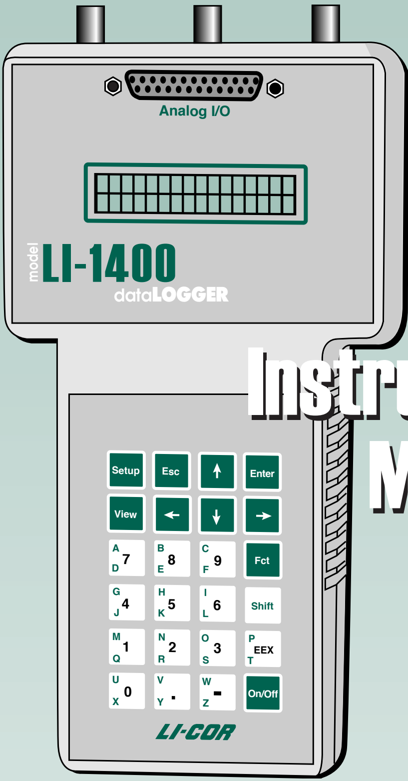
model LI-1400 dataLOGGER



Instruction Manual

LI-COR®
Biosciences

LI-1400

Data Logger
Instruction Manual

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LI-COR®
Biosciences

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How to Use this Manual

This manual contains operational information for the LI-1400 Data Logger. The manual is organized in an outline format, with headings indicated by large font and subheadings indicated with progressively smaller fonts. Read the operating instructions before using the LI-1400.

NOTICE

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Declaration of Conformity

Manufacturer's Name: LI-COR Inc.

Manufacturer's Address: 4647 Superior Street
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declares that the product

Product Name: Datalogger

Model Number(s): LI-1400

Product Options: 1400-401 AC Power Supply
1400-101 Air Temperature Sensor
1400-102 Air Temperature Sensor
1400-103 Soil Temperature Sensor
1400-402 External Battery Pack
1400-301 Terminal Block
LI-COR Light Sensors

conforms to the following Product Specifications:

EMC: CISPR 11: 1990 / EN 55011:1991 - Group 1, Class B
EN 50082-1 : 1992
IEC 801-2 : 8 kV Air Discharge, 4 KV Contact Discharge
IEC 801-3 : 27-500 MHz, 3V/m
IEC 801-4 : 1 KV - AC Lines

Supplementary Information:

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

Gregory L Biggs

Gregory L. Biggs
Director of Engineering

Document #53-04666-A
September 9, 1997

LI-1400

Component Name	Hazardous Substances or Elements					
	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Chromium VI Compounds (Cr^{6+})	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
Keypad Assembly	X	O	X	O	O	O
Digital Circuit Board Assembly	X	O	O	O	O	O
Cable Assembly	X	O	O	O	O	O
LCD	X	O	O	O	O	O
9 Pin Connector Assembly	X	O	O	O	O	O
25 Pin Connector Assembly	X	O	O	O	O	O
RS-232 Cable Kit	X	O	O	O	O	O
4-40 Screw Lock Assembly	O	O	O	X	O	O

O: this component does not contain this hazardous substance above the maxiumum concentration values in homogeneous materials specified in the SJ/T 11363-2006 Industry Standard.

X: this component does contain this hazardous substance above the maxiumum concentration values in homogeneous materials specified in the SJ/T 11363-2006 Industry Standard (Company can explain the technical reasons for the "X")

LI-1400　数据采集器						
部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr^{6+})	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
键盘组件	X	O	X	O	O	O
数码电路板组件	X	O	O	O	O	O
电缆组件	X	O	O	O	O	O
液晶显示器	X	O	O	O	O	O
9 针联接器组件	X	O	O	O	O	O
25 针联接器组件	X	O	O	O	O	O
串行 RS-232 电缆	X	O	O	O	O	O
4-40 螺丝锁定组件	O	O	O	X	O	O

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T 11363-2006 标准规定的限量要求以下。

X: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T 11363-2006 标准规定的限量要求。(企业可在此处，根据实际情况对上表中打 "X" 的技术原因进行进一步的说明。)

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1 General Description

The LI-1400 is a multipurpose datalogger that can function both as a data logging device and a multichannel, autoranging meter. The LI-1400 electronics are optimized to measure the current output of LI-COR light sensors, as well as voltage sensors and sensors with a pulsed output, such as a tipping bucket rain gauge. Data from a variety of other environmental and industrial test and measurement sensors can also be logged with the LI-1400.

The LI-1400 has 10 channels for sensor inputs. Three current input channels are located on sealed BNC connectors. Two additional channels, which are configurable for current or voltage, four dedicated voltage channels, and one pulse counting channel, can be accessed using the 1400-301 Standard Terminal Block.

The LI-1400 also has 9 math channels that sample output data from two analog channels and perform an arithmetic operation on the data.

Figure 1-1. *LI-1400 Data Logger and accessories.*

Features

The LI-1400 has a rugged, splash resistant case to protect from exposure. Four "AA" batteries provide over 50 hours of hand-held, instantaneous operation as a meter. The 1400-402 external "D" cell battery pack can provide up to 6 months of remote data logging operation from six batteries.

Data can be stored manually for instantaneous readings, or periodically logged to memory. The LI-1400 has 96K bytes RAM for data storage.

The LI-1400 can be programmed using the Windows® software or the instrument keypad. Both methods can be used to select functions and logging routines, enter calibration multipliers of sensors, set channel configurations, integration times, or choose from a list of math functions that can be applied to sensor inputs.

The display is a two line, 16 character alphanumeric LCD for viewing data and scrolling lists of available functions. The display is updated once per second when viewing instantaneous data.

Data are output through a 9-pin RS-232 port (hard-wired Data Terminal Equipment) at software selectable baud rates of 300, 1200, 2400, 4800, or 9600. Bidirectional communication allows software upgrades on Flash memory via the RS-232 port.

Internal software includes capabilities for storing or displaying instantaneous, integrated, averaged, maximum, or minimum values. Math functions allow division, multiplication, addition, and subtraction, as well as calculations such as saturation vapor pressure, dew point temperature, natural log, polynomial, or Steinhart-Hart function.

Precautions

The case of the LI-1400 is weather resistant, however, the following environmental limitations should be observed:

1. Some pins on the outside connectors carry voltages. If these pins are in contact with water (creating a current path to ground), corrosion can occur. Similarly, water in contact with the terminals on the 1400-301 Terminal Block can also cause corrosion.

   If the LI-1400 is to be left outdoors and unattended for long periods of time, it should be installed in a protective enclosure or sheltered location. Be sure to keep dust covers (part # 9914-008 and 9914-009) in place on DB9 terminals that are not in use. If the LI-1400 does become wet, dry connectors as soon as possible.

2. Exposure to direct sun decreases battery life and can cause battery leaks if the internal temperature exceeds the battery manufacturer's specifications. Cold temperatures can also significantly decrease battery life.

2 Hardware Operation

Power On

Press the On/Off key to turn the LI-1400 on. If the LI-1400 is set up as a simple meter for making instantaneous readings, the display will remain on until turned off with the On/Off key or automatically turned off after 15 minutes of inactivity. If the LI-1400 is set up to automatically log data, the display will turn off after 15 minutes of inactivity, but the electronics will continue to "wake up" as configured to log data.

Power Off

To shut down the LI-1400, press the **Fct** key and scroll with the right or left arrow key until the word “Shutdown” is displayed. Press **Enter**. Press the left or right arrow key to switch from “No” to “Yes” and press **Enter**. Shutting down the LI-1400 will not result in the loss of data or configuration files, however, when Function Shutdown is used, the LI-1400 will not log data. To turn off the display while automatically logging data, simply press the On/Off key.

Using "AA" Cell Batteries

Four alkaline "AA" cell batteries are installed in the LI-1400 at the factory. For maximum battery life and to help prevent damage resulting from battery leakage, use only high quality alkaline batteries.

Battery life varies with temperature and instrument configuration. As an example, the internal "AA" batteries will provide approximately 50 hours of operation in continuous on, hand-held mode. By contrast, the 1400-402 External Battery Pack may provide over 6 months of battery life, sampling data once per minute. Appendix F describes how to estimate battery life in detail.

Replacing the Internal Batteries

Remove the six screws on the back panel of the LI-1400. Open the case. Remove the two screws on the battery cover case. Be careful not to drop the screws onto the circuit board. Replace the batteries, observing proper polarity, and reassemble the case. Make sure that each battery makes good contact.

Whenever power to the LI-1400 is interrupted (e.g. when the batteries are changed), the instrument system is automatically reset. Time required for system re-initialization is dependent on how much data are stored in memory, and may take up to 60 seconds when memory is completely full.

The message "SYSTEM RESET: to run press ENTER" will be displayed when power is restored. Pressing the Enter key will cause the message "LI-1400 1.3, Starting..." to be displayed during re-initialization. *Note that this system reset only initializes the microprocessor, and* ***does not*** *erase data or configuration information.* The "SYSTEM RESET: to run press ENTER" message is also displayed following a Function RESET. The function RESET (see Section 4), however, *does* erase all data and configuration information.

Low Battery Indicator

The LI-1400 has a built-in low battery indicator. The display will blink on and off when the battery voltage reaches 4.0V. The instrument will shut off when the battery voltage reaches 3.8V. Replace the batteries as soon as possible when you see the low battery indicator.

If you are using both internal batteries and the external battery pack, the LI-1400 will draw power from the source providing the highest voltage. When both power sources drop to 4.0 volts, the low battery indicator will turn on.

It is not necessary to use internal batteries if the external battery pack is used.

Using External DC Power

Any 8-16VDC external power supply can be used to operate the LI-1400 (300mA at 9 volts recommended). Attach the positive (usually red) lead from the power source to terminal "VIN 8-16VDC" on the 1400-301 Terminal Block, and the negative (usually black) lead to one of the adjacent ground terminals.

1400-402 External Alkaline Battery Pack

The 1400-402 External Battery Pack is used for remote logging applications for the LI-1400. Six alkaline "D" cells are enclosed in the External Battery Pack, which provide up to 6 months of use. The

1400-402 has bare wire leads that are connected to the 1400-301 Standard Terminal Block (VIN 8-16VDC). The 1400-402 can be mounted in the 1400-201 Vented Instrument Enclosure (discontinued) or against any flat vertical surface.

Using AC Power

Any 8-16VDC external power source can be used to power the LI-1400 for long-term continuous operation (300mA at 9 volts recommended). LI-COR provides the 1400-401 AC Adapter for continuous operation using 120V AC, 60 Hz. The 1400-401 has bare wire leads that are connected to the 1400-301 Terminal Block.

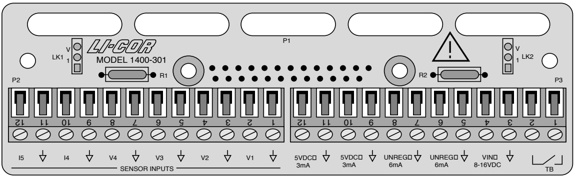
Connect the AC Adapter to pins "VIN 8-16VDC" and an adjacent ground (↓) terminal on the 1400-301 Standard Terminal Block.

Backup Battery

An internal lithium battery is provided, should the "AA" batteries fail. The lithium battery maintains the current configuration and all data in memory for as long as 7 years.

1400-301 Terminal Block

The 1400-301 Terminal Block mates with the 25-pin connector on top of the LI-1400. A description of the terminals is given below.



The terminals are as follows, reading left to right:

Terminal	**Description**
I5	Current Channel #5*
I4	Current Channel #4*
V4	Voltage Channel #4
V3	Voltage Channel #3
V2	Voltage Channel #2
V1	Voltage Channel #1
5VDC, 3mA	+5VDC, 3mA
5VDC, 3mA	+5VDC, 3mA
UNREG, 6mA	Unregulated 6mA
UNREG, 6mA	Unregulated 6mA
VIN	Voltage In, 8-16VDC
TB	Tipping Rain Bucket (Counter channel)
↓	Ground

The slots at the top of the terminal block can be used to provide strain relief, by fastening the sensor wires to the block with a cable tie.

*Can also be configured as voltage channel (see following pages).

Configuring Current Channels as Voltage Channels

To convert current channels I4 and I5 to voltage channels, locate the two black plastic jumpers on the underside of the Terminal Block. The jumper for I4 can be found under the letters "LK2" on the right hand side of the terminal block and the jumper for I5 is under the letters "LK1" on the left side. Notice that there are three pins next to both LK1 and LK2. The letter "I", which is next to the lower two pins indicates which leads should be connected in order to use the channel to measure current (Figure 2-1). The 1400-301 terminal block is initially set up with this configuration.

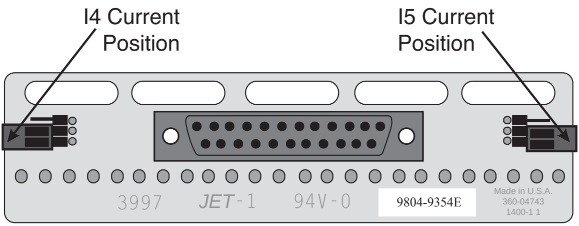


Figure 2-1. *Jumper positions that configure channels 4 and 5 to measure current.*

The letter "V", next to the top two pins, indicates which leads should be connected in order to use the channel to measure voltage (Figure 2-2). The LI-1400 records decivolts for channels that are configured this way. Any incoming values will need to be multiplied by 10 to be converted to volts.

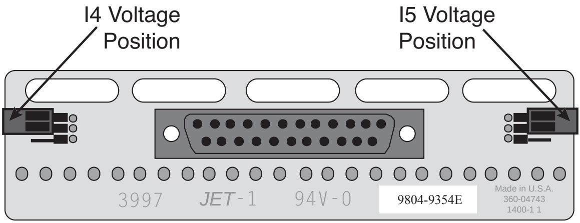


Figure 2-2. *Jumper positions that configure channels 4 and 5 to measure voltage.*

The maximum input voltage accepted by these two channels is 25 volts (250 µAmps × 100 kOhms). **Note:** Applying voltage to these channels while they are configured to measure current may damage the 1400-301 Terminal Block and the LI-1400 Datalogger.

3 Software Basics

This section will familiarize you with the general software operations of the LI-1400. Some of the concepts presented here are necessary to understand the configuration examples later in this manual. The first part of this section is dedicated to using the instrument keypad interface, while the second part is dedicated to using the Windows Interface Software.

For more detailed descriptions of the instrument and PC software and menu functions, please refer to Section 4, *Instrument Software Reference* and Section 5, *PC Software Reference*.

Instrument Software Basics

This section describes how to become familiar with the instrument using the keypad interface.

The Keypad

The LI-1400 keypad has 24 keys arranged in a 4 × 6 array (Figure 3-1). A brief description of each key's function is given below.

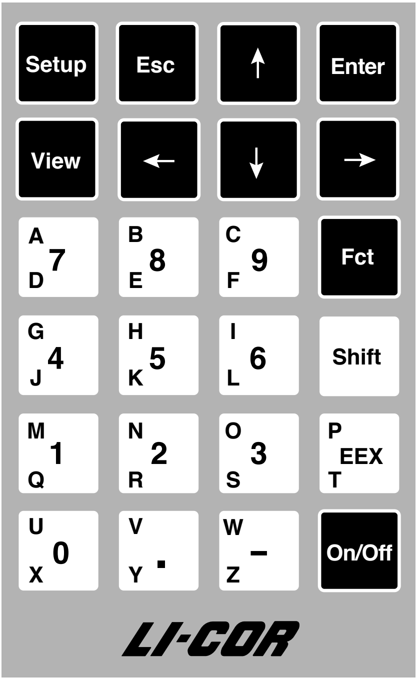
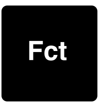


Figure 3-1. *LI-1400 keypad.*

<u>**Key**</u>	<u>**Description**</u>
	Turns the LI-1400 On or puts the instrument into low-power standby mode.
	Used to enter the exponent of numbers (EEX) or alpha characters T and P, when used with the Shift key.
	Provides access to a list of auxiliary functions.

Key	Function
Shift	Accesses the alpha characters in the upper or lower left-hand corner of the alphanumeric keys. Press Shift once to access the upper keys; press Shift twice to access the lower keys.
Enter	Accepts user input, logs instantaneous data or selects the highlighted function.
Esc	Escapes to the top of the menu.
Setup	Accesses the list of Setup functions.
View	Allows you to view instantaneous or logged data on the display.
A 7 D	Alphanumeric keys. Numbers are entered by pressing these keys. Letters in the upper left corner of these keys are entered by pressing **Shift**, followed by the key that has the letter. Similarly, letters in the lower left corner are entered by pressing the **Shift** key twice, followed by the key.
→	Scrolls through lists of available options, when ▶ is shown on the display, or scrolls to the next record to the right in a data array. Also functions as a space key.

← Functions as a backspace key to delete the previous character when entering alphanumeric characters, or scrolls through lists of available options, when ▶ is shown on the display. Scrolls to the next record to the left in a data array.

↑ Scrolls up through vertical lists on the display.

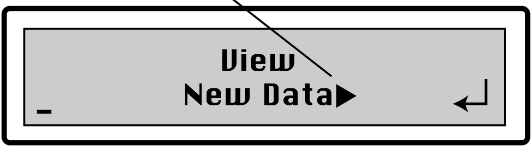
↓ Scrolls down through vertical lists on the display.

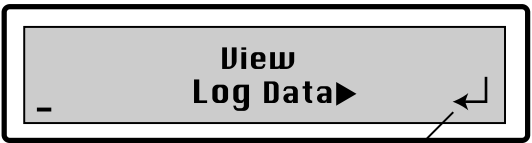
Note that the white alphanumeric keys will type the characters printed on them only when the LI-1400 is asking for input. When viewing data with custom displays defined, pressing the number keys will recall that display (see Section 7-6, *Setting Custom Displays*).

Character Description

There are a number of different display characters that may appear on the display which indicate that further action may be required, or that more selections are available. These characters are as follows:

▶ indicates more choices are available which can be accessed by pressing the right or left arrow keys. In the example below, pressing the right or left arrow key toggles the display between View New Data and View Log Data.





↵ indicates that by pressing the **Enter** key, a new sub menu for this choice will be displayed. Using the example above, if you press **Enter** when Log Data is displayed, more choices available for viewing data will be displayed.

! indicates that pressing **Enter** will execute the associated function. In the example below, pressing **Enter** while the cursor is on the !Print Mem! line will execute the Print function.

```
Stop=0000
!Print Mem          !
```

In addition, the cursor (_) indicates which line of the display is active, as well as the position of characters when entering alphanumeric characters.

When viewing Instantaneous or Logged data, you may also see some special labels, if real or calculated values encounter an overrange condition. These labels include

+INF	Illegal math calculation.
-INF	Illegal math calculation.
NAN	Not a number. This is a number that can not be calculated with the chosen math function.
+OVR	Hardware Overrange
-OVR	Hardware Overrange

Setting the Date and Time

The date and time should be set when you receive the instrument, and checked once a month thereafter (clock accuracy is ± 3 minutes per month).

The clock is a 24 hour clock (i.e., 6:00 p.m. = 1800). Midnight is displayed as 0000, and can be entered as either 0000 or 2400. Note, however, that 2400 will increment the date to the next day.

The date is entered as YYYYMMDD, where Y=Year, M=Month, and D=Day.

- To set the clock:

1. Press the **Setup** key. Press the right or left arrow key to scroll through the Setup functions until SETUP CLOCK ▶ is displayed.

2. Press **Enter**. The display will appear similar to this:

3. Simply begin entering the current year (4 digits), month (2 digits), and day (2 digits). Press **Enter**.

4. Press the ↓ key and repeat the process to enter the current time (24-hour format). Press **Enter** to accept and then **Esc** to return to the top of the menu.

PC Software Basics

This section is designed to help you become familiar with the 1400-501 Windows Interface Software that is used to connect the LI-1400 to a personal computer running a Windows operating system.

Connecting the LI-1400 to a Computer

The LI-1400 comes with a software CD that includes the 1400-501 Windows Interface Software. This software is also available for free download from the LI-COR web site. The Windows Interface Software provides one of the easiest ways to transfer setup and data files between the LI-1400 and a computer.

To establish communication with a PC using the 1400-501 Windows Interface Software, the baud rate of the LI-1400 must be set to 9600. Set the baud rate by turning on the LI-1400 from the instrument keypad. Press the **Setup** key and scroll left or right until **Hardware** is visible and press **Enter**. The display should read "Setup Hardware" on the top line and "Baud=xxxx" on the second line. Press the right or left arrow key until the second line indicates the baud rate is 9600. The LI-1400 will automatically save this setting.

If you are connecting to a computer that does not have a serial port, a USB to RS-232 adapter is needed. These are available from LI-COR (part number 6400-27) or most electronics or computer stores. Refer to the LI-COR Technical Resources Library for additional assistance when using a USB to RS-232 adapter (http://envsupport.licor.com/).

1. Connect the LI-1400 to the computer using the RS-232 cable.
2. Launch the LI-1400 Windows Interface Software.
3. Under the **Remote** menu, click **Connect**.
4. Enter the correct COM port number and click **Connect**. After a moment the LI-1400 and computer should be able to communicate.

Setting the Date and Time from a Computer

Set the date and time before attempting to log data, and check the time once a month after setting it (clock accuracy is ±3 minutes per month).

- To set the clock:
  1. Connect the LI-1400 to a computer as described on the previous page.
  2. Click on the **Remote** menu and select **Set Time…**
  3. To set the time, click in the time entry field, on any of the hour, minute, second, or AM/PM areas to highlight that parameter. Enter the time with number keys on your computer keyboard or click the up or down arrows to scroll the time up or down.
  4. Use the drop down menus to select the month and year, and click in the calendar to choose the day. When you click OK, the time will be sent to the LI-1400.

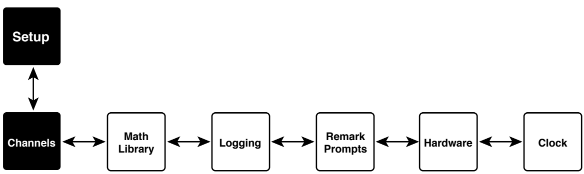
4 Instrument Software Reference

This section is a list of the software parameters in the LI-1400, including prompts accessed through scrollable menus, and functions accessed with the Function and Setup keys. Parameters are grouped by Setup functions (i.e., Setup Channels, Setup Logging, etc.), or by functions that are accessed directly (i.e., Print Memory, Clear Memory, etc.). It may be helpful to refer to the LI-1400 Reference Card to find where these software functions can be accessed.

Setup Menu

Pressing the Setup key accesses the menus described below.

Channels



Pressing the ↓ key scrolls through a list of available channels to which data can be logged, including Current channels 1-5 (denoted with the letter "I" and numbers 1-5), Voltage channels 1-4 (V1-4), Battery voltage (VB), Counter channel (CT), and Math channels 1-9 (M1-9).

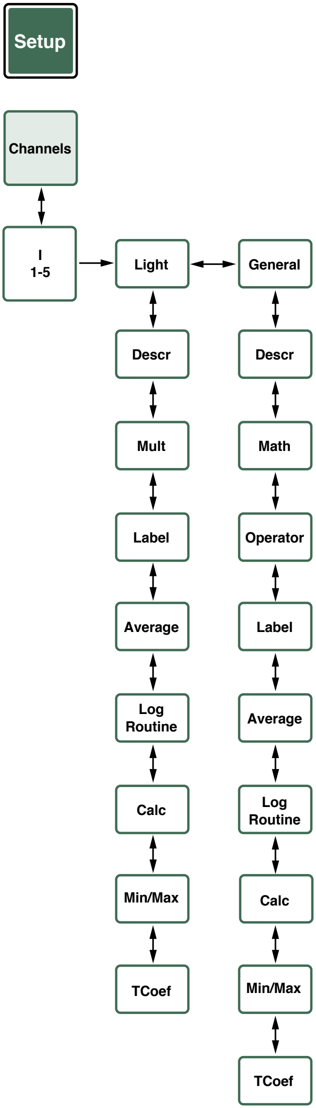
Individual channels *must* be turned on before data can be logged.

Current Channels

Five current channels are available to log data from sensors with a current output, such as LI-COR light sensors. Channels I1-I3 are BNC connectors on the top of the LI-1400 case; channels I4-I5 are accessed via the 1400-301 terminal block (see page 2-5).

To enable the current channels you must select either a *Light* or *General* configuration by pressing the right or left arrow key. These configurations are similar, with the exception that the Light configuration includes an input for a calibration multiplier, and the General configuration allows you to apply a Math library and/or Operator to the sensor output.

The *Light* configuration is appropriate for LI-COR light sensors. The *General* configuration is used for other sensors with a current output, to which you can apply a math function for sensor input scaling or linearization.


Setup
Channels
I
1-5
Light
Descr
Mult
Label
Average
Log Routine
Calc
Min/Max
TCoef
General
Descr
Math
Operator
Label
Average
Log Routine
Calc
Min/Max
TCoef

Light Sensor Configuration

Choose the Light configuration if you are using any of the five current channels with a LI-COR light sensor. The Light configuration consists of the following menu prompts:

Desc(ription)

The Description prompt allows you to enter up to 16 alphanumeric characters that can be viewed on the display along with the data output. When viewing data you can toggle between the channel output and the Description by repeatedly pressing the **View** key. See Section 7 for more information on viewing data.

Mult(iplier)

The Multiplier prompt allows you to enter the calibration multiplier of the LI-COR light sensor. A complete description of the multiplier can be found in Section 6.

Label

The Label is a prompt for a three character alphanumeric label that is displayed with the channel output in Instantaneous mode. The label is also printed when data are output.

Average

The Average prompt is used to display either an instantaneous readout of the sensor output, or a continuous running average. It is only functional when viewing new data in instantaneous mode. To average logged data, refer to the sections on logging options (pages 4-5 and 5-4) and setting up a log routine (pages 4-27 and 5-10). If you select 1 second averaging, the channel output is an instantaneous value that is updated every second. If you select 5, 15, or 30 seconds, the display will still update every second, but the number displayed is the continuous running average of instantaneous readings for the chosen period.

For example, if you choose 30 for the average, the data point displayed is the average of the instantaneous data points for seconds 1 through 30. The data point displayed will not represent a true 30 second average until 30 seconds have elapsed since the measurement began.

The average function is useful for applications where the signal to be measured is very small, or where the maximum possible resolution is desired. Setting the average to a high value increases resolution since more samples are used to compute the average.

This function is often used with light sensors when measurements are taken under water, or under changing cloud cover.

Log Routine

Up to 5 user-defined Log Routines are available. Each input channel can be assigned to any Log Routine to log data automatically. If you are logging data to memory, a Log Routine allows you to define logging start and stop times, and sampling and logging periods. Choose any of LR1-LR5. Choosing a Log Routine also causes the last logged mean, integral, or point value to appear on the display when in View New Data mode.

Calc(ulate)

The Calc prompt defines the form in which the data are collected and stored. The three values of the Calc= parameter are Integral, Mean, and Point.

When *Calc=Integral*, the LI-1400 integrates the samples collected during the sampling period. The time units are in hours.

When *Calc=Mean*, the LI-1400 stores a mean value (sum divided by the number of samples).

When *Calc=Point*, the LI-1400 stores a single point value (instantaneous reading) sampled at the end of the chosen period.

Min/Max

This prompt allows you to store the minimum and maximum data points that occur during the logging period.

The Min/Max prompt toggles between No, Yes, and Yes + Time. The Yes + Time choice stores the time stamp of the min and max values. To conserve memory, the Min/Max parameter should be set to No if these data points are not needed.

TCoef (Time Coefficient)

The LI-1400 measures time in units of hours, while many sensors have instantaneous units expressed in seconds or minutes. This mismatch of time units will cause an error in integrated values unless corrected. The TCoef value is used to compensate for this problem. The TCoef value is necessary only when integrated values are logged to memory.

See Table 4-1 for TCoef values for common units of measure for LI-COR light sensors. Please note that TCoef values for quantum sensors not only correct for the differences in time units, but also convert micromoles to moles.

Table 4-1. Common TCoef values for LI-COR Sensors

Sensor	Instantaneous Units	Integrated Units	TCoef Value
LI-190SA	μmol s^{-1} m^{-2}	mol m^{-2}	0.0036
LI-190SA	μE s^{-1} m^{-2}	E m^{-2}	0.0036
LI-191SA	μmol s^{-1} m^{-2}	mol m^{-2}	0.0036
LI-192SA	μmol s^{-1} m^{-2}	mol m^{-2}	0.0036
LI-193SA	μmol s^{-1} m^{-2}	mol m^{-2}	0.0036
LI-200SA	W m^{-2}	Wh m^{-2}	1
LI-200SA	langley min^{-1}	langley	60
LI-200SA	J s^{-1} m^{-2}	J m^{-2}	3600

General Sensor Configuration

The General configuration is similar to the Light Sensor configuration, with the exception that the General configuration allows you to apply a Math library and/or Operator to the sensor output.

Math

Allows you to select any of Math Libraries 1-5, which can be set up to use one of the six math *functions*, (Polynomial, Steinhart-Hart, Saturation Vapor Pressure, Dew Point Temperature, Natural Log, and Wind Direction). A complete description of the Math functions can be found starting on page 4-12. MLTHMSTR, which contains pre-programmed coefficients for using LI-COR thermistors, is described on page 4-23.

Operator

The Operator prompt contains math functions that perform an arithmetic operation using data for the channel being configured, and data from a second channel. For example, if a ratio of two channels is desired, data from the channel being configured can be divided by data from a second channel; the resulting *ratio* is displayed and stored in memory in place of the actual sensor output. If you want to collect data from both sensors *and* have the math data as additional information you need to use a math *channel*, as described in Section 6.

The Operator can also be used to perform an arithmetic operation on data for the channel being configured, and display the *result* of the operation on this channel. As with the example above, the result of the operation is displayed and stored in memory in place of the sensor output.

To enable the Operator, you first select one of "+" (addition), "-" (subtraction), "×" (multiplication), "/" (division), or "this chan". If you select "this chan", you will not get a prompt for a second channel; you can still apply the second math function, however.

If you choose a math operator you are then prompted to select a second channel, whose output will be used as the second term in the math operation. For example, if you select "/" (divide), followed by channel I3, the output of the channel being configured will be divided by the output of Current channel 3.

When you choose the channel that will be used as the second term of the equation, you can also apply a math function or math library that is applied *after* the two channels are combined.

Example: A LI-COR temperature sensor is connected to Current channel I4. Use the channel Operator to display the results in degrees Fahrenheit instead of Celsius.

The conversion from Celsius to Fahrenheit is

$$T_F = 1.8T_C + 32$$

where T_F and T_C are the temperatures in Fahrenheit and Celsius, respectively. The built-in math MLTHMSTR outputs the results in °C. To configure the LI-1400 to convert from °C to °F, set up Current channel I4 as General, with the following parameters:

Parameter	**I4**
Descr(iption)	TEMP
Math	MLTHMSTR
Oper(ator)	this chan
Math=	Poly
Descr=	C TO F
a0=	32
a1=	1.8
a2=	0
a3=	0
a4=	0
a5=	0
Label	F
Average	1 sec
Log Routine	none

Note that Calc, Min/Max, and TCoef are not relevant when Log Routine = None.

Channel I4 will now display temperature in °F.

Voltage Channels

Four voltage channels are available to log data from sensors with a voltage output. Setting up the voltage channels is identical to the General configuration for current channels.

Battery Voltage Channel

Battery voltage (VB) can be monitored on an independent channel, if desired. When the battery channel is turned on, you can select a Log Routine if you want to automatically log the battery voltage.

```
"Setup Battery"
Log Routin=LR1▶
```

Counter Channel

A single counter (pulse counting) channel (CT) is available for use with sensors such as tipping bucket rain gauges. The pulse counting channel configuration prompts for a description, math library, operator, label, and log routine. More information on using the counter channel can be found in Section 6.

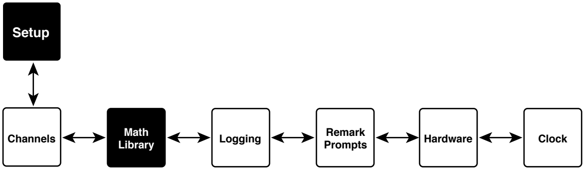
Math Channels

Nine math channels (M1-9) are available in the LI-1400. These channels operate as virtual channels to sample *output* data from one or two analog channels and perform an arithmetic operation on that data before it is logged to memory. Simple arithmetic operators (+, -, ×, or /) can be applied to the data, as can any of the available math *functions*.

The results of the arithmetic operations performed on a math channel can be displayed or logged to memory in the same way that data from the analog channels are handled. Data from the two channels on which the math operation is performed are unchanged.

More information on configuring the math channels can be found in Section 6.

Math Library

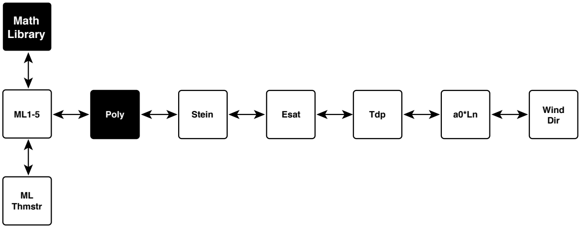


Accesses a list of five math libraries (ML1-5). Each of these five libraries can store the value(s) of any of the six math *functions*, including Polynomial, Steinhart-Hart, Saturation Vapor Pressure, Dew Point Temperature, Natural Log, and Wind Direction.

Storing values in math libraries can help eliminate re-entering these values for different sensors. For example, if the same linearization polynomial is used for several sensor inputs, you can store the calibration coefficients for this polynomial in a math library, and apply the library to multiple channels.

ML1-5

Allows you to choose from a list of five math libraries, into which you can enter values for any of the six math *functions* described below.



Poly(nomial)

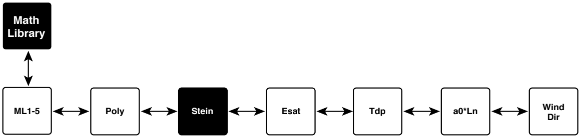
Poly is a 5th order polynomial of the form

$$\text{Poly}(x) = a_0 + a_1x + a_2x^2 + a_3x^3 + a_4x^4 + a_5x^5$$

where the a_i parameters are the coefficients of the polynomial which are unique to each sensor, and x is the actual current or voltage output of the sensor measured by the LI-1400.

When you select Polynomial, you will be prompted for a description (Descr). Enter up to 16 characters. You will then be prompted to enter the values for coefficients a_0, a_1, a_2, a_3, a_4, and a_5.

NOTE: For linear sensors, only coefficients a_0 (offset) and a_1 (span) are used.



Stein(hart-Hart)

Thermistors are widely used to measure temperature because of their large change in resistance with temperature. By accurately determining the resistance of a thermistor, the Steinhart-Hart equation can be used to accurately calculate the temperature in Kelvin.

$$\mathrm{Steinhart}(i_T) = \frac{1}{a_0 + a_1 \ln(R_T) + a_3 \left[\ln(R_T)\right]^3}$$

$$R_{therm} = R_T + R_S = \frac{5.0E6}{i_T}$$

where R_T is the thermistor resistance (not including any series resistors), and i_T is the current flowing through the thermistor and into the datalogger current channel. The software automatically converts the temperature from K to °C.

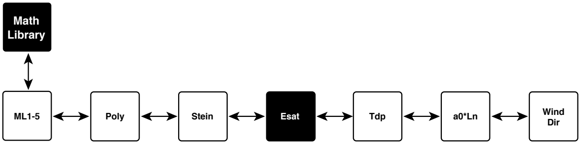
Three coefficients (a0, a1, a2) are required by the equation and are provided by the manufacturer of the thermistor. Different types of thermistors will have different coefficients, although thermistors of the same type will have the same coefficients. LI-COR thermistor type temperature probes (1000-15, 1000-16, 1000-16-2, 1400-101, 1400-102, 1400-103) use the following coefficients:

$a_0 = 0.0011259$
$a_1 = 0.00023459$
$a_2 = 8.6329E\text{-}8$

These coefficients can be entered here when configuring a channel for use with LI-COR thermistor type temperature sensors, or you can use the math library MLTHMSTR (page 4-23). This math library has these same coefficients permanently stored in memory.

The LI-1400 calculates resistance by measuring current flow when a regulated +5 volts is applied to a thermistor. A 33.2 K ohm resistor must always be in series with the thermistor to reduce current to the range of the LI-1400. All LI-COR thermistor type temperature sensors have a 33.2 K ohm resistor incorporated into the probe and need no further modification. Other custom or third party probes must have this modification to work properly.

When you select Steinhart-Hart, you are prompted for a description (Descr). Enter up to 16 characters. You are then prompted to enter the values for coefficients a_0, a_1, and a_2.

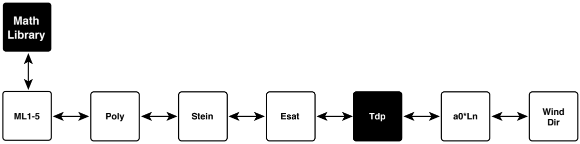


Esat

This function calculates saturation vapor pressure (E_{sat}) when temperature is input from an air temperature sensor. The equation is of the form

$$E_{sat}(T) = 0.61365e^{\frac{17.502T}{240.97+T}}$$

with the temperature in °C, and the result given in kPa.



Tdp

Tdp calculates dew point temperature using the signal output from air temperature and relative humidity sensors, such as from the 1400-104 Relative Humidity/Air Sensor. Tdp is the inverse of E_{sat} (above), and is calculated by

$$\text{Tdp (vp)} = \frac{240.97 \ln\left(\frac{vp}{0.61365}\right)}{17.502 - \ln\left(\frac{vp}{0.61365}\right)}$$

where vp is the vapor pressure in kPa and the result is in °C.

The dew point is calculated on the LI-1400 by first calculating E_{sat} from temperature, multiplying that value by the relative humidity (divided by 100), and then sending the result to Tdp. The final calculation is of the form

$$T_{dewpoint} = \text{Tdp}\left(\frac{\text{Esat(T)RH}}{100\%}\right).$$

In the LI-1400 it may be desirable to use the temperature and RH outputs on individual math channels. You can then use one math channel to calculate the saturation vapor pressure (E_{sat}) according to

$$\frac{E_{sat}(T)RH}{100\%}$$

and then use this result as the input for a second math channel containing the Tdp function (see example below).

- **Example**

You are logging the output from the 1400-104 Relative Humidity/Air Temperature Sensor on voltage channels 1 and 2; channel V1 is logging air temperature, and channel V2 is logging relative humidity. To calculate dew point temperature, follow these steps:

- Configure voltage channel V1 for air temperature:
  1. Configure V1 channel as General for air temperature. Press **Enter**.
  2. Enter a description, such as AIRTEMP.
  3. Set Math=Poly(nomial) and press **Enter**.
  4. Enter a description for the math function if desired, and enter a0 = -40, a1 = 100, a2-a5 = 0. Use the down arrow key to scroll through the coefficients. Press **Esc** to return to the main configuration list.
  5. Set Oper(ator) = none.
  6. Enter a label, such as C for the units.
  7. Enter Average = 1 sec.
  8. Set Log Routine as desired.
  9. Set Calc = Mean (or as desired).
  10. Set Min/Max = No.
  11. Set TCoef =1.
  12. Press **Esc** to return to Channel Setup.

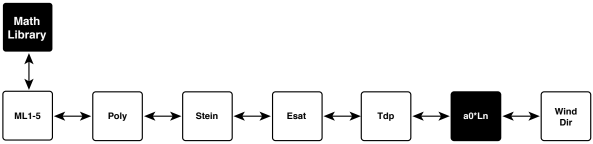
- Configure voltage channel 2 for relative humidity:

1. Configure V2 channel as General for relative humidity. Press **Enter**.
2. Enter a description, such as RH.
3. Set Math=Poly(nomial) and press **Enter**.
4. Enter a description for the math function if desired, and enter a0 = 0, a1 = 100, a2-a5 = 0. Press **Esc** to return to the main configuration list.
5. Set Oper(ator) = none.
6. Enter a Label, if desired.
7. Set Average = 1 sec.
8. Set Log Routine as desired.
9. Set Calc = Mean (or as desired).
10. Set Min/Max = No.
11. TCoef = 1.
12. Press **Esc** to return to Channel Setup.

- Saturation Vapor Pressure for water vapor at the measured temperature must be calculated. This is done on the first Math channel:
  1. Turn M1 on and press **Enter**.
  2. Enter a description for Math channel M1, such as ESAT.
  3. Select Chan=V1 (air temperature).
  4. Select Math=Esat.
  5. Set Oper(ator) = none.
  6. Enter a Label, such as kPa.
  7. Set Average = 1 sec, if desired.
  8. Set Log Routine as desired.
  9. Set Calc as desired.
  10. Set Min/Max if desired.
  11. TCoef = 1.
  12. Press **Esc** to return to Channel Setup.

- Next, dew point is calculated by finding the actual vapor pressure from which dew point can be calculated:
  1. Turn M2 on and press **Enter**.
  2. Enter a description for Math channel M2, such as DEW PT.
  3. Select Chan=V2 (relative humidity).
  4. Select Math=Poly (this will convert RH to decimal form) and press **Enter** to change the polynomial coefficients.
  5. Set a0=0, a1=0.01, a2-a5=0. Press **Esc**.
  6. Set Oper(ator) = * and press **Enter** to configure the Operator.
  7. Select Chan=M1 (this will multiply the decimal form of the RH by the saturation vapor pressure to give the actual vapor pressure).
  8. Select Math=Tdp (this calculates the dew point). Press **Esc**.
  9. Enter a Label such as DP.
  10. Set Average = 1 sec if desired.
  11. Set Log Routine as desired.
  12. Set Calc as desired.
  13. Set Min/Max as desired.
  14. TCoef = 1.

The output of Math channel M2 will now reflect the dew point temperature.



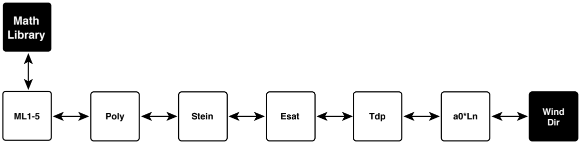
Natural Log (Ln)

This function multiplies a constant by the natural log of a channel input, and is of the form

$$Ln(x) = a_0 \ln(x)$$

where a_0 is a constant, and x is an input from another channel.

This function can be used for calculating a vertical light attenuation (extinction) coefficient by dividing two light channels and using the result as an input to the Ln function. The a_0 parameter is set to the inverse distance between the two light sensors. Alternatively, a_0 could be set to 1, and the distance logged with a depth sensor. The extinction coefficient is then calculated by dividing the Ln function by the value of the depth sensor.



Wind Direction

WindDir converts the voltage output from a wind vane into degrees. A single parameter a_0 determines the maximum output voltage from the wind vane. Zero volts is assumed to be due North, as is a_0 volts. All other voltage readings are assumed to be linear between 0 and 360°. WindDir also allows wind direction readings to be averaged.

A difficulty in averaging wind direction is that readings between 359° and 0° cannot be simply averaged. WindDir takes care of this problem by converting each individual reading into rectangular coordinates. An average is then calculated on each rectangular coordinate. The averaged coordinates are then converted back to polar coordinates to find the average wind direction. Each reading is converted to rectangular coordinates using

$$\alpha = \frac{-2\mathrm{Vin}\pi}{a_0}$$

$$y = \sin(\alpha)$$

$$x = \cos(\alpha)$$

Note that a magnitude of 1 is used instead of the wind speed. The x & y coordinates are averaged together and the final value calculated using

$$\theta = \tan^{-1}\left(\frac{\bar{y}}{\bar{x}}\right)$$

if (θ>0) then

θ = θ - 2π

endif

$$\text{winddir} = \frac{-180\theta}{\pi}$$

These calculations do *not* find the wind vector. Instead, it is simply a way of deriving a meaningful scalar wind direction when the vane is oscillating around due north.

ML Thmstr

The thermistor math library contains coefficients entered at the factory that are used with LI-COR thermistors such as the 1400-101 and 1400-102 Air Temperature Sensors, and the 1400-103 Soil Temperature Sensor.

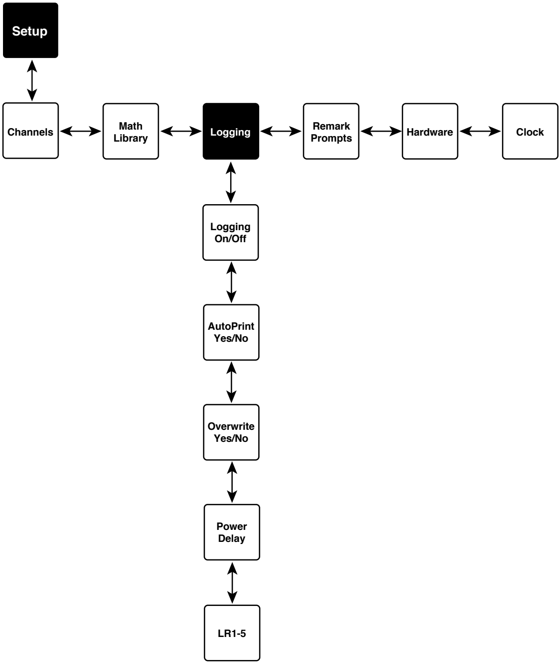
The coefficients for these sensors are as follows:

a_0 = 0.0011259

a_1 = 0.00023459

a_2 = 8.6329E-08

Choosing ML Thmstr saves time when using any of the above listed sensors, as calibration coefficients do not need to be entered.



Logging

The Logging menu contains five subroutines related to logging data with the LI-1400, including turning logging On/Off for individual channels, setting up the AutoPrint function, setting the data overwrite feature, power delay, and logging routines.

Logging ON/OFF

Turns logging ON/OFF for all channels that are enabled in the Setup Channels menu and configured to use a log routine. Even though the channels may be enabled, Logging must be ON before data will be logged unless manually logging instantaneous data. If logging is ON when channels are configured or when a configuration file is loaded to the LI-1400, logging will begin immediately.

AutoPrint Yes/No

When AutoPrint is set to Yes, each time a data point is logged, either automatically in Log mode, or manually in Instantaneous mode, the data will be sent to the RS-232 port. Modified Setup routines will also be output.

When AutoPrint is set to No, no data are sent to the RS-232 port. Logged data can be transferred to a computer manually.

Overwrite Yes/No

When Overwrite is set to Yes, the LI-1400 will continue to log data even when memory is full. Each time a new data point is stored, the oldest point in memory will be overwritten.

If Overwrite is set to No, data will not be logged after memory is full. Data must be cleared using the Clear Memory function before new data can be logged.

Power Delay

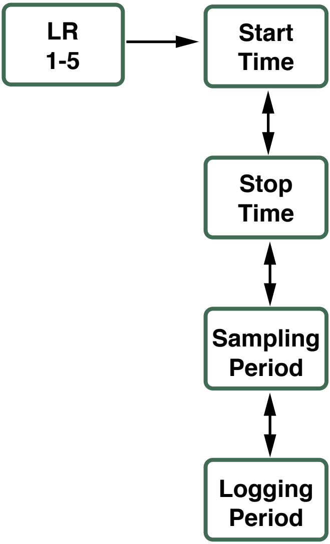
The *PwrDelay* setting determines the amount of time the 5VDC and UNREG power supplies are powered before taking a reading on any sensor. This is used with sensors that require some time to warm up after power is applied. If the *PwrDelay* is longer than or equal to the sampling period, power to the sensor will be applied continuously.

The A/D board always requires some time to power up. The minimum power delay is about 85 milli-seconds (when PwrDelay=0 Sec). The maximum is 10 seconds.

Check with the manufacturer of your sensor to determine if a power delay is required.

Log Routines

The Log Routines determine the parameters at which data are logged to memory, including the logging start and stop times, and the sampling and logging periods.



Any of Log Routines 1-5 *must* be chosen before data can be logged to memory automatically. The Log Routines consist of the following four parameters:

Start Time - start time for logging period. Note that when Start Time = Stop Time logging occurs 24 hours a day.

Stop Time - stop time for logging period.

Sampling Period - time interval between samples within a logging period.

Logging Period - time interval between data points logged to memory.

For example, if logging an average with the sampling period is set to 5 seconds and the logging period is set to 30 seconds, 6 sample values will be averaged and the average will be logged every 30 seconds.

Remark Prompts

These are the prompts that can be used to enter comments and notes. Enter up to 8 alphanumeric characters that will be the prompt for remarks that can be entered manually while logging data under Function Log Remarks (described on the next page).

Hardware

The Setup Hardware menu contains two functions for setting the baud rate at which data are output, and changing the noise filter.

Baud Rate

Toggles between 300, 1200, 2400, 4800, and 9600 baud. The baud rate must match the remote device to which data are being sent.

Noise Filter

Toggles between 50 Hz and 60 Hz. This is used to filter out noise from external devices. In the United States, most electrical devices cycle at 60 Hz, so this parameter should be set to 60 Hz. In other countries, this parameter may need to be set to 50 Hz.

The noise filter is a notch filter, meaning that a setting of 50 Hz will also filter noise at 100, 150, 200, 250 Hz, etc. This can be useful for some marine applications, whose devices operate at 400 Hz.

Clock

The clock is a 24 hour clock (i.e., 6:00 p.m. = 1800). Midnight is displayed as 0000, and can be entered as either 0000 or 2400. Note, however, that 2400 will increment the date to the next day. Refer to Section 3 to set the date and time.

Functions (Fct) Menu

Pressing the **Fct** key on the instrument keypad brings up the following menu options.

Log Remarks

A set of three Log Remarks can be defined at any time using this function. By default, the prompts are called "Remark1," Remark2," and Remark3". These can be changed to any 8 character alphanumeric prompt under the Setup Remark Prompts menu.

Remarks are entered by going to the Fct Log Remarks prompt. After pressing the **Enter** button the assigned prompts will be visible. Use the down arrow key (↓) to scroll through them. Each prompt can store up to sixteen alphanumeric characters. After entering a remark, scroll down until the "!Log Remarks!" prompt is visible and press **Enter**. The remarks will be logged along with a time stamp. They can be displayed in View mode, and they will be output with a time stamp when the data is transferred to a computer.

Print Memory

Allows you to print all or a portion of the data points to the RS-232 port. You are prompted to print all data, or to enter a start and stop time over which the data will be printed.

FCT PRINT MEMORY▶ ↵	Press Enter
"Print Memory" Print=All▶	Select All, Time Range, or Cancel
Print=All Start=0000	Select Start and Stop dates
Stop=0000 !Print Mem !	Press Enter

Clear Memory

Allows you to clear all or a portion of the data points in memory. You are prompted to clear all data, or to enter a stop time over which the data will be cleared.

Each time channel setup is modified channel configurations are stored in memory. It is common when first configuring the LI-1400 to make several modifications to channel setup before the final setup is established. It is a good practice to clear memory before the LI-1400 is used to collect data. Clearing memory erases all old channel setups, but *not* the current channel setup.

Note that if memory is full, it may take up to 60 seconds to clear the data.

Shutdown

Shutdown is a low power data storage mode that turns the LI-1400 off and stops logging. Press the ON/OFF key to "wake up" the datalogger, or press any key on your computer keyboard if using a terminal connected to the LI-1400.

In Shutdown mode all software configurations and data are saved. When Shutdown is chosen, a message will be logged to memory to indicate the time at which shutdown occurred.

Reset

This function restores the configuration to the system default values and erases all data in memory. ***Use this function cautiously, as all data will be lost with no chance of recovery.***

Once all system defaults are restored and memory is cleared, the message "SYSTEM RESET: to run press ENTER" will be displayed. Pressing the **Enter** key will cause the message "LI-1400 1.3, Starting..." to be displayed during re-initialization. Proceed with configuration and setup as desired.

Software Version

Displays the current LI-1400 software version number. Press **Esc** to continue.

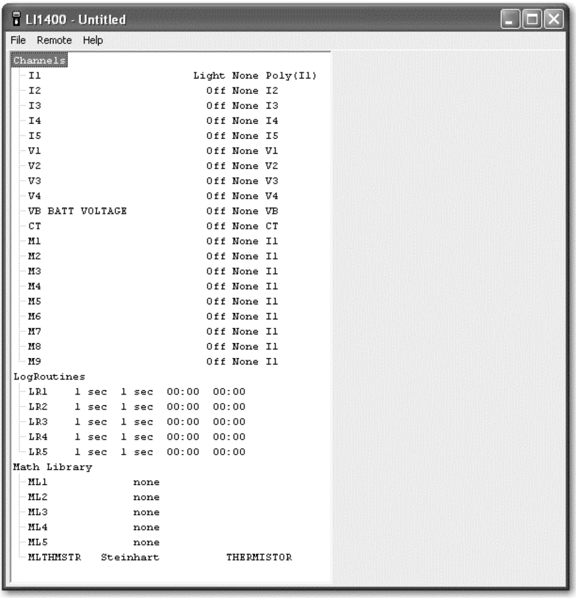
Tech Tests

Tech tests are used by LI-COR technicians to diagnose unexpected behavior exhibited by the LI-1400.

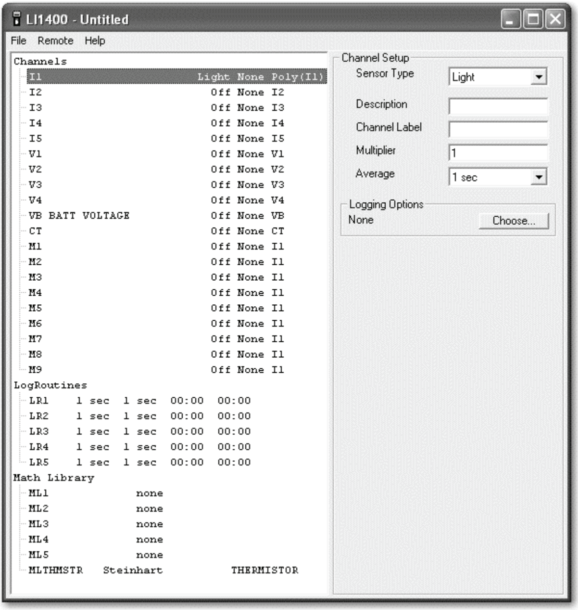
5 PC Software Reference

Main Window

This section is a description of software parameters that are used when configuring the LI-1400 from the PC interface. When the 1400-501 program is started, an untitled setup window is opened (below).



This is the window in which all of the setup parameters for the LI-1400 are selected and edited. Clicking on any of the channels, log routines, or math libraries brings up further options, which appear on the right side of the window. For example, if you click on channel I1, you are presented with available options for setting up Current channel 1 (below), including a choice of *Light* or *General* configurations. You may also enter a description, channel label, and multiplier, and configure average time, and logging options.



After all parameters have been configured using the PC interface software, the file can be sent to the LI-1400 using the Send Setup command. It will be implemented immediately. The configuration file can subsequently be saved or edited further.

Channels

The LI-1400 Channels include 5 current channels (I1-5), 4 voltage channels (V1-4), a battery voltage channel (VB), a counter channel (CT), and 9 math channels (M1-9).

Current Channels

Five current channels are available to log data from sensors with a current output, such as LI-COR light sensors. Channels I1-I3 are accessed with the three BNC connectors on the top of the LI-1400 case. Channels I4-I5 are accessed via the Terminal Block, described on page 2-5.

To enable a current channel, click on the desired channel and select either the *Light* or *General* sensor type. These configurations are similar, with the exception that the Light configuration includes an input for a calibration multiplier, and the General configuration allows you to apply a Math library and/or Operator to the sensor output.

The *Light* configuration is appropriate for LI-COR light sensors. The *General* configuration is used for other sensors with a current output, to which you can apply a math function for sensor input scaling or linearization.

Light Sensor Configuration

Choose the Light configuration if you are using any of the five current channels with a LI-COR light sensor. The Light configuration consists of the following menu prompts:

Description

The Description prompt allows you to enter up to 16 alphanumeric characters that can be viewed on the display along with the data output.

Channel Label

The Label is a prompt for a three character alphanumeric label that is included with the logged data.

Multiplier

This is where the calibration multiplier for a LI-COR light sensor is entered. A complete description of the multiplier can be found in Section 6, *Configuring Sensors and the LI-1400*.

Average

The average field is only used for viewing new data in instantaneous mode. It is used to determine averaging time for the values displayed on the instrument read out. When set to average every 5, 15, or 30 seconds, the number on the display is a continuous running average of values that are measured every second. The number on the display is the continuous running average of instantaneous readings for the chosen period.

Logging Options

When automatically logging data, a Log Routine must be selected. Choose any of LR1-LR5. Log Routines are explained in detail on page 5-9. When manually logging data, leave logging options as "none". The Calculation Type field permits you to select whether data is logged as Mean, Point, or Integral. If Integral is selected, the Time Coefficient must be selected. These are printed on the Calibration tag of LI-COR light sensors and in Table 4-1 (Chapter 4). When the Log Min-Max box is checked, the highest and lowest sampled values between logged data points will be logged, and when Log Min-Max Times is checked, the time at which the high and low occurred will be recorded as well. To conserve memory, the Min/Max parameter should be set to No if these data points are not needed.

General Sensor Configuration

The General configuration is similar to the Light configuration, with the exception that the General configuration allows you to apply a Math Library and/or Operator to the sensor output.

Input Channel

The Input Channel prompt is only active for the Math channels. It refers to the first logged term that will be used in calculating logged data values.

Average

The Average field is only used for viewing new data in instantaneous mode. It is used to determine averaging time for the values displayed on the instrument read out. When set to average every 5, 15, or 30 seconds, the number on the display is a continuous running average of samples that are update every second. The number on the display is the continuous running average of instantaneous readings for the chosen period.

Math Function

The Math Function allows you to select any of the pre-programmed math functions (Polynomial, Steinhart-Hart, Saturation Vapor Pressure, Dew Point Temperature, Natural Log, and Wind Direction), any of the Math Libraries (M1-M5) (described in detail on page 4-12), or MLTHMSTR (described in detail on page 4-23). The Function Description prompt is a 16 character alphanumeric field that will be recorded with the assigned function. The Parameters fields (a0-a5) are activated when they are used for the selected Math Function (Polynomial, Steinhart-Hart, Natural Log, and Wind Direction).

Channel Operation

The Operator prompt contains math functions that perform an arithmetic operation using data for the channel being configured and data from a second channel. For example, if a ratio of two channels is desired, data from the channel being configured can be divided by data from a second channel. The resulting *ratio* is displayed and logged to memory in place of the actual sensor output. If you want to log data from both sensors *and* have the math data as additional information, you need to use a *math channel* as described in Section 6.

To enable the Operator, select the “+” (addition), “-” (subtraction), “×” (multiplication), “/” (division), or “this chan”. The Channel prompt selects that values that are used as the second term in the math operation. For example, if you are configuring the Channel operation for Current Channel I4, and you select “/” (divide), followed by channel I3, the output of the channel being configured will be divided by the output of Current channel 3. Note that you can only select channels that are recorded prior to the channel you are performing the operation on.

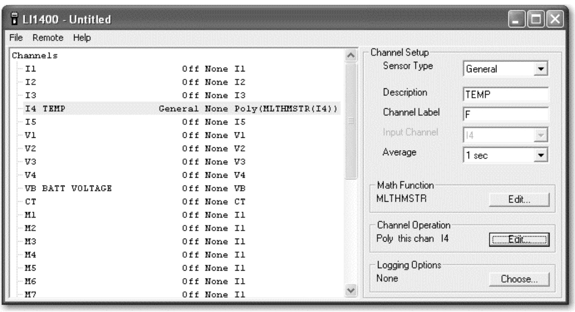
When you choose the channel that will be used as the second term in the equation, you can also apply a math function or math library that is applied *after* the two channels are combined. You can also enter a description term and terms for the polynomial.

Example: A LI-COR temperature sensor is connected to Current channel I4. Use the Channel Operation to display the results in degrees Fahrenheit instead of Celsius.

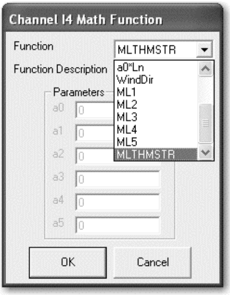
The conversion factor from Celsius to Fahrenheit is

$$T_F = 1.8T_C + 32$$

where T_F and T_C are the temperatures in Fahrenheit and Celsius respectively. The built-in math MLTHMSTR outputs the results in °C. To configure the LI-1400 to convert from °C to °F, set up Current channel I4 with the following parameters:



Set the Math Function "MLTHMSTR" and click OK as shown below:



Set Channel Operation with the following parameters:

Note that Calculation Type, Log Min-Max, and Time Coefficient are not relevant when Log Routine = none. After this setup is sent to the LI-1400, Channel I4 will display temperature in °F when a thermistor is connected and configured.

Voltage Channels

Four voltage channels are available to log data from sensors with voltage output. Setting up the voltage channels is identical to the General configuration for Current channels.

Battery Voltage Channel

Battery voltage (VB Batt Voltage) can be monitored on an independent channel if desired. When the battery channel is turned on, you can select a Log Routine if you want to automatically log the battery voltage.

Counter Channel

A single counter (pulse counting) channel (CT) is available for use with sensors such as a tipping bucket rain gauge. The pulse counting channel configuration prompts for a description, channel label, and log routine. A Math Function and Channel Operation can be applied as well. More information on using the counter channel can be found in Section 6.

Math Channels

Nine math channels (M1-M9) are available on the LI-1400, as described earlier in this section. More information on configuring Math Channels is available in Section 6.

Log Routines

If you are automatically logging data to memory, you will need to define and select a log routine. Choose any of LR1-LR5. When a Log Routine is implemented in the LI-1400, the most recently recorded values will appear on the display when in View New Data mode.

Power Delay Setting

If a sensor requires a warm-up period before reading accurately, Log Routines can be configured to power on the sensors at a specified time before data are logged. Select the Log Routine heading in the main LI-1400 window. The “Time to power on before taking measurements” prompt will appear in the right-had side of the window. Select 0 sec, 1 sec, 5 sec, or 10 sec as desired. If the Power Delay Setting is longer than or equal to the sampling period, power to the sensor will be applied continuously. Check with the manufacturer of your sensor to determine if a power delay is required.

Setting up a Log Routine

To set up a log routine, select the Log Routine that you wish to configure (LR1-LR5). You will be prompted to enter a Start Time and Stop Time. If the start time and stop time are equal, the instrument will log for 24 hours. If logging is “On,” the LI-1400 will begin logging data once the start time is reached. The Sample Period field indicates the time interval between samples within a logging period. The Logging Period indicates the time interval between data points logged to memory. For example, if logging an average with the sampling period is set to 5 seconds and the logging period is set to 30 seconds, 6 sample values will be averaged and the average will be logged.

Math Library

Each of the five Math Libraries (ML1-ML5) can be configured to execute any of the six math functions, including Polynomial, Steinhart-Hart, Saturation Vapor Pressure, Dew Point, Temperature, Natural Log, and Wind Direction. Storing values entered in math libraries can help eliminate the need to reenter these values for different sensors. For example, if the same linearization polynomial is used for several sensor inputs, you can store the calibration coefficients for this polynomial in a math library, and apply the library to multiple channels.

Function Types

When a Math Library is selected you will be prompted to enter a Function Type. The six available functions are described below and in detail in Section 4.

Poly(nomial)

Poly is a 5^{th} order polynomial that allows the current or voltage output of a sensor to be fit to a user entered polynomial. Refer to page 4-13 for a more detailed description of the polynomial function.

Steinhart(-Hart)

Thermistors are widely used to measure temperature because of their large change in resistance with temperature. The Steinhart-Hart equation converts resistance values to temperature on the Kelvin scale. Page 4-14 describes the Steinhart-Hart equation in more detail.

ESat

This function calculates saturation vapor pressure when temperature is input from an temperature sensor. The formula is described on page 4-16.

Tdp

The Tdp calculation determines dew point from the signal output of air temperature and relative humidity sensors. A detailed description and examples are given beginning on page 4-17.

a0*Ln (Natural Log)

This function multiplies a constant by the natural log of a channel input. Refer to page 4-21 for a more detailed description.

WindDir(ection)

WindDir converts the voltage output from a wind vane into degrees. A detailed description of this function is on page 4-22.

MLTHMSTR

The thermistor math library contains coefficients entered at the factory that are used with LI-COR thermistors such as the 1400-101 and1400-102 Air Temperature Sensors, and the 1400-103 Soil Temperature Sensor. Choosing MLTHMSTR saves time when using any of the sensors listed above because calibration coefficients do not need to be entered. Refer to page 4-23 for more information on this option.

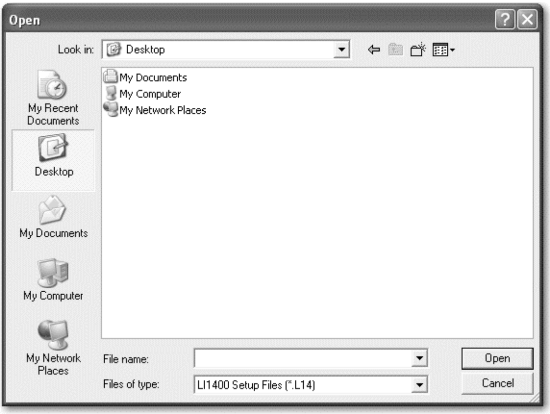
PC Software Overview

File Menu

New
Resets the setup parameters in the Main Window to their default values. If you have made changes in the window, you will be asked if you want to save these changes to a file.

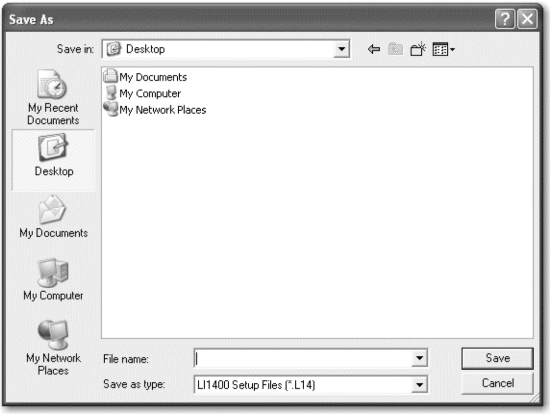
Open
Opens a standard dialog where you can search for and select an existing LI-1400 setup file for editing or downloading to the LI-1400.

Use the 'Look In' drop down menu to change directories. Note that LI-1400 Setup files are appended with a .L14 file extension.



Save

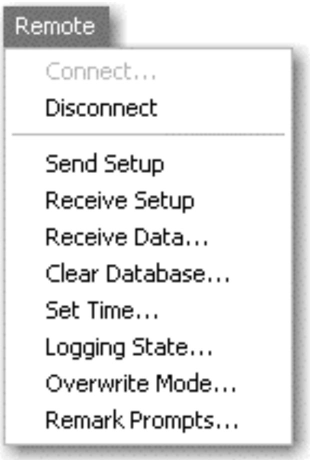
Allows you to save the current setup to a new file. This is very convenient when multiple users are utilizing the LI-1400 for a variety of measurement protocols. Enter a name for the new file; it will automatically be appended with a .L14 file extension. Use the 'Save In' drop down menu to choose a different directory.



Save As...

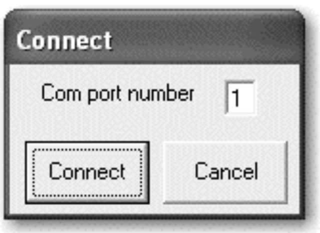
Allows you to save the current setup file to a new file with a different name.

Remote Menu



Connect

Establishes communications between the computer and the LI-1400. The baud rate for the LI-1400 must be set to 9600 to use this feature (see page 3-8). You are prompted to select the serial port to which the LI-1400 is connected.



Enter the appropriate serial port number and press Connect. A message that says 'Synchronizing' will be displayed until communication is established.

Disconnect

Terminates communications between the computer and the LI-1400.

Send Setup

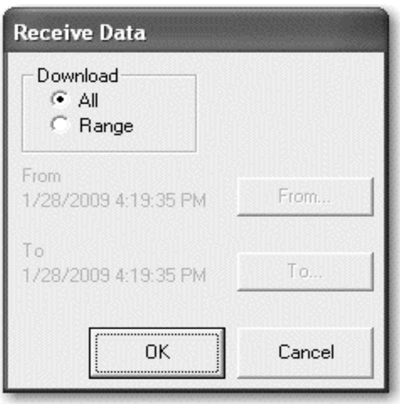
Sends the active Setup file to the LI-1400 for implementation. This will overwrite the configuration file currently programmed in the LI-1400.

Receive Setup

Loads the configuration from the LI-1400 to the Windows Interface Software. If a Setup file is currently open, you are prompted to save it before receiving the new file.

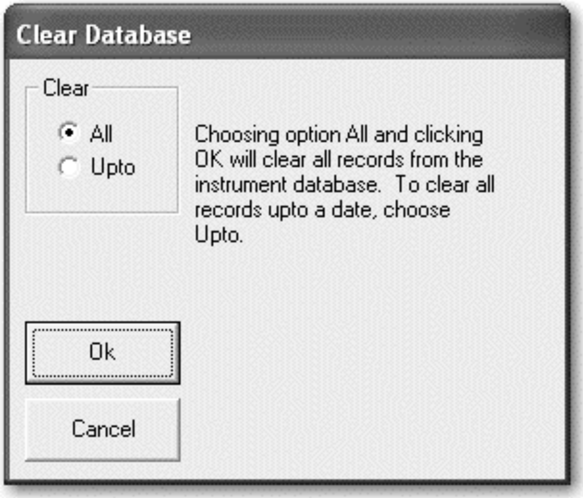
Receive Data

Transfers data from the LI-1400 in binary format and then converts it into text (ASCII) format automatically. This format is suitable for importing into most spreadsheets and databases. After selecting "OK" you will be prompted for a directory to save the file.

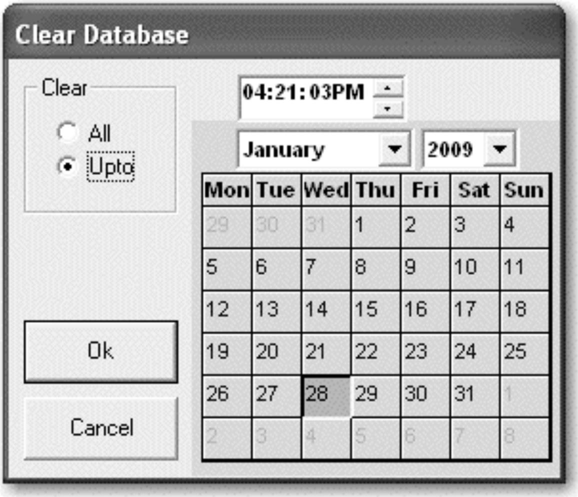


Clear Database

Clears records from the LI-1400. You can clear all records, or only those records recorded up to a chosen date, by selecting the appropriate radio button.



To clear records to a specified date, choose the Upto radio button. The dialog changes (below), and you can select the time, day and date to which data records will be cleared.



Set Time

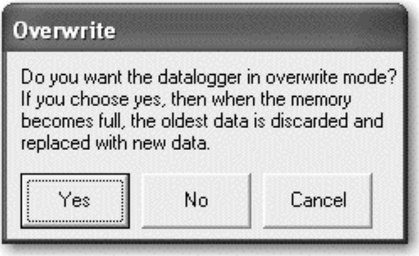
Allows you to set the time and date in the LI-1400. See Section 3 for instructions on setting the time.

Logging State

Turns logging On/Off. Select On, Off, or Cancel. If On is selected, the LI-1400 will begin logging data immediately.

Overwrite Mode

Selects the mode in which data are written to the LI-1400. Choose 'Yes' to overwrite the oldest data when memory becomes full. If you choose 'No', when memory becomes full no more data will be logged.



Remark Prompts

Opens a dialog where you can enter up to three Remark Prompts. These prompts appear when entering Remarks into the LI-1400. Enter up to 8 alphanumeric characters. See pages 4-28 and 4-29 for a more in depth description of Remark Prompts.

Help Menu

Displays the current version number of the PC interface software. Click the mouse button, or press any key to dismiss this window.

6 Configuring Sensors and the LI-1400

General Description

The LI-1400 is a highly sensitive current meter able to measure currents from 0±250 μA, with a resolution as low as 7.6 picoamps. This makes the LI-1400 ideally suited for accurately measuring photovoltaic and other sensors that produce very small currents. Most commonly, the current channels are used to measure LI-COR light sensors (pyranometers, quantum, and photometric sensors) and LI-COR thermistor-based temperature sensors, including the 1400-101, -102, and -103.

The LI-1400 measures current in units of microamps (1×10^{-6} amps). To convert microamps into more meaningful units, the appropriate multiplier or math function needs to be chosen for a particular sensor. For a detailed description of current channels, see Section 4, *Instrument Software Reference* or Section 5, *PC Software Reference* for complete details.

The 1400-301 Standard Terminal Block has four terminals to supply power to sensors requiring external power to operate. Two terminals can supply up to 3 milliamps each of regulated +5 volts to sensors requiring a highly regulated source of power. Two other terminals can supply up to 6 milliamps each of unregulated power ranging from 8-16 volts DC. Refer to the instructions for your particular sensor for recommended power requirements.

Using the Current Channels

The five current channels in the LI-1400 are designated with the letter "I" (the commonly accepted abbreviation for current), and are sequentially numbered I1-5. Channels I1, I2 and I3 are the three "BNC" type connectors located on top of the LI-1400 (Figure 6-1). These three channels are primarily used to attach LI-COR type "SA" light sensors, which have cables terminated with mating BNC connectors.

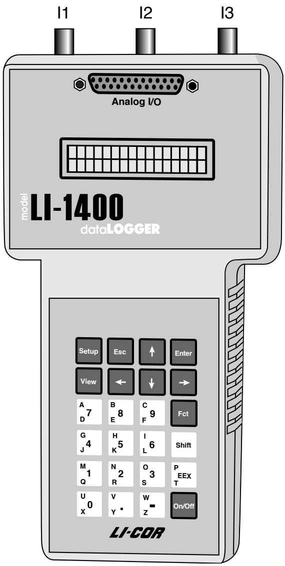


***Figure 6-1.** Channels I1-I3 are BNC connectors on top of the LI-1400.*

Channels I4 and I5 are located on the optional 1400-301 Terminal Block (Figure 6-2), which is required to access all other channels except I1-I3. The terminal block requires sensors with bare leads such as type "SZ" light sensors, or LI-COR thermistor type temperature sensors.

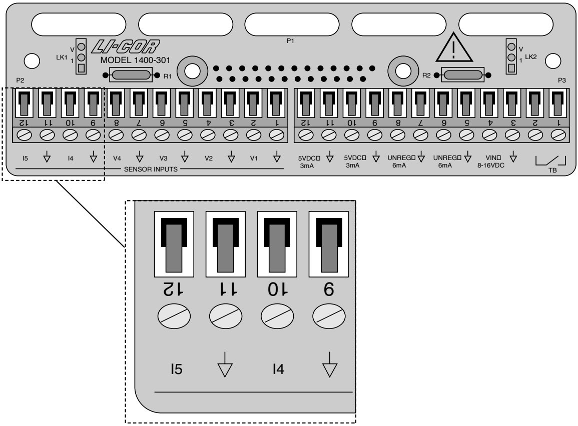


Figure 6-2. *Channels I4 and I5 are located on the 1400-301 Terminal Block.*

Connecting LI-COR Light Sensors

Light sensors with BNC connectors are simply connected to channels I1, I2, or I3 and the appropriate channel configured under the menu choice “Setup Channels”. An example is described on page 6-7. Light sensors with bare leads should be connected with the center conductor attached to position I4 or I5 on the terminal block while the shield is attached to a ground position designated ⏚. LI-COR light sensors are passive devices and do not require external power to operate. It should be noted that LI-COR light sensors are wired so the center conductor is actually negative and the shield is positive. This is done intentionally to reduce noise but results in a negative current measurement. To compensate, the multiplier simply needs to be negative. The output of LI-COR light sensors cannot be measured with the voltage channels even with a millivolt adapter because the voltage channels do not have fine enough resolution.

Calibration Multiplier

For type 'SA' sensors purchased between September 1985 and February 2009, the calibration multiplier is given on the certificate of calibration, and is also attached to the sensor. For light sensors purchased after February 2009, calibration multipliers are printed on the certificate of calibration and can be obtained at the LI-COR Technical Resources Library at http://envsupport.licor.com.

An example of a calibration label attached to a quantum sensor appears below, which would contain the value of the multiplier, as well as the serial number of the sensor, and the date of its most recent calibration.

MULT: XXX.XX

tcoef: 0.0036
Units: µmol s-1 m-2 per µA
SERIAL NO.
CAL DATE: DD/MM/YR LI-COR®

For the LI-192SA and LI-193SA Underwater Quantum Sensors, there are two calibration multipliers; one for "in air" operation and one for "in water" operation. Use the multiplier that is appropriate for your application.

If the calibration constant for your sensor has been lost or misplaced, it can be obtained from the LI-COR Technical Resources Library at http://envsupport.licor.com by providing the serial number for you sensor.

Converting Calconstants to Multipliers

For older LI-COR sensors that are not type 'SA' or 'SZ' (i.e., type 'SB', etc.), the calibration multiplier must be calculated from the calibration constant given on the certificate of calibration.

The calibration multiplier can be calculated using the following equation:

$$\text{Multiplier} = \left(\frac{-1}{\text{Calconstant}}\right)(\text{K})$$

where K is a conversion factor for obtaining a readout in units different than the units for which the sensor was calibrated. Typical K values for LI-COR sensors are given in Table 1. For type 'SA' or 'SZ' sensors the calibration multiplier can be multiplied by K to give a readout in different units.

Table 1. K values for LI-COR Sensors		
Sensor Type	K Value	Units (Instantaneous)
Quantum	1	µmol s^{-1} m^{-2}
Radiometric	1	W m^{-2} (J s^{-1} m^{-2})
	1.43E-3	cal cm^{-2} min^{-1}
	1.43E-3	langley min-1
	0.100	mW cm^{-2}
	100.0	µW cm^{-2}
	0.317	BTU ft^{-2} hr^{-1}
Photometric	1	klux
	92.9	lm ft^{-2}
	1000.0	lux

EXAMPLE: Calculate the multiplier for an LI-190SB Quantum sensor with a calibration constant of 8.0 µAmps/1000 µmol s^{-1} m^{-2}.

$$\text{Multiplier} = \frac{(-1)\left(1000\ \mu\text{mol s}^{-1}\text{m}^{-2}\right)}{8\ \mu\text{Amps}}(1) \quad \leftarrow \textit{K value}$$

$$= \frac{-125.0\ \mu\text{mol s}^{-1}\ \text{m}^{-2}}{1\ \mu\text{Amp}}$$

Since the Calibration Multiplier is unique for each sensor, it must be entered into the LI-1400 each time the sensor is changed or recalibrated.

Configuring the LI-1400 for a LI-COR Light Sensor Using the LI-1400 Keypad

The following example demonstrates how you can configure the LI-1400 with the instrument keypad to view or log instantaneous data from a single LI-190SA Quantum Sensor.

Example 1a. Configure channel I1 for a LI-COR LI-190SA Quantum Sensor whose calibration multiplier is -125.0 µmol s^{-1} m^{-2}/µAmp.

1. Connect the sensor to the BNC connector on top of the LI-1400 labeled I1.
2. Choose *Setup Channels* and press **Enter**.
3. Toggle *I1=Light* with the right or left arrow keys. Press **Enter**.
4. Type QUANTUM for the description. Press ↓.
5. Type in -125 for the multiplier. Press ↓.
6. Type UM for the label. Press ↓.
7. The running average parameter will not be used, but could be set to any desired value. Press ↓.
8. Toggle the Log Routine to *none*.
9. The remaining options do not need to be set as they apply only when using a Log Routine. Press **Esc** twice to return to the Setup menu.
10. Press the View key. After the "Implementing New Setup…" message disappears toggle to *New Data* and press **Enter**.
11. Toggle the display with the right or left arrow keys until channel I1I is displayed; this shows the instantaneous reading from the quantum sensor. The LI-1400 is now configured to display the instantaneous value of the quantum

sensor. If desired, data can be logged to memory simply by pressing the **Enter** key.

Configuring the LI-1400 for a LI-COR Light Sensor Using the PC Software

The following example demonstrates how you can configure the LI-1400 with the PC software to view or log instantaneous data from a single LI-190SA Quantum Sensor.

Example 1b. Configure channel I1 from a PC for a LI-COR LI-190SA Quantum Sensor whose calibration multiplier is -125.0 µmol s^{-1} m^{-2}/µAmp.

1. Launch the LI-1400 PC software.
2. Click on the Channel called I1. Notice that on the right side of the window, the *Channel Setup* heading appears.
3. Under the *Sensor Type* drop down menu, select *Light*.
4. Type QUANTUM for the description and UM for the channel label.
5. Enter -125.0 for the multiplier.
6. The running average will not be used, but could easily be set to any value.
7. Under Logging Options, be sure that the label indicates *none*.
8. Be sure the LI-1400 baud rate is set to 9600 (see page 3-2) and attach a RS-232 cable to the instrument and computer COM port.
9. Under the *Remote* menu, click on *Connect*. The LI-1400 does not need to be ON in order to communicate with a computer. Select the appropriate COM port and click OK. When the

computer and instrument are connected the remaining menu items will become active.

10. Under the *Remote* menu, click *Send Setup*. A window will open that indicates the transfer progress.

11. To view data, attach the Quantum sensor to I1 and press the "On/Off" button on the LI-1400.

12. Press the View key and toggle to *New Data*. Press **Enter**.

13. Toggle the display with the right or left arrow keys until channel I1I is displayed; this shows the instantaneous reading from the quantum sensor. The LI-1400 is now configured to display the instantaneous value of the quantum sensor. If desired, data can be logged to memory simply by pressing the **Enter** key.

Connecting LI-COR Thermistor Type Temperature Sensors

LI-COR thermistor type temperature sensors (1400-101 Air temperature sensor, 1400-102 Air temperature sensor, or the 1400-103 Soil temperature sensor) require the terminal block because they must be attached to either channel I4 or I5. Although not critical, the red lead is normally connected to terminal position I4 or I5 while the black lead is connected to one of the terminal positions labeled 5VDC. The shield wire is connected to one of the ground positions labeled ⏚. Unlike light sensors, these temperature sensors require power to operate; for this reason one wire must be connected to a +5V regulated power supply position. The channel can then be configured as described in the example below. Refer to Section 4, *Instrument Software Reference* for detailed descriptions of each configuration parameter. Installation instructions for thermistors can be found in Appendix C.

The LI-1400 uses the Steinhart-Hart Equation to calculate temperature from LI-COR's 1400-101, 102, and 103 temperature sensors. Only one set of coefficients is necessary and is preprogrammed into the LI-1400. When configuring a channel, select Math=MLTHMSTR in the channel setup for any of these LI-COR temperature sensors.

Configuring the LI-1400 for a LI-COR Temperature Sensor Using the LI-1400 Keypad

Example 2a. Configuration for a LI-COR thermistor-type temperature sensor.

1. Configure channel I4 as *General* for temperature. Press *Enter*.
2. Enter a description, such as *TEMP*.
3. Set *Math=MLTHMSTR*. This uses the Steinhart-Hart equation with the built in coefficients for the LI-COR thermistor temperature sensors.
4. Set *Oper(ator)=none*.
5. Enter a *Label* such as *C* for the units.
6. Set *Average=1 sec* or as desired.

To log the temperature automatically, follow the remaining steps (see Section 4, *Instrument Software Reference* for additional information).

7. Set *Log Routin* to the desired log routine.
8. Set *Calc=Mean*.
9. To capture the minimum and maximum temperatures, set *MinMax* accordingly.

10. *TCoef* has no effect when *Calc=Mean*. It is used only when integrating.
11. Configure the log routine as desired. Logging will begin when the Logging State is set to "ON".

Configuring the LI-1400 for a LI-COR Temperature Sensor Using the PC Software

Example 2b. Configuration for a LI-COR thermistor type temperature sensor.

1. Click on the Channel called I4 and select *General* for sensor type.
2. Enter a description such as *TEMP* and a channel label such as C.
3. Set *Average* to 1 second or as desired.
4. Under the Math Function heading, click the *Edit* button.
5. In the Channel I4 Math Function window, under the Function drop down menu, select MLTHMSTR and click OK. This uses the Steinhart-Hart equation with the built in coefficients for the LI-COR thermistor temperature sensors.
6. Under the Channel Operation heading, click the *Edit* button and set the Operator field to "none."

To log temperature automatically, follow the remaining steps (see Section 5 *PC Software Reference* for more information).

7. Under the Logging Options heading, click the *Choose* button and select the desired log routine (LR1-LR5). Log routines are configured to log

every second by default. Be sure to set logging interval to the desired setting.

8. Set the Calculation Type to *Mean*.
9. To capture the minimum and maximum values, select "Log Min-Max."
10. *TCoef* has no effect when the Calculation Type is set to *Mean*. It is used only when integrating.
11. Configure the log routine as desired.
12. Connect the LI-1400 to the computer and send the setup file as described before. Logging will begin when the Logging State is set to "ON".

Using the Voltage Channels

General Description

Voltage signals are generated by a wide variety of sensors and devices having signal outputs proportional to some physical parameter. The LI-1400 can be used to monitor four voltage signals up to 2.5 volts with 76 microvolt resolution in real time and convert them into meaningful engineering units shown on the display. Alternatively, the LI-1400 can be configured to automatically log these data over extended periods of time and later dump the results to a computer for further analysis.

Directions and Guidelines

Access to the voltage channels requires the optional 1400-301 Terminal block. Voltage channels are designated by the letter "V" and numbered V1-4 (Figure 6-3). Most sensors with a voltage output will attach to the terminal block in the same way. The positive lead from a sensor should be attached to one of the terminals labeled V1, V2, V3, or V4, while the negative lead should be attached to one of the terminals labeled ↓. **Please pay careful attention to documentation provided with each sensor as color coding of leads varies dramatically.**

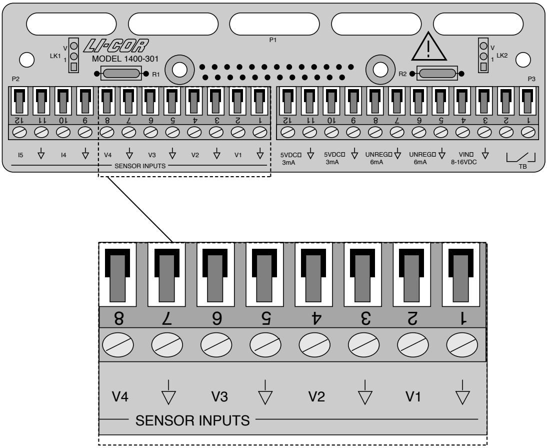


Figure 6-3. *Voltage channels are designated V1-V4.*

The LI-1400 measures voltage in units of volts. To convert volts into more meaningful units, the appropriate math function needs to be chosen along with the appropriate calibration coefficients for a particular sensor. Under “Setup Channels”, each channel should be configured as described in Sections 4 or 5. An example configuration for the 1400-104 RH/Air Temperature Sensor is given in Appendix C.

The 1400-301 Standard Terminal Block has four terminals to supply power to sensors requiring external power to operate. Two terminals can supply up to 3 milliamps each of regulated +5 volts to sensors requiring a highly regulated power source. Two other terminals can supply up to 6 milliamps each of unregulated power ranging from 8-16 volts DC. See instructions for your particular sensor for recommended power requirements.

Using the Pulse Counting Channel

General Description

The LI-1400 has a single counter channel that simply counts pulses during the logging period. The most common application is recording rainfall from a tipping bucket rain gauge. Most tipping bucket rain gauges have a reed switch that closes momentarily (SPST) whenever the bucket tips from one side to the other.

Directions and Guidelines

Leads from the device (switch) are connected to the two terminals labeled TB on the right side of the terminal block. Since this is a switch closure, the two leads can be attached to either terminal. Under "Setup Channels", the counter channel should be configured as described in Section 4, *Instrument Software Reference* or Section 5 *PC Software Reference*.

Configuring the Math Channels

The LI-1400 has 9 math channels, designated M1-9. These are virtual channels that can arithmetically combine (operators are +, -, ×, /) two analog channels and then perform any of the available math *functions* (polynomial, Steinhart-Hart, saturation vapor pressure, dew point calculation, natural log, or wind direction). Alternatively, math channels can be used simply to perform an additional math function on the same channel by using the operator "this chan(nel)".

The results of the operations can be displayed and logged to memory in the same way data from the analog channels are handled. Data from the two channels on which the math operation is performed are unchanged.

A math channel can also use a previously calculated math channel to perform additional operations. It is important to note that math channels are always calculated in numerical order. For example, math channel M3 can use the results of M1 or M2, but not M4.

Three common uses of the math channels are demonstrated below. The first example arithmetically combines two channels. The second example performs additional math functions on a single channel, and the last example uses a previously calculated math channel.

Setting up a Math Channel to Calculate Soil Temperature Using the LI-1400 Keypad

Example 3a. Two soil temperature probes, connected to Current channels I4 and I5, are used to measure soil temperature at two different depths with a sample interval of 15 seconds and a logging interval of 1 minute. A math channel such as M1 can be used to calculate the temperature difference (delta) between the two depths. Channel M1 is set up to subtract I4 from I5.

1. Set up Log Routine 1 (LR1) as follows:
   Start Time = 0000
   Stop Time = 0000
   Sampling Period = 15 sec
   Logging Period = 1 minute
2. Set up Current channels 4 and 5 (I4 and I5) for *General*, with the following parameters:

Parameter	I4	I5
Desc	Sensor1	Sensor2
Math=	MLTHMSTR	MLTHMSTR
Oper=	None	None
Label	C	C
Average	1 sec	1 sec
Log Routine	LR1	LR1
Calc=	Mean	Mean
Min/Max	No	No
Tcoef	1	1

3. Set up Math channel 1 (M1) as follows:

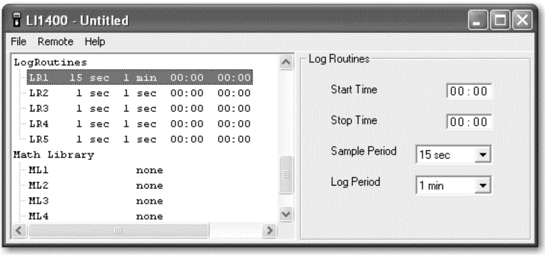
Parameter	**MI**
Desc	DELTA
Channel	I5
Math	None
Operator	-
Chan=	I4
Math=	None
Label	C
Average	1 sec
Log	LR1
Routine	
Calc=	Mean
Min/Max	No
TCoef	1

4. Turn logging On. The delta between the two soil probes will now be displayed on channel M1 and logged to memory once per minute. It can be viewed going to View>New Data and scrolling to channel M1.

Setting up a Math Channel to Measure Soil Temperature Using the LI-1400 PC Software

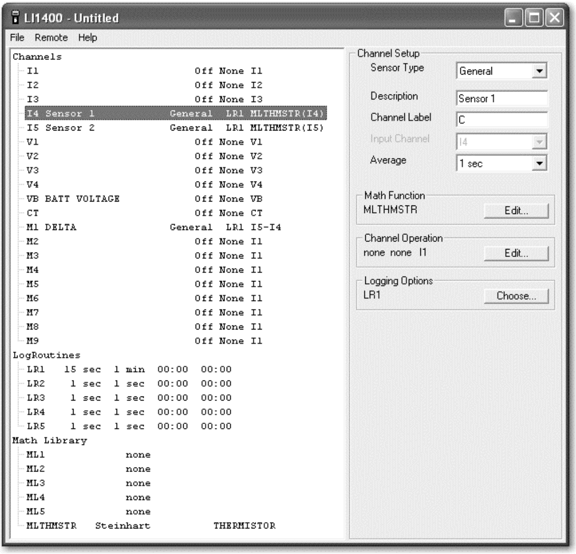
Example 3b. Two soil temperature probes, connected to Current channels I4 and I5, are used to measure soil temperature at two different depths. A math channel such as M1 can be used to calculate the temperature difference (delta) between the two depths. Channel M1 is set up to subtract I4 from I5.

1. Launch the LI-1400 program.
2. Set up Log Routine 1 (LR1) as follows:

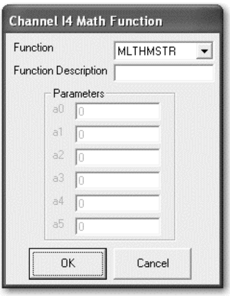


This enables 24 hour logging, which will start when logging is turned "ON". The sample interval is 15 seconds and the log interval is 1 minute.

3. Set up current channels 4 and 5 (I4 and I5) for *General*, with the following parameters:

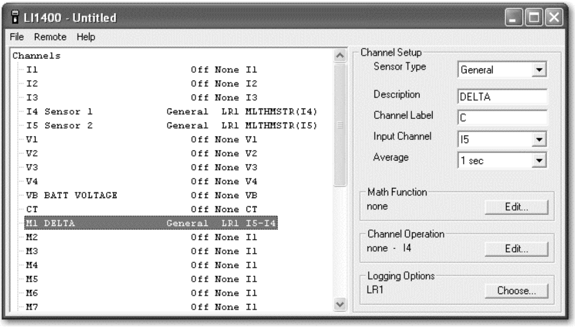


4. Set the Math Function to MLTHMSTR for both channels as shown below.

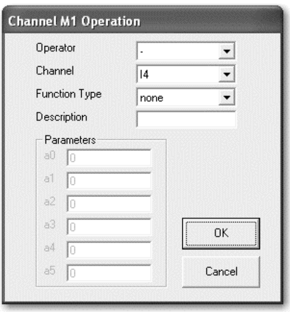


5. Leave the Channel Operation at the default setting but set the Logging Options to LR1 for both channels as shown below.

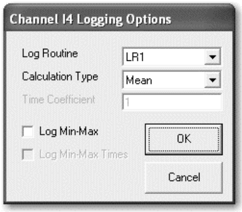
6. Set up Math Channel 1 (M1) as follows:



7. Leave the Math Function set to None. Click the **Edit** button and configure Channel Operation as shown below.



8. Set Logging Options as shown below by clicking the **Choose** button.



9. Connect the LI-1400 to the computer and establish a connection.
10. Send the setup to the LI-1400. Under the *Remote* menu, click *Logging State…* and click "On" when prompted. Logging will start immediately after the command is received by the LI-1400.
11. The delta between the two soil probes will now be displayed on channel M1 and logged to the instrument memory once per minute.

Setup to Log Saturation Vapor Pressure Using the LI-1400 Keypad

Example 4a. An air temperature sensor is connected to Voltage channel V1. Math channel M1 is set up to use channel V1 and then use a math function (ESat) to calculate the saturation vapor pressure of water based on the air temperature.

- Configure voltage channel V1 for air temperature:

1. Configure V1 channel as General for air temperature. Press **Enter**.
2. Enter a description, such as AIRTEMP.
3. Set Math=Poly(nomial) and press **Enter**.
4. Enter a description for the math function if desired, and enter a0 = -40, a1 = 100, a2-a5 = 0. Press **Esc** to return to the main configuration list.
5. Set Oper(ator) = none.
6. Enter a label, such as C for the units.
7. Enter Average = 1 sec.
8. Set Log Routine as desired.
9. Set TCoef = 1.
10. Set Calc = Point.
11. Set Min/Max = No.
12. Press **Esc** to return to "Channel Setup".

- Saturation Vapor Pressure for water vapor at the measured temperature must be calculated. This is done on the first Math channel:

1. Enter a description for Math channel M1, such as ESAT.
2. Select Chan=V1 (air temperature).
3. Select Math=Esat.
4. Set Oper(ator) = none.
5. Enter a Label, such as kPa.
6. Set Average = 1 sec, if desired.
7. Set Log Routine as desired.
8. Set Calc as desired.
9. Set Min/Max if desired.
10. TCoef = 1.
11. Press **Esc** then **View** to view the data.

Setup to Log Saturation Vapor Pressure Using the PC Software

Example 4b. An air temperature sensor is connected to voltage channel V1. Math Channel M1 is set up to use channel V1 and then use a math function (ESat) to calculate the saturation vapor pressure of water based on the air temperature.

- Configure channel V1 for air temperature:

  1. Select *General* for sensor type.
  2. Enter a description such as AIRTEMP and a channel label such as C.
  3. Set average to 1 sec.
  4. Click the *Edit* button in the Math Function frame. Select Poly(nomial) in the new window.
  5. Enter a description if desired, and enter a0 = -40, a1 = 100, and a2-a5 = 0. Click OK.
  6. Under Channel Operation, set Operator to *none*.
  7. Set the Log Routine as desired.
  8. Set Calculation Type to *Point*.
  9. Be sure the Log Min-Max is unchecked.

Calculating Dewpoint Temperature from an air Temperature Sensor and Relative Humidity Sensor

- Saturation Vapor Pressure for water vapor at the measured temperature must be calculated. This is done on the first Math Channel:
  1. For Math Channel 1 (M1), select *General* as the sensor type.
  2. Enter a description such as ESAT and a label such as kPa.
  3. Select Input Channel V1.
  4. Set average to 1 sec if desired.
  5. Under the Math Function heading, click on Edit, select the Function *ESat* and click OK.
  6. Be sure the Channel Operation is set to none.
  7. Set the Log Routine, Calculation Type, and other parameters as desired.

Example 5. An air temperature sensor is connected to Voltage channel V1 and a relative humidity sensor is connected to Voltage channel V2. A math channel M1 is used to calculate the saturation vapor pressure as described above. A second math channel M2 is set up to multiply the saturation vapor pressure by the relative humidity (RH must be in decimal form) and then perform the math function Tdp to calculate the dew point.

See Tdp in Section 4, *Instrument Software Reference*, for a complete description and example of how to use two math channels to calculate dew point temperature.

7 Viewing and Transferring Data

Viewing Data on the LI-1400

The LI-1400 Datalogger is a versatile instrument, which can be configured as a handheld meter to display instantaneous data, or it can be configured to automatically log data over an extended period of time.

Pressing the **View** key gives you two options; New Data or Log Data, accessible with the left and right arrow keys. New Data should be selected when you want to use the LI-1400 as a handheld meter to view instantaneous data from one or more sensors. All channels that are turned on and configured can be viewed on the two-line display in this mode. Log Data should be selected when you want to view data that has already been stored in memory. This option allows you to see data without having to first dump it to a computer.

When viewing logged data, either on the instrument or after it has been transferred to a computer, it is important to understand the 3-character channel code associated with the data. When viewing data on the instrument display, the code precedes the data value. When viewed on a computer, the code is part of the column heading for each logged parameter. The first two characters represent the channel and number; current channels I1-5, voltage channels V1-4, battery voltage channel VB, counter channel CT, and math channels M1-9. The meaning of the third character is shown in the table below.

Code	Description
I	Instantaneous value updated once per second.
A	Running average based on the previous 5, 15 or 30 seconds (instantaneous values).
M	Mean value calculated from the total samples collected during the logging period.
P	Point value of the last sample data point collected during the logging period.
T	Integrated value calculated from the total samples collected during the logging period.
L	Lowest value recorded during the selected logging period.
L + Time	The time at which the lowest value recorded during the logging period occurred.
H	Highest value recorded during the logging period.
H + Time	The time at which the highest value recorded during the logging period occurred.

When viewing instantaneous data on the instrument display, the letters I and A indicate if averaging is set to 1 second (I) or 5, 15, or 30 seconds (A) during channel setup. When viewing logged data on the instrument display, the three-character code will end with M, P, T, L, or H (+ Time). M, P, and T indicate the "Calculation Type" setting under "Logging Options". The L and H (+ time) indicate the minimum and maximum (low and high) values and the time at which they occurred.

After data has been imported into a spreadsheet, the three-character code will be visible for all channels. In the example below, row 1 indicates that Current channels 1 and 2 and voltage channels 1-3 were active. Current channels 1 and 2 both logged instantaneous values, as indicated by the letter I at the end of the three-digit code in cells C1 and D1. Voltage Channels 1-3 each logged an average value, as indicated by the A at the end of the three-digit code in cells E1, F1, and G1. The A indicates that in the "Channel Setup" window for V1-3, the average was set to 5, 15, or 30 seconds.

	A	B	C	D	E	F	G
1	0	12/10/2008 14:58	I1I	I2I	V1A	V2A	V3A
2	0	12/10/2008 14:58	Quantum (um)	Quantum (um)	AirTemp (C)	SoilTmp (C)	SoilTmp2 (C)
3	1	12/10/2008 14:58	I1M	I2M	V1M	V2P	V3T
4	1	12/10/2008 14:58	Quantum (um)	Quantum (um)	AirTemp (C)	SoilTmp (C)	SoilTmp2 (C)
5	2	12/10/2008 14:58					
6	2	12/10/2008 14:58					

The information in column A, rows 1 and 2 indicates which channels are active. The 1 in column A, rows 3 and 4 indicates which channels were logging on Log Routine 1. The 2 in column A, rows 5 and 6 indicates which channels were logging on Log Routine 2 (there were none). In cells C3, D3, and E3, the third letter in the code is an M, which indicates that the mean was logged for these channels. In cell F3, the P indicates that a point was logged, while in cell G3, the T indicates that an integral was logged. Minimum or maximum values were not logged in this example. If they were, the three letter code at the top of the data column would end with the letter L or H and (+ time), if applicable.

The characters following the data value on the instrument display represent the label entered during channel configuration (normally used for units). The description and label are visible below the channel heading when logged data are viewed with a spreadsheet.

New Data

Press the **View** key and select New Data with the **Enter** key. The top line will show “View New Data” and the second line will display your data. Press the down arrow to view two lines of data simultaneously. By pressing the right and left arrow keys, you can scroll through the current time/date, an indication of how much memory has been used and all of the channels that are turned on. Pressing the up or down arrow keys moves the cursor up or down and allows you to configure each line independently.

Each line on the display can be thought of as a single line of a spreadsheet. The first cell shows the current date and time, the second cell shows the amount of memory that has been used, and subsequent cells show each channel that is turned on. Press the right or left arrow keys to scroll through each cell in a circular fashion. If a logging routine was specified for a channel, there will be an additional cell for each channel showing the last value logged to memory.

Logged Data

It is often convenient or necessary to review data already logged to memory when working in the field.

The LI-1400 allows you to review logged data and show it on the display without having to first dump it to a computer. All data (including remarks or special messages) logged to memory are organized by their time stamp and how it was logged.

Press **View**, select Log Data with the right arrow key and press Enter. This will present you with a list of options (ALL, Inst(antaneous), LR1-5 (log routine 1-5), Remarks) through which you can scroll with the right or left arrow keys. When the appropriate option is displayed, press **Enter**. A vertical list of time stamps will appear. Use the down arrow key to scroll to the desired time stamp and press **Enter** to display the data. The up and down arrow keys will scroll through all of the individual channels turned on for that time stamp while the right and left arrow keys will scroll through minimum/maximum values and time stamps for that particular channel if the Min/Max option was enabled.

Data collected using different log routines (LR1-5) can be viewed separately. For example, if light, temperature and relative humidity data were collected hourly using LR1 and rainfall data was collected daily using LR2, one could view only the rainfall data collected using LR2 without having to scroll through all of the hourly data collected using LR1. This makes it easier to view only the data of interest.

Remember, there is other information logged to memory besides data from your sensors. Every time the channel configuration is changed, remarks are entered, or instantaneous data is stored, this information is logged to memory along with its time stamp. Usually the first time stamp listed contains setup information showing which channels were turned on and what logging routine was used for each channel. Subsequent time stamps will contain the sensor data.

Setting Custom Displays

When viewing New Data, you can configure as many as 10 custom displays that can be recalled to the display by simply pressing any numeric key 0-9. This can be useful for toggling between parameters you want to monitor so you do not have to scroll the display to view the parameters of interest. For example, if you are monitoring data from an "in-air" and an "in-water" sensor, you might want to configure displays that show instantaneous values for each sensor, and then toggle between these displays when you want to log data.

To set up a custom display, scroll the display until the parameters you want to view are present on each line of the display. Press the **Shift** key once, followed by a number key. This display can now be recalled simply by pressing the associated number key while at the "View New Data" menu. To erase that configuration, press the **Shift** key twice, followed by the number key.

Manually Logging Data

All channels, which are turned on, can be logged to memory at any time by simply pressing **Enter** when in "View New Data" mode (see page 7-4). For example, if you are making light measurements with LI-COR underwater light sensors, you can simply lower the sensors to the desired depth and press **Enter** to record the data along with the current time stamp. Every channel turned on will be recorded together. Special Remarks (comments) can be logged to memory whenever needed under the Fct (Function) Log Remarks option. Data can also be logged manually while a log routine is active by pressing **Enter** in the View New Data mode. Please see Section 4, *Instrument Software Reference* for instructions.

Transferring Data to a Computer

Data stored in the LI-1400 can be transferred to a computer for analysis, printing or storage using the RS-232 interface. The LI-1400 RS-232 port is configured as Data Terminal Equipment (DTE), and is bi-directional, meaning information can be transferred both into and out of the LI-1400.

Data output is independent of data collection and logging functions. Data can be output while the LI-1400 is still logging data without interrupting the logging process except when logging every second. Some data points may be missed when trying to simultaneously dump data and log data at 1 second periods.

There are 3 basic methods to transfer data from the LI-1400.

Method 1. Initiate the transfer of data and setup files in binary format between a PC and the LI-1400 using the 1400-501 Windows Interface Software provided with the LI-1400.
Method 2. Initiate the transfer of ASCII data to a PC (or serial printer) from the LI-1400 keypad.

Method 3. Initiate the transfer of ASCII data and binary setup files to a PC from the PC keyboard with any terminal program using the “Remote Menu”.

The preferred method to transfer data and setup files from the datalogger is Method 1 - using the 1400-501 Windows Interface Software that comes with the LI-1400. Most of the details of sending data between the datalogger and the PC are done by the software, which makes it very easy to use. Data are transferred in binary format (much faster than ASCII) and then converted and stored in ASCII format.

However, there may be times you must download data with a PC that does not have this software installed. Methods 2 and 3 make it easy to use nearly any generic terminal program for this purpose including those included with many laptop computers or PDAs. In addition, Method 2 or 3 is required if you wish to use “Auto Print” to see data in real-time.

RS-232 Cable

The 9975-016 RS-232 Serial Cable (or 1400-550) is a DTE to DTE cable with 9-pin connectors on both ends to plug into the 9-pin connector on the bottom of the LI-1400. This cable should be used to interface with other DTE devices such as computers, serial printers, and terminals with 9-pin serial ports. If you are connecting to a computer that does not have a serial port, see Section 3 for instructions on using a USB to RS-232 converter.

Method 1: Using the 1400-501 Windows Interface Software

The 1400-501 Windows Interface Software included with the instrument emulates many of the functions of the internal LI-1400 software, and can be used to transfer Setup routines to and from the LI-1400, receive data, and perform other maintenance functions. The 1400-501 software is compatible with PCs running Windows operating systems, including XP® and Vista®.

To transfer data from the LI-1400 to a computer, the LI-1400 needs to be connected to the computer with an RS-232 cable.

1. Set the instrument baud rate to 9600. On the LI-1400, press the **Setup** button and scroll right or left until Hardware appears on the screen. Press the **Enter** button. Scroll with the right or left arrow keys until the display reads "Baud=9600." Press **Esc**. Note that the instrument baud rate must be 9600 to use this method.
2. Launch the LI-1400 software on your computer.
3. Under the **Remote** menu click on **Connect**.
4. Select the appropriate serial port number and click **Connect**. After a moment the two devices should be able to communicate.
5. Under the **Remote** menu click **Receive Data**.
6. You will have the option of downloading all data or only data that was logged between specified dates. Select the appropriate option and click **OK**.
7. When prompted, select a directory and provide a file name. Click **Save**.

8. Data is saved as a tab delimited text file (.txt) that can be opened in a spreadsheet.

Method 2: Initiated from the LI-1400 Keypad

Method 2 is the most generic means of transferring ASCII data from the LI-1400 to a PC or serial printer. When data transfer is initiated from the keypad, ASCII data is simply sent out the serial port to whatever is attached to the other end of the cable. The LI-1400 does not know and does not care whether anything is attached to the cable. Obviously to be useful, the device on the other end of the cable must be configured to the same parameters as used by the datalogger to successfully transfer the data. Configuration of the LI-1400 serial port communication parameters is found under "Setup-Hardware." Only the baud rate is selectable, as data bits, stop bits and parity are fixed.

Normally you will want to capture the transferred data in a data file. Any commercially available terminal program or terminal programs that come with Macintosh or Windows operating systems ("Hyper Terminal") should be capable of this task. The following are general instructions that may be used with most any terminal program. Please read the terminal program documentation for specific instructions.

1. Open the terminal program.
2. Configure the program to match the LI-1400. Any device connected to the LI-1400 must have its input parameters configured to match those given below.

Baud Rate: 300, 1200, 2400, 4800, or 9600
Data Bits: 8
Stop Bits: 1
Parity: None
Flow Control: None

Make sure to select the correct serial (COM) port!

3. Open a capture file to capture the data. Although you can give the file any name, by convention ASCII files should have a *.txt extension.
4. Press the **Fct** key on the LI-1400.
5. Press the right or left arrow key until “Print Memory” is displayed. Press **Enter**.
6. Press the right or left arrow key until “Print=All” is displayed.
7. Press the down arrow key until !Print Mem! is displayed. Press **Enter**.
8. The data will usually appear on the PC screen as it is transferred. If a range was specified in step 6, then a slight delay may occur before data is seen.
9. Once the data transfer is complete, it is usually necessary to close the capture file (usually by turning capture off).

This same procedure (Steps 1-3) should be used when “Logging” and “Auto Print” are both turned on to capture data in real time as it is logged.

Method 3: Initiated from the PC Keyboard with the Remote Menu

Method 3 allows instrument setups and data transfer to be accomplished entirely from the PC keyboard with the Remote Menu (generated by the LI-1400) which can access many functions of the LI-1400 internal software from the PC. Make sure "Auto Print" is turned off prior to accessing the Remote Menu (under the Setup Logging menu). The Remote Menu can be accessed from the same terminal programs discussed above by simply following steps 1-2 from Method 2 and then pressing **Enter** (on PC keyboard) three or four times (3 times if the LI-1400 is on, or 4 times if the LI-1400 is off). If the menu fails to appear, press **Enter** several more times. The following menu will appear in the terminal window:

LI-1400 Remote Menu (1.3)

1) Set Clock 2009-02-24 14:06:46
2) Log Remarks
3) Set Remark Prompts
4) Print ALL Memory
5) Print Memory Range
6) Auto-Print
7) Turn Overwrite Off
8) Clear ALL Memory (0% used)
9) Clear Memory To Time
A) Shutdown
B) Turn Logging On
C) Set Noise Filter (60Hz)
D) Set Baud Rate
R) Reset Instrument
S) Download Setup (XMODEM)
T) Upload Setup (XMODEM)
Select:

Any of the above functions can be performed by pressing the appropriate number or letter, followed by a carriage return. Some of the menu items simply toggle between choices (i.e., Turn Logging On/Off), while others require further input. ASCII data from the LI-1400 can be downloaded and stored in a text file in your PC similar to Method 2. The only difference between Method 3 and Method 2 is that data transfer is initiated from the PC's keyboard rather than from the keypad of the LI-1400 using Method 2. Prior to pressing function 4 or 5 on the Remote Menu, open a capture file in exactly the same way as described in Method 2 and then close the file when the transfer is completed.

Transferring Instrument Setup Files

The LI-1400 stores configuration parameters in a setup file that can be downloaded and later uploaded to the LI-1400 if your terminal program has XMODEM capabilities. This can be convenient for archiving setup files or when different setups are required for different applications. Although the setup files are easily transferred with the 1400-501 Windows Interface Software, they can also be uploaded and downloaded with any terminal program.

Please note the transfer of an instrument setup file is actually a binary file transfer and is accomplished differently than transfer of ASCII data previously described. As the procedure for binary file transfer is different for different terminal programs, the following is a *general* description of the steps involved to download a setup file from the LI-1400 to a PC.

1. Repeat steps 1-2 from Method 2, and press the **Enter** key 3 or 4 times (3 if the LI-1400 is on, 4 times if the LI-1400 is off).

2. From the Remote Menu, press "S" followed by the **Enter** key. The message "Start Xmodem download now..." should appear in the Remote Menu.
3. Set up the PC terminal program to "Receive" a file using XMODEM as the protocol.
4. Select a name and destination for the file.
5. A dialog box should automatically appear indicating the progress of the file transfer. Once the transfer is complete, the box should automatically close with the setup file located in the subdirectory indicated in Step 4.

This setup file can now be uploaded at another time or into another LI-1400 to avoid keying in exactly the same setup information. Setup files can be saved for different applications. Switching between different applications is then as easy as uploading a different setup file into the LI-1400.

Uploading a setup to the LI-1400 follows a similar process described above except the function "T" Upload Setup is chosen from the Remote Menu and "Send" a file is chosen in the terminal program.

A Specifications

Current Inputs: Five channels; three through external sealed BNC connectors, and two through the 1400-301 Standard Terminal Block.

Voltage Inputs: Four high impedance (>500M ohm) single-ended channels accessed through the 1400-301 Terminal Block. Current channels I4 and I5 can be configured for voltage measurement by moving jumpers on the terminal block. When configured for voltage measurement, channels I4 and I5 have 100K ohm input impedance.

Pulse Counting Input: One pulse counting channel. Switch closure for tipping bucket rain gauge (1 Hz maximum).

Math Channels: 9 math channels. Math channels combine results of one or two channels with addition, subtraction, multiplication and division operators. Other math channel functions include fifth order polynomial, Steinhart-Hart function for thermistors, natural log, saturation vapor pressure, and dew point. Five math libraries are available to store commonly used functions.

Analog-to-Digital Converter

Resolution: 16 bit (1 part in 65,536).

Scanning Speed: 10 channels per second.

Voltage Accuracy: < 0.15% of full scale reading (25 °C). ± 0.15% (0 to 55 °C).

Current Accuracy: ± 0.3% of full scale reading (25 °C). ± 0.5% (0 to 55 °C).

Temperature Coefficient: ± 0.01% of reading per °C.

Linearity: 0.07%.

Frequency Rejection: >90 dB at 50 or 60 Hz (software selectable).

Input Noise (25 °C)

	Typical	**Maximum**
Voltage	± 76 µV	± 152 µV
Current	± 7.6 picoamps	± 30.4 picoamps

Voltage Range (Channels V1-V4):

Voltage Range	**Resolution:**
± 2.5 volts	76 microvolts

Voltage Range (Channels V5-V6):

Voltage Range	**Resolution:**
± 25.0 volts	760 microvolts

Current Range Selection: Autoranging.

Current Ranges	**Resolution**
1 ± 250 nanoamps	7.6 picoamps
2 ± 2.5 microamps	76 picoamps
3 ± 25 microamps	760 picoamps
4 ± 250 microamps	7.6 nanoamps

Current Channel Input Impedance: Typically < 0.03 ohm for ranges 1, 2, or 3; < 0.3 ohm for range 4.

Voltage Channel Input Impedance: >500M ohm on voltage channels V1 through V4.

D.C. Voltage Excitation: Two regulated: + 5.0 V (±.2%) at 3 mA; Two unregulated: 9.5V ±10% or higher at 6mA. With external 14V input, unregulated output is ≈13.4V.

Logging Periods: Seconds: 1, 5, 15, 30. Minutes: 1, 5, 15, 30. Hours: 1, 3, 6, 12, 24.

Sampling Interval: Seconds: 1, 5, 15, 30. Minutes: 1, 5, 15, 30, 60.

Short Term Averaging: Selectable at 1, 5, 15, or 30 seconds. While averaging, the oldest point is dropped when the newest point is added. Averaged readings reduce instrument noise by approximately the square root of the number of samples.

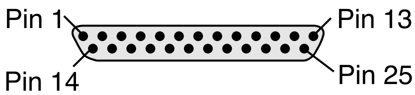
Keyboard: Sealed, 24 key tactile response keypad.
Display: Two line, 16 character alphanumeric LCD. Updated once per second. Temperature compensated readability from -15 to 55 °C.
Real Time Clock: Year, month, day, hour, minute, seconds. Accuracy: ± 3 minutes per month (25 °C).
Internal Memory: 96K bytes available for data storage.
Communications: RS-232, hardwired Data Terminal Equipment (DTE) through 9-pin port. Baud rates are software selectable at 300, 1200, 2400, 4800, and 9600. Communication is bi-directional.
Battery Requirements: Four Alkaline "AA" batteries in sealed battery compartment.
Back-up Battery: Internal lithium battery maintains memory up to seven years.
Battery Voltage: Automatic low battery instrument shut-off. Remaining power after shut-off maintains data stored in memory. Low battery warning displayed before automatic shut-off. Power management software also shuts off the instrument after 15 minutes of inactivity.
Battery Capacity with "AA" Batteries: 60 hours continuous operation.
Battery Capacity with 1400-402 External Alkaline "D" Cell Battery Pack: Up to 6 months of operation with 1 minute sampling interval.
External DC Power: 7 - 16 VDC; 300mA at 9 volts recommended.
External AC Power: 108-126 VAC, 44-66 hz with 1400-401 AC Adapter.
Enclosure: ABS plastic case for splash resistant operation and protection from wind blown dust. Equivalent to IP54 level.
Operating Conditions: -25 to 55 °C; 0 to 95% RH, non-condensing.

Storage Conditions: -30 to 60 °C; 0 to 95% RH, non-condensing.
Size: 22L x 13W x 4.3 cm D (8.6 x 5.1 x 1.7”). 9.3 cm (3.7") width of the lower case allows easy hand-held operation.
Weight: 0.7 kg (1.5 lb).

B Pin Assignments

25 Pin "D" Connector

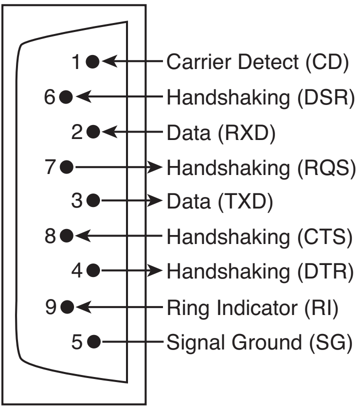
The pin numbers are stamped on the inside of the connector at the base of the pins, and read as shown below.



25 Pin "D"	Signal Name
1	Chassis Ground
2	Current Channel I4
3	Signal Ground
4	Voltage Channel V3
5	Signal Ground
6	Voltage Channel V1
7	Signal Ground
8	+5VDC, 3mA
9	Signal Ground
10	Unregulated 6mA
11	Signal Ground
12	Counter Channel
13	Counter Channel
14	Current Channel I5

25 Pin "D"	Signal Name
15	Signal Ground
16	Voltage Channel V4
17	Signal Ground
18	Voltage Channel V2
19	Signal Ground
20	+5VDC, 3mA
21	Signal Ground
22	Unregulated 6mA
23	Signal Ground
24	VIN 8-16VDC
25	Signal Ground

DB-9 Connector



C Accessories

The following section describes operation instructions for some of the LI-1400 accessories, including the 1400-402 External Battery Pack, the 1400-101, -102, and -103 Temperature Sensors, and the 1400-104 Relative Humidity/Air Temperature Sensor.

Attaching the 1400-401 Battery Pack

Attach the red lead from the Battery Pack to terminal “VIN 8-16VDC” on the 1400-301 Terminal Block, and the black lead to one of the adjacent ground terminals (Figure C-1).

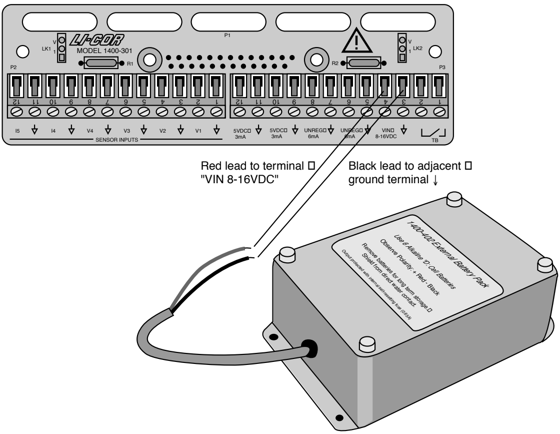


Figure C-1. *Attach the red lead to terminal "VIN 8-16VDC", and the black lead to any ground terminal.*

Changing the 1400-402 Batteries

1. Unscrew the 4 cap screws on the face of the Battery Pack and open the case.
2. Pull up on the ribbon to dislodge the batteries. Re-install new batteries with proper polarity as shown on the label inside the case. Use only alkaline "D" cells. Replace the cover.

1400-101/102 Air Temperature Sensors

The 1400-101 and 1400-102 are terminated with 3 wires that connect to the terminal block. The red lead also has a 33.2K ohm precision resistor connected in series with the thermistor. The red lead is connected to the current input terminal for the channel being used. The black lead is connected to the regulated +5 volt power supply, which is the 5VDC terminal on the 1400-301. The silver shield wire is connected to a signal ground terminal on the current channel in use (Figure C-2)

1400-103 Soil Temperature Sensor

The soil temperature sensor is designed to be as small as possible to facilitate burial at any desired depth. However, when burying the sensor at shallow depths (< 10 cm) there are some practical considerations that should be observed. At depths less than 10 cm it is much easier for the sensor to be accidentally pulled out or to be uncovered by strong winds. This can usually be prevented by burying not just the tip of the sensor, but a length of the cable as well. It is also best to bury the sensor and the cable at an angle to the soil surface (not perpendicular). Attaching the 1400-103 to the 1400-301 Terminal Block is similar attaching the 1400-101/102 (Figure C-2).

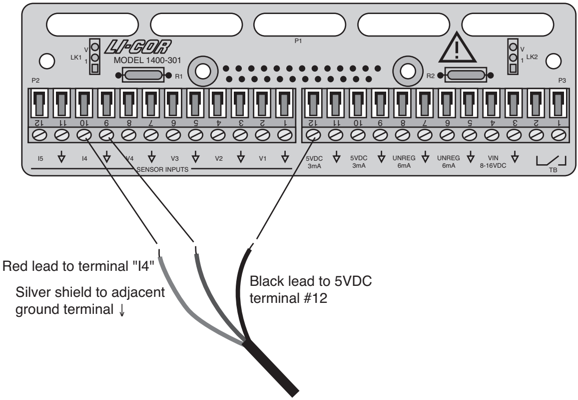


Figure C-2. *For 1400-101/102/103 sensors, attach the red lead to a current input channel, the silver lead to the adjacent ground terminal, and the black lead to a 5VDC terminal.*

1400-104 Relative Humidity/ Air Temperature Sensor

The 1400-104 Relative Humidity/Air Temperature Sensor requires a 7-28 VDC input power source and has a signal conditioned voltage output of 0-1V = -40 °C to 60 °C for air temperature and 0-1V = 0-100% for relative humidity.

1. Connect the brown wire (7-28 VDC power) to one of the two unregulated power supply terminals (UNREG). This terminal supplies power to the sensor.

2. Connect the blue wire (ground) to any ground (↓) terminal.

3. Connect the narrow gauge black wire (temperature voltage signal) to one of the voltage signal channels (V1-4).
4. Connect the black wire with a thick shield to a ground (↓) terminal.
4. Connect the white wire (RH voltage signal) to one of the voltage signal channels (V1-4).
5. Secure the cable to the strain relief slots at the top of the terminal block, if desired.

Configuring the LI-1400 Datalogger

1. **For temperature:**
1. Configure V1 channel as *General* for air temperature.
2. Enter a description, such as *Air temp*.
3. Set Math = *Poly(nomial)* and press *Ent(er)*.
4. Set description as desired, *a0 = -40, a1 = 100, a2-a5 = 0*. When finished, press *Esc* to return to the main configuration list.
5. Set *Oper(ator) = none*.
6. Enter a *Label* such as *C* for the units.

2. **For relative humidity:**
1. Configure V2 channel as *General* for relative humidity.
2. Enter a description, such as *RH*.
3. Set Math = *Poly(nomial)* and press *Ent(er)*.
4. Set *a0 = 0, a1 = 100, a2-a5 = 0*. When finished, press *Esc* to return to the main configuration list.
5. Set *Oper(ator) = none*.
6. Enter a *Label* such as *RH* for the units.

Recalibration

It is not necessary to send the 1400-104 sensor back to LI-COR for recalibration, as calibration of the RH sensor is done simply by replacing the sensor element. Contact LI-COR for details.

D Troubleshooting

Troubleshooting Procedure

This section outlines the steps to take when the LI-1400 stops working. A troubleshooting table is included at the end that lists problems, symptoms, and possible solutions.

If the LI-1400 stops working correctly, the following items should be checked in order:

1. Low batteries
2. Configuration problems
3. Memory problems

The sections below give detailed instructions for each step.

Low Batteries

Low batteries can cause a number of problems. Most of the time, the LI-1400 detects the low battery condition, blinks the display, and eventually turns off. There are, however, a few scenarios that can escape detection. Because of this, fresh batteries should be installed as the first step when troubleshooting, no matter what the problem is. Here is the procedure that should be followed:

1. Open case and remove battery cover.
2. Remove batteries.

3. Check for corrosion on the battery terminals that may prevent good contact. Clean any corrosion before installing new batteries.
4. Install the new batteries. Push each cell to make sure it makes contact with the positive battery terminal.
5. Use a voltmeter to measure the battery voltage on the battery pack terminals and the analog board. With the battery cover removed, use a voltmeter to measure voltage at the two terminals on the top right of the battery pack (Figure D-1). Battery voltage can also be measured at the 2 contacts labeled P3 and P4 (Figure D-1). Voltage with 4 new 'AA' batteries is usually around 6V or higher. Anything above 5V should be ok.
6. Press the small blue reset button (Figure D-2) on the digital board 2 times (note: pressing the system reset button *will not* erase logged data or configuration files). Make sure the display comes on with the message "SYSTEM RESET: to run press ENTER". If the message says "SYSTEM RESET: no program", the embedded instrument software needs to be loaded into the instrument (see *Memory Problems* below for loading new embedded instrument software).
7. Replace battery cover. Make sure the cables are plugged in securely and close the case.

Figure D-1. *Positive and negative terminals used to troubleshoot battery problems.*

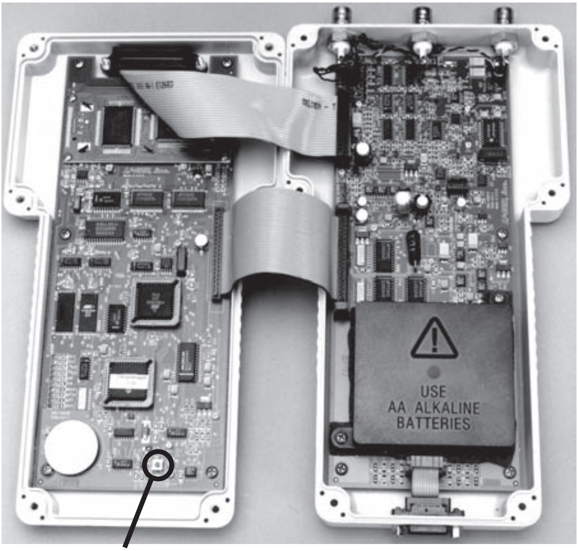


Figure D-2. *Location of reset button.*

Configuration Problems

If data are not being recorded correctly, there are a few configuration items to check. Follow the list below.

1. Make sure the clock is set to the correct time. **NOTE:** if you have to reset the clock, it is usually a good idea to dump any data and clear the database. If a future time stamp was logged into the database, every time stamp following will be equal to that incorrect time stamp. Clearing the database fixes this problem.
2. Go to **VIEW NEW DATA** and view the clock to make sure it is running. If it is not running, set the clock again under **SETUP CLOCK** to restart it.
3. **SETUP LOGGING - Logging** should be On.
4. The log routine must be set up for the correct sampling and logging period.
5. The log routine start/stop times can keep a log routine from logging during certain hours of the day. Make sure they are correct.
6. Make sure the channel you want to log is turned on under **SETUP CHANNELS.**
7. Make sure the channel parameter **Log Routine** is set to the correct log routine.

Memory Problems

There may be instances where data in the LI-1400 memory is corrupted and operation may be impaired. The following procedures describe how to correct memory problems and restore instrument operation.

1. Open the case and press the blue reset button 2 times (see Figure D-2). (note: pressing the system reset button *will not* erase logged data or configuration files). Make sure the display

comes on with the message "SYSTEM RESET: to run press ENTER". If the message says "SYSTEM RESET: no program", the embedded instrument software needs to be loaded into the instrument (see *Memory Problems* below for loading new embedded software).

Sometimes the corruption is in one data file. When attempting to download all files, the communication may “lock-up”. If this happens, try establishing communication with a PC. If possible, download blocks of files or individual files so that most data will be recovered and only the corrupt file will be lost.

There can be instances when corrupted data in LI-1400 results in impaired instrument operation. The instrument makes every attempt to make sure data aren't lost. There can be situations where the LI-1400 can't recover, however. **NOTE:** The procedures first procedures listed below will clear all data from the datalogger.

1. Press **FCT - RESET**, use the arrows to choose **Yes** and press **Enter**.
2. The screen should say "SYSTEM RESET: to run press ENTER". Press **Enter** to restart the instrument.

Alternatively, if **FCT - RESET** cannot be accessed, the following sequence should be followed.

1. Open the case and press the blue reset button 2 times (see Figure D-2).
2. The screen should say "SYSTEM RESET: to run press ENTER". Do not press **Enter** yet.

3. Press the following 6 keys in order: **SHIFT, SHIFT, Z** (minus key), **SHIFT, SHIFT, Y** (period key). The message "SYSTEM RESET: clearing memory" should appear.
4. After the message "SYSTEM RESET: to run press ENTER" comes back, press the **Enter** key to restart the LI-1400.

If the problem still is not solved, the embedded instrument software can be reloaded into the instrument. The embedded instrument software can be found at the LI-COR Technical Resources Library website (http://envsupport.licor.com).

1. Locate the LI-1400 page and click on the "Software" link.
2. Click on the link entitled "LI-1400 Instrument (Embedded) software" and when prompted, save the .zip file to a directory.
3. Extract the compressed files with any suitable software.
4. Double click on the file named "li1400-update."
5. A window will open that prompts you to select a serial port.
6. Connect the LI-1400 to the computer with an RS-232 serial cable (9975-016).
7. Choose the appropriate serial port and click the "Program Flash" button.
8. A warning will inform you that the instrument memory is about to be erased. Click the "Yes" button.
9. After the status bar indicates that the memory update is complete a window will pop up to inform you that the instrument was programmed successfully. Click "OK".
10. Check the LI-1400 for normal operation.

Communication Problems

Communication problems can arise for a variety of reasons, including faulty hardware connections, corrupt data files, or improper instrument and computer settings. The following procedure can be used to help solve communication problems between the LI-1400 and a computer.

1. Check to be sure that the RS-232 Communication Cable is the cable provided with the instrument (LI-COR part number 1400-550 or 9975-016). If the original cable is unavailable, any RS-232 "Null Modem" serial cable will work. An RS-232 straight through cable will not work.
2. Check to be sure that the computer is using the correct serial port. Open the computer 'Device Manager' and expand the 'Ports (COM & LPT)' section. All communication ports should be listed. Often the serial port is called 'COM1' but it may have a different number. Select the appropriate COM port and double-click on it to determine if the device is working properly. Sometimes portable devices such as hand-held computers and music players will 'lock' the serial ports. Make sure that this is not the case.
3. If you are using a USB to RS-232 adapter, be sure that the adapter drivers are installed correctly. If you are using a laptop computer with the USB to RS-232 adapter, the RS-232 signal may be too weak. Be sure that the USB port has sufficient power, either through a fully charged battery or AC connection (some laptops require the manufacturer's original power supply). If there is adequate power to generate a signal but

you still cannot connect, consider a different USB to RS-232 adapter. USB to RS-232 adapters that have been tested with LI-COR instruments are available from LI-COR (part number 6400-27). Your computer will assign a com port # to the USB to RS-232 adapter. See step #2 above to confirm the com port number.

4. Be sure that the LI-1400 is powered ON.
5. Check the baud rate on the LI-1400 Datalogger. With the LI-1400 powered on, press the 'Setup' button. Scroll left or right until the 'Hardware' menu is visible and press 'Enter'. Set the baud rate to 9600. The baud rate must be set to 9600 in order to communicate with the Windows Interface Software. If you are using a terminal program such as HyperTerminal, the software baud rate must be at the same setting as the LI-1400 baud rate.
6. If it appears that data transfer begins and 'bytes' are being transferred, but the transfer freezes before completion, you may have corrupt data files. If you have multiple data files, it may be possible to load smaller blocks of files or individual files to get non-corrupted files off the LI-1400. After transferring the non-corrupted files, clear the instrument memory or reset the system to remove the corrupted files.

The following table summarizes problems, symptoms, and possible solutions.

Symptoms	Possible problem	Solution
Display blinks. Display is blank.	Low battery.	Replace batteries.
Display stops updating. "SYSTEM RESET: …" message appears sporadically. Instrument doesn't respond to the keypad. Clock has incorrect date or time. Instrument locks up at the screen "LI-1400 1.0 Starting…"	Memory is corrupted.	See "Memory Problems" above.

Symptoms	Possible problem	Solution
Clock doesn't update. Clock has incorrect date or time.	Clock needs to be reset.	Set the clock. Even if the time is correct, setting the clock will reinitialize the clock completely.
Instrument won't record readings.	Configuration problem.	See "Configuration Problems" above.
Sensors on the terminal block don't read correctly.	Terminal ribbon cable is loose.	Open the case and make sure the terminal ribbon cable is aligned and plugged securely into the analog board.
	Sensors polarity is wrong. Sensors wired to wrong channels	Check wiring diagrams and labels on the 1400-301.

Symptoms	Possible problem	Solution
A light sensor plugged into a BNC connector doesn't read correctly.	Bad sensor cable. Wire between BNC and analog board is broken or connector is loose.	Check sensor cable for damage, including nicks, cuts or sharp bends. Check the BNC connector. Check the connector to make sure it is aligned properly and is securely in place.
BNC connector turns when trying to plug a light sensor in.	BNC connector is broken.	Contact LI-COR
Collected data has noise spikes in it. or A data reading is missing or a reading is duplicated.	Check noise filter settings. Bad sensor cable. Condensation inside of instrument.	Set noise filter correctly. Protect the instrument from rapid temperature changes and from high humidity. Contact LI-COR.

Symptoms	Possible problem	Solution
Can't communicate with the LI-1400 using RS-232.	The wrong cable is being used or is plugged into the wrong COM port. Wrong baud rate. USB to RS232 adapter con-figured in-correctly.	Use the LI-COR cable (1400-550 or 9975-016). Make sure cable is securely connected. Try different COM ports. Use 9600 baud 8N1 (8 data bits, no parity, 1 stop bit). See Trouble-shooting communica-tion problems in this section
LI-1400 doesn't retain data when changing the AA batteries.	Lithium backup battery on the digital board is dead.	Contact LI-COR.
Error message “A/D Error”.	Problem with Analog to digital circuit board.	Contact LI-COR.

E Storage Capacity

Data Storage Capacity

The amount of time over which the LI-1400 can log data before the memory becomes full depends on several things, including instrument configuration and the number of attached sensors. To ensure that the LI-1400 can log data for the maximum amount of time, be sure that only one configuration file is stored and that all previously logged data has been cleared from the instrument memory prior to setup. It is a good practice to clear the memory before the LI-1400 is used to collect data. Clearing memory erases all old channel setups, but *not* the current channel setup (Fct>Clear Memory using the instrument keypad or Remote>Clear Database using the PC interface software). Because of the software configuration, instrument memory is optimized when fewer log routines are used.

In order to calculate the number of days that the LI-1400 can log data, you will need to know the number of channels that will be used, the number of channels that will log min/max values, the number of channels that will log min/max times, and the total number of logs per day for each log routine in use. For most log routines, the number of days the LI-1400 can log until its memory is full can be approximated with the formula:

$$\left[\frac{92{,}880}{(14 + n4 + m8 + mt8)}\right]\Big/ l$$

where n = total number of channels in use
m = number of channels logging the min/max values
mt = number of channels logging min/max times
l = the total number of logs per day for all log routines in use.
92,880 bytes of memory are available when a single configuration file is loaded.

This formula may not be accurate when complex logging routines are used or when the memory becomes full prior to completing a full cycle (typically 24 hours).

Example 1. How long can the LI-1400 operate before the memory becomes full when configured with two sensors on Log Routine 1, logging data twice per hour with no min/max?

Each log will occupy 14 bytes for the time stamp and 8 bytes for the data, for a total of 22 bytes per log (14 + (2×4)). The LI-1400 will store about 4221 records with this configuration (92,880/(14+(2×4)). Logging data twice per hour, 48 records will be logged each day. With this configuration, the LI-1400 can log for 87 days before the memory becomes full.

Example 2. How long can the LI-1400 operate before the memory becomes full when data from 3 sensors is logged once per hour with no min/max on Log Routine 1 and data from 2 sensors is logged every 15 minutes between 6am and 10 pm with no min/max on Log Routine 2?

With 5 channels active and no min/max data or time stamps, the LI-1400 can store about 2731 records

(92,880/(14+(5×4)). Log routine 1 logs 24 records per day and LR2 logs 64 records, for a total of 88 daily. The LI-1400 can log for about 31 days under this configuration.

Example 3. How many days will pass before the memory becomes full when the output from 1 sensor is logged every 5 minutes with no min/max on Log Routine 1, output from 2 sensors is logged hourly with min/max values but no min/max times on LR2, and output from 1 sensor is logged every 30 minutes, including min/max values and min/max times on LR3?

Four channels are active, three log min/max values, and one logs min/max time. The LI-1400 can store about 1498 records with this configuration. Log Routine 1 makes 288 records daily, LR2 makes 24 logs daily, and LR3 makes 48 logs daily for a total of 360 logs daily. With 1498 records available and 360 records consumed daily, the LI-1400 can log for about 4 days before the memory becomes full.

F Battery Life

Estimating Battery Life

The LI-1400 is designed to log data without interruption for long time periods. The lifespan of batteries powering the LI-1400 depends on the type of sensors that are attached, the configuration of the datalogger, and the operating temperature of the batteries. LI-COR light sensors are passive and require no power to operate. Other sensors, such as relative humidity sensors, may require current in order to operate. If sensors require a warm up period before data is logged, additional current will be used. In the event that a sensor draws a current range, such as from 2 to 4mA, use the higher number for estimating battery life because there is no way of knowing the exact demands of the sensor. Consult the instruction manual for each sensor to determine its current demands.

The LI-1400 is in “active” mode when logging data. Between polling periods the datalogger enters “standby” mode. The total current used by the datalogger (not accounting for current used by sensors) is equal to the proportion of time in which it is “active” multiplied by the current used in “active” mode plus the proportion of time in which it is in “standby” multiplied by the current used in “standby” mode. If the instrument is configured to use multiple log routines, the most frequent sampling interval should be used when determining the proportion of time that the datalogger is “active.”

This example shows how to estimate battery life when using the 1400-402 external battery pack at 21°C. When the LI-1400 polls sensors for data, it is active for about 2 seconds and draws approximately 25 mA of current (note that when the sample period is set to 1 second, the LI-1400 is active constantly). Between polling periods, it draws approximately 0.3 mA. The power consumed by the instrument if it is polling a sensor every 1 minute (60 seconds):

Active: 25*(2/60) = 0.833
Passive: 0.3*(58/60) = 0.29
Total: 1.123 mA or 0.00112 Amps

The current drawn by a powered sensor is equal to the proportion of time that the sensor is "active" (including the warm up period if chosen) multiplied by the current demands of the sensor while "active" plus the proportion of time the sensor is "passive" multiplied by the current demands of the sensor while "passive." The 1400-104 Relative Humidity/Air Temperature Sensor draws about 2 mA when active. Power consumed if polling once every minute:

Sensor 1 active: 2*(2/60) = 0.067
Sensor 1 inactive: 0*(58/60) = 0.000
Total: 0.067 mA or 0.000067 Amps

The time until batteries are drained is approximately equal to the battery output divided by the total current demand of the datalogger. The 1400-402 has a conservatively estimated output of 7 Ahrs. The current load of the configuration described above is 0.00119 amperes (0.00112+0.000067). The batteries should last for 245 days under ideal conditions. 7 Ahrs / 0.00119 A = 5882 hours or 245 days.

Battery life of the internal AA batteries is estimated similarly. When operated with AA batteries, the LI-1400 draws approximately 30 mA when active. Most AA alkaline batteries can provide about 2 Ahrs under ideal conditions. Using parameters from the example above, the LI-1400 could log for approximately 69 days before the batteries should be replaced.

The best way to determine the battery replacement interval is to monitor battery voltage carefully. Variables such as temperature affect battery performance, making it difficult to predict exactly how long batteries will last. Temperature extremes and excessive battery drain might also result in battery leaks and damage to equipment.

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Warranty

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