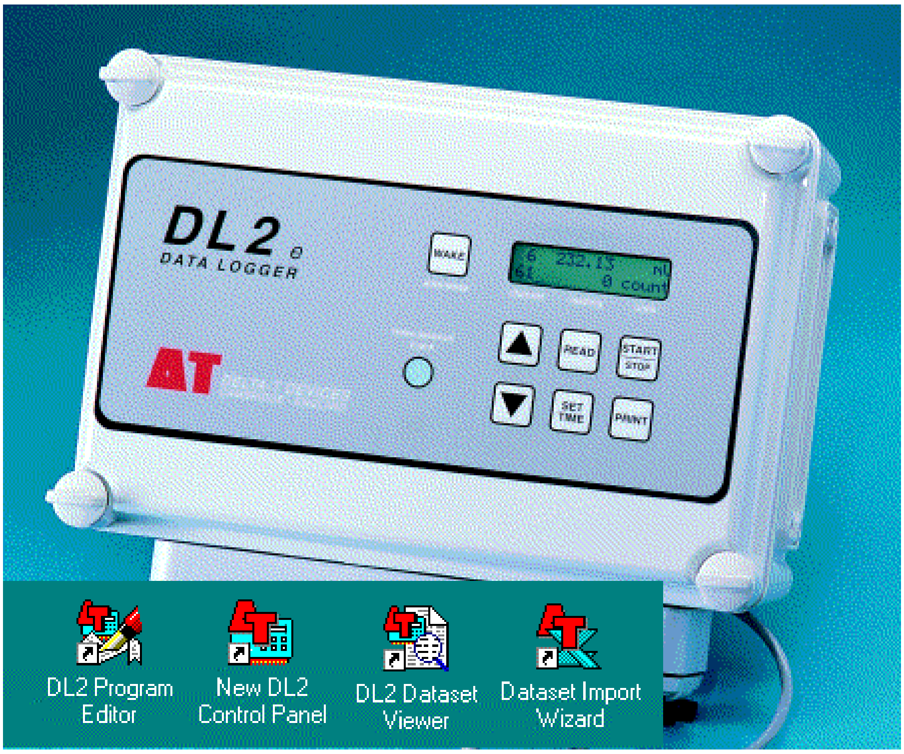
User Manual for

DL2e Data Logger

Hardware Reference



Version 3

Delta-T Devices Ltd

VERSION

Document code : DL2-UM-05-03
Version : 3
Issued : 15 Dec 2000

See also :
Getting Started,
Ls2Win on-line Help.

TRADEMARKS

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ELECTRO-MAGNETIC COMPATIBILITY

The DL2e Logger has been assessed under the European Union EMC Directive 89/336/EEC, and conforms with the following harmonised emissions and immunity standards

EN 50081-1 : 1992
EN 50082-1 : 1992:

Contents

Hardware Reference

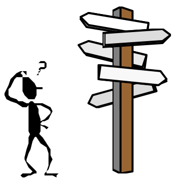
About this manual

This manual contains information about:

- using the keypad on the front panel
- power supplies and the rechargeable battery pack
- setting internal switches and rebooting,
- installing additional cards and components,
- connecting sensors
- connecting cable assemblies
- communications cables and modems
- sensor linearisation tables
- accuracy and technical specifications
- maintenance, storage, repairs and guarantee.

It also contains general guidance on the scope and application of the measurement techniques supported by the logger.

Other Documents and Help.



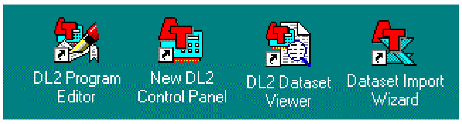
Separate Contents and Indexes exist for :
- each on-line Help,
- Hardware Reference,
- Getting Started.

So keep searching!

See the "**Getting Started**" manual for:

- Installation instructions.
- A Guided Tour for an introduction to some of the logger's facilities.
- Learn the basics of logger operation in the Tutorial.
- A brief introduction to features not covered in the tutorial.

View the **on-line Help** or press F1 in each of the Ls2Win applications for help on using the Windows software:



Sensor **Application Notes**, including wiring instructions, are provided on-line in the sensor library in the DL2Program Editor.
You can print off individual on-line Help topics.

Use all the **Indexes and Contents Lists** - in this manual, Getting Started, and in the on-line Help for Ls2Win. They are all different.

Note the following specialist, technical manuals:

- **DL2e Technical Reference** manual, consisting solely of printed circuit board schematics for the various cards and accessories.
- **DL2e Programmers Guide**. This contains terse information for programmers about communicating with the logger. It is provided on your installation disk as a text file.

Chapter 1 : About the DL2e Logger

The DL2e logger unit contains all the hardware required for capturing and storing data from a wide variety of different types of sensor, under most environmental conditions. It runs an internal logging program that is set up by the user, and tells the logger how and when to acquire data.

The logger's front panel keypad and display gives control over the essential features which are needed for field operation away from a computer, such as starting and stopping the logger, displaying current readings, providing status reports, and outputting logged data to a local printer or intermediate collection device.

The Windows software Ls2Win also provides control over all the features available from the front panel keypad. It also is used to program the logger. This involves choosing the number of channels to be logged, the types of sensor and appropriate data conversions, the rate at which each channel is to be logged, and action to be taken on out-of-limits conditions.

It also provides a range of other features that are not available from the keypad, such as timed start, triggering on events, collecting and manipulating logged data.

Password facility

Certain logger functions are protected from unauthorised use by a password facility. This is set up in the logging program using the DL2e Program Editor, which is part of Ls2Win. See also the on-line Help.

Waking and sleeping

The DL2e Logger can exist in one of two states, known as 'awake' and 'asleep', corresponding to high and low levels of activity.

Awake

When awake all of the logger's circuitry is powered up and all its functions are active. The logger is awake during a LOG, WARM-UP or EVENT (see opposite), and while communicating via its RS232 port, or performing any of the tasks controlled from its keypad. There is normally a message displayed on the logger's display, and this is the simplest way to recognise when the logger is awake. Typical current consumption in the awake state is 40mA.

Asleep

When asleep a minimum number of components are powered up, notably the clock (to keep time), memory (to conserve data), and circuitry which enables the logger to be woken. The logger's display is always blank when the logger is asleep. Typical current consumption in the asleep state is 40µA.

Waking the logger

The logger wakes of its own accord whenever required to LOG, EVENT, or WARM-UP. See Logging, opposite.

To use the logger's keypad functions press the WAKE key.

An incoming signal at the logger's RS232 port wakes the logger. This occurs when you communicate with the logger from your PC using the DL2 Control Panel, which is installed on your desktop as part of Ls2Win.

Putting the logger to Sleep

The asleep state is the logger's preferred state, with low power consumption for battery conservation. The logger automatically sleeps if it has woken specifically to LOG, EVENT, or WARM-UP (i.e. provided that it is not also busy communicating or operating under keypad control).

In other situations, the logger autosleeps if it receives no input from a user (i.e. a key press, or communication via its RS232 port) within a reasonable period of time.

There is no manual method of putting the logger to sleep from the keypad: the logger is simply left to autosleep.

The logger can be put to sleep by a warm reset (see page 16), but this method is not recommended for routine use.

Autosleep

The logger autosleeps in the following conditions:

After 10 seconds when displaying the Keypad main menu if no key is pressed.

Within a few seconds if the logger is woken by noise at its RS232 port, such as may occur if the power supply to a printer or computer is switched while connected to the logger. The logger discriminates between noise and a genuine attempt to communicate by waiting a few seconds for further signal.

After one or two minutes if no user input occurs (i.e. a key press or communication signal) at any other time.

Autosleeping can be disabled when using the 'auto-print' feature.
See "Auto-printing" on page 35.

Logging

After starting logging, the logger normally autosleeps, and then wakes when required to take readings from sensors or to switch warm-up relays. The logger is said to be 'logging', even though it is not actually recording data at a given instant, for example in messages such as 'logging started..' or 'already logging'.

LOG, EVENT, WARM-UP

While logging, recording of data may be initiated either by the logger's internal clock (readings taken at regular intervals, known as 'timed' data), or by a signal on a channel programmed as a data trigger (or 'event triggered' data). Switching of a warm-up relay is controlled by the logger's clock.

These tasks take priority over keypad functions and communication. When carrying out one of these 'priority tasks', the logger flashes up a message on its display to indicate that other logger functions are temporarily suspended.

The respective messages are:

- For recording timed data:

```
LOG
```

- For recording event triggered data:

```
EVENT
```

- For switching a warm-up relay:

```
WARM-UP
```

The logger is said to be performing a LOG, EVENT or WARM-UP.

While communicating with the logger, you may notice appreciable delays in responding to your key presses while the logger is busy performing a priority task. If the logger is programmed to log timed data very frequently you may find it difficult to establish communication with the logger, and data collection may be appreciably slower than normal.

Occasionally the logger may attempt to display the message off screen (off the edge of the logger's display). This is unusual, most likely to occur when the logger is displaying a General status report. You may then notice a delay in keypad operation without any message being displayed.

Conflicting priority tasks

It is possible for an event trigger to occur while the logger is busy logging timed data, and for timed data to become due while the logger is servicing an EVENT. If so, the logger completes the first priority task before tackling the second one.

As a result, there may be a discrepancy between the time recorded by the logger in its data file, and the actual time when an EVENT occurred, or when data was actually logged (see "Timing accuracy" on page 118 for details).

If a LOG becomes due while the logger is still working on a previous LOG, an over-run occurs (see "Over-runs" on page 26 for details).

EVENT detection is disabled on an event trigger channel while the logger is busy servicing a previous EVENT on the same event trigger channel. The logger may miss events occurring in short succession.

The logger’s keypad and display

Using the logger’s keypad and display

To use the logger’s keypad, wake the logger by pressing WAKE.

You must press WAKE while the logger is asleep. Any message on the screen indicates that the logger is already awake, for example communicating or performing a LOG. Disconnect any serial communication cable and allow the logger to autosleep (if autosleeping has not been disabled). In emergency try a warm reset or, as a last resort, coldboot the logger (see "Coldbooting" on page 15).

On its display, the logger echoes the key press:

```
<WAKE>
```

Keypad main menu

The logger displays General Status and Malfunction Reports (see "Logger " on page 19 and page "Error status" on page 24), followed by a message, known as the Keypad main menu:

```
Press key if
required..
```

Keypad functions

You can now press any key to enter one of the logger’s seven ‘keypad functions’. The keypad functions are named after the logger’s seven keys, and are summarised opposite.

Note that you can curtail the General Status and Malfunction Reports at any time by pressing one of the keys. If you hold the key down, you can also omit the main menu message and go directly into one of the keypad functions.

On entering a keypad function, for example READ, the logger first confirms the key press by displaying the name of the selected function.

```
<READ>
```

On exiting any of the keypad functions, the logger always returns to the Keypad main menu. Note however, that the logger may autosleep if left too long without a key press.

There is no keypad function for putting the logger to sleep. The logger autosleeps (see "Autosleep" on page 10).

Entering information

Some of the keypad functions require you to enter information, for example date and time, password or a selection from a menu. To do so, use σ and/or θ until the value or option that you require comes up on the display. To accept the displayed option press the key corresponding to the keypad function that you are using.

The logger displays a prompt such as:

```
use <UP> <DOWN>
& <SET TIME>..
```

Confirming a selection

Some of the keypad operations require confirmation before proceeding, for example erasing data or stopping logging. To confirm, press the key for the keypad function that you are using. In the example below, press START to execute the operation you requested. Pressing any other key, or leaving the logger to autosleep, aborts the operation.

The logger displays a prompt such as:

```
<START> confirms
other keys abort
```

Summary of keypad functions

The keypad functions are named after their corresponding keys: WAKE, σ,θ, READ, SET TIME, START and PRINT.

WAKE

The WAKE function displays a General status report:

- Battery voltage and expected life
- Current date and time.
- Configuration name
- Whether logging or not
- Date and time of start and end of logging, if appropriate
- Amount of memory installed and number of stored data.
- Malfunction Reports: battery failed, memory filled and suspect data logged on any channel.

See "Logger " on page 19 for details.

READ

The READ function is for checking a logging set up before or during logging:

- Displays instantaneous values on input channels
- Displays status of relay and event trigger channels.
- Permits switching of relay channels under keypad control.

See page 23 for details.

SET TIME

The SET TIME function sets the time on the logger's internal clock.

See "Setting the logger's clock" on page 18 for details.

START

The START function starts and stops logging. See "Starting and Stopping Logging" on page 27 for details.

PRINT

The PRINT function can be used to:

- Print out data on a serial printer.

- Output data in binary file format to a data collection terminal (not using Logger PC Software).
- Erase data.

See "Collecting and Erasing Logged Data" on page 30 for details.

s

The σ function is for testing two-way serial communication, e.g. with a computer. See "**Error! Reference source not found.**" on page **Error! Bookmark not defined.** for details.

q

The θ function is for testing one way serial communication, e.g. with a printer. See "Checking printer operation" on page 33 for details.

Resetting the logger

Coldbooting

Coldbooting restores the logger to a known basic state with the following consequences:

- Any data stored in the logger is erased.
- The logger carries out a RAM check, checking which RAM chip positions are occupied, and whether any RAM chips are faulty.
- The existing logging program is erased and the default configuration is installed.
- Any Setup string for PRINT is erased.
  XXXX See "Setup string for PRINT" in the on-line Help.
- Auto-wrap (previously called the overwrite mode) is disabled.
  See "Auto-Wrap" in the on-line Help.

The logger's clock is not reset.

The logger automatically coldboots on waking if a new PROM is installed.

The logger must be coldbooted if:

- RAM chips have been moved or installed
- The logger has crashed irretrievably for any reason, and a warm reset (see opposite) fails.
- Input cards have been removed or installed, i.e. plugged into or out of the input card stack.

The logger does not need to be coldbooted if only switches or ribbon cables have been moved, or if attenuator or input protection cards types LPR1, LPR1V have been installed.

To coldboot the logger

- Open the logger's case.
- Hold down the 'COLD BOOT' and 'STOP' buttons on the main circuit board (see Figure 2 - Main circuit board layout), and then -
  - if the logger is asleep, also press WAKE on the logger's keypad,
  - if the logger is already awake, also press the 'RESET' button on the logger's main circuit board (see Figure 2).
- The message 'coldbooting..' appears on the logger's display, followed by a sequence of reports as the logger checks RAM chips, installs a DEFAULT logging program (described in Tutorial Lesson 3 in the Getting Started manual), and goes to sleep.

Ensure that the sequence of reports above does occur. Any other type of message indicates that the logger is not in fact coldbooting.

Note that the logger also coldboots if the logger wakes for any reason while the 'COLD BOOT' and 'STOP' buttons are held down.

In extreme circumstances, you may have to remove all power from the logger before coldbooting. Disconnect any external power supply, remove the logger's internal batteries, gently lift the spring terminal from the top of the lithium cell (see "Lithium cell" on page 42) with a fingernail, and hold for 10 seconds. Replace the logger's batteries and coldboot as described above.

Warm reset

A ‘warm reset’ puts the logger to sleep without destroying any information in the logger’s memory (data, configuration, etc.). The logger can be woken to resume normal operation after a warm reset. Warm reset is not as drastic as coldbooting. Try it in preference to coldbooting if the logger crashes and gets stuck in an awake state. Coldboot only as a last resort if a warm reset fails.

The logger normally autosleeps of its own accord and warm reset should not be used to routinely put the logger to sleep. In particular, beware of resetting the logger while it is in the middle of a LOG, EVENT or WARM-UP. This may interfere with the setting of the logger’s clock in preparation for the next LOG, and have an unpredictable effect on logging of timed data.

To carry out a warm reset

- Open the logger’s case.
- Press and release the ‘RESET’ button (see Figure 2). When the button is released, the logger’s display goes blank.
- Repeat if necessary.

Password

The DL2e Logger has a password facility for preventing loss of data or interruption of logging due to unauthorised use of the logger’s keypad or PC software.

The password is set up as part of the logging program.

Once the logger is programmed with a password, the user has to enter it in order to perform the following operations:

- erase data from the logger’s memory
- stop logging
- start logging, if data is stored in the logger
- re-program the logger, if data is stored in the logger

The password does not need to be entered in order to use any other keypad or software function.

To program the logger with a password

Open or create a logging program using the DL2 Program Editor.

Enter up to 8 alphabetic characters in the Password box.

Send the program to the logger in the normal way.

Note that the logger’s keypad and display only offers upper case alphabetical characters and spaces. If your password contains lower case or non-alphabetical characters you cannot enter it from the logger’s keypad. (You can do this using any PC software.)

When prompted for a password

Using Ls2Win

DL2 Control Panel pops up the Password dialog, which prompts you to enter the logger’s password.

Remember to use upper case or you will be locked out from using some of the Keypad functions.

Using the keypad/display

When a password is required, a prompt appears on the top line and the cursor moves to the left position on the bottom line.

```
password..?
_
```

Use σ and θ to cycle through the alphabet.

When the correct character appears, press the key corresponding to the keypad function you are using: PRINT if erasing data, START if starting or stopping logging. The cursor will move to the next position.

Enter 8 characters. If the password has less than eight characters, enter spaces to make up 8 characters. To enter a space, press PRINT or START, as appropriate, without pressing σ or θ.

Remarks

You can recall the logger’s current password by retrieving the logging program from the logger.

Setting the logger’s clock

The logger has an internal clock that marks the date and time of all logged data. The date and time can be set either from the program or from the front panel keypad. You cannot set the clock while the logger is logging.

Leap Years

The logger does not keep track of years and cannot identify leap years. February is always assumed to have 28 days. In a leap year, the logger’s date has to be set to the correct date manually after 29th February.

Using Ls2Win

See the on-line Help in the PC's DL2 Control Panel program.

Using the keypad/display

At the Keypad main menu, press SET TIME.

The logger displays the following messages:

```
required..
<SET TIME>
```

```
use <UP> <DOWN>
& <SET TIME>
```

The logger displays the date and time.

```
& <SET TIME>
date: 28-01
```

The date is in European (day-month, dd-mm) or American (month-day, mm-dd) format, depending on the setting of the ‘50/60’ switch (see "Electrical mains environment" on page 48). The time is formatted as hours:minutes:seconds, hh:mm:ss.

Use σ and τ to adjust the value indicated by the cursor, and press SET TIME when the displayed value is correct. The cursor then moves onto the next field. Note that the first value that you set is always the month, irrespective of the date format.

The logger’s clock is actually set at the moment you press SET TIME to set the number of seconds.

```
date: 28-01
time: 15:29:30
```

Chapter 2 : Interrogating the DL2e logger

This chapter describes facilities that allow you to examine the current state of the logger.

Status information is supplied on the following:

- Logger, including battery voltage, date and time, logging program name, and memory status.
- Sensor channels, comprising instantaneous readings on input channels and status of relay and event trigger channels. If using the logger's keypad, relay channels can also be exercised (i.e. turned on and off for testing purposes).
- Datasets, including the amount of memory used and available
- Errors (malfunctions reports), i.e. whether any problems have occurred while the DL2e Logger has been logging, including full memory, battery failure, and suspect data on input channels. Malfunction reports can be deleted so that only new malfunctions get reported on the next occasion.

Either WAKE the logger from the Front Panel, or run a DL2 Control Panel on your PC.

General Status Report

A general status report appears transiently on the Front Panel when you wake the logger. This information may also be viewed in the DL2 Control Panel on your PC.

See also the on-line Help available in each of the following component programs of the Windows software Ls2WIN:

- DL2 Program Editor - to create and edit logging programs.
- DL2 Control Panel - to control and monitor the logger
- Dataset Import Wizard - to retrieve logged data into Microsoft Excel.
- DL2 Dataset Viewer - to view raw data files once saved to your PC.

Logger status

Logger status information is displayed on the Logger and Datasets panels, in the DL2 Control Panel on your PC.

It also appears transiently on the DL2e Front Panel as part of the general status report when you wake the logger.

PROM version

The PROM version is only shown on your PC - in the Logger panel in the DL2 Control Panel. It does not appear on the logger's Front Panel Display.

Battery voltage and % life expectancy

The reported battery voltage is the voltage available to power the logger.

The voltage available to power the logger is not always the full battery or external power supply voltage, being reduced by a diode drop (approximately 0.6V) in the following cases:

- If the logger is powered from an external power supply
- If the logger is powered from its internal batteries with the power supply selector switch set to 'EXTERNAL'.

The reported battery voltage is intended as a guideline only. Fluctuations may occur due to polarisation effects in the logger's internal alkaline cells. In particular, the batteries appear to recover during a long period of inactivity, but their voltage then falls rapidly to its previous level when the logger is awake.

The battery life is calculated on the basis of a linear interpolation between 7V (0% left) and 8.5V (99% left) and applies to alkaline cells only. A battery voltage in excess of 10V is reported as >10V, and voltages in excess of 8.5V are reported as 99% left.

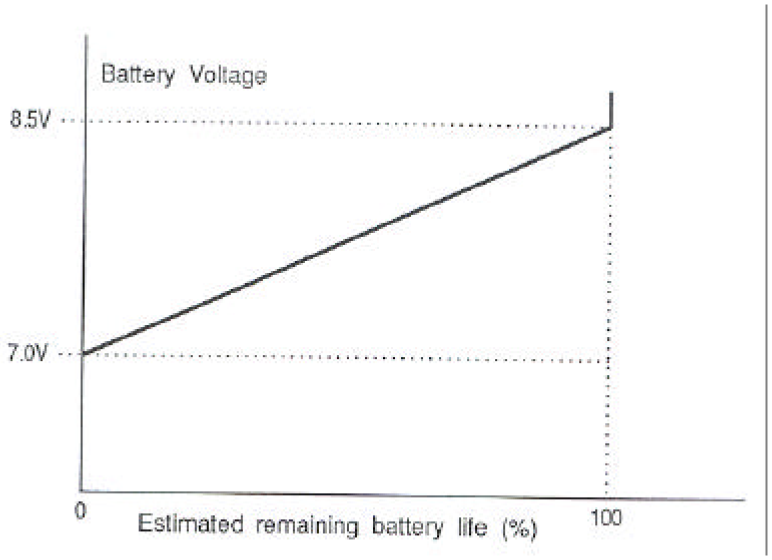


Figure 1 - Battery life interpolation

Date and time

The formatting of the date is linked to the setting of the ‘50/60’ switch (see Figure 2 - Main circuit board layout):

- ‘50’ gives European date formatting (i.e. day-month).
- ‘60’ gives American date formatting (i.e. month-day).

Leap years

The logger does not keep track of years, and cannot identify leap years. February is always assumed to have 28 days. In a leap year you must re-set the correct date manually after 29th February.

Program (or configuration) name

This is the name of the file containing the logging instructions that you download from the PC to the logging program that is installed in the logger and which tells it when to log, which channels to log, how to record results and so on. The Front Panel display calls this the configuration, abbreviated to "config'n". In Ls2Win call this the logging program.

Logging started

Shows the date and time when a command to start logging was issued. It is the date and time of a key press (if logging has been started from the keypad), or a command issued by means of the PC, and not the precise date and time of the first logged data:

- For an immediate start, either using the PC or the keypad, there is a short delay between issuing the instruction to start and the first logged data: the reported time may be up to 2 seconds earlier than the time of the first logged data.
- If the logger is set to start at a pre-set time, or set for a triggered start, there is generally a longer time delay between issuing the instruction to start logging and the first logged data.

Standing by

This message indicates that the logger is not yet logging, and contains no stored data from a previous logging session.

Logging stopped

Shows the date and time when logging stopped automatically (as a result of its memory filling up or detection of a battery failure: see "Low battery" on page 41), or was terminated from the keypad or PC. This may not necessarily be the same as the time and date of the last logged reading.

RAM STATUS and STORED DATA

The logger's memory may be partitioned into up to three independent areas or 'datasets'.

- One area can be set aside for timed data (i.e. data stored at the regular time intervals specified in the logging program).
- Two areas can be set aside for event triggered data (that is data stored when events are detected on event trigger channels) if channels 61 and 62 are programmed as event trigger channels.

These areas of memory are referred to as TIMED RAM, TRIG/61 RAM and TRIG/62 RAM or datasets respectively, and their status is reported separately.

Note that:

- 1K is 1024 bytes, and that each reading requires 2 bytes of memory.
- All TIMED RAM is available for data, for example 128K of TIMED RAM is 131072 bytes, and can store 65536 readings.
- Event triggered data is stored with an additional 7 bytes of date and time information for each repetition of an event triggered sequence, and the number of event triggered data that can be stored in a given amount of memory is reduced accordingly.
- DL2 Control Panel also reports the number of data since data was last retrieved. These readings can be retrieved from the logger separately. See the on-line Help for details.
- Auto-wrap mode allows the logger to continue logging timed data when TIMED RAM fills up, by overwriting old data (See the on-line Help for details). Auto-wrap mode status is only reported by Ls2Win.

See also the on-line help for the DL2 Control Panel program.

Using Ls2Win

The DL2 Control Panel displays logger status information. See also its on-line Help and Lesson 2 in "Getting Started".

Using the keypad/display

At the Keypad main menu, or while the logger is asleep, press WAKE.

The status report consists of a sequence of messages, each of which is displayed for approximately two seconds.

It can be curtailed at any point by pressing any key.

Sensors status

What the Sensors status provides

This shows the current status of all channels that have been programmed as sensors. It can be displayed on your PC in the Sensors panel of the DL2 Control Panel, or on the logger's Front Panel display, using the keypad READ function.

The DL2 Control Panel displays a single value for each channel.

The READ function continuously updates the displayed value for a single channel, allowing sensor connections to be conveniently tested. Relay channels can be exercised and event trigger channels can be tested prior to starting logging.

This information is independent of logging, and can be obtained before or while logging with no interference to logged data.

Each channel is identified by a number, label, and sensor code (for input channels) or by a channel function (for other non-input types of channel).

Input channels

The READ button on the Front Panel, or the Sensors panel in the DL2 Control Panel, either gives an instantaneous reading in engineering units, or it gives an error message if appropriate. See also: Error status on page 24 for interpretation of error messages, and the additional notes below for counter and frequency channels.

Counter channels

If the logger is logging, the selected channel(s) show the accumulated count without affecting logged data.

If the logger is not logging, the counter is reset to zero before returning a Channel Report.

Using the READ function, an updated accumulating count is displayed.

DL2 Control Panel displays only a single value, and not an accumulating count. If not logging, this is normally zero, unless you apply a high frequency input signal.

Frequency type channels

The logger samples frequency inputs over ½ second periods. Hence it has a resolution of 2 Hz for this purpose (e.g. for an input signal of 1 Hz, the display alternates between 0 and 2 Hz). Note that this does not apply for logged data, when the resolution of frequency channels corresponds to the selected sampling interval

Relay channels

The status of a relay channel (MAL, OUT and WRM functions) is either ON or OFF. Using the keypad READ function, the relays can be exercised for testing purposes (see "Using the keypad/display" on page 23).

Sensors powered through warm-up relays are normally only powered up during the warm-up periods specified in the logging program.

To obtain valid readings from a 'warmed-up' channel, the warm-up relay has to be switched ON.

Warm-up relays are aautomatically switiched ON when you select a channel and press **Read Now** in the Sensors panel of the DL2 Control Panel.

Remember you must manually switch warm-up relays ON when using the keypad READ function (see page 23).

On exiting the status report, warm-up relays are returned to the state required for logging, i.e. ON in a warm-up period, OFF otherwise. However, if logging is in progress, the logger switches warm-up relays OFF at the end of a warm-up period, even if they have been switched ON for a Channel Report. If this occurs, you will see faulty readings from warmed-up channels.

Event trigger channels

Event trigger channels are reported as being either a s-trigger (start trigger), or d-trigger (data trigger), with a status SET or CLR (clear).

When SET, the channel detects events and the logger acts accordingly.

When CLR, the channel ignores events.

Both start and data trigger channels are CLR when the logger receives a program, and become SET when logging is started.

When a start trigger detects an EVENT, the logger starts recording data and the start trigger becomes CLR, ignoring any further events.

Data trigger channels remain SET until logging is stopped or event triggered memory fills up.

Using Ls2Win

Sensor status information is displayed in the Sensors panel of DL2 Control Panel. See also its on-line Help and Lesson 2 in "Getting Started".

Using the keypad/display

At the Keypad main menu press READ.

The logger displays the sensor code and label for channel 1, or the first programmed channel (in numerical order) if channel 1 is not programmed).

```
ch reading units
1 TM1   cold-jn
```

After a pause, the sensor code and label are replaced with a reading in engineering units, or by an error message if the sensor is faulty or incorrectly connected.

```
ch reading units
1_  20.95 deg C
```

Error messages may be o/s limits (outside limits), over-range, or noisy. These conditions are discussed in detail on page "Sensor malfunctions" on page 25.

```
ch reading units
 1_ o/s limits
```

The display is up-dated regularly until:

- you press σ or τ to move on to another channel
- you press READ to exit the READ function, and return to the Keypad main menu
- the logger autosleeps

To change channels

Press σ or τ.

The reading on the next (or previous) programmed channel in numerical order will be displayed.

```
1  20.95 deg C
2_ 999.9 ohm
```

Note: Even if two channels are displayed, only the channel marked by the underline cursor is updated (i.e. channel 2 in this example).

Fast scrolling

Hold down σ or τ for fast scrolling through the channels.

Exercising relay channels

When you move onto a relay channel, the logger initially displays its status, and then switches the relay between ON and OFF states at 2s intervals.

When σ or τ are pressed to move onto another channel, the relay remains switched in the state last displayed. You can use this feature to power up a sensor manually, which during normal logger operation would need to be powered using the warm-up relay (WRM) function.

On exiting the READ function, or when the logger autosleeps, the relays are returned to their normal state (i.e. the state they would be in if they had not been switched by the READ function).

Note that logging requirements take priority over manual operation of the relays. If the logger wakes to LOG or WARM-UP, it will override any manual settings of a relay. In particular, the logger will not allow a warm-up relay to be switched off manually during a warm-up period preceding a reading.

Testing event trigger channels

An event trigger channel in the CLR state does not normally detect events. When reporting its status, the logger activates the trigger in a test mode. Events are then detected and an EVENT message displayed, but the normal trigger function remains disabled.

When finished...

Press READ to return to the Keypad main menu.

Error status

During logging, the logger detects and acts on four categories of malfunction:

- Battery failure
- Memory full
- Sensor malfunctions
- Over-run errors

The action taken by the logger on encountering each of these malfunctions and associated malfunction reports is described in "Sensor malfunctions" below.

The logger’s WAKE function and the Errors panel in the PC's DL2 Control Panel reports battery, memory and sensor malfunctions (but not over-runs).

Battery failure

The logger reads the battery voltage each time it wakes. If the voltage available to power the logger is less than 7.0 Volts:

- The logger briefly displays battery failure on its display.
- If logging, the logger stops logging, compiles a malfunction report and switches the malfunction-warning relay (if programmed). This is to conserve any remaining battery life and avoid any risk of corrupting or losing logged data.
- The logger autosleeps.

Remarks

The logger can only perform this routine if there is enough power available for the logger to wake. If the power supply becomes completely disconnected, the logger will be unable to take any action. On reconnection of the power supply, the logger will fail to report battery failure. If logging, the most likely outcome is a series of over-run errors as the logger attempts to catch up on lost logging opportunities.

The mechanism for detecting battery failure is not the same as for reading the battery voltage when reporting Logger status. The logger may not detect a battery failure even though it reports a battery voltage less than 7V, or the logger may have detected a battery failure, while reporting a battery voltage greater than 7V (due to battery de-polarisation).

Memory full

If an area of the logger's memory (TIMED, TRIG/61, TRIG/62) fills up, the logger:

- Briefly displays the message memory full.
- Stops logging data of the relevant data type (TIMED, TRIG/61 or TRIG/62).
- Compiles a malfunction report.
- Switches the malfunction warning relay (if programmed).

If all areas of the logger's memory are full, the logger also stops logging. This is reported on the Logger panel of the PC's DL2 Control Panel and in the status report displayed on the Front Panel.

Sensor malfunctions

The logger detects three categories of sensor malfunction: over range, noisy and outside limits. If they occur during a channel report, they are simply reported in error messages. On detecting a sensor malfunction while logging data, the logger takes the following action:

- Flags the logged data with the appropriate flag (see on-line Help).
- Compiles a malfunction report, indicating the type of sensor malfunction, and, if it is the first malfunction recorded for that particular channel, the date and time. Note that the malfunction report is more specific than the flags attached to data or error messages displayed in the Sensors status report:
- Switches on the malfunction warning relay (if programmed).

Note : The logger cannot detect errors whist issuing a sensors/channel status report. That is, data are not flagged and the malfunction report and malfunction warning relay are not affected by malfunctions detected during a Sensors status report, even if the logger is logging.

Over range

An over range condition occurs if:

- On analogue channels, the logger's full scale input range of ±2.096 Volts has been exceeded (for resistance channels this is equivalent to 1048 kΩ, 104.8 kΩ, 10.48 kΩ, and 1048 Ω for excitation currents of 2, 20, 200, 2000 µA respectively).
- On counter channels, a count of 65472 has been exceeded.
- On averaged channels, the accumulated total of readings within the averaging period has exceeded the logger's arithmetical capacity, $2x10^9$ µV, or for non-linear sensors, 2×10^7 engineering units. This is reported as **ave too large** in malfunction reports.
- For non-linear sensors, the input falls outside the linearisation table. This is reported as **outside table** in malfunction reports.
- A valid cold-junction temperature is not available for a thermocouple channel that requires a cold-junction reference. This is reported as bad cold-jn. in malfunction reports.

Noisy

The logger will not autorange both up and down during a single reading. It records a value in the less sensitive range and flags the reading as noisy.

Outside limit

Upper and lower limits for valid readings can be set to any reasonable level and will usually be the most sensitive test for malfunction (see Valid Range in the on-line Help).

Outside limits readings are reported as outside limit in malfunction reports, and as o/s limits in Channel Reports.

Over-runs

Over-runs occur when storing timed data if the logger finds that the time for its next LOG has already passed. Whenever this happens, the logger saves time by storing copies of previous readings (or adding them to averages etc.) instead of taking new readings. This is very unlikely to occur in normal use, but might happen if:

- The logger is programmed to read faster than it is able to, e.g. 60 thermistors every 5 seconds. See Appendix C for information about logging speed.
- The logger is programmed to read close to the limits of its speed and an unusual coincidence causes it to be exceptionally slow, e.g. all channels requiring autoranging on the same LOG (as can happen on the very first LOG).
- The logger is programmed to log timed and event triggered data, and the length of time spent recording triggered data is sufficient to cause it to over-run on timed readings.

Storing faulty data

Readings involving either sensor malfunctions or over-runs are recorded with lower resolution (10 bits instead of 12 bits). See also the on-line Help.

Faulty readings do not contribute to the minimum and maximum values in data file headers. See also the on-line Help.

If problems occur with individual readings on a channel employing data compression, the resulting compressed values are flagged accordingly.

Deleting malfunction reports

Malfunction reports can be deleted from the logger’s memory, so that in future the logger reports fresh occurrences of malfunctions only. Deleting malfunction reports also resets the malfunction warning relay to OFF, if programmed. Any flagged data stored in the logger’s memory remain flagged.

Using Ls2Win

The DL2 Control Panel displays error status information in the Errors panel. See also its on-line Help.

Using the keypad/display

Displaying malfunction reports

Press the WAKE key to wake the logger. BATTERY FAILURE, MEMORY FILLED and sensor malfunction reports are then displayed after the logger status report.

To end malfunction reports, at any time, press any key on the logger’s keypad.

To delete malfunction reports

After displaying the malfunction reports, the logger offers the option of deleting them.

```

to delete report_
```

Press WAKE to delete the malfunction reports, or any other key if you want to retain them in the logger’s memory.

```
<WAKE> confirms
other keys abort
```

Chapter 3 : Starting and Stopping Logging

Starting logging

Logging may be started from the keypad, or using the PC's DL2 Control Panel program. Three different methods of starting the logger are available:

- Immediate start
- Pre-set time start
- Event triggered start

Any data stored in the logger is erased on starting. The logger issues a warning to remind you that data is to be erased. If the logger is programmed with a password, you will have to enter the password in order to proceed.

As soon as the logger receives the instruction to start logging, it considers itself to be in a logging condition. The Logger Status indicates that Logging has started. Resetting the logger’s clock is not permitted, even if the logger has not yet logged any data. In particular, note that this applies to timed and event triggered starts, when a considerable time interval can elapse between issuing the instruction to start logging and actually storing the first data.

The logger stores the time of receiving the instruction to start. This is the time reported in the Logger panel of the DL2 Control Panel (see "Logger " on page 19), and does not coincide precisely with the time of the first logged data (even for immediate start).

Immediate Start

This method of starting occurs if logging is started from the keypad, or if the immediate start option is selected using the PC. The logger sets its clock to log timed data as soon as possible after receiving the command to do so. There may be a 2-second delay between issuing the command and the first logged timed data.

If a start trigger channel has been programmed, event triggered starting occurs instead (see below).

To start logging at a pre-set time

Using the PC, the logger can be made to start at a pre-set date and time (for example, on 31st January at midnight).

Event triggered start

The logger can be armed to start logging when a signal is detected on channel 61.

The logger must be programmed with channel 61 as a start trigger channel (see on-line Help). When started from the logger’s keypad, or using the immediate start option via the PC, the logger will delay logging until it receives a signal on channel 61.

Note that this is different from the action of a data trigger. After an event triggered start, the logger proceeds logging as if an ordinary immediate start had occurred, acquiring timed data at regular intervals, with no further inputs required on the start trigger channel. A data trigger causes the data to be logged whenever an input is detected on the data trigger channel, in parallel with timed data.

Using Ls2Win

Click Start or Re-start in the Logger panel of DL2 Control Panel, then make a selection from the available options in the Start Logging dialog. See also the on-line help.

Using the keypad/display

Event triggered start only

For a triggered start, first program channel 61 as a start trigger (see on-line Help). Then proceed as for Immediate start.

Immediate start

At the Keypad main menu, press START.

```

<START>
```

If the logger is already logging, you are asked if you want to stop logging (see Stopping Logging, on page 29).

```
already logging
to STOP:
```

If data exists from a previous logging session, you will be asked if you want to erase it.

```
28 readings
to be erased
```

If the logger contains data and is programmed with a password, you will be prompted to enter it.

```
password..?

```

The logger prompts you to press START again to confirm that you want to start logging and erase any previous data. Press any other key if you decide not to start logging.

```
<START> confirms
other keys abort
```

If the logger has been programmed with a Start trigger channel, a message appears indicating that the start trigger is set, i.e. awaiting a signal to start logging.

```
start trigger
set..
```

If there is no start trigger channel, the first LOG starts after 1 to 2 seconds.

```
other keys abort
logging started
```

The message LOG appears briefly, indicating that a set of timed readings has been taken.

```
other keys abort
LOG ing started
```

Stopping logging

Logging may be stopped by using either the front panel keypad or via the PC. There is also an internal ‘STOP’ button. Note there are no facilities using an event trigger to stop logging, nor for stopping at a pre-set time.

Stopping logging is protected by passwords (except if the ‘STOP’ button is used).

There is no need to stop logging in order to collect logged data, or to use any other Windows software or front panel function.

Logging stops automatically in the event of a battery failure. If the memory available for a data type (TIMED, TRIG/61, TRIG/62) fills up, the logger stops logging data of that data type (but note that overwrite mode allows the logger to continue logging timed data).

Using Ls2Win

Click Stop in the Logger panel of DL2 Control Panel.

Using the keypad/display

At the Keypad main menu, press START.

```

<START>
```

A message indicates that the logger is already logging. If this message does not appear, then this procedure will start logging instead of stopping it (see the previous section).

```
already logging
to STOP:
```

If the logger contains stored data and is also programmed with a password, you are prompted to enter it.

```
password..?

```

Press START again to confirm that you want to stop logging. Press any other key if you decide not to stop logging.

```
<START> confirms
other keys abort
```

Logging stops after confirmation and the logger returns to the main menu.

```

logging stopped
```

Using the internal STOP button

Open the logger’s lid, and hold down the STOP button (see Figure 2 - Main circuit board layout). While the STOP button is held down, do one of the following:

- If the logger is asleep, wake the logger by pressing WAKE.
- If the logger is already awake, press the RESET button (see Figure 2 - Main circuit board layout).

Logging will also stop if the STOP button is held down when the logger wakes of its own accord in order to log data.

This method of stopping logging is not protected by passwords.

Chapter 4 : Collecting and Erasing Logged Data

Data can be collected from the logger at any time during logging. There is no need to stop logging.

Data output from the logger can be controlled either from the logger's keypad, or from your PC.

Data that you have collected can be erased from the logger's memory to create space for more data. By repeatedly collecting and erasing data, you can acquire as much data as you like (regardless of the logger's memory capacity) without interrupting logging.

You can collect data from the logger in the following ways:

- Printing out data directly from the logger using a printer.
- Using the Dataset Panel in the PC's DL2 Control Panel to collect data to a computer file. Data files can be imported in to Microsoft Excel directly using Dataset Import Wizard, or converted to comma separated ASCII (.dat) format files which are suitable for importing into other data processing programs
- Using the Data Import Wizard to import data directly into a Microsoft Excel Spreadsheet.
- Outputting data to an intermediate data collection device, and subsequently transferring to a computer for further processing. Suitable devices may be stand-alone disks, cassette drives, solid state data collection terminals or simple computers that are unable to run Ls2Win.

Regardless of the technique used, you will have to specify the format, quantity, data type and starting point of the data to be collected. These options and the techniques themselves are described below.

Two related features that you may find useful are:

- Auto-printing: the logger can be set up to output data automatically whenever it stores new data to its memory (see the on-line Help).
- Auto-wrap (or Overwrite mode): automatic overwriting of old data when the logger's memory fills up (see the on-line Help for the DL2 Control Panel).

Note that data stored in the logger's memory cannot be displayed directly on the logger's display or computer screen. It must first be collected to a disk file using Ls2Win.

Data collection options

Data type

The logger partitions its memory and stores and outputs timed and event triggered data separately. Ls2Win refers to these as TIMED, TRIG/61 and TRIG/62 'datasets'. The logger refers to tham as 'data types'.

File format

The DL2e system makes use of four data formats, referred to by their associated file name suffices: .BIN, .HFD, .DAT and .PRN.

In Ls2Win you will see references to .bin, .hfd and .dat formats. If you use the keypad to output data, you will be offered .PRN and .BIN formats.

.BIN , .HFD

The .BIN format is a binary format containing compressed data (2 bytes per reading), as retrieved from the logger using a fast binary protocol or output directly from the logger using the PRINT function.

The .HFD format is a hexadecimal format containing compressed data (4 bytes per reading), retrieved from the logger using a hexadecimal protocol – which permits frequent checks during transmission but is substantially slower than the binary protocol.

Both these file formats can be imported directly into Microsoft Excel using Dataset Import Wizard, or you can open them for viewing in Dataset Viewer – DL2 Control Panel does this for you automatically after retrieving a dataset.

Neither of these file formats are suitable for printing, or importing into other data processing programs directly. They need to be converted to .DAT format: open the file in Dataset Viewer and select the Save As command (File menu).

Their structure is described in the DL2e Programmers' Guide.

.DAT

Comma separated ASCII format, with text enclosed in double quotes and data values separated by commas.

The Save As command (File menu) in Dataset Viewer creates .DAT files from .BIN or .HFD files. The detailed file structure is described in the Reference Topics section of Dataset Viewer's on-line Help.

.DAT files can be input directly into many data processing software packages, and are easily read by programmes written in common computing languages. They can also be imported into Microsoft Excel using Dataset Import Wizard.

.DAT files can be viewed and printed out directly (for example using Notepad), but the presentation is cluttered with quotes and commas.

.PRN

Printable ASCII format, with data in engineering units, space separated and aligned in columns.

The .PRN format is suitable for printing directly.

The contents and arrangement of data is similar to .DAT files, with the following major differences:

- Items are separated by spaces instead of commas, and aligned in columns
- Text items are not enclosed in double quotes
- Error flags are appended to readings (instead of preceding the reading that they refer to)

Data starting..

The logger keeps a record of where to find the first item of data in its memory and, if it has been outputting data, a record of where to find the next data to be output.

The logger can thus allow you to specify whether you want to collect data which follows on from the last data that you have collected ('follow-on data'), or to duplicate the data that you have already collected (i.e. data starting from the first item in the logger's memory).

You will only be offered this choice if you have already collected data from the logger on one or more occasions, and not erased it from the logger's memory. You cannot of course collect data that you have erased from the logger's memory.

Differences between timed and event triggered data

When collecting timed data, you will be prompted with the date and time of the **first** line of data that will be output.

When collecting event-triggered data you will be prompted with the date and time of the **last** line of data which was collected on the previous occasion (and which will not be collected again).

Number of data (to be output)

Your logger may contain more data than you can handle in a single disk file. If you don't want to collect all the data stored in the logger into a single file, you can specify the number of readings you require. You can then collect another batch of data that follows on from the first file, and so on.

Note that the number you specify will be only approximate, as the logger has to output complete 'lines' of data. A line of data is a group of readings that have been stored on any single occasion, and appear on a single line in a printout or .DAT file.

The size of a data file depends on the logging program as well as the number of data it contains. For a given quantity of data, a configuration with a small number of input channels (and hence a lot of lines) will produce a larger data file than a configuration with many input channels (and hence few lines).

Size of files

The table below shows the number of bytes in each element (File Header, Channel Header, Date-time, and Reading) in the various formats of logger data files. You can calculate the size of data files from:

File size (bytes) = (r x number of readings) + (d x number of lines of data) + (c x number of channels in data file) + h

Data type	**TIMED**			**TRIG/61 and TRIG/62**		
File format	.DAT	.HFD	.BIN	.DAT	.HFD	.BIN
file header h	219	248	120	221	248	120
Channel header c	90	38	30	90	38	30
Date-time d	24	8	1	24	24	9
Reading r	15	4	2	15	4	2

Using Ls2Win

In the Datasets panel of DL2 Control Panel, select the dataset in which you want to erase readings, click Retrieve, and make suitable selections in the Retrieve Dataset dialog.

Outputting data directly to a printer

The front panel PRINT function is used to output data directly from the logger to a printer. (You may find it faster and more convenient to use the PC to collect data to a disk file and to obtain a printout from that, see the on-line Help).

Preparation

Requirements

- a printer with an RS232 serial interface (not parallel)
- a suitable cable. "Communication cables" on page 51 describes how to construct a suitable cable. Loggers-to-computer cables are generally not suitable.

Communication parameters

The logger's communications parameters (baud rate, data bits and parity) must be set to match those of the printer (see "Communication parameters" on page 50). Refer to your printer's manual for information about setting the printer's communication parameters.

When the logger is subsequently connected back to a PC, the logger's communication parameters must be reset to match those in the Properties dialogue of the PC's DL2 Control Panel program. If you change the logger's communication parameters, then either reset the logger's internal switches to their original positions after printing, or modify the settings in the Properties window next time you use the DL2 Control Panel program.

Handshaking

Set the printer for hardware handshaking (see "Handshaking" on page 36).

Connection to printer

Connect the printer to the logger's RS232 connector using a suitable cable, and set the printer on-line.

Checking printer operation

A simple test is available to ensure that the logger is communicating correctly with a printer.

At the logger's main menu, press τ. The logger outputs a sequence of printable characters.

```
<DOWN>
 printer test.._
```

If the logger and printer are correctly connected and set up, the printer will repeatedly print out the following sequence:

!"#$%&'()*+,-./0123456789::<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[
]^_'abcdefghijklmnopqrstuvwxyz{|}~

To stop the printer press any key.

Troubleshooting printer problems

Common problems and likely causes are:

Symptom	Likely cause
No printout at all or very intermittent printing	Faulty or incorrectly wired cable
Complete nonsense	Logger/printer baud rate or data bits setting not matched.
Approximately half of the printout incorrect, e.g. italics or nonsense characters.	Logger printer parity settings not matched
Several lines of correctly formatted printout followed by missing data.	Incorrect wiring of handshake line in cable, or wrong type of handshake set up in printer.

Using the keypad/display

At the Keypad main menu, press PRINT.

In the menus that follow, use σ and τ to toggle between the options, and press PRINT to accept the option displayed.

```
use <UP> <DOWN>
& <PRINT>
```

Select PRINT, and press PRINT to accept.

```
PRINT or ERASE..
PRINT
```

Select TIMED, TRIG/61 or TRIG/62 as required, and press PRINT to accept.

```
DATA TYPE..?
TIMED
```

The message inactive source indicates that the logger is not programmed to record the type of data you have selected.

```

 inactive source
```

Select .PRN format. The alternative .BIN format is unsuitable for printing but you might choose it if using an alternative data collection device

(see "Using other data collection devices" on page 36.

```
FORMAT..?
.PRN
```

Select a date and time for the first logged data that you want to have output:

```
data starting...
11/07 15:46:03
```

Specify the number of readings to be output. If there are less than 1K (1024) readings stored, all readings is the only option. Otherwise you can choose a number of K readings. If you want to auto-print, select all readings.

```
number of data
 all readings
```

Ensure your printer is connected and online. Press PRINT to confirm that the above choices are correct, and to start printing.

```
<PRINT> confirms
other keys abort
```

The message "printing.." indicates that the logger is busy outputting data. When finished, the logger either offers **auto-printing** (see below) or returns to the Keypad main menu.

```

printing..
```

Auto-printing

Auto-printing allows you to print out data of a specified type automatically as it is logged to memory.

First start logging. The logger only offers the auto-print option if it is already logging.

Select the PRINT function, select the data type (TIMED, TRIG/61, TRIG/62) that you want to auto-print, select all readings and confirm.

When the logger has finished printing all the data up to the present time, it offers the option to auto-print.

```
AUTO-PRINT
yes
```

Disabling autosleep

Some printers and data collection devices may spuriously interpret powering up of the logger’s serial port as a character (for example, when the logger wakes to log data).

To prevent this happening, you can disable autosleep by selecting no in the AUTOSLEEP menu, but note that this will result in greatly increased power consumption.

```
AUTOSLEEP
no
```

The logger now returns to the Keypad main menu.

Auto-printing does not interfere with the logger’s keypad functions, and you can use the PC to communicate with the logger in the normal manner. The logger suspends auto-printing while the serial port is busy with another function (for example, communicating). The backlog of data is output on the next occasion when the logger would normally auto-print (i.e. when data of the given type is next due to be logged).

Note: To disable autosleep, fit a shorting link on the main board in position H2. See Figure 2 - Main circuit board layout.

To stop auto-printing:

At the Keypad main menu, press PRINT.

If the logger has been auto-printing, it stops auto-printing and exits the PRINT function.

```
ending
auto-print..
```

Using other data collection devices

It is possible to use any data storage device with a suitable RS232 serial port for collecting data from the logger. The process is identical to outputting data to a printer, except that you can choose the .BIN format option. You can then transfer the data to your PC for processing as required.

This technique may be of interest if you need to collect data from a logger situated at a remote site without interrupting logging. However, if you have to purchase a piece of equipment specifically for this purpose, we strongly recommend that you consider a portable PC instead: it will be considerably more flexible, and probably not much more expensive than a portable floppy disk drive or dedicated data collection terminal.

Suitable devices may be stand-alone disks, cassette drives, solid-state data-collection terminals or simple computers which are unable to run Ls2Win. We don't support any specific piece of equipment, and can only offer general advice here. Refer to the user manual supplied with the equipment for information on how to set it to receive data from the logger, and for procedures for transferring data to a computer.

If the device requires a sequence of control codes to initialise it for receiving data, this may be set up using the Setup string for PRINT facility (see the on-line Help), but only for .PRN format data.

Data output in .PRN format is slow. If your equipment is capable of receiving 8-bit data, then .BIN format is strongly recommended. The data can then be transferred to your computer for conversion into .DAT format using the PC. Remember that it is essential to use an 8-bit serial word format to collect .BIN format data.

Data integrity checks

For .BIN format data, the logger performs bytecount and checksum calculations and displays the results when it has finished outputting the data.

```
13576 bytes
checksum = 22143
```

These values enable you to verify that data has been correctly received. The bytecount is simply the number of bytes of data the logger has output. The checksum is calculated by adding together the binary values of each byte of data, (ignoring overflow in excess of FFFFh). Both values are displayed in decimal.

If the data collection device also performs bytecount and checksum calculations, you can compare the results to verify the integrity of the data you have collected.

Handshaking

Your equipment may be unable to store data as fast as the logger transmits it, especially .BIN format data. To avoid losing data, your equipment should have a facility for 'handshaking'. This controls the data output from the logger to a rate the equipment can accept, so that none is lost. Refer to the equipment's user manual for details of how to implement its handshaking facility.

The logger can respond to two forms of handshaking: hardware handshaking, and software or XON/XOFF handshaking. Hardware handshaking is only suitable for .PRN format data output. Follow the instructions in Communication cables, page "Communication cables" on page 51, for constructing a printer cable.

XON/XOFF handshaking is only available when the logger is transmitting .BIN format data. In XON/XOFF handshaking, the receiving equipment transmits an XOFF character (ASCII code 19) to the logger when a pause in data transmission is required, and an XON character (ASCII code 17) when ready for data transmission to resume. Since the XON and XOFF information is received in the same way as any other incoming data, a simple 3-wire cable (transmitted data, received data and 0V) is sufficient to implement XON/XOFF handshaking. See "Communication cables" on page 51 for details of the logger's RS232 connector.

Continuous data collection as a backup

By using the auto-print feature (see "Auto-printing" on page 35), a data collection device can act as a backup for the logger’s memory, with simultaneous storage of data to the logger’s memory and data collection device. Note that if you auto-print .BIN format data, you will almost certainly have to disable the logger’s auto-sleep feature. Any spurious characters in a .BIN file caused by the logger waking up will render the file completely useless.

Erasing data from the logger’s memory

Data can be erased from the logger’s memory in order to clear space for more data, and may be carried out while the logger continues to log. It is generally advisable to check that the collected data has not become corrupted during collection before irreversibly erasing it from the logger’s memory. You can do this by using Ls2Win. A duplicate set of data can be collected from the logger if a data collection fault is suspected.

As the three data types (TIMED, TRIG/61, TRIG/62) are stored and output from the logger independently, they can also be erased independently.

Timed data and event-triggered data are stored differently in the logger, and there are minor differences when erasing.

Timed data

You will only be permitted to erase data that has previously been collected from the logger. Any data logged since the last collection is protected from erasure until it has been collected.

Event triggered data

When erasing event triggered data the logger erases all data of the specified data type up to the current time, irrespective of whether it has been previously collected. There is therefore a risk of erasing data that has not been collected from the logger, for example if an EVENT occurs between collecting and erasing event triggered data. To minimise this risk, you should confirm that the number of event triggered data stored corresponds to the number of data that you have already collected before erasing event triggered data.

Protection from erasure

Data can be protected from being accidentally erased by configuring the logger with a password (see page 17).

Using Ls2Win

In the Datasets panel of DL2 Control Panel, select the dataset in which you want to erase readings, and click Delete Retrieved Records or Delete All Records.

Using the keypad/display

At the Keypad main menu, press PRINT.

If the logger has been auto-printing, it stops auto-printing and exits the PRINT function. Press PRINT again to proceed with erasing data.

```
ending
auto-print..
```

In the menus that follow, use σ and τ to toggle between the options and press PRINT to select the displayed option.

Select ERASE. Press PRINT.

```
PRINT or ERASE..
ERASE
```

If the logger has been programmed with a password, you will be prompted to enter it. See page 17 for details of how to enter a password.

```
password..?
```

Select TIMED, TRIG/61 or TRIG/62 data type. Press PRINT to accept the option shown.

```
DATA TYPE..?
TIMED
```

The logger briefly displays the date and time up to which data will be erased.

For timed data, this is the date and time of the first item of data which will not be erased.

```
erase data up to
12/02 11:15:30
```

For Event triggered data, this is the current date and time, to indicate that all data of the selected type (TRIG/61 or TRIG/62) up to the present time will be erased.

Press PRINT to proceed with the erasing data.

```
<PRINT> confirms
other keys abort
```

Chapter 5 : DL2e Logger Hardware

This section contains information on various hardware-related topics, that concern general operation of the logger, rather than its data collection and measurement functions. Sub-sections within this chapter deal with:

- Power supplies
- Rechargeable battery packs
- Installing IC's
- Communication parameters
- Making communication cables
- Modems
- Testing communication
- Electrical mains environment
- Display viewing angle
- Field installation
- Security
- Maintenance, storage, repairs and guarantee

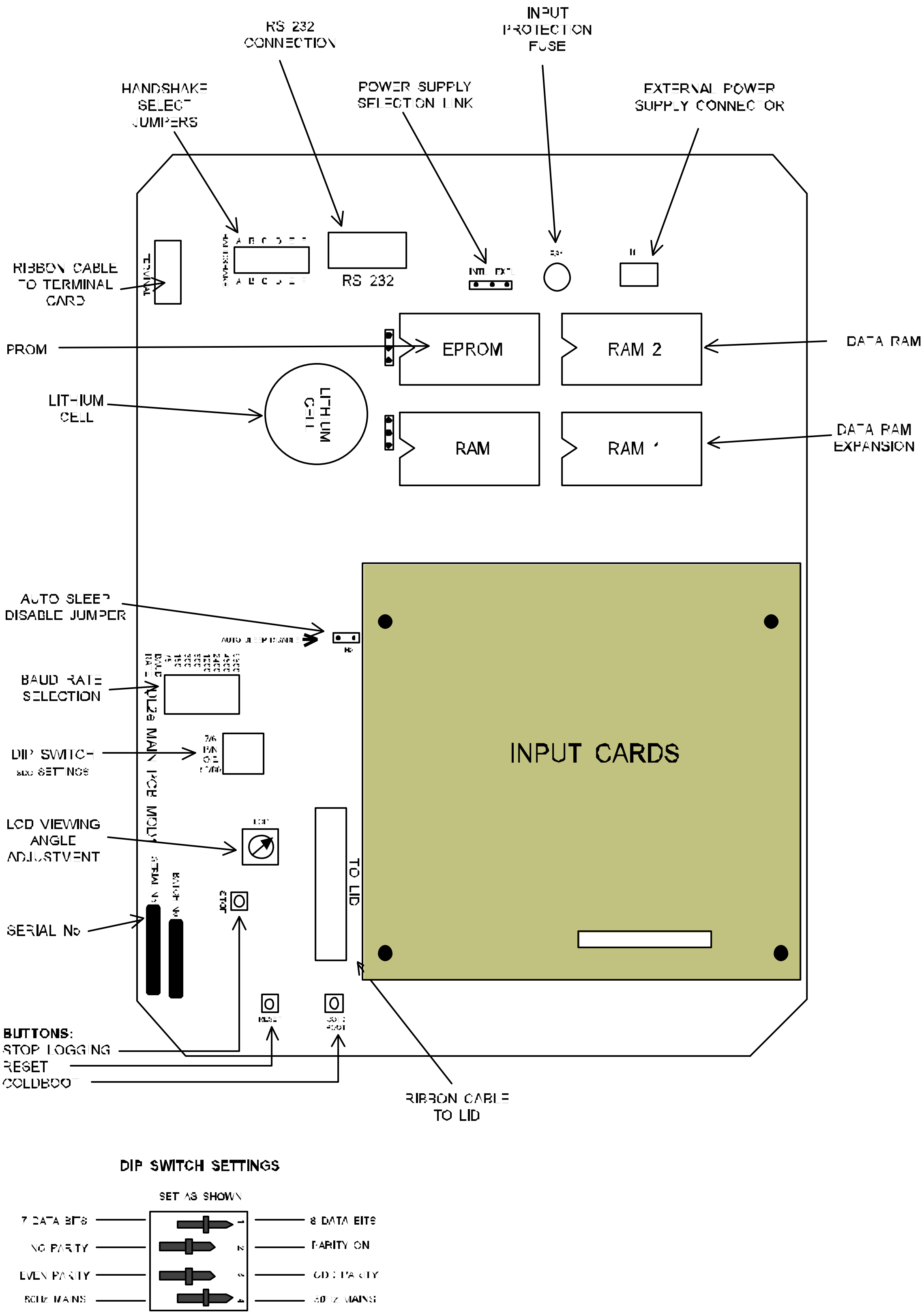


Figure 2 - Main circuit board layout

Power supplies

The logger can be powered by its own internal batteries, or from an external power supply. Suitable external power supplies include mains DC adapters, 12V car batteries and solar power systems.

The power supply selector switch determines whether the logger draws power from the external power supply socket, or from its own internal batteries.

An internal lithium cell backup enables the logger to survive short periods without a power source, for example when changing batteries.

The logger's power supply can be accessed via relay channels 63 and 64, for powering up sensors and other devices, by fitting jumpers to the terminal panel (see "Relay channels" on page 121).

The power supply selector link

The location of the power supply selector link is shown opposite. Set the switch to:

- 'INTL' to power the logger from its internal batteries
- 'EXTL' to use an external power supply

The internal batteries are still available as a backup source of power, in the event of the external power supply being interrupted (or dropping significantly below the internal battery voltage). The 'EXTL' setting is not recommended if the internal batteries are to be used as the only source of power: the voltage available for powering the logger is reduced by a diode drop (around 0.6 V) from the actual battery voltage and the useful battery life is reduced by 40%.

Internal battery operation

Battery life

At 20°C a new set of alkaline AA cells typically provides enough power for:

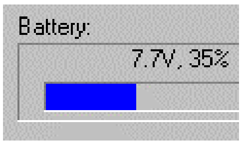
- the logger to take about 500,000 typical voltage readings. If using data compression, the number of stored readings will be much less than this. Non-linear channels, thermocouples in particular, and fast changing channels with auto-ranging are read at a slower rate and will give proportionally fewer readings from a set of batteries.

or

- 1 year of sleeping activity

or

- 24 hours' waking activity, i.e. keypad use or communicating with a computer.



The Logger panel of the DL2 Control Panel displays the battery voltage and an estimate of % battery life remaining.

Effective battery life is reduced at extremes of the logger's operating temperature range (-20°C to +60°C).

Low battery

The logger checks the battery or power supply voltage each time it wakes and if the voltage is less than 7.0 V it:

- briefly displays the message battery failure on its display
- if logging, stops logging and compiles a malfunction report.
- returns to sleep

- DL2 Control Panel will fail, displaying an error message..

Change the battery to resume normal operation.

Remarks

It is common for batteries to recover slightly after a period of rest. It is possible to wake the logger after it has stopped logging due to battery failure and to find a battery report a little above 7.0 V.

The check for low battery voltage occurs only when the logger wakes from sleeping. A logger kept awake for extended periods, for example with autosleep disabled while auto-printing, can run down its batteries well below the critical battery voltage, with unpredictable results. If you want to operate the logger in this way, it is preferable to connect an external mains power supply adapter.

If the logger's battery voltage is allowed to continue dropping, it will eventually be unable to wake at all. If batteries are removed for changing when a LOG is due, the logger will be unable to wake to execute its battery failure routine, with unpredictable consequences.

At a battery voltage of around 3V, the lithium cell backup battery takes over. It provides power for retaining configuration information and stored data in the logger's memory, and for keeping the logger's clock going.

Replacing batteries

When replacing batteries:

- Use alkaline cells only. Other less expensive types of primary battery are not suitable. They can leak corrosive chemicals and cause permanent damage to the logger.
- Ensure you insert the batteries the right way round, as indicated on the battery holder.
- Always replace a complete set of batteries. Don't mix batteries that have been discharged by different amounts.

You can change batteries without stopping logging, but you must ensure that you can complete the procedure while the logger is asleep, between LOGs. If the logger's power supply is interrupted during a LOG, it may be unable to resume after the power supply is restored.

If you need to change the batteries and continue to log data at frequent intervals, provide an external power supply while changing the batteries.

Lithium cell

The lithium cell is mounted on the logger's main circuit board (see Figure 2 - Main circuit board layout on page 40). It provides backup power for the logger's memory and clock for a period of up to 2 months.

If the logger is to be stored away or left inoperative for a period of time, remove the lithium cell to avoid discharging it unnecessarily. Lithium cells have a shelf life of 10 years, and don't need routine replacement.

It is not possible to determine the remaining life of the lithium cell.

Replace the lithium cell if you know it is partially discharged, for example, if the logger's battery voltage has dropped below 3V for an extended period of time.

To replace the lithium cell

If you have important data stored in the logger's memory, ensure that the logger is fitted with a good set of batteries, or connected to a power supply. Otherwise the stored data will be lost when you remove the lithium cell.

Any 3 Volt, 20 mm diameter lithium cell is suitable.

Slide the lithium cell out of its holder, and slide in the replacement, +ve terminal uppermost. Ensure that the spring contact grips the cell firmly.

Handling Lithium cells

When handling the lithium cell, take care not to touch the insulator between the two halves of the case. The deposit left by a fingerprint conducts enough electricity to shorten the life of the cell significantly.

External power supplies

The logger requires a power supply capable of providing 70 mA plus any current drawn from a single LFW1 voltage source (max. 60mA) at 7 to 15 V DC (i.e. 130mA total). The supply voltage does not need to be regulated.

Suitable power supplies include:

- 12V rechargeable batteries, such as a car battery or rechargeable battery pack, type LBK1 (see following page).
- Mains DC power supplies, such as are commonly used for powering portable radios. These power supplies are normally fully isolated, which is desirable. If not, you may need to take additional care when connecting sensors to avoid earth loops (see "Earth loops" on page 95).
- Solar power systems (a system is available from Delta-T - please enquire).

Power supply connections

A flying lead is supplied in the Spares and Accessories pack. Use it to make up a suitable cable:

Flying lead	Power supply
RED	+
BLACK	–

Set the power supply selector switch to ‘EXTL’ (see Figure 2 - Main circuit board layout), and plug the cable into the external power supply socket (see fig 12-3 on page 46).

It is advisable to keep a good set of internal batteries fitted in the logger. The logger will draw power from whichever source, internal or external, has the higher voltage. This means that, if the external power supply fails, or is disconnected (e.g. to charge an external battery pack), the logger will continue to operate from its internal batteries.

Power supply failure

Low battery above explains the action taken by the logger when a power supply failure occurs.

WARNINGS

Do not connect external power supplies of greater than 15V. Damage to the logger may result.

When more than one battery is used to power the DL2e and its attached sensors, the whole system must be checked to ensure that no battery can be subjected to reverse currents at any time.

Non-rechargeable batteries may swell, leak or explode if subjected to reverse currents.

This is particularly relevant to the internal alkaline batteries if fitted.

It is essential to trace all the possible connections for the different settings of the INTL/EXTL power selector on the main circuit board, and the relay channel power select links. Fig 12-2 shows an overview of the DL2e power supply connections.

NOTE:

The internal lithium battery is completely protected, and can be ignored for these issues.

Check the following:

- The positive power supply routes from internal and external batteries.
- The analogue and digital earth and battery 0V return rails.

External batteries may legitimately be connected to:

- The DL2e external power supply socket.
- The relay channels 63 and 64.
- The counter channels 61 and 62 (negative, or digital earth terminal).
- any channel input (analogue earth terminals at the end of each screw terminal connector).

If external battery power is connected to relay channels 63 or 64:

remove the internal jumpers to the relay.

If external power is used to supply the DL2e, but it is not connected through the external power socket:

remove the internal battery, OR
set the INTL/EXTL selector to EXTL, and label it to prevent INTL being accidentally selected.

DL2e LOGGER POWER SUPPLY 0V SCHEMATIC

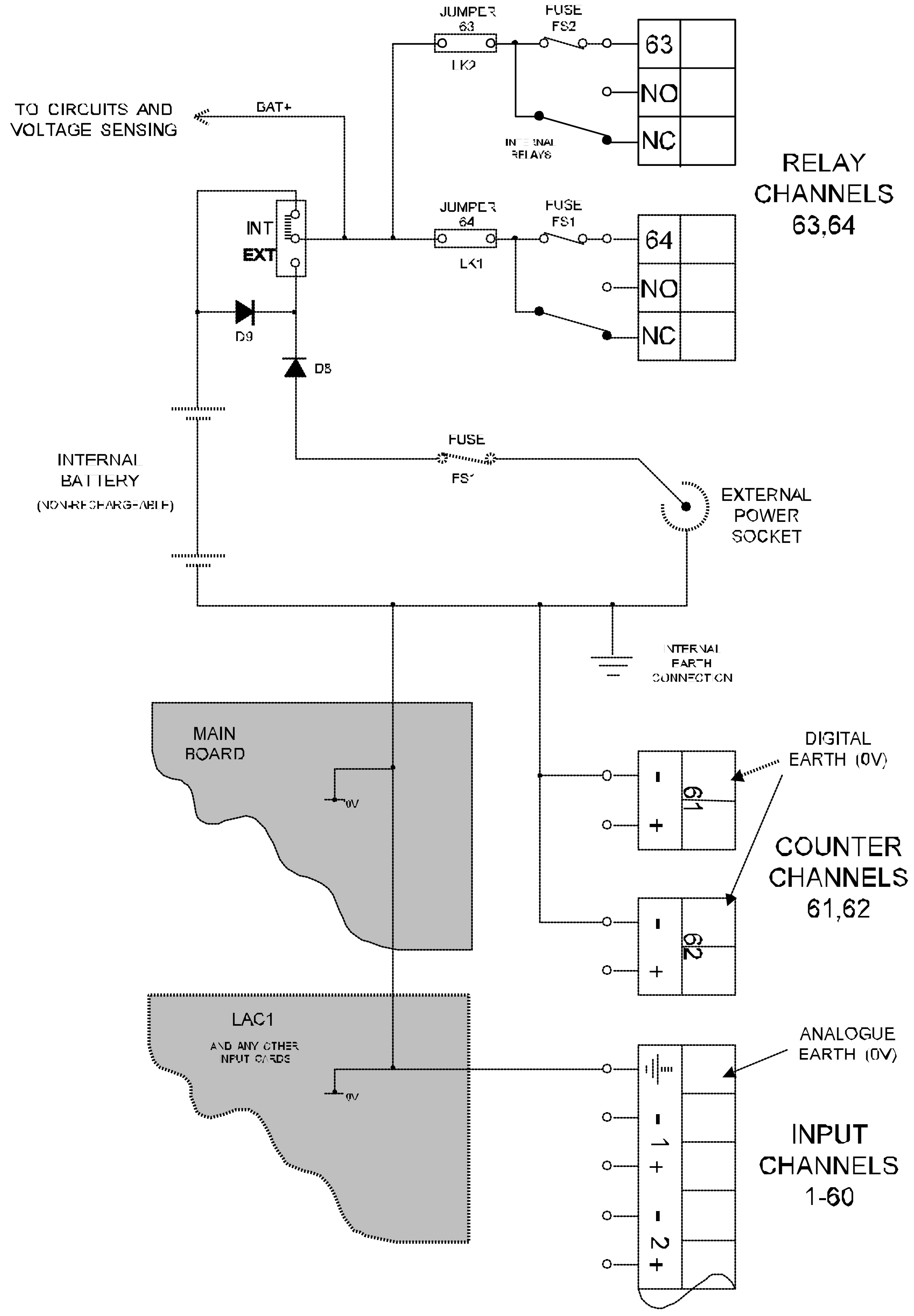


Figure 3 - power supply 0V schematic

Rechargeable battery pack, type LBK1

The battery pack contains a rechargeable sealed lead-acid battery in a weatherproof housing which mounts externally onto the logger enclosure. Fully charged, it has a capacity approximately 50% greater than the normal internal set of 6 alkaline AA cells, and can power the logger for up to 36 hours of communicating or keypad operation or for approximately 750,000 readings.

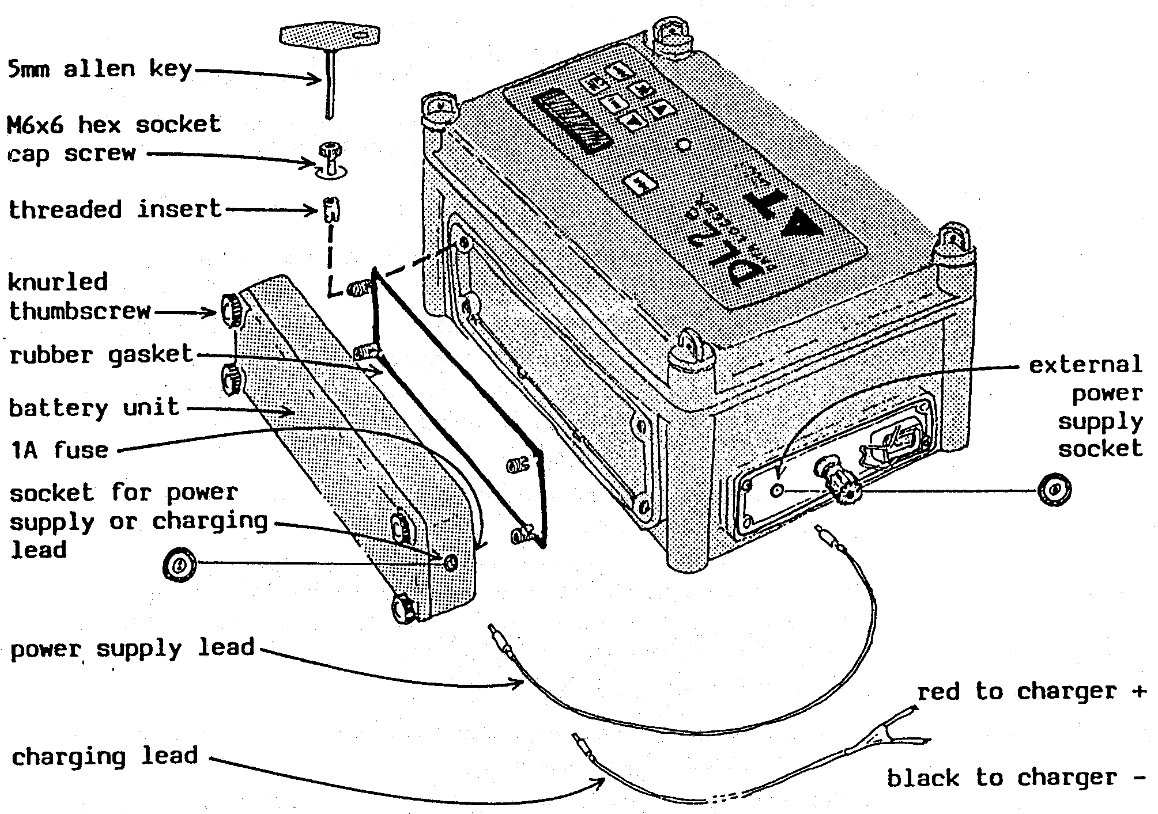


Figure 4 - Fitting the external battery pack

Components

The battery pack comprises:

- battery unit, lead-acid battery plus enclosure,
- power supply lead, for connecting to the logger’s external power supply socket,
- charging lead.

Loggers supplied with battery packs have the rubber gasket and four threaded inserts ready fitted. Otherwise the battery pack is supplied with:

- threaded inserts,
- 5mm Allen key,
- M6x6 hex socket cap screw,
- rubber gasket.

Assembling the battery pack

Battery packs ordered together with loggers are supplied assembled ready to use. Otherwise:

- Screw the four threaded inserts into their bushes (just as the threaded inserts which retain the terminal compartment cover). Use the Allen key and socket cap screw as illustrated above.

  Take particular care to ensure that the inserts are fitted centrally and squarely in their bushes.
- Fit the rubber gasket in its slot. If desired, use an adhesive (such as cyanoacrylate) to prevent it falling out when the battery pack is removed for recharging.

Fitting the battery pack to the logger

- Locate the battery pack over the gasket and inserts, and tighten the thumbscrews finger-tight.
- Plug the power supply lead into the battery pack and logger’s external power supply sockets.
- Set the logger’s power supply switch to ‘EXTL’ (Figure 2 - Main circuit board layout).

Internal batteries

Do not remove the logger’s internal batteries. Internal batteries in good condition are essential to provide backup power whenever the battery pack is removed for recharging.

Even while asleep and not logging, the logger draws a small amount of current to power its clock and memory. In the absence of any other power supply, this has to be supplied by the lithium cell, which will eventually get discharged and fail as a backup battery.

The internal batteries also allow the battery pack to be removed for recharging without interrupting logging.

Recharging

The battery pack should be recharged as soon as possible after the logger reports a battery voltage of less than 10V. Note that the reported % battery life is based on the discharge curve of alkaline cells, and gives no indication of the charge state of the battery pack.

To recharge the battery pack

- Remove the battery pack from the logger: disconnect the power supply lead and loosen the knurled thumbscrews.
- Plug the charging lead into the battery pack socket. Connect the other end to the charger:

Charging lead	Charger
RED	+
BLACK	–

- Charge for 16 hours in a well-ventilated space, according to the specifications below. A suitable battery charger is available from Delta-T.

Charging specifications

Voltage

The battery pack must be charged at a constant voltage, which is temperature dependent:

Conditions of charging for 16 hours at constant voltage. Do not exceed specified voltage

Conditions of charging for 16 hours at constant voltage. Do not exceed specified voltage	
Temperature	**Charging voltage**
15°C	13.98 ± 0.18 V
20°C	13.80 ± 0.18 V
25°C	13.65 ± 0.18 V

Current

The charging current must be limited to less than 1 Amp.

IMPORTANT WARNINGS

Do not exceed the specified voltage, as this can lead to the release of explosive gases and damage to the battery.

Do not recharge the battery pack while fitted to the logger. Accidental overcharging can lead to a build up of explosive gases in the sealed external battery compartment.

Overload protection

The battery pack is fused to protect against accidental overload. In the event of a fuse blowing:

- Find the cause and correct the fault.
- Remove the battery pack (described above), replace the 1A fuse (see Fig 12-3), and replace the battery pack.

Electrical mains environment

The logger's analogue measurement circuitry is designed to be synchronised with electrical mains frequency. This enables it to reject mains frequency noise which may be induced in signal cables installed close to mains wiring.

The 50/60 switch (DIP switch 4) on the logger's main circuit board (see Figure 2 - Main circuit board layout) selects 50 or 60 Hz operation and should be set to match your local electrical mains frequency. This is to reduce noise on readings due to the mains supply.

The position of the 50/60 switch also determines the format the logger uses for displaying the date:

50/60 switch		
ON	50 Hz	European day-month (dd-mm)
OFF	60 Hz	American month-day (mm-dd)

The factory setting is ON: 50 Hz mains, European date format.

Display (contrast)

Wake the logger and turn the contrast adjustment trimmer (see Figure 2 - Main circuit board layout) to obtain good display contrast.

Installing IC's

You may need to install IC's in the logger's main board:

- additional memory (RAM) IC's
- PROM: you will need to replace this if you want to install an updated version of the logger's internal control program.

Proceed as follows:

Take anti-static precautions

Observe normal procedures for handling CMOS devices in order to prevent static damage:

- Disconnect the logger from all external devices and power supplies. Ensure that no important data are stored in the logger, then remove the internal batteries and the lithium cell.
- Keep the IC's in conductive holders or foam until insertion. Earth yourself to the logger's safety earth terminal (see Fig 12-2) and the IC holder by touching them simultaneously.

Removing IC's

If an IC needs to be removed, gently prise it out with a small screwdriver, alternately inserting the flat blade under each end of the IC. Take care not to bend the legs.

IC position and orientation

The positions of memory and PROM IC's are illustrated in Figure 2 - Main circuit board layout. The IC's must be inserted as illustrated, with the notch on the left, when looking at the main board with the printed text upright.

Fitting memory expansion

Memory expansion IC (type LME6) is fitted in RAM 1 position (see Figure 2 - Main circuit board layout). Fitting this device will double the reading capacity available to the DL2e.

Inserting IC's

To insert an IC, make sure all the pins are straight and they line up correctly with the holes on the socket. If they do not line up, use a ruler or other flat object to bend them slightly. Push the IC into the socket, making sure that none of the pins get bent underneath.

When finished

After installing or removing IC's, replace the batteries and lithium cell and coldboot the logger.

The logger will automatically coldboot when next woken, if the batteries and lithium cell have been removed as instructed above.

Communication parameters

The logger communicates with other devices such as computers and serial printers through the RS232 serial port on the side panel of the logger's case (on older loggers, the RS232 connector is on the front panel).

Communication parameters determine the speed and format of serial data communication. For the logger to communicate successfully with a computer, printer or other device, their communication parameters must be set to match identically.

To change the logger's communication parameters, use switches on the main board. See Figure 2 - Main circuit board layout, with the following options:

Baud rate

9600, 4800, 2400, 1200, 600, 300, 150, 75. Move the baud rate selector switch to the appropriate position.

For use with DL2 Control Panel, this setting must match the baud rate selected in the DL2 Connection Properties dialog. You will be prompted automatically when creating a new DL2 Control Panel, or you can select the Properties command (File menu) to select a baud rate for an existing DLControl Panel.

Data bits

7 - DIP switch 1 OFF
8 - DIP switch 1 ON

If using DL2 Control Panel, select 8 data bits

Stop bits

1 (fixed)

Parity

None - DIP switch 2 OFF
Even - DIP switch 2 ON, DIP switch 3 OFF
Odd - DIP switch 2 ON, DIP switch 3 ON

If using DL2 Control Panel, select None.

Factory settings

9600 baud, 8 data bits, 1 stop bit, and no parity.

These are also the default settings for the DL2 Control Panel.

Note that changes in the baud rate setting take effect immediately. Changes in DIP switch settings take effect only when the logger wakes, unless the logger is executing the echo test (σ - see "**Error! Reference source not found.**" on page **Error! Bookmark not defined.**) or printer test (τ - see Outputting data directly to a printer on 33), in which case the change is immediate.

Communication cables

The construction of communication cables varies, depending on the device that is to be connected to the logger. Different cables are required for connecting the logger to:

- computers
- printers
- modems

The logger's RS232 serial port configuration

There are two types of RS232 connector fitted to the logger. Older loggers are fitted with a 25-pin male D-connector on the front panel (male connectors have pins, female have sockets). Newer loggers are fitted with a 9-pin male D-connector on the side panel. A matching female connector is required for the logger end of the cable.

Five communication functions are implemented on the logger's D-connector:

Pin no. (25 pin)	Pin no. (9 pin)	Signal	Function
1, 7	5	GND	Signal Ground - 0 V reference for all other signals.
2	3	TXD	Transmitted Data - the logger sends data on this line.
3	2	RXD	Received Data - the logger receives data on this line.
4	7	RTS	Request to Send - an output line used by the logger to indicate that it has data available for transmission. When the logger is ready to transmit data it puts a positive voltage on this line, otherwise it holds it at a negative voltage. This signal can be ignored unless you want to use the logger with a modem.
5	8	CTS	Clear to Send - an input line, which can be used to stop and start data transmission. If a negative voltage is applied to this line, it causes the logger to halt data transmission. Otherwise, (i.e. if disconnected or held at a positive voltage), the logger will continue to transmit any data that has been requested (either by a computer, or if PRINT has been used)

Computer cables

IBM compatible computers are almost universally fitted with one of two styles of serial port connector: 25-pin and 9-pin male D-connectors. You will require a matching female D-connector. The pin connections required for both styles of cable are shown in the table below.

Logger				**PC**		
Pin no. (25 pin)	Pin no. (9 pin)	Signal		Signal	Pin no. (9 pin)	Pin no. (25 pin)
7	5	GND	←→	GND	5	7
2	3	TXD	←→	RXD	2	3
3	2	RXD	←→	TXD	3	2

If your computer is fitted with a different style of connector, refer to its user manual to determine which signals are carried by which pins.

Remarks

The flow of information between the computer and logger is controlled by the software. The CTS line should not be connected to the computer.

At the computer end you may find it necessary to fit wire links to join CTS-RTS and DSR-DCD-DTR. If you do so, you might find it convenient to make the cable symmetrical, and fit the same links at the logger end (not shown in the table). This won’t affect logger operation.

Cables for printers

Printers are not generally able to print data as fast as the logger can send it.

To prevent loss of data, your printer should have a control line, which should supply a positive voltage when the printer is ready to accept data, and a negative voltage when it needs data transmission to pause. This pin should be connected to the CTS pin of the logger.

The connections required are shown below, for a typical printer with a 25-pin D-connector. The pin numbers given are for one of the most common printer RS232 port configurations, but printer RS232 ports are not standardised, and you should refer to your printer manual to determine which pins carry which signals.

Logger				**Printer**	
Pin no. (25 pin)	**Pin no. (9 pin)**	**Signal**	**Connection**	**Signal**	**Typical pin no.**
7	5	GND	•——————•	GND	7
2	3	TXD	•———►———•	RXD	3
5	8	CTS	•———◄———•	**Flow control**	**typically:**
				DTR	20
				RTS	4
				SRTS	19

Testing communication

The following test procedure may help you solve logger-computer communication problems:

Connect the logger to your computer.

Start a terminal program using a baud rate that matches the logger's baud rate:

If using Windows HyperTerminal, proceed as follows:

From the Start menu select Programs, Accessories, Hyperterminal, HyperTerminal.

In the Connection Properties dialog enter a name for the connection, eg '9600 baud on COM1'

In the Connect To dialog select the serial port to which your modem is connected in Connect using list.

In the Port Settings tab of the COMx Properties dialog, select Bits per second, Data bits and Parity to match the settings that you wish to use, Stop bits 1, Flow control None, and click OK.

Terminal mode

At the Communication Options window, press <Ctrl>-T. This puts the computer into Terminal Mode displaying the headin gacross the top of the screen.

```
-TerminalMode-
```

Anything you now type at the computer keyboard will be sent to the computer’s serial port (and not directly to the screen). The screen displays information arriving at the computer’s serial port.[KB2]

Echo test

Wake the logger using WAKE and at the keypad main menu press <σ> briefly. This puts the logger into echo test mode.

```
<UP>
echo test..
```

Press briefly. Don’t hold <σ> down, or the logger will carry out the Hayes modem initialisation routine.

If you do not obtain the `echo test..` message, but instead get a different message on the display:

`Initialising Hayes modem..` or `Communicating`

allow the logger to autosleep, and start again.

In echo test mode, the logger simply displays any character it receives at its RS232 port, and echoes it back to the Transmitted Data line of its RS232 port.

Press a few keys on the computer keyboard, not too fast. Each character will be sent to the logger and should now appear on the logger’s display. The logger then echoes, i.e. re-transmits each character, and they should appear unaltered on the computer screen. Anything you type should thus appear on the computer screen having been to and from the logger.

Diagnosing faults

If what you type does not appear on the computer screen exactly as keyed in:

- check that the logger is in echo test mode, as described above.
- check that you are not typing too fast (the logger responds relatively slowly in echo test mode).

The table below lists symptoms of possible communication problems, with likely causes and their solutions.

Symptom	Cause	Solution
Nothing that you type appears on the computer screen, nor on the logger's display	Transmitted data signals from the computer are failing to reach the logger.	Check that the logger is correctly connected to the computer serial port specified in the Communication Options dialogue window Check your cable wiring, particularly connections to the logger's RXD and GND (25-pin connector pins 1, 3, 7 or 9-pin connector pins 2 and 5) Your computer or logger may have a faulty RS232 port
Characters you type appear on the logger's display, but not on the computer screen	Data signals from the computer are reaching the logger, but data signals from the logger are failing to reach the computer	Check your cable wiring, particularly connections to the logger's TXD and GND (25-pin connector pins 1, 2, 7 or 9-pin connector pins 3 and 5) Your computer or logger may have a faulty RS232 port
Nonsense characters appear on the logger's display and/or computer screen	The logger's communication parameter settings (baud rate, data bits, parity) don't match the terminal program's serial port settings.	Check the terminal program's serial port settings. If using HyperTerminal, select the Properties command (File menu), but note that if you want to change the settings, you must exit and re-start HyperTerminal before the new settings take effect. Check the logger's communication parameters settings (see Communication parameters" on page 50)
Alternate appearance of a star shaped symbol in the logger's display	Logger is no longer in echo test mode	Put logger back into echo test mode (see "**Error! Reference source not found.**" on page **Error! Bookmark not defined.**). Note that you can change the logger's communication parameters without exiting echo test mode.

When finished..

- To exit the logger's echo test mode, press any of the logger's keys.

Other causes of communication problems

Long cables, particularly if screened, may be unable to sustain high baud rates. Try using a lower baud rate.

Cables installed in electrically noisy environments may be affected by electrical interference. Try using screened cable, in which case you may also need to use a lower baud rate

Field installation

This section explains how to make the DL2e logger secure and weatherproof for operation in the field.

Temperature

The logger is specified to work from -20°C to +60°C.

Battery life is reduced at temperature extremes.

The logger's display works at -20°C, but may become slow and difficult to read at low temperature.

Exposure to sunlight

The case will slowly degrade if left in bright sunlight over long periods. For this reason, and to prevent over-heating, the logger should be installed in a shaded location.

When reading thermocouples

For best accuracy, minimise heat flow down the thermocouple wires to the terminal panel:

- Use thin sensor cables.
- Minimise temperature differences by coiling some of the sensor cable next to the logger, in the shade.

Moisture

The logger has two compartments, the main case and the terminal compartment, which need to be separately protected from moisture.

Main case

The main case is waterproof but not hermetically sealed. It 'breathes' as the temperature changes and moist air gets drawn into the case.

To achieve high quality analogue performance, the inside of the logger's case must be kept dry. High levels of humidity can cause inaccurate readings even in the absence of condensation.

A bag of desiccant should be fitted inside the main case (held by the two clips opposite the RS232 connector) and replaced regularly. The humidity indicator on the front panel is blue when dry. The desiccant bag should be replaced as soon as the indicator starts to turn pink.

Terminal compartment

Fig 12-4 shows how to assemble the terminal compartment cover:

- Ensure gaskets are fitted to the terminal panel and extension piece, and that the foam sealing strip on the rear of the cover plate is in good condition (replace if necessary).
- Thread the sensor cables through the extension piece before plugging the connectors into the terminal panel.
- Spread the sensor cables evenly along the bottom edge of the extension piece and fit the cover plate, compressing the foam rubber seating strip against the sensor cables.

The terminal cover does not normally form an airtight seal, owing to gaps between the foam and the sensor cables. The 'drip' in the cover plate is designed to shed rain and under most conditions further sealing is not needed.

If flooding or heavy spraying is anticipated, seal the cable exits with silicone glue.

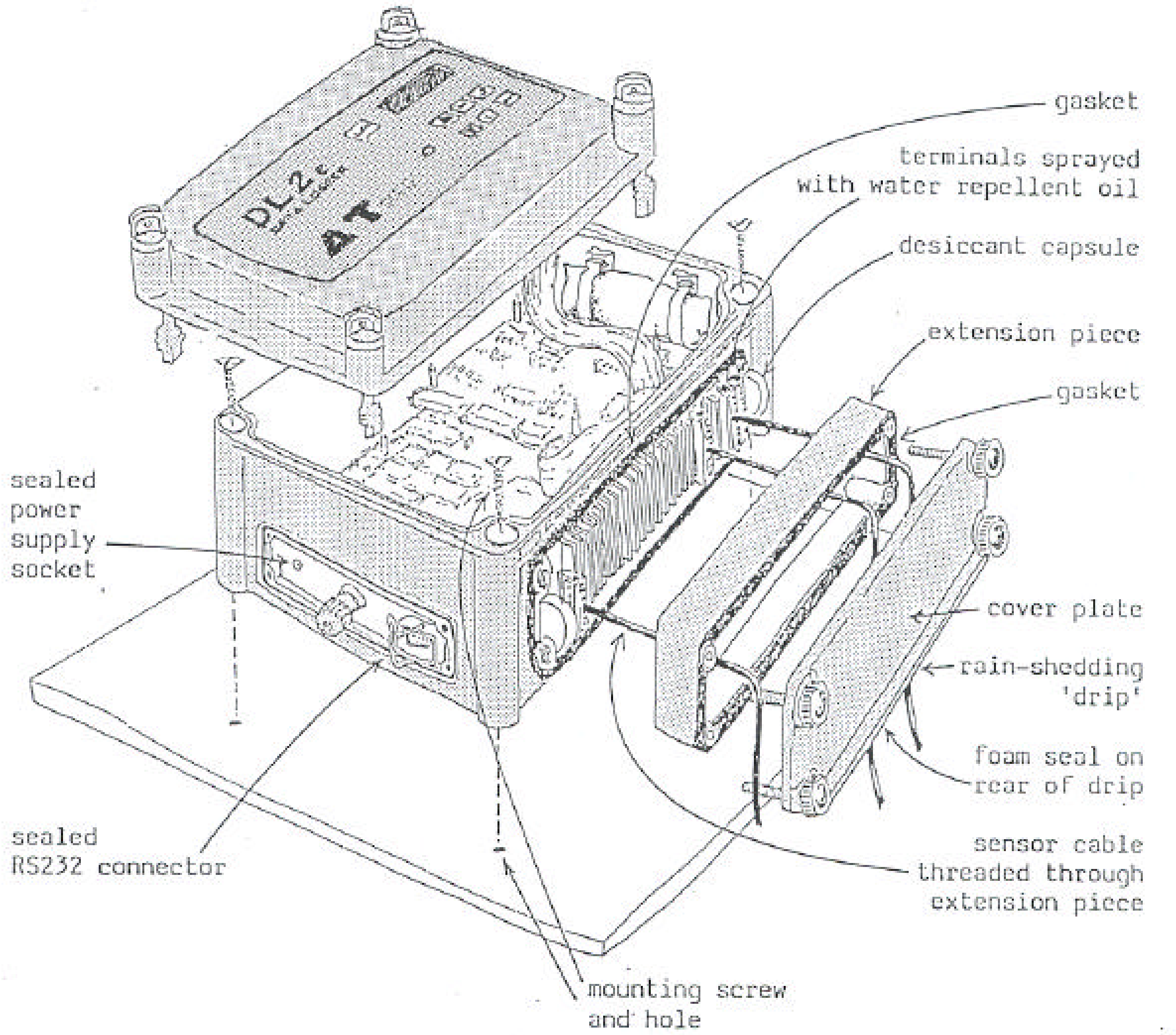


Figure 5 - Logger assembly for field installation

In exposed situations it may be better to provide a second layer of protection by enclosing the whole logger in a plastic bag with desiccant and a seal at the sensor cable exit.

High resistance and high impedance voltage measurements are particularly sensitive to the effects of moisture films on the logger's terminals. As an additional precaution against the effects of moisture or corrosive atmospheres, spray the terminals and connector blocks with water repellent contact oil, such as RS Components product stock number 567-610.

Avoid petroleum distillate sprays. These contain solvents that affect the rubber grips and labels on the terminals.

Regenerating desiccant

Place the bags in an oven at 110-120°C for 7 hours (approx.) to regenerate expired desiccant. Exceeding this temperature may cause the glue sealing some types of desiccant package to melt. When the water has been driven off, remove the capsules or bags and seal them in a plastic bag to cool down, until they are ready for use.

Maintenance, Storage, Repairs and Recalibration

Maintenance

To keep the logger functioning properly:

- Keep the batteries and desiccant fresh.
- Avoid use beyond -20ºC to +60ºC.
- Avoid storage beyond -30ºC to + 60ºC.
- Don’t leave the logger in direct strong sunlight.

Storage

If the logger is put away for storage for a long period of time, remove the main battery and the lithium cell and keep the logger in a dry place within -30ºC to +60ºC.

When the logger is again required for use, replace the batteries and cold boot the logger (see Resetting the Logger XXXX TO DO)
Then program the logger for your requirements.

Storing rechargeable battery packs (LBK1)

Battery packs may be stored at -5° to +40°C. They have a storage life in excess of 10 years if kept fully charged. The interval between recharging the stored battery packs depends on storage temperature.

Storage temp. °C	Interval between recharging
20°C	16 months
30°C	10 months
40°C	4 months

Repairs

The only repair recommended for users to carry out is the replacement of input protection components on LAC1 and LFW1 cards. Spares kits are available from Delta-T.

In the event of a logger problem that you can’t solve, please contact your local Delta-T representative if you have one, or Delta-T Devices directly. It will be useful if you can provide the following information:

- the serial numbers of the logger and any input card(s)
- the logger’s PROM version (found on the software General status report)
- the version of computer software you are using.

Recalibration service

In our experience, the DL2e logger’s calibration is typically much more stable than the worst case figures quoted in the specification.

A calibration service is available if you are concerned about the logger’s long-term accuracy. See "Service and Spares" on page 58.

The DL2e logger should be recalibrated every year to guarantee conformance to specifications.

For more information please contact your local Delta-T representative.

Warranty and Service

Terms and Conditions of Sale

Our Conditions of Sale (ref: COND: 1/00) set out Delta-T's legal obligations on these matters. The following paragraphs summarise Delta-T's position but reference should always be made to the exact terms of our Conditions of Sale, which will prevail over the following explanation.

Delta-T warrants that the goods will be free from defects arising out of the materials used or poor workmanship for a period of **twelve months** from the date of delivery.

Delta-T shall be under no liability in respect of any defect arising from fair wear and tear, and the warranty does not cover damage through misuse or inexpert servicing, or other circumstances beyond our control.

If the buyer experiences problems with the goods they shall notify Delta-T (or Delta-T's local agent) as soon as they become aware of such problem.

Delta-T may rectify the problem by supplying faulty parts free of charge, or by repairing the goods free of charge at Delta-T's premises in the UK, during the warranty period,

If Delta-T requires that goods under warranty be returned to them from overseas for repair, Delta-T shall not be liable for the cost of carriage or for customs clearance in respect of such goods. However, we much prefer to have such returns discussed with us in advance, and we may, at our discretion, waive these charges.

Delta-T shall not be liable to supply products free of charge or repair any goods where the products or goods in question have been discontinued or have become obsolete, although Delta-T will endeavour to remedy the buyer's problem.

Delta-T shall not be liable to the buyer for any consequential loss, damage or compensation whatsoever (whether caused by the negligence of the Delta-T, our employees or agents or otherwise) which arise from the supply of the goods and/or services, or their use or resale by the buyer.

Delta-T shall not be liable to the buyer by reason of any delay or failure to perform our obligations in relation to the goods and/or services, if the delay or failure was due to any cause beyond the Delta-T's reasonable control.

Service and Spares

Users in countries that have a Delta-T Agent or Technical Representative should contact them in the first instance.

Spare parts for our own instruments can be supplied from our works. These can normally be despatched within a few working days of receiving an order.

Spare parts and accessories for sensors or other products not manufactured by Delta-T, may have to be obtained from our supplier, and a certain amount of additional delay is inevitable.

No goods or equipment should be returned to Delta-T without first obtaining the agreement of Delta-T or our agent.

On receipt at Delta-T, the goods will be inspected and the user informed of the likely cost and delay. We normally expect to complete repairs within a few working days of receiving the equipment. However, if the equipment has to be forwarded to our original supplier for specialist repairs or recalibration, additional delays of a few weeks may be expected.

WARNING: before returning a meter to Delta-T you should collect any readings stored in the meter. If the battery should become disconnected or run down while transferring to Delta-T then the meter readings may be lost.

Technical Support

Check other Support Material

If you are having difficulties with this application note or the products listed within, then check for support information in documents supplied with the products. Individual manuals for Delta-T products contain some technical support information specific to that product.

Check the Delta-T Website

Delta-T put upgrades and support information on their web-site. This is also a useful source of free upgrades, such as upgrading Ls2Win.

Contact Local Agent

To obtain support with the information contained in this application note or other matters related to the products described here, contact your local agent or distributor. A list of local agents/distributors is available on the Delta-T web site.

Contact Delta-T Directly

If you are not able to contact a local agent/distributor then contact Delta-T directly.

Delta-T can be contacted via any of the following methods:

Web Site: http://www.delta-t.co.uk
e-mail: tech.support@delta-t.co.uk

Phone: +44 (0)1638 742922

Fax: +44 (0)1638 743155

Post: Delta-T Devices Ltd
128, Low Road,
Burwell,
CAMBS
UK
CB5 0EJ

Chapter 6 : Sensors and Input Cards

Overview of electrical measurement techniques

Electrical signals can be broadly categorised as analogue or digital.

Digital signals

Digital signals have two valid states, with instantaneous (in reality very short) transitions between them. The two states are variously called ON/OFF, HIGH/LOW, TRUE/FALSE, 0/1.

Electrically, the two digital states are often represented by the presence/absence of a voltage, or by the open/closed state of a switch. Both forms are suitable as inputs to the logger.

Digital signals can convey information in numerous ways. The logger has the following functions for interpreting digital signals:

Digital status

Indicates which digital state is present at a point in time.

EXAMPLE: a switch indicating whether a door is open or closed.

Counter

Counts digital pulses continuously and returns the number of accumulated counts. While logging, counter channels continue to accumulate counts even while the logger is asleep. Counter channels are reset when they are logged, and each logged reading represents the number of counts accumulated since the counter was last logged.

EXAMPLE: tipping bucket rain gauge. Each tip of the bucket briefly closes a switch. The counter channel detects and counts the switch closures, and the recorded number of counts represents a quantity of rainfall.

Frequency

Again, the logger counts pulses continuously, but calculates an average frequency by dividing the accumulated count by the sampling interval.

EXAMPLE: anemometer. Each rotation causes a brief switch closure. A frequency channel counts the switch closures and divides by the sampling interval. This may be scaled to give the average wind speed over each sampling interval.

Event

An event trigger channel detects a rising edge transition between digital states. Depending on the configuration of the event trigger channel:

- data trigger: the logger records the date and time, and data from specified channels to memory reserved for event triggered data
- start trigger: the logger starts logging, just as if it had been started manually.

The logger has two on-board digital channels (which are present in all loggers), which can be used for any of the above functions. Counter cards, type DLC1, can be fitted to the logger. Each counter card gives the logger an additional 15 counter or frequency channels (not digital status or event trigger).

Analogue signals

Analogue signals have a continuously varying values. The logger fitted with an analogue input card can be used to measure DC voltage, current and resistance.

Analogue input cards

There are three analogue input cards for the logger: types LAC1, ACD1 and LFW1. Any channel on these cards can be used for DC voltage, current and resistance measurements.

LAC1

The LAC1 card is a general-purpose analogue card. It can be set up to provide 30 analogue channels (using two terminal groups) for less demanding applications, or 15 channels (occupying a single terminal group) for higher precision measurements. The mode of operation ('15-ch' or '30-ch') is determined by the position of a slider switch on the card, and ribbon cable connections to the card. The two modes of operation are distinct, and should not be confused. They require different sensor connections and have different capabilities. Refer to page "Analogue Input Card, type LAC1" on page 69 for details.

ACD1

The ACD1 card provides up to 15 channels for AC/DC voltage measurement. Inputs can be ±2V dc or 2V-ac rms, and two or three wire resistance measurements. Measurements of ac are true rms. AC Excitation Source Card type ACS1, is also available for use with this card.

LFW1

The LFW1 card provides up to 12 channels (6 channels per terminal group). It can be used for sophisticated analogue techniques (4-wire resistance and bridge measurements) as well as for general-purpose voltage, current and resistance measurements.

Supplementary cards

LPR1, LPR1V

The supplementary cards, types LPR1 and LPR1V, are fitted in series with analogue input cards, and don't themselves provide additional channels.

The LPR1V is an input protection card which provides additional protection for LAC1, ACD1 and LFW1 cards against overload voltages accidentally applied to input channels (the input channels are already protected against small overload voltages).

ACS1

AC Excitation Source card, intended primarily for use with analogue input card type ACD1.

Provides a 2.0V square-wave excitation signal for up to 60 AC resistance sensors, such as 'gypsum block' or 'granular matrix' soil moisture sensors.

Voltage measurements

LAC1, LFW1 and ACD1 cards can be used to measure DC voltages in the range of ± 2V. ACD1 can also measure voltages in the range 0-2V ac (rms).

Voltages up to ±50V can be measured by fitting resistors in a divider configuration. Divider resistors can be fitted to the logger's screw terminals. Alternatively, if using a LAC1 or ACD1, the resistors can be mounted on an LPR1 or LPR1V card.

Single-ended and differential sensor connections

Voltage connections to either card can be single-ended or differential (except that in 30-ch mode the LAC1 accepts only single-ended connections).

In single-ended connection schemes, the logger's negative input terminal is connected to the logger's earth. In differential connection schemes neither of the logger's input terminals is connected directly to the logger's earth, and the difference in voltage between the '+ and' - input terminals is measured.

The choice between single-ended and differential connection determines the logger's ability to measure a signal accurately, and doesn't affect the logging program.

As a general rule, good results can be obtained using single-ended connections with either analogue card. The exceptions are:

- low level signals (such as thermocouples measuring ambient temperatures): LAC1 in 30-ch mode is not recommended: 15-ch mode is better (see "Voltage, single-ended" on page 86).
- electrically noisy environments: differential connection with bias resistors or sensor earthing is recommended for best rejection of induced electrical noise, particularly with sensors that have a low level output connected to the logger with long lengths of unscreened cable in noisy electrical environments. Fully floating connection is not recommended.
- existing alternative earth paths: to avoid problems associated with earth loops, sensors should be earthed via a single route only. A single-ended connection provides an earth path, and should be avoided in situations where earth paths already exist, such as:
  - > electrically interconnected sensors, for example arrays of thermocouples in contact with metalwork, groups of sensors sharing a common power supply
  - > sensor sharing the logger's power supply
  - > multiple mains power supplies if not fully isolated, including a mains powered computer.

The alternative is to use fully floating differential connections. These can in turn give rise to common mode problems. See "Earth loops" on page 95 for a discussion of earth loops and common mode problems.

Current measurement

Current is measured by fitting a precision shunt resistor in parallel with the current source and measuring the voltage generated across the resistor:

$$I = \frac{V_{measured}}{R_{precision}}$$

LAC1, ACD1, and LFW1 cards can be used for current measurements, and the guidelines for choosing between single-ended and differential connections apply in the same way as for voltage measurements (see above).

The precision resistor can be fitted directly to the logger's screw terminals. Alternatively, if using a LAC1 or ACD1, the resistor can be mounted on an LPR1 or LPR1V card.

Examples of current source sensors are: 4-20mA sensors, photodiodes.

Resistance measurements

For general purpose resistance measurements the logger passes a precision excitation current through the resistor, measures the voltage drop across it, and calculates the resistance using Ohm's law:

$$R = \frac{V_{measured}}{I_{known}}$$

You choose an excitation current from 2, 20, 200 or 2000µA. The logger performs the conversion from mV to Ω or kΩ for you.

2-, 3- and 4-wire connection schemes

LAC1, ACD1, and LFW1 cards can be used for general purpose resistance measurements. 2-wire, 3-wire and 4-wire connection schemes are available. They differ in accuracy, but don't affect the logging program.

2-wire connection schemes are most straightforward, and are available on both LAC1 and LFW1 cards. The measured resistance includes the resistance of the connecting leads, so 2-wire connections are suitable for measuring relatively large resistance's where the resistance of connecting cables is negligible.

The LAC1 in 30-ch mode introduces an additional error of up to ±20Ω, and is not recommended for accurate measurement of resistance's smaller than around 10 kΩ.

For improved accuracy, consider the following options:

- Minimise cable resistance errors: keep cable lengths as short as possible, and use heavy-duty low-resistance cable.
- Compensate for cable resistance by configuring individual channels with an offset (for linear conversion to engineering units only, and not for non-linear sensors - see "Conversion factor and offset", in the on-line Help.
- Use 3-wire connection to a LAC1 or ACD1, where only one connecting lead - the return lead - contributes to resistance error. For economy of wiring, a single heavy-duty low resistances return lead can be shared between several sensors.
- Use 4-wire connection to an LFW1, which virtually eliminates cable resistance errors and is suitable for measuring resistance's down to a few ohms.

Measuring small changes in resistance

Some sensors require accurate measurement of small deviations from a known base resistance value. Examples are strain gauges and platinum resistance sensors.

Strain gauges are commonly connected in bridge circuits. An excitation voltage (or current) is applied to the bridge, and if the values of the 4 resistors in the bridge are symmetrical, the output voltage is zero. Small changes in resistance unbalance the bridge, causing a differential output voltage, proportional to the imbalance and the excitation.

The LFW1 card can provide precision excitation for bridge measurements (see "Bridge measurements" on page 109). Alternatively, you can provide excitation from a precision voltage source and measure the bridge output as a simple voltage (beware of common mode problems). See "Power supplies to sensors" on page 64.

Another technique available using the LFW1 card is an offset for resistance measurements: a base resistance value is subtracted from the sensor resistance (this is done electrically on the LFW1 card), and the logger measures the deviation from the base resistance value. This arrangement is sometimes known as a ¼ bridge.

This technique is particularly suited to the PT100 platinum resistance sensor, where a base resistance can be specified to a high degree of accuracy, and several PT100's can be referenced to the same base resistor. It can also be set up for other sensor types.

Potentiometric measurements

The voltage excitation facility on the LFW1 can be used for potentiometer measurements, avoiding the need to measure an absolute resistance (see "Potentiometer" on page 113).

Power supplies to sensors (and other devices)

Many sensors require a power supply, including most that have a voltage (analogue or digital) or current output. Notable exceptions are thermocouples (voltage) and photodiodes (current).

Don’t confuse power supplies with excitation voltages used for resistance and bridge sensors. Excitation is precise: sensor output is proportional to excitation level. Power supply is not: within limits, the supply voltage does not affect sensor output.

Relay channels 63 and 64 can be used to draw power from the logger’s own battery (or power supply), or to control external power supplies.

Sensors can be permanently connected to the logger’s battery by fitting the power supply jumpers (see Figure 33 - sensor connections: relays). Alternatively, in situations where economical power consumption is required, use the logger’s warm-up function to power up sensors for just long enough to take a reading.

See also "Comments on earth loops and common mode" on page 95.

Summary of cards and on-board channels

Card	Channels/ Terminal Groups	Capability
LAC1, 30-ch mode	15 or 30 channels, 1 or 2 terminal groups, 15 channels per terminal group	VOLTAGE: single-ended, RESISTANCE: 2-wire (±20Ω error)
LAC1, 15-ch mode	15 channels, 1 terminal group	VOLTAGE: single-ended, differential, RESISTANCE: 2-wire, 3-wire
LFW1	6 or 12 channels, 1 or 2 terminal groups, 6 channels per terminal group	VOLTAGE: single-ended, differential, RESISTANCE: 2-wire, 4-wire, BRIDGE: full, half, 3-wire, quarter: current or voltage excited, POTENTIOMETER
LPR1	1 or 2 terminal groups, fitted in series with LAC1 (provides no additional channels)	Resistor mounting positions: SHUNT: for current measurement, DIVIDER: for voltage measurement, up to ±50V
LPR1V	1 or 2 terminal groups, fitted in series with LAC1 or LFW1 (provides no additional channels)	Additional input protection. Also, if fitted to LAC1: provides resistor mounting positions, as LPR1
DLC1	15 channels	COUNTER, FREQUENCY
ACD1, ACS1	15 channels, 1 terminal group	VOLTAGE: AC voltage true rms. 2V ac rms crest factor 1.0 to 1.7, DC voltage ±2V dc, RESISTANCE: 2-wire, 3-wire
ACS1	1-4 terminal groups fitted in series with 1-4 ACD1's.	Enables AC-excited resistance measurements by ACD1
On-board digital channels	channels 61, 62	COUNTER, FREQUENCY, DIGITAL STATUS, EVENT TRIGGER
On-board relay channels	channels 63, 64	Change-over relays, can be programmed for: warm-up, control output, malfunction warning (ch 64 only)

Summary of connections for analogue measurements

Recommended cards and sensor connections for analogue measurement applications:

Signal	**Examples**	**Card(s) & sensor connections**	**Comments**
VOLTAGE			
low-level dc	thermocouples	LAC1 15-ch, ACD1, LFW1 single-ended	
general purpose dc voltage measurements	powered transducers, solarimeters	LAC1 15-ch or 30-ch, ACD1, LFW1, single-ended	LAC1 30-ch may introduce an offset error, typically ±20µV and is not recommended for low level signals
dc voltages susceptible to electrical noise	long, unscreened leads, close to switch gear or power cables	LAC1 15-ch, ACD1, LFW1, differential with earthed sensor or bias resistors	Beware of introducing earth loops
with existing connection to the logger's earth	sensors in contact with metalwork, interconnected power supplies	LAC1 15-ch, ACD1, LFW1, fully floating differential	
signals in the range ±2 to ±50V	vehicle electrical supply	divider resistors fitted to LPR1, or LPR1V or across screw terminals	Divided voltage measured using LAC1, ACD1, or LFW1 as above. Use conversion factor to obtain absolute voltage values. LPR1(V) can be used with LAC1 or ACD1 for this purpose.
ac voltage 0-2V		ACD1 (dc / true rms)	2Vac rms (crest factor 1.0 to 1.7).
CURRENT	4-20mA loop transducers, photodiodes	shunt resistors fitted to LPR1, LPR1V or across screw terminals	Shunt voltage measured using LAC1, ACD1, or LFW1 as above. Use conversion factor to obtain absolute current values. LPR1(V) may be used with LAC1 or ACD1 for this purpose.
RESISTANCE			
10kΩ to 1MΩ	100kΩ thermistor	LAC1 15-ch or 30-ch, 2-wire, ACD1, LFW1	
<10kΩ, negligible cable resistance	2kΩ thermistors on short leads	LAC1 15-ch or 30-ch, 2-wire or 3-wire, ACD1, LFW1	Use short, heavy cables. Program channel with offset to null out cable resistance. LAC1 15-ch 3-wire connection is preferable to 2-wire
on-board cold junction thermistor		LAC1 15-ch ACD1	Connected to channel 1 by switch on terminal panel
significant cable resistance	2kΩ thermistors on long leads	LFW1, 4-wire	If LFW1 unavailable, use LAC1 15-ch 3-wire connection in preference to 2-wire connection
small changes from precise base value	PT100	LFW1, 4-wire, with offset adjustment	
small changes, no well-defined base value	strain gauge	LFW1, full, half or 3-wire bridge	
potentiometer	wind direction	LFW1, potentiometric	Can also measure resistance using 2-, 3- or 4-wire connections as above
AC-excited	gypsum blocks granular matrix	ACD1 + ACS1	ac excitation provided by card ACS1. ac readings taken by card ACD1.

Input and supplementary cards

The logger can be fitted with up to four input cards, one card for each terminal group. Any combination of input cards is permitted:

- Standard analogue card, type LAC1
- AC analogue card, type ACD1
- 4-wire card, type LFW1
- Counter card, type DLC1

In addition, the logger may be fitted with one or two supplementary cards, which do not provide additional channels by themselves, but are fitted in series with analogue input cards:

- Attenuator card, type LPR1
- Input protection card, type LPR1V

The standard logger case can accommodate up to four cards in total. A case height extension is available if you are using LPR1 or LPR1V cards and need to fit more than four cards in total.

AC excitation can be provided for sensors that require it.

- AC Excitation source card, type ACS1

This card fits on the inside of the terminal panel, and does not affect the number of input cards that can be fitted.

Installing input cards

NOTE: This procedure does not apply for LPR1, LPR1V, which are fitted on top of the input card stack (see "Capabilities" on page 80), or ACS1 which fits on the terminal board (see "AC Excitation Card, type ACS1" on page 83)

- Complete any operation that you have started. Ensure that the logger contains no valuable data. It will be lost when you power down the logger in order to install or change a card.
- Remove the lid of the logger.
- Disconnect the logger from computers, printer and external power supply. Remove internal batteries and the lithium cell.
- Remove any LPR1 or LPR1V cards from the top of the stack.
- In newer loggers, the top card in the input stack is retained by four slotted nylon nuts. Use a screwdriver to remove these nuts, and replace them with the standoff pillars supplied with the card.
- Position the long pins on the underside of the card in the corresponding socket on top of the input card stack and gently push down. Make sure that the pins are not offset from the socket and that the pins are not bent. When the card is correctly positioned the four corner holes will align with the studs at the top of the standoff pillars.
- Replace any LPR1 or LPR1V cards at the top of the stack.
- Screw down the four slotted nylon nuts (on new style loggers) or the standoff pillars supplied with the card (older style loggers) onto the protruding studs to secure the board in position.
- Re-connect the logger’s power supplies, remembering to replace the lithium battery. The logger will coldboot.
- Set up the input card and fit ribbon cables to the terminal panel, as described in the following sections:

  > LAC1: "Analogue Input Card, type LAC1" on page 69

  > ACD1: "Analogue Input Card, type ACD1" on page 73

> LFW1: "4-Wire Card, type LFW1" on page 75

> DLC1: "Digital inputs, and Counter Card type DLC1" on page 115.

Do this before fitting another card on the input stack, while all the components on the card are accessible.

Removing and fitting ribbon cables

- Do not apply excessive force to the hook-shaped latches as they are easily broken
- When fitting ribbon cables ensure that the connectors mate completely before hooking the latches over
- When removing a ribbon cable, gently pull both latches back just far enough to eject the ribbon connector
- Note that the ribbon cables are not symmetrical. If you are having trouble making a ribbon cable stretch far enough, try reversing it!

Terminal labels are supplied with the logger and with each input card. Use these to number the screw terminal blocks for your card.

Analogue Input Card, type LAC1

The LAC1 is a general-purpose analogue input card. It can be set up as a 30 channel card (‘30-ch’ mode) for simple analogue measurements, or as a 15 channel card (‘15-ch’ mode) for higher precision applications.

15-ch mode

Capability

Channels

15 channels are available on one terminal group.

Voltage inputs

Differential. A wire link can be fitted on the screw terminal block for single-ended measurements. This gives better offset performance and accuracy than 30-ch mode single-ended measurements.

Resistance measurements

3-wire current excited. A wire link can be fitted on the screw terminal block for 2-wire measurements, with better performance than 30-ch 2-wire measurements (does not suffer ±20Ω offset error).

Setting up

15/30 switch

Set to ‘15’ position.

Ribbon cables

Connect from any terminal group on the terminal panel to the card connector marked ‘differential’. Make no connections to the other two connector on the card.

Programming Issues

Programming an Input Channel

Select Input Card Type ‘LAC1, 15-channel’ for the channel group that is connected to the LAC1 card. The Input Channel tab of the Channel Properties dialog for this channel group will then offer suitable sensor types in the Sensor Type list, or if you select <Custom sensor type> the Measurement tab will offer suitable options in the Electrical Measurement list.

Programming a Sensor Type

In the Measurement tab of the Sensor Type Properties dialog, select one of the following Electrical Measurement / Connection Requirements combinations:

- DC Voltage: ‘Single-ended’, ‘Differential, low CM’, ‘Differential, high CM’
- Resistance: ‘2-wire’, ‘3-wire’
- Thermocouple: ‘Single-ended’, ‘Differential, low CM’, ‘Differential, high CM.'

30-ch mode

Capability

Channels

15 or 30 channels, one or two terminal groups.

Voltage inputs

Single-ended only with unspecified voltage offset depending on the sensors connected to the card, typically ±20µV.

Resistance measurements

2-wire only, with additional offset error up to ±20Ω (typically ±6Ω).

Setting up

15/30 switch

Set to ‘30’ position.

Ribbon cables

Connect one or two ribbon cables from one or two terminal groups on the terminal panel.

- terminal groups 1-15, 31-45 connected only to the terminal block labelled ‘1-15/31-45’
- terminal groups 16-30, 46-60 connected only to the terminal block labelled ‘16-30/46-60’.

Programming Issues

Programming an Input Channel

Select Input Card Type ‘LAC1, 30-channel’ for the channel group that is connected to the LAC1 card. The Input Channel tab of the Channel Properties dialog for this channel group will then offer suitable sensor types in the Sensor Type list, or if you select <Custom sensor type> the Measurement tab will offer suitable options in the Electrical Measurement list.

Programming a Sensor Type

In the Measurement tab of the Sensor Type Properties dialog, select one of the following Electrical Measurement / Connection Requirements combinations:

- DC Voltage: ‘Single-ended’
- Resistance: ‘2-wire’

Thermocouple: ‘Single-ended’.

Input protection (15-ch and 30-ch modes)

Input channels on the LAC1 are protected against a continuous overload voltage up to ±15 V. They can also survive brief spikes at much higher voltages. The shorter the spike the higher the voltage.

Additional input protection can be obtained by fitting an input protection card LPR1V in series with the LAC1.

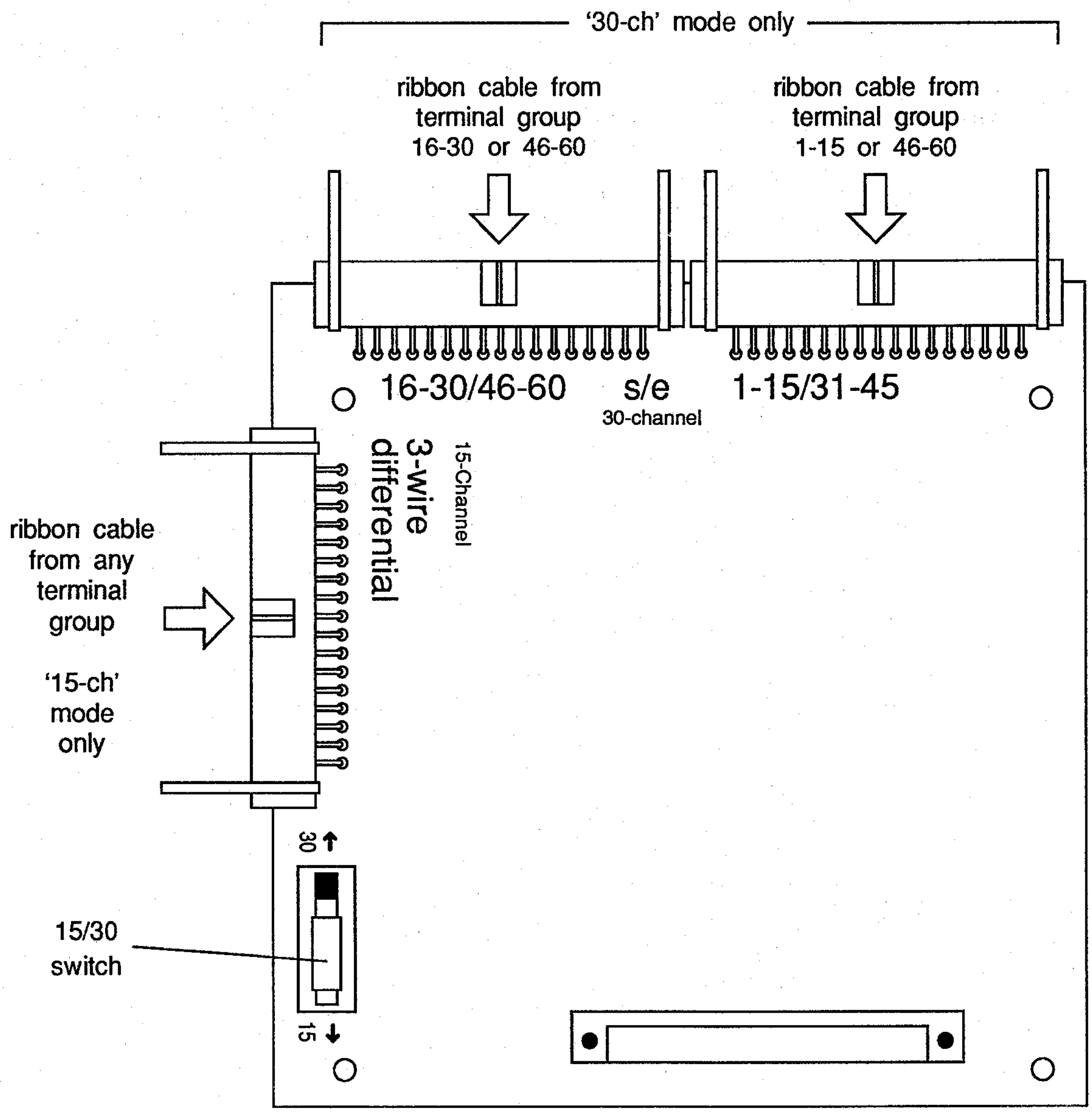


Figure 6 - LAC1 analogue input card

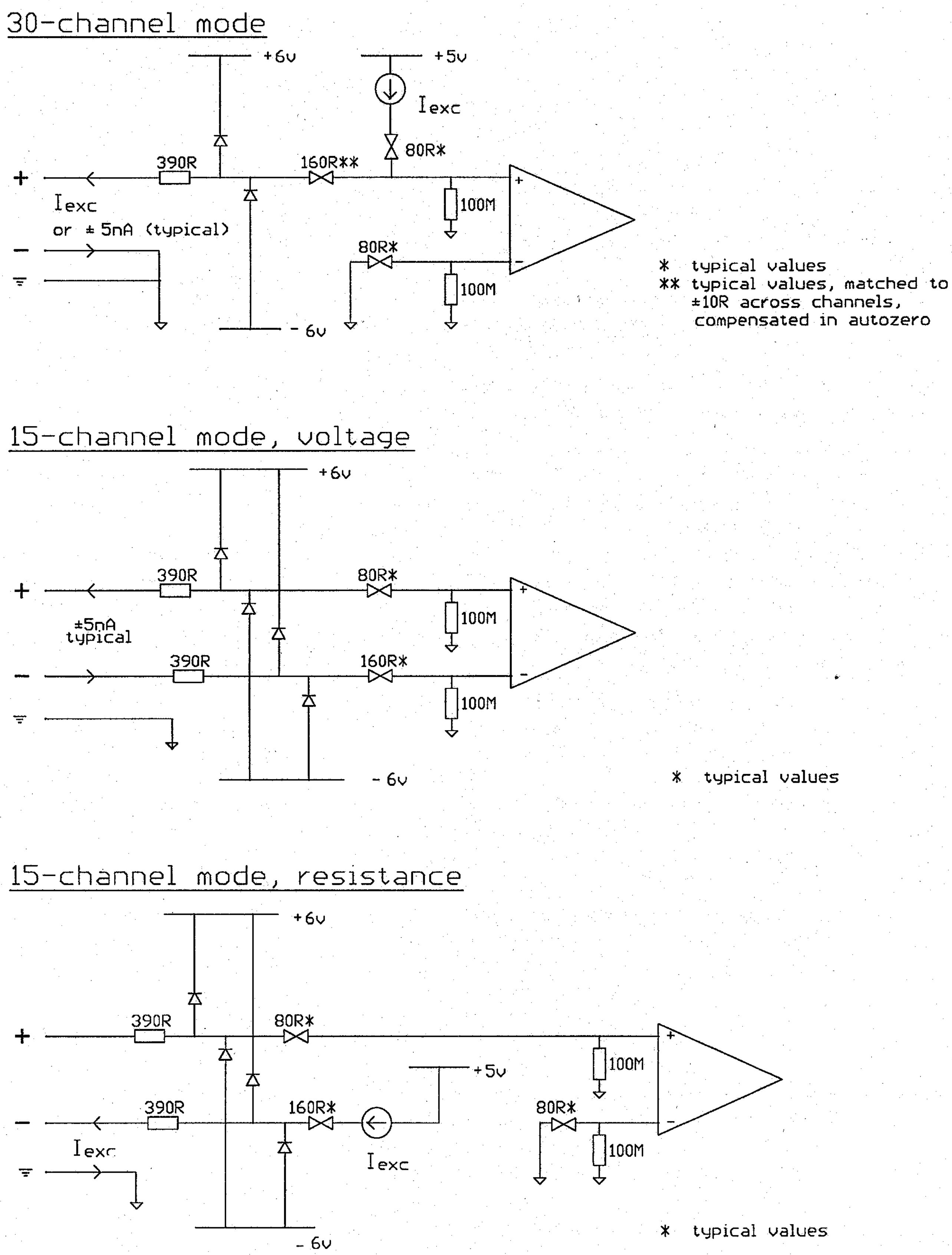


Figure 7 - LAC1 input stage schematic diagrams

Analogue Input Card, type ACD1

The AC Card, type ACD1, is a general-purpose analogue input card. It has the capability to measure 15 differential input channels, which may be dc voltages in the range ± 2V, ac voltages in the range 2V rms, and resistances.

Accuracy for dc voltage, and resistance readings, is the same as that for the LAC1 in 15 channel mode.

The ACD1 is intended mainly for measuring sensors that have an ac output signal, or that are excited by the ac source card type ACS1.

Capability

Channels

15 channels are provided on one terminal group...

Voltage inputs

Differential. A wire link can be fitted on the screw terminal block for single-ended measurements. Inputs signals up to ±2V dc or 2Vac (true rms) can be measured.

Resistance measurements

3-wire current excited. A wire link can be fitted on the screw terminal block for 2-wire measurements.(see Figure 8 - ACD1 circuit board layout).

Setting up

Ribbon cables

Connect one ribbon cable from the card to any terminal group.

All sensor connections are as LAC1 in 15-channel mode (differential).

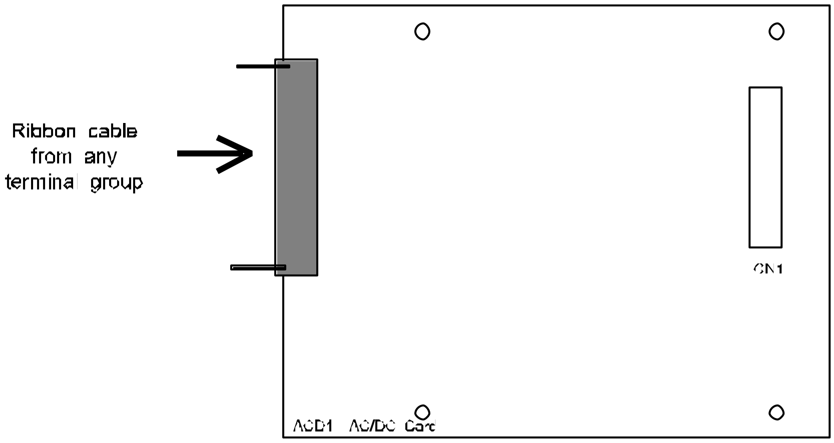


Figure 8 - ACD1 circuit board layout

Programming Issues

Programming an Input Channel

Select Input Card Type 'ACD1' for the channel group that is connected to the ACD1 card. The Input Channel tab of the Channel Properties dialog for this channel group will then offer suitable sensor types in the Sensor Type list, or if you select <Custom sensor

type> the Measurement tab will offer suitable options in the Electrical Measurement list.

Programming a Sensor Type

In the Measurement tab of the Sensor Type Properties dialog, select one of the following Electrical Measurement / Connection Requirements combinations:

- AC Voltage: ‘Voltage AC’
- DC Voltage: ‘Single-ended’, ‘Differential, low CM’, ‘Differential, high CM’
- Resistance: ‘2-wire’, ‘3-wire’
- Thermocouple: ‘Single-ended’, ‘Differential, low CM’, ‘Differential, high CM’

4-Wire Card, type LFW1

The 4-Wire Card, type LFW1, is an input card intended mainly for measuring sensors needing 4-wire connection. These include bridge-connected sensors, such as strain gauges, and low value resistors, such as platinum resistance thermometers PT100. 4-wire resistance measurements minimise cable resistance errors.

A voltage source and the logger's programmable current source are available to each channel for sensor excitation. The sensor output is measured as a differential voltage input.

Capability

Channels and terminal groups

The LFW1 provides 1 or 2 terminal groups of 6 channels per terminal group. Each channel is provided with current and voltage sources on separate terminals.

Voltage inputs

Differential. A wire link can be fitted on the screw-terminal connector block for single-ended measurements.

Resistance measurements

4-wire current excited. Wire links can be fitted to the screw terminal connector block for 2-wire measurements.

Resistance offset

A switchable offset is available for accurate measurement of small changes from a base resistance value. A typical application is PT100 measurements. When ON, it is applied to every resistance-measuring channel on the card. The offset is factory set for optimising PT100 temperature measurements in the range -20°C to +60°C. It can be adjusted as required.

Bridge measurements

Bridges can be excited using either a voltage or current source. The bridge output is measured as a differential voltage.

- ***Voltage excitation*** is provided for each channel. The voltage source is factory set to 1.048V, but can be adjusted up to 4V if required. The voltage source can supply 60mA, which has to be shared between all voltage excited channels in a terminal group. The voltage source is applied to all 6 channels in a terminal group whenever a reading is being taken from any channel in the group.
- ***Current excitation***: the current source normally used for resistance measurements is available on each channel for bridge excitation.

Potentiometric measurements

The voltage and current sources can be used to excite a potentiometer. The potentiometer output, measured as a differential voltage, represents a ratio of resistance's and is independent of the absolute resistance of the potentiometer.

Input protection

The + , - and ψ terminals on the LFW1 are protected against a continuous overload voltage up to 15 volts. Inputs can also survive brief spikes at much higher voltages: the shorter the spike the higher the voltage.

Additional input protection can be obtained by fitting an input protection card (LPR1V) in series with the LFW1, but shunt and divider resistors must not be fitted to the LPR1V.

Setting up

Ribbon cables

Any terminal group can be connected to either A or B ribbon connector blocks.

Cold junction thermistor

The LFW1 card cannot be used to read the cold-junction thermistor. If using the LFW1 card with terminal group 1-15, ensure that both halves of the cold junction thermistor switch are in the OFF position.

LFW1 connector blocks

Each LFW1 channel has 5 screw terminal connections for:

- Negative differential voltage input.
+ Positive differential voltage input.
⏚ Earth, excitation return.
I Current source, configurable to 2, 20, 200 or 2000 mA.
V Voltage source, adjustable 1-4 V.

Use the LFW1 label set to label the terminal blocks.

Voltage measurement

Set the R/PRT switch to ‘R’ (i.e. no resistance offset) if you require differential voltage measurements with significant common mode voltages, e.g. bridge measurements. If in doubt, avoid mixing differential voltage measurements and offset resistance measurements on the same LFW1 card.

Single-ended voltage measurements are not affected by the setting of the R/PRT switch.

A resistance offset degrades the logger’s ability to reject common mode noise.

Resistance measurements

Decide whether a resistance offset is required, and whether you are going to fit your own offset resistor, or use the factory-set value of 107.79Ω for temperature measurements in the range -20° to +60°C using PT100 sensors.

R/PRT switch and jumper L1

- No offset: R/PRT switch set to ‘R’
- Factory-set offset: R/PRT switch set to ‘PRT’, jumper L1 in ‘20C’ position.
- Alternative offset: R/PRT switch set to ‘PRT’, jumper L1 in ‘R4’ position. See *Calibration of resistance offset* below for further instructions.

Calibration of resistance offset

Jumper L1 selects either the factory set offset value for a PT100 at 20°C, or a value of your choice.

Preparation: factory set offset

To recalibrate the card for a 20°C PT100 offset:

- Ensure that jumper L1 is fitted in the ‘PRT’ position, as illustrated opposite.
- Connect a 107.79Ω calibration resistance to one of the LFW1 channels using the 4-wire connection scheme, and program this test channel with the sensor code PT4. Do not use the sensor codes PRT or PT3.

Preparation: alternative offset

To set up a resistance offset value of your choice:

- Move the jumper L1 to the ‘R4’ position (the card is supplied with the jumper in the ‘PRT’ position as illustrated in Figure 9)

- fit stable resistors in positions R1 and R4. Select R4 to be slightly greater than R_{base}(the new resistance offset), and calculate R1 using the formula:

$$\frac{R_1}{R_1 + R_2} \times V_{in} \max < 2.097V$$

- Connect a calibration resistance of the exact value R_{base} to one of the LFW1 channels using the 4-wire connection scheme and program the logger to read this test channel. In setting up Sensor Characteristics, remember that the logger will measure R_{base} less than the actual resistance: enter R_{base} as an offset, or subtract R_{base} from actual resistance values when entering a linearisation table.

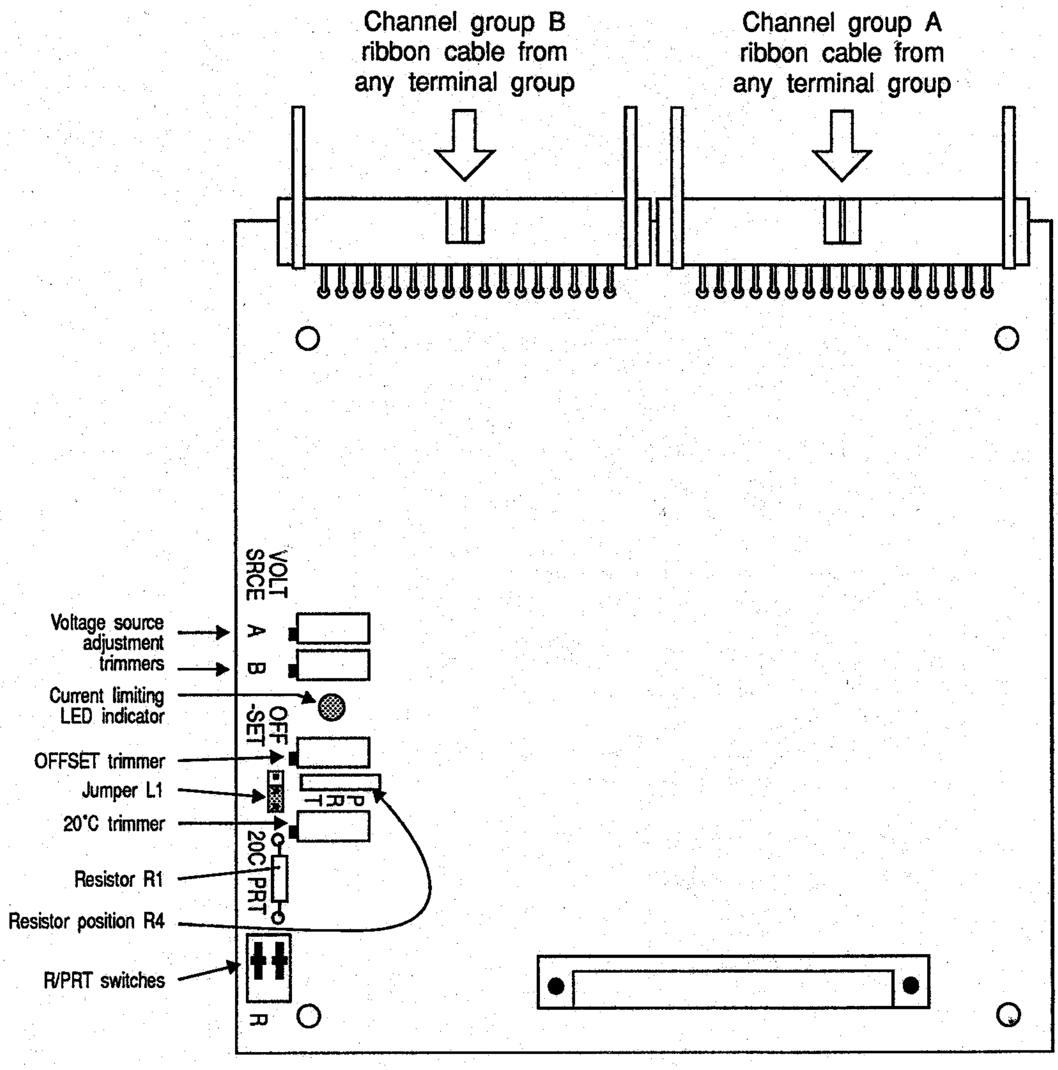


Figure 9 - LFW1 4-wire analogue input card

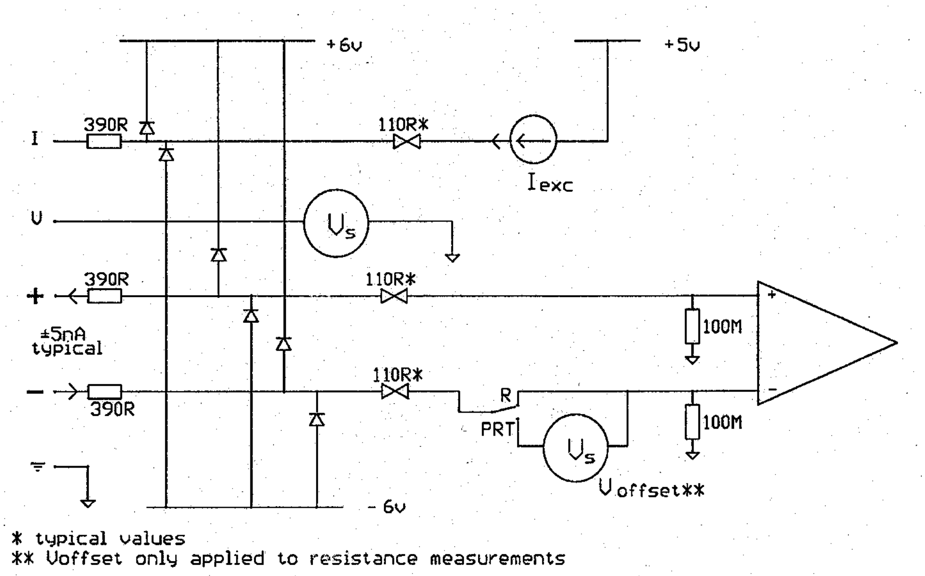


Figure 10 - LFW1 input stage schematic diagram

Adjustments

With a calibration resistor connected to a suitably programmed test channel, proceed as follows:

- Connect a voltmeter across the pair of pins labelled ‘AMP’ on the logger’s main board.
- Set the R/PRT switch to the ‘R’ position and READ the test channel.
- Adjust the 20C trimmer until the reading corresponds exactly to R_{base}, (20°C if recalibrating the factory set PT100 offset) and the OFFSET trimmer so that the voltmeter gives a reading close to zero.
- The 20C and OFFSET trimmer settings interact, and you may have to repeat the adjustment a few times until the results stabilise.

Voltage sources

There are two voltage sources on an LFW1, one for each group A and B of 6 channels. Each source is automatically turned on whenever one of the 6 channels in that group is measured.

Voltage source adjustment trimmers A and B

Adjust the voltage source outputs for their respective channel groups from 1.0486 Volts up to about 4 Volts.

Current limiting

The 6 channels in a group can draw a total of 60mA from the voltage source. Higher currents are automatically limited to prevent damage from accidental short-circuits, etc. The current limiting LED (light emitting diode) indicator on the card lights whenever the voltage source is overloaded and unable to supply enough current at the required voltage.

For example: 1.048V is suitable for exciting a full group of six 120Ω strain gauges, since the current drain would be:

$$\frac{V \times n}{R} = \frac{1.048V \times 6}{120\Omega} = 52.4mA$$

If the voltage is increased and the total required current rises to 60mA, current limiting takes place and the current limiting LED indicator lights. The voltage source is then not stabilised, and might cause misleading readings.

With sensors of higher resistance or if there are fewer than 6 in a terminal group, the voltage may be increased to give more sensor output and sensitivity.

Adjusting the voltage source

- To increase the voltage: turn trimmers A or B clockwise. Beware of creating common mode problems by applying too large an excitation voltage to bridge sensors (see "Common mode voltages" on page 96).
- To reset the voltage source: turn trimmers A and B fully anti-clockwise to reset the voltage sources to 1.0486V. This value is precise and repeatable.

Programming Issues

Programming an Input Channel

Select Input Card Type for the channel group that is connected to the LFW1 depending on resistance offset setting:

- No offset: ‘LFW1, no offset’
- Factory-set offset: ‘LFW1, 20C PT100 offset’
- Alternative offset: ‘LFW1, custom offset’

The Input Channel tab of the Channel Properties dialog for this channel group will then offer suitable sensor types in the Sensor Type list, or if you select <Custom sensor type> the Measurement tab will offer suitable options in the Electrical Measurement list.

Programming a Sensor Type

In the Measurement tab of the Sensor Type Properties dialog, select an Electrical Measurement / Connection Requirements combination from one of the following groups:

No offset:

- DC Voltage: ‘Single-ended’, ‘Differential, low CM’, ‘Differential, high CM’, ‘Potentiometer’, ‘Bridge’
- Resistance: ‘2-wire’, ‘3-wire’, ‘4-wire, no offset’
- Thermocouple: ‘Single-ended’, ‘Differential, low CM’, ‘Differential, high CM’

Factory-set offset

- DC Voltage: ‘Single-ended’, ‘Differential, low CM’, ‘Potentiometer’
- Resistance: ‘4-wire, 20C PT100 offset’
- Thermocouple: ‘Single-ended’, ‘Differential, low CM’

Alternative offset

- DC Voltage: ‘Single-ended’, ‘Differential, low CM’, ‘Potentiometer’
- Resistance: ‘4-wire, 20C custom offset’
- Thermocouple: ‘Single-ended’, ‘Differential, low CM’

Attenuator Card, type LPR1
Input Protection Card, type LPR1V

Capabilities

Channels

LPR1 and LPR1V are supplementary cards, for fitting in the logger in series with an analogue input card. Each serves two terminal groups, but provides no additional channels.

Voltages up to ±50V and currents

Both LPR1 and LPR1V have sockets for mounting precision resistors. When fitted in series with a LAC1 card, resistors can be fitted in a voltage divider configuration to attenuate voltages up to ±50V to a value that the logger can measure, or as shunts for converting currents to voltages.

Input protection

LPR1V has transient absorbing varistors fitted on all inputs. It can be fitted in series with LAC1 and LFW1 cards to provide additional input protection.

Setting up

Fitting precision resistors

Precision resistors should only be fitted to LPR1 and LPR1V cards connected to a LAC1 card. LAC1 can be set for 15-ch or 30-ch operating mode.

Resistor positions are labelled on the card with channel numbers 1-30. If you need to fit resistors to channels outside this range, refer to Appendix E.

Voltage divider resistors

Cut track links on the underside of the card for channels to be fitted with divider resistors, and fit resistors R_1 and R_2.

Select R_1 and R_2 so that:

- R1 < 24 kΩ.
- $\frac{R_1}{R_1 + R_2} \times V_{in} \max < 2.097V$
- Note that the logger's effective input impedance for the divided channel is then $R_1 + R_2$. This may affect the measurement of high impedance voltage sources.
- Precision resistors are recommended: 0.1% resistors give an additional worst case error of 0.2%.

Shunt resistors

Ensure the track link on the underside has NOT been cut.

Fit resistor R_1 only. Select R_1 so that:

$$R_1 = \frac{400 \times 10k\Omega}{2000 - V}$$

- Ensure that the current source can drive $R_1 \times I_{in\max}$ max.
- Precision resistors are recommended: 0.1% resistor gives 0.1% additional error.
- To avoid additional contact resistance error, don't select too low a value.

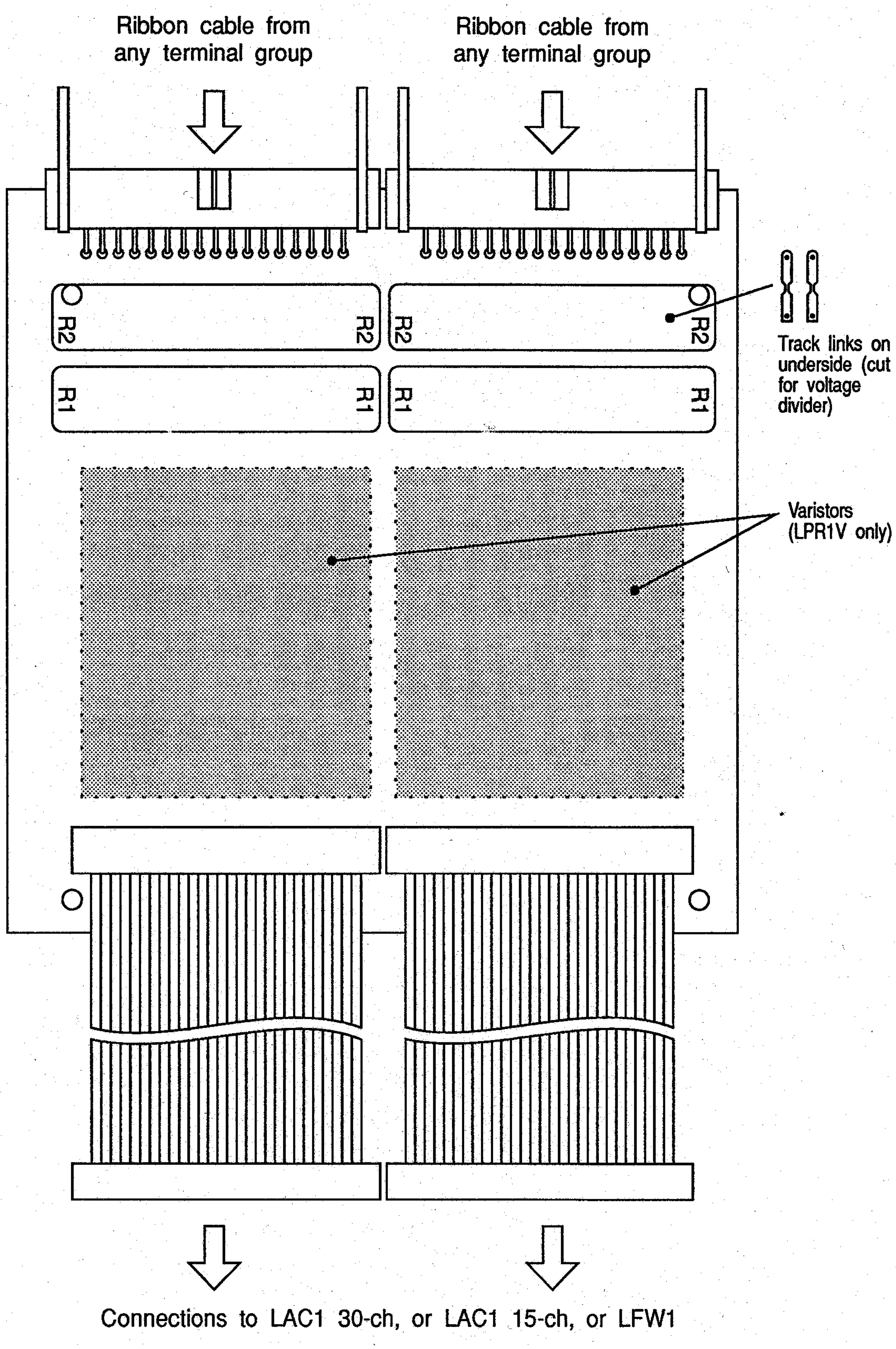


Figure 11 - LPR1 and LPR1V supplementary input cards

Fitting the card in the logger

Mount the card on top of the input card stack.

Use the standoff pillars supplied with the card. For newer style loggers, you may have to remove the slotted nylon nuts from the top of the stack and replace them with standoff pillars before fitting the card. After locating the card on the stack, screw down the nylon nuts or standoff pillars onto the protruding studs to secure the card in position.

Connect the card to the logger's terminal panel and an analogue card, as illustrated in Figure 12.

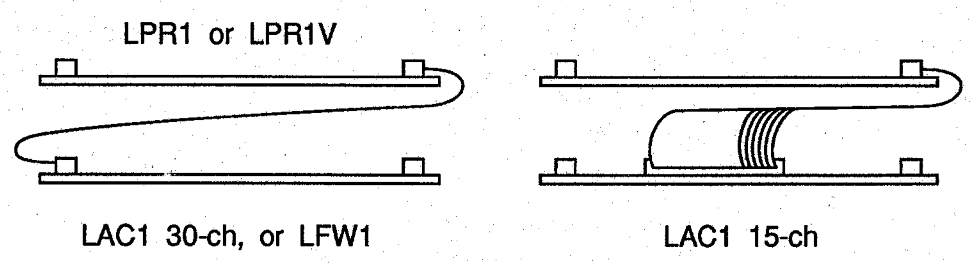


Figure 12 - Fitting LPR1 or LPR1V to input card stack

If the LAC1 is set for 30-ch mode, see "Analogue Input Card, type LAC1" on page 69 for restrictions on use of terminal groups.

Remarks

Channels without resistors fitted or cut track links are unaffected by the LPR1 card.

The LPR1V can affect the logger's precision when measuring resistance using the 2 µA excitation current. This is due to the capacitance of the varistors on the LPR1V. Measurements with larger excitation currents are much less affected and are preferable for measuring resistance's smaller than 100 kΩ.

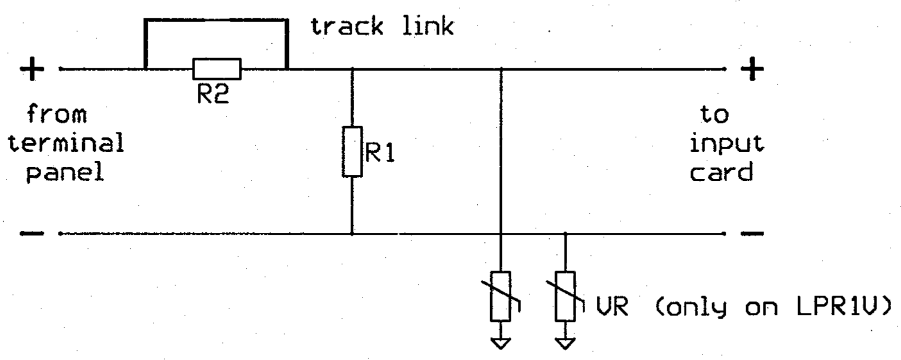


Figure 13 - LPR1, LPR1V input stage schematic diagram

AC Excitation Card, type ACS1

The ACS1 card provides AC excitation for up to 60 AC resistance sensors, such as ‘gypsum block’ or ‘granular matrix’ soil moisture sensors. The card applies ±2.0V square wave excitation (125Hz ±30Hz) to each selected channel via a (10 kΩ ±1%) socketted resistor and a 10 µF bipolar electrolytic isolating capacitor.

The ACS1 card operates from a supply of 7-15 Vdc, and has a quiescent current consumption of < 10mA.

Capability

Channels

The isolating capacitors prevent any dc polarisation of the sensors. An ACD1 is used to measure the ac voltage across the sensor, which can be interpreted as a resistance (see below).

Channels to be supplied with the AC excitation must have the corresponding shorting link and resistor fitted on the ACS1 card, see Figure 16 - ACS1 circuit board - channel details. To measure non-AC excited sensors on other input channels when the ACS1 is fitted, the corresponding socketted resistors and shorting links should be removed. This is necessary for ACD1 channels measuring DC volts or resistance, or any other kind of sensor and for channels connected to LAC1, DLC1, and LFW1 cards when an ACS1 is fitted. These channels are then not affected by the ACS1.

Installation

The ACS1 card mounts on the inside of the DL2e terminal panel, attached by 4 x 34-way through connectors. To install apply even pressure across the card, gradually easing the 4 connectors together. The normal 34-way ribbon cables connect between the ACS1 and the input card. (NOTE polarisation marking on ACS1 card).

The ACS1 is powered from the DL2e power (7-15Vdc) via a warm up relay, with jumper fitted. This is connected via flying leads (with header) soldered to the CH63 NO & CH62 0V pins on the inner side of the terminal card.

If the ACS1 has not been factory fitted, then you will need to connect the power supply lead. See Figure 17 - ACS1 power connections for details.

Setting up

Interpreting readings

The 2000 mV AC from the ACS1 is divided by the 10 kΩ resistor on the ACS1 card in series with the sensor resistance.

The resulting Vac reading can be interpreted afterwards as a sensor resistance.

- AC mV reading where R is the sensor resistance in kΩ

Therefore $R = \frac{400 \times 10k\Omega}{2000 - V}$ if $V = 400mV$ then $R = \frac{400 \times 10k\Omega}{1600} = 2.5k\Omega$

If measuring soil moisture, the sensor calibration will relate sensor resistance to soil matrix potential. Setting a channel of the logger to read soil temperature will also be useful, as the readings can then be compensated for temperature variations.

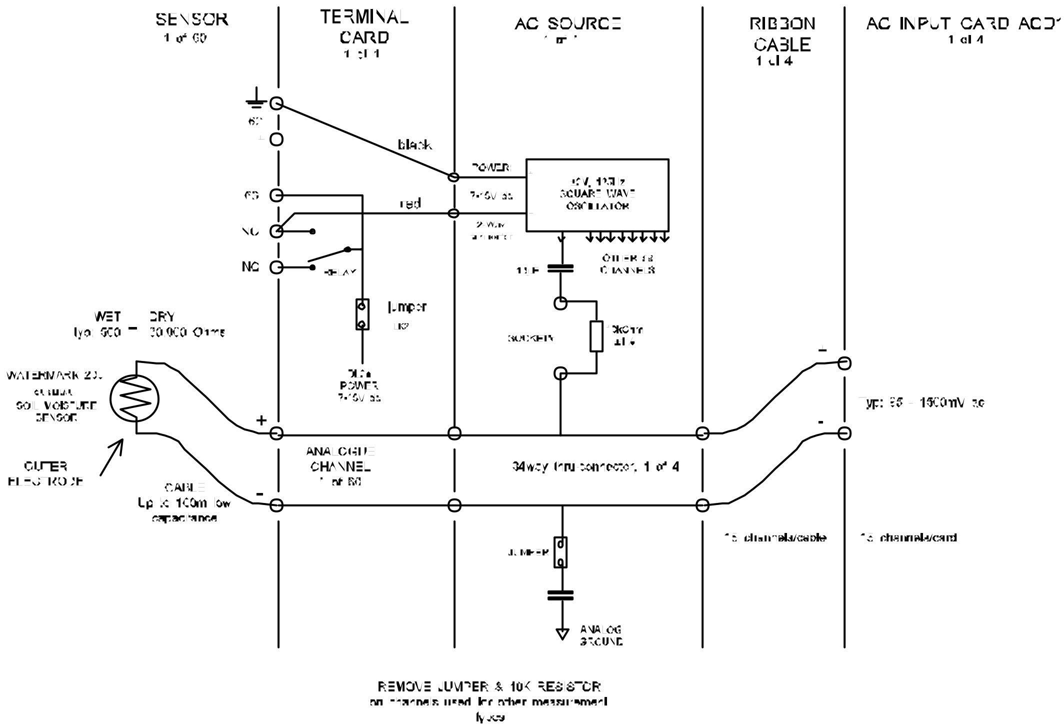


Figure 14 - ACS1 system diagram

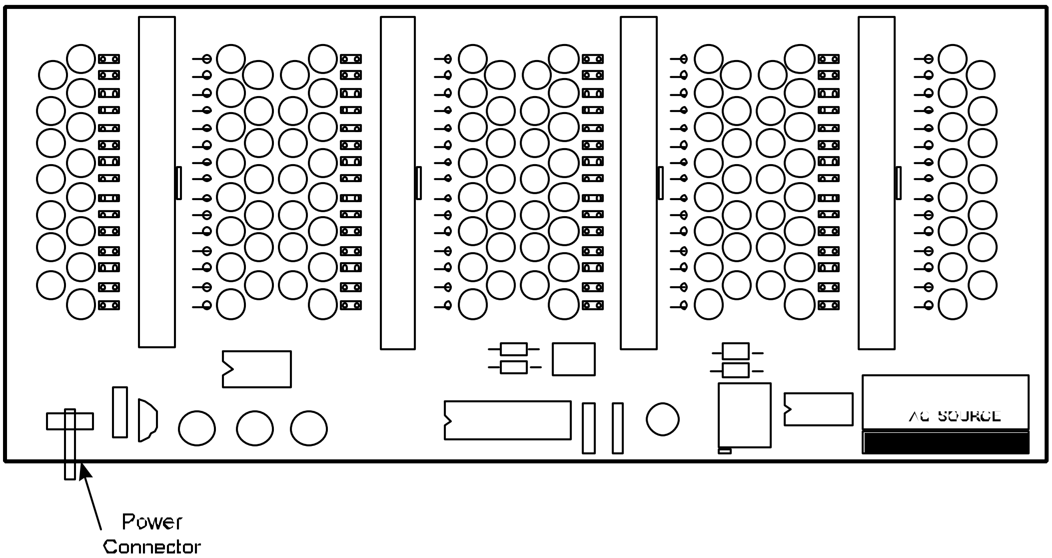


Figure 15 - ACS1 circuit board layout

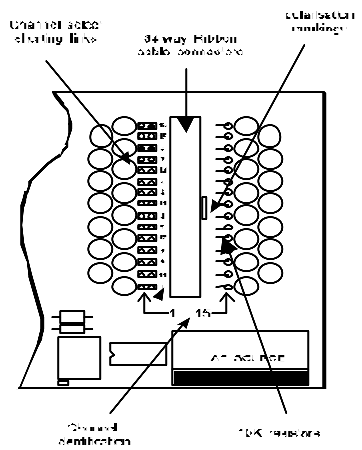


Figure 16 - ACS1 circuit board - channel details

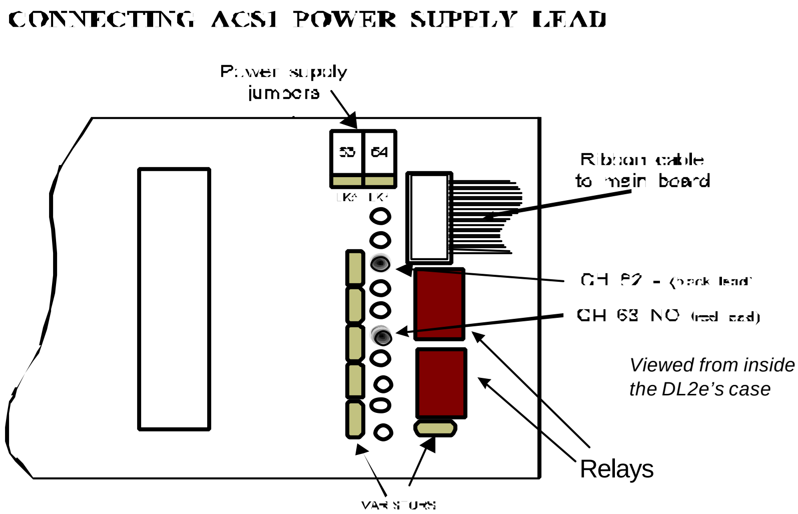


Figure 17 - ACS1 power connections

Voltage, single-ended

Single-ended sensor connection is suitable for measuring DC voltages up to ±2V. The source impedance of the voltage source should be less than 24kΩ for full logger accuracy. LAC1 in 30-ch mode is not recommended for accurate measurement of low level signals (less than ±32mV). It can introduce a relatively large offset error, typically in the region of 20µV, in addition to the logger's normal differential offset.

Setting up

LAC1, 30-ch mode

- Set the 15/30 switch to '30'.
- Install ribbon cable(s) from one or two terminal groups to the corresponding 's/e 30-channel' position(s) on the card.

The - terminal of each channel is linked to earth on the card. There is no need for an external link.

LAC1, 15-ch mode (& ACD1)

- Set the 15/30 switch to '15'
- Install one ribbon cable only, from any terminal group to the 'differential' position on the card
- Fit link L1 between – and ⏚ on screw terminal block

ACD1

- Set as LAC1, 15-ch mode.

LFW1

- Install one or two ribbon cable(s) from any terminal group(s) to either or both positions on the card.
- Fit link L2 between – and ⏚ on the screw terminal block.

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

1. Select Electrical Measurement 'DC Voltage'.
2. If programming a sensor type, select Connection Requirement 'Single-ended'.

Remarks

- Beware creating earth loops, particularly if you have:
  > electrically interconnected sensors,
  > sensors operating on a mains power supply, or sharing the logger's power supply. The alternative is to use fully floating differential connections (see "Voltage, differential" on page 89).
- For better common-mode noise rejection, consider differential connection with earthed sensor or bias resistors (see Figure 19 - Sensor connections: differential voltage).
- The logger's input impedance is only specified for the logger when awake, and may drop significantly when the logger sleeps. If using a sensor with a high source impedance, check that it can respond quickly enough (within 250ms) to the change in the logger's input impedance as it wakes.

Accuracy

The logger's basic voltage measurement accuracy, and other factors affecting accuracy, are described in Appendices A and B.

Note that the LAC1 in 30-channel mode has an offset error, typically in the region of 20µV, in addition to the differential offset quoted in the specification.

See also

- LAC1 card (on page 69), LFW1 card, (on page 75).
- Discussion of single-ended versus differential connections (page 61)
- Earth loops and common mode voltages (on page 95).
- Voltage measurements up to ±50V (on page 92).

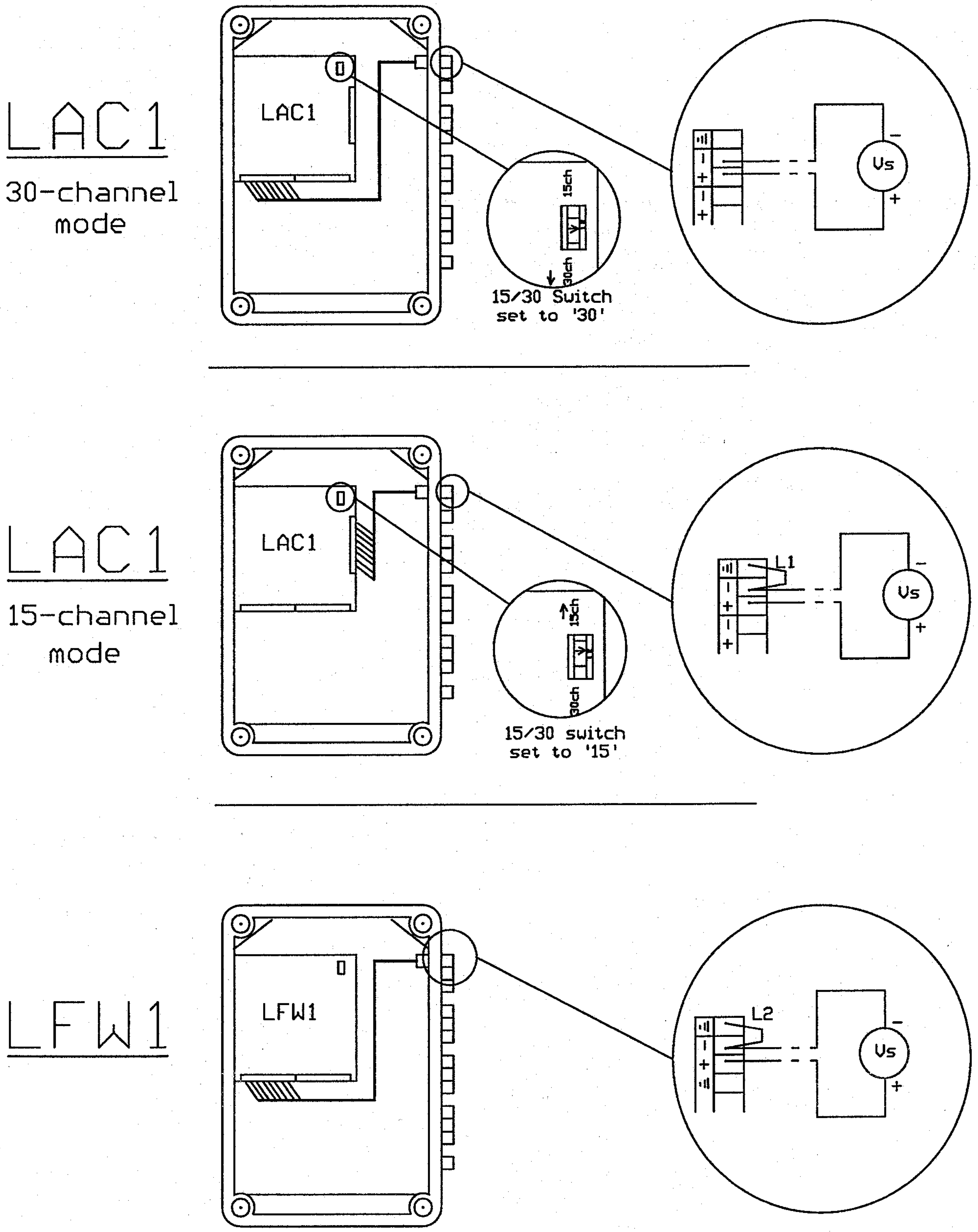


Figure 18 - Sensor connections: voltage, single-ended

Voltage, differential

Differential sensor connection is suitable for measuring DC voltages up to ±2V. Source impedance of the voltage source should be less than 24kΩ for full logger accuracy.

Fully floating

Fully floating connection is suitable for sensors with an existing connection to the logger's earth, or with a low-impedance common-mode voltage less than ±2V.

Bias resistors, earthed sensor

Differential connections with the sensor earthed or with bias resistors fitted, are superior alternatives to single-ended connection. These schemes are recommended for inputs susceptible to picking up high-impedance common-mode noise, for example thermocouples on long leads in electrically noisy environments.

Setting up

LAC1, 15-ch mode

- Set 15/30 switch to '15'.
- Connect one ribbon cable only, from any terminal group to the position marked 'differential' on the card.

ACD1

- Connect a ribbon cable from any terminal group to the card.

LFW1

- Set the R/PRT switch to 'R' position for optimum common mode rejection (see "4-Wire Card, type LFW1" on page 75).
- Connect one or two ribbon cable(s) from any terminal group to either or both positions on the card.

LAC1, ACD1 and LFW1

- Fit bias resistors or earth the sensor, if appropriate. 100kΩ is generally a suitable value for bias resistors.

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

1. Select Electrical Measurement 'DC Voltage'.
2. If programming a sensor type, also select Connection Requirement 'Differential, low CM' if the sensor output has a negligible common mode (for example a sensor powered from the logger's power supply), or 'Differential, high CM' if the sensor output has a significant common mode. The latter setting will exclude the sensor type from being programmed for a LFW1 card set up to provide a resistance offset, where common mode can introduce significant reading errors.

Remarks

The logger's input impedance is only specified for the logger when awake, and may drop significantly when the logger sleeps. If using a sensor with a high source impedance, check that it can respond quickly enough (within 250ms) to the change in the logger's input impedance as it wakes.

Accuracy

The logger's voltage measurement accuracy is described in Appendices A & B.

See also

- LAC1 card (on page 69), LFW1 card (on page 75).
- Discussion of single-ended versus differential connections ("Voltage measurements" on page 61)
- Earth loops and common mode voltages (on page 95).
- Single-ended sensor connections (on page 86).
- Voltage measurements up to ±50V (on page 92).

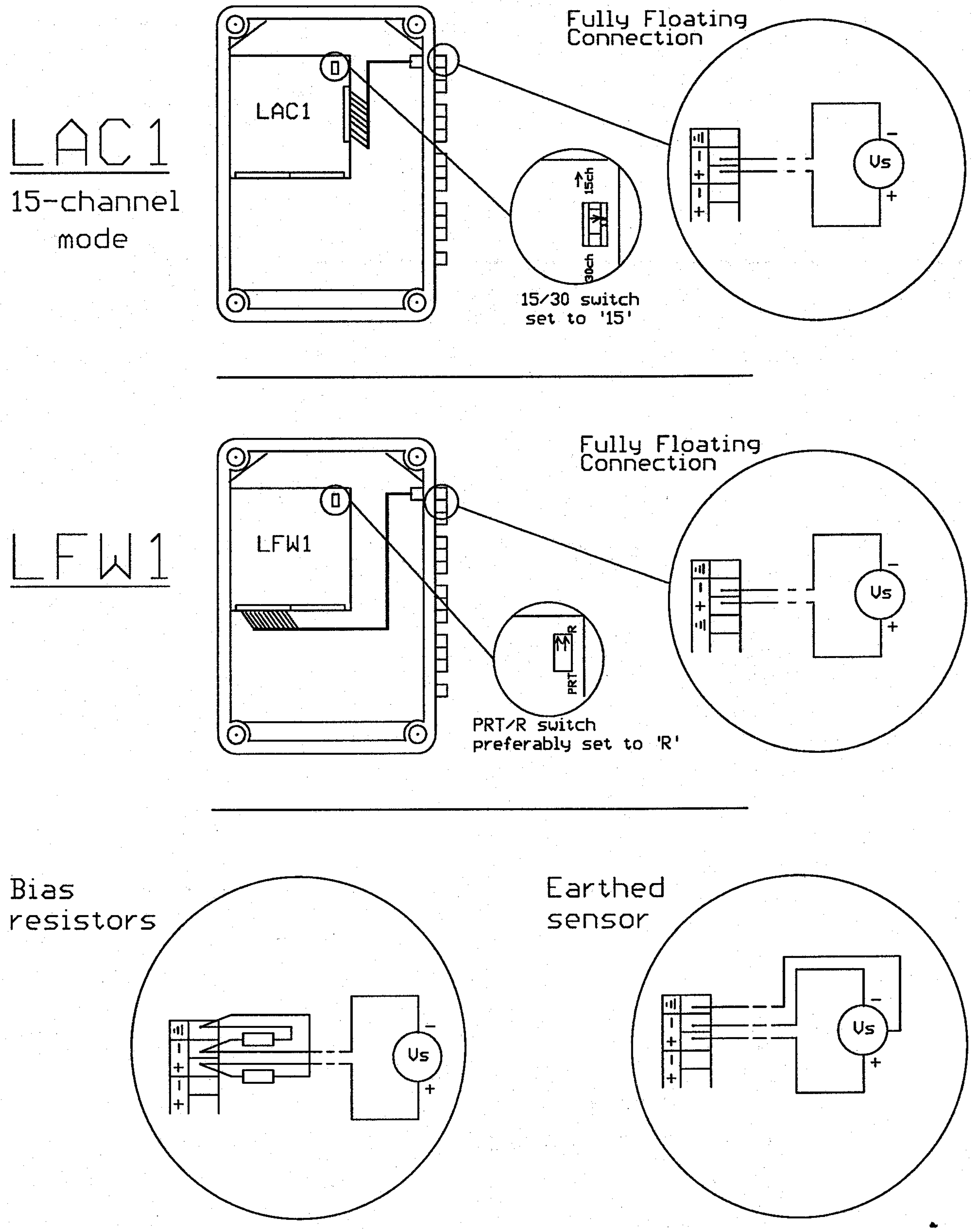


Figure 19 - Sensor connections: differential voltage

Voltage, up to ±50V DC

The connection schemes shown here are suitable for measuring DC voltages up to ±50V. Divider resistors mounted either on the screw terminals or on an LPR1 or LPR1V card in series with a LAC1 card are required for this purpose.

Setting up

Mounting divider resistors on screw terminals

- Set up LAC1, ACD1 or LFW1 and fit ribbon cables for single-ended or differential voltage measurement, as described in "Analogue Input Card, type LAC1" on page 69 and "4-Wire Card, type LFW1" on page 75.
- Fit divider resistors R1 and R2 to the screw terminal block. You will have to solder one end of R2 to your sensor lead, or provide your own terminal block.

Using LPR1 or LPR1V

- On the LPR1 or LPR1V, fit divider resistors R1 and R2, and cut the track links on the underside of the card for the required channels.
- Set the LAC1 for 15-ch or 30-ch mode operation, and connect terminal group(s) to the appropriate position on the card (see Figure 12 - Fitting LPR1 or LPR1V to input card stack).

Link L1

- Sensor connections to the screw terminal block can be single-ended or differential (see "Voltage, single-ended" on page 86 or "Voltage, differential" on page 89). Fit link L1 if required.

Selecting divider resistor values

- Use precision resistors.
- Select R_1 to be < 24kΩ.
- Select R_2 such that $V_{in} \times \frac{R_1}{R_1 + R_2} < 2V$
- Ensure the voltage source can drive an impedance of R_1+R_2. Most voltage sources will drive a 10kΩ + 100kΩ combination.

Calibrating the divider (optional)

- Program the divided channel with sensor code VLT.
- Apply a precisely known voltage V_{in}, and READ the channel to obtain V_{read}.
- The conversion factor for configuring the logger is then: $\frac{V_{read}}{V_{in}}$

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

1. Select Electrical Measurement ‘DC Voltage’.
2. If programming a sensor type, also select Connection Requirement as described in Voltage, single-ended or Voltage, differential sections.
3. Enter suitable conversion factor and offset (or linearisation table) for converting the input signal seen by the logger (ie scaled by R1/(R1 + R2) or determined by calibration), to engineering units.

Accuracy

The logger's voltage measurement accuracy is fully described in Appendices A and B. Divider resistors contribute the following additional errors:

If using a calculated value for the conversion factor, add the tolerances of each resistor, e.g. a pair of ±0.1% resistors contribute a maximum error of ±0.2%. You may also need to take contact resistances into account.

The temperature coefficient (tempco) of each resistor has to be added if the logger is to operate over an extended temperature range, e.g. if using a pair of +15ppm/°C resistors and operating over -20°C to +60°C, the maximum tempco error contribution is:

$2 \times \pm 40°C \times \pm 15\,ppm = \pm 1200\,ppm \equiv \pm 0.12$ % about a 20°C base.

Remarks

Channels connected via an LPR1 or LPR1V card with uncut tracks and no resistors fitted behave as normal channels. Remember to repair cut tracks if reconfiguring the channel for another purpose without shunt or divider resistors.

See also

- "Analogue Input Card, type LAC1" on page 69,
- "4-Wire Card, type LFW1" on page 75),
- LPR1 card ("Capabilities" on page 80).
- Discussion of single-ended versus differential connections ("Voltage measurements" on page 61)
- Earth loops and common mode voltages (on page 95).
- Single-ended (page 86) and differential (page 89) sensor connections.

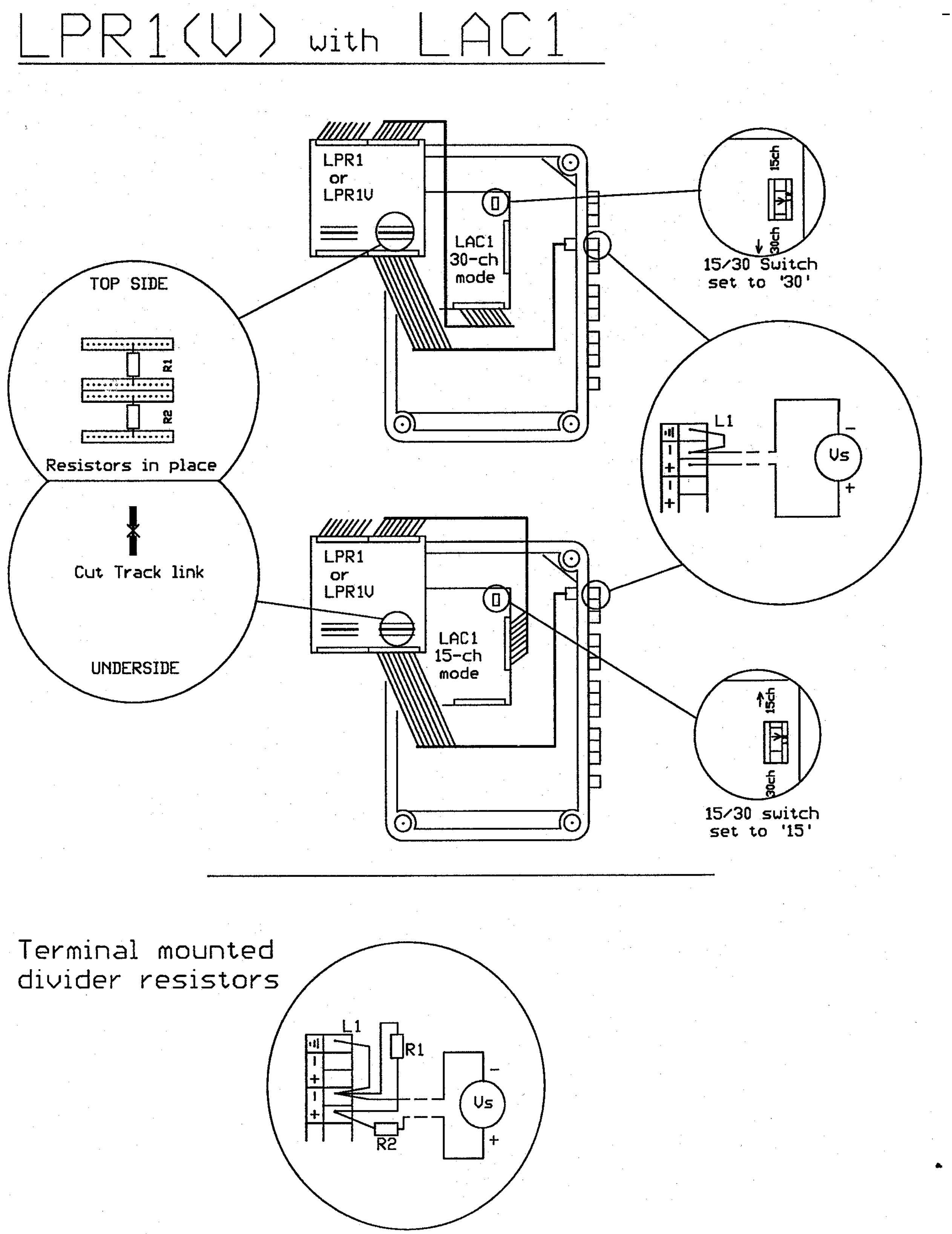


Figure 20 - Sensor connections: voltage up to +/-50V

Earth loops and common mode voltages

Earth loops

An earth loop is literally two or more earth conductors connected in a loop configuration, caused when there is more than one connection route between a sensor and the logger's earth.

You will create an earth loop if you make a single-ended connection to a sensor whose 0V output is already electrically connected to the logger's earth. Figure 21 illustrates some possible earth loop connection routes to look out for.

Current flowing round an earth loop causes a voltage drop in the cable connecting the sensor to the logger's negative - input terminal, producing an error in the voltage reading.

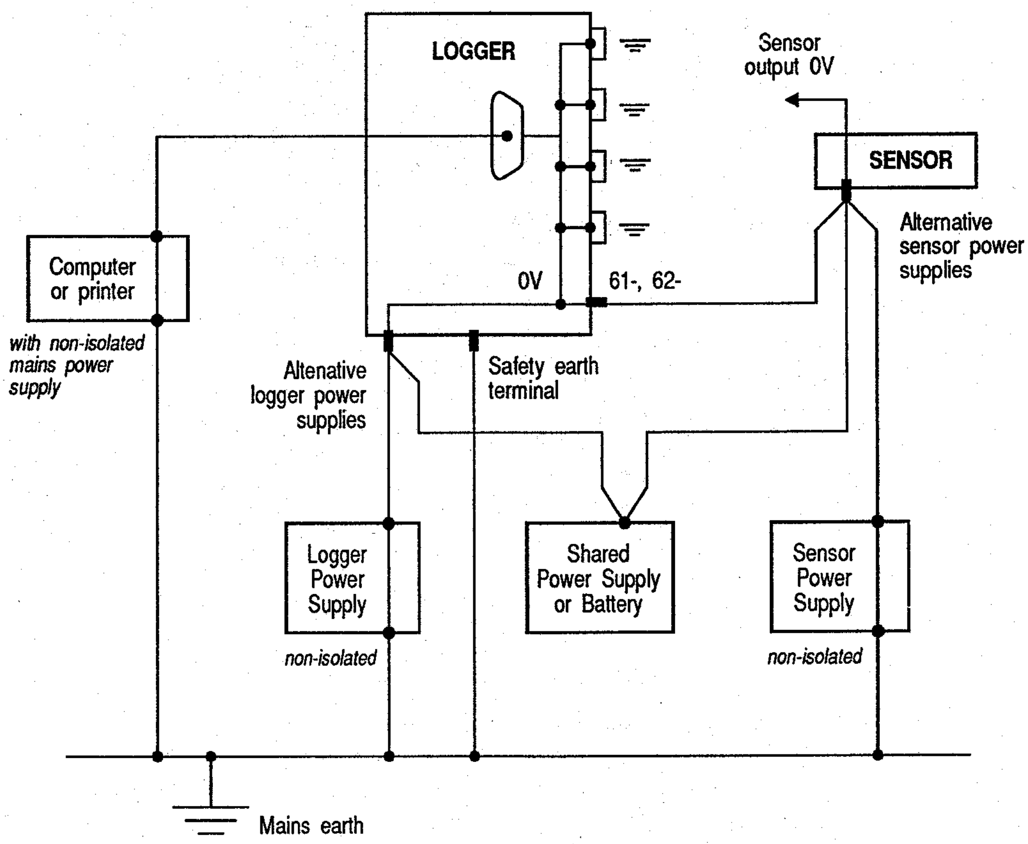


Figure 21 - Potential interconnections between sensor output -V and logger earth. Do not use single-ended connections if any of these routes are present in your system.

Earth loops can cause significant and unpredictable problems, and they should be avoided in all situations. Voltages can be generated in metalwork by effects that you may be unaware of, for example electrochemical and thermocouple effects of dissimilar metals in contact with each other. In electrically noisy environments, electrical induction can cause currents to flow in earth loops resulting in unstable or inaccurate readings.

Configurations which are prone to earth loop problems include:

- Multiple thermocouples attached to common metalwork (e.g. motor vehicle chassis). If electrically isolated sensors are not practical, connect one sensor as single-ended and the others as differential.
- Sensor and logger powered from a common power supply. If the sensor output is electrically isolated from the sensor's power supply, then you should use single-ended. Otherwise (common earth or low impedance common mode) use fully-floating differential connections
- Using non-isolated mains power supplies. Most mains power supplies, such as regular plug-in mains DC adapters, are fully isolated. If you use more than one non-isolated power supply in your logging system, mains earth provides a potential earth loop route. Again, beware of creating earth loops with single ended sensor connections.
- Connecting a logger to a mains powered computer might be a potential earth loop completion, and could cause intermittent errors coinciding with connecting a computer for communication.

Common mode voltages

In differential voltage measurements, neither of the logger's input terminals is directly connected to the logger's earth. The logger measures the difference between the voltages on its **+** and **–** input terminals, both of which float relative to the logger's earth.

For example, the input voltages on the logger's + and – terminals could be +1.6V and +0.9V respectively, relative to the logger's earth. The logger would then measure a normal mode voltage of 0.7V. The common mode voltage in this example is (0.9V + 1.6V)/2 = +1.25V.

Common mode range

The logger's common mode range is the range of common mode voltage over which its full accuracy specification applies.

The value of the logger's common mode range depends on the relative polarities of the common mode and normal mode voltages:

- same polarity: ±2V
- opposite polarities: ±1.05V.

To guarantee the better common mode performance (i.e. where common and normal mode voltages are of the same polarity), the sensor output must be unipolar, and connected such that the voltage potential at the logger's + input is further from the logger's earth potential than its – input (For a negative common mode voltage, this means that the logger's + input should be more negative than its – input).

For sensors with a bipolar output (i.e. that provide an output voltage which may be either positive or negative with respect to the common mode potential), you must assume the lower common mode range figure of ±1.05V.

Small excursions outside the common mode range cause subtle errors which might be difficult to detect. Larger excursions cause complete malfunction of the analogue input circuitry.

Look out for the following sources of common mode voltages:

- The outputs of bridge sensors have a common mode voltage. For typical bridges made up of four equal resistances, the common mode voltage is equal to half the excitation voltage. The common mode voltage will be a problem if the excitation voltage is too large and referenced to the logger's earth. For example:
  - > Bipolar bridges excited by the LFW1 voltage source if it has been set above 2.1V.

  > Bridge excitation provided by a voltage source external to the logger, and powered from the logger’s power supply. If it is necessary to share the logger’s power supply, you may need to bias the excitation power supply to bring the sensor output into the logger’s common mode range.

- Induced voltages, where sensors and connecting leads that are electrically isolated from the logger’s earth behave as aerials, picking up electrical noise signals. Such voltages are high impedance. They don’t have any current driving capacity and can be eliminated without detrimental effect by earthing either the sensor, or one of the logger’s input terminals. You can’t measure these common mode voltages with a normal voltmeter because the effect is like earthing the signal.
  Nevertheless, induced common mode voltages can easily push the inputs outside the logger’s common mode range and make the signal unreadable. This is why single-ended connections (or other earthing schemes) are essential for sensors that are otherwise electrically isolated from the logger.
- Voltage sources between the logger’s earth and the sensor, e.g. where an earth loop occurs. Such voltage sources are low impedance. You can measure them with a voltmeter, and if they exceed the logger’s common mode range, the common earth connections must be broken by using isolated power supplies, or optically isolated data links. Earthing the inputs doesn’t work.

Current

The connection schemes on this page are suitable for measuring DC current. Examples of sensors with a current output are photodiodes and 4-20mA loop transducers. A shunt resistor, mounted either on the screw terminals or on an LPR1 or LPR1V card in series with a LAC1 card, is required for this purpose.

Setting up

Mounting shunt resistors on screw terminals

- Set up the LAC1 or LFW1 and fit ribbon cables for single-ended or differential voltage measurement, as described on pages "Analogue Input Card, type LAC1" on page 69 or "4-Wire Card, type LFW1" on page 75.
- Fit the shunt resistor R_1 to the screw terminal block and connect the sensor.

Using LPR1 or LPR1V

- Fit the shunt resistor resistor R_1 on LPR1 or LPR1V for the channel required. Do not cut the track on the underside of the board.
- Set the LAC1 for 15-channel or 30-channel operation, and connect terminal group(s) to the appropriate position on the card (see "Capabilities" on page 80).

Link L1

- Sensor connections to the screw terminal block can be single-ended or differential (see "Voltage, single-ended" on page 86 or "Voltage, differential" on page 89). Fit link L1 if required.

Selecting a shunt resistor

- Use a precision resistor, or calibrate.
- Ensure that your current source has enough drive voltage. For example, using a 100Ω shunt resistor to measure a 4-20mA transducer, the sensor needs to provide a maximum voltage of 20mA x 100Ω = 2000mV = 2V
- Check that the resistor you choose can dissipate sufficient power. For example, a 100Ω shunt resistor driven by a 4-20mA transducer will need to dissipate 20mA x 2V = 40mW. Standard 0.25W resistors are suitable.
- Avoid very low value shunt resistors, as contact resistance can contribute significant errors.

Calibration (optional)

- Program the divided channel with sensor code VLT.
- Apply a precise current Iin, and READ the channel to obtain Vread.
- The conversion factor for configuring the logger is then: $\frac{V_{read}}{I_{in}}$

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

- Select Electrical Measurement ‘DC Voltage’.
- If programming a sensor type, also select Connection Requirement as described in Voltage, single-ended or Voltage, differential sections.
- Enter suitable conversion factor and offset (or linearisation table) for converting the input signal seen by the logger (ie the voltage across the shunt resistor in mV, which equals the current in mA scaled by R_1) to engineering units.

Accuracy

The logger’s voltage measurement accuracy figures (see Appendices A and B) apply to current measurements, with the following additional error contributions from the shunt resistor:

- If using a calculated value for the conversion factor, add the tolerance of the resistor.
- The temperature coefficient (tempco) of the shunt resistor has to be added if the logger is to operate over an extended temperature range.
  For example, if using a +15ppm/°C resistor and operating over -20° to +60°C, the maximum tempco error contribution is:
  ±40°C x 15ppm = 600ppm = ±0.06% (about a 20°C base).

See also

- 2-wire 4-20mA current loop transducers, on page 125.

LPR1(V) with LAC1

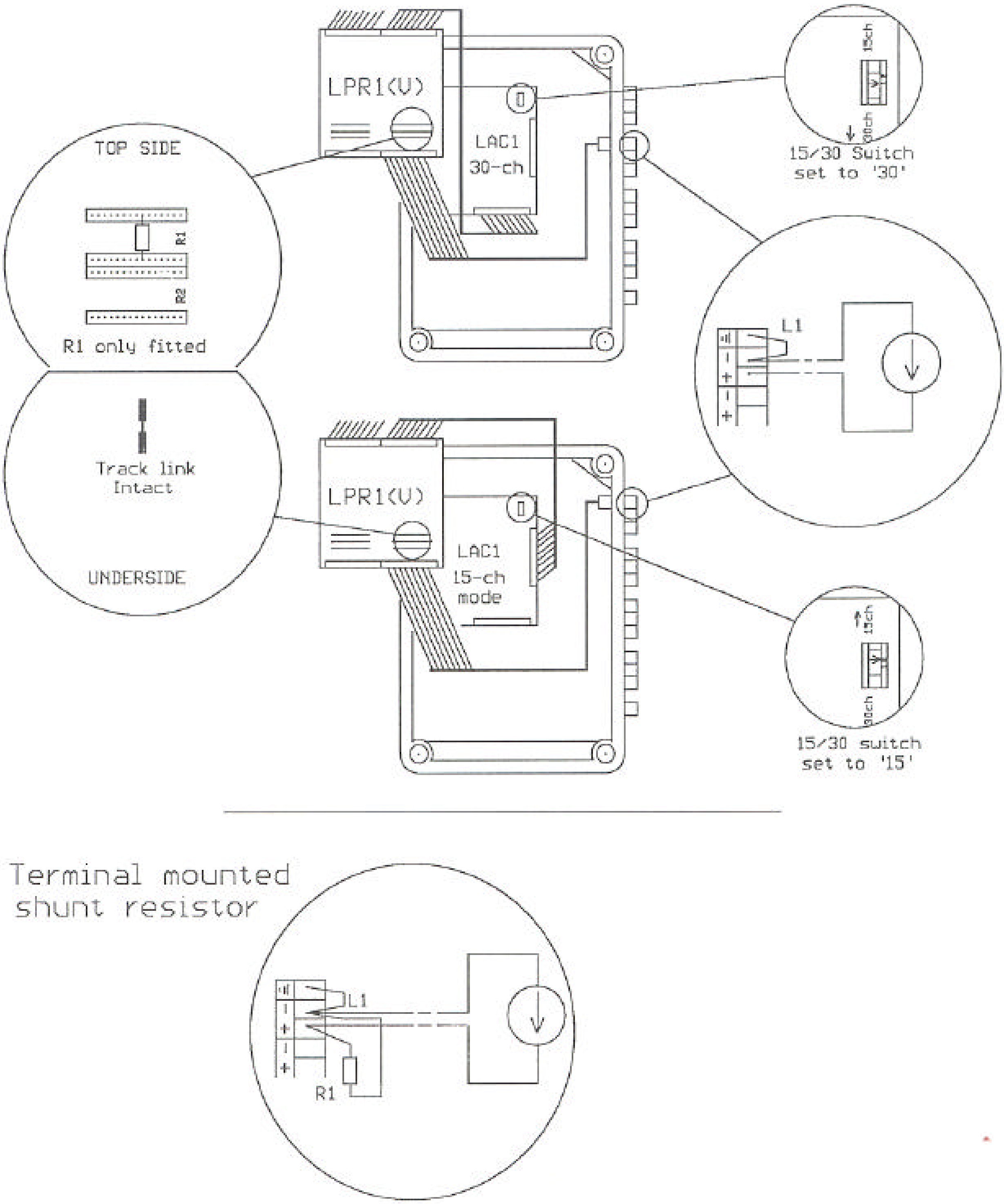


Figure 22 - Sensor connections - current

Resistance, 2-wire

2-wire connection is suitable for general-purpose resistance measurement, where cable resistance is negligible. For accurate measurement of resistance's less than about 10kΩ, use LAC1 in 15-ch mode (or LFW1). LAC1 in 30-ch mode contributes an additional error of up to ±20Ω.

Setting up

LAC1, 30-ch mode

- Set the 15/30 switch to '30'.
- Connect ribbon cable(s) from one or two terminal groups to the corresponding position(s) marked 's/e 30-channel' on the card.
- The cold junction thermistor can be switched to channel 1 for approximate temperature measurements. See Figure 23 - Sensor connections: 2-wire resistance.

LAC1, 15-ch mode (& ACD1)

- Set the 15/30 switch to '15'.
- Connect one ribbon cable only, from any terminal group to the position marked 'differential' on the card.
- Sensor connection: the + and – terminals are linked on the screw terminal block. Connect the resistance to be measured across +/- and ⏚ .
- The cold junction thermistor can be switched to channel 1. See Figure 23

LFW1

- In most cases, set the R/PRT switch to 'R'. Use the 'PRT' position if you require a resistance offset. You can compensate for it by entering a zero offset in the logging program.
- Connect one or two ribbon cable(s) from any terminal group to either or both positions on the card.

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

4. Select Electrical Measurement 'Resistance'.
5. If programming a sensor type, also select Connection Requirement '2-wire'.
6. For Excitation, select the largest excitation that can accommodate the range of resistance's that you need to measure, but note that 2000 µA excitation current is unsuitable for use with LAC1, 30-ch mode. Refer also to "Selecting a suitable excitation current" on page 108.
7. **Hint:** For sensors with linear conversion to engineering units, you can compensate for cable resistance and LAC1 30-ch mode internal errors by entering an offset value.

   To determine the offset: program the channel(s) with no offset, fit cables to each channel and short out the sensors themselves, then READ each channel to obtain the required offset value.

Accuracy

The logger's resistance measurement accuracy is fully described in Appendices A and B. Additional errors inherent in 2-wire measurements are:

- The resistance of connecting cables, which is included in the resistance measured by the logger.
- LAC1 in 30-ch mode has an additional ±20Ω (±6Ω typical) error.

Remarks

- Minimise cable resistance errors by using short cable runs of thick, low resistance cables.

LAC1 30-ch mode has an internal series resistance of 690Ω (max). The full scale resistance that can be measured is thus reduced from the nominal value for each excitation current. For example, when using 200µA excitation current, the actual full scale will be 10500Ω - 690Ω = 9810Ω (worst case).

See also

3-wire connection for LAC1, under "Resistance, 3-wire" on page 104,

4-wire connection for LFW1, under "Resistance, 4-wire" on page 106.

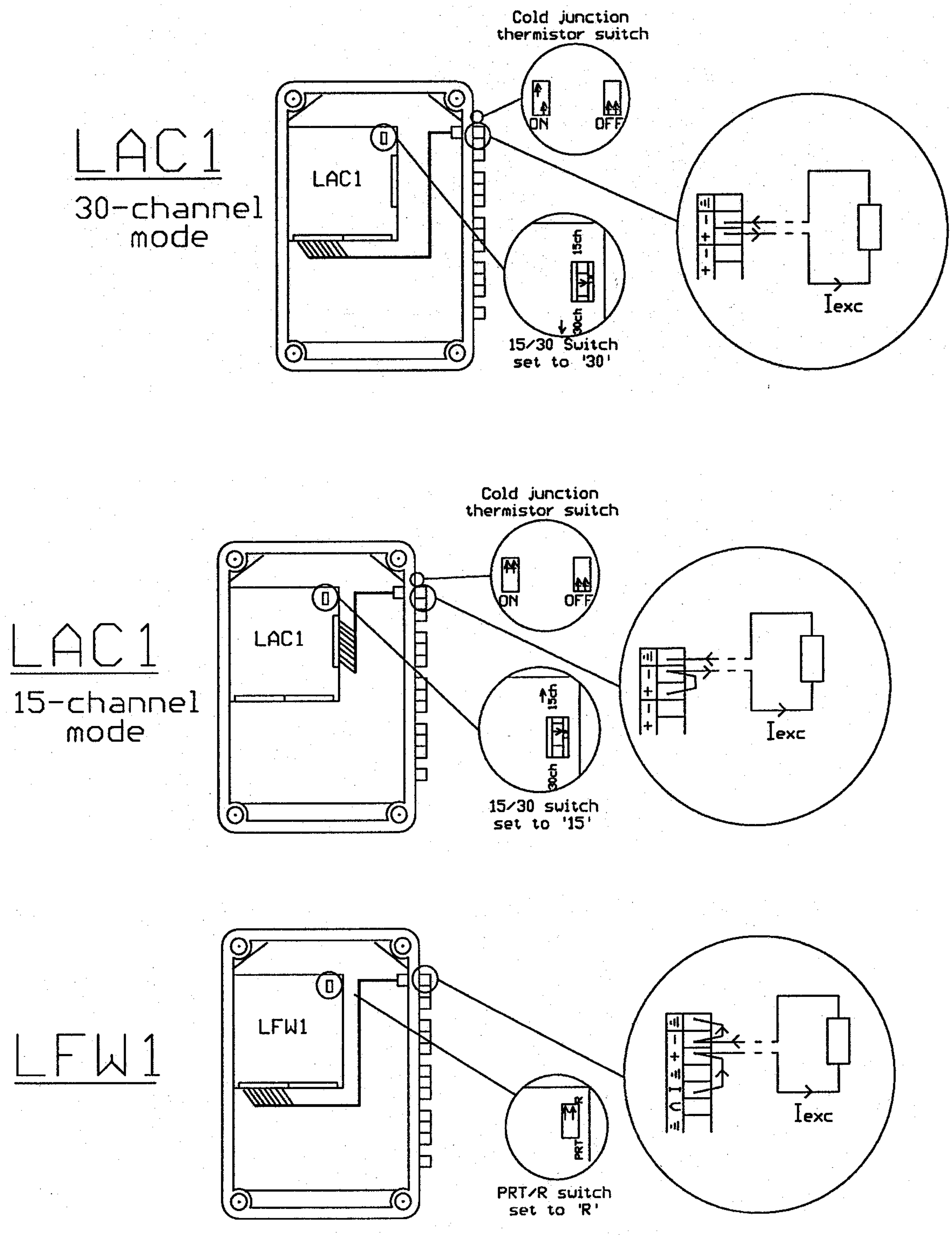


Figure 23 - Sensor connections: 2-wire resistance

Resistance, 3-wire

The LAC1 card in 15-ch mode or ACD1 can be used for 3-wire resistance measurements. This connection scheme is suitable for general-purpose resistance measurement.

Errors due to cable resistance are not completely eliminated, but are smaller than with 2-wire measurements. Only one of the sensor connection wires contributes to cable resistance error. This return wire can be made of thick low-resistance cable, and shared between several sensors for economy.

3-wire bridge

Do not confuse 3-wire resistance with 3-wire bridge measurements. Many sensors specified for 3-wire connection, for example PT100 platinum resistance thermometers, must be measured using the bridge technique. This requires an LFW1 card with precision bridge completion resistors.

Setting up

- Set the 15/30 switch to ‘15’.
- Connect one ribbon cable only, from any terminal group to the position marked ‘differential’ on the card.
- Sensor connection: the + and - terminals are wired separately to one end of the sensor. The other end of the sensor returns to earth ⏚ using low resistance cable. The return can be common to several sensors.

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

1. In the Measurement tab select Electrical Measurement ‘Resistance’.
2. If programming a sensor type, also select Connection Requirement ‘3-wire’.
3. For Excitation, select the largest excitation that can accommodate the range of resistance’s that you need to measure, but note that 2000 µA excitation current is unsuitable for use with LAC1, 30-ch mode. Refer also to "Selecting a suitable excitation current" on page 108.
4. **Hint:** for sensors with linear conversion to engineering units, you can compensate for cable resistance by entering an offset value.

   To determine the offset: program the channel(s) with no offset, fit cables to each channel and short out the sensors themselves, then READ each channel to obtain the required offset value.

Accuracy

The logger’s resistance measurement accuracy is fully described in Appendices A and B.

The only cable resistance included in the resistance measured by the logger is that of the earth return lead.

See also

"Resistance, 2-wire" on page 101.

"Resistance, 4-wire" on page 106.

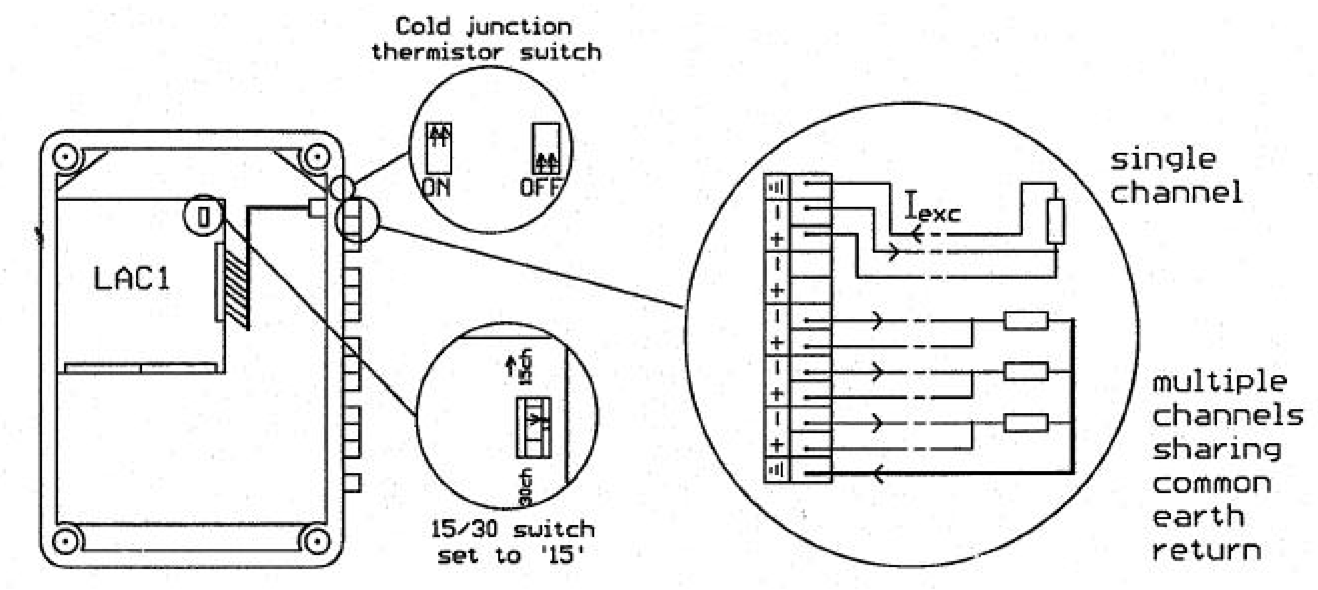


Figure 25 - Sensor connections: 3-wire resistance

Resistance, 4-wire

The LFW1 card is required for 4-wire resistance measurements. 4-wire connection virtually eliminates cable resistance errors, and is suitable for precision resistance measurements, particularly of low resistance values.

A resistance offset can be applied for accurately measuring small changes of resistance from a stable and repeatable base value. This method is particularly recommended for PT100 platinum resistance thermometer measurements.

Setting up

- Connect one or two ribbon cable from any terminal group to either or both positions on the card.

Simple resistance measurements

- Set the R/PRT switch to the ‘R’ position.

PT100, offset 20°C

- For PT100 measurements, optimised for environmental temperature measurements in the range -20° to +60°C:
- Set the R/PRT switch set to the ‘PRT’ position
- Fit jumper L1 in the ‘PRT’ position

Other resistance offsets

- Set the R/PRT switch set to the ‘PRT’ position
- Fit jumper L1 in ‘R4’ position
- Fit resistors R1 and R4, and calibrate as described in "Calibration of resistance offset" on page 76.

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

1. In the Measurement tab select Electrical Measurement ‘Resistance’.
2. If programming a sensor type, also select the appropriate Connection Requirement for the intended LFW1 card setting, ie ‘4-wire, no offset’, ‘4-wire, 20C PT100 offset’, or ‘4-wire, custom offset’.
3. For Excitation, select the largest excitation that can accommodate the range of resistance’s that you need to measure.
4. If you have chosen ‘4-wire, 20C PT100 offset’ or ‘4-wire, custom offset’, when entering conversion factor and offset values or linearisation table bear in mind that the logger measures a resistance which is lower than the real resistance value by the value of the resistance offset.

To program a channel for 4-wire PT100 measurement with resistance offset :

1. Select Input Card Type ‘LFW1, 20C PT100 offset’ for an input channel group.
2. In the Input Channel tab of the Channel Properties dialog, select sensor type *Platinum Resistance Thermometer (type Pt100), 4-wire, 20C PRT offset,* which is a Delta-T approved sensor type, provided in the standard Ls2Win sensor library.

Accuracy

The logger’s resistance measurement accuracy is fully described in Appendices A and B.

Remarks

Switching in the resistance offset has the effect of degrading the common mode performance of differential voltage measurements on the card. Avoid mixing differential voltage measurements and offset resistance measurements on the same LFW1.

See also

Bridge measurements, for accurately measuring small changes in resistance, e.g. for strain gauges (see "Bridge measurements" on page 109).

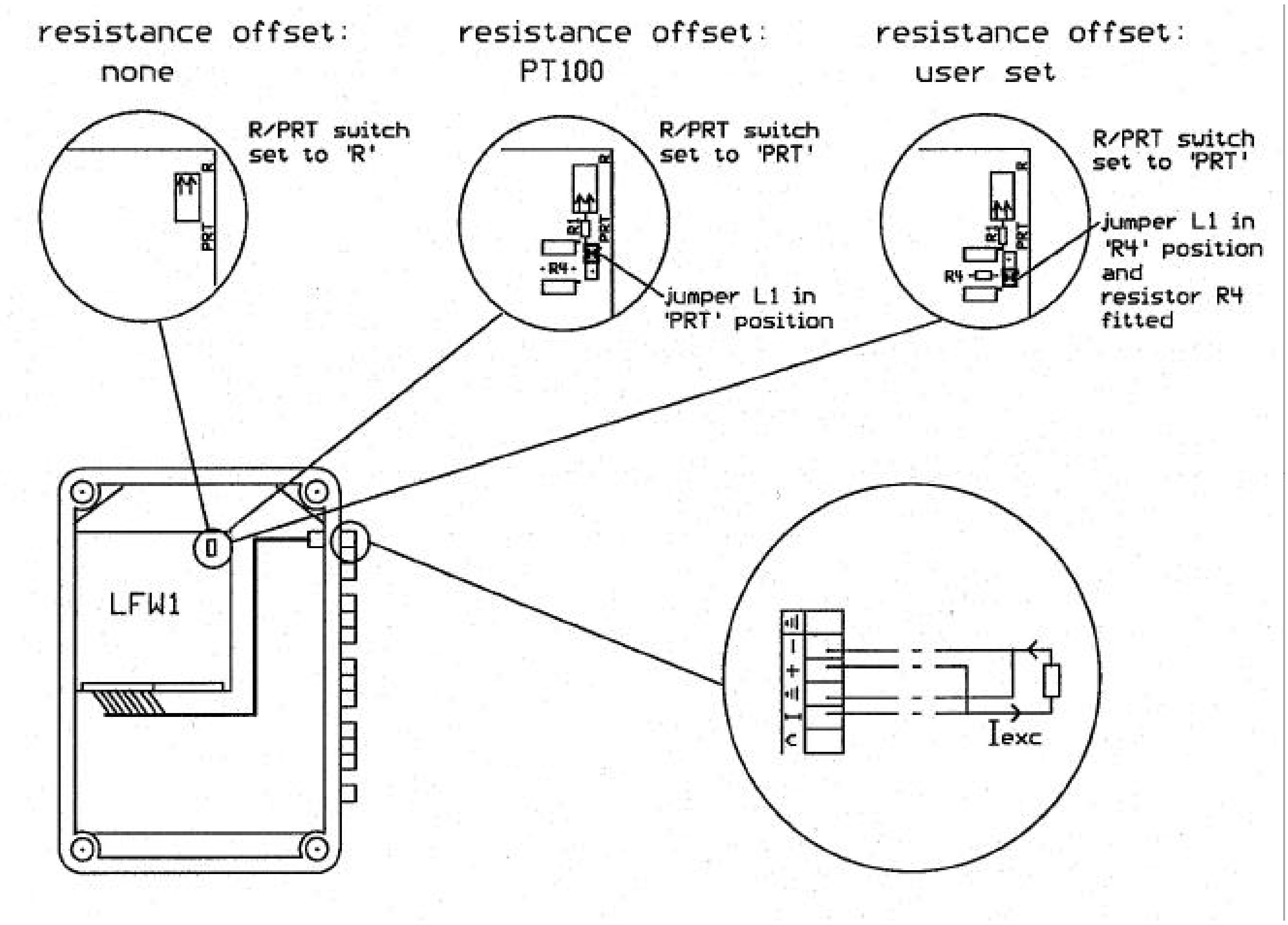


Figure 26 - Sensor connections: 4-wire resistance

Selecting a suitable excitation current

The logger measures resistance by passing a selected excitation current through the unknown resistance and measuring the resulting voltage.

Normally, you should choose the largest excitation current that accommodates the maximum resistance to be measured:

Excitation current	**2mA**	**200µA**	**20µA**	**2µA**
Standard sensor type	RR1	RR2	RR3	RR4
Maximum resistance	850Ω	10.5kΩ	105kΩ	1.05MΩ

The main exception to this rule is that the 2000µA excitation current is unsuitable for use with LAC1 in 30-ch mode. You should also consider the following:

Heating effects

The heating effect of the excitation current on resistive temperature sensors is only a problem with miniature sensors if logging at 1s intervals or using READ with the 2000µA excitation current. The factors to consider are:

- Power dissipation = I^2R, i.e. proportional to the square of excitation current
- Duration: typically, excitation current will be passed only for the duration of an analogue reading, say 0.1s. Auto-ranging may occasionally cause more than one reading as the logger changes range. Using READ applies excitation current continuously to that sensor.
- Thermal mass of the sensor
- Ability of the sensor to dissipate heat to the surrounding medium, by any of conduction, convection and/or radiation.

EXAMPLE: A miniature, 1.7mm diameter, PT100 probe has a self heating error of 0.43°C/mW in still air, falling to 0.08°C/mW in 1m/s moving air. If it were logged every second with 2mA excitation current, in still air at 0°C:

self heating error = 0.43°C/mW x I^2R x duty cycle
= 0.43°C/mW x $2mA^2$ x 100Ω x 0.1sec/sec
= 0.43°C/mW x 0.4mW x 0.1
= 0.017°C

Polarisation

Certain types of sensor suffer electrical polarisation, for example gypsum-block soil-moisture sensors. Use the ACS1 + ACD1 combination for measuring these resistances.

Leakage

Small leakage of excitation current may occur. The 2µA range is particularly susceptible, because a small leakage will have a proportionately large effect. To minimise inaccuracies due to leakage:

- Avoid the 2µA excitation current wherever possible.
- Take precautions against formation of moisture films in damp conditions, the commonest cause of leakage:
  - > Ensure the logger is fitted with fresh desiccant
  - > Spray contact oil on terminals and keep the terminal compartment dry
- Varistors used on the LPR1V card are susceptible to leakage. Avoid 2µA excitation current with LPR1V especially.

Bridge measurements

The LFW1 card is required for bridge measurements. Bridge circuits allow small changes in the resistance of one or more arms of the bridge to be measured.

A precise excitation voltage or current is applied across one diagonal of the bridge and the resulting voltage across the other diagonal of the bridge is a measure of any imbalance in the bridge resistors.

The output of the bridge is proportional to the applied excitation. Bridge sensitivity is often quoted in mV/V, that is millivolts output per volt of excitation.

Full bridge

In a full bridge, all four bridge resistors are mounted remotely from the logger. One or more of the resistors are sensing devices, with a resistance that changes in response to the applied stimulus. The remaining resistors are bridge completion resistors. In some arrangements, dummy sensors are used as bridge completion resistors, to cancel out temperature and other environmental effects.

In half and 3-wire bridges, bridge completion resistors are mounted on the logger’s terminal panel. For economy, groups of similar half or 3-wire bridges can share bridge completion resistors.

Half bridge

In a half bridge, two resistors R1 and R2 effectively act as a potential divider when excited by a voltage or current source. The completion resistors R3 and R4, provide a reference voltage so that the logger reads zero when the bridge is balanced.

3-wire bridge

A 3-wire bridge enables sensitive measurement of changes in resistance with minimal cable resistance errors, and only 3 wires to the sensor. In fig Figure 27, R1 is the sensor, and R2, R3 and R4 are bridge completion resistors. If 4-wire sensors are available, a 4-wire resistance measurement with resistance offset is easier to implement, needing no resistors mounted on the screw terminal block.

Quarter bridge

Quarter bridge is a term commonly used for 4-wire resistance measurements with a resistance offset (see "Resistance, 4-wire" on page 106).

6-wire bridge

In a 6-wire bridge the excitation voltage actually received by the bridge is sensed, rather than assumed as being equal to the excitation voltage output by the logger. To implement a 6-wire bridge, a separate logger channel should be programmed to record the excitation voltage at the bridge, and the bridge data corrected after collection to disk file. A simpler procedure is to measure the excitation voltage at the sensor manually, as described in *Conversion to engineering units* below.

Integral excitation

Another common form of bridge sensor contains an integral excitation source. This type of sensor requires a power supply rather than excitation, which may be turned on and off using the logger’s relay channels. The sensor output is measured on an individual channel as a simple voltage. See remarks below about possible common mode problems with this type of sensor.

Setting up the LFW1 card

- Connect one or two ribbon cable(s) from any terminal group to either or both positions on the card.

- Set the R/PRT switch to the 'R' position. When switched to 'PRT', the logger's common mode rejection ratio (CMRR) can be substantially degraded.

Excitation

Bridge output is proportional to the applied excitation voltage. Sensitivity is often quoted in mV/V, that is millivolts of output per volt of excitation.

Voltage excitation

A voltage source is automatically applied to the V terminal of each of the 6 channels in a terminal group whenever any channel in the terminal group is being read.

- You can adjust the voltage source for each of the two channel groups on the LFW1, if required (see " Voltage sources" on page 78).
- Ensure the current limiting LED indicator does not light. This indicates current limiting and that the voltage source output is reduced.

Current excitation

- Connect the bridge to the I terminal instead of the V terminal (Figure 27 - Sensor connections: bridge measurements), and program the channel as a resistance channel with the required excitation current (see below). The excitation current is only applied to a channel while it is being read, as for normal resistance measurements.

Bridge completion resistors

Half and 3-wire bridges require precision bridge completion resistors mounted on the logger's screw terminal blocks. These should be precise and stable, for example 0.1%, 15ppm/°C.

Half bridge

- Mount resistors R3 and R4 on the logger's screw terminal block. Select values in the range 100Ω to 10kΩ, such that R3/R4 = R1/R2 at the point where the bridge output is zero.

3-wire bridge

- Mount resistors R2, R3, R4 on the logger's screw terminal block. Select values equal to R1. For a voltage excited bridge, the I terminal can be used as a spare terminal for mounting R2.

For both half- and 3-wire bridges, the resistance of the two current- carrying wires, R_x and R_y, appear in opposite halves of the bridge. Their effects cancel out provided that they have the same resistance. It is important that these two wires are of the same length and type.

Sharing bridge completion resistors

- R3 and R4 can be shared between up to 6 similar half or 3-wire bridges in any terminal group, as illustrated in Figure 27 - Sensor connections: bridge measurements.

Calibration

Bridges can be calibrated by applying known stimuli to the sensor and noting the logger's resulting readings. This gives calibration data that can be used for configuring the logger, either by deriving a conversion factor and zero offset, or entering a linearisation table.

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

1. Voltage excited bridge:

a. Select Electrical Measurement ‘Voltage’.

b. If programming a sensor type, also select Connection Requirement ‘Bridge’.

c. There is no need to enter any information about bridge excitation: the LFW1 excitation voltage is applied to the V terminal automatically.

2. Current excited bridge:

a. In the Measurement tab select Electrical Measurement ‘Resistance’.

b. If programming a sensor type, also select the appropriate Connection Requirement for the intended LFW1 card setting, ie ‘4-wire, no offset’, ‘4-wire, 20C PT100 offset’, or ‘4-wire, custom offset’.

c. For Excitation, select the largest excitation current that matches the sensor’s specification.

3. Enter a linear conversion factor and zero offset or a linearisation table, which can be derived by calculation (ie from known sensor characteristics, for example sensor output mV per volt excitation) or by calibration (ie apply known stimuli to the sensor and note the logger resulting).

   For a current excited bridge you will need to enter conversion factor and offset or linearisation table in resistance units, so you may need to scale the bridge output accordingly.

4. Alternatively the logger can record raw voltage outputs from bridge sensors, and you can calibrate the data after collecting it to a disk file, for example using a spreadsheet.

To program a channel for 3-wire PT100 measurement:

1. Select Input Card Type ‘LFW1, no offset’ for an input channel group.

2. In the Input Channel tab of the Channel Properties dialog, select sensor type ***Platinum Resistance Thermometer (type Pt100), 3-wire bridge***, which is a Delta-T approved sensor type, provided in the standard Ls2Win sensor library.

Remarks

If the LFW1 voltage source is inadequate for your needs, for example insufficient voltage or current drive, you can provide your own bridge excitation source. You can then use a simple voltage channel to measure the sensor output. If necessary use the logger’s relay channels to switch the source on and off when taking readings.

Note that the output of a bridge typically has a common mode voltage equal to half its excitation voltage. To avoid common mode problems, ensure the external excitation source is isolated from the logger’s power supply, or bias the excitation source to ensure the bridge output is within the logger’s common mode range (see "Common mode voltages" on page 96).

The same considerations apply to powering bridge-based voltage output transducers with their own integral excitation source.

See also

- 4-wire resistance with resistance offset (1/4 bridge), on page 106.

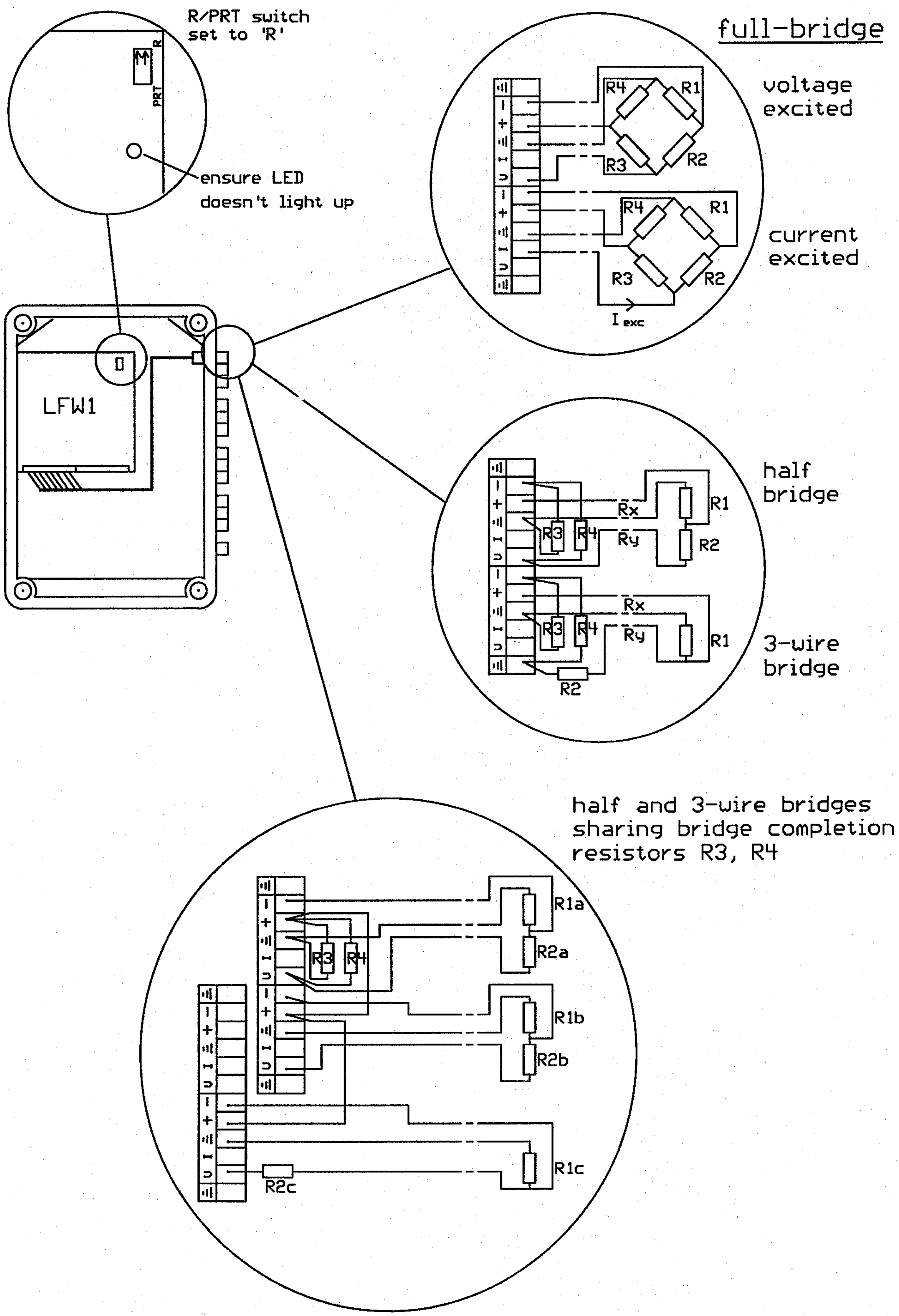


Figure 27 - Sensor connections: bridge measurements

Potentiometer

The LFW1 card is required for potentiometric measurements.

A potentiometer consists of a wiper that moves along a coil of resistance wire. Precision potentiometers are used in sensors for displacement, direction, force, and other movement sensors.

The position of the wiper can be determined by a simple resistance measurement, but a direct potentiometric measurement has the advantage of being independent of the absolute value of the potentiometer's resistance.

Setting up the LFW1 card

- Connect one or two ribbon cables from any terminal group to either or both positions on the card.
- An excitation voltage source is automatically applied to the **V** terminal of each of the 6 channels in a terminal group whenever any channel in the terminal group is being read.
  - > You can adjust the voltage source for each of the two channel groups on the LFW1, if required (see " Voltage sources" on page 78).
  - > Ensure the current limiting LED indicator does not light. This indicates current limiting and that the voltage source output is reduced.
- Wind vanes (and other rotary potentiometric transducers) have a small gap at the point where the two ends of the potentiometer meet, to prevent the wiper simultaneously contacting windings at both ends of the potentiometer. To prevent the logger recording drifting and meaningless readings, a high value (e.g. 1MΩ) resistor R1 should be fitted, to force the potentiometer output to 0V when the wiper is in the gap between the windings.

Programming Issues

When programming a sensor type, or entering measurement details for a <Custom sensor type>, proceed as follows in the Measurement tab of the Sensor Type or Channel Properties dialog:

1. In the Measurement tab select Electrical Measurement 'Voltage'.
2. If programming a sensor type, also select Connection Requirement 'Potentiometer'.
3. There is no need to enter any information about bridge excitation: the LFW1 excitation voltage is applied to the V terminal automatically.
4. When entering a conversion factor:
   a. to obtain the fractional position of the potentiometer wiper, set the conversion factor equal to the excitation voltage.
   b. If using long cable lengths, measure the excitation voltage across the sensor, to account for any voltage drop in the wiring.
   c. For wind vanes and other rotary potentiometers, refer to sensor type Windvane (type WD1), potentiometric supplied in the standard Delta-T sensor library. It has a conversion factor and zero offset for a rotary potentiometer with a 3.5° gap centred on the 0° position, excited with the factory set voltage of 1.0486V. The example below shows how these are derived:

      Conversion factor = 1.0486 / (360° - 3.5°) = 2.941 mV / °

      Zero offset = 3.5°/2, i.e. 1.75° at 0mV

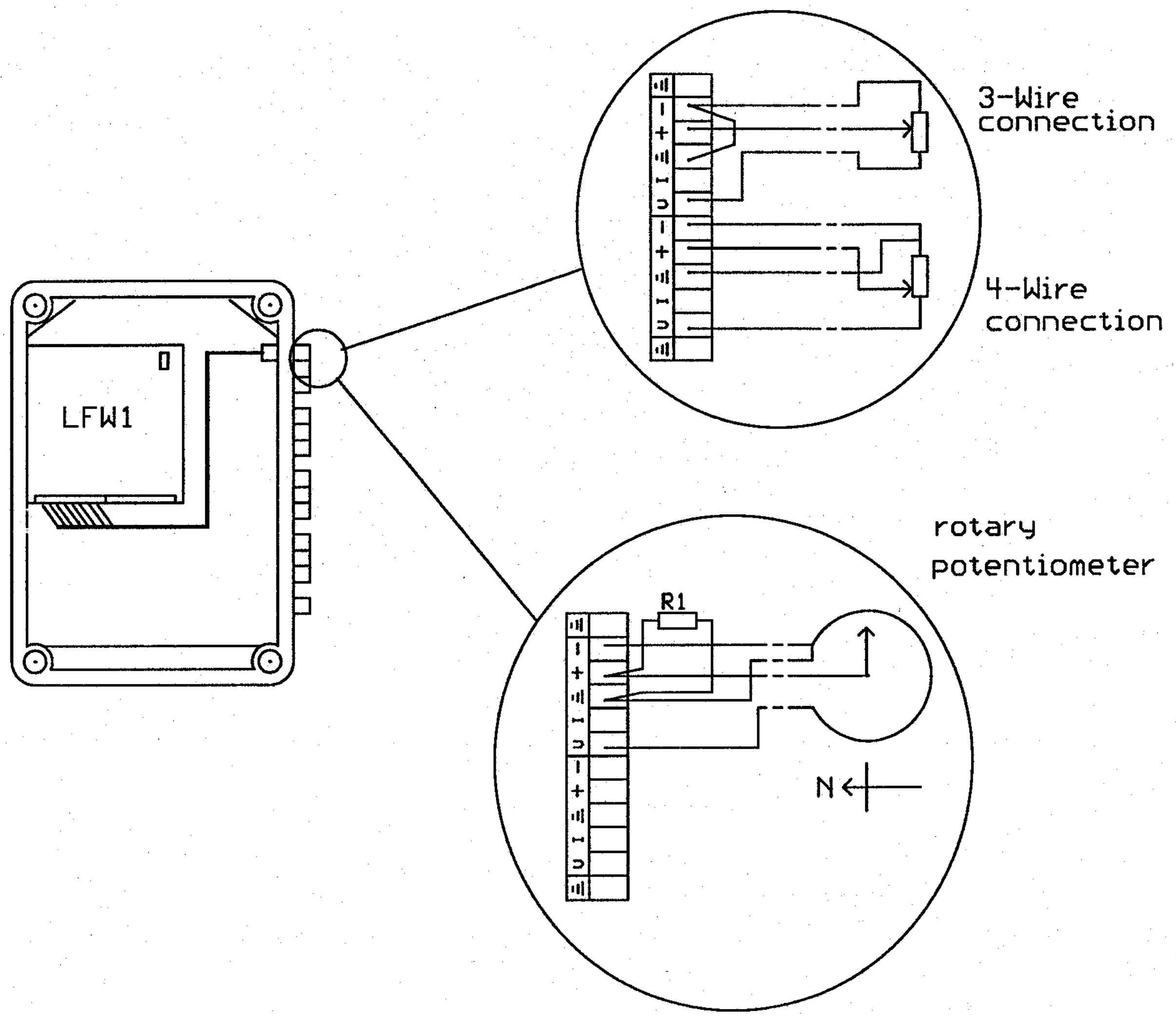


Figure 29 - Sensor connections: potentiometer

Digital inputs, and Counter Card type DLC1

Digital inputs, such as the logger's on-board channels 61 and 62 and the 15 channels provided on Counter Card type DLC1, may be used to record:

- Pulse count (over a sampling interval)
- Frequency (average pulse rate over a sampling interval)

In addition, the logger's two on-board digital channels 61 and 62 have special capabilities in being able to record:

- Digital status
- Occurrence of events. Depending on the logging program, an event can be used to set the logger logging (start trigger), or to cause data to be recorded from specified channels (data trigger).
  See also "Event trigger channels" on page 23.

Capabilities

Electrical

Inputs can be one of the following:

- mechanical voltage-free switch closures
- solid-state switches, with leakage current in the OFF state << 5µA
- logic level, TTL or CMOS, with:

  - 5.0V to +0.7V = low
  +0.7V to +3.5V = undefined
  +3.5V to +50V = high

For minimum power consumption, switches and contact sets should be of a normally open type. There is 50µA additional current consumption for each switch closed.

Counters are rising-edge triggered. The count increments when the switch opens, or the logic input goes high.

Counter capacity

Each channel can count up to 65,472 in each sampling interval. An over-range error is shown is this limit is exceeded.

Frequency response

Counter card DLC1

As supplied, the input frequency is limited to a 500Hz square wave or 1ms input high period. Briefer pulses are not counted. An RC filter on each channel limits the frequency response to reduce noise pick-up and to debounce mechanically switched inputs, preventing multiple counts from switching noise. Higher frequency pulses from digital logic can be counted by modifying the RC filter components as described below. Bursts of pulses at frequencies up to 500kHz can be counted, provided that the total count in a sampling interval is less than 65472.

On-board channels 61, 62

These have a fixed 100 Hz frequency or 5ms pulse response.

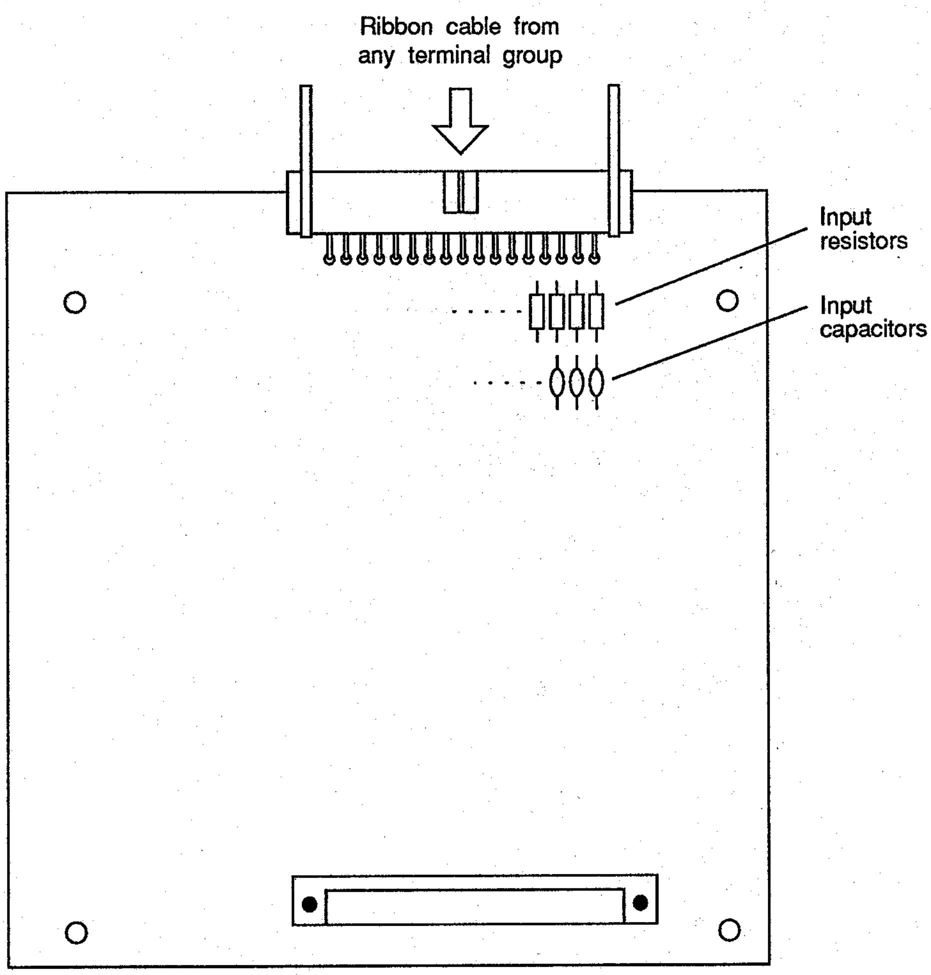


Figure 30 - DLC1 counter card

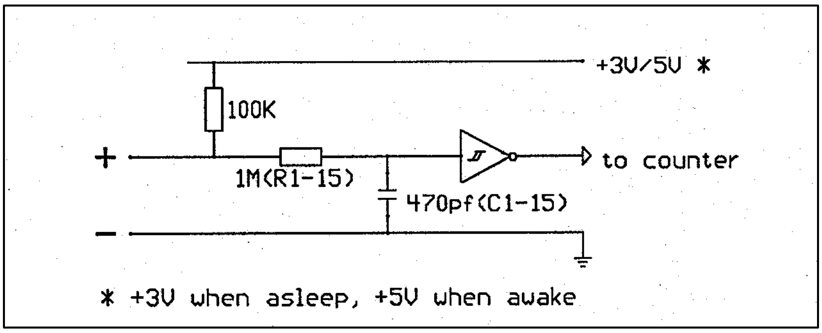


Figure 31 - DLC1 input stage schematic diagram

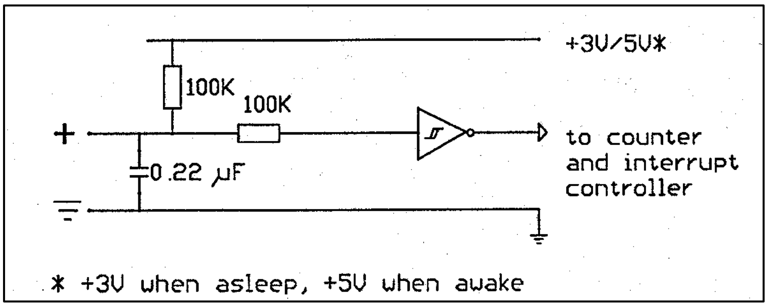


Figure 32 - On-board digital channels 61,62 input stage schematic diagram

Setting up - DLC1

Ribbon cable

- Connect to any terminal group. If using terminal group 1-15, ensure that both halves of the cold-junction thermistor switched are in the OFF position (see Figure 25 - Sensor connections: 3-wire resistance).

Counting at high frequencies

- For appropriate channels, remove or replace the socketted input capacitor, as shown opposite. For 1MHz frequency response replace the 1MΩ input resistor with 100 kΩ. The input components for channels 1-15 are numbered on the card. See Appendix E if using channel numbers higher than 15.

Min. pulse width	Max. frequency (square wave)	Input capacitor	Input resistor
1 ms	500 Hz	470 pF	1 MΩ
30 µs	15 kHz	10 pF	1 MΩ
2 µs	500 kHz	none	100 kΩ

If a clean 0-5V (e.g. CMOS logic output) signal source is used, the above maximum frequencies may be doubled.

Setting up on-board channels

- If a single data trigger channel is required, use channel 62 rather than 61. Otherwise some RAM will not be available for timed data.

Programming Issues

Programming an Input Channel

In DL2 Program Editor, if using a DCL1 Counter card, select Input Card Type ‘DLC1’ for the channel group that is connected to the DLC1 card. (For channel group 61-62, Input Card Type for is automatically set to ‘On-board digital channels’).

The Input Channel tab of the Channel Properties dialog for the channel group will then offer suitable sensor types in the Sensor Type list, or if you select <Custom sensor type> the Measurement tab will offer suitable options in the Electrical Measurement list.

Programming an Event Trigger Channel

The Channel Properties dialog for on-board digital channels 61, 62 contains a Digital Channel tab, which allows you to program these channels as ordinary input channels, or to program them as start or data triggers. Select the function that you require, then provide further details in the other tabs of the Channel Properties dialog.

Programming a Sensor Type

In the Measurement tab of the Sensor Type Properties dialog, select one of the following Electrical Measurement options:

- Counter
- Frequency

You can also select the following measurement type for use with on-board digital channels only:

- Logic Level.

Timing accuracy

Counter and frequency channels

The logger reads the number of counts that have accumulated over a sampling interval, and in the case of frequency channels, divides by the nominal length of the sampling interval. Actual intervals between sampling of counter and frequency channels are not entirely repeatable:

Over-runs

Over-runs cause late sampling, and will affect not only the reading flagged as over-run, but also the following reading which will be sampled over a shorter than nominal sampling interval.

The process responsible for over-runs can also cause the logger to get a bit behind with logging (but not sufficiently to register an over-run) with similar consequences for accuracy.

The logger assigns a high priority to logging of timed data, and over-runs only occur if event triggered logging conflicts with timed logging, or if the logger is required to log data continuously at a rate of more than a few channels per second.

Analogue channels

The time taken to take analogue readings is indeterminate. A typical analogue reading takes 100ms whereas an extreme case of auto-ranging can take 300ms. Within any group of channels with the same sampling interval, the logger reads counter and frequency channels before analogue channels in order to minimise this effect. This reading order is reflected in the arrangement of channels in data files.

Waking

The logger takes approximately 250ms to initialise itself when waking. This delay is repeatable for each waking of the logger, but the delay doesn’t occur if the logger is already awake when required to log data.

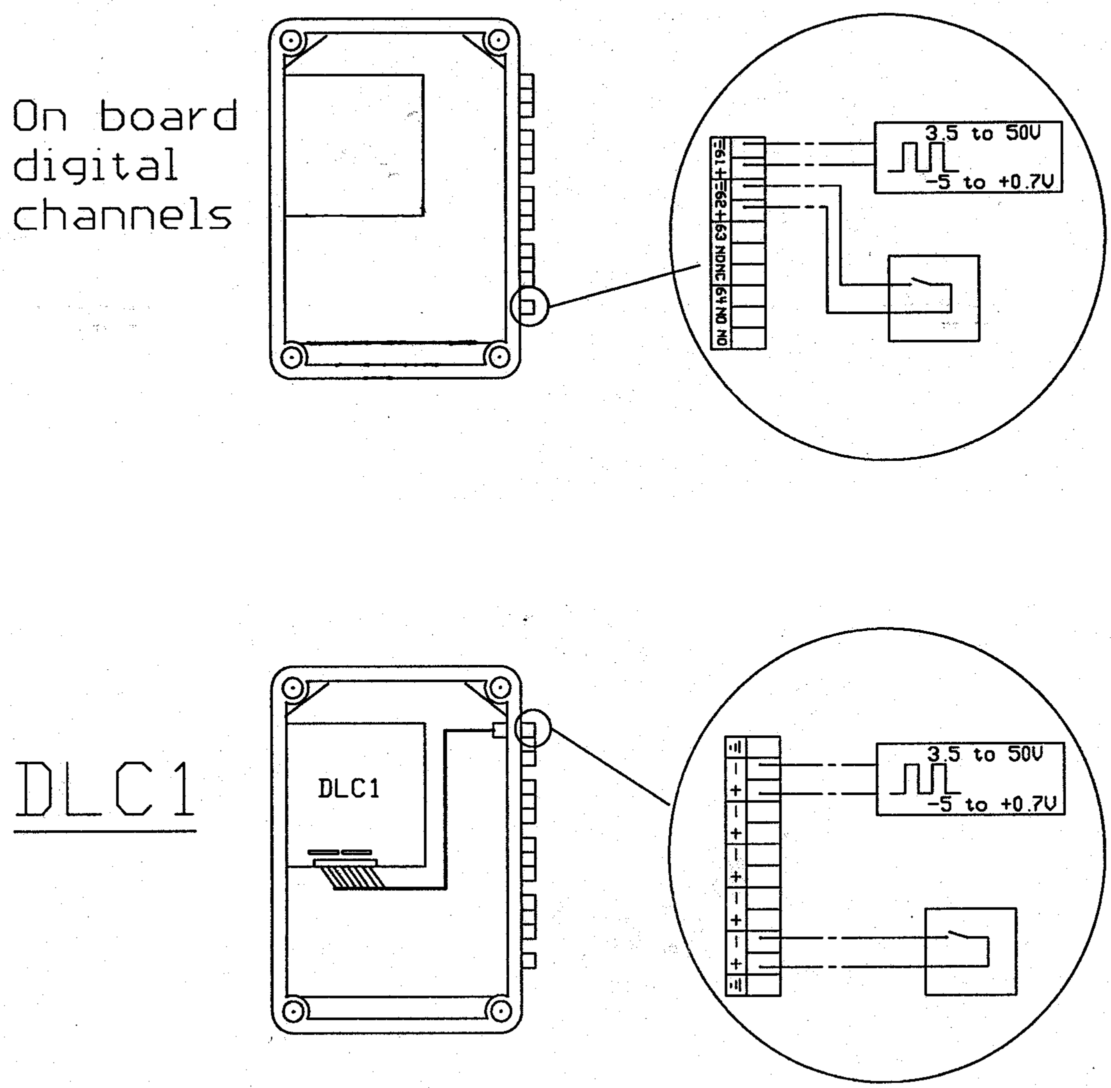


Figure 33 - Sensor connections: digital channels

Start trigger channel

The logger starts logging 1s to 2s after detection of the trigger event, just as for an immediate start.

Data trigger channel

The logger records the time when it starts to record event triggered data, rather than the time of detection of the event trigger. The size of the delay depends on whether or not the logger is already awake, and whether or not the logger is already busy with a LOG.

Providing additional digital status channels

Analogue input channels on LAC1 or LFW1 cards can be used to record digital status:

Voltage-free switching

- Fit a resistor in parallel with the switch and set up a channel for resistance measurement.

  > With the switch open, the logger measures the resistor.

  > With the switch closed, the resistor is shorted out and the logger measures 0Ω.

Logic level signals

- Fit divider resistors to measure logic level voltages, as described in " Voltage, up to ±50V DC" on page 92.
- Program the logger to take fixed range readings. If required, you can select conversion factors so that the logger returns values close to 0 and 1.

Relay channels

The logger’s relay channels 63 and 64 can be used for powering sensors or other devices, either from the logger’s own batteries or power supply, or from a completely separate power supply.

The logger’s power supply can be shared with devices requiring an unregulated supply at 7V to 15V DC. Sensors sharing the logger’s power supply should have an output which is either fully isolated from the power supply, or else has a common mode voltage less than ±2V with respect to the power supply earth.

Three different relay functions are available for controlling relay switching:

Warm-up

Used for powering up sensors a short time before taking a reading

Control output

Used for switching when the reading on an input channel crosses a prescribed threshold.

Malfunction warning

Used for switching when the logger detects a logging malfunction.

See also "Relay Channels" in the on-line Help for Ls2Win.

Electrical specification

Relay type

Changeover, or single pole double throw (SPDT), with common (labelled ‘63’ and ‘64’), normally open NO and normally closed NC terminals.

- Relay nominally OFF: NO isolated, NC connects to common.
- Relay nominally ON: NO connects to common, NC isolated.

Switching capacity

50V, 1A maximum.

Power via jumpers

When using the logger’s internal power supply, the available voltage is the battery voltage as seen by the logger. This is equal to the logger’s internal battery voltage, or, when switched to external power supply, one diode drop (around 0.7V) less than the actual power supply voltage.

Relay protection

Fuses and varistors protect the relay contacts.

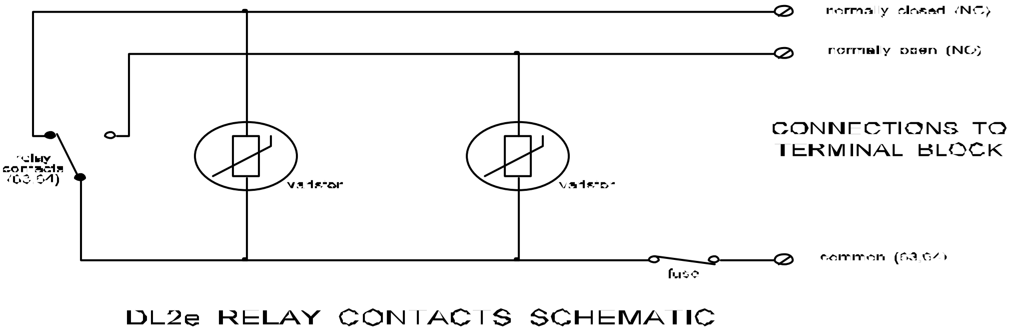


Figure 34 - DL2e relay circuit

Varistor

The varistor across the relay contacts will limit the voltage of either polarity and prevent arcing. The working voltage of the varistor must not be exceeded during normal use.

A varistor is connected across each of the relay contacts.

Varistor type

Type	RS stock No	working V	clamp V
V22ZA1	649-122	18Vdc	47Vdc

Fuses

Fuses limit the maximum current through the relay contacts, preventing welding or other contact damage.

The fuses fitted are European TR5, rated at 1A.

Fuse type

Type	Farnell stock No
TR5 1A Quickblow fuse	151-105

Setting up

Connections

- The NO terminal is the one that is connected when the relay is nominally ON. Use this terminal for normal relay operation.
- The NC terminal is connected when the relay is nominally OFF. Use this terminal if you want a control output relay to switch a device on when an input falls below the threshold value.

To draw power from the logger’s internal power supply

- Fit jumper(s) in the appropriate position(s) on the rear of the terminal panel. Otherwise, to avoid any risk of shorting out the logger’s power supply, ensure that they are removed (see Figure 34 - DL2e relay circuit).
- Use the channel 61 and 62 ⏚ terminals for power supply returns. The other earth terminals on the terminal panel are intended for earthing analogue sensors. **WARNING: Do not use one of these as a power supply return - it can cause substantial analogue errors.**
- Note that the jumpers connect the logger’s power supply to the relay common terminals. You can use these terminals for a permanent power connection.

Checking relay operation

- READ a relay channel to make it toggle between ON and OFF at 2s intervals.
- You can freeze the relay state by moving on to READ another channel (press σ or τ).
- To check operation of sensors that need to be powered by a warm-up relay:
  - > READ the warm-up relay channel
  - > freeze the relay in the ON state, then
  - > READ the warmed-up channel

See also "Exercising relay channels" on page 24.

Programming Issues

Using on-board relay channels 63, 64

In DL2 Program Editor, Input Card Type for channel group is automatically set to ‘On-board relay channels’.

The Channel Properties dialog for these channels contains a Relay Channel tab. Select a relay channel function (Warmup, Control Output or Malfunciton Warning) for these channels and provide any further information that is required in the other tabs of the Channel Properties dialog.

Remarks

If powering sensors from the logger’s power supply..

- Ensure that you have enough battery capacity to power your sensor(s) as well as the logger. A single sensor may require more power than the logger itself.
- Sharing the logger’s power supply with sensors makes the logger itself vulnerable to sensor and wiring faults. A short circuit in the sensor wiring can very quickly run down the logger’s internal battery.
- Separate power supplies for sensors are recommended for a more robust and secure system.
- If your sensor output is not fully isolated from its power supply, you will need to use fully floating differential connections to the logger (see "Voltage, differential" on page 89). Check that the sensor output has a common mode voltage that falls within the logger’s common mode range (see "Common mode voltages" on page 96). Otherwise, you will require a separate power supply for the sensor. This can be a particular problem if powering an excitation source for a bridge transducer.

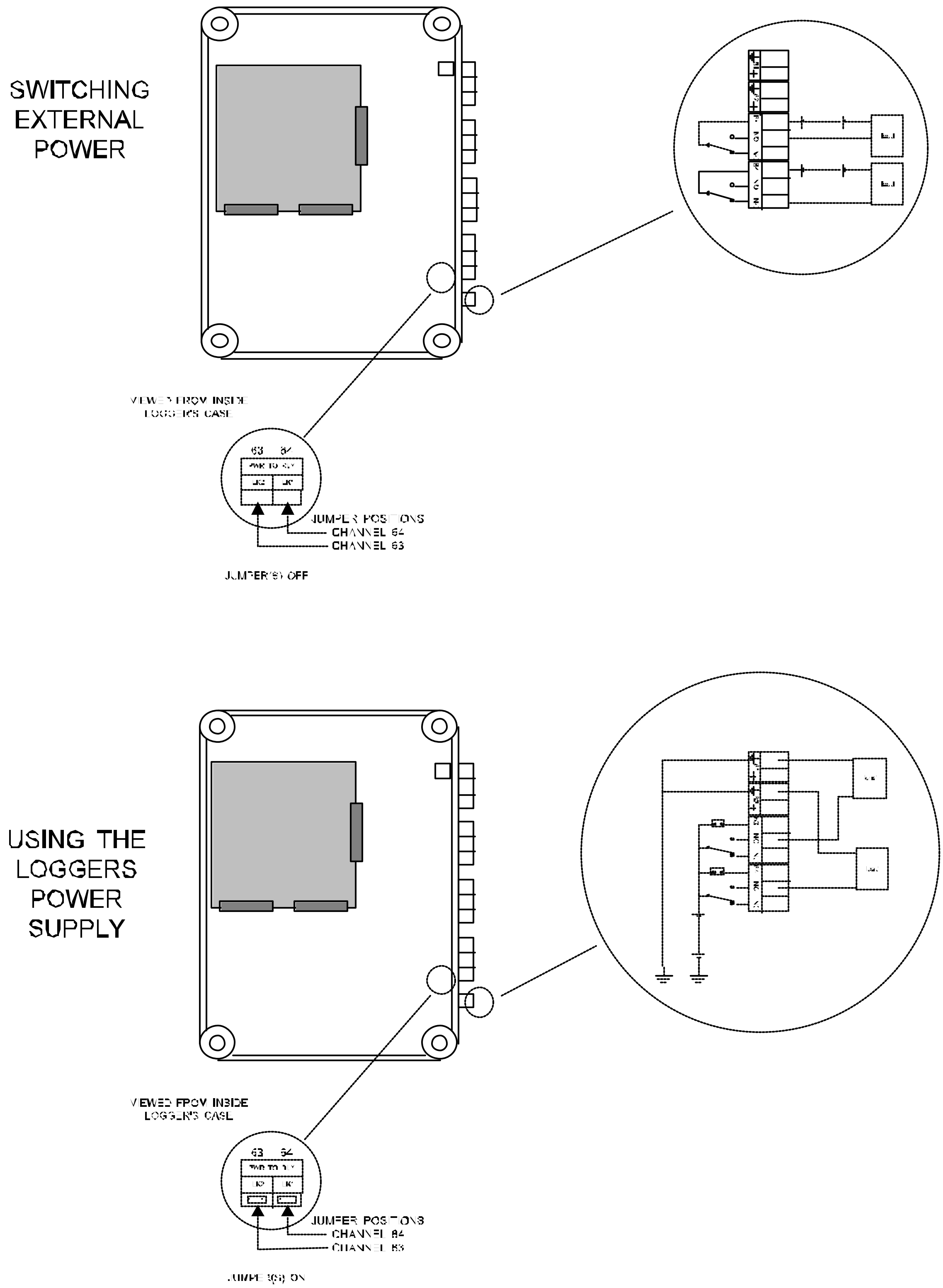


Figure 33 - sensor connections: relays

Warmed-up sensor connections

A common mistake is to connect a ‘warmed-up’ sensor to the common or NC warm-up relay terminal, to get a sensible result when first setting up and READing the sensor. For correct warm-up operation you must use the NO terminal, and READ the sensor as described above.

2-wire 4-20mA current loop transducers

The illustration below shows the wiring for switching the logger’s internal power supply to a 2-wire 4-20mA transducer.

Note that the power supply return must be kept away from the logger’s analogue earth. Use a differential connection for measuring the voltage across the shunt resistor, or mount the shunt resistor R1 on an LPR1 or LPR1V card.

See also "Current measurement", on page 98.

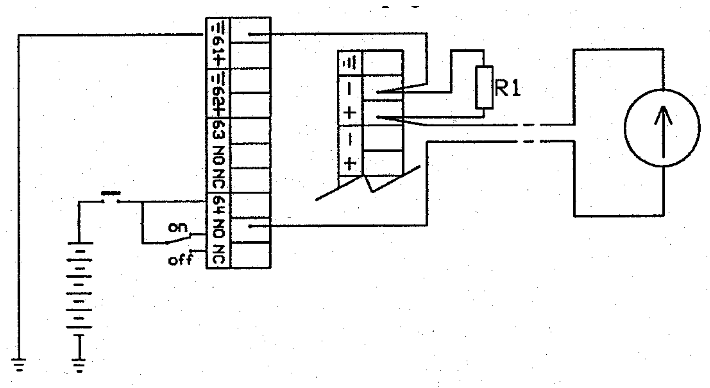


Figure 36 - Sensor connections: power supply for 4-20 mA transducers

Intermittent logging - using relay and event trigger combinations

The example below shows how the logger's relay and event trigger functions can be combined so that data is logged only when a condition on an input channel is true.

Requirement

Channel 1 is to monitor a temperature. When this temperature rises above 20°C, temperature readings are to be logged from channels 1 to 5 at 5s intervals. No readings are to be logged when the temperature on channel 1 is below 20°C.

Explanation

On starting logging, the logger monitors a temperature on channel 1 at 1s intervals and stores a 4 hour average. The warm-up relay (channel 63) switches on and off with a repeat period of 5s.

When the reading on channel 1 rises above 20°C, relay channel 64 closes. Event trigger channel 62 can now detect the switching of relay channel 63. Each time the warm-up relay opens (i.e. turns the warm-up off), channel 62 detects an event and records TRIG/62 data from channels 1 to 5.

When the reading on channel 1 falls below 20°C, the switching of the warm- up channel is no longer visible to the event trigger channel, and no further TRIG/62 readings are logged until the reading on channel 1 rises again.

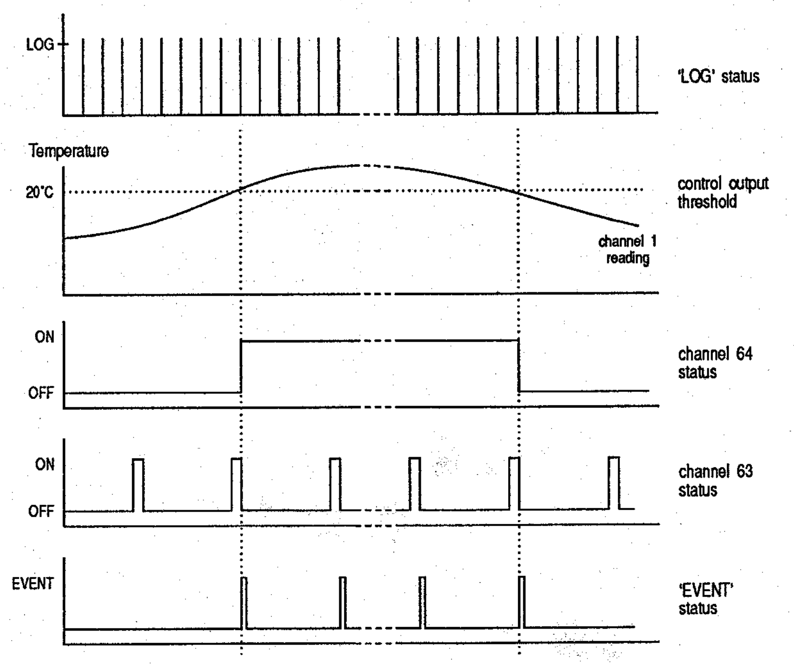
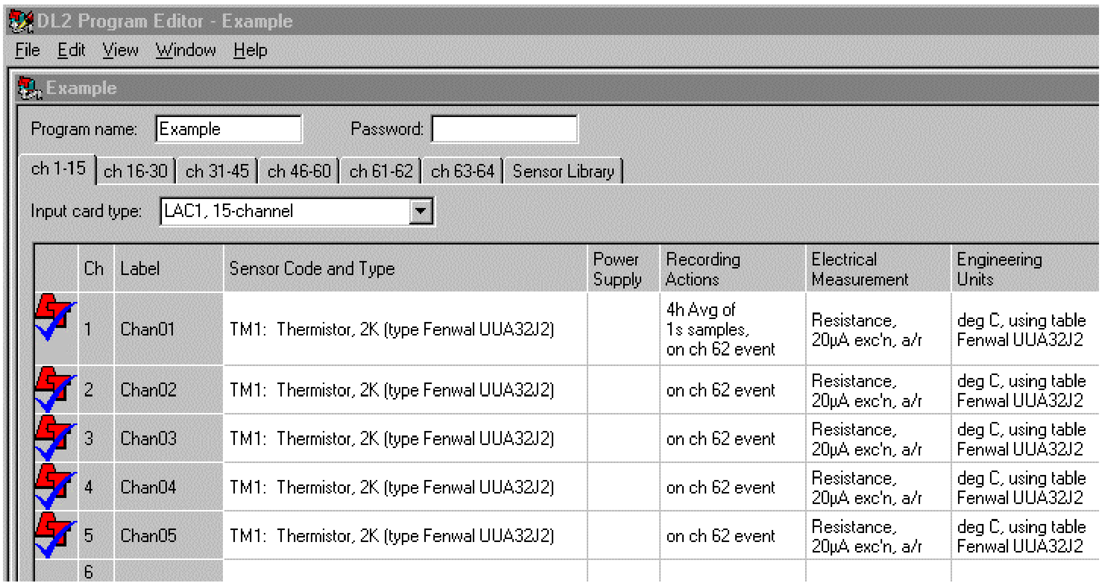


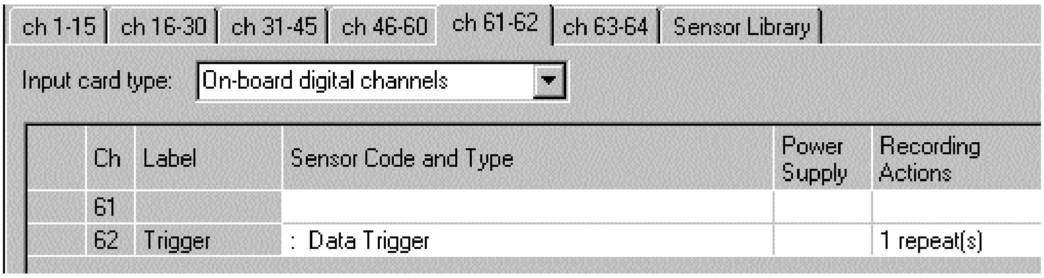
Figure 37 - Timing diagram for intermittent logging

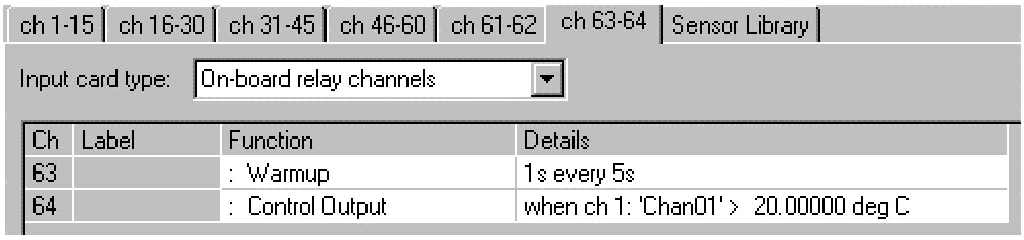
Manual control of logging

To log data on demand from an operator, a manually operated switch can replace the control output relay channel.

Example Program and Wiring for Intermittent Logging







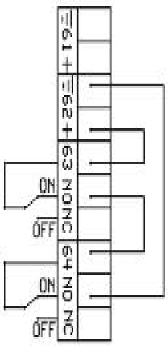


Figure 38 - relay and trigger channel wiring for intermittent logging example

Thermistors

Thermistors are low-cost resistive sensors suitable for general purpose temperature measurements.

Thermistors are manufactured from semiconducting material. They have a negative temperature coefficient, which means that their resistance decreases with rising temperature.

The main point in their favour is that they respond to temperature changes with a relatively large change in resistance (a typical temperature coefficient at 25°C is -4.5% per °C), and this makes them easy to use for temperature measurements without resorting to specialist measurement techniques.

A disadvantage of thermistors is that their response to temperature is highly non-linear, and linearisation tables spanning wide temperature ranges may contain significant errors. This is not an issue for environmental temperature measurements in the range -20 to +60°C.

Although thermistors can't match the accuracy and stability of high quality Platinum Resistance Temperature Detectors, they are considerably easier to use. When used with the logger for environmental temperature measurements, thermistors can give temperature measurements of accuracy comparable with PT100's, at a fraction of the cost

Thermistors are available in a variety of forms:

- nominal resistance values range from tens of ohms to megOhms at 25°C.
- temperature range: around -80°C to +150°C is common, but wider temperature range versions to 100's of °C are available
- accuracy: 0.2 °C is common, more expensive 0.1°C versions are available.
- shape and size: The commonest form is encapsulated in a match-head sized bead. Other forms are available for specialist applications, for example miniature chip thermistors which are suitable for suitable for attaching to leaves for measuring leaf temperature.

Among the commonest are Fenwal Unicurve 2K, 2K252, 10K, and 100K. The logger has resident linearisation tables for these thermistors, covering the range -20°C to + 60°C. These are given sensor codes TM1 to TM4.

Using thermistors with the logger

Sensor Connections

High resistance thermistors, 10K to 100K

2-wire connection using LAC1 in 30-ch mode give adequate results.

2µA excitation current has to be used for measuring resistances greater than 100KΩ, and there is a possibility of introducing significant errors due to current leakages, especially in damp conditions.

Low resistance thermistors, less than 10K

LAC1 in 15-ch mode gives significantly better results than 30-ch mode, which suffers from an additional 20Ω error.

2-wire connection is adequate provided that cable resistance is negligible. If necessary, eliminate cable resistance effects with 4-wire connection using LFW1, or minimise by using 3-wire connection to LAC1 when only one of the sensor leads contributes to cable resistance error. Consider using a common return for multiple 3-wire connected sensors (see "Resistance, 3-wire" on page 104).

Programming the logger

Fenwal Unicurve and equivalent thermistors

The logger has resident linearisation tables for four common thermistors, spanning the range -20°C to +60°C. These correspond to sensor types TM1, TM2, TM3, TM4.

Theses tables are listed in Appendix D and can also be viewed, copied and modified in the DL2 Program Editor's Sensor Library.

Other thermistors

To create a new sensor, you may copy and modify an existing sensor type in the Sensor Library tab of the DL2 Program Editor. See the on-line Help for details.

Remember that thermistor linearisation curves have a negative slope.

For maximum accuracy and resolution, select the largest excitation current that covers the resistance-span of the linearisation table.

Accuracy

On-board cold junction thermistor

The logger's on-board cold junction thermistor is specified to an accuracy of 0.1°C for 0°C to 70°C, and 0.13°C from -20°C to 0°C.

Logger contribution to thermistor errors

The table below shows the maximum logger contribution to thermistor errors for common thermistors measuring a temperature in the range -20°C to +60°C:

Maximum °C errors due to logger operating temperature.

Connection:	LAC1/15-ch or LFW1		LAC1/30-ch	
Logger Temp:	20°C	-20°C to +60°C	20°C	-20°C to +60°C
Thermistor type	**Maximum °C errors due to logger**			
2k, 2k252	0.14°C	0.17°C	1.24°C	1.25°C
10k	0.29°C	0.62°C	0.47°C	0.74°C
100k	0.39°C	0.93°C	0.39°C	0.93°C

See Appendix B for a worked example of a logger accuracy calculation.

Errors due to cable resistance

With 2K and other low value thermistors on long thin cables, the cable resistance may cause slight errors. The increased resistance reading causes a reduction in the temperature reading. The following table shows the °C error per ohm of cable resistance:

Thermistor type	**°C error per extra W resistance at temperature:**			
	-20°C	+20°C	+40°C	+60°C
2k, 2k252	-0.001	-0.009	-0.023	-0.055
10k	-0.0002	-0.002	-0.005	-0.01
100k	-0.00002	-0.0002	-0.0004	-0.001

Note that:

- The effect is temperature dependent and most pronounced at higher temperatures when the thermistor resistance is low.
- For 2-wire connection, the resistance of both connecting leads must be included. For 3-wire connection, only the return lead contributes to the error.

Platinum Resistance Thermometer and other RTDs

Resistance Temperature Detectors (RTDs) are resistive temperature sensors made from metallic conducting materials.

Although other materials are in use, the commonest RTD material is platinum. Its temperature response is highly stable and repeatable. Platinum Resistance Thermometers offer a means of making extremely accurate temperature measurements in the range -259°C to 631°C.

The PT100 sensor is the commonest form of Platinum Resistance Thermometer, with a resistance of 100 Ohms at 0 °C. It is available in a number of different accuracy specifications, for example:

Specification	Accuracy
DIN	0.41°C
1/5 DIN	0.08°C

Unlike thermistors, the PT100 and other RTDs have a positive temperature coefficient, i.e. resistance increases as temperature rises. They have a much less non-linear temperature response. This means that linearisation tables covering a wide temperature span can be used without introducing unacceptable linearisation errors.

The main disadvantage of RTDs, platinum and other materials, is their low temperature coefficient (around 0.4% per °C for platinum), which means that simple resistance measurements are not adequate for making use of their potential accuracy. The resistance offset facility on the LFW1 card is recommended for accurate RTD measurements.

Using PT100 And other RTDs with the DL2e logger

Sensor connections

- A rough temperature measurement can be obtained using 2-, 3- and 4-wire connection to LAC1 in 15-ch mode or LFW1 without resistance offset using sensor code PRT. These measurements will be inaccurate, as seen below. Do not confuse the logger’s 3-wire resistance measurements with 3-wire sensors intended for 3-wire bridge connection.
- The recommended technique is to use the LFW1, with offset. The factory set default is for PT100 measurements centred on 20 °C.

Programming the logger

There are three LFW1 Input card type options in the DL2 Program Editor corresponding to the three possible combinations of the R/PRT switch and the L1 jumper (R4 or 20°C) on the LFW1 board.

PT100 using simple resistance measurement

If the LFW1 card has the R/PRT switch set to "R", signifying no offset, then select **Input card type** "LFW1, no offset" in the DL2 Program Editor.

For the Sensor Type select the "Platinum Resistance Thermometer (type Pt100), simple resistance" from the sensor library (sensor code PRT).

PT100 centred on 20 °C, using LFW1 with offset

If the LFW1 input card has the R/PRT switch set to "PRT" and jumper L1 in the "20°C" position then select Input card type "LFW1, 20C PRT Offset" in the DL2 Program Editor.

Use sensor code PT4, of type "Platinum Resistance Thermometer (type Pt100), simple resistance" supplied in the sensor library. This suits PT100 sensors with a temperature coefficient of 0.385Ω per °C

Other RTD using LFW1 with offset

Create a new sensor type. When entering a linearisation table, remember to subtract the offset from the resistance values that you enter in the table.

Accuracy

Logger contribution to PT100 errors

The table below shows the maximum logger contribution to PT100 temperature measurements, without and with resistance offset:

		Logger Temperature	
		+20°C	-20°C to +60°C
	PRT Temp. range	**Max Error**	
LAC1/15-ch or LFW1 without offset	-200°C to +80°C	0.37°C	0.78°C
	+80°C to +600°C	2.0°C	6.3°C
LFW1 with 107.79 Ω resistance offset	-17°C to +57°C	0.06°C	0.20°C
	-220°C to +317°C	0.43°C	1.08°C
	+317°C to +836°C	3.34°C	8.06°C

See Appendix B for a worked example of a logger accuracy calculation.

Errors due to cable resistance

For 2- or 3-wire connection, cable resistance has a big effect on the accuracy of PT100 readings: 2.6°C error per W.

For 4-wire connection to LFW1 the error is less than 0.001°C error per W.

Thermocouples

Thermocouples are sensors that generate a voltage output. They comprise a junction of two dissimilar metals, e.g. copper/constantan.

The thermocouple's output voltage depends on the pair of metals used, and is roughly proportional to the temperature difference between the thermocouple junction and a cold junction. Thermocouple cable is made of the thermocouple materials, and the cold junction is the point at which the thermocouple cable terminates in a connection to measuring instrument, or a junction box.

To obtain an absolute temperature reading, the temperature of the cold junction has to be measured and added to the temperature difference derived from the thermocouple voltage. The logger can perform this calculation, which is known as 'cold junction compensation' or 'cold junction referencing'.

The logger's terminal panel is designed to be isothermal (i.e. all terminals held at the same temperature). It has a thermistor mounted on it to measure its temperature. The thermistor can be optionally switched into channel 1 to provide a cold junction temperature for thermocouple measurements.

Thermocouples are small and rugged, some capable of measuring temperatures in excess of 1000 °C. Because they are derived from voltages, thermocouple measurements are not adversely affected by cable resistance, but long lengths of unscreened cable may pick up electrical noise which can cause errors.

Disadvantages are that the sensors themselves are not very accurate (see below) and additional errors arise from measurement of the cold-junction temperature. Their output for small temperature differences is low, typically 30 to 40 µV per °C. The logger's voltage offset can therefore cause an error amounting to a significant fraction of a °C.

Accuracy

Typical errors of common thermocouples, measuring -20°C to +60°C:

Thermocouple	Error
Class 1 types J, K	1.5°C
Class 1 type T	0.5°C

Using thermocouples with the DL2e logger

Setting up

Sensor connections

Single-ended voltage connection is suitable for many applications, but bear in mind the following points:

- A large offset (typically 20µV) is possible on LAC1 voltage measurements in 30-ch mode, corresponding to errors of 0.5 °C or more. Use LAC1 in 15-ch mode if this is unacceptable.
- Beware of creating earth loops. In particular, avoid bare sensors in contact with metalwork or conducting substances such as water. If unavoidable, use fully floating connections, but beware of common mode problems (sees "Earth loops" on page 95 and "Common mode voltages" on page 96).
- In electrically noisy conditions, noise rejection can be achieved by using screened thermocouple cable and earthing it to the logger, or by earthing the sensor or fitting bias resistors (see "Voltage, differential" on page 89 for details).

Cold junction compensation

- Use the on-board cold junction thermistor switched into channel 1.
- LAC1 should be set to 15-ch mode for better accuracy, but can be set to 30-ch mode if reduced accuracy is acceptable.

Isothermality

The logger's terminal panel is designed to be isothermal under stable conditions of use.

- Avoid situations that can cause temperature differences to develop across the terminal panel, resulting in cold junction errors. For example:
  - > Thermocouple cables, warmed by exposure to direct sunlight or other heat sources, can conduct heat into the terminal panel.
  - > Rapid change in the logger's temperature, e.g. moving it from a cold to a warm place, can cause uneven warming or cooling of the terminal panel.

Programming the logger

J, K, T type thermocouples

The logger has resident linearisation tables spanning the range -120°C to +200°C for J, K, and T type thermocouples.

- Use the corresponding sensor codes **TCJ, TCK, TCT** respectively. The tables are listed in Appendix E.

Other thermocouple types

- Create a new sensor code and enter a linearisation table. Note that the table must include the expected cold-junction temperature to enable the logger to perform cold-junction compensation calculations.

Cold junction compensation

- Program the cold junction channel before the thermocouple channel itself:
  - > On-board thermistor: specify sensor code TM1 for channel 1.
  - > Other cold junction channel: program a channel as a temperature-measuring channel. Note that the logger requires cold junction channels to be linearised channels, expecting an RTD or thermistor, but not another thermocouple.
- Leave the cold junction channel with no sampling interval if you are not interested in logging the cold junction temperature itself. Then enter the cold junction channel number for the thermocouple channel.

Accuracy

As mentioned above, thermocouples in themselves are not very accurate. There are further contributions from cold junction temperature error, as a result of non-isothermality, and from logger input offset voltages.

Logger contribution to thermocouple errors

The tables below show the errors arising from the logger's measurement of thermocouple voltages:

Maximum logger contribution to thermocouple errors (uncompensated)

Measurement range:		-20°C to +60°C		-120°C to +200°C	
Logger temperature:		20°C	-20°C to +60°C	20°C	-20°C to +60°C
		Logger Error			
Thermocouple	type J	0.27°C	0.42°C	0.95°C	2.09°C
	type K	0.25°C	0.54°C	1.79°C	2.85°C
	type T	0.36°C	0.55°C	0.80°C	1.76°C

A cold junction measurement error has to be added to these figures:

Logger temperature:	**20°C**	**-20°C to +60°C**
Thermistor contribution	0.1°C	0.13°C
Logger contribution	0.14°C	0.17°C
Maximum total	0.24°C	0.30°C

Appendices

Appendix A : DL2e Technical Specifications

Logging

Logging interval and speed

1, 5, 10, 30 sec, 1, 5, 10, 30 min, or 1, 2, 4, 12 or 24 hours, programmable for each channel. Readings can also be reduced to averages, maxima or minima at these intervals. Typically 10 channels/sec.

Input channels

60 Channels maximum, depending on the number and type of input cards installed, plus 2 resident digital inputs and 2 relay outputs.

Analogue inputs

Analogue Card, LAC1

Each LAC1 multiplexer card can select analogue inputs from:
Either: 15 channels of differential voltages and 3-wire resistances
Or: 30 channels of single-ended voltages and 2-wire resistances.

It directly measures voltages up to ±2V or resistances <1MΩ.
Voltages up to ±50V and currents can be measured using attenuator resistors, mounted on the input screw terminals or on an LPR1 or LPR1V card.

Analogue Card, ACD1

Each ACD1 card can select analogue inputs from 15 channels of differential voltages and 3-wire resistances.

It directly measures voltages up to ±2Vdc, 2Vac rms, or resistances <1MΩ.

4-Wire Card, LFW1

Each LFW1 card can select up to 12 bridge, potentiometric, differential voltage, or 2- or 4-wire resistance sensors.
4-wire resistance measurements virtually eliminate cable resistance errors.

PT100 platinum resistance thermometers, (e.g. DIN 43760/BS1904 type) are measured over -200°C to + 850°C.
In the -17°C to +57 °C range of logger and PT100 temperature, 0.01°C resolution and 0.2°C accuracy is obtained.

Voltage source

1.0486V to approx. 4V, adjustable, 60mA max per group of 6 channels.
Output impedance < 0.5Ω
Temperature coefficient < 50ppm/°C
1.0486V repeatability < 0.5mV

DC Voltage readings via LAC1, ACD1 or LFW1

12 bit + sign. 4 Ranges, user-selected or autoranged:

Range	Full Scale	Resolution
1	±4mV	1μV
2	±32mV	8μV
3	±262mV	64μV
4	±2.097V	0.5mV

Errors

Maximum values shown with typical figures in brackets:

Logger Temperature	20 °C	-20 °C to 60 °C
Full scale error	±0.07% (0.04%)	±0.02% (0.1%)
Long term stability	±0.25% (0.02%) over 1 year	
Differential Offset	±10 μV (3μV), ±0.02%	±12 μV, ±0.02%
Noise	0.2μV RMS	
Input Impedance	approximately 100 MΩ	
Common Mode Range	±2V (or ±1.05V if + input closer to logger 0V than - input)	
Common Mode Rejection ratio	140 dB typical, on voltage range 1	

AC Voltage readings via ACD1

12 bit + sign. 4 Ranges, user-selected or autoranged:

Input type and frequency	Input Level (mV ac rms)	Accuracy
Sinusoidal signals 45 to 60 Hz -20 to + 60 °C	0 to 10 10 to 50 50 to 100 100 to 2000	Zero reading in this range ±3mV ±0.6 % of reading ±0.25mV ±0.6% of reading
Sinusoidal signals 65 to 1000 Hz	10 to 2000	Maximum additional error ±0.5% of reading.
Non-sinusoidal signals Crest factor 1.0 to 1.7 (square or triangular wave)	10 to 2000	Maximum additional error ±1.0% of reading
Common mode rejection	at dc up to 1kHz	0.1% (= 65dB) 0.5% (= 45db)

Resistance readings dc via LAC1, ACD1 or LFW1

Autoranging 12 bit voltage readings with programmable 2, 20, 200 or 2000µA excitation, giving 1MΩ full-scale or <0.01Ω resolution.

Accuracy

As voltage readings, with additional errors:

Logger Temperature	20°C	-20 to +60 °C
2 µA current	±0.3% full scale	±0.6% (to + 50°C)
Other currents	±0.05%	±0.1%
2-Wire LAC1 only	±20Ω (6Ω typical) additional offset.	

See also Appendix B.

Resistance readings ac

Using ac excitation card type ACS1 & ACD1.

Accuracy

Overall system accuracy ±2% for R= 500 to 30,000 Ohms.

Input protection

Analogue inputs withstand ±15V continuously, and much higher voltages in brief pulses. For additional protection, see LPR1V below.

Attenuator Card, LPR1

For use with LAC1 Analogue Card only.
Provides sockets for signal conditioning resistors for 30 channels.
Resistor positions may be left vacant or resistors fitted in shunt or divider configuration, respectively for measuring currents up to 0.1 Amp or voltages up to ±50V.

Input Protection Card, LPR1V

Connects transient-absorbing varistors to 30 LAC1 Analogue Card inputs, or 12 LFW1 4-Wire Card inputs, for additional input protection.

Also provides socketted resistor positions for signal conditioning, (only suitable for this application when used with LAC1 - see LPR1 above). Avoid using LPR1V when measuring resistances >100KΩ, as varistor leakage currents may be a source of significant error.

Digital inputs and outputs

Digital inputs

All DL2e's have 2 resident 16-bit counter channels that can continuously monitor logic levels or switch-closures, recording digital status, counts or frequency (up to 100Hz), or can trigger special logging sequences.

Relay outputs

2 SPDT relays for powering up sensors, or providing alarms or malfunction warnings. 1 Amp, 50 V contact rating.

Counter Card, DLC1

Each DLC1 card provides up to 15 extra 16-bit counter or frequency channels. Maximum frequency: 500Hz/1ms pulse for switch closures, 500kHz for 5V logic level signals (see page 117 for details). Each channel can log up to 65,472 counts between scans.

Other specifications

Processing

The logger can convert readings into engineering units using linearisation tables or a conversion factor and zero offset. User-expandable sensor library includes Delta-T sensors, Platinum Resistance Thermometers, Thermistors (Fenwal 2K, 2K252, 10K and 100K types) and Thermocouples (types J, K and T). Cold junction temperature measured at isothermal terminals.

For thermistor errors see also page 129.
For Platinum Resistance Thermometer errors see page 132.
For Thermocouple errors see page 133.

Display

A 2 line LCD shows instantaneous output from any sensor (in engineering units), time, battery and memory condition, and status messages, without disturbing logging.

Memory

Highly reliable 2 battery-backed RAM.
Expandable from 64K to 128K timed readings.
Automatic RAM check.

Data format

ASCII, easily loaded into spreadsheets and other popular software, such as Excel etc.
Transmitted readings are date/time stamped, labelled in engineering units with errors flagged.
Data files, created by the Ls2Win, are comma separated.

Interface

RS232 Serial interface up to 9600 Baud.
Up to 10,000 readings transferred per minute (without disturbing logging).

Computers & Software

The logger Windows software LS2Win enables a PC to communicate with the logger, edit logging programs and collect accumulated data.

To operate the logger from your PC you need the following:

- A PC running Windows 95, 98, 2000 or NT4.0 Service Pack 4, or later.
- One free RS232 serial port.
- CD-ROM drive (required for installation.
- at least 16M RAM memory and 5M of hard disk space.
- Logger-PC RS232 cable: Type LRS1 available from Delta-T, or you can make one up. See "Communications cables" on page 51.
- Ls2Win distribution disk.

Power

6 internal AA alkaline cells provide power for 500K readings, or 24 hours of keypad/LCD or RS232 interface operation. The internal lithium cell will retain memory for 2 months in the event of a power supply failure.

Environmental

Operating temperature: -20°C to +60°C. IP65 weatherproof case with desiccant and humidity indicator.

Dimensions and weight

Size: 280 x 220 x 140 mm, Weight: 2.7kg.

Rechargeable battery pack LBK1

Battery type

Dryfit A200, or equivalent, sealed lead-acid with thixotropic electrolyte gel.

Voltage

12V nominal; 12.6 - 12.9V fully charged, 10.5V fully discharged at 20°C.

Capacity

1.8Ah nominal, sufficient for 36 hours operation awake, or 1 year asleep at 20°C (less at higher temperatures).

Charging conditions

16 hours at constant voltage, which is temperature dependent:
13.98V ±0.18V at 15°C
13.80V ±0.18V at 20°C
13.65V ±0.18V at 25°C.

Important: do not exceed the specified charging voltage.

Fuse

1 Amp, 20x5mm cartridge fuse

Sealing

IP65

Dimensions & Weight

220 x 85 x 85 mm, 1kg

Electro-Magnetic Compatibility

The DL2e logger has been assessed under the European Union EMC Directive 89/336/EEC, and conforms with the following harmonised emissions and immunity standards:

EN 50081-1 : 1992
EN 50082-1 : 1992

Appendix B : Accuracy of logger readings

There are several categories of error that should be considered when estimating the accuracy of logger readings:

Analogue errors:

These are due to the inherent limitations of the electronic components used in the logger.

Arithmetic errors:

These are due to the approximations made by the logger when it performs calculations and stores data.
These logger errors are discussed in detail below.

In addition to the logger's contribution, errors can be attributed to other sources:

Sensor errors:

These depend on the inherent accuracy of a sensor, as specified by the manufacturer.

Sampling errors:

(1) These can be caused when a sensor is subject to influences that distort measurement of the desired parameter, for example poor shielding of an air temperature sensor in bright sunlight. These errors can be minimised by careful attention to sensor installation.

(2) These can be caused when readings of a fluctuating parameter are not logged frequently enough to build up an accurate picture of how it varies.

Cabling errors:

Cable resistance can cause significant errors when measuring resistance sensors. Techniques for minimising the effects of cable resistance are discussed in
"2-, 3- and 4-wire connection schemes" on page 63),
Thermistors: "Errors due to cable resistance" on page 129, and
Platinum Resistance Thermometers: "Errors due to cable resistance" on page 132.

Adding errors from different sources

The logger specification in Appendix A quotes maximum and typical accuracy figures for the logger.

The accuracy calculations in this section, and the figures quoted in the temperature measurement section, are derived by adding together maximum error figures. This procedure gives an absolute, worst-case, accuracy figure, which would result if all the error sources conspired to act in the same direction.

In practice, worst case errors of this magnitude are unlikely to occur. A more realistic estimate of likely errors can be obtained by calculating the 'root mean square' of independent error contributions, i.e. calculate the square of each error, add them up and take the square root.

Analogue accuracy

Voltage reading accuracy

The logger reads voltage on 4 ranges, normally auto-ranged:

Range	Full Scale	Resolution
1	±4mV	1µV
2	±32mV	8µV
3	±262mV	64µV
4	±2.097V	0.5mV

The key voltage reading accuracy specifications are given below, (maximum values with typical figures in brackets)

Logger Temperature:	20°C	-20 to +60°C
Full scale error	±0.07% (0.04%)	±0.2% (0.1%)
Long term stability	±0.25% (.02%) over 1 year	
Differential Offset	±10µV (3µV), ±0.02%	±12µV, ±0.02%
Noise	0.2µV RMS	
Input Impedance	approximately 100 MΩ	
Common Mode Range	±2V (or ±1.05V if + input is closer to logger 0V than –input)	

Near the full scale of each range of a recently calibrated logger, the maximum error is the **Full Scale Error** .

At the lower end of each scale the errors are dominated by the **Resolution** plus the **Differential Offset**.

EXAMPLE

When reading a 2 Volt input with the logger at 60°C:

- Maximum error is 2V x 0.2% = 0.004V = 4mV

When reading 5mV with the logger at 20°C:

- Resolution is 8µV, on voltage range 2
- Differential offset is 10µV
- Maximum error is 8µV + 10µV = 18µV.

Note that:

- The differential offset is only specified for differential voltage readings. Single-ended voltage readings may have much larger offsets, typically 20µV.
- There is a 10% hysteresis band between voltage ranges, to prevent the logger changing voltage ranges too frequently: this means that voltages in the upper 10% of each voltage range may be read with a resolution corresponding the next highest range.

Other voltage reading error sources are:

Error source	Specification	Comment
Long term stability	±0.25% max. (0.02% typical) over 1 year	a small typical error
Noise	0.2µV RMS	negligible
Input Impedance	approx. 100 MΩ	negligible for source input impedance <10kΩ
Common Mode Range	±2V (or ±1.05V if logger's + input is nearer to logger's earth than the - input)	the average of the input voltages must be within the Common Mode Range

Resistance reading accuracy

The following additional errors apply to resistance readings:

Logger Temperature:	20°C	-20 to +60°C
2µA current	±0.3% full scale	±0.6% (to +50°C)
Other currents	±0.05%	±0.1%
2-Wire LAC1 only	±20Ω (6Ω typical)	

To calculate the error in a resistance reading:

- First calculate the voltage the logger sees when the chosen excitation current is applied to the resistor ($V = I_{exc} \times R$), determine the voltage error as above, and convert it back to a resistance error :

$$R_{error} = V_{error} \ / \ I_{exc}$$

- Add the additional resistance reading error(s) from the table above. Note the additional error inherent in 2-wire resistance measurements.

Example:

Taking a 4-wire reading of 1000Ω with the logger at room temperature, using 2000µA excitation current:

Voltage contribution
The logger will be measuring a voltage of 1000Ω x 2000µA = 2V
The maximum error will be 2V x 0.07% =1.4mV
expressed in Ω, this will be 1.4mV / 2000µA = 0.7Ω

Resistance contribution
Resistance contribution = 1000Ω x 0.05% = 0.5Ω

Total maximum error = 0.7Ω + 0.5Ω = 1.2Ω

Calculation of logger analogue accuracy: a worked example

This example shows how to calculate the maximum logger error when measuring a temperature in the region of 20°C using a 2K thermistor, 2-wire connection to a LAC1 in 30-ch mode, measured as sensor type TM1, with the logger at 20°C.

1. Determine the resistance measured by the logger

- Using the table on page " on page 153, the resistance at 20°C is 2.498kΩ.

2. Calculate the corresponding voltage measured by the logger

- From the sensor characteristics of the standard sensors, the excitation current for sensor type TM1 is 20µA
- Using V = I x R, the voltage measured by the logger is
$(2.498 \times 10^3)\Omega \times (20 \times 10^{-6})A = 0.04996\ V = 49.96mV$

3. Calculate the voltage measurement error

- The voltage is measured on range 3, so resolution is 64µV
- Differential offset is 10µV (logger at 20°C)
- The % reading error at 49.96mV is
0.07% x 49.96mV = 0.035mV = 35µV.

Resolution plus voltage offset (64µV + 10µV = 74µV) is greater than % error, so take 74µV as the voltage measurement error.

4. Convert voltage measurement error into resistance (R = V / I)

- Using R = V / I, error in measured resistance is 74µV / 20µA = 3.7Ω

5. Calculate additional resistance reading errors

- for 20µA excitation current: $0.05\% \times 2.498 \times 10^3\Omega = 1.25\Omega$
- for 2-wire resistance measurements: 20Ω.

6. Combined worst case resistance reading error is:

3.7Ω + 1.25Ω + 20Ω = 24.95Ω

8. Convert the resistance reading error into a temperature

- Using the table on page 153, the resistances at 22.5°C and 17.5°C are 2.234 kΩ and 2.800 kΩ.
- The change in resistance over a 5°C change in temperature is

  2.800 kΩ - 2.234 kΩ = 0.566 kΩ = 566 Ω
- The change in temperature for 1°C temperature change is

  566Ω / 5 = 113.2Ω
- 24.95Ω resistance reading error corresponds to a temperature error of

  24.95Ω / 113.2Ω = 0.22°C

Answer: the maximum logger error is 0.22°C.

Arithmetic accuracy

Analogue sensors: linear conversion to engineering units

The logger stores readings from analogue sensors as raw data with no additional loss of accuracy (other than the analogue errors described above). Ls2Win converts these raw data to engineering units, and presents readings with a sufficient number of decimal places to represent each resolution step.

The maximum rounding error that can occur is just less than one resolution step.

Counter and frequency sensors: linear conversion to engineering units

Rounding

The logger stores readings as a number of counts, with large numbers of counts being rounded to the multiples of 8 or 64:

Number of counts	**Resolution**
0 to 4095	1
4096 to 32760	8
32768 to 65472	64

Resolution of frequency readings

The frequency represented by each stored count, and hence the resolution of frequency channels, depends on the length of the sampling interval. For example:

Sampling interval	**Resolution**
1 s	1 Hz
10 s	0.1 Hz
1 minute	0.0167 Hz (1/60 Hz)

Linearisation errors

The logger calculates engineering unit values from linearisation tables by linear interpolation, i.e. it treats each segment of a linearisation curve as a straight line. The error due to this is as illustrated below:

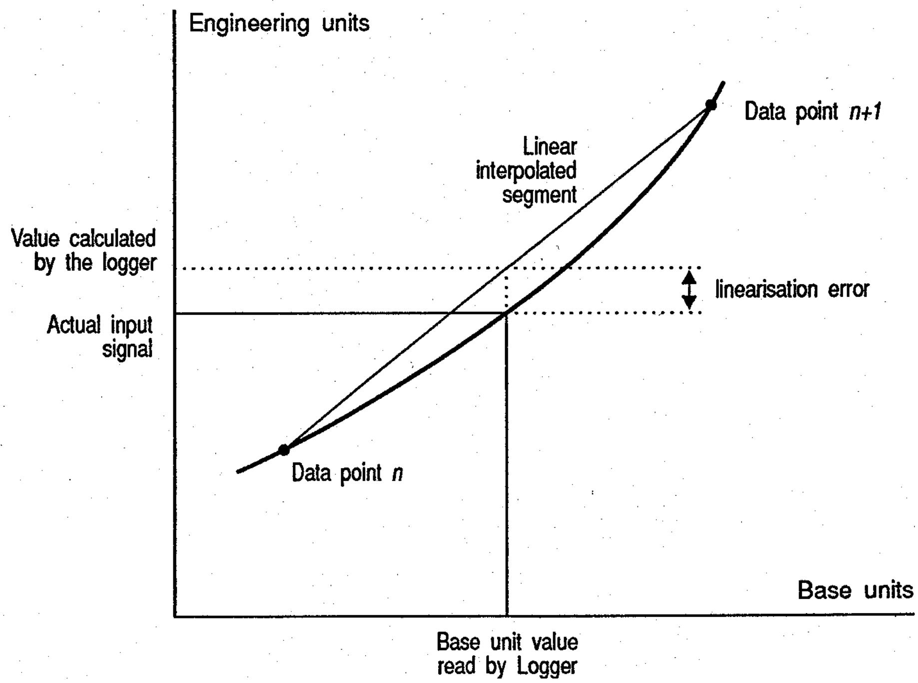


Figure B-1 : Error due to linear interpolation

Once linearised, the stored data is rounded to a resolution that depends on the magnitude of the deviation of the reading from the zero offset.

Rounding errors for linearised data (in engineering units):

Deviation from offset	Resolution
0 to 40.95	0.01
40.96 to 327.6	0.08
327.68 to 2620.8	0.64
2621.44 to 20966.4	5.12

For example, for sensor code PT4, a resolution of 0.01°C is available over the environmental temperature range of 20°C ±40.95°C (i.e. -20°C to +60°C).

Appendix C: Calculating the speed of data readings

The time it takes for the logger to complete one cycle of readings (a scan) is made up of the scan overheads at the start and end of each cycle, plus the time taken for each of the various channel readings in the scan, and their associated processing functions.

In most applications where channels are to be sampled at less than about 3 readings per second, you will not need to take into consideration the time it takes for the logger to service the scan.

The following table and notes provide information on how to calculate the time it takes for the logger to service individual readings, and the complete scan, in applications where:

- the scan involves taking readings more frequently than 3 times per second.
- many channels of widely differing readings that require frequent and unpredictable autoranging are to be logged.
- many channels require processing and/or compression of data prior to storage.

Time taken servicing a LOG or EVENT (msec)		
SCAN OVERHEADS[1]	*Awake*	*Asleep*
Start of scan	80	250
End of scan	200	200
SERVICING TIMES PER READING		
Digital Reading	65	
	Zero	***Full scale***
Analogue Reading [2], [3]	41	80
	Ranging down	***Ranging up***
extra for autoranging [4]	40 per range	80 + 80 per range
	LAC1 30-ch mode resistance	***All other analogue channel types***
extra for autozero [5] (per analogue reading type per terminal group)	60	41
Extra for processing		
linearisation	17	
cold junction referencing [6]	32 (extra to linearisation)	
STORAGE TO MEMORY	***Storing a single reading***	***Calculating and storing an average***
	10	26

NOTES:

[1] SCAN OVERHEADS is the time taken for the logger to prepare for taking readings at the beginning of a LOG or EVENT, and performing ‘housekeeping’ calculations when finished.

[2] The time required for an analogue reading depends on the magnitude of the input signal. ‘Full scale’ is with respect to the voltage range being used. If autoranging, the full scale figure applies for inputs of 4mV, 32mV, 262mV, 2.048V, and for corresponding resistance values (V_{in}= R x $I_{excitation}$).

[3] The timings quoted above apply for the 50/60 switch set to the European mains frequency, 50Hz. When set to 60Hz, all analogue timings are approximately 20% faster (see "Electrical mains environment" on page 48).

[4] Autoranging to a less sensitive range is slower than to a more sensitive range, and requires an over-range recovery cycle in addition to the reading being taken.

[5] The logger takes separate autozero readings for each terminal group, for voltage and resistance readings at each excitation current, as required for a LOG or EVENT. You can minimise autozero overheads for mixed resistance readings by grouping channels that use the same excitation current on consecutive input channels in the same terminal group.

EXAMPLES: two autozero readings are required for channels 1 to 30 programmed as VLT channels: 5 autozero readings are required for channels 1 to 6 programmed as TM1, RR1, RR2, RR3, RR4, VLT, as in the DEFAULT configuration.

[6] The logger takes a single cold junction reading for any number of thermocouple measurements in a single scan.

Appendix D : Resident linearisation tables

The following pages set out the conversion tables that the logger uses to determine temperature values from measurements taken using the various thermistor, thermocouple and PRT sensors the Logger can handle.

Thermistor tables

Temp (°C)	Resistance (kΩ) for sensor code and thermistor type:			
	TM1 (2K) Fenwal UUA 32J2	TM2 (2K252) Fenwal UUA 32J3	TM3 (10K) Fenwal UUA 41J1	TM4 (100K) Fenwal UUT 51J1
60.0	0.49760	0.56025	2.48780	22.5900
57.5	0.54490	0.61355	2.72450	24.9025
55.0	0.59720	0.67245	2.98610	27.4750
52.5	0.65570	0.73830	3.27840	30.3660
50.0	0.72060	0.81125	3.60230	33.5910
47.5	0.79300	0.89295	3.96510	37.2265
45.0	0.87400	0.98375	4.36840	41.2920
42.5	0.96440	1.08580	4.82140	45.8900
40.0	1.06540	1.19950	5.32640	51.0480
37.5	1.17940	1.32765	5.89530	56.8980
35.0	1.30600	1.47090	6.53140	63.4800
32.5	1.45000	1.63280	7.25045	70.9700
30.0	1.61140	1.81140	8.05680	79.4220
27.5	1.79440	2.02035	8.97120	89.0740
25.0	2.00000	2.25200	10.00000	100.0000
22.5	2.23400	2.51560	11.17050	112.5200
20.0	2.49800	2.81320	12.49200	126.7400
17.5	2.80000	3.15300	14.00100	143.0950
15.0	3.14200	3.53810	15.71100	161.7300
12.5	3.53400	3.97960	17.67150	183.2450
10.0	3.98000	4.48130	19.89900	207.8500
7.5	4.49300	5.05900	22.46450	236.3600
5.0	5.07800	5.71810	25.39100	269.0800
2.5	5.75500	6.48000	28.77450	307.1550
0.0	6.53000	7.35280	32.65000	351.0200
-2.5	7.43000	8.36640	37.15100	402.2750
-5.0	8.46600	9.53180	42.32600	461.5500
-7.5	9.67100	10.89050	48.35900	531.1000
-10.0	11.06600	12.45900	55.32600	611.8700
-12.5	12.69700	14.29700	63.48700	707.0600
-15.0	14.59000	16.42900	72.95100	818.0700
-17.5	16.81800	18.93700	84.09150	949.5050
-20.0	19.41400	21.86100	97.07200	n/a

Thermocouple tables

Temp (°C)is the temperature difference between hot and cold junctions.

Temp (°C)	Output (mV) for sensor code and thermocouple type:		
	TCJ, type J, (Iron/Constantan)	TCK, type K, (Chromel/Alumel)	TCT, type T, (Copper/Constantan)
-120	-5.426	-4.138	-3.923
-110	-5.036	-3.852	-3.656
-100	-4.632	-3.553	-3.378
-90	-4.215	-3.242	-3.089
-80	-3.785	-2.920	-2.788
-70	-3.344	-2.586	-2.475
-60	-2.892	-2.243	-2.152
-50	-2.431	-1.889	-1.819
-40	-1.960	-1.527	-1.475
-30	-1.481	-1.156	-1.121
-20	-0.995	-0.777	-0.757
-10	-0.501	-0.392	-0.383
0	0.000	0.000	0.000
10	0.507	0.397	0.391
20	1.019	0.798	0.789
30	1.536	1.203	1.196
40	2.058	1.611	1.611
50	2.585	2.022	2.035
60	3.115	2.436	2.465
70	3.649	2.850	2.908
80	4.186	3.266	3.357
90	4.725	3.681	3.813
100	5.268	4.095	4.277
110	5.812	4.508	4.749
120	6.359	4.919	5.227
130	6.907	5.327	5.712
140	7.457	5.733	6.204
150	8.008	6.137	6.702
160	8.560	6.539	7.207
170	9.113	6.939	7.718
180	9.667	7.338	8.235
190	10.222	7.737	8.757
200	10.777	8.137	9.286

Appendix E : Identifying components on cards

To identify component positions on a card relating to a specific input channel, refer to the table below:

- debounce capacitors on a DLC1
- shunt and divider resistor positions on a LPR1 or LPR1V

Channel	DLC1: debounce capacitor	LPR1 and LPR1V: shunt or divider positions
1, 16, 31, 46	1	1 or 16
2, 17, 32, 47	2	2 or 17
3, 18, 33, 48	3	3 or 18
4, 19, 34, 49	4	4 or 19
5, 20, 35, 50	5	5 or 20
6, 21, 36, 51	6	6 or 21
7, 22, 37, 52	7	7 or 22
8, 23, 38, 53	8	8 or 23
9, 24, 39, 54	9	9 or 24
10, 25, 40, 55	10	10 or 25
11, 26, 41, 56	11	11 or 26
12, 27, 42, 57	12	12 or 27
13, 28, 43, 58	13	13 or 28
14, 29, 44, 59	14	14 or 29
15, 30, 45, 60	15	15 or 30

Index

M

N

O

P

Q

R