Manual

STARLOG DATA LOGGING SYSTEMS

Training Manual 1

'Introduction to Data Logging'

Revision History

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Previous version BX	2004	RS/ JH
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1. Scope and References

Scope

This course is designed for users of UNIDATA dataloggers who have some basic computer and instrumentation skills along with a desire to measure environmental data using electronic instrumentation.

References

UNIDATA Australia Website www.unidata.com.au
UNIDATA America Website www.UnidataAmerica.com
UNIDATA Europe Website www.Unidata-Europe.co.uk

Abbreviations

Mnemonic	Meaning
AI	Analog Input
CI	Counter Input
CPU	Central Processing Unit
DI	Digital Input
DO	Digital Output
FTS	Field Termination Strip
GSM	Global System Mobile
HSIO	High Speed Serial Input / Output
I/O	Input – Output
PC	Personal Computer
PDL	Portable Data Logger
PSTN	Public Switch Telephone Network
SDI-12	Serial Digital Interface – 1200 Baud
SIM	Subscriber Identity Module

2.4 Other Copyrights

NOTES

2. Introduction

The course covers the following topics:

1. Datalogging
    - History
    - Tasks

2. Dataloggers
    - Architecture / Components
    - Operation
    - Memory Capacity
    - Communications
    - Power Sources

3. Instruments
    - Types
    - Signals (AI, DI, CI, HSIO, SDI-12)
    - Power Requirements

4. Starlog Software
    - Menu
    - Schemes
    - Instruments

5. Logging Schemes
    - Display / Print Information
    - Load and Unload Files
    - Display Plot / Table
    - Real Time Data

6. Basic Control

7. Basic Telemetry

NOTES

3. Concept of Data Logging

History of Data Logging

DATA LOGGING is the process of collecting and retrieving data. It is not new. Humans have collected data for over hundreds of years. E.g., Scientists have taken readings from an instrument and written them down in a logbook together with the current date and time. Normally this type of recording was quite labor intensive. It was also difficult to proceed with if an experiment lasted through the night of over a long period or had very high sampling rates required.

As history passed by and humanity entered the Industrial Age it became possible to automate data logging. The first type of automated equipment was the chart recorder. An instrument was connected to a pen that continuously left marks on a piece of paper, thus eventually resulting in a graph.

In the early 1970's, the first microprocessor came on the market. This development was a major step forward in the process of fully automating data logging. It also meant that is became possible to keep collected data in a form that is suitable for further processing using computers. At this time the Data Logger was born. A Data Logger is truly a battery-powered computer with specialized I/O, power systems and memory.

In the late 1980's, we saw a move toward telemetric data logging where data could be collected via a dial up satellite or PSTN link. Regulations and cost prohibited wide spread use however.

In the 1990's the advent of cheaper cellular phones and modems made possible much more telemetric logging. The problems of scaling such systems into large-scale automated data collection networks have become apparent.

The next decade will see data logging change due to the advent of the Internet and high-speed wireless links. Data logging will still occur but much more emphasis will be placed on increased frequency of data collection and dissemination of that information.

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The requirement for environmental monitoring will never reduce. Population increase, economic growth and reducing natural resources all require more use of existing resources. Environmental measurement and recording adds value to real assets.

Data Logging Projects

A data logging project consists of three components:

- Instruments to measures the desired parameters
- A Data Logger to record the measurements
- A Computer to analyse the results of the readings.

In some modern systems such as the Starflow the Data Logger is now combined with the instrument. This saves space and cost at the cost of extendibility.

The Task of Data Logging

There are 5 major tasks to Data Logging as outlined on the next page.

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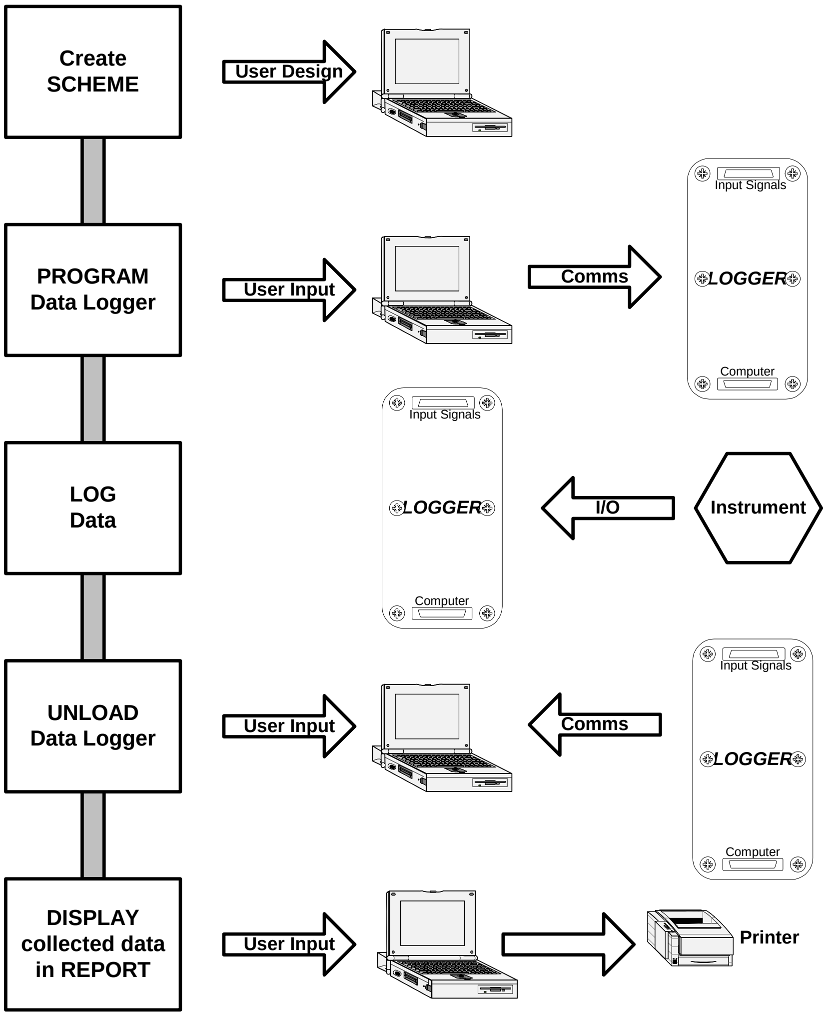
Create
SCHEME
User Design
PROGRAM
Data Logger
User Input
Comms
Input Signals
LOGGER
Computer
LOG
Data
Input Signals
LOGGER
Computer
I/O
Instrument
UNLOAD
Data Logger
User Input
Comms
Input Signals
LOGGER
Computer
DISPLAY
collected data
in REPORT
User Input
Printer

NOTES

- CREATE a Scheme

A SCHEME is a comprehensive list of instructions which tell the data when and what to log. It also tells the software package (STARLOG) what instruments are connected and how the collected data is to be reported (displayed).

- PROGRAM a Data Logger

The Data Logger is a fully programmable device. Hence it needs to be programmed (loaded) before it can execute the expected type of monitoring.

- LOG Data

After the task of programming the data logger, the instruments can be connected in the field. This signals the data logger to start reading the instruments and LOGGING the data. At the end of the required data collection period the instruments can be disconnected which will stop the recording task. NOTE: Some instruments are directly connected and this sequence varies slightly.

- UNLOAD a Data Logger

The UNLOADing task is the reverse of the PROGRAMMING task. This task transfers the logged data out of the data logger to the computer for use by the software package.

- DISPLAY collected data

After successful UNLOADING of logged data the data can be displayed (REPORTED) either on the computer screen, printed on a printer or saved in a file format suitable for use by another program.

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4. The Data Logger

What is a Data Logger?

As we have seen in the previous chapter, a Data Logger is similar to an automated logbook. Hence a Data Logger is a device that can; -

- Automatically take and record an instrument together with the current data and time either at regular scheduled intervals (log intervals) or on an ad-hoc basis (event logs).

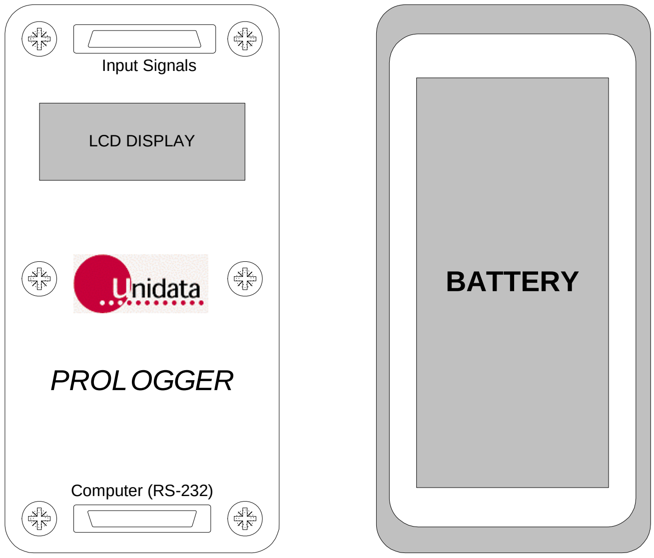
- Provide the data in a format suitable for computer processing.

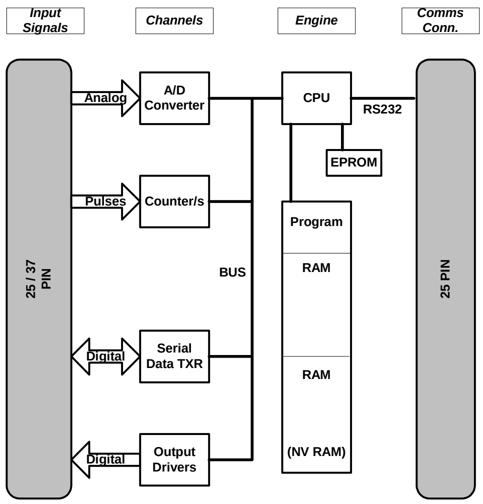
Components of a Data Logger

There are four major components of a Data Logger. In the case of a Instrument Logger there are five major components. These are;

1. Power Supply.
2. Circuit Boards
3. Input /Output Signal Connector/s
4. Communications Connector
5. Instrument (for Instrument Loggers)

The next page shows the major components of a Starlogger or Prologger.


Input Signals
LCD DISPLAY
Unidata
PROLOGGER
Computer (RS-232)
BATTERY


Input Signals
Channels
Engine
Comms Conn.
Analog
A/D Converter
CPU
RS232
EPROM
Pulses
Counter/s
Program
RAM
BUS
25 / 37 PIN
25 PIN
Digital
Serial Data TXR
RAM
Digital
Output Drivers
(NV RAM)

Input and Output Signals

The output signal of an instrument or the input to external controls enters the Data Logger via a 25 pin or 27 pin connector marked “INPUT SIGNALS”. For ease of connection and for applications with more than one instrument a ‘Field Termination Strip (FTS)’ may be used. An FTS can also provide signal conditioning.

Channels – Depending on the type of signal that is being sampled the various channels are connected to different pins on the ‘INPUT SIGNAL’ connector. This allows the signal to be applied to different processing paths within the Data Logger. The paths are called CHANNELS.

Analog Channel. Before an analog signal, (a voltage that varies with the measurement) can be processed in the Data Logger the signal needs to be converted into a digital format (i.e. 0’s and 1’s). This conversion is carried out by an Integrated Chip call an Analog to Digital converter , commonly abbreviated A/D.

- A/D can be of varying precision and resolution. Commonly 10 bits of resolution (providing 1000 counts approximately) is the minimum acceptable. The Prologger provides 16 bits of resolution – this resolution provides useful of widely varying signals. Furthermore, the input voltage range of an analog input must be taken into account. A typical analog instrument is a temperature probe. Analog inputs may also be single ended or differential.

Counter Channels – A continuously on/off switched signal is called a pulsing signal. This type of signal is normally fed into a COUNTER channel that accumulates the number of pulses over a given time period. Counters have different input frequency limits and different counting capacities. A typical counting input would be a tipping bucket rain gauge (a slow pulse) or a wind anemometer. Counter inputs can be potential free, sources or sinks.

Serial Data Channels – These vary from one manufacturer to another. Unidata supports the SDI-12 standard and our own HSIO standard.

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- HSIO – High Speed Serial I/O. This is used to transmit data from complex instruments to the Data Logger. Some of the Unidata instruments convert a physical parameter directly into digital data that needs only be transmitted to one of the Data Logger SERIAL CHANNELS.

- SDI-12. This standard is similar but is used by other manufacturers so other brand instruments can be connected to the logger. SDI-12 is a high resolution, floating point, slow speed, multi-drop standard specifically designed for low power instruments that take time to power up. It is relatively difficult for a novice user.

Output Channels. The output channels are use to activate / deactivate instruments. For example a water sampler can be turned on and off with a Data Logger. The Instrument Loggers also have output control/s. The Unidata Data Loggers have CMOS and Open Collector outputs that require different connection circuitry.

The Engine of the Data Logger

The engine of the Data Logger consists of a CPU that is a micro-controller. The Unidata Data Loggers use Intel ’51 series and TI MSP series Micro controllers. The logger uses two different types of memory.

- FLASH. The flash memory used by the logger contains the firmware, which is the control program for the Data Logger. The firmware interprets and executes the program that is downloaded at the time of programming a Data Logger.

- RAM. The RAM memory in Unidata Data Loggers is based on battery backed SRAM. Most of this memory is reserved for the logging but a small part for the ‘log program’ that is loaded into the Data Logger at the time of programming the Data Logger.

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The Computer Connection ('Comms Conn,').

This connector is used connecting a computer for direct communications using Starlog software for programming, unloading etc… It can also be used for connecting a modem for telemetry functions such dial up unloading or dial out alarms. In the case of an Instrument Logger, this is the only connector fitted (although the connector usually has SDI-12, HSIO and an Output in varying combinations available as well).

The computer connection supports RS232 level signals.

The baud rate is typically set at 9600 baud. The system is capable of operating from 300 to 76,800.

- Direct Connect. The normal unload / unload procedure is to exchange the Data Loggers in the field with a newly programmed one and to return the full one to the office for unloading – this allows the batteries to be checked and changed as well. In the case of the Instrument Loggers, however it is more common to take a laptop to the field location and unload the logger there or to use telemetry.

- Telemetry. This option allows for remote interrogation and unloading of collected data via the telephone system. The equipment used is a PC with a modem at the computer end and a GSM modem or RTU at the remote end. This option is widely used to reduce the cost of data collection but there are issues such as lightening damage and scalability that cause problems.

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Internal Operations of a Data Logger.

Scan Rate and Log Interval are terms used by Unidata to describe two important parameters.

- Scan Rate. The Data Logger is a sampling device. The speed of sampling is determined by the scan rate set in the scheme. The Data Logger takes a sample every n seconds that is programmed by the scan rate. For environmental monitoring 5 seconds is usually adequate. The sample is kept in the Data Logger control area of memory and is overwritten at the next scan. For averaging purposes the sample is copied into a different register (memory area) and added up over a certain time period (which can either be the log interval or the sub interval).

- Log Interval. The log interval referred to above is the time between samples (from a scan) being into the LOG BUFFER. The log interval is a multiple of the scan rate. The two can be the same value. If averaging is selected the average of a channels sum is calculated at this time.

- Sub Interval. The scan rate in some cases may be too fast for some averaging purposes. In this case a user may choose a sub interval (a multiple of the scan rate) as the period at which samples should be taken for averaging of a particular channel.

Memory Capacity

As mentioned previously collected data is stored in SRAM. Hence it is important to know how much data can be collected before the Data Logger is ‘full’. This also tells us how long a Data Logger can be left in the field before the data needs to be unloaded. A Starlogger (and all Instrument Loggers) have 128 Kbytes of memory. A Prologger has 512 Kbytes of memory.

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- Memory Usage. Based on the Starlogger and Instrument logger a channel normally occupies 2 bytes of memory per recording. There are some exceptions particularly for SDI-12 channels that may use 4 bytes.
- Memory Duration. The Starlog S/W package automatically calculates how many bytes of memory a newly created scheme will use and will determine the memory duration. However, a quick estimate of memory duration can be done with a few simple rules. (Not for Events)

Rule 1 – The first 8kbytes of data are reserved for the log program and hence not available for data storage.

Rule 2 – Determine the number of bytes for each channel to be recorded.

Rule 3 – Determine how many mathematical functions are to be applied and recorded per channel. Each requires 2 bytes. Eg. MAX/MIN/AVE/SD.

Now enter your findings from Rule 1 to 3 in the following formula to calculate the number of recordings the Data Logger can store:-

$$\textbf{Recordings} = \frac{\textbf{memory size - 8000 bytes}}{\textbf{bytes per channel x \# of channels x \# of functions per channel}}$$

If you then wish to determine the memory duration then simply multiply the number of recordings by the log interval.

Example:

Four thermistor probes are to be connected to a Starlogger (128 Kbytes). The user decides to log the Min / Max and Ave readings for each probe (but not the raw reading) every 5 minutes. How many recordings can be stored and how many days will the Data Logger run for without running out of memory or having the circular buffer over-run?

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$$\text{Recordings} = \frac{(128 \times 1024) - 8000 \text{ bytes}}{2 \text{ bytes per channel} \times 4 \text{ channels} \times 3 \text{ of functions per channel}}$$

Using the above formula there are 10,256 recordings possible.

To take reading every 5 minutes means that the logger is full after 5 x 10,256 minutes (51,280) that equals 854 hours, which equals 35.6 days.

Data Logger Power Sources

The power source provided in the Starloggers and Prologgers is in the form of a battery pack consisting of 6 ‘D’ size cells. The pack is integral to the logger. Care should be taken if constructing one of your own to fully solder all connections and to use batteries of the highest quality.

Because the logger is powered down most of the time and only powers up for a short time (< 100mS is typical) when performing a scan the logger’s power requirement is minimal. The largest use is in the instrumentation although most of Unidata’s instruments are designed for low power consumption (<4 mA) and can be powered directly from the logger UPS (User Power Supply).

Logger Instruments are generally more power hungry (i.e. the Starflow and Turbidity Instrument).

The borehole logger (DWLR) uses Lithium battery packs which provide very long life times.

- Battery packs. There are two battery packs available for the Starlogger and Prologger. There is an Alkaline and a Ni-Cad pack. The Ni-Cad pack needs recharging and is only recommended for use where fast sampling rates are required.

- External Power. All Unidata Data Loggers and Instrument Loggers can be externally powered from the Mains (via a plug pack) or from a 12v Gel Cell battery and Solar Panel combination. The Solar Panel and Gel Cell battery combination is also suitable for GSM telemetry sites.

NOTES

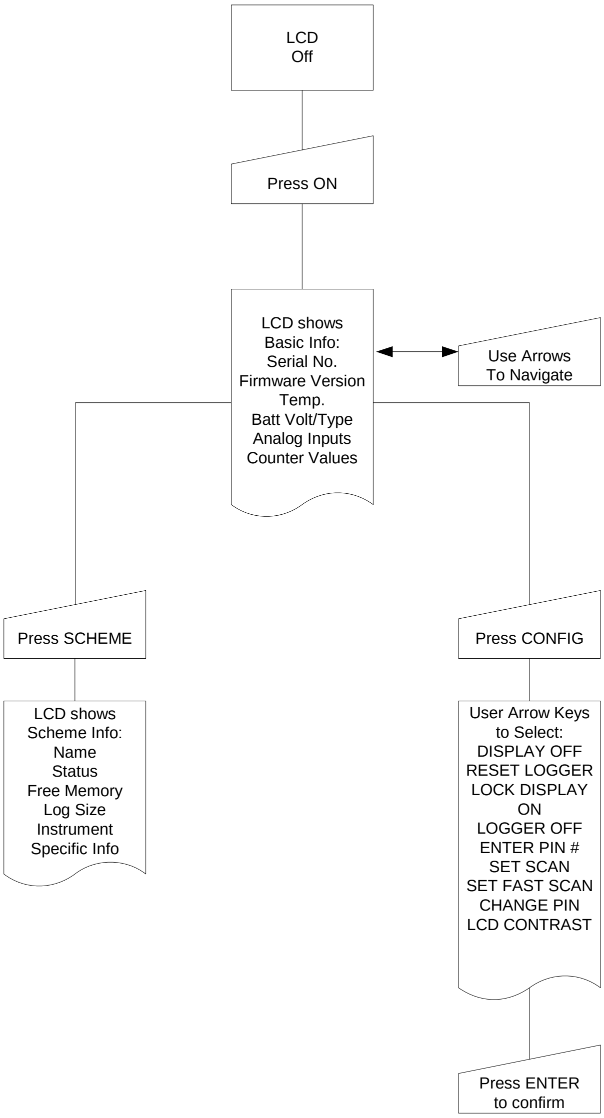
As mentioned previously collected data is stored in SRAM. Hence, it is possible to lose memory contents if the internal batteries (for Prologgers, Starloggers and DWLRs) go flat. The logger firmware will halt processing when the battery level reaches an intial low level and preserve memory contents in the hope that an unload will occur before the batteries are completely dead.

A lithium battery for memory back up is an option. In the case of the Starflow and Turbidity instrument this not available and care must be taken to calculate the power consumption and duration if external or solar power is not available. Both instruments have super caps allowing short periods of memory preservation when no power is fitted (i.e. for battery change over etc).

The Data Logger provides several sources of output power for powering instruments. These include switched regulated supplies and un-switched unregulated supplies. When these are used, care must be taken to observe the maximum loads permitted.

Logger Keypad LCD Operation

The Data Logger Keypad and LCD are designed to assist users in the field with verifying Logger operations and measurements. The table on the following pages shows a flow chart of operations and indications.


LCD Off
Press ON
LCD shows Basic Info: Serial No. Firmware Version Temp. Batt Volt/Type Analog Inputs Counter Values
Use Arrows To Navigate
Press SCHEME
LCD shows Scheme Info: Name Status Free Memory Log Size Instrument Specific Info
Press CONFIG
User Arrow Keys to Select: DISPLAY OFF RESET LOGGER LOCK DISPLAY ON LOGGER OFF ENTER PIN # SET SCAN SET FAST SCAN CHANGE PIN LCD CONTRAST
Press ENTER to confirm

Logger LED Operation

The Star Logger LEDs are designed to assist users in the field with verifying battery status and operation status. The meaning of the Status LED's is as follows:

LED (flashing)	State	Description
None	No Scheme Loaded	Stopped
Green	Waiting for signal connection and to begin logging.	Primed
Green and Red	Actively logging.	Logging
Red	Needs unloading	Stopped (Overflow)

The meaning of the Battery LED's is as follows:

LED (flashing)	State	Description
None	No battery power	Battery flat or in 'sleep' mode
Green	Scanning	Battery is OK.
Green and Red	Scanning	Battery is Low
Red	Standby	Battery Flat

6. Instruments

Unidata and many other manufacturers make instruments suitable for the Unidata Data Loggers.

Types of Instruments

Most instruments can be classified as of a simple type. This means that the instrument has only one transducer fitted to it. E.g. a thermistor temperature probe or a DC current shunt.

A more complex instrument is one that has multiple transducers fitted such as the wind speed and direction instrument that has three transducers – two for win direction and one for wind speed.

Finally, there are the 'smart' instruments that have their own processing or digitization circuitry fitted. The 6541 Water Level instrument is the simplest of these while the Starflow (which is a combined Instrument Logger) is probably the most complex,

Signals

- Analog signals on simple instruments require some basic math and knowledge to make the best use of a Data Logger. Mismatching of the instrument output range to the Data Logger input range will result in loss of resolution or clipping of the measurement.
- Cable lengths for analog instruments must be limited and shielded to avoid electrical interference, signal loss and cross talk. Generally, no more than 30 m. lengths are recommended. The cable lengths for pulsing signals and digital signals can be much longer but there could be problems with lightening damage or other accidental damage.

Power Consumption

Power consumption of all instruments must be calculated if no external power supply is available. There are two forms of power consumption. Some instruments only power up during a scan. Other instruments that require long recording periods or need to stabilize for long periods are continually powered up. The UNIDATA Data Logger can also power up an instrument prior to a scan on a programmable interval.

7. USING STARLOG VERSION 3 SOFTWARE

This chapter describes the usage of the Starlog Software Package. This chapter is based on the following example.

Data Logger	Instrument Used	Project
Blue Starlogger	Unidata Red Thermistor Probe Model 6507A	Measure, plot and tabulate the average temperature at your work place every 10 seconds over a few minutes

We will use the Starlog V3 Users Manual as our guide from here on.