Using the Carbon Node

LI-720 Carbon Flux Sensor on LI-COR Cloud

LI-COR®

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Notes on Safety

This LI-COR product has been designed to be safe when operated in the manner described in this manual. The safety of this product cannot be assured if the product is used in any other way than is specified in this manual. The product is intended to be used by qualified personnel. Read this entire manual before using the product.

Equipment markings:	
	The product is marked with this symbol when it is necessary for you to refer to the manual or accompanying documents in order to protect against injury or damage to the product.
WARNING	Warnings must be followed carefully to avoid bodily injury.
CAUTION	Cautions must be observed to avoid damage to your equipment.
Manual markings:	
Warning	Warnings must be followed carefully to avoid bodily injury.
Caution	Cautions must be observed to avoid damage to your equipment.
Note	Notes contain important information and useful tips on the operation of your equipment.

CE Marking:

This product is a CE marked product. For conformity information, (typically EMC, Safety, RoHS, and/or Wireless) contact LI-COR Support at envsupport@licor.com for a Declaration of Conformity. Outside the U.S., contact your local sales office or distributor.

For ReaCH (Regulation (EC) n.1907/2006) related questions, information is available on the European Chemicals Agency maintained website for the Waste Framework Directive SCIP database.

You can search by product name (for this product "LI-720"), or request an "SCIP number" from the email above.

LI-COR scientific products are for professional use (non-consumer products). These products do not fall within the voluntary scopes of regulations: UNI EN ISO 14024, TCO Certified, EPEAT 2018,

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California Proposition 65 Warning

WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Federal Communications Commission Radio Interference Statement

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

Waste Electronic and Electrical Equipment (WEEE) Notice

This symbol indicates that the product is to be collected separately from unsorted municipal waste. The following applies to users in European countries: This product is designated for separate collection at an appropriate collection point. Do not dispose of as household waste. For more information, contact your local distributor or the local authorities in charge of waste management.

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Specifications

Standard Terms and Conditions

Section 1.
The LI-720 and Carbon Node

Welcome, and thank you for your purchase of the LI-720 Carbon Flux Sensor. The LI-720 reports the total transport of carbon dioxide gas and evapotranspiration over an area, along with other biological and meteorological parameters. The LI-720, when paired with an IoE Module, is a Carbon Node on LI-COR Cloud.

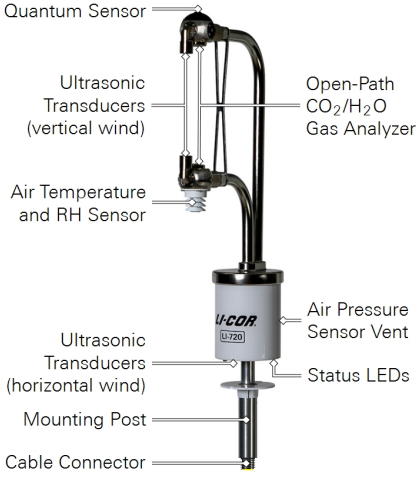


***Figure 1-1**. The LI-720 Carbon Flux Sensor consists of ultrasonic transducers for wind measurements, an open-path CO_2/H_2O gas analyzer, quantum sensor, air pressure sensor, and combined air temperature and RH sensor.*

Warning: *The LI-720 has internal voltages that may exceed 100 volts. Handle the device carefully if the external cover is removed. Avoid touching circuit boards or exposed conductors.*

Warning: *The gas analyzer housings include small packets of Ascarite II and Magnesium Perchlorate. Use caution if handling these components.*

If you have just received your LI-720, check the packing list to be sure you have everything that you ordered. The LI-720 may include some or all of the components listed below.

Caution: Keep the box and foam packaging materials so you can ship and store the instrument safely.

LI-720 Carbon Flux Sensor

Part number 99512-012

The sensor (*Figure 1-1* on the previous page) features one cable connector for power and data and a mounting post for installation onto an IoE Module, a tripod, or other platform using a 1" (2.54 cm) cross-over fitting.

USB data and power cable

Part number 99512-062

The USB data and power cable is to operate the device from a computer for configuration and calibration procedures. The LI-720 cannot be operated in a field situation with the USB cable because the USB power supply is not adequate.

Data and power cable

Part number 392-19605

Each sensor includes a 5-meter long combined data and power cable. The cable features a connector and bare leads for connecting to a datalogger that supports SDI-12 and serial (RS-232) communication.

Spares kit

Part number 99512-056

Each LI-720 is shipped with a spares kit, which includes a variety of spare parts (see *Table 1-1* below).

Table 1-1. Spares and accessories for the LI-720.

Description	Part #
Temperature and RH Sensor (1)	99512-007
Phillips Screws Panhead M2×0.4 6 mm Stainless Steel (8)	150-14386
Washers 0.093 × 0.187 × 0.010 Stainless Steel (8)	167-09198
O-ring; 28×1.5 mm Viton 75 (1)	192-20923

CarbonWare application

An application for Windows OS computers, CarbonWare is used to adjust the user-calibrations, apply firmware updates, enter site information relevant to flux calculations (if not using LI-COR Cloud), and other tasks.

Download CarbonWare from licor.com/support. Search for **CarbonWare**.

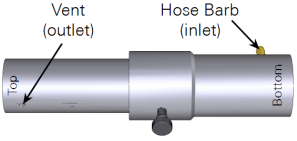
Optional accessories

The accessories below are available from LI-COR.

Calibration shroud

Part number 99512-055

The calibration shroud is required for setting the zero and span. You can use a single shroud to calibrate multiple LI-720 instruments, and therefore it is not included with the sensor. The shroud includes three meters of Bev-a-Line tubing to connect to a tank.



Caution: Do not attempt to calibrate with a homemade shroud. The calibration shroud is designed to prevent reflections and optimize flow. Attempts to calibrate with a homemade shroud tube will lead to unexpected performance.

Extension cable

Part number 392-20529

25-meter extension cable with weather-resistant connectors on each end. Extends the data/power cable for a total length of 30 meters.

IoE Module overview

The IoE Module may include some or all of the following components and services:

- Cellular service plan and access to LI-COR Cloud (extendable).
- Backup data logging to a removable Micro SD card (all configurations).
- Built-in charge controller for the solar power supply (all configurations).
- Solar and battery power supply (optional).
- Mounting structure and enclosure for sensors and equipment (optional).

The IoE Module powers sensors for continuous long-term operation, while simultaneously posting data to the LI-COR Cloud via a cellular network. It allows operators to view data and assess results from sensors remotely.

IoE configurations are given in *Table 1-2* below and described in the following sections.

Table 1-2. IoE modules are available in a variety of configurations.

Part #	LI-COR Cloud	IoE Module	Frame and Mast	Solar Power
99512-014	-	Yes	-	-
9000-01	Yes	-	-	-
9000-02	Yes	Yes	Yes	Yes
9000-03[a]	Yes	Yes	-	-
9000-04	Yes	Yes	Yes	-

[a]Mounting hardware not included; order with 9000-05 mounting hardware.

IoE module only

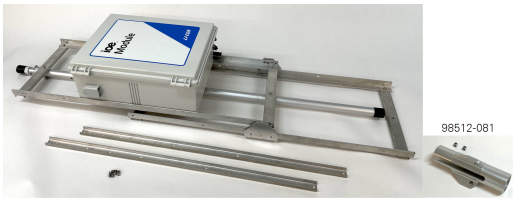
Part number 9000-03

The stand-alone IoE module includes the enclosure, electronics, power and data cable for the sensor (392-20750), cellular service, and LI-COR Cloud data service. Cellular and LI-COR Cloud service contracts can be extended. We recommend the optional hardware mounting kit (9000-05) with this configuration.

IoE module, mast, and frame assembly

Part number 9000-04

This configuration includes everything listed previously, plus the frame with mast, assembly hardware, instrument and guy wire adapter, earth anchor kit, grounding kit, and tool kit. The mast allows height adjustment resolution of 20 cm at heights from 2 to 5 meters.



Assembly hardware kit

The hardware kit includes parts and accessories to assemble the system.

Description	Part #
Braces; 1.25×0.5" U-channel; 39" long	98512-052
M6×1 6-mm stainless lock nuts (4)	157-20957
M6×1 12-mm cap screws (4)	151-20958
Instrument and guy wire adapter (1)	98512-081
Instrument and guy wire adapter (discontinued)	98512-013
M8×1.25 set pins (2)	155-16763

Earth anchor kit

The anchoring kit includes hardware to stabilize the mast when it is extended.

Description	Part #
14-inch earth anchors with eye-bolts (3)	609-20822
Guy wires with clip (3)	609-20846
Gripple cable locks (3)	-
Gripple release key (1)	611-21003

Grounding kit

The grounding kit includes hardware for an earth-ground.

Description	Part #
Ground rod (1); 1.5 meter	609-20976
Ground wire (1); 2 meters; 8-gauge	374-12937
Ground rod clasp (1)	354-20819

Tools

Several assembly tools are included.

Description	Part #
10 mm and 1/2" wrench (1)	98512-066
Multipurpose screwdriver (1)	611-07902
4 mm hex key (1)	611-21236

IoE module, mast, frame, battery, and solar panel

Part number 9000-02

The turnkey IoE Module includes everything listed previously, plus a solar panel, battery, and hardware for the solar power and battery. The panel rails provide angle adjustments to allow the solar panel to face the sun in different latitudes and seasons.

Battery kit

Part number 99512-031

The battery kit includes a 100-Ah 12-volt absorbed glass mat (AGM) battery, cables, and a bracket to secure the battery.

Description	Part #
100-Ah 12-volt AGM lead-acid battery	442-20708
Battery cable assembly	99512-022
Battery hold-down bracket	98512-065

Solar panel kit

The solar power kit includes a solar panel and hardware for the power supply.

Description	Part #
100-watt 12-volt solar panel	590-20735
Solar panel extension cables	392-20841
Solar panel bracket assemblies (2)	
Angle bracket (installed)	98512-050
U-channel bracket (installed)	98512-051
16-mm serrated flange bolts (installed)	150-20955
M6×1 6-mm nylon lock nuts (installed)	157-20957
1/4" clevis pin with 1/16" cotter pin	186-20847
M6×1 12-mm cap screws (4)	151-20958
Panel clamps (4)	98512-010

Sensor cable

Part number 392-20750

Each IoE Module includes a sensor cable to connect the LI-710 or LI-720 to the **SENSOR** connector on the

IoE Module. It is a 5-meter long 5-pin cable with connectors on each end.

Optional mounting hardware

Part number 9000-05

Stand-alone IoE modules (9000-03) can be mounted with the mounting hardware kit, which is compatible with a vertical mast, horizontal cross arm, or pipe at nearly any angle. The kit includes two brackets, two band clamps, and additional hardware.

Warning: *Do not use the optional mounting hardware with the battery kit (99512-031) or any other heavy battery. The mounting hardware (9000-05) is not strong enough to safely hold the battery, and may present a risk of injury if a battery is installed.*

Optional auxiliary power cables

Power cables are used to power the IoE Module from external power (9 to 33 VDC, 3.0 A). Power cables are available in three lengths:

Description	Part #
3-meter power cable	8150-706
5-meter power cable	9975-030
25-meter power cable	9975-056

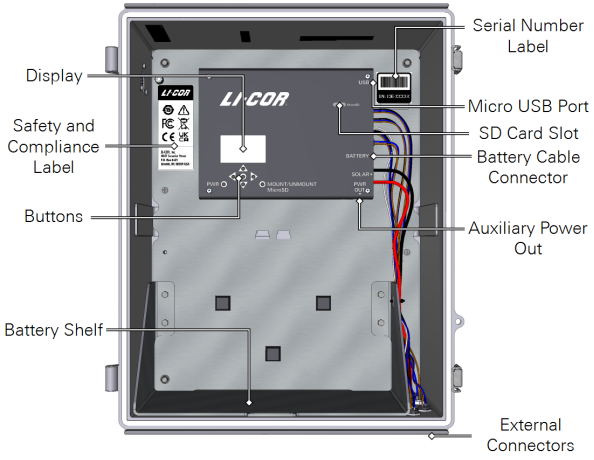
Enclosure and electronics

The enclosure houses the electronics, antennas, and other components.

Warning: *Read and understand the operating instructions and safety information before using this equipment. Failure to understand the safety information may result in bodily injury, damage to equipment, or unsatisfactory results.*

Components

Components of the enclosure are labeled and described below.



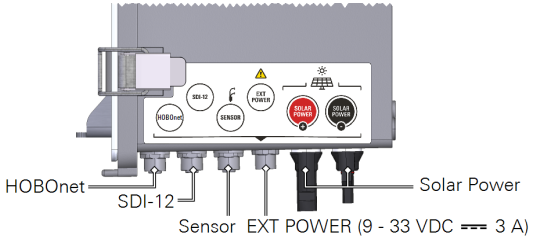
- **Display**: Monochrome display that presents status and configuration information. See *IoE module interface reference* on page 10-1 for a tour.
- **Buttons**: Buttons include power (PWR), navigation (▲, ▶, ▼, ◀), select (), and mount/unmount card.
- **Battery Shelf**: To support the optional battery. Always use the hold-down bracket when a battery is installed.
- **Serial Number Label**: The serial number label gives the product serial number, which may be useful if you need technical support.

- **Micro USB Port**: To connect to a computer for manual firmware updates. Accepts a Micro-B connector.
- **Micro SD Card Slot**: The slot is for the included Micro SD card to store a backup of data. An 8 GB card is included (part number 616-21301). The 8 GB card can store many years of data, typically. Most micro SD cards (FAT12, FAT16, FAT32, and ExFAT format) will work as long there is free space for files.
- **Battery Cable Connector**: The cable from the optional 12-volt lead-acid battery attaches to this connector.
- **Auxiliary Power Out**: One auxiliary power supply is provided inside the enclosure. Contact LI-COR technical support if you want to use the power out.

External connectors

The external connectors are for sensors, auxiliary power, and solar panels.

Warning: *Read and understand the operating instructions and safety information before using this equipment. Failure to understand the safety information may result in bodily injury, damage to equipment, or unsatisfactory results.*



- **HOBOnet Connector**: For the HOBO Node Link (available on new IoE Modules).

- **SDI-12 Connectors**: One connector for SDI-12 devices. Power, configuration, and data transfer are supported. The device must have a 5-pin sealed connector. The Stevens Soil Probe available from LI-COR (part number 900-19016) has the connector. The SDI-12 power supply provides 12 VDC with a maximum of 2.5 amps total, including the Sensor Connector.
- **Sensor Connector**: Accepts the LI-710 or LI-720 cable (392-20750). It features a 5-pin sealed connector for a combined SDI-12/RS-232 port. The SDI-12 power supply provides 12 VDC with a maximum of 2.5 amps total, including the two SDI-12 connectors.
- **Auxiliary Power Input**: For operation from an external power supply (other than the solar panel or battery). Supports 9 to 33 VDC, 3.0 A maximum current. Be sure the power supply is stable. Unstable power may result in damage if power is lost while data are being written.
- **Solar Panel Inputs**: To attach the solar panel extension cables. The maximum input is 9.15 A (circuitry is current limited to prevent damage). Compatible panels should output 17 to 21 V, with a maximum open circuit voltage of 32 V.

Extension cable (optional)

Part number 392-20529

25-meter extension cable with weather-resistant connectors on each end. Extends the IoE Module data/power cable for a total length of 30 meters.

Warning: *Do not connect solar panels with voltage rating that is higher than specified. Doing so can damage equipment or cause injury.*

HOBOnet Carbon Node Network

The optional Carbon Node Network provides supplemental data to the carbon node. All sensors send data to the Node Link, which is connected to the IoE Module. Measurements from a Node Link are available on LI-COR Cloud as part of the Carbon Node. The Node Link is supported by new IoE Modules (indicated by the HOBOnet label and cable connector) with firmware v1.2 or newer.

Node Link

Part numbers 900-21996 (NA), 900-21995 (EU), 900-21997 (AU)

The Node Link communicates with wireless sensors and the IoE Module. It connects to the IoE Module with a 9-pin threaded connector. A Node Link allows up to 50 sensor nodes to be added to a IoE Module. Node Link data are uploaded to LI-COR Cloud.

Each Carbon Node Network includes the sensors given below. Duplicates and other sensors can be added as well.

Soil moisture, temperature, and electrical conductivity sensor

Part number RXW-T12-xxx

Measures soil water content and conductivity. Each node network package includes three soil sensors.

Air temperature and relative humidity sensor

Part number RXW-THC-xxx

Measures ambient air temperature and humidity. One sensor is included.

Rain gauge

Part number RXW-RGF-xxx

Measure liquid precipitation and rainfall intensity. One sensor is included.

Solar radiation meter

Part number RXW-LIB-xxx

Measures total solar radiation. One sensor is included.

Summary of theory of operation

The output from the LI-720 is computed CO_2 flux, evapotranspiration, and energy flux for the previous time period (30 minutes by default but configurable from 5 to 30 minutes). Biomet outputs include photosynthetic photon flux density (PPFD), air temperature, relative humidity, wind speed, and wind direction averaged over the period. It uses the SDI-12 protocol to transfer computed results. It supports RS-232 serial communication to transfer raw (10 Hz) data to an IoE Module or external data recorder. It is directly compatible with LI-COR Cloud data management service. When connected to LI-COR Cloud, the LI-720 is a Carbon Node.

The LI-720 uses eddy covariance calculations that are optimized for the hardware and sensor configuration. It combines ultrasonic vertical wind speed measurements with high-precision gas measurements in the open air (non-dispersive infrared) to compute CO_2 flux and evapotranspiration from the area surrounding the sensor. When the prevailing wind directions around the LI-720 are random or uniform, measurements represent the surrounding area and vegetation (known as the "fetch footprint"). When wind is from a prevailing direction, measurements represent the land area and vegetation under the prevailing winds. The fetch footprint represents an area around the LI-720 that is 50 to 100 times the height of the sensor above the canopy (e.g., a 2-meter height above the canopy has a fetch footprint of 100 to 200 meters).

The LI-720 also measures horizontal wind, and therefore, the fetch footprint of the measurement can be assessed on LI-COR Cloud. In a proper deployment, the footprint will represent a uniform land area surrounding the sensor or

an area upwind of the prevailing wind direction (see *Installing the LI-720* on page 4-1 for more information).

Section 2.

Getting started

If you have just unpacked the LI-720, gather the sensor and the USB data/power cable (part number 99512-062) and prepare to connect to a Windows PC.

First things first

Always store and ship the LI-720 in the shipping box with foam. This protects the optics from impacts that may alter the calibration. See *Shipping the LI-720* on page 8-19.

Caution: Do not drop the LI-720 or expose the spheres to impacts, and do not handle the instrument when it is powered on. Drops and impacts will affect the calibration. If the LI-720 is subject to a drop or impact, STOP. Check the RSSI (see *Checking and adjusting the signal strength* on page 8-13). If the RSSI is not close to 100, clean the optics. If the RSSI does not approach 100 after cleaning the optics, check the zero (see *Calibrations* on page 8-8). If the zero has shifted, perform a zero and span calibration.

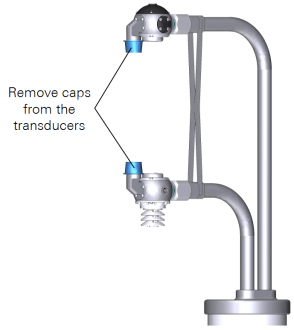
Connect the LI-720 to a PC

Although you don't need to connect the LI-720 to a computer most of the time, follow these steps for the initial performance check and for calibration adjustments.

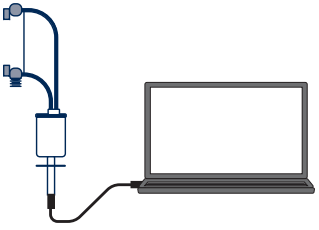
1 Download the CarbonWare application and install it on your computer (Windows® OS).
Search for **CarbonWare** at licor.com/support.

2 Unpack the LI-720 and gently place it on a desk or lab bench.

3 Remove the caps from the sonic transducers.

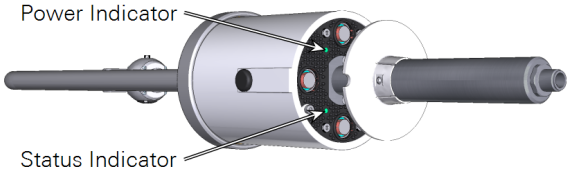


4 Install the USB data/power cable (part number 99512-062) between the sensor and your computer.
Connect the USB cable directly to the LI-720 and computer. Do not use a USB extension cable or device extension cable when operating the LI-720 from a 5 V USB power supply. Extension cables may result in voltage drops that affect both power and digital communication. Do not deploy the LI-720 while powered from 5 V USB power. The LI-720 requires 9 to 33 VDC for field operation.



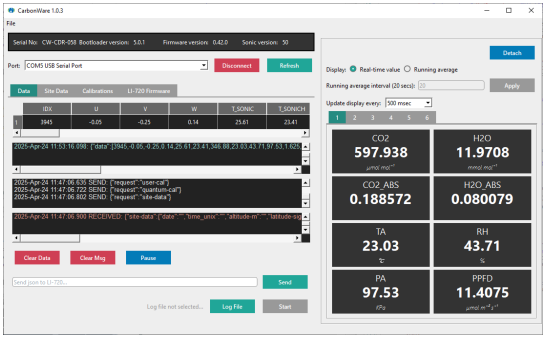
5 Launch the CarbonWare application.
The LI-720 is presented as a COM port; most likely, it is the only item in the list, or one of a few items. If you can't tell which port hosts the LI-720, search the computer device manager to identify port numbers.

6 Select the COM port and click Connect.
The Power LED will stay on and measured data will stream into the CarbonWare interface. The Status LED is off during normal operation.



Initial performance check

To verify the performance of the LI-720, you can observe some measurements and responses in the CarbonWare application. Many of these parameters are displayed by default the first variables tab. Select the third variables tab and add other variables to it to see the readings.



- Check readings for *CO2*, *H2O*, *TA*, *RH*, and *PA*. Readings should be plausible. Exhale through the optical path and observe the CO_2 and H_2O readings. Both measurements will spike briefly when exhaled air passes through the path. If the CO_2 and H_2O readings seem implausible, check the zero and span.
- Observe the PPFD reading. In an office or lab, expect a reading between 2 and 100, depending on how close the sensor is to the light. Shade the quantum sensor with your hand. The reading will approach zero when covered.
- Check the *RSSI*, *T_det*, *T_src*, and *RH_src* (see *Adding variables to the display list* on page 2-10). If the RSSI is less than 95, clean the optics with a soft, lint-free cloth. *T_det* and *T_src* should be 1 – 2 degrees above ambient; *RH_src* should be near zero.

Now, you're ready for the next steps:

- Working with the CarbonWare application (see *A tour of CarbonWare* on the facing page).
- Configure the LI-720 as a Carbon Node on LI-COR Cloud (see *Configuring the Carbon Node* on page 5-1).
- Configure the LI-720 for data loggers (see the application note at licor.com/support.

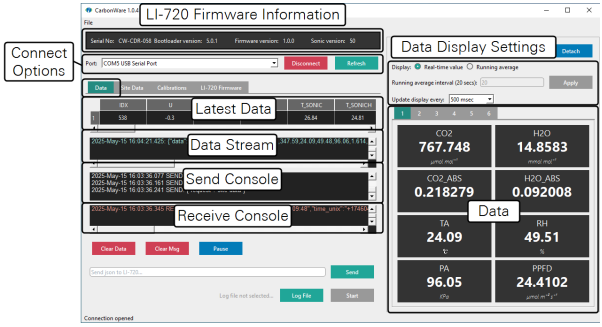
A tour of CarbonWare

An application for Windows OS computers, CarbonWare is used to adjust the user-calibrations, apply firmware updates, enter site information relevant to flux calculations (if not using LI-COR Cloud), and other tasks.

Download CarbonWare from licor.com/support. Search for **CarbonWare**.

Home window

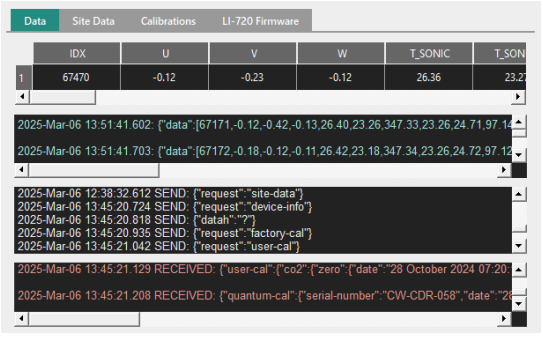
After connecting, you'll see data stream into the interface, along with status information and measured data. The interface reports firmware information for the connected LI-720, tabs (**Data**, **Site Data**, **Calibrations**, and **LI-720 Firmware**), data display settings, and data.



Data tab

The **Data** tab presents four frames with text, data, or other information.

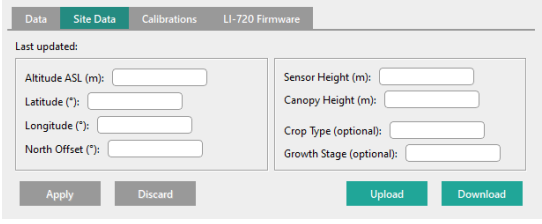
- **Latest Data**: A table of the most recent 10 Hz `.json` data. Scroll to the right to see the full table.
- **Data Stream**: Up to 600 lines of the latest 10 Hz data received from the instrument.
- **Send Console**: Up to 100 lines of the most recent messages sent from the application to the LI-720, and any app errors parsing serial data from the LI-720.
- **Receive Console**: Up to 100 lines of the most recent messages received by the application from the LI-720 that are not 10 Hz data. This includes any error messages output by the LI-720 and all LI-720 responses to setting calibrations.



Site Data tab

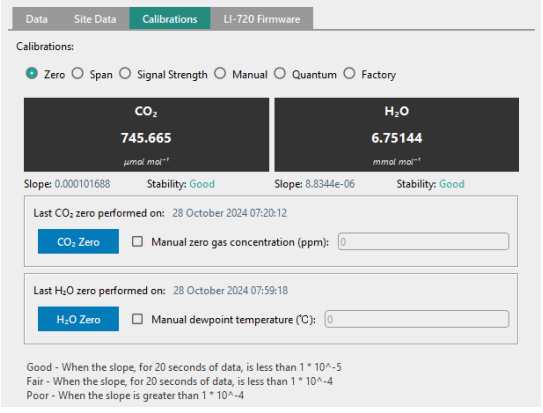
Site Data will be used to compute flux results and must be entered for accurate calculations. Site data is stored in the LI-720. Parameters include:

- **Altitude ASL (m)**: Altitude above sea level in meters. If blank, the LI-720 uses GPS altitude.
- **Latitude (°)**: Decimal degrees. Enter a positive number for north or a negative number for south. If blank, the LI-720 uses GPS latitude.
- **Longitude (°)**: Decimal degrees. Enter a positive number for east or a negative number for west. If blank, the LI-720 uses GPS latitude.
- **North Offset (°)**: Degrees of rotation clockwise past magnetic north. The LI-720 features a built-in magnetometer and it will compute the North Offset automatically (not corrected for declination). However, in environments where magnetic material may affect the measurement, a user-entered value should be used instead.
- **Sensor Height (m)** or **Measurement Height (m)**: Distance between the center of the sample path and the soil surface in meters.
- **Canopy Height (m)**: Distance between the top of the plant canopy and the soil surface in meters.
- **Crop Type (optional)**: Free entry for record keeping and analysis, the crop type can assist with interpreting the data.
- **Growth Stage (optional)**: Free entry for record keeping and analysis, the growth stage can assist with interpreting the data.



Calibrations tab

Each component may need to have calibrations adjusted. The **Calibrations** tab presents the controls, beginning with CO_2 and H_2O zero settings. Other options include CO_2 and H_2O spans, signal strength scale adjustments, quantum sensor calibration, and options to upload or download a calibration file. Full user-calibration instructions are in *Calibrations* on page 8-8.

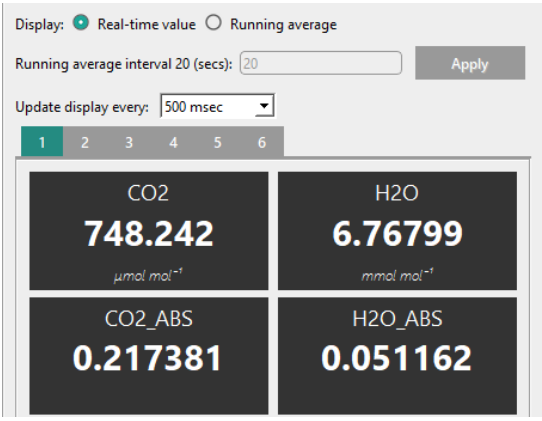


Firmware tab

The **Firmware** tab allows you to manually apply a firmware update to the LI-720. Full instructions are in *LI-720 firmware* on page 8-1.

Data display settings

You can change the data display settings to reduce the update rate or apply block averaging. This is a display setting that does not affect logging or computations.



Display options

Numerical data are displayed in eight tabs. You can change the display options:

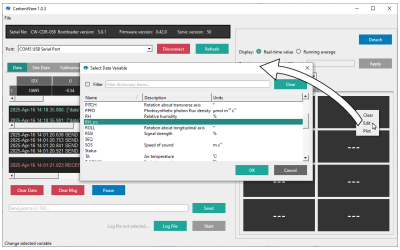
- Select **Real-time value** to allow the interface to update 10 times per second.
- Select **Running average** to display an average of a time period once per second. You can also set the time period by entering a **Running average interval**.
- **Update display every**: Select 100 ms to update at 10 Hz. Or, select a longer time period for a less frenetic update frequency.
- **Detach**: To view the measurements in a different part of your computer display, click **Detach** to make a new window or **Reattach** to combine the windows.

Adding variables to the display list

Tabs 1 and 2 are configured to show some common variables. You can customize them and add variables to the other tabs. To customize the variable list:

1 Right-click in a tile to open the menu and click **Edit**.

2 Select a variable from the table.



3 Click **OK** to add it to the table.

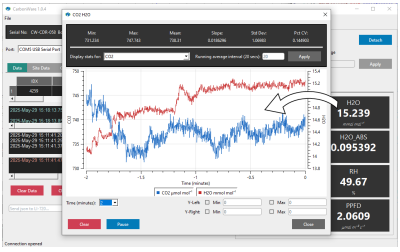
Viewing a quick plot

1 Double click a variable to open plot of the variable.

...or...

2 Right-click a variable and click **Plot**.

Click and drag more variables from the table into the plot to view multiple variables in one plot. You can add as many variables as you want and you can change the time period and left and right axis scales.



Section 3.

Assembling the IoE Module

The following steps can be undertaken indoors or outdoors. If it is your first time with an IoE Module, you may find it worthwhile to do this in the comfort of your office, and then you'll know exactly what is needed for your work in the field.

Unpacking the boxes

The hardware is shipped in corrugated cardboard boxes with cardboard sheets, boxes of components, empty boxes, and foam blocks to secure components while in transit. Unpack the hardware before going to the field. Be careful to avoid discarding hardware when you discard the packaging materials. Some packaging materials are hard to remove while the frame is collapsed; remove them when you unfold the frame. Use a box cutter to open packaging and a clippers to cut zip ties used in packaging.

1. Set the large box on the ground in your workshop, lab, or office.
2. Cut all of the tape on the seams and unfold the cardboard.
3. Lift off the loose pieces of cardboard to expose the solar panel box.
4. Continue to remove spacer boxes and boxes of parts until they are all separated from the packaging.
5. Open every box and separate the packaging materials and filler until you have identified every component included in your order.

Warning: *The components of this product are heavy (see Specifications on page 11-1 for weights). Use caution to avoid injury when lifting and securing components. Moving the fully assembled product should not be undertaken without appropriate precautions (e.g., a mechanical lift system, two-person lift, or other suitable lifting method).*

Check the lists of components in *IoE Module overview* on page 1-4.

Installation considerations

In this section, we describe how to deploy the system, with a focus on the hardware installation and assembly.

Assembly time and personnel

Be prepared before starting to install the device. Gather tools in advance. Allow ***at least three hours*** to unpack and assemble the structure. Components are heavy and bulky; ***at least two people*** should transport and set it up.

User-supplied installation tools

You will need a number of tools for the installation:

- Adjustable wrench.
- Impact driver with a 1 3/8" six-point socket to install the earth anchors, although you can install them by hand using the ground rod as a lever.
- Sledge hammer or hammer drill with a ground rod bit to install the ground rod.
- Red or reflective tape to mark guy wires and call attention to trip hazards.
- Zip ties or hook-and-loop cable ties to secure cables.
- Angle gauge or cellphone with level app to estimate the

angle of guy wires.
- Sturdy gloves and safety goggles.

Site inspection

It is critical that you know of any underground utilities that are installed at your site. Local laws may require an inspection before installing the ground rod. In the USA, call 811 to arrange a site inspection. Check for unexploded ordnance, gas lines, water lines, sewer lines, pipelines, electrical wires, fiber optics, or any other underground infrastructure before installing the ground rod or earth anchors. The rod may extend up to 1.5 meters (5 feet) into the ground. The earth anchors may extend up to 35 cm (14 inches) into the ground. Failure to check may result in bodily injury, death, damage to infrastructure, or damage to equipment.

Vertical and horizontal clearance

Do not install the device near overhead power lines. If using the guy wires, allow clearance around the mast that is equal to the height of the mast. For example, fully extended to 5 m (15 feet), ensure a radius of the same distance around the mast remains clear for the guy wires.

Soil characteristics

The earth anchors are designed for hardpan, dense sand or gravel (class 1), medium sandy gravel (class 2), loose medium-to-fine sand (class 3), or loose, and fine uncompacted sand (class 4). Earth anchors may not anchor in some soil types. If the soil is unsuitable, choose an alternative anchor or a different location.

Prepare for field deployment

If you did the initial assembly and configuration in an office or lab, partial disassembly of the hardware will make it easier to move to the field.

- Power off the IoE Module and disconnect the sensor cables. Keep track of which sensor is connected to which connector, you'll need to connect them the same way or repeat the steps in *Configuring the Carbon Node* on page 5-1.
- Remove the battery (see *Removing the main battery* on page 8-20).
- Remove the four nuts and bolts that were installed in the frame rails and fold the frame. Keep the nuts and bolts for reassembly.
- Gather your tools and hardware. Get some water, a snack, and put a smile on your face. It'll be a good day!

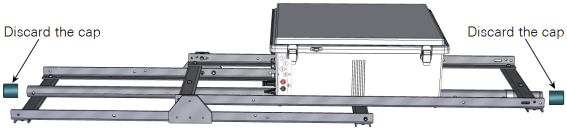
Initial assembly

Warning: *The components of this product are heavy (see Specifications on page 11-1 for weights). Use caution to avoid injury when lifting and securing components. Moving the fully assembled product should not be undertaken without appropriate precautions (e.g., a mechanical lift system, two-person lift, or other suitable lifting method).*

Mast and frame

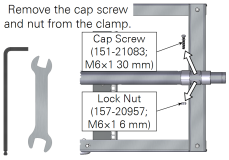
Caution: Wear gloves and goggles for safety.

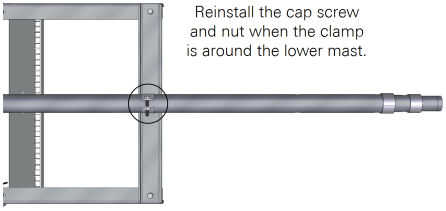
1 Remove and discard the black caps from the top and bottom of the mast.



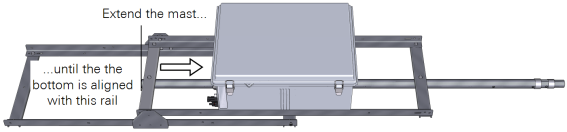
2 Release the upper mast clamp.

Remove the nut and cap screw that secure the mast, and then pull the mast out of the bracket. Slide the mast up and then press the largest section of the mast into the clamp. Then reinstall the hardware.



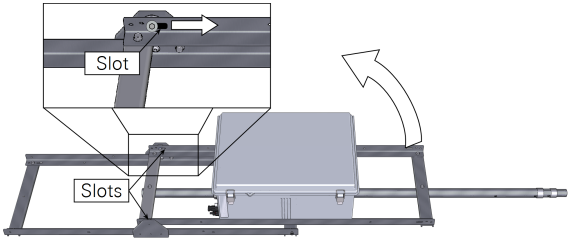


3 Extend the mast so the bottom is aligned with the lower rail.



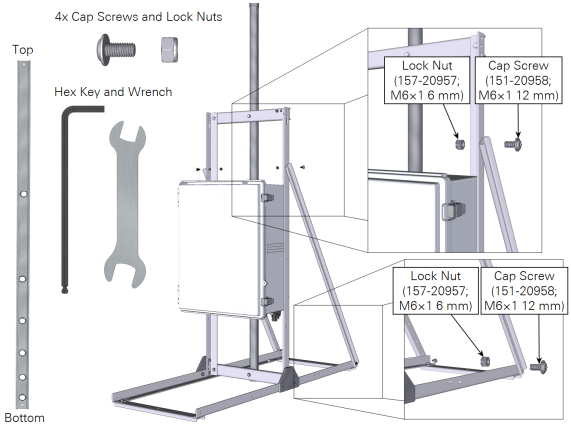
4 Rotate the enclosure frame to a vertical position.

Be sure the slots are not seated on the pins.



5 Install two angle-braces to secure the frame in the vertical position.

The high-density panel adjustment holes will be oriented toward the bottom. Install it with four cap screws and four lock nuts.

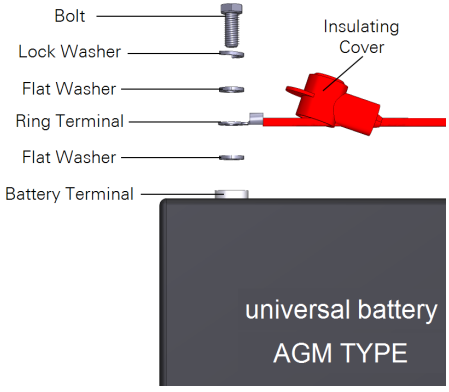


Installing the battery

Warning: *The battery can explode, start a fire, or cause severe burns if the terminals are shorted together. Exercise extreme care when handling the battery. Use insulated tools when practical.*

1 Connect the cable to the battery.

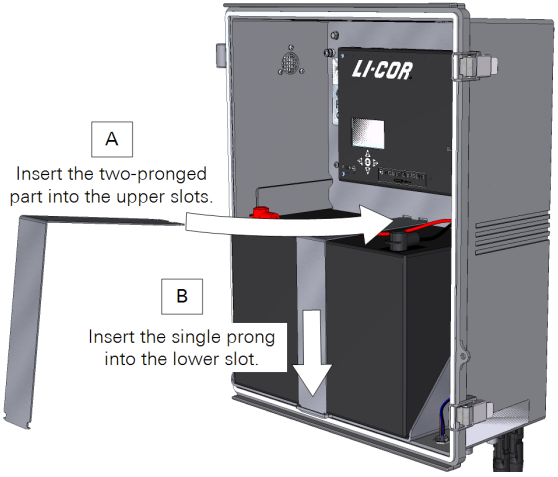
The cable (part number 99512-022) connects to the battery terminal with this hardware arrangement: flat washer, cable ring terminal, flat washer, lock washer, and finally, the bolt. Washers and bolts are included with the battery. Attach the red cable to the red terminal (+) and the black cable to the black terminal (-). Tighten the bolts securely with the wrench and then slide the insulating covers over the terminal.



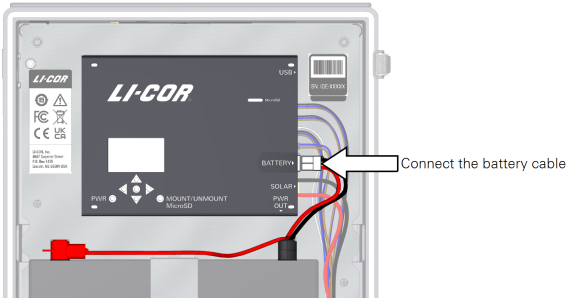
2 Set the battery on the shelf with the terminals toward the front of the box.

3 Install the battery bracket.

Insert the two-pronged part into the upper slots (A) and the single prong into the lower slot (B). The bracket holds the battery in place if the system falls over, protecting you and the equipment.



4 Connect the battery cable to the connector.



See *Removing the main battery* on page 8-20 for removal instructions.

Using an external power supply

The IoE Module can be powered from an external power supply that delivers 9 to 33 VDC, 3.0 A current. If using an external power supply, do not connect a solar panel or battery. Instead, rely solely on the external power. See *Optional auxiliary power cables* on page 1-10 for cable options.

Field installation

See *Initial assembly* on page 3-4 for the initial hardware assembly.

Site preparation

Place the frame on level ground. The LI-720 should have a vertical orientation. If the ground under the frame is sloped or uneven, use a shovel to level the surface. Pack any soil that was loosened – tamp it with your feet. Position the frame so that the solar panel faces the equator for maximum solar power.

Installing the adapter and LI-720

Caution: Wear gloves and goggles for safety.

1 Insert the two set screws into the adapter until they are flush with the inside wall.

2 Install the adapter for guy wires and the instrument.
It threads onto the upper mast. Position the mast in such a way that the guy cables are oriented as shown in *Figure 3-1* on the next page.

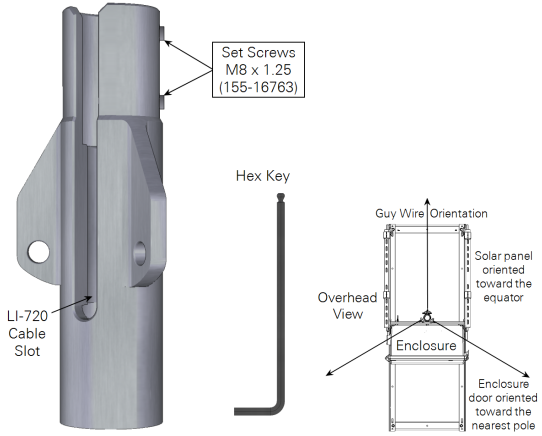


Figure 3-1*. The adapter threads onto the mast. Rotate the mast so one guy wire extends the direction opposite the enclosure door and the other two extend to the sides.*

3 Connect the power/data cable to the LI-720 and tighten it securely.

Leave the other end disconnected for now.

4 Clip the guy cables in place.

Let them dangle for now.

5 Install the LI-720 in the adapter.

Set the sensor in place and tighten both set screws with the 4-mm hex key. Tighten until it contacts the post, and then an additional ¼ turn clockwise.

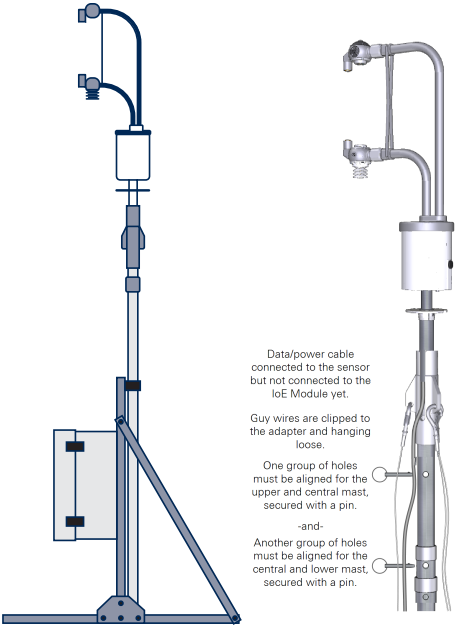
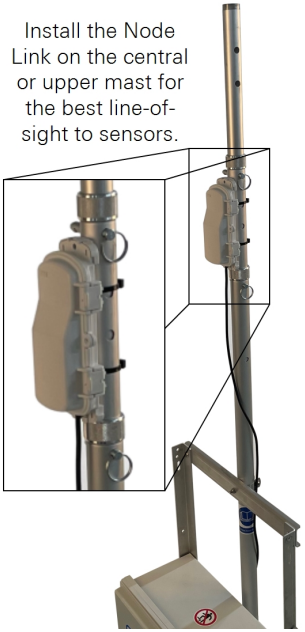


Figure 3-2*. Two pins secure the telescoping mast sections. The upper and central mast sections are secured with one pin. The central and lower mast sections are secured with the second pin.*

Installing the Node Link

If your Carbon Node includes a Node Link, install it on the central or upper mast segment. Identify the top of the bracket and then attach it to the IoE module mast using two zip ties. Then install the Node Link in the bracket.



See *Adding a Node Link to the Carbon Node* on page 5-7 for more details on Node Link installation and configuration.

Adjusting the mast

The mast features knurled clasps to hold the sections in position while you make adjustments, and two pins to lock the mast.

Caution: Do not allow the mast to slam down. Use two hands to extend the mast. If the mast de-extends without resistance, instruments attached may be damaged.

For measurement heights between 2 and 3.5 meters, extend the upper section of the mast to the desired height. Tighten the clasp and secure the upper and central portions of the mast with a pin.

For measurement heights between 3.5 and 5 meters, fully extend the upper mast and then extend the central section of the mast to the desired height. Tighten the clasp and secure the lower and central sections of the mast with a pin. The mast can be adjusted in 20 cm increments. Both pins are needed to secure the mast when it is extended. One pin secures the central and upper mast sections; the other pin secures the central and lower mast section.

Installing earth anchors and guy wires

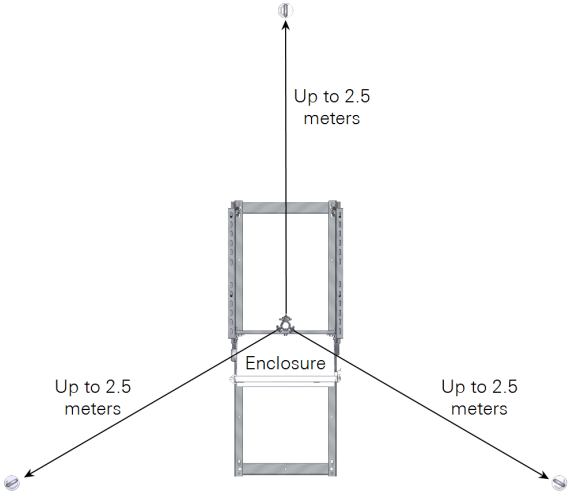
Guy wires are required for stability if the mast is extended. If the mast is not extended, sandbags can be used to stabilize the platform.

If you stand facing the door of the enclosure, one guy wire should be oriented directly away from you, one should be to your right, and the other to your left. Rotate the mast until the fins on the adapter are oriented that way.

The guy cables should be around 20° to 30° angle from the mast. You can approximate the angle by pacing off the distance or measure the angle with an app on a smart phone.

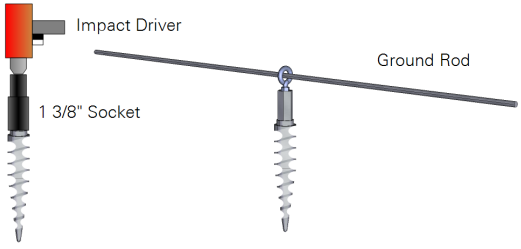
1 In the direction that each guy will extend, pace off or measure the distances for the anchors.

2 Mark points for the three earth anchors on a radius around the mast, providing three equidistant anchor points along the radius.



3 Drive the earth anchors straight into the ground, perpendicular to the surface.

To install, insert the ground rod through the eye bolt. Use the rod as a lever to drive the anchor, being careful to avoid bending the rod. Or, use an impact wrench and a 1 3/8" socket.



4 Drive each anchor until all of the threads are below the soil surface.

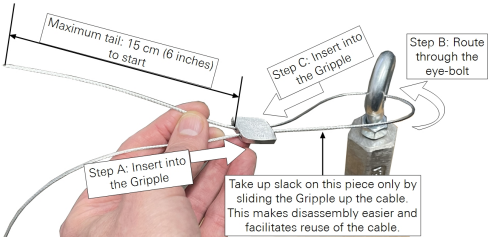
If the opening in the eye bolt is not perpendicular to the mast, drive it further until the opening is perpendicular toward the mast.

5 Install the guy cables.

A First, push the cable through the Gripple.

B Route the guy cable through the eye-bolt on top of the anchor.

C Push the cable through the other side of the Gripple.



D Repeat this for the other guy cables, leaving them loose until all three are installed.

6 Tighten each guy wire to achieve equal tension.

Guy wires should not apply any load to the mast. They should be just tight enough to provide stability.

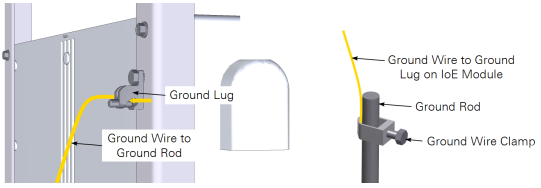
Releasing a Gripple (loosening a cable)

Gripple cable locks can be released with the key (part number 611-21003). Insert the key in the hole adjacent to the cable. Press the release key until the cable moves freely in the Gripple. If the Gripple has been in the field for a while, dirt or corrosion may make it difficult to release. First, attempt to tighten the cable slightly to loosen the mechanism. If you are unable to free the cable, you may need to cut it. Make the cut in such a way that you preserve a long, usable piece of cable.

Installing the ground rod

The ground kit includes a ground rod, copper wire, and clasp. The ground rod can be inserted into the ground to ground the equipment. Drive the ground rod as close as possible to the IoE Module frame, preferably between the lower rails, behind the enclosure to prevent tripping hazards.

To drive the ground rod, use a hammer drill with ground rod bit or a sledge hammer. Attach the copper wire between the ground lug on the back of the box and the ground rod using the ground wire clamp. Tighten it with the 1/2" open-end wrench and slotted screwdriver.



Attaching the solar power supply

If your system has solar power components, attach them as described here. Install the battery as described in *Installing the battery* on page 3-6.

1 Consider the ideal angle for the solar panel.

Determine the ideal attachment point for the lower U-rails to position the solar panel at an angle that faces the sun at midday. The angle of the panel can be the same as the latitude of your site to ensure optimal charging. For example, installations in northern Canada, Sweden, or Siberia will have optimal charging with the panel at a 45° angle and a southward orientation.

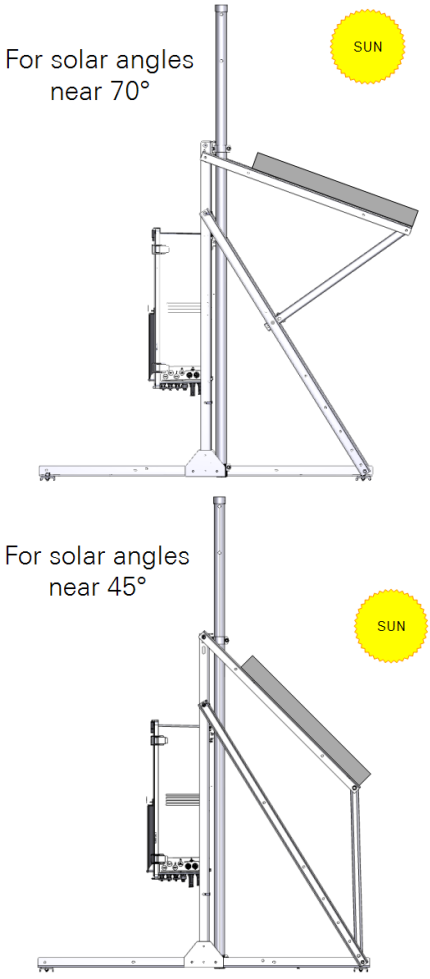
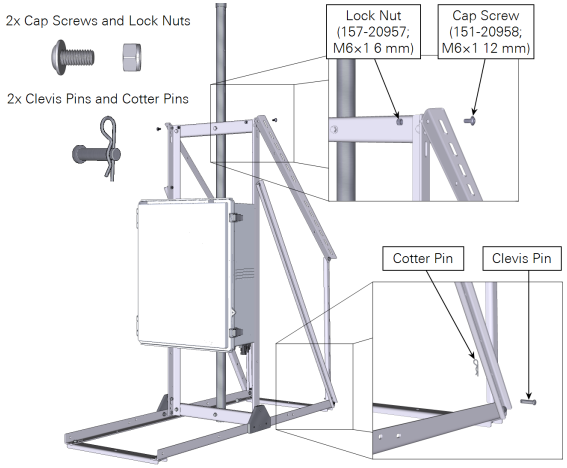


***Figure 3-3**. Orient the panel so it has the maximum exposure to sunlight.*

2 Attach the solar panel rails at the desired angle.

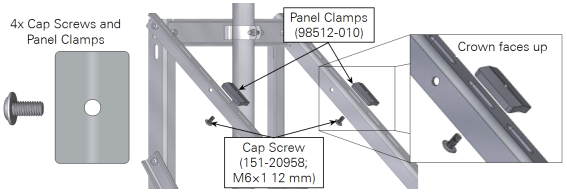
The upper angle rails attach to the top with two cap screws and nuts. The lower U-rails attach with two clevis/cotter pins.



3 Remove the panel from the box and discard the packaging material.

Retain the warranty information and manufacturer's documentation.

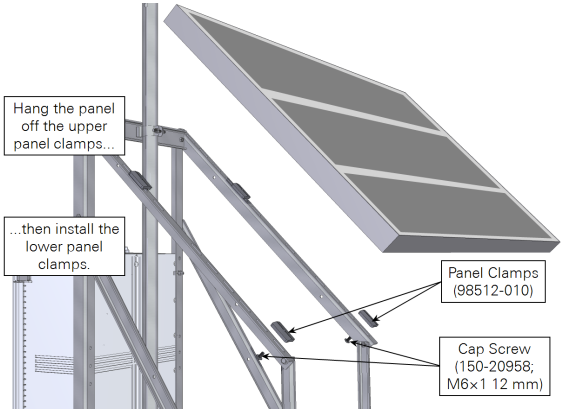
4 On the panel frame rails, loosely install two upper clamps as shown.



5 Place the solar panel over the upper clamps so they hold the frame to the rails.

6 Install the two lower clamps under the solar panel frame.

You may need to adjust the position of the panel and clamps to ensure that all four clamps secure the panel frame.



7 Tighten all four clamps securely.

8 Install the solar panel power cables between the panel and the two connectors on the bottom of the enclosure.

Section 4.
Installing the LI-720

The LI-720 is designed for easy installation with the LI-COR IoE Module and other meteorological stations. It uses a single cable for power and communications (SDI-12 and RS-232 serial protocols). Remove the caps that cover the transducers, gas analyzer, PPFD sensor before powering on the instrument (see *Figure 4-1* below).

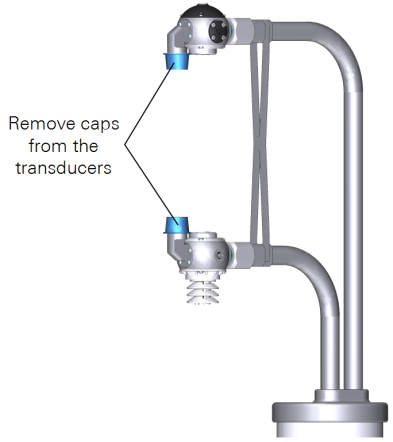


***Figure 4-1**. Protective caps should be removed before powering on the sensor.*

Caution: Keep the LI-720 powered off when handling it and installing it. Impacts and collisions – especially when it is powered on – may affect the calibration.

Deployment considerations

Be mindful of these considerations to ensure that the data you collect accomplishes your measurement goals.

Distance from surrounding elements

To ensure that the LI-720 measures a representative area-of-interest, install it above or as far as possible from large obstructions that affect the flow of wind, such as buildings or large solitary trees. Small elements, such as instruments on a weather station, are not problematic, allow clearance of at least two (2) meters, if possible.

Caution: If deploying the LI-720 near other LI-720s, LI-710s, or sonic anemometers, allow at least two (2) meters of clearance to prevent ultrasonic interference. If deploying the LI-720 near a radio antenna, position the antenna >2 meters away from the LI-720 to reduce the risk of electromagnetic interference.

Measurement area

Measurements from the LI-720 represent an area immediately surrounding the sensor. Therefore, you should install the sensor in the middle of the area-of-interest. Large open areas are ideal. For crops and grasslands, the middle of the field is ideal.

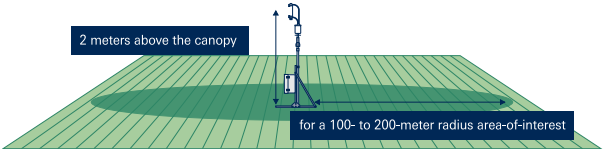


***Figure 4-2**. When possible, deploy the LI-720 in the middle of the area of interest. The sensor should be at least 2 meters above a uniform canopy for a measurement area of 100 to 200 meters around the device.*

If you are unsure where to install the sensor, put it in the middle of the area you want to measure. If you have to choose a side, choose the side that is downwind of the prevailing wind over the area-of-interest (see *Figure 4-3* below).

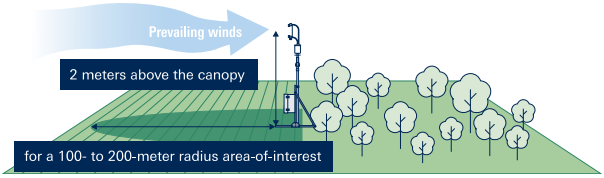


***Figure 4-3**. Where the LI-720 cannot be deployed in an area-of-interest, it can be positioned at the edge on the downwind side. At a height of 2 meters above the canopy, assume a 100 to 200 meter area-of-interest in the upwind direction.*

Height above the canopy

The area represented in measurements from the LI-720 will depend on its height above the plant canopy. The LI-720 should be installed at least 2 meters above the canopy. At a 2-meter mounting height, the fetch is assumed to be a 100 to 200 meter radius around the LI-720 (see *Figure 4-4* on the next page). All landscape elements within this range can contribute to the carbon dioxide flux measurement.

Over fast-growing canopies, such as soybeans, sorghum (milo), wheat, flax, rice, maize (corn), vegetables, and cotton, install the LI-720 at 3.5 to 5 meters above the surface before germination for a fetch up to 350 to 500 meters. As the crop grows, the distance between the canopy and sensor will become smaller, and so will the fetch. This is an ideal measurement scenario - the area measured represents the area-of-interest for the entire growing season. Alternatively, you can raise the height of the LI-720 over

the growing season to maintain a consistent measurement height.

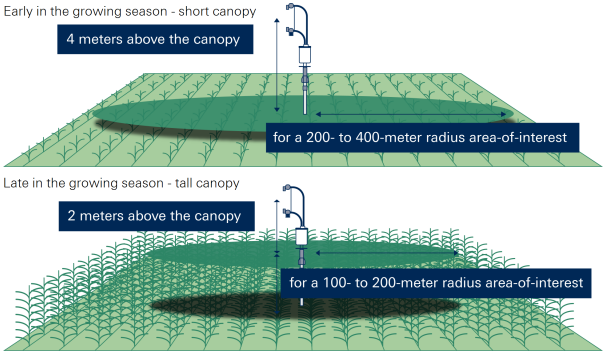


***Figure 4-4**. The LI-720 can be installed at a fixed position over crops. Install it at a height that is at least 2 meters above the expected canopy height.*

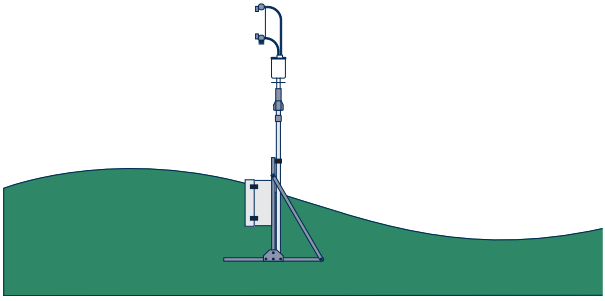


***Figure 4-5**. Over a short canopy with rolling terrain, the instrument should be at least 2 meters above the top of the canopy.*

Over orchards and woodlands, which are characterized by partial to full canopy closure, the LI-720 should be at least 2 or 3 meters above the top of the canopy.

Figure 4-6*. The LI-720 should be at least 2 to 3 meters above the top of orchards, woodland, and forest canopies.*

Slope and tilt

The LI-720 should have a vertical orientation. Both pitch and roll are reported by the sensor, but you can use the **level application** on a mobile phone to confirm that the sensor is vertical.

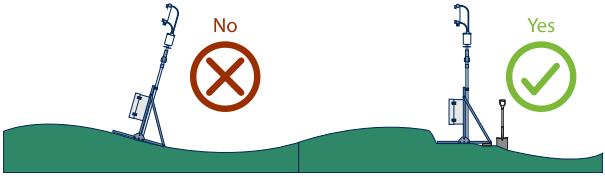
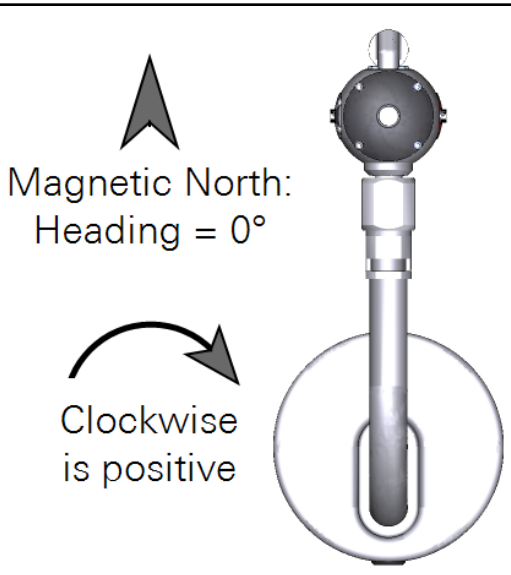


Figure 4-7*. Install the IoE Module with an LI-720 with 0° of tilt. Use a shovel to level the ground under the IoE Module or use concrete paving stones for support.*

North offset

The LI-720 has a built-in magnetometer that reports a heading of 0° when the sensor is oriented toward magnetic north (not corrected for declination). Headings are positive clockwise, reported as *heading* in the dataset (see *Table 6-1* on page 6-16).

Note: Magnetometers are sensitive to electromagnetic interference from magnetic materials and electrical equipment. If the reported heading seems implausible, move the sensor so it is far from interfering equipment. If there is risk of interference at the site, you can override the measured value with a user-entered value (see *Entering site metadata* on page 6-3).



Mounting the LI-720

The LI-720 mounts readily to the IoE Module. Connect the power/data cable to the LI-720 before installing it in the adapter. Install the LI-720 in the adapter (part number 98512-081). Tighten set screws with a 5/32" or 4 mm hex key to 22 N-m (16 ft-lbs). If no torque wrench is available, tighten each set screw until it contacts the pipe, then ¼ turn more.

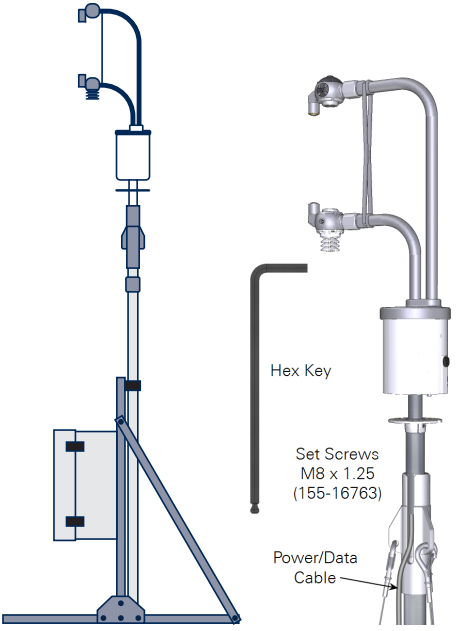


***Figure 4-8**. The LI-720 can be installed in the IoE Module to create a Carbon Node on LI-COR Cloud.*

Section 5.

Configuring the Carbon Node

The Carbon Node – an LI-720 connected to LI-COR Cloud with an IoE Module – presents the simplest and most scalable way to use the LI-720. Here we describe how to use the LI-720 as a Carbon Node. After assembling the IoE Module and mounting the LI-720 on the mast, (see *Assembling the IoE Module* on page 3-1 and *Installing the LI-720* on page 4-1), return to this section to configure the Carbon Node.

Initial setup

Leave the LI-720 cable disconnected at this point. You'll connect the cable as part the configuration.

Adding a sensor

1 Power on the IoE Module.
Short-press the power button (PWR ○) and wait until the main screen is displayed.

2 Set the time zone.
To apply an offset to the default UTC time, press left four times (◀◀◀◀) and use the up and down buttons to choose an offset. Press **Select** (○) to apply the timezone and return to home. The IoE Module does not account for daylight saving time.

3 Prepare to add sensors.

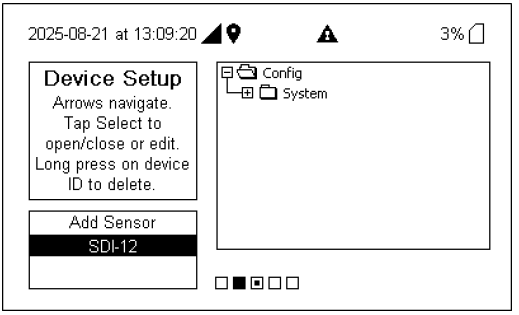
The IoE Module must have a strong cellular connection during configuration. Keep the sensors nearby but leave the cable disconnected for now.

4 Navigate to the **Device Setup** screen.

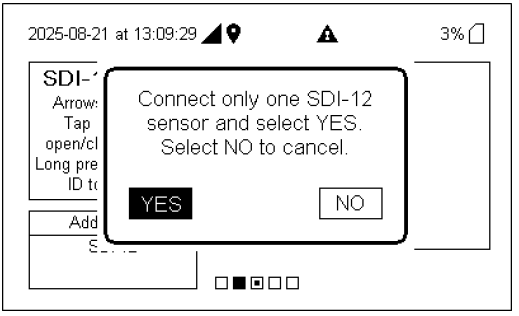
From the home screen, press left three times (◀◀◀) to access the **Device Setup** screen.

5 Select **SDI-12** and press **Select** (O) to begin.

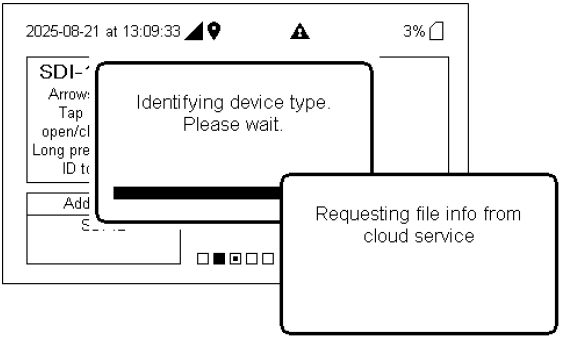
Leave all device cables disconnected but nearby.



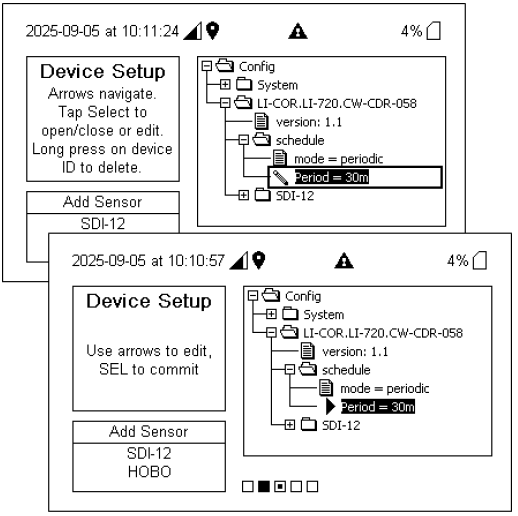
6 Connect one SDI-12 sensor and select **YES** to proceed.



The IoE Module will recognize the device and request configuration information from LI-COR Cloud. Several messages will indicate the progress.

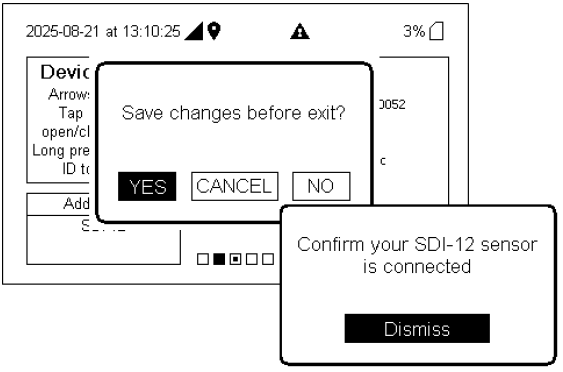


7 Preview the device information and make changes if desired. Leave the period at 30 minutes to use cleaning and gap filling on LI-COR Cloud.

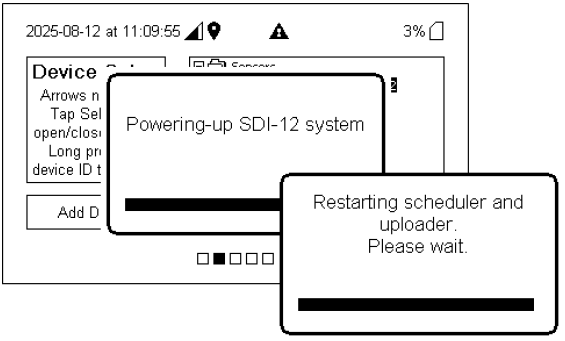


8 Save the configuration.

Press **Right** (▶) and then **Select** (O) to save changes, and then confirm that you want to save. You MUST save changes and dismiss the next prompt.



9 Watch as the IoE Module finishes the configuration.
Be sure the device returns to the **Home** screen, indicating success.



- If the IoE Module is partially configured but has no interactions for one hour, it will abort the configuration and return to the prior configuration and display the home screen.

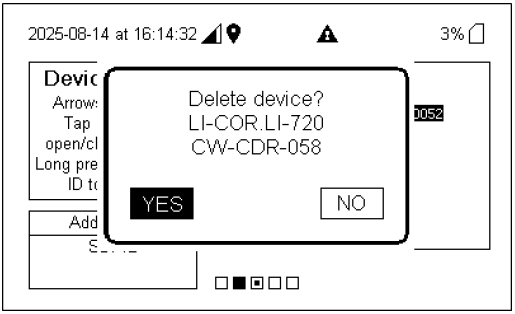
- Trouble registering a sensor? See *IoE Module troubleshooting* on page 7-5.

Deleting a sensor

If you have connected a device but want to delete it for some reason or another, follow these steps.

1 Enter **Device Setup** and select the device to remove.

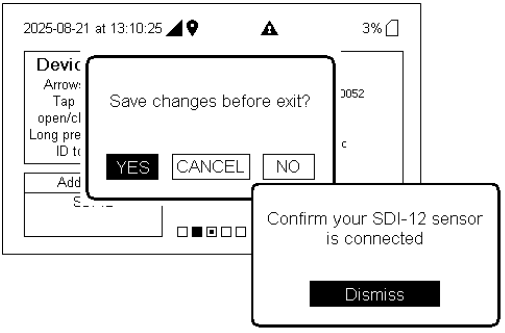
2 Long-press **Select** (O) until prompted:



3 Select **YES** to remove the device and its configuration from the IoE Module.

4 Save the configuration.

Press **Right** (▶) once to open the prompt, then press **Select** (O) to save the changes. You MUST save changes and dismiss the prompt for the settings to be applied.



5 Watch as the interface returns to the home screen, indicating success.

Changing the reporting period

The reporting period can be set at the IoE module. The LI-720 and Carbon Node reports results every 30 minutes by default, but this can be changed to any interval between 15 and 60 minutes (5-minute resolution). The Stevens probe reports results every 10 minutes by default but it can be any interval between 10 and 60 minutes (5-minute resolution).

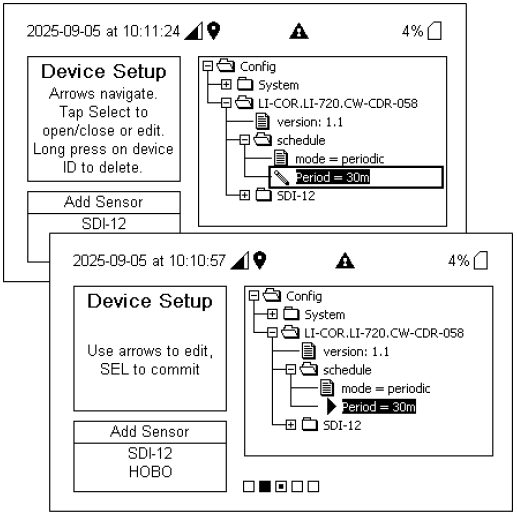
Note: Use a 30-minute averaging period if you want to use outlier detection and gap filling on LI-COR Cloud.

To change the reporting interval:

1 Go to the **Device Setup** screen and select a device.

2 Use the arrow keys to select the item to adjust - in this case, select **Period** to open options.

Follow the directions on the screen.



3 After making changes, use the arrow keys to navigate away from the **Device Setup** screen.

4 When prompted to save changes, select **YES**.

Adding a Node Link to the Carbon Node

Each Water Node and Carbon Node can host a Node Link, which supports up to 50 sensor nodes. The Node Link is supported by new IoE Modules (indicated by the HOBOnet label and cable connector) with firmware v1.2 or newer.

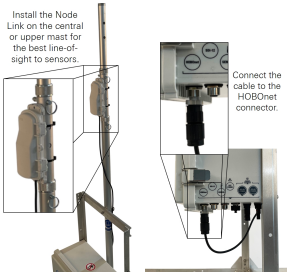
Each wireless device in a Node Link must have line-of-sight with other devices or the Node Link (<200 meters distance between sensors). Data can be transmitted through up to five sensors. Vegetation can block wireless signals, so be sure each transceiver is above the plant canopy, even as it grows

Installing the Node Link and adding sensors

Follow these steps if it is your first time setting up the Node Link. Keep the sensors close to the IoE Module for now so you can interact with both devices during the registration steps.

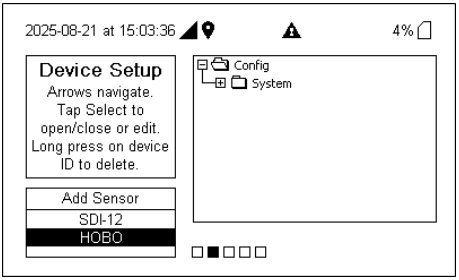
1 Power off the IoE Module.

2 Install the Node Link and connect the cable to the IoE module.
Install the Node Link on the central or upper mast segment. Identify the top of the bracket and then attach it to the IoE module mast using two zip ties. Then install the Node Link in the bracket.

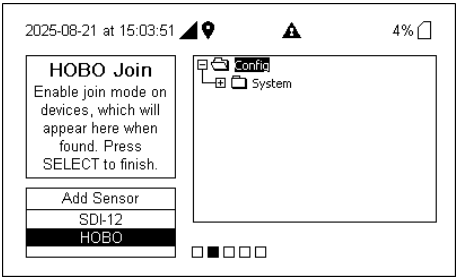


3 Power on the IoE Module.

4 Press left three times (◀◀◀) to enter **Device Setup** mode.
Under **Add Sensor**, look for **HOBO**, which indicates that the Node Link cable is physically connected and Node Link is recognized by the IoE Module.

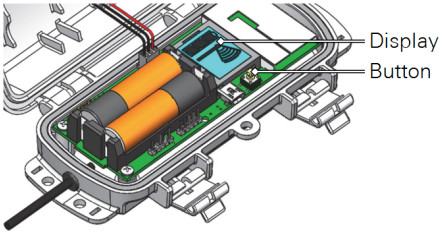


5 Select **HOBO** and then press **Select** (O) to add a device. Now the Node Link is ready to connect with individual sensors.



6 Prepare one sensor - follow the included instructions.
For some sensors, you may need to install batteries before the first use. Other sensors may need to be assembled before being powered on. Follow the directions included with each sensor before placing it in JOIN mode.

7 While the IoE Module is waiting, press and hold the button on the sensor for 3 seconds to enter JOIN mode.



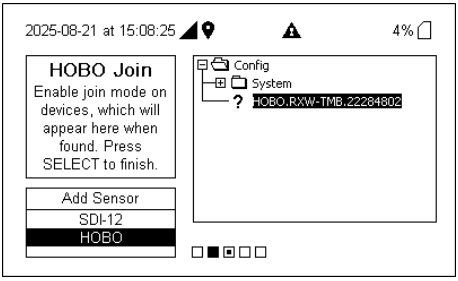
Watch the display as the sensor joins the network.

The signal strength icon blinks while searching for a network.

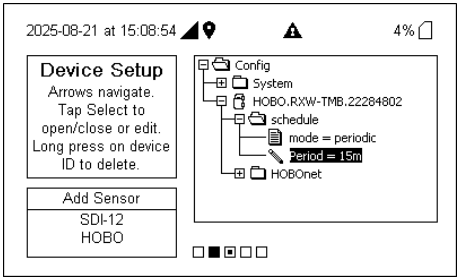
Once a network is found, the icon stops flashing and the bars cycle from left to right. The **X** icon blinks while the sensor completes the registration process. This may take up to five minutes.

Once the sensor has finished joining the network, the **X** icon disappears. The sensor should be connected to the node link.

8 When recognized, the device will appear in the list on the IoE Module.

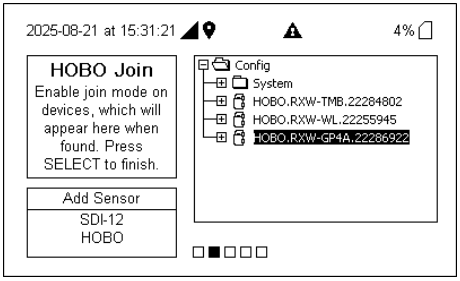


9 Press **Select** (O) to complete the registration for this sensor.



10 Repeat steps 5 to 9 with additional sensors.

A Node Link can support up to 50 wireless devices. To delete a sensor, select it and long-press **Select**.



11 Save changes when you're done.

Press right (▶) until prompted to save changes. Accept the prompt and be sure the device returns to the home screen, indicating success.

Trouble registering a sensor? See *Carbon node sensor network issues* on page 7-13.

Installing sensors

Each sensor included with the Node Link includes a printed installation guide. Follow assembly and installation instructions on the guide. Additional information is available at onsetcomp.com/help-center.

Working with Node Link data

After registering the IoE Module with LI-COR Cloud (see *Adding a Node Link to the Carbon Node* on page 5-7), data are uploaded and can be viewed and retrieved from LI-COR Cloud (see *Working with Carbon Node data* on page 6-6).

Logging high-speed data

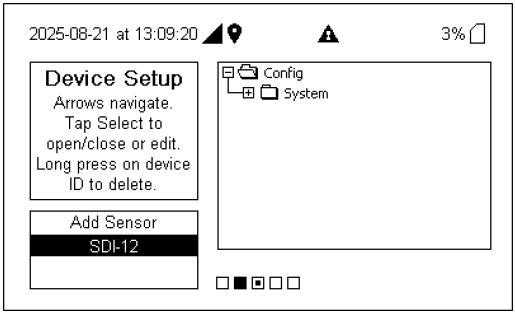
Caution: 10 Hz logging (under **Device Setup> Config > System**) is supported by the LI-720 only. Enabling 10 Hz logging with an LI-710 will cause unstable performance and the desired data will not be logged.

The 10-Hz raw data from the LI-720 can be recorded on the SD card as `.csv` text files. Note that raw data will fill the SD card quickly and should only be used under special circumstances. You will not be able to compute the same results with the raw data without additional data preparation and processing.

Caution: Only do this if you have a purpose for the raw data. There is no need to recompute under normal circumstances. 10 Hz data will not be recorded if the SD card is not mounted. Logging will stop when the card is out of storage space.

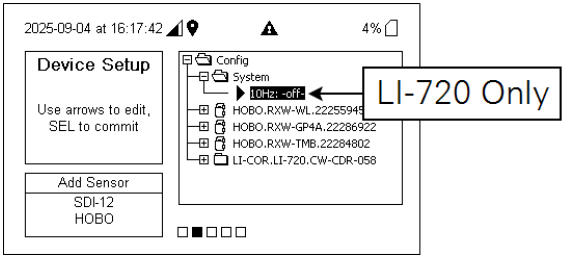
High-speed data are not stored on LI-COR Cloud. Instead, the files are logged to the SD card. The 8 GB card can record a maximum of 23 days of data. A 128 GB card is available, and it will store more. To enable 10-Hz logging:

1 From the home screen, press left three times (◀◀◀) to view the **Device Setup** screen.



2 Wait for the configuration folders to load and then press right once (▶) to enter the folders,

3 Open the **System** folder and select **10 Hz** -off-.



4 Press **Select** to enable editing and use the up and down (▲ ▼) keys to change the setting to **10Hz: ON**.

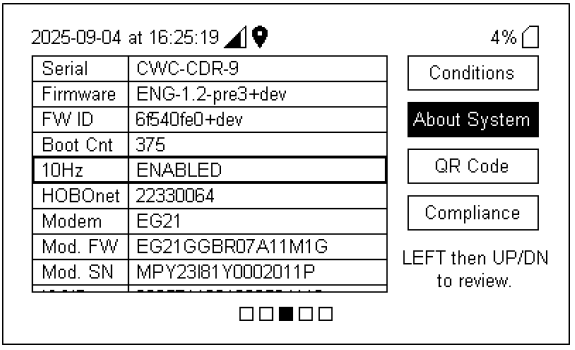
5 Press **Select** to apply the setting and then exit the device setup screen.

6 Save the changes.

Press right (▶) until prompted to save changes. Accept the prompt and be sure the device returns to the home screen, indicating success.

7 Verify the setting.

In the **About System** table, look for **10Hz ENABLED**. The logging state is persistent — if the IoE Module restarts, it will restart with the prior logging state.



Section 6.
Adding the LI-720 to LI-COR Cloud

A Carbon Node is an LI-720 that is connected to LI-COR Cloud with an IoE Module. You need an account – either a new one or an existing account – and the IoE Module must be registered.

Creating an account

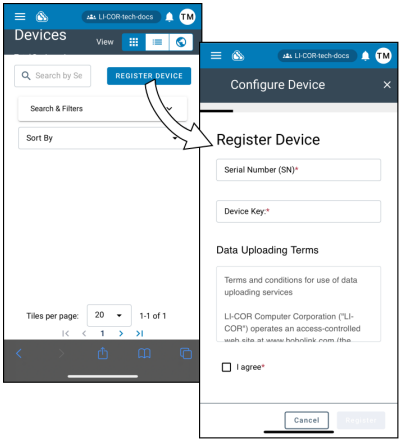
To create a new account:

1. Go to www.licor.cloud and select **Register Account**.
2. Fill in the form and accept the terms and conditions.
   Use a unique organization name and user name.
3. Confirm your account.
   Check your email (possibly the spam folder) for a verification message. Follow the instructions in the message to activate your account.
4. Log in.

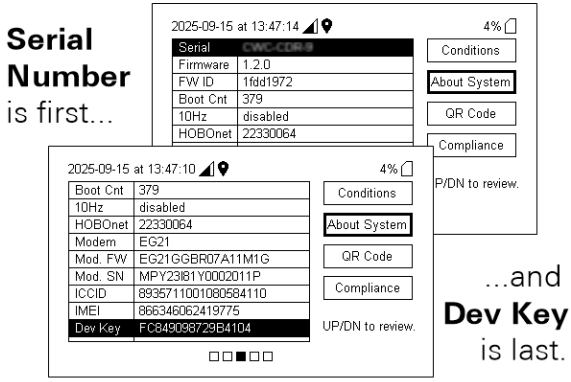
Registering the IoE Module

All devices must be registered to appear in LI-COR Cloud. To register a device:

1. Create a new account or log into your account at www.licor.cloud.
2. Select **Register Device**.



3 Enter the IoE Module **Serial Number** and device **Key**.
The key and serial number are on the IoE Module display (press left ◀ and down ▼ to view the system information).



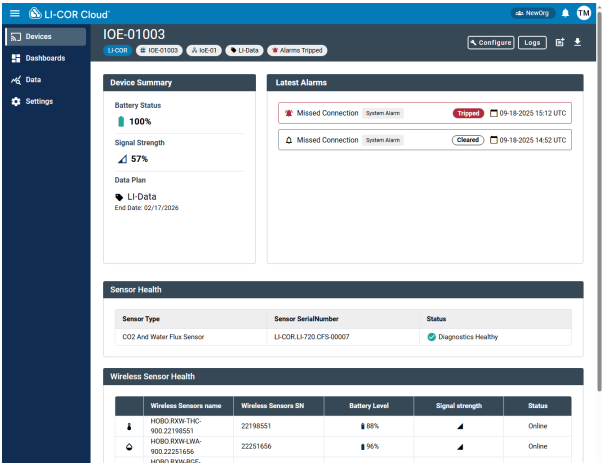
4 Fill in any additional information and complete registration.

5 Save the settings.

The IoE Module is now registered with LI-COR Cloud. Next, you'll configure the Water Node (LI-710) or Carbon Node (LI-720).

Viewing the Device Information

Click **Devices** and select a device for a quick overview of devices and status information.



Entering site metadata

Site metadata describes the deployment. It includes some details that are required to accurately display the flux footprint. Be sure to configure these parameters when you set up the device. Three parameters are required; others are optional.

This can be entered in the LI-COR Cloud interface (see *Figure 6-1* on the next page). The information is stored in the LI-720 itself.

- **Canopy Height (m)**: Distance between the top of the plant canopy and the soil surface in meters.
- **Measurement Height (m)**: Distance between the center of the sample path and the soil surface in meters.
- **North Offset (°)**: Degrees of rotation clockwise past magnetic north.

To enter site metadata:

1 From **Devices** view, select the device and click **Configure**.

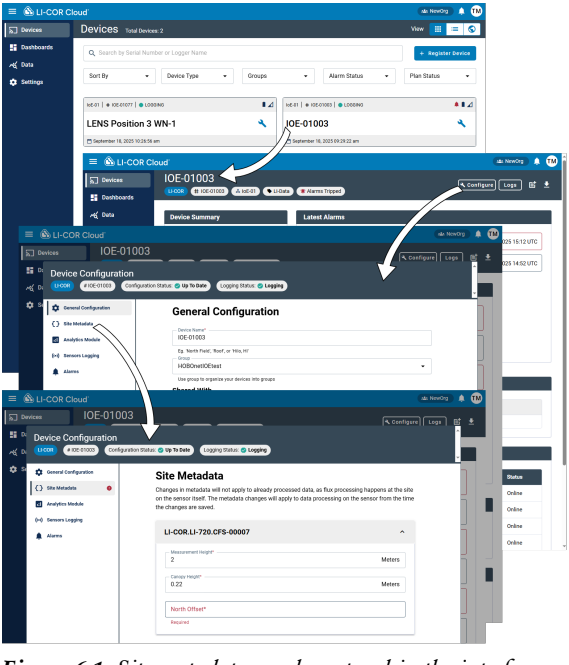


***Figure 6-1**. Site metadata can be entered in the interface.*

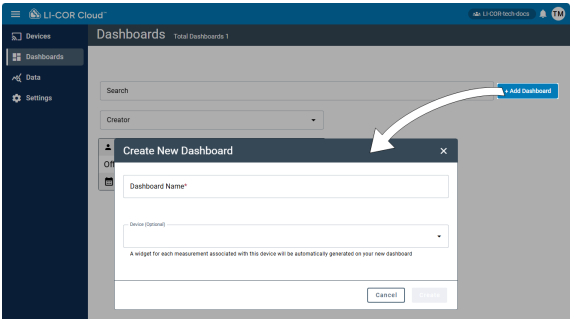
2 Select the **Site Metadata** tab.

3 Enter the parameters and click **Save** to apply the updates.

Creating a dashboard

After creating an account and registering the IoE Module that hosts the LI-720, you can customize the LI-COR Cloud Dashboard. Start by selecting some default Dashboard settings:

1 Select **Dashboards** and click **+Add Dashboard**.



2 Enter a **Dashboard Name**.

The name must be unique.

3 Select a **Device Template**.

LI-COR Cloud will list options for the widget for each measurement associated with this device.

4 Click **Create**.

LI-COR Cloud displays the new Dashboard along with some pre-configured widgets. Next, you can customize the Widgets or add others to the dashboard. If you have just powered everything on, there will not be much data to display so you may see an empty graph, but that will change as data accumulate. By default, the interface displays the last 1 day, but you can load a longer time span.

Congratulations! You have created a Carbon Node on LI-COR Cloud. Now, you can view data, process data, and

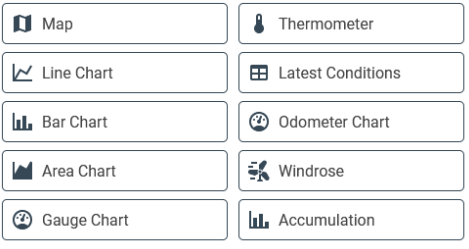
perform advanced data processing, including Gap Filling, CO_2 Accumulation, Flux Footprints, and more. See *Working with Carbon Node data* below for more details.

Working with Carbon Node data

Results from a Carbon Node are uploaded to LI-COR Cloud on the schedule (every thirty minutes by default). Widgets are used to display data from the Carbon Node. Widgets may be used to with default settings or customized to show parameters from multiple sensors and different parameters from the same station.

Overview of Dashboards

To view data from an instrument, you will create a Dashboard and add Widgets to it. LI-COR Cloud will show a variety of widgets by default. You can add, move, and resize widgets to suit your preferences. For Carbon Nodes, two widgets may be of special interest: accumulation and gap filling.



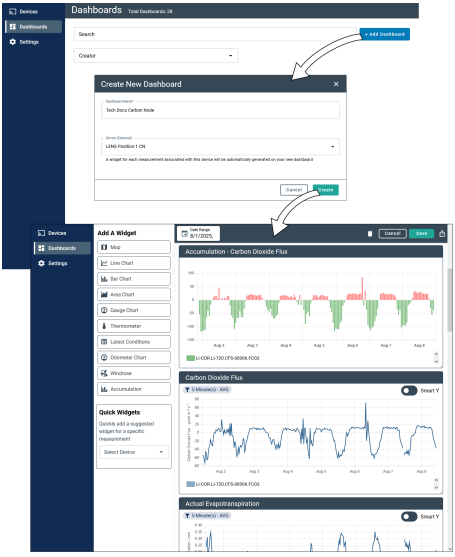
Accumulation widget

Accumulations can be computed for any variable. A chart of accumulations can show data from different instruments and parameters in the group. This maybe useful for comparison of measurements from multiple sensors or

sites of different parameters that help interpret the data. To set up an accumulation widget:

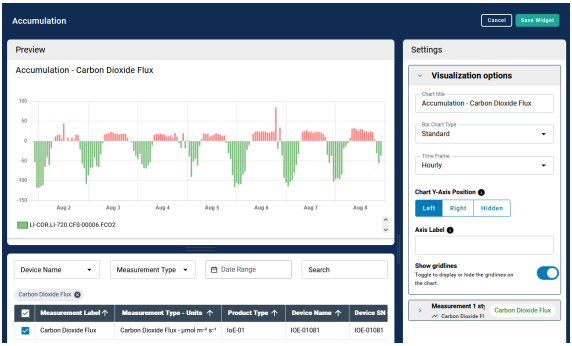
1 Add a Dashboard.

Widgets relevant to Carbon Nodes will be added automatically after you select a Carbon Node, including the Carbon Dioxide Flux Line Chart and the Accumulation widgets.



2 Customize the Widget.

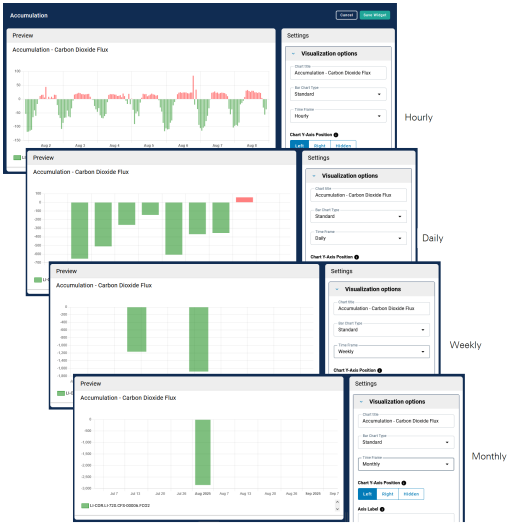
If you have saved the Widget, click Edit to view the Widget options. Then select the menu to view Chart Options. Use the Device Name and Measurement Type to constrain the list. This is to make it easier to find the parameter of interest. You can also search for measurements and constrain the date range.



The parameter will be added to a chart when selected.

3 Configure the display **Settings**, starting with **Visualization Options**.

Under **Bar Chart Type**, you can choose **Standard** to display bars side-by-side or **Stacked** to display bars on top of each other. Under **Time Frame**, choose Hourly, Daily, Weekly, or Monthly to change the accumulation period.



4 Apply more display properties

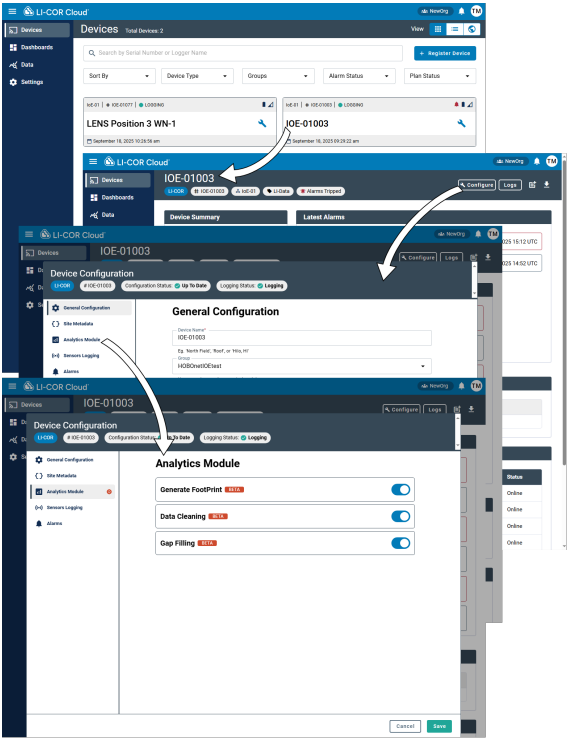
You can customize the y-axis label and position, and change the display parameters of each variable. You can apply threshold indicators to change the color of a displayed parameter if it is outside some configurable bounds.

5 Save the widget to display it on the dashboard.

Data cleaning, gap filling, and footprint widgets

Data cleaning, gap filling, and footprints are available in the interface. For fluxes from a Carbon Node, gap filled data are presented as a line chart, featuring the same display options. The footprint is part of the map. To use the feature:

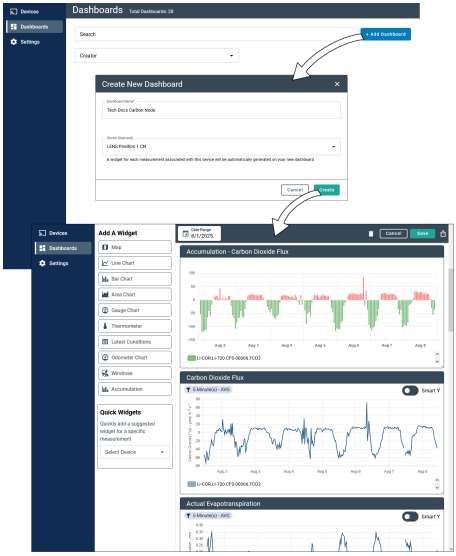
1 Enable the options under **Device Settings**.



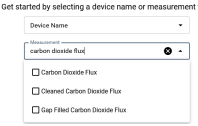
2 Save the changes.

3 Add a Dashboard.

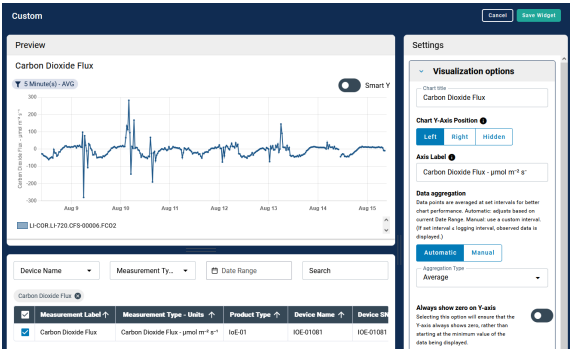
Widgets relevant to Carbon Nodes will be added automatically after you select a Carbon Node, including the Carbon Dioxide Flux Line Chart and the Accumulation widgets.



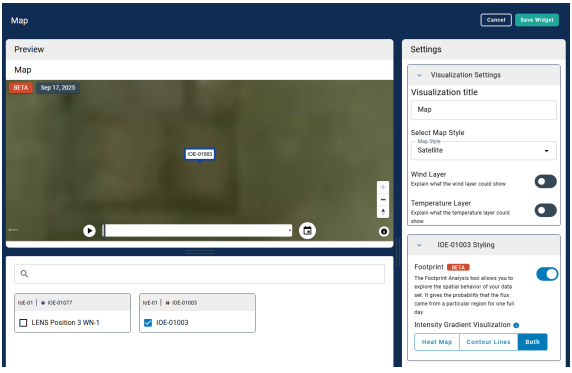
4 Add more variables and configure the display settings.



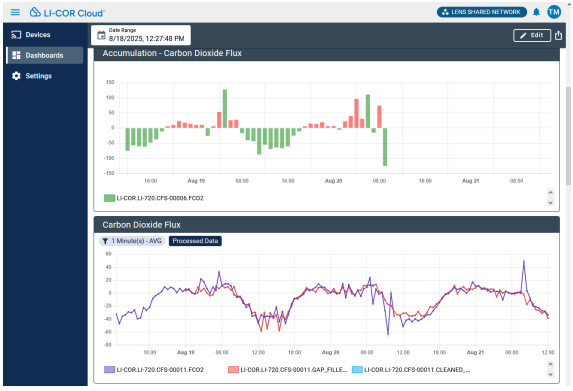
You can search for variables by device name, measurement type, and more. Display properties of each parameter can be changed to bring forth the most interesting aspects of the measurement.



5 Enable the footprint in the Map widget.



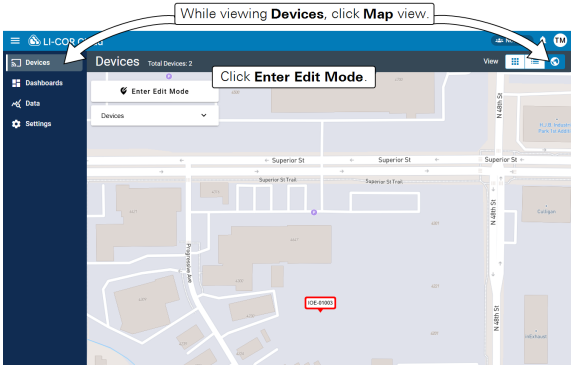
6 Save the settings and then save the **Dashboard**.



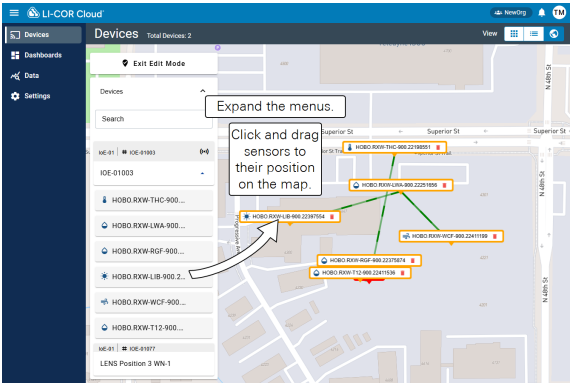
Adding RX sensors to the map

RX sensors that connected to the IoE Module via the Node Link can be displayed on the map. You'll need to specify the location of each sensor in the LI-COR Cloud interface. Follow these steps:

1 From the **Devices** tab, click **Map** view.



2 Click **Enter Edit Mode** to enable editing.



3 Expand the menus and click and drag each sensor to the position.

4 Click **Exit Edit Mode** to save the changes.

Variables, data, and diagnostics

Normally, the LI-720 reports flux results every 30 minutes with averages of biological and meteorological variables. It can be configured to provide the results in as short as five minutes or as long as one hour in five minute increments. In addition, high-speed raw data can be recorded at 10 Hz.

Flux results are reported to LI-COR Cloud via an IoE Module, stored in the IoE Module SD card, or logged to an external data logger. When enabled, raw data (10 Hz) are continually output over the RS-232 serial wires, and can be recorded to the IoE Module SD card or an external data logger.

Time stamp

When used with an IoE Module, the LI-720 does not use its internal clock. Instead, it enters an external trigger mode upon recieving the first trigger from the IoE Module

via SDI-12. In this mode, the IoE Module controls the timing of flux intervals. The IoE Module clock is automatically aligned with time stamps from GPS satellites.

When not connected to an IoE Module or data logger that can trigger a measurement period, the LI-720 disciplines its internal clock to the GPS time stamp from its own GPS receiver. If the LI-720 recieves one trigger but no follow up trigger, it will self-trigger a new measurement period after 36,000 samples have been recorded (1 hour of raw data). This is a fallback; a properly configured data logger will issue the trigger command on a schedule of 5 to 60 minutes (30 minutes recommended).

All time stamps are logged in UTC with no offset. You can apply an offset for the local time zone manually on the IoE module or you can choose a time zone when you download data from LI-COR Cloud. The offset applied to the time stamp is indicated in the data file.

Note: When setting a time zone on the IoE Module, use Standard Time. Do not apply an offset for Daylight Saving time to prevent artificial gaps and overlaps in the time series.

When data from a sensor, such as LI-710 or LI-720, are requested by the IoE Module, data are delivered with time stamp from the IoE Module. Those results are delivered to LI-COR Cloud with the time data intact. LI-COR Cloud will read the time that is included with sensor data, and it uses that information to construct the time series for displayed parameters. When you download data from LI-COR Cloud, you can choose a time zone to be applied to the data. The time stamp will be adjusted by adding or

subtracting hours. The offset is indicated in the time field (+0000 is UTC, -0006 is US Central Time, and so on).

Raw data

Raw data are provided at 10 Hz. You can view the data in the CarbonWare app or record it on the IoE Module or an external data logger.

Table 6-1. Variables, definitions, and units for raw data.

Variable	Description	Units
IDX	Index - a count at 10 Hz	#
U	Horizontal wind speed	$m\ s^{-1}$
V	Horizontal wind speed	$m\ s^{-1}$
W	Vertical wind speed	$m\ s^{-1}$
T_SONIC	Air temperature computed from the vertical anemometer.	°C
T_SONICH	Air temperature computed from the horizontal anemometer.	°C
SOS	Speed of sound computed from the vertical anemometer.	$m\ s^{-1}$
TA	Air temperature measured by the air temperature sensor.	°C
RH	Relative humidity measured by the RH sensor	%
PA	Air pressure	kPa
V_r0		
V_w0	Detector voltage for water reference band	Volts
V_c0	Detector voltage for CO_2 reference band	Volts
V_ref		Volts

Table 6-1. Variables, definitions, and units for raw data. (...continued)

Variable	Description	Units
V_h2o	Detector voltage for H_2O absorption band	Volts
V_co2	Detector voltage for CO_2 absorption band	Volts
V_par	Quantum sensor output voltage	Volts
V_det	Thermistor output voltage	Volts
T_det	Optical detector temperature.	°C
T_src	Optical source temperature.	°C
RH_src	Relative humidity inside the upper gas analyzer housing.	%
VTX		
PITCH	Offset from vertical front-to-back	°
ROLL	Offset from vertical side-to-side	°
HEADING	Offset from magnetic north	°
Status	Performance indicator	#
SEQ		#
VIN	Power supply voltage	#
RSSI	Residual signal strength indicator	#
PPFD	Photosynthetic photon flux density	µmol m^{-2} s^{-1}
H2O_ABS	Optical absorption by H_2O	#
CO2_ABS	Optical absorption by CO_2	#
H2O	Water vapor mol fraction	mmol mol^{-1}
CO2	Carbon dioxide mol fraction	mmol mol^{-1}
CO2_MOLAR_DENSITY	Carbon dioxide molar density	mmol m^{-3}
H2O_MOLAR_DENSITY	Water vapor molar density	mmol m^{-3}

Computed results

Computed results are fluxes over the thirty-minute period and averages of biological and meteorological parameters over the same period. Computed results can be logged to an external data logger (SDI-12), LI-COR Cloud via an IoE Module, or an IoE Module that is not connected to LI-COR Cloud. The parameters delivered are the same.

When retrieved from LI-COR Cloud, the file will be presented as text or a MS Excel spreadsheet. The file name is the date of the dataset. The time stamp is in UTC. If a time zone offset it applied, it is indicated in the data. After extracting the compressed data, you'll see one file for each component that contributed data. You may have one file from the LI-720 and one from the IoE Module. Additional files may be present if other devices are connected to the IoE Module.

Table 6-2. Parameters reported by the LI-720 via the SDI-12 protocol. All parameters are reported to LI-COR Cloud automatically.

Variable	Description	Units	Precision	Group
FCO2	CO_2 Flux	umol m^{-2} s^{-1}	3	0
H2O_FLUX	H_2O Flux	mmol m^{-2} s^{-1}	3	0
ET	Eva-potranspiration	mm	3	0
LE	Latent heat flux	W m^{-2}	3	0
H	Sensible heat flux	W m^{-2}	3	0
TAU	Momentum flux	kg m^{-1} s^{-2}	3	0
SAMP_CNT	Sample count	#	0	0

Table 6-2. Parameters reported by the LI-720 via the SDI-12 protocol. All parameters are reported to LI-COR Cloud automatically. (...continued)

Variable	Description	Units	Precision	Group
SEQ	Sequence number	#	0	0
WD	Wind direction	degrees	2	1
WS	Windspeed	$m\ s^{-1}$	3	1
OFFSET	Offset from magnetic north	degrees	2	1
U_SIGMA	Standard deviation of U	$m\ s^{-1}$	3	1
V_SIGMA	Standard deviation of V	$m\ s^{-1}$	3	1
W_SIGMA	Standard deviation of W	$m\ s^{-1}$	3	1
T_SONIC_SIGMA	Standard deviation of sonic temperature	C	2	1
TILT	Sensor tilt	degrees	0	2
FLUX_SSITC_TEST	8 is a placeholder, then QC parameters *tau*, *WTS* (QC Flag for heat flux), *WC* (QC Flag for CO_2 flux), and *WH* (QC Flag for H_2O Flux) 0,1,2 or 9. 9 is missing	#	0	2
USTAR	Friction velocity	$m\ s^{-1}$	3	2
MO_LENGTH	Monin-Obukhov length	m	3	2
T_SONIC	Sonic temperature	C	3	2

Table 6-2. Parameters reported by the LI-720 via the SDI-12 protocol. All parameters are reported to LI-COR Cloud automatically. (...continued)

Variable	Description	Units	Precision	Group
TA_SONIC	Sonic temperature corrected for humidity	C	3	2
CO2	CO_2 mole fraction	umol mol^{-1}	3	2
H2O	H_2O mole fraction	mmol mol^{-1}	3	2
AH	Absolute humidity	g m^{-3}	2	3
RH	Relative humidity	%	2	3
SVP	Saturated vapor pressure	kPa	2	3
VPD	Vapor pressure deficit	kPa	2	3
PA	Atmospheric pressure	kPa	2	3
TA	Air temperature (not sonic)	C	2	3
TD	Dewpoint temperature	C	2	3
PPFD	Photosynthetically active radiation	umol m^{-2} s^{-1}	1	3
INST_PWR	Instrument Power	W	2	4
INPUT_V	Input Voltage	V	2	4
DIAG	Diagnostic Value	#	0	4
RSSI	Signal Strength	#	0	4
U_RECORDS	Number of Valid U Records	#	0	5

Table 6-2. Parameters reported by the LI-720 via the SDI-12 protocol. All parameters are reported to LI-COR Cloud automatically. (...continued)

Variable	Description	Units	Precision	Group
V_RECORDS	Number of Valid V Records	#	0	5
W_RECORDS	Number of Valid W Records	#	0	5
TSONIC_RECORDS	Number of Valid TSONIC Records	#	0	5
CO2_RECORDS	Number of Valid CO2 Records	#	0	5
H2O_RECORDS	Number of Valid H_2O Records	#	0	5
TA_RECORDS	Number of Valid TA Records	#	0	5
PA_RECORDS	Number of Valid PA Records	#	0	5
RH_RECORDS	Number of Valid RH Records	#	0	5
PAR_RECORDS	Number of Valid PAR Records	#	0	5
SITE_ALTITUDE	Altitude at the site	m	2	6
SITE_LATITUDE	Latitude at the site	degrees	5	6
SITE_ZGEOM	Sensor height above ground	m	2	6
SITE_ZCANOPY	Canopy height	m	2	6
SITE_NOFFSET	User or default north offset	degrees	1	6

Section 7.
Troubleshooting

Here we describe how to identify and resolve problems that may arise, starting with connection issues and finishing with diagnostic information.

LI-720 troubleshooting

Connection issues

Most connection issues can be resolved by checking the wiring connections or the data logger configuration.

- **If connecting to a PC with the CarbonWare app, is it using the correct serial port?**
  Typically, only valid serial ports are listed. You can try them one at a time or check the port number assignment in you computer Device Manager. To find the serial port number, open the **Device Manager** (press the Windows key  , type **Device Manager**, then press **Enter**). Click **Ports (COM & LPT)**. Look for **USB Serial Port (COM#)**. The serial port numbers are shown beside the ports.
- **Power supply inadequate?**
  If connecting to a PC with the USB cable, do not extend the cable. Voltage drops over a long cable can cause problems with the power supply (not enough power) or digital communication.

Measurement issues

- **Air temperature and RH readings implausible or -9999?**
  The sensor unit may have failed. See *Replacing the air temperature and RH sensor* on page 8-18.

Flux diagnostics

Before computing any results, the LI-720 filters implausible values from the 10 Hz raw data. A diagnostic code is provided for every computed result. The diagnostic code can reveal more about what was wrong with a particular measurement, details about environmental conditions for the time period, and information about the LI-720 performance over that time period. Some diagnostic codes are simply for your information - there is nothing to do besides know what the code indicates. Other codes may indicate that service is required. A few are reserved. A diagnostic code of 0 indicates normal operation.

Decoding the diagnostic

The diagnostic code is a 16-bit binary value encoded as a decimal value. It is included as the last parameter in output groups 0 and 1. The decimal value ranges from 0 to 65535 (corresponding to bit positions 0 through 15). It encodes up to 16 issues.

You can decode the diagnostic from decimal to binary using the calculator included with your computer operating system (Windows and macOS; select programmer mode). Enter the diagnostic value and observe the positions of the **0**s and **1**s in the binary results. Associate the **1**s with the descriptions in *Table 7-1* on the facing page.

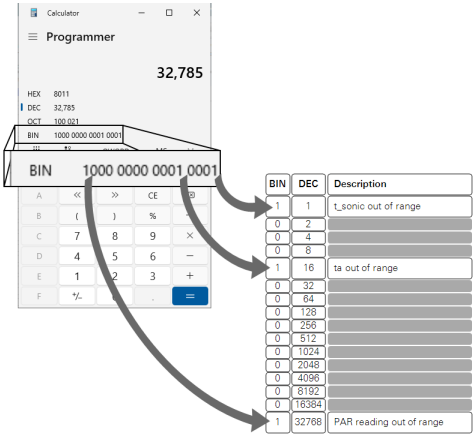


Figure 7-1**. You can decode the decimal diagnostic using a converter such as the calculator included with your computer operating system. Then, associate the binary* **1s with conditions described in Table 7-1 below.*

Table 7-1. A diagnostic code is included with each flux result. A diagnostic is triggered if the threshold was exceeded for more than 10% of samples in a measurement period.

Bit Position	DEC	Description	Threshold
-	0	Normal operation	No issues reported
0	1	Sonic temperature - vertical	*t_sonic* <-25 or >50 °C
1	2	Sonic signal quality - horizontal	
2	4	Sonic signal quality - vertical	
3	8	Temp/RH sensor	1 = error; 0 = OK
4	16	Temperature	*ta* <-25 or >50 °C
5	32	RH sensor	*RH* >100 or <0%

Table 7-1. A diagnostic code is included with each flux result. A diagnostic is triggered if the threshold was exceeded for more than 10% of samples in a measurement period. (...continued)

Bit Position	DEC	Description	Threshold
6	64		
7	128	Lamp temperature	*t_src* <-25 or >50 °C
8	256	Source RH scrub quality	*RH_src* >4%
9	512	Ambient pressure	1 = error; 0 = OK
10	1024	Ambient pressure	*P*<45 or > 115
11	2048	Signal strength (RSSI)	<80%
12	4096	Level sensor	1 = error; 0 = OK
13	8192	Compass	1 = error; 0 = OK
14	16384	Detector temperature	detector temperature <-25 or >50 °C
15	32768	PAR sensor reading	*PPFD* <-20 or >3000
16	65536	H_2O out of range	H_2O <10 or >60
17	131072	CO_2 out of range	CO_2 <-10 or >1500
18	262144	Missing sonic data frames	-
19	524288	Data storage invalid	Invalid JSON detected on startup
20	1048576	GPS and RTC	0 = GPS good; 1 = no update during interval
21	2097152	Flux QC flag	>40% of high speed data flagged as bad

IoE Module troubleshooting

If you encounter unexpected performance or other problems with the IoE Module, start here to find a solution.

SDI-12 configuration problems

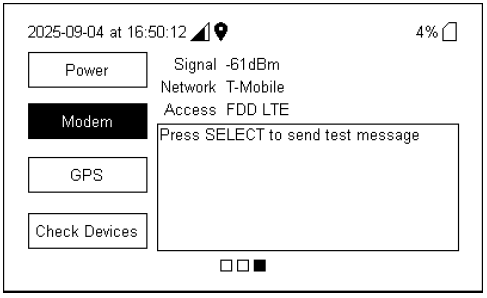
Configuration issues are related to communication between the IoE Module and attached sensors.

- **SDI-12 devices not registered on the IoE module?**
  Go through the steps in *Configuring the Carbon Node* on page 5-1 to configure the sensors.
- **Unsupported device?**
  The IoE module supports the LI-710, LI-720, Stevens HydraProbe (firmware v4 and up), and Node Link (available on new IoE Modules indicated by the HOBOnet label and cable connector with firmware v1.2 or newer).
- **Device cable disconnected?**
  If a sensor has been configured but the cable is disconnected as you go through the configuration steps, the IoE Module will issue an error. Be sure the cables for all sensors are connected and select **YES** to try again.

Cellular or network problems

- **Adequate cellular signal strength?**
  Be sure there is a strong cellular signal. If you are near the IoE Module, check the signal status on the IoE module. From the home screen, press right (▶) and down (▼) to view the status. You should see signal strength and the name of the cellular provider. A strong signal is close to 0 dBm, while a weak signal is close to -120

dBm. Press **Select** to send a test data message to LI-COR . If you see any message besides **PASS**, or if the signal strength is outside the expected range, contact LI-COR.



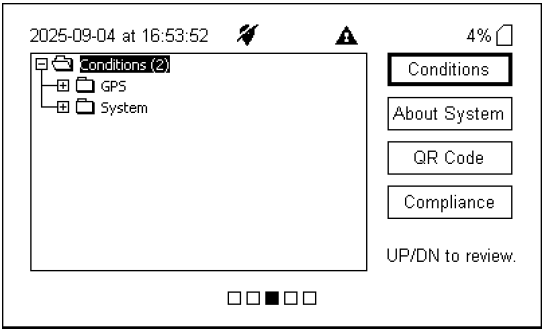
Problems powering on

Power supply problems can be resolved by checking the cable connections and voltage of the source. A multimeter may be useful for measuring voltages.

- **Power cables connected properly?**
  See *Attaching the solar power supply* on page 3-17 or *Using an external power supply* on page 3-9.
- **External power supply problems?**
  If using an external power supply, be sure it provides 10 to 33 VDC with 3.0 amp capacity.
- **Battery depleted?**
  Measure the battery voltage with a multimeter. If it is less than 11 volts, the device will power off until the battery voltage is above 12. Allow the battery to charge from the solar panel or charge it with a compatible external charger. If the solar panel is not delivering enough power to charge the battery, clean it and adjust the angle and orientation so it faces the sun.

Classes and conditions

The device interface presents classes and conditions that indicate a problem. Classes are a category and conditions indicate the type of problem (see *Table 7-2* below). Press left (◀) once view **Conditions.**



With the exception of conditions that are triggered during the startup cycle, conditions will remain visible on the display until cleared, even if the issue is resolved. This is intentional so that operators can observe conditions that have been triggered previously. Press **Select** to clear past conditions and show only current conditions.

Table 7-2. Classes, conditions, and the meaning.

Class	Condition	Meaning
Battery	Battery not connected	No voltage measured from a battery. Check battery connections.
Battery	Voltage low	Critically low battery voltage. Apply external power or use solar charger.
Battery	Voltage high	Charger malfunction.
Battery	Load current high	System board malfunction; drawing too much power.
Battery	Charge current high	Charger malfunction; possible short circuit in battery system.

Table 7-2. Classes, conditions, and the meaning. (...-continued)

Class	Condition	Meaning
Battery	Rntc out of range	Internal temperature sensor mal-functioning.
Cloud	Can't connect to MQTT broker	Cellular data is fine but connection to cloud back-end was refused. Most likely a security problem.
Cloud	Last cloud session failed	There was a problem during the previous cloud session. This should resolve at the next cloud session. If this persists, there's something else wrong.
Config	Bad or missing SDI-12 network info	SDI-12 Network is not configured. Run the configuration tool.
Config	Bad or missing modem info	CRITICAL PROVISIONING FAILURE – important configuration data for cellular connectivity is missing[1],[2].
Config	Bad or missing cloud info	CRITICAL PROVISIONING FAILURE – device credentials for accessing the cloud service are missing[1],[2].
Config	No security certs	CRITICAL PROVISIONING FAILURE – device has no security certificates[1],[2].

[1]This can be cured by supplying this information to the IoE as a special file on an SD card.

[2]Modem config (how to reach the cellular network), cloud config (credentials), serial number, and the security certificate are all backed up internally so they may be recovered automatically in case of memory corruption. If any of these are reported missing after a restart, this is a critical failure. All but the serial number can be re-imported to the device via the SD card if necessary. Contact LI-COR if you observe issues like this.

Table 7-2. Classes, conditions, and the meaning. (...-continued)

Class	Condition	Meaning
Config	Bad or missing sensor info	Sensor configuration information missing (this is downloaded from LI-COR Cloud). This code should resolve itself at the next successful cloud session. Measurements cannot be obtained from a sensor with this problem.
Config	<sensor name> not supported	The named sensor is not supported by IoE.
Config	Bad or missing schedule	There is no schedule for measurements (run the configuration tool) or a schedule refers to a sensor for which configuration data is not available (should resolve at next successful cloud session).
GPS	Not locked	GPS location is unknown (also cannot synchronize to GPS time).
Logger	Card not mounted	SD card is either not present or was not mounted using the mount button[1].
Logger	SD card FULL	SD card is <5% free[2].
Logger	SD card nearly full	SD card is <25% free.
Logger	Sensor data cache nearly full	The IoE is nearly out of room to hold data in RAM.

[1]The IoE module will work fine without an SD card, as long as there is a cellular connection. The SD card offers the following features, which are not available if the card is not mounted: CSV data files, backlog for data in case of cellular connectivity problem, backup of data in case of power loss before upload.
[2]The 8 GB card has space for years of data. The IoE will gracefully stop using a full card, but it's best to not get there that way.

Table 7-2. Classes, conditions, and the meaning. (...-continued)

Class	Condition	Meaning
Logger	Sensor data cache FULL	The IoE is out of room to hold data in RAM. If an SD card is mounted and not full, data is also backlogged there, so nothing will be lost in this case.
Modem	Can't connect to network	Modem cannot connect to cellular network. SIM card issue, perhaps. Maybe no coverage or signal strength issue.
Modem	Low or no signal	Cellular signal is critically low or no connection at all.
Modem	Modem unresponsive or missing	CRITICAL HARDWARE PROBLEM – cellular modem is malfunctioning.
SDI-12	<sensor name> Read failure	Malfunction while reading this sensor.
SDI-12	<sensor name> Sensor doc bad or missing	Sensor configuration data went missing. This is unexpected but should self-correct at the next successful cloud session.
SDI-12	Bus voltage low	SDI-12 power supply malfunction or excessive load attached.
SDI-12	Bus voltage high	SDI-12 power supply malfunction or possibly there is an external power source applied (don't do that).
SDI-12	Bus current high	Excessive draw from attached SDI-12 sensors or wiring fault.
System	DEVICE MISSING SERIAL	CRITICAL PROVISIONING FAILURE – device has no serial number. This is indicative of acute system failure. Contact LI-COR.

Table 7-2. Classes, conditions, and the meaning. (...-continued)

Class	Condition	Meaning
System	No cloud connection since restart	This is a transient notice that simply lets you know the system has restarted and not yet successfully talked to the cloud service.
System	Scheduler halted	CRITICAL SYSTEM FAILURE – no measurements will be taken. Probably due to not being configured properly.
System	Uploader halted	CRITICAL SYSTEM FAILURE – no data will be sent to the cloud. If there is an SD card, CSV files will still be written and backlog data will be kept for when the uploader restarts. The uploader is halted by the configuration tool but should be running at all other times.

Interface is unresponsive

If the IoE Module interface becomes unresponsive (no longer responding to button presses), and stays that way for more than a few minutes, you can force the device to restart.

- **Force power off**: Press and hold the power button for 5 seconds. The IoE module will shut down inelegantly and open data files may be lost.
- **Disconnect the power supply**: As a last resort, if the none of the buttons are responsive, disconnect the power supply for 30 seconds to a minute. Reconnect the power and allow a few minutes for the device to start. If the unresponsive behavior persists, contact LI-COR.

Persistent power cycling or unstable behavior

If you observe continuous restarts or unpredictable behavior in the interface that is not resolved by restarting the device, you can take more drastic measures and restore the IoE Module to the factory configuration.

Before doing this, however, check the power supply to make sure the IoE module is getting enough power to operate. If the battery voltage is close to 11 volts, it may be too low and the battery should be charged before attempting a factory reset. Check the cellular signal strength. Although poor signal strength will not cause power cycling, it could cause delays in the interface, which are easily confused with unstable behavior.

After verifying that the problem is unrelated to power or signal strength, factory reset may be the best option. Factory reset will clear everything from the IoE Module except the factory provisioning data (cellular network, LI-COR Cloud services, security credentials, device serial number).

To perform the factory reset:

1. Power-off the device.
2. Press and hold **UP** and **MOUNT/DISMOUNT** simultaneously.
3. While **UP** and **MOUNT/DISMOUNT** are pressed, short-press the **POWER** button.
4. Continue to hold **UP** and **MOUNT/DISMOUNT** until the screen with the version info below the product name is displayed.
5. Release all buttons and allow the IoE module to finish starting up.
6. After resetting, you must re-configure SDI-12 sensors and schedules.

Carbon node sensor network issues

This section describes some steps you can take to resolve problems with the HOBO link and Node Link devices. If you have trouble with the Carbon Node Sensor Network, start by reviewing licor.com/support/Cloud/topics/tips-for-wireless-sensors.html. If you are unable to resolve any issues, contact LI-COR or your representative.

Sensor not appearing in the Device Setup list

- **Being impatient?**
  Each RX sensor may take up to 5 minutes to register with the Node Link. You may just need to wait a little longer.
- **Batteries depleted or installed incorrectly?**
  Verify that the batteries are installed correctly. Then, expose the solar panel to sunlight for a few minutes.
- **Out of range?**
  During the registration process, keep each sensor close to the Node Link. After registering successfully, you can position sensors up to 200 meters from each other. Sensors can transmit data through each other (up to 5 hops) for a maximum total distance of 1500 meters.

LI-COR Cloud issues

If you configured everything but do not see data on LI-COR Cloud, you may just need to wait at least 10 but possibly 30 or more minutes for results to be published. As you wait, you can check the status on the IoE Module display. It is normal for several messages to be in the queue, but if there are many and the number is increasing over time, there may be an issue.

Check the SDI-12 configuration. From the home screen, press right once and down three times to select SDI-12. Press **Select** and the IoE Module will scan all SDI-12 ports and report the status. It will give **Last Seen** and the time of that communication. The time indicated should be recent, and if so, everything is working, and you should just wait for the data to be presented on LI-COR Cloud. See *SDI-12 status* on page 10-10 for more details.

Finally, be sure that the IoE Module has been registered with LI-COR Cloud and that you have an account that allows you to view data from this IoE Module.

Section 8.
Maintenance

Some routine attention will ensure that the LI-720 and IoE Module provide dependable performance over long time periods, and will help you get more complete, continuous datasets.

Updating firmware

The IoE Module and any connected device must have compatible firmware. We recommend reinitializing the sensors after applying a firmware update. By reinitializing, the devices will request the most current configuration and operating information from LI-COR Cloud, ensuring that the stack of devices and software are all compatible.

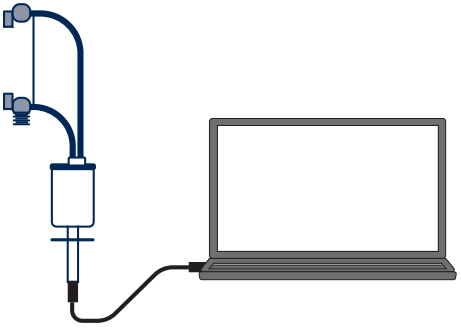
LI-720 firmware

Note: If going to a remote field site that lacks internet access, download the latest version of the CarbonWare application before going to the site. LI-720 firmware is included with the CarbonWare app.

Manual firmware updates are carried out with the USB cable (part number 99512-062). To update the firmware:

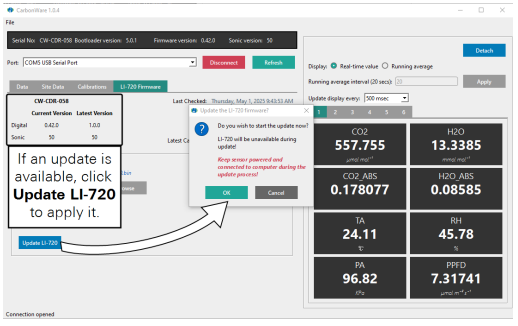
1. Download the CarbonWare app to your computer.
   Firmware is included with the CarbonWare application from licor.com/support. Search for **CarbonWare**.
2. Connect the USB cable between the LI-720 and computer.

Connect the USB cable directly to the LI-720 and computer. Do not use a USB extension cable or device extension cable when operating the LI-720 from a 5 V USB power supply. Extension cables may result in voltage drops that affect both power and digital communication. Do not deploy the LI-720 while powered from 5 V USB power. The LI-720 requires 9 to 33 VDC for field operation.



3 In CarbonWare, connect with the LI-720 and click the **LI-720 Firmware** tab.

The firmware running on the LI-720 and the latest version are both displayed. If an update is needed, click **Update LI-720** to apply it.



4 Keep the sensor powered and connected to the computer during the update.

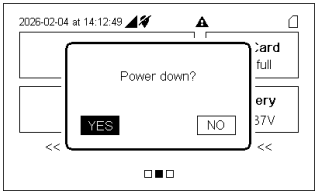
IoE Module firmware

Leave sensors connected to the IoE Module when updating the IoE Module firmware.

IoE Module firmware updates are loaded from a computer to the IoE Module using the USB port. To apply the update:

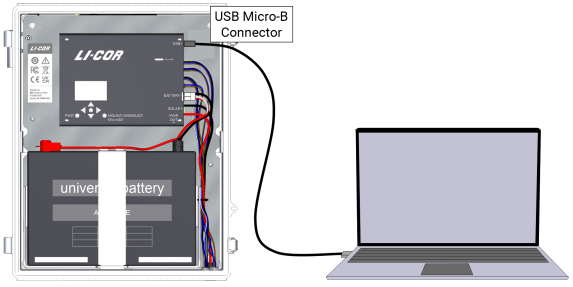
1 Download the file to your computer.
Firmware files are available from licor.com/support. Search for **IoE Firmware.** The file name is `cwcfw_1.2.0.ioe_pkg` or something similar.

2 Power off the IoE Module.
Press the power button (PWR ⏻) and then select **Yes** to power off the device.



3 Connect a USB cable between the module and your computer.
The USB connector is labeled in the IoE Module. It accepts a USB Micro-B connector.

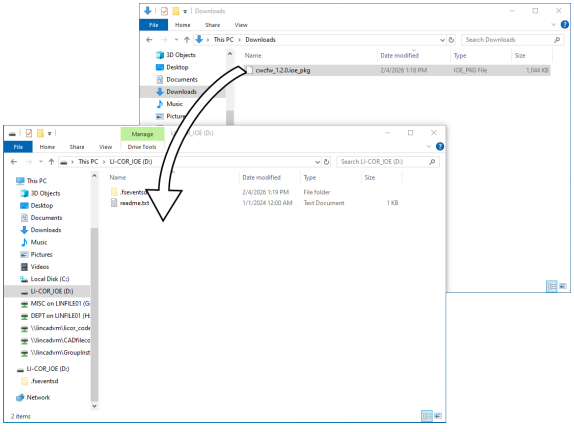
> **Caution:** The Micro-B connector is fragile. Do not apply lateral force to the cable connector when inserting and removing the cable to avoid damaging the circuit board.



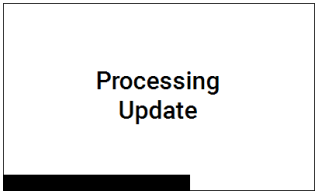
4 Power on the IoE Module.

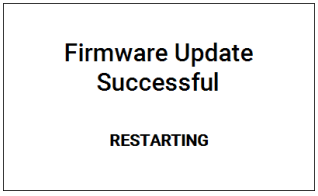
It will start in update mode and appear as a USB drive on your computer called **LI-COR_IOE**.

5 Drag the file or copy and paste the file to the folder.



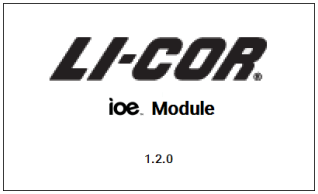
The IoE Module will apply the update. Progress is shown on the display.

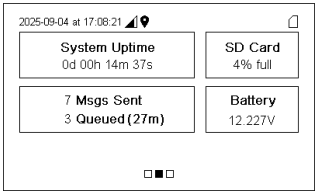




6 Watch as the IoE Module restarts.

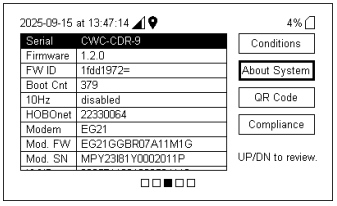
The initialization screen displays the firmware version briefly before advancing to the home screen.





7 Disconnect the USB cable.

To check the version number, press left once (◀) and down once (▼) to view **About System**, where the firmware version is displayed.

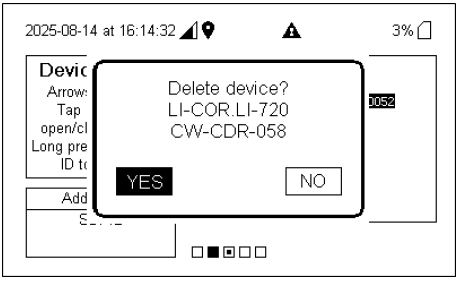


Reinitialize after firmware updates

If you have updated the LI-720 firmware, be sure to apply the latest device configurations. This is accomplished by deleting the LI-720 and adding it again, which ensures that the IoE Module has acquired the compatible configuration file from LI-COR Cloud. Follow these steps:

1 Enter the **Device Setup** screen and select device to remove.

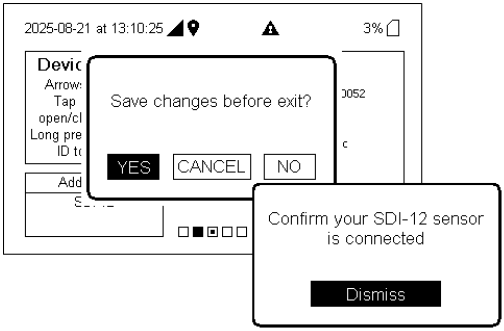
2 Long-press the **Select** button (●) until prompted:



3 Highlight **YES** and then press **Select** (●).

4 Save the configuration.

Press **Right** (▶) once to open the prompt, then press **Select** (O) to save the changes. You MUST save changes for the settings to be applied.



5 Follow the steps in *Initial setup* on page 5-1 to reconfigure the sensor.

LI-720 Maintenance

Basic sensor checkup

You can conduct a basic check just by inspecting the LI-720. Look for the following:

- Inspect the vertical sonic transducers to be sure they are not covered in dirt, bird droppings, or other deposits. Clean them with a soft, damp cloth. Use a mild detergent if needed.
- Inspect the optics for dirt, bird droppings, or other deposits. Check the RSSI (see *Checking and adjusting the signal strength* on page 8-13). If the optics are dirty or the RSSI is low, clean the lenses with water and a soft, lint-free cloth. Use a mild detergent if needed.
- Inspect the horizontal sonic anemometer components. Look for insect colonies or other foreign objects. Clear

anything that might obstruct the airflow or ultrasonic signals.
- Inspect the radiation shield that covers the air temperature and RH sensor. Clear any obstructions.
- Wipe the quantum sensor with a soft lint-free cloth. Use mild detergent if needed. Do not use alcohols on the quantum sensor; alcohols can damage the diffuser.

Calibrations

User calibrations adjust the output from the sensor to ensure accurate measurements. Check the calibration in a controlled environment such as a lab or office. Do not attempt to calibrate while installed on a tower or tripod.

Before adjusting the zero and span, check the RSSI and clean the optics (see *Checking and adjusting the signal strength* on page 8-13). Wipe each lens with a soft lint-free cloth. Use mild dish soap and water to remove any stubborn deposits from the lenses. Wipe the lenses dry after cleaning.

Calibration gases

A user calibration is only as good as the gas. For the zero gas, use a tank of CO_2-free dry air or a user-supplied pump and chemicals such as soda lime and magnesium perchlorate or Drierite® to scrub CO_2 and H_2O from the air. For the CO_2 span, use a tank with a known CO_2 concentration that is above the typical concentrations you will measure. For most applications, 450 to 500 ppm CO_2 balanced in air is good enough. For the H_2O span, use a dewpoint generator such as the LI-610 or Sable Systems DG-4 to create an air stream with a known, stable dewpoint.

Setting the H_2O and CO_2 zeros

Start with the zeros. A zero adjustment changes every measurement by a fixed amount.

1 Clean the lenses with a soft, lint-free cloth.

Use a mild detergent, if needed. Dry the lenses. Check the RSSI. If it is less than 95, clean the optics again.

2 Insert the calibration fixture into the optical path, ***being cautious to not apply pressure to the upper and lower spheres - do not deform the structure***.

The hose barb on the calibration fixture is the inlet; install the fixture so the inlet is next to the bottom sphere. Loosen the set screw and insert the shroud into the optical path. Extend it so that each end surrounds the lens and is in gentle contact with the sphere. Tighten the set screw. The calibration fixture will not seal. It should have outward leaks from the top, bottom, and the vent hole.

3 Connect a zero gas to the hosebarb on the calibration fixture.

The zero gas can be from a tank (*Figure 8-1* on the next page) or created with scrubbers and a user-supplied pump (*Figure 8-2* on the next page).

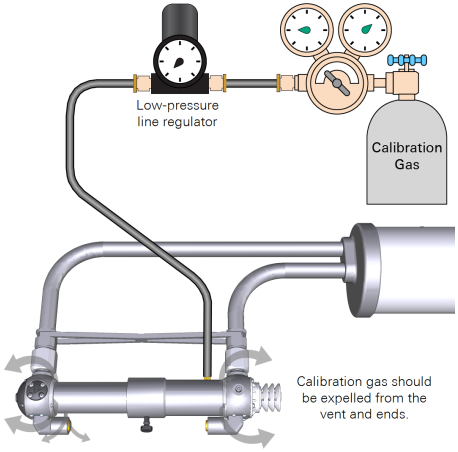


Figure 8-1. *Calibration gas can be from a tank.*

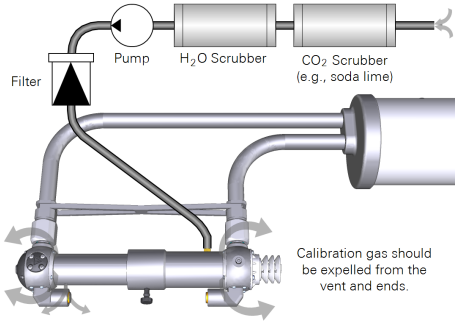


Figure 8-2. *Zero gas can be created with scrub chemicals, a pump, and filter.*

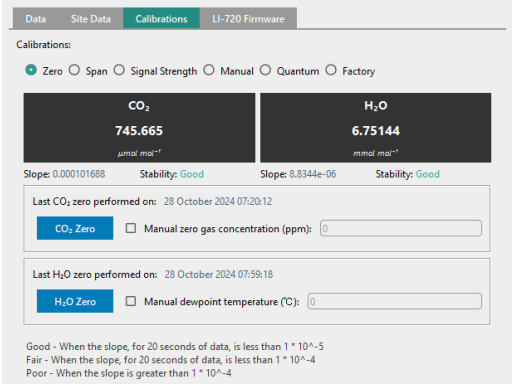
4 Set the flow rate to approximately 1 liter per minute.

Allow the gas to flow through the cell while observing the readings in the CarbonWare application. The application reports the slope and provides guidance about the

stability for a zero or span using a 20-second running average.

- **Poor:** Slope >1×10^{-4} (20 second running average).
- **Fair:** Slope <1×10^{-4}
- **Good:** Slope <1×10^{-5}

5 When the interface reports that the reading is **Good** (allow up to 20 minutes), click **Zero** for each gas.



6 Verify that the readings have changed to match the zero gases.

Setting the CO_2 span

7 Connect a tank of high-quality span gas that has a known CO_2 concentration.

8 Set the flow rate to about 1 liter per minute.

9 Allow the gas to flow through the cell while observing the readings in the CarbonWare application.

10 Enter the concentration of the span gas.

11 When the interface reports that the stability is **Good**, click **CO_2 Span**.

12 Verify that the reading has changed to match the span gas.

Setting the H_2O span

13 Connect an air stream with a known dew point.

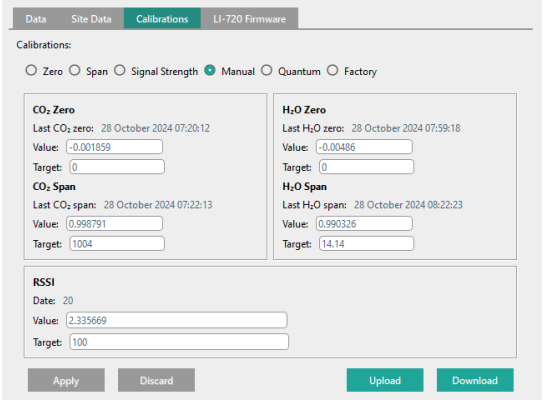
14 Set the flow rate to about 1 liter per minute.

15 Allow the air to flow through the cell while observing the readings in the CarbonWare application.

16 Enter the Dewpoint Temperature (°C) of the air stream.

17 When the stability indicator shows **Good**, click **H_2O Span**.

Under the **Manual** page, verify that all intended calibrations have a new value and updated date.



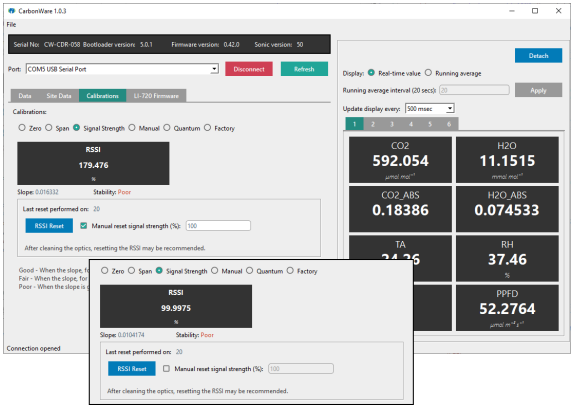
Checking and adjusting the signal strength

Signal strength (RSSI for Residual Signal Strength Indicator) indicates the relative strength of optical system. RSSI decreases when the optics are dirty. You can adjust the RSSI scale so it has a maximum near 100 to simplify interpretation of the measurement. When RSSI is scaled to a maximum of 100, clean optics are indicated by an RSSI >95.

1 Clean the optics.

It is undesirable to rescale the RSSI while the optics are dirty. If low, clean the optics with mild detergent and a soft, lint-free cloth.

2 When the lenses are clean, check the RSSI in the CarbonWare app.



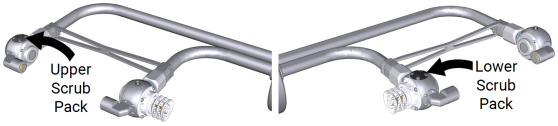
3 To rescale RSSI, enter a maximum and click **Reset**.

For simplicity, RSSI should have a maximum near 100.

Replacing desiccant and scrub chemicals

A small packet of desiccant and CO_2 scrub chemical is in each of the upper and lower gas analyzer housings. The packets keep the housing interior free of water vapor and CO_2 gas. We recommend replacing them if the RH in the lower housing is >4%, as indicated in the variable *RH_src* (if using CarbonWare, see *Adding variables to the display list* on page 2-10). At an *RH_src* >4% for 10% of samples in a 30-minute reporting period, the LI-720 will report an issue in the diagnostics for that 30-minute flux result (see *Table 7-1* on page 7-3).

- Both the upper and lower housings have scrub packs. Always replace both of them at the same time.



- Do not open the packs until you are ready to install them. Install the replacement scrub packs promptly after receiving them.
- Complete the procedure in dry ambient air, such as a room or vehicle cab with the air conditioning on. The scrub packs may become depleted if exposed to humid air prior to installation.

Part Number	Description
99512-080	Scrub Pack Kit
99512-058	Scrubber Assembly (2)
98512-092	Custom Washer (2)
150-14386	Machine Screw; M2 x 6 mm (12)

Warning: *Scrub packs enclose small quantities of Ascarite™ II and magnesium perchlorate. These chemicals may be hazardous. Wear goggles and skin protection (e.g., latex gloves). Do not breath dust or allow the chemicals to come into contact with your skin. Check local regulations before discarding the scrub packs. For SDS, go to licor.com/support and search for SDS.*

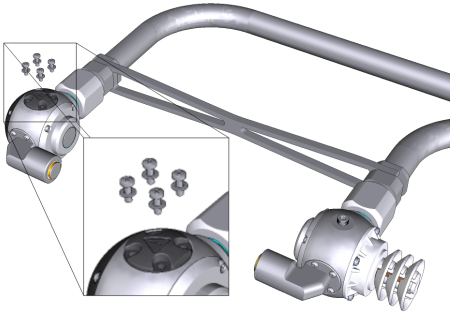
To replace the scrub packs:

1 Power off the sensor, remove it from the tower, and set it on a workbench.

Handle the instrument carefully and avoid impacts.

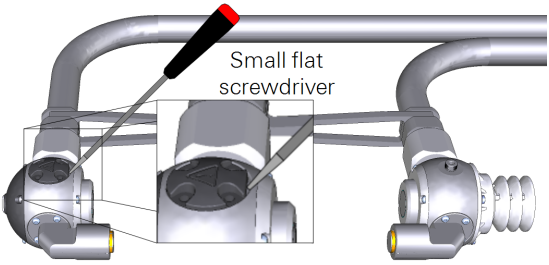
2 Remove the four screws (PH1 Phillips driver) and washers that secure upper the scrub pack.

The old screws and washers can be discarded. Be sure to dispose of the packs safely and in accordance with local laws.



3 Pull the scrub pack straight up.

Use a small flat screwdriver to dislodge it, and be sure the O-ring comes out with the scrub pack.

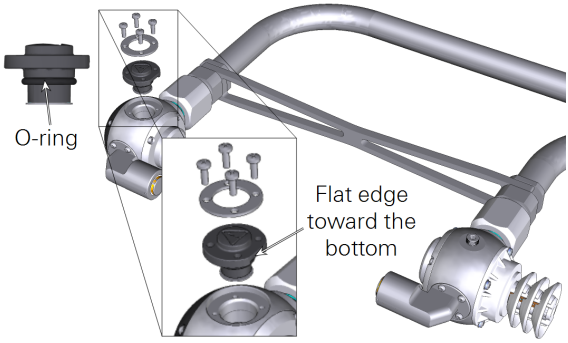


4 Open the new scrub pack only when you are ready to install it.

Do not open scrub packs early, as doing so will reduce the scrubbing efficacy. Install them immediately after opening the package.

5 Be sure the O-ring is in place, and then press the new scrub pack into place.

The flat side should be toward the bottom of the sensor.



6 Insert each screw into the ring washer and tighten until hand-tight.

The kit includes four extra screws.

7 Repeat this with the scrub pack in the lower housing.

After replacement, it will take some time to scrub the volumes of CO_2 and water vapor. At an *RH_src* >4% for 10% of samples in a 30-minute reporting period, the LI-720 will report an issue in the diagnostics for that 30-minute flux result. ***Allow at least 24 hours for the scrub packs to remove CO_2 and moisture from the housings.*** Diagnostics related to *RH_src* should clear after several hours or days.

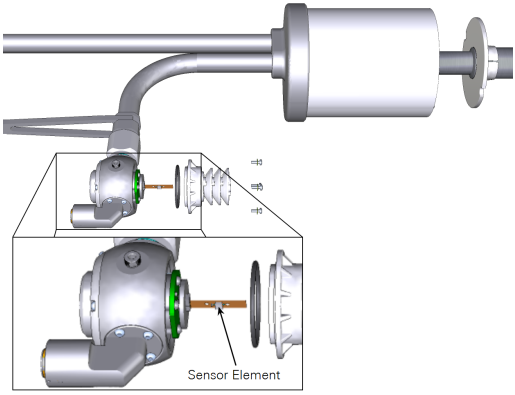
Replacing the air temperature and RH sensor

The external temperature and RH sensor is protected by the solar radiation shield. If the readings are implausible or -9999, replace the sensor. One spare is included with the spares kit (part number 99512-007). Additional sensors are available for purchase.

To replace the temperature and RH sensor:

1 Power off the sensor, remove it from the tower and set it on a workbench.

2 Remove the four screws (PH1 Phillips) and washers that secure the radiation shield.



3 Remove the radiation shield and collect the O-ring.

4 Grip the sensor and pull it free from the connector.

5 Insert the new sensor.

Handle it carefully. Avoid bending the component. Grip it by the end. Do not touch the element with bare fingers. The sensor element faces the front.

6 Be sure the O-ring is on the white radiation shield, and align the slit in the foam pad with the sensor and gently maneuver the

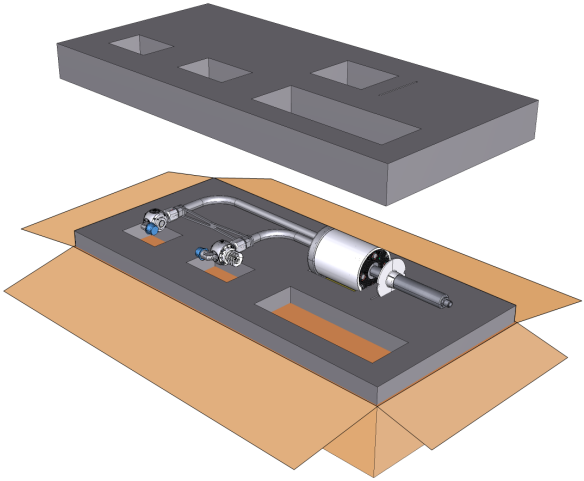
radiation shield into position.

7 Tighten the screws to snug.

8 Power on the LI-720 and check the temperature and RH values. If the readings are plausible, the replacement was successful.

Shipping the LI-720

Keep the foam and cardboard packaging materials so you can ship and store the LI-720 safely. Always use the box and both foam pads to protect the optics.



IoE Module

The IoE Module should provide maintenance-free operation, typically. It has no user-serviceable parts inside besides the main battery and clock battery. If you encounter problems, contact LI-COR or your distributor for assistance. Some simple maintenance procedures may

be needed when moving the IoE Module or when placing it into storage.

Disconnecting the solar panel

Read and follow all safety instructions provided with the solar panel. Do not disconnect the panel while it is under load. Cover the solar cells with a blanket or invert it so the cells are away from the sun to reduce the voltage output. Then disconnect the cables from the panel.

Replacing the Micro SD card

The Micro SD card reader supports the FAT32 and ExFAT. Any properly formatted card will work, so long as it has space for files. Other files can be on the card, but they take away storage space that would otherwise be available for data files. You can swap the card while the device is powered off, or use the mount/unmout button to swap the SD card while the device is powered on.

Removing the main battery

Power off the device. Hot swapping is not supported, so be sure to shut down the device before changing the power configuration.

Warning: *The battery can explode, start a fire, or cause severe burns if the terminals are shorted together. Exercise extreme care when handling the battery. Use insulated tools when practical.*

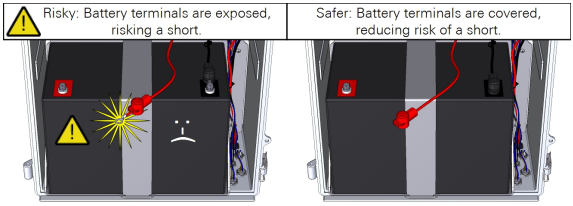
Caution: Cover the solar panel before disconnecting cables. Remove the solar panel power cables before disconnecting the battery cables. When disconnecting the battery, start with the black cable to reduce the risk of shorting the circuit.

1 Power off the device (press the power button, then select **YES**).

2 Cover or invert the panel to reduce its output, then disconnect one or both solar panel cables.

3 Remove the black cable from the battery post.

Remove the black one first to reduce the risk of shorting the circuit. Dangling cables may contact metal parts, causing problems. Avoid the problems by covering the contacts with the plastic covers to reduce risk of short.



4 After disconnecting a cable, slide the red and black covers over the metal contacts to reduce risk of a shorted circuit.

Replacing the coin-cell battery

A CR2032 battery is installed on the circuit board. This battery maintains the clock when power is off. If the IoE Module is unable to keep time while powered off, this battery may need to be replaced.

Caution: This procedure exposes the circuit boards of the instrument, which puts them at risk of electrostatic discharge (ESD). Work on an anti-static mat and wear an ESD wrist strap while performing this procedure.

To remove it:

1 Power off the IoE Module and disconnect the power supply and battery.

2 Remove the circuit board cover.

The battery is behind the display circuit board on the lower left side of the main board (*Figure 8-3* below).

3 Dislodge it with a non-conductive tool, such as a toothpick or stiff plastic coffee stirrer.

4 Replace the battery, then reinstall the cover.

Replacing the Subscriber Identity Module (SIM)

Note: Do not provide your own SIM. Contact LI-COR or your distributor if you need to replace the SIM.

The SIM is behind the circuit board cover (*Figure 8-3* below). To replace it, power off the device, remove the cover, slide the card out of the slot, and install the new one. After powering on the IoE Module, it will connect with the network automatically if the card is valid and the device has a cellular signal.

Caution: This procedure exposes the circuit boards of the instrument, which puts them at risk of electrostatic discharge (ESD). Work on an anti-static mat and wear an ESD wrist strap while performing this procedure.

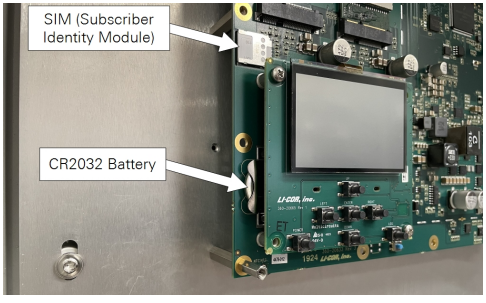


***Figure 8-3**. The SIM and clock battery (CR2032) are under the circuit board cover.*

Section 9.

Disassembling an IoE Module

Follow these steps to take down an IoE Module and prepare it for storage.

Tools

Several tools are needed, including gloves, goggles, adjustable wrench, hex key (4 mm; included), Gripple release key (included), zip ties, and an impact driver with 1 3/8" socket.

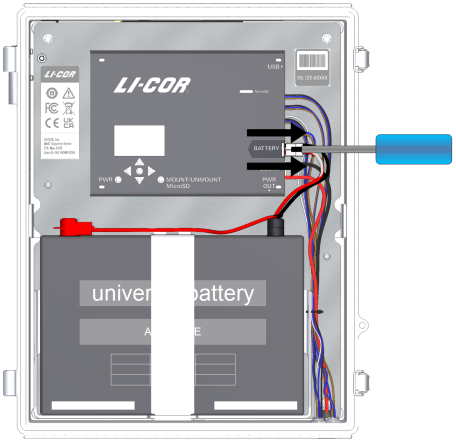
Steps

Caution: Wear gloves and goggles for safety.

1. Power off the IoE Module.
   Press the power button (PWR ⏻) and accept the prompt (**Power Down? > Yes**).
2. Disconnect all cables from the IoE Module external connector panel.
   The IoE Module may have solar panel cables and device cables.
3. Disconnect the ground wire.
   If you cannot remove the ground rod, mark it for visibility. Coil the ground wire and collect the hardware for safekeeping.

4 Disconnect the battery cable and remove the battery.

Use a flat screwdriver to disconnect the battery cable from the connector. Lift the battery out of the enclosure.

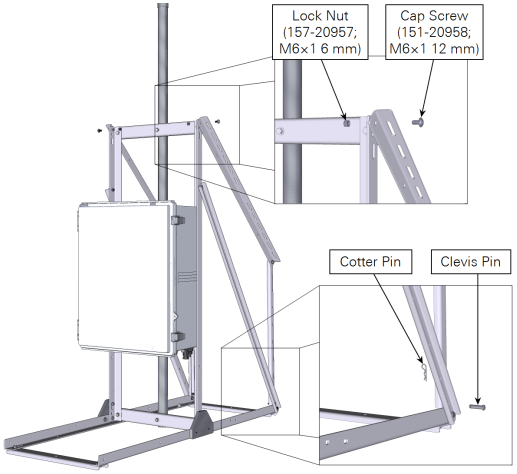


5 Remove the solar panel from the rails.

Be sure the cables are disconnected from the IoE module first. You can leave the cable extensions connected to the panel. Loosen the panel clamps and lift the solar panel off of the rails. You can leave the clamps on the rails or remove and collect them.

6 Remove the solar panel rails.

Each rail is secured with a nut and bolt and pins. Keep the hardware in a bag or insert it back into the brackets for safekeeping.



7 Close the door and secure the clasps.

8 Prepare to lower the mast.

Always support the mast with one hand when adjusting it. Do not allow the mast to slam down without resistance. While gripping the extended portion of the mast, pull the lower pin. Continue to grip the mast and then loosen the knurled clasp. Lower the mast with a hand-over-hand motion. Repeat with the upper segment, if needed. Install the pins in the lowered mast.

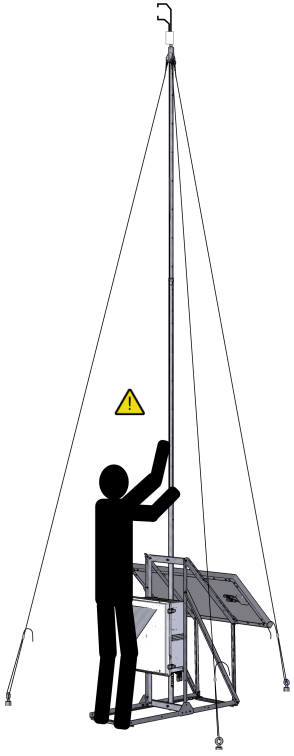


***Figure 9-1**. Always grip the mast and use a hand-over-hand motion when lowering it. Do not allow the mast to slam down.*

9 Remove the guy wires.

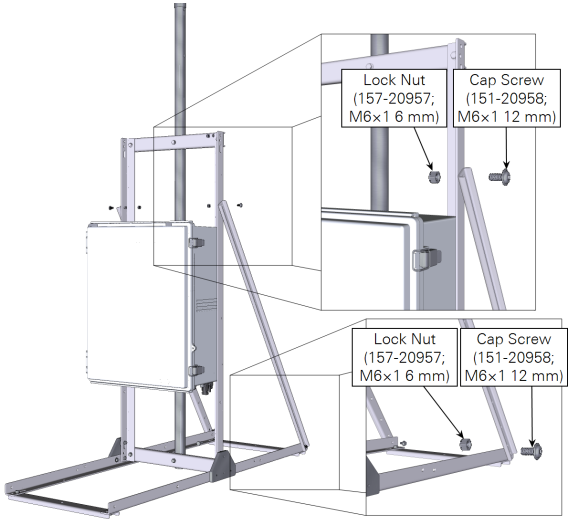
Separate the clips from the adapter. The wires pass through a Gripple® clasp. If needed, loosen the Gripple using the key. Be careful, as the Gripple might fall apart if too much pressure is applied.

10 Remove the sensor from the adapter with the hex key.

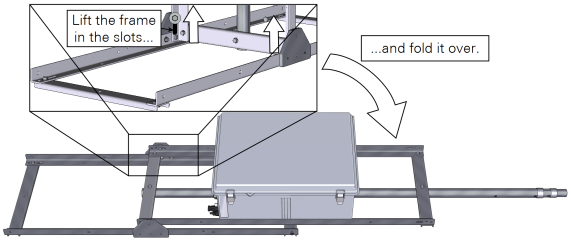
Store the LI-710 or LI-720 in the original package to protect it from impacts. You can leave the sensor adapter on the mast or remove it to make the assembly more compact. Remove any other peripheral components and store them safely.

11 Remove the frame rails.

Each rail is secured with two bolts. Remove both bolts. You can keep them in bag or insert them back into the openings for safekeeping.

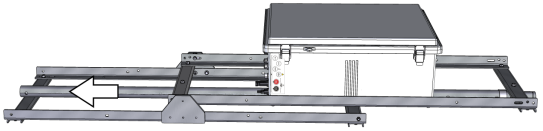


12 Lift the vertical portion of the frame it in the slots and fold it over.



13 Slide the mast to align it with the frames.

Use a zip tie or twine to secure the frame in the closed position.



14 Remove the earth anchors using an impact driver.

Be sure to handle the LI-720 carefully, as described in *Shipping the LI-720* on page 8-19.

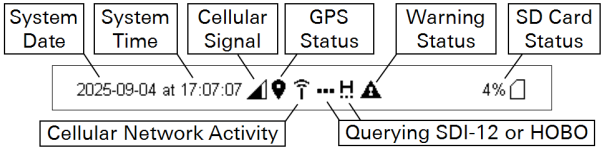
Section 10.

IoE module interface reference

This section is a reference for the device interface, including screens and messages.

System status

The status bar displays general information about the IoE module.



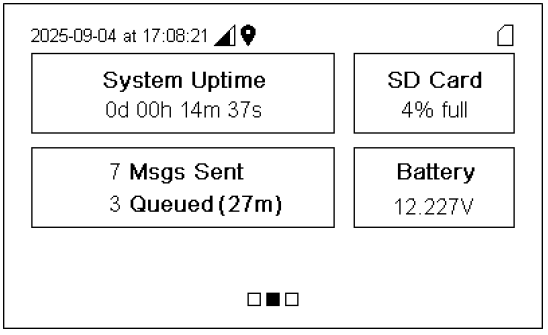
- **System Date**: The current date in YYYY-MM-DD format.
- **System Time**: The current time in HH:MM:SS format, offset from UTC.
- **Cellular Signal**: Displays graphically the cellular signal strength with the following conditions:
  - Blinking: Searching for network
  - Outline: No signal
  - Solid or partially filled: Connected
- **Position Status**: The GPS status with the following conditions:
  - Blinking: Acquiring location
  - Outline with slash: No fix
  - Solid: Location acquired

- **Warning Status**: When displayed, a condition code is active. Review conditions on the screen to the left.
- **SD Card Status**: Displays approximate used capacity by filling the outline <25%, 25-50%, 50-75%, >90%. A slash indicates the card is not mounted.
- **Cellular Network Activity**: Displayed when active.
  - Blinking: Connecting
  - Solid: Communication with LI-COR Cloud
  - Off: Idle
- **Querying SDI-12 Sensor**: Displayed when communicating with an SDI-12 sensor, absent otherwise.

Home

The home screen is displayed after starting up. It presents general status information:

- **System Uptime**: Days, hours, minutes, seconds since last restart.
- **SD Card**: Status and capacity.
- **Msgs Sent**: Number of messages sent since last start.
- **Queued**: Number of messages waiting to be sent and a countdown to the next send.
- **Battery**: Voltage at the battery connector.



Messages

The interface may present a messages as it boots up and during normal operation. These messages may require an interaction to dismiss or they are dismissed automatically.

Message	Indication
Sensor config data needed. Please wait for cloud session to complete.	Configuration tool needs information from LI-COR Cloud.
Unsupported sensors have been removed	Configuration tool concluded that at least one attached sensor is not supported by the IoE Module or LI-COR Cloud yet.
SDI-12 is in use	Cannot perform SDI-12 network scan while measurements are being taken.
Please wait while downloading data	Actively receiving data during cloud session.
It is now safe to remove the card	SD card dismounted and ready for removal.
Mounted "SD CARD"	Displayed after mounting the SD card.
Waiting for SD card to be idle before dismounting…	Displayed if attempting an un-mount action or soft power-down while the IoE Module is writing to the card.

System Information

Press left (◀) once to view system information, starting with **Conditions**.

Conditions

Under **Conditions**, you'll see a table of classes and conditions. Normally the table is empty, but it will display useful information if something should be brought to your attention, or if something has gone wrong (see *Classes and conditions* on page 7-7).

With the exception of conditions that are triggered during the startup cycle, conditions will remain visible on the display until cleared, even if the issue is resolved. This is intentional so that operators can observe conditions that have been triggered previously. Press **Select** to clear past conditions and show only current conditions.

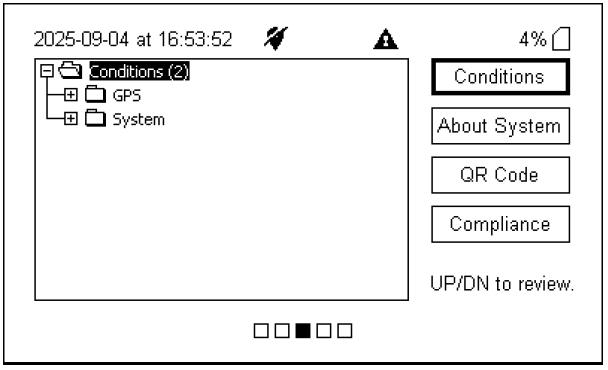
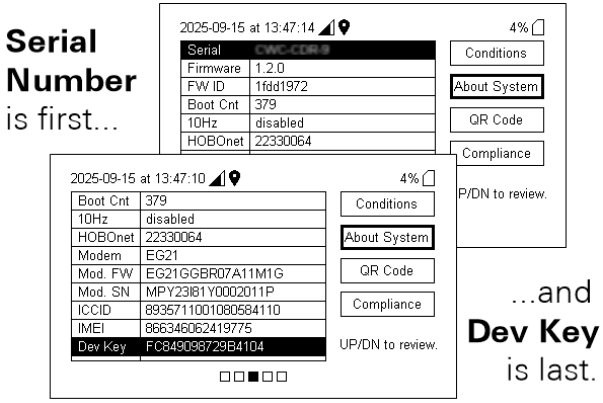


Figure 10-1*. The Conditions table informs you of issues. Several conditions will be displayed momentarily as the IoE Module starts up and establishes the cellular connection, GPS information, and communication with LI-COR Cloud.*

About System

Press down (▼) to access system information. The **About** page gives details about the hardware and software, including the **Reg Key** and device details. Scroll down to view everything in the list.



- **Serial**: Device serial number[1].
- **Firmware**: Firmware version currently running.
- **FW ID**: Firmware ID.
- **Boot Cnt**: Number of times booted.
- **Modem**: Modem ID.
- **Mod. FW**: Modem firmware version.
- **Mod. SN**: Modem serial number.
- **ICCID**: Integrated Circuit Card Identifier (ICCID) from the SIM card[1].
- **IMEI**: International Mobile Equipment Identity (IMEI) a unique numeric identifier for the IoE module[1].
- **Dev Key**: A unique identifier for the device.

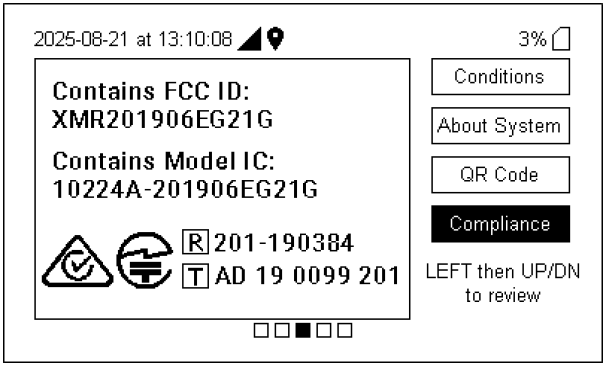
[1]Also encoded in the QR code, denoted by SN, ICCID, IMEI, and Reg Key.

QR code

The QR code encodes information about the IoE module, including the device serial number (SN), SIM identifier (ICCID), International Mobile Equipment Identity (IMEI), and the Reg Key (KEY).

Compliance

To view digital **Compliance** information (e-labeling), from the **Home** screen, press left once (◀) and down three times (▼▼▼). For more information, press left once and then up or down to see additional digital certificates.

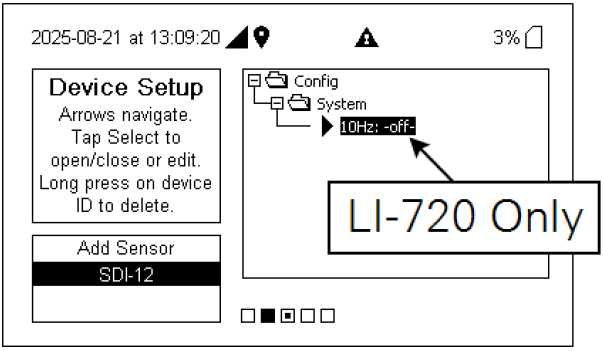


The digital compliance certificate gives the US FCC ID code and more details about certifications and compliance.

SDI-12 Setup

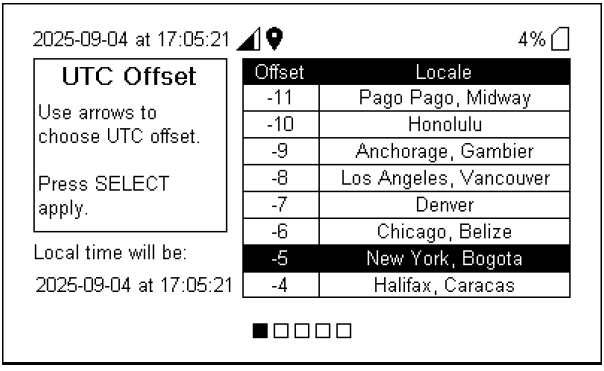
The SDI-12 page is to add sensors to this IoE node. Follow the steps on the display and see "Initial setup" on page 5-1 for more details.

Caution: 10 Hz logging (under **Device Setup> Config > System**) is supported by the LI-720 only. Enabling 10 Hz logging with an LI-710 will cause unstable performance and the desired data will not be logged.



UTC Offset

Press left (◀) again to access time settings, where you can apply an offset to the UTC time provided by the GPS receiver. Use the up and down buttons and press **SELECT** to apply.

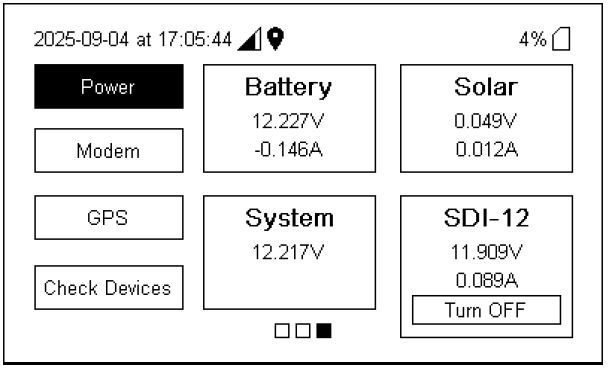


IoE Module status information

From the home page, press right (▶) to access status pages, starting with **Power**.

Power status

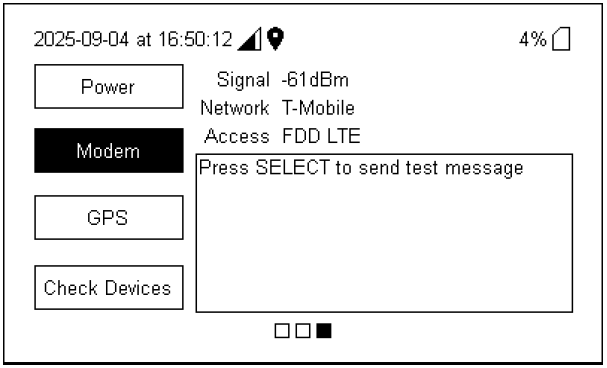
Information related to the battery, solar power supply, system voltage, and SDI-12 power output.



- **Battery**: The battery voltage (V) is given, as well as current (A) used.
- **Solar panel**: The solar panel output voltage (V), measured at the circuit board (normally is <25 volts).
- **System**: System voltage.
- **SDI-12**: Voltage (V) delivered and current (A) used by SDI-12 sensors. Press **Select** O or **Right** once to select an option to **Turn Off** or **Turn On** the SDI-12 power.

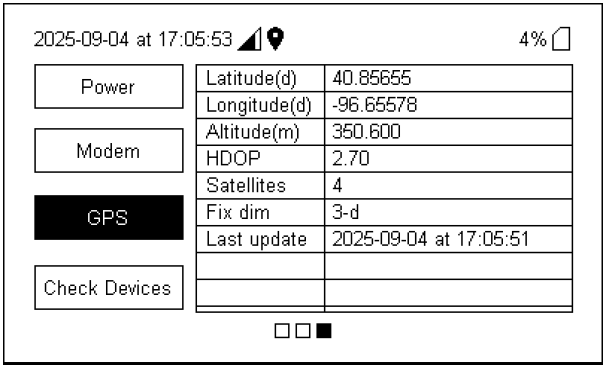
Modem status

Information about the cellular network, including signal strength and the service provider. Press **Select** to send a test message, which pings the network connection and returns a success or failure message, along with details.



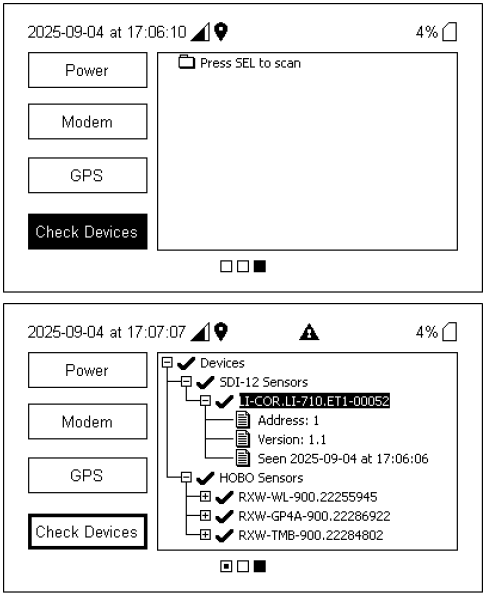
GPS status

View information about the GPS signal, including the recorded position, altitude, HDOP (horizontal dilution of precision), number of satellites, and the date of the last fix.



SDI-12 status

Status of connected sensors. Press **Select** and the module will scan each SDI-12 channel and return information about connected sensors.



- **First line:** Sensor manufacturer and model, as reported by the sensor.
  - For the LI-720, look for **LI-COR LI-720**.
  - For the Stevens HydraProbe, expect something like **STEVENSW 056012**.
- **Second line:** Serial number.
- **Third line:** Most recent communication or data request.
  - Last seen YYYY-MM-DD at HH:MM:SS

- Not pinged yet indicates that the IoE Module has not communicated with the sensor yet. This message should clear shortly.

Powering off

To power off the IoE Module, short-press the power button. In the pop-up message, select **Yes** and then press **Select**.

Glossary of icons

The interface presents icons that serve to communicate meaningful information to you (the device operator). The iconography is described below.

Status bar

The status bar icons give a status information at a glance.

 Cellular signal and strength.

 GPS position not established. Typically resolved with the passage of time.

 GPS position established.

 Transmit or receive data.

 Querying SDI-12 sensor.

 Querying HOBO sensor.

 A warning symbol is displayed if a normal function is paused or if something is not working as expected.

 SD card present.

 SD card missing. Resolved by inserting and mounting compatible SD card.

Device Setup

The following icons may be displayed when viewing or editing the **Device Setup** screen.

 Sensor or device information; expandable.

 Sensor or device information; expanded.

 HOBO Sensor added but not configured yet.

 HOBO Sensor information, expandable.

 Information that describes the device.

 An editable setting. Press **Select** to enable editing.

 The editable setting in edit mode. Use arrow keys to change the setting and follow the instructions in the interface.

Check Devices

The following icons may be displayed after running the **Check Devices** operation.

 Sensor or device has passed all checks. Expand the menu to view parameters and results.

 Sensor or device checks not yet passed.

Specifications

LI-720 Carbon Flux Sensor

General

Weight: 2.02 kg

Power Requirements:

Voltage: 9 – 33 VDC nominally; Can be powered from a standard USB port (2.0 or newer) for calibration and firmware updates. Outdoor operation from a 5 V USB power supply is not supported.

Power Consumption: 1.5 W

Communication Interface: SDI-12, RS-232 (10 Hz data); compatible with LI-COR IoE Modules and some data loggers

Operating Temperature Range: -25 – 50 °C

CO_2 measurement

Calibration Range: 0 to 1500 µmol mol^{-1}

Accuracy: Within 1.5% of reading

Zero Drift per °C: ±0.15 ppm typical, ±0.3 ppm maximum

RMS Noise: @10 Hz: 1.0 ppm (typical @ 400 µmol mol^{-1} CO_2)

Direct Sensitivity to H_2O: ±2.00E-05 typical, ±4.00E-05

maximum

Reporting Frequency: 10 Hz (samples per second)

H_2O measurement

Calibration Range: 0 to 60 mmol mol^{-1}

Accuracy: Within 1.5% of reading

Zero Drift (per °C): ±0.03 mmol mol^{-1} typical, ±0.05 mmol mol^{-1} maximum

RMS Noise: @10 Hz: 0.05 mmol mol^{-1} (typical @ 10 mmol mol^{-1} H_2O)

Direct Sensitivity to CO_2: ±0.02 typical, ±0.05 maximum

Reporting Frequency: 10 Hz (samples per second)

Wind speed measurements

Measurement Axes: U, V, W

Measurement Range: 0 – 30 m s^{-1} (horizontal wind)

W Offset at Zero Wind: ±0.06 m s^{-1}

W Noise (1 standard deviation): <0.1 m s^{-1} at 5 m s^{-1}, <0.15 m s^{-1} at 15 m s^{-1}

Sonic Temperature Accuracy: ±0.7 °C maximum offset at 20 °C

Reporting Frequency: 10 Hz (samples per second)

Biomet measurements

Photosynthetic Photon Flux Density:

Range: 0-3000 µmol m^{-2} s^{-1}

Accuracy: ±5% of reading

Cosine Correction: Corrected up to 75° angle of incidence

Air Temperature:

Range: -40 to 60 °C

Accuracy: ±1.5 °C; No solar load conditions

Atmospheric Pressure:

Range: 50 – 110 kPa

Accuracy: ±0.2 kPa

Relative Humidity:

Range: 0-100% – non-condensing

Accuracy: ±1% typical

Position and orientation

GPS: Provides location and precise time, including for edge flux processing

Magnetometer: Reports orientation relative to magnetic north (°)

Accelerometer: Reports instrument tilt (°)

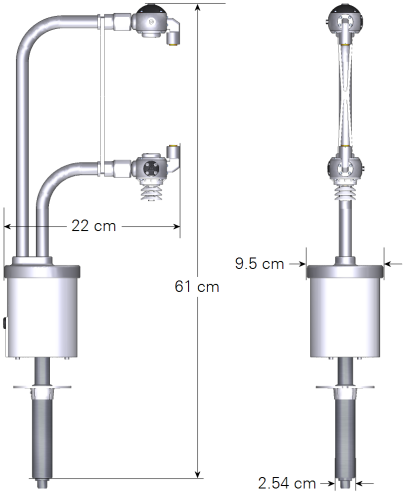


***Figure 11-1**. LI-720 dimensions. Additional clearance is required for the cable.*

IoE Module

General

Operating Temperature Range: -25 to 50 °C
Operating Humidity Range: 0 to 95%, non-condensing
Storage Temperature Range: -40 to 65 °C; 85% RH
Ingress Protection: IP24 Rating
Enclosure Flame Rating: UL94-V-0
GNSS (GPS) Support: GPS receiver for time synchronization and location information.
Display: 35 x 55 mm; monochrome

Auxiliary power input

Input Voltage Range: 9 to 33 VDC (>11 V recommended for startup)
Maximum Current: 3.0 A

Digital inputs/outputs

SDI-12 ports: 2
  Output Voltage: 12 V
  Maximum Total Current: 2.5 A
Sensor Ports (SDI-12 'plus'): 1 (combined SDI-12 with fast serial T/R)
USB port: Micro-B connector

Structure and load

Ground Area Required:
  Without Guy Wires: 42 × 107 cm (16.25 × 42 inches)
  With Guy Wires at 15°: 244 × 244 cm (96 × 96 inches)
Maximum Load on Mast: 4.54 kg (10 lbs.)

Maximum Battery Weight: 45.4 kg (97 lbs.)
Soil Types for Anchors: 1 to 4

Weights

System (total): <45.4 kg (<100 lbs.)
Battery: 24.9 kg (55.0 lbs.)
Solar Panel: 7.5 kg (16.5 lbs.)
Frame: 13 kg (28.7 lbs.)

Data

Data Storage: Removable Micro SD card; 8 GB. If the modem is offline, data are stored until connectivity is restored (storage for 2 weeks of data).
Data Format: Text; Comma-separated values (CSV)

Cellular

Wireless Protocols: LTE CAT1

Specifications subject to change without notice.

Standard Terms and Conditions

1. General. LI-COR Inc. ("LI-COR") is delivering these goods and products ("Products") and/or performing services ("Services") subject to these Terms and Conditions of Sale ("Conditions"). Buyer will be deemed to have assented to these Conditions upon Buyer's placement of order. Notwithstanding the above, failure of LI-COR to object to provisions contained in any purchase order or other form or document from Buyer shall not be construed as a waiver of these Conditions nor an acceptance of any such provision.

2. Buyer's Use Only/No Resale. The purchase of Products only conveys to Buyer the non-transferable right for only Buyer to use the quantity of Products and components of Products purchased in compliance with the applicable intended use statement, limited use statement or limited label license, if any, in LI-COR catalogues or on the label or other documentation accompanying the Products (all such statements or licenses being incorporated herein by reference as if set forth herein in their entirety). Buyer has no right to resell the Products, or any portion of them to a third party outside Buyer's corporate organization, and any such purchase by a reseller for the purpose of resale is strictly prohibited unless LI-COR first accepts and approves a purchase order and acknowledges in writing that the Products may be resold by Buyer and the terms of such resale.

3. Prices/Taxes. All prices are quoted for delivery to Buyer when goods are loaded on the carrier at LI-COR premises in Lincoln, Nebraska, USA exclusive of shipping, insurance and installation charges, all of which are Buyer's sole responsibility. All prices are exclusive of all sales, use, excise, value added, withholding and other taxes, all customs, duties, documentation charges, and freights forwarder charges and charge of any nature now or hereafter claimed or imposed by any governmental authority upon the sale of the Products or performance of the Services. Any such charges will be added to the product invoice or subsequently invoiced to the Buyer. In the event LI-COR is required to pay any such tax, duty or charge, Buyer will promptly reimburse LI-COR.

4. Payment Terms. All payments shall be made in immediately available U.S. Dollars net thirty (30) days from the date of invoice for qualified accounts, without set-off, deduction or withholding of any kind, unless otherwise stated by LI-COR in writing and may be paid by check (drawn on a U.S. bank), wire transfer or major credit card. All open account invoicing must be pre-approved. Any amounts not paid when due will accrue interest at the rate of 1 1/2% per month, or the maximum amount allowed by law, if lower. In the event that any payment is more than thirty (30) days late, LI-COR shall have the right to suspend doing business with Buyer until all past due balances are made current. Buyer shall pay for all costs (including reasonable fees) incurred by LI-COR in connection with the collection of late payments. Each accepted purchase order is a separate, independent transaction, and Buyer has no right of set-off against other purchase orders or other transactions with LI-COR. Buyer hereby grants LI-COR a security interest in the Products or any deliverable in the amount of the unpaid balance of the purchase price until paid in full. LI-COR may file a financing statement for such security interest and Buyer shall sign any such statements or other documentation necessary to perfect LI-COR security interest.

5. Return Policy. Buyer may return non-consumable Products to LI-COR within forty-five (45) days of invoice date only with prior authorization by LI-COR. The Product(s) being returned new and unused condition and must be resalable as new. Any returned Product(s) are subject to payment of a fifteen percent (15%) re- stocking fee on all items returned. Buyer shall be responsible to make payment to LI-COR for any and all expenses related to de-installation of the Product(s), including but not limited to shipping, duties, and taxes. All payments subject to this provision shall be made to LI-COR within thirty (30) days of return, or de- installation, of the Product(s).

6. Delays In Performance. LI-COR shall not be liable for any delay in performance hereunder due to unforeseen circumstances or due to circumstances beyond its control including, but not limited to, acts of nature, acts of government, labor disputes, delays in transportation, delays in customs clearance and delays in delivery or inability to deliver by LI-COR suppliers.

7. Shipment and Packing. All Product prices exclude costs of shipping and handling and insurance, in accordance with delivery terms designated by LI-COR. Unless otherwise agreed in writing, such costs will be paid by the Buyer and will appear as a separate item on LI-COR invoice. LI-COR shall ship in accordance with LI-COR standard practices. Buyer may specify different shipping instructions, subject to

agreement by LI-COR. Unless otherwise agreed to in writing by LI-COR, all products shall be packaged, if appropriate, for shipment and storage in accordance with standard commercial practices. All packing shall conform to carrier requirements.

8. Partial Shipments. LI-COR reserves right to make delivery in partial shipments ("Installments"). Any Products delivered in Installments may be invoiced individually and is payable subject to Section 4 of these Conditions. Additional shipping and handling charges for Installments may apply. Delay in delivery of any Installment shall not relieve Buyer of Buyer's obligation to accept remaining deliveries.

9. Title/Risk of Loss. All domestic shipments are made FOB per Uniform Commercial Code. All international shipments are made per INCOTERMS 2020 designated by LI-COR. Title to the Products and the risk of loss of or damage to the Products ordered by the Buyer will pass to Buyer at time of LI-COR delivery of Products to the carrier. The carrier shall be deemed Buyer's agent, and any claims for damages in shipment must be filed with the carrier. LI-COR is authorized to designate a carrier pursuant to LI-COR standard shipping practices unless otherwise specified in writing by Buyer.

10. Intellectual Property Rights. Title to and ownership of the documentation, and any improved, updated, modified or additional parts thereof, and all copyright, patent, trade secret, trademark and other intellectual property rights embodied in the Products, shall at all times remain the property of LI-COR or LI-COR licensors.

11. Acceptance. All sales are final and all Products shall automatically be deemed accepted upon delivery to Buyer when goods are loaded on the carrier at LI-COR premises in Lincoln, Nebraska, USA. Failure to provide written notice to LI-COR of any shortages, defects, or damages relating to the Products within fifteen (15) days after receipt shall conclusively deem that the Products conform to the terms set forth in these Conditions. Buyer may not return any Products to LI-COR except as provided for by LI-COR warranty or as provided herein.

12. Product Warranties. Unless otherwise specified by LI-COR:

a) LI-COR warrants that, for a period of twenty-four (24) months from the date of shipment of the Products from LI-COR (the "Warranty Period"), unless otherwise specified for individual Products (such as products with a specified shelf life) or extended by a Support Contract or Extended Warranty Contract (the "Extended Warranty"), the Products sold hereunder will be free from material defects in materials and workmanship and will conform to LI-COR

published specifications in effect as of the date of manufacture. LI-COR SPECIFICALLY DISCLAIMS ANY INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES (INCLUDING LOSS OF USE OR LOST PROFITS) WHICH MAY RESULT FROM THE USE OF PRODUCTS PURCHASED HEREUNDER, AS FURTHER SET FORTH IN SECTION 13 OF THESE CONDITIONS OF SALE. This limited warranty extends only to Buyer as original purchaser unless otherwise agreed upon in writing by LI-COR.

b) The foregoing warranty/extended warranty coverage shall not apply if the defective Product (i) has been subjected to abuse, misuse, neglect, negligence, accident, improper testing, improper installation, improper storage, improper handling or use contrary to any instructions issued by LI-COR, (ii) has been repaired or altered by persons other than LI-COR, (iii) has been moved/relocated once originally installed unless LI-COR approved deinstall/reinstall procedures are followed; (iv) has not been installed, operated, repaired and maintained in accordance with the documentation or operated outside of the environmental specifications for the Product; (v) has failed due an Act of God, including but not limited to fire, flood, tornado, earthquake, hurricane or lightning or (vi) has been used with any devices, accessories or products not manufactured by or approved by LI-COR. In addition, the foregoing warranty shall not apply to Products (i) marked or identified as "sample," (ii) loaned or provided to Buyer at no cost, or (iii) which are sold "as is."

c) If during the Warranty/Extended Warranty Period: (i) LI-COR is notified promptly in writing upon discovery of any defect in the Product, including a detailed description of such alleged defect, (ii) such Product is returned, transportation charges prepaid, to LI-COR designated manufacturing facility subject to the prior approval of LI-COR with a valid Return Material Authorization ("RMA") number, and (iii) LI-COR inspections and tests determine that the Product is indeed defective and the Product has not been subjected to any of the conditions set forth above, then, as Buyer's sole remedy and LI-COR sole obligation under the foregoing warranty, LI-COR will, at LI-COR option, repair or replace without charge the defective Product. In no event will the Buyer itself nor will the Buyer allow any party other than LI-COR or a third party authorized in writing by LI-COR to perform any service on the Products.

d) Any Product that has either been repaired or replaced under this warranty shall have warranty coverage (parts only) for the longer of

one (1) year or the remaining original warranty period. Replacement parts and/or replacement Products used in the repair or replacement of Products may be new or equivalent to new at LI-COR sole discretion.

e) EXCEPT FOR THE WARRANTIES SET FORTH IN THIS SECTION, LI-COR MAKES NO OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, WITH RESPECT TO ANY SERVICES, PRODUCTS OR OTHER PRODUCTS PROVIDED IN CONNECTION WITH THESE CONDITIONS, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NONINFRINGEMENT, OR ARISING FROM COURSE OF PERFORMANCE, DEALING, USAGE OR TRADE.

f) Notwithstanding anything herein to the contrary, LI-COR makes no warranty with respect to any third party products provided under these Conditions. Buyer's sole remedy with respect to such third party products shall be pursuant to the original manufacturer's or licensor's warranty, if any, to Buyer, to the extent permitted by the original manufacturer or licensor.

13. Limitation of Liability. IN NO EVENT SHALL LI-COR, ITS LICENSORS OR ITS SUPPLIERS BE LIABLE TO BUYER OR ANY THIRD PARTY FOR COSTS OFPROCUREMENT OF SUBSTITUTE PRODUCTS OR SERVICES, LOST PROFITS, DATA OR BUSINESS, OR FOR ANY INDIRECT, SPECIAL, INCIDENTAL, EXEMPLARY OR CONSEQUENTIAL DAMAGES OF ANY KIND ARISING OUT OF OR IN CONNECTION WITH THE USE OF THE PRODUCTS OR THESE CONDITIONS, HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY (WHETHER IN CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY, PRODUCTS LIABILITY OR OTHERWISE). LI-COR TOTAL AND CUMULATIVE LIABILITY ARISING OUT OF OR IN CONNECTION WITH ANY PRODUCTS PURCHASED BY BUYER OR SERVICES PERFORMED BY LI-COR ON BEHALF OF BUYER HEREUNDER SHALL IN NO EVENT EXCEED THE PURCHASE PRICE PAID BY BUYER FOR SUCH PRODUCTS OR SERVICES. THE LIMITATIONS SET FORTH IN THIS SECTION SHALL APPLY EVEN IF LI-COR OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, AND NOTWITHSTANDING ANY FAILURE OF ESSENTIAL PURPOSE OF ANY LIMITED REMEDY.

14. Severability. If any portion of these Conditions is held invalid, the parties agree that such invalidity shall not affect the validity of the remaining portions of these Conditions.

15. Export Control. Buyer acknowledges and agrees that the Products purchased under these Conditions or Services performed by LI-COR may be subject to restrictions and controls imposed by the United States Government and the regulations thereunder. BUYER WARRANTS THAT IT WILL NOT EXPORT OR RE-EXPORT ANY PRODUCTS PURCHASED OR DELIVERABLES FROM SERVICES PERFORMED BY LI-COR WITHOUT PRIOR WRITTEN NOTIFICATION AND APPROVAL OF LI- COR.

16. Assignment. Buyer shall not assign or transfer these Conditions or any rights or obligations under these Conditions, whether voluntary or by operation of law, without the prior written consent of LI-COR. LI-COR may freely assign these conditions. LI-COR or any successor may assign all or part of the right to payments under these Conditions. Any assignment or transfer of these Conditions made in contravention of the terms hereof shall be null and void. Subject to the foregoing, these Conditions shall be binding on and inure to the benefit of the parties' respective successors and permitted assigns.

17. Entire Agreement. These Conditions of Sale and Performance of Services take precedence over Buyer's additional or different terms and conditions, to which notice of objection is hereby given. Acceptance by Buyer is limited to LI-COR Conditions of Sale. Neither LI-COR commencement of performance nor delivery shall be deemed or construed as acceptance of Buyer's additional or different terms and conditions. These Conditions supersede all prior communications, transactions, and understandings, whether oral or written, and constitute the sole and entire agreement between the parties pertaining to the referenced quotation or purchase order, provided that: (1) these Conditions shall not, without LI- COR prior written consent, supersede any conflicting terms of: (a) prior written agreements duly executed by LI- COR, or (b) governmental purchase orders, terms of purchase, requests for quotation or acquisition regulations relative to governmental purchasers; and (2) to the extent not in conflict with any such prior or governmental terms, these Conditions shall supplement them. No modification, addition or deletion, or waiver of any of the terms and conditions of these Conditions shall be binding on either party unless made in a non-preprinted agreement clearly understood by both parties to be a modification or waiver, and signed by a duly authorized representative of each party.

18. Force Majeure. Shipping/delivery dates are approximate and may be delayed absent prompt receipt from Buyer of all necessary information. LI- COR shall not be responsible for any failure to perform or delay attributable in whole or in part to any cause beyond its reasonable control, including but not limited to Acts of God, government actions, war, civil disturbance, insurrection, sabotage, labor shortages or disputes, failure or delay in delivery by LI-COR suppliers or subcontractors, transportation difficulties, customs clearance, shortage of energy, raw materials or equipment, or Buyer's fault or negligence. In the event of any such delay the date of delivery shall, at the request of LI-COR, be deferred for a period equal to the time lost by reason of the delay.

19. Governing Law and Venue. These Conditions and performance by the parties hereunder shall be construed in accordance with the laws of the State of Nebraska, U.S.A., without regard to provisions on the conflicts of law.

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