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Instruction Manual

Model LC-3x2

Dual Channel MEMS Datalogger

(Doc Rev H, 10/06/2021)

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EQUATIONS

1. INTRODUCTION

The Model LC-3x2 Dual Channel Datalogger is a low cost, battery powered and easy to use measurement instrument designed to read up to two uniaxial or 1 biaxial MEMS sensor(s) equipped with thermistors.

The 512K (bytes) of standard memory provides storage for 21,000 data arrays. Each array consists of a datalogger ID string (16 characters maximum), a timestamp consisting of the year, date (julian day of the year or month/day format), time (hhmm or hours/minutes format) and seconds when the reading was taken. Also included in the data is the internal 4.5V (or external 12V) battery voltage, the datalogger temperature, the MEMS readings, the sensor temperature and the Array #.

Internal math is calculated using 32-bit floating-point notation (IEEE). Math operations on the instrument readings, such as application of zero readings, gauge factors (or calibration factors) and offsets when using a linear conversion technique or polynomial coefficients when using the polynomial conversion, provide outputs directly in engineering units. The dataloggers internal configuration is defined through communication with a computer using the supplied RS-232 or USB interface cable. The datalogger is configured and monitored using LogView, a GEOKON proprietary Graphic User Interface (GUI) software application (See Section 2.2). The datalogger can also be configured and monitored via text-based commands with any standard terminal emulator software, such as Microsoft Windows HyperTerminal™ (see Section 3 - Command List).

The following communications options are available for the LC-3x2:

LC-3x2 Model #	Communication
8003A-1, 8003A-2	RS-232
8003B-1, 8003B-2	USB
8003C-2	RS-232
8003D-2	USB

8003A-X & 8003C-2: Communication with the LC-3x2 is implemented via the host computer's RS-232 COM port, either internal or through an USB-to-Serial Converter. See Section 2.2.6 for further information.

8003B-X & 8003D-2: Communication with the LC-3x2 is implemented via a host computer's USB 2.0 port. When connected to a computer via the USB port, the LC-3 is seen as a "virtual" COM port. The LC-3x2 datalogger also receives operating power from the computer, thus extending the internal 4.5V (or external 12V) battery life. When disconnected from the USB port, the datalogger automatically switches to the internal 4.5V (or external 12V) battery pack. See Section 2.2.7 for further information.

All data, both readings and configuration, are stored in non-volatile EEPROM with a typical storage life of 10 years (minimum). The internal temperature compensated real-time clock, used to provide timekeeping and triggering of readings, is accurate to ±2 minutes/year. The comma delineated ASCII output format allows for easy importing into popular spreadsheet programs such as Lotus 1-2-3™ or Microsoft Excel™. See Appendix D for sample data files.

2. GETTING STARTED

The following equipment will arrive with the Model LC-3x2 datalogger;

1. Set of three alkaline 'D' cell batteries.

2. One desiccant pack inside the enclosure.

3. Accessories:
   8003A-X & 8003C-2: P/N COM-108 (DB-9F to 10-pin Bendix Male) RS-232 Communication Cable. Optionally, a USB-to-Serial converter (8001-7) may also be supplied.

   8003B-X & 8003D-2: P/N COM-109 (USB-A to 10-pin Bendix Male) USB Communication Cable

4. Model LC-3x2 Dual Channel MEMS Datalogger Instruction Manual.

If any of these items are missing or damaged contact the factory for replacements. The following are optional accessories:

- MEMS Sensor with built-in thermistor (2 maximum).

Section 2.1 below outlines the connection options for the different LC-3 models in conjunction with GEOKON's model 6160-2, biaxial MEMS Tilt Sensor and the 6160-1, uniaxial MEMS Tilt Sensor.

2.1 Sensor Installation

8003A-2 & 8003B-2: Connect the green circular metal, military style, connector from the 6160-2 sensor to the LC-3 connector labeled: "Sensor A". If connecting two 6160-1 sensors, connect one sensor to the connector labeled: "Sensor A" and the other sensor to the connector labeled: "Sensor B"

8003A-1 & 8003B-1: Connect the green circular metal, military style, connector from the 6160-1 sensor to the LC-3 connector labeled: "Sensor"

8003C-2 & 8003D-2: The sensors are factory installed (see Appendix F).

2.2 Software Installation and Setup

LogView Graphical User Interface (GUI) software is used to communicate with the datalogger using a personal computer running a Microsoft Windows® operating system. Other general-purpose communication programs (i.e. Windows HyperTerminal™) can also be used to communicate with the Model LC-3x2 via text-based commands. LogView, along with the LC-2/LC-3 USB drivers, can be downloaded from the GEOKON web-site at: www.GEOKON.com/software.

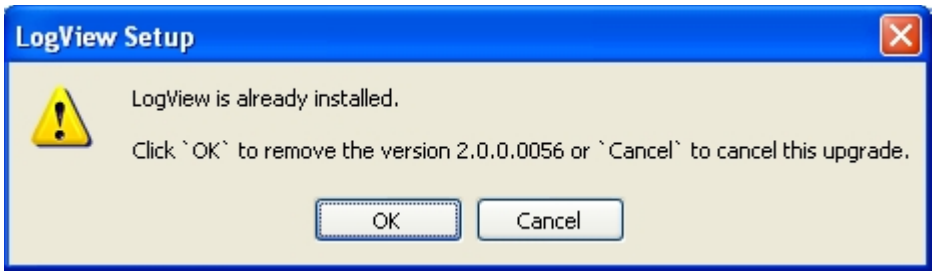
Perform the following steps to install LogView software for each computer that will connect to an LC-3x2. These instructions are for computers running Windows XP. The installation procedure is very similar for computers running Windows 7®, Windows 2000® and Windows 98®. This installation procedure needs to be performed just once for each computer that will run LogView to communicate with a LC-3x2 datalogger.

Make sure that the three 1.5V D-cell alkaline batteries are installed in the datalogger (See Section 4.2 for instructions) and that the LC-3x2 datalogger is not connected to the computer at this time.

2.2.1 LogView Installation

1) Using Windows Explorer, navigate to the extracted downloaded files. Double click on the file, "start.bat" to start the install process.

2) The LogView installer first installs USB drivers needed to communicate with the 8003B-X or 8003D-2. It then checks to see if there is any other version installed and, if so, the following dialog box is displayed:



NOTE: The USB drivers are only required for LC-3x2 models 8003B-X and 8003D-2. Communication with models 8003A-X and 8003C-2 require either an internal COM port or a USB-to-Serial converter (which may require its own drivers).

3) Click "**OK**" to proceed or "**Cancel**" to cancel the installation and leave the previous version installed. If "OK" is selected, the uninstall process must be confirmed, then will take a few seconds to complete. Click on "**Close**" when done.

4) Click "**Next >**" when the **Welcome** window appears.

5) When the **Choose Users** window appears, a choice must be made whether to install LogView so that all users of the PC can use it or just the user installing LogView. If the user installing LogView is not a local administrator, then the only valid selection is "Install just for me". Click "**Next>**" when done.

6) When the **Choose Start Menu Folder** window appears, choose an appropriate folder (default is GEOKON) then click "**Install**".

7) Click "**Next >**" when the **Java Installation Complete** window appears.

8) Click "**Finish**" when the **Completing the LogView Setup Wizard** window appears.

9) Remove the LogView installation CD from the computer's CD drive.

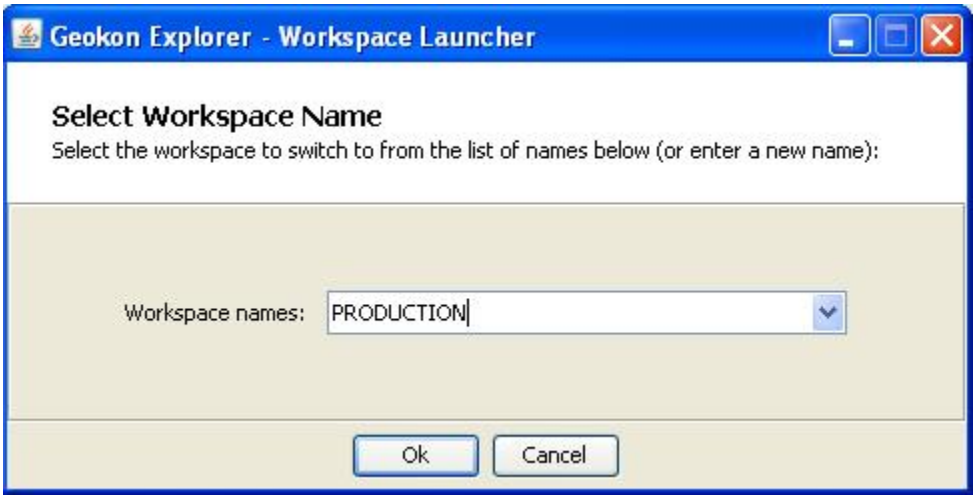
2.2.2 Launching LogView

Launching LogView can be accomplished two different ways. Double clicking on the desktop icon:

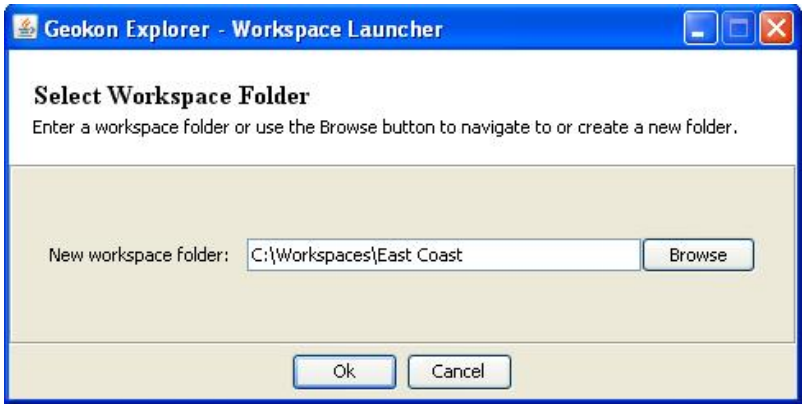
Or via the Windows Start button: "Programs -> GEOKON -> LogView"

2.2.3 LogView Workspaces

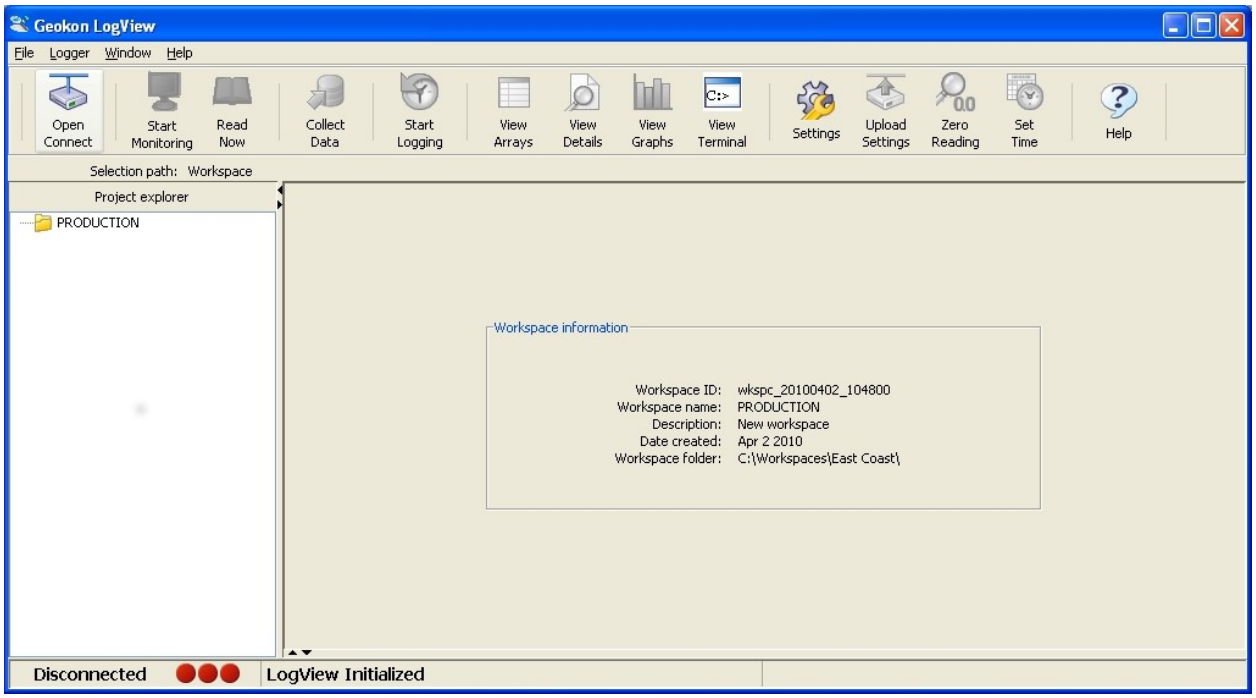
When opening LogView for the first time, the user will be prompted to create a workspace name (Figure 2). The workspace name can be any combination of letters and numbers and, ideally, will be descriptive in nature. See the LogView User's Guide for more information on workspaces.



Once the workspace name has been selected, clicking on "**Ok**" causes LogView to prompt the user to choose or create a folder where all the workspace elements will be stored (Figure 3). The folder location may be entered directly, i.e., `C:\Workspaces\East Coast`, or the **Browse** button may be used to navigate to a folder location or to create a new folder (see below). This workspace location will be stored in the LogView configuration for subsequent application access. Once workspaces are created, future user access is always by name.

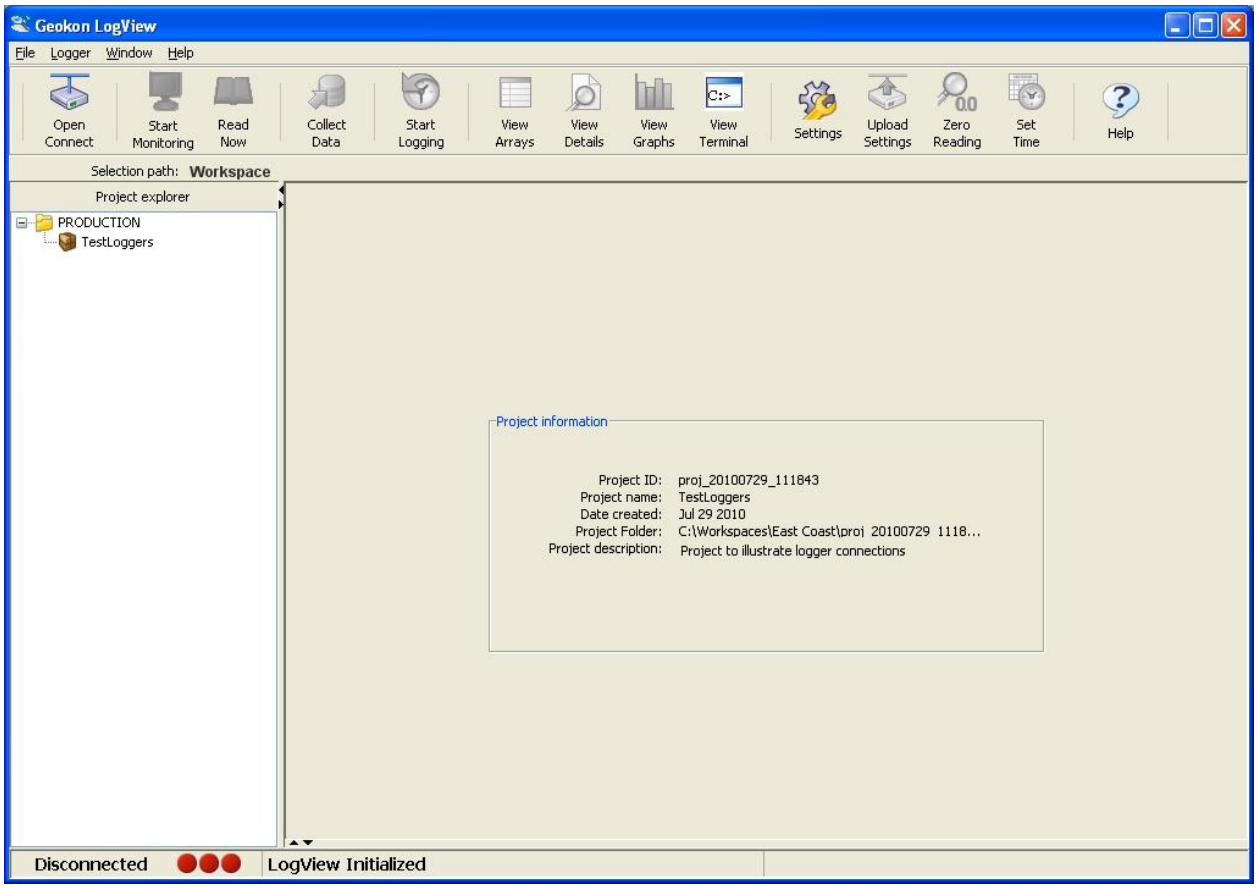


A default folder path is displayed based on the system default workspace path combined with the new workspace name. This path will be used if no other is specified. After the folder path has been specified, clicking on "**Ok**" will display the main window of LogView (Figure 4). On the left-hand side of the main window is the Project Explorer displaying the newly created workspace. The user can add new project(s), datalogger(s) and sensor configurations to the workspace by right-clicking on the workspace and using the menu tools.



2.2.4 Adding Projects to LogView Workspaces

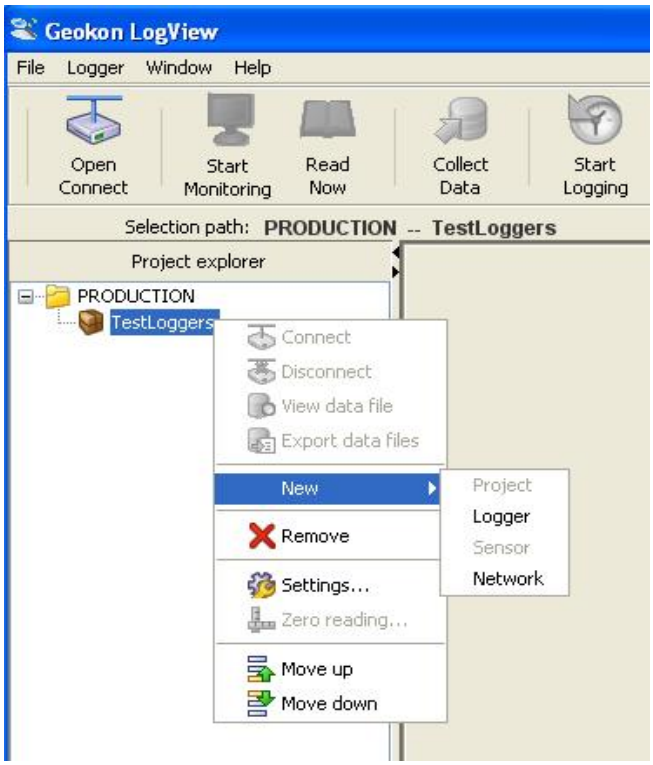
Right-clicking on the "**PRODUCTION"** workspace brings up a context sensitive menu that allows the user to add projects to this workspace (using the "**New->Project**" menu selection). Select a name that makes sense for the real-world project this program will be used for. In this example "TestLoggers" was chosen as the project name.

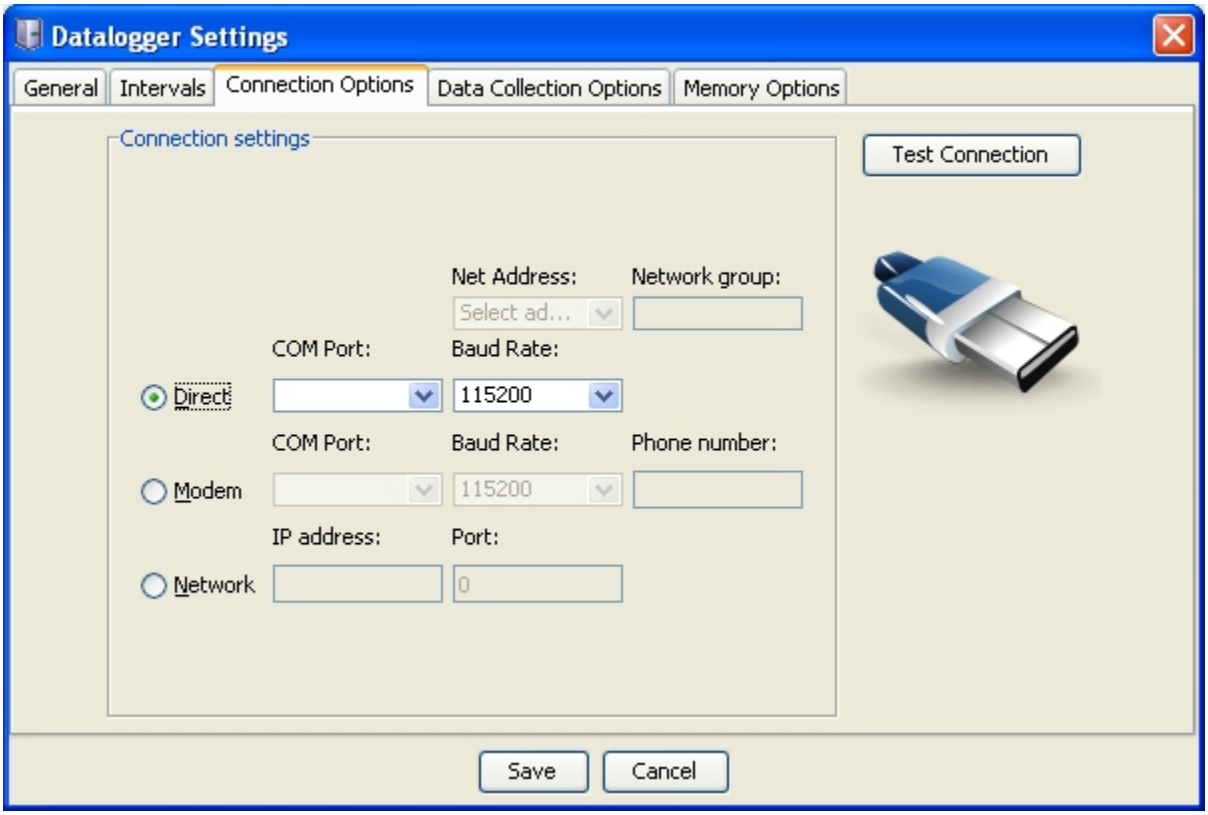


2.2.5 Adding Dataloggers to LogView Projects

Right-clicking on the "**TestLoggers**" project brings up a context sensitive menu (Figure 6) that allows users to add dataloggers to their projects. Selecting **New->Logger** from the context menu causes the "**Datalogger Settings**" dialog to be displayed. Like Workspaces and Projects, Dataloggers can be assigned a unique human-readable name. For this example, "MyLogger" was chosen for the Datalogger name. For a complete description of all datalogger settings please see the LogView Online Help section on Datalogger Settings. For connection purposes, the relevant tab in this dialog is "**Connection Options**" (Figure 7).

Once connected to a PC, all LC-3x2 dataloggers require a COM port to be identified in the "**Connection Options**". LC-3x2 dataloggers currently operate at a default baud rate of 115200 so the default setting should not be changed unless the datalogger has been previously set to another baud rate (See Figure 7).


Geokon LogView
File
Logger
Window
Help
Open Connect
Start Monitoring
Read Now
Collect Data
Start Logging
Selection path: PRODUCTION -- TestLoggers
Project explorer
PRODUCTION
TestLoggers
Connect
Disconnect
View data file
Export data files
New
Remove
Settings...
Zero reading...
Move up
Move down
Project
Logger
Sensor
Network


Datalogger Settings
General
Intervals
Connection Options
Data Collection Options
Memory Options
Connection settings
Test Connection
Net Address:
Network group:
Select ad...
COM Port:
Baud Rate:
Direct
115200
COM Port:
Baud Rate:
Phone number:
Modem
115200
IP address:
Port:
Network
0
Save
Cancel

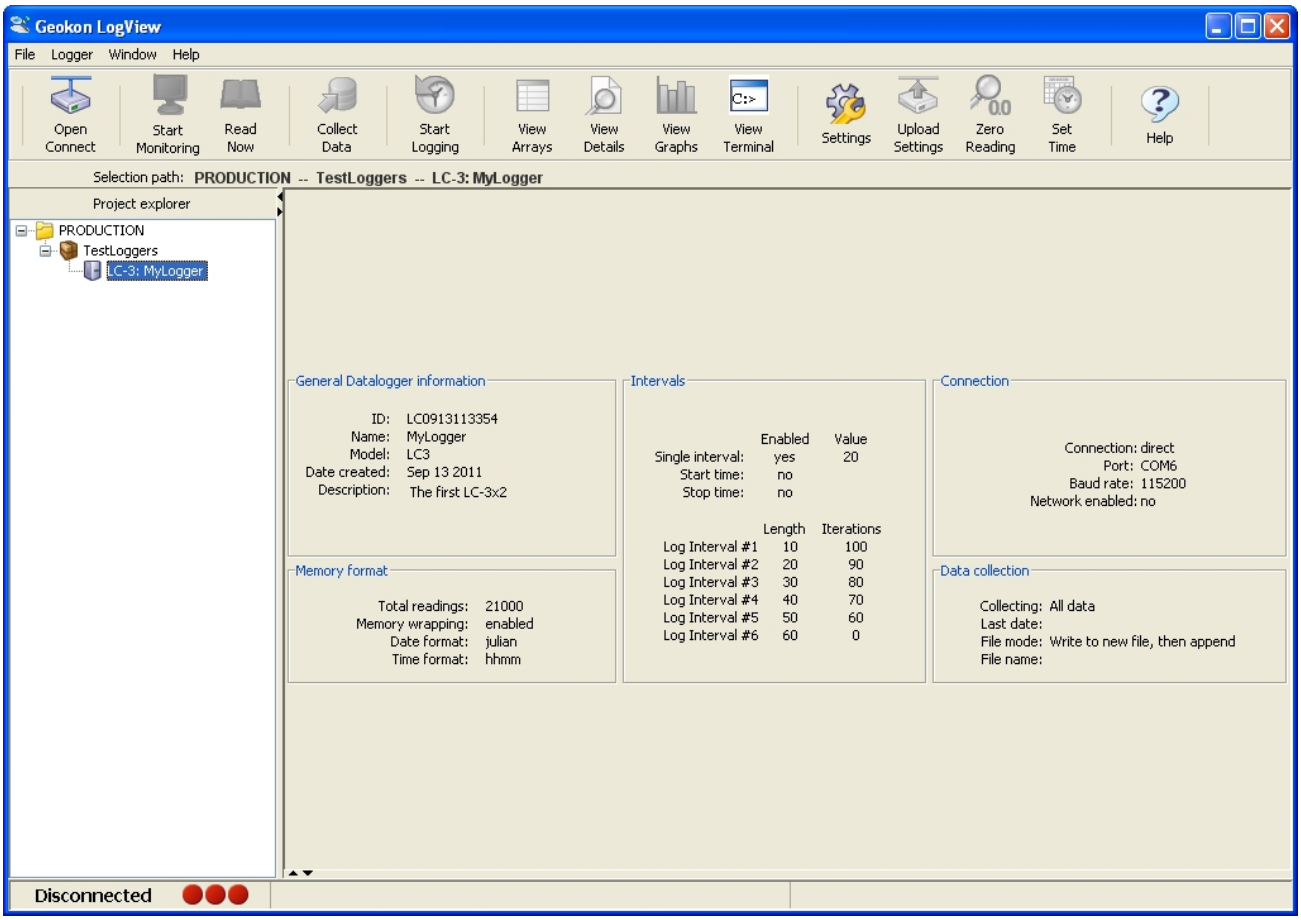
2.2.6 LC-3x2 Connection (8003A-X and 8003C-2, RS-232)

Connect the supplied LC-3x2 RS-232 Communications cable (COM-108) to the COM port of the LC-3x2 datalogger. The protective cap on the datalogger COM connector is removed by pushing in and turning. Plug the DB-9 end of the RS-232 Communications cable into the host computer's RS-232 port (either internal or external via a USB to Serial converter). Proceed to Section 2.2.8, Connecting to a Datalogger with LogView

2.2.7 LC-3x2 Connection (8003B-X and 8003D-2, USB)

Connect the supplied LC-3x2 USB Communications cable (COM-109) to the USB port of the LC-2 datalogger. The protective cap on the datalogger USB connector is removed by pushing in and turning. Plug the USB-A (male) end of the USB cable into an available USB-2.0 port on the host computer.

NOTE: On certain PCs with operating systems older than XP, Service Pack 3, 8003B-X and 8003D-2 dataloggers may require the installation of a driver to properly communicate with the PC. If the PC does not recognize the datalogger's internal USB to serial converter when the connection above is performed, then the driver should be installed by executing the program CDM20814_Setup.exe on the LogView Install CD.



2.2.8. Connecting to a Datalogger with LogView

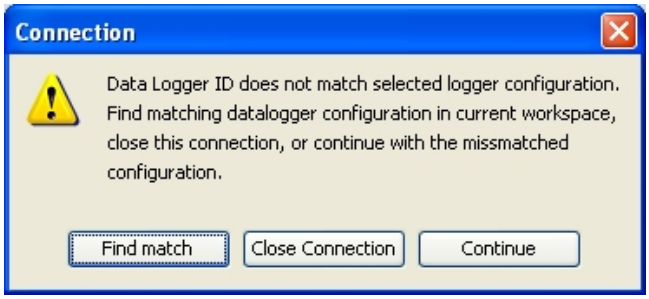
1) With a Datalogger profile configured and selected in the Project Explorer (Figure 8), click on the "**Open Connect**" button on the LogView Toolbar.

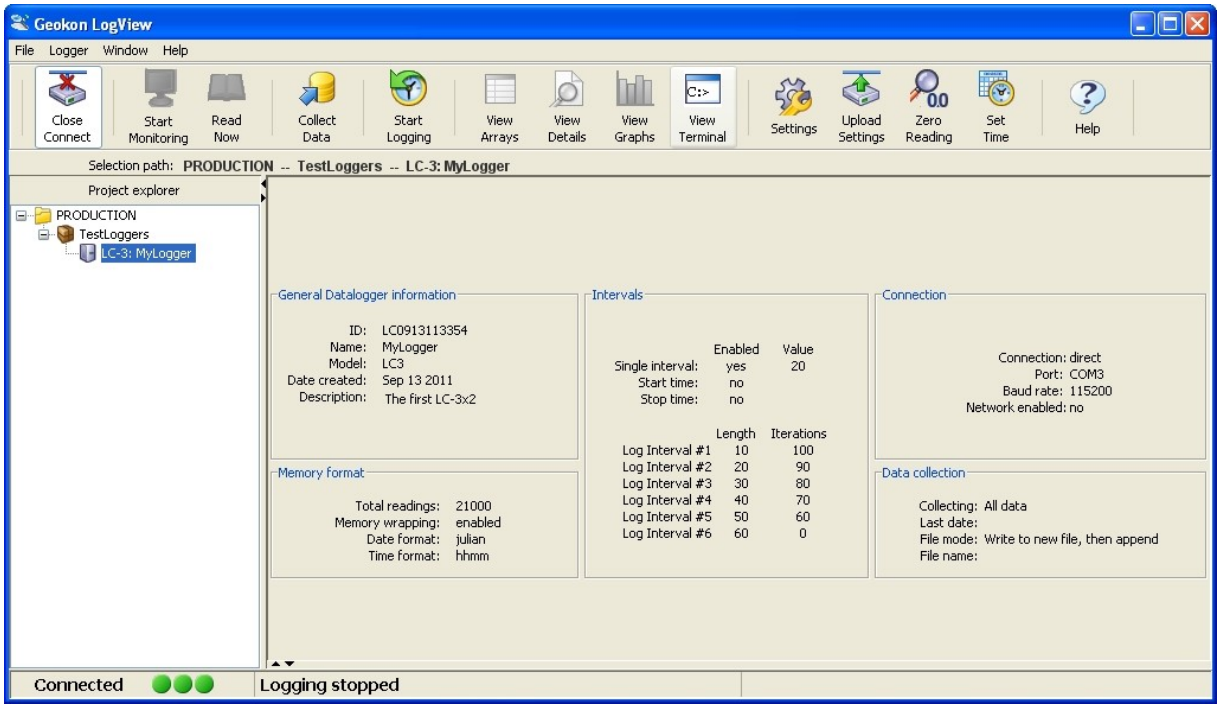
2) When connecting to a new Datalogger for the first time, the message below (Figure 9) may be displayed after several seconds. This is normal and is only an indication that the datalogger doesn't match the configuration created in the Project Explorer. Click on "Continue" to finish connecting to the datalogger.

3) Click on the "**Upload Settings**" button on the LogView Toolbar to synchronize the datalogger with the LogView configuration (Figure 10).

4) LogView is now connected and configured correctly for the LC-3x2 datalogger. Sensors can now be added to the datalogger in a similar fashion as adding Dataloggers to Projects. Sensor settings are accessed via the context menu from the Project Explorer.

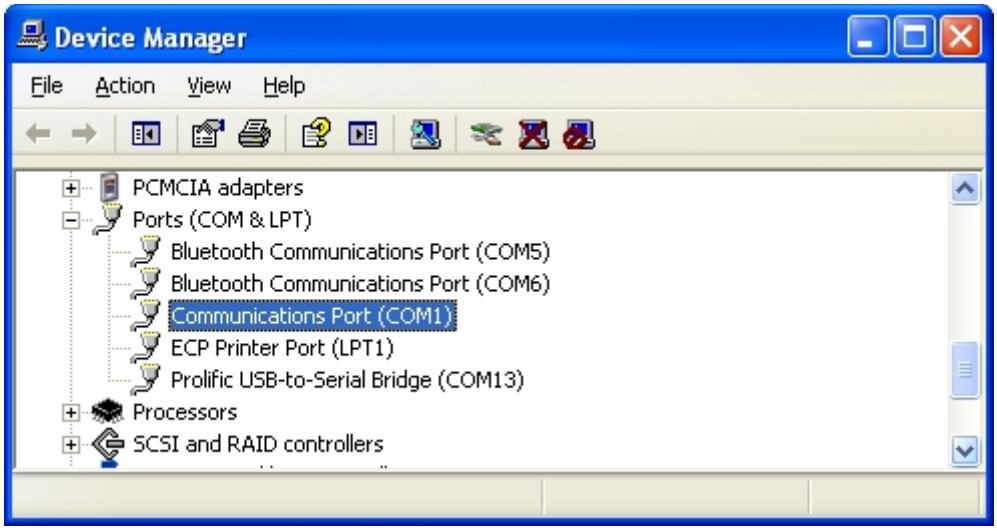
5) Always upload the new settings to the datalogger after changing its configuration in LogView.



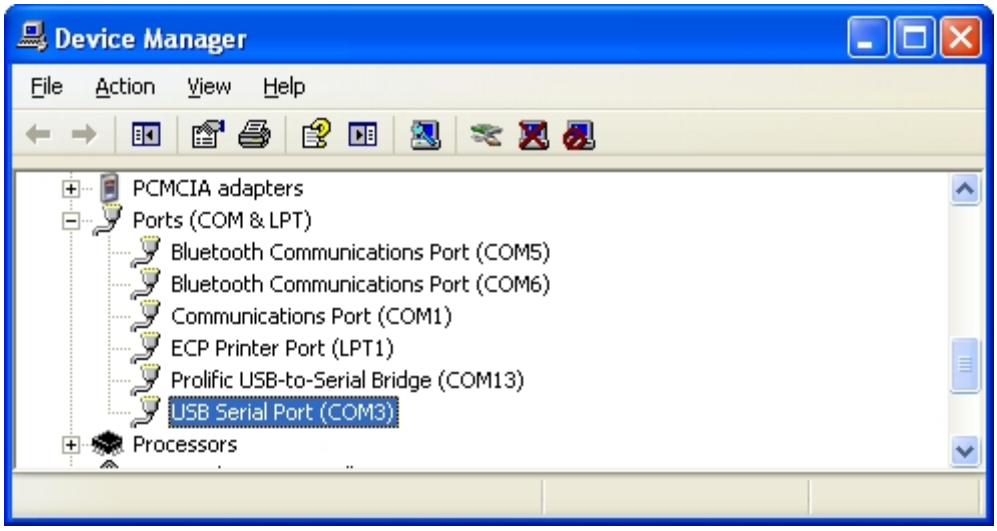


2.2.9 Determining COM Port Numbers

When connecting an 8003A-X or an 8003C-2 datalogger to a PC with an internal serial port(s) the COM Port number that LogView requires is usually COM1 or COM2 but, occasionally may be COM3 if the PC has more than one internal serial port. Figure 11 illustrates that the PC has 2 serial ports, one internal (COM1) and the other via a USB to serial converter (COM13).



When connecting an 8003B-X or an 8003D-2 datalogger to a PC, the COM Port number LogView requires can be any number and is dependent on how many other devices are attached to the PC like, internal serial ports and wireless devices. Figure 12 below illustrates that the PC has 3 serial ports, one internal (COM1) and the other two via USB to serial converters (COM13 and COM3). One way to determine which COM port an 8003B-X or an 8003D-2 datalogger is attached to is to disconnect the cable and see which COM device disappears from the Device Manager Ports list. In this case, COM3 is actually an 8003B-X or 8003D-2 datalogger and not a universally available serial port.



2.3 Example Setup Using Text Commands

NOTE: If using an 8003B-X or an 8003D-2, USB LC-3x2, it is important that the LC-3x2 first be connected to the computer's USB port before attempting to communicate so that the LC-3x2 can be recognized by the computer as a virtual COM port.

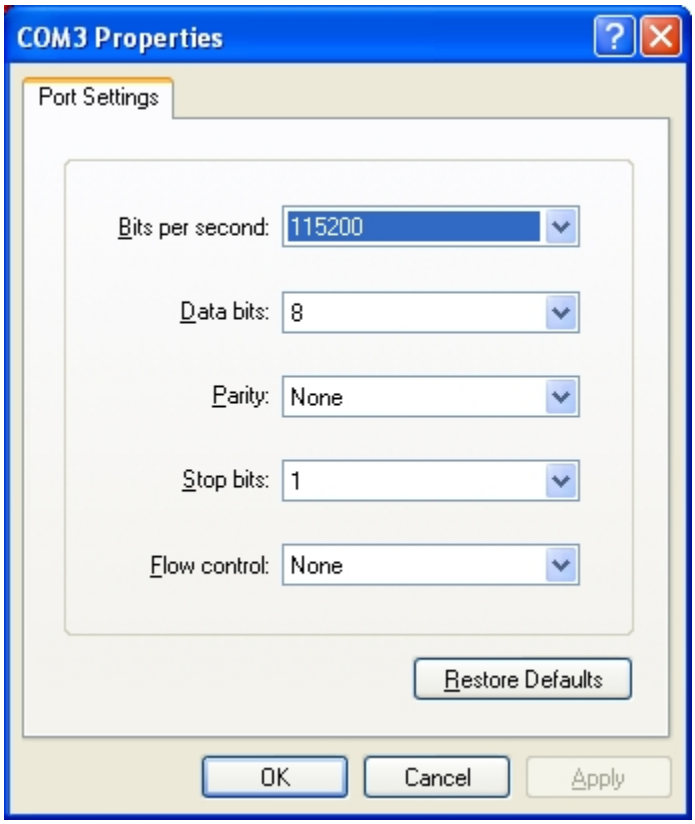
Proceed with the following steps to connect with the datalogger using a terminal emulator program such as Microsoft Windows HyperTerminal™:

1) Launch HyperTerminal (Start→All Programs→Accessories→Communications→ Hyper Terminal). If running under Vista or newer, contact GEOKON for GEOKON's Terminal Window Software).

2) Enter a name for the New Connection and click OK.

3) In the Connect Using window, select the appropriate COM port.

4) In the COM Properties window, configure the COM port.



8003A-X & 8003C-2 (RS-232): Configure the COM port (typically COM1 or COM2) as 115200 Bits per second, 8 Data bits, no Parity, 1 Stop bit, no Flow control.

8003B-X & 8003D-2 (USB): Configure the new COM port that is added when the LC-3x2 is connected as 115200 Bits per second, 8 Data bits, no Parity, 1 Stop bit, no Flow control.

5) Click Apply then OK.

6) Press <ENTER> <ENTER> to wake the datalogger from sleep. The datalogger returns the power up prompt;

```
Hello. Press "?" for Help.
*
```

Note: If no characters are received in 15 seconds the datalogger will return to its low power sleep mode. Press <ENTER> <ENTER> to wake it again.

7) Type ? <ENTER> to display the Help list. See Section 3 for detailed information on all the commands listed. **All commands must be entered in capital letters!**

***?**

Command	Description
BRnnn	View/set Baud rate BR2 = 2400 bps BR4 = 4800 bps BR9 = 9600 bps BR19 = 19200 bps BR38 = 38400 bps BR57 = 57600 bps BR115 = 115200 bps (default)
C	View current Clock
CSmm/dd/yy/hh:mm:ss	Clock Set
DEFAULT	Load factory DEFAULT gauge settings
DF	Date Format(0=julian,1=month,day)
Dnnnnn	Display nnnnn arrays from pointer
E	End communications and go to sleep
G	View gauge(s) information
Gtt/c/szzzzzz/sffffff/soooooo *or* **G**tt/c/saaaaaa/sbbbbbb/sccccc	Set Gauge information, where; tt = Gauge Type Valid types: 80A, 80B, 81A, 83A, 83B, 84A, 84B c = Conversion Type(L/P) For Linear (L) Conversion: szzzzzz = zero reading with sign sffffff = gauge factor with sign soooooo = offset with sign For Polynomial (P) Conversion: saaaaaa = polynomial coefficient A with sign sbbbbbb = polynomial coefficient B with sign sccccc = polynomial coefficient C with sign
IDddddddddddddddddd	View current ID,set to ddddddddddddddddd
Ln/llllll/iii	View Log intervals/change n interval llllll = length iii = iterations of interval
LD,LE	Log intervals Disable, Enable
M,MD,ME	Monitor status, Disable, Enable
N	Display Next time to read
Pnnnnn	Position array pointer to nnnnn
R	Reset memory
RESET	RESET processor
S,SS	Datalogger Status, System Status
SCnnnnn	View SCan interval/enter nnnnn interval
SPhh:mm	StoP logging, hh:mm = stop time
SR	Synchronize Readings(0=not synch'd,1=synch'd)
SThh:mm	STart logging, hh:mm = start time
SV	Software Version
TEST	System Test
TF	Time Format(0=hhmm,1=hh,mm)
TR,TR0	display TRap count, zero TRap count

UF	Update Firmware
VL	display Lithium cell Voltage
V3	display 4.5V Battery Voltage
V12	display 12V Battery Voltage
WFn	Wrap Format(0=don't wrap memory,1=wrap memory
X	Single Reading - NOT stored
Z	Zero MEMS

These commands are executed by typing with the correct syntax and pressing <ENTER>. If the command has not been entered correctly, the datalogger will respond with an asterisk only. For example;

```
*L7/100/255
*
```

The datalogger will respond to correctly entered commands by displaying the modified values. The purpose and syntax of each of these commands are discussed in the following sections.

3. COMMAND LIST

3.1 “BRnnn” - Set or Display the Current Baud Rate

Display or set the current baud rate. The example below changes the baud rate to 9600.

```
*BR9
This will change the Baud Rate to 9600 bps.
Are you sure(Y/N)?Y
Resetting...
```

3.2 “C” - Display Current Clock Settings

Display the current datalogger real-time clock settings. The **CS** command section explains how to adjust the clock settings.

```
*C
Date: 02/21/07 Time: 10:43:08
*
```

3.3 “CSmm/dd/yy/hh:mm:ss” - Set the Internal Clock

Set the datalogger’s internal real time clock; mm represents the month, dd the day of the month, yy the year, hh the hours, mm the minutes, and ss the seconds. Illegal combinations will be ignored (i.e. CS02/30/07 or CS///12:60). Fields can be left blank to avoid changing (i.e. CS//07 to just change the year).

```
*CS///10:45:00
Date: 02/21/07 Time: 10:45:00
*
```

Note:
If logging is currently started and the clock is changed, a restart of the scan interval or log interval table will occur.

3.4 “DEFAULT” - Load Factory Default Settings

The DEFAULT command will reload the datalogger’s channel and gauge settings to the factory default settings, along with the reading synchronization and memory wrap settings. This results in:

All channels Enabled
Gauge Types set to 80A and 80B
All Zero Readings set to 0.00000
All Gauge Factors set to 1.00000
All Gauge Offsets set to 0.00000
All channels use linear conversion
Scan interval = 5S
All readings synchronized to the top of the hour
Memory will wrap when full and continue logging

***DEFAULT**
This will load all channels with factory default gauge settings!
Are you sure(Y/N)?Y
All channels restored to factory default gauge settings.

3.5 “DF” - Display or Set Date Format

Display or set the date format. This setting determines how the date information will be displayed in the array when the monitor mode is active, or arrays are displayed from memory. Entering DF displays the current date format. Entering DF0 sets the date format to julian. Entering DF1 sets the date format to month,day. The default date format display is Julian (decimal) day.

```
*DF
Date format is julian.

*DF1
Date format is month,day.

*DF0
Date format is julian.
```

3.6 “Dnnnnn” - Display Arrays Forward from User Position

Use the D command to display arrays forward from the User Position for verification or collection. The updated memory pointers are displayed by this command.

```
*P1
MS:3146 OP:3147 UP:1
*D4
2011,10,23,17,52,43,3.10,25.51,9039.950,-999999.0,23.2,---,1
2011,10,23,17,53,43,3.10,24.77,9040.149,-999999.0,23.2,---,2
2011,10,23,17,54,43,2.97,24.42,9040.319,-999999.0,23.2,---,3
2011,10,23,17,55,43,2.98,24.22,9039.622,-999999.0,23.1,---,4

MS:3146 OP:3147 UP:5
*
```

MS represents the Memory Status of the datalogger. This number indicates how many arrays have been written to memory. In this example, **MS:3146** indicates that 3146 out of 21000 arrays have been written to memory. **OP:3147** indicates that the next memory location to be written to is location 3147. **UP:1** indicates that the memory location currently being pointed to (via the P command) is memory location 1. Use the D command to display arrays forward from the User Position. In this case, **D5** displays the arrays stored at memory locations 1,2,3,4 and 5, and leaves the memory pointer at memory location 6. Figure 16 on the following page illustrates the ring memory scheme.

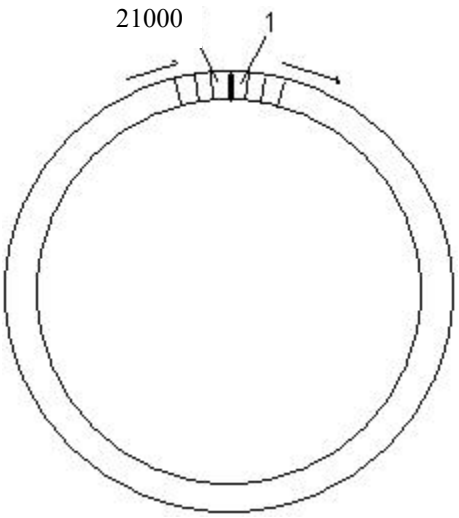


Figure 16 - Order of Array Usage

OP represents the Output Position that the next array will be written to.

UP represents the User Position. This value is updated by D and P commands. The user may display arrays from this position or re-position to another array.

The format is comma delineated ASCII, identical to that displayed when the Monitor mode is active. See Appendix D for a sample data file. See Appendix C in regards using the D command to collect data. When the array display is finished, the memory pointers are displayed.

3.7 “E” - Low Power Sleep Mode

Returns the datalogger to its low power sleep mode (readings continue to be logged and displayed in this mode). **This command should always be used when finished communicating with the datalogger to ensure the lowest power consumption.** However, the datalogger will enter sleep mode regardless if no command is received in a period of approximately 15 seconds.

To return from the low power operating mode press <ENTER> <ENTER>. The datalogger responds;

```
Hello. Press "?" for Help.
*
```

3.8. “Gtt/c/szzzzzz/sffffff/soooooo or Gtt/c/saaaaaa/sbbbbbb/sccccccc” - Gauge Settings

The **G** command is used to set up both datalogger channels. All the sensor parameters, including the type of conversion (linear or polynomial) are set with this command.

The syntax for this command is:

Linear Conversion:
Gtt/c/szzzzzz/sffffff/soooooo

Where;

tt = Gauge Type (see Table 1 for a full description of Gauge Types):
80A: 61xx-2, A-axis, Datalogger Channel A
80B: 61xx-2, B-axis, Datalogger Channel B
81A: 61xx-1, Datalogger Channel A (Channel B disabled)
83A: Internal Sensor, Channel A (8003C-2 & 8003D-2)
83B: Internal Sensor, Channel B (8003C-2 & 8003D-2)
84A: 61xx-1, Datalogger Channel A
84B: 61xx-1, Datalogger Channel B
c = Conversion Type(L/P) where L=Linear and P=Polynomial
szzzzzz = zero reading with sign
sffffff = gauge factor with sign
soooooo = offset with sign

Example: To setup a uniaxial model 6160-1 MEMS Tiltmeter on Channel A, with a Zero Reading of 490 digits, a Gauge Factor of –0.0015 and a Gauge Offset of 0, enter:

G81A/L/3/490/-0.0015/0 <ENTER>

The LC-3x2 will return:
GT: 81A ZR: 490.0000 GF: -0.00150 GO: 0.00000

When using linear conversion (L) of the instrument reading, the G command is used to select the gauge type and enter the gauge zero reading, gauge factor, and gauge offset.

Linear Conversion is described further as follows:
szzzzzz represents the zero reading for the sensor being read, sffffff represents the multiplier (calibration or gauge factor) that will be applied to the reading to convert to engineering units and soooooo is the offset that will be applied to the gauge reading. The zero reading, gauge factor and offset can be entered with a sign and decimal point. The maximum number of digits, including sign and decimal point is 15. The entered value will display to a maximum of 5 places to the right of the decimal point.

For MEMS Tiltmeters, the basic formula for calculation of displayed and stored values is as follows;

$$\text{Display} = ((\text{CurrentReading} - \text{ZeroReading}) \times \text{Multiplier}) + \text{Offset}$$

Equation 1 - Displayed Gauge Reading using Linear Conversion

Where “Display” equals the angle of inclination

Gauge Type	Model	Description
80A	61xx-2, A-axis, Datalogger Channel A	Biaxial MEMS sensor, A-axis, programmed as Channel A of the datalogger
80B	61xx-2, B-axis, Datalogger Channel B	Biaxial MEMS sensor, B-axis, programmed as Channel B of the datalogger
81A	61xx-1, Datalogger Channel A (Channel B disabled)	Uniaxial MEMS sensor programmed as Channel A of the datalogger, Channel B is not used
83A	Internal Sensor, Channel A (8003C-2 & 8003D-2)	MEMS sensor, mounted in the datalogger enclosure, programmed as Channel A of the datalogger
83B	Internal Sensor, Channel B (8003C-2 & 8003D-2)	MEMS sensor, mounted in the datalogger enclosure, programmed as Channel B of the datalogger
84A	61xx-1, Datalogger Channel A	Uniaxial MEMS sensor programmed as Channel A of the datalogger
84B	61xx-1, Datalogger Channel B	Uniaxial MEMS sensor programmed as Channel B of the datalogger

Table 1 - Gauge Type Descriptions

3.9 “IDddddddddddddddddd” - Display or Set Datalogger ID

Displays or sets the datalogger ID. The ID is a 16-character string that can be used to identify a datalogger and the data that is transmitted by it. If an ID is entered it will be transmitted as the first element in each array of data. For example;

```
*ID
Datalogger ID:
*ID
Datalogger ID:
*IDDatalogger#1
Datalogger ID:Datalogger#1
*ST
Logging started.
Datalogger#1,2011,10,24,11,25,16,2.92,20.93,9.020,-999999.0,22.0,---,1
Datalogger#1,2011,10,24,11,25,21,2.92,20.95,9.061,-999999.0,22.0,---,2
Datalogger#1,2011,10,24,11,25,26,2.92,21.04,9.045,-999999.0,22.0,---,3
Datalogger#1,2011,10,24,11,25,31,2.92,21.09,9.014,-999999.0,22.0,---,4
```

To clear the ID, enter a <SPACE> character as the ID. When the ID is cleared the arrays from the logger will display beginning with the year. To display the current ID, enter **ID** <ENTER>.

3.10 “L” - Display Log Intervals

Display all six log intervals.

```
*L
Log Intervals List
-----------------------------------------------
Interval #1 Length: 5          Iterations: 3
Interval #2 Length: 10         Iterations: 9
Interval #3 Length: 16         Iterations: 54
Interval #4 Length: 48         Iterations: 180
Interval #5 Length: 384        Iterations: 225
Interval #6 Length: 3600       Iterations: 0
*
```

This command has no effect on the current interval (scan or log). If logging is started and log intervals are enabled the iterations value will be followed by the number of readings left at that interval. For example;

```
*L
Log Intervals List
-----------------------------------------------
Interval #1 Length: 5          Iterations: 3/1
Interval #2 Length: 10         Iterations: 9/9
Interval #3 Length: 16         Iterations: 54/54
Interval #4 Length: 48         Iterations: 180/180
Interval #5 Length: 384        Iterations: 225/225
Interval #6 Length: 3600 Iterations: 0
*
```

The above list indicates that there is one iteration of Interval 1 left before Interval 2 begins execution. See the **Ln/lllll/iii** command section to modify intervals.

3.11 “Ln/lllll/iii” - Define Length and Iteration of Interval

Define the length and iteration of any interval in the list; n refers to the number of the interval (1-6), lllll is the length (5-86400), and iii is the iterations (0-255), or the number of readings that will be taken at that interval. If zero is entered for the iteration value that interval will execute indefinitely. Illegal entries will be ignored, i.e. `L7/10/100` or `L1/1000/500`. If the entry is correct the modified interval will display:

```
*L1/100/0
Interval #1 Length: 100 Iterations: 0
*
```

NOTE! If log intervals are enabled and logging was started, any change to the interval list will result in a restart of the table!

Table 2 lists possible logarithmic interval lengths and iterations. Any combination of lengths and iterations is permissible.

Interval	Length	Iterations	Elapsed Time
1	5 seconds	3	15 seconds
2	10 seconds	9	90 seconds
3	16 seconds	54	864 seconds
4	48 seconds	180	144 minutes
5	384 seconds	225	1440 minutes
6	3600 seconds	0	endless

Table 2 - Logarithmic Intervals List

3.12 “LD” - Disable Log Intervals

Disable use of log intervals. If logging is started (**ST** command) it will continue based on the scan interval entry (**SC** command).

```
*LD
Log intervals disabled.
*Datalogger#1,2011,10,25,11,41,17,2.92,20.63,9.055,-999999.0,22.5,---
,549
*
```

3.13 “LE” - Enable Log Intervals

Enable use of log intervals. If logging is started (**ST** command) it will continue based on the interval lengths and iterations of the log list (**SC** command).

```
*LE
Log intervals enabled.
*Datalogger#1,2011,10,26,11,42,56,2.92,21.51,9.042,-999999.0,22.5,---
,622
```

3.14 “M” - Display Current Monitor Mode Setting

Display the current Monitor mode setting. The monitor mode will display arrays as they are stored in memory during logging. This is useful where a test is being conducted and immediate display of logged values would be helpful. Use the **MD** and **ME** commands (next two sections) to disable or enable the use of the Monitor mode.

```
*M
Monitor mode enabled.
*
```

3.15 “MD” - Disable Monitor Mode

Disable the Monitor mode. Arrays will not be sent to the host computer as they are logged.

```
*MD
Monitor mode disabled.
*
```

3.16 “ME” - Enable Monitor Mode

Enable the Monitor mode. Arrays will be sent to the host computer as they are logged.

```
*ME
Monitor mode enabled.
*
```

3.17 “N” - Display Next Measurement Cycle

Display the next time the datalogger will initiate a measurement cycle. If the start time (**ST** command) has been set this command will display when logging will begin.

```
*ST12:00
Logging will start at: 12:00:00
*N
Next time to read: 12:00:00
*
```

If logging has not been started, issuing this command causes the following to be displayed:

```
*N
Logging stopped.
*
```

3.18 “Pnnnn” - Set User Position Memory Pointer

Position the User Position memory pointer. Type **P** and a number between 1 and 21000 to position the pointer. Arrays can then be displayed (**D** command) from the new position. The updated pointers will display after entering a valid position.

```
*P1
MS:3200 OP:1567 UP:1
*
```

3.19 “R” - Reset Memory Pointers

Reset memory pointers to default settings. Gauge and interval settings, as well as the real-time clock settings, are not affected by this command. User will be asked to verify before executing. Press **Y** to continue, any other key to abort.

```
*R
Are you sure(Y/N)?Y
Memory cleared.
*
```

Note: This command does not erase memory. If the need arises to recover data that was previously taken, take 1 (or more) readings and then position the memory pointers via the **P** and **D** commands to recover previously taken readings.

3.20 “RESET” - Reboot the LC-2 Microprocessor

RESET (re-boot) the LC-2 microprocessor. All stored readings and settings, as well as the ID and real-time clock settings are not affected by this command.

```
*RESET
Resetting...
RESET COMPLETE
*
```

3.21 “S” - Display Status

Display the datalogger **S**tatus.

```
*S
MS:1004 OP:1005 UP:1004
GT: 81A ZR: 490.0000 GF: 0.0015 GO: 0.0000
Scan interval: 10 second(s).
Logging stopped.
Log intervals disabled.
Monitor mode enabled.
*
```

Line	Description	Manual Sections
1	Status of memory pointers	3.6, 3.18
2	Gauge Parameters	3.8
3	Scan interval setting	3.22
4	Logging Start/Stop status	3.24, 3.26
5	Stop time (optional)	3.24
6	Log interval status	3.12, 3.13
7	Monitor mode status	3.14, 3.15, 3.16

Table 3 - S Command Information

3.22 “SCnnnnn” - Set Scan Interval

Enter the **SC**an interval, in seconds. Range of entry is 5 to 86400 and is dependent on the number and type of sensors connected. Only whole numbers are accepted. Typing **SC** with no value returns the current setting only

```
*SC
Scan interval: 60 second(s).
*SC300
Scan interval: 300 second(s).

*
```

3.23 “SS” - Display System Status

Display the **S**ystem **S**tatus of the datalogger.

```
*SS
UART Trap count: 0
WDT Trap count: 0
Start/Stop times occur once.
Time format is hhmm.
Date format is julian.
*
```

Line	Description
1	Universal Asynchronous Receiver/Transmitter Trap Count (Communication errors counter)
2	Watch-Dog Timer Trap Count
3	Status of “Repeat Daily” function (not yet implemented)
4	Current time format configuration.
5	Current date format configuration.

Table 4 - SS Command Information

3.24 “SPhh:mm” - Stop Logging

Sto**P** the datalogger logging values; hh is the hour (24-hour format) of the day to stop and mm the minutes. The time entry is optional.

```
*SC60
Scan interval: 60 second(s).
*ST
Logging started.
Datalogger#1,2011,10,25,14,10,05,2.94,23.99,9.071,---,22.9,---,1


*SP12:00
Logging will start at: 15:13:46
Logging will stop at: 12:00:00
*
```

Note that when SPhh:mm is issued, the datalogger responds with the time of the next reading along with the time at which logging will stop.

3.25 “SR” - Synchronize Readings

Synchronize **R**eadings to the top of the hour. If enabled (default) via the SR1 command, then all readings after the first reading will synchronize to the top of the hour. In the examples below, monitor mode was previously enabled:

```
*SR1
Readings are synchronized to the top of the hour.
*ST
Logging started.
2011,318,1314,41,3.50,24.45,-8961.077,-999999.0,23.1,---,6645

*2011,318,1314,45,3.50,24.57,-8961.276,-999999.0,23.2,---,6646
2011,318,1315,0,3.50,24.86,-8960.023,-999999.0,23.2,---,6647

*SR0
Readings are not synchronized to the top of the hour.
*ST
Logging started.
2011,318,1316,31,3.50,24.39,-8960.209,-999999.0,23.9,---,6648

*2011,318,1316,46,3.50,24.80,-8960.090,-999999.0,23.3,---,6649

2011,318,1317,1,3.50,24.80,-8961.173,-999999.0,23.4,---,6650
```

3.26 “SThh:mm” - Start Logging

STart the datalogger logging values; hh is the hour of the day (24-hour format) to start and mm the minutes. The time entry is optional. Entry is ignored if logging is already started (unless a time is entered).

```
*ST
Logging already started!
*ST11:00
Logging will start at: 11:00:00
*
```

3.27 “SV” - Display Software Version

Return the **S**oftware **V**ersion of the datalogger’s operating system software. Consult the factory to check on latest versions available.

```
*SV
Software version: 2.5.0
*
```

3.27 “TEST” - Perform Internal Self-Tests

TEST is a set of internal self-tests that are performed at the factory during final test.

```
*TEST


LC-3 TEST MENU:

SELECTION TEST

 0 +5V_X: Analog Power Supply
 1 +5V_X_2: MEMS Power Supply
 2 MEMS A AXIS
 3 MEMS B AXIS
 4 EEPROM
 5 RTC 32KHz
 X EXIT TEST MENU

ENTER SELECTION:
```

Selection	Description
0	Test the Analog power supply
1	Test the MEMS power supply
2	Test the MEMS A axis
3	Test the MEMS B axis
4	Test the EEPROM
5	Test the Real-Time Clock 32 Khz signal
X	Exit and return to normal operations

Table 5 - TEST Menu Information

3.29 “TF” - Display or Set Time Format

Display the current **T**ime **F**ormat display option setting. This setting determines how the time information will be displayed in the array when the Monitor mode is active (see Section 3.14) or arrays are being displayed from memory. Entering TF alone returns the current time format. Entering TF0 sets the time format to hhmm. Entering TF1 sets the time format to hh,mm. The default time format display is hhmm.

```
*TF
Time format is hh,mm.
*TF0
Time format is hhmm.
*TF1
Time format is hh,mm.
*
```

3.30 “TR” - Display Current Trap Count

Display the current **TR**ap Count. The trap counter is a register that keeps track of the number of times that the internal processor has detected a communications or Watch-Dog Timer error. This is a useful register to check if communication problems are suspected.

3.31 “TR0” - Reset Trap Count

Reset the **TR**ap count register to **0**.

3.32 “UF” - Enter Firmware Update Mode

Causes the datalogger to enter “Firmware Update” mode. **This command is intended for use with LogView ONLY to update the datalogger’s firmware and should not be issued from a terminal emulator program.**

3.33 “VL” - Display Lithium Coin Cell Voltage

Display the Lithium Coin Cell Voltage. The internal 3V lithium coin-cell is used to supply power to the real-time clock circuit. The 3V lithium coin cell life is rated at 10 years minimum.

```
*VL
Lithium Cell Voltage = 2.92V
*
```

3.34” V3” - Display D-Cell Voltage

This is a legacy command meant to display the 3V D-cell battery pack voltage. In the case of the LC-3 it is a 4.5V, 3 D-cell battery pack.

```
*V3
4.5V Battery Voltage = 4.30V
*
```

3.35 “V12” - Display External Battery Voltage

Display the external 12V battery voltage. Replace or recharge the battery when this voltage is less than 10.5 VDC

```
*V12
12V Battery Voltage = 12.33V
*
```

NOTE: If there is no external 12V source then the value that is displayed will be close to zero.

3.36 “WF” - Display Current Wrap Format

Display the current Wrap Format. Memory “wrapping” means that once the memory has filled, the datalogger will continue taking readings and overwrite the stored values in a circular fashion (see Section 3.6).

When the wrap format is set to 0, logging will stop once the memory becomes full. This is useful if critical data is stored and it must not be inadvertently overwritten and lost.

When the wrap format is set to 1, logging will continue when the memory becomes full and the original stored values will be overwritten. With this setting, logging will continue indefinitely until told to stop with the SP command, the programmed stop time has been reached, or the battery has fallen to 2.3 volts if operating from the internal 4.5-volt source or 6.0 volts if operating from the external 12-volt power.

```
*WF
Logging will not stop when memory is full
*WF0
Logging will stop when memory is full
*WF1
Logging will not stop when memory is full
*
```

3.37 “X” - Take Immediate Reading

Take and display one reading, but do not store this reading in memory. Useful if interested in obtaining a reading at the moment, without interrupting or affecting the current logging schedule.

```
*D

MS:3 OP:4 UP:3
*X
Datalogger#1,2011,10,25,13,11,39,2.93,23.59,9.060,---,22.8,---

*D

MS:3 OP:4 UP:3
*
```

Note: In this example, channel B is disabled.

3.38 “Z” - Zero MEMS output

Test and setup command allowing the MEMS output to be “zeroed”.

```
*Z
ZERO MEMS...
-0.09 : +0.07
```

Press any key to stop looping.

4. MAINTENANCE

The Model LC-3x2 Datalogger is designed to operate in field environments, nevertheless there are some basic maintenance procedures that should be followed to insure maximum reliability and functionality.

4.1 Cleaning

The outside of the box can be cleaned using a cloth dampened with soap and water. **DO NOT USE ANY TYPES OF SOLVENTS OR SCOURING AGENTS!**

The connector sockets can be cleaned using a small stiff brush (small painters brush) dipped in soap and water. The sockets are water resistant, so the internal electronics will not be adversely affected by them filling with water or other liquids. Be aware however, readings could be affected by shorting or other effects of an improper connection due to fluids being present in the connector. Dry connections thoroughly before using.

4.2 Batteries

When the unit is not in use, especially for extended periods of time, the 'D' cells should be removed to prevent damage due to leakage. **The warranty does not cover damage due to battery leakage.** Table 6 details an approximate operating time for the Alkaline 'D' cell batteries that are used with the Model LC-3x2, based on a one-hour scan rate.

Battery Type	Battery Capacity	1 Hour Scan Rate
Alkaline	18 AHr	≥1.5 years

Table 6 - Approximate Operating Time

The above table assumes a constant temperature environment of 21 °C (not field conditions!). Battery life is shortened by temperature extremes. If the datalogger is continuously connected to an active computers USB port, all operating power will be supplied via the USB port. As soon as USB power is lost, the datalogger will immediately switch over to its internal 4.5V (or external 12V) battery pack.

Batteries should be replaced when the measured voltage drops below 2.5 VDC (internal 4.5V battery) or 10.5 VDC (external 12V battery)[1]. All data and operating parameters are retained when removing batteries, even for an extended period (years) of time due to non-volatile EEPROM memory. If the datalogger was logging when it stopped itself due to low battery voltage, it will resume logging as soon as new batteries are installed or as soon as it is connected to a USB port.

[1]The datalogger electronics will stop the datalogger from logging if the battery goes below 2.3 VDC (internal 4.5V battery) or 6.0V (external 12V battery).

4.2.1 Battery replacement instructions

1) Remove the 4 captive lock regular head screws on the top of the case and lift the cover off. Underneath the cover is the 'D' cell battery holder.

2) Remove the three batteries from the holder being careful not to bend the sides outward. Note the polarity outline on the bottom of the battery holder for proper battery installation. Insert the new batteries straight down into the holder. Check for secure connection between the battery terminals and holder. If a gap exists, remove batteries and bend the holder sides inward.

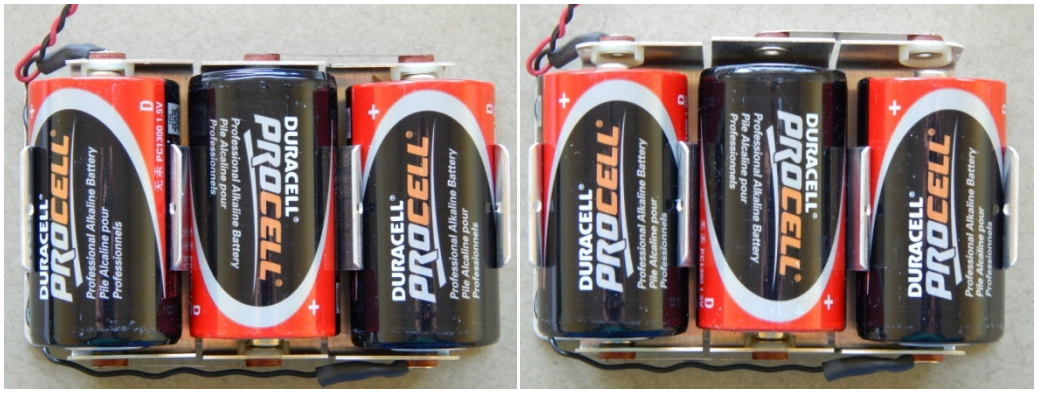


Figure 17 - Proper Battery installation Faulty Battery installation

3) Re-install the cover. Check datalogger for proper operation.

4.2.2 Using Lithium 'D' Cell Batteries

When operating the LC-3x2 in extremely cold environments (colder than -20° C), the standard Alkaline batteries should be replaced with Lithium 'D' cell batteries. This type of battery can operate at a much lower temperature. Because each Lithium 'D' cell produces 3.6 volts, the battery pack connection to the LC-3x2 circuit board will need to be moved to the connector marked "12V" just to the right of the "4.5V" connection. Figure 18 below shows the battery pack connection set for 3 Alkaline batteries (4.5V).

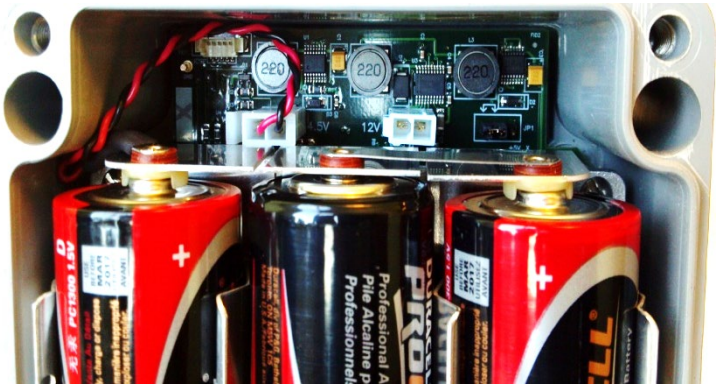


Figure 18 - Datalogger Battery Pack Connections

5. TROUBLESHOOTING

Listed below are a few commonly experienced problems and remedial action. Contact the factory should a problem arise not explained herein or additional information be needed.

Symptom: Unit will not respond to communications:

- ✓ Wrong COM port selected.
- ✓ The USB Drivers may not be properly installed. See Section 2.2.1 and 2.2.7 for more information about USB driver installation.
- ✓ If RS-232 communications is being used, the internal batteries of the datalogger may be low, dead or have a faulty connection to the holder. Replace/check batteries according to the **"Battery replacement instructions:"** in Section 4.2.
- ✓ The COM cable may be damaged or incorrect for the datalogger. 8003A-X and 8003C-2 models use a COM-108 cable while 8003B-X and 8003D-2 models use a COM-109 cable.

Symptom: MEMS gauge measurement reads -999999.0:

- ✓ Ensure that the sensor cable connector is properly seated and tightened securely.
- ✓ Check the datalogger with another known good sensor. If it still reads –999999.0, the datalogger may be malfunctioning.
- ✓ Check that the proper gauge type is selected (see Section 3.8).
- ✓ Check that the sensor cable is not damaged.

Symptom: Gauge measurement (MEMS) reads -999999.9:

- ✓ A mathematical over-range has occurred. Check the magnitude of the reading, zero reading, multiplier and offset. The result must be in the range of 1.0×10^{-7} to 1.0×10^{7}.

Symptom: MEMS reading is unstable:

- ✓ Is there a source of electrical noise nearby? Likely candidates are generators, motors, arc welding equipment, high voltage lines, etc. If possible, move the datalogger and sensor cables away from the power lines or electrical equipment.
- ✓ Check if the proper gauge type is selected (see Section 3.8).

Symptom: Thermistor measurement shows -99.9 degrees Celsius:

- ✓ Indicates open circuit to thermistor leads. Check connections from datalogger to thermistor leads. If okay, check thermistor with ohmmeter. Appendix F details the resistance versus temperature relationship. It should read between 10K ohms and 2.4K ohms (0° to +30° Celsius). If thermistor checks out okay consult the factory to schedule repair of unit.

APPENDIX A. SPECIFICATIONS

A.1 Measurement Capability

- MEMS.
- External temperature (thermistor).
- Internal temperature (thermistor).
- Main battery voltage (4.5V and 12V)
- RTC lithium battery voltage.

A.2 Power

Power supply:	Internal 4.5 VDC (7.5Vmax) or External 12 VDC (15Vmax)
Processing/communication current:	<50 mA
MEMS measurement current:	<400 mA
Quiescent current:	<600 μA
RTC battery type:	Panasonic CR2032 3V lithium coin cell: 20mm, 225 mAHr
RTC battery life:	>10 years
Operating temperature range:	–30 to +50° C

A.3 Memory

Data memory:	512K EEPROM
Program memory:	24K EEPROM
Array storage	21000
Data memory type:	ring (oldest over-write)
Array elements:	ID (optional)
	Year
	Julian day (or month,day)
	Time (hhmm or hh,mm)
	Seconds
	Battery voltage
	Datalogger temperature
	Channel A Sensor reading
	Channel B Sensor reading
	Channel A Sensor temperature
	Channel B Sensor temperature
	Array #

A.4. Clock

Features:	full calendar
Time format:	12 or 24 hour (selectable)
Date Format:	mm,dd or julian (selectable)
Accuracy:	±2 minutes per year

A.5. Serial Interface (all LC-3x2 models):

Speed:	2400 - 115200 bps
Parameters:	8 Data bits
	1 Stop bit
	no Parity
	no Flow control
Data output format:	ASCII text

A.6. MEMS Measurement

Excitation voltage:	+5V
Measurement Technique:	Differential 18-bit Delta-Sigma ADC
Accuracy:	0.01% F.S.R.
Resolution:	38.15 µV
Standard Range	±15°

A.7. Internal/External Temperature Measurement

Thermistor:	Dale #1C3001-B3 (YSI 44005)
Sensor accuracy: ±0.5° C	
Measurement accuracy:	0.5% FSR
Resolution:	0.01° C (Internal)
	0.1° C (External)
Linearization error:	0.02% FSR
Temperature range:	–40 to +60° C
Overall accuracy:	1.0% FSR (±1°)

A.8. Main Battery Measurement

4.5V Battery:		12V Battery:	
Range:	0 to 7.5 VDC	Range:	0 to 15 VDC
Accuracy:	±1.83mV	Accuracy:	±3.662mV
Resolution:	0.01 VDC		

APPENDIX B. CONNECTOR PINOUTS

B.1 Sensor Cable Connections

Table 7 illustrates the connections for the connector marked: “Sensor A” (8003A-X and 8003B-X only). The mating 10 pin Bendix plug is part number PT06F-12-10P (BiAxial MEMS).

10 Pin Bendix	Description	Sensor Cable Wire Color
A	+12 Volts Out	RED
B	Ground	BLACK
C	Chan A Out +	WHITE
D	Chan A Out -	BLACK
F	Chan B Out +	GREEN
G	Chan B Out -	BLACK
J	Thermistor A+	BLUE
K	Thermistor A-	BLACK
E	Analog Ground (shield)	BARE WIRE

Table 7 - Sensor A Connector Pinout

Table 8 illustrates the connections for the connector marked: “Sensor B” (8003A-2 and 8003B-2 only). The mating 10 pin Bendix plug is part number PT06F-12-10P (UniAxial MEMS).

10 Pin Bendix	Description	Sensor Cable Wire Color
A	+12 Volts Out	RED
B	Ground	BLACK
C	Chan B Out +	WHITE
D	Chan B Out -	BLACK
F	No Connection	
G	No Connection	
J	Thermistor B+	GREEN
K	Thermistor B-	BLACK
E	Analog Ground (shield)	BARE WIRE

Table 8 - Sensor B Connector Pinout

B.2 RS-232 Connector Pinout (8003A-X & 8003C-2)

The mating 10 pin Bendix plug is part number PT06F-12-10P.

10 Pin Bendix	Internal Wire Color	PCB connector J5 pin	Description
A	Brown	1	Ground
B	Red	2	Tx
C	Orange	3	Rx
D	Yellow	4	RTS
E	Green	5	CTS
F	Blue	6	N/C
G	Violet	7	DTR
H	Grey	8	+5V
J	White	9	N/C
K	Black	10	Ground

Table 9 - RS-232 Connector Pinout

B.3 USB Connector Pinout (8003B-X & 8003D-2)

The mating 10 pin Bendix plug is part number PT06F-12-10P.

10 Pin Bendix	Internal Wire Color	PCB connector J5 pin	Description
A	Brown	1	USB VCC
B	Red	2	USB DM
C	Orange	3	USB DP
D	Yellow	4	Digital Ground
E	Green	5	N/C
F	Blue	6	N/C
G	Violet	7	N/C
H	Grey	8	N/C
J	White	9	N/C
K	Black	10	N/C

Table 10 - USB Connector Pinout

APPENDIX C. DATA FILE TRANSFER TO A WINDOWS PC

Data can be downloaded to the PC via either via LogView software (refer to the LogView Online Help) or Windows HyperTerminal, which is supplied with most personal computers (prior to Windows Vista) as part of the Accessories → Communications option of the Start Menu.

C.1 Downloading Data using LogView

The steps below assume that a successful connection has been previously established between LogView and the datalogger (see Section 2.2.8).

Click on the "Collect Data" button from the Main Toolbar (Figure 19).

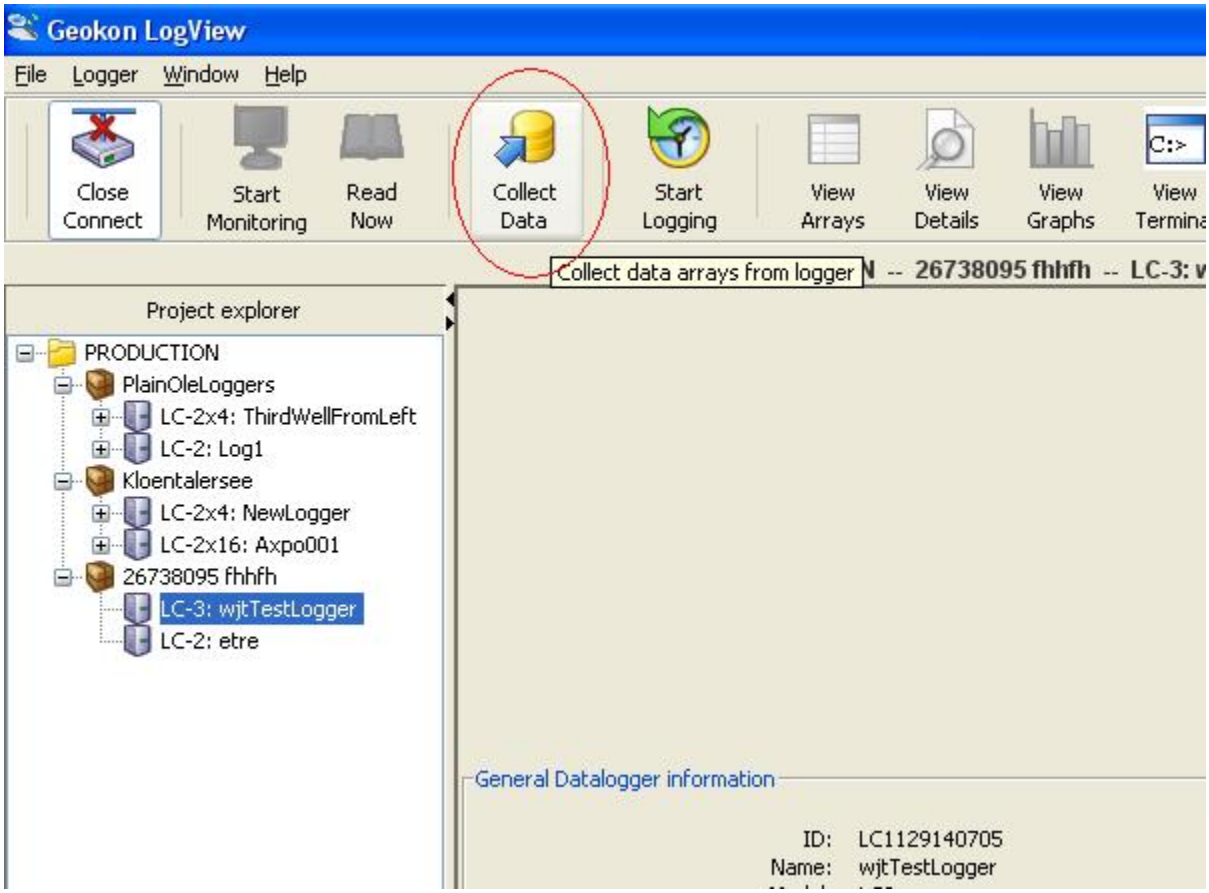


Figure 19 - LogView Collect Data Button

If the datalogger configuration is set for "Collect all data" in "Datalogger Settings->Data Collection Options" (see the LogView on-line help menu covering datalogger settings) then LogView will issue commands to the datalogger to initiate a download of all arrays logged on the datalogger. If the memory has wrapped, then 21000 arrays will be downloaded starting at the current User Pointer (see Sections 3.6 and 3.18).

If the datalogger configuration is set for "Collect new data since last download" in "Datalogger Settings->Data Collection Options" then LogView will issue commands to the datalogger to initiate a download of all arrays since the last time data was downloaded.

Once the data collection has been initiated, the following progress bar (Figure 20) will be displayed until the collection has completed.

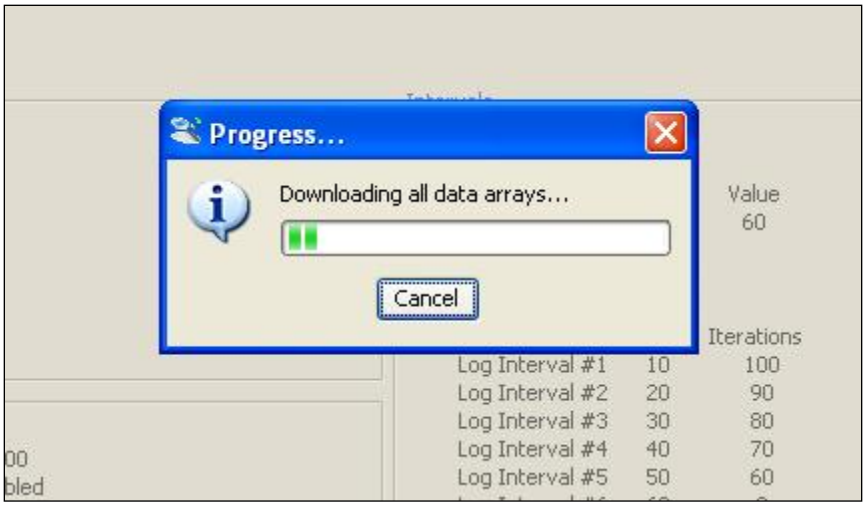


Figure 20 - Data Collection Progress Bar

After a data collection has finished LogView will display the message shown in Figure 21.

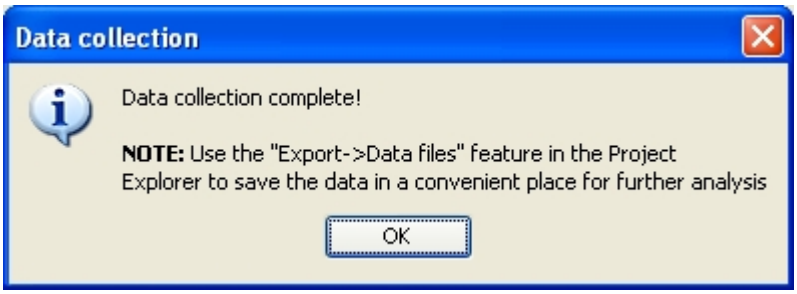


Figure 21 - Data Collection Complete Message

C.2 Downloading Data using HyperTerminal (or equivalent)

The steps to download the data using HyperTerminal are as follows:

`Start HyperTerminal: Start → Programs → Accessories → Communications → Hyper-Terminal`

1) Enter a name for the New Connection – Select OK.

Figure 22 - HyperTerminal Connection Description

2) Change the "Connect using" setting to the appropriate COM port (in this case COM3).

Figure 23 - HyperTerminal Connection Selection

3) In the COM Properties Dialog, enter the “Port Settings”. Select Apply. Select OK.

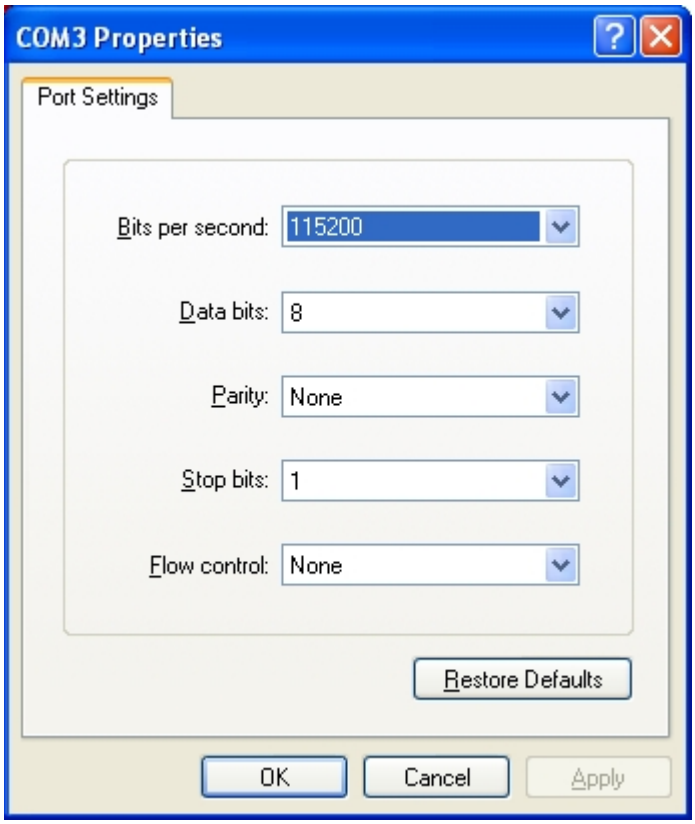


Figure 24 - COM Port Settings

4) With the cursor in the display screen, press the Enter key a few times to verify that communication has been established. The datalogger should return the power up prompt:

```
Hello. Press "?" for Help.
*
```

5) Upon confirmation of communication, select Transfer, then Capture Text.

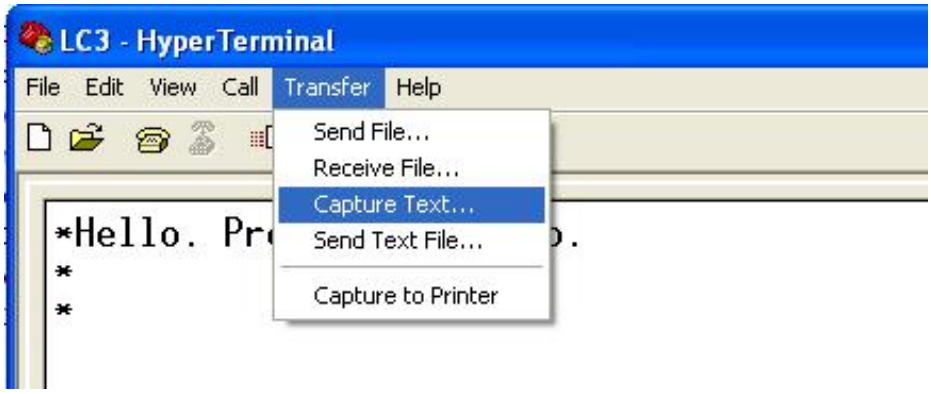


Figure 25 - HyperTerminal Transfer Menu

6) Enter the path and name of the file you wish to create, either directly or with the Browse button. Select Start:

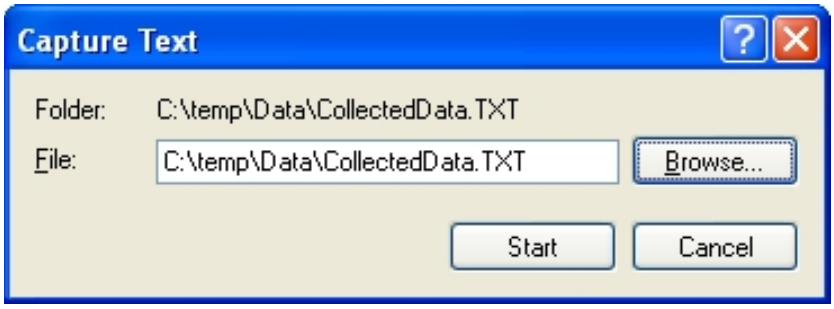


Figure 26 - Specifying a Data Capture File

Note: Specifying a filename with a .CSV extension will allow data to be directly imported into common spreadsheet programs such as Microsoft Excel™

7) With the cursor in the display screen, push the Enter key a few times to wake-up the datalogger. Then complete the following:

-Type “S” to get the Status of the datalogger.
-Type “P1” to position the data array Pointer at location 1.
-Type “D5” to Display the readings stored in memory.
-Select Transfer | Capture Text | Stop.

8) The data are now stored in the specified file, as shown in see Figure 27.

```
Hello. Press ? for Help.
*
*
*Hello. Press ? for Help.
*
*S
MS:2   OP:3   UP:2
GT: 81A   ZR: 490.0000   GF: 0.0015   GO: 0.0000
Scan interval: 10 second(s).
Logging stopped.
Log intervals disabled.
Monitor mode disabled.
*P1
MS:2   OP:3   UP:1
*D5
LC0725162743,2011,245,1442,55,4.29,23.82,-999999.0,-999999.0,-99.0,---,1
LC0725162743,2011,245,1443,0,4.29,23.82,-999999.0,-999999.0,-99.0,---,2
LC0725162743,2011,215,0416,0,4.13,20.95,-2.8379,---,20.2,---,3
LC0725162743,2011,215,0416,20,4.13,20.95,-2.8383,---,20.2,---,4
LC0725162743,2011,215,0416,40,4.13,20.95,-2.8385,---,20.2,---,5

MS:2   OP:3   UP:6
*
*
```

Figure 27 - Data Arrays Captured

APPENDIX D. SAMPLE DATA FILE

D.1 Sample Raw Data File

Datalogger#1,2011,290,1421,0,2.93,25.01,-0.2654,---,23.7,---,1
Datalogger#1,2011,290,1421,10,2.93,25.13,-0.2652,---,23.7,---,2
Datalogger#1,2011,290,1421,20,2.93,25.42,-0.2650,---,23.7,---,3
Datalogger#1,2011,290,1421,30,2.93,25.30,-0.2645,---,23.7,---,4
Datalogger#1,2011,290,1421,40,2.93,25.16,-0.2671,---,23.7,---,5
Datalogger#1,2011,290,1421,50,2.93,25.07,-0.2653,---,23.7,---,6
Datalogger#1,2011,290,1422,0,2.93,25.04,-0.2660,---,23.7,---,7

The comma delineated columns above represent the following:

Column 1 represents the datalogger id
Column 2 represents the year when the array was stored.
Column 3 represents the julian day (or day, month format, see section 3.4).
Column 4 represents the time (or hh,mm format, see section 3.26).
Column 5 represents the seconds.
Column 6 represents the main battery voltage (alkaline batteries, nominal 4.5 VDC).
Column 7 represents the internal temperature in degrees Celsius.
Column 8 represents the Channel A MEMS reading.
Column 9 represents the Channel B MEMS wire reading. (disabled)
Column 10 represents the Channel A external temperature in degrees Celsius.
Column 11 represents the Channel B external temperature in degrees Celsius. (disabled)
Column 12 represents the Array #

APPENDIX E. THERMISTOR TEMPERATURE DERIVATION

E.1 Standard Thermistor

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3

Resistance to Temperature Equation:

$$T=\frac{1}{A+B(LnR)+C(LnR)^3}-273.15\ ^\circ C$$

Equation 2 - Convert Thermistor Resistance to Temperature

Where: T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
A = 1.4051×10^{-3} (coefficients calculated over the −50 to +150° C. span)
B = 2.369×10^{-4}
C = 1.019×10^{-7}

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	**3000**	**25**	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table 11 - Standard Thermistor Resistance versus Temperature

E.2 High Temperature Thermistor

Resistance to Temperature Equation for *US Sensor 103JL1A*:

$$T=\frac{1}{A+B(LnR)+C(LnR)^3+D(LnR)^5}-273.15\ ^\circ C$$

Equation 3 - High Temperature Resistance to Temperature

Where;
T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance.
$A = 1.127670 \times 10^{-3}$
$B = 2.344442 \times 10^{-4}$
$C = 8.476921 \times 10^{-8}$
$D = 1.175122 \times 10^{-11}$
Note: Coefficients optimized for a curve "J" Thermistor over the temperature range of 0°C to +250°C.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
32,650	0	7,402	32	2,157	64	763.5	96	316.6	128	148.4	160	76.5	192	42.8	224
31,029	1	7,098	33	2,083	65	741.2	97	308.7	129	145.1	161	75.0	193	42.1	225
29,498	2	6,808	34	2,011	66	719.6	98	301.0	130	142.0	162	73.6	194	41.4	226
28,052	3	6,531	35	1,942	67	698.7	99	293.5	131	138.9	163	72.2	195	40.7	227
26,685	4	6,267	36	1,876	68	678.6	100	286.3	132	135.9	164	70.8	196	40.0	228
25,392	5	6,015	37	1,813	69	659.1	101	279.2	133	133.0	165	69.5	197	39.3	229
24,170	6	5,775	38	1,752	70	640.3	102	272.4	134	130.1	166	68.2	198	38.7	230
23,013	7	5,545	39	1,693	71	622.2	103	265.8	135	127.3	167	66.9	199	38.0	231
21,918	8	5,326	40	1,637	72	604.6	104	259.3	136	124.6	168	65.7	200	37.4	232
20,882	9	5,117	41	1,582	73	587.6	105	253.1	137	122.0	169	64.4	201	36.8	233
19,901	10	4,917	42	1,530	74	571.2	106	247.0	138	119.4	170	63.3	202	36.2	234
18,971	11	4,725	43	1,480	75	555.3	107	241.1	139	116.9	171	62.1	203	35.6	235
18,090	12	4,543	44	1,432	76	539.9	108	235.3	140	114.5	172	61.0	204	35.1	236
17,255	13	4,368	45	1,385	77	525.0	109	229.7	141	112.1	173	59.9	205	34.5	237
16,463	14	4,201	46	1,340	78	510.6	110	224.3	142	109.8	174	58.8	206	33.9	238
15,712	15	4,041	47	1,297	79	496.7	111	219.0	143	107.5	175	57.7	207	33.4	239
14,999	16	3,888	48	1,255	80	483.2	112	213.9	144	105.3	176	56.7	208	32.9	240
14,323	17	3,742	49	1,215	81	470.1	113	208.9	145	103.2	177	55.7	209	32.3	241
13,681	18	3,602	50	1,177	82	457.5	114	204.1	146	101.1	178	54.7	210	31.8	242
13,072	19	3,468	51	1,140	83	445.3	115	199.4	147	99.0	179	53.7	211	31.3	243
12,493	20	3,340	52	1,104	84	433.4	116	194.8	148	97.0	180	52.7	212	30.8	244
11,942	21	3,217	53	1,070	85	421.9	117	190.3	149	95.1	181	51.8	213	30.4	245
11,419	22	3,099	54	1,037	86	410.8	118	186.1	150	93.2	182	50.9	214	29.9	246
10,922	23	2,986	55	1,005	87	400.0	119	181.9	151	91.3	183	50.0	215	29.4	247
10,450	24	2,878	56	973.8	88	389.6	120	177.7	152	89.5	184	49.1	216	29.0	248
10,000	**25**	2,774	57	944.1	89	379.4	121	173.7	153	87.7	185	48.3	217	28.5	249
9,572	26	2,675	58	915.5	90	369.6	122	169.8	154	86.0	186	47.4	218	28.1	250
9,165	27	2,579	59	887.8	91	360.1	123	166.0	155	84.3	187	46.6	219		
8,777	28	2,488	60	861.2	92	350.9	124	162.3	156	82.7	188	45.8	220		
8,408	29	2,400	61	835.4	93	341.9	125	158.6	157	81.1	189	45.0	221		
8,057	30	2,316	62	810.6	94	333.2	126	155.1	158	79.5	190	44.3	222		
7,722	31	2,235	63	786.6	95	324.8	127	151.7	159	78.0	191	43.5	223		

Table 12 - Thermistor Resistance Versus Temperature for HT Models

APPENDIX F. LC-3 DATALOGGER/TILTMETER (8003C-2 AND 8003D-2) INSTALLATION

The 8003C-2 and 8003D-2 are biaxial MEMS tiltmeters mounted inside the LC-3 datalogger. The 8003C-2 communicates to a host PC via a serial RS-232 interface while the 8003D-2 communicates via a USB interface.

The datalogger/tiltmeter is delivered with the sensors pre-installed and zero set at the ordered orientation. If the mounting surface is out of plumb or flatness by a noticeable amount the sensor can be re-zeroed by observing the sensor output after the housing has been installed. If this out of plumb or flatness condition is not more than a few degrees, this will usually not be necessary since the sensors have a ±15 degree range.

Set the logger scan rate at the minimum and observe the sensor output. The orientation of the sensors is controlled by two screws; the large one that goes through the case and the smaller socket head cap screw that attaches the sensor assemblies to the mounting block (see Figure 29). By slightly loosening the screws the orientation can be changed in both axes until the desired outputs are obtained. Retighten the screws when finished, observe a few more readings and then zero the logger and reset the scan interval and start the datalogging.

Figure 28 - LC-3 Datalogger/Tiltmeter (8003C-2 and 8003D-2)

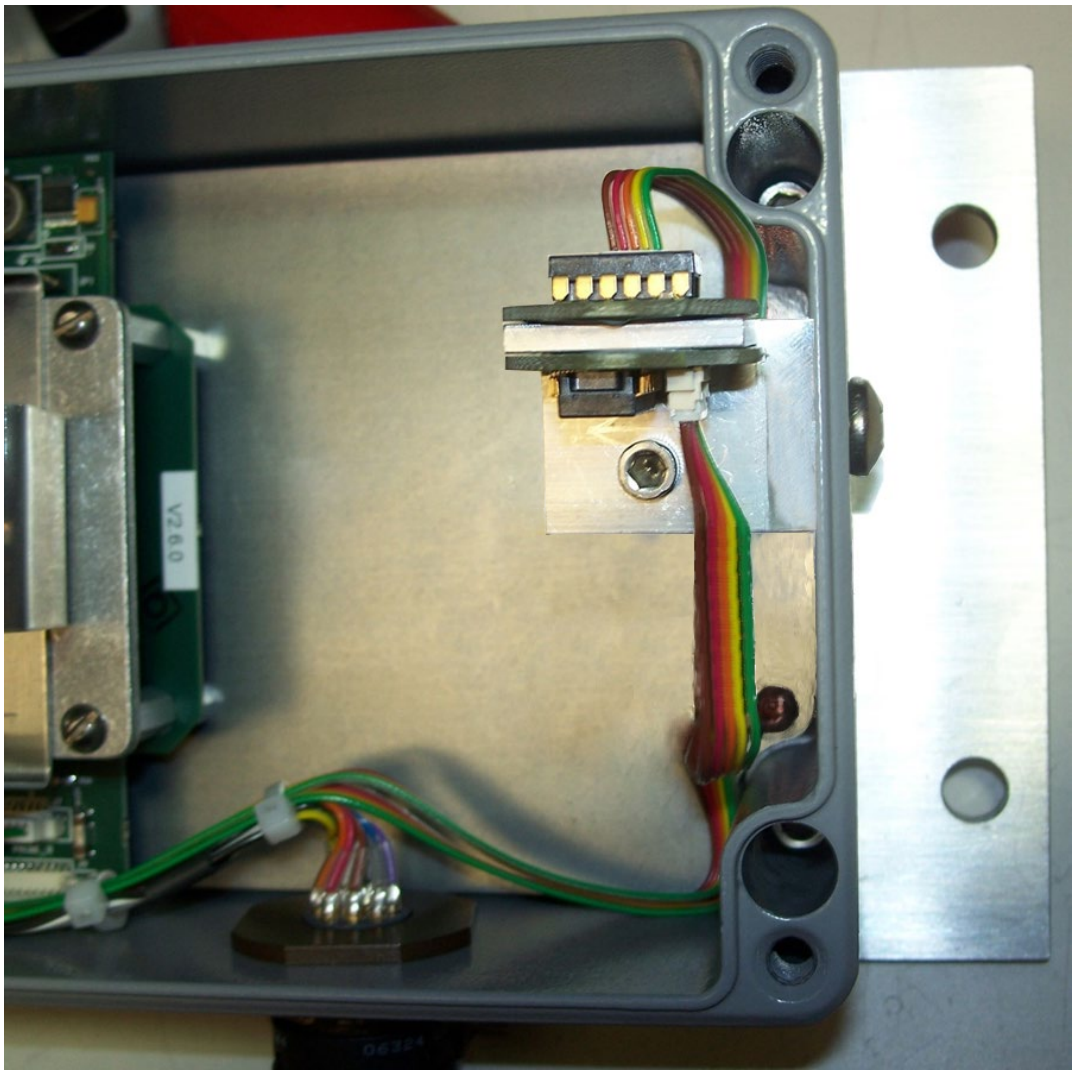


Figure 29 - Tiltmeter Sensor Adjustment

APPENDIX G. LITHIUM COIN CELL

G.1 Description

Under normal operating conditions, the 1.5V 'D' cells provide all the power required to operate the LC-3x2 datalogger. To maintain the correct date and time settings for those periods when the 'D' cells are removed, the LC-3x2 datalogger incorporates a 3V lithium coin cell (Panasonic CR2032) to supply operating current to the internal Real Time Clock.

Since the power requirements of the Real Time Clock circuit are minimal (3µA max.), the clock will continue to operate for up to 10 years under these conditions.

However, if the lithium cell voltage falls to 2.5V or less, it should be replaced using the following replacement procedure.

G.2 Replacement Procedure

Materials Required:

1/4" Slotted Screwdriver
1/8" Slotted Screwdriver
1/4" Nut driver
CR2032 Lithium Coin Cell (GEOKON P/N BAT-115)
Disposable Grounding Wrist Strap (3M P/N 2209 or equivalent)

Procedure:

1) Put on the disposable grounding wrist strap and connect to a good earth ground.

2) Using the 1/4" slotted screwdriver, loosen the four captive screws and remove the datalogger cover.

3) Remove the three 'D' cells.

4) Using the 1/4" slotted screwdriver, remove the four 3/8" 6x32 battery plate mounting screws.

5) Lift the battery plate and disconnect the two-wire Molex connector from the header labeled "4.5V" ("12V" if applicable). Set the battery plate aside.

6) Using the 1/4" nut driver, remove the four standoffs securing the printed circuit board to the case.

7) Lift the printed circuit board up to expose the bottom of the circuit board.

8) Using the 1/8" slotted screwdriver, gently pry the lithium coin cell battery from the battery holder.

9) Insert the replacement lithium coin cell into the battery holder (+ side facing out).

10) Re-install the printed circuit board back into the case.

11) Thread the four standoffs onto the set screws, using the nutd river to gently tighten the standoffs.

12) Reconnect the two-wire Molex connector to the header labeled “4.5V” (“12V” if applicable).

13) Position the battery plate over the standoffs and re-install using the four 3/8” 6x32 battery plate mounting screws.

14) Reinstall the ‘D’ cells.

15) Reinstall the datalogger cover.

Lithium coin cell replacement complete.