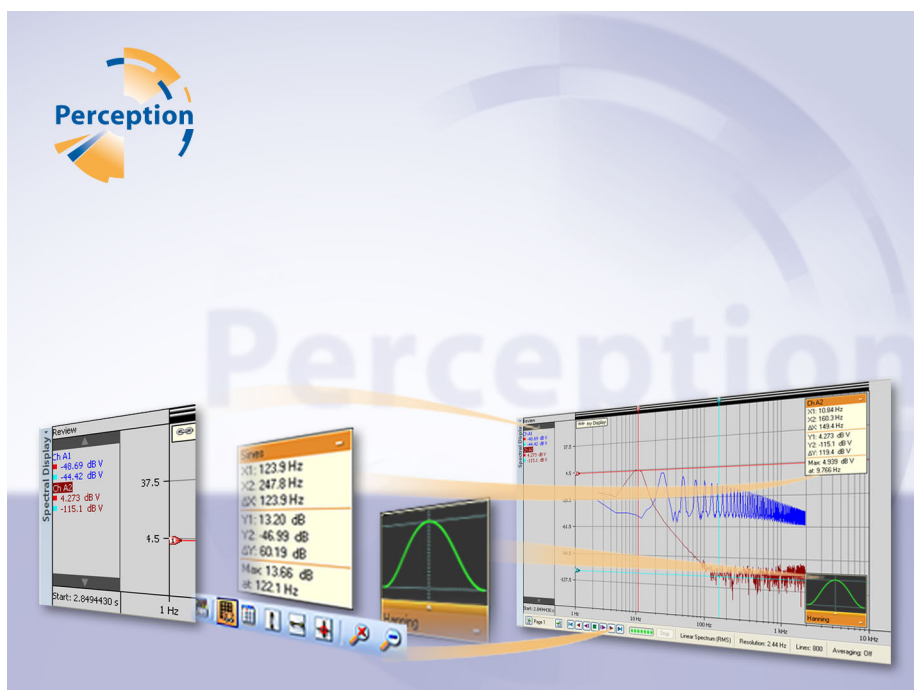


User Manual

English



Spectral Display Option Perception

Document version 1.2 - October 2012

For Perception 6.20 or higher

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1 Spectral Display

1.1 Introduction

In physics and systems engineering a **frequency** spectrum is a plot of the intensity of a random function of time, such as the amplitude of noise in a system, as a function of frequency.

For example a source of sound can have many different frequencies mixed together. Each frequency stimulates a different length receptor in our ears. When only one length is predominantly stimulated, we hear a note. A steady hissing sound or a sudden crash stimulates all the receptors, so we say that it contains some amounts of all frequencies in our audible range. Things in our environment that we refer to as noise often comprise many different frequencies. Therefore, when the sound spectrum is flat, it is called white noise. This term carries over into other types of spectrums than sound.

As another example each broadcast radio and TV station transmits a wave on an assigned frequency (or channel). A radio sender adds them all together into a single function of amplitude (voltage) versus time. The radio tuner picks out one channel at a time (like each of the receptors in our ears). Some channels are stronger than others. If we made a graph of the strength of each channel versus the frequency of the tuner, it would be the frequency spectrum of the antenna signal.

1.1.1 How to install the Spectral Display option

The Perception software requires a HASP key. HASP (Hardware Against Software Piracy) is a hardware-based (hardware key) software copy protection system that prevents unauthorized use of software applications. Each HASP key contains a unique ID number used for personalization of the application according to the features and options purchased. The key is also used for storing licensing parameters, applications and customer-specific data. If you have purchased the Spectral Display option as a separate item, you will receive a personalized "key file". Use this file to unlock the additional features.

You can find the serial number of your key in **Help ▸ About Perception**

To update the key information:

- 1 Choose **Help ▸ Update Key...**
- 2 In the Open dialog locate the Key File (*.pKey) and click **Open**.
- 3 If everything is OK you will see the following message:

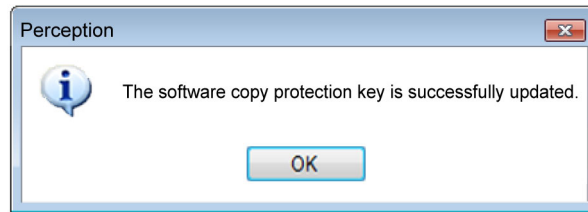


Figure 1.1: Software copy protection dialog

4 Click **OK**.

After the installation you can go to **Help** ▶ **About Perception** ▶ **More...** to see all installed options.

You will need to restart the program before the changes take effect. The Spectral Display option is now available.

1.2 Spectral analysis

Analysis means decomposing something complex into simpler, more basic parts. As we have seen, there is a physical basis for modeling sound, radio waves and other phenomena as being made up of various amounts of all different frequencies. Any process that quantifies the various amounts versus frequency can be called **spectral** (or spectrum) **analysis**. It can be done on many short segments of time, or less often on longer segments, or just once for a deterministic function.

The **Fourier transform** of a function produces a spectrum from which the original function can be reconstructed by an inverse transform, making it reversible. In order to do that, it preserves not only the magnitude of each frequency component, but also its phase. This information can be represented as a 2-dimensional vector or a complex number, or as magnitude and phase (polar coordinates). In graphical representations, often only the magnitude (or squared magnitude) component is shown.

Because of reversibility, the Fourier transform is called a representation of the function, in terms of frequency instead of time, thus, it is a **frequency domain** representation. Linear operations that could be performed in the time domain have counterparts that can often be performed more easily in the frequency domain. It is also helpful just for understanding and interpreting the effects of various time-domain operations, both linear and non-linear. For instance, only non-linear operations can create new frequencies in the spectrum.

The Fourier transform of a random waveform (or noise) is also random. Some kind of averaging is required in order to create a clear picture of the underlying frequency content. Typically, the data is divided into time-segments of a chosen duration, and transforms are performed on each one. Then the magnitude or (usually) squared-magnitude components of the transforms are summed into an average transform. This is a very common operation performed on digitized (or sampled) time-data, using the **discrete Fourier transform (DFT)**. When the result is flat, as we have said, it is commonly referred to as white noise.

1.3 Spectral Display

With the Perception Spectral Display option you have the capability to do basic spectral analysis. The display provides the means to transform very easily time-domain data into a frequency domain representation.

As said Spectral Analysis is a term used to describe the analysis of mathematical functions or signals with respect to frequency. The discrete Fourier transform (DFT) is one of the specific forms of Fourier analysis, and as such it transforms a function in the time domain into a frequency domain representation. A fast Fourier transform (FFT) is an efficient algorithm to compute the discrete Fourier transform (DFT) and its inverse.

Perception uses FFT to compute the information for the spectral display. Within the Spectral Display Properties dialog you have access to the parameters of the FFT calculation, averaging functionality and grid and scaling settings.

2 Spectral Display Fundamentals

2.1 Introduction

The Spectral Display provides an automatic representation of time-domain data in the frequency domain.

On the active sheet and user sheets one or more spectral displays can be positioned. Each spectral display can have multiple pages. Each page of the display can then have any number of overlapped traces.

2.2 Display concepts and components

Concept

By default a spectral display is linked to a specific time domain display. It will take over all layout information from that time domain display. It will also “follow” the settings of the time domain display: modifications made in the time domain will automatically reflect in the spectral display. You can also link to any other time domain display. When you link to another time domain display all settings from the new time domain display will be used.

Pages

A page is a part of a display, just like a page that is part of a book. Each display has at least one page, but can have multiple pages. Multiple pages are used to display a large number of traces with the same X-axis parameters like start- and stop frequency, cursor position, etc.

Only one page per display can be shown at a time. The other pages are positioned virtually “behind each other”. You can switch to other pages easily using the page control. Within a page one or more traces can be displayed.

Traces

A trace is the fundamental graphical representation of an FFT of a digitized real-world analog signal, or a formula/calculation on such a signal.

Views

In addition to the standard arrangement options, a display page can be divided furthermore into views. A view is a display-in-a-display and is used to represent the same data in a different way, for example as a zoomed part of the original trace(s).

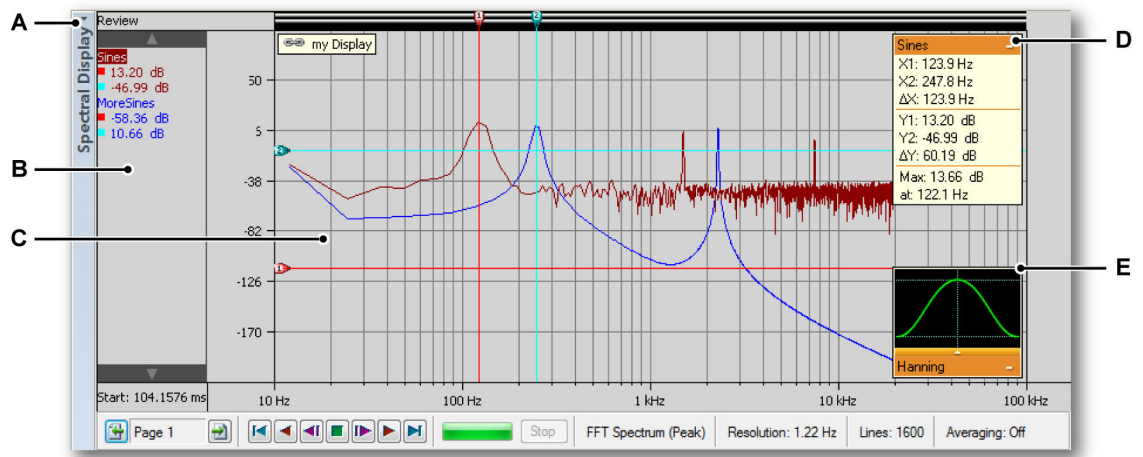


Figure 2.1: Display components - part 1

- A Display title bar
- B Y-annotation area
- C Trace area
- D Cursor values and statistics
- E FFT window selection

Within a display page there can be a maximum of four views. Depending on the settings these are:

- Main view: review in either sweep or recording mode.
- Zoom: a detail of the review view.
- Alternate zoom: another detail of the review view.
- Live: live streaming data

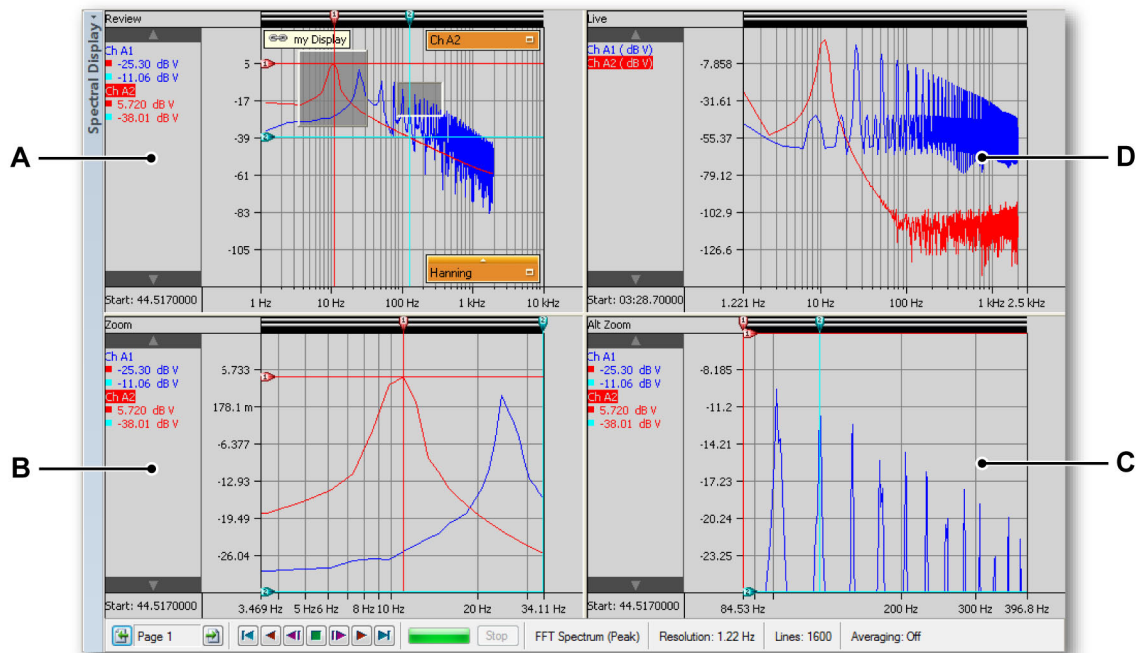


Figure 2.2: Display components - part 2

- A Review
- B Zoom
- C Alternate zoom
- D Live

Each view is laid out as an individual display. However, due to the nature of views, they are “connected” to each other.

The display view area in detail

The display view area provides a wealth of functions and information.

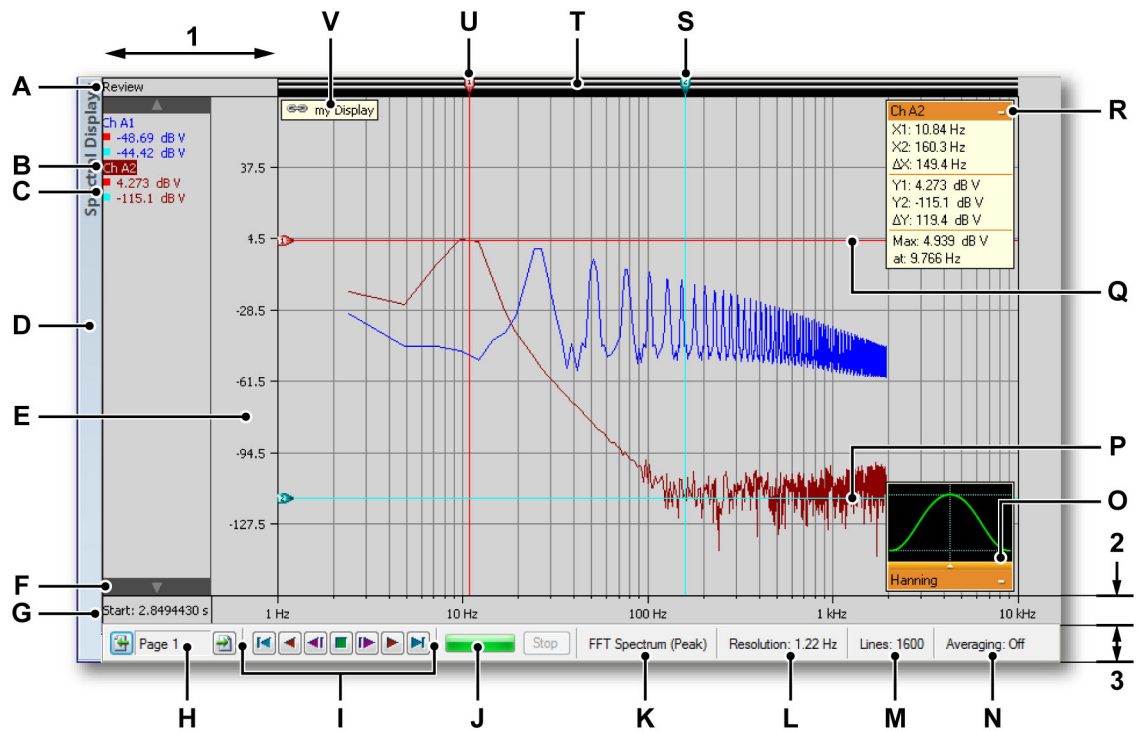


Figure 2.3: Display components - part 3

The display view area can be divided into four main regions:

- 1 Y-annotation area
- 2 X-annotation area
- 3 Control area
- 4 Trace area = the rest

- A View type
- B Trace name (active trace)
- C Cursor values
- D Display Title Bar (contains the name of the spectral display)
- E Y-Range scale
- F Active trace selector
- G Start of the time frame
- H Page selector
- I Frame cursor control
- J Calculation progress indicator
- K Current selected FFT
- L Current selected resolution
- M Current selected number of spectral lines

- N** Current Averaging status
- O** Windowing selection
- P** Passive horizontal cursor
- Q** Active horizontal cursor
- R** Trace information (cursor values and statistics)
- S** Passive measurement cursor
- T** Event bar
- U** Active measurement cursor
- V** Link (contains the name of the linked display)

A View type Here you see and select the type of this view. The following basic types are available:

- Review
- Zoom
- Alternate zoom
- Live

Depending on the selected basic type various options are available. The view type indicator is highlighted when the view is selected. When selected it is the “active view”.

B Trace name When it is highlighted it denotes the “active” trace.

C Cursor values Here you can see the cursor values as:

- Active cursor value
- Both cursor values
- Difference between the two cursor values

The selection follows the ‘linked’ time display.

D Display title bar

E Range indicator Shows the Y-Annotation scale. You can make a selection on how the scaling should be.

F Active trace selector Use these up/down arrows to step through the traces. The active trace will be displayed on top of the other traces in the view.

G Start time The start time of the FFT frame cursor in the time domain display.

H Page selection control Refer to the Time Display description for detailed information.

I Frame cursor control You can use this control to move the frame cursor over the time domain signal. The FFT of the part covered by the frame cursor will be calculated.

- J Calculation progress** This indicator shows the progress of the current FFT calculation. When the frame cursor is moved, a new FFT will be calculated. The progress bar gives a indication of the processing time and progress.
- K Currently selected spectral analysis**
- L Currently selected resolution**
- M Currently selected spectral lines**
- N Currently selected averaging mode (on/off)** When on it will show the number of averaging FFT's used to show the FFT result.
- O Windowing selection** Shortcut to select a specific FFT window.
- P Passive horizontal cursor** The passive horizontal cursor is the cursor that is not selected. It is color-coded blue.
- Q Active horizontal cursor** The active cursor is the cursor that is currently selected. It is color-coded red. When cursor tracking is enabled, the horizontal line will follow the crossing of the vertical cursor with the active trace.
- R Trace information** The window can be opened by clicking on the rectangle. It will show the cursor values and the maximum value. When the tracking cursors are selected the Y-Values will be updated also.
- S Passive measurement cursor** The in-active cursor, color-coded blue.
- T Event bar** A placeholder for the vertical cursor handles.
- U Active measurement cursor** The active cursor is the cursor that is currently selected. It is color-coded red.
- V Link indicator** This will be shown when a spectral display is linked to a time display. The name of time display is shown.

2.2.1 The Y-annotation area

On the left-hand side of the display there is the Y-annotation area. It is divided into two sections. The first is the annotation area. This will show the traces currently available within the page. The second part shows the amplitude values of the FFT.

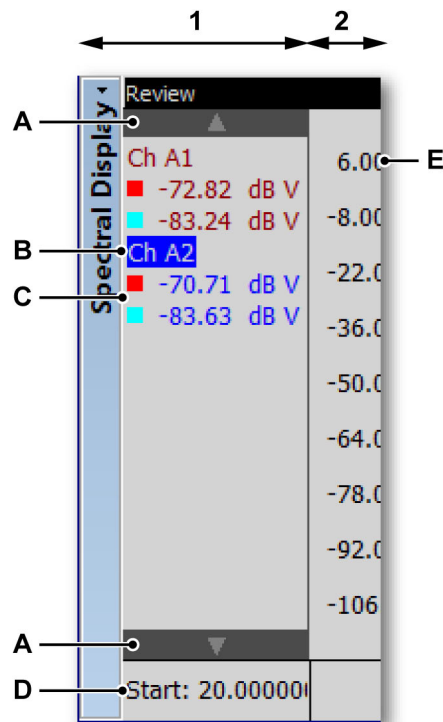


Figure 2.4: Y-annotation area

- 1 Annotation area** Names and cursor information. You can set the width of this annotation area through the width properties of the linked display. The width of the annotation area in the spectral display will follow the width of the linked display proportionally.
- 2 Scaling information**
- A Active Trace Selector** Use these up/down arrows to step through the traces. The active trace will be displayed on top of the other traces in the view.
- B Trace name** The active trace is shown highlighted in the list.
- C Cursor values** Here you can see the cursor values as:
 - Active cursor value
 - Both cursor values
 - Difference between the two cursor values

The selection follows the “linked” time display.

- D Start time** The calculation frame cursor in the time domain display.
- E Y-Scaling** The scaling can be selected through the properties menu of the spectral display.

2.2.2 The X-annotation area

The X-annotation area is used to display a frequency scale. The scaling can be selected through the properties menu of the spectral display.

2.2.3 Control area

The control area is the part of the display that contains the various controls.

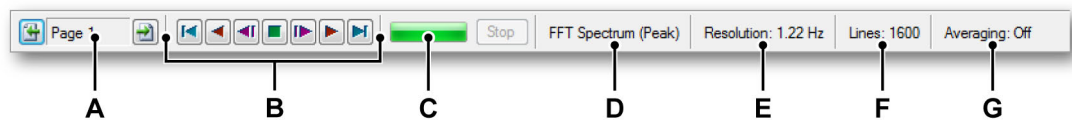


Figure 2.5: Control area

- A Page selection control** Refer to the Time Display description for detailed information.
- B Frame cursor control** You can use this control to move the frame cursor over the time domain signal. The FFT of the part covered by the frame cursor will be calculated.
- C Calculation progress** This indicator shows the progress of the current FFT calculation. When the frame cursor is moved, a new FFT will be calculated. The progress bar gives a indication of the processing time and progress.
- D Currently selected spectral analysis**
- E Currently selected resolution**
- F Currently selected spectral lines**
- G Currently selected averaging mode (on/off)** When on it will show the number of averaging FFT's used to show the FFT result.

Frame cursor control

The frame cursor control enables the automatic - movement of the frame cursor for FFT calculations. The frame cursor is the time area section over which the FFT calculation will be executed and shown.

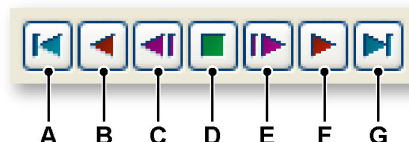


Figure 2.6: Frame cursor control (detail)

- A** Move frame cursor to the beginning of the time-domain signal.
- B** Automatically move the frame cursor in steps towards the beginning of the recording.
- C** Move the frame cursor one step towards the beginning of the recording.
- D** Stop the automatic frame cursor movement.
- E** Move the frame cursor one step towards the end of the recording.
- F** Automatically move the frame cursor in steps towards the end of the recording.
- G** Move frame cursor to the end of the time-domain signal.

2.2.4 Trace Area

In the trace area the Spectral information will be displayed. It contains two additional windows.

- Trace information
- Window selection

Trace Information

The title shows the name of the currently active trace. When maximized the following information will be shown.

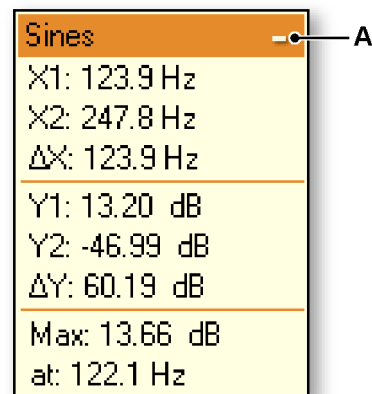


Figure 2.7: Trace Information (detail)

A Maximize/minimize

The trace information shows the following information:

- X1 The frequency of cursor 1.
- X2 The frequency of cursor 2.
- ΔX The frequency difference between the cursors.

- Y1 The amplitude of the crossing between cursor 1 and the FFT signal.
- Y2 The amplitude of the crossing between cursor 2 and the FFT signal.
- ΔY The difference in amplitude of the results of Y1 and Y2.
- Max The maximum value found in the frequency signal.
- At The frequency where the above maximum was found.

Window Selection

When minimized, the dialog has the following layout:

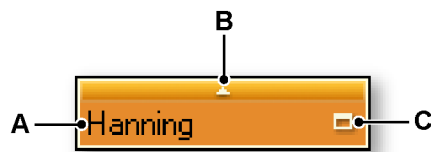


Figure 2.8: Window selection (detail)

- A** Selected Window name
- B** Show Window selection menu
- C** Maximize/minimize

This dialog shows the current selected FFT window and allows you to select another one.

To maximize or minimize the dialog:

- Click on the maximize/minimize icon.

When maximized the following information will be shown:

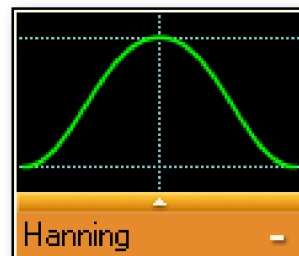


Figure 2.9: Maximized window selection

To select an FFT window do the following:

- 1 Click on the small arrow pointing upwards.
- 2 In the list that comes up select the FFT window that you want to use.
The graphical representation will be updated.

Note on Flat Top Window

The Flat Top window is a derived window that can have many implementations (with a non-fixed number of coefficients), optimized for the needs of the application.

The name comes from the low ripple in the passband. The ripple is negligible and the amplitude error will be determined by the overall linearity of the digitizer. Thus the window is designed mainly for calibration purposes.

The implementation of the window within the Spectral Display is based on a maximum Side Lobe Level of -93 dB.

Coefficients used:

$c_0=0.9961005$, $c_1=1.9050531$, $c_2=0.5374825$, $c_3=0.09127422$,
 $c_4=0$

$$WindowData[i] = c_0 - c_1 * \cos\frac{2\pi i}{N} + c_2 * \cos\frac{4\pi i}{N} - c_3 * \cos\frac{3\pi i}{N} + c_4 * \cos\frac{4\pi i}{N}$$

With:

i = sample number

N = number of samples

3 Display Operations

3.1 General

This section describes how to use the various display tools.

3.1.1 Linked display

Within Perception a spectral display is typically linked to a time-domain display. Pages, colors, traces are all copied from the linked time-domain display and when something changes in this area, the change is copied over to the spectral display. So if you add a trace to a time-domain display this trace is also added to the spectral display.

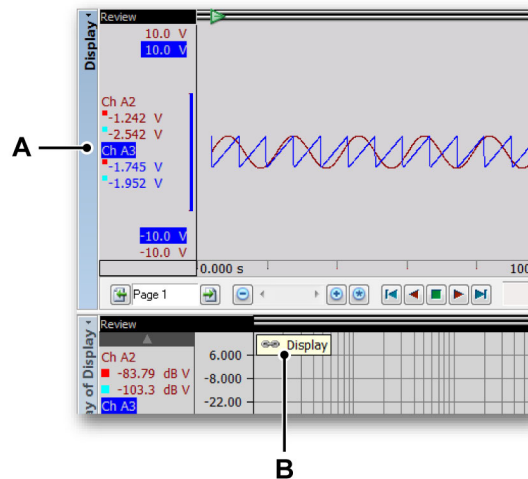


Figure 3.1: Time-domain display

A Name of the time-domain display

B Link indicator in the spectral display showing that it is linked to time-domain display “my Display”

When a spectral display is linked to a time-domain display you see the link indicator in the spectral display showing which time-domain display it is linked to. When there is no link, this icon is not shown at all.

Linking is done to keep an intuitive relationship between time and frequency domain data. By using the automatic link behavior you will always be looking at the same data in the time and frequency domain through the linked displays. However, you can also remove and restore the link at any time.

Changes that are made to a time-domain display when the spectral display is not linked will not get transferred to the spectral display.

Note *When you restore the link between a time and spectral display, the layout of the spectral display will be updated to match the linked display, this will also happen if you change the link from one display to another one.*

3.1.2 Adding/removing traces to a spectral display

You cannot add or remove traces directly to a spectral display. You need to have a link between the spectral display and time-domain display, and configure the time-domain display. Traces that are added to the time-domain display also get added to the spectral display, traces that are removed from the time display are also removed from the spectral display.

3.1.3 Modifying the display layout

You cannot change the display layout of the spectral display. Colors and other layout behavior are copied from the linked time-domain display.

3.1.4 Zooming and panning in the spectral display

A powerful feature of the display is the ability to zoom in on a segment of interest of the spectrum. Perception supports fully free-style zooming and panning in two areas of the spectral data. The second zoom area is called the alternate zoom. All zoom functions on the alternate zoom are performed exactly the same as on a normal zoom but with the Alt-key pressed.

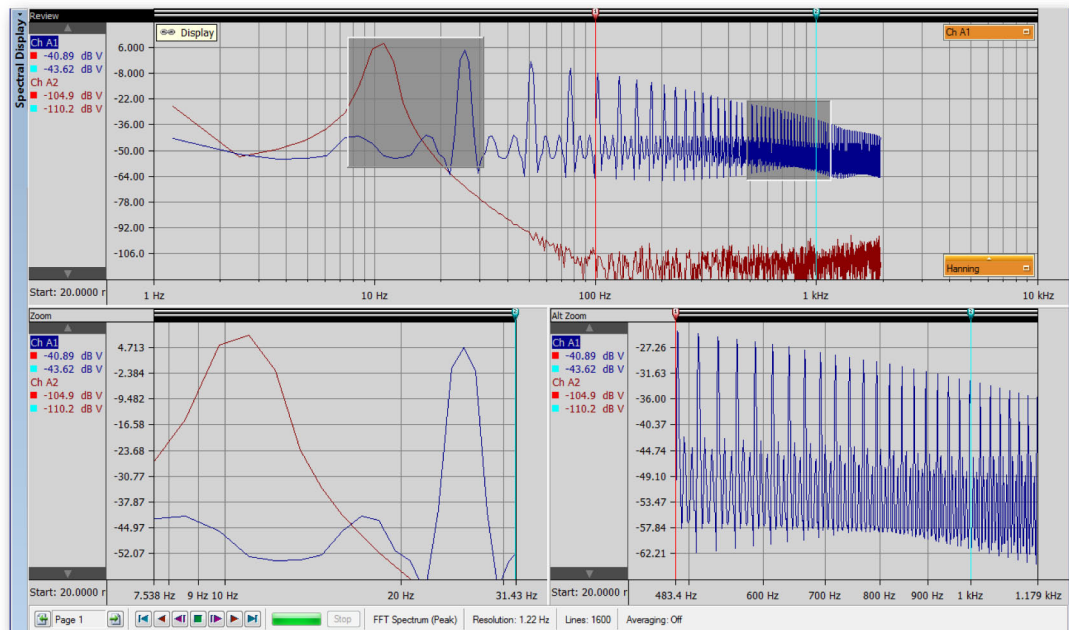


Figure 3.2: Zoom areas

To zoom in:

Click and drag the mouse. A bounding box with a semi-transparent fill will appear indicating the zoom area. When you release the mouse, a zoom view will be created filled with the zoomed portion of the original view. The zoom area is shown as a raised semitransparent bounding box in the review view. The alternate zoom area is shown as a sunken semitransparent bounding box in the review view. When zooming you can press the Ctrl or Shift key to constrain the zoom area in the X or Y direction respectively.

To resize a zoom area:

You can resize a zoom area by dragging a side or a corner of the bounding box to another location as follows:

- With the mouse hover over a border or corner. When an arrow cursor appears click and drag in the required direction.

To move the zoom area:

You can move the zoom area by dragging it to another location as follows:

- With the mouse hover over the zoom area. When the four-way cursor shape appears click and drag the zoom area to another location.

To unzoom:

- Right-click the view. Click the Unzoom command in the context menu that comes up. The zoom area will disappear.

3.1.5 Replay data

Analyzed data can be replayed within a Review view of the spectral display.

The replay functionality is controlled by the **frame cursor replay control** that is located in the control bar of the display.

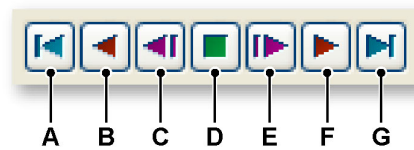


Figure 3.3: Frame cursor control (detail)

Replaying in non averaging mode:

- A** Go to begin: show the frame with start time at the beginning of the time-domain recording.
- B** Step back automatically full frames at a fixed interval until the start of the time-domain recording is reached.
- C** Step back a single full frame.
- D** Stop automatic replay
- E** Step forward a single full frame.
- F** Step forward automatically full frames at a fixed interval until the end of the time-domain recording is reached.
- G** Go to end: jump to the last available full frame for the time-domain recording.

Replaying in averaging mode:

- A** Go to begin: show the frame with start time at the beginning of the time-domain recording. This action resets the average.
- B** Step back automatically full frames at a fixed interval until the start of the time-domain recording is reached. Each step back will reset the average.
- C** Step back a single full frame. Each step back will reset the average.
- D** Stop automatic replay. This will show the average calculated until now.
- E** Step forward a single full frame. The new frame will be added to the current average.

- F** Step forward automatically full frames at a fixed interval until the end of the time-domain recording is reached. The average until the end of recording will be calculated.
- G** Go to end: jump to the last available full frame for the time-domain recording. This will jump immediately to the final average without showing intermediate results.

3.1.6 Interaction between the spectral display and the time display


When linked to a display the entire layout of the time-domain display is copied to the spectral display.

3.1.7 Frame cursor in non-averaging mode

In the time-domain display a frame cursor will now be shown. This frame cursor indicates what area of the waveform is included in the frequency frame.

The frame cursor will dynamically show you the new area of the spectral display when using the replay buttons. You can also use the frame cursor to look at the frequency characteristics at a position you are interested in. The frame cursor is displayed as a semi transparent red area with two solid red lines annotating the start and end time of the frame.

You can move the frame cursor in the time domain display manually. To do so:

- 1** Hover over a vertical edge of the frame until you see the bi-directional arrow cursor .
- 2** Click and drag the frame to the desired position.
- 3** Release the mouse button.

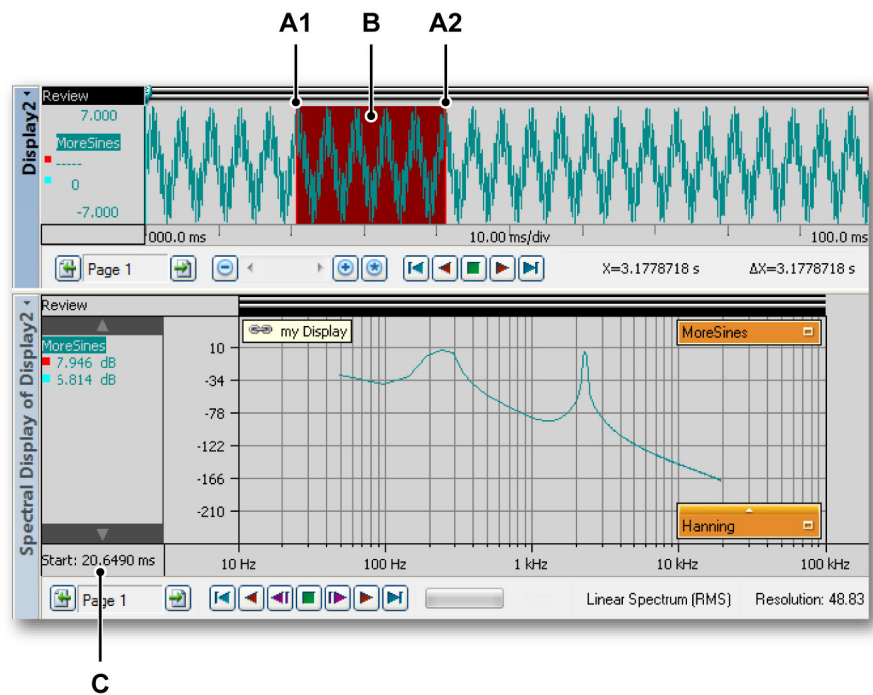


Figure 3.4: Time-domain display with frame cursor in non-averaging mode

- A1** This is the start time of the frame currently shown in the spectral display. The numerical value of this time is annotated at **C**
- A2** This is the end time of the frame currently shown in the spectral display. In case of multiple traces in the display, the properties (sampling rate) of the active trace are used to determine where the frame ends.
- B** The area that is being shown in the spectral display is shown in a transparent red area.
- C** This is the start time of the frame currently shown in the spectral display.

3.1.8 Frame cursor in averaging mode

When using averaging the semi-transparent overlay is extended to show the averaging behavior of the spectral display.

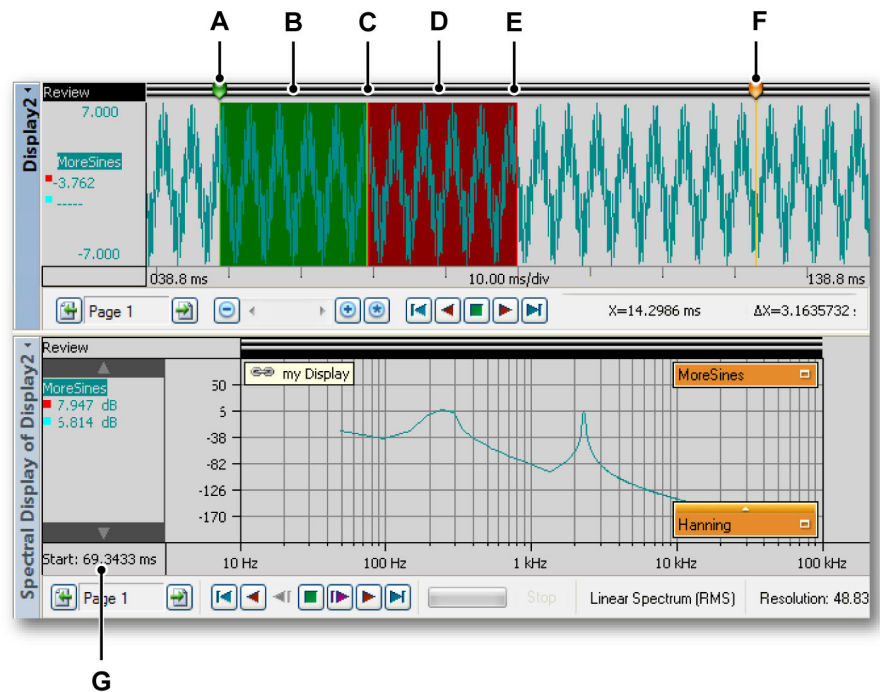


Figure 3.5: Time-domain display with frame cursor in averaging mode

- A** The position of the first data that is included in the average.
- B** The area that was previously averaged and is still included in the average frame.
- C** The start position last frame added to the average.
- D** The area of the last frame that was added to the average.
- E** The end position of the last frame that was added to the average.
- F** The end position of the area that will be included in the average.
- G** The start time of the last frame that was added to the average.

In general the frame cursors always use the active trace to calculate at which position a cursor should be drawn or how wide it should be. When using a single sample rate this will not change anything if another trace is made active, but when different traces in the display are recorded using different sample rates the width and position of the frame cursor may change when activating another trace.

3.1.9 Linking

Spectral displays may be added to the active sheet and all user sheets. If a spectral display is added to a sheet that already contains a time-domain display, the spectral display will automatically be linked to that display.

If more than one time-domain display exists on the sheet, the active time domain display will be automatically linked to the new spectral display.

To change the linked time-domain display, do one of the following:

- Right-click in a view of the spectral display. On the shortcut menu that comes up point to **Link With**. In the submenu that comes up select the display you want to link to.
- If the spectral display is active go to the dynamic menu. On the dynamic menu point to **Link With**. In the submenu that comes up select the display you want to link to.
- If the spectral display is not active, go to the dynamic menu. On the dynamic menu point to **Spectral Display**, point to **Link With**. In the submenu that comes up select the display you want to link to.

If no display existed at the moment you added the spectral display, there will be no link. The spectral display will not be automatically linked to a time-domain display if the time-domain display is added last. In these cases you can setup the link manually.

To set link a time-domain display to a spectral display do one of the following:

- Right-click in a view of the spectral display. On the shortcut menu that comes up point to **Link With**. In the submenu that comes up select the display you want to link to.
- If the spectral display is active go to the dynamic menu. On the dynamic menu point to **Link With**. In the submenu that comes up select the display you want to link to.
- If the spectral display is not active, go to the dynamic menu. On the dynamic menu point to **Spectral Display**, point to **Link With**. In the submenu that comes up select the display you want to link to.

4 Measurements

4.1 Cursors and basic measurements

Within the Review or Zoom view of a Spectral Display there are two types of cursors:

- The **vertical** measurement cursors. These are the primary cursors for a variety of measurements. They also serve as boundaries for calculations.
- The **horizontal** cursors. These are additional cursors that provide amplitude information.

Both cursor types can be visible or hidden on a per display basis. Cursors can also be 'tracking': when the tracking option is turned on, each horizontal cursor moves simultaneously with the respective vertical cursor along the frequency spectrum trace.

The various cursor commands are accessible through the toolbar, the dynamic sheet menu and the display shortcut menu.

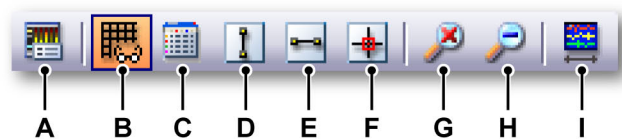


Figure 4.1: Cursor toolbar (detail)

- A Display properties
- B Show/hide grid
- C Show/hide cursor table
- D Show/hide vertical cursors
- E Show/hide horizontal cursors
- F Enable/disable trace tracking cursors
- G Unzoom
- H Zoom back
- I Set View to Y-t display Period/Sets the framecursor size to the best match with the times of the view in the linked display.

To show or hide cursors:

To show or hide specific cursors do one of the following:

- Click on the corresponding visibility button in the toolbar.
- Using the dynamic sheet menu when the spectral display is active:
 - Click on the required cursor type.
- Using the dynamic sheet menu when the spectral display is not active:
 - 1 Point to **Spectral Display**.
 - 2 Click on the required cursor type.
- Using the context menu:
 - 1 Right-click in the spectral display area.
 - 2 In the context menu that comes up click on the required cursor type.

When cursor visibility is switched to visible, the cursors come up to default positions on the spectral display area. The vertical cursors are positioned at 100 Hz and at 1 kHz. The horizontal cursors are both positioned at zero amplitude level.

Cursors are moved by clicking on the handle or on the cursor line using the mouse and dragging the cursor to the new location. When you hover the mouse pointer over the cursor the mouse pointer changes to indicate that you can drag the cursor or the cursor handle.

When the **Trace Tracking Cursors** option is enabled, each vertical cursor is paired with the corresponding horizontal cursor. When you drag the vertical cursor the corresponding horizontal cursor remains locked to the vertical, i.e. their crossing point always falls onto the spectral waveform of the active trace.

To enable or disable tracking cursors:

To enable or disable tracking cursors do one of the following:

- When available click the **Use Trace Tracking Cursors** command in the toolbar.
- Using the dynamic sheet menu when the spectral display is active:
 - Click the **Use Trace Tracking Cursors** command
- Using the dynamic sheet menu when the spectral display is not active:
 - 1 Point to **Spectral Display**.
 - 2 Click the **Use Trace Tracking Cursors** command
- Using the context menu:
 - 1 Right-click in the spectral display area.
 - 2 In the context menu click the **Use Trace Tracking Cursors** command

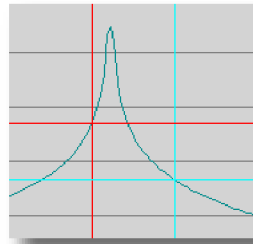


Figure 4.2: Trace Tracking Cursors maintain their crossing point on the spectral waveform

4.1.1 Vertical cursors

The event bar at the top of the spectral display contains cursor “handles” used for moving the vertical cursors. Cursors are moved by clicking on the handle or on the cursor line using the mouse and dragging it to a new location. When you move the pointer over the cursor the mouse pointer changes to indicate that you can drag the cursor.

The values of the vertical cursors can be displayed in the measurement window and in the Y-annotation area.

In addition the cursors also have a number. This number is fixed for that specific cursor, that is it does not change. This makes it easy to reference the cursors.

4.1.2 Horizontal cursors

Horizontal cursors are additional cursors that you can use for amplitude measurements. Cursors are moved by clicking on the handle or on the cursor line using the mouse and dragging it to a new location. When you move the pointer over the cursor the mouse pointer changes to indicate that you can drag the cursor.

In addition the cursors also have a number. This number is fixed for that specific cursor, i.e. it does not change. This makes it easy to reference the cursors.

4.1.3 Cursor measurements

The values of the vertical cursors can be displayed in the information window and in the Y-annotation area.

In addition a window can be displayed containing all cursor values, including horizontal cursors. The Cursor Table shows the cursor values of the active spectral display.

This window also provides functionality to copy values to clipboard and post values to Excel.

To show or hide the Cursor Table make sure a spectral display is active and do one of the following:

- When available in the **toolbar** you can click the **Cursor Table** button.
- With the spectral display selected: press the **space bar**.
- Using the **dynamic sheet menu** and with the spectral display selected click the **Cursor Table** command.
- Using the context menu:
 - 1 Right click the spectral display area.
 - 2 In the context menu that comes up click the Cursor Table command.
- In addition you can close the Cursor Table as follows:
 - Click the **Close** button in the title bar of the window.
 - Click the **Close** command in the **Settings** menu of the window.

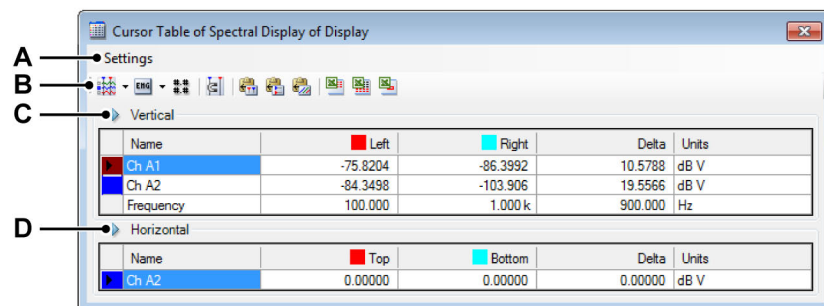


Figure 4.3: Cursor Table

- A Menu bar
- B Toolbar
- C Vertical cursors
- D Horizontal cursors

- A Menu bar** The menu bar has one menu: Settings. The settings menu provides access to all additional features of the Cursor Table.

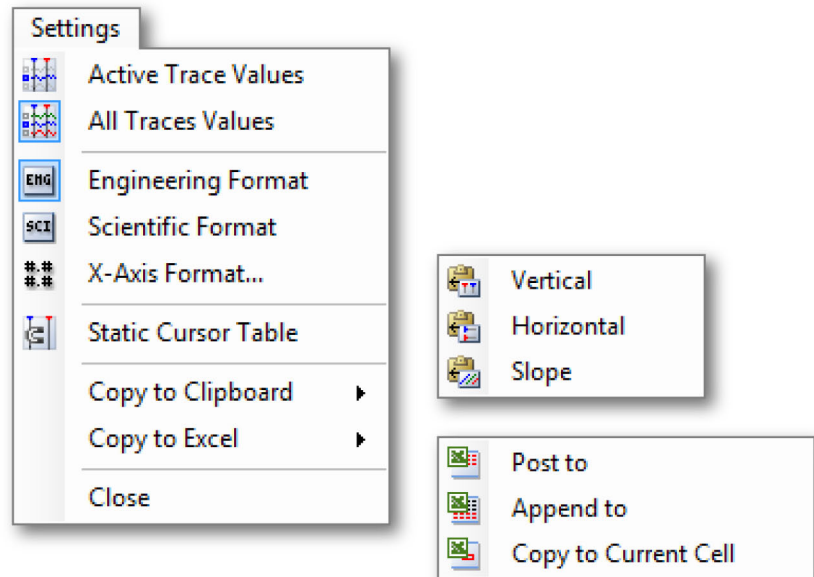


Figure 4.4: Cursor Table Settings menu

- **Active Trace Values** Show only the values of the vertical cursors and the active trace. When information on horizontal cursors is available these will be shown also.
- **All Traces Values** Show the values of the vertical cursors and all traces. When information on horizontal cursors is available these will be shown also.
Values are displayed in technical units.
- **Engineering Format** Select this option when you want the displayed values to be in engineering format. This format is a scientific notation in which the power of ten is a multiple of three.
- **Scientific Format** Select this option when you want the displayed values to be in scientific format. This format is a shorthand way of writing very large or very small numbers. A number expressed in scientific notation is expressed as a decimal number between 1 and 10 multiplied by a power of 10.
- **X-Axis Format** Select this command to set the format used to display frequency.
By default the frequency is displayed as short as possible: only the available information is displayed without leading zeros. In the format dialog you can set the number of **decimal places** used behind the integral part of the frequency.
- **Static Cursor Table** Select this option when you want to use the fixed numbers of the horizontal and vertical cursors as reference instead of

the relative “left/right” and “top/bottom” naming. Use this option if you want the values in the columns related to a cursor remain in the same column. For example when you move one cursor to the other side of the other cursor, the indication remains in the same column: values from one cursor are always in the same column, regardless of the position of the cursor.

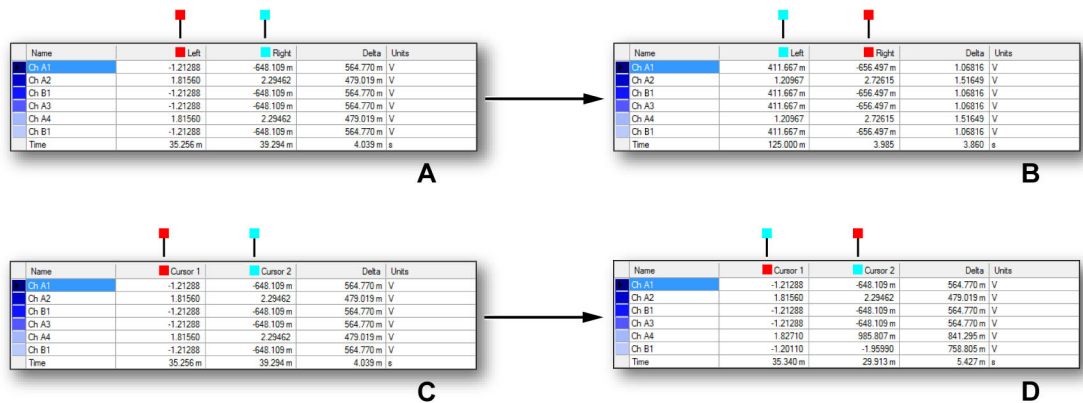


Figure 4.5: Static and non-static cursor table

- **Copy to Clipboard** You can copy values to clipboard and paste these values in another application. You can select to copy only the values of the horizontal, vertical or slope cursors. The copy includes the column headers.
- **Copy to Excel** You can copy the values directly to Microsoft Excel with the following options:
 - **Post To** This will place the complete table into Excel on a sheet called “ Perception - display name”. When Excel is not active it will be launched. When the sheet already exists data will be overwritten.
 - **Append To** The data will be appended to the data that is already in the sheet called “ Perception - display name”.
 - **Copy to Current Cell** Data will be placed in the currently active sheet with the upper left-hand cell of the cursor table in the currently active cell of the sheet.
- **Close** Close the Cursor Table.

B Toolbar The toolbar provides quick access to the most commonly used commands.

C Vertical cursors The vertical cursors area has rows for each trace and a bottom row to display the time information. The columns provide the following information:

- **Name** The name of the trace.
- **Left/Cursor 1** The Y-value of a trace at the named cursor position. The cursor position in time is shown in the Time row. A red and blue indicator is used to denote the active (red) and passive (blue) cursor.
- **Right/Cursor 2** The Y-value of a trace at the named cursor position. The cursor position in time is shown in the Time row. A red and blue indicator is used to denote the active (red) and passive (blue) cursor.
- **Delta** The difference between the cursor values.
- **Units** The technical units of each trace and the frequency.

D Horizontal cursors The horizontal cursors area has a single row. This row displays the active trace. The columns provide the following information:

- **Name** The name of the active trace.
- **Top/Cursor 1** The level of this cursor with respect to the active trace. Depending on the location of the cursor this level may be well above or below the actual levels of the active trace. A red and blue indicator is used to denote the cursor of respective color.
- **Bottom/Cursor 2** The level of this cursor with respect to the active trace. Depending on the location of the cursor this level may be well above or below the actual levels of the active trace. A red and blue indicator is used to denote the cursor of respective color.
- **Delta** The difference between the cursor values.
- **Units** The technical units.

5 Spectral Display Properties

5.1 Introduction

Spectral Analysis is a term used to describe the analysis of mathematical functions or signals with respect to frequency.

The discrete Fourier transform (DFT) is one of the specific forms of Fourier analysis, and as such it transforms a function in the time domain into a frequency domain representation.

A fast Fourier transform (FFT) is an efficient algorithm to compute the discrete Fourier transform (DFT) and its inverse.

Perception uses FFT to compute the information for the spectral display.

Within the Spectral Display Properties dialog you have access to the parameters of the FFT calculation, averaging functionality and grid and scaling settings.

In this dialog you also set the name of the display.

To gain access to the Spectral Display Properties use one of the following procedures:

- When the Spectral Display is the active component on a sheet, select **Properties** on the dynamic sheet menu.
- When the Spectral display is not the active component on a sheet, point to **Spectral Display** on the dynamic sheet menu and select **Properties** in the submenu.
- Right-click anywhere in the Spectral Display area and select **Properties** in the shortcut menu that comes up

5.2 Spectral Settings

The Spectral Settings page gives access to the various settings related to the FFT calculation.

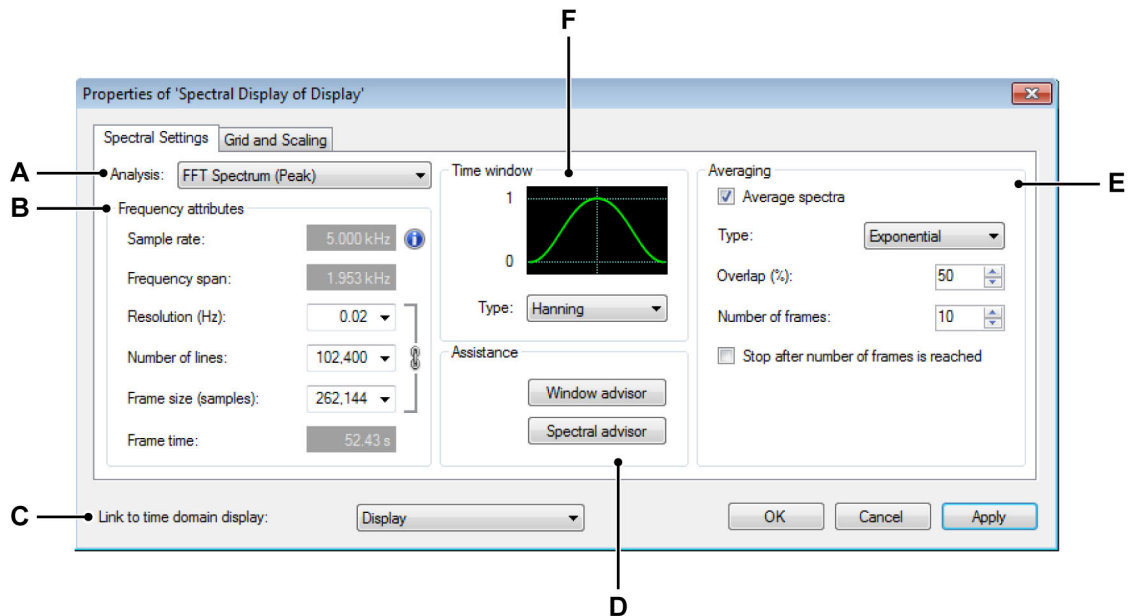


Figure 5.1: Spectral Display Properties dialog

- A Type of analysis** Select your output spectrum.
- B Frequency attributes** Define the “accuracy” of the output.
- C Link to time domain display** Select the time domain display.
- D Assistance** Here you find on-line help.
- E Averaging** When required make your average settings here.
- F Time window** Apply a window on the time domain signal before the analysis

5.2.1 Analysis

Here you can select the type of analysis that you want to do. Click **Spectral Advisor** under **Assistance** to get additional help.

Frequency attributes

The frequency attributes are divided into two categories: fixed (result) values and an array of three linked values. The following section describes the theoretical background of these values and their relations. You may skip this section and continue with the next section if you are not interested in the theory.

Frequency attributes – theoretical background

There are multiple ways to come to the relations between the various FFT frequency parameters. First the definitions:

Sample rate: f_s (in Hz)

Sample period (in seconds):

$$\Delta t = \frac{1}{f_s}$$

Number of points acquired: N , also known as frame size

Total acquisition time:

$$T = N \bullet \Delta t$$

The best resolution an FFT can produce is determined by the total acquisition time T as follows:

Frequency resolution:

$$\Delta f = \frac{1}{T} = \frac{1}{N \bullet \Delta t} \quad [1]$$

As a result there will be a number of lines available within the FFT. This is related to the following theorem:

The theorem is commonly called the Shannon sampling theorem, and is also known as Nyquist–Shannon–Kotelnikov, Whittaker–Shannon–Kotelnikov, Whittaker–Nyquist–Kotelnikov–Shannon, WKS, etc., sampling theorem, as well as the Cardinal Theorem of Interpolation Theory. It is often referred to as simply **the sampling theorem**.

Note *Exact reconstruction of a continuous-time baseband signal from its samples is possible if the signal is band-limited and the sampling frequency is greater than twice the signal bandwidth.*

Therefore the maximum frequency range (span) will be half the sample rate. The conclusion, that perfect reconstruction is possible, is mathematically correct for the model, but only an approximation for actual signals and actual sampling techniques. This will have an impact, as we will discuss later.

Theoretically:
Frequency span:

$$F = 0.5 \bullet f_s \quad [2]$$

This yields:
Number of lines:

$$L = \frac{F}{\Delta f} \quad [3]$$

The above computations for the frequency axis demonstrate that the sampling frequency determines the frequency range (span) of the spectrum [2] and that for a given sampling frequency, the number of points acquired in the time-domain signal record determine the frequency resolution [1].

As a result, when we assume a fixed sample rate f_s :

- **Number of lines L:** you set the number of lines. From [2] and [3] this results in a given Δf and therefore through [1] a fixed frame size N , or
- **Frame size N:** you set the frame size N . From [1] this results in a given Δf and through [2] and [3] this yields the number of lines L , or
- **Frequency resolution:** you set the frequency resolution Δf and from [3] this results in the number of lines L . Through [1] this also yields the frame size N .

A note on the frequency span

It is just described using the sampling theorem how to come to the frequency span F . However, because most times the analog signal passes through an anti-aliasing filter at the input, the entire frequency span is not useable. A filter has a flat response from DC to a frequency lower than the Nyquist frequency and then rolls off. No filter can make a steep transition instantly. Therefore the frequency span is typically set to a smaller value:

Frequency span:

$$F_{smaller} = 0.4 \bullet f_s$$

This is also the range that is shown in the display. However, the factor 0.4 is 'random'. Usually a value of 0.390625 is chosen, e.g. not divide by 2 (Nyquist) but by 2.56, which results in so-called "nice" values:

Number of lines [3]:

$$L = \frac{F}{\Delta f} \quad [3]$$

Frequency resolution [1]:

$$\Delta f = \frac{1}{T} = \frac{1}{N \bullet \Delta t} \quad [1]$$

And frequency span [2]:

$$F = afactor \bullet f_s = \frac{afactor}{\Delta t} \quad [2]$$

Otherwise stated:

$$L = F \bullet N \bullet \Delta t$$

which yields:

$$afactor = \frac{L}{N}$$

Example: with a typical frame size $N = 2048$ and a “requested” nice value of $L = 800$

The resulting factor is:

$$afactor = \frac{L}{N} = \frac{800}{2048} = 0.390625$$

For FFT's, block sizes of 2^n are used, so this is a typical value.

Frequency attributes – the settings

Sample rate

The sample rate is defined by the sample rate of the data in the time-domain display. The Spectral Display supports only one sample rate. When multiple sample rates are used in the time domain display, the sample rate of the top-most trace in the time-domain display is used. When you hover over the information icon behind the sample rate value a tooltip shows the sample rate source.

Frequency span

The frequency span defines to what frequency the FFT calculation produces a result. Refer to "A note on the frequency span" on page 41 for detailed information.

Resolution (Hz)

Here you select the frequency resolution that you want to see. The drop-down list provides a list of available options. When you select a new resolution, the **Number of Lines** and **Frame size** will change accordingly.

Number of lines

Here you select the number of lines that you want to have. The drop-down list provides a list of available options. When you select a new value, the **Frequency span** and **Frame size** will change accordingly.

Frame size (samples)

Here you can select a frame size. The drop-down list provides a list of available options. When you select a new value, the **Frequency span** and **Number of lines** will change accordingly.

Frame time

This is the result of sample rate times frame size.

5.2.2 Time Window

You can use windows in the time domain to minimize the effects of performing an FFT over a non-integral number of cycles.

Within the Perception Spectral Display you can select one-out-of-many type of windows. Each window is based on a mathematical function.

Although it is technically very simple to choose a window (just pick one from the list), in practice there are some intricacies. Each window has its own characteristics, and different windows are used for different applications. Click **Window Advisor** under **Assistance** to get additional help.

5.2.3 Assistance

To get on-line assistance on major topics click the command button you need. A dialog will come up with information on the selected topic.

5.2.4 Averaging

Averaging many spectra together improves the accuracy and repeatability of measurements.

The following types of averaging are currently supported:

- **Linear Averaging** Linear averaging combines M (number of averages) spectra with equal weighting. When the number of averages has been completed, the averaging can stop or be reset.
- **Exponential Averaging** Exponential averaging weights new data more than old data. Averaging takes place according to the formula:

$$AverageM = \left(NewSpectrum \bullet \frac{1}{M} \right) + \left(Average_{M-1} \right) \bullet \frac{(M-1)}{M}$$

with M is the number of averages.

Exponential averages "grow" for approximately the first 5 spectra until the steady state values are reached. Once in steady state, further changes in the spectra are detected only if they last sufficiently long.

- **Peak Hold** Peak Hold is not really averaging, rather the new spectral magnitudes are compared to the previous data, and if the new data is larger, then the new data is stored. This is done on a frequency bin by bin basis. Peak Hold detects peaks in the spectral magnitudes and only applies to spectrum and PSD measurements.

Overlap processing

Overlap processing when averaging can be done in real-time (i.e. when the data keeps coming in) or after a complete recording has been made.

With real-time acquisition and overlap processing of averaged frames, the Spectral Display does not wait for the next complete time record before computing the next FFT. Instead it uses data from the previous time record as well as data from the current time record to compute the next FFT. This speeds up the processing rate. With overlap the 'windowed' points at the beginning and end of the time record are "re-used" and appear as middle points in other time records. This is why overlap effectively speeds up averaging and smoothes out window variations.

Settings

Average spectra

Select this check box to enable averaging of the spectra.

Type

Select the type of averaging that you want to do.

Overlap

Select the percentage of overlap of the frames: 0 % is no overlap, 100 % is full overlap (complete record minus 1 sample).

Number of frames

The number of frames to average. You can either stop after this or choose to reset and start again.

Stop after number of frames is reached

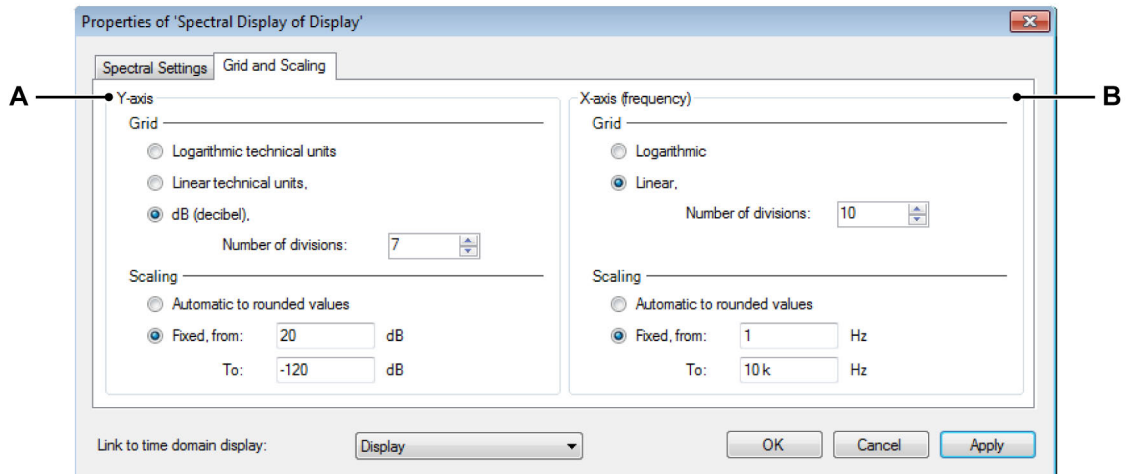
Select this option for a one-time only averaging.

5.2.5 Link to time domain display

Here you select the time domain display to which the spectral display must be linked. Select **none** to unlink the spectral display.

5.3 Grid and Scaling

The Grid and Scaling page gives access to the various settings related to the Y- and X-axis.



A Y-axis settings: grid and scaling

B X-axis settings: grid and scaling

5.3.1 Y-axis

The grid options define what type of grid is displayed. This can be either a **linear** or a **logarithmic** grid, both in technical units.

In addition you have the option to have a **dB (decibel)** grid.

To set a grid:

- 1 When no grid is visible make sure the Spectral Display is the active display and do one of the following:
 - On the dynamic menu select **Show Grid**.
 - Right-click in the Spectral Display. On the shortcut menu that comes up select **Show Grid**.
 - When available select the **Show Grid** command in the toolbar.
- 2 Open the Spectral Display **Properties** dialog and select the **Grid and Scaling** page.
- 3 Select one of the options under **Grid** in the Y-axis section.
- 4 For **Linear technical units** or **dB (decibel)** you can optionally set the **Number of divisions**.
- 5 Click **Apply** or **OK** when done.

To set the scaling:

- 1 Make sure the grid is visible as described above.
- 2 Open the Spectral Display **Properties** dialog and select the **Grid and Scaling** page.
- 3 Select one of the options under **Scaling** in the Y-axis section.
- 4 When **Fixed** is selected also enter the **from** and **to** values.
- 5 Click **Apply** or **OK** when done.

A note on decibel

Most often, amplitude or power spectra are shown in the logarithmic unit decibels (dB). The decibel is a unit of ratio and is computed as follows:

$$dB = 10 \log_{10} \frac{P}{P_r}$$

where P is the measured power and P_r is the reference power.

Use the following equation to compute the ratio in decibels from amplitude values:

$$dB = 20 \log_{10} \frac{A}{A_r}$$

where A is the measured amplitude and A_r is the reference amplitude.

The reference mentioned above corresponds to the 0 dB level. A common convention is to use the reference 1 Vrms for amplitude or 1 Vrms squared for power, yielding a unit in dBV or dBVrms. In the Perception Spectral Display 1 Vrms corresponds to 0 dB.

5.3.2 X-axis

The grid options define what type of grid is displayed. This can be either a **linear** or a **logarithmic** grid.

The scaling defines the start and end point of the complete X-axis.

To set a grid:

- 1 When no grid is visible make sure the Spectral Display is the active display and do one of the following:
 - On the dynamic menu select **Show Grid**.
 - Right-click in the Spectral Display. On the shortcut menu that comes up select **Show Grid**.
 - When available select the **Show Grid** command in the toolbar.

- 2 Open the Spectral Display **Properties** dialog and select the **Grid and Scaling** page.
- 3 Select one of the options under **Grid** in the X-axis section.
- 4 For **Linear** you can optionally set the **Number of divisions**.
- 5 Click **Apply** or **OK** when done.

To set the scaling:

- 1 Make sure the grid is visible as described above.
- 2 Open the Spectral Display **Properties** dialog and select the **Grid and Scaling** page.
- 3 Select one of the options under **Scaling** in the X-axis section.
- 4 When **Fixed** is selected also enter the **from** and **to** values.
- 5 Click **Apply** or **OK** when done.

Some grid and scaling examples:

Grid = linear or logarithmic

Scaling = fixed

X-Start = 5 Hz (entered value)

X- End = 80 kHz (entered value)

Result: Frequency axis will display data from 5 Hz to 80 kHz, irrespective of actual data

Grid = logarithmic

Scaling = Automatic to rounded values

Start = 3 Hz (calculated value)

End = 82 kHz (calculated value)

Result: Frequency axis will range from 1 Hz to 100 kHz, data will range from 3 Hz to 82 kHz

Grid = linear

Scaling = Automatic to rounded values

Start = 3 Hz (calculated value)

End = 82 kHz (calculated value)

Result: Frequency axis will range from 0 Hz to 90 kHz, data will range from 3 Hz to 82 kHz

6 Miscellaneous

6.1 Spectral display shortcut menu

When you right-click in the spectral display a shortcut menu comes up. This section explains each shortcut in this menu.

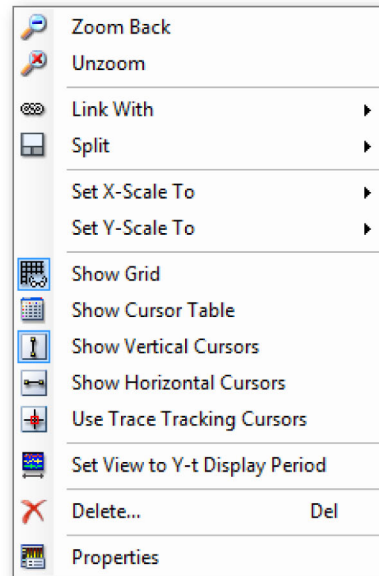


Figure 6.1: Spectral Display shortcut menu

- **Zoom Back** Returns to the previous zoom
- **Unzoom** When a zoom or Alt-zoom is available use this option to remove it
- **Link With** Link with another waveform display or unlink from the current waveform display
- **Split** Change the display layout
- **Set X-Scale To** Set type of X-Scale
- **Set Y-Scale To** Set type of Y-Scale
- **Show Grid** Show/Hide Grid
- **Show Cursor Table** Show the cursor table
- **Show Vertical Cursors**
- **Show Horizontal Cursors**
- **Use Trace Tracking Cursors** Automatically places the horizontal cursors at the level of the active trace at the position of the vertical cursor
- **Set View to Y-t Display Period** Sets the framecursor size to the best match with the times of the view in the linked display.
- **Delete** Deletes the spectral display from the sheet
- **Properties** Shows the spectral display properties

6.1.1 Link With submenu

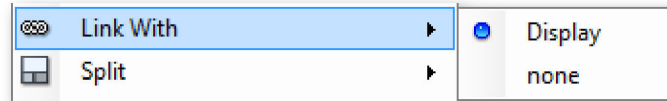


Figure 6.2: Link With submenu (detail)

- **None** Removes the link with waveform display “Display”.
- **Display** Connects to waveform display “Display”. This action changes the layout of the spectral display.

6.1.2 Set X-Scale To submenu

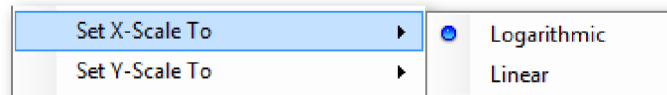


Figure 6.3: Set X-Scale To submenu (detail)

- **Logarithmic** Sets X-axis to logarithmic scale.
- **Linear** Sets X-axis to linear scale.

6.1.3 Set Y-Scale To submenu

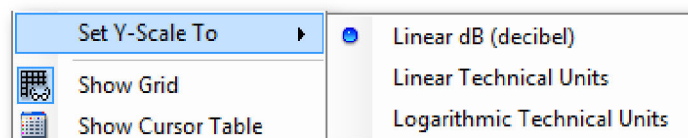


Figure 6.4: Set Y-Scale To submenu (detail)

- **Linear dB (decibel)** Sets Y-axis to dB scale. The dB values are drawn at a linear scale.
- **Linear Technical Units** Sets Y-axis to Linear Technical Units. The technical unit values are drawn at a linear scale.
- **Logarithmic Technical Units** Sets Y-axis to Logarithmic Technical Units. The technical unit values are drawn at a logarithmic scale.

6.1.4 Split submenu

Please refer to the waveform display section on display layout "Zooming and panning in the spectral display" on page 24 and split for more information on this subject.

7 Dynamic menu and toolbar

7.1 Dynamic menu

Perception supports a dynamic menu, located on the menu bar. The name of the menu is the same as the currently active sheet in Perception

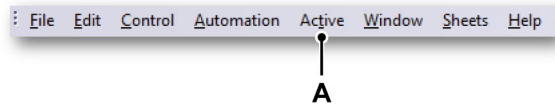


Figure 7.1: Perception Menu bar

A Active menu

The dynamic menu contains commands that depend on the currently active component on the sheet.

When a Spectral Display is the active component, the following menu will appear.

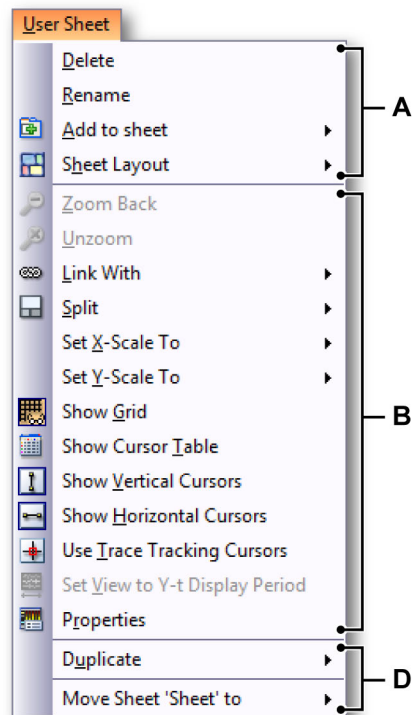


Figure 7.2: Dynamic menu with Spectral Display

- A** Operations on the layout of the sheet
(see Perception manual for more information)
- B** Operations on the currently active component on the sheet, in this case the Spectral Display. For the operation of the different menu items refer to the shortcut menu items described in this manual.
- C** Operations on other currently not active components on the sheet
(see Perception manual for more information, or the corresponding component)
- D** Operations on the sheet within Perception workbooks
(see Perception manual for more information)

7.2 Dynamic toolbar

When one of the components on a sheet becomes active, it will show extra items on the toolbar that depend on the component. For a Spectral Display the following toolbar items are added. See Figure 7.3.

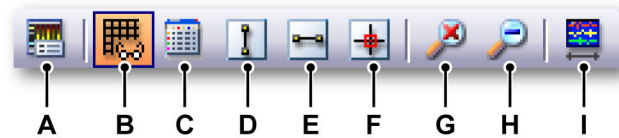


Figure 7.3: Dynamic Toolbar (detail)

- A Properties** Show the properties dialog of the Spectral Display.
- B Show/Hide grid** in the Spectral Display.
- C Cursor Table** Show/Hide
- D Vertical cursor** Show/Hide
- E Horizontal cursor** Show/Hide
- F Tracking cursor** Enable/Disable
- G Unzoom** the current spectral display view.
When the active view is "Review", both Zoom and Alt-Zoom views are removed.
When the one of the zoom views is active only that one will be removed.
- H Zoom Back** will return to the previous selected zoom boundaries of the currently active view.
- I Set View to Y-t display Period** Sets the framecursor size to the best match with the times of the view in the linked display.

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