LI-7500 Open Path CO_2/H_2O Analyzer

LI-COR®

Biosciences

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The smooth, simple, aerodynamic profile of the LI-7500 Open Path CO_2/H_2O Analyzer belies the innovations within - optics, electronics, and software - that allow fast, precise measurements of *in situ* densities of CO_2 and H_2O in turbulent air structures. The novel open path design provides a number of benefits over other flux measurement systems, including:

- High speed and precision.
- Low power consumption, so that in remote environments, the LI-7500 can be powered by batteries and solar panels.
- Absence of internal or external tubing allows for undamped measurements of CO_2 and water vapor fluctuations, and no time delays.
- A sealed sensor head with sapphire optical windows allows operation in harsh environments at temperatures ranging from -25 to +50 °C (-40° C characterization optional). In addition, the lightweight LI-7500 sensor head can be mounted in virtually any desired orientation.

A weatherproof box houses the control unit's high speed Digital Signal Processing (DSP) electronics. Serial data are output at selectable speeds of up to 20 Hz, and linearized, user-configurable Digital-to-Analog Converters (DACs) output analog signals which are updated at 300 Hz.

A simple Windows® software interface provides for easy setup, calibration, and monitoring. In addition, the Windows® and LI-7500 software provide:

- Real-time graphical data output.
- On-board diagnostics to alert the user to potential problems that can compromise data.
- User-programmable Delay Time feature to synchronize CO_2 and H_2O data with data from sonic anemometers.

LI-7500 sensor head used with a sonic anemometer [1]

The LI-7500 is a high speed, high precision, non-dispersive infrared gas analyzer that accurately measures densities of carbon dioxide and water vapor in turbulent air structures. In the eddy covariance technique, these data are used in conjunction with sonic anemometer air turbulence data to determine the fluxes of CO_2 and H_2O. Applications of the LI-7500 include determining the carbon dioxide and water vapor budgets of agricultural or natural landscapes such as forests, grasslands, deserts and oceans for global change and ecological research. The LI-7500 is also used in CO_2 sequestration, monitoring applications as well as urban flux studies.

The Eddy Covariance Method

In the eddy covariance method, the flux, F_c of gas c (e.g. CO_2, H_2O) is given by

$$F_c \simeq -\overline{w'\rho_c'}$$

where c' is the density fluctuations of gas c (mol/m^3), and w' is the vertical wind velocity fluctuations (m/s). Near the ground, vegetation and other roughness elements induce eddies. To correctly sample these eddies a high speed, high precision analyzer is required. The photo above shows a typical eddy covariance station. The flux of CO_2 or H_2O from a landscape is obtained from the vertical wind speed (measured with a sonic anemometer) and the concentration of the eddy (measured with the LI-7500).

To minimize flow disturbances, the LI-7500 sensor head has a smooth, aerodynamic profile. In addition, the open path measurement eliminates the need for a pump, greatly reducing the overall power requirement of the flux system. This is especially important in remote locations where electrical power supply may be limited. The LI-7500 requires less than 10 Watts of power to operate (initial power-up can draw up to 30 Watts). The open path analyzer also eliminates time delays, pressure drops, and sorption/desorption of water vapor on tubing employed with closed path analyzers.

[1] Photo copyright Campbell Scientific Inc, Logan, UT, USA. All rights reserved, used by permission.

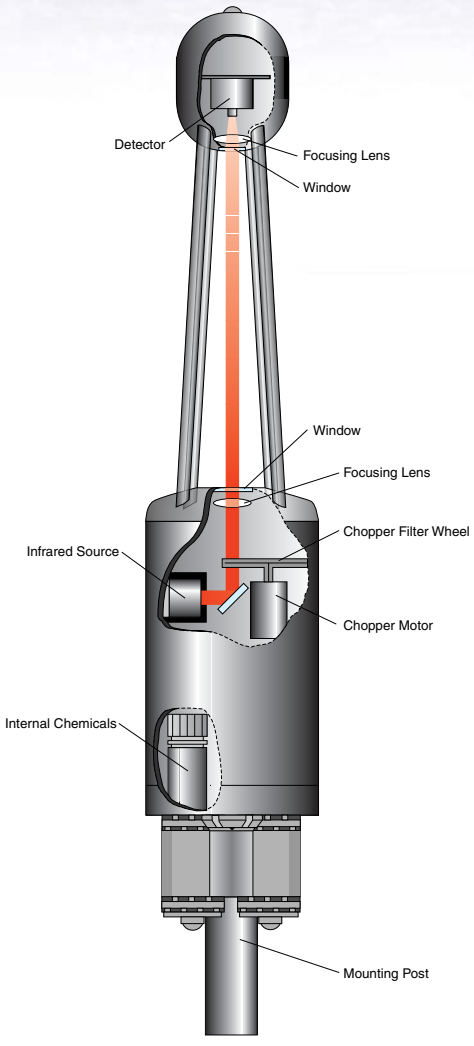
Operational Overview

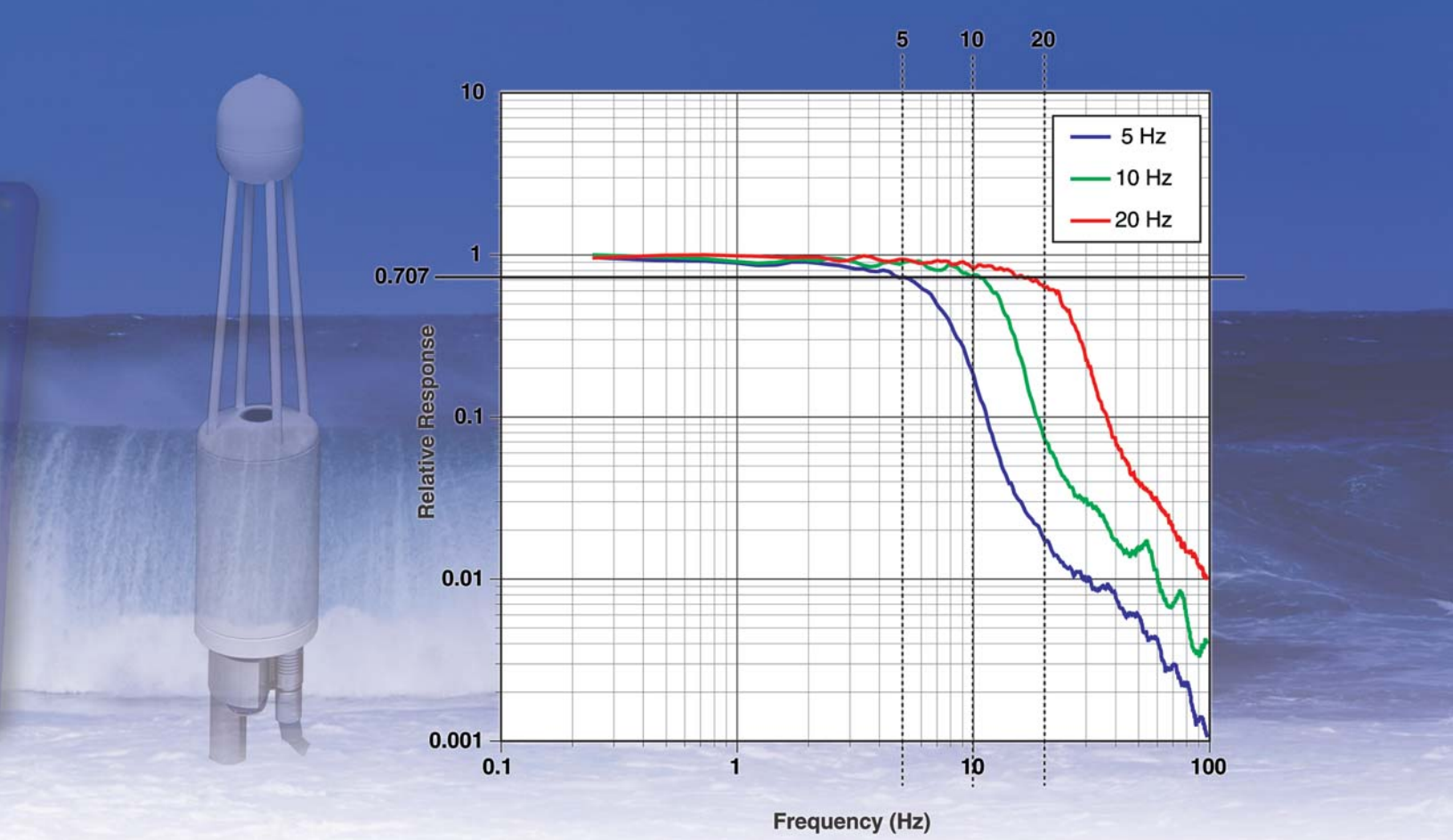
Mounting

The LI-7500 is normally mounted vertically or at a slight tilt (allows water to run off), since this causes the least obstruction to wind over a range of azimuthal directions. The sensor head can be mounted in any orientation desired without affecting performance. The signals from the LI-7500 are modulated at 150 Hz, so that variations in ambient light have virtually no effect on operation.

Analyzer Description

The LI-7500 sensor head has a 12.5 cm open path, with single-pass optics and a large 1 cm diameter optical beam. Reference filters centered at 3.95 µm provide for attenuation corrections at non-absorbing wavelengths. Absorption at wavelengths centered at 4.26 µm and 2.59 µm provide for measurements of CO_2 and water vapor, respectively. These features minimize sensitivity to dirt and dust, which can accumulate during normal operation. The LI-7500 operates over a temperature range of -25 to +50 °C (-40° C characterization optional). The figure at right shows a cut-away representation of the LI-7500 sensor head. The **Infrared Source** emits radiation which is directed through a **Chopper Filter Wheel**, **Focusing Lens**, and then through the measurement path to a cooled **Lead Selenide Detector**. Source and detector lifetimes are greater than 20,000 hours. A brushless **Chopper Motor** rotates the chopper wheel at 9000 rpm. The chopper motor also has a lifetime in excess of 20,000 hours. The windows at both ends of the optical path are made of sapphire, which is extremely hard and scratch resistant, allowing for worry-free cleanup of dirt and dust accumulation. The control box that houses the analyzer electronics is weatherproof, as are the cables and connectors used for data output, power, and auxiliary input.





LI-7500 Open Path Analyzer Noise Spectra For 3 Bandwidths

Data Output

The LI-7500 supports three data output options; linearized analog voltages via the Digital-to-Analog Converters (DACs), RS-232 serial data, and Synchronous Device for Measurement (SDM) output for Campbell Scientific Inc. (Logan, Utah, USA) dataloggers. Selectable output bandwidths of 5, 10, or 20 Hz are available (response times of approximately 0.1, 0.05, and 0.025 seconds, respectively).

The LI-7500 has a user-programmable feature known as Delay Time to allow synchronization of LI-7500 CO_2 and H_2O data with data from sonic anemometers. This delay time applies to all LI-7500 outputs (SDM, RS-232, and DAC).

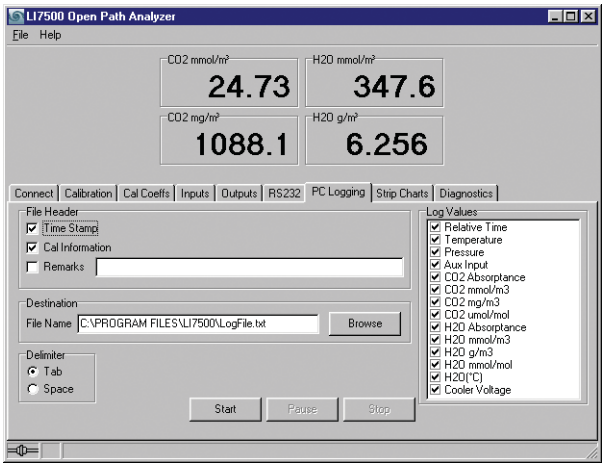
RS-232 Output

Serial data output is available at baud rates to 38400, at rates of up to 20 times per second.

A software command or serial hardware control line is also available to query the LI-7500 for individual data records.

Digital/Analog Output

The LI-7500 uses a simple Windows® interface for setup and calibration. Two user-configurable linear DACs are updated 300 times per second by Digital Signal Processing (DSP) electronics.



Real-time data setup and output options are available with a simple Windows® interface.

SDM Output

Serial data can also be output at rates of up to 40 Hz using the SDM interface for Campbell Scientific Inc. (CSI) dataloggers. The SDM interface offers the advantage of polling the LI-7500 on demand for measurement or diagnostic information. This allows the user to see real-time measurements and LI-7500 status information in the field without the aid of a laptop computer. Polling also allows a method for synchronizing CO_2, water vapor, and vertical wind speed data with CSI Sonic Anemometers.

Calibration

There are two aspects to calibration; factory calibration and user calibration. The factory calibration consists of determining the values of the calibration coefficients. User calibration (weekly or monthly) consists of setting analyzer zero and span. The accuracy of the LI-7500 depends on both calibrations. Calibration coefficients determined at the factory are typically valid for several years. The zero and span settings make the analyzer's response agree with its previously determined factory response at a minimum of two points. Calibration gases of 1% accuracy can often be obtained without too much difficulty; for higher accuracy the user should obtain WMO standards which are within the range of concentrations to be encountered during experimental measurements. It is recommended that the user keep these WMO gases as primary standards for checking less expensive working gas calibration tanks.

Factory Calibration

LI-COR uses a series of thirteen working calibration gases ranging in concentration from zero to 3,000 ppm. The thirteen working standards are verified against a set of primary WMO standards known to an absolute accuracy of 0.06% or better. Factory calibration coefficients are obtained from a 5th order polynomial fit to the entire range of concentration from zero to 3,000 ppm. The nominal accuracy of the polynomial fit across the entire range of concentrations is about 1%, but the absolute measurement accuracy obtained by the user depends primarily on the accuracy of the calibration gas used to set the analyzer span.

The calibration procedure for water vapor is similar to that for CO_2, except that water vapor mole fractions are generated using the LI-COR LI-610 Portable Dew Point Generator. Fifteen data points between 0 °C and 40 °C dewpoint are used during the calibration procedure, and a third order polynomial is fit to the data. The LI-610 is certified by the National Institute of Standards and Technology (NIST) to have an absolute accuracy of 0.2 °C.

LI-7500 User Calibration

The LI-7500 is calibrated by inserting the calibration tube into the optical path. The tube volume is then flushed with a flow of zero gas to set the zero, and a known concentration calibration gas to set the span. In general, the analyzer zero and span are stable over a several month period; the span stability affects H_2O the most during large variations in temperature, so the frequency of user calibration is largely dependent on the operating environment. Atmospheric or diurnal pressure variations are generally not a concern. The zero and span settings make the analyzer's response agree with its previously determined factory response at a minimum of two points. The calibration is performed via the Windows® interface software.

LI-610 Portable Dew Point Generator

LI-7500 sensor head and calibration tube

LI-7500 Power Spectral Density and Noise Specifications

CO_2		µmol mol^{-1}	mmol m^{-3}†	mg m^{-3}†
Calibration range		0 - 3000	0 - 117	0 - 5148
RMS noise at ambient (370 ppm) PSD* = 35 ppb/√Hz typical 70 ppb/√Hz max.	Bandwidth: 5 Hz 10 Hz 20 Hz	 0.08 0.11 0.16	 0.0031 0.0043 0.0061	 0.13 0.19 0.27
Zero drift with temperature (per C)	Maximum± Typical±	0.3 0.1	0.012 0.004	0.5 0.2
Gain drift with temperature at 370 ppm (% of reading per C)	Maximum± Typical±	0.1% 0.02%		
Direct sensitivity to H_2O (mol CO_2/mol H_2O)	Maximum± Typical±	4.00E-05 2.00E-05		

H_2O		mmol mol^{-1}	mmol m^{-3}†	g m^{-3}†
Calibration range		0 - 60	0 - 2340	0 - 42
RMS noise in moist air (10 mmol mol^{-1}) PSD* = 1.5 ppm/√Hz typical 2.5 ppm/√Hz max.	Bandwidth: 5 Hz 10 Hz 20 Hz	 0.0034 0.0047 0.0067	 0.13 0.18 0.26	 0.0024 0.0033 0.0047
Zero drift with temperature (per C)	Maximum± Typical±	0.05 0.03	2 1	0.04 0.02
Gain drift with temperature at 20 mmol mol^{-1} (% of reading per C)	Maximum± Typical±	0.3% 0.15%		
Direct sensitivity to CO_2 (mol H_2O/mol CO_2)	Maximum± Typical±	0.05 0.02		

†at 25° C, 98 kPa
*Power Spectral Density

* Power Spectral Density (PSD) = RMS noise/square root of bandwidth. To compute RMS noise at any bandwidth, multiply the PSD value by the square root of the bandwidth.

LI-7500 Specifications

Type: Absolute, open-path, non-dispersive infrared gas analyzer.

Detector: Thermo-electrically cooled lead selenide.

Bandwidth: 5, 10, or 20 Hz, software selectable.

Operating Temperature Range: -25 to 50° C (-40° C characterization optional).

User Interface: Windows® based software supports all setup, configuration and calibration functions through the RS-232 serial port.

Outputs: RS-232 (20 Hz Maximum). SDM (> 40Hz). 2 user scalable 16-bit DACs updated at 300 Hz.

Temperature/Pressure Inputs: Windows software allows user to choose between on-board pressure and temperature sensor or customer-supplied sensor through auxiliary input channel (12 bit input, 0 to +4.096 V).

Path Length: 12.5 cm (4.72").

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.

Control Box: 35 cm × 30 cm × 15 cm (external dimensions).

IRGA Cable: 3 meters (between sensor head and electronics control box).

Power, Serial, DAC, Auxiliary Input and SDM Cables: 4 meters.

Weight: Head: 0.75 kg (1.65 lb.) Control Box and Cables: 4.8 kg (10.5 lb.)

Specifications subject to change without notice.

Ordering Information

LI-7500: Includes calibration tube, IRGA cable (3 meters), serial, DAC, auxiliary input and SDM cables (4 meters), and Windows® Interface Software.

LI-7500DP: Special Pricing--Package includes LI-7500 Open Path Analyzer with LI-610 Portable Dew Point Generator.

9975-018 Cold Temperature Test: Characterize LI-7500 instrument performance at -40° C.

USA and Canada

Prices are F.O.B. Lincoln, Nebraska. Written price quotations are available upon request. Prices are valid only for final destinations in the USA and Canada. Contact LI-COR for pricing on instruments that will ultimately be delivered to other countries.

To place an order, contact LI-COR directly. Unless otherwise specified, LI-COR will determine the shipping method, prepay freight and insurance, and add it to the invoice.

Payment terms to qualified USA and Canada accounts are net 30 days from the invoice date; otherwise, shipment is upon payment in advance, C.O.D., or credit card.

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LI-COR has many exclusive distributors and agents worldwide. Please contact LI-COR for a distributor near you.

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For more information on other LI-COR products, go to www.licor.com

LI-8100 Automated Soil CO_2 Flux System

LI-7000 CO_2/H_2O Analyzer

LI-840 CO_2/H_2O Analyzer

LI-820 CO_2 Analyzer

LI-COR® Biosciences

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The LI-COR Board of Directors would like to take this opportunity to return thanks to God for His merciful providence in allowing LI-COR to develop and commercialize products, through the collective effort of dedicated employees, that enable the examination of the wonders of His works.

"Trust in the LORD with all your heart; and do not lean on your own understanding.
In all your ways acknowledge Him, and He will make your paths straight."
--Proverbs 3:5,6

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