

LI-710 Evapotranspiration Sensor

Instruction Manual



LI-COR®

LI-710 Evapotranspiration Sensor

Instruction Manual

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Section 1.

Introduction to the LI-710

The LI-710 Evapotranspiration Sensor measures the total transport of water from evaporation and transpiration over an area using automated eddy covariance flux calculations. The output from the LI-710 is evapotranspiration, energy flux, and other parameters in 30-minute increments. It uses the SDI-12 protocol to transfer data to an external data recorder.

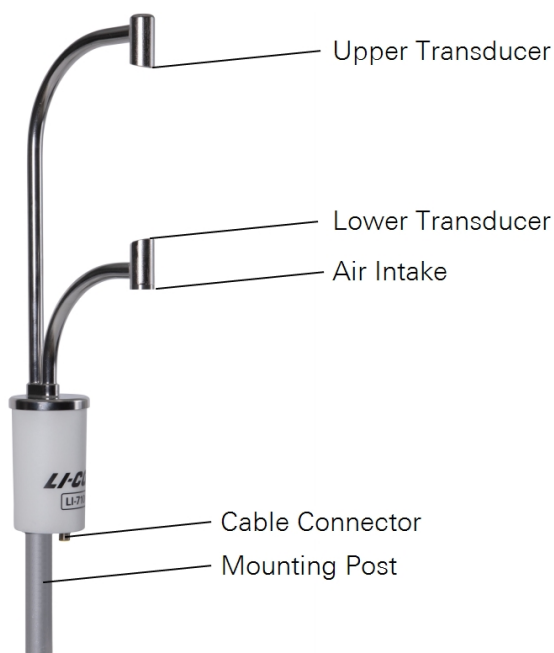


Figure 1-1. The LI-710 Evapotranspiration Sensor consists of two transducers for anemometric measurements and an air intake.

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 *Deploying the LI-710* on page 2-1 for more information).

What's what

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.

Evapotranspiration sensor

Part number
9971-010

The sensor features one cable connector for power and data and one mounting post for mounting onto a tripod or meteorological sensor platform using a 1" (2.54 cm) cross-over 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* on the facing page 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

Replacement parts

The spares kit included with each LI-710 includes the parts listed in *Table 1-1* above. Additional replacement parts are available for purchase.

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 one pump, two O-rings, and four screws.

Accessories

The accessories below are available from LI-COR.

Extension cable

Part number
392-20529

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

Crossover fitting

Part number
7900-342

The LI-710 can mount to a horizontal cross bar (1¼" outside diameter) with a ¾" × 1" crossover fitting.

Swivel mount

Part number
7900-344

The LI-710 can mount to a vertical mast (1" outside diameter) with a $\frac{3}{4}$ " swivel mount.

Mounting kit with riser bar

Part number
7900-340

The mounting kit includes a crossover fitting ($\frac{3}{4}$ " $\times$ 1"), swivel mount ($\frac{3}{4}$ "), and a 56 cm (22") riser bar.

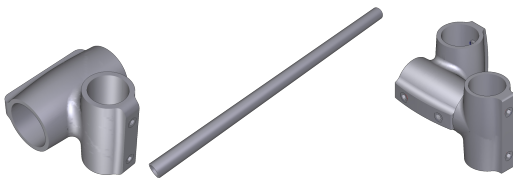


Figure 1-2. The crossover fitting, riser bar, and swivel mount are available individually or as a kit.

Cross bar and mounting hardware

The following components can be used to add a cross bar to a mast with an outer diameter of 2.375" (about 6 cm).

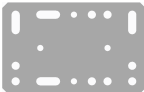
Cross Bar (1): 1.5 m long, 3.3 cm OD Schedule 80 aluminum pipe 6061-T6.

Part number
9879-010



Mounting Plate: For mounting the cross bar to a mast.

Part number
9879-020



Brackets (4): For mounting the cross bar to the mast.

Part number
9879-043



Mounting Hardware Kit: For mounting the cross bar to a mast.

Part number
9979-018



Section 2.

Deploying the LI-710

The LI-710 is designed for easy installation into meteorological stations. It uses a single cable for power and communications (SDI-12 protocol). Remove the caps that cover the transducers and air intake before powering on the LI-710 (see *Figure 2-1* below).

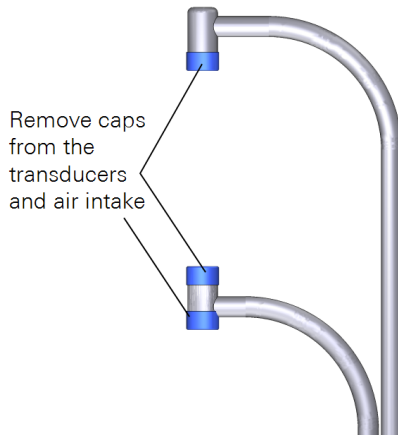


Figure 2-1. Protective caps should be removed before powering on the sensor.

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.

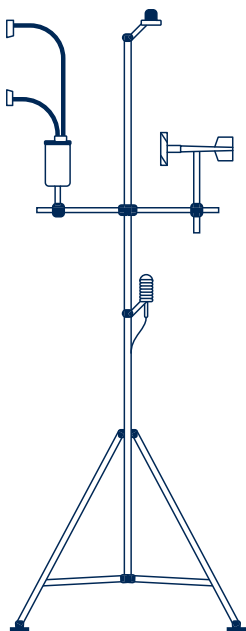


Figure 2-2. Many weather stations meet the installation requirements of the LI-710.

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.

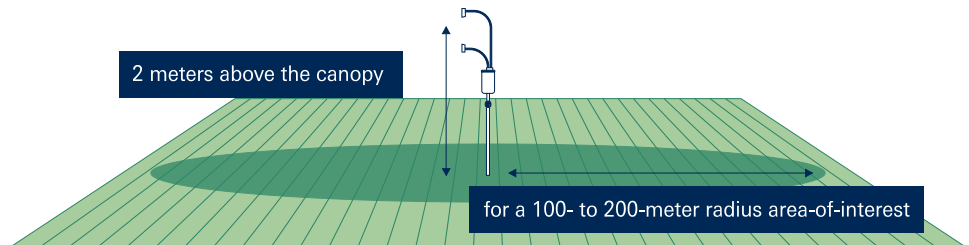


Figure 2-3. The sensor should be at least 2 meters above a uniform canopy for an area-of-interest of 100 to 200 meters around the device.

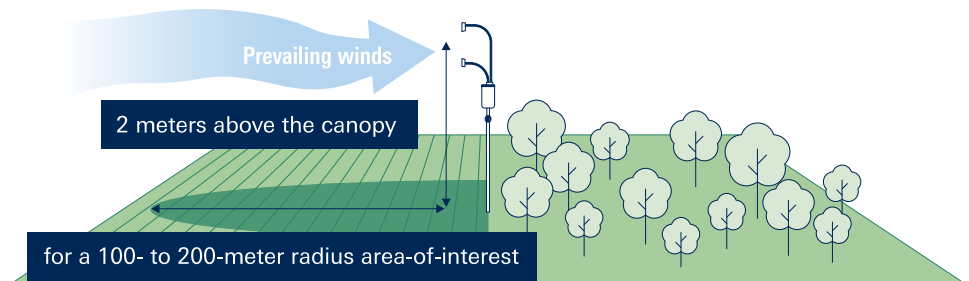


Figure 2-4. Where the LI-710 cannot be deployed in an area-of-interest, it can be positioned at the edge on the downwind side. At a height of 2 meters above the canopy, assume a 100 to 200 meter area-of-interest in the upwind direction.

Height above the canopy

The area represented in measurements from the LI-710 will depend on its height above the plant canopy. The LI-710 should be installed at least 2 meters above the canopy. At a 2-meter mounting height, the fetch is assumed to be a 100 to 200 meter radius around the LI-710 (see *Figure 2-3* on the previous page). All landscape elements within this range can contribute to the evapotranspiration measurement.

The LI-710 is designed for measurements over annual crops and orchards. Over fast-growing canopies, such as soybeans, sorghum (milo), wheat, flax, rice, maize (corn), vegetables, and cotton, install the LI-710 at 3.5 to 5 meters above the surface before germination for a fetch up to 350 to 500 meters. As the crop grows, the distance between the canopy and sensor will become smaller, and so will the fetch. This is an ideal measurement scenario - the area measured represents the area-of-interest for the entire growing season. Alternatively, you can raise the height of the LI-710 over the growing season to maintain a consistent measurement height.

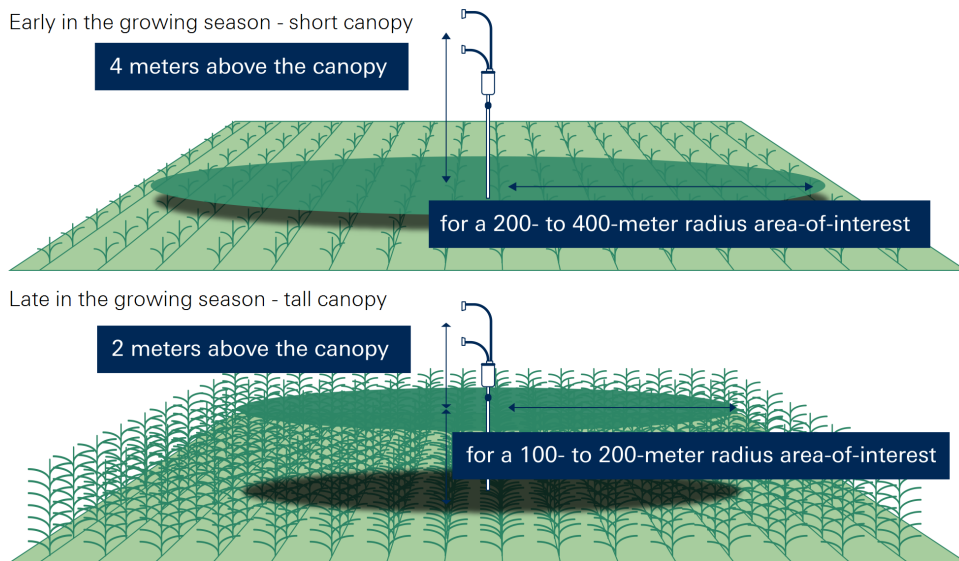


Figure 2-5. The LI-710 can be installed at a fixed position over crops. Install it at a height that is at least 2 meters above the expected canopy height. Alternatively, you can raise the LI-710 as the crop grows to maintain a consistent height for the season.

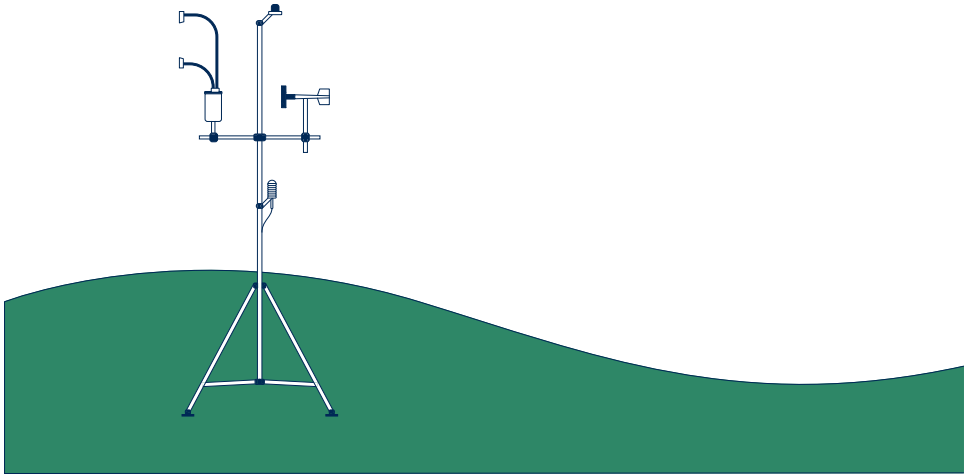


Figure 2-6. Over a short canopy with rolling terrain, the instrument should be at least 2 meters above the top of the plant canopy.

Over orchards and woodlands, which are characterized by partial to full canopy closure, the LI-710 should be at least 2 meters above the top of the canopy.



Figure 2-7. The LI-710 should be at least 2 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 8-2).

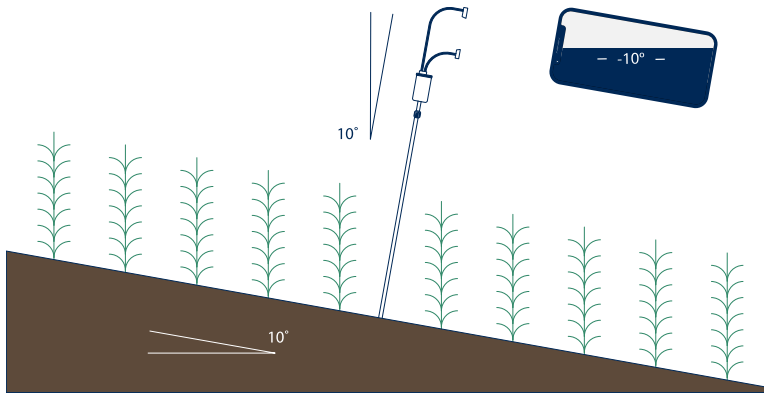


Figure 2-8. On sloped terrain, install the LI-710 perpendicular to the predominant slope of the area-of-interest. A few degrees of difference is acceptable.

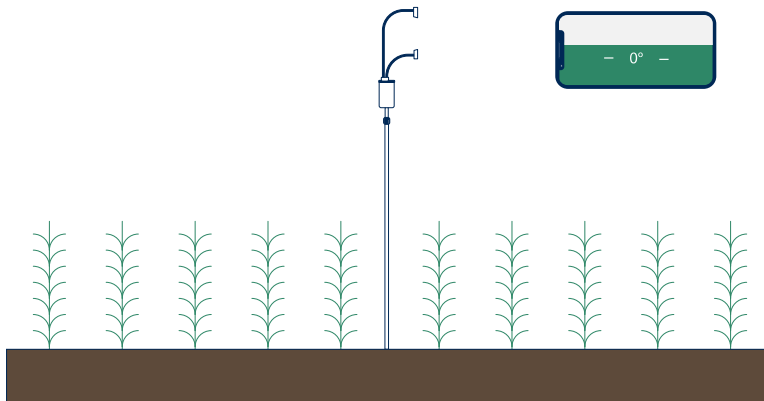


Figure 2-9. On level ground, install the LI-710 with 0° tilt, although a few degrees of difference is acceptable.

Mounting the LI-710

The LI-710 can be deployed as a stand-alone sensor, in a weather station, or as part of an eddy covariance flux station. It mounts readily to hardware that is common to irrigation infrastructure, weather stations, and other equipment.

Horizontal cross bar

The LI-710 can be attached to a standard $\frac{3}{4}$ " crossover fitting or any other fitting with a 1" opening. Suitable crossover fittings ($\frac{3}{4}$ " $\times$ 1") are available from LI-COR (part number 259-13276).

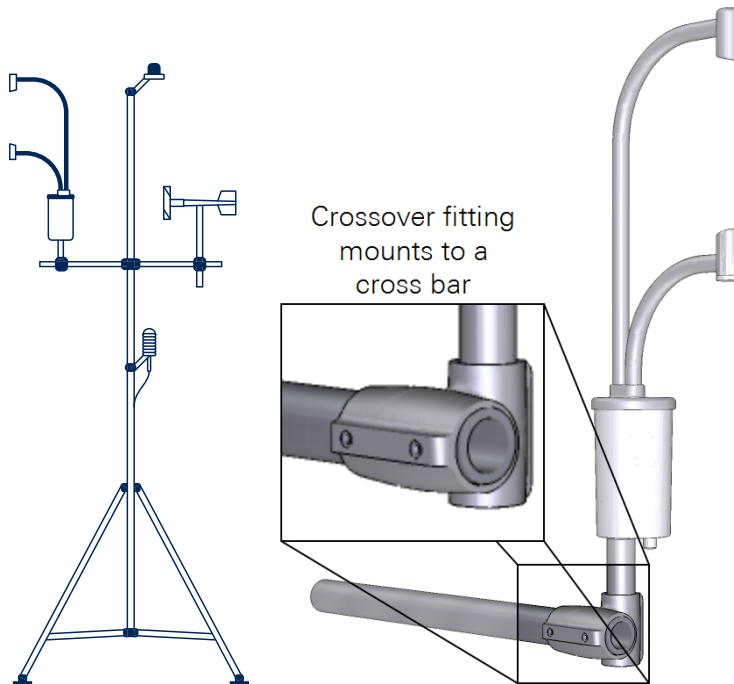
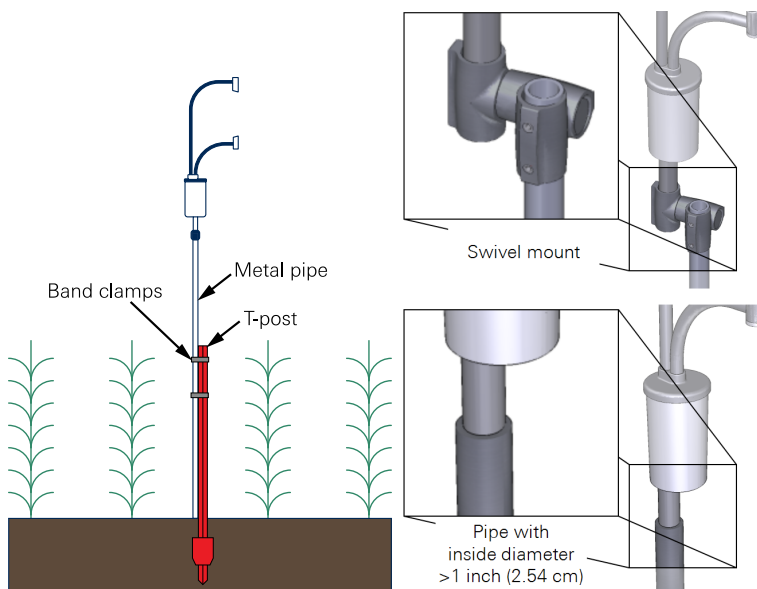


Figure 2-10. The LI-710 mounted to a cross bar with a crossover fitting.

Tighten set screws with a $\frac{5}{32}$ " hex key to 22 N-m (16 ft-lbs). If no torque wrench is available, tighten each set screw until it contacts the pipe, then one more full revolution for aluminum pipe, or $\frac{1}{4}$ revolution for stainless steel.

Vertical pipe and T-post

For a stand-alone installation, the LI-710 can be attached to a T-post and vertical mast, like a piece of pipe. The LI-710 can attach to a pipe using a swivel mount, or the post can be installed inside a pipe that has an inside diameter >1 inch (2.54 cm) and a means to secure the post (*Figure 2-11* below).



If you are using a T-post in soft or saturated soils, check the installation regularly to ensure that the post does not shift over time.

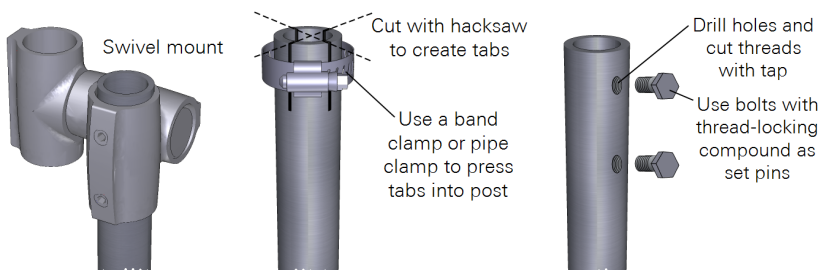


Figure 2-11. Secure the LI-710 mounting post to a pipe or tube using a swivel mount or another method.

Section 3.

Overview of SDI-12 and the LI-710

The LI-710 is an SDI-12 device. It must be connected to a device that supports SDI-12 communication, such as a datalogger with SDI-12 capabilities or an SDI-12-to-USB translator. In this section, we describe the requirements for using the LI-710 on an SDI-12 device. Specific examples, including working sample programs for common dataloggers are described later.

Wire assignments

The LI-710 is powered over the brown wire (9 to 33 VDC). Data are transferred over the blue DATA wire. The black wire connects to ground. Some SDI-12 power supplies do not provide enough current to power up the LI-710. If you observe continuous power cycling, consider powering the LI-710 directly from the data logger power supply.

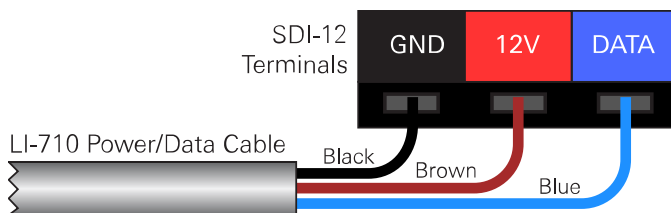


Figure 3-1. Wires from the LI-710 connect to power and an SDI-12 data bus.

Default address

All LI-710s leave LI-COR with an address of 0. The address can be changed with the `A` command. Multiple LI-710s can be connected to a single SDI-12 bus, but each LI-710 requires a unique address.

The trigger command

The LI-710 is designed to respond to trigger (XT) commands on a schedule. Trigger options and the expected results are described below.

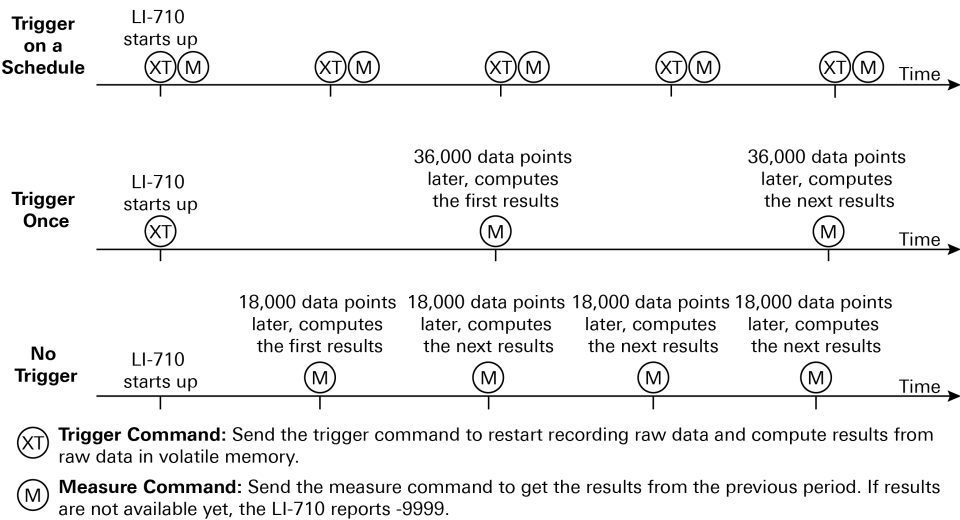


Figure 3-2. Operating modes in the LI-710. We recommend triggering every 30 minutes.

Trigger on a schedule with the XT command

Note: We recommend **Trigger on a schedule** for deployments. In this mode, the datalogger sends the **XT** command to start a measurement period and the **M** command to request results from the previous period. This gives you control over the measurement time period and aligns results to the datalogger clock.

In triggered mode, the LI-710 starts up and begins recording raw data to its volatile memory. When the LI-710 receives an **XT** command, it computes results from data in the volatile memory and starts recording new raw data to the volatile memory. These results are reported in response to an **M** command until new results are available – a few seconds after the LI-710 receives another **XT** command (see **Trigger on a schedule** in Figure 3-2 above).

We recommend sending the **XT** command every 30 minutes, but you can choose any time period between 5 and 60 minutes. The time period for computing results is defined by the time period between **XT** commands sent by the datalogger.

Trigger once

Note: **Trigger once** is for testing or a fallback if the trigger is not received.

If the LI-710 receives an **XT** command but does not receive another, it will compute results when it has recorded 36,000 data points, which is around one hour (see **Trigger once** in *Figure 3-2* on the previous page). If triggered only once, the subsequent measurements will gradually drift from the datalogger clock.

No trigger

Note: Use **No trigger** for testing only.

The LI-710 operates in untriggered mode unless it receives a trigger command. In untriggered mode, the measurement period does not have explicit alignment with a clock. Instead, the LI-710 begins recording raw data to its volatile memory almost immediately after it is powered on. After it has recorded 18,000 data points (about 30 minutes of data), it computes results for that time period. These results are reported until the next results are ready 18,000 data points later (see **No trigger** in *Figure 3-2* on the previous page).

Common commands

The following commands are supported by the LI-710.

- **?** – get the sensor address
- **I** – get sensor information
- **A** – set the sensor address
- **M** – report current measurements
- **XT** – trigger to start a new measurement period.

Measurement settings

Send the sensor the `M` command to collect data and the `XT` command to trigger a new measurement period. `M0` collects the basic data set. `M1`, `M2`, or `M3` collect different data sets. The contents of each packet that is returned by the `M` commands are defined in *Data and variables* on page 8-1.

Detailed instructions for common dataloggers are in following sections:

- *Using an SDI-12-to-USB translator* on page 4-1.
- *Connecting to Campbell Scientific dataloggers* on page 5-1.
- *Connecting to the Sutron 9210 datalogger* on page 6-1.
- *Connecting to the Thermo Fisher dataTaker* on page 7-1.

Section 4.

Using an SDI-12-to-USB translator

An SDI-12-to-USB translator can give access to the LI-710 configurations and results.

Requirements for this tutorial

The following items are required to complete this tutorial:

- **LI-710 Evapotranspiration Sensor.**
- **SDI-12-to-USB Translator** (we use the vegetronix.com translator for this tutorial).
- **Personal Computer** (Windows OS).
- **Terminal Emulator** (we use Tera Term).

You will connect the ground and BUS wires from the LI-710 to the data and ground connectors on the translator, and provide power to the LI-710 from an external power supply (see *Figure 4-2* on the next page).

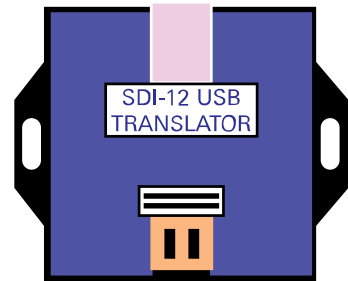


Figure 4-1. An SDI-12-to-USB translator allows communication with the LI-710.

Connecting the device

Connect the wires and power on the LI-710, then connect the USB cable to your computer. The computer will establish a COM port, which may be indicated in the notifications or found in the Device Manager.

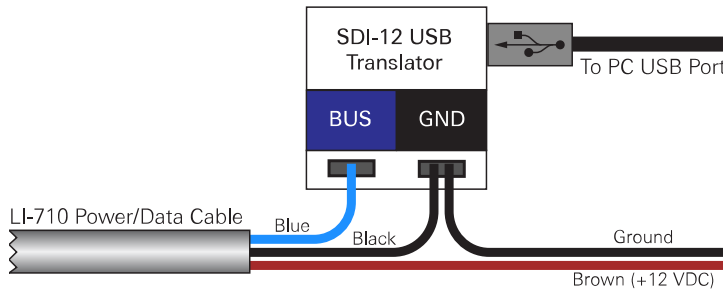


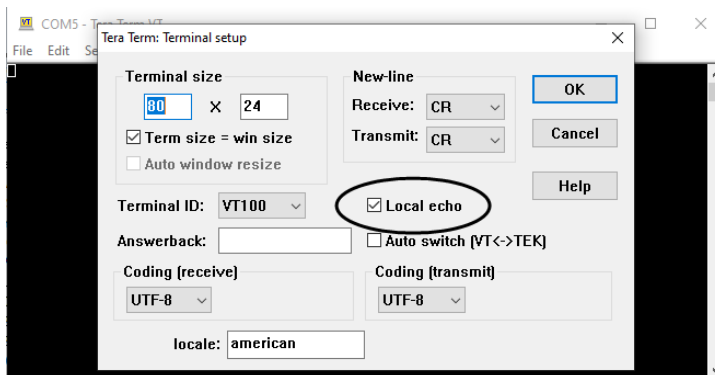
Figure 4-2. When connecting the LI-710 to an SDI-12-to-USB translator, connect the data wire to the BUS terminal and the ground wire to both GND and power ground. Connect the power and ground leads to a power supply (12 VDC).

To connect to the SDI-12 translator:

- 1 Launch a terminal program, such as Tera Term.
- 2 Select **Serial** as the connection type, select the port for the USB translator, and then click **OK**.

In the default configuration, Tera Term will pass your keystrokes directly to the COM port - you will not see what you have typed. Change the setting under **Setup > Terminal**, and check **Local Echo** and your keystrokes will appear in the terminal, along with replies from the sensor. This is a matter of convenience - so you can see what you are sending to the device.

Note: The **New-line Receive** and **Transmit** settings must be **CR**.



Communicating with a command-line interface

This section presents a variety of commands and replies that you can use to configure and view data from the device. This is a practical tutorial; you won't do this when the LI-710 is deployed. You will do this to observe the configuration and familiarize yourself with the data structure. Normally, communication with the LI-710 (including data logging) will be carried out by a data logger.

Use transparent mode

Some queries must be sent in transparent mode. This is accomplished by preceding the command with a capital **T**. In the following examples, the letter is included where needed.

Get the address

To request the address of the sensor connected to the SDI-12 bus, enter the following.

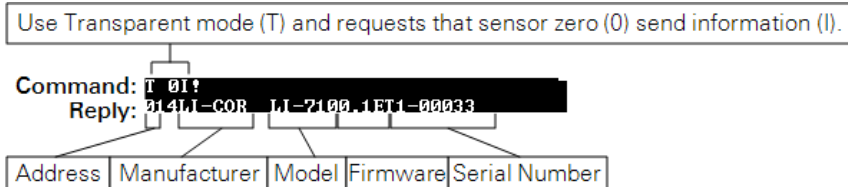
- **Command:** **T ?!**
- **Reply:** OK 0

```
Command: T ?!
Reply: OK
       0
```

The number in the reply (0 in this case) is the connected sensor's address.

Device information

Each LI-710 is configured with an address of 0. The first time you connect to an LI-710, it should be the only device attached to the SDI-12 array. After connecting initially, you can set the address and then power up the remaining SDI-12 devices.



- **Command:** `T 0I!` (T for transparent mode followed by a space, the number zero, the capital letter I for information, ending with an exclamation point).
- **Reply:** `014LI-COR LI-7101.0ET100033` (identifying information for the sensor, including the device address, manufacturer, model, firmware version, and serial number)

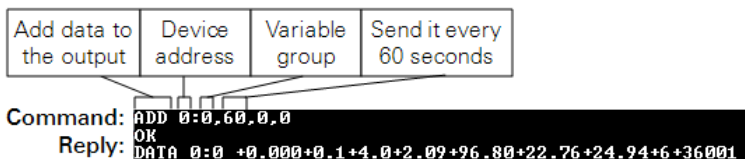
Set the address

To change a sensor's address, the command starts with the address of the sensor to change followed by a capital A for address, followed by the new address number.

- **Command:** `T 0A1!` (T for transparent mode followed by a space, the number zero for the sensor with address 0, capital letter A for address, the number 1, which is the new address, and the exclamation point).
- **Reply:** `OK 1` (the new address)

Adding a variable set to a scheduled output

To view the output, at least one of the four data packets must be added to the scheduler. The scheduler will inquire with the specified sensor on the specified schedule for the requested data at the specified interval (60 seconds in this example).



- **Command:** `ADD 0:0,60,0,0`
- **Reply:** `OK DATA 0:0` (followed after a moment by parameters in the group)

To add four groups of variables, send the following four commands:

- **Command:** `ADD 0:0,60,0,0`
- **Command:** `ADD 0:1,60,0,0`
- **Command:** `ADD 0:2,60,0,0`
- **Command:** `ADD 0:3,60,0,0`

To remove a group (3 for example), send the following.

- **Command:** `DEL 0:3`
- **Reply:** `OK`

This will remove variable group 3 from the output of sensor 0. Use a modified version of the same command to remove variable groups 0, 1, or 2.

Adding the dataset to the scheduler is not enough; however, you must also request that the device send the data packets by turning the scheduler on (simply type `START`).

Turn off or on the scheduler

To keep the configuration but stop the transfer of data, simply send the command `STOP`. The sensor will retain settings but stop sending the data to the terminal program. To turn it back on, send the command `START`. The device will resume sending data at the specified interval.

Send a trigger (XT) command

Send the trigger command to compute results from data in volatile memory and restart the measurement period. Follow the trigger command with the `READ` command to report the results.

- **Command:** `T 0XT!`
- **Reply:** `OK`

Report the measurement immediately

After you have added a variable to the output, you can view the data in that group at any time by sending `READ` followed by the sensor address and the data group. It'll look like this:

```
Command: READ 0:0
OK
Reply: DATA 0:0 +0.000+0.1+6.4+2.08+96.73+22.75+25.04+7+36001
```

- **Command:** `READ 0:0`
- **Reply:** `OK DATA 0:0` (followed by parameters in the group 0).

You may need to turn off the scheduler (type `STOP`) for the device to respond to commands in transparent mode.

Logging data to your computer

You can record measurements directly to your computer. This may be practical if you have a computer that is dedicated to logging data. However, a personal computer may not be ideal because it may shutdown and not restart if power is disrupted, it may spontaneously restart after updates, or it may enter sleep mode. These are just a few things to consider if you are using a personal computer as a data logging device. Nevertheless, it may work for you, and if you deem these risks to be acceptable, proceed:

- 1** In Tera Term, click **File > Log**.
- 2** Select a directory where the file will be written.
- 3** Click **Log** to start.

Tera Term will write data to the file until you stop it or until something disrupts the process.

The logging options in Tera Term are somewhat limited compared with those available in dedicated data loggers. But, if your goal is to record the data, this will get it done for a short time period.

Section 5.

Connecting to Campbell Scientific dataloggers

You can record data from the LI-710 on Campbell Scientific® dataloggers that support the SDI-12 protocol. This tutorial provides the steps and simple programs for connecting the LI-710 to a CR1000X, CR1000, CR300, CR6, or CR5000 datalogger. The programs described here will read data from the LI-710 only. If you want to add the LI-710 to an existing program, the task is more complicated. Campbell Scientific can provide the technical assistance that is required for modifying datalogger programs beyond what is described here.

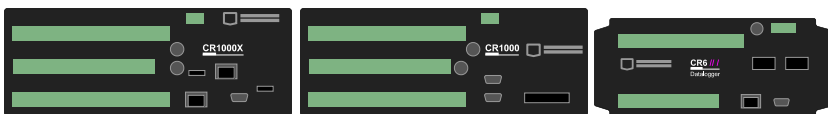


Figure 5-1. The LI-710 is compatible with the CR1000X, CR1000, CR6, and other Campbell Scientific dataloggers that support the SDI-12 protocol.

Requirements for this tutorial

The following items are required to complete this tutorial.

- **LI-710 Evapotranspiration Sensor.**
- **Datalogger programs** for the logging LI-710 data to a Campbell Scientific datalogger from licor.app.boxenterprise.net/s/vzy8p3jz4ttvrz3sixutuh3ho3ycjt6a. Some programs are for 1-minute data logging for testing. The others are for 30-minute data logging for deployment.
- **Personal Computer** (Windows OS).
- **Campbell Scientific datalogger:** CR1000X, CR1000, CR6, or CR5000.
- **PC400 software** from Campbell Scientific, Inc. The software is available from campbellsci.com/downloads/pc400. This tutorial describes version 4.7.

Configuring the datalogger

Follow these steps to connect an LI-710 to the datalogger.

- 1 Connect the LI-710 to the datalogger terminals.

The terminals must provide power (12 VDC), ground, and a data connection. In this example, we use terminal C1, which is labeled on the logger and specified in the program as the SDI-12 terminal for this sensor.

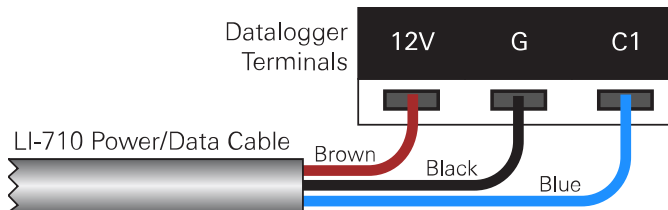


Figure 5-2. The LI-710 connects to a 12 VDC power supply (brown), ground (black), and an SDI-12 terminal (blue to C1 in this example).

- 2 Power on the datalogger.

The datalogger will power on when power is supplied.

- 3 Connect a communication cable between the datalogger and your computer.

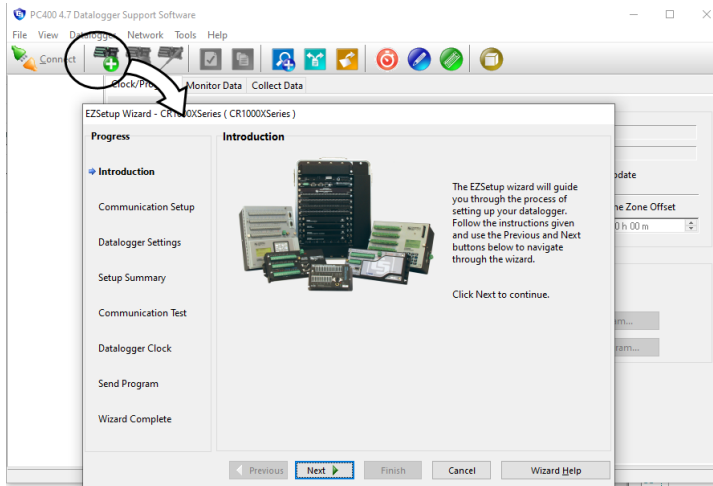
We use the USB connection on the CR1000X for this tutorial.

You may need to use the serial or Ethernet connection with dataloggers that do not support USB. In any case, the steps are the same after you have established communication between your PC and the datalogger.

- 4 Launch the PC400 application.

If you've configured the connection already, just connect to the datalogger and go to the next step.

If it is the first time you've connected, add a datalogger to the list and configure the settings.



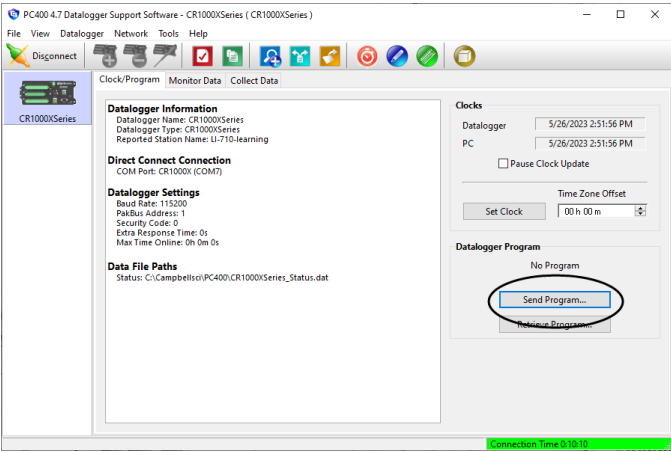
- Select the datalogger model and assign a name.
- Select Direct Connection as the type.
- Select a COM port number (if it is the first time connecting, install the device driver now).
- Click through the remaining prompts, leaving the default settings as they are or making changes to suit yourself. You could send a program to the datalogger in the Wizard, but there are some other settings to check and configure before doing so.

5 Consider the LI-710 SDI-12 address.

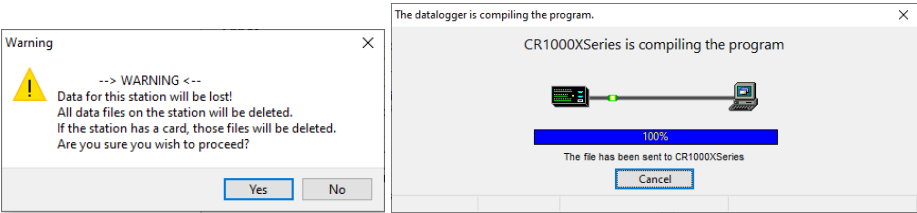
Each LI-710 has an SDI-12 address of 0 by default. The sample programs use an address of 0 as well, and are compatible with the LI-710 in its default configuration. If you need to change the sensor address, we describe that in *The PC400 terminal program* on page 5-6. If you change the address, you must also modify the program as well (you can do this easily in a text editor).

6 Click **Send Program** to send the program to the datalogger.

For testing, we provide a program that records measurements every one minute. The program you use in deployments records measurements every 30 minutes; we provide those too.

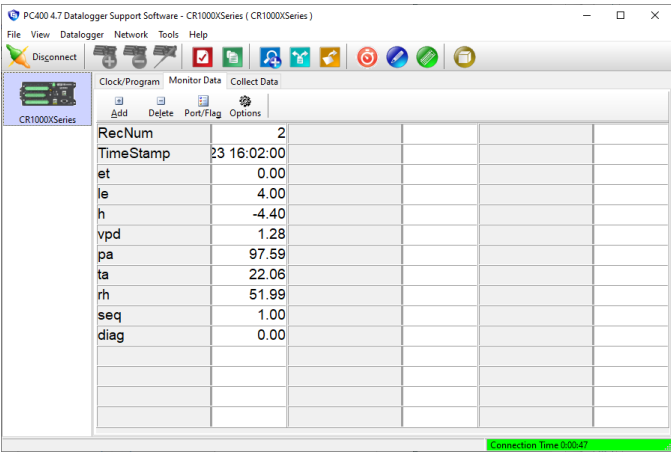


7 Click **Yes** to dismiss the warning; allow the logger to compile the program.



8 The datalogger will restart; reconnect after it restarts.

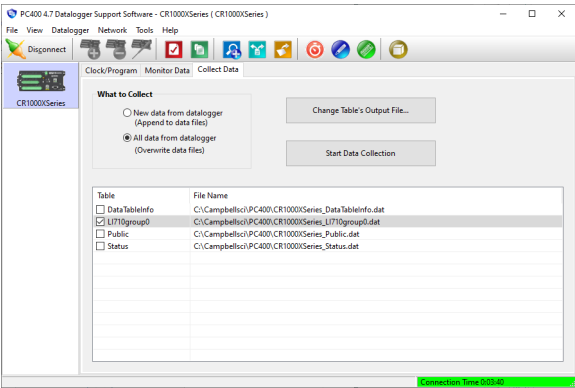
9 Click **Monitor Data** to view the latest results.



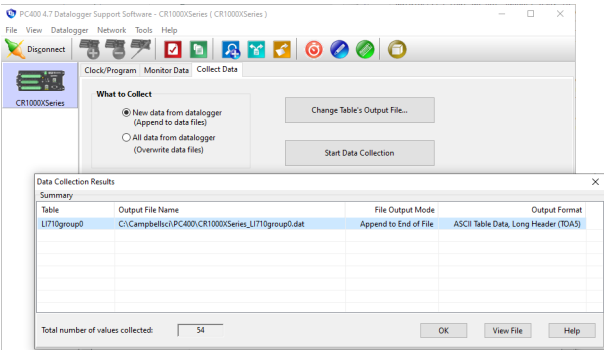
Retrieving logged data

The datalogger stores the readings to its internal memory. To copy the data to your computer:

- 1 Click **Start Data Collection** to save the logged data to a file on your computer.

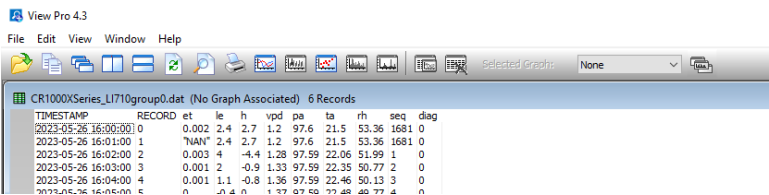


- 2 Select an output file and click **OK**.



The directory is indicated in the column called **Output File Name**.

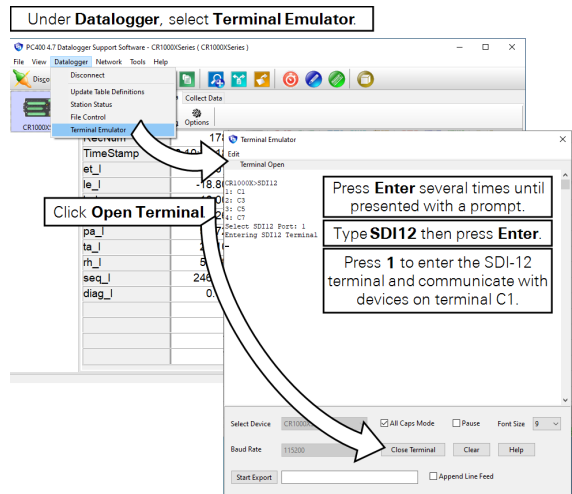
- 3 Click **View File** to see the records saved so far.



The PC400 terminal program

The PC400 has a built-in terminal emulator that you can use to communicate with the LI-710. To use it, connect with the datalogger as described earlier and follow these steps:

- 1 In PC400, click **Datalogger > Terminal Emulator**.
- 2 In the new window, click the **Open Terminal** button and then click in the terminal to bring focus to that window.
- 3 Press **Enter** one or more times to get a response from the datalogger. The response will be something like `CR1000X>`.
- 4 Type `SDI12` and press **Enter**.
- 5 When presented the menu, select the port (press **1** if your LI-710 is on terminal C1).
- 6 Now you can query the LI-710 with the following commands:



Get the address

- **Command** `?!`
- **Reply:** 0 (or whatever the address is)

Set the address

To change the address from 0 to 1

- **Command:** `0A1!`
- **Reply:** 1

Note: If you change the address, you must modify the address in the program to match the sensor's address.

Get information

- **Command:** 0I! (the number zero, the capital letter I for information, ending with an exclamation point).
- **Reply:** 014LI-COR LI-7101.0ET100033 (identifying information for the sensor, including the device address, manufacturer, model, firmware version, and serial number).

Read current data from a group

The command to read data.

- **Command:** 0R0!
- **Reply:** 0+0.00+0.02+0.02+1.39+97.55+22.47+48.87+0
- **Command:** 0R1!
- **Reply:** 1+0.00+0.02+0.02+97.55+22.47+48.87+600+0

The two examples show data group 0 and data group 1. Enter 2 or 3 in place of the 0 or 1 to read those data groups.

Simple program with comments

The program in *Listing 5-1* below is for a Campbell Scientific CR1000X, CR1000, CR5000, or CR6 Datalogger. This example includes comments to show you which parameters can be modified.

Listing 5-1. A program for Campbell Scientific, Inc. CR1000X, CR1000, CR5000, or CR6 datalogger.

```
'LI-710 simple logger
'Rev: 0.1
'Date: May 23, 2023
'Author: licor.com

Public LI710A(9) 'names an array and specifies that it has 9
variables
Alias LI710A(1)=et_l 'the first of 9
Units et_l=mm
Alias LI710A(2)=le_l
Units le_l=W/M^2
Alias LI710A(3)=h_l
Units h_l=W/M^2
```

```
Alias LI710A(4)=vpd_l
Units vpd_l=kPa
Alias LI710A(5)=pa_l
Units pa_l=kPa
Alias LI710A(6)=ta_l
Units ta_l=C
Alias LI710A(7)=rh_l
Units rh_l=%
Alias LI710A(8)=seq_l
Units seq_l=count
Alias LI710A(9)=diag_l
Units diag_l=Dimensionless

DataTable (LI710group0,True,-1) 'creates and names a data
table
    DataInterval(0,30,Min,10) 'specifies the interval for
writing to the table
    Sample(9,LI710A,IEEE4)
EndTable

BeginProg
    Scan(30,Min,1,0) 'specifies the interval for scanning for
new data
    SDI12Recorder(LI710A,C1,0,"XT!",1.0,0) 'instructs the SDI-
12 device on terminal C1 to start sampling
    SDI12Recorder(LI710A,C1,0,"M0!",1.0,0) 'requests group 0
(M0) from the SDI-12 device on terminal C1
    CallTable LI710group0
NextScan
```

Section 6.

Connecting to the Sutron 9210 datalogger

You can log data from the LI-710 to Sutron dataloggers that support the SDI-12 protocol. This tutorial and program provide the basic steps for accomplishing this with a Sutron 9210 datalogger. If you want to add the LI-710 to an existing program, the task may be more complicated. Contact Sutron technical support for assistance.

Requirements for this tutorial

The following items are required to complete this tutorial.

- **LI-710 Evapotranspiration Sensor.**
- **Datalogger program** for logging LI-710 data to the 9210. A sample program is available from licor.app.boxenterprise.net/s/xnr4f3wg9hpnoz9nlc93rw0ntfvvp8vb
- **Personal Computer** (Windows OS).
- **Sutron 9210 Datalogger.**
- **Xterm** for Sutron products (from otthydromet.com).

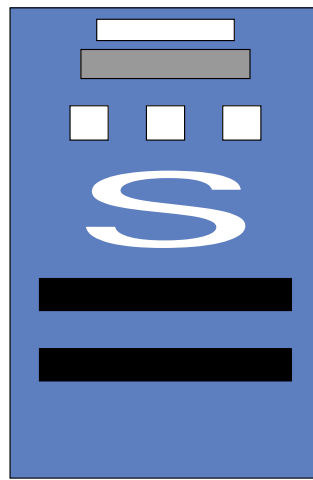


Figure 6-1. The Sutron 9210 XLite datalogger can record data from the LI-710.

Configuring the datalogger

Follow these steps to connect the LI-710 to a Sutron datalogger.

- 1 Connect the LI-710 to the SDI-12 terminals.

Connect the brown wire to a +12 VDC power supply and the black wire to the ground. Connect the blue wire to the DATA terminal.

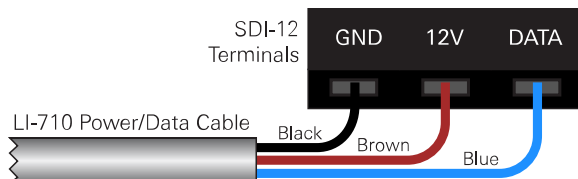
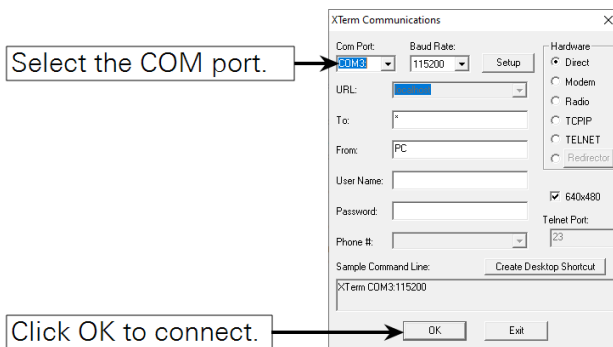


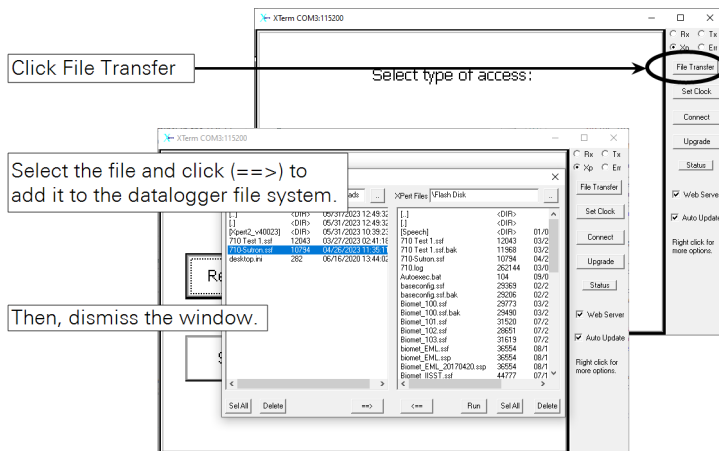
Figure 6-2. The LI-710 connects to a 12 VDC power supply (brown), ground (black), and an SDI-12 terminal (blue).

- 2 Connect power to the datalogger to power it on.
- 3 Connect a communication cable between the datalogger and your computer.
We use an RS-232-to-USB adapter for this example. You can also connect using Ethernet.
- 4 Launch Xterm, select the COM port that hosts the datalogger, and click OK.
Or, connect to the logger using your preferred method.



5 Load the configuration file onto the datalogger.

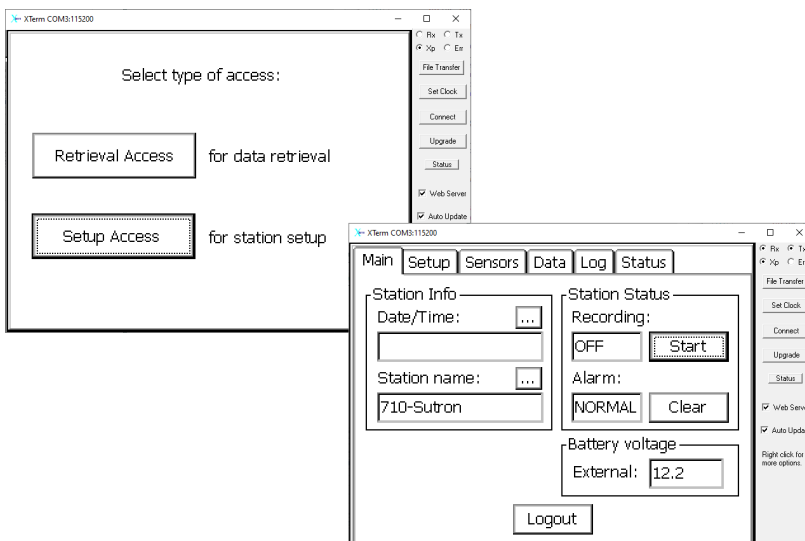
- A** Click **File Transfer**, select the file, and click ==> to add it to the list.



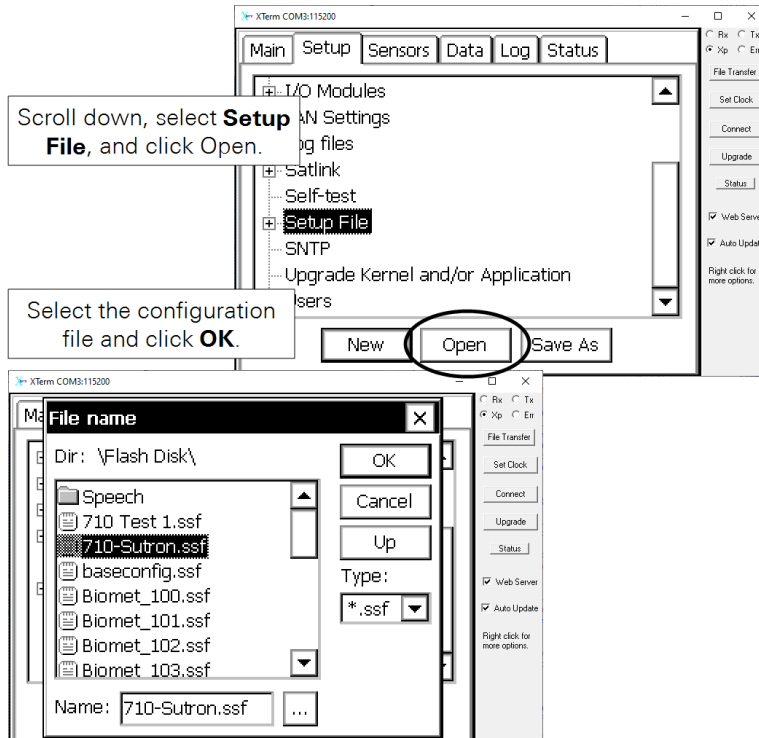
- B** After the transfer is complete, dismiss the window.

6 Click Setup Access and set the Station Name.

Click the ... button next to **Station Name** and enter a name that matches the name of the configuration file. In doing so, you configure that datalogger to run that specific program when it starts up.



- 7 Under the **Setup** tab, scroll down, select **Setup File** and click **Open**.
- 8 Select the configuration file that you loaded earlier and click **OK**.



- 9 After the program has loaded, you can check the measurements.

Under the **Sensors** tab, select an item and click **Meas**. The most recent results will be presented. If the LI-710 has been on for less than 30 minutes, data will be placeholder values of -9999. After the first 30 minutes has passed, actual measurements are presented.

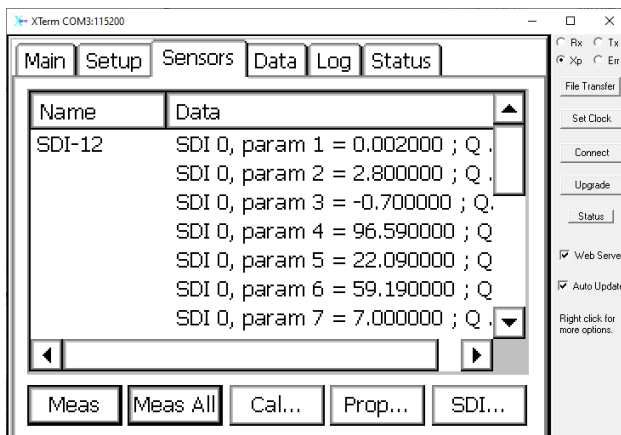
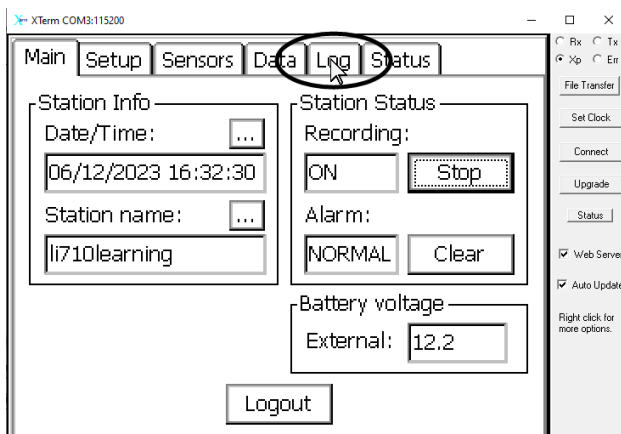


Figure 6-3. Measurements are presented in the **Sensors** tab.

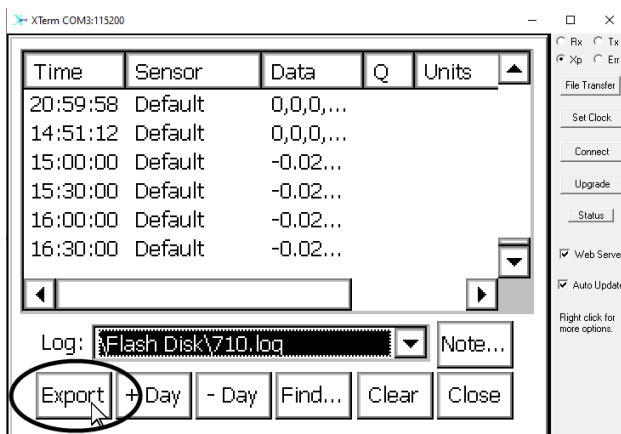
Retrieving logged data

After data are logged to the datalogger internal memory, you can copy the data files to your computer. Here's how:

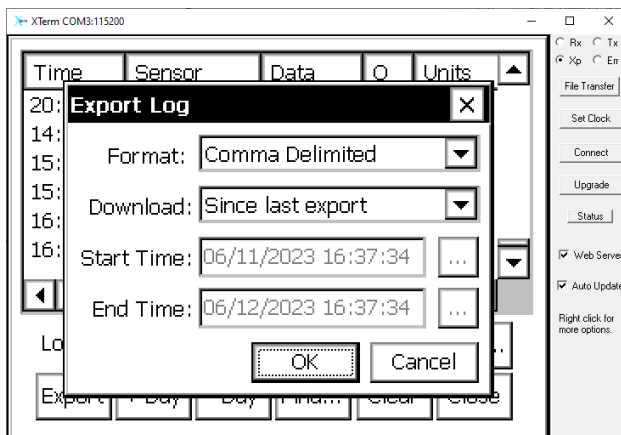
- 1 Connect a computer to the datalogger using an RS-232-to-USB adapter or another method.
- 2 After a successful connection, select the **Log** tab.



- 3 Click **Export**.



- 4 Select the **Format** and **Download** options.
Set the **Start Time** and **End Time** if needed.



- 5 Select a directory on your computer and save the files.

More SDI-12 options

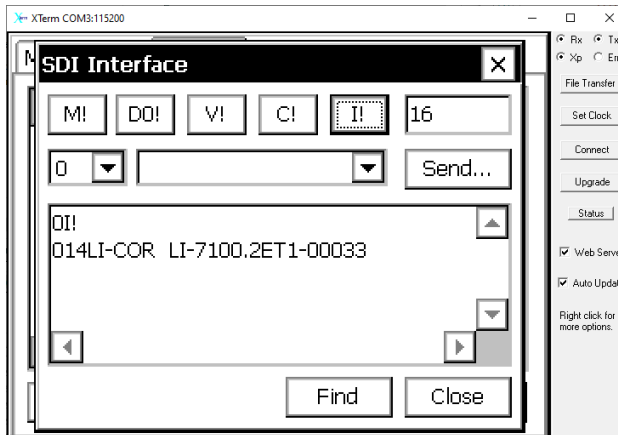
You can read information from the sensor in the Xterm program. This might be useful for troubleshooting or configuring the device initially. Connect with the device and select the **Sensors** tab (*Figure 6-3* on page 6-5). Click **SDI...** in the lower right to open the **Sensors** tab.

Find sensors

Click the **Find** button to initiate a query for all sensors connected to the SDI-12 terminals. After a moment, the interface will present information (including the addresses) of connected sensors.

Get information

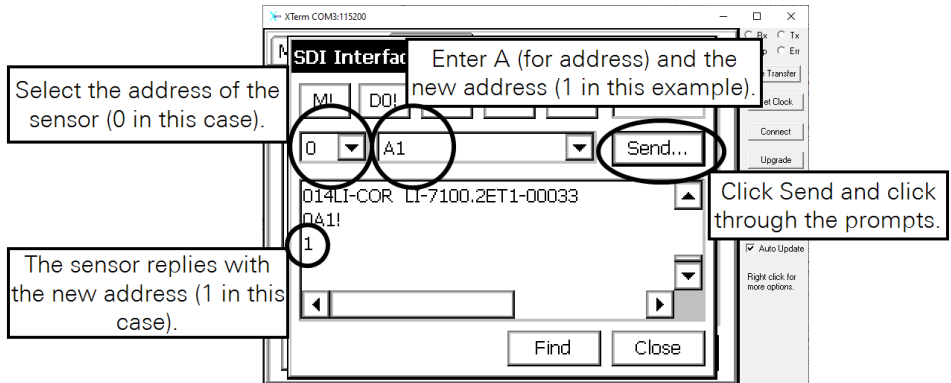
Click the **I!** button to request information from the sensor. The sensor replies with identifying information, including the device address, manufacturer, model, firmware version, and serial number.



Set the address

The command to change a sensor address can be sent through the interface.

- 1 We start with a sensor address of 0.



- 2 Select the current address in the first field.
- 3 Enter the command **A1** into the second field.
- 4 Click **Send** and click through the prompts.

The sensor replies with the new address.

Section 7.

Connecting to the Thermo Fisher dataTaker

You can log data from the LI-710 to Thermo Fisher dataTaker DT82E and other loggers that support the SDI-12 protocol. This tutorial and program provide the basic steps for accomplishing this. If you want to add the LI-710 to an existing program, the task may be more complicated. Contact Thermo Fisher for assistance.

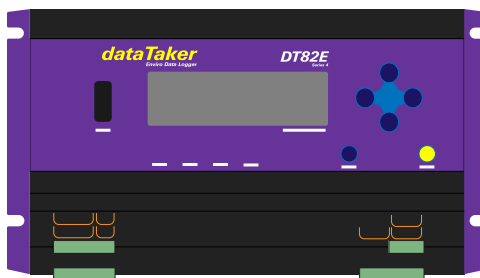


Figure 7-1. The Thermo Fisher dataTaker DT82E Series 4 data logger can record data from the LI-710.

Requirements for this tutorial

The following items are required to complete this tutorial.

- **LI-710 Evapotranspiration Sensor.**
- **Logger program** for logging LI-710 data to the dataTaker from licor.app.boxenterprise.net/s/vjp4jn6zzk9x8eg4aatyxoczppeqn2i6. This program will log all parameters output by the LI-710.
- **Personal Computer** (Windows OS).
- **dataTaker DT82E Series 4 data logger.**
- **dEX® 2.0 software** for Thermo Fisher dataTaker data loggers (from thermofisher.com/us/en/home/industrial/manufacturing-processing/data-acquisition/software-firmware-drivers.html).

Configuring the logger

Follow these steps to connect the LI-710 to a dataTaker and configure the logger.

- 1 Connect the LI-710 cable to the terminals.

Connect the brown wire to a +12 VDC power supply and the black wire to the ground. Connect the blue wire to the 4D terminal.

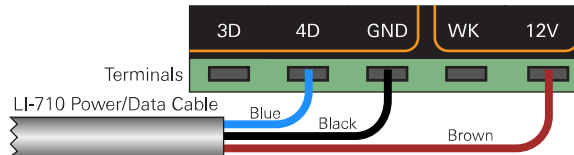


Figure 7-2. The LI-710 connects to a 12 VDC power supply (brown), ground (black), and the 4D terminal (blue).

- 2 Connect power to the logger to power it on.

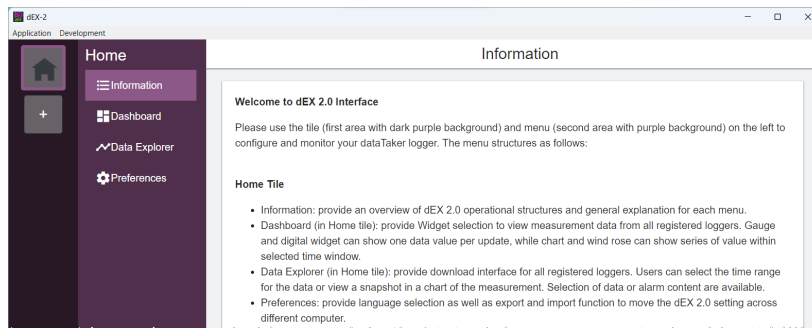
- 3 Connect an Ethernet cable between the logger and your computer.

You can also connect it to your local network.

- 4 Find the IP address that is assigned to the logger.

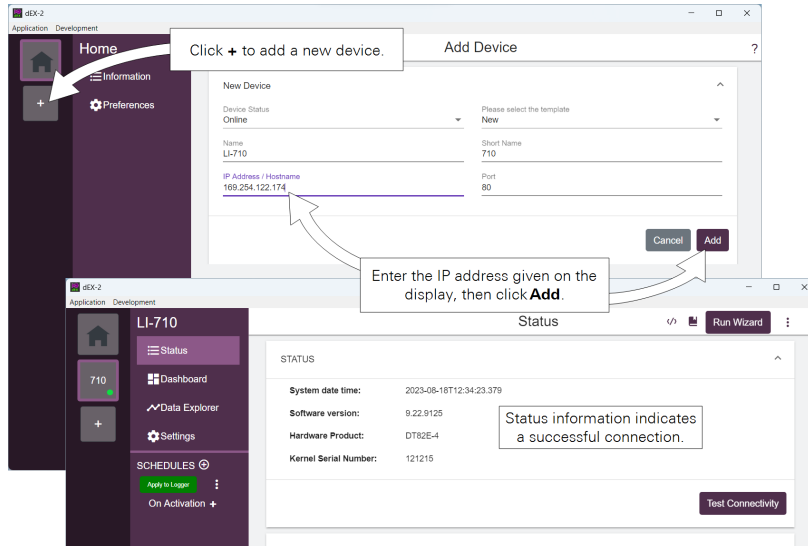
Press the down arrow key on the keypad two or three times to see the IP address. If no IP address is given, check the cable to be sure it is connected.

- 5 Launch the dEX application.



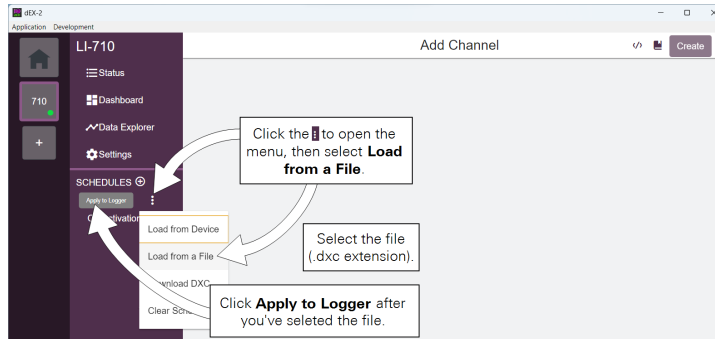
- 6 Add the LI-710 and configure the connection.

Click the + button and enter the IP address. Click **Add**. When connected, the **Status** pane will show information about the logger. You can also set the name and short name as desired.



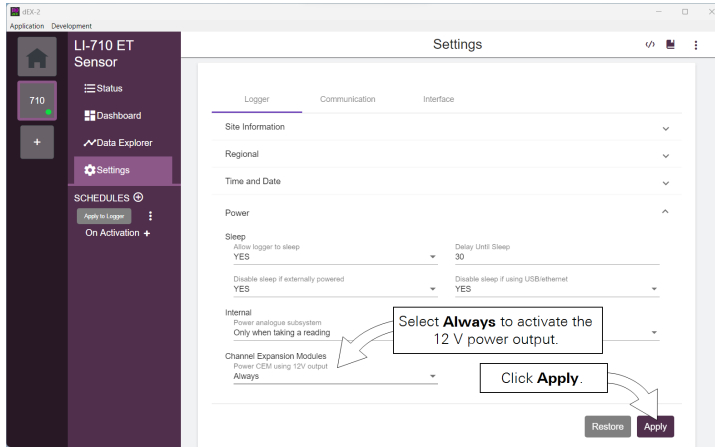
7 Load the example program.

The program (from licor.app.boxenterprise.net/s/vjp4jn6zzk9x8eg4aatyxoczppeqn2i6) records all parameters output by the LI-710. To load it, click the three dots and select **Load from a File**. Select the file (.dxc extension) and then click **Apply to Logger** to load the program. The program includes a trigger command that is required by the LI-710, as well as instructions for recording the LI-710 output.



8 Activate the 12 V power supply.

Under **Settings > Logger > Power > Channel Expansion Modules**, set **Power CEM using 12V output** to **Always**. You have to do this any time you change the logger configuration.



After loading the configuration file and activating the power supply, the dataTaker should record all parameters from the LI-710 every thirty minutes. You can customize the configuration to record only the parameters of interest. Be sure to activate the 12 volt power supply after you have applied the changes.

Retrieving logged data

After data are recorded to the logger internal memory, you can copy the data files to your computer. Here's how:

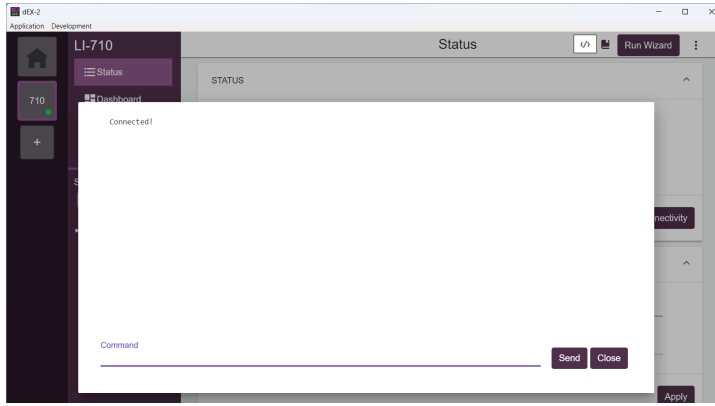
- 1 Connect a computer to the logger using the network cable, open dEX software, and select the device to connect.
- 2 Click **Data Explorer**.
- 3 Select a date range by entering a start time and stop time, or select all values.
- 4 Click **Load Schedule Tree** and check the box to select all variables or select the variables of interest.
- 5 Click **Download**.
Leave **Download as** set to **.csv** to download a text file with comma-separated values.
- 6 Select a directory on your computer and save the file.

You can also view a graph of parameters in the dEX application by following the steps above and clicking **Draw** instead of **Download**.

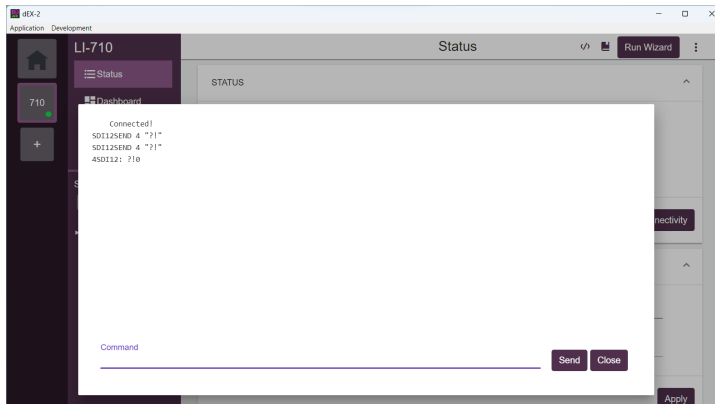
The dEX terminal program

The dEX application has a built-in terminal emulator that can be used to read parameters from LI-710. To use it, connect with the logger as described earlier and follow these steps:

- 1 From the home screen, click the **Command Line Interface** button.



- 2 In the console, type `SDI12SEND 4 "?!"` and press **Enter**.



The LI-710 will reply with its address.

- 3 You can query the LI-710 with more commands, some of which are described below.

Get information

- **Command:** `SDI12SEND 4 "0I!"` (the command is SDI12SEND, the number 4 indicates terminal 4D, followed by quotes enclosing the number zero, the capital letter I for information, and an exclamation point).
- **Reply:** `4SDI12: 0I!014LI-COR LI-7101.0ET100033` (the command, identifying information for the sensor, including the device address, manufacturer, model, firmware version, and serial number).

Set the address

Use this command if you need to change the address from 1 to 0.

- **Command:** `SDI12SEND 4 "1A0!"`
- **Reply:** `4SDI12: 1A0!0` indicating that the address was changed from 1 to 0.

Read current data from a group

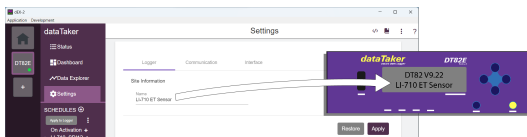
- **Command:** `SDI12SEND 4 "0R0!"` (reads data from group 0)
- **Reply:** `4SDI12: 0R0!0+0.00+0.02+0.02+1.39+97.55+22.47+48.87+0`
- **Command:** `SDI12SEND 4 "0R1!"` (reads data from group 1)
- **Reply:** `4SDI12: 1+0.00+0.02+0.02+97.55+22.47+48.87+600+0`

Additional settings

Some settings are not relevant to the evapotranspiration measurement, but may be useful to you for record keeping and convenience.

dataTaker name

You can change the name of the dataTaker. Click **Settings > Logger > Site Information** and enter a **Name**. Click **Apply**. The name will be visible on the display.



dataTaker time and date

You can adjust the date, time, and time zone, or set them to match your computer under **Settings > Logger > Time and Date**.

Section 8.

Data and variables

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 8-1. Data group 0 includes results for a measurement period.

Output	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 8-2. Data group 1 includes results and the sample count.

Output	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 8-3. Data group 2 has environmental information without any flux results.

Output	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 8-4. Data group 3 presents diagnostic information and details that can assist with diagnostics.

Output	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

Section 9.

Troubleshooting

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

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 8-2), and the percent used as the eighth parameter of group 3 (*Group 3: Performance information and diagnostics* on page 8-3).

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 0s and 1s in the binary results. Associate the 1s with the descriptions in *Table 9-1* on the next page.

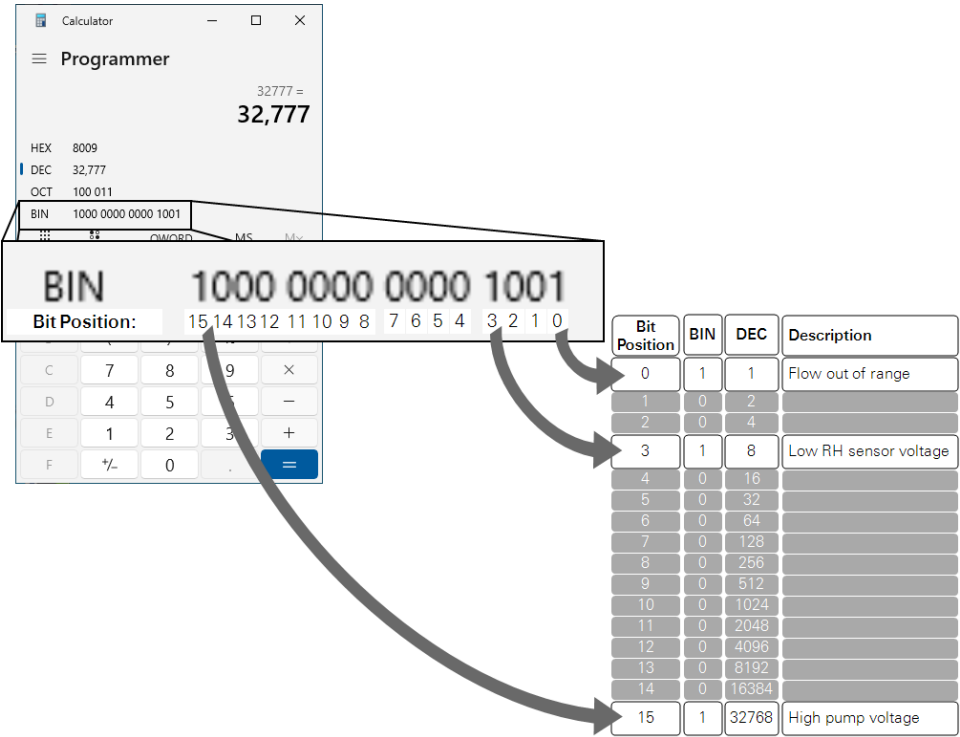


Figure 9-1. You can decode the decimal diagnostic using a converter such as the calculator included with your computer operating system. Then, associate the binary 1s with conditions described in Table 9-1 on the next page.

Table 9-1. 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 9-2* below presents bit positions and combinations, possible scenarios, and potential solutions.

Table 9-2. Bit positions and combinations can be interpreted and resolved by maintenance, or sometimes, just waiting.

Bit Position				Scenario	Solution 1	Solution 2	Solution 3
and	or	or	or				
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

¹See *Replacing the intake filter* on page 10-2.

²See *Accessing the outlet vent* on page 10-7.

³Similar to clogged inlet filter or clogged outlet.

⁴See *Replacing the pump and O-rings* on page 10-4.

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

Section 10.

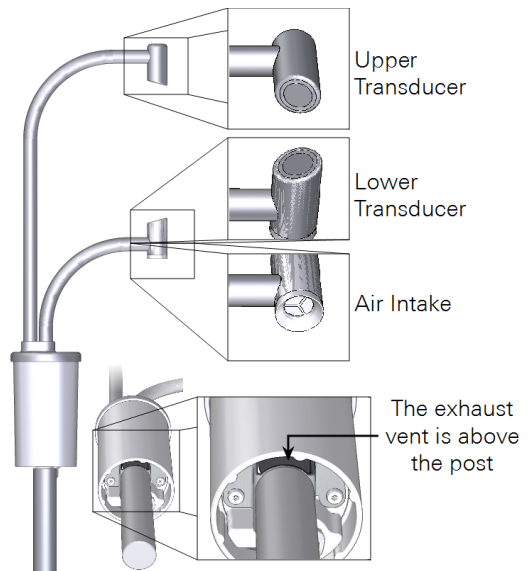
Maintenance

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.

Basic sensor checkout

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* on the next page).
- 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 10-7).



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 10-1. 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).



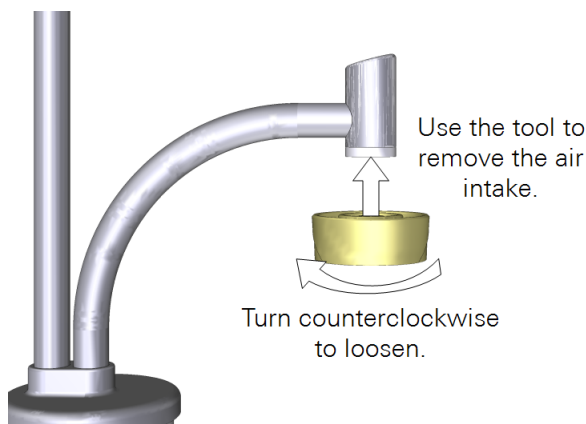
Air intake tool

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.

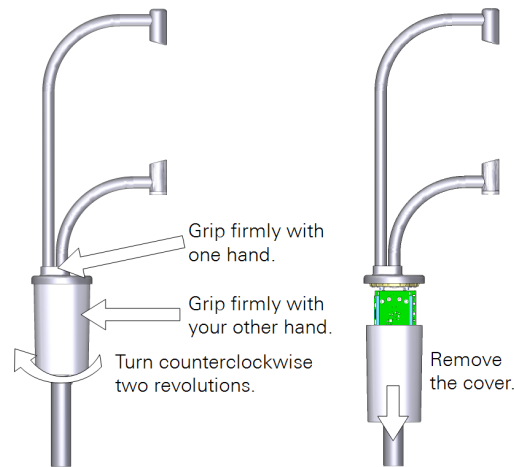
Replacing the pump and O-rings

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.

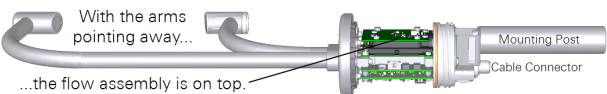
Table 10-2. The kit includes a pump, hardware, and a hex key.

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.



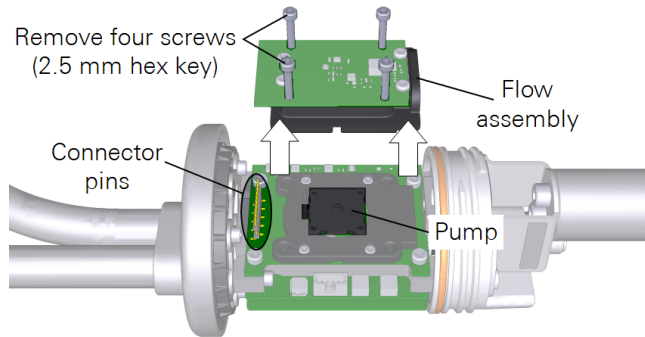
- 3 Set the LI-710 on a workbench with the arms pointing away from you.



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.

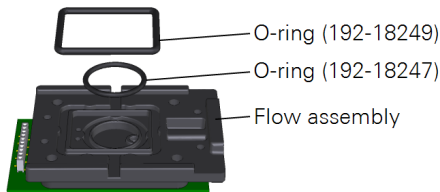


5 Remove the old pump.

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

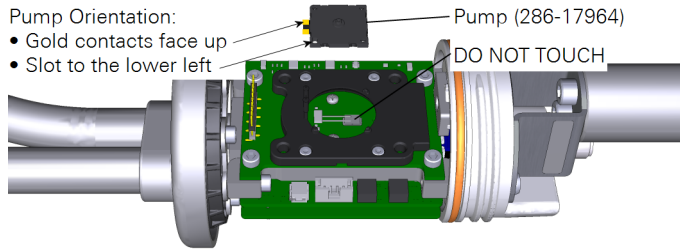
6 Inspect the O-rings - if you see cracks or damage, replace them.

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



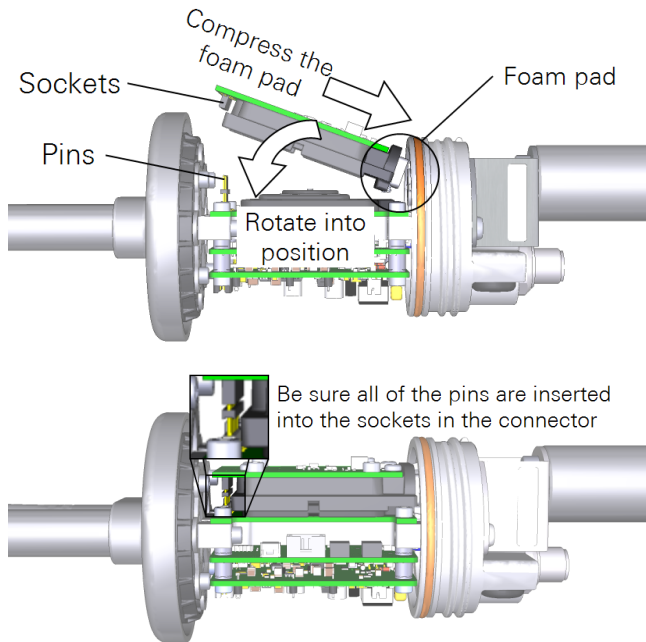
7 Set the new pump in place.

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.

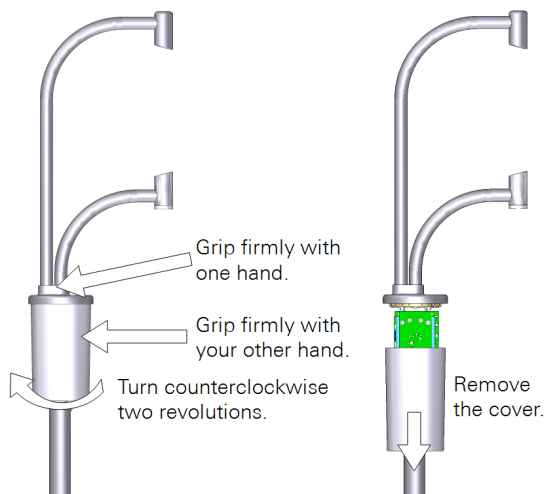


Figure 10-1. Remove the cover to access the exhaust vent. Do not apply torque to the arms.

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.

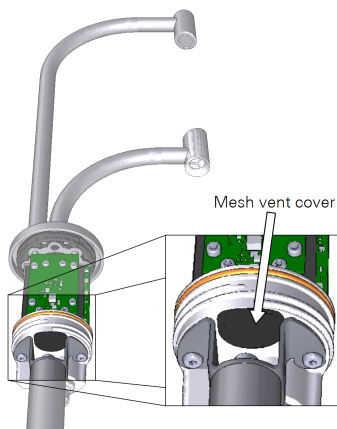


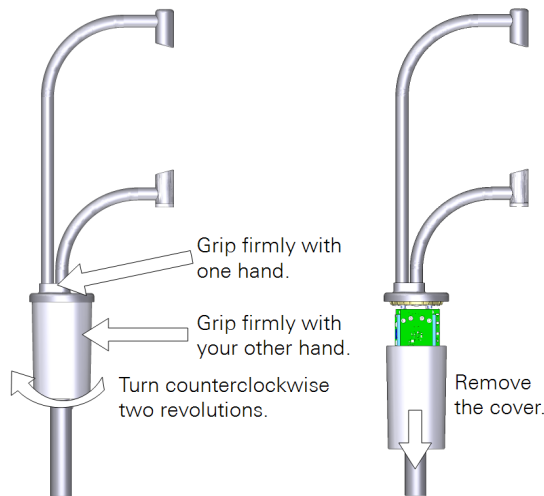
Figure 10-2. The exhaust vent is between the post and body.

Updating the firmware

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

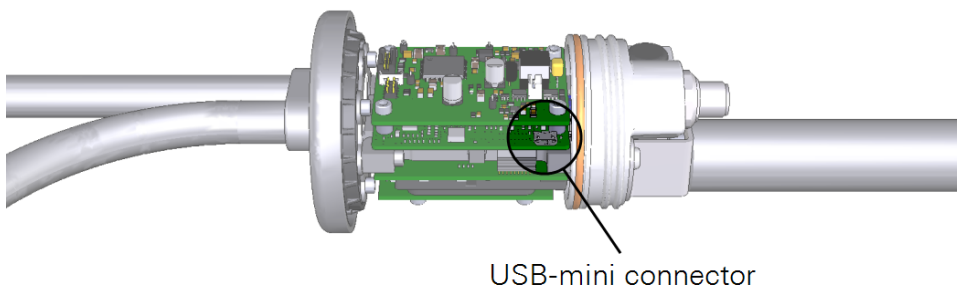
- 1 Download the firmware to a directory on your computer.
Firmware updates will be provided at licor.com/710-software.
- 2 Power off the instrument by removing the power cable at the connector.
- 3 Remove the electronics cover.

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-mini 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 "notifies" 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.

Section 11.

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

H₂O Mole Fraction Range: 0 to 60 mmol/mol

H₂O 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 cm³/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

^aSampling cell temperature.

^bFlow, required for ET and RH, turns off ≤5 °C, unless custom insulated or heated.

Installation Requirements

Separation Between LI-710s: ≥ 2 meters

Mounting Height: >1 meter above the plant canopy

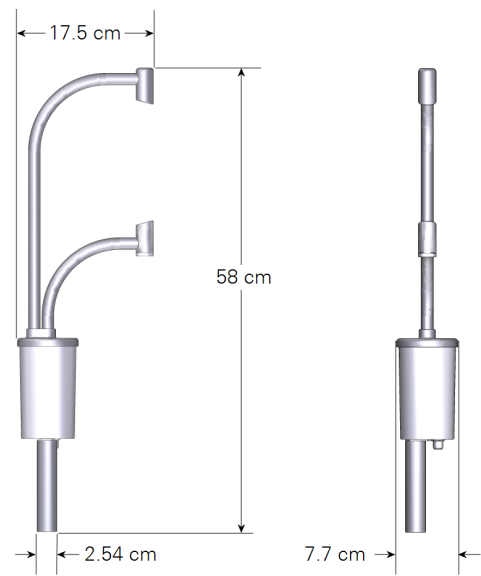


Figure 11-1. LI-710 dimensions.

Table 11-1. 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

Specifications subject to change without notice

Standard Terms and Conditions

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

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

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

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

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

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

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

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The LI-COR logo is displayed in a bold, italicized, sans-serif font. The letters 'LI' are connected to 'COR', and a registered trademark symbol (®) is located at the bottom right of the word 'COR'. The logo is white and stands out against the solid blue background of the footer.