Pi Toolbox

User Guide

Pi Toolbox User Guide

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Refers to Software version 3.1, including Pi Data Access 3.16.71

Disclaimer

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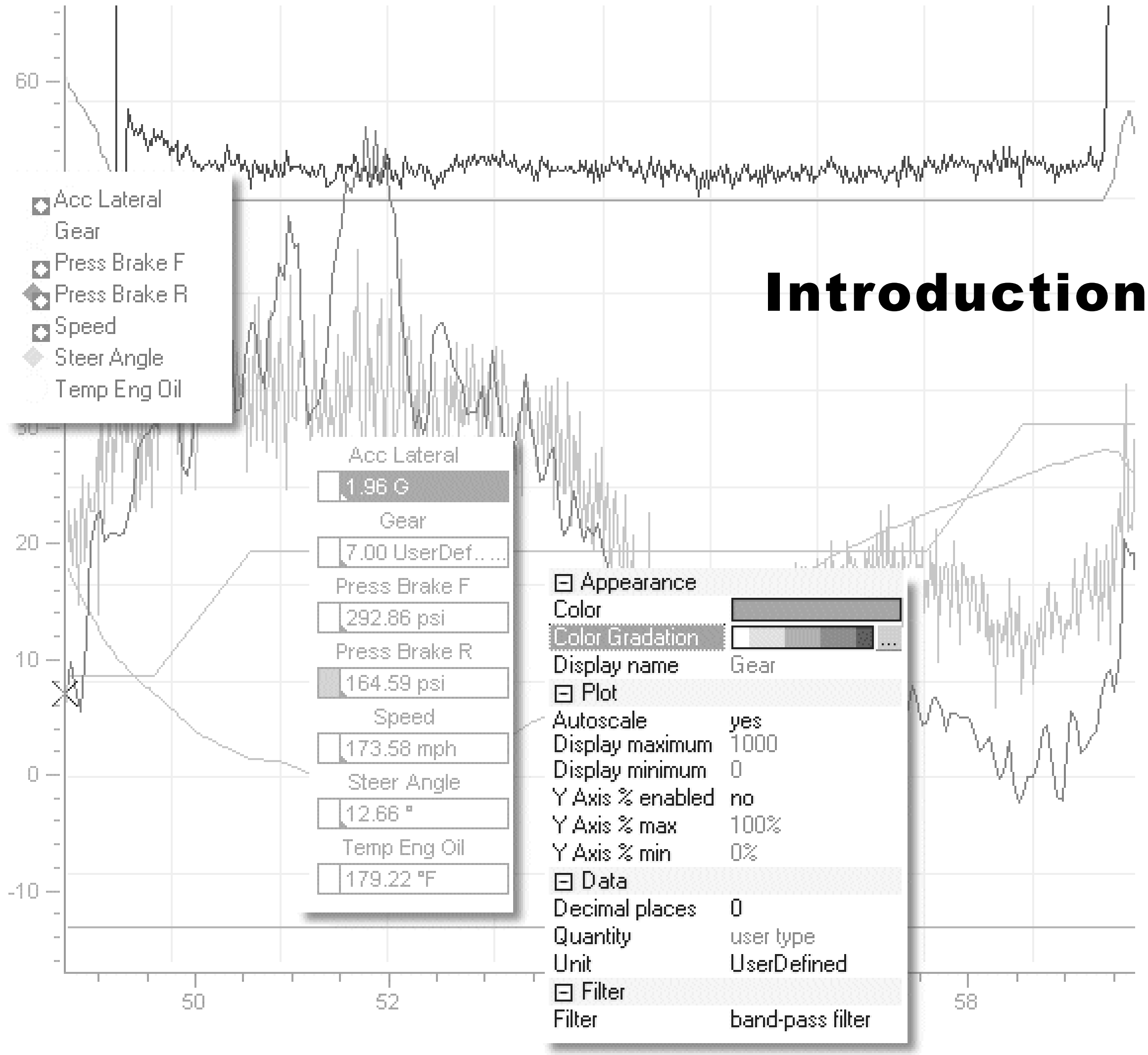
Introduction



About Pi Toolbox

Welcome to Pi Toolbox – a suite of flexible and powerful data analysis tools with development potential that can help you solve engineering and design problems.

Its power and flexibility have been designed to assist and complement problem solving techniques employed by data analysis technicians and engineers.

About this guide

This guide is divided into sections designed to take you through the typical steps for analyzing data using Pi Toolbox.

In the Installation section you will find information about:

- Checking the requirements of your computer system.
- Installing the software.
- Starting Pi Toolbox for the first time.

The User Guide provides information about the basic analysis of data, including graphing, looking for trends, mapping and reports.

Conventions used in this guide

Keyboard commands

This guide assumes that you are using a wheel mouse to open and close menus, and to choose commands, and that the mouse configuration is the default, i.e. left click: select - right click: context menu.

Because the application will be used in many different environments, where the use of a mouse may not be available, a full set of keyboard commands are provided. Instructions throughout the guide refer to both the menu selections using the mouse, e.g.

'… to view the Task Explorer select: **View > Task Explorer**'

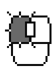
and the equivalent keyboard commands, e.g.

'… to view the Task Explorer: Alt + 1

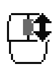
For ease of use and speed, much of the application's functionality is driven by context menus; accessed by right-clicking the mouse (default configuration) or by pressing the context key. Throughout the guide we have used the context key symbol to indicate that the selection is made from the context menu, e.g.

'… to create a task:  **> Add Task.**

Other symbols used

 Left click.

 Wheel click.

 Wheel rotate (in direction of arrow).

What's new in this guide?

Listed below is a brief description of the new features included in V3.0 & V3.1 of Pi Toolbox. For further information, refer to information in this guide or the HTML Help. To see the new features for V3.1 click here.

Auto-update of Excel reports

Excel reports now have the ability to be configured to auto generate when new data is detected.

Channel display

Alarms can now be displayed in the Channel display. Different alarms can be configured to display different colors when triggered.

Channel groups

Channel groups can be configured to stay collapsed or automatically expand when you view channel groups. This is set on the *File > Preferences* dialog under the *Navigation* tab.

General

General performance enhancements have been made to this version.

IfExists maths function

This function allows different channels to be used if the primary channel is not available in the dataset. This can be implemented to use laser ride height if sensors are fitted and contained in the dataset, but then switch to a calculated ride height if the primary channel is not available. See example below:

ifExist([Laser FL],[Calculated Rideheight FL])

A valid expression cannot contain undefined channels, but IfExists functions can be embedded to choose from 2 channels. The example below shows how to select one of 2 channels if you are not sure which channel exists in the dataset:

ifExist([RPM],ifExist([EngineSpeed],-50))

RPM will be returned. If RPM is not present in the current dataset, EngineSpeed will be returned. If neither channel exists, the function will return –50 to indicate an error.

Lap performance

This option controls the format that Pi Toolbox will use to display the fastest lap information. This is a global option and will be applied to any workbook that is opened allowing lap time or lap speed to be selected. If you chose lap speed, this is a function of lap time and lap distance. The lap distance is taken from the current map. If no map is loaded, the current distance is used. Therefore you must ensure that the official lap distance is correctly entered into the map being used. This should be set when creating the map, but can be amended at any time from the following menu: *Data* > *Map* > *Properties* dialog.

Laptime filter

A filter can be applied to the fastest lap. When enabled, any lap below the time set in the filter will not be labeled as a fastest lap.

Long comments

The Long comment in the Task Explorer can now be longer than one line. A carriage return can also be inserted by using SHIFT + ENTER. The long comment will be displayed as a tooltip if there is insufficient space in the task explorer pane.

Offsetting the Y – axis in a Time and Distance chart

Using the SHIFT + O shortcut in a Time and Distance chart will allow the active trace to be dragged in the Y-axis to allow the user to view data with an alternative offset or re-zero data such as brake wear.

Specifying Offline Auto-update paths

Auto-update paths that are offline can be specified in the Auto-update configuration pages. This means that if the server that is normally used is unavailable until the user is at the track, the path can still be specified. When an offline path has been selected, Pi Toolbox will display a dialog asking if this is the correct path.

Note: This feature is supported on Microsoft Windows XP only.

Split report display

The Split report control displays channel data per map sector in a spreadsheet format, using laps as row headings and sectors as column headings. Additional columns containing lap performance, differences between current and fastest lap, and two additional rows containing the fastest rolling lap and theoretical fastest lap data can be displayed.

Summary display

The Summary display is made up of 3 features. You can display any or all of the features at any time.

- A Channel display.

  Up to 4 channels can be displayed, with the option of using channel alarms.

- A Map.

  The map displayed is for reference only.

- Lap performance.

Time and Distance chart cursor lock

The cursor can be locked on a TD chart by pressing L or by selecting the *Lock Cursor* option from the context menu. When the cursor is locked, the view will change so that the cursor is in the centre of the screen i.e. the chart will scroll to bring the cursor to the centre of the screen.

XYC channel display

A third channel - C, can be added to any existing channel pair on a XY chart or added at the time of configuration to make it an XYC chart. The extra channel will display data using its color gradation scheme, adding an extra dimension to the chart.

Zoom control

The Zoom control feature has been added to the context menu for the Time and Distance chart, the X-Y chart, the PSD chart and the Real-time chart recorder.

V3.1 New features

Listed below is a brief description of the new features included in V3.1 of Pi Toolbox.

Bit Indicators

General display enhancements have been made to Bit Indicators, for example tooltips are displayed if the bit caption or status caption is not fully visible.

Note: **The Bit Indicator caption text is displayed horizontally regardless of the orientation of the display.**

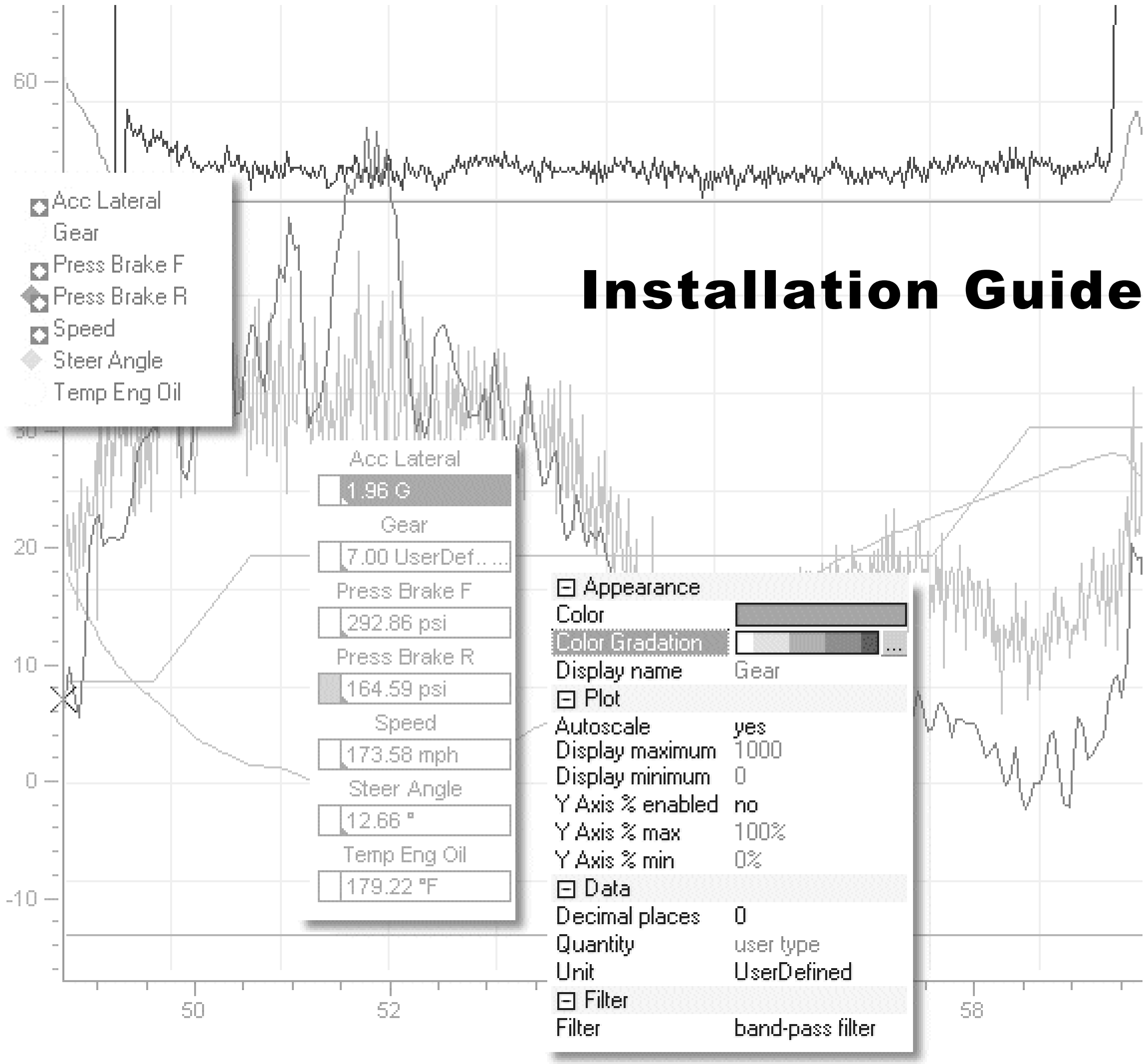
General

General performance enhancements have been made to this version.

Pi Remote Toolbox

Pi Remote Toolbox uses a Palm Tungsten T3 PDA to show compatible displays via a wireless link from a host PC running Pi Toolbox. You can access menus and displays by using the touch screen of the handheld or by using the keypad controls.

Installation Guide



System Requirements

Minimum System specification

Hardware

- 1 GHz Pentium III (or equivalent) processor.
- 256MB Memory.
- 1.5GB Free Disk Space.
- 1024 x 768 resolution screen, greater than 256 colors.
- CD-ROM Drive.

Operating Systems

- Windows 2000/XP.

Other requirements

- Internet Explorer 5.5 or above.
- Excel 2000 or above (only required for Excel Reports and Constants).

Note: *Running Excel Reports on versions of Excel below 2000 may result in unpredictable behavior*

Recommended System specification

Hardware

- 2 GHz Pentium 4 (or equivalent) processor.
- 512MB Memory.
- 10GB Free Disk Space.
- 1280 x 1024 resolution screen, greater than 256 colors.
- CD-ROM Drive.

Operating Systems

- Windows XP Service Pack 1.

Other requirements

- Internet Explorer 6 or above.
- Excel 2000 or above.
- Wheel Mouse.

Note: *Running Excel Reports on versions of Excel below 2000 may result in unpredictable behavior.*

Installing Pi Toolbox

Identifying your version of Pi Toolbox

The Release Notes that are included on your CD-ROM contain information about your version of Pi Toolbox. You should make a note of this and quote it whenever you contact Pi Research. It will help when dealing with your request.

Pi Toolbox Lite and Professional

Pi Toolbox has two basic levels of functionality: Pi Toolbox Lite and Pi Toolbox Professional.

If you are not sure which version of Pi Toolbox you are running, select About Pi Toolbox in the Help menu. The About Pi Toolbox dialog will state either 'Lite' or 'Professional'.

Both versions have the same core set of display types and the same functionality that each display type provides. Users of Pi Toolbox Lite are restricted to a single Task and a single Worksheet, although there is no reduction in the data analysis capabilities of the software. However, the multiple Task and Worksheet functionality, available in Pi Toolbox Professional, provides greater flexibility for manipulation of datasets and displays etc.

Note: *Video displays are not available to Pi Toolbox Lite users*

Upgrading

Users of Pi Toolbox Lite and Pi ToolBox Professional can expand the core set or displays/features available to them. Users of Pi Toolbox Lite can also upgrade to Pi ToolBox Professional.

For information about upgrading Pi Toolbox contact the Pi Research Support Dept.

Supported Languages

Pi Toolbox is designed to support US/English character sets only. File names, Directory names etc. that contain other languages may cause the application to behave unpredictably if you try to access or open them.

To install Pi Toolbox

Note: *When installing or upgrading Pi Toolbox, make sure that the Hardware Key is* ***NOT*** *connected to the computer until the installation is complete.*

1 Insert the Pi Toolbox CD into the CD-ROM drive. The Installation Wizard should start automatically.

2 The Wizard Welcome page contains important information about steps to take before starting to install. Take a moment to read this page, and then click 'Next'.

3 On the next page it is important that you read and agree to accept the terms and conditions of the license agreement before proceeding to install.

4 Select 'I accept the license agreement' and click 'Next'.

5 Follow the Installation Wizard instructions to complete the installation procedure.

Note: *Other Wizard options available are: install shortcut on desktop, place Release Notes on desktop, and install Pi Toolbox Samples.*

6 Double-click the Pi Toolbox icon to start the application.

Note: *If the Installation Wizard does not start automatically, select 'Run' from the Windows Start menu and browse the Pi Toolbox CD for the program 'Setup.exe'. When selected, click 'OK' on the Run dialog to run the Installation Wizard.*

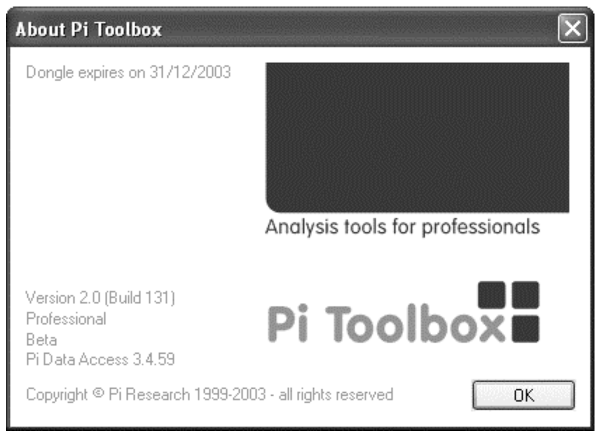
Note: *Removing and/or refitting of a hardware key while Pi Toolbox is running can result in the application becoming unstable or unpredictable.*

Hardware keys

Hardware Keys or Dongles are used by Pi Research as a security device for the licensing of Pi Toolbox. If you are using the professional version of Pi Toolbox, you will need a hardware key to run the application. The key can either be of the USB or Parallel port type.

Hardware keys are programmed with information including a user name and an expiry date.

You can view the expiry date and any other information in the *About* dialog, opened from the *Help* menu.



Viewing the Hardware key status

The status of the hardware key is displayed in the lower right hand side of the Pi Toolbox main window, as a colored icon, the configured username is also displayed in the same area.

Note: *Removing and/or refitting of a hardware key while Pi Toolbox is running can result in the application becoming unstable or unpredictable.*

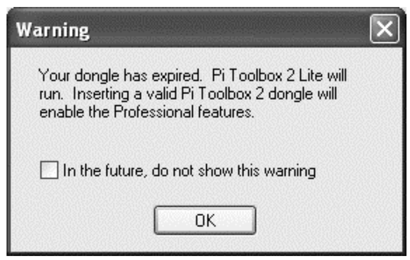
Hardware key status display

Valid Hardware key

The hardware key icon is green, indicating that a valid hardware key has been detected. The user name is displayed next to the status display.

Hardware key expired

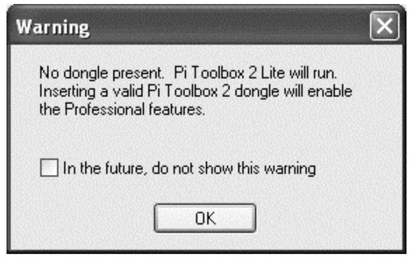
If the hardware key has expired, Pi Toolbox will display a warning:



Pi Toolbox will revert to Pi Toolbox Lite. The status display will be grayed and the application name is displayed instead of a user name. For information on reactivating the key, contact Pi Support. For more information on contacting Pi Support, refer to the contacts page of the Pi Toolbox User Guide.

No Hardware key detected

If no hardware key is detected, Pi Toolbox will display a warning:

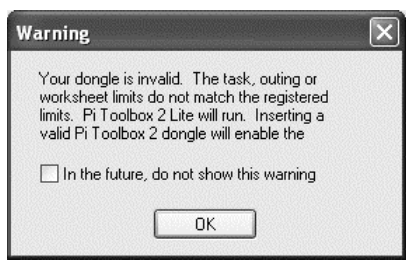


Pi Toolbox will revert to Pi Toolbox Lite. The status display will be grayed and the application name is displayed instead of a user name.

Hardware key mismatch

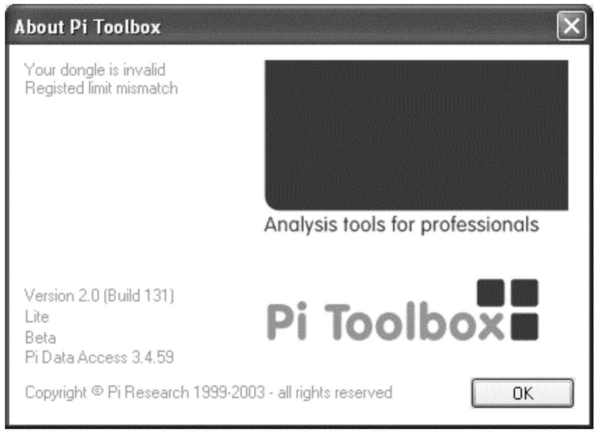
The hardware key stores information about the configuration of your copy of Pi Toolbox. If you have updated your version of Pi Toolbox and added extra features to it, but not updated your hardware key, when you start Pi Toolbox there will be a mismatch between the configuration stored in the hardware key and the configuration stored in the PC's registry.

Pi Toolbox will display a warning:



Pi Toolbox will then revert to Pi Toolbox Lite, until you have updated your hardware key.

Information about the mismatch will be displayed on the About dialog.



Parallel port hardware keys

If you are using a Parallel port hardware key, make sure that the port is enabled in the system bios. For more information, contact your PC manufacturer's support department. You may also find that the dongle device driver adversely affects external devices that are powered through the parallel port, i.e. external floppy drives.

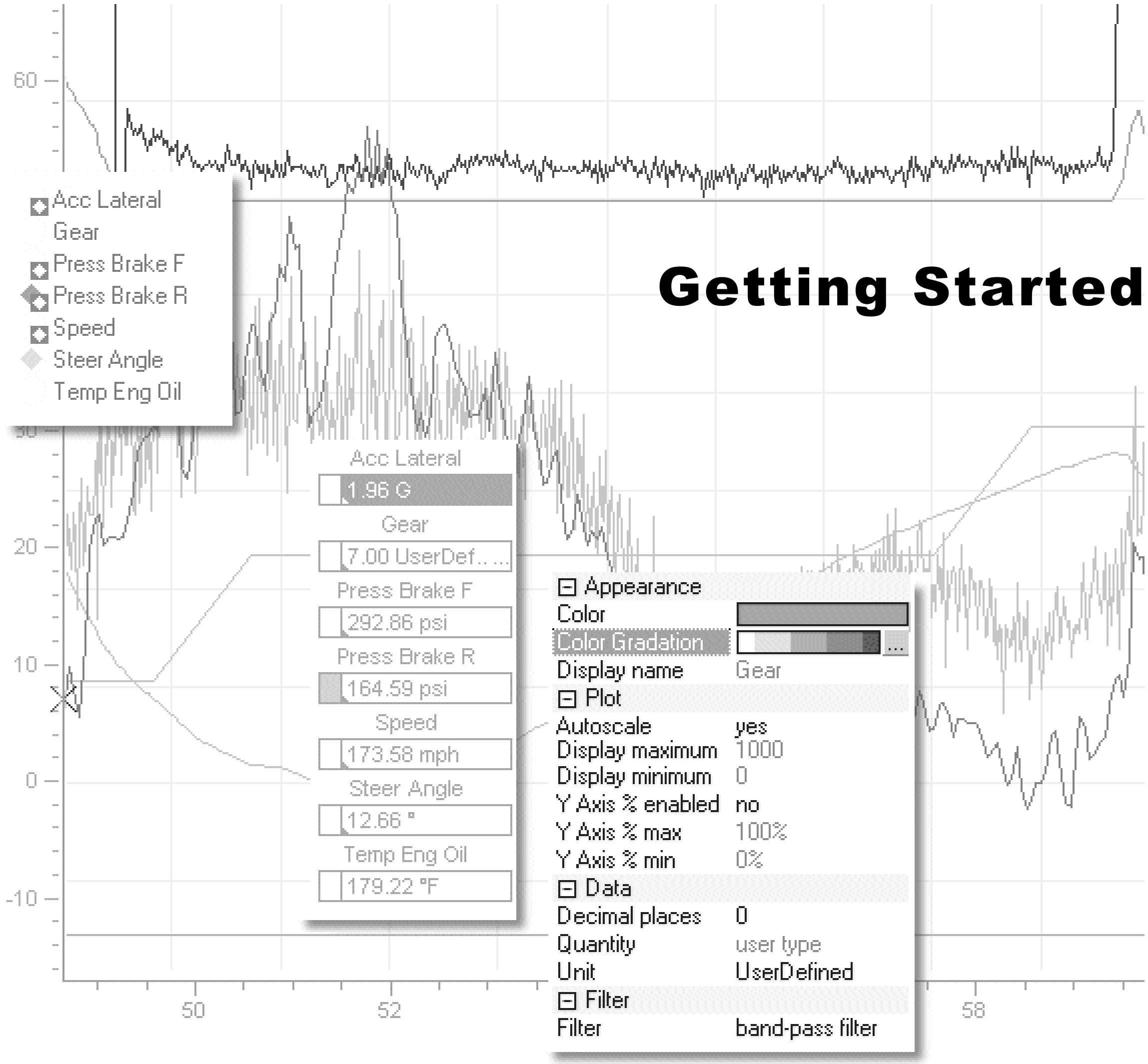
This can be alleviated by the use of a USB dongle.

Windows XP users

If for any reason you need to re-install dongle drivers (XP only) you will see a dialog stating that the drivers have not been verified for use under XP. In this case click 'Continue' to resume the installation. The drivers will install successfully.

When restarting the computer for the first time after installing Pi Toolbox, the 'Add New Hardware' Wizard is launched stating that the dongle needs to be installed. The Wizard must be completed to activate the dongle.

Getting Started



Introduction

Pi Toolbox has the familiar look and feel of many popular Windows applications, and with the implementation of many standard Windows commands, it is easy to use. The way that engineers work with data to solve problems has been paramount in the design of the application.

You will notice that context menus and keyboard shortcuts drive much of the application's functionality, reducing to a minimum the need to move from one part of the work environment to another.

Starting Pi Toolbox

To start the application:

1 Locate the Pi Toolbox shortcut icon on your computer Desktop. If you did not install a shortcut on your desktop, browse for the application and locate the Pi Toolbox application icon.

2 Double-click the icon to start the application.

When you start the application for the first time you will be prompted to create a new Workbook from a default template.

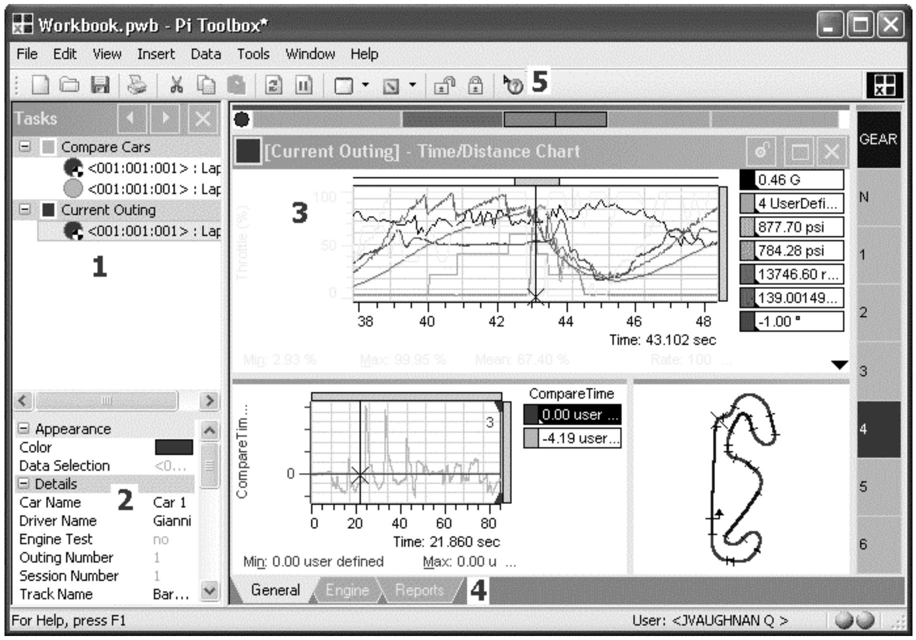
3 Double-click the Default Template icon to open the application window.

See the following illustration for an overview of the different areas of the work environment.

Note: *There can only be one instance of the application running at any one time.*

The Main window

Pi Toolbox has two main work areas - the *Display Area* where charts, reports etc. are displayed, and the *Explorer* where you control what you see in the display area.



1 The Explorer is where tasks are created, outings are loaded, and channels or events etc. are selected for displays.

Tasks are a convenient means of storing outings that you want to display. You connect tasks to displays to associate outings with the display.

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2 Details Panes show information about the selections you make in the upper panes of the Explorer.

3 The Display Area can hold up to 8 displays.

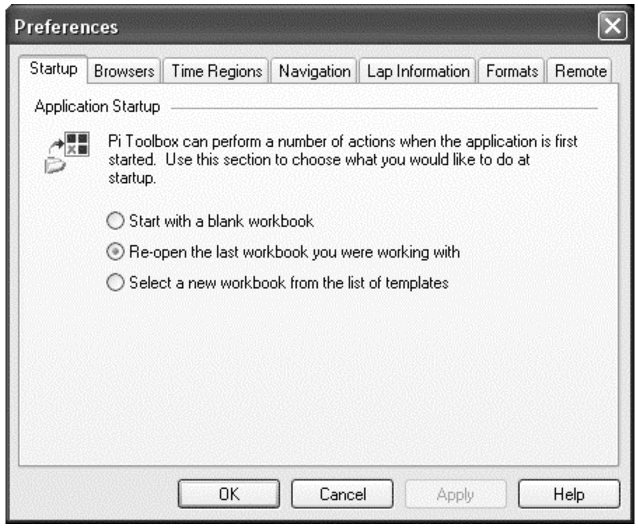
4 Up to 16 worksheets can be held in a workbook.

5 The Toolbar provides shortcuts to many Pi Toolbox functions.

Start up preferences

Startup page

You can control the way that Pi Toolbox behaves on Startup. The ***Preferences*** dialog is opened by selecting: **File > Preferences**.



Start with a blank workbook

Starts with a new Workbook that contains a blank Worksheet. You need to add a Task to the Worksheet and select a display before you can start working.

Re-open the last workbook you were working with

Starts with the last Workbook saved. The top-most Worksheet will be opened.

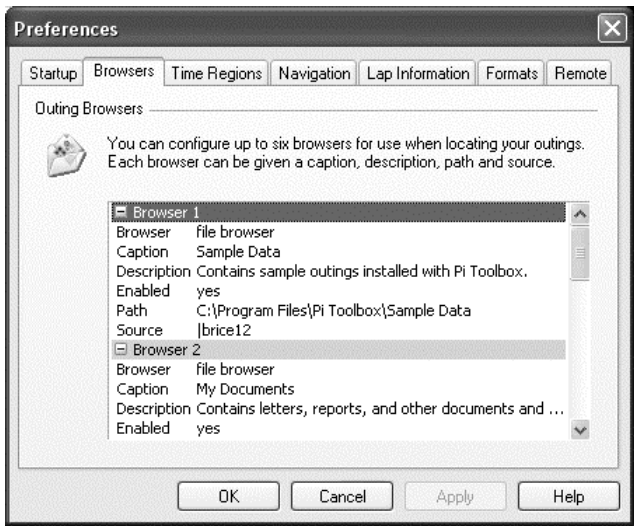
Select a new workbook from the list of templates

Starts with the new (Workbook) dialog. Here you can choose to create a Workbook from the Default template or create a Workbook based upon existing Workbooks.

- **Default workbook:** Comprises of a single Worksheet, which contains a task, a Time/Distance display connected to the task, and a default channel selected.
- **Existing workbook:** The 'Existing' tab of the *New* dialog allows you to browse previously created Workbooks to use as templates. The new Workbook will be a complete copy of the existing one, including worksheets, tasks, outings, displays and channels. It will be untitled and should be saved immediately.

Browsers page

Here you assign default directories and captions for the browser buttons on the Add dialog. You can also enable further **My Data** buttons to which you can add default directories.



To set the default directory of the button double-click ‘Path’ and use the Browse dialog to locate the default directory.

It is possible to configure up to 6 browser buttons. The properties of each browser button can be viewed by expanding the ‘Browser’ node.

To change a property, click on the property name and select from a drop-down list. The properties available are as follows:

Browser

Defines the action for the browser button. The default is the 'File Browser', which opens a folder defined by the path property, allowing Pi Datasets to be selected.

Clicking 'Browser' opens a list of the currently available custom browsers, which can be assigned as an action to the browser button. See: Adding a Custom Browser, page 62.

Caption

Enter a name which will appears beneath the browser button on the Add dialog.

Description

Enter a description for the browser button, which will appear as a tool tip.

Enabled

Select *Yes* to add the browser button to the Add dialog.

Path

Enter the path to the browser buttons default directory.

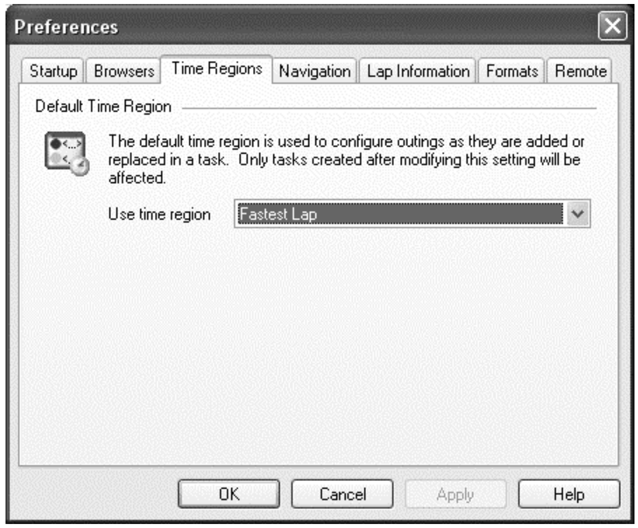
Source

Enter a custom string which can be used for user data that may be required be a custom browser. For example, if the custom browser is for a database, the string may be some SQL code that identifies the last browsed position in the database.

Time regions

Default Time Region

You can specify which time region is to be displayed from a data selection added to the task, or replace an existing data selection in the task:



Fastest Lap: Displays the fastest lap from the outing.

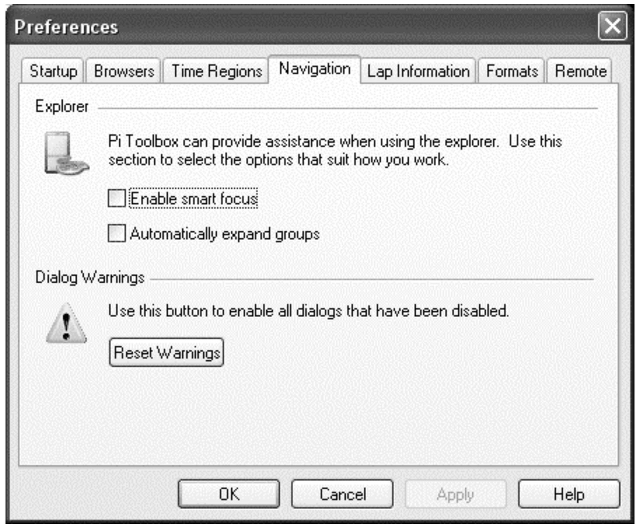
Entire Outing: Displays the complete dataset

Last Region: Display the lap leading up to the last lap marker.

Unchanged: As outings are updated or added, the current time region selected will not be changed.

Note: *This setting defines the default time region property applied to new tasks added to the Workbook. The property can be overridden locally by setting the time region for a specific Task in the Task properties pane of the explorer.*

Navigation



Enable Smart Focus: With Smart Focus enabled, the current explorer window intuitively determines which of its focusable areas receives focus when the user navigates between displays and explorer windows.

For example, if a channel is selected in the Properties explorer, focus will be on the channel's properties. If the user navigates to the display and then back to the explorer, focus will remain on the channel properties.

Smart Focus examples

Action	Smart Focus On
Action User makes selections in the Selection explorer, moves to the lower pane to deselect a channel then goes to a display	**Smart Focus On** When the user returns to the Selection explorer, focus is given to the upper pane where most actions take place
	Smart Focus Off When the user returns to the Selection explorer, focus is given to the last area worked in. In this case the lower pane.
Action User changes a channel property in the Properties explorer, moves to the upper pane to make a selection, and then goes to a display.	**Smart Focus On** When the user returns to the Properties explorer, focus is given to the lower pane where most actions take place.
	Smart Focus Off When the user returns to the Properties explorer, focus is given to the last area worked in, in this case the upper pane.

Automatically Expand Groups

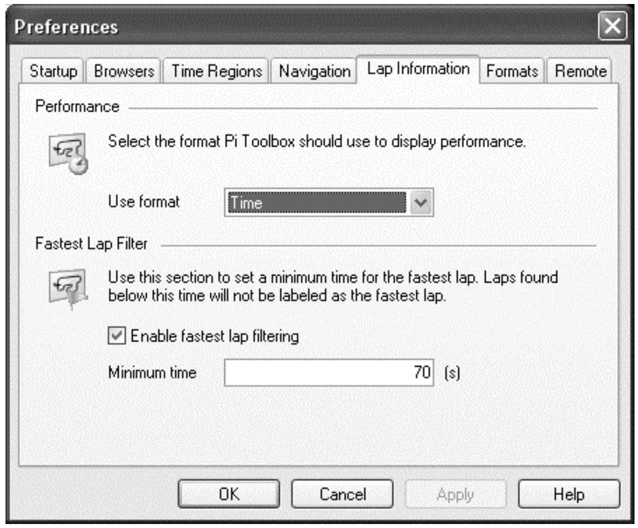
The automatically expanding groups feature allows you to enable groups to expand to show the active channel when you load a workbook, open a display or add a channel to a group. This is a global option and will be applied to any workbook that is opened.

Note: *This feature is enabled by default.*

Dialog Warnings

Warnings that have been disabled can be reset from the *Navigation* tab of the *Preferences* dialog. For example: Starting Pi Toolbox without a hardware key (*Dongle*) will cause a warning to be displayed, you can disable this warning. Pressing the Reset Warnings button will re-enable all currently disabled warning dialogs.

Lap Information



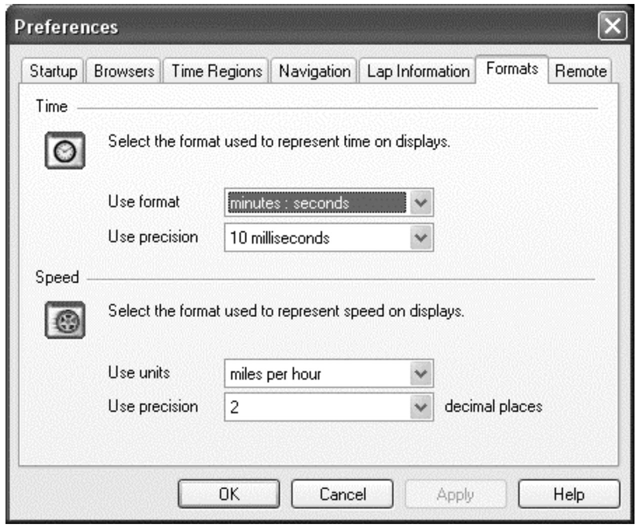
Performance: this option controls the format that Pi Toolbox will use to display the fastest lap information. This is a global option and will be applied to any workbook that is opened allowing lap time or lap speed to be selected. If you chose lap speed, this is a function of lap time and lap distance. The lap distance is taken from the current map. If no map is loaded, the current distance is used. Therefore you must ensure that the official lap distance is correctly entered into the map being used. This should be set when creating the map, but can be amended at any time from the following menu: *Data* > *Map* > *Properties* dialog.

Fastest Lap Filter: A filter can be applied to set a minimum time (in seconds) for fastest laps, any time below the filter target will not be displayed as a fastest lap.

Note: *The fastest lap filter is disabled by default. When first enabled the default time will be set to 5 seconds.*

Note: *Once you have set the Lap Information options, you must make sure that the options on the Formats tab are set correctly.*

Formats

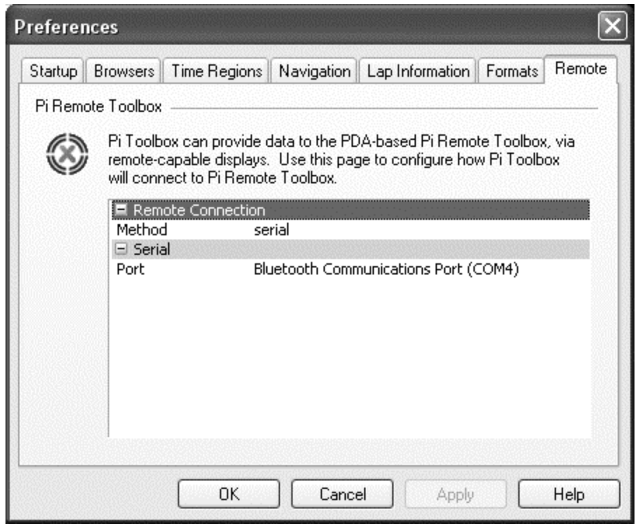


The options that can be set on this page are global options and will be applied to all workbooks viewed. The configuration specified is persisted between Pi Toolbox sessions.

Time: The format that is used by Pi Toolbox to display the time on displays. You can select either seconds, minutes and seconds or hours, minutes and seconds. You can also select the precision that it is measure to. You can select from 1 nanosecond to 100 milliseconds.

Speed: The format that is used by Pi Toolbox to display the time on displays. You can select either meters per second, miles per hour, feet per second and kilometers per hour. You can also set the number of decimal places that the speed will be measured too. You can select from 0 to 9 decimal places.

Remote



This tab is where the configuration for the Bluetooth connection for the Pi Remote PDA is done.

Remote connection: Select the method of connection that you want to use. Currently there are two options, *Serial* or *No connection*. You may want to select none if you are using the Bluetooth connection for another purpose.

Serial: Select the Bluetooth serial port that you setup when you installed the Bluetooth PC adapter.

Note: *It is important that you specify the same port details as the Bluetooth PC adapter or you will not be able to establish a Bluetooth connection.*

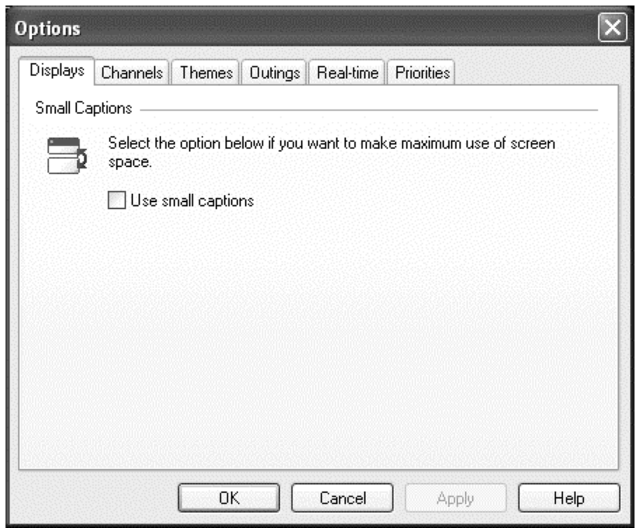
The Options dialog

The Options dialog lets you define colors and themes for displays throughout the workbook. It is also used to associate common channel names to the real channels, held in the Pi Toolbox Channel List and set up Real-time options.

Open the Options dialog by selecting: **Tools > Options**.

The dialog has five tabs.

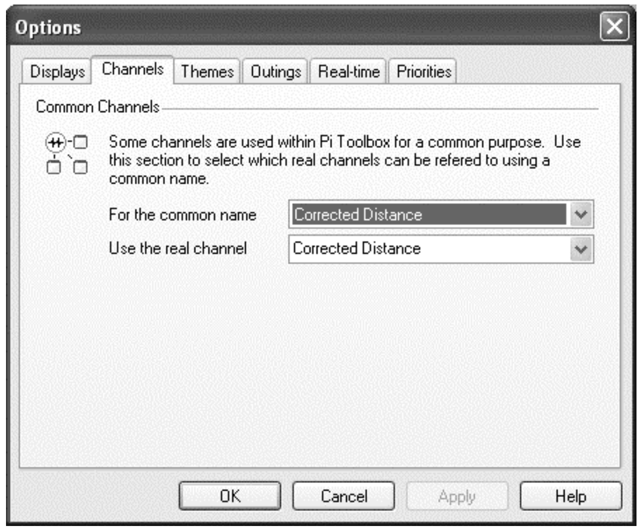
Displays



Use Small Captions**:** This option is designed to maximize the available space in the Display Area. Check **Use small captions** to set the Title Bars of all displays in the Workbook to 'Auto Roll-up', i.e. the Title Bars remain hidden until the cursor is held over the top of the display.

Channels – Mapping Common Channels

Some channels are required by Pi Toolbox components to generate maps, display or compare data against distance, and generate corrected data channels. These are ‘Common Channels’. As users may have different names for these channels, a system has been provided for identifying them to Pi Toolbox components as common channels.



The lower 'real channel' field lists channels that equate to the 'common name' displayed above it. For example, with Corrected Distance selected, the lower field shows all channels that measure distance.

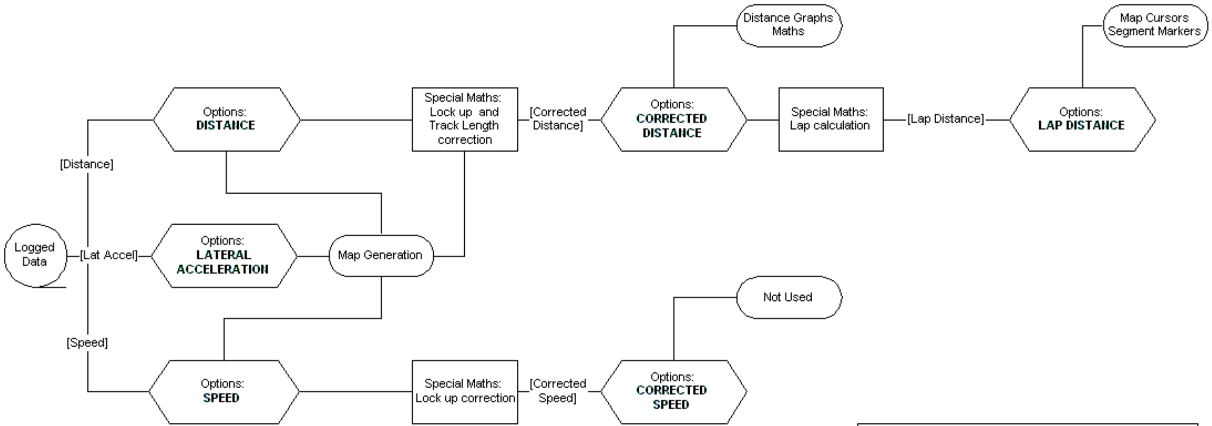
Common channels definitions

Real channels	
Common Channel name	**Definition**
Corrected Distance	The channel specified for *Corrected Distance* will be used for all distance-based charts and math functions within Toolbox.
Corrected Speed	Not used by anything.
Distance	The channel specified for *Distance* will be used when creating a standard map. It is also used as the input channel for the Special Math channel **[Corrected Distance]**.
Fuel used	This channel is used with the Corrected Distance channel in the Fuel consumption calculation for reporting fuel consumption in Excel reports.
Lap Distance	The channel specified for *Lap Distance* will be used as the input channel for the special Math channel **[Map Position D]** for Standard Map types.
Lateral Acceleration	The channel specified for *Lateral Acceleration* will be used when creating a standard map.
Map Position D	The channel specified for *Map PositionD* is used to determine the cursor and segment/split positions on the map control.
Map position X	Not used.
Map position Y	Not used.
Map position Z	Not used.
Speed	The channel specified for *Speed* will be used when creating a standard map.

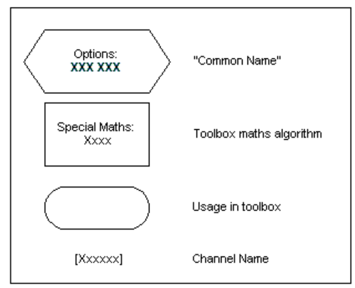
Real channels definitions

Special Math channels	
[Corrected Distance]	When a map is loaded, this channel is calculated per lap to match the official track length. Taking into account the Distance Correction settings in the Data Correction dialog. (Note. Before a map is loaded, this channel will be the same as the channel specified for the common channel *Distance* with lockup correction applied.)
[Corrected Speed]	After a map is created, this is calculated based on the channel specified for common channel *Speed* and the options set in the Data Correction dialog.
[Elapsed Lap Time]	Based on **[Elapsed Time]** reset to 0 on each end of lap.
[Elapsed Time]	The elapsed time of the outing.
[Lap Distance]	**[Lap Distance]** is created using the **[Corrected Distance]** special math channel, reset to 0 on End of Lap.
[Map Position D]	**[Map Position D]** is created to show the car's distance on the track from the start point. For standard map types this is based on the channel specified for common channel *Lap Distance*.
[Map Position X], [Map Position Y], [Map Position Z]	After a map is created, these channels are generated and represent the location of the car in a Cartesian coordinate system. For standard maps the Z channel will provide a constant value of 0m.

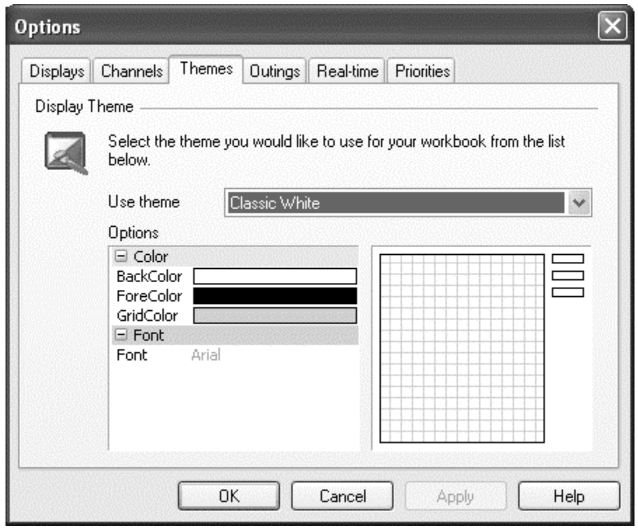
The image below shows the default path for distance correction, by Pi Toolbox.



All Channel names can be changed. Above diagram shows the default path for distance correction by toolbox.
By changing the appropriate "Real Channel" in the Options dialog of toolbox lockup and distance correction can be disabled or replaced with a user defined algorhythm.
The Special maths engines will always output the channel names shown above whether or not they are used in subsequent processes



Themes



Use Themes to define color and font options for all displays in the Workbook. You can define the background color, grid color and foreground color (cursor value text, cursor etc.) as well as font style and size.

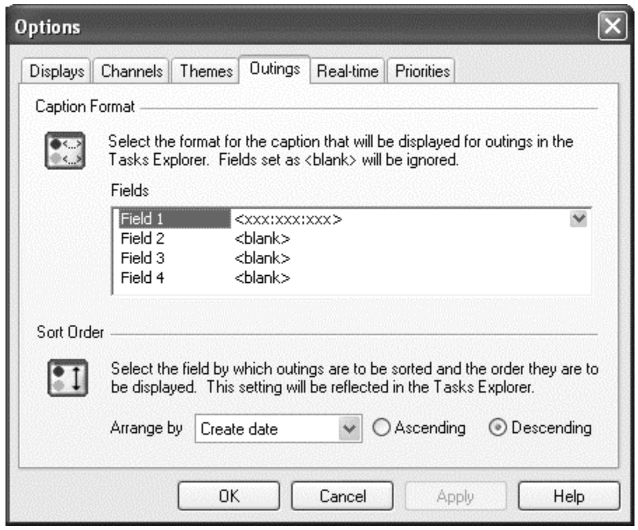
These properties define a look or 'Theme' for your workbook. However, individual displays can be changed by setting color options locally, in the display's Properties dialog.

There are three options in the Use theme field:

- **Classic Black:** black background, white foreground
- **Classic White:** white background, black foreground
- **Custom Theme:** with Custom Theme selected, color and font options are enabled.

Note: *To reset all displays to a custom theme (individual displays may have had color schemes set locally in their Properties dialog) select a classic theme and click Apply, then reselect the custom theme and click Apply.*

Outings



Caption format

Use the Outings tab to format the outing caption displayed in the Task Explorer. The caption definition affects all outings in the current Workbook.

The default format is <Session: Outing: First Lap Number>.

The outing caption can contain up to four elements - each element selected by one of the four drop-down lists. The preview window shows an example caption for the current selections. The Lap selection is always shown after the caption.

Note that the default format can itself be a single element of an outing caption, making the following example possible:

<006:005:001>, **John**, **Car#1**, **Phoenix**: **Lap 1 - Lap 4**

Sort Order

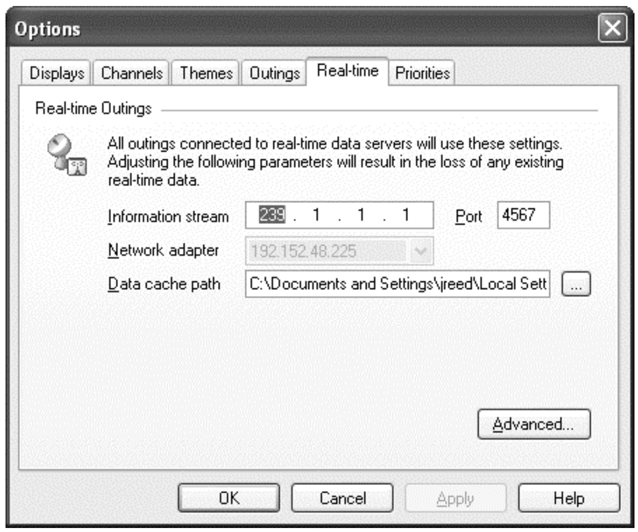
This selection defines the order in which outings are displayed when a Task icon is expanded in the Task explorer. Select the Arrange by method and then choose to display them in ascending or descending order.

This command is also available in Task explorer. To access the context menu, hold the cursor in the area below the Tasks and select:

> **Arrange Outings By > Car Name/Create Date**

The Sort Order is applied to all Tasks in the Workbook, regardless of where the order is defined (Task explorer or Options dialog)

Real-time - setting up



Use the fields on the Real-time tab to set global real-time outing settings.

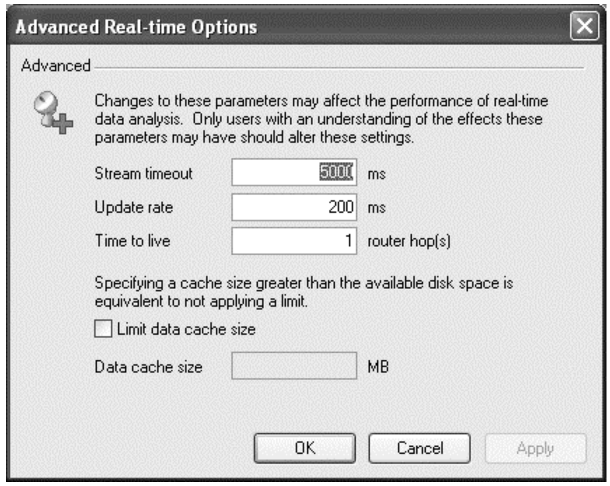
Information stream/Port: These are editable fields used to configure the information stream and port that the desired server machine is to broadcast on.

Network adapter: The IP address of the Network Adaptor that multicast data is received on.

Data cache path: This field is used to enter or browse for the location of temporary data files.

Setting the Advanced Real-time options

Clicking 'Advanced' opens the Advanced Real-time Options dialog.



Stream Timeout: This field is used to enter the timeout limit for the detection of a data stream.

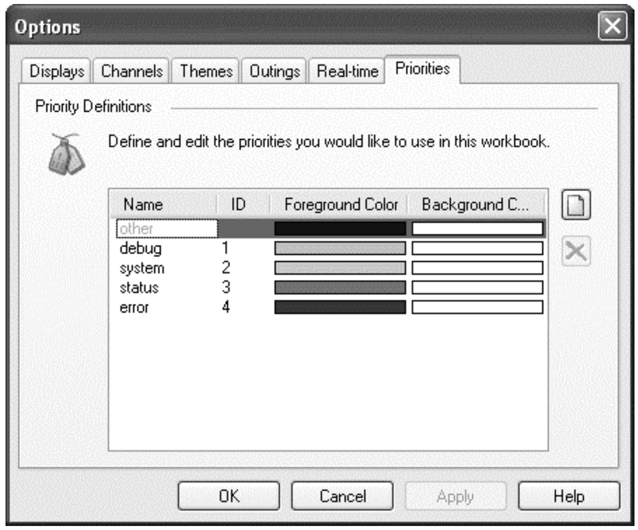
Update Rate: This field is used to enter the rate at which displays showing Real-time data are updated.

Time to Live: this field is used to configure the time to live for packets sent from the real time data manager to the desired server machine.

Limit data cache size: Multicast data is stored in a data cache on the hard drive (see data cache path on Real-time page). When unchecked, data cache size is unlimited. When checked, the oldest data is removed to maintain the file at the size specified in the field below.

Data cache size: This field determines the data cache size.

Priorities

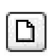


This option is for setting event priorities. Priorities allow the user to categorize events based on their severity, importance or source. The Event display can then be configured to plot events by priority.

There are four default priorities: Debug, System, Status, Error. Priority properties (Name, colors etc.) can be changed if required and further priorities can be added up to a total of eight.

Priorities are created using IDs which correspond to Event IDs. Events are placed in priorities accordingly. If an event is assigned an ID that does not exist in the priorities defined for the workbook, it is placed into the 'other' priority. This is unique in that it cannot be deleted and it does not have an ID.

Name, ID, fore color and back color properties of the default priorities can be changed if necessary.

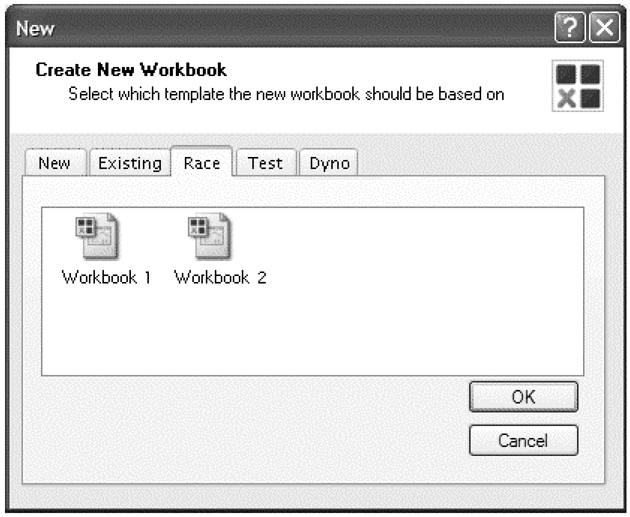
Click  to add further priorities and then set the properties as required.

Click  to delete the highlighted priority.

Organizing Templates

New template categories can be created so that when the *New* dialog is opened, extra tabs are created in addition to the default tabs.

For instance you may wish to add team specific template categories such as: Test Templates, Race Templates, Dyno Templates, as shown in this example.



To add Template categories:

1 Create a directory on your server or data drive, e.g. Pi Toolbox Templates.

2 Create three sub-directories, Race, Test and Dyno.

3 Create Shortcuts to the sub-directories.

4 Put the shortcuts in C:\Program Files\Pi Toolbox\Templates (default installation directory).

5 Name the shortcuts, Race, Test and Dyno.

The New dialog will now have three extra tabs: Race, Test and Dyno from which you can select templates saved in the sub-directories.

The Add dialog

General

The dialog can be opened by selecting: **> Add Outing** in the Task Explorer.

Alternatively, the shortcut: Ctrl + L opens the dialog from any part of the application.

The dialog is used to add historic outings (Pi Datasets) or real-time outings to a task. The default configuration for this dialog has three browser buttons to enable rapid location of outings.

- **Sample data:** locates the sample PiDatasets installed on the user's PC at installation (if selected during installation)
- **My Documents:** locates a pre-selected directory of your data.
- **Real-time:** locates Real-time telemetry or watch data servers.

***Note:** Three further 'My Data' browser buttons can be added to the dialog. These are enabled in the Preferences dialog. You can assign default directories and names for 'My Documents' and additional 'My Data' browser buttons in the Preference dialog (Browers tab). See page 38.*

Custom Browsers

The Add dialog can also be used to host custom browsers so that users can access their outings, irrespective of their file type and location. See *Adding a Custom Browser* on page 62.

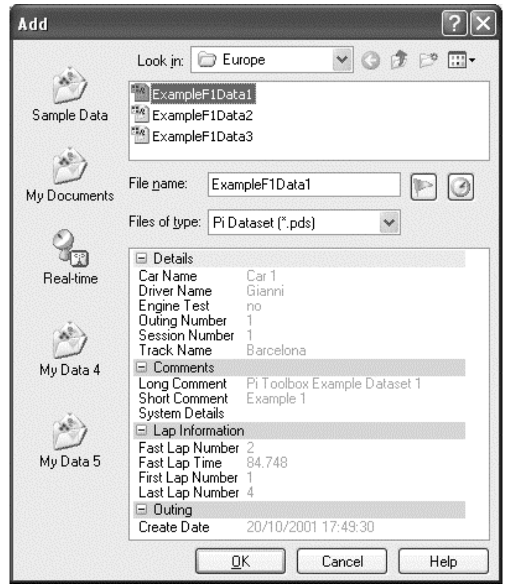
Adding Historic Data

This button  automatically selects the outing, from those currently in view, which contains the fastest lap.

This button  selects the most recent outing from those currently in view.

***Look in*:** Use the Look in field and the browse tools to locate an outing.

***File Window*:** The outings (datasets) contained in the selected data folder are displayed here. When you highlight a dataset, details are displayed in the lower pane. Clicking OK will add the selected dataset to the Task selected in the field above.



***File Name*:** Displays the name of the outing file (.pds file) selected.

***File of Type*:** Use this field to select the format of the outing, i.e. Pi, MATLAB or ASCII.

***Details*:** Details of the highlighted outing appear in this window to help you identify it. Properties are listed in categories that can be expanded or collapsed as required.

Default directories

You can set up the default directories for the browser buttons in the Preference dialog (Directories tab). To open this dialog select: **File > Preferences**.

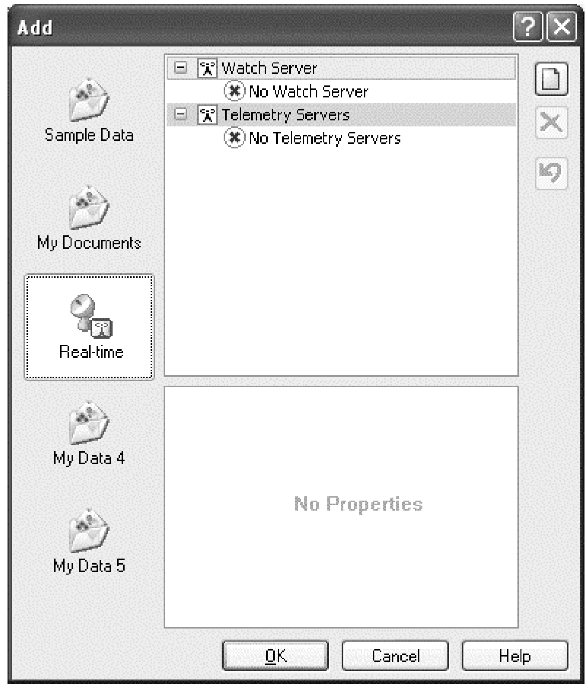
An alternative method of setting a default directory is as follows:

1 Browse for the required directory in the **Look in** field.

2 Ctrl + click **My Documents** or additional **My Data** browser buttons.

The directory becomes the default for that button and it path is entered in the Browsers tab of the preferences dialog.

Adding Real-time data



Browser View - The Window contains two nodes: **Watch** and **Telemetry. Watch** lists the *Watch* data servers and **Telemetry** lists the *Telemetry* data servers. If no servers are present, double-clicking 'No Watch Servers' or 'No Telemetry Servers' opens the Browse for Computer dialog.

Alternatively, click to open the Browse for Computer dialog.

Note: *To replace a server, double-click an existing computer in the Watch or Telemetry list and select another in the Browse for Computer dialog. Clicking OK will replace the server. Only one Watch server can be loaded at any time.*

Click the delete button to delete a computer from the Watch or Telemetry list.

Details**:** Details of the highlighted outing appear in this window to help you identify it. Properties are listed in categories, which can be expanded or collapsed as required.

OK**:** Click OK to add the outing.

Two types of server can be connected:

- **Watch servers** – server physically connected to the car. Only one Watch server can be connected.
- **Telemetry servers** – server not physically connect to the car. More than one Real-time server can be connected. However, only one instance of each server is can be selected.

Important Note: Users of NT4 operating Shell 32 versions below V4.71 may experience some difficulty with the Browse for computer dialog box. Details of a possible solution are given in the Installation section of the User Guide, page 30.

To add a Real-time data outing:

1 Make sure that the data server settings are correctly configured. Do this in the Real-time tab of the Options dialog.

2 With the required task highlighted select: > **Add Outing**.

3 Select Real-time in the navigation bar of the Add dialog.

4 Open the Real-time list.

5 Double-click 'No Telemetry Server' or click

The Browse for Computer dialog opens.

6 Browse for a Real-time server and click OK. Alternatively enter the server name (without prefixes).

The server is added to the Telemetry Servers list.

7 Click OK.

Adding a Custom browser

Pi Toolbox allows you to configure Real-time and file browser settings as well as adding your own custom outing browsers. This means that it is easier to access your outings, irrespective of their file type and location.

To add a custom browser:

1 Select File > **Preferences**.

2 Click the **Browsers** tab.

3 From the list, select the position where you want your custom file browser to appear. Each position in the list represents a button on the *Places bar* in the **Add/Replace** dialog.

4 Double-click the browser property.

In the drop-down list, select your custom file browser.

5 The caption to be displayed will be added underneath the browser button. It is taken from the actual browser name. For example: Pi Real-time browser will be displayed as Real-time.

Note: *The caption is also user definable. You can edit the caption by double clicking in the caption field.*

6 You can add a description to your browser; it will be displayed in the form of a tool tip, when the cursor hovers over the button. For example: this can be information about what data is stored in the directory.

To add a description, double-click in the **Description** field, type your text in the edit box. If you do not enter a description, a tool tip based on the browser's settings will be displayed. For example:

- If you have entered a file path, this will be displayed as the tool tip.
- If you haven't entered a file path, the caption that has been entered will be displayed as a ToolTip.
- If the caption field is empty, then no tool tip will be displayed.

7 By default, when you add a browser the corresponding button will be displayed in the **Add/Replace** dialog.

To switch the button off double-click **Enabled**. In the drop down list, select **No**.

8 If you are using a Real-time browser, you can provide a default set of servers using the **Source** field. This must be entered in the standard Real-time source format. For example:

- If you are connecting to a Watch server and a Telemetry server, type the following:

  <*watch*>|<*telemetry*>, where <*watch*> is the name of the Watch server and <*telemetry*> is the name of the Telemetry server.

- If you are just connecting to a Watch server, type <*watch*>, where <*watch*> is the name of the Watch server.
- If you are only connecting to a Telemetry server, type <*telemetry*>|, where <*telemetry*> is the name of the Telemetry server.

Note: *Not all browsers utilize the directory path and source string fields.*

Quick start

The Quick Start Guide is to help new users quickly create displays and plot data. When the application is run, a default Worksheet is provided with a single Task included. However, the following steps assume that you are starting with an empty Worksheet. To open an empty worksheet, click the new button on the toolbar.

Create a task:

Go to the task window of the Explorer (Alt + 1) and select: > **Add Task**. Name the task by double-clicking 'Name' in the Details pane and overtyping the default name. Press Enter or click away from the edit box to accept the name.

Load an outing:

Highlight the task and select: > **Add Outing**. Browse for a PDS (Pi Dataset) in the Load outing dialog.

Add a display to a worksheet

Click the Insert Display button on the toolbar and select a display type from the list. Note that this button remembers the last display type added and shows the appropriate icon.

Connect the display to a task

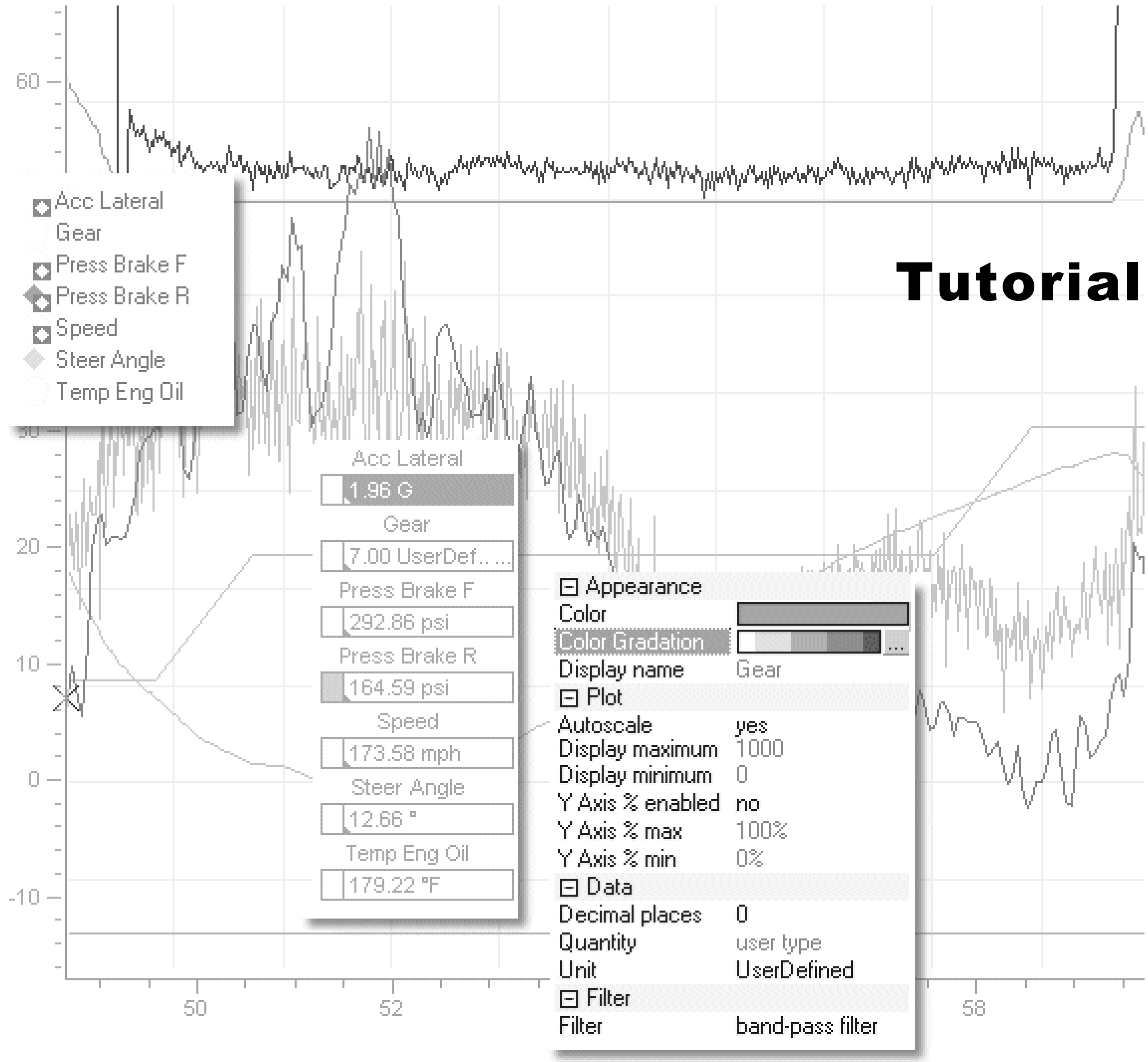
In order for the display to plot data, it must be connected (or associated) to a task.

To do this click the 'No Task' icon in the top left of the display title bar and from the drop-down list of available tasks, choose the task you have created.

Select channels to display

Go to the Selections Explorer - press Alt + 2 - to see the channels in the outing. With your display in focus, double-click the channels that you want to appear. The channels selected will appear in the lower pane of the Explorer and the data will appear on the display.

Tutorial


Acc Lateral
Gear
Press Brake F
Press Brake R
Speed
Steer Angle
Temp Eng Oil
Acc Lateral
1.96 G
Gear
7.00 UserDef...
Press Brake F
292.86 psi
Press Brake R
164.59 psi
Speed
173.58 mph
Steer Angle
12.66 °
Temp Eng Oil
179.22 °F
Appearance
Color
Color Gradation
Display name Gear
Plot
Autoscale yes
Display maximum 1000
Display minimum 0
Y Axis % enabled no
Y Axis % max 100%
Y Axis % min 0%
Data
Decimal places 0
Quantity user type
Unit UserDefined
Filter
Filter band-pass filter
60
20
10
0
-10
50
52
58

About the tutorial

In the following tutorial you will learn how to use Pi Toolbox's common commands and procedures - including creating tasks, adding displays, loading data, selecting channels and changing properties.

The Worksheets that you will create are typical layouts that can be used in practical trackside analysis. The Data used to create the displays are the example Pi Datasets stored on the Pi Toolbox CD. These datasets may also be located on your hard disc (if selected at installation).

The tutorial is divided into logical sections which follow standard working routines. Pi Toolbox can be configured to open with a new Workbook, the last Workbook or the default Workbook. For the purposes of this tutorial, start with a blank Workbook.

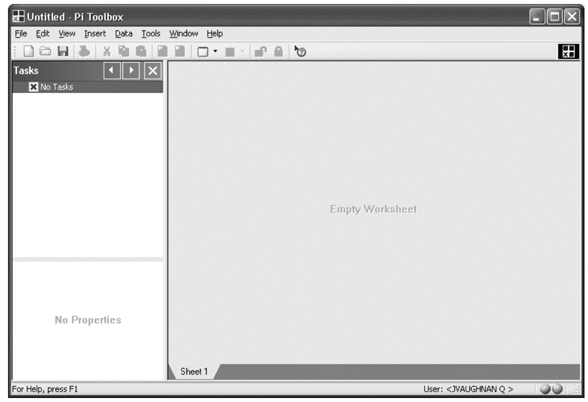
Note: *The default mouse configuration is assumed, i.e. left click: select - right click: context menu. Therefore, references to 'right-click' in the text indicate that the context menu is opened.*

Add a Time and Distance display to a blank worksheet

1

Click the New button **to open a blank Workbook.**

Save changes to an existing Workbook if prompted to do so.

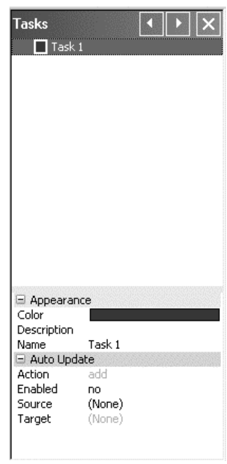


2

The left-hand pane headed 'Tasks' is the Task Explorer.

Right-click in the Task Explorer and select: Add Task

A task named 'Task 1' is created in the explorer.



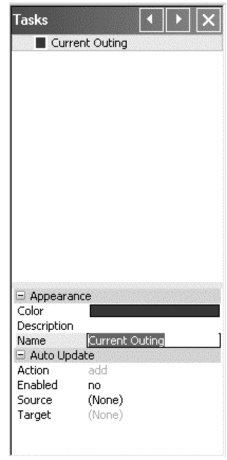
3

In the lower pane of the Task Explorer, double-click 'Name' and enter: 'Current Outing'.

Press Return.

The new task name is displayed next to the task icon in the upper pane.

You can accept the default color given to the task or change the color by double-clicking 'Color' in the lower pane and selecting a color from the palette.



4

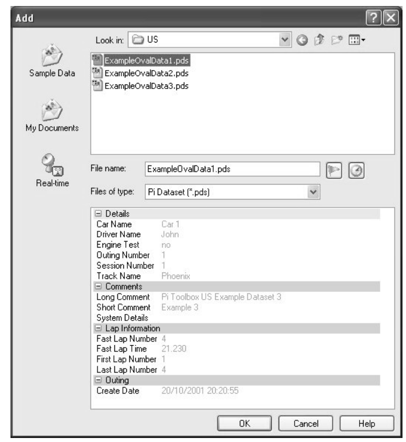
With the task highlighted right click and select: Add Outing

The Add dialog opens.

The Add dialog defaults to the 'My data' window, which allows you to browse for historical data.

Browse for a PDS file (Pi Dataset) in the Files tab and click OK.

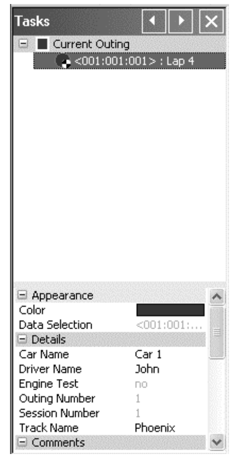
The selected dataset is added to the task.



5

In this part of the tutorial the Pi Dataset used: <ExampleOvalData1> is selected from the directory ‘Pi Toolbox>Sample Data>US’. Sample datasets are included as part of the Pi Toolbox installation (if selected).

Pi Toolbox can display all the laps in an outing, or a selection of laps. By default the fastest lap from the dataset is selected. Dataset information is displayed beneath the task in the form: <000:000:000>: Lap 3 (session:outing: first lap: lap selected).

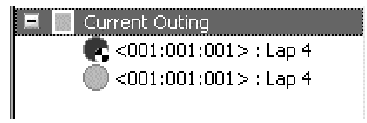


6

Tasks can contain one or more datasets. One of them is defined as the Datum, indicated by the overlay on the dataset icon: .

A single dataset is automatically made the datum.

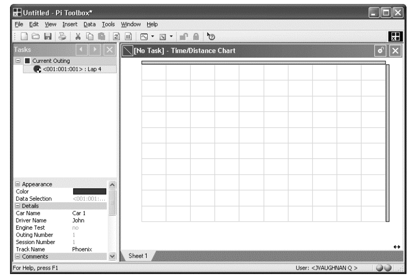
*The datum can be changed by right-clicking on a dataset and selecting: **Make Datum**.*



At first you will create a general Worksheet that has several functions. The Worksheet will enable you to:

- Analyze general performance parameters in a Time and Distance display, i.e. brakes, steering, engine speed, throttle, engine oil temperature, lateral acceleration, engine water temperature
- Visualize where certain events occur on a circuit map
- Show what gear the driver has selected using a Bit Indicator display
- Change laps rapidly using the Navigator bar
- Compare the performance of two drivers.

7



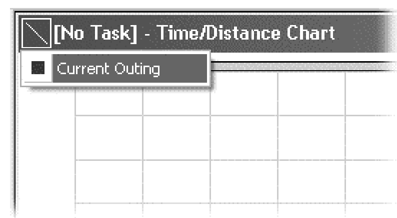
Click the Insert Display button  **on the toolbar.**

Select a Time and Distance display from the drop-down list.

The display is added to the worksheet.

This button remembers the last display type added and shows the appropriate icon. If the button is not displaying the icon of the display you want, click the down arrow adjacent to the button and select from the drop-down list.

8



The Worksheet title bar reads [No Task]. The display grid is shown but no data is displayed.

Click the 'No Task' icon and select 'Current Outing' from the drop-down list.

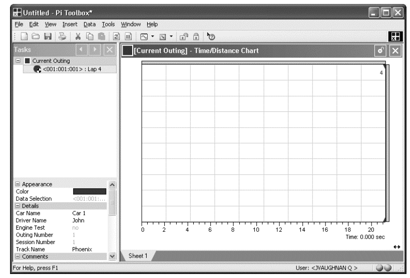
The Display is connected to the 'Current Outing' task.

Note: Displays connected to the same task share a common Data Cursor position. As you move the cursor along the X - axis or click a data point or event in one display, the cursor moves simultaneously in all displays connected to the task. See The Principle of Tasks and Outings, page 111.

9

The X-axis scale is drawn on the display. The default quantity is 'Time' and extent of the scale is determined by the data selection (in this case a single lap).

End of Lap beacons are also drawn if they exist in the data selection.

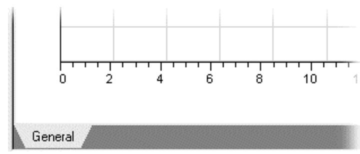


10

Go to the Worksheet name tab and double-click the default name 'Sheet 1'.

Enter: 'General'.

The shortcut: Ctrl + F2 *highlights the name tab.*

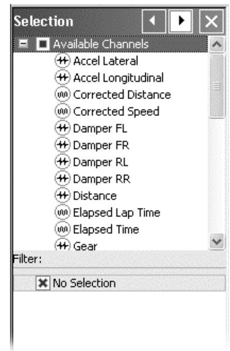


11

Go to the Selections Explorer.

Shortcut: Alt + 2.

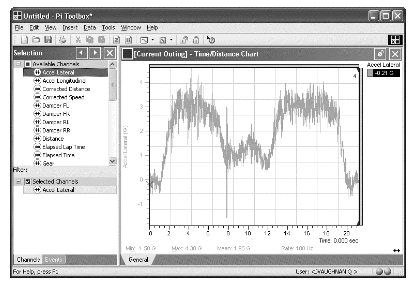
The Selections Explorer is used to select Channels and Events (and other elements) for display. Generally there are two tabs in the lower pane, ‘Channels’ and ‘Events’. With the default ‘Channels’ tab selected, the channels available for the data selection are listed in the upper pane.



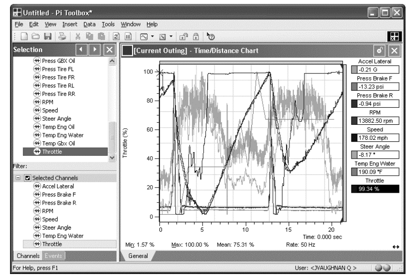
12

In the upper pane, double-click the channel: Accel Lateral.

The channel appears in the ‘Selected Channels’ list in the lower pane and its trace is drawn on the Time and Distance display.



13



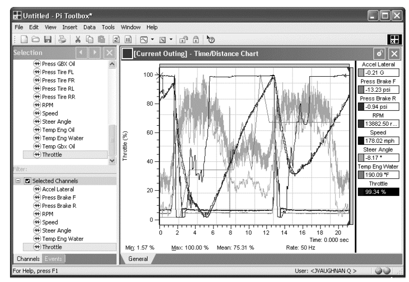
Select the following channels in the same way:

Press Brake F, Press Brake R, RPM, Speed, Steer Angle, Temp Eng Water, Throttle.

Your display should look similar to the one shown here.

Time and Distance displays can display traces 'Tiled' or 'Overlaid'. The shortcut T *toggles the two modes.*

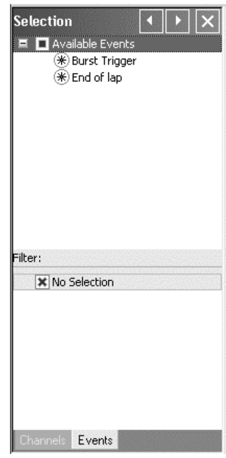
14



When you select channels for a Time and Distance displays, their values are displayed to the right of the plot area in Legends. You can adjust the space allocated to the legends manually, by holding the cursor over the border between the plot area and the legends and moving the splitter bar horizontally.

15

Events are selected for displays in the same way as channels. To see the available events in a dataset, select the Events tab in the Selection Explorer.



16

Select: File > Save.

Enter: 'My Sample Workbook' in the File Name field and save the workbook (.pwb file) in a directory of your choosing.

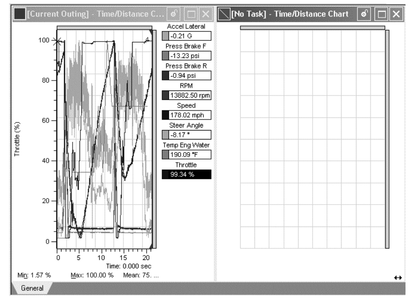
Add Further Displays to the worksheet

17

Click the Insert Display button.

A second Time and Distance display is added to the worksheet.

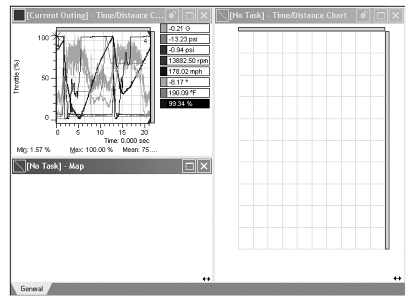
The button should display the Time and Distance display icon  *because one was selected previously.*



18

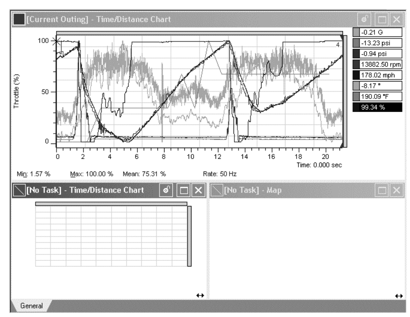
Click the down arrow adjacent to the Insert Display button and select Map from the drop-down list.

A Map display is added to the Worksheet.



19

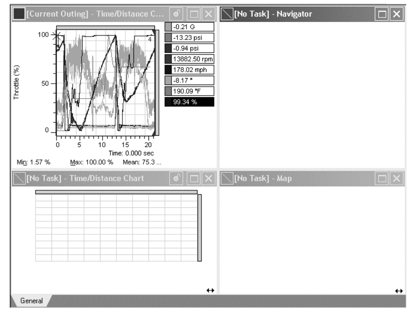
Using resizing and click and drag techniques explained on page 117 re-arrange the Worksheet to resemble the one shown here.



20

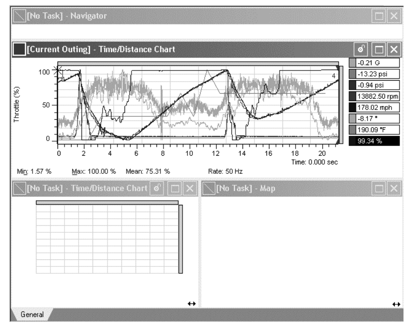
Click the down arrow adjacent to the Insert Display button and select 'Navigator' from the drop-down list.

A Navigator display is added to the Worksheet.



21

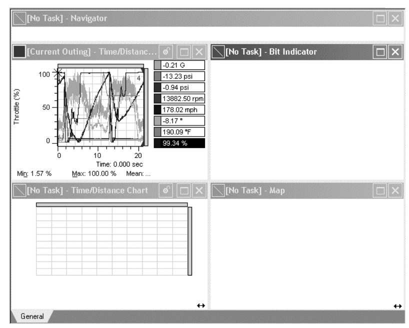
Using resizing and click and drag techniques move the Navigator above the first Time and Distance display.



22

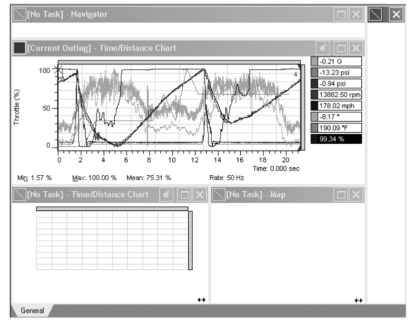
Click the down arrow adjacent to the Insert Display button and select 'Bit Indicator' from the drop-down list.

A Bit Indicator display is added to the Worksheet.



23

Reposition and resize the Bit Indicator display so that it occupies the right-hand edge of the Worksheet.



24

Save your work.

Create Another Task and Add Data

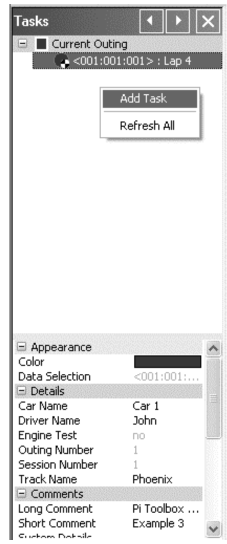
25

Go back to the Task Explorer.

Shortcut: Alt + 1

Right click in the Task Explorer and select: 'Add Task'.

A task named 'Task 1' is created.

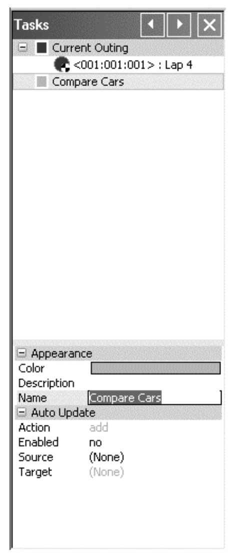


26

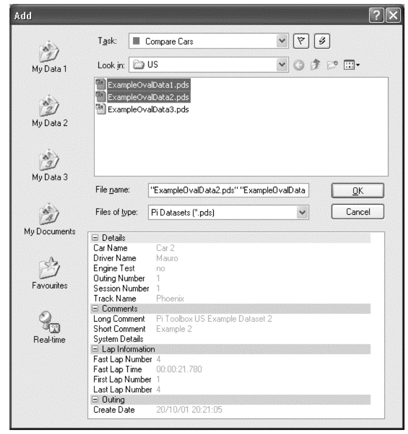
In the lower pane of the Task Explorer, double-click 'Name' and enter: Compare Cars.

Press 'Return'.

The new task name is displayed next to the task icon in the upper pane.



27



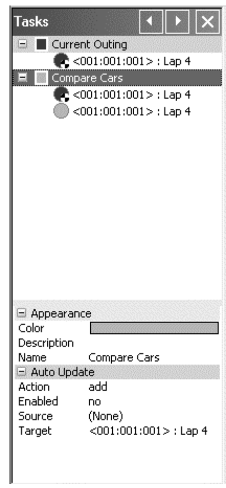
Right-click on the Compare Cars task and select: Add Outing.

The Add dialog opens.

Browse for the same dataset that was added to the first task: <ExampleOvalData1>.

Shift + click the second outing <ExampleOvalData2> so that both outings are selected.

28



Click OK.

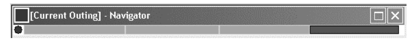
The selected datasets are added to the task.

You can also use the Copy and Paste toolbar buttons to copy the dataset from one task to another

Save your work.

Connect the New Displays

29



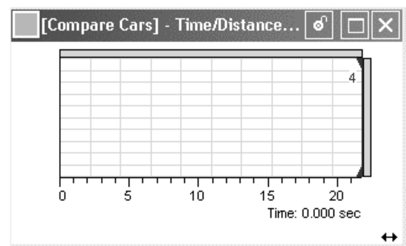
Click the 'No Task' icon of the Navigator display and select 'Current Outing' from the drop-down list of available tasks.

The display is connected to the 'Current Outing' task and displays a navigator bar.

The bar is a graphical representation of the dataset in the task. The bar is divided into segments, usually representing laps. Clicking on a segment will change the data selection, of any display connected to the same task, to that segment.

There are no configuration pages associated with a Navigator display.

30



Click the 'No Task' icon of the second Time and Distance display and select 'Compare Cars' from the drop-down list.

The display is connected to the 'Compare Cars' task.

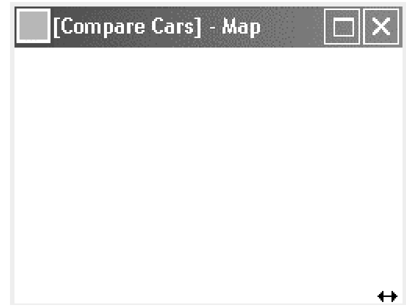
31

Click the 'No Task' icon of the Bit Indicator and select 'Current Outing' from the drop-down list.

The display is connected to the 'Current Outing' task.

32

Click the ‘No Task’ icon of the Map and select ‘Compare Cars’ from the drop-down list.

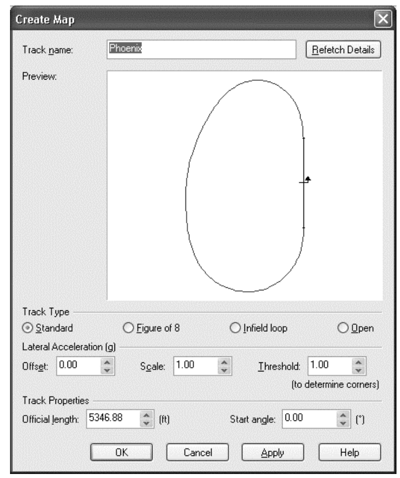


33

Right-click in the Map display and select: Create.

The Create Map dialog opens. A map of the circuit is created in the Preview window, using lateral acceleration and corrected speed data from the outing.

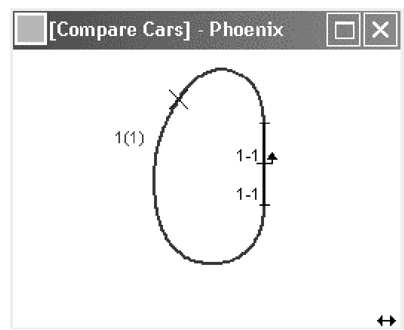
If the Map does not draw, you may need to go to the Options dialog (Tools > Options) and check that the common channel names are mapped to the correct real channels for your outings. See Mapping Common Channels, page 48.



34

Click OK to draw the map in the display.

Save your work



Create Math Channels

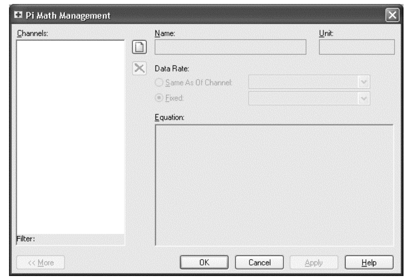
When Math Channels are created, they are listed with other channels in the Selection Explorer, identified by their icon: .

Using the Selection Explorer they can be selected for any display in the Workbook.

35

Select: Tools > Pi Math > Edit

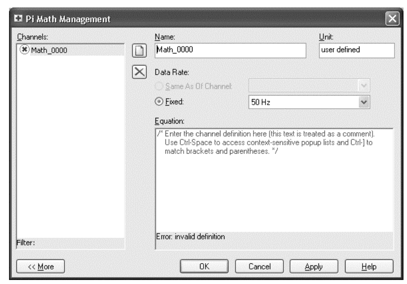
The Pi Math Management dialog opens. This is for the creation and management of math channels. All the math channels you define or import can be accessed and edited here.



36

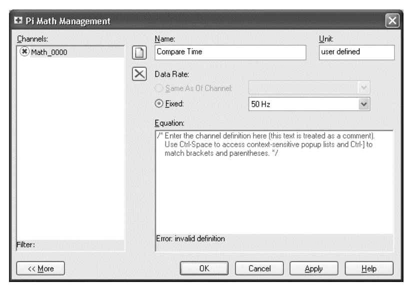
Click the New button: .

A default name <Maths_0000> for a new math channel appears in the ‘Channels:’ list.



37

Highlight the default name in the Name field and enter the name: CompareTime.

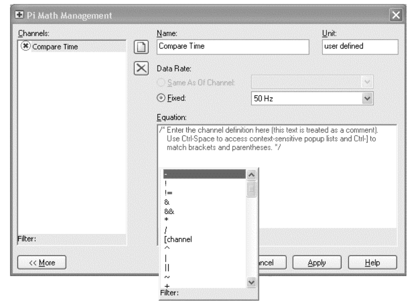


38

Click in the Equation field beneath the equation description.

If required, a description of the math channel function may be added. Insert the description between the characters: /*Description Here*/, *or after the characters*: //Description Here.

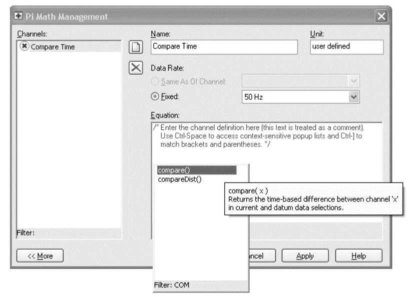
Press: Ctrl + Space to access a drop-down list of mathematical functions, operators and channels.



39

With the drop-down list in view, enter the characters: COM.

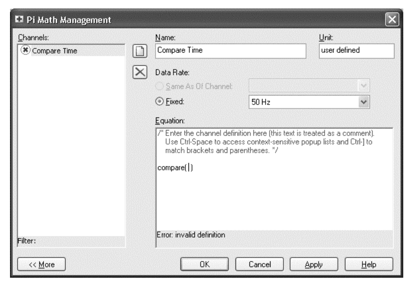
The list is filtered to show the mathematical functions starting with these characters.



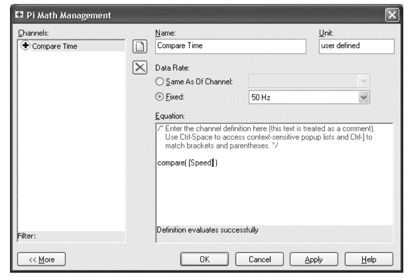
40

Press: ↵ to add the 'Compare' function to add it to the equation.

The beginning of the equation should be: compare( )



41



Press: Ctrl **+** Space.

A drop-down list of available channels is displayed.

With the drop-down list in view, enter the characters: SP.

The list is filtered to show the channels starting with these characters.

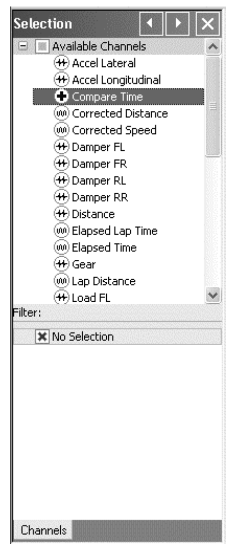
Press: ↵ **to add the channel to the equation.**

The complete equation should be:

Compare([Speed])

Note that equations can also be keyed in manually.

42



Click OK

The Pi Math Management dialog closes and the Math Channel is added to the list of available channels.

43

Click on the lower Time and Distance display so that it has focus.

(The display connected to the ‘Compare Cars’ task).

Go to the Selection Explorer

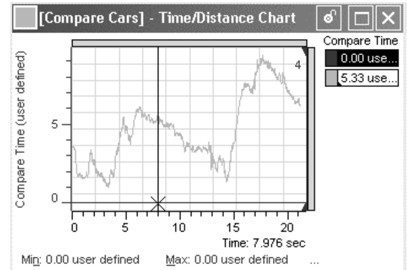
Shortcut: Alt + 2.

Scroll down the list of available channels in the upper pane and locate the Math Channel.

It should look like this: CompareTime

Double-click the CompareTime Math Channel.

The channel appears in the ‘Selected Channels’ list in the lower pane and its trace is drawn on the Time and Distance display.



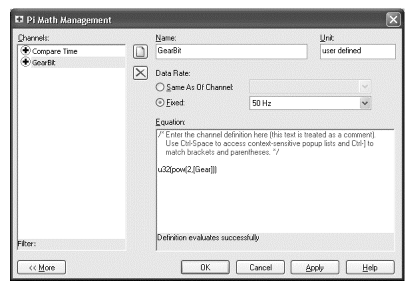
44

Select: Tools > Pi Math > Edit

The Pi Math Management dialog opens.

Create a new Math Channel called GearBit.

Follow the procedure used for creating the CompareTime Math Channel, only this time manually enter the equation: u32(pow(2,[Gear]))



45

Click on the Bit Indicator display to give it focus.

Go to the Selection Explorer

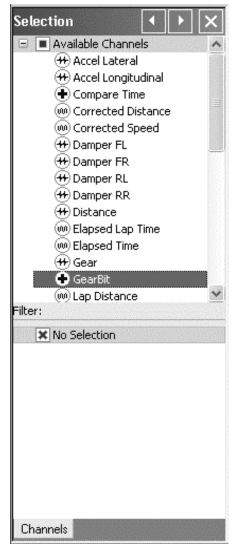
Scroll down the list of available channels in the upper pane and locate the Math Channel.

It should look like this: GearBit

Double-click the GearBit Math Channel.

The channel appears in the 'Selected Channels' list in the lower pane and is selected for the Bit Indicator.

Save your work

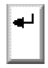


Configure the Bit Indicator

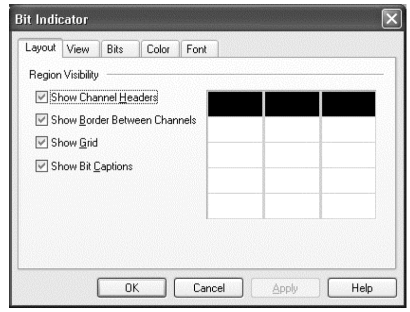
46

Right-click on the Bit Indicator display and select: Properties.

Shortcut: 

+ 

The Bit Indicator Properties dialog opens.



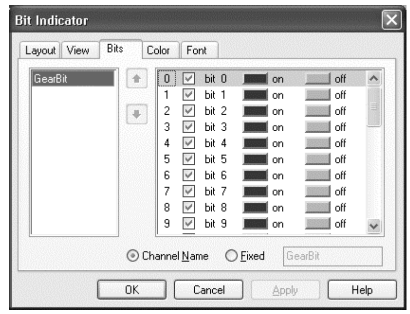
47

The default parameters on the Layout and View tabs of the dialog do not require editing for this Worksheet.

Select the ‘Bits’ tab.

Highlight the math channel ‘GeartBits’ in the channel list on the left of the dialog.

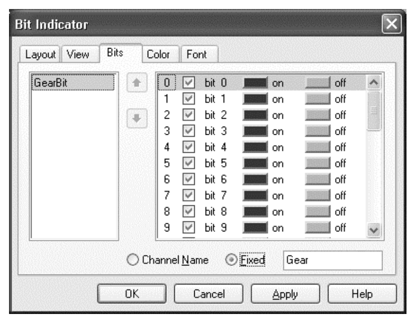
This is only necessary when there is more than one channel selected for the Bit Indicator. The Bit settings are for the channel highlighted.



48

Select the ‘Fixed’ option and enter ‘GEAR’ in the adjacent field.

This is the Name that appears as a title at the top of the Bit Indicator display.



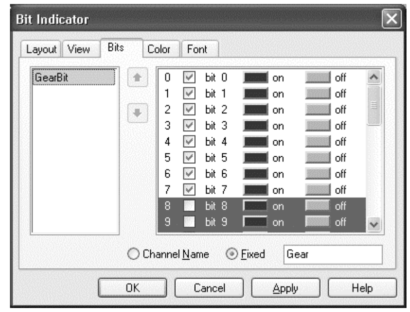
49

Uncheck any unwanted bits.

In this example the Bit Indicator is used to display the gear selected.

To disable a group of bits, click on the first bit then shift click the last bit. With the group highlighted, click on the checkbox of any of the bits - all bits selected will become disabled.

You can also use this method with multiple channels selected.



50

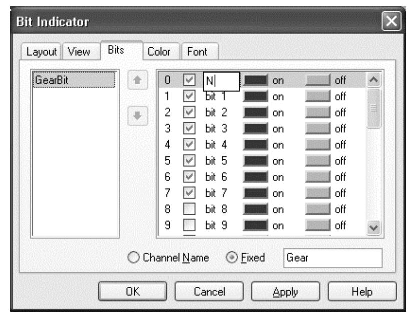
Rename the Bit Captions

To do this:

Double-click the caption bit 0. Delete the caption and enter ‘N’.

Change the remaining captions to 1, 2, 3 etc. to indicate gear number.

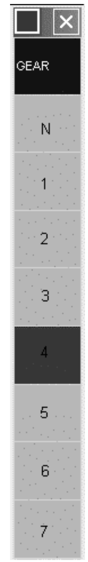
The default colors for On and Off states can be changed if required. To do this, double-click the color panel for each bit and select a new color from the color palette.



51

Click OK.

The Bit Indicator should resemble the one shown here.



Save your work.

Create a second worksheet

The next worksheet you will create is an engine worksheet which shows key engine performance parameters including:

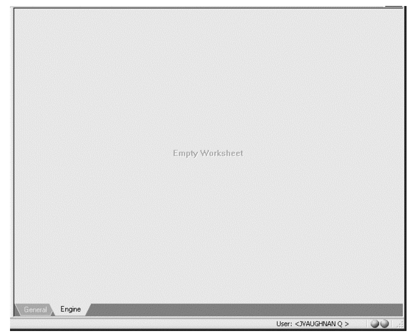
- An X-Y chart to show the relationship between engine oil pressure and engine RPM
- Histograms to show the distribution of RPM and gears over a lap or the entire outing
- Time and Distance displays to show all engine parameters of time.

52

Select: Insert > Worksheet

A new worksheet is created and given the default name 'Sheet 1'

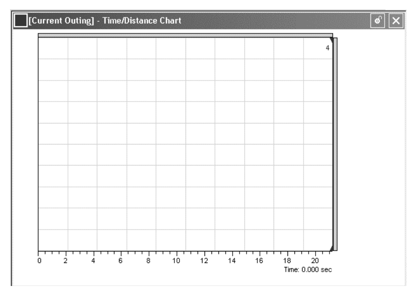
Double-click the default name and enter the new name: Engine



53

Click the down arrow adjacent to the Insert Display button and select a Time and Distance display from the drop-down list.

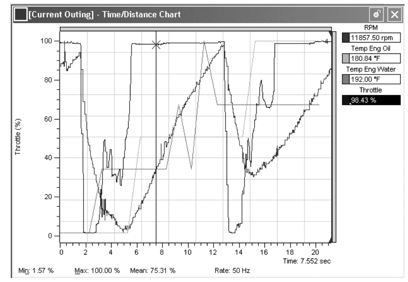
Click the 'No Task' icon in the display title bar and select 'Current Outing' from the drop-down list.



54

Go to the Selection Explorer and select these channels for the Time and Distance display:

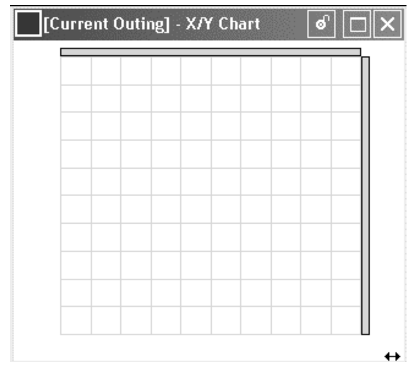
RPM, Temp Eng Oil, Temp Eng Water, Throttle.



55

Create an X-Y display and connect it to the 'Current Outing' task.

X-Y Displays illustrate the correlation between two channels plotted on Cartesian axes, and identify patterns of behavior. Typical uses may be to analyze the engine oil system performance by plotting engine oil pressure against engine RPM.



56

Channels are added in pairs to X-Y displays.

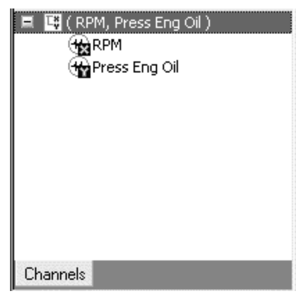
With the X-Y display in focus, go to the Selection Explorer.

Double-click the RPM channel.

The first channel will provide X-axis data.

Double-click the Press Eng Oil channel.

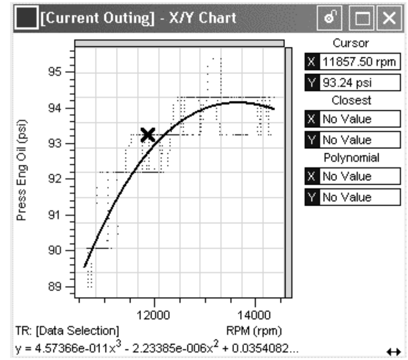
The second channel will provide Y-axis data.



57

The data points and resulting polynomial are drawn on the X-Y display

To swap the X-Y assignment of channels, right click on the channel Pair folder icon and select: **Swap**.

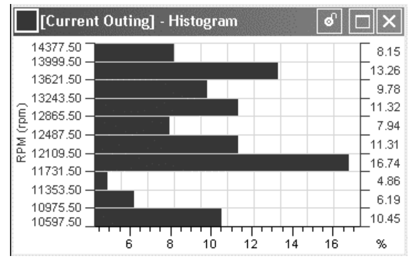


58

Create a Histogram and connect it to the 'Current Outing' task.

With the histogram in focus, go to the Selection Explorer. Double-click the RPM channel.

The channel is selected for the Histogram.

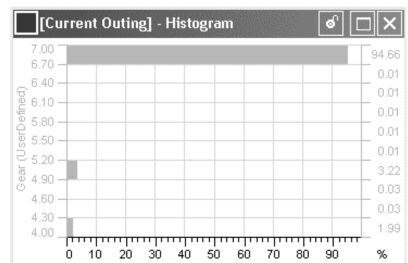


59

Create the other Histogram and connect it to the 'Current Outing' task.

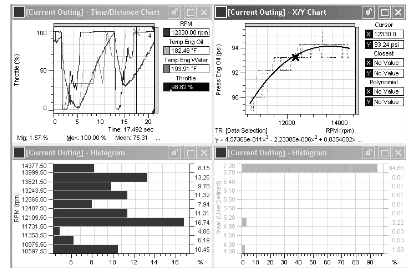
With the histogram in focus, go to the Selection Explorer. Double click the Gear channel.

The channel becomes selected for the Histogram.



60

The completed Worksheet should look like the one shown here.



Save your work

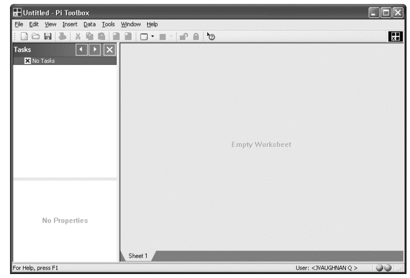
Create a new worksheet and add a reports table

61

Select: Insert > Worksheet

A new worksheet is created and given the default name 'Sheet 1'

Double-click the default name and enter the new name: Reports

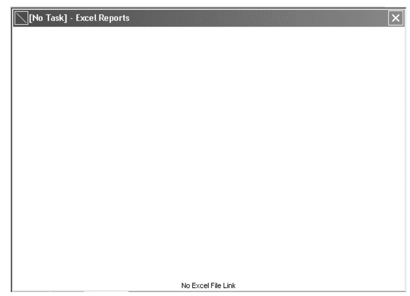


62

Click the down arrow adjacent to the Insert Display button and select Excel Reports from the drop-down list.

A Report display is added to the Worksheet.

Click the 'No Task' icon in the display title bar and select 'Current Outing' from the drop-down list.



63

Holding down the Ctrl key, click and drag the title bar of the Report display.

When you release the mouse button a copy of the first display is added to the Worksheet. Creating a new display in this way copies the parameters of the original display. Therefore the new display will be connected to the Current Outing task.

64

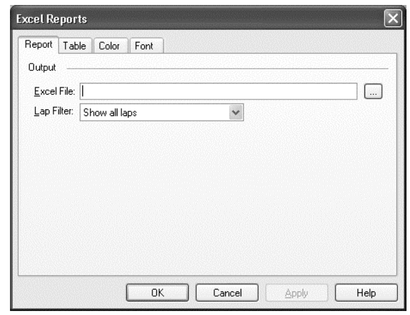
Connect the second Report display to the 'Compare Cars' task.

65

With the 'Current Outing' Report display in focus, select Properties from the context menu.

The Excel Reports properties dialog opens.

The Excel File field shows the filename of the Excel file linked to all tables in the display. This file is the template for the report. In practice the Excel file would be formatted beforehand to correspond to your data output. The Browse button is used to locate the Excel File.



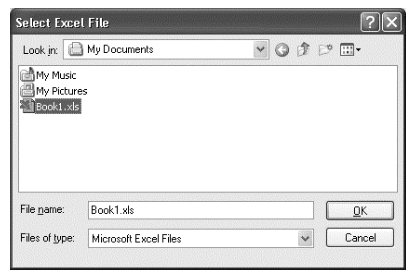
66

Click Browse

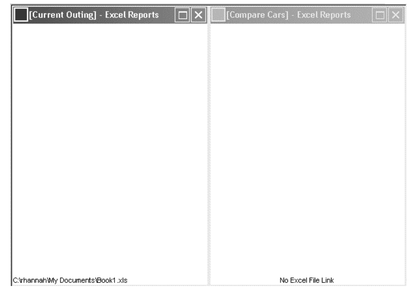
The Select Excel File dialog opens.

Browse for the Excel File that you wish to use as a template.

Click OK and OK again in properties dialog to return to display



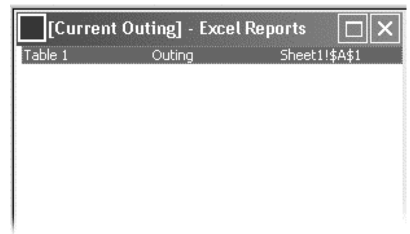
67



The Display shows the path to the selected Excel file.

Connect the second Report display to the Excel file in the same way.

68



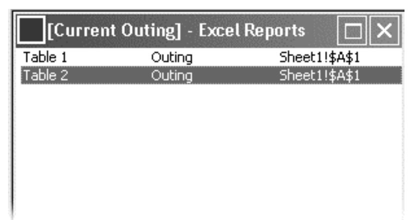
From the context menus select New Table

A Report display is made up of one or more tables (up to a maximum of eight). When you generate a report you can choose a single table or all tables.

The content of the table is configured in the Excel Report properties dialog (Table tab).

The default report type for a table is an Outing Report.

69



Add a second Table.

70

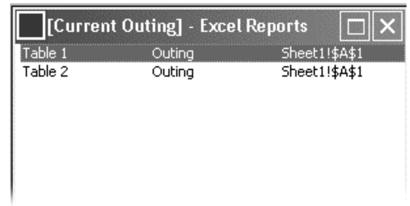
Go to the Selection Explorer and select the following channels for the Report display that is connected to the Current Outing task.

Press Eng Oil, Press GBX Oil, RPM, Speed, Temp Eng Oil, Temp Eng Water, Temp Gbx Oil.

These channels will then be available for inclusion in individual tables.

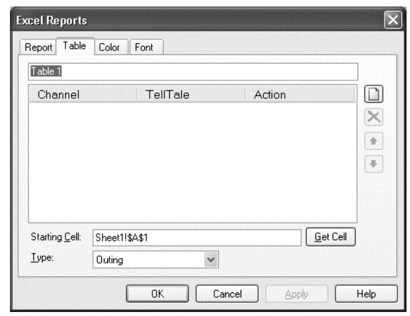
Highlight Table 1 and select Properties from the context menu.

The Excel Report properties dialog opens.



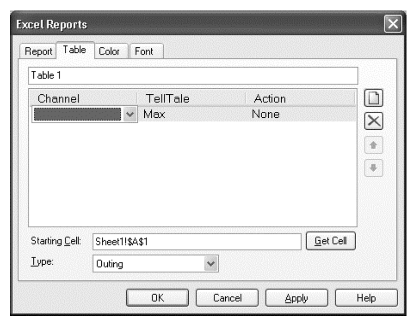
71

Select the Table tab.



72

Click new button to add a blank line to the table, ready for a new channel.

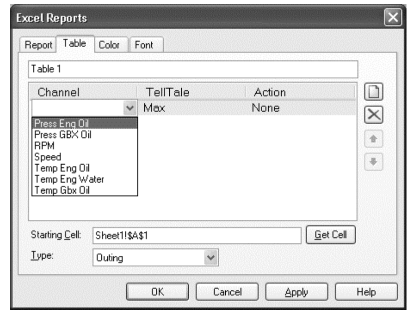


73

Open the drop-down list of channels and Select: Press Eng Oil.

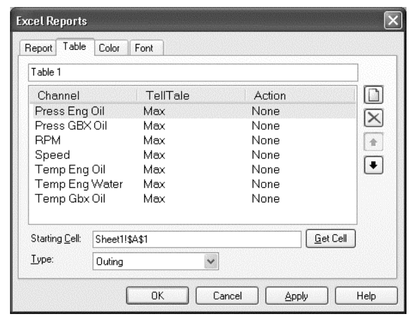
The values that can be displayed in the report can be calculated from channel values using the following functions (selected in the Telltale column):

Min/Max, Mean, Standard Deviation, Start Value / End Value. Leave the Telltale in its default condition for this example, i.e. Max.



74

Add more new lines and select the remaining channels as shown here.



Note: The Get Cell button opens the Excel file associated with the display. In the Excel file you select a cell that will define the top left cell of the data read into the file. If the Excel file has been formatted with heading information such as Title, Track etc. a starting cell should be selected below this.

75

Click Get Cell

The Excel file opens

Bring the Excel file to the front of your Desktop and click a cell that will be the top left starting point of your table.

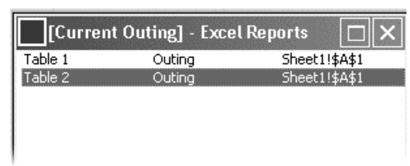
Bring Pi Toolbox to the front of your Desktop and click Get Cell again.

The starting cell is entered in the field.

Click OK to go back to display

76

Highlight table 2 and open its properties.



77

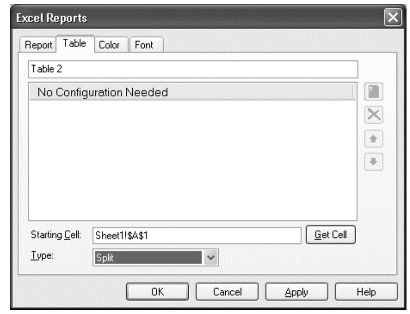
Select the Table Tab

In the Type field select Split

Configuration of channels is unnecessary in a Split type report. The Report looks at times for key segments or features of the track (e.g. slow corners, fast corners, straights).

Click Get Cell to choose a cell defining the top left cell of the table.

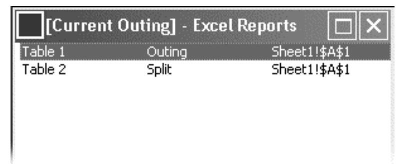
Click OK to return to the Report Display



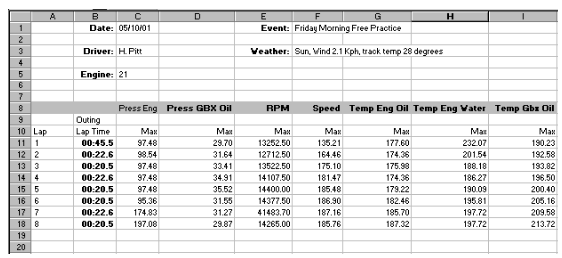
78

Highlight Table 1 and select Run Table from the context menu.

The data from the channels selected for this table is read into the selected Excel file.



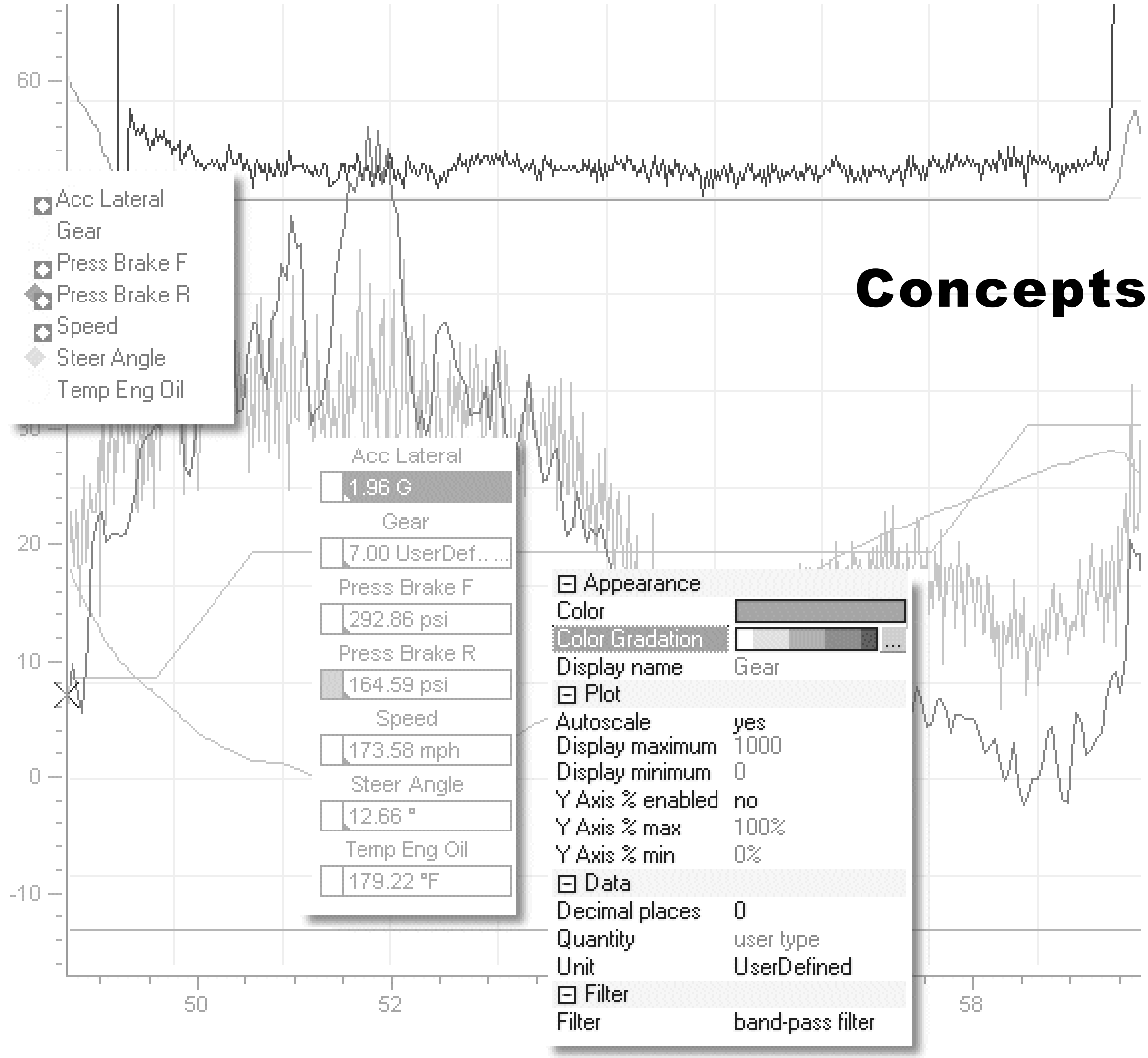
The output from the table created should look similar to the illustration shown. The 'template' Excel file can be formatted with titles and heading information prior to report generation.



	A	B	C	D	E	F	G	H	I
1		**Date:**	05/10/01		**Event:**	Friday Morning Free Practice			
2									
3		**Driver:**	H. Pitt		**Weather:**	Sun, Wind 2.1 Kph, track temp 28 degrees			
4									
5		**Engine:**	21						
6									
7									
8			Press Eng	**Press GBX Oil**	**RPM**	**Speed**	**Temp Eng Oil**	**Temp Eng Water**	**Temp Gbx Oil**
9		Outing							
10	Lap	Lap Time	Max	Max	Max	Max	Max	Max	Max
11	1	**00:45.5**	97.48	29.70	13252.50	135.21	177.60	232.07	190.23
12	2	**00:22.6**	98.54	31.64	12712.50	164.46	174.36	201.54	192.58
13	3	**00:20.5**	97.48	33.41	13522.50	175.10	175.98	188.18	193.82
14	4	**00:22.6**	97.48	34.91	14107.50	181.47	174.36	186.27	196.50
15	5	**00:20.5**	97.48	35.52	14400.00	185.48	179.22	190.09	200.40
16	6	**00:20.5**	95.36	31.55	14377.50	186.90	182.46	195.81	205.16
17	7	**00:22.6**	174.83	31.27	41483.70	187.16	185.70	197.72	209.58
18	8	**00:20.5**	197.08	29.87	14265.00	185.76	187.32	197.72	213.72
19									
20									

Note: You may need to change the Excel file cell format. For instance, if your output data is in times, you may need to change the cell format to display times correctly, e.g. 00:01:51. See **Data Format in Excel**, page 351.

Concepts



60
20
10
0
-10
50
52
58
Acc Lateral
Gear
Press Brake F
Press Brake R
Speed
Steer Angle
Temp Eng Oil
Acc Lateral
1.96 G
Gear
7.00 UserDef...
Press Brake F
292.86 psi
Press Brake R
164.59 psi
Speed
173.58 mph
Steer Angle
12.66 °
Temp Eng Oil
179.22 °F
Appearance
Color
Color Gradation
Display name Gear
Plot
Autoscale yes
Display maximum 1000
Display minimum 0
Y Axis % enabled no
Y Axis % max 100%
Y Axis % min 0%
Data
Decimal places 0
Quantity user type
Unit UserDefined
Filter
Filter band-pass filter

What is Pi Toolbox?

- Pi Toolbox is a standalone application that uses the concept of Workbooks. All work is done in Workbooks, which contain all the information about the environment you create in them. Only one Workbook can be open in the Pi Toolbox container at any time.
- Workbooks can hold up to 16 worksheets. You can create as many Workbooks as you like and save them for later use. Distribute a single Worksheet or a complete Workbook by email or on disk to other team members. All channels, outings and anything else you create, is saved in the Workbook so that others can see exactly what you see.
- The manipulation of data is quick and efficient. Intuitive display area features let you move displays quickly around the Worksheet (or to another Worksheet) to create the layout you want.
- The foundation of Pi Toolbox and its future development is centered on event-based technology. Events can be used for system error detection and car performance analysis.
- The concept of Task based data manipulation is fundamental to the operation of Pi Toolbox. Tasks contain outing data and provide the connection between the data and displays.
- COM technology gives you the flexibility to embed Pi Toolbox displays in other applications that support ActiveX™ such as Microsoft Excel™, giving fully integrated and flexible data analysis. The open architecture allows Visual Basic™ and C++ programmers to develop Tools for specialized analysis tasks.
- Intuitive editing tools allow you to create and distribute math channel definitions quickly.
- Existing users can obtain new controls from Pi, in order to expand their toolset within the application.

The following pages explain how Pi Toolbox's flexibility allows you to distribute anything you create freely around the team, letting others use the templates you create.

Event based Technology

Events are points of interest that occur at a specific instant in time. An event is generated when a set of conditions are true.

Events can either be generated in the Sigma hardware system, referred to as **Hard Events**, or can be created locally on the PC, referred to as **Soft Events**.

Hard or soft events can be displayed as markers on Time and Distance displays, or in Event Displays, giving the user the means of automatically searching through data to find points of particular interest.

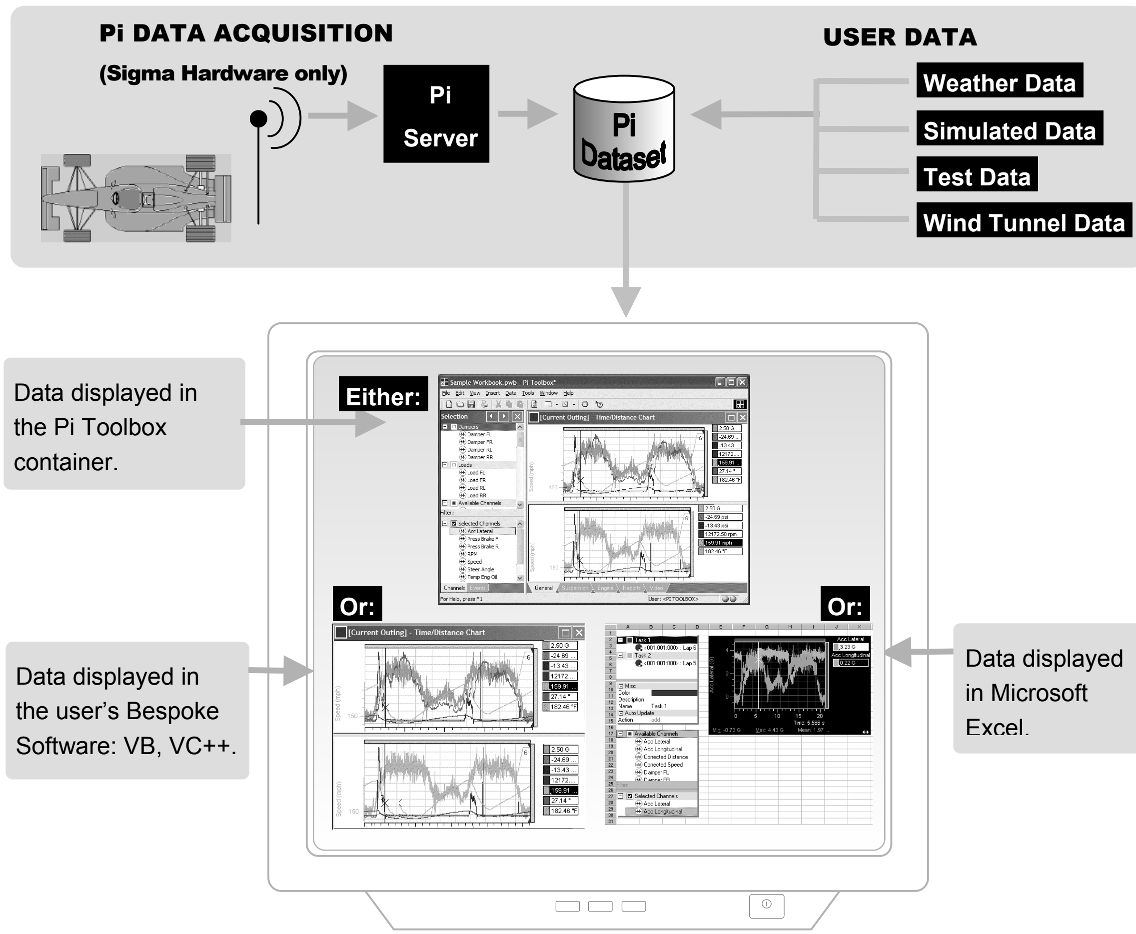
Unlike hard events that are part of the outing data, soft events are always calculated at run time on the PC.

Events can be used for system error detection or when analyzing car performance, and form the basis of future enhancements in Pi Toolbox.

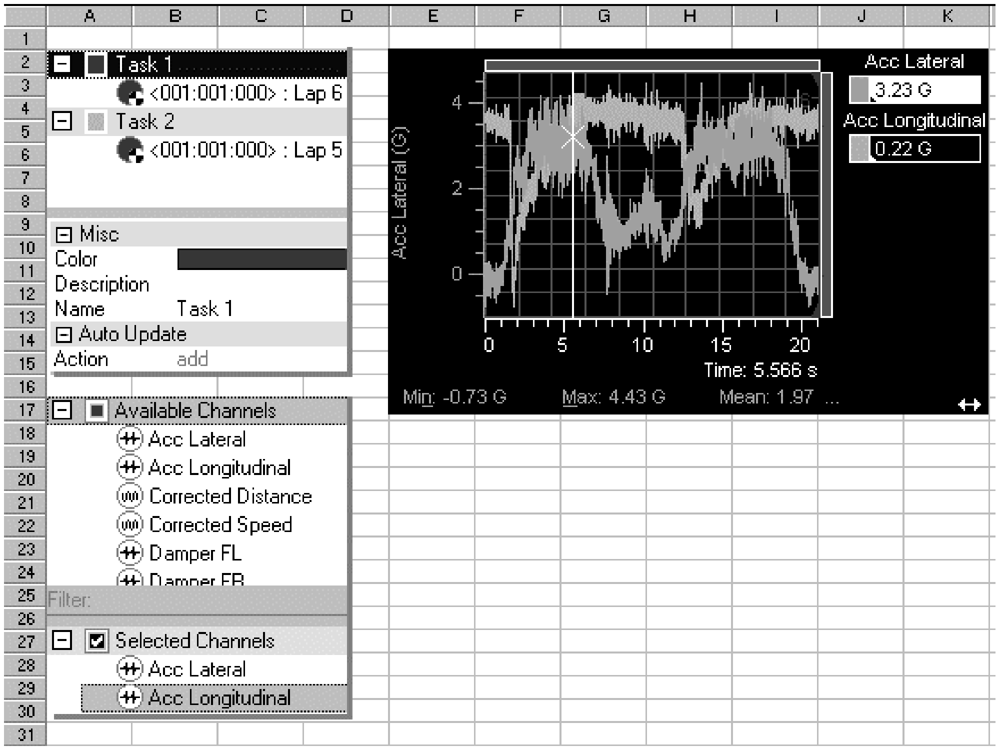
Soft event definitions can be exported in a single external Event Definition file and can then be subsequently imported into other Workbooks.

Flexibility within your work environment

The open architecture enables fully integrated and flexible data analysis, allowing controls to be embedded in your software, with full Pi Toolbox functionality.



Using displays in Microsoft Excel

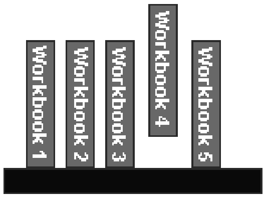


The example above illustrates the potential use of Pi Toolbox components in Excel worksheets. The concept of task based data manipulation is retained, as are many other data analysis features.

This advanced functionality is intended for users with knowledge of coding in VBA. A sample of VBA code for Excel is shown in Appendix C.

Note: *There may be a reduction in data processing performance when using Pi Toolbox controls in Excel or Visual Basic Environments.*

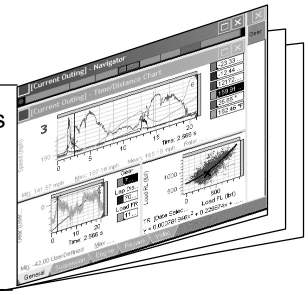
Workbooks and Worksheets



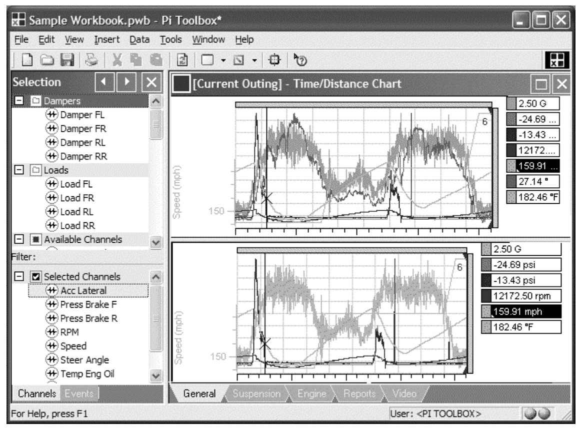
Store

Everything you do in Pi Toolbox is contained in a Workbook.

Organize Workbooks can contain up to 16 Worksheets. Each Worksheet contains up to eight displays.



Save



Analyze

Open a Workbook in Pi Toolbox (or create a new one). Add Worksheets, add displays, create layouts.

Distribute

Email layouts. Workbooks contain Math Channels, Soft Events etc. Worksheets contain Displays. Displays contain local channel properties.

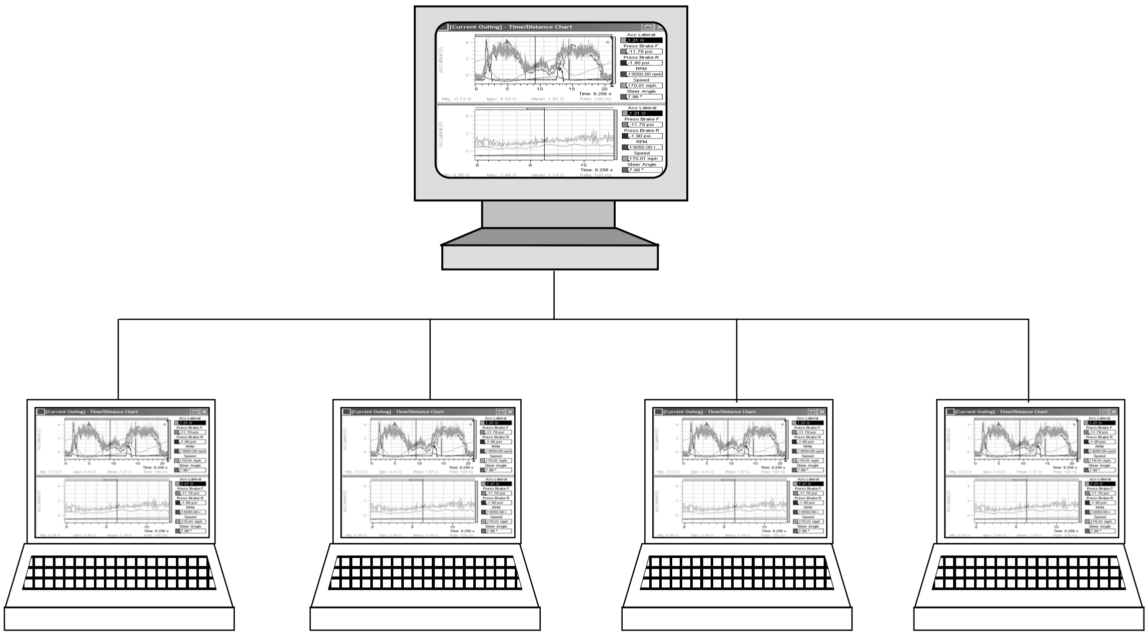
Workbooks
- Math Channels
- Soft Events
- Constants
- Global Channel Properties
- Worksheets

Worksheets
- Displays

Displays
- Local Channel Properties

Distribution

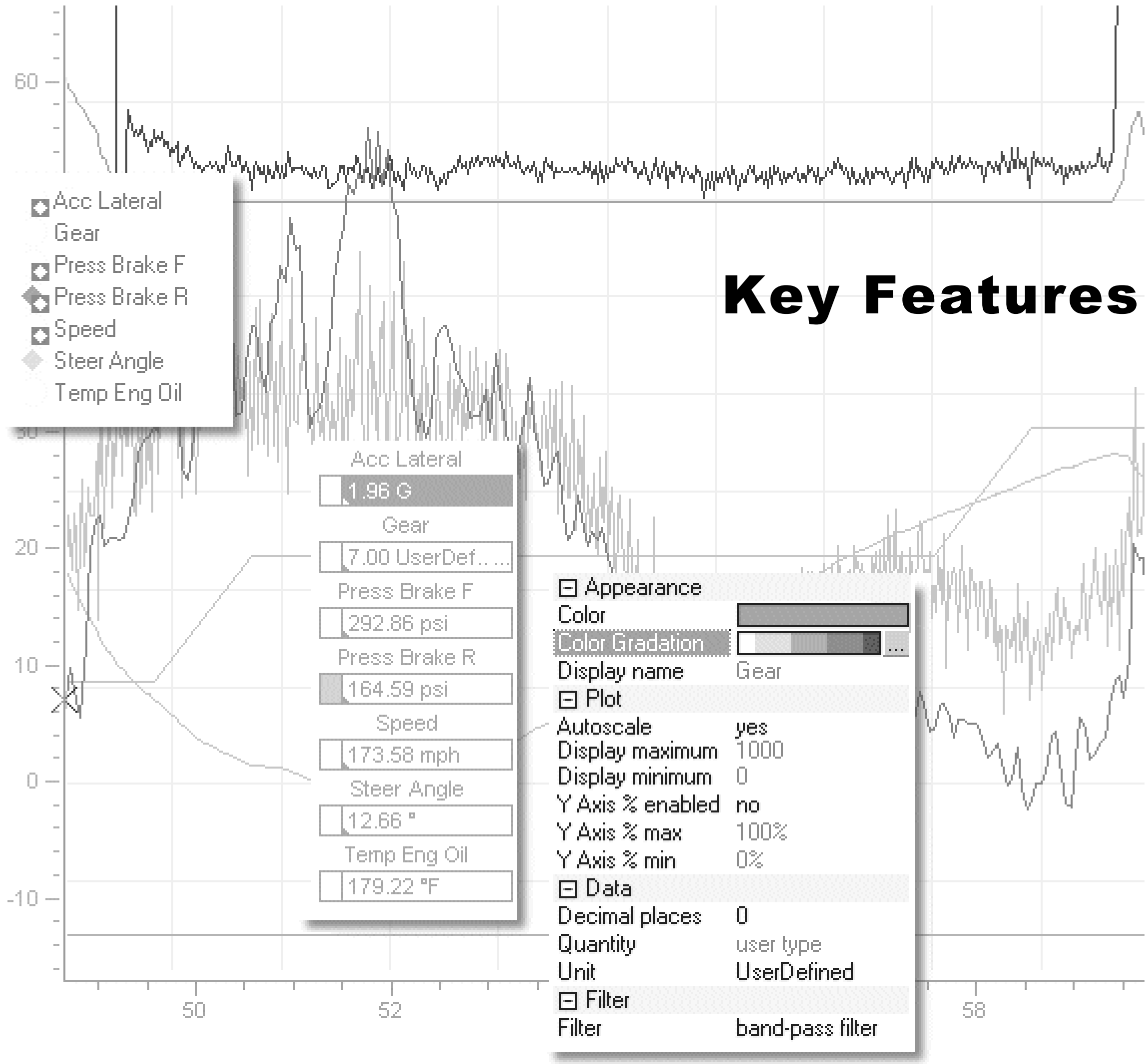
One of Pi Toolbox's most important features is the ability to distribute workbooks, worksheet layouts, displays (in fact, anything you create) around the team. Some of the great advantages are the ability to create templates for common use; save workbooks after the occurrence of an event and distribute for analysis by others; share definitions of math channels, constants and soft events; and distribute displayed and qualifying data.



Exporting and Importing Data

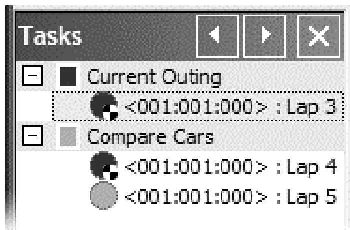
Pi Toolbox provides import and export wizards to make the distribution of work quick and simple.

Key Features



The Principle of Tasks and Outings

What are Tasks?



A task is a collection of outings, created and controlled in the Task Explorer and color-coded for identification.

A task can be connected to any display in the Workbook (on any Worksheet). When you connect a display to a task you ‘associate’ it with the outings contained in the task. Once a display is connected, the contents of the task, and any changes you may make to the content, will be conveyed to the display. For example a Time and Distance display connected to a task called ‘Current Outing’ may be showing a gearbox temperature trace for lap three. If you change the lap selection of the outing in the task to lap four, the connected display changes accordingly. Alternatively you may replace the outing data in ‘Current Outing’ with a new outing. Again the connected display will change accordingly.

When the connection is made between the task and its contents, and a display on the Worksheet, the elements of the display can be built; i.e. the channels and events selected, properties set, math channels defined, etc. The display has a knowledge of which Task it is connected to, so that when outings are replaced, or added, to the task, the display shows the same channels, properties, events etc., for the new data and/or additional data.

Note: *The sort order for outings contained in a task is defined in the Options dialog. The default sort order is set to ‘Create Date in Ascending order’.*

The Task Cursor

Displays connected to the same task share a common Data Cursor position. As you move the cursor along the X-axis or click a data point or event, the cursor moves simultaneously in all displays connected to the task.

Using this feature you can copy a display and, by setting different zoom levels, view data in detail on one display while maintaining an overview in the other.

Tasks and Outings

To each task you add one or more outings, up to a maximum of eight. The data channels contained in the outings can then be selected for the displays connected to the task.

Note: *If a display is connected to a task that has more than one outing dataset added, selecting a channel for the display will cause a trace to be drawn for every outing added.*

Connecting Outings

Some displays, e.g. Bit Indicators, Channel displays, handle data from only one outing. In a task of more than one outing, select which outing the display is connected to as follows:

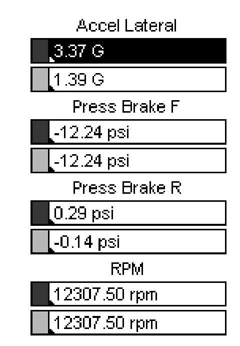
1 Make sure the appropriate display has focus.

2 Highlight the desired outing and select: **> Connect**.

The outing icon will change from this: to this: to show that it has been selected.

Tasks containing multiple outings

Channel data is plotted using global properties unless a local override exists. Therefore the color of individual channel traces on a display depends upon the channel's properties. If a task contains multiple outings, all channel traces are plotted in the outing color, not individual channel colors. The outing color is set by highlighting the outing in the upper pane of the Task Explorer, and editing the color property in the details pane.



With multiple outings added, cursor value legends are grouped together in the cursor region. The illustration shows a cursor value for every outing contained in the task.

In a display one channel is the 'Active' channel, or the channel in focus, its cursor value legend is highlighted. The active channel can be changed by clicking on the legend or using the ↑↓ keys. See Time and Distance Displays, page 243.

When using multiple outings, the active channel determines which outing is the 'Active Data Selection'. In this illustration, with a channel from the 'red' outing highlighted, the red outing is active.

Changing the active data selection on the display in focus changes the active data selection in all displays connected to the same task.

Note: *For visual reference, the Y-axis scale and statistics are displayed in the same color as the active channel. For multiple outings they are displayed in the color of the active data selection.*

Selecting laps

When an outing is initially connected to a task, the fastest lap of the outing is loaded. This data is then available to be displayed through selected channels.

The Select dialog lets you select the lap or set of laps you want to analyze.

To open the select dialog select**:** **Data > Select > Laps** (alternatively double-click an outing).

Shortcut: ⇧ + Ctrl + L

Useful shortcuts

Ctrl + E Selects all laps in the outing. This command affects all displays connected to the task.

Ctrl + Q Selects the quickest lap in the outing. This command affects all displays connected to the task.

Note: *You can select a single lap or a number of laps from an outing to display. You can quickly change the lap selection from within the display by pressing:* Ctrl + ⇧ + Pge Up / Pge Down.

If, for example, you have laps 12 to 14 selected, pressing Ctrl + ⇧ + Pge Down *will advance the selection to 13 to 15.*

Automatically updating tasks

Using the Auto Update command, a task can be made to ‘watch’ a directory for new outings, as they become available. This is typically when data has been downloaded from the car at the end of a run. The task will automatically ‘Add’ the outing to the task or ‘Replace’ the current outing, depending upon the parameters set. In this way displays can be updated with the latest data downloaded to a network server.

Users can specify the source directory for new outings, a target outing and the time region to be selected from the target outing.

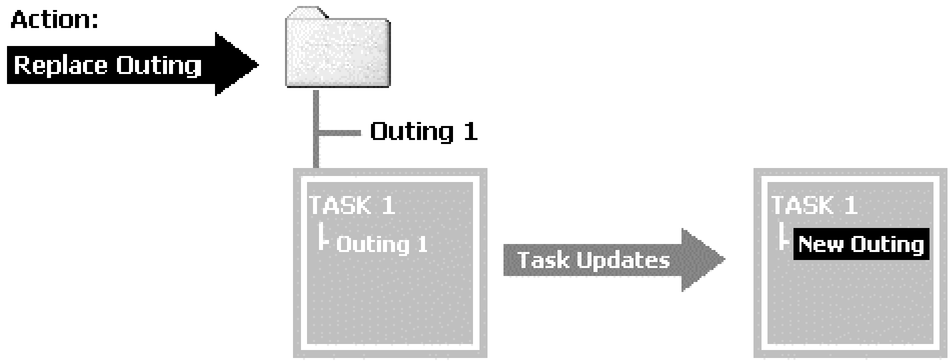
The Auto Update mechanism works by scanning the source directory for the most recent file creation time. If the latest time stamp becomes more recent since the last scan, Pi Toolbox automatically adds/replaces the respective file.

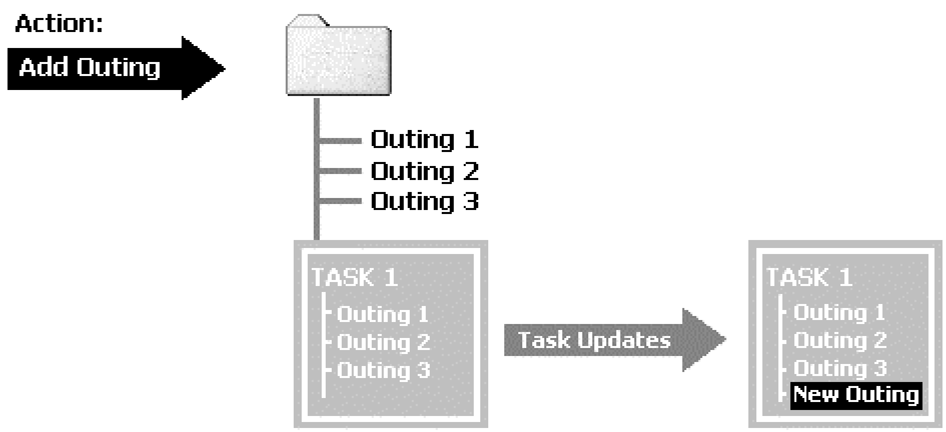
Auto update is configurable on a task-by-task basis.

To enable Auto Update:

1. Highlight a task in the Task Explorer.
2. The task’s properties are displayed in the details pane.
3. Expand the Auto Update options.
4. Click Enabled and select ‘Yes’.
5. Click ‘Select’ and choose a time region to display.
6. Use the selection property to specify what time region is to be displayed from the new/updated outing.
7. Click ‘Source’ and use the ‘Browse for Folder’ dialog to locate the watched directory.
8. Click ‘Target’ and select the outing to be added/replaced.

Auto update options





Note: *When the task contains the maximum number of outings (eight), adding another outing to the watched directory will have no effect on the task.*

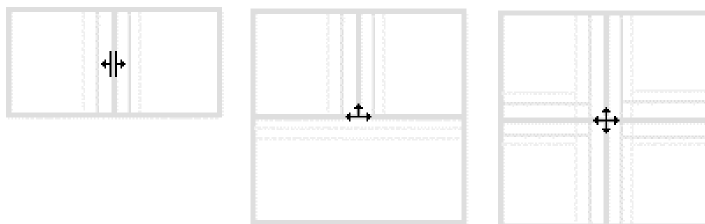
Layout customization

When you add a display to a Worksheet, you change the display area of the Worksheet. Pi Toolbox assembles displays intelligently as you add them to make best use of the available screen space.

However, resizing and repositioning displays in the Display Area could not be easier.

Resize displays using the splitter:

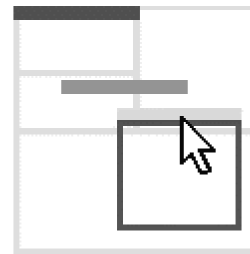
Hold the mouse cursor over the border of two displays, or the intersection of three or four displays, then as the cursor changes click and drag to resize.



Reposition using click and drag:

Click the title bar of a display and drag to a new position in the Display Area. As you drag you will see a bounding box that changes shape as you move the display. This is the area that the display 'snaps to' when you release.

Did you know?



When you click and drag, hold down the CTRL key to copy the display.

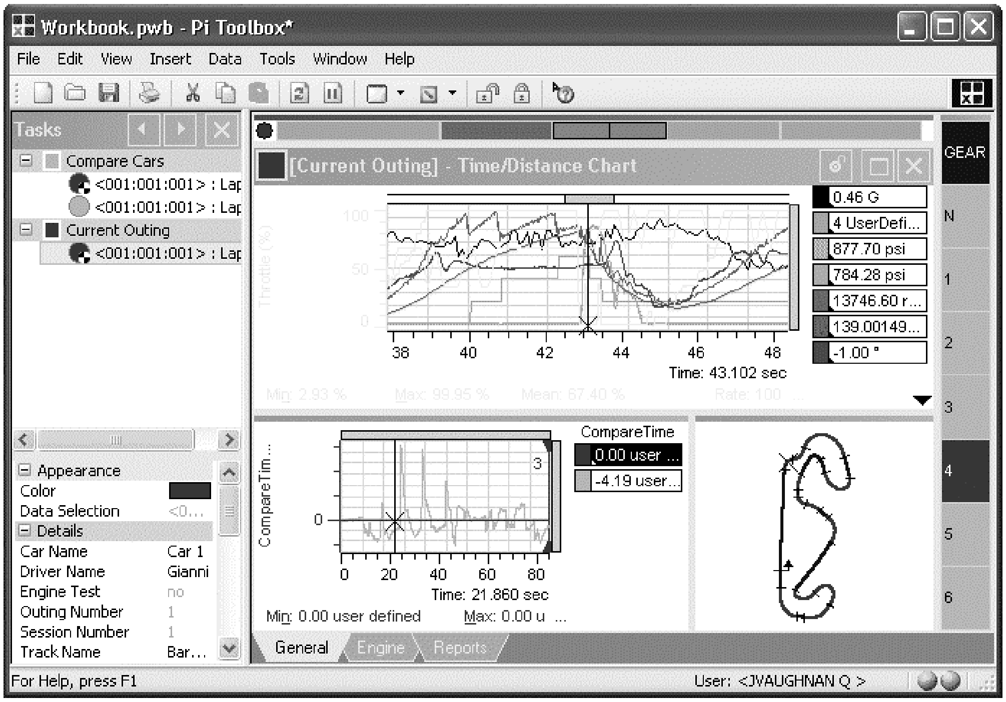
Drag the display onto a Worksheet name tab to move the display to that Worksheet. CTRL + drag to copy to another Worksheet.

You can also cut, copy and paste, see page 121.

Typical Layout

Using both resizing and repositioning techniques, you can customize your Worksheet layout to suit your needs.

A typical layout might look like this:



Maximize Workspace

All displays on the Worksheet can be maximized to make use of all the available display area. When maximized, all displays on the Worksheet can be scrolled through by using the arrows on the display title bar.

Real-time Outings

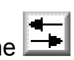
The principle of tasks and outings in Pi Toolbox is applied to Real-time data as well as historic data (Pi Datasets). The Real-time options on the Add (outing) dialog are used to connect the task to Real-time data servers. Telemetry and Watch data can be viewed and analyzed in Time and Distance displays, X-Y charts, Histograms, Event displays, Channel displays, Bit Indicators, Chart Recorders and Maps. Maps display single or multiple car cursors to indicate track position.

Real-time data can be exported as a Pi Dataset from Time and Distance displays. The data exported starts at the beginning of the data stream and ends at the time that the Export command was executed.

Active channel & Data selection persistence

Active channel

In a display one channel is the 'Active' channel, or the channel in focus. For visual reference the Y-axis scale is displayed in the same color as the active channel, and its cursor values legend is highlighted. You can scroll through the available channels using the  keys, making each in turn the active channel. The data cursor is a vertical line drawn through the active channel trace from the X-axis to the upper limit of the Y-axis.

You can move the Data Cursor along the active channel trace using the  keys.

Data selection

The Data Selection is the portion of the Outing data that is selected for displaying. Outings are contained in Tasks that are associated with displays. Therefore a display on the Worksheet shows a selection of the data held in its associated Task. A Data Selection can be a single lap, multiple laps or the complete outing.

Persistence

Active channels/active channel pairs and data selections in displays that support active channels are persisted when the Workbook is saved and subsequently opened.

Exported displays that are imported into other Worksheets also persist their active channels/channel pairs.

Cut, copy and paste

Throughout Pi Toolbox there are numerous ways in which you can use the Cut, Copy and Paste Features. Generally the commands are available when the toolbar buttons are active (not grayed out).

The standard Windows shortcuts for these commands apply:

Ctrl + X = Cut

Ctrl + C = Copy

Ctrl + V = Paste

Here are some examples of where you can use these commands:

- Copy and Paste Displays across Worksheets and Workbooks
- Copy and Paste Displays into Excel spreadsheets or Word documents as Enhanced Metafiles
- Copy and Paste outings across tasks.

Printing displays

Selected displays or whole worksheets can be printed from Pi Toolbox. You can also select to print all of the axes for displays with more than one axis.

The Print dialog

You can open the print dialog from the file menu, **File > Print**; or by using the keyboard shortcut ***CTRL + P***.

Print options

Active display: Print the display that is currently in focus on the worksheet.

Worksheet: Print all of the displays in the worksheet.

Print all axes: Print all axes for all channels selected for the display(s).

Note: *The print all axes option is independent of the multiple axes (link) setting for individual displays, which is a per-channel setting. Users can view displays with active channels axes only, but print out all axes for reference.*

You can preview the display, using the Print Preview option, before printing.

Note: *Cursor value legends are only included on the printed output if they are visible on the display. Statistics are shown for the active channel in all data selections.*

Print preview

Selecting **File > Print Preview** opens the Print Preview window that displays how the printed output will appear, either for the worksheet or a display.

Print preview options

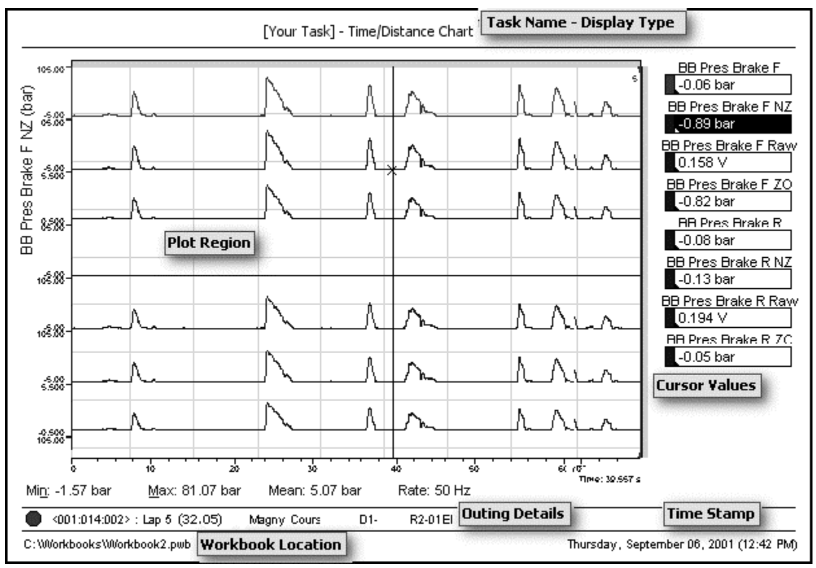
Active display: Prints the display that currently has focus on the worksheet.

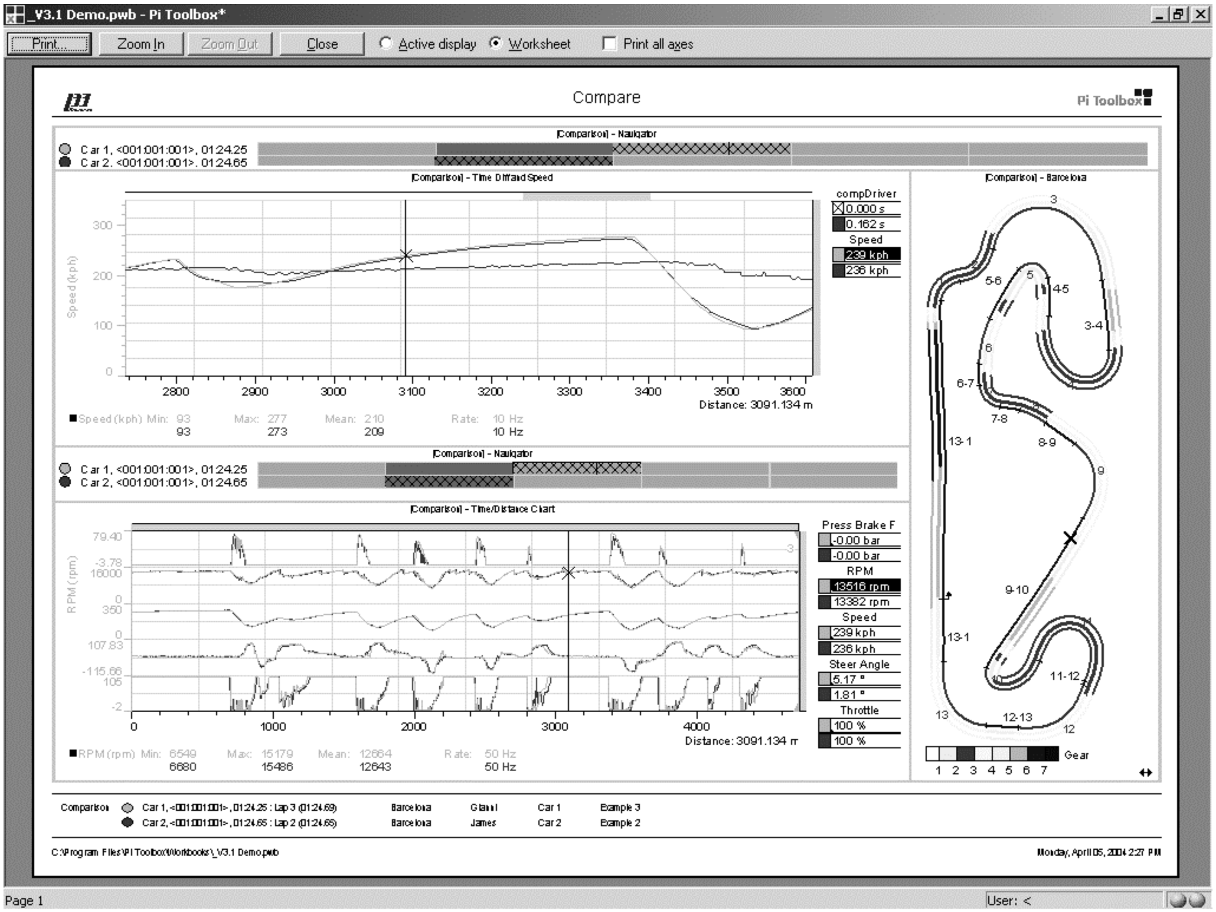
Worksheet: Prints all of the displays on the worksheet.

To adjust page margins and page orientation for the printed output, close the Preview window, then click **File > Page Setup**.

The printed output includes: task and display title, outing properties and the time and date of printing.

Example images




_V3.1 Demo.pwb - Pi Toolbox*
Print...
Zoom In
Zoom Out
Close
Active display
Worksheet
Print all axes
Compare
Pi Toolbox
Car 1, <001:001:001>, 01:24.25
Car 2, <001:001:001>, 01:24.65
Distance: 3091.134 m
Page 1
User: <

Expandable toolsets

Users of Pi Toolbox can expand their toolset within the application by obtaining additional controls from Pi Research. These can be distributed via the Pi Website, by email or on CD. When the controls are installed, new menu options are activated within the existing Pi Toolbox container, immediately integrating the new controls with your existing toolset.

Software Development Kit

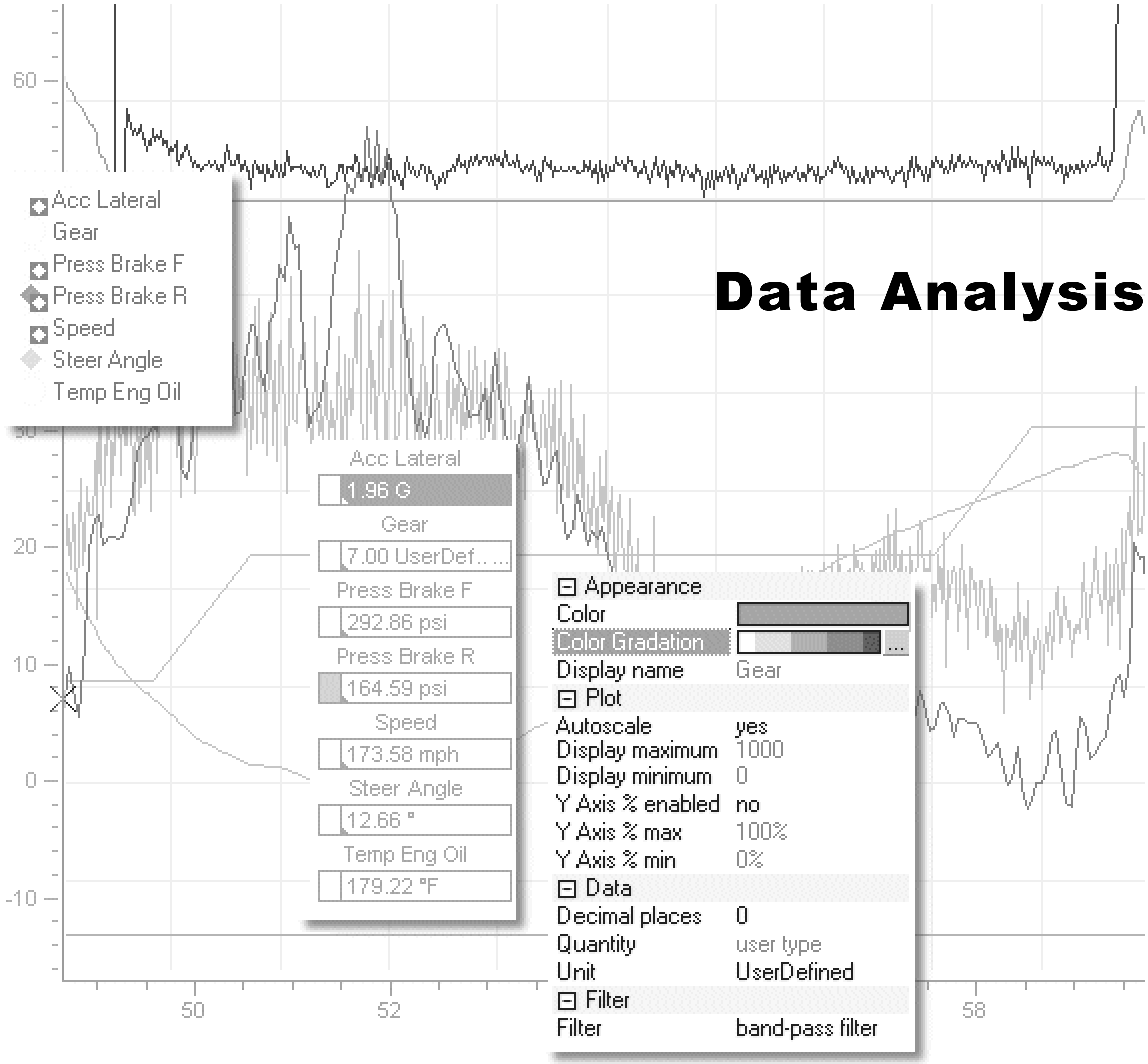
A Software Development Kit (SDK) is available from Pi Research for the purpose of expanding the capabilities of Pi Toolbox. For example, creating new controls, math channels and noise filters. The SDK supports Microsoft Visual Studio 6 or higher. It is supplied with its own user documentation and is therefore not covered in this guide. For further information contact your Pi Representative.

Quantities and Units

Channel data units can be quickly changed in the Properties Explorer, instantly changing the values shown in the cursor value legends on the displays.

A channel highlighted in the explorer displays properties in the details pane. Double-clicking 'Unit' displays a drop-down list of units appropriate to the channel quantity. Simply select the units you require.

Quantities and units can also be selected for math channels and can also be user defined.



Data Analysis

Display type summary

Pi Toolbox is designed to let you view and manipulate data. Using the software you are better equipped to make informed decisions about your race setup and make changes to improve performance.

- **Time/Distance Displays** - let you display data against time or distance.
- **X-Y Displays** - lets you plot one channel against another.
- **Histograms** - show data in percentage and time values between specified boundaries.
- **Reports** - can be designed for specific analysis requirements; stored and re-run with any outing. Layout and printing is performed in Microsoft Excel. Excel allows easy manipulation of data, and the development of complex report integration using comprehensive mathematical and statistical functions.
- **Maps** - show a pictorial representation of the track, built from logged data.
- **Video Displays** - enable MPEG files to be viewed in synch with Task Cursor time.
- **Bit Indicators** - examine system status channels looking for error conditions.
- **Channel Displays** - display the numeric values of the selected channels for real time (last point) or historic data.
- **Event Displays** – display events from both real-time and historic data, depending on the type of data stream it is associated with.
- **Chart Recorders** - display real-time data from the car as it proceeds around the track. The chart constantly updates with the latest data, resulting in a scrolling behavior.
- **Navigators** - provides a quick and easy means of selecting time regions within outings, changing the range of data plotted by displays connected to the same task.

Time/Distance displays

The Time and Distance display is typically the most commonly used, as you can relate data to actual track position or time. By overlaying data from several laps you can compare visually the difference in performance at any point on the track. Time and Distance displays can be configured to show either Time or Distance on the X-axis.

Normally you will look at a single lap of data or part of a lap. Often it is useful to look at data for more than one lap, and perhaps over the entire outing. This can be useful for noticing trends such as the temperature of the engine.

X-Y plots

An X-Y plot allows you to plot one channel against another and can be used to identify patterns of behavior. Plotting RPM against Speed produces a characteristic saw tooth plot showing how each gear is used through the speed range.

X-Y plots are useful for analyzing vehicle dynamics. Plotting lateral acceleration against in-line acceleration gives a characteristic 'traction' or 'g-g' diagram. By comparing two plots from different laps, it may be possible to identify handling characteristics, and how close the driver is to the limit of the vehicle's performance.

More advanced use of the X-Y plot involves creating and plotting Math channels to analyze the dynamic behavior of the vehicle.

Histograms

A histogram is a graphical method of displaying the distribution of data against time in the form of a bar chart.

Each bar represents how long each channel spends between two bin values.

For example a histogram may be used to display the time a car spent in each gear, helpful in determining if the gear ratios are correct for a given set of conditions.

The **Y-axis** displays the range of values of the active channel, divided into a number of bins. The axis is displayed in the color of its associated channel.

The **X-axis** shows the absolute time or percentage of time that each channel spends between two bin values.

The **Bin-axis** (to the right of the plot area) shows the absolute time and percentage of time for every bin.

Microsoft Excel reports

Pi Toolbox lets you design reports to show exactly the information you want quickly and efficiently in Microsoft Excel.

Split reports

The Split report is based on the track sections. Each track section is marked by a split beacon point. This can be a physical beacon or a beacon inserted using the software. By dividing the track into appropriate sections you can see how fast and consistent the driver is in each section of the track. By comparing laps you will notice how adjustments made to the setup affect performance.

Creating a Split report using elapsed time gives a very useful Split Time report. The Split Time report provides two unique performance indicators: the theoretical fastest lap and the fastest rolling lap.

The theoretical fastest lap gives the lap time that could be achieved if the best split section times from an outing were all in one single lap.

The fastest rolling lap is the fastest lap time using a start and end point, which may not be the end-of-lap beacon. Comparing achieved lap times to the theoretical fastest lap time shows driver consistency.

Tabular Outing report

The Tabular Outing report is useful when used with the entire outing plot. The Tabular Outing report shows channel values lap-by-lap for the entire outing and is ideal if you want to analyze trends during an outing; for example, engine temperatures or pressures.

Tabular Lap report

The Tabular Lap report uses the map segments created by the mapping software to divide laps into straights and corners. Tabular Lap reports show channel values for segments of each lap.

Event reports

Event reports show when an event occurred and any associated channel values.

Video displays

This display enables Video data to be viewed synchronized with Task Cursor time, on displays sharing the same task. As the video is scrolled forwards or reverse, cursor movements are made simultaneously in all displays connected to the same task.

Bit Indicators

The Bit Indicator control enables the engineer to examine system status channels looking for error conditions to occur. A typical example would be where the health status channel comprising a 32 bit word which had Bits 0, 1, 2, 5 and 7 assigned to the errors identified in the gearbox.

Channel displays

The Channel display can display multiple channels from the connected data selection. Channel names, values and units are shown in a list view. The position of channels in the grid, and the grid format, can be specified.

Event displays

The Event Display, displays events in a list view from both real-time and historic data, depending on the type of data stream it is associated with.

Selecting an event in the display causes the task cursor to be set to the event's timestamp. All displays connected to that task navigate to the time the event occurred. For example a display can be set up to show gearbox parameters such as temperatures and pressure, together with more general car parameters such as lateral acceleration, speed. Then if an event occurs, say, 'Low Gearbox Oil Pressure' and is selected in the Event display, the cursor positions in the associated displays update, allowing engineers to see what other parameter values were at the event time.

The principle of connecting tasks to a display and selecting channels for viewing, as in Time/Distance Charts, applies to Event Displays.

Layout Options

The information shown for listed events is controlled in the Layout tab of the Properties dialog. The event name is always displayed. Time, Source, Category and Message columns can be shown or hidden as required. Column widths can be customized by dragging the vertical border between columns.

Chart recorders

A Chart Recorder provides a means of viewing real-time data from the car as it proceeds around the track. The chart constantly updates with the latest data, resulting in a characteristic scrolling behavior.

Constants

Constants let you express numerical values as a 'word' that can be used in Math channels. If you use the constant in several Math channels and you want to change its value then you need only change the constant definition; the Math channels will then all use the new constant value.

Soft Events

Unlike ‘hard events’ that are part of the outing data, ‘soft events’ are always calculated on the PC at run time. Engineers may need to create their own events based on set conditions. An example could be during a circuit test to investigate the efficiency of the gearbox oil pick-up when the car is accelerating or braking. In this instance stationary and cornering conditions would need to be excluded.

Math Channels

There is a limit as to what can be measured by sensors. A greater understanding of performance can be gained by combining data and physical constants in mathematical equations, the result of which is a Math channel; this can be plotted on displays and used in histograms and reports.

Pi Toolbox is supplied with a comprehensive set of standard math functions.

User written channel sources

Pi Toolbox allows you to link to your own external math functions. User Math Functions are written as a DLL (Dynamic Linked Library) to a format specified by Pi Research. When you run Pi Toolbox the DLL is linked and the User Functions appear in the Add in Manager dialog and can be accessed by any part of Pi Toolbox.

Typically User Math allows you to provide data, for which description by an equation is insufficient, for example an accurate kinematics model of the car.

The Explorer

The way the Explorer works should be familiar to most users of Windows applications. The Explorer is where you create tasks; load outing datasets and select channels from the outings to display. When you have finished work in the Explorer it can be quickly hidden to maximize the screen area for data analysis.

The Explorer has four panes, the Task Explorer, the Selections Explorer, the Channel Properties and the Event Properties Explorer. You can quickly switch between the three using keyboard shortcuts.

The Task Explorer is mainly used to create tasks, add outings to the tasks and select the laps that you are interested in.

The shortcut Alt + 1 opens the Task Explorer.

The Selections Explorer is used to select channels, events and other elements for individual displays.

The shortcut Alt + 2 opens the Selections Explorer.

The Channel Properties Explorer is used to manage channel properties, affecting the appearance of the displayed data.

The shortcut Alt + 3 opens the Channel Properties Explorer.

The Event Properties Explorer is used to view and edit event properties, and select priorities for events to be assigned to. This Explorer has two tabs, Workbook and Display:

The shortcut Alt + 4 will open the Event Properties explorer.

Note: *Tasks are an important feature of Pi Toolbox. A Workbook can contain up to eight tasks, all of which are available to each Worksheet contained in the Workbook. They can contain single outings or multiple outings up to a maximum of eight. The outings that you add to a task are available to all displays that you create and connect to the task. Connecting displays to the same task provides you with added functionality such as linked data cursors and linked zooming.*

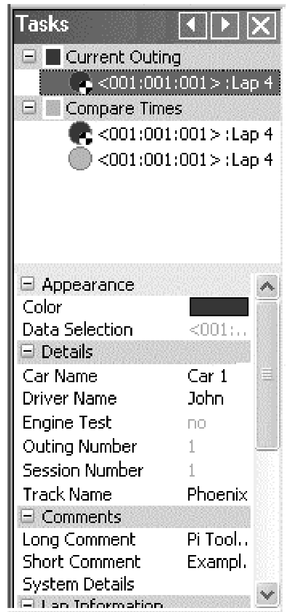
The Task explorer

Pi Toolbox opens with the Task explorer in view. This is where tasks are created. Tasks are a convenient method of storing outing data. You create a task by right clicking in this pane and selecting the 'Add Task' option. When you highlight a task, its properties (Color Name and Description) are displayed underneath in the Details pane.

Note: *To change a task property, double-click the property name.*

Click the ⊞ icon to expand the task and view its outings.

The Details pane shows the properties of the task currently highlighted above. If you have a task expanded and an outing highlighted, details of the outing will be displayed here.



Note: *To change a task property, double-click the property name.*

Working in the Task explorer

You can perform various tasks in the explorer.

Adding a task

1 In the upper pane select: **> Load Task**.

2 A task called Task 1 is added.

3 Double-click **Name** in the Details pane

4 The name Task 1 is highlighted.

5 Overtype Task 1 with a name of your choice.

6 Press **Return**.

7 Connect a task to a display

8 Make sure that the display that you want to connect the task to is selected (has the current focus).

9 In the Data menu, select: Connect > Task *task name*

10 The display is connected to the task. The colored task icon will change from looking like this to this .

Note: *You can also connect to a task by using the Connect Task button, the task icon on the task bar, or the Connect menu item from the Task view.*

Load an Outing

1 Click on the task that you want to load the outing into.

2 Select: > Add Outing.

3 In the Load Outing dialog, browse for the required outing dataset (*.pds file*).

4 Select the required outing dataset.

5 The Outing details are summarized in the Details pane of the Load Outing dialog.

6 Click OK.

Select Laps

When an outing is initially connected to a task, the data from the fastest lap of the outing is loaded.

Highlight the outing whose laps are selected.

Select: > Select Laps (Alternatively double-click the outing or press Enter).

The Select dialog lists all the laps contained in the outing.

Select the required lap or laps.

To highlight a group of laps: Click the first in the group, the Shift + click the last.

Click Select.

Set the datum outing

If a task has a number of outings loaded, you can choose one to be the datum.

Click on the outing you want to make the datum.

Select: > Make Datum.

The outing is now the datum, indicated by the icon.

Task properties

Task properties are displayed in the details pane when a task is highlighted or selected. The properties can be listed in categories that can be expanded or collapsed, or listed alphabetically. To change the method of display select: **> alphabetic/categorized**.

Appearance

> ***Color:*** The identifying color of the task. Double-click the color panel to select another color from the color palette.
>
> ***Description*:** Double-click to enter a short description of the task. Press **Enter** to close the dialog.
>
> ***Name*:** Double-click and type a name for the task. Press **Enter** to close the dialog.

Auto Update

Using the Auto Update command, a task can be made to watch a directory for new outings. The task will automatically **Add** the outing or **Replace** the current outing, depending upon the parameters set. In this way displays can be updated with the latest data downloaded to a network server.

> ***Enabled*:** Click **Enabled** and select **Yes** or **No** from the drop-down list to enable/disable Auto Update.
>
> ***Source*:** Click **Source**, then click the browse button. Use the Browse for Folder dialog to locate the watched directory. You can type the path to a directory that does not currently exist in the text field below the explorer view.

Note: *A dialog box will be displayed telling you that the path cannot be found. You must click* ***Yes*** *to enable the path.*

Target - Use the Target property to determine how Auto Update responds to new outings. Click **Target** and select an option from the drop-down list.

> ***Data selection caption:*** The outings added to the current task are listed here. When the selected outing is updated in the source directory, the task is updated.
>
> ***Add Always:*** Any new outing added to the source directory will be added to the task.
>
> ***Add Initial:*** This is the default option. The latest dataset added to the source directory will be added to the task. The target will then be set to that outing.

Time regions

Initial Selection**:** Use the selection property to specify what time region is to be displayed from a data selection added to a Task, or replacing an existing data selection in a task:

Fastest Lap: Displays the fastest lap from the outing.

Entire Outing**:** Displays the complete dataset

Last Region**:** Display the lap leading up to the last lap marker.

Unchanged**:** As outings are updated or added, the current time region selected will not be changed.

Note*: This property affects all outings added/replaced in the task. You can define a time region globally (across the workbook) by setting the time region default in the* ***Preferences*** *dialog. The time region defined for the task overrides the global setting.*

Outing properties

Outing Properties are displayed in the lower Details pane when an outing is highlighted in the upper pane.

Properties can be listed in categories, which you can expand or collapse, or listed alphabetically. To change modes select: **> alphabetic/categorized**.

Appearance

Color**:** The default color of the outing. When two or more outings are contained in a task, all channel traces will take on the default color of the outing it is contained in. This does not affect the individual properties of channels.

Data Selection**:** Displays the outing caption and the data (Lap/s) selected for display. The outing caption can be configured in the Outings tab of the Options dialog. Select: **Tools > Options** to open the dialog.

Details

There are several properties in the Details section that can be changed, such as Driver Name and Track Name. This information is included in display print-outs.

Comments

Short Comments / Long Comments**:** Double-click to enter a short and/or long comment.

Note: *Long comments can be more than one line. You can also insert a carriage return by using Shift + Enter. The long comment will be displayed as a tooltip when there is insufficient space in the Task Explorer.*

Lap Information

Lap Information is not editable.

Outing

Outing Information is not editable.

Data

Show Hidden Regions**:** Double-click and choose Yes or No to show/hide hidden regions e.g. Warm up and Cool Down laps.

Time Offset**:** When the task contains more than one outing, a time offset can be added to change the position of one outing relative to another. Double-click, enter a time offset then press Return. Offset can be set manually in a Time/Distance Chart. See the relevant help topics for the Time/Distance Chart.

Task shortcuts

The following shortcuts apply to the Task List in the upper task window, and the Properties List in the lower task window (with an outing selected in the upper task window).

Task list

Shortcut	Description	Menu
Ctrl + T	Creates a new task from anywhere in Pi Toolbox.	**> Add Task**
↵ (task highlighted)	Opens the Add Outing dialog that is used to locate and load outings into the selected task.	**> Load Outing**
↵ (outing highlighted)	Opens the Select dialog which is used to select laps for the current outing.	**> Select Laps**
Del (task highlighted)	Deletes the highlighted task or outing from the current Workbook.	**> Delete Task**
Ctrl + E	Selects all laps in the outing (outing highlighted or display in focus)	
Ctrl + Q	Selects the fastest lap in the outing (outing highlighted or display in focus)	

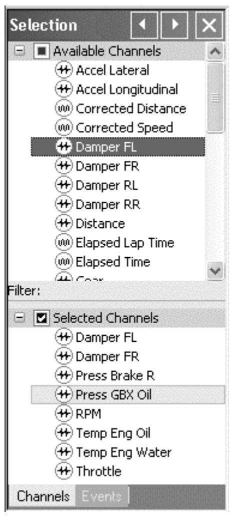
Properties list

Shortcut	Description	Menu
↵	Edits the highlighted property	None
Esc	Cancels the Edit	None
+ -	Expands or collapses property category	None
← →	Expands/Collapses category and navigates up and down	None

The Selection explorer

The available channels of data and events contained in the loaded outings are listed in the Selection pane. These include channels and events from outings as well as math channels and soft events created in Pi Toolbox. You use the Selection Explorer to select channels and events that are to be presented on displays in the Display Area. The lower Details pane shows you which channels and events are selected for individual displays.

Note: *If you have several displays on a Worksheet, the Details pane shows the selections made for the display that has focus.*



Data channels, groups, events, cameras (and other elements unique to certain display types) are listed in the Selection pane. Here you can select elements for displays and modify them.

Generally, a 'Channels' tab is displayed, showing a list of channels available from the task connected to the display in focus. For Excel Reports or Time/Distance displays, a second tab 'Events' shows events available.

Some displays do not have selection tabs associated with them, or may have specialized tabs, e.g. Videos.

The lower pane shows only those channels selected for the display currently in focus. Some displays, such as Time and Distance and Histogram, can have groups and individual channels as part of their selection. Others such as X-Y displays can have only individual channels associated with them.

With the Events tab selected, the Selection Explorer is used for selecting events for the display currently in focus.

Note: *The Selections Explorer generally has two tabs: Channels and Events. This allows channels and events to be listed separately. However, both channels and events are selected in a similar manner.*

To add a channel to a display:

***Note:** See Quick Start on page 64 to help you create a display*

1. Make sure that the display you want to add a channel to has focus.
2. Go to the Selections Explorer and select the Channels tab.
3. Enter the first few letters of the channel you want to add.

This reduces the channels in view to those starting with the letters you type.

4. From the Matching Channels list double-click the channel to Add. Alternatively highlight the channel and select: > **Select**.

   The channel will appear in the lower pane under 'Selected Channels' and the data will be plotted on the display in focus.

   If you select the wrong channel by mistake, simple double-click the channel in the lower pane to remove the selection.

***Note:** If the channel fails to be added to the active display, you may have reached the channel limit for that display.*

Deleting or removing a channel from a display

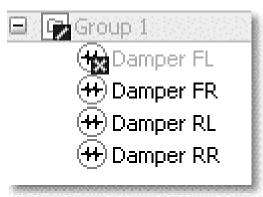
Channels can be deleted from the display in focus without the need to go to the Selection explorer and deselect channels manually. There are two ways of deleting channels from the display:

- Pressing Del will delete the active channel from that display.
- The context menu option: **Trace > Delete** will achieve the same result.

Deleting or removing a channel from a group

Deleting channels from a display does not remove the channel from any groups it may be contained in. However the channel trace will be removed from the display.

For example: The group shown below contains the channel Damper FL. Deleting the channel from the display using the delete key or the context menu.



The channel trace is removed from the display and the channel is deselected for that display. In the group (in the lower pane of the Selection explorer) the channel is grayed out to show that it is deselected, but it remains in the group. The icon indicates that it is not displayed. The group icon overlay indicates that it contains channels that are not displayed.

To re-select a channel that has been deleted, select the group icon (in the upper or lower pane) and press .

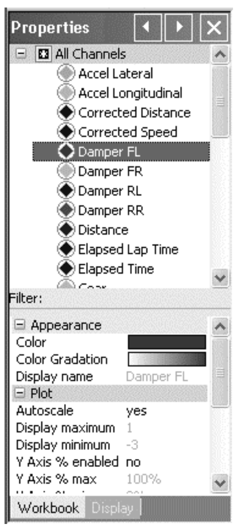
The Channel Properties explorer

The Channel properties explorer is used to view and edit channel properties, which affect how a channel's data will be plotted on the display. As with the Selection Explorer, channel groups appear at the top of the pane.

This Explorer has two tabs, Workbook and Display:

- In the Workbook tab, all available channels and groups are in view. Properties edited here affect the whole Workbook, not just the display in focus.
- In Display tab, only those channels that are being displayed by the active display are in view. Properties edited here, will only affect the display in focus, overriding those set for the Workbook in the Workbook tab.

The Detail pane shows the properties of the channel or channels currently highlighted in the upper pane. The channel properties that cannot be changed are 'grayed out'.



With the Display tab selected: The changes you make to properties are 'local' changes, and will not affect the channel in other displays.

If the channel icon is overlaid as shown here,  local property changes have been made.

With the Workbook tab selected: Changes made to a channel's properties in the Workbook tab are global and will affect all displays in the workbook that are displaying that channel's data.

Note: *You can change the properties of multiple channels. Simply select a number of channels in the upper pane and change the appropriate properties in the lower pane.*

About Properties

When a channel is highlighted in the upper pane, its properties are displayed in the lower Details pane of the Explorer. To edit a property, double-click the property name or value and enter values or make selections as required. Properties are listed by category in the Details pane. Each category can be expanded or collapsed as required, by clicking the +/- icons, double-clicking the category, or using the < > cursor keys. The properties can also be viewed as an alphabetical list by right-clicking and selecting 'Alphabetic'.

Generally, properties that you cannot edit show their properties grayed out.

Appearance

***Color*:** The channel's default (or base) color.

Color Gradation: Enables a channel’s plotted color to be graded according to the channels value at that point. See Color Gradation, page 160.

***Display name*:** The channel name.

Plot

***Autoscale*:** Enables/disables Autoscale. When Autoscale is on the trace expands to the full extent of the axis relating to the channel’s data, to maximize the data in the plot area.

***Auxiliary axis*:** Enables or disables multiple axes to be displayed on Time and Distance charts, Histograms, etc. A display will show a Y-axis for the active channel and a Y-axis for any channel it has selected having this property enabled.

***Display maximum*:** The maximum extents of the axis relating to the channels data when plotted on a display. This parameter is disabled when Autoscale in on.

***Display minimum*:** The minimum extents of the axis relating to the channels data when plotted on a display. This parameter is disabled when Autoscale in on.

***Interpolation*:** Determines the interpolation technique applied between sample points. Select either Linear or Sample and hold.

***Y-axis percent enabled*:** Enables or disables Y-axis percent of the channel. When enabled, the Y-axis percentage occupied by the channel and its vertical position on the scale can be changed.

***Y-axis percent max/min*:** determines the maximum and minimum percentage of the Y-axis occupied by the channel. Use this to move a channel trace clear of other overlaid traces to aid visibility.

Data

***Decimal Places*:** The number of decimal places to which channel values are displayed.

***Quantity*:** What the channel is measuring, for example pressure, velocity.

***Units*:** °C, MPH, KPH, liters, mm, bar, volts.

Filter

***Filter*:** Select a filter type from the drop-down list. The default options are: No filter, band-pass filter, gating-function filter, and moving average filter. When a filter is selected the **Filter *Enabled*:** Indicator changes to **Yes**. Custom filters developed using the SDK will also appear in the drop-down list.

***Filter enabled*:** Indicates filter on or off state.

***Filter Properties*:** Double-clicking this property opens the Property dialog for the filter type selected.

For more information, refer to Data Filters on page 153.

Note: *Properties that exist but are not listed in the categories above will be listed in the 'Others' category.*

Global or Local channel properties

Channel Properties can be changed on two levels:

- Globally - for the workbook, so that every time you select a particular Channel from the outing, the new Channel properties are used.
- Locally - for an individual display. Locally defined properties override global properties. Other displays using the channel will show default Channel properties or the properties set for the outing.

Note: *You can revert to the default properties at any time. When reverted, local properties change back to the channel's global properties.*

To change channel properties globally:

1 Go to the Properties Explorer. Shortcut: Alt + 3

2 Select the Workbook tab

This will make the changes globally for the outing

3 Highlight a channel

4 In the lower 'Details' pane change properties as necessary. For example, double-click 'Color' and use the palette to select a new color.

5 Properties grayed out cannot be changed.

To change channel properties locally:

- Follow the steps above but select the 'Display' tab instead of the Workbook tab. This will make the changes local to the Display currently in focus.

Note: *Channel data will be plotted using global properties unless a local override exists. If multiple outings are being plotted the outing color will be used to plot the data instead of the channel color.*

To revert Global channel property changes to default:

1. Go to the Properties Explorer. Shortcut: Alt + 3
2. Select the Workbook tab.
3. Highlight the channel whose properties you want to revert.
4. Select: **> Revert to defaults**.

To revert Local channel property changes to Global:

1. Go to the Properties Explorer. Shortcut: Alt + 3
2. Select the Display tab.
3. Highlight the channel whose properties you want to revert.
4. Select: **> Revert**.

The Event properties explorer

The Event Properties explorer is used to view and edit event properties, and select priorities for events to be assigned to. This Explorer has two tabs, Workbook and Display:

In the **Workbook** tab, all available events are in view. Properties edited here affect the whole Workbook, not just the display in focus.

In the **Display** tab, only those events that are being displayed by the active display are in view. Properties edited here, will only affect the display in focus, overriding those set for the Workbook in the Workbook tab.

With the Workbook tab selected, all available events in the Workbook are displayed. Properties of the highlighted event appear in the Details pane. Event properties can be edited (if they are not grayed out). You can change the properties of multiple events. Simply select a number of events in the upper pane and change the appropriate properties in the lower pane.

Events are assigned Priorities in the Details pane. These are defined in the Options dialog.

With the Display tab selected, only those events that are associated with the display in focus are shown. In 'Display' the changes you make to properties are 'local' changes, and will not affect the event in other displays.  This icon overlay indicates local property changes.

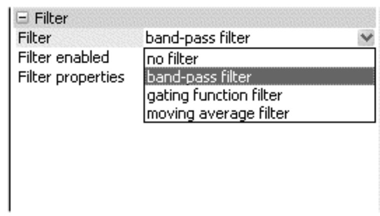
Note: *Changes made to event properties in the Workbook tab are global.*

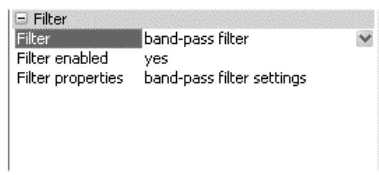
To change an event property, double-click the property name, e.g. Color.

Data filters

Filters modify channel data by applying a math algorithm to the channel. A typical application would be to remove 'noisy' data from a channel by setting up a high-pass filter.

Data filters can be applied globally or locally. When applied globally all uses of that channel will display filtered data. When applied locally to a channel in a specific display, the channel data is only filtered in that display. This means that users can now filter a channel in one display and simultaneously view the same channel in a second display unfiltered (or with a different filter). Global filters are defined in the **Workbook** tab of the Channel Properties explorer. Local filter properties are defined in the **Display** tab of the Channel Properties explorer.





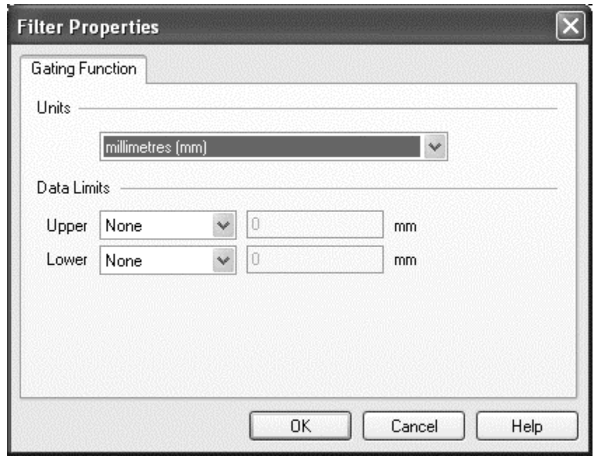
Filters are set up in the Property Explorer. Initially channels do not have filters associated with them. Selecting a channel type from the **Filter** drop-down list enables the filter. When set up, the filter parameters are specific to that channel. Using the **Filter enabled** property; the filter can be switched on or off as required for a channel. A filter associated with a channel can be switched on and off as required. When enabled, a filter is applied across all displays in the Workbook plotting the channel.

Note: *Filter settings, configured for a particular channel, will be lost if the Filter property is subsequently set to 'no filter'.*

Gating Function filter

Gating Function filters use preset upper and lower values to limit the data that passes through the filter. Data that falls outside of these values is not plotted on the display, causing regions of discontinuity in the data stream.

Filter Properties



Units**:** the units available for selection depends upon the channel that the filter is being created for.

Upper**:** (None, Less, Less or Equal, Greater, Greater or Equal) - Selecting *None* means that there is no upper value limit on data allowed to pass the filter. Selecting Less passes data below the value entered in the adjacent field and blocks data above it. Selecting Greater passes data above the value entered in the adjacent field and blocks data below it.

Lower**:** (None, Greater, Greater or Equal, Less, Less or Equal) - Selecting None means that there is no lower value limit on data allowed to pass the filter. Selecting Greater passes data above the value entered in the adjacent field and blocks data below it. Selecting Less passes data below the value entered in the adjacent field and blocks data above it.

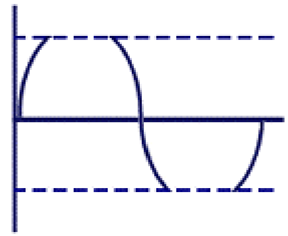
Examples

Using the options available in the Upper and Lower fields, the following cases are possible:

Inclusive Filter

Upper (Less, Less or Equal)

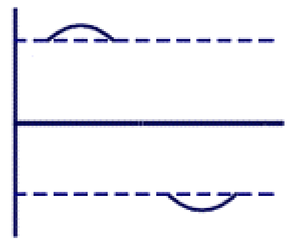
Lower (Greater, Greater or Equal)



Exclusive Filter

Upper (Greater, Greater or Equal)

Lower (Less, Less or Equal)

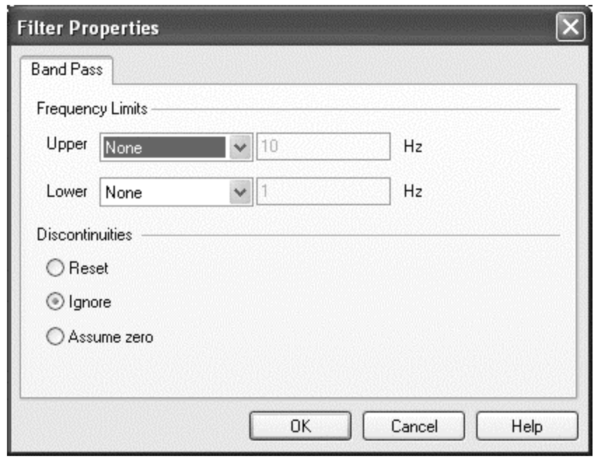


Band-pass filters

Band-pass filters remove frequencies above and below a preset threshold.

Typical use: Removing high frequency noise – for example, on an accelerometer measuring the lateral acceleration of a car. The acquisition frequency could be 100Hz, but in the calculations the user may wish to reject frequency spikes and only require a maximum frequency of 25Hz.

Filter Properties



Upper (None or Less)**:** Selecting ***None*** means that there is no upper limit to the frequencies allowed through the filter. Selecting ***Less*** passes all frequencies below the value entered in the adjacent field.

Lower (None or Greater)**:** Selecting None means that there is no lower limit to the frequencies allowed through the filter. Selecting Greater passes frequencies above the value entered in the adjacent field.

Discontinuity handling

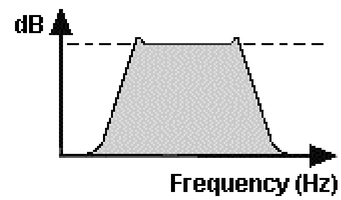
Reset: In 'Reset' mode the filter kernel is clipped on the boundaries of discontinuities effectively processing each continuous region as a data block.

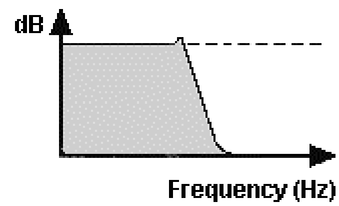
Ignore: Discontinuities are ignored.

Assume Zero: Mode works much like 'Reset' in that it process each continuous region as a data block, however it assumes that input channel has zero values outside continuous regions (i.e. filter kernel is not clipped).

Examples

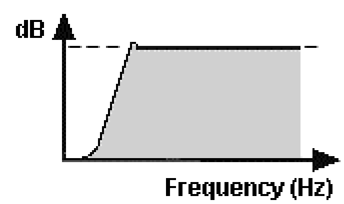
Band pass filter: A combination of low and high pass filters. It filters frequencies below some lower bound and above some upper bound frequencies.





Low Pass filter: A specific upper limit frequency value and a lower limit of "None".

High Pass filter: A specific lower limit frequency value and an upper limit of "None".



Algorithm

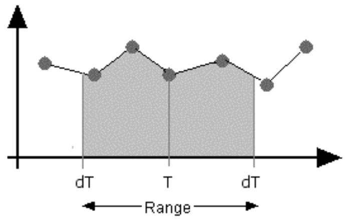
See Appendix D.

Moving Average filter

This filter works by averaging data within a pre-set time interval around each data point.

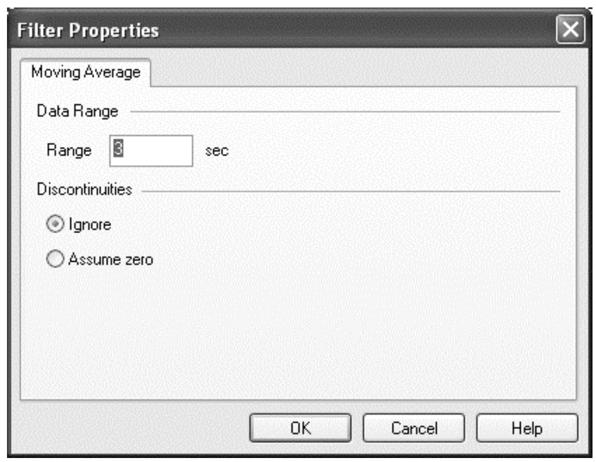
Typical use: Smoothing data to identify trends.

For the sample at time T, moving average returns the integral over time interval (T-dT, T+dT). Linear interpolation is used to calculate values at the boundaries of the time region where there are no samples.



Filter properties

The Filter Properties dialog is accessed by double-clicking Filter Properties in the lower pane of the Properties Explorer.



Data Range: Determines the time interval around each data point for calculating data average. Higher settings produce smoother traces on the display.

Discontinuities: These options determine how the filter handles discontinuous data.

Ignore: Discontinuities are ignored.

Assume Zero: Assumes that there is no data beyond the point where the discontinuity starts.

Working with Data filters

To add a Band-pass filter:

1 Add a Time and Distance display and select the required channel to filter

2 With the correct display in focus, go to the Properties Explorer

Shortcut Alt + 3

3 In the Details pane of the Explorer, click the Filter down arrow and select: Band-pass Filter

The **Filter enabled** property field changes to **Yes**.

4 Double-click Filter properties

The Filter Properties dialog opens.

5 In the **Upper** field select: Less and enter a value in the adjacent field

6 In the **Lower** field select: Greater and enter a value in the adjacent field

7 Click OK.

Color gradation

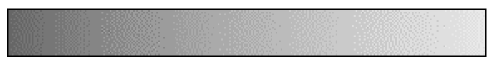
Color gradation allows Pi Toolbox displays that support color grading, to plot channels as graded bands of color, each color representing a different channel value. Color gradation is typically used in Graphical Lap Reports, although other uses could include grading bars in histograms.

There are two modes of color gradation:

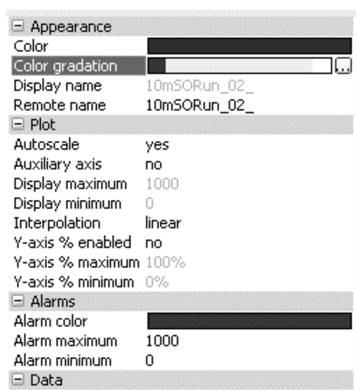
Discrete: The discrete scheme grades channel values into color bins. Each bin has an upper and lower value. Values within those bounds are assigned to the bin's color.

Discrete scheme: 

Gradient: The gradient scheme is defined by a start and end color. The start color represents the channel's lowest plot value, the end color it's highest. Channel values lying between these are plotted with a color that is graded between the start and end color.

Gradient scheme: 

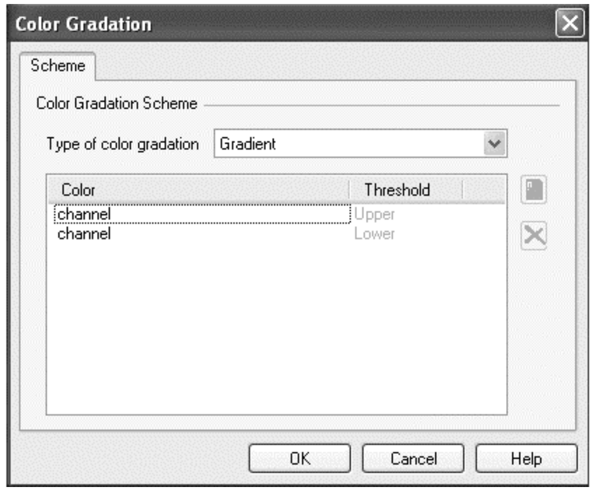
Setting color gradation properties



The color gradation channel property is available in the Properties Explorer. To set properties, click the browse button . The gradation properties dialog opens and defaults to a 'Gradient' gradation scheme.

For more information, refer to *Discrete gradation properties* on page 161.

Gradient Scheme properties



The main window is made up of two columns: Color and Threshold.

The color property for each band is set by double-clicking the band to access a drop-down list of color options. These are:

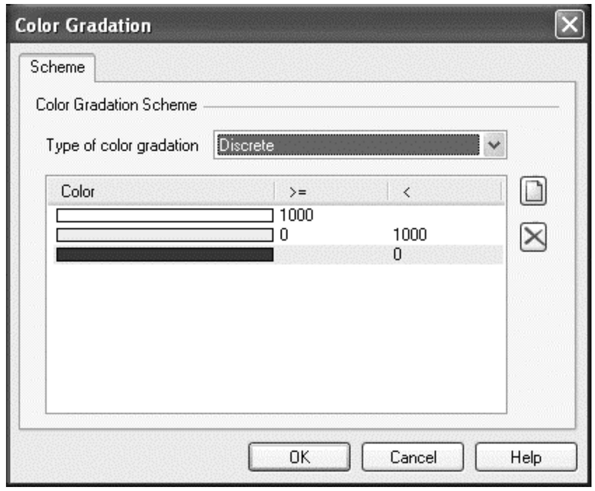
- **Custom:** Uses the color defined in the 'Color' property, selected from the color palette.
- **Channel:** Uses the color property of the selected channel.
- **Display Background:** Uses a color determined by the background color of the display plotting the data.

With **Channel-Channel** selected for both nodes, the minimum color is a variation of the channel color so that a gradient based on the channel color is used.

Display Background-Display Background selected for both nodes, the maximum color is a variation of the plotting display's background color.

Note: *There are only two color bands because a gradient scheme can only have a start and an end band. The 'Add' and 'Delete' buttons are therefore disabled.*

Discrete scheme properties



The main window consists of a three columns 'Color', >= (lower boundary) and < (upper boundary).

Color

The color property for each band is set by double-clicking the band to access a drop-down list of color options. These are:

- **Custom:** Uses the color defined in the 'Color' property, selected from the color palette.
- **Channel:** Uses the color property of the selected channel.
- **Display Background:** Uses a color determined by the background color of the display plotting the data.

Lower and upper boundaries

Color band boundaries can be edited individually by highlighting the default and entering a new value. Boundaries for adjacent bands are adjusted to accommodate new bands. For more information see About Boundaries on page 479.

Context Menu Options

Each band displays its bounds and assigned color. For each item or selected group of bands, the following context menu options are available.

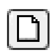
Insert/Delete: These commands add or delete a color band in the same way as the Add/Delete buttons. See below.

Interpolate: This option determines boundary values for a selected group of color bands based upon adjacent bands or the top and bottom band in the selection. This command is only enabled when either the upper or lower band is included in the selection.

Graduate Colors

This option produces a smooth gradient across a number of color bands. After adding the required number of bands, the user selects a group of bands to apply the Graduate command to. The gradient colors produced depend upon the colors of the upper and lower bands selected in the group.

This command is only enabled when the 'Color Source' of the top and bottom bands selected, is set to 'custom'.

 Adds a color band above the band currently selected. Alternatively press Insert.

 Removes the currently selected band. Bounds are reassigned to take up the gap created. Alternatively press Del.

Working with color gradation

Changing a color band’s values (discrete gradation scheme)

1 Go to the Properties Explorer. Keyboard shortcut: Alt + 3

2 Select the channel you want to change.

3 In the lower pane click the ... button adjacent to the Color Gradation property

The Gradation Properties dialog opens.

4 In the ‘Type of color gradation’ field select: Discrete.

In the main window the color bands for the selected channel are displayed. By default, channels are given an upper, middle and lower band.

5 If required, click to add a band to the scheme.

Additional bands are inserted above the band currently highlighted. The source color defaults to 'channel'. This can be changed if necessary by double-clicking the default value and selecting a source from the drop-down list.

6 Double-click the upper or lower boundary of the color band that you want to change, so that the current value is highlighted.

7 Enter a new value for the boundary.

Note: *Altering the lower bound will affect the upper bound of the preceding color band. Altering the upper bound will affect the lower bound of the proceeding color band.*

Setting up a gear change scheme for a graphical lap report

The example below shows how, using a discrete color gradation scheme, it is possible to quickly set up a gear change indicator. The Color Band indicates the gear change points on the track and the Active Channel Indicator shows the color allocated for each gear. On the Indicator, note that the color band up to the value 2.00 denotes 1st gear, up to 3.00 denotes 2nd gear etc.

1 With the Map in focus, go to the Selection Explorer and select the Gear channel.

2 Go to the Properties Explorer and click on the Gear channel.

3 Double-click Color Gradation in the Details pane.

The Color Gradation Properties dialog opens.

4 In the Type of color gradation field select Discrete.

5 Using the New button add three new color bands.

6 Set the Lower Bound property to 2 and the Upper Bound Property to 6.

The gap between bands should be 1.

To set the color bands:

1 Double-click the bottom color band and select 'custom' from the drop-down list. From the color palette, select a color to represent the 1st gear.

2 Double-click the top color band and select a color to represent 6th gear.

3 Select all color bands by clicking the top band then shift + clicking the bottom band.

4 Select: **> Graduate Colors**.

5 Colors graded in depth between the first and last gears are selected automatically.

6 Click OK.

Note: *In the Gear channel details pane, you can set the Decimal place property to '0' so that the divisions read 2, 3, 4 etc.*

You can use a discrete color gradation scheme to set up a gear change indicator scheme for map displays, see Setting Up a Gear Change Scheme, page 333.

Explorer Icon summary

Throughout the Pi Toolbox explorer various icons are used to represent channels, math channels, events etc. As well as the standard icons, various overlays are used to represent certain conditions. Generally red overlays indicate an error condition, whilst blue overlays are for information.

The tables below summarize the icons and overlays used.

Icons

Channel

Hard Event

Soft Event

Real-time Channel

Global Math Channel

Special Math Channel

Map position icon

In Global Math and Soft Events the definition is invalid. In channel trees elsewhere, none of the outings associated with the display provide data for this channel.

Property Explorer Icons and Overlays

This Properties Explorer icon represents any channel. Without an overlay it indicates default properties.

This Properties Explorer icon represents any event. Without an overlay it indicates default properties.

The properties for this event have been locally overridden.

Overlays

Channels and Events

Undefined in at least one source outing.

Cyclic in at least one source outing.

Channels and Channel Collections

Part of this group/collection is not displayed on the associated display.

This channel or all of this group/collection is not displayed on the associated display.

This overlay indicates that a channels or math channels has a filter currently applied (band-pass, moving average etc.). The overlay only appears in the Selection explorer.

The icon overlay takes a low precedence over all the other possible icon overlays. If there is any other reason for a channel to have an overlay, e.g. the x or y overlay on channels selected for an XY display, the filter overlay will not be visible.

About Groups

Groups are created to group together related sets of channels. They appear at the top of the Selection or Properties pane, above the list of Available Channels. Groups can be created in the Selection or Properties Explorer. Groups are dynamic elements when selected for a display. If you change the contents of a group (add channels, change properties, etc.) connected displays are directly affected.

Note: *When you delete a channel that exists in a selected group, the channel remains in the group but the trace is removed from the display. Selecting the group icon and pressing 'Return' will re-select the channel.*

With groups you can:

- Add a group of Channels to a Display in a single action.
- Change Channel properties or add/delete a Channel - the change is propagated to all Displays connected to the group.

Note: *When you highlight a channel group (or multiple channels) in the upper pane of the Properties Explorer, values that differ between channels in the highlighted group, are shown as <multiple> in the Details pane.*

To create a group (working in the Properties Explorer)

1 Click the Workbook tab and select the channels you want to include in the Group.

2 In the upper pane select:  > **Add to > New Group**.

A new group folder is inserted above the All Channels folder.

3 Highlight the folder.

The group's properties are displayed in the Details pane.

4 Double-click Group Name.

5 Enter a Name and press Enter.

The new group name appears in the upper pane.

To create a group (working in the Selection Explorer)

1 Click the Channels tab and select the channels you want to include in the group.

2 In the upper pane select:  > **Add to > New Group**.

An empty new group folder is inserted above the Available Channels folder.

To rename the group go to the Properties Explorer, Alt + 3.

3 Highlight the folder.

The group's properties are displayed in the Details pane.

4 Double-click Group Name, enter a name for the group and press Enter.

The new group name appears in the upper pane.

The channels you have selected appear in the group folder. When you highlight a channel, its properties appear in the Details pane.

Adding the group of channels to a display is the same as adding a single channel to a display. Make sure the correct display has focus and double-click the group in the upper pane. The group will appear in the lower pane of the Explorer and the channel data will be loaded into the display

Note: *You can also create a group by selecting a number of channels, right clicking and selecting the Add to > New Group option.*

To add a channel to a group:

1 Open the All Channels list.

2 Filter the list if necessary.

3 Highlight the channels you want to add to the group.

To highlight a sequential group of channels: Click the first, then Shift + Click the last.

To highlight a discontinuous group of channels: Ctrl + Click the required channels.

To highlight two separate blocks of channels: Shift + Ctrl + Click.

4 Select: > **Add To** (choose from the existing groups or create a new one).

Note: *To reduce the number of channels in view (filter), types the first letter or letters of the channel you are looking for. Press Esc to remove the filter.*

To remove a channel from a group:

1 Open the group folder to view the channels

2 Highlight the channel you want to remove and select: > **Ungroup**.

Note: *Group names must be unique in the Workbook.*

To remove a group from a display:

1 Make sure that the display you want to remove the group from has focus

2 Go to the Selection Explorer, Alt + 2

3 In the lower pane highlight the group or channel you want to remove

4 Select: **> Remove** or press Del.

Note: *To delete the group, in the upper pane select: > Delete Group*

Changing channel group properties

The properties of channels in a group can be edited simultaneously by highlighting the group.

When a group is initially created, the channels within it retain their properties. The properties of each channel within the group can be edited individually or in multiple selections. All channels in the group can be simultaneously edited by selecting the group. Even other groups and channels can be brought into the selection to have their properties edited simultaneously.

To change channel properties globally in a group:

1 Go to the Properties explorer .Keyboard shortcut: Alt + 3

2 Highlight the group in the upper pane

The group properties are displayed in the Details pane.

3 Edit group properties as required.

All channels in the group will share the same properties.

***Note**: A channel within a group can still have its properties edited individually if required.*

Filtering Channel and Event lists

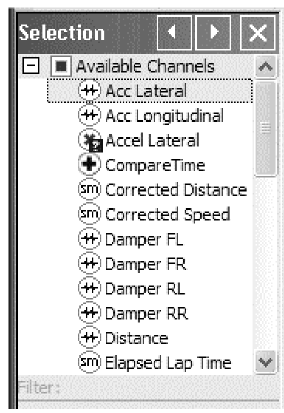
Applying list filters to channels or events in the Selection Explorer has two main functions:

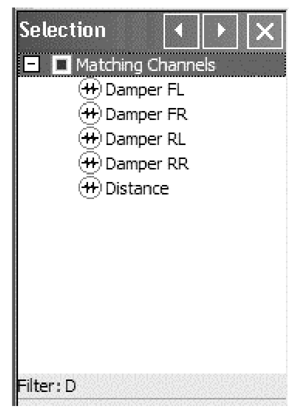
- To reduce the number of channels or events in view in the Selection Explorer, making selection easier
- To create an inclusion or exclusion filter for events. Therefore, whenever a workbook is opened, the display will include (or exclude) events that pass through (or are blocked by) the filter, for any dataset loaded into the task.

Note: *The filtering process is the same for both channels and events.*

Apply a Simple filter

In the Selection Explorer, all channels/events associated with the outing dataset loaded, are listed in the Available Channels (Events) list.





To apply a filter, with the Explorer having focus type in the first letter of the channels you are interested in. Typing more characters filters the list more.

To remove a filter character press 'Backspace'. To remove the filter press 'Esc'.

Note: *Holding down the shift key whilst navigating the Explorer, e.g.* ⇧ + Alt + 3 *clears any filters applied to the channel selection list. Holding down the shift key when you click the navigation arrows has the same effect.*

Advanced filters

Create advanced filters by using a mixture of normal and wildcard characters.

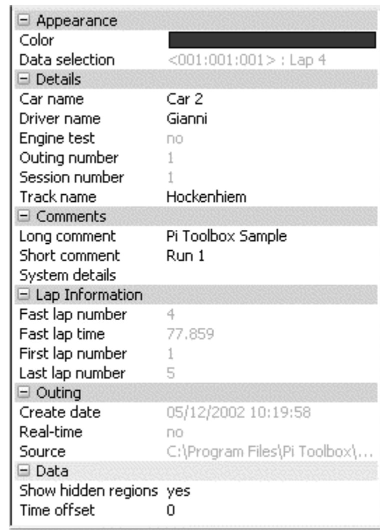
Wildcard characters

* Any character or group of characters ? Single character. ?? Two characters etc.

To enter a wildcard character press Ctrl + ⇧ + * or ?

Filter: TE **Comments**: Finds channels beginning 'TE' and channels with first word starting with 'T' and second word starting with 'E'. 'TEW' would find Temp Engine Water. **Results**: Temp Brake FL Temp Brake FR Temp Brake RL Temp Brake RR Temp Clutch Temp Engine Oil TH Error TM Error Etc.	**Filter**: C*E **Comments**: Finds channels beginning with 'C' and ending with 'E'. **Result**: CF Status.CLF Mode CL Last Event Code CL Override CL Press Line Corrected Distance CR Status.Cruise Etc.	**Filter**: **Comments**: Finds channels of 5 characters long. **Result**: EN RPM G Long G Vert Etc.	**Filter**: Damper **Comments**: Finds channels that start with the word Damper, and are followed by two characters. **Result**: Damper FL Damper FM Damper FR Damper RL Damper RM Damper RR Etc.

Changing Explorer properties



When a task, outing or channel is highlighted in the upper pane, its properties are displayed in the lower details pane. To change a property, double-click the property name or value and enter values/make selections as required. Generally properties that cannot be edited are grayed out.

Note: *Properties can be listed by category or alphabet. The categories can be expanded and collapsed in a similar manner to channel lists. To change modes, highlight a property or category in the Details pane and select alphabetic or categorized from the context menu.*

Configuring the Task Explorer

When you create a task it is given a default name and color. Change these as required. You can also enter a brief description of the task by double-clicking the Description field.

Note: *Task and outing properties can only be changed in the Task Explorer.*

Task Properties are as follows:

Appearance

Color**:** The identifying color of the task. Double-click the color panel to select another from the palette.

Description**:** Double-click to enter a short description of the task. Press ENTER.

Name**:** Double-click and enter a name for the task. Press ENTER.

Auto Update

Using the Auto Update command, a task can be made to 'watch' a directory for new outings. The task will automatically 'Add' the outing or 'Replace' the current outing, depending upon the parameters set. In this way displays can be updated with the latest data downloaded to a network server.

Enabled**:** Click 'Enabled' and select Yes or No from the drop-down list to enable/disable Auto Update.

Selection**:** Use the Selection property to specify what time region is to be displayed from the new/updated outing:

> ***Default*****:** Displays the fastest lap from the outing.
>
> ***Entire Outing*****:** Displays the complete dataset.
>
> ***Last Region*****:** Display the lap leading up to the last lap marker.
>
> ***Unchanged*****:** As outings are updated or added, the current time region selected will not change.

Source**:** Click ‘Source’, then click the browse button. Use the ‘Browse for Folder’ dialog to locate the watched directory.

Target**:** Use the Target property to determine how Auto Update responds to new outings. Click ‘Target’ and select an option from the drop-down list.

> ***Data selection caption*****:** The outings added to the current task are listed here. When the selected outing is updated in the source directory, the task is updated.
>
> ***Add Always*****:** Any new outing added to the source directory will be added to the task.
>
> ***Add Initial*****:** This is the default option. The latest dataset added to the source directory will be added to the task. The target will then be set to that outing.

Changing Outing properties

There are a limited number of outing properties that you can edit. These may vary but include: Color, Driver Name, Time Offset and Track name.

Note: *When two or more outings are added to a task, all channels plotted from that task will be traced in the color of the outing. This does not affect the properties of the channel.*

Changing the Channel properties

When a channel is highlighted in the upper pane, its properties are displayed in the lower Details pane of the Explorer. To edit a property, double-click the property name or value and enter values or make selections as required. Properties are listed by category in the Details pane. Each category can be expanded or collapsed as required, by clicking the +/- icons, double-clicking the category, or using the '<', '>' cursor keys. The properties can also be viewed as an alphabetical list by right-clicking and selecting 'Alphabetic'.

Generally, properties that you cannot edit show their values grayed out.

Appearance

***Color*:** The channel's default (or base) color.

***Color Gradation*:** Enables a channel's plotted color to be graded according to the channel's value at that point.

***Display name*:** The channel name.

Plot

***Autoscale*:** When Autoscale is on; the trace expands to the full extent of the axis relating to the channel's data to maximize the data in the plot area.

***Auxiliary-axis*:** Enables or disables multiple axes to be displayed on Time/Distance charts, histograms etc. A display will show a Y-axis for the active channel, and a Y-axis for any channel it has selected having this property enabled.

***Display maximum*:** The maximum extents of the axis relating to the channels data when plotted on a display. This parameter is disabled when Autoscale in on.

***Display minimum*:** The minimum extents of the axis relating to the channels data when plotted on a display. This parameter is disabled when Autoscale in on.

***Interpolation*:** Determines the interpolation technique applied between sample points. Select either 'Linear' or 'Sample and Hold'.

***Y-axis percent enabled*:** Enables or disables Y-axis percent of the channel. When enabled, the Y-axis percentage occupied by the channel and its vertical position on the scale can be changed.

***Y-axis percent max/min*:** Determines the maximum and minimum percentage of the Y-axis occupied by the channel. Use this to move a channel trace clear of other overlaid traces to aid visibility.

Data

***Decimal Places*:** The number of decimal places to which channel values are displayed.

Note: *The channel values displayed in a Time/Distance Chart are limited to 10 characters (including decimal point). If the number of decimal places exceeds this limit, the displayed value is trimmed to 10 significant figures.*

Quantity: What the channel is measuring. For example: pressure, velocity.

Units: °C, MPH, KPH, liters, mm, bar, volts.

Filter

Filter: Select a filter type from the drop-down list. The default options are: No filter, band-pass filter, gating-function filter and moving average filter. When a filter is selected the Filter Enabled indicator changes to Yes. Custom filters developed using the SDK will also appear in the drop-down list.

Filter enabled: Indicates filter on or off state.

Filter Properties: Double-clicking this property opens the Property dialog for the filter type selected.

Note: *Properties that exist but are not listed in the categories above will be listed in the 'Others' category.*

Navigating the Time/Distance display

Pi Toolbox has been designed for operation in many different work environments, and caters for the various keyboard and mouse navigation techniques that people will use. Therefore, there is a variety of ways of finding and examining areas of interest on a display.

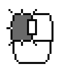
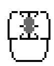
Moving the cursor

The cursor keys move the display's time cursor forwards or backwards along the active channel trace. Scrolling moves the visible plot region without moving the cursor. When you scroll it can be thought of as a sliding window moving over a larger area.

Zoom control

Zooming can be performed from the keyboard or by using the mouse. Keyboard and mouse wheel zooming centers on the data cursor. Whereas the Ctrl + click and drag technique zooms on the dragged area. This may or may not include the data cursor.

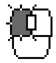
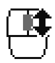
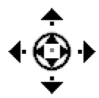
Cursor control

← →	Moves the cursor to the previous/next data sample in the active channel trace.
⇧ + ← →	Moves the cursor quickly along the active channel trace. Each press moves the cursor 5% of the visible time region.
Home End	Moves the cursor to the beginning or end of the active channel trace.
Pge Up Pge Down	Moves 50% of the visible time region.
	Moves the cursor along the active channel trace following the mouse cursor.
↑ ↓ Or ⇧ + 	Moves the cursor to the next or previous trace making it the new active channel. The cursor value legends (if displayed) highlight to indicate which is the active channel. For further visual reference the Y-axis scale changes to the same color as the new active channel.

Note: *When the cursor is moved beyond the visible time region it is re-centered; effectively scrolling the visible time region to follow the cursor.*

Scrolling

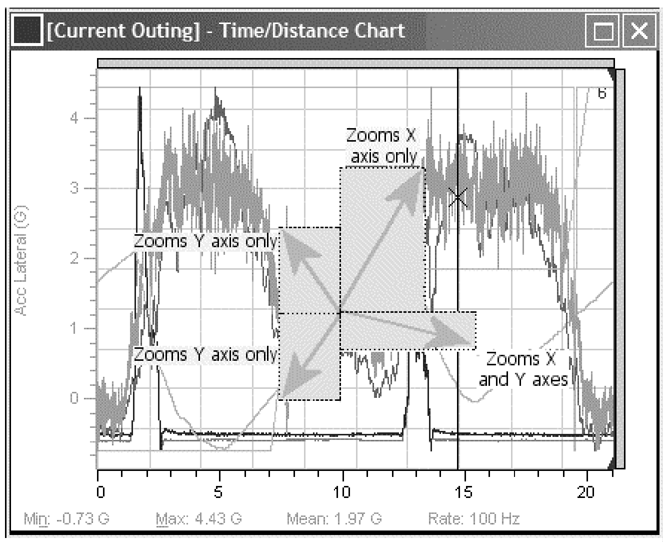
The following scrolling commands apply only when zoomed in.

Alt + 	The mouse cursor becomes an open hand. With the key held down click and drag to scroll.
Alt + ← →	Moves the view port by 10% of its width in the arrow direction.
Alt + ↑ ↓ Or 	Scrolls the view port up or down by 10% of its height. If vertical scrolling is not possible, the view port will scroll forwards or backwards by 10%.
	 Places this marker cursor where you click. Move the mouse left, right, above or below the marker to auto-scroll in that direction. The arrow cursor depends upon your mouse position. The scroll speed depends on how far you move your mouse from the marker. To cancel click middle button again.
+ - Or _ - +=	Auto-scrolls the view port. The initial key press starts the scroll at slow speed. Each subsequent press doubles the speed. Each key press in the opposite direction undoes the previous key press, until scrolling stops.

Zooming

Ctrl + (mouse drag)	Zooms into the specified drag area. You can vary the function of this technique by dragging the mouse in different directions. See Click and Drag Zooming below.
Ctrl + (mouse wheel) Or Z	Zoom centered on the data cursor.
← (Backspace)	Undo Zoom.
Ctrl + ← (Backspace)	Undo all zooms.

Click and drag zooming



There are three modes of operation depending upon which way the mouse is dragged from the click point:

Drag to the left to zoom the Y-axis only.

Drag to the top right to zoom the X-axis only.

Drag to the bottom right to zoom in both X and Y.

Note: *In Tiled mode only X-axis zooming is possible. X and Y axis zooming requires the display to be in Overlay mode.*

Linked Zooming

Displays within a Workbook that share the same task, can have their zoom level linked together. With two or more displays in a task linked, zooming in on any of the displays will cause all linked displays to zoom to the same level, i.e. share the same X-axis time region. This function operates regardless of the zooming method employed. All Task Cursor functionality is retained while link zooming is enabled, so that cursor movements and scrolling is tracked by the other displays.

When linked zooming is disabled, all displays return to their previous state and become unlocked. If a display was zoomed prior to becoming linked, it will return to its previous zoom level.

There are two ways to apply linked zooming:

Link All / Unlink All – Clicking Link All or Unlink All on the main toolbar will affect all displays in the task associated with the display in focus.

Link individual displays – Clicking the toggle button on a display's title bar, links or unlinks individual displays.

Shortcuts

F7	Links all controls ihn the task associated with the display in focus.
⇧ + F7	Links the display in focus.
F8	Unlinks all controls in the task associated with the display in focus.
⇧ + F8	Unlinks the display in focus.

***Note:** Linked zooming only adjusts the time range of the visible data. It does not zoom on a channel's axis. Therefore it will not zoom 'into' data on an XY display but will alter the time range of the data shown, as if the data selection had been altered to show that range.*

To link individual displays in a task:

1 On the first display click the toggle button so that the locked icon is shown:

Keyboard shortcut: F11

2 Repeat this for all displays in the task that you want to link.

3 Zoom in on any linked display using any zoom method.

All linked displays will zoom to the same level

Note: *When you unlink a display – the toggle button shows the unlocked icon - it will revert to its previous zoom level prior to becoming linked.*

To link a display to another 'zoomed' display:

1 Zoom the first display to the required level

2 Click the toggle button so that the locked icon is shown:

Keyboard shortcut: F11

3 Move the focus to another display

4 Click the toggle button so that the locked icon is shown:

The display will zoom to the level of the first display.

Channels

Overview

The channels of data contained in a dataset are presented in the Available Channels list of the Selection Explorer.

To commence data analysis, channels of data must be added to the display. Each display in the Workbook (of whatever type) must have its own channels selected. The Channels Available list will contain all the channels present in the outing currently loaded into the task.

Channel data is displayed in the form of a trace on a display.

Real channels

Real Channels (referred to simply as 'channels') are generated in the data acquisition and control system and are not user generated.

A channel is identified in the explorer like this: Accel Vertical

Math channels

A greater understanding of performance can be gained by combining 'real' channel data, and mathematical equations and functions, to create Math channels. These can be thought of as user generated 'virtual' channels derived from the result of a mathematical operation. Math channels can be used in the same way as real channels, and the results displayed in charts or reports etc.

A math channel is identified in the explorer like this: Math Channel.

Other channel icons

Special Math:

No data available:

Channel icon overlays

Channels/Events can exist in different states depending upon their definition and their existence in outings. If a channel/event displays the overlay, it is undefined. This means that some of the input data for the channel is missing. If a channel/event displays the overlay, the definition of that channel/event contains a cyclic dependency. This means that an error has been created in the math definition such that the data provided by the given channel is required in order to produce the data for that channel. (E.g. A=f(B), B=f(A).)

Mapping common channels

Some channels are required by Pi Toolbox components to generate maps, display or compare data against distance, and generate corrected data channels. These are 'Common Channels'. As teams may use different names for these channels, a system has been provided for identifying them to Pi Toolbox components as common channels.

The lower 'real channel' field lists channels that equate to the 'common name' displayed above it. For example, with Corrected Distance selected, the lower field shows all channels that measure distance.

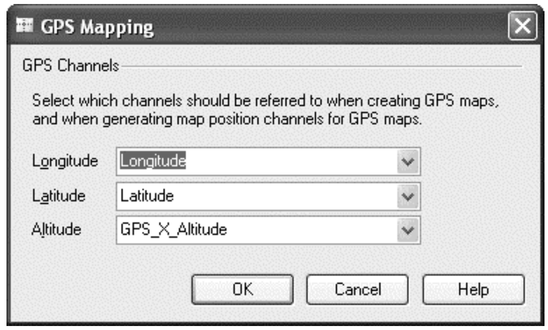
For each common name select the required real channel.

For more information on mapping common channels, refer to Channels - Mapping Common channels on page 48.

GPS channels

GPS Channels are used to generate GPS Maps and the map positioning channels: Map Position X, Y, Z and D. Users may use different names for GPS channels, therefore a system has been provided for identifying them to Pi Toolbox components as common channels. Use the GPS Mapping dialog to specify the correct GPS channel for each GPS coordinate.

Note: *Access the GPS Mapping dialog: Tools> GPS Mapping > Edit.*



For each coordinate select a channel from the drop down list.

Map Positioning Channels

GPS channels create the map positioning channels when a GPS map is initially created or loaded into the Workbook. They can be identified by their icons:

Map Position X: Map positioning channel when a Map is currently loaded in the Workbook.

Map Position Y: Map positioning channel with no Map currently loaded in the Workbook.

For each X, Y and Z point, the nearest point on the track is found and its distance is assigned to the Map position D channel. The D channel is used to position the cursor on the Map. It measures the distance into the map from the first point, enabling accurate cursor positioning in either direction, i.e. whichever direction the car is traveling on the map.

The X and Y channels can be used as a channel pair in XY Charts to show the car trajectory

Working with Channels

To add a channel to a display:

1 Make sure that the display you want to add a channel to has focus.

2 In the Explorer select the Channels tab.

3 Click on the 'Filter' bar and type the first few letters of the channel you want to add.

This reduces the channels in view to those starting with the letters you type.

4 From the Matching Channels list double-click on the channel to Add (alternatively right click on the channel and choose select from the pop-up menu)

The channel will appear in the lower pane under 'Selected Channels" and the data will be loaded into the display in focus.

To add a group of channels to a display:

1 Make sure that the display you want to add the group to has focus

2 In the Explorer select the Channels tab.

3 Right click on the group you want to add and choose select from the pop-up menu.

The group will appear in the lower pane of the Explorer and the channel data will be loaded into the display in focus.

To remove a channel or group from a display:

1 Make sure that the display you want to remove the group or channel from has focus

2 In the lower pane right click on the group or channel you want to remove

3 Select Remove.

The data from the channel or group of channels is removed from the display.

Math Channels and Soft Events

Introduction

Pi Math allows users to perform complex data analysis. Generally a math channel takes one or more input channels and produces an output channel. Input channels can be real channels or other math channels.

The operators and functions that are available to math channels are also available to soft events. Soft Events are simply math channels with a Boolean value. For a given sample point, if the event occurs, it is On/True. If the event does not occur it is Off/False. For Example: [Speed]>80.

What is a Math Channel?

A greater understanding of performance can be gained by combining 'real' channel data, mathematical equations and functions to create a Math channel. These can be thought of as user generated 'virtual' channels derived from the result of a mathematical operation. Math channels can be used in the same way as real channels. The results can be displayed in the Time and Distance displays, Histograms, Reports etc.

A Math channel is identified in the explorer like this: **Math Channel name**

What is a Soft Event?

Engineers need to create their own events based on set conditions within channel data, for this purpose soft events are provided. Unlike hard events, which are part of the outing data, soft events are always calculated at run time. For example, on a circuit test to investigate the efficiency of the gearbox oil pickup, when the car is accelerating, braking, stationary and not cornering conditions need to be excluded. Setting event parameters to exclude lateral acceleration data greater that 0.5g or less than –0.5g and the RPM data greater than 10,000rpm, would be carried out in the Soft Events Management dialog.

A soft event is identified in the explorer like this: **Soft Event Name**.

See Also: Soft Events, page 217.

Math channels give Pi Toolbox users the ability to perform complex data analysis. Generally a math channel takes one or more input channels and produces an output channel. Input channels can be real channels or other math channels. Therefore a simple math channel is in the form of:

Math Channel = ƒ (Input1, Input2,)

Calculating the aerodynamic downforce that the car is subjected to is a typical math channel:

TotalAero = AeroF + AeroR

Where:

AeroF = FL Pushrod Load + FR Pushrod Load

AeroR = RL Pushrod Load + RR Pushrod Load

TotalAero is a math channel whose inputs, AeroF and AeroR are also math channels. These, however, are derived from the input data (real) channels: FL Pushrod Load, FR Pushrod Load, and RL Pushrod Load.

Math Channel editing

Editing is carried out in the Pi Math Management dialog, which is accessed from the Tools menu: **Tools > Pi Math > Edit…**

Global definitions

All Math channels defined are stored in the Workbook and are listed in the Pi Math Management dialog. They can be exported and imported for use in other Workbooks.

Math Channel Equation components

Equation components

Math channels and Soft Event equations can contain a single component or multiple components, from those listed below.

***Channels*: ** Generally a math channel takes one or more input channels and produces an output channel.

***Math Channels*:** An input channel can also be a math channel.

***Soft Events*:** User generated events (created locally on the users PC) referred to as **Soft Events**.

***Constants*:** A constant is a named time-invariant value, used in math channel equations. Constants can be Simple, Excel or Literal.

***Registers*:** See page 209.

Properties

When a math channel is defined it is given a set of default properties that determine how the channel trace appears in Displays. These properties can be viewed and edited in the extended section of the Pi Math Management dialog, accessed by clicking ‘<< More’.

Like real channels, math channel properties are displayed in the Properties Explorer when the channel is selected. If not grayed out, they can be edited in the explorer as well as the management dialog.

The following properties can be defined for math channels:

***Autoscale*:** Enables/disables Autoscale. When Autoscale is on the trace expands to the full extent of the axis relating to the channel’s data, to maximize the data in the plot area.

***Min / Max*:** defines the minimum or maximum extents of the axis relating to the channels data when plotted on a display. This parameter is disabled when Autoscale in on.

***DPS*:** defines the number of decimal places that channel values are displayed in.

***Color*:** The channel's default (or base) color.

***Note**: To ensure math channel uniqueness can be maintained, the math channel name cannot be edited in the Properties Explorer*

Built in functions

Equation strings for math channels and soft events are created in the Equation field of the Management dialogs. Select: **Tools > Pi Math > Edit** or **Tools > Soft Events > Edit**.

Building equations is facilitated by built-in mathematical functions and operators. Selection is made from a drop-down list, accessed by pressing Ctrl + Space in the equation field.

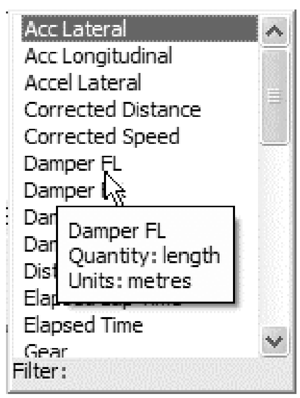
To select, use the up/down arrow keys to highlight the required operator and press Enter. The Channel or Operator is inserted in the equations at the cursor location.

The list can be filtered if required. The backspace key will delete filter characters.

The content of the drop-down list depends upon the context of the equation when accessed:

After '[' or between '[' and ']' a list of available channels is displayed.

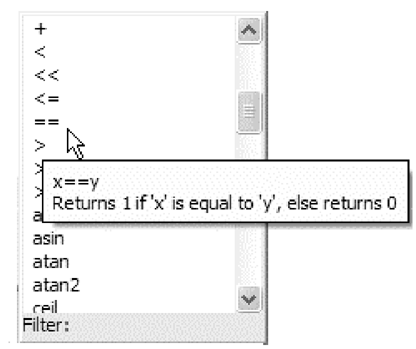
When highlighted, or with the cursor held over, a tool tip displays the name and quantity of the channel.



Between two sub-expressions a list of operators is displayed.

Note: *Enter a space after the ']' character, before pressing Ctrl + Space, to access the list of operators.*

When highlighted, or with the cursor held over, a tool tip shows the syntax and description of the operator.



Calculation rate

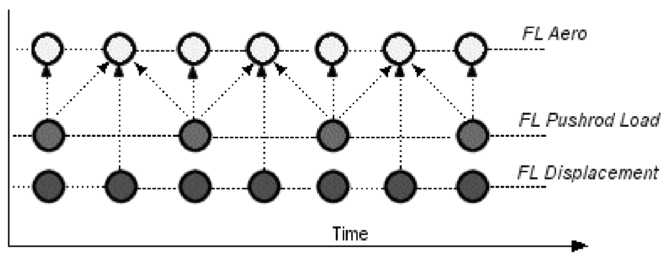
Math channels consist of one or more input channels that are often acquired at different frequencies.

The user determines the Calculation or Sampling Rate of a math channel, and can either be the same rate as one of the constituent channels or user defined.

Same rate as Constituent Channel

In the Pi Math Management dialog, the user selects from a drop-down list of constituent channels, which channel will set the calculation rate. If the selected channel rate is higher than the lowest of the constituent channels, Linear Interpolation is employed.

For example, in the math channel: FL Aero = ƒ (FL Pushrod Load, FL Displacement) the FL Pushrod Load is acquired at 25 Hz and FL Displacement at 50 Hz, and the user sets the rate to be that of the highest channel - the calculation rate is as shown below:



User Defined Rate

The user can assign a frequency for the calculation.

Math Channel definitions

To define a math channel, the following parameters should be specified:

Name

Each math channel must have a unique name.

CAUTION: *Math channel names are case sensitive. Make sure that you do not create a math channel that has the same name as an existing one, but different capitalization.*

Equation

The equation string represents a mathematical formula for calculating samples of a math channel, and should be in the form of the following example:

```
[ChannelName] +CONST(ConstantName)/ƒ ([ChannelName], [ChannelName]) – 3
```

A description is optional but can aid in quickly identifying the purpose of the channel, for example: **Tire slip angle calculation uses Pace jka '96 coefficients'**.

Insert the description between the characters: /*Description Here*/, or after the characters: //Description Here.

Quantities and Units

Math channel units default to user-defined units. These are entered directly in the Units field of the Pi Math Management dialog.

A math channel's quantity can be changed to a pre-defined quantity in the extended section of the dialog. When the quantity is defined, the user can then define the units.

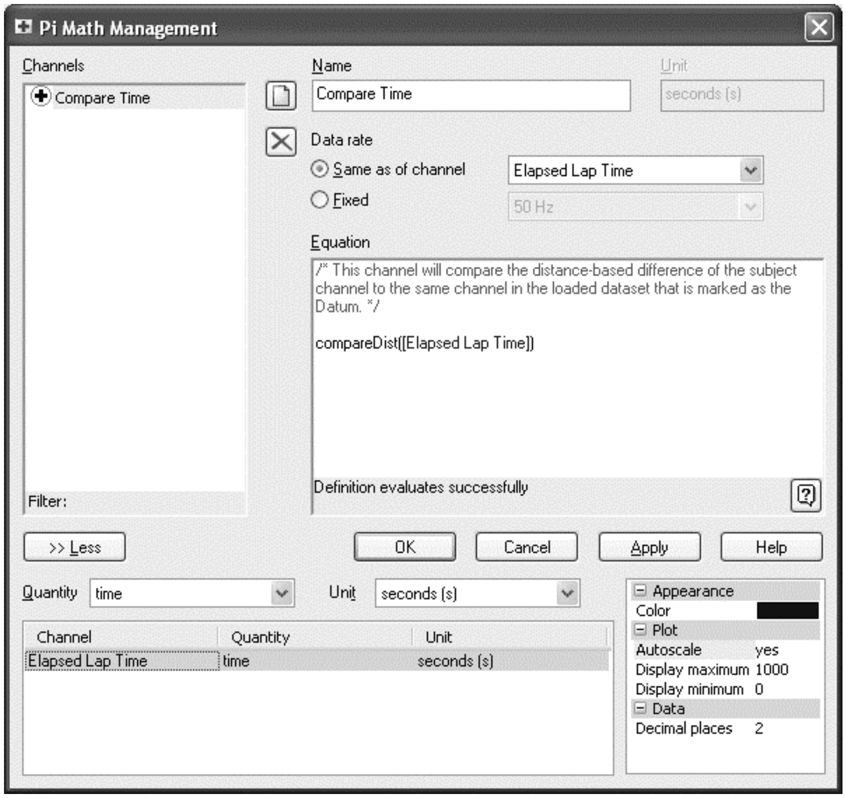
Calculation rate

The calculation rate defines the data rate (sampling rate) of the math channel.

Math Channel management

The Pi Math Management dialog is for the creation and management of math channels. All the math channels you define or import can be accessed and edited here.

To open the dialog, select: **Tools > Pi Math > Edit**.



Channel Name List

This is a list of all existing math channels. When a math channel is highlighted in the list, its details are displayed in the panels on the right.

 Inserts a default name for a new math channel in the math channel list.

 Deletes the math channel currently highlighted in the math channel list.

***Note:** You can select single or multiple channels in this list using '**Shift + Click**' or '**Ctrl + Click**'. Alternatively select all channels by pressing '**Ctrl + A**'. With multiple selections, filtering will deselect non-matching records, whilst the matching records remain selected.*

***CAUTION:** A math channel may be a sub-expression of another math channel equation, i.e. the math channel is dependent on another. Deleting the first channel would cause the dependent channel to become globally non-valid.*

Name

Displays the name of the math channel highlighted in the channel list. The name can be edited in this field.

Unit

Math channel units default to user-defined units. These are entered directly in the Unit field of the Pi Math Management dialog.

A math channel's quantity can be changed to a pre-defined quantity in the extended section of the dialog. When the quantity is defined, the user can then define the unit.

Data rate

Math channels consist of one or more input channels that are usually acquired at different frequencies.

The user determines the Calculation or Sampling Rate of a math channel, which can either be the same rate as one of the constituent channels, or user defined.

***Same as of Channel*:** Allows you to select from a drop-down list, which contains the constituent channels of the equation. The calculation rate of the math channel will be the same as the data rate of the channel selected here.

***Fixed*:** Allows you to define a data rate from a range of fixed frequencies from 1 to 1000 Hz. This option can be used when a math channel has no constituent real channels.

Equation

This field is for entering the math channel equation string - a mathematical formula for calculating samples of a math channel. To make creating equations easy, you can access drop-down lists of channels and operators, at any point in the equation string, by pressing Ctrl + Space. Selecting an element from the list inserts it at the cursor location.

The syntax is color highlighted as follows: Red = error, Green = comment, blue = keyword.

If required, a description may be added to aid identification. Insert the description between the characters: /*Description Here*/, or after the characters: //Description Here.

Note: *The status bar beneath the equation field displays 'Definition evaluates successfully' or 'Invalid Definition' as you build the equation, to indicate the accuracy of the equation syntax.*

<< More

Expands the dialog to show the input channels list, i.e. a list of all real channels referenced in the math channel equation. Here you can change the quantities and units of individual channels. Simply double-click a quantity or unit, and select from a drop-down a list of options appropriate to the channel.

Note: *The Default Properties panel is used to define math channel properties. The properties displayed are those of the channel selected in the Channel Name list. These properties appear in the Properties Explorer and determine the appearance of the math channel trace.*

About Intellitype

The Management dialogs 'Intellitype' system enables faster editing by allowing the user to concentrate on the equation rather than its syntax.

As you type in the Equation field, Intellitype functionality auto-completes as you type, auto-corrects case and colorizes different components.

Colorization

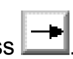
The equation is automatically colorized as it is built. Different colors are used for comments, functions, channels, constants, operators and errors.

Auto-case correction

As a function is typed into the equation, Intellitype automatically changes case to the correct one (if required). For example: If the user enters 'COMPAREDIST or comparedist, Intellitype automatically corrects the case to 'compareDIST'.

Auto-completion

Auto-completion attempts to complete the word being entered into the equation, depending on the context of the equation at that point. For example: 'com..' would be completed to 'compare'. 'compared' would be completed to 'compareDIST', (auto completion and auto-case correction).

To accept the word suggested in the equation field, press .

Syntax

Precedence in Math channels

Certain mathematical operators have a higher precedence than others. This affects how math channels are calculated; for example 2*5-3 gives 7 but 2-3*5 gives -13.

Multiplication and division have a higher precedence than all other Standard functions. Addition (+), Subtraction (-), less than (<), less than or equal to (<=), greater than (>), greater than or equal to (>=), have equal precedence.

Syntax

Math channel equations should be written in the form:

```
[ChannelName] +CONST(ConstantName)/ƒ([ChannelName], [ChannelName]) - 3
```

Input channels

Input Channels are referenced using the following syntax: [Channel Name]

When an input channel is referenced in the equation, an attempt is made to match this to an existing channel of that name. This is used to determine the current units defined for that channel in Pi Toolbox.

***Note**: If a channel is entered in the expression, which is not in the channel database, its quantity must be specified in the 'Advanced' section of the Pi Math Management dialog, otherwise defaults will be used.*

Operands

The following objects may be used as operands in the equation:

- Channels.
- Global math constants (name).
- Outing constants (name).
- Real number constants (value).

Constants

Constants are referenced using the following syntax: CONST (Constant name)

GLOBALCONST (Constant name)

OUTINGCONST (Constant name)

Error checking

The Status bar beneath the equation field displays ‘Definition evaluates successfully’ or ‘invalid Definition‘ as you build the equation, to indicate the accuracy of the equation syntax.

An invalid definition is also indicated by the math channel icon, which changes from for a valid definition to for an invalid definition.

Example Math channels

Note: *The following math channels are examples and should be treated as such. Their appropriateness for a specific purpose in your Workbook is not guaranteed.*

Name	**Air box Efficiency**
Syntax	2 * ([Air box pressure] - [static pressure])/(GLOBALCONST(Air Density) * pow([Speed],2)
Channels	Air box Pressure, Static Pressure, Speed
Definition	Air box efficiency is the ratio of the pressure in the air box to the maximum available pressure. The maximum available pressure is the pressure of a free stream flow due to the speed of the car.

Name	**Gear Ratio**
Syntax	([RPM] * OUTINGCONST(Wheel Diameter) * GLOBALCONST(pi))/[Speed]
Channels	RPM and Speed
Definition	Gear ratio is the number of turns of the engine to each turn of the driven wheels.

Importing and Exporting Math channels

Exporting Math channels

Math channels can be exported from the Workbook as a file. This enables teams to build up libraries of standard math functions that can then be E-mailed to the relevant engineers for importing into their Workbooks.

Importing Math channels

When importing a math channel you are warned if there are duplications of channels and/or constants, and given the choice of overwriting or rejecting duplicates.

When you open a global math definition file in the wizard you can import all channels contained in the file or select specific channels. Check the channels you want to import when prompted.

Lookup tables

Lookup tables are contained in external excel files. Tables can be included in math channel and soft event equations by mapping to the external table with a definition string.

There are two table types: 1 input parameter (1D) and two input parameters (2D).

1D table example

Spring Rate

Suspension Travel (mm)	Rate (Kg/mm)
10	1.80
20	2.24
30	2.48
40	2.36
50	2.12

The function's input channel is a damper channel where suspension travel values vary between 10 and 30. The user has devised a math function that requires spring rate to be used as part of the calculation. This can be derived by looking up in the table the value for the spring rate as a function of wheel travel.

Data is linearly interpolated between values.

2D table example

Efficiency					
	Front Ride Height (mm)				
Rear Ride Height (mm)	10	20	30	40	50
10	1.80	1.70	1.60	1.10	0.30
20	2.24	1.85	1.46	1.07	0.68
30	2.48	2.00	1.32	1.04	1.06
40	2.36	2.15	1.18	1.01	1.44
50	2.12	2.30	1.04	0.98	1.82

The functions input channels are Front Ride Height and Rear Ride Height. The values for both input channels vary between 10.0 and 50.0 mm in steps of 10.0 mm. The user has derived an aerodynamic function that requires the coefficient of drag to be used as part of the calculation. This can be found by looking up in the table the value for coefficient given the inputs of front and rear ride height.

Data is linearly interpolated between values.

Table Definition Strings and Hyperlinks

A string is used in the math channel equation to uniquely define a lookup table. Strings are in the form of: name\filename\sheet!cellfrom:cellto. For more formation, refer too Look up table Syntax.

Definition strings can be entered manually into the equation or pasted from the clipboard.

When the string is entered in the Equation field of the Pi Math Channels Management dialog it becomes a hypertext link. Clicking the hyperlink opens the table in Excel and highlights the specified cells. Right-clicking the same hyperlink offers the following context options:

Verify Table Definition: Verifies the table defined in the hyperlink clicked on.

Verify All Table Definitions: Verifies all tables definitions in the equation.

The verification process attempts to locate the specified file, sheet and cells and verifies for errors. If errors are detected during this process, they are reported in the equation status bar.

Lookup table Syntax

Both 1D and 2D tables are defined in the math channel/soft event equation using the following syntax:

table #name = path\filename\sheet\!cellfrom:cellto;

Where:

Table: Keyword is used for defining lookup tables

Name: Is the lookup tables name. It must always start with a '#' symbol.

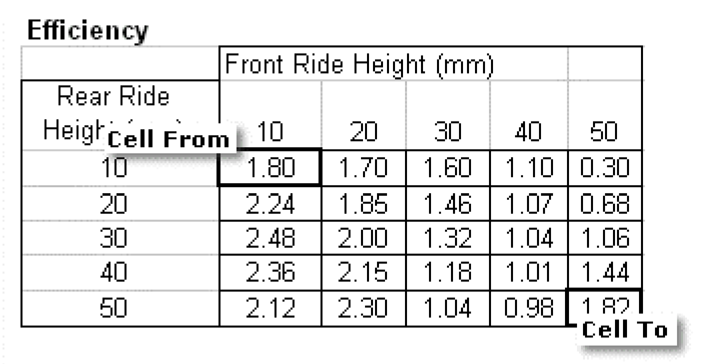
Path: Is the driver plus directory path of the Excel file. Relative network paths can also be used. See the examples below.

Sheet: Is the Excel sheet name.

Cellfrom: The lookup table's top/top left value cell.

Cellto: The lookup table's bottom/bottom left value cell.

Cellto and Cellfrom arguments can be specified using the Excel Cell syntax, e.g. cell A3 would be A3.


Efficiency

	Front Ride Height (mm)				
Rear Ride Heigh	10	20	30	40	50
10	1.80	1.70	1.60	1.10	0.30
20	2.24	1.85	1.46	1.07	0.68
30	2.48	2.00	1.32	1.04	1.06
40	2.36	2.15	1.18	1.01	1.44
50	2.12	2.30	1.04	0.98	1.82

Examples

table #local = C:\Lookup Tables\My Tables.xls\Sheet1!B4:B8

table #srv = \\server\c\Lookup Tables\Server Tables.xls\Sheet1!B4:B8

Usage

Lookup Tables can be used in channel/event definitions with the following syntax:

#name (exp[,mode])

#name (exp1, exp2[, mode])

Where:

Name: Is the name of the table.

Exp: Is the input argument used in 1D lookup tables

exp1 and **exp2** - are input arguments used in 2D lookup tables. exp1 specifies the IndexColumn and exp2 the IndexRow.

Mode: Is optional parameter. It specifies modes of interpolation/extrapolation. If not specified explicitly, the 'Snap' value will be assumed. It can have one of the following values

Interpolation: Interpolation is performed

Extrapolation: Extrapolation is performed.

Both: Interpolation and extrapolation is performed.

Snap (default value)**:** neither interpolation or extrapolation is performed - the nearest value is returned.

Hold: As Snap mode but will snap the value always to the previous one.

Lookup table errors

If errors are detected in the validation process they will be reported in the equation status bar of the Pi Math Management dialog.

- A valid lookup table must have the following properties:
- Numbers in the IndexColumn and IndexRow sorted in ascending order
- No duplication of numbers in the value cells
- 2D tables - no empty cells in the selected range of cells except the upper left cell.
- 1D tables - value cells must not be empty.

Cell Range Validation

- 2D tables must contain at least 3 x 3 cells.
- 1D lookup tables must have at least 2 value cells

Error Handling

If the validation for any lookup table in an equation fails, the math channel/soft event will be marked as undefined and will return no samples (discontinuity) for the entire outing time range.

Using Math channels

To define a math channel:

1 Open the Pi Math Management dialog - **Tools > Pi Math > Edit**

2 Click

A default name for a new math channel appears in the math channel list. If required, edit the default in the name field.

3 Enter units in the Unit field if required.

Note: *A math channel's quantity and units can be changed to pre-defined values in the Advanced section of the dialog. See below*

4 Enter a brief description of the purpose of the channel (optional).

5 Build the math channel equation.

Note: *Pressing* Ctrl + Space *at any point in the equation string, opens a drop-down list of channels or operators for you to select from. The list is 'Channels' if the cursor is after or between these characters '[' ']', or 'Operators' if you are between sub-expressions, or 'Constants' if after CONST(, etc.*

6 Select a data rate.

If you want to select a quantity or unit, other than the default, for any of the constituent channels, do the following:

7 Click << More

A list of all input channels referenced in the math channel is displayed.

8 Double-click a quantity for a particular channel and select from the drop-down list. Repeat for the units.

9 Click OK.

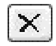
The math channel is added to the database and will appear in the Selections Explorer.

Note: *Math channels are listed with the real channels. Identified by their icon:*

To delete a math channel:

1 Open the Pi Math Management dialog.

2 In the Channel list highlight the channel or channels to delete.

3 Click 

Note: *Another math channel may be dependent upon the one you are attempting to delete, i.e. the one being deleted may be a sub-expression of another math channel equation, so deleting it would cause the dependent channel to become globally non-valid.*

4 Click Yes to delete the channel.

Registers

Registers are used for storing discrete variables (real numbers). The value of a register after the current sample is evaluated, is propagated as a value for the next sample evaluation.

Registers are calculated for each sample of the math channel. Typical uses of registers are to:

- Simplify equations by providing means for defining local variables. For example:

  AveSpeedFront = ([SpeedFL] + [SpeedFR]) / 2

  AveSpeedRear = ([SpeedRL] + [SpeedRR]) / 2

  (AveSpeedFront + AveSpeedRear) / 2

- Make recurrent definitions by persisting registers sample-by-sample. For example:

  Summ = Summ + [Speed]

  Will set Summ equal to the value of Summ in the previous sample plus the value of the Speed channel in the current sample.

Declaration

Before a register can be used it must be declared: register @R;

Register names are case sensitive and must start with the '@' character.

As part of the declaration the user can specify an initial value for the register:

Register @R=1;

When not specified, initial value defaults to zero.

Note: *Register declarations must precede all other statements in an equation.*

Initial value

A register takes its initial value only for the first sample of the math channel (which is equivalent to initialization of static variables in C++)

Assignment

Once a register is declared, its values can be changed with an assignment operator: <register> = <expression>;

For example: @R = @R + 1;

Registers in expressions

The value of registers can be used in any expression by simply specifying the register name:

Sin(@R);

@R3 = log (@R1+@r2);

Limitations

Registers cannot be used as arguments of multi-sample functions because these functions need to evaluate their arguments forward in time, which can cause cyclic dependencies between them and their arguments. For example:

@a =@a+1;

@a = maximum (@a);

Values of Registers

The following rules apply to the values of registers:

- All registers are of the type: double.
- Before the first sample of math channel is evaluated, registers have their initial values (as set in their declarations).
- Registers can change their value between consecutive statements of channel definition (using assignment operators).
- The value of registers after sample is evaluated (all statements of channel definition are evaluated) they are propagated as initial values of the registers for the next sample.
- A register can have a #NAN for a value.

Data Discontinuity Handling

Registers are calculated for each sample point of the math channel.

Note: *The math channel will not have a sample at a given time stamp if any of its inputs is discontinuous with the time stamp.*

This implies that the registers will never be calculated over a discontinuity.

Register Syntax

There are three types of statement (in the order in which they appear): Declaration, Assignment and Final Expression:

[[[<declaration>;]…][[<Assignment>;]…]][<final expression>;]

The syntax requires the following rules:

- Register declarations must precede any other statements.
- Register assignments can occur anywhere after the declaration.

- The value of the math channel's sample is the value of the last statement in the expression. Depending on the statement the math channel ends with its sample value as follows:

  Declaration – The initialization value, explicit or implicit.

  Register assignment – The value assigned to the register.

  Final Expression – The value of the expression.

Note: *Placing any expression (that is not a register assignment or declaration) before the last statement is irrelevant, as its value will not affect the channels value.*

Declaration

Declarations are the first statements in the equation and are used to define the register in the equation and set its initial value.

Syntax: register name [= expression];

Where **register** is the key word, name is the name of the register, and expression (optional) is an arbitrary expression, which is evaluated and is set as the initial value of the register.

Assignments

Assignments are used to set values for registers.

Syntax: name=expression;

Where name is the name of the register, and expression is an arbitrary expression, which is evaluated and is set as a new value of the register.

Final Expressions

Final expression is the last statement in definitions.

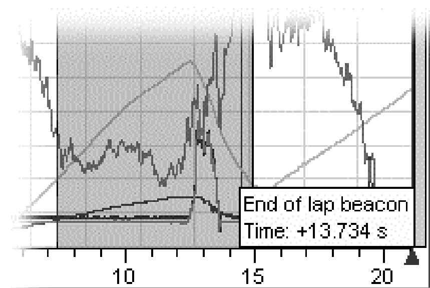
Syntax: expression;

Events

Overview

Events are points of interest that occur at a specific instant in time. They give the user a rapid method of searching data for points of interest, and are invaluable for system fault finding.

Events markers appear on Time and Distance displays as triangles. Holding the cursor over an event marker will display the Name and Time of the event. You can 'Pin' event information by clicking the marker. A pinned marker will be displayed in Print Preview and will appear on a printed output of the display. To unpin the event click on the display again.



***Note:** You can easily move between consecutive events on a trace by using the < > keys.*

Events that are generated in the data acquisition and control system are referred to as **Hard Events**. In addition to Hard Events, Pi Toolbox facilitates user-generated events (created locally on the PC) referred to as **Soft Events**.

Filtering Events

Inclusion and Exclusion filters

Events can be selected for displays in the same way as channels are selected. These are individual events (unfiltered) and are saved with the Workbook.

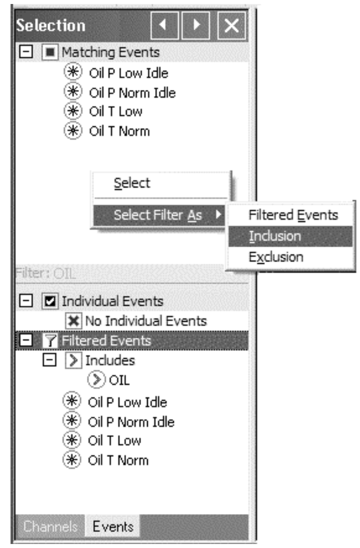
Alternatively, the user may want to create an event filter for a display so that whenever the workbook is opened the display will include events that pass through the filter, and those events will appear for any dataset loaded into the task. For example, the user may want the display to show all events with 'Oil' in the title. By constructing the filter the display will show any 'Oil' event and also include any new 'Oil' events.

The user also has the facility to exclude events that have passed through the filter. For example, the engineer may be interested only in oil pressure events. While the 'Oil' event filter lets all events through that have 'Oil' in the title, the filter can be constructed to block any 'Oil' event that has the word 'Temp' in it.

Event naming schemes are obviously determined by the user.

Note: *The filtering method is the same for both channels and events. See Filtering Channels and Events, page 172.*

Filter

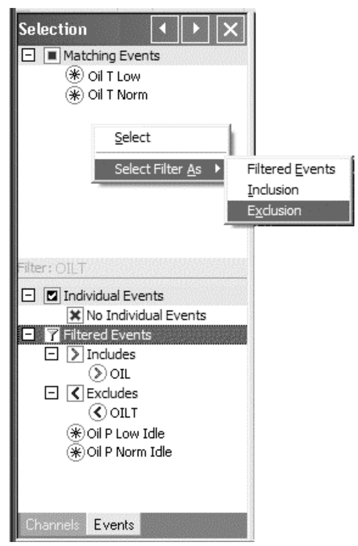


To create a filter that will find events starting with the word 'Oil' in the title, enter 'OIL'. The upper pane shows the 'Matching Events'. To include these events right click and select 'Inclusion', or press Insert.

The lower pane will list the filter events indicated by the event icon ✳.

The 'Include' filter will be indicated by the > icon.

Note: *You can create as many Include filters as you require.*



To modify the filter to exclude certain events (in this example 'Oil' events with the letter 'T' in the title). Highlight the upper pane and enter 'OILT' (clear the filter first or just add a ‘T’). The upper pane shows the 'Matching Events'. To exclude these events right click and select 'Exclusion', or press ⇧ + Insert.

The lower pane will now show a modified list of events. The Exclude modifiers are indicated by the < icon.

Note: *To delete a filter press* ⇧ + Del.

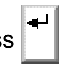
Working with Events

To add an Event to a Time and Distance display:

1 Make sure the Time and Distance display you want to add the event to has focus

2 Go to the Selections Explorer

3 Click the Events tab

4 From the list of Available Events, double-click the event – or press  - to add to the display.

The event is added to the individual events list in the lower pane of the Explorer and will appear on the Time and Distance display (if the event conditions have been met within the data selection region on the display).

Note: *You can set up filters specific to the current display so that certain events are run every time the display is opened.*

Soft Events

Engineers need to create their own events based on set conditions within channel data, for this purpose, soft events are provided. Unlike hard events, which are part of the outing data, Soft events are always calculated at run time. For example, on a circuit test to investigate the efficiency of the gearbox oil pick-up, when the car is accelerating or braking, stationary and not cornering conditions need to be excluded. Setting event parameters to exclude lateral acceleration data greater than 0.5g or less than -0.5g and the RPM data greater than 10,000RPM would be carried out in the Soft Events Management dialog.

Importing and Exporting

You can export groups of soft event definitions as single external PXE (event definition) files. These files can then be imported into other Workbooks, where the imported events can be selected in the Soft Events Management dialog.

 This icon identifies soft events.

Event priorities

Event priorities allow events to be categorized based on their severity, importance or source. The Event display can then be configured to plot events by priority.

Priorities are set up in the Priorities tab of the Options dialog. Background and foreground colors can be set to aid recognition in the Event display. There a four default priorities, Debug, System, Status, Error. Priority properties (name, colors etc.) can be changed if required and further priorities can be added up to a total of eight.

Priority ID’s

Priorities are created using IDs which correspond to Event IDs. Events are placed in priority categories accordingly. If an event is assigned an ID that does not exist in the priorities defined for the workbook, it is placed into the 'other' category. This is unique in that it cannot be deleted and it does not have an ID.

Creating and Editing

Soft events are created, edited and managed in the Soft Events Management dialog.

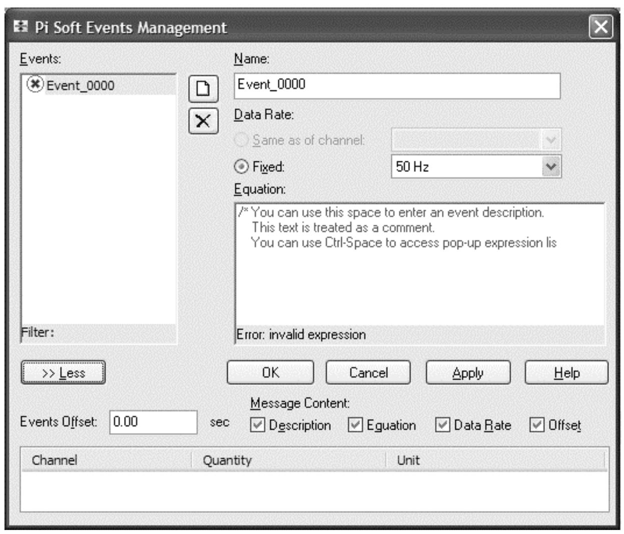
To open the dialog select: **Tools > Soft Events > Edit**.

Soft Events are defined by a math equation. The equation string represents a mathematical formula for defining event conditions.

Events

This is a list of all events created or imported. When an event is highlighted in the list, its properties are displayed in the panels on the right. Soft events can have the same name as a hard event. Where this occurs the soft event will take precedence.

Note: *A 'Broken Event' in the list indicates that a constituent channel of the soft event equation is missing, or the equation is incomplete. The Soft Event becomes invalid and cannot be used.*



 Creates a new soft event with a default name.

 Deletes the soft event currently highlighted in the soft event list.

Name

Displays the name of the soft event highlighted in the event list. The name can be edited in this field.

You can select single or multiple channels in this list using '**Shift + Click**' or '**Ctrl + Click**'. Alternatively select all channels by pressing '**Ctrl + A**'. With multiple selections, filtering will deselect non-matching records, whilst the matching records remain selected.

Data Rate

Soft events consist of one or more input channels that are usually acquired at different frequencies.

The user determines the Calculation or Sampling Rate of a soft event, which can either be the same rate as one of the constituent channels, or user defined.

Same as of Channel - Allows you to select from a drop-down list, which lists the constituent channels of the event. The calculation rate will be the same as the data rate of the channel selected here.

Fixed - Allows you to define a data rate from a range of fixed frequencies from 1 to 1000 Hz.

Equation

This field is for building the soft event equation string. To make creating equations easy, you can access drop-down lists of channels and operators, at any point in the equation string, by pressing Ctrl + Space. Selecting an element from the list inserts it at the cursor location. This method is the same when creating math channels; see Built in Functions and Operators, page 192. The status bar beneath the equation field displays 'Definition evaluates successfully' or 'Invalid Definition' as you build the equation, to indicate the accuracy of the equation syntax.

If required, may be added to aid identification. Insert the description between the characters /*Description Here*/

Note: *All channels that occur in the soft event equation (input channels) are listed in the 'Advanced' section of the dialog.*

<< More / >> Less

Expands the dialog to extend dialog options.

Extended options

The Extended section of the Soft Events Management dialog is hidden until the <<More button is pressed. Here you can define further soft event options:

Event offset

This field is used to define an event Offset. An Offset specifies that the actual event will occur at a time (given by the offset) after the conditions were satisfied. The Offset can be a negative value.

Message content

The Message Content panel is used to define what data appears in the soft event 'Flag'. Check the elements of the message that you want to appear.

Channel name, quantity, units

The input channels list is a list of all channels referenced in the soft event equation. Here you can change the quantities and units of individual channels. Simply double-click a quantity or unit, and select from a drop-down a list of options appropriate to the channel.

Working with Soft Events

To create a soft event:

1 Open the Soft Events Management dialog

2 Click 

An empty default event definition is created and should now be named.

3 In the Name field overtype the default name if required. The soft event name must be unique to the Workbook. However a soft event can have the same name as a hard event. Where this occurs the soft event will take precedence.

4 In the Equation window enter a brief description of the soft event (optional).

5 Build the soft event equation.

Note: *Pressing* Ctrl + Space *at any point in the equation string, opens a drop-down list of channels or operators for you to select from. The list is 'Channels' if the cursor is after or between these characters '[' ']', or 'Operators' if you are between sub-expressions.*

---

6 Select a data rate.

7 If you want to select a quantity or unit, other than the default, for any of the constituent channels, do the following:

8 Click << More

A list of all input channels referenced in the soft event is displayed.

9 Double-click a quantity for a particular channel and select from the drop-down list. Repeat for the units.

10 Click OK.

Building Equations

Soft events are defined by a math equation. Every time the equation results in a non-zero, an event is generated.

For Example:

- [Speed]>80
- fabs([Speed FL] - [Speed FR])<10

Note: *The operators and functions are available to both math channels and soft events.*

Special functions

In addition to math operators, soft events definitions can include special functions. These are accessed by opening the drop-down list of operators - Ctrl + Space - and scrolling to the bottom of the list. The last four operators are as follows:

Minimum (channel)/Maximum (channel)

An event is created when the expression reaches its maximum or minimum value within the current data selection. For example:

- maximum([Speed])
- minimum(fabs([Speed FL] - [Speed FR]))

Edge(channel, difference, time)

This function has three parameters – expression, constant and dt. Returns 1 if the magnitude of the difference ‘c’ and its value ‘t’ seconds before is greater that ‘d’, else returns 0. Expression is evaluated in two consecutive samples (at times (t-1) and (t) - based on the sample rate) and depending on the sign of the constant function returns:

- If const > 0 function returns 1 when (expr(t) – expr(t-dt)) > const
- If const < 0 function returns 1 when (expr(t) - expr(t-dt)) < const

This way the function combines Rising Edge, Falling Edge and Edge functionality.

Note: *The result of the function is highly dependant on the sample rate. For example Edge([Speed], 20] will return different results on sampling rate 10Hz and 200Hz. Higher rates effectively decrease the difference between two consecutive samples*

Cond (expr, pre-guard, post-guard, assume)

This function has four arguments:

- expr: expression
- pre-guard: pre-guard time - non-negative numerical constant (in seconds)
- post-guard: post-guard time - non-negative numerical constant (in seconds)
- assume: numerical constant

and returns non-zero (at time t) if the following conditions are met:

- expr is non-zero at t
- expr is zero in the time interval [t - pre-guard, t)
- expr is non-zero in the time interval (t, t + post-guard]

In all other cases function returns zero.

Every time when expr has no value (out of data range or data discontinuity) the value of the assume parameter is used instead of expr.

The pre-guard time is designed to filter-out events that will be otherwise generated in a series of data points that satisfy the standard event conditions and to leave just the first event since which the event conditions are met.

The post-guard time is designed to filter for events that mark a start of a long data sequence in which the alarm conditions are satisfied.

It implies: Generate only the events where the conditions are met by all data points within the period of post-guard time seconds following the event data point.

The pre/post-guard validation is performed on all data points (depending on the type of sampling rate) that fall in the range of pre/post-guard time.

Note: *If there are no sample points within pre/post-guard time it is considered that the pre/post-guard condition is met.*

Example of cond function

The following soft event is intended to detect when oil pressure drops to less than 4.5bar, for 5 s (post guard time) given that it was greater than 4.5 bar for the previous 2 s (pre guard time).

The Soft Events Management dialog

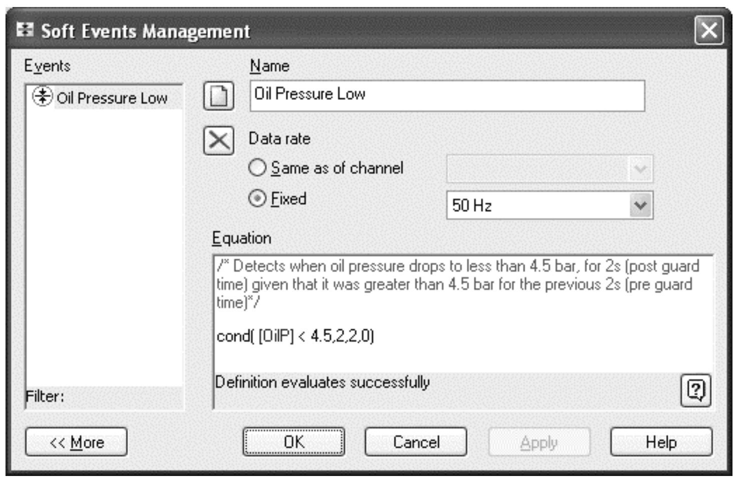
The equation below:

<expression> = [OilP] >4.5

<pre-guard-time> = 2 (in seconds)

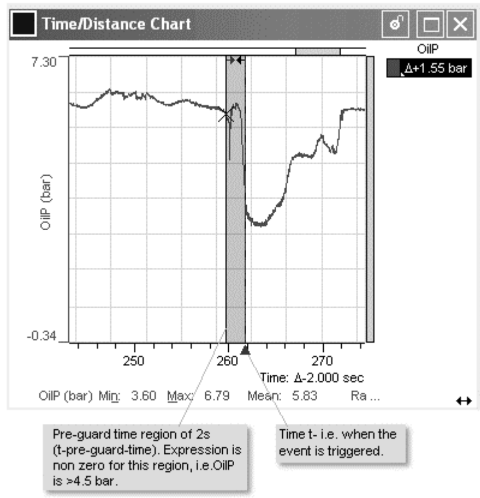
<post-guard-time> = 2 (in seconds)

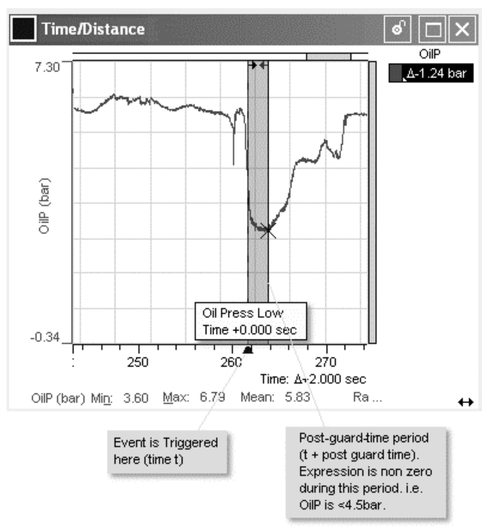
<assume> = 0 so that the event will not trigger if <expression> is out of range.



Results

The results are shown in following Time/Distance Charts.





If the soft event definition is changed so that the post guard time is 5s, then the event does not trigger because the OilP channel recovers to >4.5bar before the post-guard-time period has expired.

<expression> = [OilP] >4.5

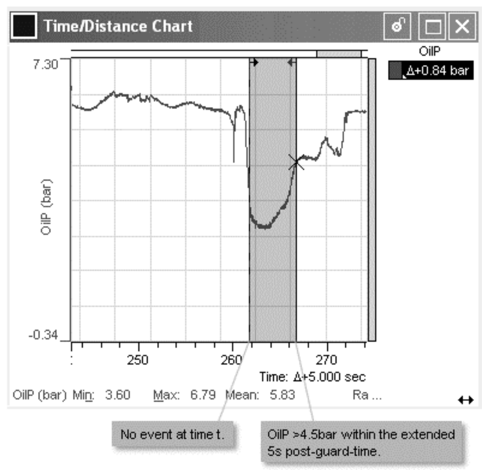
<pre-guard-time> = 2 (in seconds)

<post-guard-time> = 5 (in seconds)

<assume> = 0 so that the event will not trigger if <expression> is out of range.

cond([OilP]<4.5,2,5,0)

Result



Units and Arguments

Functions requiring specific units

Only trigonometric functions have specific requirements for the units of their arguments. These are:

- *Sin () – radians*
- *Cos () – radi*ans
- *Tan () – radians*

Functions requiring channel arguments

The arguments of all functions can be arbitrary expressions, with the following exceptions:

- *Compare ()*
- *CompareDist ()*
- *TimeDiff ()*

These functions only accept channels as their arguments.

Registers not accepted in arguments

Some multi-sample functions do not accept registers as part of the argument. These are functions that read their argument forward in time. For example, '*derivative ()'* reads three samples of the input argument, the current input argument, the previous input argument and the next input argument.

This could result in cyclic dependencies between multi-sample functions and the register. For example: *Reg= derivative(reg)*

The functions in this category are:

- *Gate()*
- *MoveAverage()*
- *BandPass()*
- *Derivative()*
- *Slope()*
- *Integral()*
- *Minimum()*
- *Maximum()*
- *Edge()*
- *Cond()*

Time as an indirect argument

All functions having time as an indirect argument assume that time is in seconds. For example: *integral(), which* multiplies the difference between two consecutive values of the argument by the time difference between them, takes the time difference in seconds.

The functions in this category are:

- *Integral()*
- *Derivative()*
- *Slope()*

Pre-Guard and Post-Guard times

Pre-Guard Time

This prevents numerous events from generating, where a series of data points satisfy the standard event conditions. The first event where conditions are met is retained.

Example: An event is set up to flag oil pressure failures, where typically the pressure falls below a certain level and stays low for some time. All data points for the time of the failure will create an event. Setting a Pre-Guard time of say 0.5 seconds only allows an event to be generated if oil pressure was in its normal range for the preceding 0.5 seconds.

Post-Guard time

The Post-Guard time is designed to filter events that mark the start of a long data sequence in which the event Conditions are satisfied. This will prevent events being triggered by channel noise.

Example: Looking for a drop in engine revs for a sustained period.

Event Offset

An Offset specifies that the actual event will occur at a time (given by the offset) after the conditions were satisfied. The Offset can be a negative value.

Note: *When you click OK, the event is saved with the current Workbook and will be available for use in any outing that you load. Soft events are listed alphabetically with hard events. They are identified by their icon:*

Constants

Introduction

A constant is a named, time-invariant value that has a global or outing context.

Constants can be used in math channels; for example, if several math channels use a spring rate value, that value can be represented by a constant created in Pi Toolbox. If the spring rate needs to be changed, by changing the constant value to the new rate, all channels using the constant are recalculated using the new value.

Scope

Global Constants

A global constant has scope across all datasets and is saved as part of a Workbook. They are available for all Math Channels. Constant values, for instance: tire diameter, which do not change from one outing to the next, are defined as Global Constants.

Outing Constants

An outing constant only has scope within an outing and is saved as part of a dataset. Constant values, for instance: track temperature, which can change from one outing to the next are defined as outing constants.

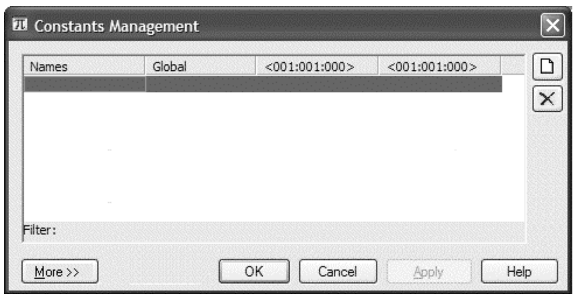
***Note**: Constants are created in the Constants Editor where they are defined as either Global or Outing constants.*

Simple constants and Excel constants

There are two constant variants:

- **Simple Constant:** Which is defined as a numeric value
- **Excel Constant:** Which takes its value from an Excel cell. When math channels containing the constant are calculated, the value is taken from the spreadsheet cell, for example, a component value in the setup sheet. Certain actions can be executed in Excel before the cell value is retrieved, e.g. Execute a Macro.

Constant management



Global constants and outing constants are defined in the Constants Editor. The scope of the constant depends upon where the value is entered in the Editor.

To open the dialog, select: **Tools > Constants > Edit**

Names - The constants that exist for the current Workbook or for any of the outings contained in the Workbook are listed in the Name column.

Global - A constant value entered here creates a Global constant. Enter a value by double-clicking in the Global field and typing.

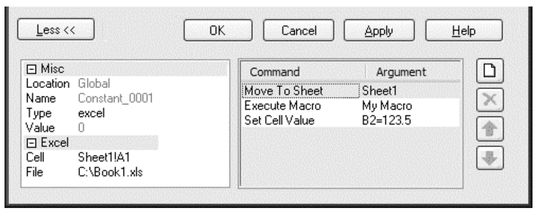
Outing - The columns following the Global column represent the outings currently loaded in the Workbook. A constant value entered here creates an Outing constant. Values are entered by double-clicking in the Outing field and typing.

Note: *A colored triangle in the bottom left corner of the value field indicates the type of constant, i.e. Black = Simple Constant, Green = Excel Constant.*

Inserts a new constant in the Name Column. Change the name if required by double-clicking the default name and overtyping with the new one. You can also enter a constant name by typing directly in an empty name field.

Note: *Values entered in the Global or Outing columns create Simple Constants. To create an Excel Constant, click the 'More' button to extend the dialog.*

Excel constants



The Constants Editor is extended when the 'More' button is pressed. These commands are used for creating Excel Constants.

The left window shows details of the constant currently highlighted in the main window of the dialog. To create an Excel Constant, select Excel in the Type field and enter the name of the Excel workbook to be used. Then enter the cell address of the cell holding the constant value, into the Cell field, using the standard Excel format.

Excel cell: Enter the location of the cell which holds the constant value, the location is in the form: Sheet name! A1 or A1, (column letter, row number).

Excel file: Opens a browse dialog to let you browse for the Excel File.

Note: *You can copy a value from an Excel spreadsheet and paste it into a Constant value field. The Excel Cell location and Excel File paths are automatically entered. See Copy and Paste Excel Cell Value, page 58.*

Name: The name of the constant that is currently highlighted in the main window. This will become the Excel Constant.

Type: Simple or Excel.

Value: Shows the value of the constant.

Command: The right hand window gives further command and argument options. Commands are activated each time Pi Toolbox attempts to acquire a value from a cell **before** the value is read. You can add as many commands as you wish and change their order using the up/down arrow buttons. To add a command, right-click in the Commands column and select from the available list.

Enter arguments by typing directly in the field.

The commands available are:

Move to Sheet: Activates an Excel Sheet (argument: sheet number)

Execute Macro: Executes an Excel Macro (argument: Excel Macro Name)

Set Cell Value: Sets a value in a cell in the active Excel Workbook (argument: A1=value).

Cut, Copy and Paste commands

There are several cut, copy and paste options available within the Constants Management dialog. You can access these commands from the context menu or use keyboard shortcuts. You can copy and paste constants, globally, individually or by outing.

Select all constants by clicking the Global or Outing header bar. Alternatively select individual constants by shift + clicking.

Paste commands

Ctrl + V **Paste:** Only the constant values and properties are pasted, the constant names are ignored.

Ctrl + ⇧ + V **Paste Named:** The constant names are used when pasting. If a constant with the same name is found in the target – it is replaced. If a constant with the name does not exist – it is created in the target.

Ctrl + E **Paste Excel Cell:** An Excel cell value when copied from a spreadsheet and pasted into a constant creates an Excel Constant.

Working with Constants

To create a simple constant:

1 Select: Tools > Constants > Edit.

The Constants Editor opens.

2 Click the  button.

A unique default name is entered in the Name column. To change the name double-click the name field and overtype with the required name.

3 Enter a constant value in the Global column or one of the Outing columns. To do this double-click the field and enter the value.

4 Click OK to create a Simple Constant.

To create an Excel constant:

1 Highlight a Constant in the main window and click the Global column.

2 Click << More

The Constant Editor is extended to show the constant properties and commands windows. The details of the highlighted Constant are displayed.

3 In the Constant Properties Window double-click Type and select: Excel.

4 Double-click Excel File. Use the Open dialog to browse for the Excel file required.

5 Double-click the Excel Cell field and enter the location of the cell that holds the constant value.

Use the form A1 (column name, row number) to locate the cell.

6 Click OK to create the Excel Constant.

To add a command to a constant:

1 Create an Excel Constant following the instructions above.

2 In the command column double-click and select a command.

The available commands are:

Move to Sheet: Select this to Activate an Excel Sheet (argument: sheet number)

Execute Macro: Select this to Execute an Excel Macro (argument: Excel Macro Name)

Set Cell Value: Select this to set a value in a cell in the active Excel Workbook (argument: A1=value)

3 Double-click the argument column adjacent to the command and enter an argument.

4 To add another command, click in the field beneath the last command listed and select the command.

5 To change the command order, highlight a command and use the up / down arrows.

To copy and paste an Excel cell value

1 Click the  button.

A unique default name is entered in the Name column. To change the name double-click the name field and overtype with the required name.

2 Copy a value from an Excel Cell, Ctrl + C.

3 Click in the Constant Value field (Global or Outing).

4 Paste the cell value, Ctrl + E.

<New> will be displayed in the field until the cell value has been evaluated

5 Click Apply.

The cell value is evaluated and entered in the Constant Value field. An Excel Constant is created and the Excel Cell location and Excel File paths are automatically entered.

Working with Real-time data

Real-time Outing functionality

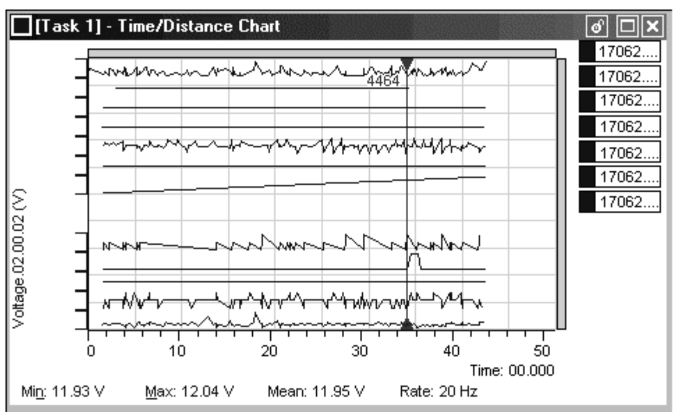
Outing functionality

PiDatasets (Historic Data outings)	Real-time Data outings
Add up to 8 outings in a task.	Same.
Cut, copy and paste outings from one task into another task (or a the same task).	Same.
Automatically update outings in a task by 'watching' a specified directory for added or replaced outings.	Same.
Select any lap in the outing from the Select Laps dialog.	Same when in Paused mode.
Select all laps in the outing using the keyboard shortcut: Ctrl + E .	Same when in Paused mode.
Select fastest lap from the dataset using keyboard shortcut: Ctrl + Q.	Same when in Paused mode.
Move the data selection to the Next, Previous, First or Last laps.	Same when in Paused mode.
Export qualifying data and displayed data from Time and Distance displays.	Same.
Change channel properties locally and globally.	Same.
Apply filters to individual channels.	Same.

Display Features

Link zoom all displays connect to a task.	Same.
Display X-axis in Time or Distance.	Same.
Display traces tiled or overlaid.	Same.
Show/hide cursor value legends	Same.
Display and edit lap markers.	Display only.
Show/Hide and Flash traces.	Same.

Real-time display features



Displays

Real-time data can be viewed in Time and Distance displays, Chart Recorders, Histograms, X-Y charts, Bit Indicators, Channel displays, Event displays and Maps.

Map displays

Maps displays connected to real-time outings display car cursors to indicate track position. A Cursor is drawn for each real-time outing in the task. Graphical Lap Reports plot data in real-time.

Export displayed data

Real-time data can be exported as a Pi Dataset from Time and Distance displays. The export data starts at the beginning of the data stream and ends at the time that the Export command was executed.

Pi Dataset format data files support channel, event and lap marker data. Exported real-time datasets can be subsequently added to tasks and viewed as historic data.

Pause mode

 Use the pause button on the main toolbar - or shortcut: Pause to pause the incoming data stream. In Pause Mode data selection functionality is similar to that of displays showing historic data. Previous laps can be selected (one or more). When the pause button is pressed again Pause Mode is cancelled. How the display responds when Pause Mode is cancelled depends upon several factors. See **Pause Characteristics**.

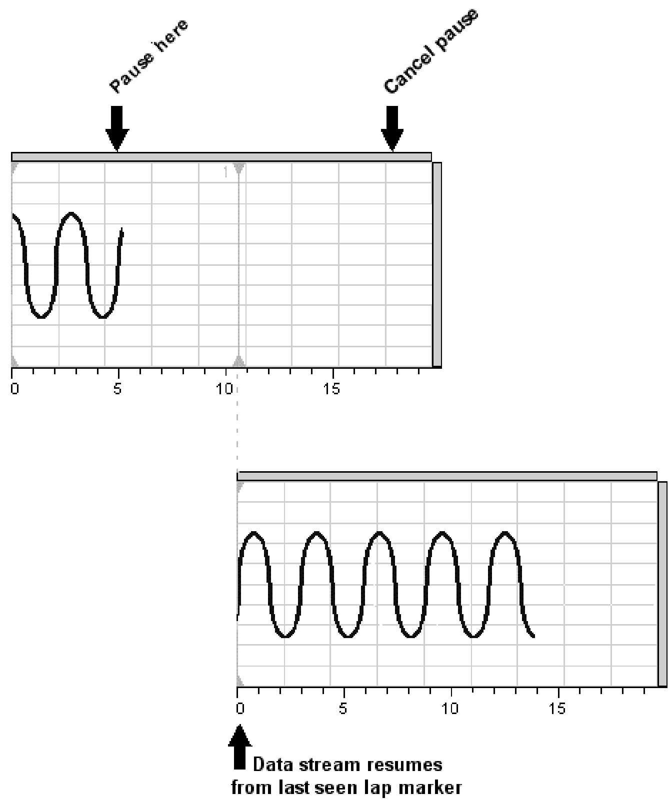
Note: *In Pause, automatic updating of the data selection is suspended, but the data stream continues.*

Pause characteristics

As the data stream continues and extends over several laps, the time span of the X-axis changes lap-by-lap to reflect the length of the last complete lap.

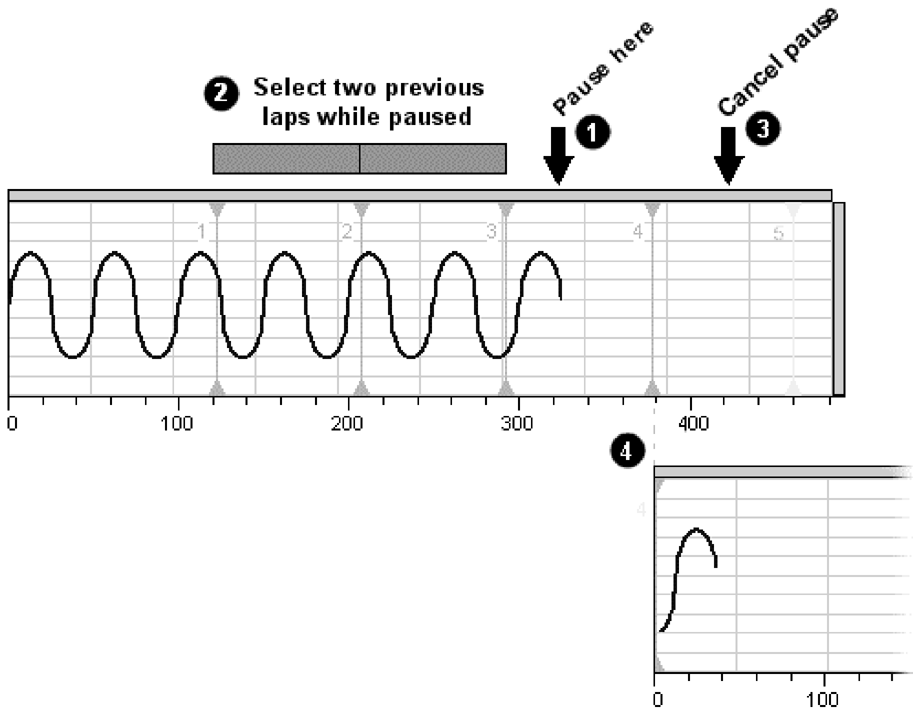
In the example below when the data is paused the trace stops. Data continues to be recorded but the display does not update. When pause is cancelled, the display snaps back to the last seen lap marker and the data stream continues.

Pause characteristics examples:



The following illustration shows how the user can pause the data stream then scroll back and select a number of laps already received. When pause is cancelled the data selection snaps to the beginning of the incoming lap.

In this example the user pauses the data **1** and selects two previous laps **2**. When pause is cancelled **3**, the display snaps to the current lap **4** (incoming data).



Setting up a Real-time display

Set up real-time options

1 Add a real-time display to the worksheet.

For example, Real-time Chart recorder, Time and Distance display, Bit Indicator etc.

2 Select: **Tools > Options**

3 Select the Real-time tab.

4 The Information stream field contains the IP address of the real-time server. If necessary, you can check that the address is correct. Go to the Pi Server application, select Telemetry tab and check the address in the Information Stream field.

5 Click **OK** on the Options dialog.

Add a Real-time outing to the task

1 Create a task.

2 Select (right click button) **> Add Task** to create a new task.

3 Select (right click button) **> Add Outing**.

4 Click the Real-time button.

The file window contains two nodes: **Watch** lists watch data servers. **Telemetry** lists telemetry data servers. If no servers are present, double clicking ‘No Watch Servers’ or ‘No Telemetry Servers’ opens a ‘Browse for Computer dialog’.

5 Double-click ‘No Telemetry Servers’. Alternatively select the telemetry node and click the add button.

The ‘Browse for Computer’ dialog opens where you can browse for the telemetry server you require.

6 Click OK to add the server to the telemetry list.

7 Click OK in the Add dialog to add the real-time outing to the task.

Select channels in the usual way in the Outing explorer.

CPU usage

Users with machines rated at the recommended system specification should not experience performance problems in Real-time mode. However some worksheet configurations may cause high demands on CPU usage, for instance where the maximum permissible channels are used on several displays.

One option for users who find that their CPU usage is too high is to reset the Update rate. This is the rate at which displays showing Real-time data are updated. The default is every 200ms.

To lower the Update rate, open the Options dialog select the Real-time tab and click the Advanced button. Enter a new time in the Update Rate field.

Time and Distance displays and Real-time chart recorders

Setting the drawing style of these display types to ‘Draw using Points’ can increase CPU usage. To reduce CPU usage the drawing style should be set to ‘Draw using Lines’. This property is set on the Drawing page of the display’s property page dialog.

Time and Distance charts

A Time and Distance display is a graphical method of displaying channel data values against Time and Distance in the form of a trace.

A display can hold up to a 32 channels. Each channel creates a single trace on the display. If two outings are loaded each channel will create two traces, one for each outing. The Offset feature allows two traces from different outings to be aligned and compared.

Shortcuts

T	Tile/Overlay traces
D	Time/Distance mode
N M	Finds Min or Max values in the data selection
Z	Zoom
←	Undo zoom
Ctrl + ←	Undo all zooms
← →	Move cursor left or right
⇧ + ⇆	Move cursor quickly left or right
Home End	Move cursor to start or end of trace
↑ ↓	Scroll through channels in display
O	Enter or exit time offset mode
⇧ + O	Enter or exit value offset mode
H	Hide trace

F	Flash trace
Ctrl + A	Selects all laps in the Select dialog
Ctrl + Q	Selects the fastest lap in the outing (outing highlighted or display in focus)
Ctrl + E	Selects the all laps in the outing (outing highlighted or display in focus)
Alt + ↵	Displays the Time and Distance display Properties dialog.
L	Lock/unlock the task cursor.

Features

Time or Distance mode

You can display values against time or distance in the X-axis. This applies to both historic and real-time datasets. To toggle between the modes, press 'D'.

Tile or Overlay traces

Traces can be overlaid, or tiled vertically. To toggle between the two layouts, press T. Tiles hold one channel only but can hold multiple outings of that channel.

The Active channel

In a display one channel is the 'Active' channel, or the channel in focus. For visual reference the Y-axis scale is displayed in the same color as the active channel, and the cursor values legend is highlighted. You can scroll through the available channels using the ↑ ↓ keys, making each in turn the active channel.

Active Channel selection

Channel traces can be selected directly in the display plot area by shift-clicking the trace. The selected trace becomes the active channel. The active channels can also be changed by using the keys to scroll through the available channels.

The Task cursor

The data cursor is a vertical line drawn through the active channel trace from the X-axis to the upper limit of the Y-axis. Move the Data Cursor along the X-axis using the keys. The value at the intercept of the active channel (and all other channels) is displayed in the Data Value legends. In a Workbook two or more Time and Distance Displays can be connected to the same task. Cursor movements are made simultaneously in all displays connected to the same task.

The data cursor can be locked on a TD chart by pressing L or by selecting the *Lock Cursor* option from the context menu. When the cursor is locked, the view will change so that the cursor is in the centre of the screen i.e. the chart will scroll to bring the cursor to the centre of the screen.

Reference cursor

Press R to place a reference cursor at the current cursor location. While in 'Reference Cursor' mode, all cursor values are relative to the reference cursor location, i.e. the difference between the data cursor and the reference cursor values.

Auto-sized Cursor value legends

Displays Y-axis values for the current Cursor position for both the active channel and all other channels. The legends continually update as the data cursor moves. With 'Auto size cursor values' selected in Properties, the maximum width required to show the cursor values / channel names in full is calculated, and the display area adjusted automatically.

Circuit maps

Include a circuit map in the display to provide a visual reference to track position for a given data point. As the Task Cursor is moved along the active channel trace, the car cursor moves to the relevant position on the map. This map is for visual reference only and cannot be edited. Circuit maps can be created using Pi Toolbox and presented in their own display.

Flash or hide the active channel trace

For ease of identification you can flash the active channel trace by pressing F. Press F again to stop the flash. You can also hide the active channel trace by pressing H.

Event markers

An event marker - a triangle on the X-axis, indicates events on a display. Holding the mouse over the marker displays the event message. You can easily move between consecutive events on a trace by using the **< >** keys.

Lap markers

Lap markers generated by End of Lap beacons can be added to a display. They can be moved, deleted and reset as required.

Statistics

Maximum, Minimum and Mean values, and where applicable, the rate of data acquisition, are shown beneath the X-axis. Values can be shown for the active channel or for all channels selected for the display (All Traces). When the All Traces option is selected, a scroll bar is provided, to allow the user to scroll through all entries.

Auto size statistics region

Selecting this option (Properties dialog) forces the statistics region to expand so that values for all channels can be read without scrolling. This only applies when All Traces is selected.

Offset mode

A time offset can be added to all channels in an outing to change the position of the outing relative to another. This can be used typically to align two events from different outings, which occurred at different times in the respective outings, on the same circuit, e.g. a braking point. Pressing O on the keyboard allows you to drag all channel traces for the active outing (the outing belonging to the active trace) along the X-axis.

Linked zooming

Displays sharing the same task can have their zoom level linked. When linked zooming is enabled, zooming in on one display will cause all other displays to zoom to the same level, i.e. share the same time region.

Scale the Y-axis of an individual trace

Where several traces are overlaid, an individual trace can be scaled and moved vertically in the Y-axis, pulling the trace clear of the overlaid ones.

Changing the Y-axis scale for a channel overrides the channel properties for that display.

Map segments and Split positions

If a Map has been created and is open, displays sharing the same task will show a segment bar along the full extent of the X-axis. The bar represents the Map’s segments, the segment colors matching those set for the Map. Split Beacon positions are shown below the Segment Bar. Double-clicking a segment or a split will cause the zoom region to be set to the extent of the segment/split.

Zooming and Scroll bars

Zoom in and out using the 'Z' key or the 'Ctrl - click and drag' method. Using the keyboard zooms in on the cursor region, leaving the cursor at the center of the display. Using the mouse you can zoom in on any region of the data selection. Use 'Backspace' to zoom out. When zoomed in scroll bars are added to the display.

Panning in a zoomed region

When zoomed in you can Pan forwards or backwards along the trace using the '+' and '-' keys. Multiple presses of the key will increase pan speed. Pressing the opposite key will decrease the speed.

Auxiliary axes

A separate Y-Axis can be displayed for every channel selected for the Display. The feature can be switched on and off individually in the Property Explorer for each channel. When the feature is switched off the axes displayed are for the active channel only. When switched on, the axes for the active channel are displayed closest to the plot area. Changing the active channel re-orders the axes so that the new active channel's axes are nearest to the plot area. Displays having multiple data selections show multiple axes for each data selection. The shortcut key 'Y' toggles the auxiliary axis for the active channel between left, right and off.

Real-time features and behavior

Time and Distance Displays can be used to display historic and real-time outings. For more information see **Setting up a Real-time Display**, page 241 to find out how to add a Real-time outing.

Pause characteristics

- When *Pause mode* is entered, data is frozen on the display but it continues to be buffered.
- When *Pause mode* is cancelled, the buffered data is displayed from the last seen *End of Lap* beacon.

Behavior

- When a display begins to display real-time data the Y-axis range expands until an End of Lap beacon event is detected.

  The Y-axis is then set to the length of the first full lap.
- For real-time outings, *Distance mode* is disabled.

The default drawing style "*Draw using Lines*" is recommended in real-time mode as this reduces CPU usage.

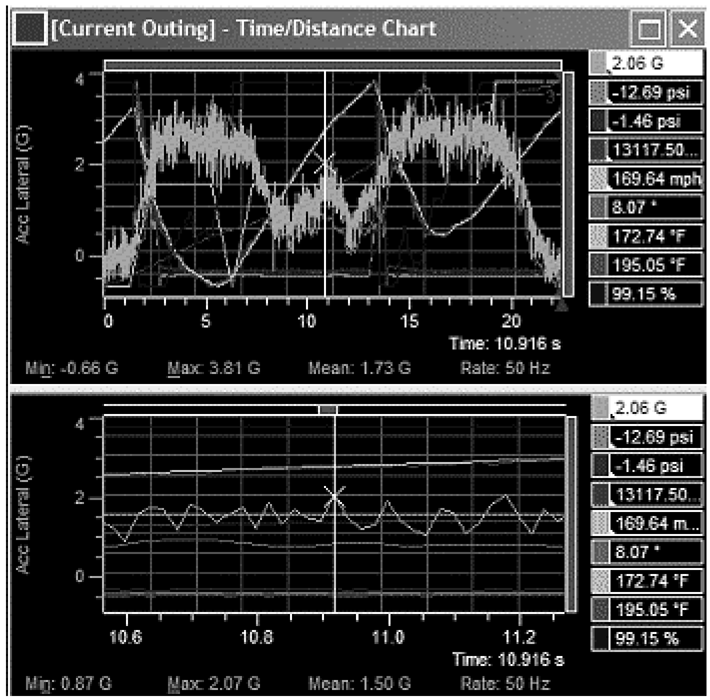
Working with Time and Distance displays

The Task cursor

Time/Distance Charts connected to the same task share a common Data Cursor position. As you move the cursor along the X-axis or click a data point or event, the cursor moves simultaneously in all displays connected to the task.

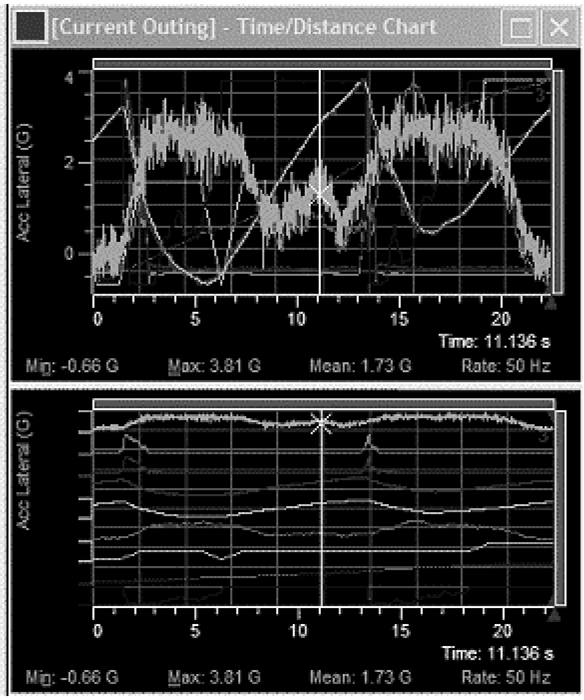
This allows you to copy a display and, by setting different zoom levels, view data in detail on one display while maintaining an overview in the other.

You can copy a display by 'Ctrl + click and drag' on the display title bar.



Tile or Overlay Traces mode

Traces can be overlaid or tiled vertically. In Tiled mode a tile can hold one channel only but can hold multiple outings of that channel.



The illustration shows the same data overlaid and tiled. In the tiled view the data is scaled in the Y-axis to accommodate all traces in the available display area.

In the tiled view the data is scaled in the y-axis to accommodate all traces in the display.

To change the display mode:

1 Right click in the display.

2 Select: **> Axes > Tiled** (or Overlaid).

- Or use the keyboard shortcut: with the display in focus, press T.

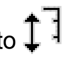
Scale an Individual trace

A single trace on a display in Overlay mode can be scaled in the Y-axis and moved above or below the remaining traces to give a clearer view. This feature may be unavailable if the Y-axis is zoomed.

To scale a single trace:

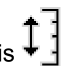
1 Make the trace you want to tile the active channel.

2 Place the cursor over the Y-axis at the top or bottom.

The cursor changes to  or  depending upon where you are pointing.

3 Click and drag to the required scale.

4 When scaled, place the cursor over the center of the Y-axis to move the axis to the required vertical position on the display.

The cursor will change to this 

Note: *When 'Y Axis % enable' (in the details pane of the explorer) is set to 'Yes', Axis % max and min values can be edited in the explorer. This will achieve the same result as above. Note that values set in the Display tab of the explorer are local to the display, and override those set in the Workbook tab. Because of this, values entered in the Workbook tab will be ignored if local values have been previously set in the Display tab.*

Using Time offset mode

A time offset can be added to all channels in an outing to change the position of the outing relative to another. This can be used typically to align two events from different outings, which occurred at different times in the respective outings, on the same circuit, e.g. a braking point. Offset mode can only be accessed when the task contains more than one outing.

To align traces:

1 Select a channel in the outing you wish to move.

2 Press . Note that the offset value is displayed.

3 Click and drag the trace to align with the other outing.

4 Press  again to accept the offset.

You can enter the offset value by selecting the outing in the Task Explorer and changing 'Time Offset' in the Details pane.

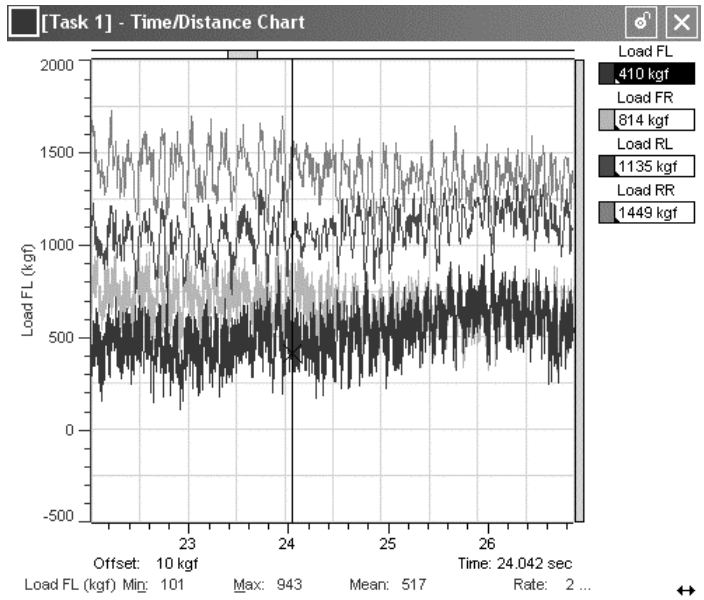
To remove an offset, change the Time Offset property to zero.

Using Value offset mode

Active channels can be offset by a specified value. For example, you can compensate for an incorrectly zeroed ride height sensor by offsetting the channel by the amount that the sensor is out of calibration by. When an offset is applied it will affect the channel and data selection that the offset was set on, it will not affect a different data selection with a channel of the same name, even if the other data selection contains the same outing. Offsets can be applied to any channel including raw outing channels, maths channels and special maths channels. The offset is saved in the workbook not the *.pds* file.

The value that the channel is offset by is displayed in the bottom of the Time and Distance chart. See example below.

Note: *If you have applied a* Time *and a* Value *offset, only one can be displayed at a time. When the channel with the value offset is selected, a box is drawn around the offset value, highlighting it.*



Setting an offset

To set an offset manually: with this option enabled you can drag the active channel trace up and down on the chart until the desired offset is achieved, once the offset is set, exit the offset mode. **> Offset > Value**

An offset can be set numerically from a dialog or by manually moving the whole channel trace to the desired offset position.

You can specify a numerical offset in two ways:

Offset relative to original values

Selecting this method allows you to offset the whole active channel by a value. For example, if a ride height sensor has not been zeroed correctly, you can offset the ride height trace by the amount that the sensor is out.

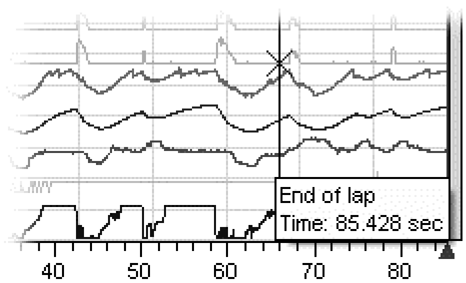
Offset to a target value

Selecting this method, channel values will be offset so that the value at the current cursor position becomes the value shown.

> Offset > Set Value Offset

Pin Event markers

Holding the cursor over an event marker will display Name and Time of the event. You can 'Pin' event information by clicking the marker. A pinned marker will be displayed in Print Preview and will appear on a printed output of the display. To unpin the event click on the display again.



Setting the size of the Plot region

Including cursor values and a map on Time/Distance Charts reduces the plot region in the X-axis. You can extend the plot region, without switching off cursor values and maps.

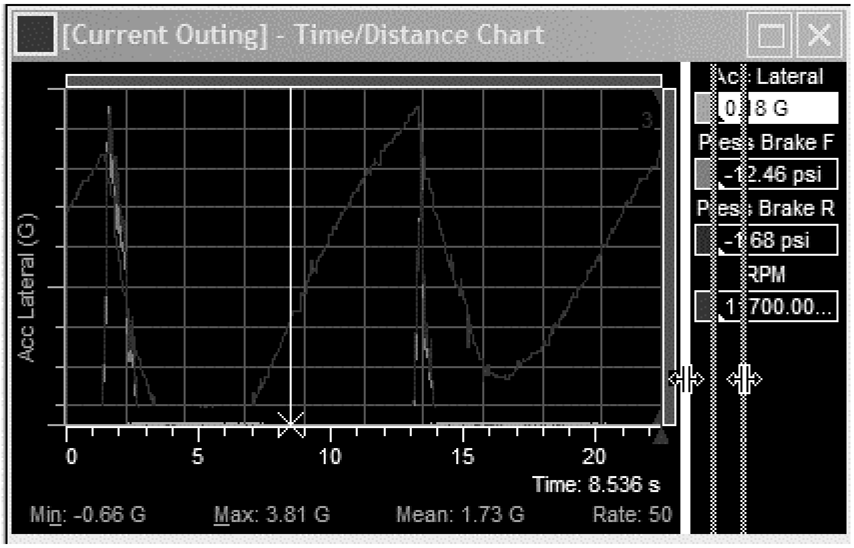
To extend the plot region:

1 Move the cursor to the end of the X-axis

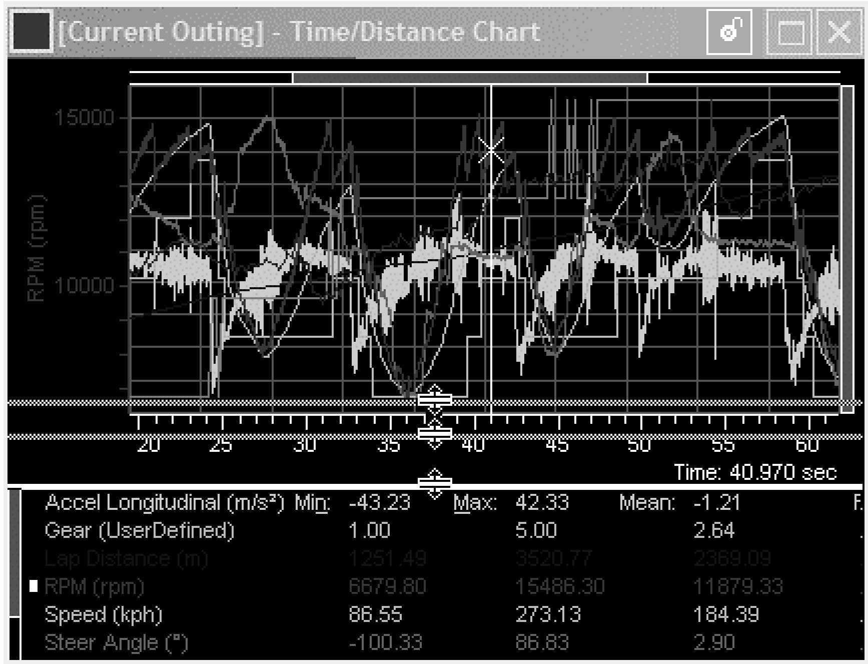
The cursor changes to and the plot region border is drawn.

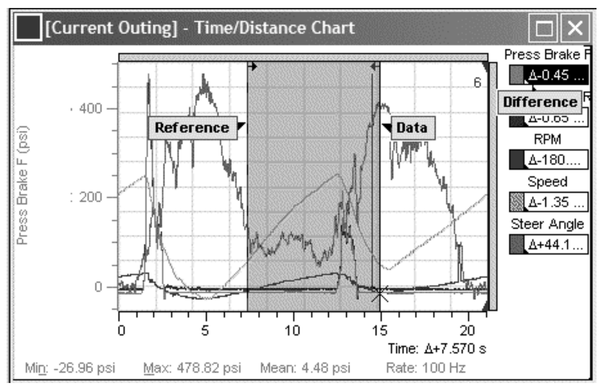
2 Click and drag the plot region border.

The cursor values region is reduced and may result in the legends becoming partially hidden.



You can adjust the space allocated to the statistics region in the same way. Hold the cursor between the statistics region and the plot region. This method only applies when the All Traces option is selected on the Properties dialog (show statistics for all traces).





Setting the Reference cursor

Setting the Reference Cursor on a Time and Distance Display forces the cursor value legends to show cursor values relative to the Reference Cursor Location. This applies to both Time and Distance mode displays.

To set the Reference cursor:

1 Move the Data Cursor to a point on the active channel trace where you want to place the Reference Cursor.

2 Press R

The Data Cursor position now becomes the reference point.

3 Click on a different point on the trace (alternatively click and drag the cursor).

The Data Cursor is re-drawn. The region between the Reference Cursor and Data Cursor is shaded in red (depending upon operating system used). All cursor values are given relative to the Reference Cursor location (zero), e.g. Δ 8.6 psi. The difference values can be positive or negative, depending upon where you place the Data Cursor on the trace.

Note: *The Time (or Distance) from the Reference Cursor is shown below the X-axis, e.g. Δ5.200s.*

Note: *Event times are also shown relative to the reference cursor position.*

Using Lap markers

Lap markers are indicated by a vertical line intersecting all traces. A number to the top left of the marker indicates the number of the lap that has just finished. Lap marker menu options are accessed from the Time and Distance display context menu.

***Note**: The remove menu option is only enabled when the cursor is over the marker.*

Insert

It is possible that a car passing a beacon would not record the event. For instance, an overtaking car may obscure the beacon. In this case the user needs to add a lap marker to an outing. Added lap markers cause all following lap markers to have their lap number increased by 1. Note that:

- A lap marker can only be edited in Pi Datasets.
- A lap marker cannot be added with the same time as an existing lap marker.

Remove

A lap marker may need to be removed if it was added in the wrong place, or if there are spurious lap markers in an outing (most likely generated by lap beacons at the track with duplicate codes). When a lap marker is removed, all subsequent lap markers and lap numbers are decreased by 1.

Move

If an adjustment to the lap beacon position is required, a correction can be made on the display by shifting the lap markers.

You specify the distance along the track that you want to shift lap markers. All lap markers then adjust to the new virtual beacon position.

A lap marker:

- Can be shifted if derived from a hard End of Lap event or if inserted by the user.
- Cannot be shifted if it derives from a Car Halt event.
- Cannot be shifted past an existing lap marker.

A distance channel must exist at the current location of the lap marker, and the new position for the lap marker.

Reset

All lap markers can be reset to their original non-shifted times. Any inserted lap markers will be removed, and removed lap markers will be reinstated, when the reset command is executed.

Note: *Editing a lap marker does not alter the 'End of Lap' events.*

To export Real-time data from a Time and Distance display:

1 In the Real-time display select: **> Export > Displayed data**

It is recommended that Pause Mode is selected prior to exporting the data in order to guarantee the export range.

2 Alternatively highlight the required outing in the Task Explorer and select: **> Export**

The Data Export Wizard opens.

3 Select the Channels to Export.

4 Select the Events to Export.

5 Browse for a File Location.

6 Select an Export Format option.

The options are: MATLAB, ASCII and Pi Dataset. See Exporting Data, Page 425.

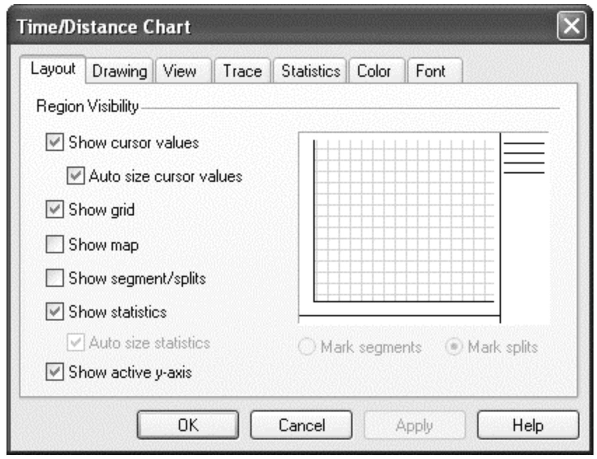
7 Check Summary and Click Finish.

Properties

To display the *Properties* screen, right-click on the Time/Distance chart to display the shortcut menu. Click **Properties**.

Or select: **> Properties**

Layout



Show cursor values: Displays cursor value legends for the selected channels.

Auto size cursor values: calculates the maximum width required to show the cursor values / channel names in full, and adjusts the display area automatically.

If the cursor value region is resized manually, auto sizing is disabled.

Show grid: Display a grid to aid data visualization.

Show Map: Places a pictorial representation of the circuit map in the display, to provide a visual reference to track position for a given data point.

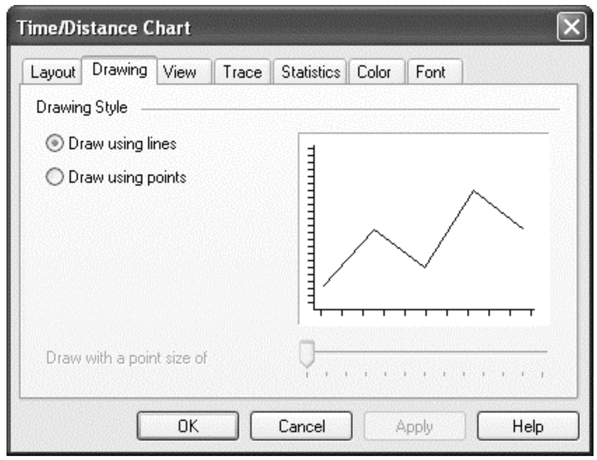
Show segments/splits: places a segment bar along the full extent of the x-axis which represents the Map's segments and split beacons. Vertical reference lines are drawn at each segment or split beacon (depending upon which is selected).

Show statistics: places maximum, minimum, mean values, and where applicable, rate of data acquisition, for the active channel, beneath the x-axis.

Auto size statistics: If checked, the statistics region will automatically adjust vertically, so that all statistics are visible beneath the plot region. This only applies if the 'All Traces' option is selected on the statistics tab of this dialog. If not checked, a scroll bar is provided on the left of the statistics region.

Show active Y-axis: displays the active channel axis closest to the plot region.

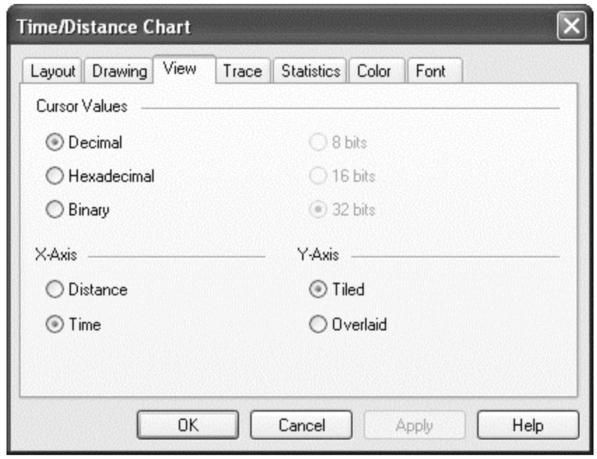
Drawing



Draw using lines: Data points are connected by a line to render a trace on the display.

Draw using points: Each data value is drawn as a point. With ‘draw using points’ selected, the slider is enabled. Use this to increase or decrease the size of data point when rendered on the display.

View



Cursor Values: Sets the display mode of cursor values.

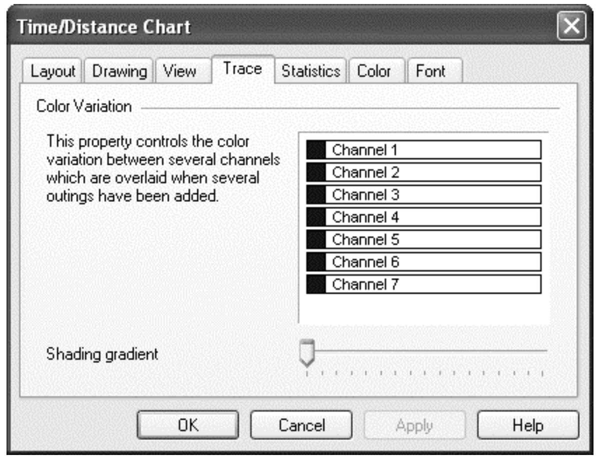
When Hexadecimal or Binary mode is selected, the Bit depth buttons are enabled.

The values will be limited to 8, 16, or 32 bits when in hex and binary mode. If 'Auto size cursor values' is checked (Layout tab) the cursor value region will adjust automatically.

X-Axis: Display values against time or distance in the X-axis. With a Time and Distance display selected, press D to toggle these modes.

Y-Axis: Traces can be tiled or overlaid. With a Time and Distance display selected, press T to toggle these modes.

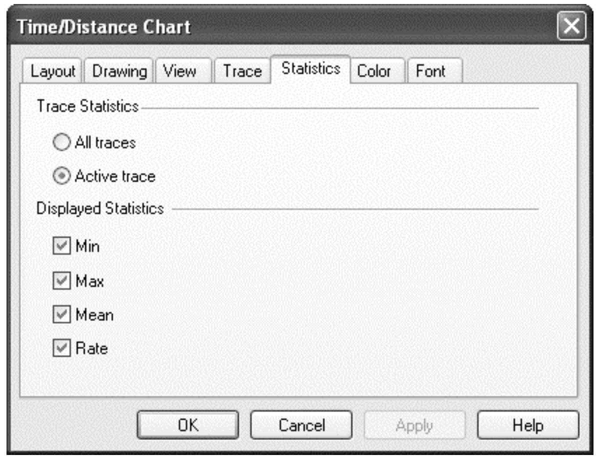
Trace



In displays with multiple data selections, the Trace properties page can be used to progressively vary the color applied to channel traces over the range of data selections. Use the Color Variation slider to increase or decrease the intensity of the color variation.

Statistics

Channel statistics: maximum, minimum, mean values, and where applicable, rate of data acquisition, are displayed beneath the plot region of the display.



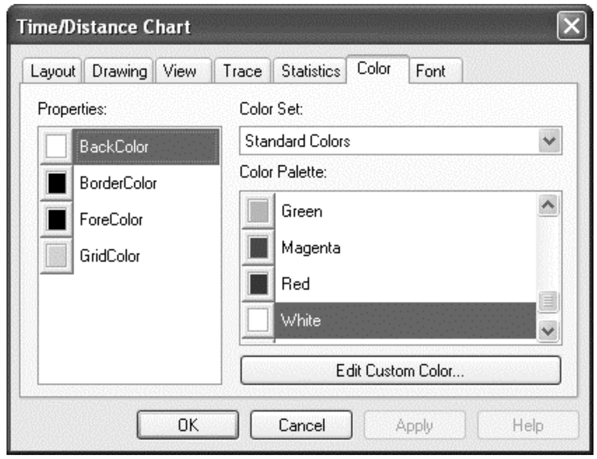
All Traces: Select this option to display statistics for every channel selected for the display.

Active Trace: Select this option to display statistics for the active channel only.

Note: *With '**All Traces**' selected, there may not be sufficient space to display all statistics. In this case a scroll bar is provided to the left of the statistics. A splitter bar is also provided between the plot region and the statistics region to allow the space allocated to each to be adjusted.*

Displayed Statistics: Select the statistics that you want to be displayed. The Channel statistics: maximum, minimum, mean values, and where applicable, rate of data acquisition, are displayed beneath the plot region of the display.

Color



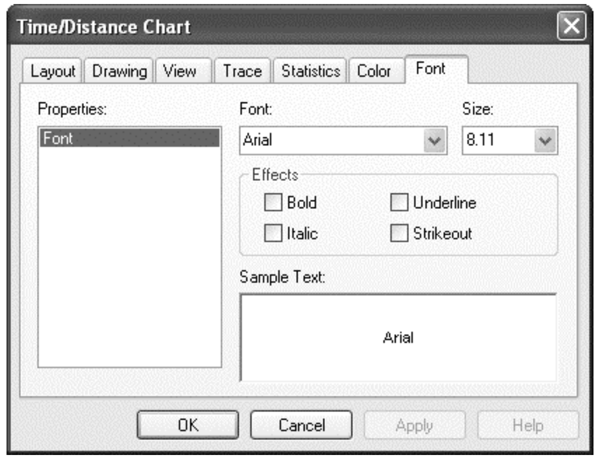
Properties: The various elements of the plot region are listed in this window with their assigned colors.

Color Set: Allows you to choose Standard or Windows System colors.

Color Palette: Shows the colors available for the Color Set selected.

Edit Custom Color: Opens the custom color palette.

Font



The standard Windows Font dialog controls the fonts used in the plot region of the display.

Histograms

A histogram is a graphical method of displaying the distribution of data against time, or as a percentage of total time, in the form of a bar chart.

Each bar represents how long each channel spends between two bin values.

For example a histogram may be used to display the time a car spent in each gear, helpful in determining if the gear ratios are correct for a given set of conditions.

The **Y-axis** displays the range of values of the active channel, divided into a number of bins. The axis is displayed in the color of its associated channel.

The **X-axis** shows the absolute time or percentage of time that each channel spends between two bin values.

The **Bin-axis** (to the right of the plot area) shows the absolute time and percentage of time for every bin.

Shortcuts

Shortcut	Description	Menu
↑ ↓	Changes the active channel.	> Properties
Alt + ↵	Displays the Histogram Property dialog.	None
Ctrl + ⇧ + C	Copies bin values for all channels and all data selections to the clipboard.	> Layout > Tile bins/ Overlaid bins
T	Tile/Overlay y-axis mode.	> Copy as Text

Features

The Active channel

In a display one channel is the 'Active' channel, or the channel in focus. For visual reference the y-axis scale is displayed in the same color as the active channel. You can scroll through the available channels using the ↑ ↓ keys, making each in turn the active channel.

Display scales as a time or a percentage

You may need to view data as a percentage of total time or as an absolute value, i.e. the car spent 45 seconds at full throttle in a lap of 1 minute 20 seconds.

Display an X and Y-axis with graduations

An axis and its associated graduations are used as a visual reference to data values when analyzing data and debriefing drivers. The Y-axis is shown in the same color as the active channel. For clarity, the X-axis is the reverse color of the background.

Change the number of divisions or bins

You can vary the number of divisions - 'bins' - within the data, up to a maximum of 32.

Zoom the data range in time or distance.

You can limit the data region in the X-axis, over which the data is displayed, by either time or distance. For example, you may wish to analyze damper velocity distribution on the main straight only.

Show vertical bins

Histograms can be displayed in a vertical orientation by selecting ‘Show Vertical Bins’ in the Property dialog. In this mode, the bin values are shown at the top of the plot area and the range of values displayed at the bottom.

Linked zoom

Displays within a Workbook that share the same task, can have their zoom level linked together. With two or more displays in a task linked, zooming in on any of the displays will cause all linked displays to zoom to the same level, i.e. share the same X-axis time region.

Copy bin values as text

Using the ‘Copy as Text’ context menu command, the bin values for all channels and all data selections can be passed into an Excel spreadsheet in a tab de-limited format.

Multiple Axes

A separate Y-axis and Bin axis can be displayed for every channel selected in the Histogram. The feature can be switched on and off in the Property dialog. It can be selected for screen only, print only or both.

When the feature is switched off the axes displayed are for the active channel only, when the feature is activated, the axes for the active channel are displayed closest to the plot area. If you change the active channel then the channels will be displayed so that the new active channel is displayed closest to the plot area. Histograms having multiple data selections show multiple axes for each data selection.

Note: *You can change the active channel in the following ways: using the up and down arrow keys, by clicking on the Y-axis or Bin axis of the ‘non-active’ channel and by clicking on a bar in the plot area.*

Non-linear bins

By default, the Histogram shows an equal number of bins for all channels selected for the display. Users can set specific channels to show non-linear bins, i.e. the bin count and intervals can be set separately for individual channels. In non-linear mode, a channel's bin count and intervals is determined by the color gradation property in the Property explorer.

Displaying non-linear bins

1 In the Properties Explorer select the channel that you want to display in non-linear bins.

2 In the lower pane click the button adjacent to the Color Gradation property.

3 The Gradation Properties dialog opens.

4 In the 'Type of color gradation' field select: Discrete.

5 Click to add the required number of bands - this will determine the number of bins.

6 Select each color band in turn and in the right-hand window expand the 'Bounds' node (if necessary) and set lower and upper bound values.

Note: *Altering the lower bound will affect the upper bound of the preceding color band. Altering the upper bound will affect the lower bound of the proceeding color band.*

7 Click *OK* to close the dialog box and accept the changes.

8 Go to the Histogram display and select the channel for the display.

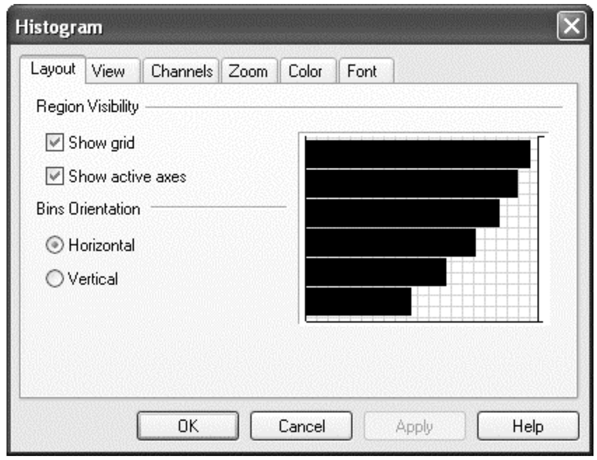
9 Select: > Properties to open the Properties dialog and select the Channels tab.

10 Select the 'Non-linear Bins' and 'Color Gradation' checkboxes.

11 Click OK to return to the Histogram.

Properties

Layout



Region Visibility

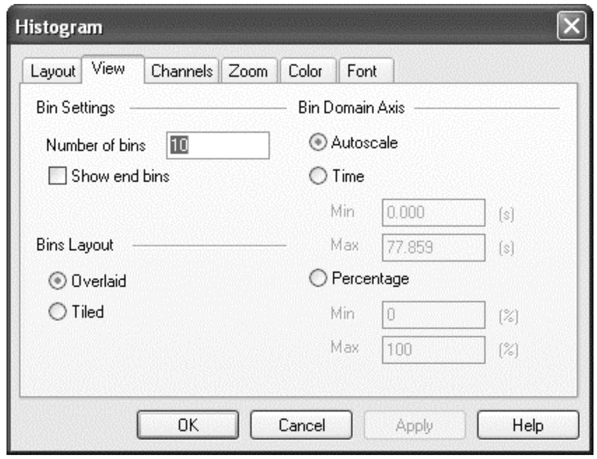
Show Grid: Switches the background grid On and Off.

Show active areas: Toggles the X-axis on and off.

Bins Orientation

Determines the orientation of the display between Horizontal and Vertical.

View



Bin settings

Number of bins: Sets the number of divisions 'bins' of data. The default value is 10 bins. If, for example, engine speed were the active channel, the total engine rev range would be divided into 10 bins. With the channel maximum value set at say 14,000rpm the first bin would be 0 to 1400 rpm; and the last bin would be 12,600 to 14,000.

Note: *Data falling outside of the display minimum and maximum values set for the channel (the data range) can be displayed in End bins.*

Show End Bins: Shows the total value of the data that falls outside of the data range set (display maximum and minimum) for the channel. For example, the time, or percentage of total time, that a value spent above a set maximum limit, would be shown in the End Bin.

Bin Layout

Overlaid/Tiled: Bins can be overlaid or tiled. Tiles hold one channel only but can hold multiple outings of that channel. When in tiled mode the shown bins will be grouped by channel, not by bin number. Toggle modes by pressing 'T'.

Bin Domain Axis

***Autoscale*:** When checked, Autoscale adjusts the X-axis scale to the highest value of data found in all the channels displayed on the histogram, and then adds 5%. This ensures that data is displayed on the full width of the histogram whilst leaving a 5% margin. When not checked the X-axis scale is determined by the Max and Min field values set for Percentage and Time.

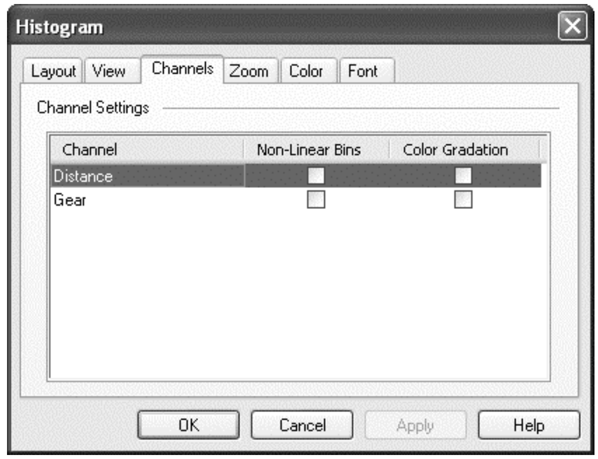
***Note**: Autoscale affects all channels displayed on the histogram. You can set auto scaling in the Y-axis for individual channels in the Properties Explorer.*

***Percentage*:** With *Percentage* selected the X-axis shows the percentage of total time occupied by data in each bin. The scale default max is 100%. The highest value of data found is displayed as 100% of the X-axis (with Auto scale off). If, for example, you select 50% max, only half of the highest value of data will be displayed.

***Time*:** With *Time* selected the X-axis shows absolute values for data in each bin. With Autoscale off the range of the X-axis is determined by the Max and Min value fields.

Channels

The page lists the channels in the Histogram and enables them to be selected for displaying in non-linear bins mode. The bin count and intervals are determined by the color gradation property in the Property explorer.



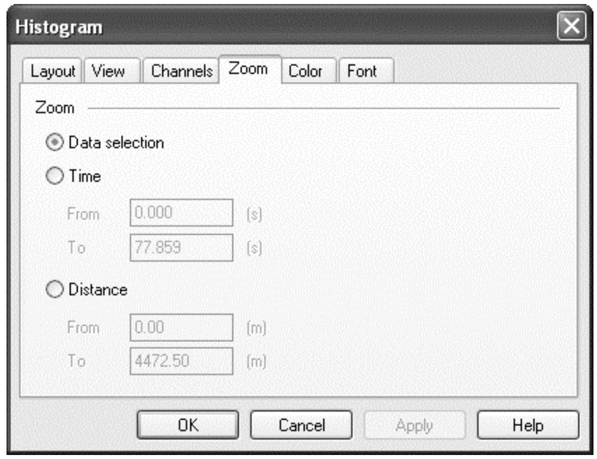
Non-linear bins: When selected the bin count for the channel is determined by the number of steps selected in the color gradation property for that channel (in the Properties explorer). The bin intervals are determined by the boundary settings for the property. In this mode the bin setting for the display (View page) is ignored.

Note: *The color gradation mode must be 'Discrete' for non-linear bins to function.*

Color gradation: When selected the bins are displayed in the colors set in the color gradation property. This option can be selected separately from the non-linear option above. Color gradation mode can be Discrete or Gradient.

Note: *Non-linear bins will only function with one data selection added to the task.*

Zoom



Data Selection: When selected, the data plotted is taken from the full extent of the outing data.

Time: When selected the 'From' and 'To' fields are enabled. Adjust these times so that the plotted data is taken from a specific time period, effectively zooming in on that portion of data.

Distance: When selected the 'From' and 'To' fields are enabled. Adjust these distances so that the plotted data is taken from a region in the outing that corresponds to a specific portion of the track.

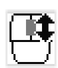
Note: For information about customizing the appearance of the display, see page 258

X-Y Charts

X-Y Displays graphically illustrate the correlation between two channels plotted on Cartesian axes, and identify patterns of behavior. This chart can be used in both Historic and Real-time modes.

Typical uses may be to analyze the suspension stiffness of the car by plotting wheel force against wheel displacement, or to analyze the engine oil system performance by plotting engine oil pressure against engine RPM. X-Y display can support up to 16 pairs of channels to display.

Shortcuts

← →	Moves the X cursor to the next/previous data point.
⇧ + ← →	Moves the X cursor through the data quickly.
Home End	Moves the X cursor to the beginning or the end of a trace.
↑ + Ctrl + P	Show / Hide the Polynomial curve.
↑ + Ctrl + U	User defined Polynomial
↑ + Ctrl + E	Copy Equation.
↑ + Ctrl + C	Copy Coefficients.
↑ ↓ Or ⇧ + 	Changes the active channel pair.
Alt + ↵	Displays the X-Y Properties dialog.
Z	Zoom in

←	Zoom out
Ctrl + ←	Undo all zooms

Features

Active channel pair selection

On an XY display one pair of channels is the “Active” pair (active trace), or the channel pair in focus. For visual reference the Y-axis scale is displayed in the same color as the active pair. You can scroll through the available channel pairs using the ↑ ↓ keys, making each in turn the active pair. Active channel pairs are persisted when the workbook is saved and subsequently opened. They are also persisted when the display is exported.

Data cursor

There are two cursors. The free cursor '+' snaps to the nearest data point to the mouse cursor and follows the mouse movements. The task cursor 'X' cursor is drawn at the nearest data point to where you click. The task cursor is locked to this data point until you click again or click and drag. In a Worksheet two or more displays (XY and Time/Distance) can be connected to the same Task. You can click and drag the task cursor around the data region in XY Displays to move the cursor simultaneously in all other displays connected to the same task. This is known as the 'Task Cursor' concept.

Data Range zooming

The time region of the X-axis is displayed below the axis and shows the time region in which data is calculated. By default the PSD display's time region is the whole of the data selection, indicated on the display by the legend - TR: [Data Selection]. Using the Zoom tab on the Properties dialog, the user can determine a specific time or distance range for the X-axis, effectively zooming in on a portion of data. The time region legend shows the specific time/distance region selected, e.g. TR: [0.00..60.00] or DR [0.00..4500.00]. Note that the time/distance range is applied relative to the beginning of each data selection.

Polynomial curves

Polynomial Curves represent the polynomial relationship between two channels. For example, when comparing left and right suspension stiffness, there are two pairs of channels, *FL_Load* against *FL_Displacement* and *FR_Load* against *FR_Displacement*. There will be two polynomial curves. When polynomial curves are ON, the active polynomial equation (the active channel pair) is displayed below the X-axis as an indication of the curve's fit.

User defined Polynomial curves

Users can change the offset and/or gradient of first order polynomials that have been automatically generated. This may be useful for graphs that include some non-linear points in the plot area that cause an undesirable polynomial to be generated. Editing is achieved by dragging the whole line, or the end points of the line, with the mouse.

Zoom and Scroll in the Data region

Using the mouse or menu commands you can zoom the data to investigate an area of interest. Horizontal and vertical scroll bars allow you to pan the zoomed area.

Linked Zooming

Displays sharing the same task can have their zoom level linked together. When linked zooming is enabled, zooming in on one display will cause all other displays to zoom to the same level, i.e. share the same time region. In X-Y displays the display would show only the data between the start and end zoom time.

Data value legends

The 'Cursor' legend shows the data values for the task cursor position and only changes when you click in the data region or click and drag. The 'Closest' legend shows the data value at the free cursor. The 'Polynomial' legend shows the value of the polynomial curve at the point nearest to the free cursor.

Auxiliary Axes

A separate X-axis and Y-axis can be displayed for every channel pair selected for the display. The feature can be switched on and off in the property dialog and can be selected for screen only, print only or both. When the feature is switched off the axes displayed are for the active channel pair only. When switched on, the axes for the active channel pair are displayed closest to the plot area. Changing the active pair re-orders the axes so that the new active pair's axes are nearest to the plot area. Displays having multiple data selections show multiple axes for each data selection.

Copy and Paste polynomial expressions

Copy Equation and Copy Coefficients commands are used to copy the polynomial expression in the following formats: Plain text for pasting into text processing applications, e.g. Notepad; Rich text format for pasting into RTF aware applications, e.g. Word; and Tab delimited coefficients for Excel.

Displaying data in three dimensions

The XY charts can show data in 3 dimensions by using a third channel (**C**) to color the XY plotted data points via the color gradation scheme applied to the channel.

Real-time features and behavior

XY charts can be used to display historic and real-time outings. See **Setting up a Real-time Display**, page 241 to find out how to add a Real-time outing.

The following list describes the behavior of XY charts in Real-time mode.

- When Real-time mode is paused, the display behaves and functions in exactly the same way as in **Historic mode**.
- The Polynomial is disabled and the Polynomial values are not shown.
- Zooming the data region is disabled and all current data zooms are discarded.
- The display zoom is not affected.
- The free cursor is disabled and its values are not displayed.
- The time region indicator displays: **TR [data selection, real-time]**

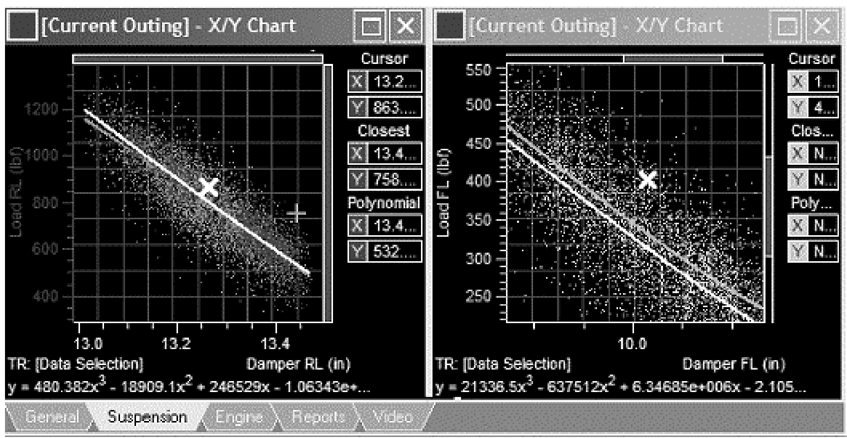
Working with X-Y charts

The Task cursor concept

Other charts connected to the same task share a common Data Cursor position. In XY charts the task cursor 'X' is fixed until you click (or click and drag) in the data region. The task cursor snaps to the point nearest to where you have clicked (or if you are dragging, the point where you release), The cursor moves simultaneously in other XY charts, or Time/Distance Charts, connected to the task.

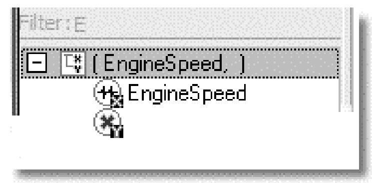
This allows you to copy a display and, by setting different zoom levels, view data in detail on one display while maintaining an overview in the other. You can also compare the same data in an XY chart and a Time/Distance Chart.

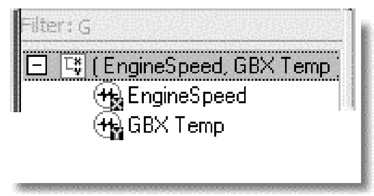
You can copy a display by 'Ctrl + click and drag' on the display title bar.



Selecting Channel pairs

Channels are added in pairs to XY charts up to a maximum of 16 channel pairs. After creating the XY Display and connecting it to a task, you can select channel pairs to be displayed. Initially, the details pane will display 'No Selection'.





To select a channel pair:

1 Double-click the first channel or press 'Enter'

The channel appears in the details pane. The icon indicates that the first channel will provide x-axis data.

2 Double-click the second channel or press 'Enter'

The icon indicates that the second channel will provide Y-axis data.

Note: *Repeat the above steps to create multiple XY plots, e.g. Speed-RPM, Speed-Oil Pressure.*

To swap the XY assignment of channels:

- Highlight the pair header and select: **> Swap**

The X and Y channels swap their assignment.

To remove a channel pair:

Highlight the pair header and select: **> Remove**

You can replace either channel in the pair by highlighting one and selecting: **> Remove**, then selecting another channel to replace it from the Available Channels list.

Showing or hiding the Polynomial curve

When you add a channel pair to an XY display a polynomial curve of the third order is automatically generated and displayed. You can choose to change the order or of the curve or hide it.

***Note:** Changing the Polynomial order affects all channel pairs added to the display, it cannot be set for individual pairs. Likewise the Show/Hide commands affect all channel pairs.*

- With the XY display in focus select: ***> Polynomial > Show Polynomial***.

  The checkmark is removed from 'Show Polynomial' and the curve is hidden.

***Note:** You can also use the keyboard shortcut* ⇧ + Ctrl + P

To change the polynomial order

- Select: > Polynomial > Polynomial Order > 1, 2, 3, 4, 5 or 6

Alternatively, the Polynomial order can be set in the Properties dialog.

Creating a user defined Polynomial curve

First order Polynomials can be re-defined if required. This can be useful where graphs include some non-linear points in the plot area that cause an undesirable polynomial to be generated. User defined Polynomials can be created individually for each channel pair.

To change the Polynomial curve

1 With the XY Chart in focus select the required channel pair using the arrow keys to scroll through the available pairs.

***Note:** The selected channel pair becomes the 'Active' pair. The Polynomial Curve of the Active pair is drawn in black.*

2 **Select:** > Polynomial > User Defined Polynomial.

***Note:** You can also use the keyboard shortcut* ⇧ + Ctrl + U.

'Grab' handles are added to the ends of the Polynomial line. When the mouse cursor is held over the Polynomial, the line becomes bold to indicate that it is in user-defined mode.

3 To change the offset of the Polynomial, hold the mouse cursor over the middle part of the line, left click and drag the line to a new location.

4 To change the gradient of the line, hold the mouse cursor over either of the line's endpoints, left click and reposition.

Note: *You can revert to the automatically generated Polynomial at any time by selecting* ***> Polynomial > User Defined Polynomial*** *again. User defined Polynomials are not persisted when the Workbook is closed.*

Tip: *You can replace one or both of the channels in a pair. Right click on a channel in the Available Channels list and choose 'Select as X in.' or 'Select as Y in.'. The submenu displays a list of existing channel pairs. Choose one of the pairs to insert the new channel as X or Y data.*

Adding a C channel to a display

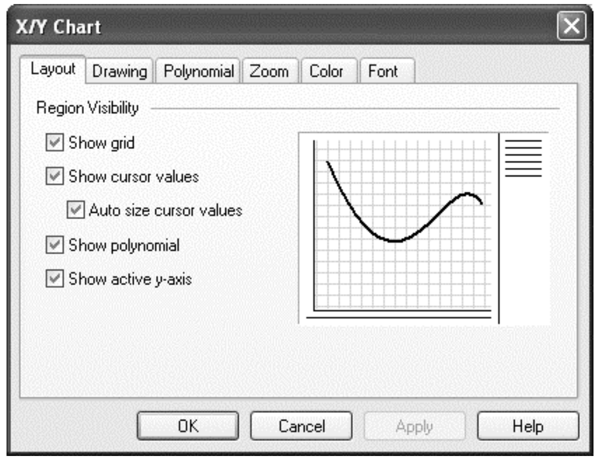
A third channel - C, can be added to any existing channel pair on a XY chart or added at the time of configuration to make it an XYC chart. The extra channel will display data using its color gradation scheme, adding an extra dimension to the chart.

To add a C channel to a display:

- The C channel can either be added to an existing channel pair - in the Channel explorer, ***> Select as C***
- To add a C channel at the time of configuring a chart, in the Channel explorer, multiple select the channels you want to add to the display, select the 3rd channel or C channel, this will be shown with the following icon: 

Properties

Layout



***Show grid*: ** Display a grid to aid data visualization.

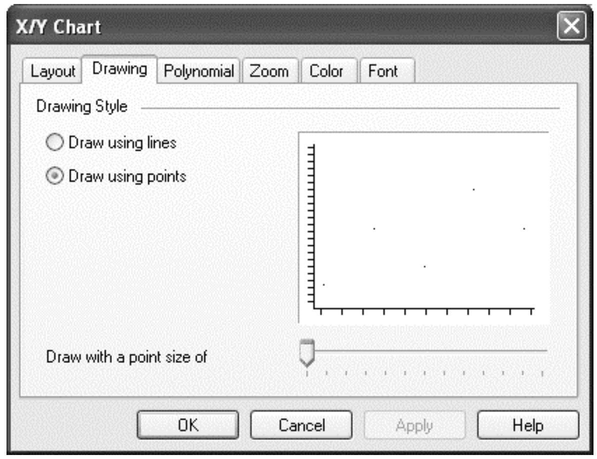
***Show cursor values*: ** Displays cursor value legends for the selected channels.

***Auto size cursor values*: ** Calculates the maximum width required to show the cursor legends in full, and adjusts the display area.

***Show polynomial*: ** Displays the polynomial curve on the plot region.

***Show active Y-axis*: ** Displays the active channel axis closest to the plot area.

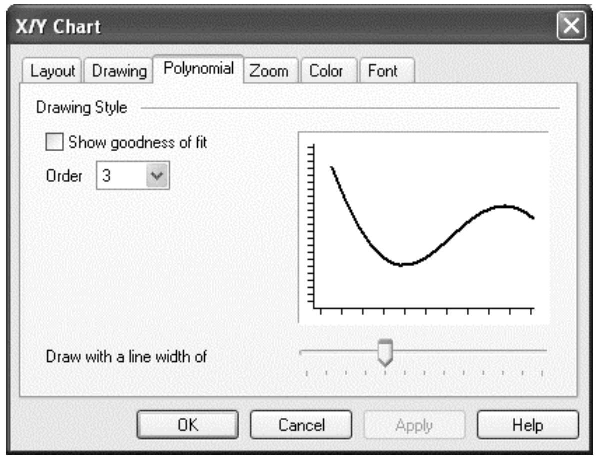
Drawing



Draw using lines**:** Data points are connected by a line to render a trace on the display.

Draw using points**:** Each data value is drawn as a point. With Points selected, the slider is enabled. Use this to increase or decrease the size of data point when rendered on the display.

Polynomial

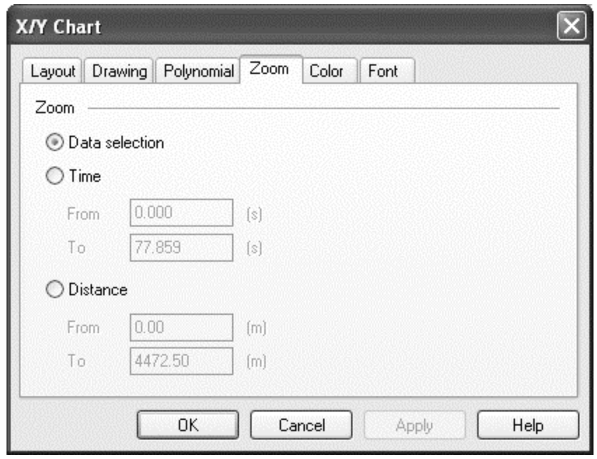


Show goodness of fit: How well data matches the reference model defined by the polynomial curve.

Order: Order of the Polynomial from 1st to 6th. Defined by the reference model being compared with the data.

Width: The Width slider increases or decreases the width of the polynomial curve rendered on the display.

Zoom



Data selection: When selected, the data plotted is taken from the full extent of the outing data.

Time (sec): When selected the 'From' and 'To' fields are enabled. Adjust these times so that the plotted data is taken from a specific time period, effectively zooming in on that portion of data.

Distance: When selected the 'From' and 'To' fields are enabled. Adjust these distances so that the plotted data is taken from a region in the outing that corresponds to a specific portion of the track.

Note: For more information about customizing the appearance of the display, see page 258

The Split report display

The Split Report displays channel data per map sector in a spreadsheet format, using laps as row headings and sectors as column headings. Additional columns containing Lap performance, differences between current and fastest lap, and two additional rows containing the fastest rolling lap and theoretical fastest lap data can be displayed. The Split report also displays outing details, outing short comments and optionally the outing report type.

The display can work in both historic data and real-time modes:

- In real-time mode the report updates continuously, with the latest lap data always being displayed. The scroll bar is disabled until Pause mode is entered.

  Use the keyboard shortcut P to activate/deactivate the Pause control.

- Historic mode displays data for the complete outing. Scroll bars are displayed and are active.

Split report features

Types of Split report

There are 3 types of split report that you can choose from:

- Auto
- Hard
- Soft

The display checks the outing for any Soft or Hard splits, if none are detected then the display defaults to auto. If any splits are detected then the display will default to the type of split detected.

Exporting to MS Excel

Selecting Export to Excel from the context menu will open MS Excel (if not already opened) and export the Split report to a new worksheet in the current workbook. The layout in MS Excel will match the layout of the Split report.

Pause mode in Real-time

Entering Pause mode inhibits further data from reaching the display. The scroll bar becomes active, allowing scrolling through previous laps from the outing. When Pause mode is cancelled, the buffered data will be added to the report and continuous updating will resume.

Connecting to a single outing

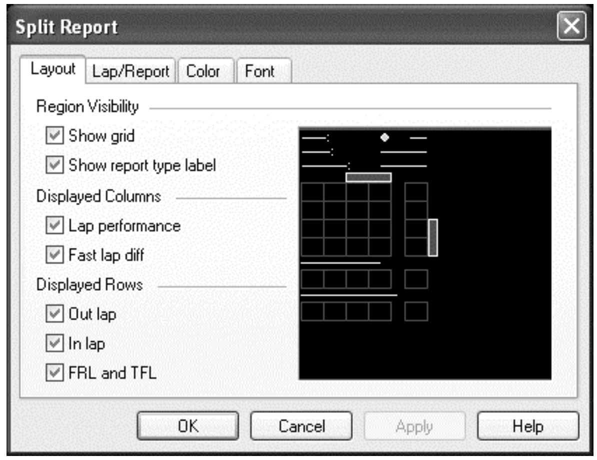
The display shows data for a single channel in a single outing. Where tasks contain multiple outings. The information displayed can be changed by connecting to another outing.

Copying the data as text

The display can be pasted as text into an MS Excel spreadsheet by using CTRL + SHIFT + C to copy the display and CTRL + V to paste the display into the spreadsheet.

Split report properties

Layout



Show grid: Check to show grid lines on the display.

Show report type label: Check to show the table header information.

Lap performance: Check to show the lap performance column. This could be either lap speed or lap time depending on the global setting.

FL difference: Check to show the fastest lap column.

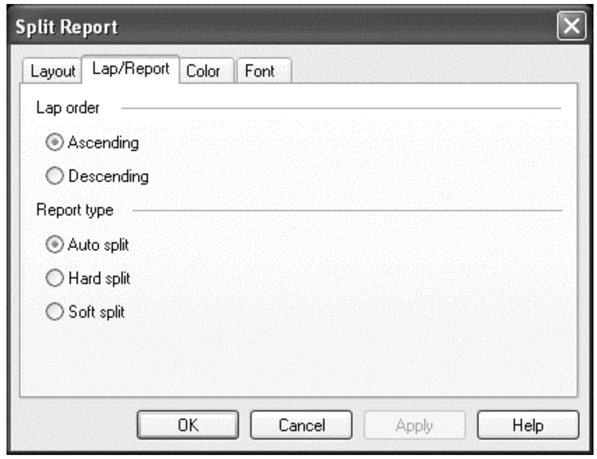
Out lap: Check to show the out lap row.

In lap: Check to show the in lap row.

FRL and TFL: Check to show the Fastest rolling lap and Theoretical fastest rolling lap rows.

Note: *All options are enabled by default.*

Lap/Report



Ascending: Click to set the lap order to ascending.

Descending: Click to set the lap order to descending.

Auto split: Click to set the type of split report to Auto.

Hard split: Click to set the type of split report to Hard.

Soft split: Click to set the type of split report to Soft.

Creating a Split report and setting the telltales

The following steps assume that you have created a task and loaded the datasets that you want to report on.

1 Select: **Insert > Display > Split Report**, or use the *Insert Display* button.

An empty Split report display is added to the worksheet.

2 Select: **Data > Connect** and select the required task.

3 With the report display in focus, go to the Selection Explorer (Alt + 2) and select the channel required for the report.

The display is populated by data from the selected channel. Maximum channels are shown by default.

***Note:** All laps in the outing are reported on, regardless of the current data selection.*

4 In the Split report, select the desired telltale for each sector from the dropdown list.

Changing the connected outing

When a Split report is added to a worksheet and connected to a task, the report is initially connected to the first outing added to the Task.

Highlight the appropriate outing and select: **> Connect**.

The outing icon will change from this: to this: to show that it has been selected.

Split report display shortcuts

Shortcut	Description	Menu
Alt + ↵	Display the Split report property pages	**+ Properties**
⇧ + F10	Display the Context menu for the Split report	
Ctrl + ⇧ + C	Copy the data as text	**N/A**
P	Pause the Real-time display	**> Local Pause**

The Summary display

The Summary display is made up of 3 features. You can display any or all of the features at any time.

A Channel display: Up to 4 channels can be displayed, with the option of using channel alarms.

A Map: The map displayed is for reference only.

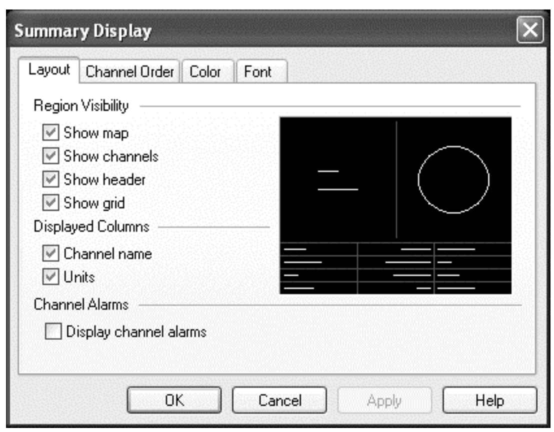
Lap performance: The lap number and either lap time or lap speed is displayed depending on the global setting in the workbook.

Note: *The Lap performance information is always displayed.*

The Summary display can also be shown on a Palm PDA running Pi Remote Toolbox. For more information see Pi Remote Toolbox on page 300

Summary display properties

Layout



***Region Visibility*:** This section controls how the features in the Summary display are displayed. The channel list and map are optional, the Lap information is always displayed.

***Show map*:** Display the map. A miniature map is drawn in the preview pane, to illustrate how the Summary display will look.

***Show channels*:** Show or hide the selected channel information.

Note: *If the Show channels option is disabled, all features that relate to this option are also disabled. When the feature is re-enabled, the associated features will also be re-enabled.*

***Show header*:** Display a heading row in the channel table.

***Show grid*:** Display the channel table within a grid display.

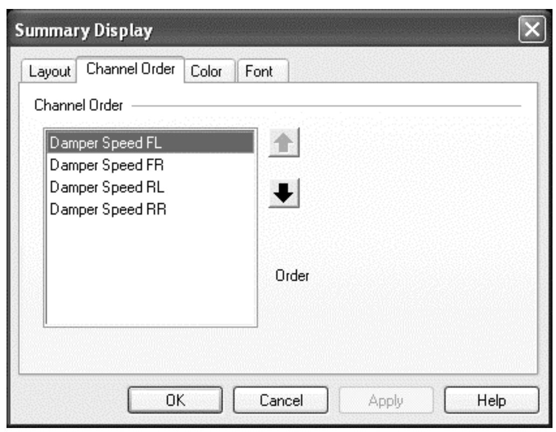
Displayed columns

***Channel name*:** Check to show the selected channel names.

***Units*:** Check to show the associated units with the channels.

***Channel alarms*:** Displays or hides channel alarms.

Channel Order



This page controls the order that the channels are displayed in the channel table. To move a channel up or down in the table, select it and change its position using the *Up* or *Down* arrow.

Color

From here you can set the color for the display. To change a color, select the color to be changed in the *Properties* section, then select a new color from the color palette. You can choose between two color palettes.

Font

You can set fonts the information displayed in the Channel display here. Select the Font to be altered in the *Properties* pane, edit the settings and preview the result in the *Sample text* pane.

Font	Default paragraph font, showing channel values etc.
Header Font	Table heading row text (if enabled)
Performance Labels font	Label text for Performance value
Performance Values font	Performance value font

Channel display

This display enables channel names, values and units to be displayed in a list view on the worksheet. The display can work in both historic data and real-time modes and is generally used for viewing channel values for car parameters in real-time.

Note: *Only 4 channels can be displayed in the Channel display section of the Summary Display.*

- In real-time mode, the values of the last data sample of the channel are displayed.
- In historic mode, channel values are based on the position of the task cursor.

The default layout of the Channel Display is a column made up of three sub-columns: channel name, value and units.

The default channel color is indicated by a colored square adjacent to the channel name.

The principle of connecting tasks to a display and selecting channels for viewing, as in Time/Distance Charts, applies to Channel Displays.

Using Channel alarms

Alarms can be configured and displayed in the Channel display and Summary display.

To use the alarm function, you must do the following:

- Enable the Alarm function. This can be done in either the Channel display or Summary display properties.
- Set the Global alarm properties in the Channel Explorer.
- Add the channel to the display.

Setting local alarm properties

Once the channel is added to the display, you can set local alarm properties for any channel in the display.

This is a useful feature if you are monitoring a channel closely, as soon as the value changes, the alarm will be triggered.

- Select the alarm in the display, **> *Set Thresholds***. Keyboard shortcut S

The channel alarm thresholds are now locally set to the current value that is displayed in the table.

Note: *You can revert to the global alarm properties at any time. Select the channel in the display, in the Channel Explorer click the Display tab,* ***> Revert****.*

Summary display shortcuts

Shortcut	Description	Menu
Alt + ↵	Display the Summary display property pages.	**+ Properties**
⇧ + F10	Display the context menu for the Summary display.	
Ctrl + C	Copy the display	N/A
S	Set the low and high alarm thresholds to current channel value.	+ S
F9	Connect the display to Pi Remote Toolbox.	***Data > Remote display***
F10	Enable data transfer to Pi Remote Toolbox.	***Data > Pi Remote Toolbox***

Pi Remote Toolbox

Pi Remote Toolbox utilizes a PDA handheld device with a built in Bluetooth adapter as a wireless solution for viewing compatible Pi Toolbox displays.

When Pi Toolbox is installed, a folder called Remote is created in the Pi Toolbox directory. This folder contains a file called *PiToolbox.prc* and a file called *Mathlib.prc*. These files need to be installed on the handheld device by using the Hot Sync function between the PC and the handheld. For more information on using or installing the handheld device, refer to the supplied manufacturers documentation.

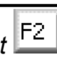
Note: *To successfully use Pi Remote Toolbox, you must have a suitably enabled Pi Toolbox dongle and be running Pi Toolbox V3.1 or higher.*

Before you can view the displays on a PDA, you must first select the communication protocol that is to be used to connect to the PDA. This is done on the *Preferences* dialog. Once the protocol is selected, you must configure Pi Toolbox to be able to transmit data to the PDA and the Pi Toolbox Remote software. This setting can be found on the *Data > Remote display* menu.

Compatible displays can now be selected within Pi Toolbox by clicking the enable remote icon  or by using keyboard shortcuts and view the information on a compatible PDA.

As handheld devices have lower screen resolutions than a PC, any activated display will change to match the remote version of the display. For example: The remote channel name property will be used and the list of displayed channels in a Channel list may be reduced so that the view on the PC closely replicates the image that is seen on the handheld device. When a display is shown on the handheld device, the following icon is displayed in the upper right corner of the parent display in Pi Toolbox .

A list of available displays can be navigated and selected on the handheld device once all of the required displays have been enabled for remote data transmission (maximum of 32).

Note: *The displays can be named using the keyboard shortcut* 

. This is the name that will appear on the display list on the handheld device.

Overview

To be able to successfully view Pi Toolbox displays on the handheld device you must carry out the following steps:

1 Install the Bluetooth PC adapter.

2 Configure the Bluetooth serial port.

3 Install the Handheld PDA.

4 Install the Pi Remote Toolbox application on the handheld device.

5 Start Pi Remote Toolbox.

6 Configure the displays in Pi Toolbox and check their operation with the handheld device.

Note: *This overview assumes that you have already installed a version of Pi Toolbox that supports Pi Remote Toolbox. If you haven't done so, you must carry this out before attempting any of the other tasks.*

Installing the Bluetooth PC adapter

Install the supplied Bluetooth PC adapter as per the supplied manufacturers instructions.

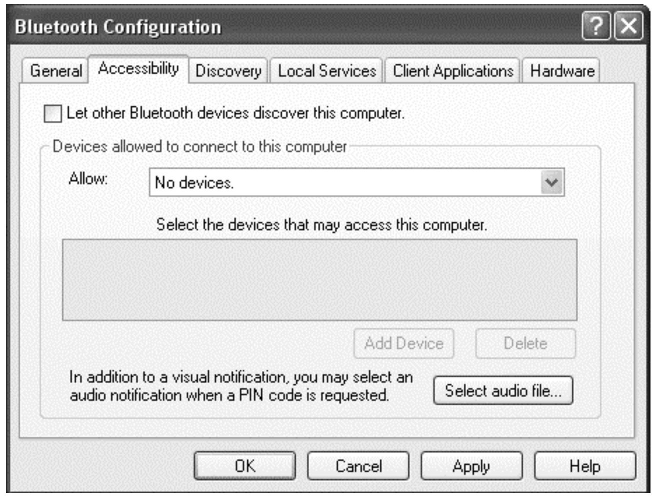
Setting up the Bluetooth serial port

Once you have installed the Bluetooth PC adapter, the Bluetooth serial port must be configured. You need to do this to configure the security options and to obtain the port details so that you can configure Pi Toolbox.

To set up the Bluetooth serial port

1 Right-click on the Bluetooth icon in the System tray to bring up the shortcut menu, select *Advanced Configuration*.

The *Bluetooth Configuration* dialog is displayed, click the *Accessibility* tab



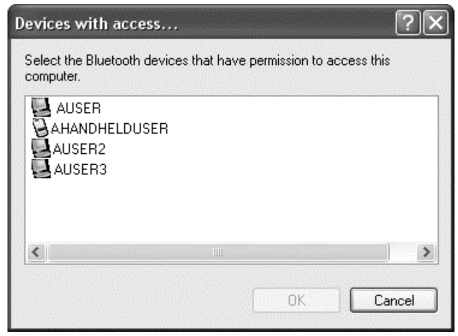
2 In the *Allow* field, select *Only Devices listed below* from the list.

This will mean that only devices added to a permissions list will be able to connect to the PC via Bluetooth.

3 Click Add.

The PC will search the network for Bluetooth devices.

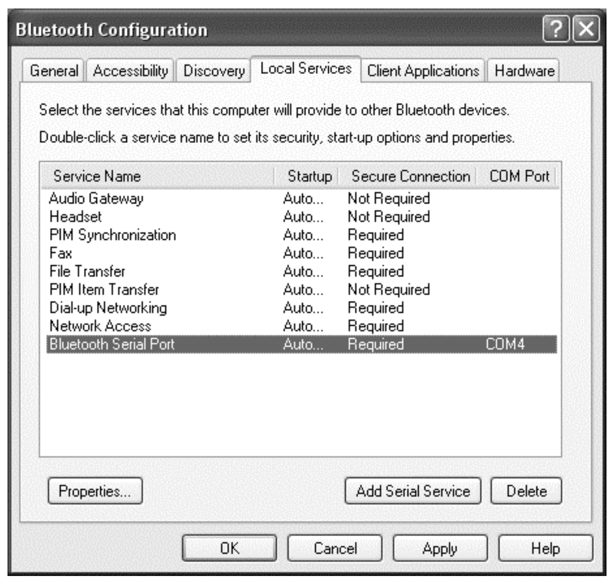
The Devices with access… dialog will be displayed.



4 Select the user(s) that you want to be able to connect to the PC.

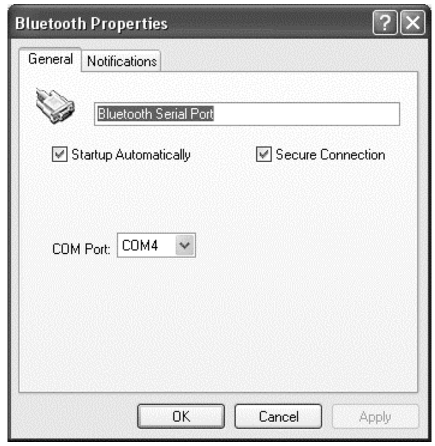
5 Click OK.

6 Click the Local Services tab.



7 Select Bluetooth Serial Port from the list, click *Properties*.

The Bluetooth properties dialog is displayed.



8 Click to select the *Startup Automatically* box if it isn't already selected. This will mean that your virtual Bluetooth port will automatically start when the PC is started. Remember the COM port details that are displayed. This setting has to be the same for the Bluetooth adapter and the handheld device.

Note: *Configuration for the handheld device COM port is done in Pi Toolbox.*

Note: *Pi Toolbox must use the same COM port number that is displayed in the Bluetooth properties dialog.*

9 Click OK.

10 Click OK.

Installing the handheld device

Install the supplied handheld device as per the supplied manufacturers instructions.

Installing Pi Remote Toolbox

The final step in configuring the elements of Pi Remote Toolbox is the installation of the *PiToolbox.prc* file and the *Mathlib.prc* file.

1. Browse to the location where you installed Pi Toolbox, for example: *C:\Program files\Pi Toolbox.*
2. Locate and open the Remote folder.
3. Select the two *.prc* files contained in the folder and double-click them. This will add them to the *Hot-Sync* process.
4. Hot-Sync your handheld device with your PC. The files are installed.
5. Start Pi Remote Toolbox. Tap the  icon.

Getting Started

Once you have installed Pi Remote Toolbox on your handheld device, you must make sure that Pi Toolbox is configured correctly to transmit the information and that your Bluetooth PC adapter is set up properly.

Setting up Pi Toolbox

1 Open Pi Toolbox.

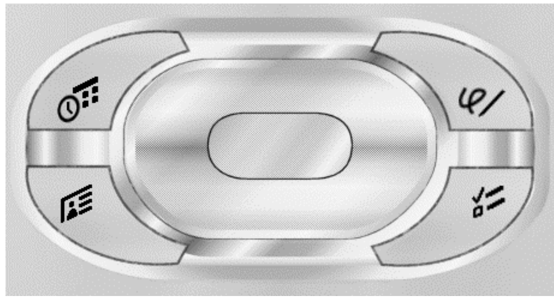
2 On the File menu, select Preferences.

3 Click the Remote tab.

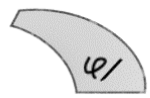
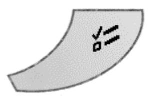
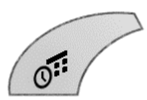
4 Make sure that the Remote Connection method is set to *Serial*.

5 Make sure that the Serial port is set to the same port number as the Bluetooth PC adapter. If you need to check what your Bluetooth adapter port number is, see Checking your PC adapter on page 313

The handheld function buttons



The function buttons can be used to perform various tasks:

	Disconnect the Bluetooth connection.
	Open the Displays menu.
	Discover Bluetooth devices.
	Connect/ Re-connect to the host PC and Pi Toolbox.
	4 way scroll & Select/Exit.

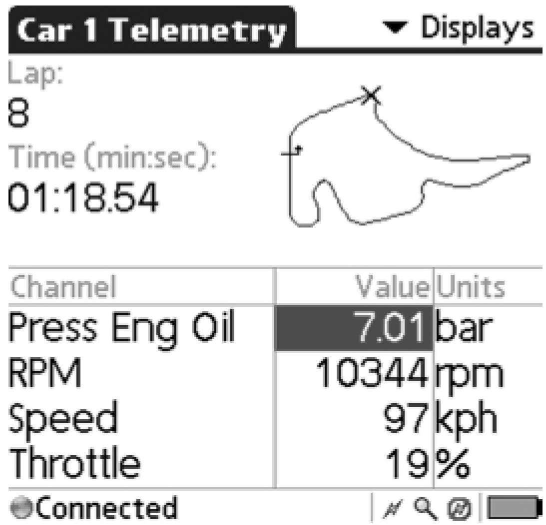
The handheld toolbar

The toolbar on the handheld device allows you to personalize its appearance and configure some of the settings.

Toolbar features: (from left to right)

- Home.
- Find.
- Display the Context menu for the current menu.
- Clock and handheld settings.
- Alert.
- Bluetooth settings.
- Enable/Disable full screen writing.
- Rotate screen.
- Input.

Summary display overview



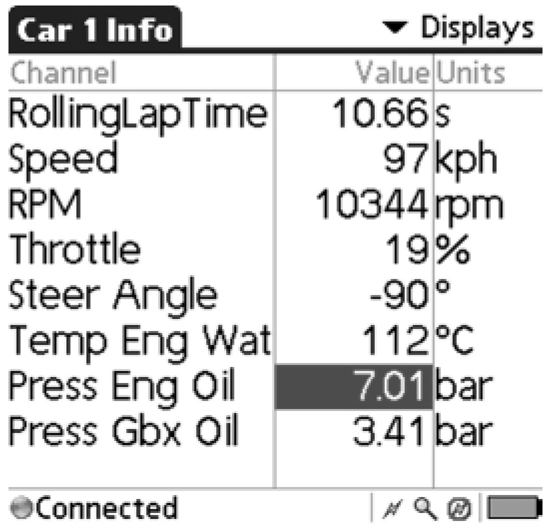
The Summary display has 3 components:

- **A Channel display:** Up to 4 channels can be displayed, with the option of displaying channel alarms.
- **A Map:** Displayed for reference only.
- **Lap performance:** The lap number and either lap speed or lap time is displayed depending on the global setting specified in the Pi Toolbox workbook.

Note: *The Lap performance information is always displayed.*

The display can be customized in Pi Toolbox to only display certain information, adjust font sizes, etc. These settings will then be applied to the display on the handheld device.

Channel display overview



The Channel display enables channel names, values and units to be shown in a tabulated list. Data can be shown in historic or real-time modes and it is generally used for viewing channel values of car parameters in real-time.

- In real-time mode, the values of the last data sample of the channel are displayed.
- In historic mode, channel values are based on the position of the task cursor.

Channel alarms can also be viewed on the handheld device. When the channel value moves outside of the specified minimum or maximum value, it will be displayed with a red background. The alarm value can be set globally or locally. Local alarms can be useful if you are watching a specific channel for a change in its status. For example: a differential channel.

Trouble shooting

In this section you can find useful tips to help you if you are having difficulty configuring your handheld device or displaying data.

Data is not displayed on the handheld device

If there is no data being displayed on the handheld device, you need to check the following:

1 Make sure that you are within the range of your Bluetooth PC adapter. For more information, refer to the manufacturers handbook.

2 Make sure that no other handheld devices are connected to the PC. Bluetooth cannot multicast. Only one connection can be made at any time.

3 Make sure that the device is fully charged.

4 Make sure that you have configured the Bluetooth serial port correctly. For more information, see Setting up your Bluetooth serial port, on page 303

5 Make sure that you have configured Pi Toolbox to use the same Bluetooth serial port as the Bluetooth PC adapter. For more information, see Checking your Bluetooth PC adapter, on page 313.

6 Make sure that you have enabled data transfer to Pi Remote Toolbox – keyboard shortcut F10.

7 If you have changed your Bluetooth PC adapter and cannot establish a connection. For more information, see Changing your Bluetooth PC adapter, on page 313

The Pi Toolbox display changes when Pi Remote Toolbox is enabled

As handheld devices have lower screen resolutions than a PC, any activated display will change to match the remote version of the display. For example: The remote channel name property will be used and the list of displayed channels in a Channel list may be reduced so that the view on the PC closely replicates the image that is seen on the handheld device.

Checking your Bluetooth PC adapter

To successfully set up Pi Toolbox and Pi Remote Toolbox, you must make sure that they are both configured to use the same Bluetooth serial port.

To check your Bluetooth serial port

1 Right-click on the Bluetooth icon in the System tray to bring up the shortcut menu. Select *Advanced Configuration*.

2 The Bluetooth configuration dialog is displayed, click the *Local Services* tab.

3 Locate the *Bluetooth Serial Port* from the list. The COM port number displayed next to this is the number that you must specify in the Pi Toolbox Remote setup.

Changing your Bluetooth PC adapter

If you have changed your Bluetooth PC adapter, when you try to establish a connection with the adapter from the handheld device, it will fail.

This is because the new adapter has a different identification to the old one and the handheld will try to use this detail to establish the connection. To establish a successful connection, you must first delete the old Bluetooth PC adapter details from the handheld and then discover the new one.

Pi Remote Toolbox shortcuts

Keyboard shortcuts

Shortcut	Description	Menu
F9	Activate a selected display to be shown on a handheld device.	*Data* > *Pi Remote display*
F10	Enable transmission of data from Pi Toolbox to Pi Remote Toolbox.	*Data* > *Pi Remote Toolbox*

PDA Graffiti shortcuts

Shortcut	Description	Menu
R	Displays the preferences dialog.	N/A
D	Displays the details for the dialog.	N/A

Maps

A Map display is a pictorial representation of a circuit layout that can be divided into straight and corner segments to enable detailed analysis of car/driver performance. Standard maps are constructed from on-car inertial information. GPS maps are produced by decoding data logged from the local coordinate system, using math channels to create GPS coordinate math channels: **Latitude**, **Longitude** and **Altitude.**

Note: *GPS Maps are an optional feature.*

The GPS option allows maps to be created when conditions differ from those where inertial data can create accurate maps, i.e. enclosed lap circuits. These conditions may include:

- Individual stages from point A to B, not forming individual laps with lap start/finish beacons.
- Where vehicles operate at high roll and slip angles, on low grip surfaces, where high levels of wheel-spin render calculation of distance traveled difficult.
- Where stages are used in both directions during testing. The Map Position D channel allows runs to be plotted in either direction.

Note: *The Latitude and Longitude math channels quantity is 'Angle'. The Altitude math channel quantity is 'Length'.*

Maps provide a pictorial representation of where the car is on a circuit at any instant in time and allow segment-by-segment comparison of car/driver performance.

Note: *Workbooks can only have one map loaded at a time. Multiple Map displays can be created so that they can display different channel data, but they will all reference the same map.*

Graphical Lap Reporting

An additional functionality of Map displays is to provide Graphical Lap Reports. Here channel values for specific map segments are displayed in labels and color bands. For further details see Graphical Lap Reporting page 327.

Shortcuts

← →	In edit mode with map element selected, selects consecutive map elements, i.e. boundary, segment, beacon.
⇧ + ⇆	In edit mode selects multiple map elements.
Ctrl + ⇆	In edit modes with boundary selected, moves boundary.
Alt + ↵	Displays the Map Property dialog.

Features

Edit mode

Selecting Edit mode disconnects the map from the task cursor and allows you to edit segments, move borders, insert split beacons and edit segment captions. Exit Edit mode to view the car cursor and reconnect the task cursor.

Create and save new maps

Using the Create Map dialog, you create maps from distance, speed and lateral acceleration data. A preview window on the dialog continually updates as you change map parameters; providing a visual aid as you adjust the map shape to accurately represent the circuit.

Segment editing

After creating the map you can change the number of segments manually. For instance, you may need closer analysis of a corner and want to break it down into three segments. In Edit mode you can split or merge segments, move segment borders, create segment names and define colors.

Map editing

Choose custom colors to represent straights, corners, borders etc. Increase or decrease circuit line width and move segment captions.

Car cursors

Cursors on the map display car positions. In historic mode the relevant track position is shown for a given data point on Time and Distance and/or XY Displays, sharing the same task. The task cursor looks like this: **X**.

Save and load map file

The maps that you create can be saved, along with the segmentation and split parameters that you have set. Map files can be loaded locally or sent to other users.

Real-time features and behavior

Maps can be used in Historic or real-time modes.

Pause characteristics

- When Pause mode is entered the car cursor (disc) is frozen on the map.
- When Pause mode is cancelled the car cursor jumps to the current track position.

Behavior

- Maps can be created from Real-time data. However, real-time must be in pause mode.
- In order to create from real-time data the Lateral Acceleration and Speed channels, must be selected on a display in the workbook. The display must have been viewed in the current Pi Toolbox session.

Creating Maps

Note: *Before creating a map, go to the GPS Mapping dialog (Tools > GPS Mapping > Edit). Check that the common GPS channel names are mapped to the correct GPS co-ordinates in the Pi Toolbox database. For more information, refer to Mapping Common Channels, page 48.*

To create a map:

1 Create a task and select the required outing.

1 Create a Map Display and connect it to the task.

2 Go to the Task Explorer, right-click on the required outing.

3 Select: **> Create > Standard Map / GPS Map**

Note: *The map types available from this sub-menu depends upon the types currently registered.*

4 Set the parameters in the Create Map dialog box.

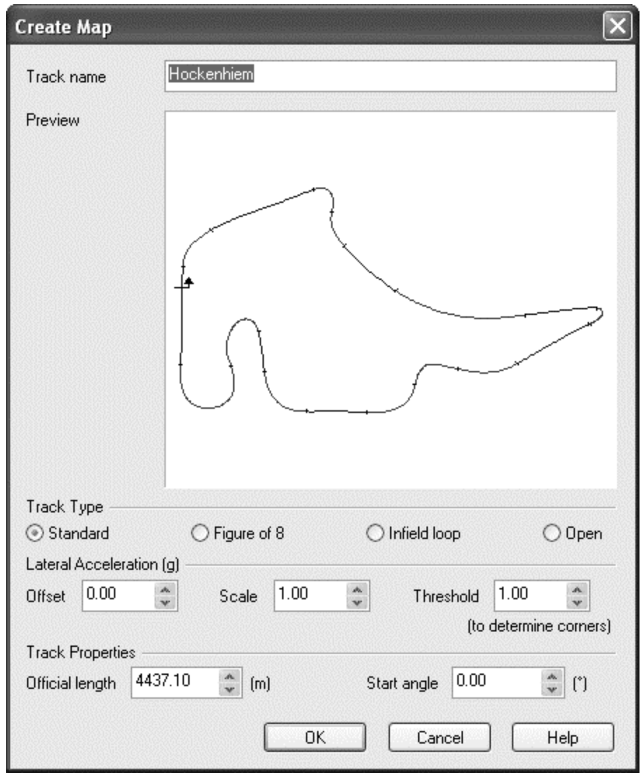
5 Click 'Apply' to create the Map.

6 From the Create Map Preview check the shape of the Map.

7 If you are satisfied that the Map is an accurate representation of the circuit, click 'OK'. If you are not satisfied, adjust the lateral acceleration parameters as described above.

Note: *The Map is profile is based on the datum data selection in the task it is connected to.*

Configuring a Standard Map



Track Name: Enter the name of the circuit.

Refetch Details: Updates the map to include outing property changes that have been made in the Task Explorer, e.g. Track Name.

Track Type**:** Select the type of circuit. Select standard if the circuit does not contain in field loops, figure-of-eights and is 'Closed'.

Preview: The preview window continually updates as you change map parameters, providing a visual aid as you adjust the map shape to accurately represent the circuit.

Lateral acceleration

The Map shape is determined by the speed, distance and lateral acceleration. If the Map appears incorrect, set lateral acceleration parameters to adjust the Map appearance.

Offset: Calibrates the accelerometer so that when lateral acceleration is zero, output is zero.

Scale: Sets the gain of the accelerometer, i.e. increases or decreases the output.

Threshold: Sets the threshold for determining corners. Setting a lower threshold creates more corner segments, setting a higher threshold creates fewer corner segments.

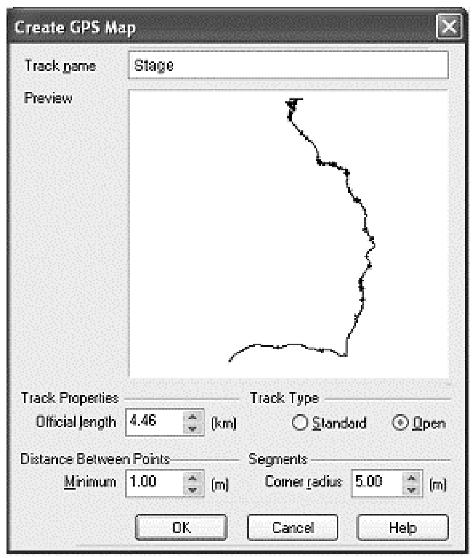
Track properties

Official length: Enter the Official track length if available.

Start Angle: Enter the angle for the start line.

Configuring a GPS Map

When you are creating a GPS map, you have to configure the map dialog.



***Track name*:** Use this field to enter the name of the circuit.

***Preview*:** The preview window continually updates as you change map parameter, providing a visual aid as you adjust the map shape to accurately represent the track.

Track Properties

***Official length*:** Track length is calculated by adding the distances between consecutive lap points. The user can enter the official length if known. In this case the distance between map points is proportionally scaled so that the total distance between points equals the official track length.

Track Type

***Standard / Open*:** When 'Standard' is selected, a copy of the first point of the track is added at the end of the list so that the first and last points share the same X, Y and Z coordinates. GPS Maps are generated as 'Open' tracks by default.

Distance Between Points

***Minimum*:** defines the average distribution of map points around the track. When the distance between two consecutive points is less that the minimum, the second point is removed. When greater than the minimum, a linear interpolation is performed to create a point mid-way between the two points. The default distance is 1M.

Segments

***Corner radius*:** Sets the threshold for determining corner segments. The default threshold is 50M. Setting a lower radius creates more corner segments, setting a higher radius creates fewer corner segments.

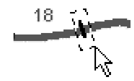
Editing Maps

All map editing is done in Edit mode, which disconnects the map from the task cursor and allows you to edit segments, move borders, insert split beacons and edit segment captions. Context menu options are different in Edit mode, to increase edit functionality.

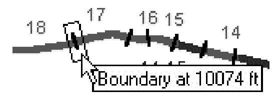
To enter Edit mode select: **> Edit**, to leave select: > **Edit > Done**.

To edit a map element:

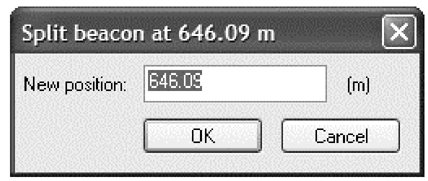
- Hold the cursor over a map element to highlight it:



- Click on the element to select it:



- Press Enter to open the edit box:



***Note**: With a border element selected, you can use the tab key to select consecutive segment names. Using the arrow keys will select consecutive map elements, i.e. boundary, segment, beacon, segment, boundary. Press Enter to edit a selected Map element.*

***Tip:** You can use the following keyboard shortcut to exit the edit mode.* Ctrl +

Map cursors

Time/Distance Charts connected to the same task as a Map share a common Data Cursor position. As you move the cursor along the Map using the arrow keys, or click on a point on the Map, the cursor moves simultaneously to the corresponding data point in all connected displays. Conversely the relevant track position is shown on the Map when you move the Task Cursor along the active channel trace of a chart. This is the Task Cursor concept.

In real time the Map retrieves the last time/value sample from the Lap Distance channel and uses this value to position the cursor.

Saving and Loading a Map

To save a Map:

1. Select: **Data > Map > Save As**.
2. In the Save as dialog browse for a directory to save the Map (*.pxt*) file.

To Load a Map:

1. Select: **Data > Map > Load**
2. In the Load dialog search for a Map (*.pxt*) file to load.
3. The map will become the loaded map in the Workbook and be shown in the display, replacing the existing map.

Printing a Map

- With the map display selected, select: ***File > Print*** from the Pi Toolbox Main menu.

Note: *If segment names are switched off in the map display, they will not be printed. Use the Print Preview command to preview the printout.*

Editing Segments

Map segments are created using lateral acceleration data. After the Map is created you can split segments and move segment boundaries to precise positions in order to analyze a particular portion of the track. For instance you may wish to divide a corner segment into 'entrance', 'apex' and 'exit' segments.

All editing is done in Edit mode.

Naming segments and positioning segment captions

To rename a segment:

1 Double-click the segment caption or the segment itself.

2 Overtype the segment caption.

To reposition a segment caption:

- Click and drag the segment caption to the required location.

Splitting and merging segments

When you split a segment, the split is made at the middle map point of the segment. You can then move the new boundary to a precise position if required. The segments created by splitting take the name of the original segment, i.e. segment name 1 and segment name 2. Change these if required.

To split a Segment:

1 Click the segment once to select it

2 Select: **> Split Segment**.

Merging segments is achieved by removing the boundary between two segments. The resulting segment will be a straight (if both segments are straight) or a corner (if either of the segments is a corner).

To merge two segments:

1 Click a segment boundary once to select it

2 Press Del.

Moving Segment boundaries

Two adjacent segments share a segment boundary. A boundary can be moved by clicking and dragging. When dragged, the boundary snaps to the nearest map point. A tool tip displays the track position as you drag, in the units of the Lap Distance channel.

To precisely position a boundary, double-click and enter a distance in the edit box.

Editing Beacons

Split Beacons

The Map is divided into straight and curved segments from lateral acceleration data. However, to split the track into more appropriate sections, e.g. to analyze performance through a complex sequence of corners, you can add split beacons. Split Beacons are precise points on the racetrack, measured from the end of lap beacon, which define timing regions. Segments and split points can be shown on Time and Distance displays on the Segment Bar.

To add a split beacon:

1 Hold the mouse cursor over the part of the track where you want to add a split beacon.

2 Select: > **Insert Split Beacon.**

The beacon is inserted in the segment at the mouse cursor location.

To reposition a split beacon:

1 Double-click the beacon marker.

2 Enter a precise distance in edit box (if required).

To remove a split beacon:

1 Click the beacon marker once to highlight it.

2 Press Del.

Start-Finish line

The Start-Finish line beacon is drawn on the map at distance 0.0. This beacon cannot be edited or deleted.

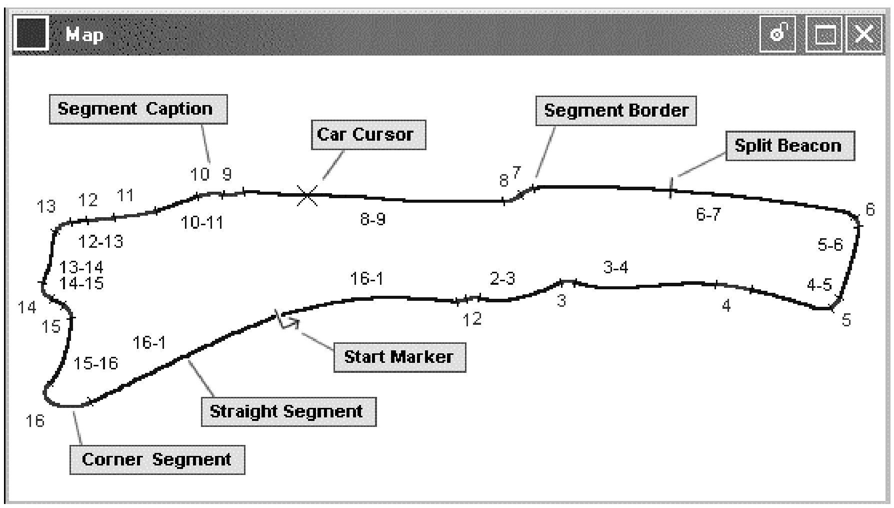
Graphical Lap reporting

Graphical Lap reports consist of two main elements:

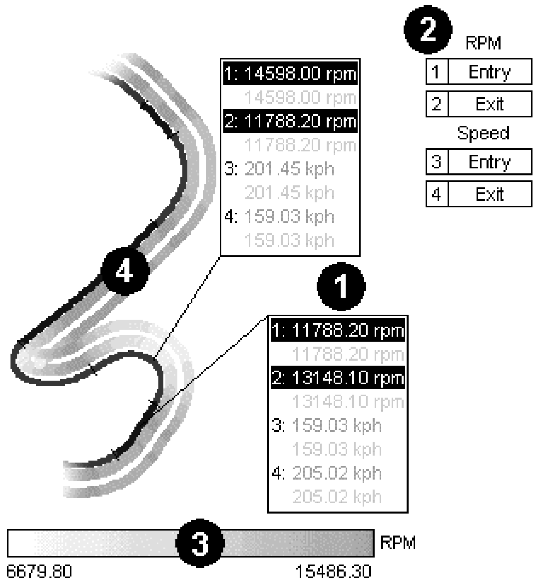
- Labels displaying channel values for a specific part of the track, e.g. a straight or curved segment, beacons etc. For each channel included in the label, a function, or several functions can be selected. Channels and functions are set up in the Labels property page.
- Color bands with gradient or discrete color fills, which follow the line of the track and indicate channel values through variations in color.

In order to report on channels in the map display, channels must be selected for the display using the Selection Explorer. The selected channels are then available for including in labels.

Adding, deleting and positioning labels is done in the Edit Reports mode. Setting up the label contents is done in the Labels property page in either mode.



Overview



1 Channel Value labels - Labels are associated with a specific track element, i.e. segment, split, beacon etc. To make channels available for Graphical Lap Reports, they must be selected for the Map display.

Adding and deleting labels to and from track elements, and positioning labels, is carried out in Edit Reports mode. For more information about labels see Channel Value Labels page 329.

2 Label legends - The Label Legend lists the channels that have been included in the labels. Functions are listed beneath each channel title. For example, the Speed channel may appear several times in a label with different functions: Speed on entry to the region, maximum speed in the region and speed on exit from the region.

The label legend indicates what the functions are and what order they appear in the label.

3 Active Channel Indicator - The color bar beneath the map indicates the active channel, and the min, max values of the channel in the data selection. Its color is derived from the channel properties, as is the color gradation scheme, i.e. Discrete or Gradient. Color gradation properties for a channel are set up in the Properties Explorer. These properties also determine the look of the Color Bands displayed around the track.

4 Color Bands - These are drawn around the track using gradient or discrete color fills and represent values for the active channel as the car progresses around the track. Color depth gives a visual indication of how values increase or decrease along straight or curved sections of the track.

Channel Value labels

A label is associated with a map element, e.g. straight or curved segment, beacon etc. Labels can be added to any map element in the display. The channels and channel values contained in the label are defined in the Labels property page. The label configuration is global to the map display, i.e. each label created for the display, has the same contents.

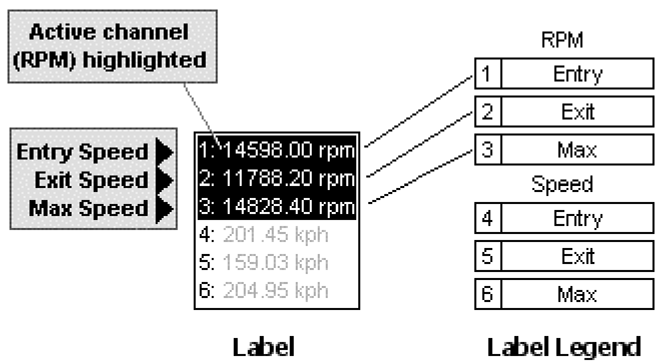
A label can consist of single channel with multiple functions (e.g. max, min, average for segment) or multiple channels with various functions.

Labels are positioned on the map display, in edit mode, using the click and drag technique.

The layout of a label changes depending upon the number of outings contained in the task.

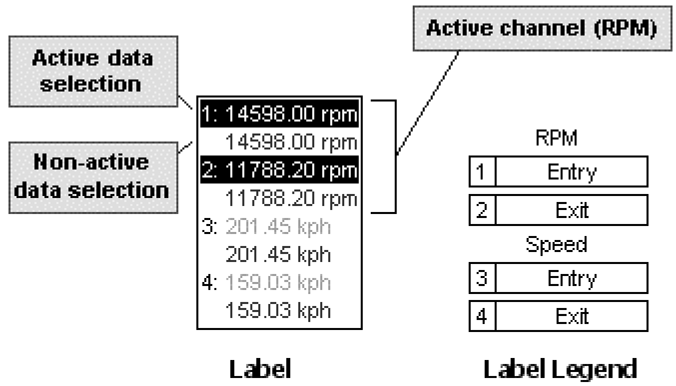
Single outing labels

The illustration below shows a label created for a Map display that has a single outing associated with it. Two channels are selected for the label, RPM and Speed. The label legend shows the order of the value functions for each channel in the label. The active channel is RPM. Each instance of the active channel is highlighted in the label.



Multiple outing labels

The illustration below shows a label created for a Map display that has two outings associated with it. Values are given for each outing and displayed in the outing color. In this example pairs of values are give for each channel function, Entry and Exit (RPM or Speed).



Graphical lap report editing

Any map element can have a label added to it. The contents of the label are defined in the Labels property page in either View or Edit modes. Adding and Deleting labels and positioning them is carried out in Edit Report mode.

- To enter edit mode select: **> Edit Report.**
- To exit edit mode select: **> Edit > Done.**

Selecting Edit Report mode disconnects the map from the task cursor as in Edit Map mode.

Before adding a label to an element the label contents must be configured in the Labels property page.

Creating graphical lap reports

Add channels to a Map display

1 With the Map display in focus go the Selection Explorer. Keyboard shortcut: Alt + 2

2 From the Available Channels list double-click the channels to select.

These will appear in the lower pane under 'Selected Channels'

The selected channels will now be available for inclusion in the graphical lap report Label.

Configure a label

1 In the Map display select: **> Properties**.

2 In the Properties dialog select the Labels tab.

3 Click to add a blank label entry line, alternatively press Insert.

4 Double-click the blank entry line under the Channels column.

5 From the drop-down list of available channels, select a channel.

6 Double-click the blank entry line under the Functions column.

7 Select a function, e.g. Region Entry.

8 Add as many channels as required and click OK.

Add Labels to a Map element

1 Select: **> Edit Report** to enter edit mode.

2 Place the cursor over a map element (segment, boundary etc.)

3 Select: **> Add** Label. Keyboard shortcut: Insert

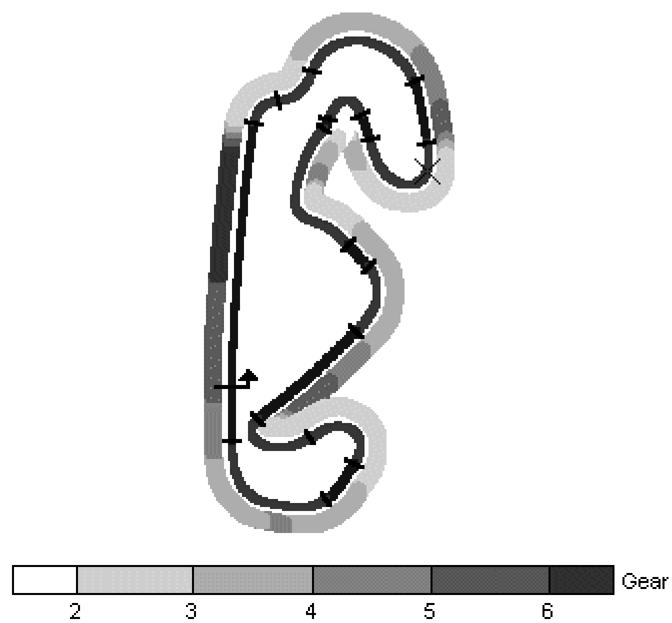
A new label is added with a leader line centered on the selected element

4 Click and drag the label to the required position on the display.

5 Select: **> Edit > Done** to exit edit mode.

Setting up a Gear Change scheme

The example below shows how, using a discrete color gradation scheme, it is possible to quickly set up a gear change indicator. The Color Band indicates the gear change points on the track and the Active Channel Indicator shows the color allocated for each gear. On the Indicator, note that the color band up to the value 2 denotes 1st gear, between 2 and 3 denotes 2nd gear etc.



1. With the Map in focus, go to the Selection Explorer and select the Gear channel.
2. Go to the Properties Explorer and click on the Gear channel.
3. Double-click Color Gradation in the Details pane.

The Color Gradation Properties dialog opens.

4. In the Type of color gradation field select Discrete.
5. With the root node (Discrete) still selected in the left-hand window, set the Bound Settings property to Automatic.
6. Set the Lower Bound property to 2 and the Upper Bound Property to 6.

7 Using the New button add three new color bands (until the gap between bands in the left-hand window is 1).

To set the color bands:

1 Click the bottom node in the left-hand window (<2).

2 Double-click the color property and, from the color palette, select a color to represent the 1st gear.

3 Click the top node (>=6) and select a color to represent 6th gear.

4 Click on the root node (Discrete) and select: **> Determine Colors**.

   Colors graded in depth between the first and last gears are selected automatically.

5 Click OK.

Note: *In the Gear channel details pane, you can set the Decimal place property to '0' so that the divisions read 2, 3, 4 etc.*

Properties

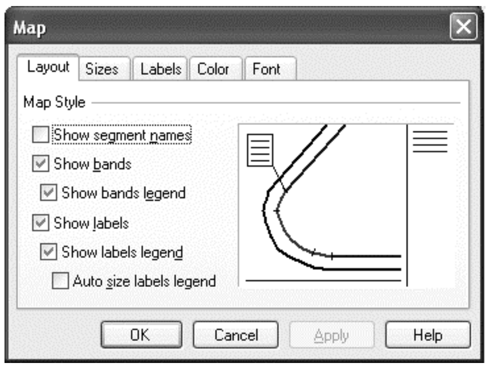
The Map (properties) dialog is where the line width, segment and border colors are determined.

Access the dialog by selecting: **> Properties**.

***Note:** You can access this dialog in both 'Live' and Edit modes. In Edit mode there is a separate 'Map Properties' context menu, which allows you to reset map parameters in the Map dialog.*

Layout

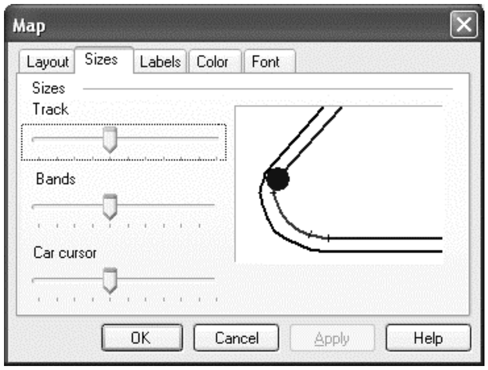
Map style



The check boxes are used to select the items to be shown on the display. The preview window updates continuously to give visual indication of the items selected.

Color bands

Sizes

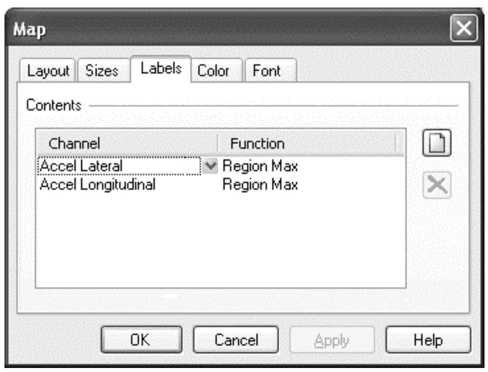


Track: This slider control changes line width of the various Map elements, e.g. segments, boundaries etc.

Bands: This slider control changes line width of the color bands that are drawn around the track to represent active channel values.

Car Cursor: This slider control changes the size of the car cursor (disc).

Labels



Contents

Adds a blank entry line to the label.

Deletes a Label line.

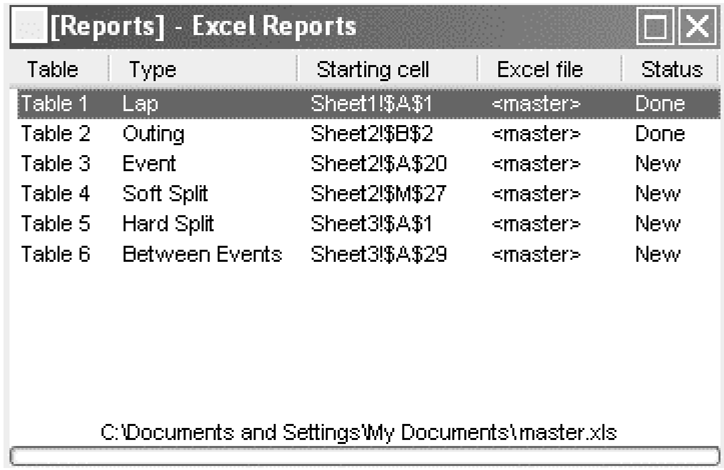
Channel: Double-click to open a drop-down list of available channels (channels which have been selected for the Map display).

Function: Double-click to open a drop-down list of reporting functions.

Note: *For more information about customizing the appearance of the display, see page 258*

Excel reports

The Excel Reports display provides a means of summarizing and organizing data for display and printing in Excel spreadsheets.



Like other Pi Toolbox displays, it is connected to a task. Data channels are added to the display so that they are available for selection by individual tables in the display.

In the Excel Reports display you create tables that are listed by name in the order that you create them. A table's properties are defined in the Report tab of the Excel Report (properties) dialog. The properties you set are the Excel Report Type, the Excel file, the channels and the channel functions (min, max, mean etc.).

Channels and events added to the display are automatically selected for all Lap and Outing tables. They can be deselected to create channel / event subsets for individual tables, however they will not be deleted from the display, and will be available for re-selection.

From the display you can run the whole report, which outputs all tables to an Excel spreadsheet, or you can run individual tables.

Up to eight Excel reports can be added to a Worksheet.

Shortcuts

Insert	Adds a new table.
Del	Deletes the selected table.
Ctrl + ↵	Runs the entire report.
↵	Run the selected table.
Esc	Cancels a report or table run.
Alt + ↵	Opens Properties dialog for selected table.

Excel report features

Reports generated in Microsoft Excel

Excel is commonly used as a reporting tool throughout the world. Engineers can create and control the Report format in an environment that is familiar, without needing to retrain on new software.

Master workbooks

A master workbook can be defined for an Excel Report display. This becomes the default template for all tables in the Report (data is output to this destination). However, individual tables can have their output destinations changed to additional workbooks if required.

Task based to enable rapid selection of outings and laps to report

Excel Reports are task based like other Pi Toolbox displays so changing outings for a report is done at the task level and is quick and easy.

Excel report templates

Excel Reports displays can be exported as part of a Worksheet, or as an individual display, and subsequently imported at other locations and used as templates.

Multiple outing

The report order for multiple outings is the same as the order of selected outings in the task. You can produce 'trend' reports that show the trend of a parameter over multiple outings.

Report on Soft Events and Math Channels

Soft Events and Math Channels can be selected for an Excel Report display in the same way as real events and channels. These are then available for selection by all tables in the display.

Run Macros in Excel

At the Run Report or Run Table commands, Pi Toolbox initiates a macro before data is downloaded to Excel and after data download is complete. The macros are available for programming in the Visual Basic Editor of Excel, to your own requirements.

Repetitive headings

Generation of repetitive lap, lap time and telltale headings for all but the first outing can be switched on and off by the user. The initial headings row cannot be switched off.

Error messages

A progress bar and error messages are shown beneath the list of tables in the Excel Report display.

Report Types

Lap reports

Lap Reports use Map segments to divide laps into straights and corners and show channel values segment by segment. They are typically used to show maximum values achieved in each segment of a lap over the course of a complete outing. Before the report can be generated a circuit map must be created with segments defined and currently loaded.

	A	B	C	D	E	F	G
1		**Date:**	05/10/01		**Event:**	Friday Morning Free Practice	
2							
3		**Driver:**	H. Pitt		**Weather:**	Sun, Wind 2.5 kph	Track Temp 25 degrees
4							
5		**Engine:**	21				
6							
7							
8				**Speed (mph)**	**Press Eng Oil (psi)**	**RPM (rpm)**	
9		Outing					
10	Lap	Segment	Segment Time	Max	Max	Max	
11	1	3-1	0:00:14	156.92	97.48	12195.00	
12	1	1-1	0:00:31	175.10	98.54	13522.50	
13	2	3-1	0:00:13	181.47	97.48	14107.50	
14	2	1-1	0:00:29	185.48	97.48	14400.00	
15	3	1-2	0:00:09	185.48	97.48	14400.00	
16	3	3-1	0:00:12	186.90	97.48	14400.00	
17	4	2-1	0:00:09	187.16	174.83	41483.70	
18	4	1-1	0:00:28	187.16	174.83	1483.70	
19	5	2-3	0:00:09	187.16	197.08	1483.70	
20							

In the above example, the engineer is interested in maximum speed, oil pressure and engine RPM for each segment of an outing of several laps.

For each channel, the function selected is the maximum value.

When the Report is generated, the outing information, lap number and lap time are given. Then the lap is divided into segments with the maximum values of the associated channels.

Note: *When the report contains a 'compare' math channel, e.g. Compare Speed, the time region for the datum outing is typically the fastest lap. This applies to all Excel Report types except Split reports.*

Outing reports

Outing Reports are used to examine channel values lap by lap over for an entire outing and are typically used for analyzing trends during an outing; for example, engine temperatures or pressures.

	A	B	C	D	E	F	G	H	I
1		**Date:**	05/10/01		**Event:**	Friday Morning Free Practice			
2									
3		**Driver:**	H. Pitt		**Weather:**	Sun, Wind 2.1 Kph, track temp 28 degrees			
4									
5		**Engine:**	21						
6									
7									
8			Press Eng	**Press GBX Oil**	**RPM**	**Speed**	**Temp Eng Oil**	**Temp Eng Water**	**Temp Gbx Oil**
9		Outing							
10	Lap	Lap Time	Max	Max	Max	Max	Max	Max	Max
11	1	**00:45.5**	97.48	29.70	13252.50	135.21	177.60	232.07	190.23
12	2	**00:22.6**	98.54	31.64	12712.50	164.46	174.36	201.54	192.58
13	3	**00:20.5**	97.48	33.41	13522.50	175.10	175.98	188.18	193.82
14	4	**00:22.6**	97.48	34.91	14107.50	181.47	174.36	186.27	196.50
15	5	**00:20.5**	97.48	35.52	14400.00	185.48	179.22	190.09	200.40
16	6	**00:20.5**	95.36	31.55	14377.50	186.90	182.46	195.81	205.16
17	7	**00:22.6**	174.83	31.27	41483.70	187.16	185.70	197.72	209.58
18	8	**00:20.5**	197.08	29.87	14265.00	185.76	187.32	197.72	213.72
19									
20									

Soft Split reports

Split Time Reports split the track into key segments or features (e.g. slow corners, fast corners, straights). Before a report can be generated a circuit map must be created with segments defined and currently loaded.

This type of report may typically be used to determine the effect of chassis set-up changes with respect to car performance within key areas of the track layout.

The report provides two unique performance indicators - the theoretical fastest lap and the fastest rolling lap. The theoretical fastest lap gives the lap time that could be achieved if the best split section times from an outing were all in one single lap. The fastest rolling lap is the fastest lap time using a start and end point that may not be the end-of-lap beacon. Comparing achieved lap times to the theoretical fastest lap time shows driver consistency.

	A	B	C	D	E	F	G	H
1		**Date:**	05/10/01		**Event:**	Friday Morning Free Practice		
2								
3		**Driver:**	H. Pitt		**Weather:**	Sun, Wind, 2.1 kph, Track temp 28 degrees		
4								
5		**Engine:**	21					
6								
7		**Outing**						
8	Lap	**1**	2	3	**4**	Lap Time	FL Diff	
9	1	**00:45.5**	00:16.8	00:42.5	**00:19.1**	00:26.7	00:05.6	
10	2	**00:22.6**	00:15.7	00:39.0	**00:18.9**	00:24.3	00:03.2	
11	3	**00:20.5**	00:14.4	00:37.2	**00:18.6**	00:22.5	00:01.4	
12	4	**00:19.0**	00:13.6	00:36.5	**00:18.5**	00:21.5	00:00.4	
13	5	**00:18.2**	00:13.4	00:36.3	**00:31.2**	00:21.2	00:00.1	
14	6	**00:17.9**	00:13.2	-	-	00:21.1	00:00.0	
15	7	**00:17.8**	00:14.3	-	-	00:41.4	00:20.3	
16	8	**00:21.6**	-	-	-	00:00.2	00:20.9	
17	Theoretical Fastest Lap							
18		**00:17.8**	00:13.2	00:36.3	**00:18.5**	01:25.9	01:04.8	
19	Fastest Rolling Lap							
20	4	-	00:13.6	00:36.5	**00:18.5**			
21	5	**00:18.2**	-	-	-	01:26.8	01:05.7	

This example shows that the Excel Report consists of the lap number, lap time, the number of split beacons you have added to the circuit map and the time difference of the lap to the flying lap time. The times between split beacons are shown in the columns headed 1, 2, 3 etc.

Each row corresponds to an individual lap of the outing. The cells that correspond to the fastest time between the split beacons are highlighted.

Hard Split Reports

Hard split reports generate event data for Split Beacon events in an outing.

Event reports

Event Reports show when an event occurred and any associated channel values. To create an Event Report both channels and events must be added to the Excel Report display to be available for selection.

Note: *The following example shows a typical Event Report layout for post V2.x versions of Pi Toolbox. Data output can be configured to generate V1.x Event Report layouts. This differs slightly from post V2 versions, in that all event occurrences are listed for all associated channels.*

	A	B	C	D	E	F	G	H	I
1			Event	Time (s)	Distance (r	Channel	Value		
2		Outing	3:4 Day3:R2						
5									
6	Lap	Lap Time		Time (s)	Distance (m)	EN RPM (rpm)	Gbox IPS Rpm (rpm)	Gbox Drum Dmd (°)	Gbox Oil Press (bar)
7	2	02:02.3	Gbox SOS	17.78	0.00	3502.91	3514.78	69.75	2.09
8	2	02:02.3	Gbox SOS	17.78	0.00	3502.65	3510.88	69.75	2.09
9	2	02:02.3	Gbox SOS	27.80	91.78	9949.02	10042.05	46.50	4.17
10	2	02:02.3	Gbox SOS	31.52	207.80	15551.53	15603.67	93.00	4.34
11	2	02:02.3	Gbox SOS	32.68	260.79	15637.13	15960.10	139.25	4.28
12	2	02:02.3	Gbox SOS	33.82	319.81	15424.03	15493.37	186.00	4.16
13	2	02:02.3	Gbox SOS	35.38	408.66	14807.23	14911.46	232.50	3.92
14	2	02:02.3	Gbox SOS	37.38	531.72	14022.43	14079.55	279.00	3.91
15	2	02:02.3	Gbox SOS	39.38	644.58	9180.22	9035.97	325.50	3.68
16	2	02:02.3	Gbox SOS	39.66	656.82	9226.82	9214.47	279.00	3.62
17	2	02:02.3	Gbox SOS	40.66	693.80	7695.01	7635.05	232.50	3.24

In this example the Event GBox SOS has assigned channels GBox IPS, GBox Drum Dmd and Gbox Oil Press. The Event's description is turned off.

Each row consists of one event and one or more channels associated with that event.

Lap	Lap Time	Event	Time	Description	Channel 1	Channel 2 etc.

Between Events

Between Event reports generate data between events occurring within a lap or outing. The user can set independently the start and end events. They can typically be useful for testing engines on a dyno where a transition occurs in RPM (start event), is held constant for a period of time and then stepped to the next target event (end event). The user can generate a report examining what the RPM variation was between the start and end events.

The output is similar to an outing report except that channel TellTales are calculated between the start and end events.

	A	B	C	D	E	F	G
1			Shift Start			Shift Stop	EngineSpeed (rpm)
2		Outing	1:5 Day 1:R2				
3	Lap	Lap Time	Time (s)	Lap	Lap Time	Time (s)	Max
4	8	01:56.6	15.723	8	01:56.6	17.151	4330.008189
5	8	01:56.6	30.443	8	01:56.6	30.719	13904.02632
6	8	01:56.6	31.983	8	01:56.6	32.251	14843.02765
7	8	01:56.6	33.363	8	01:56.6	33.625	15098.02826
8	8	01:56.6	34.343	8	01:56.6	34.685	14520.02679
9	8	01:56.6	39.803	8	01:56.6	39.933	9167.017132
10	8	01:56.6	40.043	8	01:56.6	40.163	9974.019191
11	8	01:56.6	40.343	8	01:56.6	40.503	10724.01983
12	8	01:56.6	41.283	8	01:56.6	41.423	10257.01956
13	8	01:56.6	47.083	8	01:56.6	47.355	15101.02874
14	8	01:56.6	47.863	8	01:56.6	48.135	14659.02775
15	8	01:56.6	48.583	8	01:56.6	48.845	14777.02772
16	8	01:56.6	49.443	8	01:56.6	49.707	14902.02763
17	8	01:56.6	50.323	8	01:56.6	50.583	14552.02718
18	8	01:56.6	51.243	8	01:56.6	51.501	14130.02702

In this example the first two sections of the report define a time region where data is collected. The last section contains the selected telltales. See graphic below.

Lap	Lap Time	Start Event Time	Lap	Lap Time	End Event Time	TellTale 1	TellTale 2 etc.

Time regions are defined using the following rules.

- The time region starts at the first occurrence of the start event in the outing
- The time region ends at the first occurrence of the end event in the outing
- Consecutive events of the same type are ignored.

Report layouts

The position of individual tables in an Excel report display is determined by the starting cell selected (in the Excel Reports dialog - Table tab).

For each table you select a starting cell, shown like this in the illustration, which determines the top left starting point. Individual tables are shown surrounded by borders.

In the display selecting: **> Run Report**, runs all tables in the display and positions them according to their starting cell.

Selecting: **> Run Table**, runs only the table highlighted, positioning it according to its starting cell.

To Select a Starting Cell:

1 Double-click a table in the display.

2 Select the Table Tab in Excel Reports dialog.

3 Click 'Get Cell'.

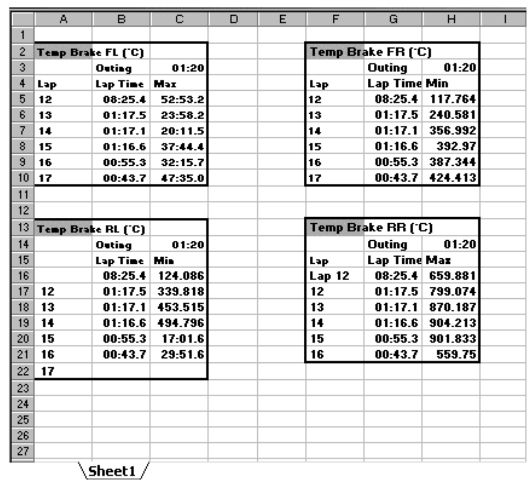
4 Maximize Excel.

5 Click in starting cell.

6 Go back to Pi Toolbox.

7 Click 'Get Cell' again.

The starting cell appears in the Starting Cell field like this: Sheet1A20.



	A	B	C	D	E	F	G	H	I
1									
2	Temp Brake FL (˚C)					Temp Brake FR (˚C)			
3		Outing	01:20				Outing	01:20	
4	Lap	Lap Time	Max			Lap	Lap Time	Min	
5	12	08:25.4	52:53.2			12	08:25.4	117.764	
6	13	01:17.5	23:58.2			13	01:17.5	240.581	
7	14	01:17.1	20:11.5			14	01:17.1	356.992	
8	15	01:16.6	37:44.4			15	01:16.6	392.97	
9	16	00:55.3	32:15.7			16	00:55.3	387.344	
10	17	00:43.7	47:35.0			17	00:43.7	424.413	
11									
12									
13	Temp Brake RL (˚C)					Temp Brake RR (˚C)			
14		Outing	01:20				Outing	01:20	
15		Lap Time	Min			Lap	Lap Time	Max	
16		08:25.4	124.086			Lap 12	08:25.4	659.881	
17	12	01:17.5	339.818			12	01:17.5	799.074	
18	13	01:17.1	453.515			13	01:17.1	870.187	
19	14	01:16.6	494.796			14	01:16.6	904.213	
20	15	00:55.3	17:01.6			15	00:55.3	901.833	
21	16	00:43.7	29:51.6			16	00:43.7	559.75	
22	17								
23									
24									
25									
26									
27									

Sheet1

Generating reports

To create an Excel report and add a table:

The following steps assume that you have created a task and loaded the datasets that you want to report on.

1 Select: **Insert > Display > Excel Reports** or the Insert Display toolbar button.

An empty report display is added to the Worksheet.

2 Select: **Data > Connect** and select the required task.

3 Select:  **> New Table**.

An empty table is added to the report display.

4 Repeat the above steps to add further tables as required.

To select channels and Events for the Excel report display:

Data channels and Events are added to the Excel Report Display so that they are available for selection by individual tables in the display. Channels selected are specific to a display. Every Excel Report display on the Worksheet must have its own channels selected.

Select channels in the same way as you would for other display types.

Setting the Excel report properties

1 Highlight the table in the Excel Report control that you want to configure, select: **> Properties**. Alternatively you can double-click the table or use the keyboard shortcut: + .

2 In the Excel Reports dialog set the table properties:

Report tab

***Master Excel file*:** This field shows the path filename of the Excel file to link to all tables in the display. Use the 'Browse' button to search for a file. Before running a report you should devise a spreadsheet that matches your expected data output and use this as linked Excel file.

***Lap filter*:** Use this field to restrict the output of the Excel Report as required.

Table Name: Enter a name for the table is required.

Target Excel File: To change the target to an additional Excel file, click <master>, and then click the browse button to browse for a file.

Starting Cell: Displays the sheet and cell of the target Excel file that will be the top left cell of the current table. To select a starting cell, click the existing cell and then click the Get Cell button. The target Excel file opens and with the Select Cell dialog displayed. Select the required sheet then click in a cell. The sheet/cell data is entered into the dialog edit box. Click OK to return to the Property dialog.

Automation tab

Auto Generation: This option enables MS Excel reports to be automatically generated when a task has been updated. This setting is disabled by default and is persisted in the system registry.

Content tab

Table: From the drop-down list select the table to configure

Type: Select the type of Excel Report to generate.

Outing headings etc: Select the heading to display in the report.

Channel: For every channel displayed set the Telltale and Action required.

Use the delete key to remove unwanted channels from the table. They will not be deleted from the display but they will not appear in the report.

1. Click OK.

To run an Excel report and save it:

You have two options when generating Excel Reports:

- Run Table - Runs the table currently highlighted in the display.
- Run Report - Runs all the tables listed in the Display.

1 Highlight a table in the Excel Report Display and select: **> Run Report** or **Run Table**.

The Excel file associated with the display opens, and data loads into the worksheet.

2 In Excel select: **File > Save As**. Name the report and browse for a location of your choosing.

Using an Excel report as a template

Excel Report displays can be exported as part of a Worksheet, or as an individual display, and subsequently imported at other locations and used as templates.

To export an Excel Report display:

1 Make sure that the display is currently open in your Workbook.

2 Select: File > Export...

The Export Workbook Wizard opens

3 Follow the Export Wizard's instructions.

You can choose to export the entire Worksheet that the display is on, or the display only.

4 Click Finish.

To Import a Worksheet

1 Open the Workbook that you want to import the display into.

2 Select: File > Import...

The Import Workbook Wizard opens.

3 Follow the Wizard's instructions.

4 Click Finish.

A Worksheet is opened containing the imported display. Use this to generate new Excel Reports.

To run a macro in Excel:

When a Report or Table is run, a macro is initiated before data is downloaded to Excel and after data download is complete. The macros are available for programming in the Visual Basic Editor of Excel, to your own requirements. If you do not activate the macros they are ignored.

Note: *The macros must be created in a book module and not a worksheet.*

1 In Excel select: **Tools > Macro > Visual Basic Editor** (Shortcut Alt + F11)

2 In the VBA Project window select: **> Insert > Module**.

3 To create a macro to run before the data is downloaded, enter the following in the module window:

```
Public Sub OnDataStart ()
```

4 To create a macro to run at the end of the data download - enter the following in the module window:

```
Public Sub OnDataEnd ()
```

5 Press Enter

6 Enter your macro code and save the module

7 Quit the Visual Basic Editor

8 The macros will run on the Run Table and Run Report commands.

__Note:__ An Excel Report display is linked to an Excel file, which is the template for the Tables in the display. The Macros must be saved in this File. If you link the display to a different Excel file, the macros must be recreated in the new file. Alternatively, copy the Excel file containing the macros and edit it as required.

Data format in Excel

If the data format in your Excel Reports is not as expected, you may need to change the Excel file cell format. For instance, if your output data is in times, you may need to change the cell format to display times correctly, e.g. 00:01:51. To change cell format right click in any cell in the Excel file and select: Format Cells.... Choose the appropriate format from the 'Category:' list.

Example:

To change time format to display thousandths

1 Select the cells to format.

2 Select: > Format Cells…

3 In the Category window select ‘Custom’.

4 In the Type window scroll down and select the format: mm:ss:00 so that it appears in the Type field above it.

5 In the Type field change the format to: mm:ss:000

6 Click ‘OK’.

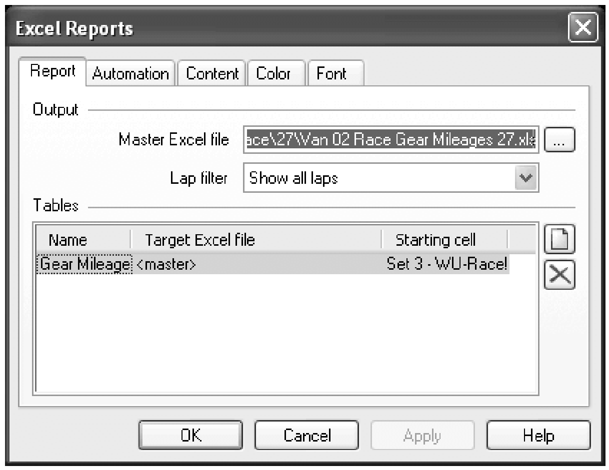
Excel report properties

To open the Excel Reports Properties dialog, highlight a table and select: **> Properties**; or double-click the table.

The commands on the Report tab are global, affecting all tables in report. The commands on the Content tab are specific to the table highlighted in the Excel Report display.

Note: *Split reports rely on circuit map data, and have no configuration options available on the Table tab.*

Report tab



Master Excel File: This field shows the path and filename of the Excel file linked to all tables in the Excel Report control. Data is output to this destination. Use the 'Browse' button to search for a file. Before creating an Excel Report you should devise a spreadsheet that corresponds to your expected data output.

Lap Filter: Use this field to restrict the output of the Excel Report as required.

Tables

This window displays the tables that have been created for this display.

Name: Double-click the default name to enter a new one.

Target Excel file: Displays <master> if the target Excel file is the master (defined above). To change the target to an additional Excel file, click <master>, and then click the browse button to browse for a file.

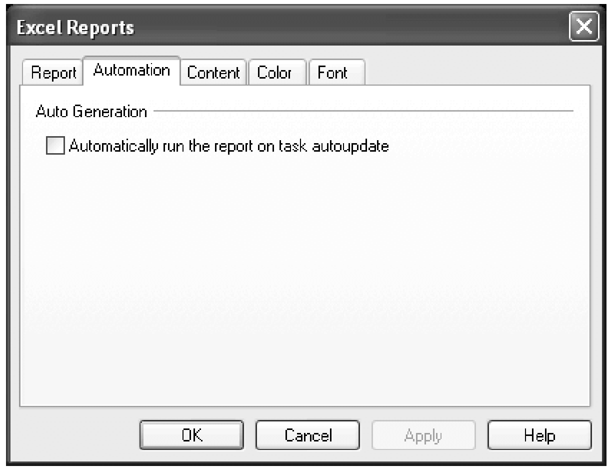
Starting cell: Displays the sheet and cell of the target Excel file that will be the top left cell of the current table. To select a starting cell, click the existing cell and then click the get cell button. The target Excel file opens and with the Select Cell dialog displayed. Select the required sheet then click in a cell. The sheet/cell data is entered into the dialog edit box. Click OK to return to the Property dialog.

Did you know: *You can copy and paste a cell reference from an open Excel file to the Excel Reports Property dialog. In the Excel file select a cell and press Ctrl + C. In the Property dialog, highlight the required table and press Ctrl + E.*

Note: *For the Get Cell operation to work correctly, Excel macros should be enabled. You must select a cell for each table in the report; in this way you control the layout of the report.*

Add or Delete tables to/from the report.

Automation tab



Auto Generation: This option enables MS Excel reports to be automatically generated when a task has been updated. This setting is disabled by default and is persisted in the system registry.

Content tab

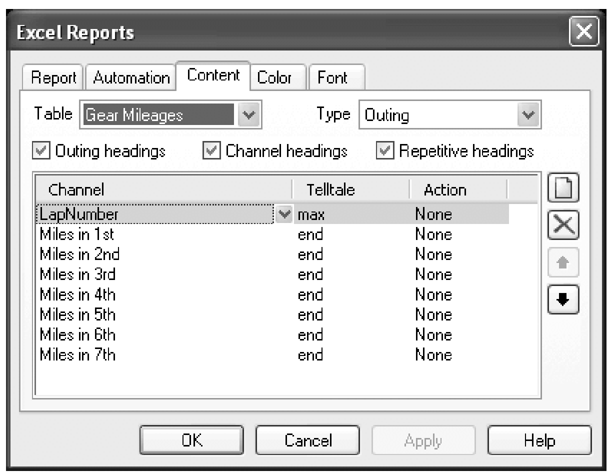


Table: Drop down list of tables created in the Report tab. The Properties of the selected table are displayed on the property page.

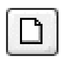
Type: Select the type of Excel Report to generate, i.e. Lap, Outing, Soft Split, Hard Split, Event, Between Events.

Start / End (Between Event Reports Only): Select the Start and End Events for the report. The drop-down list displays the Events added to the display in the Selection Explorer.

Outing/Channel headings: controls the visibility of headings in the report for the table selected. This option is not applicable to Soft/Hard split reports and Event reports.

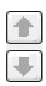
Repetitive headings: Uncheck this to hide lap, lap time and telltale headings for all but the first outing in the report.

Channel List: This window shows the channel list for the selected table. Initially, all channels that are added to the Excel Report display (in the Selection Explorer) appear in this list. A subset of channels can be created for individual tables by deleting unwanted channels. Channels deleted from the table will not be deleted from the display, and will be available for re-selection.

 Adds a blank line to the table, ready for a new channel. Use the combo boxes to select from a list of channels that have been previously added to the display. For each channel, set the Telltale and Action required.

Note: *Use this button to add a special 'Fuel Consumption' channel for which MPG or KPL TellTales can be selected. These TellTales cannot be added to any other channels in the list.*

 Deletes a channel from the table.

 Moves the highlighted channel up or down the list, changing the order in which the channels appear in the table.

Telltale

The values that can be displayed in the report columns can be calculated from channel values using the following functions (or TellTales).

Min/Max: Shows the maximum and minimum value of the channel for every lap.

Mean: Shows the mean value of the channel for every lap.

Standard Deviation: Shows the standard deviation of the channel for every lap.

Start Value / End Value: Shows the value of the channel at the start and end of every lap.

Difference: shows the difference in the value of the channel between the start and the end of every lap.

AtSame: shows the channel value at the same point in the lap as the previous channel in the report list.

Kilometer per Liter / Miles per Gallon: shows the fuel consumption within a given region (lap, segment or between events). These TellTales can only be added to a Fuel Consumption channel. This channel is added in this property dialog using the button.

[Fuel Consumption] = d (Corrected Distance) / d (Fuel Used) where d gives the difference in channel values taken at the boundaries of the corresponding time region.

Action

Determines formatting parameters for the report when a change in data is detected. These options provide a useful means of highlighting where changes of data occur in the report.

Blank line on change**:** Insert a blank line in the report where a data change occurs.

Show only on change: Inserts data into the column only when a change occurs. Following cells in the column remain blank until the next change occurs.

Note: *Telltale and Action properties only apply to outing or lap reports.*

Note: *In the Table tab, when an 'Event' report type is selected the table property options change. For each event, use the combo boxes in the Channel column to select a channel value to report when the event occurs.*

Events

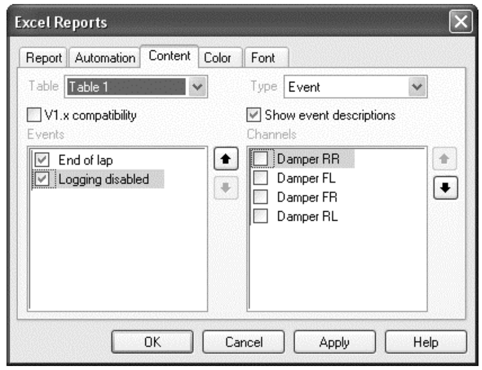


Table: Drop down list of tables created in the Report tab. The Properties of the selected table are displayed on the property page.

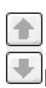
Type: Select the type of Excel Report to generate, i.e. Lap, Outing, Soft Split, Hard Split, Event, Between Events.

Show events description: includes the description in the data output.

V1.x compatibility: Event data output can be configured to generate Pi Toolbox V1.x Event Report layouts. This differs slightly from post V2 versions, in that all event occurrences are listed for all associated channels.

Events: This window shows the event list for the selected table. Initially, all events that are added to the Excel Report display (in the Selection Explorer) appear in this list. A subset of events can be created for individual tables by clicking to clear unwanted events. Events deleted from the table will not be deleted from the display, and will be available for re-selection.

Channels: This window shows the channel list for the selected table. Check the channels whose values you want to record when the events occur.

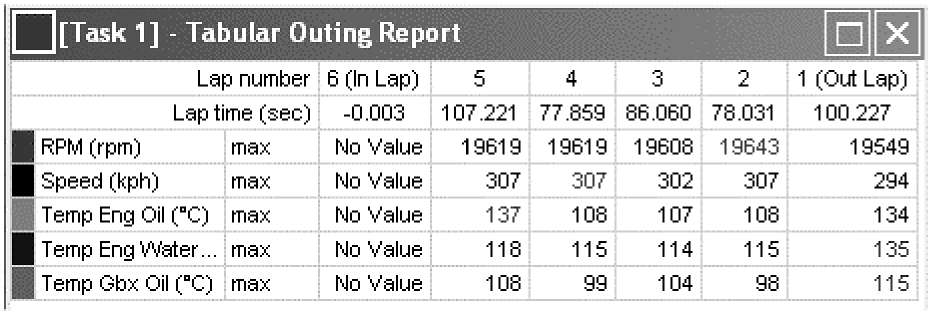
Moves the highlighted event or channel up or down the list; changing the order in which events appear in the table.

Note: *For more information about customizing the appearance of the display, see page* *258*

Tabular Outing reports (TOR)

Tabular Outing Reports (TOR) are used to display channel values in a list view on the Worksheet, lap by lap, over an entire outing. They are typically used for analyzing trends during an outing; for example, engine temperatures or pressures.

All channels in the report can have Telltale indicators (e.g. max value in the lap, mean value in the lap etc.) set individually.



	Lap number	6 (In Lap)	5	4	3	2	1 (Out Lap)
	Lap time (sec)	-0.003	107.221	77.859	86.060	78.031	100.227
RPM (rpm)	max	No Value	19619	19619	19608	19643	19549
Speed (kph)	max	No Value	307	307	302	307	294
Temp Eng Oil (°C)	max	No Value	137	108	107	108	134
Temp Eng Water...	max	No Value	118	115	114	115	135
Temp Gbx Oil (°C)	max	No Value	108	99	104	98	115

The display can work in both historic data and real-time modes:

- In real-time mode the report updates continuously, with the values of the last full lap always being in view. The scroll bars are disabled until Pause mode is entered.
- Historic mode displays data for the complete outing, regardless of the current data selection. Scroll bars are displayed if necessary and are active.

Features

Vertical or Horizontal layout

The report can be configured to show channel data in horizontal rows or vertical columns. In vertical mode the complete channel name may not be displayed as column width is fixed. A ToolTip is provided showing the full channel name.

Exporting to Excel

Selecting Export to Excel from the current menu will open an MS Excel session (if one is not already running) and export the full report to a new worksheet in the current Excel workbook. The layout in Excel will match that of the Tabular Outing Report (TOR).

In-place editing

A channel's Telltale can be edited directly in the display. Double-clicking a Telltale cell, or highlighting a channel and pressing Enter, will produce a drop-down list of TellTales. The required Telltale is located using the arrow keys and selected using the enter key.

Lap Order

Reports can be configured to display laps in ascending or descending order.

Channel order

The channel order can be changed by dragging a highlighted channel to a new location in the list. This can also be achieved in the Properties dialog.

Real-time Pause mode

Activating Pause mode in Real-time will inhibit further data from reaching the display. The scroll bar will become active allowing you to scroll through previous laps in the outing. When Pause mode is de-activated, the buffered data will be downloaded to the report and updating in real-time will continue.

Duplicate channels

Highlighting a channel and pressing 'D' will duplicate the channel and Telltale pair. This feature allows users to look at two or more different TellTales for the same channel.

Active channel

The channel highlighted in the report becomes the active channel. The Properties Explorer displays the properties of the new active channel.

Connected to a single outing

The display shows data for a single outing. In tasks containing multiple outings the displayed outing can be changed by connecting to the required outing.

Copy data as text

The display can be copied and pasted as text into an Excel spreadsheet.

To copy a display, first select the text, then press CTRL + SHIFT + C.

To paste it into a spreadsheet, use CTRL +V.

Real-time features and behavior

Tabular Outing Reports can be used to display historic and real-time outings.

Pause characteristics

- Entering Pause mode inhibits further data from reaching the display.
- The scroll bar becomes active, allowing scrolling through previous laps from the outing.
- When pause mode is cancelled, the buffered data will be downloaded to the report and continuous updating will resume.

Behavior

A new lap column will only be added after an indication that a lap has been completed is received, e.g. an end of lap beacon. Data in the new column will be continuously updated until the lap is completed.

Once sufficient laps have been received to fill the display a scroll bar is added. This will remain disabled until Pause mode is entered.

The newest lap will always be displayed on left or right depending on the selected lap or (ascending or descending).

If the application is configured to allow events from hidden regions to be viewed, the regions will form empty columns with the associated text for the region displayed in the lap number cell.

Using Tabular Outing reports

Create a Tabular Outing report

1. Select: **Insert > Display > Tabular Outing Report** or use the Insert Display toolbar button.

   An empty report display is added to the Worksheet.

2. Select: **Data > Connect** and select the required task

3. With the report display in focus, go to the Selection Explorer (Alt + 2) and select the channels required for the report.

   The display is populated by data from the selected channels. Maximum values are shown by default.

   Note: *All laps in the outing are reported on, regardless of the current data selection.*

4. In the report display select: **> Properties.**

5. The Tabular Outing Report Properties dialog opens.

6 Select the Data tab.

7 For each channel double-click the current telltale and select one from a drop-down list.

8 Click OK to return to the display.

Change the connected outing

When a Tabular Outing report is added to a Worksheet and connected to a Task, the report is initially connect to the first outing added to the Task.

- Highlight the appropriate outing and select: **> Connect**.

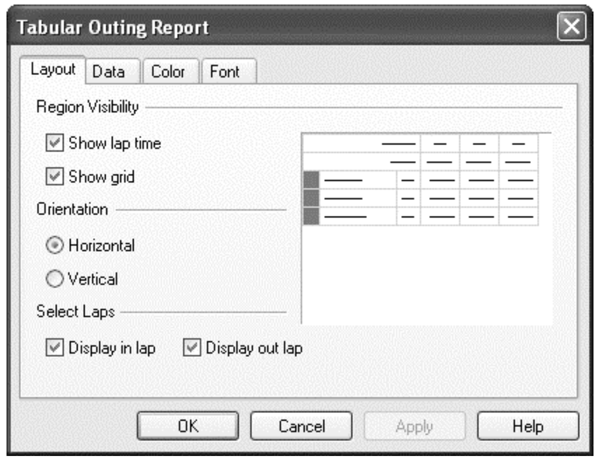
The outing icon will change from this: to this: to show that it has been selected.

Displaying Real-time data

For more information on displaying real-time data, see Setting up a Real-time display on page 241.

Tabular Outing report properties

Layout



Show lap time: Check to show lap times beneath the lap number.

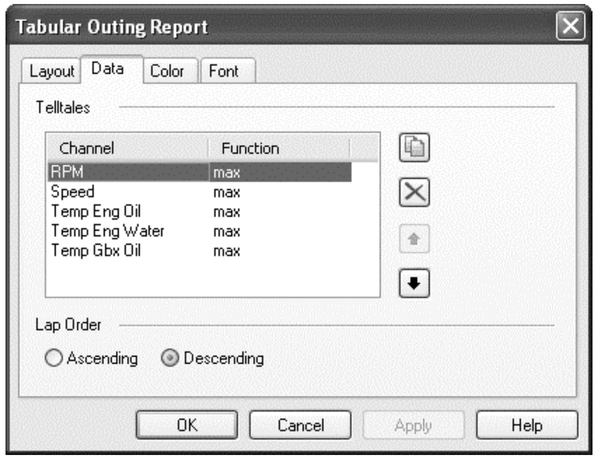
Show grid: Check to show grid lines on the display

Horizontal/vertical: Select the required orientation for the display.

Note: *In vertical orientation the complete channel name may not be displayed as column width is fixed. A ToolTip is provided showing the full channel name.*

Display in/out lap: Check these to include in lap and out lap data columns. These checkboxes will be disabled during real-time operation.

Data

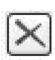


Channel: The channels list shows the channels added to the display in the Selection Explorer.

Function: For each channel set a function by double-clicking 'max' (default function) to display a drop-down list.

Ascending/Descending: Select the order in which incoming laps are displayed.

 Duplicates the highlighted channel. This allows users to set two or more different TellTales for the same channel.

Deletes the highlighted channel. Deleting a channel here removes it from the list of channels selected for the display.

 Moves the highlighted channel up or down the list; changing the order in which channels appear in the table.

Note: For information about customizing the appearance of the display, see page 258

TOR Telltale definitions

Lap max/lap min (max/min): The maximum or minimum data value that occurs during the lap.

Lap difference (diff): Lap max minus lap min.

Lap start (start): The data value taken from the EOL burst data from the previous lap if available. Otherwise interpolated to the start of lap from other data available.

Lap end (end): Initially displayed as an interpolated data value and subsequently updated from the EOL burst data if available.

Lap mean (mean): Shows the mean value of the channel for every lap.

Standard deviation (stddev): Shows the standard deviation of the channel for every lap.

TOR Shortcuts

Shortcut	Description
Ctrl + ↑ + C	Copies the selected data as text.
Alt + ↵	Opens the Properties dialog.
Ctrl + Home End	Moves the focus to the first/last row of data.
← + →	In Historic and Paused mode, scrolls one lap forward.
Home End	In Historic and Paused mode, goes to the first/last lap.
Pge Up Pge Down	In Historic and Paused mode, scrolls the display.
D	Duplicates the selected channel.
Ctrl + ↑ ↓	Moves a highlighted channel up or down the list.
P	Toggles local pause mode.

Video displays

This display enables videos to be viewed, synchronized with the Task Cursor time on displays sharing the same task. As the video is scrolled, cursor movements are made simultaneously in all displays connected to the same task. To display a video, an MPEG must first be associated with an outing. Video display commands are all accessed from context menus.

***Note**: For correct operation of Video displays make sure that Pi Datasets are not write protected.*

The number of laps selected from the outing determines the start and end points of the video in the display. Although the video may cover a complete outing, the user can only scroll from the beginning of the first lap selected, to the end of the last.

The data selection may go beyond the extent of the video. If the task cursor in a connected display is in a data region not covered, the video slider will rest at the beginning or end of the slider bar. The video display will be static until the task cursor is moved into a data region covered by the MPEG.

***Note:** To successfully load the MPEG file there must be at least one beacon on the audio track, and at least one end of lap event. If the beacons match the outing currently loaded, the MPEG frame numbers will synchronize to the task cursor time. If the beacons do not match, the video is synchronized via a single point, i.e. the first beacon pulse to the first end of lap event. The user can then define a time offset to manually align the beacon times.*

Shortcuts

← →	Moves to the previous/next frame in the MPEG.
Home End	Move to the first/last frame in the MPEG within the limits of the data selection.
Pge Up Pge Down	Fast forward/Fast reverse.
Space	Play/Pause.
O	Enter/leave Offset mode.
Alt + ↵	Opens Video Properties dialog.

Features

Keyboard or mouse play and pause controls

Start and stop the video by simply clicking the display or pressing the space bar.

Beacon times and offsets

If an outing with an associated MPEG file is highlighted in the Selections Explorer, beacon pulse times and matching end of lap times are shown in the Properties pane. These times are used as synchronization points, to synchronize the video with the Task Cursor. If the MPEG file did not associate with the outing, the video and Task Cursor are synchronized via a single pair of beacon pulse / end of lap event, whose times are displayed.

User defined offsets

The user can manually adjust this synchronization by defining an offset. In Offset mode, the link between the cursor and video is broken. The Video will remain static while the slider can be used to move the Task cursor through the data selection, to re-align the video with a new position within the data selection. Exiting Offset mode reconnects the video with the task cursor.

Resizing

Video displays can be resized like any other Pi Toolbox display. The user can force the video to maintain its original aspect ratio (at recording) regardless of the display aspect ratio.

Audible beacon pulses

When the mute option is deselected in the Properties dialog, audible beacon pulses are available to the PC sound card.

Loading MPEGs

The following procedure assumes that you have created a task and loaded an outing that has a corresponding MPEG video file.

1 Add a new Video display to the Worksheet and connect it to the appropriate task. This is the same as adding any other type of display.

2 With the Video display in focus, select: Alt + 2 to go to the Selection Explorer.

A camera icon is displayed beneath the outing name for every camera used on the outing.

3 Highlight the required camera and select: **> Load Video**.

4 Use the Open dialog to browse for an MPEG to load.

The dialog box has an active preview panel with video controls to aid MPEG selection.

5 Double-click on the required MPEG to load the video.

MPEG file association

When the load operation has completed, an attempt is made to synchronize the video with Task Cursor time. This is achieved by trying to associate each beacon pulse found in the MPEG file with a corresponding end of lap event from the Outing. If no MPEG beacon pulses are found, the load operation will fail and the MPEG cannot be selected for the video display.

Association is successful if a sequence of end of lap events is found in the outing whose event-event time separation matches the beacon-beacon time separation in the sequence of MPEG beacons i.e. both the end of lap events and the MPEG beacons define a matching sequence of lap durations. A +/- 0.5% tolerance is allowed in the matching algorithm, to allow for possible differences in clock speed between the hardware used to generate the two data sets.

If the association succeeds, the MPEG file is loaded into the outing and this icon is shown. The times for each associated end of lap event / MPEG beacon are shown in the Selections Explorer properties pane. With the MPEG file highlighted, select: **> Select** to display the video. When the video is run, video time is synchronized with Task Cursor time via each of these end of lap event / MPEG beacon pairs.

If MPEG beacon pulses are found but they do not match the outing End of Lap event times, the MPEG file is loaded into the outing and this icon is shown, to indicate that a match has not been made. In this case the video is synchronized with Task Cursor time by associating the first beacon pulse found in the MPEG file with the first end of lap event in the Outing. The times for this end of lap event / MPEG beacon are shown in the Selections Explorer properties pane, and the MPEG can then be selected for the video display.

Note: *The association process time varies according to the size of the MPEG file.*

User defined offsets

The synchronization between video time and Task Cursor time which results from the above association process can be manually adjusted if required, by setting a user defined offset. The Task Cursor time that corresponds to the current video frame can be offset to a new value selected by the user. This is achieved by entering Offset Mode and, with the video disconnected from the task cursor, using the slider bar to re-position the Task Cursor.

To set an offset:

1 In the display select: **> Offset Mode** to enter Offset mode.

The video is stopped at the current frame and disconnected from the task cursor. An offset field showing the current offset is displayed next to the slider bar, which itself is re-mapped to show the Task Cursor position within the current data selection.

2 Move the Task Cursor to a point within the data selection, which is to be synchronized with the current video frame.

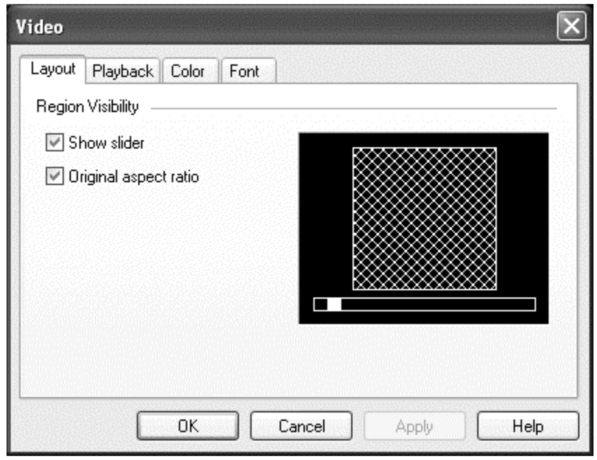
This is achieved either by moving the slider bar on the video display, or by moving the Task Cursor itself on any other display sharing the same task.

3 Select: **> Offset Mode** again to exit Offset mode.

Note: *When an offset is defined it will remain in effect until it is deleted by selecting:* > ***Delete Offset****. When this is selected, the synchronization will return to that made when the video was initially loaded.*

Properties

Layout

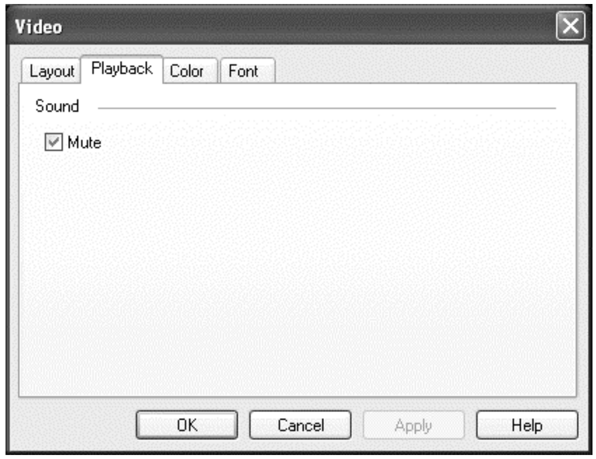


***Show Slider*:** Display the slider bar at the bottom of the video. This is used to scroll through the video within the limits of the current data selection or, if it is shorter that the data selection, the length of the MPEG.

***Original Aspect Ratio*:** The video is shown at the aspect ratio that it was recorded. Areas of black may show at the edges of the video when the aspect ratio of the display window differs from that of the video. Resizing the display window can minimize this.

When deselected, the video stretches to fill the display window.

Playback



Mute: When selected the beacon pulses, stored in the MPEG sound track, are inaudible.

Note: *For more information about customizing the appearance of the display, see page 258*

Bit Indicator displays

The Bit Indicator display enables the engineer to examine system status channels looking for error conditions to occur. A typical example would be where the health status channel, comprised of a 32-bit word, has Bits 0, 1, 2, 5 and 7 assigned to the errors identified in the hydraulic differential system.

Error condition	**Bit**
Pressure transducer - peak value exceeded	0
Pressure transducer - open circuit	1
Pressure transducer - high noise presence	2
Moog valve - coil failure	5
System Hydraulic Pressure - low	7

Typically when an error condition occurs i.e. Bit value changes from 0 to 1, the indicator for that bit will change color.

The display is in the form of a grid. Bits are mapped to the cells of the grid and the cell's color is dependant upon the status of the bit.

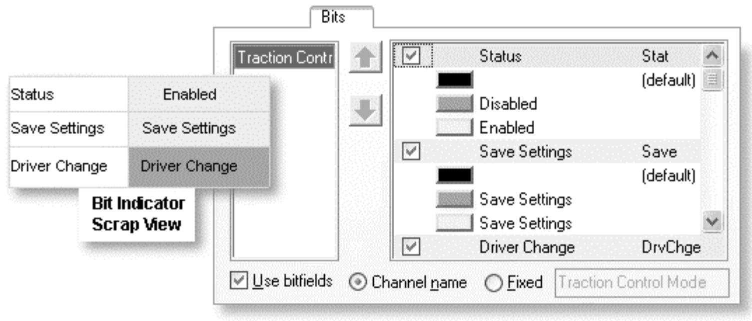
Bit-fields

Status channels can have one or more bit-fields pre-defined, allowing different values to be displayed for each field. For example, a 'Pressure Transducer Status' field could have the values 'Enabled', 'Disabled', 'Failed'.

Bit-field definitions are contained in outing datasets (real-time or historic) making it convenient for engineers to use status channels in displays and math channels with little setting up. When a status channel is added to a Bit Indicator display or included in a math channel, it automatically conforms to its bit field definition as long as a definition exists in the outing.

About Bit-fields

Bit-field definitions, contained in historic and real-time outing datasets, define the number of fields that a status channel can have and how many possible values each field has, along with each field value's associated color and text.



In the above example the Traction Control Mode channel has several fields, three of which are visible: Status, Save Settings and Driver Settings. The corresponding Bits tab of the Properties dialog shows the possible values of each field. For example the Status field has three possible values: default (no title), 'Disabled' and 'Enabled'.

When a channel (with an associated bit-field definition) is added to a Bit Indicator, the display for that channel is automatically configured to the bit-field definition; the 'Use bit-fields' option is checked by default.

Checkboxes adjacent to the Bit-field names are used to enable or disable individual fields. Disable fields will not appear on the display.

Note: *Users can uncheck 'Use Bit-fi*elds' in the Properties dialog so that the channel ignores the definition and reverts to individual bit behavior.

Note: *If no bit-field definitions are present within the dataset, then the 'Use Bit-field' check box will be disabled, and behavior will revert to normal channel bits display.*

Editing

Field background color and text can be edited if required.

Definitions have a global context across the outing. Each instance of a channel, with a bit-field definition, used in a Bit Indicator display will be configured according to the definition. Changes made to background color and field text are applied on a per display basis.

Note: *If an outing is updated with a new bit-field definition, local field properties set up in Bit Indicators will be lost.*

Bit field definition file format

The file format used is XML, with Pi specific XML elements employed to cater for the bit-field definitions. Bit-Field definitions can come from several application sources. They all need to be combined before they are converted into a blob (to be added to the target PDS file), since each application will produce channels that are logged and stored in a single PDS file.

The definitions will be specified on a per application basis, as seen below. Usually there will be one XML file per application, but it is also permissible to have several applications defined within one XML file.

Note*: The tag name attribute of the <channel> element must be unique across all applications.*

For example:

```
<status_def version="1.00">
        <application name="Gearbox Control" id="48dbefa1" >
                <channel tagname="GB_Status" colour="0xff0000">
                        <field name="Heartbeat" abbr="Htbt" bitmask="0x0100">
                                <entry value="0x0000" text="Off" colour="0xff0000" />
                                <entry value="0x0100" text="On" colour="0x00ff00" />
                        </field>
                        <field name="Mode" abbr="Md" bitmask="0x0003">
                                <entry value="0x0000" text="Disabled" colour="0xff0000" />
                                <entry value="0x0001" text="Enabled" colour="0x00ff00" />
                                <entry value="0x0002" text="Failed" colour="0xff0000" />
                                <default text="Undefined" colour="0xa1a1a1" />
                        </field>
                </channel>
                <channel tagname="GB_Selection" color="0x005566">
                        <field bitmask="0xffff">
                        <entry value="0x0000" text="R" />
                        <entry value="0x0001" text="1" />
                        <entry value="0x0002" text="2" />
                        <entry value="0x0003" text="3" />
                        <entry value="0x0004" text="4" />
                        <entry value="0x0005" text="5" />
                        <entry value="0x0006" text="6" />
                        <default text="-" />
                        </field>
                </channel>
        </application>
        </status_def>
```

The above example defines two fields in the first status channel. The first is a heartbeat that changes between the two states to indicate that the application is still running. The second indicates the state of the application:

1 Disabled by the user.

2 Enabled by the user and functioning.

3 Enabled by the user but there is an error and the application has been disabled automatically (e.g. an input sensor is out of range).

Note: *The second field contains a default text string that should be displayed if the value does not matching any of the above.*

The second status channel is a special case where the channel contains only one, unnamed sub-field. The gearbox position channel should therefore be treated as a normal channel but with the ability for Toolbox displays to show the text associated with the specified values.

XML elements

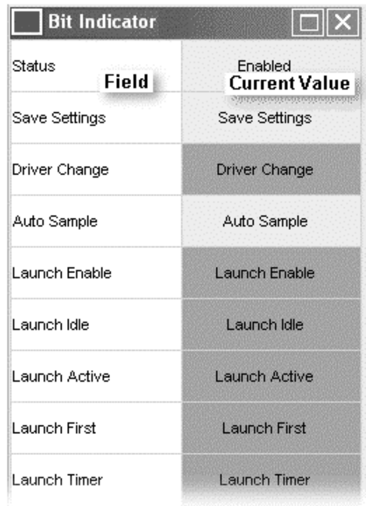
In addition to the XML elements required to describe the bit-field definitions, extra elements are needed to provide such data as version information, build information and timestamp etc.

Example strings

For examples of XML strings, see Appendix E, XML Example strings on page 479.

Bit field Maintenance tool

Use the maintenance tool to import Bit-field definitions from XML files, for writing to Pi Datasets. Bit-field definitions define the number of fields that a status channel can have and how many possible values each field contains. See the example below to see how channels with Bit-fields defined can be used in Bit Indicators.



The Maintenance Tool can be operated in two modes: Using the Bit-field Maintenance Tool dialog box, or using command line parameters through the standard console.

The command line interface is intended to be used when automation of the tool is required.

Command line operation

The Bit field maintenance tool can be accessed from the command prompt; this is so that the operation can be included in batch files as an automated process.

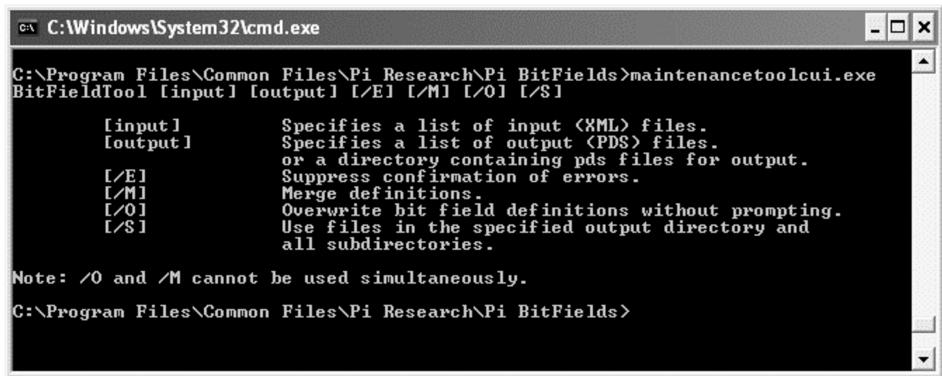
To access the Bit-field Maintenance Tool from the command prompt:

1 Open a Command line session.

2 Change the displayed directory to the following: *C:\Program Files\Common Files\Pi Research\Pi Bitfields*.

3 At the prompt, type *maintenancetoolcui.exe*.

The Maintenance tool will open and a list of options will be displayed.



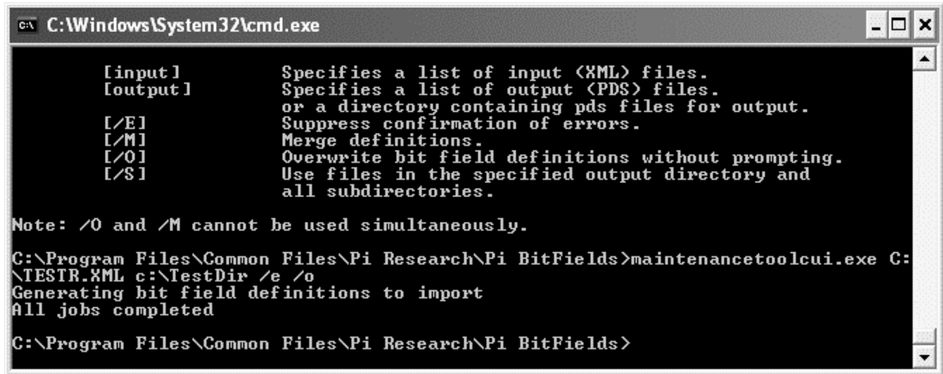
4 Enter a location for the XML source file, an output directory and any of the options that you want to include. For example:

```
Maintenancetoolcui.exe <source file> <output directory> <options>
```

```
Maintenancetoolcui.exe c:test.xml c:testdirectory /e /o
```

In the above example, c:test.xml is the source file. C:testdirectory is the output directory and options /e, Suppress confirmation of errors and /o, Overwrite bit field definitions without prompting are applied.

5 The application will display status messages as it carries out the process.



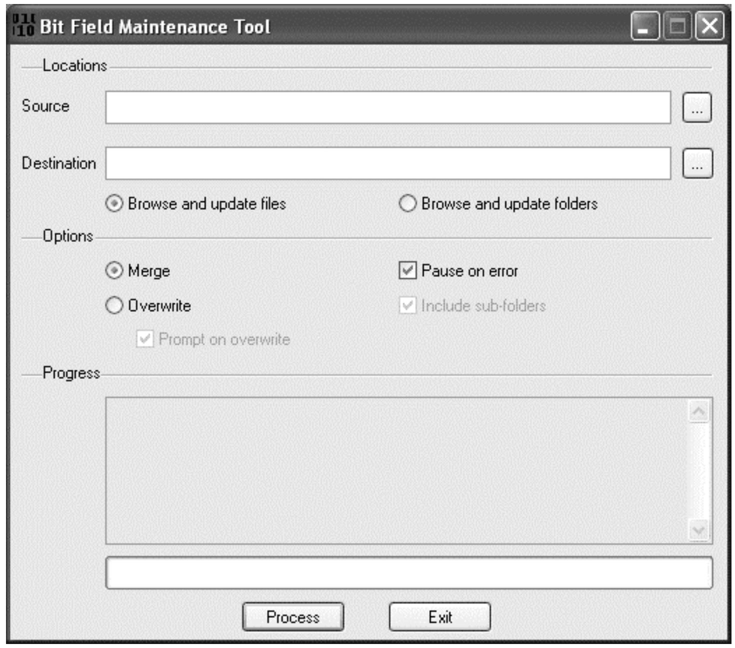
Options

Name	Definition
/E	Suppress prompting to confirm errors.
/M	Merge definitions. If this parameter is not supplied then the definitions in the destination files will be over written.
/O	Suppress prompting to confirm overwriting existing definitions.
/S	Recursive. This option is only valid if the destination contains a folder. If the destination is not a folder and this parameter is supplied then an error will occur and the application will quit.

Dialog box operation

The Bit-field Maintenance Tool dialog is intended for single import operations. You access the Bit field Maintenance tool from the Start menu.

Click *Start* > *All Programs* > *Pi Research* > *Pi Tools* > *Pi Bit Field Definitions Maintenance.*



Source: The source files are XML files. Enter the path/name of the source file or use the browse button.

Target: Target files are Pi Datasets (.pds files). Enter the path/name of the target file or use the browse button.

Browse and update file(s): With this option selected you can import definitions into a single pds file, or a selection of files. Clicking the browse button (with this option) displays a multi-selection File Open dialog where single or multiple files can be selected.

Browse and update folders: with this option selected you can import definitions to into every pds file contained in a folder.

Include sub-folders: Checking this will include in the import, any sub-folders that may contain *.pds* files.

Options

Merge: with the Merge option selected, the Bit-field definitions from the source files will be added to the definitions contained in the target files.

Overwrite: with the Overwrite option selected, all Bit-field definitions in the target files will be removed before the definitions from the source files are added.

Prompt on overwrite: Check this to display a prompt dialog if destination files contain definitions that will be removed.

Pause on Error: If an error occurs either reading definitions from a source file or writing them to a target file, then a continue/stop prompt will be displayed.

Shortcuts

Alt + ↵	Opens the Bit Indicator Properties dialog.

Features

Bit selection

Select bits to display from any channel, choose true/false colors and edit the caption text.

Outing selection

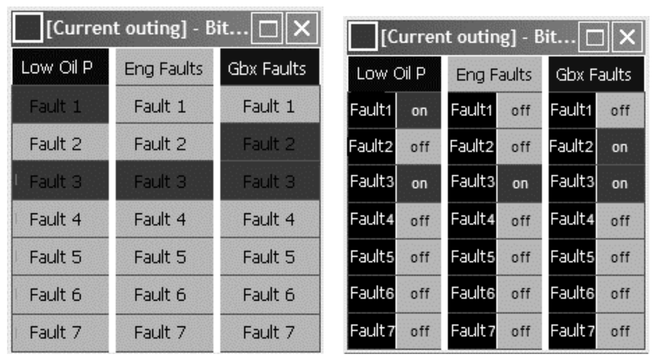
The display can be assigned to a single outing only. In a task containing multiple outings, you can select which one to display by highlighting the outing and selecting: **> Connect**.

Display resizing

The display can be resized vertically and horizontally. The display of the status channel can be either by row or by column. When resizing, the bits from each channel will always remain within their assigned column.

Layout options

These examples illustrate two options for bit caption placement. The display on the left has bit captions inside the indicator. You can also place the captions outside (right, left, above, below) as shown on the display on the right. Placement is defined in the Properties dialog.



***Note**: both of these displays are in a vertical format. Channels can also be laid out horizontally.*

To create a bit indicator:

1 Using the Insert Display toolbar buttons, place a Bit Indicator display on the Worksheet and connect it to a task.

2 With the Bit Indicator in focus, go to the Selections Explorer and select the channels to display.

***Note:** The 'Show Bit Captions' default is 'Yes'. However, they may not show initially if the space allocated to the display on the Worksheet is too small. Also, the display will have 32 bits enabled for every channel selected. Deselect unwanted bits in the Properties dialog.*

3 Open the Properties dialog.

4 Select the 'Bits' tab and highlight a channel in the channel list on the left of the dialog.

5 Uncheck any unwanted bits. Repeat this for all channels selected.

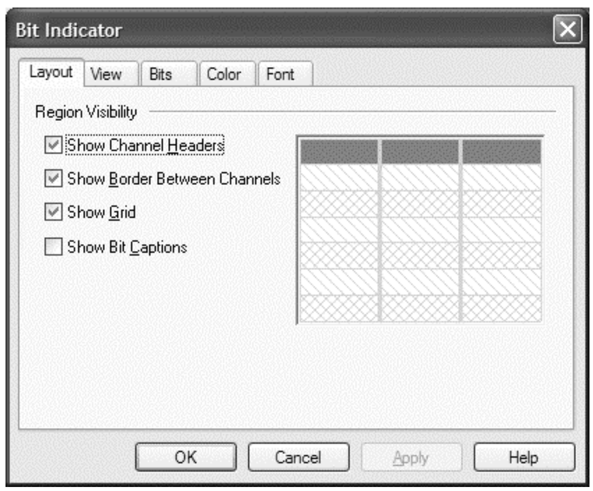
Tip: *To disable a group of bits, click on the first bit then shift click the last bit. With the group highlighted, click on the checkbox of any of the bits - all bits selected will become disabled. You can also use this method with multiple channels selected.*

6 Define other properties as required.

7 Click 'OK'.

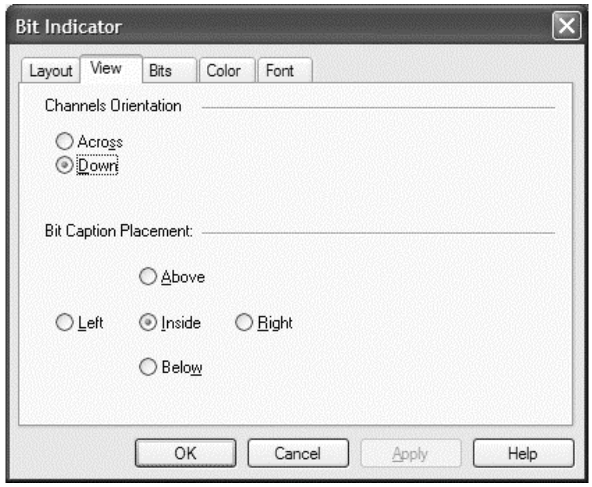
Properties

Layout



Show Channel Headers: Selects various elements to show on the display. The preview window aids visualization of the layout.

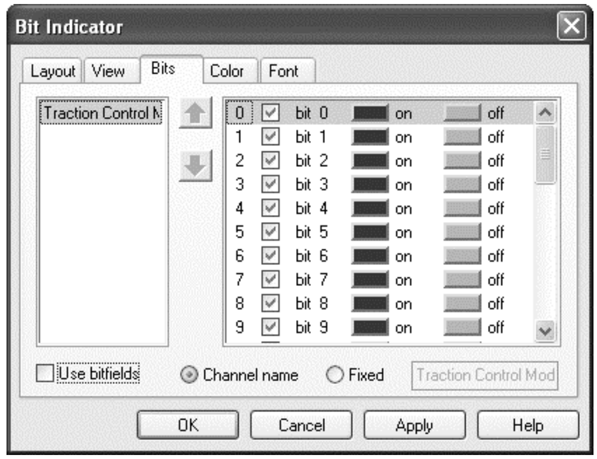
View



Channels Orientation: Determines the format of the display grid - horizontal or vertical.

Bit Caption Placement: Determines where the bit caption is placed in relation to the channel indicator.

Bits (Normal view)



Channel list: Displays all the channels selected for the display.

Use the up/down arrows to move the highlighted channel up or down the list. This will change the column order in the display.

Bit control panel: Shows the bit status for the channel highlighted in the channel list.

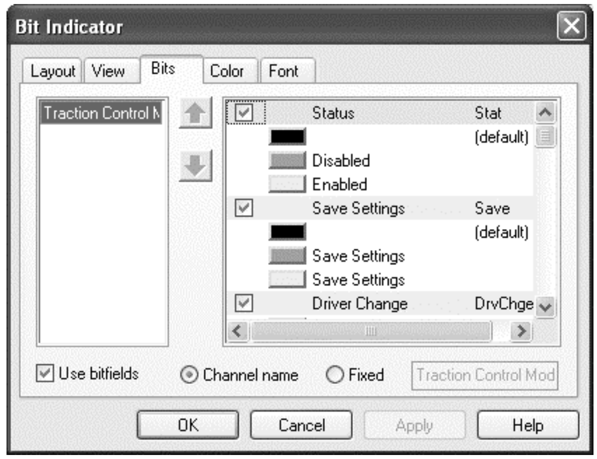
Uncheck the bits that you do not want to appear on the display.

All bit titles are editable. Double-click the bit text and enter the caption that you want to appear on the display. Double-click a color panel and select a color from the color palette.

Use Bit fields: When checked, forces channels in the channel list to conform to their associated Bit Field Definitions in the outing data (if they are present). If the highlighted channel has an associated definition, the configuration of the Bit Control Panel changes

Channel Name/Fixed: Defines the column header text for the highlighted channel. To define a header other than the channel name, select 'Fixed' and enter the new header in the adjacent field.

Bits (using Bit-field definitions)

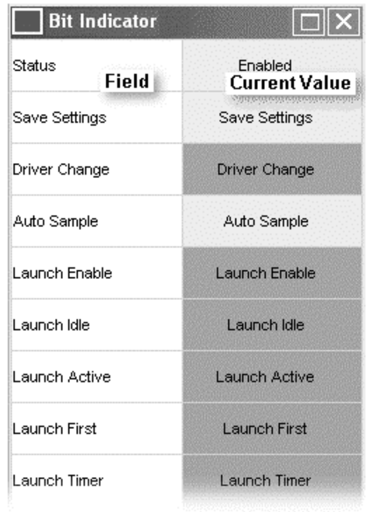


Channel list: Displays all the channels selected for the display.

Use the up/down arrows to move the highlighted channel up or down the list. This will change the column order in the display when the *Apply* button is clicked.

Bit Control Panel: The number of fields is defined in the Bit Field Definition. This example shows the Traction Control Mode channel (Pi Datasets in Sample Data folder). The channel has several fields, three of which are visible here: Status, Save Settings and Driver Change. The Field name and abbreviation can be edited. The abbreviation is displayed if the column width of the display is too small for the complete name. Each field has a pre-defined number of values (Status has three in this example: default (no title), Disabled and Enabled). The value names and background colors can be edited if required.

The example shows how the Traction Control Mode channel appears.



Enable: Use this checkbox to enable/disable individual fields of the selected channel.

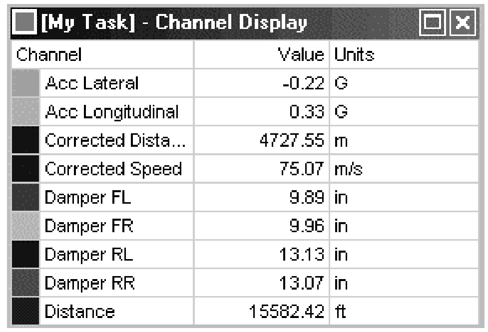
Use bit-fields: When checked, forces channels in the channel list to conform to their associated Bit Field Definitions in the outing data (if they are present).

***Note**: If no bit-field definitions are present within the dataset, then the 'Use Bit-field' check box will be disabled, and behavior will revert to normal channel bits display.*

Channel Name/Fixed: Defines the column header text for the highlighted channel. To define a header other than the channel name, select 'Fixed' and enter the new header in the adjacent field.

***Note**: For information on customizing the appearance of the display,* *see page 258*

Channel displays



The Channel display enables channel names, values and units to be displayed in a list view on the Worksheet. The display can work in both historic data and real-time modes and is generally used for viewing channel values for car parameters in real-time.

- In real-time mode, the values of the last data sample of the channel are displayed.
- In historic mode, channel values are based on the position of the task cursor.

The default layout of the Channel display is made up of three columns: channel name, value and units. The display can be configured to display a combination of any of the 3 columns. The default channel color is indicated by a colored square adjacent to the channel name.

Channel alarms can also be shown in the channel display. When the channel value moves outside of the specified minimum or maximum value, it will be displayed with a red background. The Alarm value can be set globally or locally. Local alarms can be useful if you are watching a specific channel for a change in its status, a differential channel for example.

The principle of connecting tasks to a display and selecting channels for viewing, as in Time and Distance charts, applies to Channel displays.

Note: *Because Channel displays are primarily real-time displays; only Channels from a single connected data selection are displayed.*

Shortcuts

Ctrl + H	Hide/Show the column headers
Ctrl + H	Toggle table header visibility on/off
Alt + ↵	Opens Channel Display Properties dialog.
F9	Enable the display in Pi Remote Toolbox
F10	Enable Pi Remote Toolbox

Features

Column width

Change column widths by dragging the column header border. Double click the column header for a 'Best Fit'.

Number of columns

Define the columns to display: value only; value and name or units; or value, name and units. The display can be configured to display a combination of any of the 3 columns.

Channel order

Move channels up or down the order in the channel display.

Show header/grid

Show or hide the channel headers and grid lines.

Channel color indicator

If the channel name sub-column is displayed, the channel's color (set in Properties Explorer) is indicated by a colored square.

Data point indicator

In historic mode when the cursor is on a data point, the value field will display the data point indicator: ◣.

Channel alarms

Channel alarms can be shown in the channel display. When the channel value moves outside of the specified minimum or maximum value, it will be displayed with a red background.

The Alarm value can be set globally or locally. Local alarms can be useful if you are watching a specific channel for a change in its status, a differential channel for example.

Pi Remote toolbox

Information that is currently being displayed in the Channel display can be shown on a Palm PDA running Pi Remote Toolbox. For more information on Pi Remote Toolbox, see page 300

Working with Channel displays

Channel Displays are created in the same way as other types of display. The display must be connected to a task that contains an outing, and have channels selected channels. The channels selected will appear in the Channel Display.

To add channels to the display:

1 With the Channel display in focus go to the Selection Explorer.

2 In the upper pane double-click the channel you want to add.

The channel appears in the Selected Channels list of the explorer and is added to the bottom of Channel Display list.

To change the channel position in the channel display

1 Select: ☰ > Properties.

The Channel Properties dialog opens.

2 Click the Channels Order tab.

3 In the Channels list select the channel to move.

4 Use the up/down arrows to move the channel up or down the list.

5 Click OK.

Using Channel Alarms

Alarms can be configured and displayed in the Channel display and Summary display.

To use the alarm function, you must do the following:

- Enable the Alarm function. You can do this in either the Channel display or Summary display properties.
- Set the Global alarm properties in the Channel Explorer.
- Add the channel to the display.

Setting the local alarm properties

Once the channel is added to the display, you can set local alarm properties for any channel in the display. This is a useful feature if you are monitoring a channel closely, as soon as the value changes, the alarm will be triggered.

To set a local alarm

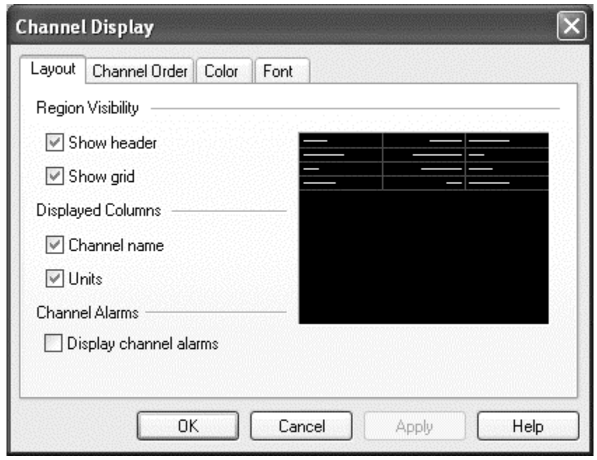
- Select the alarm in the display, > Set Thresholds. Keyboard shortcut S

The channel alarm thresholds are now locally set to the current value that is displayed in the table.

Note: *You can revert to the global alarm properties at any time. Select the channel in the display, in the Channel Explorer click the Display tab, > Revert.*

Properties

Layout



Show Header: Click to clear the Show header check box to disable this feature.

Show Grid: Click to clear the Show grid check box to disable this feature.

Channel name: Click to clear the Channel name check box to disable this feature.

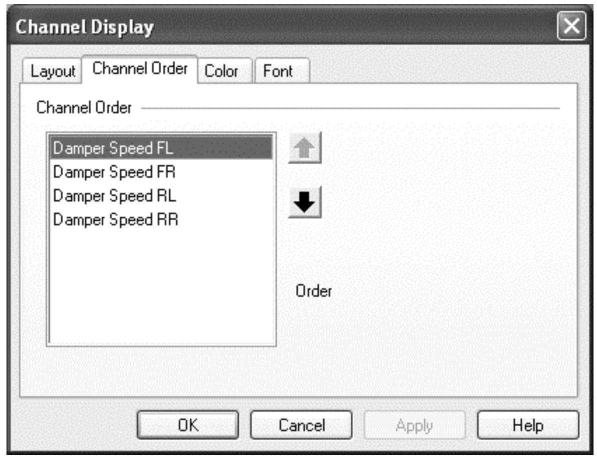
Units: Check to show the units sub-column for the channel selected in the layout window.

Note: *These options are all enabled by default.*

Display Channel alarms: Check this option to enable channel alarms to be displayed within the Channel display.

Note: *This option is disabled by default.*

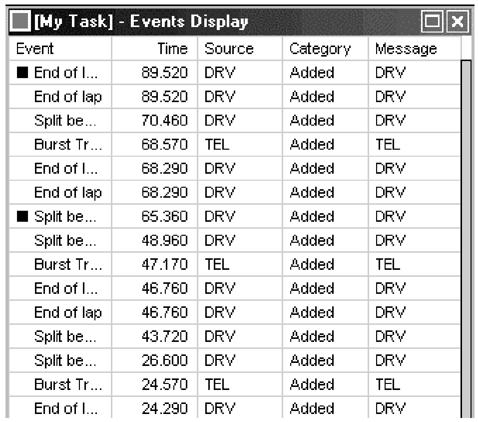
Channel order



To change the position of a channel in the Channel display, select the channel in the Channel Order list and use the up/down arrows to change the order.

Note: *For information about customising the appearance of the display, see page 258*

Event display


[My Task] - Events Display

Event	Time	Source	Category	Message
■ End of l...	89.520	DRV	Added	DRV
End of lap	89.520	DRV	Added	DRV
Split be...	70.460	DRV	Added	DRV
Burst Tr...	68.570	TEL	Added	TEL
End of l...	68.290	DRV	Added	DRV
End of lap	68.290	DRV	Added	DRV
■ Split be...	65.360	DRV	Added	DRV
Split be...	48.960	DRV	Added	DRV
Burst Tr...	47.170	TEL	Added	TEL
End of l...	46.760	DRV	Added	DRV
End of lap	46.760	DRV	Added	DRV
Split be...	43.720	DRV	Added	DRV
Split be...	26.600	DRV	Added	DRV
Burst Tr...	24.570	TEL	Added	TEL
End of l...	24.290	DRV	Added	DRV

The Event display, displays events in a list view from both real-time and historic data, depending on the type of data stream it is associated with.

Selecting an event in the display causes the task cursor to be set to the event's timestamp, so that all displays connected to the same task can navigate to the event's moment in time. For example a Display can be set up to show gearbox parameters such as temperatures and pressure, together with more general car parameters such as lateral acceleration, speed. Then if an event occurs, say, 'Low Gearbox Oil Pressure' and is selected in the Event display, the cursor positions in the associated displays update, allowing engineers to see what other parameter values were at the event time.

Source: This column indicates the logger application which generated the event e.g. DRV.

Category: This column contains a classification specifying how and where the event has been generated. The categories can be:

Box: Added by Sigma.

Added: Added by Pi Toolbox.

Algorithm: Added by an algorithm in Pi Toolbox (a soft event).

The principle of connecting tasks to a display and selecting channels for viewing, as in Time and Distance displays, applies to Event Displays.

Shortcuts

↑ ↓	Changes the event selection in the Display.
⇧ + ↑ ↓	Scroll up and down the events without changing the selection.
⇧ + Pge Up Pge Down	Scroll the event list one page up or down without changing the selection.
Home End	Go to the start or end of the event list.
Space	Toggle the ‘marked’ status of the selected event.
Ctrl + ↑ ↓	Move to the next/previous marked event.
G	Toggles the Event group mode.
+ -	Expands or collapses all groups in the display.
Ctrl + + -	Expands or collapses all groups in the display.
P	Toggle Paused/Running Modes.
↵	Opens the Event Details dialog for the selected event. Alternatively, double-click the event.
Alt + ↵	Opens the Event display Properties dialog.

Features

Soft and hard events

The Event display shows both **Hard** events, generated in the data acquisition and control system, and **Soft** events, user-generated (created locally on the PC) from a single real-time data stream or an historic outing.

Current event

The selected event in the display is the Current Event. The task cursor is set to the current event's timestamp. When the current event is changed the task cursor is set to the new timestamp. If the task cursor in an associated display is set to a time where no events occurred, there will be no current event in the display.

Display modes in real-time

There are two real-time modes: paused and running. When paused the display behaves as if it were connected to historic data. When the display is running and a new event occurs, the display auto-scrolls to display the new event. Modes are selected at task level in real-time.

Shortcuts: R and P.

Multiple events occurring simultaneously

If two or more events occur at the same time they are listed alphabetically. By their event set name and then by their source. If an event is marked, other events occurring at the same time are marked as well.

Event order

New events can be added to the top or bottom of the events already listed. The selection is made in the Properties dialog.

Marked events

Pressing the space bar can mark events listed in the display. Users can navigate quickly from one marked event to the next/previous one using the shortcut: Ctrl + ↑ ↓.

Event details

Complete event data from any event listed, can be displayed in the Event Details dialog. Double-clicking an event opens the dialog.

Copy events to Excel

The Event details displayed can be copies as text into Excel spreadsheets using the Copy as Text context menu.

Priorities

Priorities allow events to be categorized based on their severity, importance or source. The Event display can then be configured to plot events by priority. Priorities are set up in the Options dialog. Background and foreground colors can be set to aid recognition in the Event display. There a four default priorities, Debug, System, Status, Error. Priority properties can be changed if required and further priorities can be added, up to a total of eight. Choosing to show/hide selected priorities can therefore filter events.

Grouping

Events with the same name can be grouped in the display. Grouping is optional and can be switched off if required. The group header displays the name of the Events held in the group and how many Events it contains. Groups can be expanded and collapsed using keyboard shortcuts.

Layout options

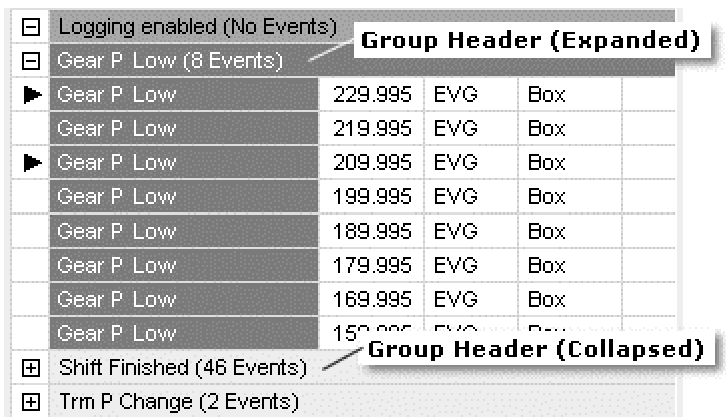
The information shown for listed events is control in the Layout tab of the Properties dialog. The event name is always displayed. Time, Source, Category and Message columns can be shown or hidden as required.

Sizing

Column widths can be customized by dragging the vertical border between columns.

Event grouping

Events with the same name can be grouped in the display. Grouping is optional and can be switched off if required. The group header displays the name of the Events held in the group and how many Events it contains. Groups can be expanded and collapsed using keyboard shortcuts.



The order of events in the group can be set to 'Ascending' or 'Descending' in the Properties dialog.

Note: *In Group mode group headers are displayed even if there are no instances of the corresponding event in the current data selection.*

Expanding and Collapsing Groups

Clicking on the expand/collapse icons to the left of the group header expands or collapses the group. Or:

- + Expands or collapses the highlighted group header

Ctrl + - And Ctrl + + will expand or collapse all groups in the display.

Event priorities

Event priorities allow events to be categorized based on their severity, importance or source. The Event display can then be configured to plot events by priority.

Priorities are set up in the Priorities tab of the Options dialog. Background and foreground colors can be set to aid recognition in the Event display. There a four default priorities, Debug, System, Status, Error. Priority properties (name, colors etc.) can be changed if required and further priorities can be added up to a total of eight.

Priority ID’s

Priorities are created using IDs which correspond to Event IDs. Events are placed in priority categories accordingly. If an event is assigned an ID that does not exist in the priorities defined for the workbook, it is placed into the 'other' category. This is unique in that it cannot be deleted and it does not have an ID.

Working with Event displays

To select events for an Event display:

1 From the Insert Display list select an Event Display

An empty Event display is added to the Worksheet.

2 Connect the display to a task

3 With the event display in focus go to the Selection explorer. **Keyboard Shortcut**: Alt + 2

When the event display has focus, the Selection explorer only shows the Events tab.

4 In the Available Events list of the explorer, double-click the events that you want to appear in the display.

The selected events appear in the lower pane of the explorer in the Individual Events list, and are listed in the display.

Note: *Alternative methods of selecting events include Shift click and Ctrl click techniques.*

Copy events to Excel

1 In the Event display select: **> Copy as Text**

2 Open the required Excel spreadsheet

3 Click on a starting cell and select: **> Paste**

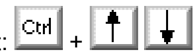
All the events listed in the display are pasted into the spreadsheet as editable text.

Marking an Event

You can mark an event of interest and then scroll through any marked events, saving you time in searching for them.

- Click the area to the left of the event name.

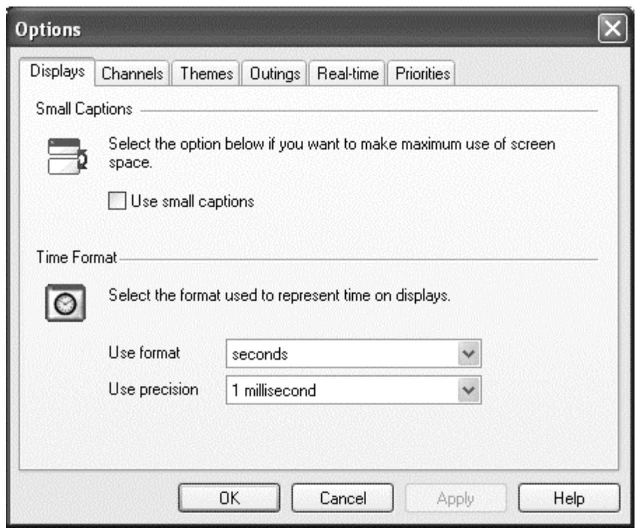
  A black triangle indicates that the event is marked.

To navigate marked events use the shortcut: 

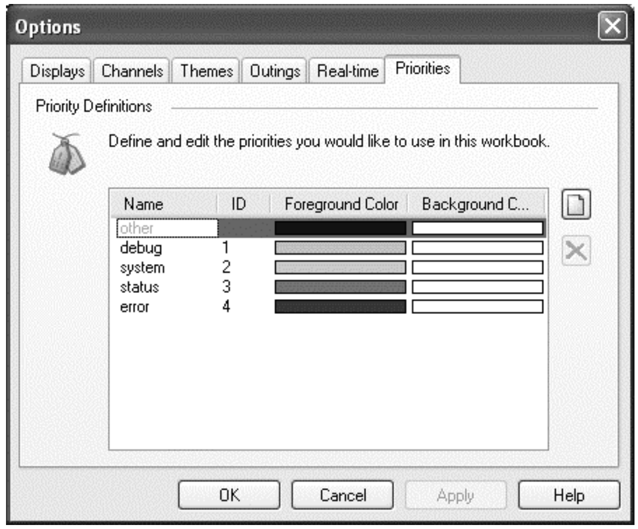
Create an Event priority

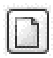
1 Select**:** Tools > Options

2 The Options Dialog opens.



3 Select the Priorities tab.



4 Click 

5 A new priority is added to the bottom of the default priorities list.

6 Edit the various properties of the Priority, i.e. Name, ID, Foreground Color, Background Color.

Note: *A maximum of eight priorities (default and custom) is allowed.*

Assigning Events to a priority

You can assign either Single or Multiple events to a priority.

Note: *It is assumed that Event priorities have been previously created in the Options dialog.*

1 Go to the Event Properties Explorer. Shortcut: Alt + 4.

2 Select an Event or multiple events in the upper pane of the explorer.

Event properties are displayed in the lower pane.

3 In the lower pane double-click the 'Priority' property to display a drop-down list of available priorities.

4 Select a priority from the list.

The selected Event/s will be placed in the new priority and will be displayed in accordance with its properties in an Event display.

Note: *When an Event is assigned a priority, its icon in the upper pane of the Explorer, changes to the Foreground and Background colors set for the priority.*

Filtering Events by Priority

Displays can be filtered to hide selected Event priorities. This can be done from either the *Properties dialog* or the *Context menu*.

Via the Properties dialog:

1 In the Event display select: **> Properties**.

2 In the Properties dialog select the View tab.

The Priorities panel lists the available priorities.

3 Uncheck the priorities that you wish to filter out of the display.

Via the Context menu:

1 In the Event display select: **> View by Priority > Priority 1, Priority 2**. Etc.

2 From the drop-down list of available priorities select or deselect as required**.**

There are two further commands in the menu:

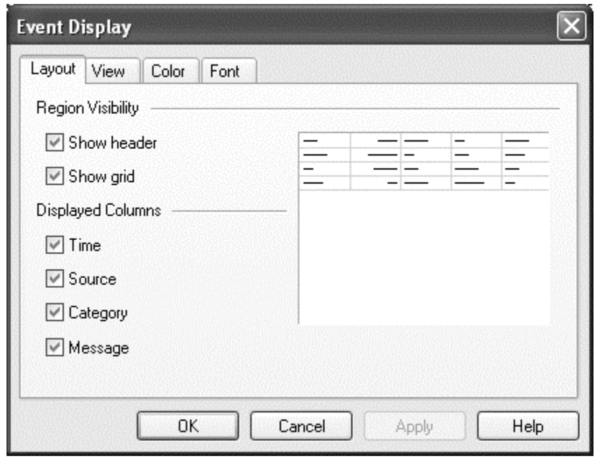
All Priorities: Selects all available priorities for display.

Toggle: Reverses the current priorities selection.

Note: *When all priorities are selected, the 'Toggle' command can be used to reverse the selection, i.e. no priorities selected, and then reselect a single priority. This can save time deselecting priorities individually.*

Properties

Layout



Show Header: Check to show headers

Show Grid: Check to show grid lines

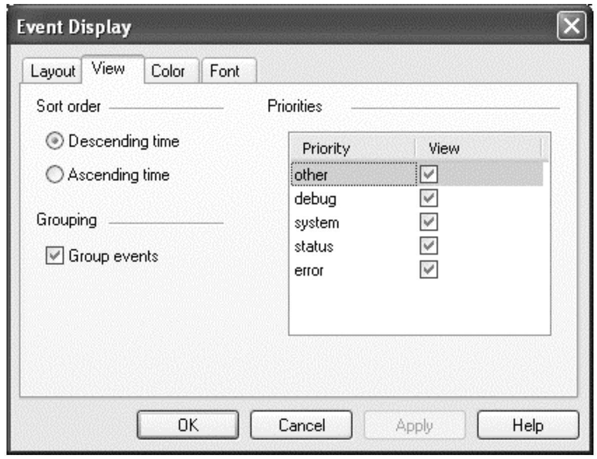
Time: Check to show the Time column. This is the time value at which the event occurred.

Source: Check to show the Source column. This is where the event was generated, e.g. 'BOX'.

Category: Check to show the Category column. This is the category of the event, e.g. Box, Algorithm, etc.

Message: Check to show the Message column. This is the text string associated with the event.

View



Sort Order

Descending/Ascending time: Determines the sort order of events, either within groups or as a flat list.

Grouping

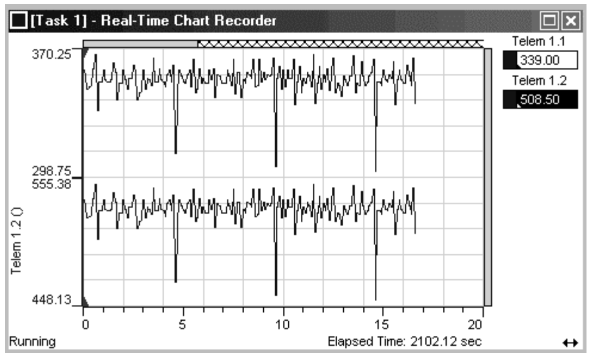
Group events: When checked the display groups events of the same name under a group header. Groups can be expanded and collapsed using keyboard shortcuts.

Priorities

Event priorities allow the user to categorize events based on their severity, importance or source. The checkboxes related to priorities in this list can be used to show/hide priority groups.

Note: For information about customizing the appearance of the display, see page 258

Chart Recorders



The Chart Recorder provides a means of viewing real-time data from the car as it proceeds around the track. The chart constantly updates with the latest data, resulting in a scrolling behavior. At any time the user can pause the display and scroll back to investigate a data feature.

The Chart Recorder possesses many of the features associated with Time and Distance displays, but is for use only with real-time data. The advantage of using a Chart Recorder is the ability to view data over a pre-determined time span, regardless of lap boundaries.

Tasks, channels and properties functionality is the same as Time and Distance displays.

Shortcuts

P	Toggles 'Paused' and 'Running' modes. Also click in display to pause.
T	Tile/Overlay Y axis mode.
Alt + ↵	Opens the Chart Recorder Properties dialog.

In Pause mode many of the shortcuts used in Time and Distance displays apply to Chart Recorders. These include:

Z	Zoom
H F	Hide / flash trace
↑ ↓	Scroll through channels in display

Features

Modes of operation

The chart has two modes; 'normal' (continuous update) and 'paused'; pressing 'P' toggles these modes. In normal mode the chart is continually updated with the latest data from the car. Note that in Normal operation the Data Cursor is not displayed. If the user sees a data feature such as a sudden decrease in oil pressure, the chart can be paused. The data can then be scrolled back, zoomed and investigated. When normal mode is restarted the cursor tracks the latest data point again.

Data display

The Chart Recorder displays a single real-time outing. Up to 32 data channels can be displayed simultaneously. Channel traces are displayed in the Channel property color.

Data time span

The X-axis time span is user defined. When the traces reach the X-axis limit the screen clears and the traces grow again from zero. The default time span is 20 seconds. A time between 1 and 999 seconds can be set.

Elapsed time

This is displayed beneath the X-axis. The time display format can be configured in the Options dialog, Displays tab. The options are: seconds, minutes: seconds, hours: minutes: seconds.

Zooming

Zooming functionality is the same as Time and Distance displays but is only active when the chart is in paused mode.

Channel selection

As with other displays, channels are selected in the Selection Explorer. The added channel will display all the data previously logged for it in the real-time outing.

Active Channel selection

In a display one channel is the 'Active' channel, or the channel in focus. For visual reference the Y-axis scale is displayed in the same color as the active channel, and the cursor values legend is highlighted. You can scroll through the available channels using the ↑↓ keys, making each in turn the active channel. As with Time and Distance displays the Data Cursor follows the active channel trace. See Using Time and Distance Charts for information about the Data Cursor.

Multiple axes

A separate Y-Axis can be displayed for every channel selected for the Display. The feature can be switched on and off individually in the Property Explorer for each channel. When the feature is switched off the axes displayed are for the active channel only. When switched on, the axes for the active channel are displayed closest to the plot area. Changing the active channel re-orders the axes so that the new active channel's axes are nearest to the plot area. Displays having multiple data selections show multiple axes for each data selection. The shortcut key 'Y' toggles the auxiliary axis for the active channel between left, right and off.

Real-time features and behavior

See **Setting up a Real-time display**, page 241 to find out how to add a real-time outing.

Pause characteristics

- When *Pause mode* is entered, data is frozen on the display but it continues to be received and buffered.
- When *Pause mode* is cancelled, the buffered data is added to the display and you are then moved to the latest block of received data.

Behavior

The default drawing style "*Drawing Using Lines*" is recommended in real-time mode as this reduces CPU usage.

Working with Chart recorders

1 Create and name a Task.

2 Select: **> Add Outing**.

The Add dialog opens.

3 Select Telemetry in the navigation bar of the Add dialog.

4 Open the Telemetry list.

5 Double-click 'No Real-time Server' or click .

The Browse for Computer dialog opens.

6 Browse for a telemetry server and click OK.

7 The server is added to the Telemetry list.

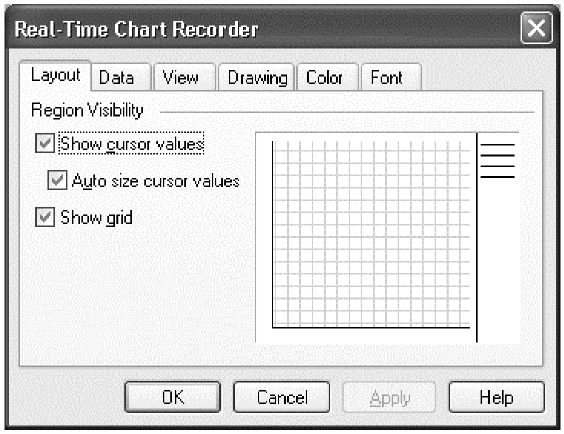
8 Click OK.

9 Go to the Selections Explorer, shortcut: Alt + 2 and select the required real-time channels.

10 If required open the Chart Recorder Properties dialog, select the data tab, and enter a new data time span.

Properties

Layout



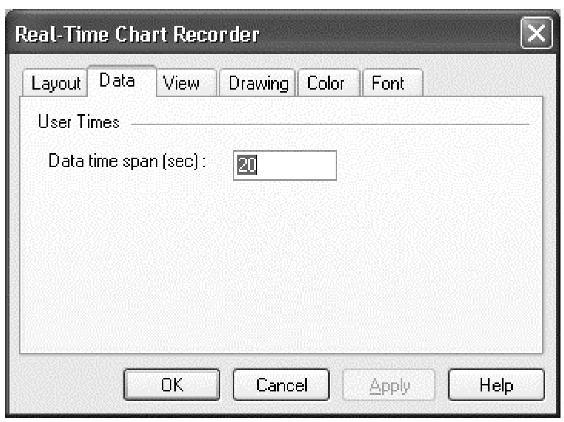
Show cursor values: Displays cursor value legends for the selected channels.

Auto size cursor values: Calculates the maximum width required to show the cursor values / channel names in full, and adjusts the display area automatically.

If the cursor value region (top right) is resized manually with the splitter bar, auto sizing is disabled.

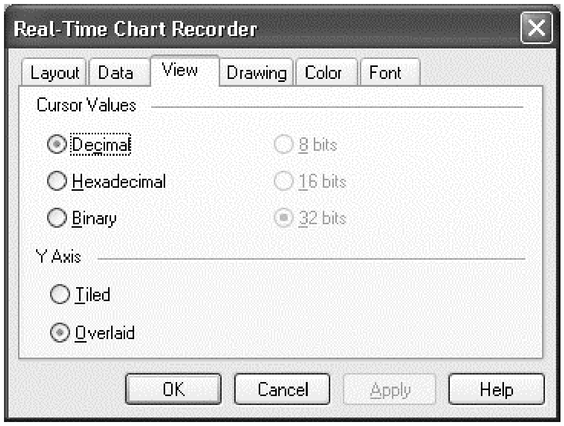
Show grid: Display a grid to aid data visualization.

Data



Data Time Span: The X-axis time span is defined in this field. When the traces reach the X-axis limit the screen scrolls. The default time span is 20 seconds. A time between 1 and 999 seconds can be set.

View



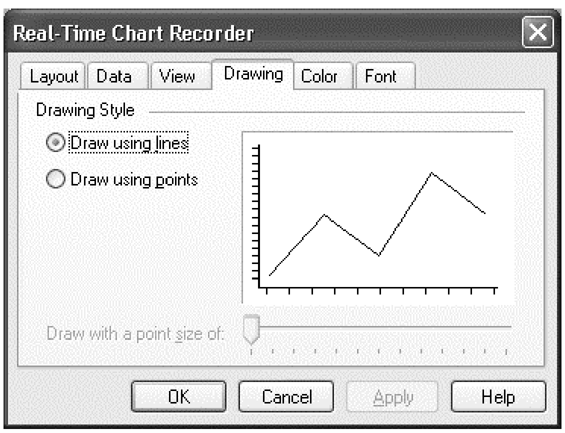
***Cursor Value Base*:** Sets the display mode of cursor values.

When Hexadecimal or Binary mode is selected, the Cursor Value Width buttons are enabled.

***Cursor Value Width*:** The values will be limited to 8, 16, or 32 bits when in hexadecimal and binary mode. If 'Auto size cursor values' is checked (Layout tab) the cursor value region will adjust automatically.

***Y-Axis*:** Traces can be tiled or overlaid. With the display in focus, press 'T' to toggle these modes.

Drawing



***Draw using lines*:** Data points are connected by a line to render a trace on the display.

***Draw using points*:** Each data value is drawn as a separate point. With Points selected, the slider is enabled. Use this to increase or decrease the size of data point rendered on the display.

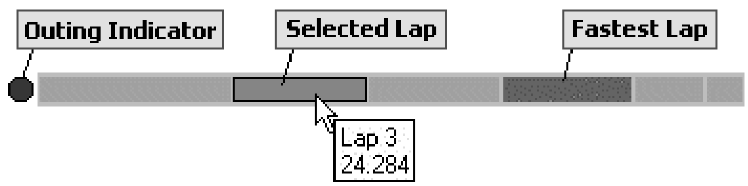
***Note:** For information about customizing the appearance of the display, see page 258*

Navigator displays

These provide a quick and easy means of selecting data regions in a display. Like all other Pi Toolbox displays, Navigators are connected to a specific task. Navigators create a linear representation or navigator bar, for each outing loaded in the task. Each division of the navigator bar represents a region of data. A region is defined as a lap.

Holding the mouse cursor over a region displays a tool tip defining the lap number/region and time. Simply click on a region to make all displays sharing the same task display that region.

The illustration below describes each region of the navigator bar. In this example regions represent laps.



To select multiple regions:

To make connected displays span more than one region, click the first region then drag the cursor along the navigator bar. Release at the last region to display.

To select the entire region:

Double-click the outing indicator: 

Note: *When there are multiple navigation bars in the display, shift click to span the same regions in all outings.*

To show outing text:

To display the outing title adjacent to the navigator bar select:

 **> Layout > Show Outing Text.**

To show hidden regions:

You can choose whether the navigator bar shows or hides hidden regions at each end of the bar, e.g. Warm up and Cool Down laps.

1 Go to the Task Explorer and select the required outing.

2 In the Details pane double-click 'Show Hidden Regions' (in the Data category).

3 Select Yes or No to Show/Hide hidden regions.

Track the cursor location:

As you select data points on connected displays, a vertical line on the navigator bar indicates the cursor location within the selected region.

Note: *You can select all regions by double-clicking the disc at the left of the navigator bar.*

PSD Displays (Optional)

A Power Spectral Density (PSD) display allows the analysis of the power spectral density of channel data in both historic and Real-time modes.

A power spectrum describes the distribution of power contained in a signal over frequency, based on a finite set of data. It is useful in a variety of applications, including the detection of signals buried in wide-band noise.

Channel data is displayed graphically as a trace, which represents the magnitude of the channels data at a specific frequency range. Frequency values are placed on the X-axis and the power magnitude values measured in dB/Hz are on the Y-axis.

Typically this display type may be used when analyzing car ride performance, which in turn is indicative of the mechanical grip characteristics of the car. The input channel will be vertical acceleration and the objective would be to minimize the peak value by adjusting spring and damper settings.

The principle of connecting tasks to a display and selecting channels for viewing, as in Time and Distance displays, applies to Event Displays.

Note: *Traces can only be displayed in overlaid mode.*

Shortcuts

← →	Move to the previous/next frequency value in the active trace.
⇧ + ← Or →	Move the cursor backwards/forwards by 5% of the visible frequency region.
Alt + ← Or →	Scrolls the zoomed region left or right.
H End	Moves to the first/last frequency sample in the active trace.
Z	Zoom in.

←	Zoom out.
Ctrl + ←	Undo all zooms

Features

Data display

Up to 32 data channels can be displayed in overlay mode. Channel properties such as color, scale etc can be customized fully as in Time and Distance displays.

Data cursor

The Data cursor is displayed on the chart together with data values at the intersection. However, because the chart is based in the frequency domain, the cursor is not linked to other displays sharing the same task, as with Time and Distance displays, Histograms, etc.

Data range zooming

The time region of the X-axis is displayed below the axis and shows the time region in which data is calculated. Y default the PSD display's time region is the whole of the data selection, indicated on the display by the legend – TR: [Data Selection]. Using the *Zoom* tab on the *Properties* dialog, the user can determine a specific time or distance range for the X-axis, effectively zooming in on a portion of data. The time region legend shows the specific time/distance region selected, for example: TR: [0.00.60.00] or [0.00.4500.00]

Note: *The time/distance range is applied relative to the beginning of each data selection.*

Note: *In a display one channel is the 'Active' channel, or the channel in focus. For visual reference the Y-axis scale is displayed in the same color as the active channel and the cursor values legend is highlighted. You cab scroll through the available channels using the keys, making each in turn the active channel.*

Active channel

In a display one channel is the 'Active' channel, or the channel in focus. For visual reference the y-axis scale is displayed in the same color as the active channel, and the cursor values legend is highlighted. You can scroll through the available channels using the keys, making each in turn the active channel. Active channels are persisted when the Workbook is saved and subsequently opened, and also persisted when the display is exported.

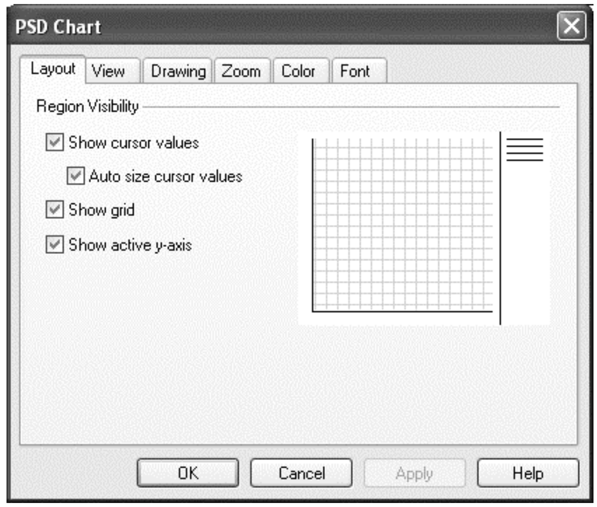
Multiple axes

A separate Y-Axis can be displayed for every channel selected for the Display. The feature can be switched on and off individually in the Property Explorer for each channel. When the feature is switched off the axes displayed are for the active channel only. When switched on, the axes for the active channel are displayed closest to the plot area. Changing the active channel re-orders the axes so that the new active channel's axes are nearest to the plot area. Displays having multiple data selections show multiple axes for each data selection.

The shortcut key 'Y' toggles the auxiliary axis for the active channel between left, right and off.

Properties

Layout



Region Visibility

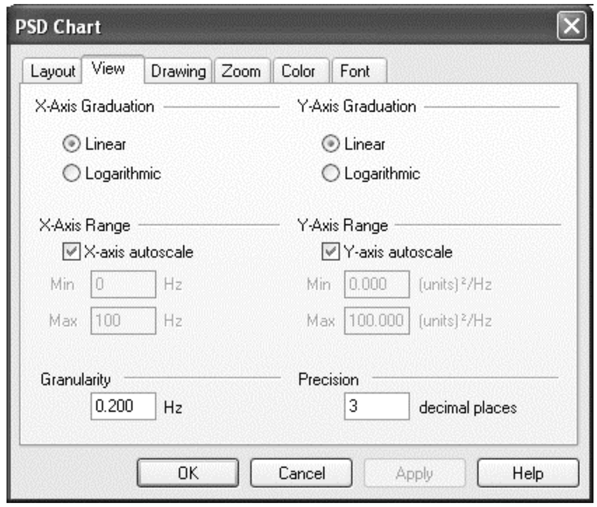
Show cursor values: Displays cursor value legends for the selected channels.

Auto size cursor values: Calculates the maximum width required to show the cursor values / channel names in full and adjusts the display area automatically.

Show grid: Display a grid of equally spaced horizontal and vertical lines to aid data visualization.

Show active Y-axis: Displays the active channel Y-axis closest to the plot region.

View



X-Axis graduation:

- X-Axis graduation can be plotted with a linear scale or with a log 10 scale.

Y-Axis graduation:

- Y-Axis graduation can be plotted with a linear scale or with a log 10 scale.

X and Y-Axis Range

X-Axis Autoscale: When checked, Autoscale adjusts the X-axis scale to the highest frequency data found in all the channels displayed on the PSD Chart, and then adds 5%. This ensures that data is displayed on the full width of the PSD chart whilst leaving a 5% margin. When not checked, the X-axis scale is determined by the Max and Min field values set in Hz.

***Y-Axis Autoscale*:** When checked, Autoscale adjusts the Y-axis to the highest amplitude of data found in all the channels displayed on the PSD Chart. When not checked, the Y-axis scale is determined by the Max and Min field values that set the square of the amplitude of the wave component at that frequency.

Granularity and Precision

The frequency range of the calculation will depend on the X-axis min-max range, specified by the user, or on the frequency spectrum of the channel data, if X-axis is auto scaled. The granularity of the frequency range is controlled by the Granularity and the Precision properties.

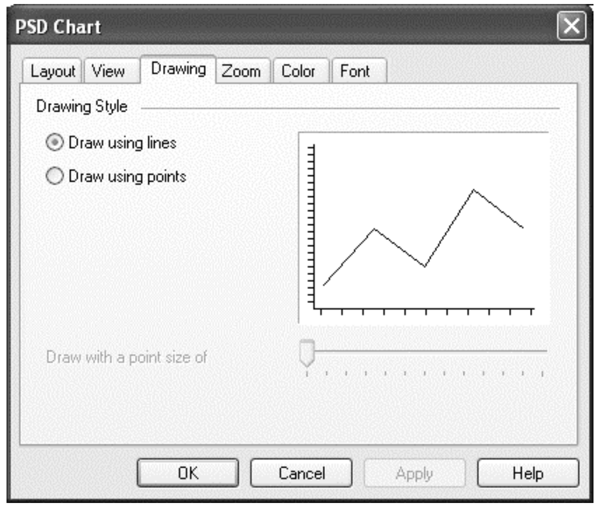
Granularity: defines the minimum difference (or the step) in the frequency range.

Frequencies that differ after the Precision decimal symbol are considered equal and their powers are accumulated together.

The power range of the Y-axis will depend on its min-max range, or on the actual channel data, if the axis is auto scaled.

Precision: The granularity of the Power Range is controlled by the Precision property, which defines the number of significant decimal symbols in the resulting frequencies and powers.

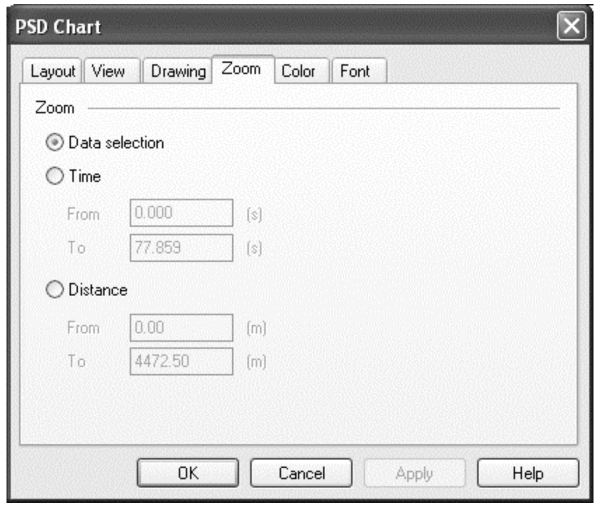
Drawing



Lines: Data points are connected by a line to render a trace on the display.

Points: Each data value is drawn as a separate point. With points selected, the slider is enabled. Use this to increase or decrease the size of data point when rendered on the display.

Zoom



Data selection: When selected, the data plotted is taken from the full extent of the outing data.

Time (sec): When selected the ‘From’ and ‘To’ fields are enabled. Adjust these times so that the plotted data is taken from a specific time period, effectively zooming in on that portion of data.

Distance (m): When selected the ‘From’ and ‘To’ fields are enabled. Adjust these distances so that the plotted data is taken from a region in the outing that corresponds to a specific portion of the track.

Note: *For information about customizing the appearance of the display, see page 258*

Exporting Data

Overview

There are several options available when exporting data:

Exporting all data – from the Task Explorer

The Export command is available from the context menu when an outing is highlighted. The Data Export Wizard allows the user to export the entire outing dataset for selected channels and events.

Exporting displayed data – from the Time and Distance Display

Selecting **Export > Displayed Data** from a Time and Distance display opens the Data Export Wizard. This allows the user to export the data that can be seen at the current zoom level. Displayed Data can be exported in MATLAB, ASCII or Pi Dataset.

- MATLAB format data files support channel data only. Events and lap marker data will not be exported.
- ASCII format data files support channel and event data, but not lap markers.
- Pi Dataset format data files support channel, event and lap marker data.

Note: *The Data Export Wizard allows the user to edit outing details prior to export.*

Note: *Pi Toolbox Lite only supports pds files for the import and export feature.*

Exporting qualifying mode data – From the time and Distance Display

Qualifying Mode files are binary files used to store Distance - Time pairs, i.e. at distance x the time was y.

Distance values are generated either by using beacons (soft or hard) or by setting a distance interval for which a time is required.

Data Export wizard

Channel selection page

This page lists the channels currently selected for the display. Here the channels to be exported are selected. The same applies to the Events Selection page.

File location page

Use the browse button to open the Choose File dialog where the export file location is selected, as well as the export format.

Outing page

Use this page to change outing property details such as Short Comment, Long Comment etc. Outing property changes will appear in the Task Explorer when the exported outing is imported by other users.

To make changes, double-click the property and overtype the existing text in the edit box.

Properties that cannot be changed are 'grayed out'.

Summary page

Summarizes the export file information including the channels and events you have selected for export.

Clicking 'Next' in the summary page starts the export process.

Results page

The results page indicates whether or not the export has succeeded. When the process is complete click the Finish button. You can close the wizard during a long export process if required. The export will continue to completion however, you will not be informed of successful completion.

Time Range selection

Select the time range of data to export. Choose either the displayed time range or an A to B range within the displayed time range.

Data Rate Selection page

Select the rate at which data is exported. Choose either the data acquisition rate of the source dataset or a fixed rate. If fixed rate is selected, existing data will be interpolated.

Event Selection page

This page lists the events currently selected for the display. From the list of available events, select which ones are to be exported. This page will not be shown unless events are selected for the display.

Note: *If you see the message "No data found for channel X" on the results page, for a channel known to have data, repeat the export process.*

Displayed Data export formats

MATLAB

MATLAB format data files (.mat) support channel data only. Events and lap marker data will not be exported. The following is intended to supplement the user's knowledge of the MATLAB environment.

Note: *If the 'System details' category heading of the outing properties has the extension: 'Externally Written Data', this indicates that the dataset was last modified externally, e.g. in MATLAB.*

Channel names

MATLAB format data, re-imported into Pi Toolbox, will remove spaces from channel names and replace them with underscores.

Adding outing properties in MATLAB

The following outing properties can be added in MATLAB. These will be subsequently editable in the Pi Toolbox Properties Explorer. The format and capitalization must be as shown below. Items not preceded by 'Tbx..' will be ignored by Pi Toolbox.

TbxDriverName = 'name'

TbxTrackName = 'track name'

TbxCarName = 'car name'

TbxShortComment = 'comment'

TbxOuting = '<000:000:000>'

Note: *Outing information is in the form: session: outing: first lap, e.g. <002:005:010>*

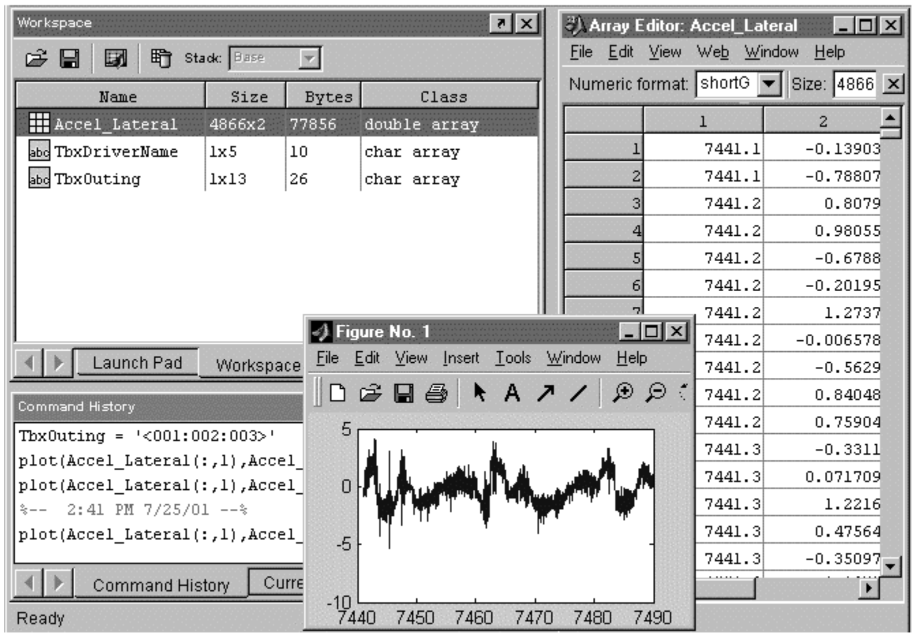
Display plots in MATLAB

To display plots in MATLAB use the following form:

`plot((channel name)(:,1),(channel name)((:,2))` where the value (:,2) is plotted against time (:,1)

MATLAB time and distance data

Pi Toolbox will recognize as channels double array data of n x 2 columns, where the 1st column is sequential time and the 2nd column is data values.



Working with MATLAB files in Pi Toolbox

You cannot add channels, events, lap markers, etc. to re-imported MATLAB data. Only the channels exported initially (or added in MATLAB) will be available for analysis.

MS Excel format

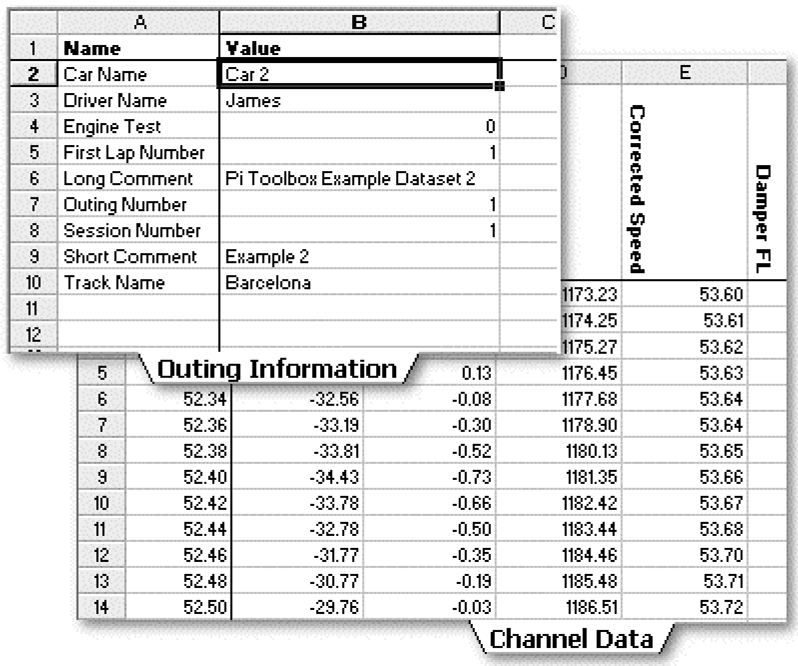
Excel export utilizes the multiple worksheet feature of the application to export different types of data to different named sheets. These are Outing Information, Channel Data, and Event Data. Outing data is exported to the first sheet, channel data to the second and event data to the third.

Channel Data

The first column contains times, with subsequent columns containing the channel data. Both time and channel values will be exported as doubles so that no precision is lost from the source data.

Event Data

Event times will be exported as doubles. Other values will be exported as strings.



Export constraints

Spreadsheets are limited to 255 columns and 655535 rows, resulting in the following limitations for Excel data export:

Channels = 254

Samples per channel = 65535.

If these constraints are exceeded the user will be informed on the Results page of the Wizard, e.g.

The following channels cannot be exported: Damper RR, Damper RL.

ASCII

ASCII format data files (.txt) support channel and event data, but not lap markers. The following information is intended to supplement the user's knowledge of ASCII text file environment.

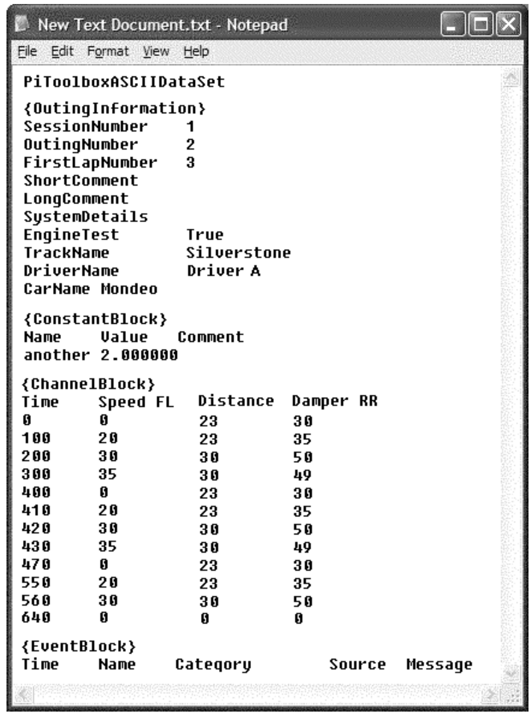
Editing ASCII text files in a text editor or Excel

Pi Toolbox ASCII text file headers are in the form: `PiToolboxASCIIDataset`.

Blocks of data are headed in the form: `{OutingInformation}`, `{ChannelBlock}`, etc.

Example:

***Note**: To re-import ASCII text files, they must be saved in Excel as: Text (Tab Delimited) *.txt files.*



New Text Document.txt - Notepad

File Edit Format View Help

```
PiToolboxASCIIDataSet
{OutingInformation}
SessionNumber    1
OutingNumber     2
FirstLapNumber   3
ShortComment
LongComment
SystemDetails
EngineTest       True
TrackName        Silverstone
DriverName       Driver A
CarName Mondeo
{ConstantBlock}
Name    Value   Comment
another 2.000000
{ChannelBlock}
Time    Speed FL   Distance  Damper RR
0       0          23        30
100     20         23        35
200     30         30        50
300     35         30        49
400     0          23        30
410     20         23        35
420     30         30        50
430     35         30        49
470     0          23        30
550     20         23        35
560     30         30        50
640     0          0         0
{EventBlock}
Time    Name    Category        Source  Message
```

Adding outing properties in a text editor or Excel

When adding outing properties in a text editor, make sure the data block is headed `{OutingInformation}` and that the property name and value are tab delimited. To re-import into Pi Toolbox, save Excel file as Text (Tab Delimited).

Adding channels in a text editor or Excel

Channels can be added in Excel or a text editor. Add columns under the `{ChannelBlock}` header, making sure that new columns are tab delimited from the preceding ones. To re-import into Pi Toolbox, save Excel file as Text (Tab Delimited).

Importing ASCII text files into Excel

When Importing ASCII text files into Excel, use the Text Import Wizard defaults of 'Delimited' and 'Tab'.

To view the plot, highlight the data columns and select the Chart Wizard toolbar button. Follow the wizard instructions.

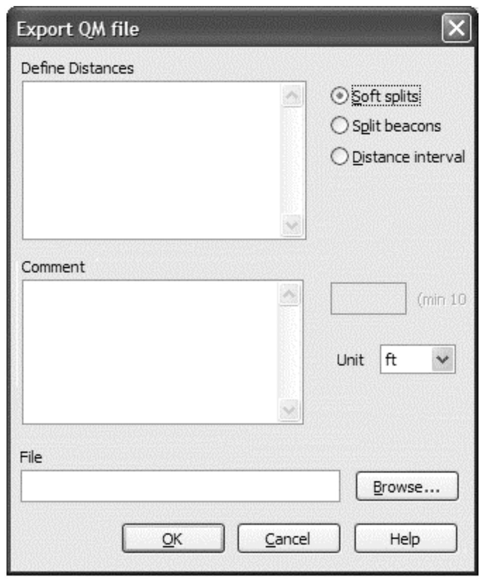
Pi Datasets

Pi Dataset format data files support channel, event and lap marker data. Pi Dataset is the Pi Toolbox native format.

Export Qualifying mode

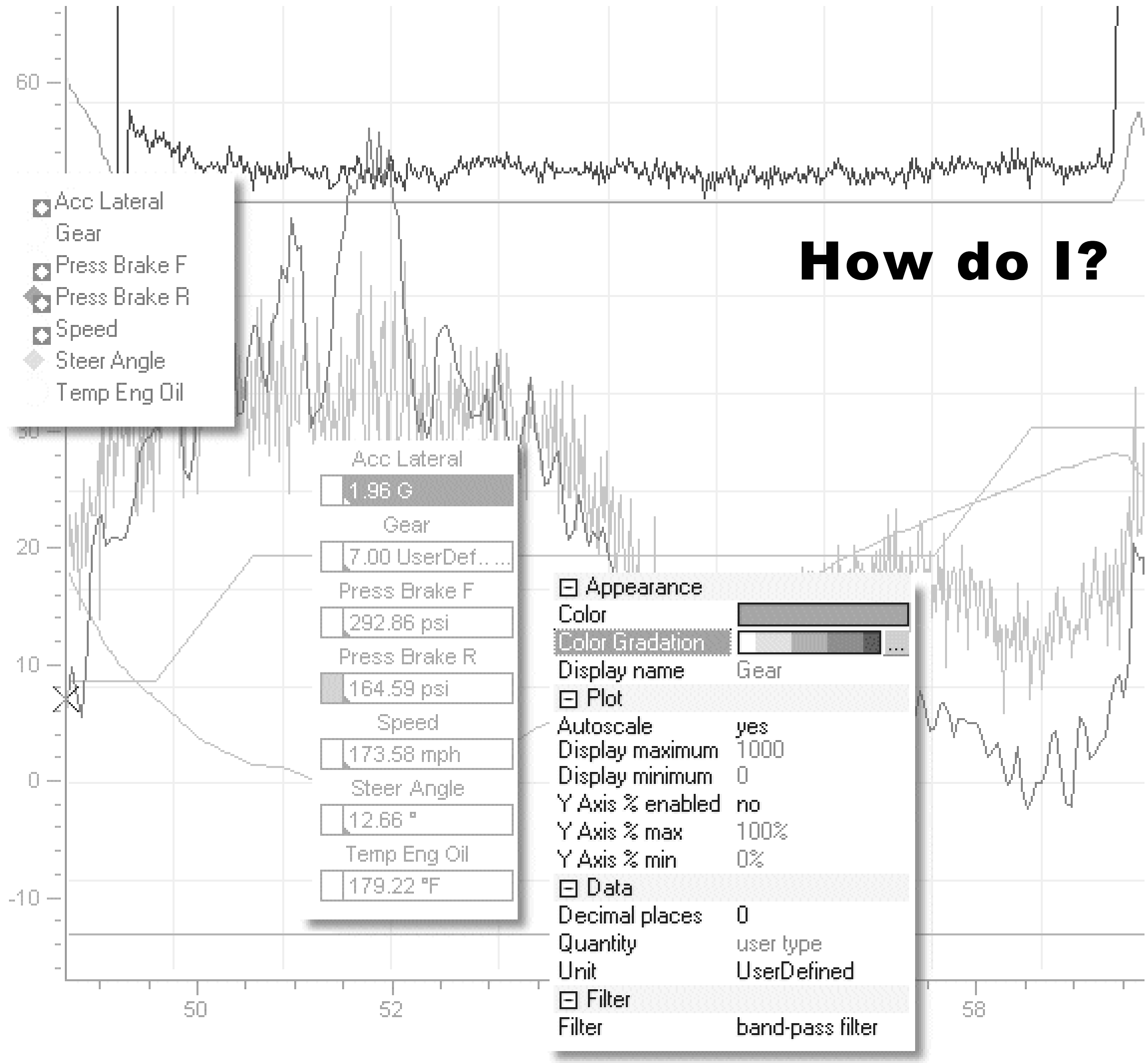
The Export QM file dialog creates a file for export, which contain split times for regions in a single lap.

The Export QM file dialog is accessed by selecting **> Export > Qualifying Mode...** in a Time and Distance display.



The Define Distances window lists the distances between Soft splits, Split beacons or Distance intervals, depending upon which option is selected. When Split beacons are selected the distances are not editable. When Distance interval is selected, enter a distance and select a unit, 'm' or 'ft'. The distance intervals will be transferred to the Define Distance window. Use the Browse button to browse for a location for the exported file.

How do I?



60
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58
Acc Lateral
Gear
Press Brake F
Press Brake R
Speed
Steer Angle
Temp Eng Oil
Acc Lateral
1.96 G
Gear
7.00 UserDef...
Press Brake F
292.86 psi
Press Brake R
164.59 psi
Speed
173.58 mph
Steer Angle
12.66 °
Temp Eng Oil
179.22 °F
Appearance
Color
Color Gradation
Display name
Gear
Plot
Autoscale
yes
Display maximum
1000
Display minimum
0
Y Axis % enabled
no
Y Axis % max
100%
Y Axis % min
0%
Data
Decimal places
0
Quantity
user type
Unit
UserDefined
Filter
Filter
band-pass filter

How do I?

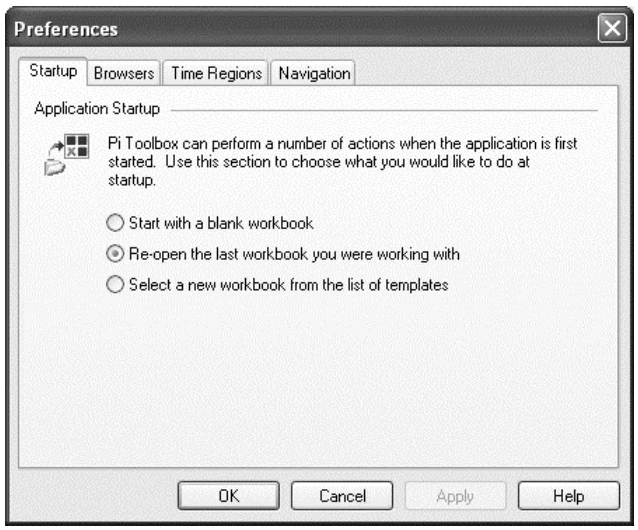
This section of the manual is designed as a quick reference guide for common tasks that may incorporate the setting up of one or more dialogs in Pi Toolbox.

Real-time Broadcast set up

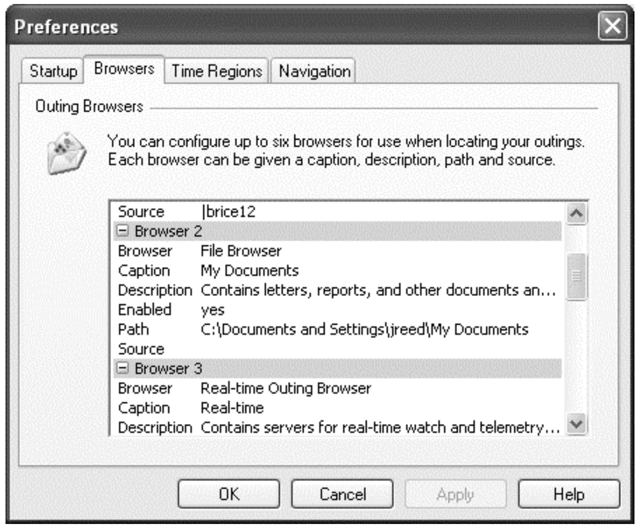
1 Check that a Real-time browser is enabled**.**

- On the *File* menu, click *Preferences*.

The *Preferences* dialog is displayed.



- Click the Browsers tab.



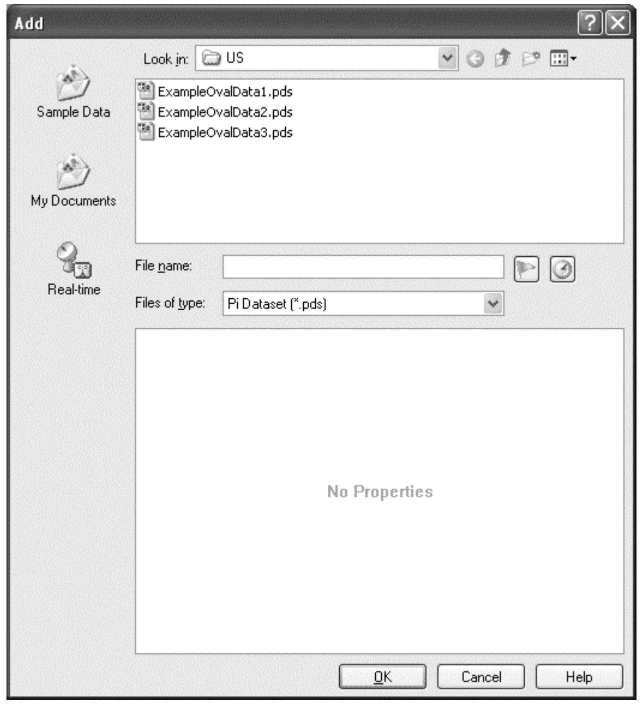
- Make sure that one of the browsers in the list is configured as a Real-time browser. If you need to configure a Real-time browser, see Setting up a Real-time display on page 241 for more information.
- Click *OK*.

2 Add a task to the worksheet. If there are no spare tasks in the worksheet, add a new task.

- Press **CTRL** + **T** to add a new task.
- If you want to rename the task, you can do this by editing the *Name* field in the *Appearance* section of the task column.

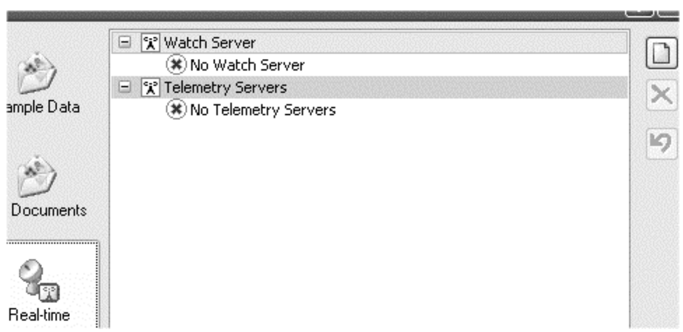
3 Add an outing to the to the task.

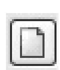
- Press **CTRL** + **L**, the *Add* dialog is displayed.



- Click the *Real-time* button.

The *Real-time* options will be displayed.



- Select *Telemetry Servers*.
- Click , the Browse dialog is displayed.

- Browse to or type the name of the telemetry server in the name field.
- Click *OK*.

4 Add a Real-time chart recorder display to a worksheet.

- On the *Insert* menu, point to *Display* then select *Real-time chart recorder*.

Note: *You cannot have more than 8 displays in a worksheet.*

5 Make sure that all controls are linked to the appropriate telemetry task.

6 Add your required channels to the display.

- The channels list will only become populated after telemetry data has been received.

Common Issues

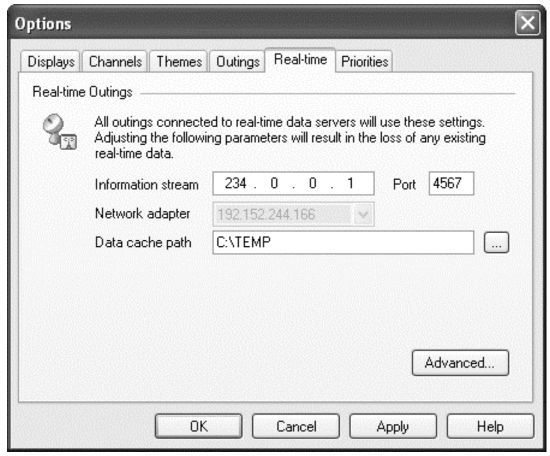
The Real-time server will not connect to the Telemetry server

1 Using Windows Explorer, browse to the Telemetry server.

- If you can see the Telemetry server, make sure that your configured details are the same as the properties for the server.
- If you cannot see the Telemetry server, make sure that you have access rights on the network.

2 If you still cannot see the Telemetry server:

- On the Tools menu, click Options.
- Click the Real-time tab.

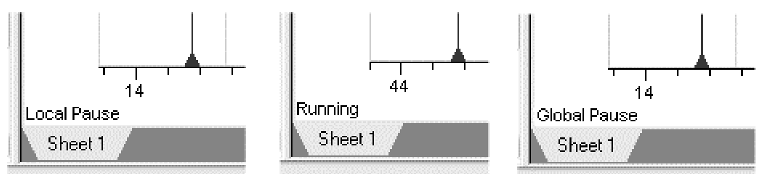


- Make sure that settings in the *Information stream* field are the same as the settings for the Real-time server.

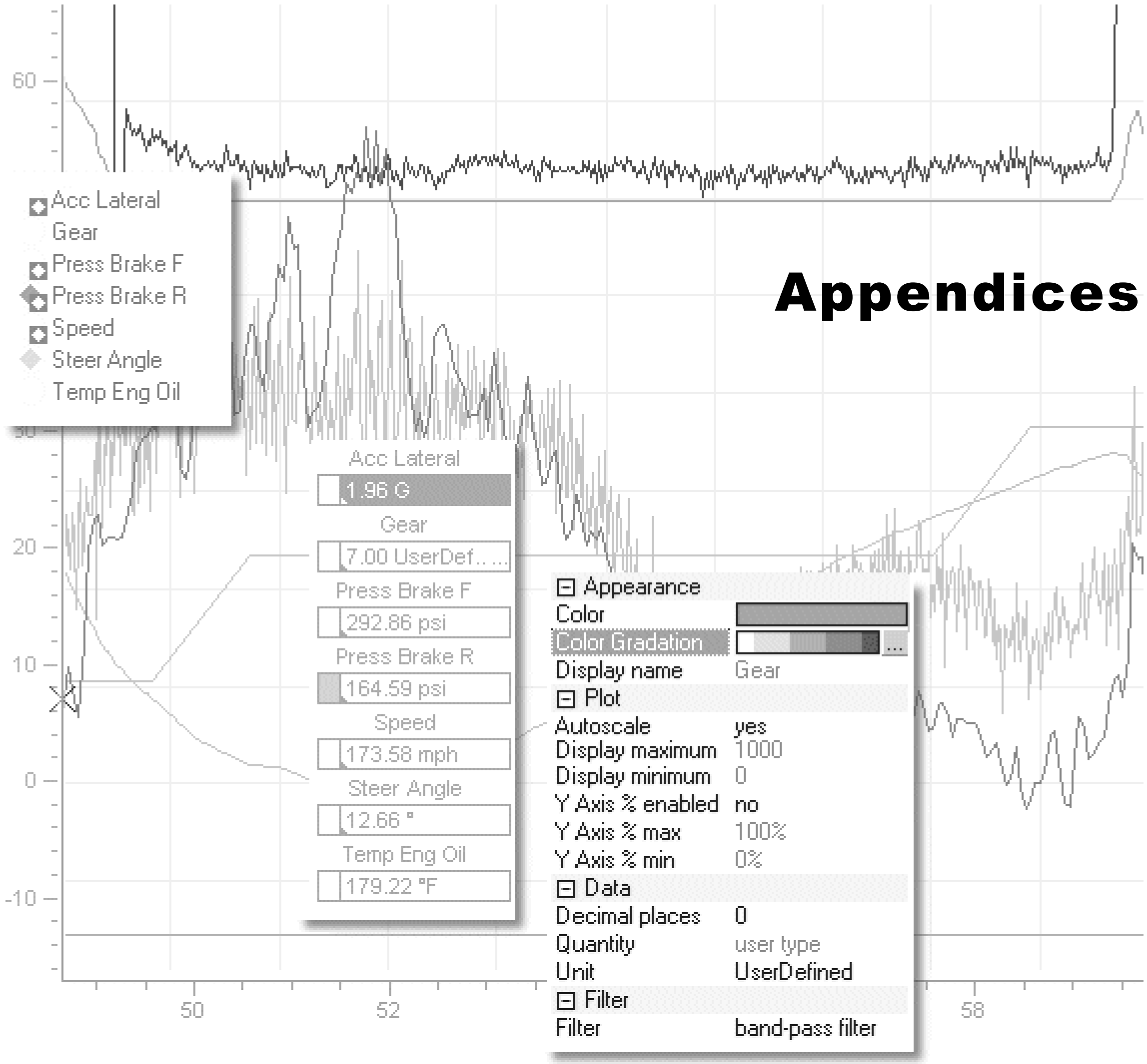
The Real-time control freezes

Clicking in the real-time control will pause the update, this can be confirmed by the text *Local Pause* in the bottom left of the display. To release the display, click in the display area and press *P*. The text displayed will change to *Running*.

To pause all displays, click the Global pause button. The text will display *Global Pause*.



Appendices



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Gear
Press Brake F
Press Brake R
Speed
Steer Angle
Temp Eng Oil
Acc Lateral
1.96 G
Gear
7.00 UserDef... ...
Press Brake F
292.86 psi
Press Brake R
164.59 psi
Speed
173.58 mph
Steer Angle
12.66 °
Temp Eng Oil
179.22 °F
Appearance
Color
Color Gradation
Display name
Gear
Plot
Autoscale
yes
Display maximum
1000
Display minimum
0
Y Axis % enabled
no
Y Axis % max
100%
Y Axis % min
0%
Data
Decimal places
0
Quantity
user type
Unit
UserDefined
Filter
Filter
band-pass filter
50
52
58

Appendix A – Standard Math operators

Mathematical operators

Operators	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division

Logical operators

Operator	Usage	Description
!	!a	Logical Negation. If ‘a’ is not zero returns 0 else 1.
&&	a&&b	Returns 1 if both ‘a’ and ‘b’ are non-zero, else 0.
^^	a^^b	Returns 0 if both ‘a’ and ‘b’ are 0 or 1, else 1.
||	a||b	Returns 1 if either ‘a’ or ‘b’ are non-zero, else 0.

Bitwise operators

Operator	Usage	Description
~	~a	Casts a to a 32 bit integer and inverts each bit.
&	a&b	Casts both ‘a’ and ‘b’ to a 32 bit integer and AND’s the two results.
|	a|b	Casts both ‘a’ and ‘b’ to a 32 bit integer and OR’s the two results.
<<	a<<n	Casts ‘a’ as a 32 bit integer and shifts it to the left by n bits.
>>	a>>n	Casts ‘a’ as a 32 bit integer and shifts it to the right by n bits.
^	y^y	Returns u32(’x’)XORed with u32(‘y’)
rol()	rol(a,b)	Returns u32('a') rotated left by u32('b') bits.
ror()	ror(a,b)	Returns u32('a') rotated right by u32('b') bits.

Comparison operators

Operator	Usage	Description
>	a>b	Returns 1 if ‘a’ is greater than ‘b’, else 0.
>=	a>=b	Returns 1 if ‘a’ is greater than or equal to ‘b’, else 0.
<	a<b	Returns 1 if ‘a’ is less than ‘b’, else 0.
<=	a<=b	Returns 1 if ‘a’ is less than or equal to ‘b’, else 0.
= =	a= =b	Returns 1 if ‘a’ is equal to ‘b’, else 0.
!=	a!=b	Returns 1 if ‘a’ is not equal to ‘b’, else 0.
choose(,,)	choose(c,a,b)	Returns ‘a’ if ‘c’ is non-zero else ‘b’.
compare()	Compare(a)	Returns a channel with values equal to difference between the current outing and the Datum, for channel. The differences are calculated, based on time.
compareDist	CompareDist([x])	Returns a channel with values equal to difference between the current outing and the Datum, for channel. The differences are calculated, based on Distance.
edge()	edge(c,t,d)	Returns 1 if the magnitude of the difference between 'c' and its value 't' seconds before is greater than 'd', else returns 0.

Trigonometric functions

Operator	Usage	Description
acos()	acos(a)	Returns the arc cosine of ‘a’.
asin()	asin(a)	Returns the arc sine of ‘a’.
atan()	atan(a)	Returns the arc tangent of ‘a’.
atan2(,)	atan2(a,b)	Returns the arc tangent of ‘a/b’.
cos()	cos(a)	Returns the cosine of ‘a’.
sin()	sin(a)	Returns the sine of ‘a’.
tan()	tan(a)	Returns the tangent of ‘a’.
hypot(,)	hypot(a,b)	Returns the length of the hypotenuse of the right-angled triangle specified by ‘a’ and ‘b’.

Hyperbolic functions

Operator	Usage	Description
sinh()	sinh(a)	Returns the hyperbolic cosine of ‘a’.
cosh()	cosh(a)	Returns the hyperbolic sine of ‘a’.
tanh()	tanh(a)	Returns the hyperbolic tangent of ‘a’.
exp()	exp(a)	Returns the exponential value of ‘a’.

Conversion operators

Operator	Usage	Description
ceil()	ceil(a)	Returns the smallest integer that is greater than or equal to ‘a’.
floor()	floor(a)	Returns the largest integer that is less than or equal to ‘a’.
fmod(,)	fmod(a,b)	Returns the floating-point remainder of ‘a/b’.
fabs()	fabs(a)	Returns the absolute value of ‘a’.
iflt()	iflt(a)	Returns 'a', reinterpreted as floating-point
is32()	is32(a)	Returns 'a', reinterpreted as 32-bit signed integer.
iu32()	iu32(a)	Returns 'a', reinterpreted as 32-bit unsigned integer.
min(,)	min(a,b)	Returns the lesser of ‘a’ and ‘b’.
max(,)	max(a,b)	Returns the greater of ‘a’ and ‘b’.
minimum()	minimum(a)	Returns 1 if 'a' reaches its minimum at current timestamp, else returns 0.
maximum()	maximum()	Returns 1 if 'a' reaches its maximum at current timestamp, else returns 0.
shl(,)	shl(a,n)	Casts a to a 32 bits integer, right shifts ‘a’ by ‘n’ filling the higher order bits with zeroes.
s8()	s8(a)	Casts ‘a’ to 8 bit signed integer.
s16()	s16(a)	Casts ‘a’ to 16 bit signed integer.
s32()	s32(a)	Casts ‘a’ to 32 bit signed integer.
u8()	u8(a)	Casts ‘a’ to 8 bit unsigned integer.
u16()	u16(a)	Casts ‘a’ to 16 bit unsigned integer.
u32()	u32(a)	Casts ‘a’ to 32 bit unsigned integer.

Miscellaneous operators

Operator	Usage	Description
log()	log(a)	Returns natural logarithm of 'a'.
log10()	log10(a)	Returns the logarithm base 10 of 'a'.
pow(,)	pow(a,b)	Returns 'a' raised to the power 'b'.
sqrt()	sqrt(a)	Returns the square root of 'a'.
slope()	slope(a,Left|Right, Reset|Ignore|NoData])	Returns the left/right partial first-derivative of 'a'.
Rand	Rand	Returns a random value in the range 0 to 1.
register	register'x'[='y']	Declares a new register 'x' and initializes it with 'y' or zero if 'y' is missing. The name of the register must start with '@'.
derivative()	derivative(x, Reset|Ignore|NoData)	Returns the first derivative of 'x'
integral()	integral(x, Ignore|Reset|Hold)	Returns the integral of 'x'
timeDiff()	timeDiff(x, Previous|Next, Reset|Ignore)	Returns the distance from the previous to current sample or from the current to the next sample of channel 'x'
BandPass()	Bandpass(x,l,h,Ignore| AsumeZero)	Applies band pass filter to expression 'x' with low frequency 'l' and high frequency 'h'. When 'l'('h') is zero, this function works like low(high) pass filter.
Gate()	Gate(x,y)	Returns 'y' if 'x' is non-zero, otherwise returns discontinuity.
MovAverage()	MovAvergae(x,y,Ignore|AssumeZero)	Applies running average filter to expression 'x' in time interval of 'y' seconds.

Operator	Usage	Description
.warning	{ID off | level N }	This warning control pragma disables a particular warning or establishes an upper warning level threshold (inclusive).
Table	Table ‘x’ = ‘y’;	Declares a new lookup table ‘x’ and initializes it with ‘y’. The name of the lookup table must start with ‘#’.
IfExist()	IfExist([channel name],x)	Defines values for specific channels, even if the channel is currently undefined. The channel does not need to be present in the current list of defined channels. 'x' will be any valid math channel expression. **Note:** if the data rate of the math channel is set to [channel_name] then the math channel will still be undefined if [channel_name] does not exist. To ensure that the math channel is not undefined either set the data rate to an unconditional channel, or set a fixed rate for the calculation.

Constant operators

Operator	Usage	Description
OUTCONST ()	OUTCONST ()	Returns the value of the constant from the outing
GLOBALCONST ()	GLOBALCONST ()	Returns the value of the global constant
CONST ()	CONST ()	Returns the outing constant, if this fails, selects the global constant.

Appendix B - Shortcuts

In this section you will find the keyboard and menu shortcuts for Pi Toolbox.

File Menu

Shortcut	Description	Menu
Ctrl + N	Creates a new Workbook	*File > New*
Ctrl + O	Opens an existing Workbook	*File > Open*
Ctrl + S	Saves the active Workbook	*File > Save*
Ctrl + P	Prints the Active panel	*File > Print*

Edit Menu

Shortcut	Description	Menu
Ctrl + X	Cuts the selection and places it on the clipboard	*Edit > Cut*
Ctrl + C	Copies the selection and places it on the clipboard	*Edit > Copy*
Ctrl + V	Pastes the clipboard contents	*Edit > Paste*
Ctrl + Del	Delete a Worksheet	*Edit > Delete Worksheet*
F2	Rename a Display	*Edit > Rename Display*

Ctrl + F2	Rename a Worksheet	*Edit > Rename Worksheet*

View Menu

Shortcut	Description	Menu
Alt + 1	Explores the available tasks	*View > Tasks*
Alt + 2	Explores the active display's selection	*View > Selections*
Alt + 3	Explores the channel properties of the active display	*View > Channel Properties*
Alt + 4	Explores the event properties of the active display	*View > Event Properties*
Alt + X	Hides/Shows the Explorer bar	*View > Hide/Show Explorer Bar*
Ctrl + Tab	Cycles tabs in Explorer, e.g. Channels, Events	*N/A*

Data Menu

Shortcut	Description	Menu
Ctrl + T	Add a task	*Data > Add Task*
F5	Refresh	*Data > Refresh*
F7	Link Zoom	*Data > Link Zoom*

F8	Unlink Zoom	*Data > Unlink Zoom*
F9	Enable Pi Toolbox display in Pi Remote Toolbox	*Data > Remote Display*
F10	Enable transmission of data from Pi Toolbox to Pi Remote Toolbox	*Data > Pi Remote Toolbox*
⇧ + Ctrl + L	Opens the Select (Laps) dialog with Laps selected	*Data > Select Laps*
Ctrl + E	Selects all laps in the outing	*Data > Entire Outing*
Ctrl + Q	Selects the fastest lap in the outing	*Data > Fastest Lap*
⇧ + Ctrl + E	Selects all laps for all the outings in the task	*Data > Entire Outings*
⇧ + Ctrl + Q	Selects the fastest lap for all outings in the task	*Data > All Fastest laps*
Ctrl + L	Opens the Add Outing dialog	*Data > Add Outing*
Ctrl + R	Opens the Replace Outing dialog (outing highlighted)	*Data > Replace Outing*
Ctrl + D	Deletes the outing highlighted	*Data > Delete Outing*
⇧ Pge Down + Ctrl + Pge Up	Go to the next or previous lap in the outing	*Data > Move Next/Previous*
⇧ End + Ctrl + Home	Go to the first or last lap in the outing	*Data > Move First/Last*

Windows Menu

Shortcut	Description	Menu
Ctrl + F4	Closes the selected display	*Window > Close*
Ctrl + F6	Moves to the next pane	*Window > Next*
⇧ + Ctrl + F6	Moves to the previous pane	*Window > Previous*
Ctrl + F10	Maximizes / Restores the selected display	*Windows > Maximize / Restore*

Help Menu

Shortcut	Description	Menu
F1	Displays help for the current dialog, command etc.	*N/A*
⇧ + F1	What's this? Help for selected Buttons, Menus and Windows	*N/A*

Task explorer

Shortcut	Description
Ctrl + T	Creates a new task in Pi Toolbox.
↵	Opens the *Load Outing* dialog (when a task is highlighted).
↵	Opens the *Select* dialog (when an outing is highlighted).
Del	Deletes the selected task or outing from the current workbook.
Ctrl + Q	Selects the fastest lap in the current outing.
Ctrl + E	Selects all laps in the current outing.

Details pane

Shortcut	Description
↵	Edits the selected property.
Esc	Cancels the edit procedure.
+ -	Expands or collapses the property category.
← →	Expands or collapses the category and navigates up and down.

Selection explorer

1 D channel selection

Shortcut	Description
↵	Adds the currently selected channels or groups to a display. If the root node is selected, all items under the node are added.
Esc	Clears the filter.
←	Deletes a character from the filter.
Del	Deletes an item from the display in focus. A channel, group or event must be selected in the upper pane.

2D Channel selection

Shortcut	Description
↵	**One channel highlighted** The channel is added to the first empty X or Y assignment in the display's selection. **Two channels highlighted** The channels are added as a pair to a display, with the channel selected first assigned to the X axis and the channel selected second assigned to the Y-axis.
Esc	Clears the filter.
←	Deletes a character from the filter.

Del	In an X – Y display, with a channel highlighted in the upper pane. The channel in the last channel pair is deleted, if there isn’t a channel there, then the channel in the previous channel pair is deleted.

Event Selection

Available with the Events tab selected.

Shortcut	Description
↵	Adds the currently highlighted events to the control. If the root node is selected, all events under the node are added to the control.
Esc	Clears the filter.
←	Deletes a character from the filter.
Del	Attempts to remove the highlighted items from the selection. If a parent node is selected then an attempt to remove all items under the node is made.
Insert	When the filtered list has input focus and if a filter has been entered, this adds the filter as an inclusion for the controls event selection filter.
⇧ + Insert	When the filtered list has input focus and if a filter has been entered, this adds the filter as an exclusion for the controls event selection filter.
⇧ + Del	When the filtered list has input focus, this removes the currently entered filter from both the exclusions and inclusions of the controls event selection filter.

Properties explorer

Properties list

Shortcut	Description
↵	Edits the selected property.
Esc	Cancels the edit procedure.
+ - (keypad)	Expands or collapses the property category.
← →	Expands or collapses the category and navigates up/down.

Channel list

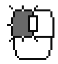
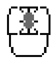
Shortcut	Description
Esc	Clears the filter.
←	Deletes a character from the filter.

Time and Distance displays

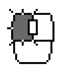
Cursor movement

Shortcut	Description
← →	Moves the X cursor left or right or:
	Changes the Offset when in offset mode.
⇧ + ← →	Moves the X cursor left or right (Quickly).
Home	Moves the X cursor to the beginning of the trace and:
	Moves the zoom region to the beginning of the trace when in Keyboard zoom mode.
End	Moves the X cursor to the end of the trace or:
	Moves the zoom region to the end of the trace when in keyboard zoom mode.
< >	Moves the cursor to the previous or next event.
M N	Finds the Maximum or Minimum cursor values.

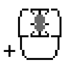
Zoom control

Shortcut	Description
Z	Zoom on current cursor position (50%).
Ctrl + 	Zooms using the mouse. Left click and drag the boundary to size. Release to set the size.
Ctrl + 	Zoom in or out on current cursor position.
←	Undo last zoom.
Ctrl + ←	Undo all previous zooms

Scrolling

Shortcut	Description
+ -	Scrolls along the trace in a zoomed region. Multiple presses increase scroll speed.
Alt + 	Open hand cursor, click and drag to scroll.
Alt + ← → ↑ ↓	Moves the view port by 10% of its width in the arrow direction.

Display mode

Shortcut	Description
D	Time/Distance mode.
F	Flash/Display the active channel trace.
H	Hide/Show the active channel trace.
O	Enter/Exit the Time Offset mode.
⇧ + O	Enter/Exit the Value Offset mode.
T	Tile/Overlay Y - axis mode.
Esc	Cancels the current mode.
↑ ↓	Changes the active channel.
⇧ + 	

Other shortcuts

Shortcut	Description
Alt + ↵	Displays the Time and Distance display properties dialog.
R	Enter/Exit the Reference cursor mode.
S	Mark a split or mark a Segment when the segment bar is enabled.
Ctrl + E	Selects all the laps in the outing (outing highlighted or display selected).
Ctrl + Q	Selects the fastest lap in the outing (outing highlighted or display selected).
Y	Toggles the auxiliary axis for the active channel between

	left, right and off.
L	Toggles the locked cursor on or off.
Del	Removes the active channel from the display.

Histograms

Shortcut	Description
Alt + ↵	Displays the Histogram property dialog.
↑ ↓	Changes the active channel.
T	Tile/Overlay Y-axis mode.
Y	Toggles the auxiliary axis for the active channel between left, right and off.
Ctrl + ⇧ + C	Copies the bin values for all channels and all data selections to the clipboard.

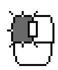
Maps

Shortcut	Description
Alt + ↵	Displays the Map property dialog.
← →	(In *Edit* mode), with a map element selected, selects consecutive map elements, i.e. boundary, segment, beacon.
⇧ + ← →	(In *Edit* mode), selects multiple map elements.
← →	(In *Edit* mode), with a boundary selected, moves the boundary in the arrow direction.

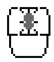
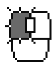
Cursor movement

Shortcut	Description
← →	Moves the X cursor to the next/previous data point.
⇧ + ← →	Moves the X cursor through the data quickly.
Home End	Moves the X cursor to the beginning or end of the trace.
⇧ + Ctrl + P	Show/hide the Polynomial curve.
⇧ + Ctrl + U	Enter/Exit User defined Polynomial mode.
⇧ + Ctrl + E	Copy the Polynomial equation (for pasting as plain text or rich text).
⇧ + Ctrl + C	Copy the Polynomial coefficients (for pasting as tab delimited text).

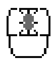
Zoom control

Shortcut	Description
Z	Zoom on current cursor position (50%).
Ctrl + 	Zooms using the mouse. Left click and drag the boundary to size. Release to set the size.
Ctrl + 	Zoom in or out on current cursor position.
←	Undo last zoom.
Ctrl + ←	Undo all zooms.

Scrolling

Shortcut	Description
+ -	Auto scrolls along the trace in a zoomed region.
	Scroll in a zoomed region.
	Open hand cursor.
	Click and drag to scroll in a zoomed region.
Alt + ← →	Moves the view port by 10% of its width in the arrow direction.

Display mode

Shortcut	Description
↑ ↓	Changes the Active channel pair.
⇧ + 	
Y	Toggles the Auxiliary axis for the active channel between left, right and off.

Other shortcuts

Shortcut	Description
Alt + ↵	Displays the X-Y display properties dialog.

Reports

In the Report display

Shortcut	Description
Insert	Adds a new table.
Del	Deletes the selected table.
Alt + ↵	Opens the properties dialog for the selected table.
Ctrl + ↵	Runs the entire report.
↵	Runs the selected table.
Esc	Cancels a report or a table run.

In the Properties dialog

Shortcut	Description
Insert	Adds a new data item.
Del	Deletes a selected data item.
⇧ + ↑ ↓	Moves a data item up or down.
← →	Moves the selection left or right.

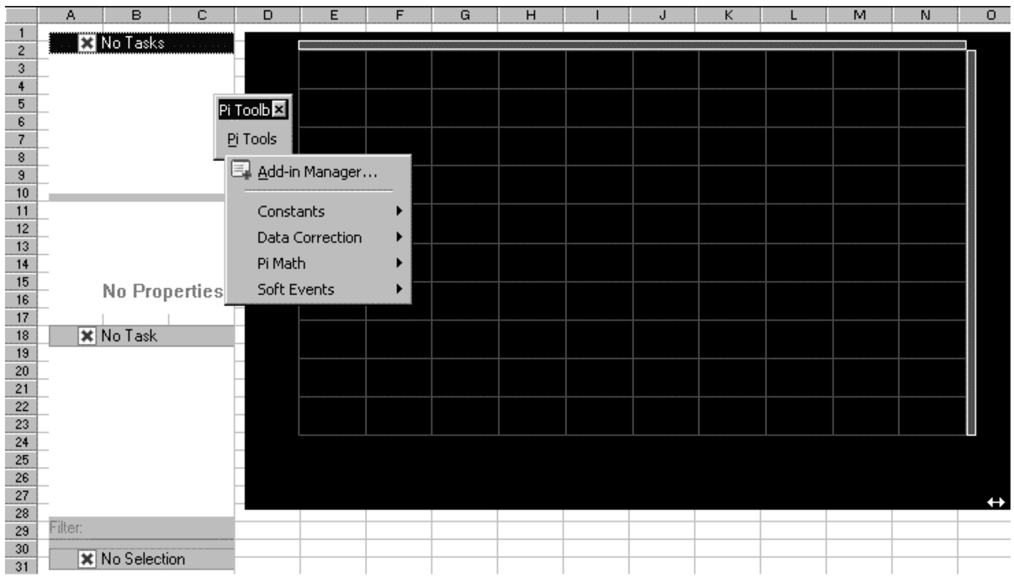
Video display

Shortcut	Description
← →	Moves to the previous or next frame in the video.
Home End	Moves to the first/last frame in the video, within the limits of the data selection.
O	Toggle Offset mode on/off.
Pge Up Pge Down	Fast forward/ Fast Rewind.
Space	Play/Pause.
Alt + ↵	Opens the properties dialog for the selected display.

Appendix C

Sample code for Excel

Note: *Place code in a new worksheet with a Pi Toolbox task configuration page, a Pi Toolbox 1D channel selection page and a Pi Toolbox Time and Distance display are embedded into sheet 1.*



See following pages for sample code.

This workbook

```
Option Explicit

Private Sub Workbook_BeforeClose(Cancel As Boolean)

Module1.OnClose

End Sub

Private Sub Workbook_Open()

Module1.OnOpen

End Sub
```

Module (called Module 1)

```
Option Explicit

Dim g_oConfigPage As ITbxConfigurationPage
Dim g_oADM As ITbxADM
Dim g_oCtl As ITbxControl

Dim g_ADMSink As CADMNotificationsSink
Dim g_ControlSink As CControlNotificationsSink

Sub OnOpen()

'Connect TaskView and ADM
Set g_oConfigPage = Sheet1.TaskView1
Set g_oADM = Sheet1.ADM1
g_oConfigPage.ADM = g_oADM

'Connect Chart and ADM
Set g_oCtl = Sheet1.TimeDistCtl1
g_oCtl.ADM = g_oADM

'Connect ChannelSelect to the ADM and the Chart
Set g_oConfigPage = Sheet1.ChannelSelect1
g_oConfigPage.ADM = g_oADM
g_oConfigPage.Control = g_oCtl

'Subscribe for ADM Notifications, so we can be notified when
'a new task has been selected.
Set g_ADMSink = New CADMNotificationsSink
Call g_ADMSink.Subscribe(g_oADM)

'Subscribe for Control Notifications, so we can be notified when
'the a new channel has been selected.
Set g_ControlSink = New CControlNotificationsSink
Call g_ControlSink.Subscribe(g_oCtl)

'Call Task Changed which will rehook up any persisted tasks
TaskChanged

'Tidy up
Set g_oConfigPage = Nothing

End Sub

Sub OnClose()
```

```
On Error Resume Next

'Finished with notifications
Call g_ControlSink.UnSubscribe
Set g_ControlSink = Nothing

Call g_ADMSink.UnSubscribe
Set g_ADMSink = Nothing

'Must terminate the ADM before quitting
g_oADM.Terminate

'Tidy up
Set g_oCtl = Nothing
Set g_oADM = Nothing

On Error GoTo 0

End Sub

'Called by the TaskChanged method of ITbxADMNotifications, implemented
'in CADMNotificationsSink
Sub TaskChanged()

If g_oADM.Tasks.Count > 0 Then
    'Set the Chart Task to the new task / last added task
    g_oCtl.TaskIndex = g_oADM.Tasks.Count
End If

End Sub
```

Class Module (called CADMNotificationsSink)

```
Option Explicit

Implements ITbxADMNotifications

Dim lCookie As Long
Dim oADM As ITbxADM

Private Sub Class_Initialize()

lCookie = 0
Set oADM = Nothing

End Sub

Private Sub ITbxADMNotifications_ChannelPropertyFactoryChanged(ByVal
punkCaller As PiToolboxLib.ITbxADM, ByVal pChannelPropertyFactory As
PiToolboxLib.ITbxChannelPropertyFactory)
'Comment to implement method
End Sub

Private Sub ITbxADMNotifications_CircuitMapDataChanged(ByVal punkCaller As
PiToolboxLib.ITbxADM, ByVal pMapData As PiToolboxLib.ITbxCircuitMapData)
'Comment to implement method
End Sub

Private Sub ITbxADMNotifications_CommonChannelsChanged(ByVal punkCaller As
PiToolboxLib.ITbxADM)
'Comment to implement method
End Sub

Private Sub ITbxADMNotifications_GroupFactoryChanged(ByVal punkCaller As
PiToolboxLib.ITbxADM, ByVal pGroupFactory As PiToolboxLib.ITbxGroupFactory)
'Comment to implement method
End Sub

Private Sub ITbxADMNotifications_RealTimeSettingsChanged(ByVal punkCaller As
PiToolboxLib.ITbxADM)
'Comment to implement method
End Sub

Private Sub ITbxADMNotifications_TasksChanged(ByVal punkCaller As
PiToolboxLib.ITbxADM)

'Calls sub to change task index of control and clear table
```

```
Module1.TaskChanged

End Sub

Private Sub ITbxADMNotifications_Terminating(ByVal punkCaller As
PiToolboxLib.ITbxADM)
'Comment to implement method
End Sub

Public Sub Subscribe(ByVal pADM As PiToolboxLib.ITbxADM)

'Pi Toolbox VB Helper must be selected in the references
Dim oHelper As VBNotificationsHelper

'Create a new Helper object
Set oHelper = New VBNotificationsHelper

'Check oADM and pADM and store the object if everything is OK
If pADM Is Nothing Then
    'Bad Parameter passed in
    MsgBox "Error - Attempted to subscribe with unset source", , "ADM
Notifications Sink"
ElseIf Not oADM Is Nothing Then
    'We've already subscribed
    MsgBox "Error - Sink already used for subscription", , "ADM
Notifications Sink"
    GoTo Exit_Sub
Else
    'No error, so store the object being subscribed
    Set oADM = pADM
End If

'Subscribe, storing the returned cookie so we can unsubscribe later
lCookie = oHelper.Subscribe(tbxADMNotifications, oADM, Me)

Exit_Sub:
    'Tidy up
    Set oHelper = Nothing
    Exit Sub

End Sub

Public Sub UnSubscribe()

'Pi Toolbox VB Helper must be selected in the references
Dim oHelper As VBNotificationsHelper
```

```
'Create a new Helper object
Set oHelper = New VBNotificationsHelper

'Check we can unsubscribe
If oADM Is Nothing Or lCookie = 0 Then
    'Haven't sucessfully subscribed yet
    MsgBox "Error - Attempted to unsubscribe without having subscribed
sucessfully", , "ADM Notifications Sink"
Else
    'Unsubscribe to the stored object
    Call oHelper.UnSubscribe(oADM, lCookie)
End If

'Tidy up and reset
Set oADM = Nothing
Set oHelper = Nothing
lCookie = 0


End Sub
```

Class Module (called CcontrolNotificationsSink)

```
Option Explicit

Implements ITbxControlNotifications

Dim lCookie As Long
Dim oControl As ITbxControl

Private Sub Class_Initialize()

lCookie = 0
Set oControl = Nothing

End Sub

Private Sub ITbxControlNotifications_ActiveChannelsChanged(ByVal pControl As
PiToolboxLib.ITbxControl)
'Comment to implement method
End Sub

Private Sub ITbxControlNotifications_ADMChanged(ByVal pControl As
PiToolboxLib.ITbxControl, ByVal pNewADM As PiToolboxLib.ITbxADM)
'Comment to implement method
End Sub

Private Sub ITbxControlNotifications_DisplayedChannelsChanged(ByVal pControl
As PiToolboxLib.ITbxControl)
'Comment to implement method
End Sub

Private Sub ITbxControlNotifications_TaskChanged(ByVal pControl As
PiToolboxLib.ITbxControl, ByVal pNewTask As PiToolboxLib.ITbxTask)
'Comment to implement method
End Sub

Public Sub Subscribe(ByVal pControl As PiToolboxLib.ITbxControl)

'Pi Toolbox VB Helper must be selected in the references
Dim oHelper As VBNotificationsHelper

'Create a new Helper object
Set oHelper = New VBNotificationsHelper

'Check oControl and pControl and store the object if everything is OK
If pControl Is Nothing Then
```

```
    'Bad Parameter passed in
    MsgBox "Error - Attempted to subscribe with unset source", , "Control
Notifications Sink"
ElseIf Not oControl Is Nothing Then
    'We've already subscribed
    MsgBox "Error - Sink already used for subscription", , "Control
Notifications Sink"
    GoTo Exit_Sub
Else
    'No error, so store the object being subscribed
    Set oControl = pControl
End If

'Subscribe, storing the returned cookie so we can unsubscribe later
lCookie = oHelper.Subscribe(tbxControlNotifications, oControl, Me)

Exit_Sub:
    'Tidy up
    Set oHelper = Nothing
    Exit Sub

End Sub

Public Sub UnSubscribe()

'Pi Toolbox VB Helper must be selected in the references
Dim oHelper As VBNotificationsHelper

'Create a new Helper object
Set oHelper = New VBNotificationsHelper

'Check we can unsubscribe
If oControl Is Nothing Or lCookie = 0 Then
    'Haven't sucessfully subscribed yet
    MsgBox "Error - Attempted to unsubscribe without having subscribed
sucessfully", , "Control Notifications Sink"
Else
    'Unsubscribe to the stored object
    Call oHelper.UnSubscribe(oControl, lCookie)
End If

'Tidy up and reset
Set oControl = Nothing
Set oHelper = Nothing
lCookie = 0

End Sub
```

Appendix D

Band Pass filter algorithm

Direct FIR implementation of digital filtering for Toolbox.

Toolbox requires filtering of the sampled signal as follows:

- high pass (freq < F1);
- low pass (freq > F2);
- band pass (F2>freq>F1).

All of these can be computed from one or two low-pass filtered signals. Note that:

- high pass is [(original signal)– (low pass)]
- band pass is [(low pass at higher freq) – (low pass at lower freq)]

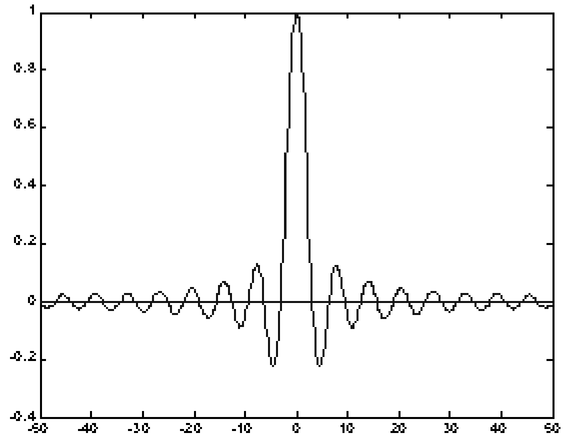
hence all implementable quickly as array addition/subtractions.

Here we use a finite impulse response (FIR) filter to implement a low-pass filter. It is recognized that in many circumstances a spectral domain (FFT) method is quicker, but this is more complicated in the case of data sampled at different frequencies and non-periodically. We will implement it non-causally (i.e. using time before and after the point in question) so far as possible, and truncate when necessary (at edges of time periods).

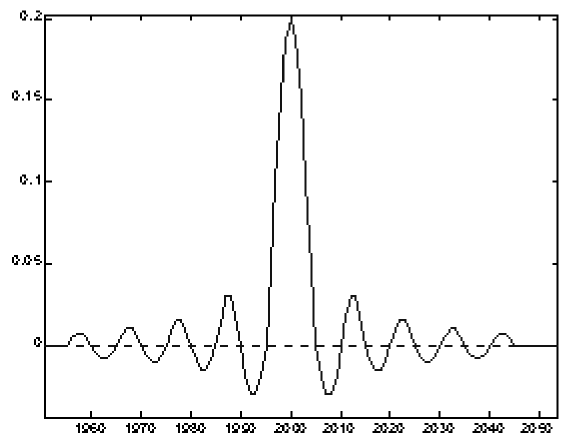
However this is still apparently slower than the FFT implementation.

By using a simple FIR filter, with redundancy, we can reduce the number of computations to comparable to the number required for a FFT implementation – or less.

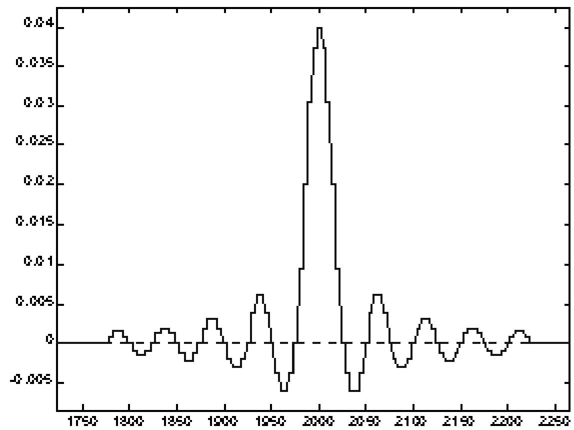
A perfect low-pass filter has as impulse response a sinc (sine(x)/x) function, as:



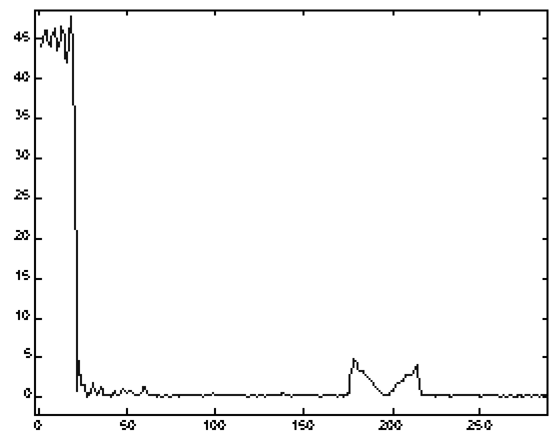
We will approximate this by using a sinc function for the central peak, but sin values for the subsidiary peaks, scaled appropriately. Like this each peak is self-similar, reducing computations. We will take the central peak and 8 neighboring peaks, so that we take a total of 9 wavelengths of time at the cutoff frequency for the FIR filter. Note that the 'tails' are a series of sin values over 1 period (so every other peak is the same height). The resulting impulse response is as below.



We further approximate by quantizing this:



this gives a very good approximation to the ideal frequency response:



We have quantized in time to 10 times in each ‘period’ of the tail (= filter cut-off frequency period).

We note that the central ‘hump’ has only 5 discrete values, 1 of which (in the center) is 1. The sine waves in the side ‘tails’ are all similar, and hence only have two discrete values (plus a weighting for each peak).

The two functions are a sinc wave from x=0 to x=pi, which I call function ‘A’, and which for us has 5 values, A(1 … 5) and the sine wave approximation, which in this approximation has two values, B(1, 2). (Note we ignore the part of the impulse response, which is zero.

For a waveform the output of a filter of finite impulse response is the sum of the coefficients times the input.

If the input channel is x, then we say the values are:

x(1….j….N)

and for each there is a time t(1….j…N) and equivalently a sampling interval dt(1….j….N) (noting that one end has to be fiddled) where dt(i)=t(i+1)-t(i) (say dt(N) = dt(N-1)).

For each input channel point we compute 6 interim arrays:

x*dt*A(1...5) and x*dt*B(1,2).

Call the results (2-D matrices) fA(1...4,1..i...N) and fB(1..2, 1....i...N)

Say the cut-off frequency of the filter is fc. Then the points in the impulse response are separated by 1/(20*fc) (since we chose 10 points in the quantization above). Then let it have a variable tx which is half this for simplicity,

tx = 1/(20*fc)

and then we see that at any given output time our output is given by

out(t) = sum(XA(0,ts)[while(ts-t<tx<ts-t)]) ! central ‘plateau’

+ sum(XA(1,ts)[while(tx<ts-i<3*tx]) + sum(XA(1,ts)[while(tx<i-ts<3tx]) ! first step 2 sides

etc for all the A terms

+w1*[sum(XB(1,ts)[while(11*tx<ts-i<13*tx]) + sum(XB(1,ts)[while(11*tx<i-ts<13*tx]) !first quarter sine

+ sum(XB(2,ts)[while(13*tx<ts-i<15*tx]) + sum(XB(2,ts)[while(13*tx<i-ts<15*tx]) !first quarter sine

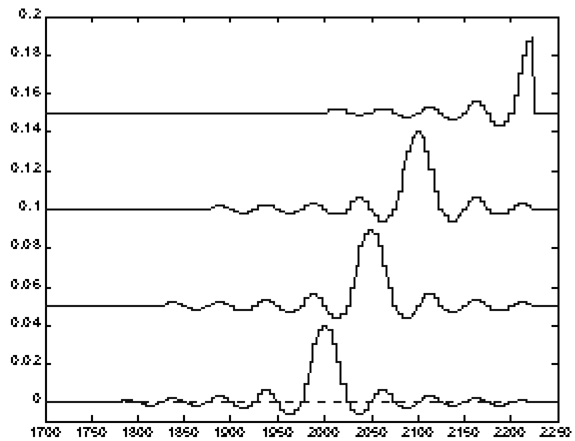
+ sum(XB(2,ts)[while(15*tx<ts-i<17*tx]) + sum(XB(2,ts)[while(15*tx<i-ts<17*tx]) !first quarter sine

+ sum(XB(1,ts)[while(17*tx<ts-i<19*tx]) + sum(XB(1,ts)[while(17*tx<i-ts<19*tx])] !first quarter sine

for first hump

and etc for each hump.

As an edge is approached, not just whole periods should be used as they become affected. As the periods are sine waves the d.c. response, hence scaling, is not affected:



but when the central peak reaches the edge, then cut the central peak into two and double the scaling.

Flag the area where the kernel is truncated as “edge affected” and re-compute if adjoining data becomes available.

Appendix E

XML Example strings

All the required elements and their associated attributes are listed and described below:

<status_def>

The root element of the Bit-Field Definitions.

version

The version of the bit-field definition XML file format

Format: text

For example: <status_def version="1">

<application name>

The name of the application.

Format: text

id

The id used to uniquely identify a build of code. In this example: the build of code for this application.

Format: text

For example: <application name="Gearbox Controller" id="aabbccdd">

<channel>

The source of data used in the creation of a bit-field.

Tagname

The “master” name of the channel

Format: text

Color

The display color used by clients when displaying the channel’s data.

Format: COLOUR

For example: <channel tagname="TC_Status" color="0xff0000">

<field>

A definition of a bit-field

Name

The name of the bit-field

Format: text

abbr

An abbreviated version of the “name” attribute

Format: TEXT

bitmask

The bit-mask applied to the parent status channel.

Format: VALUE

For example: <field name="Heartbeat" abbr="Htbt" bitmask="0x0100">

<entry>

Describes a specific bit or value of the parent status channel.

value

A specific bit or value of the parent status channel.

Format: VALUE

text

The display text for the associated “value”

Format: text

Color

The color to be used when displaying this entry

Format: COLOUR

For example: <entry value="0x0000" text="Off" color="0xff0000"/>

<default>

Describes a default entry that is to be used when no **<entry>** matches are found.

Text

The display text

Format: TEXT

Color

The color to be used when displaying this entry.

Format: COLOR

For example : <default text="Undefined" coloured="0xa1a1a1"/>

Data formats

Color

Format: 24bit hex number

most significant byte = Red value

middle byte = Green value

least significant byte = Blue value

Example: 0xff00ff

text

Format: Ascii string

Length dependant on use

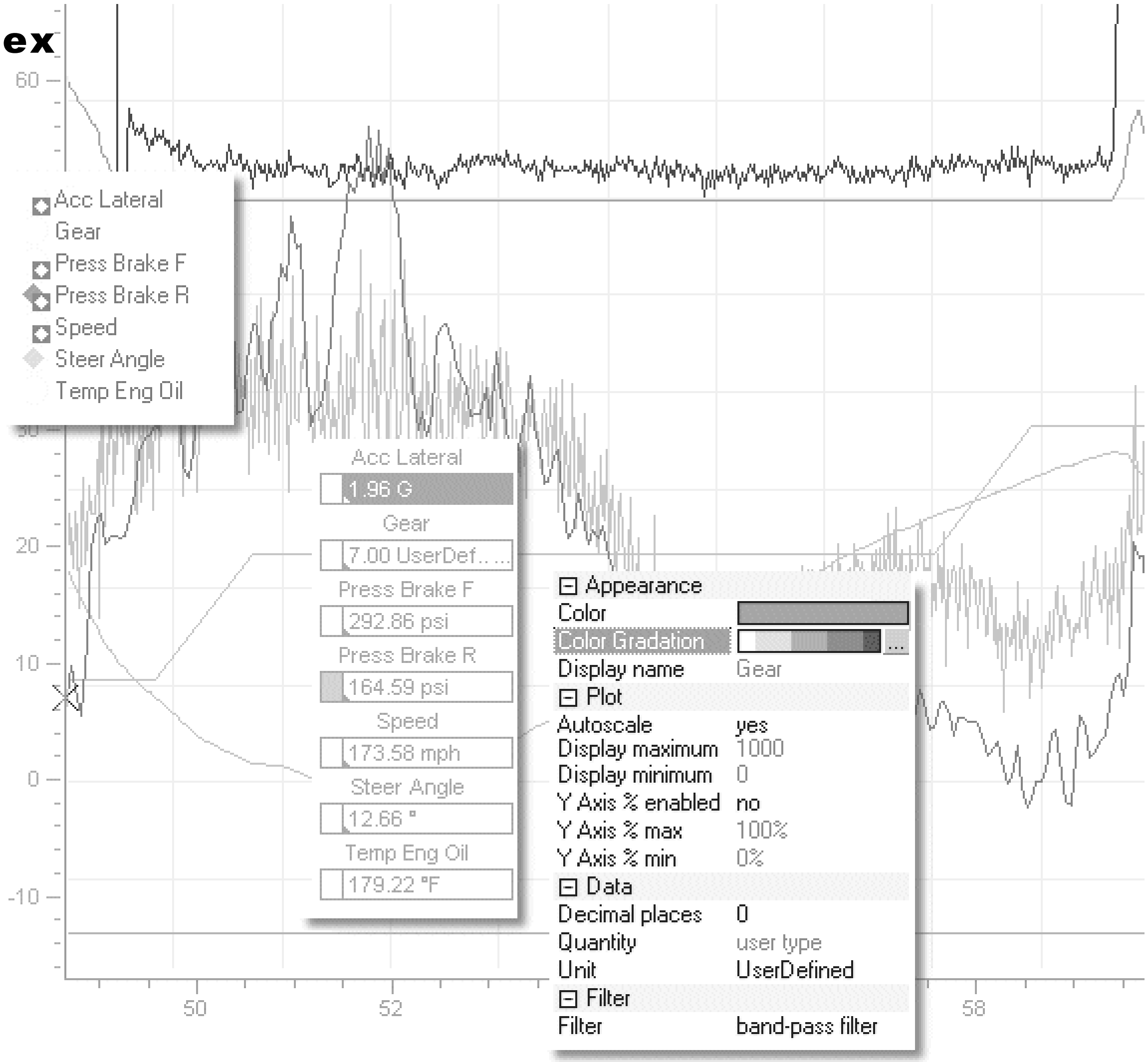
Example: Ratio

value

Format: 32bit hex number (maximum)

Example: 0x00400

Index



60
20
10
0
-10
Acc Lateral
Gear
Press Brake F
Press Brake R
Speed
Steer Angle
Temp Eng Oil
Acc Lateral
1.96 G
Gear
7.00 UserDef...
Press Brake F
292.86 psi
Press Brake R
164.59 psi
Speed
173.58 mph
Steer Angle
12.66 °
Temp Eng Oil
179.22 °F
Appearance
Color
Color Gradation
Display name Gear
Plot
Autoscale yes
Display maximum 1000
Display minimum 0
Y Axis % enabled no
Y Axis % max 100%
Y Axis % min 0%
Data
Decimal places 0
Quantity user type
Unit UserDefined
Filter
Filter band-pass filter
50
52
58

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