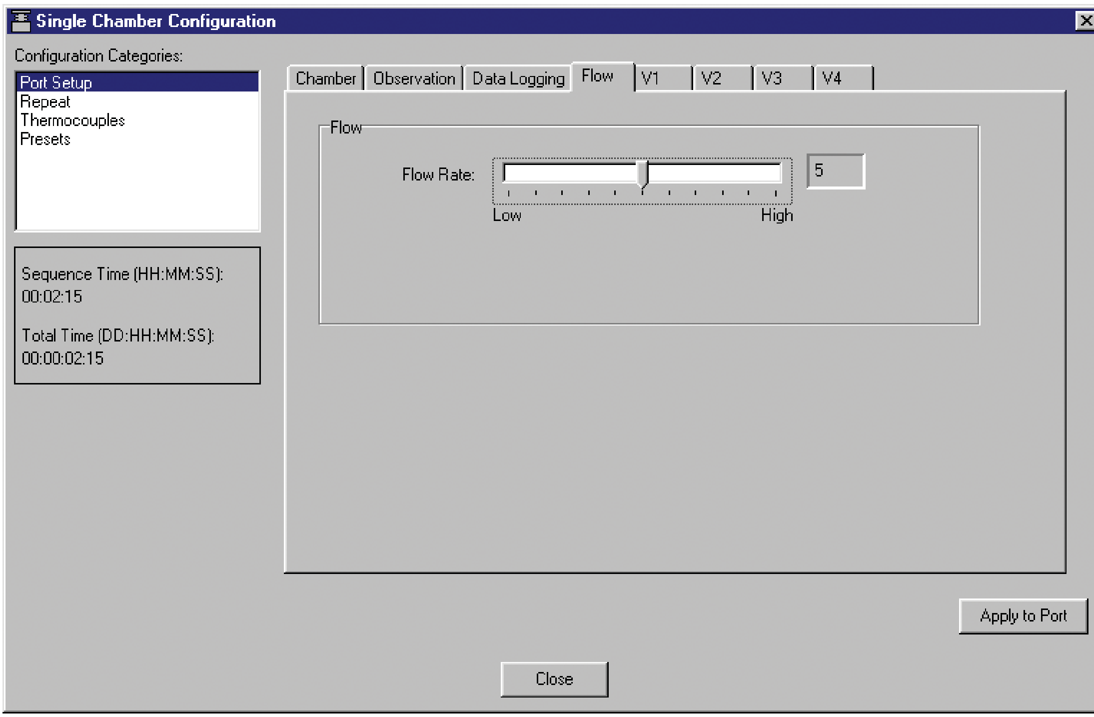
Port Setup: Data Logging

The Data Logging page contains a number of Optional Data Fields that can be logged with each Observation. These fields are not used in any flux calculations. Choose **Select All** to enable all records, or **Clear All** to disable these records. If you want to perform flux calculations after each Measurement is completed, enable the 'Perform Flux Computations' check box.



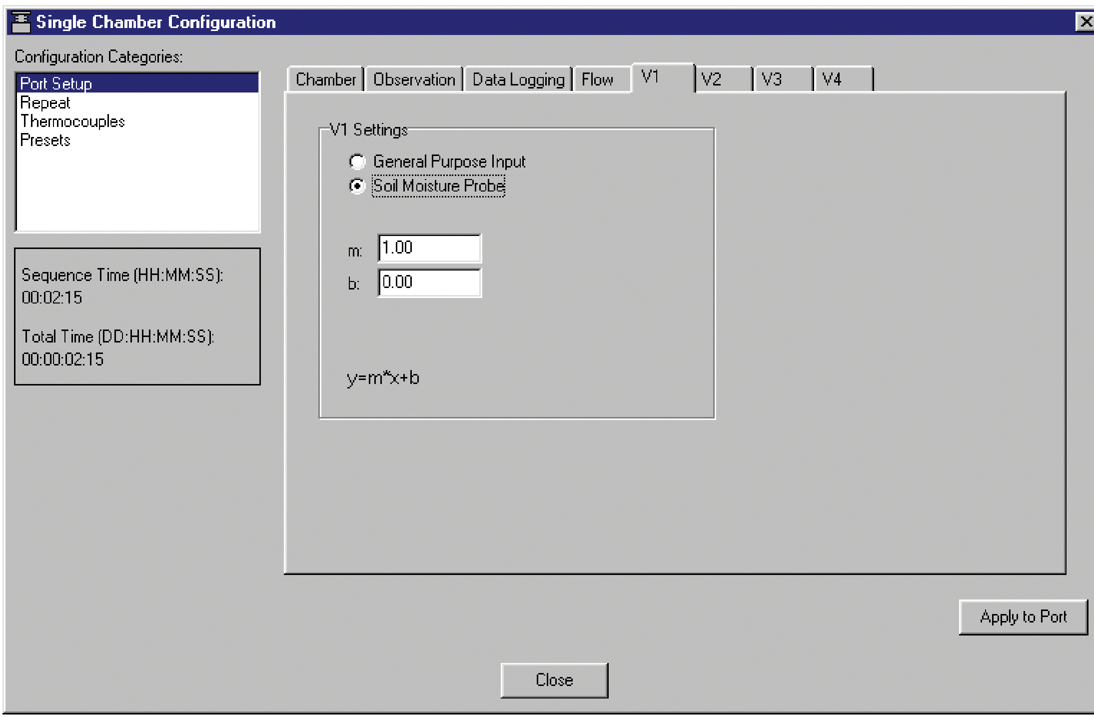
Port Setup: Flow

Click on the Flow tab to set the chamber flow rate. When a Multiplexer is not connected, the flow can be set to whatever rate you choose. When a Multiplexer is attached, the flow rate is automatically set to High when a measurement is active.



Port Setup: V1 (V2, V3, V4)

The V1, V2, V3, and V4 windows are the areas in which you can input the coefficients for linear external input devices connected to the Auxiliary Sensor Interface box. There is a General Purpose Input and a dedicated input for the Decagon EcH_2O or Delta-T Theta soil moisture probes that can be monitored on any of V1, V2, V3, or V4 voltage channels. When a Multiplexer is used, thermistors can be monitored on V1-V4 voltage channels.



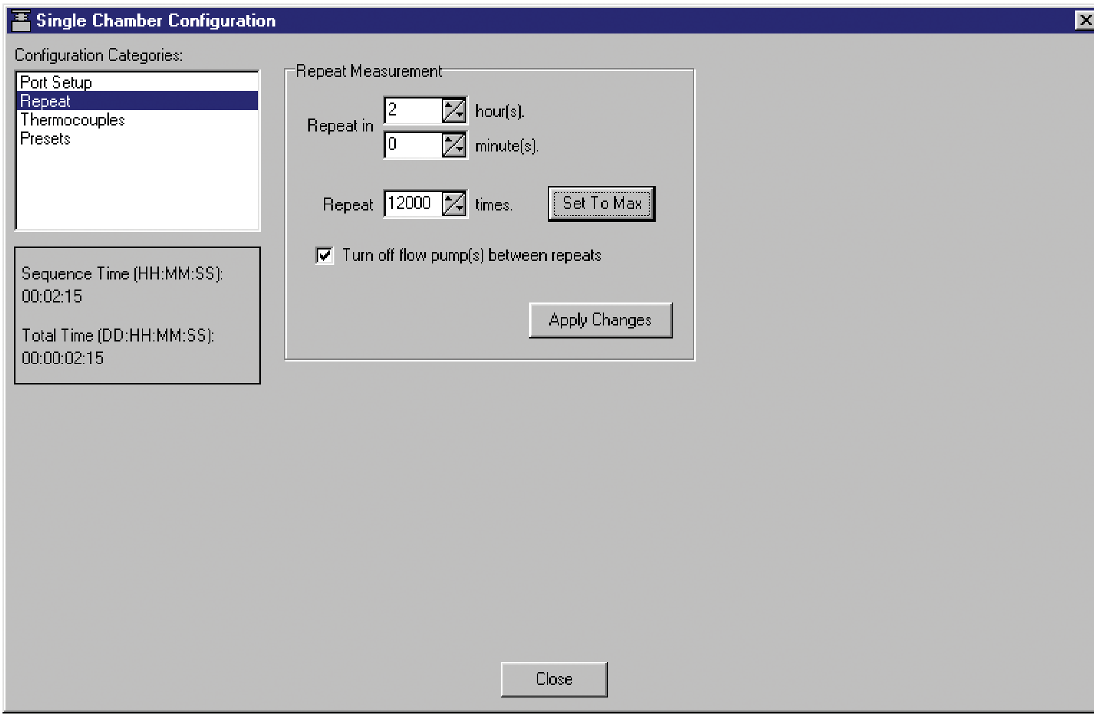
Enter the slope and offset values (obtained from the manufacturer) for each device attached to the voltage inputs.

NOTE: If a soil moisture probe is connected, the probe is automatically powered for about 10 seconds to allow it to stabilize, before it is sampled.

The voltage ouput from the input devices connected to the Auxiliary Sensor Interface can be viewed in the Main Window.

Repeat

The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.

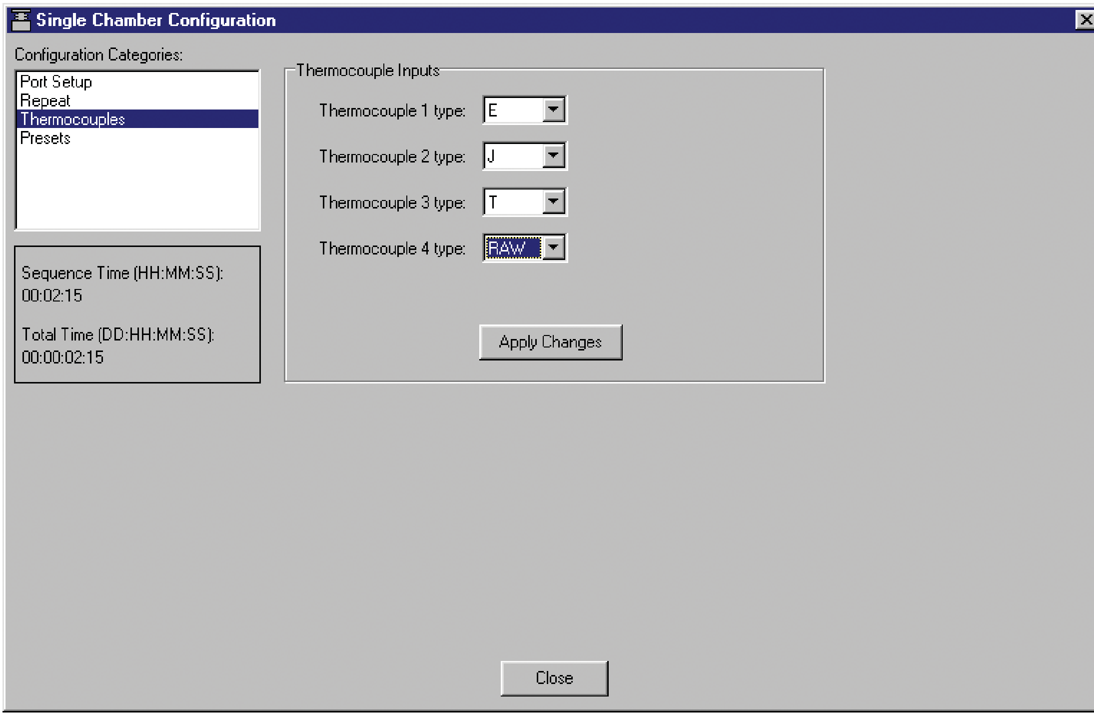


For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 times (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Set To Max** button).

You can elect to turn off the flow pump between repeated measurements to conserve battery life and extend the life of the pump by enabling the check box.

Thermocouples

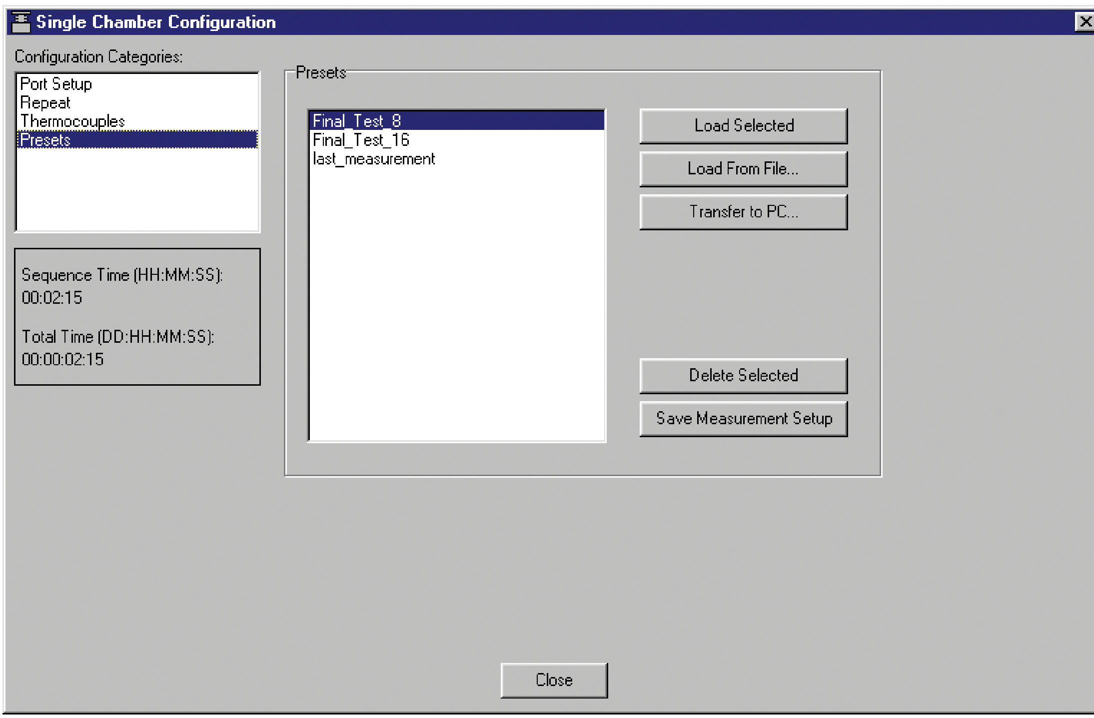
The Thermocouples window is the area in which you can input the coefficients for thermocouples attached to the Auxiliary Sensor Interface. There are 4 thermocouple channels (Type E, J, or T); choose the thermocouple type from the pull-down menu.



Click **Apply Changes** to send the values to the LI-8100.

Presets

After you have finished defining a set of measurement protocols, you can save the definition as a **Preset**, which can then be recalled and applied globally, rather than re-defining the protocol each time it is to be used. For example, you might have a series of measurement protocols for daytime, nighttime, and diurnal measurements. Any or all of these protocols can be saved individually for later recall.

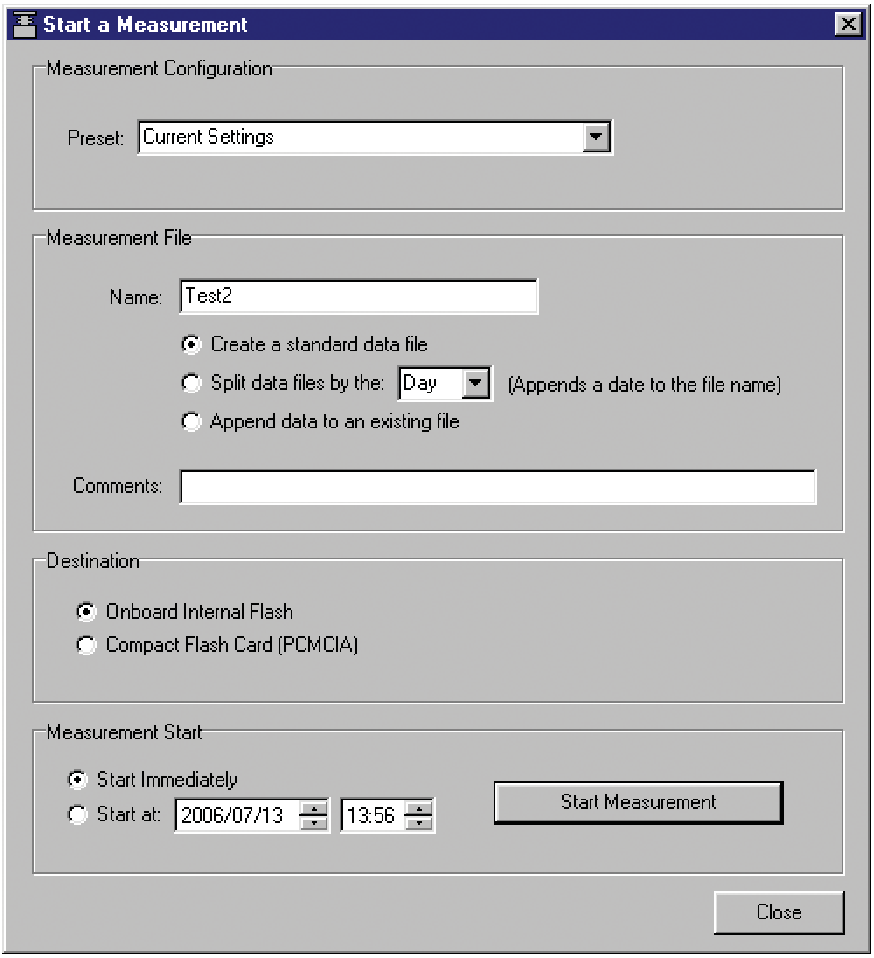


Click **Save Measurement Setup** to save the configuration as currently defined to a measurement Preset. You are prompted for a filename for the Preset. After the Preset is saved, you can save it to the computer by clicking **Transfer to PC**, and choosing a destination for the file (by default, they are saved in a folder named Presets in the LI-8100 Program Files folder). Preset files are appended with a .81p file extension.

To load a Preset, choose a Preset from the list, and click **Load Selected**, or click **Load From File** and locate the file on the computer.

Click **Delete Selected** to remove a Preset from the list.

Start Measurement



Measurement Configuration

You can choose a defined set of measurement parameters from the Preset pull-down menu, or use the configuration as currently defined (see **Measurement Configuration:Presets** above).

Measurement File

Enter a **File Name** and optional **Comments**. The **Comments** appear only in the header information. Files can be created in the standard data file format, where the entire data set is placed in a single file, as defined by the measurement configuration. Large files can be split into smaller files, in increments of 1 day, or 1 week. Files split by the day are appended with a date, beginning at 12:00 a.m. each day; files split by the week are appended with a date, and are also split at 12:00 a.m each day. Click the ‘Append data to an existing file’ button to add new measurement data at the end of the currently defined file.

Destination

Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card; you can log to one or the other, but not both at the same time. Data stored to the internal memory can be transferred to a Compact Flash card or to the PC when a measurement is not active.

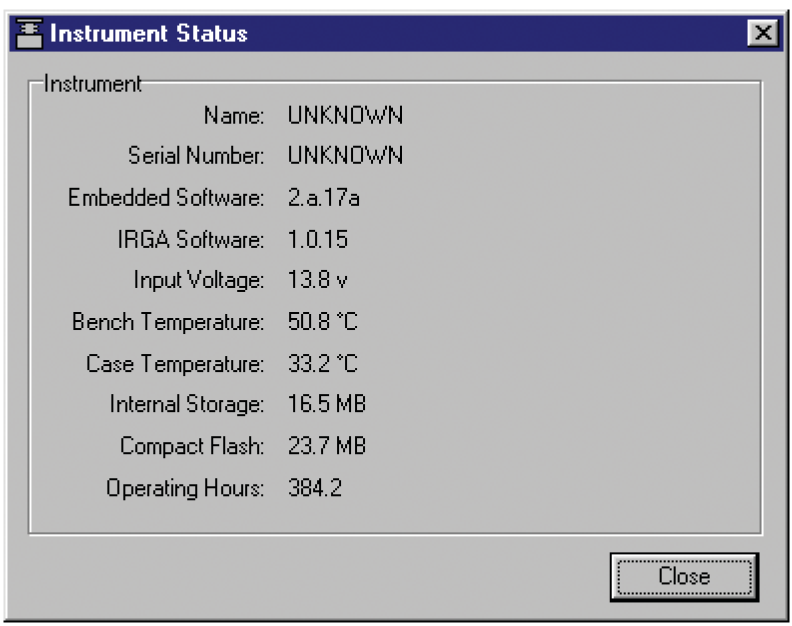
Measurement Start

Enter a **Start** time. You can start the measurement immediately or choose to begin the measurement at a specified date and time.

View Menu

Instrument Status

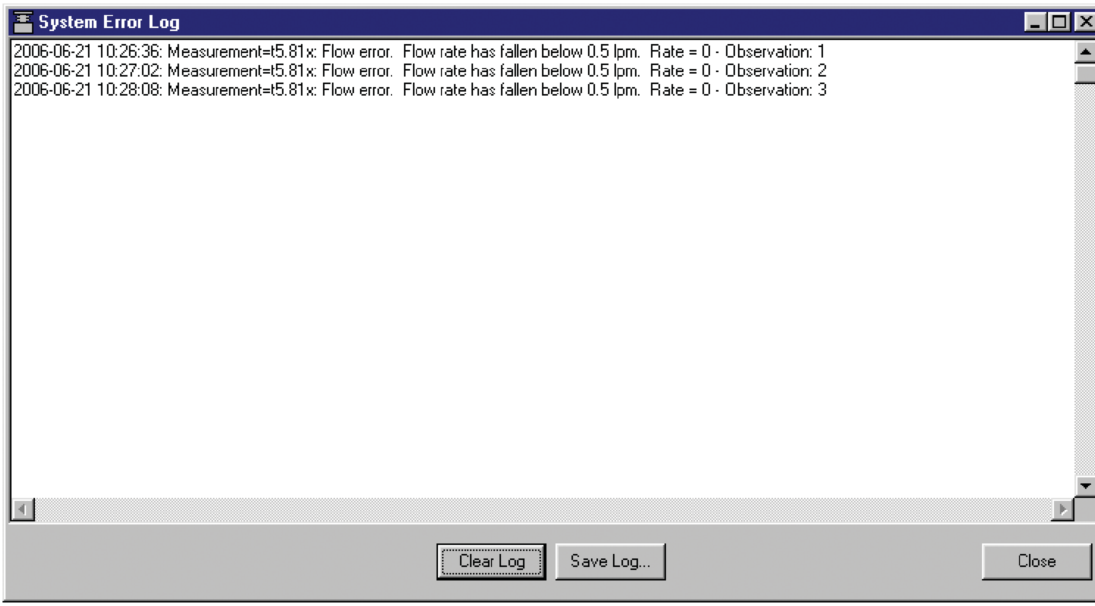
Opens a window that displays the current operating state of the LI-8100.



Click **Close** to close the window.

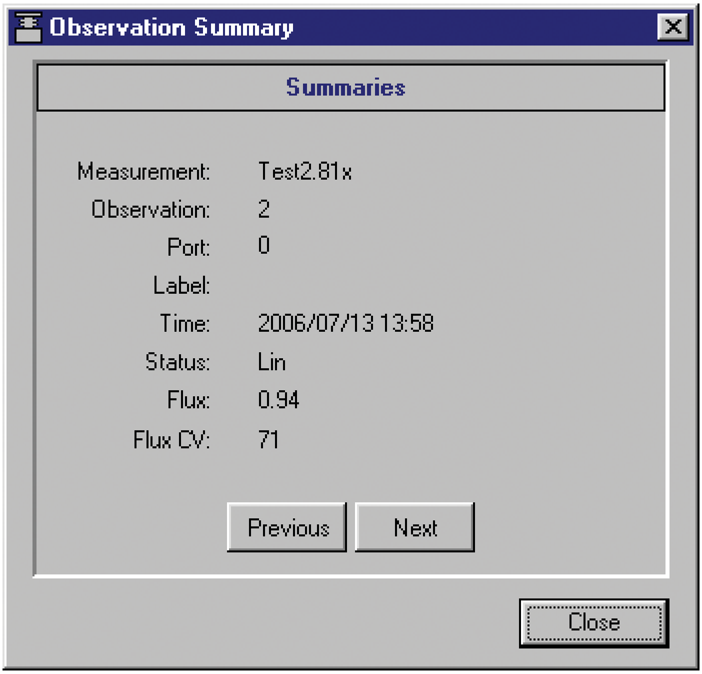
Error Log

Opens a window that displays any logged errors that occurred during a measurement cycle. Click **Clear Log** to delete all messages, or **Save Log** to enter a filename and save the Error Log to a text file.



Summary Records

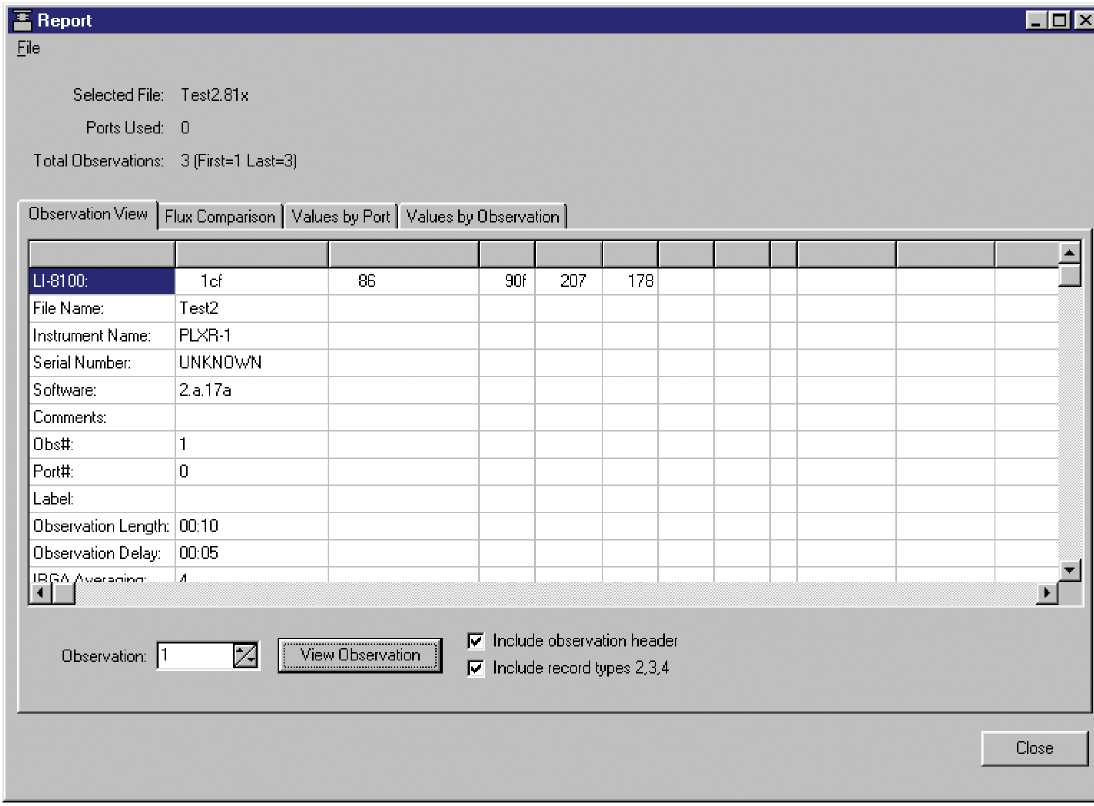
Opens a window that displays select records, including Status (linear or exponential flux calculation), Flux values and Flux CV for each observation. Click **Previous** or **Next** to scroll through all Summary Records.



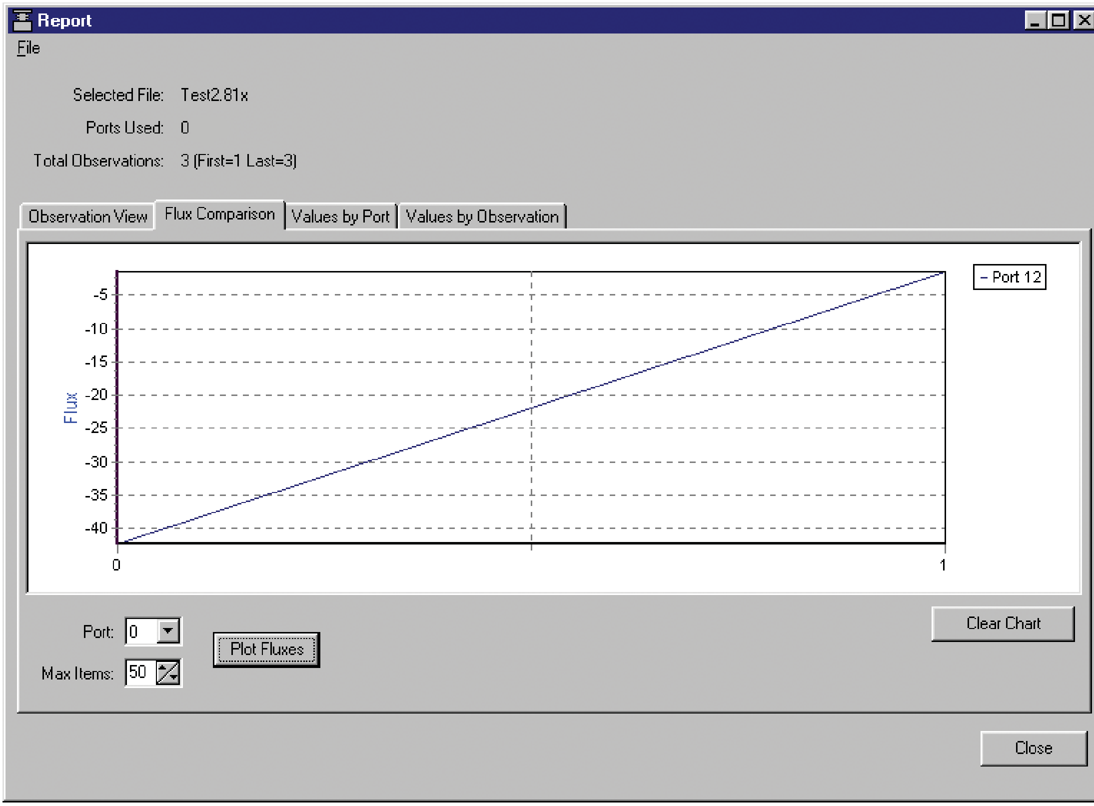
Reports

Opens the Report window, which provides a variety of ways to view selected Observations. Choose **Select Data File** from the File menu, and choose the file whose Observations you want to view.

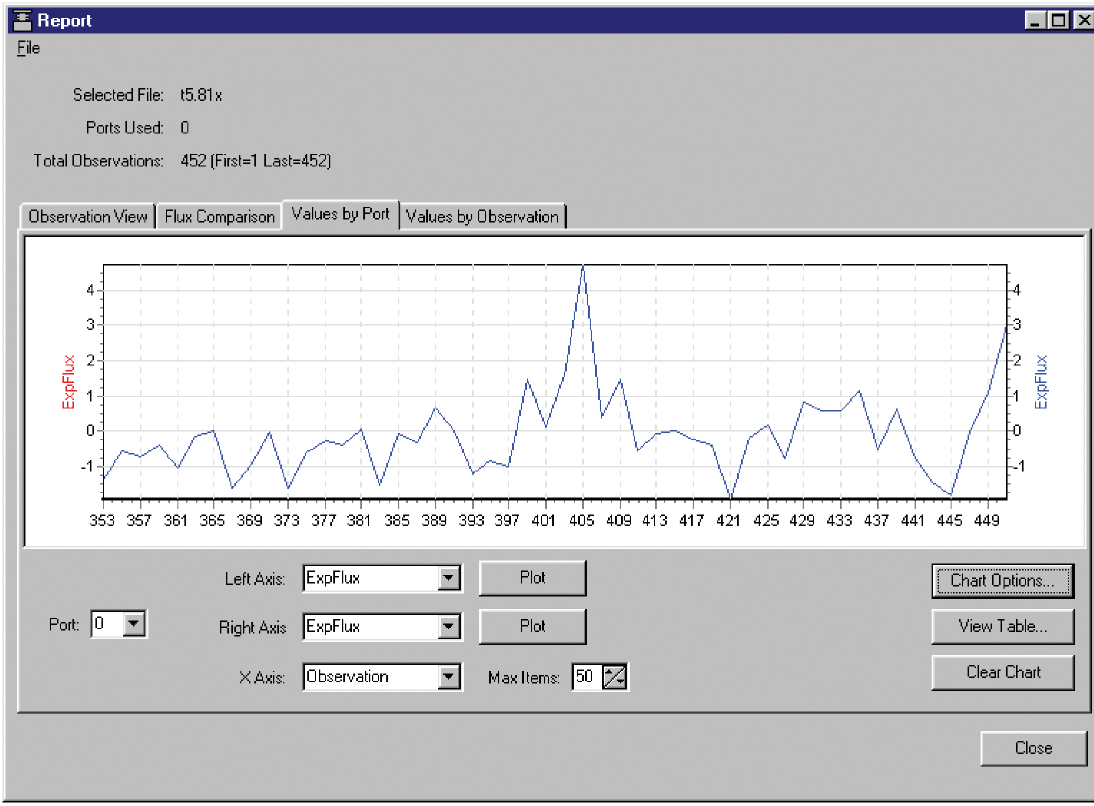
The **Observation tab** displays the Observation's data in tabular format. Choose the Observation number using the scroll arrows, or just type it in, and click **View Observation**. If you do not want to view the observation header and/or the summary records (Type 2, 3, and 4 records), disable the check box(es).



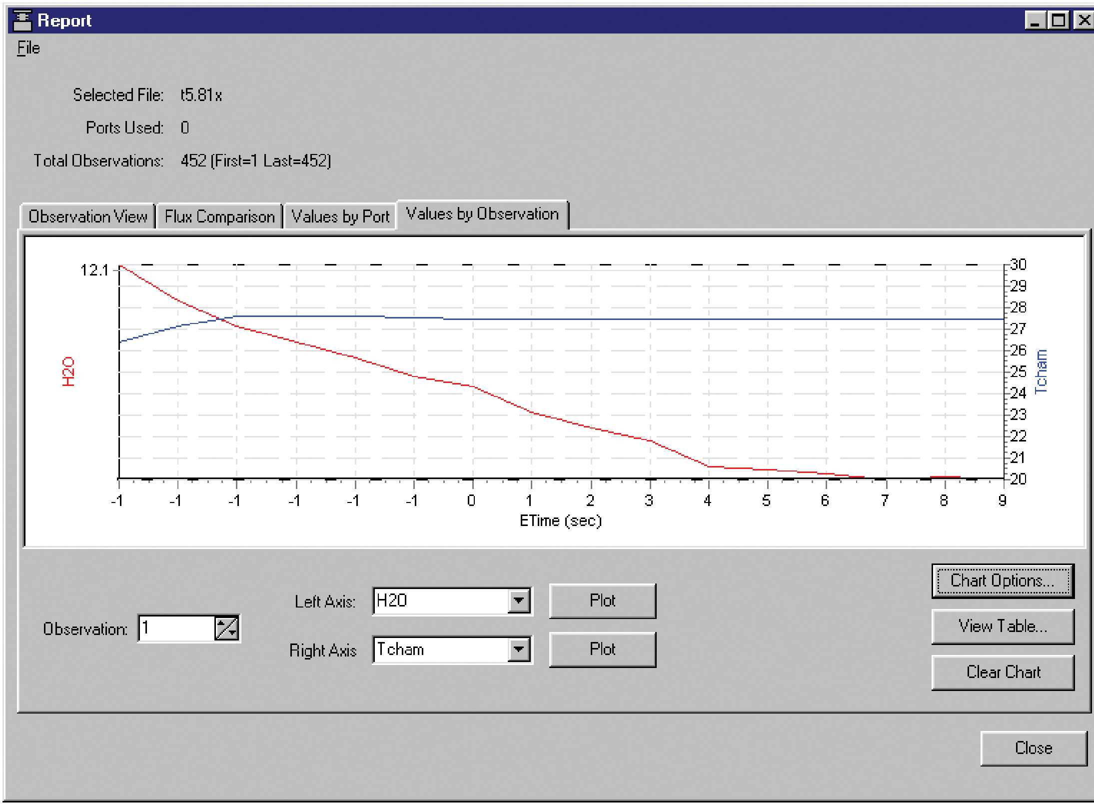
The **Flux Comparison tab** allows you to plot flux values on a chart. Choose the number of flux data points to be plotted, and click **Plot Fluxes**. The Max Items denotes the number of points to plot. The data plotted on the graph are always the most recent in the file. Click **Clear Chart** to remove all plots from the chart.



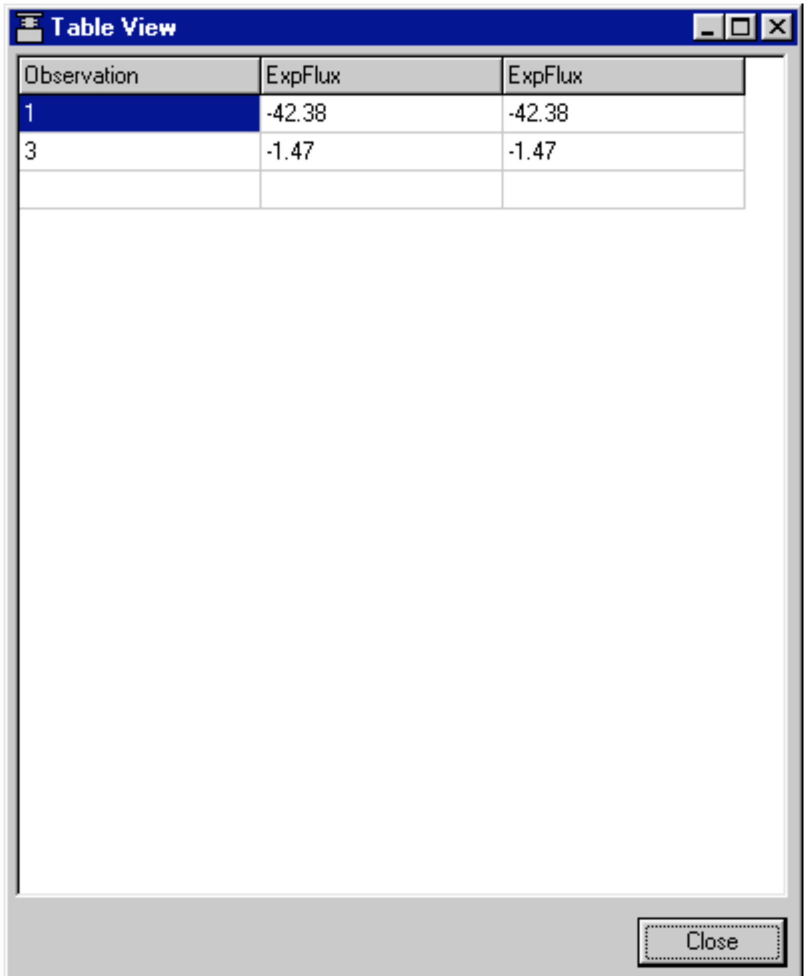
Click on **Values by Port** to graph two specific data items for a given port. The points are data from the last (Max Items) observations. Select the variable to plot on each axis. Click **Plot**. To automatically scale the left and/or right axes, click on **Chart Options**. Enable automatic scaling, and set the maximum and minimum values for the axes, if desired. To view the selected Observations in tabular format, click on **View Table**. Click **Clear Chart** to remove all data from the chart.



Click on **Values by Observation** to plot records *by observation*, on left and right axes, against elapsed time (ETime). **Values by Observation** displays all of the raw data values for a particular observation; this is used to view a single observation in detail. Choose the Observation whose records you want to plot, and then select the variable to plot on each axis. Click **Plot**.



To automatically scale the left and/or right axes, click on **Chart Options**. Enable automatic scaling, and set the maximum and minimum values for the axes, if desired. To view the selected Observations in tabular format, click on **View Table**.

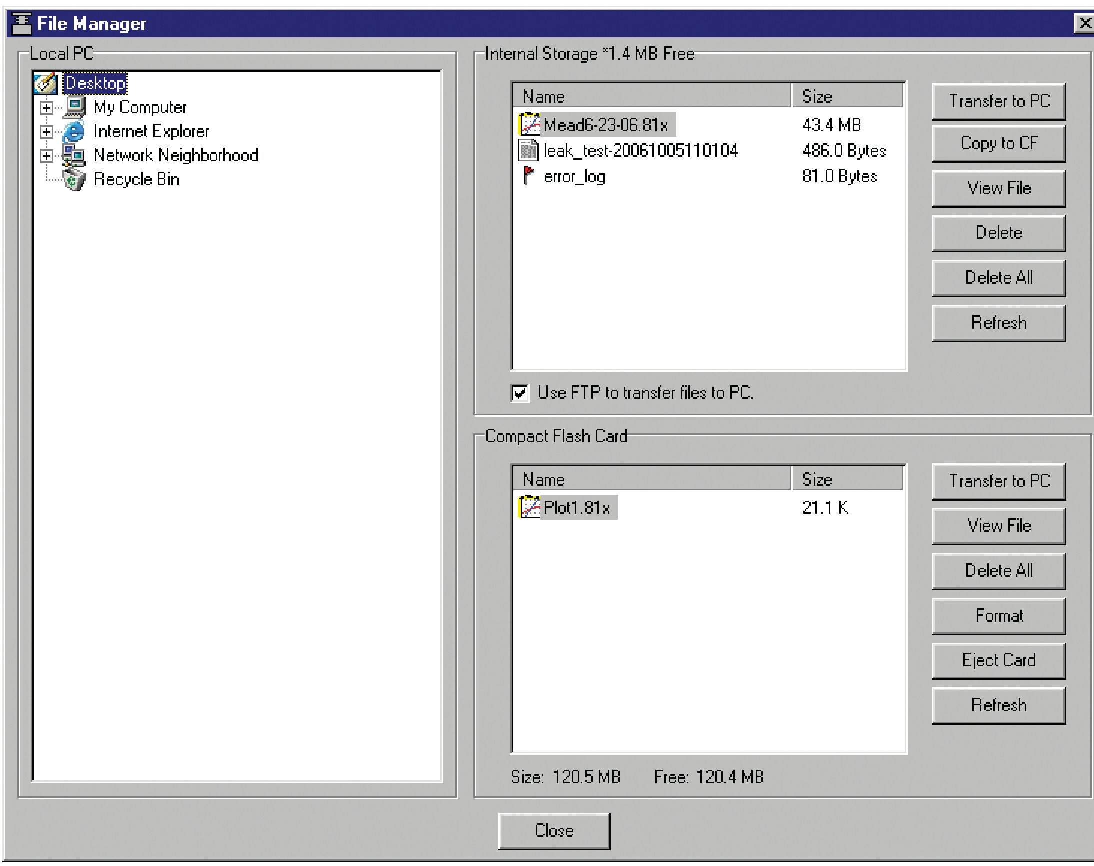


Click **Clear Chart** to remove all data from the chart.

Utilities Menu

File Manager

Opens the File Manager dialog, where you can move files from the LI-8100 to your computer or optional compact flash card.



The Local PC window displays a directory tree of the files on your computer. The Internal Storage window displays the LI-8100 data files currently stored on the LI-8100 internal flash memory, and the amount of free memory available. Note that there is an asterisk by the Internal Storage free memory available shown; this is a reminder that data files stored on the LI-8100 are compressed. Therefore, the free memory available on the LI-8100 may not be indicative of how many files can be stored there. Files are compressed at a ratio of roughly 3:1, meaning if 15 MB of free space are indicated, approximately 45 MB of LI-8100 data files may be stored. The file sizes listed in the directory list are actual size, however.

If a compact flash card is present, the Compact Flash window also shows the amount of available memory on the card. To move files from the LI-8100:

1. Select the file you want to transfer and select **Transfer to PC** or **Copy to CF**. When **Transfer to PC** is selected, the file(s) will be transferred to the selected destination in the Local PC area.

2. Click, drag and drop the file(s) you want to transfer.

Some useful keyboard shortcuts: Most of the common keyboard shortcuts can be used when selecting and/or moving files in the LI-8100 directory list. For example, press CTRL + A to select all files, Shift + click to select a range of files, or CTRL + click to select multiple files individually. You can also "drag and drop" selected files to the PC destination of choice, or to the Compact Flash card.

From Internal Storage...

Click the **Transfer to PC** button to move the highlighted file(s). When you are finished moving files, you can delete selected files, or all files, by clicking **Delete**, or **Delete All**, respectively. Click on **Refresh** to update the file list. Click **Copy to CF** to move the selected files to the compact flash card. Click **View File** to open the entire file in a new text window.

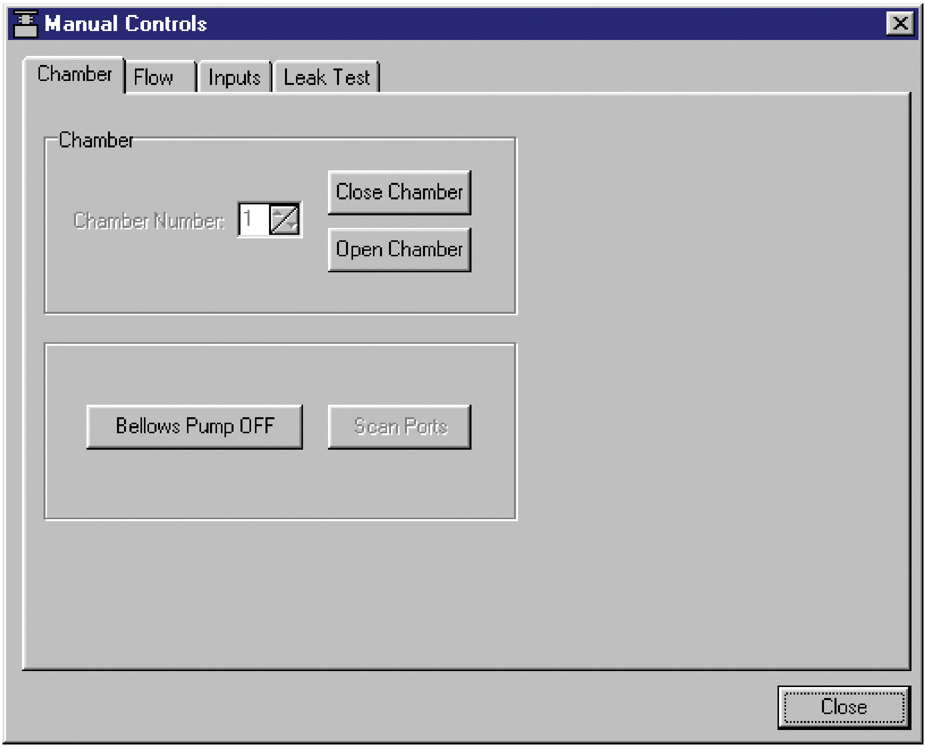
Files generated by the LI-8100 are denoted with a .81x file extension, and contain all of the raw data records and summaries.

From the Compact Flash Card...

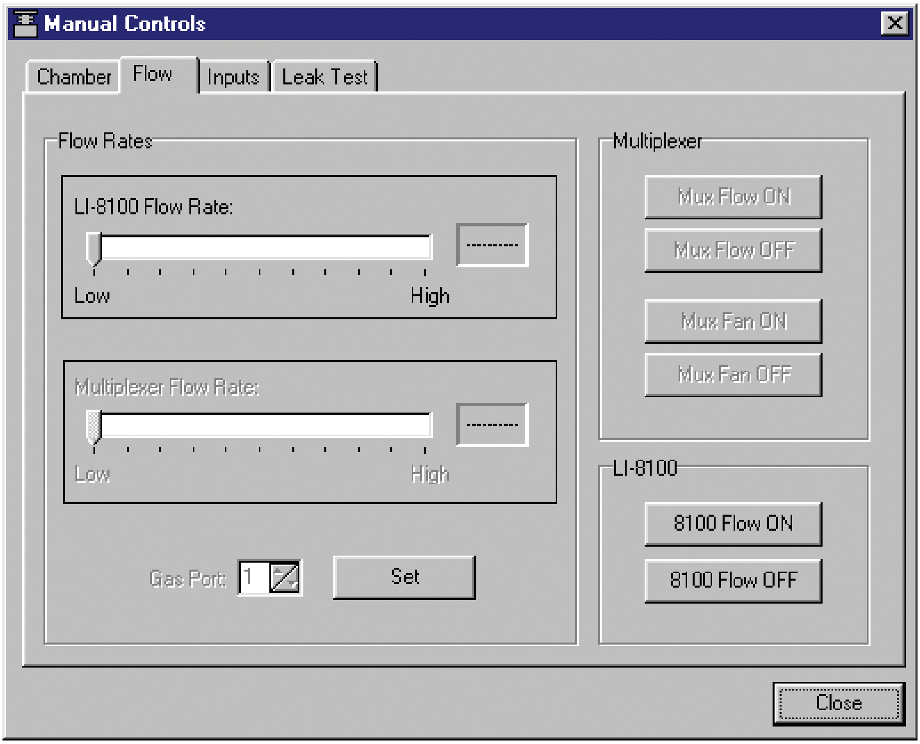
Click on **Format** to format the compact flash card. ***Note that all files on the card will be deleted.*** Click the **Transfer to PC** button to move the highlighted file(s). When you are finished moving files, you can delete all files by clicking **Delete All**. Click **View File** to open the entire file in a new text window. Click **Eject Card** to unmount the compact flash card, and facilitate safe removal from the instrument. Click on **Refresh** to update the file list.

Manual Controls

Opens the Manual Controls dialog, where you can use manual chamber controls to open or close the chambers, turn the LI-8100 flow on or off, or turn the bellows pump off. Controlling the chamber flow manually is useful when performing user calibration of the infrared gas analyzer, as described in Section 5. In general, the Manual Controls are used for diagnostic purposes, and are not used when making typical measurements. Note, too, that the functions on the Leak Test and Inputs tabs are disabled in single-chamber mode; they are used for Multiplexing only.



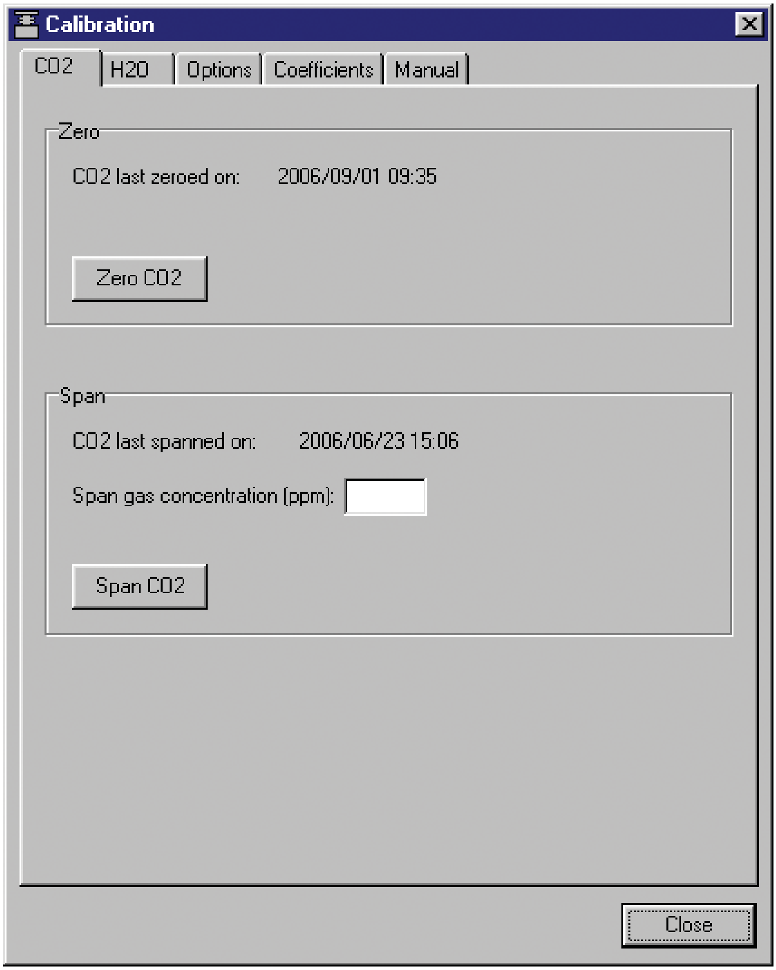
Click the **Close Chamber** or **Open Chamber** button to manually close or open the attached soil chamber.



The Flow tab contains controls for adjusting the flow rate of the LI-8100. The LI-8100 flow rate can be adjusted, from Low to High as desired, as well as turned Off and back On. Note that when a measurement is started, the LI-8100 flow rate is automatically set to High, regardless of how it might be set in the Manual Controls dialog.

Calibration

Select **Calibration** to open the Calibration window. This is the area in which you set the zero and span of the infrared gas analyzer in LI-8100 Analyzer Control Unit. Step-by-step instructions for performing user calibrations are given in Section 5.



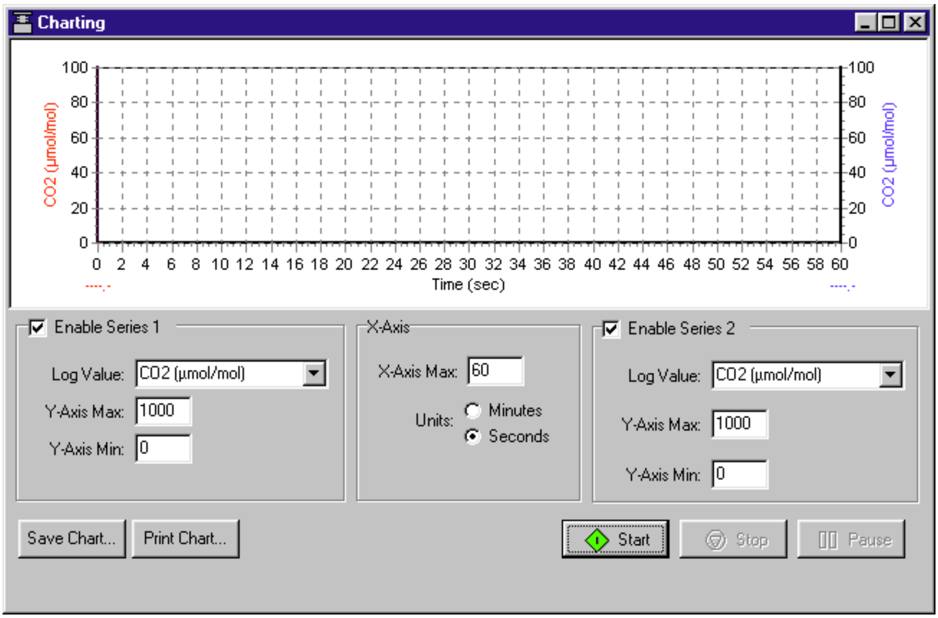
The calibration functions for both CO_2 and H_2O correct for pressure fluctuations that may be present. To disable this correction, click on the Options tab and uncheck the 'Enable Pressure Compensation' check box.

The LI-8100 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. These coefficients are fixed at the factory, and are present on the calibration sheet included with the instrument.

The calibration constants for CO_2 and H_2O zero and span calibrations are found on the Manual page. These constants are stored to a file on the computer by clicking on **Save Values**. Click **Load Values** to restore the values in this window using the file on the PC. If new constants are entered in this window, click **Apply** to send the values to the LI-8100 for implementation; the constants are not automatically saved to the computer until you choose **Save Constants**.

Charting

Select **Charting** to open the Charting window (below). This is the window in which you can set up the parameters for plotting your real-time 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.

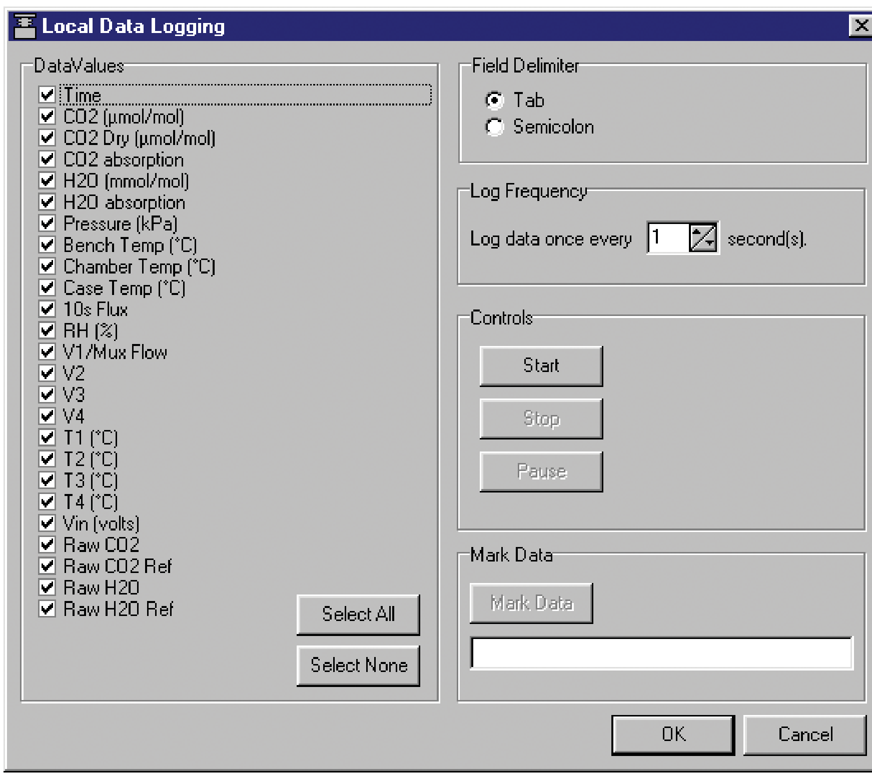
X-Axis Max

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. Click on **Save Chart** to save the plot as currently displayed in the window to a .bmp file. Click **Print Chart** to print the currently displayed plot to your printer.

PC Data Logging

Opens the Local Data Logging dialog, where you can configure the output options for collecting selected real-time data records on your computer. By default, log files are denoted with a .txt file extension.



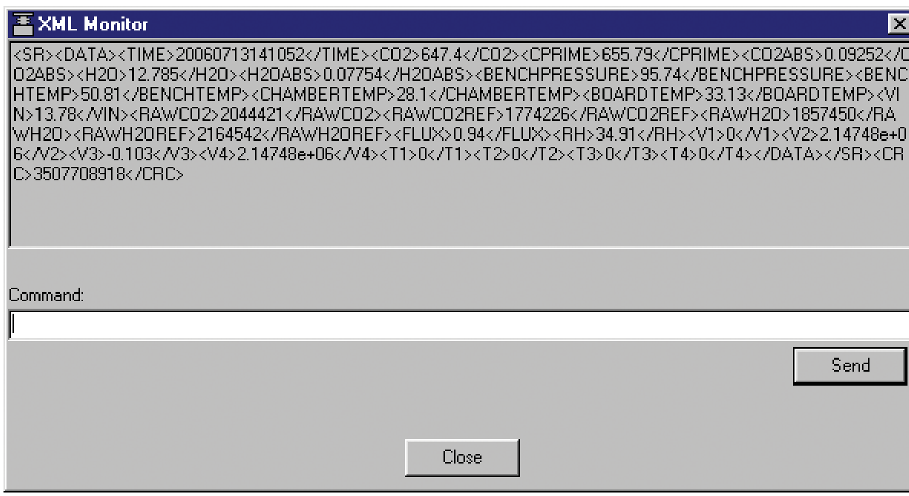
Choose the frequency at which to log data (seconds), and the delimiter for the data fields (tab or semicolon character). Use the **Controls** buttons to manually start or stop data logging, independent of any measurement protocol that is currently defined. You are prompted for a file name and destination for the log file. After the **Start** button is pressed and data logging begins, you can enter comments in the Mark Data field and click the **Mark Data** button to insert the comment into the data file. For example, if you observed an anomaly while logging data and want to make note of the time of its occurrence, you could enter a comment and insert it into the log file for later reference.

The data values that can be output are as follows:

Label	***Description***
Time	Instrument time.
CO2 (µmol/mol)	Chamber CO_2 concentration in µmol/mol.
CO2 Dry (µmol/mol)	Chamber CO_2 concentration, corrected for water vapor dilution.
CO2 absorption	Absorption of photons in the optical bench due to the presence of CO_2.
H2O (mmol/mol)	Chamber water vapor concentration, in mmol/mol.
H2O absorption	Absorption of photons in the optical bench due to the presence of water vapor.
Pressure (kPa)	Atmospheric pressure in the optical bench.
Bench Temp (°C)	Temperature of the optical bench.
Chamber Temp (°C)	Air temperature inside the soil chamber.
Case Temp (°C)	Air temperature inside the Analyzer Control Unit case.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
RH (%)	Relative humidity inside the soil chamber.
V1/Mux Flow	Output at voltage channel 1 (multiplexer flow when attached).
V2	Output at voltage channel 2.
V3	Output at voltage channel 3.
V4	Output at voltage channel 4.
T1 (°C)	Output at thermocouple channel 1, in degrees C.
T2 (°C)	Output at thermocouple channel 2, in degrees C.
T3 (°C)	Output at thermocouple channel 3, in degrees C.
T4 (°C)	Output at thermocouple channel 4, in degrees C.
Vin (volts)	Input (battery) voltage.
Raw CO2	CO_2 raw signal.
Raw CO2 Ref	A measure of the optical amplitude of the CO_2 channel, primarily for diagnostic purposes.
Raw H2O	H_2O raw signal.
Raw H2O Ref	A measure of the optical amplitude of the H_2O channel, primarily for diagnostic purposes.

XML Monitor

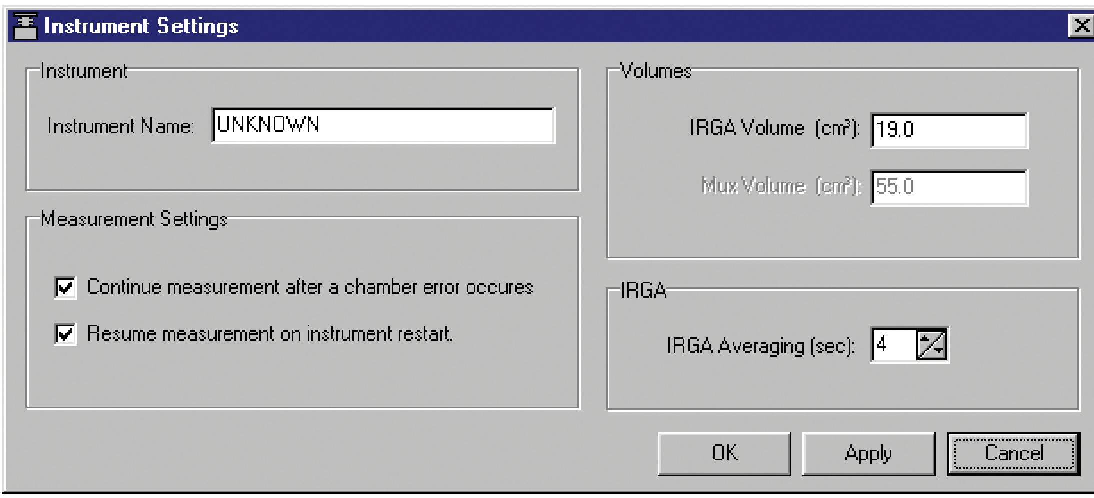
The configuration grammar used to communicate with the LI-8100 is based upon a subset of XML (eXtensible Markup Language). XML relies on the use of tags to “Markup” or give structural rules to a set of data. The XML Monitor window is primarily a diagnostic tool that displays real-time XML communication; a command line field is present that allows the user to send an XML command to the LI-8100 for implemenation. This can be useful for diagnosing problems, as a LI-COR technician can gauge the instrument’s response to given commands, and determine if the instrument is functioning properly.



8100 Menu

Instrument Settings

You can enter a name for the instrument, decide how to proceed after a chamber error or instrument restart occurs, choose default values for IRGA and Multiplexer volumes, and choose the time interval (in seconds) over which to average the IRGA readings in this window.



The instrument name is a user-entered name; enter a maximum of 30 characters. The instrument name is used to identify data from multiple instruments; when logging data to a compact flash card, a directory is created with the instrument name under which to store the data.

The Measurement Settings determine whether or not the measurement will continue after a chamber error (e.g. the chamber fails to close because of an obstruction) occurs, and whether to resume a measurement after an instrument restart, as can occur from a power failure or a low battery condition.

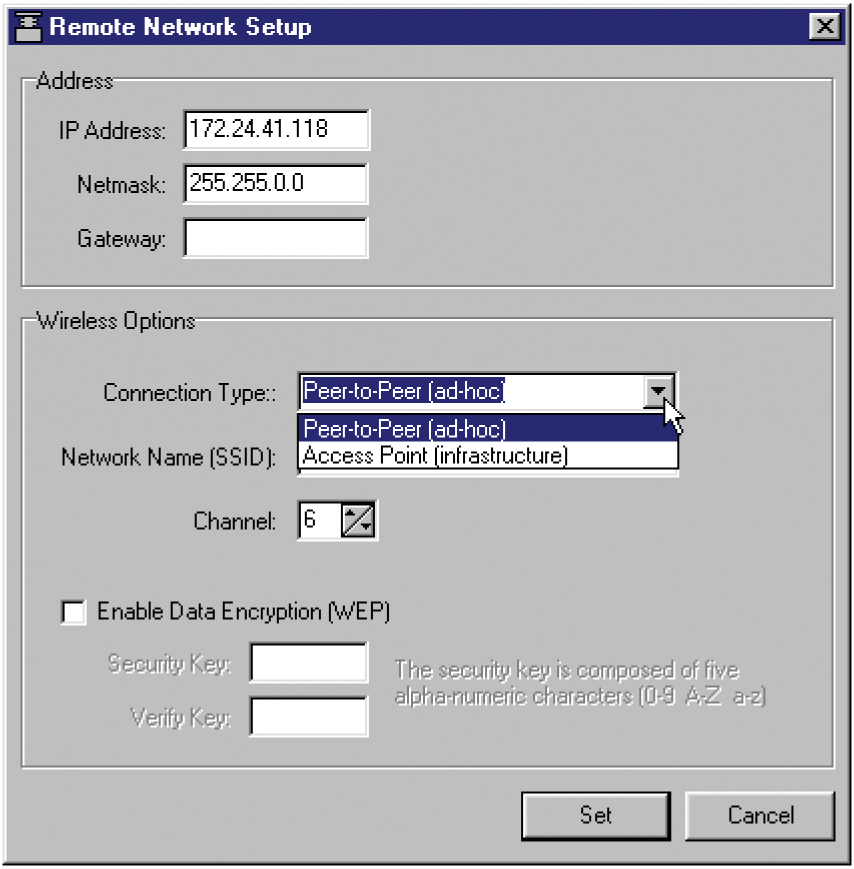
The Volume is used as default value for the IRGA in the LI-8100. In most cases this value should not be changed. The default value is 19 cm^3 for the IRGA volume.

The IRGA Averaging setting controls the amount of averaging that is done to CO_2 and H_2O signals from the IRGA. The IRGA is sampled at 2Hz. With 4 second IRGA Averaging (the default recommended setting) 8 data points will go into any value of CO_2 or H_2O. As data stream in, earlier data are dropped from the average. The minimum is 1 second and the maximum is 20 seconds.

Click on **Apply** to send these values to the LI-8100 for implementation.

Networking

The LI-8100 can be connected to a PC or PDA via a wireless network if desired. The Remote Network Setup window allows you to configure wireless options for the LI-8100.



Connection Type

The LI-8100 is preconfigured for a **peer-to-peer** (ad-hoc) wireless 802.11b network. An ad-hoc, or peer-to-peer wireless network consists of a number of devices, each equipped with a wireless networking interface card. Each device can communicate directly with all of the other wireless enabled devices. These devices can share information, but may not be able to access wired LAN resources, unless an **access point** (below) is used. A peer-to-peer network allows the LI-8100 to connect other devices (e.g. the computer or Palm PDA) without a separate server running on that network.

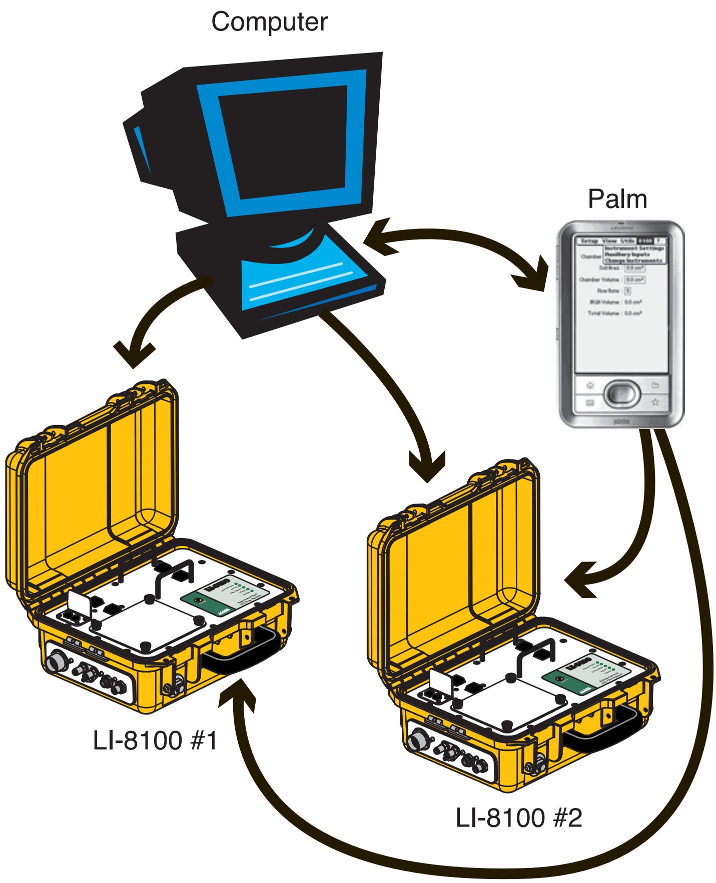


Figure 11-1. *On an Ad-hoc network, each device can communicate with other wireless enabled devices.*

The LI-8100 can also be connected to a specific hardware **access point**; this can be a dedicated hardware access point (HAP) such as a linksys wireless router/access point, or it can be a Software Access Point that runs on a computer equipped with a wireless network interface card. The access point acts as a hub to provide connectivity for the wireless devices. Note that even with an access point present, only one client (PC or PDA) can talk to an LI-8100 at a time.

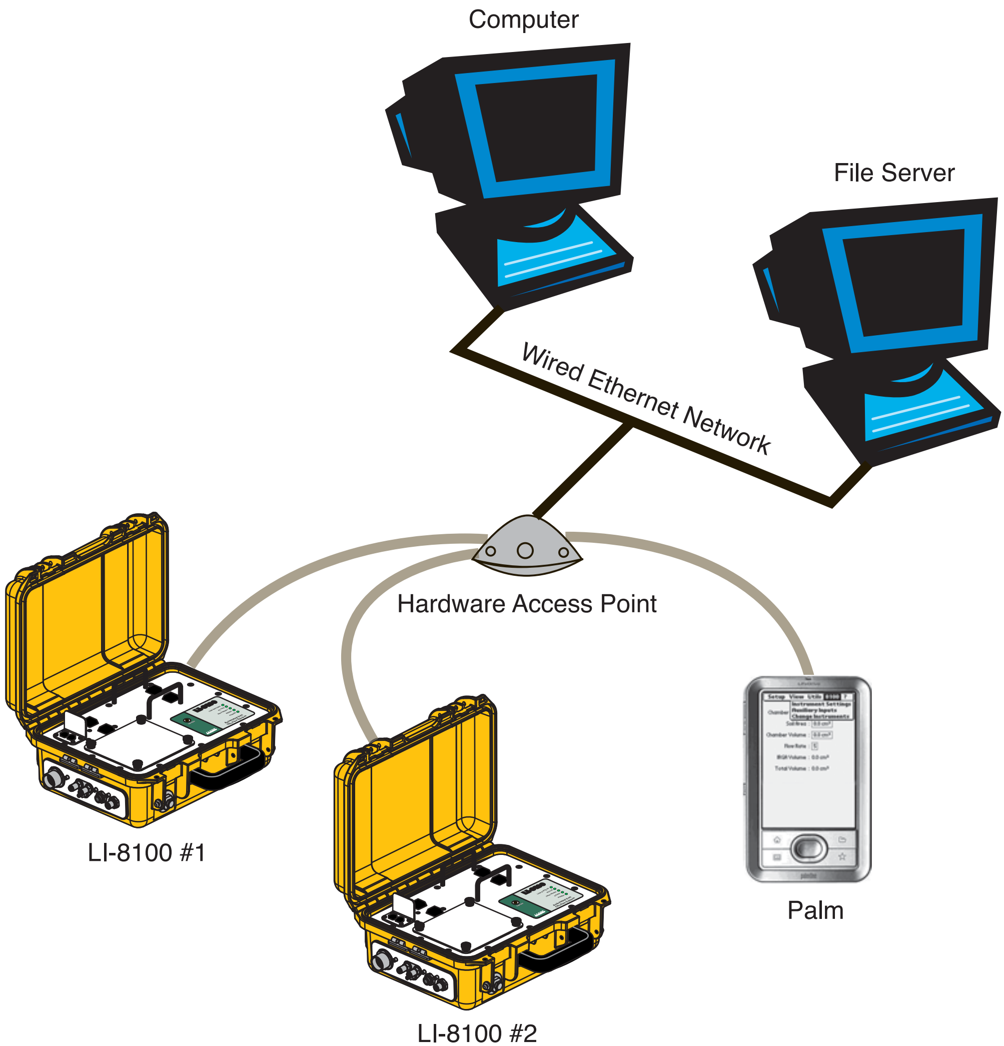


Figure 11-2. *A hardware access point can be used to bridge wireless and wired network devices.*

In order to communicate with other devices, the LI-8100 must be given a unique IP address, netmask, network name, and channel. Optionally, data encryption can be enabled.

The **IP address** is a number that uniquely identifies each node on the network. The address is composed of a set of four numbers called "octets", where each octet ranges in value from 0 to 255. When entering an IP address, the octets are separated with a period. For example, 192.168.100.2 is a valid IP address.

Some IP address ranges have been set aside for private use, and are typically used by organizations for internal networks. LI-COR recommends choosing an IP address from the private range 192.168.100.0 to 192.168.100.255. In this range, the first 3 octets, which represent the network address, are fixed at 192.168.100. The last octet, which represents the host address, must be different for each node on the network. For simplicity, you can number your first device 192.168.100.1, your second device 192.168.100.2, and so on.

For example, suppose you have two LI-8100s, a computer, and a Palm handheld device (Figure 10-2). You could assign the following IP addresses to each device (ad-hoc):

LI-8100 #1:192.168.100.1
LI-8100 #2:192.168.100.2
Computer:192.168.100.3
PDA:192.168.100.4

For an access point, you will need to know the network addresses for the access point and assign an IP address in that range.

The **netmask** is a set of 4 octets used to separate an IP address into two parts; the network address and the host address. If you are using LI-COR's recommended IP address range, the netmask should be set to 255.255.255.0.

The **Gateway** is a node that routes traffic to another network (for ad-hoc configurations, leave this blank).

The **Wireless Options** are inherent to 802.11 networks. The network is given a name, a frequency, and optional encryption keys.

The **network name**, or **SSID** (Service Set Identifier), is a name given to a wireless local-area network (WLAN). Each device that needs to communicate must have the same SSID. The LI-8100 supports a network name of up to 30 characters.

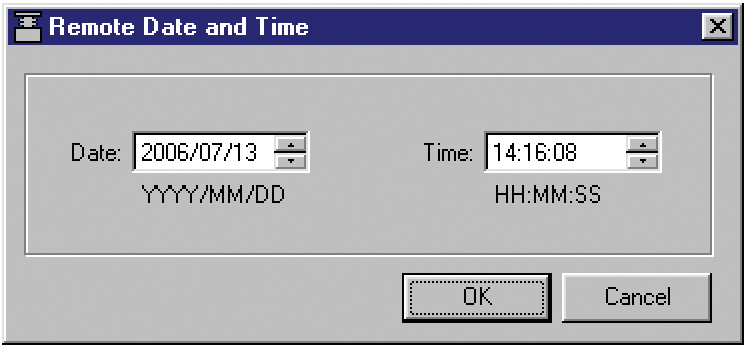
A range of radio frequencies between 2.4 and 2.5 GHz have been designated for public use in most countries. The **channel** refers to a specific portion of the total frequency range that is given to a device for communication. The LI-8100 supports channels 1 to 11. Choose an appropriate channel for the country where the instrument will be located.

Country	Channels
Europe	1-13
USA	1-11
France	10-13
Japan	1-14

WEP (Wired Equivalent Policy) is an encryption standard built into 802.11b, and is supported by the LI-8100. If data encryption is enabled, the same 40-bit (5 character) key must be entered on all devices of the WLAN. The key is used for data encryption and decryption.

Date and Time

Sets the clock in the LI-8100.



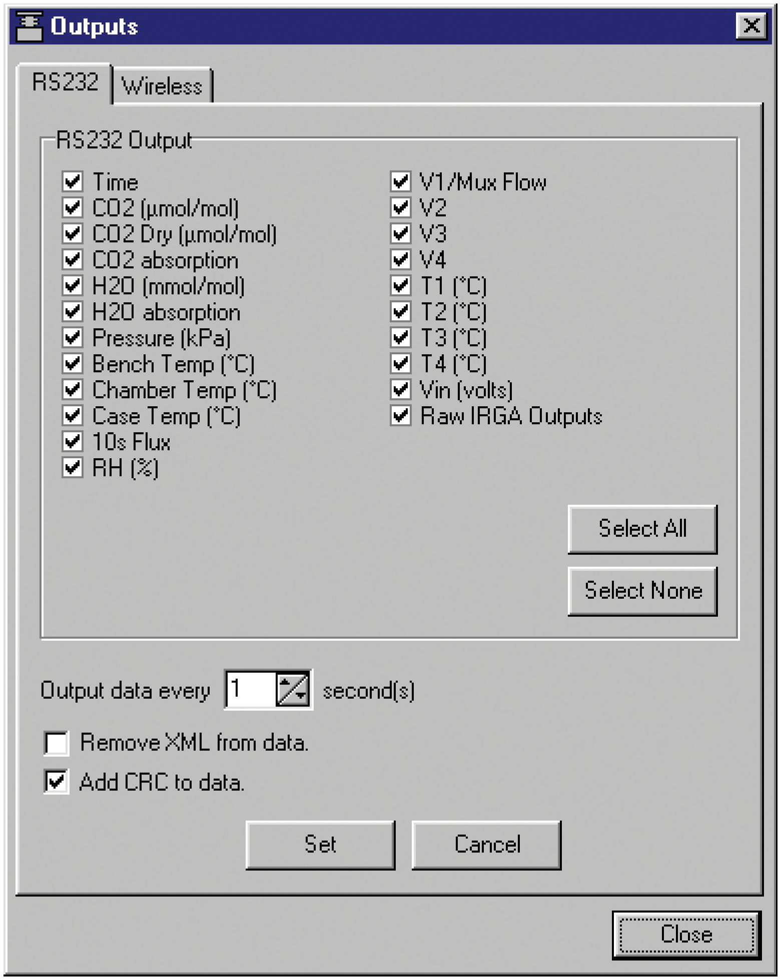
Click on year, month, or day field to highlight the text, and use the up or down arrow buttons to increase or decrease the numbers. Alternatively, highlight the desired field and type in the new number.

Click on the hour, minutes, or seconds field and use the up or down arrow buttons to adjust the time. The clock is a 24-hour clock; i.e., 13:00:00 is 1:00 p.m.

Click **OK** to dismiss the dialog and accept the change(s).

Outputs

Opens the Outputs dialog, where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included, as when using the PC Data Logging options.



Choose the raw data values to be sent to the RS-232 port and output frequency (seconds). Note that when the LI-8100 outputs data, each field is "marked up" using eXtensible Markup Language (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the **'Remove XML from data'** check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

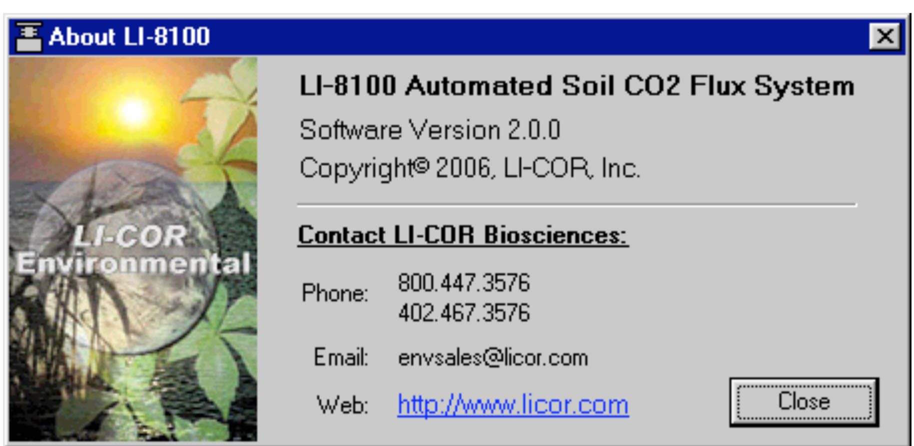
Disable the 'Add CRC to data' check box to remove CRC from the data.

Click on the RS-232 or Wireless tabs to configure data values to be output over that channel. You can configure either channel while connected to that channel; however, changes will not take effect until you disconnect.

Help Menu

Help
Opens the on-line help index, where you can choose help topics related to the Windows application software.

About
Displays the current LI-8100 Windows software version number and contact information for LI-COR.



12 Using a PDA (Single Chamber Mode)

About Wireless Communication

The LI-8100 is a Wi-Fi-enabled device that allows for wireless communication between other Wi-Fi-enabled devices, such as many handhelds. Wi-Fi (short for "wireless fidelity") is the term for a high-frequency wireless local area network (WLAN), such as an 802.11b network. The 802.11b (Wi-Fi) technology operates in the 2.4 GHz range, offering data speeds up to 11 megabits per second. The LI-8100 requires the 802.11b standard for wireless communication.

This section details how to set up your handheld device to communicate with the LI-8100, using either wireless (Wi-Fi) or wired (serial) communication.

Handheld Requirements for Wireless or Serial Communication

At the time of this printing, LI-COR is recommending the Palm™ LifeDrive™ handheld PDA for use with the LI-8100 (the older Palm™ Tungsten C will work, as well). The Palm LifeDrive contains a built-in 802.11b radio that enables connection to a Wi-Fi network or to a Wi-Fi-enabled device such as the LI-8100. Note, however, that PDA models change frequently; go to LI-COR's LI-8100 support page on the web at http://www.licor.com to see the most current handheld recommendations.

For the purposes of this manual, descriptions and discussion for using the LI-8100 with a handheld device will reference the use of the Palm LifeDrive.

Serial Communication Cabling

The handheld can also be connected to the LI-8100 via a serial cable, if wireless communication is not desired. Connect the round female end of the serial cable interface (p/n 9981-018) to the LI-8100 RS-232 port (male port). Connect the 9-pin male end of the serial cable interface to one end of the standard RS-232 cable (p/n 9975-016). Connect the other end of the standard RS-32 cable to the RS-232 cable for the Palm (p/n 8100-558). Connect the RS-232 cable for the Palm to the Palm LifeDrive (see Section 2, *Initial Setup*). Note that the serial cable adapter used with the Palm LifeDrive requires an additional driver be installed on the LifeDrive.

Handheld Software Requirements

The LI-8100 Palm Interface Software requires a handheld running Palm OS3.51 and above. The LI-8100 currently has no interface software available for use with Microsoft Pocket PC or other handheld operating systems.

Wireless Network Cards for the LI-8100

The LI-8100 uses a fixed wireless networking Type II PC card. The currently supported card (Model #AIR-PCM352, Cisco Systems) is an 11 Mbits/s wireless networking card (802.11b) that features an extended form factor, low power consumption, and built-in antenna.

The wireless PC card fits into either of the two PC card slots in the LI-8100 Analyzer Pack (see Section 2, *Initial Setup*).

Initial Handheld Setup

If you have just received your Palm handheld device, there are a number of initial setup steps that should be performed prior to installing the LI-8100 Palm Interface Software. Some of these steps include charging the handheld, calibrating the display, and installing the Palm Desktop software. Refer to the setup instructions included with your handheld to perform these steps before continuing.

Installing the Palm™ Desktop Software

Before installing the Palm Desktop software, make sure your computer system meets the following requirements:

Minimum Requirements: Windows Computers

- IBM-compatible Pentium-class computer
- Windows NT 4.0 Workstation, Windows 98/ME/2000 Pro/XP Home or Pro
- Internet Explorer 4.1 or above
- 50MB available hard disk space
- VGA monitor or better (16 Bit or High Color, 800 × 600 or better)
- CD-ROM or DVD-ROM drive
- At least one available USB port or serial port (serial cradle/cable not included)

Minimum Requirements: Macintosh Computers

- PowerPC processor
- Mac OS X, version 10.1.2 or later
- 25MB available hard disk space
- 12MB available RAM
- Monitor supporting screen resolution of 800 × 600 or better
- CD-ROM or DVD-ROM drive
- At least one available USB port

■ **To install the Palm Desktop Software:**

1. Put the Palm Desktop software CD-ROM in the CD-ROM drive.

2. **Windows:**
   Follow the installation instructions that appear on your computer screen.
   Mac:
   Double-click the Palm Desktop Installer icon.

3. After installation has finished, press the Home button on the handheld to open the Applications Launcher.

Installing the LI-8100 Interface Software for Palm OS

The LI-8100 Interface Software for Palm OS is located on the program CD included with the instrument, and is named LI8100_palm_xxx.prc, where xxx is the current software version number. Insert the CD into your CD-ROM drive on your computer, and run the Setup.exe program, or alternatively, just double-click on the CD-ROM drive icon to open the Software Update window (Windows® only).

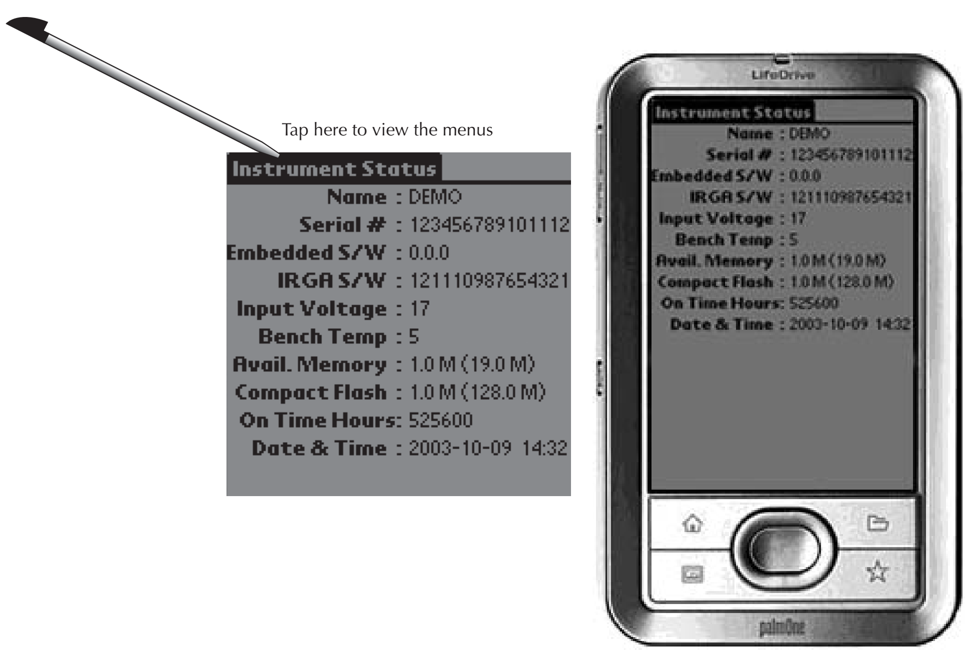
Click the **Add Palm Application to HotSync List** button. When you perform the next hotsync operation, the LI-8100 Interface Software for Palm OS will be automatically updated on your PDA.

Using the LI-8100 Interface Software for Palm OS

Locate the LI-8100 program icon. It may initially be located in an Unfiled category, until you move it into a different location (i.e., All, or Main). Tap the LI-8100 program icon to start the program. Tap the **Connect by Serial** or **Connect by TCPIP** button, depending on whether you are connected to the LI-8100 via a serial cable or via a wireless network, respectively.

In the Palm Interface Software, fields surrounded by a dashed line are editable fields that can be modified by tapping inside the field.

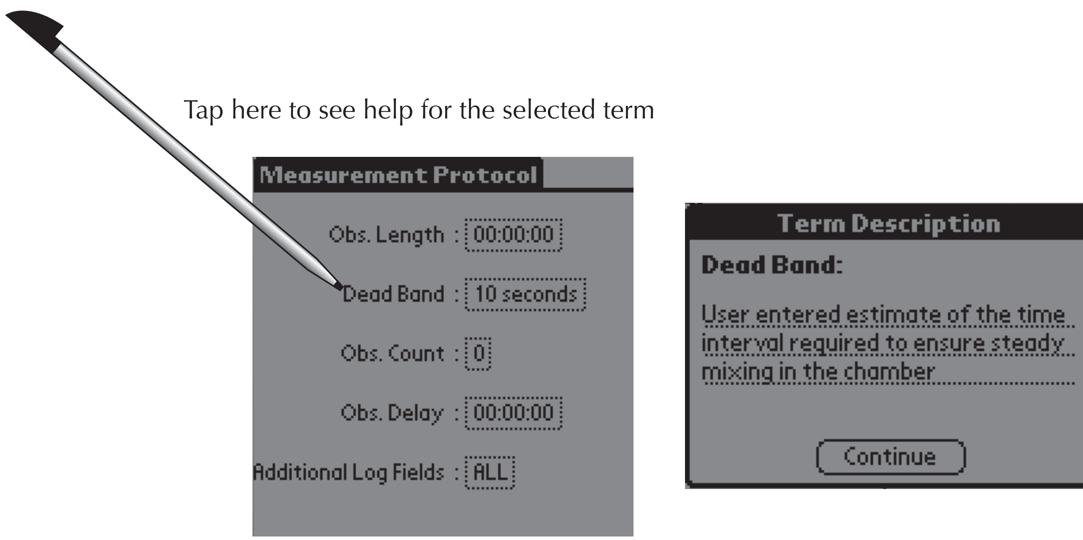
There are 5 menus on the LI-8100 menu bar; Setup, View, Utils, 8100, and Help?. Tap the menu bar at the top of the page to view the menus. Note that you can set the default page that appears when the program is started (see *Set Start Page* in the Utils menu, below). In the example below, the Start Page is set to display the Instrument Status page.



Accessing On-line Help

There are two ways to obtain on-line help in the Palm OS application. Tap the Help menu and choose **Indicators** to see a list of the indicators that may appear on the PDA screen when using the LI-8100 application. For example, if the @ indicator is visible on-screen, it indicates that an active measurement is in progress. You can also tap on the indicator itself to bring up a description.

Descriptions of most terms used in the LI-8100 application can be viewed by tapping on the text of the term for which you want to view help. For example, tapping the Dead Band term in the Measurement Protocol screen brings up the following term description:

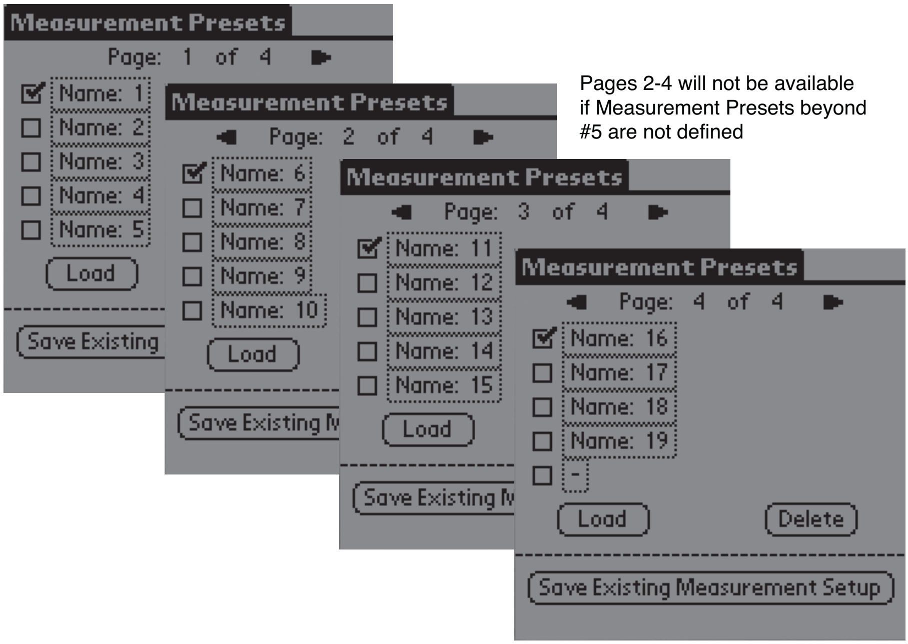


The Setup Menu

Measurement Presets

Opens the Measurement Presets page, where you can define up to 19 different configurations containing measurement setup parameters. These parameters can be saved and recalled for later use, without the need to redefine experimental parameters before each experiment. For example, individual parameters for different types of soil chambers can be defined (e.g. 10 cm and 20 cm survey chambers), and saved as unique measurement presets; switching between chambers can then be easily done by simply loading the appropriate preset and starting the measurement.

Each preset contains the experimental parameters defined on the Measurement Protocol page, as well as the Area, Volumes and Flow Rate, Start Measurement, and Instrument Settings pages.



By default, the presets are unnamed until they are saved with a new name. When the experimental parameters have been defined, tap **Save Existing Measurement Setup** to name the preset; the name will apear next to the box that is enabled (checked). Select a different preset by enabling the checkbox next to the preset name, and tap **Load** to activate that preset's predefined parameters. Tap **Delete** to remove the active preset.

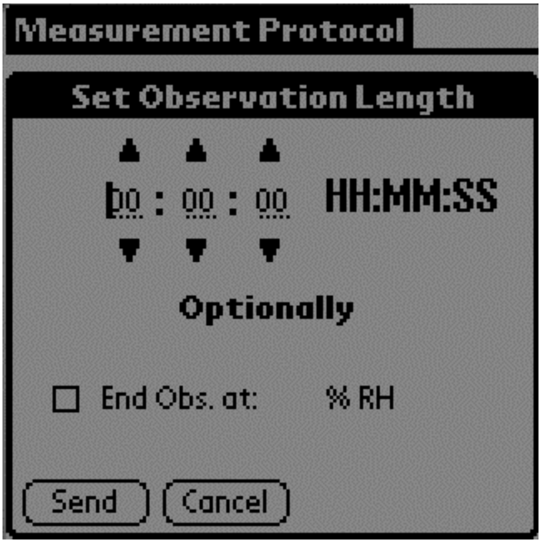
Measurement Preset pages are added as more Presets are defined (4 in the example above); tap the arrow keys to scroll between the Preset pages.

Measurement Protocol

Opens the Measurement Protocol page, where you can set the parameters for making a soil CO_2 flux measurement.

Observation Length

The **Observation Length** is the time period from the instant the chamber is closed until just before it begins to open again, and includes the specified **Dead Band** period. At low to moderate CO_2 fluxes an **Observation Length** of 90 to 120 seconds is usually adequate.

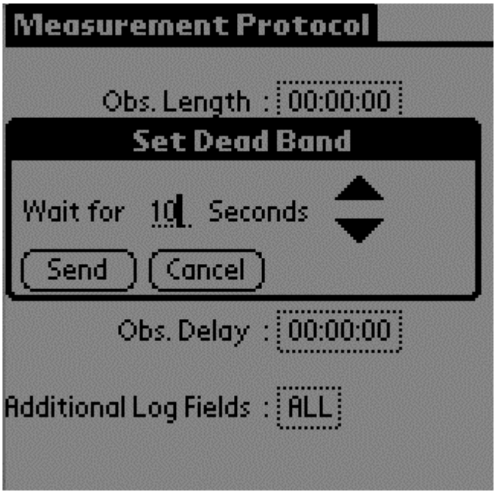


Note that the LI-8100 starts logging data when the chamber is actuated and starts to close. Raw, or Type 1 records are recorded throughout the entire observation period. The Elapsed Time (labeled *etime* on the data output) does not increment, however, until the chamber is closed. While the chamber is closing, *etime* is set to -1 for all records collected.

Enable the 'End Obs. at' check box and enter a relative humidity value, if desired. The observation will abort if the measured relative humidity in the chamber exceeds this value at any time during the measurement. If the observation is aborted, a message is placed in the log file, and the measurement will continue at the next observation.

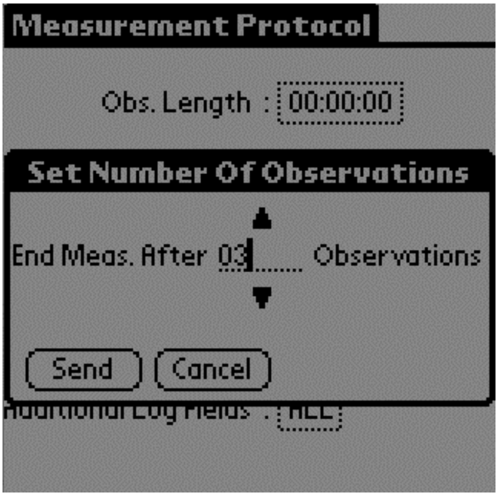
Dead Band

The **Dead Band** is the time period that starts when the chamber closes and continues until steady mixing is established and the measurement begins. The **Dead Band** requirement changes depending upon the chamber geometry, system flow rate, and collar and site characteristics. Testing at LI-COR has indicated that a **Dead Band** between 10 and 60 seconds generally provides for adequate mixing. There may be conditions, however, where a longer **Dead Band** is required. Note, too, that collected data can be recomputed using longer (or shorter) **Dead Bands** with the LI-8100 File Viewer program (if Raw records are collected).



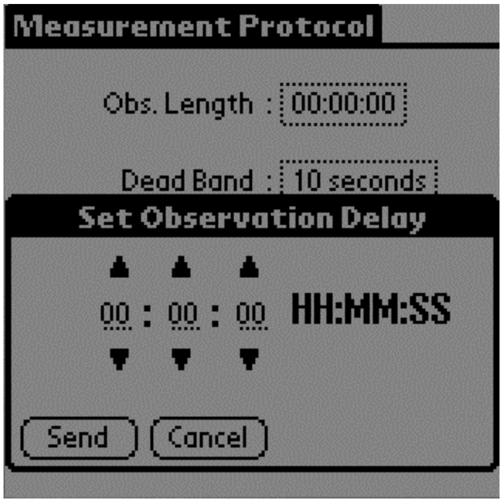
Observation Count

You can make repeated observations under the same set of parameters by setting the **Observation Count** to reflect the number of times to repeat the observation. Individual observations are separated by the **Observation Delay** (see below).



Note that in most cases, it may be more desirable from a scientific and/or statistical standpoint to replicate measurements on multiple soil collars rather than repeating them on the same collar.

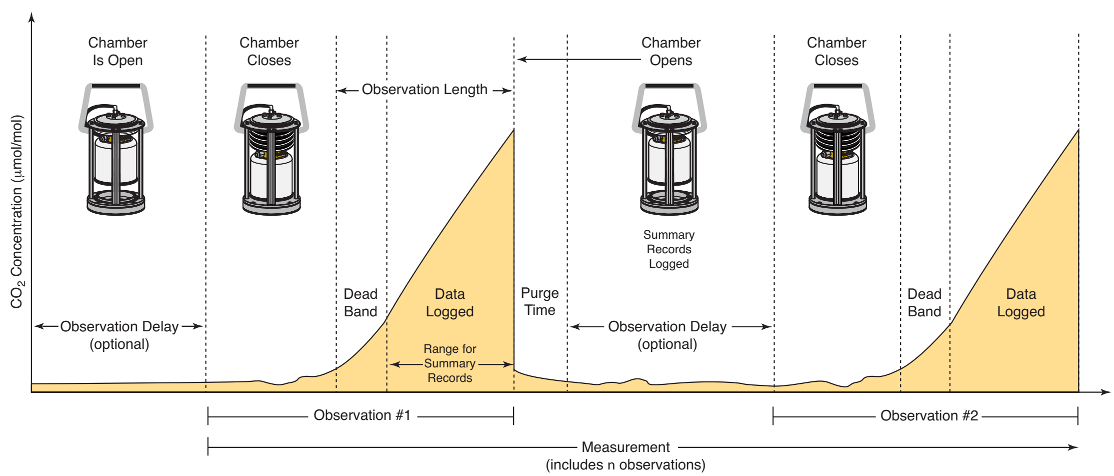
Observation Delay
When making repeated observations, a delay is required to allow the chamber air to return to ambient conditions before beginning the next observation cycle. This delay is referred to as the **Observation Delay**.



When an observation is complete, the chamber will automatically rise up off of the soil collar. If the **Observation Count** (above) is set to 2 or more, the **Observation Delay** sets the time during which the chamber is open. Under very still conditions it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions the chamber air may return to ambient in as little as 20 or 30 seconds. Note, too, that the **Observation Delay** begins as soon as the chamber starts to open - it may take as long as 90 seconds for the Long-Term chamber to completely move away from the soil collar. Therefore, it is possible to set a delay time that is too short for the chamber to fully open before it begins closing again.

Purge Time
The **Purge Time** is the amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete. This is important in certain cases where environmental factors may influence the amount of CO_2 or moisture, for example, that is present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the Purge Time to ensure that the gas sampling lines are purged of moisture that may condense in the lines, before the next measurement using that chamber is started. In most cases, a Purge Time of about 45 seconds is adequate.

IMPORTANT NOTE: The **Purge Time** function was added to the Windows Application Software V2.0 to accommodate the use of multiple chambers with the LI-8150 Multiplexer, where it is important to purge the gas sampling lines before making the next measurement with that chamber. Because the **Purge Time** starts after the measurement is complete, it has slightly different implications for use in single-chamber mode. As shown in the chart below, after the first measurement is complete, the **Purge Time** starts, followed by the **Observation Delay**; thus, the **Purge Time** and **Observation Delay** become *additive*. In most single-chamber applications, the combination of the two delays is excessive. Note, too, that before the *first* measurement starts, the chamber will not close until the **Observation Delay** has finished; again, in most cases this delay is unwanted, particularly when moving the chamber from collar to collar. For these reasons, you may want to use the **Purge Time** value instead of the **Observation Delay**; in other words, set the **Observation Delay** to zero, and set the **Purge Time** to 20-30 seconds, or more, depending on the conditions described above at "Observation Delay".

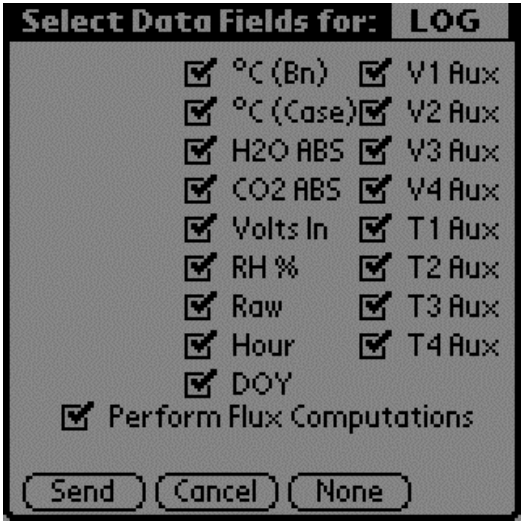


Additional Log Fields

Tap on Additional Log Fields to choose the values to be logged to memory. Data collected by the LI-8100 can be stored to the instrument's internal memory, or to an optional Compact Flash card.

Data stored to the internal memory can be transferred to a Compact Flash card or to the PC at any time.

Enable the Perform Flux Computations check box to automatically compute the flux rate after each measurement.



Tap **Send** to send the selected data fields to the LI-8100 for implementation.

Tap **Cancel** to close the page without sending the data fields.

Tap **None** to disable (uncheck) all data fields. None changes to **All** when the fields are disabled.

The additional data values that can be logged are as follows:

Label	***Description***
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
Hour	Time of day.
DOY	Day of the year.
V1 Aux	Input at voltage channel 1.
V2 Aux	Input at voltage channel 2.
V3 Aux	Input at voltage channel 3.
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

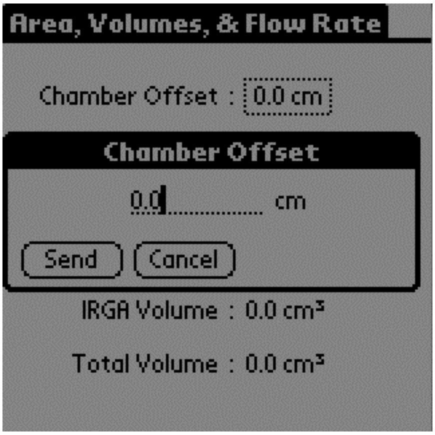
Area, Volumes, and Flow Rate

Opens the Area, Volumes, and Flow Rate page, where you can set the chamber offset and flow rate, and choose the default soil area and chamber volume values, which determine the total system volume of air.

The Total Volume value is computed and displayed after the Chamber Offset, Soil Area, and Chamber Volume values are entered. IRGA Volume is set at "Instrument Settings" and is displayed here.

Chamber Offset

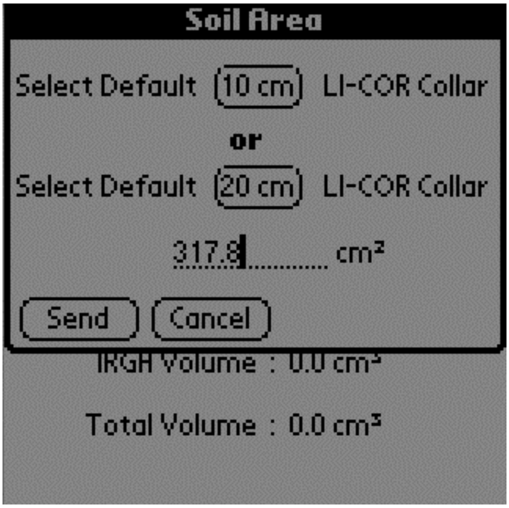
The **Chamber Offset** is the distance (in cm) between the soil surface and the top of the soil collar, and is dependent upon the depth that the collar is inserted into the ground (discussed in Section 2, *Initial Setup)*. The soil CO_2 flux measurement requires an accurate estimate of the Total System Volume. The LI-8100 software uses the **Chamber Offset** and the **Soil Area** values to calculate the volume of air inside of the soil collar. This value is, in turn, added to the **Chamber Volume** to obtain the **Total Volume**. Measuring the **Chamber Offset** is described in Section 2, *Using Soil Collars*.



If you measured the Chamber Offset in inches, remember to multiply by 2.54 to convert the value to cm.

Soil Area

The **Soil Area** is the surface area of soil encompassed by the soil collar. Tap on the 10 cm button if you are using the Survey Chamber with a 10 cm soil collar from LI-COR, or tap on the 20 cm button if you are using the 20 cm Survey Chamber or Long-Term Chamber with a 20 cm soil collar from LI-COR; the soil area is calculated automatically and is shown in the window.

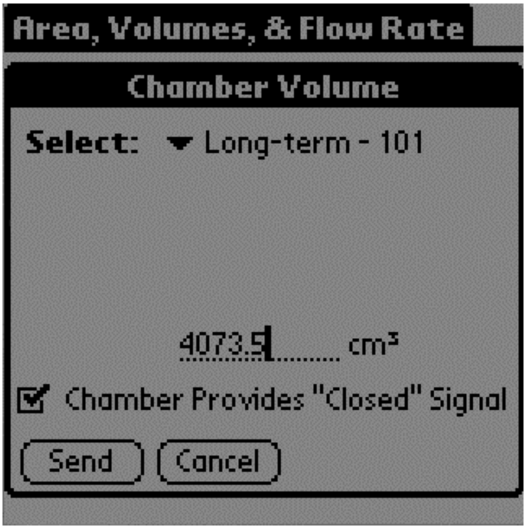


Alternatively, if you are using a collar of your own making, you can enter the soil area (in cm^2) manually.

Chamber Volume

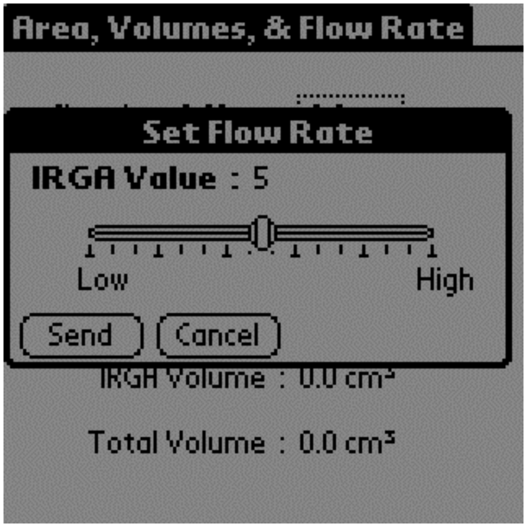
The **Chamber Volume** is the volume of air within the soil chamber. Tap on the arrow next to Select and choose the chamber connected to the instrument. Choose 10 cm Survey if you are using the 10 cm Survey Chamber, 20 cm Survey if you are using the 20 cm Survey Chamber, Long-term 101 for the 8100-101 Long-Term Chamber, or Long-term 104 for the 8100-104 Long-Term chamber; the chamber volume (cm^3) is calculated automatically and is shown in the window. If you choose Custom Chamber, you will be required to manually enter the chamber volume. Choose Instrument Setting to view the volume currently active in the intrument.

Note that all LI-COR soil chambers provide an electronic signal when the chamber is closed; if you have constructed a custom chamber for use with the LI-8100 that does not provide an electronic "closed" signal, make sure that the 'Chamber Provides "Closed" Signal' is not selected. This is important, for example, when calibrating the instrument;



Flow Rate

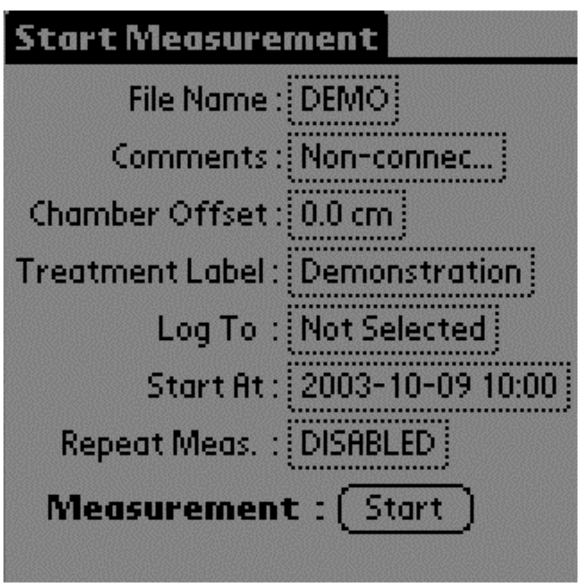
Drag the slider bar to set the flow rate. The Low flow rate is equivalent to approximately 0.6 liters/minute, and the High flow rate is equivalent to approximately 1.7 liters/minute.



In most cases it is recommended that you use the highest flow rate when making measurements, to ensure adequate mixing of the air within the chamber.

Start Measurement

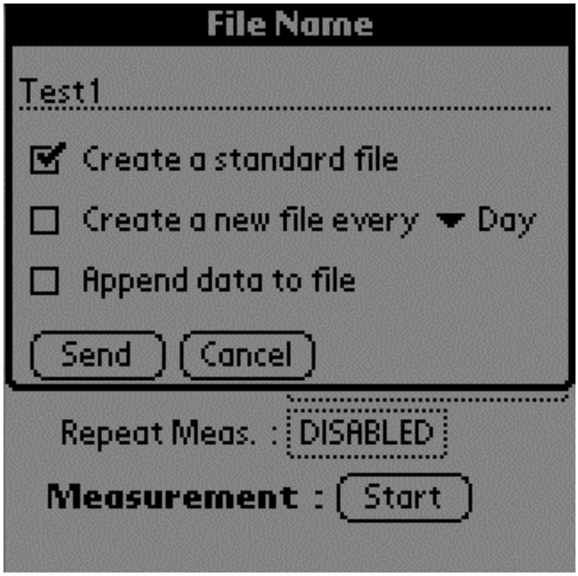
Opens the Start Measurement page, where you can enter the **File Name**, optional **Comments**, and **Treatment Label**, as well as the **Chamber Offset** value, the location at which the data are stored, Start Time, and number of times to repeat the measurement.



The File Name and Treatment Labels can be up to 30 characters in length. The Comments can be up to 100 characters in length. In the File Name page, enable the 'Append Data To File' check box to add new data at the end of an existing file.

Comments are included in the data file header; the Treatment Label appears as a separate column in the data.

Enter a File Name, Treatment Label and optional Comments. Enter the Chamber Offset (cm). The Chamber Offset is the distance that the soil collar protrudes above the soil. Enter the Start Time; you can choose to start the measurement immediately ('now'), or at a defined date and time.

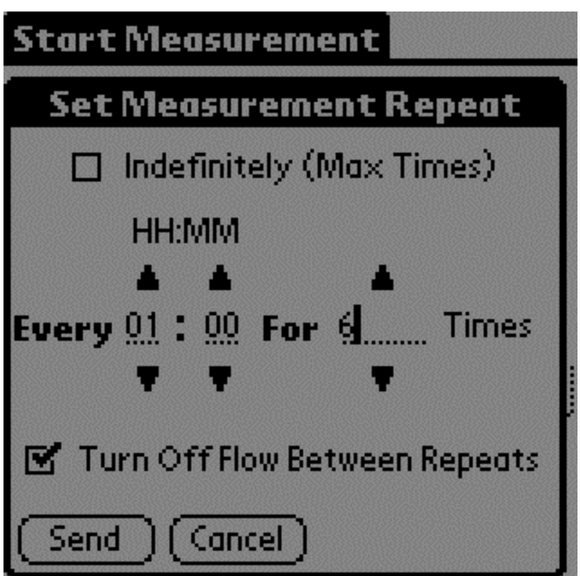


Enable the 'Create a standard file' to log data to a single file that is not split and/or appended.

You can create a new file every Day or Week; note that you must first enable the Repeat Measurement field (below) to use this function.

Enable the 'Append Data To File' check box to add new data at the end of an existing file.

The **Repeat Measurement** page allows you to repeat the defined protocol at a regular clock interval. These functions are particularly useful when making long term, unattended measurements.



For example, you could specify a 90 second Obs. Length, 45 second Deadband, Obs. Delay of 2 minutes, and Obs. Count of 3. This protocol could then be repeated every hour for 240 hours (10 days). The resulting data set would include 240 measurements, with each measurement consisting of three 90-second observations on the chosen port. The maximum number of repeats is 12000 (**Set To Max** button).

You can elect to turn off the flow pump between repeated measurements to conserve battery life and extend the life of the pump by enabling the check box.

Tap **Start** to begin the measurement.

The View Menu

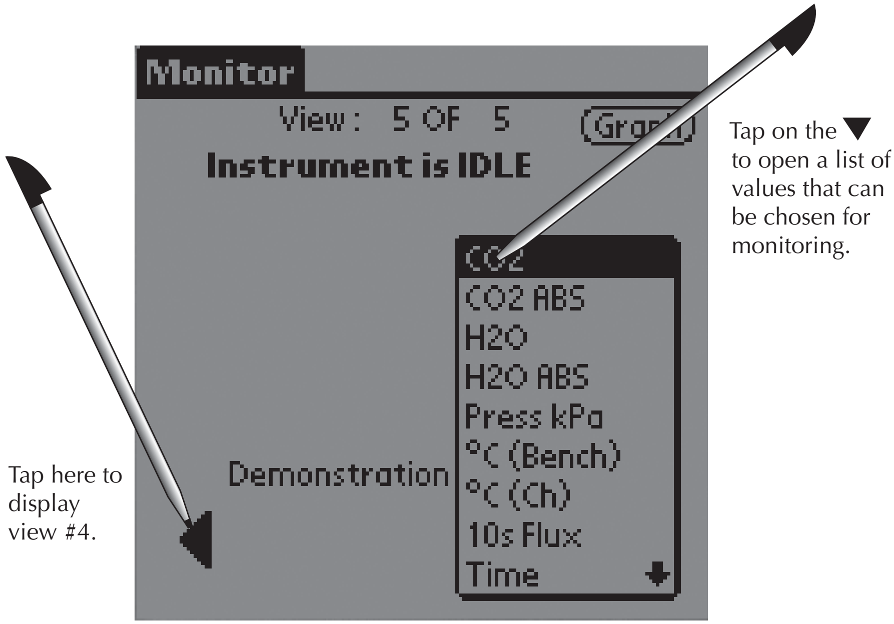
Instrument Status

Opens the Instrument Status page, where you can view the current operating state of the LI-8100.

The Instrument Status page displays the user-entered instrument name and serial number, the instrument software versions, input (battery) voltage, IRGA bench temperature, available memory in the instrument and optional compact flash card, the log file destination (internal memory or compact flash card), the number of accumulated hours of instrument operation, and the current date and time.

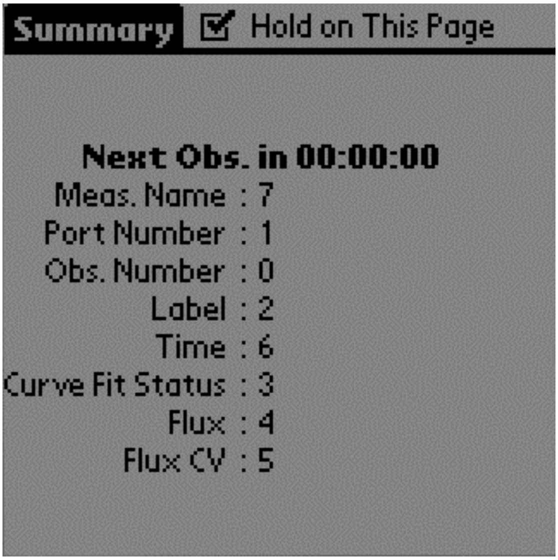
Monitor Page

Opens a page where you can view real-time values of selected instrument outputs. You can define as many as five "views" that contain up to five values each; tap on the right or left arrow to scroll the views. Tap on **Graph** to display a chart showing the top value on the page (CO_2 in the example below) against time.



Summary Page

Opens a page where you can view the summary records for the most recent measurement. Note that in normal operation the Summary Page will toggle to the Monitor page when a new measurement is started; enable the 'Hold on This Page' box to retain the Summary Page on the display when a new measurement starts.

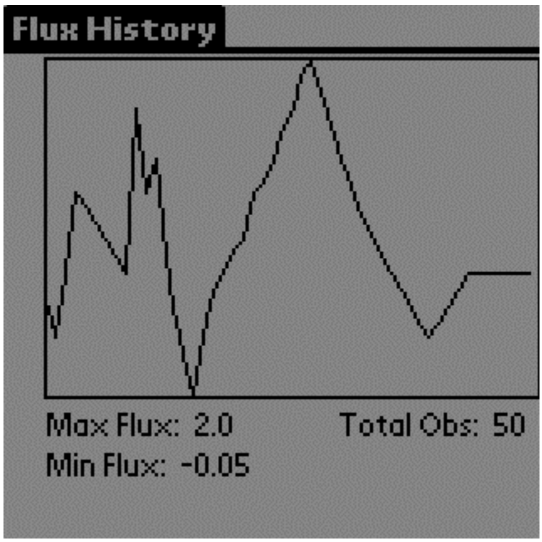


A timer that displays the time remaining until the next defined measurement is also shown on the Summary Page. The Summary Values that can be monitored on this page are as follows:

Label	***Description***
Meas. Name	Measurement name.
Obs. #	Current observation number.
Label	Treatment label for current observation.
Time	Time in HH:MM:SS.
Curve Fit Status	?
Flux	Ten second running estimate of soil CO_2 flux rate.
Flux CV	CV of flux (Exponential fit).

Flux History

Displays a running chart of the last 50 observed flux values by gas port. Choose the Port from the pull-down menu at the top of the page to view flux values from a different port.

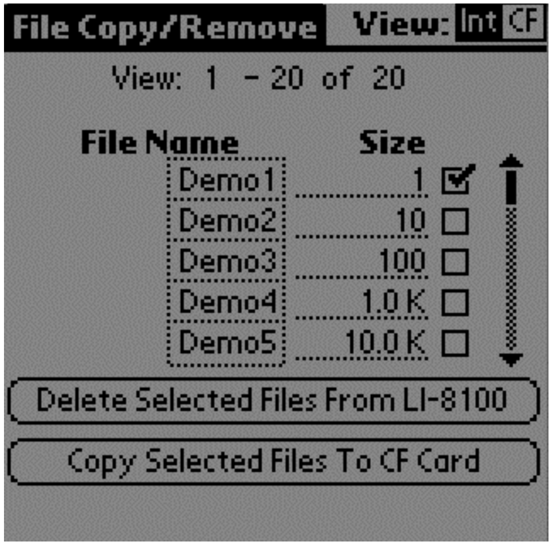


The Utilities Menu

File Manager

Opens the File Manager page, where you can perform file and/or storage operations on existing data files. The first File Manager page displays the amount of available memory on the LI-8100 and on the optional compact flash card.

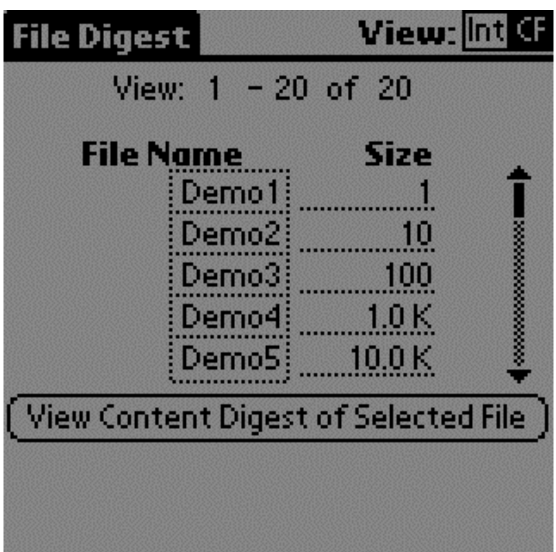
Tap **File Copy/Removal** to delete selected files from the LI-8100 internal memory, or to format the compact flash card.



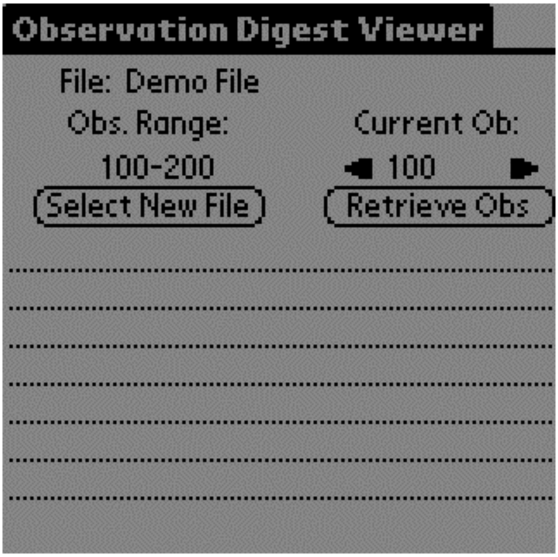
Tap Int or CF to view files on the LI-8100 internal memory, or compact flash card, respectively.

Files stored in internal memory can be selected for deletion, or for copying to the compact flash card.

Tap **File Digest Viewing** to display a notepad containing data from the observations within the chosen file.

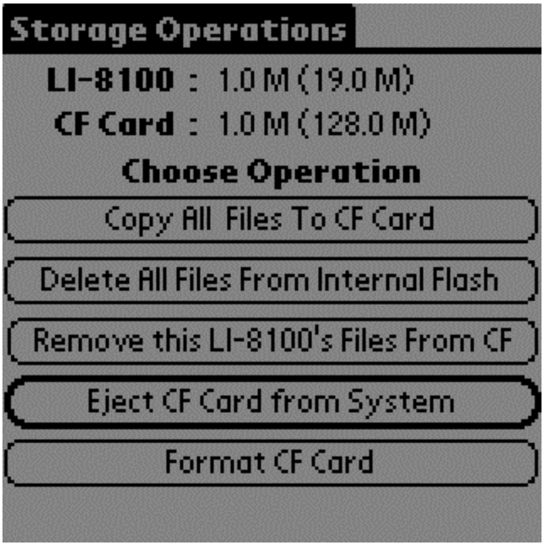


Tap on **View Content Digest of Selected File** to open the selected file. The Observation Digest Viewer appears.



The range of Observations is shown; tap the right or left arrow to scroll through observations within this range. *Note that if data scrolls off the bottom of the window, you must use the Palm navigation button to scroll the window.*

Tap **Storage Operations** to delete all files from the LI-8100 internal memory or compact flash card, or to move all files to the compact flash card.



Copy All Files to CF Card: Copies all files from the LI-8100 internal memory to the optional compact flash card.

Delete All Files From Internal Flash: Removes all files from the LI-8100 internal memory.

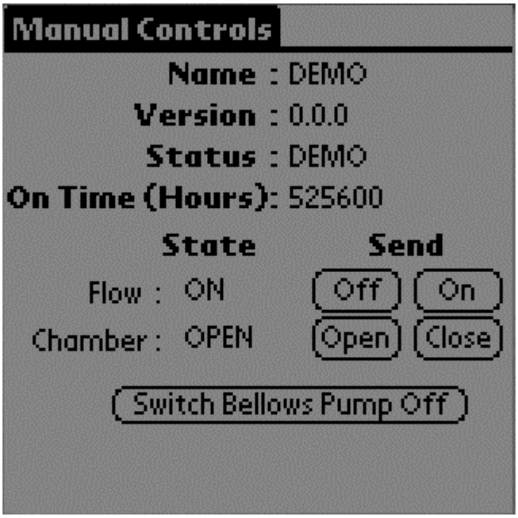
Remove this LI-8100's Files From CF: When files are copied to the compact flash card, the LI-8100 creates a directory on the card with the instrument name. This operation removes that directory and its contents from the card.

Eject CF Card from System: Unmounts the compact flash card safely; you should always eject the card before removing it from the PC card slot to ensure the integrity of the data.

Format CF Card: Deletes ***all files*** from the compact flash card.

Manual Controls

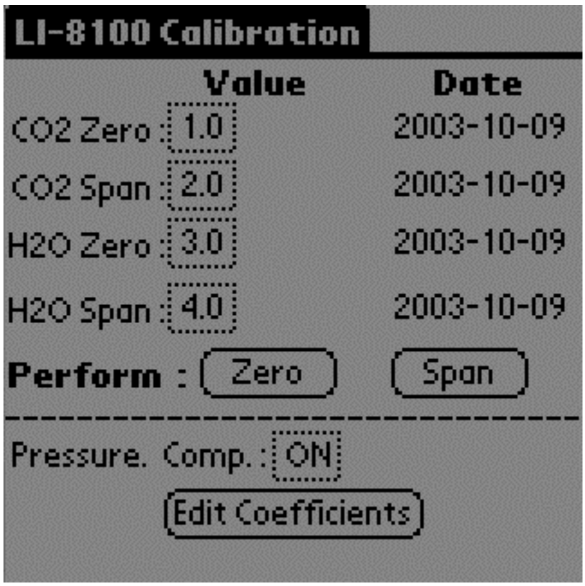
Opens the Manual Controls page, where you can use manual chamber controls to open or close the survey or long-term chambers, turn the flow to the chamber on or off, or turn the survey chamber bellows pump off. Controlling the chamber flow manually is useful when performing user calibration of the infrared gas analyzer, as described in Section 5.



The **On Time (Hours)** shows the total accumulated time the instrument has been powered on since leaving the factory.

Calibration

Opens the Calibration page, where you set the zero and span of the infrared gas analyzer in LI-8100 Analyzer Control Unit. Step-by-step instructions for performing user calibrations are given in Section 5.

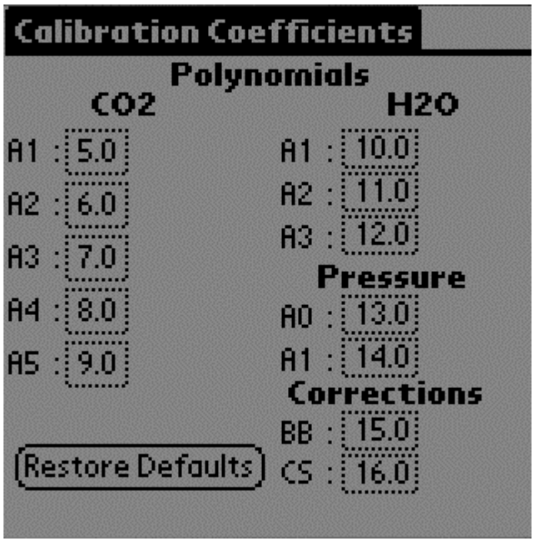


The calibration constants displayed here are updated each time you perform a zero or span. In most cases there is no need to edit these values manually. If you do edit the values, the dates will not change. The dates reflect the last time the instrument was zeroed and/or spanned.

The calibration constants for CO_2 and H_2O zero and span calibrations are found on the Calibration page. If new constants are entered in this page, tap **Send** to send the values to the LI-8100 for implementation (note that the dates will not change).

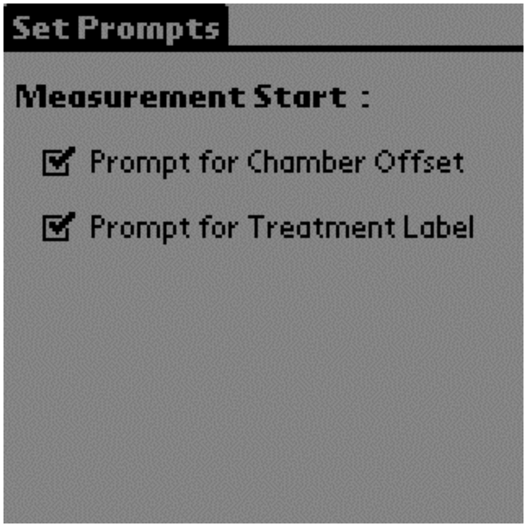
The calibration functions for both CO_2 and H_2O correct for pressure fluctuations that may be present. To disable this correction, tap the 'Pressure Comp.' field and then tap **Off**.

The LI-8100 uses a fifth order polynomial for the CO_2 calibration, and a third order polynomial for H_2O calibration. Tap the 'Edit Coefficients' field to view the Coefficients page. This page displays these factory-determined calibration coefficients, as well as those for band broadening (BB) and cross sensitivity (CS). These coefficients are fixed at the factory, and are present on the calibration sheet included with the instrument.



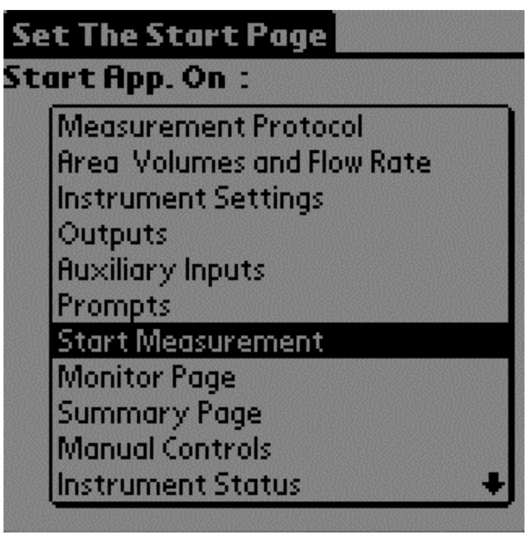
Prompts

Opens the Set Prompts page, where you can enable or disable the prompts that may appear on the screen when you perform various operations. When starting a new measurement, prompts appear if collar height and/or treatment labels are not entered. A prompt will also appear when deleting files with the File Manager. Disable any of the check boxes if you do not want to view these prompts.



Set Start Page

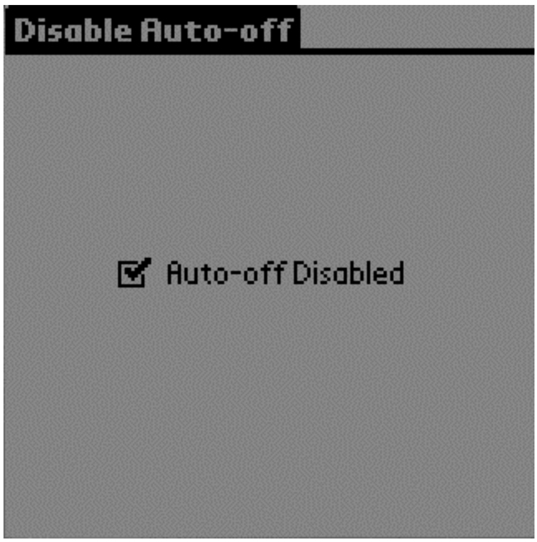
Allows you to choose the application page that is displayed when the LI-8100 Application for Palm OS is started.



Choose the start page from the pull-down menu, and tap the menu bar to exit. The selected page will be displayed the next time the LI-8100 application is started.

Disable Auto-Off

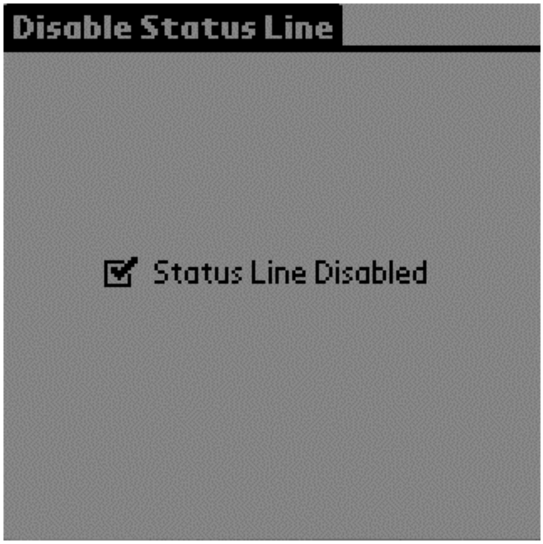
Many PDAs have an energy-saving feature that turns the handheld off after a certain period of inactivity. This can be an inconvenience when using the PDA with the LI-8100. Use this page to disable the auto-off feature while the LI-8100 application is running.



When Auto-off is disabled, a ø symbol appears in the lower righthand corner of the screen.

Disable Status Line

When a measurement is being made, a status line appears at the bottom of the page that indicates the activity that is occurring on the PDA (e.g., "querying config"). Use this page to disable the status line, if desired.



The 8100 Menu

Instrument Settings

Opens the Instrument Settings page, where you can view and/or edit the current operating state of the LI-8100.

Name: The instrument name to which the PDA is connected. The instrument name is limited to 30 characters. Files copied to a Compact Flash card are put into a directory with this name.

Date: Current date, in YYYYMMDD.

Time: Current time, in HHMM.

Network Parameters: The IP address of the wireless card in the LI-8100.

Automatic Restart: When enabled, allows the measurement to restart following a power interruption to the instrument. This is not the default option, as it requires that a hardware jumper be installed; contact LI-COR for more information.

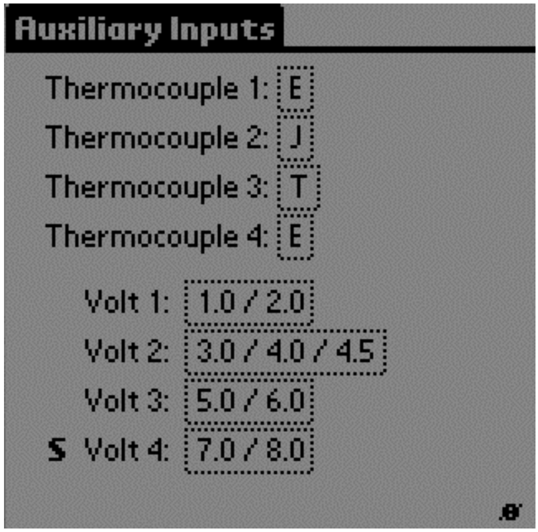
Chamber Error: Determines how an error condition affects the measurement; you can choose to log the chamber error and continue the measurement, or log the error and stop the measurement. Tap **Send** to enable this function.

IRGA Averaging: The amount of averaging of the CO_2 and H_2O signals from the IRGA. The IRGA in the LI-8100 is sampled at 2 Hz. With 4 second signal averaging (the default), 8 data points are averaged for each CO_2 or H_2O value. As more data are received, previous data are dropped from the average. The minimum value is 1 second, and the maximum value is 20 seconds.

IRGA Volume: Volume of air (cm^3) in the optical bench and associated tubing inside the Analyzer Control Unit case. In most cases this number should not be changed.

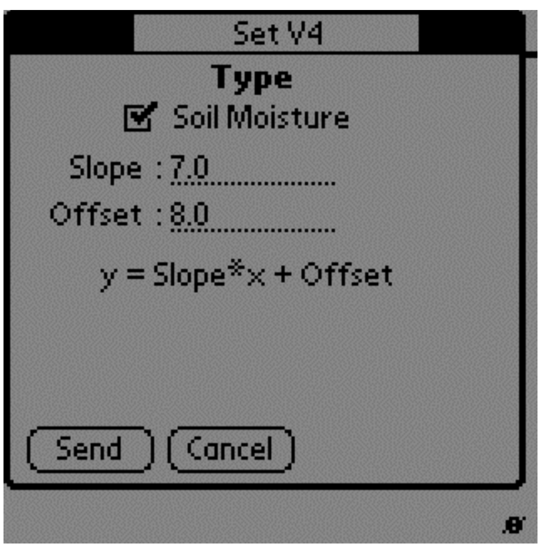
Auxiliary Inputs

The Auxiliary Inputs page is the area in which you can input the coefficients for linear external devices connected to the Auxiliary Sensor Interface. There are 4 thermocouple channels (Type E, J, T, or Raw), and 4 general voltage input channels (0-5VDC); any of the four voltage channels can be used for the Decagon ECH_2O or Delta-T Theta soil moisture probes. When configured for a soil moisture probe, the probe is powered for 10 seconds to allow it to stabilize, and is then sampled.

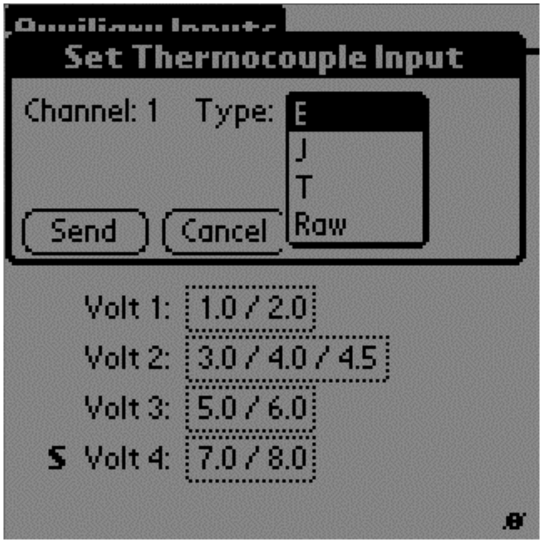


The 'S' indicates that Voltage Channel 4 is currently configured for a soil moisture sensor. Voltage channel 2 is displaying 3 calibration coefficients; this is typical of thermistors (LI-8150 only).

Enter the slope and offset values (obtained from the manufacturer) for each device attached to the voltage inputs. If you are attaching a soil moisture probe, enable the 'Soil Moisture' box.

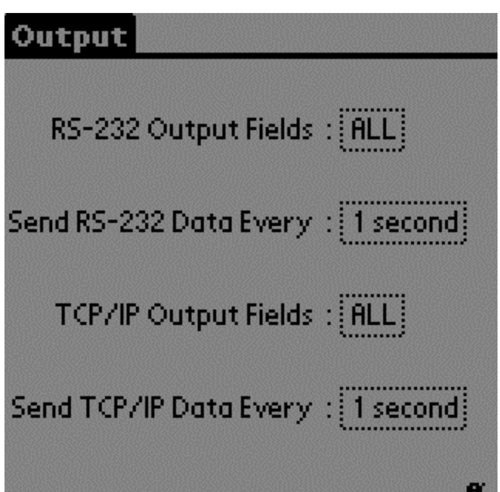


Choose the thermocouple type for the appropriate thermocouple channel, and tap **Send**.

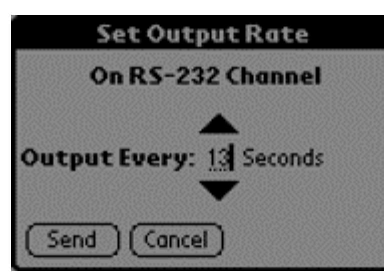


Outputs

Opens the Outputs page, where you can configure the raw data values that are sent by the instrument via the RS-232 port, or via the wireless card, if you are using the LI-8100 in a wireless network. This is primarily used when capturing raw data values with an external data logging device. Note that these values are simply sent as a data stream; data are not parsed, nor is header information included. You can also choose the output frequency for both RS-232 and/or TCP/IP data.

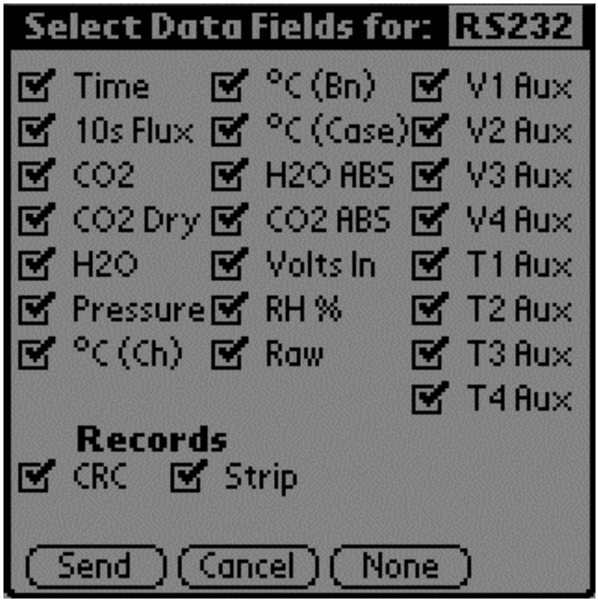


Data can be output via RS-232 or TCP/IP at intervals between 1 and 20 seconds.



RS-232

Choose the data values to be sent to the RS-232 port.



The data values that can be output are as follows:

Label	***Description***
Time	Instrument time.
10s Flux	Ten second running estimate of soil CO_2 flux rate.
CO2	Chamber CO_2 concentration in µmol/mol.
CO2 Dry	Chamber CO_2 concentration, corrected for water vapor dilution, in µmol/mol.
H2O	Chamber water vapor concentration, in mmol/mol.
Pressure	Atmospheric pressure in the optical bench (kPa).
°C (Ch)	Air temperature inside the soil chamber.
°C (Bn)	Temperature of the optical bench.
°C (Case)	Air temperature inside the Analyzer Control Unit case.
H2O ABS	Absorption of photons in the optical bench due to the presence of water vapor.
CO2 ABS	Absorption of photons in the optical bench due to the presence of CO_2.
Volts In	Input (battery) voltage.
RH%	Relative humidity inside the soil chamber.
Raw	CO_2 raw signal.
V1 Aux	Input at voltage channel 1.
V2 Aux	Input at voltage channel 2.

V3 Aux	Input at voltage channel 3.
V4 Aux	Input at voltage channel 4 (soil moisture).
T1 Aux	Input at thermocouple channel 1, in degrees C.
T2 Aux	Input at thermocouple channel 2, in degrees C.
T3 Aux	Input at thermocouple channel 3, in degrees C.
T4 Aux	Input at thermocouple channel 4, in degrees C.

Note that when the LI-8100 outputs data, each field is "marked up" using e**X**tensible **M**arkup **L**anguage (XML) to delimit that field. For example, when a CO_2 value is output, the data value is placed between two "tags" that describe what that value is, as in:

<CO2>350.21</CO2>

Enable the 'Strip' check box to remove the markup from the data stream. The resulting data set is a data stream where each data field is separated by a space.

CRC (Cyclic Redundancy Check) is an algorithm that is used to verify the integrity of the data. Before each data packet is sent by the LI-8100, a CRC is calculated (pre-transmission) for that packet, and then appended to the packet. When the client (e.g. the computer) receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match, it is assumed that the packet was transmitted correctly. When CRC values are appended to the data packet, the value is automatically marked up. A typical CRC will appear as

<CRC>3067450353</CRC>

Disable the 'CRC' check box to remove CRC from the data. Note that the LI-8100 Palm OS application itself does *not* use CRC checking.

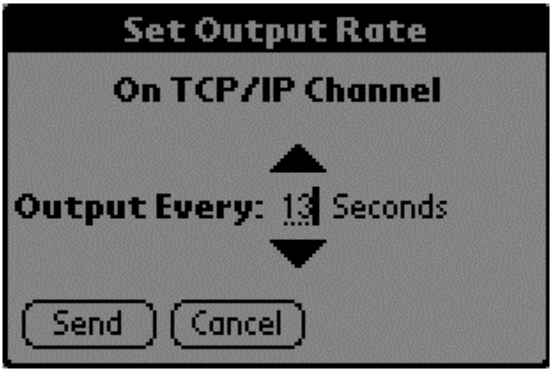
TCP/IP

Tap on the TCP/IP field to configure the data values to be sent via the wireless card, if desired. Note that you can configure the TCP/IP (wireless) and/or RS-232 options while the other is enabled; changes will not take effect until data logging is stopped and restarted, however. For example, if you are currently logging data to the PC, you can configure the wireless output, but you must first stop logging data to the PC before beginning wireless output with the new configuration.

The data values that can be output are as shown above at RS-232 Output.

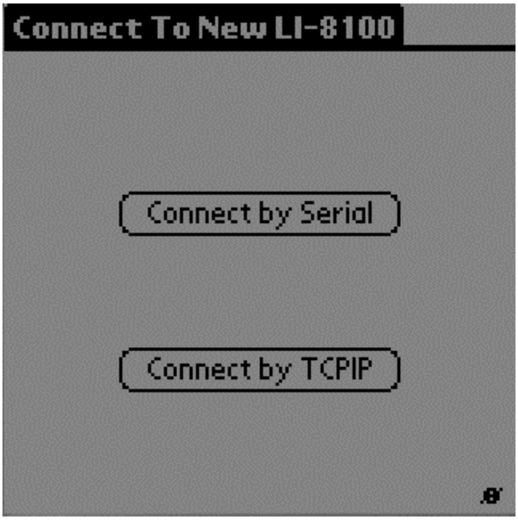
Log Every

Sets the frequency at which to log data (seconds).



Change Instruments

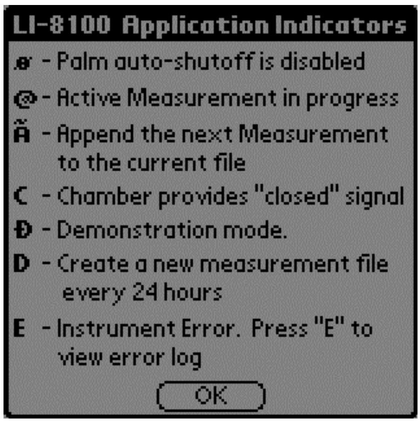
The Connect to New LI-8100 page allows you to connect to a different LI-8100 without requiring you to close the program. Tap 'Connect by Serial' if you are connecting to the new instrument via the serial cable, or 'Connect by TCPIP' if you are connecting via the wireless card. You are then prompted to enter the IP address of the instrument to which you want to connect.

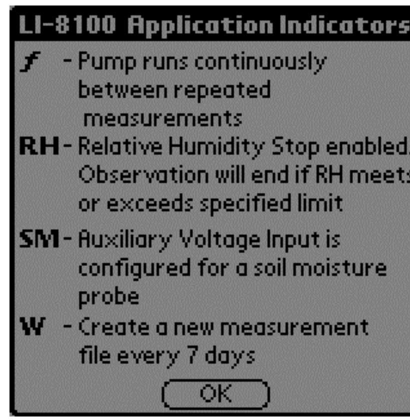


The Help Menu

Indicators 1 and 2

Opens the Indicators page(s), where you can view the definitions of indicators that can appear on the screen.





About LI-8100

Displays a screen that shows the LI-8100 Application Software for Palm OS version number and contact information for LI-COR.

13 Updating the Instrument Software

About the Instrument Software

The LI-8100 internal instrument software is programmed into the instrument's flash memory; it can be updated using the FluxUpdate program available from LI-COR's web site at http://www.licor.com. LI-COR may periodically provide updates to the instrument software; follow the instructions below to install the instrument (embedded) software.

Installing the Instrument Software

Note that the following operation may require 20-30 minutes to complete. Make sure that if you are using battery power that you have sufficient charge to operate the LI-8100 for 30 minutes or more. Follow these steps to update the instrument software:

1. Turn the LI-8100 OFF. Make sure the computer and the LI-8100 are connected via the serial cables included, as described in Section 2, *Initial Setup*.

fluxupdate.exe

2. Locate the *fluxupdate.exe* program, and double-click on the icon to start the program. Alternatively, select **Run** from the Windows Start menu, and locate the *fluxupdate.exe* program.

3. Choose the serial port on your computer to which the LI-8100 is connected using the arrow keys in the Update Window at Step 2.

4. Click on the **Connect** button.

5. Turn the LI-8100 ON.

6. The update will begin. A series of messages will appear in the window, as shown in Figure 12-1 below.

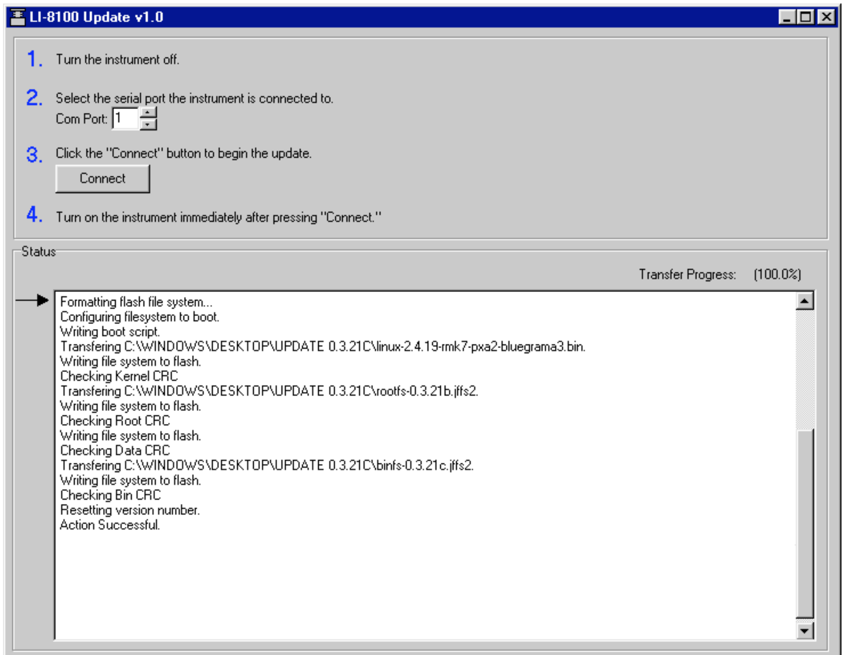


Figure 12-1. Progress messages appear in the Update window.

7. Wait for the message "Action Successful" to appear.

8. Close the LI-8100 Update window.

9. Turn the LI-8100 OFF, and then back ON.

10. Wait 5 minutes or so, until the green Ready light on the LI-8100 keypad turns on. The LI-8100 instrument software is now ready to use.

14 Maintenance

Cleaning the Optical Bench

There is a Balston air filter in-line on the flow path leading to the IRGA optical bench. It is very important that incoming air be filtered. This is because any dirt in the optical cell will cause an immediate zero shift.

The 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. If significant dirt accumulates in the optical bench, linearity errors that exceed the stated specifications can also result. If you determine that the LI-8100 IRGA's linearity error for CO_2 and H_2O is excessive, you can make adjustments to the coefficients using the **CalAdjust.exe** utility program on the LI-8100 CD. This procedure requires two span gases for CO_2, or an LI-610 Portable Dew Point Generator to generate two known dew points for H_2O. See *Linearity Adjustment* in Section 5.

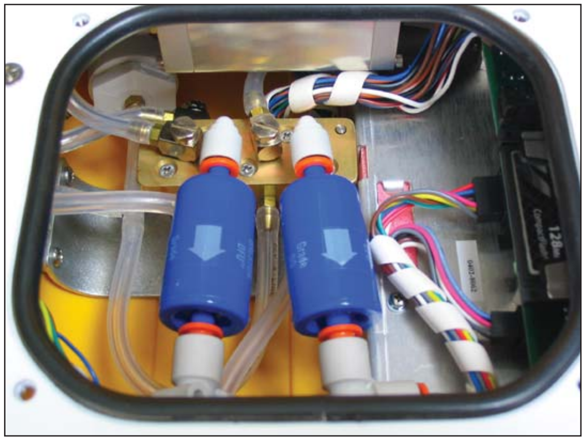
Follow these steps to clean the optical bench:

> **NOTE:** Make sure that you are properly grounded to avoid any electro-static discharge events that can damage the internal components.

1. Power the instrument off and remove the battery or other external power source.

2. Open the Analyzer Control Unit case and remove the access panel by loosening the 4 thumbscrews.

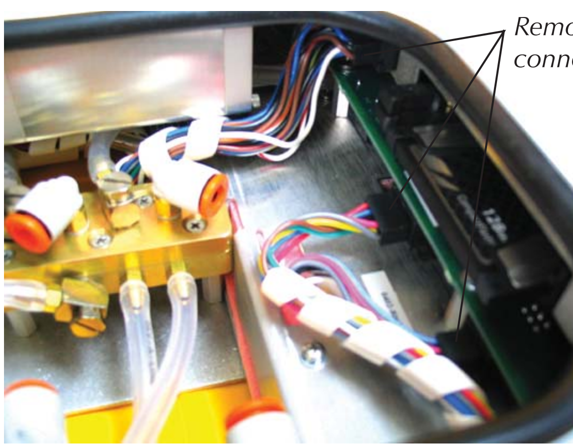
3. Mark one of the Balston air filters with a marker or piece of tape to make sure that you are able to return them to their original locations when re-assembling. This is important, as one of the filters is in-line with the bellows air circuit to the Survey Chamber, and is bi-directional, meaning dirt can be introduced into the filter in both directions. If this filter is inserted into the optical bench air path during re-assembly, dirt can be inadvertently blown into the optical bench.



Note the orientation of the filters, and mark one of them (e.g. "L" or "R").

Remove both air filters by pressing the orange part of the quick-connect fittings toward the white part of the connector and pulling the filter out.

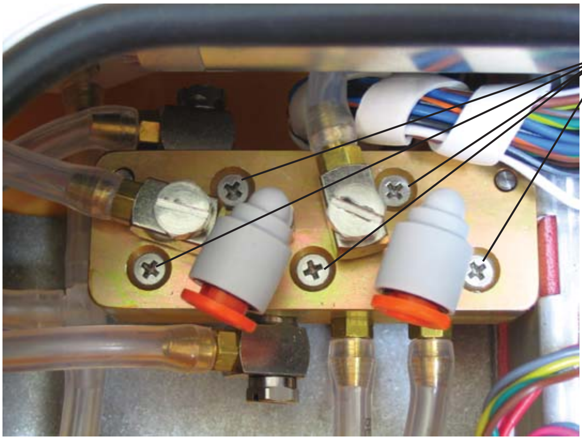
4. There are 3 electrical connectors that must be removed. Two of them are on a single wiring harness, just to the right of filters in the photo above; the third is about 2 inches further back from them, just beyond the edge of the access panel, as shown below.



Remove these 3 connectors

Pull straight out on the connectors to remove them. The large connector under the access panel can be difficult to reach; you can gently pull on the wire harness and slowly rock the connector back and forth to remove it, if necessary. When reinserting the connector, make sure that you check the pin alignment before pushing the connector into place, as the upper right hand side pins can easily become bent if misaligned.

5. Remove the 5 screws from the top of the air manifold, as shown below.



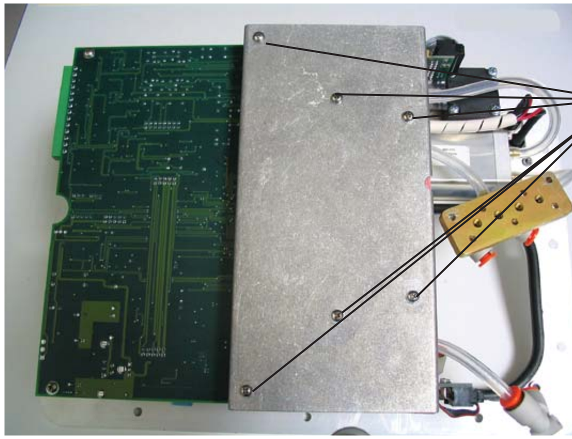
Remove the 5 screws from the top of the air manifold.

The top half of the manifold rests on two pins; lift the top half until it is completely separated from the bottom half. It is not necessary to remove any of the hoses.

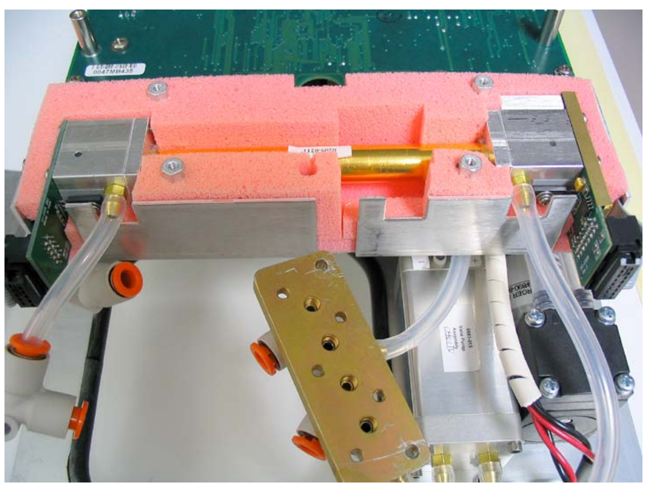
6. Remove the 12 screws around the outer edge of the white panel, as shown below.

Remove the 12 screws around the outer edge of the white panel.

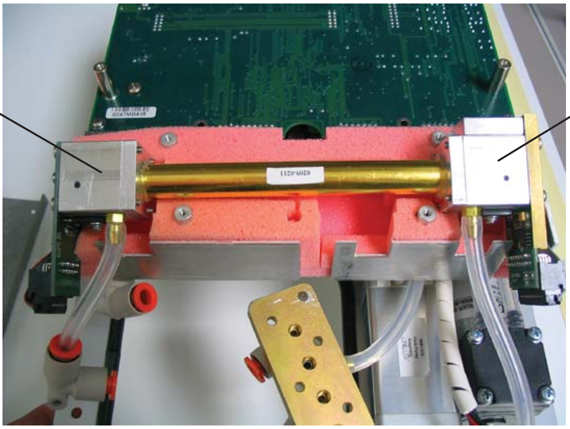
7. Lift the analyzer control unit from out of the yellow case. Turn the control unit upside down. It will appear as shown below.



8. Remove the 6 screws from the optical bench cover, as shown above. The optical bench will appear as shown below.

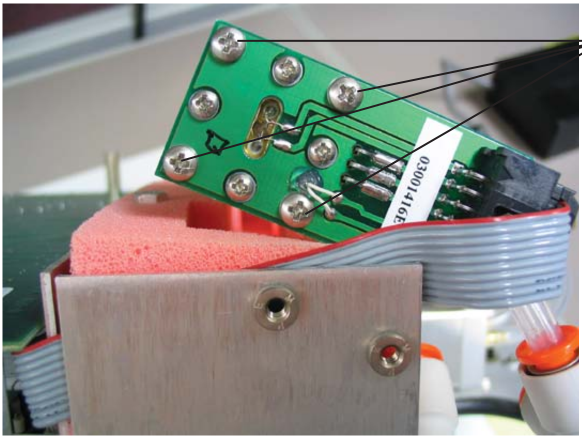


9. Leave the hoses connected to the optical bench, and lift the bench out of the foam casing.

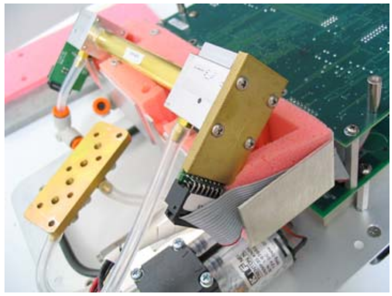


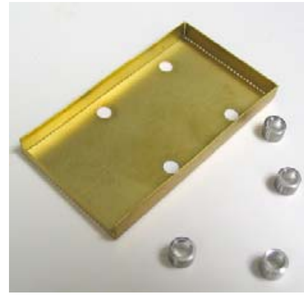
Lift the optical bench out of the foam casing.

10. There are four screws on the source and detector circuit boards that must be removed. Remove the four screws in the corners of the source housing circuit board, as shown below. Do not remove the remaining four screws.



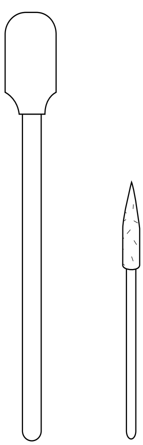
Remove the four screws from the detector housing cover, as shown below. Note that there are some small standoffs inserted over the screws behind the cover; tilt the housing down when removing the cover so these standoffs don't get lost.





11. The optical bench can now be removed. The bench will appear as shown below.

Note that there are o-rings on both ends of the optical bench. It is a good practice to replace the O-rings when cleaning or replacing the optical path.



Optical Path Swab   Reflector Swab

12. 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.***

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

14. 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.*

15. 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.

16. Re-assemble the LI-8100 case. Make sure that the foam insulation on the inside top cover is positioned over the optical bench; it is required for thermal stability.

17. Perform zero and span calibrations as described in Section 5, User *Calibration*.

Replacing the Air Filters

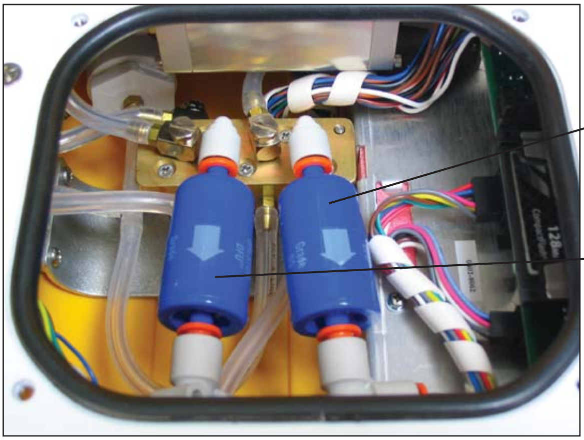
There are two Balston air filters located inside the Analyzer Control Unit. One of the filters is on the flow path to the attached chamber, and the other is on the bellows air path, and is used only when the Survey Chamber is attached. The bellows air path draws air from outside of the Analyzer Control Unit through a port on the front panel. This port also has a built-in filter, so the Balston air filter on this line should not need to be changed with any regularity, if at all.

The air filter on the flow path will need to be replaced after about every 3 months of continuous use, depending upon the conditions under which the instrument is used. You can look at the clear Bev-a-line tubing to get a visual indication of how much dirt is present in the line, or alternatively, if the instrument zero and span settings are fluctuating widely (see Section 5, *User Calibration*), it may be time to change the filter. Follow these steps to replace the Balston air filters (there are 2 in the spares kit under p/n 300-01961):

1. Power the instrument off and disconnect the battery or other external power source.

2. Open the Analyzer Control Unit case and remove the access panel by loosening the 4 thumbscrews.

3. Never swap one used filter for another! This is important, as the filter that is in-line with the bellows air circuit to the Survey Chamber is bi-directional, meaning dirt can be introduced into the filter in both directions. If this filter is inserted into the optical bench air path, dirt can be inadvertently blown into the optical bench.



Note the orientation of the filters.

This filter protects the bellows flow path...

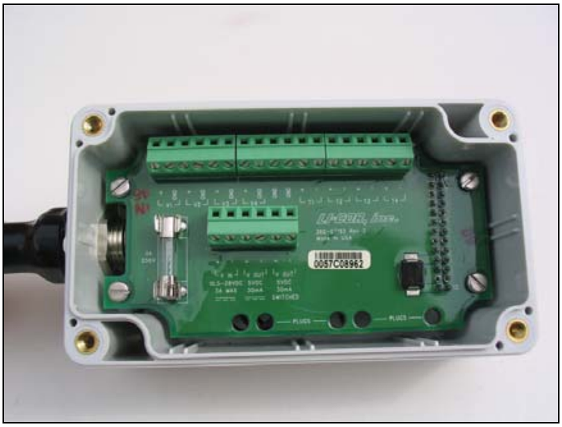
and this filter protects the analyzer flow path.

Remove the air filters by pressing the orange part of the quick-connect fittings toward the white part of the connector and pulling the filter out. Insert the new filters as oriented in the photo above.

Fuses

If your LI-8100 fails to turn on when powered up, and you are confident that the battery is fully charged, there is a possibility that a fuse has blown. There is a fuse inside the 6400-03 battery; instructions for testing the battery and replacing the fuse are given below at 6400-03 Batteries.

A second fuse is located inside the Auxiliary Sensor Interface, which protects the unit from overcharges due to improper connection of an external power supply. To check this fuse, simply loosen the 4 screws on the Auxiliary Sensor Interface cover and remove the cover.



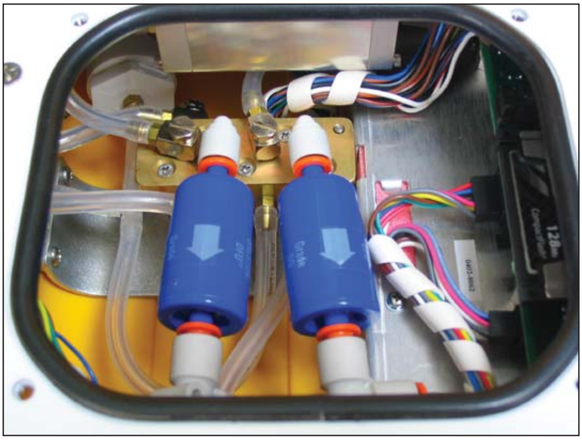
The screws on the 8100-661 Auxiliary Sensor Interface cover are "captive" screws, meaning they are retained in the cover so they can't fall out. Loosen them until you can lift the cover off. There is a spare 250V, 3A fast-blo fuse in the spare parts kit (p/n 439-04215).

A third fuse is located inside the Analyzer Control Unit, and protects the unit from overcharges from a battery attached via the LI-8100 battery connectors on the inside panel. In most cases this fuse will not blow; we recommend that you test the battery to make sure it is fully charged as described below at *6400-03 Batteries* before attempting to check this fuse, as it requires a number of steps to disassemble the Analyzer Control Unit. If you have eliminated all other possibilities, follow these steps to check the Analyzer Control Unit power fuse:

1. Power the instrument off and remove the battery or other external power source.

2. Open the Analyzer Control Unit case and remove the access panel by loosening the 4 thumbscrews.

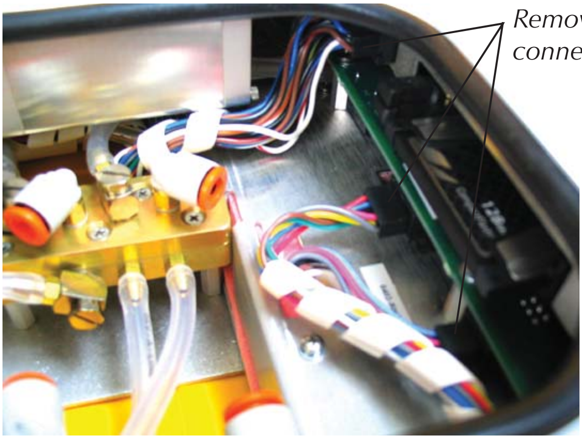
3. Mark one of the Balston air filters with a marker or piece of tape to make sure that you are able to return them to their original locations when re-assembling. This is important, as one of the filters is in-line with the bellows air circuit to the Survey Chamber, and is bi-directional, meaning dirt can be introduced into the filter in both directions. If this filter is inserted into the optical bench air path during re-assembly, dirt can be inadvertently blown into the optical bench.



Note the orientation of the filters, and mark one of them (e.g. "L" or "R").

Remove both air filters by pressing the orange part of the quick-connect fittings toward the white part of the connector and pulling the filter out.

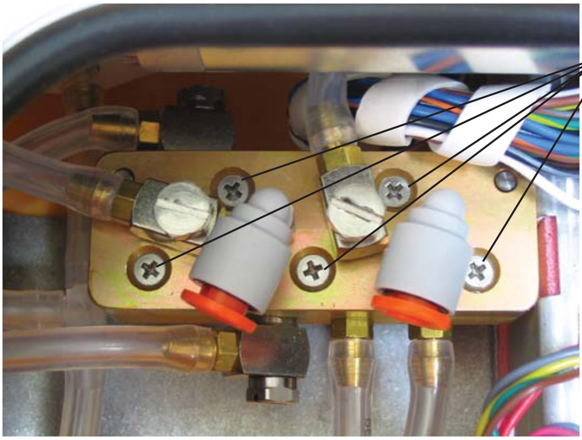
4. There are 3 electrical connectors that must be removed. Two of them are on a single wiring harness, just to the right of filters in the photo above; the third is about 2 inches further back from them, just beyond the edge of the access panel, as shown below.



Remove these 3 connectors

Pull straight out on the connectors to remove them. The large connector under the access panel can be difficult to reach; you can gently pull on the wire harness and slowly rock the connector back and forth to remove it, if necessary. When reinserting the connector, make sure that you check the pin alignment before pushing the connector into place, as the upper right hand side pins can easily become bent if misaligned.

5. Remove the 5 screws from the top of the air manifold, as shown below.



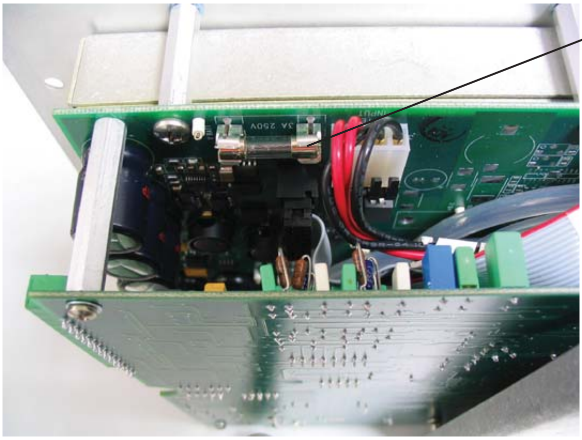
Remove the 5 screws from the top of the air manifold.

The top half of the manifold rests on two pins; lift the top half until it is completely separated from the bottom half. It is not necessary to remove any of the hoses.

6. Remove the 12 screws around the outer edge of the white panel, as shown below.

Remove the 12 screws around the outer edge of the white panel.

7. Lift the analyzer control unit from out of the yellow case. The power fuse is located on the back of the control unit as you face the instrument, as shown below.



Power fuse location. There is a spare 250V, 3A fast-blo fuse in the spares kit under pn 300-01961.

8. If the fuse has blown, replace and re-assemble the Analyzer Control Unit.

6400-03 Batteries

Charging the 6400-03 Batteries

Batteries are normally charged with the LI-6020 battery charger.

1. *Select the proper voltage.*
Make sure that the voltage selector slide switch on the back of the LI-6020 battery charger is set to the appropriate line voltage (115 or 230 VAC).

2. *Plug the charger into mains power.*
The AC indicator light will illuminate. If the charge indicator lights up instead, you've got the wrong voltage selected.

3. *Connect the batteries.*
The CHARGE indicator illuminates if any of the batteries connected to the charger are being charged. One method for testing a battery's charge is to connect it to the charger when no other batteries are attached. If it is charged, the CHARGE light comes on for only a few seconds, if at all. If the CHARGE light does not come on, either the battery is fully charged, or else the battery's fuse has blown. (To test, plug the battery by itself into the LI-8100, and power it on. If nothing happens, then the problem is the fuse, or the battery is dead.)

A fully discharged 6400-03 battery requires about 3 hours to recharge. Four discharged batteries connected simultaneously would require approximately 10 to 12 hours to recharge. We recommend you not leave a battery on the charger for more than 24 hours after the charge light has gone out.

Storing the 6400-03 Batteries

Store batteries fully charged, and in a cool place, if possible. For long term storage, place the batteries on the charger overnight every three months.

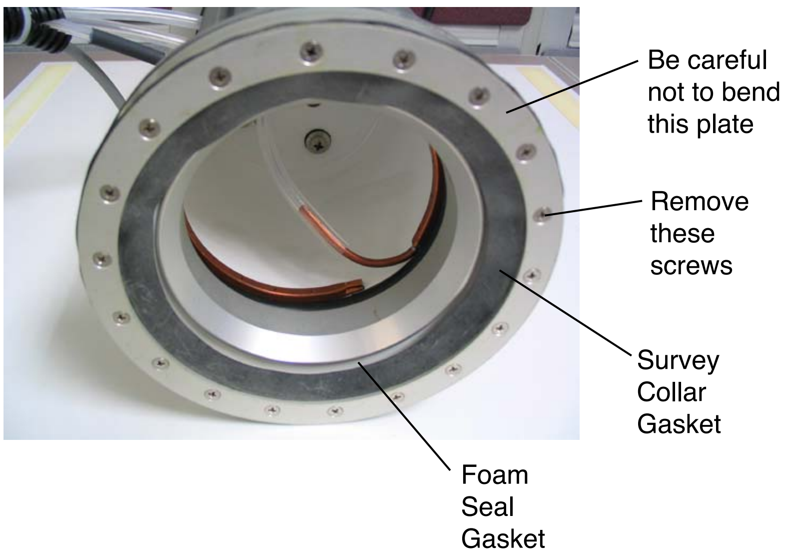
Replacing the Battery Fuse

There is a 10A automotive type fuse located inside the metal cover of the 6400-03 battery. If the battery fails to power the LI-8100, and will not light the charge indicator on the battery charger, check to see if the fuse has blown.

To replace the fuse, cut the black tape on the battery pack along the long axis, between the two halves of the battery. Carefully remove the top half of the battery (the half with the electrical cables), and lay it to the side with the wires still attached. Check to see if the fuse has blown. Replacement fuses (p/n 438-03142) plug into the spade connectors; no soldering is required. After replacing the fuse, tape the battery covers together.

10 cm Survey Chamber Gasket Replacement

The 10 cm Survey Chamber uses a series of 3 gaskets to seal the chamber against air leaks between the soil collar and the chamber. The first gasket is a black neoprene "rolled" type gasket that is located on the bottom of the moveable part of the chamber; in most cases this gasket will not need to be replaced unless it is inadvertently damaged. The other two gaskets are located on the underside of the chamber, beneath the metal flange that envelopes the soil collar. These two gaskets, and in particular, the white foam gasket, may need to be changed with some regularity. A gasket kit containing the black rubber gasket and foam seal gaskets can be purchased under part number 8100-622.



The black rubber gasket is referred to as the Survey Collar Gasket; four spares are included in the gasket kit under pn 6581-065. The white foam gaskets are referred to as Foam Seal Gaskets; a package of 20 is included in the gasket kit under p/n's 8100-622 (kit) or 6560-229 (1 each).

The Foam Seal Gaskets can become cracked or lose their shape relatively quickly, depending upon the conditions they are used in, and the pressure with which they are placed over the soil collar. Inspect the foam seal gasket before you start making measurements each day; if it appears that it might not form a tight seal against the soil collar, you should replace it. The Survey Collar Gasket should not need to be replaced unless it is torn.

To replace either the Survey Collar Gasket or the Foam Seal Gasket, you will need to remove the thin metal plate that covers the Survey Collar Gasket. ***Be***

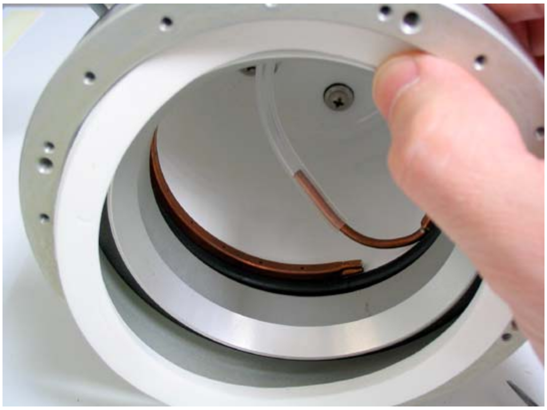
careful with this plate - it is thin and can be bent easily. If the plate is bent or mishapen, it will not seal properly.

■ To replace the Survey Collar and/or Foam Seal Gaskets, follow these steps:

1. Remove the 18 philips head screws from the metal plate on the bottom of the Survey Chamber, as shown above. Remove the plate and set aside. Remove the Survey Collar Gasket.

2. If you need to replace the Foam Seal Gasket, simply pry it out with a knife or a screwdriver. Discard.

3. Insert the new Foam Seal Gasket by working the gasket with your fingers into the recessed area of the flange. It may help to work the gasket in with the inside edge first, as shown below. Press in opposite sides of the gasket to prevent stretching it. Make sure the gasket is seated all the way down into the flange, and that it lays flat without warping.



4. Turn the chamber upside down, and align the Survey Collar Gasket holes with the holes in the flange. Place the metal plate over the Survey Collar Gasket and align the holes.

There is a front and back side to the Survey Collar Gasket; if it does not align with the holes on the flange, turn the gasket over and try again.

5. Insert the screws on opposite sides of the flange, ***but do not fully tighten until all screws are started.*** Partially tighten the screws on opposable sides, and work your way around the ring so that the metal plate lays flat and does not bow. The screws should not be fully tightened, as this will distort the gasket - tighten until the gasket begins to deform, and then back off slightly.

Replacing the Bellows on the 10 cm Survey Chamber

If the bellows on the Survey Chamber is punctured or is otherwise damaged and develops a leak, it will not operate properly. If the chamber fails to raise or lower when the bellows pump is operating, the bellows and/or the Bev-a-line tubing on the bellows air path may be damaged. Check the Bev-a-line tubing first to see if it has developed a leak, and replace if necessary. If you have determined that the bellows is damaged, you can replace it with the LI-8100 Bellows Kit (p/n 8100-623), sold separately.

■ Follow these steps to replace the Survey Chamber bellows:

1. Remove the Survey Chamber hoses and chamber connector from the Analyzer Control Unit side panel.

2. Remove the handle from the chamber. When the handle is in a horizontal position, it can be removed by pulling out on both sides of the handle.

3. Remove the 4 thumbnuts from the top plate of the pressure relief valve assembly. The top plate and attached hose can stay attached to the manifold; it will hang along side the chamber while you complete the disassembly.

You should be able to remove the nuts with your fingers; if not, gently loosen with a pair of pliers. It is not necessary to remove the black hose.

4. Remove the 4 standoffs from the lower plate of the pressure relief valve assembly with an open end wrench.

5. Remove the 8 screws that attach the top plate to the chamber supports, and the 4 screws near the center of the plate that attach to the top of the bellows. Remove the chamber top plate.

Remove the 12 screws on the chamber top plate.

Note that the 4 screws nearest the center of the plate are slightly larger than the other 8, and have a small red o-ring seal on them. Make sure these o-rings are present and are not damaged when re-assembling the chamber. Replace if necessary.

6. The bellows assembly appears as shown below. Note the orientation of the black plate at the top of the bellows. There are screw inserts on the underside of this plate; it it important to re-insert this plate in the proper orientation during re-assembly. Note, too, that there is a thin film of silicone lubricant along the top edge of the bellows. This helps seal the bellows against the chamber top plate. There is a tube of silicone lubricant in the bellows kit that you can apply to the new bellows during re-assembly.

Insert your finger between the bellows and the black plate and pry the plate out. If necessary, you can lift the entire chamber out of the strut assembly.

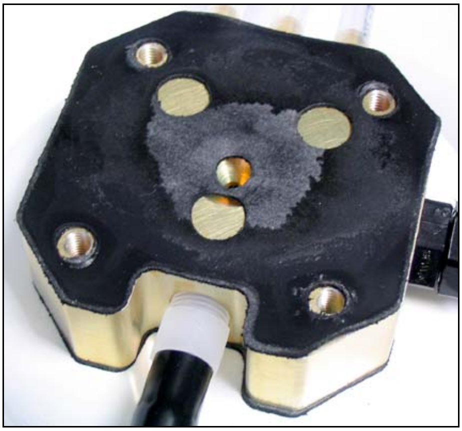
7. There are two more plates at the bottom of the bellows. Remove the 4 screws from the base plates and remove the bellows.

8. The underside of the bellows appears as shown below.

Again, note that there is a film of silicone lubricant applied to the bottom of the bellows, which helps seal it against the outer black plate. Remove the inner plate from the bellows, and discard the old bellows.

9. To re-assemble the bellows, insert the lower black plate into the new bellows, by running your finger along the edge of the plate, as shown below (top plate insertion shown).

10. Apply a thin film of silicone lubricant around the edge of the bellows, and place the second black plate over the bellows. Align the holes between the two black plates. If the manifold gasket (below) is torn or otherwise damaged, there are two spares in the spare parts kit.



Align the bellows with 2 attached plates with the holes in the manifold (above). Note that there is a seam on the bottom edge of the bellows. Before tightening the screws, align the seam in the bellows with one of the long edges of the manifold and attach with the 4 screws removed in Step 7 above. In other words, do not align the seam in the bellows with any of the corners of the manifold.

11. Insert the black plate into the top of the bellows as shown in Step 9. Note that the screw inserts should be on the underside of the plate, as shown below. Apply a film of silicone lubricant around the top edge of the bellows.

The screw inserts are on the underside of the top plate, and face downward, into the center of the bellows.

12. If the chamber was removed earlier, re-insert it into the strut assembly. Make sure that the hoses are positioned between two of the struts with adequate clearance. Place the chamber top plate on top of the struts, align the screw holes, and secure the top plate to the struts with the 8 screws removed in Step 5.

13. The assembly should appear similar to that shown below. You now need to attach the bellows to the chamber top plate. Lift up on the bottom of the chamber to compress the bellows to verify placement and clearances, and rotate slightly until the 4 screw holes on the chamber top plate and the bellows top plate align.

Use the 4 screws with red o-rings that were removed in Step 5 to secure the bellows to the chamber top plate.

14. Re-attach the lower plate from the pressure relief valve assembly using the 4 nuts with attached star washers, as shown in Step 4 above. Attach the upper plate with the 4 thumbnuts, as shown in Step 3 above. Re-attach the handle. Connect the chamber to the Analyzer Control Unit and manually open and close the chamber a few times to verify that there are no leaks.

8100-101 Long-Term Chamber Maintenance

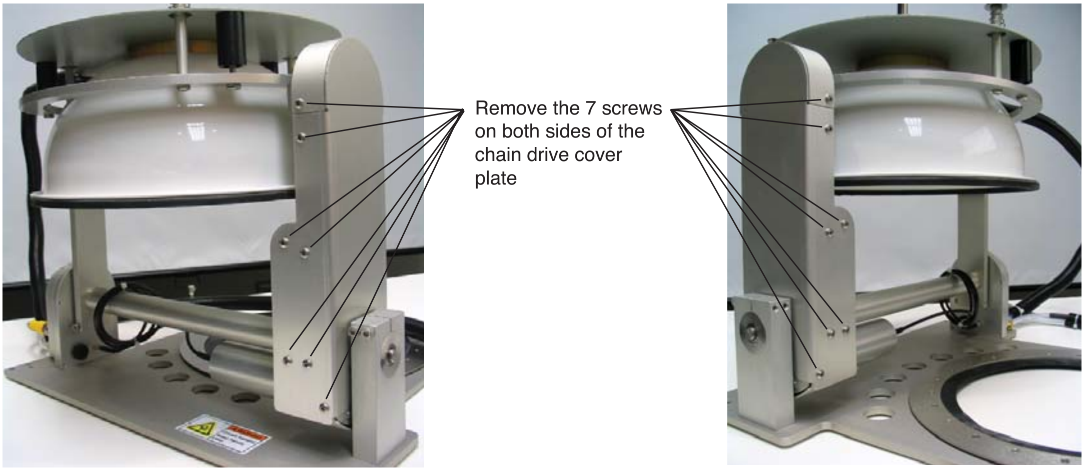
The 8100-101 Long-Term Chamber is designed to require only minimal maintenance. Periodic tightening and lubrication of the drive chains may be required on a yearly basis, or more often as needed. The black neoprene collar gasket can be easily replaced should it become damaged; two spare gaskets (p/n 6581-060) can be found in the Long-Term Chamber Gasket Kit (p/n 8100-612).

Drive Chain Lubrication

There are two stainless steel drive chains that are used to move the chamber onto and off of the soil collar. These chains are very durable and should require only minimal maintenance. The chains should be lubricated on a yearly basis with readily available motor oil, or a spray type lubricant for bicycle chains. To lubricate the chains, follow these steps:

1. Manually open the chamber, using the ***Manual Controls*** function in software, until it reaches a vertical position at the apex of its movement. Power the unit off when it reaches this point. This will allow you to remove all of the screws on the chain cover.

2. There are seven Philips head screws on either side of the chain guard. Remove these fourteen screws, as shown below.

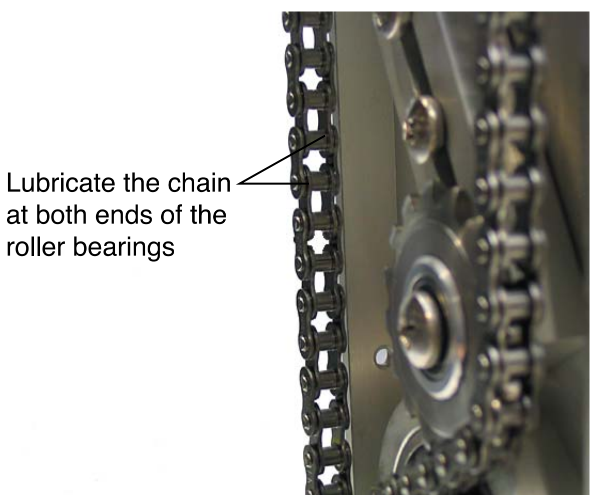


Remove the fourteen screws on either side of the chain guard.

3. The chain guard consists of four individual pieces, which can now be removed to expose the two chains.

The chain guard has four individual pieces; (clockwise from top) outer cover, top, bottom, and inner cover.

4. The chain consists of a number of roller bearing cross members. Lubricant should be applied to both ends of these roller bearings, as shown below. A toothpick dipped in motor oil can be applied to the ends of the roller bearings; the oil will "wick" into the seam between the bearing and the chain. Alternatively, the chain can be sprayed with a bicycle type chain oil. Re-assemble the chain guard.



Lubricate the individual roller bearings at both ends.

Drive Chain Tightening

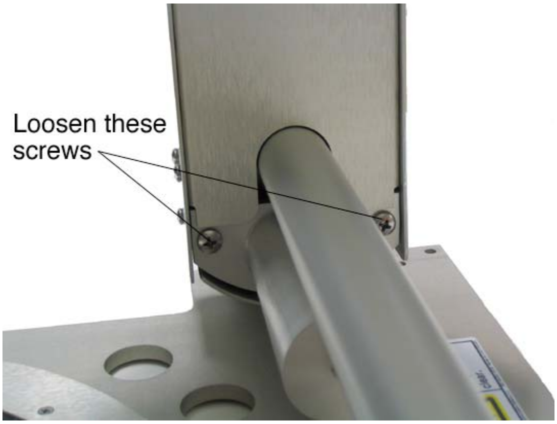
The two stainless steel drive chains can stretch and become loose over time. When this happens, you may notice that the chamber has some vertical "play", meaning that it can be moved up and down slightly when pressure is applied to it. The chamber will still operate properly, however, the tension applied to the chamber when it is closed will be reduced. If you notice that the chains appear to have loosened, you can tighten them as described below.

1. Manually open the chamber, using the ***Manual Controls*** function in software, until it reaches a vertical position at the apex of its movement. Power the unit off when it reaches this point. This will allow you to remove all of the screws on the chain cover.

2. There are seven Philips head screws on either side of the chain guard. Remove these fourteen screws, as shown above.

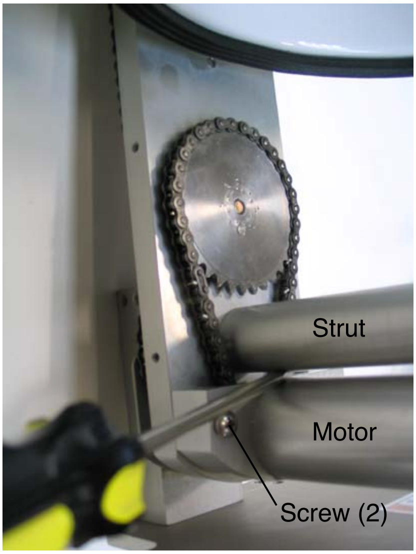
3. The chain guard consists of four individual pieces, which can now be removed to expose the two chains, as shown above.

4. The inner (short) chain is tightened by loosening the two screws on the bottom of the chain guard, near the motor attachment, as shown below.



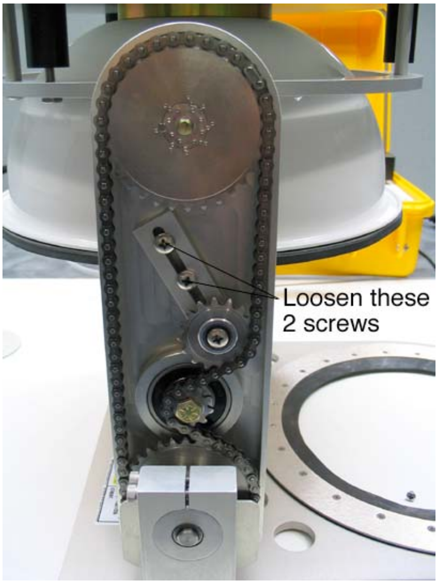
Loosen the two screws near the motor attachment.

5. Insert a screwdriver between the motor and the strut as shown below. Use the screwdriver as a lever to pry the motor away from the strut to tighten the chain. Leave a bit of slack in the chain. When the chain is nearly taut, tighten the two screws.



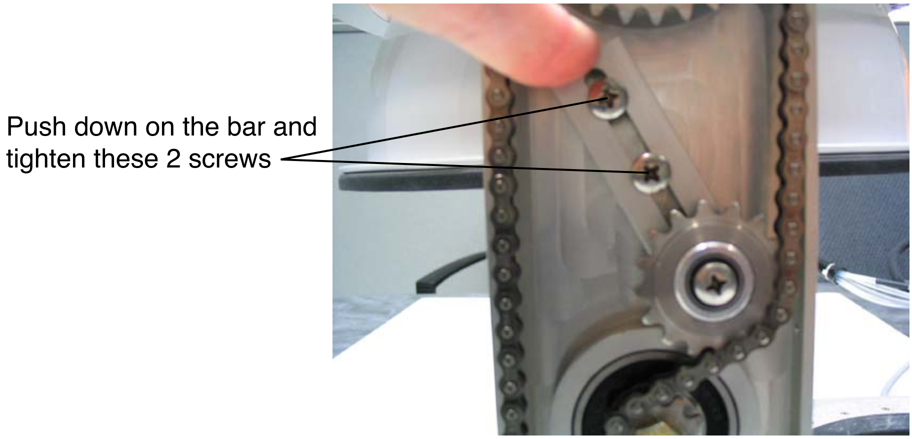
Pry between the motor and the strut to tighten the chain. Be careful not to overload the chain, as it will stretch.

6. The outer (long) chain is tightened by loosening the two screws on the adjustment bar, as shown below.



Loosen the 2 screws on the adjustment bar.

7. Apply pressure to force the adjustment bar downward to tighten the chain. Leave a bit of slack in the chain. While holding the bar, tighten the two screws on the adjustment bar.



Slide the adjustment bar down to tighten the chain.

8. Re-assemble the chain guard.

Collar Gasket Replacement

1. Manually open the chamber, using the ***Manual Controls*** function in software, until it reaches a vertical position at the apex of its movement. Power the unit off when it reaches this point. This will allow you to remove all of the screws on the collar gasket cover.

2. There are 24 Philips head screws that attach the collar gasket cover plate to the main base plate. Remove these 24 screws and lift off the cover plate.

Remove the screws around the circumference of the cover plate.

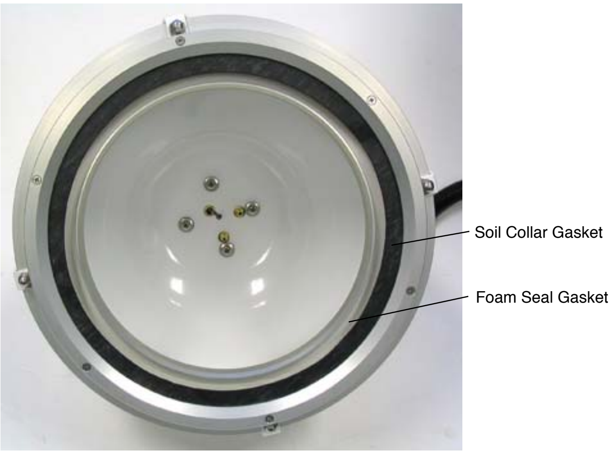
3. Remove the old gasket. Align the screw holes of the new gasket with the holes in the base plate. Place the gasket cover plate over the new gasket and align the holes. Replace the screws. Partially tighten the screws on opposite sides of the cover plate, around the entire circumference of the plate, to apply even pressure to the plate before fully tightening all of the screws.

NOTE: Be careful not to bend the collar gasket cover plate, or it will not seal the neoprene gasket properly.

8100-103 20 cm Survey Chamber Maintenance

Gasket Replacement

The 20 cm Survey Chamber uses a series of 3 gaskets to seal the chamber against air leaks between the soil collar and the chamber. The first gasket is a black neoprene gasket (p/n 224-07606) that is located on the bottom of the moveable part of the chamber; in most cases this gasket will not need to be replaced unless it is inadvertently damaged. The other two gaskets are located on the underside of the chamber, beneath the metal flange that envelopes the soil collar. These two gaskets, and in particular, the white foam gasket, may need to be changed with some regularity.



The black rubber gasket is referred to as the **Soil Collar Gasket**; four spares are included in the spares kit under p/n 6581-108. The white foam gaskets are referred to as **Foam Seal Gaskets**; a package of 20 is included in the 8100-632 gasket kit, or individually under p/n 6581-107.

Foam Seal Gasket

The Foam Seal Gaskets can become cracked or lose their shape relatively quickly, depending upon the conditions they are used in, and the pressure with which they are placed over the soil collar. Inspect the foam seal gasket before you start making measurements each day; if it appears that it might not form a tight seal against the soil collar, you should replace it.

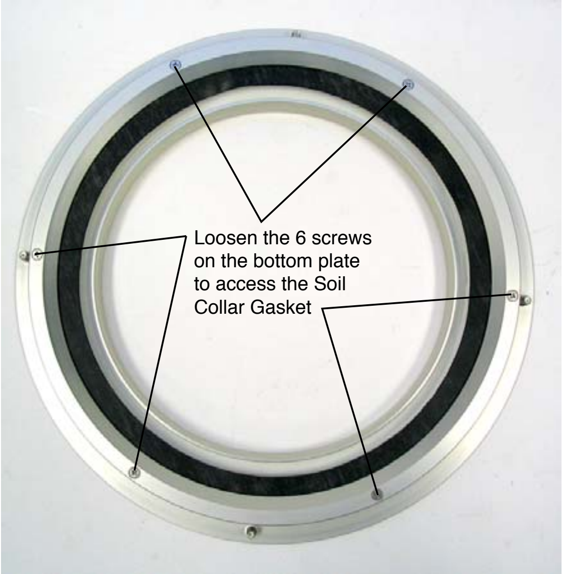
If you need to replace the Foam Seal Gasket, simply pry it out with a knife or a screwdriver. Discard. Note that is some cases you can simply flip the gasket over and use the reverse side before replacing.

Insert the new Foam Seal Gasket by working the gasket with your fingers into the recessed area of the flange. It may help to work the gasket in with the inside edge first, as shown below. Press in opposite sides of the gasket to prevent stretching it. Make sure the gasket is seated all the way down into the flange, and that it lays flat without warping.

It is not necessary to remove the Soil Collar Gasket when replacing the Foam Seal Gasket. The collar plates do not need to be removed from the chamber; it is shown detached at left for illustration only.

Soil Collar Gasket

The Soil Collar Gasket should not need to be replaced unless it is torn. To replace the gasket, loosen the 6 screws on the chamber bottom plate. Remove the plate and gasket. Align the new gasket with the screw holes and reassemble.



The 6 screws on the bottom plate are captive; they need only be loosened, not completely removed.

Chamber Gasket

The bottom of the soil chamber "bowl" has an attached adhesive gasket that seals the chamber against the bottom plate. This gasket has a long life, and should be replaced only if it is damaged and does not form a tight seal.

■ Follow these steps to replace the Chamber Gasket:

1. Remove the 4 nuts from the bottom of the chamber supports, as shown below.

Remove the 4 nuts
from the support legs

2. Bend the supports out slightly to remove the bottom plate assembly.

3. Use a knife or razor blade to remove the old gasket. Clean the rim of the chamber with alcohol if necessary to remove any adhesive residue.

4. Remove the adhesive backing from the new gasket and install around the rim of the chamber. Trim the gasket as needed so that the ends are touching.

5. Apply a small amount of Loctite to glue the ends together (below).

Replacing the Bellows on the 20 cm Survey Chamber

If the bellows on the 20 cm Survey Chamber is punctured or is otherwise damaged and develops a leak, it will not operate properly. If the chamber fails to raise or lower when the bellows pump is operating, the bellows and/or the Bev-a-line tubing on the bellows air path may be damaged. Check the Bev-a-line tubing first to see if it has developed a leak, and replace if necessary. If you have determined that the bellows is damaged, you can replace it using the LI-8100 Bellows Kit (p/n 8100-623).

■ Follow these steps to replace the 20 cm Survey Chamber bellows:

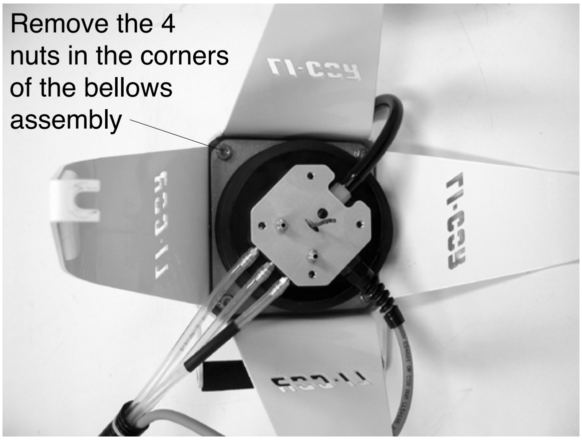
1. Remove the hoses and chamber connector from the Analyzer Control Unit side panel.

2. Remove the 4 nuts from the bottom of the chamber supports, as shown below.

3. Bend the supports out slightly to remove the bottom plate assembly.

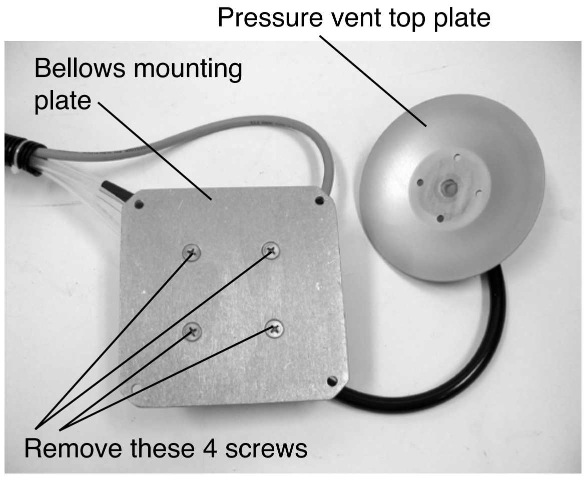
4. Remove the 4 screws from the inside of the chamber as shown below, and remove the chamber bowl from between the chamber supports. This will expose the manifold and bellows assembly.

5. Remove the four #10 Kep nuts in each corner of the bellows assembly with a 3/8" nut driver. Lift the bellows assembly out of the support frame.

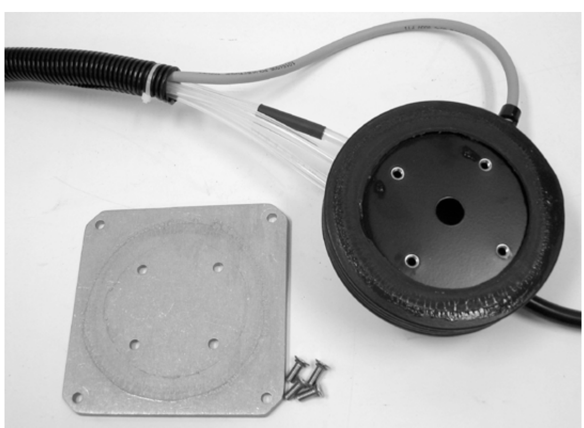


6. Remove the 4 thumb screws from the top plate of the pressure vent assembly and lift the top plate off (optional).

7. The underside of the bellows assembly appears as shown below. Remove the 4 screws from the bellows mounting plate.



8. Note the orientation of the black plate at the top of the bellows. There are screw inserts on the underside of this plate; it it important to re-insert this plate in the proper orientation during re-assembly. Note, too, that there is a thin film of silicone lubricant along the top edge of the bellows. This helps seal the bellows against the bellows mounting plate. There is a tube of silicone lubricant in the bellows kit that you can apply to the new bellows during re-assembly. Apply the lubricant in a thin film only; too much is worse than using none at all.



Insert your finger between the bellows and the first circular black plate and pry the plate out.

9. There are two more plates at the bottom of the bellows. Remove the 4 screws from the two remaining circular base plates (inside the bellows) and remove the bellows from the manifold.

10. The underside of the bellows appears as shown below (outer plate removed).

Again, note that there is a film of silicone lubricant applied to the bottom of the bellows, which helps seal it against the outer black plate. Remove the inner plate from the bellows, and discard the old bellows.

11. To re-assemble the bellows, insert the lower black plate into the new bellows, by running your finger along the edge of the plate, as shown below (top plate insertion shown).

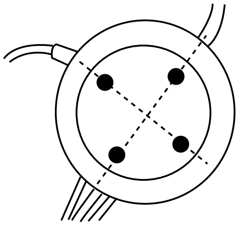
12. Apply a thin film of silicone lubricant around the edge of the bellows, and place the second black plate over the bellows. Align the holes between the two black plates. If the manifold gasket (below) is torn or otherwise damaged, there is a spare in the bellows kit.

Align the bellows and 2 attached plates with the holes in the manifold (above). Note that there is a seam on the bottom edge of the bellows. Before tightening the screws, align the seam in the bellows with one of the long edges of the manifold and attach with the 4 screws removed in Step 9 above. In other words, do not align the seam in the bellows with any of the corners of the manifold. Make sure that the bellows remains centered with respect to the two clamping plates.

13. Insert the remaining black plate into the top of the bellows as shown in Step 11. Note that the screw inserts should be on the underside of the plate, as shown below. Apply a film of silicone lubricant around the top edge of the bellows.

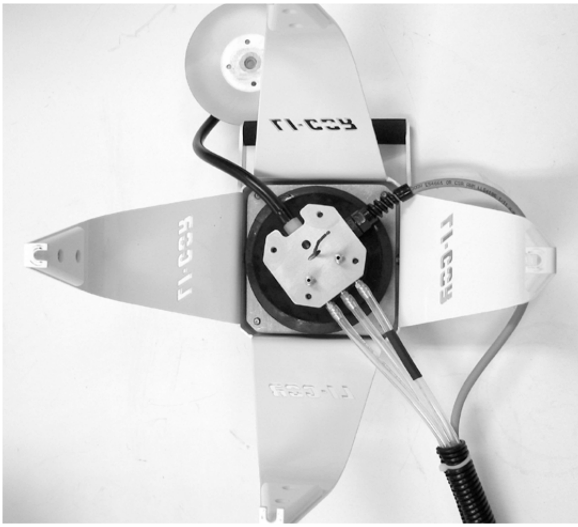
The screw inserts are on the underside of the top plate, and face downward, into the center of the bellows.

14. Align the screw holes in the clamping plate with the tubing and control cables attached to the manifold, as shown below. Reattach the bellows mounting plate removed in Step 7.



Align the holes with the cables and tubing as shown

15. Re-insert the bellows assembly into the support frame. Make sure that the plastic standoffs are still present on the 4 studs on the support frame. Note too that the gray control cable should extend around the outside of one of the support struts, as shown below.



16. Re-attach the chamber bowl, making sure to insert the sensor wire through the small hole at the center of the bowl.

17. Re-attach the bottom mounting plate with the 4 nuts removed in Step 2.

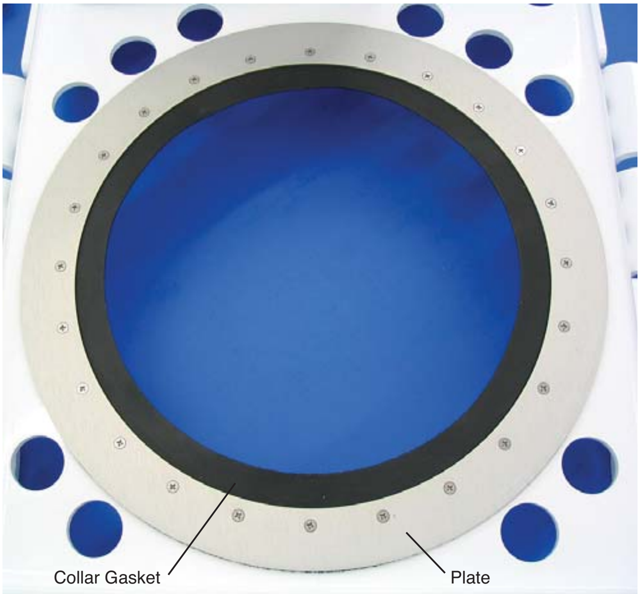
18. Re-attach the top plate of the pressure vent using 4 thumb screws. The finished assembly should appear as shown below.

8100-104 Long-Term Chamber Maintenance

The 8100-104 Long-Term Chamber is designed to require only minimal maintenance. The black neoprene collar gasket can be easily replaced should it become damaged; two spare gaskets (p/n 6581-060) can be found in the Long-Term Chamber Gasket Kit (p/n 8100-612). Instructions are also given for replacing the tubing/cable assembly, replacing the thermistor assembly, and replacing the shaft seal assembly.

Replacing the Collar Gasket

The Soil Collar Gasket should not need to be replaced unless it is cracked, brittle, or otherwise worn. To replace the gasket, move the chamber to its open position. Loosen the 24 screws on the chamber gasket plate. Remove the plate and gasket. Align the new gasket with the screw holes and re-assemble. Torque screws to 4 lb.-in.

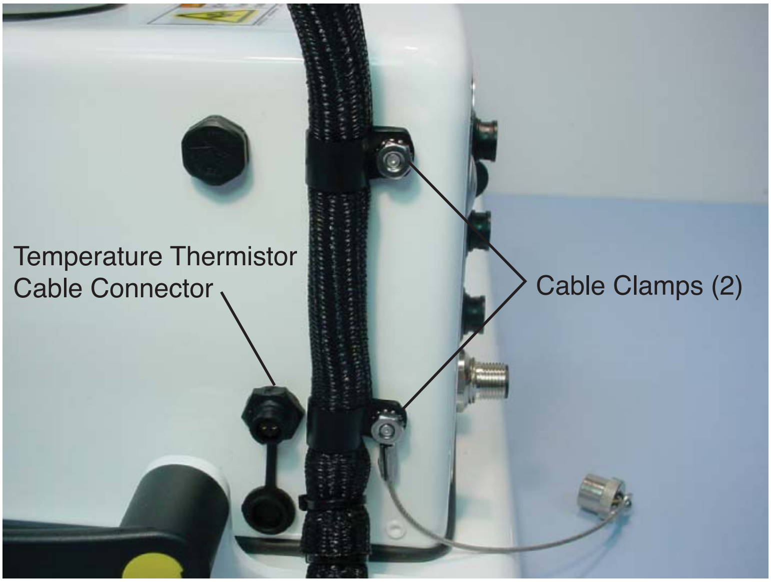


Replacing the Tubing/Cable Assembly (p/n 9981-141)

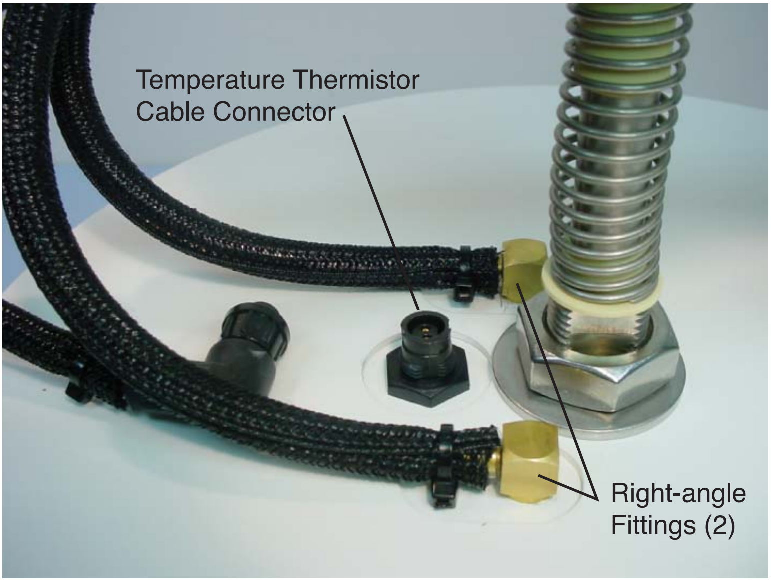
The tubing/cable assembly may need replacement if the tubing becomes cut or damaged (most often by rodents).

■ Follow these steps to replace the tubing/cable assembly:

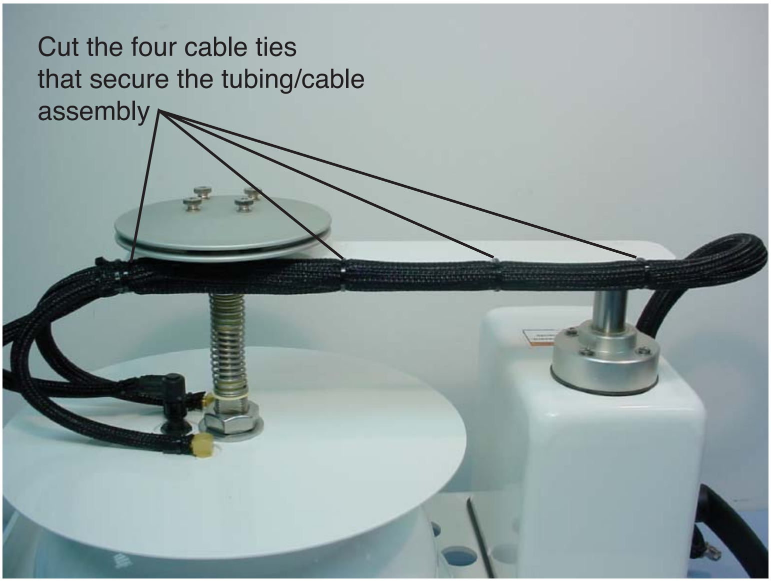
1. Disconnect the temperature thermistor cable from the side of the enclosure by loosening the thumb nut and pulling the cable connector straight out. Remove the two cable clamps with an 11/32″ nut driver.



2. Disconnect the temperature thermistor cable from the top of the chamber by loosening the thumb nut and pulling the cable connector straight out. Remove the two right-angle fittings by loosening the nuts on the underside of the chamber bowl with a 3/8″ nut driver.



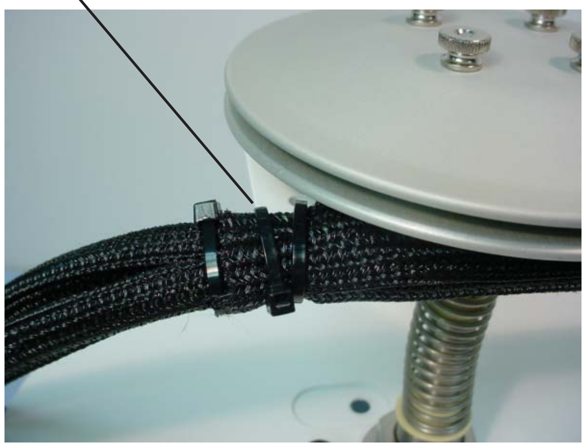
3. Cut the four cable ties that secure the tubing/cable assembly to the arm assembly, and remove the tubing/cable assembly.



4. On the new tubing/cable assembly, locate the end containing the right-angle fittings. Use a cable tie to loosely attach the tubing/cable assembly to the end of the arm nearest the pressure vent. The portion of the

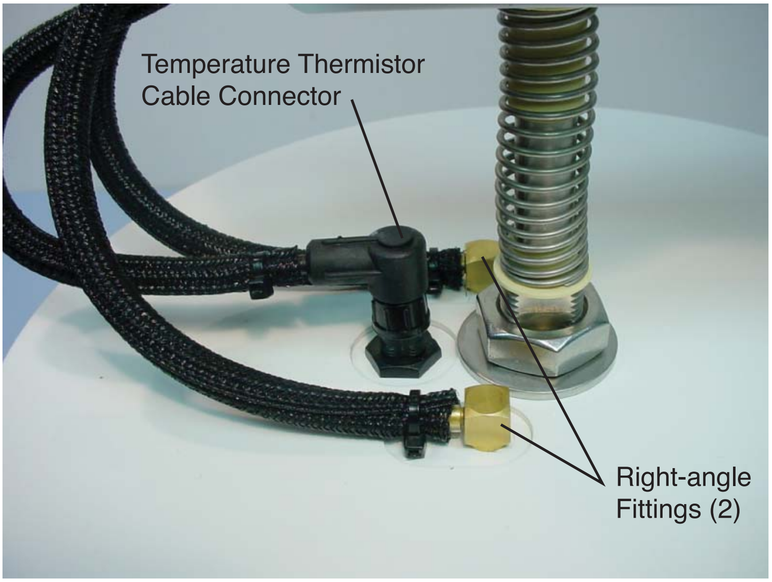
tubing/cable assembly that splits into three separate cables should be attached so that it is approximately even with the end of the arm, as shown below.

Align the portion of the tubing/cable assembly that divides into three parts with the end of the arm

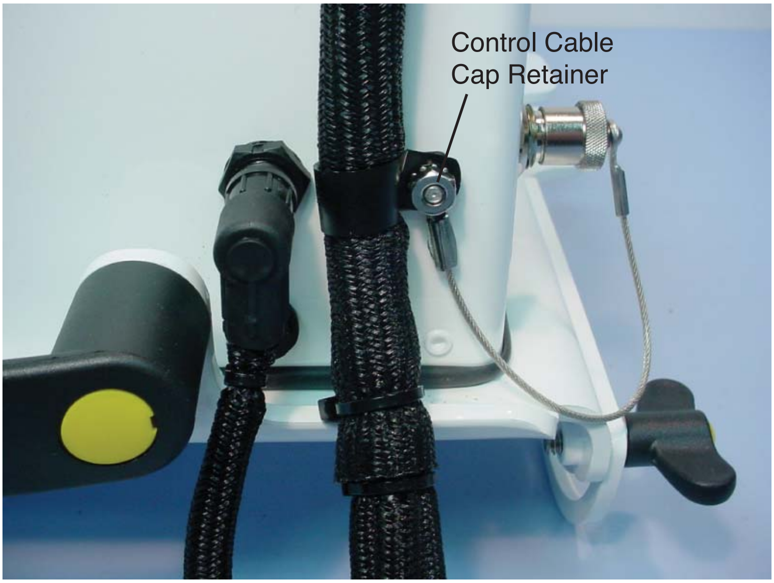


5. Loosely install the three remaining cable ties to secure the tubing/cable assembly to the arm. Verify that the assembly is positioned properly, and tighten the cable ties. Trim the excess end from the cable ties.

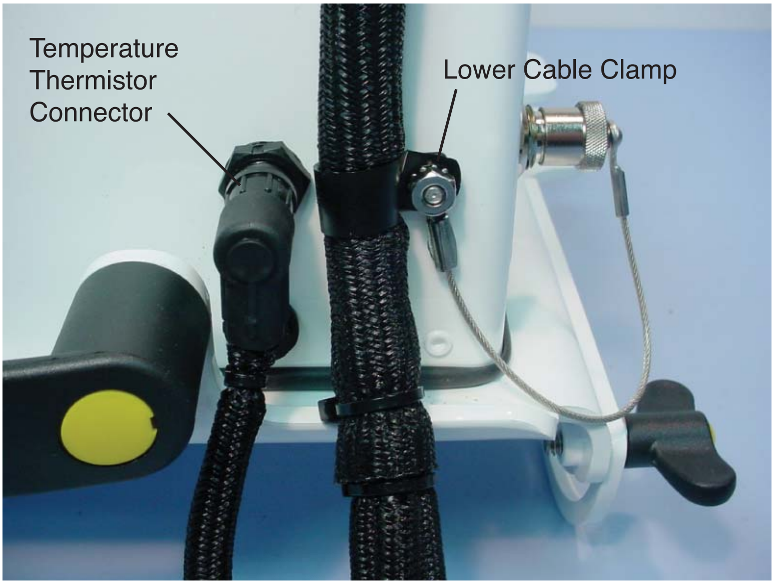
6. Make sure the O-rings are present in the temperature cable connector and right-angle fittings. Install the two right-angle fittings by tightening the nuts on the underside of the chamber bowl with a 3/8″ nut driver (it does not matter which fitting goes into each hole). Connect the temperature cable; make sure the connector is fully seated and the outer thumbnut is tight (you should feel a slight snap as it locks into place).



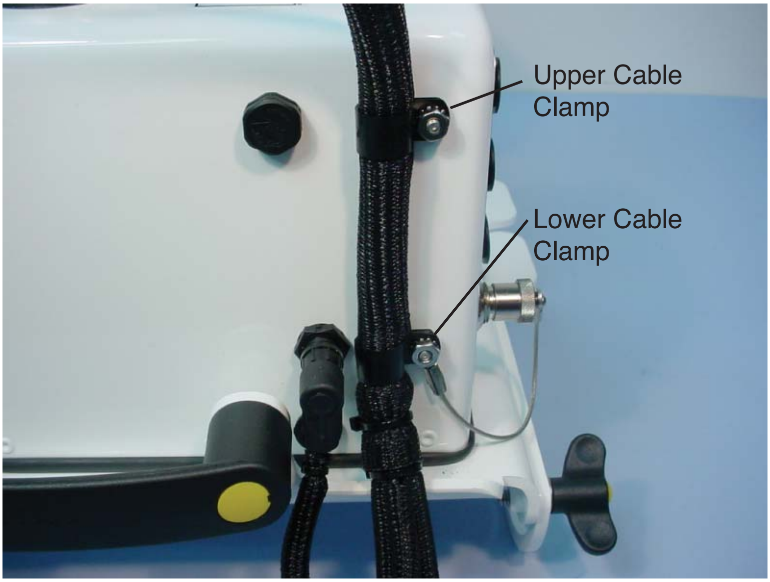
7. Place the control cable cap retainer over the stud. Align the portion of the tubing/cable assembly that divides into three separate cables with the edge of the baseplate. Loosely install the bottom cable clamp.



8. Connect the temperature cable; make sure the connector is fully seated and the outer thumbnut is tight (you should feel a slight snap as it locks into place).



9. Loosely install the upper cable clamp. Adjust the clamps if necessary, and tighten the nuts.

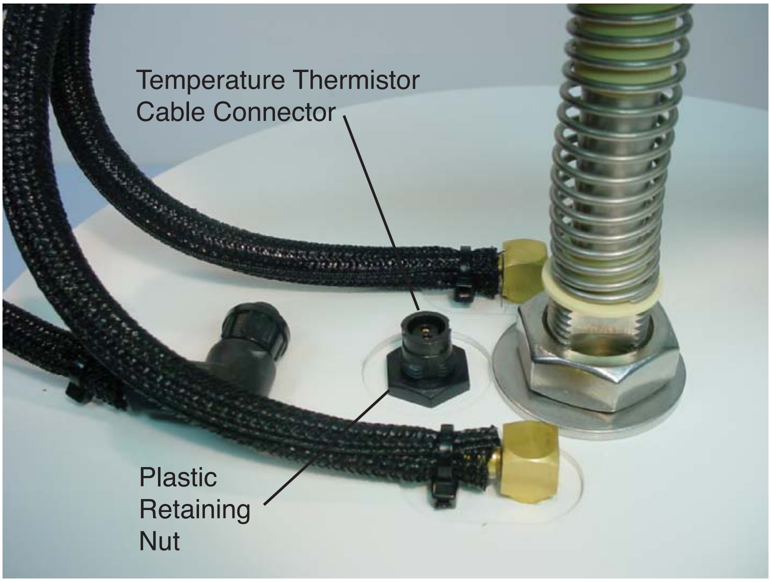


Replacing the Thermistor Assembly (p/n 9981-125)

The thermistor on the underside of the chamber may need replacement due to mechanical damage, moisture damage, or because the chamber temperature values are consistently erroneous.

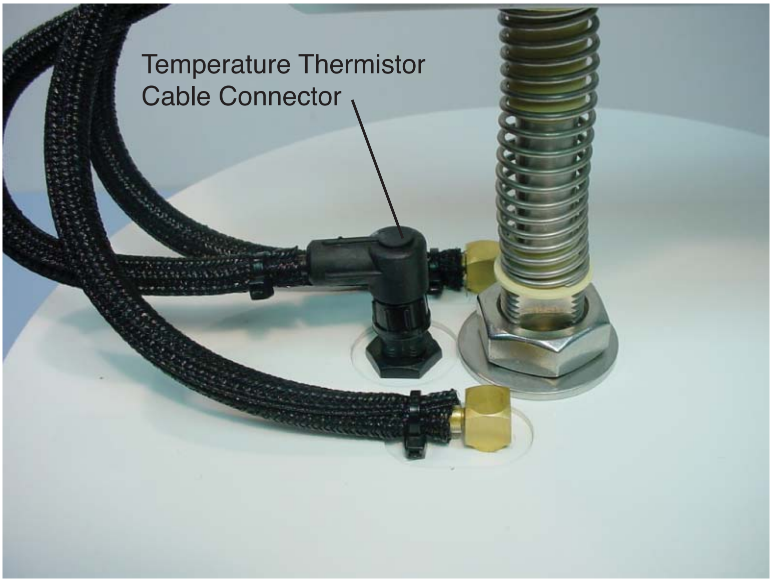
■ Follow these steps to replace the temperature thermistor assembly:

1. Disconnect the temperature thermistor cable from the top of the chamber by loosening the thumb nut and pulling the cable connector straight out. Remove the plastic retaining nut with a 5/8″ open-end wrench.



2. Make sure the rubber seal is present on the bottom of the new thermistor connector body, and install the new thermistor. Tighten the plastic retaining nut just enough to compress the rubber seal; do not overtighten the nut (torque to 5 lb.-in.).

3. Connect the temperature cable; make sure the connector is fully seated and the outer thumbnut is tight (you should feel a slight snap as it locks into place).



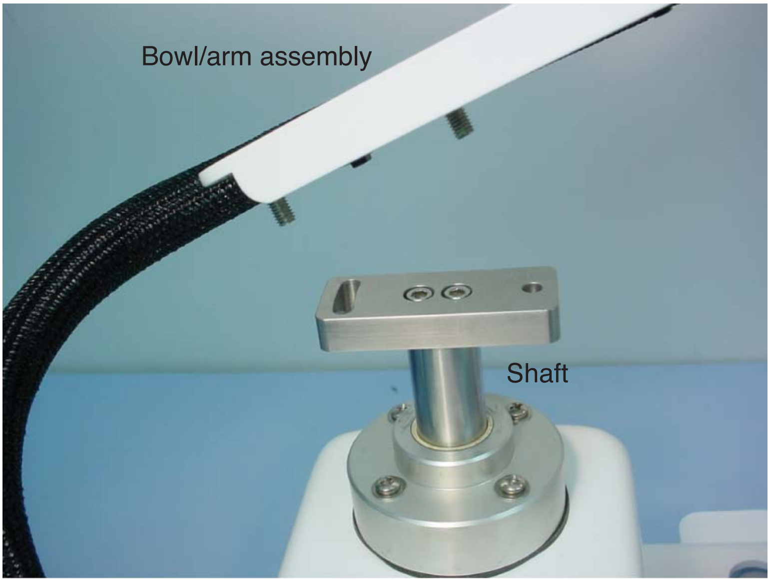
Replacing the Shaft Seal Assembly (p/n 9981-143)

The shaft seal assembly has a recommended replacement cycle of three years; replacement is required when the arm mechanism squeals or shudders during motion.

■ Follow these steps to replace the chamber arm shaft seal assembly:

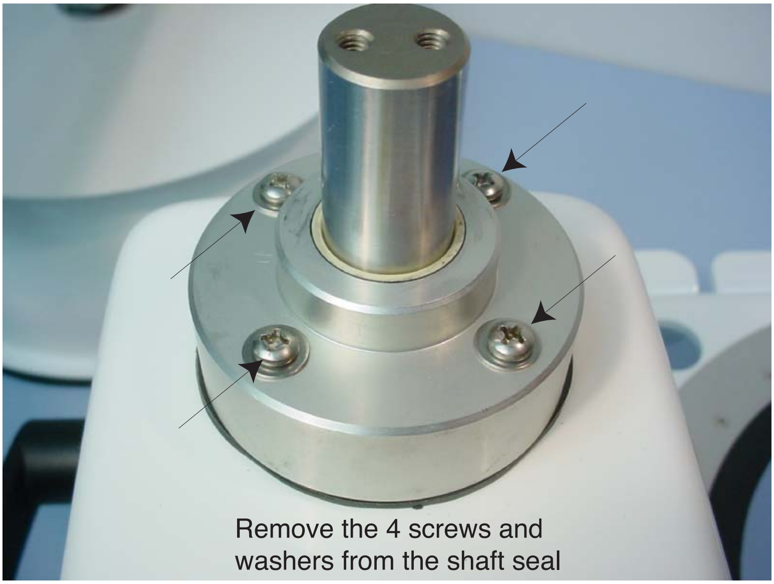
1. Press the OPEN/CLOSE button twice in succession to move the chamber to its “Park” position.

2. Remove the two nuts on the underside of the shaft that hold the arm/bowl assembly, using a 3/8″ wrench or socket.

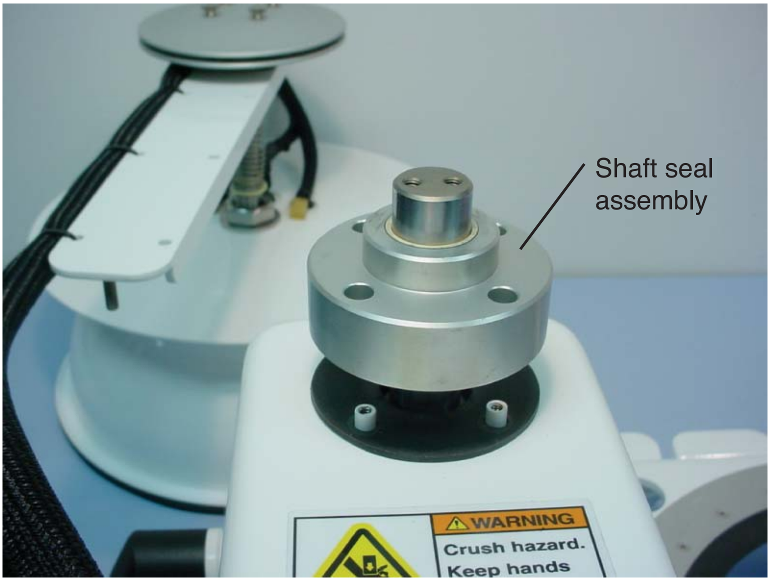


3. Remove the two hex screws on the drive column adapter using a 9/64″ hex wrench.

4. Remove the four screws and washers from the shaft seal assembly.

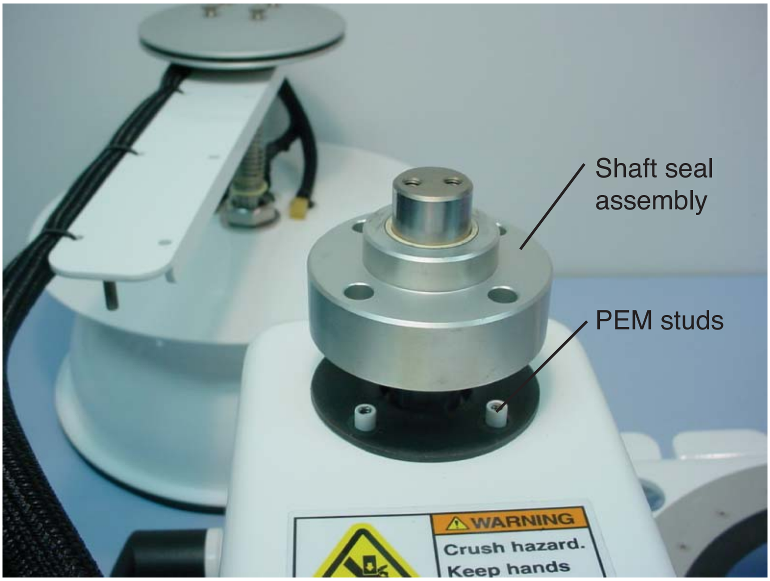


5. Remove the shaft seal assembly from the drive column.



6. Replace the support gasket (p/n 6581-163) if needed. Install the new shaft seal assembly on the shaft; carefully press the assembly past the O-ring. Simultaneously, press and twist the assembly to get past the main shaft seal.

Position the assembly over the PEM studs (see below) on the top of the enclosure.

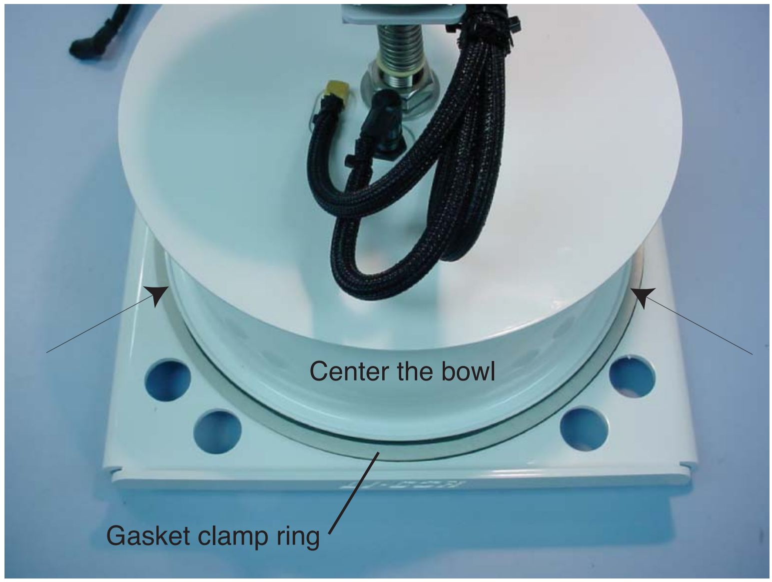


7. Secure the shaft seal assembly using the screws and washers removed in Step 4. Torque screws to 4 lb.-in.

8. Re-install the drive column adapter. Torque hex screws to 40 in-lbs.

9. Re-install the bowl/arm assembly using the nuts and washers removed in Step 2. Tighten the nuts only finger tight.

10. Adjust the chamber bowl so that it is centered over the gasket clamp ring. Tighten the two nuts that secure the bowl/arm assembly. Torque nuts to 40 lb.-in.



A Specifications

LI-8100 Automated Soil CO_2 Flux System

PDA Requirements:

With serial cable: PDA running Palm OS 3.51 or higher.
Wireless: PDA running Palm OS 4.1 or higher, and supporting 802.11b wireless connectivity.

Analyzer Control Unit

Memory: 18 MB on-board flash memory for data collection (32 MB total)
  Compact Flash: Type I industrial grade, 256 MB with adapter sleeve included, will accept Type II with appropriate adapter sleeve
Wireless PC Card: Fixed wireless networking Type II PC Card. Cisco Systems Aironet® 350 Series 11 Mbps DSSS for Wi-Fi (802.11b) networking
RS-232
  Signal output rate: 1 Hz
  Baud rate: 57,600 bps
Pressure Sensor
  Measurement Range: 15-115 kPa
  Accuracy: 1.5% over 0 to 85 °C
Maximum Gas Flow Rate: 1.7 liters/min
Power Requirements
  Auxiliary Input Voltage: 10.5-28 VDC
  Battery Input Voltage: 10.5-15 VDC
  3A @ 12V (36W) maximum during warm-up with heaters on
  1A @ 12V (12W) average after warm-up with heaters on
Operating Range
  Temperature: –20 °C to 45 °C
  Relative Humidity: 0 to 95% RH, Non-Condensing
Weatherproof Rating: Tested to IEC IP55 standard
Dimensions: 29 cm L × 38.1 cm W × 16.5 cm H (11.4" × 15" × 6.5")
Weight: 5.3 kg (11.8 lb.) without battery; 6.7 kg (14.8 lb.) with battery
Battery Weight: 1. 4 kg (3.0 lb.)

Auxiliary Sensor Interface

Dimensions: 10.2 cm L × 3.8 cm W × 6.4 cm H
(4" × 1.5" × 2.5")
Inputs: 4 Thermocouple channels (Type E, J, or T)
3 General input channels (0-5 VDC)
1 Dedicated channel for Decagon ECH$_2$O® probe or Delta-T Theta™ probe. 0-5V
Power Out: 0-5 VDC
Power In: 10.5-28 VDC
Connections: Terminal strip with screw posts

Infrared Gas Analyzer

Measurement Principle: Non-Dispersive Infrared
Traceability: Traceable to WMO standards for CO_2.
NIST traceable LI-610 Portable Dew Point Generator for H2O

CO_2
Measurement Range: 0-3000 ppm
Accuracy: 1.5% of reading
Calibration Drift
Drift at 0 ppm: <0.15 ppm/°C
Span Drift[1]: < 0.03 %/°C
Total Drift at 370 ppm: <0.4 ppm/°C
RMS Noise at 370 ppm with 1 sec signal averaging: <1 ppm
Sensitivity to water vapor: < 0.1 ppm CO_2/mmol/mol H_2O

H_2O
Measurement Range: 0-60 mmol/mol
Accuracy: 1.5% of reading
Calibration Drift
Drift at 0 ppt: <0.003 mmol/mol/°C
Span Drift[1]: <0.03 %/°C
Total Drift at 10 ppt: <0.009 mmol/mol/°C
RMS Noise at 10 ppt with 1 sec signal averaging: <0.01 mmol/mol
Sensitivity to CO_2: <0.0001 mmol/mol H_2O/ppm CO_2

[1] Residual error after zero correction

10 cm Survey Chamber – 8100-102

System Volume: 854.2 cm^3
Soil Area Exposed: 83.7 cm^2 (13 $in.^2$)
Dimensions: 15.2 cm L × 15.2 cm W × 25.4 cm H (6" × 6 " × 10")
Air temperature thermistor
  Operating Range: –20 to 45 °C
  Accuracy: ± 0.5 °C over 0-70 °C
Cable length: 1. 01 m (40")
Weight: 1.6 kg (3.5 lb.)

20 cm Survey Chamber – 8100-103

System Volume: 4843 cm^3
Soil Area Exposed: 317.8 cm^2 (49.3 $in.^2$)
Dimensions: 28.7 cm L × 28.7 cm W × 29.2 cm H (11.3" × 11.3 " × 11.5")
Air temperature thermistor
  Operating Range: –20 to 45 °C
  Accuracy: ± 0.5 °C over 0-70 °C
Cable length: 1. 01 m (40")
Weight: 2.9 kg (6.4 lb.)

Long-Term Chamber – 8100-101

System Volume: 4092.5 cm^3
Soil Area Exposed: 317.8 cm^2 (49.3 $in.^2$)
Dimensions: 43.2 cm L × 38.1 cm W × 20.3 cm H (17" × 15" × 8")
Weatherproof Rating: Tested to IEC IP55 standard
Air temperature thermistor
  Operating Range: –20 to 45 °C
  Accuracy: ± 0.5 °C over 0-70 °C
Cable length: 2 m (6.56 ft.)
Weight: 5.9 kg (13 lb.)

Long-Term Chamber – 8100-104

System Volume: 4076.1 cm^3
Soil Area Exposed: 317.8 cm^2 (49.3 $in.^2$)
Dimensions: 48.3 cm L × 38.1 cm W × 33.0 cm H (19" × 15" × 13")
Weatherproof Rating: Tested to IEC IP55 standard
Air temperature thermistor
  Operating Range: –20 to 45 °C
  Accuracy: ± 0.5 °C over 0-70 °C
Cable length: 2 m (6.56 ft.) or 15 m (49.2 ft.)
Weight: 5.9 kg (13 lb.)

Accessories

Soil Temperature Probe (Type E, p/n 8100-201): 6.4 mm (0.25") dia., 250 mm (10") immersion length
Soil Temperature Thermistor (p/n 8100-203)
Soil Moisture Probe (ECH$_2$O Model EC-5, p/n 8100-202): 5 cm (2") length
Soil Moisture Probe (ThetaProbe Model ML2, p/n 8100-204)
8100-664 Trace Gas Sampling Kit: Used to collect samples from the same air stream used to measure CO_2 flux for further trace gas analysis.

LI-8150 Multiplexer

Dimensions: 40.6 cm L x 57.2 cm W x 21.1 cm H (16″ x 22.5″ x 8.3″)
Weatherproof Rating: Tested to IEC IP55 standard
Weight
- **8 port version:** 9.4 kg (20.7 lb)
- **16 port version:** 11.2 kg (24.8 lb)

Operating Range
- **Temperature:** –20 to 45 °C
- **Humidity:** 0 to 95% RH, non-condensing

Coverage Area
- **Max radius from LI-8150 to chambers:** 15.0 m (49.2 ft)
- **Max diameter of measurement circle:** 30.0 m (98.4 ft)

Plumbing
- **Flow rate to/from chambers:** 2-5 lpm (user adjustable)
- **Flow rate between LI-8100 and LI-8150:** 1.7 lpm
  Pump in the LI-8100 sub-samples air stream in the LI-8150
- **LI-8150 Pump Type:** Rotary-vane (non-pulsating flow)

Display
- **Four LED Indicators:** Power, Check Error Log, Manual Chamber Activation Indicator, Active Chamber Error
- **Five 7-segment LED Displays:** Active Chamber, Active Valve, three voltage channel indicators

Power Requirements: 10.5 – 14.5 VDC (120 VAC and 240 VAC with optional power supply)
Power supplied through the LI-8150; LI-8150 powers the LI-8100 when connected

See example below for total system power requirements

LI-8100 + LI-8150 + n Chambers	Sampling: No chamber movement		Sampling: Two chambers move at one time		Warm-up: Up to four chambers move at one time	
n Chambers	Amps @ 12.5VDC	Watts	Amps @ 12.5VDC	Watts	Amps @ 12.5VDC	Watts
1	1.0	12.5	3.0	37.5	3.0	37.5
2	2.0	25.0	3.8	47.5	3.8	47.5
4	2.1	26.3	3.8	47.5	4.8	60.0
8	2.1	26.3	3.8	47.5	4.8	60.0
16	2.3	28.8	3.8	47.5	4.8	60.0

Chamber Sensor Interface

Dimensions: 10.2 cm L x 3.8 cm W x 6.4 cm H (4" x 1.5" x 2.5")
Inputs: 3 general input channels (0-5 VDC)
Power supply (external or from LI-8150):
- **Constant or switched:** 0-5 VDC
- **Unregulated:** 12 VDC (12-13.5 VDC typically)
- **Connections:** Terminal strip with screw posts

Accessories

Soil temperature thermistor (p/n 8150-203):
6 foot cable. Accuracy: ±1.0 °C from –20 to 50 °C
Soil Moisture Probe (ECH$_2$O Model EC-5, p/n 8150-202): 5 cm (2") length
Soil Moisture Probe (ThetaProbe Model ML2 p/n 8150-204)
Cable/hose extension assembly
Length: 15 m
Connections:
- **Electrical cables:** Turck weatherproof connectors
- **Air hoses:** Quick-connect fittings

8150-662 Profiling Kit: Used for performing atmospheric profiling studies using the LI-8150 Multiplexer and LI-8100 Analyzer Control Unit.

8150-770 DC Power Supply

Power Requirements: 115-120VAC or 230-240VAC, 50/60 Hz, 230W. Input voltage range is switch-selectable and must be configured before applying power. Fuses located inside box cover.
Weatherproof Rating: Tested to IEC IP55 standard
Output Voltage: 12VDC, 4.5A
Operating Temperature Range: -20 to 50 °C (-4 to 122 °F)
Environmental Operating Conditions: Tested to IP55 for dust and water ingress.
Dimensions: 18.1 cm D x 28 cm L x 10.2 cm T (7.125″ x 11″ x 4″)
Weight: 31 kg (14.05 lbs.)

B Pin Assignments

The LI-8100 uses a round Turck connector on the side panel for RS-232 output. A serial adapter cable (p/n 9981-018) with a round Turck connector and a DB-9 connector attaches to the LI-8100 RS-232 port. A second standard LI-COR cable (p/n 9975-016) in turn attaches to the serial adapter cable, which connects to the DB-9 connector on a computer. The pin assignments on the DB-9 connectors on both LI-COR cables are given below; note that not all pins are used for communication between the
LI-8100 and a computer. If you want to make a custom cable for use with the LI-8100, follow the list below for the proper connections.

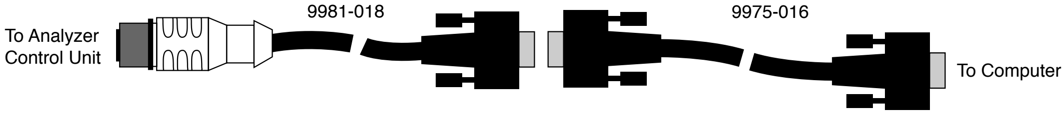
The standard LI-COR RS-232 cable and Serial Adapter cable pin assignments are as follows:

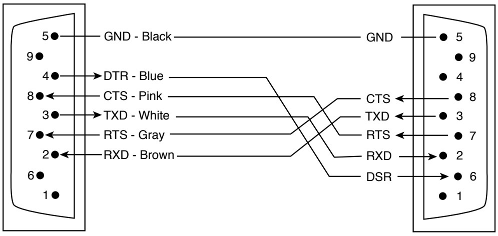
9981-018

Color	PIN	Function
Black	5	GND
Brown	2	RXD
Pink	8	CTS
Blue	4	DTR
Gray	7	RTS
White	3	TXD

9975-016

PIN	Function
5	GND
3	TXD
7	RTS
6	DSR
8	CTS
2	RXD





C Glossary of Terms

Add CRC to data. CRC (Cyclic Redundancy Check) is an algorithm used to verify data integrity. Before each data packet is sent from the LI-8100, a CRC is calculated (pre transmission) for that packet and appended to it. When the client receives the packet, it strips off the appended CRC and calculates its own CRC (post transmission). If the two CRC values match the packet was transmitted OK. When the CRC values are appended to a data packet, the value is always marked up. A typical CRC will appear like the following: <CRC>3067450353</CRC>. The LI-8100 uses the POSIX 1003 definition to compute a 32 bit CRC.

Auto Restart. Causes the instrument to resume an interrupted measurement on instrument restart.

Bench Temp. Temperature of the optical bench. Labeled Tbench in the data. Units; °C

Case Temp. Temperature measured inside the system case. Labeled Tboard in the data. Units; °C

Chamber Offset. Computation of soil CO_2 flux requires an estimate of the total system volume. The IRGA, chamber and tubing volumes have been determined by LI-COR. The air volume inside the collar above the soil is an unknown and must be calculated from the Area and the chamber offset measured as described in Section 2, *Measuring the Chamber Offset*. Units; cm.

Chamber Temp. Air temperature inside the chamber. Labeled Tcham in the data. Units; °C

Chamber Volume. The volume of the chamber and associated tubing. Labeled Vcham in the data. Units; cm^3.

Channel. A range of radio frequencies between 2.4 GHz and 2.5 GHz have been designated for public use in most countries. The channel refers to a specific portion of the total frequency range that is given to a device for communication. The LI-8100 supports channels 1 to 11.

CO_2. Chamber CO_2 concentration. Units; µmol CO_2 mol^{-1} air

CO2 Abs. Absorption of photons in the optical bench due to CO_2

CO_2 Absorption. Absorption of photons in the optical bench due to CO_2

CO2 Dry. CO_2 corrected for water vapor dilution. Labeled Cdry in the data. Units; µmol CO_2 mol^{-1} air.

Comments. User entered information included in the data file header. Maximum of 100 characters.

Compact Flash Card. Removable card used for additional/transportable data storage

CrvFit.
2: Number of points used in the curve fit
3: A
4: Cx

CrvTime.
2: T_o
3: Dead band
4: Domain of the fit (Stop time-Start time)

Date. Output in the format; 02/19/2004 14:26
Units; Month:day:year:hour:minute:second

DCdry/dt.
2: Slope at To (Exponential fit)
3: Slope of linear fit
4: Standard error (Exponential fit)

Dead Band. After a chamber closes there is a time interval before steady mixing is established. The Deadband is a user entered estimate of what this interval is. Data collected prior to the end of the Deadband interval are not used in the flux computations, however, the data are stored in the raw file. The Deadband requirement will change depending upon the chamber geometry, system flow rate and collar and site characteristics (Fig. 4-2 Shows a time series of CO_2 vs time across two observation cycles. This Figure illustrates Deadband, Obs. Length and Obs. Delay). Generally we have found a Deadband between 10 and 60 seconds to be adequate. However, there may be conditions where longer deadbands are needed and the user can recompute the data with different deadbands in the "File Viewer" software. Units; seconds.

Enable Data Encryption. WEP (Wired Equivalent Policy) is an encryption standard built into 802.11b and is supported by the LI-8100. If data encryption is enabled, the same 40 bit (5 character) key must be entered on all devices of the WLAN. The key is used for data encryption and decryption.

Etime. The instrument begins logging data (Raw or Type 1) the instant the chamber is actuated and begins to close (closing). The elapsed time label (etime) is set to 0 for all records which are collected while the chamber is closing. Once the chamber is closed the elapsed time increments with clock time in seconds.

File Name. The data file name can be up to 30 characters long. The file name is case sensitive (Windows file naming is not case sensitive so be careful NOT to name two files with the same name but in different case).

Flow Rate. The system pump provides a flow of between 0.5 to 1.5 liter per minute. We recommend that both the Survey and the Long Term Chamber should be operated at the High flow rate which is about 1.5 liter per minute.

Flux.
2: Flux at To (Exponential fit)
3: Flux at To (Linear fit)
4: CV of flux (Exponential fit)

H_2O. Chamber Water Vapor Concentration. Units; mmol H_2O mol^{-1} air

H2O Abs. Absorption of photons in the optical bench due to H_2O

H_2O Absorption. Absorption of photons in the optical bench due to H_2O

Instapp.exe. Palm Application used to install software from a PC to the Palm

Instrument Name. User entered name for an instrument. Maximum of 30 characters.

IP Address. The IP address is a number that uniquely identifies each node on the network. The address is composed of a set of four numbers called octets, where each octet ranges in value from 0 to 255. When entering an IP address, the octets are separated with a period. For example, 192.168.100.2 is a valid IP address.

IRGA Averaging. This setting controls the amount of averaging that is done to CO_2 and H_2O signals from the IRGA. The IRGA is sampled at 2Hz. With 4 second IRGA Averaging (the default recommended setting) 8 data points will go into any value of CO_2 or H_2O. As data stream in earlier data are dropped from the average. The minimum is 1 second and the maximum is 20 seconds.

IRGA Volume. Volume of optical bench and associated tubing inside the system case. Labeled Virga in the data. Units; cm^3.

Log Every. User specified rate that Type 1 (Raw) records are being stored. Typically set to 1 second. However, if an observation length of more than 2 minutes is specified the user may want to consider changing the Log Every value to 2 or 3 seconds just to keep the number of records manageable

Log raw data records. Logs the default data set plus all selected variables at the specified Log Every interval

Measurement. A collection of one or more observations.

Netmask. The net mask is a set of four octets used to separate an IP address in to the network address and the host address

Network Name. The network name or SSID (Service Set Identifier) is a name given to a wireless network (WLAN). Each device that needs to communicate must have the same SSID. The LI-8100 supports a network name of up to 30 characters.

Observation. The collection of data sets over a user-specified time period, which is typically the time during which the chamber is closed.

Obs#. The current observation number.

Observation Count. Number of observations for a given measurement.

Observation Delay. Time interval between the instant a chamber begins to open after an observation and the instant it begins to close for the next observation (Fig 4-2). Units; minutes,seconds.

Observation Length. Time from the instant the chamber closes until the instant it begins to open (see Fig 4-2). Units; minutes,seconds.

Onboard Internal Flash. Memory built into the LI-8100 system.

Optional Data Fields. Optional data fields which can be logged but have no effect on the final flux calculation.

Outputs. The Outputs window is used to independently configure each of the LI-8100's output channels. This functionality is intended for those who want to control the LI-8100 with a custom communication device. Changing any of the outputs will have no effect on a measurement or future connections with the PC or Palm Clients.

Pressure. Atmospheric pressure measured in the optical bench. Units; Kpa

Purge Time. The amount of time during which air continues to flow through the chamber as it begins to open, after the measurement is complete.

Quit if RH exceeds. The LI-8100 will abort the measurement and open the chamber if the RH exceeds the user set limit and the check box in the software is checked.

RAWCO2. CO_2 Raw signal

RAWH2O. H_2O Raw signal

Remove XML from data. Before the LI-8100 outputs data, each field is "marked up" to delimit that field. For example, when a CO_2 value is output, the value is placed between two tags to describe what that value is: <CO2>350.21</CO2>. Checking "Remove XML from data" will strip all of the markup from the data stream. Therefore, the end result is a data stream where each data field is separated by a space.

Repeat the Same Protocol. Repeats the measurement seup *n* number of times every time interval.

RH. Relative Humidity

Soil Area. Area encompassed by the chamber collar. In the data set this variable is called Area. Units; cm^2.

Soil Moisture. User voltage channel 4 (dedicated to soil moisture)

T1. User Thermocouple Channel 1. Units; °C

T2. User Thermocouple Channel 2. Units; °C

T3. User Thermocouple Channel 3. Units; °C

T4. User Thermocouple Channel 4. Units; °C

10s Flux. A 10 second running estimate of soil CO_2 flux only found in the real time display of data. Units; $\mu mol\ CO_2\ m^{-2}\ s^{-1}$

Total Volume. Total System Volume. Labeled Vtotal in the data and is computed as follows, (Vtotal = Virga + Vcham + (chamber offset x Area)). Units; cm^3.

Treatment Label. User entered information which can be prompted for and included in a data record. Maximum of 30 characters.

Turn off flow pump. Shuts the pump off until the user ticks the button again or the LI-8100 is restarted.

Type.
Type 1 = Raw records
Type 2 = Initial Value
Type 3 = Mean
Type 4 = Range

V1. User Voltage Channel 1

V2. User Voltage Channel 2

V3. User Voltage Channel 3

Vin. Input (battery) voltage. Units; volts

D Equation Summary: Final Variables

As described in Section 3, *About LI-8100 Data Records*, the **Summary Records** consist of a number of **Measured Variables**, some of which appear in all **Observations**, and some of which are optional, and a number of **Final Variables** of Type 2, 3, or 4, as shown in Table 3-1.

As described in Section 4, *Theory of Operation*, the value of C_{dry} is the instantaneous water-corrected chamber CO_2 mole fraction called $C'(t)$in equation (4-13); its initial value is computed from the intercept of a linear regression of the first 10 points after the chamber closes. This is used as a parameter in the non-linear regression that fits equation (4-13) to the $C'(t)$ *vs* t data between the end of the Dead Band and the end of the observation. This regression yields values needed to obtain the soil CO_2 efflux rate. The discussion below describes how the appropriate slope of C_{dry} is computed and used to compute the Final Variables in the LI-8100 Summary Records.

Computing the slope of C_{dry} requires a three-step process:

1. Fit C_{dry} vs E_{time} for Type 1 data. This is called function $f(t)$, which is shown in Equation (4-13).

2. Compute time t_0 such that

$$t_0 = f^{-1}(C_0) \qquad \text{D-1}$$

where C_0 is the initial value of C_{dry}.

3. Compute the slope from the derivative of $f(t)$ at time t_0:

$$\frac{dC}{dt}dry = \frac{d}{dt}f(t_0) \qquad \text{D-2}$$

Standard error of this slope (used for the Type 4 value of "dCdry/dt") is given by

$$SE\Big|_{slope} = \sqrt{\frac{SS_E}{(n-2)S_{tt}}} \qquad \text{D-3}$$

where

$$SS_E = \sum_{i=1}^{n} (y_i - f(t_i))^2 \qquad \text{D-4}$$

y_i are the individual C_{dry} values, $f(t_i)$ are the computed C_{dry} values at E_{time} t_i, and n is the number of points used.

$$S_{tt} = \sum_{i=1}^{n} t^2 i - n(\bar{t})^2 \qquad \text{D-5}$$

where $\bar{t}$ is the mean E_{time}. The coefficient of determination R^2 of the fit (used for the Type 4 value of "CrvFit") is given by

$$R^2 = 1 - \frac{SS_E}{S_{yy}} \qquad \text{D-6}$$

where

$$S_{yy} = \sum_{i=1}^{n} y^2 i - n(\bar{y})^2 \qquad \text{D-7}$$

where $\bar{y}$ is the mean C_{dry} value.

Flux is computed from Equation (4-12).

The coefficient of variation (CV in %) of the Flux F_c (used for the Type 4 value of "Flux") is estimated by

$$CV\Big|_{Flux} = 100\sqrt{\left(\frac{SE\big|_{slope}}{\frac{dc_{dry}}{dt}}\right)^2 + \left(\frac{E_P}{P_0}\right)^2 + \left(\frac{E_T}{)T_0 + 273}\right)^2 + \left(\frac{E_W}{(1000 - \overline{W})}\right)^2} \qquad \text{D-8}$$

where E_P, E_T, and E_W are the assumed absolute errors of pressure, temperature, and water measurements. E_P, E_T, *and* E_W are all assumed to be 1.0.

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 an 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 or 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 location to location. 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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