



Automated Equipment

Aqua TROLL® 100 and 200

Conductivity/Salinity, Temperature, Plus Water Level Logging

Conductivity measurements can be used to characterize water quality changes relative to a baseline or to estimate the concentration of contaminants. The In-Situ® Aqua TROLL 100 and Aqua TROLL 200 instruments measure and log conductivity and temperature. For added flexibility, the Aqua TROLL 200 also measures and records water level/pressure.

The In-Situ four-electrode conductivity cell is less subject to fouling and resists electrical field effects from pumps and well casings. The cell design allows for a wide measurement range with a narrow diameter instrument (0.72 in; 18.3 mm).

Rugged design

- Durable titanium housing resists fouling and safeguards against corrosion, even in the harshest conditions.
- Completely sealed—Withstands pressures up to 500 psi

Extended deployments

- Internal batteries guaranteed to last for 5 years when reading every 15 minutes. External batteries, solar power, or external 8-36 VDC options are also available.
- Reference electrode compensates for light fouling.
- Use with the TROLL® Shield antifouling system to reduce biofouling and significantly increase deployment time.

Accurate results

- Dynamic density compensation delivers superior water level accuracy in estuarine and coastal environments where salinity values may vary due to rainfall or tides.
- Instruments are factory-calibrated and validated with NIST®-traceable standards.

Flexible communications

- SCADA and telemetry-ready units include built-in Modbus/RS485, SDI-12, and 4-20 mA output communications.
- The In-Situ RuggedCable® system includes titanium Twist-Lock connectors for quick, reliable connections.
- Easily connects to a RuggedReader® handheld PC, laptop, or TROLL® Link telemetry system.

Simplified setup and data acquisition

- Win-Situ® software simplifies instrument setup, automates site management, displays graphical data, and provides real-time data and instrument status.



Aqua TROLL[®] 100 and 200 SPECIFICATIONS

Applications

- **Aquifer storage and recovery**
- **Deep saline aquifer studies**
- **Discharge monitoring**
- **Estuary studies**
- **Irrigation return flows**
- **Mine water quality analysis**
- **Remediation projects**
- **Road salt runoff studies**
- **Saltwater intrusion monitoring**
- **Storm surge analysis**
- **Surface water testing**
- **Tide gage monitoring**
- **Tracer studies**
- **Wetlands restoration projects**

TROLL[®] Shield antifouling system

When used in coastal environments and high-fouling sites, the TROLL Shield antifouling system combats biofouling of the Aqua TROLL instrument and its conductivity cell. Reduced sensor fouling extends instrument deployment by up to 8 weeks and improves instrument accuracy and performance. The TROLL Shield antifouling system includes a copper nose cone and coiled copper guard.



GENERAL		
Operational temp. range	-20° to 65°C (-4° to 149°F)	
Storage temperature	-40° to 65°C (-40° to 149°F)	
Diameter, OD	0.72 in (18.3 mm)	
Length	12.4 in (31.5 cm)	
Weight	1.0 lb (0.5 kg)	
Output options	Modbus RS485, SDI-12, 4-20mA	
Housing	Titanium	
Pressure range of operation	0 psi to 500 psi (0–1153 ft)	
POWER		
Internal battery	3.6 V Lithium	
Battery life	5 years or 200,000 readings ¹	
External power	8-36 VDC	
LOGGING		
Memory	4MB; 380,000 data points ²	
Log types	Linear, linear average ³ , event ³	
Fastest logging rate		
Linear	1 per minute	
Linear average	1 per 2 seconds	
Event	1 per second	
Maximum number of logs	50	
Fastest polling rate— Modbus, SDI-12, 4-20 mA	1 per second	
TEMPERATURE		
Range	EPA Method 170.1 -20° to 65°C (-4° to 149°F)	
Unit of measure	Celsius or Fahrenheit	
Accuracy	±0.1°C	
Resolution	0.1°C	
CONDUCTIVITY		
Sensor type	Std. Method 2510, EPA Method 120.1 PVC/titanium balanced 4-electrode cell	
Range	5 µS/cm to 100,000 µS/cm	
Accuracy	< 80,000 µS/cm ±0.5% of reading +1 µS/cm Above 80,000 µS/cm ±1.0% of reading	
Resolution	0.1 µS/cm	
PARAMETERS SUPPORTED ⁴		
	Units	Range
Actual conductivity	µS/cm, mS/cm	5–100,000 µS/cm
Specific conductivity ⁵	µS/cm, mS/cm	5–100,000 µS/cm
Salinity ⁶	PSU	0–42 PSU
Total dissolved solids	ppm, ppt	0–82 ppt
Resistivity	Ohms-cm	10–200,000 Ohms-cm
Density (water salinity)	g/cm ³	0.98–1.14 g/cm ³
PRESSURE/LEVEL ⁷ (Aqua TROLL 200 only)		
Sensor type	Silicon strain gauge	
Material	Titanium	
Range, non-vented 30; 100; 300; 500 psia	0–35 ft (10.5 m); 0–200 ft (60 m); 0–650 ft (200 m); 0–1100 ft (340 m)	
Range, vented 5; 15; 30; 100; 300; 500 psig	0–11.5 ft (3.5 m); 0–35 ft (11m); 0–70 ft (21 m); 0–230 ft (70 m); 0–700 ft (210 m) 0–1150 ft (350 m)	
Units of measure	psi, kPa, bar, mbar, mmHg, inHg, cmH ₂ O, and in H ₂ O, m, mm, cm, in, and ft	
Accuracy ⁸ @ 15° C	±0.05% full scale (FS)	
0 to 50° C	±0.1% FS	
-20 to -1 and 51 to 65° C	±0.25% FS	
Resolution	±0.005% FS or better	
Max. pressure/burst pressure	2X range/3X range	

¹ 1 reading = time and date plus all available parameters polled or logged from device

² 1 data point = time and date plus one parameter logged

³ External power or battery pack recommended when using Linear Average or Event Testing

⁴ Parameters derived from temperature at 25°C and actual conductivity range of 5 µS/cm to 100,000 µS/cm with a ±0.5% plus 1 µS/cm accuracy

⁵ Derived from Standard Methods 2510B

⁶ Defined by the Practical Salinity Scale 1978 Standard Methods 2520B

⁷ Real-time level compensation based on water density

⁸ Accuracy with 4-20 mA output option: ±0.25% FS

Warranty

The Aqua TROLL 100 and 200 instruments come with a one-year warranty. Warranty on RuggedCable[®] systems is 2 years. Extended warranties available, call for details.



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TROLL® Link Telemetry Systems

Real-Time, Remote Data Access

In-Situ® Inc. TROLL® Link telemetry systems offer reliable, secure access to remote site data 24 hours a day. TROLL Link systems are designed for remote monitoring applications, including long-term aquifer monitoring, stream and tide gaging, flood warning, storm surge monitoring, and real-time water quality monitoring.

- **Save time and money** – Quickly access data while reducing site visits, labor costs, and travel expenditures.
- **Communicate with every site** – Choose from satellite or cellular options to ensure communication with your site.
- **Stay informed** – Event-driven sampling and real-time alarm notifications alert you to changing conditions, including early detection of sensor fouling or damage.
- **Retrieve data when you need it** – View and analyze data from anywhere in the world via Win-Situ® Plus software or the secure In-Situ® Data Center web site.
- **Reduce power consumption** – Low-power systems eliminate the need for on-site power and preserve instrument battery life by using solar power.
- **Get expert advice and service** – Call for free technical support – 24/7.

Direct-access telemetry systems

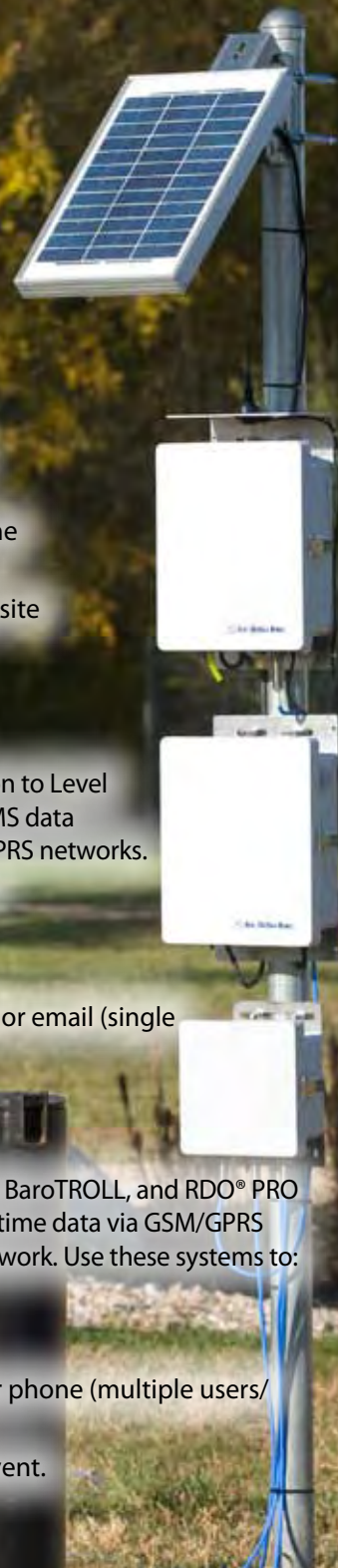
TROLL Link 100 and 102 systems use Win-Situ® Plus software and offer direct connection to Level TROLL®, Aqua TROLL®, and BaroTROLL® instruments. Transmit real-time readings via SMS data messaging for TROLL® 9500 instruments. **TROLL Link 100 systems** operate on GSM/GPRS networks. **TROLL Link 102 systems** operate on domestic CDMA networks. Use these systems to:

- Remotely configure field instrumentation and the telemetry system.
- Remotely extract data from field instruments.
- Set up real-time alarm and warning notifications of user-defined events via SMS or email (single user/single parameter).
- Provide external power to attached instrumentation.

Web-access telemetry systems

TROLL Link 101 and 201 systems offer access to Level TROLL, Aqua TROLL, TROLL 9500, BaroTROLL, and RDO® PRO instruments via the secure In-Situ Data Center. **TROLL Link 101 systems** transmit real-time data via GSM/GPRS networks. **TROLL Link 201 systems** transmit real-time data via the Iridium satellite network. Use these systems to:

- Remotely configure the telemetry system.
- Provide access to real-time data for large user groups.
- Set up real-time alarm notifications of user-configured events via SMS, email, or phone (multiple users/multiple parameters).
- Conduct event sampling and automatically increase data logging during an event.
- Provide external power to attached instrumentation.



TROLL® Link Telemetry Systems

Specifications

	TROLL Link 100	TROLL Link 102	TROLL Link 101	TROLL Link 201
Communications				
Technology	Cellular – GSM/GPRS	Cellular – CDMA	Cellular – GSM/GPRS	Iridium Satellite
Frequency Range	Quad-Band 850/900/1800/1900 MHz	Dual 800/1900 MHz	Quad-Band 850/900/1800/1900 MHz	1616 to 1626.5 MHz
Market				
Global	✓ ¹		✓	✓
USA/Canada (only)		✓		
Data Access Mode				
TCP/IP; Dial-Up/CSD; SMS Data	✓	✓		
ISI Data Center			✓	✓
Alarm Notifications				
SMS and Email	✓	✓	✓	✓
Phone			✓	✓
Single Contact; Single Parameter	✓	✓	✓	✓
Multiple Contacts; Multiple Parameters			✓	✓
Compatibility				
Level TROLL 200, 300, 500, 700; Aqua TROLL 100, 200; BaroTROLLs	✓	✓	✓	✓
TROLL 9500; RDO PRO sensor	✓ ²	✓ ²	✓	✓
I/O				
Discrete Input/Counter (pulse counter)	✓	✓		
12V Discrete Input/Output (relay)	✓	✓		

¹ CE Mark; ² SMS data only; no alarming

Standard Equipment

- NEMA 4X fiberglass enclosure
- Modem and controller board
- Mounting hardware for 2.5-inch diameter post
- 1W solar panel (10W and 20W panel options available)
- 12V, 7Ah sealed lead-acid battery
- Built-in internal and in-line desiccants protect units from moisture and ensure accurate readings when measuring gauged pressure/level.

Specifications

Telemetry Systems

Enclosure (NEMA 4X)	10 x 12 x 5 in (25.4 x 30.5 x 12.7 cm)
Communication options	Satellite, cellular GSM/GPRS, or CDMA
Sensor options	Level TROLL® 200, 300, 500, 700; Aqua TROLL® 100, 200; TROLL® 9500; BaroTROLL; BaroTROLL 100; RDO® PRO sensor
Power supply options	10W solar panel; 20W solar panel; 12V, 14Ah battery kit with charge controller
Temp. range (operating)	Cellular: -20° to 60° C (-4° to 140° F) Satellite: -40° to 70° C (-40° to 158° F)
Weight	15 lbs (6.8 kg)
Warranty	1 year on components



TROLL® Net Hub

Use the TROLL Net hub to set up a network of up to 32 devices (connected by up to eight TROLL Net hubs). Each cable within the network has a maximum length of 4000 feet per Modbus RS485 protocol. Networked devices can be connected to a single TROLL Link telemetry system.



Specifications

TROLL Net Hub

Enclosure (NEMA 4X)	6.1 x 6.1 x 4.18 in (15.5 x 15.5 x 10.6 cm)
Power requirements	9-36 VDC (refer to instrument documentation for cable length and voltage limitations)
Temp. range (operating)	-40° to 60° C (-40° to 140° F)
Weight	4 lbs (1.8 kg)
Warranty	1 year

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Vaisala Weather Transmitter WXT520 Access to Real Time Weather Data



The WXT520 has an automatic control circuit that switches the heating on at low temperatures.

Features/Benefits

- Measures 6 most essential weather parameters
- Accurate and stable
- Low power consumption – works also with solar panels
- Compact, light-weight
- Easy to install with one-bolt mounting method
- No moving parts
- Heating available
- Vaisala Configuration Tool for pc
- USB connection
- IP66 housing with mounting kit
- Applications: weather stations, dense networks, harbors, marinas

WXT520

The Vaisala Weather Transmitter WXT520 measures barometric pressure, humidity, precipitation, temperature, and wind speed and direction.

To measure wind speed and direction, the WXT520 has the Vaisala WINDCAP® sensor that uses ultrasound to determine horizontal wind speed and direction. The array of three equally spaced transducers on a horizontal plane is a Vaisala specific design. Barometric pressure, temperature, and humidity measurements are combined in the PTU module using capacitive measurement for each parameter. It is easy to change the module without any contact with the sensors.

The WXT520 is immune to flooding clogging, wetting, and evaporation losses in the rain measurement.

Measuring acoustic precipitation

The WXT520 precipitation measurement is based on the unique Vaisala RAINCAP® Sensor, which detects the impact of individual rain drops. The signals exerting from the impacts are proportional to the volume of the drops. Hence, the signal from each drop can be converted directly to the accumulated rainfall.

The WXT520 measures accumulated rainfall, rain intensity and duration of the rain — all in real time.

The Vaisala RAINCAP® Sensor is the only maintenance-free precipitation sensor on the market.

Technical data

Wind

SPEED	
range	0 ... 60 m/s
response time	250 ms
accuracy	
0 ... 35 m/s	± 0.3 m/s or $\pm 3\%$, whichever is greater
35 m/s ... 60 m/s	$\pm 5\%$
output resolutions and units	0.1 m/s, 0.1 km/h, 0.1 mph, 0.1 knots
DIRECTION	
azimuth	0 ... 360°
response time	250 ms
accuracy	$\pm 3^\circ$
output resolution and unit	1°

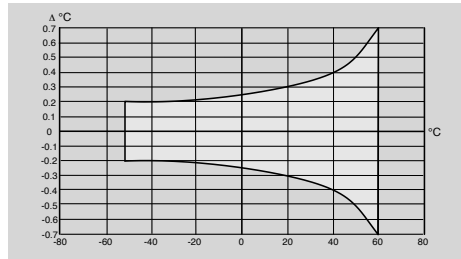
Liquid precipitation

RAINFALL	cumulative accumulation after the latest automatic or manual reset
output resolutions and units	0.01 mm, 0.001 inches
accuracy	5%*
RAINFALL DURATION	counting each ten-second increment whenever water droplet is detected
output resolution and unit	10 s
RAIN INTENSITY	one-minute running average in ten-second steps
range	0 ... 200 mm/h (broader range with reduced accuracy)
output resolutions and units	0.1 mm/h, 0.01 inches/h
HAIL	cumulative amount of hits against the collecting surface
output resolutions and units	0.1 hits/cm ² , 0.01 hits/in ² , 1 hits
HAIL DURATION	counting each ten-second increment whenever hailstone is detected
output resolution and unit	10 s
HAIL INTENSITY	one-minute running average in ten-second steps
output resolutions and units	0.1 hits/cm ² h, 1 hits/in ² h, 1 hits/h

* Due to the nature of the phenomenon, deviations caused by spatial variations may exist in precipitation readings, especially in a short time scale. The accuracy specification does not include possible wind induced errors.

Air temperature

Range	-52 ... +60 °C (-60 ... +140 °F)
Accuracy for sensor at +20 °C	± 0.3 °C (± 0.5 °F)
Accuracy over temperature range (see graph below)	



Output resolutions and units	0.1 °C, 0.1 °F
------------------------------	----------------

Barometric pressure

Range	600 ... 1100 hPa
Accuracy	± 0.5 hPa at 0 ... +30 °C (+32 ... +86 °F) ± 1 hPa at -52 ... +60 °C (-60 ... +140 °F)
Output resolutions and units	0.1 hPa, 10 Pa, 0.0001 bar, 0.1 mmHg, 0.01 inHg

Relative humidity

Range	0 ... 100 %RH
Accuracy	± 3 %RH within 0 ... 90 %RH ± 5 %RH within 90 ... 100 %RH
Output resolution and unit	0.1 %RH

General

Operating temperature	-52 ... +60 °C (-60 ... +140 °F)
Storage temperature	-60 ... +70 °C (-76 ... +158 °F)
Operating voltage	5 ... 32 VDC
Typical power consumption	3 mA at 12 VDC (with defaults)
Heating voltage	5 ... 32 VDC / 5 ... 30 VAC _{RMS}
Serial data interface	SDI-12, RS-232, RS-485, RS-422, USB connection,
Weight	650 g (1.43 lb)
Housing	IP65
Housing with mounting kit	IP66

Electromagnetic compatibility

Complies with EMC standard	
EN61326-1; Industrial	
Environment IEC standards	IEC 60945/61000-4-2 ... 61000-4-6

VAISALA

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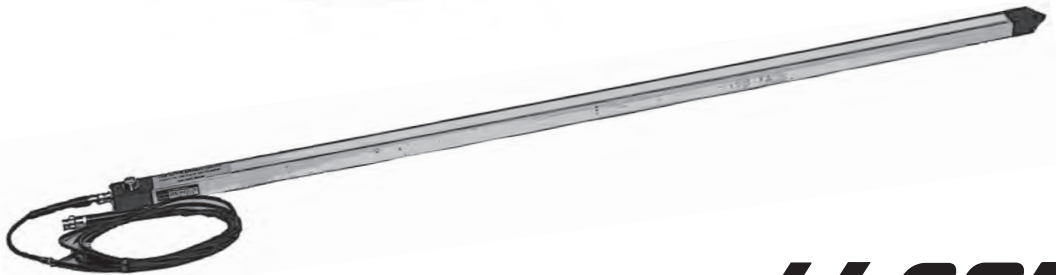


LI-COR Terrestrial Radiation Sensors

Instruction Manual



LI-190 Quantum Sensor
LI-191 Line Quantum Sensor
LI-200 Pyranometer
LI-210 Photometric Sensor



LI-COR[®]
Biosciences

LI-COR Terrestrial Radiation Sensors

Instruction Manual

LI-COR[®]

Biosciences

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Register Your Instrument On-line

Register on-line at www.licor.com/register to ensure that you receive future information and updates for your instrument. In some cases, your instrument serial number will be required.

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Appendix A. Specifications

Restriction of Hazardous Substances (RoHS)

Declarations of Conformity

Section 1. LI-COR Radiation Sensors - Applications

Quantum Sensor

LI-COR quantum sensors measure photosynthetically active radiation (PAR) in the 400 to 700 nm waveband. The unit of measurement is micromoles per second per square meter * ($\mu\text{mol s}^{-1} \text{m}^{-2}$).

The quantum sensor is designed to measure PAR received on a plane surface. The indicated sensor response (Figure 1-1) is selected because it approximates the photosynthetic response of plants for which data are available. A silicon photodiode with an enhanced response in the visible wavelengths is used as the sensor. A visible bandpass interference filter in combination with colored glass filters is mounted in a cosine corrected head. Error calculations indicate that under sun-and-sky radiation, and various natural or artificial light sources found in environmental research, the relative errors are less than $\pm 5\%$.

Measuring PAR within plant canopies, greenhouses, controlled environment chambers, confined laboratory conditions, or at remote environmental monitoring sites are all typical applications for this sensor.

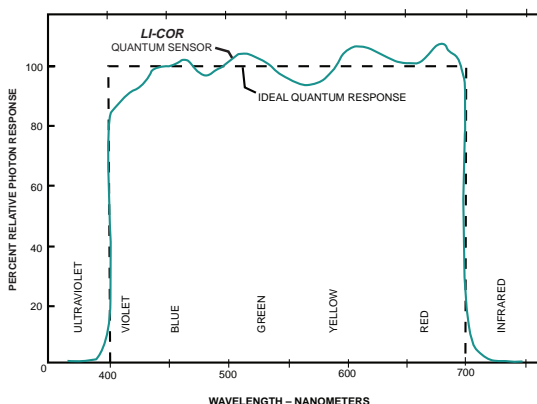


Figure 1-1. Typical spectral response of LI-COR Quantum Sensors vs. Wavelength and the Ideal Quantum Response (equal response to all photons in the 400-700 nm waveband).

*Units currently in use are photons, moles and einsteins. $1 \mu\text{mol s}^{-1} \text{m}^{-2} = 6.02 \times 10^{17} \text{ photons} = 1 \mu\text{E s}^{-1} \text{m}^{-2}$. Full sun plus sky PPFD is approximately $2000 \mu\text{mol s}^{-1} \text{m}^{-2}$ or $2000 \mu\text{E s}^{-1} \text{m}^{-2}$.

Pyranometer

The LI-200 Pyranometer is designed for field measurement of global solar radiation in agricultural, meteorological, and solar energy studies. The LI-200 features a silicon photovoltaic detector mounted in a fully cosine-corrected miniature head. Current output, which is directly proportional to solar radiation, is calibrated against an Eppley Precision Spectral Pyranometer (PSP) under natural daylight conditions in units of watts per square meter (W m^{-2}). Under most conditions of natural daylight, the error is <5% (4).

The spectral response of the LI-200 does not include the entire solar spectrum, so it must be used in the same lighting conditions as those under which it was calibrated. ***Therefore, the LI-200 should only be used to measure unobstructed daylight. It should not be used under vegetation, artificial lights, in a greenhouse, or for reflected solar radiation.***

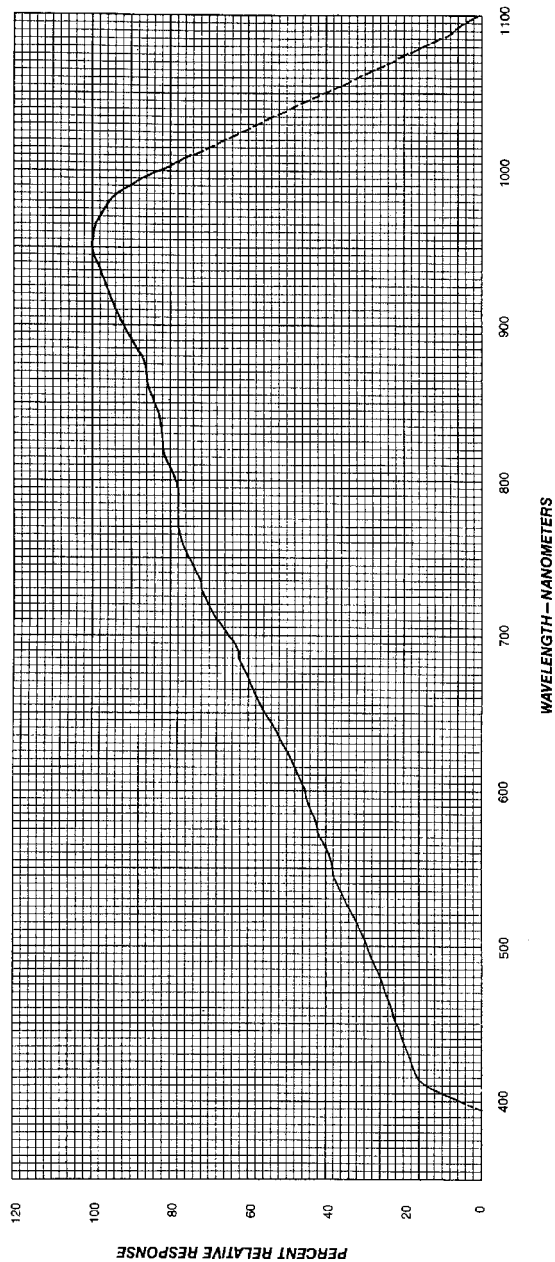


Figure 1-2. LI-200SA Spectral Response Curve.

Photometric Sensor

The LI-210 Photometric Sensor is designed to measure illumination in terms of lux (1 footcandle = 10.764 lux). This is radiation as the human eye sees it. Some of the applications for the LI-210 Photometric Sensor include interior and industrial lighting, outdoor illuminance, passive solar energy, architecture and lighting models, illumination engineering, and biological sciences that require illuminance measurements. The spectral response is shown in Figure 1-3.

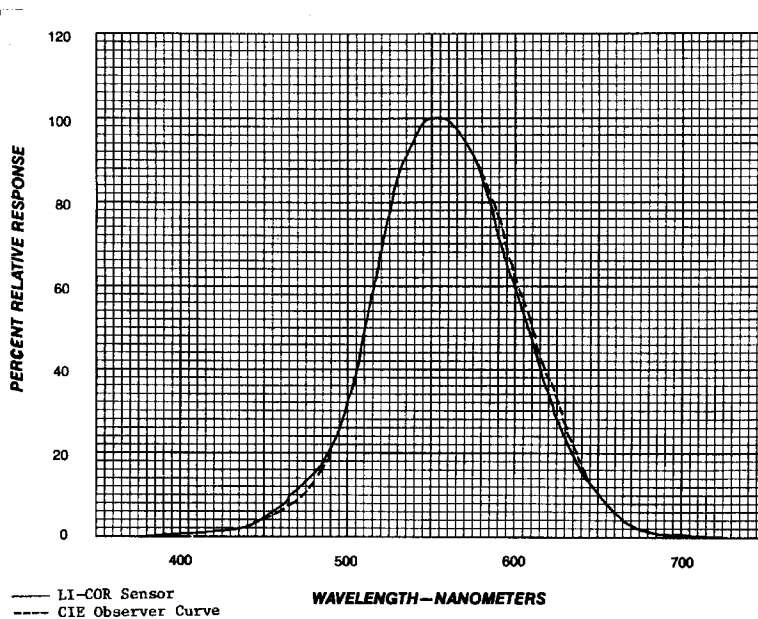


Figure 1-3. Spectral response of the LI-210.

Section 2. Sensor Configurations

LI-COR currently offers three sensor configurations; the designators “SA”, “SZ”, and “SL” refer to the type of connectors (or lack thereof) which terminate the sensor cable. The appropriate connector is determined based on the readout device to which the sensor will be connected. Note that type “SA” and “SZ” sensors produce a *current* signal, not voltage. Type “SL” sensors produce a mV signal at their termination.

Type SA Sensors

Type “SA” sensors (e.g. LI-190SA) have a coaxial cable that terminates with a BNC connector. This type of connector allows for direct connection to the LI-COR LI-250A Light Meter or the LI-1400 DataLogger. Figure 2-1 shows a typical SA type sensor.

This connector also allows the sensor to be used with older (discontinued) instruments, including the LI-189 Quantum/Radiometer/Photometer, LI-250 Light Meter, the two current channels of the LI-1000 Datalogger or LI-1200 Minimum Data Set Recorder, or with older LI-COR integrators.

Type SA terrestrial sensors include the LI-190SA Quantum Sensor, the LI-191SA Line Quantum Sensor, the LI-200SA Pyranometer Sensor, and the LI-210SA Photometric sensor.



Figure 2-1. “SA” type sensors are terminated with only a BNC connector on the end of the coaxial cable.

When a LI-COR Light Meter or data logger is not used, type SA sensors can be used with other millivolt recorders or data loggers by connecting a millivolt output conversion adapter. See Section 3 for more information.

Type SZ Sensors

LI-COR "SZ" type sensors are characterized by having the sensor cable terminated with the two bare wire leads of the coaxial cable. Figure 2-2 shows a typical SZ type sensor.

Type SZ terrestrial sensors include the LI-190SZ Quantum Sensor and the LI-200SZ Pyranometer Sensor.



Figure 2-2. "SZ" type sensors have no connector and are terminated with only the bare wire leads of the coaxial cable.

The bare wires on the "SZ" sensors allow them to be used with the two *current* channels of the LI-1400 Datalogger located on the screw-down terminals (I4, I5) of the 1400-301 terminal block. The shield of the coaxial cable is positive and the center conductor is negative. This is done because the trans-impedance amplifier used in LI-COR light meters requires a negative signal.

To use type SZ sensors with the LI-1400, the calibration constant must be entered into the LI-1400 in the form of a multiplier. The multiplier is given on the certificate of calibration. For complete information on configuring the LI-1400 please consult the LI-1400 Instruction manual.

When a LI-COR Light Meter or data logger is not used, the sensor can be used with other millivolt recorders or data loggers by connecting a resistor across the leads of the coaxial cable. See Section 3 for more information.

Type SL Sensors

Type “SL” sensors (e.g. LI-190SL) have a coaxial cable that terminates with a BNC connector. The BNC connector is coupled to a millivolt adapter containing a variable resistor. This resistance is adjusted to each sensor’s current output to provide a standardized millivolt output. The end of the millivolt adapter is terminated with bare wire leads for connection to other manufacturer’s data loggers or data acquisition systems. Figure 2-3 shows a typical type SL sensor.

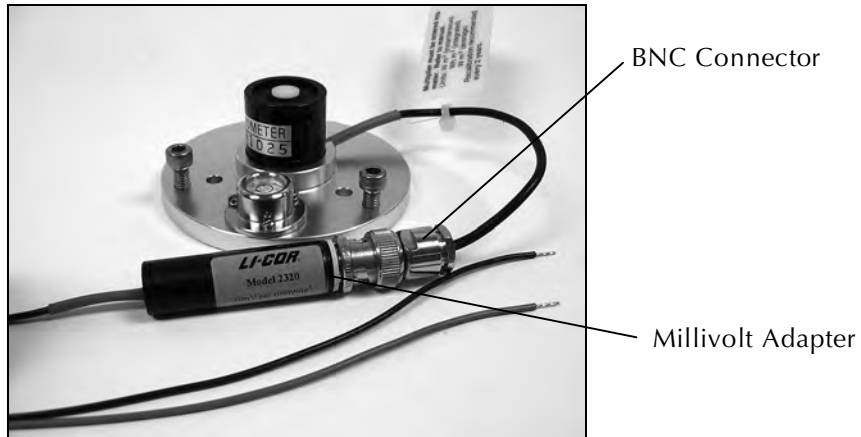


Figure 2-3. "SL" type sensors are terminated with a BNC connector and millivolt adapter on the end of the coaxial cable.

Each type SL sensor is calibrated with its corresponding millivolt adapter to provide a standardized sensor output, with a range of 0-10 mV full scale. Standardizing the output allows sensors to be changed out in the field without the need to enter unique calibration constants or multipliers. Because of this, each sensor can be used only with the millivolt adapter that is supplied with it (i.e., the serial numbers must match). Type SL sensors are offered for terrestrial radiation sensors, but not for underwater sensors, which have different outputs for terrestrial and underwater measurements.

Using Type SL Sensors with Dataloggers and Recording Devices

The shield of the coaxial cable on LI-COR light sensors is positive, and the center conductor is negative. If the datalogger or recorder being used has \pm signal capability, connect the positive (red) lead to the common (low) terminal, and connect the negative (black) lead to signal (high) input. This will help minimize noise.

If the datalogger has high, low, and ground terminals, place a jumper wire between the common (low) and ground terminals.

If \pm signal capability is not available, connect the positive (red) lead to signal input, and the negative (black) lead to the common terminal.

The multiplier used to convert the signal into appropriate units will be a negative value.

The standardized output for each of the available SL sensor types is given in Section 3.

Section 3. Calibration Constants and Multipliers

Relationship between the Calibration Constant and the Calibration Multiplier

All LI-COR radiation sensors produce a current proportional to the radiation intensity. During factory calibration, sensor output (in microamps) is measured while the sensor is exposed to a standard lamp of known intensity. The sensor output at this intensity has general units of microamps per radiation unit and is called the **Calibration Constant** (Calconstant). Each sensor has a slightly different output at a given radiation intensity and will therefore have a unique Calconstant.

LI-COR Light Meters and dataloggers measure the current output of the sensor in units of microamps, and convert the measured current to units of radiation. To make this conversion, LI-COR instruments use the sensor **Calibration Multiplier**. The Calibration Multiplier is the negative reciprocal of the Calconstant.

$$\text{Multiplier} = \frac{-1}{\text{Calconstant}}$$

The Calibration Multiplier is always a negative number (because the shield of the coaxial cable of the sensor carries the positive signal instead of the negative signal), and is expressed in radiation units per microamp.

If the calibration constant for your sensor has been lost or misplaced, it can be obtained from LI-COR by providing the serial number of the sensor.

Using Other Manufacturer's Meters or Data Loggers with LI-COR Sensors

Type SA Sensors

When a LI-COR Light Meter or data logger is not used, type SA sensors can be used with other millivolt recorders or data loggers by connecting a millivolt adapter, available from LI-COR. Table 3-1 lists the millivolt adapters required for each sensor and the resistance of each adapter.

Table 3-1. Millivolt adapters for “SA” type sensors

Sensor	Millivolt Adapter	Resistance
LI-190SA	2290	604 Ohm
LI-191SA	2290	604 Ohm
LI-192SA	2291	1210 Ohm
LI-193SA	2291	1210 Ohm
LI-200SA	2220	147 Ohm
LI-210SA	2290	604 Ohm

The millivolt adapter connects to the BNC connector of the sensor, and the wire leads of the adapter are connected to the data logger (see note below). Sensor output (in millivolts) when using the millivolt adapter can be computed using "Ohm's Law" (Voltage = Current X Resistance).

Example: Calculate the millivolt output of an LI-190 Quantum Sensor which has a calibration constant of $8.0 \mu\text{A}/1000 \mu\text{mol s}^{-1} \text{m}^{-2}$. Assume the 2290 millivolt adapter is used with the sensor.

$$\frac{8.0 \mu\text{A}}{1000 \mu\text{mol s}^{-1} \text{m}^{-2}} \times \frac{1 \text{ A}}{10^6 \mu\text{A}} \times 604 \text{ Ohm} = \frac{0.004832 \text{ volts}}{1000 \mu\text{mol s}^{-1} \text{m}^{-2}} = \frac{4.83 \text{ mV}}{1000 \mu\text{mol s}^{-1} \text{m}^{-2}}$$

The multiplier to use in your data acquisition system is the reciprocal of this result. For example,

$$\frac{1}{\frac{4.83 \text{ mV}}{1000 \mu\text{mol s}^{-1} \text{m}^{-2}}} = 207 \mu\text{mol s}^{-1} \text{m}^{-2}/\text{mV}$$

NOTE: The shield of the coaxial cable on LI-COR light sensors is positive, and the center conductor is negative. If the datalogger or recorder being used with the millivolt adapter has \pm signal capability, connect the positive (green) lead to the common (low) terminal, and connect the negative (blue) lead to signal (high) input. This will help minimize noise.

If the datalogger has high, low, and ground terminals, place a jumper wire between the common (low) and ground terminals.

If \pm signal capability is not available, connect the positive (green) lead to signal input, and the negative (blue) lead to the common terminal.

The calculated multiplier used to convert the signal into appropriate units will be a negative value.

Type SZ Sensors

Type SZ sensors can be used with other millivolt recorders or data loggers by connecting a resistor across the leads of the coaxial cable. Choosing the value of the resistor is important, since it can affect the operation of the sensor. Choosing a resistance that is too large can result in a non-linear response from the sensor. The value of the resistor used in LI-COR millivolt adapters and the maximum recommended output for each sensor (in millivolts) is shown in Table 3-2.

Table 3-2. Recommended resistor values for “SZ” type sensors

Sensor	Resistance	Maximum Output
LI-190SZ	604 Ohm	10 mV/2000 $\mu\text{mol s}^{-1} \text{m}^{-2}$
LI-200SZ	147 Ohm	10 mV/1000 W m^{-2}

Sensor output when using a resistor with type SZ sensors is computed using “Ohms Law” as described above.

Type SL Sensors

Type "SL" sensors are available for the LI-190, LI-191, LI-200, and LI-210 Sensors. The Type SL Sensor produces a standardized millivolt output, and may be used in place of the Type SA Sensor and Millivolt Adapter. Table 3-3 shows the standardized output for type “SL” sensors.

Table 3-3. Standardized output for “SL” type sensors

Sensor	Standardized Output
LI-190SL	10 mV/2000 $\mu\text{mol s}^{-1} \text{m}^{-2}$
LI-191SL	10 mV/2000 $\mu\text{mol s}^{-1} \text{m}^{-2}$
LI-200SL	10 mV/1000 W m^{-2}
LI-210SL	10 mV/100 klux

Section 4. Cosine Response and Error

Cosine Response

Measurements intended to approximate radiation impinging upon a flat surface (not necessarily level) from all angles of a hemisphere are most accurately obtained with a cosine corrected sensor.

A sensor with a cosine response (follows Lambert's cosine law) allows measurement of flux densities through a plane surface. This allows the sensor to measure flux densities per unit area (m^2). A sensor without an accurate cosine correction can give a severe error under diffuse radiation conditions within a plant canopy, at low solar elevation angles, under fluorescent lighting, etc.

The cosine relationship can be thought of in terms of radiant flux lines impinging upon a surface normal to the source (Figure 4-1A) and at an angle of 60° from normal (Figure 4-1B). Figure 4-1A shows 6 rays striking the unit area, but at a 60° angle, only 3 rays strike the same unit area. This is illustrated mathematically as

$$S = (I) (\cosine\ 60^\circ) \text{ per unit area}$$

$$3 = (6) (0.5) \text{ per unit area}$$

where S = vertical component of solar radiation; I = solar radiation impinging perpendicular to a surface and $\cosine\ 60^\circ = 0.5$.

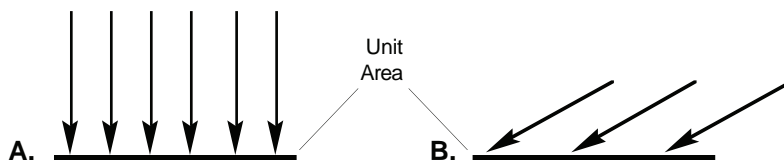


Figure 4-1. *Lambert's Cosine Law.*

Cosine Correction Properties

Cosine corrected LI-COR terrestrial type sensors are all (with the exception of the LI-191 Line Quantum Sensor) designed for the same cosine response characteristics. The percent of true cosine response is presented in Figure 4-2. The error is typically less than $\pm 5\%$ for angles less than 80° from the normal axis of the sensor. At 90° a perfect cosine collector response would be zero and at that angle any error is infinite.

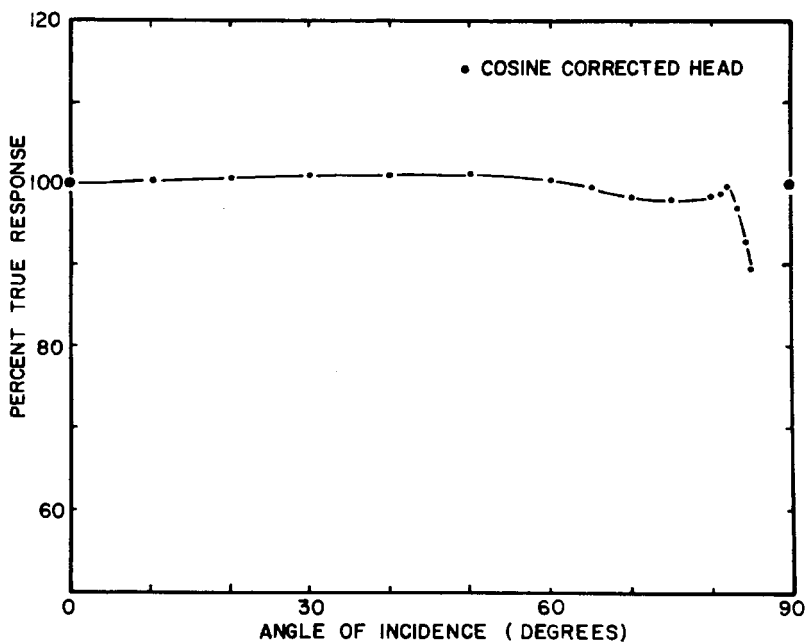


Figure 4-2. Cosine response of LI-COR terrestrial type sensors.

LI-191 Cosine Correction Properties

Due to the large non-symmetrical sensing area of 1 meter by 12.7 mm, the LI-191 cannot be compensated completely for true cosine response. Figure 4-3 shows the approximate cosine error for collimated light at angles of incidence from 0° (normal) to 90° .

Since the sensing area is a flat acrylic diffuser, the response at a given angle of incidence is fairly constant as the azimuth angle around the sensor is varied. It is specified at less than $\pm 2\%$ at a 45° angle of elevation for 360° of sensor rotation.

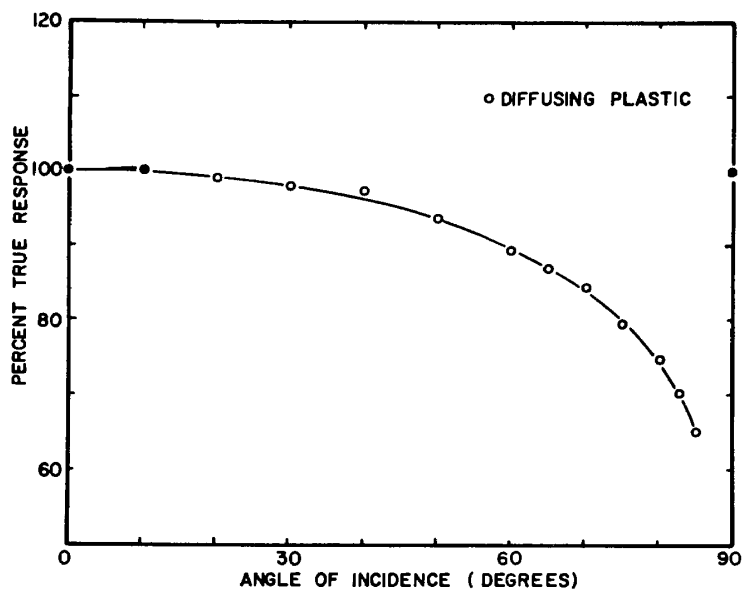


Figure 4-3. Cosine Response of LI-191 Line Quantum Sensor

Section 5. Factory Calibration Procedures

LI-190 Quantum Sensor

The LI-190 calibration is obtained at LI-COR using a standard light source calibrated against a National Institute of Standards and Technology (NIST) lamp. The photon flux density from the standardized lamp is known in terms of micromoles $\text{s}^{-1} \text{m}^{-2}$ where one micromole = 6.022×10^{17} photons. The uncertainty of the calibration is $\pm 5\%$.

The following procedure is used to calculate the quantum flux output from the lamp. The lamp flux density (ΔE) in watts m^{-2} , in an increment at a wavelength can be expressed as

$$\Delta E = E(\lambda)\Delta\lambda$$

where $E(\lambda)$ is the spectral irradiance of the lamp at wavelength λ .

The number of photons $\text{s}^{-1} \text{m}^{-2}$ in $\Delta\lambda$ is

$$\text{Photons s}^{-1}\text{m}^{-2} = \left[\frac{\lambda}{hc} \right] E(\lambda)(\Delta\lambda)$$

where h is Plank's constant and c is the velocity of light. This can be summed over the interval of 400-700 nanometers (nm) to give

$$\text{Photons s}^{-1}\text{m}^{-2} = \left[\frac{\lambda}{hc} \right] \int_{400}^{700} E(\lambda)(\Delta\lambda)$$

The result is adjusted to $\mu\text{mol s}^{-1} \text{m}^{-2}$ by dividing by 6.022×10^{17} .

LI-191 Line Quantum Sensor



The uncertainty of the LI-191 calibration is $\pm 10\%$ due primarily to basic calibration limitations and a transfer error when calibrating the LI-191 against a reference quantum sensor in a spatially uniform light beam. This method is required because of the large physical size of the LI-191.

Calibration of the reference quantum sensor is performed on a specially equipped optical bench containing a high intensity quartz-halogen lamp traceable to NIST (National Institute of Standards and Technology) standard lamps. The photon flux density and irradiance produced by the lamp in the bandwidth of 400-700 nm is known.

LI-200 Pyranometer



The LI-200 Pyranometer is calibrated against an Eppley Precision Spectral Pyranometer (PSP) of which the calibration is periodically confirmed. The calibration is performed under daylight conditions by a computer sampling of instantaneous readings from the Eppley and LI-COR pyranometers. Instantaneous paired sensor and reference readings are taken every minute throughout the day for several days. Manual and statistical methods are used to select data from which the calibration constant is derived. The uncertainty of calibration is $\pm 5\%$.

LI-210 Photometric Sensor



The LI-210 Photometric Sensor is calibrated against a standard lamp. The uncertainty of the calibration is $\pm 5\%$.

All LI-COR photometric sensors are calibrated using 683 lumens per watt as the value of spectral luminous efficacy at a wavelength of 555 nm. This value conforms to the recommendations of the International Committee for Weights and Measures (CIPM).

Section 6. Using Quantum Sensors

Terrestrial Quantum Sensors

LI-190 Quantum Sensor

The LI-190 can be hand held or mounted at any required angle. In its most frequent application, the quantum sensor is set on a level surface free from any obstruction to direct or diffuse radiation. The sensor may be conveniently leveled using the LI-COR 2003S Mounting and Leveling Fixture.

Keep the sensor clean and treat it as a scientific instrument in order to maintain the accuracy of its calibration. The vertical edge of the diffuser must be kept clean in order to maintain appropriate cosine correction.

LI-191 Line Quantum Sensor

The LI-191SA Sensor is designed for measuring PAR (photosynthetically active radiation) in applications where the radiation to be measured is spatially non-uniform (such as within plant canopies). To achieve this, the sensor features a sensing area that is one meter in length.

The LI-191 has the quantum (photon) response through the wavelength range of 400-700 nm for PPFD (photosynthetic photon flux density) as generally preferred for PAR measurements, and has an output in units of moles where

$$1 \mu\text{mol s}^{-1} \text{m}^{-2} \equiv 1 \mu\text{E s}^{-1} \text{m}^{-2} \equiv 6.02 \times 10^{17} \text{photons s}^{-1} \text{m}^{-2}$$

Error can be introduced by the user when using a single small sensor to characterize the radiation profile within a crop canopy or growth chamber. The flux density measured on a given plane can vary considerably due to shadows and sunflecks. To neglect this in measurements can introduce errors up to 1000%. Multiple sensors or sensors on track scanners can be used to minimize this error. The LI-191 Line Quantum Sensor, which spatially averages radiation over its 1 meter length, minimizes the error and allows one person to easily make many measurements in a short period of time. The sensor is sealed against moisture (except the BNC connector); *the sensor should be mounted, however, so that water does not pool around the sensor.*

Normal use by a single user when measuring radiation within a crop canopy is done by supporting the sensor with one hand and cantilevering it into the

canopy. The sensor should be maintained in a level position as much as possible. Since radiation levels vary considerably, the user error introduced by not leveling exactly is usually very small in correspondence to the total radiation error which might occur due to variations within the canopy. If the user desires to permanently mount the unit in the field, this can be done by using common laboratory supply clamps in conjunction with ring stands.

The LI-191 can be used for absolute measurements above the canopy, but if precise absolute measurements above the canopy are desired, the LI-190 Quantum Sensor should be used.

Do not immerse the LI-191 in water or other liquids. If the LI-191 is mounted to a support, make provisions to allow water drainage away from it. The LI-191 is sealed against normal weather conditions, but may leak if submerged.

The LI-191 may be cleaned with a mild detergent and water, but care should be observed to avoid disturbing the silicone rubber seal which is adjacent to the diffuser. Do not attempt to disassemble the sensor, as the weatherproof seal will be broken and the calibration and spatial response will be affected.

An anodized aluminum "nose cone" is provided which can be screwed into the 1/4-20 threaded hole on the end of the sensor. This will allow easier insertion of the sensor into dense foliage. **WARNING:** Do not drop the sensor since the point of the nose cone could cause injury!

Surface Variation Errors

The response uniformity along the 1 meter sensing length is specified to vary less than $\pm 7\%$ when tested with a beam of light that is one inch in width. It is determined by the diffuser and internal optical design.

Spectral Response

The spectral response of the LI-191 is comparable to that of the LI-190 Quantum Sensor. All LI-COR quantum sensors use computer tailored filter glasses to achieve a response that closely approximates the desired ideal quantum response. See Figure 1-1.

Section 7. Using Pyranometers

LI-200 Pyranometer

The silicon photodiode has made possible the construction of simple pyranometers of reasonable accuracy where the photodiode is stable. The response of the silicon photodiode sensor (Figure 1-2) is not ideal, (equal spectral response from 280-2800 nm) but does not cause serious error provided the photodiode is used only for solar radiation and not under conditions of altered spectral distribution. **IMPORTANT:** For this reason, we do not recommend its use under artificial lighting, within plant canopies or to measure reflected radiation.

The LI-COR pyranometer may be handheld or mounted at any required angle, provided that reflected radiation is not a significant portion of the total. In its most frequent application, the pyranometer sensor is set on a level surface free from any obstruction to either direct or diffuse radiation. The sensor may be most conveniently leveled by using the 2003S Mounting and Leveling Fixture.

LI-200 Spectral Response

The relative spectral response of the silicon photodiode does not extend uniformly over the full solar radiation range. A typical response curve is presented in Figure 1-2. The response is very low at 0.4 μm and increases nearly linear to a maximum at about 0.95 μm and then decreases nearly linear to a cutoff near 1.2 μm . Changes in the spectral distribution of the incident light, coupled with the non-uniform spectral response, can cause errors in the photodiode output. Hull³ shows that in the 0.4 to 0.7 μm range, the spectral distribution of sun plus sky radiation on a horizontal surface is remarkably constant even when clear and overcast days are compared. However, Gates² indicates that the major change in spectral distribution of solar radiation occurs in the near infrared where water vapor absorption takes place on cloudy days. Data collected at low solar elevations can show significant error because of altered spectral distribution which changes in atmospheric transmission. This is a small part of the daily total so the possible observed error usually has an insignificant effect on daily integrations.

References,
Section 11

The area under the spectral irradiance curve of the source is directly proportional to the energy received by a horizontal surface. Under specific but typical conditions, energy received on a completely overcast

day has been estimated to be 11.3% of that received on a clear day. When both spectral distributions are weighted according to a typical response curve of a silicon photodiode, the response on this cloudy day is 12.6%. Therefore, errors incurred under different sky conditions, due to the spectral response of the photodiode, will be small. The field tests of Federer and Tanner¹ and Kerr, Thurtell and Tanner⁴ confirm this conclusion.

Section 8. Using Photometric Sensors

Photometric Terms

Although characteristics of the human eye vary from person to person, standard luminosity coefficients for the eye were defined by the Commission Internationale de Eclairage (C.I.E., International Commission on Illumination) in 1931. An absolute "sensitivity" figure established for the standard eye relates photometric units and radiant power units. At 5550 angstroms (555 nm) the wavelength of the maximum sensitivity of the eye, one watt of radiant power corresponds to 680 lumens.

References,
Section 11

The sensitivity of the eye outside the wavelength limits defined by the C.I.E. is very low but not actually zero. Studies with intense infrared sources have shown that the eye is sensitive to radiation of wavelength at least as long as 10500 angstroms. According to Goodeve⁵, the ultraviolet sensitivity of the eye extends to between 3125 and 3023 angstroms. Below this level the absorption of radiation by the proteins of the eye lens apparently limits further extension of vision into the ultraviolet. Radiation having a wavelength of 3023 angstroms is detected by its fluorescent effect in the front part of the eye.

Photometry deals with the measurement of radiation in reference to the effect produced on the theoretical standard C.I.E. observer. Measurements are made by visual comparison, or by some equivalent photoelectric method. Units, standards, and systems of measurement have been developed to correspond to the effect as observed by the eye.

Luminous intensity (or candle-power) is a measure of a light source which describes its luminous flux per unit solid angle in a particular direction. For many years, the standard measure of luminous intensity was the international candle established by a group of carbon-filament lamps at the Bureau of Standards. In 1948 the International Commission of Illumination agreed on the introduction of a new standard of luminous intensity and recommended the adoption of the name candela to distinguish it from the international candle.

The candela is defined by the radiation from a black body at the temperature of solidification of platinum. A candela is one-sixtieth of the luminous intensity of one square centimeter of such a radiator. The major advantage of the new standard is that it may be reproduced in any

laboratory. The effective change in the value of the candle as a result of the 1948 agreement is of the order of tenths of one percent and, therefore, is negligible in practical measurements.

Luminous flux is the time rate of flow of light energy that is characteristic of radiant energy which produces visual sensation. The unit of luminous flux is the lumen, which is the flux emitted in units per solid angle by a uniform point of source of one candela. Such a source produces a total luminous flux of 4π lumens.

A radiant source may be evaluated in terms of luminous flux if the radiant energy distribution of the source is known. If $W(\lambda)$ is the total radiant power in watts per unit wavelength, total radiant power over all wavelengths is

$$\int_0^{\infty} W(\lambda) d\lambda$$

and the total luminous flux L in lumens can be expressed as

$$L = \int_0^{\infty} [680W(\lambda)][y(\lambda)] d\lambda$$

where $y(\lambda)$ represents the luminosity coefficient as a function of wavelength and $d\lambda$ is a differential of wavelength.

Illuminance is the density of luminous flux incident on a surface. A common unit of illuminance is the lux, which is the illumination produced by one lumen uniformly distributed over an area of one square meter. It follows that a source of one candela produces an illuminance of one lux at a distance of one meter. A footcandle is one candela at a distance of one foot.

Spectral Response

The spectral response of a typical LI-COR LI-210 Photometric Sensor compared to the C.I.E. standard observer curve is presented in Figure 1-2. LI-COR has had sensor calibration data verified by the National Research Council of Canada (NRC), one of the major standards laboratories in the world.

Section 9. Cleaning and Maintenance

DO NOT use alcohol, organic solvents, abrasives, or strong detergents to clean the diffuser element on LI-COR light sensors.

The acrylic material used in LI-COR light sensors can be crazed by exposure to alcohol or organic solvents, which will adversely affect the cosine response of the sensor.

Clean the sensor ***only*** with water and/or a mild detergent such as dishwashing soap. LI-COR has found that vinegar can also be used to remove hard water deposits from the diffuser element, if necessary.

Keep the sensors clean and treat them as a scientific instrument in order to maintain the accuracy of the calibration. The vertical edge of the diffuser must be kept clean in order to maintain appropriate cosine correction.

Section 10. Sensor Accessories

Accessories for Terrestrial Sensors

2003S Mounting and Leveling Fixture

The 2003S is for use with LI-COR terrestrial type sensors (2.38 cm Dia.). The base is anodized aluminum with stainless steel leveling screws and a weatherproof spirit level.



Mounting and
Leveling Fixture

2222SB Extension Cable

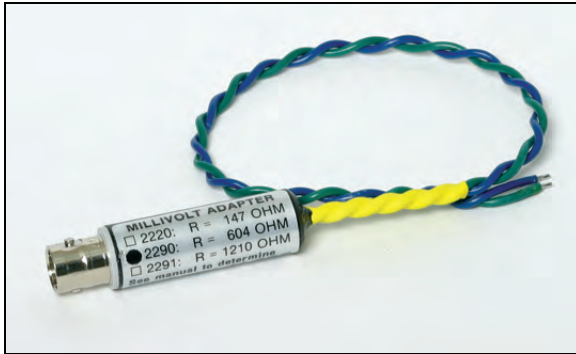
This cable is for use with LI-COR terrestrial type sensors. Standard length is 15.2 m (50 ft.). A 100 ft. (30.4 m) cable is also available under p/n 2222SB-100. Cable lengths up to 1000 feet can be used with LI-COR readout instruments.

Millivolt Adapters

Used for connecting sensors to other manufacturer's datalogger or stripchart recorder.

2290 Millivolt Adapter

For the LI-190SA Quantum Sensor, LI-191SA Line Quantum Sensor, or LI-210SA Photometric Sensor (604 Ohm resistance).



2220 Millivolt Adapter

For the LI-200SA Pyranometer Sensor (147 Ohm resistance).

2291 Millivolt Adapter

For the LI-192SA Underwater Quantum Sensor or LI-193SA Spherical Quantum Sensor (1210 Ohm resistance).

Section 1 1. References and Bibliography

References

1. Federer, C.A., and C.B. Tanner, 1965. A simple integrating pyranometer for measuring daily solar radiation. *J. Geophys. Res.* 70, 2301-2306.
2. Gates, D.M., 1965. Radiant energy, its receipt and disposal. *Meteor. Monogr.*, 6, No. 28, 1-26.
3. Hull, J.N., 1954. Spectral distribution of radiation from sun and sky. *Trans. Illum. Eng. Soc. (London)*, 19:21-28.
4. Kerr, J.P., G.W. Thurtell, and C.B. Tanner, 1967. An integrating pyranometer for climatological observer stations and mesoscale networks. *Journal of Applied Meteorology*, 6, 688-694.
5. Goodeve, D.F., 1934. Visions in the ultraviolet, *Nature*.

Bibliography

Combs, W.S., Jr. 1977. The measurement and prediction of irradiance available for photosynthesis by phytoplankton in lakes. University of Minnesota Ph.D. Thesis, Limnology.

Incoll, L.D., S.P. Long and M.R. Ashmore. 1977. SI units in publications in plant science. *Commentaries in Plant Science* (No. 28). Published in: *Current Adv. Plant Science* 9:331-343.

Jerlov, N.G. 1968. *Optical Oceanography*. Elsevier.

McCree, K.J. 1979. *Radiation*.

NBS Technical note 910-1, 1976. Self-study manual on optical radiation measurements.

Shibles, R. 1976. Committee Report: Terminology pertaining to photosynthesis. *Crop Sci.* 16: 437-439.

Tyler, J.E., and R.W. Preisendorfer. 1962. Light in the sea, p. 399-400. In M.N. Hill (ed.), *The Sea*, V.I. Interscience.

Appendix A. Specifications

LI-190 Specifications

Absolute Calibration: $\pm 5\%$ traceable to the U.S. National Institute of Standards and Technology (NIST).

Sensitivity: Typically $5\ \mu\text{A}$ to $10\ \mu\text{A}$ per $1000\ \mu\text{mol s}^{-1}\ \text{m}^{-2}$.

Linearity: Maximum deviation of 1% up to $10,000\ \mu\text{mol s}^{-1}\ \text{m}^{-2}$.

Stability: $< \pm 2\%$ change over a 1 year period.

Response Time: $10\ \mu\text{s}$.

Temperature Dependence: $\pm 0.15\%$ per $^{\circ}\text{C}$ maximum.

Cosine Correction: Cosine corrected up to 80° angle of incidence.

Azimuth: $< \pm 1\%$ error over 360° at a 45° elevation.

Tilt: No error induced from orientation.

Detector: High stability silicon photovoltaic detector (blue enhanced).

Sensor Housing: Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware.

Size: 2.38 Dia. x 2.54 cm H (0.94" x 1.0").

Weight: 28 g (1 oz.)

Cable Length: 3.0 m (10 ft.) standard. 50 ft. cable length available.

Accessories: 2003S Mounting & Leveling Fixture, 2222SB Extension Cable.

LI-191 Specifications

Absolute Calibration: $\pm 10\%$ traceable to NIST. The LI-191 is calibrated via transfer calibration using a reference LI-190 Quantum Sensor. Transfer error is $\pm 5\%$ (included in the $\pm 10\%$).

Sensitivity: Typically $7\ \mu\text{A}$ per $1000\ \mu\text{mol s}^{-1}\ \text{m}^{-2}$

Linearity: Maximum deviation of 1% up to $10,000\ \mu\text{mol s}^{-1}\ \text{m}^{-2}$.

Stability: $< \pm 2\%$ change over a 1 year period.

Response Time: $10\ \mu\text{s}$.

Temperature Dependence: $\pm 0.15\%$ per $^{\circ}\text{C}$ maximum.

Cosine Correction: Acrylic diffuser.

Azimuth: $< \pm 2\%$ error over 360° at 45° elevation.

Sensitivity Variation over Length: $\pm 7\%$ maximum using a 1" wide beam from an incandescent light source.

Sensing Area: 1 meter L x 12.7 mm W (39.4" x 0.50").

Detector: High stability silicon photovoltaic detector (blue enhanced).

Sensor Housing: Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware.

Size: 116 L x 2.54 W x 2.54 cm D (45.5" x 1.0" x 1.0").

Weight: 1.8 kg (4.0 lb..)

Cable Length: 3.1 m (10.0 ft.)

Accessories: 2222SB Extension Cable.

LI-200 Specifications

Calibration: Calibrated against an Eppley Precision Spectral Pyranometer (PSP) under natural daylight conditions. Absolute error under these conditions is $\pm 5\%$ maximum, typically $\pm 3\%$.

Sensitivity: Typically $90 \mu\text{A}$ per 1000 W m^{-2} .

Linearity: Maximum deviation of 1% up to 3000 W m^{-2} .

Stability: $< \pm 2\%$ change over a 1 year period.

Response Time: $10 \mu\text{s}$.

Temperature Dependence: $\pm 0.15\%$ per $^{\circ}\text{C}$ maximum.

Cosine Correction: Cosine corrected up to 80° angle of incidence.

Azimuth: $< \pm 1\%$ error over 360° at 45° elevation.

Tilt: No error induced from orientation.

Detector: High stability silicon photovoltaic detector (blue enhanced).

Sensor Housing: Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware.

Size: 2.38 Dia. x 2.54 cm H (0.94" x 1.0").

Weight: 28 g (1 oz.).

Cable Length: 3 meters (10 ft) standard. 50 ft. cable length available.

Accessories: 2003S Mounting and Leveling Fixture, 2222SB Extension Cable.

LI-210 Specifications

Absolute Calibration: $\pm 5\%$ traceable to NIST.

Sensitivity: Typically $30 \mu\text{A}$ per 100 klux.

Linearity: Maximum deviation of 1% up to 100 klux.

Stability: $< \pm 2\%$ change over a 1 year period.

Response Time: $10 \mu\text{s}$.

Temperature Dependence: $\pm 0.15\%$ per $^{\circ}\text{C}$ maximum.

Cosine Correction: Cosine corrected up to 80° angle of incidence.

Azimuth: $< \pm 1\%$ error over 360° at 45° elevation.

Tilt: No error induced from orientation.

Detector: High stability silicon photovoltaic detector (blue enhanced).

Sensor Housing: Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware.

Size: 2.38 Dia. x 2.54 cm H (0.94" x 1.0").

Weight: 28 g (1 oz.)

Cable Length: 3.0 m (10 ft.)

Accessories: 2003S Mounting & Leveling Fixture, 2222SB Extension Cable.

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 of fitness for a particular purpose on underwater cables or on expendables such as batteries, lamps, thermocouples, and calibrations.

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

The laws of some locations may not allow the exclusion or limitation on implied warranties or on incidental or consequential damaged, so the limitations herein may not apply directly. This warranty gives you specific legal rights, and you may already have other rights which

vary from state to state. All warranties that apply, whether included by this contract or by law, are limited to the time period of this warranty which is a twelve-month period commencing from the date the instrument is shipped to a user who is a customer or eighteen months from the date of shipment to LI-COR, inc.'s authorized distributor, whichever is earlier.

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

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

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

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

Restriction of Hazardous Substances (RoHS)

LI-190 QUANTUM						
Component Name	Hazardous Substances or Elements					
	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Chromium VI Compounds (Cr ⁶⁺)	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
Cable Assembly	X	O	O	O	O	O
Cable Assembly for 10' Sensor	X	O	O	O	O	O
Quantum Sensor Sub Assembly	X	O	O	O	O	O
Photodiode Interface Circuit Board Assembly	X	O	O	O	O	O
O: this component does not contain this hazardous substance above the maximum concentration values in homogeneous materials specified in the SJ/T 11363-2006 Industry Standard.						
X: this component does contain this hazardous substance above the maximum concentration values in homogeneous materials specified in the SJ/T 11363-2006 Industry Standard (Company can explain the technical reasons for the "X")						
LI-190 光合有效辐射传感器						
部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr ⁶⁺)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
电缆组件	X	O	O	O	O	O
3 m 长传感器的电缆组件	X	O	O	O	O	O
光合有效辐射传感器子组件	X	O	O	O	O	O
光电二极管界面电路板组件	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。)						

LI-191 LINE QUANTUM						
Component Name	Hazardous Substances or Elements					
	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Chromium VI Compounds (Cr ⁶⁺)	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
Calibration Connector	X	O	O	O	O	O
LI-191 Cell and Glass Assembly	X	O	O	O	O	O
Cable Assembly for LI-191	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-191 棒状光合有效辐射传感器						
部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr ⁶⁺)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
标定联接器	X	O	O	O	O	O
LI-191 密封室及玻璃组件	X	O	O	O	O	O
LI-191 电缆组件	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。)						

LI-200 PYRANOMETER						
Component Name	Hazardous Substances or Elements					
	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Chromium VI Compounds (Cr ⁶⁺)	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
Calibration Connector	X	O	O	O	O	O
Cable Assy for 10' Sensor	X	O	O	O	O	O
Pyranometer Sub Assembly	X	O	O	O	O	O
Photodiode Interface 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-200 太阳总辐射传感器						
部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr ⁶⁺)	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
标定联接器	X	O	O	O	O	O
3 m 长传感器的电缆组件	X	O	O	O	O	O
总辐射传感器子组件	X	O	O	O	O	O
光电二极管界面电路板组件	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。)						



Biosciences

■ LI-COR, inc.
Environmental
4647 Superior Street
P.O. Box 4425
Lincoln, Nebraska 68504 USA

■ Phone: 402-467-3576
FAX: 402-467-2819
Toll-free: 1-800-447-3576 (U.S. & Canada)
E-mail: envsales@licor.com

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: Quantum Light Sensor

Model Number(s): LI-190

Product Options: LI-190SA, LI-190SL, LI-190SZ, LI-190SA-50, LI-190SL-50, LI-190SZ-50

conforms to the following Product Specifications:

EMC: FCC 47 CFR Part 15.109 Radiated Emissions, Class B
EN 55011 : 1998 Radiated Emissions, Class B
IEC 61000-4-2 : 1995 ESD, 8KV/15KV Contact/Air
IEC 61000-4-3 : 1995 Radiated RF Immunity, 10V/m

Supplementary Information:

The product herewith complies with the requirements of the EMC Directive 2004/108/EC (formerly 89/336/EEC).

John Rada
Director of Engineering



Biosciences

■ LI-COR, inc.
Environmental
4647 Superior Street
P.O. Box 4425
Lincoln, Nebraska 68504 USA
■ Phone: 402-467-3576
FAX: 402-467-2819
Toll-free: 1-800-447-3576 (U.S. & Canada)
E-mail: envsales@licor.com

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: Pyranometer

Model Number(s): LI-200

Product Options: LI-200SA, LI-200SL, LI-200SZ, LI-200SA-50, LI-200SL-50, LI-200SZ-50

conforms to the following Product Specifications:

EMC: FCC 47 CFR Part 15.109 Radiated Emissions, Class B

EN 55011 : 1998 Radiated Emissions, Class B
IEC 61000-4-2 : 1995 ESD, 8KV/15KV Contact/Air
IEC 61000-4-3 : 1995 Radiated RF Immunity, 10V/m

Supplementary Information:

The product herewith complies with the requirements of the EMC Directive 2004/108/EC (formerly 89/336/EEC).

John Rada
Director of Engineering



Biosciences

4421 Superior Street • P.O. Box 4425 • Lincoln, NE 68504 USA
North America: 800-447-3576 • International: 402-467-3576 • FAX: 402-467-2819
In Germany - LI-COR GmbH: +49 (0) 6172 17 17 771
envsales@licor.com • envsupport@licor.com • www.licor.com

Argonaut-SL

Useful options and accessories make the Argonaut-SL a complete, turn-key solution.



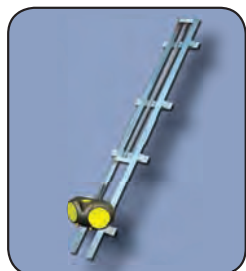
Real-time Flow Display: Provides an easy-to-use interface for monitoring both output data and the system status.



Modbus Interface Module (MIM): Integrate into any Modbus-enabled system using Modbus RS-232 protocol. Acting as an RTU slave device, the MIM stores data in a series of registers so it can be reported to the master unit in real-time.



SonUtils PDA Edition: An easy answer for both set-up and analysis, SonUtils PDA software allows for quick programming and automatic downloads.



Canal Mount: An easy solution for installation in open channels.

Specifications

Water Velocity

- Transducer: Two-beam horizontal, 25° slant angle for 2D water velocity
- Range: ± 6 m/s (20 ft/s)
- Resolution: 0.1 cm/s (0.003 ft/s)
- Accuracy: $\pm 1\%$ of measured velocity ± 0.5 cm/s (0.015 ft/s)

Standard Features

- Vertical acoustic beam for water level
- "Multicell" velocity profiling (programmable, up to 10 equally-spaced cells)
- "Independent" velocity measurement cell. This cell can be different in size from the 10 Multicells and located anywhere within the instrument's sampling range. This cell is used for flow calculations or other specialized functions.
- Flow computation and output, including total volume
- FlowPack Velocity-Index Discharge Rating software package
- 4MB internal nonvolatile memory
- Temperature sensor
 - Resolution: $\pm 0.01^\circ\text{C}$
 - Accuracy: $\pm 0.1^\circ\text{C}$

Communications

- RS 232/SDI-12 power/communications cable (10m standard. Longer cables are also available up to 100m)
- ViewArgonaut Software (Windows 95/98/NT/2000/XP/Vista) for instrument setup, data collection, flow calculation
- SonUtils PDA software for PocketPC



YSI incorporated



OSIL
Environmental Instruments
and Systems

Culkin House,
C8 Endeavour Business Park,
Penner Road, Havant,
Hampshire PO9 1QN

T: +44 (0)2392 488240

E: osil@osil.co.uk

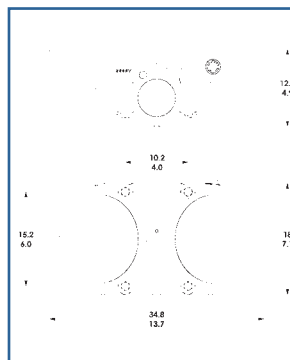
W: www.osil.co.uk

Physical Parameters

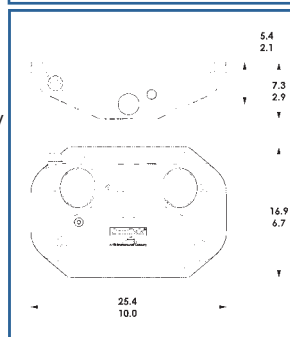
- Operating temperature: -5° to 60°C (23°F to 140°F)
- Storage temperature: -10° to 70°C (14°F to 148°F)

Optional Features

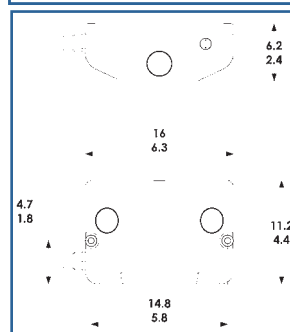
- Real-time Flow Display
- External battery pack for autonomous operation (500WH)
- Wave Spectra output (SL500 and SL1500 models only)
- Analog output module (4-20mA or 0-5V)
- Modbus Interface Module (MIM)
- RS422 output for cable lengths to 1500 m
- Canal Mounting Apparatus
- YSI ECONET satellite or radio telemetry



SL500



SL1500



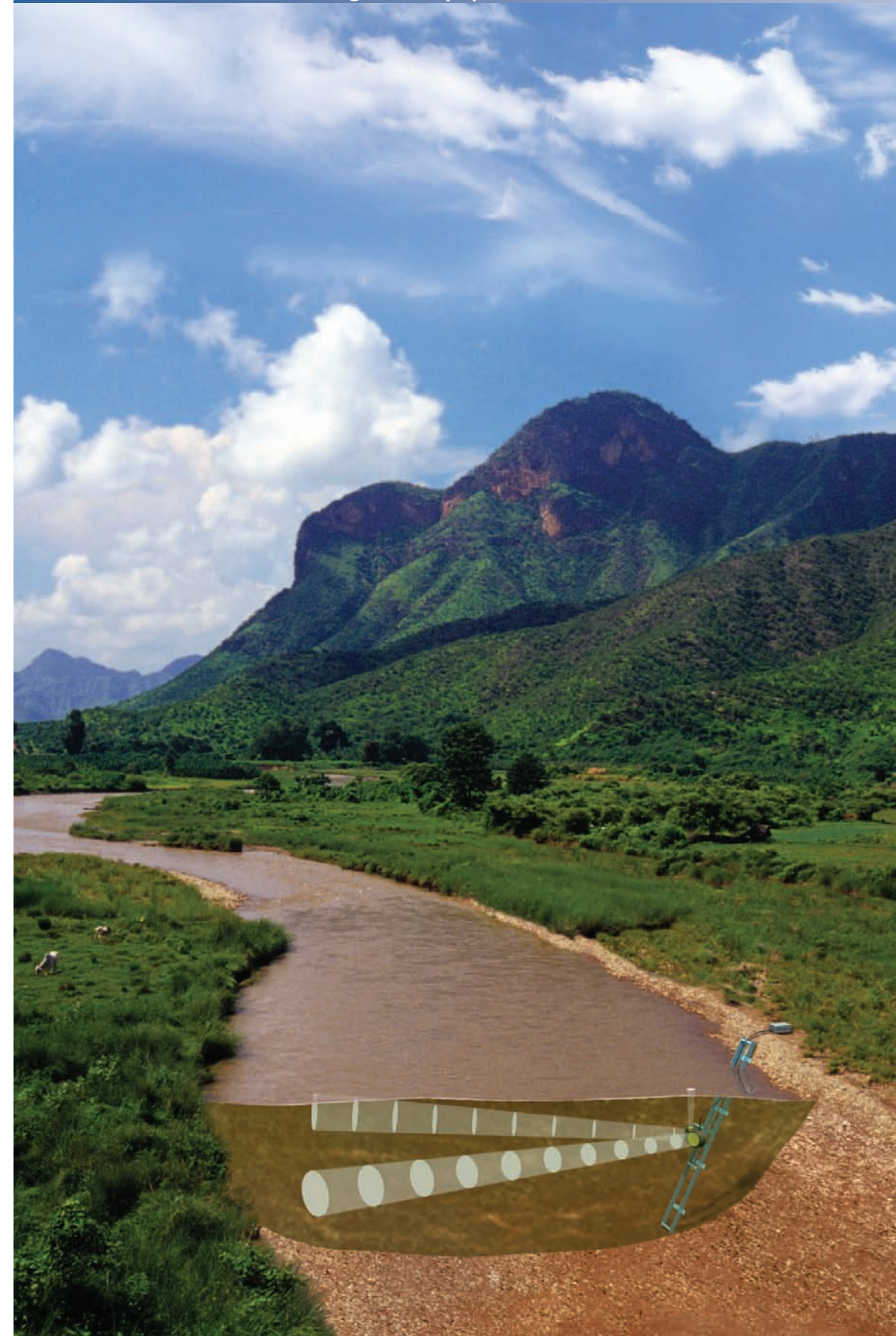
SL3000

SonTek/YSI, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instruments for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories. SonTek/YSI is an employee-owned company.

SonTek and Argonaut are trademarks of SonTek/YSI, San Diego, CA USA
The Argonaut-SL is made in the USA. Lit. code S04-05 0307

Argonaut-SL

Side-Looking Doppler Current Meter



Argonaut® - SL

Side-Looking Doppler Current Meter

Sound Principles. Good Advice.



Simple. Sleek. Superior.

Inspired by the need for a **SIMPLE** way to measure water velocity and level in open channels, the Argonaut-SL, (affectionately known as the *Side-Looker*) has earned worldwide acceptance as a long-term monitoring solution. Fully featured with accessories, mounting options, software, and a variety of integration formats, the Argonaut-SL fits your application in the way you need it to.



Designed specifically for side mounting on bridges, canal walls, or riverbanks, the SL's **SLEEK** low-profile housing makes installation easy. With three models to choose from, the SL can be used in channels as small as you can jump across to rivers as wide as the Amazon.

Ultra narrow beam widths combined with unmatched side lobe suppression provide the **SUPERIOR** acoustic directivity necessary for achieving maximum horizontal range free of interference from surface or bottom boundaries.

Preparing an SL500 for an irrigation channel in India.

Display. Process. Analyze.

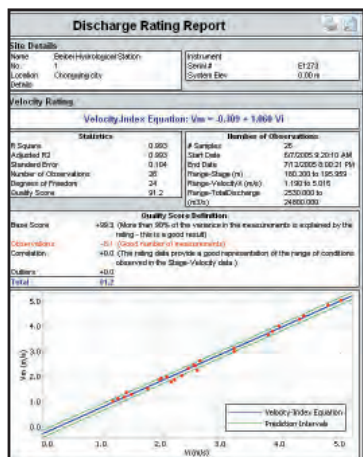
Each Argonaut-SL comes complete with the industry leading Windows software packages **VIEWARGONAUT** and **FLOWPACK**. ViewArgonaut provides comprehensive data collection and processing tools and also a full range of export options and a user-friendly deployment wizard.



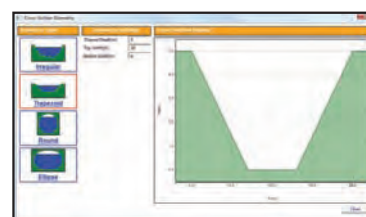
VIEWARGONAUT Set-up Screen

Integrate, store and analyze data from multiple sites with SonTek's Velocity-Indexing discharge rating software, FlowPack. Now you can print professional reports easily and quickly with the confidence that you will produce consistent and robust results.

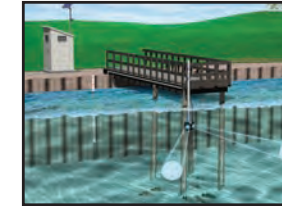
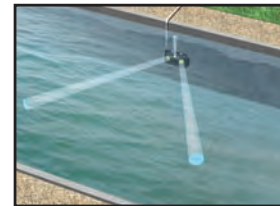
An entire rating analysis can be completed in a matter of minutes, with automatically developed Stage-Area relationships and selection of the best-fit Velocity-Index equation. Data can be imported from a variety of sources including all SonTek instruments, and other devices.



FLOWPACK Rating and Analysis



Multiple Channel Geometries



Argonaut-SL in the Field

Applications

- River Discharge Monitoring
- Irrigation Canals
- Ports and Harbors
- Shallow Streams and Estuaries
- Water Supply

Features

- Water Velocity and Level
- MultiCell Current Profiling
- PowerPing Hi-precision Sampling
- Mounting and Display, and I/O
- Velocity-Indexing Software

	SL3000	SL1500	SL500
Sampling Range¹	0.1 to 5m (0.3 to 17 ft)	0.2 to 20m (0.7 to 66 ft)	1.5 to 120m (5 to 400 ft)
Minimum Channel Width	0.75m (2.5 ft)	1.50m (5 ft)	6.5m (21 ft)
Acoustics			
-Horizontal Beam Width ²	1.4°	1.4°	1.4°
-Vertical Beam Width ²	1.4°	2.9°	3.8°
-Side Lobe Suppression ³	>60dB	>60dB	>60dB
PowerPing Hi-Precision	✓	✓	n/a
SonTek TrueCompass/Tilt	n/a	✓	✓
Water Level			
-Vertical Beam Range	0.1 to 5.0 m (0.3 to 17 ft)	0.15 to 10m (0.5 to 33 ft)	0.2 to 18.0m (0.7 to 59 ft)
-Accuracy	(depth < 3 m): ±0.3 cm (0.01 ft) (depth ≥ 3 meters): ± 0.1%	(depth < 3 m): ±0.3 cm (0.01 ft) (depth ≥ 3 meters): ±0.1%	(depth < 6 m): ±0.6 cm (0.02 ft) (depth ≥ 6 meters): ±0.1%
-Pressure Sensor (Accuracy)	n/a	0.25%	0.25%
-Wave Height Spectra	n/a	Optional	Optional
Power			
-Input	7-15 VDC	7-15 VDC	7-15 VDC
-Consumption ⁴	0.5 – 0.7 W	0.5 – 0.7 W	0.7 – 1.0 W
Physical			
-Weight in Air	1.2 kg (2.6 lb)	2.4 kg (5.3 lb)	6 kg (13.2 lb)
-Weight in Water	0.3 kg (0.7 lb)	0.2 kg (0.5 lb)	1.1 kg (2.5 lb)
-Pressure Rating (Max Depth)	30 m (98 ft)	30 m (98 ft)	30 m (98 ft)
-Mounting Plate Dimensions	28 x 25 x 1 cm (11" x 8" x 0.4")	Integrated Mount	35.5 x 22.9 x 1.5 cm (14" x 9" x 0.6")

¹ Actual Maximum range depends on environmental conditions

² Full beam width reported at half power level (-3dB)

³ Side lobe suppression improves the aspect ratio of the instrument enabling greater measurement range in shallower water.

⁴ Power consumption will be higher with PowerPing and/or Flow Display enabled



River Discharge and Flow



Ports and Harbors



Irrigation Canals



YSI incorporated

S O N T E K

Argonaut-SW[®]

Shallow Water Flow, Level and Velocity



Argonaut-SW[®]

Shallow Water Flow, Level and Velocity

Built to Last. Made to Perform.



Using SonTek's proven pulsed acoustic Doppler technology, the Argonaut-SW is the superior choice for accurate flow measurements in natural streams, man-made channels, and pipes. Because it is a "fast sampling" velocity profiler, the SW accounts for variations in the velocity field to make the most accurate flow measurements possible.

Typically mounted on the bottom of a channel or pipe, the SW combines velocity and water level data with user-supplied channel geometry to compute total flow in real time. Its unique "all-in-one" transducer and electronics design features an internal recorder and requires no top-side processing.

Display. Process. Analyze.

Every Argonaut-SW comes with **ViewArgonaut** - a user-friendly software program for setting up your system and analyzing data. A flow configuration utility makes flow measurement simple!



ViewArgonaut consists of five modules:

- **Diagnostics** - Deployment site survey and diagnostics tool.
- **Recorder** - Extracts data from or erases the Argonaut's internal recorder.
- **Deployment** - Sets up the Argonaut for an Autonomous or SDI-12 deployment.
- **Realtime** - Sets up the Argonaut to collect and display real-time data.
- **Processing** - Lets you play back and manipulate Argonaut data.



Velocity-Indexing is a Snap with FlowPack Software!

One of the main benefits to the Argonaut-SW is its ability to calculate flow using uniquely derived flow equations for individual channels via the velocity-index method. SonTek's optional FlowPack software facilitates velocity-index rating development, making your data reporting process a whole lot friendlier and faster! FlowPack provides a simple method to store flow, velocity, and stage measurements and convert this information into comprehensive reports, helping you make better and more informed decisions.

Sound Principles. Good Advice.

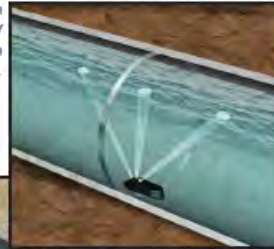
Flow
Level
Velocity



Continuous Flow Monitoring Under Complex Conditions

Reversing flow? Rapid changes? Tidal influence? Pumping? Backwater? Under ice? Small, portable and easy to use, the Argonaut-SW is your friend for all these challenging shallow-water conditions. The SW operates in depths from 0.2 to 5.0 meters (0.7 to 16 ft) and automatically adjusts its velocity cell with changing water level while also reporting a velocity profile for subsequent analysis. Just provide power, and the SW can either output data in real time or record data internally for periodic downloads.

Example of an Argonaut-SW installed in an industrial pipe.



Features Include:

- Unique "all-in-one" design
- Provides 10 cells of velocity profiling
- Internal data recorder
- Real time output (RS 232/422, SDI-12, Modbus, analog)
- External flow display
- Total volume output
- Measures under ice

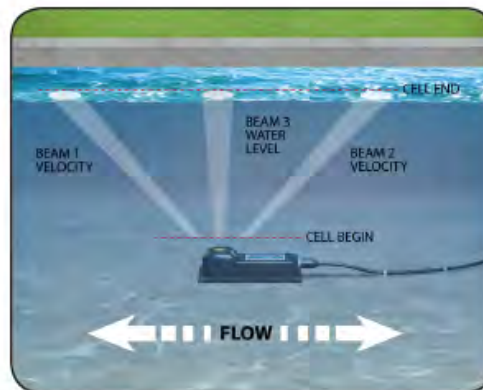


Example of an Argonaut-SW installed in an irrigation canal.

How it Works

The Argonaut-SW has three acoustic beams. When properly bottom-mounted (usually in a channel), one of these beams points straight up, and the other two point up/down stream at a 45-degree angle. The upward-looking beam measures water level. The two slanted beams measure the water velocity in two dimensions via the acoustic Doppler method.

Profiling water velocity provides a more accurate depiction of flow characteristics, enabling use under conditions where stratification exists. This level and velocity information is then used (together with the geometry of the channel) to compute flow, volume, mean velocity, and area.



This illustration depicts an Argonaut-SW mounted on the bottom of a shallow irrigation canal, with water flowing in either direction. The SW has the ability to switch to a one beam solution if either of the velocity beams are blocked, and then revert to 2-beam solution when the blockage clears or is cleared.



Natural Streams



Pipes and Culverts



Irrigation Canals



SonTek
YSI incorporated

Argonaut-SW Specifications

Useful options and accessories make the Argonaut-SW a complete, turn-key solution!



Real-time Flow Display: Provides an easy-to-use interface for monitoring both output data and the system status.



SW Mounting Shoe: This streamlined, hard plastic casing helps deflect sediment in canals, channels and pipes. Also has slots for pipe-ring mounting.



Modbus Interface Module (MIM): Integrate into any Modbus-enabled system using Modbus RS-232 protocol. Acting as an RTU slave device, the MIM stores data in a series of registers so it can be reported to the master unit in real-time.



Sliding Mount: Rail system for easy instrument deployment and retrieval. A modular design allows for multiple length and depth configurations.

Standard Features

- 2-D velocity measurement (using 2 acoustic beams) along channel and vertical velocity components
- Water level measurement using vertical acoustic beam
- Automatically adjusts sampling volume location to measure the maximum possible portion of the water column
- RS-232/SDI-12 communication protocol
- Real-time flow calculations using user-supplied channel geometry
- 4 MB recorder capacity (over 50,000 samples)
- Temperature sensor
 - Resolution: $\pm 0.01^\circ \text{C}$
 - Accuracy: $\pm 0.5^\circ \text{C}$
- ViewArgonaut Windows 2000/XP/Vista software for instrument setup, data collection, and post processing.
- PDA software (SonUtils and deployment module)
- Multi-cell current profiling
- Mounting plate

Velocity Profiling Range

- Maximum Depth: 5.0m (16ft)
- Minimum Depth: 0.3m (1ft)*

Water Level Measurement

- Minimum Depth:
 - Above transducer: 0.10m (0.3ft)
 - Total water depth: 0.20m (0.6ft)
- Maximum depth: 5.0m (16ft)
- Accuracy: $\pm 0.1\%$ of measured level, $\pm 0.3\text{cm}$ (0.01ft)

Water Velocity

- Range: $\pm 5 \text{ m/s}$ (16 ft/s)
- Resolution: 0.1 cm/s (0.003 ft/s)
- Accuracy: $\pm 1\%$ of measured velocity, $\pm 0.5 \text{ cm/s}$ (0.015 ft/s)

Optional Features

- FlowPack velocity indexing software
- 4-20 mA and 0-5VDC output modules; possible variables are X velocity, Y velocity, velocity magnitude, temperature, SNR, stage, volume and flow.
- Custom mounting shoe (at left)
- Deployment sliding mount (at left)
- Flow Display (at left)
- Durable plastic shipping case
- RS-422 for cable runs longer than 100m



YSI incorporated

SonTek/YSI
9940 Summers Ridge Road
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Fax: +1 (858) 546-8150
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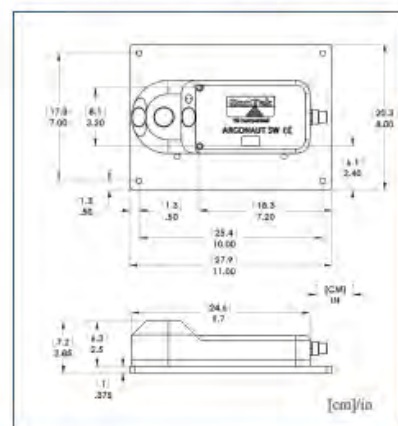
Physical Parameters

- Dimensions: 24.5cm (9.7 in) long by 10cm (4 in) wide by 6.3cm (2.5 in) high
- Weight:
 - In air: 1.2kg (2.6 lb)
 - In water: 0.15kg (0.3 lb)
- Pressure rating: 25m (80 ft)
- Operating temperature: -5°C to 60°C (23°F to 140°F)
- Storage temperature: 10°C to 70°C (14° to 158°F)

Power Requirements

- Input power: 5-15 VDC
- Power consumption: 500 mW nominal

*Can operate in shallower depths down to 0.2m (0.7ft) with performance limitations. Contact SonTek for details.



SonTek/YSI, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instruments for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories. SonTek/YSI is an employee-owned company.

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