LogWorks User Manual

1 Overview

LogWorks is a software application that interfaces with the LM-1 digital Lambda Meter and other Innovate Motorsports' products. It enables easy analysis and manipulation of engine data acquired by the auxiliary input capabilities of the LM-1. With the appropriate firmware in the LM-1 this software package also allows view engine data in real-time on the on-screen virtual gauges.

1.1 Specifications

Computer requirements

Operating System	Windows 95 or later
Computer speed	300MHz Pentium 1 or faster
RAM	Min. 48 Mbyte
Hard Disk space	Min. 100 Mbyte free space
Display	Thousands of colors, 800 x 600 Min.
Other	1 free serial port or USB to serial adapter

LM-1

Firmware version required	1.1 (1.33b or later recommended)
LM-1 Input Impedance	> 1 MOhm (- 0.5 to + 5.5V input range) < 10 kOhm (< - 0.5V or > 5.5V input range)
LM-1 Dynamic Input Impedance	Low pass filter 10 kOhm / 4700 pF
Data logging rate	12.21 times/second for all inputs concurrently Equivalent to 81.92 msec per data set
LM-1 Max. Logging time internally	44 minutes
LM-1 Max number of sessions intern.	1024

LogWorks limits

Max. Session Size	1 hr 45 minutes
Max. Number of sessions per log	1024
Max. Number of logs open	32 open concurrently

1.2 Logging engine data

The LM-1 unit has 5 analog inputs for datalogging external signals. These inputs have a capability to digitize signals between 0 Volt and 5 Volt. The input signal is converted by an analog-to-digital converter in the LM-1 into a number between 0 and 1023 or a total of 1024 steps incl. 0. This is equivalent of a 10 bit resolution (2^{10} = 1024). The resulting resolution is therefore about 4.9 mV. Any signal variations smaller than that cannot be resolved.

Because the LM-1 measures the input signal relative to its internal ground, differences in grounds between the signal source (sensor) and the internal ground of the LM-1, will show up as shifts in the digitized signal. LogWorks has features to allow compensating for these potential differences.

Voltages are very seldom required to analyze engine data. Other quantities like throttle position (TPS), RPM, manifold pressure (MAP), exhaust temperature (EGT) or cylinder-head temperature (CHT) and so on are more useful. Specialized sensors in the engine typically convert these quantities into a voltage that can be used by the fuel-injection computer and also by the LM-1 analog inputs. LogWorks has capabilities to convert the logged number back to the original quantity, provided the characteristics of the original sensors are known. This means that LogWorks needs to know how to convert the voltage output of the original sensor to the measured quantity equivalent.

The Air-Fuel-Ratio signal of the LM-1 is not digitized from an external analog voltage. Instead it is internally calculated. For logging purposes this signal is internally always stored as Lambda with a resolution of 10 bits (1024 steps). To create the Air-Fuel-Ratio, the Lambda value is multiplied with the stoichiometric ratio for the given fuel (like 14.7 for gasoline) by the LogWorks software. The datalog range for Lambda is 0.5 to 1.523, equivalent to 1024 steps with a resolution of 0.001 Lambda (for gasoline this is equivalent to a 0.0147 AFR with a range of 7.4 to 22.4 AFR). This range is more than sufficient for spark ignited internal combustion engines. AFR/Lambda ranges outside of the logging range are pegged at the minimum or maximum point respectively.

1.3 Logs and Sessions

Different to other datalogging products, LogWorks organizes the acquired data in logs and sessions. A session is a contiguous data set. This means there is no interruption in the data stream and all data points are spaced equally in time (81.92ms apart). Each time you start logging a new session is created and the session ends when the logging stream is stopped.

A log is a collection of sessions. In a typical qualifying race or tuning session multiple runs are made, and each run is datalogged. LogWorks conveniently organizes these runs into a common log. The sessions in a log are numbered from 1 through x. Typically they are sequential in time, starting with the oldest session as session 1 and so on. Each log can be stored in a separate file on the computer.

In addition each log contains the information how to convert the digitized numbers (see Logging engine data) into the original quantities. These so called input settings apply to all sessions in a log.

LogWorks distinguishes three different kinds of logs:

a) Real-time log

This is a log created by connecting the LM-1 serial port to a computer and recording the real-time data stream from the LM-1. New sessions can be added at any time by starting to record the serial stream. Real-time logs require LM-1 firmware version 1.33b or later.
Only one real-time log can be open at any time.
The current real-time input settings apply to the real-time log.

b) LM-1 log

This is a log created by downloading log data from the LM-1's internal memory, but not yet stored in a file. Only one LM-1 log can be open at any time.
The current real-time input settings apply to LM-1 log.

c) File logs

File logs are data files created by LogWorks when saving a real-time log or a LM-1 log. Up to 30 such logs can be opened by LogWorks concurrently. LogWorks stores logs in either of two file formats:

Log files (file extension .log)
Or
DIF files (file extension .dif)

The .log file format is native to LogWorks. It stores the original data in a very compact format and also stores additional information like measurement points, filter parameters and all input settings. This allows to change and manipulate the data later more conveniently than the DIF file format.

The DIF file format is used to allow importing the log data into spreadsheet program like Microsoft Excel.

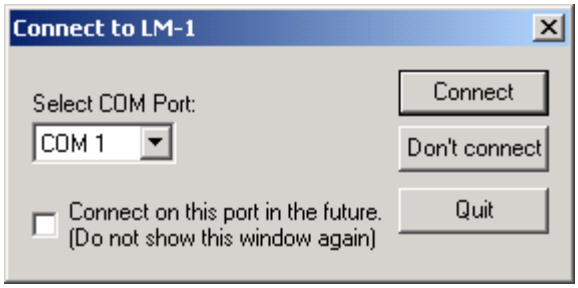
The DIF format stores the data as manipulated by LogWorks and already converted into the real engine quantities. Because of that, information can be lost when reloading a DIF file for further manipulation.
The DIF format should only be used when the log data is to be processed by external software like Excel.

2 Using LogWorks

2.1 Starting up LogWorks

Connect your LM-1 serial port to a free serial port on your computer and start the LogWorks program. The LM-1 can either be currently operating in the car or can be connected (running from its internal battery) to the computer. Real-time logging can of course only be done when running the LM-1 in the car.

The following dialog box will appear:



Select the serial port (COM Port) to which the LM-1 is connected. Then press the Connect button.

To quit here and don't start LogWorks press the Quit button.

If you do not wish to connect to the LM-1 (or don't have it connected), Press the "Don't connect" button.

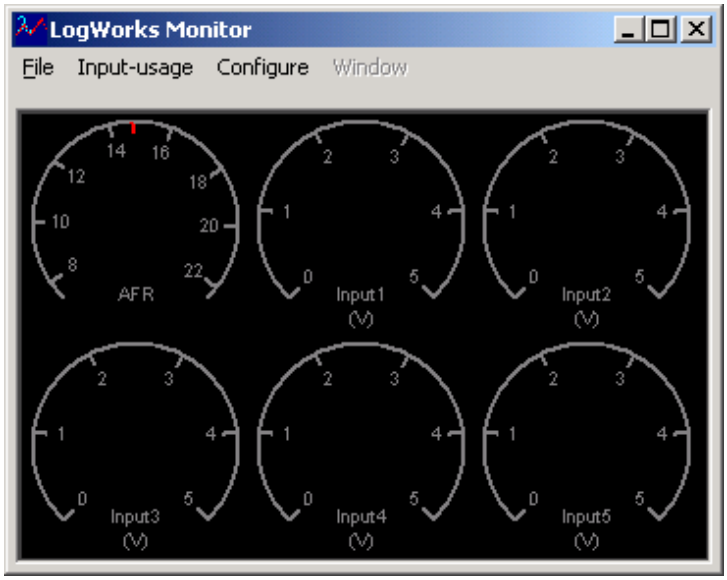
Check the "Connect on this port in the future" checkbox if you want to auto-connect on the selected port always in the future (you can change that later on if you wish).

LogWorks can also be started by dragging one or more log files on the LogWorks icon (if you installed one on the desktop). In this case the log files will be opened automatically.

 ***Make sure no other program (including LM Programmer or LM-1 Manager) is using the selected serial port.***

2.2 The LogWorks Main Window

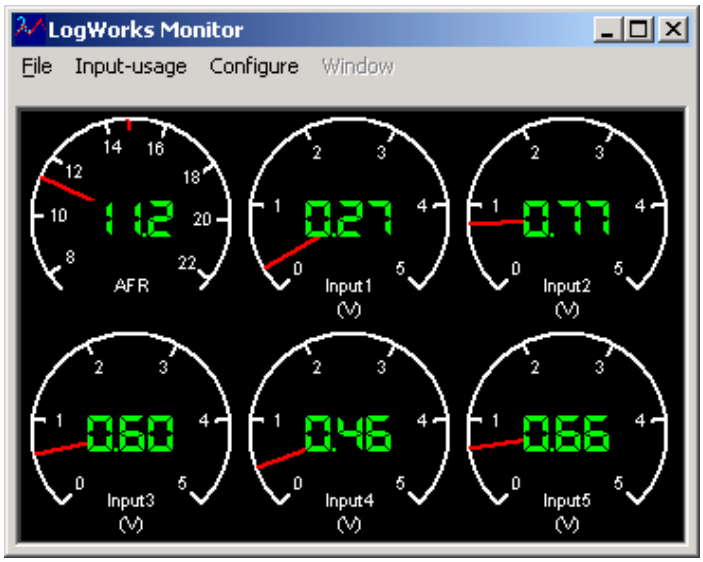
After this the main window of LogWorks, the LogWorks Monitor, appears:



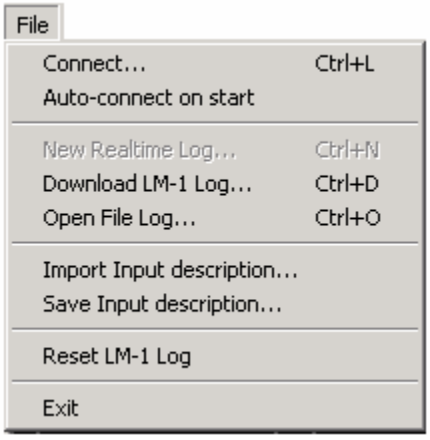
This window is resizable by grabbing on the lower edge of the window. The round gauges are typically arranged in a 3 x 2 arrangement. This arrangement will be changed depending on the window width and height to maximize the gauge size. All gauges are grayed out until:

a) LogWorks is connected to the LM-1
b) A valid serial data stream is detected on the serial port
c) The appropriate input is enabled.

When this happens the window might look like this:



2.2.1 LogWorks Main File Menu



Connect…
Allows the connection of LM-1 on the serial port if LogWorks was started without connecting.

Auto-connect on start
Allows auto connecting at LogWorks start to be switched off or on.

New Real-time Log…
Starts a new real-time log or brings the real-time log window to the front if it is already open.

Download LM-1 Log…
Creates a new LM-1 log by downloading data internally logged in the LM-1. During downloading the car may not be running (engine off) because the WB sensor's heater is switched off during downloads. After a download completes, the LM-1 is automatically restarted (heater runs again).

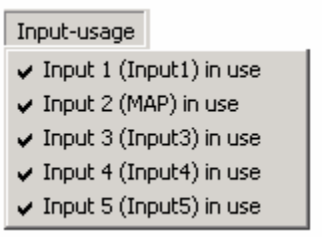
Open File Log…
Opens a saved log for further inspection and manipulation.

Import Input description…
Extracts the input settings data from an existing log file. Note that .dif files do not contain the entire input description data.

Save Input description…
Saves the current input settings (see Configuring the Inputs) in a .log file. This log file will contain only the input settings, no session data. Trying to open it as a file log results in an error.

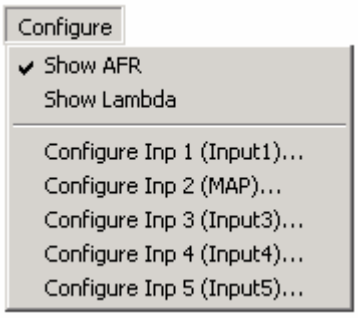
Reset LM-1 Log
Resets the log memory in the LM-1. This works only in LM-1 firmware version 1.33b or later.

2.2.2 LogWorks Main Input Usage Menu



Allows selectively switching inputs off that are not connected or not used for datalogging. The appropriate gauge is grayed out when switching the input off and the data from that input is not used or shown in the real-time log or LM-1 log.

2.2.3 LogWorks Main Input Configure Menu



The first two items allow you to select if Lambda data from the LM-1 is to be shown as Lambda or air-fuel-ratio (AFR).
The other items allow you to custom configure each input. See Configuring the Inputs.

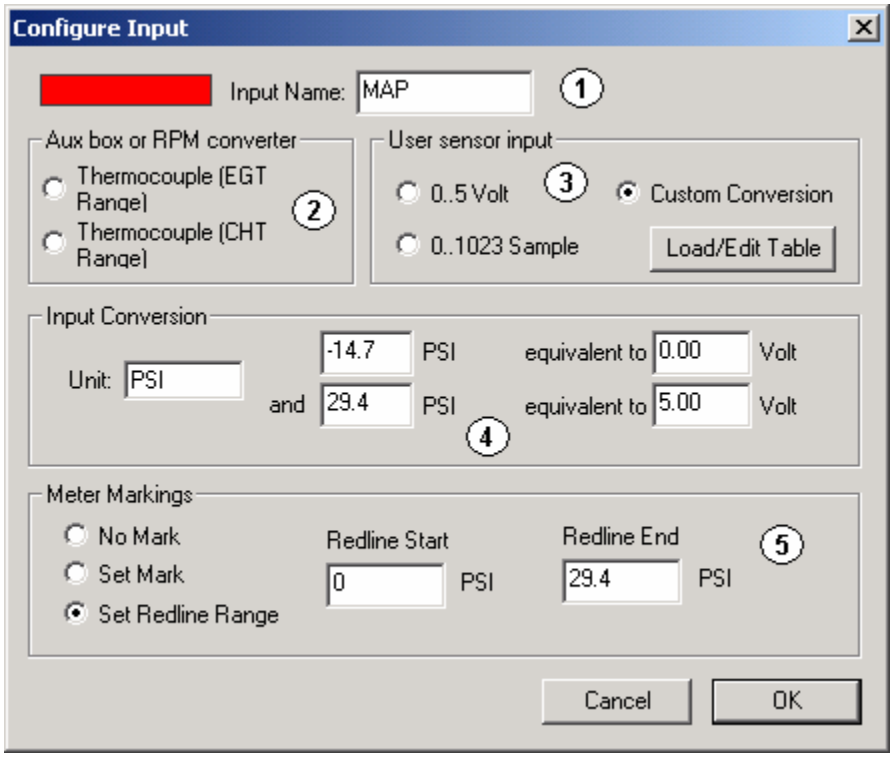
2.2.4 LogWorks Main Window Menu

Use this menu to quickly switch between open logs.

2.3 Manipulating the Inputs

2.3.1 Configuring the Inputs

The Configure Menu of the main window allows configuring the LM-1 inputs. The AFR/Lambda input can't be configured. You can only switch it between displaying Lambda or AFR. To configure an input, select the appropriate input from the Configure menu or double-click on the appropriate instrument. The following dialog box appears:



This dialog box contains 5 fields.

Field 1.
In field one you can specify a name for the input for easy identification. The left side of this field shows a colored box. This color is the trace color of this input in the logs.
The following (case sensitive) names can NOT be used to name an input:

RPM
TEMP
DWELL
PRESS
ACCEL

These names are reserved for inputs from the Aux-Box or RPM converter.

Field 2.
Field 2 is used when using the Aux-Box or RPM converter. It allows you to specify whether the appropriate input of the Aux-Box/RPM converter is used and on which setting. The actual settings for the Aux-Box or RPM converter are shown in the grayed out items of Field 4.

Field 3. and 4.
The buttons in this field allow you to create your custom conversions from voltage to the appropriate quantity measured.
The voltage/sample buttons are simple. The log will just contain the voltages measured or the appropriate sample number (a number between 0 and 1023, equivalent to 0..5V).
Clicking the "Custom Conversion" button allows you to specify in Field 4 the unit measured (PSI in the above example) and two voltages (0 and 5V in the above example) and the equivalent measurement quantity (- 14.7 and 29.4 PSI respectively in the example). If voltages different than 0 and 5V are specified, the range will be automatically expanded to 0..5V, even if the sensor is not capable to produce 0..5V (the measured signal will stay within the range the sensor produces).

The Load/Edit table button allows you to import or create a custom lookup table for the input. More on that later.

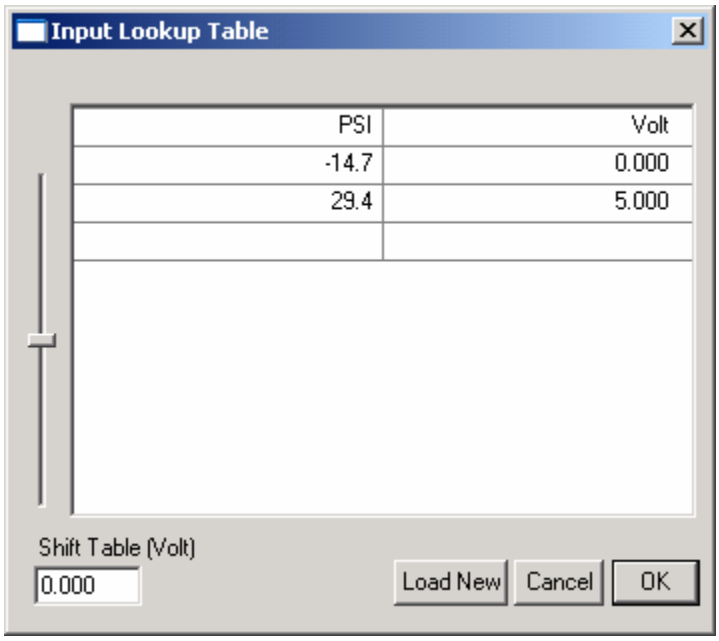
Field 5.

This field only affects the display of the gauges in the LogWorks Monitor window.
This allows you to specify either no markings, a single mark (a red line) or a red-line area in the gauge as in the resulting example:

Note:
If this dialog box was started from the LogWorks main window, a real-time log window or the LM-1 log window, right clicking on one of the 'equivalent to' voltage input fields will show a menu that allows you to paste the current input voltage of this input.

2.3.2 Custom Input Lookup Tables

Press the Load/Edit Table button in field 3, and you will be presented with the following dialog box:



Double click on any field in the table to modify it. Click on a field to select it. To delete an entry, select it and hit the delete key.

If you make changes by editing, click anywhere in the table to make the changes permanent.

You can import a new lookup table from a text file (extension .txt) or a DIF file created by a spreadsheet program (extension .dif). A text table must have two columns, separated by spaces or tabs.

The first line contains in the left column the unit of the measured quantity (PSI in our example). The right column, first line must contain the word “Volt”.

Underneath that first line listed are the individual equivalents of the lookup table. Left column contains the measured quantity and the right the equivalent voltage.

Note:

The slider on the left of the window shifts the entire table voltages up or down to compensate for ground differences between LM-1 and the measurement sensor.

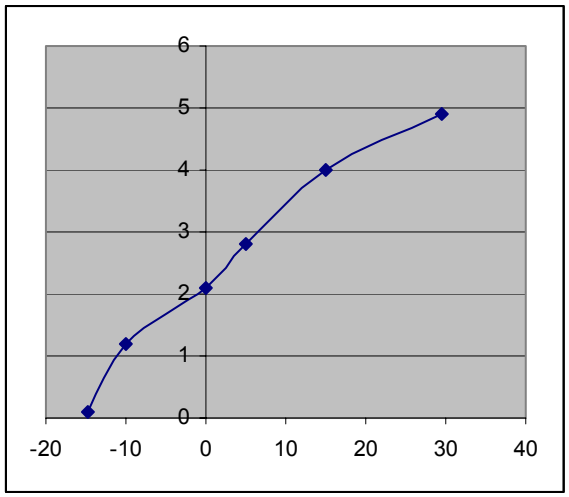
The following is an example of an input lookup table:

PSI	Volt
-14.7	0.1
-10.0	1.2
0	2.1
5	2.8
15	4
29.4	4.9

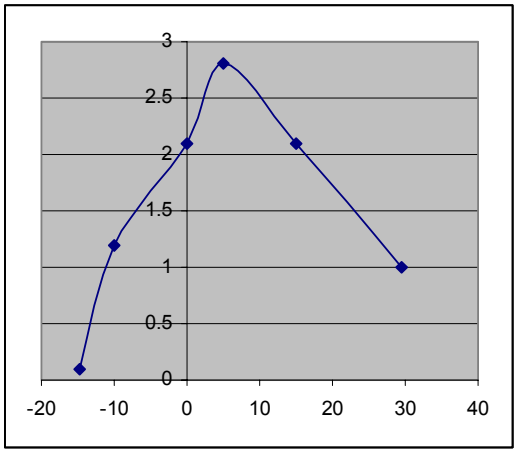
A DIF file must be organized similarly. The top left entry in the spreadsheet (field A1) must contain the measured unit. The second entry (field B1) MUST contain the word “Volt”. The rest of the ‘A’ column contains the measured quantity equivalents and the rest of the ‘B’ column contains the equivalent voltages.

When loading the table LogWorks sorts it in ascending order by voltage. LogWorks then creates a custom lookup table for all 1024 possible input values by linearly interpolating between table points. The table must be monotone rising or falling. If the difference between the second quantity and the first quantity is positive, the quantities must be always rising (third bigger than second and so on. If the difference is negative, the quantities must be always falling (third smaller than second and so on). If this were not the case, the same voltage could mean different measured quantities.

Example of monotone lookup table (x in PSI, y in Volt):



An example of a wrong table:



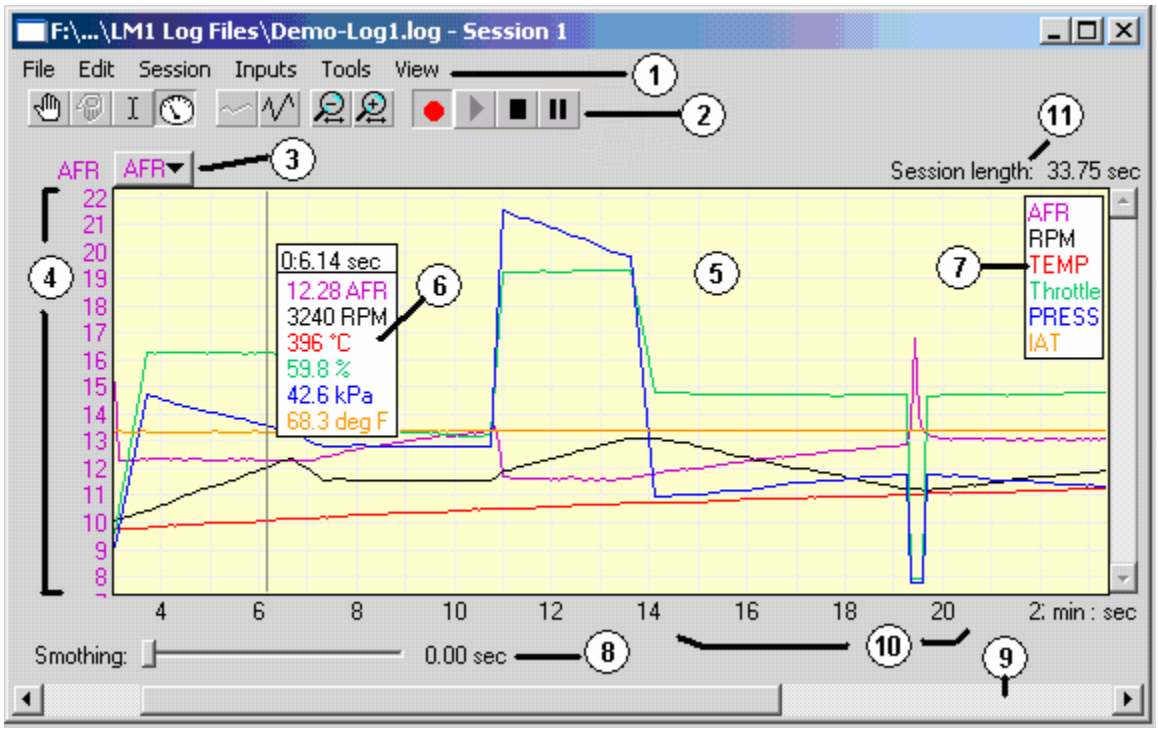
Note that 2.1 V could either mean 0 PSI or 15 PSI.

Note1:
Different than the custom setting in Field 3. of the Input Settings dialog box, the lookup table will NOT be automatically expanded to 0..5V. Instead the resulting log is clipped to the minimum and maximum of the table entries.

Note2:
If this dialog box was started from the LogWorks main window, a real-time log window or the LM-1 log window, double-clicking on one of the voltage fields, then right clicking on it will show a menu that allows you to paste the current input voltage of this input.

3 Working with Logs and Sessions

3.1 The Log Window



The Log window can be resized to any size. It is divided into different areas:

1. Menu area
Contains the Log menus.

2. Tool area.
Allows selecting the various tools and functions to manipulate the log

3. Active trace selection
Select the input to which the manipulations apply. Click on the button to pop-up a menu of the active traces/inputs.

4. Vertical scale
Shows the vertical scale of the graph for the currently active input.

5. Graph area
Shows the graphs of the active traces color coded. This is the same color as shown in the input configuration menu described in Configuring the Inputs field 1.
6. Measurement point
Any number of measurement points can be inserted in a graph. The measurement points scroll with the graph. A measurement point shows the values of all active inputs at that particular point in time.

7. Legend
Shows the names of the input traces and their respective color. The legend can be switched on and off. By default it is off.

8. Smoothing filter
The smoothing filter slider allows smoothing an input trace by replacing each data point with the running average of its neighbors and itself. The position of the slider determines how many of the neighbors are included in the running average (0 to 32 neighbors on each side).

9. Scroll slider
Selects which portion of a session is visible in the graph.

10. Time scale

11. Session length info
Shows the total length of the session.

3.2 Log Window Tools

Select the tool by clicking on it. You can also switch between tools using a keyboard shortcut.

3.2.1 Hand Tool (Shortcut Ctrl-H) 

Scroll the graph left and right. If the current trace is vertically magnified (see vertical magnification tools) also scrolls the graph up or down. To scroll, click in the graph (left mouse button) and drag the graph left or right.
If the active trace is vertically magnified, right clicking anywhere on the graph centers the trace.
If a real-time session is currently recording, the graph will automatically scroll to show the latest data. Scrolling with the hand-tool or the horizontal scroll bar to an earlier time in the recording will stop the auto scrolling. To restart auto scrolling, scroll the graph to the rightmost end.

3.2.2 Overlay scroll tool (Shortcut Alt-H) 

When an overlay is pasted onto a session, this tool moves the overlay relative to the underlying graph. To scroll, click in the graph (left mouse button) and drag the overlay left or right.

3.2.3 Selection Tool (no shortcut) 

Allows selecting a portion of a session. To select a portion, click in the graph (left mouse button) and drag the mouse left or right. Whenever you click (without any other keys held down), the current selection is removed. Holding down the shift key while clicking extends the selection from the first click to the new click.

Holding down the Ctrl key while clicking allows selecting multiple areas without removing the previous selection.

3.2.4 Measurement tool (Shortcut Ctrl-M) 

Use this tool to add measurement points in the graph as shown in item 6 of the window. Click anywhere in the graph to add a measurement point. Click in the measurement window (rectangular area showing the measurement results) to remove a measurement point. Click and drag to fine-position a measurement point. Any number of measurement points can be added. When holding down the Ctrl-key while releasing the mouse button, the measurement point is considered temporary and will be removed.

3.2.5 Vertical Magnification Tools (Shortcuts Ctrl-□ or Ctrl-□) 

These tool buttons are used to increase or decrease the vertical magnification of the active trace to see fine details. The trace can be magnified up to 16 times.

3.2.6 Time Magnification Tools (Shortcuts Ctrl-□ or Ctrl-□) 

These tool buttons are used to increase or decrease the horizontal or time magnification of the session to see fine details. The time scale can be expanded up to 32 times.

3.2.7 Real-time Logging Start button (Shortcut Ctrl-N) 

This button is only visible in the real-time session window. Clicking this button starts a new real-time session.

3.2.8 Playback button (Shortcut Ctrl-Spacebar) 

This button starts playback of the current session on the LogWorks main window. The gauge settings reflect the settings of the playing log during playback. Playback always starts at the left edge of the current session window. If areas in the session are selected, only the selected areas will be played back.

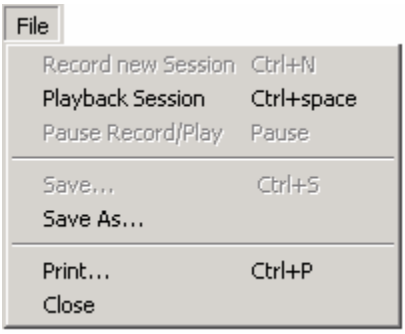
3.2.9 Stop button (Shortcut Ctrl-Spacebar) 

Clicking this button stops recording a real-time session or stops playback.

3.2.10 Pause button (Shortcut Pause-key) 

Clicking this button pauses recording/playback. When recording, the log window will not be updated, but recording continues in the background. Click the button again to un-pause and resume updating of the log window.

3.3 Log Window File Menu



3.3.1 Record new Session

Starts/Stops a real-time session. Same as Real-time Session Start button.

3.3.2 Playback Session

Starts playback of the current log. Same as playback or Stop button.

3.3.3 Pause Record/Play

Pauses the real-time recording. Same as Real-time Session Pause button.

3.3.4 Save…

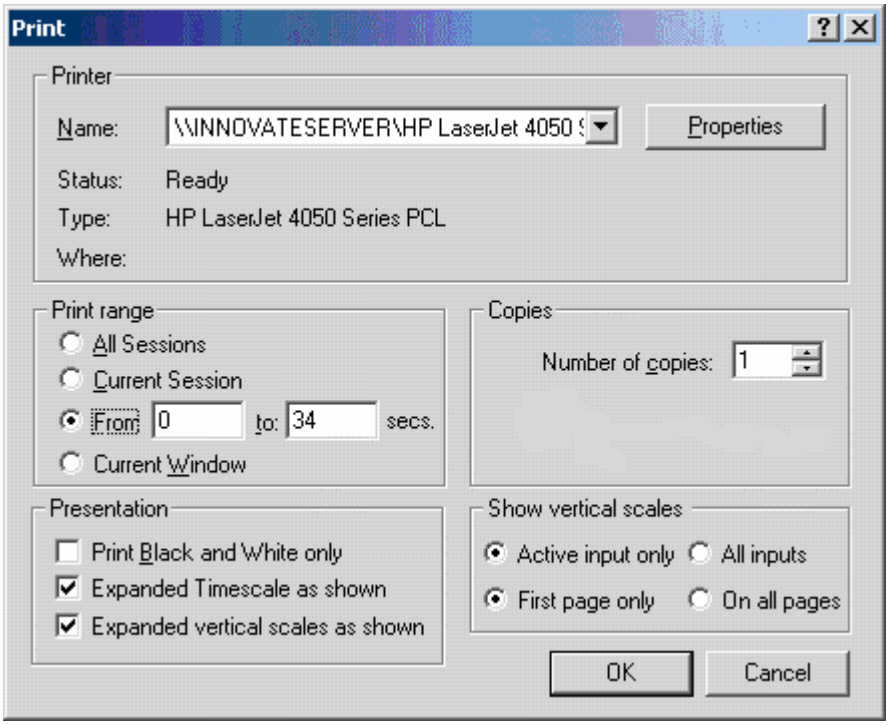
Saves the log into a log file. Either as .log or as .dif file.

3.3.5 Save As…

Saves the log under a different file name.

3.3.6 Print…

Prints the log or current session. A print dialog box like below appears:



This dialog is divided into four sections:

In the ‘Printer’ section select the printer to use. Usually you do not need to touch this section.

The ‘Print range’ section allows you to select the time range you want to print.

The ‘Presentation’ section allows you to select if you want to show the time-scale or vertical scales for each input expanded as in the window or at their normal scale.

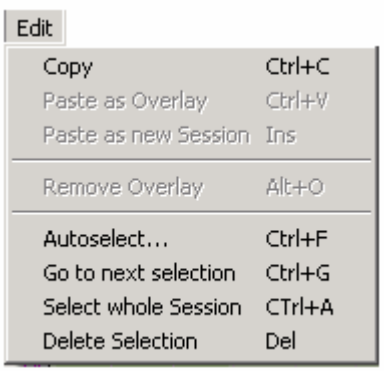
Check the ‘Print Black and White only’ button if you do not print on a color printer.

The ‘Show vertical scales’ section allows you to select if you want to show the vertical scale on the left of the graph on every page or only on the first one, or if you want to show the scales for all traces or only for the input-of-interest trace. The input-of-interest trace (the one currently selected in the graph display) will always be shown next to the graph and the grid-lines represent divisions of that trace.

3.3.7 Close

Closes the log window.

3.4 Log Window Edit Menu

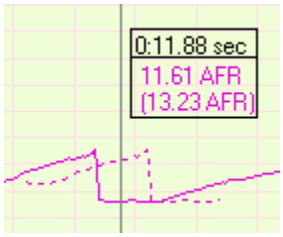


3.4.1 Copy

Copies a selection (see Selection Tool) into the LogWorks internal clipboard.

3.4.2 Paste as Overlay

Pastes the clipboard content on top of the current session as overlay. The traces of the overlay are shown as dashed instead if solid as in the example below:



Using the overlay scroll tool you can move the overlay left and right. If a measurement point overlaps an overlay trace, the overlay measurements at this point are shown in brackets (). The hand tool or horizontal scroll bar moves underlying graph and overlay together. Overlays are not saved with a log.

3.4.3 Paste as new session

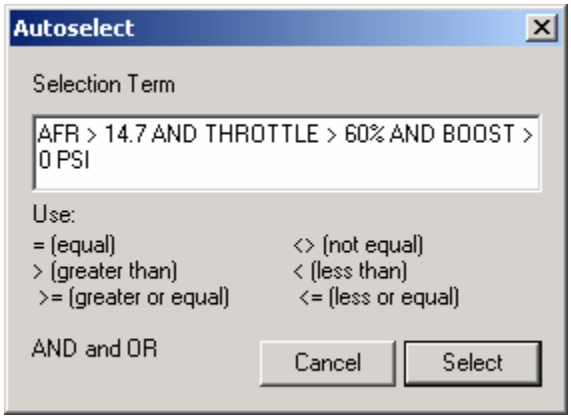
You can only paste a session or part of a session into an existing log from another log. Not within the same log. The input definitions of the source and destination logs have to match.

3.4.4 Remove Overlay

Removes the overlay.

3.4.5 Autoselect…

Autoselect is a very powerful tool to select areas of interest in a session. Selecting this item brings up the following dialog box:



In the window of this dialog box you can specify up to 32 search terms like “AFR > 14.7” and so on. You can then connect these terms with ‘AND’ or ‘OR’. LogWorks will process the entire session and select those areas which satisfy the search criteria. In the above example all lean spots leaner than 14.7 AFR are selected where the engine is under boost and the throttle position is bigger than 60%. You do not have to specify a unit (like % after 60% or PSI after 0 PSI). Note that the input names are case sensitive. Afr would be different than AFR. Make sure you type the input name correctly.

3.4.6 Go to next selection

This menu item (equivalent to a search function) jumps directly to the beginning of the next selection created by for example the Autoselect function. It also puts a temporary measurement point at that point.

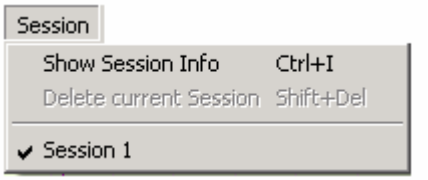
3.4.7 Select whole session

Equivalent to the select all function of other programs. Selects the entire session.

3.4.8 Delete Selection

Deletes the selected area from a session. Note that only areas at the beginning or end of a session can be deleted. Deleting in the middle would cause a non-contiguous data area and is therefore not allowed.

3.5 Log Window Session Menu



3.5.1 Show Session Info

Shows information about the session:
Session length (in minutes and seconds)
Record start time and date (only for real-time sessions).

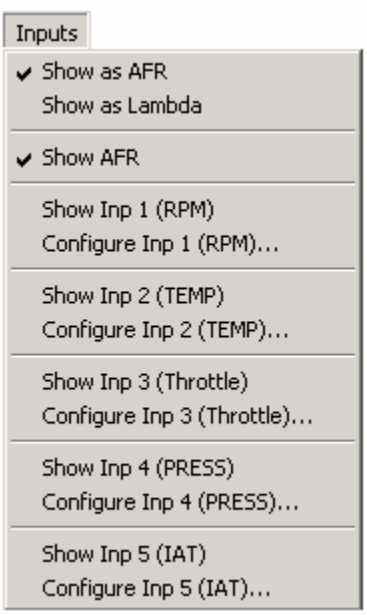
3.5.2 Delete current session

Deletes the current session from the log. If only one session is left, it cannot be deleted (logs can't be empty).

3.5.3 Session selection

Select which session you want to view/manipulate.

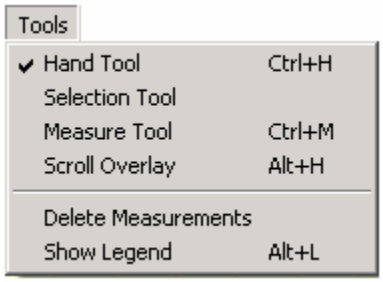
3.6 Log Window Input Menu



This menu allows switching mixture display between AFR and Lambda. It also allows selectively switching input traces on and off and configuring the inputs.
The input configuration is described in Manipulating the Inputs.

Input configuration changes performed in the real-time log window also apply to the LogWorks main window and vice versa. The same is true for the LM-1 log window.
File log input changes only affect the current file log.

3.7 Log Window Tools Menu



3.7.1 Tool Selections

The Hand Tool, Selection Tool, Measure Tool and Scroll Overlay selections are the same as described in the Log Window Tools chapter.

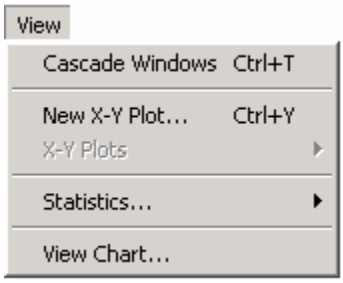
3.7.2 Delete Measurements

Deletes all measurement points in the current session.

3.7.3 Show Legend

Shows/Hides the legend window.

3.8 Log Window View Menu

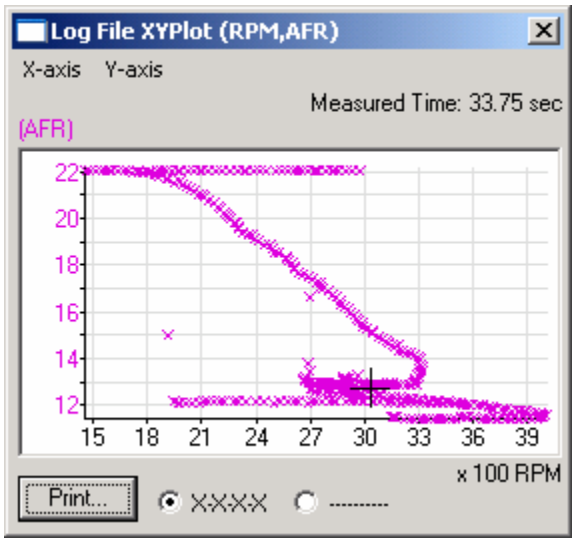


3.8.1 Cascade Windows

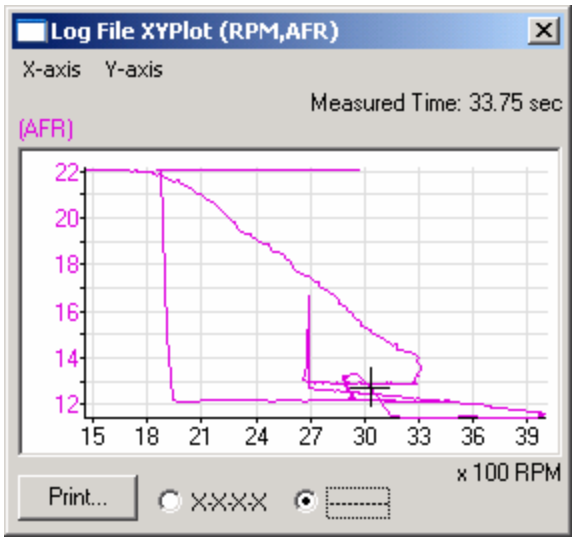
This item causes all auxiliary views of the session (Statistics Window or X-Y Plot Window, see below) to be stacked in the top left corner of your screen.

3.8.2 New X-Y Plot…

This opens a new X-Y Plot window. An X-Y plot window shows the data of any two inputs in a two-dimensional graph like this:



In this case the Y-axis is AFR and the X-axis is RPM. You can select any two inputs as either of the X or Y axis. If nothing in the graph is selected, the X-Y Plot represents the data of the entire session. If a part of the session is selected (Selection Tool), only the data of the selected areas is represented.
For example if you are only interested in the AFR over RPM curve for wide open throttle (WOT), you can either hand-select these areas or use the Autoselect tool if you have a throttle position input connected to the LM-1.
As shown above the individual data points are shown as small "x"s. Clicking the '----' button shows the data connected with lines as in this:



In either case measurement points in the graph are represented by black + marks.

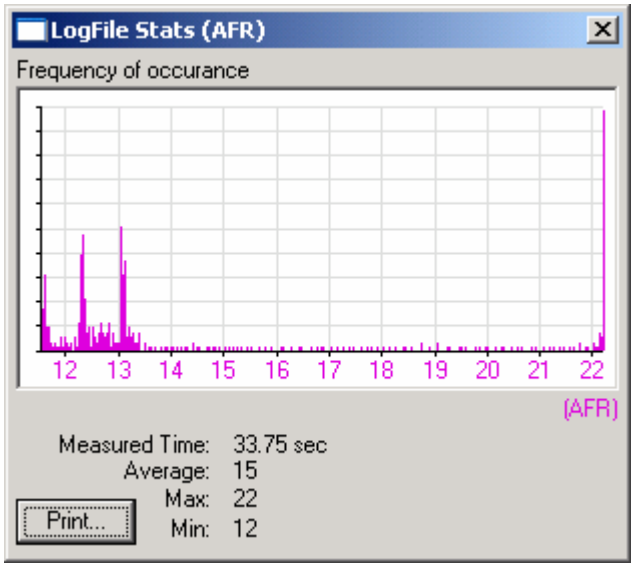
The X and Y axis are automatically scaled to the range of input values for the respective axis. Manipulating the session data with the smoothing filter, changing selection or adding/deleting measurement points will be automatically represented in the X-Y Plot.

3.8.3 X-Y Plots

This submenu lists all open X-Y Plot windows and allows you to quickly bring one to the top.

3.8.4 Statistics…

This submenu opens a statistics window for the selected input. A statistics window looks like this:



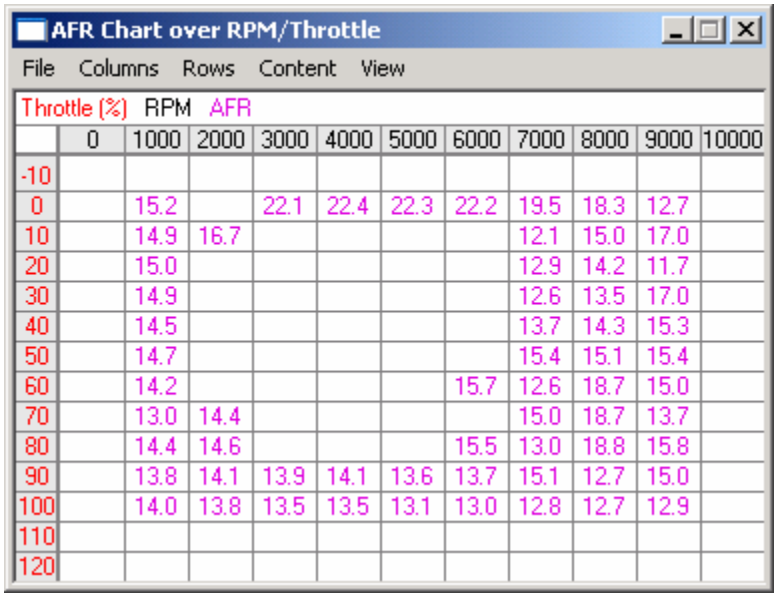
This window shows how often a certain input value happened during a session or partial session. If nothing in the graph is selected, the Statistics window represents the data of the entire session. If a part of the session is selected (Selection Tool), only the data of the selected areas is represented.

The vertical axis is automatically scaled relative to the highest occurrence. The horizontal axis is automatically scaled to the range of the input with the session or selection.
In addition the window shows how many data points (time) are represented, the average of the selected data and the minimum and maximum points in the selected data range or entire session.

Manipulating the session data with the smoothing filter, changing selection or adding/deleting measurement points will be automatically represented in the statistics.

3.8.5 View Chart…

This item creates a 3D chart that looks like this:

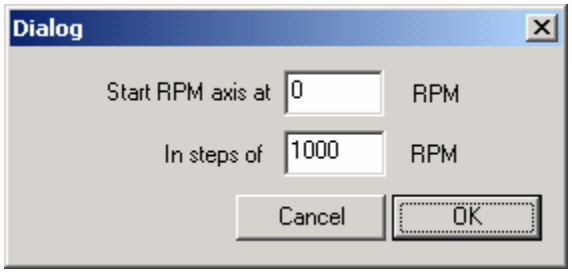


Throttle (%) \ RPM	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
-10											
0		15.2		22.1	22.4	22.3	22.2	19.5	18.3	12.7	
10		14.9	16.7					12.1	15.0	17.0	
20		15.0						12.9	14.2	11.7	
30		14.9						12.6	13.5	17.0	
40		14.5						13.7	14.3	15.3	
50		14.7						15.4	15.1	15.4	
60		14.2					15.7	12.6	18.7	15.0	
70		13.0	14.4					15.0	18.7	13.7	
80		14.4	14.6				15.5	13.0	18.8	15.8	
90		13.8	14.1	13.9	14.1	13.6	13.7	15.1	12.7	15.0	
100		14.0	13.8	13.5	13.5	13.1	13.0	12.8	12.7	12.9	
110											
120											

This example shows average AFR over throttle position and RPM.

Setting Columns and Rows

The Columns/Rows menus allow you to select any input as the horizontal/vertical axis of the chart. You can also specify the step size and start value. Select the “Set Step size” item in the Columns or Rows menu. The following dialog box will show up:



This allows you to set the start value and step size of each axis.

Printing/Saving

These choices in the file menu are obvious. The chart is saved as .dif file so it can be easily imported into a spreadsheet.

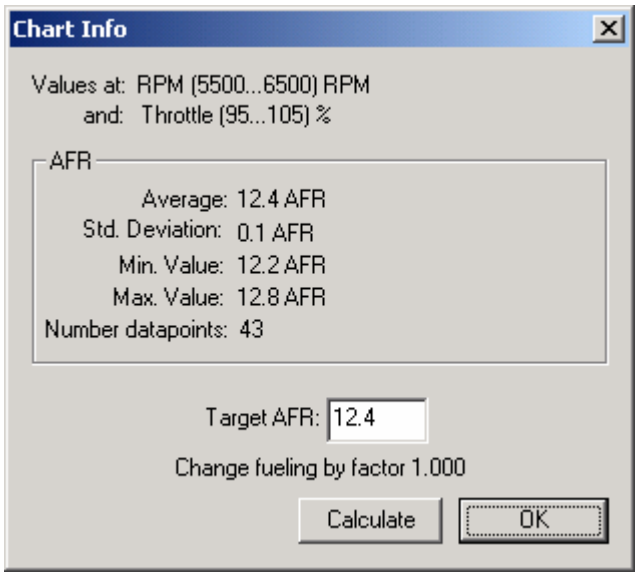
Chart Views

In the view menu you can select if you want to see the average, standard deviation, min/max values and number of data points contributing to each field in the chart.
You can also elect to create the chart from all sessions in the log or only from the current session. If the current session is viewed only, but areas in the session are selected, the chart will reflect only the selected areas.

Working with charts

You have to be careful when using the chart for tuning the main fuel map of your EFI system. The chart reflects what's in the log, including transition points and so on. So acceleration enrichment and possible warm-up enrichment are reflected in the averages as well. The best way to create a chart is to create an as long log as possible with steady load points. This way the effects of transitions are minimized. The fewer data points are represented, the less reliable the data. This is reflected as well in the standard deviation.

Double-Clicking on a field in the chart brings up the following dialog box:



This shows the current values of the clicked field. The target AFR or Lambda calculation functions are only available if the field content is AFR or Lambda. The fueling change calculation is based on fuel flow control where higher numbers represent more fuel. If for example your EFI is set by injector timing, just multiply the timing setting by the suggested number.

This number is a suggested value only, different EFI systems will react differently.

During real-time logging the chart will be updated in real-time as well. The currently updating field is highlighted. This allows to 'drive by load point' to make sure you are filling all the chart fields.

Acceleration runs in low gears are not ideal for calculating the load points. The same problem as in inertial dynos exists. The acceleration enrichment might still be active and reliable load point data can't be extracted from only a few data points.

4 Summary of Shortcuts

Shortcuts are keyboard sequences or mouse-clicks that allow you to quickly perform a function without selecting a menu item or clicking a button.
Keyboard shortcuts usually involve a modifier key like Ctrl, Alt or Shift.
To perform the shortcut, hold down the modifier key and then press the shortcut key.
Example:
Ctrl-N means hold down the Ctrl key and then press the N-key.
Alt-O means hold down the Alt key and then press the O-key.

Other shortcuts in this section contain Mouse button clicks (usually left mouse button) together with holding down a modifier key.
Some shortcuts are performed by clicking the right mouse button or pressing a special key.
Double clicks means that you click the left mouse button twice rapidly.

4.1 LogWorks Main Window

Ctrl-L	Connect to the LM-1 for real-time logging/monitoring if not connected
Ctrl-N	Start a new real-time log
Ctrl-D	Download a log from the LM-1
Double-click dial	Configure this input
Pause key	Freezes/Unfreezes the gauge displays

4.2 Input Configuration and Lookup Table

Rick click on Voltage input field	Brings up a popup-menu (real-time settings only) that allows to insert the current input voltage in the field

4.3 Log Window

4.3.1 Real-Time log control

Pause key	Pause real-time logging
Ctrl-N	Start real-time logging
Ctrl-Spacebar	Stop logging/playback or start playback

4.3.2 Saving/Printing

Ctrl-S	Save the log
Ctrl-P	Print the log/session

4.3.3 Tool shortcuts

Ctrl-H	Switch to Hand Tool
Ctrl-M	Switch to Measure Tool
Alt-H	Scroll Overlay tool
Ctrl-L	Hide/Show Legend
Ctrl- left mouse up	Delete current measurement point, making it temporary

4.3.4 Selections/Search

Ctrl-F	Start the Autoselect function
Ctrl-G	Jump to the next selection
Ctrl-A	Select the whole session

4.3.5 Copy/Paste/Delete

Ctrl-C	Copy selected data to internal clipboard
Insert key	Insert clipboard as new session
Delete key	Delete selection

4.3.6 Overlay shortcuts

Ctrl-V	Paste clipboard as overlay
Alt-O	Remove overlay
Alt-H	Scroll Overlay tool

4.3.7 Scrolling shortcuts

→ key	Scroll graph to the right (earlier time)
← key	Scroll graph to the left (later time)
↑ key	Scroll graph up
↓ key	Scroll graph down
Page Up key	Scroll graph by one window width left (later time)
Page Down key	Scroll graph by one window width right (earlier time)
Home key	Scroll graph to beginning of session
End key	Scroll graph to end of session
Right-click in graph	Center active trace if magnified
Alt-H	Scroll Overlay tool

4.3.8 Magnifying shortcuts

Ctrl- ← key	Decrease time magnification
Ctrl- → key	Increase time magnification
Ctrl-↑ key	Increase vertical magnification
Ctrl-↓ key	Decrease vertical magnification

4.3.9 Selection tricks

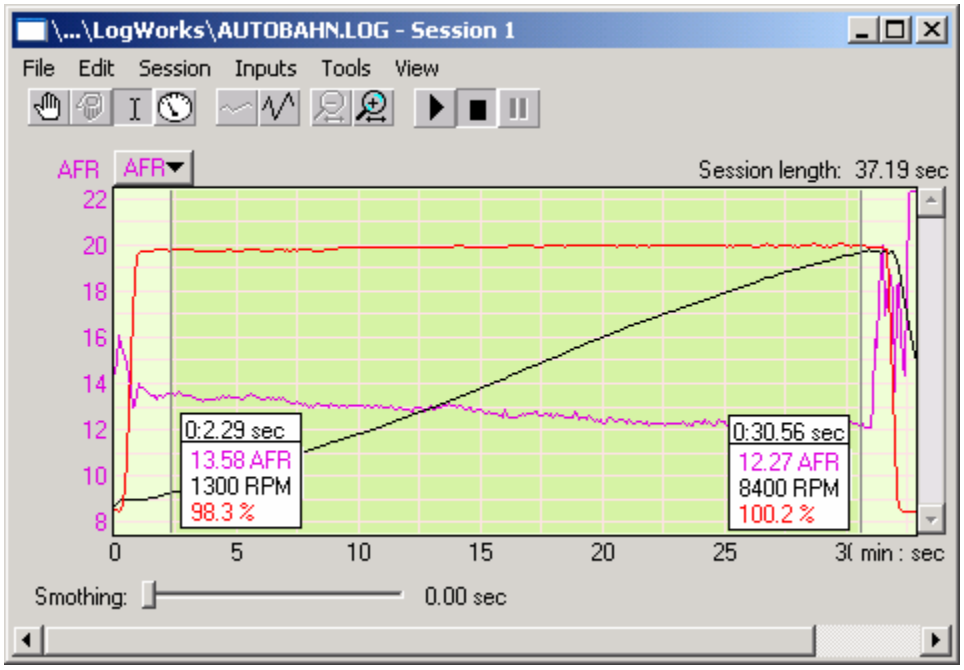
Click in graph and drag	Remove all selections, select dragged-over range
Shift-click in graph	Extend selection from first click to new click
Ctrl-click and drag	Select dragged-over range without removing other selections. Ctrl-click in a selection range removes that selection range.

5 Tips & Tricks for using LogWorks

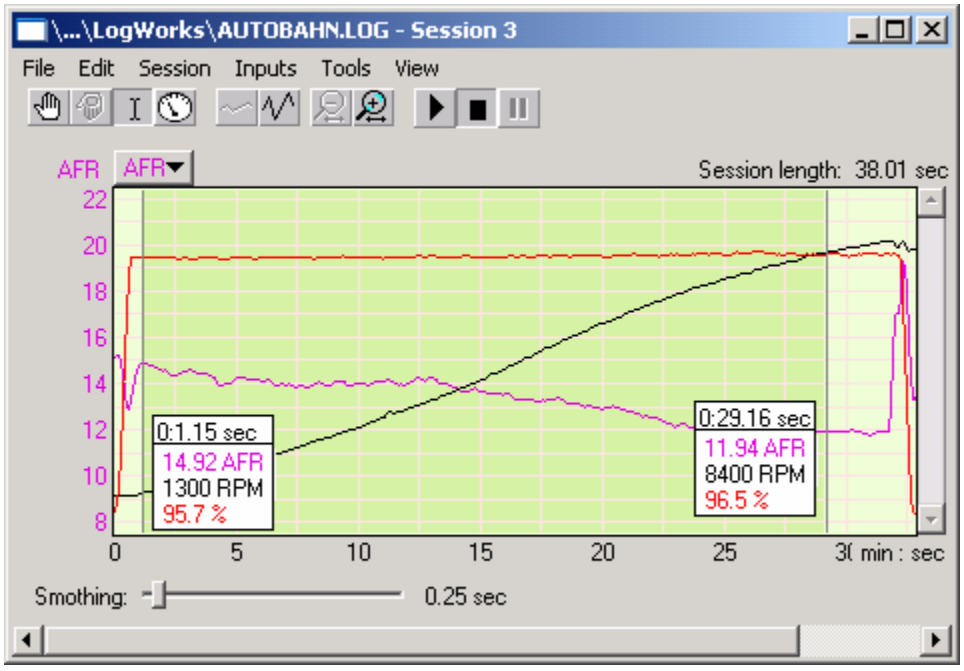
The included log file example Autobahn.log shows a good example of using the features of LogWorks to determine if a fueling change made a difference in power of the engine.

Let's look at Session 1 and Session 3 in the example. Both are 3rd or 4th gear pulls from low RPM to redline. We look at the run from 1300 RPM to 8400 RPM.

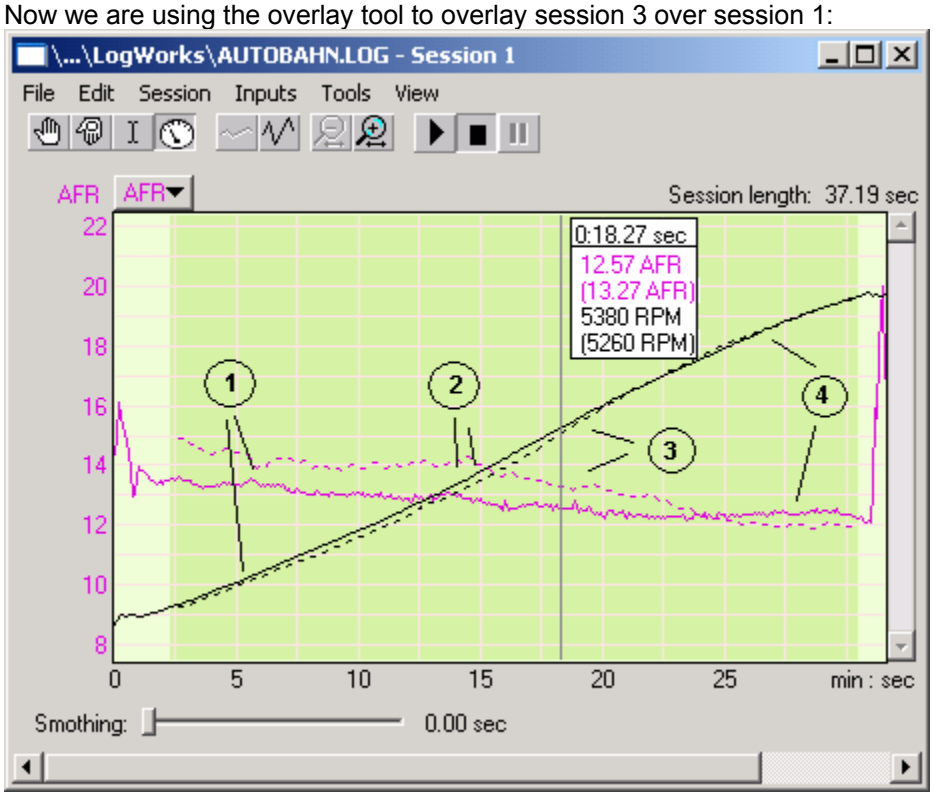
Session 1. Time between 1300 RPM and 8400 RPM is 28.18 sec



Session 3. Time between 1300 RPM and 8400 RPM is 27.93 sec



Now we are using the overlay tool to overlay session 3 over session 1:



What is immediately noticeable is that the AFRs of session 3 are higher than those of session 1 in the area below 7000 RPM, but lower above. Let's see how that affects power and acceleration. Acceleration can be determined by the slope of the RPM curve. The steeper the slope, the higher the acceleration and therefore power (assuming other conditions like weight and wind are the same).

In area 1, acceleration is lower in session 3, while AFRs are higher than in session 1.
In area 2, both RPM slopes match. Therefore the AFR change had little effect.
In area 3, the RPM slope of session 3 is noticeably steeper. The engine made more power with the leaner AFR.
In area 4, the RPM slope of session 3 is flatter. The engine made less power, but AFRs are richer than in that area.

You can also see than when you compare the WOT rows in the charts of the session

Session 1

Throttle (%) RPM AFR

	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500
100	13.4	13.4	13.1	13.0	12.9	13.0	12.7	12.6	12.6	12.4	12.3	12.3	12.4	12.4	12.3

Session 3

Throttle (%) RPM AFR

	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500
100	14.7	14.3	14.0	14.0	14.0	14.1	13.7	13.5	13.3	13.1	12.9	12.4	12.1	12.0	12.0

You can see that the power curve can be improved by richening up the fields below ~4500 RPM and leaned out in the fields at 7000 RPM and above.

6 Revision History

1.1 Initial release – April 28, 2004