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LI-1000

DataLogger

Instruction Manual

LI-COR

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LI-1000 DataLogger
Instruction Manual

Publication No. 8510-0051

Revision 1 **November, 1987**

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How to Use this Manual

The LI-1000 is a multipurpose instrument capable of measuring a wide variety of sensors. Because of this, not all sections of this manual will be important to all users. A summary for each section and a recommendation for which users should read that particular section is given below.

Sections I and II discuss general features of the LI-1000 and contain basic operational information. These sections are relevant for all users.

Section III begins the discussion of the LI-1000's software. It contains information that all users need to understand, such as setting the time, configuring the instrument, and viewing stored data.

Section IV discusses the light sensor channel configuration and the use of the accessory terminal blocks as they apply to LI-COR radiation sensors. This section need not be read by users who do not intend to use LI-COR radiation sensors with the LI-1000.

Section V discusses the general channel configuration which can be used with a wide variety of sensors including LI-COR air and soil temperature sensors. Users who wish to connect sensors with a voltage or current output (other than radiation sensors or thermocouples) should read this section.

Section VI discusses the thermocouple channel configuration and the use of the 1000-10 Thermocouple Terminal Block for measuring thermocouples.

Section VII discusses the use of the pulse counting channels which are generally used with such sensors as the 1000-20 Tipping Bucket Rain Gauge or with anemometers.

Section VIII contains information on the math channel, which is used to do things like logging or displaying the ratio of two channels.

Section IX contains detailed information on each of the accessory terminal blocks and cables. It also includes information on the 1000-08 Instrument Enclosure. Read the portions of this section which relate to the accessories you have purchased.

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Section X discusses data output from the LI-1000. The discussion includes sending your data to a printer, computer, or lap-top computer.

Section XI contains general maintenance information and troubleshooting information if you have operational problems.

For users who have upgraded a version 1.02 LI-1000 to a version 2.00, Appendix D lists the differences and indicates the sections of the manual which you should read.

Printing History

First release - Software 1.02 - December 1985
Revision 1 - Software 2.00 - November 1987

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Section I
General Information

Instrument Description

The LI-1000 DataLogger is a 10 channel datalogger that functions both as a data logging device and a multichannel, autoranging meter. The electronics of the LI-1000 have been optimized for highly accurate measurement of LI-COR radiation sensors which have a current signal. The LI-1000 is also well suited to measure low impedance voltage sensors such as thermocouples, and sensors with a pulsed output (tipping bucket rain gauges, etc.). A wide variety of other sensors for environmental and industrial test and measurement can also be measured with the LI-1000.

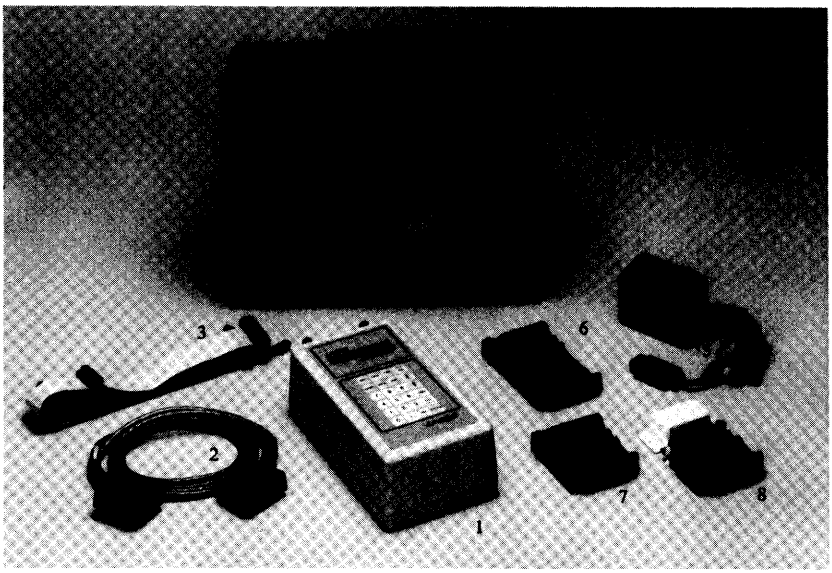


Figure 1. 1) LI-1000 Datalogger, 2) 1000-03 Printer/Terminal Cable, 3) 1000-04 Communication Cable, 4) 1000-07 Carrying Case, 5) 1000-02 AC Adapter, 6) 1000-06A AC Terminal Block, 7) 1000-05 Terminal Block, 8) 1000-10 Thermocouple Terminal Block.

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Operational Features

The LI-1000 has 10 channels for sensor inputs. Two current input channels are located on the two sealed BNC connectors. Six channels for current or single-ended voltage inputs, and two pulse counting channels are accessed using the 1000-05 or 1000-06A terminal blocks. The 1000-10 Thermocouple Terminal Block also provides connections for up to 5 thermocouples.

The LI-1000 has a rugged, weatherproof, polycarbonate enclosure and long battery life (up to 10 months) allowing extended operation in the field with minimal maintenance.

The LI-1000 can operate as either a multichannel, autoranging meter or an integrator/datalogger.

Data can be stored manually for instantaneous readings or logged automatically. Internal memory for data storage is 8K bytes for the LI-1000-8, or 32K bytes for the LI-1000-32.

The keyboard is used to enter calibration multipliers of sensors, to set channel configurations, integration times, input ranges, units, and for storing readings.

The display is a 16 character alphanumeric LCD used to view data stored in memory, or to view the output of a sensor.

Data is output through an RS-232C interface (hardwired as Data Terminal Equipment).

The software includes capabilities for storing or displaying instantaneous, integrated, average, running average, maximum or minimum readings. The math functions also allow division, multiplication, addition, or subtraction of two channels.

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Accessories

The following accessories for the LI-1000 were available at the time of writing. Contact LI-COR for current information

1000-02 AC Adapter (108-126/216-252 VAC, 48-66 hz).
1000-03 Printer/Terminal Cable (DTE to DTE)
1000-04 Communications Cable (DTE to DCE)
1000-07 Carrying Case for LI-1000 and accessories.
1000-08 Instrument Enclosure
1000-12 37-Pin "D" Connector
E95 Replacement Battery (alkaline D cell)

Terminal Blocks

1000-05 Terminal Block
1000-06A AC Terminal Block
1000-10 Thermocouple Terminal Block
1000-14 Sensor Connection Cable and Air Temperature Sensor

Sensors

1000-15 Soil Temperature Sensor
1000-16 Air Temperature Sensor
1000-16-2 Air Temperature Sensor (for use with 1000-08 Instrument Enclosure
1000-20 Tipping Bucket Rain Gauge
LI-COR Radiation Sensors: Available for both BNC connectors and terminal blocks (type "SA" (e.g. LI-190SA) for BNC connections and type "SZ" (e.g. LI-190SZ) for terminal blocks).

2200 Adapter: Adapts cables with BNC connections for use with Terminal blocks.
9960-031 RS-232C Tester
DL1000 Software. Used to transfer data to an IBM PC or compatible.

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Section II
Preoperation

Using "D" Cell Batteries

Six alkaline "D" cell batteries are installed in the LI-1000 at the factory. For maximum battery life and to prevent battery leakage, use only high quality alkaline batteries. The batteries installed by LI-COR are Eveready E-95 "D" cells (LI-COR Part Number E95).

Battery life specifications are given in Table 1. Battery life varies with instrument configuration and temperature.

Table 1. Battery Life of the LI-1000 (25 °C)

Configuration	Battery Life
1 channel, 1 to 24 hour periods	12 months
8 channels, 1 to 24 hour periods	10 months
1 channel, 10 minute periods	55 days
8 channels, 10 minute periods	30 days
Continuous Operation	550 hours

When there is approximately 10% of battery life left, the word "$^{L}_{O}$" is displayed to indicate the battery voltage is low. If operation is continued, automatic shutoff will occur when the battery voltage drops to 5.8 volts. After automatic shutoff, the memory is maintained by the remaining power in the batteries. A lithium battery mounted on the digital circuit board also provides back-up power for the memory when the main battery pack is removed. As long as the battery pack is removed for only short periods of time, both the memory and the channel configurations will be maintained.

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Using External DC Power

For longer battery life a 9 - 24 VDC power source can be connected to pins 9 (-) and 10 (+) of the 25 pin "D" connector (Appendix A). When an external source is connected, the LI-1000 will use either the internal batteries or the external battery depending on which has the higher voltage. (The internal batteries will supply a maximum of 9 VDC).

IMPORTANT: Pin 6 on the 37-pin connector also carries battery voltage, however, it is only for battery voltage output and should not be used to connect a DC power source (Appendix B).

Using AC Power

For long term indoor monitoring applications the 1000-02 AC Adapter can be used to provide continuous power. The 1000-02 plugs into the LI-1000 25-pin connector and has a pass-through connector so that the RS-232C cable can be connected while using AC power. Power requirements are 108-126/216-252 VAC, 48-66 hz.

Environmental Factors

The case of the LI-1000 is weatherproof. An O-ring seals the two halves of the case and all of the connectors are sealed from the inside. However, the following environmental limitations should be observed:

1) Some of the 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 contacting the terminals of the 1000-05, 1000-06A, or 1000-10 terminal blocks can also cause corrosion.

   If the LI-1000 is to be left outdoors and unattended for long periods of time, it should be installed in the 1000-08 Instrument Enclosure or equivalent (Figure 13). The 1000-08 is not weatherproof but does keep

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rain water from directly hitting or collecting on the LI-1000. If the LI-1000 does get wet, the connectors should be dried as soon as possible.

2) The LI-1000 should not be exposed to direct sunlight for long periods of time. The environmentally sealed case cannot vent the heat built up during prolonged exposure to the sun. Exposure to the sun will also decrease battery life and could cause battery leaks if the internal temperature exceeds the battery manufacturers specifications. The 1000-08 Instrument Enclosure should be used to shade the LI-1000 for applications requiring it to be exposed to the sun.

   The operating temperatures range from -25 to 55 °C; however, the display operates from -15 to 50 °C. At high temperatures the display may turn black, but usually operates normally after the instrument cools down. When operating at cold temperatures, the battery life will be significantly decreased.

3) A silica gel desiccant pack is provided to prevent condensation inside the sealed case. The desiccant should be checked each time the batteries are replaced (Section XI).

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Section III
Instrument Operation

This section will familiarize you with some of the general software operations of the LI-1000. First time users should read through this section from beginning to end. Many of the concepts presented are necessary to understand the specific configuration examples in later sections.

The Keypad

The keypad has 24 keys laid out in a 4 by 6 array. A brief description of each keys' function is given below.

Key	Description
OFF	Turns the LI-1000 off.
CFG	Enters *Configuration mode* and allows channel configuration.
TIME	Used to check or set the internal clock.
FCT ON	Turns the LI-1000 on and provides access to a list of auxiliary functions.

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Key	Description
CHAN	Used to view a different channel on the display in *INSTantaneous* or *LOG mode*, and to change channels in *Configuration mode* or *View mode.*
VIEW	Used to enter and exit *View mode* in which stored data can be examined on the display.
OUT	Used to output data through the RS-232C port.
↑	Scrolls the display in *View mode* or accesses the blue alpha characters in the upper left corners of the numbered keys.
↓	Scrolls the display in *View mode* or accesses the blue alpha characters in the lower left corners of the numbered keys.
EEX SPACE	Used to enter the exponent of numbers (EEX) or a SPACE when used with the [↓] key.
←	Used to correct mistakes. Backs up one space and deletes the character in that space.
ENTER	Used to terminate user input.

The 10 grey keys act as function keys to change the mode of operation or to execute an assigned function. The 14 white keys are used to input numbers

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or letters. Numbers are typed by pressing the key with the appropriate number on it. To type the alphabetic characters in the upper and lower corners of the numbered keys, the [↑] and [↓] keys must be used. Letters in the upper left corner are accessed by pressing [↑] and then the key which has the letter on it. Letters in the lower corner are accessed by pressing [↓] and then the key which has the letter on it.

The white keys will type the characters printed on them only when the LI-1000 is asking for input. In any other situation they will only scroll the display.

Some Preliminary Information

1) When the LI-1000 prompts for numbers or letters to be input (e.g. calibration multiplier, label, etc.), the current value of the parameter is shown on the display and can be retained by pressing [ENTER]. When numbers or letters are entered to change a parameter, the input must be terminated by pressing [ENTER].

2) When the LI-1000 prompts for input and there are only a few choices (e.g. channel numbers), the LI-1000 presents all the choices in a list. To select a parameter from the list, you can use the [↑] or [↓] keys (or any other keys except [CFG], [CHAN], [ENTER]) to scroll through the list. Again, you must press [ENTER] to lock-in your choice.

3) The operation instructions contain several examples which show the display after a given key stroke. Where numbers are displayed that represent data, the number shown in the example will be zero. These numbers are not intended to match what you see on the display of your instrument.

Start-Up

Press [ON] to turn the LI-1000 on. A start-up message (LI-1000.02.00) is displayed which indicates the version of software resident in your instrument

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(version 2.00 in this case).

After the start-up message the LI-1000 enters *Display mode*, in which the output of a channel is shown on the display (usually the lowest numbered channel that has been configured by the user). If more than one channel has been configured, you can view a different channel by pressing [CHAN]. The number displayed can be interpreted as described in the section below on *Configuration mode*.

NOTE: If you press [ON] for too long a time, you will see the message "FCT:Log Remarks". This indicates you are in the auxiliary functions list as described later in this chapter. To exit this list and return to *Display Mode*, press the [ON] key a second time.

The LI-1000 is normally in *Display mode* except when using one of the other modes of operation (*View, Output*, etc.). After exiting other modes of operation the LI-1000 will always return to *Display mode*.

Setting the Time

Time mode is used to check or to set the internal clock. The time should be set when the instrument is first received and checked once a month thereafter (clock accuracy is ± 3 minutes per month).

The clock is a 24 hour clock (i.e. 7:00 pm = 19:00). Also, midnight is 0000 and not 2400. After 2359 the clock resets to 0000.

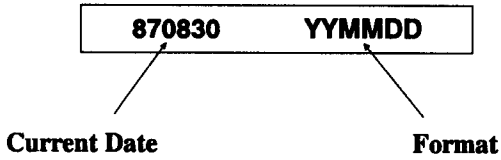
Setting the time is a 3 step process.

1. Enter *Time mode* by pressing [TIME].
2 Enter the current date using the white numbered keys and then press [ENTER].
3. Enter current time using numbered keys and press [ENTER].

After entering *Time mode*, the current date is displayed on the left side of the display in year (YY), month (MM), day (DD) format. The format used

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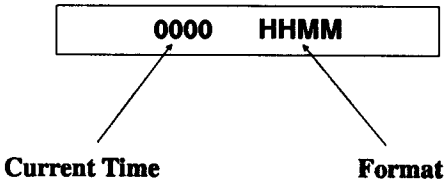
to enter a new date (YYMMDD) is displayed on the right side of the display.



The year, month and day should each be entered as a two digit number. If April 3, 1987 is entered as 8743, it will be interpreted as 870300.

Entering the date in YYDDMM format (a common European format) is not possible.

After entering the date, the current time in hours (HH) and minutes (MM) is displayed on the left side of the display. The format used to enter a new time (HHMM) is displayed on the right side of the display.



After the time is entered the LI-1000 automatically exits *Time mode* and displays the output of the lowest numbered active channel.

Configuration Mode

Configuration mode is used to configure each channel to correctly display or to log the output of a sensor. In *Configuration mode* you can choose to operate the LI-1000 as a simple autoranging meter or as a datalogger. In addition, each analog channel has three configurations. They include a light sensor configuration for operation with LI-COR light sensors, a thermocouple configuration for operation with the 1000-10 Thermocouple Terminal Block, and a general channel configuration for use with most other types of sensors.

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ENTERING CONFIGURATION MODE

Entering *Configuration mode* is a three step process.

1) Press [CFG] to enter *Configuration mode*.
2) Choose INST (*INSTantaneous mode*) or LOG (*LOG mode*).
3) Select the channel at which you want to start the configuration.

After entering *Configuration mode* you can choose to setup the LI-1000 as a light meter (*INSTantaneous mode*) or as a data logger (*LOG mode*). The mode that you choose affects all channels. It is not possible to have one channel be in *INSTantaneous mode* while another is in *LOG mode.*

In *INSTantaneous mode* the LI-1000 can display an instantaneous reading or a running average for each active channel. *INSTantaneous mode* is often used to configure the LI-1000 as a light meter for use with LI-COR radiation sensors.

In *LOG mode* data is sampled either at regular intervals for a user-defined period of time, or once at the end of the period. At the end of the period if the data meets a user defined threshold, it is stored in memory along with a time stamp that indicates the date and time when the logging period began. After the data has been stored the next collection period is started.

When the prompt "mode is ..." is given, all choices can be viewed by scrolling the display. (Press any key **except** [ENTER], [CFG] or [CHAN] to scroll the display). In this case there are two choices (INST and LOG) so the display just switches back and forth between the two.

In *LOG mode*, the current integration or the current value of the average is normally displayed. The instantaneous output of a sensor can also be displayed by pressing [↑] or [↓]. The prompt "show point" is given to indicate that the LI-1000 is switching to the display of point values. To switch back to displaying the total or averaged values press [↑] or [↓] again.

Switching from the display of a point value to an integrated value in *LOG mode* does not interrupt the logging process. The logging process can only be interrupted by entering *Configuration mode*. Using *Output mode* to send

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data through the RS-232C port, or *View mode* to see data values stored in memory does not effect the logging process.

If you are following this example with your LI-1000, scroll the display to "mode is INST" and press **ENTER**. The display now indicates that channel 1 (ch1) is either OFF, or turned on and configured as LIGHT, GEN, or THERM. "LIGHT" indicates the light sensor channel configuration, "GEN" is the general purpose configuration, and "THERM" is the thermocouple configuration.

Channel configuration normally begins with channel 1 and proceeds sequentially through channel 8 (ch8). **If you want to skip to a different channel, press CHAN until the status of the channel you wish to configure is displayed.**

> **To exit *Configuration mode* at any time, press CFG**. Note however, that if all the channels are turned off, the LI-1000 will not let you leave *Configuration mode*. At least one channel must be turned on. The automatic shutoff features also do not operate in *Configuration mode*. If you leave the instrument turned on and in *Configuration mode*, it will remain turned on until the batteries are exhausted.

Channels 1 - 8 are analog channels that can be configured either as voltage or current input channels. In *INSTantaneous mode* the analog channels are followed by the math channel (chM). In *LOG mode* the analog channels are followed by two pulse counting channels (chA and chB), and the math channel.

The three channel configurations LIGHT, GEN, and THERM for both *INSTantaneous* and *LOG mode* are discussed in Sections IV, V and VI respectively. Section VII discusses the pulse counting channels, and Section VIII discusses the math channel.

The remainder of the instructions in this section use concepts that are presented in the channel configuration sections. If you find the instructions unclear, you may want to skip ahead and read either Section IV, V, or VI before finishing this section.

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Storing Instantaneous Data in Memory

When the LI-1000 is configured for instantaneous readings and is in *Display mode* (showing the output of one of the active channels), data points can be stored in memory by pressing [ENTER] . Each time [ENTER] is pressed the LI-1000 will store a data value and a time stamp for all channels that are active (not just the channel displayed).

After pressing [ENTER] , the time stamp of the data point that has been stored in memory will be displayed for a few seconds. If several data points are stored during the same minute they will have the same time stamp. The resolution of the time stamp is 1 minute.

Data stored in memory can be reviewed using *View mode*, or transmitted to an external device using *OUTput mode*.

Viewing Data Stored in Memory

Data that have been stored using either *INSTantaneous* or *LOG mode* can be examined on the display by pressing [VIEW] .

If there are no data stored in memory when you press [VIEW] , the prompt "NO DATA" is displayed and the LI-1000 exits *View mode*. If you currently have no data stored in memory, use Example #7 in Section IV to configure the LI-1000 to store some data. This will help you to follow the examples below.

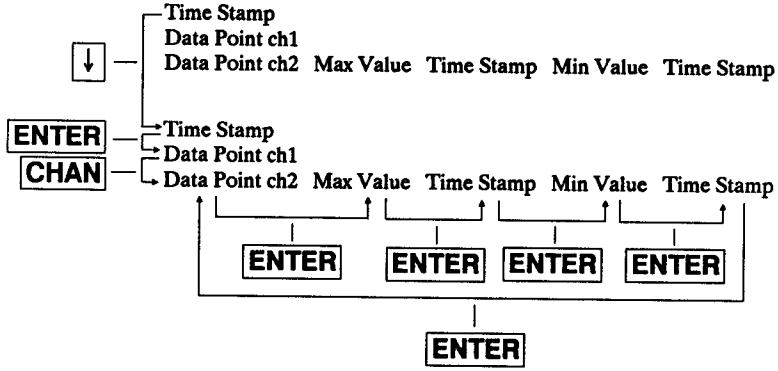
NOTE: To exit from *View mode* at any time, press [VIEW] a second time.

Upon entering *View mode* the time stamp of the **most recent** data point (or remark) is displayed. This is a 6 digit number followed by a 4 digit number which is the year (YY), month (MM), day (DD), hour (HH), minute (MM) that the data was collected. The format is YYMMDD HHMM.

The block of text shown below illustrates how data are stored in the LI-1000's memory and how they are displayed using *View mode*. The text represents

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the data collected for two logging periods with 2 channels turned on. Channel 2 was also configured to store min/max values and time stamps.



To move from the time stamp of the logging period to the first data channel for which data was stored, press ENTER. To move between channels (i.e. from ch1 to ch2) press CHAN. If the display does not change when you press CHAN, there is data stored for only one channel.

To view the maximum data point for channel 2, use CHAN to display the data point for ch2 and then press ENTER. Press ENTER again to display the time stamp of the maximum value (if any). If you continue to press ENTER, you will scroll through the minimum data value, its time stamp, and then back to the data point for channel 2.

To move from the data of one logging period to another press the ↑ key to move to the next sequentially older time stamp or the ↓ key to move to sequentially newer time stamps.

To view all the data for a given channel, use the CHAN key to display the desired channel and then repeatedly press ↑ (or ↓) and ENTER. If a given time stamp does not have any data stored for the channel you are looking at the data value will be displayed as 0.0.

When a time stamp is shown on the display it could refer to either logged data or remarks. When you press ENTER the LI-1000 will display either the first data point that uses that time stamp, or the first remark. The use

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of the user-entered remarks is discussed in the section on the auxiliary functions below.

Interpreting the Data

Each data point is of the form CR N.NNN LL, where C designates the channel (1 through 8, A, B, or M), R indicates how the channel was configured when the data were collected, N.NNN is the data point and LL is the label.

If the data were collected in *INSTantaneous mode*, R would be I for instantaneous, or A for average. If the data were collected in *LOG mode*, R would be T for integrated, M for mean, or P for point value. "R" can also be H for the maximum data point or L for the minimum data point.

If the value of the number (N.NNN) is greater than 9999. the form of the data point will change to N.NNN E ± XX where N.NNN is the mantissa and E ± XX is the exponent of the data value.

Moving to a Specific Time Stamp

In *View mode*, you can move to a specific time stamp by pressing **TIME**. After pressing **TIME** you will be prompted for the time stamp at which to start (YYMMDD HHMM format). If the time stamp you specify does not match any stored in memory the LI-1000 displays "not found" and goes to the newest time stamp.

> To exit *View mode*, press **VIEW**. "exiting View" is briefly displayed followed by a display of the output of the lowest numbered active channel (*Display mode*).

Memory Capacity

There are two models of the LI-1000 varying only in data storage capacity; the LI-1000-8 (8K RAM) and the LI-1000-32 (32K RAM). The system software utilizes approximately 1500 bytes of RAM, which leaves 6,792 bytes

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of available memory in the LI-1000-8 and 31,368 bytes in the LI-1000-32. The figures for the total available RAM assume that none of the channels have the average (in *INSTantaneous mode*) set at a high value. Since the average function allocates user RAM to hold the data for the average the total storage capacity will be decreased if the averages are set to a high value.

When a channel is configured to store data, each data point, time stamp and the min/max value (determined by the configuration) consume a specific number of bytes of memory.

Each Time Stamp = 6 bytes
Each Active Channel = 4 bytes
Each Channel Configured to Store Min/Max = 16 bytes (with time stamps, 8 bytes without).
Each Set of Remarks = 48 bytes (34 bytes with only 2 sets of prompts and remarks, 20 bytes with one prompt and remark).

The period, reset time, and threshold values set during configuration also effect data storage. Several examples are given below to show how these factors relate to data storage and how they can be used to predict minimum service intervals (the length of time until a given configuration fills the LI-1000's memory).

NOTE: When the memory is full the LI-1000 will continue to log data. Each time a new data point is stored, the oldest point in memory will be deleted to make room.

Example #1

Configuration: 8K memory with 2 channels configured to store at 1 hour periods with the same reset time (both channels use the same time stamp) and min/max values (no time stamps) stored for both channels. There will also be one set of remarks stored.

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2 Active Channels (2 x 4 bytes)	8 bytes
Time Stamp	6 bytes
2 Min/Max (2 x 8 bytes)	+ 16 bytes
	30 bytes/hour
	x 24 hr/day
	720 bytes/day

Remarks (6792 - 42) 6750 bytes / 720 bytes/day = 9.4 days

Since there is only one set of remarks (not added at each hourly period), 42 bytes is subtracted from the total available memory.

Lets assume the sensors are radiation sensors. The memory consumption can be slowed by use of the threshold parameter in the channel configuration. For radiation sensors, the threshold could be set so that data is collected only during daylight hours (assume 14 hours for this example).

30 bytes / hour x 14 hours/day / 420 bytes/day and 5562 days / 420 bytes/day = 13.2 days

Example #2

Configuration: 32K memory with 4 channels storing data at 1 hour periods with the same reset time and two channels configured to store min/max values (with time stamps).

4 active channels (4 x 4)	16 bytes
2 min/max (2 x 16)	32 bytes
Time stamp	+ 6 bytes
	54 bytes/hr

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$$\frac{31{,}368 \text{ bytes}}{54 \text{ bytes/hr}} = 580 \text{ hours, or } 24.2 \text{ days}$$

If the min/max time stamps are not stored the hourly memory consumption is 38 bytes/hour and the memory will last 34 days. If min/max values are not stored at all, the memory consumption is 22 bytes/hour and will last 59 days.

Example #3

Configuration: 8K memory with 1 channel active, storing data at 10 minute intervals.

1 active channel	4 bytes
Time stamp	+ 6 bytes
	10 bytes/data point

10 bytes/data point x 6 data points/hr = 60 bytes/hr.

$$\frac{6792 \text{ bytes}}{60 \text{ bytes/hr}} = 113.2 \text{ hours} = 4.7 \text{ days}$$

Example #4

Configuration: 32K memory with 8 channels operating. 4 channels storing data at 24 hour periods and 4 channels storing data at 1 hour periods. The reset time on all channels is the same.

4 channels, hourly (4 x 4 bytes)	16 bytes
Time stamp	+ 6 bytes
	22 bytes/hr

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	22 bytes/hr
	x 24 hr/day
	528 bytes/day
4 channels 24 hr periods	+ 16 bytes/day
	544 bytes/day

$$\frac{31{,}368 \text{ bytes}}{544 \text{ bytes/day}} = 57.6 \text{ days}$$

Example #5

Configuration: 32K memory with 2 channels storing data hourly, each channel having a different reset time. Notice how different reset times effect storage capacity. If two or more channels have the same reset time they will use the same time stamp.

1 active channel	4 bytes
Time stamp	6 bytes
1 active channel	4 bytes
Time stamp	+ 6 bytes
	20 bytes/hr
	x 24 hours/day
	480 bytes/day

$$\frac{31{,}368 \text{ bytes}}{480 \text{ bytes/day}} = 65.3 \text{ days}$$

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Both channels with the same reset time ....

2 active channels	8 bytes	
Time stamp	+ 6 bytes	
	14 bytes/hr	
	x 24 hours/day	
	336 bytes/day	
	30,168 bytes / 336 bytes/day	= 89.8 days

Turning the LI-1000 Off

In *INSTantaneous mode* the LI-1000 is turned off by pressing [OFF]. It is not necessary to turn all the channels off before turning the instrument off. In *INSTantaneous mode* there is no battery drain due to channels being left on as long as the instrument is turned off.

In *LOG mode*, the LI-1000 will automatically begin to sample data when configuration is complete. At this point the instrument can be turned off by pressing [OFF] . While turned off, the LI-1000 will turn on at the smallest sampling interval, make a measurement, store data values (if necessary), and then turn itself off. Pressing [OFF] in *LOG mode* essentially just turns off the display, but the LI-1000 continues to collect and store data.

NOTE: The LI-1000 will also automatically shut itself off 20 minutes after the last keystroke.

It is not possible to turn the LI-1000 off until configuration is complete. (*Configuration mode* can be quickly exited by pressing [CFG]).

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Auxiliary Functions on the FCT/ON Key

Pressing [ON] after the LI-1000 is turned on results in the display of a scrollable list of auxiliary functions. Use the [↑] or [↓] keys to scroll through the list. To exit the list, press [ON] again.

Log Remarks:

To store a set of remarks, scroll to Log Remarks and press [ENTER]. A series of up to three prompts are displayed which are defined by the Def Prompts function described below. Eight character alpha or numeric remarks can be entered in response to the prompts. After entering the last remark, a current time stamp and the remarks are stored in memory. The remarks can be displayed in *View mode* or output through the RS-232C port after they are stored in memory.

Def Prompts:

This function is used to define the prompts which are given in the Log Remarks function. You can define up to 3 prompts, each of which can be 8 characters (alpha or numeric). The prompts should be defined before using the Log Remarks function.

Mem Status:

The memory status function is used to determine the available memory and to find newest and oldest time stamps. To start the status function, scroll the function list to "Mem Status" and press [ENTER]. The LI-1000 responds by displaying the total size of the memory (8K or 32K) and the percent of memory that is unused. To view the first or last time stamp stored in memory press [↑] or [↓]. To leave the memory status function press [ENTER] again.

Clear Ram:

This function clears all data points and remarks stored in memory. When the "FCT:Clear Ram" prompt is displayed press [ENTER]. The prompt "ok clr mem? NO" is given to make sure you that you really want to continue. To clear the memory scroll the display to YES and press [ENTER].

Instrument Reset:

This function restarts the LI-1000's software. All data points in memory are cleared, all channel configurations are reset to the default values, and the

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internal clock is set to zero. After resetting the instrument, you will be prompted to enter the current time and turn on at least one channel (you will not be able to leave *Configuration mode* if all the channels are turned off).

Tech Tests:

The LI-1000 has a number of built-in software features used to identify electronic or software problems, or to verify that the instrument is performing correctly.

When you select Tech Tests from the function menu the LI-1000 will send the prompt "OK STOP LOG NO". It is necessary to stop logging data in order to perform the tech tests. Press [ENTER] if you do not wish to stop logging. If you wish to proceed, scroll the display to "YES". The prompt "test:" is given, to which you must respond with a keystroke that designates the desired test. Shown below are the keys to press, the name of the test, and some comments. If you press any key besides those shown below, the LI-1000 will exit *Test mode* and return to *Display mode*. After the conclusion of each test the LI-1000 will also return to *Display mode*.

[5]	RAM test	Loads all zero's and all ones into all locations of RAM. It also detects how much RAM is installed. At the conclusion of the test, "8K RAM OK" or "32K RAM OK" should be displayed. If an error is found "8K RAM ERR" or "32K RAM ERR" will be displayed. Press [ENTER] to exit test mode or any other key to restart the test.
[6]	EPROM test	Displays "ROM OK" if the test is successful or "ROM ERR" if an error is found. To exit *Test mode* press [ENTER] or any other key to restart the test.
[9]	Display test	Displays all characters in all positions on the display. Press any key to stop the test. LI-1000 returns to *Display mode* upon completion of the test.

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EEX Keyboard test — The display shows the matrix position of the key pressed. The numbers displayed for each key are shown below. All 24 keys must be pressed before the test will terminate. NOTE: the power cannot be turned off while this test is being performed.

3,5	2,5	1,5	0,5
3,4	2,4	1,4	0,4
3,3	2,3	1,3	0,3
3,2	2,2	1,2	0,2
3,1	2,1	1,1	0,1
3,0	2,0	1,0	0,0

NOTE: The remainder of the tests require special test equipment. These tests are generally used only by LI-COR or LI-COR distributors. The keystrokes needed to initiate these tests are given below as a reference only. Please contact LI-COR for further information on these tests.

7 RS-232C Test

8 Real Time Clock Test

VIEW Digital Counter Test

0 Range Test

3 Low Battery Test

2 Overrange Test

1 Channel Test

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Section IV
Using LI-COR Radiation Sensors

This section describes both the hardware and software configurations used to measure LI-COR radiation sensors. The discussion includes configuring the LI-1000 as a simple meter in *INSTantaneous mode*, and how to set-up the LI-1000 to log sensor outputs.

NOTE: Radiation sensors can also be used with the GENeral channel configuration.

Light Sensor Channel Configuration In Instantaneous Mode

In *INSTantaneous mode* the LI-1000 prompts for the Range (range =), a Multiplier (mult =), a Label, and the Average (Ave =).

RANGE: The "range =" prompt is used to set the range of the measurement electronics. The range parameter scrolls between A, 1, 2, 3, or 4. "A" indicates autoranging in which the LI-1000 will select range 1, 2, 3, or 4 according to the level of the input signal. If 1, 2, 3 or 4 is chosen, the LI-1000 will use only that range. The current ranges and resolutions for each measurement range are given in Table 2.

The range is often set at autorange (A) in order to cover the widest input signal range with the best resolution. For example, a typical LI-COR LI-190SA Quantum Sensor has a maximum output of approximately 16 μAmps when used to measure solar radiation. Table 2 indicates that the sensor output would fall within range 3 (± 20 μAmps, 2.5 nanoamp resolution). However, if the sensor output dropped to 1 μAmp, the signal would still be measured with a resolution of 2.5 nanoamps. In the same situation using the autorange feature, the measurement would be made using range 2 (0.25 nanoamp resolution).

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Table 2. LI-1000 Current Ranges		
Range	**Current Range**	**Resolution**
1	±200 nanoamps	25 picoamps
2	±2 microamps	0.25 nanoamps
3	±20 microamps	2.5 nanoamps
4	±200 microamp	25 nanoamps

There are several applications where it is best not to use the autorange feature. In situations where the radiation levels are rapidly fluctuating, the LI-1000 may not be able to find the range before the signal has changed. If this happens the LI-1000 will show all 9's on the display until the signal level stabilizes enough for the LI-1000 to find the range. To solve this problem, choose one of the standard ranges (1 - 4).

For underwater radiation sensors, the autorange feature may not be useful in near surface environments where waves passing over the sensor can cause rapid fluctuations in sensor output. Also, some luminaires which do not emit radiation continuously (arc lamps, etc.), may require the use of the standard ranges.

Choosing autorange slows the rate at which the channels can be scanned. The scanning speed is slower because the range must be determined before the measurement is taken. The normal scan time of 0.25 seconds per channel can increase to as much as 0.7 seconds. Although the slower scanning speed is not detrimental for most applications, it should be kept in mind when choosing the range.

If you choose a standard range which is too low for the sensor output the LI-1000 will overrange. This results in the LI-1000 displaying all 9's until the signal level decreases enough to be measured with the selected range.

MULTIPLIER: "mult =" is a prompt to enter the calibration multiplier of the LI-COR radiation sensor. For type "SA" (LI-190SA, etc.) and "SZ"

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(LI-190SZ, etc.) sensors purchased after September 1985, the calibration multiplier is given on the certificate of calibration and can be entered directly.

For older type "S", "SB", and "SZ" LI-COR Sensors, the calibration multiplier must be calculated from the calibration constant given on the certificate of calibration.

NOTE: If the Calibration Constant is entered instead of the Calibration Multiplier, any data collected will be erroneous.

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.

The calibration multiplier can be calculated using the following equation:

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

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 (instantaneous readings only) are given in Table 3. For type "SA" sensors the calibration multiplier can be multiplied by "K" to give a readout in different units.

The calibration multipliers for LI-COR radiation sensors are always negative because the shield (ground) in the cable is positive instead of negative.

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

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Table 3. "K" values for LI-COR Sensors		
Sensor Type	K Value	Units (Instantaneous)
Quantum	1	$\mu mol\ s^{-1}\ m^{-2}$
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	$\mu W\ cm^{-2}$
	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-190S Quantum sensor with a calibration constant of 8.0 μAmps/1000 $\mu mol\ s^{-1}\ m^{-2}$.

$$\text{Multiplier} = \left(\frac{(-1)(1000\ \mu mol\ s^{-1}\ m^{-2})}{8.0\ \mu Amps}\right)(1)$$

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

Example: Calculate the calibration multiplier for an LI-200S Pyranometer sensor whose calibration constant is 80.0 μAmp/1000 Watts m^{-2}. Additionally, it is desired for the sensor to readout in $mW\ cm^{-2}$.

$$\text{Mult.} = \left(\frac{(-1)(1000\ W\ m^{-2})}{80.0\ \mu Amps}\right)\left(\frac{0.1\ mW\ cm^{-2}}{1\ W\ m^{-2}}\right) = -1.25\ mW\ cm^{-2}/\mu Amp$$

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LABEL: "label =" is a prompt for a two character alpha or numeric label that is displayed with the output of a channel in *Display mode*. The label is also printed when data is output.

Letters in blue, in the corners of the numbered keys, are accessed by pressing the [↑] or [↓] key and then the key with the appropriate letter on it.

When viewing data stored in memory or viewing the output of a channel in *Display mode*, the label immediately follows the data value. The first character should be a letter or a space to eliminate confusion with the data value.

AVERAGE: The "ave =" prompt is used to display either an instantaneous readout of the sensor output, or a continuous running average.

Any integer greater than or equal to 1 can be used for the average. However, in practice the average is limited by the available memory. When the memory is full, it is only possible to get a total of 33 seconds of averaging time (i.e. a 26 second average on one channel and a one second average on each of the other channels). Also, if you set the average to a very high number, all available memory is used for the average, leaving none for data storage. In this situation, if you try to store data, the message "DATA NOT STORED" will be displayed. If an average is entered that would require more memory than is available, the averages will automatically be changed, and a message will be displayed that indicates the changes.

Each integer in the average represents one second. If 1 is chosen, the output of the channel is displayed as an instantaneous value that is updated every second. If a number N is chosen such that $N > 1$, the display will still update every second but the number displayed will be the continuous running average of instantaneous readings for the past N seconds.

For example, if 30 were entered for the average, the number displayed is the average of the instantaneous data points for seconds 1 through 30. When the display updates after 1 second, the number displayed is the average of seconds 2 through 31, followed by 3 through 32, etc. The number displayed will not represent a 30 second average until 30 seconds have elapsed since

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you exited configuration mode (after 5 seconds its a 5 second average, etc.).

The average function is advantageous 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 the resolution because of the higher number of samples used in the average.

The average function is often used with radiation sensors when measurements are taken under changing cloud conditions or under water.

EXAMPLE #6: Configure channel 1 to obtain a 60 second running average for a LI-COR LI-190SA Quantum Sensor whose calibration multiplier is -125.0 μmol s^{-1} m^{-2}/μAmp. Set the range to autorange (A) and use UM (for μmol s^{-1} m^{-2}) for the label. NOTE: No sensors need to be connected for this example.

STEP 1: Press [CFG] to enter Configuration mode, select INSTantaneous mode of operation.

Keystrokes	Resulting Display
[CFG]	mode is INST
[ENTER]	ch1 is OFF

If the mode is LOG, you should scroll the display to INST by pressing [↑]. The channel status could also be displayed as LIGHT, THERM or GEN.

STEP 2: Scroll the channel status prompt to the LIGHT sensor channel configuration and press [ENTER] to lock it in. (First time users may want to scroll through all the choices).

[↑]	ch1 is LIGHT
[ENTER]	range = A

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STEP 3: Scroll the range to autorange (if necessary) and press [ENTER].

[ENTER]	mult = 1.000

The number displayed after the "mult =" prompt is the current value of the multiplier. Press [ENTER] without entering any other numbers if the value is already correct.

STEP 4: Enter calibration multiplier (-125.0 for this example) using the numbered keys.

[-] [1] [2] [5] [.] [0]	mult = -125.0
[ENTER]	label =

STEP 5: Enter UM for the label using the [↑] key to access the blue letters in the upper corners of the keys.

[↑] [2] [↑] [3]	label = UM
[ENTER]	ave = 1

The current label (if any) is always displayed with the label prompt. If the current label is correct, press [ENTER] to retain it.

STEP 6: Enter the average (60) using the numbered keys.

[6] [0]	ave = 60
[ENTER]	ch2 is OFF

Press [ENTER] without entering any numbers if the current value is correct.

Entering the average completes the configuration of channel 1. A prompt

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is displayed to indicate channel 2 (ch2) is either OFF, LIGHT, GEN, or THERM.

The configuration parameters for each of the 8 analog channels (ch1 - ch8) are identical. Steps 2 through 6 can be repeated for any of the eight analog channels. The LI-1000 will proceed sequentially through the configuration for each of the other 7 channels unless you either press CFG to exit *Configuration mode*, or skip to another channel by pressing CHAN.

NOTE: Pressing CFG in *Configuration mode* always results in exiting *Configuration mode* and returning to *Display mode*. All changes are retained, and all channels not edited are left unchanged. The LI-1000 will also automatically exit *Configuration mode* after configuring the math channel (chM) since it is the last channel in the configuration sequence.

LIGHT Sensor Channel Configuration in LOG Mode

The LIGHT channel configuration in *LOG mode* prompts for the range, multiplier, label, period, reset, threshold, store, tcoff, min/max, and min/max time stamp. The range, multiplier, and label prompts are the same as those discussed in *INSTantaneous mode* for light sensors. The others are discussed below.

LOGGING PERIOD: "per =" is a list of values which represent the length of the logging period in minutes. The period is also the time over which average or integrated values are calculated. When the display is scrolled, logging periods of 1, 5, 10, 15, 30, 60, 120, 180, 360, 720, and 1440 minutes are displayed.

The sampling interval is the frequency at which the LI-1000 "wakes up" to record data during the logging period. The sampling interval is 5 seconds for the 1, 5, 10, 15 and 30 minute periods, and is user-selectable at 5 or 60 seconds for the 60 through 1440 minute periods. Choosing the 5 second sample interval is advantageous since more samples are used in the data for each logging period. However, since the LI-1000 will be sampling much

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more often, the battery life will be decreased. For long term unattended monitoring applications, it is more advantageous to use the longer sampling intervals to extend the battery life.

If you choose the 1, 5, 10, 15, or 30 minute periods the sampling interval is automatically set at 5 seconds and the "interval =" prompt is not given.

RESET TIME: "reset =" is the reset time (24 hour clock) when the LI-1000 will begin the first logging period. The 4 digit number following "reset =" is the current value of the reset time in hours (HH) and minutes (MM), and HHMM is the format in which a new reset time must be entered.

IMPORTANT: Even though the LI-1000 begins logging data immediately after configuration is complete, *data is not stored until the reset time is reached for the first time*. For example, if the current time is 4:00 p.m. and you set the reset time for 6:00 a.m., all of the data collected before 6:00 a.m. tomorrow morning will not be stored. If you want to begin logging immediately, set the reset time for current time plus a few minutes (add enough time to finish the configuration).

Normally the reset time is set "on the hour" for hourly readings and at midnight for daily (24 hour) totals. The default reset time is 0000 (midnight).

The reset time also effects the storage capacity (Section III).

THRESHOLD: The "thr =" prompt is for the threshold value below which no data for that channel will be stored.

The threshold parameter is very useful for radiation sensors. By setting the threshold at a low value, the LI-1000 can be made to collect data during the day when the sensor output is high, but not at night when sensor output is below the threshold value. Storing only meaningful data points saves memory space.

For example, the hourly integrations of a pyranometer sensor will generally

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be over 150 Wh m^{-2} around midday on a sunny day, and will drop below 1 Wh m^{-2} at sunset. In this case the threshold could be set at 1 to prevent storage of night time readings.

For integrated data, the threshold should be based on the length of the period (e.g. a one day integration would have a different threshold than a 10 minute integration).

For applications where threshold is not important, it should be set at a large, negative number. The default value is -.1000E+10.

STORE: The "store =" parameter defines the form in which the data will be collected and stored.

The three values of the "store =" parameter are INT, MEAN, or PT. When "store = INT", the LI-1000 integrates the samples collected during the sample period. The time units are in hours.

When "store = MEAN", the LI-1000 will store a mean value (sum divided by the number of samples).

When "store = PT", the LI-1000 will store a point value (instantaneous reading) sampled at the end of the chosen period.

TCOFF: "tcoff =" (time coefficient) is a parameter needed to convert integrated data to the proper units when using certain sensors. Its use is best illustrated by the following example.

Consider an LI-190SA Quantum Sensor which is illuminated by a light source of variable intensity. If the average intensity over a defined period is, say, 1000 μmol s^{-1} m^{-2}, then the total quanta accumulated over the period is just the average intensity times the period duration. In the LI-1000, the period duration is always measured in hours. So, if the period in our example is 2 hours, then the total number of quanta is 1000 μmol s^{-1} m^{-2} x 2 hours = 2000 μmol hr s^{-1} m^{-2}. These mixed units can be reduced by multiplying by 3600 s hr^{-1} x 10^{-6} mol/μmol = 0.0036. This is "tcoff". The final answer

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is 7.2 mol m^{-2} as you can verify. Some typical values of "tcoff" for LI-COR radiation sensors are shown in Table 4.

Table 4. Common "tcoff" values for LI-COR Sensors

Sensor	Instantaneous Units	Integrated Units	tcoff 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
LI-210SA	lux	lux h	1

The "tcoff" prompt is given only when the store parameter is set to INT (integrate). If the store parameter is set for MEAN or PT, the LI-1000 will not prompt for the time coefficient (tcoff) because the data are not integrated over time.

MIN/MAX: The "min/max =" prompt allows you to choose whether to store the minimum and maximum data values that occur during the logging period.

"min/max =" is a list which scrolls between NO and YES. When "min/max" is YES, the minimum and maximum data points are stored in memory. To conserve memory, the min/max parameter should be set to NO if the min/max data points are not needed.

NOTE: If the "store" parameter is PT, the LI-1000 will not display the min/max prompt. PT stores only a point value at the end of the period.

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When collecting min/max values for radiation sensors that are exposed to solar radiation, you may notice that some maximum values appear very high. This phenomenon generally occurs under partly cloudy sky conditions and is caused by the forward scattering of solar radiation when the sun is near the edge of a cloud. Under these conditions, local radiation levels are higher that you would expect under full sunlight conditions.

MIN/MAX TIME STAMP: If the "min/max =" prompt is set to YES, then the "time stamp =" prompt is displayed before the channel configuration is completed. This prompt determines whether or not the time stamps for both the minimum and maximum data points will be stored with the data points. Again, not storing the time stamps for the min/max data points conserves memory space.

EXAMPLE #7: Configure channel 2 to collect and store hourly integrated values with the same LI-190SA Quantum Sensor used in Example #6. Logging should start at 6:00 a.m. tomorrow morning, and the maximum and minimum data values with their time stamps should be stored.

STEP 1: Enter *Configuration mode*, set the mode to *LOG mode*, and change the channel to channel 2.

Keystrokes	Resulting Display
CFG	mode is INST
↑	mode is LOG
ENTER	ch1 is LIGHT
CHAN	ch2 is OFF

CHAN is used to skip over a channel without changing its configuration. You can also press CHAN in the middle of channel configuration to move to the next channel and leave the rest of the configuration on the current channel the same.

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STEP 2: Change the channel configuration to the LIGHT channel configuration.

↑	ch2 is LIGHT
ENTER	range = A

STEP 3: Set Range to autorange.

ENTER	mult = 1.000

STEP 4: Enter -125.0 for the calibration multiplier (from example #6).

- 1 2 5 . 0	mult = -125.0
ENTER	label =

STEP 5: Enter a Label (UM).

↑ 2 ↑ 3	label = UM
ENTER	per = 1

STEP 6: Change the integration period to 60 for 60 minute (hourly) collection periods and set the sample interval to 60 seconds.

↑ ↑ ↑ ↑ ↑	per = 60
ENTER	interval = 5
↑	interval = 60
ENTER	reset = 0000 HHMM

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STEP 7: Set reset time for 6:00 a.m.

0 6 0 0	reset = 0000 0600
ENTER	thr = -1.000E+10

The current value of the reset time is displayed after the "reset =" prompt. It can be retained by pressing ENTER.

Reminder: The internal clock is a 24-hour clock (e.g. 7:00 p.m. = 19:00).

STEP 8: Press ENTER to leave the threshold value at the default number since no threshold was specified for this example.

ENTER	store = INT

STEP 9: Press ENTER to retain INT (integrate) as the method of data storage.

ENTER	tcoff = 1.000

STEP 10: Enter tcoff value of 0.0036 for units conversion.

0 . 0 0 3 6	tcoff = 0.0036
ENTER	min\max = YES

STEP 11: Scroll MIN/MAX to YES (if necessary) in order to store maximum and minimum values.

ENTER	time stamp = YES

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STEP 12: Scroll time stamp prompt to YES (if necessary) in order to store the time stamps of the maximum and minimum data points.

ENTER	ch3 is OFF

Hardware Configuration

The LI-1000 has two current channels for "SA" type radiation sensors located in the two BNC connectors at the top of the case. With the front panel face up and the display at the top, channel 1 is the left hand BNC connector, and channel 2 is the right hand BNC connector. The channel numbers are also indicated on the back panel.

Six additional current channels can be accessed through the 37-pin "D" connector using the 1000-05 Terminal Block or the 1000-06A AC Terminal

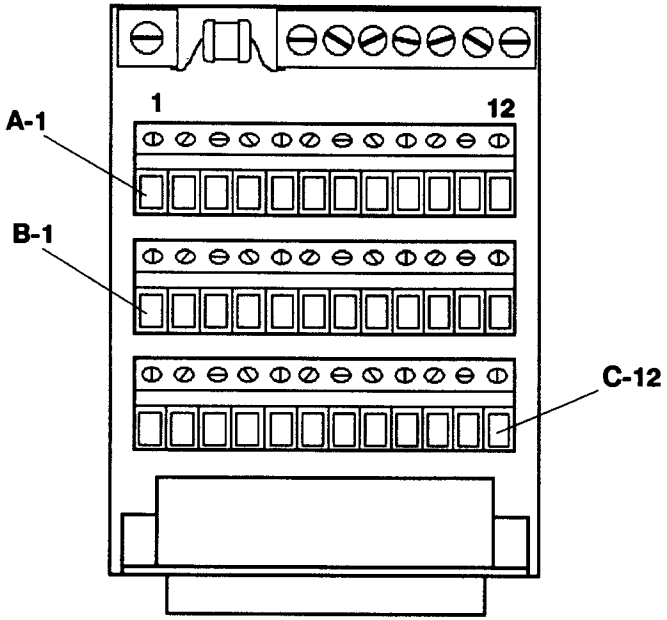


Figure 2. 1000-05 Terminal Block.

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Block. The 1000-05 and 1000-06A have three terminal blocks, a ground block, and a female 37 pin "D" connector which mates with the 37 pin male connector on the LI-1000 (Figure 2). Each terminal block has a row of terminals lettered A, B, or C. Each of the terminals are numbered 1 through 12 from left to right. The 1000-05 and 1000-06A have the same terminal locations for the current channels used with LI-COR radiation sensors. However, there are many differences between the 1000-05 and 1000-06A which are explained in Section IX.

To connect a LI-COR type "SZ" radiation sensor to channel 3 using the 1000-05 or 1000-06A, the shield of the coaxial cable (ground) is connected to terminal A-2, and the center conductor (signal current) to terminal A-1.

Table 5. Terminal Locations of Current Channels 3-8 (1000-05 or 1000-06A).

Channel Number	Terminal #
Channel 3 signal current	A-1
Channel 3 signal ground	A-2
Channel 4 signal current	A-4
Channel 4 signal ground	A-5
Channel 5 signal current	A-7
Channel 5 signal ground	A-8
Channel 6 signal current	A-10
Channel 6 signal ground	A-11
Channel 7 signal current	B-1
Channel 7 signal ground	B-2
Channel 8 signal current	B-4
Channel 8 signal ground	B-5

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Section V
Using the General
Channel Configuration

The general purpose channel configuration can accommodate the widest variety of sensors. Sensors commonly used with this configuration include low output impedance voltage sensors such as thermopile pyranometers, or non-linear thermistors for temperature measurement.

This section contains a discussion of the software features of the general channel configuration, followed by specific information on how to use LI-COR temperature thermistors.

General Channel Configuration In INSTantaneous Mode

The general purpose channel configuration is similar to the LIGHT and THERM configurations except that it has a fifth order polynomial for sensor input scaling or linearization.

The GEN channel configuration in *INSTantaneous mode* sequentially prompts for range, a0, a1, a2, a3, a4, a5, math, label, and average.

RANGE: The "range =" prompt is for the voltage or current measurement range. The range parameter scrolls between A, 1, 2, 3, or 4. "A" indicates autoranging in which the LI-1000 will select range 1, 2, 3, or 4 according to the level of the input signal. If 1, 2, 3 or 4 is chosen, the LI-1000 will use only that range. The current and voltage ranges (and resolutions) for each measurement range are given in Tables 2 and 3 (repeated below).

The range is often set at autorange (A) in order to cover the widest input signal range with the best resolution. For example, a sensor with a 1.5 volt

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output could be measured using voltage range 3 with a resolution of 0.25 millivolts. However if the output of that sensor dropped to 0.1 volts it could be more accurately measured using range 2 (25 microvolt resolution). If the autorange function is used, the range would automatically switch to range 2. If the standard range 3 is used, the signal would be measured using range 3 with lower resolution.

Table 2. LI-1000 Current Ranges

Range	Current Range	Resolution
1	± 200 nanoamps	25 picoamps
2	± 2 microamps	0.25 nanoamps
3	± 20 microamps	2.5 nanoamps
4	± 200 microamps	25 nanoamps

Table 3. LI-1000 Voltage Ranges

Range	Voltage Range	Resolution
1	± 20 millivolts	2.5 microvolts
2	± 200 millivolts	25 microvolts
3	± 2 volts	0.25 millivolts
4	± 20.0 volts	2.5 millivolts

There are also several applications where is is best not to use the autorange feature. In situations where the input signal fluctuates rapidly, the LI-1000 may not be able to find the range before the signal has changed. If this happens the LI-1000 will show all 9's on the display until the signal level stabilizes enough for the LI-1000 to find the range. To solve this problem, choose one of the standard ranges (1 - 4).

Choosing autorange also slows the rate at which the channels can be scanned. The scanning speed is slower because the LI-1000 must determine

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which of the four ranges to use before the measurement is taken. The normal scan time of approximately 0.25 seconds can increase to as much as 0.7 seconds.

If you chose a standard range which is to low for the sensor output the LI-1000 will overrange. This results in the LI-1000 displaying all 9's until the signal level decreased enough to be measured with the selected range.

CALIBRATION COEFFICIENTS: a0 through a5 are calibration coefficients of a fifth order polynomial:

$$Y = a0 + (a1)X + (a2)X^2 + (a3)X^3 + (a4)X^4 + (a5)X^5$$

where Y is the output of the sensor in the engineering units (e.g. W m^{-2}, °C, etc.), a0 through a5 are the coefficients of the polynomial which are unique for each sensor, and X is the actual current or voltage output of the sensor measured by the LI-1000.

Calibration coefficients are entered using characters 0 thru 9 plus a decimal point. If no decimal is entered, it is assumed to lie to the right of the entry (e.g. 900 = 900.). Similarly, if a negative sign is not enter it is assumed to be positive.

Four significant digits are displayed by the LI-1000 but calibration coefficients should normally be entered as 5 digit numbers.

The range of acceptable numeric entries is approximately 1×10^{20} to -1×10^{20}. The closest non-zero numbers to zero that can be entered are 1×10^{-20} and -1×10^{-20}. Data can also be entered in exponential format. For example, 2000 can be entered as 2E3. The E designates an exponent that is entered by pressing the **EEX** key followed by a 1 or 2 digit number representing an exponent of 10. The exponent is assumed to be positive unless entered as a negative number.

For linear sensors only coefficients a0 and a1 are used. (The output of a linear sensor is always directly proportional to the input over the entire measurement range.)

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The response curve for a linear sensor with zero offset is shown in Figure 3. The calibration equation for such a sensor is Y = a1X. a0 and a2 through a5 are zero. a1 is the slope of the line (the sensor calibration curve).

Figure 4 shows a linear sensor with a non-zero offset. The calibration equation for such a sensor is Y = a0 + a1X, where a0 is the offset from zero (Y intercept) and a1 is the slope of the line.

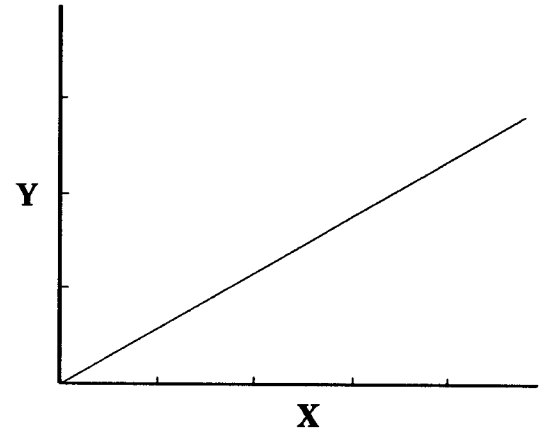


Figure 3. Response curve of a linear sensor no zero offset.

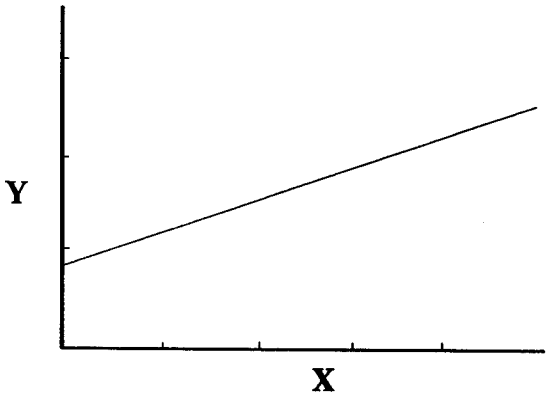


Figure 4. Response curve of a linear sensor with a non-zero offset.

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When the output of a sensor is non-linear, a graph of sensor response vs. input is a curve. (The output of a non-linear sensor is not directly proportional to the input). The calibration equation for a non-linear sensor is a polynomial that approximates the response curve of the sensor as closely as possible.

IMPORTANT: The LI-1000 reads current directly in microamps and voltage in units of 0.1 volts (unless you have added an external resistor to change the input impedance). When calculating the calibration coefficients these measurement units must be taken into account. For example, the calibration constant for a LI-COR LI-200SA Pyranometer sensor is typically 80 microamps, per 1000 Watts m^{-2}. Since the units are already given in microamps it is not necessary to convert the units before calculating the calibration multiplier (Section IV). However if the same calibration constant were given as 8.0×10^{-5} amps/1000 Watts m^{-2} it would have to be converted from amps to microamps before calculating calibration multiplier.

Voltage is measured in units of 0.1 volts. If a1 is set at 1, the LI-1000 would indicate 100 volts when a 10 volt source is connected. If a1 were set at 0.1 the display would correctly indicate that the signal was 10 volts. If a calibration constant is given in units of volts, the calibration multiplier (calculated from the calibration constant) must be divided by 10 before it is entered in the LI-1000.

Calibration Coefficients for Linear Sensors

The formula below can be used to calculate the calibration multiplier (a1) for linear sensors which don't have an offset.

$$\text{Multiplier} = \left(\frac{1}{\text{Calibration Constant}}\right)$$

This formula only applies if the calibration constant is given in the proper units (e.g. μAmps or 0.1 volts). If not, the calibration constant must be adjusted before using the equation.

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Example #8: Calculate the multiplier for an Eppley Precision Spectral Pyranometer (PSP) with a calibration constant of 9.0×10^{-6} volts/Watt m^{-2}. Since the calibration constant is given in units of volts, the calibration multiplier must be calculated using the above formula and then divided by 10 before entering the number in the LI-1000 as the calibration multiplier.

$$\text{Multiplier} = \left(\frac{1}{9.0 \times 10^{-6} \text{ volts/watt m}^{-2}}\right) = 1.1 \times 10^{5} \text{ watt m}^{-2}\text{/volt}$$

and $$\frac{1.1 \times 10^{5} \text{ watt}}{\text{m}^{-2}\text{/volt}} \times \frac{10^{-1} \text{ volt}}{(0.1 \text{ volt})} = 1.1 \times 10^{4} \text{ watt m}^{-2}\text{/(.1 volt)}$$

For linear sensors with a non-zero offset the calibration multiplier is calculated as shown above and entered as a1. In addition, the amount of the offset from zero is entered as a0. All other calibration coefficients would be zero. If there is a change in units a0 must be multiplied by the same factor as a1.

Calibration Coefficients for Non-linear Sensors

Non-linear sensors have a sensor response curve that can usually be represented by a polynomial. In many cases a calibration polynomial is supplied by the sensor manufacturer. If only a set of calibration points are given, the polynomial must be calculated by "fitting" a curve to the data points. If there are many calibration points, the curve fitting calculations quickly become very tedious and are usually accomplished by use of a computer. Software packages for statistical analysis usually contain curve fitting routines.

MATH: The "math =" prompt is for a math function that performs 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, the data from the channel being configured can be divided by data from a

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second channel resulting in a ratio of the two channels being displayed on the channel with the math function.

The math function is turned on by scrolling the display and choosing between "+" (addition), "-" (subtraction), "*" (multiplication), or "/" (division).

The first term in the arithmetic statement is always the data from the channel that is being configured. The second term in the statement is the data from the channel whose channel number is entered in response to the "using ch..." prompt. This prompt is a scrollable list from which you can select a channel number less than or equal to the channel being configured. Table 6 shows how the two terms relate to one another.

Table 6. Term assignment for the math function.

Operation	Current channel	"Using chx"
Addition	1st Addend	2nd Addend
Subtraction	Minuend	Subtrahend
Multiplication	1st Multiplicand	2nd Multiplicand
Division	Numerator	Denominator

The LI-1000 assumes that the channels selected for the arithmetic operation are turned ON and properly configured. After the number of the second channel for the math operation is entered, the LI-1000 prompts for the math calibration coefficients (b0, b1, b2, b3, b4, and b5). These are coefficients of a fifth order polynomial also of the form:

$$Y = b0 + (b1)X + (b2)X^2 + (b3)X^3 + (b4)X^4 + (b5)X^5$$

For the math calibration polynomial, X is the result of the math operation rather than the output of a single sensor and Y is the number that is displayed (or logged) as a result of both the math operation and the subsequent application of the math calibration polynomial.

For most applications (including LI-COR light sensors) b0, b2, b3, b4, and b5 are usually set at zero and b1 should be 1 (multiplies by 1).

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In *INSTantaneous mode*, the math function most commonly used to find the ratio of two sensors in which a calibration function is applied to each sensor first, and then the ratio is computed using the math channel.

IMPORTANT: When the math function is used for a particular channel, the result of the math channel is displayed and stored in memory in place of the data from the sensor that is connected to that channel. If you want to collect the data from both sensors and have the math data as additional information, you should use the math channel (chM) instead of the math function on the analog channels.

LABEL: "label =" is a prompt for a two character alpha or numeric label that is displayed with the output of a channel in *Display mode*. The label is also printed when data is output.

Letters in blue in the corners of the numbered keys are accessed by pressing the [↑] or [↓] key and then the key with the appropriate letter on it.

When viewing data stored in memory or viewing the output of a channel in *Display mode*, the label immediately follows the data value. The first character should be a letter or a space to eliminate confusion with the data value.

AVERAGE: The "ave =" prompt is used to display either an instantaneous readout of the sensor output, or a continuous running average.

Any integer greater than or equal to 1 can be used for the average. However, in practice the average is limited by the available memory. When the memory is full, it is only possible to get a total of 33 seconds of averaging time (i.e. 26 second average on one channel and a one second average on each of the other channels). Also, if you set the average to a very high number, all available memory is used for the average, leaving none for data storage. In this situation, if you try to store data, the message "DATA NOT STORED" will be displayed. If an average is entered that would require more memory than is available, the averages will automatically be changed, and a message indicating the changes will be displayed.

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Each integer in the average represents one second. If 1 is chosen, the output of the channel is displayed as an instantaneous value that is updated every second. If a number N is chosen such that N > 1, the display will still update every second but the number displayed will be the continuous running average of instantaneous readings for the past N seconds.

For example, if 30 were entered for the average, the number displayed is the average of the instantaneous data points for seconds 1 through 30. When the display updates after 1 second, the number displayed is the average of seconds 2 through 31, followed by 3 through 32, etc. The number displayed will not represent a 30 second average until 30 seconds have elapsed since you exited *Configuration mode* (after 5 seconds, its a 5 second average, etc.)..

The average function is advantageous 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 the resolution because of the higher number of samples used in the average.

Example #9: Configure channel 2 to display the instantaneous output of a 1000-16 Air Temperature Sensor whose calibration coefficients are given below. (Detailed information on LI-COR temperature thermistors is found later in this section).

a0 = - 83.370
a1 = 3.4948
a2 = - .078427
a3 = .0010130
a4 = - 6.4891E-6
a5 = 1.6748E-8

STEP 1: Enter *Configuration mode*, select *INSTantaneous mode* and start at channel 1.

CFG	mode is INST
ENTER	ch1 is OFF

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STEP 2: Scroll the channel status to GEN (general configuration).

↑ ↑	ch1 is GEN
ENTER	range = A

STEP 3: Set range at autorange (A).

ENTER	a0 = 0.0

STEP 4: Enter calibration coefficients a0 - a5 .

- 8 3 . 3 7 0	a0 = -83.370
ENTER	a1 = 1.000
3 . 4 9 4 8	a1 = 3.4948
ENTER	a2 = 0.0
- . 0 7 8 4 2 7	a2 = -.078427
ENTER	a3 = 0.0
. 0 0 1 0 1 3 0	a3 = .0010130
ENTER	a4 = 0.0
- 6 . 4 8 9 1 EEX - 6	a4 = -6.4891E-6

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ENTER	a5 = 0.0
1 . 6 7 4 8 EEX - 8	a5 = 1.67478E-8
ENTER	math = OFF

STEP 5: Leave the math function in its default state (OFF).

ENTER	label =

STEP 6: Enter "C" for the label to signify °C.

↑ 4	label = C
ENTER	ave = 1

STEP 7: Enter 1 as the average in order to display an instantaneous readout.

ENTER	ch2 is OFF

STEP 8: Exit *Configuration mode*.

CFG	1I 0.0

General Channel Configuration In LOG Mode

The GEN channel configuration in *LOG mode* sequentially prompts for range, a0, a1, a2, a3, a4, a5, math, label, period, reset, threshold, store, tcoff,

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max/min, and the max/min time stamps.

The range, a1, a2, a3, a4, a5, and label prompts are the same as described above in the *INSTantaneous mode* discussion. The math, period, reset, threshold, store, tcoff, min/max, and min/max time stamps are described below.

MATH: In *LOG mode* the math function is used for a different purpose than either the math function in *Instantaneous mode* or the Math Channel. The math function allows the input of one channel to be transferred to another channel where it can be treated according to a second configuration. The prompts for the math operation (+, -. * or /) and the math calibration coefficients are the same, but they are used for a different purpose.

To illustrate the use of the math function, lets assume that there is a pyranometer sensor connected to channel 1 and that it is configured to collect 24 hour totals of solar radiation. Using the math function you can configure channel 2 (or any of the other analog channels) to collect 1 hour averages using the same sensor input. To accomplish this you would set the calibration coefficients of channel 2 to zero and then add channel 1 using the math function. The coefficients of the math calibration polynomial would all be zero except of b1 which would be 1. The logging periods, reset times, mode of data storage, or any of the other parameters can be changed on the second channel to collect data in a different way.

To illustrate an incorrect usage of the math function, lets consider two radiation sensors that are collecting integrated data for 1 hour periods. If you tried to use the math function to collect a simple ratio of the channels, the result will be that you will collect an integrated ratio. The reason is as follows. The math function is set to integrate because the channel on which it is used (one of the sensor channels) is set to integrate. Each time the LI-1000 samples data it would divide the instantaneous output of the two channels and use the result in the integration. At the end of the period the integrated ratio is stored as the data for the channel which has the math function turned on. Although this configuration will result in storing a meaningless data point, if the min/max values are collected they will accurately reflect the highest and lowest ratio's during the collection period.

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The math function differs from the math channel in that the math function samples the channel input of the second channel (instantaneous sensor output), and the math channel samples the channel output (current integration, average, etc.).

PERIOD: "per =" is a list of values which represent the length of the logging period in minutes. The period is also the length of time over which the average or integrated values are calculated. When the display is scrolled, logging periods of 1, 5, 10, 15, 30, 60, 120, 180, 360, 720, and 1440 minutes are displayed. The sampling interval is 5 seconds for the 1 to 30 minute periods, and it can be set to 5 or 60 seconds for the 60 through 1440 minute periods. (Sampling interval is the frequency at which the LI-1000 will "wake-up" and sample the channels during a logging period, e.g. every 5 seconds).

If the period is set to 60 minutes or longer the prompt "interval = " is given which scrolls between 5 and 60 seconds. Normally the interval is set to 60 unless sensor outputs are frequently changing during the logging period. With radiation sensors for instance, it is sometimes advantageous to use the shorter sampling interval.

Choosing the 5 second sampling interval will decrease the battery life because the LI-1000 must be turned on and sampling at more frequent intervals. For long term logging where rapid sampling is not needed, the interval should be set at 60 to improve the battery life.

RESET: "reset =" is the reset time (24 hour clock) when the LI-1000 will begin the first logging period. The 4 digit number following "reset =" is the current value of the reset time in hours (HH) and minutes (MM), and HHMM is the format in which a new reset time must be entered.

IMPORTANT: The reset time is very important if you want the LI-1000 to begin logging immediately or at a specific time. For example, if the current time is 5:00 p.m. and the reset time is set for 5:00 a.m., all of the data collected before 5:00 a.m. tomorrow morning will not be stored even though the LI-1000 appears to be logging data. The LI-1000 does not store any data until the reset time is reached for the first time.

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Normally the reset time is set "on the hour" for hourly readings and at midnight for daily (24 hour) totals. The default reset time is 0000 (midnight). The reset time also effects the storage capacity (Section III).

THRESHOLD: "thr =" is the threshold value below which no data for that channel will be stored.

By setting the threshold at an appropriate value, the LI-1000 can be made to store data only when it is above a certain threshold level. For example, if you are collecting hourly averages of ambient temperature but don't want to store any data when the average temperature is below 10 °C, the threshold value could be set at 10.

For integrated data, the value that is set should be based on the length of the period (e.g. a one day integration might have a different threshold than a 10 minute integration).

For applications where threshold is not important, it should be set at a large, negative number. The default value is -.1000E+10.

STORE: The "store =" parameter defines the form in which the data will be collected and stored.

The three values of the "store =" parameter are INT, MEAN, or PT. When "store = INT", the LI-1000 will store an integrated value. The time units are in hours.

When "store = MEAN", the LI-1000 will store a mean value (sum divided by the number of samples).

When "store = PT", the LI-1000 will store a point value (instantaneous reading) sampled at the end of the chosen period.

Tcoff: "tcoff =" (time coefficient) is a parameter needed to convert integrated data to the proper units when using certain sensors. Its use is best

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illustrated by the following example.

Consider an LI-190SA Quantum Sensor which is illuminated by a light source of variable intensity. If the average intensity over a defined period is, say, 1000 μmol s^{-1} m^{-2}, then the total quanta accumulated over the period is just the average intensity times the period duration. In the LI-1000, the period duration is always measured in hours. So, if the period in our example is 2 hours, then the total number of quanta is 1000 μmol s^{-1} m^{-2} x 2 hours = 2000 μmol hr s^{-1} m^{-2}. These mixed units can be reduced by multiplying by 3600 s hr^{-1} x 10^{-6} mol/μmol = 0.0036. This is "tcoff". The final answer is 7.2 mol m^{-2} a you can verify. Some typical values of "tcoff" for LI-COR radiation sensors are shown in Table 4.

The "tcoff" prompt is given only when the store parameter is set to INT (integrate). If the store parameter is set for MEAN or PT, the LI-1000 will not prompt for the time coefficient (tcoff) because the data are not integrated over time.

MIN/MAX: The "min/max =" prompt allows the user to choose whether to store the minimum and maximum data values that occur during the logging period.

"min/max =" is a list which scrolls between NO and YES. When "min/max" is YES, the minimum and maximum data points are stored in memory. To conserve memory, the min/max parameter should be set to NO if the min/max data points are not needed.

NOTE: If PT was chosen as the "store" parameter the LI-1000 will not display the min/max prompt. PT stores only a point value at the end of the period.

MIN/MAX TIME STAMP: If the "min/max =" prompt is set to YES, then the "time stamp =" prompt is displayed before the channel configuration is completed. This prompt determines whether or not the time stamps for both the minimum and maximum data points will be stored with the data points. Again, not storing the time stamps for the min/max data points conserves memory space.

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Example #10: Configure channel 2 to collect averaged readings over 10 minute logging periods for the same type of thermistor used in Example #9 (e.g. use the same calibration coefficients). Data collection should begin at 2:00 p.m.

STEP 1:
Enter *Configuration mode*, select *LOG mode*, and start the configuration at channel 2.

CFG	mode is INST
↑	mode is LOG
ENTER	ch1 is OFF
CHAN ENTER	ch2 is OFF

STEP 2: Change the status prompt of channel 2 to GEN.

↑ ↑	ch2 is GEN
ENTER	range = A

STEP 3: Set range at autorange (A).

ENTER	a0 = 0.0

STEP 4: Enter calibration coefficients a0 - a5 .

- 8 3 . 3 7 0	a0 = -83.370

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ENTER	a1 = 1.000
3 . 4 9 4 8	a1 = 3.4948
ENTER	a2 = 0.0
- . 0 7 8 4 2 7	a2 = -.078427
ENTER	a3 = 0.0
. 0 0 1 0 1 3 0	a3 = .0010130
ENTER	a4 = 0.0
- 6 . 4 8 9 1 EEX - 6	a4 = -6.4891E-6
ENTER	a5 = 0.0
1 . 6 7 4 8 EEX - 8	a5 = 1.67478E-8
ENTER	math = OFF

STEP 5: Leave the math function OFF since no math operation was specified.

ENTER	label =

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STEP 6: Enter C for the label to signify °C.

↑ 4	label = C
ENTER	per = 1

STEP 7: Change the period prompt to 10 for 10 minute collection periods.

↑ ↑	per = 10
ENTER	reset = 0000 HHMM

STEP 8: Set reset time for 2:00 p.m.

1 4 0 0	reset = 0000 1400
ENTER	thr = -1.000E10

Reminder: The internal clock is a 24-hour clock (e.g. 2:00 p.m. = 14:00).

STEP 9: Leave the threshold value at the default number. No threshold was specified for this example.

ENTER	store = INT

STEP 10: Change the "store = " prompt to MEAN (average).

↑	store = MEAN
ENTER	min/max = YES

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STEP 11: Scroll MAX/MIN to YES (if necessary) in order to store maximum and minimum values.

ENTER	time stamp = NO

STEP 12: Scroll time stamp prompt to NO to prevent the time stamps of the min/max data points from being stored.

↑	time stamp = NO
ENTER	ch2 is OFF

STEP 13: Press CFG to exit configuration mode

CFG	2M 25.0C

Using LI-COR Temperature Sensors

LI-COR temperature sensors for use with the LI-1000 include the 1000-15 Soil Temperature Sensor, the 1000-16 Air Temperature Sensor, and the 1000-16-2 Air Temperature Sensor. Each of these sensors can be used with the 1000-14 Sensor Connection Cable, the 1000-05 Terminal Block, or the 1000-06A AC Terminal Block. These sensors cannot be used with the 1000-10.

Connecting the Temperature Sensors. Each sensor has an adapter plug that is terminated with two bare wire leads which allows connection to a terminal block. The red lead contains a 33.2K precision resistor and is connected to the current input terminal for the channel being used. The black lead is connected to terminal C-9 on the 1000-05 or C-10 on the 1000-06A, which is a 5 volt power supply. Any of the temperature sensors (1000-15, 1000-16, or 1000-16-2) can be connected in this manner. When using these sensors with the 1000-14 Sensor Connection Cable, the adapter

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plug should be removed. See Section IX for a complete description of the 1000-14.

Installation of the 1000-15 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 ($\leq$10 cm) there are some practical considerations which should be observed. At depths less that 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).

If using the 1000-08 Instrument Enclosure, the cable of the 1000-15 can be run up through the bottom of the enclosure and connected to the LI-1000.

Installation of the 1000-16-2 Air Temperature Sensor. The 1000-16-2 Air Temperature sensor mounts in a hole in the bottom of the 1000-08 Instrument Enclosure. It is held in place by two mounting collars which slide along the shaft of the sensor. Take off one of the collars and put the temperature sensor through the hole in the bottom of the enclosure. Replace the collar and so that one is on either side of the bottom and the tip of the air temperature sensor is one inch from the bottom of the enclosure. In this position, the sensor will be correctly shaded by the shade ring and still have good air circulation around it. If the 1000-08 is not used, the sensor should be mounted so it will be shaded during the entire day and has good air circulation.

Installation of the 1000-16 Air Temperature Sensor. Like the 1000-16-2, the 1000-16 should be mounted such that it is shaded from direct sunlight throughout the day and has good air circulation. If you are using the 1000-06A with the 1000-08 Instrument Enclosure, it is best to run the cable up through the bottom of the enclosure for connection to the LI-1000.

Sensor Calibration. LI-COR Temperature sensors are manufactured using non-linear thermistors. They are calibrated by calculating a polynomial which represents its response curve. Several sets of calibration coefficients for various temperature ranges are given in Appendix F.

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The calibration coefficients in Appendix F apply to all LI-COR thermistor type temperature sensors including the 1000-15, 1000-16, and 1000-16-2. The user should choose the set of calibration coefficients which best fits his climatic temperature range while taking note that some of the sets of coefficients fit the sensor response curve better that others (e.g. some have a smaller RMS error that others). Both the error and temperature range should be kept in mind when choosing a set of coefficients.

NOTE: The RMS errors given in Appendix F represent only the error contributed by the polynomial. The overall error for LI-COR temperature thermistors is +/- 0.5 °C at 25 °C.

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Section VI
Thermocouple Measurements

The thermocouple channel configuration in the LI-1000 allows type T, J, E, K, R and S thermocouples to be measured using the 1000-10 Thermocouple Terminal Block. This section describes both the software operation and hardware configuration as it applies to thermocouple measurement. For additional functions available on the 1000-10 consult Section IX.

Theory of Operation

The following discussion is a very brief and generalized description of thermocouple measurement. For more complete information, several references are given in Appendix E.

A thermocouple is manufactured by joining two dissimilar metal wires at one end. When the junction is heated a potential difference is created across the two free ends. This potential difference (called the Seebeck voltage) is a function of the junction temperature and the composition of the metals.

Measurement of this Seebeck voltage is not as easy as it would first appear. If a voltmeter is connected to the thermocouple wires, the voltmeter's leads act as two new thermocouple leads and any measurement is erroneous. This problem can be solved by the configuration shown in Figure 5.

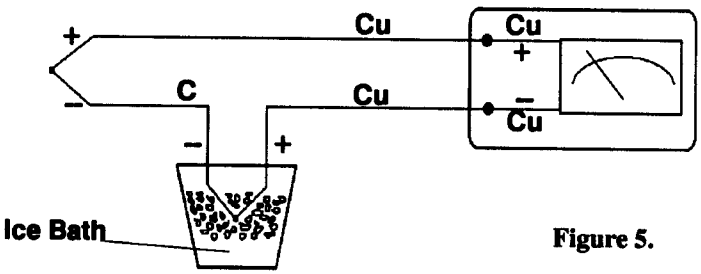


Figure 5.

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In this configuration there are two important things to notice. The first is that the two copper-constantan thermocouples are configured such that the two constantan leads are connected together and the copper leads are connected to the copper voltmeter terminals. There is only one new thermocouple junction in this configuration.

The second important feature in this hypothetical set-up is that the new junction is immersed in an ice bath. The voltage that the voltmeter reads is now equal to the measurement thermocouple voltage minus the ice bath thermocouple voltage. By adding the thermocouple in the ice bath, the voltage output is now referenced to 0 °C. The ice point is used by the National Bureau of Standards (NBS) as the fundamental reference point for their thermocouple tables so the measured voltage can be converted directly to temperature using an NBS table for the type of thermocouple in use.

The circuit in Figure 5 can be generalized as follows to eliminate the unwieldy ice bath.

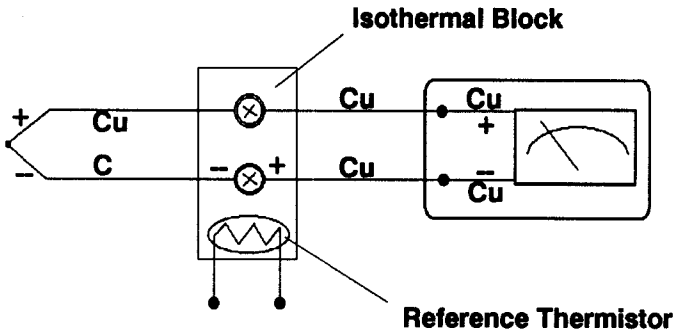


Figure 6.

Here the constantan-copper reference junction has been placed on an isothermal block in which the connecting junctions are at the same temperature but are electrically isolated. No voltage is generated by the copper-copper junction, but a potential which varies with the temperature of the block is generated at the constantan-copper junction. If the block temperature is 0 °C then the measured voltage of the circuit in Figure 6 will be the same as that in Figure 5.

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If the temperature of the block in Figure 6 is different from zero but is measured with a thermistor, then the voltage of the constantan-copper reference junction on the block can be calculated from a calibration polynomial which is derived from standard NBS tables relating temperature to voltage for that particular junction.

In that case, the circuit output voltage will equal the difference between the voltages generated by the measuring junction and the reference junction. The measuring junction voltage can then be computed and its temperature calculated.

Not all thermocouples have copper as one of their leads. The example in Figure 7 uses a chromel-constantan thermocouple. Notice that there are now two junctions on the isothermal block: copper-constantan and chromel-copper. It can be shown that these two opposing junctions (at the same reference temperature) are equivalent to one chromel-constantan junction at the reference temperature.

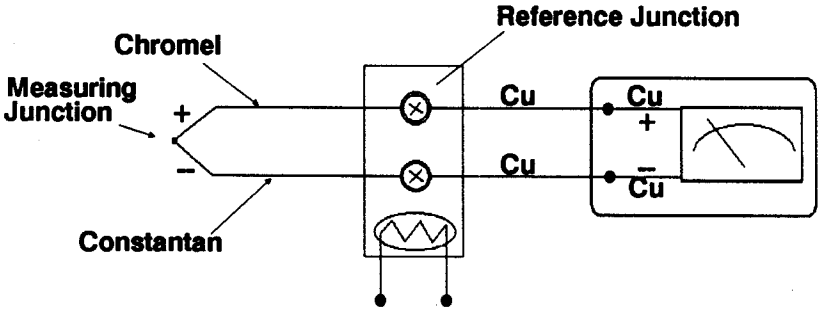


Figure 7.

So, regardless of the type of thermocouple being used, the circuit output voltage is equal to the difference between the temperature-dependent voltage generated by the measuring junction and the voltage of that same type of thermocouple at the known reference temperature. In summary then, for a given thermocouple, the reference voltage is computed from the reference temperature, the measuring junction voltage is computed as the output voltage minus the reference voltage, and the measuring junction temperature is calculated from the junction voltage.

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The LI-1000 uses a configuration similar to those shown in Figures 6 and 7. Calibration polynomials relating temperature to voltage and voltage to temperature for each of the major types of thermocouples (E, J, K, R, S and two sets for type T (T and t)) are stored in the memory of the LI-1000. When a thermocouple type is selected in software the correct calibration functions are automatically applied.

Error Analysis

There are a number of sources of error when measuring thermocouples. A summary of the sources of errors as they apply to the LI-1000 when used with the 1000-10 are given below.

1) Errors due the thermocouple itself (non-homogeneous composition of the wire, etc.).
2) Accuracy of the reference thermistor (± 0.1 °C for the 1000-10).
3) Age of the reference thermistor
4) Curve fit for the reference thermistor.
5) Significant digits used in the LI-1000's math.
6) The curve fit of the measurement thermocouple.
7) Curve fit of the reference junction thermocouple.
8) Temperature gradients in the reference block.
9) Noise in the LI-1000 measurement electronics.
10 Overall error from the LI-1000.

Table 7 contains the typical errors and the maximum errors expected for each thermocouple type over the indicated temperature range.

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Table 7. Thermocouple Error Specifications			
Type	**Temperature Range (°C)**	**Maximum Error (°C)**	**Typical Error (°C)**
Copper-Constantan (t)	-50 to 70	1.76	± 0.80
Copper-Constantan (T)	-100 to 300	2.88	± 0.90
Iron-Constantan (J)	0 to 760	6.87	± 2.25
Chromel-Constantan (E)	-50 to 300	4.00	± 1.75
Chromel-Alumel (K)	-50 to 300	5.57	± 2.25
Platinum-13% Rhodium (R)	-50 to 800	15.6	± 5.00
Platinum-10% Rhodium (S)	-50 to 800	13.7	± 5.00

Hardware Configuration

The 1000-10 Thermocouple Terminal Block contains 5 sets of terminals used to connect thermocouples and a terminal block with 12 terminals used for other functions (see Section IX).

The copper block that is attached to the circuit board has five terminals which connect to the negative lead of the thermocouple. The copper block also houses the reference thermistor. On top of the block are five copper posts that are electrically isolated from the copper block. The positive lead of the thermocouple is attached to the post that corresponds to the negative terminal. Figure 8 shows the locations of each channel on the terminal block.

Table 8 indicates which lead is positive and which is negative for the six thermocouple linearizations contained in the LI-1000's memory.

For example, to connect a type T thermocouple to channel 4, the copper lead is attached to the copper post on the left side of the terminal block, and the constantan lead is attached to the negative terminal on the copper block.

NOTE: If the thermocouple is connected with the polarity backwards the

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result will be that you will see temperature decreases when you would expect increases.

Table 8. Polarity of Thermocouple leads.

Type	Positive lead	Negative lead
J	Iron	Constantan
E	Chromel	Constantan
R	Platinum	Platinum + 13% Rhodium
S	Platinum	Platinum + 10% Rhodium
K	Chromel	Alumel
T, t	Copper	Constantan

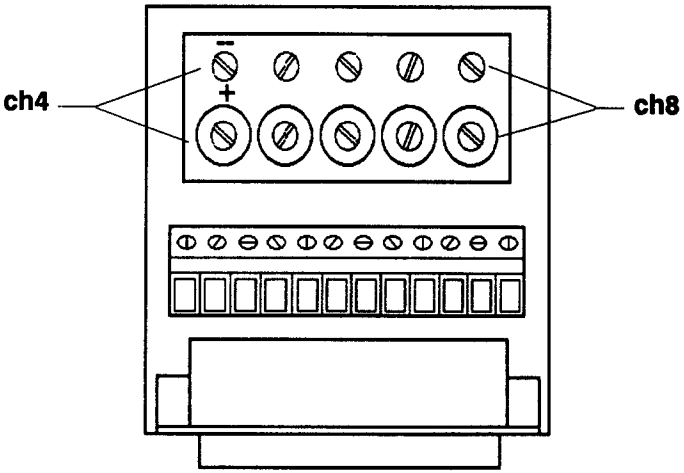


Figure 8. The 1000-10 Thermocouple Terminal Block

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Set-up Considerations

As indicated in the theory section, the LI-1000 assumes that the copper block to which the thermocouples are connected is in an isothermal condition. It is important to keep the 1000-10 shielded from any heat source which could create a temperature gradient across the copper terminal block. This is particularly important when working in sunlight where direct sun can rapidly create a thermal gradient. The white protective shield will help to minimize thermal gradients and should always be replaced after the thermocouples have been connected.

Thermocouple Channel Configuration

The Thermocouple channel configuration allows a channel to be rapidly configured for measurements of thermocouples. It includes a choice of 7 standard thermocouple calibration polynomials and prompts for the channel number to which the reference junction is connected.

Thermocouple Channel Configuration in INSTantaneous Mode

The THERM channel configuration in *INSTantaneous mode* sequentially prompts for range, resistance, reference channel, type of thermocouple, offset, label, and average.

RANGE: The "range =" prompt is used to set the range of the measurement electronics. The range parameter scrolls between A, 1, 2, 3, or 4. "A" indicates autoranging in which the LI-1000 will select range 1, 2, 3, or 4 according to the level of the input signal. If 1, 2, 3 or 4 is chosen, the LI-1000 will use only that range. The voltage range and resolution for each measurement range are given in Table 9.

For temperatures below 260 °C the output of most common thermocouples is below 20 millivolts. For these conditions the range of the LI-1000 can be set to range 1. When working at high temperatures with the range set at 1,

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the LI-1000 may overrange and display all nines. If this occurs the range can be changed to autorange or the next highest standard range (2, 3, etc.).

Table 9. LI-1000 Voltage Ranges

Range	Voltage Range	Resolution
1	± 20 millivolts	2.5 microvolts
2	± 200 millivolts	25 microvolts
3	± 2.0 volts	0.25 millivolts
4	± 20.0 volts	2.5 millivolts

RESISTANCE: The default value for the resistance is 100.0. The default value represents the 100k ohm input impedance of the LI-1000. When using long thermocouples, the resistance of the thermocouple wires will increase the input impedance. This is particularly true when using very thin thermocouples. Table 10 lists the thermocouple resistance (in ohms/double foot) for most of the common thermocouple wire gauges. (A thermocouple that is one double foot in length, has two 12 inch lengths of wire that are connected at the junction.)

Using the information in Table 10 the true resistance (R) can be computed by the following formula

$$R = 100 + \frac{\text{(ohms/double foot)(length in double feet)}}{1000}$$

For example, if you are using a 0.003", Type E thermocouple that is 3 feet long then

$$R = 100 + \frac{(73.57)(3)}{1000} = 100.22071$$

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Table 10. Thermocouple Wire Size and Resistance.
(Ohms / double foot)

AWG No.	Diam inches	Type					
		T	J	E	K	S	R
6	0.162	0.012	0.014	0.027	0.023	0.007	0.007
8	0.128	0.019	0.022	0.044	0.037	0.011	0.011
10	0.102	0.029	0.034	0.069	0.058	0.018	0.018
12	0.081	0.046	0.054	0.109	0.091	0.028	0.029
14	0.064	0.074	0.087	0.175	0.146	0.045	0.047
16	0.051	0.117	0.137	0.276	0.230	0.071	0.073
18	0.040	0.190	0.222	0.448	0.374	0.116	0.119
20	0.032	0.298	0.357	0.707	0.586	0.185	0.190
24	0.0201	0.7526	0.878	1.78	1.490	0.464	0.478
26	0.0159	1.204	1.405	2.836	2.381	0.740	0.760
30	0.0100	3.043	3.551	7.169	5.984	1.85	1.191
32	0.0080	4.758	5.599	11.31	9.524	1.96	3.04
34	0.0063	7.66	8.946	18.09	15.17	4.66	4.82
36	0.0050	12.17	14.20	28.76	24.08	7.4	7.64
38	0.0039	19.99	23.35	45.41	38.20	11.6	11.95
40	0.00315	31.64	37.01	73.57	60.88	18.6	19.3
44	0.0020	76.09	88.78	179.2	149.6	74.0	76.5
50	0.0010	304.3	355.1	716.9	598.4	185	191
56	0.00049	1217	1420	2876	2408	740	764

The value that is entered for resistance should be entered as a 5 digit number even though the LI-1000 will only display it as a 4 digit number.

In general, if the resistance when measuring the thermocouple is less than 100.1001 (0.1% error) the resistance value can be left at 100.

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REFERENCE CHANNEL: The reference channel is the number of the channel which will be used to receive input from the reference thermistor and to calculate the corresponding reference junction voltage. The 1000-10 Thermocouple Block always uses channel 3 as a reference.

The reference channel is always assumed to be a channel number below the channel being configured. Since channels 4 through 8 are available for thermocouple inputs and the reference is channel 3, this generally works out correctly. You will note, however, that you cannot scroll to a channel number higher than the current channel. So, if you try to configure channel 1 as a thermocouple channel, you can choose only channel 1 as the reference and that will not work. Channels 1 through 3 are not normally used for thermocouples.

IMPORTANT: In *LOG mode*, the reference channel should be configured with the same reset times, logging periods, sampling intervals, and thresholds as the THERM channel.

The reference junction temperature of the 1000-10 Thermocouple Block is measured with a non-linear thermistor. When using the 1000-10, the polynomial coefficients needed to calibrate the thermistor must be entered on channel 3 using the GENeral channel configuration (Section V). The calibration coefficients used in the calibration polynomial for the reference thermistor are given below.

a0 = -112.50
a1 = 4.9571
a2 = -0.10598
a3 = 0.0012529
a4 = -7.4253E-6
a5 = 1.7952E-8

When a temperature measurement is made using the 1000-10, the temperature of the reference thermistor is measured and converted to an equivalent reference junction voltage for the thermocouple type being measured. The measuring junction voltage is then calculated by subtracting the reference voltage from the voltage measured by the LI-1000 and it is converted to a temperature using the appropriate calibration polynomial stored in the LI-1000's memory.

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THERMOCOUPLE TYPE: Calibration functions for type J, E, R, S, K and two calibration functions for type T (T and t) thermocouples are stored in memory.

J = Iron vs. Constantan
E = Chromel vs. Constantan
R = Platinum vs. Platinum + 13% Rhodium
S = Platinum vs. Platinum + 10% Rhodium
K = Chromel vs. Alumel
T = Copper vs. Constantan
t = Copper vs. Constantan

The two type T thermocouple calibration functions cover different temperature ranges with different accuracies. Type t covers a temperature range of -50 to 70 °C with an accuracy of ± 0.8 °C. Type T covers a temperature range of -100 to 300 °C with an accuracy of ± 0.9 °C. The thermocouple type is selected by scrolling to the appropriate letter that represents the thermocouple type.

Due to the wide variety of thermocouple types and styles, the thermocouple manufacturers product information is the best source of information for selecting a thermocouple for your application. There are several considerations which should be kept in mind. When using the 1000-10 Thermocouple Block you should use single junction thermocouples that have a bare wire termination. There are a variety of configurations for the junction (bare, encapsulated in a probe, cement on types for surface mounting, etc.) and for the wire insulation (bare, teflon coated, glass braid, etc.). The gauge of the thermocouple wire and the environment it will be subjected to, should also be considered. If you choose a very fine thermocouple it will have a very fast response time but may break easily.

The names of two suppliers of thermocouples for industrial and scientific applications are given below and a large number of others can be found in the various guides to scientific instruments that are published.

Omega Engineering, Inc.
One Omega Drive
Stamford, Connecticut 06907-0047, U.S.A
(203) 359-1660

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Thermometrics, Inc.
808 U.S. Highway 1,
Edison, N.J. 08817
(201) 287-2870

OFFSET: The thermocouple offset is used to compensate for any differences between the thermocouple and the reference thermistor when both are at the same temperature. The offset is added to the final reading after all other math, calibrations, etc. have been completed.

In general the offset between the thermocouple and the reference thermistor changes very little with time. When a thermocouple is first connected the offset should be measured and compensation made as necessary. After that, it may be necessary to check the offset only when setting-up a new configuration or periodically when measurements are made for a long period of time.

When using the 1000-10 the offset is be determined by the following steps.

1) Set the offset to 0.0
2) Place the thermocouple on the reference block and make sure there is good contact between the them.
3) Allow the temperature to stabilize (20 to 30 minutes with no air movement).
4) Read the reference channel value (°C) and subtract the thermocouple value (°C). Enter this value as the offset.

NOTE: The value of the offset entered should be in °C.

LABEL: The "label =" prompt in the thermocouple channel configuration operates somewhat differently than in the other channel configurations. It is used to select a readout in degrees celsius (°C), Fahrenheit (°F), or Kelvin (°K). The label is not entered by typing in an appropriate label (as with the other channel configurations) but is selected from a scrollable list containing the letters C, F, and K.

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When data stored in memory is printed, this label is printed with the data. When viewing data stored in memory or viewing the output of a channel in *Display mode*, the label immediately follows the data value.

AVERAGE: The "ave =" prompt is used to display either an instantaneous readout of a thermocouple, or a continuous running average.

Any integer greater than or equal to 1 can be used for the average. However, in practice the average is limited by the available memory. When the memory is full, it is only possible to get a total of 33 seconds of averaging time (i.e. 26 second average on one channel and a one second average on each of the other channels). Also, if you set the average to a very high number, all available memory is used for the average, leaving none for data storage. In this situation, if you try to store data, the message "DATA NOT STORED" will be displayed. If an average is entered that would require more memory than is available, the averages will automatically be changed, and a message indicating the changes will be displayed.

Each integer in the average represents one second. If 1 is chosen, the output of the channel is displayed as an instantaneous value that is updated every second. If a number N is chosen such that N > 1, the display will still update every second but the number displayed will be the continuous running average of instantaneous readings for the past N seconds.

For example, if 30 were entered for the average, the number displayed is the average of the instantaneous data points for seconds 1 through 30. When the display updates after 1 second, the number displayed is the average of seconds 2 through 31, followed by 3 through 32, etc. The number displayed will not represent a 30 second average until 30 seconds have elapsed since you exited configuration mode (after 5 seconds, its a 5 second average, etc.).

The average function is advantageous 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 the resolution because of the higher number of samples used in the average.

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EXAMPLE #11: Configure channel 4 to display an instantaneous readout of a type E thermocouple in degrees Kelvin. Assume the reference junction potential is computed in channel 3 and that the thermocouple is connected to channel 4. Assume there is no zero offset for this thermocouple.

STEP 1: Enter *Configuration mode*, select *INSTantaneous mode*, and start the configuration at channel 4.

CFG	mode is INST
ENTER	ch1 is OFF
CHAN CHAN CHAN	ch4 is OFF

If the mode is not already set to INST, you will have to scroll the display before pressing ENTER.

STEP 2: Change the status prompt of channel 4 to the THERM channel configuration.

↑ ↑ ↑	ch4 is THERM
ENTER	range = A

STEP 3: Set Range to range 1.

↑	range = 1
ENTER	res = 100.0

STEP 4: Use the default resistance value of 100K Ohms. (Assume the thermocouple is short and errors are low).

ENTER	ref ch1

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STEP 5: Scroll the display until channel 3 is displayed for the reference channel.

[↑] [↑]	ref ch3
[ENTER]	type = t

STEP 6: Scroll the display until thermocouple type E is displayed for the thermocouple type.

[↑] [↑] [↑]	type = E
[ENTER]	OFS = 0.0

STEP 7: Use the default offset of 0.0.

[ENTER]	label =

STEP 8: Scroll the display until K is displayed for a readout in °K.

[↑] [↑]	label = K
[ENTER]	ave = 1

STEP 9: Use the default value of 1 for the average in order to obtain an instantaneous temperature readout.

[ENTER]	ch5 is OFF
[CFG]	4I 298.0 K

Channel 3 must also be configured for the reference thermistor. A summary of the steps is given below. A complete discussion of using the GENeral channel configuration for thermistors can be found in Section V.

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- Set channel status of channel 3 to GEN.
- Range = A (autorange).
- Enter the coefficients of the calibration polynomial given in the discussion of the reference channel above.
- Turn the math function off.
- A label is optional.
- Set the average at 1. (the average is actually not important because the thermocouple channel will look at the instantaneous sensor output regardless of how the average is set).

THERMocouple Channel Configuration in LOG mode

The THERM channel configuration in *LOG mode* prompts for range, resistance, reference channel, type of thermocouple, offset, and a label in the same fashion as in *INSTantaneous mode*. Additionally, the LI-1000 also prompts for period, reset, threshold, store, tcoff, min/max and min/max time stamp.

PERIOD: "per =" is a list of values which represent the length of the logging period in minutes. The period is also the interval over which averaged or integrated values are calculated. When the display is scrolled, logging periods of 1, 5, 10, 15, 30, 60, 120, 180, 360, 720, and 1440 minutes are displayed. The sampling interval during a period is 5 seconds for the 1 through 30 minute periods, and it can be set to 5 or 60 seconds for the 60 through 1440 minute periods. (Sampling interval is the frequency at which the LI-1000 will "wake-up" and sample the channels during the period, e.g. every 5 s).

Generally, for the longer logging periods the 60 second sampling interval is sufficient. However, more frequent sampling may be advantageous in situations where temperature rapidly fluctuates. If you choose the 5 second sampling interval, the battery life will be decreased due to the more frequent sampling.

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RESET: "reset =" is the reset time (24 hour clock) when the LI-1000 will begin the first logging period. The 4 digit number following "reset =" is the current value of the reset time in hours (HH) and minutes (MM), and HHMM is the format in which a new reset time must be entered.

IMPORTANT: The reset time is very important if you want the LI-1000 to begin logging immediately or at a specific time. For example, if the current time is 5:00 p.m. and you set the reset time for 6:00 a.m., all of the data collected before 6:00 a.m. tomorrow will not be stored even though the LI-1000 appears to be logging data. The LI-1000 does not store any data until the reset time is reached.

Normally the reset time is set "on the hour" for hourly readings and at midnight for daily (24 hour) totals. The default reset time is 0000 (midnight).

The reset time also effects the storage capacity (Section III).

THRESHOLD: "thr =" is the threshold value below which no data for that channel will be stored.

By setting the threshold at an appropriate value, the LI-1000 can be made to store data only when it is above a certain threshold temperature. For example, if you were collecting hourly averages of ambient temperature but didn't want to store any data when the average temperature was below 10 °C, the threshold value could be set at 10.

For applications where threshold is not important, it should be set at a large, negative number. The default value is -.1000E+10.

STORE: The "store =" parameter defines the form in which the data will be collected and stored.

The three values of the "store =" parameter are INT, MEAN, or PT. When "store = INT", the LI-1000 will store an integrated value. The time units are in hours.

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When "store = MEAN", the LI-1000 will store a mean value (sum divided by the number of samples). When "store = PT", the LI-1000 will store a point value (instantaneous reading) sampled at the end of the chosen period.

Tcoff: The "tcoff =" prompt is given only when the "store =" parameter is set to INT for integrated values. It is not used when measuring thermocouples and should be left at the default value of 1. (A discussion of the use of the tcoff parameter can be found in Section IV).

MIN/MAX: The "min/max =" prompt allows the user to choose whether to store the minimum and maximum data values that occur during the logging period.

"min/max =" is a list which scrolls between NO and YES. When "min/max" is YES, the minimum and maximum data points are stored in memory. To conserve memory, the min/max parameter should be set to NO if the min/max data points are not needed.

NOTE: If PT was chosen as the "store" parameter the LI-1000 will not display the min/max prompt. PT stores only a point value at the end of the period.

MIN/MAX TIME STAMP: If the "min/max =" prompt is set to YES, then the "time stamp =" prompt is displayed before the channel configuration is completed. This prompt determines whether or not the time stamps for both the minimum and maximum data points will be stored with the data points. Again, not storing the time stamps for the min/max data points conserves memory space.

EXAMPLE #12: Configure channel 5 to log the output of a 100 foot, 30 gauge, type T thermocouple in degrees Fahrenheit. Assume the reference junction is connected to channel 3 and that channel 3 is properly configured. Assume there is no zero offset for this thermocouple. Configure channel 5 to collect 5 minute averages starting at 8:00 a.m., and to store min/max values

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but not min/max time stamps. Set the threshold at 50 to store data only when the average is > 50 °F.

STEP 1: Enter *Configuration mode*, select *LOG mode*, and start the configuration at channel 5.

CFG	mode is INST
↑	mode is LOG
ENTER	ch1 is OFF
CHAN CHAN CHAN CHAN	ch5 is OFF

STEP 2: Change the status prompt of channel 5 to THERM.

↑ ↑ ↑	ch5 is THERM
ENTER	range = A

STEP 3: Set Range to autorange.

ENTER	res = 100.0

STEP 4: Enter 100.3 to compensate for the resistance of the thermocouple (see Table 10).

1 0 0 . 3	res = 100.3
ENTER	ref ch1

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STEP 5: Select channel 3 as the reference channel.

↑ ↑	ref ch3
ENTER	type t

STEP 6: Assume that the narrow temperature range is adequate and select thermocouple type t (rather that type T).

ENTER	OFS = 0.0

STEP 7: Set the offset to the default value of 0.0.

ENTER	label =

STEP 8: Scroll the display to F for a readout in degrees Fahrenheit.

↑	label = F
ENTER	per = 1

STEP 9: Set the period prompt to 5 for 5 minute collection periods.

↑	per = 5
ENTER	reset = 0000 HHMM

STEP 10: Set reset time for 8:00 a.m.

0 8 0 0	reset = 0000 0800
ENTER	thr = -1.000E+09

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STEP 11: Set the threshold to 50 so that periods with averages below 50 °F are not stored.

2 0	thr = 20
ENTER	store = INT

STEP 12: Set the store parameter to MEAN.

↑	store = MEAN
ENTER	min/max = YES

STEP 13: Select the default min/max value of YES in order to store maximum and minimum values.

ENTER	time stamp = YES

STEP 14: Scroll time stamp prompt to NO so that the time stamps of the maximum and minimum data points are not stored.

↑	time stamp = NO
ENTER	ch6 is OFF

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Section VII
Configuration of the
Pulse Counting Channels

In *LOG mode* there are two pulse counting channels (chA and chB) that are commonly used with sensors such as tipping bucket rain gauges or anemometers. This section contains information on hardware and software configuration of the LI-1000, and information on using the LI-COR 1000-20 Tipping Bucket Rain Gauge.

The pulse counting channels are configured somewhat differently than the analog channels. The prompts for the pulse counting channels include a multiplier, label, period, reset time, threshold, and mode of data storage (sum or average).

MULTIPLIER: The multiplier for the pulse counting channels is equal to the magnitude of the physical parameter being measured (in appropriate units) that each count represents.

The 1000-20 Tipping Bucket Rain Gauge provides a typical example of how to use the multiplier. With this type of rain gauge, a certain amount of precipitation is needed to tip the buckets inside the gauge. Each time the bucket tips, a switch momentarily closes and the LI-1000 records one count. Each count then represents a number of millimeters (inches, etc.) of rain. It is the number of millimeters per count that is entered as the multiplier. In the case of the 1000-20, the multiplier is 1.0 since each tip of the buckets is equal to 1.0 mm of rainfall.

LABEL: "label =" is a prompt for a two character alpha or numeric label that is displayed with the output of a channel in *Display mode.* When data stored in memory are printed, this label is printed with the data.

Letters in blue in the corners of the numbered keys are accessed by pressing

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the [↑] or [↓] key and then the key with the appropriate letter on it.

When viewing data stored in memory or viewing the output of a channel in *Display mode*, the label immediately follows the data value. The first character should be an alpha character (letter) to eliminate confusion with the data value.

LOGGING PERIOD: "per =" is a list of values which represent the length of the logging period in minutes. When the display is scrolled, logging periods of 1, 5, 10, 15, 30, 60, 120, 180, 360, 720, and 1440 minutes are displayed.

RESET TIME: "reset =" is the reset time (24 hour clock) when the LI-1000 will begin the first logging period. The 4 digit number following "reset =" is the current value of the reset time in hours (HH) and minutes (MM), and HHMM is the format in which a new reset time must be entered.

IMPORTANT: The reset time is very important if you want the LI-1000 to begin logging immediately or at a specific time. For example, if the current time is 3:00 p.m., and you set the reset time for 8:00 a.m., all of the data collected before 8:00 a.m. tomorrow would <u>not</u> be stored even though the LI-1000 appears to be logging data. The LI-1000 does not store any data until the reset time is reached.

Normally the reset time is set "on the hour" for hourly readings and at midnight for daily (24 hour) totals. The default reset time is 0000 (midnight).

The reset time also effects the storage capacity (Section III).

THRESHOLD: "thr =" is the threshold value below which no data for that channel will be stored.

The anemometer sensor provides an example of how to use the threshold parameter. By setting the threshold at an appropriate value, the LI-1000

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can be made to store data only when the average wind speed is above the threshold. Storing only meaningful data points saves memory space.

If your are collecting the sum of all pulses, the value of the threshold parameter should be based on the length of the period (e.g. a one day sum would have a different threshold than a 10 minute sum).

For applications where threshold is not important, it should be set at a large, negative number. The default value is -.1000E+10.

STORE: The "store = ..." prompt for the pulse counting channels has only two options, SUM and AVE. Choosing SUM results in the stored data being based on the sum of all the pulses from the logging period. Choosing AVE results in the stored data being the sum of all pulses collected during the logging period divided by the length of the logging period.

Example #13: Configure pulse counting channel A (chA) to collect daily totals of precipitation from a LI-COR 1000-20 Tipping Bucket Rain Gauge. The calibration for the rain gauge indicates that 1 tip of the buckets (1 pulse) is equal to 1 mm of rainfall.

STEP 1: Enter *Configuration mode*, select *LOG mode* and start configuration at channel A.

CFG	mode is INST
↑	mode is LOG
ENTER	ch1 is OFF
CHAN (8x)	chA is OFF

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STEP 2: Scroll the status prompt to ON. (The only options are ON and OFF for the status prompt of the counter channels).

↑	chA is ON
ENTER	mult = 1.000

STEP 3: Press ENTER to retain the default value of 1.0 since it matches our calibration multiplier..

ENTER	label =

STEP 4: Enter MM for the label to represent mm of rainfall.

↑ 2 ↑ 2	label = MM
ENTER	per = 1

STEP 5: Select a 1440 minutes to obtain daily collection periods.

↑	per = 1440
ENTER	reset = 0000 HHMM

STEP 6: Set reset time for midnight (0000) so that each logging period represents a calendar day.

ENTER	thr = -1.00E+09

STEP 7: Leave the threshold at the default number since no threshold was specified for this example.

ENTER	store = SUM

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STEP 8: Select SUM for the store prompt in order to collect daily totals.

ENTER	chB is OFF

Hardware Configuration

The pulse counting channels can be accessed through the 37-pin "D" connector using the 1000-05 Terminal Block, the 1000-06A AC Terminal Block, 1000-10 Thermocouple Block, or the 1000-14 Sensor Connection Cable.

The counter channels are designed so that each time the signal goes to 0 volts the LI-1000 will record 1 count. The maximum frequency the LI-1000 can count is 1 kHz with an external device that can sink and source current, or 200 Hz with a mechanical switching device such as a tipping bucket rain gauge.

The terminal locations of the 2 pulse counting channels for each of the terminal blocks are given below. The terminal locations are shown in Section IX.

Table 11. 1000-05 Terminal Locations for chA and chB

Description	Terminal Locations		
	1000-05	1000-06A	1000-10
Counter Channel A Signal	C-3	B-7	A-2
Counter Channel A Ground	C-4	B-8	A-3
Counter Channel B Signal	C-5	B-9	A-4
Counter Channel B Ground	C-6	B-10	A-5

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Using the 1000-20 Tipping Bucket Rain Gauge

The 1000-20 has a 50 foot cable for connection to the LI-1000. The cable is terminated with a male snap-lock connector which is used to connect the rain gauge to the 1000-14 Cable. Also included is an adapter which is a female snap-lock connector with two wires coming out of it. The two wires are use to connect the 1000-20 to one of the terminal blocks. Since the 1000-20 just acts as a simple switch it does not matter which wire goes to the signal terminal and which goes to the ground.

If you are using the 1000-08 Instrument Enclosure, the cable should run up through the hole in the bottom of the 1000-08 to prevent rain water from flowing down the cable and into the instrument enclosure.

Site Requirements: The placement of the rain gauge is important since it determines the quality of the precipitation catch.

The precipitation catch is more accurate when there are objects in the vicinity of the rain gauge that reduce the prevailing wind speed. The best site for the gauge is often found in openings in groves of trees; or near orchards, bushes, shrubbery, fences or other objects that act as a windbreak.

In areas where the height of the obstructions and their distance from the gauge is uniform, the best placement is usually at a distance that is less than twice the height of the obstruction. Most sites also change with time. The growth of vegetation, trees and shrubbery, or man made alterations of the surroundings can slowly change the quality of the precipitation catch.

In open areas, individual or small groups of isolated objects near the gauge may set up eddy currents. The distance of the gauge from such objects should not exceed twice the height of the objects. In open sites away from isolated objects, it is necessary to set up a wind break to prevent loss of precipitation catch or false readings caused by high winds flowing through the gauge and tipping the buckets. A windshield (model 2525) is available from Sierra Misco, Inc. (manufacturer of the 1000-20 Tipping Bucket Rain Gauge).

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Installation: The 1000-20 is shipped with three mounting legs attached upside down on the 1/4-20 bolts. Detach and replace legs in the correct position with the legs pointing downwards and the ends of the legs pointing away from the gauge. Be sure the wing nuts are tight.

Take off the funnel and carefully remove all packing material and the tape that keeps the tipping bucket from moving during the shipment. The bucket should now move freely between the calibration screws. Put the funnel back in place on the top of the gauge.

The gauge should be mounted level on a platform or tower. The holes in the mounting legs are sized for 1/4 inch diameter mounting bolts. The top of the gauge (the funnel) must be level. This can be checked by laying a carpenter's level across the open top of the gauge in two directions at right angles. Washers can be used as leveling shims between the mounting legs on the gauge and the platform or tower.

Maintenance The gauge is calibrated at the factory and recalibration should not be necessary unless damage in shipment as occurred.

Calibration Check: Pour water into the funnel, tipping the bucket and wetting the gauge. The gauge must be wet when calibrated. Using a graduated cylinder or calibrated burette pour 32.43 milliliters of water into the funnel at a flow rate of approximately 1/2 mL per second (1 tip per minute). The bucket should tip within tolerance. Check the alternate bucket in the same manner. If both buckets tip when filled with the correct amount of water, the gauge is in proper calibration. If the buckets do not tip or if they tip too early, they should be recalibrated.

To recalibrate the gauge, the following procedure should be followed:

1) Release the lock nuts on the calibration screws that the bucket rests on. Tip the bucket manually in both directions to empty buckets. Do not wipe the buckets dry.

2) Pour water through the inner funnel into the bucket at approximately 1/2 milliliter per second and note how much water it takes to make the bucket tip. If it takes more than the correct amount of water to tip the bucket then the calibration screw for that side of the bucket should be adjusted

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upwards so that it will take less water to tip the bucket. If it takes less water than the correct amount to tip the bucket then the calibration screw for that side of the bucket needs to be adjusted downwards so that it will take more water to tip the bucket. Do not wipe water from the bucket in between tips.

3) Once the correct height for each calibration screw has been determined, carefully tighten the lock nuts without changing the position of the calibration screw.

4) After tightening both calibration screws, check the calibration again.

Servicing: The rain gauge should be serviced annually. In heavily forested areas or where airborne debris is a consideration, it should be serviced more frequently.

The bucket assembly and drains should be checked to make sure they are clean and free from obstructions. The tipping bucket and inner funnel should be carefully wiped clean.

Once a year or after six months of heavy operation a drop of light oil should be placed at each pivot point.

Checking the switch closure: The standard switch closure is a momentary SPST, NO contact. Connect an ohmmeter to the rain gauge at the terminal strip. With the bucket at rest on one of the calibration screws, the ohmmeter should read infinite resistance. Slowly move the bucket simulating the tipping motion, until contact closure is made. The resistance of the contacts should be less than 1 ohm. The ohmmeter should again read infinite resistance when the bucket rests on the other calibration screw.

Check that the gauge is still level when the maintenance is complete.

In order to maintain the accuracy of the rainfall catch, the rim of the funnel should be protected from dents or other damage that might alter its shape.

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Trouble Shooting: Check the cable connections to make sure they are properly connected. Also check to see that the bucket moves freely on the pivots and that the magnet is securely in place and the switch is working properly.

If the LI-1000 registers low or does not register anything during precipitation, check for debris in the inlet funnel and drains which can affect bucket movement. If the LI-1000 registers high during precipitation, check the level of the orifice to ensure sensor is properly installed and leveled. Recheck calibration.

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Section VIII
Configuring the Math Channel

General Information

In *INSTantaneous mode* the math channel (chM) is similar to the math function found in the general channel configuration with the exception that the math channel operates as a virtual channel. The math channel samples the output data from two analog channels and performs an arithmetic operation (+, -, x, or /) on them.

The result of the arithmetic operation can be displayed or logged in memory in a fashion similar to the way the data from the analog channels are handled. The data from the two channels on which the math operation is performed are left unchanged. When using the math function in the general channel configuration, the data from the channel which has the math function turned on is not stored, the result of the math operation is stored instead.

Although the math channel is similar to the math function in *INSTantaneous mode*, it is quite different in *LOG mode*. These differences are explained in detail below.

Configuration of the Math Channel in INSTantaneous Mode

In *INSTantaneous mode* the math channel sequentially prompts for the channel status (OFF, +, -, *, or /), the first channel in the math operation (1st =), the second channel in the math operation (2nd =), math channel calibration coefficients a0 - a5, a label, and the number of readings to average.

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CHANNEL STATUS. The math channel is capable of adding, subtracting, multiplying, or dividing the data from two channels. The channel status prompt "chM is ..." allows you to turn the channel on and select one of the math operations, or to turn the channel off.

"1st =, 2nd =" The prompts "1st = " and "2nd = " are used to designate the first and second channels in the math operation. Table 12 shows how the 1st and 2nd channels are used in each math operation.

Table 12. Term Assignment for first and second channels

Operation	Usage
Addition	1st channel + 2nd channel
Subtraction	1st channel - 2nd channel
Multiplication	1st channel x 2nd channel
Division	1st channel ÷ 2nd channel

NOTE: The LI-1000 assumes that the channels selected for the arithmetic operation are turned ON and properly configured. It is left to the user to make sure the channels chosen are configured correctly.

CALIBRATION POLYNOMIAL. The math channel has a fifth order calibration polynomial with coefficients a0, a1, a2, a3, a4, and a5 that is similar to the polynomial discussed in the general channel configuration (Section V). For most applications (including LI-COR light sensors) a0, a2, a3, a4, and a5 are usually set at zero and a1 should be 1 (multiplies by 1).

LABEL: "label =" is a prompt for a two character alpha or numeric label that is displayed with the output of a channel in *Display mode*. This label is also printed with any stored data for the same channel number.

Letters in blue in the corners of the numbered keys are accessed by pressing the [↑] or [↓] key and then the key with the appropriate letter on it.

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When viewing data stored in memory or viewing the output of a channel in *Display mode*, the label immediately follows the data value. It is recommended that the first character be an alpha character to eliminate confusion with the data value.

In *Display mode* (or *View mode*), the data for the math channel is displayed in the form MP N.NNN LL, where:

1) M designates the math channel.
2) When the "ave = " prompt on the data channels is set to 1 then P is I for instantaneous. P can also be A when the average is greater than 1.
3) N.NNN is the numeric value of the data (+ or -) (this can also be in exponential form if the number is large).
4) LL is the label defined during configuration.

AVERAGE: The "ave = " prompt is used to display either an instantaneous readout of the result of the math operation, or a continuous running average. Any integer greater than or equal to 1 can be used for the average. However, in practice the average is limited by the available memory.

When the memory is full, it is only possible to get a total of 33 seconds of averaging time (i.e. 26 second average on one channel and a one second average on each of the other channels). Also, if you set the average to a very high number, all available memory is used for the average, leaving none for data storage. In this situation, if you try to store data, the message "DATA NOT STORED" will be displayed. If an average is entered that would require more memory than is available, the averages will automatically be changed, and a message indicating the changes will be displayed.

Each integer in the average represents one second. If 1 is chosen, the output of the channel is displayed as an instantaneous value that is updated every second. If a number N is chosen such that N > 1, the display will still update every second but the number displayed will be the continuous running average of instantaneous readings for the past N seconds.

For example, if 30 were entered for the average, the number displayed is the average of the instantaneous data points for seconds 1 through 30. When the display updates after 1 second, the number displayed is the average of seconds 2 through 31, followed by 3 through 32, etc.

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The average function is advantageous 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 the resolution because of the higher number of samples used in the average.

Configuration of the Math Channel in LOG Mode

In *LOG mode* the math channel is different from the math function in that it uses a different sampling technique. The math channel samples the current value accumulated for the channel designated 1st or 2nd (current integration or current average), where the math function samples the instantaneous output of the sensors designated 1st and 2nd.

Suppose channels 1 and 2 are both integrating LI-COR radiation sensors and it is desired to obtain a ratio of the two sensor outputs. If the math function were used, the instantaneous output of both channels would be divided and then integrated, since the math function uses the same method of storage (integration) as the channel on which the math function is used. The result would be that an integrated ratio would be stored for the channel on which the math function is being used.

In the same situation the math channel could be configured to store a simple ratio of the two integrated values by setting the store parameter to point (PT). Point is chosen for the store parameter because the math channel uses the channel output (current value accumulated for each channel) to perform the math operation. In this situation the math channel would divide the last sample in the collection period which will be the total integrations collected on the other two channels.

In *LOG mode* the configuration prompts for the math channel (chM) include the channel status, 1st channel, 2nd channel, calibration coefficients, label, logging period, reset time, threshold, store, tcoff, max/min, and max/min times stamps. The prompts for the channel status through the label prompt are the same in *LOG mode* as in *INSTantaneous mode* above.

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Important: The math channel and the two analog channels must have the same logging periods and reset times. For example, if channel 1 was configured for 10 minute logging periods, channel 2 for 15 minute logging periods, and the math channel set for hourly periods, the data on the math channel would be meaningless.

LOGGING PERIOD: "per =" is a list of values which represent the length of the logging period in minutes. When the display is scrolled, logging periods of 1, 5, 10, 15, 30, 60, 120, 180, 360, 720, and 1440 minutes are displayed. The logging period should be set to match the logging period of the two channels used in the math operation.

RESET TIME: "reset =" is the reset time (24 hour clock) when the LI-1000 will begin the first logging period. The 4 digit number following "reset =" is the current value of the reset time in hours (HH) and minutes (MM), and HHMM is the format in which a new reset time must be entered. The math channel reset time should be the same as the reset times for the two channels used in the math function.

IMPORTANT: Even though the LI-1000 begins logging data immediately after configuration is complete, data are not stored until the reset time is reached for the first time.

THRESHOLD: "thr =" is the threshold value below which no data for the math channel will be stored. For example, if you were collecting the ratio of two sensors but were interested only in finding out when the ratio was above a certain level, the threshold could be set at that level.

For applications where threshold is not important, it should be set at a large, negative number. The default value is -.1000E+10.

STORE: The "store =" parameter defines the form in which the data will be collected and stored. The three values of the "store =" parameter are INT, MEAN, or PT.

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The "store =" parameter for the math channel is normally set to PT for a point reading. In this configuration the math operation is performed on the data which would be stored for each channel at the end of the period. For example, if channels 1 and 2 are integrating data, the math channel would use the integrated values at the end of the period as the data for the math operation.

In contrast, if the store parameter were set to integrate (INT), the math operation would be performed each time the LI-1000 sampled during the period, and the result would be integrated during the collection period. In this case, if you were dividing two channels you would get an integration of the ratio's of the channels. Similarly, if the MEAN were collected you would get the mean value of the ratio's during the sampling period.

Tcoff: The "tcoff =" prompt is given only if the "store =" prompt is set to INT for integrated values. In general the time coefficient is not used for the math channel, however, it can be used to multiply the result of the math operation by a constant (the result of the math operation is multiplied by the tcoff value after the calibration polynomial has been applied). If you do not want to use the tcoff parameter, it should be left at the default value of 1. A more complete discussion of the tcoff prompt can be found in Section IV

MIN/MAX: The min/max prompt and min/max time stamp prompt are given only if the store parameter is set to either INT or MEAN. The "min/max =" prompt allows the user to choose whether to store the minimum and maximum data values that occur during the logging period.

"min/max =" is a list which scrolls between NO and YES. When "min/max" is YES, the minimum and maximum data points are stored in memory. To conserve memory, the min/max parameter should be set to NO if the min/max data points are not needed.

MIN/MAX TIME STAMP: If the "min/max =" prompt is set to YES, then the "time stamp =" prompt is displayed before the channel configuration is completed. This prompt determines whether or not the time stamps for both the minimum and maximum data points will be stored

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with the data points. Again, not storing the time stamps for the min/max data points conserves memory space.

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Section IX

Hardware Reference

This section contains information on the LI-1000's hardware and specific information on the 1000-05, 1000-06A, 1000-10 and 1000-14 sensor input accessories.

The information presented should be considered supplementary to that given in the preceding sections dealing with configuration of the LI-1000. The information given in those sections is presented again in abbreviated form, along with information on the auxiliary functions of the terminal blocks.

To get the greatest benefit from this section you should read the general information and then scan through the information on the sensor input accessory that you purchased.

For those who wish to build their own terminal block or sensor input cable, Appendix B identifies the function of each pin on the 37-pin "D" connector.

General Information

The LI-1000 has ten channels for sensor inputs. Two current channels are located in the two BNC connectors on the top of the LI-1000 case. Six current or voltage channels and two pulse counting channels are located on the 37-pin "D" connector. When using the 1000-05 Terminal Block or the 1000-06A AC Terminal Block, the 6 analog and 2 digital channels on the 37-pin "D" connector are accessible through the screw down terminals.

The illustration below shows the location of the two current channels, the 37-pin "D" connector, and the 25-pin "D" connector (used for data output).

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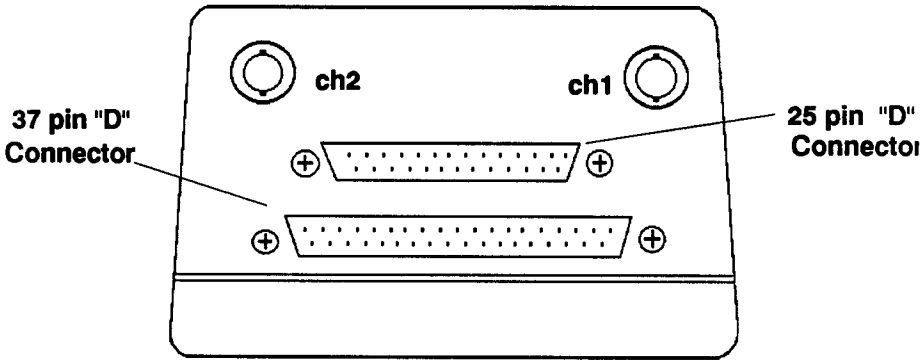


Figure 9 is a schematic diagram of the input channels and the amplifier of the LI-1000. The LI-1000 uses a high quality, transimpedance amplifier to provide highly accurate measurement (25 picoamp resolution) of current sensors such as LI-COR radiation sensors. This amplifier has an extremely low input impedance to current sensors which results in excellent linearity.

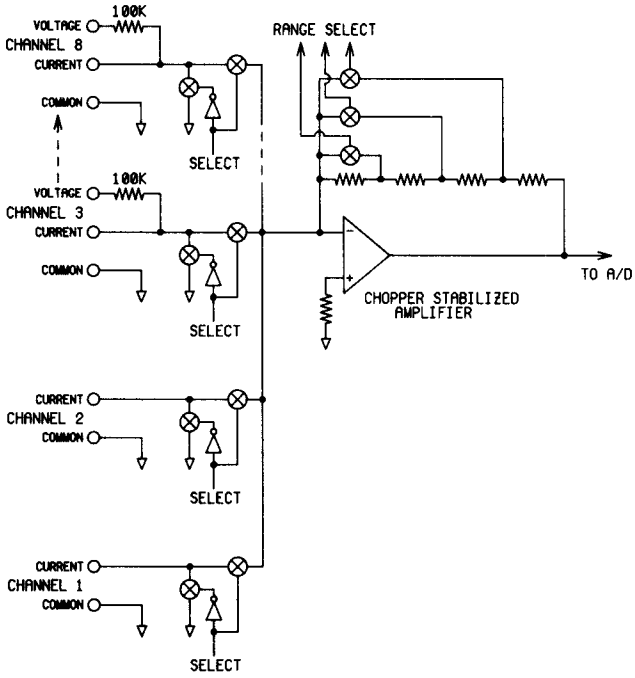


Figure 9. Schematic diagram of LI-1000 input electronics.

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For voltage inputs, the LI-1000 has a 100K Ohm input impedance. This allows accurate measurement of low output impedance (< 1000 Ohms) voltage sensors such as thermistors, thermocouples, thermopiles and thermopile pyranometers.

The 100K Ohm input impedance for the voltage channels is necessary to get the most useful voltage ranges (and resolutions) for the LI-1000. An external resistor can be added (in series) to increase the input impedance, however the ranges and resolutions of the LI-1000 will change proportionately.

High output impedance voltage sensors should not be used with the LI-1000 unless an external resistor is added or unless corrections are made to the calibration multiplier.

By using Ohms law (voltage = current x resistance) the magnitude of any error caused by the low value of the input impedance resistor can be calculated. The voltage in this case is the output of the sensor, the current is the current measured by the LI-1000 and resistance is assumed to be the 100K Ohm value of the input impedance resistor. However, the true value of the resistance is the input impedance of the LI-1000 plus the output impedance of the sensor (they are connected in series). If the output impedance is comparatively low (e.g. 1K Ohm), then the increase in the resistance would be fairly small (from 100K to 101K). If, however the output impedance were high (100K Ohm), the actual resistance in the measurement circuit would be 200K Ohms rather than 100K Ohms and the error would be very significant.

The calibration multiplier for voltage sensors can be corrected by the following equation:

$$\text{Calibration Multiplier} \times \frac{\text{output impedance of sensor} + 100\text{K Ohm}}{100\text{K Ohm}}$$

NOTE: This correction is for the calibration multiplier calculated as described in the general channel configuration and not the calibration constant provided by the manufacturer.

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The equation above can also be used to compensate for the resistance in a wire if a long wire is used with a voltage sensor.

The 1000-05 Terminal Block

The 1000-05 has three terminal blocks, a ground block, and a female 37 pin "D" connector which mates with the male 37 pin connector on the LI-1000 (Figure 10). Each row of terminals is lettered A, B, or C. Each row has 12 terminals which are numbered 1 through 12 from left to right.

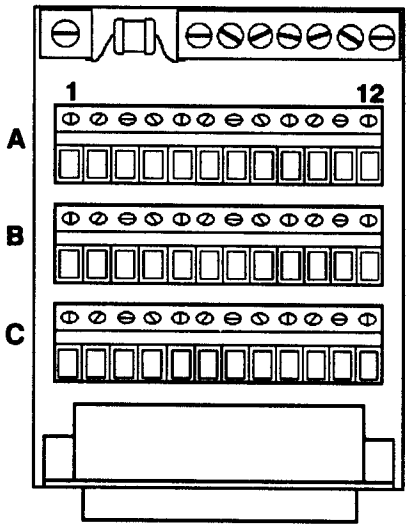


Figure 10. 1000-05 Terminal Block.

Terminal C-9 is a regulated voltage source at + 5 volts D.C. with a current of 5 milliamps. Terminal C-9 is commonly used as a voltage supply for thermistors. Terminal C-10 is a constant voltage source at -4.5 volts D.C. with a current of 5 milliamps.

Terminals C-1 and C-2 are a direct output of the battery voltage. This allows

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the LI-1000 to act as a DC power source for other devices. It should be noted however that using the battery output to power another device will significantly decrease the battery life of the LI-1000. Battery voltage can be monitored by attaching a jumper between C-1 and the voltage input terminal of an unused channel.

Terminals B-7 through B-11 are DC excitation sources which provide a continuous 5 volt signal with a 100K Ohm resistor in series. Terminal B-12 is the ground for these channels.

Table 13. 1000-05 Terminal Locations.

Term.	Description	Term.	Description
A-1	Channel 3 signal current	B-7	DC Excitation #1
A-2	Channel 3 signal ground	B-8	DC Excitation #2
A-3	Channel 3 signal voltage	B-9	DC Excitation #3
A-4	Channel 4 signal current	B-10	DC Excitation #4
A-5	Channel 4 signal ground	B-11	DC Excitation #5
A-6	Channel 4 signal voltage	B-12	Analog Ground
A-7	Channel 5 signal current	C-1	Battery Voltage Out (+)
A-8	Channel 5 signal ground	C-2	Battery Ground (-)
A-9	Channel 5 signal voltage	C-3	Counter Channel A
A-10	Channel 6 signal current	C-4	Counter Channel A Ground
A-11	Channel 6 signal ground	C-5	Counter Channel B
A-12	Channel 6 signal voltage	C-6	Counter Channel B Ground
B-1	Channel 7 signal current	C-7	163.84 kHz
B-2	Channel 7 signal ground	C-8	Digital Ground
B-3	Channel 7 signal voltage	C-9	+ 5 volts D.C.
B-4	Channel 8 signal current	C-10	-4.5 volts D.C.
B-5	Channel 8 signal ground	C-11	Op-Amp out
B-6	Channel 8 signal voltage	C-12	Analog Ground

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GROUNDING THE 1000-05

When installing the LI-1000 outdoors for long term monitoring, it should be protected from the transient voltage encountered in a lightning strike (direct or indirect). Provision is made for this in the form of the heavy copper bars and the spark gap located at the top of the 1000-05.

The small bar with the lug on it should be connected to some form of earth ground (water pipe, buried pole, etc.). The large copper bar is used to ground the sensors. Screws are provided on the block which can be used as terminals to attach the ground wires. It is highly recommended that the LI-1000 and 1000-05 be properly grounded to protect the instrument from possible damage.

The 1000-06A AC Terminal Block

The 1000-06A consists of three terminal blocks, a ground block, electronics for AC resistance measurements, and a female 37 pin "D" connector which mates with the 37 pin male connector on the LI-1000 (Figure 11). In Figure 11, each row of terminals is lettered A, B, or C. Each row also has 12 terminals in it which are numbered 1 through 12 from left to right.

Analog channels 7 and 8 can be configured in two different ways. As explained in Section V, the first use is to measure DC current or voltage. Alternately, they can also be configured to measure AC impedance.

To configure channels 7 or 8 for AC impedance measurements, jumper J3 (Figure 11) must be moved to the proper pair of pins. Table 15 shows the function of each jumper.

As an example, configure channel 7 so that it can be used with a humidity sensor requiring an AC impedance measurement and an AC voltage of 40 Hz. First the jumper would be removed from jumper pins J3-2 and moved to J3-1. This configures channel 7 as an AC channel rather than a DC channel. The jumper can be removed by pulling the black plastic jumper straight up and off of the jumper pins. Carefully remove the jumpers to avoid bending the jumper pins.

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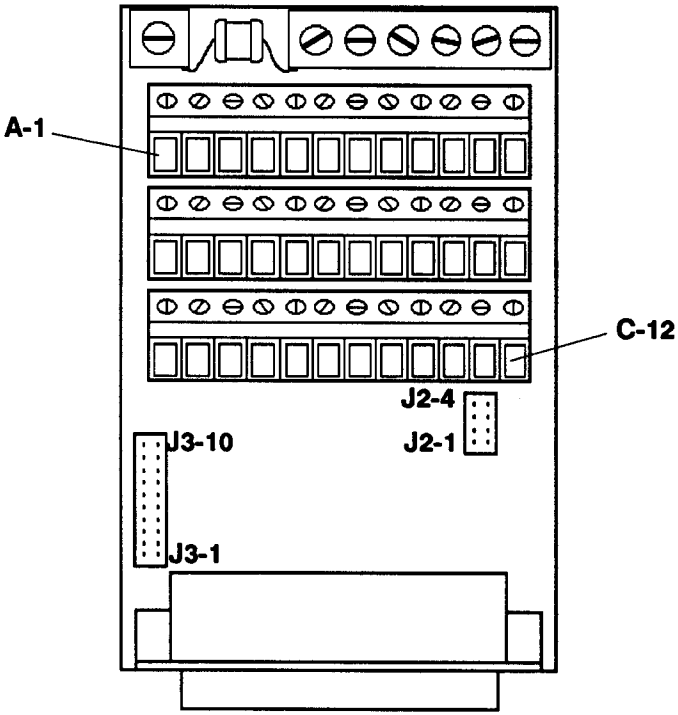


Figure 11. 1000-06A AC Terminal Block

There are six frequencies varying from 40 to 1280 Hz which are selected by moving the jumper to the jumper pins which select the appropriate frequency (Table 16). To continue our example, the frequency select jumper should be moved to J3-5 to select 40 Hz.

The leads of the humidity sensor in our example are attached to terminals C-1 and C-2. Note that terminals B-1, B-2, and B-3, which are used when channel 7 is configured for DC measurements, are now deactivated.

Terminals C-11 and C-12 are a low voltage pulse counting channel. The low voltage pulse counting channel is used for counting frequency of AC signals from sensors such as magnetic pulse flow transducers or other low voltage, sine wave outputs.

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Table 14. 1000-06A Terminal Locations.

Term.	Description	Term.	Description
A-1	Channel 3 signal current	B-7	Counter Channel A Ground
A-2	Channel 3 signal ground	B-8	Counter Channel A
A-3	Channel 3 signal voltage	B-9	Counter Channel B Ground
A-4	Channel 4 signal current	B-10	Counter Counting Channel B
A-5	Channel 4 signal ground	B-11	AC Ground
A-6	Channel 4 signal voltage	B-12	Divided AC Out
A-7	Channel 5 signal current	C-1	AC Channel #1 Input
A-8	Channel 5 signal ground	C-2	AC Ground
A-9	Channel 5 signal voltage	C-3	AC Channel #2 Input
A-10	Channel 6 signal current	C-4	AC Ground
A-11	Channel 6 signal ground	C-5	Ground
A-12	Channel 6 signal voltage	C-6	Ground
B-1	Channel 7 signal current	C-7	DC Excitation
B-2	Channel 7 signal ground	C-8	DC Excitation
B-3	Channel 7 signal voltage	C-9	DC Excitation
B-4	Channel 8 signal current	C-10	+ 5 volts D.C.
B-5	Channel 8 signal ground	C-11	Low Voltage Counter #1
B-6	Channel 8 signal voltage	C-12	Low Voltage Ground

Table 15. 1000-06A JUMPER ASSIGNMENTS

Jumper	Description	Jumper	Description
J3-1	AC Channel 7	J3-6	80 Hz
J3-2	DC Channel 7	J3-7	160 Hz
J3-3	AC Channel 8	J3-8	320 Hz
J3-4	DC Channel 8	J3-9	640 Hz
J3-5	40 Hz	J3-10	1280 Hz

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When a jumper is installed on jumper pins J2-1 of jumper J2, the digital pulse counting channel designated as channel A (chA) in the software is switched to the low voltage pulse counting channel (still designated chA in software). The location of jumper J2 is shown in Figure 11.

To use the low voltage pulse counting feature a jumper must be placed on either J2-3 or J2-4. These jumpers determine the mode of power delivery to the operational amplifier. For instance, if the jumper is placed on pins J2-3 +5 volts will be delivered to the amplifier. If the jumper is placed on J2-4 the battery voltage will be delivered to the amplifier. Each has advantages and disadvantages. Which one is selected depends on the application.

For example, if the jumper is placed on J2-3 (+ 5 volts), less voltage is required for operation. However, if the LI-1000 were in LOG mode there would be no power to the amplifier during the times when LI-1000 is not sampling. In log mode power is supplied to the amplifier only when the LI-1000 "wakes up" and scans channels. Any pulses during the time when the LI-1000 was off would not be counted.

Conversely, if a jumper were placed on J2-4 there would be continuous power to the amplifier even when the LI-1000 was not "awake" and scanning channels. The disadvantage in this situation is that more power is drawn from the batteries and the battery life is diminished.

Terminals C-7 through C-10 are DC excitation sources which provide a continuous 5 volts and have a 100K Ohm resistor in series.

GROUNDING THE 1000-06A

When installing the LI-1000 outdoors for long term monitoring, it should be protected from transient voltage such as that encountered in a lightning strike. Provision is made for this in the form of the heavy copper bars and the spark gap located at the top of the 1000-06A.

The small bar with the lug on it should be connected to some form of earth ground (water pipe, buried pole, etc.). The large copper bar is used to ground the sensors. Screws are provided on the block which can be used as

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terminals to attach the ground wires. It is highly recommended that the LI-1000 and 1000-06A be properly grounded to protect the instrument from possible damage.

The 1000-10 Thermocouple Terminal Block

The 1000-10 consists of 5 copper connection terminals, an auxiliary sensor connection block with 12 terminals, and a 37-pin connector which mates to the LI-1000 (Figure 12).

The use of the five copper terminals for connection of thermocouples is described in Section VI. Alternate uses for these terminals and the function of each of the terminals on the terminal block are discussed below.

The five copper terminals which are normally used for connection of thermocouples can also be used as general voltage input channels as explained in the discussion of the general channel configuration found in Section V. As indicated in the diagram below, the copper terminals connect to channels 4 through 8 from left to right. The terminal on the post should be used for the voltage signal and the terminal located on the copper block used for the reference ground.

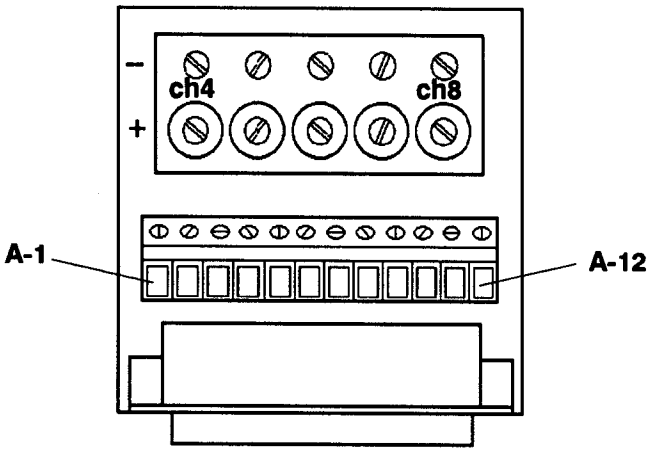


Figure 12. The 1000-10 Thermocouple Terminal Block.

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The other functions located on the 12 connector terminal block are listed in Table 16.

Table 16. 1000-10 Thermocouple Block

Term.	Description	Term.	Description
A-1	Battery voltage output	A-7	+ 5 volts D.C. (regulated)
A-2	Counter Channel Ground	A-8	- 4.5 volts D.C. (regulated)
A-3	Counter Channel A	A-9	Not Used
A-4	Counter Channel Ground	A-10	Not Used
A-5	Counter Channel B	A-11	Not Used
A-6	Counter Channel Ground	A-12	Ground

The 1000-14 Sensor Connection Cable

The 1000-14 consists of an air temperature sensor which mounts in the 1000-08 Instrument Enclosure, and two connectors which are usually used for the 1000-20 Tipping Bucket Rain Gauge and the 1000-15 Soil Temperature Sensor. The 1000-15 connects to the male plug of the 1000-14 and the 1000-20 is connected to the female plug. Since the genders of these plugs are opposite it is not possible to connect them incorrectly. Although the plug for the temperature sensor is only for a LI-COR temperature sensor (1000-15, 1000-16, or 1000-16-2), the other plug is connected to digital channel A (chA) and can be used with any sensor with a pulsed output. The male plug for the temperature sensor is connected to channel 4.

The air temperature sensor mounts in a hole in the bottom of the 1000-08 Instrument enclosure and is held in place by two mounting collars which slide along the shaft of the temperature sensor. Take off one of the collars and put the temperature sensor through the hole in the bottom of the enclosure. Replace the collar and so that one is on either side of the bottom and the tip of the air temperature sensor is one inch from the bottom of the 1000-08. In this position the sensor will be correctly shaded by the shade

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ring and still have good air circulation around it.

The air temperature sensor is a non-linear thermistor. The calibration coefficients for this sensor are given in Appendix F. This sensor is connected to channel 3 on the LI-1000. A schematic diagram of the 1000-14 is given in Appendix G.

NOTE: The LI-1000 should be turned off when the 1000-14 is plugged-in.

The 1000-08 Instrument Enclosure

The 1000-08 is used to shield the LI-1000 from solar radiation and rainwater during long term monitoring applications (Figure 13).

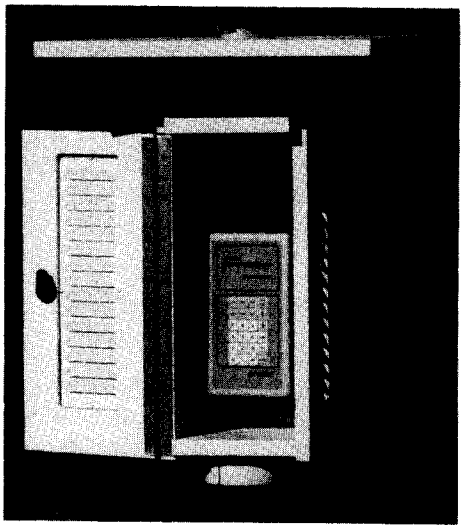


Figure 13. The 1000-08 Instrument Enclosure.

INSTALLING THE INSTRUMENT MOUNTING PLATE

Attaching the instrument mounting plate to the back of the LI-1000 is a 3 step process.

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1) Remove the battery pack by unscrewing the 4 screws in the corners of the bottom half of the case and disconnecting the battery connector (Section XI). Remove the 4 screws from the case by pulling them up and twisting them until the threads of the screws engage with the plastic. Unscrew the screws with a screwdriver while still applying upward pressure with your fingers.

2) The spares kit contains 4 spacers which must be pressed into the case in the 4 holes from which the screws were removed. To press the spacers in, start them by hand and then press them into place with a pair of pliers.

3) The spares kit contains four 1 1/8" screws similar to those taken out in step 1. These go through the mounting plate, through the spacers, and through the case in a similar fashion to those that were removed. The mounting plate should be attached to the back of the case so that the narrow portion of the keyhole shaped holes will be pointed toward the top of the instrument.

1000-08 ASSEMBLY

The 1000-08 Instrument Enclosure is shipped with the roof removed and packed separately in the bottom of the shipping carton. The roof is mounted on the enclosure with 4 wood screws (provided).

LI-1000 INSTALLATION

The mounting plate has a keyhole shaped hole in each corner. The LI-1000 is installed in the 1000-08 by pushing the holes in the mounting plate over the heads of the 4 wood screws in the back of the 1000-08 and lowering the LI-1000 until the slotted portion of the keyhole comes to rest on the shaft of the wood screw.

INSTALLING THE 1000-08

There are may possible ways to mount the instrument enclosure. The enclosure is made of wood which allows maximum flexibility in choosing an installation method. The enclosure has no holes provided for installation but it can easily be nailed, screwed or clamped to another object. When

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choosing an installation method make sure that the enclosure will be attached securely enough so that it cannot be blown off by strong winds.

The best results are usually obtained by using screws to mount the enclosure to a wooden post (fence post, telephone pole, etc.). The following steps can be used to mount the enclosure.

1) Drill three small holes in the back wall of the enclosure to act as pilot holes for the screws. The holes should be 3 - 4 inches apart and centered in the back wall such that the enclosure will be level when mounted.

2) Attach the enclosure to the post using three flathead wood screws that are at least 2 inches long. The screws should be tightened down until the heads of the screws pull into the wood of the back wall. This will allow the mounting plate of the LI-1000 to pass over the screw heads with no interference.

   If the enclosure is not mounted at the top of the pole, the roof of the enclosure may get in the way. If this happens, there is an alternate set of mounting holes on the roof which allow the roof to be mounted so that the back of the roof is even with the back of the enclosure.

   Another important aspect to correctly mounting the enclosure is to make sure there is proper air circulation around the air temperature sensor (if there is one installed). Mounting the enclosure to a post allows air circulation both around and underneath the air temperature sensor.

   If a radiation sensor is to be mounted on the roof of the enclosure it should be mounted so that the sensor has unobstructed, 360°, direct sunlight at all times of the day (i.e. no shadows).

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Section X

Data Communications

General Information

Although it is entirely possible to view all the data stored in memory and write it down by hand using *VIEW mode*, it is often a long, tedious job when large amounts of data have been collected. For this reason, an EIA RS-232C interface has been provided for transferring data to another device for printing or storage. The RS-232C port is configured as Data Terminal Equipment (DTE) and can only be used to transfer data out of the LI-1000.

The output functions used to transfer data are completely separate from the data collection and storage functions. In other words, data can be output while still collecting data with no interruption of the collection process.

Data output is a six step procedure.

1) Connect the LI-1000 to the output device using the proper cable.
2) Press [OUT] to enter Output mode.
3) Choose baud rate (300 or 4800).
4) Choose output format (Vertical or Horizontal).
5) Set the maximum number of characters per line (horizontal format only).
6) Select to output all or a portion of the memory.

Any device connected to the LI-1000 must have its input parameters configured to match those given below:

Baud Rate: 300 or 4800
Data bits: 8
Stop bits: 2
Parity: none

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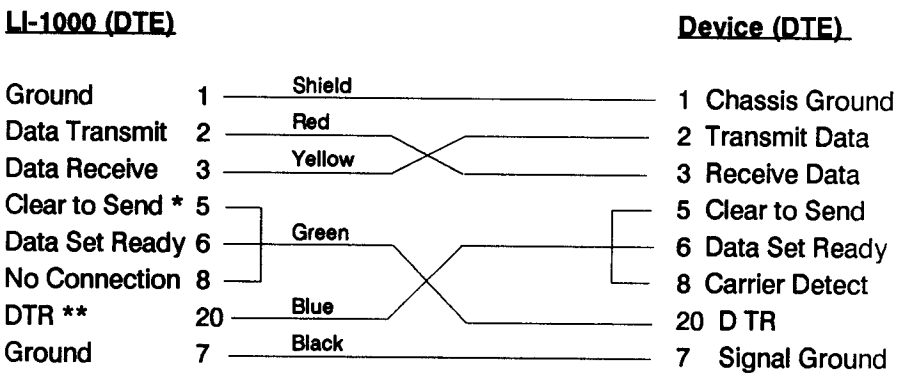
Selecting a Cable

The output port is the 25 pin connector on the top of the LI-1000. The 1000-03 and 1000-04 accessory cables plug into this port. The 1000-03 DTE to DTE Cable (DTE = Data Terminal Equipment) is used when interfacing with other DTE devices (personal computer, printer, terminal, etc.), the 1000-04 DTE to DCE Cable is used when interfacing to devices such as computers that are configured as Data Communication Equipment (DCE).

The 1000-04 DTE to DCE Cable (ribbon cable with two connectors on each end) is simply a pin for pin connection between the 25 pin connectors on either end. Both male and female connectors have been provided on each end so that connection can be made to any device regardless of the gender of the connector.

The 1000-03 Terminal/Printer Cable is wired as shown below. If the gender of the connector on the 1000-03 does not mate with the output device, the 1000-04 or a female-to-female gender changer (with pin for pin connections) can be used to change the gender.

1000-03 DTE to DTE Cable



* Pin 4 (RTS) and Pin 5(CTS) are jumpered together inside the LI-1000.

** A + 5 volt supply is connected to line 20 so that it is always held high.

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Using the Output Software

STEP 1: Connect the LI-1000 to the output device (properly configured of course) and press [OUT].

[OUT]

```
baud = 3
```

STEP 2: Select 3 for 300 baud or 48 for 4800 baud.

[↑]

```
baud = 48
```

[ENTER]

```
form = V
```

STEP 3: Select H for horizontal format.

[↑]

```
form = H
```

[ENTER]

```
len = 80
```

The toggled values are H for horizontal and V for vertical. Examples of both formats are given below.

```
870626 1200
1T 152.8WM  1H  923.3WM 870626 1159  1L  911.1WM 870626 1150
2M 929.3WM  2H  961.1WM 870626 1135  2L  890.3WM 870626 1150
3P 935.6WM
4T 159.9WM
5T 158.7WM
870626 1230
1T 154.8WM  1H  934.4WM 870626 1219  1L  922.6WM 870626 1211
3P 934.4WM
4T 153.2WM
5T 155.5WM
870626 1300
1T 157.8WM  1H  942.3WM 870626 1249  2L  932.9WM 870626 1231
2M 834.2WM  1H  888.0WM 860626 1235  1L  771.8WM 870626 1206
3P 951.4WM
4T 155.8WM
5T 153.2WM
```


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The vertical output format (above) lists the time stamp on one line followed by a carriage return and line feed. Underneath the time stamp are the data points for each channel that was stored data using that time stamp. The data point for each channel (or data point + min/max values and time stamps) is followed by a carriage return and a line feed so that the data from each channel is a different line.

The horizontal format lists the time stamp and all the data points associated with that time stamp on the same line(s) with a carriage return and line feed only after the data for the last channel associated with that time stamp.

870626 1200 1T 152.8WM 1H 923.3WM 870626 1159 1L 911.1WM 870626 1150
2M 929.3WM 2H 961.1WM 870626 1135 2L 890.3WM 870626 1150 3P 935.6WM
4T 159.9WM 5T 158.7WM
870626 1230 1T 154.8WM 1H 934.4WM 870626 1219 1L 922.6WM 870626 1211
3P 934.4WM 4T 153.2WM 5T 155.5WM
870626 1300 1T 157.8WM 1H 942.3WM 870626 1249 2L 932.9WM 870626 1231
2M 834.2WM 1H 888.0WM 860626 1235 1L 771.8WM 870626 1206 3P 951.4WM
4T 155.8WM 5T 153.2WM

STEP 4: Select the maximum number of characters in each line according to the capabilities of your printer (or computer program). The default value is 80.

7 5	len = 75
ENTER	dump all = YES

STEP 5: Scroll the "dump all =" prompt to dump all data in memory (Yes) or only a portion of it (No).

ENTER	dumping . . .

If NO is chosen in response to the "dump all =" prompt, the user is prompted for the year, month, day, hour, and minute (time stamp) at which to begin data transfer, and also the date and time at which to end transfer.

After responding to the "dump all =" prompt, data transfer should begin (as indicated by the message "dumping...").

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When ENTER is pressed the LI-1000 checks pin DSR (Data Set Ready - pin 6 on RS-232C connector) to see if it is high (> + 4 volts). If it is high, the first character is transferred. If DSR is low the LI-1000 will wait until DSR is high. The LI-1000 will check DSR before each character to make sure the receiving device is ready.

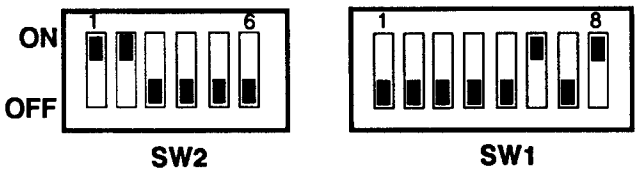
When the entire memory (or the specified portion of it) has been transferred the output process will automatically terminate. To terminate the output before the entire memory is sent (or if there is some problem in sending the data), the output can be stopped by pressing OUT a second time.

Data is transferred starting with the oldest data point first and ending with the newest.

When data transmission begins, the portion of the memory designated by the "dump all" prompt is transmitted. To pause transmission electronically, set pin 6 on the RS-232C connector at a voltage lower than approximately 3 volts. The LI-1000 uses pin 6 (DSR - Data Set Ready) to handshake with the receiving device. When pin 6 is low, data transmission will stop until the DSR line is high again.

Printing Data on the 6000-03A Printer

The 6000-03A serial configuration is determined by 2 banks of DIP switches located on the serial interface board. They are set at LI-COR for 2 stop bits, parity odd and disabled, flag positive, and 4800 baud. The dip switches should be set as shown below.



Consult the EPSON Serial Interface manual for additional information on these switches.

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The 6000-03A is connected to the LI-1000 using the 1000-03 DTE to DTE Cable.

Sending Data to a Computer

The IBM Personal Computer.

In order to transfer data into an IBM PC two things are needed, the proper cable(s) and software that writes the incoming data into a data file.

The LI-1000 can be connected to the standard IBM PC using the 1000-03 Printer Cable and the 1000-04 Communication Cable, or alternately, the 1000-03 and a female to female gender changer with pin for pin connections between the two female connectors. The 1000-04 is needed only to change the gender of the 25-pin connector. If you are using an IBM AT or an AT clone you will need a 25-pin to 9-pin conversion cable, which you should be able to find at a local computer store.

For the data transfer software, a number of programs are available. A simple BASIC program is available from LI-COR (#DL1000) that writes the incoming ASCII data into a file. The DL1000 software also has a program which sorts the data by channel number.

Most commercially available communication packages also include software to perform this type of data transfer. Several inexpensive programs and their manufacturers are listed below.

Program: ProComm
Datastorm Technologies, inc.
P.0. Box 1471
Columbia, MO 65205

Program: PC-Talk
Freeware
P.O. Box 862
Tiburon, CA 94920

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The NEC PC8300 (or PC8201A)

The NEC PC8300 and similar computers (i.e. Radio Shack TRS80 model 100) have several advantages as a portable data capture device including price, high degree of portability, and ease of use. One major disadvantage however is the lack memory for data storage. In general you will need at least three times the storage space in the computer as you have in the LI-1000 because the LI-1000 uses a compact binary storage scheme but transfers data to the computer as ASCII character strings.

The PC8300 has 64K bytes RAM (divided in to two 32K banks) as its standard configuration which makes it very useful in a number of situations. For example, you can dump the entire memory of an 8K LI-1000 into one 32K bank of PC8300. If you have an LI-1000 with 32K RAM you will get approximately 36% of the stored data in each 32K bank. To accomplish this you will need to select the range of time stamps to dump into each bank by using the "dump all =" prompt in the LI-1000 output software.

The PC8300, PC8201A, and Radio Shack computers all have different amounts of standard memory and different memory capacities with the optional memory expansions. The data storage capacity of each can be estimated as described below.

Operation. The simplest way to use the PC8300 is to use the terminal mode and download features to create a text file which can be edited or printed using the word processing software bundled with the computer. Such a file can also be sent back out the RS-232C port using a simple basic program. Alternatively, if you want your data formatted in some particular way, you could use the BASIC interpreter to write your own data input software.

Connect the PC-8300 to the LI-1000 using the 1000-03 Printer Cable. In order to communicate with the LI-1000, the PC-8300 must be configured as a terminal and the communication parameters set to match the LI-1000.

The program on the main menu named TELECOM configures the PC-8300 as a terminal. To execute this program, use the cursor movement keys on the upper right of the keyboard to move the cursor over TELECOM and press the return key.

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After executing "TELECOM", the last line of the display contains the commands STAT and TERM (terminal). This line shows which functions are assigned to the five function keys at the top of the keyboard. STAT is assigned to F*4 and TERM to F*5. STAT is used to change the communication parameters as described in the PC8300 users guide, and TERM enters terminal mode.

The top line of the display has a string of characters (7N8INNP1O, or similar) that represent the baud rate, parity, etc., of the PC-8300. For the LI-1000, 7N8IXSP1O represents the correct configuration (NOTE: the last character is an "oh" not a zero). For the PC8201A the status line should read 7N8INN. If something different is indicated, it will need to be changed.

Set the communication parameters and then press F*5 to enter terminal mode.

Transferring data from the LI-1000 to the NEC

When in terminal mode, press function key F*5 (labeled DOWN) to "download" a file from the LI-1000 into the NEC. The NEC responds with the prompt "FILE TO DOWNLOAD?" which is a request for the name of the file in which the transferred data will be stored. File names can be 6 characters long.

When the "download" function is used, all information transferred is both displayed and stored in a file in the PC-8300. If data transmission is finished before the bank is full, you must press F*5 to exit the download function. If the memory is full before data transmission is complete, the PC8300 will automatically exit the download function.

Memory Capacity. If you want to know often you would need to retrieve data from the LI-1000 and have it all fit into the PC8300, there are several ways to accomplish this. The easiest is to configure the LI-1000 as it will be configured in the field, only set the logging periods to 1 minute. This will quickly fill up the memory. When the memory is full send the data to the NEC and count how many integration periods are stored in each bank. If you can store 500 integration periods in both banks and you intend to use hourly periods, you will need to dump your data every 500 hours.

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The Radio Shack TRS-80 Model 100

The TRS-80 model 100 operates in a fashion very similar to the NEC PC8300. The operation description given above can be applied to the TRS-80 model 100 with the exception that a few of the prompts are different. A brief operation summary is given below

1) Connect the LI-1000 to the TRS-80 using the 1000-03 and 1000-04 (the 1000-04 is needed because the connector on the 1000-03 is too large).
2) Enter TELECOM mode.
3) Press F*3 for Status mode and set the communication parameters to 78N2D,10 pps.
4) Press F*4 to enter Terminal mode
5) Press F*2 to use the download function.
6) Transfer data.
7) Press F*8 to exit the download function. Press F*8 again to return to the main menu.

Solving Communication Problems

Below are a few of the common communication problems encountered and something to check in order to facilitate solving the problem.

PROBLEM	WHAT TO CHECK
Nothing happens	Proper cable? Connections tight?
All characters are wrong	Baud rate.
Some characters are wrong	Data bits, stop bits, or parity.

The most common problem in RS-232C communications is the use of the wrong cable. If you have communication problems that cannot be resolved, you may wish to purchase an RS-232C indicator card (Model # 9960-031). This card indicates which lines in the cable are being used and generally indicates where the problem is. Also, an application on RS-232C communications is available from LI-COR.

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SECTION XI

Maintenance

Replacing the "D" Cell Batteries

Battery replacement is a 4 step process:

1. Unscrew the 4 screws in the back cover and carefully lift it off of the front cover. Be careful not to put tension on the wire which connects the battery pack to the circuit board.

2. Disconnect the battery pack from the circuit board by pulling the battery connector straight up and off of the circuit board. The battery connector is shown in Figure 14.

IMPORTANT: There are no user serviceable parts inside the LI-1000 except the batteries and desiccant.

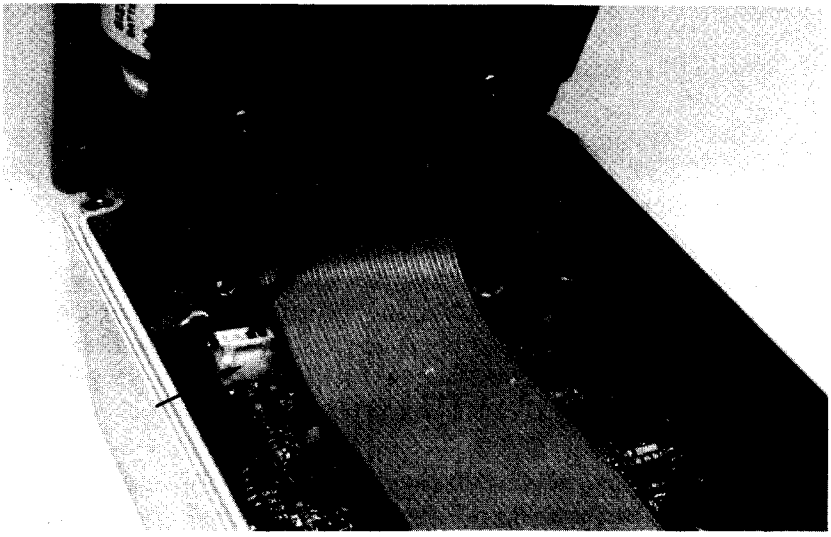


Figure 14. Location of the battery connector.

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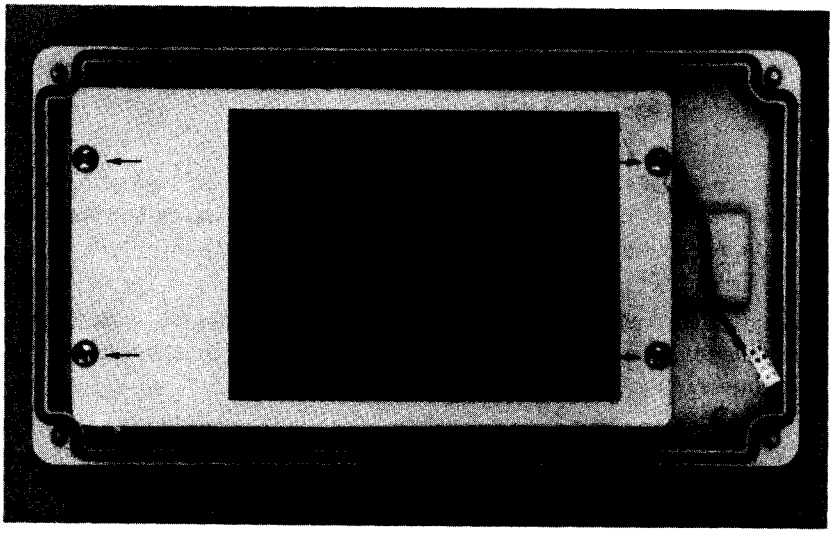


Figure 15. Location of the screws securing the battery cover plate.

3) Remove the 4 screws which secure the battery cover plate (shown in Figure 15) and remove the old batteries.

4) Install the new batteries matching the polarity of the batteries to the polarity indicated on the inside of the bottom cover. Install the battery cover plate, connect the battery connector, and screw the back cover onto the front cover. Note that the battery connectors are polarized connectors and can be pushed together in only one direction.

A lithium battery is mounted on the circuit board to provide a backup battery for the memory when the main battery pack is removed. As long as the battery pack is removed for only short periods of time, both the memory and

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the configuration will be maintained by the backup battery (the lithium battery will maintain the memory for approximately 500 hours).

The LI-1000 should be turned ON and checked for proper operation after the batteries have been replaced.

Renewing the Desiccant Pack

The desiccant pack is located at the lower end of the battery pack as shown in Figure 16. The desiccant is an indicating silica gel which changes color from blue when dry, to pink when it absorbs water. The desiccant pack should be removed and checked when the batteries are changed. If the color is pink it should be dried in an oven at 175 °F for 1 hour or until the blue color has returned. The pack is removed by loosening the bracket which holds it in place and sliding it out.

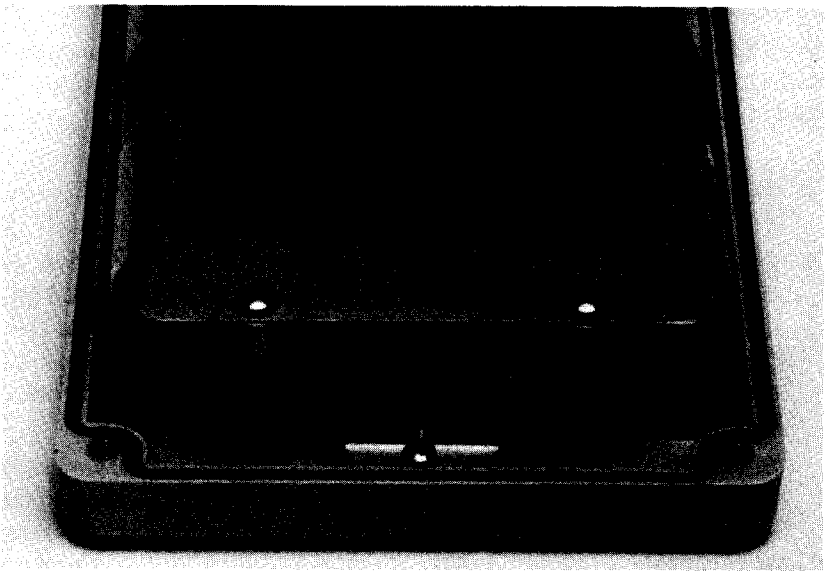


Figure 16. Location of the Silica-Gel desiccant pack.

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Restarting the Software.

This procedure is used to restart the LI-1000 software if the instrument locks-up and cannot be reset or turned off by any other method. If this happens, it should be a rare occurrence. If you have recurring problems with the instrument locking up it could be a sign of a hardware malfunction and should be returned for repair.

If you are using the autorange feature and the LI-1000 appears to be locked-up (displaying all nines), disconnect all sensors and check again to make sure it is still not working correctly. If the autorange feature is used with a sensor whose signal is rapidly fluctuating, the LI-1000 can appear to be locked up while it autoranges and tries to find the correct range. If this is the case the LI-1000 will return to normal operation when the sensors are disconnected (if a large number of points are being averaged this may take some time).

The software is restarted by using a copper wire or other good conductor to short two pins on the circuit board in order to short-out the back-up battery.

IMPORTANT: The following procedure erases all data stored in memory and changes all channel configurations to the default configurations. It should be used only when absolutely necessary.

1) Remove the back cover and disconnect the battery pack.

2) Turn the LI-1000 so that the BNC connectors face away from you. As shown in Figure 17 there is a row of 24 solder joints surrounded by a white rectangle located about 2.5" from the top of the box. If the third and fifth pins from the right-hand side are shorted together for a few seconds, the software will restart when the battery pack is reconnected.

   NOTE: On some of the earliest units, the LI-1000 had a black connector with 24 gold posts sticking up out of it in place of the 24 solder joints. The 3rd and 5th pins from the right are also jumpered on these instruments.

3) Reconnect the battery and replace the back cover on the LI-1000.

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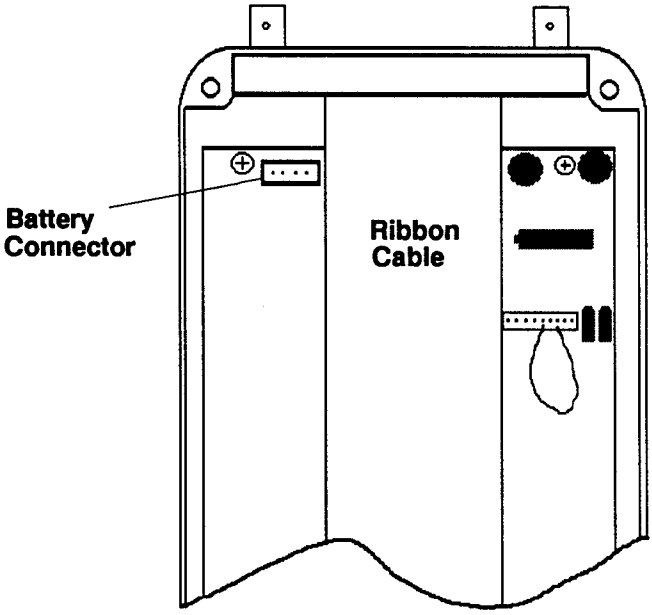


Figure 17. Location of the pins used to restart the LI-1000 software.

4) When the battery is reconnected the LI-1000 will prompt for current date, current time, and then go through the configuration sequence. Note that you will not be able to leave the configuration sequence unless you turn on at least one channel.

5) Enter the auxiliary functions list and use the clear memory function to clear the memory. (The memory is already empty but this ensures the instrument is properly reset).

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Appendix A
LI-1000 Pin Assignments
(25 Pin "D" Connector)

25 Pin "D"	Signal Name
1	Chassis Ground
2	RS-232C Data Out (to device)
3	RS-232C Data In (from device)
4	Wired to pin 5
5	Wired to pin 4
6	RS-232C DSR
7	RS-232C Ground
8	not used
9	Battery (-)
10	Battery (+)
11	not used
12	not used
13	not used
14	not used
15	not used
16	not used
17	not used
18	not used
19	not used
20	DTR (1K Ohm resistor to +5 volts)
21	not used
22	not used
23	not used
24	not used
25	not used

NOTE: Pin numbers are stamped on the inside of the connector at the base of the pins.

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Appendix B
LI-1000 Pin Assignments
(37 Pin "D" Connector)

37 Pin "D"	Signal Name
1	-4.5 volts
2	Ground
3	Digital Ground
4	163.84 Khz
5	Digital Counter Channel # 1
6	Battery (+) (output only)
7	Digital Counter Channel # 2
8	Digital Ground
9	Voltage Channel # 5
10	Voltage Channel # 6
11	Voltage Channel # 7
12	Voltage Channel # 8
13	Voltage Channel # 4
14	Voltage Channel # 3
15	Current Channel # 3
16	Current Channel # 4
17	Current Channel # 5
18	not used
19	not used
20	Op Amp OUT
21	Ground
22	Excitation
23	Excitation
24	+ 5 volts
25	Excitation
26	Excitation
27	Excitation
28	Channel 5 ground
29	Channel 6 ground
30	Channel 7 ground
31	Channel 8 ground
32	Channel 4 ground

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37 Pin "D"	Signal Name
33	Channel 3 ground
34	Current Channel # 8
35	Current Channel # 7
36	Current Channel # 6
37	not used

NOTE: Pin numbers are stamped on the inside of the connector at the base of the pins.

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Appendix C
Specifications

Analog Inputs: Eight total analog inputs configured as voltage or current channels:

Current Inputs: Eight channels; two sealed BNC connectors and six channels accessed directly through 37 pin D connector or by connecting 1000-05 Terminal Block, or 1000-06A AC Terminal Block.

Voltage Inputs: Six single-ended channels accessed directly through 37 pin D connector or by connecting 1000-05 Terminal Block, 1000-06 AC Terminal Block, or 1000-10 Thermocouple Terminal Block. Channels 1 and 2 can also be configured for voltage measurement by placing an input impedance resistor in the sensor cable.

Pulse Counting Inputs: Two pulse counting channels. Switch closure to ground (200 hz); external signal driving (1 Khz). Inputs have hysteresis so there is no minimum rise time.

Analog to Digital Converter

Type: Voltage to Frequency

Resolution: 14 bit (1 part in 16,000)

Scan Rate: 4 channels per second, (200 ms integration time (for 50/60 Hz noise rejection).

Accuracy

Voltage: ± 0.3% of full scale reading (25 °C). ± 0.55% (0 to 55 °C).

Current: ± 0.2% of full scale reading (25 °C). ± 0.45% (0 to 55 °C).

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

Linearity: 0.05%

Normal Mode Rejection: > 60 dB at 50 or 60 Hz

Voltage Input Noise (25 °C)

Typical: ± 2.5 μV

Maximum: ± 5 μV

60 Second Average (Typical): ± 0.4 μV

60 Second Average (Maximum): ± 0.8 μV

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Current Input Noise (25 °C)
Typical: ± 25 picoamps
Maximum: ± 50 picoamps
60 Second Average (Typical): ± 4 picoamps
60 Second Average (Maximum): ± 8 picoamps

Typical Noise Level using LI-COR sensors (current channel, Range 1, 25 °C)

LI-190SA (μmol s^{-1} m^{-2}):Instantaneous: 0.005, 60 Second Average: 0.001
LI-191SA (μmol s^{-1} m^{-2}): Instantaneous: 0.007, 60 Second Average: 0.002
LI-192SA (μmol s^{-1} m^{-2}): Instantaneous: 0.01, 60 Second Average: 0.002
LI-193SA (μmol s^{-1} m^{-2}): Instantaneous: 0.007, 60 Second Average: 0.002
LI-200SA (W m^{-2}): Instantaneous: 0.0006, 60 Second Average: 0.0001
LI-210SA (lux): Instantaneous: 0.15, 60 Second Average: 0.03

Range Selection: Autoranging or software selectable:

Voltage Ranges	**Resolution**
1 ± 20 millivolts	2.5 microvolts
2 ± 200 millivolts	25 microvolts
3 ± 2.0 volts	0.25 millivolts
4 ± 20.0 volts	2.5 millivolts

Current Ranges	**Resolution**
1 ± 200 nanoamps	25 picoamps
2 ± 2 microamps	0.25 nanoamps
3 ± 20 microamps	2.5 nanoamps
4 ± 200 microamps	25 nanoamps

Input Impedance:
Current Inputs: 0.2 ohm on all 8 channels.
Voltage Inputs: 100K Ohm on all 6 voltage channels. Channels 1 and 2 can also be configured for voltage measurement by placing an input impedance resistor in the sensor cable

A.C. Excitation: 1000-06A A.C. Terminal Block performs A.C. resistance measurement which eliminates the need for A.C. excitation.

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DC Output Supply: + 5.0 V at 5 mA or battery voltage 6-9 V (unregulated) requires 1000-05.

Integrated Measurements

Integration Period	Sampling Interval
1 minute	5 seconds
5 minutes	5 seconds
10 minutes	5 seconds
15 minutes	5 seconds
30 minutes	5 seconds
1 hour	5 seconds or 1 minute
3 hours	5 seconds or 1 minute
6 hours	5 seconds or 1 minute
12 hours	5 seconds or 1 minute
24 hours	5 seconds or 1 minute

Short Term Running Averages: User selectable number of seconds for instantaneous values to be averaged. For example, 30 is entered for a 30 second continuous running average (i.e., oldest point dropped when newest point added). Useful for averaging readings under fluctuating conditions or to reduce the noise level. (Noise reduction = 1 / number of samples multiplied by the noise

Keyboard: Sealed, 24 key tactile response keypad for setup, operation, data communications.

Display: One line, 16 character alphanumeric LCD. Updated every second (instantaneous mode).

Real Time Clock: Year, month, day, hour, minute. Accuracy: ± 3 minutes per month.

Internal Memory: 8K bytes RAM (1-2 channels typical usage) or 32K bytes RAM (1-10 channels typical usage).

Memory Capacity: Dependent on configuration (integration period, number of channels active, min/max selected, reset time, etc). Each data point requires 4 bytes and each time stamp requires 6 bytes (only one time

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stamp per integration period for all the channels). Min/max requires 16 bytes (min, max, and time stamp for each, 8 bytes if time stamps are not stored). Memory available for data storage in LI-1000-8 is approximately 6792 bytes; LI-1000-32 is 31368 bytes.

Communications: RS-232C hardwired Data Terminal Equipment (DTE). Baud rate software selectable at 300, 4800. Accessory output cables are the 1000-03 DTE to DTE Cable and 1000-04 Communications Cable (DTE to DCE).

Power

Batteries: Six alkaline "D" cells.

External Power: 108-126/216-252 VAC, 48-66 Hz using 1000-02 Battery Charger; or 9-24 VDC.

Backup Battery: Internal lithium battery for memory backup when changing main batteries.

Battery Voltage: Low battery warning displayed. Automatic instrument shutoff occurs when batteries reach the end of useful life. This provides power for maintaining the data stored in memory.

Battery Capacity (25 °C)

1 channel, 1 to 24 hour periods: 12 months

8 channels, 1 to 24 hour periods: 10 months

1 channel, 10 minute periods: 55 days

8 channels, 10 minute periods: 30 days

Continuous Operation: 550 hours

Enclosure: Rugged O-ring sealed, weatherproof polycarbonate case.

Environmental Conditions

Operating: -25 to 55 °C, 0-100% RH (noncondensing).

Display Operating Range: -15 to 50 °C.

Storage: -30 to 60 °C, 0-100% RH (noncondensing).

Dimensions

Size: 21 L x 11.4 W x 6.9 cm D (8.3" x 4.5" x 2.7").

Weight: 1.6 kg (3.5 lbs) with D cells.

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Appendix D

Software Version 2.0 for Previous LI-1000 Users

Version 2.0 software contains a number of operational enhancements which make the LI-1000 easier to use. A list of some of the new features and where to find information on them is given below.

1) Numbers are displayed in decimal form unless they are very large or small. See "Viewing Data Stored in Memory", in Section III.

2) Configuration Mode. Each channel has three configurations, one for LI-COR light sensors, one for thermocouples and a general channel configuration which resembles the channel configuration in version 1.02 software. The LIGHT and THERM configurations contain only the prompts needed to configure those types of sensors. See "Configuration Mode", Section III.

3) In Instantaneous mode the average can be set at any number and is limited only by the available memory in the LI-1000. See "Light Sensor Channel Configuration in Instantaneous Mode, Section IV.

4) In Log mode, several short logging periods have been added (1, 5, 15, and 30 minutes). Also, for the 1 through 24 hour periods the sample interval can be set at 5 or 60 seconds. See "Light Sensor Channel Configuration in Log Mode", Section IV.

5) In Log mode you can now store min/max values without storing the time stamps (saves memory). See "Light Sensor Channel Configuration in Log Mode", Section IV.

6) A thermocouple channel configuration provides support for type T, J, E, R, K, and S type thermocouples. See Section VI.

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7) A math function has been added to each channel. In Instantaneous mode it performs like the math channel in version 1.02, but in Log mode it is very different. See "General Channel Configuration in Log Mode", Section VI.

8) A feature has been added to the function key to allow you to store a set of three remarks in response to three prompts which you can define. Other functions have been moved to the function key including the memory status, clearing the memory, etc. See Section III, "Auxiliary Functions Available on the FCT/ON key".

9) The output function now has the ability to dump all of the memory or only the portion which you define (Section X). Similarly, in View mode you can go to a specific time stamp without having to page through all the others.

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Appendix E
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Appendix F

Thermistor Calibration Coefficients

NOTE: The RMS errors given below represent only the error contributed by the polynomial. The overall error for LI-COR temperature thermistors is typically +/- 0.5 °C at 25 °C.

Temperature Range: -10 to + 50 °C RMS Error(°C): 0.0164

a0 = -112.50
a1 = 4.9571
a2 = - 0.10598
a3 = 0.0012529
a4 = - 7.4253E-6
a5 = 1.7952E-8

Temperature Range: -20 to + 60 °C RMS Error(°C): 0.082

a0 = -83.370
a1 = 3.4948
a2 = - 0.078427
a3 = 0.0010130
a4 = - 6.4891E-6
a5 = 1.6748E-8

Temperature Range: -30 to + 70 °C RMS Error(°C): 0.234

a0 = -70.138
a1 = 2.7873
a2 = - 0.065364
a3 = 0.00091648
a4 = - 6.2909E-6
a5 = 1.7108E-8

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Temperature Range: -40 to + 80 °C RMS Error(°C): 0.419

a0 = -64.621

a1 = 2.4379

a2 = - 0.058010

a3 = 0.00085469

a4 = - 6.1225E-6

a5 = 1.7195E-8

Temperature Range: -80 to + 40 °C RMS Error(°C): 1.36

a0 = -75.144

a1 = 3.6563

a2 = - 0.10410

a3 = 0.0016129

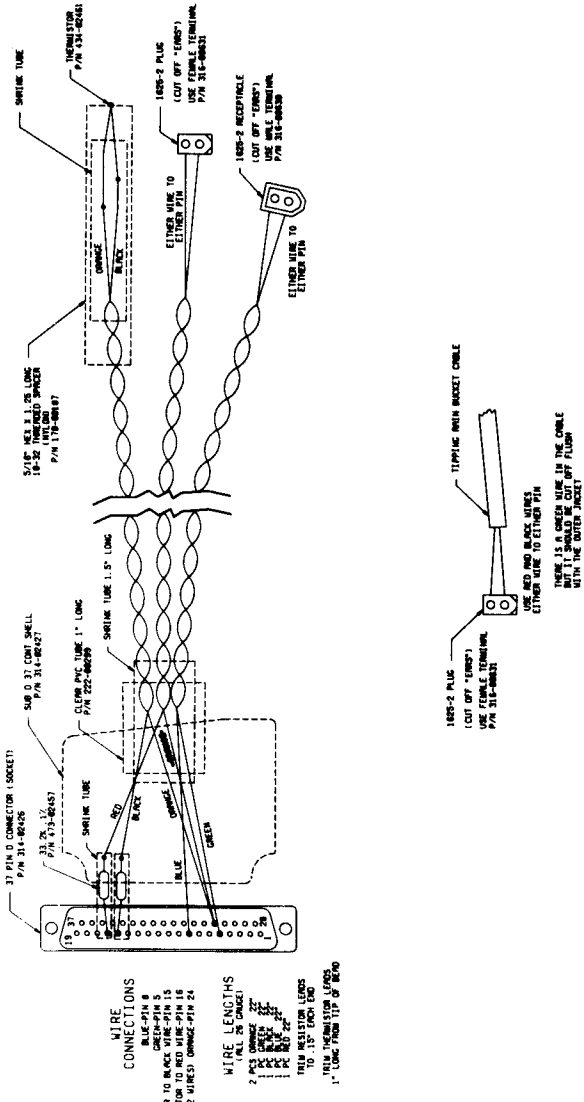
a4 = - 1.1768E-5

a5 = 3.2806E-8

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Appendix G

1000-14 Sensor Connection Cable



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