Inspect User Guide

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SYNOPSYS®

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Contents

About This Guide

Inspect is a curve display and analysis program. It works with curves specified at discrete points. Inspect enables users to work interactively with data using both a graphical user interface and a scripting language.

Related Publications

For additional information, see:

- The TCAD Sentaurus™ release notes, available on the Synopsys SolvNet® support site (see Accessing SolvNet on page xii).
- Documentation available on SolvNet at https://solvnet.synopsys.com/DocsOnWeb.

Conventions

The following conventions are used in Synopsys documentation.

Convention	Description
Blue text	Identifies a cross-reference (only on the screen).
Bold text	Identifies a selectable icon, button, menu, or tab. It also indicates the name of a field or an option.
`Courier font`	Identifies text that is displayed on the screen or that the user must type. It identifies the names of files, directories, paths, parameters, keywords, and variables.
Italicized text	Used for emphasis, the titles of books and journals, and non-English words. It also identifies components of an equation or a formula, a placeholder, or an identifier.
Key+Key	Indicates keyboard actions, for example, Ctrl+I (press the I key while pressing the Control key).
Menu > **Command**	Indicates a menu command, for example, **File** > **New** (from the **File** menu, select **New**).

Customer Support

Customer support is available through the Synopsys SolvNet customer support website and by contacting the Synopsys support center.

Accessing SolvNet

The SolvNet support site includes an electronic knowledge base of technical articles and answers to frequently asked questions about Synopsys tools. The site also gives you access to a wide range of Synopsys online services, which include downloading software, viewing documentation, and entering a call to the Support Center.

To access the SolvNet site:

1. Go to the web page at https://solvnet.synopsys.com.
2. If prompted, enter your user name and password. (If you do not have a Synopsys user name and password, follow the instructions to register.)

If you need help using the site, click **Help** on the menu bar.

Contacting Synopsys Support

If you have problems, questions, or suggestions, you can contact Synopsys support in the following ways:

- Go to the Synopsys Global Support Centers site on synopsys.com. There you can find e-mail addresses and telephone numbers for Synopsys support centers throughout the world.
- Go to either the Synopsys SolvNet site or the Synopsys Global Support Centers site and open a case online (Synopsys user name and password required).

Contacting Your Local TCAD Support Team Directly

Send an e-mail message to:

- support-tcad-us@synopsys.com from within North America and South America.
- support-tcad-eu@synopsys.com from within Europe.
- support-tcad-ap@synopsys.com from within Asia Pacific (China, Taiwan, Singapore, Malaysia, India, Australia).
- support-tcad-kr@synopsys.com from Korea.
- support-tcad-jp@synopsys.com from Japan.

CHAPTER 1 Introducing Inspect

This chapter introduces Inspect and its graphical user interface.

Functionality of Inspect

Inspect can display and analyze curves. It features a graphical user interface, a scripting language, and an interactive language for computations with curves.

An Inspect curve is a sequence of points defined by a one-dimensional array of x-coordinates and y-coordinates (floating-point values). An array of coordinates that can be mapped to one of the axes is referred to as a *dataset*. In Inspect, datasets can be combined and mapped to the x-axis and y-axis to create and display a curve.

Inspect works on data consisting of *groups* of datasets. Each group consists of two or more datasets of equal length, where elements with an identical index represent related values. Datasets in a group can be divided into *named groups*. By pairing related values of two datasets from the same group, points (or nodes) of a discrete curve are obtained.

Usually, a dataset represents a physical quantity, such as voltage, current, or time. Groups of datasets represent functionally related physical quantities, for example, measurements of current and voltage, and the times at which these measurements are taken. Named groups represent semantically related datasets, for example, meshing results at one of several contacts of a semiconductor device.

In addition to its name, a dataset can have other attributes associated with it, for example, the name of the physical quantity represented by the dataset, the name of the unit in which this quantity has been measured, the preferred color of the curve when it is visualized, and interpolating function. Depending on the particular input file format, this information can be stored partially in the data file and partially in separate files.

Inspect can read different data formats and file formats (see Data Formats on page 4).

Data in TDR and TIF formats contains the names of the physical quantities that datasets represent. The TDR and TIF formats allow you to split a dataset group into named groups.

Data in XGRAPH format always has groups consisting of two datasets only. Additional dataset attributes are specified inside the file with appropriate keywords.

To distinguish datasets from different data files, the datasets from one data file are grouped into a *project*. The name of the data file without an extension is taken as the project name. When more than one file with the same name is loaded, Inspect adds the suffix `.n` to the project name, where `n` is the smallest number not yet used as a suffix for another project name.

Graphical User Interface

The graphical user interface (GUI) of Inspect has the following work areas (see Figure 1):

- Datasets group box
- Curves group box
- Plot area

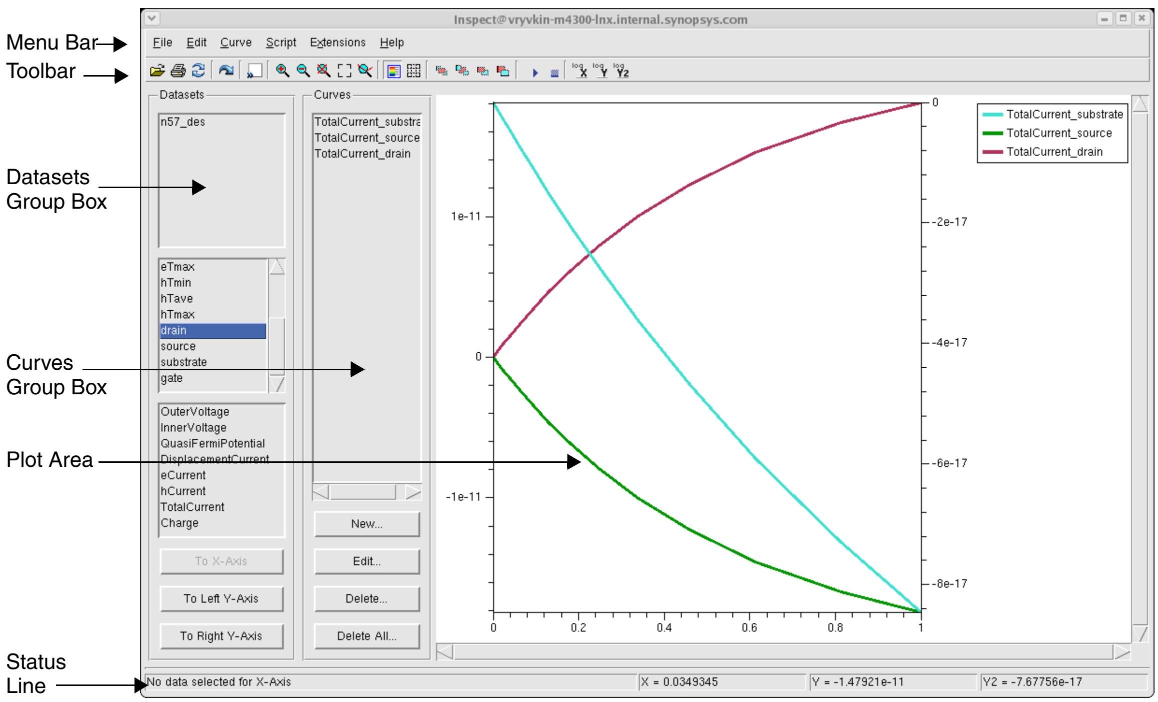


Figure 1 Main window of Inspect showing work areas

The menus and toolbar buttons are documented in Appendix A on page 111.

The status line at the bottom of the main window displays information about the current Inspect session and the position of the pointer in the plot area.

Datasets Group Box

This group box has the following panes for selecting and combining datasets to create curves:

- The *top pane* lists the currently loaded data files (or *projects*). In the example shown in Figure 1 on page 2, only one data file `n57_des` has been loaded (the file extension is not displayed).
- The *middle pane* lists the names of the dataset groups belonging to the selected data file. A group having one or more datasets can correspond to an electrode or a thermode of a device. Datasets that do not belong to any group are also displayed. In Figure 1, `hTave` and `hTmax` are independent datasets. In addition, `drain`, `source`, `substrate`, and `gate` are groups, each having several datasets.
- The *bottom pane* lists the names of the datasets belonging to the selected group.

The **To X-Axis**, **To Left Y-Axis**, and **To Right Y-Axis** buttons map datasets to a particular axis.

Curves Group Box

This group box has one pane that displays the names of existing curves, and it has the following buttons:

- Click **New** to create a curve using the formula library (see Creating Curves Using Formulas on page 18).
- Click **Edit** to change the graphical attributes of a curve (see Changing Attributes of a Curve on page 15).
- Click **Delete** to remove curves that are selected in the pane.
- Click **Delete All** to remove all curves in the pane.

Plot Area

The plot area is where curves are drawn. The toolbar buttons are used to change the coordinate system for zooming sessions, to display or remove the legend text, to change the order in which curves are displayed, and to switch between linear and logarithmic scale.

Supported File Types and Data Formats

This section describes the supported file types and data formats in Inspect.

Data Formats

Inspect works with different file formats, which contain a series of points, described by x-coordinates and y-coordinates, representing datasets. Inspect handles and displays these datasets as curves.

Table 1 Supported data formats

Data format	Description
CSV	Comma-separated value format, which is recognized by many applications. The file extension is `.csv`.
PLT	Plain text format for 1D curves.
PLX	Format generated by Sentaurus Process.
TDR	Format recognized by most Synopsys TCAD tools. The file extension is `.tdr`. For a description of the TDR format, see the *Sentaurus™ Data Explorer User Guide*.
TIF	Synopsys TCAD format for I–V curves, recognized by most Synopsys TCAD tools. The file extension is `.ivl`. For a description of the TIF format, see the *Taurus™ Visual User Guide*, Data Formats.
TXT	Tab-delimited text format. The file extension is `.txt`. Each curve is written into a block with the curve name, and the x- and y-data.
XGRAPH	Each curve is written into a block with the curve name, and the x- and y-data. The file extension is `.xy`. Typically, there is one xy data–point pair per line. Each value or column is separated by space, tabs, commas, semicolons, or colons. For more information, go to http://www.xgraph.org.
XMGR	Format used by the shareware xy plotting tool Xmgr. The file extension is `.xmgr`. For more information, go to http://plasma-gate.weizmann.ac.il/Xmgr/.

Parameter Files

When Inspect is customized interactively according to user preferences, the current setup can be stored in a parameter file, which usually has the extension `.par`. In a parameter file, Inspect stores the following information:

- Plot area attributes
- Coordinate area attributes

- Axes attributes
- User-defined macros
- Printer setup
- Curve attributes

When Inspect is started, it looks for a parameter file named `inspect.par` in the current directory. If such a file is found, Inspect loads it and sets the plot settings, macros, and printer setup according to the values in this file. If no file is found in the current directory, Inspect looks for a parameter file named `inspect.par` in the `STDB` directory. If no file is found, Inspect uses the default values.

You can also load a parameter file explicitly when starting Inspect or during its execution.

Curve attributes saved in the parameter file are not applied automatically to curves in Inspect. To do this, the command-line option `-applyCurveAttr` must be specified when launching Inspect.

Save Files

The entire current state of Inspect (projects, curves, and settings) can be saved to a save file, which is used to restore the saved state at any time and usually has the extension `.sav`.

Data from all loaded projects is also stored in a save file. This means that for restoring the saved state, the data files are no longer necessary.

Starting Inspect From the Command Line

You can start Inspect from the command line by typing:

```
inspect [<options>] [<FILES>]
```

You can also specify options (see Table 2 on page 6) and files on the command line. For examples of use, see Examples of Using Command-Line Options on page 6.

The `<FILES>` arguments can be one or several data files, or a save file that is loaded when Inspect is started. Inspect automatically distinguishes between data files and save files.

NOTE You can also start Inspect from Sentaurus Workbench.

Table 2 Command-line options

Option	Description
-applyCurveAttr	Applies curve attributes saved in a parameter file (.par) and a save file (.sav).
-batch	If specified, Inspect does not open the graphical user interface while executing a script file.
-c FILE[1]	Reads the specified setup file after Inspect is launched.
-display	Sets the display to use.
-f FILE[1]	Executes the specified script file after Inspect is launched.
-geometry	Sets the size and position of the main window of Inspect.
-h[elp]	Displays information about the command-line options.
-m FILE[1]	Executes the specified macro file after Inspect is launched.
-oldInterpol	Forces Inspect to use the interpolation criteria of earlier versions.
-oldplx	Loads a .plx file and automatically creates curves with the old scheme.
-v[ersion]	Prints the version of Inspect.
-verbose	Displays all messages.

1. Simulation results (.plt, .tdr, .ivl) files as well as save (.sav) files.

Examples of Using Command-Line Options

Inspect starts in interactive mode and loads datasets from the n53_des.plt file:

```
inspect n53_des.plt
```

Inspect starts in interactive mode, loads three data files, and reads the plot area, axes, macros, and printer setup from the parameter file mySetup.par:

```
inspect file1.plt file2.plt file3.plt -c mySetup.par
```

Inspect starts in interactive mode and executes the bipolar.cmd script file:

```
inspect -f bipolar.cmd
```

Inspect starts in batch mode and executes the bipolar.cmd script file:

```
inspect -batch -f bipolar.cmd
```

CHAPTER 2 Basic Operations Using the Graphical User Interface

This chapter describes the basic operations in Inspect using its graphical user interface.

Loading Datasets

You must open a data file to load a dataset.

To load a dataset:

1. Choose **File** > **Load Dataset**, or press Ctrl+L.

   The Load Dataset dialog box is displayed.

2. Select a data file by changing the **Files of type** field if needed.
3. Click the **Open** button or double-click a file to open it.

Reloading Datasets

You can reload displayed datasets if the file is updated while viewing it in Inspect.

To reload a dataset:

- Choose **File** > **Update Datasets**, or press Ctrl+U.

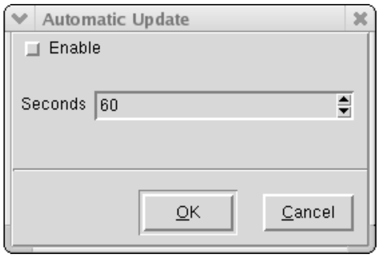
Updating Datasets Automatically

If a dataset displayed in the plot area is updated frequently by other tools, such as the Optimizer tool, it can be useful to reload the dataset frequently so that refreshed data is shown in the plot area.

To update datasets automatically:

1. Choose **File > Automatically Update Datasets**.

   The Automatic Update dialog box is displayed.



2. Select the **Enable** option.
3. Set the time (in seconds) between reloads.
4. Click **OK**.

Applying Plotting Actions

When working with multiple datasets of a similar structure, it is useful to apply several plotting actions made on one dataset to other datasets. These plotting actions include creating curves (explicitly and by formula) and changing curve attributes. Inspect stores the set of actions made on the current dataset.

To repeat plotting actions for another dataset:

1. Select the dataset or datasets.
2. Choose **Edit > Redo Last Plot**, or press Ctrl+E.

All plotting actions are applied to the selected datasets.

This feature is helpful when datasets contain data of a similar structure, for example, projects with groups of the same names. Otherwise, it can happen that the current dataset does not contain some data necessary for creating a curve. In this case, Inspect generates an error message.

NOTE Inspect stores plotting actions applied to the currently selected dataset only. When you select another dataset, the accumulated set of stored actions is cleaned up.

Zoom Operations

To perform zoom operations on curves displayed in the plot area, use the relevant toolbar buttons (see Table 7 on page 111).

Working With Scripts

In Inspect, any sequence of operations can be stored and reproduced using scripts (see Chapter 7 on page 41). The recorded operations are repeated when the script is executed. The following operations can be recorded in a script:

- Loading and unloading projects
- Loading and saving the current project
- Changing axis attributes
- Exporting, creating, and deleting curves
- Changing curve attributes
- Transforming actions on curves
- Any use of the formula library to create other curves

Creating Scripts

To create a script:

1. Choose **Script** > **Record** > **Start**.

   The Record Script File dialog box is displayed.

2. Select or create a script file, and click **Save**.

   Inspect starts to store every operation until you stop recording.

3. Choose **Script** > **Record** > **Stop**.

Running Scripts

To run a script:

1. Choose **Script** > **Run Script**, or press Ctrl+R.

   The Run Script File dialog box is displayed.

2. Select a script file.
3. Click **Open**.

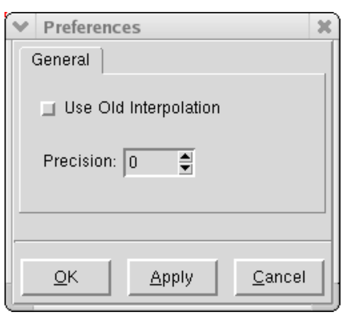
Preferences

In Inspect, preferences relate to the precision of values handled for curve coordinates and the interpolation method used to operate on and display curves.

To set the preferences:

1. Choose **File** > **Preferences**.

   The Preferences dialog box is displayed.

2. In the **Precision** box, select the number that indicates how many decimal digits are used to handle coordinates for curve points.
3. If required, select the **Use Old Interpolation** option to force Inspect to use the interpolation criteria of earlier versions to handle all computations with curves.
4. Click **OK**.

Saving Files

To save files, you can either:

- Choose **File** > **Save Setup** to save the current setup in a parameter `.par` file.
- Choose **File** > **Save All** to save the entire current state of Inspect in a `.sav` file.

Exporting Curve Data

Curve data can be written to data files in different formats (see Data Formats on page 4). You can select different formats from the **File** > **Export** command.

To export curve data in TDR format:

1. Choose **File** > **Export** > **TDR**.

   The Write .tdr File dialog box is displayed.

2. Select or create a TDR file.
3. Click **Save**.

Printing Curves Shown in the Plot Area

Curves shown in the plot area can be printed as a single image.

To print curves shown in the plot area:

1. Choose **File** > **Print**, or press Ctrl+P.

   The Printer Setup dialog box is displayed.

   On the Windows operating system, a standard print dialog box is displayed. On Linux operating systems, a special print dialog box is displayed (see Figure 2 on page 12).

2. Specify the print configuration as required.

   NOTE In the **Command** field, you can specify a command for using the printer.

3. Click **OK**.

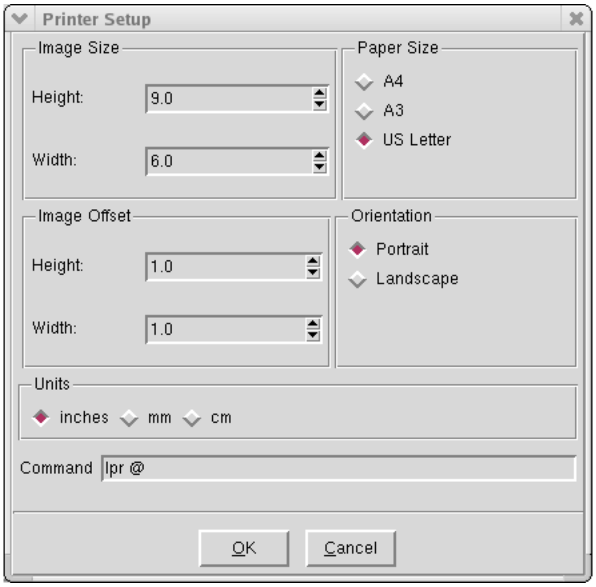


Figure 2 Printer Setup dialog box

Saving Curves in PNG Format

Curves shown in the plot area can be saved as a bitmap file in PNG format. This bitmap file can be imported into applications for documentation and reporting purposes.

To save curves in PNG file format:

1. Choose **File** > **Write Bitmap**, or press Ctrl+W.

   The Write PNG bitmap file dialog box is displayed.

2. Enter the name of the file.

3. Click **Save**.

You can save the curves shown in the plot area in a `.png` file directly from your Inspect script using the `fi_writeBitmap` command (see fi_writeBitmap on page 43). This is a screen-image exporting method that works when Inspect starts in interactive mode.

NOTE Since this exporting method is based on the X11 utility `xwd`, it works only if a valid `DISPLAY` is available, that is, an X server is required.

CHAPTER 3 Working With Curves

This chapter describes how to create and work with curves using the graphical user interface of Inspect.

Selecting Multiple Projects and Groups

Inspect displays curves that are formed by datasets from different data files.

You select projects and groups from the Datasets group box (see Datasets Group Box on page 3). If you select more than one group, only the dataset names that exist in all the selected groups appear in the bottom pane.

In Figure 1 on page 2, if two groups (`drain` and `source`) are selected in the middle pane, the dataset names `OuterVoltage`, `InnerVoltage`, `QuasiFermiPotential`, `DisplacementCurrent`, `eCurrent`, and `hCurrent` appear in the bottom pane. If the group `hTmax` is selected, in addition, no dataset names are displayed in the bottom pane because no datasets with identical names exist in all the selected groups.

NOTE The names of datasets must be identical. Datasets, themselves, can be different.

When more than one project is loaded, the same rule applies. Consequently, Inspect shows only common groups and datasets of multiple-selected projects in the middle and bottom panes of the Datasets group box.

Creating Curves

The first curve displayed in Figure 1 maps `time` to the x-axis and `TotalCurrent` of `drain` to the left y-axis.

To create a curve:

1. Select the dataset group `time` in the middle pane of the Datasets group box.
2. Click the **To X-Axis** button.
3. Select the group `drain` in the middle pane of the Datasets group box.

4. Select the dataset `TotalCurrent` from the bottom pane of the Datasets group box.
5. Click the **To Left Y-Axis** button.

Inspect draws a curve in the plot area using these two datasets. The name of the curve is generated automatically using names and other attributes of groups and datasets (and possibly projects). The upper-right corner of the plot area shows the legend, which displays curve names and drawing styles.

The second curve is created in the same way: `time` is mapped to the x-axis and `TotalCurrent` from `source` is mapped to the left y-axis. The next curve is created with `time` mapped to the x-axis and `TotalCurrent` from `substrate` mapped to the right y-axis.

When these steps are completed, the main window of Inspect resembles Figure 1 on page 2.

Automatically Generated Curve Names and Legend Text

When a curve is created, a default name for it is generated. With plot files (TDR or TIF files), the name is a combination of the physical quantity name and the group name of the y-dataset if the dataset belongs to a group.

For example, if the physical quantity name is `OuterVoltage` and the dataset belongs to a group named `drain`, the curve name is `OuterVoltage_drain`.

With XGRAPH files, a default name is created using the data file name and the comment line preceding the dataset pair in the file. If the generated curve name already exists, an `.n` suffix is added, where `n` is the smallest number not yet used as a suffix in another name.

In addition to a name, a curve has legend text, which identifies the curve in the plot area. When a curve is created, the corresponding text is initialized with the curve name.

Selecting and Unselecting Curves

To select a curve:

- Click the curve name in the Curves group box, or click the curve name in the legend.

After selection, the curve name is highlighted in the Curves group box, the plot area, and the legend.

To unselect a curve:

- Right-click in the plot area.

Changing Attributes of a Curve

A curve is displayed according to its attributes. When a curve is created, default values are assigned to all attributes. A curve is drawn with lines connecting nodes and, optionally, with node markers.

To change the attributes of a curve:

1. Double-click a curve in the plot area or in the Curves group box.

   The Curve Attributes dialog box is displayed (see Figure 3 on page 16).
2. On the **General** tab, change the axis to which the curve is mapped, if required.
3. On the **Line** tab, change the following attributes of lines:

Color	Default color is assigned from a list of colors that are not assigned to existing curves.
Style	When all available colors are exhausted, a line drawing style is assigned from a list of styles, so that each curve has a unique combination of color and style.
Width	Line width in pixels. Default: 1.

4. On the **Marker** tab, change the following attributes of node markers:

Shape	No node markers by default.
Size	Size of markers in pixels. Default: 5.
Outline Color	It is the same as the line color by default.
Outline Width	Width of markers in pixels. Default: 1.
Fill Color	It is the same as the line color by default.

5. On the **Interpolation** tab, change the interpolation used on the x-axis and y-axis, if required.
6. Click **Apply**.
7. Click **OK**.

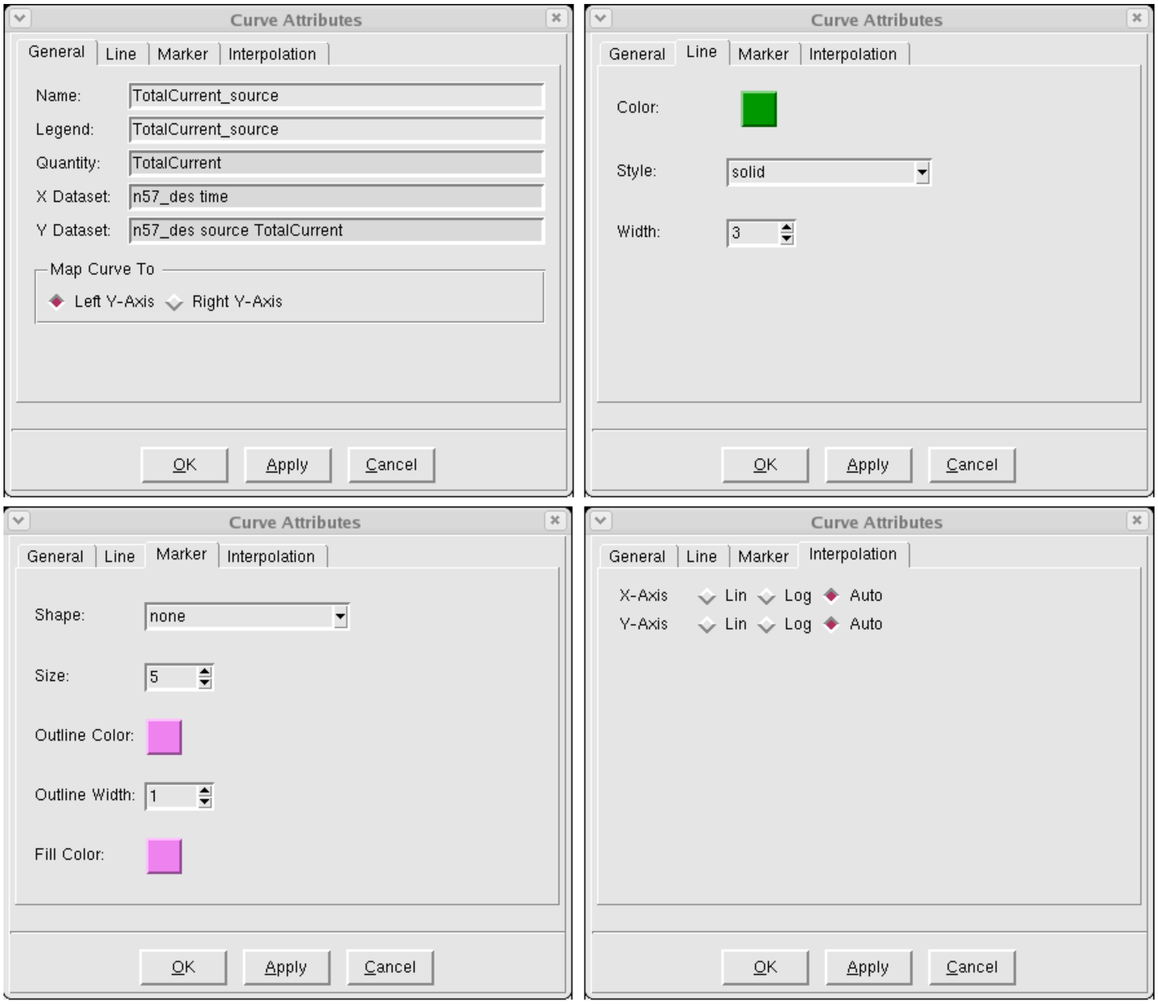


Figure 3 Curve Attributes dialog box with all tabs shown

Example: Displaying a Curve With Data Points and No Lines Between Points

To display a curve with data points and no lines between these points:

1. Double-click a curve in the plot area or in the Curves group box.

   The Curve Attributes dialog box is displayed (see Figure 3).

2. Click the **Marker** tab.
3. In the **Shape** box, select **circle**.

4. Click the **Line** tab.
5. Set **Width** to 0.
6. Click **Apply**.
7. Click **OK**.

Moving the Legend

To move the legend in the plot area:

- Use the middle mouse button and drag the legend to its new location.

Reordering Curves

You can change the order in which curves are displayed in the plot area to distinguish one curve from another, for example, if some have a significant intersection.

To reorder curves:

- Choose one of the following options from the **Curve** menu (see Curve Menu on page 113) or click the corresponding toolbar button:
  - **Drawing Order > Move to Front**
  - **Drawing Order > Move to Back**
  - **Drawing Order > Move Forward**
  - **Drawing Order > Move Backward**

Creating Curves

You can create curves in different ways.

Creating Curves Automatically When Loading Files

When a PLT, TDR, or TIF file is loaded, Inspect does not create curves immediately in the plot area. This is because a curve might be formed from any pair of datasets belonging to different groups and only a few of these are likely to interest users. Curves must be created explicitly, when required, by mapping pairs of datasets to x-axes and y-axes.

When a PLX or an XGRAPH file is loaded, Inspect creates curves automatically in the plot area, from the pairs of datasets defined in the loaded file, with the y-dataset being mapped to the left y-axis. The y-dataset can be remapped later to the right y-axis.

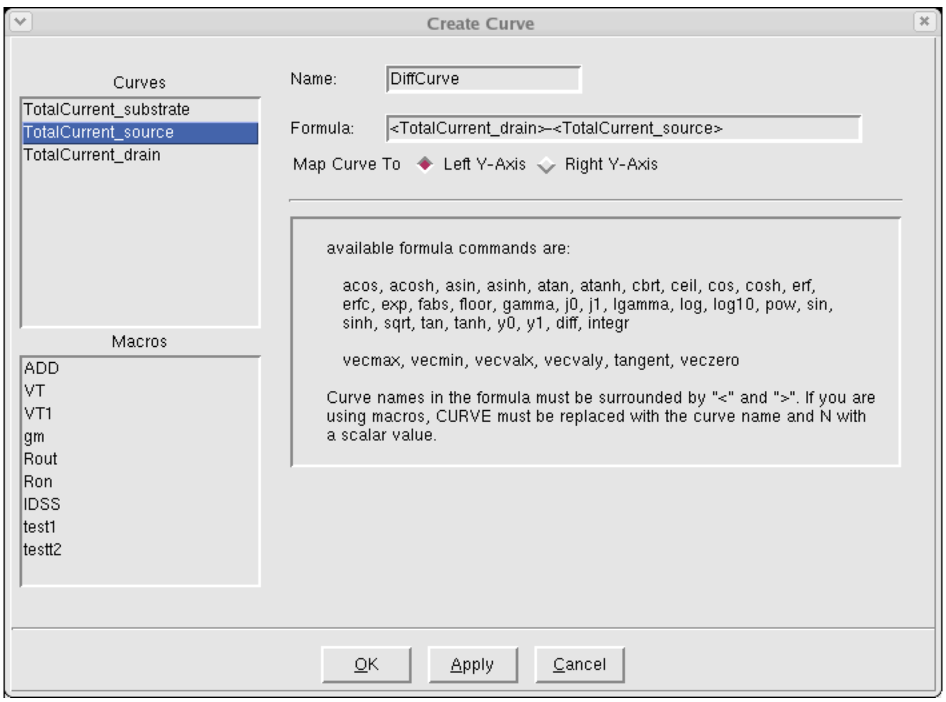
Creating Curves Using Formulas

You can create curves by applying formulas to existing curves (see Using Formulas on page 35).

To create a curve using a formula:

1. In the Curves group box, click the **New** button.

   The Create Curve dialog box is displayed.



2. In the Curves pane, click a curve to highlight it.
3. In the **Name** field, enter the name of the new curve.

   Inspect provides a default.
4. In the **Formula** field, enter the formula to be used to create the curve.
5. Map the curve to either the left y-axis or the right y-axis.

6. Click **Apply**.
7. Click **OK**.

Example: Creating a Curve That Is the Difference Between Two Curves

To create a curve that is the difference between two curves:

1. In the Curves group box, click the **New** button.

   The Create Curve dialog box is displayed.
2. In the Curves pane, click a curve to highlight it.

   The curve name appears in the **Formula** field enclosed by angle brackets.
3. Type a hyphen after the closing angle bracket in the **Formula** field.
4. Double-click a different curve in the Curves pane.

   The name of the second curve appears in the **Formula** field.
5. Select the axis to which the new curve is mapped.
6. Click **Apply**.
7. Click **OK**.

The new curve is displayed in the plot area.

Creating Curves Using Macros and Library Formulas

You can create and handle new curves using macros and library formulas included in Inspect. You can create macros using the Macro Editor, which allows you to select existing macro functions, different operations, and formulas from the libraries (see Figure 4 on page 20). For more information about using macros, see Using Macros on page 38.

Macros are stored in the file `inspect_macro.par` in the `STDB` directory. This file is created automatically the first time Inspect is run. Initially, it stores predefined macros. You can then add or modify macros using the Macro Editor.

To open the Macro Editor:

- Choose **Edit** > **Define Macros**.

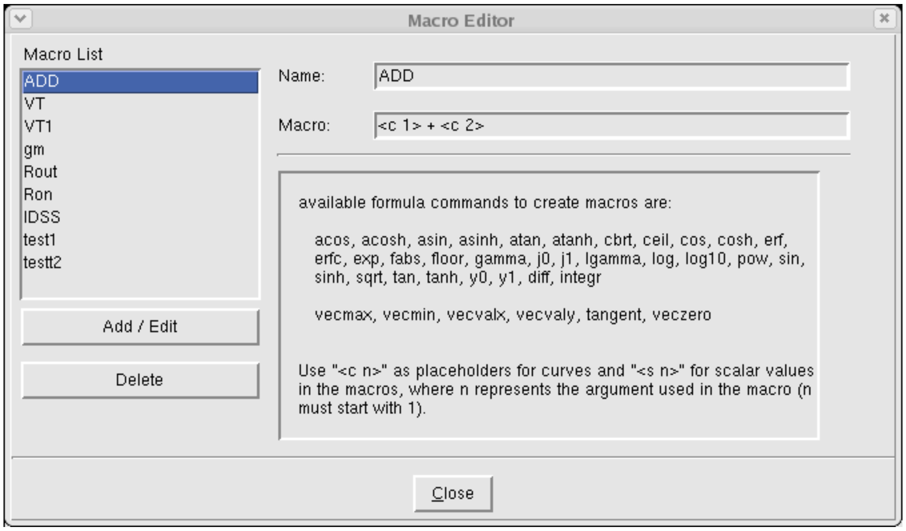


Figure 4 Macro Editor

Deleting Curves

You can delete either selected curves or all curves listed in the Curves group box.

To delete selected curves:

1. Select the curves in the Curves group box.
2. Click the **Delete** button.
3. Confirm the deletion.

To delete all curves:

1. Click **Delete All** button.
2. Confirm the deletion.

CHAPTER 4 Configuring the View

This chapter describes how to modify the way in which Inspect displays loaded datasets.

Modifying Axes

This section describes different ways you can modify the axes.

Scaling an Axis

You can scale the x-axis, the left y-axis, and the right y-axis. The scale of each axis can be changed independently.

To change the scale of an axis:

1. Click the relevant toolbar button:
   - Click the  button to switch on logarithmic scale on the x-axis.
   - Click the  button to switch on logarithmic scale on the left y-axis.
   - Click the  button to switch on logarithmic scale on the right y-axis.
2. Click the corresponding toolbar button again to switch off logarithmic scale for an axis.

When logarithmic scale is switched off, the axis reverts to linear scale.

Handling Data When Axes Set to Logarithmic Scale

If an axis is set to logarithmic scale, Inspect handles data in the following way:

- Negative values are set to positive.
- Zero values are set to 1e-20.

When an axis switches to linear scale, data is restored to its original values.

Limits of Axes Set to Logarithmic Scale

When an axis is set to linear scale, you can set the minimum and maximum values of the axis.

When an axis is set to logarithmic scale, Inspect might be unable to set an axis to the given values. In this case, Inspect sets the minimum and maximum values of the axis to the nearest power of 10 values.

Changing Attributes of Axes

To change the attributes of axes:

1. Choose **Edit** > **Axes**, or press Ctrl+A, or double-click any axis in the plot area.

   The Axes dialog box is displayed (see Figure 5 on page 23).
2. Click the required tabs to change attributes.
3. Click **OK** or **Apply** to accept the changes.

For example, to change the x-axis from linear scale to logarithmic scale:

1. Click the **X-Axis** tab.
2. Click the **Scale** tab.
3. Select the **Log** option.
4. Click **OK** or **Apply** to accept the changes.

Figure 5 Axes dialog box

Configuring the Plot Area

This section describes different ways you can modify the plot area.

Changing Attributes of Plot Area

You can change the appearance of the plot area and modify attributes such as the name of the plot area, the legend text that references the displayed curves, the plot frame, and the grid.

To change the attributes of the plot area:

1. Choose **Edit** > **Plot Area**, or press Ctrl+G.

   The Plot Area dialog box is displayed (see Figure 6 on page 25).
2. Click the required tabs to change attributes.
3. Click **OK** or **Apply** to accept the changes.

For example, to change the position of the legend text in the plot area:

1. Click the **Legend** tab.
2. In the **Position** box, select the new position.
3. Click **OK** or **Apply** to accept the changes.

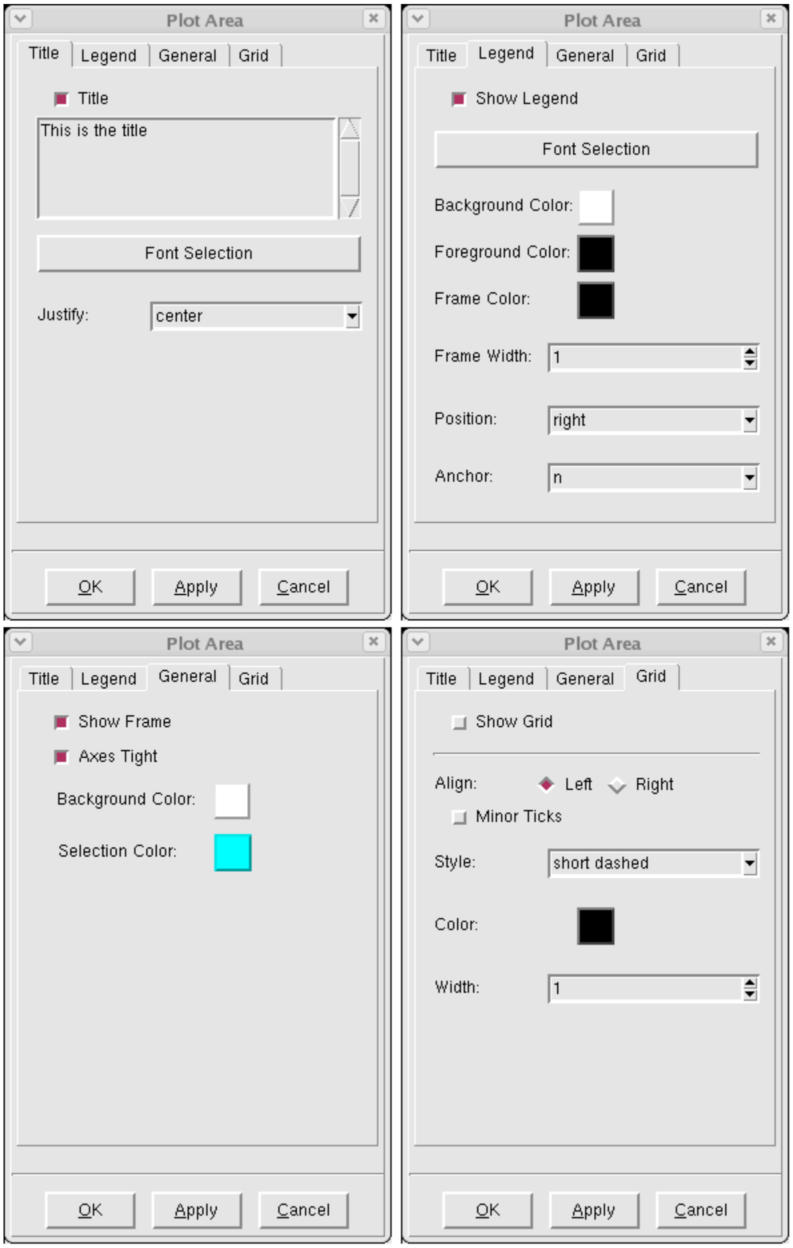


Figure 6 Plot Area dialog box showing all tabs

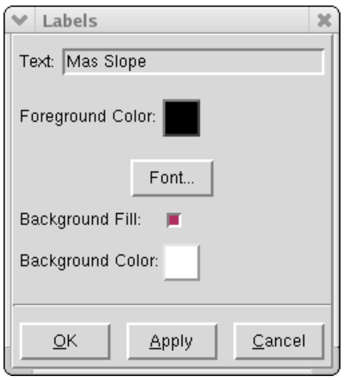
Adding Labels

You can add labels to the plot area. These labels provide useful information about the mapped curves. Labels can be edited and removed from the plot area.

To add a label:

1. Choose **Edit** > **Labels** > **Add**.

   The Labels dialog box is displayed.

2. In the **Text** field, type the label text.
3. Select a color and font for the label.
4. Click **OK** or **Apply** to insert the new label in the plot area.

To move a label:

1. Select a label in the plot area using the middle mouse button.
2. Move the label inside the plot area as required and release the middle mouse button.

To delete a label:

1. Choose **Edit** > **Labels** > **Remove**.

   The pointer changes to the delete mode.

2. In the plot area, click the label to be removed.

When the label is removed, the pointer reverts to the standard mode.

Displaying the Dataset of a Curve

Each curve displayed in the plot area has an associated dataset.

To view the points (data) included in the dataset of a specific curve:

1. Select a curve from the Curves group box.
2. Choose **Curve** > **Curve Data**, or press Ctrl+D.

   The Curve Data dialog box is displayed, which shows a table of the x-coordinates and y-coordinates for each point in the datasets represented by the selected curve (see Figure 7).
3. Highlight a data point in the table.
4. Click **Delete** to remove it from the displayed curve.

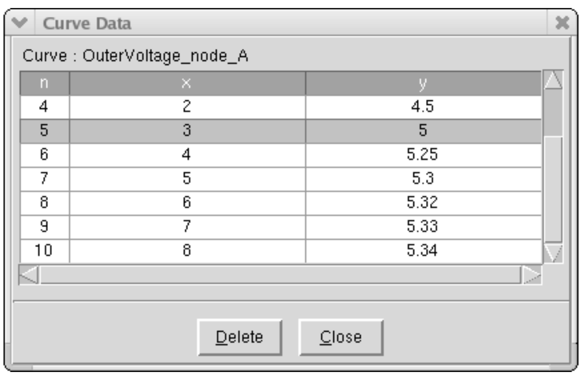
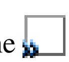


Figure 7 Curve Data dialog box

Cleaning Up the Plot Area

You can clean up the plot area, in which case, all existing curves are deleted, the legend is removed, and the plot area is reinitialized.

To clean up the plot area:

- Choose **Edit** > **Clean Plot Area**, or click the  toolbar button.

Sampling Points in the Plot Area

To sample points in the plot area:

1. Choose **Curve** > **Inspector**.

   The Inspector dialog box is displayed (see Figure 8).

2. In the plot area, select the first point by clicking a specific location (usually on a curve).
3. Drag the pointer to a second location (usually on another curve) to mark the second point.

NOTE The Inspector dialog box works only for the x-axis and left y-axis.

Positions are represented by circles that are connected by a line. The Inspector dialog box shows different values calculated from the two selected positions.

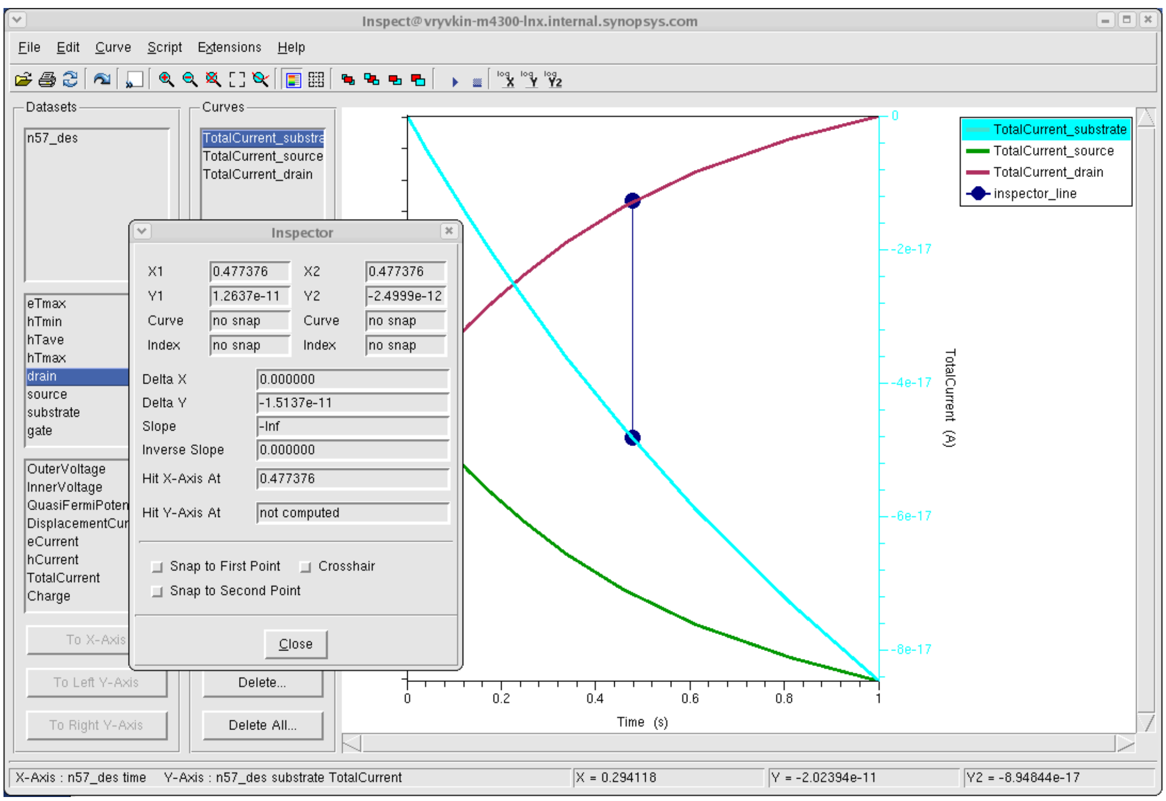


Figure 8 Example of using Inspector dialog box to sample points in the plot area

CHAPTER 5 Curve Interpolation and Operations

This chapter discusses curve interpolation and operations.

Curve Operations

A curve is defined as a set of two or more (x, y) points. Each curve has its own set of points called datasets. Inspect can display the resulting (continuous) curve by plotting all data points and completing the curve with a graphical linear interpolation method. Figure 9 shows three different curves, each defined by different datasets.

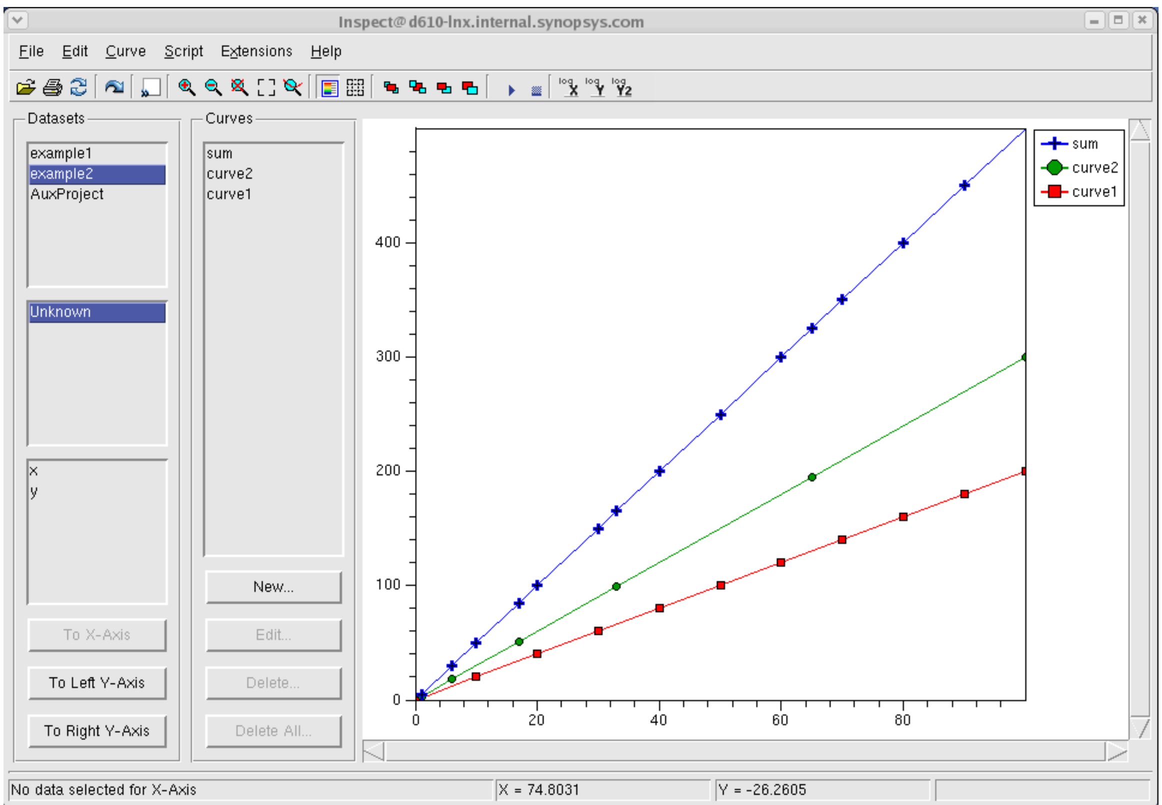


Figure 9 Different curves displayed as lines

Inspect offers different operations with curves. This requires an efficient way to handle curves and to create datasets for curves resulting from operations with other curves. Some operations result in a new curve or a scalar value. These operations include the sum of two or more curves, integration, differentiation, and the maximum value on the y-axis or the x-axis.

Limitation of the X-Axis Values of the Dataset

NOTE Only curve segments that have x-axis values monotonically increasing or decreasing can be used in a formula.

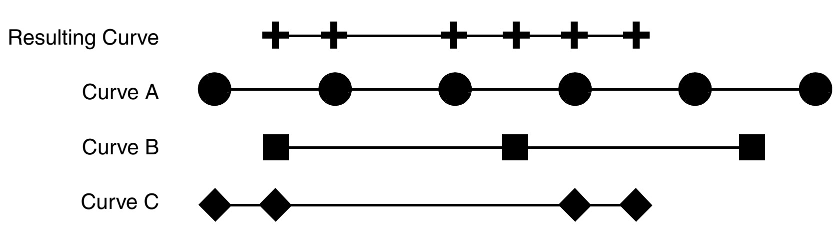
Curves used in a formula are checked for monotonically increasing or decreasing values inside the range defined by the current zoom level in the plot area. This means formulas apply only to the currently displayed points. By defining the optimal zoom level for the selected curves, it is possible to cut off curve segments that do not have monotonically increasing or decreasing x-values.

This general rule has *one exception*. An Inspect formula can involve only one curve with nonmonotonous x-axis values. In this case, Inspect splits this curve into monotonous segments of x-axis values, applies the formula to those segments, and builds the resulting curve automatically. For example, a scaling formula can be applied to a curve that is nonmonotonous on the x-axis. However, calculating the sum of two curves, where both curves are nonmonotonous on the x-axis, is not possible.

More Than One Curve in a Formula

If a formula includes more than one curve, Inspect interpolates all curves to a common x-axis dataset. This is demonstrated in the following example.

The data points of curves A, B, and C are marked with circles, squares, and diamonds, respectively. The points in the resulting curve are marked with plus signs. The formula used is $\langle A \rangle + \langle B \rangle + \langle C \rangle$. The resulting curve includes points of all three input curves:



Inspect creates an array of all x-coordinates of all curves that are used in a formula and interpolates those curves to obtain y-values for each of the new x-values added to each curve.

Handling Datasets in Formula Processing

The following examples illustrate the dataset handling method that Inspect uses to work with more than one curve in a formula (see Figure 10).

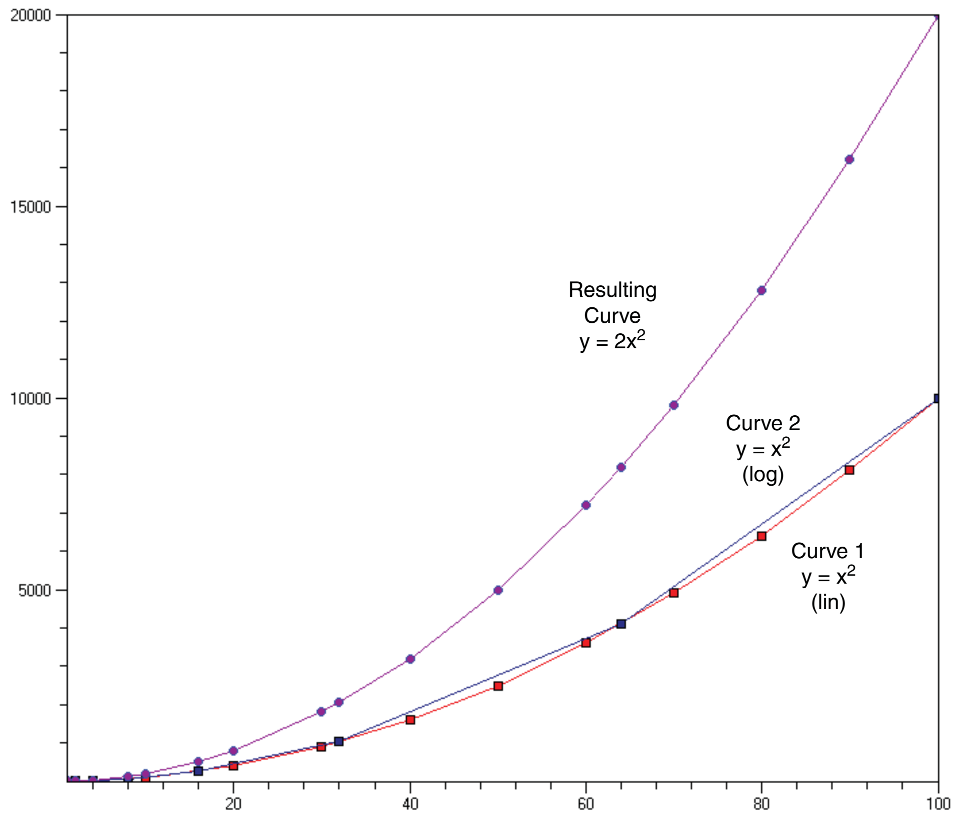


Figure 10 Resulting plot showing curves

Curve 1: $y = x^2$, linear scale on x

X	1	10	20	30	40	50	60	70
Y	1	100	400	900	1600	2500	3600	4900

Curve 2: $y = x^2$, logarithmic scale on x

X	1	2	4	8	16	32	64
Y	2	4	16	64	256	1024	4096

The combined set of x-coordinates needed to produce the resulting curve (the sum of both curves) is:

Resulting curve: $y = 2x^2$

X	1	2	4	8	10	16	20	30	32	40	50	60	64

The last point of Curve 1 (x = 70) is not included because no data is available beyond x = 64 in Curve 2.

For y-values, interpolation is performed on Curve 1 and Curve 2 to fill the gaps and sum both curves. Therefore, y-values for this resulting curve are:

Y	2	8	32	128	200	512	800	1800	2048	3200	5000	7200	8192

Dataset Created for Result Curves

For each curve created by a formula that involves more than one curve, Inspect generates a new dataset. During the Inspect session, this dataset is stored in a special project called `AuxProject`. When the current project is saved in a file, the `AuxProject` is also saved; otherwise, this project with all its datasets is lost when Inspect is closed.

The datasets in `AuxProject` are handled in the same way as datasets from loaded data files.

Curve Handling on Interpolation

Inspect handles both linear-scaled and logarithmic-scaled curves. Each curve is treated independently. Therefore, when working with two curves, one with linear scale and the other with logarithmic scale, Inspect:

- Creates new points for the first curve for all x-values of the second curve using a linear interpolation method.
- Creates new points for the second curve for all x-values of the first curve using a logarithmic interpolation method.
- Operates with the common set of points.

Determining the Scale (Linear or Logarithmic) of Curves

Deciding how to handle a curve involves analyzing its slope, which is defined as:

$$\frac{dy}{dx} = \frac{y_{i1} - y_i}{x_{i1} - x_i} \tag{1}$$

First, the curve is treated as linear, and the minimum (MinSlope) and maximum (MaxSlope) slopes are calculated.

Second, a quotient is created:

$$\frac{\text{MaxSlope}}{\text{MinSlope}} \tag{2}$$

The same calculation is performed by treating:

- The x-axis as logarithmically scaled.
- The y-axis as logarithmically scaled.
- Both axes as logarithmically scaled.

Of these four values, the one closest to 1.0 indicates the best way of handling the curve.

CHAPTER 6 Formulas and Macros

This chapter describes how to use formulas and macros in Inspect.

Using Formulas

Inspect recognizes two variable types: curve and scalar. Mixed curve–curve and curve–scalar operations are evaluated as follows:

1. The range of the result of a curve–curve operation is the intersection of the x-range of the operands.
2. When one operand is a curve and the other is a scalar, the respective operation is performed as a scalar operation on each element of the curve operand.

The binary operators that can be used are +, –, *, /, and ^ (power operator).

Formula Library

The formula library allows you to perform some basic calculations on one or more curves. The result can be a new curve or a scalar value (see Table 3 on page 36). The following examples show how the formula library is used:

`sin (<curve_1> + 10)`	The result is a new curve. Inspect adds 10 to the y-value of each curve point from `curve_1` and computes the sinus.
`maxslope(<curve_1>)`	The result is a scalar value, which is the maximum slope of `curve_1`.

Table 3 on page 36 lists functions that create a new curve by applying a mathematical transformation to each element of the curve. These functions can also be applied to scalar values. Table 4 on page 37 lists special functions that either require more than one parameter or do not return a curve. Table 5 on page 37 lists functions that manage or compute fast Fourier transformation (FFT) and related operations.

NOTE A curve can be defined by one point only, in which case, the curve is treated as a scalar input. Some curves require as input a *curve only*, that is, a curve that has at least two points.

Table 3 Standard mathematical functions

Function	Input type	Output type	Description
`acos`	curve	curve	Returns the arc cosine. The returned angle [radian] is given in the range 0 (zero) to π .
`acosh`	curve	curve	Returns the inverse hyperbolic cosine. Curve values must be greater than or equal to 1.
`asin`	curve	curve	Returns the arc sine. The returned angle [radian] is given in the range from $-\pi/2$ to $\pi/2$.
`asinh`	curve	curve	Returns the inverse hyperbolic sine.
`atan`	curve	curve	Returns the arc tangent. The returned angle [radian] is given in the range from $-\pi/2$ to $\pi/2$.
`atanh`	curve	curve	Returns the inverse hyperbolic tangent. Curve values must be between –1 and 1 (excluding –1 and 1).
`cbrt`	curve	curve	Returns the cube root.
`ceil`	curve	curve	Rounds up each element to the smallest integer not less than itself.
`cos`	curve	curve	Returns the cosine.
`cosh`	curve	curve	Returns the hyperbolic cosine.
`diff`	curve only	curve	Returns the first derivative of the curve.
`erf`	curve	curve	Returns an error function of the curve values.
`erfc`	curve	curve	Returns the complementary error function of the curve values.
`exp`	curve	curve	Returns the number raised to the power of each curve value.
`fabs`	curve	curve	Returns the absolute value.
`floor`	curve	curve	Rounds down each element to the largest integer not greater than itself.
`gamma`	curve	curve	Returns the Gamma function.
`integr`	curve only	curve	Returns the integral of the curve.
`j0`	curve	curve	Returns the Bessel function of the first kind of order 0.
`j1`	curve	curve	Returns the Bessel function of the first kind of order 1.
`lgamma`	curve	curve	Returns the natural logarithm of the absolute value of the Gamma function.
`log`	curve	curve	Returns the natural logarithm of the given curve.
`log10`	curve	curve	Returns the base 10 logarithm of the given curve.

Table 3 Standard mathematical functions

Function	Input type	Output type	Description
`sin`	curve	curve	Returns the sine.
`sinh`	curve	curve	Returns the hyperbolic sine.
`sqrt`	curve	curve	Returns the square root.
`tan`	curve	curve	Returns the tangent.
`tanh`	curve	curve	Returns the hyperbolic tangent.
`y0`	curve	curve	Returns the Bessel function of the second kind of order 0.
`y1`	curve	curve	Returns the Bessel function of the second kind of order 1.

Table 4 Special functions

Function	Input type	Output type	Description
`pow`	curve, scalar	curve	Returns the curve raised to the power of the given scalar.
`tangent`	curve, scalar	curve	Returns a curve that is tangent to the given curve, at the given x-value.
`vecmax`	curve	scalar	Maximum y-value.
`vecmin`	curve	scalar	Minimum y-value.
`vecvalx`	curve, scalar	scalar	The x-value at a given y.
`vecvaly`	curve, scalar	scalar	The y-value at a given x.
`veczero`	curve	scalar	The x-value at y = 0.

Table 5 Fast Fourier transformation (FFT) and related functions

Function	Input type	Output type	Description
`cfftim`	curve_real, curve_imaginary	curve	Returns the imaginary part of the FFT of the given complex curve.
`cfftre`	curve_real, curve_imaginary	curve	Returns the real part of the FFT of the given complex curve.
`cifftim`	curve_real, curve_imaginary	curve	Returns the imaginary part of the inverse FFT of the given complex curve.
`cifftre`	curve_real, curve_imaginary	curve	Returns the real part of the inverse FFT of the given complex curve.
`fftabs`	curve_real, curve_imaginary	curve	Returns a vector holding the absolute value of the given complex curve.
`fftim`	curve	curve	Returns the imaginary part of the FFT of the given curve.
`fftre`	curve	curve	Returns the real part of the FFT of the given curve.

Table 5 Fast Fourier transformation (FFT) and related functions

Function	Input type	Output type	Description
ifftim	curve	curve	Returns the imaginary part of the inverse FFT of the given curve.
ifftre	curve	curve	Returns the real part of the inverse FFT of the given curve.

Using Macros

Macros can define complex formulas. Inspect expands a macro by using the actual arguments specified in the call to the macro (see Figure 4 on page 20).

In a macro definition, the argument type must be specified. Types can be curve or scalar. This information is needed to expand the macro into the correct formula.

The syntax for argument placeholder specification is `<c n>` for curves and `<s n>` for scalars, where `n` is an integer value used to distinguish between different arguments; `n` must start with 1.

In the Inspect macro parser, the macro prototype is not specified explicitly. It is determined automatically from the formula that defines the macro. The order of arguments is determined by their first appearance in the formula and not by numbers in the argument placeholders.

Example: ADD Macro

The macro `ADD` is defined as:

```
<c 1> + <c 2>
```

This macro adds two curves. The macro prototype looks like:

```
ADD(<CURVE>, <CURVE>)
```

The argument placeholder `<CURVE>` must be replaced by an actual curve name.

Example: DIFFMULT Macro

The macro `DIFFMULT` is defined as:

```
diff(<c 1>) + (<s 3> * <c 2>)
```

This macro takes the derivative of a curve `<c 1>` and adds to it a curve `<c 2>` multiplied by a scalar `<s 3>`. A call to this macro has the form:

```
DIFFMULT(<CURVE>, S, <CURVE>)
```

The argument placeholder `<CURVE>` must be replaced by an actual curve name, and `S` must be replaced by an expression that generates a scalar value.

CHAPTER 7 Using the Scripting Language

This chapter describes the operations available using the scripting language of Inspect.

Overview of the Scripting Language

In addition to the graphical user interface (GUI), you can control Inspect using a scripting language (see Working With Scripts on page 9). The scripting language allows you to manipulate and display data without using the GUI, and it is very useful for running complex calculations on datasets and displaying results, for example:

- Repeated manual actions can be recorded and run later by simple script invocation.
- Several computations using the formula library can be performed in one run.
- Results can be written automatically to a file.

You can write a script manually or create a script by recording actions performed in the GUI (see Creating Scripts on page 9).

Inspect uses the tool command language (Tcl) as its scripting language. For more information about Tcl, go to http://www.tcl.tk.

Some commands have been added to Tcl (in the form of Tcl procedures) to perform application-specific actions. For more specific needs, you can create your own commands.

Most of the additional commands in Inspect return a status string. A return status not equal to 1 indicates an error. If an error occurs, Inspect prints an error message to the standard error output and terminates the execution of the script.

NOTE Arguments in braces are *optional*. The first term in the braces is the name of the argument, and the second term is the default value of the argument. For example, a command that has been defined as `command {arg def_value}` can be called as `command` (which is equivalent to `command def_value`) and also as `command other_value`.

General-Purpose Commands

ft_scalar

`ft_scalar variableName variableValue`

Action: Produces the following output line:
`DOE: variableName variableValue`

If the current Inspect command file belongs to a Sentaurus Workbench project, this output line results in the creation of a new Sentaurus Workbench extracted variable with the name *variableName* and the value *variableValue*
(see Sentaurus™ Workbench User Guide, Extracted Variables on page 133).

Input: *variableName*, name of the Sentaurus Workbench variable to extract
variableValue, value of this Sentaurus Workbench variable

Returns: None

Reading and Writing Files

cv_write

`cv_write type fileName curveList`

Action: Writes (exports) the data of the specified curves to a file in the specified format.

Input: *type*, output format to use: `plt`, `xgraph`, or `xmgr`
fileName, file to write
curveList, list of curve names

Returns: Status of the write operation

fi_writeBitmap

`fi_writeBitmap` *`fileName`*

Action: Writes the plot area to a PNG file.

Input: *`fileName`*, file to write

Returns: Status of the write operation

fi_writeEps

`fi_writeEps` *`fileName`* {*`orientation`* `portrait`} {*`height`* `""`} {*`width`* `""`}

Action: Writes the plot area to an EPS file. This command is not generated automatically when script recording is switched on. If height or width is not specified, the actual plot size is taken into account. Some examples are:

```
fi_writeEps test.eps
fi_writeEps test.eps landscape
fi_writeEps test.eps landscape 200 100
```

Input: *`fileName`*, file to write
`orientation`, image orientation: `portrait` (default) or `landscape`
`height`, height of the saved image in pixels
`width`, width of the saved image in pixels

Returns: Status of the write operation

fi_writePs

`fi_writePs` *`fileName`* {*`orientation`* `portrait`} {*`printSize`* `US_LETTER`} {*`height`* `""`} {*`width`* `""`} {*`offsetHeight`* `""`} {*`offsetWidth`* `""`} {*`sizeUnit`* `""`}

Action: Writes the plot area to a PostScript® file. This command is not generated automatically when script recording is switched on. When height or width is not specified, the actual plot size is taken into account. Some examples are:

```
fi_writePs test.ps
fi_writePs test.ps landscape
fi_writePs test.ps landscape DIN_A4
fi_writePs test.ps portrait US_LETTER 450 300 5 5 m
```

Input: *`fileName`*, file to write
`orientation`, image orientation: `portrait` (default) or `landscape`
`printSize`, page size: `US_LETTER` (default), `DIN_A3`, or `DIN_A4`
`height`, height of the saved image in size units (*`sizeUnit`*)
`width`, width of the saved image in size units (*`sizeUnit`*)
`offsetHeight`, vertical page offset in size units (*`sizeUnit`*)
`offsetWidth`, horizontal page offset in size units (*`sizeUnit`*)
`sizeUnit`, unit for *`height`*, *`width`*, *`offsetHeight`*, and *`offsetWidth`*:
  `i`: inch (default)
  `m`: millimeter
  `c`: centimeter

Returns: Status of the write operation

graph_load

`graph_load` *`fileName`*

Action: Loads the specified save file into Inspect. All currently loaded projects are deleted.

Input: *`fileName`*, name of file to load

Returns: Status of the load operation

graph_write

`graph_write` *`fileName`*

Action: Saves the current state to a specified file.

Input: *`fileName`*, name of file

Returns: Status of the write operation

param_load

`param_load` *`fileName`*

Action: Loads a parameter file.

Input: *`fileName`*, name of file to load

Returns: Status of the load operation

param_write

`param_write` *`fileName`*

Action: Saves a parameter file.

Input: *`fileName`*, name of file

Returns: Status of the write operation

proj_getDataSet

`proj_getDataSet` *`projectName dataSetId`*

Action: If no dataset is found, the return value is an empty list. For example, the following commands set the variable `x_data` to the values of the dataset `time` and the variable `y_data` to the values of the dataset `data_1` of `node_A`:

```
set x_data [proj_getDataSet "tutorial_ins" "time"]
set y_data [proj_getDataSet "tutorial_ins" "node_A data_1"]
```

Input: *`projectName`*, name of project
`dataSetId`, name of a dataset including its group name if applicable

Returns: List of all the values of the dataset

proj_getList

`proj_getList`

Action: Returns a list of all projects. If no projects are found, an empty list is returned.

Input: None

Returns: List of all loaded projects

proj_getNodeList

`proj_getNodeList` *`projectName`*

Action: Returns a list of group names of the given project. If no groups have been found, an empty list is returned.

Input: *`projectName`*, name of project

Returns: List of group names

proj_load

`proj_load` *`fileName`*

Action: Loads a data file and creates a new project. The base name of the file is used as the project name (see Data Formats on page 4).

Input: *`fileName`*, name of file

Returns: Status of the load operation

proj_unload

`proj_unload` *`projectName`*

Action: Deletes a project and all the project-related curves.

Input: *`projectName`*, name of project

Returns: Status of the delete operation

proj_write

`proj_write` *`projectName fileName`*

Action: Writes a project to a specified file.

Input: *`projectName`*, name of project
`fileName`, name of file

Returns: Status of the write operation

Creating, Displaying, and Deleting Curves

A dataset used for curve creation is identified by its data path, which consists of the project name, the group name when the dataset belongs to a group, and the dataset name.

cv_create

`cv_create` *`curveName xDataPath yDataPath`* {*`axis`* `y`}

Action: Creates a curve with the given name using the specified datasets without displaying it. The datasets must be already loaded; otherwise, an error is returned. For example, the following command creates a curve `mycurve` using the dataset `time` on the x-axis and the dataset `OuterVoltage` of the group `Gate` on the y-axis, with both datasets belonging to the project `nmos_n7_des`:

```
cv_create mycurve "nmos_n7_des time" "nmos_n7_des Gate OuterVoltage"
```

Input: *`curveName`*, unique name for the new curve
`xDataPath`, x-dataset data path
`yDataPath`, y-dataset data path
`axis`, axis to use; the default is `y`

Returns: Status of the create operation

cv_createDS

`cv_createDS` *`curveName xDataPath yDataPath`* {*`axis`* `y`}

Same as `cv_create` except that the curve is displayed. See cv_create.

cv_createFromScript

`cv_createFromScript` *`curveName xdata ydata`* {*`axis`* `y`}

Action: Creates a curve using the given name and data. If the number of values for x and y are not the same, the number of curve points is according to that of the smaller dataset. Curves created with this command are stored in `AuxProject`. For example, the following command creates the curve `mycurve` defined by the specified data:

```
cv_createFromScript mycurve "0 1 2 3 4 5 6 7 8 9" "1 2 1 2 1 2 1 2 1 2"
```

Input: *`curveName`*, unique name for the new curve
`xdata`, list of data to use for the x-dataset
`ydata`, list of data to use for the y-dataset
`axis`, axis to use: `y` (default) or `y2`

Returns: Status of the create operation

cv_createWithFormula

`cv_createWithFormula` *`curveName formula xmin xmax ymin ymax`*

Action: Computes a new curve using the formula applied to the data of the argument curves within the given range. Setting the range to any nonnumeric value (for example, `A`) instructs Inspect to set no limit in the corresponding direction. For example, the following command creates the curve `f3` using the entire data range of curves `f1` and `f2`:

```
cv_createWithFormula f3 "<f1>+<f2>+10" A A A A
```

Input: *`curveName`*, unique name for the new curve
`formula`, formula or macro
`xmin`, *`xmax`*, *`ymin`*, *`ymax`*, range for which the formula is applied

Returns: Status of the create operation

cv_delete

`cv_delete curveName`

Action: Deletes a curve.

Input: *curveName*, name of curve

Returns: Status of the delete operation

cv_display

`cv_display curveName {axis y}`

Action: Displays a curve using the specified y-axis.

Input: *curveName*, name of curve to display
axis, axis to use; the default is `y`

Returns: None

cv_logScale, cv_log10Scale

```
cv_logScale curveName newCurveName {axis x}
cv_log10Scale curveName newCurveName {axis x}
```

Action: Creates a new curve where all values on a given axis are transformed to a log (log10) scale.

Input: *curveName*, curve to transform
newCurveName, name of the new curve
axis, axis on which the curve is scaled; the default is `x`

Returns: Status of the create operation

cv_split

`cv_split` *`curveName axis newCurveList`*

Action: Splits the input curve into several curves at the points where the x-values are nonmonotonic, that is, $x[i+1] < x[i]$. The number of names for the new curves must match the actual number of created curves; otherwise, an error is returned.

This command is similar to choosing **Curve** > **Transform** > **Suppress Backtrace** (see Table 10 on page 113). The difference is that this command creates a set of new curves. With **Suppress Backtrace** selected, the backtrace lines are suppressed only on the plot.

Input: *`curveName`*, name of curve to split
`axis`, y-axis to map the new curves onto
`newCurveList`, list of names for new curves

Returns: Status of the operation

cv_split_disc

`cv_split_disc` *`curveName axis newCurveList`*

Action: Splits the input curve into several curves at the points where there are discontinuities, that is, $x[i+1] == x[i]$ and $y[i+1] != y[i]$. The number of names for the new curves must match the actual number of created curves; otherwise, an error is returned.

Input: *`curveName`*, curve to split
`axis`, y-axis to map the new curves onto
`newCurveList`, list of names for new curves

Returns: Status of the operation

Changing Attributes

These commands change the attributes of the title, axes, curves, and legend.

cv_lineColor

```
cv_lineColor curveName color
```

Action: Sets the color of the curve line.

Input: *curveName*, name of curve
color, color of the curve line

Returns: None

cv_lineStyle

```
cv_lineStyle curveName style
```

Action: Sets the drawing style of the curve line.

Input: *curveName*, name of curve
style, drawing style of the curve line: `dashed`, `dotted`, `"long dashed"`, `"long dotted"`, or `solid`

Returns: None

cv_renameCurve

```
cv_renameCurve curveName newName
```

Action: Renames a curve.

Input: *curveName*, name of curve
newName, new name of curve

Returns: None

cv_set_interpol

`cv_set_interpol` *`curveId axis type`*

Action: Sets the interpolation method to be applied to each particular dataset of a curve.

Input: *`curveId`*, curve identification
`axis`, axis on which the interpolation is set: `X` or `Y`
`type`, interpolation method to set: `AUTO`, `LIN`, or `LOG`

Returns: None

cv_setCurveAttr

`cv_setCurveAttr` *`curveName legend color style width shape size outColor outWidth fillColor`*

Action: Sets curve-drawing attributes.

Input: *`curveName`*, name of curve
`legend`, curve legend
`color`, color of the curve line
`style`, drawing style of the curve line: `dashed`, `dotted`, `"long dashed"`, `"long dotted"`, or `solid`
`width`, width of the curve line
`shape`, marker shape: `none`, `circle`, `cross`, `diamond`, `plus`, `scross`, `splus`, `square`, or `triangle`
`size`, marker size
`outColor`, color of the marker outline
`outWidth`, width of the marker outline
`fillColor`, fill color of the marker

Returns: None

gb_setpreferences

`gb_setpreferences` *`type val`*

Action: Sets new values for the preference options. The following options can be modified:

`precision`: Defines the precision used to display coordinate values in the status line; any integer can be set.
`old_interpolation`: Specifies whether the old interpolation is used to compute curves:
`1`: Activates old interpolation.
`0`: Deactivates old interpolation.

Input: *`type`*, preference option to be modified
`val`, new value for option

Returns: None

gr_createLabel

`gr_createLabel` *`label coordX coordY fontStr color`*

Action: Creates a label in the plot area.

Input: *`label`*, label text
`coordX`, x-coordinate
`coordY`, y-coordinate
`fontStr`, label font
`color`, label color

Returns: Label ID

gr_deleteLabel

`gr_deleteLabel` *`labelId`*

Action: Deletes a label from the plot area.

Input: *`labelId`*, label ID

Returns: None

gr_formatAxis

`gr_formatAxis` *`axis format`*

Action: Changes the format of the displayed axis.

Input: *`axis`*, axis to be formatted
`format`, the options are `default`, `engineering`, `fixed`, or `scientific`

Returns: None

gr_mappedAxis

`gr_mappedAxis` *`axis yesno`*

Action: Changes the visibility of an axis.

Input: *`axis`*, specifies a y-axis: `y` or `y2`
`yesno`, specifies the axis visibility: `True` or `False`

Returns: None

gr_precision

`gr_precision` *`axis prec`*

Action: Changes the precision of a given axis.

Input: *`axis`*, axis to be formatted
`prec`, numeric precision to be set for the axis

Returns: None

gr_setAxisAttr

`gr_setAxisAttr` *`axis title tfont min max color width font angle div scale`* {*`tcolor`*}

Action: Sets the axis attributes.

Input:
`axis`, specifies an axis: `X`, `Y`, or `Y2`
`title`, axis title
`tfont`, font size of the axis title
`min`, *`max`*, minimum and maximum values of the axis
`color`, color of the axis
`width`, width of the axis line
`font`, font size of the tick label
`angle`, angle at which the tick labels are drawn
`div`, number of secondary ticks between the main ticks
`scale`, specifies linear (lin) or logarithmic (log) display of the axis
`tcolor`, color of the axis title

Returns: None

gr_setGeneralAttr

`gr_setGeneralAttr` {*`showFrame`* `true`} {*`axesTight`* `true`} {*`backColor`* `white`} {*`selectColor`* `cyan`}

Action: Sets the general attributes of the plot.

Input:
`showFrame`, Boolean indicator of plot frame appearance; default is `true`
`axesTight`, Boolean indicator of the tightness of axes; default is `true`
`backColor`, plot background color; default is `white`
`selectColor`, color of the selected curve; default is `cyan`

Returns: None

gr_setGridAttr

```
gr_setGridAttr {showGrid false} {gridAlign left} {minorTicks false}
   {gridStyle "short dashed"} {gridColor black} {gridWidth 1}
```

Action: Sets the grid attributes of the plot.

Input: *showGrid*, Boolean indicator of grid appearance; default is `false`
gridAlign, grid alignment: `left` (default) or `right`
minorTicks, Boolean indicator of the appearance of minor ticks; default is `false`
gridStyle, attribute of the grid style: `dashed`, `"dot-dashed"`, `dotted`, `"long dashed"`, `"long dotted"`, `"short dashed"` (default), or `solid`
gridColor, color of the grid lines; default is `black`
gridWidth, thickness of the grid lines; default is `1`

Returns: None

gr_setLegendAttr

```
gr_setLegendAttr {showFlag true} {fontName helvetica} {fontSize 10} {fontStyle {}}
   {backColor white} {foreColor black} {frameColor black} {frameWidth 1} {framePos right}
   {frameAnchor n}
```

Action: Sets the attributes of the legend.

Input: *showFlag*, Boolean indicator of legend appearance
fontName, legend font name; default is `helvetica`
fontSize, legend font size; default is `10`
fontStyle, legend font style: `bold`, `italic`, `overstrike`, or `underline`; default is an empty list { }
backColor, legend background color; default is `white`
foreColor, legend foreground color; default is `black`
frameColor, legend frame color; default is `black`
frameWidth, legend frame width; default is `1`
framePos, legend frame position: `left`, `right` (default), `top`, `bottom`, `free`, or `plot`
frameAnchor, legend frame anchor: `n` (default), `e`, `s`, `w`, `ne`, `se`, `sw`, or `nw`

Returns: None

gr_setLegendPos

`gr_setLegendPos x y`

Action: Changes the position of the displayed legend in the plot area.

Input: *x*, new x-coordinate for the legend in the plot area
y, new y-coordinate for the legend in the plot area

Returns: None

gr_setTitleAttr

`gr_setTitleAttr title {fontSize 14} {just center}`

Action: Sets the title attributes.

Input: `title`, title text
`fontSize`, size of title font; default is `14`
`just`, title justification: `center` (default), `left`, or `right`

Returns: None

Accessing Curve Data

cv_getVals

`cv_getVals curveName`

Action: Returns a list of the x- and y-data. The x-data and y-data can be assessed using:

```
set xy [cv_getVals "f1"]
set x [lindex $xy 0]
set y [lindex $xy 1]
```

After this, the variables `x` and `y` hold the x- and y-datasets, respectively.

Input: `curveName`, name of curve

Returns: List of the x- and y-data

cv_getValsX

`cv_getValsX` *`curveName`*

Action: Returns a list that holds the x-dataset.

Input: *`curveName`*, name of curve

Returns: List of the x-data

cv_getValsY

`cv_getValsY` *`curveName`*

Action: Returns a list that holds the y-dataset.

Input: *`curveName`*, name of curve

Returns: List of the y-data

cv_getXaxis

`cv_getXaxis` *`curveName`*

Action: Returns the project name and the dataset ID using:

```
set answer [cv_getXaxis "myCurve"]
set projectName [lindex $answer 0]
set dataSetId [lindex $answer 1]
```

Input: *`curveName`*, name of curve

Returns: List with the project name and the dataset ID of the x-dataset

cv_getYaxis

`cv_getYaxis` *`curveName`*

Action: Returns the project name and the dataset ID as for `cv_getXaxis`.
See cv_getXaxis.

Input: *`curveName`*, name of curve

Returns: List with the project name and the dataset ID of the y-dataset

cv_printVals

`cv_printVals` *`curveName`*

Action: Writes the x- and y-data of a curve to standard output.

Input: *`curveName`*, name of curve

Returns: List of the printed values

Transforming Curve Data

These commands change the way in which curve data is displayed without changing the curve datasets.

cv_abs

`cv_abs` *`curveName axis`*

Action: Replaces negative values of the x- or y-dataset by their absolute values, depending on the axis argument. This command has the same effect as choosing **Curve** > **Transform** > **Abs X** or **Abs Y** (see Table 10 on page 113).

Input: *`curveName`*, name of curve
`axis`, axis specifier

Returns: Status of the operation

cv_delPts

```
cv_delPts curveName indexList
```

Action: Deletes the points in the *indexList* from the set of points being displayed.

Input: *curveName*, name of curve
indexList, list of indices of curve points

Returns: Status of the delete operation

cv_inv

```
cv_inv curveName axis
```

Action: Reflects a curve about the specified axis. This command is equivalent to choosing **Curve** > **Transform** > **Reflect X** or **Reflect Y** (see Table 10 on page 113).

Input: *curveName*, name of curve
axis, axis specifier

Returns: Status of the operation

cv_reset

```
cv_reset curveName
```

Action: Restores the original appearance of the curve after a transformation. This command is equivalent to choosing **Curve** > **Restore Data** (see Table 10 on page 113).

Input: *curveName*, name of curve

Returns: Status of the operation

Extracting Parameters

These commands extract standard parameters of semiconductor devices. Some arguments of the commands have default values that are used when an argument is not specified.

f_Gamma

`f_Gamma` *`VT1 VT2 VB1 VB2 const`*

Action: Computes the body-effect parameter at two different source–substrate voltages. The formula used to compute the body-effect parameter is:
`Gamma = (VT2 - VT1)/( (const + VB2)`$^{1/2}$` - (const + VB1)`$^{1/2}$` )`

Input: *`VT1`*, *`VT2`*, two threshold voltages
`VB1`, *`VB2`*, two different source–substrate voltages
`const`, $2\varphi_F$ where φ_F is the Fermi-level potential; default value is 0.8 V

Returns: `Gamma` [$V^{1/2}$] as a scalar or `f_error` in the case of an error

f_gm

`f_gm` *`curveName xmin xmax ymin ymax`*

Action: Computes the maximum of transconductance for a given I_d–V_g curve.

Input: *`curveName`*, curve used to calculate gm
`xmin`, *`xmax`*, *`ymin`*, *`ymax`*, range for computing the result; the default values correspond to the full curve range

Returns: Value of gm [A/V] of the curve or `f_error` in the case of an error

f_hideInternalCurves

`f_hideInternalCurves`

Action: Hides the internally used curves created by the commands of this section.
See f_showInternalCurves on page 64.

Input: None

Returns: None

f_IDSS

`f_IDSS` *`curveName xmin xmax ymin ymax`*

Action: Computes the saturation current.

Input: *`curveName`*, I_d–V_d curve at the fixed gate–source voltage
`xmin`, *`xmax`*, *`ymin`*, *`ymax`*, range for computing the result; the default values correspond to the full curve range

Returns: Saturation current value or `f_error` in the case of an error

f_KP

`f_KP` *`gm VDS`*

Action: Computes the transconductance parameter.

Input: *`gm`*, transconductance value
`VDS`, drain source voltage; default is `0.1`

Returns: KP [A/V^2] value or `f_error` in the case of an error

f_Ron

`f_Ron` *`curveName xmin xmax ymin ymax`*

Action: Computes the on-state resistance in the linear region.

Input: *`curveName`*, I_d–V_d curve at the fixed gate–source voltage
`xmin`, *`xmax`*, *`ymin`*, *`ymax`*, range for computing the result; the default values correspond to the full curve range

Returns: Value of R_{on} [$k\Omega$] or `f_error` in the case of an error

f_Rout

`f_Rout curveName xmin xmax ymin ymax`

Action: Computes the output resistance in the saturation region.

Input: *curveName*, I_d–V_d curve at the fixed gate–source voltage
xmin, *xmax*, *ymin*, *ymax*, range for computing the result; the default values correspond to the full curve range

Returns: Value of R_{out} [$k\Omega$] or `f_error` in the case of an error

f_showInternalCurves

`f_showInternalCurves axis`

Action: Displays the internally used curves created by the commands of this section.
See f_hideInternalCurves on page 62.

Input: *axis*, axis to use; default is `left`

Returns: None

f_TetaG

`f_TetaG VT gm idvgs vgsvgs xmin xmax ymin ymax`

Action: Computes the mobility modulation `TetaG` using the formula:

```
TetaG = gm(VGSlow)/ID(VGShigh) - 1/(VGShigh - VT)
```

Input: *VT*, threshold voltage value
gm, transconductance value
idvgs, I_d–V_g curve
vgsvgs, V_g–V_g curve
xmin, *xmax*, *ymin*, *ymax*, range for computing the result; the default values correspond to the full curve range

Returns: Value of `TetaG` [V^{-1}] or `f_error` in the case of an error

f_VT

`f_VT` *`curveName xmin xmax ymin ymax`*

Action: Computes the threshold voltage [V] of the given curve. The formula used to compute the threshold voltage is:

```
VT = intercept(maxslope(curve))
```

Example 1: This statement computes V_{th} using default values for the range:

```
set vt1 [f_VT idvgs]
```

Example 2: This statement computes V_{th} using *`xmin`* `= 0.1` *`xmax`* `= 0.3` and default values for the y-range:

```
set vt2 [f_VT idvgs 0.1 0.3]
```

Input: *`curveName`*, name of curve
`xmin`, *`xmax`*, *`ymin`*, *`ymax`*, range for computing the result; the default values correspond to the full curve range

Returns: Threshold voltage value or `f_error` in the case of an error

f_VT1

`f_VT1` *`curveName xmin xmax ymin ymax`*

Action: Computes the threshold voltage [V] of the given curve.
V_{th} is typically extracted at $I_d = 0.1\ \mu A/\mu m$.

Input: *`curveName`*, name of curve
`xmin`, *`xmax`*, *`ymin`*, *`ymax`*, range for computing the result; the default values correspond to the full curve range

Returns: Threshold voltage value or `f_error` in the case of an error

f_VT2

`f_VT2 curveName`

Action: Computes the threshold voltage [V] of the given curve. The method used to extract V_{th} is the intersection of `MaxSlope` and `MinSlope` lines in the log of the given curve.

Input: *curveName*, name of curve

Returns: Threshold voltage as a scalar value or `f_error` in the case of an error

Computing

cv_compute

`cv_compute formula xmin xmax ymin ymax`

Action: Computes a scalar value using the formula.

Input: *formula*, string with the formula to evaluate
xmin, *xmax*, *ymin*, *ymax*, range for which the formula is applied

Returns: Scalar computation result

cv_getZero

`cv_getZero curveName xmin xmax ymin ymax`

Action: Computes the x-coordinate of the point where the curve intersects the x-axis. If the curve does not cross the x-axis, an empty string is returned.

Input: *curveName*, name of curve
xmin, *xmax*, *ymin*, *ymax*, range for which the command applies

Returns: The x-value where the curve intersects the x-axis

macro_define

`macro_define` *`macroName macroDef`*

Action: Defines a macro, which can be used later for computations.

Input: *`macroName`*, name of the macro
`macroDef`, macro definition

Returns: Status of the operation

Controlling Scripts

script_break

`script_break`

Action: Suspends the execution of a script and passes control to the GUI. The script execution can be resumed by choosing **Script > Continue Script** (see Table 11 on page 114).

Input: None

Returns: None

script_exit

`script_exit`

Action: Stops the execution of a script and exits Inspect.

Input: None

Returns: None

script_sleep

```
script_sleep sec
```

Action: Stops the execution of a script for a given number of seconds.

Input: *sec*, time in seconds

Returns: None

Examples of Using the Scripting Language

Computing the Dose of Implanted Arsenic

If `As_Implant` is the name of an As profile previously created, compute the dose of implanted As by integrating the profile. Limit the integration to portions of the curve with a concentration larger than 1e14 but without other limitations in depth or maximum concentration value:

```
set Dose_As [cv_compute "vecmax(integr(<n30_sd_Arsenic_Implant>))" A A 1e14 A]
```

If `IdVg` is the name of an I_{ds}–V_{gs} curve previously created, compute a transconductance curve using `diff`. Limit the computation to the window in the I_d–V_g curve defined by `Vmin` = 1.0 V, `Vmax` = 4.0 V, `Id_min` = 1e-10, and `Id_max` = 5e-6:

```
set gm [cv_compute "vecmax(diff(<IdVg>))" 1.0 4.0 1e-10 5e-6]
```

Creating a Macro to Compute Vt

Create a macro to compute V_t from the maximum of the second derivative of an I_d–V_g curve. Use `<c n>` as placeholders for curves and `<s n>` for scalars, where `n` represents the argument used in the macro and must start at 1. In the example, `<c 1>` should be an I_d–V_g curve and `<s 2>` is a multiplication factor:

```
macro_define Vt2d "<s 2>*vecvalx(diff(diff(<c 1>)),
   0.999*vecmax(diff(diff(<c 1>))))"
```

If `IdVg` is the name of an I_{ds}–V_{gs} curve previously created, use the macro created to compute V_t in mV:

```
set Vt2 [cv_compute "Vt2d(<IdVg>,1e3)" A A A A]
```

CHAPTER 8 Working With Script Libraries

This chapter describes how to work with script libraries in Inspect.

The scripting language of Inspect is complemented by libraries that provide additional functionality for specific operations such as curve comparison.

Loading Libraries

You use the `load_library` command to load libraries:

```
load_library libraryName
```

where *`libraryName`* is a library identifier.

This command makes available all the functionality provided by the specified library.

All commands of a particular library have a common prefix, for example, `iccap` for commands provided by the IC-CAP model parameter extraction library (see IC-CAP Model Parameter Extraction Library on page 106).

Adding a Site Library

The `$STROOT_LIB/inspectlib` directory stores all libraries as well as the `lib_index` file, which provides an index of all available libraries.

To add a library, the administrator (a person with write permissions to the TCAD distribution directory `$STROOT`) copies the library to the `$STROOT_LIB/inspectlib` directory and enters text in the index that describes the new library. The following fields must be provided:

```
<library_name> <library_prefix> <library_filename>
```

where:

- <library_name> is the name specified to call this library.
- <library_prefix> is the prefix used for all commands.
- <library_filename> is the name of the file where all commands are implemented.

Extraction Library

The commands provided by this library extract parameters from I–V curves. You can load the library with the command:

```
load_library EXTRACT
```

The library is located at `$STROOT/$STRELEASE/lib/inspectlib/EXTRACT.tcl`. If you need to customize the library, you can create a local copy of the library and edit the scripts. In this case, the local version is loaded by sourcing the script:

```
source EXTRACT.tcl
```

cv_linTransCurve

This command applies a linear transformation to the x- and y-values of a curve. It is called using:

```
cv_linTransCurve <Curve> <Xm> <Xb> <Ym> <Yb> <Axis>
```

where:

- `<Curve>` is the name of the curve.
- The x- and y-values of the curve are replaced by the transformed values given by $X' = X*\texttt{Xm} + \texttt{Xb}$ and $Y' = Y*\texttt{Ym} + \texttt{Yb}$, respectively.
- `<Axis>` can be either `y` or `y2`, and determines on which y-axis the transformed curve is displayed.

Example

Shift an I_d–V_{gs} curve by 0.55 V:

```
cv_linTransCurve IdVgs 1 0.55 1.0 0.0 y
```

cv_scaleCurve

This command scales the x- and y-values of a curve. It is called using:

```
cv_scaleCurve <Curve> <XFactor> <YFactor> <Axis>
```

where:

- `<Curve>` is the name of the curve.
- The x- and y-values of the curve are multiplied by `<XFactor>` and `<YFactor>`, respectively.
- `<Axis>` can be either `y` or `y2`, and determines on which y-axis the scaled curve is displayed.

Example

Scale an I_d–V_{gs} curve from $\mathrm{A}/\mu\mathrm{m}$ to mA/mm:

```
cv_scaleCurve IdVgs 1 1e6 y
```

ExtractBVi

Breakdown curves sometimes exhibit a pronounced snapback, in which case, another relevant definition is the bias voltage at which the current reaches a certain level. This type of extraction is performed with the `ExtractBVi` command. It is called using:

```
ExtractBVi <Name> <Curve> <Ilevel>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the curve.
- `<Ilevel>` refers to the mentioned current level.

Example

```
ExtractBVi BVcboi VcIc 1e-12
```

results in output such as:

```
DOE: BVcboi 9.09e+00
BVi: 9.09e+00
```

ExtractBVv

The breakdown voltage can be defined as the maximum voltage that can be applied to a contact. The `ExtractBVv` command extracts this value. It is called using:

```
ExtractBVv <Name> <Curve> <Sign>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the curve.
- `<Sign>` can take the values `+1` (n-p-n) or `–1` (p-n-p), and distinguishes different types of bipolar transistor. (In general, specify `–1` if the breakdown occurs at a negative bias.)

Example

```
ExtractBVv BVcbov VcIc 1.0
```

results in output such as:

```
DOE: BVcbov 9.09e+00
BVv: 9.09e+00 V
```

ExtractEarlyV

This command extracts the Early voltage from an I_c–V_{ce} curve. It is called using:

```
ExtractEarlyV <Name> <Curve> <Vtarget>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the curve.
- `<Vtarget>` is the bias point at which the slope of the I_c–V_{ce} curve is determined for the computation of the Early voltage.

Example

```
ExtractEarlyV Va IcVc 1.25
```

results in output such as (where `Ro` is the output resistance and `Va` is the Early voltage):

```
DOE: Ro 3.283e+04
DOE: Va -1.836e+01
```

ExtractGm

This command extracts the maximum transconductance from an I_d–V_{gs} curve. It is called using:

```
ExtractGm <Name> <Curve> [<Type>]
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is to the name of the I_d–V_{gs} curve.
- See ExtractVtgm on page 76 for details about `Type`.

Example

```
set gm [ExtractGm gmLin IdVg]
```

results in output such as:

```
DOE: gmLin 1.123e-04 gm: 1.123e-04
S/um Max gm is at Vg= 0.540 V
```

ExtractGmb

This command is the same as `ExtractGm` except that the `ExtractGmb` command uses parabolic interpolation to find the gate bias at which the maximum transconductance occurs (see ExtractGm).

For I_d–V_{gs} curves with a limited number of gate–bias sample points, better accuracy is achieved with the `ExtractGmb` command.

ExtractIoff

This command extracts the drain leakage current from an I_d–V_{gs} curve. It is called using:

```
ExtractIoff <Name> <Curve> <Voff>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the I_d–V_{gs} curve (computed for a high drain bias).
- `<Voff>` defines the gate voltage at which the drain leakage current is extracted, typically, at a small nonzero value to avoid noise.

Example

```
if { $Type == "nMOS" } { set SIGN 1.0 } \
else { set SIGN -1.0 }
set Ioff [ExtractIoff Ioff [expr $SIGN*1e-4]]
```

results in output such as:

```
DOE: Ioff 5.167e-11
Ioff: 5.167e-11 A/um
```

ExtractMax

This command extracts the maximum of a curve. It is called using:

```
ExtractMax <Name> <Curve>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the curve.

Example

```
set IdSat [ExtractMax IdSat IdVg]
```

results in output such as:

```
DOE: IdSat 4.028e-04
Max: 4.028e-04
```

ExtractRon

This command extracts the on-state resistance from an I_d–V_{ds} curve. It is called using:

```
ExtractRon <Name> <Curve> <Von>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the I_d–V_{ds} curve (computed for a high gate bias).
- `<Von>` defines the drain voltage at which the on-state resistance is extracted, typically, well beyond saturation.

Example

```
set Ron [ExtractRon Ron IdVd 1.1]
```

results in output such as:

```
DOE: Ron 14909.555
Ron: 14909.555 Ohm um
```

ExtractSS

This command extracts the subthreshold voltage swing from an I_d–V_{gs} curve. It is called using:

```
ExtractSS <Name> <Curve> <Vgo>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the I_d–V_{gs} curve.
- `<Vgo>` defines the gate voltage at which the slope is extracted. It should be a value well below the threshold voltage.

NOTE The slope can be *noisy* at the beginning of the curve or at very low current levels, so better results are often obtained when setting `Vgo` > 0 V.

Example

```
set SS [ExtractSS SSlin IdVg($N) 0.01]
```

results in output such as:

```
DOE: SSlin 79.758
SS (subthreshold voltage swing): 79.758 mV/dec
```

ExtractValue

This command extracts the y-value at a given x-point. It is called using:

```
ExtractValue <Name> <Curve> <Xo>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the curve.

- <Xo> defines the x-point at which the value is extracted.

Example

```
set CggP [ExtractValue CgP Cgg 1.2]
```

results in output such as:

```
DOE: CgP 1.426e-15
CgP: 1.426e-15
```

Here, Cgg is the name of the Inspect total gate–capacitance versus the gate–voltage curve.

ExtractVtgm

This command extracts the threshold voltage from an I_d–V_{gs} curve using the maximum transconductance method. It is called using:

```
ExtractVtgm <Name> <Curve> [<Type>]
```

where:

- <Name> is the name of the extracted parameter as it appears in the Variable Values column of Sentaurus Workbench.
- <Curve> is the name of the I_d–V_{gs} curve.
- <Type> specifies the transistor type, which can be one of the following values:
  - nMOS or nMOSneg for NMOSFETs with a positive or negative drain current convention.
  - pMOS or pMOSneg for PMOSFETs with a positive or negative drain current convention.

  The MOSFET threshold and transconductance extraction commands require prior knowledge of the transistor type and the sign convention for the drain current.

  If <Type> is omitted, the transistor type is determined internally by analyzing the first and last points of the given curve.

The command ExtractVtgm passes the extracted value to Sentaurus Workbench and prints it to the log file. It also returns the value to Inspect.

Example

```
set Vt [ExtractVtgm Vtgm IdVg]
```

results in output such as:

```
DOE: Vtgm 0.392
Vt (Max gm method): 0.392 V
```

ExtractVtgmb

This is the same as `ExtractVtgm` except that the `ExtractVtgmb` command uses parabolic interpolation to find the gate bias at which the maximum transconductance occurs (see ExtractVtgm on page 76).

For I_d–V_{gs} curves with a limited number of gate–bias sample points, better accuracy is achieved with the `ExtractVtgmb` command.

ExtractVti

This command extracts the gate voltage from an I_d–V_{gs} curve at which the drain current exceeds a given current level. It is called using:

```
ExtractVti <Name> <Curve> <Ilevel>
```

where:

- `<Name>` is the name of the extracted parameter.
- `<Curve>` is the name of the I_d–V_{gs} curve.
- `<Ilevel>` defines the drain current level at which to extract the gate voltage.

Example

```
set Vti [ExtractVti Vti IdVg 1e-7]
```

results in output such as:

```
DOE: Vti 1.476
Vti (Vg at Io=1.000e-06): 1.476 V
```

FilterTable

The `FilterTable` command processes data from the Sentaurus Workbench Family Tree to create a plot of one Sentaurus Workbench parameter as a function of another Sentaurus Workbench parameter for a certain subset of experiments. Threshold voltage roll-off plots are a typical application of this utility.

To better understand this utility, it is helpful to first consider the kind of data on which it is designed to operate.

In an Inspect script, you can use the dynamic preprocessing feature of Sentaurus Workbench `@<`*`parameter_name`*`>:all@` to access a list of input parameters and extracted values for all Sentaurus Workbench experiments. For example:

```
set Types [list @Type:all@]
set Lgs   [list @lgate:all@]
set Vts   [list @Vt:all@]
set Ids   [list @Id:all@]
...
```

Here, the Tcl list `Types` contains, for all experiments, the values of the Sentaurus Workbench input parameter `Type`, which for example can take the value `nMOS` or `pMOS`, depending on whether an NMOS or a PMOS structure is created in this experiment.

Similarly, the Tcl list `Lgs` contains for all experiments a *parallel* list of values of another Sentaurus Workbench input parameter, which for example contains the value of the gate length of the given MOSFETs. The corresponding extracted parameter can be accessed in the same way. The Tcl lists `Vts` and `Ids` can contain the extracted values for the threshold voltage and the drain current for each respective experiment.

NOTE The values in the various lists might or might not be numeric, and they might not be ordered.

Syntax of FilterTable

The `FilterTable` command takes lists of Sentaurus Workbench parameters as arguments. The first two lists identify the x- and y-values, which will be processed to create a plot. The subsequent arguments control the conditions an experiment must fulfill to be included in the plot. These conditions are defined using optional pairs of a target value and a Sentaurus Workbench list.

The syntax of `FilterTable` is:

```
FilterTable XList YList [ConditionTarget1 ConditionList1] \
   [ConditionTarget2 ConditionList2] [ConditionTarget3 ConditionList3] [...]
```

The command returns two lists of values:

- The first list contains a subset of the `XList`. The subset is restricted to the selected experiments. The values are given in ascending order.
- The second list contains the corresponding values of the `YList`.

In addition, `FilterTable` ignores all entries of `YList` that contain a nonnumeric value. You can use this feature to omit failed extractions. In the tool input file that performs the extraction (for example, a previous Inspect instance), use the `#set` directive to preset the extracted variable to the value `x`:

```
#set Vt x
...
set Vt [ExtractVtgmb Vt IdVg]
```

The actual extraction process, here using the `ExtractVtgmb` command, overwrites the preset value `x` with the actual value. However, if the extraction process fails, the preset value persists.

For example, after preprocessing, Sentaurus Workbench preprocessor references such as `@Type:all@` are expanded and the resulting preprocessed file can look like:

```
set Types [list nMOS  nMOS  nMOS  nMOS   pMOS   pMOS  pMOS  pMOS]
set Lgs   [list 0.090 0.045 0.130 0.065  0.065  0.045 0.130 0.090]
set Vts   [list 0.424 0.313 0.414 0.408 -0.344 -0.232   x  -0.374]

set XYLists [FilterTable $Lgs $Vts "nMOS" $Types]
cv_createFromScript Vt_vs_Lg_nMOS [lindex $XYLists 0] [lindex $XYLists 1] y
cv_display Vt_vs_Lg_nMOS y

set XYLists [FilterTable $Lgs $Vts "pMOS" $Types]
cv_createFromScript Vt_vs_Lg_pMOS [lindex $XYLists 0] [lindex $XYLists 1] y
cv_display Vt_vs_Lg_pMOS y
```

This script creates two separate V_t roll-off curves: one for all `nMOS` experiments and one for all `pMOS` experiments. The values are shown in order and the data point for `Type=pMOS` and `Lg=0.130`, for which the extraction failed (`Vt=x`), is omitted.

The extend Library

The `extend` library implements high-level commands to provide:

- Better control of curve attributes (`cv_autoIncrStyle`, `cv_disp`, `cv_nextColor`, `cv_nextSymbol`, `cv_setFillColor`)
- Curve manipulation (`cv_addCurve`, `cv_addDataset`, `cv_linTrans`, `cv_monotonicX`, `cv_scale`, `cv_sort`)
- Additional curve information (`cv_getGlobalExtrema`, `cv_getLocalExtrema`, `cv_getNames`, `cv_getRange`, `cv_getXmax`, `cv_integrate`, `cv_linFit`)
- Extraction of dataset information (`ds_getValue`, `proj_datasetExists`)
- A simple debug print function (`dbputs`)
- Functions to work with lists (`ldiff`, `lintersect`, `ltranspose`, `lunion`)
- An ASCII file import filter (`fi_readTxtFileHeader`)

You can load the library with the command:

```
load_library extend
```

The library is located at `$STROOT/$STRELEASE/lib/inspectlib/extend.tcl`.

If you need to customize the library, you can create a local copy of the library and edit the scripts. In this case, the local version is loaded by sourcing the script:

```
source extend.tcl
```

The commands of the library are described in the following sections. If a command is applied to a curve, the creation of the curve is not mentioned explicitly in the examples for brevity. For test purposes, curves can be created easily with the following line:

```
cv_createFromScript c1 {0 1} {1 2}
```

NOTE Arguments in braces are *optional*. The first term in the braces is the name of the argument, and the second term is the default value of the argument. For example, a command that has been defined as `command {arg def_value}` can be called as `command` (which is equivalent to `command def_value`) and also as `command other_value`.

cv_addCurve

`cv_addCurve` *`cname cname2`*

Action: Adds the y-values of the curve *`cname2`* to the y-values of the curve *`cname`*.

Input: *`cname`*, *`cname2`*, name of curves

Returns: None

Example

```
cv_createFromScript c1 {0 1} {1 2}
cv_createFromScript c2 {0 1} {3 4}
cv_addCurve c1 c2
puts "y: [cv_getValsY c1]"
> y: 4 6
```

cv_addDataset

`cv_addDataset` *`cname xdset ydset`*

Action: Adds the y-values of a dataset to an existing curve.

Input: *`cname`*, name of curve to which datasets will be added
`xdset`, dataset name of the x-values to be added
`ydset`, dataset name of the y-values to be added

Returns: None

Example

```
# sum the total currents of nContact and nContact2
cv_addDataset iv "n4_des pContact OuterVoltage" "n4_des nContact TotalCurrent"
cv_addDataset iv "n4_des pContact OuterVoltage" "n4_des nContact2
   TotalCurrent"
```

cv_angularMap

`cv_angularMap` *`cname`* `{`*`astart`* `0} {`*`aend`* `360}`

Action: Maps a periodic curve to a fixed angular range of *`astart`* to *`aend`*.
For angular data, you might want to reduce all data points to the first period. For example, if a full circle with 0..360° will be plotted, but datapoints with x-values higher than 360 exist, these should be mapped to the first period, that is, the y-value at x=361 will be added to the datapoint x=1.

Input: *`cname`*, name of curve
`astart`, start of the angular range; default is `0`
`aend`, end of the angular range; default is `360`

Returns: None

Example

```
cv_createFromScript a {0 1 2 90 91 92} {1 2 3 4 5 6}
cv_angularMap a 0 90
puts [cv_getVals a]
-> {0 1 2 90} {1 7 9 4}
```

cv_autoIncrStyle

`cv_autoIncrStyle {`*`stylelist`* `{color fillColor line symbol}} | off`

Action: Sets the curve attributes to be incremented by one whenever a curve is displayed using `cv_disp`. The attributes are incremented in the order given by *`stylelist`*.

Input: *`stylelist`*, list of options; default is `{color fillColor line symbol}`
`off`, switches off the automatic increment feature

Returns: None

Example

```
# First increment color. If all colors are used, increment symbol
# and start with first color again.
cv_autoIncrStyle {color symbol}
cv_disp c1
cv_disp c2
```

cv_disp

`cv_disp` *`cname`* `{`*`label`* `""} {`*`axis`* `"y"}`

Action: Displays a curve using the specified label and axis. The curve attributes are incremented by default, such that each displayed curve can be easily distinguished.
Additional control of the curve attributes is given by the following commands: `cv_autoIncrStyle`, `cv_nextColor`, `cv_nextLine`, `cv_nextSymbol`, `cv_resetColor`, `cv_resetFillColor`, `cv_resetLine`, `cv_resetStyle`, `cv_resetSymbol`.

Input: *`cname`*, name of curve
`label`, specifies the curve label to be displayed in the legend; default is the curve name
`axis`, specifies the axis to use: `y` (default) or `y2`

Controlling attributes manually makes most sense when `cv_autoIncrStyle` is switched off.

Returns: None

Example

```
cv_disp iv "simulated IV" y
```

cv_exists

`cv_exists` *`cname`*

Action: Checks whether a curve exists.

Input: *`cname`*, name of curve

Returns: `1` (the curve exists) or `0` (the curve does not exist)

Example

```
if {[cv_exists iv]} {puts "curve iv exists"}
```

cv_getGlobalExtrema

`cv_getGlobalExtrema` *`cname`* {*`type`* `max`}

Action: Returns the global maximum or minimum of a curve as a list.

Input: *`cname`*, name of curve
`type`, specifies either the global maximum (`max`) or global minimum (`min`); default is `max`

Returns: If *`type`* equals `max`: {`xmax ymax`}
If *`type`* equals `min`: {`xmin ymin`}

Example

```
set cmin [cv_getGlobalExtrema iv min]
puts "The minimum of the iv-curve is [lindex $cmin 1] and occurred at
   [lindex $cmin 0]"
```

cv_getLocalExtrema

`cv_getLocalExtrema` *`cname`* {*`type`* `max`}

Action: Returns all local maxima or minima of a curve as a list.

Input: *`cname`*, name of curve
`type`, specifies either the local maxima (`max`) or local minima (`min`); default is `max`

Returns: If *`type`* equals `max`: {{`xmax1 ymax1`} {`xmax2 ymax2`} `...`}
If *`type`* equals `min`: {{`xmin1 ymin1`} {`xmin2 ymin2`} `...`}

Example

```
set cmax [cv_getLocalExtrema iv "max"]
puts "All maxima of the iv-curve: $cmax"
```

cv_getNames

`cv_getNames`

Action: Returns all existing curve names.

Input: None

Returns: List of curve names

Example

```
puts "the following curves exist currently: [cv_getNames]"
```

cv_getRange

`cv_getRange` *`cname`*

Action: Returns the x- and y-range of a curve as a list.

Input: *`cname`*, name of curve

Returns: `{xmin,xmax,ymin,ymax}`

Example

```
puts "{xmin,xmax,ymin,ymax}: [cv_getRange iv]"
```

cv_getXmax

`cv_getXmax` *`cname`*

Action: Returns the upper boundary of the x-values of a curve.

Input: *`cname`*, name of curve

Returns: `xmax`

Example

```
puts "upper boundary of the x values of iv: [cv_getXmax iv]"
```

cv_getXmin

`cv_getXmin` *`cname`*

Action: Returns the lower boundary of the x-values of a curve.

Input: *`cname`*, name of curve

Returns: `xmin`

Example

```
puts "lower boundary of the x values of iv: [cv_getXmin iv]"
```

cv_getYmax

`cv_getYmax` *`cname`*

Action: Returns the upper boundary of the y-values of a curve.

Input: *`cname`*, name of curve

Returns: `ymax`

Example

```
puts "upper boundary of the y values of iv: [cv_getYmax iv]"
```

cv_getYmin

`cv_getYmin` *`cname`*

Action: Returns the lower boundary of the y-values of a curve.

Input: *`cname`*, name of curve

Returns: `ymin`

Example

```
puts "lower boundary of the y values of iv: [cv_getYmin iv]"
```

cv_integrate

`cv_integrate` *`formula`* {*`xstart`* {}} {*`xend`* {}} {*`mode`* {}} {*`xdigits`* {}}

Action: Performs integration of a formula, and returns the integration value.

Input: *`formula`*, formula to be integrated as it is specified for `cv_createWithFormula`
`xstart`, start of the integration interval; if not specified, the start of the curve is used
`xend`, end of the integration interval; if not specified, the end of the curve is used
`mode`, defines the integration mode:
- If not specified, it is set to {}, which performs the Inspect internal integration using `integr()`
- `sumup` sums all y-values
- `trapez` performs the integration using the trapezoidal rule

`xdigits`, when using `sumup`, the number of data points is crucial; *`xdigits`* specifies the number of digits to determine whether two x-values are identical

When the formula contains more than one curve and these curves have different sets of x-values, summation is performed over all x-values.

Returns: Integration value

Example

```
# P_t is the time-dependent power
puts "energy in the first second is: [cv_integrate P_t 0 1 trapez]"
```

cv_isVisible

`cv_isVisible` *`cname`*

Action: Checks whether a curve is displayed.

Input: *`cname`*, name of curve

Returns: `1` if curve is currently displayed; otherwise, `0`

Example

```
if {[cv_isVisible iv]} {puts "curve iv visible"}
```

cv_linFit

`cv_linFit` *`formula`* {*`xstart`* {}} {*`xend`* {}}

Action: Performs a linear fit $y = A + B \cdot x$ to a curve formula.

Input: *`formula`*, formula to be fitted, as it is specified for `cv_createWithFormula`
`xstart`, start of the fit interval
`xend`, end of the fit interval

Returns: Fit results as a list:
– (Estimate of) Intercept A
– (Estimate of) Slope B
– Standard deviation of y relative to the fit correlation coefficient R^2
– Number of degrees of freedom df
– Standard error of intercept A
– Significance level of A
– Standard error of slope B
– Significance level of B

Example

```
set res [cv_linFit "log(<cname>)"]
```

cv_linTrans

`cv_linTrans` *`cname xm`* {*`xb`* `0`} {*`ym`* `1`} {*`yb`* `0`}

Action: Scales a curve linearly, and replaces x with $xm \cdot x + xb$ and y with $ym \cdot y + yb$.

Input: *`cname`*, name of curve
`xm`, slope of the x-values
`xb`, offset of the x-values
`ym`, slope of the y-values
`yb`, offset of the y-values

Returns: None

Example

```
# Scaling an IV curve given in A over V, to mA over mV.
# In addition, the curve had a current offset of 2A, which you want to remove.

cv_linTrans iv 1e3 0 1e3 -2000
```

cv_monotonicX

`cv_monotonicX` *`cname`*

Action: Extracts the part of a curve where the x-values increase monotonically to the maximal x-value.

Input: *`cname`*, name of curve

Returns: None

Example

```
cv_createFromScript iv {0 1 2 0 2 4} {1 2 3 4 5 6}
cv_monotonicX iv
puts "values: [cv_getVals iv]"
-->values: {0 2 4} {4 5 6}
```

cv_nextColor

`cv_nextColor {`*`cindex`*` ""}`

Action: Sets the next color of the curve from the `extend::COLORPALETTE` list.

Input: *`cindex`*, if *`cindex`* is specified, the specified entry from the `extend::COLORPALETTE` list is taken; otherwise, the next entry is chosen

Controlling attributes manually makes most sense when `cv_autoIncrStyle` is switched off.

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextColor
cv_disp iv2
```

cv_nextLine

`cv_nextLine {cindex ""}`

Action: Sets the next line style of the curve from the `extend::LINEPALETTE` list.

Input: *`cindex`*, if *`cindex`* is specified, the specified entry from the `extend::LINEPALETTE` list is taken; otherwise, the next entry is chosen. If the last line style is reached, the first line style is returned again.

Controlling attributes manually makes most sense when `cv_autoIncrStyle` is switched off.

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextLine
cv_disp iv2
```

cv_nextSymbol

`cv_nextSymbol {cindex ""}`

Action: Sets the next symbol type of the curve from the `extend::SYMBOLPALETTE` list.

Input: *`cindex`*, if *`cindex`* is specified, the specified entry from the `extend::SYMBOLPALETTE` list is taken; otherwise, the next entry is chosen. If the last symbol is reached, the first symbol is returned again.

Controlling attributes manually makes most sense when `cv_autoIncrStyle` is switched off.

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextSymbol
cv_disp iv2
```

cv_resetColor

`cv_resetColor`

Action: Resets the color to the default entry that equals the first entry from the `extend::COLORPALETTE` list.

Input: None

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextColor
cv_disp iv2
cv_resetColor
cv_nextSymbol
cv_disp iv3
```

cv_resetFillColor

`cv_resetFillColor`

Action: Resets the fill color to white.

Input: None

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextColor
cv_disp iv2
cv_resetFillColor
cv_nextSymbol
cv_disp iv3
```

cv_resetLine

`cv_resetLine`

Action: Resets the line style to the default entry that equals the first entry from the `extend::LINEPALETTE` list.

Input: None

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextLine
cv_disp iv2
cv_resetLine
cv_nextSymbol
cv_disp iv3
```

cv_resetStyle

`cv_resetStyle`

Action: Resets all curve style attributes such as color, fill color, symbol, and line style to their default values.

Input: None

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextSymbol
cv_nextColor
cv_disp iv2
cv_resetStyle
cv_disp iv3
```

cv_resetSymbol

`cv_resetSymbol`

Action: Resets the symbol to the default entry that equals the first entry from the `extend::SYMBOLPALETTE` list.

Input: None

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextSymbol
cv_disp iv2
cv_resetSymbol
cv_nextColor
cv_disp iv3
```

cv_round

`cv_round` *`cname xdigits ydigits`*

Action: Rounds off the x-data and y-data values to the specified number of digits.

Input: *`cname`*, name of curve
`xdigits`, number of digits to be kept for x-values; default is `-1` (no rounding)
`ydigits`, number of digits to be kept for y-values; default is `-1` (no rounding)

Returns: None

Example

```
cv_createFromScript c {1.01 5.05} {9.09 7.07}
cv_round c 1 1
puts "[cv_getVals c]"
=> {1 5.1} {9.1 7.1}
```

cv_scale

`cv_scale` *`cname xm ym`*

Action: Scales a curve linearly, and replaces x with $xm \cdot x$ and y with $ym \cdot y$.

Input: *`cname`*, name of curve
`xm`, scale applied to x-values
`ym`, scale applied to y-values

Returns: None

Example

```
# Scales a current over time given in A over s to mA over us.
cv_scale i_t 1e6 1e3
```

cv_setFillColor

`cv_setFillColor {`*`mode`*` 1}`

Action: Switches the fill color on and off.

Input: *`mode`*, sets the fill color:
– `1` fills the symbol with the curve color; default is `1`
– `0` specifies the fill color is white

Returns: None

Example

```
cv_autoIncrStyle off
cv_setSymbol 1
cv_disp iv1
cv_nextColor
cv_setFillColor 1
cv_disp iv2
```

cv_setSymbol

`cv_setSymbol {mode 1}`

Action: Switches symbols on and off.

Input: *mode*, sets the symbol:
– `1` specifies that the symbols are shown
– `0` specifies that the symbols are not shown; default is `1`

Returns: None

Example

```
cv_autoIncrStyle off
cv_disp iv1
cv_nextColor
cv_setSymbol 1
cv_disp iv2
```

cv_sort

`cv_sort cname {xdigits 20}`

Action: Sorts data points of a curve according to x-values, and removes duplicates.

Input: *cname*, name of curve
xdigits, number of digits of x-value to determine whether two values are identical

Returns: None

Example

```
cv_createFromScript c {1 2 0.0001 3 0} {2 3 -1 4 1}
cv_sort c 3
puts "[cv_getVals c]"
==> {0 1 2 3} {1 2 3 4}
```

cv_write

`cv_write` *`type filename curveList`*

Action: Exports curve data to a file. This command works like the native `cv_write` command but, in addition, allows exporting data in CSV format, which is most suitable for transferring data to spreadsheet applications.

Input: *`type`*, type of file: `csv`, `plt`, `xgraph`, or `xmgr`
`filename`, name of file in which to export data
`curveList`, list of curves

Returns: `1` if successful, `0` otherwise

Example

```
cv_write csv export.csv "idvg cv($n)"
```

dbputs

`dbputs` *`str`* {*`dbglevel`* `1`}

Action: Debugs output, where *`str`* is displayed in the log if the debug variable `::DEBUG` is greater than or equal to the debug level.

Input: *`str`*, string to be printed to standard output
`dbglevel`, sets the debug level

Returns: None

Example

```
dbputs "test1"
set ::DEBUG 2
dbputs "test2"
dbputs "test3" 2
dbputs "test4" 3
set ::DEBUG 0
dbputs "test5"
==> test2, test3
```

ds_getValue

`ds_getValue` *`proj datasetName`* {*`index`* `end`}

Action: Returns the *`index`*-th value of a dataset.

Input: *`proj`*, project name of the loaded `.plt` file
`datasetName`, name of dataset
`index`, the index of the dataset item to return; counting starts with 0 and finishes with `end`; default is `end`

Returns: Real number

Example

```
proj_load n5_des.plt
puts "first value [ds_getValue n5_des "anode OuterVoltage" 0]"
puts "last value [ds_getValue n5_des "anode OuterVoltage"]"
```

fi_readTxtFile

`fi_readTxtFile` *`fname cname`* {*`columnIdx`* `1`}

Action: Reads in data from an ASCII file, where columns are separated by space. The x-values are taken from the first column; the column to be used for the y-values can be specified. The file can contain comment lines starting with a hash character (#).

Input: *`fname`*, name of ASCII file
`cname`, name of curve to be created
`columnIdx`, column index to be used for y-values; column-counting starts with 0; default is the second column (*`columnIdx`* = 1)

Returns: None

Example

```
fi_readTxtFile "am15g.txt" spec
```

fi_readTxtFileHeader

`fi_readTxtFileHeader` *`fname`*

Action: Reads and returns the header line – a single line that is neither data nor comment.

Input: *`fname`*, name of ASCII file

Returns: List of strings

Example

```
puts "[fi_readTxtFileHeader "am15g.txt"]"
==> Wavelength [um] Intensity [W*cm^-2]
```

gr_axis

`gr_axis` *`axis title`* `{`*`xmin`* `""} {`*`xmax`* `""} {`*`scale`* `lin}`

Action: Sets the attributes of the x-axis and y-axis.

Input: *`axis`*, specifies axis to be modified: `x`, `y`, or `y2`
`title`, axis label
`xmin`, *`xmax`*, sets the range of the axis, where { } specifies automatic scaling
`scale`, specifies the scaling to apply: `lin` (default) or `log`

Returns: None

Example

```
gr_axis x {voltage [V]}
gr_axis y {current [A]} {} {} log
```

gr_resetAxis

`gr_resetAxis`

Action: Resets all the axis attributes and, in particular, switches off the y2-axis.

Input: None

Returns: None

Example

```
gr_axis x {voltage [V]}
gr_axis y {current [A]} {} {} log
gr_resetAxis
```

gr_setStyle

`gr_setStyle` *`mode`*

Action: Sets the style of the plot area.

Input: *`mode`*, specifies the mode:
- `"screen"` (default) is used for the interactive mode
- `"presentation"` uses larger font sizes suitable for copying plots into presentations

Returns: None

Example

```
gr_setStyle "presentation"
```

ldiff

`ldiff` *`list1 list2`* `{`*`symmetric`* `""}`

Action: Returns all items of *`list1`* that are not in *`list2`*.

Input: *`list1`*, *`list2`*, lists to be compared
`symmetric`, if specified, indicates that the returned list will also contain all items of *`list2`* that are not in *`list1`*

Returns: List

Example

```
set l1 {1 2 3 4}
set l2 {1 2 5}
puts "[ldiff $l1 $l2]"
==> {3 4}
puts "[ldiff $l1 $l2 1]"
==> {3 4 5}
```

lintersect

`lintersect` *`list1 list2`*

Action: Returns all items that are members of both *`list1`* and *`list2`*.

Input: *`list1`*, *`list2`*, lists to compare

Returns: List

Example

```
set l1 {1 2 3 4}
set l2 {1 2}
puts "[lintersect $l1 $l2]"
==> {1 2}
```

ltranspose

`ltranspose` *`list`*

Action: Transposes a list.

Input: *`list`*, list to transpose

Returns: List

Example

```
set l {{1 2} {3 4} {5 6}}
puts "[ltranspose $l]"
==> {{1 3 5} {2 4 6}}
```

lunion

`lunion` *`list1 list2`*

Action: Returns a list of unique items that are members of *`list1`* or *`list2`*.

Input: *`list1`*, *`list2`*, lists to compare

Returns: List

Example

```
set l1 {1 2 3 4}
set l2 {1 2 5}
puts "[lunion $l1 $l2]"
==> {1 2 3 4 5}
```

proj_check

`proj_check` *`proj`*

Action: Checks all datasets in a project to see whether all entries are valid.

Input: *`proj`*, project name of the loaded `.plt` file

Returns: List of dataset names containing invalid data (nonnumeric values)

Example

```
proj_load n5_des.plt
proj_check n5_des
```

proj_datasetExists

`proj_datasetExists` *`proj datasetName`* `{`*`groupName`* `""}`

Action: Checks whether a project contains data with the specified dataset and group name.

Input: *`proj`*, project name of the loaded `.plt` file
`datasetName`, name of dataset
`groupName`, group name of dataset; if no group name is given and the dataset name contains a space, the first word of *`datasetName`* is taken as the group name

Returns: `1` (dataset exists) or `0` (dataset does not exist)

Example

```
proj_load n5_des.plt
if {[proj_datasetExists n5_des "anode OuterVoltage"]}
   {puts "anode OuterVoltage exists"}
if {[proj_datasetExists n5_des "OuterVoltage" "anode"]}
   {puts "anode OuterVoltage exists"}
if {[proj_datasetExists n5_des "NO_NODE time"]} {puts "time exists"}
```

proj_getGroups

`proj_getGroups` *`proj`*

Action: Returns a sorted list containing all group names of the project.

Input: *`proj`*, project name of the loaded `.plt` file

Returns: List of strings

Example

```
proj_load n5_des.plt
puts "all group names: [proj_getGroups n5_des]"
```

proj_groupExists

`proj_groupExists` *`proj groupName`*

Action: Checks whether a project contains a particular group.

Input: *`proj`*, project name of the loaded `.plt` file
`groupName`, name of group

Returns: `1` (group exists) or `0` (group does not exist)

Example

```
proj_load n5_des.plt
if {[proj_groupExists n5_des "anode"]} {puts "group anode exists"}
```

proj_loadPlx

`proj_loadPlx` *`fileName`* {*`curveName`*} {*`appendDatasetName`*}

Action: Opens a `.plx` file, and creates a curve without displaying it.

Input: *`fileName`*, name of `.plx` file from which to load data
`curveName`, name of curve; if not specified, the dataset name is used
`appendDatasetName`, if set to 1, it appends the dataset name to the curve name:
– If *`curveName`* is empty, the dataset name is used
– If a simple curve name is given, the dataset name is appended in parentheses, for example, `cname(data)`
– If the curve name contains parentheses, the dataset name is appended in the parentheses, for example, `cname(cval,data)`

Returns: None

Example

```
Content of test.plx:
"data"
0 0
1  2.8
...

proj_loadPlx test.plx
puts "visible: [cv_isVisible data]"
==> visible: 0
proj_loadPlx test.plx c(1) 1
puts "visible: [cv_isVisible c(1,data)]"
==> visible: 0
```

The PhysicalConstants Library

This library defines a set of variables of major physical constants [1].

To load the library, use the command:

```
load_library PhysicalConstants
```

Table 6 Variables defined in PhysicalConstants library

Name of variable	Value	Unit
`AtomicMassConstant`	1.660540210e-27	kg
`AvogadroConstant`	6.022136736e23	mol^{-1}
`BohrMagneton`	9.274015431e-24	J/T
`BoltzmannConstant`	1.38065812e-23	J/K
`ElectronMass`	9.109389754e-31	kg
`ElectronVolt`	1.6021773349e-19	J
`ElementaryCharge`	1.6021773349e-19	C
`FaradayConstant`	9.648530929e4	C/mol
`FineStructureConstant`	7.2973530833e-3	1
`FreeSpaceImpedance`	376.730313462	Ω
`GravitationConstant`	6.6725985e-11	$m^3/kg/s^2$
`MagneticFluxQuantum`	2.0678346161e-15	Wb
`MolarVolume`	22.4141019e-3	m^3/mol
`Permeability`	12.566370614e-7	H/m
`Permittivity`	8.854187817e-12	F/m
`Pi`	3.141592653589793	1
`PlanckConstant`	6.626075540e-34	Js
`ProtonMass`	1.672623110e-27	kg
`RydbergConstant`	1.097373153413e7	m^{-1}
`SpeedOfLight`	299792458	m/s
`StefanBoltzmannConstant`	5.6705119e-8	$W/m^2/K^4$

All variables are defined in the namespace `::const::`. To access a variable, use `$::const::<varName>` or `$const::<varName>`, where `<varName>` must be replaced by a particular variable name, for example:

```
load_library PhysicalConstants
puts "c=$const::SpeedOfLight"
```

The function `getVarNames` returns a list of all variable names, for example:

```
set varlist [const::getVarNames]
puts "all variables: $varlist"
==> all variables: AtomicMassConstant AvogadroConstant BohrMagneton ...
```

To see a list of all variables, the function `printVarNames` prints directly the names of all available variables:

```
const::printVarNames
==>
AtomicMassConstant
AvogadroConstant
BohrMagneton
...
```

IC-CAP Model Parameter Extraction Library

The commands of this library are used to export device simulation results to the Integrated Circuit Characterization and Analysis Program (IC-CAP) model extraction tool. These commands can create files that can be later imported by IC-CAP.

To load the library, use the command:

```
load_library ise2iccap
```

Exporting Data

`iccap_Write` *`fileName headerInfo data`*

Action: Exports data to a file using the IC-CAP data management file data format [2].

Input: *`fileName`*, file name
`headerInfo`, header information (see Header Information on page 107)
`data`, array of curve data (see Array Data on page 108)

Returns: None

Header Information

The header information *headerInfo* is a list formed by the sublists `userInput`, `iccapInput`, and `output`.

A detailed description of the header section is presented in the literature [2]. You can use the following examples as guides.

userInput

This sublist contains information about variables that cannot be swept in a traditional IC-CAP setup.

In the following example, no user sweeps are considered:

```
userInput: {}
```

iccapInput

This sublist contains information about variables that can be swept in an IC-CAP setup. For example:

```
iccapInput: {{vg V G GROUND {LIST 1 26 0.0...2.5}}
             {vb V D GROUND {LIN 2 -0.1 -0.5 3}}
             {vd V S GROUND {CON 0.0}}}
```

In this example, there are three IC-CAP input variables, where:

- The first element is the name of the input variable.
- The second element is the mode.
- The third and fourth elements are the names of the positive and negative nodes for the corresponding input variable.
- The fifth element is a list that describes the sweep. The first element of this list is the sweep type, which can be `LIN`, `LIST`, `CON`, `LOG`, or `SYNC`.

The sweep information for the first input variable (`vg`) is a list where:

- `LIST` indicates that all sweep values are explicitly defined.
- `1` is the sweep order (1 is the innermost or fastest varying sweep).
- `26` is the number of values.
- `0.0...2.5` indicate all values that the particular variable can take.

The sweep information for the second input variable (`vb`) is a list where:

- `LIN` indicates that the sweep values are a set of values defined in a linear scale.
- `2` is the sweep order.
- `-0.1` is the start value.
- `-0.5` is the end value.
- `3` is the number of values.

The sweep information for the third input variable (`vd`) is a list where:

- `CON` indicates that there is only one value for this variable.
- `0.0` is a constant value.

output

This sublist contains information about output variables that can be recognized in an IC-CAP setup. For example:

```
output is {{id I D GROUND}}
```

In this example, there is only one output variable, which is the drain current. The first element is the name of the output variable, the second element is the mode, and the third and fourth elements are the names of the positive and negative nodes for the corresponding output variable.

Array Data

The array data must contain, at least, the following information:

```
data(<input tuples>,<output>)
```

There is one array cell for each pair formed by a tuple of input variable values and an output variable. The `<input tuples>` order is the inverse of the sweep order.

For example, using the example in Header Information on page 107, the array data contains the following information:

```
data(<vb>,<vg>,id)
```

In this case, each cell stores the drain current (`id`) for a particular combination of substrate voltage value (`<vb>`) and gate voltage value (`<vg>`).

For example, the tuple `data(-0.1,1.0,id)` stores the drain current for `vb` = –0.1 V and `vg` = 1.0 V.

Curve Comparison Library

The commands of this library compare two curves by computing the square difference between the two curves within a given domain.

To load the library, use the command:

```
load_library curvecomp
```

cvcmp_CompareTwoCurves

`cvcmp_CompareTwoCurves` *`curve1 curve2 windowX use_log n`*

Action: Computes the square difference between two curves within a given domain (window) using either linear scale or logarithmic scale.

Input: *`curve1`*, *`curve2`*, curves to compare
`windowX`, window in the x-axis
`use_log`, `true` if logarithmic scale is used
`n`, base name for the internal curves

Returns: Square difference between two curves

cvcmp_DeltaTwoCurves

`cvcmp_DeltaTwoCurves` *`exp_file sim_file minX maxX use_log name`*

Action: Writes the square difference between two curves within a given domain (window) to the standard output. This difference can be computed using either a linear or logarithmic scale. Both curves are read from files. This command uses the `ft_scalar` command to export the computed difference to the Family Tree of Sentaurus Workbench.

Input: *`exp_file`*, *`sim_file`*, files where the two curves are stored
`minX`, *`maxX`*, window in the x-axis
`use_log`, `true` if a logarithmic scale is used
`name`, name of the column of the Family Tree of Sentaurus Workbench where the computed difference is stored

Returns: None

References

[1] G. Woan, *The Cambridge Handbook of Physics Formulas*, Cambridge: Cambridge University Press, 2000.

[2] *IC-CAP Data Management File Format Specification: Final IC-CAP 5.0 file specification*, E. Arnold and M. Peroolmal (eds.), HP-EESOP document archive, March, 1997.

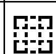
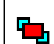
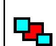
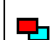
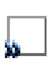
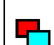
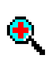
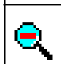
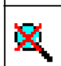
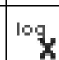
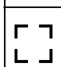
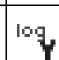
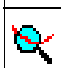
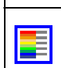
APPENDIX A Graphical User Interface

This appendix lists the toolbar buttons and menus available from the graphical user interface of Inspect.

Toolbar Buttons

The toolbar provides quick access to commonly used operations that are also available from the menus.

Table 7 Inspect toolbar buttons

Button	Description	Button	Description
	Loads a dataset file		Shows or hides the grid
	Prints the current plot		Moves selected curve to the front of all curves
	Reloads the dataset file		Moves selected curve to the back of all curves
	Applies recent plotting actions made on the previous dataset to the current dataset		Moves selected curve forward
	Removes all curves, and cleans up the plot area		Moves selected curve backward
	Zooms in to a selected area		Runs or continues executing script
	Zooms out of an area		Stops executing script
	Displays the entire plot area		Switches on or switches off logarithmic scale on the x-axis
	Centers the view in the plot area (applies to a zoomed plot only)		Switches on or switches off logarithmic scale on the left y-axis
	Zooms in to one selected curve		Switches on or switches off logarithmic scale on the right y-axis
	Shows or hides the legend text		

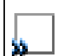
File Menu

Table 8 File menu commands

Command	**Toolbar button**	**Shortcut keys**	**Description**
Load Dataset		Ctrl+L	Opens dataset file.
Update Datasets		Ctrl+U	Reloads datasets from opened files and updates related curves.
Automatically Update Datasets			Automatically reloads datasets from opened files.
Delete Datasets			Deletes selected projects and the curves that use data from them.
Load Setup			Loads preferences stored in setup file.
Save Setup			Saves preferences to setup file.
Restore All			Loads a previously saved project from a `.sav` file.
Save All			Saves current state of Inspect to a `.sav` file.
Export			Saves current curves to different file formats.
Write Bitmap		Ctrl+W	Creates a bitmap file of plot area image in PNG format.
Write EPS			Creates an EPS file of plot area image.
Write PS			Creates a PostScript file of plot area image.
Print		Ctrl+P	Opens the Printer Setup dialog box.
Preferences			Opens the Preferences dialog box.
Exit		Ctrl+Q	Exits Inspect.

Edit Menu

Table 9 Edit menu commands

Command	**Toolbar button**	**Shortcut keys**	**Description**
Redo Last Plot		Ctrl+E	Applies the last plotting actions to selected datasets.
Plot Area		Ctrl+G	Opens the Plot Area dialog box to change attributes of plot area.
Clean Plot Area			Cleans up the plot area.
Axes		Ctrl+A	Opens the Axes dialog box to change attributes of axes.
Labels			Displays options to add, edit, and remove labels from the plot area.
Define Macros			Opens the Macro Editor.

Curve Menu

Table 10 Curve menu commands

Command	**Toolbar button**	**Shortcut keys**	**Description**
Transform			Displays the following options: **Abs X**: Maps x-value of all data points of selected curves to its absolute value and redisplays the curve. **Abs Y**: Maps y-value of all data points of selected curves to its absolute value and redisplays the curve. **Reflect X**: Reflects curve about x-axis. **Reflect Y**: Reflects curve about y-axis. **Suppress Backtrace**: Data points of a selected curve where the x values are not monotonically increasing (where the current x-value is less than the previous one) indicate the start of a new line. In this case, no line connects the previous point to the current point.
Curve Data		Ctrl+D	Opens a dialog box that shows the points of the dataset corresponding to the selected curve.
Restore Data			Undoes all changes to selected curves.

Table 10 Curve menu commands

Command	Toolbar button	Shortcut keys	Description
DeltaX (X)			Creates a deltaX curve for each selected curve. The deltaX curve is obtained by taking the x-dataset of the original curve as the x-dataset of the new curve and computing the y-dataset at every point by subtracting the x-value at the current point from the x-value at the next point.
Intersect X ?			Opens a dialog box displaying the x-coordinate at which the selected curve crosses the x-axis. If more than one curve is selected, no action is taken.
Inspector			Opens the Inspector dialog box.
Drawing Order			Opens a submenu to rearrange order of curves. Options are: **Move to Front**: Moves the selected curve to the front of all curves. **Move to Back**: Moves the selected curve to the back of all curves. **Move Forward**: Moves the selected curve one step closer to the front. **Move Backward**: Moves the selected curve one step closer to the back.

Script Menu

Table 11 Script menu commands

Command	Toolbar button	Shortcut keys	Description
Run Script		Ctrl+R	Opens a dialog box to select the script file to be run. The default filter for the script file is `*.cmd`.
Record			Creates a script file. Options are: **Start**: Opens the Record Script File dialog box for selecting the output file and starts to record a sequence of operations. **Add Pause**: Adds a sleep command to the script. The length of the pause is selected from the submenu. **Add Break**: Adds a break command to the script. **Stop**: Stops the recording.
Continue Script		Ctrl+C	When a break command is encountered in a script, the execution is suspended and user input is possible. This option reactivates the execution of the script.
Abort Script		Ctrl+N	When script execution is suspended by a break command, this command omits the remaining part of the script.

Extensions Menu

Table 12 Extensions menu command

Command	Toolbar button	Shortcut keys	Description
Two-Port Networks		Ctrl+T	Opens the RF Parameter Extraction dialog box.

Help Menu

Table 13 Help menu command

Command	Toolbar button	Shortcut keys	Description
About		Ctrl+B	Provides version information.

APPENDIX B Limitations in Inspect

This appendix describes known limitations that affect working with Inspect.

The diff(…formula…) and integr(…formula…) Operators

The `diff()` and `integr()` operators require a *curve only* argument, which can be defined as a curve that contains more than one point, since a curve that contains only one point is treated as a scalar. When a formula is used as an argument for these operators, the parser cannot always decide if the argument curve for the `diff()` or `integr()` operators will have more than one point. Therefore, an error message is generated.

For example, to obtain proper results, `diff(log10(...formula...))` must be performed in two steps:

1. Create the curve `log10(...formula...)`.
2. Apply the `diff()` operator to the resulting curve.

The vecvalx(…formula…) and vecvaly(…formula…) Operators

It is advisable to compute the curve defined by `...formula...` before applying the `vecvalx()` or `vecvaly()` operators. In addition, if the curve displays exponential behavior, better results are obtained if the curve is transformed to logarithmic scale before applying these operators.

For example, suppose you want to compute the value:

```
vecvalx(diff(<c1>), 1e-7)
```

and the curve defined by `diff(<c1>)` has an exponential behavior. In this case, to obtain more precise results, create a curve `<c2>`, which will be equal to `log(diff(<c1>))`, and then compute the required value:

```
vecvalx(<c2>, log(1e-7))
```

No Support for Right Y-Axes

The Inspector dialog box works only for the x-axis and left y-axis.