LOGADEC

User Manual

For version 1.0.58 / 2026-10-28

NOURETE ／ https://logadec.com

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Chapter 1

Introduction

LOGADEC is software for displaying and analyzing time-series measurement data. It consists of a single HTML file and runs simply by opening it in a browser. It needs no installation and no internet connection.

This chapter summarizes what LOGADEC can do and what you should know before using it. If you want to start right away, go to Chapter 2 The First Five Minutes.

1.1 What LOGADEC can do

Task	What LOGADEC can do
Load	Loads CSV, Excel (.xlsx/.xls/.xlsm), and NI TDMS. The delimiter (comma, tab, semicolon), decimal separator (dot, comma), character encoding, header row, and unit row are detected automatically. The X-axis column can also be a date-time (such as 2026-10-01 08:00:00) or a time of day only. You can also import all files in a folder at once and join them into one series in time order (Chapter 4)
View	Overlays many series, or arranges them in separate tiers by item. Zoom and pan work with just the mouse wheel and dragging (Chapter 5)
Analyze	Formula calculations (Chapter 7), analyses such as FFT, STFT, wavelet, change-point detection, outlier detection, and correlation and lag (Chapter 8, Chapter 9), and XY scatter plots with fitted curves (Chapter 10). Filters can be applied per series (Chapter 5)
Share	Saves the entire analysis state to an `.lgd` file that you can hand to colleagues. You can also export images (PNG and others) and CSV/Excel (Chapter 11)

Figure 1-1 Hand over your analysis screen as-is with an .lgd file

1.2 System requirements

Item	Details
Browser	Latest version of Google Chrome or Microsoft Edge (recommended)
Other browsers	LOGADEC also runs in Firefox and Safari. However, saving works as a download instead of overwriting the same file
Graphics	WebGL must be available (almost all current PCs support it)
Installation	Not required. No administrator rights are needed either
Network	Not required. LOGADEC never communicates with anything outside your PC

> **Tip: Using LOGADEC on company PCs**
>
> LOGADEC needs only one HTML file and a browser. You can use it as-is on test equipment without internet access and on business PCs where you cannot install software.

1.3 Free and paid editions

All display and analysis features are available in the free edition. The differences are the number of series you can handle and whether you can save `.lgd` files.

	Free edition (Free)	Paid edition (Personal, Commercial)
Number of series you can load	Up to 1,000	Unlimited
Number of series displayed at once	150 (fixed)	300 (adjustable from 10 to 2,000)
Saving `.lgd` files	Not available (you can open them)	Available
Display, analysis, image and CSV export	All available	All available

> **Note: About the paid edition**
>
> Paid licenses are in preparation. The start of sales will be announced at https://logadec.com.

1.4 How your data is handled

- **No external communication.** The data you load is never sent outside your PC.
- **Your original data is never modified.** Formulas, unit conversions, and filters are all applied to the display only. The files you loaded stay unchanged.
- **Settings stay in your browser.** Theme and display settings are saved in the browser you use. They are not carried over to other PCs.

1.5 How to read this manual

- Text shown on screen appears in brackets, like [**Save**].
- Keyboard keys appear like `Ctrl` + `S`.
- The numbers on screenshots (1, 2, ⋯) correspond to the numbers in the descriptions below each screenshot.
- Screenshots are taken with practice sample data (data from a fictitious endurance test). You can download the sample data from the manual's table of contents page. Some screenshots in Chapter 4 are taken with fictitious data-logger logs split by hour.

Chapter 2

The First Five Minutes

This chapter walks you through the steps from downloading LOGADEC to displaying a graph of the sample data.

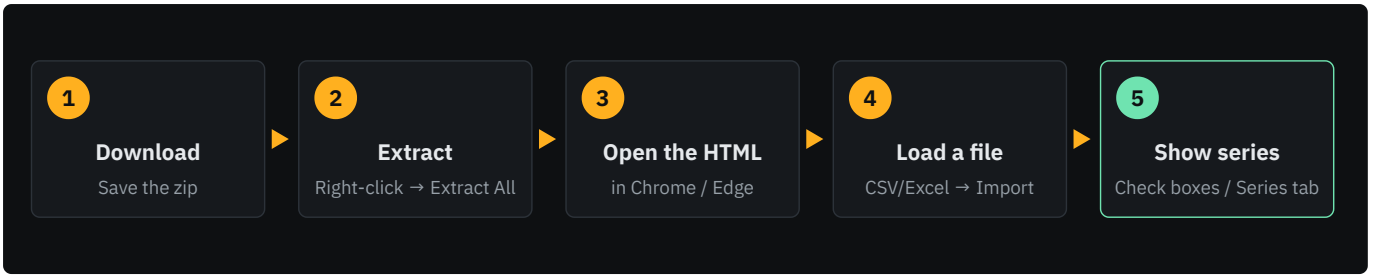

Figure 2-1 The steps to your first graph

2.1 Download and extract

1. On https://logadec.com, click [Download free edition]. On the download page, read the End User License Agreement, agree to it, and then save the zip file (named like `LOGADEC-1.0.33.zip`; the numbers indicate the version).
2. Right-click the saved zip file and choose [Extract All] (on Windows).
3. You are ready when the extracted folder contains the following files.

File	Contents
`logadec_1_0_33.html` (the numbers indicate the version)	The LOGADEC application. Open this file
`EULA.md`	The End User License Agreement
`README.txt`	A short description of how to start
`THIRD-PARTY-NOTICES.md`, `licenses/`	Notices and full license texts for the third-party software included in LOGADEC

> **Caution: Do not open the file directly from inside the zip**
>
> If you double-click the HTML inside the zip without extracting it, Windows copies it to a temporary folder before opening it. That folder may be deleted later, so the file can no longer be found the next time you try to open it. Always extract the zip before opening the file.

2.2 Open LOGADEC

Double-click `logadec_1_0_33.html` (the numbers indicate the version) in the extracted folder. Your browser opens and shows the LOGADEC screen.

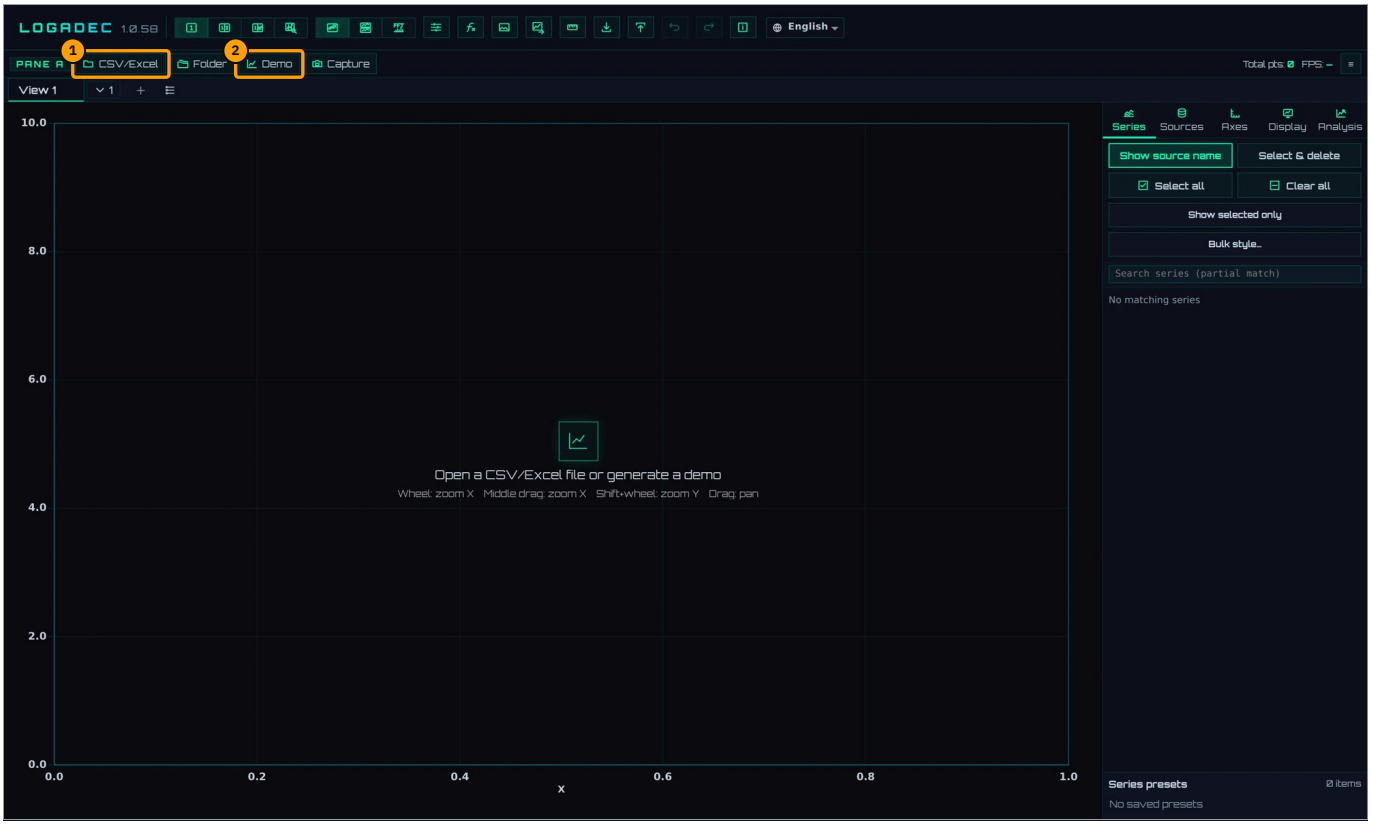

Figure 2-2 The screen right after startup

1 [**CSV/Excel**]: Selects a file to load

2 [**Demo**]: Creates demo data for practice (click [**Generate**] to create it)

> **Tip: If a browser other than Chrome or Edge opens**
>
> Right-click the HTML file and choose [Open with] → [Microsoft Edge] (or [Google Chrome]).

2.3 Load a file

1. Click [**CSV/Excel**] at the top left of the screen and select the file to load. You can also drag and drop the file onto the graph. For practice, use the sample data `sample_endurance_run_en.csv`.
2. The import screen opens. LOGADEC examines the contents of the file and automatically detects the header row, the unit row, where the data starts, and which column to use as the X axis.
3. If the detected result matches the preview and looks correct, click [**Import**].

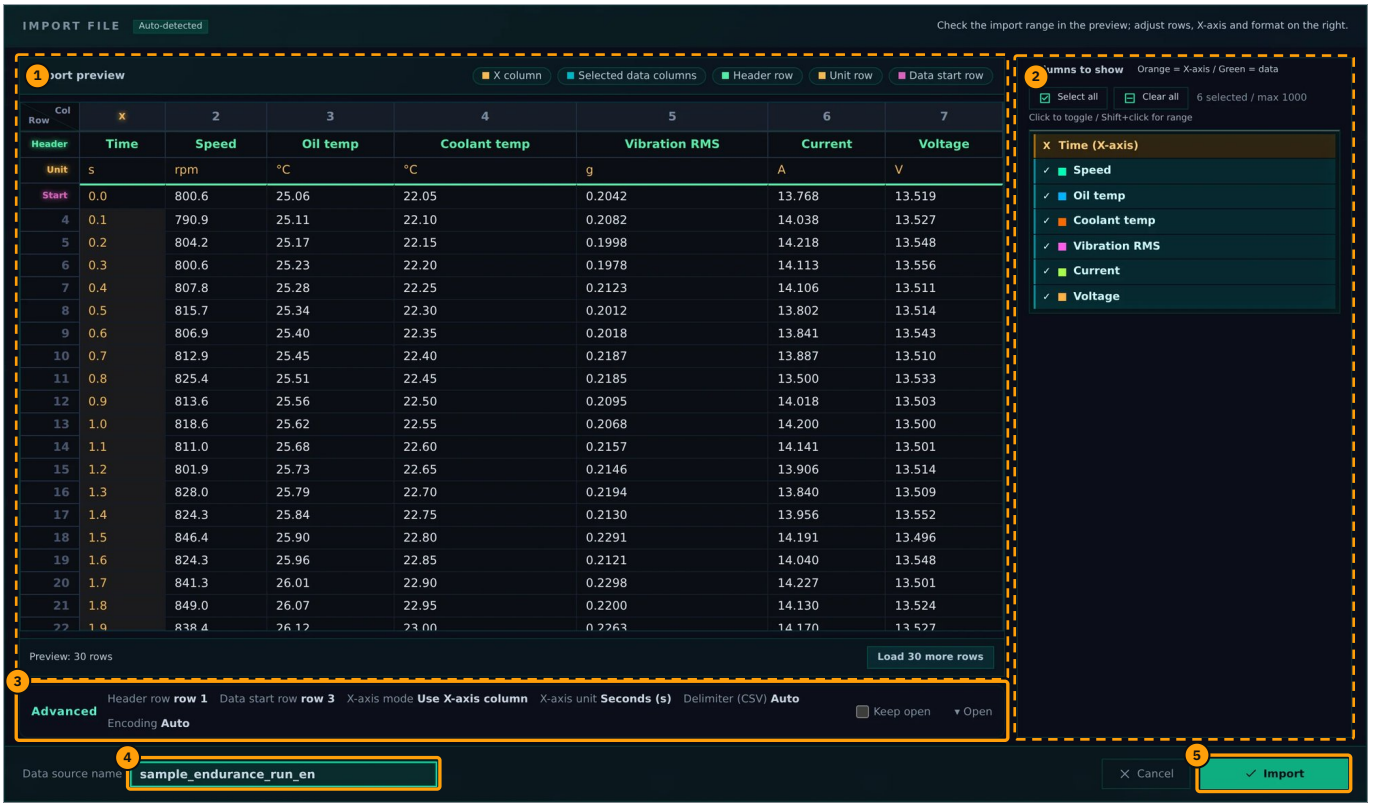

Figure 2-3 The import screen

1. [**Import preview**]: The beginning of the file. Colors indicate the X-axis column, the data columns, the header row, the unit row, and where the data starts
2. [**Columns to show**]: Selects the columns to load. Click to toggle selection; `Shift` + click selects a range
3. [**Advanced**]: The results of automatic detection. If anything is wrong, open this and correct it
4. [**Data source name**]: The name given to the loaded data. It appears after each series name
5. [**Import**]: Loads the data with these settings

> **Note: If automatic detection does not work well**
>
> Automatic detection may be wrong for files whose headers span two rows or that use an unusual delimiter. Open [**Advanced**] and correct [**Header row**], [**Data start row**], [**Delimiter (CSV)**], and [**Encoding**]. The preview updates immediately.

2.4 Display series

Right after loading, nothing is shown on the graph. The loaded series are listed in the sidebar on the right side of the screen. Check the series you want to display.

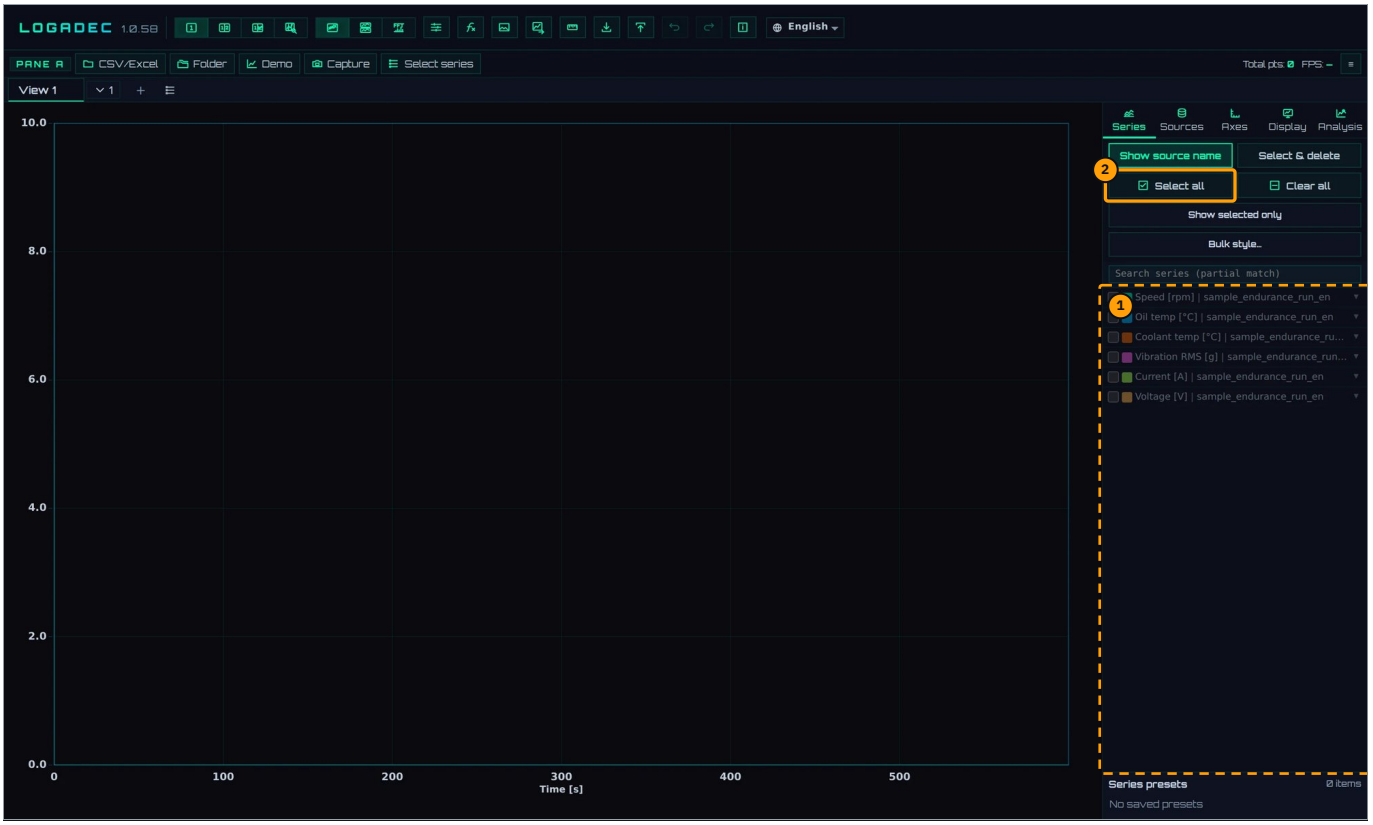

Figure 2-4 Right after loading (no series displayed yet)

1 The list of loaded series. Checked series are shown on the graph

2 [**Select all**]: Displays all series in the list

When you click [**Select all**], all series are overlaid on one graph. A vertical axis is provided for each Y range (series with the same range share one axis), and colors show which axis belongs to which series.

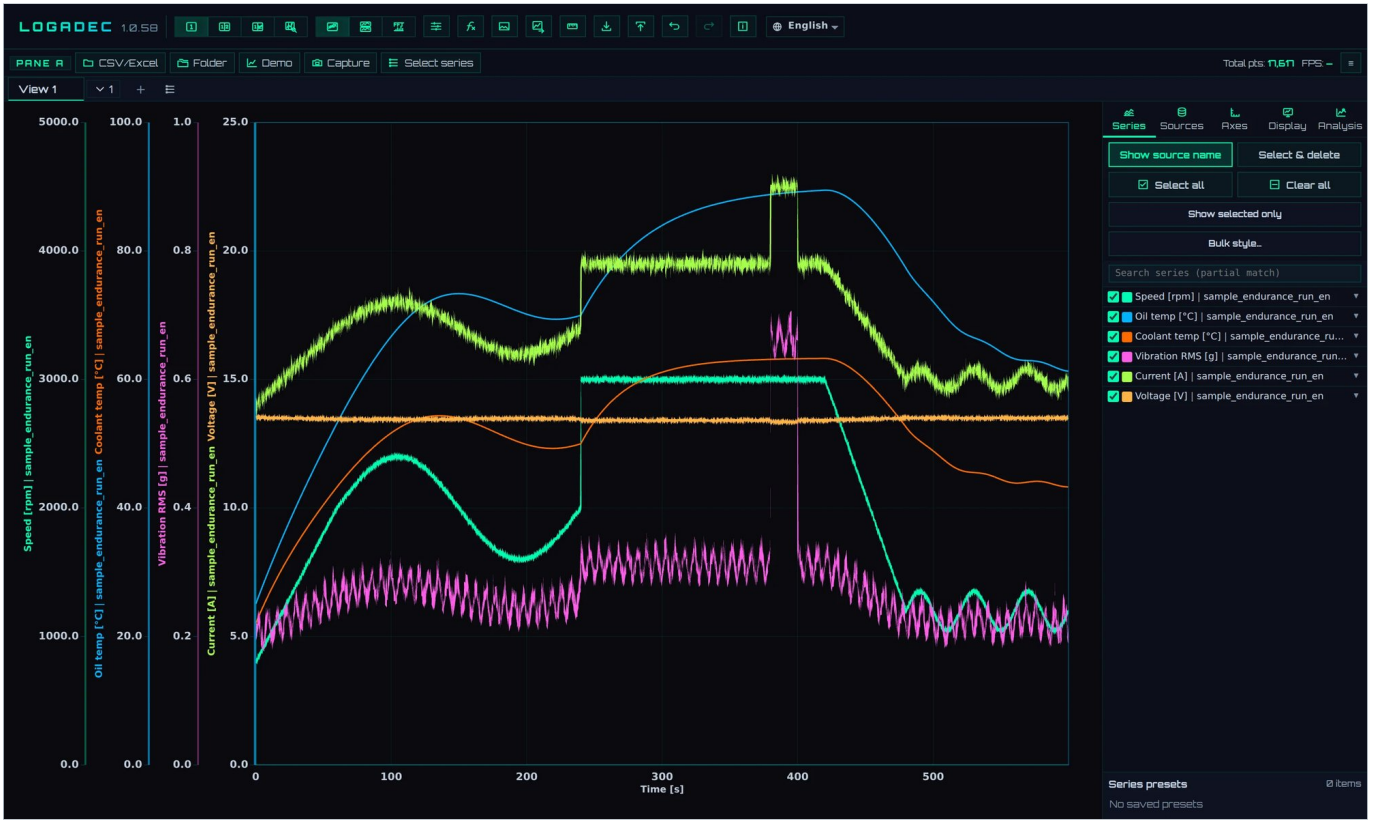

Figure 2-5 All series displayed ([**Overlay**] view)

2.5 Make the graph easier to read

Split items into separate tiers

With many series, an overlaid display becomes hard to read. Click [**Stacked**] at the top of the screen to give each series its own tier, aligned on the same time axis.

Figure 2-6 Items in separate tiers ([**Stacked**])

1 [**Overlay**]: Overlays the series on one graph

2 [**Stacked**]: Shows each series in its own tier

Zoom and pan

You can zoom and move the graph with the mouse alone.

Action	Effect
Wheel	Zooms X in or out around the mouse position
Drag	Moves in the X direction
Click the number at the left or right end of the X axis	Enter the X range as numbers
Click a tick number on the Y axis	Enter the Y range as numbers

Other operations, such as Y zoom, are described in Chapter 5.

The next figure shows the sample data zoomed in to 360–420 seconds. You can see that vibration and current rise between 380 and 400 seconds.

Figure 2-7 View zoomed in to 360–420 seconds

> **Tip: Undo**
>
> Changes to settings such as lines, colors, and filters can be undone one step at a time with `Ctrl` + `Z`. If you undo too far, redo with `Ctrl` + `Y`. Zooming and moving cannot be undone; to return to the full view, see "Return to the full view" in Chapter 5.
>
> Loading data (including appending, opening a .lgd file, and generating demo data) cannot be undone. If you undo a step made before loading, only view settings such as the display style and pane layout are restored; the loaded data stays.

2.6 Try it with demo data

Even without your own data, you can create practice data: click [**Demo**], choose [**Type**] and [**Series**] in the pane bar that appears, and click [**Generate**] (the created series are not displayed at first). You can work with demo data just like loaded data.

Chapter 3

The Screen

This chapter describes the name and role of each part of the LOGADEC screen. Later chapters use the names introduced here.

3.1 The whole screen

Figure 3-1 Names of the screen parts

1. Logo: Click it to open [**About and licenses**]. This is where you check the version and enter a license key
2. Screen layout: Switches between [**1 pane**], [**2 panes**], [**Analysis**], and [**Investigate**]
3. Display mode: Switches between [**Overlay**], [**Stacked**], and [**FFT**]
4. Tools: [**Presets**], [**Formula**], [**Export image**], [**Export data**], [**Measure**]
5. [**Save**], [**Load**]: Save and open settings or data (.lgd)
6. [**Undo**], [**Redo**]: Undo and redo operations
7. The shortcut list, and switching the display language (Japanese/English)
8. Pane bar: [**CSV/Excel**], [**Folder**], [**Demo**], [**Capture**]
9. View tabs: Keep display states on separate tabs and switch between them. Click + to create a [**New view**]
10. Graph: Where series are displayed
11. Sidebar tabs: [**Series**], [**Sources**], [**Axes**], [**Display**], [**Analysis**]
12. Sidebar contents: Shows the contents of the selected tab

3.2 The toolbar at the top

The strip at the very top of the screen holds buttons that affect the whole screen. Hover the mouse over a button to see its name.

Button	What it does	Chapter
[**1 pane**]/[**2 panes**]	Shows one graph, or two graphs side by side	Chapter 5
[**Analysis**]	Shows an XY scatter plot next to the time series	Chapter 10
[**Investigate**]	Examines analysis results in detail next to the time series	Chapter 8, Chapter 9
[**Overlay**]/[**Stacked**]/[**FFT**]	Overlays series / splits them into tiers / shows them by frequency	Chapter 5, Chapter 8
[**Presets**]	Registers and recalls display ranges and combinations of items	Chapter 6
[**Formula**]	Creates new series from formulas	Chapter 7
[**Export image**]	Exports the graph as an image (PNG, JPG, WEBP, SVG)	Chapter 11
[**Export data**]	Exports data to CSV, TSV, or Excel	Chapter 11
[**Measure**]	Measures the difference (time and value) between two points you specify	Chapter 5
[**Save**]/[**Load**]	Saves and opens settings only, or settings with data (.lgd)	Chapter 11
[**Undo**]/[**Redo**]	Undoes / redoes operations (`Ctrl` + `Z` / `Ctrl` + `Y`)	—

3.3 The pane bar

The strip above the graph holds operations for each "pane" (an area that displays a graph). With [**2 panes**], the left and right panes each get their own bar.

Button	What it does
[**CSV/Excel**]	Loads a file into this pane. In a pane that already has data, the file is added
[**Folder**]	Finds files in a folder and imports them all at once (Chapter 4)
[**Demo**]	Creates demo data for practice (choose the type and number of series, then [**Generate**])
[**Capture**]	Exports this pane as an image
[**Select series**]	Opens the [**Select series to display**] screen, where you search by name and select the series to display. Appears once data is loaded
[**Wheel: X-axis**]/[**Wheel: scroll**]	Appears only in [**Stacked**] and [**FFT**]. Switches whether the wheel zooms X in and out or scrolls all tiers up and down (Chapter 5)
[**Reorder**]	Appears only in [**Stacked**]. Reorders the tiers by dragging. Lights up while on (Chapter 5)
≡ (right end)	Shows or hides the [**Sidebar**]

3.4 The five sidebar tabs

The sidebar is where you set which series to display and how the graph looks. The five tabs at the top switch its contents.

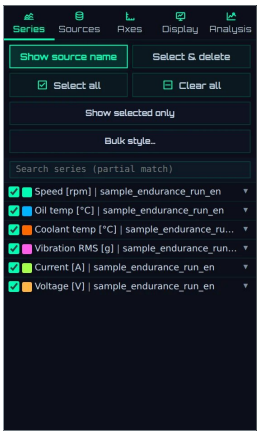

Figure 3-2
[Series]

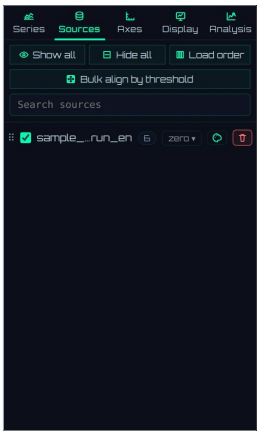

Figure 3-3
[Sources]

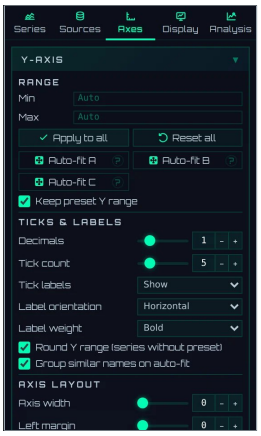

Figure 3-4
[Axes]

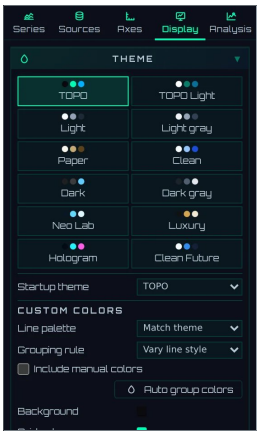

Figure 3-5
[Display]

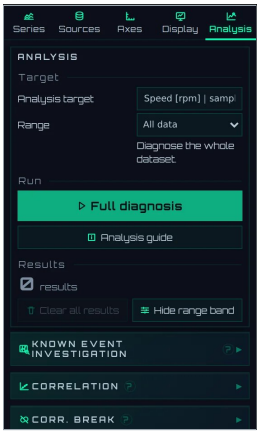

Figure 3-6
[Analysis]

Tab	Main contents
[**Series**]	The list of series. Toggle display with the check boxes, and use ▾ to set color, line style, filters, and more. You can also use [**Show selected only**] and filter by name. [**Bulk style…**] changes colors and line styles all at once
[**Sources**]	The list of loaded files (data sources). For each file, you can show or hide it, change the look of its series all at once, or delete it
[**Axes**]	Sets the range, ticks, labels, axis placement, and font size for the Y and X axes
[**Display**]	Display settings such as [**Theme**], [**Legend**], [**Zoom behavior**], and [**Max visible series**]
[**Analysis**]	Where you run analyses. Run all analyses at once with [**Full diagnosis**], or open and run analyses one at a time

3.5 Keyboard and mouse

This is a list of frequently used operations. In LOGADEC, press ? to display the list of operations. Zoom operations are described in detail in Chapter 5.

Action	Effect
Wheel	Zooms X in or out
`Shift` + wheel / wheel over the Y axis	Zooms Y in or out
Drag	Moves in the X direction
Hold the middle button and drag up or down	Zooms X in or out
`Ctrl` + wheel (in [**Stacked**] or [**FFT**] with [**Wheel: scroll**])	Zooms X in or out (the wheel without a modifier key scrolls up and down)
[**Click X-axis edge**]	[**Enter value to change X range**]
[**Click Y-axis**]	[**Enter value to change Y range**]
`Ctrl` + `Z`	[**Undo**]
`Ctrl` + `Y`	[**Redo**]
`Ctrl` + `S`	[**Save data; subsequent presses overwrite the same file**]
`?`	[**Show this shortcut list**]
`Esc`	[**Close dialog / cancel measurement**]

Chapter 4

Loading Data

In Chapter 2, you loaded the sample data with the automatically detected settings. This chapter describes the settings on the import screen in detail. It also explains how to load data whose X axis is a date-time or time of day, how to add a second file, how to import all files in a folder at once, and how to use the [**Sources**] tab to manage loaded files.

4.1 Files you can load

Format	Extension	Notes
CSV (text)	`.csv`	Detects the delimiter (comma, tab, semicolon) and character encoding (UTF-8, Shift_JIS) automatically. Files separated by semicolons with a comma as the decimal separator (such as `1,50;20,25`) are also read as-is
Excel	`.xlsx`, `.xls`, `.xlsm`	Reads one sheet per import. For `.xls` and `.xlsm`, a confirmation screen appears before loading
NI TDMS	`.tdms`	Loads numeric channels as columns named "group/channel"
LOGADEC data	`.lgd`	Restores the saved state as-is without opening the import screen (Chapter 11)

To select a file, click [**CSV/Excel**] in the pane bar, or drag and drop the file onto a pane. [**CSV/Excel**] selects one file. To load many files at once, use [**Folder**] in the pane bar (see "Import all files in a folder" below).

> **Note: Drag and drop**
>
> - With two panes, the file is loaded into the pane you drop it on.
> - When you drop one file, the same import screen opens as when you select it with [**CSV/Excel**].
> - When you drop two or more files, or a folder, the [**Import from folder**] screen opens.
> - Files in formats that cannot be loaded are not loaded, and you are notified.

> **Note: Opening .lgd files**
>
> An `.lgd` file is applied to the screen only after its entire contents have been checked. If the file is corrupted (for example, series or X data are missing), nothing is replaced and the reason is displayed. The data currently open stays as it is.

4.2 The import screen

When you select a file, the import screen opens. LOGADEC examines the contents of the file, estimates the header row, the unit row, where the data starts, and which column to use as the X axis, and shows them in color in the preview.

The preview shows the first 30 rows of the file. Click [Load 30 more rows] below it to see further ahead, 30 rows at a time (up to 1,000 rows). The dialog keeps the same size even for a file with only a few rows.

Select the columns to load

Use [**Columns to show**] on the right of the screen to select the columns to load.

- Click a column name to toggle it between selected and not selected.
- Hold down `Shift` and click to toggle all columns in between.
- [**Select all**] and [**Clear all**] toggle all columns at once.

Advanced settings

If the result of automatic detection is wrong, open [**Advanced**] and correct it. Even when it is closed, a short summary of the detected result appears next to its heading. The preview updates immediately when you make a correction, so adjust the settings while watching the colors.

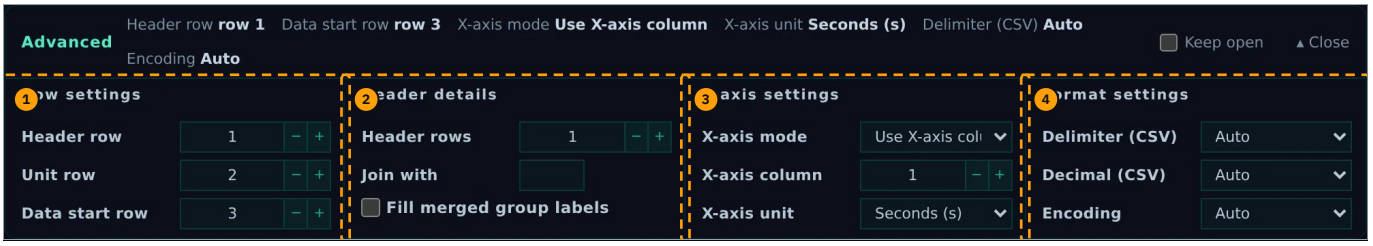

Figure 4-1 [**Advanced**] opened

1. [**Row settings**]: Specifies which rows hold the headers, the units, and the start of the data. Rows are numbered from 1; 0 means "none"
2. [**Header details**]: Settings for files whose headers span two or more rows
3. [**X-axis settings**]: Specifies the column to use for the X axis and its unit
4. [**Format settings**]: Specifies the delimiter, decimal separator, character encoding, and (for Excel) the sheet

Setting	Description
[**Header row**]	The row that contains the column names
[**Unit row**]	The row that contains the units. The unit is appended to the series name, like `[rpm]`
[**Data start row**]	The row where the numeric values start
[**Header rows**], [**Join with**]	When headers span several rows, the number of rows and the separator character used to join them
[**Forward-fill**]	Fills headers of merged cells in Excel into the columns to the right
[**X-axis mode**]	Choose from [**Use X-axis column**] (use a column such as time as X), [**Generate from sampling interval**] (when there is no time column, create X at a fixed interval), [**Cumulative sum of interval column**] (create X by adding up a column of intervals), and [**Build from hour/min/sec columns**] (when hours, minutes, and seconds are in separate columns; see the next section)
[**X-axis column**]	The number of the column to use as the X axis
[**X-axis unit**]	The unit of the X axis ((none / original), ms, seconds, minutes, hours). If the file's unit row (in the X column) contains a time unit, it is selected from the start (ms for ms). Without a unit row, seconds are used. Time units not in the list, such as µs and ns, become [**(none / original)**], and the file's unit is used as-is
[**Delimiter (CSV)**], [**Decimal (CSV)**]	The CSV delimiter and decimal separator. If both are [**Auto**], files separated by semicolons with a comma as the decimal separator (such as `1,50;20,25`) are also read correctly. If a column has no values that can be read as numbers, you are notified after loading (check the delimiter and decimal separator settings). Changing the delimiter or similar settings clears the column selection
[**Encoding**]	The character encoding. If Japanese names appear garbled, try switching between UTF-8 and Shift_JIS

> **Tip: When you load files of the same format every time**
>
> Check [**Keep open**] to have [**Advanced**] open from the start.

The data source name

[**Data source name**] at the bottom of the screen is the name given to the loaded data. Initially it contains the file name (for Excel, "file name / sheet name"). This name is appended to the item name of each series, like "Speed [rpm] | sample_endurance_run_en". When you load two or more files of the same format, it is convenient to give them distinguishable names such as `run_01` and `run_02`.

4.3 Data with a date-time or time-of-day X axis

Files whose X-axis column contains date-times (`2026-10-01 08:00:00`) or only times of day (`08:00:00`), like data-logger logs, can be loaded as-is. LOGADEC recognizes the date-time column and selects it as the X-axis column.

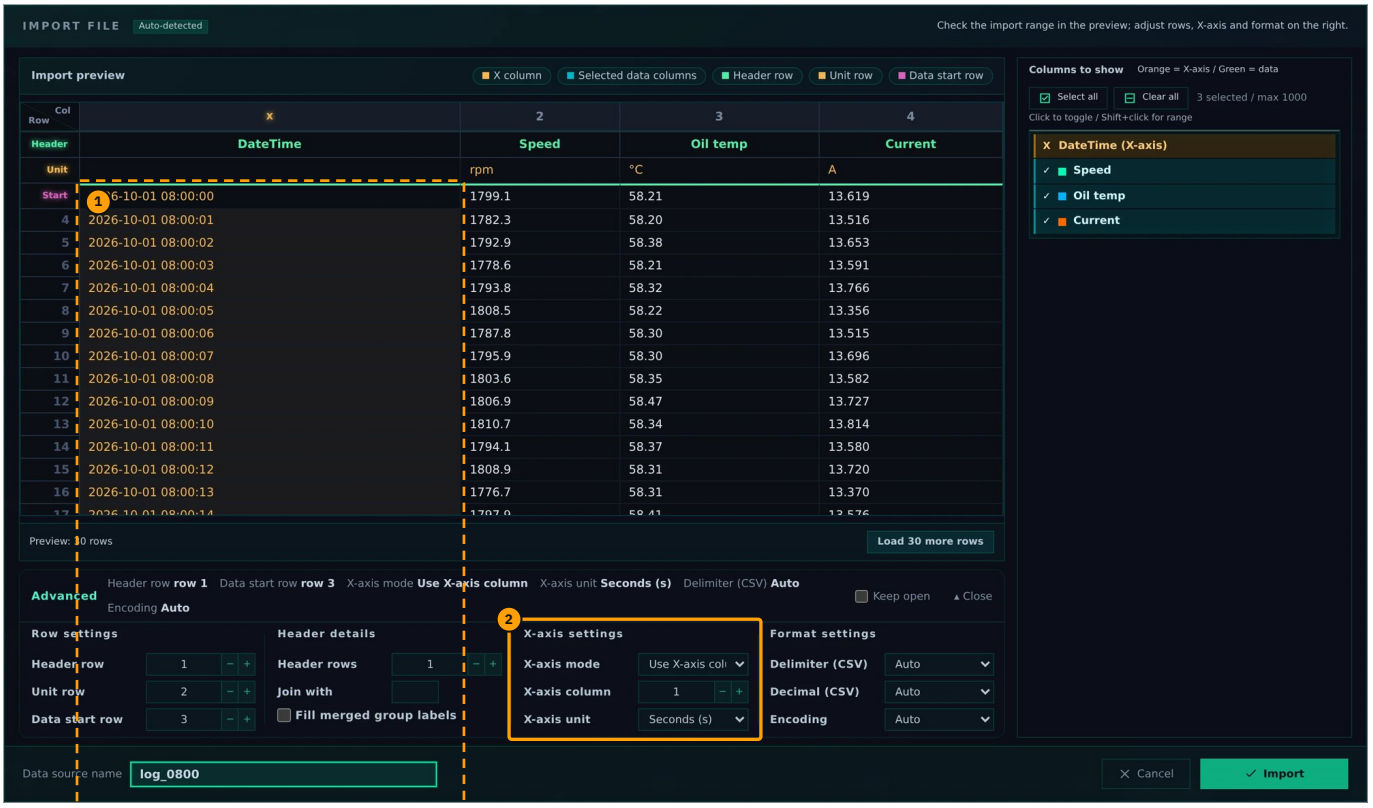

Figure 4-2 A file whose X-axis column is a date-time, selected

1 X-axis column: The date-time text is detected as the X-axis column (orange)

2 [**X-axis settings**]: [**X-axis mode**] stays at [**Use X-axis column**]. Use [**X-axis unit**] to choose the unit of X after loading

When loaded, X becomes the **elapsed time from the first row**. For example, a file recorded every second for one hour starting at `2026-10-01 08:00:00` becomes a graph with X from 0 to 3,599 seconds. Choose the unit of the elapsed time with [**X-axis unit**] (seconds at first).

Format	Example	Notes
Date and time	`2026-10-01 08:00:00`, `2026/10/01 08:00:00`, `2026.10.01 08:00:00`, `2026年10月01日 08:00:00`	Date and time are separated by a space or `T` (`2026-10-01T08:00:00`). Seconds can be omitted, and fractions (`08:00:00.500`) can be read
Date-time with time zone offset	`2026-10-01T08:00:00+09:00`, `2026-10-01T08:00:00Z`	The offset is subtracted, and times are counted in UTC
Time of day only	`23:59:58`, `00:00:01`	Where the time goes back by more than 12 hours, it is treated as crossing midnight and counting continues (`00:00:00` after `23:59:59` is 1 second later)
Excel cells with a date/time format	A cell displayed as `2026/10/01 8:00:00`	Recognized as a date-time from the cell format. Workbooks using the 1904 date system (such as those created in Excel for Mac) are also read with correct dates

- If the date-time column contains a value in a different form partway through (such as a row with only a number), that row is not loaded.
- The first date-time is used as the reference for ordering files when you import files from a folder "joined in time" (described later).

When hours, minutes, and seconds are in separate columns

For files with "hour", "minute", and "second" in separate columns, choose [**Build from hour/min/sec columns**] in [**X-axis mode**]. LOGADEC finds the columns whose headers are "時・分・秒" (or hour, min, sec, and so on) and assembles the time. If there is a "日付" (or date) column, the date is used too. Even without a date column, where the time goes back by more than 12 hours, it is counted as the next day. After loading, the X axis is named "Time".

Start time of TDMS waveforms

When you load TDMS waveform channels (those with a start time `wf_start_time`) with [**Generate from sampling interval**], the waveform start time is kept as the start date-time of that data. The time is converted to the local time of your PC's region. As with other data, X is the elapsed time from the start.

4.4 Excel and TDMS files

- **Excel**: Select the sheet to load with [**Sheet (Excel)**] in [**Format settings**]. The first sheet is selected initially. When you switch sheets, the column list and the preview are replaced with that sheet's contents. To use two or more sheets, repeat the import for each sheet.
- **TDMS**: All numeric channels are listed as columns named "group name/channel name". Row 1 holds the channel names, and row 2 the units. If there is a time channel (such as Time), it becomes X; otherwise [**Generate from sampling interval**] is used, and the sampling interval is set to the file's waveform interval (`wf_increment`). Columns to load are selected the same way as for CSV.

4.5 Add a second file

When you click [**CSV/Excel**] in a pane that already has data, the selected file is **added**. The previous data is not removed. For example, you can overlay the first and second runs of the same test to compare them.

- Added series are not displayed at first. Check them on the [**Series**] tab to display them.
- Even if the two files differ in time range or interval, they are overlaid as they are. The X axis covers a range that includes both.
- Specify the X unit of the added data with [**X-axis unit**] on the import screen (if the file's unit row contains a time unit, it is selected from the start). If you choose a time unit different from the previous data (for example, the previous data is in seconds and the added data is in ms), the X of the added data is converted to the previous data's unit when loaded. [**X-axis unit**] keeps the value you chose last time, so check it before loading.
- If the units are not both time units (for example, the previous data is in seconds and the added data is in mm), the data is not loaded. Match [**X-axis unit**] and load again.
- To replace the previous data, delete it on the [**Sources**] tab before loading.

4.6 Import all files in a folder

When you have many files of the same format, such as logs split by day or by hour, use [**Folder**] in the pane bar. It finds the CSV, Excel, and TDMS files in a folder and imports them all at once. There are two ways to import.

For practice, download `sample_daily_logs_en.zip` from the manual's table of contents page and extract it. Its `daily_en` folder contains three fictitious data-logger logs split by hour.

[**How to combine**]	**Result**
[**One source per file**]	Each file becomes one data source. Use this to compare files side by side
[**Concatenate by time into one source**]	Joins all files into one series in time order and makes one data source. Use this to turn split logs into a single time series

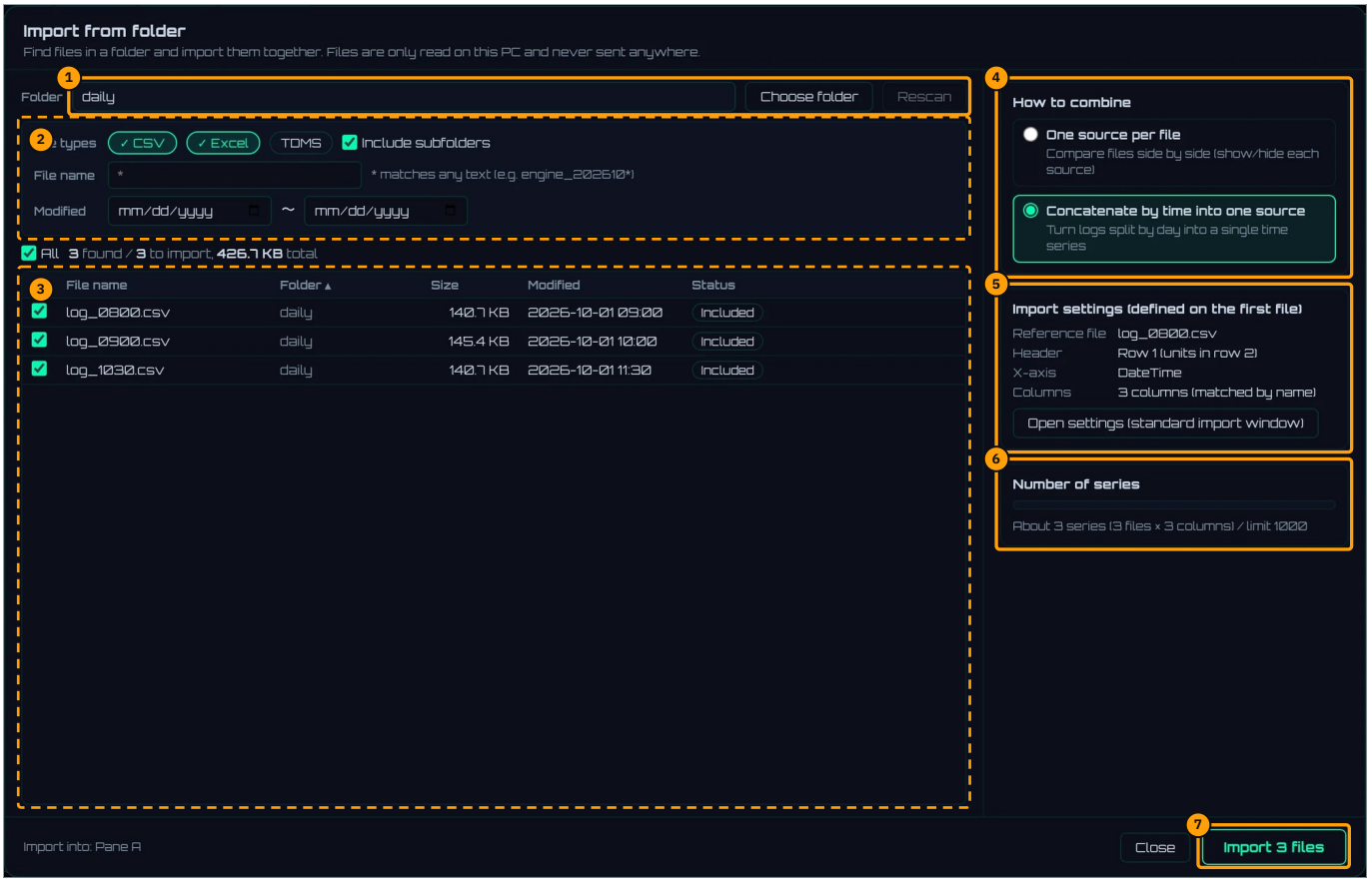

Figure 4-3 The [**Import from folder**] screen (three logs found, [**Concatenate by time into one source**] selected)

1. [**Folder**]: Select a folder with [**Choose folder**]. [**Rescan**] searches the same folder again
2. Filters: Narrow down the files to import with [**File types**] ([**CSV**], [**Excel**], [**TDMS**]), [**Include subfolders**], [**File name**] ("*" matches any characters), and [**Modified**]
3. The list of files found. Unchecked files are not imported. Hold `Shift` while checking to switch all rows from the previously checked row to this one. The [**Status**] column shows the import result
4. [**How to combine**]: Choose [**One source per file**] or [**Concatenate by time into one source**]
5. [**Import settings (defined on the first file)**]: The import settings decided on the first file
6. [**Number of series**]: The approximate number of series to load, and the limit
7. Starts the import (the button shows the number of files to import)

Steps

1. Click [**Folder**] in the pane bar and select a folder with [**Choose folder**]. You can also drag and drop a folder (or two or more files) onto a pane.
2. Check the list. Initially [**CSV**] and [**Excel**] are included and [**TDMS**] is not. When [**Include subfolders**] is checked, folders inside are searched too.
3. Click [**Open settings (standard import window)**]. The usual import screen opens with the first file. Adjust the header row, X axis, and columns to load, and click [**Use these settings**] (nothing is loaded yet at this point). Clicking [**Open settings (standard import window)**] again opens the screen with the decided settings applied.
4. Choose [**How to combine**] and click the button at the bottom right to import.

- The settings decided on the first file are applied to the second and later files. Columns are matched by **column name**, so the same columns are imported even from files with a different column order. Excel sheets are also matched by name (the first sheet if no sheet has the same name).
- For a file missing some columns that the first file had, only the existing columns are imported, and a "⚠" mark is shown in the [**Status**] column. Files without the X-axis column are not imported.
- If some files fail partway, the import continues without stopping and shows the numbers of successes, warnings, and failures at the end. The reason is shown in the [**Status**] column (hover over it to see the full text). If a file cannot be read, for example because it is open in another app or stored only in the cloud, "[**Cannot read the file (it may be open in another app or stored only in the cloud)**]" is shown. If you stop with [**Stop**], the files read up to that point remain.
- CSV files are read several at a time, depending on the number of CPU cores. The import order stays the same as the list.
- With [**One source per file**], each source is named after its file, and the series are not displayed at first. X is the elapsed time from the start of each file.
- If the number of series to load exceeds the limit (1,000 in the free edition), you cannot import. Reduce the files or narrow down the columns to load. This estimate includes series already loaded on the screen (shown as "already loaded n + files × columns").

> **Note: About the folder selection screen**
>
> Depending on the browser, the folder selection screen may say "Upload". LOGADEC only reads the files on your PC and never sends them anywhere.

Import joined in time

When you import with [**Concatenate by time into one source**], the [**Review the concatenation**] screen opens after all files have been read. It lines up the files in time order and shows whether the joints have overlaps or gaps.

Figure 4-4 The [**Review the concatenation**] screen (the second file overlaps the previous one by 2 minutes, and there is a 30-minute gap before the third)

1. The list of files. They are in time order, showing [**Time basis**], [**Start**], [**End**], [**Length**], and [**Boundary**] (overlap or gap)
2. How to handle the overlap at each joint. If left at [**Use common setting**], the setting on the right applies
3. [**Overlaps**]: Chooses how to handle all overlaps at once
4. [**Result**]: The number of series, number of points, period, and numbers of overlaps and gaps in the joined result
5. [**Concatenate and import**]: Imports the files as one data source with these settings

The time used to order the files is determined from the file contents.

[Time basis]	File contents	Ordering
[**Date-time**]	Files whose X axis is a date-time	Ordered by the first date-time
[**Time + file date**]	Files whose X axis is only a time of day	Ordered using the file's modification date as the date
[**Elapsed time only**]	Files whose X axis is elapsed time (numbers)	Chosen with [**Files without timestamps**]: either [**Continue after the previous file**] (in file-name order, each file starts right after the end of the previous one) or [**Treat the modified time as the end of recording**] (the start is the modification time minus the length)

Choose one of four ways to handle overlaps.

Overlap handling	Joined result
[**Prefer the later file**]	For the overlapping time, the later file's data is used (the earlier file is cut at the start of the later file)
[**Prefer the earlier file**]	For the overlapping time, the earlier file's data is used (the later file is used from the end of the earlier file)
[**Keep both**]	Keeps the data of both files and sorts it in time order
[**Exclude the later file**]	Does not use the overlapping later file at all

- At gaps (where the time from the end of one file to the start of the next exceeds twice the data interval), the line is not connected and is left open.
- The X of the joined data is the elapsed time from the earliest data. The source is named "folder name (N files joined)".
- Click [**Back**] to return to the previous screen without importing.
- CSV files are read several at a time, depending on the number of CPU cores. Even when joining several large files, the [**Review the concatenation**] screen opens in about the time it takes to read one file.
- When you click [**Concatenate and import**], LOGADEC builds the joined data and the reduced data used to draw wide ranges quickly. Meanwhile the button reads "[**Concatenating…**]". The reduced data keeps the maximum and minimum of each pixel column, so the shape of the graph does not change.

4.7 The Sources tab

The [**Sources**] tab lists the loaded files (data sources), one per row.

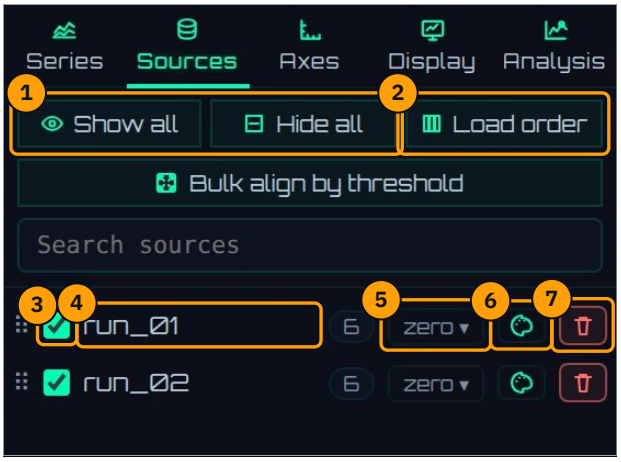

Figure 4-5 The [**Sources**] tab with two files loaded

1. [**Show all**], [**Hide all**]: Toggles the display of all sources
2. Sort order: Each click switches between [**Load order**], [**By name**], [**By count**], and [**Manual order**]
3. Check box: Hides that source's series from both the list and the graph. The data is not deleted
4. Source name: Double-click to rename it. The change is reflected in the series names too
5. X zero point: Shifts the position of X = 0 to align the start with other sources
6. Palette button: Opens [**Bulk series style**] for this source's series only (Chapter 5)
7. Delete (trash button): Deletes the source and its series

- Drag the left end of a row (⠿) to reorder the sources. The order is reflected in the series list, the Y axes, and the legend.
- When there are many sources, use the search box above the list to filter them by name.

Align X zero points by a threshold

When you repeat a test several times, the time from the start of recording to the operation differs from run to run. With [**Bulk align by threshold**], you can set the X zero point of each source to the moment an item crosses a value you choose. Any number of sources are aligned at once.

For practice, download `sample_start_runs_en.zip` from the manual's table of contents page and extract it. It contains three fictitious motor start tests (`run_1.csv` to `run_3.csv`). The motor starts at 6.3 s, 14.8 s, and 9.1 s.

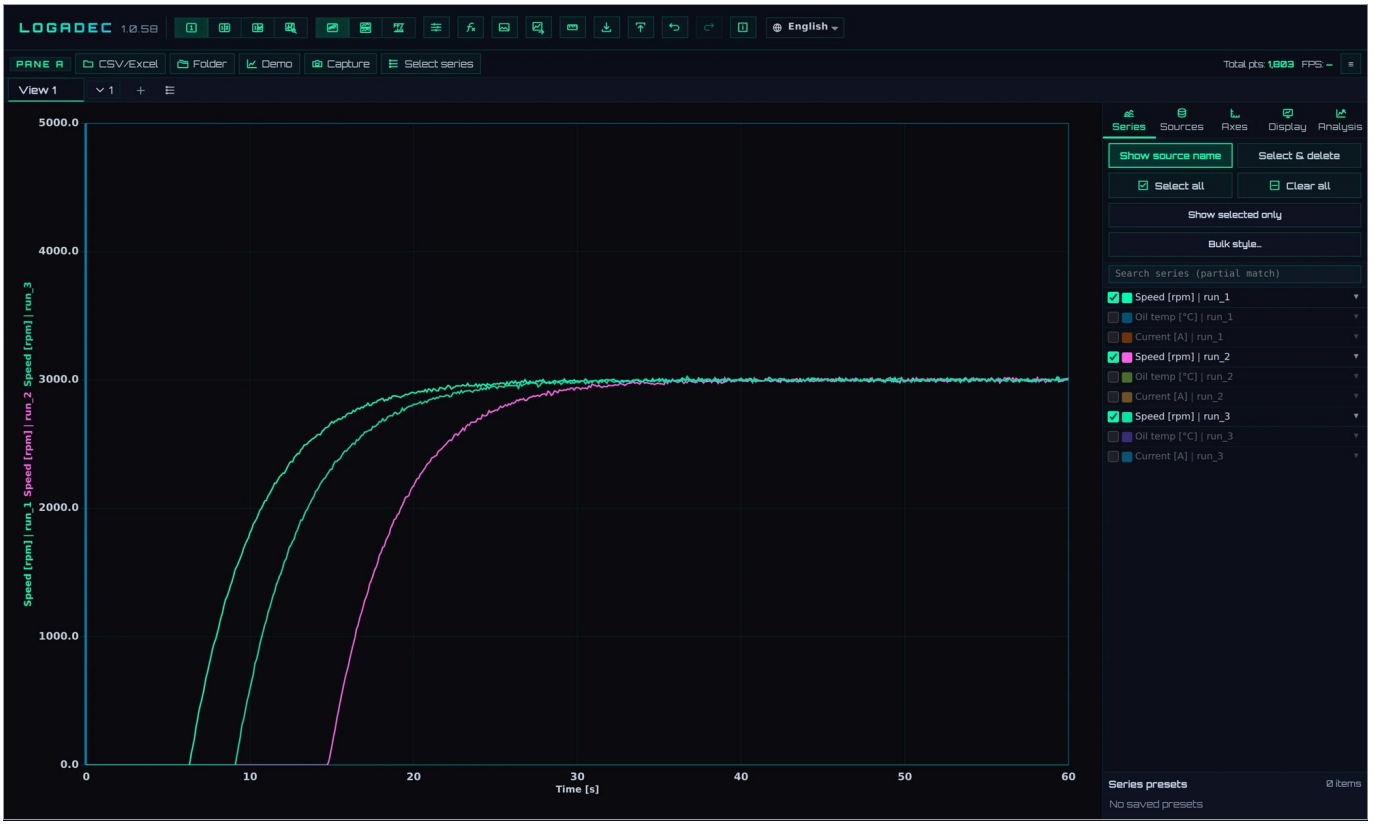

Figure 4-6 Speed of the three runs. The start times differ

1. Load the three files (add the second and third with [**CSV/Excel**]), and check the three Speed series on the [**Series**] tab.
2. On the [**Sources**] tab, click [**Bulk align by threshold**].
3. Fill in the fields below and click [**Preview**] to check how many sources are found.
4. Click [**Apply**].

Figure 4-7 Setting the zero point to the moment the speed exceeds 1000 rpm

1. [**Target parameter (series name)**]: The name of the item to use as the marker. Choose an item with the same name in all sources (suggestions appear as you type)
2. [**Threshold**]: The moment the data crosses this value becomes the zero point. The crossing time is found by joining neighboring data points with a straight line
3. [**Direction**]: Choose [**Rising edge ↑**] (crossing upward), [**Falling edge ↓**] (crossing downward), or [**Both**]. The first crossing is used
4. [**Search range**]: Search the [**Entire range**] data or only the [**Current view range**]. To use a later peak as the marker, zoom in around it and choose [**Current view range**]
5. [**Target sources**]: [**All**], or [**Visible only**] (sources checked on the Sources tab)
6. [**Preview**]: Shows how many sources were found and not found, without changing the zero points. The names of sources not found are also shown
7. [**Apply**]: Changes the zero points of the sources found

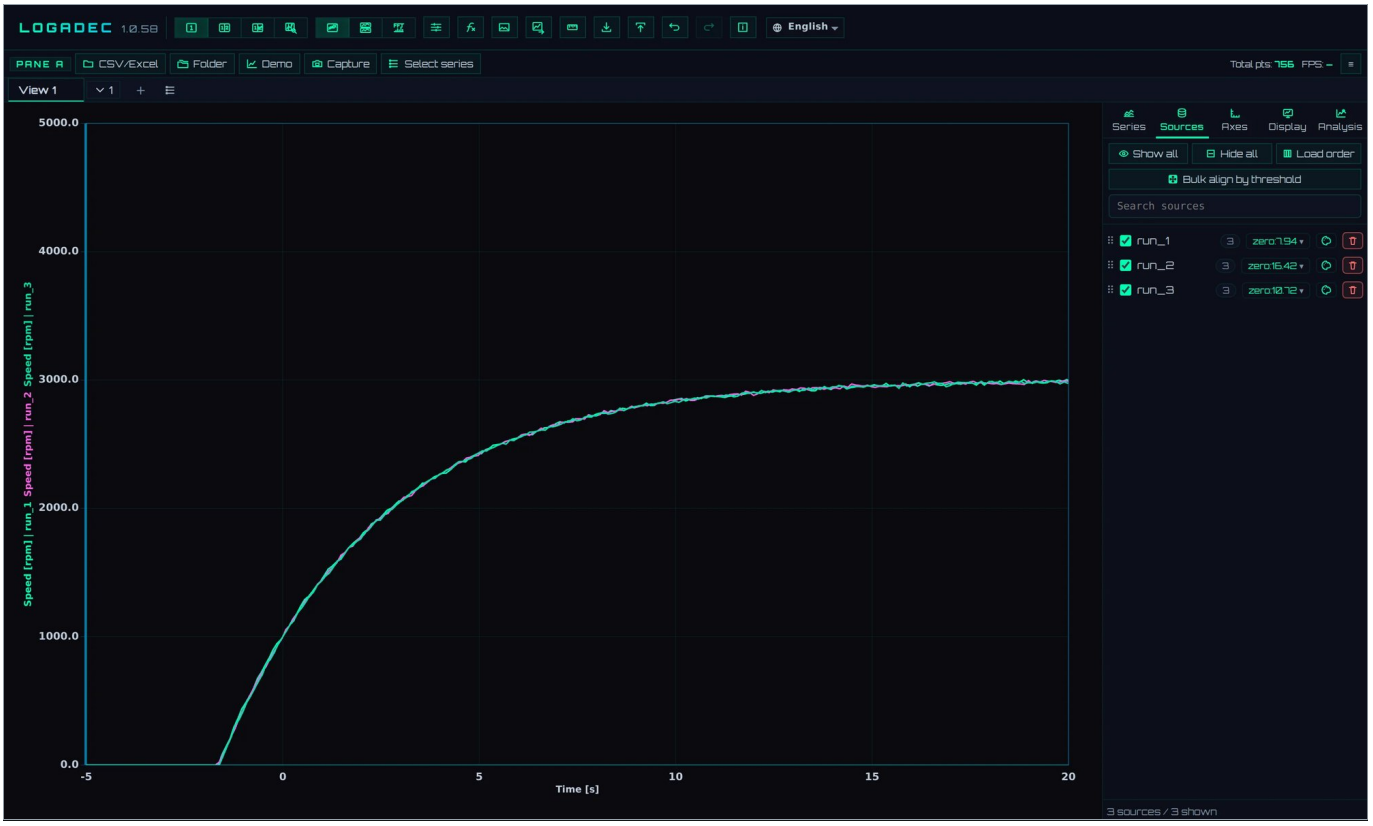

Figure 4-8 After aligning (zoomed to −5 to 20 s). All three runs exceed 1000 rpm at 0 s

- The zero point is shown on the [**zero**] button of the source row. Click the button to edit the zero point as a number or to reset it.
- To undo, press `Ctrl` + `Z`.
- A source is not found for one of two reasons: it has no item with that name (no series), or the data does not cross the threshold within the range (no cross).
- The zero point applies to all series of the source.

> **Tip: Remove the source name from series names**
>
> When there is only one source, click [**Show source name**] on the [**Series**] tab to hide the " | source name" part of series names. This makes the graph legend and axis names cleaner.

4.8 Limits of the free edition

The free edition has the following limits on loading and display. When a limit is exceeded, a message appears at the bottom of the screen.

Limit	What happens when it is exceeded
Up to 1,000 series in total can be loaded on one screen (series already loaded are counted)	The excess is cut off starting from the most recently loaded series, and a notice is shown
Up to 150 series can be displayed at once	[**Select all**] displays the first 150 series

[**Stacked**] and [**FFT**] views have no limit on the number of series displayed at once.

On paid editions, you can change the number of series displayed at once with [**Max visible series**] on the [**Display**] tab (300 at first). When you hit the limit, click [**Change limit**] in the message to open that field.

4.9 Large files

Progress is shown at the bottom of the import screen. When you load a new large file, LOGADEC first displays the graph with part of the data and loads the rest in the background. When [**Import complete**] appears, all the data has been applied.

Chapter 5

Working with Graphs

This chapter describes displaying series and setting their appearance, zooming and moving, legends, reading and measuring values, comparing in two panes, and view tabs.

5.1 Display and configure series

The [**Series**] tab lists the loaded series, one per row. Click ▾ to open the detailed settings for that series.

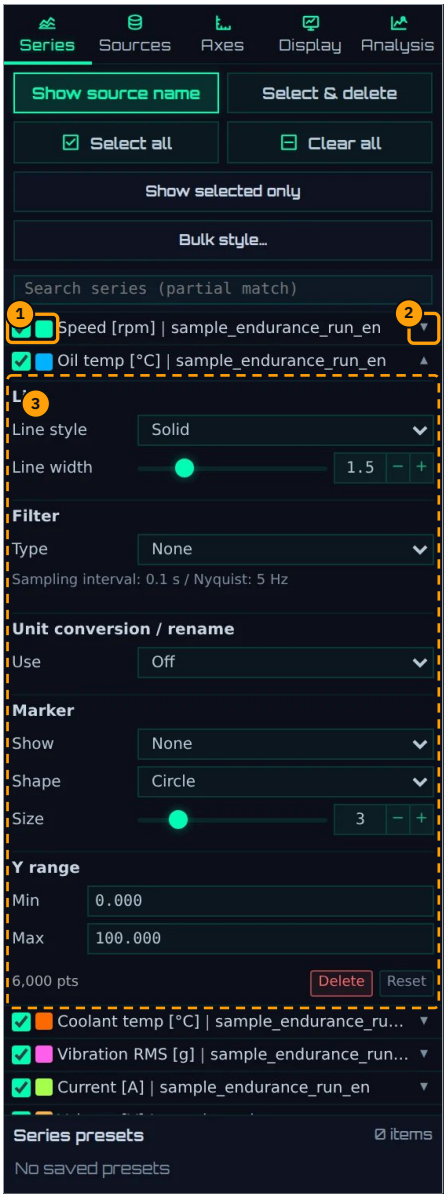

Figure 5-1 A series with ▾ opened

1. Check box and color: The check box toggles display (hold down `Shift` and click to toggle all series in between). Click the color square to choose the series color
2. ▾: Opens the detailed settings for the series. The opened series is shown bright and the other series dim
3. Detailed settings: Set the line, filter, unit conversion, marker, and Y range

Setting	What you can do
[**Line**]	Changes the [**Line style**] (8 kinds, such as solid and dashed) and [**Line width**]
[**Filter**]	Applies a low-pass, high-pass, or band-pass filter. You can choose the characteristic (Butterworth, Chebyshev, Bessel), the order, and the cutoff frequency. The data interval and the highest frequency that can be handled (the Nyquist frequency) are also shown
[**Unit conversion / rename**]	Converts values with a factor and an offset, and changes the displayed unit and name. For example, use it to convert a voltage signal to pressure
[**Marker**]	Puts marks (circles, squares, and so on) on the data points
[**Y range**]	Sets the Y minimum and maximum of this series as numbers

Filters and conversions are applied to the display only. The loaded data itself is not changed.

Change the appearance all at once

When there are many series, use [**Bulk series style**] to change colors, line styles, line widths, and markers all at once. Click [**Bulk style…**] on the [**Series**] tab to open it.

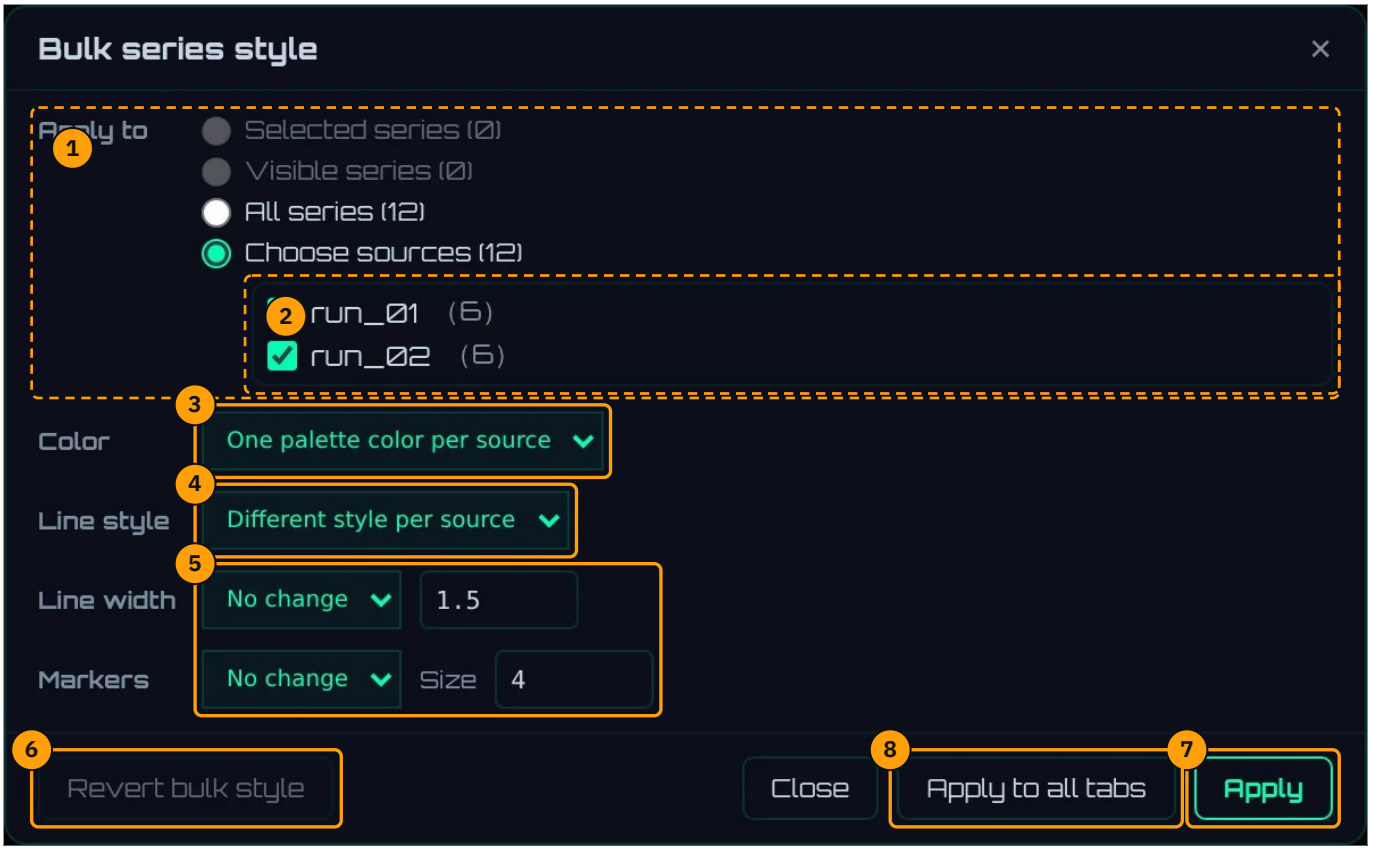

Figure 5-2 [**Bulk series style**] (two sources selected, with color and line style changed per source)

1. [**Apply to**]: Choose from [**Selected series ({n})**], [**Visible series ({n})**], [**All series ({n})**], and [**Choose sources ({n})**]. The number in parentheses is the number of series
2. The list of sources shown when [**Choose sources ({n})**] is selected. Check the sources to include
3. [**Color**]: Choose from [**No change**], [**Single color**], [**Re-color in palette order**], and [**One palette color per source**]
4. [**Line style**]: Choose [**No change**] or [**Different style per source**], or pick one line style to apply to all
5. [**Line width**], [**Markers**]: Choose a common width, and whether to show markers (and their size)
6. [**Revert bulk style**]: Restores the colors, line styles, widths, and markers from before the bulk change
7. [**Apply**]: Applies the changes to the target series
8. [**Apply to all tabs**]: Gives the target series the same style in every view tab (View 1, View 2, ...)

How to open	Initially selected target
[**Bulk style⋯**] on the [**Series**] tab	[**Visible series ({n})**] ([**Selected series ({n})**] when series are selected in [**Select & delete**])
Select series in [**Select & delete**] and click [**Style**]	[**Selected series ({n})**]
Right-click on the graph and choose [**Bulk style⋯**]	Same as the first row
The palette button on a source row of the [**Sources**] tab	[**Choose sources ({n})**] (that source)

- [**One palette color per source**] and [**Different style per source**] give each source its own color or line style. When you overlay the first and second runs of the same test, this makes it easier to tell which line belongs to which file. The source order is the order on the [**Sources**] tab.
- Series colors and lines are remembered separately in each view tab. [**Apply**] changes only the current tab, and [**Apply to all tabs**] changes every tab. [**Revert bulk style**] works only on the current tab.
- [**Revert bulk style**] restores the state from before the first bulk change. You can also undo one step at a time with `Ctrl` + `Z`.

Find and filter series

When there are many series, use the tools above the list.

Tool	Effect
Item search	Enter part of a name to keep only matching series in the list (for example, "temp" for Oil temp and Coolant temp)
[**Show selected only**]	Keeps only checked series in the list
[**Select & delete**]	Select series by clicking (`Shift` for a range) and delete them all at once. Once clicked, this mode stays on until you click it again

5.2 Zoom and move

Action	Effect
Wheel	Zooms X in or out around the mouse position
Drag	Moves in the X direction
Middle-button drag (or `Shift` + drag)	Moving up or down zooms X in or out around the point where you pressed
Click the number at the left or right end of the X axis	Enter the X range as numbers (confirm with `Enter`)
Click a tick number on the Y axis	Enter the Y range as numbers
Double-click the Y-axis name ([**Overlay**])	Changes the axis name, name color, axis line color, and display range on the [**Edit axis**] screen
Wheel over the Y axis ([**Overlay**])	Zooms Y of that axis in or out
`Shift` + wheel	In [**Overlay**], zooms the Y axis of the series nearest the mouse; in [**Stacked**], zooms Y of the tier under the mouse

> **Note: Y zoom in [Overlay]**
>
> - Turning the wheel with `Shift` on the graph zooms the Y axis of the series nearest the mouse. Series grouped on the same Y axis change together.
> - When the mouse is over a series row in the sidebar, only that series changes.
> - Turning the wheel over a Y axis also zooms Y of that axis (`Shift` is not needed).

Make the wheel scroll in Stacked and FFT

In [**Stacked**] and [**FFT**] with many tiers, click [**Wheel: X-axis**] in the pane bar to make the wheel scroll all tiers up and down (the button label changes to [**Wheel: scroll**]). Click it again to return to the original behavior, where the wheel zooms X in and out.

Action with [Wheel: scroll]	**Effect**
Wheel	Scrolls all tiers up and down
`Ctrl` + wheel	Zooms X in or out
`Shift` + wheel	Zooms Y in or out

This setting is per pane, and is saved in settings files, `.lgd` files, and view tabs.

Return to the full view

Double-clicking does not return to the full view (in the Overlay view, double-clicking near a line adds a legend label). Zooming and moving cannot be undone with `Ctrl` + `Z` either. Use the following methods.

- **Show all of X**: Click [**Reset**] for the X axis on the [**Axes**] tab.
- **Fit Y**: Use [**Auto-fit A**], [**Auto-fit B**], or [**Auto-fit C**] on the [**Axes**] tab to recalculate the Y ranges from the data. [**Reset all**] returns the Y ranges of all series to the ranges used right after loading (rounded tick ranges, or the Y range of a range preset if one applies).

Y-axis groups and tier height

- In [**Overlay**], series with the same Y range share one axis. For example, Oil temp and Coolant temp at 0–100 °C are grouped on one axis. Up to 6 axes are displayed.
- In [**Stacked**], each tier displays one series. You can change the height of all tiers together with [**Height**] on the [**Axes**] tab. To make only one tier taller, drag its bottom edge.

Overlay the same item from different sources in Stacked

When you load two or more files, [**Stacked**] normally gives each series (each file) its own tier. Check [**Overlay same names**] under [**Stacked**] on the [**Axes**] tab to overlay series with the same name in one tier. Use this to compare the first and second test runs item by item.

Figure 5-3 The same items from two sources (run_01, run_02) overlaid in one tier

1 [**Overlay same names**]: Overlays series with the same name from multiple sources in one tier

2 [**Wheel: X-axis**]: Switches the wheel behavior (described above)

- The source names appear in color next to the tier name. While overlaid, line colors are assigned per source.
- Series renamed to the same name with display names (Chapter 6) are overlaid too. Series with different units are not overlaid.

Reorder the tiers in Stacked

In [**Stacked**], you can change the order of the tiers by dragging. Click [**Reorder**] to the right of [**Wheel: X-axis**] in the pane bar. The button lights up and a ≡ handle appears at the top right of each tier. Drag a handle to the tier where you want it and release. Releasing on the upper half of a tier puts it before that tier; releasing on the lower half puts it after. When you are done, click [**Reorder**] again.

- [**Reorder**] appears only in [**Stacked**].
- [**Reorder**] ON/OFF under [**Stacked**] on the [**Axes**] tab does the same. Switching either one updates the other.

Where Stacked shows the Y-axis name

In [**Stacked**], each tier's name (series name and unit) normally appears as a horizontal tag at the top left of the tier. Choose where it appears with [**Y-axis title**] under [**Stacked**] on the [**Axes**] tab.

[**Y-axis title**]	**Display**
[**Top-left tag**]	Shows the name as a horizontal tag at the top left of the tier (as before)
[**Along Y-axis**]	Shows the name vertically to the left of the Y-axis numbers, as in [**Overlay**]. If a tier is too short, the name wraps to two lines and the rest is shortened with "⋯"

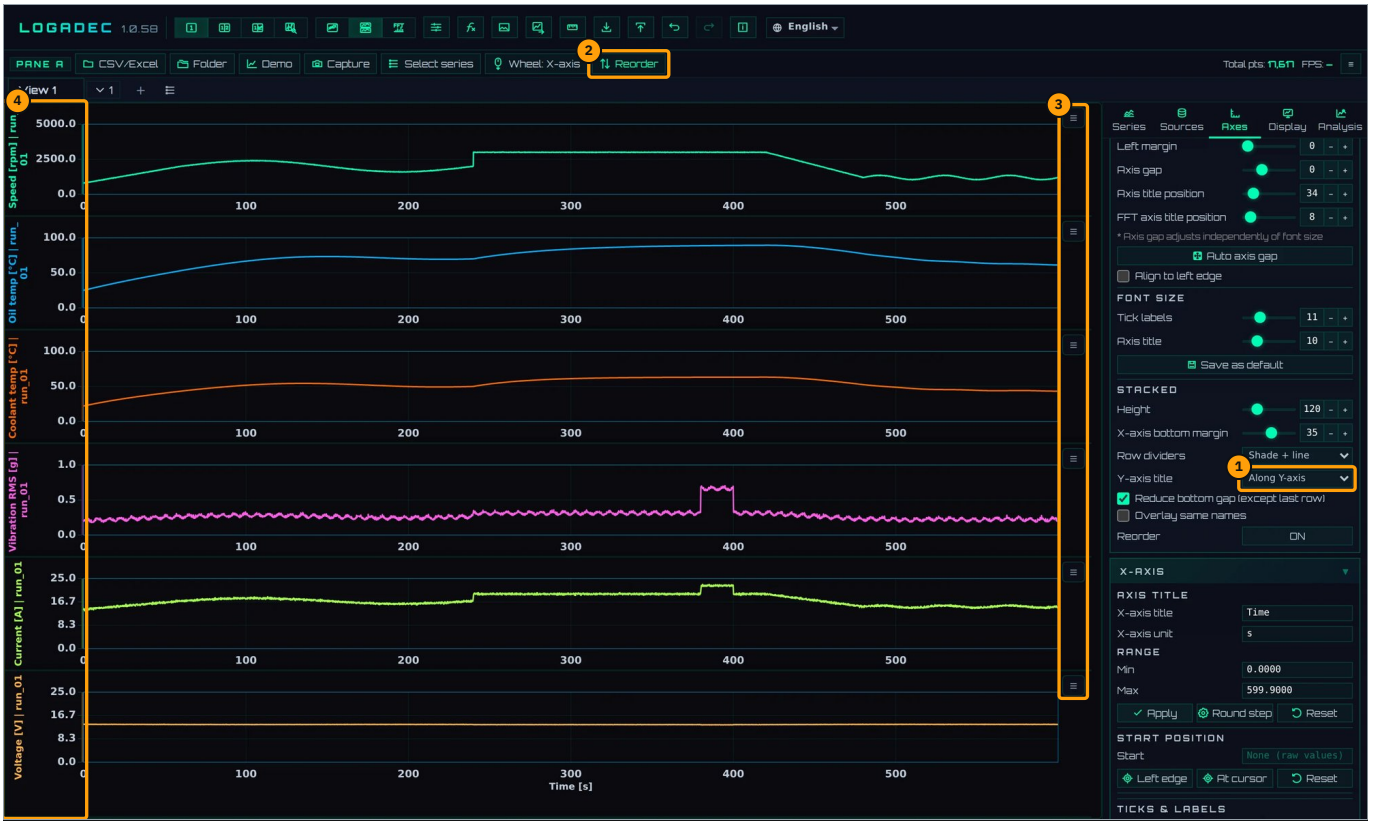

Figure 5-4 [**Along Y-axis**] selected and reordering turned on with [**Reorder**]

1. [**Y-axis title**]: Chooses where the tier name appears
2. [**Reorder**]: Turns reordering on. The button lights up while it is on
3. ≡: Drag this handle to move the tier
4. The tier name appears vertically to the left of the Y axis

- Exported images use the same layout as the screen. The setting is saved in the file (.lgd).
- In tiers overlaid with [**Overlay same names**], the top-left tag stays even with [**Along Y-axis**] (its colors tell you which line comes from which source).
- [**FFT**] tiers already show the quantity name vertically on the Y axis, so this setting does not change them.

5.3 Legend

You can display a legend that lists series names and line samples on an [**Overlay**] graph. Set it up under [**Legend**] on the [**Display**] tab. There are two kinds of legend.

[**Type**]	**Display**
[**Legend box**]	Shows series names and line samples (color, line style, marker) together in one frame
[**Labels (callouts)**]	Places a balloon with the name and value near the line of each series

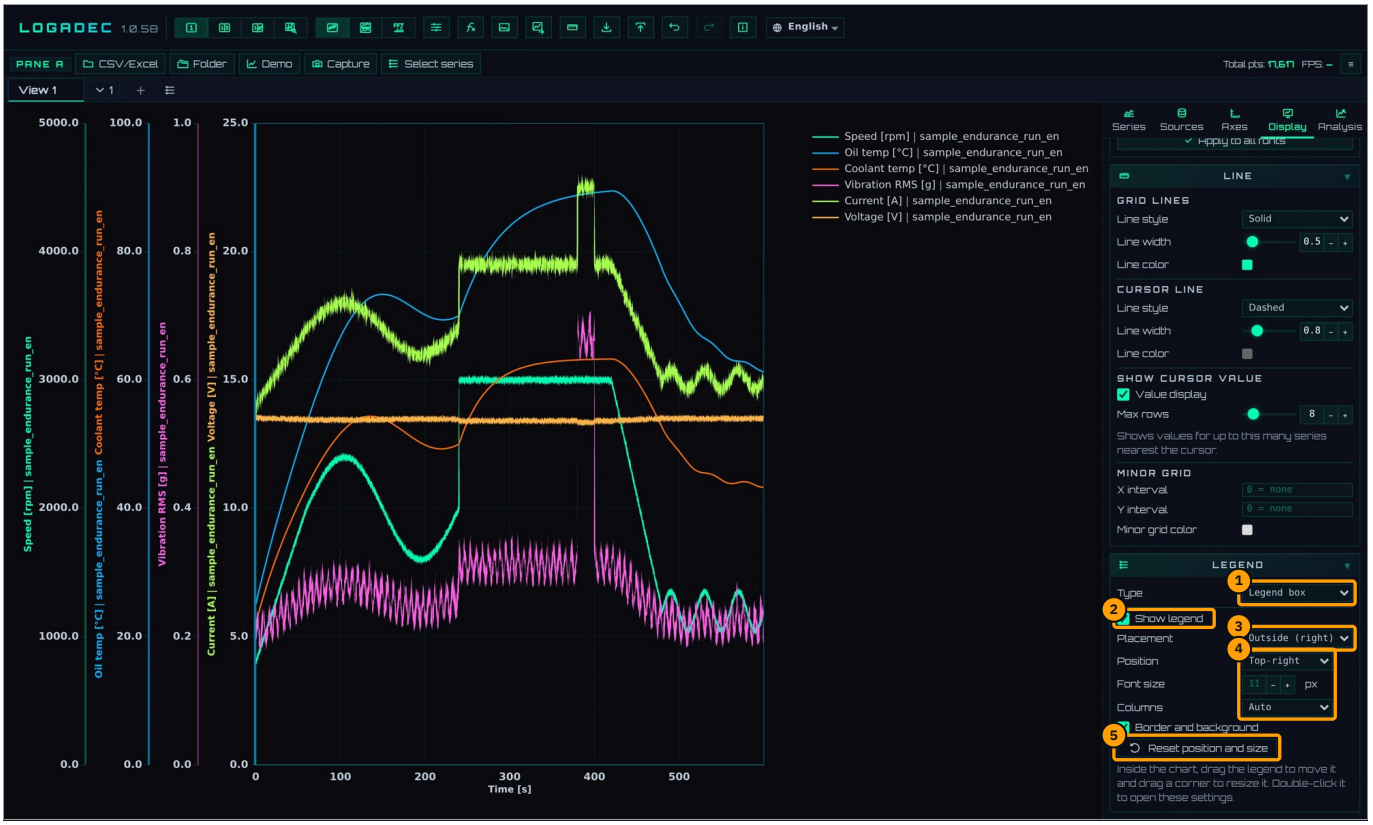

Figure 5-5 A legend box placed [**Outside (right)**]

1. [**Type**]: Choose [**Legend box**] or [**Labels (callouts)**]
2. [**Show legend**]: Check to display the legend
3. [**Placement**]: Choose from [**Inside the chart**], [**Outside (right)**], and [**Outside (below)**]
4. The position when [**Placement**] is [**Inside the chart**] (top right, top left, bottom right, bottom left), the font size, and [**Columns**]
5. [**Reset position and size**]: Restores the position and size changed by dragging

Legend box

- A legend placed [**Inside the chart**] can be moved by dragging. Drag a corner to resize it.
- Double-click the legend to open the legend settings on the [**Display**] tab.
- With [**Outside (right)**] or [**Outside (below)**], the legend does not overlap the graph lines. The plotting area becomes smaller by that amount.
- Uncheck [**Border and background**] to draw no frame or background.

Legend labels (balloons)

When you choose [**Labels (callouts)**] in [**Type**], the balloon settings appear. Click [**Add all visible series**] to add balloons to all displayed series. To add them one at a time, choose a series in [**Series**], click [**Add at clicked point**], and click on the graph where you want to place it.

Setting	What you can do
[**Style**]	Choose an overall look from [**Standard**], [**Subtle**], and [**Emphasis**]. If you change individual settings, it becomes [**Custom**]
[**Line: shape**], [**Line: style**], [**Line: width**]	The shape ([**Straight**], [**Elbow**], [**Curve**], [**None**]), style, and width of the leader line connecting the balloon and the line
[**Label**]	Choose [**Box**] (enclosed in a frame) or [**Text only**]
[**Border: corners**], [**Border: style**], [**Border: width**], [**Border: color**]	The frame shape ([**Rounded**], [**Square**]), line style, width, and color ([**Series color**] or [**Custom**])
[**Text shown**]	Choose from [**Default (series)**], [**Series name only**], and [**Source name only**]
[**Value**], [**Anchor dot**]	Choose whether to show the value, and whether to draw a mark on the data point at the end of the leader line
[**Font size**], [**Font weight**], [**Max labels**]	The font size and weight, and the maximum number of balloons you can add (1–50; 12 at first)

- Click a balloon to open a small window with the settings of that balloon only. [**Anchor dot (data point)**] and [**This label only**] start collapsed; click their headings to open them. Added balloons can be listed in [**Legend labels**], where you can toggle their display or delete them.
- Drag the root of the leader line (the data end) to move it. A dot appears when you hover over the root. Moving it switches the balloon to [**Free**] ([**Screen-fixed**] balloons stay [**Screen-fixed**]). Undo with `Ctrl` + `Z`.
- When you reach [**Max labels**], the message shows [**Change limit**]. Click it to open the [**Max labels**] field on the [**Display**] tab.
- Balloons are for [**Overlay**] only.

5.4 Read values

When you place the mouse on the graph, a vertical line and a list of the values at that position appear. The list shows values starting from the series nearest the mouse, up to the number of rows set in [**Max rows**] on the [**Display**] tab (8 at first).

5.5 Measure between two points

Use [**Measure**] on the toolbar to measure the time difference and value difference between two points.

1. Click [**Measure**] to open the measurement screen.
2. Click [**Start measuring**].
3. On the graph, click the first point (A) and the second point (B). Each is automatically snapped to a data point of the series nearest the clicked position.
4. The results are shown on the right.

Figure 5-6 Measuring between two points

1. [**Measure**]: Opens or closes the measurement screen
2. [**Start measuring**]/[**Stop measuring**]: Starts or ends measuring
3. [**Two points**], [**Range stats**]: Choose how to measure
4. [**Snap to**]: Chooses whether the clicked point snaps to a data point, a peak, a valley, or a zero crossing
5. Results: The values of A and B and their difference, the slope, the rate of change, and the frequency derived from the period

Measurement	What you get
[**Two points**]	X and Y of A and B, and their difference (B − A). The slope (ΔY/ΔX), the rate of change (%), and the frequency when ΔX is taken as the period (Hz and min^{-1})
[**Range stats**]	The mean, minimum, maximum, standard deviation, RMS, median, p-p, number of data points, and area (integral) over the range from A to B. Choose the area baseline (0, the value at point A, or the range minimum) with [**Integral baseline**]. The area is calculated without spanning time gaps (where the spacing exceeds 1.5 times the data interval) or missing values, and the number of skipped spans is shown in the results

- Copy the results to the clipboard with [**Copy**]. [**Clear**] removes the measured points.
- Press Esc to cancel a point you are placing. Pressing it when there are no points ends measuring.
- To compare points on different series, check [**Compare across series**].

5.6 Compare in two panes

Click [**2 panes**] on the toolbar to split the screen into left and right (Pane A and Pane B). You can load different files into the two panes. Load them from [**CSV/Excel**] in each pane's bar.

Figure 5-7 The first run (left) and the second run (right) side by side in two panes

1. [**2 panes**]: Splits the screen into left and right
2. [**CSV/Excel**] of Pane A: Loads into the left pane
3. [**CSV/Excel**] of Pane B: Loads into the right pane

> **Note: X ranges are not linked**
>
> The X ranges of the two panes are operated separately. To compare over the same time range, click the numbers at the ends of the X axis and enter the same range in both.

5.7 View tabs

View tabs let you keep the state "which series to look at, over which range" on separate tabs. For example, if you create tabs such as "Overview", "Speed & current", and "Temperature", you can switch views with one click.

Figure 5-8 A tab named "Speed & current" created

1. The tab that exists from the start (View 1)
2. A newly created and named tab
3. + ([**New view**]): Creates a new tab
4. ▾: Opens the list of tabs. The number is the number of tabs
5. [**Show views as a list on the left**]: Shows the tabs as a vertical list to the left of the graph (see below)

Action	How
Create	Click +. The tab starts with all series hidden, so check the series you want to see
Rename	Double-click the tab, enter a name, and press `Enter`
Switch	Click the tab. `Alt` + `PageUp` / `PageDown` moves to the previous or next tab (not while typing text)
Duplicate, delete	Use [**Duplicate this view**] or [**Delete view**] (×) on the tab
Reorder	Drag the tab

Each tab keeps the displayed series and their settings such as color and line, the X and Y ranges, the display mode ([**Overlay**], [**Stacked**]), the screen layout, and so on. The data itself and the presets in Chapter 6 are shared by all tabs.

When there are many tabs

When the tabs no longer fit horizontally, ‹ and › appear at the left end. Click them to scroll toward the hidden tabs. You can also scroll by turning the mouse wheel over the tabs. The tab you switch to is scrolled into view automatically.

Click ▾ to list all tabs with numbers. Enter text in the box at the top to narrow the list to tabs whose names contain that text. `Enter` goes to the top tab; `Esc` or clicking outside the list closes it.

Long names are shortened with "⋯" to fit the tab width. Hover the mouse over a tab to see the full name.

Show views as a list on the left

Click the button at the right end of the tab bar ([**Show views as a list on the left**]) to show the tabs as a vertical list to the left of the graph. This is useful when you have many tabs. Long names are shortened with "⋯"; hover over a row to see the full name.

Figure 5-9 Views shown as a list on the left (3 tabs)

1. [**Back to tabs**]: Returns to the horizontal tabs
2. [**Collapse the list**]: Narrows the list to show only the numbers. Click again ([**Expand the list**]) to restore the width
3. Search box: Narrows the list to views whose names contain the text. `Enter` goes to the top view; `Esc` clears the filter
4. The selected view: Shows the number, the name, and the number of displayed series
5. [**New view**]: Creates a new view

- The rows work like tabs: click to switch, double-click to rename, and drag to reorder. Hover over a row to show [**Duplicate this view**] and [**Delete view**] (×).
- In [**2 panes**], a single list appears to the left of both Pane A and Pane B. Switching changes the display of both panes together.
- Drag the right edge of the list to change its width (160 to 480 pixels). Double-click the right edge to restore the original width.
- Whether the views are shown as a list, whether the list is collapsed, and the list width are remembered the next time you open the app. The search text is not remembered.

Chapter 6

Presets

When you look at the same kind of data again and again, you develop fixed ways of viewing it, such as "I always want to see Oil temp at 60–120 °C" or "First, I want to line up only temperatures and current". Presets let you register such views under a name and recall them with one click.

LOGADEC has three kinds of presets.

Kind	What is registered	How it is applied
[**Range**]	The Y range and color for each item	Applied automatically when you load a file. You can also apply it manually
[**Series**]	A combination of items to display, and how they look at that time	Choose from the list to apply
[**Display names**]	Alternative names for items (for example, Speed → Engine speed)	Always applied once registered

Presets are linked to series by item name (such as "Speed" or "Oil temp", the part before " | "). So once registered, they can be used as-is with **other files of the same format**.

6.1 Open the presets screen

Click [**Presets**] on the toolbar to open the presets screen. The three tabs at the top switch between the kinds.

- The left side has input fields for registering new presets.
- The right side lists registered presets. Use the search box above the list to filter by name.
- [**Pane A**] and [**Pane B**] at the top right choose which pane to create presets for when you use two panes (Chapter 5).

6.2 Range presets

For each item, you register a Y range (minimum and maximum) and, if needed, a color. For example, if you register "Oil temp at 60–120 °C, shown in red", every file you load that has an Oil temp column is displayed with that range and color.

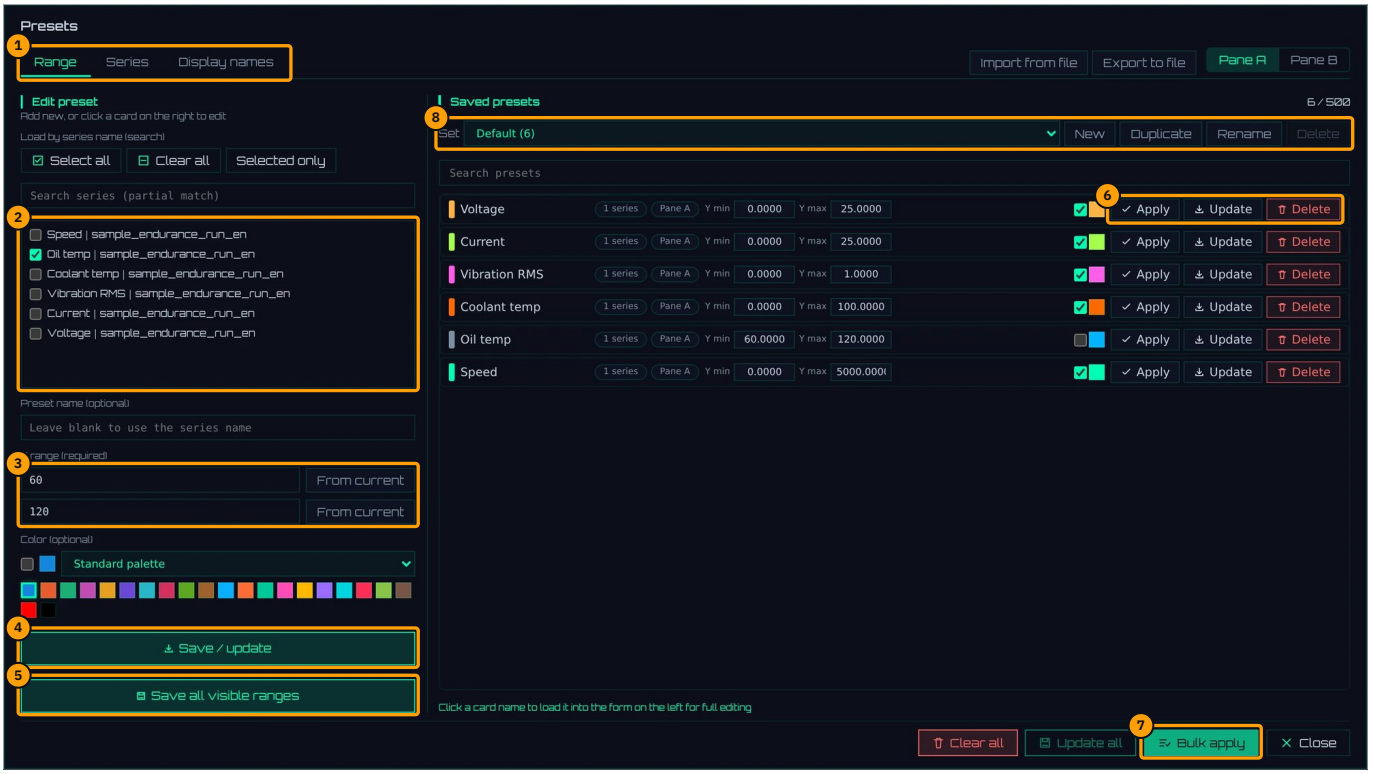

Figure 6-1 The [**Range**] tab (six items registered, with Oil temp changed to 60–120)

1. Kind tabs: [**Range**], [**Series**], [**Display names**]
2. Item list: Check the items to create presets for
3. [**Y range (required)**]: The Y minimum and maximum. Click [**From current**] to fill in the values of the current graph
4. [**Save / update**]: Registers the entered values
5. [**Save all visible ranges**]: Registers all currently displayed series at once with their current ranges and colors
6. Card buttons: [**Apply**] (apply to the graph), [**Update**] (save the card's values), [**Delete**]
7. [**Bulk apply**]: Applies all registered presets
8. [**Set**]: Switches the preset list (set) (described later)

Register presets one by one

1. In the item list ([**Load by series name (search)**]), check the items to create presets for.
2. Enter the Y minimum and maximum in [**Y range (required)**]. To use the current graph's range, click [**From current**].
3. To set a color as well, check [**Color (optional)**] and choose a color.
4. Click [**Save / update**]. A card is added to the list on the right.

If you leave [**Preset name (optional)**] empty, the item name becomes the preset name. If a preset with the same name already exists, it is overwritten.

> **Tip: Narrow down a long item list**
>
> Type part of a name in the search box above the item list to narrow it down (for example, "temp" shows Oil temp and Coolant temp). [**Select all**] and [**Clear all**] check or clear only the items shown in the list. Click [**Selected only**] to show only the checked items; click it again to show all items. The item list on the [**Series**] tab works the same way.

> **Tip: Register the same range for two or more items**
>
> If you select two or more items in step 1, one preset is created for each selected item (all with the same range and color). For example, you can register 0–150 °C for Oil temp and Coolant temp at once.

Register all at once from the current graph

After adjusting the graph by hand, click [**Save all visible ranges**] to turn the current Y range and color of every displayed series into presets. This is the quickest way to register.

> **Caution: Registering all at once overwrites presets**
>
> If presets with the same names exist, they are overwritten with the values of the current graph. To keep a preset you registered earlier, hide that series before clicking.

Apply presets

- **When you load a file**: The preset ranges and colors are applied automatically to series with matching names. You do not need to do anything.
- **Apply just one**: Click [**Apply**] on the card.
- **Reapply all**: Click [**Bulk apply**] at the bottom of the screen.

> **Note: One preset per item**
>
> If two or more presets apply to the same item, it becomes unclear which range [**Bulk apply**] will use. Create only one preset per item.

Edit and delete

- **Edit on the card**: When you change the Y minimum, maximum, or color on a card, the card border and its [**Update**] button turn orange (hovering over the card shows "[**Unsaved**]"). Save cards one at a time with [**Update**] on the card, or all at once with [**Update all**] below. To revert without saving, click [**Discard edits**].
- **Edit in the input fields**: Click a card's name to load its contents into the input fields on the left. Make your changes and click [**Save / update**].
- **Delete**: Delete cards one at a time with [**Delete**] on the card. A card is deleted after a confirmation and cannot be restored with `Ctrl` + `Z`. [**Clear all**] deletes all range presets after a confirmation.

Use different sets

You can keep multiple named lists of range presets. Such a list is called a "set". For example, if you keep separate sets for each kind of test, such as "Engine test" and "Motor test", the same item names can be displayed with ranges suited to each test.

Choose the set to use with [**Set**] above the list.

Button	Action
[**New**]	Creates an empty set and switches to it
[**Duplicate**]	Creates a copy of the current set and switches to it
[**Rename**]	Renames the current set
[**Delete**]	After a confirmation, deletes the current set together with its presets (the last set cannot be deleted)

- Only one set is in use at a time. Registering, [**Bulk apply**], and the automatic application when loading a file all act on the currently selected set.
- Switching sets does not change the current graph. To display with the ranges of the set you switched to, click [**Bulk apply**].
- If there are unsaved changes on cards, a confirmation appears before switching.
- You can have up to 20 sets, and up to 500 presets per set.

Auto-fit or presets: which takes priority

[**Auto-fit A**], [**Auto-fit B**], and [**Auto-fit C**] on the [**Axes**] tab recalculate the Y ranges from the data. When [**Keep preset Y range**] below them is checked (it is checked at first), items that have presets keep their preset ranges even when you click an auto-fit button.

Figure 6-2 [**Keep preset Y range**] on the [**Axes**] tab

1. Auto-fit buttons
2. [**Keep preset Y range**]: When unchecked, auto-fit takes priority over presets

6.3 Series presets

Register combinations of items to display. This is useful for switching between frequently used combinations, such as "Temperatures & current" or "Vibration", in data with many series.

More than just the combination of items is registered. The color, line, filter, unit conversion, and Y range of each series at the time of registration, and the X range, are kept as well.

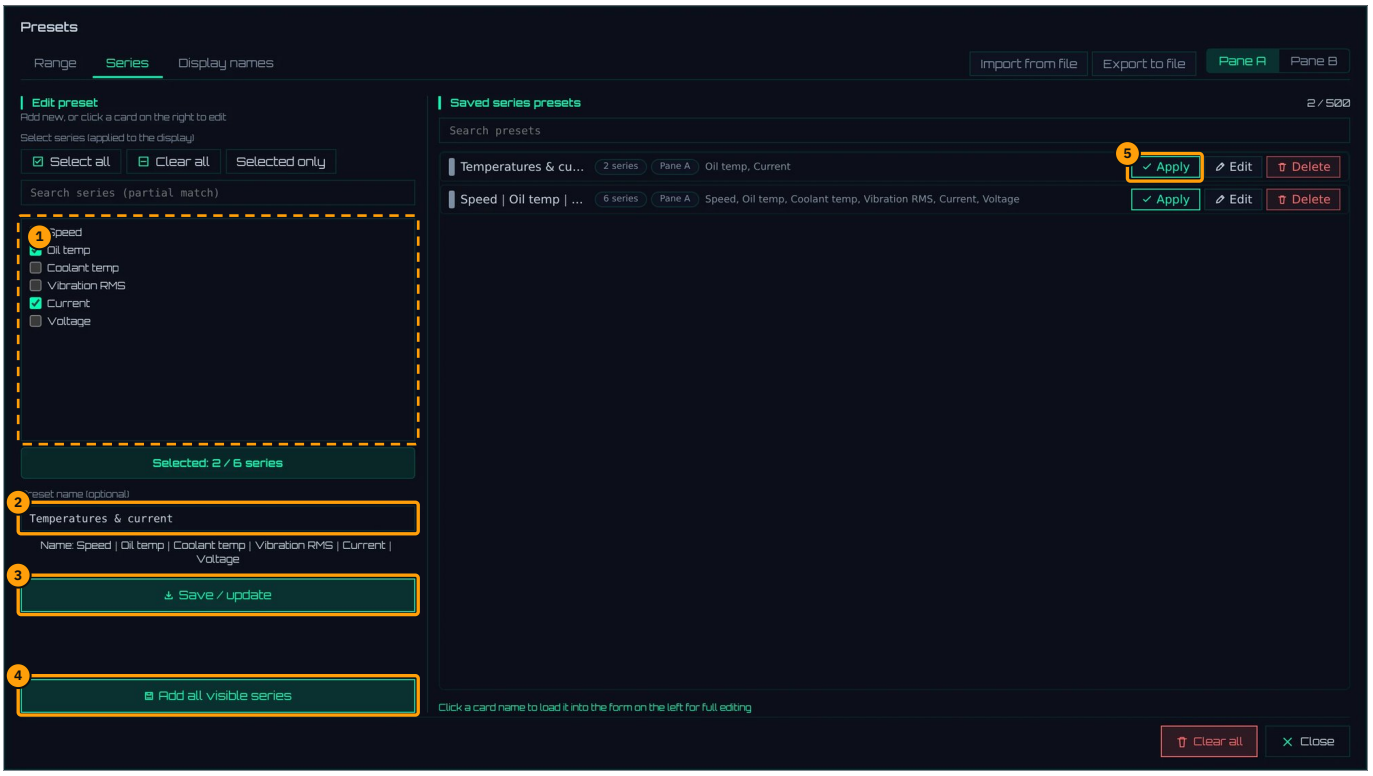

Figure 6-3 The [**Series**] tab ("Temperatures & current" registered)

1. Item list: Check the items to include in the combination
2. Preset name: If left empty, the name is made by listing the item names
3. [**Save / update**]: Registers the preset
4. [**Add all visible series**]: Registers the combination of currently displayed items as-is
5. [**Apply**]: Applies this preset (the presets screen closes)

Register

- **Select items and register**: Check the items in the list, enter a name, and click [**Save / update**].
- **Register from the current display**: Display the items you want to see on the graph, then click [**Add all visible series**].

Recall

You can also recall presets from the [**Series presets**] list at the very bottom of the [**Series**] tab. You can switch without opening the presets screen, so this is usually more convenient.

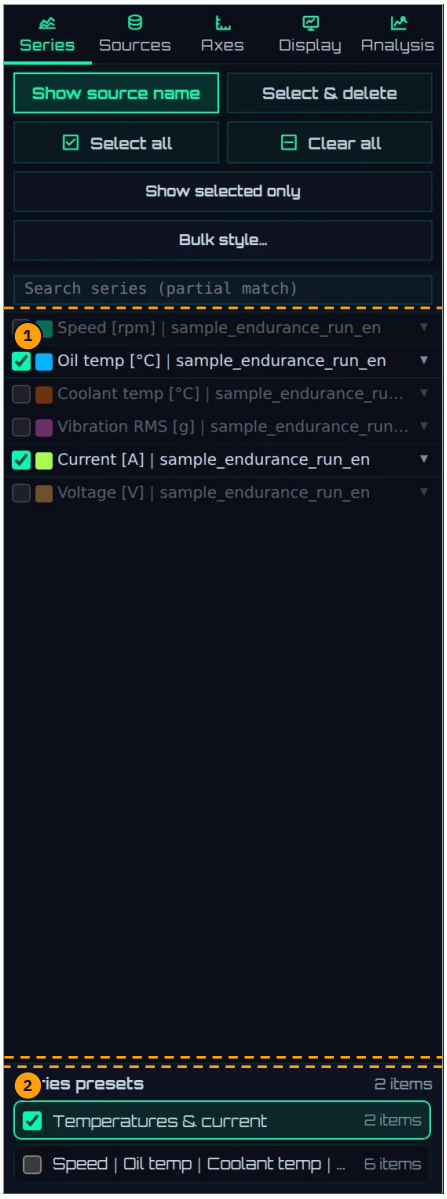

Figure 6-4 "Temperatures & current" applied from [**Series presets**]

1. Only the items of the applied preset are displayed
2. [**Series presets**]: Click a name to apply it. The applied preset is marked

- Clicking the applied preset again removes the preset, and all series are hidden.
- The list shows only the presets of the current pane (Pane A or Pane B).

> **Caution: A preset is not applied if even one item is missing**
>
> A series preset is applied only when all registered items exist in the data. If any items are missing, their names are shown at the bottom of the screen and the display does not change.

6.4 Display names

Display names replace item names with different names on the graph only. For example, you can show a column named "Speed" by the measuring instrument as "Engine speed" to match your report.

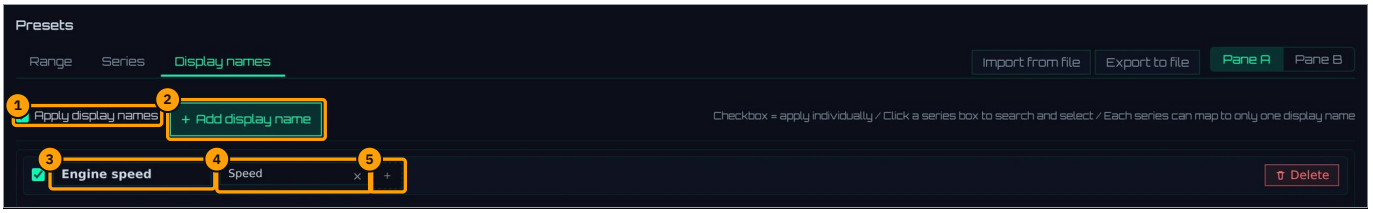

Figure 6-5 The [**Display names**] tab (showing Speed as "Engine speed")

1. [**Apply display names**]: When unchecked, all renaming stops and the original names return
2. [**Add display name**]: Adds one new renaming row
3. Enter the name to display
4. The original items to rename. Remove them with ×
5. +: Choose an original item from the list and add it

Register

1. Click [**Add display name**]. A new row appears at the top of the list.
2. Enter the name you want to display.
3. Click + and choose the original item to rename from the list.

From the moment you register it, the graph legend and axis names use the new name. In the [**Series**] tab list, the original name stays, with the new name shown next to it.

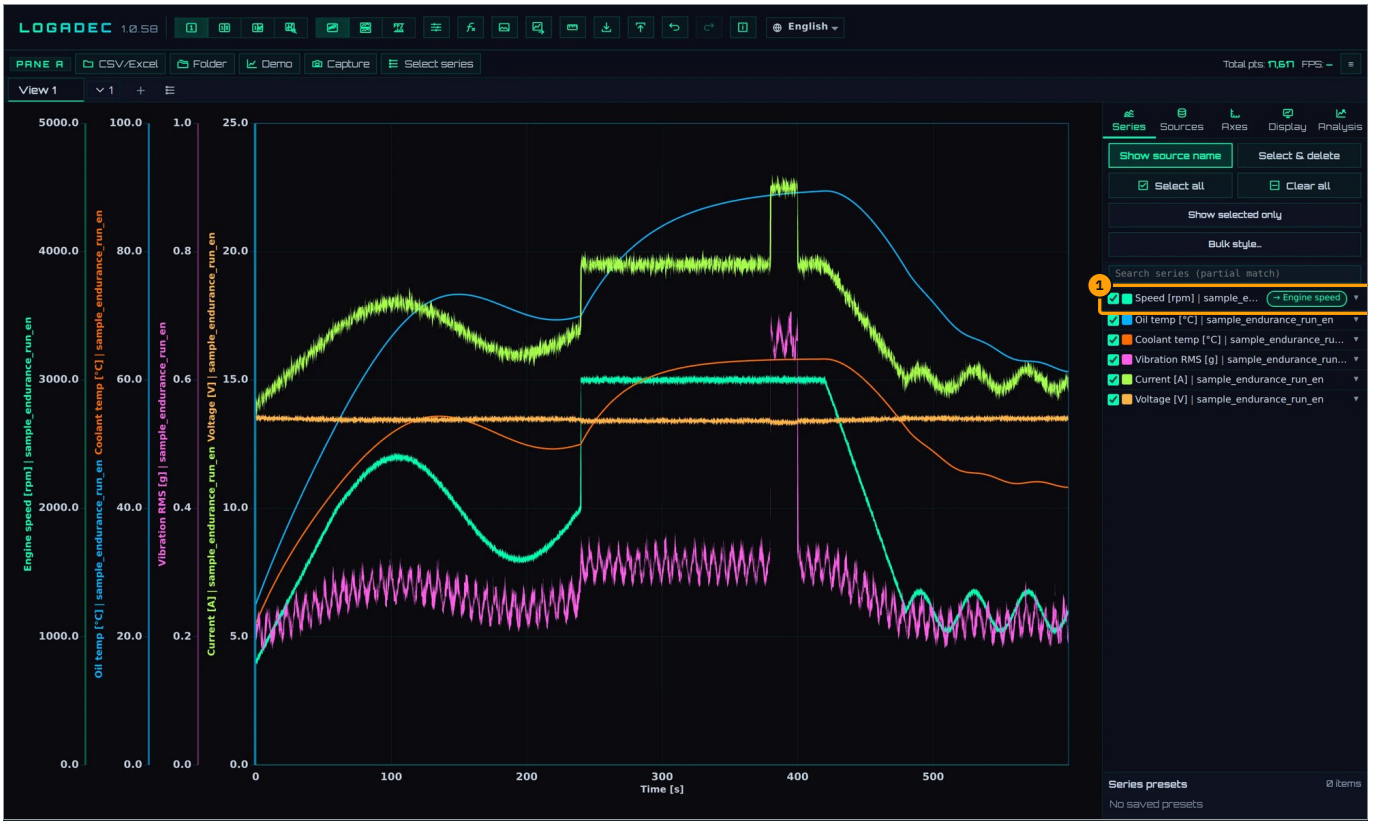

Figure 6-6 The [**Series**] tab after renaming

1. The new name is shown next to the original name. Click it to open the presets screen

- You can map two or more original items to one name. For example, columns named "Speed" or "NE" depending on the file can both be shown as "Engine speed".
- An original item can be linked to only one name. If you choose an item that is linked to another name, it moves from that name.
- Use the check box on the left of a row to turn off individual renamings.
- Display names are shared by Pane A and Pane B.

6.5 Import and export with files

You can export presets to CSV or Excel files and import them from files. Use this to create ranges for many items in Excel and register them all at once, or to exchange presets with colleagues. Click [**Export to file**] or [**Import from file**] on the presets screen.

Export

Click [**Export to file**], choose a format, and click [**Export**].

Format	Contents
[**Excel (range, series and display-name sheets plus notes)**]	An `.xlsx` file with three sheets, "Range", "Series", and "Display Names", plus a sheet explaining how to write them
CSV	A `.csv` file (UTF-8) containing only the presets of the kind on the currently open tab

The file columns are as follows. Row 1 is the header row, and the contents start from row 2.

Kind	Columns
Range	[**Pane**] (A / B; empty means A), [**Item**] (required), [**Y min**], [**Y max**] (if both are empty, Y is not specified), [**Color**] (`#RRGGBB`; if empty, no color is set)
Series	[**Pane**], [**Preset**] (required), [**Item**] (required). Rows with the same pane and the same preset name form one preset
Display names	[**Display name**] (required), [**Original name**], [**Enabled**] (1 / 0; empty means 1). Rows with the same display name are grouped

> **Note: Information not included in the file**
>
> For series presets, the per-series color, line, filter, unit conversion, and Y range, and the display mode, are not included in the file. When you apply a series preset imported from a file, the current appearance stays as it is. Range presets go into the set currently in use.

Import

Click [**Import from file**] and select a file. Before importing, a screen opens showing what will change.

Figure 6-7 The [**Import presets**] screen (a range CSV with an error in one row)

1. For each kind, the numbers that will be [**Add**], [**Overwritten**], [**Unchanged**], or [**Skipped**]
2. Import method: Choose [**Add and overwrite (keep items not in the file)**] or [**Replace preset types found in the file**]
3. [**Errors and warnings ({n}; rows with errors are not imported)**]: Shows which row and which part is wrong. Error rows are not imported
4. [**Cannot be set in the file**]: Explains the information that cannot be written in the file
5. [**Import**]: Imports with these settings

- The kind (range, series, or display names) is identified from the names in the header row. Headers may be in Japanese or English. Rows starting with `#` are ignored.
- The character encoding of CSV files (UTF-8, Shift_JIS) is detected automatically.
- After importing, [**Undo**] appears on the screen. Click it to return to the state before importing (this is not possible after you close the screen).

6.6 Saving and carrying over presets

- Presets are saved in the browser you use. They remain after you close LOGADEC and are available the next time you open it.
- Settings files and `.lgd` files saved with [**Save**] on the toolbar include the presets. Hand them to colleagues so they can use the same presets.
- Range and series presets are separate for Pane A and Pane B. On the [**Range**] tab of Pane B, [**Copy presets from Pane A**] copies the presets of Pane A.
- All preset features are available in the free edition too.

When a settings file or .lgd file is open

When you open a settings file or an `.lgd` file, the range presets, series presets, and display names switch to those contained in the file. If you add or change presets or display names while the file is open, only the contents of that file change. Your usual presets and display names saved in the browser do not change.

- To keep the changed presets in the file, save the file with [**Save**]. Until you save, the [**· unsaved**] mark appears at the top of the formula screen.
- If you try to open another settings file or `.lgd` while there are unsaved changes, a screen appears asking whether to [**Discard and open**]. When you close or reload the browser tab, the browser also asks for confirmation.
- When you reload the browser, your usual presets and display names return.
- Settings files also include all sets of range presets. When you open a settings file saved with a version that had no sets (up to 1.0.1), only the contents of the currently selected set are replaced, and the other sets remain.

Chapter 7

Formulas

Formulas let you calculate new series from the loaded series. For example, you can multiply current by voltage to get power, and integrate power to get energy. The series you create (formula series) can be displayed like ordinary series and used for measurement and analysis.

> **Note: Your original data does not change**
>
> A formula only reads the loaded series and creates another series. The values of the original series do not change. When you delete a formula, only the formula series disappears.

The examples in this chapter are values calculated with the sample data `sample_endurance_run_en.csv`.

7.1 Open the formula screen

Click [**Formula**] on the toolbar to open the formula screen. It opens at full size at first, with the list of saved formulas on the left and the fields for creating a formula on the right.

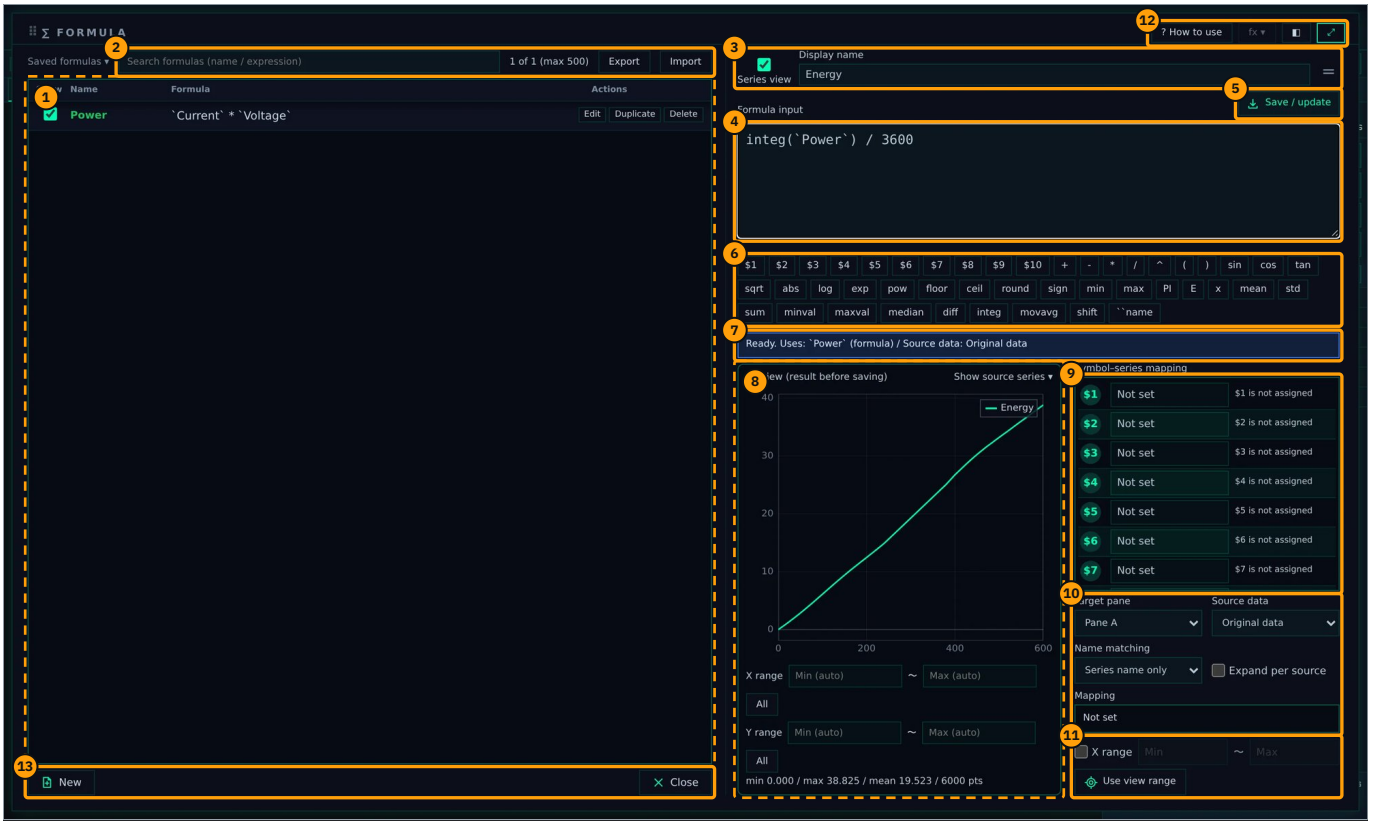

Figure 7-1 The formula screen ("Power" saved, "Energy" being entered)

1. [**Saved formulas**]: The list of saved formulas. The [**Show**] check box on the left toggles display on the graph
2. List search (filter by part of a name or expression), and [**Export**] and [**Import**]
3. [**Series view**] and [**Display name**]: The name of the series to create. If you uncheck [**Series view**], the series is not displayed on the graph even when saved
4. [**Formula input**]: The field where you write the expression
5. [**Save / update**]: Saves the formula and creates the series
6. Buttons for symbols, operators, and functions. Clicking one inserts it at the cursor position in the input field
7. Status display: Shows the series used in the expression and whether it can be calculated. If there is a syntax error, the reason is shown
8. [**Preview (result before saving)**]: The calculation result before saving
9. [**Symbol–series mapping**]: Assigns series to the symbols $1–$10
10. [**Target pane**], [**Source data**], [**Name matching**], [**Expand per source**], [**Mapping**]
11. [**X range**]: Limits the X range to calculate
12. Switches the screen display (see the table below)
13. [**New**] (clears the input fields to start a new formula), [**Close**]

The buttons at the top right of the screen switch the display. The display you choose is used the next time you open the screen too.

Button	Action
[**? How to use**]	Shows a short description of how to write symbols and functions. Click again to hide it
⤢ ([**Maximize / restore to normal size**])	Switches between the full-size display and a slightly smaller display. In the smaller display, the list of saved formulas appears below
◧ ([**Compact view**])	Shows a thin bar with only the input field below the graph (described later)
fx ▾ ([**Functions**])	Available only in compact view. Opens and closes the function buttons

7.2 Create a series with a formula

As an example, create power from current and voltage.

1. Click [**Formula**] to open the formula screen.
2. Enter "Power" in [**Display name**]. If you leave it empty, the name will be something like "CALC1".
3. Enter `` `Current` * `Voltage` `` in [**Formula input**]. Enclose series names in half-width backquotes (`).
4. Check that the status display shows [**Ready**] and that the result appears in the preview.
5. Click [**Save / update**].

"Power" is added at the end of the list on the [**Series**] tab and displayed on the graph. With the sample data, the value at 0 s is 13.768 A × 13.519 V = 186.13. Below the preview, the overall values min 182.695 / max 306.133 / mean 232.981 / 6000 points are shown.

Input aid	How to use
[**`` `name`**] button	Inserts two backquotes and places the cursor between them. Then type the name
Suggestions	While you type, suggestions for functions, series, and saved formulas appear. You can also show them with `Ctrl` + `Space`. Select with `↑` and `↓`, and insert with `Enter` or `Tab`
Full-width symbols	Full-width operators such as ×, ÷, −, and （） are read as their half-width equivalents. Full-width digits (for example, ３) and the long vowel mark "ー" cannot be read as a minus sign (see the table in the appendix)

- Formula series have no unit or file name. The name is exactly as entered in [**Display name**].
- A saved formula series is displayed only on the view tab that was open when you saved it. On other tabs, it is added to the list unchecked.
- For formula series too, you can set filters, unit conversion, color, and more from ▾ (Chapter 5).
- You cannot create formulas with the same name in the same pane (case is not distinguished).

7.3 Check with the preview

The preview is the calculation result before saving. When you change the expression, it is recalculated immediately.

Figure 7-2 The preview (Temperature difference = Oil temp − Coolant temp, with the source series overlaid, reading the value at 552 s)

1. Graph: The result of the formula. Hover the mouse to show a vertical line and the values at that position (X, result, source series)
2. [**Show source series ▾**]: Also overlays the series referenced by the expression as thin lines. When clicked, it changes to [**Hide source series ▴**]
3. [**X range**], [**Y range**]: Set the displayed range as numbers. [**All**] returns to automatic
4. The overall minimum, maximum, mean, and number of points. If some points have no value, their number (NaN) is shown too

Action	Effect
Wheel	Zooms X in or out around the mouse position
`Shift` + wheel	Zooms Y in or out
Wheel over the axis numbers	Zooms only that axis
Drag	Moves (dragging over the Y-axis numbers moves Y)
Double-click	Returns to the full view

- Zooming and moving in the preview are for viewing only. They do not change the formula result or the graph's display range.
- The min, max, and mean below are values over all calculated points, not over the displayed range.
- In the example in the figure, Temperature difference 19.75 is shown from Oil temp 64.02 and Coolant temp 44.27 at 552 s.

7.4 Reference series

There are three ways to refer to a series in an expression.

Syntax	Example	Description
`` `name` ``	`` `Current` ``, `` `Current｜sample_endurance_run_en` ``	Enclose the series name in backquotes. You can write just the item name (the part before "｜") or include the file name
$1–$10	`$1 * 2`	Assign series to the symbols in [**Symbol–series mapping**]
Unenclosed name	`Base * 2`	Only names consisting of half-width letters, digits, and "_" can be written without enclosing. Names with any other characters, such as Japanese names or names with spaces, must always be enclosed (otherwise an invalid character error occurs)

Use symbols ($1–$10)

With symbols, you can swap only the referenced series without changing the expression.

1. Write a symbol such as $1 in the expression.
2. In [**Symbol–series mapping**], click the field for that symbol ([**Not set**] at first) and choose a series. Enter part of a name in the field to narrow down the candidates. Besides the data series, saved formulas are also listed as candidates.
3. The assignment is also shown in [**Mapping**].

Example: Calculate angular velocity (rad/s) from speed. The expression is `2*PI*$1/60`, with "Speed｜sample_endurance_run_en" assigned to $1. The value at 0 s becomes 83.84 from 800.6 rpm.

You cannot save while a symbol in use is still [**Not set**].

Reference rules

References written as `` `name` `` find series using the following rules.

Situation	Rule
Name comparison	Leading and trailing spaces and the case of letters are not distinguished
A data series and a formula have the same name	The data series is used. The status display says so
A name not found among the data series	Saved formulas in the same pane are searched (next section)
Only the item name is written, and one file has that item	The series from that file is used
Only the item name is written, and two or more files have that item	One file is chosen in this order: 1. the same file as other references in the same expression, 2. the file used when the formula was saved, 3. the top file in the list on the [**Sources**] tab. The chosen file is shown in the status display. To calculate for all files, use [**Expand per source**]
One file has two or more columns with the same name	The first column is used, and the status display says so. To use another column, choose it with a symbol
[**Name matching**] is [**Series name + file name**]	Write the file name too (for example, `` `Current | run_02` ``). The item name alone is not found

A series chosen with a symbol keeps using the chosen column after the file is reloaded, as long as the name is the same. It is not swapped even if there are other columns with the same header.

Calculations between series with different X

When an expression uses series with different steps or times, it is calculated on the X of the first series referenced in the expression (the series of a symbol, if symbols are used). The other series are linearly interpolated to those X times.

- Outside the X range of a referenced series, there is no value (NaN).
- Series whose X goes backward partway cannot be interpolated, so they have no value.
- When a referenced series has a time gap of more than 1.5 times its step, no interpolation is done inside the gap, and there is no value.

Formulas with such warnings are shown with their names in red in the list. Hover over the name to see the reason, such as the number of points given no value.

[**Source data**]

Option	Values used for the calculation
[**Original data**]	The values as loaded
[**Filtered data**]	The values after the filter and unit conversion set with the series' ▾ (the values visible on the graph). When a formula series is referenced, the values after the filter and conversion set on that formula series are used too

For example, if you set a unit conversion with a factor of 1000 on the Current series, the result of `` `Current` `` is 13.5–22.927 with [**Original data**] and 13500–22927 with [**Filtered data**] (shown as 1.35e+4–2.29e+4 below the preview).

7.5 Call a saved formula by name

A saved formula can be used in other formulas by writing `` `formula name` ``. In the status display, [**(formula)**] is appended to the name.

Example: Integrate the "Power" (W) created earlier to get energy (Wh).

1. Click [**New**] and enter "Energy" in [**Display name**].
2. Enter `` integ(`Power`) / 3600 `` as the expression. integ integrates in the unit of X (seconds here), so divide by 3600 to get Wh.
3. Click [**Save / update**].

With the sample data, the result is 0 at 0 s and 38.825 at 599.9 s.

- You can call formulas in the same pane ([**Target pane**]). A formula cannot call itself. If you try to save formulas edited so that they reference each other, a message appears saying that the formula cannot be saved because of a circular reference, and nothing is saved.
- When you rename a formula that is being called, the name inside the calling expressions is rewritten to the new name.
- A formula called from other formulas cannot be deleted. First edit or delete the calling formulas.
- A formula set to [**Expand per source**] can be called only from formulas also set to [**Expand per source**].

7.6 Expand per source

When you load two or more files of the same format, one formula can create a result for each file (source). For example, you can create the power of the first and second test runs at once.

1. Enter the formula and check [**Expand per source**].
2. The status display shows the number of sources that can be calculated. The preview shows the result for the first source.
3. Click [**Save / update**].

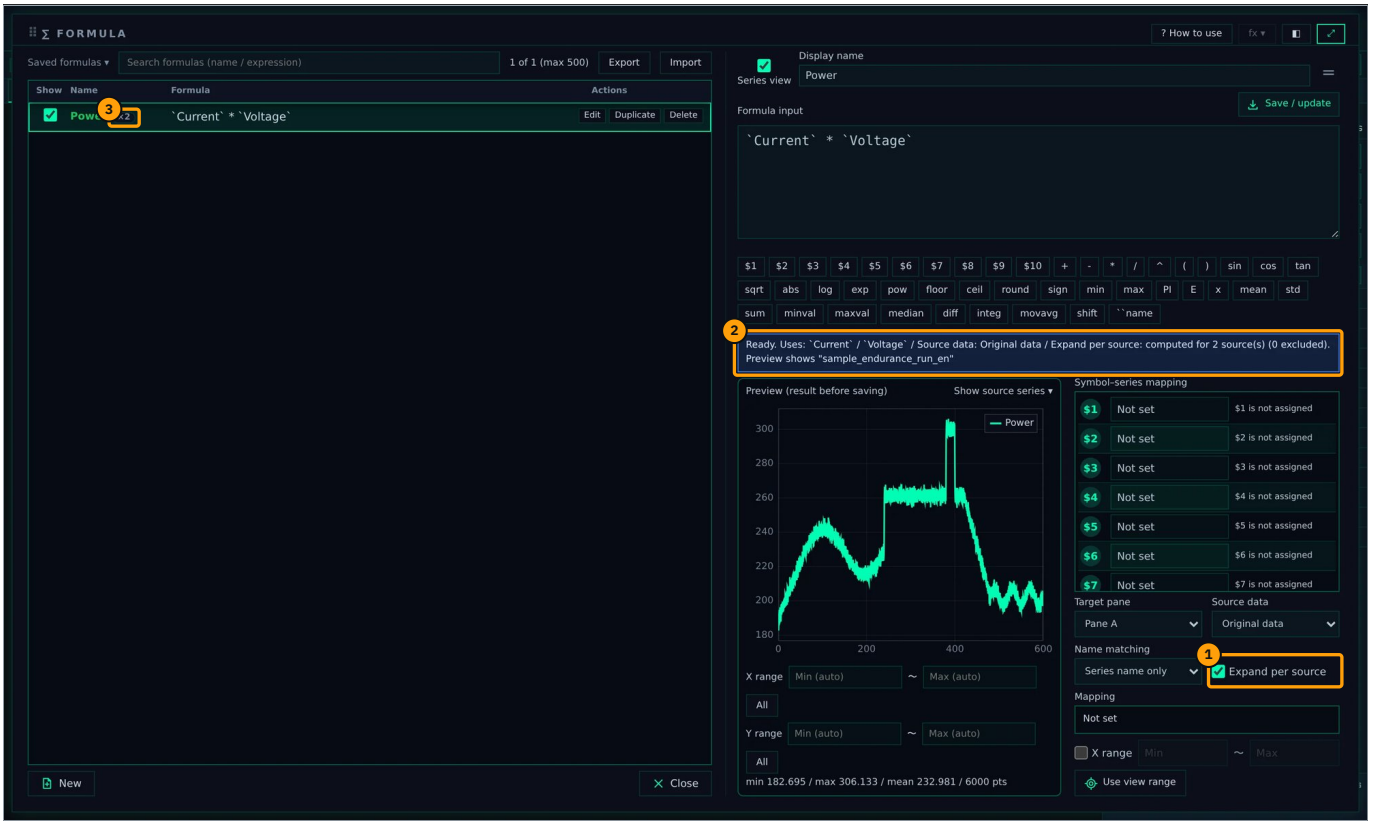

Figure 7-3 Two files (sample_endurance_run_en and run_02) loaded, with power expanded

1 [**Expand per source**]: When checked, a result is created for each source

2 Status display: The number of sources to calculate and the number of excluded sources

3 Number of series created: Hover over the name to see the calculated sources, and the excluded sources with their reasons

- Results are named "formula name | source name". In the example in the figure, two series are created: "Power | sample_endurance_run_en" and "Power | run_02".
- References are by item name and are looked up within each source. You do not need to write the file name.
- Each source is calculated on its own X. There is no interpolation across sources.
- Sources that lack a referenced item, and sources with two or more columns of the same name where the column to use cannot be determined, are excluded.
- The [**Show**] check box in the list shows or hides all expanded results at once. To toggle them one at a time, use the [**Series**] tab.

> **Note: There is a limit on the number of expanded results**
>
> Expanded results are limited to 2000 series in total across all formulas. They are allocated starting from the formula at the top of the list. If saving or duplicating would reduce another formula's results (or leave this formula's results incomplete), the formula is not saved. If you later load more sources and exceed the limit, the number of series that could not be created is shown.

7.7 Calculate over a limited X range

Check [**X range**] and enter a minimum and maximum to calculate only within that range.

- Points outside the range have no value.
- Aggregate functions such as mean and maxval, and time-series functions such as integ, are also calculated using only the values within the range.
- Click [**Use view range**] to fill in the current X display range of the graph.

Example: `mean(`Oil temp`)` is 71.816 over the whole data, but with [**X range**] set to 100–200 it becomes 71.603 and is displayed only between 100 and 200 s.

7.8 Handling missing values and time gaps

When the data has missing values (empty cells), or at points that cannot be calculated (division by 0, square root of a negative number, and so on), there is no value (NaN). The graph line breaks at points without a value.

Each function handles them as follows.

Function	Handling of missing values and time gaps
integ	Intervals that include a missing value, and time gaps of more than 1.5 times the step (the median interval), are not spanned and not integrated. The integral does not increase over that interval and continues adding from the next interval. Hover over the name in the list to see the number of spans skipped
Interpolation of referenced series	No interpolation is done inside time gaps, and there is no value. Hover over the name in the list to see the number of points given no value
movavg	If the window contains a missing value, that point has no value
diff	A point has no value if the point before or after it is missing
mean, std, sum, minval, maxval, median	Calculated excluding points without a value

Example: For data with values every 1 s (always 2) at 0–10 s and 20–30 s, and a gap at 10–20 s, the integ result is 20 at 10 s, still 20 at 20 s, and 40 at 30 s. Integrating across the gap over 10–20 s would give 60, but LOGADEC does not span gaps.

The detailed rules for each function are summarized in the appendix "Formula Functions".

7.9 Manage saved formulas

Saved formulas are listed one per row.

Column/button	Action
[**Show**]	Whether to display the formula series on the graph
[**Name**]	The name of the formula. Formulas that cannot be calculated or have warnings are shown in red; hover to see the reason
[**Formula**]	The expression. Hover to also see the [**Source data**] and symbol assignments
[**Edit**]	Loads the formula into the input fields on the right. Make changes and click [**Save / update**] to overwrite it
[**Duplicate**]	Creates a copy, saves it in the list, and loads it into the input fields (the name will be something like "CALC1"). The copy remains even if you do not click [**Save / update**]
[**Delete**]	Deletes without confirmation (you can restore it with `Ctrl` + `Z`). A formula called from other formulas cannot be deleted

- Text entered in the search box above the list filters by name and expression.
- You can save up to 500 formulas. The count is shown above the list.
- Saved formulas remain in the browser you use. Even after you close LOGADEC, they are listed the next time you open it. When you load data, saved formulas are calculated automatically with that pane's data (this also applies to the first file you load after opening LOGADEC).

- Formulas are per [**Target pane**]. With [**2 panes**], choose [**Pane A**] or [**Pane B**] before creating formulas.

7.10 Export and import formulas

You can export formulas you create to a file and use them on other PCs or in other documents.

- **Export**: Click [**Export**] above the list. Choose [**All formulas**] or the formulas in the list as filtered by your search, and click [**Export**]. A file named `logadec_formulas_<date>_<time>.json` is saved.
- **Import**: Click [**Import**] and select an exported file. You can also select a settings file (.json) to import the formulas in it. Imported formulas are added to the current list.

When formulas with the same name already exist, choose how to handle them.

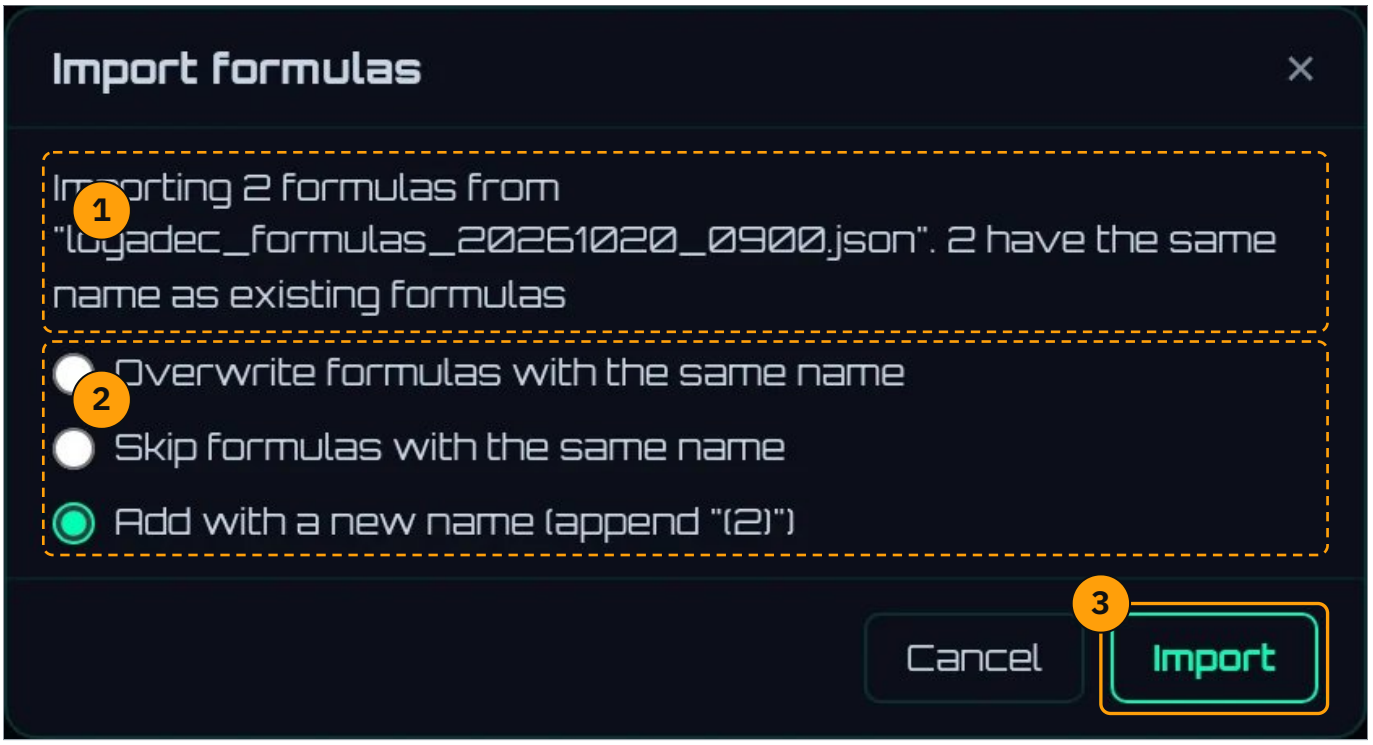

Figure 7-4 Importing a file containing two formulas with existing names

1. The number of formulas to import and the number of formulas with the same name
2. Choose how to handle formulas with the same name
3. [**Import**]: Imports the formulas

Option	Result
[**Overwrite formulas with the same name**]	Replaces existing formulas with the same name with the file's contents
[**Skip formulas with the same name**]	Does not import formulas with the same name
[**Add with a new name (append "(2)")**]	Adds them with " (2)" appended to the name (this is selected at first). Expressions that call the renamed formulas are also rewritten to the new names when imported

For example, importing "Power" and "Energy" (`integ(`Power`)/3600`) under other names creates "Power (2)" and "Energy (2)" (`integ(`Power (2)`)/3600`). Any formulas beyond 500 in total are not imported.

7.11 Formulas per document

Your usual formulas are in the list inside the browser (the shared list remembered on this PC). Data saves (.lgd) and settings files (.json) also include the formulas at that time (Chapter 11).

When you open an .lgd or settings file, the formulas and presets in it are used as that document's own.

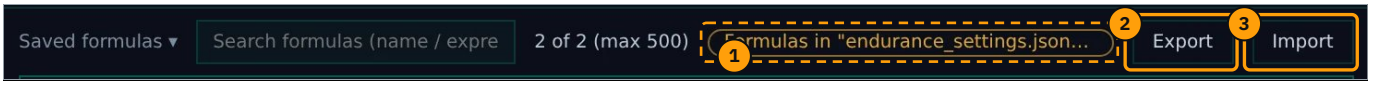

Figure 7-5 A formula added after opening a settings file

1. The mark showing that the document's formulas are in use. [· **unsaved**] is added when there are unsaved changes
2. [**Export**]
3. [**Import**]

- While a document is open, adding, changing, or deleting formulas affects only the document. When you save the document, the changes go into the document. The shared list does not change.
- Even if you delete a formula in another document, the formula is all there when you open a document that contains it.
- When you reopen LOGADEC, the shared list is used again.

> **Caution: Confirmation of unsaved changes**
>
> When the document's formulas or presets have unsaved changes, a confirmation appears before the following operations.
>
> - Opening another .lgd or settings file: A message appears saying that the formulas/presets of the document "⋯" have unsaved changes. Click [**Discard and open**] to discard the changes and open. [**Cancel**] cancels opening.
> - Closing or reloading the browser tab: The browser asks whether to leave the page.
>
> To keep the changes, save the document first.

7.12 Write formulas while viewing the graph in compact view

Click ◧ ([**Compact view**]) to turn the formula screen into a thin bar below the graph. You can edit expressions while viewing the graph.

Figure 7-6 Compact view (with the function buttons opened)

1. The expression input field. [**Display name**] is on its left
2. Symbol and function buttons
3. [**Save / update**]
4. fx ▴: Opens and closes the function buttons
5. ◱ ([**Full view**]): Returns to the full formula screen
6. Saved formula series are added at the end of the list on the [**Series**] tab

- Compact view does not show the preview, the list of saved formulas, [**Expand per source**], and so on. To use them, return to the full screen.

Chapter 8

Frequency Analysis

This chapter describes the features for examining signals such as vibration by frequency: [**FFT view**], which displays the graph by frequency; [**Filter**], applied per series; and [**STFT peak**], [**Wavelet**], and [**Freq. anomaly**] on the [**Analysis**] tab.

The examples in this chapter use the practice sample data `sample_vibration_en.csv`. It is data from a fictitious motor vibration test (not a record of a real test).

Item	Details
Columns	Two: Time [s] and Acceleration [m/s²]
Recording	18 seconds at 1000 Hz (every 0.001 seconds). The highest frequency that can be handled (the Nyquist frequency) is 500 Hz
Components always present	50 Hz (amplitude 1.0) and 120 Hz (amplitude 0.5)
Component added partway	230 Hz (amplitude 1.5) is added only from 12 to 16 seconds. During this time, 230 Hz is the strongest component
Noise	Random noise (standard deviation 0.3) is present throughout

8.1 What frequency analysis can do

Feature	What you learn	Where to operate
[**FFT view**]	Which frequency components, and how large, are contained in the whole data (or part of the time)	[**FFT**] on the toolbar, and [**FFT view**] on the [**Analysis**] tab
[**Filter**]	A waveform keeping only the components below (or above) a set frequency	▾ of a series on the [**Series**] tab
[**STFT peak**]	How the strongest frequency changes over time	[**Analysis**] tab
[**Wavelet**]	The distribution of component strength on both time and frequency axes	[**Analysis**] tab
[**Freq. anomaly**]	Time periods when the frequency characteristics differ from usual	[**Analysis**] tab

All analyses on the [**Analysis**] tab are used in the order [**Target**] (choose the [**Analysis target**] and the [**Range**]) → [**Run**] → [**Results**]. The results appear as a table in [**Analysis results**] at the bottom of the screen. This flow and how to read the results are explained in Chapter 9. This chapter describes only the settings and results specific to frequency analysis.

8.2 Frequency units

Frequency values are derived from the unit of the X axis. The unit used by each feature is as follows.

Feature	Frequency unit
[**FFT view**], [**STFT peak**], [**Wavelet**], [**Freq. anomaly**]	When [**Frequency unit**] is [**Hz equiv.**] (the default) and the X-axis unit is a time unit (ms, seconds, minutes, hours, days, and so on), the calculation is converted to seconds and done in Hz. Even for data with an X axis in milliseconds, a 50 Hz component is shown as 50 Hz
Same as above (when the X-axis unit is not a time unit)	Calculated as the reciprocal of the X unit as-is, with the unit shown as [**Hz equiv.**]
Same as above (when [**Frequency unit**] is [**1/X**])	The reciprocal of the X unit, regardless of the X-axis unit. If the X axis is in milliseconds, a 50 Hz component is shown as 0.05
[**Filter**]	The cutoff frequency (fc) is always the reciprocal of the X unit. Hz if the X axis is in seconds, 1/ms if in milliseconds (1/ms is 1000 Hz). The unit in use is shown in the series details

> **Note: Check the X-axis unit when loading**
>
> The X-axis unit is determined by [**X-axis unit**] under [**Advanced**] on the import screen. If the file's unit row (in the X column) contains a time unit (ms, s, min, and so on), it is selected from the start. For files without a unit row, it is [**Seconds (s)**]. If you load millisecond data as seconds, frequencies become 1/1000 of their value (a 50 Hz component is shown as 0.05 Hz). For millisecond data without a unit row, choose [**Milliseconds (ms)**].

8.3 FFT view

The FFT view applies a Fourier transform to series and displays graphs (spectra) with frequency on the horizontal axis.

1. On the [**Series**] tab, check the series you want to examine to display them.
2. Click [**FFT**] on the toolbar. A spectrum is shown in its own tier for each displayed series. In the sidebar, [**FFT view**] opens on the [**Analysis**] tab.
3. To return to the time-series view, click [**Overlay**] or [**Stacked**].

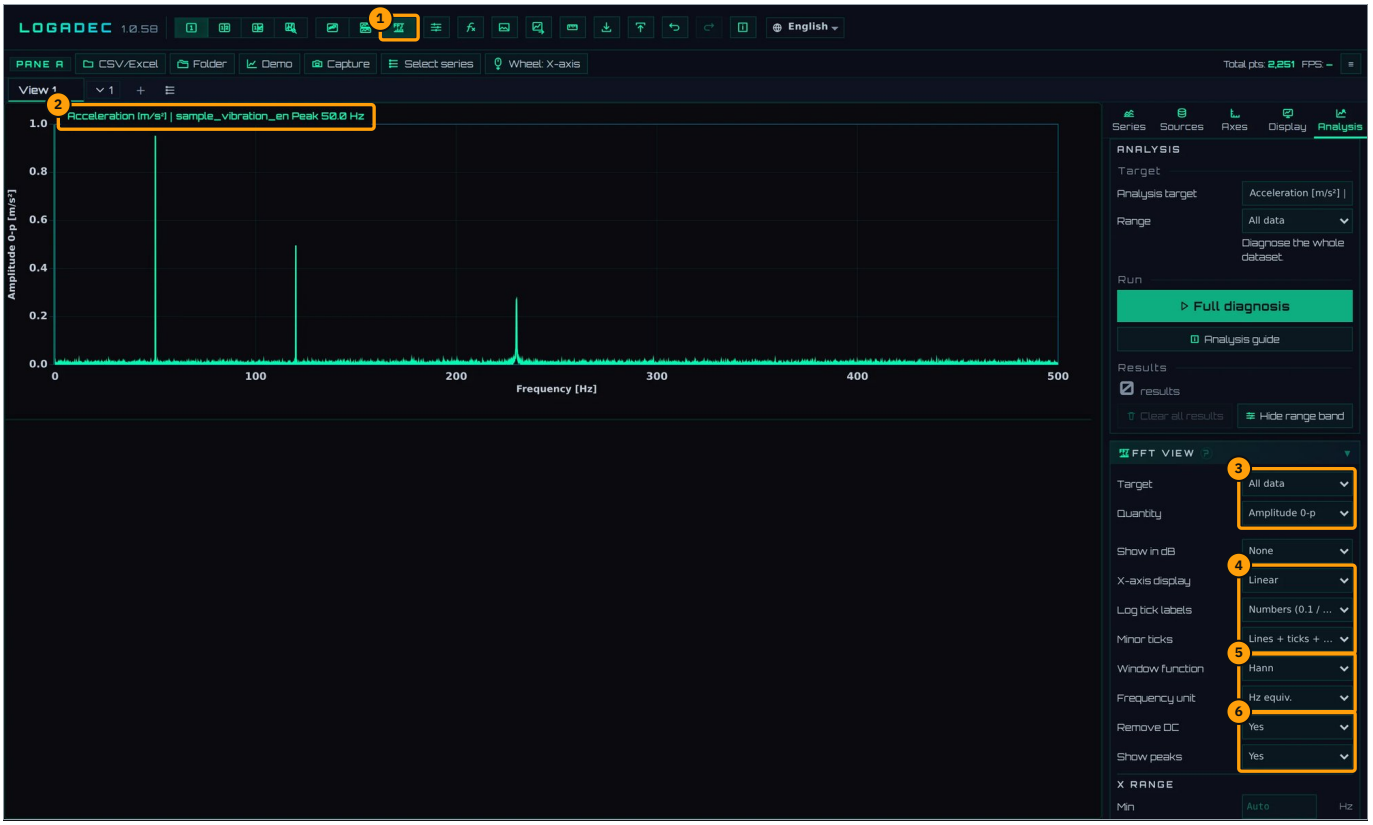

Figure 8-1 Spectrum of the sample data ([**Amplitude 0-p**], [**Linear**] horizontal axis)

1. [**FFT**]: Displays the graph by frequency
2. Tier name: Shows the frequency of the largest component ([**Peak**]) after the series name. When there is a caution about the calculation, [**Warning**] is added; hover to see the details
3. [**Target**], [**Quantity**]: The time range used for the calculation, and the quantity shown on the vertical axis
4. [**X-axis display**], [**Log tick labels**], [**Minor ticks**]: Whether the horizontal axis is linear or logarithmic, and how log ticks are shown
5. [**Window function**], [**Frequency unit**]: The window function used for the calculation, and the frequency unit
6. [**Remove DC**], [**Show peaks**]: Whether to subtract the mean before calculating, and whether to show [**Peak**] in the tier name

In the sample data, peaks appear at 50 Hz (about 0.96), 120 Hz (about 0.50), and 230 Hz (about 0.27). The 230 Hz component has an amplitude of 1.5, but it is present for only 4 of the 18 seconds, so it appears small when calculated over the whole data. To know its size during that time only, set [**Target**] to [**Current display range**], display 12–16 seconds in the time-series view, and then return to [**FFT**]. This way, 230 Hz reads about 1.50.

List of settings

Setting	Options (bold is the default)	Description
[**Target**]	[**All data**]/[**Current display range**]	With [**Current display range**], only t X range last displayed in the time-series view ([**Overlay**], [**Stacked**]) is calculated
[**Quantity**]	[**Amplitude 0-p**] and others (table below)	The quantity shown on the vertical a
[**PSD method**], [**Segment length**], [**Overlap**]	[**Periodogram (single segment)**]/[**Welch (averaged PSD)**]	Shown only when [**Quantity**] is [**PSD** (described later)
[**Show in dB**]	[**None**]/[**Show in dB**]	Shows the vertical axis in dB, relativ [**Reference**] (1 at first). If [**Peak = 0** is [**Yes**], the maximum value of each tier becomes 0 dB
[**X-axis display**]	[**Linear**]/[**Log**]	With [**Log**], the 0 Hz point is omitted from the plot
[**Log tick labels**]	[**Numbers (0.1 / 1 / 10)**]/[**Powers of 10 (10^0 / 10^1)**]	How the tick numbers on a logarithr horizontal axis are written. Has no effect with [**Linear**]
[**Minor ticks**]	[**None**]/[**Grid lines**]/[**Axis ticks**]/[**Lines + ticks + 2/5**]	How ticks between powers of 10 (2 times) are shown on a logarithmic horizontal axis. With [**Lines + ticks + 2/5**], 2 and 5 are als labeled with numbers
[**Window function**]	[**Hann**]/[**Hamming**]/[**Blackman**]/[**Flat top (amplitude accuracy)**]/[**Rectangular**]	Table below
[**Frequency unit**]	[**Hz equiv.**]/[**1/X**]	See the section "Frequency units"
[**Remove DC**]	[**Yes**]/[**None**]	With [**Yes**], the mean is subtracted before calculating. This prevents a l value at 0 Hz from making other pea hard to see
[**Show peaks**]	[**Yes**]/[**None**]	Shows in the tier name the frequenc the largest point, excluding 0 Hz
[**X range**]	[**Min**], [**Max**]	Set the displayed frequency range a numbers and click [**Apply FFT rang** [**Reset FFT range**] returns to the ful range
[**Y range (all series)**]	[**Min**], [**Max**]	Gives the vertical axes of all tiers th same range ([**Apply Y range to all**]/[**Reset Y ran**

Turn the wheel over a spectrum to zoom the frequency axis in or out, and drag to move it. Only the display range changes; the spectrum is not recalculated.

Display amount

Display amount	Description	Vertical-axis unit (when the series unit is m/s²)
[**Amplitude 0-p**]	The amplitude of a sine wave (from 0 to the peak)	m/s²
[**Amplitude p-p**]	The size from peak to valley. Twice the 0-p value	m/s²
[**RMS**]	The effective value. For a sine wave, $1/\sqrt{2}$ times the 0-p value	m/s²
[**Power**]	The square of the 0-p value	$(m/s^2)^2$
[**PSD**]	Power per 1 Hz (power spectral density). It does not depend on the number of points used in the calculation, so use it to compare noise levels	$(m/s^2)^2/Hz$

p-p and RMS are correct values for sine-wave components. To compare the size of noise spread over a wide frequency range, use [**PSD**].

Window functions

A window function is a weighting that smoothly brings both ends of the calculated interval close to 0. The choice slightly changes the height and width of peaks. The values read for the sample data's 50 Hz component (amplitude 1.0) with [**Amplitude 0-p**] are included.

Window function	Suitable use	50 Hz reading
[**Hann**]	Everyday use. This is the default	0.964
[**Hamming**]	Properties close to Hann	0.957
[**Blackman**]	When you want to narrow the skirts of large peaks	0.970
[**Flat top (amplitude accuracy)**]	When you want to read amplitude as a number. Peaks become wider, and two close frequencies are harder to separate	0.991
[**Rectangular**]	Applies no weighting. For signals where the interval length is exactly an integer multiple of the period	0.918

With Hann, when a component's frequency falls between the calculation step (resolution) ticks, the amplitude can read up to about 15% low. When you use amplitude values in a report, choose [**Flat top (amplitude accuracy)**].

PSD and the Welch method

When you set [**Quantity**] to [**PSD**], you can choose the [**PSD method**].

Method	How it is calculated
[**Periodogram (single segment)**]	Calculates the whole data as one interval. Frequencies are finely resolved, but the noise part is jagged
[**Welch (averaged PSD)**]	Divides the data into intervals of [**Segment length**] and averages the spectra of the intervals. The noise part becomes smooth, making the noise level easier to read. In exchange, the frequency resolution becomes coarser

- [**Segment length**] is specified in seconds (seconds even for data with an X axis in milliseconds). If set to 0, one eighth of the number of data points is used as the interval.
- [**Overlap**] is the proportion by which adjacent intervals overlap ([**0%**], [**50%**], [**75%**]).
- The frequency resolution is 1 ÷ (the number of points in the interval rounded up to a power of 2 × the step). With the sample data and a segment length of 0.5 seconds, 500 points are rounded up to 512 points, and the resolution is about 1.95 Hz. Peak frequencies are also read on this grid, so the 50 Hz component is shown as 50.8 Hz.
- If two or more intervals cannot be obtained, the calculation uses [**Periodogram (single segment)**], and [**Warning**] is added to the tier name ([**Too few segments; computed as a periodogram. Use a shorter segment length.**]).

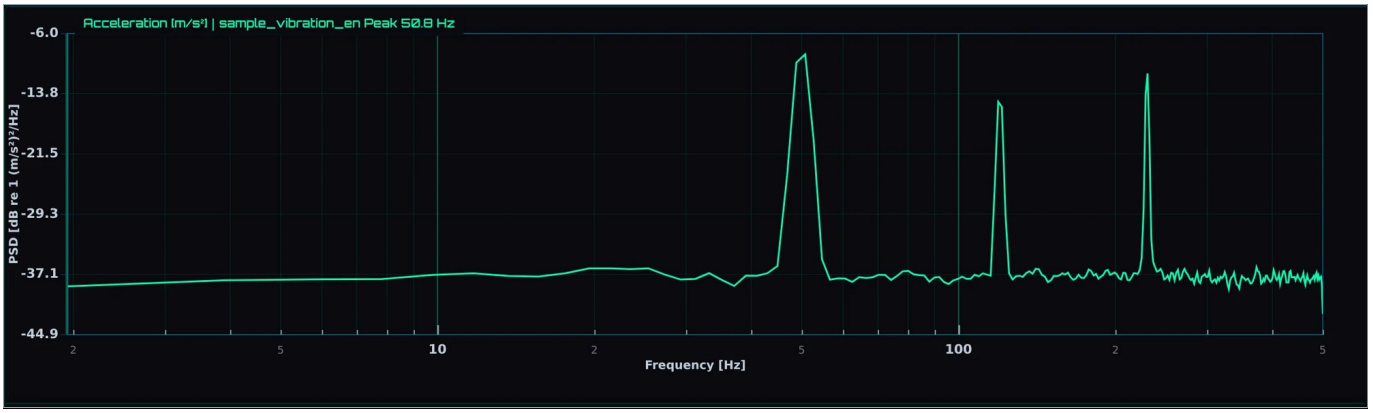

Figure 8-2 [**PSD**] with [**Welch (averaged PSD)**] (segment length 0.5 seconds), shown in dB with a logarithmic horizontal axis

Calculation rules

- The values used for the calculation are the values plotted on the graph (after [**Unit conversion / rename**] and filters).
- When there are more than 65,536 points, an averaging that suppresses aliasing (high frequencies appearing as low frequencies) is applied, and the points are reduced before calculating. High-frequency components become smaller. [**Warning**] is added to the tier name.
- When there are fewer than 8 points, nothing is calculated.
- When X goes backward or the same X repeats somewhere, nothing is calculated ([**The data is not uniformly sampled, so the FFT is not computed**] is shown).
- When the step deviates from the median by more than 5% somewhere, the data is treated as evenly spaced for the calculation, and [**Warning**] is added (with a note that the FFT frequencies are approximate because the X spacing varies widely). This caution also appears when there are missing values or time jumps (see the section "Handling missing values and time jumps").

8.4 Series filters

A filter removes components at set frequencies from a series' waveform. On the [**Series**] tab, click ▾ for the series and set it up in the [**Filter**] field.

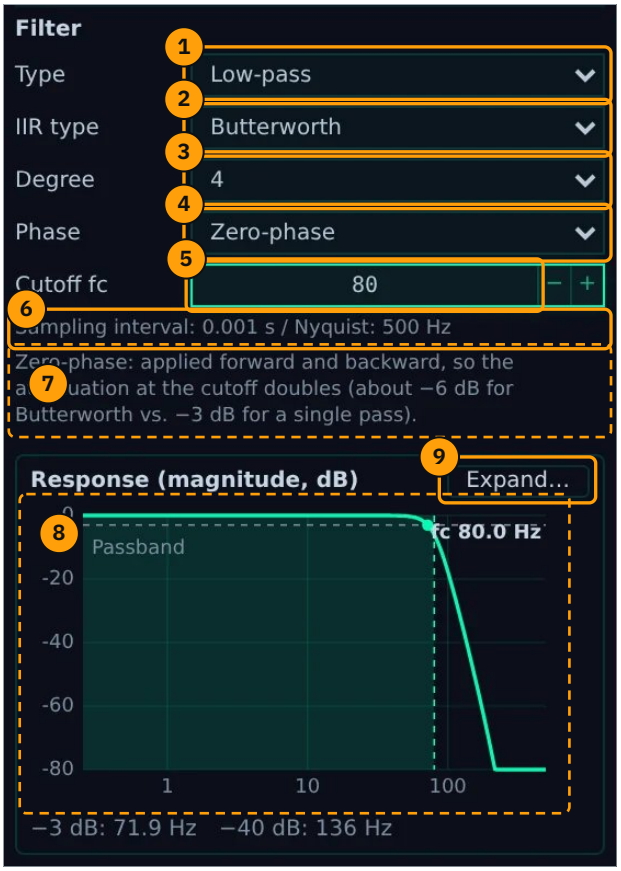

Figure 8-3 Acceleration with an 80 Hz low-pass filter (Butterworth, 4th order, zero-phase)

1. [**Type**]: Choose from [**None**], [**Low-pass**], [**High-pass**], [**Band-pass**], [**Band-stop**], [**Notch**], [**Moving average**], and [**Moving median**]. The fields below change with the type (described later)
2. [**IIR type**]: Choose from [**Butterworth**], [**Chebyshev (1dB)**], and [**Bessel**]
3. [**Degree**]: 1 to 6. The larger the value, the more steeply frequencies outside the cutoff are reduced
4. [**Phase**]: Choose [**Normal**] or [**Zero-phase**]
5. [**Cutoff fc**]: The cutoff frequency. For [**Band-pass**], there are two: [**Low fc**] and [**High fc**]
6. The data step and the highest frequency that can be handled (Nyq = Nyquist frequency). Enter the cutoff frequency in this unit
7. Explanations and cautions about the calculation (described later)
8. Response graph: shows how much this filter reduces each frequency (the amplitude ratio in dB) (described later)
9. [**Expand⋯**]: Opens the larger view

Setting	Default
[**Type**]	[**None**]
[**IIR type**]	[**Butterworth**]
[**Degree**]	1
[**Phase**]	[**Normal**]
[**Cutoff fc**], [**Low fc**]	0.1 times the Nyquist frequency (50 Hz for the sample data)
[**High fc**]	0.3 times the Nyquist frequency (150 Hz for the sample data)

The cutoff frequency is kept within the range from one trillionth of the Nyquist frequency to just below the Nyquist frequency.

Filtered values are used for the graph, the FFT view, and analyses (when [**Data**] is [**Filtered (as displayed)**]). When [**Unit conversion / rename**] is used, the filter is applied to the converted values. The loaded data itself does not change.

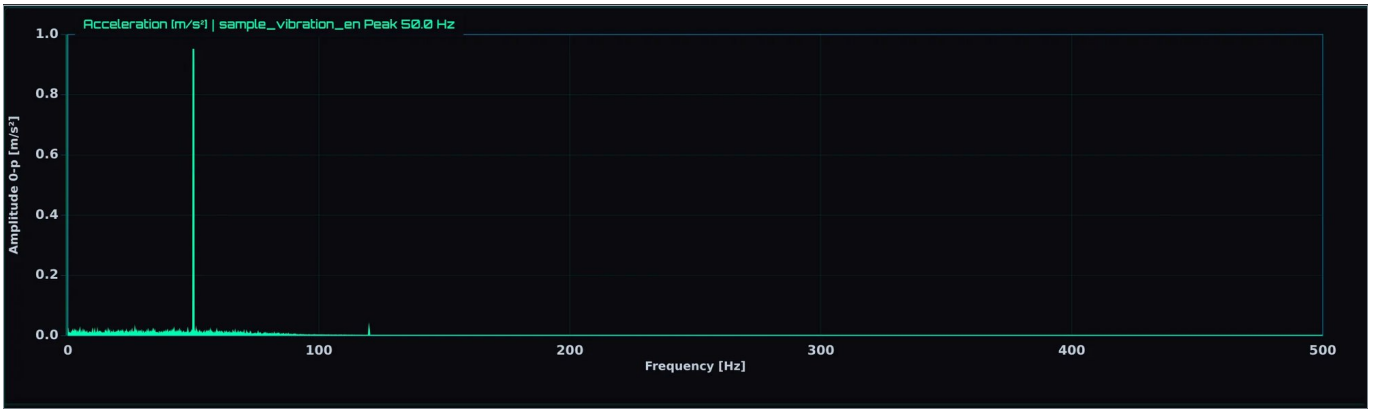

Figure 8-4 The spectrum after filtering (120 Hz drops from about 0.50 to about 0.015, and 230 Hz disappears)

What the cutoff frequency (fc) means

Type	Frequencies passed	Attenuation at fc
[**Low-pass**]	Frequencies below fc	−3 dB (amplitude about 0.71 times) with [**Normal**], −6 dB (about 0.50 times) with [**Zero-phase**]
[**High-pass**]	Frequencies above fc	Same as above
[**Band-pass**]	Between [**Low fc**] and [**High fc**]	A high-pass at the low fc and a low-pass at the high fc are applied in succession. Each fc has the same attenuation as above

For all three characteristics, fc is "the frequency at which a single pass gives −3 dB". For [**Chebyshev (1dB)**] too, fc is the −3 dB point, not the edge of the passband ripple.

These are the results of filtering a sine wave at the same frequency as fc and measuring the amplitude ratio (1000 Hz data, fc 50 Hz; orders 1–6 and all three characteristics gave the same values).

Phase	Amplitude ratio at fc
[**Normal**]	−3.01 dB (0.707 times)
[**Zero-phase**]	−6.02 dB (0.500 times)

Differences between characteristics

These are the results of measuring the amplitude ratio (dB) at each frequency and the overshoot in response to a step input, with [**Low-pass**], 4th order, [**Normal**], and fc 50 Hz.

Characteristic	10 Hz	20 Hz	30 Hz	40 Hz	50 Hz	100 Hz	Overshoot
[**Butterworth**]	0.00	0.00	−0.07	−0.66	−3.01	−25.0	10.9%
[**Chebyshev (1dB)**]	+0.55	+0.96	+0.11	+0.66	−3.01	−36.7	21.9%
[**Bessel**]	−0.11	−0.44	−1.01	−1.85	−3.01	−14.1	0.9%

- [**Butterworth**]: Passes frequencies below fc almost flat. Choose this if you are unsure.
- [**Chebyshev (1dB)**]: Reduces frequencies above fc most steeply. In exchange, the amplitude ripples by up to about 1 dB below fc, and it rings strongly after a step.
- [**Bessel**]: The attenuation is gradual, but it hardly distorts the waveform shape. Choose it when you want to see the shape of steps and pulses.

Normal phase and zero phase

Phase	How it is applied	Characteristics
[**Normal**]	Applied once, forward in time	The filtered waveform lags behind the original. The attenuation at fc is −3 dB
[**Zero-phase**]	Applied forward, then once more backward	No time lag. Suitable for comparing with the original waveform at aligned times. Because it is applied twice, the attenuation at fc is −6 dB, and the attenuation outside fc also doubles (in dB). Small ringing also appears before a step

How the band-pass is built

[**Band-pass**] is a high-pass at [**Low fc**] followed by a low-pass at [**High fc**]. [**Degree**] is used for each of the high-pass and the low-pass. When the low and high limits are close, the attenuation of the two filters overlaps, and frequencies in between are reduced too.

Band (Butterworth, [**Zero-phase**])	Ratio at low fc	Ratio at center	Ratio at high fc
30–100 Hz, 4th order	−6.02 dB		−6.46 dB
40–60 Hz, 2nd order	−7.57 dB	−6.33 dB (50 Hz)	−7.57 dB

Band-stop and notch

[**Band-stop**] removes the band from [**Low fc**] to [**High fc**] and passes the frequencies outside it (the opposite of a band-pass). It is built by transforming the low-pass prototype of the [**IIR type**] into a band-stop filter. The attenuation is −3 dB at the low and high limits (−6 dB with [**Zero-phase**]).

[**Notch**] removes only a very narrow band around [**Center f0**]. Use it to remove 50/60 Hz mains noise or the first order of a rotation.

Field	Meaning
[**Center f0**]	The frequency to remove
[**Q (sharpness)**]	A higher Q removes a narrower band. The removed width (the −3 dB width) is about f0/Q. The default is 30
[**Harmonics**]	How many of f0, 2f0, 3f0 ⋯ to remove together (1 to 10; 1 removes only f0). Frequencies above the Nyquist frequency are skipped

The amplitude ratios (dB) below were computed for 1000 Hz data.

Band and settings	5 Hz	20 Hz	30 Hz	50 Hz	80 Hz	120 Hz	200 Hz
[**Band-stop**] 20 to 120 Hz (Butterworth, 4th order, [**Normal**])	0.00	−3.01	−23.6	almost 0×	−25.5	−3.01	−0.01

[**Notch**] (f0 50 Hz)	40 Hz	45 Hz	49 Hz	50 Hz	51 Hz	55 Hz	60 Hz
Q 30	−0.02	−0.10	−2.20	almost 0×	−2.27	−0.13	−0.03
Q 5	−0.76	−2.72		almost 0×		−3.13	−1.09

Moving average and moving median

These smooth the series over time by combining neighboring points. Both compute over [**Window (pts)**] points centered on each point, so there is no time delay. Near the ends of the series, only the available points are used.

Type	Calculation	Use
[**Moving average**]	Mean of N points	Smooths out noise. It works like a low-pass, and fs/N (the frequency at which N points make exactly one cycle) and its multiples are removed
[**Moving median**]	Median of N points	Removes spikes. If spikes fill less than half of the window, the original waveform is kept almost unchanged. It selects values by size (nonlinear), so it has no frequency response

For 1000 Hz data, the −3 dB frequency of a [**Moving average**] is about 90 Hz with 5 points and about 40 Hz with 11 points.

Response graph

Below the [**Filter**] field in the series details, a response graph for the current settings appears. The horizontal axis is frequency (log), and the vertical axis is the amplitude ratio (dB). Shading marks the passband; dotted lines mark −3 dB and fc. The curve is computed from the very coefficients that are applied. With [**Zero-phase**], it shows the attenuation of the two passes. A [**Moving median**] has no frequency response, so an explanation appears instead of the graph.

Click [**Expand⋯**] to open a larger view.

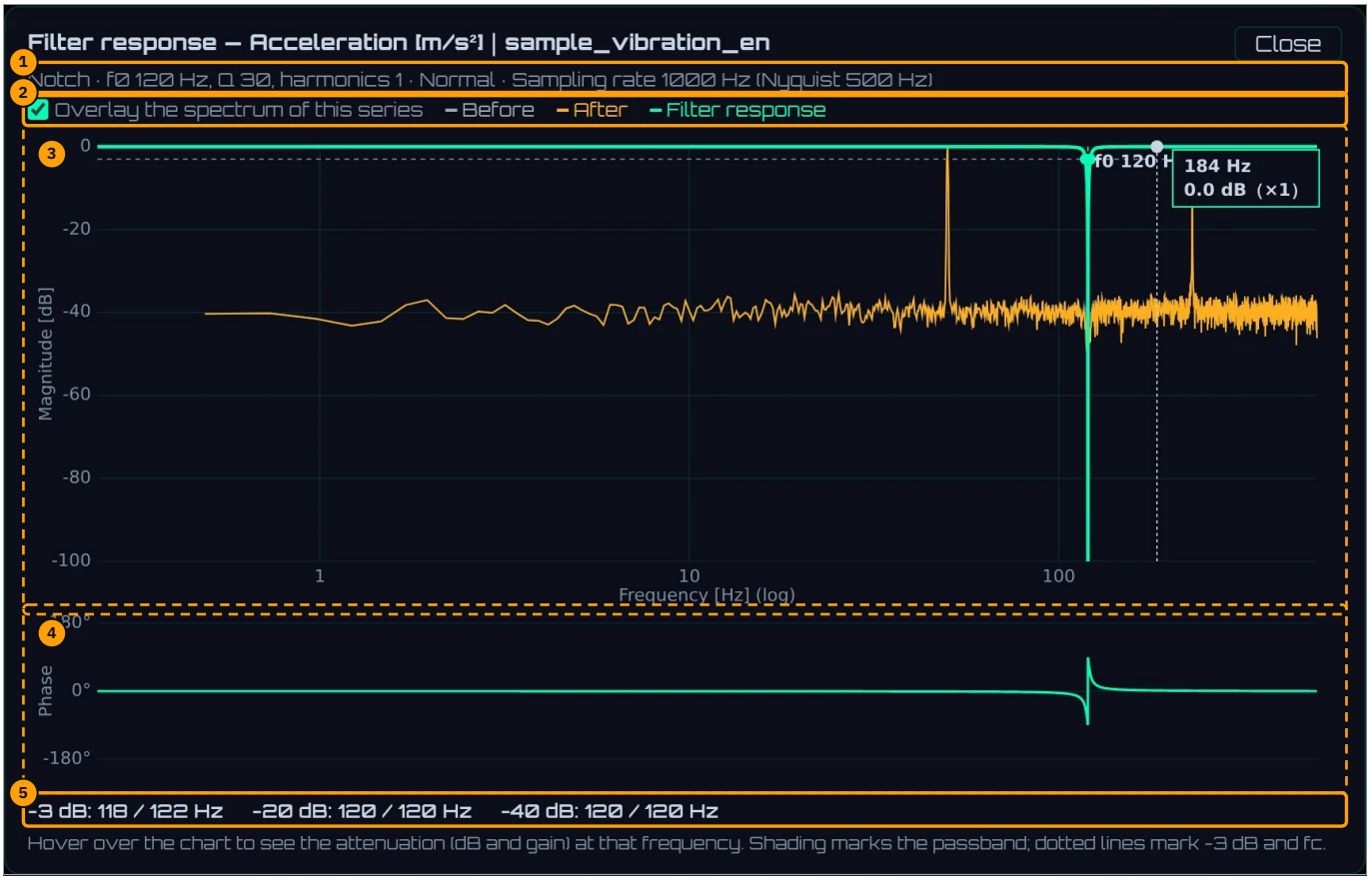

Figure 8-5 The larger view of a 120 Hz notch (Q 30). In the spectrum after filtering, the 120 Hz peak is gone

1. A summary of the settings and the data step (sampling frequency and Nyquist frequency)
2. [**Overlay the spectrum of this series**]: Overlays the spectrum of the series before (gray) and after (orange) filtering
3. Amplitude ratio (dB). Hover over the graph to see the attenuation (dB and gain) at that frequency
4. Phase shift. With [**Zero-phase**], there is none
5. The frequencies where the attenuation reaches −3 dB, −20 dB, and −40 dB, and the attenuation at 2× and 10× fc

To close it, click [**Close**] or press Esc.

Explanations and cautions shown

The following text is shown below the [**Filter**] field in the series details.

Display
[**Zero-phase: applied forward and backward, so the attenuation at the cutoff doubles (about −6 dB for Butterworth vs. −3 dB for a single p**
[**Band-pass: a high-pass (low fc) followed by a low-pass (high fc). When the two are close, frequencies between them are attenuated too**]
[**Band-stop: removes the band between the low and high fc (the low-pass prototype transformed to a band-stop; −3 dB at both edges)**]
Text starting with [**Notch: removes only around f0**]
Text starting with [**Moving average: the mean of**]
Text starting with [**Moving median: the median of**]
Text containing [**split at missing values and time gaps**]
Text containing [**Filters assume even spacing, so the result is approximate**]
Text containing [**is shorter than 3 periods of fc, so edge transients remain large in the result**]

Display
Text containing [**Not filtered**]

> **Caution: Do not apply a low fc to short segments**
>
> At the start of a segment, the filter starts by assuming that "the first value had continued all along" (with [**Zero-phase**], the same applies at the end of the segment when it is applied backward). If a segment is shorter than 3 periods of fc, the ringing (transients) at its start and end remains large in the result. Take particular care when applying a high-pass with a low fc to a series finely split by missing values.

Missing values and time jumps

The filter splits a series into segments at missing values (non-numeric values such as blanks) and time jumps (intervals of more than 1.5 times the median step), and applies the filter to each segment. Values are never connected across segments. Missing positions remain empty after filtering. The step used is the median of the intervals between adjacent points. Missing values and jumps do not cause the step to be overestimated.

8.5 STFT peak

STFT peak divides the data into short time windows, calculates a spectrum for each window, and finds the strongest frequency in each window. Use it to track changes in rotational speed or components that appear partway.

1. On the [**Analysis**] tab, choose the series to examine in [**Analysis target**].
2. Open [**STFT peak**] and enter [**Window**] and [**Step**].
3. Click [**Compute peak trend**].

Figure 8-6 STFT peak (window 1 second, step 0.25 seconds) calculated, with a peak series added

1. [**Window**], [**Step**], [**Results shown**]: The window length, the interval by which the window shifts, and the number of rows in the table
2. [**Compute peak trend**]: Calculates
3. Results table: The time at the center of the window, the strongest frequency, its strength, and [**Assessment**]. Sorted by strength in descending order
4. [**Add peak series**]: Adds the peak frequency of each window to the graph as a new series

In the sample data, the peak frequency changes from 49.8 Hz to 230.5 Hz only between 12 and 16 seconds. The added series (its name includes [**STFT peak**], and its unit is Hz) shows when the change occurred.

Setting	Default	Description
[**Window**]	10	Specified in X units. The number of points in the window is kept within 8–8192 points. For 1000 Hz data, specifying 10 seconds gives 8192 points (8.192 seconds). The window width actually used is shown in the result heading
[**Step**]	2	Specified in X units. It cannot be larger than the window width. If there would be too many calculations, it is widened automatically
[**Results shown**]	20	3–100

- The frequency resolution is 1 ÷ (the number of points in the window rounded up to a power of 2 × the step). With a 1-second window (1000 points → 1024 points), it is about 0.98 Hz. That is why 50 Hz is shown as 49.8 Hz and 230 Hz as 230.5 Hz.
- The window function and frequency unit are those of [**Window function**] and [**Frequency unit**] in [**FFT view**]. Strength is amplitude (0-p). When [**Quantity**] in [**FFT view**] is [**Power**], it is power.
- [**Assessment**] is the change compared with the peak frequency of the previous window. More than 8% higher is [**Rising**], more than 8% lower is [**Falling**], and anything else is [**Flat**].

> **Tip: Make the window shorter than the change you want to see**
>
> With a long window, short-term changes are averaged within the window and become invisible. If you calculate the sample data with the default settings (10, actually 8.192 seconds), only 5 windows can be taken, 50 Hz is the peak in every window, and the 230 Hz period does not appear. With a 1-second window, the 230 Hz period appears clearly. However, a shorter window makes the frequency resolution coarser.

8.6 Wavelet analysis

Wavelet analysis displays component strength on both time and frequency axes as a color distribution (scalogram). It is suitable for finding components that appear only briefly. The calculation uses the Morlet wavelet.

1. On the [**Analysis**] tab, choose the series to examine in [**Analysis target**].
2. Open [**Wavelet**] and, if necessary, enter [**Min frequency**] and [**Max frequency**].
3. Click [**Compute wavelet**].

Figure 8-7 Result of wavelet analysis (20–400 Hz)

1. [**Min frequency**], [**Max frequency**], [**Frequency bins**], [**Time limit**]: The frequency range to calculate, and how frequency and time are divided
2. [**Compute wavelet**]: Calculates
3. Scalogram: Time runs horizontally and frequency vertically (low at the bottom, logarithmic scale). Redder means a stronger component. The dark areas at the edges are the [**Cone of influence (COI)**]
4. Results table: The strongest frequency at each time (the ridge), sorted by strength in descending order

In the sample data, a 50 Hz band is visible throughout, and a 230 Hz band from 12 to 16 seconds.

Setting	Default	Description
[**Min frequency**]	[**Auto**]	Automatically, 1 ÷ the data length (seconds). About 0.056 Hz for the sample data
[**Max frequency**]	[**Auto**]	Automatically, 0.8 times the Nyquist frequency. 400 Hz for the sample data
[**Frequency bins**]	48	12–96. Divides the range from minimum to maximum into equal logarithmic intervals
[**Time limit**]	900	100–2000. The maximum number of points calculated in the time direction. The actual number also does not exceed 12000 ÷ [**Frequency bins**] (about 250 points with 48 bins)
[**Results shown**]	20	3–100

- The frequency unit follows [**Frequency unit**] in [**FFT view**]. When [**Frequency unit**] is Hz, the automatic lower limit is calculated in seconds regardless of the X-axis unit (when 1/X is chosen, it is calculated in X-axis units).
- The [**Cone of influence (COI)**] (the range affected by the boundaries) is the low-frequency part near the ends of the data. Strength in this part comes out small because the calculation is cut off at the ends. In the table, [**Assessment**] is [**Inside COI (indicative only)**], and these rows are also excluded from the ridge calculation. Other rows are [**Energy burst**] if their strength is at least half of the table maximum, and [**Baseline**] if less than half.
- With [**Add peak series**], you can add the ridge frequency at each time to the graph as a new series.

> **Note: Strength can be compared across frequencies**
>
> Wavelet strength is normalized so that for a sine wave it equals the square of the amplitude. With the same amplitude, the strength is the same even at different frequencies. In the sample data, 230 Hz (amplitude 1.5) at 12–16 seconds is shown stronger than 50 Hz (amplitude 1.0), and the ridge moves to around 230 Hz only during that time. The frequency scale consists of logarithmically spaced bins, so the ridge frequency is a bin value (for example, 225.4 Hz).

8.7 Frequency anomaly

Frequency anomaly extracts one metric from the spectrum of each window and lists windows where that metric differs greatly from usual as candidates.

1. On the [**Analysis**] tab, choose the series to examine in [**Analysis target**].
2. Open [**Freq. anomaly**] and enter [**Metric**], [**Window**], [**Step**], and [**Threshold**].
3. Click [**Detect frequency anomalies**].

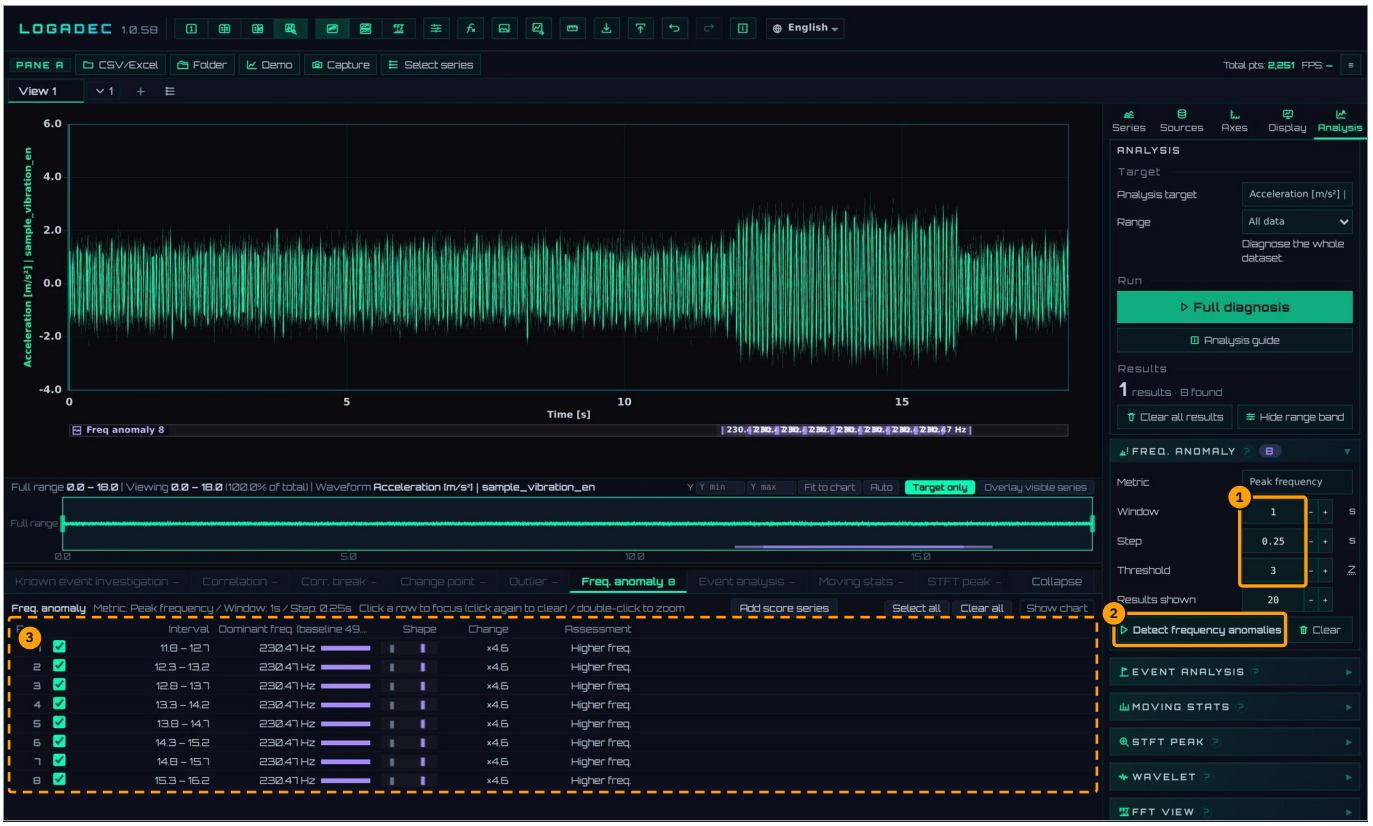

Figure 8-8 Result of frequency anomaly ([**Peak frequency**], window 1 second, step 0.25 seconds)

1. [**Metric**], [**Window**], [**Step**], [**Threshold**]: What to compare, the window length and interval, and the size of Z that makes a candidate
2. [**Detect frequency anomalies**]: Detects
3. Results table: The interval, main frequency, change, and verdict of each candidate window. Sorted in time order

In the sample data, 8 windows from 11.8 to 16.2 seconds become candidates. The main frequency is 230.47 Hz (about 4.6 times the baseline of 49.80 Hz), and [**Assessment**] is [**Higher freq.**].

Setting	Default	Description
[**Metric**]	[**Peak frequency**]	[**Peak frequency**]: The strongest frequency in the window. [**Peak amplitude**]: Its strength (amplitude 0-p). [**Band power**]: The mean of the squared values in the window (excluding 0 Hz; the unit is the square of the series unit)
[**Window**]	10	Specified in X units. The number of points in the window is kept within 8–8192 points (same as [**STFT peak**])
[**Step**]	2	Specified in X units
[**Threshold**]	3	0.5–20. Windows whose Z (how many times the usual spread they deviate) is at or above this value become candidates. The meaning of Z is explained in Chapter 9
[**Results shown**]	20	3–100

- Of candidates that are close together (closer than half the window width), the one with the larger Z is kept.
- [**Dominant freq. (baseline {b})**] in the results table is the peak frequency of the candidate window. The baseline is the median of the peak frequencies of all windows. [**Change**] is the ratio to the baseline: more than 1.15 times is [**Higher freq.**], less than 0.87 times is [**Lower freq.**], and anything else is

[**Flat**].

- The window function and frequency unit use the [**FFT view**] settings.
- With [**Add score series**], you can add Z for each window to the graph as a new series.
- As with [**STFT peak**], make the window shorter than the change you want to see. If you calculate the sample data with the default settings, only 5 windows can be taken, and there are 0 candidates.

8.8 Handling missing values and time jumps

Missing values (non-numeric values such as blanks) and time jumps (intervals of more than 1.5 times the median step) are handled by each feature as follows.

Feature	Handling	On-screen display
[**FFT view**]	Excludes missing points and calculates the remaining points packed into one series. Time jumps are also joined as they are for the calculation	[**Warning**] in the tier name (a note that the FFT frequencies are approximate because the X spacing varies widely)
[**Filter**]	Splits into segments at missing values and jumps, and filters each segment. Missing positions remain empty	Text containing [**split at missing values and time gaps**]
[**STFT peak**], [**Freq. anomaly**]	Rearranges the data onto an evenly spaced grid at the median step, leaving the positions of missing values and jumps empty. Gaps within a window are filled with that window's mean. Windows more than half empty are not calculated	[**missing points left empty**], [**missing points in windows filled with the window mean**], and [**windows skipped (more than half missing)**], each with its count, in the result heading
[**Wavelet**]	Rearranges onto the same grid, and fills gaps with the overall mean	[**missing points left empty**] with its count in the result heading

- Series in which X goes backward or the same X repeats are not calculated by any feature. The reason is shown on screen.
- When time jumps are too large to arrange the data on an evenly spaced grid, the analysis stops and asks you to select a range.

> **Tip: To see a spectrum that does not span jumps**
>
> [**FFT view**] joins jumps for the calculation, so the waves do not connect across a jump, and peaks can become lower and wider (when a 1.01-second jump was inserted in the middle of a 50 Hz sine wave and read with the default [**Window function**] (Hann), the peak of about 0.98 dropped to about 0.65 and split into peaks on both sides). For series with jumps, set [**Target**] to [**Current display range**], display only one side of the jump in the time-series view, and then switch to [**FFT**].

Chapter 9

Time-Domain Analysis

This chapter describes the analyses on the [**Analysis**] tab of the sidebar that examine how values change over time. Frequency analysis (FFT, STFT, Wavelet, [**Freq. anomaly**]) and filters are described in Chapter 8.

Analysis	What you learn	Suitable for
[**Moving stats**]	Mean, RMS, spread, maximum, minimum, and change within a window	Smoothing a strongly fluctuating signal to see the trend
[**Change point**]	Times when the level or slope of the values changed	Steps, level shifts, and the onset of changes
[**Outlier**]	Points that stand out from their neighbors	Single spikes and value jumps
[**Correlation**]	Series that move strongly together with the target series, and their time offset	Finding candidate causes
[**Corr. break**]	Time periods when the usual co-movement of two series broke down	Intervals where the amplitude is small but the relationship went wrong
[**Event analysis**]	Series that moved at the same time as, before, or after events in the target series	The trigger of an anomaly and the order in which it spread
[**Known event investigation**]	When the interval in which an anomaly occurred is known, the series that moved in that interval	Investigations where the time of a fault is known

The examples in this chapter use the sample data `sample_endurance_run_en.csv`. At 380–400 seconds, Vibration RMS and Current rise temporarily.

9.1 Common flow on the Analysis tab

The upper part of the [**Analysis**] tab is common to all analyses. It is divided into three stages: [**Target**], [**Run**], and [**Results**]. This part does not move when you scroll the sidebar, so you can always see what is being analyzed over which range, even while looking at the analysis cards below.

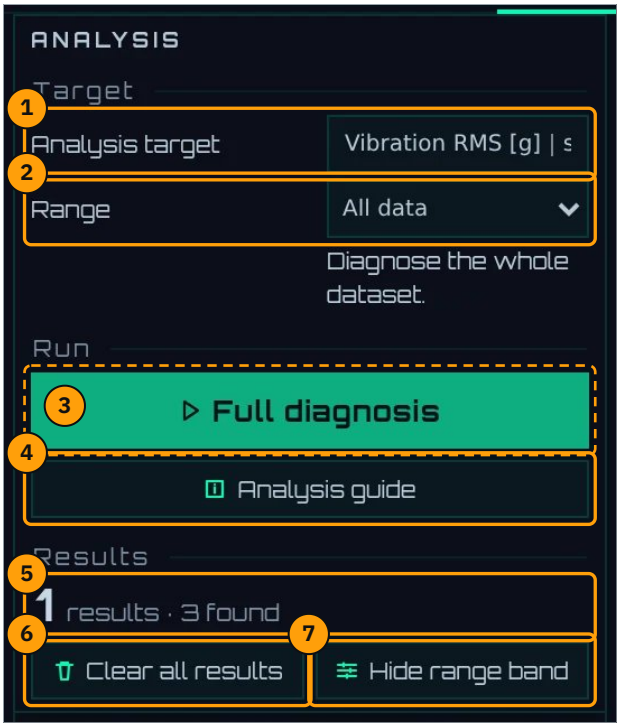

Figure 9-1 The upper part of the Analysis tab (after running change-point detection)

1. [**Analysis target**]: Choose the series to analyze. Enter part of a name to filter
2. [**Range**]: The X range to analyze ([**All data**], [**Visible**], [**Selected**])
3. [**Full diagnosis**]: Runs the analyses all at once (described later)
4. [**Analysis guide**]: Choose which analysis to use based on what you want to find out
5. Result count: The number of analyses with results, and the total number of findings
6. [**Clear all results**]: Clears all analysis results and the marks on the graph (including the results of [**Known event investigation**])
7. [**Hide range band**]: Hides the light-blue display showing the [**Selected**] range (the range itself remains)

1. Choose the target

- [**Analysis target**]: All analyses target the one series chosen here. Hidden series can also be chosen. Series of data sources hidden on the [**Sources**] tab are not listed. When you change the target, the previous results of each analysis and of [**Full diagnosis**] (summary and findings) are cleared, and the count above returns to 0.
- [**Range**]: Choose the X range to analyze.

Range	Range analyzed
[**All data**]	The whole loaded data
[**Visible**]	The X range currently visible on the graph. If you zoom in on an area of interest first, you can examine just that area
[**Selected**]	A specified range. Click [**Specify range**], then click (or drag) the start and end on the graph, or enter numbers in the two fields below. If you enter only one end, the other end becomes the end of the data (the field stays empty and shows the end value in light text). If the start is after the end, they are swapped and you are notified. [**Clear**] cancels the specification

[**Corr. break**] and [**Known event investigation**] have their own separate ranges in their cards (described later). The number of specified ranges is shown in the [**Clear all ranges**] button (the button does not appear when there are none), and this button clears all specifications at once. Analysis results are not cleared.

2. Run

Analyses are run one at a time in the cards listed below. Click a card's heading to open it. In every card, set the conditions and click the run button (for example, [**Detect change points**]). [**Clear**] clears only that card's results.

Button	Available in	Action
[⚙ **Auto run**]	[**Change point**], [**Event analysis**]	Determines the window width and threshold automatically and combines the results of several trial settings into candidates. The chosen values are entered in the card's fields, and the reasons are shown above the results
[**Add score series**], [**Add to series**]	Moving stats, change point, outlier, correlation break, and others	Adds intermediate values of the analysis (scores or moving averages) as new series (described later)
◀, ▶ ([**Zoom to previous finding**], [**Zoom to next finding**])	Change point, outlier, correlation break, event analysis, and others	Zooms in on the detected positions one after another

Enter time fields such as the window width in the X unit of the loaded data (the unit is shown to the right of the field). For data with X in milliseconds, 5 seconds is 5000.

Click [**Analysis guide**] to see a list of goals, such as "Pinpoint sudden jumps / spikes" and "Extract series that move around an anomaly timing". Choose one to open the cards of the analyses suited to it.

> **Note: Calculations use all points**
>
> Analyses use the numeric points within the range without thinning them out. There is no setting that reduces the number of points for speed.

3. View the results (the investigate screen)

When you open the [**Analysis**] tab, the screen switches to the [**Investigate**] layout. Below the graph, an overview waveform and a table of analysis results appear. In [**2 panes**], opening the [**Analysis**] tab of Pane B shows Pane B in this layout (click [**2 panes**] to return).

Figure 9-2 The investigate screen (change points detected in Vibration RMS)

1. [**Investigate**]: The screen switches to this layout automatically when you open the Analysis tab
2. Result marks: One row per kind of analysis, showing the detected positions
3. Overview waveform: A frame shows the range you are currently viewing. Drag the frame to move it, and drag its edges to zoom in or out. Click outside the frame to move to that position
4. Analysis tabs: Switch between the results of each analysis. The number is the count of findings (– means the analysis has not been run yet)
5. Results table: Sort by clicking a column heading. Drag the border between columns to change column widths
6. Analysis cards: Set conditions and run

- Collapse the table with [**Collapse**] at the top right of the results table to use more of the screen for the graph. Drag the border between the table and the graph to change the table height.
- The "Shape" column in the table is a small drawing of the waveform around the detected position.
- Click [**Show chart**] at the top right of the table to also show the results as a chart (trends or rankings).

If you do not want this switch, open [**Display & bulk actions**] under [**Other**] below the cards and uncheck [**Open the Investigate view when the Analysis tab opens**]. This setting is kept in the browser you use. When you return to [**1 pane**] or another layout, the results are shown inside the cards in the sidebar.

Setting in [Display & bulk actions]	**Description (initial state)**
[**Chart legend**]	Shows an analysis legend on the graph (on)
[**Result tracks**]	Shows rows of result marks below the graph (on)
[**Marks on chart**]	Marks shown inside the graph: [**Glyphs (flag / step / ring)**], [**Vertical dashed lines**], [**Range brackets and ▼**], [**Range fill**] (all off)
[**Auto-widen sidebar on Analysis tab**]	When not on the investigate screen, widens the sidebar when you open the Analysis tab (on)
[**Open the Investigate view when the Analysis tab opens**]	Switches to [**Investigate**] when you open the Analysis tab (on)
[**Result cards on chart**]	The number of result cards overlaid on the graph ([**Off**])

Working with the results table

Some results tables have one row per "position" ([**Change point**], [**Outlier**], [**Corr. break**], and others), and some have one row per "series" ([**Correlation**], the candidates of [**Event analysis**], [**Known event investigation**]).

Action	Table with position rows	Table with series rows
Row check box	Shows the mark for that finding below the graph	For [**Event analysis**] candidates, selects the series to display when you click [**Show candidates**]
Click	Highlights that position on the graph (focus)	Displays that series and highlights the related positions. Series displayed by the previous click are hidden again
Click again	Removes the highlight	Removes only the highlight (the series stays displayed)
Double-click	Zooms in around that position	—
`Ctrl` + click	—	Displays the series in addition, keeping the previously displayed series
`Shift` + click	—	Displays (or hides) all series between two rows at once

You can also remove the highlight by clicking outside the table or pressing `Esc`.

Tidy up displayed series

When some series have been displayed by clicking rows, [**Tidy up shown series**] appears below the result count. Click it to hide again only the series that were displayed by clicking rows. Series you displayed by checking them yourself stay displayed.

Turn intermediate values into series

Click [**Add score series**] ([**Add to series**] for [**Moving stats**]) to add intermediate values of the analysis as a new series. Added series can be displayed, saved, and exported like ordinary series, and can also be the target of another analysis.

Analysis	Series added (example)	Unit
[**Moving stats**]	Vibration RMS Moving average	Same as the original series ([**Rate (Δ per X unit)**] is "Y unit/X unit")
[**Change point**]	Vibration RMS change-point score	Z
[**Outlier**]	Vibration RMS outlier score	Z
[**Corr. break**]	Target series name + correlation-break score	drop (amount of decrease in correlation)

Data used for calculation ([**Filtered (as displayed)**], [**Raw data**])

The [**Outlier**], [**Correlation**], and [**Corr. break**] cards have a [**Data**] field.

Option	Values used for the calculation
[**Filtered (as displayed)**] (initial state)	The values plotted on the graph: the values after the unit conversion and filter set with the series' ▾ (Chapter 5)
[**Raw data**]	The values as loaded from the file

> **Caution: [Data] is shared by all analyses**
>
> [**Data**] in the three cards is one and the same setting. Changing it in one card changes the other two as well, and analyses such as [**Change point**] and [**Moving stats**] also calculate with the same data. Likewise, [**Method**] in [**Correlation**] and [**Corr. break**] is one setting.

Handling missing values and the direction of X

- **Empty or non-numeric values**: Those points are not used. Analyses that use a window width arrange the points on a grid at the X step (the median step) for calculation, so missing positions remain empty. A window never spans a gap to put distant points into the same window. For results with missing points, the count is shown above the results, like "100 missing points left empty".
- **Time jumps**: Time gaps wider than 1.5 times the step are also treated as missing. When matching series by time (correlation, correlation break, event analysis), values are never filled in across missing values or gaps.
- **Data where X goes backward**: Series in which X becomes smaller than the previous point, or the same X repeats, are not analyzed. When the analysis target is such a series, you are notified with a message like ""…" cannot be analysed: X goes backward (1) or repeats (0)". Narrowing [**Range**] does not change this (the whole series is checked before the range is cut out). When a non-target series is like this, that series does not appear in the results.
- Right before and after a gap, fewer points are in the window, so [**Change point**] and others may produce extra candidates. Check on the graph whether a candidate position falls on the edge of a gap.

Full diagnosis

Click [**Full diagnosis**] to run the following analyses in order under the [**Analysis target**] and [**Range**] conditions. Window widths and similar settings are determined automatically from how quickly the target series changes (the reference time constant). The chosen values are written in the summary. The fields in the [**Change point**] and [**Event analysis**] cards (method, window width, threshold, and so on) are not overwritten.

1. [**Change point**] ([⚙ **Auto run**])
2. [**Event analysis**] ([⚙ **Auto run**])
3. [**Outlier**]
4. [**Freq. anomaly**]
5. [**Corr. break**]
6. [**Correlation**]
7. [**Moving stats**]
8. [**STFT peak**]
9. [**Wavelet**]
10. [**Known event investigation**] (only when an abnormal interval is specified)

The results are collected on the [**Full diagnosis**] tab. Click a row to move to that analysis's tab and zoom in on the corresponding position. The results of each analysis are also placed on their own tabs.

Figure 9-3 Results of full diagnosis (sample Vibration RMS, all data)

1 The [**Full diagnosis**] tab: The summary is on the left, and the findings of each analysis are listed one per row on the right

[**Freq. anomaly**] is run with five window widths, and only the places that at least half of them mark as anomalous become findings (with a single window width, places where nothing happens can be counted as anomalies).

Full diagnosis is the starting point when you do not know where to begin. For analyses that produced findings, change the conditions in their cards to confirm.

Practice with the analysis tutorial

Click [**Demo**] in the pane bar, choose [**Analysis tutorial**] in [**Type**], and click [**Generate**] to create practice data for analysis (6 series, 120 seconds, step 0.01 seconds). The analysis cards are filled with conditions suited to this data. If you run each analysis as-is, the following positions are detected.

Analysis	Detected positions
[**Outlier**]	24.5, 72.2, 101.4 seconds
[**Change point**]	42, 88 seconds
[**Freq. anomaly**]	Around 58–72 seconds
[**Corr. break**]	Around 58–75 seconds

The series names ([**Normal tracking**], [**Delayed response**], [**Leading event**], [**Unrelated noise**], and so on) indicate the role of each series.

[**Full diagnosis**] also finds the positions above for [**Outlier**], [**Change point**], and [**Freq. anomaly**]. It does not find the [**Corr. break**], because Full diagnosis chooses the other series automatically (the most correlated one, [**Normal tracking**]). To find the break with [**Correlation break**], choose it as the other series in the card.

If you add `?demo=tutorial` to the end of the address when you open the file in a browser, the analysis tutorial data is created at startup (only when Pane A has no data).

9.2 Moving stats

Calculates statistics within a window for the target series. The window is "that point and the window width before it". The results are shown in the sidebar and on the [**Moving stats**] tab, and can be added as a series with [**Add to series**].

[**Type**]	**Value calculated**
[**Moving average**] (initial state)	The mean within the window
[**Moving RMS**]	The root mean square within the window
[**Moving std dev**]	The standard deviation within the window
[**Moving min**], [**Moving max**]	The minimum and maximum within the window
[**Delta (now − prev)**]	The current value − the value one window width earlier. Not calculated if there is no point one window width earlier
[**Rate (Δ per X unit)**]	The change ÷ the difference in X

- The initial value of [**Window**] is 5 (in X units).
- The results show the number of points in the window, the number of points output, and the mean, maximum (position), and minimum (position).
- Results appear only at positions where the original series has points. Missing positions remain empty.

> **Tip: Find gradual changes**
>
> Small, slow changes are easier to find if you calculate [**Rate (Δ per X unit)**] with a fairly long window, add it as a series, and run [**Event analysis**] ([**High-value event**], [**Low-value event**]) with that series as the target.

9.3 Change-point detection

Finds times when the level (or slope) of the values changed. For each point, windows are taken before and after it, the difference between the before window and the after window is calculated point by point, and places where that difference is larger than usual become candidates.

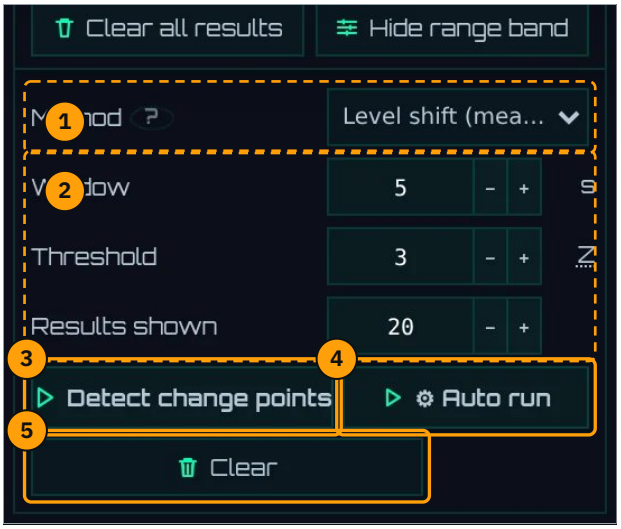

Figure 9-4 The [**Change point**] card

1. [**Method**]: Choose [**Level shift (mean diff)**] or [**Slope change (trend diff)**]
2. [**Window**], [**Threshold**], [**Results shown**]
3. [**Detect change points**]: Detects with these conditions
4. [⚙ **Auto run**]: Determines the window width, threshold, and method automatically, then detects
5. [**Clear**]: Clears this card's results

Setting	Description	Initial value
[**Method**]	[**Level shift (mean diff)**]: The difference between the means of the before and after windows. Suitable for steps and level shifts. [**Slope change (trend diff)**]: The difference between the slopes of the regression lines of the before and after windows. Suitable for the start and end of gradual changes	[**Level shift (mean diff)**]
[**Window**]	The length of the before and after windows (in X units). Set it to about the length of the change you are looking for	5
[**Threshold**]	The minimum Z for a candidate (0.5–20)	3
[**Results shown**]	The maximum number of candidates shown (3–100)	20

Z (robust Z-score)

The thresholds of [**Change point**], [**Outlier**], and [**Event analysis**] are set in Z. Z is a number that expresses "how many times the usual spread a value deviates".

- Z = (value − median) ÷ (MAD × 1.4826). MAD is the median of the absolute differences from the median. Multiplying by 1.4826 gives a size equivalent to the standard deviation of a normal distribution.
- Because the median and MAD are used instead of the mean and standard deviation, the yardstick is not pulled by the abnormal values themselves.
- As a guideline, 2 is sensitive (more candidates), 3 is standard, and 4–5 catches only definite anomalies.
- In [**Change point**], Z is calculated over the sequence of differences between the before and after windows. Open [**About Z-score**] in the card to read the same explanation.

Reading the results

When points above the threshold are consecutive, they are merged into the single point with the largest Z within the window width. A line above the results such as "238 pts over threshold -> merged to 1 per 5s window: 3 shown" gives this breakdown.

Column	Description
[**Position**]	The X of the change point
[**Score**]	Z
[**Before → after (Δ)**]	The means before and after the change point, and their difference
[**Duration**]	The length until the next change point (for the last change point, until the end of the data)
[**Assessment**]	Rise or fall, and the shape of the change ([**Step**], [**Spike**], and so on)

When you examine Vibration RMS in the sample data with the initial conditions ([**Level shift (mean diff)**], window width 5, Z 3), three places are found: 239.4 seconds (where speed was raised to 3000 rpm), and 380.0 and 400.0 seconds (where vibration rose and returned) (see the figure of the investigate screen).

9.4 Outlier detection

Finds points that stand out from the surrounding points (the Hampel method). A window is taken centered on each point, and the point's Z is calculated from the median and MAD within the window.

Setting	Description	Initial value
[**Data**]	[**Filtered (as displayed)**], [**Raw data**] (described above; shared by all analyses)	[**Filtered (as displayed)**]
[**Window**]	The window length including both sides of the center (in X units). Kept between 3 and 801 points	5
[**Threshold**]	The minimum Z for an outlier (0.5–20)	3.5
[**Results shown**]	The maximum number of candidates shown	20

Figure 9-5 Outliers in the analysis tutorial (24.5, 72.2, 101.4 seconds)

1. The [**Outlier**] tab
2. Results table: [**Position**], [**Score**] (Z), [**Value**], the window [**Median**], [**Assessment**]

- "Spike (recovers within 3 samples)" in [**Assessment**] means that the value returned close to the median within 3 points.

- When the window contains almost the same value throughout (MAD is 0), points that differ from the median are reported as strong outliers with a score of 99. For signals with constant stretches or coarse resolution (quantized signals), even a one-step difference becomes a candidate.

9.5 Correlation analysis

Calculates the correlation between the [**Analysis target**] and all other series, and lists them in order of correlation strength. It can also search for a time offset (lag).

Setting	Description	Initial value
[**Method**]	[**Pearson**]: The linear relationship between values. [**Spearman**]: The relationship between the ranks of values (robust to curved relationships and outliers). [**Difference correlation**]: The correlation between differences from the previous point (removes slow trends to see co-movement of fine fluctuations)	[**Pearson**]
[**Data**]	Described above (shared by all analyses)	[**Filtered (as displayed)**]
[**Max lag**]	The range over which to search for a time offset (in X units). At 0, no offset is searched	0
[**Lag step**]	The step for searching offsets. 0 is automatic (the data step). Up to 151 offsets are searched; if there would be too many, the step is widened, and the area around the best offset is searched again more finely	0
[**Results shown**]	The number of series shown (3–100)	20

The partner series are compared at the times of the target series. When searching for offsets, offsets at which the overlapping points are fewer than half of the total (at least 10 points) are not used.

Figure 9-6 Results of correlation analysis (analysis tutorial; the verdict column is widened by dragging its border)

1. [**Correlation**]: The correlation coefficient r (−1 to +1). The bar length is |r|
2. [**Lag**]: The time offset adopted
3. [**95% CI**], [**p-value**]: The 95% confidence interval and the p-value (corrected for the number of offsets searched)
4. [**Assessment**]: Strength, direction, significance, and the direction of the time offset

Significance ([95% CI], [p-value])

Points in a time series are not independent of each other, so using the number of points as-is makes even chance correlations look significant. LOGADEC calculates the confidence interval and p-value with an effective number of points that takes the autocorrelation of the series into account. When offsets are searched, the p-value and confidence interval are corrected for the number of offsets searched (Bonferroni). The corrected confidence interval spans 0 when the corrected p-value is greater than 0.05.

Significance is shown in one of the following three ways.

State	Condition	Display in [Assessment]
Significant	The p-value was obtained and is 0.05 or less	Strength and direction. Example: Strong positive
[**No significant evidence**]	The p-value was obtained and is greater than 0.05	[**No significant evidence**]
Not computed	No p-value is calculated (with [**Difference correlation**], and also when the effective number of points is too small)	"([**significance not computed**])" after the strength and direction. [**95% CI**] and [**p-value**] are —

- Strength is "Strong" when |r| is 0.7 or more, "Moderate" when 0.3 or more, and "Weak" when smaller.

- [**No significant evidence**] does not mean "there is no correlation". It means that with this number of points and this spread, you cannot say there is a correlation.
- Series whose confidence interval spans 0 are shown in gray in the chart.

Direction of the time offset

When [**Lag**] is positive, the partner series moves before the target (a candidate for the cause). When it is negative, the partner follows later. [**Assessment**] adds the direction in words.

[**Lag**]	**How [Assessment] is written**
Positive (example: +30.00 s)	Example: Strong positive ([**candidate leads by**] 30.00 s)
Negative (example: −1.11 s)	Example: Moderate positive ([**candidate lags by**] 1.11 s)
0	Strength and direction only

In the analysis tutorial, [**Delayed response**] is "Moderate positive (partner lags by 1.11 s)", and [**Correlation break**], [**Leading event**], and [**Unrelated noise**] are [**No significant evidence**] (figure above). With Vibration RMS in the sample data as the target and [**Max lag**] set to 30, Coolant temp and Oil temp are "partner lags by 30.00 s". This is because temperatures follow changes in rotation with a delay. Conversely, with Coolant temp as the target, Speed, Current, Voltage, and Vibration RMS are "partner leads by 30.00 s" (Voltage is negatively correlated). When the offset equals [**Max lag**], it has hit the edge of the search range. Widen the range to confirm.

How full diagnosis reports it

The [**Correlation**] row of [**Full diagnosis**] counts only series that are significant with |r| of 0.3 or more.

- When there are matching series: It reports the number of matching series and the strongest series, like "Correlation: 5/5 [**series significant (|r|≥0.3)**]. Strongest: Current (r=0.80, Strong positive)".
- With [**Difference correlation**], when no series has significance computed: It reports "Correlation: [**significance not computed**] with the difference method (5 series; ⋯)".
- Otherwise: It reports "Correlation: none significant (5 series)".

View candidates on the graph

Click a row to display that series on the graph and highlight it. Click [**Show top**] in the sidebar card to display only the target series and the series checked in the table, hiding the other series.

9.6 Correlation break

Finds time periods when the usual co-movement of two series broke down. It is suitable for finding changes that begin as a shift in the relationship, even if they are small in amplitude.

1. Calculates the correlation of the two series over the whole range (the baseline correlation).
2. Shifts a window and calculates the correlation in each window.
3. Windows where the drop from the baseline correlation (measured in the direction of the baseline correlation) is at least [**Drop threshold**] become candidates. When the direction of the correlation reverses, the drop exceeds 1 (for example, +0.9 → −0.9 gives 1.8).

Setting	Description	Initial value
[**Target series**], [**Comparison series**]	The two series to compare. Chosen separately from the [**Analysis target**]	—
[**Range**]	[**All data**], [**Current display range**], [**Specified chart range**]. Specify [**Specified chart range**] with [**Specify range**]	[**All data**]
[**Method**], [**Data**]	Settings shared with correlation analysis	[**Pearson**]
[**Window**], [**Step**]	The window length and the step by which it shifts (in X units). The step is never wider than the window	10, 2
[**Drop threshold**]	The minimum drop for a candidate (0.01–2)	0.4
[**Results shown**]	The maximum number of candidates shown	20

Figure 9-7 Correlation break in the analysis tutorial (around 58–75 seconds)

1. [**Target series**], [**Comparison series**]
2. [**Range**]: A range for this card only
3. Results table: [**Interval**], [**Pair**], [**r before → after**] (baseline correlation → window correlation), [**Assessment**]

[**Assessment**]	Meaning
[**Inverted**]	The window correlation is in the opposite direction from the baseline, with an absolute value of 0.3 or more
[**Decorrelated**]	The absolute value of the window correlation is less than 0.3
[**Weak**]	Neither of the above, but weaker than the baseline

9.7 Event analysis

Finds "events" in the target series and examines whether other series moved at the same time, before, or after them.

Setting	Description	Initial value
[**Type**]	How events are found (table below)	[**Sudden change (diff Z)**]
[**Anchor time**]	The X of the event with [**Specified time (known event)**]. Use [**Pick on chart**] to take it from the graph	—
[**Threshold**]	The minimum Z for an event (0.5–20)	3
[**Pre-window**], [**Post-window**]	The ranges before and after the event in which to look for movement of other series (in X units)	5, 5
[**Min interval**]	Events closer than this are merged into one	1

[**Type**]	Where events are placed
[**Sudden change (diff Z)**]	Where the difference between adjacent points is large (the Z of the difference is at or above the threshold)
[**Specified time (known event)**]	Only the one specified time. Use it when the time of the anomaly is known
[**High-value event**], [**Low-value event**]	Where the Z of the value itself is high or low
[**Change-point candidate**]	Where the difference between the means of the before and after windows is large. The window is twice [**Min interval**] (it also catches gradual co-movement)

Up to 80 events are found. For each other series, the place with the largest Z of change within the range before and after the event is found, and if it exceeds the matching criterion, it counts as a "match". The matching criterion is set taking into account how much that series moves where there are no events. This makes it harder for noisy series to match even unrelated events.

Figure 9-8 Sample Vibration RMS examined with [**Change-point candidate**]

1 [**Events**]: The events found (close events are merged and shown with start, end, and duration)

2 [**Candidate series (check to show on chart)**]: The matching series, in descending order of matches

Candidate column	Description
[**Match**]	The number of matched events / the number of events
[**Lead/lag**]	The average time offset at the matches. Negative means leading (moved before the target), positive means lagging
Z	The average Z of change at the matches

For Vibration RMS in the sample data, around 380 and 400 seconds and 239.4 seconds become events, and Current and Voltage match 7/7. With [**Sudden change (diff Z)**] left as-is, the fine fluctuations of vibration also become events, reaching 80. In that case, raise [**Threshold**], or use [**Change-point candidate**] or [**Specified time (known event)**].

> **Note: Number of candidates**
>
> The number of series shown as candidates is determined by [**Results shown**] in the [**Correlation**] card (20 at first).

Click [**Show candidates**] to display only the target series and the checked candidate series.

9.8 Known event investigation

Use this when the interval in which an anomaly occurred is already known. It compares that interval (the abnormal interval) with a normal interval (the baseline), examines all series, and lists the series likely to be related together with the evidence. It is used differently from [**Full diagnosis**], which searches the whole data for anomalies.

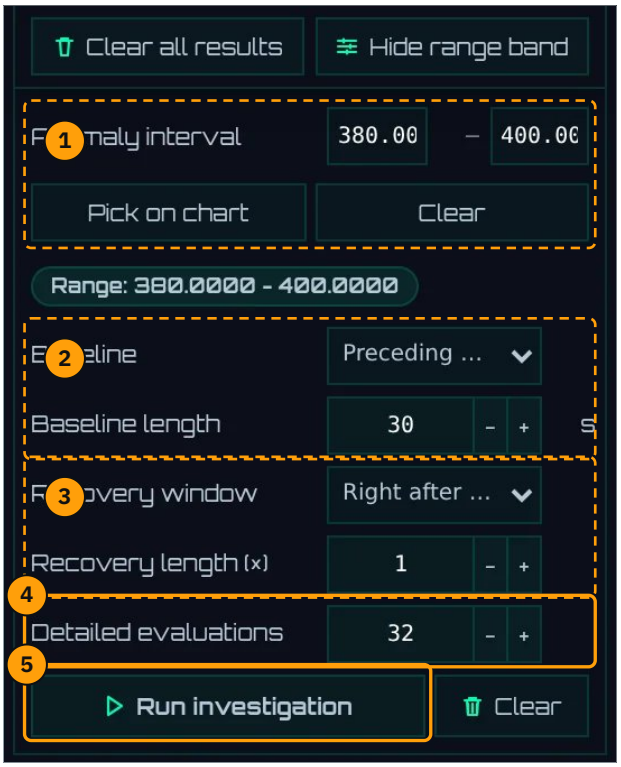

Figure 9-9 The [**Known event investigation**] card (abnormal interval 380–400 seconds)

1. [**Anomaly interval**]: Enter numbers, or specify it on the graph with [**Pick on chart**]
2. [**Baseline**], [**Baseline length**]: The normal interval to compare against
3. [**Recovery window**], [**Recovery length (×)**]: The interval after the abnormal interval (to see whether things returned to normal)
4. [**Detailed evaluations**]: The maximum number of series to examine in detail
5. [**Run investigation**]: Runs the investigation

Setting	Description	Initial value
[**Anomaly interval**]	The interval in which the anomaly occurred. If you enter only one end, the other end becomes the end of the data (the field stays empty and shows the end value in light text)	—
[**Baseline**]	[**Preceding N sec**]: The interval of [**Baseline length**] right before the abnormal interval. [**Selected normal interval**]: An interval specified on the graph with [**Pick normal interval**]	[**Preceding N sec**]
[**Baseline length**]	The length of the preceding interval (in X units; if X is in milliseconds, 30 seconds is 30000)	30
[**Recovery window**]	[**Right after the anomaly interval**]: The interval immediately after the abnormal interval. [**Do not use**]: No recovery interval is used	[**Right after the anomaly interval**]
[**Recovery length (×)**]	Length of the recovery interval = length of the abnormal interval × this scale (0.1–10). Not used if not even half of it can be taken before the end of the data	1
[**Detailed evaluations**]	The number of series examined in detail in stage 2 (1–200)	32

How it examines

1. **Stage 1 (all series)**: For the abnormal interval and the normal interval, calculates the difference in medians (as a multiple of the usual spread) and the ratio of spreads. Series that do not cover at least half of the abnormal interval, and series that hardly move in either (the median difference is less than 1.5 times the usual spread, and the spread ratio is between about 0.7 and 1.4), are excluded here.
2. **Stage 2 (in descending order of change, up to the number set in** [**Detailed evaluations**]**)**: Calculates the change-point time, the correlation with a search for time offset, and a spectrum comparison. The range for the correlation offset search is the length of the abnormal interval (at least 20 data steps) when [**Max lag**] in [**Correlation**] is 0.
3. Using the change-point time (or the correlation offset if there is none), the series are classified as [**Leading**], [**Simultaneous**], or [**Lagging**]. The width for "simultaneous" is the larger of 3 times the data step and 5% of the length of the abnormal interval. Series whose level hardly changed and whose correlation offset hit the edge of the search range are classified as [**Unrelated**].

Reading the results

Figure 9-10 Sample Vibration RMS with 380–400 seconds as the abnormal interval

1 [**Related candidates**]: The evidence for each series. Sort by clicking a column heading

2 Switches between [**Event timing**], [**Three-window comparison**], and [**Spectrum comparison**]. Choose the series to view in detail in the field on the right

3 [**Event timing**]: 0 is the start of the abnormal interval. Dots are change-point times, and lines extend to the correlation offset

Column	Description
Class	[**Leading**], [**Simultaneous**], [**Lagging**], [**Unrelated**]
[**Δt (change point)**]	The time from the start of the abnormal interval to the change point. Negative means leading
Lag correlation	The r of the correlation with an offset search, and that offset (r value @ offset). **Here, negative means leading** (the sign is opposite to [**Lag**] in correlation analysis, aligned with the direction of Δt)
[**Level shift**]	The median difference ÷ the usual spread (σ)
[**Spread change**]	The ratio of spreads (for example, ×0.4)
[**Spectrum**]	The result of comparing the spectrum split into low, mid, and high bands (bands match, low band up, and so on)
[**Overlap**], [**Missing**]	How much of the abnormal interval is covered, and the proportion missing
Recovery	Whether the recovery interval returned to the normal interval ([**returned**], [**did not return**]). It is [**returned**] if the median difference is within the usual spread and the spread ratio is about 0.7–1.4

In the sample data, Current (+19.0 σ) and Voltage (−2.9 σ) are [**Simultaneous**] and [**returned**]. Oil temp and Coolant temp appear as [**Leading**], but this is because the temperatures keep rising slowly. Series that keep moving slowly can appear as [**Leading**], so check their shape on the graph.

- [**Three-window comparison**] lists the median, spread, slope, and number of points of the three intervals (normal, abnormal, recovery), and states whether things returned to normal.

- [**Spectrum comparison**] overlays the spectra of the three intervals. When X is in a time unit (s, ms, and so on), frequencies are shown in true Hz (fixed in 1.0.28 so that ms data shows the same Hz as the FFT).
- [**Show all**] and [**Hide all**] above the table show or hide all candidate series on the graph at once.
- The results indicate temporal association and do not guarantee causation.

Export the results to CSV

Click [**Export candidates + event window (CSV)**] to save `logadec_known_event.csv`. This button is in the sidebar card, so it is not shown on the [**Investigate**] screen. Switch to [**1 pane**], open the [**Known event investigation**] card, and click it (the results remain).

The CSV consists of three parts.

Part	Contents
Leading `#` lines	The target series, the abnormal interval (`# event`), the normal interval (`# baseline`), the recovery interval (`# recovery`), the X unit (`# x_unit`), and the sign convention (`# sign`; negative means leading)
Candidate table	One series per row. Class (`lead`, `coi`, `lag`, `none`), Δt, correlation, offset, level change, spread change, spectrum, overlap, missing, recovery, and the median and spread of the three intervals
Data	The values of the target and candidates from the start of the normal interval to the end of the abnormal interval

- **Units of Δt and offset**: When the X unit is known to be a time unit (s, ms, and so on), the values are converted to seconds and written in the `dt_sec` and `lag_sec` columns. Otherwise they are written in X units as `dt_x` and `lag_x`. Interval values and data X stay in X units.
- **Series with different steps**: If all series have the same X as the target, an `x` column is followed by the value columns of the series. If even one series has a different step (such as a series from another file), each series is written as a pair of an `x:series name` column and a value column. This is because aligning by row number would put values from different times on the same row (fixed in 1.0.27; before that, rows were aligned, and ms values were written in the `dt_sec` column).

Chapter 10

XY Analysis

XY analysis plots two series against each other on the horizontal axis (X) and the vertical axis (Y), drawing values at the same times as points. For example, with Speed as X and Current as Y, you can see in one chart how current increases as speed rises. You can also draw fitted curves through the points and get the equation and the goodness of fit (R^2).

This chapter uses Speed and Current from the sample data `sample_endurance_run_en.csv`.

10.1 Open XY analysis

Click [**Analysis**] on the toolbar at the top of the screen to show the time-series graph (Pane A) on the left and XY analysis on the right. XY analysis uses the data loaded in Pane A.

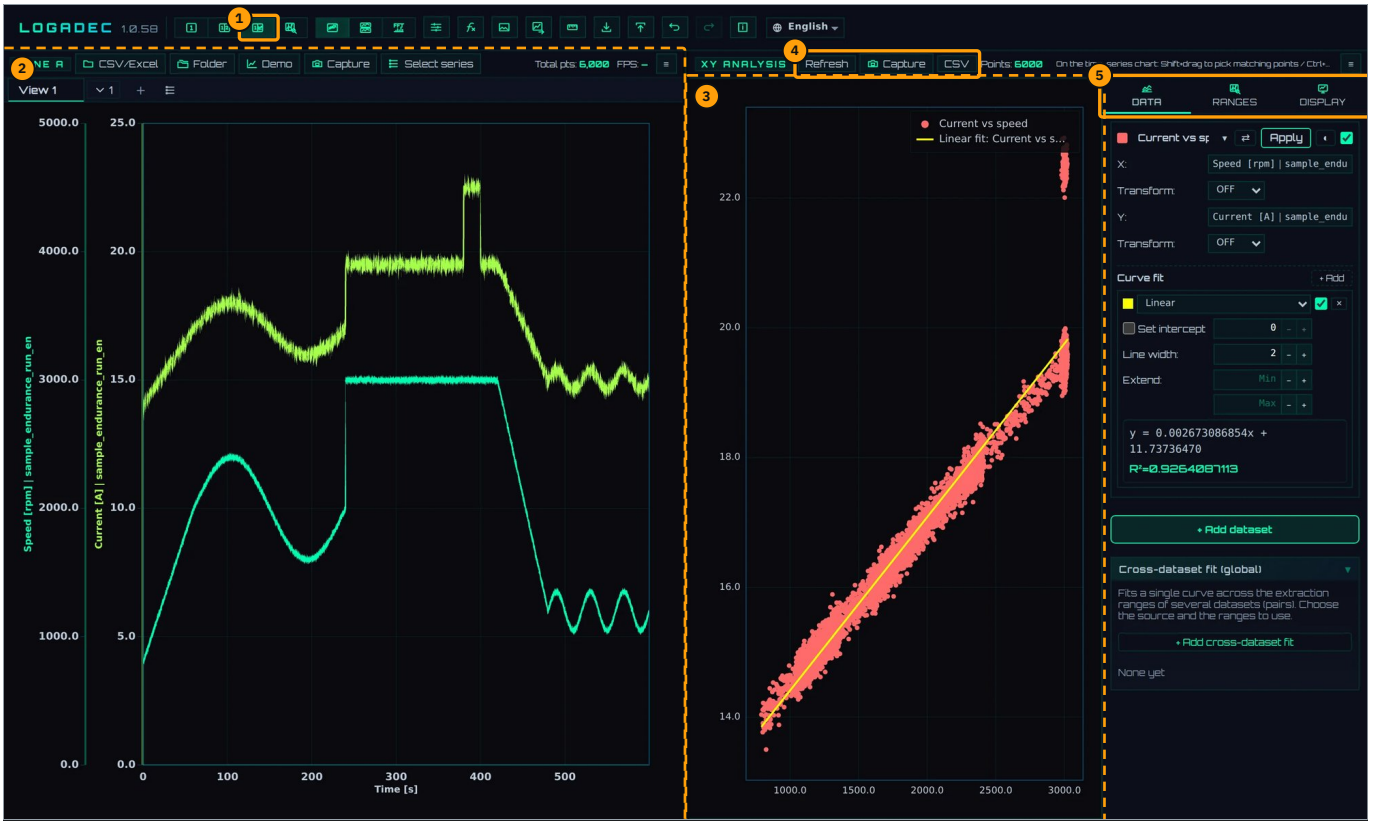

Figure 10-1 XY analysis opened, with a linear fit drawn through the points of Speed (X) and Current (Y)

1. [**Analysis**]: Switches to the screen that shows the time series and XY analysis side by side
2. Time-series graph (Pane A): Linked to the XY points by time
3. XY graph: Draws the points of the two selected series and the fitted curves
4. [**Refresh**], [**Capture**], [**CSV**]: Redraws, saves an image, and saves the points as CSV
5. Sidebar tabs: [**Data**], [**Ranges**], [**Display**]

Tab	Contents
[**Data**]	Creates combinations of series for X and Y (called "pairs" in this chapter). Transforms, pre-processing, and fitted curves are also set here
[**Ranges**]	Specifies, with ranges, which times of the time series supply the points
[**Display**]	Sets the look of the graph: point size, ticks, text, margins, legend, and so on

[**Points**] in the XY analysis bar is the number of points currently drawn. ≡ at the right end shows or hides the XY analysis sidebar.

> **Tip: Show the time-series side in [Overlay]**
>
> Linking with the time-series graph (the vertical line when hovering, adding ranges with `Ctrl` + drag, selecting points with `Shift` + drag) works when the time-series graph is in the [**Overlay**] view. It does not work in the [**Stacked**] view.

10.2 Create a pair

The first pair (a card on the [**Data**] tab) is provided from the start.

1. Click the X field on the card to open the list of series in Pane A. Choose the series for X (for example, Speed). Enter part of a name to narrow the list.
2. In the same way, choose the series for Y (for example, Current) in the Y field.
3. When both X and Y are set, points are drawn on the XY graph.

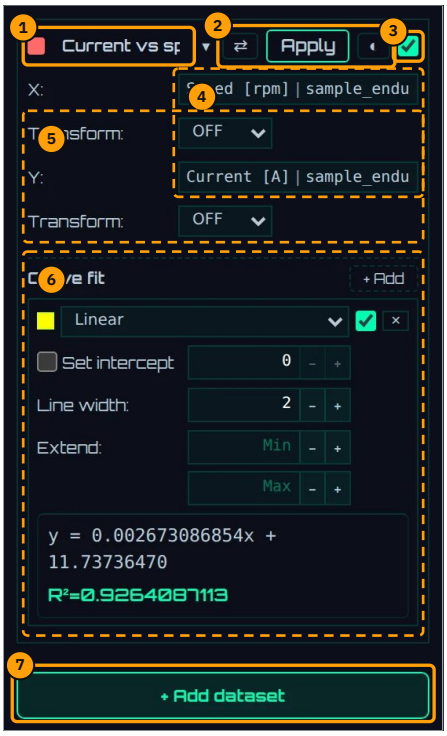

Figure 10-2 The pair card (Speed and Current)

1. Color and name: Choose the point color with the color square. The name is shown in the legend. If empty, "Y series vs X series" is shown
2. ⇄ ([**Swap X- and Y-axes**]), [**Apply**] ([**Apply this dataset definition to other sources**]), ◐ ([**Appearance (color, marker, line)**])
3. Check box: Whether to display this pair
4. X, Y: Fields for choosing series
5. [**Transform**]: Applies calculations to the X and Y values (described later)
6. [**Curve fit**]: Adds fitted curves (described later)
7. [**+ Add dataset**]: Adds more pairs

- Collapse a card with ▾ to show it briefly in the form "Y vs X".
- When there are two or more pairs, you can delete one with ✕ on its card.
- Point values are the values visible on the time-series graph (after [**Unit conversion / rename**] and [**Filter**]).
- Points are drawn for all times of the series, regardless of the zoom of the time-series graph.

How times are matched

XY points are created one for each time of the X series.

Case	How points are created
X and Y times are aligned (such as columns in the same file)	Values on the same row are paired as-is
Times are not aligned (different files, different recording intervals)	The Y value at each X time is obtained by linear interpolation from the Y values before and after it
The X time is outside the time range of the Y data	No point is created
The Y data has a time gap larger than 1.5 times its recording interval (median)	No points are created for times within that gap
The X or Y value is missing	No point is created

For example, if Speed recorded at 10 Hz is X and outside air temperature recorded every second is Y, the air temperature is interpolated to values every 0.1 seconds and paired.

Line up data from different files

For the X and Y of a pair, you can choose series from any file loaded in Pane A. To overlay the first and second test runs on the same XY graph, create a second pair in one of the following ways.

- Click [**+ Add dataset**] and choose series from the second file for X and Y.
- Click [**Apply**] on the first pair. On the [**Apply dataset definition in bulk**] screen, choose the [**Matching rule**] (match by name and unit, match by name, or partial match on name) and the [**Target data sources**], and run it to create pairs of the same items for the chosen files. The transform settings are copied as well (fitted curves are not).

In every pair, the points carry the times of that pair's X series. Linking with the time-series graph (described later) also works with the correct times for each pair.

10.3 Narrow down points with extraction ranges

Extraction ranges determine "which times of the time series supply the points used for XY". When you create ranges, only points at times within the ranges are drawn in XY, and only points within the ranges are used for fitted curves.

In the next figure, 100–370 seconds, where operation is stable, is a range named "Normal", and 380–400 seconds, where vibration increased, is a range named "High vibration". Points outside the ranges are drawn in gray.

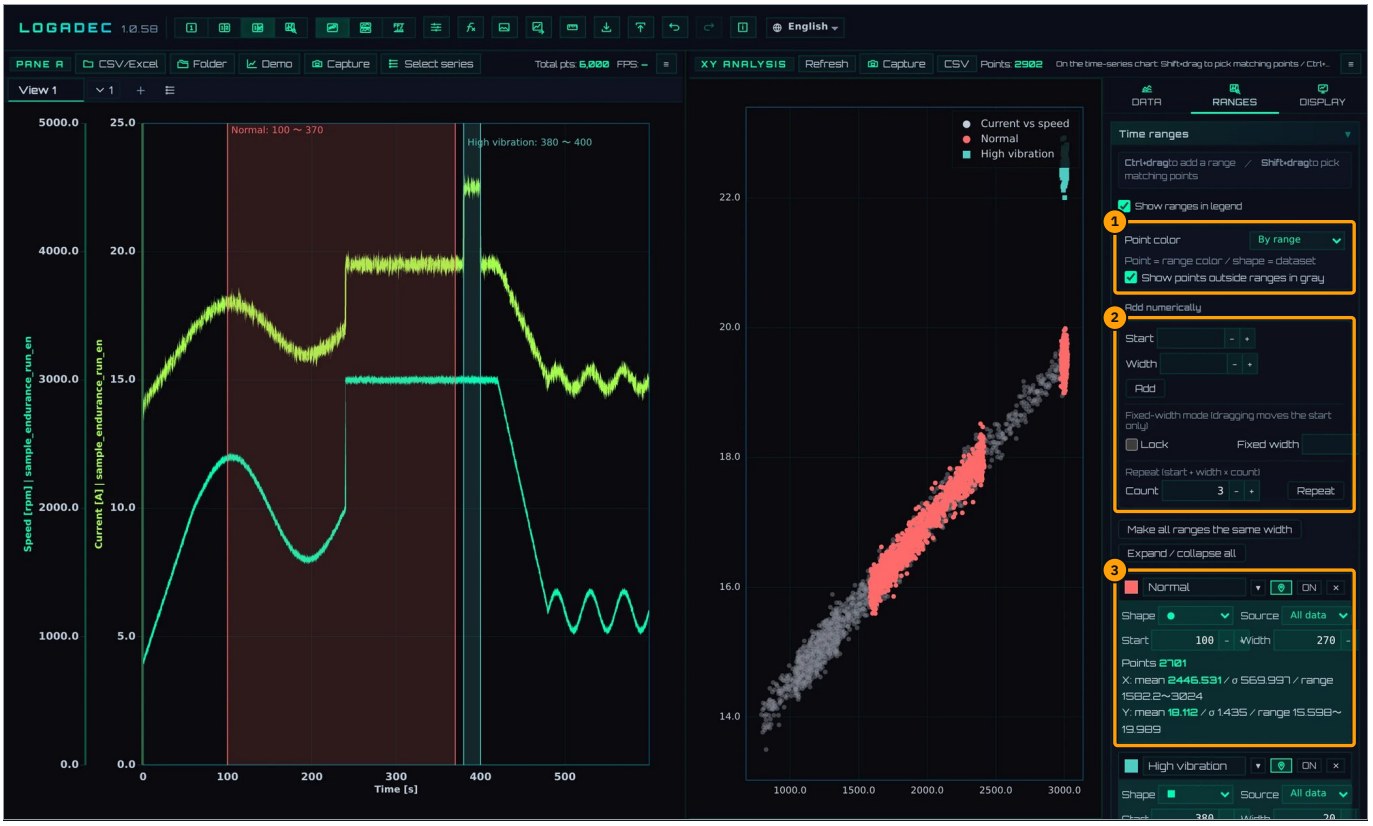

Figure 10-3 Two ranges created, with points drawn in each range's color

1. [**Point color**] and [**Show points outside ranges in gray**]: How points are colored, and how points outside the ranges are handled
2. [▸ **Add numerically**]: Adds a range by numbers
3. Range cards: The settings for each range, and statistics of the points within it

Create ranges

Method	Operation
Create on the time-series graph	On the time-series graph, hold down `Ctrl` and drag horizontally
Create by numbers	Enter [**Start**] and [**Width**], and click [**Add**]
Create consecutive ranges of the same width	Enter [**Start**], [**Width**], and [**Count**] (up to 50), and click [**Repeat**]. The specified number of ranges is created, each shifted by the width from the start

- If you check [**Lock**] ([**Fixed-width mode (dragging moves the start only)**]) and enter [**Fixed width**], dragging on the time-series graph creates a range of the fixed width from the position where you started dragging.
- [**Make all ranges the same width**] sets the width of all ranges to the entered [**Width**] (the starts do not change).
- The start and width of a range are specified in X values of the time series (seconds for the sample data). Points exactly at the start and end times are included in the range.
- When ranges overlap, a point belongs to the range higher in the list.

Range cards

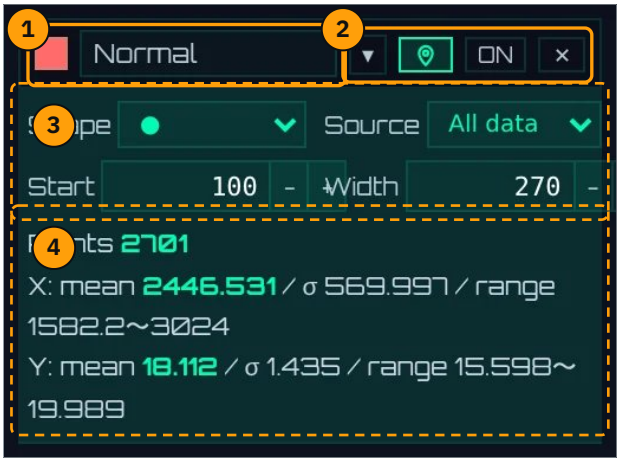

Figure 10-4 A range card ("Normal")

1. Color and name: The name is shown in the legend
2. ▾ (open/close details), show the range on the time-series graph, [**ON**]/[**OFF**] (whether to use the range), × (delete)
3. [**Shape**], [**Source**], [**Start**], [**Width**]
4. Statistics: [**Points**] of the points within the range, and [**mean**], σ, and [**range**] (minimum–maximum) of X and Y

Setting	Description
[**Shape**]	The marker used to draw points within the range (9 kinds, such as ●, ■, and ▲). Each new range is assigned a different marker in turn
[**Source**]	The pair whose points this range narrows down. [**All data**] means all pairs. If you choose a specific pair, the points of other pairs are not affected by this range
Show the range on the time-series graph (pin icon)	Shows the range on the time-series graph as a colored band with its name
[**ON**]/[**OFF**]	A range set to [**OFF**] is used neither for narrowing down points nor in the legend

σ in the statistics is the standard deviation, calculated with division by the number of points n ($\sqrt{\Sigma(\text{value}-\text{mean})^2/n}$). For the "Normal" range of the sample data, there are 2701 points, and X (Speed) has a mean of 2446.531 and σ of 569.997.

Color points by range and draw points outside ranges in gray

When there is at least one range, you can choose how points are colored at the top of the [**Ranges**] tab. You can also switch it from the menu that appears when you right-click an empty area of the graph.

[**Point color**]	**Point color**	**Point marker**
[**By dataset**] (initial state)	The pair's color	The range's [**Shape**]
[**By range**]	The range's color	The range's [**Shape**]

When you check [**Show points outside ranges in gray**], points outside the ranges are also drawn faintly in gray. Gray points are not used for fitted curves, range statistics, or point selection. Even with ranges, you can see where points sit in the whole data, which is useful for comparing points from off-normal operation.

> **Note: When there are no ranges**
>
> When you have not created any ranges, all points are drawn ([**No ranges — showing all data**]).

10.4 Transforms and pre-processing

You can apply calculations to X and Y values before plotting them as points. For example, multiply current by voltage to get power, and look at its relationship with speed.

1. Set [**Transform**] below the X or Y series to [**ON**].
2. If necessary, set [**Preprocess**] to [**ON**], and enter [**Scale**], [**Offset**], and [**+ Series**].
3. Choose the kind of calculation in [**Type**], and choose the partner series and other settings as required by the type.

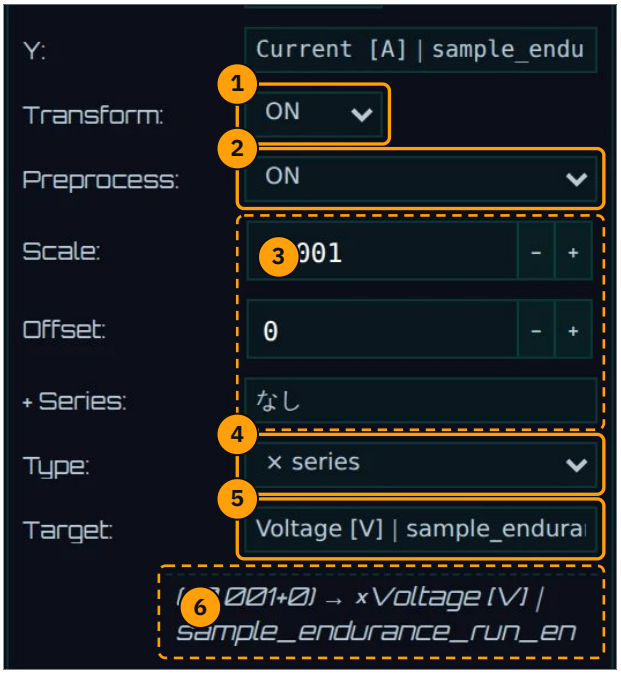

Figure 10-5 Y Current multiplied by 0.001 and then by Voltage to get power (kW)

1. [**Transform**]: When set to [**ON**], the settings below open
2. [**Preprocess**]: Applies a scale and offset before the calculation of the type
3. [**Scale**], [**Offset**], [**+ Series**]: Pre-processing values
4. [**Type**]: The kind of calculation
5. [**Target**]: The partner series to multiply, divide, add, or subtract
6. A description of the calculation

Calculations are done in the following order.

1. [**Preprocess**]: value × [**Scale**] + [**Offset**] + the value of the [**+ Series**] series
2. The calculation of [**Type**]

[**Type**]	**Calculation**
[**None**]	Does nothing (choose this to apply only pre-processing)
[**Scale × value + offset**]	value × scale + offset
[**× series**], [**÷ series**], [**+ series**], [**− series**]	Multiplies, divides, adds, or subtracts the [**Target**] series
[**Correction (δ/θ)**]	Corrects to standard conditions using pressure and temperature series (table below)
[**√ square root**], [**1/x reciprocal**], []	x

- When the times of a partner series ([**+ Series**], [**Target**]) differ, it is linearly interpolated to the times of the series being calculated. Outside its time range or at missing times, the result is also missing, and that point is not drawn.
- Square roots of negative numbers, natural logarithms of 0 or less, and division by 0 also give missing values.
- When you set [**Transform**] to [**OFF**], pre-processing is not applied either. The settings remain, so setting it back to [**ON**] restores the original calculation.

- In the example in the figure, power is calculated in kW as Current × 0.001 × Voltage (the point at 13.768 A and 13.519 V is 0.18613 kW).

[**Correction (δ/θ)**]

Calculates $\delta = P / P_{ref}$ and $\theta = T / T_{ref}$ point by point from pressure P and temperature T series, and multiplies or divides values by them.

Setting	Description
P_{ref}, T_{ref}	The reference pressure (kPaA) and temperature (K). Initially 101.325 kPaA and 288.15 K
[**Pressure**], [**P unit**]	The pressure series and its unit (kPaA, kPaG, MPaA, MPaG, PaA, atm, psi). For gauge pressure (G), [**Atm. pressure**] is added to get absolute pressure
[**Temperature**], [**T unit**]	The temperature series and its unit (K, °C)
[**Apply**]	How the correction is applied (9 ways, such as ÷ δ and × δ/√θ). [**Correction guide ▸**] shows correction formulas for commonly used quantities

Points where the temperature is 0 K or below, and points at times when the set pressure or temperature series has no value, are made missing, and you are notified.

10.5 Fitted curves

Draws fitted curves through a pair's points and shows the equation and R^2.

Add a fitted curve

- **Add from the card**: Click [**+ Add**] under [**Curve fit**] on the pair card, choose a type, and check the box on the right (display).
- **Add from the graph**: Right-click a point and choose a type from [**Add fit**]. It is displayed immediately.

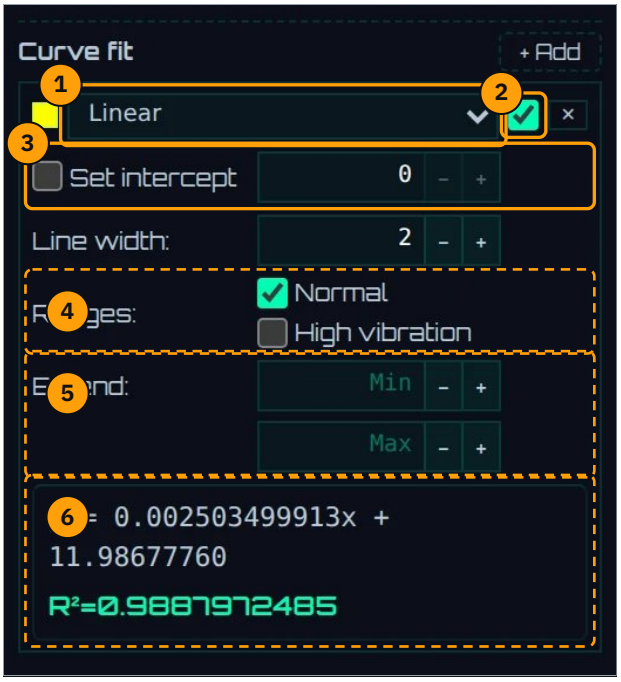

Figure 10-6 A linear fit using only the "Normal" range

1. Type: Choose the form of the fitted equation
2. Check box: Whether to display it on the graph. Choose the line color with the color square on the left
3. [**Set intercept**]: Fits with y at x = 0 fixed to the entered value
4. [**Ranges**]: The ranges used for the fit (shown only when there are ranges)
5. [**Extend**]: Extends the X range over which the curve is drawn beyond the data
6. Results: The fitted equation and R^2

Types of fit

Type	Equation	Method
[**Linear**]	y = ax + b	Least squares
[**Polynomial**]	$y = \Sigma a_i x^i$	Least squares. [**Order**] is 1–10 (2 at first)
[**Exponential**]	y = a·e^(bx)	Fits a straight line to ln y and x. Points with y of 0 or less are not used for the fit
[**Log**]	y = a·ln(x) + b	Fits a straight line to y and ln x. Points with x of 0 or less are not used
[**Power law**]	y = a·x^b	Fits a straight line to ln y and ln x. Points with x or y of 0 or less are not used
[**Moving average**]	No equation	Sorts the points by X in ascending order and draws a line averaging the Y of [**Window**] adjacent points. The window is 2–200 (5 at first). At both ends, only the available points are averaged
LOESS	No equation	A smooth line made by fitting straight lines piece by piece with weights on nearby points. span (0.05–1, 0.3 at first) is the proportion of nearby points used
[**Custom formula**]	Any equation	Enter [**Formula**], [**Variables**], and [**Initial**], and the coefficients are found by iterative least squares (the Levenberg–Marquardt method). The allowed symbols are [**Allowed: x, +-*/^, exp/log/sin/cos/sqrt/abs/pow**]
Gaussian	$a \cdot \exp(-(x-\mu)^2/2\sigma^2)$	Coefficients are found the same way as for a custom formula
Lorentzian	$a/(1+((x-\mu)/\gamma)^2)$	Coefficients are found the same way as for a custom formula

- [**Instant**] types (Linear through Moving average) are recalculated immediately when the points or settings change.
- [**Advanced (iterative)**] types (LOESS through Lorentzian) are not calculated automatically. Click [**Run**] or [**Run optimization**]. If the points or ranges change after the calculation, [**The points or ranges changed. Press Run to recompute.**] appears next to the result; click the button again to recalculate.
- For Moving average and LOESS, click [**To formula**] to show an equation that represents the resulting line as a polynomial of [**Polynomial order**] (1–10, 4 at first). The [**R²**] shown then indicates how well the polynomial reproduces the original line.

The equation and R² shown

- Equation coefficients are shown with 10 significant digits.
- R² is calculated for the points used in the fit with the following equation (shown with 10 decimal places). $\hat{y}$ is the value of the fitted equation, and $\bar{y}$ is the mean of y. When all points have the same y (the denominator is 0), it is 0.

$$R^2 = 1 - \Sigma(y - \hat{y})^2 / \Sigma(y - \bar{y})^2$$

- For exponential, logarithmic, and power fits too, R² is calculated with the original y values. Only the points used in the fit are used (for exponential, points with y greater than 0; for logarithmic, points with x greater than 0; for power, points with x and y greater than 0). If some points were not used, their number is shown next to the result.
- R² for Moving average and LOESS is calculated with the same equation, taking the value of the line as $\hat{y}$.

> **Note: Polynomial equations when X is far from 0**
>
> When X takes values far from 0, such as UNIX time, writing the coefficients as a polynomial in x runs out of digits. In that case, the equation is shown as a polynomial in u = (x − mean of X) / standard deviation of X, with the definition of u appended after the equation. When a in an exponential equation becomes extremely large or small, it is also shown in the form $y = a \cdot e^{b(x - x_0)}$ with a reference point x_0.

Example with the sample data

A linear fit of Speed (X) and Current (Y) gives the following.

Points used for the fit	Equation	R²
All points (6000 points)	y = 0.002673086854x + 11.73736470	0.9264087113
Only the "Normal" range (100–370 seconds, 2701 points)	y = 0.002503499913x + 11.98677760	0.9887972485
All points, [**Set intercept**] 12	y = 0.002560844928x + 12.00000000	0.9245799957

When all points are used, the slope becomes larger because it is pulled by the points at 380–400 seconds, where vibration increased (the points separated at the upper right). Restricting [**Ranges**] to "Normal" gives a line that fits the cluster of points well, and R² rises.

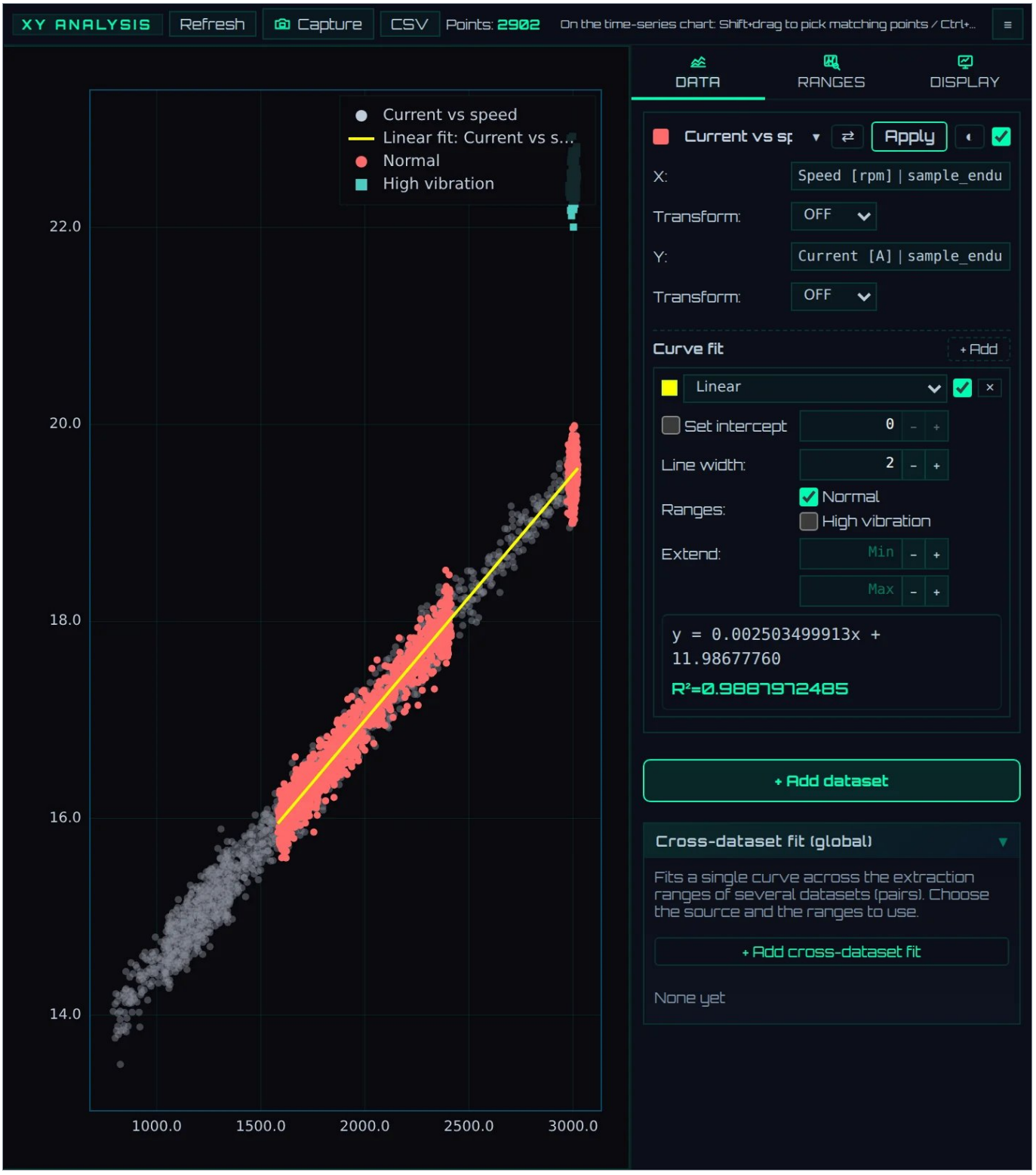

Figure 10-7 The fitted line drawn using only the "Normal" range (gray points are outside the ranges)

Set the intercept

When you check [**Set intercept**], y at x = 0 is fixed to the entered value, and the remaining coefficients are found by least squares. It is available only for linear, polynomial, and exponential fits.

- For exponential fits, the value fixed is the coefficient a (y at x = 0). Set a to a value other than 0. Points where y / a is 0 or less are not used, and the number of points not used is shown next to the result.
- It is not available for logarithmic fits (no value at x = 0) or power fits (always 0 at x = 0).

Ranges and display range

- [**Ranges**]: Fits using only points within the checked ranges. If all are checked, points in all ranges are used.

- [**Extend**]: Enter X values in [**Min**] and [**Max**] to draw the curve beyond the data. The part outside the data is drawn as a dashed line.
- [**Line width**]: The thickness of the line (0.5–5).

[**Cross-dataset fit (global)**]

This is at the very bottom of the [**Data**] tab. Click [**+ Add cross-dataset fit**] and choose pairs and ranges in [**Source (dataset × ranges)**] to draw one fitted curve through the points of the chosen pairs together. Use it, for example, to fit the points of the first and second test runs together. When the X or Y items or units of the chosen pairs differ, a caution is shown.

10.6 View and adjust the graph

Mouse operations

Action	Effect
Wheel inside the graph	Zooms X and Y together around the mouse position
Wheel over the X-axis tick numbers	Zooms only X
Wheel over the Y-axis tick numbers	Zooms only Y
Drag	Moves in both X and Y directions
Drag with the right button	Zooms in on the enclosed area
Double-click inside the graph	Returns to the full view
Click near the numbers at either end of the X or Y axis	Enter that end's value as a number
`Shift` + drag	Selects the enclosed points (described later)
Place the mouse on a point	Shows the pair name, X and Y values, and time

Resize the frame

When you hover over the left, top, or bottom edge of the graph frame, a handle lights up. Drag it to change the margin on that side and resize the graph frame. Double-click the handle to restore the original margin. You can also set the margins as numbers with [**Padding (px)**] on the [**Display**] tab.

Move the legend or place it outside the graph

- The legend inside the graph can be moved by dragging. Drag its lower-right corner to change its width.
- Under [**Legend**] on the [**Display**] tab, you can choose [**Inside the chart**], [**Outside (right)**], or [**Outside (below)**] for [**Placement**]. Placing it outside makes the graph smaller by the size of the legend, so points and the legend do not overlap.
- Double-click the legend to open the legend settings on the [**Display**] tab.
- To restore a moved legend, right-click an empty area of the graph and choose [**Reset position and size**].

Change the look of points and legend by right-clicking

Right-click a point or a pair's row in the legend to open the menu for that pair. You can also open the same menu from ◐ on the card.

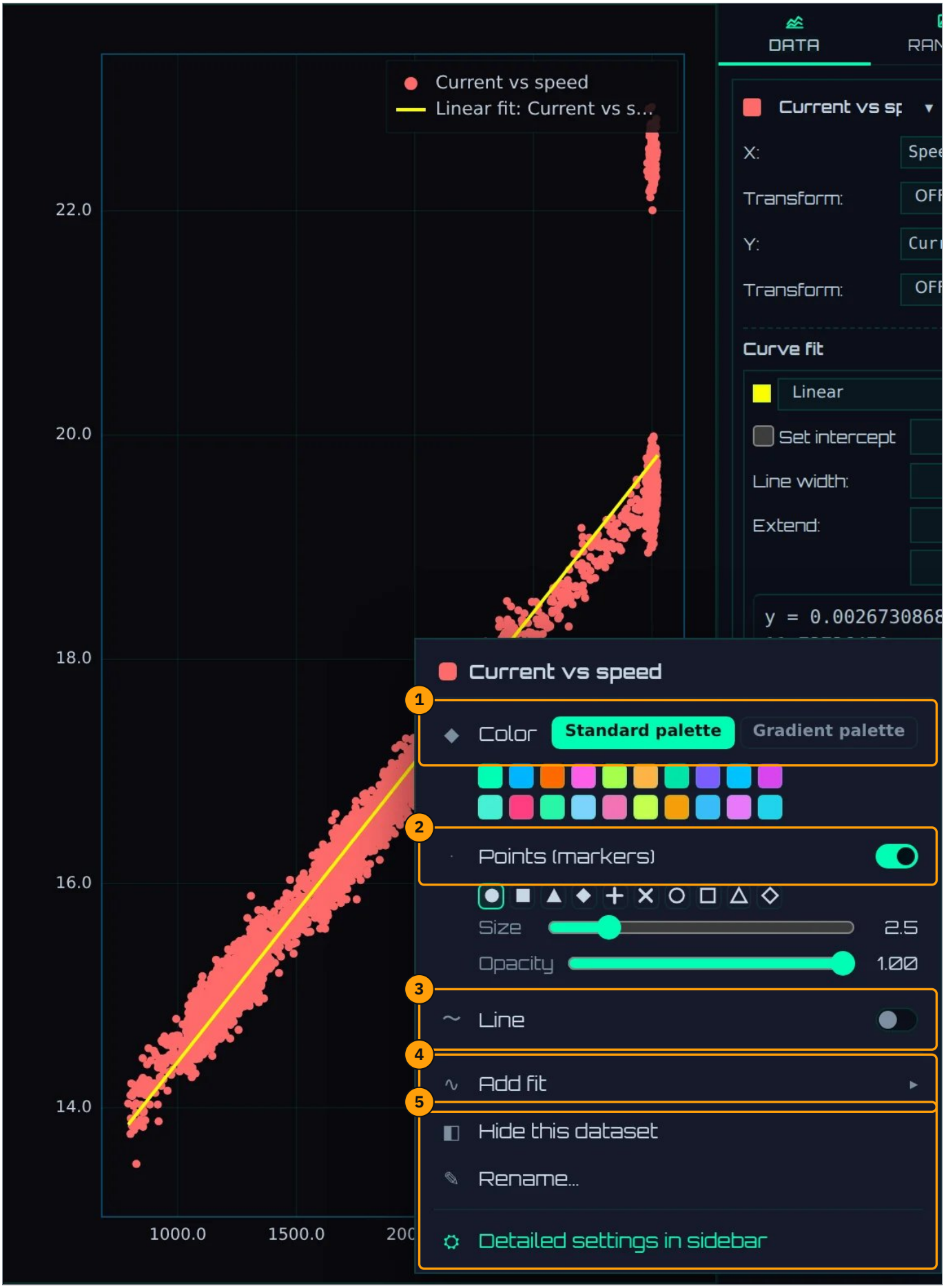

Figure 10-8 The menu shown when you right-click a point

1 [**Color**]: Chooses the pair's color

2 [**Points (markers)**]: Whether to draw points, and the marker, [**Size**], and [**Opacity**]

3. [**Line**]: Whether to connect points with a line in time order, and the line style and [**Line width**]
4. [**Add fit**]: Adds a fitted curve
5. [**Hide this dataset**], [**Rename⋯**], [**Detailed settings in sidebar**]

Right-clicking an empty area of the graph opens a menu with [**Legend settings⋯**], [**Reset view**], [**Point color**] (when there are ranges), [**Save as image**], [**Save as CSV (selected points only, if any)**], and [**Chart settings (Display tab)**].

Change axis names and ranges

Double-click the band of tick numbers (or the axis name) of the X or Y axis to open the settings window for that axis. Right-clicking the same place also opens it.

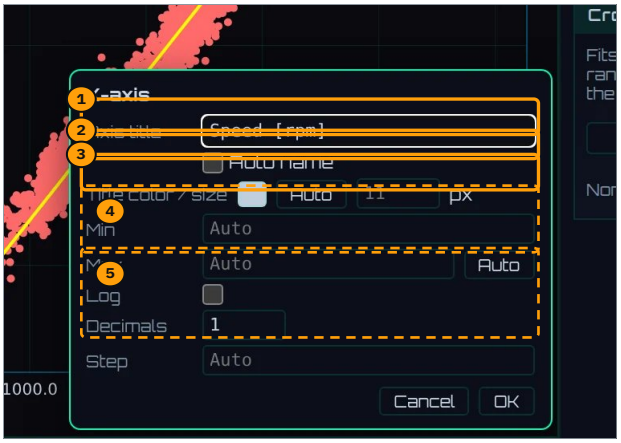

Figure 10-9 The X-axis settings window ("Speed [rpm]" entered as the axis name)

1. [**Axis title**]: The axis name
2. [**Auto name**]: When the X (Y) of all pairs is the same series, uses that series name as the axis name
3. [**Title color / size**]: The color and font size of the axis name
4. [**Min**], [**Max**]: The axis range. [**Auto**] returns to a range fitted to the data
5. [**Log**], [**Decimals**], [**Step**]: Logarithmic axis, the number of decimal places of the tick numbers, and the tick interval

What you enter appears on the graph immediately. Confirm with `Enter` or OK, and return to the state before opening with `Esc` or [**Cancel**]. On a logarithmic axis, points with values of 0 or less are not drawn, and the number of points not drawn is shown at the lower left of the graph.

The [**Display**] tab

It is divided into the sections [**Drawing**], [**Grid & frame**], [**Text**], [**X-axis**], [**Y-axis**], [**Padding (px)**], and [**Legend**]. Here you set point size and transparency, tick line style and color, font size and font, axis ranges and ticks, the legend position, number of columns, and font size, and so on. Appearance changed per pair by right-clicking takes priority over these common settings.

10.7 Undo operations

XY analysis operations can be undone with `Ctrl` + `Z` and redone with `Ctrl` + `Y`. The main operations covered are the following.

- Adding ranges (`Ctrl` + drag, adding by numbers), changing and deleting them, and switching how points are colored
- Adding and deleting fitted curves, and changing their settings
- Transform and pre-processing settings
- Changing colors, markers, and lines from the right-click menu, dragging the legend and frame, and the axis settings window
- Settings on the [**Display**] tab

Undo in XY analysis does not rewind the state of the time-series graph. Undo steps back through the same history as operations on the time-series side, so it may go back as far as operations done on the time-series side before the XY operations (such as switching the screen layout).

> **Note: Operations that cannot be undone**
>
> Zooming and moving the XY graph cannot be undone. To return to the full view, double-click inside the graph.

10.8 Link with the time-series graph

The XY graph and the time-series graph are connected by time.

Action	Effect
Hover over an XY point	Shows a vertical line (light-blue dashed line) and the time on the time-series graph at that point's time
Hover over the time-series graph	Indicates the points at that time on the XY graph with crosshairs and a ring (for each pair)
Click an XY point	Keeps showing that time. Click the same point again or click an empty area to release it
`Shift` + drag on the time-series graph	Selects the points of that time span in XY
`Shift` + drag on the XY graph	Selects the enclosed points and shows their times on the time-series graph

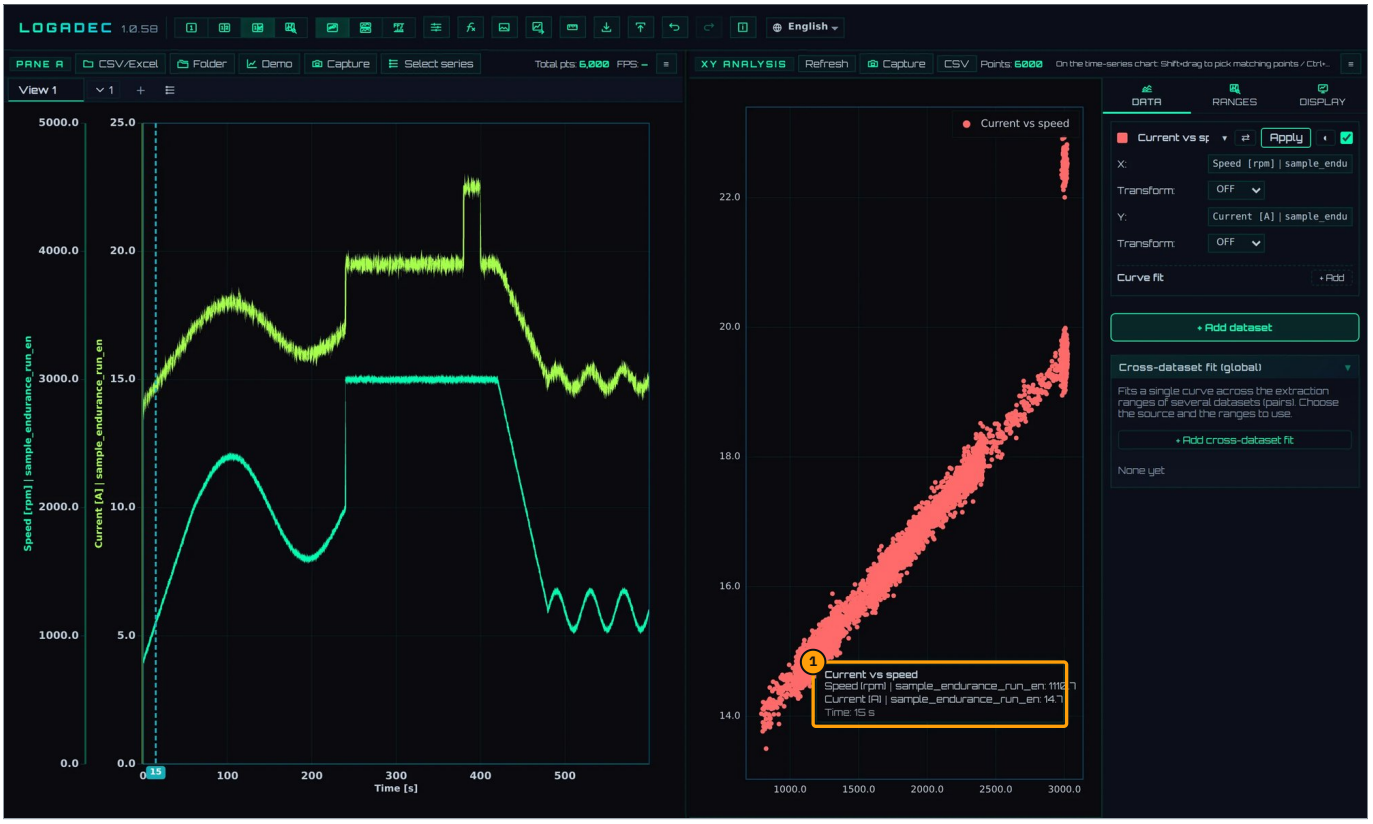

Figure 10-10 Hovering over an XY point (a vertical line appears at 15 seconds on the time-series graph)

1 Point information: The pair name, X and Y values, and time

- Selected points are highlighted with rings, and other points fade. Clear the selection with [**Clear selection**] in the XY analysis bar or by clicking the XY graph.
- You can export only the selected points to CSV (next section).

10.9 Export

Save as an image

Click [**Capture**] in the XY analysis bar to open a small save window.

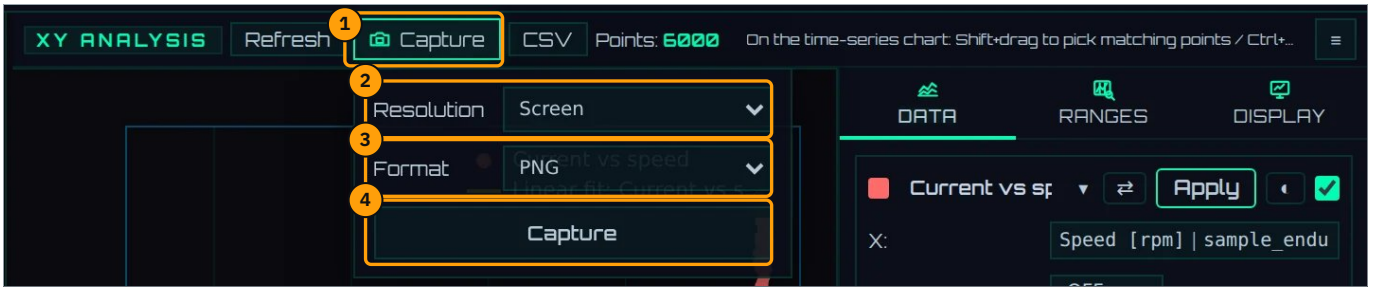

Figure 10-11 The small image save window

1. [**Capture**]: Opens the small window
2. [**Resolution**]: Choose from [**Screen**], ×1–×4, and [**Max**]
3. [**Format**]: Choose from PNG, JPG, WEBP, and SVG
4. [**Capture**]: Saves with these settings

- The image is the XY graph exactly as seen on screen (points, fitted curves, legend, axes). The crosshairs and rings that follow the mouse are not included.
- SVG is exported in a vector format whose lines and text can be edited afterward.
- The file name starts with `XY_`.
- You can also save by right-clicking an empty area of the graph and choosing [**Save as image**].

Save points as CSV

Click [**CSV**] in the XY analysis bar to open a small CSV window.

Figure 10-12 The small CSV save window

1. [**CSV**]: Opens the small window
2. [**Target**]: [**All points**] or [**Selected points (Shift+drag)**] (available only when points are selected)
3. [**Save CSV**]: Saves

The CSV contains the points of the displayed pairs, one point per row.

Column	Contents
[**Pair**]	The pair name (the name in the legend)
[**Time**]	The time of the point (the time of the X series)
X, Y	The point values (after transforms)
[**Range**]	The name of the range containing the point. Gray points outside the ranges are [**Outside ranges**]

- Gray points outside the ranges are included only when [**Show points outside ranges in gray**] is checked.
- The character encoding is UTF-8 with BOM. Text does not appear garbled when opened in Excel.
- The file name is `XY_points_<date>.csv`.
- You can also save by right-clicking an empty area of the graph and choosing [**Save as CSV (selected points only, if any)**]. When points are selected, only the selected points are included.

Chapter 11

Export and Save

This chapter describes how to turn graphs into images, how to export values to CSV and other formats, how to save the entire analysis state to an `.lgd` file and reopen it, and how to save only the display settings.

What you want to do	Feature	Button
Paste figures into reports or slides	Image export	[**Export image**] on the toolbar
Quickly turn the current screen into an image	Capture	[**Capture**] above the graph
Use values in Excel or other software	Data export	[**Export data**] on the toolbar
Hand the analyzed state to colleagues, or reopen it later	Saving an `.lgd` file (paid edition)	[**Save**] → [**Data and settings**]
Keep only display settings, presets, and formulas	Saving settings	[**Save**] → [**Settings only**]

11.1 Export images

Click [**Export image**] on the toolbar to open the [**High-resolution image export**] screen. The preview on the right is the same picture as the image that will be saved. Set the size and format on the left, and click the save button at the bottom right.

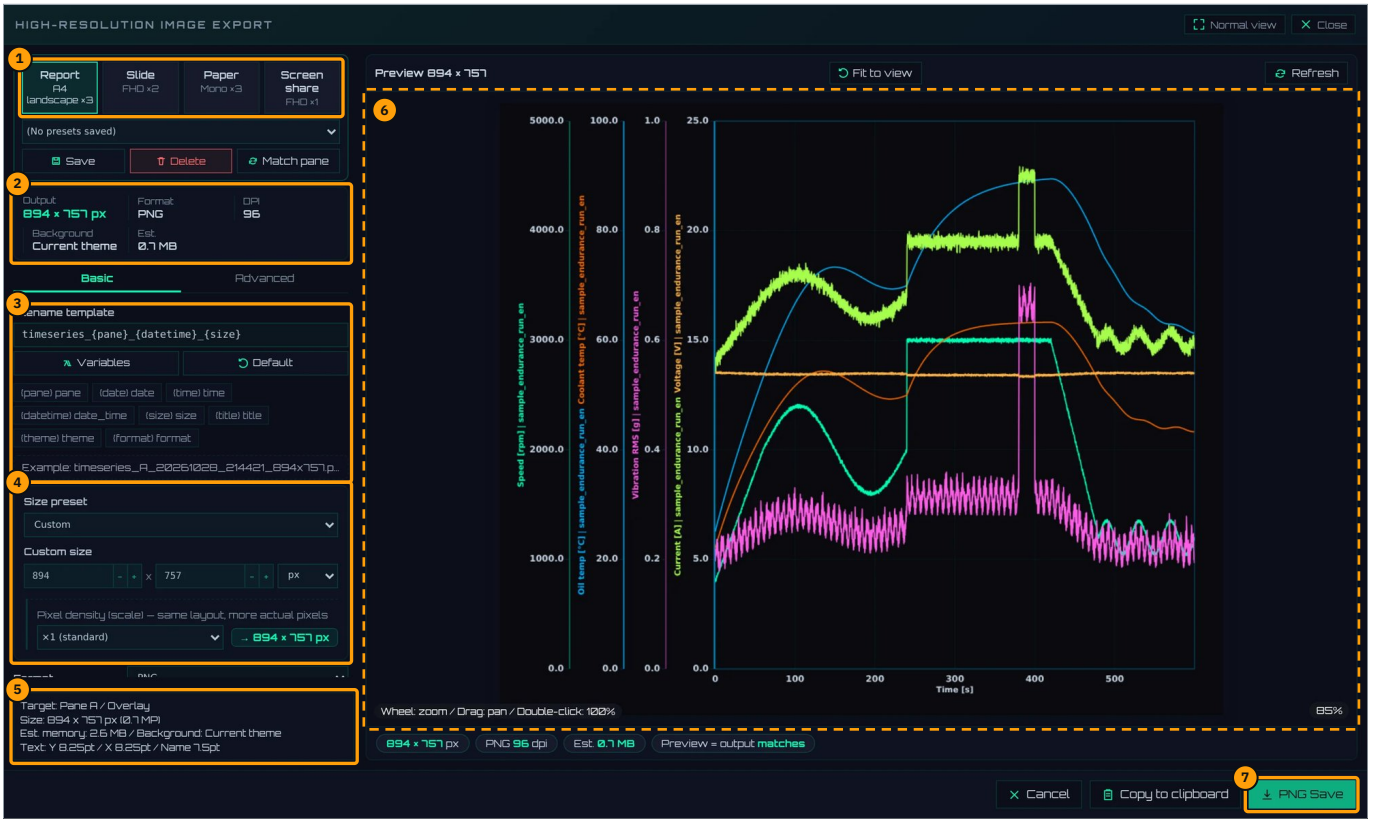

Figure 11-1 The [**High-resolution image export**] screen (right after opening)

1. Purpose cards: Click one to switch the size, density, and export theme all at once (described later)
2. Summary: The output pixel dimensions, format, DPI, background, and estimated file size
3. [**Filename template**]: How the name of the saved file is determined. An example name appears below
4. Size: Set [**Size preset**], [**Custom size**], and density
5. Information area: The target pane and display mode, the final pixel dimensions, and the estimated memory use
6. Preview: Zoom with the wheel, move by dragging, and double-click for 100% view. Drag the edge to resize
7. Save button: Shows the format name and [**Save**]. [**Copy to clipboard**] on its left is for pasting without creating a file

Right after opening, the size is the same as the graph on screen ([**×1 (standard)**], [**PNG**]). Settings changed on this screen remain while LOGADEC is open, even after you close the screen. To match the graph on screen again, click [**Match pane**].

You can export [**Overlay**], [**Stacked**], and [**FFT**] graphs as images. Save XY analysis graphs from the XY analysis screen (Chapter 10).

Choose with a purpose card

If you are unsure, choosing one of the cards at the top settles things quickly. All cards use the [**PNG**] format.

Card	Size	Density	Export theme	Output pixels
[**Report**]	2456 × 1736 px	×3	[**For print (white background, dark lines, light grid)**]	7368 × 5208
[**Slide**]	1920 × 1080 px	×2	[**Same as screen**]	3840 × 2160
[**Paper**]	2456 × 1736 px	×3	[**Monochrome (for publication)**]	7368 × 5208
[**Screen share**]	1920 × 1080 px	×1	[**Same as screen**]	1920 × 1080

If you change settings after clicking a card, [**Modified**] appears at the top. You can keep settings you adjusted yourself under a name with [**Save**] below the cards. Recall kept settings from the list to its left.

Choose a format

Format	Suitable use	Notes
[**PNG**]	Reports and slides. Lines and text stay crisp	DPI is written into the image
[**JPG**]	When you want a smaller file	The background cannot be [**Transparent**]. DPI is written into the image
[**WEBP**]	Images for the web	DPI is not written
[**SVG**]	When you want to edit lines or text later	Choose [**Vector (editable lines/text)**] (the initial choice) or [**Embedded image (legacy)**]. Density is not used. [**Copy to clipboard**] copies the [**SVG**] together with a [**PNG**] of the same picture (apps that do not accept [**SVG**] paste the [**PNG**])

With [**Vector (editable lines/text)**], [**SVG**] exports lines and text as shapes. They do not become coarse when enlarged, and you can edit colors and text in Illustrator, Inkscape, and similar software. Only image parts such as spectrograms are embedded as images.

Size and DPI

How the size is set depends on the unit of [**Custom size**].

Unit	Meaning of width and height	DPI written into the image
[**px**]	Number of pixels	96 × density
[**mm**], [**inch**]	Printed dimensions. The number of pixels is determined by dimensions × [**Resolution (DPI)**]	[**Resolution (DPI)**] × density

Density (×2, ×3) increases only the pixels, without changing the layout of the figure or the font size. Because DPI rises with the pixels, the size when pasted into Word or PowerPoint does not change.

The following table shows values of images actually exported.

Setting	Image pixels	Image DPI	Size when pasted
1200 × 800 px, ×1	1200 × 800	96	About 318 × 212 mm
1200 × 800 px, ×2	2400 × 1600	192	About 318 × 212 mm
170 × 100 mm, 300 DPI, ×1	2008 × 1181	300	170 × 100 mm
170 × 100 mm, 300 DPI, ×2	4016 × 2362	600	170 × 100 mm
170 × 100 mm, 600 DPI, ×1	4016 × 2362	600	170 × 100 mm

Figure 11-2 Setting the printed dimensions (170 × 100 mm, 300 DPI)

1. [**Size preset**]: Choose a size such as A4 or Full HD
2. Width, height, and unit: With the unit set to [**mm**] or [**inch**], you can enter dimensions
3. [**Resolution (DPI)**]: Shown only when the unit is [**mm**] or [**inch**]. The number of pixels appears on the right
4. Density: Increases only the pixels while keeping the dimensions

> **Note: Print presets switch the unit to mm**
>
> When you choose a print size such as [**A4 landscape 300dpi**] in [**Size preset**], the unit switches to [**mm**] ([**inch**] for Letter) and DPI to 300. The pixel dimensions are 3508 × 2480, the same as A4 at 300 DPI, and the image becomes A4 size when pasted into Word.

- [**SVG**] ([**Vector (editable lines/text)**]) is written at the drawn size. Density is not used. When the unit is [**mm**] or [**inch**], those dimensions (for example, 170 × 100 mm) are written, so the image has the same size in the software you paste it into.
- The size limit is 8192 × 8192 px, or 50 million pixels (50 MP) in total. If exceeded, "[**The maximum is 8192 × 8192 px or 50 MP.**]" is shown in the information area, and the save button cannot be clicked.
- The initial size for [**Stacked**] and [**FFT**] stacks the tiers vertically, as many as there are, at their on-screen tier height. The information area shows the number of tiers.

Add a title

When you check [**Embed title / caption**], you can write a [**Title**] and [**Subtitle**] into the image. Choose how they are added in [**Mode**].

[**Mode**]	How it is added	Image size
[**Expand image (recommended)**]	Adds a band above (or below) the graph and writes there	The band height is added to the specified height
[**Semi-transparent band**]	Overlays a semi-transparent band on the graph	As specified

The specified width × height does not include the title band. For example, if you add a title (24 pt) and a subtitle (14 pt) at 1200 × 800 px, the image becomes 1200 × 894 px (1200 × 866 px with the title only). You can check the final size in the information area and the example file name. When the background is [**Transparent**], titles are added as [**Semi-transparent band**] even if [**Expand image (recommended)**] is selected.

What is included and what is not

- **Only displayed series are included.** Series unchecked on the [**Series**] tab, and series of sources hidden on the [**Sources**] tab, are not included.
- **Legend:** If [**Show legend**] is checked on the [**Display**] tab, the legend is included in the image too.
- **Colors:** With [**Export theme (does not affect the display)**], you can make only the image use a white background ([**For print (white background, dark lines, light grid)**]) or black and white ([**Monochrome (for publication)**]), leaving the screen colors as they are. Choose [**Background**] from [**Current theme**], [**White**], and [**Transparent**].
- **Other:** You can also add an [**Annotation**] (drag on the preview to place it), a [**Watermark**], and a [**Margin / border**]. Margins are taken inside the specified size. Font size, number of ticks, line widths, and so on can be changed on the [**Advanced**] tab.

File name and save location

The file name is determined by [**Filename template**]. The initial template is `timeseries_{pane}_{datetime}_{size}`, which gives names like `timeseries_A_20261020_003548_1200x800.png`. {size} is the final pixel dimensions including the title band and density ([**SVG**] with [**Vector (editable lines/text)**] uses the size without density).

Variable	Contents
{pane}	The pane letter (A, B)
{date}, {time}, {datetime}	The date saved (20261020), the time (003548), or both
{width}, {height}, {size}	The image width, height, and widthxheight
{theme}, {format}, {ext}	The theme, format, and extension

Year, month, day, hour, minute, and second can be inserted individually with {year}, {month}, {day}, {hour}, {minute}, and {second}. Click [**Variables**] to see the list of available variables. Clicking a variable button inserts it at the cursor position.

How files are saved differs by browser.

Browser	How files are saved
Chrome, Edge	A save dialog opens, where you can choose the location and name
Firefox, Safari	Saved as a download. The location is determined by the browser's download settings

Even in Chrome and Edge, in environments where the save dialog cannot be opened, the file is saved as a download, and the reason is shown at the bottom of the screen.

> **Tip: Choose where to save every time in Safari or Firefox**
>
> Safari and Firefox do not let web pages open a save dialog. You can set the browser to ask where to save each download. - Safari (Mac): Safari Settings → General → set "File download location" to "Ask for each download" - Firefox: Settings → General → under Downloads, choose "Always ask you where to save files"

- In Chrome and Edge, the save dialog opens after the picture is ready. If preparing it takes a while, "[**The file is ready to save ({size}). Choose where to save it.**]" appears; click [**Choose location**] to choose where to save. After writing, the file is read back and checked; if it was not written correctly, it is also saved as a download.
- The save dialog opens in the folder where you last saved that kind of file (images, `.lgd` files, data export, and so on). Whether it still does so after you reopen LOGADEC depends on the browser.

When you set [**Export target**] to [**Pane A + Pane B**], both panes of the two-pane layout (Chapter 5) are saved, one image each, with the same settings.

- In Chrome and Edge, you choose the destination folder. If a file with the same name exists in the folder, it is not overwritten; `_2`, `_3` is appended to the name instead.
- With a template that gives both images the same name (one without {pane}), `_A` and `_B` are appended to distinguish them.

Save the screen as-is quickly (Capture)

Click [**Capture**] above the graph to open a small window. Choose [**Resolution**] and [**Format**], and click [**Capture**] in the window to save the current graph as-is. The [**High-resolution image export**] screen does not open.

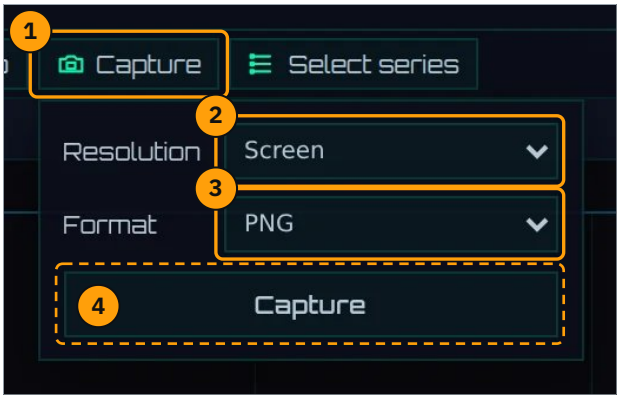

Figure 11-3 The [**Capture**] window

1. [**Capture**]: Opens the window
2. [**Resolution**]: [**Screen**] (the size visible on screen), ×1–×4, [**Max**] (up to the 8192 px limit, keeping the aspect ratio)
3. [**Format**]: [**PNG**], [**JPG**], [**WEBP**], [**SVG**]
4. [**Capture**]: Saves

The image DPI is 96 × the scale, so the size when pasted is the same as the size visible on screen. For example, saving a graph 1160 px wide on screen at ×2 gives a 2320 px, 192 DPI image.

11.2 Export values (Export Data)

Click [**Export data**] on the toolbar to open the data export screen. It exports the values of the series plotted on the graph to CSV, TSV, or Excel files.

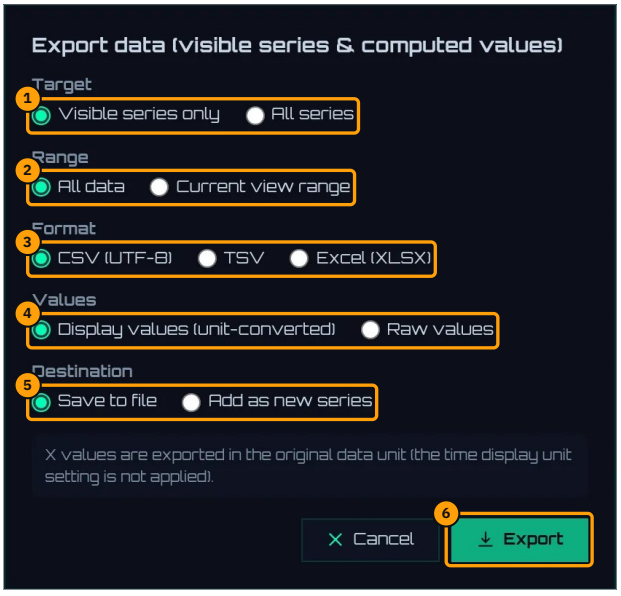

Figure 11-4 The data export screen

1. [**Target**]: [**Visible series only**] or [**All series**]
2. [**Range**]: [**All data**] or [**Current view range**] (the current X range)
3. [**Format**]: [**CSV (UTF-8)**], [**TSV**], [**Excel (XLSX)**]
4. [**Values**]: [**Display values (unit-converted)**] or [**Raw values**] (table below)
5. [**Destination**]: Whether to create a file or register the values as new series (described later)
6. [**Export**]: Exports

Values exported

[Values]	Values exported
[Display values (unit-converted)]	The values plotted on the graph: the values after [Unit conversion / rename] (pre-processing, scale, offset) and [Filter]
[Raw values]	The values as loaded. No conversion or filter is applied. Column names and units are also those at loading

For example, for a pressure series with a conversion of scale 2 and offset 1, when the original value is 100, [Display values (unit-converted)] writes 201 and [Raw values] writes 100.

File layout

Row 1 holds the series names, row 2 the units, and the values start from row 3. Exporting the sample data gives the following beginning (up to column 3).

Row	Column 1	Column 2	Column 3
Row 1 (names)	Time	Speed [rpm] | sample_endurance_run_en	Oil temp [°C] | sample_endurance_run_en
Row 2 (units)	s	rpm	°C
Row 3 (values)	0	800.6	25.06

- **Each source gets its own X column.** When two or more files are loaded, groups of "X column, then the columns of that source's series⋯" are placed side by side, one group per source. Rows are in the order of each source's 1st point, 2nd point, and so on.
- **X values are after each source's zero alignment.** X created with [Generate from sampling interval] at import is also written with its values.
- **The X unit stays the unit of the original data.** Switching the display unit of time on the [Axes] tab does not change the exported values.
- With [Current view range], only points within the range are exported. Rows outside the range are not output. When there are two or more sources and, on the same row, some sources are inside the range and some outside, the value cells of the sources outside are left empty.
- CSV is written in UTF-8 (with BOM), so Japanese text does not appear garbled when opened in Excel. Excel files are written to the sheet "data". When exporting to Excel, if the number of cells (rows × columns) exceeds 2 million, a confirmation appears warning that it will take time (not for CSV or TSV).
- The file name is determined by [Filename template] of image export. The pixel size {size} becomes `0x0`.
- In Chrome and Edge, the save dialog opens after the file contents are ready. If preparing the file takes a while, "[The file is ready to save ({size}). Choose where to save it.]" appears; click [Choose location] to choose where to save. After writing, the file is read back and checked; if it was not written correctly, it is also saved as a download (the same as for .lgd files).

Register as new series

When you set [Destination] to [Add as new series], the values of the chosen range are added inside LOGADEC as new series without creating a file. Use this to cut out only the displayed range and handle it as separate data.

- The new series go into a new source whose name is the original source name with the prefix "Extract: ". The range (for example, [0-3]) is appended to each series name.
- In [X values], choose [Keep original X] or [Shift start to 0].
- The values are those chosen in [Values]. [Format] is not used.
- The registration can be undone with `Ctrl` + `Z`.

11.3 Save the entire analysis state (.lgd file)

An `.lgd` file contains the loaded data together with the display and analysis settings. If you hand it to colleagues, they can open the same screen. When you review later, you can check under the same conditions.

Contents	Details
Data	All loaded series, including hidden series. Series added by analysis or data export, and demo series, are included with their names unchanged. Values are as loaded, before filters and unit conversions
Settings	Per-series color, line, filter, and conversion; axes; display range; display mode; screen layout; view tabs; and the state of XY analysis
Presets and formulas	Range presets, series presets, display names, and formula definitions (formula values are recalculated when the file is opened)

The original CSV or Excel files themselves are not included. An `.lgd` file is not a backup of the original files, so keep the original files separately.

> **Note: Saving .lgd files is a paid-edition feature**
>
> In the free edition, choosing [**Save**] → [**Data and settings**] shows "
> [**Saving data is a paid feature. Loading and analysis remain available in the Free edition.**]". You can open `.lgd` files you receive even in the free edition.

Save

1. Click [**Save**] on the toolbar. The [**What to save**] screen opens.
2. Click [**Data and settings**].
3. Choose [**Numeric storage format**] (table below).
4. In Chrome and Edge, a save dialog opens; choose the location and name. The initial name contains the date and time, like `logadec_dataset_20261020_004627.lgd`.

Figure 11-5 After clicking [**Save**]

1. [**Settings only**]: Saves only display settings, presets, and formulas (described later)
2. [**Data and settings**]: Saves data and settings to an .lgd file

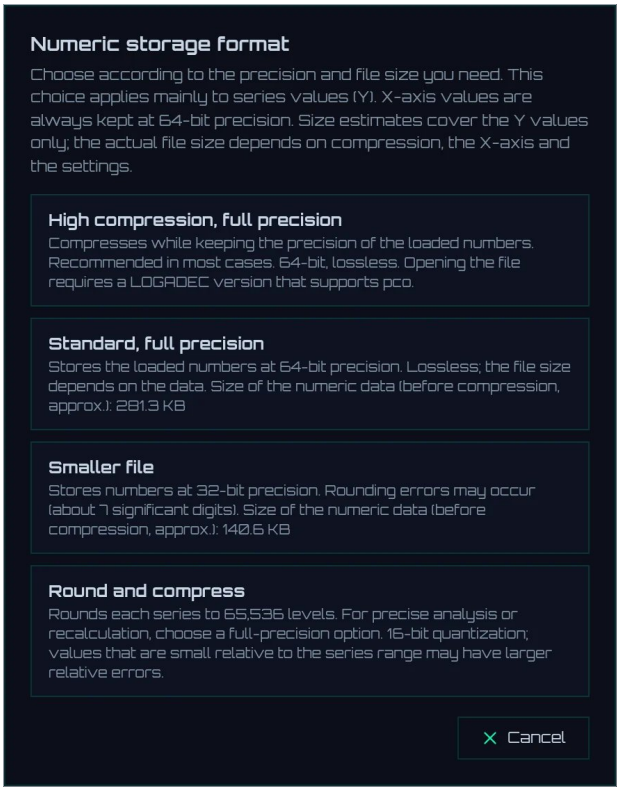

Figure 11-6 [**Numeric storage format**] (paid edition)

Method	Description	File size with the sample data
[**High compression, full precision**]	Compresses to a small size while keeping 64-bit precision. Choose this normally	About 39 KB
[**Standard, full precision**]	Saves with 64-bit precision as-is	About 158 KB
[**Smaller file**]	Saves as 32-bit. About 7 significant digits	About 73 KB
[**Round and compress**]	Rounds the values of each series to 65,536 levels. Not suitable for precise analysis or recalculation	About 49 KB

The first two save the loaded values without changing them at all. If you are unsure, choose [**High compression, full precision**]. With every method, X values are saved with 64-bit precision. The right column shows the sizes when saving the sample data (6 series of 6,000 points each, about 270 KB as CSV). Sizes vary with the data.

Saving again

After saving once, `Ctrl` + `S` saves again with the same method, without showing any screen. If you press `Ctrl` + `S` before saving for the first time, the [**Numeric storage format**] screen opens.

Browser	How files are saved	Message after saving (bottom of the screen)
Chrome, Edge	Writes to the file chosen in the save dialog. `Ctrl` + `S` overwrites the same file	"Data and settings saved", or "Data and settings overwritten" when overwriting
Firefox, Safari	Saves as a download every time. The same file cannot be overwritten	"Download started. Please check where the file was saved"

The method and file size are appended to the message. If the chosen file cannot be written, the file is saved as a download instead, and "[**Could not write to the chosen location, so the file is being downloaded instead.**]" is shown.

- In Chrome and Edge, the save dialog opens after the file contents are ready. If preparing a large file takes a while, "[**The file is ready to save ({size}). Choose where to save it.**]" appears; click [**Choose location**] to choose where to save.

- After writing, the file is read back and checked. If it was not written correctly, it is also saved as a download, and "[**The saved file did not read back correctly, so it was also saved as a download.**]" is shown.

While saving

- Progress such as [**Finishing the file**] and the elapsed seconds are shown at the bottom right of the screen. Large data takes time.
- What is saved is the state at the moment saving started. Operating the screen during saving does not change the file contents.
- While saving, undo, redo, loading, and saving again are not available. If you try, "[**Please try again after saving has finished**]" is shown.

11.4 Open .lgd files

Click [**Load**] on the toolbar and select an `.lgd` file. The import screen does not open; the saved state is restored as-is. The data currently open is replaced with the file contents.

- While loading, progress such as [**Reading the file…**], [**Unpacking data…**], and [**Drawing charts…**] is shown, along with the file name and elapsed seconds.
- For files with more than 200 series, displayed series are restored first. Series that are not displayed are restored when you display them or when the app is idle.
- When opening finishes, "Dataset loaded" is shown at the bottom of the screen.
- When opened in the free edition, up to 1,000 series are loaded. For files containing more series, you are notified after loading.
- An empty (0-byte) file or a file that was only partly saved cannot be opened. A message such as "[**This file is empty (0 bytes). Saving may have failed partway. If a file named "<name>.lgd.crswap" remains in the same folder, renaming it to end in**] is shown, and the data currently open stays as it is.

> **Caution: Corrupted files are not opened**
>
> If the file is corrupted (for example, some series are missing), loading stops without replacing anything, and a notice is shown. When series are missing, the names of the missing series appear, like "Not loaded: the file is damaged (1 place(s): …). Your current data is unchanged." The data currently open stays as it is. If the file itself is corrupted (truncated partway, or not a zip), "Failed to load data" appears in the status area.

When there are unsaved changes

When you open an `.lgd` file or a settings file, the presets and formulas in it are used as that file's own (the formula screen shows "Formulas of "file name""). If you change these presets or formulas and then try to open another file or close the browser tab, a confirmation appears.

Button	Action
[**Discard and open**]	Discards the changes and opens the other file
[**Cancel**]	Cancels opening. Save with [**Save**] first

> **Caution: Confirmation appears only for changes to presets and formulas**
>
> Display changes such as zooming or showing and hiding series do not trigger a confirmation. When you open another file, those changes are lost. To keep them, save first.

11.5 Save and load settings only

You can save only display settings, presets, and formulas to a file (`.json`), without the data. Use this when you always want to view data of the same format in the same way. Saving settings is available in the free edition too.

Save

1. Click [**Save**] on the toolbar.
2. Click [**Settings only**].
3. In Chrome and Edge, choose the location and name. The initial name is like `timeseries_settings_20261020_004631.json`.

After saving, "[**Settings JSON saved**]" is shown at the bottom of the screen.

Load

1. Click [**Load**] on the toolbar and select a `.json` file.
2. The settings are applied to the data currently open. If no data is loaded, "[**Settings JSON loaded (no data)**]" is shown.
3. If the settings still contain information about the files that were loaded when they were saved, you are asked whether to load those files again. Click OK to open a file selection screen. When you select a file, the import screen opens with the saved settings filled in; check them and click [**Import**].

> **Note: Handling of presets and formulas**
>
> While a settings file or an `.lgd` file is open, the presets and formulas in the file are used. The shared presets and formulas remembered in the browser are not overwritten. When you reopen LOGADEC, the shared ones are used again.

Chapter 12

Appendix: Formula Functions

This appendix lists all operators, constants, and functions you can use in formulas (Chapter 7). The values in the "Example" columns are results calculated with the sample data `sample_endurance_run_en.csv` (0–599.9 s, every 0.1 s, 6000 points).

12.1 Syntax rules

Element	Syntax	Description
Number	`3`, `0.25`, `1e3`, `2.5E-1`	At most one decimal point. An exponent (e, E) must be followed by digits. Full-width digits cannot be used
Series (name)	`` `Current` ``, `` `Current|sample_endurance_run_en` ``	Enclose in half-width backquotes
Series (symbol)	`$1` – `$10`	Assign series in [**Symbol–series mapping**]
Series (unenclosed name)	`Base`	Only names that start with a half-width letter or `_` and consist only of letters, digits, and `_`
Time variable	`x`	The X value of each point (described later)
Separator	`,`	Separates function arguments
Whitespace		Spaces and line breaks in the expression are ignored

- Write function names in lowercase. `SIN(x)` gives an unknown function error.
- The constants `PI` and `E` are uppercase. If you write `pi`, it is looked up as a series name.
- The following full-width and Japanese symbols are read as their half-width equivalents (not inside names enclosed in backquotes).

Symbol written	Read as
×, ✕, ✶	`*`
÷, ／	`/`
− (U+2212), ― (full-width), –, —	`-` (the long vowel mark "—" and the hyphen " - " are not converted and become invalid characters)
（ ） , ， 。	`(` `)`, `,`, `.`
√(	`sqrt(`

12.2 Operators

Operator	Meaning	Example	Result
`+` `-`	Addition, subtraction	`2+3*4`	14
`*` `/`	Multiplication, division	`7/2`	3.5
`^`	Exponentiation	`2^-2`	0.25
`-` (prefix)	Negation	`-2^2`	−4
`( )`	Evaluates first	`(2+3)*4`	20

- The order of evaluation is exponentiation → negation → multiplication and division → addition and subtraction.
- Exponentiation is evaluated from right to left. `2^3^2` is 2^9, which is 512.

- Negation comes after exponentiation. `-2^2` is −(2^2), which is −4, and `(-2)^2` is 4. Versions before 1.0.11 calculated `-2^2` as 4. If a saved formula has this form, a notice appears when you open LOGADEC (formulas that use movavg are notified in the same way that the calculation rules changed).
- There is no remainder operator (`%`). It gives an invalid character error.

12.3 Constants and variables

Name	Meaning	Example	Result
`PI`	Pi	`sin(PI/2)`	1
`E`	The base of the natural logarithm	`log(E)`	1
`x`	The X value of each point (in X-axis units)	`x`	0–599.9

An expression that references no series (for example, `sin(2*PI*x/60)`) is calculated on the X of the data loaded on the screen. The status display shows "[**Ready**] ([**constants/functions only**] ⋯)". It cannot be saved before data is loaded.

12.4 Point-by-point functions

Calculated at each point. Arguments can be series, numbers, or expressions.

Function	Meaning	Example	Result
`sqrt(a)`	Square root	`sqrt(16)`	4
`abs(a)`	Absolute value	`abs(-3.5)`	3.5
`log(a)`	Natural logarithm (base e). For the common logarithm, use `log(a)/log(10)`	`log(100)`	4.60517
`exp(a)`	e to the power a	`exp(1)`	2.71828
`sin(a)` `cos(a)` `tan(a)`	Trigonometric functions (a in radians; for degrees, use `a*PI/180`)	`cos(PI)`	−1
`pow(a, b)`	a to the power b (exactly two arguments)	`pow(2, 10)`	1024
`min(a, b, …)`	Point-by-point minimum (two or more arguments)	`min(3, 1, 2)`	1
`max(a, b, …)`	Point-by-point maximum (two or more arguments)	`max(3, 1, 2)`	3
`floor(a)`	To the smaller integer	`floor(-2.5)`	−3
`ceil(a)`	To the larger integer	`ceil(-2.5)`	−2
`round(a)`	To the nearest integer. Exactly half rounds toward the larger	`round(2.5)`, `round(-2.5)`	3, −2
`sign(a)`	Sign (−1 for negative, 0 for 0, 1 for positive)	`sign(-7)`	−1

- Points that cannot be calculated have no value (NaN). Examples: `sqrt(-1)`, `log(-1)`, `1/0`. The graph line breaks there.
- `min` and `max` compare point by point. For the minimum and maximum of a whole series, use `minval` and `maxval`. Example: `max(\`Current\`, 15)` sets points below 15 A to 15.

12.5 Aggregate functions

Calculates one value from the whole series and puts the same value at every point. Write one series or expression as the argument.

Function	Meaning	Example	Result
`mean(s)`	Mean	`mean(`Oil temp`)`	71.8156
`std(s)`	Standard deviation (divided by the number of points N)	`std(`Current`)`	2.00724
`sum(s)`	Sum	`sum(`Current`)`	103944.097
`minval(s)`	Minimum	`minval(`Speed`)`	790.9
`maxval(s)`	Maximum	`maxval(`Speed`) - minval(`Speed`)`	2233.1
`median(s)`	Median (with an even number of points, the mean of the middle two)	`median(`Current`)`	17.0755

- Points without a value are excluded from the calculation.
- With [**X range**], only points within the range are used.
- The argument can be an expression. `mean(`Current`*2)` is 34.648. `sum(1)` gives the number of points (6000).
- Common forms: `` `Oil temp` - mean(`Oil temp`) `` (deviation from the mean), `` `Vibration RMS` / maxval(`Vibration RMS`) `` (normalize the maximum to 1).

12.6 Time-series functions

Calculated using the points before and after.

Function	Meaning	Example	Result
`diff(s)`	Derivative. (current value − previous value) ÷ (current X − previous X)	`diff(`Speed`)`	−97 at 0.1 s (rpm/s)
`integ(s)`	Integral. Accumulates by the trapezoidal rule, with the first point as 0	`integ(`Power`) / 3600`	38.825 at 599.9 s
`movavg(s, n)`	Moving average. The mean of the last n points including the current point	`movavg(`Vibration RMS`, 10)`	0.2072 at 0.9 s
`shift(s, n)`	Shifts by n points. Positive n gives past values, negative n gives future values	`shift(`Current`, 1)`	13.768 at 0.1 s (the value at 0 s)

diff

- The unit is "the unit of the original series ÷ the X unit". If X is in seconds, it is the change per second.
- The first point has no value because there is no previous point.
- Points where X does not increase (the same time or a time going backward), and points where the point before or after has no value, have no value.

integ

- The unit is "the unit of the original series × the X unit". Integrating power (W) over seconds gives J. To get Wh, divide by 3600.
- The first point is 0.
- The following intervals are not added (the integral stays as it is and continues adding from the next interval).
- Intervals where either end has no value
- Intervals where the X spacing exceeds 1.5 times the step (the median interval)
- Intervals where X does not increase

movavg

- n is an integer of 1 or more, written as a number (series and decimals cannot be used). If omitted, it is 5.
- The first n−1 points have no value because not enough points are available.
- If any of the n points being averaged has no value, that point also has no value.

- Example: `movavg(`Current`)` is a 5-point average; the value at 0.4 s is 14.0486, the mean of the 5 points from 0 to 0.4 s.

shift

- n is an integer, written as a number. If omitted, it is 1.
- Points that fall outside the data as a result of shifting have no value.
- Example: `` `Speed` - shift(`Speed`, 1) `` is the difference from the adjacent point.

12.7 Error messages

If the expression has an error, the reason appears in the status display, and the formula cannot be saved.

Message	Cause and fix
Message about an invalid character	There is a character that cannot be used: a Japanese name not enclosed in backquotes, full-width digits, `%`, and so on
Message about an unknown function	The function name is wrong. Check that it is not written in uppercase
Message that (function name)() requires ⋯ arguments	The number of arguments is wrong. Examples: `pow(2)` (two required), `min(1)` (two or more required)
[**movavg needs n as a constant integer ≥ 1**]	The n of movavg is a decimal, 0, a series, or similar
[**shift needs n as a constant integer**]	The n of shift is a decimal, a series, or similar
Message about an unclosed (backquote)	A backquote is not closed
[**Invalid number**]	A number is written incorrectly. Examples: `1.2.3`, `1e+`
Syntax error message about an extra token	An operator is missing. Examples: `2 3`, `$11`
Message that $ must be followed by a number from 1 to 10	The symbol number is wrong. Example: `$0`
Series "⋯" was not found. Check the name.	There is no series or saved formula with that name. Check the name
Select the item for (symbol).	No series is assigned to a symbol used in the expression
Message about a circular reference	Formulas reference each other. This appears not in the status display while you type but when you try to save, and the formula is not saved