DLOG97 Data Analysis Software

& DA97 Data Logger

User Guide

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Introduction

GEMS DLOG97 is a data analysis package designed to be used in conjunction with the **GEMS** ***DA97*** logger. **DLOG97** offers many advanced analysis features including overlays, histograms, XY plots, maths channels, lap analysis, track drawing and channel alarms. In addition, **DLOG97** is the means by which the ***DA97*** data logger is programmed. **DLOG97** runs under the *Windows 95*™ operating system.

The ***DA97*** data logger is a powerful, compact unit that can monitor up to 99 inputs split over analogue, thermocouple, speed, serial and CAN channels. Up to 60 of these channels can be recorded with individual channel rates selectable from 200Hz to 5 min. Data is stored on PCMCIA memory cards (with up to 1 Mb capacity) which facilitates very rapid data transfer between logger and PC.

Documentation

This *User Guide* is split into two main sections. The first, *Getting Started*, contains instructions on programming and reading data from the logger and a brief overview of many of the **DLOG97** features. The second section, *Reference*, discusses the features of **DLOG97** in detail and outlines the methodology behind installing and calibrating sensors for use with the logger and the use of **GEMS** beacons for lap timing purposes.

Throughout this guide, procedures in **DLOG97** are referred to using the menu commands separated by a **|** symbol. Thus **File | Open** means select the **Open** command from the **File** menu. If a keyboard shortcut or a button on the **DLOG97** toolbar also performs the same task, this is shown in the left hand margin.

A comprehensive on-line help system is provided with **DLOG97** to give more details on using the package. To view the help, press **F1** or select **Help | Help Topics**.

Help can also be obtained in dialog boxes by clicking on the ? in the top right hand corner of the box and then clicking on the item for which you require help.

Installing DLOG97

DLOG97 is supplied on 3½" floppy disk. To install **DLOG97**:

- Insert the **DLOG97** installation disk in drive A.
- From the *Windows 95*™ Start menu, select Run.
- In the run dialog, type in A:\Setup and select OK.
- Follow the prompts from the installation program.

To program set-ups into and retrieve data from the ***DA97*** data logger, **DLOG97** requires Card Services drivers to be loaded to enable it to communicate with PCMCIA memory cards. If you have installed **DLOG97** onto a PC that is not equipped with PCMCIA slots, these drivers are not required.

The files CSMAPPER.SYS and CARDDRV.EXE should have been installed into the WINDOWS\SYSTEM directory of your computer when *Windows*™ was installed and PCMCIA slots were detected. If these files are not present, contact your computer supplier.

It may be necessary to make changes to the CONFIG.SYS files according to the following instructions:

- From the *Windows 95*™ Start menu, select Run.
- In the run dialog, type SYSEDIT and select OK. This will invoke the system configuration editor.
- Select the CONFIG.SYS window. Add the following lines if they are not already present:
    - DEVICE=C:\WINDOWS\SYSTEM\CSMAPPER.SYS
    - DEVICE=C:\WINDOWS\SYSTEM\CARDDRV.EXE /SLOT=n (Where n is the number of PCMCIA slots on your computer)
- Restart your computer for the changes to take effect.

These drivers will create a new drive for each slot on the computer. The position of the drives will depend on what other drives are installed on the computer and it is necessary to tell **DLOG97** which drive letter corresponds to which slot:

- Use windows explorer to identify the new drives (they will be labelled as Removable Disks).
- Choose **Config | Options** and select the File Naming tab.
- Enter the drive letter corresponding to slot number in the Slot Mapping box.

Transferring Data to and from the Logger

Data is transferred between the logger and the PC using PCMCIA SRAM cards. Before their first use, these SRAM cards need to be formatted by the data logger. To format a card, simply insert it into a powered up logger.

Programming the Data Logger

To program the data logger:

F4

- Load the setup to be programmed into **DLOG97** using **Setup | Open**. (Note: **DLOG97** automatically opens the last setup used when run. The currently loaded setup is shown in the status bar - if this is the desired setup, you will not need to use **Setup | Open**).
- Insert the SRAM card into the programming slot on your laptop. The programming slot can be set using **Config | Program**.

Shift F4

- Select **Setup | Program**. A message will appear when the card has been programmed.
- Insert the card into the data logger with the logger powered up. The logger will now be programmed and the card will be made ready to receive data. The logger status on the dash screen (if fitted) should show ***CARD IN***. Note that the cards and logger only need to be programmed when the setup is changed or when it is thought that the setup in the logger has become corrupt. This is indicated by a logger status of ***SETUP FAIL*** on the dash screen (if fitted).

Recording Data

To start the logger recording data, use the record switch mounted on the dash. The following points should be noted when recording data:

- The logger will only record data when it is powered up, the record switch is turned ON and a SRAM card is inserted. The logger status on the dash screen (if fitted) will show ***RECORDING*** when the logger is recording data.
- If the record switch is turned OFF the Logger will pause. Logging will resume from the same point if the record switch is turned ON again, provided the SRAM card remains inserted and the Logger is continuously powered

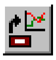
- If the logger is powered down with the record switch turned ON and powered up again with the record switch still turned ON, logging will resume from the same point.
- If the logger is powered up with the record switch turned OFF or with no SRAM card inserted, a new logging session will be initiated.

Reading Data

Once logging is finished, the data logged onto the SRAM card can be read to disk:

- Remove the card from the logger and insert it into the read slot on the laptop. The read slot can be set using **Config | Read**.

Shift F3



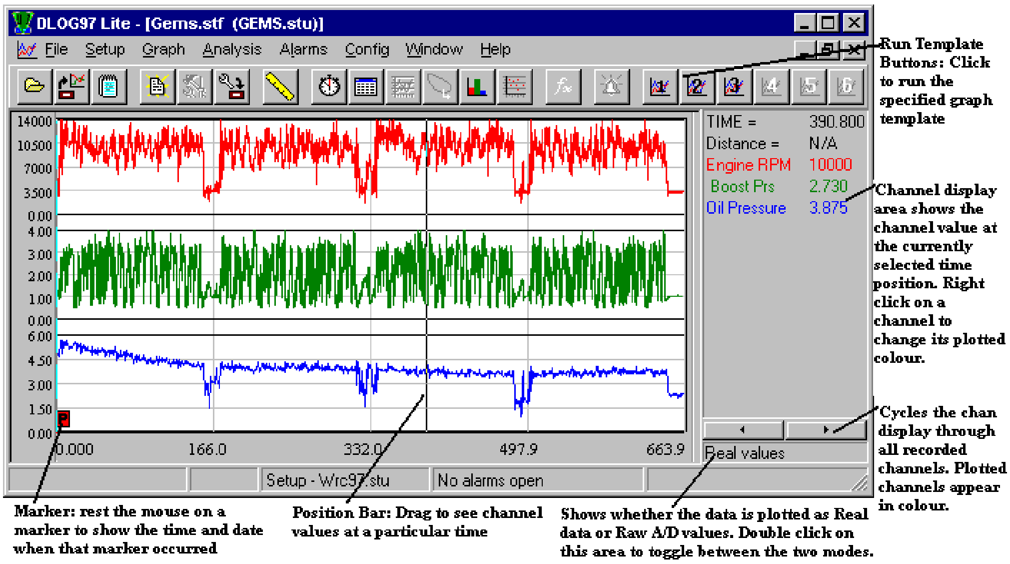
- Select **File | Read**. You will be prompted for a file name. Note that **DLOG97** can be set to automatically name files: open the Options editor with **Config | Options** and select the **File Naming** page. Click on **Date** in the **File Naming System** box.
- The data will be read from the card and saved to disk. If **Open On Read** is checked in the **Config** menu, this data file will then be opened and displayed on the screen. Otherwise, the file can be opened using **File | Open**.

DLOG 97 Quick Reference

The following sections give a brief overview of options and menu commands available in **DLOG97**. For more information, see either the on-line help or the *Reference* section later in this *User Guide*.

The Main Graph Screen

The following screenshot shows a typical DLOG97 graph screen with areas of interest marked.



Many of the commands in the Graph menu are reproduced in the graph popup menu. To view this menu, right click on the graph itself.

To zoom in on the graph to view the data in more detail:

Keypad +

- Select **Graph | Zoom | In**. The cursor will change into a  showing that you are in x axes zoom mode.
- Click on the area of the graph where you want the zoom to start.
- Click on the area of the graph where you want the zoom to end. The graph will be redrawn with the new zoom range.
- The selected zoom range is bounded by red vertical lines at the start and end. Using the scroll bar at the bottom of the graph, data outside this zoom range can be viewed.

- If there is data outside the scrollable region, a ◄ or ► will be shown at the edge of the scrollable area. These will shift the zoom area to the left or right respectively.

Ctrl Keypad +

The y axis can be zoomed in a similar manner by selecting **Graph | Zoom | Expand** which will change the cursor to to show that you are in y axis zoom mode.

Menu Commands

The following section gives a brief overview of the menu commands and their use. If a tool bar button or a keyboard shortcut can be used to perform the same function, it is shown in the left hand margin.

File Menu

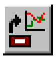
The File Menu contains all the commands used for file management:

F3

Open
- Use the open command to open a log file.

Reopen
- Allows a file to be selected from the most recently opened log files.

Shift F3



Read
- Reads a log file off a PCMCIA card and saves it to disk. See ***Transferring Data to and From the Logger*** earlier in this guide for more information.

Compress
- Compresses a log file to its minimum size.

Compress All
- Compresses all log files in the current directory.
- Data files retrieved from a PCMCIA memory card are of the same size as the memory card used. However, the space required for the data is often significantly less than this size. Using the compress command reduces data files to their minimum size and should be carried out whenever disk space is short.

Update
- Updates files from previous versions of **GEMS** data loggers for use in **DLOG97**.

Erase Card
- Erases all data on the card in the active slot.
- Erasing a card clears all data from and checks the integrity of the card. If you suspect a card has errors on it, insert it into the selected programming slot and select erase. If errors exists, the number of errors on the card and the position of the first error will be reported. This can be used to determine how much usable space there is on the card.

Export
- Exports data in an ASCII format suitable for use in other applications such as word processors or spreadsheets.

Abstract
- Copies selected channels into a new data file.

Ctrl F3

Notes
- Displays notes about the current data file and allows new notes to be added.

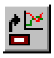
Exit
- Quits DLOG97.

Setup Menu

The Setup Menu contains commands for retrieving, editing and programming logger set-ups. For more information on creating set-ups, see the Reference section of this guide.

Create
- Creates a new default setup. This is useful when the new setup to be created is very different from any existing set-ups.

Shift F3



Open
- Opens a setup file for programming into the logger.

Reopen
- Allows a recently used setup to be reopened.

Ctrl E

Extract

- Extracts the setup from the currently active data file and makes it the currently active setup for editing and saving.

Shift F5

Edit

- Allows the currently active setup to be edited and saved.
- Buttons are also available in the setup editor for Programming and Printing the setup.

Shift F2

Save

- Saves the currently active setup to disk.

Print

- Prints the currently active setup.
- Only the desired elements of the setup need be printed.

Shift F4

Program

- Programs the current setup into a logger. See ***Transferring Data to and From the Logger*** earlier in this guide for more information.

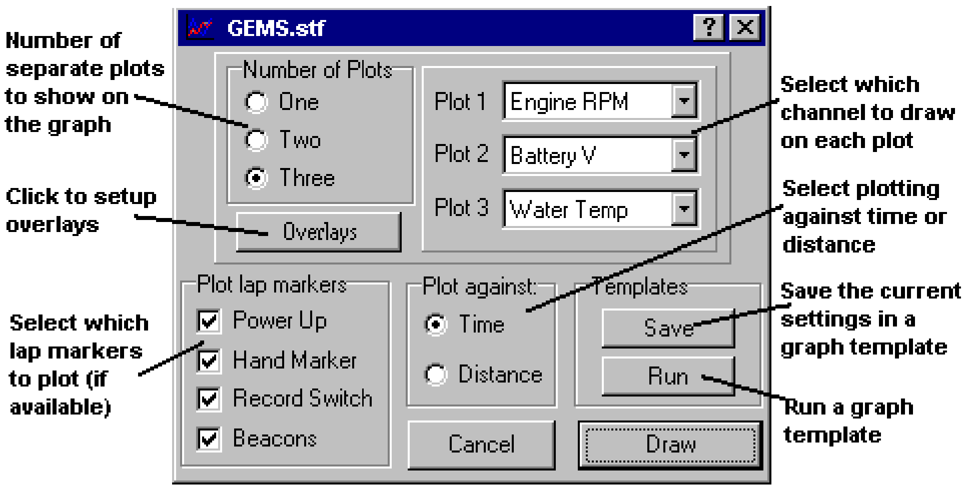
Graph Menu

The Graph Menu contains commands used for displaying and printing graphs.

Ctrl G

Graph

- Invokes the graph options editor where the number of lines, overlays and lap markers can be specified. An example screen is shown below



Setup

- **Edit** edits the setup of the currently active graph. (Note that this is different from the currently active setup).
- **F2** **Update Log File** saves any changes made to the data file.

Shift Overlays

- Allows the x axis of any overlayed *Files* to be moved relative to the base graph x axis by dragging the plot. When in shift mode, the cursor will change to a . Click on the graph and drag the overlayed plots to a new position.

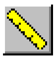
Zoom

- Allows zooming in or out on the x and y axes.
- ***In*** Zooms in the x axis.
- ***Out*** Zooms out the x axis.
- ***Expand*** Zooms in the y axis.
- ***Contract*** Zooms out the y axis.
- ***Normal*** Resets all zooms.

Values

- Selects either plotting with A/D values (raw data) or scaled real values.

Ctrl T



Tape Measure

- Displays the Tape Measure window. This allows the difference between two points on a graph to be measured.

Print

- Prints the current graph.

Analysis Menu

The Analysis Menu contains commands for examining the data in more detail than possible via a simple graph.

F5

Lap Times

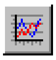
- Use to display lap markers, split, total lap times and average lap speed.

F6

Statistics

- Displays minimum, maximum and average values of channels.
- Double clicking on a minimum or maximum value will automatically zoom the graph around that point.

F7



Time-Distance

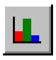
- Shows relative performance over several runs.
- The time for the overlayed graph is subtracted from the time for the base graph and plotted against distance. A positive time difference indicates that the base graph run is faster than the overlayed graph, whereas a negative time difference indicates that the overlayed graph is faster than the base graph.

F8

Draw Track

- If either yaw or lateral g have been recorded, it is possible to plot a trace of the track that the vehicle has travelled. For more information on track drawing and lap analysis, see the reference section of this guide.

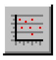
Ctrl F7



Histogram

- Shows the frequency of occurrence of values in a channel as a percentage of the current zoom range time or distance.

Ctrl F8



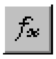
XY Plot

- XY plots allow one channel to be plotted against another thus allowing the relationship between the two channels to be explored.

Maths Menu

The Maths Menu allows recorded channel data to be mathematically manipulated. This manipulated data is stored in a new channel which can then be accessed and plotted as any other channel.

Shift F9



Edit Library

- User defined maths equations are stored in a maths library. Use this menu command to edit existing maths equations or add new ones.

F9

Add To Log File

- Adds a maths equation from the library to the currently active data file, creating a new maths channel in the process.
- Note that the channels referred to in the maths equation used must be recorded in the data file for the maths channel to be calculated.

F2

Save To Log File

- Saves any created maths channels to the active data file.

Alarms Menu

Channel alarms can be used to alert users if data in a channel exceeds a predefined limit. Alarms can also be set to be conditional on two channels exceeding their limits. A maximum of 100 alarms can be set. A setup file must be loaded before Alarms can be edited.

Create
- Creates a new alarm file.

Open
- Opens an existing alarm file.

F10

Edit
- Edits the current alarms list.

Ctrl F10

Save
- Saves the current alarm list.

Shift F10

Show for Current
- Displays any activated alarms for the currently loaded log file

Active On Read
- When checked, any activated alarms will be displayed when a card is read.

Active On Open
- When checked, any activated alarms will be displayed when a log file is opened.

Config Menu

Read
- Use to set the default read location for log files.

Program
- Use to set the default location for programming cards.

Options
- Edit various global options associated with *DLOG97*.

Show Toolbar

- If Checked, the tool bar will be displayed.

Close On Read

- When checked, all existing data files will be closed when a new file is read from a card. This can be useful during a logging session that may result in the potentially confusing situation of many windows being open at once. Opening files will not force other windows to close. When not checked, existing files remain open when a new file is read from a card.

Notes On Read

- When checked, the user will be prompted to enter notes about the data file whenever a new file is read from a card.

Window Menu

Tile

- Arranges windows in a tiled format.

Cascade

- Arranges windows in a cascaded format.

Arrange Icons

- Arranges iconized windows.

The numbered list at the foot of the Window menu can be used to make the desired window active.

Cascaded windows appear on the screen diagonally, from upper left to lower right, overlapping so that the title bar of each window remains visible.

Tiled windows are distributed to each corner of the screen, so that each window is visible and none overlap.

Icons (or reduced windows) appear at the bottom of the DLOG97 main window. Each icon remains visible. Double-click an icon to make that window active.

Help Menu

F1

Help Topics

- Display the Help Topics dialog box:

About

- Display program version and serial number information.

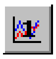
To find a topic in Help:

- Click the Contents tab to browse through topics by category.
- Click the Index tab to see a list of index entries: either type the word you're looking for or scroll through the list.
- Click the Find tab to search for words or phrases that may be contained in a Help topic.

Context sensitive help can be obtained by pressing the **F1** key.

Help can also be obtained in dialog boxes by clicking on the **?** in the top right of the dialog box and then clicking on the item for which you require help.

F11



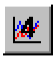
Graph Templates

Shift F11

Graph templates allow frequently used graph set-ups to be applied at the click of a button. To use graph templates:

F12

Shift F12



Ctrl F11

Ctrl F12

- Create the desired graph setup, i.e. number of lines, channels to plot, overlayed files, etc.
- Within the Graph Options editor, click the Save button and enter a filename for the template.
- Select Config | Options and assign the template filename to one of the template buttons.
- The template can now be run at any time by clicking the appropriate template button.

Creating Data Logger Set-ups

In order for the logger to record data, it is necessary for it to be programmed with a setup. The setup specifies the channels to record and the rates and gains at which to record them. In addition, the setup enables **DLOG97** to convert raw 8 or 16 bit data into real engineering units.

Shift F5

Set-ups are edited using the Setup Editor. To invoke the editor, choose **Setup | Edit**.

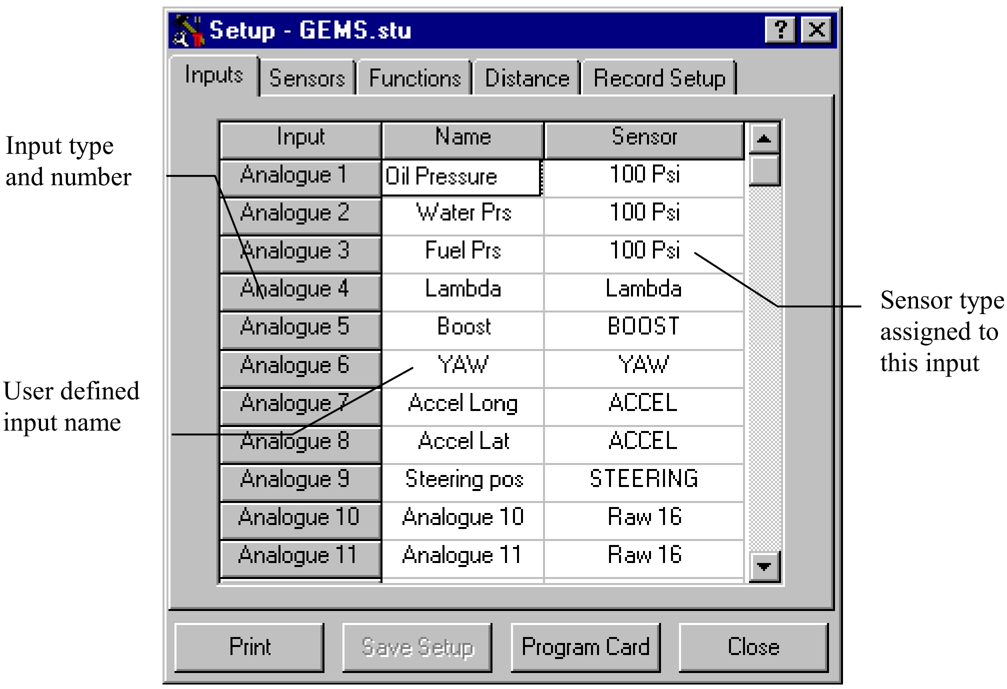
There are four steps to creating a logger setup:

1. Specifying the Input Allocation Table.
2. Specifying the sensor calibrations.
3. Specifying the speed input to be used for the distance channel.
4. Specifying the record list.

Each of these four steps will be considered below.

The Input Allocation Table

The input allocation table specifies what is connected to the various inputs of the logger. An example of the input allocation page is shown below.



The left hand column of the table gives the type of the input and always runs Analogue 1-24, Temperature 1-8, Speed 1-6, Distance, CAN and Serial. The number of CAN and Serial channels depends on the current application. See Appendix A for details of how the inputs map to physical pins on the data logger.

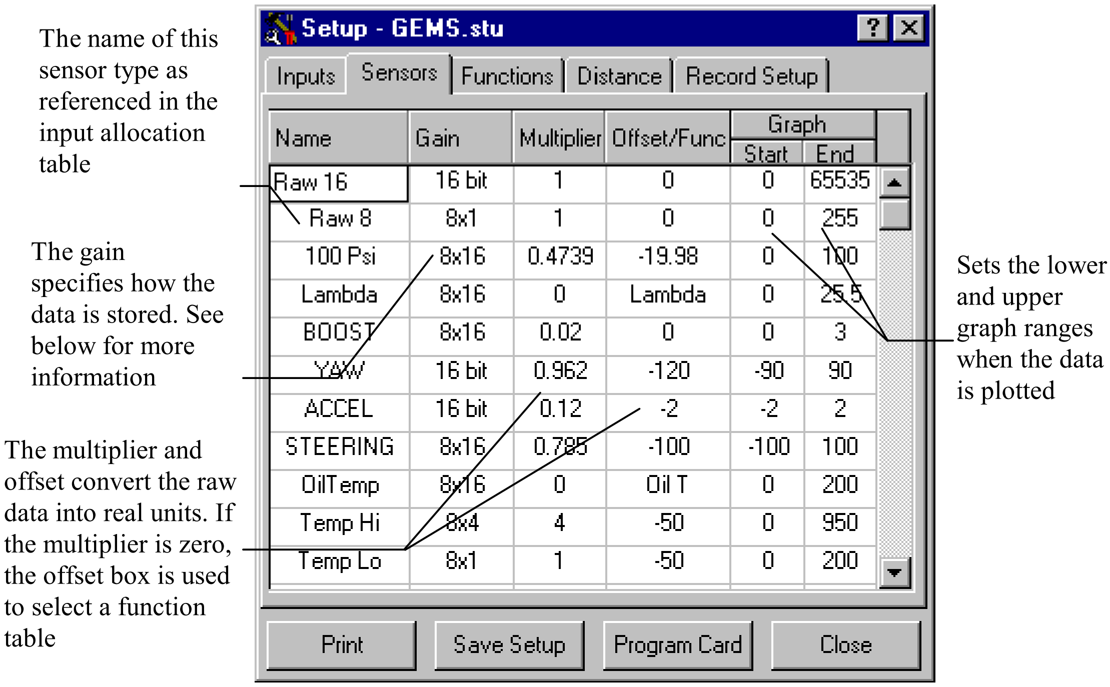
The middle column specifies the name of the data source connected to that input. For example, in the setup shown above, a pressure transducer measuring the engine oil pressure is connected to Analogue 1 on the logger. This name can be any 12 characters but since it is used for accessing recorded data and other functions, it is useful for it to be a meaningful name.

The right hand column specifies the sensor type used by that particular input. The sensor type is used by the logger to determine what gain should be used when recording that particular channel. The sensor type also specifies how the raw 8 or 16 bit data is converted into real engineering units by **DLOG97**. Note that a sensor type can be used by more than one channel. Thus if all thermocouples used are of the same type and range, all can be assigned to a common temperature sensor, saving time in creating the setup and making the setup more legible.

Calibrating sensors is considered in the next section.

The Sensors Table

Sensors need to be calibrated to allow the **DLOG97** to display values in real units. Calibrations are entered into the Sensors page of the setup editor and assigned to an input using the Inputs page. An example Sensors page is shown below.



Name	Gain	Multiplier	Offset/Func	Graph Start	Graph End
Raw 16	16 bit	1	0	0	65535
Raw 8	8x1	1	0	0	255
100 Psi	8x16	0.4739	-19.98	0	100
Lambda	8x16	0	Lambda	0	25.5
BOOST	8x16	0.02	0	0	3
YAW	16 bit	0.962	-120	-90	90
ACCEL	16 bit	0.12	-2	-2	2
STEERING	8x16	0.785	-100	-100	100
OilTemp	8x16	0	Oil T	0	200
Temp Hi	8x4	4	-50	0	950
Temp Lo	8x1	1	-50	0	200

The Name column specifies the name of the sensor as referenced in the inputs table. The name can be up to 12 characters long.

The Gain column specifies how the raw data is stored. The DA97 logger holds data in a 16 bit form before writing to the PCMCIA card and uses the gain value to determine how this value is converted before it is stored onto the card:

- If a gain of 16 bit is selected, the 16 bit value is stored directly onto the memory card. This offers the greatest possible resolution at the expense of using twice the memory an 8 bit value would use.

- If an 8 bit gain is selected, only 8 bits of the 16 bit number are stored. The 8 bits stored are determined by the gain as shown in the following table:

Gain	8 bits stored
8x1	bits 0 to 7
8x2	bits 1 to 8
8x4	bits 2 to 9
8x8	bits 3 to 10
8x16	bits 4 to 11
8x32	bits 5 to 12
8x64	bits 6 to 13
8x128	bits 7 to 14
8x256	bits 8 to 15

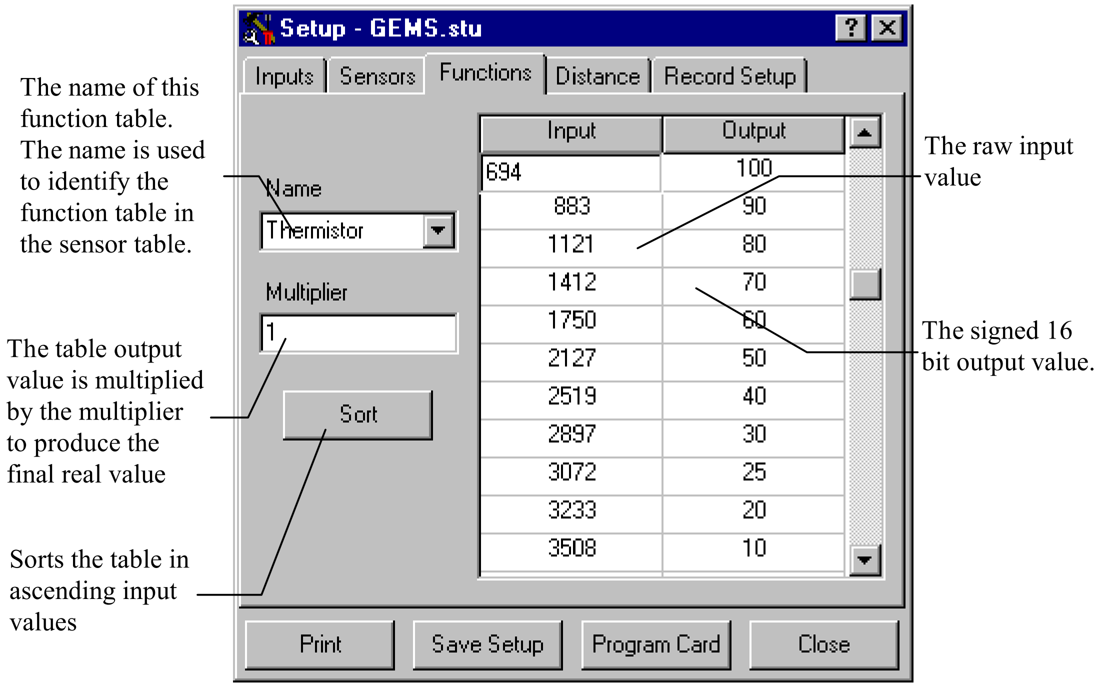
- Since the DA97 has a 12 bit A/D converter, a gain of 8x16 gives the maximum range for an analogue channel stored in 8 bit. The 8 bit gain factor (x1, x2, x3 etc.) can be considered to be the number the 16 bit value is divided by before the lower 8 bits are stored.

The multiplier and offset columns specify how the raw 8 or 16 bit data is converted into real units. The following equation is used to convert raw data into real units:

$$\boldsymbol{Real = Raw \times Multiplier + Offset}$$

The Graph Start and Graph End values define the lower and upper limits of the y axis when the data is plotted. See the **Calibrating Sensors** section for more details on setting up the sensor table.

If a multiplier of zero is specified, the offset box is used to select a function table. Function tables are used to convert non-linear sensor output into linear real data and are entered into the Functions page of the setup editor. An example function table page is shown below:



The name box is used to specify the name of the currently selected function table, which can be up to 12 characters. The name is used to identify the function table in the sensor table. The name box is also used for selecting the current function table to be edited. There are ten function tables available.

To create a function table, enter the 8 or 16 bit raw values in the input column and the corresponding output values in the output column. The output values are signed 16 bit and so have a range of -32768 to 32767. If values outside this range are required, the multiplier can be used.

Function tables calculate the real value by looking up the raw value in the input list and matching it to an output value which is multiplied by the multiplier. Linear interpolation between nearest sites is carried out if necessary.

Setting up the Distance Channel

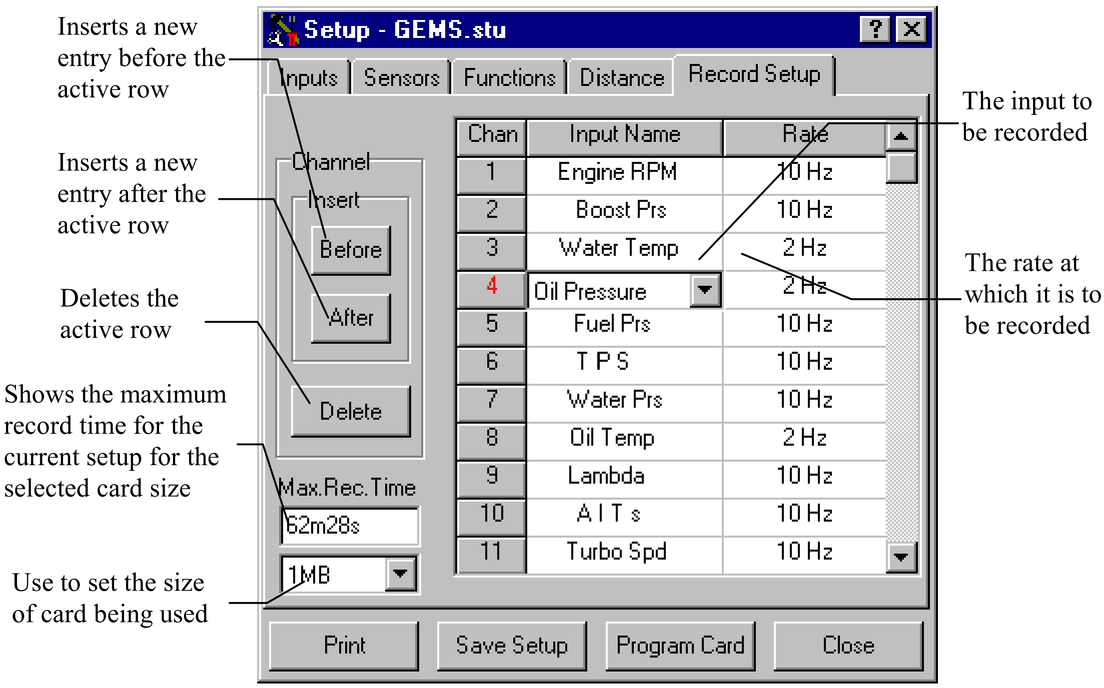
The distance channel is created by the logger by monitoring the pulses of a wheel speed sensor. Distance channels are setup using the distance page of the setup editor. In the speed input box, select which one of the 6 available speed inputs is to be used to create the distance channel. This input will normally be connected to a road wheel speed sensor.

In the Meters/Pulse box enter the number of meters that will be covered by one pulse. To calculate this, the number of pulses per revolution and the circumference of the road wheel need to be known. Consider a road wheel of 3m circumference fitted with a speed sensor having 10 teeth i.e. 10 pulses per revolution. Thus the Meters/Pulse constant is 3/10 or 0.3.

Note that having the distance channel setup does not mean that distance will be recorded. This distance channel must still be specified in the record list for it to be recorded.

The Record List

The record list tells the logger which channels to record and the rate at which to record them. A typical record list page is shown below:



To add items to the record list, click the Before or After buttons which will insert a new entry in the list before or after the currently active row. The active row is denoted by the channel number being in red. (Channel number in this case merely refers to the position in the record list and not any physical channel). To delete an entry, select it by clicking on the input or gain for that entry and then click the delete button.

In the Input column, select the input to record. In the rate column, select the rate at which that channel is to be recorded. Recording a channel at a high rate can provide more information on fast transient signals at the expense of using more memory. Slow moving signals, such as air temperature, can be recorded at a relatively slow rate such as 2Hz saving memory and thus extending that maximum available run time.

The Max Rec. Time box shows the maximum available run time for the current record list based on the size of the card selected below. The card size does not have to be set correctly since it is only used to calculate the maximum record time displayed in the setup editor for information purposes. However, it is useful to set the card size box to the size of card being used so that the maximum record time is correct.

Sensor Calibration

Sensors need to be calibrated to allow the **DLOG97** to display values in real units. This section will consider the various inputs available and give examples on calibrating sensors for them.

Available Inputs

There are five types of input available; Analogue, Serial, CAN Temperature and Speed. The allocation of the Serial and CAN channels is dependant on the particular application and will not be discussed here. The Analogue, Temperature and Speed inputs will be examined in more detail.

Analogue Inputs

There are two types of Analogue input available, Single Ended and Differential. There are 8 Differential inputs numbered Analogue 17 to Analogue 24 and all are identical. There are 16 single ended inputs all with a basic capability to measure 0 to 5V. However, some of the inputs have been modified to suit particular sensors. The details of the Single Ended analogue channels are shown below:

Input	Comments
A1 to A3	Fitted with a 470kΩ pull down resistor after the 100kΩ series resistor for use with 1 to 6V pressure sensors.
A4 to A12	Standard 0 to 5V inputs.
A13, A14	Fitted with a 1kΩ pull up resistor for use with two wire resistive sensors e.g. thermistors.
A15	Fitted with a 100Ω pull up resistor for use with simple resistive fuel level sensors.
A16	Fitted with a 39kΩ pull down resistor after 100kΩ series resistor to give a range of 0 to 17.82V for measuring battery voltage.

Example Calibrations

To illustrate the method by which sensors are calibrated, the process for calibrating some typical sensors for typical ranges will be covered below.

Thermistors

Thermistors are devices whose resistance changes with temperature and should be connected between A13 or A14 (as these are fitted with a 1kΩ pull up resistor to 5V) and Analogue 0V. Thus the voltage recorded by the A/D converter at any given resistance of the thermistor is given by

$$V_{out} = \frac{R_{Therm}}{R_{Therm} + 1000} \times 5$$

where R_{Therm} is the resistance of the thermistor at the current temperature. The A/D converter fitted to the DA97 has 12 bit resolution and consequently produces a digital value of 4096 for a full scale 5V. Thus the digital value at the current input voltage is given by:

$$Raw12\,bit\,value = \frac{V_{Out}}{5} \times 4095$$

Because thermistors are non-linear devices it is necessary to use a function table to produce calibrated temperature values from the raw data. Another consideration required is the gain to use. For maximum accuracy, a gain of 16 bit will allow bit level resolution at the expense of requiring twice as much memory to store as an 8 bit value. An 8 bit value, however, uses half the memory and will often provide enough resolution for the signal being measured. To obtain the maximum 8 bit range of a 12 bit A/D value, use a gain of 8x16 which divides the 16 bit value by 16 before storage in 8 bits.

The following table shows the values obtained using the above equations for a Weber thermistor. The values in the first two columns were obtained from the Weber data sheet.

Temp. /°C	Resistance /kΩ	V_{Out} /V	12 bit value	8x16 value
-40	100.950	4.95	4056	253
-30	53.100	4.91	4020	251
-20	29.121	4.83	3960	248
-10	16.599	4.72	3863	241
0	9.750	4.53	3715	232
10	5.970	4.28	3508	219
20	3.747	3.95	3233	202
25	3.000	3.75	3072	192
30	2.417	3.54	2897	181
40	1.598	3.08	2519	157
50	1.080	2.60	2127	133
60	0.746	2.14	1750	109
70	0.526	1.72	1412	88
80	0.377	1.37	1121	70
90	0.275	1.08	883	55
100	0.204	0.85	694	43
110	0.153	0.66	544	34
125	0.102	0.46	379	24

It can be seen that the approximate resolution using all 12 bits is 0.045 °/bit whereas the approximate resolution for 8x16 is 0.72 °/bit. To utilise these values within **DLOG97** enter the 12 bit or 8x16 bit values in the function table input column and enter the temperature values in the output column.

1 to 6V Pressure Sensors

Pressure sensors with a 1 to 6V output should be connected to either A1, A2 or A3 since these inputs have a 4k7Ω pull down resistor giving the input a range of 0 to 6.06V. The following example calibrates a 1 - 6V sensor with a range of 100 PSI:

The voltage recorded by the A/D converter is given by:

$$V_{Out} = \frac{4.7}{5.7} \times V_{Press}$$

where V_{Press} is the output of the pressure sensor. Thus the 12 bit values for the limits of the sensor can be calculated to be:

$$0\ PSI \equiv 1V = 675 \ \ and \ \ 100\ PSI \equiv 6V = 4053$$

The multiplier can be calculated from these limits as follows:

$$\frac{Real_{End} - Real_{Start}}{AD_{End} - AD_{Start}} = \frac{100 - 0}{4053 - 675} = 0.0296$$

The offset can be calculated as follows:

$$Real - (Multiplier \times AD) = 0 - (0.0296\ .\ 675) = -19.98$$

If using an 8 bit gain, multiply the multiplier *only* by the gain factor i.e. for a gain of 8x16 the multiplier becomes:

$$Multiplier_{8x16} = Multiplier_{16\ bit} \times 16 = 0.0296 \times 16 = 0.4736$$

Gains lower than 8x16 can be used to increase the resolution of the stored data at the expense of the range. The following table shows the resolutions and ranges for various gains using the example pressure sensor above:

Gain	Resolution/ PSI per bit	Range/ PSI
16 bit	0.0296	0 - 100
8x16	0.4739	0 - 100
8x8	0.1608	0 - 41
8x4	0.0392	0 - 10

Because the pressure sensor has a minimum output of 1V, gains of 8x2 and 8x1 will always read full scale since

$$AD_{1V} = 1 \times \frac{4.7}{5.7} \times \frac{4096}{5} = 675$$

and 8x1 uses the lowest 8 bits of the 12 bit value (0 - 255) and 8x2 uses bits 2 to 9 (1 - 511).

If it is desired to calibrate the sensor in Bar, simply substitute the Bar pressure range for PSI and calculate the multiplier and offset. Thus a range of 0 - 100 PSI is equivalent to 0 - 6.9 Bar and gives a multiplier of 0.002 and an offset of -1.35.

Load Cells

This example will look at a typical load cell with a two wire voltage output. Such a sensor should be connected to one of the differential analogue inputs i.e. A17 to A24. The differential inputs have a range of -2.5V to +2.5V with 0V equivalent to an AD value of 2048. Consider a load cell capable of push-pull operation with an output of ±1.5V corresponding to a load of ±20lbs. The span of AD values obtained from such a sensor is

$$2048 - (1.5/2.5 \times 2048) \text{ to } 2048 + (1.5/2.5 \times 2048) = 1229 \text{ to } 3277$$

Because the range of the resultant AD values is not very large a 16 bit gain must be used to achieve good resolution. An 8 bit gain such as 8x1 cannot be used to achieve good resolution because the AD values start higher than the range achievable with such a gain. The resolution obtained with a 16 bit gain is as follows:

$$3 / (3277 - 1229) = 1.46 \text{ mV/bit}$$

or

$$\mathbf{20 / (3277 - 1229) = 0.00977 \text{ lbs/bit}}$$

This value can be used as the multiplier for the sensor. Given that 0lbs corresponds to an AD value of 2048, the offset can now be calculated as follows:

$$0 - (2048 \times 0.00977) = -20 \text{ lbs}$$

Thermocouple Inputs

Eight thermocouple inputs are available, all of which are designed for use with type ***K*** thermocouples. Each has a range of -50 to 1150°C which corresponds to a raw reading of reading 0-1200.

The following table shows multipliers and offsets required for various ranges of temperature measurement:

Gain	Multiplier	Offset	Range/°C
16 bit	1	-50	-50 to 1150
8x1	1	-50	-50 to 205
8x2	2	-50	-50 to 460
8x4	4	-50	-50 to 970
8x8	8	-50	-50 to 1150

Speed Inputs

The speed inputs are opto-isolated two wire inputs. Input high occurs at >3.5V; input low occurs at <1V.

Speed inputs 1-4 have a range of 7.4-655.35Hz with a resolution of 0.01Hz.
Speed inputs 5-6 have a range of 74-6553.5Hz with a resolution of 0.1Hz.

To calibrate a road wheel sensor in kph:

- It is necessary to know the number of pulses per revolution and the circumference of the road wheel. These are used to calculate the metres per pulse.
- The speed channels record data in 100^{ths} (inputs 1 to 4) or 10^{ths} (inputs 5 to 6) of Hz i.e. pulses per second. Since the number of metres per pulse is know, the metres per second can be calculated. This value is then multiplied by 3600/1000 to convert it to kilometres per hour. Thus the multiplier required for calibrating a speed sensor as KPH for a 16 bit gain is:

$$KPH\ Multiplier = \frac{Wheel\ Size}{Pulses\ per\ rev} \times SI\ resolution \times \frac{3600}{1000}$$

where *SI resolution* is the speed input resolution which is 0.01Hz for speed inputs 1 to 4 and 0.1Hz for speed inputs 5 to 6. The offset will always be 0.

To calculate a speed sensor in RPM, the number of teeth on the wheel (i.e. pulses per rev) need to be known. The multiplier required for calibrating a speed sensor as RPM for a 16 bit gain is:

$$RPM\ multiplier = \frac{SI\ resolution}{Number\ of\ teeth} \times 60$$

where *SI resolution* is the speed input resolution which is 0.01Hz for speed inputs 1 to 4 and 0.1Hz for speed inputs 5 to 6. The offset will always be 0.

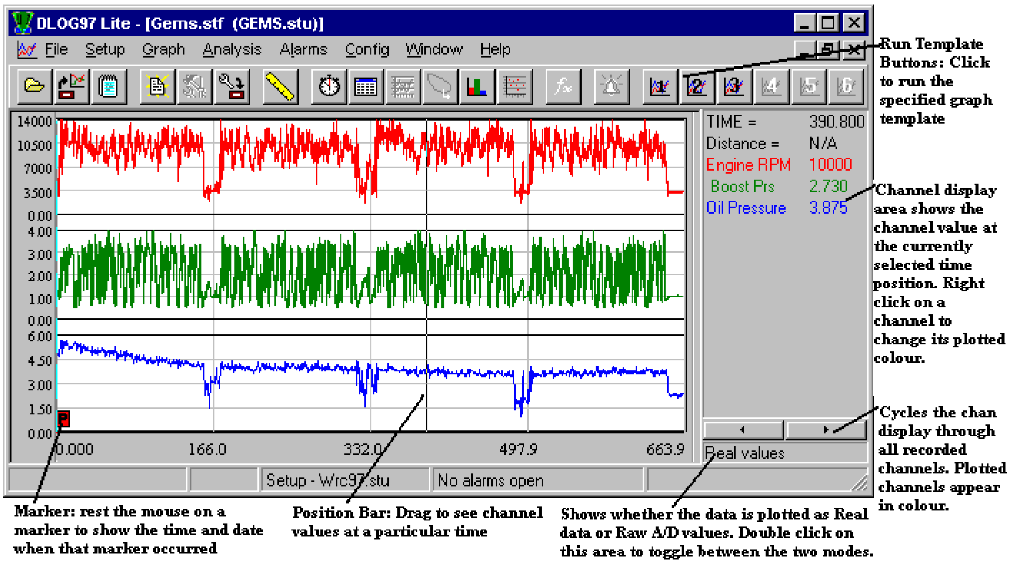
Analysing Data

F3

Once a data file has been opened, data can be viewed and analysed by several means in DLOG97, each of which will be considered in detail below.

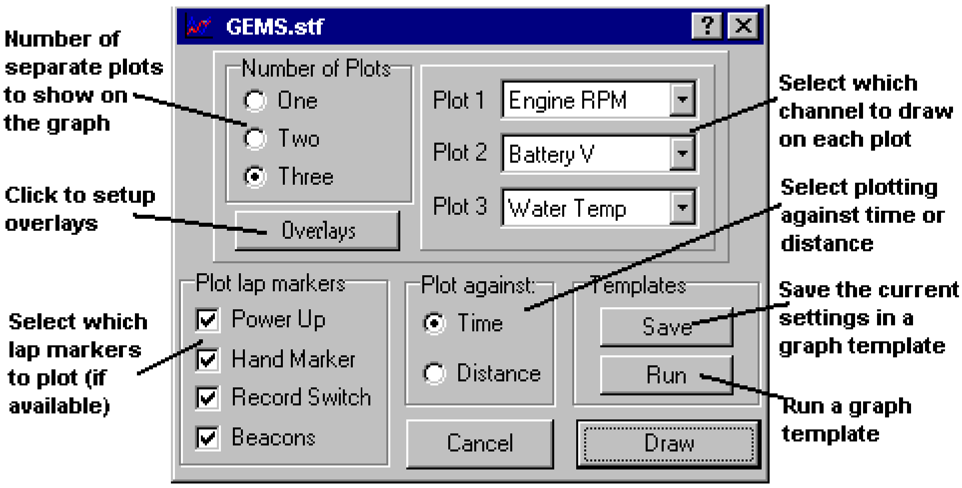
Simple Graphs

The simple graph allows channel data to be plotted against time or distance (if recorded). A typical graph screen is shown below:



To alter the graph settings, commands from the graph menu are used. Many of these commands are reproduced in the graph popup menu. To view this menu, right click on the graph itself.

To change the lines plotted, choose **Graph | Graph** and the graph setup editor will be shown:



If the distance channel was successfully recorded, it will be possible to select plot against distance. Overlays can also be added from here by clicking the overlay button. Overlayed channels can be from either the existing file or from additional externals files. Up to four external files can be added; when plotted, overlayed channels from external files are preceded with a number corresponding to the file number in the overlay list.

Overlays from external files can be shifted relative to the base graph by selecting **Graph | Shift Overlays**. This allows starting points of data to be easily synchronised.

To zoom in on the graph to view the data in more detail:

Keypad +

- Select **Graph | Zoom | In**. The cursor will change into a showing that you are in x axes zoom mode.
- Click on the area of the graph where you want the zoom to start.
- Click on the area of the graph where you want the zoom to end. The graph will be redrawn with the new zoom range.
- The selected zoom range is bounded by red vertical lines at the start and end. Using the scroll bar at the bottom of the graph, data outside this zoom range can be viewed.
- If there is data outside the scrollable region, a or will be shown at the edge of the scrollable area. These will shift the zoom area to the left or right respectively.

Keypad -

- To zoom out to the previous zoom level, select **Graph | Zoom | Out**.

Ctrl Keypad +

- The y axis can be zoomed in a similar manner by selecting **Graph | Zoom | Expand** which will change the cursor to  to show that you are in y axis zoom mode.

Ctrl Keypad -

- To contract the y axis to the previous lever, select **Graph | Zoom | Contract**.

The right hand side of the graph shows the values at the current position (shown on the graph by a vertical black line). This position marker can be moved by clicking the left mouse button on the graph and dragging the bar whilst still holding the mouse button down. Alternatively, the left and right cursor keys can be used (holding the shift key down whilst pressing the cursor keys will move the bar ten times as fast).

Clicking the right mouse button on the values area of the graph will show a menu allowing line colours, style and y axis limits to be changed. This menu can also be used to add boundary lines for highlighting ranges on the graph.

The y axis labels of the graph show the real or raw ranges of the graph. If a particular plot has overlays, the axis limits will show the current percentage range. By clicking on the y axis, the y axis labels will cycle through all actual channel limits for that plot.

The functions available from the Analysis menu will now be considered.

Statistics

F6

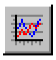
The statistics screen displays the minimum, maximum and average values of all channels in the base graph over the current zoom range and the times at which these occur. Double clicking the mouse on the time at which a minimum or maximum value occurs will zoom the graph in around this point. An example statistics screen is shown below:

Statistics - GEMSDemo.stf - 0s to 160.6s

Channel	Minimum	Time at Min	Maximum	Time at Max	Average
Engine RPM	1500	21.5	5750	143.5	3236.6
Boost Prs	0.18	59.6	1.26	93.2	0.62453
Water Temp	73	127	94	5.5	80.811
Oil Pressure	2.3332	21.5	4.1624	141.5	3.7393
T P S	8	18.4	84	124.7	27.463
Oil Temp	99	135	104.5	45.5	101.25
A I T s	17	135.2	43	5	25.447
Battery V	13.16	21.5	13.86	121	13.712
Speed Right	0	0	81.4	97.6	50.158
Speed Left	0	3.9	105.6	0.5	49.46
Yaw	-85.964	129	16.926	100.5	-7.9904
Distance	0	0	2568	160.5	1189.5

Time-Distance

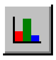
F7



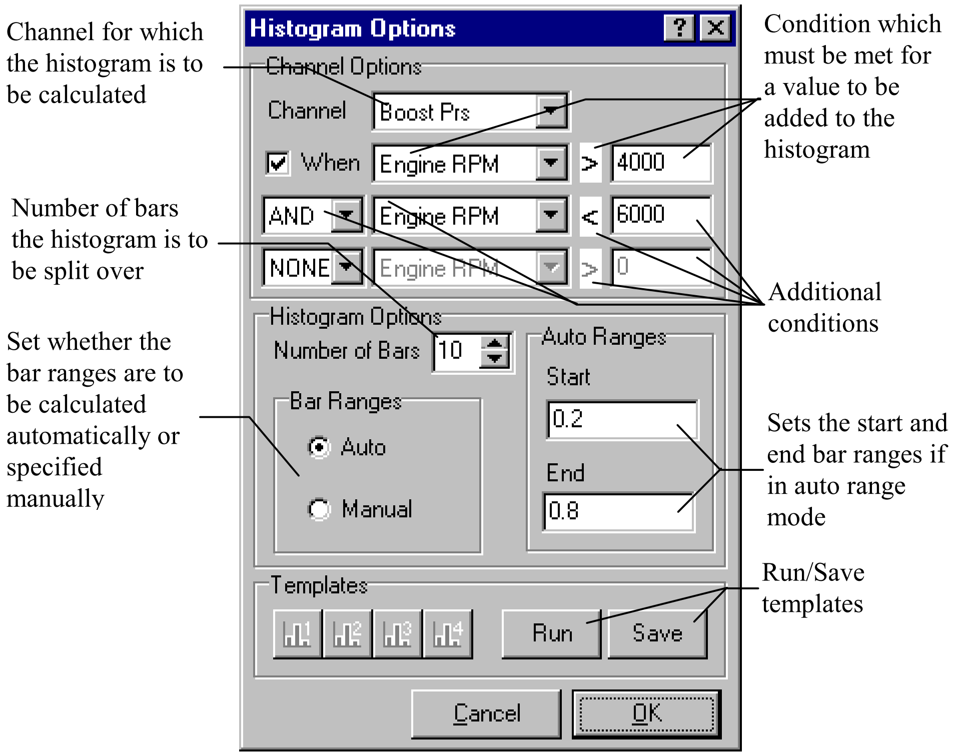
The time-distance plot shows the time difference between overlayed files and the base graph against distance A positive time difference indicates that the base graph run is faster than the overlayed graph, whereas a negative time difference indicates that the overlayed graph is faster.

Histograms

Ctrl F7

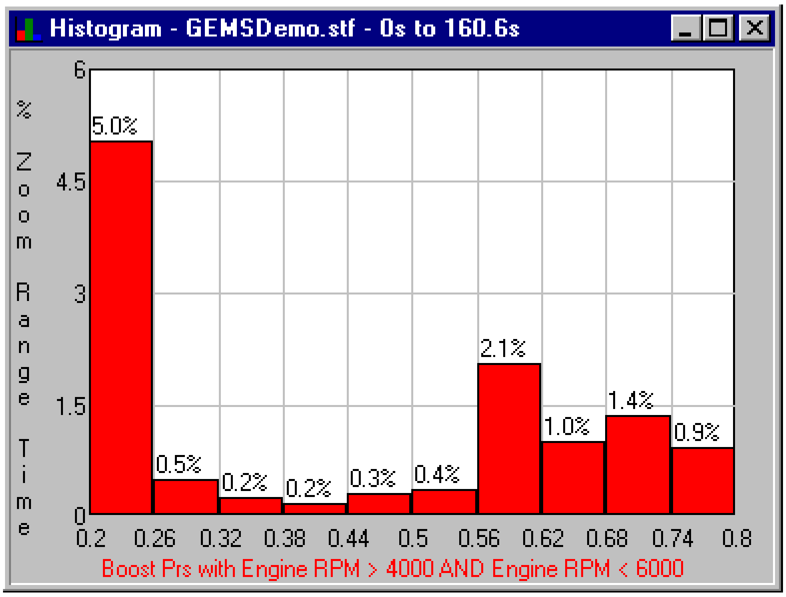


Histogram shows the frequency of occurrence of values in a channel as a percentage of the current zoom range time or distance. Choose **Analysis | Histogram** to show the histogram setup editor:



Set channel to the channel for which the histogram is to be calculated. Conditions can then be applied to the histogram to limit the amount of data included by checking the When box and entering the condition desired. Up to three conditions can be specified and are combined with the logical operators AND, OR, NOT. Only values that meet the specified criteria will be included in the histogram. The number of bars to plot and the bar ranges can now be specified.

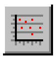
Once the setup is complete, click OK and the histogram will be drawn:



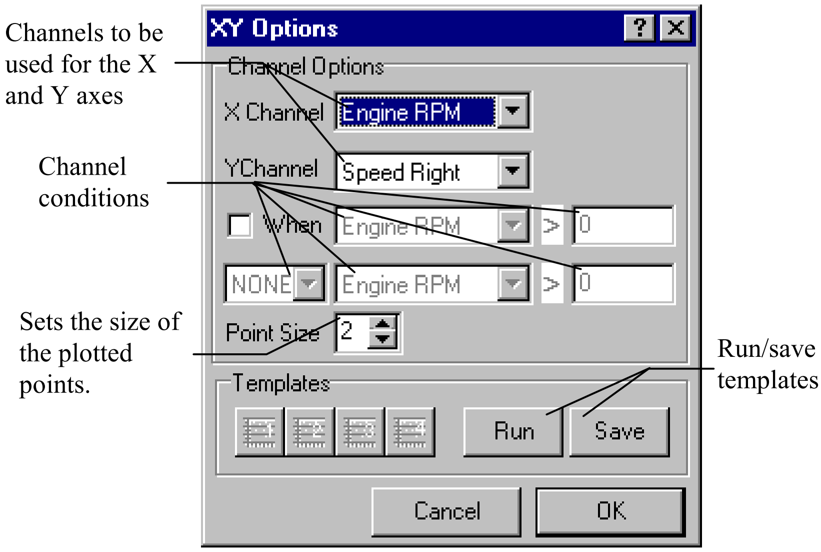
Once a histogram is drawn, the histogram editor can be re-entered by right clicking on the histogram. Once a histogram setup has been created it can be saved to a histogram template by clicking the Save button in the histogram editor. Histogram templates can be assigned to buttons in the histogram editor by selecting **Config | Options** and entering the filename in the histogram buttons page.

XY Plots

Ctrl F8



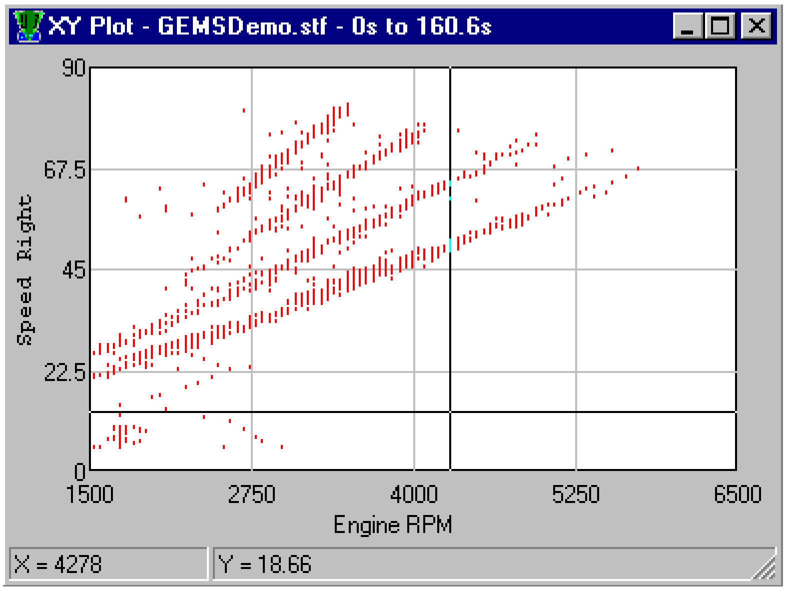
XY plots allow one channel to be plotted against another thus allowing the relationship between the two channels to be explored. To create an XY plot, choose **Analysis | XY Plot**; the XY plot editor will be shown:



Set the X and Y channels for which the XY plot is to be draw. Conditions can then be applied to the plot to limit the amount of data included by checking the **When** box and entering the condition desired. Up to two conditions can be specified and are combined with the logical operators AND, OR, NOT. Only values that meet the specified criteria will be included in the XY plot.

The point size changes the size of the plotted points. On plots using a large amount of data, a small point size should be used. However, when the data set used is small, a larger point size helps to show any trends in the data

Once the setup is complete, click OK and the XY plot will be drawn:



By clicking and holding the left mouse button on the graph, the mouse can move the cross hairs on the plot. The X and Y values at the current cross hair position are shown in the status bar at the foot of the graph.

Once an XY plot is drawn, the XY plot editor can be re-entered by right clicking on the plot. XY plot settings can be saved in an XY plot template by clicking the Save button in the editor. XY templates can be assigned to buttons in the editor by selecting **Config | Options** and entering the filename in the XY plot buttons page.

Maths Channels

Maths channels allow recorded data to be mathematically manipulated; the new data is stored in a maths channel which behaves like any other recorded channel i.e. it can be plotted, analysed and even used to create another maths channel.

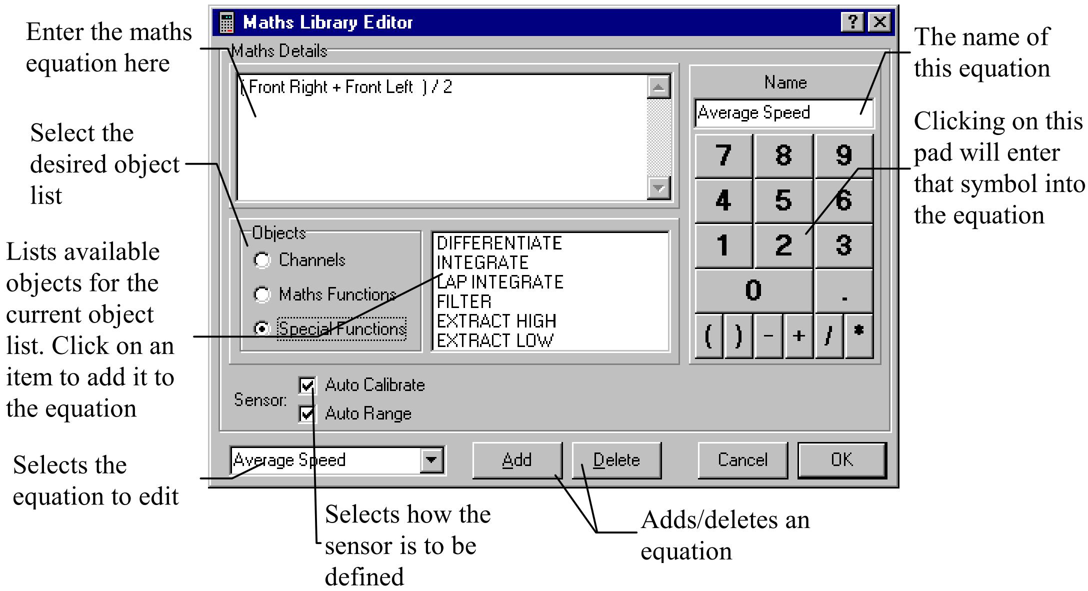
Maths channels are created from mathematical expressions defined in the maths library. This allows the user to build up a library of commonly used expressions which can easily be applied to a data file.

Defining Maths Equations

A setup must be loaded before the maths library can be edited. To define a new expression in the maths library:

Shift F9

- Click **Maths | Edit Library**. The Maths Library Editor will appear:



- Select the maths equation to edit using the box at the bottom left of the screen.
- To create a new entry in the maths library, click the Add button.
- The equation will appear as it is entered in the top left edit window.
- To add a channel to the equation, ensure **Channels** is selected in the Object box, then click on the desired channel from the list displayed.
- To add numbers, +, -, /, * or brackets, simply type in using the keyboard or use the mouse with the keypad displayed to the right of the Maths Editor. Note: no operators have no precedence in the Maths Editor: i.e. 1+2*3 will evaluate as 3*3. Use brackets to change the evaluation order: i.e. 1+(2*3) will evaluate as 7.
- To add a maths function, ensure **Maths Functions** is selected in the object box, then click on the desired function. Maths functions are commonly used mathematical functions such as *LOG*, *LN*, *SQUAREROOT*, etc. See the on-line help for a full list of maths functions.
- To add a special maths function, ensure **Special Functions** is selected in the object box. Special maths functions are time based functions such as *INTEGRATE*, *DIFFERENTIATE*, *FILTER*, etc. Special functions can only be used on their own with a single channel e.g. *INTEGRATE(Speed)*. See the on-line help for a full list of special functions.

- Enter text (up to 12 characters) in the **Name** edit box to identify the maths channel.

The **Auto Calibrate** and **Auto Range** check boxes determine how the sensor is defined when the maths channel is created:

- If **Auto Calibrate** is checked, a multiplier and offset will be calculated to derive real values from the 16 bit raw maths channel data. Otherwise, specify a multiplier and offset (or function table) in the edit boxes provided.
- If **Auto Range** is checked, values for the Graph Start and Graph End will be automatically calculated dependant on the range of the calculated data. Otherwise, specify a value for the Graph Start and Graph End in the edit boxes provided.

Sensors for maths channels are allocated as follows: Maths Channel 1 is stored in Sensor 60, Maths 2 in Sensor 59 and so on.

Once all desired maths equations have been entered, click OK..

Adding Maths Channels

If there are less than 60 channels stored in the log file, it will be possible to add a maths channel. Before a maths channel can be entered, At least one maths library entry must have been defined (see above).

F9

- Select **Maths | Add To Log File**. A window will be displayed showing currently used maths channels and available equations in the maths library.
- Select where to create the maths channel in the left hand box. **Select Add New…** to create a new maths channel or select an existing maths channel to replace.
- Select which maths equation to use from the right hand box. Note that the channels referred to in the equation must be recorded for the maths channel to be calculated.
- Click OK. The maths channel will be calculated. This may take several seconds, depending on the complexity of the equation and the size of the data file. Any errors encountered whilst calculating the channel will be displayed.
- The maths channel can now be plotted and analysed as desired.

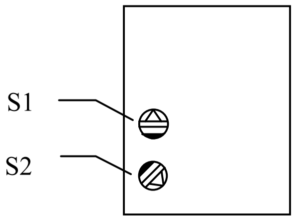
Lap Timing and Analysis

DLOG97 has the ability to provide lap analysis information from beacons positioned around the track. If a yaw or g sensor is fitted to the car, it is also possible to draw a map of the circuit. This allows data for a particular area on the circuit to be easily identified.

GEMS can supply a beacon transmitter and receiver kit which enables lap or stage segment timing to be carried out. Each car must be fitted with a receiver to pick up the beacon signal. At least one beacon must be used which will normally be positioned on or near the start/finish line. Additional beacons can be placed around the circuit or along the stage so that split times can be monitored.

Beacon Setup and Use

The GEMS beacon transmitter unit can be set to one of 28 codes for unique beacon identification at a session. The beacon code is set using two rotary switches inside the unit. To open the unit, remove the four screws in the corners of the front panel. On opening the unit the circuit board will be seen. The switches can be identified by their position on the circuit board as follows:



Equivalent to beacon code 34

The following table shows the switch positions for the various beacon codes. All other switch positions are invalid. If an invalid switch position is selected, the red LED on the front of the transmitter will not illuminate when the beacon is switched on.

S2 \ S1							
	34	64	94	123	152	182	212
	42	71	101	130	160	189	219
	49	78	108	138	167	197	226
	56	86	116	145	174	204	233

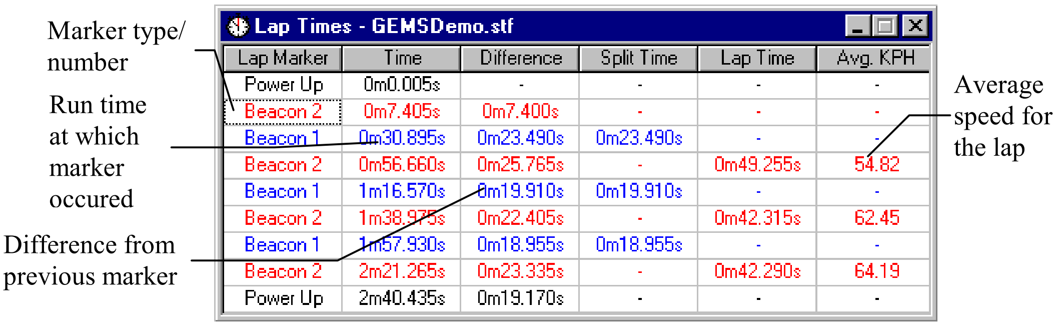
Once the beacon code is set as desired, reassemble the beacon. The beacon can be mounted on any structure facing the track; it must be mounted upright.

The receiver unit is fitted to the car such that the window side will face the beacon as it passes. Other beacon transmitters can be mounted at split points on the circuit but must be positioned such that they will all face the same side of the car. As the car passes the beacons, the beacon code will be recorded.

Lap Analysis

F5

Once lap data has been recorded, and read into DLOG97, a view of the lap times can be displayed by selecting **Analysis | Lap Times**:

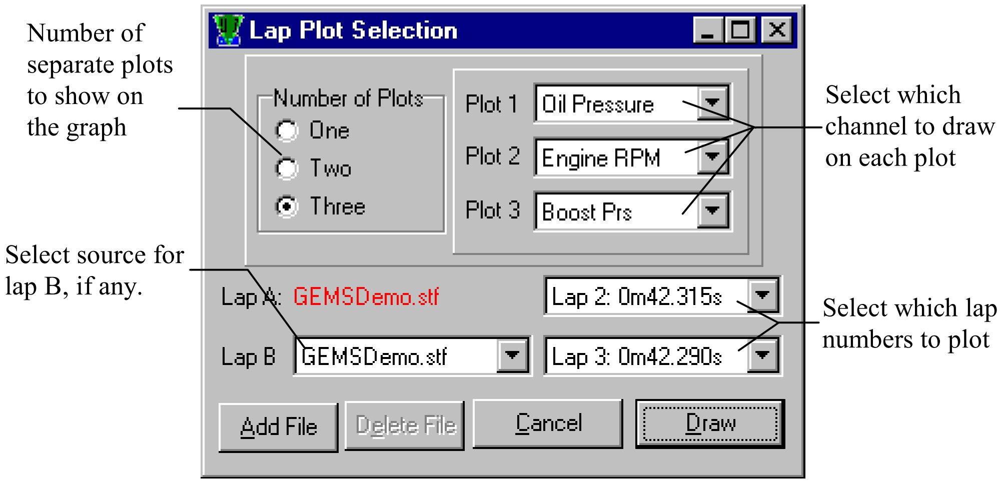


The lap marker column shows the type of marker. Marker type are shown in the following table

Marker Type	Description
Power Up	Recorded when logger is powered up
Rec Switch	Recorded when Record Switch set to ON
Hand Marker	Recorded when hand marker button is pressed
Beacon	Recorded when receiver passes beacon transmitter

Ctrl + L

To compare laps, Select **Graph | Lap Plot**. The lap plot setup editor is similar to the graph setup editor:



In this case, however, it is possible to select the lap number to plot. If it is desired to overlay another lap on the base lap, select a lap for Lap B. To overlay a lap from another file, select add file to add the file and then select the lap number. Files added are considered to be standard overlay files and will appear in the overlay editor. Conversely, files added in the overlay editor will be available in the lap plot setup. Click draw to draw the lap plot.

The lap plot appears similar to the standard graph; apart from lap information below the x axis. If an overlay lap has been specified, the values area to the right of the graph will show a difference value which is the difference between the two laps for that channel at the current position marker position.

Track Drawing

If yaw or lateral g are recorded, it is possible to display a plot of the circuit driven. Once displayed, the circuit can be split up into segments and analysis of the various statistics entering, during and exiting the segment can be carried out.

Before track drawing can be carried out, it is necessary to accurately calibrate the yaw or g sensor being used. **DLOG97** incorporates an automatic yaw and g sensor calibration routine.

To calibrate the sensors:

- Drive a simple circuit (a small circle is adequate) whilst logging yaw or g, speed and distance.
- Ensure that the start and end points of the circuit are noted. This can be done using lap mark beacons or just by recording the time relative to the start of logging.
- Read the data from the card into DLOG97.

F8

- Select **Analysis | Draw Track** to show the track options editor.
- On the Define Track page set track type to circuit and specify the start and end of the track as follows:
    - If the track limits are defined by lap markers, set **Get Track Limits From** to *Lap Markers* and specify the lap marker and lap number to use in the **Lap Markers** box.
    - If the start and end time of the lap is known relative to the start of the log, select *Absolute Time* in the **Get Track Limits From** box and specify the time in the **Absolute time** box.
- Select the Sensor page of the editor and set the **Sensor Type** to the type of sensor being used i.e. Yaw or g and set the channel to where the sensor is stored. If a g sensor is being used, it will also be necessary to specify a wheel speed sensor to use.
- Click the **Calibrate as** button to start the calibration process. Progress will be shown and once calibration has finished, a message will appear reporting whether or not the calibration process was successful. If unsuccessful, check that the track limits and sensor type have been specified correctly.

This sensor calibration can now be used for all runs using this sensor. If a new or different sensor is used, it is advisable to calibrate the sensor again.

With the sensor calibrated, the track can now be drawn by clicking the OK button. By moving the position marker across the graph, the relative position on the track will be shown by a red circle. The start point and direction of travel is shown by a green line/arrow.

The track options editor can be shown again by right clicking on the track and selecting track options. If section track is checked in the options page of the editor, the track will be segmented into individual corners and straights. By selecting the Segment Analysis option from the track pop-up menu, the entry and exit points for segments of the track can be analysed.

Channel Alarms

Channel alarms can be used to alert users if data in a channel exceeds a predefined limit. Alarms can also be set to be conditional on two channels exceeding their limits. A maximum of 100 alarms can be set. A setup file must be loaded before Alarms can be edited.

Creating/Editing Channel Alarms

To create/edit channel alarms:

F10

- Choose **Alarms | Create** to create a new alarm list or **Alarms | Edit** to edit the current alarms list. The Alarms editor will be invoked. Enter the desired alarm parameters in the relevant columns:
- Alarm Name - A 12 character name for the alarm.
- Channel - The channel to which this alarm will apply. The channel names are obtained from the currently loaded setup.
- <> - If > is specified, the alarm is activated if the Limit is exceeded. If < is specified, the alarm is activated if the channel value falls below the Limit.
- Limit - The numerical value of the limit.
- With - Specifies if another channel limit has to be exceeded to activate the alarm. If NONE is specified, the alarm is based on the preceding parameters only. If AND, NOT or OR are specified, the first *Channel* <> *Limit* sequence is combined with the second *Channel* <> *Limit* sequence with the specified logical operator.
- Click the Add button or Insert key to add a new alarm.
- Click the Remove button or Delete key to remove the currently selected alarm. The arrow keys can be used to navigate around the alarms grid. When the desired item is highlighted, pressing the space bar allows it to be edited. Pressing the Enter key returns to navigate mode.

Ctrl F10

- When the alarms have been created as desired, save them using **Alarms | Save**.

The following table shows some example alarms and their meanings:

Alarm	Meaning
Water Temp > 110	Activated if the water temperature exceeds 110
Oil Pressure < 3 AND Engine RPM > 2000	Activated if the oil pressure falls below 3 and the engine RPM is greater than 2000. If the RPM is less than 2000, the alarm will not activate
Left Speed > 200 OR Right Speed > 200	Activated if either the left or right speed exceeds 200

Using Channel Alarms

Once the channel alarms have been created as desired, they can be used as follows:

- Select when to show any alarms:
    - If **Alarms | Active On Read** is checked, any alarms activated will be shown when a card is read.
    - If **Alarms | Active On Open** is checked, any alarms activated will be shown when a log file is opened.

Shift F10
- **Alarms | Show for Current** can be used to show alarms for the currently active data file.

The last loaded alarm file will automatically be loaded on starting **DLOG97**. A newly created set of alarms must be saved before it can be used as the default alarm list.

If any alarm limits are activated, the alarm report will be shown. This shows the alarm activated, the time at which it was initially activated and the duration for which it was activated. The minimum and maximum values of the main alarm channel over the alarms' duration will also be shown. By double clicking on the alarm, the graph will be automatically zoomed in around the initial alarm occurrence point.

Appendix A - Logger Pin Outs

The DA97 logger is fitted with 5 connectors as shown in the following table:

Connector	Type	Position
P1	9 way D type	Front Top Left
P2	9 way D type	Front Top
P3	37 way D type	Front Bottom
P4	5 pin CAN	Front Top Right
P5	37 way D type	Rear

Note that the Rear of the logger is considered to be the end with the PCMCIA card slot.

Each of the connectors are configured as follows:

P1: 9 way D type:

1. Serial Tx 1
2.
3. Serial Rx 1
4. +12V power
5. Serial 0V
6. Beacon receiver input
7. -12V power
8.
9. Record switch

P2: 9 way D type:

1.
2. Serial 0V
3. Serial Tx 2
4. Serial Rx 2
5. Serial Rx 3
6.
7.
8.
9. Serial Tx 3

P3: 37 D type:

1. Analog 0V ref	20.
2. Analog Ch. 1	21. Analog Ch. 2
3. Analog Ch. 3	22. Analog Ch. 4
4. Analog Ch. 5	23. Analog Ch. 6
5. Analog Ch. 7	24. Analog Ch. 8
6. Analog Ch. 9	25. Analog Ch. 10
7. Analog Ch. 11	26. Analog Ch. 12
8. Analog Ch. 13	27. Analog Ch. 14
9. Analog Ch. 15	28. Analog Ch. 16
10. Speed Input 5 -ve	29. Speed Input 5 +ve
11. Speed Input 6 -ve	30. Speed Input 6 +ve
12. Speed Input 3 -ve	31. Speed Input 3 +ve
13. Speed Input 2 -ve	32. Speed Input 2 +ve
14. Speed Input 1 -ve	33. Speed Input 1 +ve
15. Speed Input 4 -ve	34 Speed Input 4 +ve
16.	35.
17.	36.
18.	37.
19.	

P4: Can bus:

1.
2.
3. CAN L
4.
5. CAN H

P5: 37 D type:

1. Analog 0V ref	20. Analog Ch. 24 +ve
2. Analog Ch. 24 -ve	21. Analog Ch. 23 +ve
3. Analog Ch. 23 -ve	22. Analog Ch. 22 +ve
4. Analog Ch. 22 -ve	23. Analog Ch. 21 +ve
5. Analog Ch. 21 -ve	24. Analog Ch. 20 +ve
6. Analog Ch. 20 -ve	25. Analog Ch. 19 +ve
7. Analog Ch. 19 -ve	26. Analog Ch. 18 +ve
8. Analog Ch. 18 -ve	27. Analog Ch. 17 +ve
9. Analog Ch. 17 -ve	28.
10.	29. Analog 5V ref
11.	30. Thermocouple 1 -ve
12. Thermocouple 1 +ve	31. Thermocouple 2 -ve
13. Thermocouple 2 +ve	32. Thermocouple 3 -ve
14. Thermocouple 3 +ve	33. Thermocouple 4 -ve
15. Thermocouple 4 +ve	34 Thermocouple 5 -ve
16. Thermocouple 5 +v	35. Thermocouple 6 -ve
17. Thermocouple 6 +ve	36. Thermocouple 7 -ve
18. Thermocouple 7 +ve	37. Thermocouple 8 -ve
19. Thermocouple 8 +ve	

When wiring up sensors to analogue inputs, always ensure that the sensor 0V is connected to Analog 0V reference. Failure to do this will result in incorrect and spurious results.