LI-7500A

Open Path CO_2/H_2O Gas Analyzer

Instruction Manual

LI-7550
Analyzer Interface Unit

For use with:
- LI-7200 CO_2/H_2O Analyzer
- LI-7500A CO_2/H_2O Analyzer
- LI-7700 CH_4 Analyzer

LI-COR
Biosciences

LI-COR
LI-7500A

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Biosciences

LI-7500A Open Path CO$_2$/H$_2$O Analyzer Instruction Manual

Declaration of Conformity

Manufacturer's Name: LI-COR, Inc.

Manufacturer's Address: 4647 Superior Street
Lincoln, Nebraska USA 68504

declares that the product

> **Product Name:** Open Path CO_2/H_2O Infrared Gas Analyzer

> **Model Number(s):** LI-7500A

> **Product Options:** None

conforms to the following Product Specifications:

> EMC: FCC 47 CFR Part 15.109 Radiated Emissions, Class A

> EN 55011 : 2002 Radiated Emissions, Class A
> IEC 61000-4-2 : 2000 ESD, 4KV/8KV Contact/Air
> IEC 61000-4-3 : 2002 Radiated RF Immunity, 10V/m
> IEC 61000-4-4 : 2004 EFT/Burst
> IEC 61000-4-6 : 2003 Conducted RF Immunity, 3V

Supplementary Information:

The product herewith complies with the requirements of the EMC Directive 2004/108/EC.

John Rada
Director of Engineering

Document #53-10970
July 22, 2009

LI-7500A						
	Hazardous Substances or Elements					
Component Name	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Chromium VI Compounds (Cr^{6+})	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
Head Assembly	X	O	O	X	O	O
Head Board Circuit Board Assembly	X	O	O	O	O	O

O: this component does not contain this hazardous substance above the maxiumum concentration values in homogeneous materials specified in the SJ/T 11363-2006 Industry Standard.

X: this component does contain this hazardous substance above the maxiumum concentration values in homogeneous materials specified in the SJ/T 11363-2006 Industry Standard (Company can explain the technical reasons for the "X")

LI-7500A 开路式CO_2/H_2O 分析仪						
	有毒有害物质或元素					
部件名称	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr^{6+})	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
探头组件	X	O	O	X	O	O
探头电路板组件	X	O	O	O	O	O

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T 11363-2006 标准规定的限量要求以下。

X: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T 11363-2006 标准规定的限量要求。(企业可在此处，根据实际情况对上表中打 "X" 的技术原因进行进一步的说明。)

NOTICE

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

Publication No. 984-10563

Printing History
New editions of this manual will incorporate all material since the previous editions. Update packages may be used between editions which contain replacement and additional pages to be merged into the manual by the user.

The manual printing date indicates its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates which are incorporated at reprint do not cause the date to change).

The LI-7500A is covered by U.S. Patent #6,317,212, German Patent # 020031-006700DE and Great Britain Patent #020031-006700GB; other patents pending.

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1st Printing - December, 2009
2nd Printing – April, 2011
3rd Printing – June, 2012
4th Printing – March, 2013

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1   General Information

Overview of the LI-7500A

The LI-7500A is a high performance, non-dispersive, open path infrared CO_2/H_2O analyzer designed for use in eddy covariance flux measurement systems. Some of the LI-7500A's important features include:

- Simultaneous measurements of CO_2 and H_2O in the free atmosphere.
- High speed measurements. Internal 150 Hz measurements are digitally filtered to provide a true 5, 10, or 20 Hz bandwidth.
- Withstands exposure to rain or snow without damage or calibration shift.
- Versatile output options with the included LI-7550 Analyzer Interface Unit: Ethernet, DACs, Synchronous Device for Measurement (SDM), and RS-232.
- Simple Windows® software provides for easy user calibration and configuration.

> **IMPORTANT NOTE!** LI-COR Biosciences does not endorse the suitability of the LI-7500A for applications on moving platforms or in applications where the instrument is exposed to corrosive elements (i.e., oceanographic salt water spray). If you have questions about the suitability of the LI-7500A for your application, please contact LI-COR.

What's What

If you have just taken delivery of your LI-7500A, check the packing list to verify that you have received everything that was ordered and that you have also received the following items:

- **Standard Spare Parts Kit -** (part #7500-028). This kit contains replacement parts for your LI-7500A. Among other items, the spares kit contains the calibration accessory, tubing and sensor head mounting kit. As you become familiar with the analyzer you will learn which items to keep close at hand and which items can be stored away. The LI-7550 Analyzer Interface Unit also has a spare parts kit (p/n 9975-023) with spares that are

specific to the Interface Unit; this is where the cables (below) and Analyzer Interface Unit mounting brackets are located.

The spares kits include these commonly used items:

Description	Qty.	LI-COR Part No.
LI-7500A Spares Kit	1	7500-028
Bev-a-line Tubing	15'	222-01824
Sensor Head Mounting Kit	1	9975-010
Calibration Accessory	1	9975-024
Calibration Accessory Gaskets	1	9975-014
Ambient Temperature Sensor	1	9975-026
LI-7550 Analyzer Interface Unit Spares Kit	1	9975-023
Control Unit Mounting Kit	1	9972-029
RS-232 Cable	1	392-10268
Power Cable	1	9975-030
Analog Input/Output Cable	1	392-10109
Ethernet Cable	1	392-10108
Ethernet Adapter Cable	1	392-10107
SDM Interface Cable	1	392-10093
5 Amp Fuse	2	439-04214
16 GB USB Flash Drive	1	616-10723
(Optional) Auxiliary Sensor Interface Spares Kit	1	9975-032
U-Bolt, ¼ x 20	2	184-09842
Hex Nut	4	163-00138
Santoprene 1/16" I.D., 3/16" O.D.	2'	222-08325
Quick Connect Plug	10	300-07393

●   **RS-232 Cable** - (part #392-10268). Used to connect the LI-7550 to a computer. This null modem cable is terminated with a 9-pin DB-9 type connector; if your computer has a 25-pin serial connector, you will need to use a 9-pin to 25-pin adapter.

●   **Power Cable** - (part #9975-030). Used to connect the LI-7500A to a 10.5-30VDC power supply (3A or greater). The power cable is terminated with bare wires for connection to a user-supplied battery or other DC power supply.

- **Ethernet Cables** - Two Ethernet cables are included for connection to a Local Area Network (LAN) via an Ethernet port. Part #392-10108 is a 5m cable terminated on both ends with a male Turck connector; one end plugs into the LI-7550 Analyzer Interface Unit, and the other end plugs into the Ethernet Adapter Cable. Part #392-10107 is a short Ethernet adapter cable that is terminated with an RJ-45 connector, and is used to connect the 5 m Ethernet cable to an Ethernet wall socket or into your computer's Ethernet port.

- **SDM Interface Cable** - (part #392-10093). Used to connect the LI-7500A in a Synchronous Device for Measurement (SDM) loop, such as those used by Campbell Scientific data recording devices.

- **Analog Input/Output Cable** - (part #392-10109). Used to connect external sensors, including temperature and/or pressure transducers, or a sonic anemometer to the LI-7550, or for DAC outputs from the LI-7500A.

- **External Temperature Sensor** - (part #9975-026). An external temperature thermistor is included for measuring ambient temperature outside of the LI-7550 Analyzer Interface Unit.

- **Sensor Head Control Cable** - (part #392-09806). Connects the sensor head to the LI-7550 Analyzer Interface Unit. A second 5m control cable can be connected, as well, to extend the distance between the sensor head and the LI-7550 Analyzer Interface Unit to 10 meters. Only one extension cable can be used.

- **Data Communications Software -** (part #7500A-50). This Windows® XP/Vista/7/8 compatible software allows your computer to communicate with the LI-7500A. The software is provided on CD. A complete description of this software can be found in Section 4, *Operation*.

- **Calibration Accessory -** (part #9975-024). Contains a calibration shroud required for setting the zero and span of the LI-7500A. Complete calibration instructions can be found in Section 5.

- **Calibration Certificate** - Contains the calibration coefficients for your LI-7500A sensor head. These values are unique to each sensor head, and have been entered into the control box at the factory. Keep this sheet in case you need to re-enter these values.

● **Sonic Anemometer Cable(s)** – Optional cables are available for direct connection between the LI-7550 Analyzer Interface Unit and sonic anemometers from Gill Instruments Ltd. (Hampshire, England) and Campbell Scientific Inc. (Logan, UT). Cable part number 9975-033 connects the LI-7550 to the Gill Windmaster™ sonic anemometer, and cable part number 9975-035 connects the LI-7550 to the Campbell Scientific CSAT3 sonic anemometer.

Getting Started Tutorial

The following section briefly covers the basic steps you might follow to set up the LI-7500A to collect and record data. Many of these steps are described in greater detail elsewhere in this manual.

1

Connect Sensor Head

The LI-7500A sensor head is connected to the control module using the 392-09806 Sensor Head Control Cable, which is a 5 m (15') shielded cable. The cable has a circular connector which is attached to the sensor head as shown in Figure 1-1. Align the cable connector and the sensor head, and push straight in. Tighten the knurled nut. Make sure the nut and connector are not cross-threaded and form a good seal. An additional ½ turn after finger tightening using a pair of pliers helps to ensure a watertight seal is formed. The other end of this cable attaches to the LI-7550 Analyzer Interface Unit at the connector labeled **IRGA**.

Figure 1-1. Align the connectors and tighten the knurled nut.

2

Connect Power Supply

The power supply cable (#9975-030) has a circular connector that attaches to the LI-7550 Analyzer Interface Unit front panel at the location marked **POWER**. The other end has bare wire leads for connection to a 10.5-30VDC supply (3A or greater). Connect the red lead to the positive terminal of the power supply, and the black wire to the negative terminal.

3

Connect External Temperature Sensor

An external temperature thermistor (Figure 1-2) is included for measuring ambient temperature outside of the LI-7550 Analyzer Interface Unit. The thermistor plugs into the connector labeled **SENSOR** on the LI-7550 front panel.
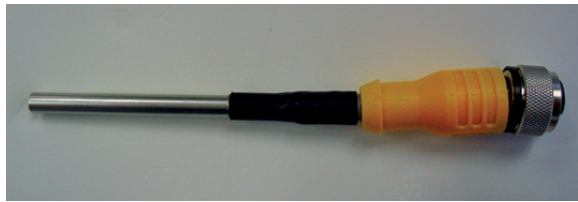
Figure 1-2. 9975-026 External temperature sensor.

4

Install LI-7500A PC Communications Software

This software is required for communicating with a computer. Installation instructions can be found in Section 4, *Installing the PC Communications Software on Your Computer*.

5

Connect RS-232 or Ethernet Cables

Connect the RS-232 cable, or the 392-10108 Ethernet cable to the LI-7550 front panel. If using the Ethernet cable, attach the Ethernet Adapter Cable (p/n 392-10107) to the the 392-10108 cable, and plug the RJ45 connector into your computer or a network jack.

6

Start LI-7500A Communications Program

Open the **LI-7500A** Windows Communications program. If you are connected via the Ethernet cable, you should see your instrument listed by serial number in the 'Connect to:' window. Select it and click **Connect**. Alternatively, choose the COM (serial) port to which the RS-232 cable (Step 4) is connected to the computer, select a baud rate, and click on **Connect**. After a few seconds, you should see "live" numbers on the display.

7

Verify Calibration Coefficients

Click on the Calibration icon on the toolbar, click on the Coefficients tab, and verify that the information on this page matches what is printed on the calibration sheet for the sensor head being used. (Sensor heads are interchangeable, but the calibration coefficients, as well as the zero and span parameters on the *Calibration* page, are unique to each sensor head). Save the correct calibration configuration to your computer.

8

Verify CO_2 and H_2O Response

If the sensor head is indoors, it may be reading very high values of CO_2; if you exhale toward the sensor head, CO_2 and H_2O should show a sudden spike upward.

9

Monitor Signal Strength

Select and display "CO_2 Signal Strength". Make a note of this value, as it represents the "clean window" baseline value (assuming your instrument is new). Typical "clean window" values will be close to 100. As dirt accumulates on the windows (or anywhere in the optical path), the "CO_2 Signal Strength" value will decrease. Use the trend in this value as an indicator of when to clean the windows and check the calibration. More information can be found on pages 3-7 and 7-5.

10 (Optional) Verify Calibration

If you have facilities to check zero and span, do so now (see Section 5, *Calibration*). This was done at the factory prior to shipping, so should not be necessary on new instruments*. Note the zero values for CO_2 and H_2O, if this is a new instrument. As the internal chemicals become depleted, these values will increase (when you re-zero).

* If you find the span needs re-setting, it is possible that your CO_2 (or H_2O) gas standards differ from LI-COR's.

2   Initial Setup

Installing the LI-7500A

Mounting the LI-7550 Analyzer Interface Unit

Two mounting plates (p/n 9979-022) are included that can be used to mount the LI-7550 using hose clamps to secure the box to a tripod or other post. There are holes in the four corners of the box, as well, that can be used to attach the box directly to a flat surface, if desired.

The mounting plates and hose clamps are designed to accomodate a square or circular mounting post of up to 2.75" in width (diameter). Hardware is included to attach the mounting plates to the Analyzer Interface Unit using 4 hex head bolts (p/n 150-12943). The hose clamp mounting brackets are attached to the mounting plates, and then the hose clamps can be inserted through the holes in the hose clamp mounting brackets, and tightened around the post, as shown in Figure 2-1. The hose clamp mounting brackets can be inserted through any of the holes in the mounting plates to accomodate a variety of mounting options for the LI-7550, as shown in Figure 2-1.

Item	Qty.	Part No.	Description
1	4	150-12943	M6x1 x 16 MM Hex Head Bolt
2	4	167-02054	Flat Washer 1/4 x 5/8"
3	2	167-05635	Split Washer 5/16"
4	2	235-13234	Single Bolt Flared Leg Mounting Bracket
5	2	300-13293	Hose Clamp, 9/16"
6	2	9879-044	Mounting Plate
7	2		5/16-24 x 1/2" Hex Head Bolt (included w/item #4)
8	2		5/16" Flat Washer (included w/item #4)
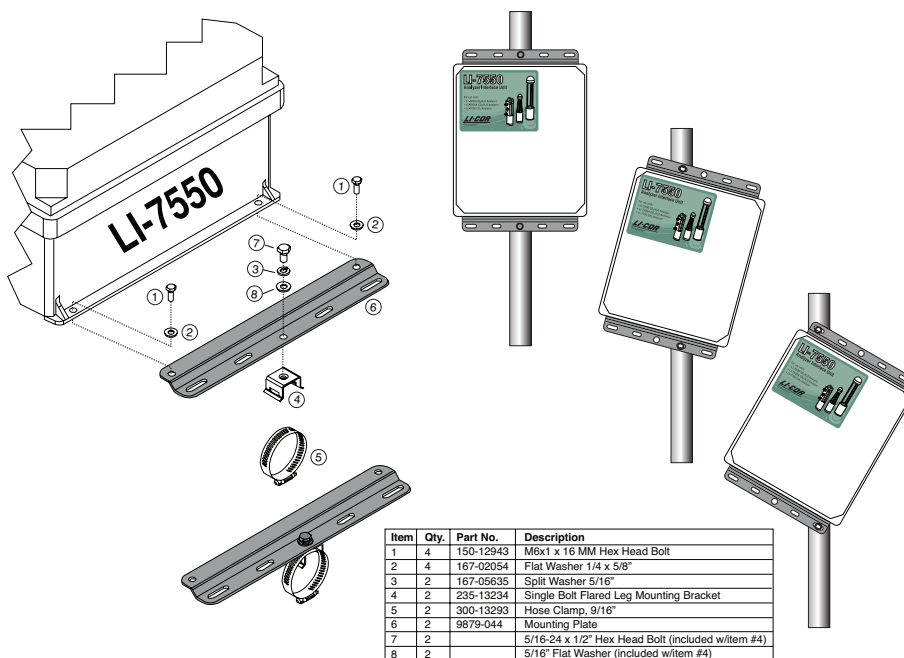
Figure 2-1. Attach mounting plates to Analyzer Interface Unit, attach hose clamp mounting brackets to mounting plates, and secure to mounting post using hose clamps.

There are some additional considerations that should be taken into account when locating the Analyzer Interface Unit, including:

1. The cable that connects to the sensor head is 5 meters in length; determine the height at which the sensor head will be mounted, and plan to mount the Analyzer Interface Unit accordingly. A second sensor head control cable (p/n 9972-032) can be added, if necessary, to extend the total cable length to a maximum of 10 meters.

2. The thermal properties of the Analyzer Interface Unit are such that it is OK to place the box in direct sun.

3. The power cord provided is 5 meters in length. Longer cables can be purchased through distributors of Turck, Inc. (see *List of Suppliers* in Appendix C). Note, however, that longer cables may require a larger power source.

Mounting the Sensor Head

The LI-7500A sensor head has a mounting post that can be used to mount the analyzer. The mount is threaded to accept standard 3/8-16 tripod screws (a 1/4-20 adapter is also included, which can be threaded into the mounting post). Mounting the sensor head at a slight angle from vertical (~10-15°) may also help prevent water droplets from remaining on the windows during rainstorms.
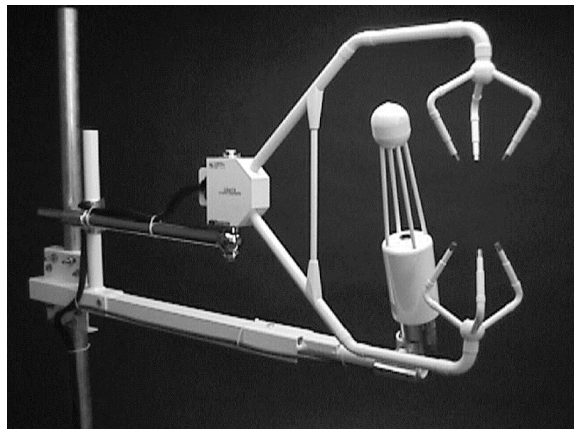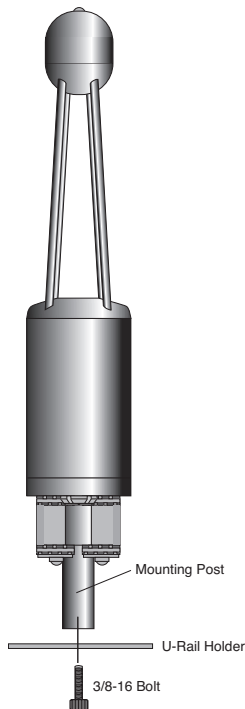
Figure 2-2. Mount the sensor head near the sonic anemometer, at a slight vertical angle.

The sensor head mounting post can also be attached to a U-rail type holder and fastened with a 3/8-16 screw (or a 1/4-20 screw, when using the adapter bushing).

A vertical mounting orientation provides 360° acceptance for wind direction (neglecting the sonic anemometer location, of course), and this is the recommended orientation. However it is oriented, the sensor head should be placed as close to the sonic anemometer as possible, and at equal heights, as shown in Figure 2-2.

About the LI-7550 Analyzer Interface Unit

The LI-7550 Analyzer Interface Unit is a weatherproof case that houses the electronics for data output from the LI-7500A sensor head. The front panel also has cable connections for connecting the sensor head and data input/output cables (see Figure 2-4).

The inside of the LI-7550 case is shown on the following page. Note that there is a USB connector for use with a USB flash drive. This provides a convenient method of collecting data. ***LI-COR recommends that you use only an industrial rated USB flash drive; non-industrial rated flash drives can fail, causing you to lose data.*** LI-COR includes a 16 GB industrial rated drive from APRO Co., Ltd. (www.apro-tw.com); see List of Suppliers in Appendix C. *We recommend that you use a flash drive tested by LI-COR, as designated in Appendix C.* As an example, if you are logging all data variables at 10 Hz (10 samples/second), approximately 180 MB of data would be generated each day; thus, the 16 GB drive could collect about 80 days' data, with no compression. With compression, a daily file would be about 50 MB; the 16 GB drive could then collect about 288 days' data.

Always be sure to eject the USB drive properly before removing. After pressing the Eject button, the LED will turn off when it is safe to remove the drive.

⚲ **USB LOGGING -** USE INDUSTRIAL GRADE ONLY!
●   SOLID LED - DRIVE MOUNTED, NOT LOGGING
● ● ● ●   RAPID BLINK - LOGGING
●   ●   SLOW BLINK - ERROR. EJECT AND RETRY
○   NO LED - DRIVE NOT MOUNTED, OK TO REMOVE
WARNING! FAILURE TO PRESS EJECT BUTTON BEFORE REMOVING USB DRIVE WILL RESULT IN LOSS OF DATA!
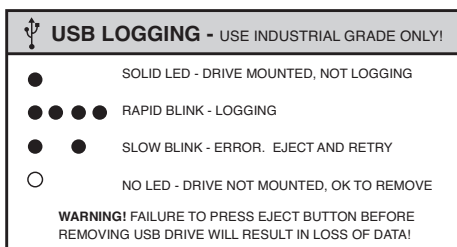
This graphic is part of a larger label present on the inside cover of the LI-7550 Analyzer Interface Unit.

Note that there are three Ethernet connectors inside the LI-7550 case, two of which are connected internally to the Ethernet 1 and Ethernet 2 ports on the front panel. It does not matter to which ports these internal cables are connected (they're connected to ports 2 and 3 in the photo below). The third port is not connected to the panel, but can be used in the field to connect an Ethernet device, if desired (e.g. to calibrate the instrument).

Pressure transducer
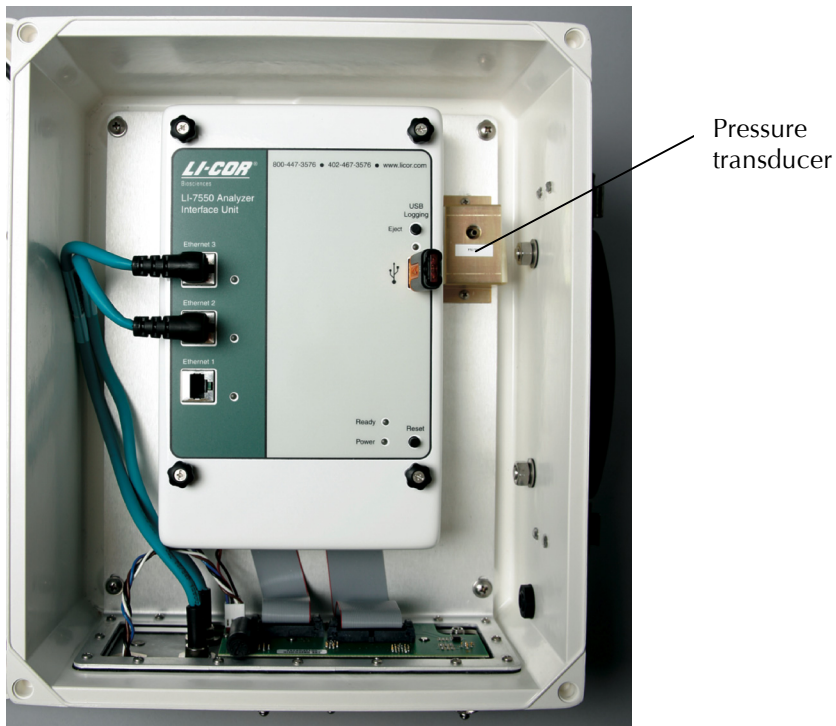
Figure 2-3. LI-7550 indicator panel.

Power On

The LI-7500A has no power switch; it is turned on when power is supplied through the power cable attached to the LI-7550 Auxiliary Interface Unit. The LI-7500A requires a constant power source of 10.5-30VDC (3A or greater). When power is applied, the Power LED on the LI-7550 indicator panel will illuminate, and will stay lit as long as power is supplied. The Ready LED will turn on when the instrument (embedded) software has loaded and the instrument is ready to communicate with a computer.

Cables and Cable Connections

The LI-7500A includes a variety of cables for connecting the sensor head to the LI-7550 Analyzer Interface Unit, and for connection to a user-supplied power supply, as well as to your computer or other data collection devices. All cables are 5 meters in length, and are manufactured by Turck, Inc. (Minneapolis, MN). If you need longer cable lengths, there are several options available:

1. In some cases, LI-COR can provide an extension cable. For example, a second sensor head control cable (p/n 9972-032) can be added, to extend the sensor head up to 10 m from the Analyzer Interface Unit. For other cables (e.g. the Serial and/or Ethernet cables), extension cables are readily available from other suppliers.

2. Custom cable lengths can be purchased from Turck, Inc. Table 2-1 below lists both LI-COR part numbers and Turck part numbers for each cable.

Table 2-1. Turck Eurofast® cables used to connect to the LI-7550.
* = cable length

LI-COR Part Number	Cable	Cable Connector	Turck Part Number
9975-030	Power	4-pin female	RK4.41T-*/S529
392-10093	SDM Interface	4-pin male	RSS 4.4T-*
392-10268	Serial	6-pin female to DB-9 female	RKC 6T-*-DB9F/CS12317
392-10109	Analog In/Out	12-pin male	RSS 12T-*
392-10108	Ethernet	8-pin male-male	RSS RSS841-*M
392-10107	Ethernet Adapter	8-pin female to RJ45	RKC RJ45 840-*M

3. Where appropriate, you can construct your own extension cable(s); Table 2-2 lists the pin assignments and wire colors for the Power, SDM, and Analog In and Out cables. This table is reproduced on the inside front cover of the LI-7550 Analyzer Interface Unit.
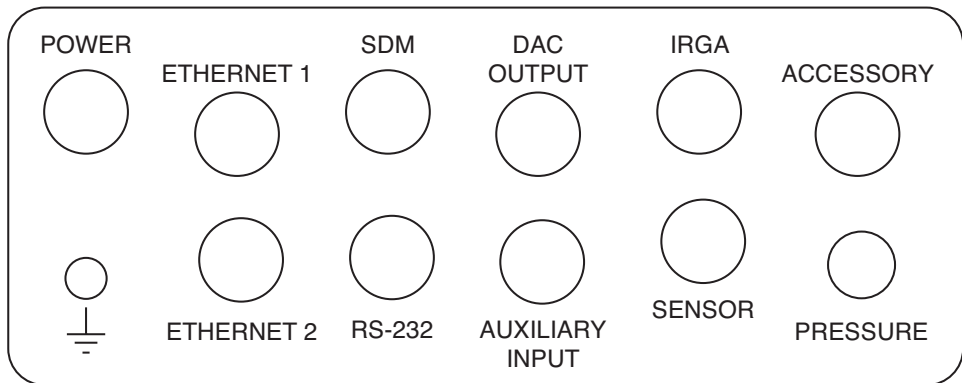
Figure 2-4. LI-7550 Connector Panel.

Power Cable (p/n 9975-030)

The 4-pin female connector plugs into the connector labeled **POWER** on the LI-7550 Analyzer Interface Unit front panel. The power cable is terminated with black (VIN-) and red (VIN+) wires for connection to a user-supplied 10.5-30VDC power supply (3A or greater).

SDM Interface Cable (p/n 392-10093)

For connection to Campbell Scientific (Logan, UT) dataloggers for Synchronous Device for Measurement (SDM) data communications. SDM communications are enabled in the datalogger using either the SDM LI-7500 or CS7500 instructions, depending the datalogger. For more information on using these instructions refer to SDM Output (page 4-20 in this manual) or the instruction manual for your datalogger, published by Campbell Scientific. The SDM Interface Cable connects to the connector labeled **SDM** on the LI-7550 Analyzer Interface Unit front panel.

The pin assignments of the SDM Interface Cable are given in Table 2-2. Generally the blue wire (SDM_DATA) will connect to C1 on the datalogger, the white wire (SDM_CLK) to C2, the brown wire (SDM_EN) to C3 and the black wire (ground) to ground.

Analog Input/Output Cable (p/n 392-10109)

The Analog Input/Output cable is for connection to user-supplied sensors (i.e., pressure, temperature, sonic anemometer). The pin assignments and wire colors are shown below in Table 2-2. There are four analog input channels available. When used with external input devices, this cable plugs into the

connector labeled **AUXILIARY INPUT** on the LI-7550 Analyzer Interface Unit front panel.

This cable is also used for data output to logging devices using the digital-to-analog converters (DACs). Six DAC channels are available; the pin assignments and wire colors are shown below in Table 2-2. The cable plugs into the connector labeled **DAC OUTPUT** on the LI-7550 Analyzer Interface Unit front panel.

This cable can also be used to connect directly to sensors or output devices; an optional weatherproof Auxiliary Interface Box (p/n 7550-101) can be used in place of this cable. Use of the 7550-101 is described later in this section. Note that only one Analog Input/Output cable is included with the LI-7500A; if you intend to use both the Auxiliary Input and DAC Output ports on the LI-7550, you will need to purchase an additional 392-10109 cable, or the 7550-101 Auxiliary Sensor Interface.

Table 2-2. Pin assignments and wire colors for Power, SDM, Auxiliary Input and DAC Output cables.

LI-7550 Pin Assignments

SDM			AUXILIARY INPUT			DAC OUTPUT		
PIN 1	BROWN	SDM_EN	PIN 1	WHITE	AUX1+	PIN 1	WHITE	DAC1
PIN 2	WHITE	SDM_CLK	PIN 2	BROWN	AUX1-	PIN 2	BROWN	DAC2
PIN 3	BLUE	SDM_DATA	PIN 3	GREEN	AUX2+	PIN 3	GREEN	DAC3
PIN 4	BLACK	GND	PIN 4	YELLOW	AUX2-	PIN 4	YELLOW	DAC4
COUPLING	BARE	EARTH GND	PIN 5	GREY	AUX3+	PIN 5	GREY	DAC5
POWER			PIN 6	PINK	AUX3-	PIN 6	PINK	DAC6
PIN 1	BROWN — BLACK	VIN-	PIN 7	BLUE	AUX4+	PIN 7	BLUE	READY
PIN 2	WHITE	VIN-	PIN 8	RED	AUX4-	PIN 8	RED	NC
PIN 3	BLUE — RED	VIN+	PIN 9	ORANGE	+5V	PIN 9	ORANGE	NC
PIN 4	BLACK	VIN+	PIN 10	TAN	GND	PIN 10	TAN	GND
INPUT: 10.5 - 30VDC ⎓			PIN 11	BLACK	GND	PIN 11	BLACK	GND
FUSE: 5A F 125/250V ⊏⊐			PIN 12	VIOLET	GND	PIN 12	VIOLET	GND

Serial RS-232 Cable (p/n 392-10268)

This 5m null modem cable has a 6-pin female circular connector that plugs into the connector labeled **RS-232** on the LI-7550 Analyzer Interface Unit front panel. The other end has a standard DB-9 female connector for direct connection to a computer. If your computer has a 25-pin serial connector, you will need to use a 9-pin to 25-pin adapter.
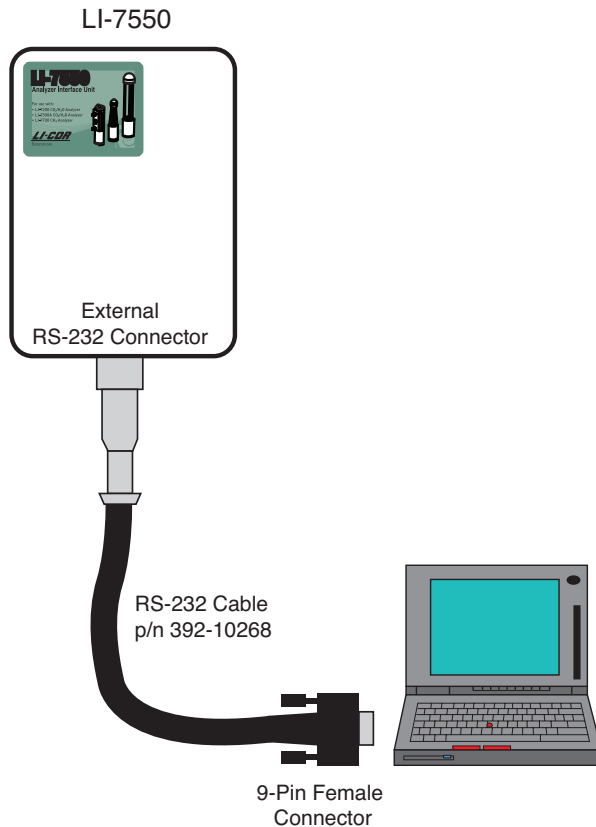
Figure 2-5. The RS-232 Cable is terminated with a standard DB-9 connector for connection to a 9-pin serial port on your computer.

Ethernet Cables (p/n 392-10107 and 392-10108)

Two Ethernet cables are included for connection to a Local Area Network (LAN) via an Ethernet port. Part #392-10108 is a 5m cable terminated on both ends with a male Turck connector; one end plugs into the LI-7550 Analyzer Interface Unit, and the other end plugs into the Ethernet Adapter Cable. Part #392-10107 is a short (0.3m) Ethernet adapter cable that is terminated with an

RJ45 connector, and is used to connect the 5 m Ethernet cable to an Ethernet wall socket or into your computer's Ethernet port.
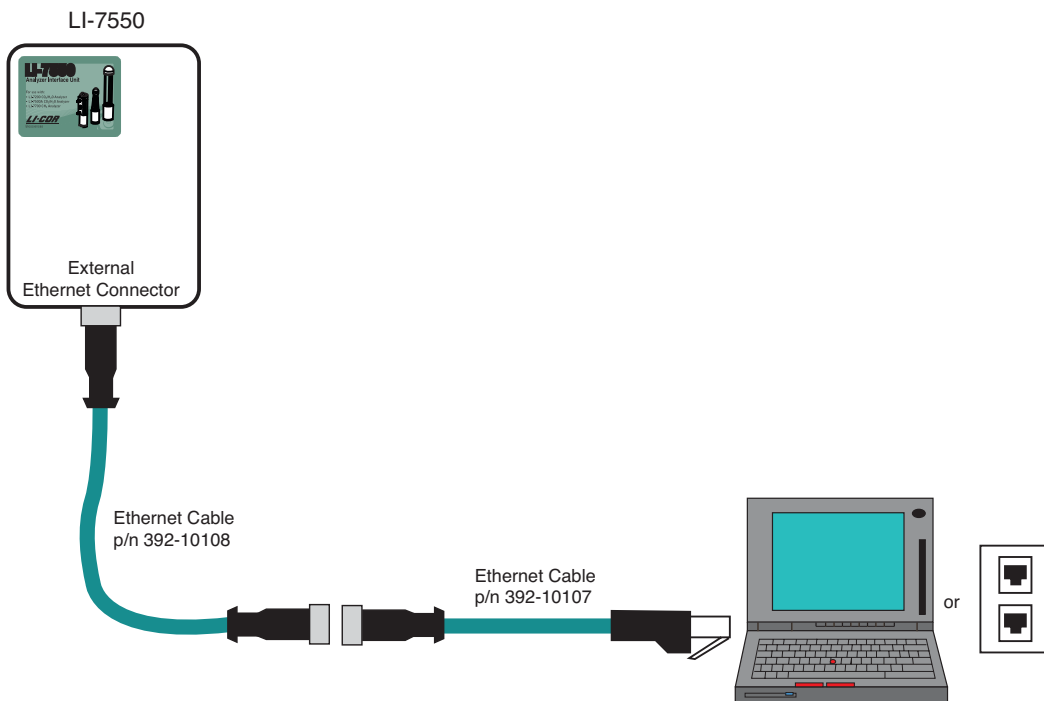
Figure 2-6. Two Ethernet cables are included for connection to an RJ45 connector on a computer or wall socket.

Sensor Head Control Cable (p/n 392-09806)

Connects the LI-7500A sensor head to the LI-7550 Analyzer Interface Unit. A second control cable can be connected to extend the distance between the sensor head and the LI-7550 to 10 meters. Note that only one extension cable can be used. The Sensor Head Control cable plugs into the connector labeled **IRGA** on the LI-7550.

Connecting the Sensor Head Control Cable

It is important that the Sensor Head Control Cable be properly mated to the LI-7500A sensor head to prevent connection problems. Here are some general guidelines to ensure that you have a good connection and proper strain relief to increase the life of the cable(s):

- Note that there is a gasket in the control cable connector; when tightening the connector, rock the connector back and forth 4 or 5 times to adequately compress the gasket.

- Note too, that you should provide sufficient bend radius to allow the cable to absorb the energy of the bending over a greater portion of its length. The manufacturer recommends a minimum bend radius of 5x the cable diameter; for the Sensor Head Control Cable, this would be a 1.75″ minimum bend radius (or 3.5″ minimum loop width).

- Install the cables to allow for adequate stress loops and freedom of motion, as shown below.
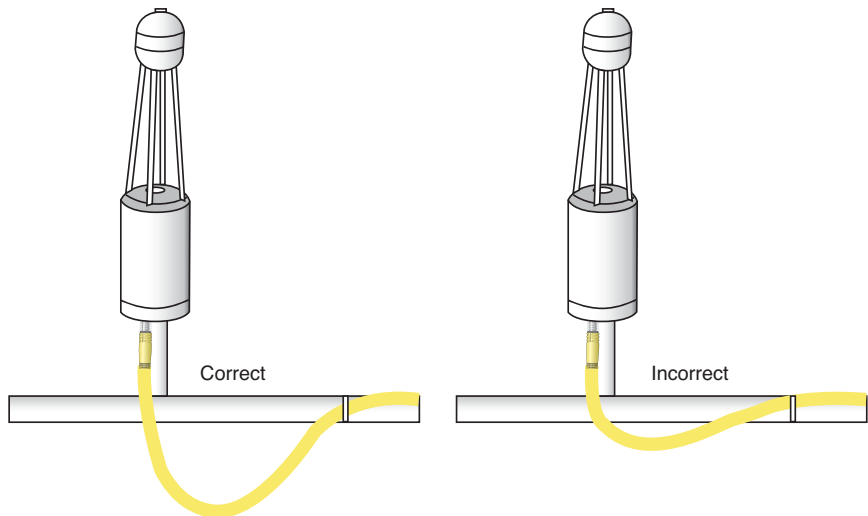
- When tying cables with cable ties, leave the ties loose enough for the cables to slide freely under the tie. Never overtighten the tie to the point where the cable jacket becomes pinched.

External Temperature Thermistor (p/n 9975-026)

An external temperature thermistor is included for measuring ambient temperature outside of the LI-7550 Analyzer Interface Unit. The thermistor plugs into the connector labeled **SENSOR** on the LI-7550 front panel.

Using the 7550-101 Auxiliary Sensor Interface

The optional Auxiliary Sensor Interface serves as a convenient, weatherproof junction box that can be used in place of the Analog Input and/or Analog Output cables. The Sensor Interface is O-ring sealed, and has connections for up to six DAC outputs, or four general purpose analog input voltage channels. Sensors can be powered with a constant 5 VDC source (5 mA max.).

Note that the Auxiliary Sensor Interface can be configured to work with the LI-COR LI-7700 Open Path CH_4 Analyzer, as well. There is a small jumper located at position LK1 (far right in Figure 2-8 below); when using the Interface Box with the LI-7500A, make sure that the jumper is positioned over the 2 pins nearest the LI-7550 label (the topmost 2 pins in Figure 2-8 below). This jumper is positioned over the 2 pins nearest the LI-7700 label when used with the LI-COR LI-7700 Open Path CH_4 Analyzer.

Mounting the Auxiliary Sensor Interface

The Auxiliary Sensor Interface has an attached mounting plate that can be used to attach the Interface to a 1-1½″ post. Two U-bolts and hex nuts are included in the 7550-101 spare parts kit that can be used to attach the Interface, as shown below in Figure 2-7. The Auxiliary Sensor Interface can be mounted either vertically or horizontally. If you do not want to use the attached mounting plate, remove the top cover of the Interface, and remove the two screws in opposite corners of the Interface box that secure the lid to the mounting bracket. You can then secure the Interface using wire, cable ties, or other methods of your choosing.

7550-101 Auxiliary Sensor Interface Top View

Nut

Mounting Bracket

Post

U-bolt

Side View

Auxiliary
Sensor
Interface
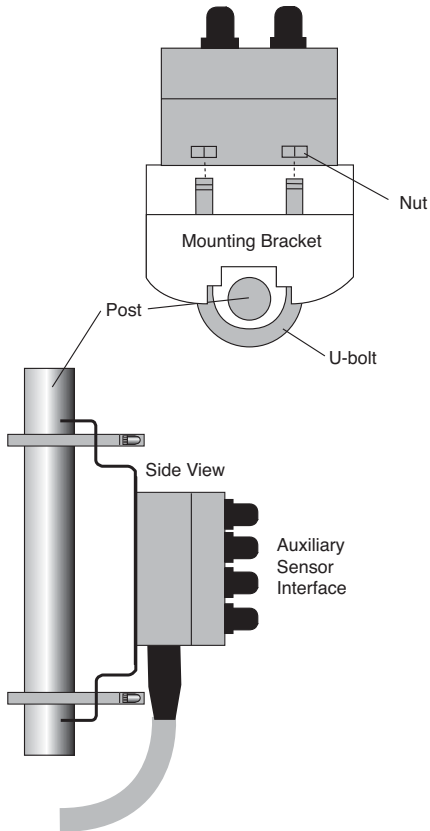
Figure 2-7. Use the included U-bolts and hex nuts to secure the Auxiliary Sensor Interface to a post, if desired.

Auxiliary Sensor Interface Terminals

Loosen the four philips head screws in each corner of the Auxiliary Interface Box module and remove the top cover. The interior of the interface appears as shown in Figure 2-8 below.
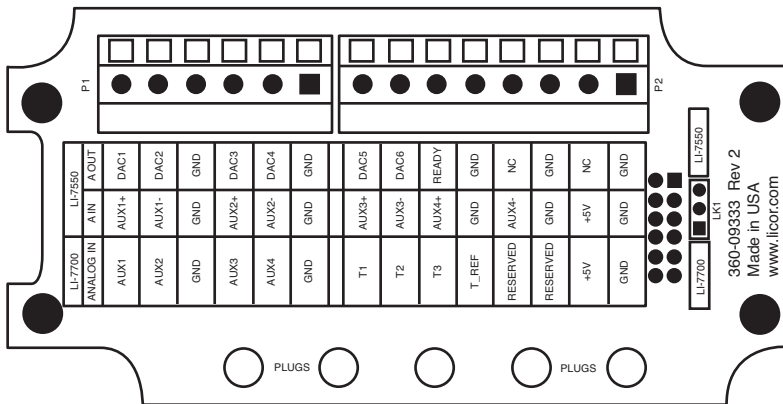
Figure 2-8. Schematic diagram of interior of Auxiliary Interface Box.

There are 2 terminal strips, with connections as follows:

When Used for Analog Inputs
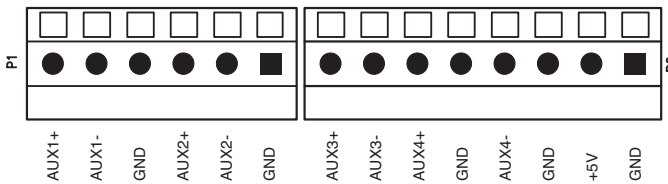
Figure 2-9. Terminal connections for Analog Inputs.

When Used for Analog Outputs
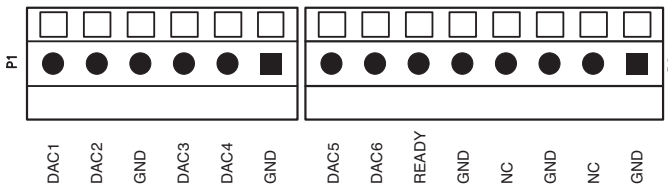
Figure 2-10. Terminal connections for Analog Outputs.

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

Terminal	Analog Inputs[1]	Description	Analog Outputs[2]	Description
1	AUX1+	Auxiliary Input 1 positive	DAC1	DAC channel 1 positive
2	AUX1-	Auxiliary Input 1 negative	DAC2	DAC channel 2 positive
3	GND	Ground	GND	Ground
4	AUX2+	Auxiliary Input 2 positive	DAC3	DAC channel 3 positive
5	AUX2-	Auxiliary Input 2 negative	DAC4	DAC channel 4 positive
6	GND	Ground	GND	Ground
7	AUX3+	Auxiliary Input 3 positive	DAC5	DAC channel 5 positive
8	AUX3-	Auxiliary Input 3 negative	DAC6	DAC channel 6 positive
9	AUX4+	Auxiliary Input 4 positive	READY	Analyzer ready
10	GND	Ground	GND	Ground
11	AUX4-	Auxiliary Input 4 negative	NC	No connection
12	GND	Ground	GND	Ground
13	+5V	+5V supply	NC	No connection
14	GND	Ground	GND	Ground

[1] Analog Inputs ±5V
[2] Analog Outputs 0-5V

Electrical Connections

All analog devices connected to the 7550-101 Auxiliary Sensor Interface must be referenced to the ground (GND) connection; some examples are shown below.

Analog Device   7550-101 Analog Inputs

Analog Out +	Aux +
Analog Out -	Aux -
Ground or Common	Aux Ground

Analog Out +	Aux +
Ground or Common	Aux -
	Aux Ground

Analog Out +	Aux +
Common	Aux -
Ground	Aux Ground

Analog Out +	Aux +
Common	Aux -
Ground NC	Aux Ground
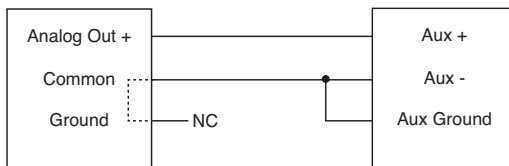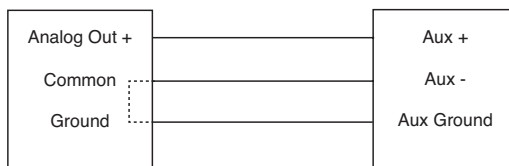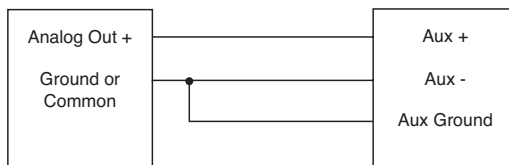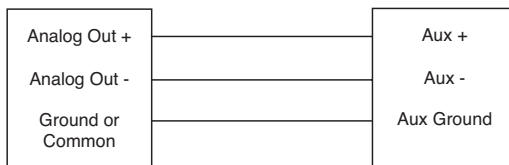
Connection Notes:

1. All LI-7500A auxiliary analog input ground connections are internally connected together.
2. All LI-7500A auxiliary analog output ground connections are internally connected together.
3. Analog devices with both ground and common outputs can share these outputs with their power supply ground.
4. LI-7550 analog inputs are electrically isolated from the LI-7550 power input.
5. LI-7550 analog outputs are electrically isolated from the LI-7550 power input and isolated from the analog inputs.

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 wires pass, after which the wires are connected to the appropriate screw terminals. To attach your sensor(s) or power supply to the Auxiliary Interface Box, follow these steps:

1. Remove the philips head screw in each of the 4 corners of the Auxiliary Sensor Interface 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.
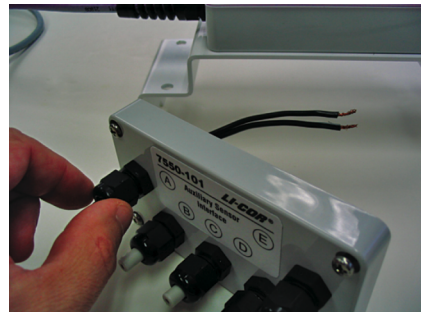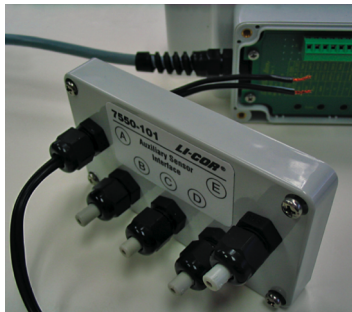
4. Use a small flathead screwdriver to loosen the appropriate screw terminal, and insert the wire leads into the terminal strip. Tighten the screw terminals. Make a note of which plug the wires are passing through (e.g. A, B, C, D, or E), and to which terminal channels the wires are connected. This information will be needed later when you enter the sensor calibration coefficients into software.
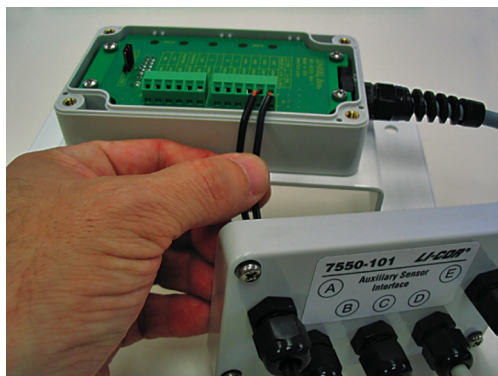
5. Pull lightly on the wires to remove excess wire from inside the interface, re-attach the interface top cover, and tighten the gland plug cap.

6. When you have finished installing all of your sensors, attach the Auxiliary Sensor Interface cable connector to the connector on the side panel of the Analyzer Interface Unit labeled **ANALOG IN**.

7. There are 5 EPDM type plugs inside the box that can be inserted into unused gland plugs on the Auxiliary Interface Box; 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) (gland plug A, 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 placed
around 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.

3   Theory of Operation

Relating Absorption to Concentration

The scaling law of Jaimeson et. al. (1963) shows the effect of pressure on infrared absorption. If the amount of absorber of some gas u_i (mol m^{-2}) and absorption in a band are related by some function $h_i()$, then

$$\frac{\alpha_i}{P_{ei}} = h_i\left(\frac{u_i}{P_{ei}}\right)$$

3-1

The subscript i denotes a particular (i^{th}) gas. Pressure is denoted as P_{ei} because it is the equivalent pressure for the ith gas. Equivalent pressure is potentially different from total pressure P if there are gases present other than i that affect how the ith gas absorbs radiation.

We rewrite this in terms of number density (mol m^{-3}) by introducing a path length λ, and noting that $u_i = \rho_i\lambda$. Substituting this into Equation 3-1, and solving for the number density ρ_i of gas i yields

$$\rho_i = \frac{P_{ei}}{\lambda}h_i^{-1}\left(\frac{\alpha_i}{P_{ei}}\right)$$

3-2

We rewrite Equation 3-2 as

$$\rho_i = P_{ei}f_i\left(\frac{\alpha_i}{P_{ei}}\right)$$

3-3

by combining λ and the inverse $h()$ functions into a new function $f_i()$. The calibration function $f_i()$ is generated by measuring a range of known densities ρ_i and fitting a curve to ρ_i/P_{ei} plotted against α_i/P_{ei}. Since gas standards are not available in "known densities", the ρ_i values are computed from known concentrations m_i (moles of gas per mole of air) using the ideal gas law

$$\rho_i = m_i \frac{P}{RT}$$

3-4

Measuring Absorptance

Given a source with radiant power Φ, and a detector some distance away, in the absence of reflection, absorptance by gas i can be determined from

$$\alpha_i = 1 - \tau_i = 1 - \frac{\Phi_i}{\Phi_o}$$

3-5

where τ_i is transmittance through gas i, Φ_i is transmitted radiant power in the absorption band with some concentration of gas i present, and Φ_o is the transmitted radiant power in the absorption band with zero concentration of i present. The LI-7500A approximates absorptance by

$$\alpha_i = \left(1 - \frac{A_i}{A_{io}} \right)$$

3-6

where A_i is the power received from the source in an absorbing wavelength for gas i, and A_{io} is the power received from the source in a reference wavelength that does not absorb gas i. The LI-7500A measures A_i and A_{io} alternately 150 times per second.

If we combine Equations (3-6) and (3-3), we can write the full equation for computing molar density from absorptance.

$$\rho_i = P_{ei} f_i \left(\left[1 - \frac{A_i}{A_{io}} z_i \right] \frac{S_i}{P_{ei}} \right)$$

3-7

Note the zeroing term z_i and the span adjustment term S_i in Equation (3-7). The span adjustment term is a linear function of absorptance:

$$S_i = S_{i0} + S_{i1}\alpha_i$$

3-8

Cross Sensitivity

Because the LI-7500A uses one detector for measuring A_c, A_{co}, A_w, and A_{wo}, (the absorbed and non-absorbed power for CO_2 and H_2O, respectively), there is a slight cross-sensitivity between gases due to imperfections in the detector's frequency (time) response. This varies from detector to detector, but is measured during calibration, and is corrected in software. Equation 3-6 is written as

$$\alpha_i = \left(1 - \left[\frac{A_i}{A_{io}} + X_{ji}\left(1 - \frac{A_j}{A_{jo}}\right) \right] \right) \qquad \text{3-9}$$

where X_{ji} is the cross sensitivity response of gas j on gas i (determined during calibration), and A_j and A_{jo} are the absorbed and non-absorbed power for gas j. Equation 3-7 becomes

$$\rho_i = P_{ei}f_i\left(\left[\left| 1 - \left(\frac{A_i}{A_{io}} + X_{ij}\left[1 - \frac{A_j}{A_{jo}}\right]\right) \right] z_i \right] \frac{S_i}{P_{ei}} \right) \qquad \text{3-10}$$

Zero Drift

Even though the detector and filters are temperature controlled in the LI-7500A, the detector is subject to slight temperature drift as ambient temperature changes. This error is directly related to the detector cooler control voltage, which is measured, and thus provides a mechanism for a software "fine tuning".

The zero term z_i is computed from

$$z_i = Z_{io} + Z_i T_{box} \qquad \text{3-11}$$

where T_{box} is box temperature (measures head body temperature), Z_i is the slope of the relationship between T_{box} and z_i (determined during calibration), and Z_{io} is the zero factor determined when setting the zero.

Equation Summary

H_2O

In the atmosphere, the absorption of radiation by water vapor is not significantly influenced by any other gas, so the effective pressure for water vapor P_{ew} is simply the total pressure P.

$$P_{ew} = P \qquad\qquad\qquad 3\text{-}12$$

H_2O absorptance α_w is (from Equations 3-9 and 3-11)

$$\alpha_w = \left(1 - \left[\frac{A_w}{A_{wo}} + X_{cw} \left[1 - \frac{A_c}{A_{co}} \right] \right] \left(Z_{wo} + Z_w V_d \right) \right) \qquad 3\text{-}13$$

where X_{cw} is the cross sensitivity factor for CO_2 on water vapor ("H_2O XS" on the calibration sheet), Z_w is the zero drift coefficient ("H_2O Z" on the calibration sheet).

H_2O number density ρ_w is given by

$$\rho_w = P f_w \left(\frac{\alpha_w S_w}{P} \right) \qquad\qquad 3\text{-}14$$

The coefficients for the 3rd order polynomial $f_w(\ )$ are given on the calibration sheet. The polynomial has the form $AX + BX^2 + CX^3$, where $X = \left(\frac{\alpha_w S_w}{P} \right)$.

CO_2

The absorption of radiation by CO_2 molecules is influenced by several other gases, including O_2 and H_2O. Since the concentration of H_2O is most variable, it must be accounted for in the equivalent pressure of P_{ec}. A method of doing this (LI-COR Application Note #116) is

$$P_{ec} = P\psi(W_f) \qquad\qquad\qquad 3\text{-}15$$

where

$$\psi(W_f) = 1 + (a_w - 1)W_f \qquad\qquad 3\text{-}16$$

3-4

and W_f is the mole fraction of water vapor (mol/mol). a_w has been determined to be 1.15 for the LI-7500A.

CO_2 Absorptance α_c is given by

$$\alpha_c = \left(1 - \left[\frac{A_c}{A_{co}} + X_{wc}\left[1 - \frac{A_w}{A_{wo}}\right]\right]\left(Z_{co} + Z_cV_d\right)\right)$$

3-17

where X_{wc} is the cross sensitivity factor for H_2O on CO_2 ("CO_2 XS" on the calibration sheet), Z_c is the zero drift coefficient ("CO_2 Z" on the calibration sheet).

CO_2 molar density ρ_c (mmol m^{-3}) is

$$\rho_c = P_{ec}f_c\left(\frac{\alpha_cS_c}{P_{ec}}\right)$$

3-18

The coefficients for the 5th order polynomial $f_c(\ )$ are given on the calibration sheet. The polynomial has the form $AX + BX^2 + CX^3 + DX^4 + EX^5$, where $X = \left(\frac{\alpha_cS_c}{P_{ec}}\right)$.

LI-7500A Implementation

Atmospheric pressure P_g (kPa) and temperature T_g (°C) are measured by sensors in the Analyzer Interface Unit.

Table 3-1. Fundamental equations used in the LI-7500A calculations.

Label	Description	Equation	
H_2O mmol/m³	H_2O number density	$$\rho_w = P_g f_w \left(\frac{\alpha_w S_w}{P_g} \right)$$	3-19
H_2O g/m³	H_2O mass density	$$W_m = \frac{18}{1000} \rho_w$$	3-20
H_2O mmol/mol	H_2O mole fraction	$$W_f = \frac{\rho_w R(T_g + 273.15)}{1000 P_g}$$	3-21
Dew Point (°C)	Dew point temperature	$$T_d = \frac{240.97 x}{17.502 - x}$$ $$x = \ln\left(\frac{W_f}{613.65} P_g \right)$$	3-22
CO_2 mmol/m³	CO_2 number density	$$\rho_c = P_g \psi \left(\frac{W_f}{1000} \right) f_c \left(\frac{\alpha_c S_c}{P_g \psi \left(\frac{W_f}{1000} \right)} \right)$$	3-23
CO_2 mg/m³	CO_2 mass density	$C_m = 44 \rho_c$	3-24
CO_2 µmol/mol	CO_2 mole fraction	$$C_f = \frac{\rho_c R(T_g + 273.15)}{P_g}$$	3-25

A Note About Pressure And Temperature

Since the LI-7500A is calibrated for number density, accurate temperature is not required for the calculation, and accurate pressure measurement is not needed either (Equations 3-19 and 3-23). For example, if you introduce a 1% error in the pressure sensor on a perfectly calibrated instrument, the resulting CO_2 mole density error would be about 0.25%, and the H_2O mole density error about 0.5% in typical ambient conditions.

When calibrating (specifically when setting spans), temperature and pressure are more important. Calibrating with a 1% pressure error will cause the resulting CO_2 mole density to have a 1% error, but no error in the resulting H_2O mole density (because the water span target is computed from dew point, not mole fraction). A 1% error in temperature (3 °C) will cause a 1% error in both CO_2 and H_2O mole density.

LI-7500A Diagnostics

LI-7500A Signal Strength

The raw reference signal A_{co} (for CO_2) can be used for diagnostic purposes. A_{co} is insensitive to CO_2 and H_2O concentrations, so if it is reduced, it could be due to obstructions (dirt, precipitation, etc.) in the optical path. The value of this signal by itself is not very informative: all you are guaranteed of is that it will be somewhere between 0 and 65535, but more typically between 25000 to 50000. To get a useful diagnostic out of A_{co}, one needs to know the expected value for a particular instrument when everything is clean and normal. If A_{cx} is the maximum expected value for A_{co}, then we could calculate a signal strength S_c for CO_2 from

$$S_c = \frac{A_{co}}{A_{cx}} 100$$

3-26

S_c is on a 0 to 100 scale, where 100 is clean. This value is not 'clipped' at 0 or 100, so may slightly exceed 100, especially after signal strength is reset. This simply reflects slight differences from reality of the temperature compensation function f(T), as shown below in Equation 3-28.

The problem with an implementation this simple is that the raw signals are a function of not only the optical throughput (obstructions, source and detector aging, etc.), but also temperature. Unless one accounts for that, the S_c could

actually respond to diurnal temperature changes as much or more than contamination changes. Thus, the proper A_{cx} needs to be a function of temperature. Fortunately, we characterize this response at the factory as part of the factory calibration of each individual unit, which allows us to use the following formulation for signal strength for CO_2:

$$S_c = \frac{100 * A_{co}}{C_x * f(T)}$$

3-27

where C_x is the maximum value of A_{co} that we would expect from this unit. The function $f(T)$ characterizes how the raw reference signal varies with cooler voltage V:

$$f(V) = \frac{0.2}{1 + b * e^{c(V-2.5)}} + 0.8$$

3-28

Average values of *b* and *c* are 1.6 and 3.2, but the values for a particular unit are found on its calibration sheet. Figure 3-1 below illustrates this function by showing the range of responses for a large population of LI-7500As.
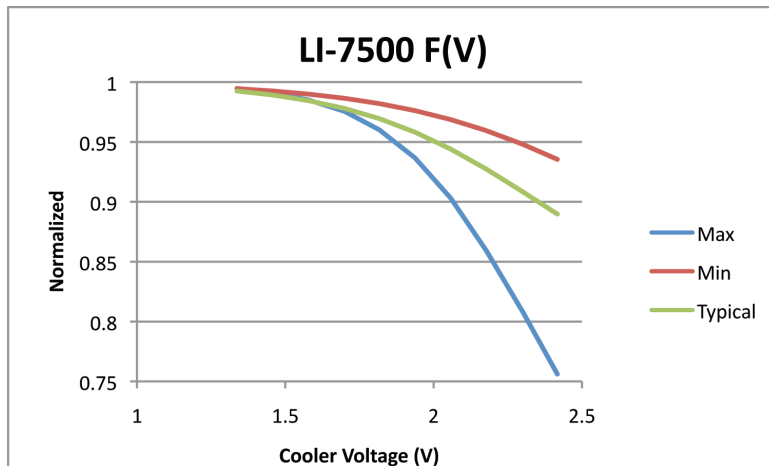
Figure 3-1. The function f(T) characterizes how the raw reference signal varies with temperature.

The C_x value is determined at the factory, but it is not really a "factory parameter"; it will likely change over time, due to source or detector aging, or even some thin-film contaminant that gets on a window that you just can't

clean off. Thus, the LI-7500A has a provision for you to easily reset C_x to a value that reflects the reality of your instrument at any point in time. The Calibration button of the Windows Interface program (see *Calibration* in Section 4) opens a window with a Signal Strength tab. There you will find a button labeled "Reset Signal Strength" that you can push if you've decided your instrument is as clean as you can reasonably make it, and you want to reset the signal strength to 100. It does this by using the current value of A_{co} and performing the following computation:

$$C_x = \frac{A_{co}}{f(V)}$$

3-29

A signal strength-based value is available from the LI-7500A when using the Windows interface program.

The instrument's grammar also makes S_c available for output as well. See Appendix D, *Data and Status Records*.

Operational Considerations

Dew
The LI-7500A can tolerate droplets on the windows to a certain extent; the Automatic Gain Control (AGC) value will increase, but the calibration is unchanged. If the droplets coalesce and get big enough, the AGC will go to 100%, and eventually the readings will become bad. This can be minimized by sensor orientation, and by coating the windows with a wax such as RainX®.

Rain/Snow
Flying droplets and flakes in the optical path will affect the performance of the LI-7500A, even if the total light blockage is small enough that the AGC does not reach 100%. The reason is that the objects are moving, and if a droplet or flake is in the path for a sample measurment, but out of the path for a reference measurement (or vice versa), it will influence the resulting reading. Figure 3-1 illustrates a strip chart trace made during a light snow shower. The occasional spikes are due to blockage changes between sample and reference readings. Notice that in some cases both CO_2 and H_2O are affected, and sometimes just one. Also, the spikes are equally likely to be up or down.
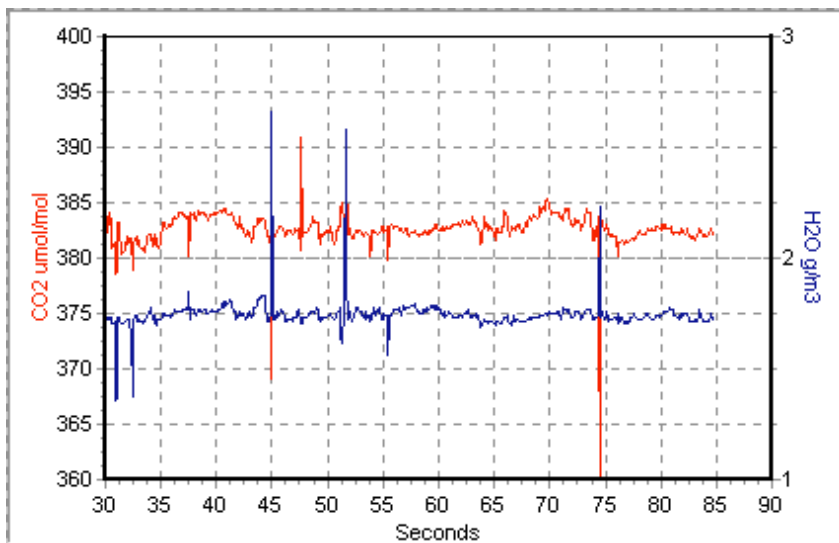
Figure 3-1. Typical strip chart trace taken during a light snow shower.

The higher the bandwidth, the more pronounced this effect, since less averaging is done.

Dust, Pollen and Salt Deposits
The LI-7500A is quite tolerant of particulates on the windows, as long as they are small, and spectrally neutral. Pollen and salt deposits may become a problem because they are sticky and can accumulate, so monitor the CO_2 Signal Strength value and clean the windows as needed.

Vibrations
The LI-7500A is vibration sensitive to frequencies of 150 Hz ± the bandwidth. Thus, if the bandwidth is 10Hz, the frequency problem range is 140 to 160 Hz (and upper harmonics). The instrument is completely insensitive to vibrations slower than this, and very slightly sensitive at frequencies higher than this.

For land-based installations, probably the most likely source of vibrational problems would be on a tower with tight guy wires. For other settings (aircraft, ships, etc.) where there may be vibrations in the problem range, you should try to minimize the problem through alternative mounting attachments.

4   Operation

Installing the Windows® Software on Your Computer

The LI-7500A PC software is shipped on a CD. Your computer must have an Ethernet or RS-232 serial (COM) interface, and Windows XP/Vista/7/8.

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-7200/LI-7500A' program icon will be placed in the Programs menu, and a shortcut placed on your desktop.

Using the LI-7500A Windows Application Software

Data from the LI-7500A can be transferred to a computer for analysis, printing or storage using either the Ethernet or RS-232 interface. The LI-7500A 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-7500A.

Double-click on the LI-7200/LI-7500A program icon to launch the application. The Connect page appears.

Connect – Establishing Communications

The Connect page is the area in which you select the communication parameters for connecting the LI-7500A to your computer. The serial (COM) port or Ethernet address, baud rate (RS-232), and data acquisition frequency (in Hz) are chosen in this page.
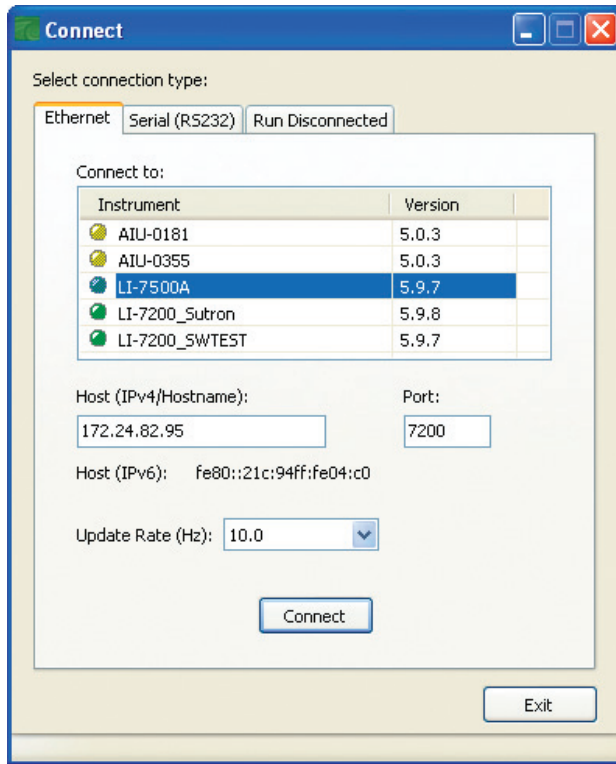
The yellow indicators are displayed when the instrument (embedded) software version is incompatible with the Windows interface software version. In this instance, we recommend that you visit LI-COR's support site at www.licor.com and download and install the latest instrument software. Green indicators are displayed when instrument and Windows software versions are compatible.

Ethernet Tab

The LI-7500A can communicate with a computer via Ethernet; if the instrument is powered on, and is connected to an Ethernet port on the same subnet as the computer, the instrument name will automatically be displayed in the 'Connect to:' window. By default, the instrument name is set to the serial number of the Analyzer Interface Unit; you can rename the instrument, if desired, in the Settings Dialog Box, Network Tab (see description later in this section). Alternatively, you can manually enter the IPv4 Address or Hostname (if known) of the instrument to which you want to connect. The IP address can be obtained automatically, or assigned manually in the Settings Dialog Box. If Ipv6 (Internet Protocol verson 6) addressing is available on the network and enabled on the computer, the instrument's Ipv6 address is displayed as well.

The LI-7500A (and LI-7200) use the **Port** number 7200 for Ethernet communications. Therefore, when connecting to an LI-7500A on a network you will enter the IP address of the instrument and port 7200 in the connection dialog of the application software to initiate communication. Typically, you

can select the instrument from the list of instruments on the same network if your computer is directly connected to the instrument or the instrument is connected to the same network as your computer.

In some network setups it may be necessary to forward communication traffic on a port from a public IP address to a private IP address to gain access to an instrument. For example, assume you have an LI-7500A installed in the field and the instrument is connected to a wireless gateway such as a cellular modem. The instrument will acquire a **private** IP address from the cellular modem, but this address is only visible to nodes on the private network. On the other hand, the cellular modem is assigned a public IP address that can be accessed from any node on the Internet. For this discussion let's assume the public address is 166.66.77.88. In order to connect to the instrument in the private network, a port forwarding rule must be created in the cellular access point to "forward" all communications on port 7200 coming into the access point to a node on the network.
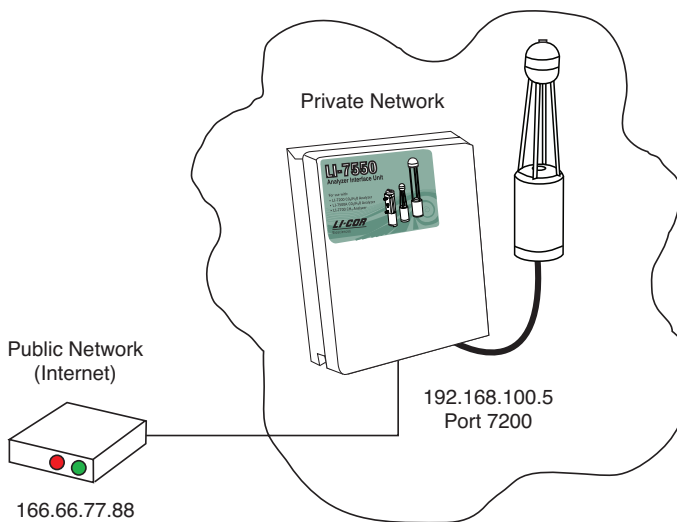
Public IP	Public Port	Private IP	Private Port
166.66.77.88	7200	192.168.100.5	7200
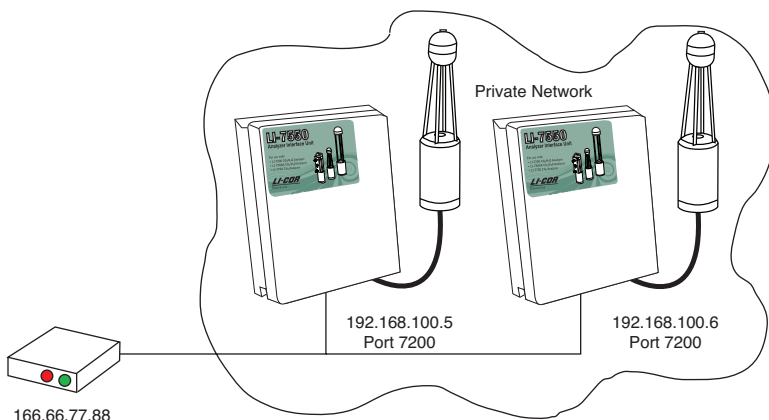
The public port number should be changed when there is more than one LI-7500A and/or LI-7200 in the private network. In this case, to connect to each instrument, two port forwarding rules must be set up, similar to that shown below.

Public IP	Public Port	Private IP	Private Port
166.66.77.88	7201	192.168.100.5	7200
166.66.77.88	7202	192.168.100.6	7200

Note that you can run multiple LI-7500A Windows software sessions at the same time, as well, to communicate with different analyzers. Simply double-click on the LI-7500A program icon and open another session, and connect to a different instrument.

The Update Rate is the update frequency to be used while the LI-7500A Windows program communicates with the LI-7500A. Select from 0.1, 0.2, 0.5, 1, 2, 5, 10, or 20 Hz.

Click on the **Connect** button to establish communications with the LI-7500A. If something is wrong, it will time out after about 15 seconds. If this happens, make sure you've got the correct instrument selected, and retry. Click on the **Disconnect** icon on the toolbar to terminate communications.

Serial (RS232) Tab
Use the arrow buttons to select the serial port on your computer to which the LI-7500A RS-232 cable is connected. Valid numbers are between 1 and 50.

Use the Baud Rate pull-down menu to select the baud rate at which to communicate with the LI-7500A through the LI-7550 serial port. The rate of data transfer is also dependent upon the maximum rate available with your computer's serial port, and the update rate (below) to be used while the program communicates with the LI-7500A. Select from 9600, 19200, 38400, 57600, or 115200.

The Update Rate is the update frequency to be used while the LI-7500A Windows program communicates with the LI-7500A. Select from 0.1, 0.2, 0.5, 1, 2, 5, 10, or 20 Hz. **Note that at 9600 baud, the maximum update frequency is 2 Hz; at 19200 baud, 5 Hz; at 38400 baud, 10 Hz; at 57600 baud, 15 Hz; and at 115200 baud, 20 Hz.**

Click on the **Connect** button to establish communications with the LI-7500A. Click on the **Disconnect** icon on the toolbar to terminate communications.
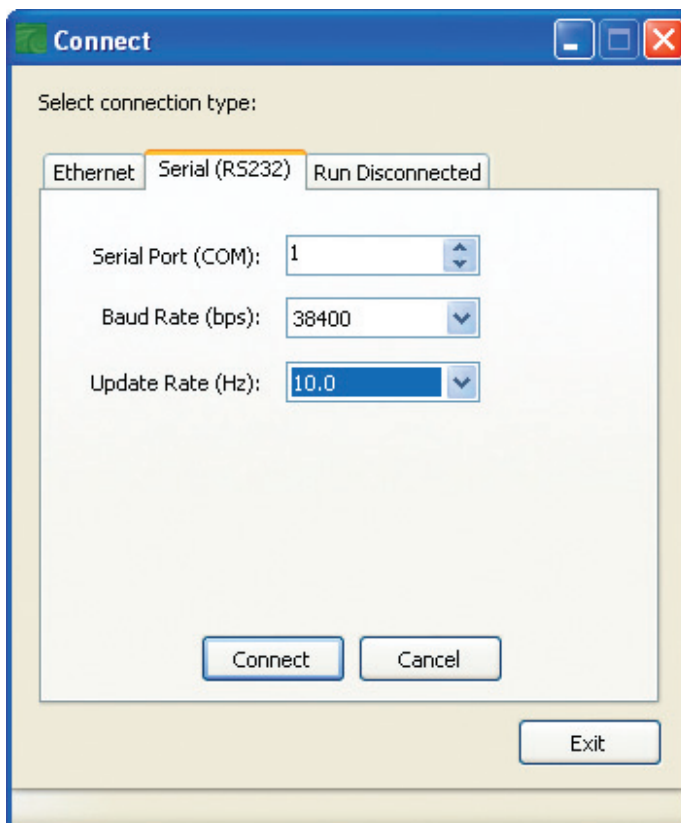
Run Disconnected

The Windows software application can be used independent of the LI-7500A by clicking on the Run Disconnected tab and choosing "Run as an LI-7500A". This can be useful for training purposes, or for creating a configuration file that can then be saved and transferred to instruments in the field. Some of the functionality of the software is disabled in this mode (e.g. data will not appear, so charting is unavailable), but functions that do not require an active connection are fully functional.

Main Window

The main window of the Windows communication program contains a toolbar with icons for the various software operations, six data display windows, and a status window that displays a variety of operational parameters of the LI-7500A, including the serial number of the instrument currently connected, the output rate chosen, diagnostics, connection status of optional LI-7700 CH_4 Analyzer and 7900-100 Biomet station, and the state of USB and/or PC data logging.
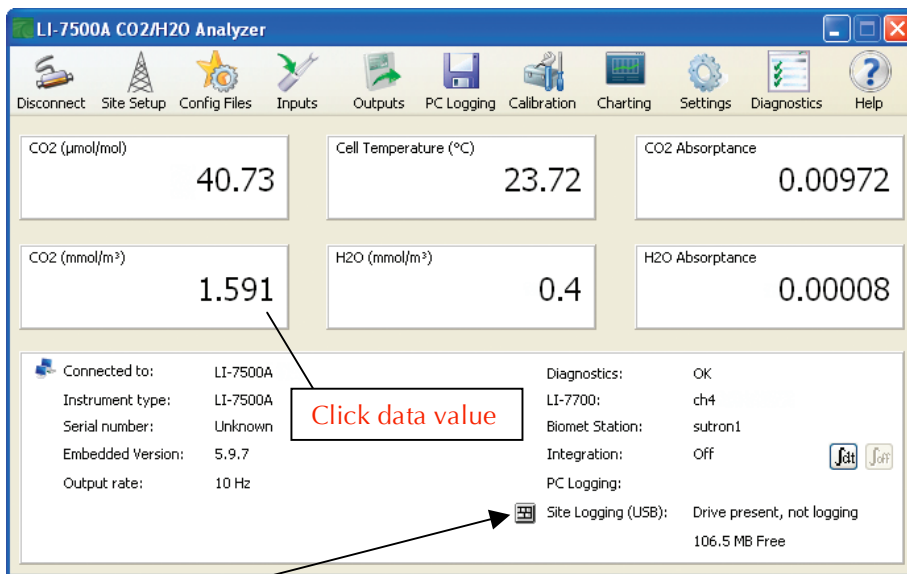
Click here to open the Data Logging Controls window (below) to start or stop logging to the USB drive, or to eject the drive. Note that these controls are also available in the Site Setup window, under the USB Log File tab, and in the PC Logging page.

Data Logging Controls

			Size:	494.5 MB
⊙ Start	Stop	⏏ Eject	Free Space:	106.5 MB
			USB Status:	Drive present, not logging

To change the variable(s) displayed in the data windows, click on the data value; a pop-up Data Items window appears (below), from which you can select the variable you want to display.

The data items available for display are as follows:

Data Items	Variable	Description
Time	Time	Time in HH:MM:SS:MS
Date	Date	Date in YY:MM:DD
Sequence Number	Sequence Number*	Index value, increments every 3.3 ms (1/300s)
CO2 (mmol/m³)	$CO2$ (mmol/m^3)	CO_2 concentration density
CO2 Absorptance	CO2 Absorptance	CO_2 raw absorptance value
CO2 (µmol/mol)	CO2 (µmol/mol)	CO_2 mole fraction
H2O (mmol/m³)	H2O (mmol/m^3)	H_2O concentration density
H2O Absorptance	H2O Absorptance	H_2O raw absorptance value
H2O (mmol/mol)	H2O (mmol/mol)	H_2O mole fraction
Dew Point (ºC)	Dew Point (°C)	Dew point temperature (°C)
Temperature (ºC)	Temperature (°C)	Temperature measured at LI-7550
Pressure (kPa)	Pressure (kPa)	Pressure measured in LI-7550
Cooler Voltage (v)	Cooler Voltage (v)	Detector cooler voltage
Diagnostic Value	Diagnostic Value	Diagnostic value 0-255
Diagnostic Value 2	Diagnostic Value 2	Diagnostic value 0 or 1 (sync clocks)[†]
CO2 Signal Strength	CO2 Signal Strength	CO_2 Signal Strength
7550 Auxiliary Input 1	7550 Auxiliary Input 1	Auxiliary input 1 value
7550 Auxiliary Input 2	7550 Auxiliary Input 2	Auxiliary input 2 value
7550 Auxiliary Input 3	7550 Auxiliary Input 3	Auxiliary input 3 value
7550 Auxiliary Input 4	7550 Auxiliary Input 4	Auxiliary input 4 value
Integral	Integral	Integration result (area under curve)
Peak Height	Peak Height	Integration peak height
CO2 Sample	CO2 Sample	Floating point value, power received from source in absorbing wavelength for CO_2 (see Eq. 3-6)
CO2 Reference	CO2 Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for CO_2
H2O Sample	H2O Sample	Floating point value, power received from source in absorbing wavelength for H_2O
H2O Reference	H2O Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for H_2O
OK Cancel		

* Sequence number is displayed as **Ndx** (Index) in data output header

[†] A value of 0 indicates that the clocks in the LI-7550 and LI-7700 (if connected) are not synchronized, and/or the LI-7550 is not logging data to USB drive. A flag will appear next to 'LI-7700' in the main window in this state. A value of 1 indicates clocks are synchronized, and data are being logged to USB drive.

Site Setup

The Site Setup window allows you to enter the site information that will comprise the METADATA file. Note that a more complete description of the METADATA file and its use can be found in the on-line help information provided with EddyPro. The introduction of the METADATA file inside the .ghg archive, while adding a negligible amount of bytes (it contributes about 0.1% to the file size), allows you to:

● avoid duplicate retrieving and re-typing of information needed for processing the file from any external data source;
● easily store raw data for future reprocessing;
● properly account for dynamic site parameters that change over the course of the data collection period (e.g. the canopy height of a crop);
● to a large extent, simultaneously process files acquired with different set-ups.

Ideally, you are not required to consider the METADATA file explicitly, as it is created and modified in the LI-COR gas analyzer configuration software, and used unobtrusively by EddyPro. Nevertheless, all information is stored as plain text and can be retrieved and edited at any time.

Sensitive meta-information in the METADATA file includes:

Site and setup information
● Canopy height;
● Canopy roughness length;
● Boundary layer displacement height;
● Site coordinates and altitude;
● Acquisition frequency;
● File duration

Instruments
● Anemometer(s) manufacturer and model;
● Anemometer(s) height;
● Anemometer settings:
● Whether the built-in head correction is applied;
  ● Whether the wind components are given in AXIS or SPAR configuration (Gill anemometers);
  ● Yaw offset with respect to due north;

- Displacement from the reference anemometer in a Cartesian North/East/Vertical system (only for anemometers other than the reference one).
- Gas analyzer(s) manufacturer and model;
- Gas analyzer settings:
  - Flow rate and intake tube length and inner diameter (for closed path gas analyzers only);
  - Displacement of the reference anemometer in a Cartesian North/East/Vertical system

Raw file columns

- Name of the variable;
- The instrument that measured the variable;
- For gas concentrations, the type of measurement (molar density, mole fraction or mixing ratio);
- Physical units of the variable, as stored in the raw file;
- If applicable, linear conversion information:
  - Type of conversion (either Zero/Full Scale or Gain/Offset);
  - Units of the variable as stored in the raw file;
  - Input range;
  - Output range or gain/offset.
  - Physical units of the variable, as expected after the linear conversion;
- Nominal time-lag for the variable, based either on the displacement of the instrument from the reference anemometer (open path analyzers), or on the intake tube properties and flow rate (closed path analyzers).
- Minimum and maximum plausible time lags, for automatic time lag determination by means of circular correlation.

USB Log File

Data can be logged to a file on your computer (see *PC Logging* later in this section), or to a USB flash drive inserted into the connector inside the LI-7550 Analyzer Interface Unit (USB logging). Note that the Windows application does not need to be actively running to log to the USB drive; data are logged to the USB flash drive as soon as it is inserted. The USB Log File tab simply allows you to configure the Update Rate, File Duration, and the action to take should the USB flash drive run out of space. The values to be logged to the USB flash drive from the LI-7500A, and from the optional LI-7700 CH4 Analyzer and 7900-100 data logger, are chosen under the CO2 Analyzer, CH4 Analyzer, and Biomet tabs, repectively.
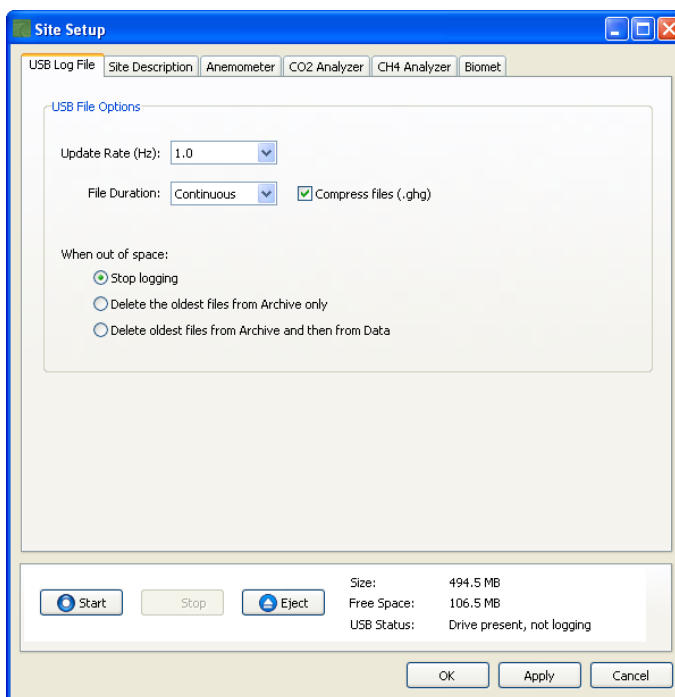
Data can be logged at up to 20 Hz, which can result in large data files. These files can be split into smaller files, if desired, at 15, 30, 60 minutes, or 1.5, 2, 4, or 24 hour intervals. Note that the files are split based on the instrument clock; thus, if you choose to split the files at 15 minute intervals, and start logging at 10:22, the file will be split at 10:30, 10:45, 11:00, etc.

All files are assigned a timestamp with the format YYYY-MM-DDTHHMMSS_InstrumentName.ext, where date and time are year, month, day, and HHMMSS is 24-hour time (e.g. hour 15 = 3:00 p.m.). The file extension appended is either .data, .metadata, or .status.

Begin Logging Data
Press **Start** to begin logging data. Press **Stop** to quit logging. The USB Log File page also has a button to eject the USB flash drive; note that you can also eject the drive from inside the LI-7550 case using the Eject button.

About File Compression (USB Logging Only)
Data, Metadata, LI-7700 Status files, and Biomet sensor outputs can be compressed (zipped) by enabling the 'Compress files (.ghg)' check box. Files

are typically compressed at a rate of about 4:1 (can be as high as 10:1, depending on file attributes), which is useful when logging data to the external USB drive. As an example, if the LI-7500A (and LI-7700 CH_4 Analyzer) are both logging data at 20 HZ, with a full 53 columns of data, a one hour file would be approximately 30 MB uncompressed, and 7 MB compressed, for an approximate 4x compression ratio.

When file compression is enabled, an archive is created, and the filename is appended with a .ghg file extension. The .ghg format is a custom raw file type used with EddyPro™ (see below); to unzip a .ghg file for use with other programs (e.g. Excel), you will need to unzip the file using a program such as Winzip or the compression tool included with Windows®. Note that if the File Duration is set to 'Continuous', files *cannot* be compressed. When files are split, they are compressed after each interval has elapsed. In other words, if the File Duration is set to 15 minutes, for example, the first .data file will be collected for 15 minutes (or some part thereof), after which it will be compressed, and the second data file will commence for 15 minutes, after which it is compressed, and so on.

File compression has a second function, as well, when used with EddyPro from LI-COR, which is a free, open source software program for processing eddy covariance raw data to obtain estimates of biosphere/atmosphere exchange fluxes. In this case, the .ghg file is not only compressed, but it also contains an archive consisting of the DATA file (.data), a METADATA file (.metadata), and an optional LI-7700 STATUS (.status) record file. The LI-7700 STATUS records are created by enabling the 'Log LI-7700 status records (.status)' check box under the CH4 tab in the Log Values window.

File Types
The DATA file is an ASCII text table with a header, and tab-delimited rows and columns of data. When paired with the METADATA file, the DATA file header is ignored by EddyPro, which uses the METADATA file to interpret the data columns and to retrieve the appropriate meta-information needed to calculate fluxes. The METADATA information is stored as plain text, and can be retrieved and edited as desired. Typical METADATA includes information such as site and setup information (canopy information, site coordinates, etc.), information about the instruments used, including sonic anemometers, and the variable definitions, including physical units, conversions, etc.

LI-COR also offers an optional Biological and Meteorological (Biomet) Station (7900-100), consisting of a Sutron Xlite 9210 data logger (Sutron Corporation,

Sterling, VA) and a suite of optional biomet sensors, whose output can be logged by connecting to a networked 9210 via the Biomet tab (see below). When connected, the 7900-100 data are collected as filename-biomet.data and filename-biomet.metadata files, respectively. More information about METADATA files and EddyPro can be found below, and in the on-line EddyPro documentation.

Overwriting Files on the USB Flash Drive

LI-COR provides a File Transfer program (see description below at "Transferring Files from the USB Drive Remotely') that can be used to transfer files from the USB drive to your computer remotely, provided you are connected to the LI-7550 Analyzer Interface Unit via an Ethernet connection. This, coupled with the optional file compression described above can obviate the need to retrieve the USB flash drive to download data. We recommend, however, that you periodically check the USB drive to make sure it is functioning correctly. If the USB drive fills with data, however, you can choose to stop logging, delete files from the archive (if files are present there) and continue logging, or delete files from the archive first, followed by the oldest data files by choosing the appropriate radio button.

Scheduling File Transfer from the USB Drive Remotely

When logging to a USB flash drive in the LI-7550 Analyzer Interface Unit, it can often be impractical to retrieve the drive to transfer files, particularly in remote locations, when the LI-7550 is mounted on a tower, etc. If the LI-7550 is connected via Ethernet, the user can connect to the instrument remotely to perform file transfer operations, eliminating the need to retrieve the flash drive in the field.

The LI-7200/LI-7500A File Transfer program is installed automatically when the LI-7500A Windows application software is installed. A program shortcut is created on the computer's desktop during installation; if it is not, the program can be found in a folder named LI-COR\7200-7500A, in your Programs folder.

The main File Transfer window appears as shown below.
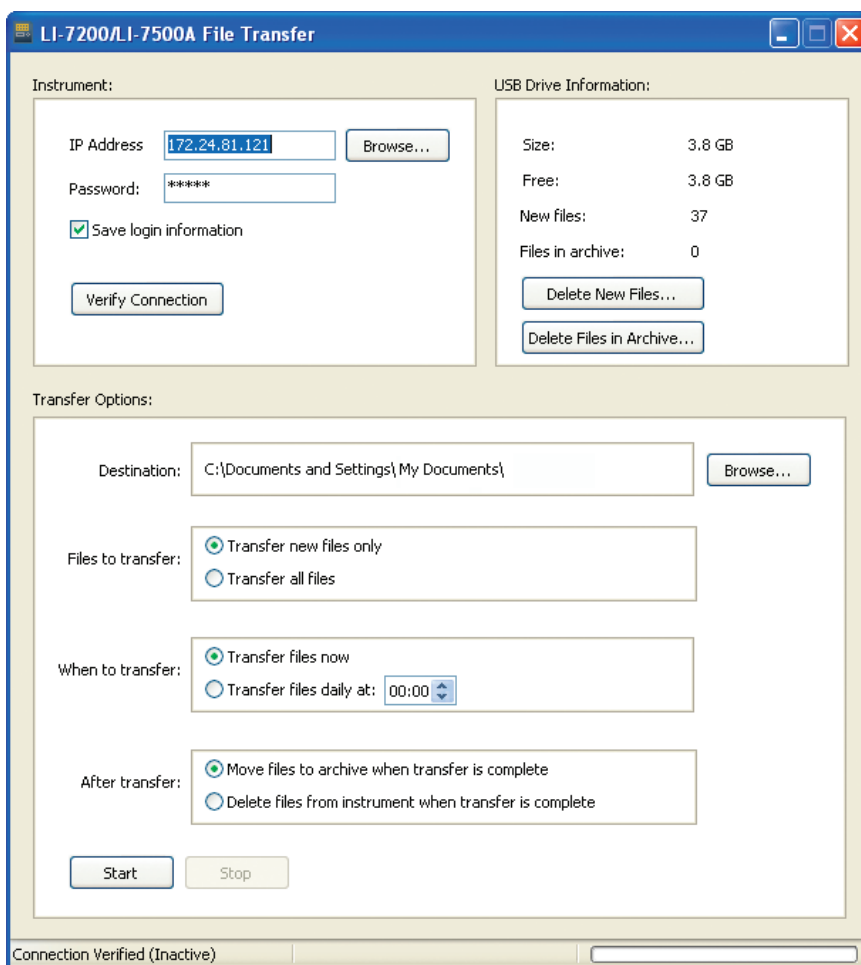
To connect to the instrument, you can enter the IP Address directly, or click the **Browse** button to view a list of instruments on the network. Enter the password, which is **licor**. Enable the 'Save login information' check box if you want the file transfer program to remember this IP address and password the next time you start the program.

The USB Drive Information portion of the window displays the size of the USB drive (16 GB when purchased from LI-COR), the amount of available memory, and the number of new (since last transfer) and/or archived files. When new files are transferred, they are then moved to the archive, or deleted, depending the Transfer Options selected (below).

Click **Delete New Files** to delete all new files. Click **Delete Files in Archive** to delete only those files present in the archive.

To transfer files, choose the Destination to which you want to move the files. You can opt to transfer new files only, or all files (new + archived). You can also choose to transfer files immediately, or automatically transfer files once each day at a user-determined time. The transfer time is entered using a 24-hour clock, where 00:00 is midnight, and 12:00 is noon.

After the files are transferred, they can be moved to the archive, or deleted. As new files are added to the USB drive, the archived files will be overwritten first as the drive fills up (when 'Move files to archive when transfer is complete' is selected), followed by the new files, based on their creation date (earliest first).

Site Description

The Site Description tab contains information about the site of interest, including:

Site Name
User-entered name for research site (e.g. LI-COR Experimental Site).

Station Name
Optional user-entered name for multiple flux stations within each site.

Altitude
Altitude (in meters) of the research site of interest.

Canopy Height
Site canopy height, in meters.

Displacement Height
Also referred to as zero plane displacement height, the displacement height of a vegetated surface (usually designated d) is the height at which the wind speed would go to zero if the logarithmic wind profile was maintained from the outer flow all the way down to the surface (that is, in the absence of vegetation). In other words, it is the distance over the ground at which a non-vegetated surface should be placed to provide a logarithmic wind field equal to the observed one. For forest canopies, the displacement height is estimated to vary between 0.6 and 0.8 times the height of the canopy. If not entered explicitly, EddyPro computes displacement height as:

$d = 0.67 \times$ canopy height

Roughness Length
In the logarithmic wind profile, the roughness length is the height at which wind speed is zero (indicated by z_0). It provides an estimate of the average roughness elements of the surface. With vegetated surfaces, because the vegetation itself provides a certain roughness, the logarithmic wind profile goes to zero at a height equal to the displacement height plus the roughness length. If not entered explicitly, EddyPro computes roughness length as:

$z_0 = 0.15 \times$ canopy height

GPS format (WGS84)
The World Geodetic System (WGS) is a standard used in cartography, geodesy, and navigation. WGS84 is the reference coordinate system used by Global Positioning Systems (GPS). Latitude and longitude coordinates for the site can be entered in any of three formats:

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Format	Description	Example
DDD MM SS.SSS	Degrees, minutes and seconds with North, South, East, or West suffix	12°20'44" N, 98°45'55" W
DDD MM.MMM	Degrees and decimal minutes with North, South, East, or West suffix	12°20.736' N, 98°45.924' W
Decimal Degrees	Decimal degrees with negative numbers for South and West	12. 3456, -98.7654

Latitude
Site latitude coordinates, entered in format chosen above at GPS format.

Longitude
Site longitude coordinates, entered in format chosen above at GPS format.

Anemometer Information

The Anemometer page allows you to enter information about the sonic anemometer, including the manufacturer and model, data output format, offset from true north, and height. Some of the available options (e.g. North Alignment) will change, depending on the chosen model.
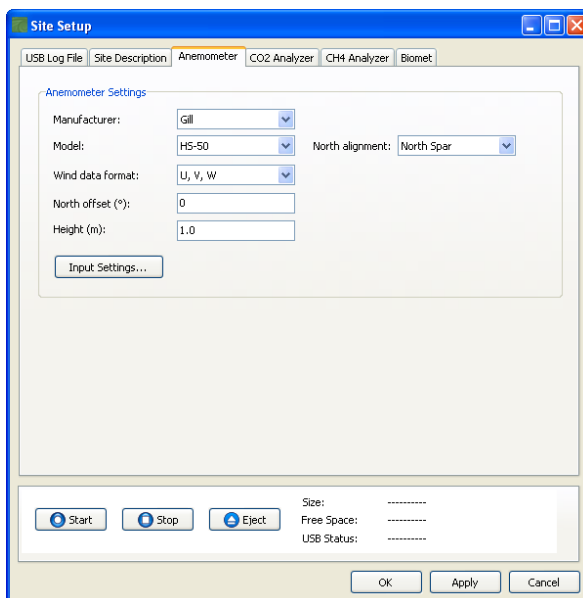
Choose the sonic anemometer manufacturer and model in the pull-down menus. LI-COR supports the following sonic anemometer models:

Manufacturer	Model(s)						
Campbell Scientific	CSAT3						
Gill Instruments	HS-50	HS-100	R2	R3-50	R3-100	Windmaster	Windmaster Pro
Metek	USA-1 Standard	USA-1 Fast					
R.M. Young	81000						

Wind Data Format
From the three axis velocities, the wind speed is calculated, and output as either signed U, V, and W, as Polar and W, or as raw velocity values. The units of output are set during the anemometer configuration.

Choose the wind data format from the pull-down menu:

U, V, W (some Gill anemometers):
U is defined as toward the direction in line with the north spar, as shown in the diagram below.
V is defined as toward the direction of 90° counter-clockwise from the N/Reference spar.
W is defined as vertically up the mounting shaft.

N

U

W

1

V

2

3

Top View

W
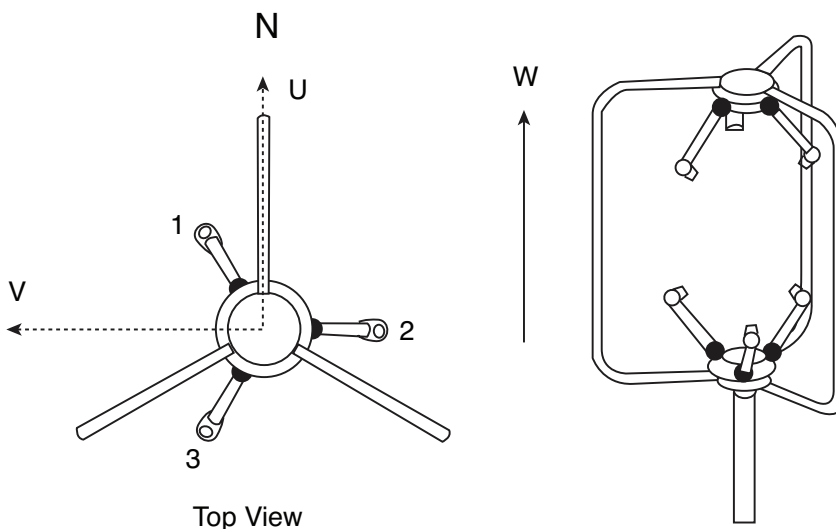
Polar, W:
The wind speed in the UV plane, with direction in degrees from 0 to 359°,
with respect to the Reference spar (normally aligned to North).

Axis velocities
Raw velocity values for U, V, W.

North Offset (°)
Offset, in degrees (0-359°) from which the Reference spar varies from true
north.

Height (m)
Sonic anemometer height above the ground, in meters, measured to center of
the anemometer sample volume.

Input Settings
Opens the Auxiliary Inputs window, where you can configure the sonic
anemometer type, units, label, and calibration coefficients (see *Auxiliary Inputs*
later in this section).

CO$_2$ Analyzer Information

Measurement of the separation between the gas analyzer(s) and the sonic anemometer used for calculating fluxes is necessary to estimate the high-frequency flux losses due to the distance between the instruments that measured the vertical wind component and the gas concentration(s). In order to allow EddyPro to determine the distance from a gas analyzer and the anemometer, distances are provided in a Cartesian coordinate system.

The CO$_2$ Analyzer tab allows you to select the type of gas analyzer used (LI-7500A, LI-7200), the values to log to the USB drive, and the separation information.

NOTES
● Units must be provided in centimeters (cm).
● The reference anemometer described in the METADATA file serves as the center of the coordinate system.
● Exact orientation of north-south and east-west axes are aligned with respect to true north, corrected for the local declination.
● For all gas analyzers and other anemometers (if any), the distances from the reference anemometer are provided along the north-south axis and the east-west axis.
● Distances are positive if the second instrument is to the north, east, or above the reference anemometer. This makes it possible for EddyPro to calculate distances between any pair of instruments.
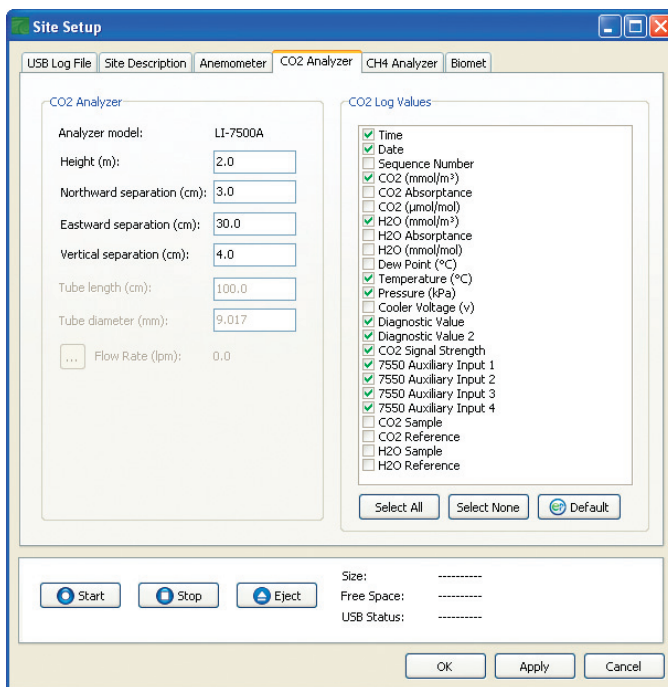
Height (m)
Gas analyzer height above the ground, in meters, measured to center of the analyzer sample volume (LI-7500A and LI-7700), or intake tube inlet (LI-7200).

Northward Separation (cm)
● Negative if south of the reference anemometer.
● Positive if north of the reference anemometer.

Eastward Separation (cm)
● Negative if west of the reference anemometer.
● Positive if east of the reference anemometer.
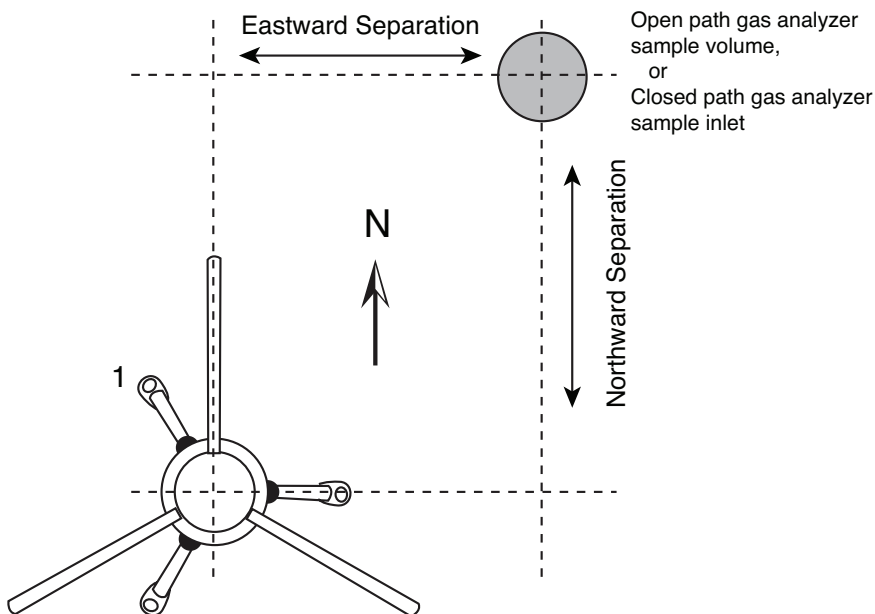
Vertical Separation (cm)
- Negative if the center of the analyzer sample volume (LI-7500A, LI-7700) or intake tube inlet (LI-7200) is below the center of the reference anemometer sample volume.
- Positive if the center of the analyzer sample volume (LI-7500A, LI-7700) or intake tube inlet (LI-7200) is above the center of the reference anemometer sample volume.
- Note that a setup as described above (and shown in the diagram below) is *not* recommended for Eddy Covariance measurements.
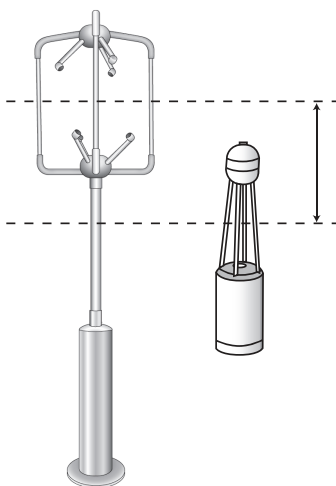
CO$_2$ Log Values

Under CO2 Log Values, select the data records that you want to output; click **Select All** to choose all, or **Select None** to disable all checked values. Click **Default** to select data records recommended for use with EddyPro™ software. The data items available for display are as follows:

Data Items	Variable	Description
Time	Time	Time in HH:MM:SS:MS
Date	Date	Date in YY:MM:DD
Sequence Number	Sequence Number*	Index value, increments every 3.3 ms (1/300s)
CO2 (mmol/m³)	CO2 (mmol/m^3)	CO_2 concentration density
CO2 Absorptance	CO2 Absorptance	CO_2 raw absorptance value
CO2 (µmol/mol)	CO2 (µmol/mol)	CO_2 mole fraction
H2O (mmol/m³)	H2O (mmol/m^3)	H_2O concentration density
H2O Absorptance	H2O Absorptance	H_2O raw absorptance value
H2O (mmol/mol)	H2O (mmol/mol)	H_2O mole fraction
Dew Point (°C)	Dew Point (°C)	Dew point temperature (°C)
Temperature (°C)	Temperature (°C)	Temperature measured at LI-7550
Pressure (kPa)	Pressure (kPa)	Pressure measured in LI-7550
Cooler Voltage (v)	Cooler Voltage (v)	Detector cooler voltage
Diagnostic Value	Diagnostic Value	Diagnostic value 0-255
Diagnostic Value 2	Diagnostic Value 2	Diagnostic value 0 or 1 (sync clocks)[†]
CO2 Signal Strength	CO2 Signal Strength	CO_2 Signal Strength
7550 Auxiliary Input 1	7550 Auxiliary Input 1	Auxiliary input 1 value
7550 Auxiliary Input 2	7550 Auxiliary Input 2	Auxiliary input 2 value
7550 Auxiliary Input 3	7550 Auxiliary Input 3	Auxiliary input 3 value
7550 Auxiliary Input 4	7550 Auxiliary Input 4	Auxiliary input 4 value
Integral	Integral	Integration result (area under curve)
Peak Height	Peak Height	Integration peak height
CO2 Sample	CO2 Sample	Floating point value, power received from source in absorbing wavelength for CO_2 (see Eq. 3-6)
CO2 Reference	CO2 Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for CO_2
H2O Sample	H2O Sample	Floating point value, power received from source in absorbing wavelength for H_2O
H2O Reference	H2O Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for H_2O

OK   Cancel

* Sequence number is displayed as **Ndx** (Index) in data output header

[†] A value of 0 indicates that the clocks in the LI-7550 and LI-7700 (if connected) are not synchronized, and/or the LI-7550 is not logging data to USB drive. A flag will appear next to 'LI-7700' in the main window in this state. A value of 1 indicates clocks are synchronized, and data are being logged to USB drive.

CH₄ Analyzer Data

The LI-7550 Analyzer Interface Unit can be connected to any LI-7700 Open Path CH₄ Analyzer on the network, providing a convenient way to integrate LI-7700 data into the same data set collected by the LI-7200 for greenhouse gas flux calculations.
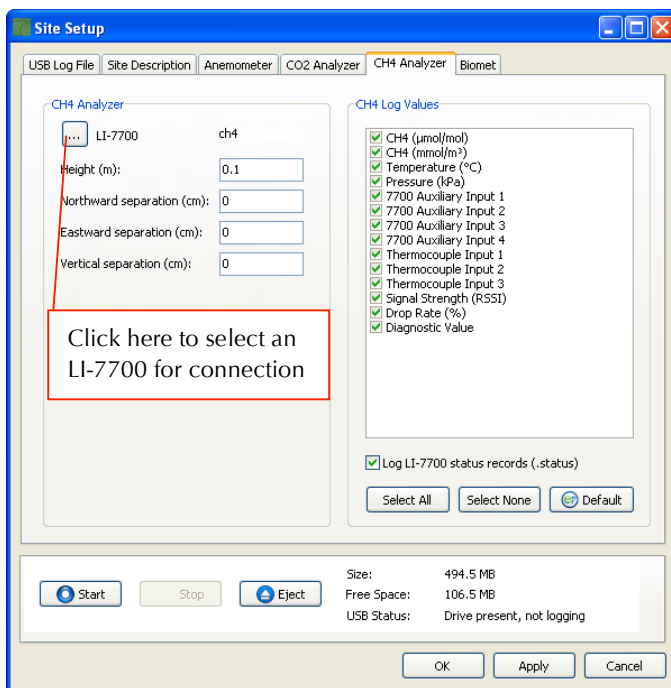
The LI-7700 data values to be logged to the USB drive are chosen under CH4 Log Values. In addition, you can enable the 'Log LI-7700 status records (.status)' check box to collect LI-7700 STATUS records. The log values available for the LI-7700 Open Path CH₄ Analyzer include:

CH4 (µmol/mol)	Methane mole fraction*
CH4 (mmol/m³)	Methane number density
Temperature (°C)	Temperature measured by LI-7700 thermocouple
Pressure (kPa)	Pressure measured by LI-7700
7700 Auxiliary Input 1	Auxiliary input 1
7700 Auxiliary Input 2	Auxiliary input 2
7700 Auxiliary Input 3	Auxiliary input 3

7700 Auxiliary Input 4	Auxiliary input 4
Thermocouple Input 1	Auxiliary thermocouple input 1 (°C)
Thermocouple Input 2	Auxiliary thermocouple input 2 (°C)
Thermocouple Input 3	Auxiliary thermocouple input 3 (°C)
Signal Strength (RSSI)	Signal strength (Residual Signal Strength Indicator (0-100%)
Drop Rate (%)	Percentage of 1000 Hz scans dropped (0-100%)
Diagnostic Value	Diagnostic value, an integer

* For calibrations and mean values; should not be used for Eddy Covariance calculations.

Click on the button next to LI-7700 to open the Settings window, where you can connect to an LI-7700 CH$_4$ analyzer (see *Settings* later in this section).

Refer to the LI-7700 Instruction Manual for more information.

Biomet Measurements

The LI-7550 Analyzer Interface Unit can be connected to any 9210 Sutron data logger on the network, providing a convenient way to integrate biomet station data into the same data set collected by the LI-7500A for greenhouse gas flux calculations.
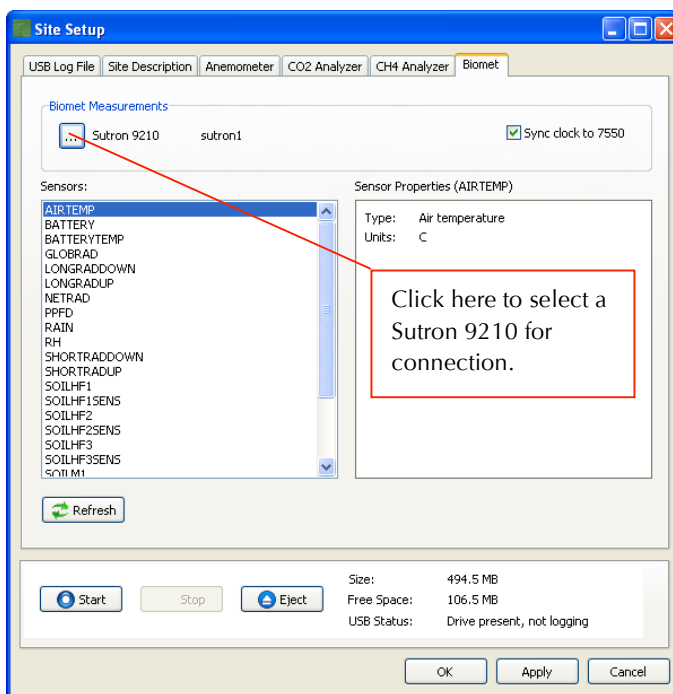
Click on the button next to Sutron 9210 to open the Settings window, where you can connect to a Sutron data logger (see *Settings* later in this section). After connection, a list of biomet sensors configured for use with the selected Sutron data logger is displayed under 'Sensors'. Click on any sensor in the list to display the Sensor Properties (e.g. Type and Units) for the selected sensor. Note that the Sensors and Sensor Properties are configured through the 9210; these lists are for reference only.

NOTE: Enable the 'Sync clock to 7550' to synchronize the 9210 and LI-7550 clocks; this is useful for synchronizing data when you are not logging biomet data to the .ghg file.

Refer to the 7900-100 Biomet Station Instruction Manual for more information.

Configuration Files

The LI-7500A Windows communication program uses configuration files to store a number of software parameters used to set up the LI-7500A for data output. These configuration files store information such as auxiliary input

calibration coefficients, DAC output channels, instrument calibration coefficients and zero/span values, and the source channels that you want to log. Unique configuration files can be set up, saved, and then re-opened to easily change your setup information.

When the LI-7500A program is started for the first time, a default set of parameters is loaded, which can be modified and saved as a new configuration file with a different name. The LI-7500A stores its configuration so that it will power on configured just as it was when it was powered off.

Config Files

To open an existing file, click on the Config Files toolbar icon and select Open Configuration. Locate the file on your computer, and click Open. The configuration file parameters are automatically applied to the current software session. You are prompted to send the configuration to the instrument; changes are not implemented in the instrument until the configuration file is applied.

To save a configuration file, click on the Config Files toolbar icon and select **Save Configuration**. Select the items in the Save Options dialog that you want to store in the configuration file, and click **Continue**.

Save Options

Select Items to save:

☑ Version Information
☑ Site Setup
☑ Settings*
☑ Inputs
☑ Outputs
☑ Zero/Span Values
☑ Calibration Coefficients

* Network settings are not saved

[Continue...] [Cancel]
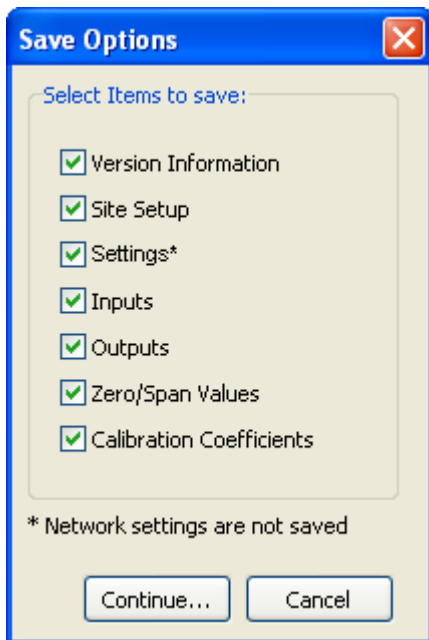
Choose the location to which you want to save the file, enter a file name, and click **Save**. File names are automatically appended with a .l7x file extension to denote an LI-7500A configuration file.

Auxiliary Inputs

Temperature and pressure values are required to convert CO_2 and H_2O density (mmol/m^3) to mole fraction (μmol/mol or mmol/mol). In addition, the LI-7500A requires a pressure value to compute CO_2 or H_2O mole density, and a temperature value to perform the band broadening correction for H_2O on CO_2.

The Inputs window allows you to specify where the temperature and pressure values are obtained; they can be measured with the on-board sensors, via a custom sensor measured at the Auxiliary Input port, or hand-entered.

In addition, other linear ±0-5V user-supplied sensors (e.g. sonic anemometer) can be input via the Auxiliary Input port; the LI-7550 has four auxiliary input channels; if you choose to use your own temperature and/or pressure sensors, then one or two of these channels would be unavailable for use with other sensors.
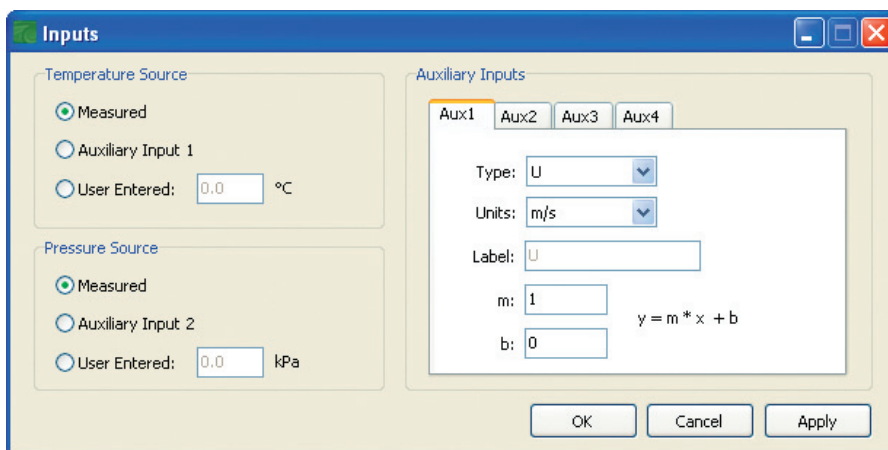
Select the **Type** of input for each channel. Choose 'Other' for any sensor input other than a sonic anemometer. For a sonic anemometer, choose the type U, V, W, Ts, or SOS (Speed of Sound) for that channel; the **Units** field describes the data *after* the coefficients m and b are applied (below). The **Label** will appear in the header of the data file.

Each auxiliary input channel has two fields that allow you to enter values for the multiplier (m) and offset (b). Linearized voltage inputs (±0-5V) use an equation of the form

$$y = m*x + b$$

where y is the sensor output, x is the voltage output of the sensor, b is the Y-axis intercept (offset), and m is the calibration multiplier, which is the slope of the line representing the sensor's response.
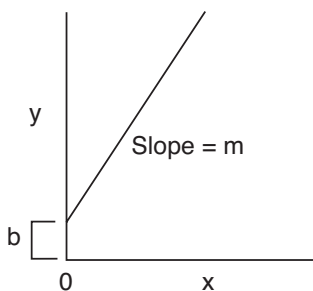
Use the temperature source and pressure source radio buttons to select the method for measuring these values. If you are using an auxiliary input, enter the values for the multiplier (m) and offset (b), and select 'Other' for the Type of input. If you have updated a user-entered value, you need to send them to the LI-7500A for implementation using the Apply button.

If you are using the on-board temperature and pressure sensors, four additional auxiliary input channels are available for use with other user-supplied sensors; enter the multiplier and offset values for these linear sensors as described above.

Using Sonic Anemometer Inputs
LI-COR offers a variety of sonic anemometers manufactured by Gill Instruments Ltd. (Hampshire, England); anemometers from other manufacturers can be input, as well, provided they have a linear output, and a maximum voltage output of ±5V. In general, the sonic anemometer must first be configured using software from the anemometers' manufacturer; some of the sonic outputs that can be output include the baud rate, alignment, measurement units, signal averaging, analog output range, and DAC outputs, among others. When purchased from LI-COR, the Gill Instruments sonic anemometers are pre-

configured at the factory with a default set of values; these default values can be modified, if desired, using Gill's Wind software program. Refer to the user manual for your sonic anemometer for further setup information.

For the purposes of the following discussion, we will use the default values input at the factory for the Gill Instruments Windmaster sonic anemometer. The default factory configuration appears below:

Field	**Option**
Message Output Format	Mode 1 ASCII UVW continuous
Baud Rate	19200
Output Rate	10 Hz
Message Terminator	<cr><lf>
Measurement Units	**m/s**
Alignment	North to Spar
Averaging (0=off)	0
Resolution	Normal resolution
Minimum Direction Resolution	50
SOS/Sonic Temp Display	SOS & Sonic Temp
Display Analogue Inputs	Off
Analog Output Mode	**0-5V, ±2.5V, ±5V**
PRT setting	Off
Unit Identifier	Q
Power on Message	Display Power on Message
Retries Enabled	On
Instantaneous Sampling	Off
Calibration Enabled	On
ASCII Format	Fixed Format
DAC Channel 1 (field)	**U output**
DAC Channel 1 (range)	**-30 to +30 m/s**
DAC Channel 2 (field)	**V output**
DAC Channel 2 (range)	**-30 to +30 m/s**
DAC Channel 3 (field)	**W output**
DAC Channel 3 (range)	**-5 to +5 m/s**
DAC Channel 4 (field)	**Sonic Temp**
DAC Channel 4 (range)	**-40 to 70 °C**
Rolling Average for Velocity Fields	Off
Rolling Average Depth	1

1. Choose the Type of Input

When using a sonic anemometer input, the 'Type' field allows you to choose from:

U – Horizontal wind speed (m/s) as measured toward the direction in line with the north spar (see diagram below)
V – Horizontal wind speed (m/s) as measured toward the direction of 90° counterclockwise from the north spar
W – Vertical wind speed (m/s) as measured up the mounting shaft
$\mathbf{T_s}$ – Sonic temperature (°C)
SOS – Speed of sound (m/s)

Top View
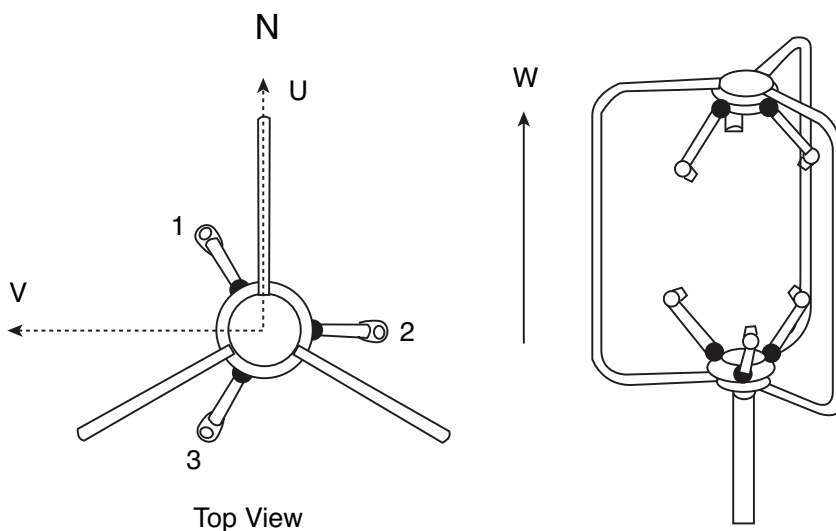
2. Choose the appropriate Units

It is important to note that the units selected for each auxiliary input determine the units label in the data file header, as well as the file header in the metadata file (if output) used with flux calculation programs such as EddyPro from LI-COR. As such, it is important to note whether or not you wish to convert the sonic inputs using the multiplier and offset values. For example, if you have configured your sonic anemometer to output U, V, and W values in volts, but want the data file and/or metadata file to record these values in m/s, you will need to set the multiplier and offset values according to the output range over which you want to scale.

Example: You have configured the Gill Windmaster to output raw voltages for auxiliary input U over the range of 0-5V, and over a full scale wind speed of -30 to +30 m/s. You want to convert the raw voltages to wind speed and output the values in units of m/s. What is the wind speed when the sonic anemometer outputs a raw voltage value of 0.5V?

1. Set the 'Type' field to U.
2. Set the 'Units' field to m/s. The Label is set automatically.
3. Enter 12 for the Multiplier (m)
4. Enter -30 for the Offset (b)

Using the equation from page 4-30,

$$y = m*x + b$$

the wind speed is calculated as

$$y = 12(0.5) + (-30) = -24 \text{ m/s}$$

Example 2: You have configured the Gill Windmaster to output raw voltages for auxiliary input U over the range of ±5V, and over a full scale wind speed of -30 to +30 m/s. You want to convert the raw voltages to wind speed and output the values in units of m/s. What is the wind speed when the sonic anemometer outputs a raw voltage value of 1.5V?

1. Set the 'Type' field to U.
2. Set the 'Units' field to m/s. The Label is set automatically.
3. Enter 6 for the Multiplier (m)
4. Enter 0 for the Offset (b)

Using the equation from page 4-30,

$$y = m*x + b$$

the wind speed is calculated as

$$y = 6(1.5) + 0 = 9 \text{ m/s}$$

The following table gives the appropriate values for m (multiplier) and b (offset) to be used when converting raw voltages into units of m/s, using the default

sonic anemometer output ranges of -30 to +30 m/s for U and V, and -5 to +5 m/s for W.

	U, V (-30 to +30 m/s)		W (-5 to +5 m/s)	
Sonic output (V)	m	b	m	b
0-5V	12	-30	2	-5
±5V	6	0	1	0
±2.5V	12	0	2	0

If you do not want to convert raw voltages, simply set m = 1, and b = 0. Set the Units to V, and the raw voltage output will be recorded in both the data and metadata files as such. Similarly, if you have set the anemometer to output U, V, and W in units of m/s, set m = 1, and b = 0; no conversion will occur, and the data and/or metadata files will mirror the actual sonic output, and in the same units.

3. Enter the Label.
The Label will appear in the file header in both the data and/or metadata files. The label cannot be changed for any of U, V, W, T_s, or SOS. The label can be entered only when 'Other' is selected.

Outputs

The Outputs window allows you to configure the DAC output channels, as well as configure the instrument's RS-232, Ethernet, or Synchronous Device for Measurement (SDM) output, for use with Campbell Scientific Inc. (Logan, UT) data loggers.
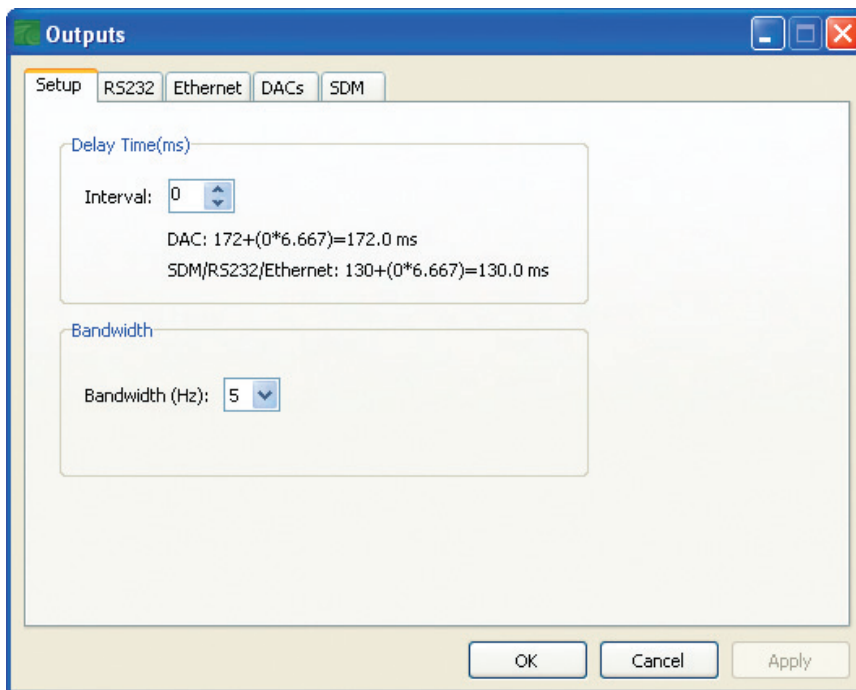
The Setup tab contains Delay Time and Bandwidth settings that affect **all** LI-7500A outputs (RS-232, Ethernet, DACs, and SDM).

Delay Time
The output signal from the LI-7500A optical bench is sampled by a high-speed A/D converter and input into a Digital Signal Processor (DSP). This signal is processed digitally and gas densities are computed from it. There is a fixed delay in this process, and an additional user-programmable delay that can be used to make the LI-7500A output occur on even sampling intervals.

The LI-7500A has a fixed throughput delay of 172 milliseconds for the DAC outputs, and 130 ms for the SDM, RS-232, and Ethernet outputs. This delay can be increased in increments of 1/150 seconds (6.667 ms), to minimize offsets between the LI-7500A and other sensors.

For example, suppose you are sampling (via SDM output) the LI-7500A with a Campbell Scientific CR5000 datalogger at 10 Hz (0.1 s). Setting the delay count of the LI-7500A to 25 yields a total delay of .297 seconds, which means the LI-7500A data will have a delay of 3 execution intervals (0.297 s/0.1 s),

which the logger can allow for in synchronizing the data to the sonic anemometer or other analog measurements made by the datalogger. Thus, the "unaccounted for" lag is .003s. Without this extra delay, the lag time would be .130 seconds, which is 1 execution interval (0.1 seconds) plus .03 seconds unaccounted for.

Similarly, if you are sampling the LI-7500A with the DAC outputs, setting the delay count to 19 yields a total delay of .299 seconds. The lag will be 0.001s.

Total System Delay Examples
Total System Delay (ms) = Delay Time + (Delay Step × Delay Step Increment)

Output	Delay Time (ms)	Delay Step (ms)	Delay Step Increment	Total Delay (ms)
DAC	172	6.667	19	299
SDM/RS-232/Ethernet	130	6.667	25	297

Bandwidth
Bandwidth (5, 10 or 20 Hz) determines the signal averaging done by the digital filter. To avoid aliasing (only a concern for co-spectra, not for fluxes), ***one should sample the LI-7500A at a frequency greater than or equal to 2 times the bandwidth***. Thus, if you are sampling at 10 Hz, set Bandwidth to 5 Hz.

Bandwidth is the frequency at which the indicated amplitude is 0.707 of the real amplitude (Figure 4-2).
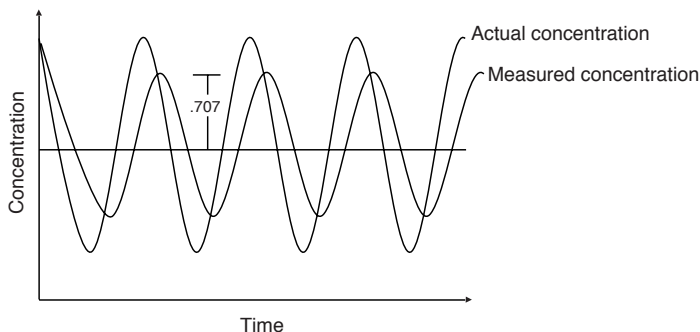
Figure 4-2. Bandwidth = 1/oscillation period.

Bandwidth is a useful indicator for characterizing real-world behavior in which there are fluctuating gas concentrations. Given a sinusoidal oscillation of

concentration, the instrument's ability to measure the full oscillation amplitude diminishes as the oscillation frequency increases.

Note About System Delay vs. Bandwidth

The bandwidth selection has *no* impact on the system delay. The filters were designed so they have exactly the same delay whether a 5, 10, or 20 Hz signal bandwidth is selected.

RS-232 Output

The RS-232 page is used to set the LI-7500A RS-232 port configuration for unattended data collection. After configuration, click Apply; the LI-7500A will begin to send data out the RS-232 port according to these parameters *after* you Disconnect from the instrument (or immediately if you are connected via Ethernet).
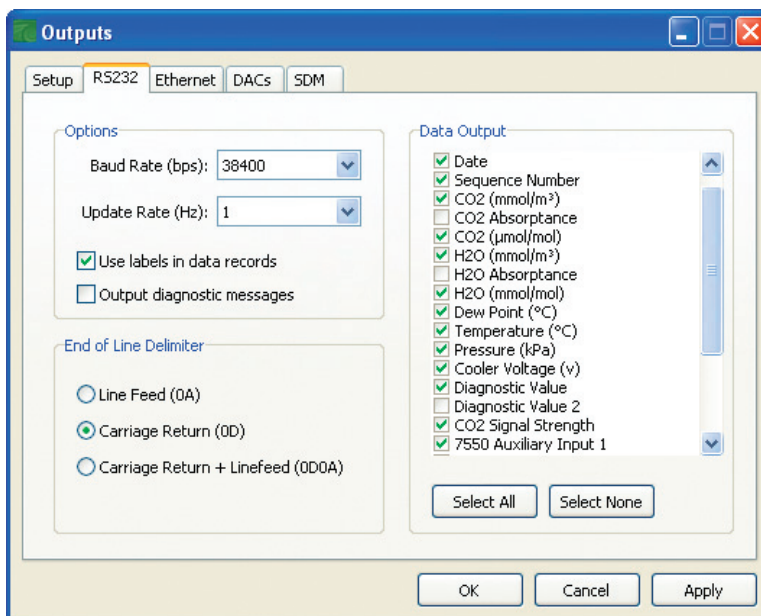
Use the Baud Rate pull-down menu to select from 9600, 19200, 38400, 57600, or 115200 baud.

Use the Update Rate pull-down menu to select from .1, .2, .5, 0, 1, 2, 5, 10, or 20 Hz. Note that at lower baud rates, you may not be able to output all data

items at high frequencies. For example, at 9600 baud, the maximum update rate is 2 Hz, when outputting all 25 data items.

Note on Data Output Rates

When sending data via a serial connection (e.g. RS-232), note that the baud rate selected may limit the number of samples that can be output. A single line of data (all Log Values selected) consists of approximately 350 bytes (2800 bits), so the maximum output rate at the available baud rates becomes:

Baud Rate	Maximum Output Rate (Samples/Second)
9600	2
19200	5
38400	10
57600	15
115200	20

Similarly, when logging to an external USB device, logging 20 samples per second (20 Hz) would result in approximately 384 MB/day data accumulation, or about 1 GB/2.5 days (uncompressed).

Under Options, you can choose whether or not to output labels with each data record, and whether to output diagnostic text records. An example of a data record sent with and without labels is shown below.

Data format with labels:
(Data (Ndx 87665) (DiagVal 757) (Date 2009-09-10) (Time 14:06:44:140) CO2Raw 0.0332911) (H2ORaw 0.19299) (CO2D 5.20672) (H2OD 755.566) (Temp 15.517) (Pres 99.4361)…

Data format without labels:
87665 757 2009-09-10 14:06:44:140 0.0332911 0.19299 5.20672…

The End of Line Delimiters determine the character(s) that terminate the data records. Depending on your recording device, a line feed, carriage return, or both may be required to properly parse the data records.

Under Data Output, select the data records that you want to output; click Select All to choose all, or Select None to disable all checked values.

Ethernet Output

The Ethernet page is used to set the LI-7500A Ethernet port configuration for unattended data collection. After configuration, click Apply; the LI-7500A will begin to send data out the Ethernet port according to these parameters immediately.

Use the Update Rate pull-down menu to select from .1, .2, .5, 0, 1, 2, 5, 10, or 20 Hz.

Under Options, you can choose whether or not to output labels with each data record, and whether to output diagnostic text records. An example of a data record sent with and without labels is shown below.

Data format with labels:
> (Data (Ndx 87665) (DiagVal 757) (Date 2009-09-10) (Time 14:06:44:140) CO2Raw 0.0332911) (H2ORaw 0.19299) (CO2D 5.20672) (H2OD 755.566) (Temp 15.517) (Pres 99.4361)…

Data format without labels:
> 87665 757 2009-09-10 14:06:44:140 0.0332911 0.19299 5.20672…

The End of Line Delimiters determine the character(s) that terminate the data records. Depending on your recording device, a line feed, carriage return, or both may be required to properly parse the data records.

Under Data Output, select the data records that you want to output; click **Select All** to choose all, or **Select None** to disable all checked values. The data items available for display are as follows:

Data Items	Variable	Description
Time	Time	Time in HH:MM:SS:MS
Date	Date	Date in YY:MM:DD
Sequence Number	Sequence Number*	Index value, increments every 3.3 ms (1/300s)
CO2 (mmol/m³)	CO2 (mmol/m^3)	CO_2 concentration density
CO2 Absorptance	CO2 Absorptance	CO_2 raw absorptance value
CO2 (µmol/mol)	CO2 (µmol/mol)	CO_2 mole fraction
H2O (mmol/m³)	H2O (mmol/m^3)	H_2O concentration density
H2O Absorptance	H2O Absorptance	H_2O raw absorptance value
H2O (mmol/mol)	H2O (mmol/mol)	H_2O mole fraction
Dew Point (ºC)	Dew Point (°C)	Dew point temperature (°C)
Temperature (ºC)	Temperature (°C)	Temperature measured at LI-7550
Pressure (kPa)	Pressure (kPa)	Pressure measured in LI-7550
Cooler Voltage (v)	Cooler Voltage (v)	Detector cooler voltage
Diagnostic Value	Diagnostic Value	Diagnostic value 0-255
Diagnostic Value 2	Diagnostic Value 2	Diagnostic value 0 or 1 (sync clocks)[†]
CO2 Signal Strength	CO2 Signal Strength	CO_2 Signal Strength
7550 Auxiliary Input 1	7550 Auxiliary Input 1	Auxiliary input 1 value
7550 Auxiliary Input 2	7550 Auxiliary Input 2	Auxiliary input 2 value
7550 Auxiliary Input 3	7550 Auxiliary Input 3	Auxiliary input 3 value
7550 Auxiliary Input 4	7550 Auxiliary Input 4	Auxiliary input 4 value
Integral	Integral	Integration result (area under curve)
Peak Height	Peak Height	Integration peak height
CO2 Sample	CO2 Sample	Floating point value, power received from source in absorbing wavelength for CO_2 (see Eq. 3-6)
CO2 Reference	CO2 Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for CO_2
H2O Sample	H2O Sample	Floating point value, power received from source in absorbing wavelength for H_2O
H2O Reference	H2O Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for H_2O

OK   Cancel

* Sequence number is displayed as **Ndx** (Index) in data output header
[†] A value of 0 indicates that the clocks in the LI-7550 and LI-7700 (if connected) are not synchronized, and/or the LI-7550 is not logging data to USB drive. A flag will appear next to 'LI-7700' in the main window in this state. A value of 1 indicates clocks are synchronized, and data are being logged to USB drive.

DAC Configuration

The LI-7550 has the capability to output up to 6 variables on DAC channels 1-6. The DACs page allows you to configure the DAC output channels by specifying the source channel (e.g. CO2 mmol/m3) that drives the analog signal, the source channel value that corresponds to zero volts, and the source channel value that corresponds to full scale voltage (5V).

For example, to configure DAC #1 to output a voltage signal proportional to CO_2 mmol/m^3, 20 mmol/m^3 full scale, select CO_2 mmol/m^3 under DAC1 'Source', and set 0V = 0, and 5V = 20.

$0V \rightarrow 0$ (X_o, zero volts corresponds to 0 mmol/m^3)
$5V \rightarrow 20$ (X_F, full scale corresponds to 20 mmol/m^3)

When a voltage range R is selected, the DAC output voltage V resulting from a CO_2 molar value X is given by

$$V = R \frac{X - X_o}{X_F - X_o}$$

where R = 5V.

The DACs are linear, so in the example above, a measured voltage signal of 3 volts would correspond to a CO_2 mmol/m^3 value of 12.

For test purposes, you can also choose 'Set Point' for the Source, and enter a Set Point voltage value; the DAC channel will then output that voltage continuously.

SDM Output

SDM addressing allows multiple SDM-compatible peripherals to be connected to a single Campbell Scientific datalogger. Choose an address under the SDM tab between 0 and 14.

SDM communications are enabled in Campbell Scientific dataloggers with one of two instructions, depending on the datalogger. For dataloggers programmed in EdLog (e.g. CR23X) SDM communications are enabled using instruction 189:SDM LI-7500. When using this instruction, parameter two (SDM Address) should be set to match the SDM address of the LI-7500A. Parameter three (Option) is used to define what variables the datalogger collects from the instrument, and can take on values from 0 to 6 (see table 4-1 for variables included in each option). Below is a programming example of instruction 189 used to collect data from an LI-7500A at SDM address 0:

```
1:  SDM-LI7500 (P189)
 1: 1        Reps
 2: 0        SDM Address
 3: 6        Get CO2 & H2O molar density, pressure, and
             cell diagnostic value
 4: 49       Loc [ LI75000   ]
```

For dataloggers programmed in CRBasic (e.g. CR5000) SDM communications are enabled using the instruction CS7500. When using this instruction, parameter three (SDMAddress) should be set to match the SDM address of the LI-7500A. Parameter four (CS7500Cmd) is used to define what variables the datalogger collects from the instrument. Unlike instruction 189, the CS7500 instruction supports a group trigger mode, so it can take on values from 0 to 7 (see table 4-1 for variables included in each option). Below is a programming example of the CS7500 instruction used to collect data from an LI-7500A at SDM address 0:

```
CS7500 (LI-7500(),1,0,6)
```

Table 4-1. Parameter 3 (EdLog) or Parameter 4 (CRBasic) value definitions.

Mode	Items Sent
0	CO_2 (mmol/m^3) H_2O (mmol/m^3)
1	CO_2 absorptance H_2O absorptance
2	Pressure (kPa) Temperature (°C) Aux channel #1 (user units) Cooler signal (Volts)
3	Diagnostic value (see below) Bandwidth (Hz) Delay interval
4	CO_2 (mmol/m^3) H_2O (mmol/m^3) CO_2 absorptance H_2O absorptance Pressure (kPa) Temperature (°C) Aux channel #1 (user units) Cooler signal (Volts) Diagnostic value (see below) Bandwidth (Hz) Delay interval
5	CO_2 (mmol/m^3) H_2O (mmol/m^3) Pressure (kPa)
6	CO_2 (mmol/m^3) H_2O (mmol/m^3) Pressure (kPa) Diagnostic Value (see below)
7	<u>Trigger Mode</u> CO_2 (mmol/m^3) H_2O (mmol/m^3) CO_2 Signal Strength Pressure (kPa)

NOTES:	LI-7500A Mode 7 requires the Campbell datalogger to broadcast a group trigger to cause data to be registered. The registered data set is held and not updated until the next group trigger.
	All serial transfers on the SDM bus are bit reversed. This means that the least significant bit is sent first and the most significant bit is sent last. This includes sending the signature.

Diagnostic Value

The cell diagnostic value is a 1 byte unsigned integer (value between 0 and 255) with the following bit map:

bit 7	bit 6	bit 5	bit 4	bit 3 bit 2 bit 1 bit 0
Chopper	Detector	PLL	Sync	<--- (Signal Strength * 6.67) --->
1=ok	1=ok	1=ok	1=ok	

Example: a value of 125 (01111101) indicates Chopper not ok, and Signal Strength = 87% (1101 binary converted to decimal is 13, times 6.67)

Bit	Name	Description
0 to 3	Signal Strength	Value x 6.67 = Signal Strength.
4	Sync	Always set to 1 (OK)
5	PLL	Lock bit, indicates that optical wheel is rotating at the correct rate.
6	Detector	1 = Detector temperature is near setpoint 0 = Detector temperature is not near setpoint
7	Chopper	1 = Chopper wheel temperature is near setpoint 0 = Chopper wheel temperature is not near setpoint

PC Logging

The PC Data Logging page is used to configure the data output parameters used while the LI-7500A Windows application is active. Data are logged to a file on your computer. You can specify the destination file, update rate, file duration, comments, and values to be logged. Note that file compression and metadata information are not available when logging to a PC; these options are available only when logging to the USB drive (see *Site Setup* earlier in this section).

Data can be logged at up to 20 Hz, which can result in large data files. These files can be split into smaller files, if desired, at 15, 30, 60 minutes, or 1.5, 2, 4, or 24 hour intervals. Note that the files are split based on the system clock; thus, if you choose to split the files at 15 minute intervals, and start logging at 10:22, the file will be split at 10:30, 10:45, 11:00, etc.

All files are assigned a timestamp with the format YYYY-MM-DDTHHMMSS_InstrumentName.ext, where date and time are year, month, day, and HHMMSS is 24-hour time (e.g. hour 15 = 3:00 p.m.). The file extension appended is either .data, .metadata, or .status.

Under Log Values, select the data records that you want to output; click **Select All** to choose all, or **Select None** to disable all checked values. The data items available for display are as follows:

Data Items	**Variable**	**Description**
Time	Time	Time in HH:MM:SS:MS
Date	Date	Date in YY:MM:DD
Sequence Number	Sequence Number*	Index value, increments every 3.3 ms (1/300s)
CO2 (mmol/m³)	CO2 (mmol/m^3)	CO_2 concentration density
CO2 Absorptance	CO2 Absorptance	CO_2 raw absorptance value
CO2 (µmol/mol)	CO2 (µmol/mol)	CO_2 mole fraction
H2O (mmol/m³)	H2O (mmol/m^3)	H_2O concentration density
H2O Absorptance	H2O Absorptance	H_2O raw absorptance value
H2O (mmol/mol)	H2O (mmol/mol)	H_2O mole fraction
Dew Point (°C)	Dew Point (°C)	Dew point temperature (°C)
Temperature (°C)	Temperature (°C)	Temperature measured at LI-7550
Pressure (kPa)	Pressure (kPa)	Pressure measured in LI-7550
Cooler Voltage (v)	Cooler Voltage (v)	Detector cooler voltage
Diagnostic Value	Diagnostic Value	Diagnostic value 0-255
Diagnostic Value 2	Diagnostic Value 2	Diagnostic value 0 or 1 (sync clocks)[†]
CO2 Signal Strength	CO2 Signal Strength	CO_2 Signal Strength
7550 Auxiliary Input 1	7550 Auxiliary Input 1	Auxiliary input 1 value
7550 Auxiliary Input 2	7550 Auxiliary Input 2	Auxiliary input 2 value
7550 Auxiliary Input 3	7550 Auxiliary Input 3	Auxiliary input 3 value
7550 Auxiliary Input 4	7550 Auxiliary Input 4	Auxiliary input 4 value
Integral	Integral	Integration result (area under curve)
Peak Height	Peak Height	Integration peak height
CO2 Sample	CO2 Sample	Floating point value, power received from source in absorbing wavelength for CO_2 (see Eq. 3-6)
CO2 Reference	CO2 Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for CO_2
H2O Sample	H2O Sample	Floating point value, power received from source in absorbing wavelength for H_2O
H2O Reference	H2O Reference	Floating point value, power received from source in reference (non-absorbing) wavelength for H_2O
[OK] [Cancel]		

* Sequence number is displayed as **Ndx** (Index) in data output header

[†] A value of 0 indicates that the clocks in the LI-7550 and LI-7700 (if connected) are not synchronized, and/or the LI-7550 is not logging data to USB drive. A flag will appear next to 'LI-7700' in the main window in this state. A value of 1 indicates clocks are synchronized, and data are being logged to USB drive.

Begin Logging Data
Press **Start** to begin logging data. Press **Stop** to quit logging.

Note on Data Output Rates
When sending data via a serial connection (e.g. RS-232), note that the baud rate selected will limit the number of samples that can be output. A single line of data (all Log Values selected) consists of approximately 350 bytes (2800 bits), so the maximum output rate at the available baud rates becomes:

Baud Rate	Maximum Output Rate (Samples/Second)
9600	2
19200	5
38400	10
57600	15
115200	20

Logging 20 samples per second (20 Hz) would result in approximately 384 MB/day data accumulation, or about 1 GB/2.5 days.

Calibration

The LI-7500A uses a fifth order polynomial for the CO_2 calibration, and a third order polynomial for the H_2O calibration. Complete instructions for calibrating the LI-7500A can be found in Section 5.

The Calibration window contains buttons to set the zero and span(s) of the LI-7500A. There are entry fields to set the target values for the span gases used to set the span of the instrument; CO_2 span gas target values are in ppm, and H_2O span gas target values are entered in degrees C dewpoint. The Zero and Span windows also provide information about the stability of the gas flowing through the sensor head; a green flag indicates that it is OK to perform the calibration. A red 'X' indicates that it is not OK to perform the calibration; wait until the red 'X' changes to a green flag before performing the calibration.
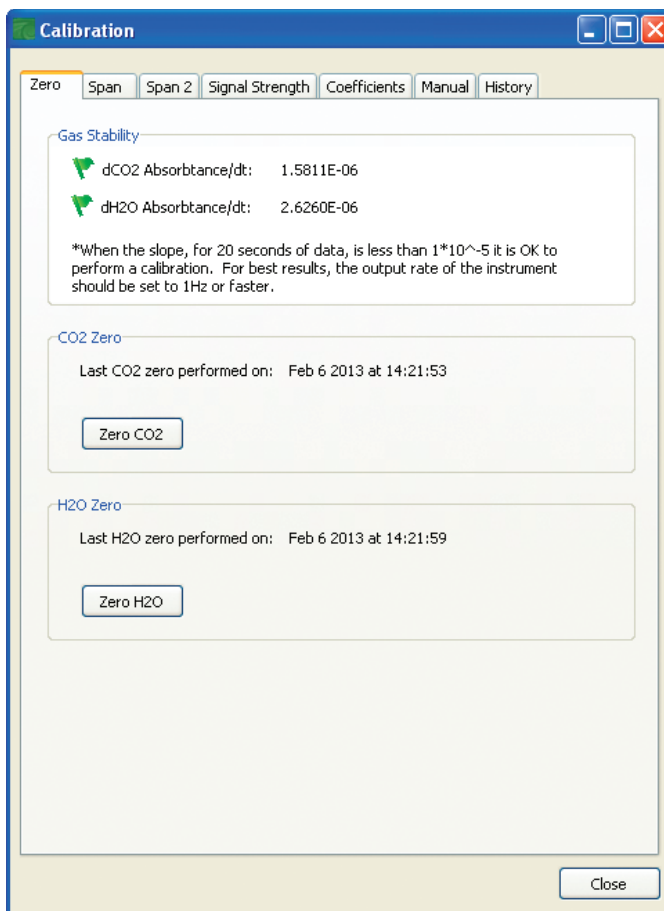
Signal Strength Tab

The Signal Strength tab contains a button labeled "Reset Signal Strength" that you can push if you've decided your instrument is as clean as you can reasonably make it, and you want to reset the signal strengths to 100. See Section 3, *LI-7500A Signal Strength*, for more information.
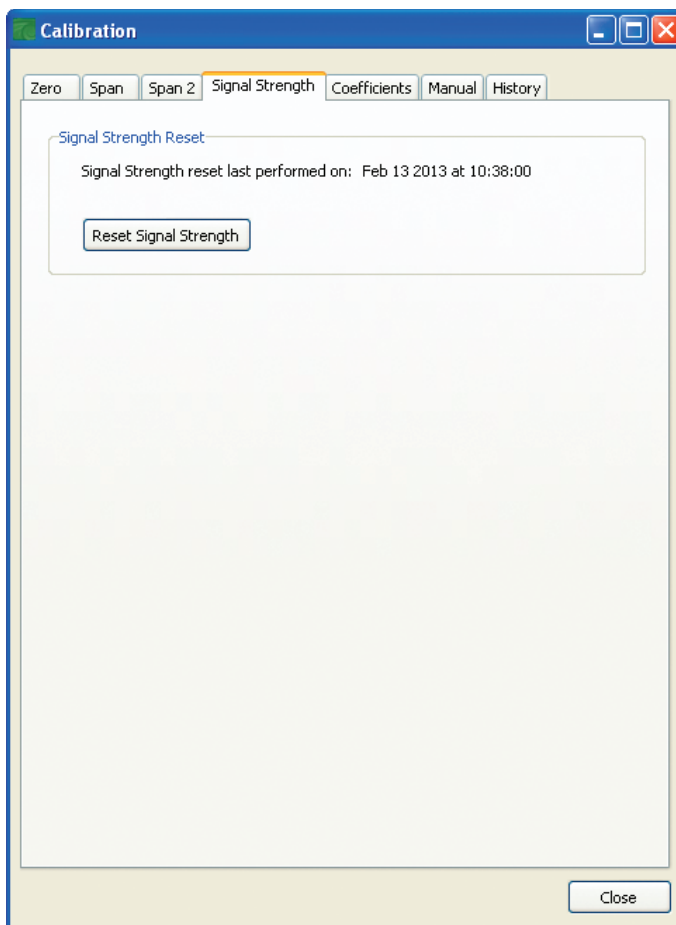
Coefficients Tab

The Coefficients tab displays factory-determined calibration coefficients, as well as a factor for correcting CO_2 measurements for band broadening due to the presence of water vapor (A), and a zero drift correction factor (Z). The coefficient shown as XS (Cross Sensitivity) compensates for slight cross sensitivity between CO_2 and H_2O signals absorbed by the detector (see Cross Sensitivity and Zero Drift in Section 3).
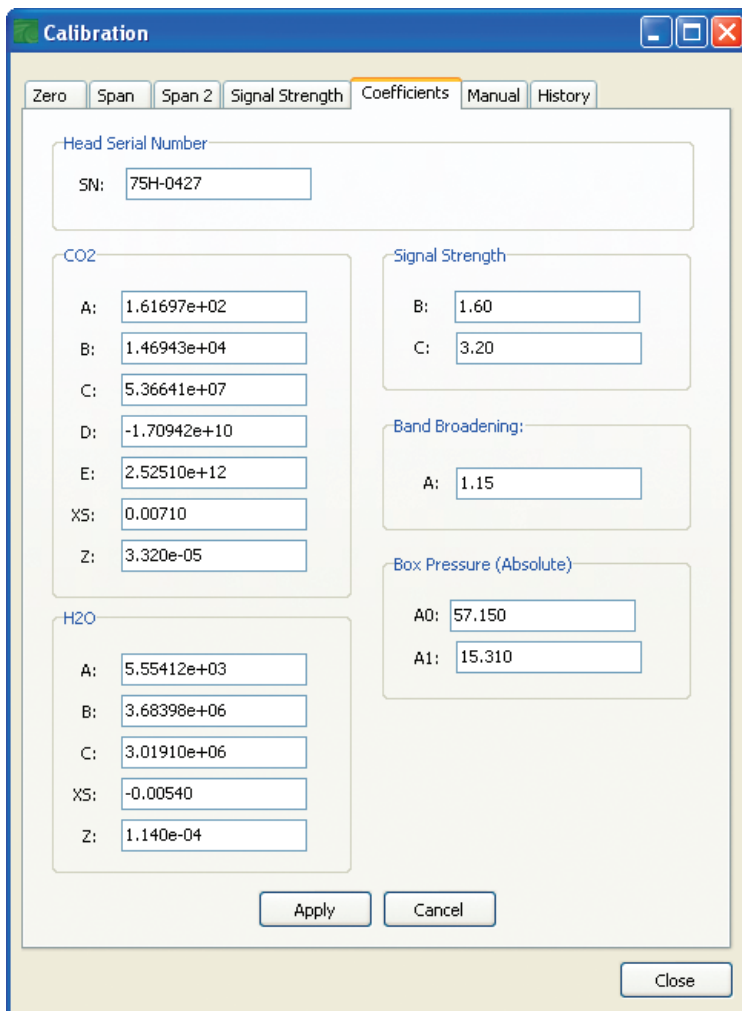
The calibration coefficients, XS, and Z values are unique to each sensor head, and may be found on the calibration sheet shipped from the factory. The Band Broadening coefficient is 1.15 for all sensor heads.

The calibration coefficients are stored in the LI-7550 Analyzer Interface Unit, not the sensor head. To change these values, edit them and then click **Apply** to send these values to the LI-7500A for implementation. Click **Cancel** to change any edited values in the window back to the state they were in before editing.

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The *Head Serial Number* displays the serial number of the LI-7500A sensor head that is associated with the coefficients.

When exchanging sensor heads, it is necessary to change calibration coefficients, and to redo the zero and span.

HINT: The easiest way to get the calibration coefficients, zero, and span updated for a sensor head is to make use of "Save Configuration" and "Open Configuration".

Changing Sensor Heads

Sensor heads are freely interchangeable between LI-7550 Analyzer Interface Units. However, the Interface Unit must have the correct calibration coefficients, and current zero and span information, for the sensor head attached to it. This can be done by hand, or "automatically".

By Hand
1. Attach the new sensor head.
2. Connect to the computer and establish communications.
3. Enter the calibration coefficients from the Calibration Certificate that came with the sensor head under the Coefficients tab.
4. Zero and span the IRGA.
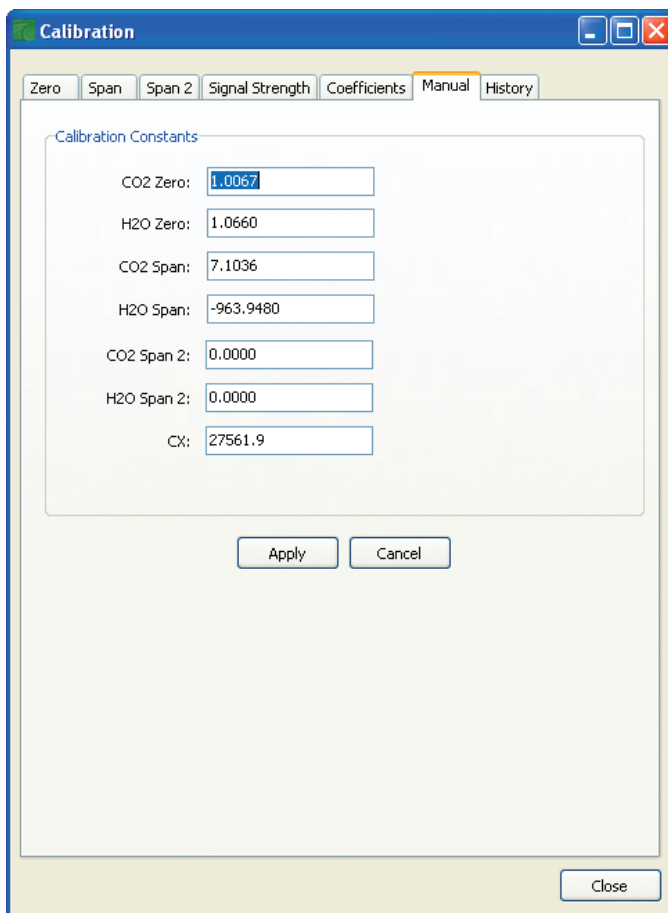
Automatic
Before removing a calibrated analyzer from its LI-7550, use "Save Configuration" to store the configuration information in a file. Then, to move this head to another LI-7550:
1. Attach the sensor head to the LI-7550.
2. Connect to the computer, and establish communications.
3. Select "Open Configuration". Choose the file saved earlier; the coefficients will automatically be loaded.
4. Manually enter the Box Pressure calibration coefficients from the Calibration Certificate that came with the sensor head under the Coefficients tab. The Box Pressure coefficients saved in the old configuration file should not be used with the new Analyzer Interface Unit.

Manual Tab
The Manual tab displays current values for CO_2 and H_2O zero and span; after performing a zero and span calibration, these values should be near 1 (zero is typically between 0.9 and 1.1, and span is typically between 0.95 and 1.05; Z_{wo} and Z_{co}, see Equations 3-13 and 3-17). Span 2 values will be near zero.

We recommend that you track the zero values over time as you re-zero the instrument. As the internal chemicals lose their effectiveness, this value will increase. The CO_2 zero drift is also somewhat temperature dependent.


In most cases you will never need to manually edit these values. If, for some reason, the instrument calibration becomes unstable (e.g. you accidentally zeroed or spanned the instrument with the wrong gas), you can manually enter a value of 1 for each of these parameters (and zero for Span 2 values), and click **Apply**. This will return the instrument to a more normal state, after which you can perform zero and span calibrations again. Alternatively, if you have performed at least one previous (successful) calibration, you can restore those values using the History tab (below).

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History Tab

The History tab displays a list of previous calibration backup files, generated during a zero and/or span calibration of the instrument (when used with the same computer used to connect to the instrument). You can click on any previous calibration in the list to view the details; you can also restore the values from a previous calibration by choosing a file in the list and clicking the Restore button. Click **Delete** to permanently remove calibration files from the list stored on the computer.

Charting

The Strip Chart page allows real time graphics display of one or two variables plotted against time. The Y-Axes (left and right) display the value chosen in the respective pull-down menus against time on the X-Axis.
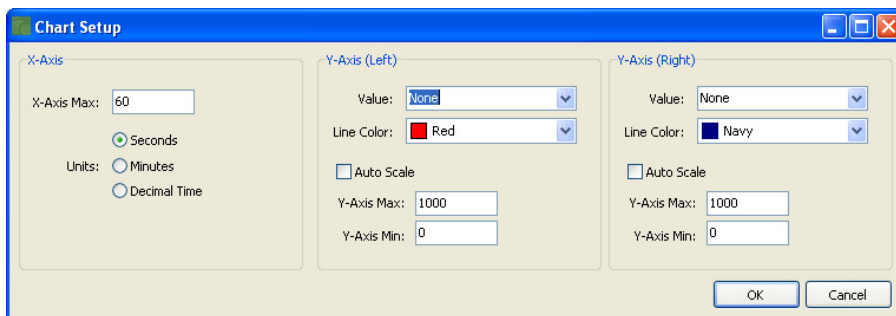

Time on the X-Axis can be displayed over user-defined values of seconds or minutes; the X-Axis Max value defines the unit of time displayed in the window before the window starts scrolling the time value off the right edge.

Choose the value for the Y-Axis Left and/or Y-Axis Right in the pull-down menu(s), and enter values for the Y-Axis maximum and minimum; choose Auto Scale if you want the chart to scale the Y-Axis automatically to keep data from scrolling off the top or bottom edges. You can also select the color of the line for both Y-Axes values.

When you are finished defining the strip chart(s) parameters, click **OK**. A new chart window will appear. Press **Pause All** to temporarily stop plotting (press Pause All again to resume); press **Save** to save a "snapshot" of the current plot to a bitmap file; press **Print** to print the currently displayed chart window, or

press **Options** to open the Chart Setup window again to make changes to the strip chart parameters.
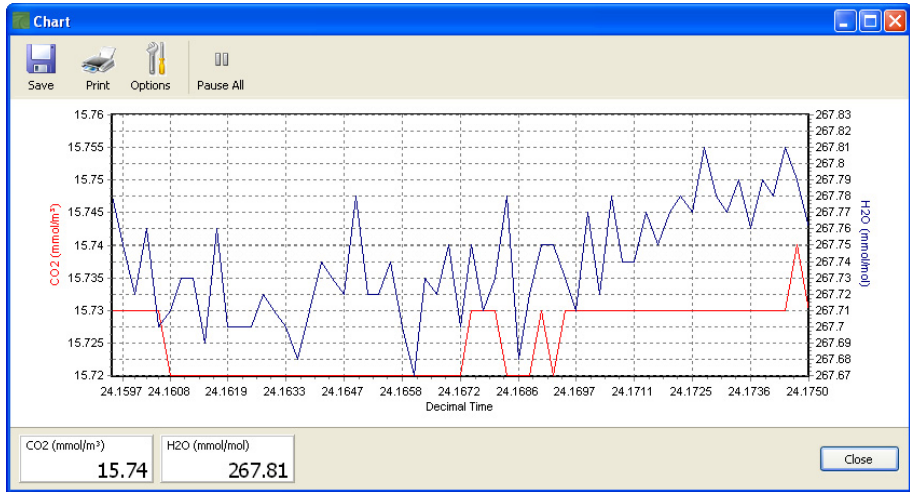
TIPS: You can rescale both Y axes of an active strip chart "on the fly", by right clicking the mouse button on the chart, holding, and dragging up or down. You can also have as many new chart windows as you want.

Settings

Time

Sets the system time and date. The clock in the LI-7550 Analyzer Interface Unit uses the Precision Time Protocol (PTP) time keeping system. PTP is a high precision time synchronization protocol for networked devices. Devices controlled with PTP can maintain accuracy in the sub-microsecond range with a sufficiently accurate master clock. PTP is defined in the IEEE 1588-2002 and 1588-2008 standards, entitled "Standards for Precision Clock Synchronization Protocol for Networked Measurement and Control Systems." A detailed summary of IEEE-1588 is available at www.ieee1588.com. Full documentation is available for purchase from the Institute of Electrical and Electronics Engineers (IEEE) at www.ieee.org.

The basic principle behind PTP is that the best time keeping can be accomplished with multiple networked devices by synchronizing all device clocks to the most precise clock on the network. Each clock on the network has a rating that indicates its relative accuracy. The IEEE 1588 protocol specifies the use of a Best Master Clock algorithm to determine which clock on the network is the most accurate. On a network, the most accurate clock becomes the master clock and all other clocks sync to the master clock.

The software implementation of PTP in the LI-7550 provides accuracy in the 10 microsecond range. Implementation of PTP is most important when the LI-7550 is used in combination with other network-based sensors such as the LI-7700 Open Path CH_4 Analyzer.

About LI-7500A Time Keeping

The LI-7500A is a network-based instrument and it is possible for multiple users to log data from a single instrument over multiple TCP/IP connections via the LI-7550 Analyzer Interface Unit. Consequently, the LI-7500A uses Coordinated Universal Time (UTC) for its onboard time-keeping tasks. The default time stamp is therefore UTC based, but local time can be set, if desired.

Generally, it is recommended that you use local time that does not get adjusted for Daylight Savings. The LI-7500A uses a time zone database that includes local time zones that are kept as constant offset from UTC. These time zones are listed as 'Etc/GMT' + offset. However, these time zone names beginning with 'Etc/GMT' have their sign reversed from what is commonly used. Thus, zones west of GMT have a positive sign, and those east have a negative sign.

For example, US/Central Standard Time is 6 hours behind GMT, and in the database this time zone is listed as 'ETC/GMT+6'.

Unix time is the number of seconds elapsed since the Unix epoch of 00:00 Coordinated Universal Time (UTC) January 1, 1970 (or 1970-01-01T00:00:0Z ISO 8601). For example, the time stamp 1262884605 translates to 01/07/2010 at 05:16:45 UTC. The date and time are converted to a conventional display format (YYYY-MM-DD; HH:MM:SS) and adjusted based on the time zone setting that you select.

The time stamp in each file header shows the instrument time and time zone.
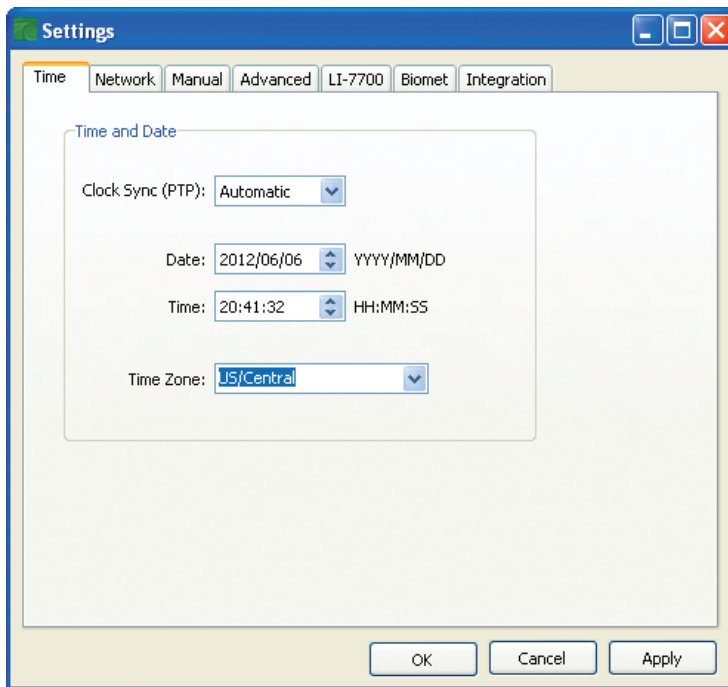
To set your local time:

1. Connect to the LI-7500A.
2. Open the Settings dialog box.
3. Set the Clock Sync (PTP) as desired (see below).
4. Choose your time zone.
5. Click **Apply** or **OK**.

The PTP clock settings available are:

Off: Turns PTP time keeping system off. Instrument time will be determined by the Date and Time set by the user, even if there is a better clock on the network.
Automatic: The LI-7550 searches the network and syncs to the most accurate clock using the Best Master Clock algorithm (could be LI-7550). This setting should be used in most circumstances.
**Slave Only:** The LI-7550 always syncs to another clock. It will search the network and synchronize to the best clock.
Preferred: The LI-7550 uses its own internal clock unless it finds a better clock on the network.

When connecting the LI-7500A/LI-7550 to the LI-7700 CH$_4$ Analyzer (see *Settings:LI-7700* Tab below), or to the 9210 data logger (see *Settings:Biomet* Tab below) we recommend that you set the LI-7550 to Preferred, and the LI-7700 and/or 9210 to Automatic.

Network Settings
By default, the instrument name that appears in the Ethernet Connect dialog is the prefix AIU (for Analyzer Interface Unit) and its associated serial number (e.g. AIU-0650). You can change this name in the Settings dialog, Network tab, if desired. Enter the new name and click **Apply**; the next time you try to connect to the instrument, this name will appear in the Connect dialog.
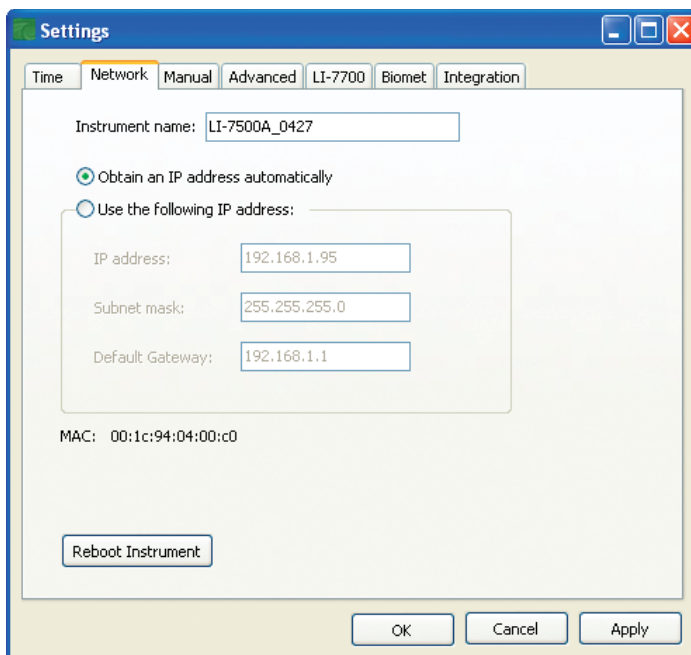
The Internet Protocol (IP) address is a numerical identifier that is assigned to devices participating in a computer network; in many cases this address is assigned automatically (Dynamic IP address). In other cases, your network administrator may assign a permanent address (Static IP address) that can be entered manually.

If you enable the 'Obtain an IP address automatically' radio button, the IP address, Subnet mask, and Default Gateway fields are filled in automatically; if you choose to enter the IP address manually, the address fields are editable.

The **Subnet Mask** is a set of 4 octets used to separate an IP address into two parts; the network address and the host address. The **Gateway** is a node that routes traffic to another network.

Click **Apply** after you have entered the addressing information to send to the LI-7500A.

Manual Tab – Sending Instrument Commands

A command line field is present that allows the user to send a command to the LI-7500A for implementation. 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. The complete command language instructions are given in Appendix D, *Configuration Grammar*.
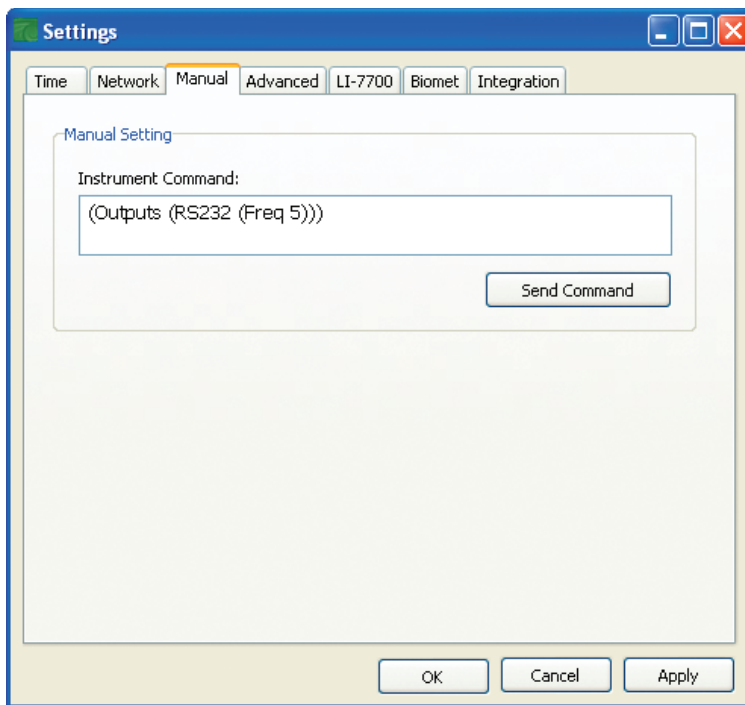

Advanced Tab – Setting the Chopper Housing Temperature

The chopper motor housing temperature can be set to a lower operating temperature (5 °C) in winter to reduce power consumption and minimize surface heating by the electronics, if desired. LI-COR recommends changing this setting only when the average ambient temperature drops below 5 °C; you can change the setting again to 30 °C when the average ambient temperature is above 5 °C. Note, however, that the instrument will still function properly when the chopper motor housing temperature is set to 30 °C, even when temperatures are below 5 °C.

Do not set the chopper housing temperature to 5 °C when ambient temperatures are above 5 °C, however, as the instrument will not function properly. When changing between winter and summer settings, you will need

to perform a zero and dual span calibration, as described in Section 5, *Calibration*.
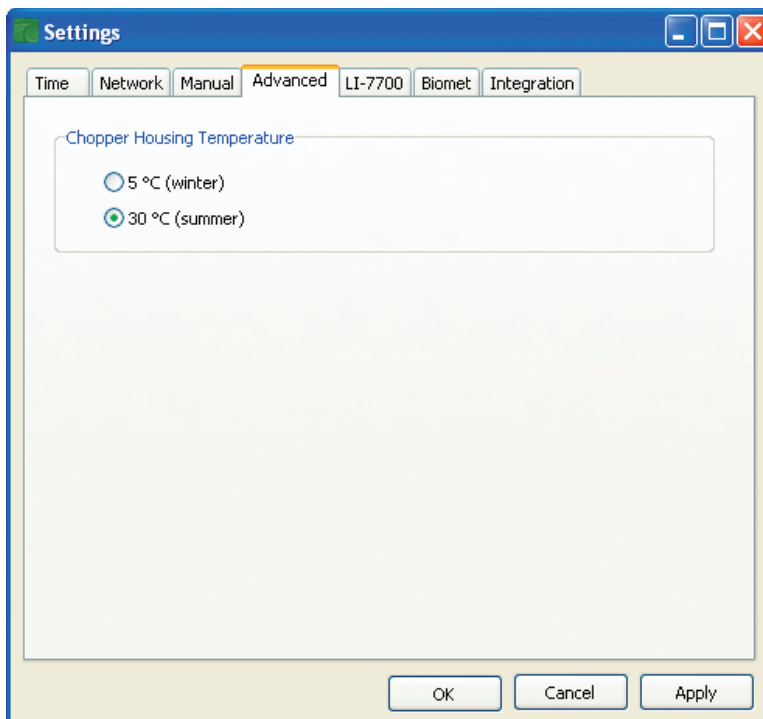
LI-7700 Tab

The LI-7550 Analyzer Interface Unit can be connected to any LI-7700 Open Path CH$_4$ Analyzer on the network, providing a convenient way to integrate LI-7700 data into the same data set collected by the LI-7500A for greenhouse gas flux calculations. The LI-7700 data values to be logged are chosen in the Site Setup window, under the CH4 Analyzer tab (see "CH4 Analyzer Data" earlier in this section).
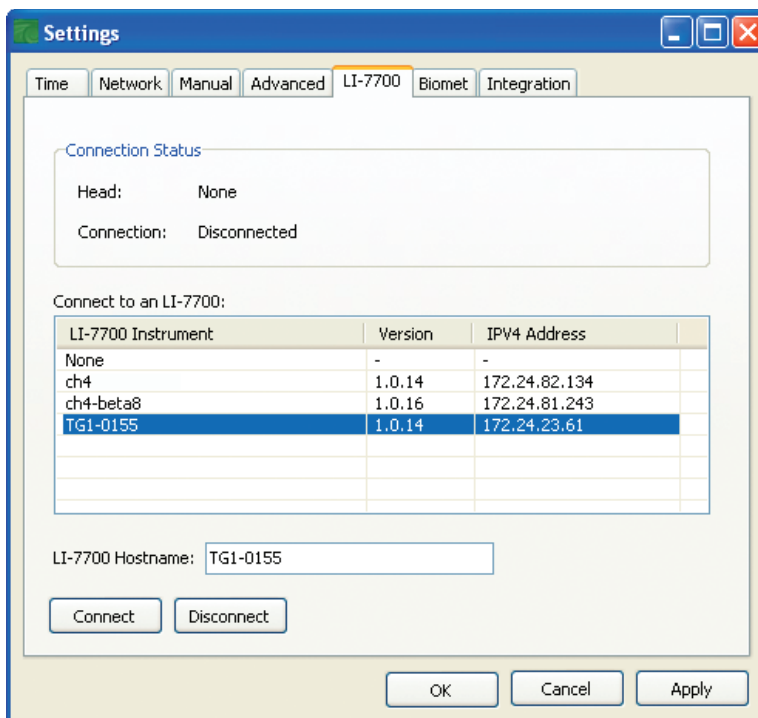
The LI-7700 tab displays a list of LI-7700 instruments available on the network (same subnet as computer). Select an LI-7700 from the list, or enter an IP address in the 'LI-7700 Hostname' field (networked device on different subnet mask as computer) and click **Connect**. Click **Apply** or **OK**. When you start logging data with the LI-7550 via USB, the chosen data values for the LI-7700 will be logged, as well.

Biomet Tab

The Biomet tab displays a list of Sutron 9210 Dataloggers available on the network (same subnet mask as computer). Select a Sutron 9210 from the list, or enter an IP address in the '9210 Hostname' field (networked device on different subnet mask as computer) and click **Connect**. Click **Apply** or **OK**. When you start logging data with the LI-7550, the chosen data values for the 9210 will be logged, as well.
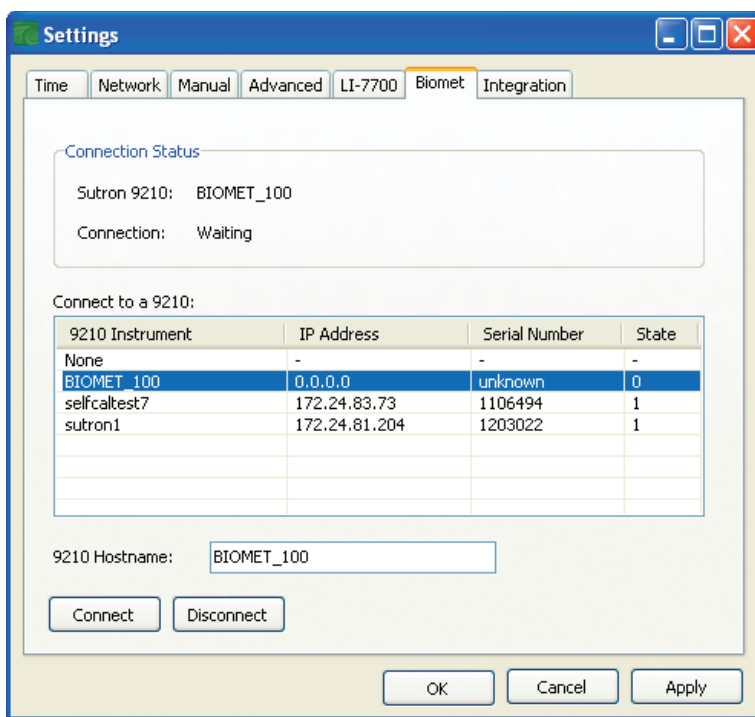
Integration Tab

Allows for the setup of an integration function using a selected CO_2 source ($mmol/m^3$ or $\mu mol/mol$). The integrated value selected can be viewed as a data source in the main software window (choose **Integral** in the Data Items list).
To integrate a CO_2 source:

1. Choose a source to be integrated from the Integration Channel list.
2. Choose the method to start the integration; immediately, or using a threshold value.
3. Choose the method to stop the integration; manually, with a threshold value, or after a user-enterd elapsed time (s) has expired.
4. Enter the threshold value for the start or stop (or both) of the integration, if either was chosen in Steps 2 or 3 above.
5. Click on the Apply button.
6. If Start Immediately was chosen for the Start Time, the integration function is started and/or stopped manually by clicking the ∫**dt Integration On** or ∫**dt Integration Off** buttons (available on the main window, as well).

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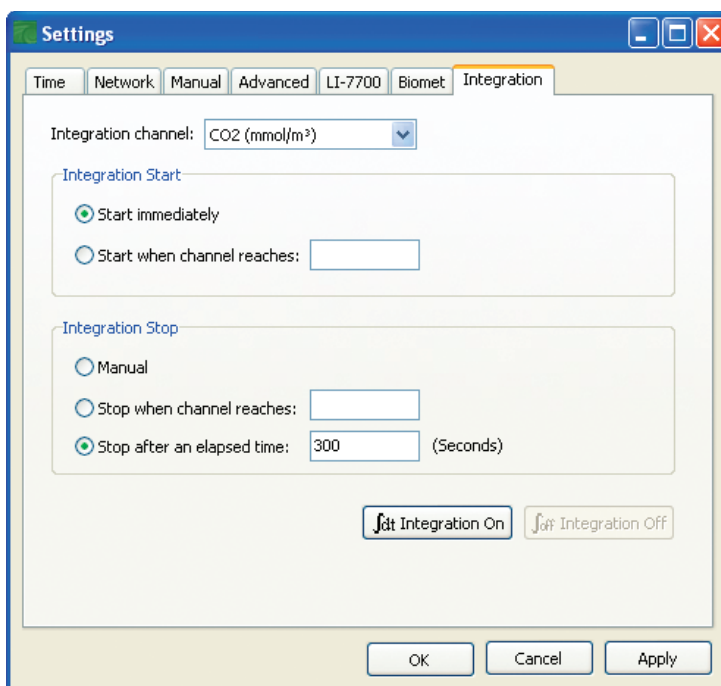
■ **Example**: Start integrating CO_2 (μmol/mol) after it reaches a value of 500 μmol/mol, and continue integrating for 5 minutes.

1. Choose CO2 (μmol/mol) from the Integration Channel list.
2. Click the 'Start when channel reaches' radio button and enter 500 in the text entry field.
3. Click the 'Stop after an elapsed time' radio button and enter 300 (seconds) in the text entry field.
4. Click Apply.
5. Click the **∫dt Integration On** button. Click **OK** to dismiss the dialog.

The integration result (area under the curve) can be viewed in the main window.

Diagnostics

The Diagnostics page allows you to view the current operational state of the LI-7500A, including current software version numbers, values of CO_2 and H_2O absorptance, optical bench properties, and the current analyzer configuration. See Section 7, *Troubleshooting* for more information about the diagnostic indicators.
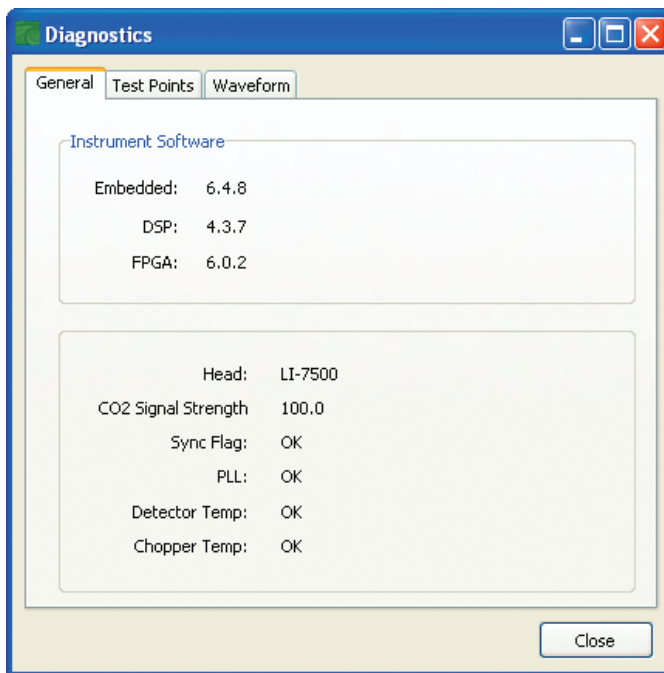
5   Calibration

Introduction

The LI-7500A's measurement accuracy depends upon its calibration. There are two major components to the calibration: 1) determining the values of calibration coefficients, and 2) setting zero and span. During a factory calibration, both of these steps are performed. The values of the coefficients that are determined should be valid for several years. The zero and span adjustments are used to bring the LI-7500A's actual response into line with its previously determined factory response, at least at two points. It is the user's responsibility to do this step at regular intervals; monthly at first, and then adjust the frequency according to the stability of your instrument; see '*How Stable are Zero and Span?*' below.

How Stable are Zero and Span?

The analyzer's zero is primarily affected by temperature, and the state of the internal chemicals. The internal chemicals should be changed annually (see Section 6, *Maintenance*). The zero's response to temperature is relatively small (typically 0.1 or 0.2 ppm per °C for CO_2, or 0.01 mmol/mol/°C for H_2O). Also, this drift is measured at the factory, and subsequently compensated for in software (Equation 3-10), so the effective zero drift should be quite small. Therefore, the zero should be quite stable over a several month period, but you might want to check it after an extreme temperature change (>30 °C).

The analyzer's span is affected by temperature, pressure, and the state of the internal chemicals. <u>Temperature</u>: A 10 °C change will typically change the H_2O span by 1 to 2%. For CO_2 at ambient concentrations, the span is very *insensitive* to temperature, however. <u>Pressure</u>: A large pressure change (40 kPa) will affect the CO_2 and H_2O spans by <1%, for ambient CO_2 concentrations (≈ 400 ppm) and high humidities (20 mmol/mol). So, diurnal pressure variations should not be a concern. <u>Chemicals</u>: Reduced internal chemical effectiveness will affect the span, but the effect on the zero will be much more pronounced. In summary, span stability is mostly a concern with H_2O, when there are large temperature changes.

Checking the Zero - Considerations

The zero is checked with dry CO_2-free air within the optical path of the analyzer. A suitable source of air for setting the zero can be generated with chemical scrubbers (such as soda lime for removing CO_2 and magnesium perchlorate or Drierite® for removing water), or obtained from a cylinder of zero grade gas. When using chemical scrubbers, it is important to make sure that the chemicals are fresh, and that air goes through the chemicals in the right order; soda lime first, desiccant last (if the desiccant is Drierite®, allow time for the CO_2 to "wash out" of it). When using a cylinder, it is important to make sure that the air in the cylinder really is CO_2-free since a typical cylinder of standard grade nitrogen might have as much as 20 ppm of CO_2 in it. 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 thirty pounds per square inch.

Checking the Span - Considerations

For checking the CO_2 span, use a cylinder of CO_2 in air with a concentration that is at the higher end of the range of concentrations which may be encountered during measurements. For example, a 500 to 1000 PPM cylinder of CO_2 in air, which has been verified to be accurate to within at least 1% would be a suitable choice for many applications. Be cautious, as the stated value of the calibration cylinder may be significantly different from the actual gas concentration.

For the water vapor span, a convenient standard to use is a dew point generator such as the LI-COR LI-610. 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, allow plenty of time for the reading to stabilize. It is important not to rush through the water vapor calibration. If it is more convenient, CO_2 and water vapor zero and span calibrations can be done separately. *In general, if reliable calibration standards are not available or if there is not enough time to do the job properly, it is better to leave the zero and span settings alone than to rush through the procedure and make incorrect settings.*

In software version 4.0 and above, span is a linear function of absorptance (Equation 3-8, page 3-2), so there is an offset term and a slope term. Both are

determined at the factory, and when a (normal) span is set by the user, only the offset term changes. The slope term can be changed by performing a secondary span at a much different concentration than the previous (normal) span.

Setting the Secondary Span – Considerations (Version 4.0 and above)

If you find that after zeroing then spanning at one concentration, the instrument is not within specifications at a different concentration, a secondary span may be in order. The most common reason for doing this would be after a change in the chopper housing temperature set point (see Advanced Settings tab, Section 4). The two span concentrations used for the span and secondary span should be as far apart as possible. For example, at the factory, this is typically done for CO_2 using 200 ppm and 3000 ppm. At a minimum, the pair should be at least 500 ppm apart, and bracket your intented operating range (e.g. 300 ppm and 800 ppm). For H_2O, you are constrained by the temperature of the air. You would normally choose a very low dewpoint, such as 5 °C, and something close to (just below) ambient. If the air temperature is 15 °C or less, you should probably avoid doing a secondary span.

What Actually Happens

In the LI-7500A, the zero and span parameters are set in software (see Section 4). What actually happens when the zero is set is that the value of Z_{c0} (or Z_{w0} for water) is determined. For example, when CO_2-free air is in the optical path of the analyzer, α_c should be 0. From Equation 3-17,

$$\alpha_c = 0 = \left(1 - \left[\frac{A_c}{A_{co}} + X_{wc}\frac{A_w}{A_{wo}}\right]\left(Z_{co} + Z_c V_d\right)\right)$$

so

$$Z_{co} = \frac{1}{\dfrac{A_c}{A_{co}} + X_{wc}\dfrac{A_w}{A_{wo}}} - Z_c V_d \qquad\qquad 5\text{-}1$$

Similarly,

$$Z_{wo} = \frac{1}{\dfrac{A_w}{A_{wo}} + X_{cw}\dfrac{A_c}{A_{co}}} - Z_w V_d \qquad\qquad 5\text{-}2$$

When the span is set, the value of S_{c0} (or S_{w0} for water) is determined. For example, if there is a known CO_2 density ρ'_c in the optical path and the measured absorptance is α'_c, then from Equations 3-18 and 3-8, we can write

$$\rho'_c = P_{ec}f_c\left(\frac{\alpha'_c(S_{c0} + S_{c1}\alpha'_c)}{P_{ec}}\right)$$

so

$$S_{c0} = \frac{P_{ec}f_c^{-1}\left(\dfrac{\rho'_c}{P_{ec}}\right)}{\alpha'_c} - S_{c1}\alpha'_c \tag{5-3}$$

We rewrite this in terms of a known mole fraction C'_f instead of density.

$$S_{c0} = \frac{P_{ec}f_c^{-1}\left(\dfrac{C'_f P}{P_{ec}RT}\right)}{\alpha'_c} - S_{c1}\alpha'_c \tag{5-4}$$

If we assume that the CO_2 span gas is dry, then $P_{ec} = P$, so

$$S_{c0} = \frac{P_{ec}f_c^{-1}\left(\dfrac{C'_f}{RT}\right)}{\alpha'_c} - S_{c1}\alpha'_c \tag{5-5}$$

Similarly, for a known H_2O mole fraction W'_f and resulting measured absorptance α'_w,

$$S_{w0} = \frac{Pf_w^{-1}\left(\dfrac{W'_f}{RT}\right)}{\alpha'_w} - S_{w1}\alpha'_w \tag{5-6}$$

Whenever the CO_2 span is set, the instrument saves two values that are used if and when a secondary CO_2 span is performed. These values are

$$I_c = Pf_c^{-1}\left(\frac{C'_f}{RT}\right)$$

$$A_c = \alpha'_c \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 5\text{-}7$$

When a secondary span for CO_2 is performed at a mole fraction m'_c with measured absorptance α'_c, then the span slope term S_{c1} is computed from

$$S_{c1} = \frac{\dfrac{Pf_c^{-1}\left(\dfrac{C'_f}{RT}\right)}{\alpha'_c} - \dfrac{I_c}{A_c}}{\left(\alpha'_c - A_c\right)} \qquad\qquad\qquad 5\text{-}8$$

A new offset term S_{c0} is then computed using Equation 5-5, since the slope term S_{c1} has changed. Similarly, for H_2O, each time a normal water span is set, the instrument retains

$$I_w = Pf_w^{-1}\left(\frac{W'_f}{RT}\right)$$

$$A_w = \alpha'_w \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 5\text{-}9$$

and when a secondary H_2O span is performed at water mole fraction m'_w with measured absorptance α'_w, then the span slope term is computed from

$$S_{w1} = \frac{\dfrac{Pf_w^{-1}\left(\dfrac{W'_f}{RT}\right)}{\alpha'_w} - \dfrac{I_w}{A_w}}{\left(\alpha'_w - A_w\right)} \qquad\qquad\qquad 5\text{-}10$$

and a new offset term S_{w0} is computed from Equation 5-6.

Complete Step-by-Step Calibration Instructions

1. Run the LI-7500A Windows interface program. Click on the *Calibration* button in the Main Window.

2. Disconnect the temperature thermistor at the **Sensor** connector on the LI-7550 front panel.

3. Connect the thermistor cable from the Calibration Accessory to the **Sensor** connector on the LI-7550 front panel.
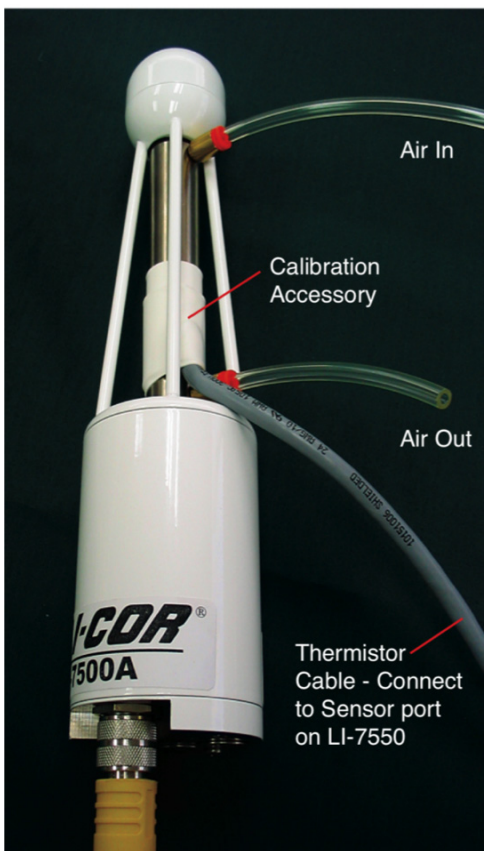
Figure 5-1. Flow calibration gas into either port.

Insert the top of the fixture at the widest opening in the struts, near the bottom window, slide up, and slide the bottom into place. It is very important that the fixture is centered between the source and detector windows. It can be helpful to click on the *Diagnostics* button in the 7500A-50 software, and view the AGC value while centering the fixture; if the AGC value increases when the fixture is in place, it indicates that one or both of the windows are partially or totally obscured. Move the fixture

back and forth until the AGC value reads the same value as before the fixture was inserted. The fixture is easy to center; if it looks centered, it probably is.

NOTE: The two ports are interchangeable; it doesn't matter which port you use as the air inlet.

3. Verify that temperature and pressure are working OK. (If you are using an alternate source for temperature and pressure, click on the *Inputs* button and set that up). Click on the *Calibration* button.

> **IMPORTANT NOTE:** Always zero the instrument before spanning (don't span, then zero).

4. Flow CO_2-free air through the calibration accessory at a rate of about 0.5 to 1.0 LPM. Attach the zero gas to the calibration fixture at one of the ports shown in Figure 5-1. The calibration accessory has quick connect fittings for use with standard 1/8" I.D. Bev-a-line (or other) tubing.

Zero CO$_2$

**5.** Click on the Manual tab and view the value of Z_{co} (CO$_2$ Zero).
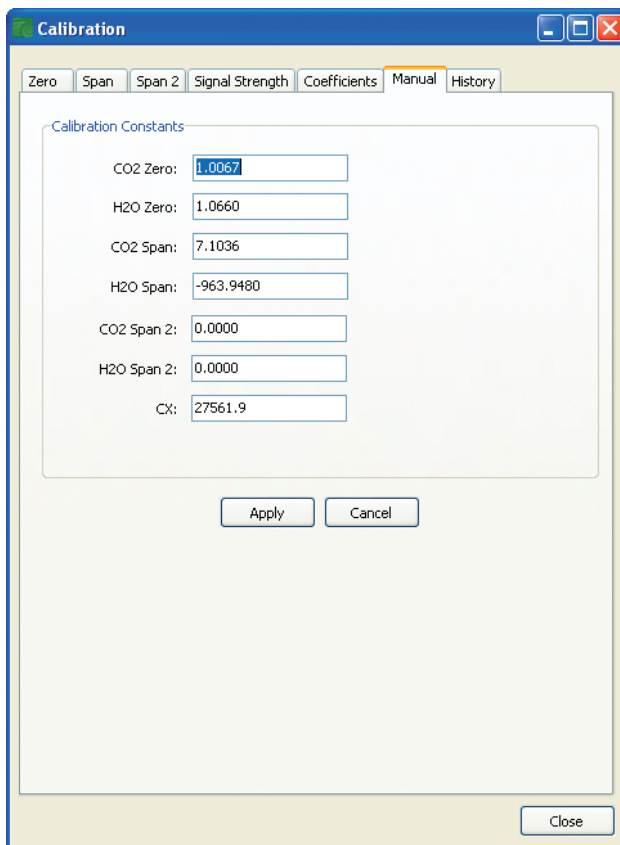
Figure 5-2. Note value of Z_{co}, shown as CO2 Zero.

6. Click the Zero tab. When the reading has stabilized in the main window, and the Gas Stability flag is green (below), click **Zero CO2** to set the CO$_2$ zero.
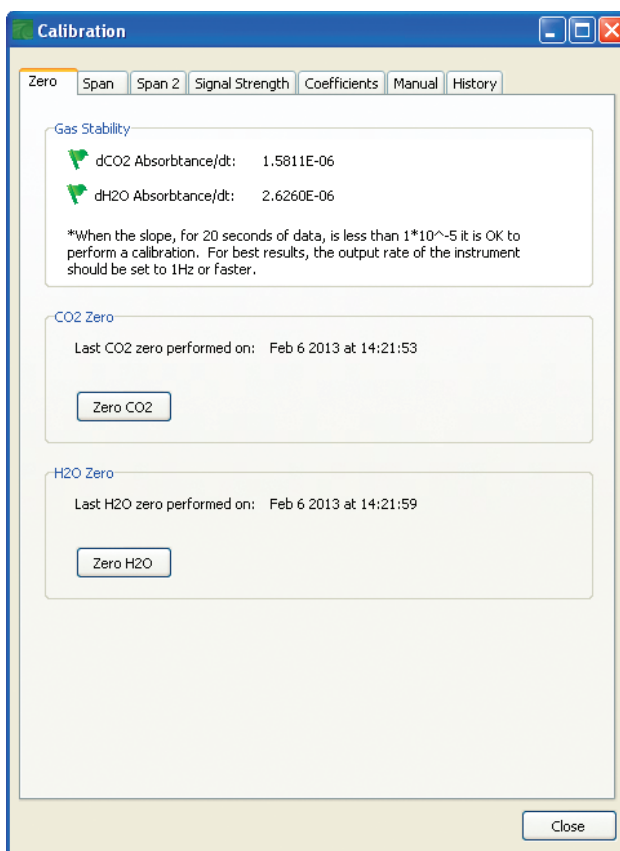
After a brief delay, the displayed CO_2 value should be fluctuating around zero. Check the resultant value of Z_{co} shown on the Manual tab (Figure 5-2). It should be near 1 (typically between 0.85 and 1.1). This value will steadily increase over time (2-3 months) as the internal chemicals lose effectiveness.

Zero H_2O

7. Now is a good time to check or set the H_2O zero, if you have been flowing dry, CO_2-free air through the optical path. Click the Manual tab, and note the present value of Z_{wo} (H2O Zero).

8. Wait for the H_2O reading to stabilize in the main window (3 or 4 minutes). The Gas Stability flag will turn from a red 'X' to a green flag when it is OK to perform the calibration.

9. Click the Zero tab, and click **Zero H2O.** Note the new value of Z_{wo} (typically between 0.65 and 0.85).

Span CO_2

10. Flow a CO_2 span gas through the calibration tube at 0.5 to 1 liter/minute.

11. Click on the Span tab and enter the mole fraction in the 'Span gas concentration' field.

12. When stable (1-2 minutes) click **Span CO_2**. Click the Manual tab and check the new CO_2 Span value S_c (typically 0.9-1.1).

Span H_2O

13. To set the H_2O span, flow air of known dew point through the calibration tube at about 0.5 to 1.0 LPM. To avoid condensation, use a dew point temperature several degrees below the ambient temperature.

14. Click the Manual tab, and note the present value of the H_2O Span value S_w. Go back to the Span tab and enter the span gas dew point temperature in the 'Dew point temperature' field.

15. Observe the H_2O dew point in the main window and wait for it to stabilize. The Gas Stability flag will turn from a red 'X' to a green flag when it is OK to perform the calibration. ***This may take up to 15 or 20 minutes***.

16. When the reading has stabilized, click **Span H_2O**. Click the Manual tab again and note the new H_2O Span value S_w (typically 0.9-1.1).

Complete Step-by-Step Secondary Span Instructions (CO_2)

1. Zero the instrument (Steps 5 and 6 above).

2. Span the instrument at a concentration below your normal operating range (something in the 200-300 ppm range, for example, Steps 10-12 above).

3. Flow a concentration through the calibration accessory that is at or above your upper operating range (above 800 ppm, for example). Click on the Span2 tab, and when stable, click **Span 2 CO_2**.

NOTE: You can reverse the concentrations if you wish. The normal span can be the high concentration, and the secondary the low concentration. Also, multiple secondary spans can follow a normal span. Simply make sure that the concentration difference between the normal span and any secondary span is large.

Complete Step-by-Step Secondary Span Instructions (H₂O)

1. Zero the instrument (Steps 7 through 9 above).

2. Span the instrument at a dew point that is just below the ambient temperature (Steps 13-16 above).

3. Flow a very low dew point through the calibration accessory. Click on the Span2 tab, and when stable, click **Span 2 H₂O**. Note that it may take another 10 minutes or so to ensure equilibrium is reached when changing from one concentration to another, due to water present in the tubing, calibration shroud, etc.
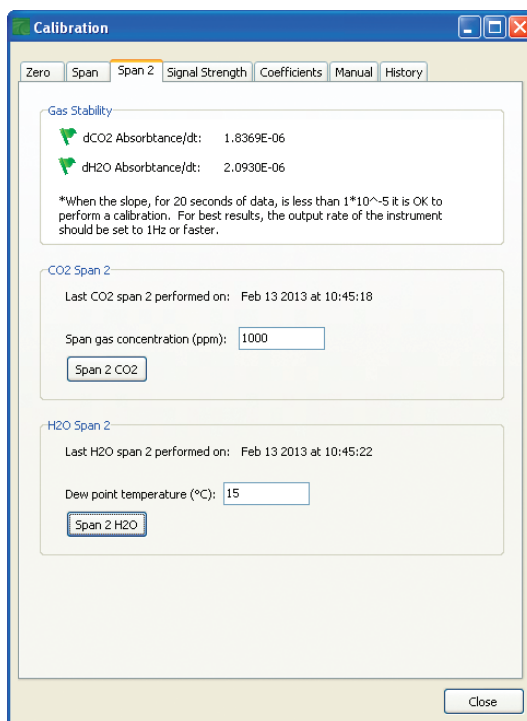
NOTE: You can reverse the concentrations if you wish. The normal span can be the high dew point, and the secondary the low dew point. Also, multiple secondary spans can follow a normal span. Simply make sure that the concentration difference between the normal span and any secondary span is large.

6   Maintenance

Cleaning the Optical Path

The LI-7500A optical windows should cleaned when necessary (visible dirt or stains, or smaller than expected Signal Strength).

The windows are sapphire, and are extremely durable and resistant to scratches; clean the windows with any mild detergent or glass cleaner. Also, coating the windows with a water resistant windshield type coating (such as Rain-X®) or a high quality automobile type wax may help prevent droplets from remaining on the windows during rainstorms. Mounting the sensor head at a slight angle from vertical (~10-15°) may also help prevent water droplets from remaining on the windows during rainstorms.

The sensor head shown below in Figure 6-1 is from a long term test on a roof top on a snowy day (January 2001) in Lincoln, NE. Note the small puddle of water on the sapphire window; the AGC value (older software; now given as Signal Strength) was at 100%.
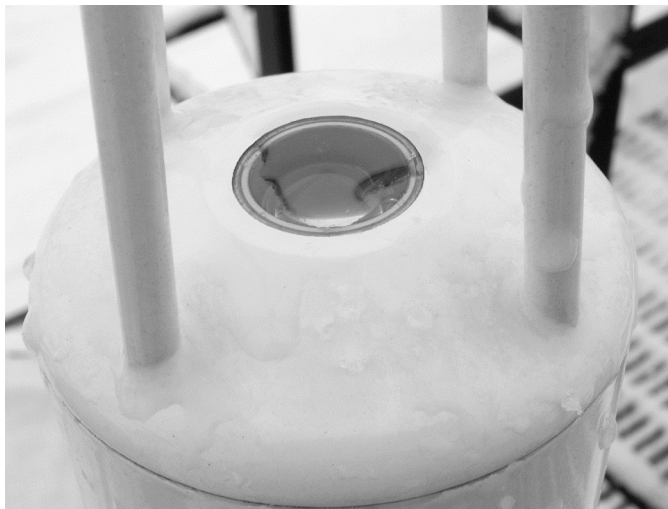

Figure 6-1. Water on the sapphire windows can cause AGC values at or near 100%.

Changing the Fuse

The LI-7500A power supply is protected by a 5A 125/250V, 5 × 20 mm fast-blow type fuse located on the main circuit board inside the Analyzer Interface Unit case (Figure 6-2). If the battery or other power source fails to power the LI-7500A, check to see if the fuse has blown.

Fuse holder cover - turn counterclockwise to release

Figure 6-2. LI-7550 fuse location.

To check the fuse, power the unit off, disconnect the power to the unit, and open the case of the LI-7500A Analyzer Interface Unit. The fuse is located on the inside wall, opposite the connector panel, in the lower lefthand corner, as shown in Figure 6-2. Replacement fuses (part #439-04214, in the spares kit) plug into the fuse holder; no soldering is required. Use a flat blade screwdriver to push down on the fuse holder cap, and turn counterclockwise to release the cap. Check the fuse and replace if necessary. Note that sometimes fuse breaks can occur under the metal caps; carefully check these areas, too.

Replacing the Internal Chemicals

There are two small plastic bottles, each containing Ascarite II and magnesium perchlorate, inserted into the analyzer housing that keep the detectors free of CO_2 and water vapor. These bottles should be recharged with fresh chemicals annually (or every 6 months in hot, humid climates). Replacement "charged" bottles are available from LI-COR in sets of two under part number 7500-950.

If you want to recharge the bottles yourself, see *Appendix C, Suppliers*, for a list of suppliers of Ascarite II and magnesium perchlorate.

NOTE: Calibration shifts will occur if CO_2 or H_2O are not kept out of the analyzer housing.

■ **To change the sensor head soda lime/desiccant bottles:**

1. The plastic bottles are located in the analyzer housing in the sensor head. The bottles are accessed by removing the mounting bracket from the analyzer housing (Figure 6-3). Remove the two screws on the bottom of the mount; be careful not to lose the spacers and washers.
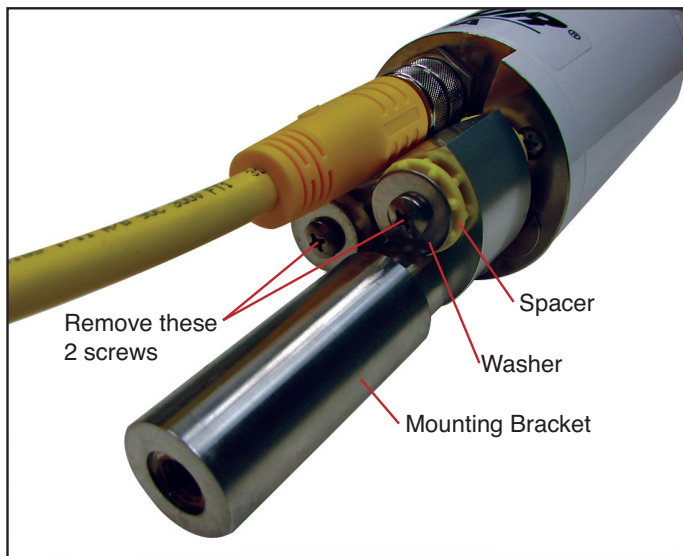

Figure 6-3. Remove the 2 screws on the base of the mounting bracket.
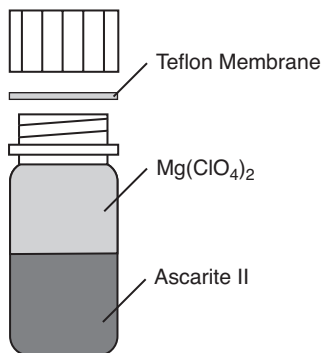
2. Fill the bottles half full with Ascarite II first, followed by the magnesium perchlorate. Place the teflon membrane in the lid to keep the chemicals from spilling into the detector housing.

3. There are two bottle covers, each with an O-ring seal, at the base of the sensor head (Figure 6-5). Remove the cover retention thumbscrew. Thread this same screw into each bottle cover and pull straight out.
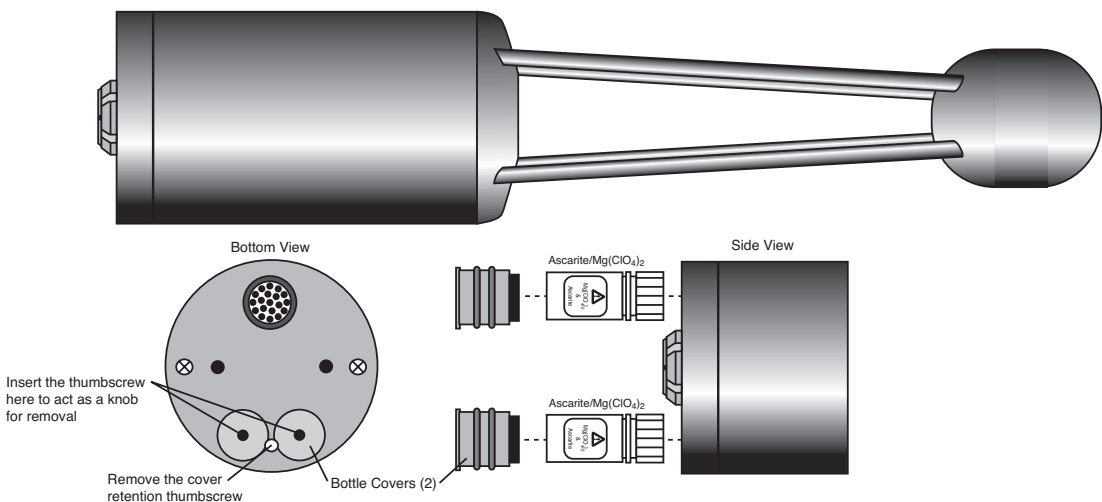

Figure 6-5. Remove the thumbscrew, thread into the bottle covers and replace the chemicals.

4. Make sure the cap has a hole in it to allow for air transfer. Insert the recharged bottles into the analyzer housing *cap first*. Replace the bottle covers and the cover retention screw and reattach the mounting bracket.

5. After installing, ***allow at least 24 hours (with the instrument powered on)*** to scrub the housing; otherwise, the instrument may still drift. This should be followed by setting the CO_2 and H_2O zeros. Check the zero again, if possible, after one or two days.

NOTE: LI-COR has written a publication that describes the use of chemical scrubbing agents with LI-COR gas analyzers. This publication, entitled "*Using CO_2 and H_2O Scrubbers with LI-COR Gas Analyzers*" is available free of charge from LI-COR. Ask for publication #IRG4-101. An electronic version is also available for download at the Technical Support section of LI-COR's web site.

7 Troubleshooting

Power On Problems

The instrument requires between 10 and 30 VDC, at 3 Amps, to operate (a LI-COR LI-6020 battery charger, for example, will *not* by itself power the LI-7500A). When adequate power is first applied to the instrument, the Power LED in the Analyzer Control Unit will light up and remain on. If the Power LED blinks, the power supply is providing barely enough power for proper operation. Make sure the Turck connector on the LI-7550 front panel is inserted properly, and is tight.

The LI-7500A requires about 30W at startup, and about 10W during operation.

LED does not light at power on
This can be due to a blown fuse, or inadequate power supply, or faulty wiring (make sure the black wire on the power cable goes to ground, and the red wire to power).

PC Connection Problems

When the Connect button in the LI-7500A Windows program is pressed, the program sets a break condition on the communication line, signaling the LI-7500A to change to 9600 baud and send its current configuration. The PC then sends the desired configuration (update rate, baud rate, etc.) back to the LI-7500A. Both units then change to the desired baud rate, and operations begin. When the Disconnect button is pressed, the PC signals to the LI-7500A to change its RS-232 configuration back to what it was originally (or to that set up in the RS-232 panel).

"Port in use or does not exist" when connecting
This message indicates that the COM port setting on the Connect page is either incorrect, or else that COM port is already in use by some other program running on the PC. If you are sure that the COM port is correct, and there is nothing else running, try rebooting.

"Not able to connect to the LI-7500A successfully" when connecting

Press **Connect** again. Sometimes it takes a couple of attempts. If repeated attempts fail, then make sure the COM port is in fact the one into which you are connected. Make sure the LI-7500A is in fact powered and running (press the Reset button (below) and see if the LED lights for about 5 seconds).

"Parse Error"

When connecting the LI-7550 to a computer via the RS-232 cable, the initial Connect dialog box contains choices for selecting both Baud Rate and Update Rate. The Baud Rate pull-down menu is used to select the baud rate at which to communicate with the LI-7500A through the LI-7550 serial port. The rate of data transfer is also dependent upon the maximum rate available with your computer's serial port, and the update frequency (below) to be used while the program communicates with the LI-7500A. Select from 9600, 19200, 38400, 57600, or 115200.

The Update Rate is the update frequency to be used while the LI-7500A Windows program communicates with the LI-7500A. Select from 0.1, 0.2, 0.5, 1, 2, 5, 10, or 20 Hz. **Note that at 9600 baud, the maximum update frequency is 2 Hz; at 19200 baud, 5 Hz; at 38400 baud, 10 Hz; at 57600 baud, 15 Hz; and at 115200 baud, 20 Hz**.

Use a faster Baud Rate and/or a slower Update Rate to resolve this problem.

Instrument software is unresponsive

If the instrument software is not responding, the instrument can be rebooted using the Reset button on the LI-7550 control panel. Pressing the Reset button restarts the boot process; if connected via Ethernet, the instrument will attempt to reconnect to the Windows software. If connected via RS-232, you may need to restart the Windows software and reconnect manually. Make sure that your Windows® and instrument (embedded) software versions are compatible. Yellow indicators in the Connect dialog box are displayed when the instrument (embedded) software version is incompatible with the Windows interface software version. In this instance, we recommend that you visit LI-COR's support site at www.licor.com and download and install the latest instrument software. Green indicators are displayed when instrument and Windows software versions are compatible.

Location of Reset button in LI-7550.

Bad Temperature or Pressure Readings

The source of the values of temperature and pressure displayed on the Calibration page are determined by the setting on the Inputs page. If the source is "Measured", the readings come from the LI-7500A's 9975-026 External Temperature Sensor (or the thermistor on the calibration tube, if that is connected), or the pressure sensor inside the LI-7550. If the source is "Aux Input", then the temperature or pressure are coming from an external sensor that you have wired and connected. This signal is modified according to the Auxiliary Coefficients that appear on that same page. If the source is "User-Entered", then whatever you enter manually in the text boxes is used for the value.

Temperature is Measured, and reads -65 (or so)
The external temperature sensor is broken, or disconnected.

Pressure is Measured, and doesn't match my barometer

The pressure sensor in the LI-7500A is good to about 0.1%. For operating purposes, it doesn't need to be very good (See "Note on Temperature and Pressure" on page 3-7). When setting the span(s) of the LI-7500A, however, it is more important. If you know the pressure better than the LI-7500A does, then use the "User-Entered" option and enter it.

Bad CO_2 or H_2O Readings

Section 3 details what the LI-7500A measures, and how it computes. Most of the relevant parameters are available for viewing with the LI-7500A Windows software program, such as calibration coefficients, absorptances, and zero and span values. The first thing to check when tracking down bad readings is to make sure all of the coefficients on the "Cal Coeffs" page match those on the calibration sheet for the head in use. The Band Broadening coefficient should be 1.15. After that, go to the "Diagnostics" page and check the value of Signal Strength, and also the CO_2 and H_2O absorptances. Are any of the diagnostic flags (PLL, etc.) set? Finally, go to the "Calibration" page and make sure the current values of zero and span are near 1.

### Absorptances make sense, densities don't

If the absorptance value seems correct (*rough* rule of thumb: absorptance = 0 when density = 0, CO_2 absorptance is about 0.1 with a mole fraction of about 400 ppm, and H_2O absorptance is about 0.1 with a mole fraction of about 20 mmol/mol), but if the displayed values of density or mole fraction are obviously bad, then the problem is in one of the following: calibration coefficients, span parameter, pressure value, and the band broadening value (CO_2 only).

Readings very noisy

Put the calibration tube in place, just to dampen natural fluctuations. You don't necessarily need to have anything flowing through the tube. The noise in absorptance values should be stable, with only the 4th decimal place changing once in a while. If density or mole fraction is still noisy, watch the temperature and pressure values to see if they are the source of the noise (or change to a hand entered, constant value to try this). Check the calibration coefficients and band broadening value (if the problem is with CO_2) to make sure they are correct.

Diagnostic Messages

The Diagnostics page allows you to view the current operational state of the LI-7500A, including current software version numbers, diagnostic flags, optical bench properties, and technician test point values.
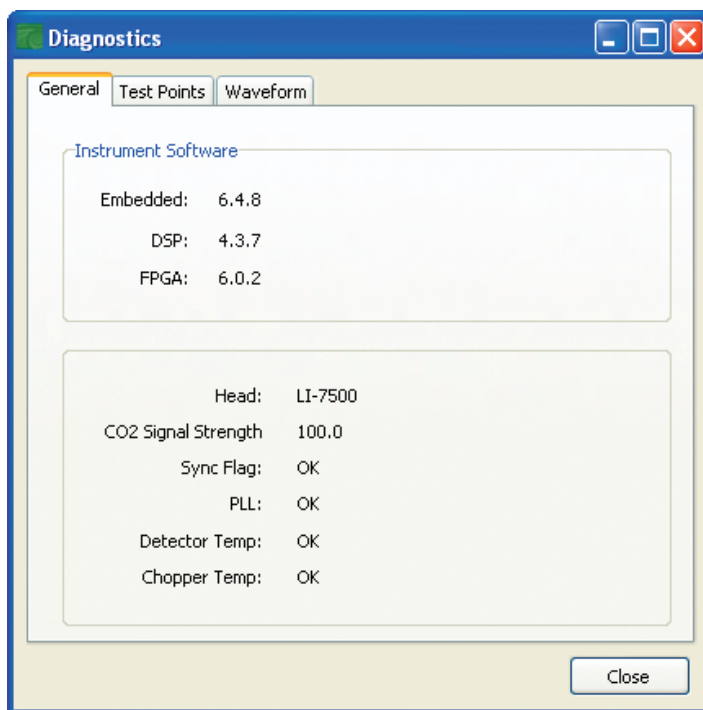
General indicators

Diagnostic indicators for the Sync Flag, PLL, Detector Temperature, and Chopper Temperature will read either 'OK' or 'Service'.

Head – Displays the model of the sensor head currently connected to the LI-7550 Analyzer Interface Unit (LI-7200 or LI-7500A).

CO_2 Signal Strength – CO_2 Signal Strength (defined on page 3-7) is a coarse indicator of when to clean the instrument, where 100 is clean, 80 is relatively dirty, 50 is very dirty (the equivalent of an AGC value of 100 in earlier versions of the LI-7500A software), and 0 would mean no signal at all. See Section 3, *LI-7500A Signal Strength*.

**Sync Flag** – Not used in LI-7500A. Will always read OK.

PLL - Phase Lock Loop offset, indicates the status of the optical filter wheel for the IRGA. Common causes of a service indication are not having a sensor head connected to the LI-7550, or the 19-pin IRGA cable is attached but the connectors have not been tightened properly.

Detector Temperature - If not OK, indicates the detector cooler is not maintaining the proper temperature: this will happen at temperatures above 50 °C. Note that this does *not* always indicate a serious problem; the cooler may simply have not yet reached the target temperature during instrument startup, or it may be out of range due to external environmental conditions. Readings may still be OK. The sensor head may not be attached to the LI-7550, or the IRGA cable may not be tight. Check cables and wiring.

Chopper Temperature - If not OK, indicates the chopper temperature controller is out of range, hot or cold. As with the Detector Temperature indicator above, this may or may not indicate a serious problem. The chopper should be able to temperature control when ambient is between +50 and -25 °C. Check that the sensor head cables to the LI-7550 are tight, and make sure the chopper temperature is not set to Winter when measuring in high ambient temperatures.

Test Point Values
The Test Points tab displays voltages and raw counts of a variety of LI-7500A diagnostic test points. Though primarily for LI-COR technician reference, values outside of the "normal" range may give you an indication of where problems may be originating.

Diagnostics

General | Test Points | Waveform

IR A/D (V):	4.4690	Box Pressure (V):	3.7957
Detector Temp (V):	3.0820	Head Pressure (V):	0.0000
Aux Ref +:	64836	In-Temp (V):	0.0000
Aux Ref -:	589	Out-Temp (V):	0.0000
ADC CH1 (V):	0.0000	Box Temp (V):	0.0000
ADC CH2 (V):	0.0068	Chopper Temp (V):	2.4665
ADC CH3 (V):	-0.0059	Short:	32766
ADC CH4 (V):	0.0003	Cooler Voltage (V):	2.0548

Close
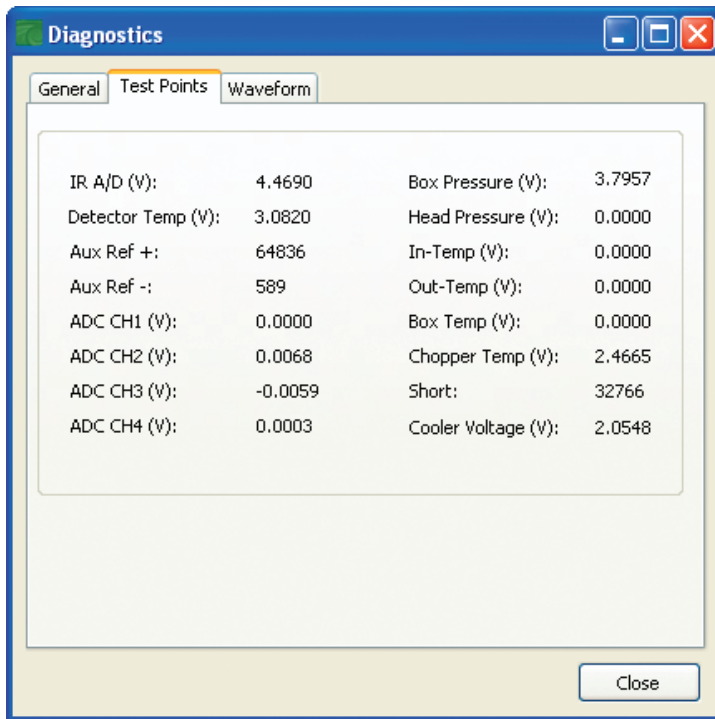
Test Point	Description	Normal range
IR A/D (V)	Voltage from IRGA being sent to A/D converter	0.2 – 4.8V
Detector Temp (V)	Detector temperature voltage	2.9V. Readings near +5V or 0V are normal for a few seconds after power on.
Aux Ref +	16-bit conversion of positive reference voltage used in Auxiliary Input circuit	~64830
Aux Ref -	16-bit conversion of negative reference voltage used in Auxiliary Input circuit	~600
ADC CH1 (V)	DAC channel 1 output	-5V to +5V. A reading near 0 is normal for an open input.
ADC CH2 (V)	DAC channel 2 output	-5V to +5V. A reading near 0 is normal for an open input.
ADC CH3 (V)	DAC channel 3 output	-5V to +5V. A reading near 0 is normal for an open input.
ADC CH4 (V)	DAC channel 4 output	-5V to +5V. A reading near 0 is normal for an open input.
Box Pressure (V)	Absolute pressure	Any value between 0 and 5
Box Temp (V)	LI-7550 temperature	3.5 at room temperature
Chopper Temp (V)	Displays voltage of chopper housing temperature control circuit.	2 is normal. Readings near 0V or +5V indicate that the temperature control circuit is unable to control the chopper temperature.
Short (V)	Reference short in auxiliary input circuit	32768
Cooler Voltage (V)	Displays voltage of detector cooler. If this value gets below 0.5V, it may be too cold; the detector may not be temperature controlling. This will typically occur at -30 °C or below.	0-5V

Waveform

The Waveform tab displays the current state of the analyzer's chopping shutter disk. Though primarily for LI-COR technician reference, if problems are encountered, it may be useful to log the waveform data for troubleshooting purposes. Note that waveform data can only be logged when the Diagnostics window is open.
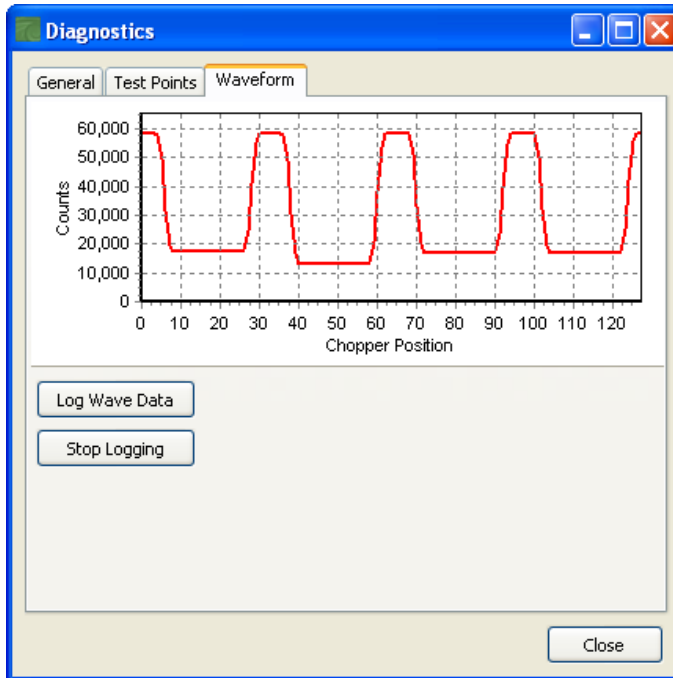
A   Specifications

	CO_2	H_2O
Calibration Range	0-3000 ppm	0-60 mmol/mol
Accuracy	Within 1% of reading (nominal)	Within 1% of reading (nominal)
Zero drift (per °C)	±0.1 ppm typical ±0.3 ppm max.	±0.03 mmol/mol typical ±0.05 mmol/mol max.
RMS Noise: 5 Hz @370 ppm CO_2: 10 Hz and 10 mmol m^{-1} H_2O: 20 Hz	0.08 ppm 0.11 ppm 0.16 ppm	0.0034 mmol/mol 0.0047 mmol/mol 0.0067 mmol/mol
Gain drift (% of reading per °C)	±0.02% typical ±0.1% max. @370 ppmv	±0.15% typical ±0.30% max. @20 mmol/mol
Direct sensitivity to H_2O (mol CO_2/mol H_2O)	±2.00E-05 typical ±4.00E-05 max.	- -
Direct sensitivity to CO_2 (mol H_2O/mol CO_2)	- -	±0.02 typical ±0.05 max.

Data Storage: Removable industrial grade USB flash storage.
Data Communication: Ethernet, Synchronous Device for Measurement (SDM; User-selectable to 50Hz), RS-232 (115200 baud); 20 Samples/Sec. max., 6 DACs (single ended; 0-5V).
Type: Absolute, open-path, non-dispersive infrared gas analyzer.
Detector: Thermo-electrically cooled lead selenide.
Bandwidth: 5, 10, or 20 Hz, software selectable.
Path Length: 12.5 cm (4.72").
Operating Temperature Range: -25 to 50°C (-40 to 50 °C verification test available on request).
Relative Humidity Range: 0-95% (non-condensing).
Weatherproof Rating: Tested to IEC IP65 standard.
User Interface: Windows® based software supports all setup, configuration and calibration functions through RS-232 or Ethernet ports.
Outputs: RS-232 (20 Hz Maximum)

SDM (User selectable to 50Hz)
Ethernet
6 user-scalable 16 bit DACs (0-5V range, single-ended).
Inputs: Ethernet, 4 analog input channels (±5V, 16 bit).
Power Requirements: 10.5 to 30 volts DC.
Power Consumption: 30 W during warm-up, 10 W in steady state.
Dimensions:
  Head: Dia 6.5 cm, Length 30 cm. Designed for minimal wind flow disturbance.
  LI-7550 Analyzer Interface Unit: 35 cm × 30 cm × 15 cm (external dimensions).
  IRGA cable: 5 meters (between sensor head and electronics control box). Can connect two
  IRGA cables together for a maximum length of 10 meters.
 **Power, Serial, Analog Input, Analog Output, Ethernet and SDM cables**: 5 meters
Weight: Head: 0.75 kg (1.65 lb.), LI-7550 and Cables: 4.8 kg (10.5 lb.)

B   Pin Assignments

LI-7550 Pin Assignments

SDM			AUXILIARY INPUT			DAC OUTPUT		
PIN 1	BROWN	SDM_EN	PIN 1	WHITE	AUX1+	PIN 1	WHITE	DAC1
PIN 2	WHITE	SDM_CLK	PIN 2	BROWN	AUX1-	PIN 2	BROWN	DAC2
PIN 3	BLUE	SDM_DATA	PIN 3	GREEN	AUX2+	PIN 3	GREEN	DAC3
PIN 4	BLACK	GND	PIN 4	YELLOW	AUX2-	PIN 4	YELLOW	DAC4
COUPLING	BARE	EARTH GND	PIN 5	GREY	AUX3+	PIN 5	GREY	DAC5
POWER			PIN 6	PINK	AUX3-	PIN 6	PINK	DAC6
PIN 1	BROWN	VIN-	PIN 7	BLUE	AUX4+	PIN 7	BLUE	READY
	BLACK		PIN 8	RED	AUX4-	PIN 8	RED	NC
PIN 2	WHITE	VIN-	PIN 9	ORANGE	+5V	PIN 9	ORANGE	NC
PIN 3	BLUE	VIN+	PIN 10	TAN	GND	PIN 10	TAN	GND
	RED							
PIN 4	BLACK	VIN+	PIN 11	BLACK	GND	PIN 11	BLACK	GND
INPUT: 10.5 - 30VDC			PIN 12	VIOLET	GND	PIN 12	VIOLET	GND
FUSE: 5A F 125/250V								

DB-9 Connector on RS-232 Cable

The LI-7550 Analyzer Interface Unit uses a round Turck connector on the front panel for RS-232 data output. A serial cable (p/n 392-10268) with a round Turck connector and a female DB-9 connector attaches to the LI-7550 RS-232 port, and to the DB-9 connector on a computer. The pin assignments on the DB-9 connector on the serial cable are given below; note that not all pins are used for communication between the LI-7550 and a computer.

```
        1 ●
    6 ●━━━━━━━━▶ Handshaking (DTR)
        2 ●━━━▶ Data (TXD)
    7 ●◀━━━━━━ Handshaking (CTS)
        3 ●◀━━ Data (RXD)
    8 ●◀━━━━━ Handshaking (RTS)
        4 ●
9 ●
        5 ●━━━━ Signal Ground (SG)
```
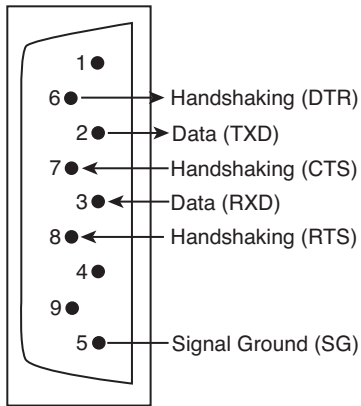
C   Suppliers

The company names, addresses, and phone numbers are the most current we have at the time of this printing. In some cases the information may change without notice.

Chemical Sources

Material	LI-COR Part Number
Ascarite II, 500 g	9970-022
Magnesium Perchlorate, 2 kg	9960-078

Fisher Scientific www.fishersci.com 800-766-7000 770-871-4500	**VWR Scientific Products** www.vwrsp.com 800-932-5000 908-757-4045
Thomas Scientific www.thomassci.com 800-345-2100 856-467-2000	**GFS Chemicals, Inc.** www.gfschemicals.com 800-394-5501 740-881-5501
P.W. Perkins Co., Inc. www.pwperkins.com 856-769-3525	**LI-COR Biosciences** 4421 Superior Street Lincoln, NE 68504 USA 800-447-3576 402-467-3576 www.licor.com

Internal Chemical Bottle Kit

The internal scrubbing bottles on the LI-7500A gas analyzer can be purchased in a pre-charged kit that is ready to use. The bottles contain magnesium perchlorate and Ascarite II. The LI-7500A kit can be ordered under part number **7500-950**, and contains two small bottles.

Turck® Cables (see Table C-1)

Turck Inc.
3000 Campus Drive
Minneapolis, MN 55441
Phone: 612-553-7300
FAX: 612-553-0708
www.turck.com

Table C-1. Turck® cables used to connect to the LI-7500A.

LI-COR Part Number	Cable	Cable Connector	Turck Part Number
392-10094	Power	4-pin female	RK4.41T-*/S529
392-10093	SDM Interface	4-pin male	RSS 4.4T-*
392-10268	Serial	6-pin female to DB-9 female	RKC 6T-*-DB9F/CS12317
392-10109	Analog In/Out	12-pin male	RSS 12T-*
392-10108	Ethernet	8-pin male-male	RSS RSS841-*M
392-10107	Ethernet Adapter	8-pin female to RJ45	RKC RJ45 840-*M

* = cable length

Industrial Rated USB Flash Drives

NOTE: The USB flash drive listed below has been tested by LI-COR; if you want to use other drives in the LI-7550, please contact LI-COR for more information.

APRO Co., Ltd.
www.apro-tw.com
16GB Drive: **LI-COR part #616-10723**
            APRO part #WMUFD016G-ACCMC/3C

D   Configuration Grammar

Introduction

This section describes the protocol used by the LI-7500A to communicate via RS-232 and Ethernet, for both configuration and data output purposes. Commands sent to the LI-7500A have a certain structure that must be followed, and data sent by the LI-7500A comes packaged in a particular way. For example, to set the Bandwidth to 10Hz, the following string

```
(Outputs(BW 10))
```

should be sent followed by a line feed character (decimal 10). Each command begins with a left parenthesis '`(`', and ends with a right parenthesis '`)`'. Some commands, such as `(BW...)` contain a single value, while other commands, such as `(Outputs...)`, can contain one or more commands. The parentheses mark the start and stop of the command, and extra characters before or after are ignored, as well as white space (spaces and tabs) before or after the parentheses. This string would work equally as well, for example:

```
This is ignored (  Outputs (BW 10   )) and so is this
```

The LI-7500A does not try parsing a command string until a line feed is received. Since "extra" characters are ignored, commands can be terminated with carriage return and line feeds equally as well.

Another example of a command string is

```
(Outputs(RS232(Freq 10)(Pres TRUE))(BW 5))
```

In this case, we are setting the RS-232 output frequency to 10Hz, requesting that Pressure be included in the output records, and that the bandwidth be 5 Hz. Notice the 2 parentheses at the end of `(Pres TRUE))`. This is because `(Pres..)` and `(Freq..)` are `(RS232..)` commands, while `(BW..)` is not. `(BW..)` and `(RS232..)` are both `(Outputs..)` commands, however, and the "extra" paranthesis at the end of `(BW 5))` signals the end of the `(Outputs..)` command.

An illegal command string would be

```
(BW 5)
```

because the `(BW...)` command is only recognized within the context of an `(Outputs...)` command.

The LI-7500A configuration grammar is case sensitive. That is, `(Outputs(BW 10))` will work, while `(outputs(bw 10))` will not.

Who Sends What

Not all of the commands in the LI-7500A's grammar are really commands. Some are designed to be used by the LI-7500A to package outgoing data. The `(Data..)` command, or record, might look like this

```
(Data (CO2D 2.2083146e1)(H2OD 3.5485935e2)(Temp
2.5886261e1)(Pres 9.8157062e1))
```

This record is showing the latest values of CO_2 and H_2O mole density (mmol m^{-3}), temperature (°C), and pressure (kPa). The fields present in a `(Data..)` record, and how often they are output, is determined by the `(Outputs..)` command.

Once it has established communications with a host computer (discussed in the next section), the LI-7500A's RS-232 communications is largely made of up of outgoing `(Data..)` and `(Diagnostics..)` records. The only other type of records it might send are `(Error..)` and `(Ack..)`. The `(Error..)` record is sent whenever the LI-7500A receives a command it cannot parse or recognize, and the `(Ack..)` record acknowledges a configuration change. It is also used to pass back the new zero or span setting after a `(Calibrate..)` command.

Command Summary

In the following sections, some abbreviations are used:

{int} means an integer value, such as 0, 10, 452, etc.
{float} means any integer or floating point value, such as 0, 3.14159, 1E-7, -3.47e-09, etc.

{string} means anything (< 40 characters) contained by double quotes, such as "Hey, you!"
{ `item1` | `item2` | `item3` } means you must include one of the items in the list.
{bool} - { `TRUE` | `FALSE` }

The (Outputs..) Command

`(Outputs..)` is used to configure the items pertaining to data output, including the bandwidth, delay time, DACs (digital to analog convertors), the RS-232 port, Ethernet and USB Logging. The actual RS-232 and Ethernet output uses the `(Data..)` record described in Table 2.

Table 1: The Outputs Command

Command	Subcommands				Remarks
`(Outputs`	`(BW {5 / 10 / 20})`				Sets instrument bandwidth to 5, 10, or 20 Hz.
	`(Delay {int})`				Output delay interval (0 to 32), where each interval is 1/150 seconds. This is added to the 220 ms system delay.
	`(Dac1` `(Dac2` `(Dac3` `(Dac4` `(Dac5` `(Dac6`	`(Source {List`[a]`})`		`)`	The variable that drives the DACs (digital to analog converters)
		`(Zero {float})`	`)`		Value that corresponds to 0 Volts output
		`(Full {float})`			Value that corresponds to 5 Volts output
	`(SDM`	`(Address {int})`	`)`		SDM address (0 thru 14).

Command	Subcommands			Remarks
(Outputs	(RS232	(Baud {9600 | 19200 | 38400 })	)	Baud rate for RS-232
		(Freq {*float*})		Output frequency of (Data..) records in Hz. Usable values: 0.0 thru 20.0
		(Labels {*bool*})		
		(DiagRec {*bool*})		
		(EOL {*"hex code(s)"*})		User defined termination character(s) for data record in "hex" (e.g. "0D0A" would be carriage return line feed). Default is "0A" = line feed.
		({List[b]} {*bool*})		These commands determine what is included in the (Data output record
	(ENet	(Freq {*float*})	))	
		(Labels {*bool*})		
		(DiagRec {*bool*})		
		(EOL {*"hex code(s)"*})		
		({List[b]} {*bool*})		
	(Logging	(Freq {1|2|5|10|20}	)	
		(Split {0|15|30|60|90|120|240|1440})		
		(Zip {bool})		
		(Full { Delete | DeleteAll | Stop })		
		(7700Status {bool})		
		({List[b]} {*bool*})		
		(Metadata)		See Metadata below

Command	Subcommands			
(Metadata		(Log {bool})		
	(Site	(site_name {string})		
		(altitude {float})		
		(gpsformat {DDD MM SS.SSS | DDD MM.MMM | Decimal Degrees})		

		(latitude {+|– xxxd xx' xx.xxx"} |
		          {+|– xxxd xx.xxx'} |
		          {+|– xxx.xxxx}
		)		

		(longitude {+|– xxxd xx' xx.xxx"} |
		          {+|– xxxd xx.xxx'} |
		          {+|– xxx.xxxx}
		)		

		(canopy_height {float})		
		(displacement_height {float})		
		(roughness_height {float})		
	(Station	(station_name {string})		
	(Instruments	(instr_1_manufacturer {string})		
		(instr_1_model {string})	)	)
		(instr_1_height {float})		
		(instr_1_wformat {uvw|polar_w|axis})		
		(instr_1_wref {spar|axis})		
		(instr_1_north_offset {float})		
		(instr_2_manufacturer {string})		
		(instr_2_model {string})		
		(instr_2_height {float})		
		(instr_2_north_separation {float})		
		(instr_2_east_separation {float})		
		(instr_2_vertical_separation {float})		
		(instr_2_tube_length {float})		
		(instr_2_tube_diameter {float})		
		(instr_3_manufacturer {string})		
		(instr_3_model {string})		
		(instr_3_height {float})		
		(instr_3_north_separation {float})		
		(instr_3_east_separation {float})		
		(instr_3_vertical_separation {float})		

a. Auxiliary Outputs: { NONE | CO2A | CO2MMOL | H2OA | H2OMMOL | TEMPERATURE | PRESSURE | AUX |

   AUX2 | AUX3 | AUX4 | CO2MF | CO2MFD | H2OMF | H2OMFD | DEWPT | SETPOINT}

b. Data Outputs: Ndx | Time | Date | CO2Raw | H2ORaw | DiagVal | DiagVal2 | CO2D | H2OD | Temp | Pres | Aux | Aux2 | Aux3 | Aux4 | Cooler | CO2MF | CO2MFd | H2OMF | H2OMFd | DewPt | H2OAW | H2OAWO | CO2AW | CO2AWO | CO2SS

(EOL "{hex code(s)"})
End of Line character. Enter hex value in double quotes.

Example:
`(Outputs(RS232(EOL "0D0A")))lf`
would terminate data strings with a carriage return and a line feed.

(Ndx {bool})
Determines whether an index value is transmitted or not.

Example:
`(Outputs(RS232(Ndx TRUE)))lf`
would cause the data stream to contain an index value. The index value is incremented approximately every 6.7 milliseconds (e.g. 150 Hz) and ranges from approximately -2.0E8 to +2.0E8.

(DiagRec {bool})
Controls whether independent (Diagnostic) **text** records are ever sent. If TRUE, operates normally (1/second or on a change). If FALSE, never sends a Diagnostic record.

Example:
Transmitted: `(Outputs(RS232(DiagRec TRUE)))lf`
Received: `(Diagnostics (SYNC TRUE)(PLL TRUE)(DetOK TRUE)(Chopper TRUE)(Path 61))`

(DiagVal {bool})
Controls whether or not a 1 byte diagnostic value (0-255) is output (same as SDM diagnostic value) in the (Data stream. "Diag" is used for the label when (Labels TRUE is set.

Example:
Transmitted: `(Outputs(RS232(DiagVal TRUE)))lf`

Received: `(Data... (Diag 249...))`

NOTE: The (DiagRec and the (DiagVal are two separate outputs and are independent of one another.

(Labels {bool})
This command controls whether or not data labels are transmitted with the data stream. Default is TRUE, and this means that data are transmitted in the normal (Data) format record. When (Labels FALSE), however, data output are values only and are tab-delimited. To maximize available bandwidth, when (Labels FALSE), a data record might appear as

    15.1234<tab>354.123<tab>101.3<tab>249<eol>

The following are several examples of data formatting. The command string sent to the LI-7500A is terminated with a line feed character.

EXAMPLE (Labels TRUE) Data format

Transmitted to LI-7500A
```
(Outputs(RS232(Freq 1)(EOL "0D0A")(Ndx TRUE)(DiagRec
FALSE)(DiagVal TRUE)(Labels TRUE)))lf
```

Received from LI-7500A
```
(Data (Ndx 1545)(DiagVal 250)(CO2Raw 1.5386712e-1)(CO2D
3.2183277e1)(H2ORaw 3.57
75542e-2)(H2OD 1.9687008e2)(Temp 2.4227569e1)(Pres
9.8640356e1)(Aux 0)(Cooler 1.5756724))
(Data (Ndx 1809)(DiagVal 250)(CO2Raw 1.5380490e-1)(CO2D
3.2162146e1)(H2ORaw 3.57
57541e-2)(H2OD 1.9677452e2)(Temp 2.4227569e1)(Pres
9.8543587e1)(Aux 0)(Cooler 1.5750400))
```

EXAMPLE (Labels FALSE) Data format

Notice how this format is much cleaner and reduces the overhead of redundant label transmissions. The data selected for output data record is accomplished with the (Outputs(RS232(CO2Raw TRUE)...))command.

Transmitted to LI-7500A

```
(Outputs(RS232(Freq 1)(EOL "0D0A")(Ndx TRUE)(DiagRec
FALSE)(DiagVal TRUE)(Labels FALSE)))lf
```

Received from LI-7500A
```
252    250     0.15401 32.2167 0.03569 196.703 24.33    98.6    0
1.5730
511    250     0.15404 32.2174 0.03572 196.816 24.42    98.5    0
1.5683
765    250     0.15402 32.2342 0.03579 196.995 24.49    98.6    0
1.5703
1033   250     0.15400 32.2097 0.03571 196.771 24.63    98.5    0
1.5724
1288   250     0.15405 32.2341 0.03578 196.838 24.76    98.5    0
1.5734
1544   250     0.15406 32.2385 0.03575 196.782 24.72    98.5    0
1.5724
```

Examples:

1. To set the LI-7500A to output only CO_2 and H_2O molar densities once every 2 seconds:

```
(Outputs(RS232(Freq .5)(Pres FALSE)(Temp FALSE)(Aux
FALSE)(CO2Raw FALSE)(CO2D TRUE)(H2ORaw FALSE)(H2OD
TRUE)(Cooler FALSE)))
```

2. To configure DAC #1 to output CO_2 mole density with this scaling: $0V = 12$ mmol m^{-3}, and $5V = 15$ mmol m^{-3}.

```
(Outputs(Dac1(Source CO2MMOL)(Zero 12)(Full 15)))
```

Data and Status Records

The (Data..) and (Diagnostics..) records are the vehicles with which the LI-7500A outputs data through its RS-232 port. The frequency with which it outputs (Data..) records is determined by the (Outputs(RS232(Freq..))) command, shown in Table 1. Data and status record formats are determined by the (Outputs(RS232 (boolean controlled command structure. (EOL {"hex codes"}) and (Labels {boolean}) determine the termination characters and whether or not (Data labels are output.

Table 2: Data and Diagnostics Records

Record	Subcommands		Remarks	
(Data	(Ndx *{int}*)		Index value. Increments by 150 every second.	The values included are set by (Outputs(...)). How often this is output is determined by (Outputs (Freq...)).
	(Time *{}*)		Time	
	(Date *{}*)		Date	
	(Temp *{float}*)		Temperature, °C	
	(Press *{float}*)		Pressure, kPa	
	(Aux *{float}*)		Auxiliary input value	
	(Aux2 *{float}*)	)	Auxiliary input value 2	
	(Aux3 *{float}*)		Auxiliary input value 3	
	(Aux4 *{float}*)		Auxiliary input value 4	
	(CO2AW *{float}*)		CO_2 Source	
	(CO2AWO *{float}*)		CO_2 Reference	
	(CO2Raw *{float}*)		CO_2 absorptance	
	(CO2D *{float}*)		CO_2 density (mmol m^{-3})	
	(CO2MF *{float}*)		CO_2 mol fraction (µmol/mol)	
	(H2OAW *{float}*)		H_2O Source	
	(H2OAWO *{float}*)		H_2O Reference	
	(H2ORaw *{float}*)		H_2O absorptance	
	(H2OD *{float}*)		H_2O density (mmol m^{-3})	
	(H2OMF *{float}*)		H_2O mol fraction (mmol/mol)	
	(Cooler *{float}*)		Detector cooler (Volts)	
	(DiagVal *{int}*)		Diagnostic value 0-255. Boolean controlled output.	
	(DiagVal2 *{int}*)		31 bit diagnostic value	
	(CO2SS *{float}*)		CO_2 Signal Strength	

Record	Subcommands		Remarks	
(Diagnostics	(PLL *{bool}*)	)	Phase lock loop status	Diagnostics are always output at 1 Hz
	(DetOK *{bool}*)		Detector temperature control	
	(Chopper *{bool}*)		Chopper temperature control	
	(Path *{float}*)		Signal Strength (0-100)	
(Ack	(Received TRUE)	)	Sent by the LI-7500A to aknowledge any incoming command.	
	(Val *{float}*)		Only sent after zeroing and spanning commands. Contains the new, computed value of zero or span.	
(Error (Received TRUE))			Sent by the LI-7500A when it cannot parse or recognize a command.	
(EmbeddedSW	(Version *{string}*)	)	Embedded software version	
	(Model *{string}*)		Instrument model e.g. LI-7500A	
	(DSP *{string}*)		Embedded DSP software version	
	(FPGA *{string}*)		Embedded FPGA software version	
(Command {start_logging | stop_logging | eject_usb | factory_reset })				
(Info (USB	(Size {float})	)	0: Drive not present 1: Logging 2: Drive present, not logging 3: Error	
	(Free {float})			
	(State {0|1|2|3}			

Examples:

1. A typical `(Data..)` output record, with all items present, is shown below:

```
(Data (Ndx 215713)(CO2Raw 1.2831902e-1)(CO2D
2.2083146e1)(H2ORaw 5.5372476e-2)(H2OD 3.5485935e2)(Temp
2.5886261e1)(Pres 9.8157062e1)(Aux 0)(Cooler 1.0537354))
```

2. A typical `(Diagnostics..)` record is shown below:

```
(Diagnostics (Sync TRUE)(PLL TRUE)(DetOK TRUE)(Chopper
TRUE)(Path 63))
```

Data Polling (Software and Hardware)

A software command using the ENQ character (0x05) is available to query the LI-7500A for a data record over RS-232. When transmitted to the LI-7500A, via RS-232, the record is built as presently defined (Labels TRUE or FALSE, etc.), and is added to the serial output queue. This software command is normally used when the update frequency is set to zero, as shown in the command below.

```
(Outputs (RS232 (Freq 0)(DiagRec FALSE)))lf
```

The LI-7500A also supports toggling of the Clear To Send (CTS) line to request a data record. This hardware polling would be normally used when the update frequency is set to 0 as described above. Since the CTS line is an *input*, the host software should toggle the Request To Send (RTS) line from the host computer. This method of transmitting a data record occurs when the CTS line goes from low to high.

Users familiar with programming RS232 interfaces may already understand that RS-232 logic TRUE (1) is considered a low (or negative) voltage and logic FALSE (0) is considered a high (or positive) voltage. Thus, the CTS toggle sequence would look like:
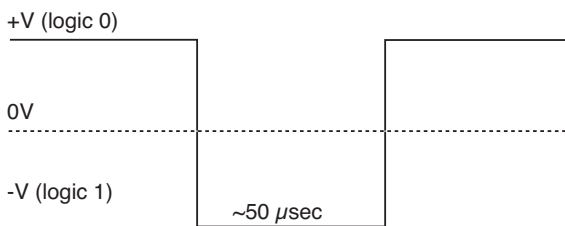
Data are updated to RS-232 at 20 Hz. If the CTS line is toggled, record will be output the next time one is ready. The CTS line is pin 7 on the LI-COR RS-232 Cable, part #392-10268. The RS-232 serial pinout from a DB9 connector on an AT style computer is defined as:

Pin	Signal Description	Function	Signal at Device
1	DCD	Data Carrier Detect	Input
2	RD	Received Data	Input
3	TD	Transmit Data	Output
4	DTR	Data Terminal Ready	Output
5	SG	Signal Ground	
6	DSR	Data Set Ready	Input
7	**RTS**	**Request To Send**	**Output**
8	**CTS**	**Clear To Send**	**Input**
9	RI	Ring Indicator	Input

A possible wiring configuration using the LI-COR RS-232 cable, part #392-10268 to a computer would be:

LI-COR CABLE Function		DB9 ON HOST COMPUTER PIN	Function
Ground		PIN 5	Ground
Receive Data		PIN 3	Transmit Data
Request To Send	PIN 8		Clear To Send
Transmit Data		PIN 2	Receive Data
Clear To Send		PIN 7	Request To Send
Data Terminal Ready		PIN 6	Data Set Ready

Note about Embedded Software RS-232 Communication Priorities

The RS-232 hardware and software trigger does not tap directly into the same data stream that is output to the DAC's and the SDM. The trigger actually sends a request to the instrument to output a single data record over the RS-232 port. The processing that is incurred to do this is relatively lengthy. The RS-232 task is also a low priority, so considerable latency could occur. If you

want output data that is tightly synchronized to an input stimulus you should use the SDM output or sample a DAC output based on your trigger; don't use RS-232.

The (Inputs..) Command

The `(Inputs..)` command is used to scale the Auxiliary input channel, and to determine how pressure and temperature are measured by the LI-7500A.

Table 3: The Inputs Command

Command	Subcommands				Remarks
(Inputs	(Pressure (Temperature	(Source *{* Aux | Measured | UserEntered *}*)	)	)	How it is determined
		(Val *{float}*)			Fixed value, for "UserEntered"
	(Aux	(A *{float}*)	)		A and B are the Slope and Intercept respectively
		(B *{float}*)			
		(Name{string})			Name: Used to denote the type of input. For example, U, V, W, Ts.
		(Units{string})			
	(Aux2	(A *{float}*)	)		
		(B *{float}*)			
		(Name{string})			Units: The units of the data after the slope and intercept are applied.
		(Units{string})			
	(Aux3	(A *{float}*)	)		
		(B *{float}*)			
		(Name{string})			
		(Units{string})			
	(Aux4	(A *{float}*)	)		
		(B *{float}*)			
		(Name{string})			
		(Units{string})			

Examples:
1. To make pressure fixed at 92 kPa, send this:

```
(Inputs(Pressure(Source UserEntered)(Val 92)))
```

2. To measure temperature from a linearized thermistor connected to the Auxiliary input, where 0 volts is 0 °C, and 5 volts is 50 °C, send this:

    ```
    (Inputs(Aux(A 10)(B 0))(Temperature(Source Aux)))
    ```

3. To measure pressure and temperature normally, using the built-in sensors, send this:

    ```
    (Inputs(Pressure(Source Measured))(Temperature(Source
    Measured)))
    ```

The (Calibrate..) and (Coeffs..) Commands

The `(Calibrate..)` and `(Coeffs..)` commands control zeroing, spanning, and factory calibration coefficients. The (Date subcommand must be present, and (Val must be absent to perform (ZeroH2O and (ZeroCO2. For (SpanCO2 and (SpanH2O, (Date and (TDensity must be present, and (Val must be absent to trigger a calibration.

Table 4: Calibration Commands

Command	Subcommands			Remark
(Calibrate	(ZeroH2O (ZeroCO2	(Val *{float}*)		For setting the zero directly. If not present will trigger a calibration.
		(Date *{quoted string}*)	)	The date field triggers the LI-7500A to do a zero immediately. The new value will be returned in an (Ack..) record.
	(SpanCO2 (Span2CO2 (SpanH2O (Span2H2O	(Val *{float}*)		For setting the span directly. If not present will trigger a calibration.
		(Target *{float}*)	)	Target value in ppm for CO_2, or °C for H_2O (for reference purposes).
		(TDensity *{float}*)	)	Target value in mmol m^{-3}. (For computational purposes).
		(Date *{quoted string}*)		
	(MaxRef	(CX {int})		Maximum expected value of raw reference signal A_{co} at -40 °C.
		(WX {int})	)	Maximum expected value of raw reference signal A_{wo} at -40 °C.
		(Date *{quoted string}*)		

Command	Subcommands				Remark
(Coeffs	(Current	(SerialNo *{quoted string}*)			The 75H-xxxx head number.
		(Band (A *{float}*))			The band broadening coefficient (1.15 for the LI-7500A).
		(CO2	(A *{float}*)	)	These values are found on the LI-7500A's calibration sheet.
			(B *{float}*)		
			(C *{float}*)		
			(D *{float}*)		
			(E *{float}*)		
			(XS *{float}*)		
			(Z *{float}*)		
		(H2O	(A *{float}*)	)	
			(B *{float}*)		
			(C *{float}*)		
			(XS *{float}*)		
			(Z *{float}*)		
		(Pressure	(A0 *{float}*)		
			(A1 *{float}*)		
		(MaxRef	(B *{float}*)		
			(C *{float}*)		

Examples:

1. To set the CO_2 zero right now (with the calibration tube in place and CO_2-free gas flowing though it), send this:

```
(Calibrate(ZeroCO2(Date "11 Aug 1999 at 2:15")))
```

Note 1: The data value can be any string, so "My Birthday" is equally valid.
Note 2: The new value of zero will be sent in the next (Ack(Val..)) record. (See Table 2).

2. To force the H_2O channel to use the value 0.96 for its zero, send this:

```
(Calibrate(ZeroH2O(Val 0.96)))
```

3. To make the LI-7500A set its CO_2 span right now, with 400 µmol mol^{-1} flowing through the calibration tube, first compute the target density using Equation 2-24 (solved for C). If the temperature is 23°C, and the pressure 98kPa, then the mode density is 15.92 mmol CO_2 m^{-3}. Then send the following:

```
(Calibrate(SpanCO2(Target 400)(TDensity 15.92)(Date "3 June
2000")))
```

The Program Reset Command

`(Program(Reset TRUE))` is the equivalent of pressing the reset button on the main board. It is generally only used to access lower level software for updating the embedded program, or when the instrument is not responding normally.

Table 5: Synchronization Commands

Command	Remarks
`(Program (Reset TRUE))`	Sending this will force the software to reset. This is equivalent to pressing the reset button on the LI-7550 inside panel.

The Network Command

Table 6: Network Commands

Command	Subcommands			Remarks
`(Network`	`(Name {{string})`		`)`	`Hostname`
	`(IP`	`(Type {dhcp │ static}`		`Address type: dhcp │ static`
		`(Address {xxx.xxx.xxx.xxx})`		
		`(Netmask {xxx.xxx.xxx.xxx})`		
		`(Gateway {xxx.xxx.xxx.xxx})`		
		`(MAC {xx:xx:xx:xx:xx:xx})`		

The Clock Command

Table 7: Clock Commands

Command	Subcommands	Remarks
(Clock	(Date {})	System date
	(Time {})	System time
	(PTP {off automatic slaveonly preferred})	Precision Time Protocol setting
	(Zone {*})	Time zone

*refer to Windows application for list of time zones

The Query Command

The Query (?) command is used to query the LI-7500A for any configuration parameter individually, as well as any node in the configuration tree.

Table 8: Query Commands

Command	Remarks
(Outputs ?) (Calibrate ?) (Coef ?) (Outputs ?) (Data ?) (Diagnostics ?) (EmbeddedSW ?) (Inputs ?) (Info ?) (Network ?) (MeteoDevices ?) (MeteoSensors ?)	The query for *individual parameters* works only for configuration parameters and *not* data or diagnostic information. All commands are followed by a line feed (lf).

Examples:
The query **(Outputs(RS232(Freq ?)))lf** would respond:

```
(Outputs (RS232 (Freq 5)))
```

whereas the query **(Calibrate ?)lf** causes a Calibrate record to be put in the output queue.

Example Response:
```
(Calibrate (ZeroCO2 (Val 0.8945)(Date 26 08 2009
10:37))(SpanCO2 (Val 1.0068)(Target 597.2)(Tdensity
23.154)(Date 26 08 2009 11:00))(Span2CO2 (Val 0.0)(Target
)(Tdensity )(ic 0.106207)(act 0.105489)(Date 4Cal))(ZeroH2O
(Val 0.791075)(Date 26 08 2009 11:20))(SpanH2O (Val
1.00585)(Target 12.00)(Tdensity 447.421)(Date 26 08 2009
11:37))(Span2H2O (Val 0.0)(Target )(Tdensity )(iw 0.059434)(awt
0.0590885)(Date 4Cal)))
```

(Coef ?)lf causes a Coefficients record to be put in the output queue.

Example Response:
```
(Coef (Current (SerialNo 75H-Beta6)(Band (A 1.15))(CO2 (A
1.56704E+2)(B 2.15457E+4)(C 4.33894E+7)(D -1.24699E+10)(E
1.75102E+12)(XS 0.0023)(Z 0.0002)
)(H2O (A 5.24232E+3)(B 3.91896E+6)(C -2.33026E+8)(XS -0.0009)(Z
0.0185))(Pressure (A0 56.129)(A1 15.250))(DPressure (A0 1.0)(A1
0.0))))
```

(Outputs ?)lf causes a Outputs record to be put in the output queue.

Example Response:
```
(Outputs (BW 10)(Delay 0)(SDM (Address 7))(Dac1 (Source
NONE)(Zero -5e-2)(Full 4
e-1))(Dac2 (Source PRESSURE)(Zero -1e-1)(Full 4e-1))(RS232
(Baud 38400)(Freq 0)(
Pres TRUE)(Temp TRUE)(Aux TRUE)(Cooler TRUE)(CO2Raw TRUE)(CO2D
TRUE)(H2ORaw TRUE
)(H2OD TRUE)(Ndx TRUE)(DiagVal TRUE)(DiagRec FALSE)(Labels
FALSE)(EOL "0D0A")))
```

(Data ?)lf causes a Data record to be put in the output queue. (Note that an
ENQ (0x05) will do the same thing...)

Example Response:
```
(Data (Ndx 2471)(DiagVal 250)(CO2Raw 1.6319131e-1)(CO2D
3.5119712e1)(H2ORaw 3.16
72954e-2)(H2OD 1.7067077e2)(Temp 2.3874512e1)(Pres
9.8735609e1)(Aux 0)(Cooler 1.
5630015))
```

(Diagnostics ?)If causes a Diagnostics record to be put in the output queue.

Example Response:
(Diagnostics (SYNC TRUE)(PLL TRUE)(DetOK TRUE)(Chopper
TRUE)(Path 65))

(EmbeddedSW ?)If causes an EmbeddedSW record to be put in the output
queue.

Example Response:
(EmbeddedSW (Version 0.0.54a)(Model LI-7500A Open Path CO2/H2O
Analyzer)(DSP 0.8.0)(FPGA 0.1.2))
(Inputs ?)If causes an Inputs record to be put in the output queue.

Example Response:
(Inputs (Pressure (Source Measured)(UserVal
9.8000002e1))(Temperature (Source Measured)(UserVal
2.5000000e1))(Aux (A 1)(B 0)))

MeteoDevices (Biomet Station)

Command	Subcommands		Remarks
(MeteoDevices	(DevList {string:string...})		Colon delimited list of devices on the network (subnet)
	(Device {string})		Current connected device
	(DeviceState {0|1})	)	0=not connected 1=connected
	(SyncClock {bool])		When TRUE, the clock on the 9210 will get updated with the time of the LI-7550

MeteoSensors (Biomet Sensors)

Command	Subcommands		Remarks
(MeteoSensors (Sensor	(Name {string})	)	Name of sensor, Defined in Coms Tag
	(Type {int})		Type of sensor
	(Units {int})		Units

The Connection Protocol

Introduction

The purpose of this section is to describe the protocol used to establish communications with the LI-7500A when it is operating in an "unknown" mode. That is, when the baud rate is not known, nor are any other details about the instrument's configuration.

Note: For simple data collection, the LI-7500A can be configured with the **LI-7500A** Windows software program, and you will not have to deal with this protocol at all. If you wish to write your own interface program or driver for the LI-7500A, and you wish to get the LI-7500A to send its configuration to you, then this protocol must be used.

Establishing Communications: Step by Step

1. Set a break condition on the RS-232 line. 500 ms should be sufficient.

2. The LI-7500A will cease normal activity, change its baud rate to 9600 baud, and begin to send ascii ENQ characters (decimal 05) at a rate of 2 Hz for up to 10 seconds. Before 10 seconds are up, the host should:

3. Send an ascii ACK character (decimal 06) to the LI-7500A.

4. Upon receipt of an ACK, the LI-7500A will output its current configuration, terminated with a line feed (decimal 10). A sample configuration is shown below. After this is sent, the LI-7500A will resume its normal operation, except it will remain at 9600 baud.

5. The host can then send the desired configuration changes, if any, to the LI-7500A. If the configuration change involves a baud rate change, the LI-7500A will send its **(Ack..)** record before changing baud rates.

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. To the extent not superseded by the terms of any extended warranty, the terms and conditions of LI-COR's Warranty still apply.

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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