# Using the Water Node

## LI-710 Evapotranspiration Sensor on LI-COR Cloud


LI-COR®

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**LI-COR Environmental**
4647 Superior Street
Lincoln, Nebraska 68504
Phone: +1-402-467-3576
Toll free: 800-447-3576 (U.S. & Canada)
envsales@licor.com
envsupport@licor.com
licor.com/

**LI-COR GmbH, Germany**
Siemensstraße 25A
61352 Bad Homburg
Germany
Phone: +49 (0) 6172 17 17 771
envsales-gmbh@licor.com
envsupport-eu@licor.com

**LI-COR Ltd., United Kingdom**
St. John's Innovation Centre
Cowley Road
Cambridge
CB4 0WS
United Kingdom
Phone: +44 (0) 1223 422102
envsales-UK@licor.com
envsupport-eu@licor.com

**Beijing LI-COR Bioscience Ltd.**
Room 502-503, 5th Floor, Jimen No.1 Office Building
Xitucheng Road, Haidian District
Beijing, China
Phone: +86-400-1131-511
china-sales@licor.com
china-support@licor.com

**LI-COR Distributor Network**
licor.com/distributors


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## Printing History


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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-710"), 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, Blue Angel, TÜV Green Product Mark, Energy Star, EU GPP, or other similar regulations. The typical scope for these regulations is lighting, furniture, copiers, mobile phones, televisions, computer/servers, home appliances, to name a few. As such, our products do not use any labeling that indicates adherence thereof.

## 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.
# Introduction to the LI-710 and Water Node

The LI-710 Evapotranspiration Sensor measures the total transport of water from evaporation and transpiration over an area. The output from the LI-710 is evapotranspiration, energy flux, and other parameters in 30-minute increments. The LI-710, when paired with an IoE Module, is a Water Node on LI-COR Cloud.

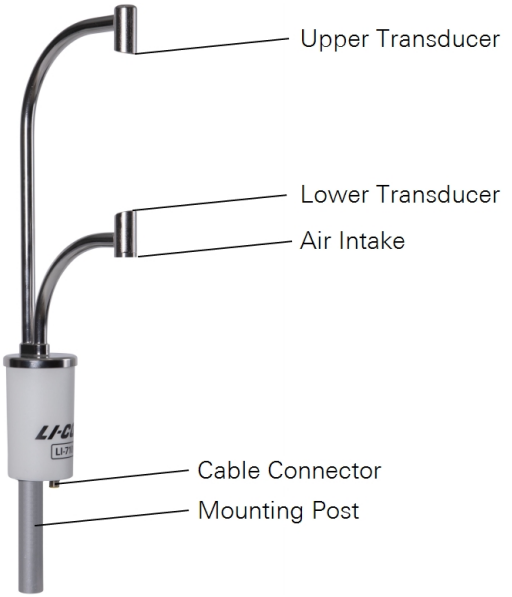



*Figure 1-1. The LI-710 Evapotranspiration Sensor consists of two transducers for anemometric measurements and an air intake.*

If you have just received your LI-710, check the packing list to be sure you have everything that you ordered. The LI-710 may include some or all of the following components.

# LI-710 Evapotranspiration Sensor

Part number
9971-010

The sensor features one cable connector for power and data and one mounting post for mounting on an IoE Module or tripod using a 1" (2.54 cm) fitting.

## Data and power cable

Part number
392-19605

Each sensor includes a 5-meter long combined data and power cable. The cable connects to the SDI-12 terminals on a datalogger.

## Spares kit

Part number
9971-008

Each LI-710 is shipped with a spares kit, which includes replacement parts and a tool for the instrument. See *Table 1-1* below for a complete list.

**Table 1-1**. Spares and accessories that are included with the LI-710.

| Description | Quantity | Part Number |
|---|---|---|
| Pump | 1 | 286-17946 |
| Pump O-ring; 16×1.5 mm VITON 75 | 1 | 192-18247 |
| Pump O-ring; 29×2 mm VITON 75 | 1 | 192-18249 |
| Screws; M3×0.5 20 Stainless Steel | 4 | 151-18159 |
| Hex key; 2.5 mm ball end | 1 | 611-20555 |
| Intake Filter Tool | 1 | 6371-021 |
| Intake O-ring; 14.5×1 mm FKM 75 | 5 | 192-09986 |
| Intake Filters | 5 | 6571-002 |

## Filter pack

Part number
9971-015

Five replacement filters are included in the spares kit. Additional filter packs are available for purchase. The filter pack includes five filters and five O-rings.

## Replacement pump

Part number
9971-016

One replacement pump is included in the spares kit. Additional pumps are available for purchase. The kit includes a pump, two O-rings, and four screws.

## Stevens HydraProbe

Part number
900-19016

The IoE Module supports a Stevens HydraProbe (firmware v4 and up) for soil moisture, temperature, and electrical conductivity measurements.

# IoE Module

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

- Cellular service plan and access to LI-COR Cloud (1 year).
- 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

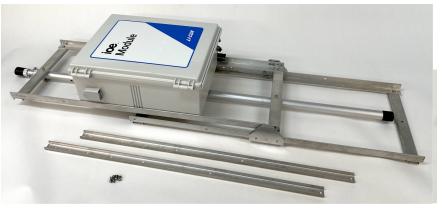
**Part number**
**9000-03**

The stand-alone IoE module includes the enclosure, electronics, power and data cable for the LI-710 (392-20750), one year of cellular service, and one year of LI-COR Cloud data service. 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**

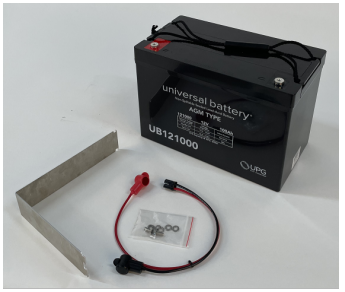
The turnkey IoE Module includes everything listed previously, plus a solar panel, battery, and hardware for the solar power and battery. The panel rails provide angle adjustments to allow the solar panel to face the sun in different latitudes and seasons.

### 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**

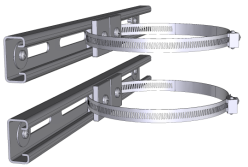
Each IoE Module includes a sensor cable to connect the LI-710 or LI-720 to the **SENSOR** connector on the IoE Module. It is a 5-meter long 5-pin cable with connectors on each end.

## 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 |

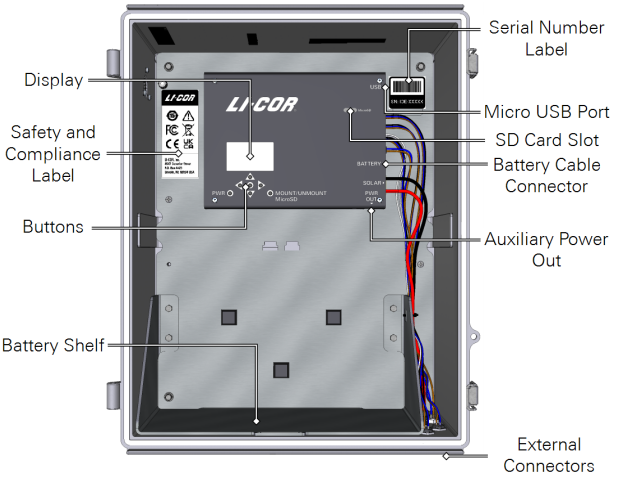
## Enclosure and electronics

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.



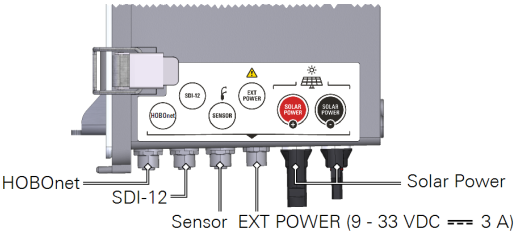

- **Display**: Monochrome display that presents status and configuration information. See *IoE module interface reference* on page 9-1 for a tour.
- **Buttons**: Buttons include power (PWR), navigation (▲, ▶, ▼, ◀), select (), and mount/unmount card.
- **Battery Shelf**: To support the optional battery. 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 Water Node Network

The optional Water Node Network provides supplemental data to the water 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 Water 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 number**
**RXMOD-RXW-900-1**

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 and stored on the SD card.

Each Water 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.

## Wind speed and direction sensor

**Part number**
**RXW-WCF-xxx**

A cup and vane anemometer measures wind speed and direction. One is included.

### Leaf wetness sensor

**Part number**
**RXW-LWA-xxx**

Measures leaf wetness. One sensor is included.

## Summary of theory of operation

The LI-710 uses eddy covariance calculations that are optimized for the hardware and sensor configuration. It combines vertical wind speed measurements with high-precision relative humidity measurements to compute evapotranspiration from the area surrounding the sensor. When the prevailing wind directions around the LI-710 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 encompasses an area around the LI-710 that is 50 to 100 times the height of the sensor (e.g., a 2-meter height above the canopy has a fetch footprint of 100 to 200 meters).

The LI-710 does not provide horizontal wind information and therefore, it does not report the fetch footprint of the measurement. In a proper deployment, the footprint will encompass a uniform land area surrounding the sensor or an area upwind of the prevailing wind direction (see *Installing the LI-710* on page 3-1 for more information).

# Section 2.
# 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 10-1 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* on page 1-3.

# 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.
- Disconnect the sensor cables from the IoE Module. Keep track of which sensor is connected to which connector, you'll need to connect them the same way or repeat the steps in *Initial setup* on page 4-1.
- Remove the battery (see *Removing the main battery* on page 7-12).
- 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!

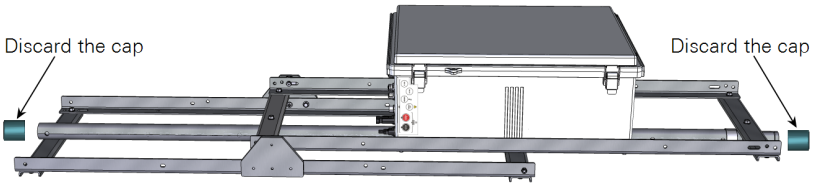
# Initial assembly

> ***Warning:*** *The components of this product are heavy (see Specifications on page 10-1 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

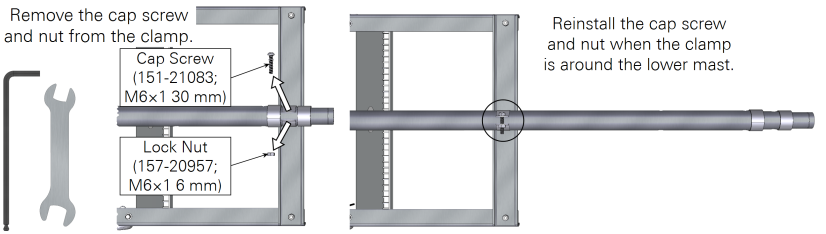
**Caution:** Wear gloves and goggles for safety.

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

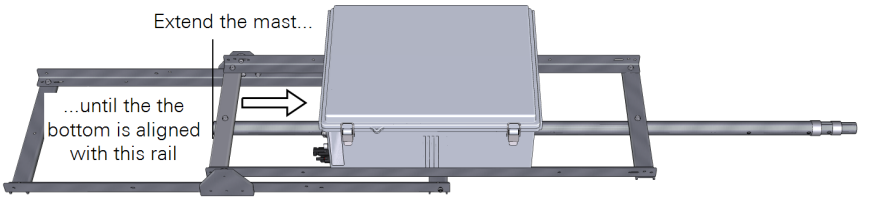



2 Release the upper mast clamp.

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.

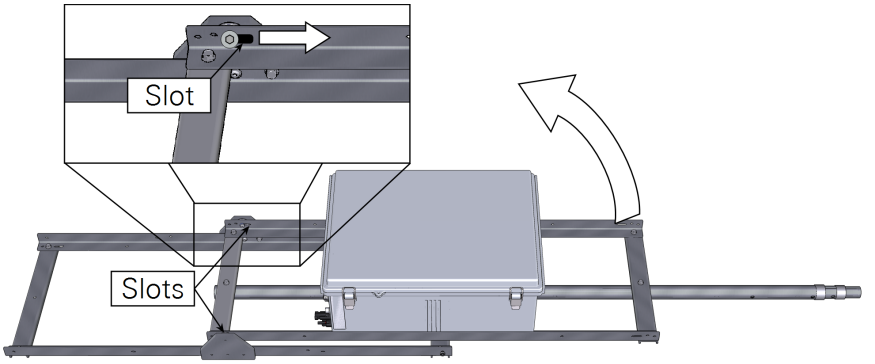



3 Extend the mast so the bottom is aligned with the lower rail.



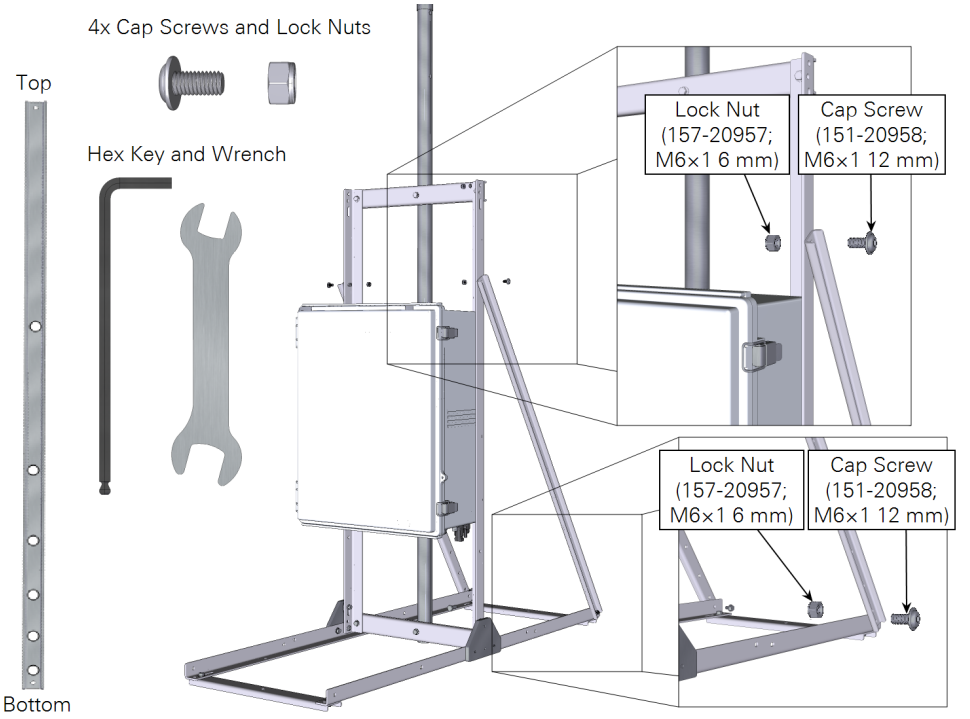

**4** Rotate the enclosure frame to a vertical position.

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.

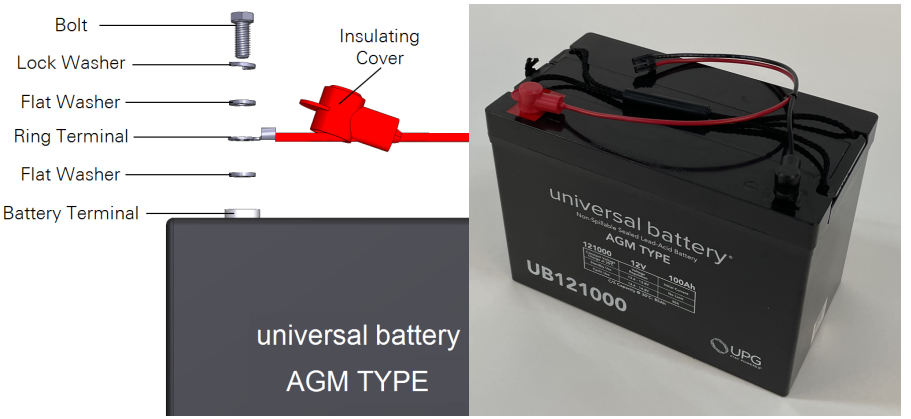



## Installing the battery

***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.

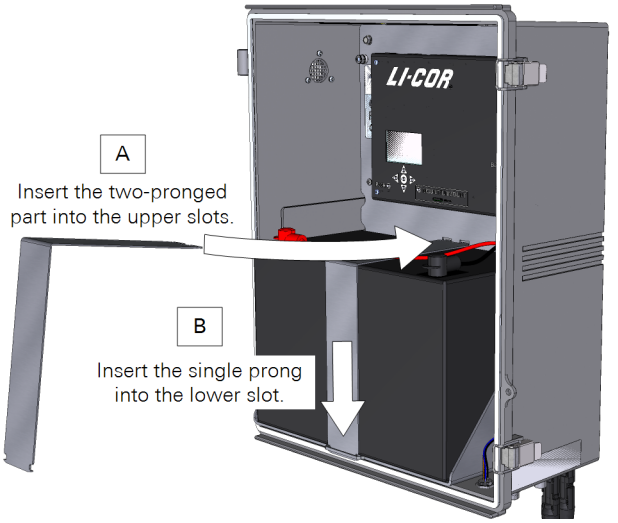
The cable (part number 99512-022) connects to the battery terminal with this hardware arrangement: flat washer, cable ring terminal, flat washer, lock washer, and finally, the bolt. Washers and bolts are included with the battery. Attach the red cable to the red terminal (+) and the black cable to the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



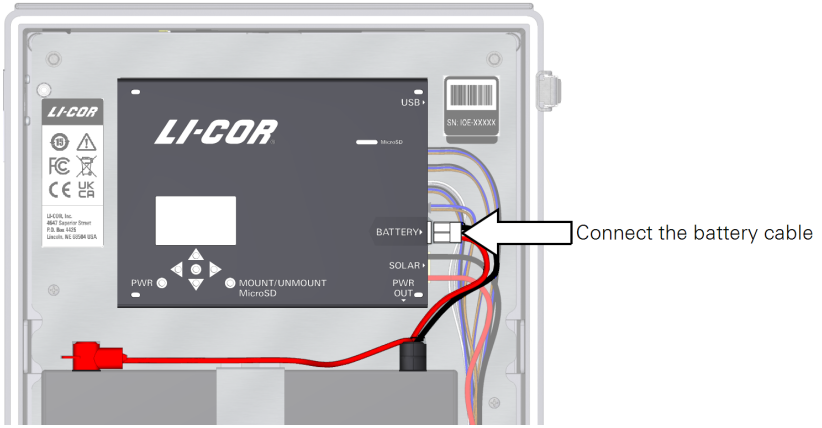

2 Set the battery on the shelf with the terminals toward the front of the box.

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 7-12 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 1-7 for cable options.

# Field installation

See *Initial assembly* on page 2-4 for the initial hardware assembly.

## Site preparation

Place the frame on level ground. The LI-710 can tolerate a tilt of up to 8° from vertical, but ***installation on level ground with a vertical mast is best***. 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-710

**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 2-1* below.

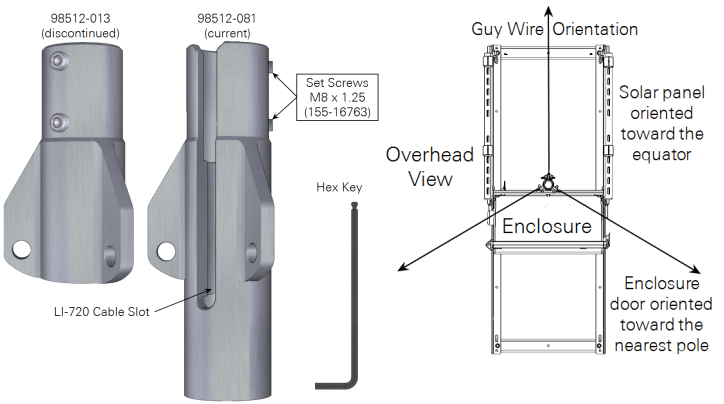



*Figure 2-1. The adapter threads onto the mast. Rotate the mast so one guy wire extends the direction opposite the enclosure door and the other two extend to the sides.*

3 Connect the power/data cable to the LI-710 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-710 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.

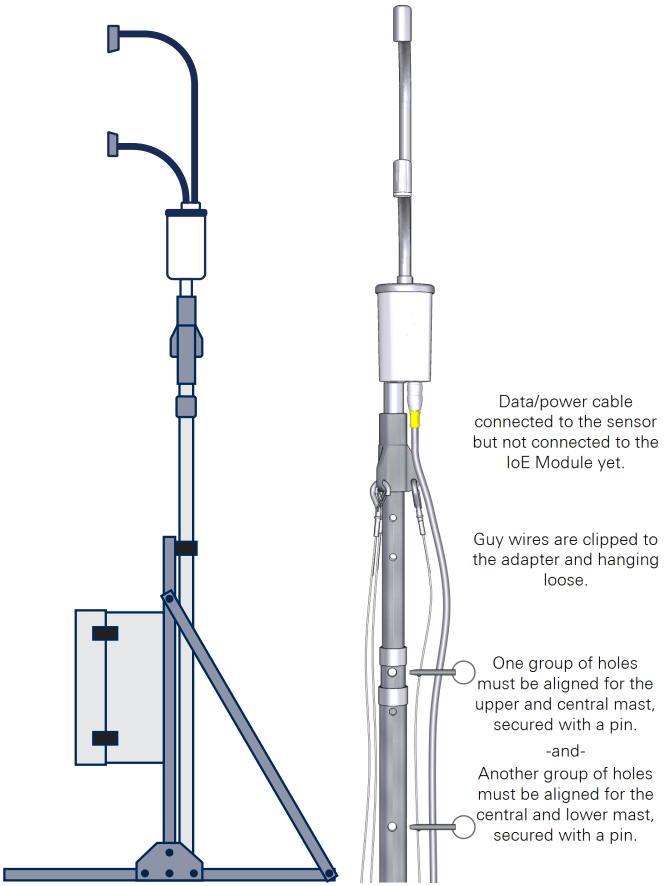
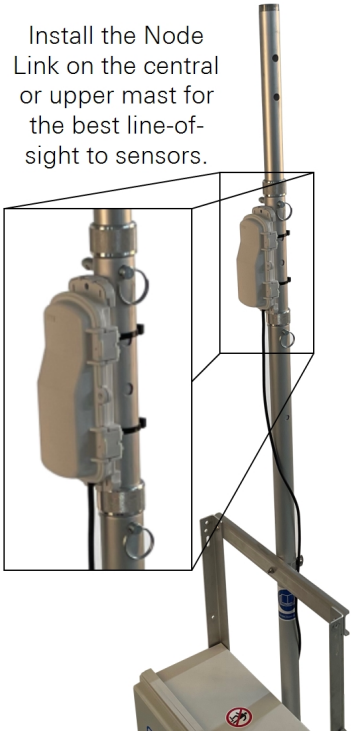



*Figure 2-2. Two pins secure the telescoping mast sections. The upper and central mast sections are secured with one pin. The central and lower mast sections are secured with the second pin.*

## 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 Water Node* on page 4-6 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.

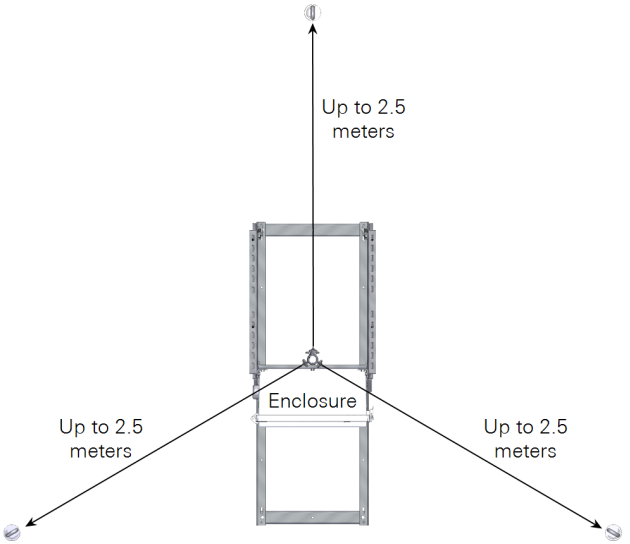
## Installing earth anchors and guy wires

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.

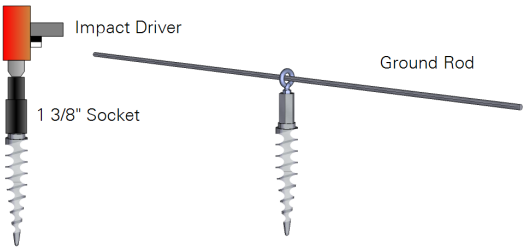
The guy cables should be around 20° to 30° angle from the mast. You can approximate the angle by pacing off the distance or measure the angle with an app on a smart phone.

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.

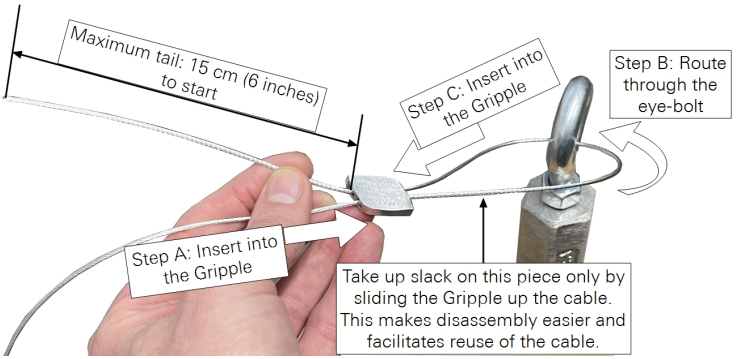
If the opening in the eye bolt is not perpendicular to the mast, drive it further until the opening is perpendicular toward the mast.

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.

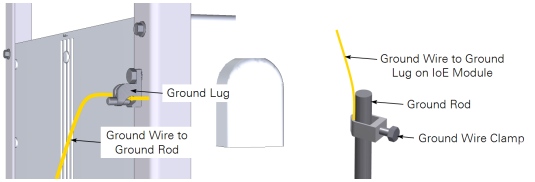
## Releasing a Gripple (loosening a cable)

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 2-6.

**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.

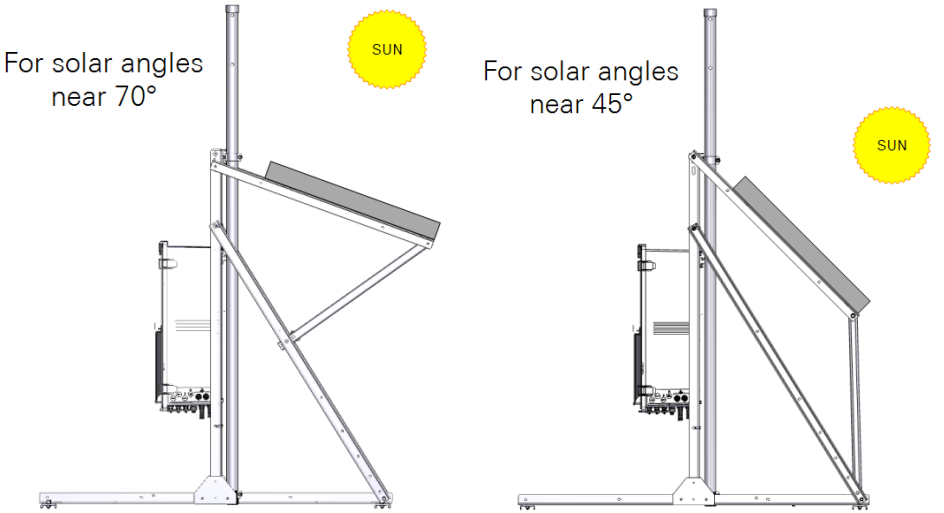
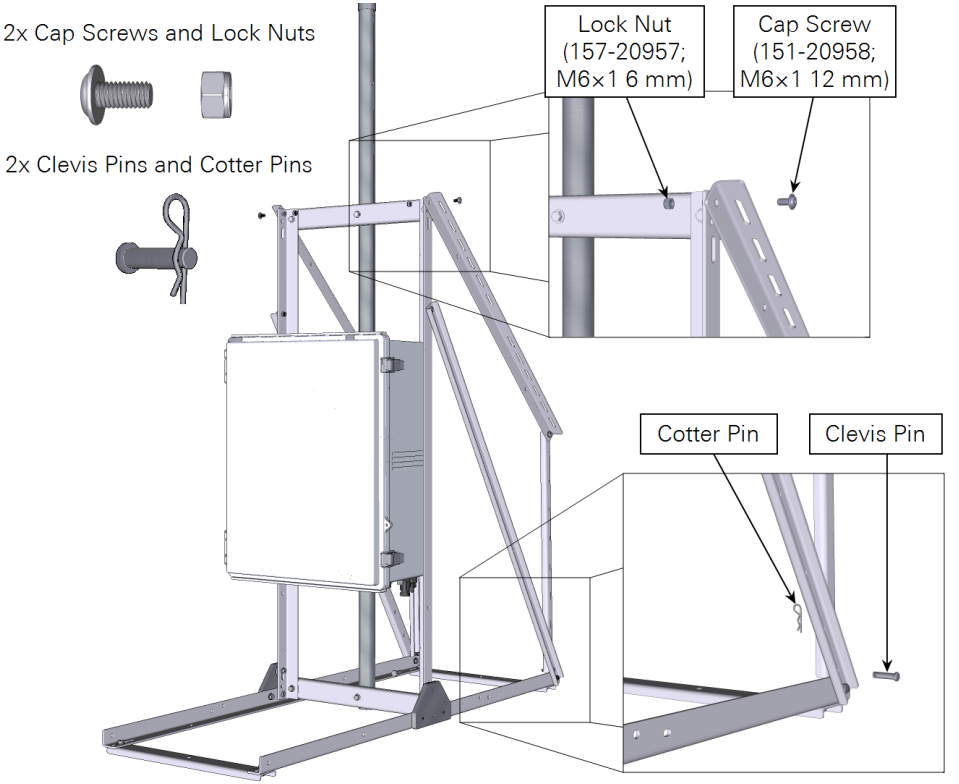



*Figure 2-3. Orient the panel so it has the maximum exposure to sunlight.*

**2** Attach the solar panel rails at the desired angle.

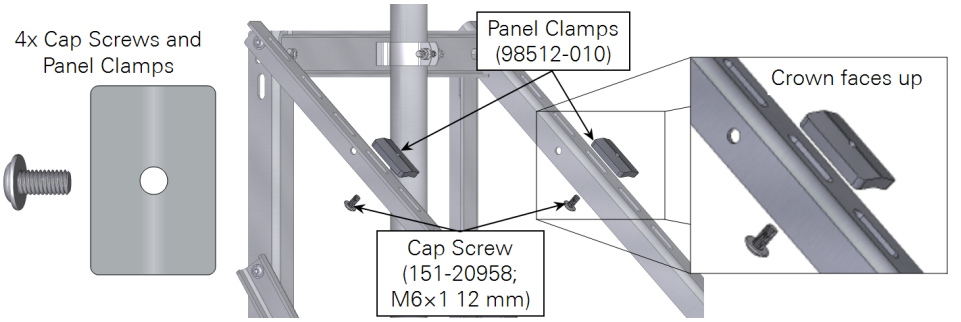
The upper angle rails attach to the top with two cap screws and nuts. The lower U-rails attach with two clevis/cotter pins.




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

Retain the warranty information and manufacturer's documentation.

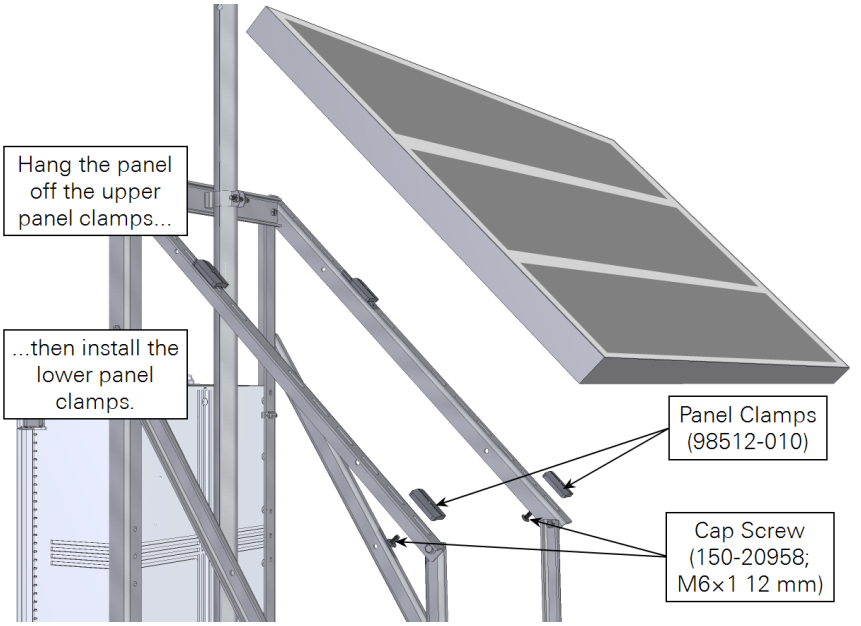
**4** On the panel frame rails, loosely install two upper clamps as shown.




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 3.
# Installing the LI-710

Remove the caps that cover the transducers and air intake before powering on the LI-710 (see *Figure 3-1* below).

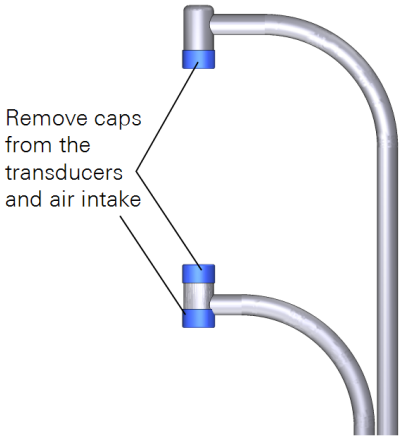



*Figure 3-1. Protective caps should be removed before powering on the sensor.*

## Deployment considerations

The LI-710 can be deployed as a stand-alone sensor, in a weather station, or as part of an eddy covariance flux station. There are a few considerations that will help ensure that the data you collect accomplishes your measurement goals.

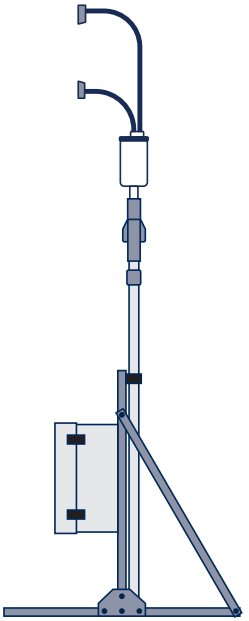


*Figure 3-2. The IoE Module with an LI-710 is a Water Node on LI-COR Cloud.*

## Measurement area

Measurements from the LI-710 represent a land 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.

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.

**Note:** If the LI-710 is installed in the middle of the area-of-interest, footprint information is not critical for interpreting the data. In cases where the footprint is required, you should collect horizontal wind information and calculate the footprint using your own methods. Ideally, the deployment will be such that there is no need to determine the footprint.

## Distance from surrounding elements

To ensure that the LI-710 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, although you should allow clearance of two meters or more, if possible.

**Caution:** If deploying the LI-710 near a cellular antenna, position the antenna at least two meters away from the LI-710 to reduce the risk of electromagnetic interference.

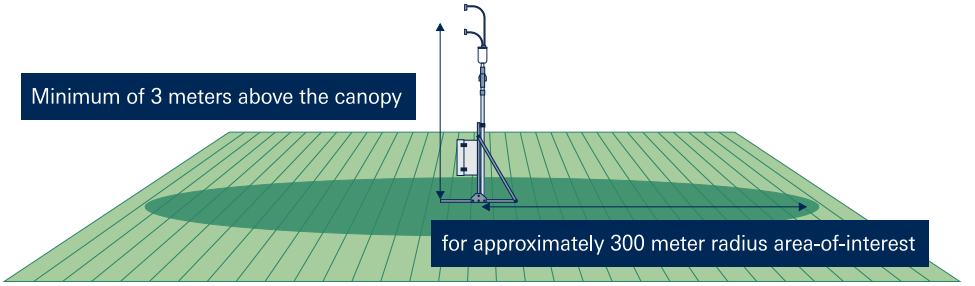



*Figure 3-3. The sensor should be at least 3 meters above ground for an area-of-interest of 300 meters around the device.*

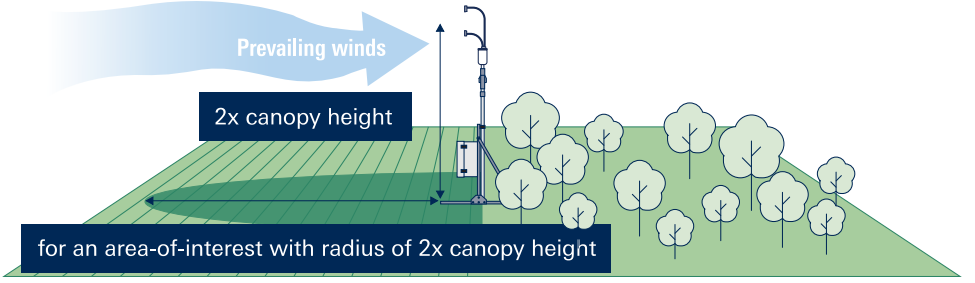



*Figure 3-4. When installation within the area of interest is not possible, the LI-710 may be mounted on the downwind boundary of the site, allowing the upwind fetch to capture the representative measurement area.*

## Height above the canopy

The measurement area represented by the LI-710 depends on its height above the plant canopy. In general, the LI-710 should be installed at least 3 m above the ground or at a height equal to twice the canopy height (2× canopy height).

For example, when mounted at a height of 4 m, the approximate fetch — the area influencing the measurement — extends to a radius of about 400 m around the LI-710 (see *Figure 3-3* on the previous page). All landscape elements within this radius can contribute to the measured evapotranspiration.

The LI-710 is designed for use over annual crops and orchards. For fast-growing canopies such as soybeans, sorghum (milo), wheat, flax, rice, corn, vegetables, and cotton, install the LI-710 3.5 m (for soybeans) to 5 m (for corn) above the soil surface before germination, providing a fetch of roughly 350–500 m.

As the crop grows, the distance between the sensor and canopy decreases, reducing the fetch. This condition is ideal — the measured area then corresponds closely to the field area of interest throughout the growing season. Alternatively, the LI-710 can be raised periodically during the season to maintain a consistent measurement height of approximately 2× the canopy height.

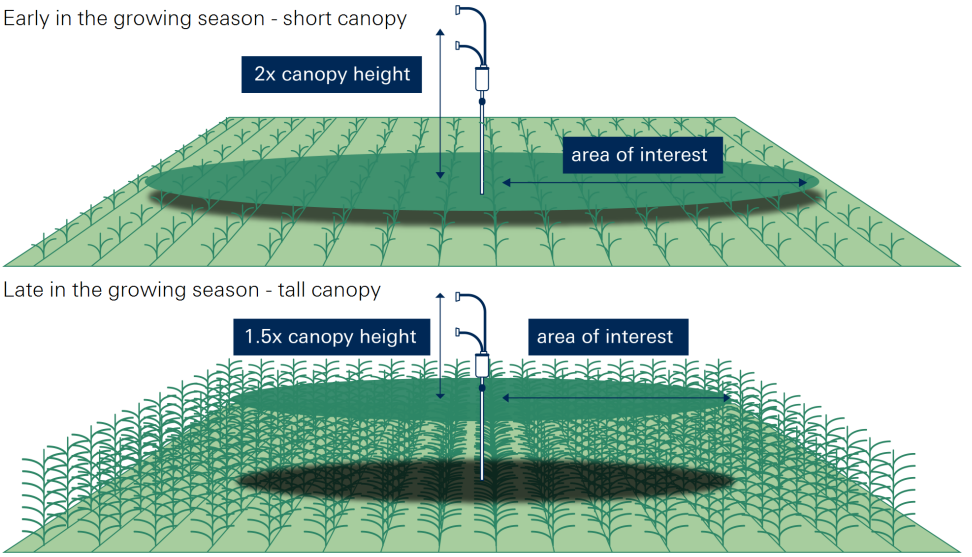



*Figure 3-5. Recommended installation height of the LI-710 in short and tall canopies.*

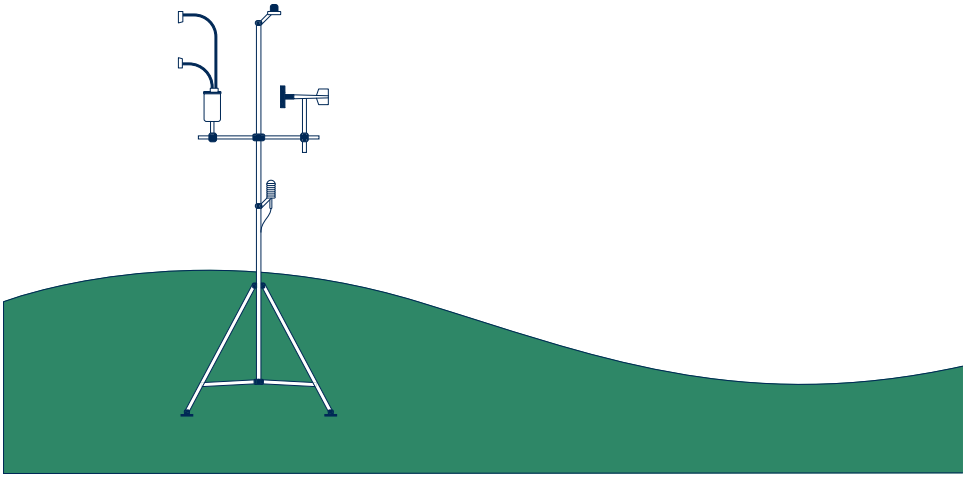


*Figure 3-6. Over a short canopy with rolling terrain, the instrument should be at least 3 meters above the top of the plant canopy.*

Over orchards and woodlands, which are characterized by partial to full canopy closure, the LI-710 should be at least 3 meters above the top of the canopy.

*Figure 3-7. The LI-710 should be at least 3 meters above the top of orchards, woodland, and forest canopies.*

## Terrain, slope, and tilt

You can expect good results ***as long as the sensor is within a few degrees of perpendicular to the slope*** of the area-of-interest. The grade can range from 0 to 10%. Measurements from the sensor are not highly sensitive to slopes up to 10° from level. The **level application** on many mobile phones is adequate to confirm that the tilt of the sensor matches the grade. Tilt from vertical is recorded in data group 2 (see *Group 2: Air, humidity, and instrument information* on page 5-13).

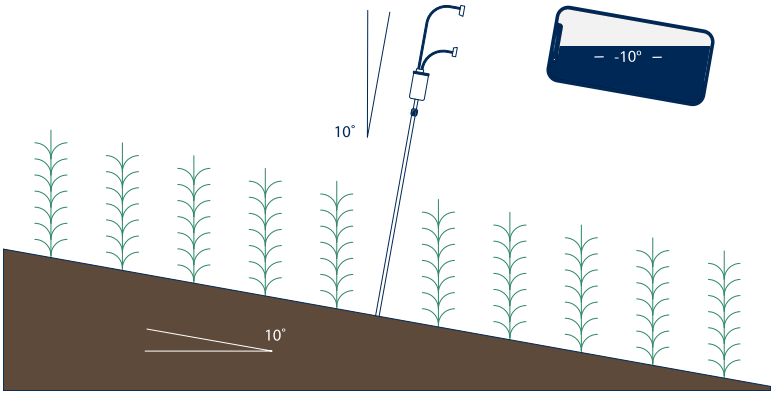



*Figure 3-8. On sloped terrain, install the LI-710 perpendicular to the predominant slope of the area-of-interest. A few degrees of difference is acceptable.*

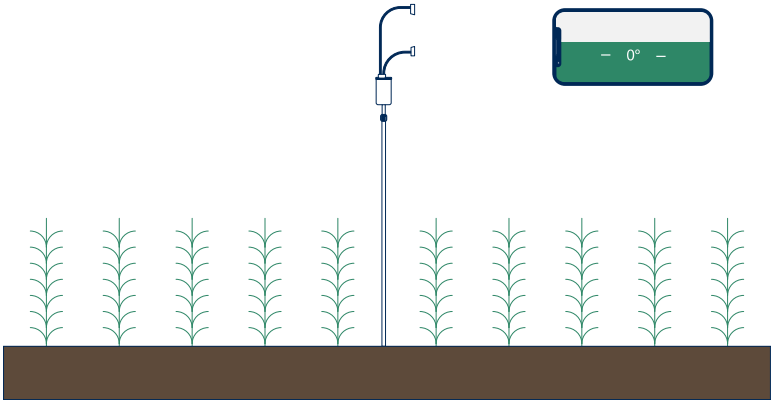



*Figure 3-9. On level ground, install the LI-710 with 0° tilt, although a few degrees of difference is acceptable.*

# Deployment example

You have completed the hardware assembly. Take a moment to review the safety and stability of your installation and make any refinements. Then, install the soil probe and determine the measurement height of the LI-710.

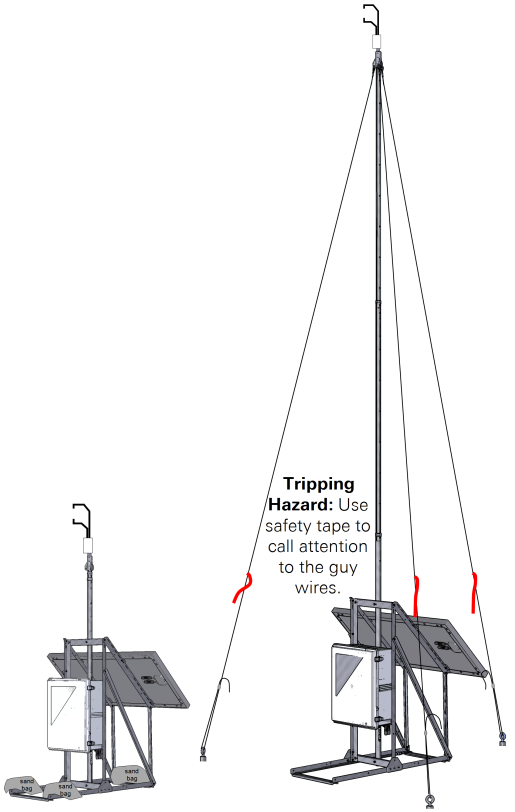



*Figure 3-10. If the mast is extended, use the guy wires for stability. If the mast is in the lowest position, guy wires are optional, but place several sandbags on the frame for stability. Tie red or reflective tape to each guy wire for visibility and safety.*

## Installing the soil probe

The soil probe can be installed at the surface or at a depth below the soil surface. Follow the installation instructions from Stevens. Place it in soil that is representative of the site, not under the shadow of the solar panel.

## Determining the measurement height

The mast can be adjusted to support the sensor at heights of 2 to 5 meters above the ground. You can estimate the height or measure it directly.

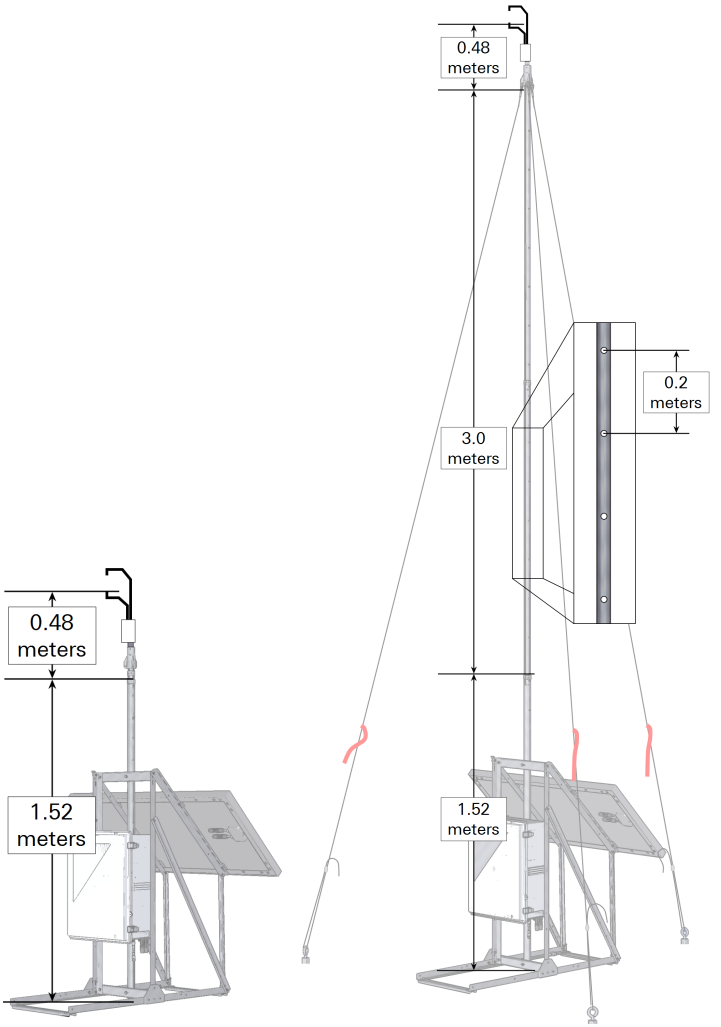



*Figure 3-11. The mast can be adjusted in 20 cm increments for an instrument height above ground level from 2 to 5 meters. You can estimate the height of the central portion by counting holes exposed and multiplying by 0.2 meters.*

# Section 4.
# Configuring the Water Node

The Water Node – an LI-710 connected to LI-COR Cloud with an IoE Module – presents the simplest and most scalable way to use the LI-710. Here we describe how to use the LI-710 as a Water Node. After assembling the IoE Module and mounting the LI-710 on the mast, (see *Assembling the IoE Module* on page 2-1 and *Installing the LI-710* on page 3-1), follow these steps to configure the Water Node.

## Initial setup

Leave the LI-710 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.

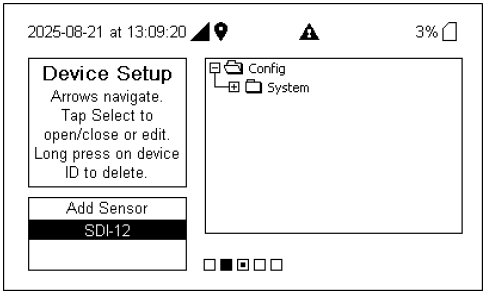
   The IoE Module must have a strong cellular connection during configuration. Keep the sensors nearby but leave the cable disconnected for now.

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

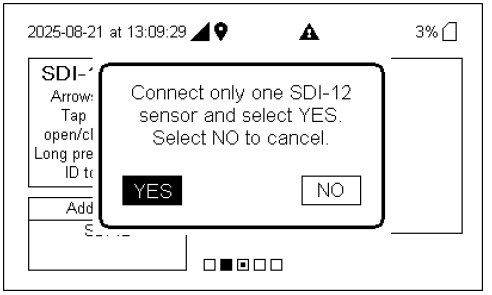
   From the home screen, press left three times (◀◀◀) to access the **Device Setup** screen.

5 While **Add Device** is highlighted press **Select** (O) to begin.

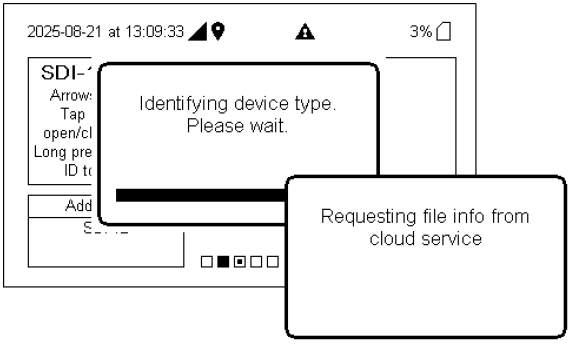
Leave all device cables disconnected but nearby.




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.

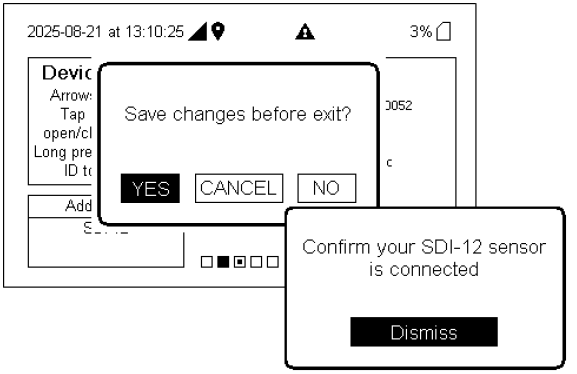



7 Preview the device information and make changes if desired.

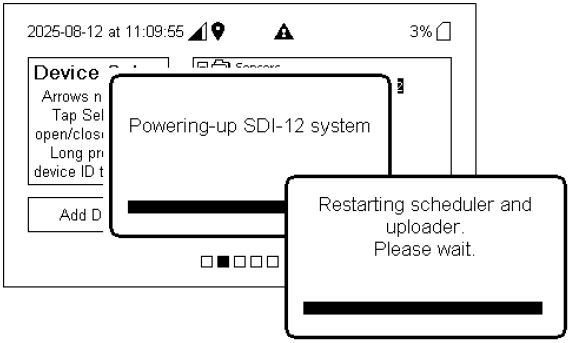
Leave the period at 30 minutes to use cleaning and gap filling on LI-COR Cloud.

8 Save the configuration.

Press **Right** (▶) and then **Select** (O) to save changes. You MUST save changes.




**9** Watch as the IoE Module finishes the configuration.

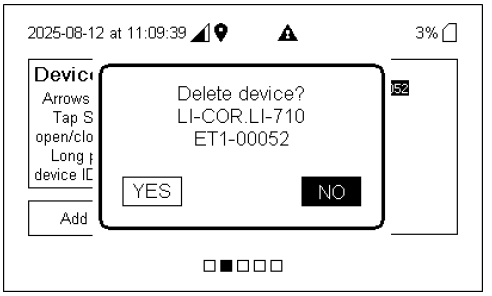



- If the IoE Module is partially configured but has no interactions for one hour, it will abort the configuration and return to the prior configuration and display the home screen.
- Trouble registering a sensor? See *IoE Module troubleshooting* on page 6-6.

## Deleting a sensor

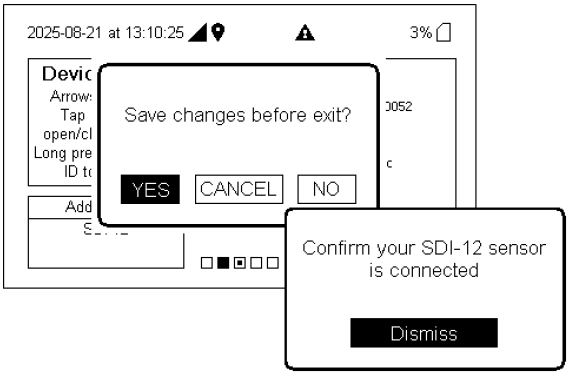
If you have connected a device but want to delete it for some reason or another, follow these steps.

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 select **YES** to save the changes and dismiss the prompt. You MUST save changes for the settings to be applied.




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

## Changing the reporting interval

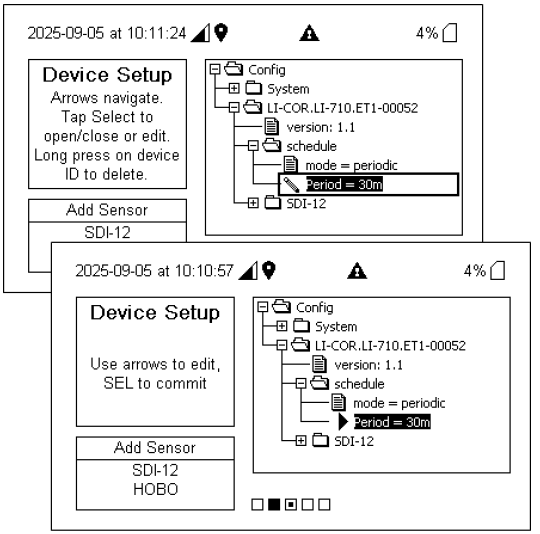
The reporting interval can be set at the IoE module. The LI-710 and IoE Module report results every 30 minutes by default, but this can be changed to any interval between 15 and 60 minutes (5 minute resolution). The Stevens probe reports results every 10 minutes by default but it can be any interval 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 Water 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.

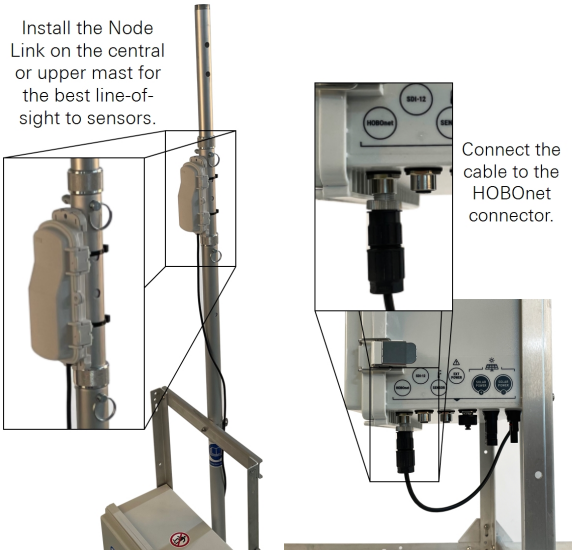
Each wireless device in a Node Link must have line-of-sight with other devices or the Node Link (<200 meters distance between sensors). Data can be transmitted through up to five sensors. Vegetation can block wireless signals, so be sure each transceiver is above the plant canopy, even as it grows

## 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.

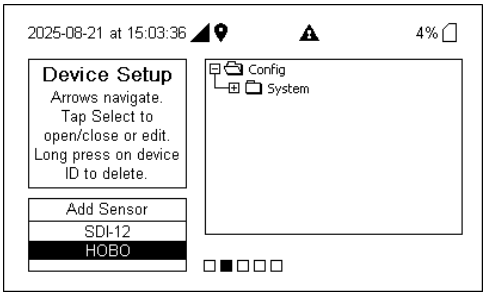
   Install the Node Link on the central or upper mast segment. Identify the top of the bracket and then attach it to the IoE module mast using two zip ties. Then install the Node Link in the bracket.



3 Power on the IoE Module.

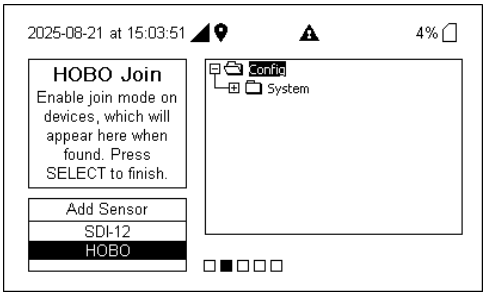
4 Press left three times (◀◀◀) to enter **Device Setup** mode.

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.

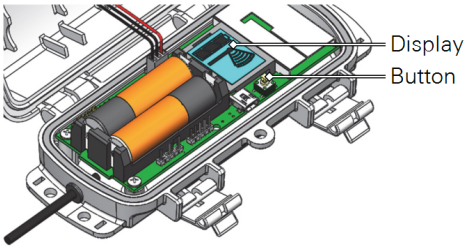
Now the Node Link is ready to connect with individual sensors.




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.



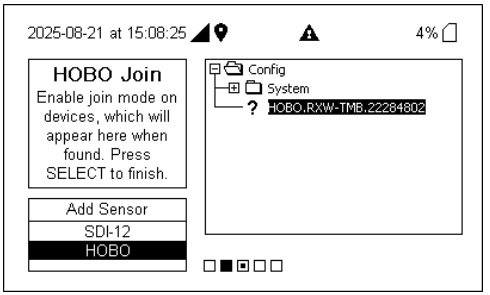

Watch the display as the sensor joins the network.

The signal strength icon blinks while searching for a network.

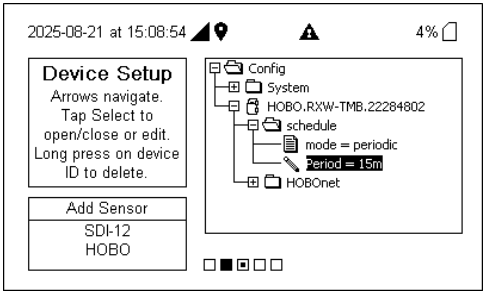
Once a network is found, the icon stops flashing and the bars cycle from left to right. The **X** icon blinks while the sensor completes the registration process. This may take up to five minutes.

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.

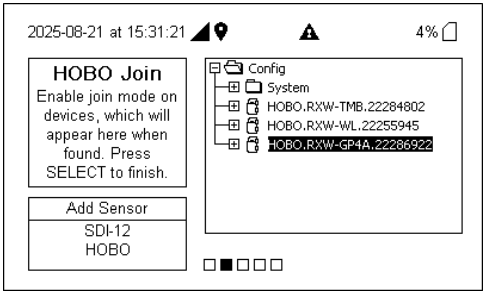



**9** Press **Select** (O) to complete the registration for this sensor.



**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 *Water node sensor network issues* on page 6-12.

## 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 the LI-710 to LI-COR Cloud* on page 5-1), data are uploaded and can be viewed and retrieved from LI-COR Cloud (see *Working with Water Node data* on page 5-5).

# Section 5.
# Adding the LI-710 to LI-COR Cloud

A Water Node is an LI-710 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.

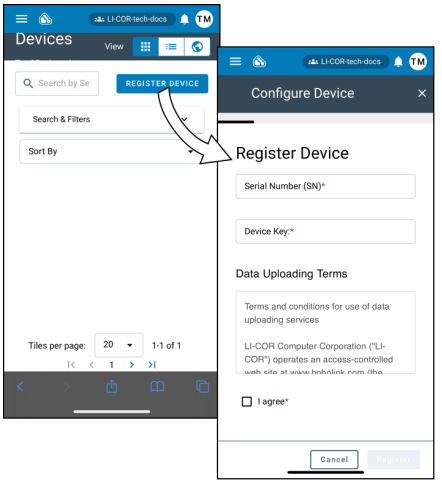
   Use a unique organization name and user name.
3. Confirm your account.

   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

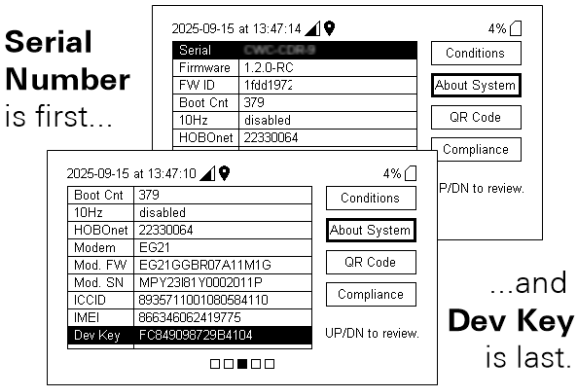
All devices must be registered to appear in LI-COR Cloud. To register a device:

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).



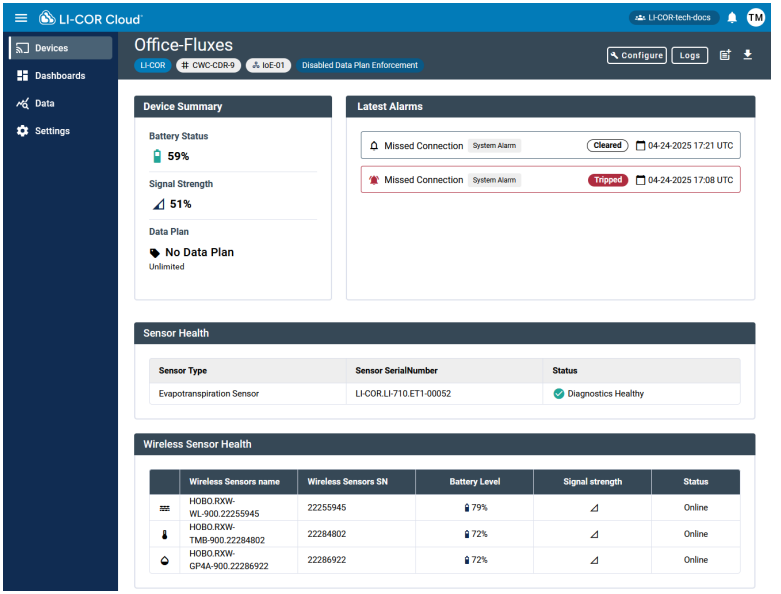

4 Fill in any additional information and complete registration.

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

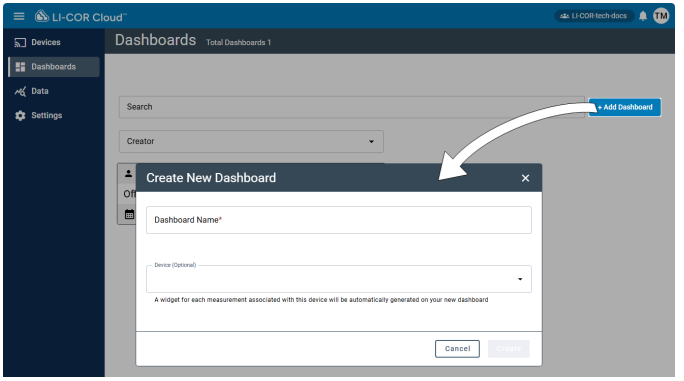
Click **Devices** and select a device for a quick overview of devices and status information.




## Creating a Dashboard

After creating an account and registering the IoE Module that hosts the LI-710, you can customize the LI-COR Cloud **Dashboard**. Start by selecting 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.

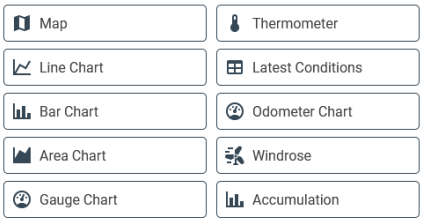
Congratulations! You have created a Water Node on LI-COR Cloud. Now, you can view data, process data, and perform advanced data processing, including Gap Filling, Total ET, Flux Footprints, and more. See *Working with Water Node data* on the facing page for more details.

# Working with Water Node data

Results from a Water Node are uploaded to LI-COR Cloud on the schedule (every thirty minutes by default). Widgets are used to display data from the Water 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 re-size widgets to suit your preferences. For Water Nodes, two widgets may be of special interest: Accumulation and Gap filling.

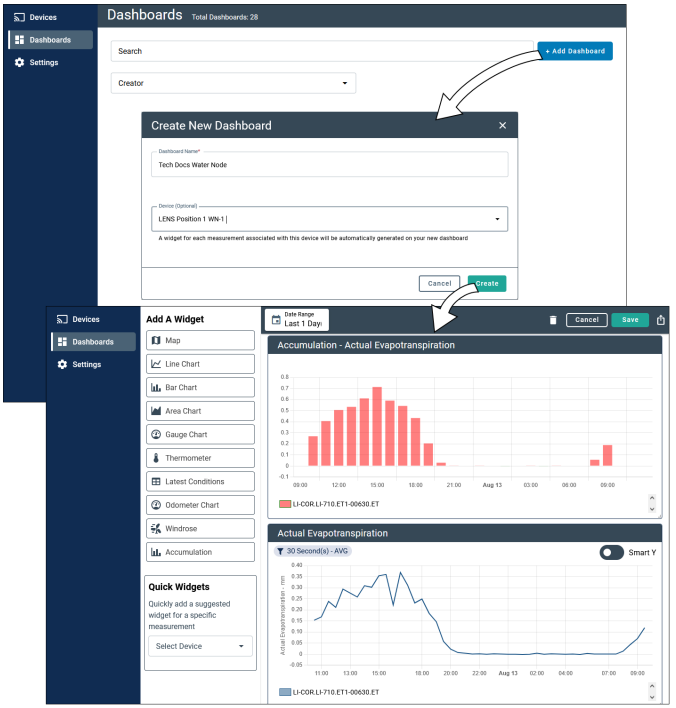



## Accumulation widget

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:

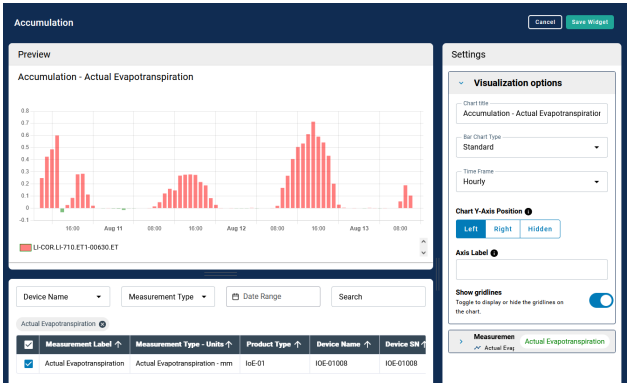
1 Add a Dashboard.

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




**2** Customize the Widget.

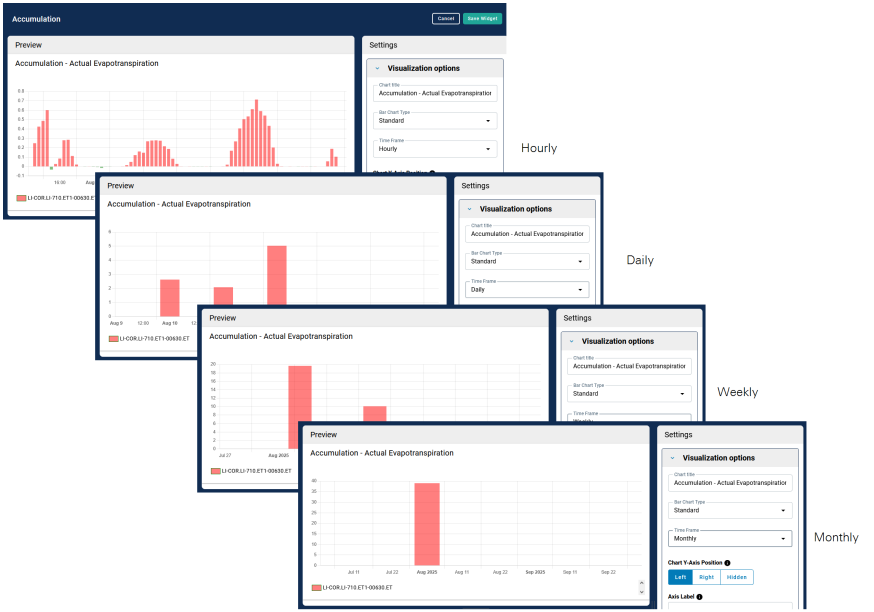
If you have saved the Widget, click Edit to view the Widget options. Then select the menu to view Chart Options. Use the Device Name and Measurement Type to constrain the list. This is to make it easier to find the parameter of interest. You can also search for measurements and constrain the date range.



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.

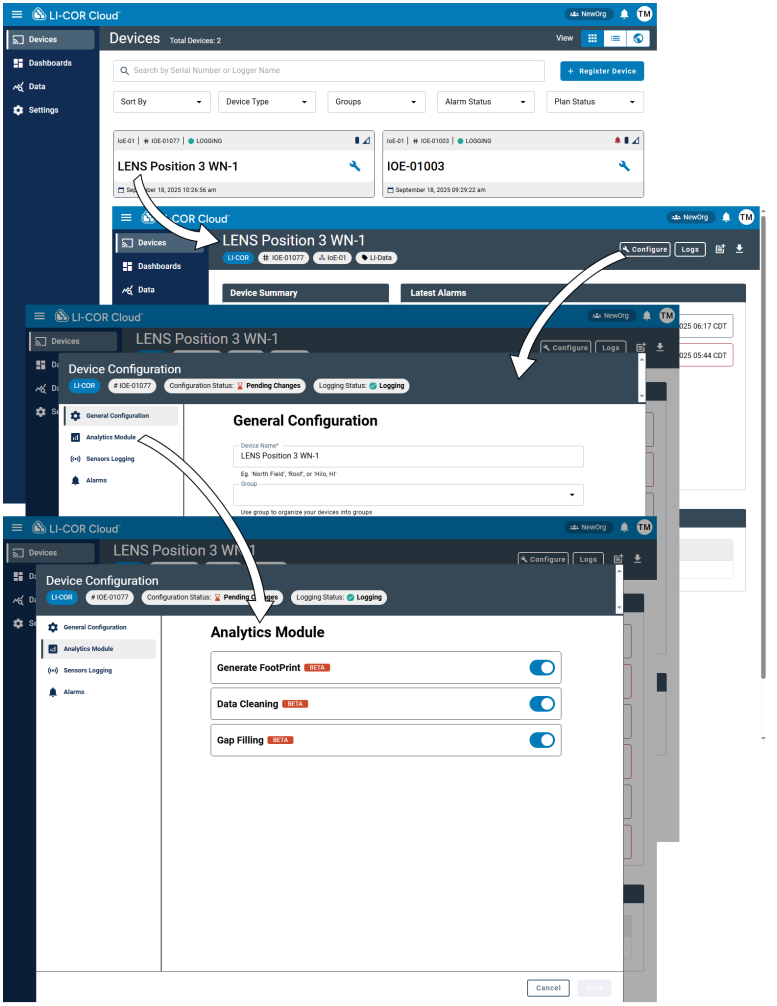
You can customize the y-axis label and position, change the display parameters of each variable, and apply threshold indicators to change the color of a displayed parameter if it is outside some bounds.

5 Save the widget to display it on your dashboard.

## Data cleaning, gap filling, and footprint widgets

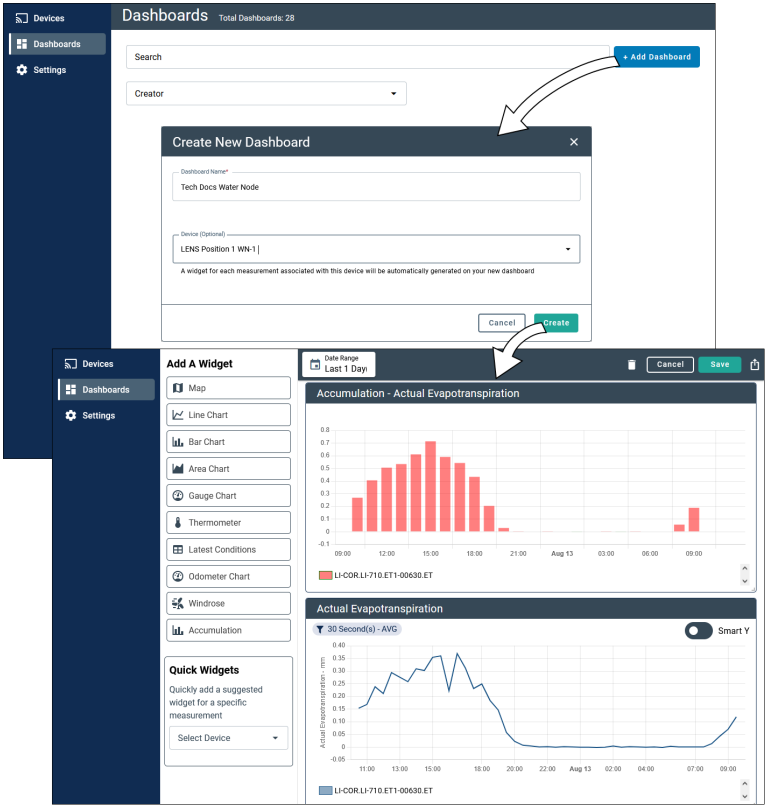
Gap filling is a procedure that uses existing data to fill in missing data with approximations using robust statistical methods. For fluxes from a Water Node (LI-710), gap filled data are presented as a line chart, featuring the same display options. To use the feature:

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



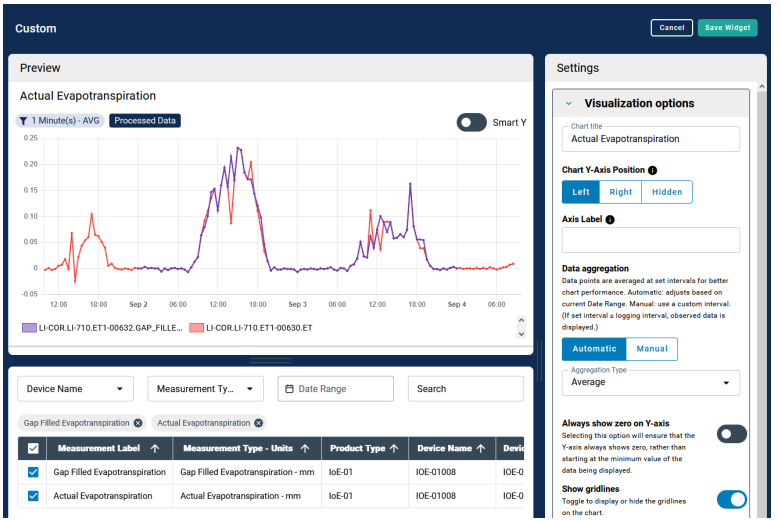
2 Add a **Dashboard**, if you haven't made one yet.

Widgets relevant to Water Nodes will be added automatically after you select a Water Node, including the Evapotranspiration Line Chart and the Accumulation widgets, among others.

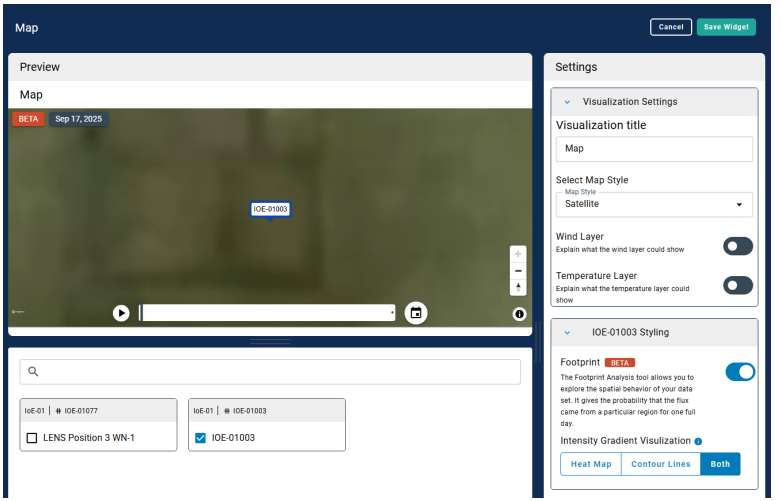



3 Add more variables and configure the display settings.

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.




4 Enable the footprint in the Map widget.



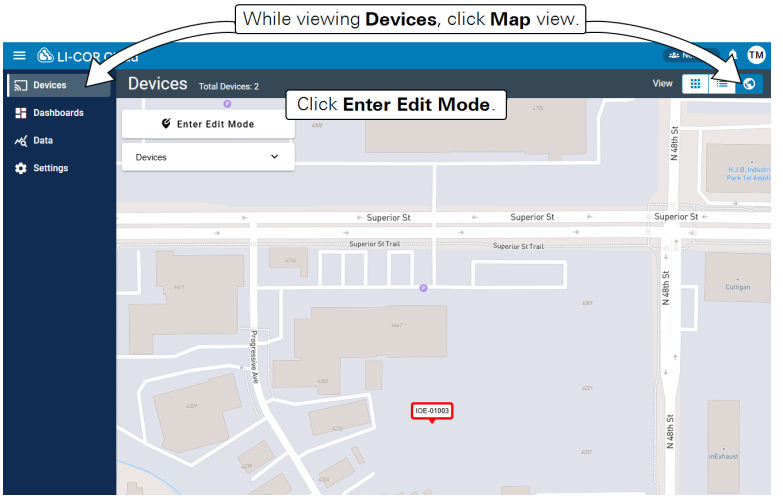

5 Save the Widget settings and then save the Dashboard.

## Adding RX sensors to the map

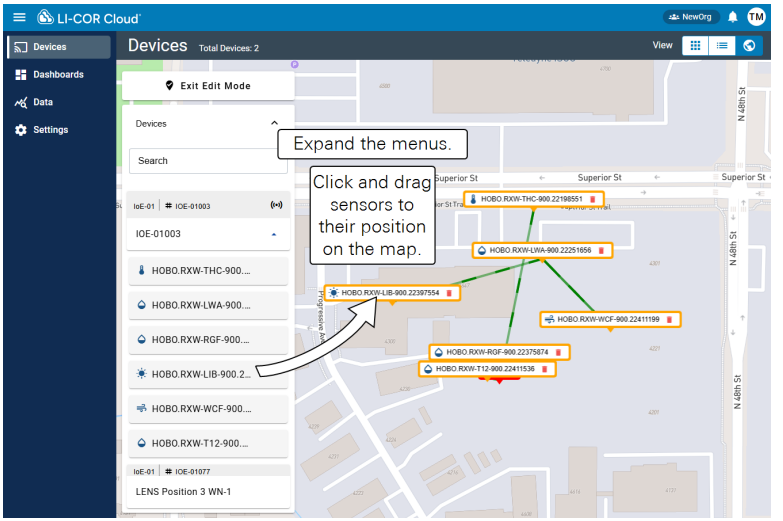
RX sensors that connected to the IoE Module via the Node Link can be displayed on the map. You'll need to specify the location of each sensor in the LI-COR Cloud

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

This section describes measurements reported by the LI-710 when using the SDI-12 protocol. Fluxes - ET, LE, and H (evapotranspiration, latent energy, and heat) - represent a quantity of something exchanged over a time period, over an area. Evapotranspiration is reported as mm. It is the total (millimeters) water vapor exchanged over the measurement period, over the fetch footprint around the sensor. Other computed parameters - VPD, PA, TA, RH, SVP, and TD (vapor pressure deficit, atmospheric pressure, air temperature, relative humidity, saturation vapor pressure, and dewpoint temperature) are the average for the measurement period. The LI-710 sends up to four packets of results, each including up to nine variables.

## Group 0: Results

Group 0 is the main set of measurements, including actual evapotranspiration, a set of measured and computed parameters, the sequence number, and diagnostic information for the measurement period.

**Table 5-1**. Data group 0 includes results for a measurement period.

| Description | Label | Units | Precision |
|---|---|---|---|
| Actual Evapotranspiration | ET | mm | 3 |
| Latent Energy Flux | LE | W $m^{-2}$ | 1 |
| Heat Flux | H | W $m^{-2}$ | 1 |
| Vapor Pressure Deficit | VPD | kPa | 2 |
| Atmospheric Pressure | PA | kPa | 2 |
| Air Temperature (not sonic) | TA | °C | 2 |
| Relative Humidity Ambient | RH | percent | 2 |
| Sequence Number | SEQ | # | 0 |
| Diagnostic Value | DIAG | # (0 - 65535) | 0 |

## Group 1: Results and sample count

Group 1 represents results and the total number of samples used in the measurement.

**Table 5-2.** Data group 1 includes results and the sample count.

| Description | Label | Units | Precision |
|---|---|---|---|
| Actual Evapotranspiration | ET | mm | 3 |
| Latent Energy Flux | LE | W $m^{-2}$ | 1 |
| Heat Flux | H | W $m^{-2}$ | 1 |
| Atmospheric Pressure | PA | kPa | 2 |
| Air Temperature (not sonic) | TA | °C | 2 |
| Relative Humidity Ambient | RH | percent | 2 |
| Sequence Number | SEQ | # | 0 |
| Raw Sample Count | SAMP_CNT | # (up to 36000) | 0 |
| Diagnostic Value | DIAG | # (0 - 65535) | 0 |

## Group 2: Air, humidity, and instrument information

Group 2 includes measurements of environmental characteristics without any flux results.

**Table 5-3.** Data group 2 has environmental information without any flux results.

| Description | Label | Units | Precision |
|---|---|---|---|
| Absolute Humidity Ambient | AH | g $m^{-3}$ | 2 |
| Relative Humidity Ambient | RH | percent | 2 |
| Saturated Vapor Pressure Ambient | SVP | kPa | 2 |
| Vapor Pressure Deficit | VPD | kPa | 2 |
| Atmospheric Pressure | PA | kPa | 2 |
| Air Temperature (not sonic) | TA | °C | 2 |
| Dewpoint Temperature | TD | °C | 2 |
| Tilt | TILT | degrees (0 - 180) | 0 |

## Group 3: Performance information and diagnostics

Group 3 includes diagnostic and performance information for the LI-710. The Data QC parameter may be of interest. It indicates how many points were discarded in the processing of the raw data. A high percentage of excluded data indicates that the measurement has poor quality.

**Table 5-4**. Data group 3 presents diagnostic information and details that can assist with diagnostics.

| Description | Label | Units | Precision |
|---|---|---|---|
| Pump Voltage | PUMP_V | V | 2 |
| Cell Pressure | PA_CELL | kPa | 2 |
| Cell RH | RH_CELL | % | 2 |
| Cell Temperature | TA_CELL | C | 2 |
| Enclosure RH | RH_ENCL | percent | 2 |
| Flow | FLOW | $cm^3\ min^{-1}$ | 0 |
| Input Voltage | INPUT_V | V | 2 |
| Data QC | DATA_QC | percent | 0 |

## Group 4: Enhanced analysis variables

Group 4 includes three variable that are used for advanced analysis. These variables are used by LI-COR Cloud when displaying the flux footprint.

**Table 5-5**. Data group 4 presents information used to display the flux footprint.

| Description | Label | Units | Precision |
|---|---|---|---|
| Standard Deviation of Vertical Wind Component ($w$) | W_SIGMA | $m\ s^{-1}$ | 3 |
| Standard Deviation of Temperature | T_SIGMA | °C | 3 |
| Standard Deviation of Water Vapor Concentration | H2O_SIGMA | $mmol\ mol^{-1}$ | 3 |

# Section 6.
# Troubleshooting

Here we describe how to identify and resolve problems that may arise.

## LI-710 troubleshooting

### Connection issues

Most connection issues can be resolved by checking the wiring connections, address of the LI-710, or the data logger configuration.

- **No data or unexpected replies?**
  Check the power wires. Be sure the black lead is connected to ground and the brown one is connected to a 9 to 33 VDC supply. When it is on, you can hear the pump running quietly and faint clicks near the sonic transducers. If you don't hear the LI-710 running, investigate the power supply. If it is running, continue with the next steps.
- **Data wire attached?**
  Check the blue data wire. Be sure it is connected to an SDI-12 terminal, and that the terminal is configured to support the SDI-12 protocol.
- **Wrong address applied to sensor or specified in the program?**
  Check the LI-710 address. Using the command-line interface provided in your data logger program, request information by sending `"?!"`, along with the syntax required by your data logger. The LI-710 should respond with information, including the current address. You can send a command to change the address if needed.
- **Address conflicts with multiple LI-710s or other devices?**

Each SDI-12 device connected to the terminals must have a unique address. Connect each device to the terminals one at a time and query each one for its address. If you find any conflicting addresses, make changes so each one is unique. You may also need to update the datalogger programs to reflect the new device addresses.

## Power issues

The LI-710 requires 1.5 watts during normal operation. When power is first supplied, it may draw up to 24.6 watts for 20 milliseconds. Some SDI-12 power supplies are current-limited and unable to provide sufficient power to satisfy the startup requirements, leading to continuous reboots or the delivery of partial data. If you observe either of the two conditions, connect the brown (+) and black (-) wires directly to the data logger power supply (9 to 33 VDC) and power it back on.

## Diagnostics

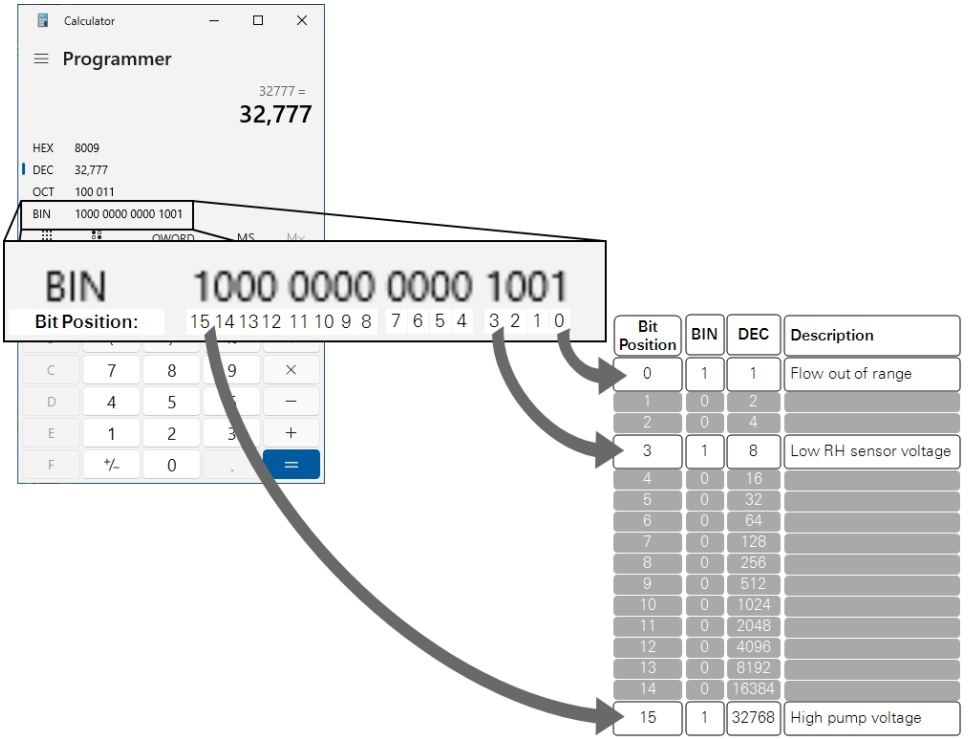
Before computing any results, the LI-710 filters implausible values from the 10 Hz raw data. You can see how many were included in a measurement period in the eighth parameter of group 1 (*Group 1: Results and sample count* on page 5-13), and the percent used as the eighth parameter of group 3 (*Group 3: Performance information and diagnostics* on page 5-14).

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-710 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 6-1* on the next page.




| Bit Position | BIN | DEC | Description |
|---|---|---|---|
| 0 | 1 | 1 | Flow out of range |
| 1 | 0 | 2 | |
| 2 | 0 | 4 | |
| 3 | 1 | 8 | Low RH sensor voltage |
| 4 | 0 | 16 | |
| 5 | 0 | 32 | |
| 6 | 0 | 64 | |
| 7 | 0 | 128 | |
| 8 | 0 | 256 | |
| 9 | 0 | 512 | |
| 10 | 0 | 1024 | |
| 11 | 0 | 2048 | |
| 12 | 0 | 4096 | |
| 13 | 0 | 8192 | |
| 14 | 0 | 16384 | |
| 15 | 1 | 32768 | High pump voltage |

*Figure 6-1. You can decode the decimal diagnostic using a converter such as the calculator included with your computer operating system. Then, associate the binary* **1***s with conditions described in Table 6-1 on the next page.*

**Table 6-1**. A diagnostic code is included with each measurement. A DEC value of 0 indicates normal operation.

| Bit Position | DEC | Description | Threshold |
|---|---|---|---|
| - | 0 | Normal operation | No issues reported |
| 0 | 1 | Flow out of range | Average flow for a 30-minute period is <125 sccm or >330 sccm |
| 1 | 2 | Reserved | Not applicable |
| 2 | 4 | Reserved | Not applicable |
| 3 | 8 | Low RH sensor voltage | Voltage ≤1.6 V for >50% of time for a 30-minute period |
| 4 | 16 | Cell temperature out of range | >65 °C or <-50 °C for >5% of time for a 30-minute period |
| 5 | 32 | Reserved | Not applicable |
| 6 | 64 | No sonic | Sonic anemometer is not detected |
| 7 | 128 | Poor sonic signal | Poor sonic signals persist for >10% of time for a 30-minute period |
| 8 | 256 | Rain detected | True for >50% of time for a 30-minute period |
| 9 | 512 | High humidity shutdown | >90% cell RH >2 data points or >90% ambient RH for 100 data points and 50% of the last 100 sonic rain flag data points |
| 10 | 1024 | Cold temperature shutdown | Cell temperature <0 °C for 100 data points |
| 11 | 2048 | High cell pressure relative to ambient | Average cell pressure - average ambient pressure is > 0.4 kPa for a 30-minute period |
| 12 | 4096 | Low cell pressure relative to ambient | Average cell pressure - average ambient Pressure is < -1.5 kPa for a 30-minute period |
| 13 | 8192 | Reserved | Not applicable |
| 14 | 16384 | Low pump voltage | Pump voltage <8 V for >50% of time for a 30-minute period |
| 15 | 32768 | High pump voltage | Pump voltage >20 V for >50% of time for a 30-minute period |

## Interpreting and responding to the diagnostic

Diagnostics presents themselves in combinations that can be reduced to a cause and solved. *Table 6-2* below presents bit positions and combinations, possible scenarios, and potential solutions.

**Table 6-2**. Bit positions and combinations can be interpreted and resolved by maintenance, or sometimes, just waiting.

| Bit Position | | | | | | | |
|---|---|---|---|---|---|---|---|
| and | or | or | or | Scenario | Solution 1 | Solution 2 | Solution 3 |
| 0, 15 | 12 | | | Intake clogged by dust | Replace filter[1] | | |
| 0, 15 | 12 | | | Exhaust clogged (unlikely) | Clean exhaust screen[2] | | |
| 0, 15 | 12 | 9 | 7 | Intake clogged by water and/or dust (unlikely) | Replace filter[1] | Wait for system to dry | |
| 0, 15 | 9 | | | Condensation on filter[3] | Wait for filter to dry | Replace filter[1] | |
| 0, 15 | 11 | 12 | | Leak in pump stack | Check O-rings, replace if damaged[4] | Replace pump[4] | |
| 14 | | | | Intake leaking | Replace filter[1] | | |
| 15 | | | | Intake clogged | Replace filter[1] | | |
| 0, 9 | 15 | 3[5] | | Flow path has water inside | Wait for system to dry | Replace pump[4] | |
| 10 | | | | Instrument temperature too low; pump disabled | Wait for ambient temperature to rise | | |
| 7, 8 | 9 | 0 | | It is raining outside | Wait for rain to stop | Wait for filter to dry | Wait for system to dry |

[1]See *Replacing the intake filter* on page 7-5.

[2]See *Accessing the outlet vent* on page 7-11.

[3]Similar to clogged inlet filter or clogged outlet.

[4]See *Replacing the pump and O-rings* on page 7-8.

[5]Low RH sensor voltage means service is required; return instrument to LI-COR.

# IoE Module troubleshooting

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

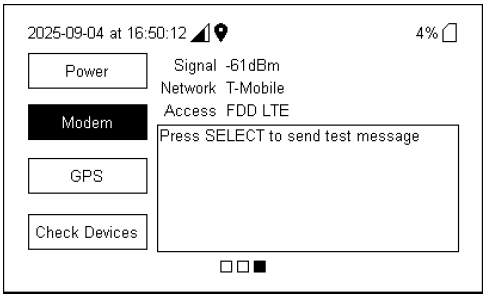
## Configuration problems

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 Water Node* on page 4-1 to configure the sensors.
- **Unsupported device?**
  The IoE module supports the LI-710, LI-720, Stevens HydraProbe (firmware v4 and newer), 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.



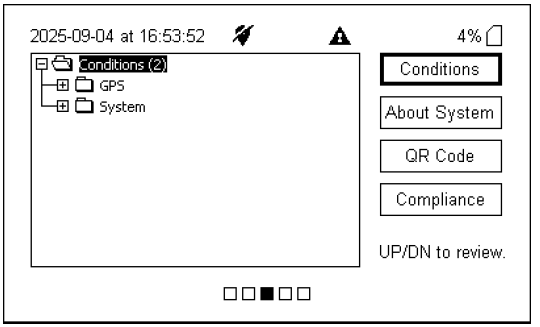

## Problems powering on

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 2-16 or *Using an external power supply* on page 2-8.
- **External power supply problems?**
  If using an external power supply, be sure it provides 10 to 33 VDC with 3.0 amp capacity.
- **IoE Module 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 6-3* on the next page). 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 6-3.** 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. |
| Battery | Rntc out of range | Internal temperature sensor malfunctioning. |
| 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. |

**Table 6-3.** Classes, conditions, and the meaning. (...continued)

| Class | Condition | Meaning |
|---|---|---|
| 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]. |
| 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[3]. |
| Logger | SD card FULL | SD card is <5% free[4]. |
| 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]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.

[3]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.

[4]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 6-3.** 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. |
| 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.

# Water 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 Water Node Sensor Network, start by reviewing licor.com/support/Cloud/topics/tips-for-wireless-sensors.html.

## 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 **Check Devices**. 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 9-10 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 7.
# Maintenance

The LI-710 requires little maintenance under normal circumstances. However, some routine attention will ensure that the instrument keeps running well over the long term, and will help you get better, more complete measurements.

## 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.

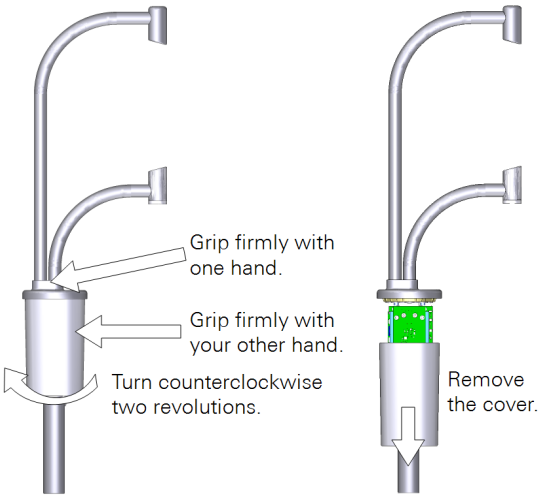
### LI-710 firmware

Firmware updates are carried out over the internal USB connector. To update the firmware:

1. Download the firmware to a directory on your computer.

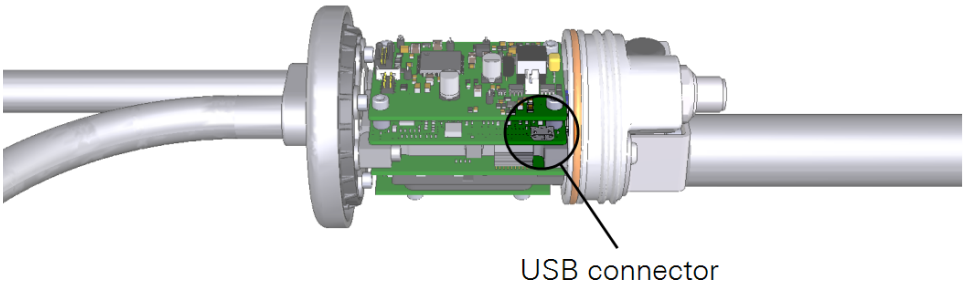
   Firmware updates are available at licor.com/support/LI-710/software.html.
2. Power off the instrument by removing the power cable at the connector.
3. Remove the electronics cover.

Do not apply torque to the transducer housings or arms.




> ***Warning:*** *Potentially hazardous voltages may be present when the cover is removed and the instrument is powered on. Do not touch any internal components or surfaces while the external cover is removed and the instrument is powered on.*

4 Connect a user-supplied USB-micro cable between your computer and the connector on the circuit board.




5 Connect the power cable to power the instrument ON.

If the instrument is powered on while a USB cable is connected, it will mount a directory to your computer called FW_UPDATE. Open the directory if it doesn't open automatically.

6 Copy the file you downloaded into the FW_UPDATE directory.

When the LI-710 "notices" the new file, it will automatically close the window and initiate the update. You may see a message indicating that the update was successful.

7 Disconnect the power and USB cables and install the electronics cover.

8 Restart the LI-710 after updating the firmware.

Be sure the USB cable is not connected when restarting for normal operation.

## 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 updates are available at licor.com/support/LI-710/software.html.

2 Power off the IoE Module.

3 Connect a USB cable between the module and your computer.

The USB connector is labeled in the IoE Module. It accepts a Micro-B connector.

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 IoE Module display.

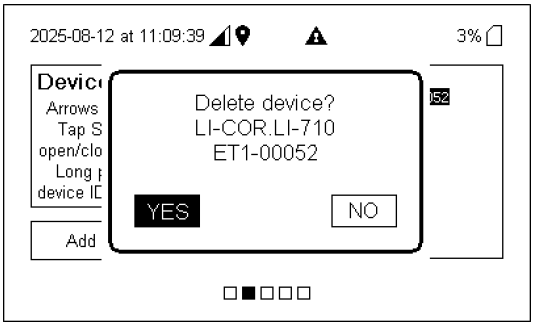
When the display indicates that the update is complete, you can disconnect the cable. To check the version number, press left once (◀) and down once (▼) to view **About System**, where the firmware version is displayed.

## Reinitialize after firmware updates

After updating the IoE Module or LI-710 firmware, be sure to apply the latest device configurations. This is accomplished by deleting the current devices and adding them again.

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

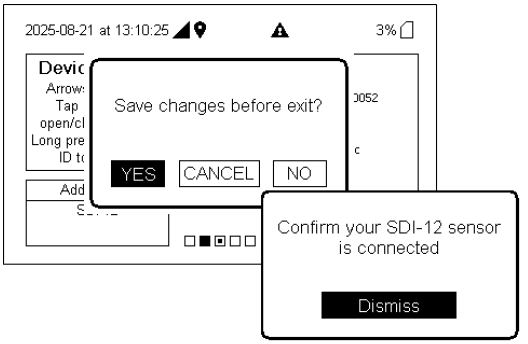
2 Long-press the **Select** button (O) until prompted:




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

4 Save the configuration.

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



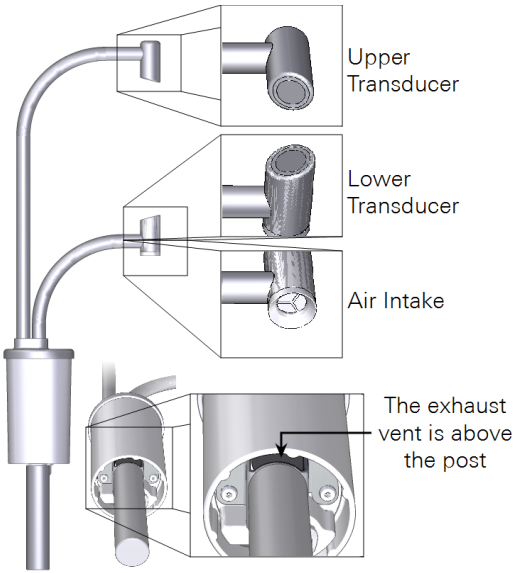

5 Follow the steps in *Initial setup* on page 4-1 to reconfigure the sensor.

# LI-710 Evapotranspiration Sensor

## Basic sensor checkup

You can conduct a basic check just by looking at the LI-710.

- Check the transducers to be sure they are not covered in bird droppings or dirt. Clean them with a moist cloth and mild detergent if necessary.
- Check the air intake - look for visible obstructions or anything that might interfere with air flow and remove it. If the filter is dirty, replace it (see *Replacing the intake filter* below).
- Inspect the exhaust vent - look for insect colonies or nests. Clear anything that might obstruct the air flow (see *Accessing the outlet vent* on page 7-11).




## Replacing the intake filter

The air intake filter should be replaced approximately once every two or three months, typically. In some conditions, the filter will not need to be replaced as often. In dusty conditions, it may need to be replaced more often.

Low flow rate or high drive voltage may indicate the filter is due for replacement. You can replace the filter and filter O-ring with new ones from the spares kit. This procedure describes how to replace the filter.

**Table 7-1**. The filter replacement kit includes five filters and O-rings.

| Description | Part Number |
|---|---|
| Filter Replacement Kit | 9971-015 |
| Filter Pack (5) | 6571-002 |
| O-ring Pack (5) | 192-19986 |

**Caution:** Do not use a pliers or other metal tools on the air intake! Doing so may deform the parts or alter the alignment of transducers. Instead, use the plastic air intake tool that is included in the spares kit (part number 6371-021).

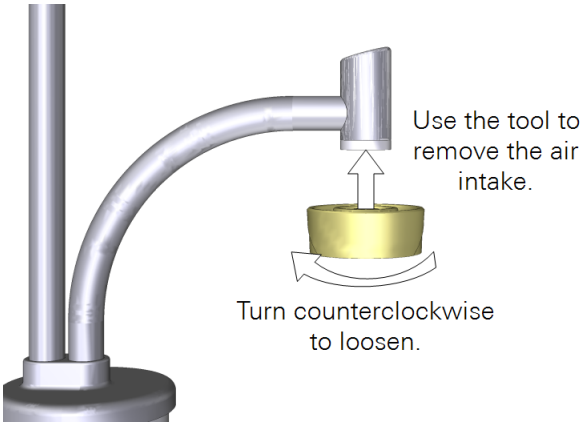
Air intake tool

The intake filter is on the bottom of the lower transducer housing.

1. Power off the LI-710 - disconnect the cable.
2. Align the intake removal tool with the keys on the air intake and turn it counterclockwise.

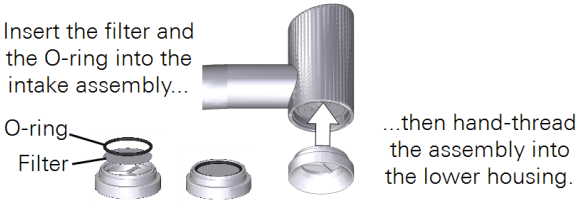
   **Caution:** Do not apply torque to the transducer housings. Doing so can affect the alignment and damage the sensor.

   Once it is loosened, you can remove the air intake with your fingers. Be sure that both the filter and O-ring come out when the intake is removed.




3. Install a new filter and O-ring from the spares kit.

   Insert the filter into the air intake, followed by the O-ring.




**4** Install the air intake.

***Do not cross-thread the air intake.*** Start tightening the intake with your fingers. Finish tightening it with the tool until it hits a hard stop - around 2 turns clockwise.

Filter replacement is complete.

## Replacing the pump and O-rings

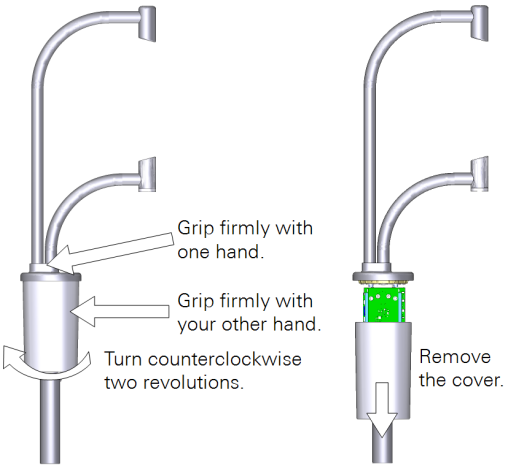
The pump inside the LI-710 has a limited life and will need to be replaced periodically. One replacement pump is included with the instrument spares. Additional pump replacement kits are available for purchase. This procedure describes how to replace the pump.

**Table 7-2.** The kit includes a pump, hardware, and a hex key.

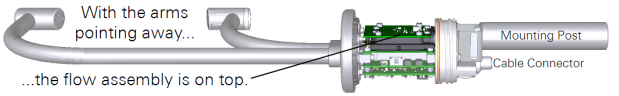
| Description | Part Number |
|---|---|
| Pump Replacement Kit | 9971-016 |
| Pump (1) | 286-17946 |
| Pump O-ring 29×2 mm VITON 75 (1) | 192-18249 |
| Pump O-ring 16×1.5 mm VITON 75 (1) | 192-18247 |
| M3×0.5-20 Installation Screws (4) | 151-18159 |
| 2.5 mm Hex Key (1) | 611-20555 |

1. Power off the LI-710 - disconnect the cable.
2. Remove the electronics cover.

   Do not apply torque to the transducer housings or arms.



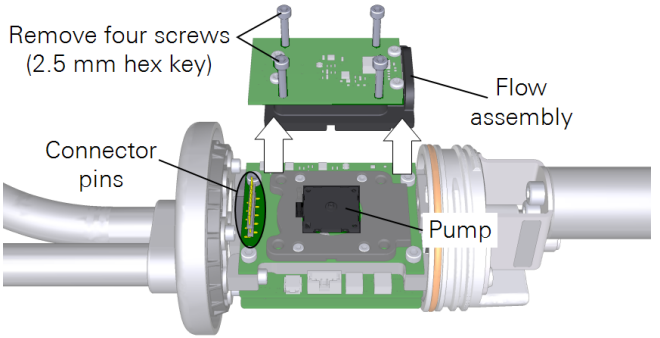

3. Set the LI-710 on a workbench with the arms pointing away from you.



4 Remove the flow assembly.

Remove the four screws using the 2.5 mm hex key from the spares kit. Pull straight up while gently wiggling the flow assembly to separate it from the connector pins.

**Important:** Do not bend the connector pins or remove any other screws.

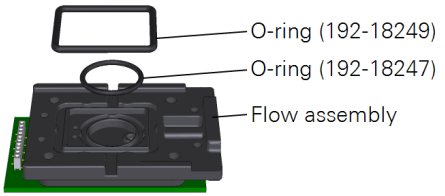



5 Remove the old pump.

It will come out easily; use a tweezers if needed.

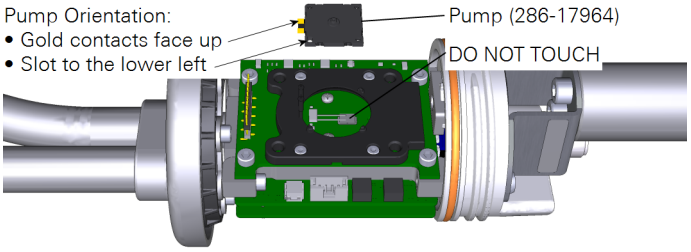
6 Inspect the O-rings - if you see cracks or damage, replace them.

Extra O-rings are in the spares kit. Both O-rings press into place in the flow assembly.



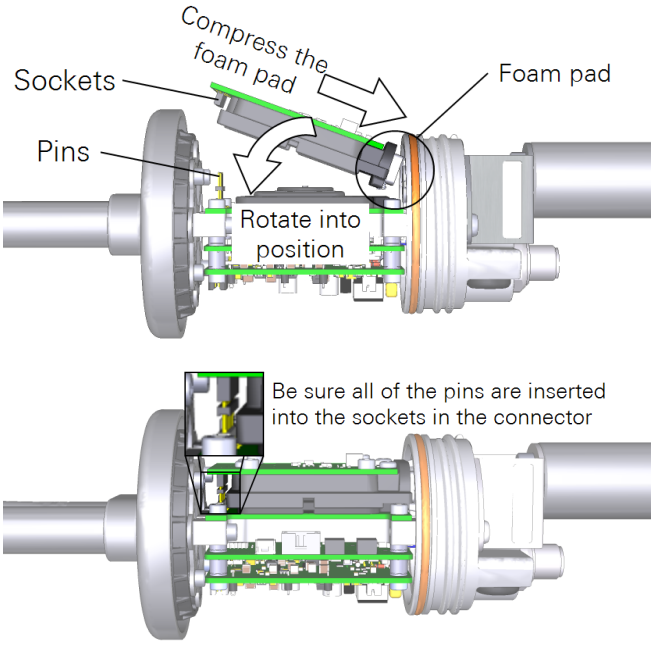

7 Set the new pump in place.

**Important:** Handle the pump by its corners. Do not touch the diaphragm or the board-mounted components under the pump. Align the new pump (part number 286-17964) with the keys.




**8** Install the flow assembly.

Compress the foam pad and then rotate the flow assembly into place. Be especially careful with the connector - ensure that each pin meets the corresponding socket, then press them together.




**9** Install the four screws that secure the flow assembly.

Extra screws are in the spares kit (part number 151-18159).

**10** Install the cover.

Tighten the cover until it hits a stop and will no longer turn - about two revolutions.

The pump replacement is complete.

## Accessing the outlet vent

Disconnect the power cable and then remove the cover to access the exhaust vent.

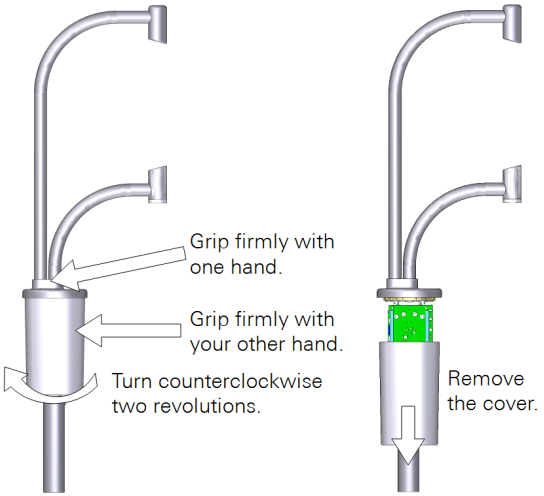



*Figure 7-1. Remove the cover to access the exhaust vent. Do not apply torque to the arms.*

The vent is between the post and the sensor body. Do not remove the post or loosen the screws that secure it. Use a cotton swab to clear debris from the vent. Do not damage the vent screen.

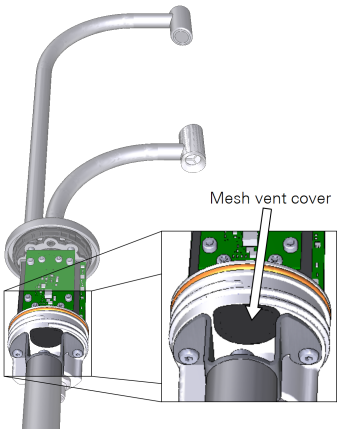



*Figure 7-2. The exhaust vent is between the post and body.*

# 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

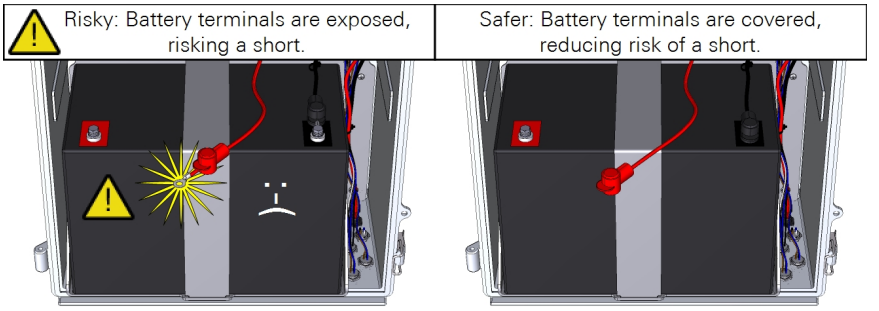
Power off the device. Hot swapping is not supported, so be sure to shut down the device before changing the power configuration.

⚠ ***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 7-3* on the next page).

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 7-3* 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.

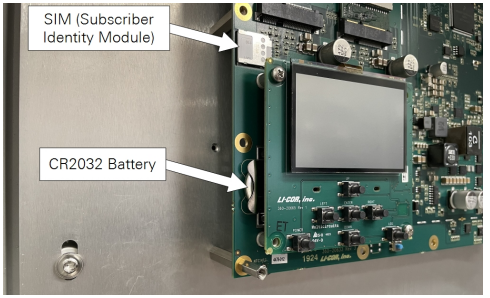



*Figure 7-3. The SIM and clock battery (CR2032) are under the circuit board cover.*

# Section 8.
# 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.

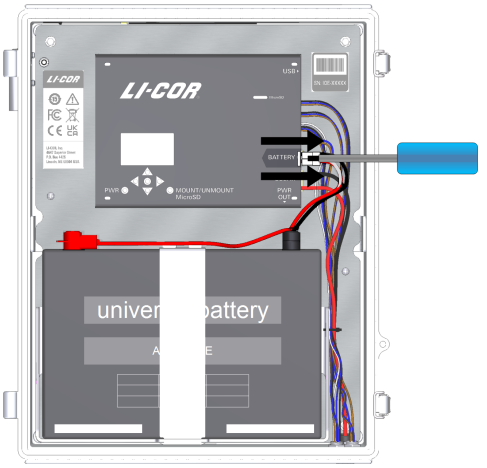
   The IoE Module may have solar panel cables and device cables.

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.

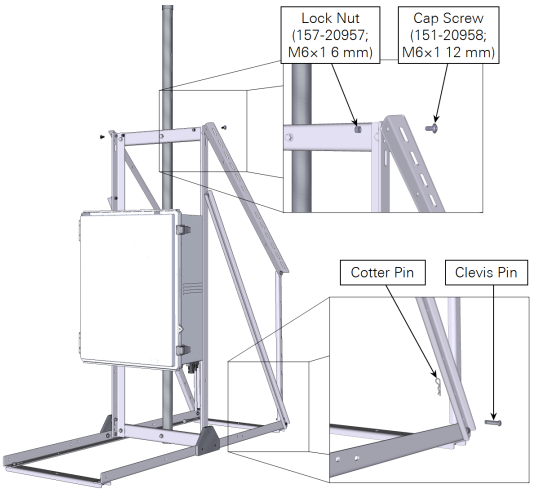



5 Remove the solar panel from the rails.

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.

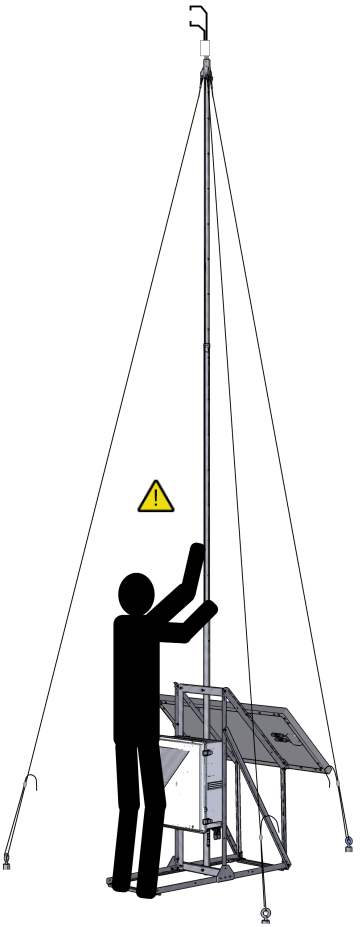


*Figure 8-1. Always grip the mast and use a hand-over-hand motion when lowering it. Do not allow the mast to slam down.*

**9** Remove the guy wires.

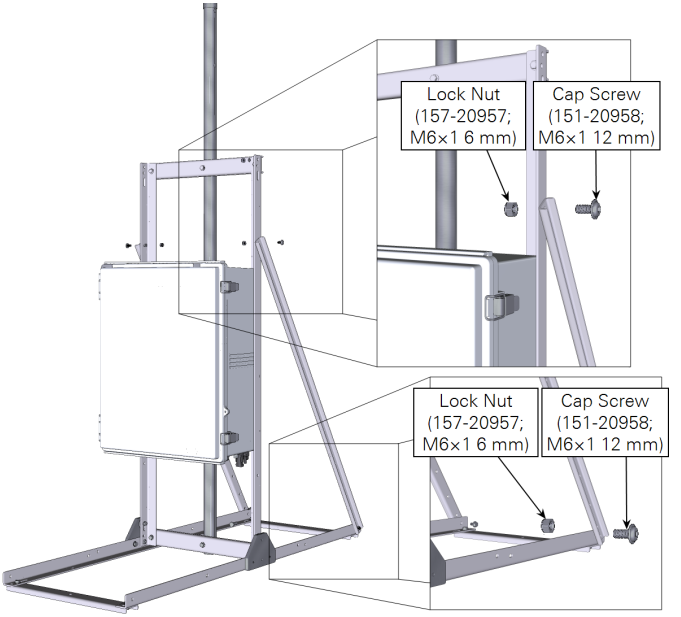
Separate the clips from the adapter. The wires pass through a Gripple® clasp. If needed, loosen the Gripple using the key. Be careful, as the Gripple might fall apart if too much pressure is applied.

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

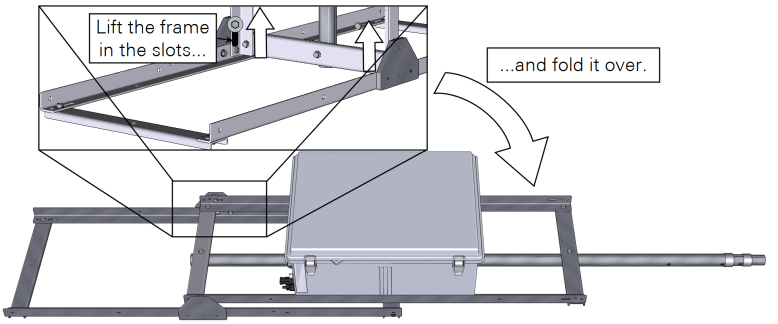
Store the LI-710 or LI-720 in the original package to protect it from impacts. You can leave the sensor adapter on the mast or remove it to make the assembly more compact. Remove any other peripheral components and store them safely.

**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.

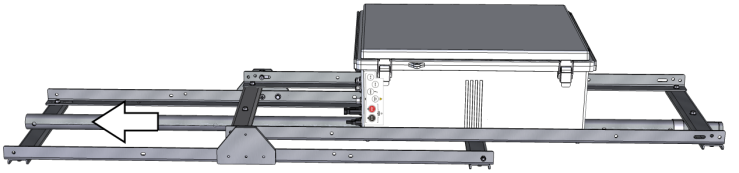



**12** Lift the vertical portion of the frame it in the slots and fold it over.




**13** Slide the mast to align it with the frames.

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



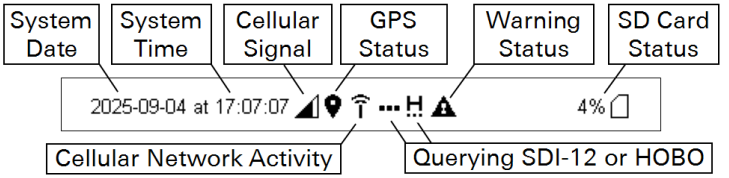
**14** Remove the earth anchors using an impact driver.

# Section 9.
# 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.



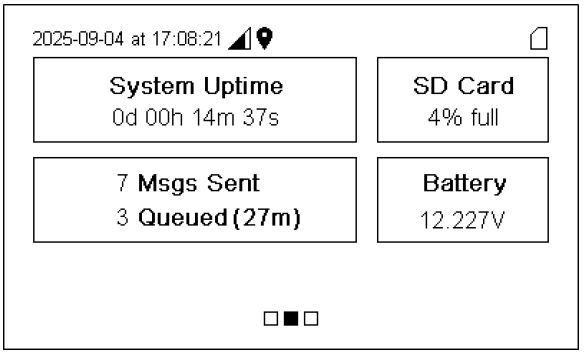

- **System Date**: The current date in YYYY-MM-DD format.
- **System Time**: The current time in HH:MM:SS format, offset from UTC.
- **Cellular Signal**: Displays graphically the cellular signal strength with the following conditions:
  - Blinking: Searching for network
  - Outline: No signal
  - Solid 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.
- **Messages**: Number Sent, Number in Queue.
- **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 6-7).

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.

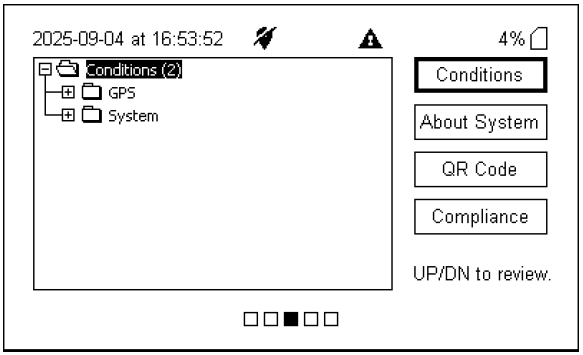
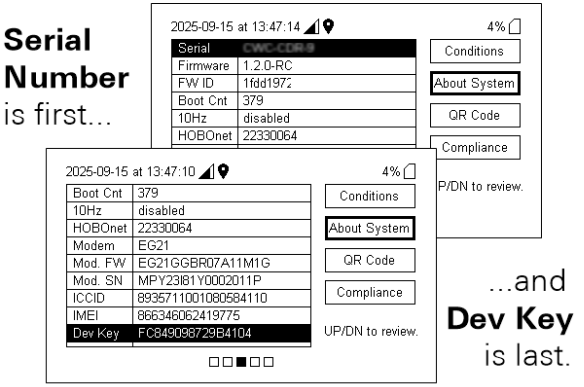



*Figure 9-1. The Conditions table informs you of issues. Several conditions will be displayed momentarily as the IoE Module starts up and establishes the cellular connection, GPS information, and communication with LI-COR Cloud.*

## 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.




You will need to 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].
- **Reg Key**: A unique identifier for client services on LI-COR Cloud[1].

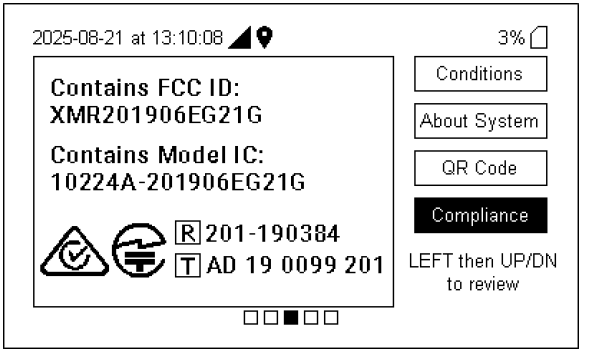
## QR code

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).

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

### Compliance

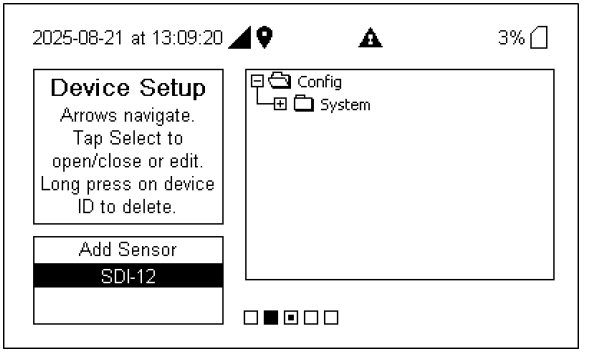
To view digital **Compliance** information (e-labeling), from the **Home** screen, press left once (◀) and down three times (▼▼▼). For more information, press left once and then up or down to see additional digital certificates.




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

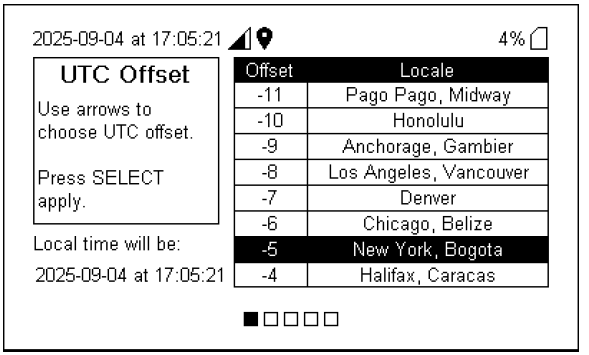
## SDI-12 Setup

The SDI-12 page is to add sensors to this IoE node. Follow the steps on the display and see *Initial setup* on page 4-1 for more details.



# 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.

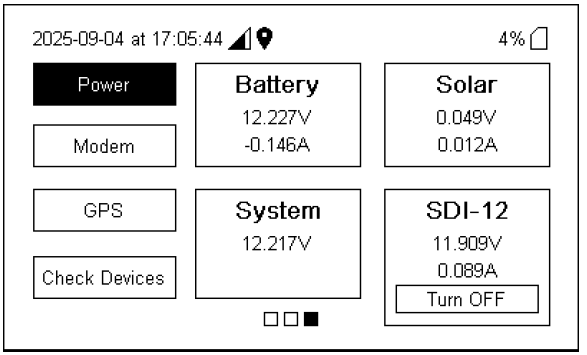


# IoE Module status information

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

## Power status

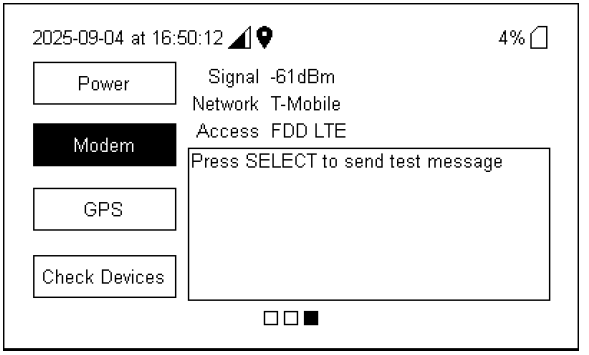
Information related to the battery, solar power supply, system voltage, and SDI-12 power output.




- **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.

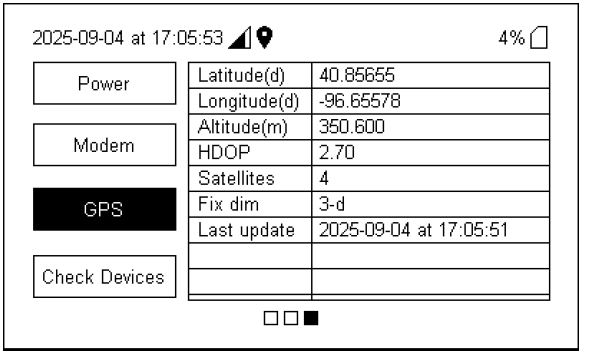
## Modem status

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



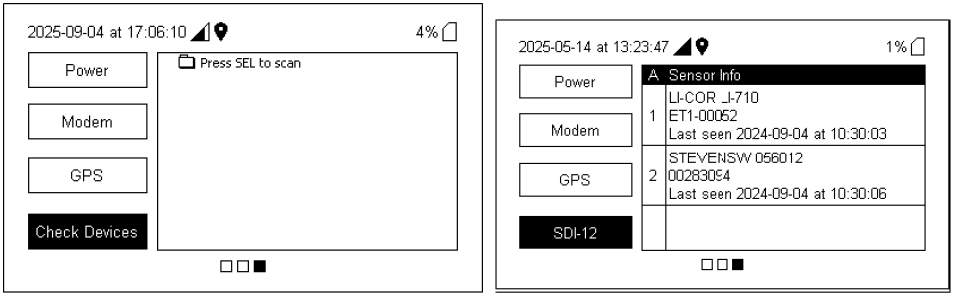

## GPS status

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 LI-710, look for **LI-COR LI-710**.
  - 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

**Temperature**

**Calibrated Operating Range:** +5[a] to 50 °C

**Ambient Operating Range:** -20[b] to 50 °C

**Deployed Non-Operating Range:** -20 to 60 °C

**Temperature Accuracy:** ±1.5 °C

**Relative Humidity**

**Calibrated Operating Range:** 0 to 85% RH

**$H_2O$ Mole Fraction Range:** 0 to 60 mmol/mol

**$H_2O$ Mole Fraction Accuracy:** 2% of reading at > 5 mmol/mol

**Deployed Non-Operating Range:** 0 to 85% RH

**Pressure**

**Operating Pressure Range:** 50 to 110 kPa

**Ambient Pressure Accuracy:** ±0.2 kPa

**Inlet Flow Rate:** 230 $cm^3$/min (typical)

**Communication:** SDI-12

**Power Requirements**

**Voltage:** 9 to 33 VDC

**Power:** ≤1.5 W nominally; up to 26.4 W for 20 milliseconds during startup

**Weight:** 1.4 kg

**Dimensions:** 58 × 17.5 × 7.7 cm (H × L × W)

**Mount:** 1 inch (2.54 cm) diameter post; compatible with 1 inch (2.54 cm) crossover fittings

**Weatherproof Rating:** Tested to IEC IP54

[a]Sampling cell temperature.

[b]Flow, required for ET and RH, turns off ≤5 °C, unless custom insulated or heated.

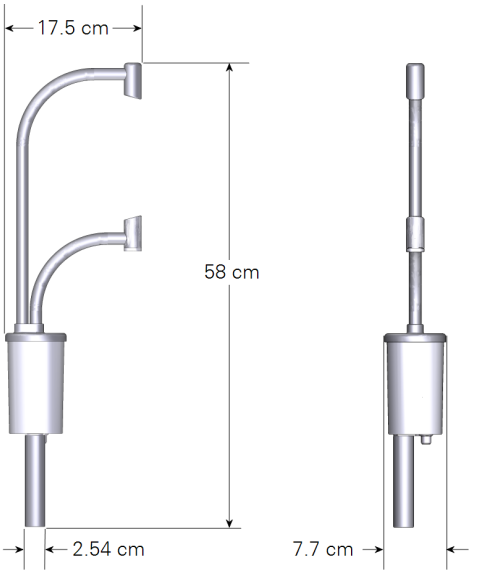



*Figure 10-1. LI-710 dimensions.*

**Table 10-1.** Parameters measured and computed by the LI-710 as 30-minute averages.

| Variable | Description | Unit |
|---|---|---|
| ET | Evapotranspiration | mm |
| LE | Latent Energy Flux | W/m^2 |
| H | Sensible Heat Flux | W/m^2 |
| VPD | Vapor Pressure Deficit | kPa |
| PA | Atmospheric Pressure | kPa |
| TA | Air Temperature | °C |
| RH | Relative Humidity Ambient | % |
| AH | Absolute Humidity Ambient | g/m^3 |
| SVP | Saturated Vapor Pressure Ambient | kPa |
| TD | Dewpoint | °C |

# 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.

**LI-COR Environmental**
4647 Superior Street
Lincoln, Nebraska 68504
Phone: +1-402-467-3576
Toll free: 800-447-3576 (U.S. & Canada)
envsales@licor.com
envsupport@licor.com
licor.com/

**LI-COR GmbH, Germany**
Siemensstraße 25A
61352 Bad Homburg
Germany
Phone: +49 (0) 6172 17 17 771
envsales-gmbh@licor.com
envsupport-eu@licor.com

**LI-COR Ltd., United Kingdom**
St. John's Innovation Centre
Cowley Road
Cambridge
CB4 0WS
United Kingdom
Phone: +44 (0) 1223 422102
envsales-UK@licor.com
envsupport-eu@licor.com

**Beijing LI-COR Bioscience Ltd.**
Room 502-503, 5th Floor, Jimen No.1 Office Building
Xitucheng Road, Haidian District
Beijing, China
Phone: +86-400-1131-511
china-sales@licor.com
china-support@licor.com

**LI-COR Distributor Network**
licor.com/distributors

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