SIEMENS EDA

Calibre® SMO RET Selection User's and Reference Manual

Software Version 2021.2

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Chapter 1
Introduction to Calibre SMO Using RET Selection

The Calibre® source-mask optimization (SMO) solution extends existing processes with next-generation computation lithography that enhances the imaging capability of lithographic systems used in the manufacturing of integrated circuits.

The Calibre SMO solution has two parts: the Calibre® pxSMO™ engine to perform the optimization, and the RET Selection interface to make it easy to configure, run, and choose the best source.

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Syntax Conventions

The command descriptions use font properties and several metacharacters to document the command syntax.

Table 1-1. Syntax Conventions

Convention	Description
Bold	Bold fonts indicate a required item.
Italic	Italic fonts indicate a user-supplied argument.
`Monospace`	Monospace fonts indicate a shell command, line of code, or URL. A bold monospace font identifies text you enter.
Underline	Underlining indicates either the default argument or the default value of an argument.
UPPercase	For certain case-insensitive commands, uppercase indicates the minimum keyword characters. In most cases, you may omit the lowercase letters and abbreviate the keyword.
[ ]	Brackets enclose optional arguments. Do not include the brackets when entering the command unless they are quoted.
{ }	Braces enclose arguments to show grouping. Do not include the braces when entering the command unless they are quoted.
‘ ’	Quotes enclose metacharacters that are to be entered literally. Do not include single quotes when entering braces or brackets in a command.
| or ||	Vertical bars indicate a choice between items. Do not include the bars when entering the command.
…	Three dots (an ellipsis) follows an argument or group of arguments that may appear more than once. Do not include the ellipsis when entering the command.
Example: **DEVice** {*element_name* [‘(’*model_name*‘)’]} ***device_layer*** {***pin_layer*** [‘(’*pin_name*‘)’] …} [‘<’*auxiliary_layer*‘>’ …] [‘(’*swap_list*‘)’ …] [BY NET | BY SHAPE]	

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Calibre SMO Overview

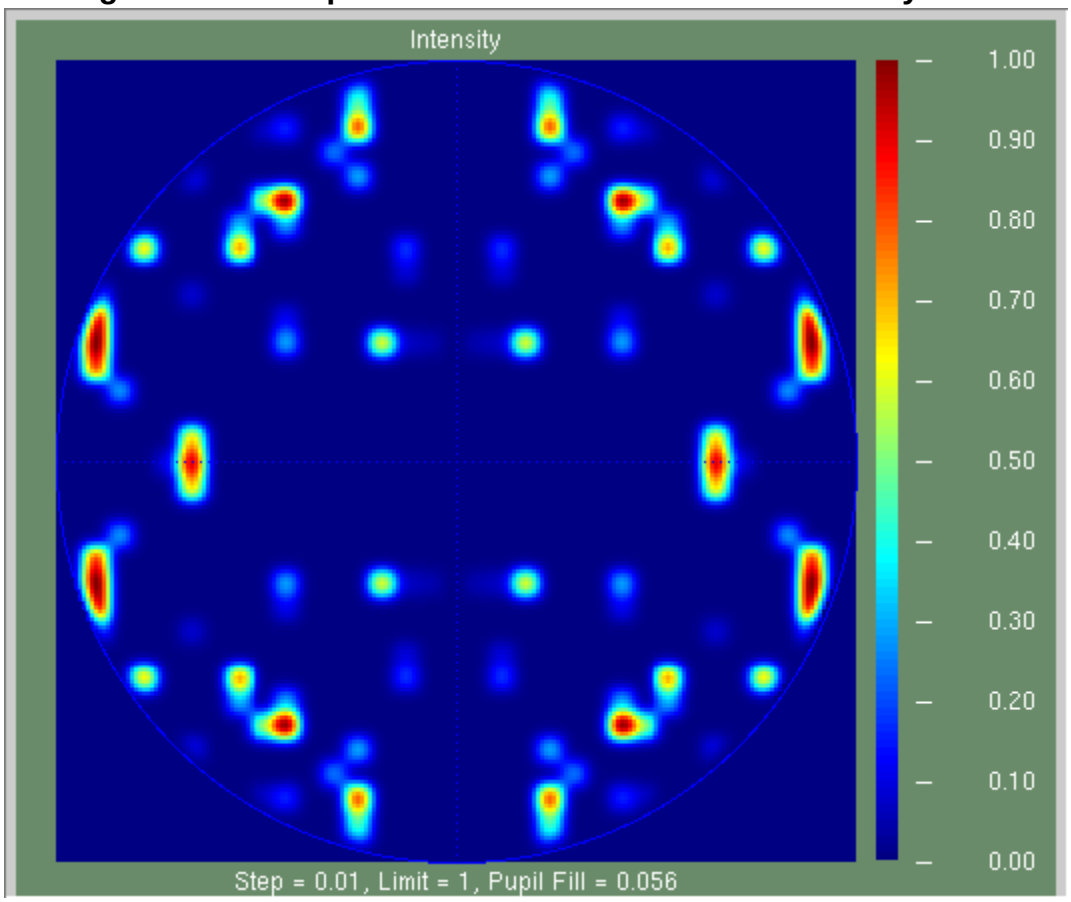
Source-Mask optimization accomplishes simultaneous source and mask optimization for each design. Optimization maximizes the imaging process window. To that end, the Calibre SMO solution leverages emerging flexibility of scanners to deliver pixelated illumination and adjusts optical properties for each individual illumination pixel.

The two parts of SMO work together to achieve this.

- **RET Selection** integrates the point tools you would otherwise need to individually set up and run. It provides application-level integration, error checking, and preconfigured best practices. It also makes it easy to compare results across experiments.
- **Calibre pxSMO** optimizes the source. It uses unconstrained solvers to produce the best possible combination of source and mask for a particular layout. The optimization is guided by a mix of objectives, grouped into jobs. It outputs thin mask or DDM optical models, depending on the style of input model.

SMO produces an optimum illumination source that can be more complicated than traditional source designs (Figure 1-1).

Figure 1-1. Example of Illumination Source Produced by SMO



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Calibre SMO Workflow

The Calibre SMO solution is integrated with the Calibre® WORKbench™ engine. It produces both a manufacturable mask and an optimized source. Generally process engineers run SMO early in the process setup phase to define the achievable technology possibilities.

Using the RET Selection window, accessed from within the Calibre WORKbench GUI, you can quickly set up an entire suite of experiments and compare the results. Each experiment uses the parameters you configure to do the following:

1. Runs Calibre® pxSMO™ to optimize the source.
2. Runs Calibre® pxOPC™ to optimize the mask with the source.
3. Runs Calibre® OPCverify™ to check final results.

After the experiments complete, you can view the source and analyze the results within the RET Selection window.

This manual only covers the Calibre pxSMO and RET Selection interfaces.

Related Topics

Calibre pxOPC Users and Reference Manual

Calibre OPCverify Users and Reference Manual

Calibre SMO Prerequisites

Before starting Calibre pxSMO and the RET Selection tool, you need to have certain required files and licenses.

The following items are required in order to run Calibre pxSMO:

- **Calibre pxSMO and Calibre WORKbench Licenses** — For more information on licensing, refer to the *Calibre Administrator's Guide*. You do not need separate licenses for Calibre pxOPC, Calibre nmOPC, or Calibre OPCverify, even though they are called by the RET Selection runs.
- **Layout** — A design file containing clips (portions of layout) that are challenging to manufacture using existing processes. The clips should be separated by approximately the clip width.
- **Gauge File** — A file in the *.gg* or *.sgd* format containing gauge objects. The gauges must be specific to the layout file as they contain coordinates. Refer to "Gauge Object Reference" in the *Calibre WORKbench User's and Reference Manual* for different techniques for creating a gauge file.

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- **Models** — A litho model containing the typical models used for OPC. These include an optical model that will be used as the starting point for optimization and a CM1 resist model. The litho model may also contain other models such as DDM.

  The litho model only needs to have the nominal defocus condition. Other focus conditions are built as needed from the process window conditions.

- **Process Window Conditions** — Details on which process window conditions are relevant. As the best solution is dependent on which conditions are common and what measures are most important, you must have decided what you are trying to optimize before beginning.

The following items are also recommended, but not required:

- **Configuration File for Distributed Processing** — Calibre WORKbench performs distributed processing using the -remotefile switch. See "Distributed Processing in Calibre WORKbench" in the *Calibre WORKbench User's and Reference Manual* for details.

- **Memory** — If you are using distributed processing, the hardware should have at least 20 GB for the primary CPU, and at least 4 GB for each remote. If the SMO setup includes more than three process window conditions, more memory will improve performance.

Opening the RET Selection Interface

The RET Selection interface is available in the standard Calibre WORKbench menus.

The RET Selection interface as well as Calibre pxSMO can also be run without a GUI (batch mode). It requires saved configurations, so is not covered in the introductory material.

Video

Training video is available on Support Center in KB article MG599114.

Prerequisites

- The CALIBRE_HOME environment variable must be set. See "Setting the CALIBRE_HOME Environment Variable" in the *Calibre Administrator's Guide* for details.

- Your PATH environment variable includes $CALIBRE_HOME/bin.

Procedure

1. In a Linux® shell, enter the following command to invoke Calibre WORKbench:

```
calibrewb
```


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2. In the Calibre WORKbench main window, choose **Litho** > **RET Selection**. This opens the RET Selection window.

Related Topics

RET Selection GUI Reference

Setting Up and Running

Key Concepts

You need to be familiar with some organizing principles in order to use Calibre pxSMO and the RET Selection interface efficiently.

Object Hierarchy

To enable reuse of setups between experiments, all items (for example, layouts, gauge files, and optimized sources) are stored in a database. While the individual objects are the same as used in the rest of Calibre WORKbench, the database organizes them hierarchically.

- **Layout/Gauge Pair** — This is the top level. It is formed by the layout and gauge specified when you start. When you change the layout or gauge file, it starts a new set of data. Note that you can change which gauges are used without starting a new layout/gauge pair.
- **Sessions** — A layout/gauge pair contains multiple sessions. A session is a specific set of models, active gauges, and process window conditions that constitute a single experiment. A single session typically includes Calibre pxSMO, Calibre pxOPC, and Calibre OPCverify. The sessions within a layout/gauge pair may differ in tool settings, active gauges, or even models.
- **Runs** — Within a session, each point tool constitutes a run. This is the same as in batch runs of the Calibre OPC tools.

Active Session

In the RET Selection window you can have multiple sessions and even layout/gauge pairs, but only one layout/gauge pair and session are active at a time. This may not be the same as the one being displayed.

The active session is the session that receives any changes you make to gauges, process window conditions, setup files, and so on. If you are editing these, the title of the various areas will indicate the session that is being edited. If you use the command window, however, there is no indicator.

Another detail to keep in mind is that if you make changes to a session after it has started executing, those changes are picked up by the tool. For example, if Run Control shows the

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active session is executing SMO and you change the process window conditions, the OPC and Verify runs will not use the same process window condition settings as SMO.

Optimal Results

Because source-mask optimization is a tool used to develop manufacturing processes, there is no single definition of "best results", or even "good enough results." There are more trade-offs than just accuracy versus run time. You might choose to emphasize process window or mask complexity, or the print quality of dense arrays more than the uniformity of via clusters. Because of this, it is important that *you* decide what factors are most important to optimize for.

The SMO solution can be set up to report many metrics, and provides tools to compare across experiments. Before you begin analysis, you must decide what are the limits of "acceptable" and also the relative importance of different factors.

In general, Calibre pxSMO works to minimize process variation (PV bands). It attempts to minimize the edge placement error (EPE) of all target shapes at all process window conditions.

Session Mode

For a session, a mode can be selected that enables full source-mask co-optimization or optimization of the mask for a batch of source shapes. After a session has been run, its mode can be changed.

- **Free-Form pxSMO** — This session mode performs a co-optimization of both source and mask. Free-Form pxSMO outputs the co-optimized source shape and mask with results for evaluation criteria. When Free-Form pxSMO is selected as the session mode, **pxSMO** is displayed in the Setup items tree.
- **Parametric Explorer** — This session mode performs a mask-only optimization for a batch of selected source shapes, outputs the optimized masks, and reports results for each tested source. When Parametric Explorer is selected as the session mode, **Parametric Explorer** is displayed in the Setup items tree.

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Chapter 2
Setting Up and Running

Calibre pxSMO source-map optimization is most easily set up using the RET Selection interface. It prompts you for required settings and makes it easy to select critical areas.

Open the RET Selection window through the Calibre WORKbench menu **Litho > RET Selection**.

Calibre pxSMO can also be run without the RET Selection interface. This is referred to as batch mode. It can be useful when you have a large number of variations to run. Results can be retrieved for later analysis using the RET Selection tools. Batch mode still requires the Calibre WORKbench engine for processing.

Video

Training videos are available on Support Center in KB article MG599114.

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Setting Up Common Elements

The RET Selection interface automates communication between the point tools you use in an optimization run. This means the first step is to define the parts shared by the tools: layout, gauges, and models.

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Restrictions and Limitations

- For models, only litho models are supported. If you have traditional models (separate resist, optical, and so on), see "Lithomodel Creation Wizard User's Guide" in the *Calibre WORKbench User's and Reference Manual* for instructions on turning your traditional models into a litho model.

  For DDM models specifically, only universal DDM models are supported. The run exits with an error if you provide DDM models with "modeltype ready" or fewer than 126 signals. See "3D Mask Modeling With DDM and HHA" in the *Calibre WORKbench User's and Reference Manual* for instructions on creating a universal DDM model.

- For gauges, only gauge data object files (*.gg*) and super gauge files (*.sgd*) are supported. Specifically, you cannot use drawn gauges, sample spreadsheet files (*.ss*), or super spreadsheet files (*.sss*). If your gauges are not in gauge data object format, see "Methods for Creation of Gauge Data Objects" in the *Calibre WORKbench User's and Reference Manual*.

Prerequisites

- A layout in GDS or OASIS®[1] format with test patterns laid out with space between.
- A gauge file (*.gg* or *.sgd*) that is based on the shapes in the layout file.
- A litho model containing at a minimum a resist model and an initial optical model. It may also contain DDM, VEB, and other advanced process models.

Video

The video series "How to Use CDOF and EL/ILS Optimization" describes and demonstrates the main functionality and key workflow steps for using CDOF or EL optimization in a Free-Form pxSMO session.

- The "Overview" video describes the main functionality and key workflow steps for using CDOF or EL optimization.

1. OASIS® is a registered trademark of Thomas Grebinski and licensed for use to SEMI®, San Jose. SEMI® is a registered trademark of Semiconductor Equipment and Materials International.

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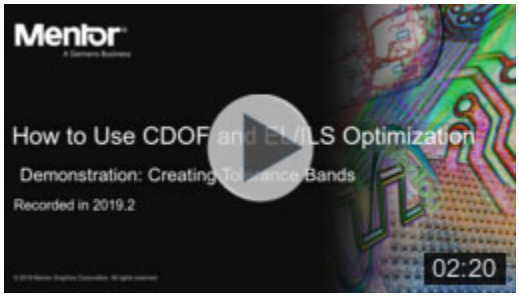
- The “Demonstration: Creating Tolerance Bands” video demonstrates the creation and mapping of tolerance bands in the Layout/Gauge Pair step.



Procedure

1. In the RET Selection window, select **File** > **Create Layout & Gauge Pair**.

   The Layout and Gauge Pair Loader wizard opens.

2. In the Layout and Gauge Pair Loader wizard, add the layout file and the gauge file.

   Click the **+** button to open the Layout File and Gauges File Selector. Use the browse button (**…**) to open a file. Click **OK**, then **Next**.

   To add multiple layout and gauge pairs, the following additional steps are required:

   a. Specify the input layers from each layout.

   b. Specify the names of the merged layout and gauge files.

   c. Specify the starting layer number of the merged layout.

3. Select Lithomodel and click **Next**. Browse or enter the path to the litho model and click **Next** again. You may see a message displayed while the information is read.

   If you select Setup File instead of Lithomodel, you will need a RET Selection setup file. It is described in “Setup File Format for RET Selection” on page 264.

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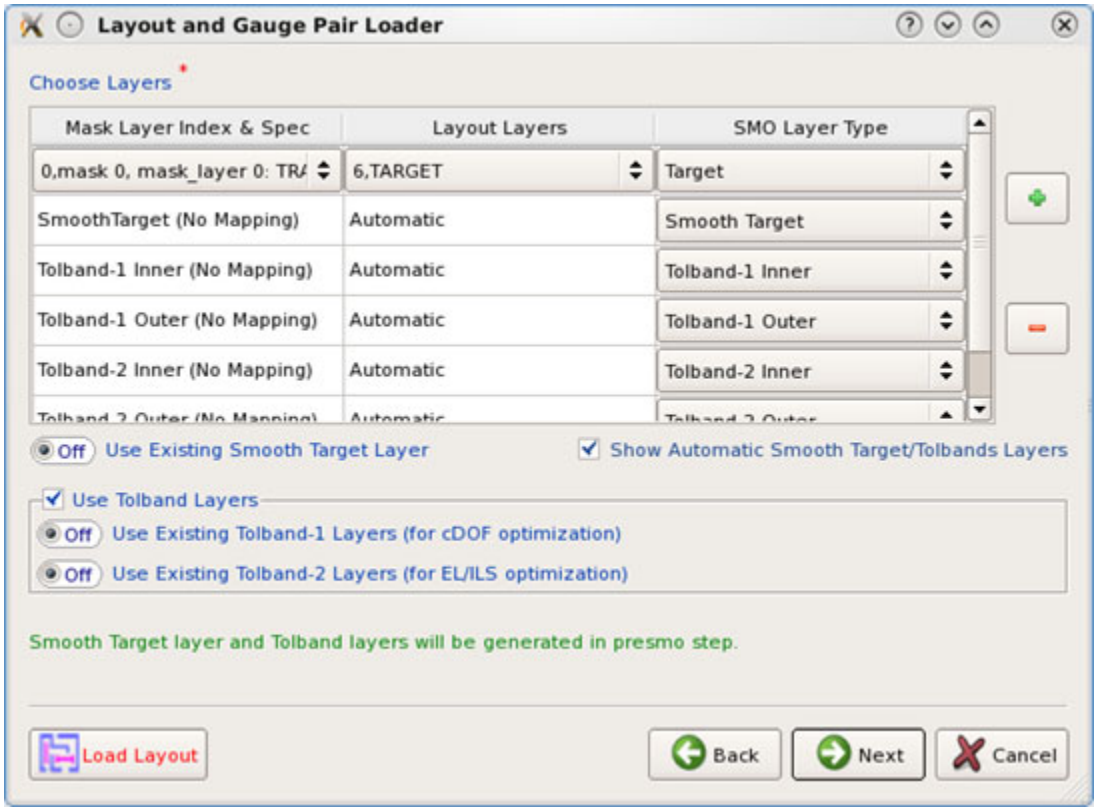
4. Map the mask layers to the layout layers and specify a type.



The fields expand to a list of choices when clicked.

a. Specify the layout layer that corresponds to the litho model's target layer by selecting the layout layer with the ideal shapes and set the SMO Layer Type to Target.

b. (Optional) Specify an existing smoothed target.

   i. Click + and select Smooth Target for the SMO Layer Type.

   ii. Set Use Existing Smooth Target Layer to On, and map an existing layer under Layout Layers.

c. (Optional) When running CDOF or EL/ILS optimization with existing tolerance bands, add the number of tolerance required by the optimization.

Note

Tolband layers and weight layers are mutually exclusive in the pxSMO step. Weight layers are unavailable for CDOF and EL/ILS optimization.

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Add the number of tolerance bands (tolbands) required for the optimization type:

- When running CDOF optimization, add one pair of inner and outer tolerance band layers. Click + two times and select Tolband-1 Inner and Tolband-1 Outer for the SMO Layer Type.
- When running EL/ILS optimization, add two pairs of inner and outer tolerance band layers. Click + four times and select Tolband-1 Inner, Tolband-1 Outer, Tolband-2 Inner, and Tolband-2 Outer for the SMO Layer Type.

Select Use Tolband Layers. Activate a Use Existing Tolband Layer option and map the corresponding layers in Layout Layers.

d. (Optional) Specify a marker layer to emphasize some sections of the layout over others.

   Before mapping a marker layer, the marker layer must already exist in the layout file. To add a marker layer, click + and select **Marker** for the SMO Layer Type. Select the marker layer in the layout file for the layout layer.

e. (Optional) Specify a correction layer if anchoring to a gauge.

   Before mapping a correction layer, the correction layer must already exist in the layout file. To add a correction layer, click + and select **Correction** for the SMO Layer Type. Select the correction layer in the layout file for the layout layer.

f. (Optional) Specify a weight layer to emphasize some sections of the layout over others.

   Before mapping a weight layer, the weight layer must already exist in the layout file. To add a weight layer, click + and select **Weight** for the SMO Layer Type. Select the weight layer in the layout file for the layout layer.

g. When all layers are mapped, click **Next**.

5. Specify a name for the RET Selection setup file. The file is written to the working directory unless you browse to a different one. Click **Next**.

Note

The setup file settings can be reused in a future run by selecting a setup file instead of a Lithomodel in Step 3. Calibre file browsers filter for *.in* files when loading setup files. However, the Layout and Gauge Pair Loader does not automatically add the *.in* suffix.

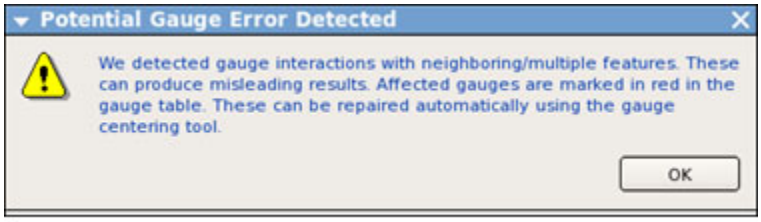
6. Review the list of settings that the Layout and Gauge Pair Loader displays, and click **OK** if you do not want to make any changes.

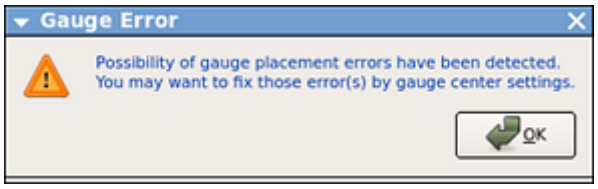
Tip

You can name the layout and session at this stage to more easily identify them later.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

The RET Selection window checks the inputs while creating the new Layout/Gauge pair. If it detects problems, you may get a message like the ones shown.





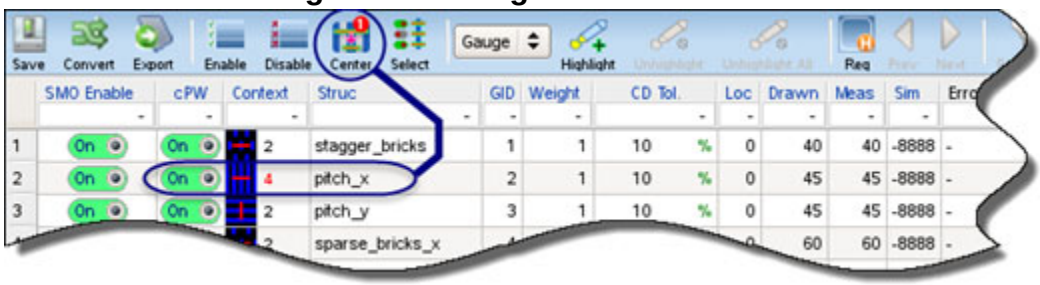
The Calibre WORKbench and RET Selection windows update to show the gauge set and layout you specified.

7. If you were shown a message about gauge errors, you can often correct them in the Gauge Analysis pane.

   a. If you are viewing the Session Browser, click **Gauges** to switch to the Gauge Analysis pane.

      - If the gauge placement and type (loc column in the gauge file) are inconsistent, a message is shown in the ErrorInfo column for the gauge. In this case, you must edit the gauge file to fix the error and then restart this procedure. A layout/gauge pair cannot reload a gauge file once the layout/gauge pair is in the database.
      - If there are gauges with red numbers in the Context column, Calibre has detected that they are interacting with multiple features in the layout.

Figure 2-1. Gauge Context Errors



   b. Hover over the small image next to the number to see a larger image.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

c. Click the **Center** button in the Gauge Analysis toolbar to open the Gauges Center Setup dialog box.

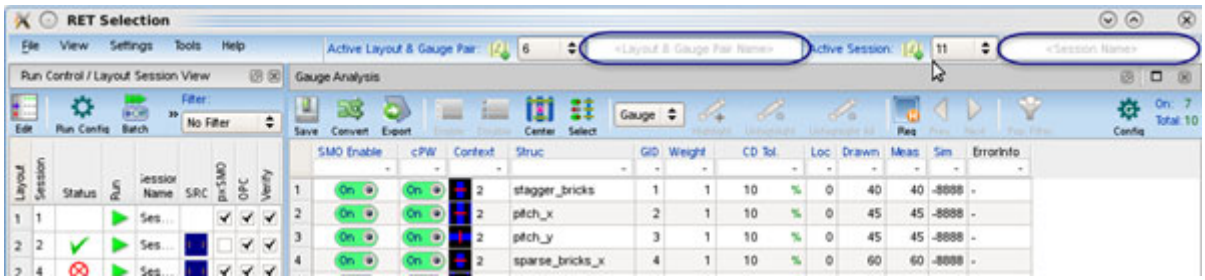
d. To fix gauges that are slightly interacting with nearby features, in the **Guard Bands** tab unselect Use Default. Reduce the Length and Width values and then click **Apply**.

e. To fix gauges that are too long or not centered on their edges, in the **Gauges Center** tab adjust the Factor if necessary and click **Apply**.

f. Dismiss the dialog box by clicking **OK**.

If some of the gauges still show an error, you may need to adjust the gauge file with an ASCII editor or by creating new gauges in the layout. A layout/gauge pair cannot reload a gauge file once the layout/gauge pair is in the database; you will need to restart this procedure with the improved gauge file.

8. In the RET Selection window, name your layout/gauge pair and session. This step is not required but is recommended so that later, when you have many layout/gauge pairs, it will aid recall.



9. In the Run Control/Layout Session View on the left, click in the row with the green arrow. This selects the session, and populates the **Session Browser** tab.

Results

The RET Selection window displays at least one layout/gauge pair and one session. The Calibre WORKbench main area shows the layout you loaded. No tools have been configured yet.

If you are satisfied with your setup, continue to "Define a Session."

Related Topics

RET Selection GUI Reference

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Define a Session

A session is a particular combination of gauges, models, and point-tool configurations. After loading the layouts and gauges, you need to define the tool configurations of your sessions before you can run.

Controlling Optimization With Gauges 26
Defining Process Window Conditions 30
Anchoring to a Gauge 32
Setting Up the Point Tools 33
Setting Up the nmOPC Engine 42
Setting Up a Custom OPC Flow 44
Setting Up the Point Tools for Parametric Explorer 45

Controlling Optimization With Gauges

Although you are required to use a single gauge file for all sessions within a layout/gauge pair, you do not have to run the same gauges for all sessions. You can selectively enable and weight gauges for different SMO runs.

Restrictions and Limitations

- Disabled gauges are still used for the OPC and Verify runs. Enabling and disabling gauges only affects the pxSMO portion of a session.
- Do not change gauges on a running or queued session.
- Changes in the Gauge Analysis pane affect the active session, which might not be the currently selected session.

Prerequisites

- The RET Selection window has a layout/gauge pair loaded.
- The session has not yet been run.

Video

The video series “How to Use Gauge Selection” describes and demonstrates the main functionality and key workflow steps for using the Gauge Selection tool.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

- The “Overview” video describes the main functionality and benefits of the Gauge Selection tool.

- The “Demonstration” video demonstrates the setup, run, and results review for the Gauge Selection tool.

Procedure

1. Display the Gauge Analysis pane.

   If you do not see the Gauge Analysis pane, check the bottom of the Session Browser for tabs. In the default layout, the Gauge Analysis and Session Browser panes share the same area.

2. To see which clip a gauge is associated with:

   a. Select the gauge row.

   b. Click the **Highlight** button in the Gauges toolbar.

   c. In the Calibre WORKbench window, look for the clip with a marker in the center.

   Tip
   To quickly view the clip, click on the thumbnail image and toggle the zoom level.

3. Before making any changes to gauge settings, verify the session you intend the changes for is active.

   The active session is shown at the top of the RET Selection window on the right, and if it has a name, the Run Control/Layout Session View window shows it in a heavier font.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

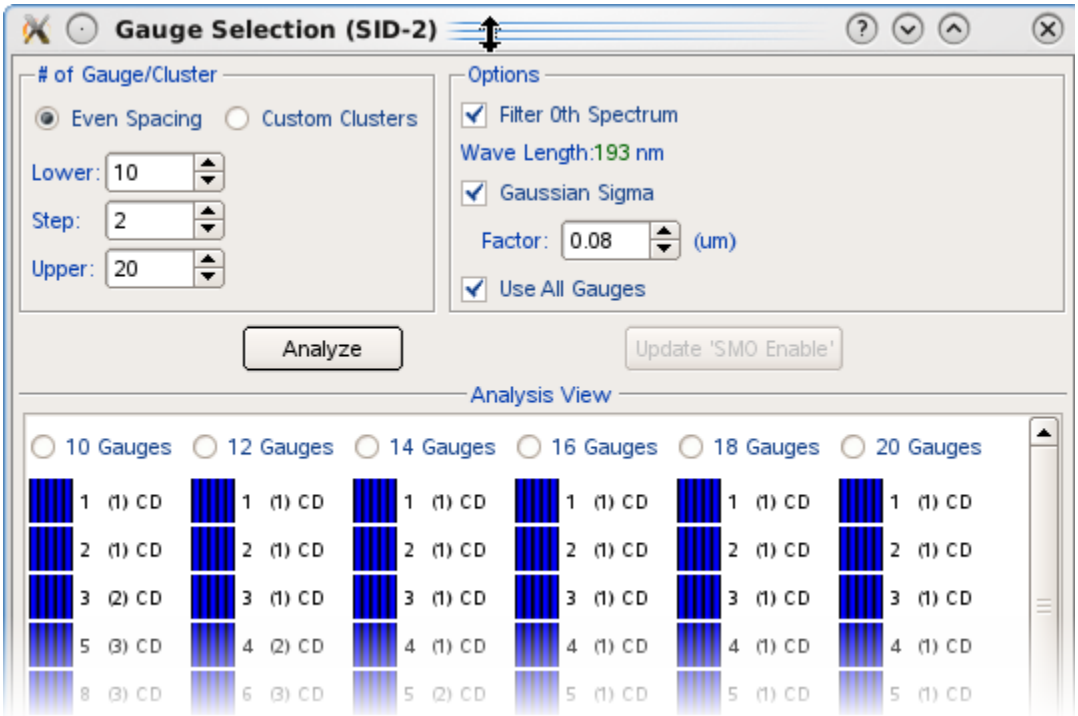
If the session you want to modify is not active, use the Active Session dropdown list to make it active.

4. To use only a subset of gauges for the SMO run, gauges can be selected automatically using Gauge Selection or manually.

   - To select gauges using Gauge Selection:

     i. Open the Gauge Selection tool by clicking the **Select** button in the Gauge Analysis pane.

     ii. Specify the number of representative gauges using a range and step size by selecting **Even Spacing** or using specific numbers by selecting **Custom Clusters**.



     iii. To run Gauge Selection on all available gauges, leave the Use All Gauges box checked. To run Gauge Selection on specific gauges, uncheck the Use All Gauges box and disable undesired gauges in the SMO Enable column.

     iv. Typically, the default settings for Filter 0th Spectrum and Gaussian Sigma are sufficient.

     v. Click the **Analyze** button and results appear in the Analysis View pane.

     vi. To apply the Gauge Selection results, choose the number of gauges in the Analysis View pane and click the **Update 'SMO Enable'** button. The SMO Enable column updates with the representative gauges selected.

       - Gauge Selection classifies each cluster of gauges as CD, Space, or Mixed (that

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

is, a mixture of lines and spaces). It is recommended to avoid numbers of gauges with mixed clusters of gauges.

- To manually select gauges:
  - Select the rows to turn on or off using Shift-click or Ctrl-click, then click **Enable** or **Disable**.
  - Use the **On/Off** button in the SMO Enable column.
  - Right-click and select **Disable SMO** or **Enable SMO**.

    By default, a new session uses gauges selected in the Gauge Analysis Pane for SMO. If you customize clips using the Clips and Gauges Editor, SMO ignores SMO Enable settings and applies the customized clips settings.

Tip

In many cases, an optimized source can be created using fewer than 20 gauges. Using additional gauges may produce a similar source while increasing run time.

5. To change the weight of the gauges, right-click and select **Set Weight**. The clip weights are applied during pxSMO stages but not during OPC stages.

   Tip

   Gauges may also be weighted using weight layers in the layout and setup file, or weighted for individual jobs in the GUI. The layer weights in OPC stages are applied the same as in pxSMO.

   Starting from the 2019.1 release, weight layers and gauge weights are unavailable when job type CDOF or EL is specified.

   If you increase the weighting of a gauge, that weight is set across the entire clip. The objective for that clip is calculated and then multiplied by the gauge's weight. Setting this weight therefore emphasizes the value of the entire clip. Weight layers emphasize only the portion of the clip that they cover. When both the gauge weight and the weight layer are set, the gauge weight is applied using the weight layer coverage.

6. To change the CD tolerance of the gauges, right-click and select **Set CD Tolerance**.

   The CD tolerance is used in calculating the common process window. By default, the tolerance is 10%, but each gauge can be set individually. CD tolerances can be expressed as a percentage, an absolute value in nanometers, or a range.

7. To further customize clips and gauges, click the **Clips** button to open the Clips and Gauges Editor.

   Customize clips using pattern symmetry and periodicity, or create custom gauges.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Related Topics

Cloning Sessions and Running Efficiently

Defining Process Window Conditions

A benefit of the RET Selection interface is that you only need to define the process window conditions once. After they are set up in the session browser you can add or remove them from the tool setups with the click of a mouse.

There should be at least five process window conditions:

- Nominal
- Overexposed
- Underexposed
- Overexposed, with roughly 1-2% more dose than the standard overexposed
- Underexposed, with roughly 1-2% less dose and 10% more defocus than the standard underexposed

The more aggressive process conditions are used for Calibre pxSMO, Calibre pxOPC, and Calibre nmOPC.

You can use more process window conditions than these five. The goal is to describe the conditions that cause the most variation in your equipment's wafer printing. The underexposed and overexposed should represent the two extremes. In simulation, the two extremes are the inner and outer contours that combined form a process variation band (PV band).

Note

More information is available on Support Center in KB article MG598348 "pxSMO Best Practice: PW Condition Selection."

To import process window conditions (and other settings) from an existing session, refer to "Migrating Session Settings to a New Layout/Gauge Pair" on page 52.

Prerequisites

- A layout/gauge pair and session.
- Values for minimum and maximum dose and defocus.
- Values for focus-dose pairs within the dose and defocus ranges. The number of pairs must meet the polynomial convergence criteria.
- Whether mask biasing needs to be accounted for.

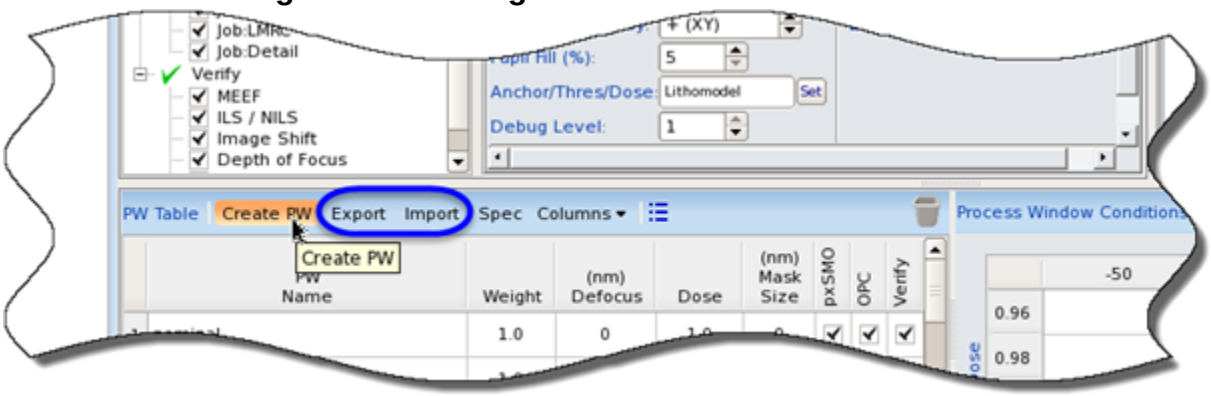
Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Procedure

1. If the Session Browser is not already visible, click the **Session Browser** tab.
2. Verify the Name area at the top of the Session Browser area shows the session you intend to configure. If necessary, select the session from the list in Run Control.
3. To add a process window condition, click the **Create PW** button at the top of the PW Table area.

   A second row appears in the table with default values.

Figure 2-2. Adding a Process Window Condition



Tip

You can also reuse PW tables with **Import** or **Export** as shown in the previous figure. The tables are saved in comma-separated value (*.csv*) format.

4. Fill in the values by clicking in the table cell and entering appropriate values for your process.
   - At least one process window condition should be named “nominal.”
   - Weight is a unitless, relative value. The default is 1. Give a higher value such as 50 to place more importance on optimizing for that condition. Note that having all conditions at 50 is the same as having all conditions at 1.
   - Defocus depends on the expectations for DOF of the layer. A reasonable starting value is typically ±50 nm.
   - Mask size refers to mask biasing and is in nanometers. Negative values mean the OPC mask edge is moved toward the interior of the feature.
   - pxSMO, OPC, and Verify make the process window conditions available in the respective setups. The nominal condition should have all three setups selected.
   - (Optional) If using a 3D optical model, image plane refers to the z-plane location inside the resist film to use for aerial image simulation.

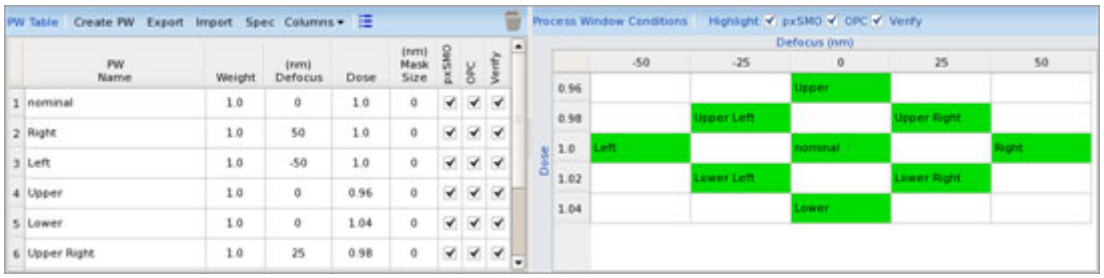
   Use the Process Window Conditions matrix to visualize the coverage.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

5. (Optional) If adding optical aberrations, click **Spec** to create optical specifications with Zernike coefficients.
6. (Optional) To change the image plane interpolation, click the **PW Option** icon and select **Image Plane Interpolation** to choose a new option.

Results

When you are done, you should have a table that looks something like this:



Related Topics

Process Window Best Practices

PW Table Pane

Setting Up the Point Tools

Anchoring to a Gauge

You can anchor the litho model threshold to a gauge that is critical to the design.

Anchoring adjusts the threshold used by the litho model to make a specified anchor gauge print on target for a specified bias. The bias is a uniform sizing applied to all target edges of the clip to produce a mask layer for simulation. Anchoring is available in both the Free-Form pxSMO and Parametric Explorer session modes.

Anchoring can be activated before, during, and after the SMO step. The Pre-SMO step performs anchoring and sets the threshold used during SMO. The Post-SMO anchoring step performs an anchoring refinement after the SMO step. Anchoring during the SMO step uses a dynamic anchoring process. During each pxSMO iteration, anchoring checks the print quality of the anchor gauge and adjusts the litho model threshold. This improves the robustness and consistency of the optimization.

Prerequisites

- A layout/gauge pair and session.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Procedure

1. In the Setup Items tree, select pxSMO. In the pxSMO Setup pane, click the **Set** button next to Anchor/Thres/Dose.
2. In the Anchor/Threshold/Dose Settings Dialog Box, select the stage to apply anchoring and an anchoring method.
3. If anchoring on a selected gauge, select an anchor gauge from the pulldown menu.
4. To apply CD bias to the anchor feature, activate **Bias** and specify either an absolute or relative mask feature size.

   Note

   The mask feature sizing is applied to the feature; half of the relative mask feature sizing is applied to each edge.

   To specify the type and size range of features to apply CD bias, fill out the Bias Config table.
5. To use focus centering when anchoring a Pre-SMO or Post-SMO stage, choose either the manual or automated option.
   - Choose **MANUAL (relative)** to specify a value for focus center.
   - Choose **Perform Focus Centering** to automate focus centering. It is recommended to manually select focus-sensitive gauges for the centering analysis.

     To adjust the beam focus and defocus start using the target CD, activate and set the **Defocus Start Adjustment**. To adjust the parabola fitting for focus centering, adjust the maximum defocus value and the number of points used for fitting.
6. (Optional) You may deactivate using the anchor clip in OPC and Verify by unchecking **OPC**. The default behavior is to use the anchor clip in the OPC and Verify stages.
7. Click **Set** to accept the settings and close the dialog box.

Results

When you are done, the Anchor/Thres/Dose setting displays the current settings in the pxSMO Setup pane.

Setting Up the Point Tools

The RET Selection GUI shows you which parts of your session have valid configurations. You can set up a basic run with just a few clicks, or customize nearly every aspect. The Session Browser pane is located to the right of the Run Control/Layout Session View pane in the default layout when you have a session selected.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Prerequisites

- A layout/gauge pair and session.
- A populated PW Table. See “Defining Process Window Conditions”.

Video

The video series “How to Use CDOF and EL/ILS Optimization” describes and demonstrates the main functionality and key workflow steps for using CDOF or EL optimization in a Free-Form pxSMO session.

- The “Demonstration: Constructing Tolerance Bands” video demonstrates the sizing, construction, and copying of tolerance bands in the Pre-SMO step.

- The “Demonstration: Setting Up CDOF Optimization” video demonstrates how to set up the CDOF job in the pxSMO step.

- The “Demonstration: Setting Up EL Optimization” video demonstrates how to set up the EL job in the pxSMO step.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

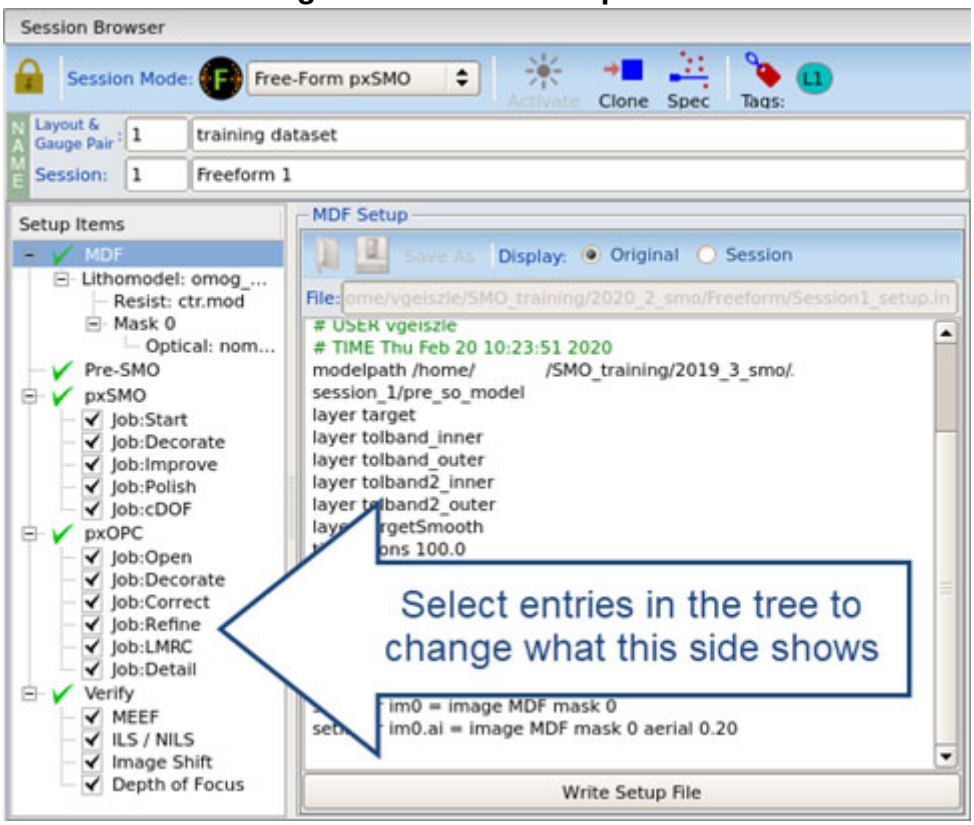
Procedure

1. In the Run Control/Layout Session View pane of the RET Selection window, select a session. If you see the Gauge Analysis pane, select the **Session Browser** tab at the bottom of the pane.

Note

The session mode default is **Free-Form pxSMO**. To perform setup for Parametric Explorer, change the session mode to **Parametric Explorer** and refer to "Setting Up the Point Tools for Parametric Explorer" on page 45.

Figure 2-3. Initial Setup Pane



A green check means that the item is able to be run with no changes. (You may still want to check its settings, however.) A circled red X means the item requires additional information.

2. Adjust the smoothed target. You can create several preview layers to compare, and use the best one.

   a. Click **Pre-SMO** in the Setup Items tree to open the Pre-SMO Setup pane.

   b. Adjust values. The goal is to match the achievable nominal contour.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

The default values for curve_target are critical distance of (λ/NA)/3 based on the nominal optical model, a line end ratio of 1.0, and maxJog of 0.010 microns. It is recommended to tune these values to achieve the expected curvature of the layer.

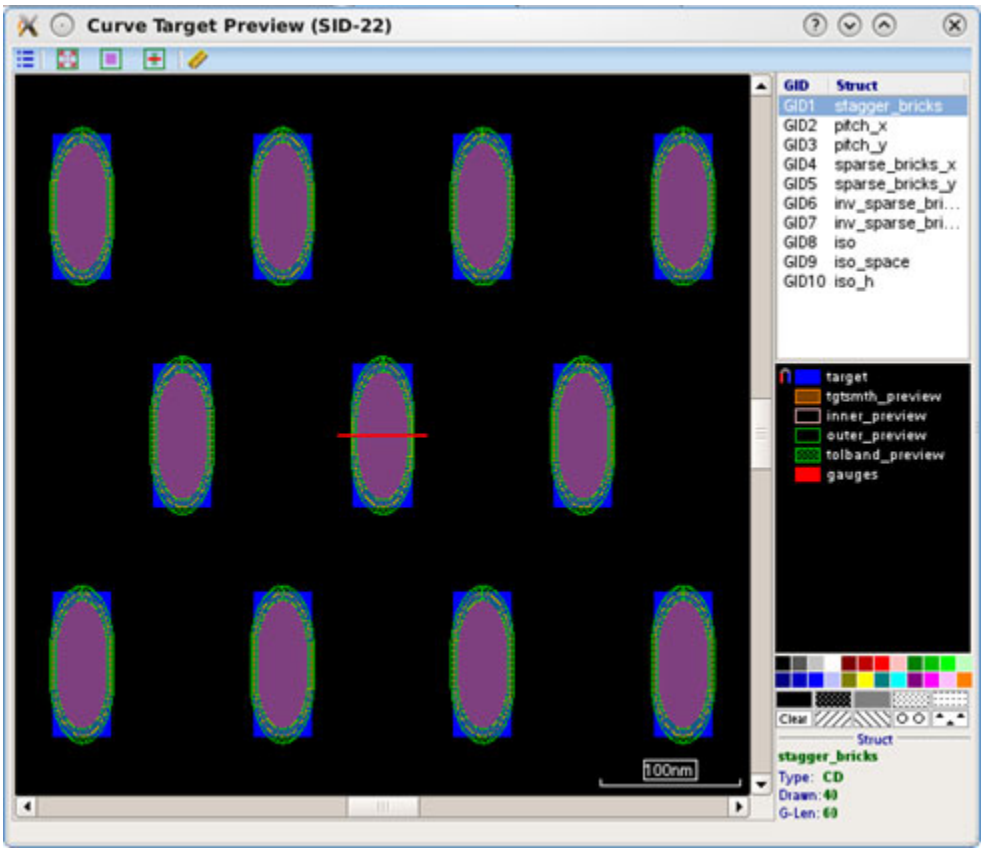
- You can smooth the target with “setlayer curve” instead by changing the Curve Command setting.
- You can tune the results by entering any keyword-value pairs for the command in the Curve Options field. The options for setlayer curve and setlayer curve_target are described in the *Calibre nmOPC User’s and Reference Manual*.

c. If you are optimizing CDOF or EL/ILS, click the **Tolerance Bands** tab to make adjustments.

To adjust the CDOF tolerance band settings, make changes in the **Tolband-1 (cDOF)** sub-tab. If you are optimizing EL/ILS, you can make adjustments to the EL/ILS tolerance band settings in the **Tolband-2 (EL/ILS)** sub-tab.

d. Check the results by clicking **Curve Target Preview**.

In the dialog box, specify a unique layer number so that you can compare the various experiments. Use the layer name to record the values you used. To inspect the gauges and tolerance bands for individual gauges, click **Generate Preview Layout**. If you receive any errors, adjust the keywords in the Curve Options field.



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Inspect the tolerance bands and markers for each gauge. If the tolerance bands appear unusual across a grating or array, reduce the maximum pitch value for the axis capturing a non-uniformity in **Copy Tolband Marker Options**.

If the tolerance bands for an individual gauge appear unusual, the pre-curve_target shapes can be inspected. To view the pre-curve_target shapes, re-run the curve target preview steps with **Show All Layers** activated in the Curve Target Preview window. Inspect the inner and outer targets for the gauges with unusual tolerance bands.

Unlike the other parts of the setup, previewing the curved target requires the session is the active session. Click **Activate** to make it the active session.

3. Check the pxSMO options. By default, the RET Selection GUI generates the Calibre pxSMO setup. It uses all process window conditions selected for pxSMO in the PW Table at all stages. The defaults follow the best practices for good results.

   - If you have an existing Calibre pxSMO setup file you would prefer to use, toggle the Generate pxSMO Setup field to off and use the folder to load the setup file.
   - Check that the scanner type and pupil fill values are appropriate for your source and litho model. If the scanner wavelength does not match the litho model, an error message is displayed.
   - Set the Image Model to Aerial (the default) or CM1. This sets the image model for all point tools (pxSMO, OPC, and Verify). The CM1 option adds a Polish-2 job. The first four jobs always use the aerial image.

     Restriction

     The CM1 option is not available in the current release.

     Tip

     Even if a litho model that includes a CM1 model is loaded, Aerial is the recommended option. The Aerial option can search for solutions beyond the loaded CM1 model parameters.

   - To improve run time, turn off some process window conditions for some jobs.
     - The Start job only requires the nominal process window condition.
     - The Decorate, Improve, Polish, and Polish-2 jobs should use all process window conditions.
   - To anchor the litho model threshold to a gauge, perform "Anchoring to a Gauge" on page 32.
   - To assign custom objectives to a pxSMO job for a marker layer with specific process window conditions, go to the Objective Region Tab of the pxSMO job. Add the marker layer and custom objectives. Then select the process window conditions for the optimization.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

- To improve the nominal condition's solution convergence and common process window, the Improve and Polish jobs should use a weight of 5 for the nominal process window condition. To set the weight, click the job in the Setup Items tree and change the weight value in the PW Table.
- To add overrides for the jobs, click the job in the Setup Items tree. The pxSMO Job pane lets you enter any valid setup file commands, increase or decrease the iterations, and select process window conditions. The setup file commands are documented in "Calibre pxSMO Setup File Commands" on page 71.
- To optimize CDOF or EL/ILS, click **Job:cDOF** or **Job:EL**, respectively, in the Setup Items tree.

  Verify that **Optimize** is set to the correct optimization. The nominal condition for the job is turned on by default. Add static process window conditions for SRAF print suppression. For the Polish job, the default number of iterations changes to 100. Specify the exposure latitude and DOF starting value.

  For CDOF optimization, set the exposure latitude higher than the target value. For example, if 5 percent is the target, set the exposure latitude value to 6 percent. For an initial run, set the **Focus Maximization Factor** value to 10.

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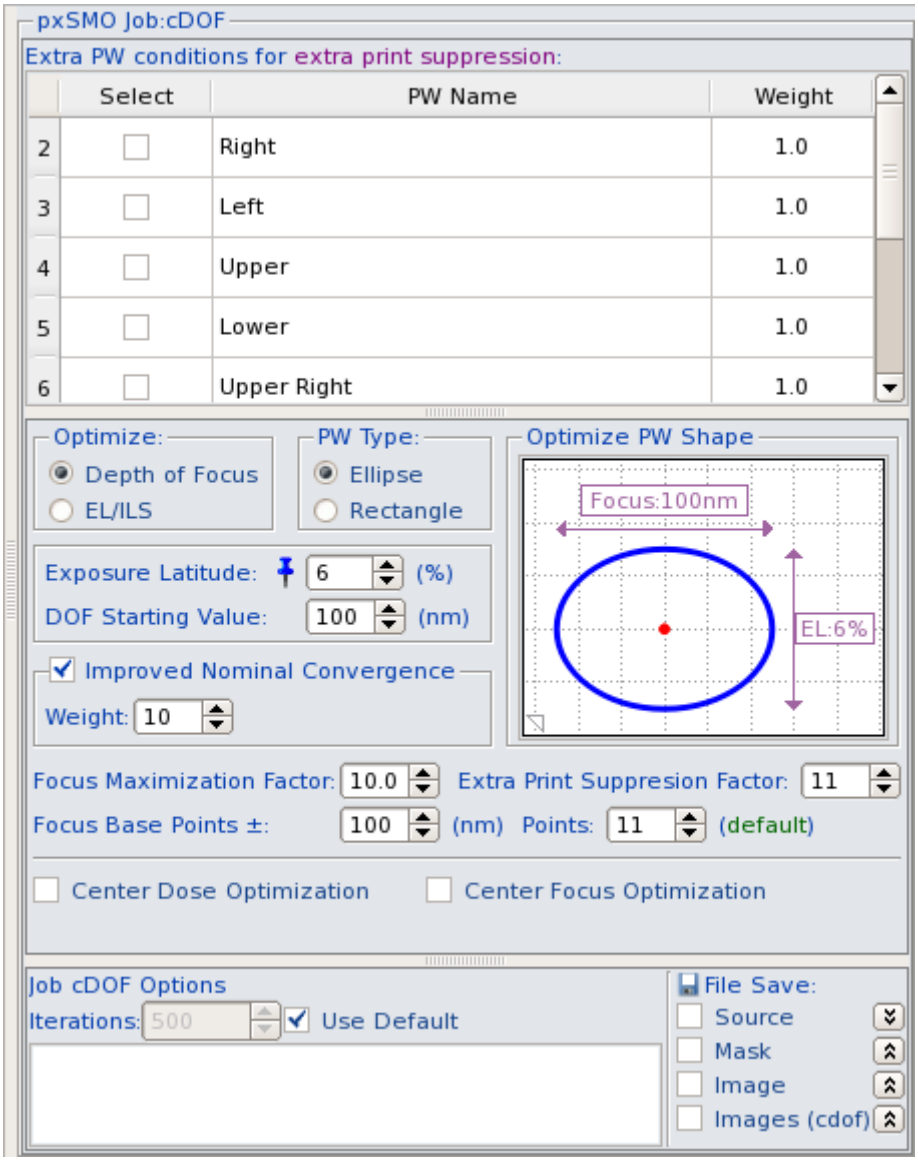
Tip

Test different values of the **Focus Maximization Factor** and choose the one that maximizes common depth of focus.



For EL/ILS optimization, specify the EL starting value and depth of focus. Set the **Dose Maximization Factor** to 100.

- To specify a custom objective for a marker layer in one of the pxSMO jobs, click the **Add** button in the job's **Objective Region** tab. Select a marker layer and specify "add" to add the custom objective to the current objective or "set" to set the custom objective as the only optimization objective. Define the custom objective by choosing the objectives and specifying their coefficients. Click **OK**.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

In the Objective Region Table, choose the PW conditions to use with the marker layer and custom objective.

- To add constant flare across all process window conditions, an EUV lithomodel with a flare model is required. To change the constant flare value, click the **Set** button next to Constant Flare (%). Select the Set mode and adjust the flare value. To set constant flare values for unique process window conditions, double-click the flare value for the condition in the PW Table and adjust.
- To save source, mask, or contour files for job-level debugging, click the job in the Setup Items tree and select the desired file types under **File Save**. For each job, you can choose the appropriate files to save and name each file.

4. Configure the OPC Setup pane. At a minimum, you need to assign a process window condition to each job. You can use either Calibre pxOPC, Calibre nmOPC or mask-only pxSMO as the OPC engine. Advanced users can use Custom OPC to build a custom flow.
   - For pxOPC:
     - Assign all available process window conditions to all jobs by clicking **Check All** above the table. (You can reduce the number of conditions per job by clearing individual checkboxes. Reducing the number of conditions reduces run time.)
     - To assign custom objectives to a pxOPC job for a marker layer with specific process window conditions, go to the Objective Region Tab of the pxOPC job. Add the marker layer and custom objectives. Then select the process window conditions for the optimization.
     - If you have an existing Calibre pxOPC setup file you would prefer to use, toggle the Generate pxOPC Setup switch to off and click the folder to load the setup file.
   - For nmOPC, complete "Setting Up the nmOPC Engine" on page 42.
   - For mask-only pxSMO:
     - After selecting **pxSMO**, the Setup Items tree updates the pxOPC items for mask-only pxSMO jobs and the setup pane displays the pxSMO PW table and a reduced set of pxSMO options. Configure the mask-only job similar to the pxSMO job. If **2nd Stage Run** is disabled in the pxSMO setup pane, the mask-only pxSMO settings are applied to all clips. If **2nd Stage Run** is enabled, then the mask-only pxSMO settings are applied to only to SMO-enabled clips.
     - (Optional) To adjust clip weights and properties for the mask-only job, use **Custom Clip Weight** to configure the clip settings.
   - For custom OPC flows, complete "Setting Up a Custom OPC Flow" on page 44.
   - To add overrides to specific jobs, select a job from the tree and type the commands in the Job Options box at the bottom of the pane. For more information, see the

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Calibre pxOPC User's and Reference Manual, especially "Calibre pxOPC Best Practices".

Note

Although pxSMO does optimize the mask, there are two reasons why it is beneficial to run OPC this second time. First, the second run allows SMO to search without constraints for the best possible source. Second, the independent mask optimization tests the source. Following best practices, more clips are used for the second mask optimization, as it is checking that the optimization is not overfitted to any one structure.

- To make changes to the mdf smo mask command block, click **Edit** in the Run Control pane. Find the mdf mask command block in the Commands pane, make changes, and click **Close**. To run an error check on changes, click **Syntax Check** at the bottom of the OPC Setup pane. The logs viewer in the session browser displays error messages when errors are detected.
- To save the mask and contours for each OPC job for debugging, select **Enable Job Outputs**.

5. Check the Verify Setup pane.
   - If the Verify job does not have a green check, examine the Verify column in the PW Table to confirm that conditions have been selected.

     If the Verify job warns that the defocus count exceeds the internal limit of 21, reduce the number of unique defocus conditions selected in the Verify column of the PW Table. The defocus count will be greater than the number of unique defocus conditions in the PW Table because the defocus count includes values that are automatically generated for PVBands, Image Shift, and Depth of Focus calculations.
   - Select which contours to write to the results layout and which checks to run. The gauge-based checks run exactly on the gauge polygon. The contour outputs measure properties along the contours. The arrow buttons open additional boxes to configure the most commonly customized fields for each.

     Tip

     Include the Depth of Focus check to calculate common process window and Bossung plots, as well as exposure latitude versus DOF.
   - To save the mask and contours for each OPC job for debugging, activate **pxOPC Job Contours**.
   - To gather data such as ILS at additional process window conditions, click **Property PW** in the Setup Items tree. Select **Custom** and click **SET** to edit the list of simulated process window conditions.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

- To make changes to the mdf smo verify command block, click **Edit** in the Run Control pane. Find the mdf verify command block in the Commands pane, make changes, and click **Close**. To run an error check on changes, click **Syntax Check** at the bottom of the Verify Setup pane. The logs viewer in the session browser displays error messages when errors are detected.

Results

All top level entries in the Setup Items tree show green checks.

Related Topics

Controlling Optimization With Gauges

Cloning Sessions and Running Efficiently

Setting Up the nmOPC Engine

As an alternative to the pxOPC engine, you can optimize the mask using the nmOPC engine.

Prerequisites

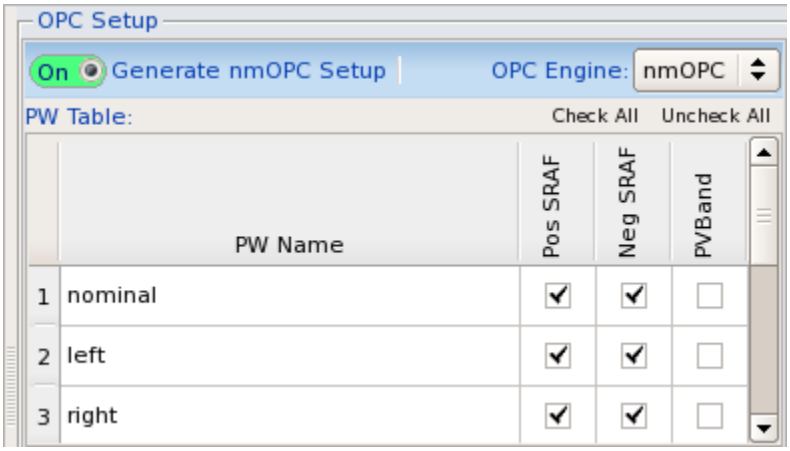
- Complete the pxSMO setup of "Setting Up the Point Tools" on page 33.

Procedure

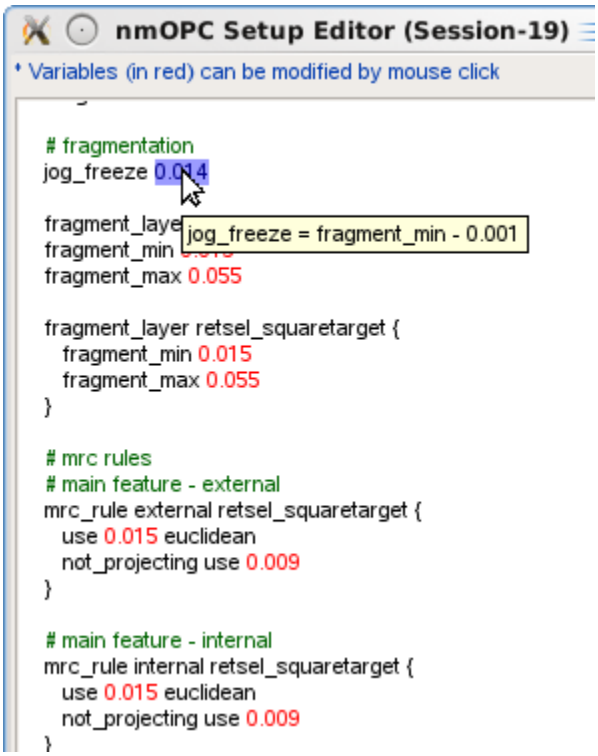
1. Select **nmOPC** in the **OPC Engine** menu. In the Setup Items tree, the jobs change to Pre-Sraf, Pos-Sraf, and Neg-Sraf.
2. The **Pre-Sraf** job is checked by default and should always be run regardless of SRAF tone.
3. **Pos-Sraf** and **Neg-Sraf** cause positive and negative SRAFs respectively to be simulated. Select the checkboxes to indicate which types of SRAFs to simulate. Simulating both tones (or no SRAFs) is supported. The nmOPC engine is run regardless of the SRAF job settings.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

4. For the selected jobs, assign process window conditions in the PW Table.



5. For **Pos SRAF** and **Neg SRAF**, use the nominal and through-focus conditions.
6. To use PVBand OPC, click the PVBand checkboxes for the corresponding PW conditions. For more information, see the "PV Band PWOPC" section in the *Calibre nmOPC User's and Reference Manual*.
7. To change nmOPC setup file options, click **Open nmOPC Setup Editor**. Red text can be modified. Blue text cannot be modified, but displays a tooltip when a cursor hovers over it. SRAF print avoidance (SPA) is available in the nmOPC setup file.



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

8. To use a setup file for the nmOPC stage or its jobs, turn off the **Generate nmOPC Setup** or **Generate *Jobname* Setup** switch and load the setup file.
9. Complete the Verify job setup in "Setting Up the Point Tools" on page 33.

Setting Up a Custom OPC Flow

The Custom OPC Flow Editor lets an advanced user build new OPC flows.

Custom flows can be built by sequencing the following setup types:

- pxopc and denseopc for OPC.
- opcbias and nmbias for mask bias.
- retsbar and mbsraf for scattering bars.
- opcverify for layer manipulation using setlayer commands.

Prerequisites

- Advanced knowledge of setup file structure and syntax. Also, advanced knowledge of setlayer statement structure and syntax.
- Complete the pxSMO setup of "Setting Up the Point Tools" on page 33.

Procedure

1. Select **Custom OPC** in the **OPC Engine** menu. Click **Edit Custom OPC Flow**.

   The Custom OPC Flow Editor appears and displays the input and output layer.
2. To add the first setup, click **Add Setup**.
3. In the Custom OPC Setup Configuration dialog box, select the setup type. Name the setup, choose the input layers, and click **Add**.
4. In the flow editor, click on the new setup icon in the flow viewer. Customize the flow manually or by loading a setup file.
   - To build a custom flow manually:
     i. If needed, map layers such as the input layers to the setup input.
     ii. Add process window conditions by clicking on them in the PW table and dragging them to the correct section in the setup file editor.
     iii. In the setup file editor, add the job types and details.
     iv. Add the setlayer statements for the setup output layers.
   - To build a custom flow from a setup file:
     i. Click **Load Setup Text**, select the setup file, and click **Open**.

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ii. Map the input layers to the setup input.

iii. If needed, change the loaded process window conditions to match the conditions defined for the session.

iv. If needed, modify the job types and details in the setup file editor.

5. Add more setups to complete the flow. Map the output of the previous setup(s) to the input of the added setup(s).
6. Map the output from the last setup to the Output Layers. The retsel_mask layer is a required output and is passed to the Verify step for simulation.
7. Check the setup file syntax.

Note

Setup files are not syntax checked in the Custom OPC Flow Editor. Syntax checking must be performed by the user.

8. Click **Close** and confirm there are no error messages.
9. Complete the Verify job setup in "Setting Up the Point Tools" on page 33.

Setting Up the Point Tools for Parametric Explorer

The Parametric Explorer tests different source shapes to find the best candidate for a diffractive optical element (DOE) to use with a design. While most of the job setup between Free-Form pxSMO and Parametric Explorer is similar, some differences exist. This procedure describes the steps that are specific to setting up Parametric Explorer runs.

Restrictions and Limitations

- Model and layout files are saved only for the source with the highest common process window that is selected by Parametric Explorer. These files can be used with OPC and verification tools.

Prerequisites

- A layout/gauge pair and session.
- Populated PW Table. See "Defining Process Window Conditions".

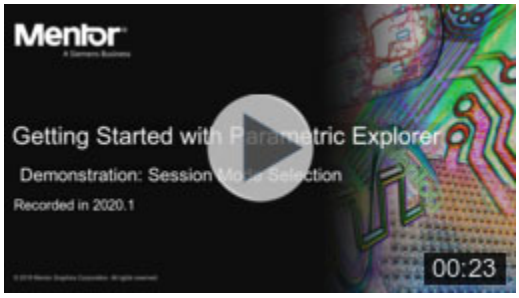
Video

The video series "Getting Started with Parametric Explorer" describes and demonstrates the main functionality and key workflow steps for using the Parametric Explorer.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

- The “Overview” video describes the main functionality and key workflow steps of Parametric Explorer.

- The “Demonstration: Session Mode Selection” video demonstrates session mode selection for Parametric Explorer.

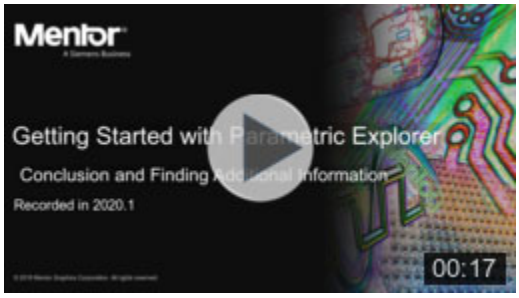


- The “Demonstration: Parametric Explorer Setup” video demonstrates setting up the Parametric Explorer step. This includes selecting the source type, selecting the source shape, specifying the source shape parameter values, and specifying the polarization type, and loading a custom source.

- The “Demonstration: Job Run Setup” video can be found in the video section of “Cloning Sessions and Running Efficiently” on page 49. The “Demonstration: Parametric Plot for Reviewing Results” video can be found in “Other Plots” on page 65. The “Demonstration: Custom Parametric Plots for Reviewing Results” video can be found in the Usage Notes of “Custom Parametric Plot” on page 233.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

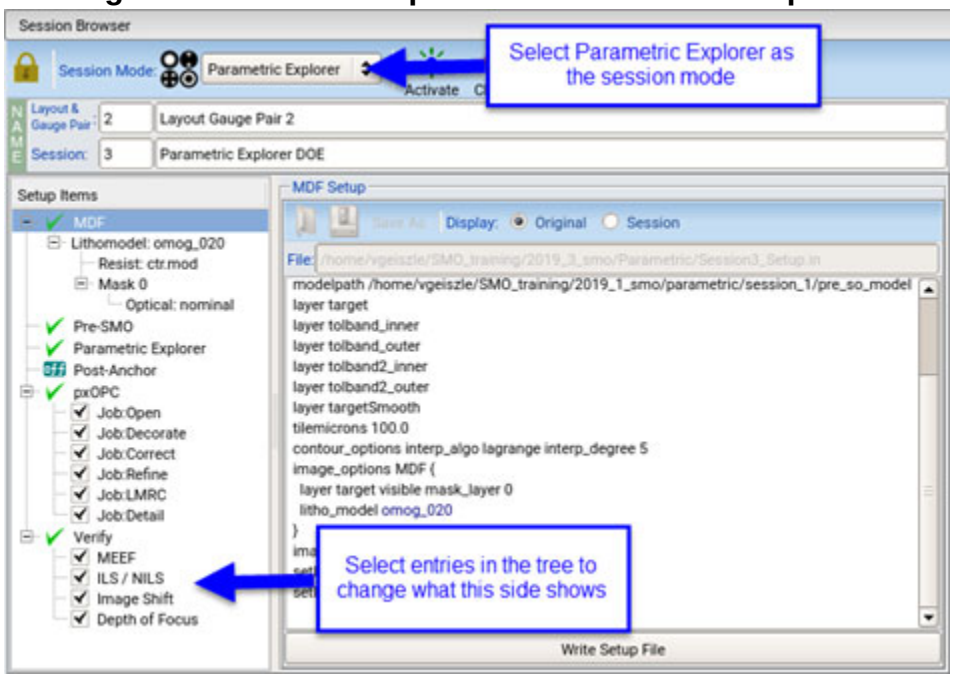
- The “Conclusion and Finding Additional Information” video describes where to find additional information.



Procedure

1. In the Run Control pane of the RET Selection window, select a session. If you see the Gauge Analysis pane, select the **Session Browser** tab at the bottom of the pane.

Figure 2-4. Initial Setup Pane for Parametric Explorer



A green check means that the item is able to be run with no changes. (You may still want to check its settings, however.) A circled red X means the item requires additional information.

2. Change the session mode to **Parametric Explorer**.

3. Adjust the smoothed target. You can create several preview layers to compare, and use the best one.

   a. Click **Pre-SMO** in the Setup Items tree to open the Pre-SMO Setup pane.

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b. Adjust values. The goal is to match the achievable nominal contour.

   The default values for curve_target are critical distance of (λ/NA)/3 based on the nominal optical model, a line end ratio of 1.0, and maxJog of 0.010 microns. It is recommended to tune these values to achieve the expected curvature of the layer.

   - You can smooth the target with "setlayer curve" instead by changing the Curve Command setting.
   - You can tune the results by entering any keyword-value pairs for the command in the Curve Options field. The options for setlayer curve and setlayer curve_target are described in the *Calibre nmOPC User's and Reference Manual*.

c. Check the results by clicking **Curve Target Preview**. In the dialog box, specify a unique layer number so that you can compare the various experiments. Use the layer name to record the values you used.

   Unlike the other parts of the setup, previewing the curved target requires the session is the active session. Click **Activate** to make it the active session.

d. Click **Generate Preview Layout**. If you receive any errors, adjust the keywords in the Curve Options field.

4. Set the Parametric Explorer options to investigate one or more illumination types and their parameters.

   - In Global Settings, check that the Source Type and Polarization match the scanner. Adjust the polarization weight if testing multiple polarization types. When using the **erf** source type, specify values for **Dillumangle**, **DSigma**, and **Dsigma In** that are suitable for the illumination shape that will be selected in Parametric Settings.
   - In Parametric Settings, select one or more illumination shapes to explore. For each parameter of each illumination shape, click **Edit** to specify a value or a range of values that will be tested. The total number of combinations increases to the product of the numbers of parameters. For example, if three parameters are specified with three values each, the total combinations is 27.
   - To compare the specified illumination shapes to a baseline source, select **Custom** in Parametric Settings. Click **Edit** and choose one or more custom source files. The total combinations increases by the number of imported sources.
   - To investigate different numerical aperture (NA) values, click **Edit** in Model Settings. Specify the NA values to test. The source is scaled to the specified NA value. The total combinations updates to the product of the number of NA values multiplied by the sum of the parametric settings and a custom source (if specified).

5. Follow the remaining steps in "Setting Up the Point Tools" on page 33.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Note

During the OPC stages, all defined gauges (regardless of the SMO Enable setting) will be run. To remove gauges from the process window calculation, turn them off in the cPW column in the gauge settings. Change CD tolerances in the gauge settings if 10% is not desired. These CD tolerances are used for the common process window calculation.

Cloning Sessions and Running Efficiently

After the first session has been created, you can create variations on the setup to run a series of experiments.

If you want to clone a completed session to create a testcase, see "Exporting a Session" on page 59.

Restrictions and Limitations

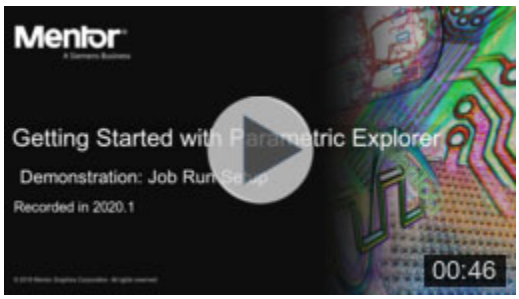
- Do not clone or switch active sessions when a run is executing without the dispatcher.
- All sessions within a layout/gauge pair are based on the same layout and gauge file.

Prerequisites

- An initial session has been defined. (All setup items have a green check rather than a red circled X.) Complete all parts of "Define a Session" if there are any red Xs.

Video

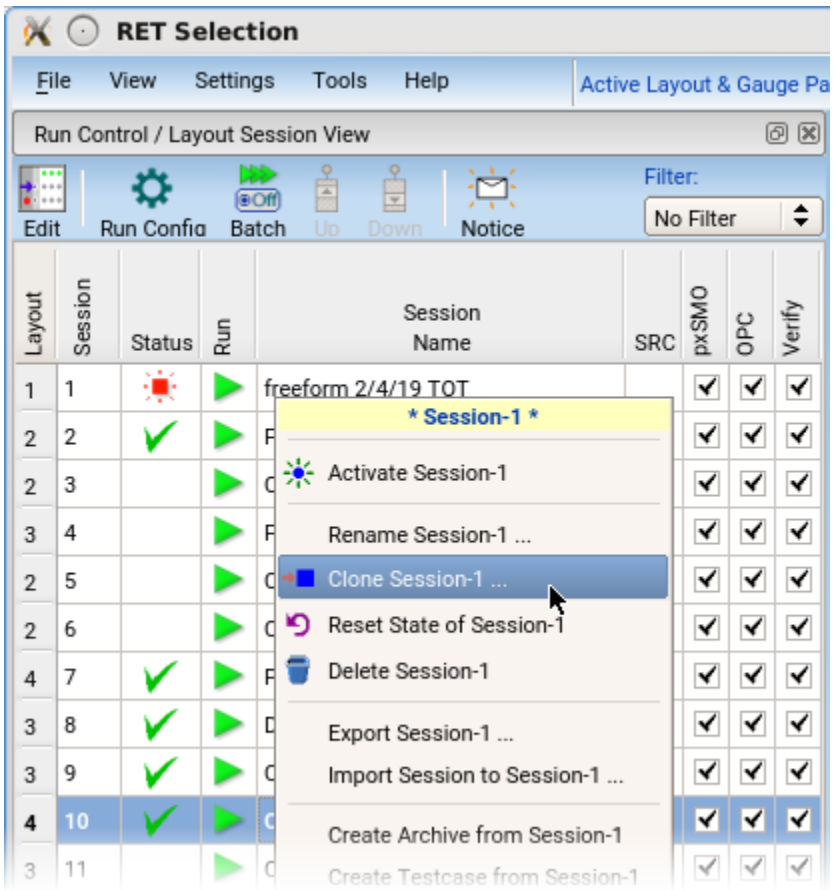
The "Demonstration: Job Run Setup" video in the "Getting Started with Parametric Explorer" video series demonstrates the job run setup for Parametric Explorer jobs.



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

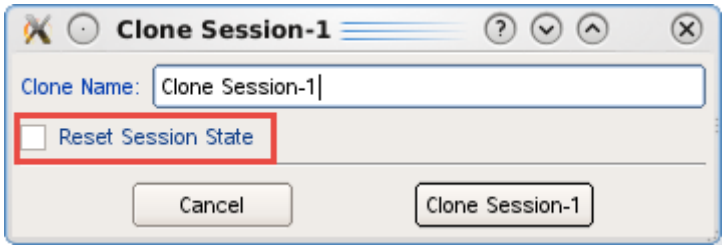
Procedure

1. In the **Run Control / Layout Session View** pane, right-click the session you want to use as the basis of a new session and click **Clone Session-*x***.



You can only make one clone at a time. The RET Selection window communicates with the database to retrieve settings before updating the window.

2. To clear the results table when cloning, click the **Reset Session State** checkbox. To clear the results table at a later time, right-click the session in the **Run Control / Layout Session View** pane and select **Reset State of Session**.



3. Supply a name for the new session in the dialog box.

4. For each session, customize the settings for the experiments you plan. Refer to "Define a Session" on page 26 for detailed instructions.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Note

When a cloned session is modified, the stages affected by the modifications are flagged with a red dot in the Setup Items tree. To clear the flag, right-click the affected stage and select **Clear *stagename* Setup modified flag**.

5. Once the sessions are ready, start them from the **Run Control** tab.
   - To launch a single session, click the green triangle next to the session name.
   - To launch multiple sessions, click **Batch** and select jobs from the Run column. Click the button with three green triangles at the bottom.

   The Run Configuration dialog box appears.

6. Modify the Run Configuration settings, if needed.
   - **Dispatcher Mode: Off** — Executes the session using the RET Selection GUI's process space. This is *not recommended* as it usually causes the RET Selection window to become very slow.
   - **Remote File Mode** — Executes on the named remote hosts. Execution for the Free-Form pxSMO and Parametric Explorer session modes is handled differently.
     - For maximum efficiency when using Free-Form pxSMO, each session should have a number of CPUs equal to (number of gauges) x maximum (number of PWs in pxSMO, number of focus base points if a CDOF job is used). For a CDOF job, the default number of PWs is 9. For an EL job, the default number of PWs is 11. Using set_on_target and suppress_extra_printing adds PWs. The default number of focus base points is 11. Each CPU receives a particular clip at a particular process window condition.

       For Free-Form pxSMO only, the dialog box displays a recommended minimum of CPUs.
     - When using the Parametric Explorer, each remote performs one source exploration and each CPU on the remote runs one clip for that source. The source explorations are sent to individual remotes until the specified remotes are busy. The remaining explorations are queued and processed as the earlier explorations are completed.
   - **Run Script Mode** — If you have a run script such as for LSF or Univa grids, you can supply it on the Run Script field. The dispatcher will use this to distribute work to the grid.

     The Run Script and Options settings can be specified by manually entering the settings into their respective fields. The icon next to each field opens an interface for faster selection of these settings and automatically fills each field.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

When using the Parametric Explorer, the runscript gets called for each source exploration. In the runscript, it is recommended to specify the number of CPUs (numcpus) to equal to the number of gauges.

- **No Remote File, No Run Script Mode** — Even if you have only a single computer available, this mode is still recommended over not using the dispatcher as it allows you to continue to interact with the RET Selection window. The optimization is run in a different process.
- **Max Parallel Session Runs** — Appears when using Parametric Explorer and limits the number of remotes used concurrently.
- **Keep All** — Keeps OPC and OPCverify for each source exploration. The default is off to minimize disk space usage and keeps files for only the highest cDOF solution.

After you set up and dismiss the Run Configuration dialog box, the RET Selection window will temporarily be non-responsive as it queues the job.

If you started more sessions than Max Parallel Session Jobs, some jobs are queued. You can adjust their order in the queue using the icons in the status column. (The number next to the icon indicates its current position in the queue.)

7. Once the sessions are submitted, ensure job notification is on in order to receive notifications by email when certain events are reached. This only needs to be set up once. The dialog box can be accessed through the **Notice** button in the Run Control window.

Results

The Run Control pane activates the first queued session and updates the progress indicators at the bottom of the pane. In the **Job Status** tab to the right of the setup pane you can see which step is being executed by a blue circling arrow. In addition, the log window displays the transcript.

When queued sessions have finished, the optimized sources are displayed as thumbnails in the **Run Control**, **Layout Session View**, and Session Browser **Result** tabs.

Related Topics

Converting GUI Sessions to Batch Mode Files

Migrating Session Settings to a New Layout/ Gauge Pair

Conditions and settings from an existing session can be used in another session with a different layout/gauge pair.

In some cases, it may be desirable to re-run an optimization with additional gauges. This requires creating a new or modified layout/gauge pair and a new session. Rather than manually

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recreate all session information, the import tool saves time by migrating process window conditions, stage settings (for Pre-SMO, SMO, OPC, and Verify), and session command settings (accessed using **Edit** in the Run Control/Layout Session View).

The Import Session Settings tool can also import gauge settings (specifically, SMO Enable and weight settings) from another session if the same gauges are used in the source and target sessions.

Prerequisites

- One existing layout/gauge pair and one new or modified layout/gauge pair.

Procedure

1. Create a new session using the new or modified layout/gauge pair.
2. In the Run Control / Layout Session View, right-click the new session and select **Import Settings to Session-*x***.
3. Select the existing session from which to copy conditions and settings. Select the conditions and settings to copy from the source session. Click **Import**.

Results

The specified conditions and settings are copied from the existing session to the new session.

Intermediate Results

Even fast runs take several hours and you may sometimes wonder if calculations are progressing. The RET Selection GUI offers several ways to check on sessions.

The longest stage is typically SMO. There are three indicators in the **Result** tab of interest: the current source view, the session log, and the objective plot.

The current source view and the objective plot do not display any information until after all pixels have been processed. The session's execution status (shown in the **Job Status** tab) should have reached at least the SMO Run stage before checking them. The session log, on the other hand, records progress as soon as the job is submitted.

Current Source View

The **Result** tab shows the current source map before SMO is complete. Unlike the final view in the **Result** tab, the intermediate view provides information on the current iteration as well as a view of the source. (If Source Map Capture in the **Advanced** tab of the SMO setup is cleared, the **Result** tab shows a gray box instead of the source map.)

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 2-5. Intermediate Source Map

Logs

The **Logs** button menu lets you view the job log, transcript, and session log, which track the current information from the different processes executing the run. The job log is a transcript captured from each job execution. The run transcript captures standard output and standard error messages during runscript execution. The session log captures the entire transcript related to the session when it is active - the models being used, setup files, gauge creation, and so on. It includes the interactions in the command window and the dispatcher job transcripts. The session history log is an archive of session logs. It updates when a session is deactivated, so it does not show the progress of a run.

PxSMO Objective Plot

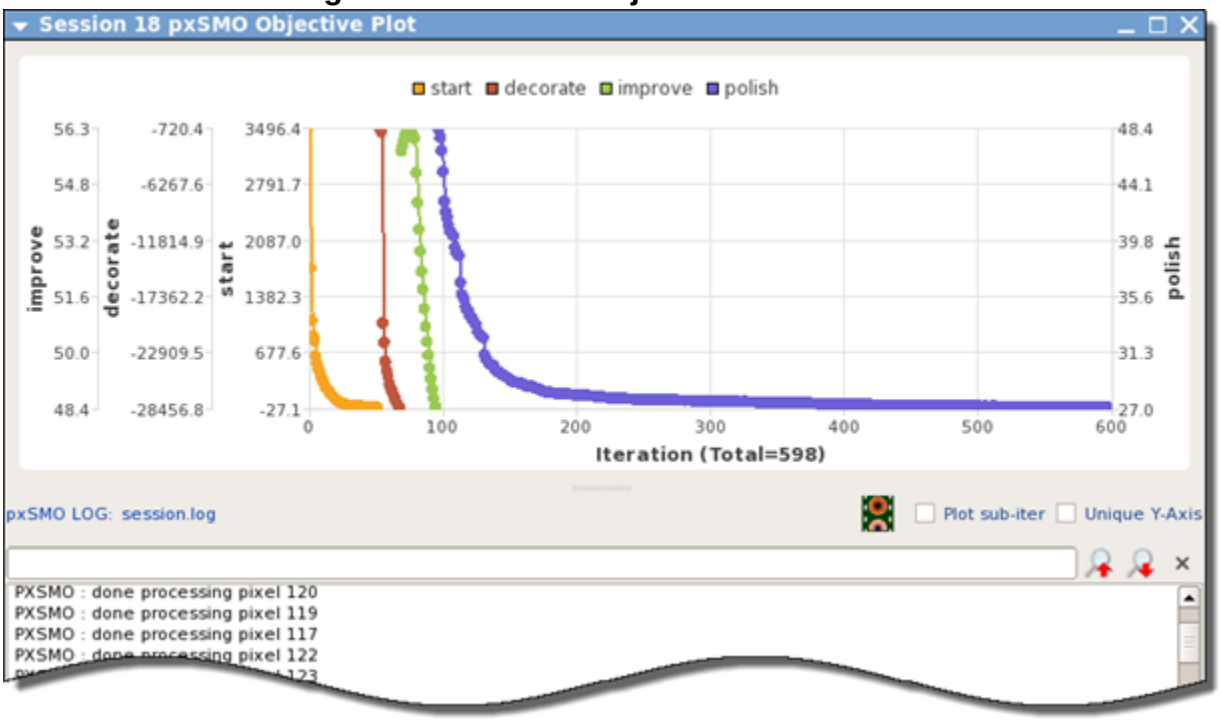
The objective plot, accessed through the PxSMO Plot icon, demonstrates how each job is converging on the objective. For runs with debug_level 1 set, a plot similar to the following figure is drawn. Generally a steep curve indicates significant movement and a flatter curve that optimization is approaching a final solution. It gives an idea of relative progress.

The following figure was captured after the run completed. The Objective Plot window includes the transcript, which you can search using the text entry field and red arrow buttons. If you set debug_level 0, the transcript may not include the same level of detail. Unlike the session log, it records only SMO activity.

The icon next to Plot sub_iter opens the Source Map Movie player. It runs through a sequence of snapshots of intermediate optical sources. Only an image of the source is saved; not the entire source map. If intermediate sources were turned off, the icon is dimmed.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 2-6. PxSMO Objective Plot Mid-Run



Related Topics

pxSMO Setup Pane

Converting GUI Sessions to Batch Mode Files

The easiest way to set up batch mode runs is to start from the RET Selection interface.

Prerequisites

- A known good session to serve as the basis of other sessions.

Procedure

1. In the RET Selection window Session Browser, step through each setup item and save the setup to a file.
2. Create the basic driver by typing the following in the Command Window pane:

   mdf smo session *sid* script *filename.tcl*

   where ***sid*** is the session number, and *filename* is a name you supply for the saved Tcl script. Unless you specify a directory, *filename.tcl* is written to the session_*N* directory for the currently active session.
3. Open the files you just created in a text editor and make any changes such as adjusting paths or optical conditions. The files obey Tcl parsing rules.

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- If you change the pixel width settings, you must specify a different pixel_socs_dir for each setting. Optical models with the same restrictions can reuse the kernels in the pixel_socs_dir.
- The pxOPC setup accepts the commands and obeys the syntax documented in the *Calibre pxOPC User's and Reference Manual*.
- The Verify setup accepts the commands and obeys the syntax documented in the *Calibre OPCverify User's and Reference Manual*.
- The pxSMO and MDF setups accept the commands documented in this manual.

4. Save the files. Launch your run with the following command:

   `calibrewb` ***`filename.tcl`***

   where *filename.tcl* is the file based on the script you saved from the Command Window.

Examples

The following is an example created using this process from session 1 of a layout/gauge pair.

Figure 2-7. Example Script for Running Without the GUI

```
## This script can be used for cloning session 1.
## Feel free to edit the script to suit your needs.
## It is also your responsibility to make sure the original layout and
## session folders are currently available,
## And you can manually copy files or directories/subdirs if needed.

mdf smo start

## == Layout commands group ==
##
## cd to the layout path first:
cd /home/myaccount/training

## To create layout 1, you need to make sure that folder:
## /home/myaccount/training exists, or has been copied
## (edit your path below).
## Commands are:
#mdf smo layout new {mdf gauges "/home/myaccount/training/gauges.sgd" \
 "/home/myaccount/training/layout.oas" 6 6}
#mdf smo layout name {your_new_layout_description}
##
## Since layout 1 has already been created,
## use the command below to set it current:
mdf smo layout 1
## Now you should be under the current layout's folder:
## /home/myaccount/training. Type "pwd" to verify.
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

```
## == Multi-sessions commands group ==
##
## To create session 1, commands are:
mdf smo session new {output/post_so_model/mdf_setup.in}
mdf smo session name {your new session description}
## Now copy all the setup files for your gensource, genmask, and
## verify steps. Format is file1;file2;...
mdf smo session files {smoo.setup;pxsmo.setup;pxopc.setup;verify.setup}

## The second time, since the new session <sid> has already been created,
## use the command below to set it current:
# mdf smo session <sid>
## You should now be under session <sid>'s folder. Type "pwd" to verify.

## Session run control: default is "disabled" without this line.
mdf smo session run disable

##Choose the smo engine type:
mdf smo session pxsmo yes

## == The actual contents of the commands below were generated
##    based on the finishing state of session 1 ==

## Preparing for source gen.
## Include commands for target layer smoothing, etc., if any:
mdf smo presmo {mdf gauges center drawn 1.5; \
   mdf litho gencliparray  ./tmpworkdir/smo/retsel_cliparray.oas \
                           ./tmpworkdir/smo/retsel_cliparray.gg \
                           ./tmpworkdir/smo/retsel_gaugelayer.oas;\
   mdf litho add smoo -setup smoo.setup -inputs {6} -outputs {tgtsmth};\
   mdf litho run;\
   mdf litho savelayout ./tmpworkdir/smo/targetSmooth.oas {tgtsmth:7 *};\
   mdf gauges layout ./tmpworkdir/smo/targetSmooth.oas 7 6 ;}

## Source generation steps:
mdf smo setup {pxsmo.setup}

## It is recommended to set a reasonable value (in optical diameter
## multiplier) for smo simulation target size.
mdf smo tgtextent 1.1
mdf smo clips gen

## You may use "mdf smo drawclips all" to verify the clips just generated.
mdf smo source

## Mask generation steps:
mdf smo preopc {}
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

```
mdf smo mask {mdf litho add loadclips \
   -inputs {./tmpworkdir/smo/retsel_smoothtarget.oas} \
   -outputs {tgtsmth} \
   -command load;\
mdf litho add loadclips2 \
   -inputs {./tmpworkdir/smo/retsel_squaretarget.oas} \
   -outputs {squaretgt} \
   -command load;\
mdf litho add pxopc -setup pxopc.setup \
   -inputs {squaretgt tgtsmth} \
   -outputs {retsel_mask} \
   -command pxopc;\
mdf litho check off;mdf litho run -distributed}

## Verification steps:
mdf smo preverify {}

mdf smo verify {mdf litho add loadclips1 \
   -inputs {./tmpworkdir/smo/retsel_squaretarget.oas} \
   -outputs {squaretgt} \
   -command load;\
mdf litho add loadclips2 \
   -inputs {./tmpworkdir/smo/retsel_mask.oas} \
   -outputs {retsel_mask} \
   -command load;\
mdf litho add loadclips3 \
   -inputs {./tmpworkdir/smo/retsel_smofilter.oas} \
   -outputs {smo_clips} \
   -command load;\
mdf litho add loadclips4 \
   -inputs {./tmpworkdir/smo/retsel_gaugelayer.oas} \
   -outputs {retsel_gauges} \
   -gauge_prop {mdf_gid} \
   -command load;\
mdf litho add verify -setup verify.setup \
   -inputs {squaretgt retsel_mask retsel_gauges smo_clips} \
   -outputs {pv nominal gauge_layer};\
mdf litho check off;\
mdf litho run -parallel;\
mdf litho savelayout ./output/ai_contour_post_so.oas {squaretgt:1\
   retsel_mask:2 retsel_gauges:3 smo_clips:4 pv nominal gauge_layer}}

## Finishing up the session. Run will be saved if enabled:
mdf smo postsmo {}
mdf smo end
```

Related Topics

RET Selection MDF Commands

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Exports and Imports

The RET Selection interface offers four types of relocatable containers for sessions and results.

- **Archive —** Archives are the most complete. They include the layout, session, results, and Tcl scripts to re-run the session.
- **Layout —** Layouts are the layout/gauge pair, without any sessions. This can be useful for creating slight variants on a layout/gauge pair for constructing experiments.
- **Session —** Sessions include process window information, settings, and results, but cannot be run outside the RET Selection interface. They can also include the layout/gauge pair.
- **Testcase —** Testcases are set up to be run outside the GUI. They include the layout/gauge pair information, all setup files, and a Tcl runscript. Testcases do not include results. Also, testcases cannot be imported to another RET Selection database.

Use archives, layouts, and sessions for moving data between different RET Selection users. Use testcases when contacting customer support, or as the basis in creating your own command-line scripts.

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Exporting a Session

To save space, session directories in the database contain references to shared information such as the layout and gauges. To move the session to another location it must first be exported in order to include the referenced information.

There are different mechanisms to use if you are exporting the session to create a test case than if it is being moved to another database.

- Use **Export Session** if you want to include the results. The session can be imported into other databases, allowing different sessions to be compared.
- Use **Create Testcase from Session** if size is a concern or to create a fully relocatable set of data.
- Use **Create Archive** for the most complete saved data. The archive has both relocatable data that can be run outside of RET Selection and also all generated files and results. It is compressed by default.

Testcases cannot be imported into other databases. If size is a concern and you want to be able to import, use Export Session and select the “Create archive” option. This does not save the same set of data as an archive, but does compress the exported directory into a single file.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Exporting and Importing a Session

Export a session by either right-clicking the session and selecting **Export Session** or from the main menu **File > Export > Session**. The Export Session dialog box allows you to export just the gauges, setup, and results, or the gauges, setup, results, and layout, and to compress the directory into a *.tar.gz* file.

You can later import the session to another database with **File > Import > Session** or **File > Import > Layout** for sessions exported with a layout. The wizard's directory navigator indicates appropriate directories with special icons: a pale aqua folder with an L for layout directories, and a gold folder or rectangle with an S for session exports. Layout directories contain session directories. Archives (a rectangle with a red A), although they contain session data, can only be imported using **File > Import > Archive**.

Note

When you import a session into another layout/gauge pair within the same database, if you specify a target session ID in the wizard, it *moves* — not copies — the session. The session no longer appears in the original layout/gauge pair. If you do not specify a target session ID, the wizard creates a new session in the destination layout/gauge pair.

Creating a Runnable Test Case

You can create a test case using either the session right-click menu **Create Testcase from Session** or from the main menu **File > Export > Create Testcase**.

The RET Selection GUI does not allow you to create a directory in sensitive locations such as the database. If Calibre WORKbench opens a dialog box with "No error message returned by Calibre Workbench," check the Log Viewer window for an mdf smo error message. Most likely the intended parent directory for the test case does not allow writing.

The test case directory contains the following files and directories:

- **runscript.tcl —** A Tcl script containing the mdf smo commands to execute the session.
- **dofile —** A shell script that when executed cleans up any files from the previous run and then calls Calibre pxSMO with *runscript.tcl*. Results are written in the test case directory.
- **cleanup —** A shell script that removes the output files created by *dofile*.
- **pxopc.setup, pxsmo.setup.<number>, smoo.setup, verify.setup, setup.in —** The setup files from the original session. Any relative paths have been modified to point to a local version.
- **gauges, layout, models —** Directories containing the gauge file, the layout, and the litho model with its collection of models, respectively.

To run a test case, execute *dofile*.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

These files are also available in archives, but you must uncompress them first.

Exporting an Optimized Source

The optimized source is saved in the session *output* directory in the *source_sopxopc.src* file by default. (You can specify a different name with the output_source command.) This file is the data shown in the RET Selection GUI source thumbnails.

The RET Selection GUI uses the Source View tool in Calibre WORKbench. Source View not only allows you to analyze the source map but to also export it in various formats.

Prerequisites

- The RET Selection GUI is open.
- At least one completed session.

  The Source View tool opens any source map and does not check that optimization is complete.

Procedure

1. Click a source thumbnail.

   Source thumbnails are available from the **Result** tab or in the SRC column of the Run Control pane.

2. In the Source View window, optionally enter a description. The description is saved with the source map, unlike the settings in the Map Options.

3. In the Source View window, select one of the following:

Format	Menu Item
Comma-separated values	**File > Export to CSV**
MATLAB™[1]	**File > Export to Matlab**
Nikon	**File > Export to Nikon**
PROLITH™[2]	**File > Save Source Map**
ASML	**Options > Save Zeros** (set) **File > Save Source Map**

1. MATLAB is a trademark of MathWorks.
2. PROLITH is a trademark of KLA-Tencor.

4. In the Save Source dialog box, verify that you are not in a Calibre-created directory such as *session_1*. Enter a filename and click **Save**.

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The Save Source dialog box automatically appends a format-specific file extension if you do not supply one.

Results

The source data is written in the format you specify. The default extension for a source map saved from Source View is *.smf*.

Examples

This is the text of a source map saved from Source View:

```
[Version]
2016.3
[Parameters]
Example 1 ;User Defined Source Shape Name
1 ;Format (0 = grid, 1 = discrete)
step 0.01

[DATA]
-0.140000 -0.990000 0.114755
-0.130000 -0.990000 0.142764
-0.120000 -0.990000 0.161577
...
```

Related Topics

output_source_file

Source Map File Format [Calibre WORKbench User's and Reference Manual]

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Chapter 3
Comparing Optimized Sources

After a session has been run, you can view the session's metrics and source in the **Result** tab. To compare session results, click **Inter-Plots** and select either **Sessions In this Layout** or **Selected Sessions...**. There are also additional steps you can take to better decide which source is best for your process.

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Evaluation Criteria

The RET Selection GUI provides several pre-defined criteria and a means to automatically calculate how close a source comes to meeting the layout specification.

The most basic criteria evaluate the quality of the mask. These may be familiar from OPC:

- **Normalized Image Log Slope (NILS) —** The rate at which the image intensity changes with respect to distance. Higher is better.
- **Edge Placement Error (EPE) —** The difference between the ideal edge location as shown in the pre-OPC layout versus the simulated edge location.
- **Process Variation Band (PV Band) —** The difference between the smallest and largest contour created by different process window conditions. The PV band is a measure of how consistently a mask will print given normal variation in lithography equipment.
- **Extra Printing or Non-Printing —** A check of whether all printing shapes have a corresponding polygon on the target layer, and whether all shapes on the target layer are represented as single shapes in the simulation.
- **Maximum Root Mean Square Error (ErrRMS) —** A measure of how much the desired and drawn (or nominal) CD on a gauge differ across process windows using the quadratic mean, also known as the root mean square or RMS. The default error tolerance is 5.

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Calibre SMO also adds analysis metrics, the aggregate scores. These are based on the layout specification and visible in the Inter-Plots window. The aggregate scores are based on the difference between the measured property and the specification.

Related Topics

Evaluation Criteria

Plot Access

The first step of comparing optimized sources is to check that the session results fit your needs. The RET Selection window provides many ways of accessing single-session plots.

Source thumbnails appear in many parts of the RET Selection GUI. Any place they appear, you can click the thumbnail to display the Calibre WORKbench source view.

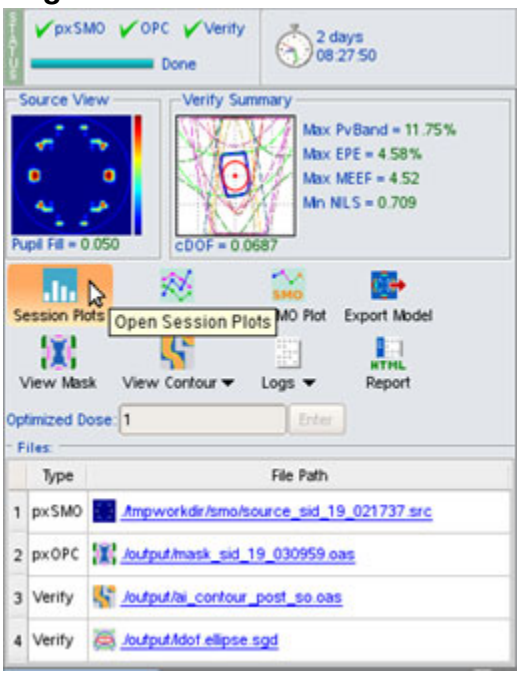
From Run Control/Layout Session View

Right-click on a session and select either **Session Plots** or **Layout-<*ID*> > Inter-Plot**.

From the Result Tab

In the default configuration, the **Result** tab is at the far right of the Session Browser window. To access the plots, click the **Session Plots** or **Inter-Plots** button.

Figure 3-1. Session Plots Button



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Other Plots

Common Process Window

The **Result** tab also gives easy access to the session's Common Process Window plot from Calibre WORKbench. Click the thumbnail of the process window plot in the Verify Summary or the SGD file link to open the Sgd Process Window gauge selector. In the dialog box, click **Plot**.

Bossung Plots

From the Common Process Window plot, right-click on a gauge in the **Gauge Table** area and select **Bossung Plot for GID**. The Bossung window offers eight CD plots.

Table 3-1. Per-Gauge Bossung Plots

CD vs Focus	CD vs Dose
CD Error vs Focus	CD Error vs Dose
Model CD vs Focus	Model CD vs Dose
Model CD Residual vs Focus	Model CD Residual vs Dose

To display the residual plots, select "Model CD Residual Plots" at the top of the window. By default, it is not selected.

EL vs DOF

The RET Selection window also helps you set up another type of process window analysis, exposure latitude versus depth of focus (EL vs. DOF).

For a single session, click the thumbnail of the process window plot in the Verify Summary in the **Result** tab. In the Process Window, select the **EL vs DOF** tab.

For multiple sessions, use the EL vs. DOF plot wizard, accessed from the RET Selection window **Tools > EL vs. DOF Plots**.

pxSMO Plot

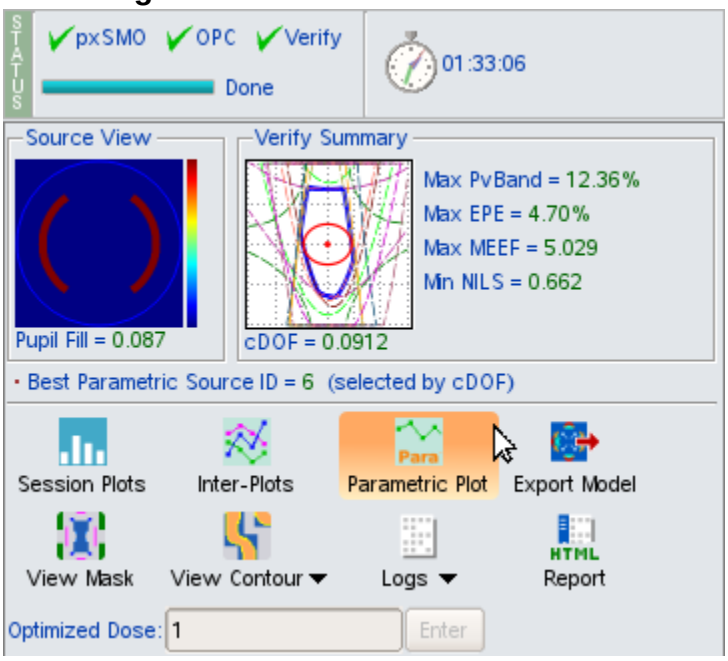
When the Free-Form pxSMO session mode is used, results are displayed in the pxSMO Plot window. To review the pxSMO objective plot and transcript, click the **pxSMO Plot** button in the **Result** tab. The plot and transcript are described in "PxSMO Objective Plot" on page 54.

Parametric Plot

When the Parametric Explorer session mode is used, results are displayed in the Parametric Plot window. To view the results, click the **Parametric Plot** button in the **Result** tab. Review the tested sources in the table using the evaluation criteria or scoring that are critical to the design.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 3-2. Parametric Plot Button



The “Demonstration: Parametric Plot for Reviewing Results” video in the “Getting Started with Parametric Explorer” video series demonstrates results review using the Parametric Plot. The plot is described in “Parametric Plot” on page 231.

Related Topics

Comparing Process Window Performance

Intermediate Results

Post-Generation - Optical Model Visualization Tools [Calibre WORKbench User's and Reference Manual]

Scoring

A quick way to compare the results of many sessions is to calculate a “goodness” score.

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Scoring is based on your decisions about what constitutes optimal results. You enter the minimum acceptable values for items such as DOF, and the maximum acceptable process variation, and also assign weights. Based on this, the RET Selection compares the measurements on gauges and computes an aggregate score for each source.

To enter the decision values, open a plotting window. Below the plots and above the gauge table is **Edit Layout Spec** ( ). This button opens the Gauge Property Spec Editor dialog box, where you can enter the values and assign per-gauge weights.

After you have entered the values you care about in the Gauge Property Spec Editor, the plots include markers to indicate the thresholds you set. The table at the bottom of the Inter-Plots window also populates the Layout-Spec Delta columns, including the aggregate score in the final column.

You can further tune the "goodness" score using the **Config Score** button ( ), in the same menu bar as Edit Layout Spec.

Benchmarking Against Existing Sources

You may want to compare SMO results against the source used by your process of record. You can use the RET Selection GUI to more precisely measure the results.

Prerequisites

- A litho model with the existing source.

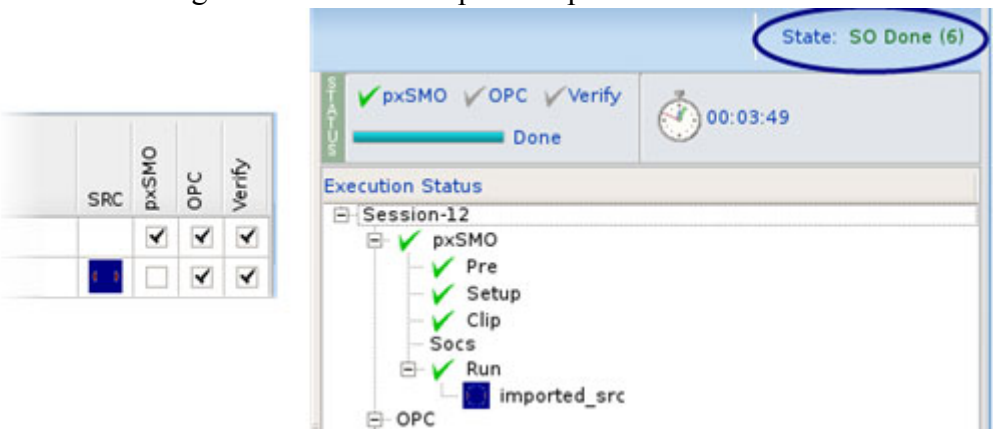
Procedure

1. Set up the sessions to optimize the source, plus one other.
2. For the session that will measure the existing source's performance, import the source.
   a. Click the **Job Status** tab. (This is in the Session Browser window at the bottom of the Result area.)
   b. The source file can be imported immediately or when the OPC stage executes.
      - To immediately import the source file, right-click the pxSMO line in the Execution Status tree and select **Import source > Now**.
      - To import the source file at the OPC stage, right-click the pxSMO line in the Execution Status tree and select **Import source > Queue**. The **Queue** option improves the import time for EUV multi-slit sources.
   c. Navigate to the source map file, which typically has a file suffix of *.src*, and select **Open**.

      The RET Selection GUI appears to be executing the session while it activates the session and imports the source. After a few minutes, the Run Control entry is set to

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

run just OPC and Verify, the Execution Status shows the state as SO Done (6), and the tree shows green checks for the pxSMO phase.



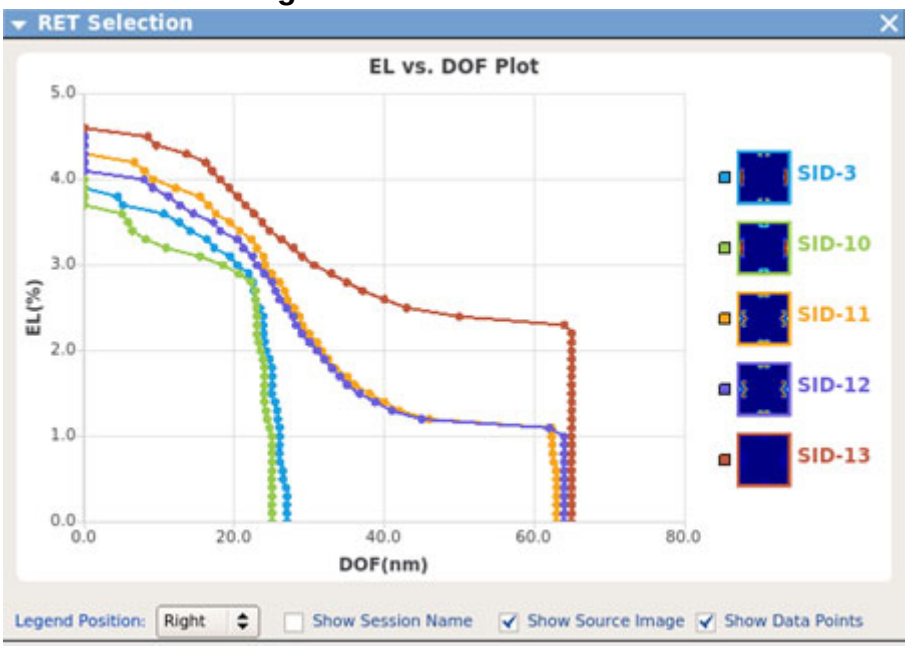
3. Importing a mask is an optional step.
   a. To import a mask, right-click the OPC line in the Execution Status tree and select **Import Mask**.
   b. Navigate to the layout file, which typically has a file suffix of *.oas* or *.gds*, and select **Open**.
   c. The RET Selection GUI appears to be executing the session while it activates the session and imports the mask. After a few minutes, the Run Control entry is set to run just Verify, the Execution Status shows the state as Submitting, and the tree shows green checks for the OPC phase. To confirm that the correct mask file was imported, hover over the OPC line and read the file name in the tooltip.
4. Run the sessions.
5. After the sessions have successfully completed, compare the results using the Inter-Plots window.
   a. In a list of sessions, right-click and select **Layout-<*ID*> > Inter-Plot** to open the window.
   b. If the Layout-Spec Delta Components column is empty, set the Layout Specification. See "Scoring" for details.

Comparing Process Window Performance

When refining an optical source, sometimes you will set up multiple layout/gauge pairs, each with many sessions in order to analyze sources across a wide variety of typical layer geometries. You can compare the source performance by looking at exposure latitude (EL) versus depth of focus (DOF) for multiple sessions within the RET Selection GUI.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 3-3. EL vs. DOF Plot



Whereas process window plots display a single DOF that corresponds to a single EL value, this chart shows DOF for a range of EL values. The curve is useful for evaluating the maximum exposure latitude for different sources and the trade-offs between EL and DOF.

Prerequisites

- All sessions to compare must have successfully completed execution.
- All layout/gauge pairs must be in the same MDF database.

Procedure

1. In the RET Selection main window, select **Tools > EL vs. DOF Plots** to open the selection dialog box.
2. In the EL vs. DOF plot wizard window, select the sessions to compare. Only sessions that completed and had more than one process window condition are shown.
3. Adjust other settings if necessary. The defaults are as follows:

Table 3-2. EL vs DOF Wizard Defaults

Type	Elliptical
Target CD	Drawn
CD Tolerance	10%
Dose Latitude	5%

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Note

If you specify a dose latitude, the EL vs DOF plot shows a single point because the dose is fixed.

4. Click **Plot**.

Results

The EL vs. DOF Plot window displays the graphs for the selected sessions.

- As you move your mouse over the graph, the DOF and EL values appear in the lower right.
- You can zoom in on an area by holding down the right mouse button and dragging right and down. Zoom back out by dragging left and up. Return to the original size by clicking the mouse in the plot area.

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Chapter 4
Calibre pxSMO Setup File Commands

Calibre pxSMO options are contained in a litho setup file. This file is generally created using the RET Selection interface. This chapter explains the commands and arguments.

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Setup File Format for Calibre pxSMO

Input for: Calibre pxSMO

Generated by: RET Selection

Litho setup files are used by most Calibre post-tapeout tools to specify local settings and encapsulate product-specific commands. You can quickly generate a Calibre pxSMO or Calibre pxOPC setup file using the RET Selection window in Calibre WORKbench.

This file reference information is provided in case you want to modify a generated file by hand.

Unlike most litho setup files, Calibre pxSMO setup files are not used with the LITHO FILE command in SVRF rule files. This is because even in batch mode Calibre pxSMO is run by Calibre WORKbench, and not the Calibre hierarchical engine invoked by “calibre -drc”. Other than that, the Calibre pxSMO setup file conforms to the standard litho setup file rules.

Format

A Calibre pxSMO litho setup file must conform to the following formatting and syntax rules:

- Each statement in the setup file must be on a line of its own. Statements can span multiple lines by ending the line with a backslash (\). The backslash character must not be followed by any other characters, even whitespace.
- Statements can appear only once in the setup file unless otherwise specified.
- Keywords are case insensitive.
- Comments begin with a pound sign (#) and end at the end of the line.
- All keywords are reserved words. Do not use them as layer or process window condition names.
- Blank lines are ignored.

Parameters

Table 4-1. Required Keywords for Calibre pxSMO Setup Files

Keyword	Example Value	Description
job	1 start	Calls the various phases and allows local overrides of settings.
pupil_fill	0.05	How much of the surface of the optical source may be illuminated.
pw_condition	NOMINAL lm_10nm aerial model	The process window conditions to use for optimization.

Examples

This is a generated setup file. It was created using the **Preview PxSMO Setup** button.

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```
version 0

pixel_socs_dir <session_path>/tmpworkdir/smo/socs_dir_1.0
output_source_file ./output/source_sopxopc.src
clip_file ./tmpworkdir/smo/clips.dat

source_symmetry +
pupil_fill 0.05
scanner asml

parallelize_by_pw_conditions yes

# PW conditions (aerial image-based)
pw_condition nominal pc_lm_fast aerial model

layer targetSmooth target mask_layer 0
layer target correction
layer weight hidden

weight_layer weight set 5

job 1 start
job 2 decorate
job 3 improve
job 4 polish
```

Related Topics

PxSMO Setup File Commands

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PxSMO Setup File Commands

The Calibre pxSMO setup file commands can be added to an SMO setup file.

The list in this manual is not exhaustive. You may see some commands in generated files that are not included here. This list represents commands that are safe to add to custom setup files as they do not interfere with the flow of data between runs.

Table 4-2. Calibre pxSMO Setup File Commands

Command	Description
anchor_gid	Identifies an anchor gauge.
anchoring_enabled	Enables optimization with anchoring to a gauge.
assist_inside_dose_multiplier	Scales aerial image from negative assist features.
assist_inside_threshold_multiplier	Scales print image from negative assist features.
assist_outside_dose_multiplier	Scales aerial image from positive assist features.
assist_outside_threshold_multiplier	Scales print image from positive assist features.
debug_level	Writes optimization rates to stdout.
delete_pixel_socs_dir_after_read	Deletes the pixel SOCS directory after reading it.
enable_periodicity	Reads clip periodicity information from the *clips.dat* file when custom clips are used.
fixed_source	Sets parts of a source to fixed illumination levels to allow optimization on the remaining parts of the source.
fixed_source_optimization_region	Optimizes source pixel intensities in a specified part of a source while other pixels remain fixed.
init	Identifies the initial mask.
initial_source	Sets the initial source type, overriding any optical sources passed in the litho model.
iterations	Specifies how many iterations the job should run.
job	Calls the various phases and allows local overrides of settings.
layer	Defines layer characteristics such as name and type.
mrc_enabled	Activates curvilinear MRC constraints.
mrc_max_internal_sraf	Constrains maximum internal spacing during MRC for SRAFs only.
mrc_min_area	Constrains the minimum SRAF area during MRC.
mrc_min_edge	Sets a preferred edge length for Manhattan MRC geometries.

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Table 4-2. Calibre pxSMO Setup File Commands (cont.)

Command	Description
mrc_min_external	Constrains external spacing during MRC.
mrc_min_external_main2sraf	Constrains external spacing during MRC between a main feature and an SRAF.
mrc_min_external_sraf	Constrains external spacing during MRC for SRAFs only.
mrc_min_internal	Sets the minimum distance between two internal edges.
mrc_min_internal_sraf	Constrains internal spacing during MRC for SRAFs only.
mrc_min_length	Sets the minimum distance between two internal edges for Manhattan shapes.
mrc_min_rect_length	Sets the minimum distance between two internal edges for Manhattan shapes.
mrc_min_rect_width	Sets the minimum distance between two internal edges for Manhattan shapes.
mrc_min_small_feature_area_excess	Sets the minimum area for features on the mask for Manhattan shapes.
mrc_min_square	Sets the minimum distance between two internal edges for Manhattan shapes.
mrc_small_feature_size	Sets the minimum distance between two internal edges for Manhattan shapes.
objective_region	Optimizes a region using specified objectives.
optimize_dose	Optimizes the dose threshold when anchoring to a gauge.
output_source_file	Specifies the name of the file for the optimized source map. If this is not specified, the source is written to *output_source_1.src* or *output_source_2.src* for the first and second exposures, respectively.
output_unblurred_source_file	Outputs an illuminator-level source map file at the end of a session run.
parallelize_by_pw_conditions	Recommended. Enables distributed processing.
parameterization	Defines the mask shapes that represent features.
pixel_socs_dir	Specifies a new directory in which to cache optical models, potentially improving runtime.
pupil_fill	Specifies the minimum percentage of pixels to illuminate in the source.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 4-2. Calibre pxSMO Setup File Commands (cont.)

Command	Description
pw_condition	Creates print image conditions for dose, focus, resist, and aerial threshold.
pw_condition_group	Creates a group of dose and focus conditions located along a defined process window shape before optimization.
pw_focus_base_points	Specifies defocus conditions for through-focus aerial image calculation. For job types other than CDOF, this command is required when focus_range or focus_center is specified by the pw_variables command.
pw_focus_range_factor	Controls the relative emphasis given to common depth of focus during process window optimization.
pw_select	Restricts simulation to only the specified processes.
pw_tolerance_bound	Requires the process window conditions for a process window condition group to produce contours within a specified area. Used when optimizing common depth of focus.
pw_variables	Specifies the variables for process window optimization.
sample_source	Sets a source to use as a reference during optimization.
save_job_cdof_print_images	Specifies the input layers and process window contours to save for CDOF jobs. Only valid for CDOF jobs.
save_job_mask	Specifies the name of an OASIS file of all clips to save at the end of a job.
save_job_print_image	Specifies the name of a file of contours of all clips to save at the end of a job.
save_job_source	Outputs a source map file at the end of a job using the specified name.
save_job_raw_source	Outputs an illuminator-level source map file at the end of a job using a specified name.
scanner	Sets source parameters to values typical for different manufacturers.
scatter_assist_type	Specifies where to place SRAFs relative to the target layer.
scatter_belt	Identifies how far from the target the SRAF rings should extend.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 4-2. Calibre pxSMO Setup File Commands (cont.)

Command	Description
scatter_offset	Specifies the minimum distance between the main feature and positive SRAFs.
scatter_offset_negative	Specifies the minimum distance between the main feature edge and negative SRAFs.
scatter_offset_type	Sets whether scatter_offset and scatter_offset_negative are calculated based on mask or target shapes.
set_on_target	Improves EPE for the nominal process window condition.
sigma_max	Controls the source manufacturability constraint on maximum allowable sigma for the optimized source.
sigma_min	Controls the source manufacturability constraint on minimum allowable sigma for the optimized source.
source_difference_weight	Sets the importance of the source similarity when the sample_source command is used.
source_symmetry	Specifies the symmetry of the optimized source.
suppress_extra_printing	Specifies SRAF printing suppression for process window conditions or process window condition groups.
variables	Specifies a subset of variables to optimize.
version	Specifies the version to use.
weight_background	Sets the default weight.
weight_layer	Identifies polygon layers which define more important areas for optimization.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

anchor_gid

PxSMO Setup File Commands

Identifies an anchor gauge.

Usage

anchor_gid ***gid***

Arguments

- ***gid***

  A required argument specifying the gauge id to anchor to.

Description

An optional command specifying the anchor gauge id. The clip for the anchor gauge is excluded from objective and gradient calculations.

Related Topics

anchoring_enabled

optimize_dose

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

anchoring_enabled

PxSMO Setup File Commands

Enables optimization with anchoring to a gauge.

Usage

anchoring_enabled { yes | no }

Arguments

- yes | no

  An optional argument specifying whether anchoring to a gauge is enabled (yes). The default is optimization without anchoring to a gauge (no).

Description

An optional setting that enables anchoring the pxSMO optimization to a gauge. When enabled, dose optimization (optimize_dose) must also be specified.

Related Topics

anchor_gid

optimize_dose

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

assist_inside_dose_multiplier

PxSMO Setup File Commands

Scales aerial image from negative assist features.

Usage

assist_inside_dose_multiplier *mult_value*

Arguments

- ***mult_value***

  A required argument giving the value by which to scale the assist features. The default is 1.

Description

An optional command that scales the aerial image near assist features *inside of the target* shapes (for example, negative scattering bars) by the given ***mult_value***.

Related Topics

assist_inside_threshold_multiplier

assist_outside_dose_multiplier

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

assist_inside_threshold_multiplier

PxSMO Setup File Commands

Scales print image from negative assist features.

Usage

assist_inside_threshold_multiplier ***mult_value***

Arguments

- ***mult_value***

  A required argument giving the value by which to scale the assist features. The default is 1.

Description

An optional command that scales the print image near assist features *inside of the target* shapes (for example, negative scattering bars) by the given ***mult_value***.

Related Topics

assist_inside_dose_multiplier

assist_outside_threshold_multiplier

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

assist_outside_dose_multiplier

PxSMO Setup File Commands

Scales aerial image from positive assist features.

Usage

assist_outside_dose_multiplier *mult_value*

Arguments

- ***mult_value***

  A required argument giving the value by which to scale the assist features. The default is 1.

Description

An optional command that scales the aerial image near assist features *outside of the target* shapes (for example, SRAFs) by the given ***mult_value***.

Related Topics

assist_inside_dose_multiplier

assist_outside_threshold_multiplier

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

assist_outside_threshold_multiplier

PxSMO Setup File Commands

Scales print image from positive assist features.

Usage

assist_outside_threshold_multiplier *mult_value*

Arguments

- ***mult_value***

  A required argument giving the value by which to scale the assist features. The default is 1.

Description

An optional command that scales the print image near assist features *outside of the target* shapes (for example, scattering bars) by the given ***mult_value***. If scatter_assist_type is set to “inside,” this command has no effect.

Related Topics

assist_inside_threshold_multiplier

assist_outside_dose_multiplier

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

debug_level

PxSMO Setup File Commands

Writes optimization rates to stdout.

Usage

debug_level {**0** | **1**}

Arguments

- **0**

  A required argument indicating no extra information should be printed. This is the default.

- **1**

  A required argument that causes additional information to be printed to standard output (stdout). The additional information includes the following:

  - Optimization rates and clip weights.
  - For CDOF optimization, post-optimization values for focus_range, focus_center, and dose_center variables.

Description

The debug_level command controls whether optimization values are output. This can be useful for tuning recipes.

Note

Do not use this command in a production setup file. It makes the log file very large and slows down the run.

Examples

```
debug_level 0
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

delete_pixel_socs_dir_after_read

PxSMO Setup File Commands

Deletes the pixel SOCS directory after reading it.

Usage

delete_pixel_socs_dir_after_read {no | yes}

Arguments

- no

  A required argument indicating the pixel SOCS directory remains after it is read. The default is no.

- yes

  A required argument that deletes the pixel SOCS directory after it is read.

Description

An optional command that deletes the pixel SOCS directory after reading it. Deleting the directory created by a pixel_socs_dir command is potentially useful when minimizing disk space usage. The default behavior is the pixel SOCS directory remains after it is read.

Related Topics

pixel_socs_dir

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

enable_periodicity

PxSMO Setup File Commands

Reads clip periodicity information from the *clips.dat* file when custom clips are used.

Usage

enable_periodicity no | yes

Arguments

- no | yes

  An optional argument specifying whether periodicity for a custom clip is enabled (yes). The default is periodicity disabled (no).

Description

An optional setting that reads periodicity information from the *clips.dat* file and applies the settings when custom clips are used. When enabled, the pxSMO stage processes the clips using the clip periodicity information. Otherwise, the custom clips are not treated as periodic clips.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

fixed_source

PxSMO Setup File Commands

Sets parts of a source to fixed illumination levels to allow optimization on the remaining parts of the source.

Usage

fixed_source *filename*

Arguments

- ***filename***

  A required argument that specifies the name of the input source map. The input source map specifies parts of the source and their illumination intensities that are fixed during source optimization. Only the parts of the input source having an intensity of zero are optimized.

Description

An optional global command that specifies parts of the source that are fixed during source optimization. The bright pixels of the input source are considered fixed if fixed_source_optimization_region is not specified.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

fixed_source_optimization_region

PxSMO Setup File Commands

Optimizes source pixel intensities in a specified part of a source while other pixels remain fixed.

Usage

fixed_source_optimization_region ***type*** sigma_min *sigma_min_val* **sigma_max** ***sigma_max_val*** illumangle *illumangle_val* rotangle *rotangle_val* {inside|outside}

Arguments

- ***type***

  A required keyword specifying the type of the source. Specify one of the following:

  standard — A single circular illuminated area defined by a sigma_max value.

  annular — A single ring defined by sigma_max and sigma_min values.

  dipolex — Two illuminated spots on the horizontal axis. Defined by illumangle, sigma_max, and sigma_min values.

  dipoley — Two illuminated spots on the vertical axis. Defined by illumangle, sigma_max, and sigma_min values.

  mirrored pole — Two illuminated spots on a rotated axis. Defined by rotangle, illumangle, sigma_max, and sigma_min values.

  quasar — Four illuminated spots on axes rotated 45 degrees from horizontal and vertical. Defined by illumangle, sigma_max, and sigma_min values.

  cquad — Four illuminated spots on the horizontal and vertical axes. Defined by illumangle, sigma_max and sigma_min values.

  In the descriptions above, sigma is measured from the center of the source out to the edge.

- sigma_min *sigma_min_val*

  An argument set specifying the inner sigma of the source optimization region. Required for annular, dipolex, dipoley, mirrored_pole, quasar, and cquad source regions.

- **sigma_max** ***sigma_max_val***

  A required argument set specifying the outer sigma of the source optimization region.

- illumangle *illumangle_val*

  An argument set specifying the illumination angle of the source optimization region. Required for dipolex, dipoley, mirrored_pole, quasar, and cquad source regions.

- rotangle *rotangle_val*

  An argument set specifying a custom rotation angle for the source optimization region. Required for mirrored_pole source regions.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

- inside | outside

  An optional argument specifying what part of the source is optimized. The inside setting optimizes pixels inside the defined source shape; the outside setting optimizes outside. The default behavior optimizes pixels inside the defined source shape.

Description

An optional command that optimizes the pixels in a specified region of the source. By restricting optimization to specific regions and fixing pixel intensities in the remaining regions, a runtime benefit may be realized.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

init

PxSMO Setup File Commands

Identifies the initial mask.

Usage

init ***layer1*** [*layer2*]

Arguments

- ***layer1***

  A required argument identifying a layer to be used for the initial mask (mask 0 if using two exposures). The ***layer1*** name should match that of a layer statement within the setup file. The layer must be of type **correction** or **target**. Names are not case sensitive.

- *layer2*

  An optional layer that initializes mask1 for a dual exposure mask. The layer must be of type **correction** or **target** and listed in a layer statement.

Description

This optional statement initializes the mask using the specified input layer(s). The ***layer1*** layer is used for the first exposure and the *layer2* layer for the second exposure.

If this command is not used in the setup file, then the starting mask is the correction layer. If the correction layer is not present or is not unique, the starting mask is the target layer.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

initial_source

PxSMO Setup File Commands

Sets the initial source type, overriding any optical sources passed in the litho model.

Usage

initial_source ***type***

Arguments

- ***type***

  A required keyword specifying the type of the source. The default is **conventional**. Specify one of the following:

  conventional — A single circular illuminated area with sigma 1.0.

  annular — A single ring with sigma from 0.75 to 1.0.

  quasar — Four illuminated spots on the outer rim. Sigma is from 0.75 to 1.0. Phi extends 0.1π around the points 1/4π, 3/4π, 5/4π, and 7/4π.

  quadrapole — Four illuminated spots on the outer rim. Sigma is from 0.75 to 1.0. Phi extends 0.1π around the points 0, 1/2π, π, and 3/2π.

  horiz_dipole — Two illuminated spots on the outer rim. Sigma is from 0.75 to 1.0. Phi extends 0.1π around the points 0 and π.

  vert_dipole — Two illuminated spots on the outer rim. Sigma is from 0.75 to 1.0. Phi extends 0.1π around the points 0.5π and 1.5π.

  random — All pixels within the normal conventional area receive a random value for intensity. The integral over the source shape equals 1.

  filename — A filename of a file containing a source map (*.src*).

  In the descriptions above, sigma is measured from the center of the source out to the edge, and phi is measured around the circumference, with 0 at the rightmost point.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

iterations

PxSMO Setup File Commands

Specifies how many iterations the job should run.

Usage

iterations ***number_of_iterations***

Arguments

- ***number_of_iterations***

  A required positive integer that specifies how many passes are performed. The default value depends on the job type:

Start	50
Decorate	15
Improve	25
Polish	500, or With Polish-2 job, 300 each (when Image Model is set to CM1). When a CDOF job is also specified, Polish defaults to 100.

Description

This command specifies the iteration count of optimization algorithms. It can be set either in the general section, in which case all jobs run through the same number of optimization passes, or on a per-job basis.

Examples

```
iterations 500
```

Related Topics

job

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

job

PxSMO Setup File Commands

Calls the various phases and allows local overrides of settings.

Usage

job ***number type***

Arguments

- ***number***

  A required integer identifying the job. Jobs are numbered sequentially starting at 1.

- ***type***

  A required argument specifying the job type. The following values are supported:

  start — Optimizes the source based on the slope of the image intensity, taking into consideration extra printing and EPE.

  decorate — Optimizes the mask by adding SRAFs. The placement and sizes of the SRAFs are set to deliver maximum process latitude for the given process corners. This job is optional if your main focus is on source optimization.

  improve — Optimizes the edge placement, as measured by reducing the range of values for the edge placement error across the selected process windows. SRAF printing is eliminated.

  polish — Performs fine-grained optimization for the best match between simulated contours and target and optimizes for the slope of the aerial image or CM1 surface. Any extra printing is eliminated.

  cdof — Optimizes source and mask for maximal depth of focus at a specified exposure latitude.

  el — Optimizes source and mask for maximal exposure latitude at a specified depth of focus.

  In general, your run should begin with start and end with polish. The other job types can be used at your discretion. If all job types are used, list them in the order in the list above.

  For a run performing source-only optimization, use the following job types:

  - start_so
  - improve_so
  - polish_so
  - cdof_so
  - el_so

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Each source-only job type performs similar functions as the full SMO version without changing mask features. If all source-only job types are used, list them in the order in the list as previously described.

For a run performing mask-only optimization, use the following job types:

- start_mo
- decorate_mo
- improve_mo
- polish_mo
- cdof_mo
- el_mo

Each mask-only job type performs similar functions as the full SMO version without changing the source. If all mask-only job types are used, list them in the order in the list as previously described.

Description

The Calibre pxSMO setup file begins with general options such as pupil_fill and then lists specific jobs. The job types are specific combinations of solvers and preset objectives that work well in sequence. You can tune the job results by specifying local overrides using other setup file commands, such as iteration.

Examples

Example 1

In this simple recipe generated by the RET Selection interface, each job uses a different combination of process window conditions. (The definitions of the process window conditions is not shown.)

```
...
job 1 start
job 2 decorate
pw_select Nominal_1.0
job 3 improve
pw_select Nominal_1.0 pxsmo_pxopc_inner_1.0 pxsmo_pxopc_outer_1.0
iterations 60
...
```


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layer

PxSMO Setup File Commands

Defines layer characteristics such as name and type.

Usage

layer ***layername mtype*** [mask_layer *lm_num*]

Arguments

- ***layername***

  A required argument specifying the name of the layer. Layer names must be alphanumeric strings less than 32 characters in length.

- ***mtype***

  A required argument specifying the layer type. Must be one of the following:

  target — The optimal layout. The output contours from simulation are compared to this layer and the difference minimized.

  correction — An initial mask.

  hidden — Weight layers. Layers of this type are neither changed nor simulated.

  visible — A layer used in optical simulations.

  Layers referenced by the init keyword must have an ***mtype*** of target or correction.

- mask_layer *lm_num*

  An optional argument that maps the layer to the mask block in the litho model. The default is 0.

Description

Names and describes the optical properties of the input layer(s). Every layer used in the pxSMO run must be declared in the setup file using this command.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_enabled

PxSMO Setup File Commands

Activates curvilinear MRC constraints.

Usage

mrc_enabled [no | yes]

Arguments

- no | yes

  An optional argument specifying activation of curvilinear MRC constraints. The default is no (curvilinear MRC constraints off).

Description

An optional command specifying activation of curvilinear MRC constraints in improve or polish jobs.

Examples

Example 1

The following example activates curvilinear MRC constraints and permits curvilinear shapes as close as 12 nanometers and as narrow as 12 nanometers wide.

```
job 3 improve
   mrc_enabled yes
   mrc_min_external 0.012
   mrc_min_internal 0.012
   ...
job 4 polish
   mrc_enabled yes
   mrc_min_external 0.012
   mrc_min_internal 0.012
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_max_internal_sraf

PxSMO Setup File Commands

Constrains maximum internal spacing during MRC for SRAFs only.

Usage

mrc_max_internal_sraf ***max_internal_val***

Arguments

- ***max_internal_val***

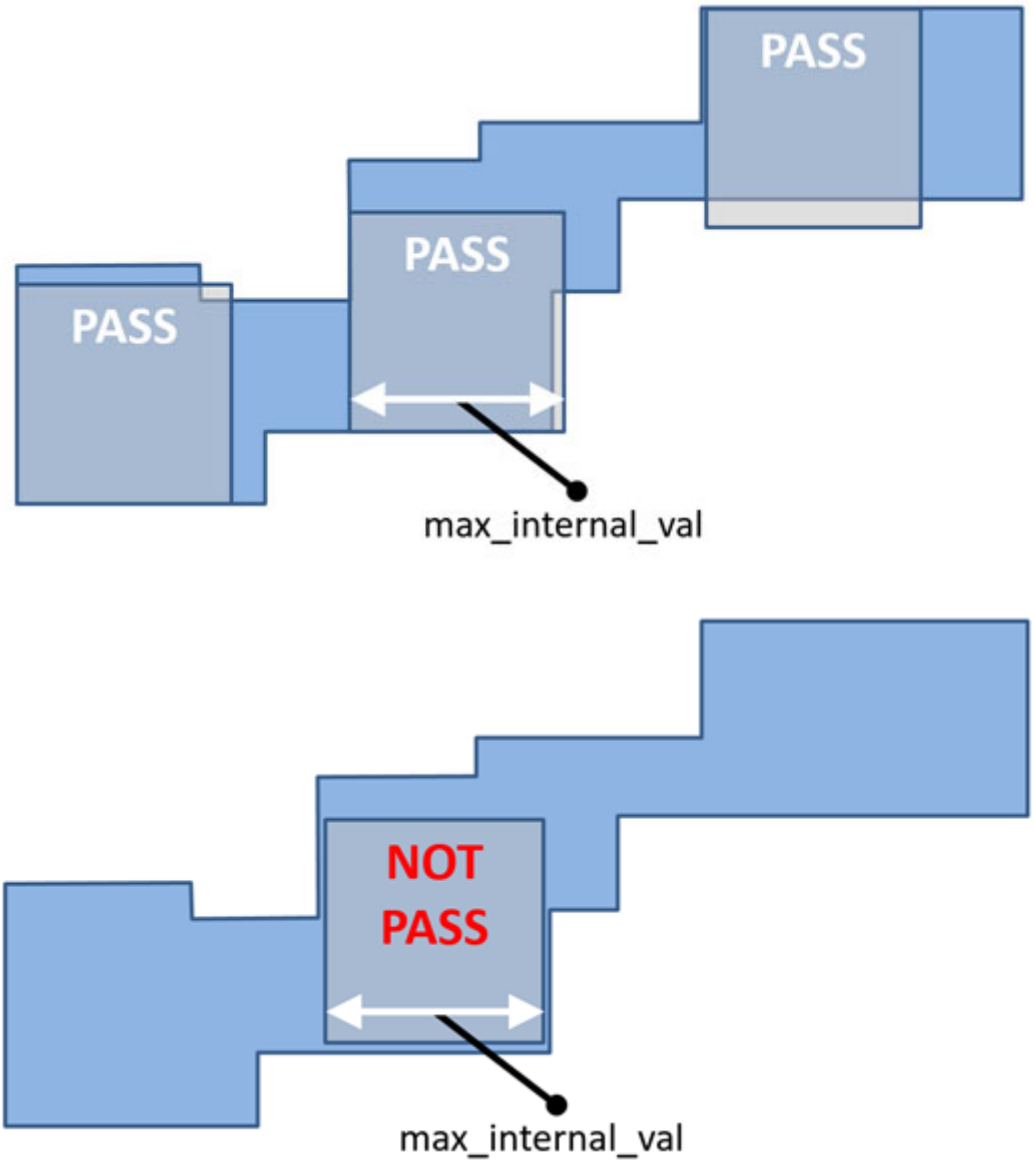
  A required argument specifying a maximum distance in microns between facing edges of a single SRAF polygon during MRC. The default behavior is to ignore maximum width.

Description

This optional command allows setting the maximum internal MRC constraint for Manhattan SRAFs explicitly. An SRAF passes the maximum internal width constraint if no square with

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

max_internal_val sides fits inside the feature. MRC attempts to shrink features to meet the maximum width constraint.



For Manhattan SRAF shapes, specify the command in the improve and polish jobs.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Examples

Example 1 - Manhattan SRAFs

This combination constrains Manhattan SRAF shapes to allow only squares with sides smaller than 25 nm to fit inside the SRAF:

```
job 3 improve
   mrc_max_internal_sraf 0.025
   ...
job 4 polish
   mrc_max_internal_sraf 0.025
   ...
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_area

PxSMO Setup File Commands

Constrains the minimum SRAF area during MRC.

Usage

mrc_min_area ***min_sraf_area_val***

Arguments

- ***min_sraf_area_val***

  A required argument specifying a minimum area for SRAFs in square microns during MRC. The default value is 0.

Description

An optional command that specifies the minimum SRAF size during MRC. For Manhhattan SRAFs, use the command in both improve and polish jobs. For curvilinear SRAFs, use the command in both the improve and polish jobs, and specify "mrc_enabled yes" in each job to activate MRC constraints for curvilinear output. For SRAFs that violate the minimum area check, the MRC increases their size to meet the constraint.

Examples

Example 1— Manhattan MRC

The following example ensures Manhattan SRAFs larger than 0.0015 square microns:

```
job 3 improve
   mrc_min_area 0.0015
   ...
job 4 polish
   mrc_min_area 0.0015
   ...
```

Example 2— Curvilinear MRC

The following example ensures curvilinear SRAFs larger than 0.0015 square microns:

```
job 3 improve
   mrc_enabled yes
   mrc_min_area 0.0015
   ...
job 4 polish
   mrc_enabled yes
   mrc_min_area 0.0015
   ...
```

The mrc_enabled statement is required to activate curvilinear MRC.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_edge

PxSMO Setup File Commands

Sets a preferred edge length for Manhattan MRC geometries.

Usage

mrc_min_edge ***min_edge_val***

Arguments

- ***min_edge_val***

  A required argument specifying the preferred length in microns of the edges for MRC-simplified geometries. The default is 0.015 um.

Description

Sets a preferred length for edges once contours are converted to shapes with fragmented Manhattan edges. This command has no effect in the early contour-driven stages and applies only to Manhattan shapes.

Notice that the length is *preferred*; this means some edges may be smaller or larger if required.

If using improve and polish jobs, set the same value for mrc_min_edge for both. A difference in values can cause SRAFs to print.

Examples

```
# set the mrc_min_edge command where it matters:
job 3 improve
mrc_min_edge 0.015
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_external

PxSMO Setup File Commands

Constrains external spacing during MRC.

Usage

mrc_min_external ***min_external_val***

Arguments

- ***min_external_val***

  A required argument specifying a minimum distance in microns between the exterior sides of edges during MRC. The default is 0.015 um.

Description

An optional command that specifies the distance between two exterior edges during MRC jobs. For Manhattan SRAFs, use the command in both the improve and polish jobs. For curvilinear SRAFs, use the command in both the improve and polish jobs, and specify "mrc_enabled yes" in each job to activate MRC constraints for curvilinear output. The edges can occur on the same polygon, such as a notch.

Examples

Example 1 — Manhattan MRC

In the following example, the mrc_min_external statement permits Manhattan shapes as close as 0.012 microns; the mrc_min_internal statement permits Manhattan features 0.012 microns and wider:

```
job 3 improve
   mrc_min_external 0.012 # permits shapes closer together than the
                          # default
   mrc_min_internal 0.012 # also permits narrower minimum feature
job 4 polish
   mrc_min_external 0.012
   mrc_min_internal 0.012
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Example 2 — Curvilinear MRC

In the following example, the mrc_min_external statement permits curvilinear shapes as close as 0.012 microns; the mrc_min_internal statement permits curvilinear features 0.012 microns and wider:

```
job 3 improve
   mrc_enabled yes
   mrc_min_external 0.012
   mrc_min_internal 0.012
   ...
job 4 polish
   mrc_enabled yes
   mrc_min_external 0.012
   mrc_min_internal 0.012
   ...
```

The mrc_enabled statement is required to activate curvilinear MRC.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_external_main2sraf

PxSMO Setup File Commands

Constrains external spacing during MRC between a main feature and an SRAF.

Usage

mrc_min_external_main2sraf ***min_external_val***

Arguments

- ***min_external_val***

  A required argument specifying a minimum distance in microns between the exterior sides of edges during MRC. The default is the maximum of mrc_min_external and mrc_min_external_sraf.

Description

An optional command that specifies the exterior distance between main features and SRAF edges during MRC. For Manhattan shapes, use the command in both the improve and polish jobs. For curvilinear shapes, use the command in both the improve and polish jobs, and specify "mrc_enabled yes" in each job to activate curvilinear MRC. If mrc_min_external_main2sraf is not set, the offset between main features and SRAFs is checked against the larger of mrc_min_external and mrc_min_external_sraf.

Examples

Example 1 — Manhattan MRC

The following example permits Manhattan shapes as close as 14 nanometers and 14 nanometers between SRAFs; main-to-SRAF distance is set to 15 nanometers:

```
job 3 improve
   mrc_min_external 0.014 # permits shapes closer together than the
                          # default
   mrc_min_external_sraf 0.014 # also permits closer SRAFs
   mrc_min_external_main2sraf 0.015 # sets a larger main-to-SRAF distance
job 4 polish
   mrc_min_external 0.014
   mrc_min_external_sraf 0.014
   mrc_min_external_main2sraf 0.015
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Example 2— Curvilinear MRC

The following example permits curvilinear shapes as close as 14 nanometers and 14 nanometers between SRAFs; main-to-SRAF distance is set to 15 nanometers:

```
job 3 improve
   mrc_enabled yes
   mrc_min_external 0.014
   mrc_min_external_sraf 0.014
   mrc_min_external_main2sraf 0.015
   ...
job 4 polish
   mrc_enabled yes
   mrc_min_external 0.014
   mrc_min_external_sraf 0.014
   mrc_min_external_main2sraf 0.015
   ...
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_external_sraf

PxSMO Setup File Commands

Constrains external spacing during MRC for SRAFs only.

Usage

mrc_min_external_sraf ***min_external_val***

Arguments

- ***min_external_val***

  A required argument specifying a minimum distance in microns between the exterior sides of edges during MRC. The default is the maximal value used for mrc_min_external and mrc_min_external_sraf.

Description

An optional command that specifies the exterior distance SRAF edges during MRC. For Manhattan SRAFs, use the command in both the improve and polish jobs. For curvilinear SRAFs, use the command in both the improve and polish jobs, and specify "mrc_enabled yes" in each job to activate MRC constraints for curvilinear output.

This command can be used to set different MRC limits for the distance between the main features and SRAFs. If mrc_min_external_main2sraf is not set, then the offset between main features and SRAFs is checked against the larger of mrc_min_external and mrc_min_external_sraf.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_internal

PxSMO Setup File Commands

Sets the minimum distance between two internal edges.

Usage

mrc_min_internal ***min_internal_val***

Arguments

- ***min_internal_val***

  A required argument specifying a minimum distance in microns between facing edges of a single polygon during MRC. The default is 0.015 um.

Description

An optional command that specifies the distance between two internal edges of a shape during MRC. For Manhattan shapes, use the command in both the improve and polish jobs. For curvilinear shapes, use the command in both the improve and polish jobs, and specify "mrc_enabled yes" in each job to activate curvilinear MRC. Use this keyword for controlling the size of primary features. Use mrc_min_rect_width or mrc_small_feature_size for controlling the size of secondary features such as SRAFs.

Examples

Example 1 — Manhattan MRC

In the following example, the mrc_min_internal statement permits Manhattan features 0.012 microns and wider; the mrc_min_external statement permits Manhattan shapes as close as 0.012 microns:

```
job 3 improve
   mrc_min_external 0.012 # permits shapes closer together than the
                          # default
   mrc_min_internal 0.012 # also permits narrower minimum feature
job 4 polish
   mrc_min_external 0.012
   mrc_min_internal 0.012
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Example 2 — Curvilinear MRC

In the following example, the mrc_min_internal statement permits curvilinear features 0.012 microns and wider; the mrc_min_external statement permits curvilinear shapes as close as 0.012 microns:

```
job 3 improve
   mrc_enabled yes
   mrc_min_external 0.012
   mrc_min_internal 0.012
   ...
job 4 polish
   mrc_enabled yes
   mrc_min_external 0.012
   mrc_min_internal 0.012
   ...
```

The mrc_enabled statement is required to activate curvilinear MRC.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_internal_sraf

PxSMO Setup File Commands

Constrains internal spacing during MRC for SRAFs only.

Usage

mrc_min_internal_sraf ***min_internal_val***

Arguments

- ***min_internal_val***

  A required argument specifying a minimum distance in microns between facing edges of a single SRAF polygon during MRC. The default is 0.015.

Description

This optional command allows setting the internal MRC constraint for SRAFs explicitly. This may be simpler to use than the other options for applying internal MRC checks to SRAFs:

- mrc_small_feature_size
- A combination of any of mrc_min_rect_length, mrc_min_rect_width, mrc_min_square, and mrc_min_length
- A combination of mrc_min_small_feature_area_excess and mrc_min_edge

For Manhattan SRAF shapes, specify the command in the improve and polish jobs. For curvilinear SRAFs, use the command in both the improve and polish jobs, and specify "mrc_enabled yes" in each job to activate MRC constraints for curvilinear output.

Examples

Example 1 - Manhattan SRAFs

This combination allows Manhattan SRAF shapes to be narrower than main features:

```
job 3 improve
   mrc_min_internal      0.02
   mrc_min_internal_sraf 0.015
   ...
job 4 polish
   mrc_min_internal      0.02
   mrc_min_internal_sraf 0.015
   ...
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Example 2 - Curvilinear SRAFs

This combination allows curvilinear SRAFs to be narrower than main features:

```
job 3 improve
   mrc_enabled yes
   mrc_min_internal      0.02
   mrc_min_internal_sraf 0.015
   ...
job 4 polish
   mrc_enabled yes
   mrc_min_internal      0.02
   mrc_min_internal_sraf 0.015
   ...
```

The mrc_enabled statement is required to activate curvilinear MRC.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_length

PxSMO Setup File Commands

Sets the minimum distance between two internal edges for Manhattan shapes.

Usage

mrc_min_length ***min_length_val***

Arguments

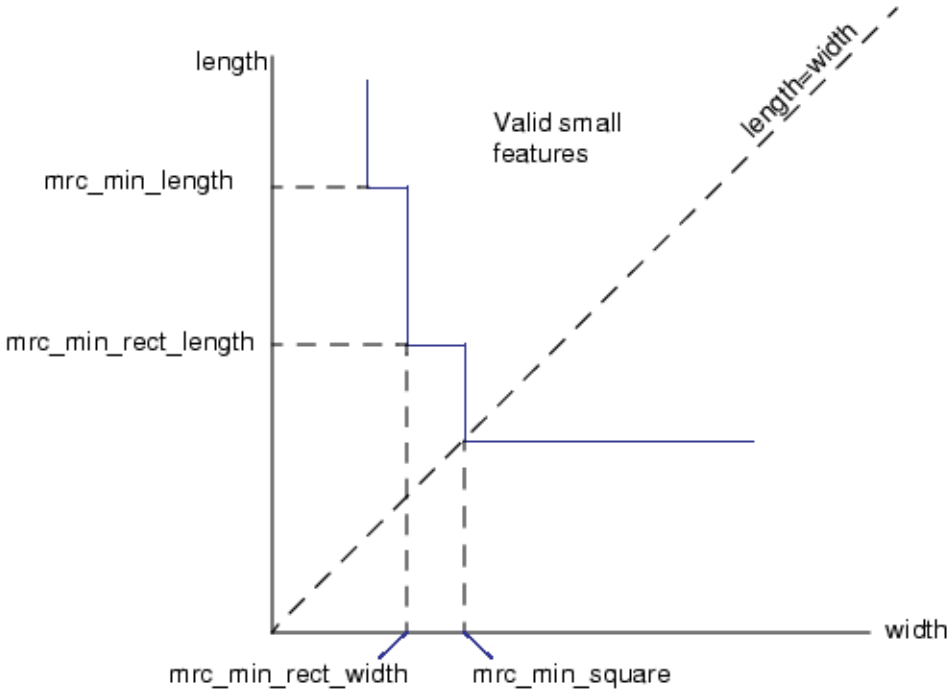
- ***min_length_val***

  A required argument specifying a minimum distance in microns between the shorter facing edges of a single polygon during MRC. The default is 0.015 um. If the polygon is square, the pair of edges are chosen arbitrarily. This command applies only to Manhattan shapes.

Description

An optional command that specifies the distance between two internal edges of a shape during MRC in improve and polish jobs. Use this control for secondary features.

Figure 4-1. Valid Small Features for MRC - mrc_min_length



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_rect_length

PxSMO Setup File Commands

Sets the minimum distance between two internal edges for Manhattan shapes.

Usage

mrc_min_rect_length ***min_val***

Arguments

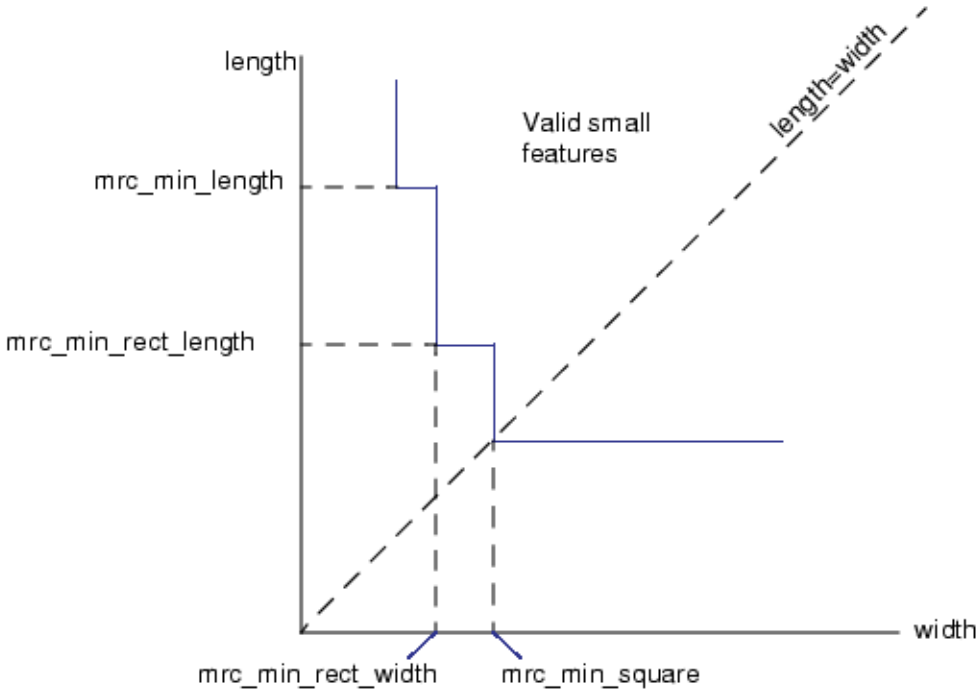
- ***min_val***

  A required argument specifying a minimum distance in microns between the shorter facing edges of a single polygon during MRC. The default is 0.015 um.

Description

An optional command that specifies the distance between two internal edges of a shape during MRC in improve and polish jobs. Use in conjunction with mrc_min_rect_width for controlling secondary features such as SRAFs. This command applies only to Manhattan shapes.

Figure 4-2. Valid Small Features for MRC - mrc_min_rect_length



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_rect_width

PxSMO Setup File Commands

Sets the minimum distance between two internal edges for Manhattan shapes.

Usage

mrc_min_rect_width *min_val*

Arguments

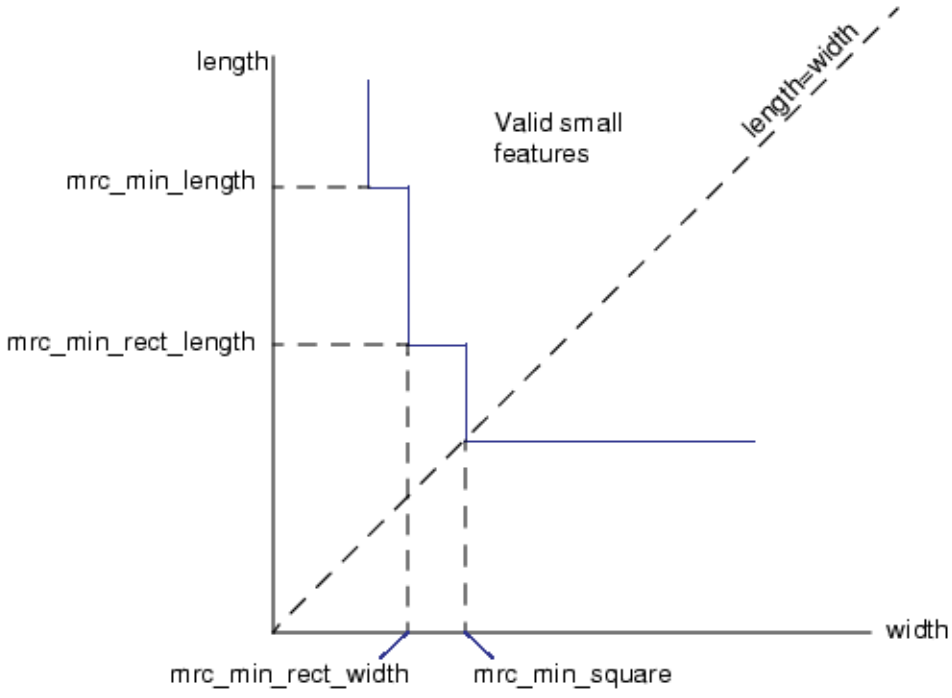
- ***min_val***

  A required argument specifying a minimum distance in microns between the longer facing edges of a single polygon during MRC. The default is 0.015 um.

Description

An optional command that specifies the distance between two internal edges of a shape during MRC in improve and polish jobs. Use in conjunction with mrc_min_rect_length to control small secondary features such as SRAFs. This command applies only to Manhattan shapes.

Figure 4-3. Valid Small Features for MRC - mrc_min_rect_width



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_small_feature_area_excess

PxSMO Setup File Commands

Sets the minimum area for features on the mask for Manhattan shapes.

Usage

mrc_min_small_feature_area_excess *min_val*

Arguments

- ***min_val***

  A required argument specifying a value in microns.

  Features that are smaller than the minimum area are either deleted so they do not appear in the output mask, or increased in size until larger than the minimum area.

  0 <= ***min_val*** < 3 * mrc_min_edge.

Description

An optional command that specifies the minimum area for features on a mask. This can be useful for preventing undersized SRAFs. This command applies to Manhattan shapes only.

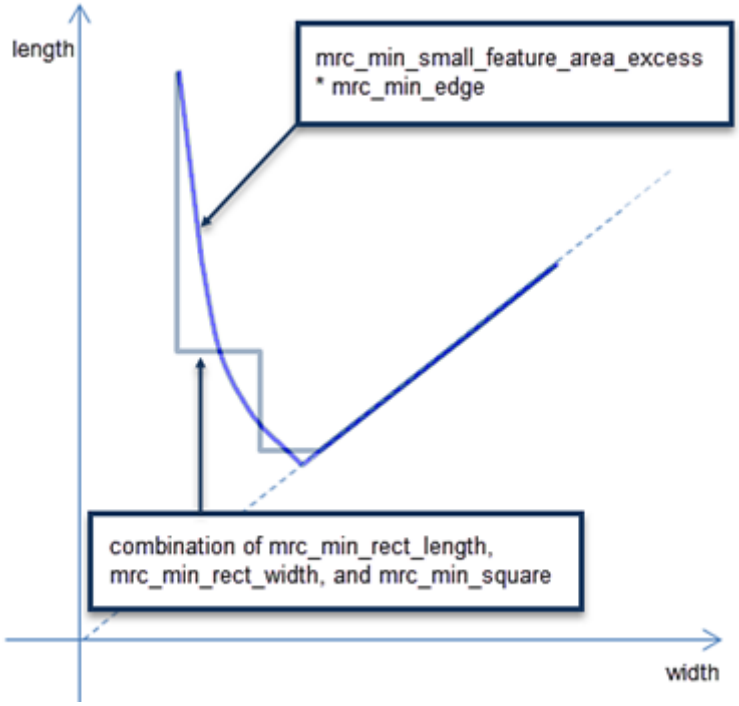
The minimum area is determined by ***min_val*** * mrc_min_edge. This does not restrict either edge's length; only the SRAF area is constrained. The default is to not have a minimum size.

The benefit of mrc_min_small_feature_area_excess is that unlike mrc_min_square, the edges are not the same size. The mrc_min_small_feature_area_excess keyword also scales with mrc_min_edge, unlike the combination of mrc_min_rect_width and mrc_min_rect_length.

The following figure contrasts the different threshold conditions for valid small features using the two methods.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 4-4. Comparison of SRAF MRC Methods



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_min_square

PxSMO Setup File Commands

Sets the minimum distance between two internal edges for Manhattan shapes.

Usage

mrc_min_square ***min_square_val***

Arguments

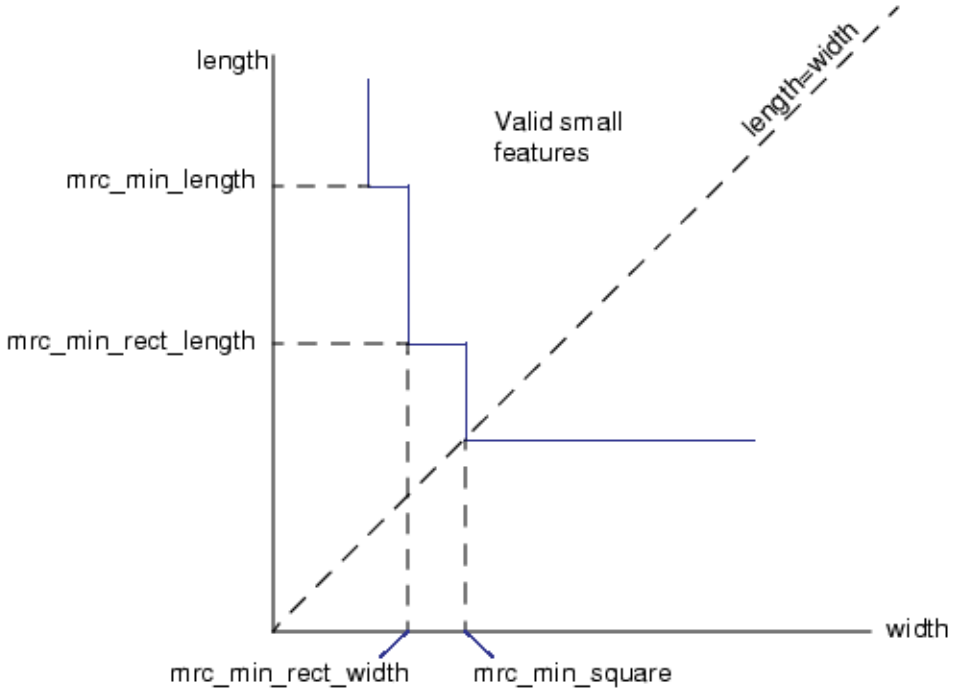
- ***min_square_val***

  A required argument specifying a minimum distance in microns between facing edges of a square during MRC. The default is 0.015 um.

Description

An optional command that specifies the distance between two internal edges of a shape during MRC in improve and polish jobs. This value should be smaller than mrc_min_length. Use to control small secondary features such as SRAFs. For primary square features such as contacts, use mrc_min_internal. This command applies to Manhattan shapes only.

Figure 4-5. Valid Small Features for MRC - mrc_min_square



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

mrc_small_feature_size

PxSMO Setup File Commands

Sets the minimum distance between two internal edges for Manhattan shapes.

Usage

mrc_small_feature_size *min_val*

Arguments

- ***min_val***

  A required argument specifying a minimum distance in microns between facing edges of a single polygon during MRC. The default is 0.015 um.

Description

An optional command that specifies the distance between two internal edges of a shape during MRC in improve and polish jobs. Features smaller than this size are not processed; they disappear from the output. This command applies to Manhattan shapes only.

To determine a good ***min_val***, one guideline is to not exceed the value of mrc_min_square.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

objective_region

PxSMO Setup File Commands

Optimizes a region using specified objectives.

Usage

objective_region {***region_layer*** | **backdrop**}
{{**set** | **add**} {***objective obj_factor***} [{*objective obj_factor*}...]}
[pw *cond_name* [*cond_name*...]]

Arguments

- ***region_layer*** | **backdrop**

  A required argument specifying the region to which the objectives are applied. Either ***region_layer*** or **backdrop** must be specified.

  region_layer

  A required argument specifying the input layer to which the objectives are applied.

  backdrop

  A required argument that applies the specified objective to the entire layout except for regions of the layer where the objectives are specified in other **objective_region** statements using the **set** argument.

  When used with the **set** argument, the specified objective replaces the existing objective. When used with the **add** argument, the specified objective is applied in addition to the pre-existing objective.

- **set** | **add** ***objective obj_factor***

  A required argument that optimizes ***region_layer*** using only a specified set of objective(s).

  - **set** — Optimizes the ***region_layer*** using only the objectives specified in the set statement.
  - **add** — Optimizes the ***region_layer*** by combining the existing objectives with the objectives specified in the add statement.
  - ***objective*** — A required objective used for optimization. At least one objective must be specified, and one factor value must follow each objective. The following objective values are supported:
    - **epe** — Optimizes the mask to minimize the sum of edge placement error (EPE).
    - **eperms** — Optimizes the mask to minimize the total area of edge placement error (EPE). Useful for layers with line-end features.
    - **slope** — Optimizes the mask to maximize the image slope.
    - **extraprint** — Optimizes the mask to minimize extra printing.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

- **contour_diff** — Optimizes the mask to minimize contour differences between the specified process window conditions. At least two process window conditions must be specified.
- *<job name>* — Applies the default objectives for the specified job name.

- ***obj_factor*** — A required non-negative coefficient applied to the specified objective. Higher values emphasize the corresponding objective.

- pw *cond_name*

  An optional argument specifying the process window conditions to simulate. The contour_diff objective requires at least two process window conditions. The process window condition name must be used as the *cond_name* in a pw_condition statement. The process window condition name must also be specified in the pw_select statement for the job. The default behavior is to simulate all PW conditions.

Description

An optional statement that applies a custom objective to optimize a marker layer. The custom objective can be a single objective or a linear combination of multiple objectives.

Examples

Example 1

The following example uses a combination of objectives for optimizing the lineends1 mask layer:

```
objective_region lineends1 set epe 0.99 extraprint 0.99 slope 0.02
```

Example 2

The next example sets different objectives to use for the same region but two different process window conditions:

```
objective_region region1 set epe 0.7 pw nominal
objective_region region1 set extraprint 0.3 pw outer
```

Example 3

The next example overrides the default polish objectives in the extraprint_region on an outer process window condition. The default polish objectives are restored for regions outside of the extraprint_region on the nominal process window condition.

```
job 5 polish
 pw_select nominal outer
 objective_region extraprint_region set extraprint 10 pw outer
 objective_region backdrop set polish 1 pw nominal
```

Example 4

The next example minimizes the contour differences in region2 for two different focus settings:

```
objective_region region2 add contour_diff 10 pw focus_plus focus_minus
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

optimize_dose

PxSMO Setup File Commands

Optimizes the dose threshold when anchoring to a gauge.

Usage

optimize_dose ***dose_min dose_max*** [nominal | all | threshold_all]

Arguments

- ***dose_min***

  A required argument specifying the minimum dose value for optimization.

- ***dose_max***

  A required argument specifying the maximum dose value for optimization.

- nominal | all | threshold_all

  An optional argument specifying the process window conditions to optimize. The following dose optimization values are supported:

  - nominal — Optimizes the dose of the nominal process window condition. The differences between the nominal dose and doses for other process window conditions are kept constant.
  - all — Optimizes the nominal dose and adjusts the doses of all process window conditions by multiplying each dose with the ratio of the optimized dose and nominal dose.
  - threshold_all — Optimizes the ratio of dose and threshold.

Description

An optional command optimizing the dose within a specified range during anchoring.

Note

The “threshold_all” optimization is recommended when anchoring to a gauge.

Examples

The following example specifies the recommended optimization method using a generous dose range:

```
optimize_dose 0.01 100 threshold_all
```

Related Topics

anchor_gid

anchoring_enabled

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

output_source_file

PxSMO Setup File Commands

Specifies the name of the file for the optimized source map. If this is not specified, the source is written to *output_source_1.src* or *output_source_2.src* for the first and second exposures, respectively.

Usage

output_source_file *filename*

Arguments

- ***filename***

  A required argument that specifies the name of the file for the optimized source map. The convention is to use a *.src* suffix, but this is not applied automatically.

  The source map is in text format. Each line consists of x and y coordinates and the filtered and smoothed intensity of a pixel.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

output_unblurred_source_file

PxSMO Setup File Commands

Outputs an illuminator-level source map file at the end of a session run.

Usage

output_unblurred_source_file *filename*

Arguments

- ***filename***

  A required argument that specifies the name of the file for the source map at the end of the session run. The convention is to use a *.src* suffix, but this is not applied automatically.

  The source map is in text format. Each line consists of x and y coordinates and the filtered and smoothed intensity of a pixel.

Description

An optional command that specifies the name of an illuminator-level source map file saved at the end of a session run. The illuminator-level source differs from a reticle-level or wafer-level source by removing blurring caused by the optical system. The command is added to the general section of a setup file to produce a source suitable for the design of a diffractive optical element (DOE).

The file is saved in the session directory.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

parallelize_by_pw_conditions

PxSMO Setup File Commands

Recommended. Enables distributed processing.

Usage

parallelize_by_pw_conditions {**yes** | **no**}

Arguments

- **yes** | **no**

  A required argument indicating whether parallelization by process window conditions is enabled (**yes**). The default is to parallelize only by clips (**no**).

Description

An optional setting that enables additional parallelization when run in Calibre MTflex mode.

By default, parallelization is done by clips only, with a remote host receiving the clip and all enabled process window conditions. (A clip is a portion of layout plus a gauge.) When this command is set to “yes”, the remote host receives a clip and single process window condition. To get the maximum benefit from this option, the remote setup file or script should request as many remote CPUs as (number of process window conditions) x (number of gauges).

The results may be slightly different between “yes” and “no” runs. This is expected because Calibre pxSMO optimization is sensitive to the order of calculations. The final sources, however, are not significantly different.

This command is added to *pxsmo.in* when the Parallel PW option in the SMO Setup **Advanced** tab is selected.

Examples

```
parallelize_by_pw_conditions yes
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

parameterization

PxSMO Setup File Commands

Defines the mask shapes that represent features.

Usage

parameterization ***main_param***

Arguments

- ***main_param***

  A required argument specifying the mask representation of the main features. If parameterization is not specified, curvilinear shapes represent all mask features. The following mask representations are supported:

  - **compliant** — All features represented with Manhattan edges and MRC-checked.
  - **compliantrectsraf** —Main features represented with Manhattan edges and assist features represented with rectangles. All features are MRC-checked.

Description

An optional command specifying the shape type used to represent features on the mask. If parameterization is not specified, curvilinear shapes represent all mask features. The decorate, improve, polish, cdof, and el job types support parameterization statements.

Examples

The following example generates Manhattan main features with rectangular assist features in the polish job:

```
job 4 polish
   parameterization compliantrectsraf
   ...
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pixel_socs_dir

PxSMO Setup File Commands

Specifies a new directory in which to cache optical models, potentially improving runtime.

Note

To reuse cached optical models, you must set Dispatcher Mode: Off in Run Control. Using one of the dispatcher modes generally improves run time more than pixel_socs_dir.

Usage

pixel_socs_dir ***cache_directory***

Arguments

- ***cache_directory***

  A required argument specifying a directory to use for caching optical models. The directory should either not exist, or should have been created by an earlier pixel_socs_dir command. It must not be shared with other content. Specifying an existing directory generates a warning.

  Use a full path for ***cache_directory***. When running in distributed mode, a local directory will not necessarily be visible to all remote CPUs.

Description

The pixel_socs_dir command uses the ***cache_directory*** directory to store all optical models that are needed during optimization for all clips, defocus conditions, and source pixels. Calibre pxSMO reuses appropriate optical models as determined by the combination of clip size, defocus condition, and source pixels. If no appropriate model is in the directory, it will generate a new model and store it as well.

Note

The models in ***cache_directory*** all use the same mapping of the source. When something changes how the source is pixelated, such as changing the scanner type, the models in the ***cache_directory*** cannot be reused.

If you are running sessions with different sigmas, pixel widths, or scanner settings, specify a different ***cache_directory*** for each pixel type. When a session is set up with a populated cache it cannot use, it deletes the contents and rebuilds the models. If you have two incompatible sessions sharing a directory, they will interfere with each other.

This command improves runtime when there are multiple experiments on the same host that use the same optical file or clip settings, because optical models can be reused rather than regenerated each time. When using distributed processing (any of the Dispatcher Modes other than Off), the SOCS directory should not be shared.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

While it is acceptable to delete the directory, the contents should never be modified by a user. Calibre pxSMO has an internal record of the contents and generates an error if the files are touched.

Related Topics

delete_pixel_socs_dir_after_read

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pupil_fill

PxSMO Setup File Commands

Specifies the minimum percentage of pixels to illuminate in the source.

Usage

pupil_fill *pf*

Arguments

- ***pf***

  A required argument specifying the minimum percentage of pixels to illuminate in the source. The final fill may be different. The default value is 0.1 (10% of pixels).

  Consult your scanner provider for an appropriate value. The minimum value is usually specified by the scanner provider for control of lens heating. The values from the RET Selection GUI can be used.

Scanner	Pupil fill
asml	0.05
nikon	0.02
euv 3300	0.38
euv 3400	0.30

Related Topics

scanner

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pw_condition

PxSMO Setup File Commands

Required statement. May appear more than once, but no more than 16 times.

Creates print image conditions for dose, focus, resist, and aerial threshold.

Usage

pw_condition *cond_name* [*litho_model_name*]
{[mask*n*] [focus *f*nm] [dose *dose1*] [bias *b*]}…
[aerial *threshold* [thr_delta *offset*[%]]] [plane *height*] [no_flare | {flare *name*}]
[weight *weight_val*] [spec *spec_name*] {inside | outside | not_inside | not_outside} *layer*

Arguments

- ***cond_name***

  A required argument that specifies the name of the process window condition. The first pw_condition statement in the setup file should have the name “nominal”.

- *litho_model_name*

  An optional argument that loads the litho model. It is required for the nominal process window condition.

  Different pw_condition statements can use different litho models. If *litho_model_name* is not specified, the litho model for the nominal condition is used. The user is responsible for making sure the litho models differ in only the areas intended to vary.

- mask*n*

  An optional argument that specifies the mask number from the litho model to which the other arguments apply. The value *n* is run into the keyword “mask”, for example, “mask0”. Mask0 is the default.

- focus *f*nm

  An optional argument that specifies the focus condition to be used for the mask specified by the mask*n* argument. The value *f* must be appended with “nm”, for example, “focus 0.2nm”.

- dose *dose1*

  An optional argument whose default is 1.0. The value of *dose1* is multiplied by the base dose specified for the mask in the litho model.

- bias *b*

  An optional argument that specifies bias in microns. It is used for sizing the mask in simulation. Bias values are not used in OPC mask movements. If any biases were specified for individual mask_layers in the litho model, those biases are added to the value specified here. The default is 0.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Note

Only mask biasing for individual mask layers is added. Mask-block level biasing using the XSHIFT or YSHIFT keywords in the litho model generates an error.

- aerial *threshold*

  An optional argument that specifies the value of the aerial threshold for this process condition. If it is not specified, the resist model defined in the litho model is used.

  The *threshold* argument can take the value “model”. This sets the aerial threshold to the image_threshold value from the litho model. If image_threshold is not set, it uses the resist model value.

- thr_delta *offset*[%]

  An optional argument that can only be used in conjunction with aerial. This argument modifies the image_threshold parameter in the litho model. The offset can be given as a numeric shift (for example, thr_delta -0.001) or a percentage change (for example, -0.1%).

- plane *height*

  An optional argument that is used for 3D resist imaging. It specifies the z-position within the resist film where the image is computed. The position (*height*) is in microns relative to the bottom of the resist and must be between 0 and the resist film thickness.

  Note

  The plane argument requires an optical model that uses the imageplanes keyword. If the condition specifies a resist model, it must be a CM1 3D resist model. There are no restrictions when used with aerial.

- no_flare

  An optional argument that can only be used with ***cond_name*** “nominal”. When specified with an EUV optical model, no process window conditions use the flare model during simulation.

  The no_flare argument cannot be specified with flare *name*.

- flare *name*

  An optional argument that sets this particular process window condition to use a named flare_longrange specification instead of the default unnamed flare_longrange. The *name* value must match that of a “flare *string*” argument on a flare_longrange specification.

  The flare *name* argument cannot be specified with no_flare.

- weight *weight_val*

  An optional argument that specifies the weight to give to the EPE defined for this condition. The default weight is 1.0.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

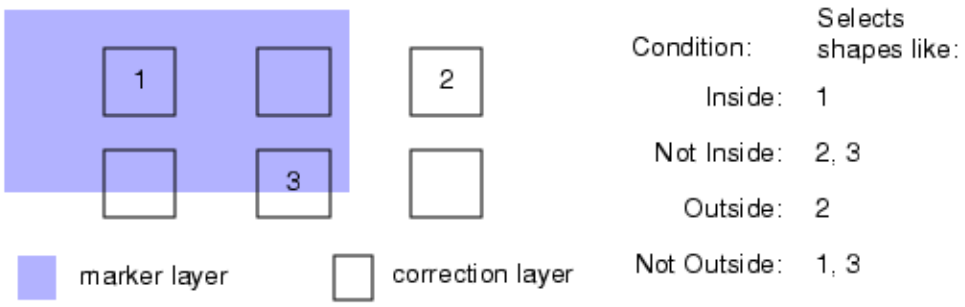
- spec *spec_name*

  An optional argument set that specifies an optical model labeled *spec_name* in the *Lithomodel* file to use for the process window condition. This argument set is commonly used to specify optical models that include aberrations.

- {inside | outside | not_inside | not_outside} *layer*

  An optional argument set that applies the defined process window condition only to polygons that meet one of the following conditions for the specified layer: completely "inside" the layer, completely "outside" the layer, not completely inside the layer, or not completely outside the layer. The default behavior is to apply the process window condition everywhere.

Figure 4-6. Inside, Not Inside, Outside, and Not Outside



Description

A required command to specify process window conditions for optimization. This command also loads the litho model. The EPE is measured for all defined process window conditions, unless restricted by pw_select. At least one condition must be defined in the setup file.

Tip

Use 1 to 2% larger exposure latitude and 10% larger focus latitude for Calibre pxSMO runs than for Calibre OPCverify runs.

Related Topics

pw_select

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pw_condition_group

PxSMO Setup File Commands

Creates a group of dose and focus conditions located along a defined process window shape before optimization.

Usage

pw_condition_group ***pw_group_name*** [shape_type *type*] [focus_range *fr_nm*] [focus_center *fc_nm*] [dose_latitude *dose_l*] [dose_center *dose_c*]

Arguments

- ***pw_group_name***

  A required argument that specifies the name of the process window condition group.

- shape_type *type*

  An optional argument that specifies the shape inscribed in the process window. The following values are supported:

  - elliptical — Inscribes an ellipse in the common process window. This is the default.
  - rectangular — Inscribes a rectangle in the common process window.

- focus_range *fr_nm*

  An optional argument that specifies a value in nanometers for the focus range. This is the initial width of the common process window shape. The default is 100.

- focus_center *fc_nm*

  An optional argument that specifies a value in nanometers for the focus center. This is the initial center of the common process window shape. The default is 0.

- dose_latitude *dose_l*

  An optional argument that specifies a value for the exposure latitude. This is the initial height of the common process window shape. The default is 0.06.

- dose_center *dose_c*

  An optional argument that specifies a value for the dose center. This is the initial center of the common process window shape. The default is 1.0.

Description

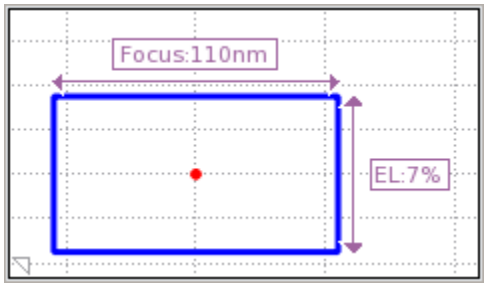
An optional command to specify a group of dose and focus conditions located along a process window shape type. The process window shape type, focus range, focus center, exposure latitude, and dose center are specified typically before an optimization. The command can be used in any job type.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Examples

The following command creates a rectangular process window with 110 nm focus range and 7% exposure latitude.

```
pw_condition_group PWG1 shape_type rectangular focus_range 110
dose_latitude 0.07
```



This is the initial shape supplied for optimization.

Related Topics

pw_select

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pw_focus_base_points

PxSMO Setup File Commands

Specifies defocus conditions for through-focus aerial image calculation. For job types other than CDOF, this command is required when focus_range or focus_center is specified by the pw_variables command.

Usage

pw_focus_base_points ***focus_list***

Arguments

- ***focus_list***

  A required argument specifying a set of defocus conditions in nanometers. At least two values must be specified. This command is applied per job. For a CDOF job, the default set is a range from -100 nm to +100 nm with 20 nm steps.

Description

A required command when focus_range or focus_center is specified by the pw_variables command in a job that is not job type CDOF. A CDOF job applies a default set of defocus conditions from -100 nm to +100 nm with 20 nm steps. Custom defocus conditions for a CDOF job can be specified using pw_focus_base_points.

Examples

```
pw_focus_base_points -100 -80 -60 -40 -20 0 20 40 60 80 100
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pw_focus_range_factor

PxSMO Setup File Commands

Controls the relative emphasis given to common depth of focus during process window optimization.

Usage

pw_focus_range_factor *pw_group_name value*

Arguments

- ***pw_group_name***

  A required name specifying a process window condition group. The name must also be used as the ***pw_group_name*** in pw_condition_group and pw_select statements.

- ***value***

  A required numerical argument. Larger values put more emphasis on maximizing depth of focus; lower values reduce the emphasis on maximizing depth of focus. If this command is not specified, it is equivalent to 0.5 in a CDOF job, and not used in other jobs.

Description

An optional command to control the relative emphasis on common depth of focus during process window optimization. Larger values put more emphasis on maximizing common depth of focus; smaller values reduce the emphasis relative to other objective components (such as extra print suppression). The command is applied per job.

Examples

```
pw_focus_range_factor PWG1 0.5
```

Related Topics

pw_condition_group

suppress_extra_printing

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pw_select

PxSMO Setup File Commands

Restricts simulation to only the specified processes.

Usage

Standard Syntax

pw_select {***cond_name*** | ***pw_group_name***} [*cond_name*...] [*pw_group_name*...]

Gauge-Based Syntax

pw_select {***cond_name*** | ***pw_group_name***} [*cond_name* ...] [*pw_group_name*...]
gid ***gid*** [*gid*...]

Arguments

- ***cond_name*** | ***pw_group_name***

  A required name of at least one process window condition or process window condition group. Names are not case sensitive.

  - A process window condition name must also be used as the ***cond_name*** in a pw_condition statement.
  - A process window condition group name must as the ***pw_group_name*** in a pw_condition_group statement.

- ***gid***

  A required argument specifying at least one gauge id to simulate using the specified process window condition or condition group names. If a pw_select statement specifies process window condition groups with gauge ids, any later pw_select statement with the process window condition groups must specify the same process set of groups (See the Examples for correct and incorrect usage). A gauge id may be specified in only one pw_select statement.

Description

An optional statement that restricts simulation to the listed processes. The process window conditions are defined in the pw_condition statements; process window condition groups are defined in the pw_condition_group statements. Only the specified process window conditions and groups are simulated. If one or more gauges are specified, the gauges are simulated only at the specified process window conditions.

This statement can be used to restrict conditions and groups for the entire run by placing it in the general section. It can also be used to override the conditions and groups on a per-job basis by placing it in a job section. In that case, only the job where the statement appears is affected; the next job runs with the general setting.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Examples

The following example correctly specifies process window condition groups by using the same set of groups in each statement:

```
pw_select PWG1 PWG2 nominal
pw_select PWG1 PWG2 gid 2 3 4
```

In the example above, nominal is a single process window condition and not a process window condition group.

The following example incorrectly specifies process window condition groups by using different sets of groups in each statement:

```
pw_select PWG1 PWG2 nominal
pw_select PWG1 gid 2 3 4
```

The second pw_select statement is incorrect because it specifies one of the process window condition groups from the first statement, but does not specify the other group.

Related Topics

job

pw_condition

pw_condition_group

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pw_tolerance_bound

PxSMO Setup File Commands

Requires the process window conditions for a process window condition group to produce contours within a specified area. Used when optimizing common depth of focus.

Usage

pw_tolerance_bound ***pw_group_name*** {**outside** | **inside**} ***layername***

Arguments

- ***pw_group_name***

  A required name specifying a process window condition group. The name must also be used as the ***pw_group_name*** in pw_condition_group and pw_select statements.

- **outside** | **inside**

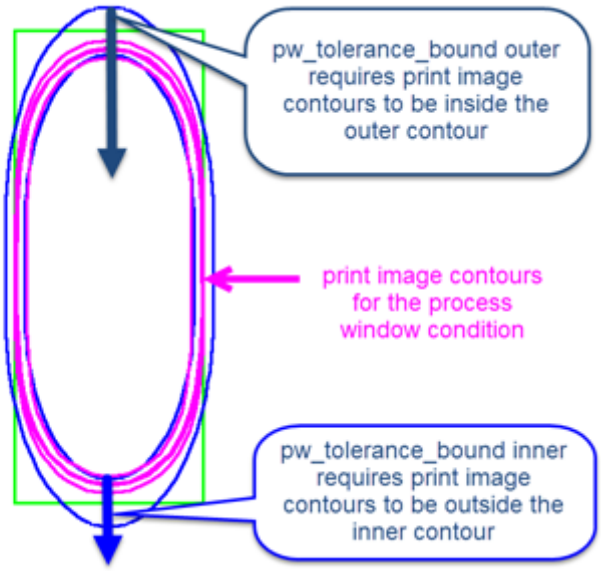
  A required argument specifying the type of contour.

- ***layername***

  A required name specifying a layer with the inner or outer contour (typically, either the inner or outer contour of a tolerance band). The name must also be used as the ***layername*** in a layer statement.

Description

An optional command that requires the process window conditions for a process window condition group produce print image contours within a specified area. The print image contours must either be outside of an inner contour or inside an outer contour. This command can be used two times per job - once for the inner contour and once for the outer contour.



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Examples

```
pw_tolerance_bound PWG1 inside tolband_outer
pw_tolerance_bound PWG1 outside tolband_inner
```

Related Topics

layer

pw_condition_group

pw_select

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pw_variables

PxSMO Setup File Commands

Specifies the variables for process window optimization.

Usage

pw_variables ***pw_group_name var_list***

Arguments

- ***pw_group_name***

  A required name specifying a process window condition group. The name must also be used as the ***pw_group_name*** in pw_condition_group and pw_select statements.

- ***var_list***

  A required argument set of one or more variables to use for process window optimization. The following var_list values are supported:

  - focus_range — Maximizes common depth of focus. For a CDOF job, this is the default.
  - dose_latitude — Maximizes common exposure latitude. Used in an EL job.
  - focus_center — Enables optimization of the focus center from its initial value.
  - dose_center — Enables optimization of the dose center from its initial value.

Description

An optional command to specify variables to use for process window optimization. For a CDOF job, the default behavior is maximizing common depth of focus. The command is applied per job.

Examples

```
pw_variables PWG1 focus_range
```

Related Topics

pw_condition_group

pw_select

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

sample_source

PxSMO Setup File Commands

Sets a source to use as a reference during optimization.

Usage

sample_source *filename*

Arguments

- ***filename***

  A required argument that specifies the name of the reference source file.

Description

An optional global command that sets a source that is used as a reference during optimization. The similarity of the reference source to the current source during optimization is set with the source_difference_weight command.

Examples

The following example sets *cquad.src* as the reference source:

```
sample_source /user/opt_engr1/sources/cquad.src
```

Related Topics

source_difference_weight

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

save_job_cdof_print_images

PxSMO Setup File Commands

Specifies the input layers and process window contours to save for CDOF jobs. Only valid for CDOF jobs.

Usage

save_job_cdof_print_images ***layout_filename*** [focus from *cdof_focus_min* to *cdof_focus_max* step *cdof_focus_step*] [dose from *cdof_dose_min* to *cdof_dose_max* step *cdof_dose_step*]

Arguments

- ***layout_filename***

  A required argument that specifies the name of an OASIS file of contours saved at the end of a job.

- focus from *cdof_focus_min* to *cdof_focus_max* step *cdof_focus_step*

  An optional argument set that specifies the focus range and step size for saving contours. The specified focus range should be within the focus range specified for the CDOF job or within the ±100nm range default of the CDOF job. By default, the values are obtained using 20 steps across a focus range determined at the end of optimization. The values are in nanometers.

- dose from *cdof_dose_min* to *cdof_dose_max* step *cdof_dose_step*

  An optional argument set that specifies the dose range and step size for saving contours. If values are not specified, then the values are obtained using 10 steps across the dose latitude specified by the user.

Description

An optional command that specifies the name of a file of contours of all clips to save at the end of a CDOF job when the option is set. The contours are saved for specified focus-dose pairs. Focus-dose sampling greater than the PW Table values can be used. The command is added to a setup file for job-level debugging. The option applies only to the job where it is specified.

The following contours are saved:

- All input layers to the pxSMO stage using a layer statement (target, smooth target, and so on).
- All print images for the process window conditions of the run. Each print image contains contours of all clips. The contours are named “f<*f*>_d<*dose*>” where <*f*> is the focus in nanometers and <*dose*> is the exposure dose. Each focus-dose pair is on a separate layer in the layout file.

The file is saved in the session directory.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Examples

Example 1

```
save_job_cdof_print_images smo_cdof.oas focus from -50 to 50 step 25 dose
from 0.96 to 1.04 step 0.02
```

Related Topics

save_job_mask

save_job_print_image

save_job_source

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

save_job_mask

PxSMO Setup File Commands

Specifies the name of an OASIS file of all clips to save at the end of a job.

Usage

save_job_mask ***layout_filename***

Arguments

- ***layout_filename***

  A required argument that specifies the name of an OASIS file to save at the end of a job.

Description

An optional command that specifies the name of an OASIS file of all clips to save at the end of the job where the option is set. The command is added to a setup file for job-level debugging. The option applies only to the job where it is specified.

The file is saved in the session directory.

Related Topics

save_job_cdof_print_images

save_job_print_image

save_job_source

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

save_job_print_image

PxSMO Setup File Commands

Specifies the name of a file of contours of all clips to save at the end of a job.

Usage

save_job_print_image *layout_filename*

Arguments

- ***layout_filename***

  A required argument that specifies the name of an OASIS file of contours to save at the end of a job.

Description

An optional command that specifies the name of a file of contours of all clips to save at the end of the job where the option is set. The command is added to a setup file for job-level debugging. The option applies only to the job where it is specified.

The following layers are saved:

- All input layers to the pxSMO job using a 'layer' statement (target, smooth target, and so on).
- All print images for the process window conditions of the job. Each print image contains contours of all clips. The contours are named "gid<*N*>_<*cond_name*>" where <*N*> is the clip number and <*cond_name*> is the name of the process window condition.
- Three summary layers calculated for the specified process window conditions:
  - "Inside_contour" — The combined innermost edges of the contours.
  - "Outside_contour" — The combined outermost edges of the contours.
  - "PV" — The PV band.

The file is saved in the session directory.

Related Topics

save_job_cdof_print_images

save_job_mask

save_job_source

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

save_job_source

PxSMO Setup File Commands

Outputs a source map file at the end of a job using the specified name.

Usage

save_job_source *filename*

Arguments

- ***filename***

  A required argument that specifies the name of the file for the source map at the end of the job where the option is set. The convention is to use a *.src* suffix, but this is not applied automatically.

  The source map is in text format. Each line consists of x and y coordinates and the filtered and smoothed intensity of a pixel.

Description

An optional command that specifies the name of a source map file saved at the end of a job. The command is added to a setup file for job-level debugging. The option applies only to the job where it is specified.

The file is saved in the session directory.

Related Topics

save_job_cdof_print_images

save_job_mask

save_job_print_image

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

save_job_raw_source

PxSMO Setup File Commands

Outputs an illuminator-level source map file at the end of a job using a specified name.

Usage

save_job_raw_source *filename*

Arguments

- ***filename***

  A required argument that specifies the name of the file for the source map at the end of the job where the option is set. The convention is to use a *.dat* suffix, but this is not applied automatically.

  The source map is in text format. Each line consists of x and y coordinates and the filtered and smoothed intensity of a pixel.

Description

An optional command that specifies the name of an illuminator-level source map file saved at the end of a job. The illuminator-level source differs from a reticle-level or wafer-level source by removing blurring caused by the optical system. The command is added to a setup file for job-level debugging. The Source View tool in Calibre WORKbench cannot open the output file. The option applies only to the job where it is specified.

The file is saved in the session directory.

Examples

Example 1

This example outputs the illuminator-level source map at the end of a job:

```
save_job_raw_source source_sopxopc_raw.dat
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

scanner

PxSMO Setup File Commands

Sets source parameters to values typical for different manufacturers.

Usage

scanner {**asml** | **nikon** | {**euv 3300** | **3400**}}

Arguments

- **asml**

  A required argument that sets internal parameters to values typical for an ASML DUV scanner. This is the default setting.

- **nikon**

  A required argument that sets internal parameters to values typical for a Nikon scanner.

- **euv 3300** | **3400**

  A required argument that sets internal parameters to values typical of an ASML NXE 3300 or NXE 3400 EUV scanner.

Description

The scanner keyword lets you conveniently set several parameters at once as listed in the following tables. Specify one of “asml”, “nikon”, “euv 3300”, or “euv 3400”. To specify the minimum pupil fill for the scanner, add the pupil_fill argument and corresponding value to the setup file.

Table 4-3. DUV Scanner Settings

Parameter	ASML	Nikon
Pixel type	asml	square
Pixel width	0.06	0.0625
sigma_max	0.98	0.99
sigma_min	0.00	0.05
Source grid	0.01 sigma	0.0078125 sigma

Table 4-4. EUV Scanner Settings

Parameter	euv 3300	euv 3400
Pixel type	asml	asml
Pixel width	0.06	0.06
sigma_max	0.92	0.98
sigma_min	0.20	0.06

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 4-4. EUV Scanner Settings (cont.)

Parameter	euv 3300	euv 3400
Source grid	0.005 sigma	0.005 sigma

The SMO setup file is processed linearly. This means that any of the parameters in the table that are set before scanner are ignored. Any of the parameters in the table that are specified after scanner take priority over the scanner setting's value.

Examples

This example demonstrates the prioritization:

```
sigma_min 0.01
...
scanner asml
...
sigma_min 0.03
```

The sigma_min value used by the pxSMO run will be 0.03 The first sigma_min of 0.01 is overwritten by the scanner asml value of 0.0. The 0.0 value is then overwritten by the second sigma_min, 0.03.

Related Topics

pupil_fill

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

scatter_assist_type

PxSMO Setup File Commands

Specifies where to place SRAFs relative to the target layer.

Usage

scatter_assist_type {**outside** | **inside** | **both**}

Arguments

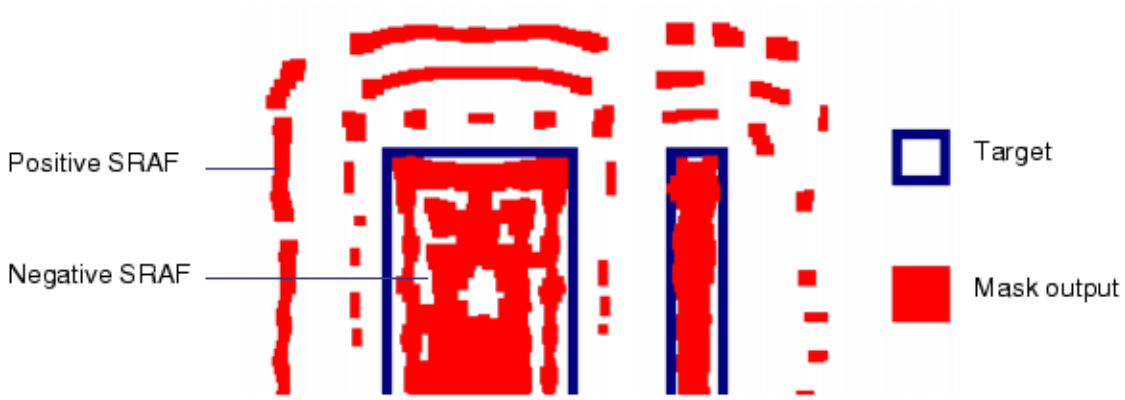
- **outside** | **inside** | **both**

  A required argument specifying whether SRAFs go outside the target layer, inside the target layer, or both inside and outside the target layer. Only one of the keywords may be specified.

Description

By default, SRAFs are placed outside the target layer shapes. Use the scatter_assist_type command to create negative scattering bars instead of or in addition to the positive SRAFs.

Figure 4-7. Positive and Negative SRAFs



Calibre pxSMO combines the SRAF shapes and OPC corrections on the same layer, unlike when OPC correction and SRAF generation are run separately. Negative SRAFs cause the main feature shape to increase significantly in complexity.

Examples

```
scatter_assist_type outside
```

Related Topics

assist_inside_dose_multiplier

assist_outside_dose_multiplier

scatter_belt

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

scatter_belt

PxSMO Setup File Commands

Identifies how far from the target the SRAF rings should extend.

Usage

scatter_belt *belt_value*

Arguments

- ***belt_value***

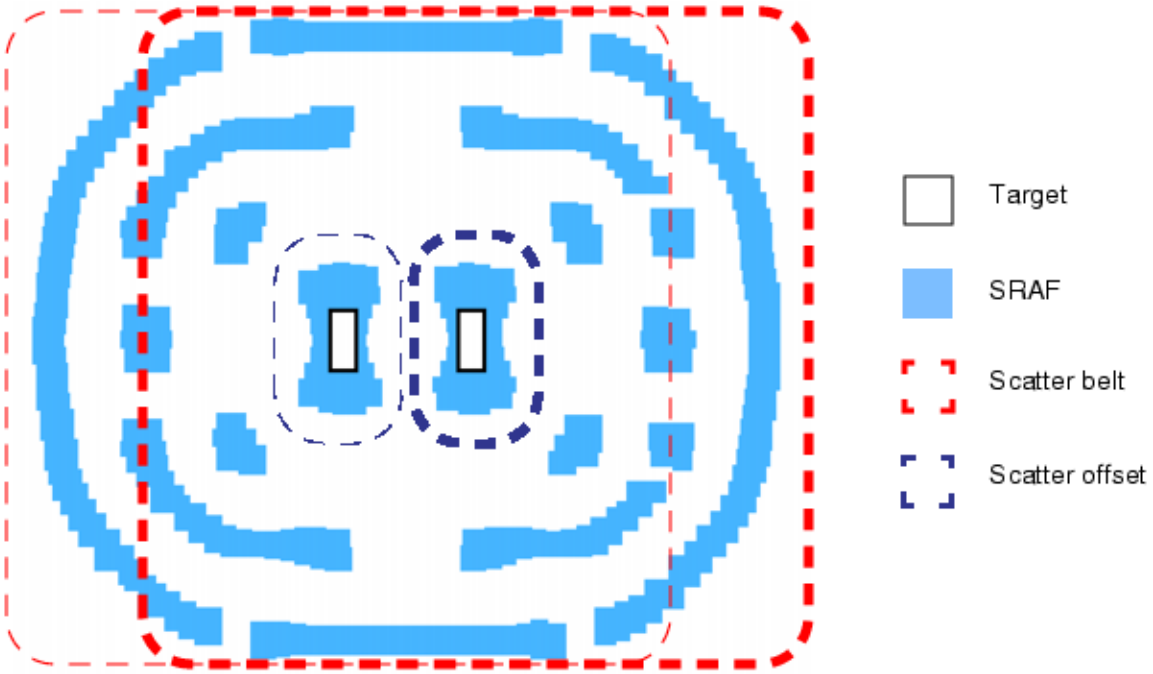
  A required argument specifying the distance in microns from the mask to the outer edge of the SRAFs.

Description

Specifies how far SRAFs extend. The distance is measured from the mask returned from the previous job. The default if the command is not specified is 0.256 um.

This command is most often used in the Decorate job. If there are too few SRAF rings, increase the ***belt_value*** by adding 0.25*CD (one quarter the critical distance).

Figure 4-8. Scatter_belt



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

scatter_offset

PxSMO Setup File Commands

Specifies the minimum distance between the main feature and positive SRAFs.

Usage

scatter_offset ***value***

Arguments

- ***value***

  A required argument in microns specifying the distance in microns from the main feature edge to the closest SRAFs. The distance must be greater than 0.

  As of 2018.4, the units are in microns. Previously the units were equal to 0.125*lambda/NA, where NA is numerical aperture and lambda is the wavelength. The default is based on the optical model. For DUV optical models, the default value is 0.1875*lambda/NA. For EUV optical models, the default value is lambda/((1+sigma_max)*NA), where sigma_max is the maximum sigma value of the optical tool.

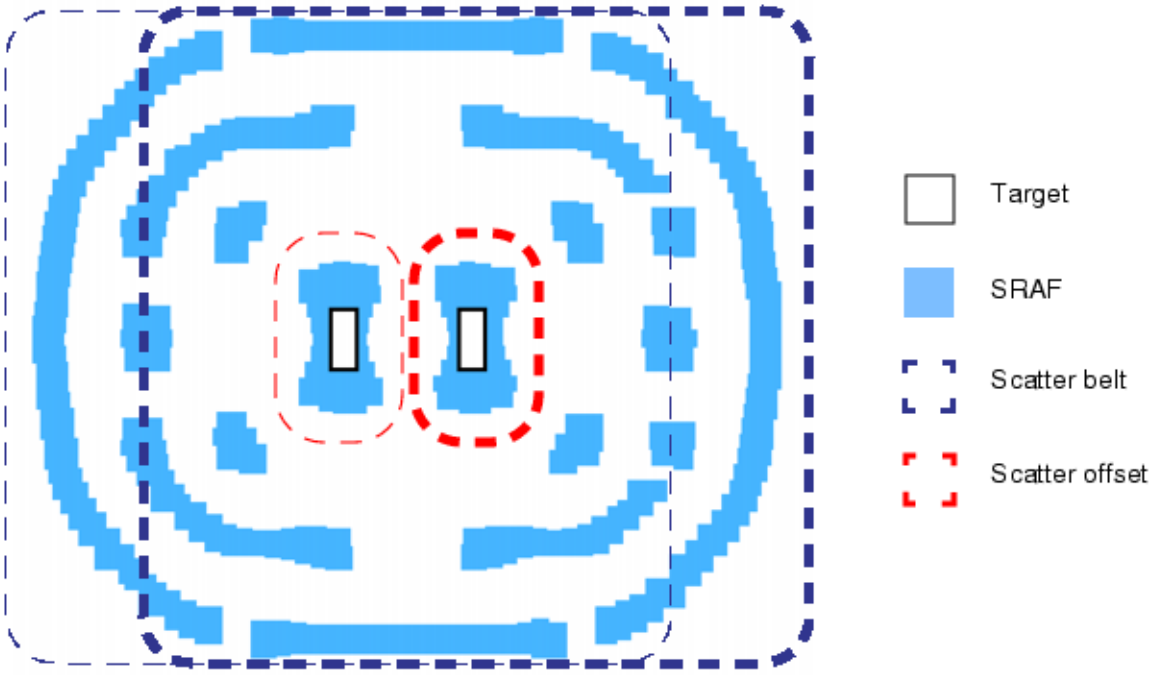
Description

This optional command specifies how close SRAFs may be to the main feature edge. The maximum distance is set by scatter_belt. The offset value affects only positive SRAFs. To set an offset for negative SRAFs, set scatter_offset_negative.

By default, the offset is calculated between the main feature and SRAF. In some cases, the difference between mask and target is large enough to allow SRAFs to be placed in undesired locations. To calculate the distance instead using the target layer and the output mask SRAF, set "scatter_offset_type target".

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 4-9. scatter_offset



Examples

Example 1

The following example sets the scatter offset to 1.3 microns:

```
scatter_offset 1.3
```

Related Topics

scatter_offset_negative

scatter_offset_type

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

scatter_offset_negative

PxSMO Setup File Commands

Specifies the minimum distance between the main feature edge and negative SRAFs.

Usage

scatter_offset_negative *value*

Arguments

- ***value***

  A required argument specifying the distance from the main feature edge to the closest SRAFs inside the drawn shape. The distance must be greater than 0.

  As of 2018.4, the units are in microns. Previously the units were equal to 0.125*lambda/NA, where NA is numerical aperture and lambda is the wavelength. The default is based on the optical model. For DUV optical models, the default value is 0.1875*lambda/NA. For EUV optical models, the default value is lambda/((1+sigma_max)*NA), where sigma_max is the maximum sigma value of the optical tool.

Description

Specifies how close SRAFs may be to the main feature edge. The maximum distance inward is set by scatter_belt_negative. (See Figure 4-10.) The offset value affects only negative SRAFs.

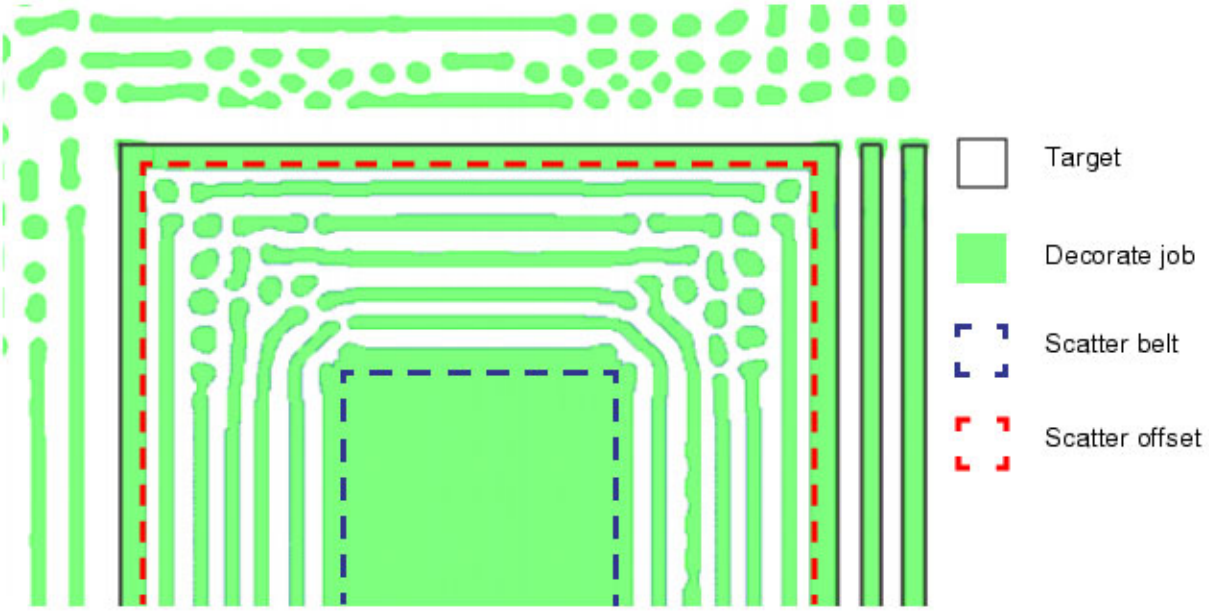
By default, Calibre pxSMO creates only positive SRAFs (that is, SRAFs outside the shape). To change this behavior, you must set “scatter_assist_type both” or “scatter_assist_type inside” to create negative (within shape) SRAFs.

The offset is calculated using the output mask by default. In some cases, the difference between mask and target is large enough to allow SRAFs to be placed in undesired locations. To calculate the distance instead using the target layer and the output mask SRAF, set “scatter_offset_type target”.

This command can appear in a job or the general section, but is most often used in the Decorate job.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 4-10. Negative Scatter Offset



Examples

Example 1

The following example sets the negative scatter offset to 1.3 microns:

```
scatter_offset_negative 1.3
```

Related Topics

scatter_offset

scatter_offset_type

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

scatter_offset_type

PxSMO Setup File Commands

Sets whether scatter_offset and scatter_offset_negative are calculated based on mask or target shapes.

Usage

scatter_offset_type {**mask** | **target**}

Arguments

- **mask** | **target**

  A required argument specifying whether to use the mask layer (the layer with type "correction") or target layer when calculating the offset of assist features. The default is mask.

Description

By default, the scatter parameters are calculated using the layer of type correction, the output mask. Sometimes this can result in weak or inconsistent SRAFs. In these cases, the target layer may provide better SRAF placement. You can try this out by adding "scatter_offset_type target" to the recipe.

The scatter_offset_type setting applies to both positive and negative SRAFs.

Examples

```
scatter_offset_type target
```

Related Topics

scatter_offset

scatter_offset_negative

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

set_on_target

PxSMO Setup File Commands

Improves EPE for the nominal process window condition.

Usage

set_on_target ***cond_name*** [*cond_name...*] [weight *weight*]

Arguments

- ***cond_name***

  A required argument that specifies the names of process window conditions. At least one process window condition name must be specified and additional names are optional. The name must also be used as the ***cond_name*** in pw_condition and pw_select statements.

- weight *weight*

  An optional argument that specifies the weight to give to the EPE defined for this process window condition. The default is 1.0.

Description

An optional command that improves the EPE for specified process window conditions. The name of the process window condition must be specified as the ***cond_name***. For a CDOF job, specifying the nominal condition is recommended.

Examples

```
set_on_target nominal weight 5.0
```

Related Topics

pw_condition

pw_select

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

sigma_max

PxSMO Setup File Commands

Controls the source manufacturability constraint on maximum allowable sigma for the optimized source.

Usage

sigma_max ***sigma***

Arguments

- ***sigma***

  A required positive number less than or equal to 1. A source pixel with its center outside sigma_max is also included in final source. The default value is 0.98.

Related Topics

sigma_min

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

sigma_min

PxSMO Setup File Commands

Controls the source manufacturability constraint on minimum allowable sigma for the optimized source.

Usage

sigma_min ***sigma***

Arguments

- ***sigma***

  A required non-negative value that must be less than 1. A source pixel with its center inside sigma_min is also included in final source. The default is 0.

Related Topics

sigma_max

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

source_difference_weight

PxSMO Setup File Commands

Sets the importance of the source similarity when the sample_source command is used.

Usage

source_difference_weight *value*

Arguments

- ***value***

  A required numerical argument. Larger values emphasize similarity of the optimized source to the reference source specified by the sample_source command. The suggested value range is 0.1 to 10. The default value is 10.

Description

An optional command that specifies the importance of source similarity between the current optimized source and the reference source specified by the sample_source command.

Examples

The following example sets *cquad.src* as the reference source and decreases the importance of the source similarity relative to the default:

```
sample_source /user/opt_engr1/sources/cquad.src
source_difference_weight 9
```

Related Topics

sample_source

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

source_symmetry

PxSMO Setup File Commands

Specifies the symmetry of the optimized source.

Usage

source_symmetry {‘**F**’ | ‘|’ | ‘-’ | ‘+’ | ‘*’}

Arguments

- ‘**F**’ | ‘|’ | ‘-’ | ‘+’ | ‘*’

  A required argument that indicates whether the output source is forced to be symmetric. Legal values are as follows:

  F — No symmetry.

  | (pipe) — Vertical symmetry (X-symmetric).

  - (hyphen) — Horizontal symmetry (Y-symmetric).

  + — Both horizontal and vertical symmetry (XY-symmetric). This is the default.

  ***** — Horizontal, vertical, and diagonal symmetry.

  The default value is XY-symmetric source, +.

Examples

The following example specifies the optimized source should be asymmetric:

```
source_symmetry F
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

suppress_extra_printing

PxSMO Setup File Commands

Specifies SRAF printing suppression for process window conditions or process window condition groups.

Usage

suppress_extra_printing {***cond_name*** | ***pw_group_name***} [*cond_name*...] [*pwgroup_name*...] [weight *weight*]

Arguments

- *cond_name* | *pw_group_name*

  A required argument specifying the name of at least one process window condition or process window condition group. A process window condition name must also be used as the *cond_name* in a pw_condition statement. A process window condition group name must also be used as the *pw_group_name* in a pw_condition_group statement. Each name must also be specified in a pw_select statement. The default action is SRAF printing suppression applied to all conditions and groups.

- *weight*

  An optional argument specifying a weight given to SRAF printing suppression. The default is 1.0.

Description

An optional command that minimizes SRAF printing at specified process window conditions or process window condition groups. In a CDOF job with no conditions or groups specified, the weight value is applied to all groups selected for the job.

Examples

```
suppress_extra_printing pw_outer1 PWG1 5.0
```

Related Topics

pw_condition

pw_condition_group

pw_focus_range_factor

pw_select

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

variables

PxSMO Setup File Commands

Specifies a subset of variables to optimize.

Usage

variables ***set*** [*set* [*set*]]

Arguments

- ***set***

  A required argument specifying which subset of variables to optimize. The following values are accepted:

  dose

  mask

  source

  Any combination can be specified. The default is to optimize source and mask.

Examples

To optimize only the dose, keeping the mask and source variables frozen:

```
variables dose
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

version

PxSMO Setup File Commands

Specifies the version to use.

Usage

version 0

Arguments

- **0**

  A required argument specifying the SMO algorithm to use. For Calibre pxSMO, version 0 is the default and the only one supported.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

weight_background

PxSMO Setup File Commands

Sets the default weight.

Usage

weight_background ***bgweight***

Arguments

- ***bgweight***

  A required non-negative value that sets the initial weight. The default is 1.

Description

Adjusts the default weight used by weight_layer. This statement may only appear once in the rule file.

Restriction

Do not use weight layers when a CDOF job is specified. Starting from the 2019.1 release, weight layers are unavailable when job type CDOF or EL is specified.

Examples

```
weight_background 1.0
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

weight_layer

PxSMO Setup File Commands

Identifies polygon layers which define more important areas for optimization.

Usage

weight_layer ***layer operation weight***

Arguments

- ***layer***

  A required argument specifying the name of the layer containing weighting information. This layer must be declared as type **hidden** in the layer statement. Within a job, ***layer*** must be unique.

- ***operation***

  A required keyword indicating how the weighting is to be performed.

  add — the ***weight*** is added to the existing weight of the region.

  set — the ***weight*** replaces the existing weight of the region. This is the default for Calibre pxSMO generated files.

- ***weight***

  A required argument specifying the weighting associated with the polygons on ***layer***. Values can be negative, positive, or zero. Values between 10 and 200 provide acceptable results.

Description

Use the **weight_layer** command to mark certain target areas as more important to optimize than others. For example, to fix line-end pullback use a weight layer with rectangles drawn over the extent the lines must reach.

Tip

Only place weight layer rectangles over the edge sections that can print. Extending the rectangles to the target's corners causes longer run times because Calibre pxOPC attempts to match the mask more closely, and little improvement is possible.

Restriction

Do not use weight layers when job type CDOF or EL is specified. Starting from the 2019.1 release, weight layers are unavailable when job type CDOF or EL is specified.

Weight layer rectangles should be centered on the target; that is, the markers should extend equally on both sides of the edge. The recommended width is 3 to 5 nm, with a length of 30 to 40 nm. If markers are too short they may not overlap contours with particularly bad EPE.

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When **weight_layer** is in the general section, it applies to all jobs. **weight_layer** statements in the job sections are combined for that job with any general statements. An options block may have any number of **weight_layer** statements but within a job, each ***layer*** must be unique.

When a region is covered by multiple **weight_layer** … **set** statements, the last **weight_layer** … **set** value is used.

The final weighted value of a region is never negative. If the accumulated weight is negative it is rounded up to 0.

Examples

```
weight_layer wt1 set 100
```

Related Topics

layer

weight_background

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Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Chapter 5
RET Selection GUI Reference

To help you access functionality, this chapter lists the major windows, tabs, fields, and menus of the RET Selection GUI. All panes of the window are able to be undocked, rearranged, and stacked with other panes.

The figures use the default layout; your particular workspace may be arranged differently.

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RET Selection Window

To access: **Calibre WORKbench > Litho > RET Selection**

The RET Selection window provides an easy way to set up Calibre pxSMO runs, analyze results, and create scripts to execute future runs from the command line.

Description

The RET Selection window consists of a common toolbar and five child windows.

- To undock a child window, select the title bar and drag, or double-click.
- To dock it where it was, click the icon to the left of the close control, or double-click.
- To restore the windows to their default positions, select **View > Default**.

Objects

Table 5-1. Default RET Selection Window Contents

Objects	Description
Active Layout & Gauge Pair selector	This is a three-part control: • Use the yellow button to begin a new layout/gauge pair. • Use the dropdown to change which layout/gauge pair is active. • Use the text entry box to enter or view a name.
Active Session selector	This control is unavailable until you load a layout/gauge pair. • Use the yellow suitcase to begin a new session. • Use the dropdown to change which session is active. • Use the text entry box to give the session a new name.
Run Control/Layout Session View window	A window with two tabs: • **Run Control** — See "Run Control Pane" on page 173. • **Layout Session View** — A hierarchical listing of layouts and sessions that displays information on the session state (see Table 5-3) and when it was last active.
Session Browser window Gauges window	These two windows share space in the RET Selection window, but can be undocked separately. • **Session Browser** — Controls for setting up the point tools and accessing plots. • **Gauges** — Also titled Gauge Analysis. Shows all the gauges for the active layout/gauge pair. When a session is active, additional controls and columns are displayed.

Other windows are hidden by default, as they are only needed for debugging or script creation.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-2. Hidden RET Selection Window Contents

Window	Description
Text fields for Gauge, Layout, Setup, and Litho	Select **View** > **Active Files**. These fields are not editable. They show the files chosen when you created the layout/gauge pair that is currently active.
Command Window	Select the **Command** button at the bottom of the RET Selection Window. The Command Window shows the equivalent mdf command for GUI interactions. It can be useful when developing a batch script, as described in "Converting GUI Sessions to Batch Mode Files" on page 55.
Log Viewer	Select the **Log** button at the bottom of the RET Selection Window. The log viewer shows the transcript, and can be searched.
Some gauge measurements	In the Gauges window, right-click on a column heading to open the Column Manager.

Usage Notes

The session states appear in the **Layout Session View** tab. They are for information only and are updated by the run control.

Table 5-3. Session States

State	Description
Init (0)	Session has been created.
MDFLITHOMODEL (1)	Model has been created.
PRESMO (2)	The smoothed curve stage is set up.
Setup Done (3)	The setup command is done.
Executing (*tool*)	The session is currently executing. If the session run was started by the dispatcher, this is shown instead of states 4 – 8.
Clips Done (4)	The clip generation command is done.
SOCS Done (5)	The optical model cache is done.
SO Done (6)	Calibre pxSMO source optimization is done.
MO Done (7)	Calibre OPC mask optimization is done.
Verify Done (8)	Calibre OPCverify verification is done.
Complete (9)	All stages are complete.

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Related Topics

Setting Up and Running

Run Control Pane

Gauge Analysis Pane

Session Browser Window

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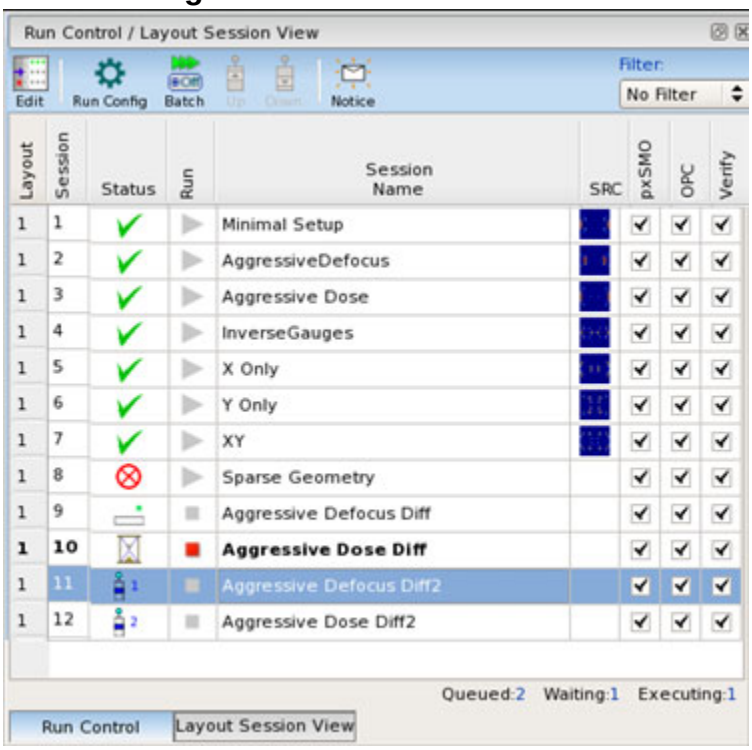
Run Control Pane

To access: RET Selection Window **View** > **Run Control**

The Run Control pane displays the status of currently running sessions and allows you to quickly start multiple runs.

Figure 5-1. Run Control Pane



Description

The Run Control pane consists of three primary areas:

- A toolbar at the top, with buttons described in the table following.
- A list of sessions. Use it to run point tools individually, start or pause a run, and view the source map of the optimized source. The active session is in bold.
- A status indicator at the bottom.

  Queued refers to sessions that are scheduled to run, but not yet started.

  Waiting refers to sessions that have moved to the dispatcher but not yet launched.

  Executing refers to the sessions that have been dispatched and are currently performing calculations.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Objects

Table 5-4. Run Control Pane Toolbar

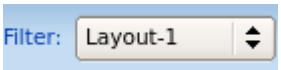
Object	Description
	Opens the Commands dialog box. Commands shows the template file used for creating Tcl scripts to run in batch mode. The lower portion lists the setup variables and current values. You can make changes in this dialog box and save for later use.
	Opens the Run Configuration dialog box, which is displayed when starting a run. See Step 6 of "Cloning Sessions and Running Efficiently" on page 49 for a description of the settings.
	Toggles batch run mode. In batch run mode, you can select multiple sessions to launch simultaneously. Once they are launched, batch run mode turns off again.
	Schedule a queued session. Select a queued session in the session pane then click one of these to move the session up or down the queue. These buttons are not active for sessions not in the queue.
	Opens the Job Notification Configuration dialog box. Use this dialog box to set up email notifications when certain events occur with running sessions. The feature requires */usr/sbin/sendmail* on the server on which RET Selection is running in order to send the email. **Note:** Email is only sent when the RET Selection window has been started. To ensure messages are sent close to the event time, leave the RET Selection window iconified while running Calibre WORKbench.
	Controls the sessions displayed in the session pane. Use to show only the sessions attached to a particular layout.

Table 5-5. Run Control Pane Icons

Objects	Description
	The green arrow indicates a session is ready to run. Click the arrow to start executing the session.
	The checkbox only appears in Batch Run mode. Selected boxes are run when you right click the Batch run button at the bottom.
	The hourglass icon indicates a session has been sent to the dispatcher but has not yet launched. A session only displays this icon briefly.
	The blue-banded icon with a number beside it indicates the session is queued. The number indicates its position in the queue. The example here is from the first session in the queue (position 1). It will run next.
	The green dot over an empty bar indicates a session is running. Use the red square to stop the session.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-5. Run Control Pane Icons (cont.)

Objects	Description
	The red square with lines radiating out indicates a session is stopped.
	The green check indicates a completed run.
	The red circle with an X indicates that a session exited with an error. The error is listed near the end of the session log. To open the session log, right-click and select **Open Log** > **Runscript Transcript** or **Job Log**.
	The small pictures are thumbnail images of the optimized source. (The appearance depends on the style you set in **Settings** > **Set Color Map**.) Click on the image to open the source view.

Usage Notes

- The Run Configuration Setup can be used to create a remote file. If the dispatcher mode is off or it is set to “No remote file, no remote script”, the SMO setup pane’s Parallel PW is ignored.
- The Job Notification feature requires that the machine upon which the RET Selection GUI was opened also has */usr/bin/sendmail*. When sendmail is not available at that location, email is not sent.

Related Topics

Cloning Sessions and Running Efficiently

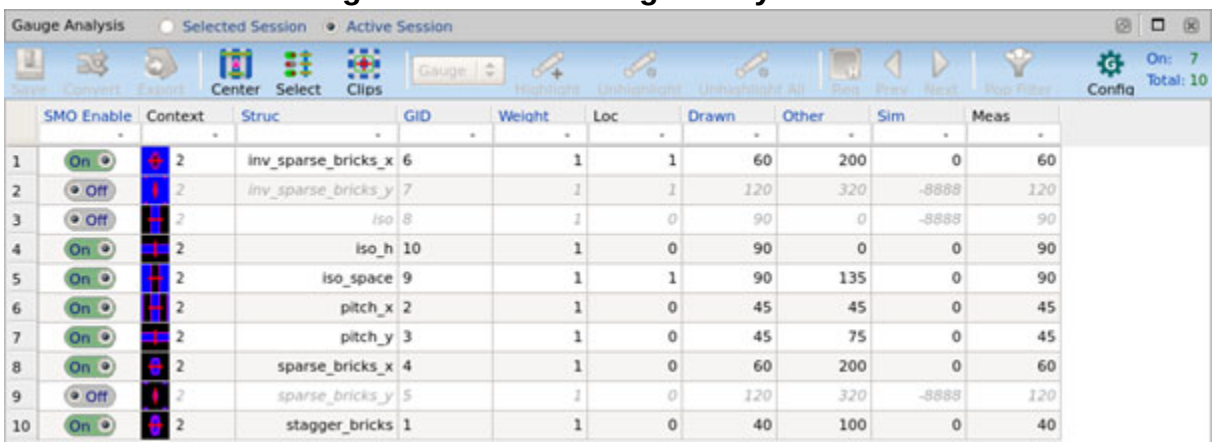
Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Gauge Analysis Pane

To access: activate a session in the Session Browser pane and click the **Gauges** tab.

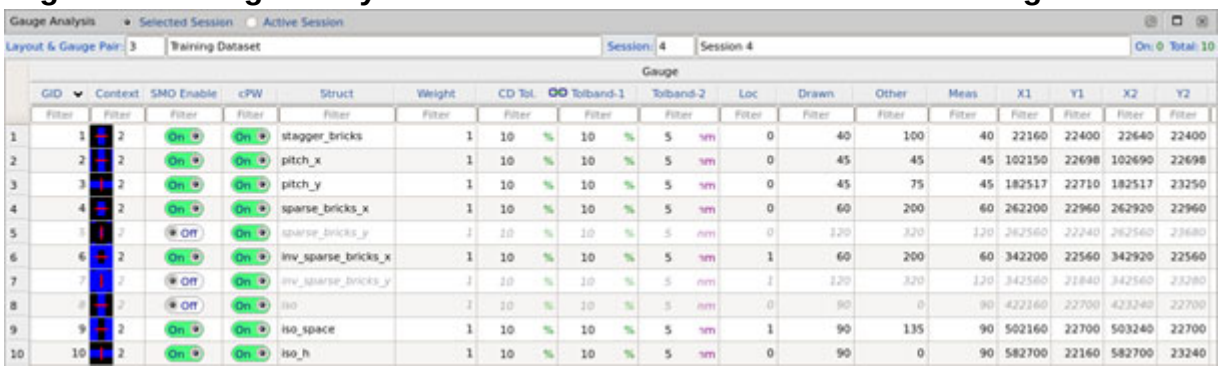
The Gauge Analysis pane shares space with the Session Browser pane. During session setup, Gauge Analysis lets you select and configure gauges for the pxSMO portion of the run.

Figure 5-2. Initial Gauge Analysis Pane



	SMO Enable	Context	Struc	GID	Weight	Loc	Drawn	Other	Sim	Meas
1	On	2	inv_sparse_bricks_x	6	1	1	60	200	0	60
2	Off	2	inv_sparse_bricks_y	7	1	1	120	320	-8888	120
3	Off	2	iso	8	1	0	90	0	-8888	90
4	On	2	iso_h	10	1	0	90	0	0	90
5	On	2	iso_space	9	1	1	90	135	0	90
6	On	2	pitch_x	2	1	0	45	45	0	45
7	On	2	pitch_y	3	1	0	45	75	0	45
8	On	2	sparse_bricks_x	4	1	0	60	200	0	60
9	Off	2	sparse_bricks_y	5	1	0	120	320	-8888	120
10	On	2	stagger_bricks	1	1	0	40	100	0	40

Figure 5-3. Gauge Analysis Pane After Session Activation and Gauge Selection



	GID	Context	SMO Enable	cPW	Struct	Weight	CD Tol.	Tolband-1	Tolband-2	Loc	Drawn	Other	Meas	X1	Y1	X2	Y2
1	1	2	On	On	stagger_bricks	1	10 %	10 %	5 nm	0	40	100	40	22160	22400	22640	22400
2	2	2	On	On	pitch_x	1	10 %	10 %	5 nm	0	45	45	45	102150	22698	102690	22698
3	3	2	On	On	pitch_y	1	10 %	10 %	5 nm	0	45	75	45	182517	22710	182517	23250
4	4	2	On	On	sparse_bricks_x	1	10 %	10 %	5 nm	0	60	200	60	262200	22960	262920	22960
5	5	2	Off	On	sparse_bricks_y	1	10 %	10 %	5 nm	0	120	320	120	262560	22240	262560	23680
6	6	2	On	On	inv_sparse_bricks_x	1	10 %	10 %	5 nm	1	60	200	60	342200	22560	342920	22560
7	7	2	Off	On	inv_sparse_bricks_y	1	10 %	10 %	5 nm	1	120	320	120	342560	21840	342560	23280
8	8	2	Off	On	iso	1	10 %	10 %	5 nm	0	90	0	90	422160	22700	423240	22700
9	9	2	On	On	iso_space	1	10 %	10 %	5 nm	1	90	135	90	502160	22700	503240	22700
10	10	2	On	On	iso_h	1	10 %	10 %	5 nm	0	90	0	90	582700	22160	582700	23240

Description

The Gauge Analysis pane controls which gauges are used for source optimization, and how they are weighted. The OPC and Verify stages always use all gauges. Each session may have a different combination of enabled gauges or weighting.

After a run has completed, the gauge table adds many columns allowing you a tabular view of per-gauge metrics such as MEEF and LDOF.

The fields at the top of each column can filter to show just the rows specified, or be used to sort the table according to the column value.

If the Gauge Analysis pane is empty when you re-open the RET Selection window, it means you do not have an active layout/gauge pair. Use the dropdown next to Active Layout/Gauge Pair at the top of the RET Selection window to access an existing setup. If the pane looks like

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Figure 5-2, there is no session currently active. Use the dropdown next to Active Session to set one.

Objects

Table 5-6. Gauge Analysis Pane Contents — Buttons

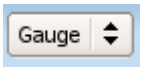
Button	Description
Selected Session	Displays metrics in the gauge table for the session selected in the Run Control/Layout Session View pane. This is the default display selection.
Active Session	Displays metrics in the gauge table for the activated session.
Center	Corrects gauge placement errors by adjusting their length and centering the gauge along its length axis between the feature edges.
Select	**Gauge Selection** Chooses a representative set of gauges from the gauge file.
Clips	**Custom Clips/Gauges** Opens the Clips and Gauges Editor for creating, editing, and managing the clips and gauges used by pxSMO and pxOPC.
Gauge/SMO/OPC 	Works with **Highlight**, **Unhighlight**, and **Unhighlight All** to display a gauge, SMO clip, or OPC clip in the Calibre WORKbench layout viewer.
Req	Crossprobes from the Layout Region takes a section highlighted in the Calibre WORKbench layout viewer and highlights the corresponding gauge in the Gauge pane.

Table 5-7. Gauge Analysis Pane Contents — Fields

Field	Description
SMO Enable cPW	Whether the gauge is used in optimizing the source (SMO Enable) and included in the calculation of the common process window (cPW). Gauges that contain outlier data should not be included in the cPW calculation. By default, a new session uses gauges selected in the Gauge Analysis pane for SMO. If you customize clips using the Clips and Gauges Editor, SMO ignores SMO Enable settings and applies the customized clips settings.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-7. Gauge Analysis Pane Contents — Fields (cont.)

Field	Description
Context	A thumbnail image of the immediate area around the gauge. If you hover over it, additional information is displayed. The number indicates the number of edges the gauge intersects. Gauges with placement issues relative to the layout have red numbers. You may be able to fix these using the **Center** button.
Struc	A short description assigned to the gauge.
GID	Gauge ID.
Weight	How much the metrics from this particular gauge should be factored in relative to other gauges. The weight is used in all stages. If you change the weight while a session is executing, the change is picked up by the next tool run.
CD Tol.	CD tolerance for computing the process window. This can be specified in percentage, absolute nanometers, or a range. Each gauge can have a different setting. The default is 10%.
Length	How long the gauge is. Gauge length is important because a gauge that is too short may not be able to measure the edge placement error, but a gauge that is too long may detect unrelated edges.
Loc	Gauge type. 0 indicates the gauge is measuring critical distance (CD) across the inside of a polygon. 1 indicates the gauge is measuring space between polygons. If the gauge is placed poorly in the layout based on its type, you must fix the layout or edit the gauge file and create a new layout/gauge pair.
Drawn	The measurement (width or space) of the target layer in nanometers.
Meas	The CD measurement of the resist in nanometers.
Sim	The measurement of the simulated image.

Usage Notes

- Right-click on the column headings to open the Column Manager. The Column Manager lets you customize what columns are displayed. Some columns are only displayed in rare cases, such as ErrorInfo.
- Right-click on the text portion of a gauge row to quickly access common actions such as highlight.
- The empty fields under the column headings can be used to filter gauges. Type a constraint in the field and press **Enter**. (For example, entering “<68” in the Drawn column of Figure 5-3 hides gauges 6 and 7.)

  Filters are additive. To remove a filter, click **Pop Filter** in the toolbar.
- **Config** opens the Gauge Table Configuration dialog box. These settings control the size of the Context thumbnail’s larger view.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

- After pxSMO and OPC complete, the **Gauges** dropdown also offers **SMO** and **OPC**. When you highlight a gauge in the layout, **Gauges** highlights only the gauge; **SMO** highlights the clip used for SMO; and **OPC** highlights the OPC clip.

Related Topics

Controlling Optimization With Gauges

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Clips and Gauges Editor

To access, use one of the following:

- Activate a session in the Session Browser pane, click the **Gauges** tab, and click the **Clips** button in the Gauge Analysis pane.
- Right-click a session in the Run Control/Layout Session View table and select **Custom Clips/Gauges**.

During session setup, the Clips and Gauges Editor lets you create and manage clips and gauges.

Figure 5-4. Initial Clips and Gauges Editor

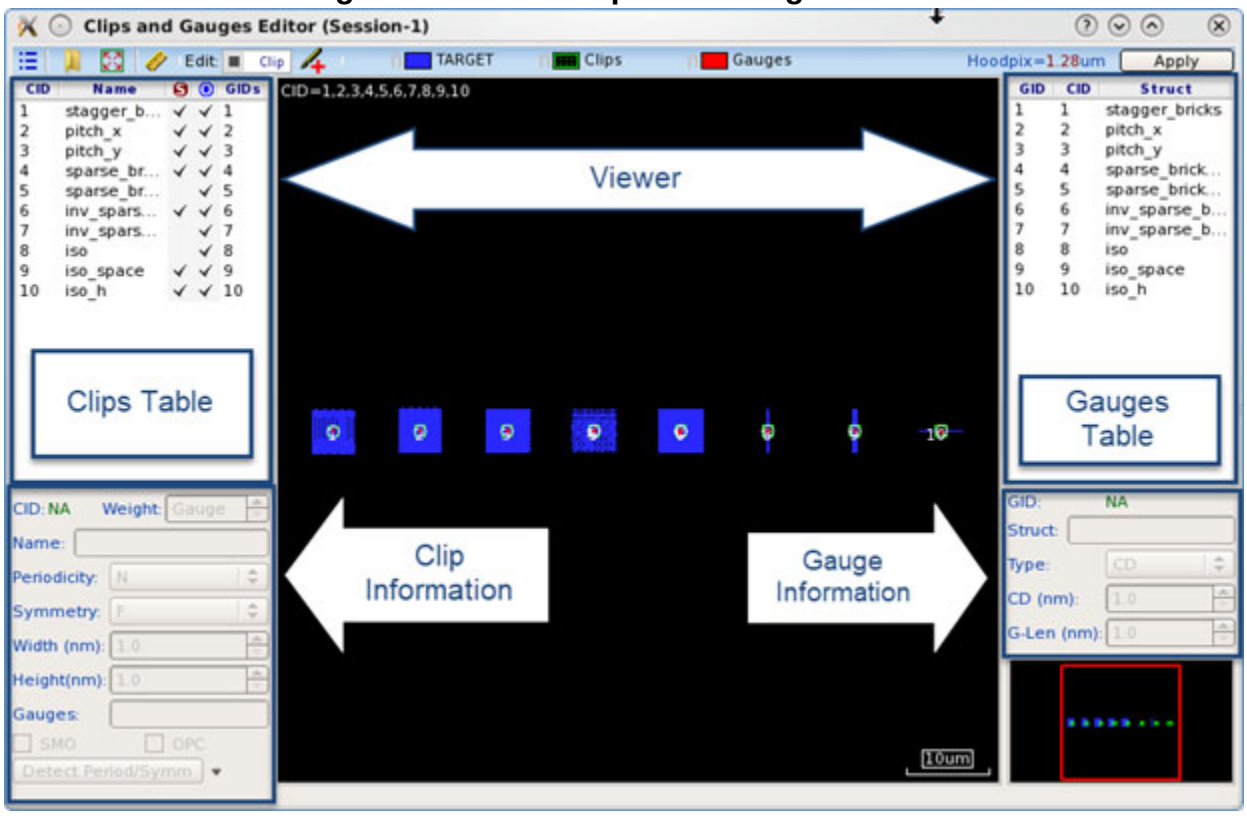


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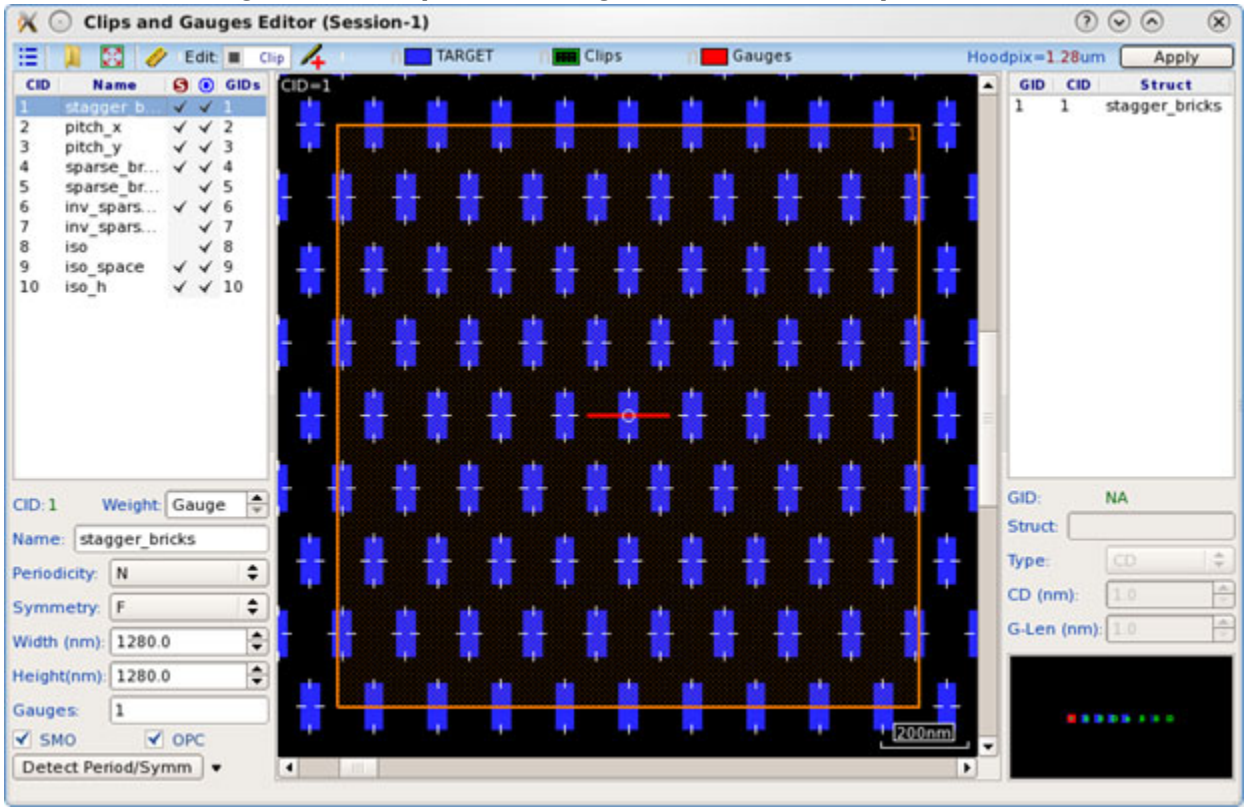
Figure 5-5. Clips and Gauges Editor With Clip Selected



Description

The Clips and Gauges Editor lets you customize the clips and gauges from the Layout/Gauge Pair step.

Objects

Table 5-8. Clips and Gauges Editor — Buttons

Button	Description
View Options	Controls the following viewer options: • Resizing window keeps view scale • Cross cursor • Reset layers color • Reset layer order/check • Open Files • Export Clips File • Export Gauges File
Reset Zoom	Resets the viewer to original magnification level.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-8. Clips and Gauges Editor — Buttons (cont.)

Button	Description
Ruler Options	Controls the following ruler options: • Clear rulers — last ruler or all rulers • Allow multiple rulers • Snaps grid • Snaps to all layers • Snap range
Edit: Gauge/ Clip Edit: Gauge	Toggles the viewer mode between editing gauges and clips.
Add Gauge/ Clip	Adds a gauge or clip, depending on the Edit mode selection.
Apply	Applies all changes made in the Clips and Gauges Editor to the session. Otherwise, no changes are applied.

Table 5-9. Clips Table Objects

Object	Description
CID	Clip ID number
S	SMO Enabled Indicates clip enabled for SMO stage. By default, a new session uses gauges selected in the Gauge Analysis Pane for SMO. If you customize clips using the Clips and Gauges Editor, SMO ignores SMO Enable settings and applies the customized clips settings.
O	OPC Enabled Indicates clips enabled for OPC and Verify stages.

Table 5-10. Clips Information Objects

Object	Description
Weight	Applies weight value to clip during optimization. By default, the SMO and OPC/Verify stages apply gauge weights during optimization. If the clip weight is not specified in clip weight mode and the clip has two gauges, then the weight of the first gauge is applied as the clip weight in the SMO stage. Changing to a numerical value changes the optimization to use clip weights.
Periodicity	Defines if the clip is periodic in X, Y, or both, or not periodic (N). See Table 5-11.

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Table 5-10. Clips Information Objects (cont.)

Object	Description
Symmetry	Defines the clip to have one of the symmetries described in Table 5-12. The symmetries can be thought of as being in two groups: • reflection (|, —, and +) • flip with reflection (ST and SL)
Width (nm) Height (nm)	Displays height and width of the clip.
Gauges	Displays gauge IDs (GIDs) for gauges in the clip.
SMO	Enables the clip for the SMO stage.
OPC	Enables the clip for the OPC and Verify stages.
Detect Period/ Symm	Performs periodicity and symmetry detection, and updates values of Periodicity, Symmetry, Width, and Height. Click the button to adjust the detection search range.

Table 5-11. Periodicity Types

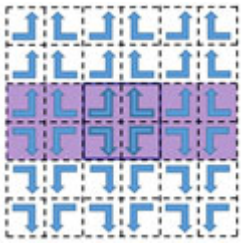
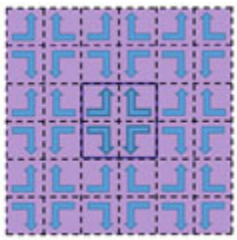
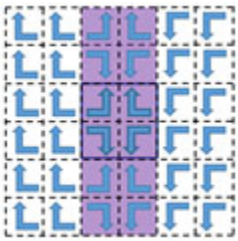
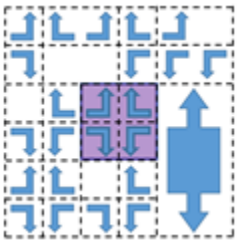
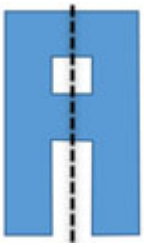
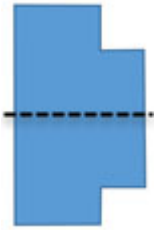
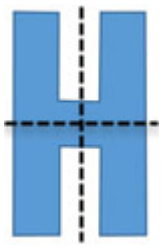
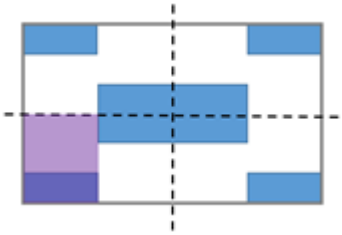
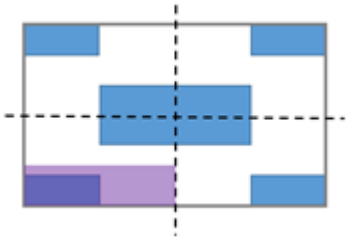
periodicity X	periodicity XY	periodicity Y	periodicity N
			

Table 5-12. Symmetry Types

F: No Symmetry	| : Y mirror	_ : X mirror	+ : mirror in X and Y
			
ST : Staggered tall		SL : Staggered long	

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-12. Symmetry Types (cont.)

Usage Notes

To combine gauges from different clips into one clip, set **Edit** to Gauge. Select the gauge in the Gauges Table. Right-click the highlighted gauge in the viewer and select **Change Clip**. Select the clip ID.

Note

To save any changes made in the Clips and Gauges Editor, you must click **Apply** before closing the editor.

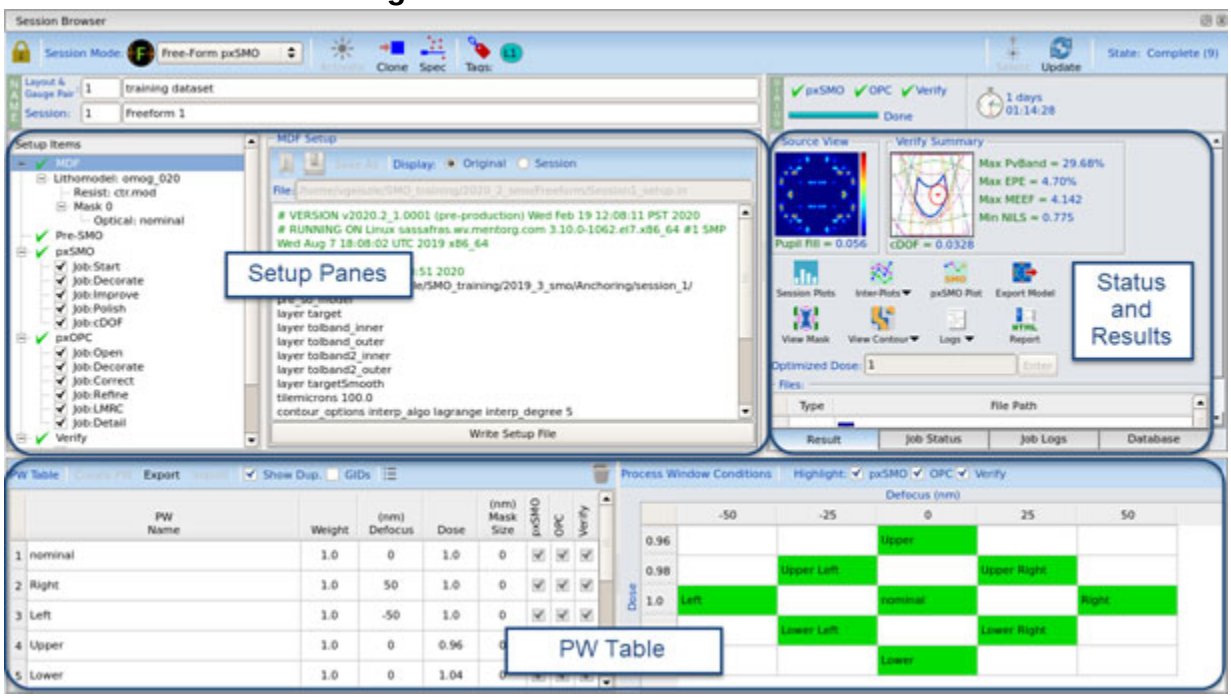
Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Session Browser Window

To access: RET Selection Window **View** > **Session Browser**

The Session Browser window offers quick access to setup and results. It is only drawn when a session is selected.

Figure 5-6. Session Browser Pane



Description

In the default layout, the Session Browser shares space with the Gauge Analysis Pane. The tabs to switch between them are at the bottom. The Setup Panes area changes based on the stage selected in Setup Items.

Objects

The following table describes the action buttons at the top of the window.

Table 5-13. Session Browser Tool and Status Bar

Object	Description
Lock/Unlock Session	Indicates whether a session's settings can be modified. By default, sessions that have completed are protected from edits (closed position). Click the lock icon to toggle the state. (If the session is currently running, it will not unlock.)
Session Mode	Indicates the mode of the session. This release supports Free-Form pxSMO and Parametric Explorer. See "Session Mode" on page 17 for detailed descriptions of the session mode options.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-13. Session Browser Tool and Status Bar (cont.)

Object	Description
Activate	Makes the selected session the active session. (If the icon is dimmed, the session is already active.) Changes made in the setup panes apply to the selected session, but commands typed in the command window or changes made in other windows apply to the active session.
Clone	Duplicates the current session. After a brief pause while the database updates, the cloned session appears in the Run Control/Layout Session View area.
Spec	Opens the Gauge Property Spec Editor. See "Scoring" on page 66.
Tags	Opens the Session Tags editor for creating, coloring, and managing session tags.
State	Displays the current state of the session. See "RET Selection Window" Table 5-3 on page 171 for a complete list and meanings.
NAME fields	The layout and session ID and any name you may have given them. Names are recommended as memory aids. The name fields are editable.
STATUS area	Displays the progress for the session.

Related Topics

Key Concepts

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

PW Table Pane

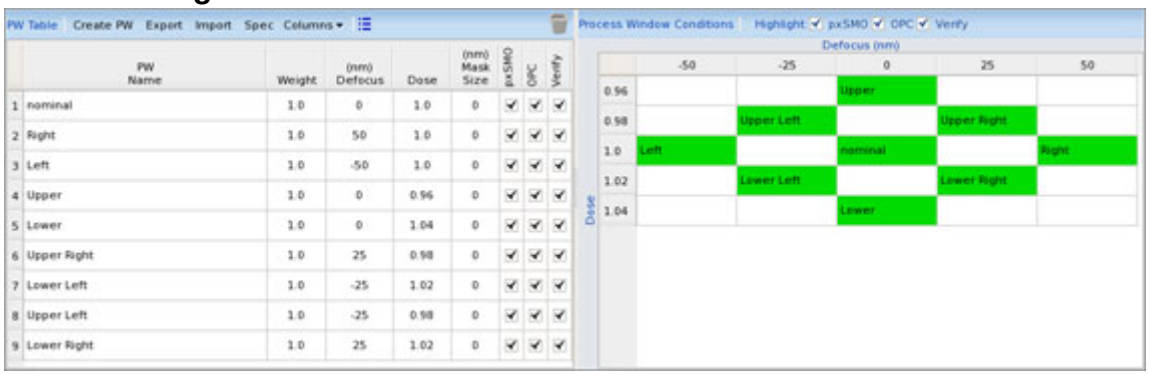
To access: In the Session Browser, activate a session

The PW Table pane manages all the process window conditions used by the session.

Description

The PW Table shows the process window conditions and assigns them to different runs within the session. It also performs simple checks, such as for duplicate condition names or non-integer defocus values.

Figure 5-7. PW Table and Process Window Conditions



Objects

Object	Description
Create PW	Adds a row to the table.
Export	Opens the Export PWs browser. You can save your process window conditions in comma-separated version (*.csv*) format and use them in other runs.
Import	Opens the Import PWs browser. Rather than manually entering the process window conditions, you can import a previously saved spreadsheet in *.csv* format. The conditions can be appended to those conditions already in the table or replace them.
Spec	Opens the Optical Model Spec Manager. The Optical Spec Manager creates, edits, and deletes optical model specifications with Zernike coefficients.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Columns	Adds GIDs and Plane columns to the PW Table. • GIDs — Displays the gauge IDs selected for PW conditions in a column in the PW table. By clicking the GIDs column for a PW condition, gauges can be selected for the PW condition. Gauges selected for a PW condition are used by pxSMO only; not by OPC or Verify, or with marker layers. • Planes — Displays image planes values for PW conditions in the PW Table.
PW Options	Sets the following PW Table options: • Global PW (without GID) — Enables or disables process window conditions to be used globally with a GID. • Image Plane Interpolation — Specifies the mode of image plane interpolation. The options include Use Model Setting, Enabled (auto mode), Disabled (only mode), and No Extra Planes (only mode). The options reflect the mdf smo configopt command arguments. • No Extra Optical Specs — Ignores optical model specifications from the input optical model that are not listed in the Optical Model Spec Manager. • Check Duplicate PWs — Highlights duplicate process window conditions in yellow. Conditions are considered duplicates if they share the same name (case-insensitive) or if all numeric values are the same. You should not run with duplicate PW Names because the behavior is unpredictable.
Delete Selected PW Conditions	Click to delete the currently selected PW Table row. If the icon is not blue, you need to select a row in the table.
Table area	You can interact with the table in the following ways: • Reorder rows by clicking on column headings. • Enter names and values in the non-checkbox columns. Defocus must be an integer. • Assign conditions to point tools using the right three columns.

Usage Notes

Only process window conditions that have a run type (pxSMO, OPC, or Verify) selected appear in the setups for the point tools. The nominal condition must exist, and should be assigned to all three.

The Process Window Conditions matrix (Figure 5-7, right side) shows the dose and defocus coverage of the PW Table. Use the highlight options to quickly check that the Verify conditions are closer to nominal than the pxSMO and OPC conditions.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Pre-SMO Setup Pane

To access: In the Session Browser, activate a session and click **Pre-SMO** in the Setup Items tree.

The Pre-SMO setup pane enables setup of the curve target and tolerance bands before run execution, or viewing of settings when the run is complete.

Description

The Pre-SMO Setup pane creates a file called *smoo.setup* by default.

Figure 5-8. Pre-SMO Setup, Curve Target Tab

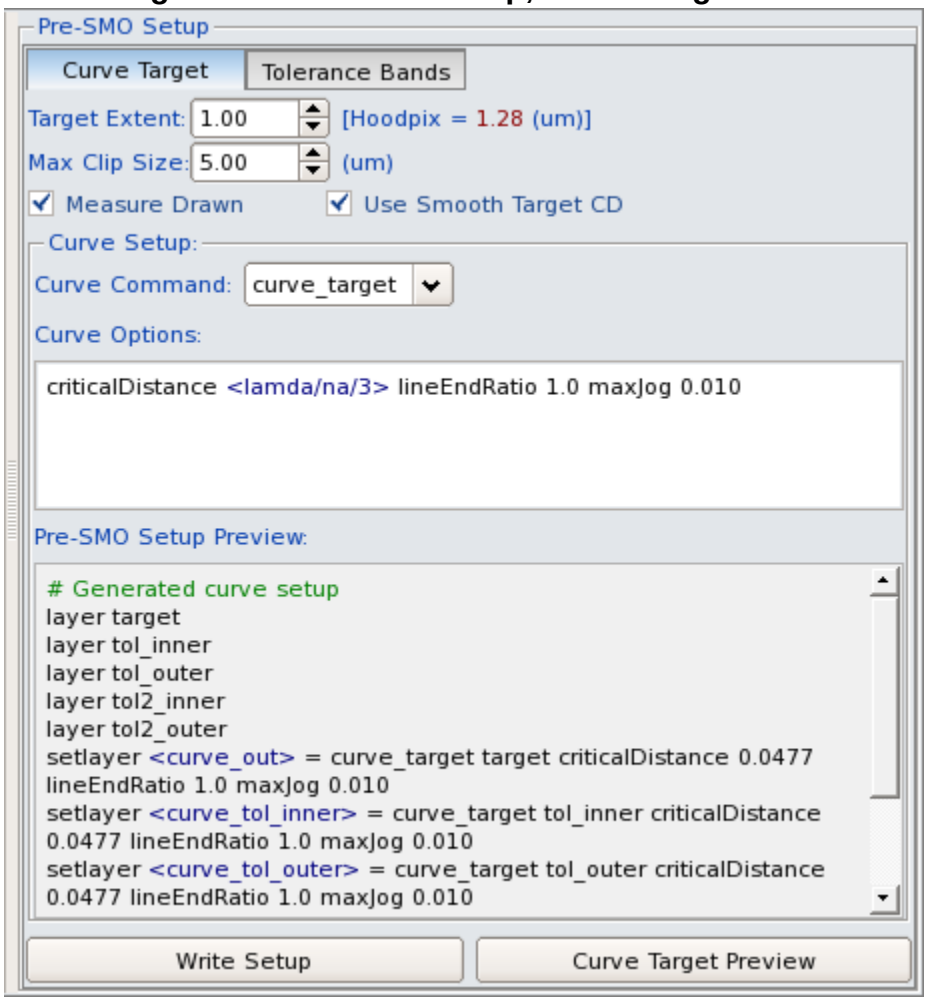


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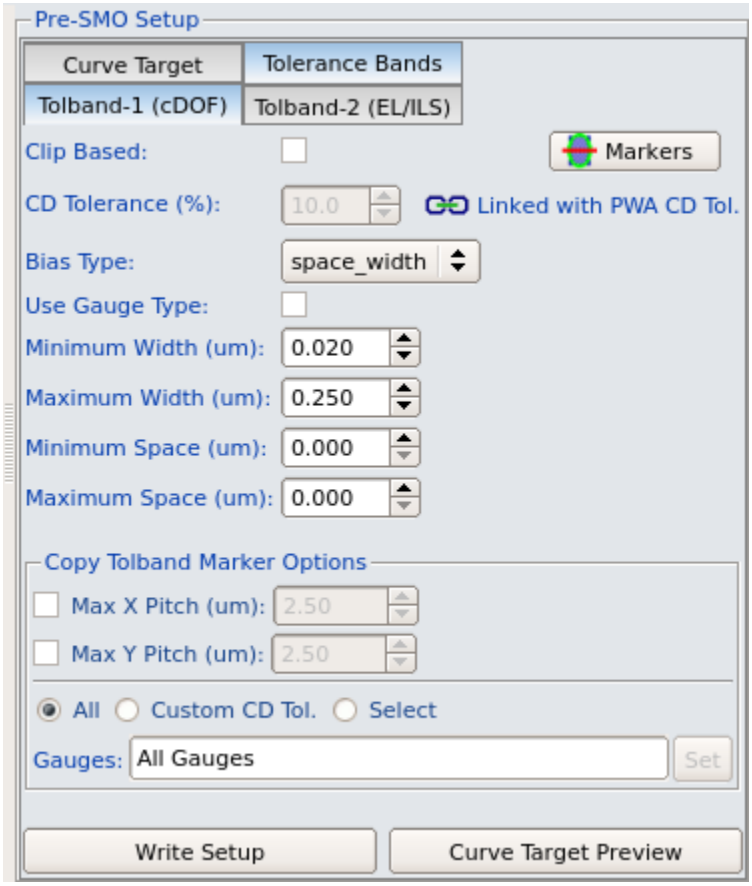
Figure 5-9. Pre-SMO Setup, Tolerance Bands Tab



Objects

Object	Description
Curve Target Tab	
Max Clip Size	Controls the maximum size used to generate a clip layout from a gauge.
Curve Command	Adjusts the target. • **curve_target** — Creates a target that mimics the final image. This is the default. • **curve** — Creates a target using a smoothing effect. The options for setlayer curve_target and setlayer curve are described in the *Calibre nmOPC User's and Reference Manual*.
Tolerance Bands Tab Objects common to **Tolband-1 (cDOF)** and **Tolband-2 (EL/ILS)**	
Clip Based	Biases all edges in a clip using the CD Tolerance (%) value.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Markers	Opens the Custom Marker Editor for drawing markers and setting the CD tolerance.
CD Tolerance (%)	Specifies the CD tolerance applied to the target. By default, the CD tolerance value is set equal to the Process Window Analysis CD Tolerance. To change the CD Tolerance, click the lock icon and adjust the value.
Bias Type	Specifies the type of CD measurements that the CD tolerance is applied to: • **space** — Applies CD tolerance to external CD measurements. • **width** — Applies CD tolerance to internal CD measurements. • **space_width** — Applies CD tolerance to the minimum of the internal and external CD measurements. This is the default for CDOF jobs. • **fix** — Applies a constant CD tolerance in nanometers. This is the default for EL jobs.
Use Gauge Type	Uses the gauge type to determine the type of tolerance band marker. Default is off.
Minimum Width Maximum Width Minimum Space Maximum Space	Applies the CD tolerance value to lines and spaces within the minimum and maximum values. • If the target CD is between the minimum and maximum, then the CD Tolerance is applied to the target CD. • If the target CD is below the minimum, the CD Tolerance is applied to the minimum value. • If the target CD is above the maximum, the CD Tolerance is applied to the maximum value. When **Minimum Space** and **Maximum Space** are set to zero, they use the **Minimum Width** and **Maximum Width** values. All values are in microns.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Copy Tolband Marker Options	Specifies which gauges have tolerance markers copied to periodic features. If a gauge is placed on a symmetrical repeated feature (for example, a contact in a 2D periodic array), the tolerance band marker for that gauge feature can be copied to its repeated instances. The Copy Tolband Marker options controls how the tolerance band marker is copied to the repeated instances. • **All** — Copies the tolerance band markers for all gauges to the repeated instances. This is the default. • **Custom CD Tol.** — Copies the tolerance band markers only for gauges that have a custom CD tolerance. • **Select** — Copies the tolerance band markers for specified gauge IDs. If Use Gauge Type is selected, then All is recommended.
Max X Pitch (um) Max Y Pitch (um)	Controls the maximum distance from the gauge for copying tolerance band markers.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pxSMO Setup Pane

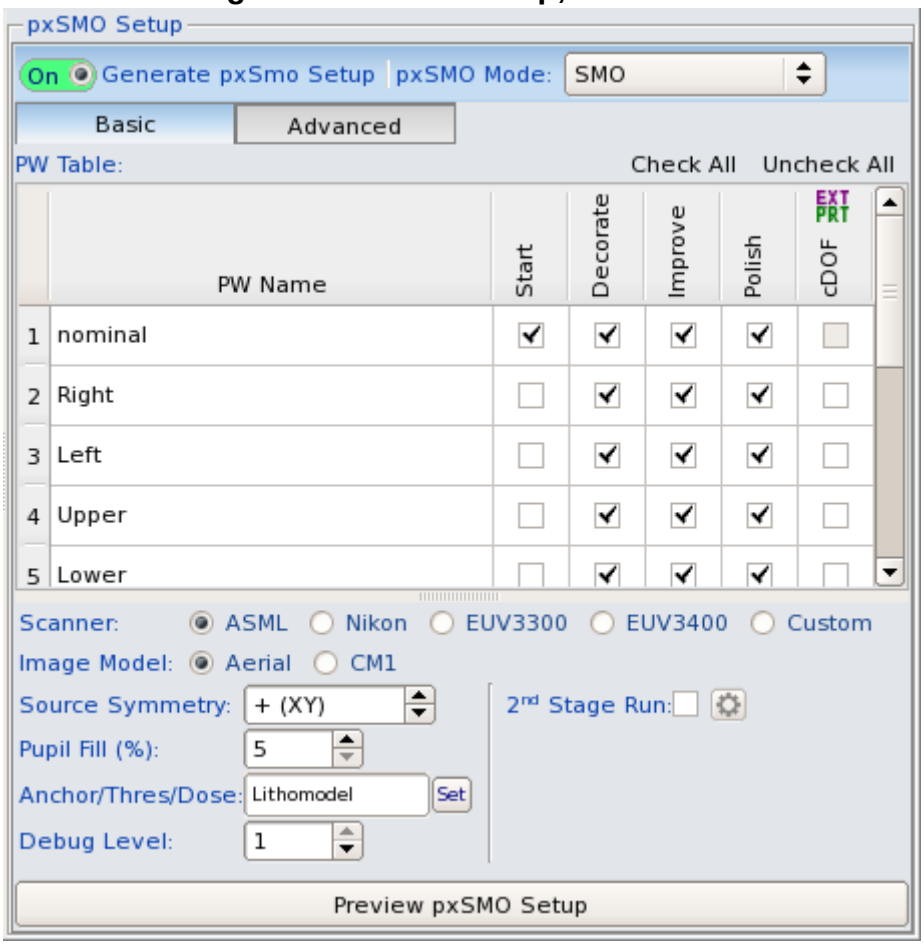
To access: In the Session Browser, activate a session and click pxSMO in the Setup Items tree

The pxSMO setup pane enables quick setup of the SMO run before execution, or viewing of settings when the run is complete.

Description

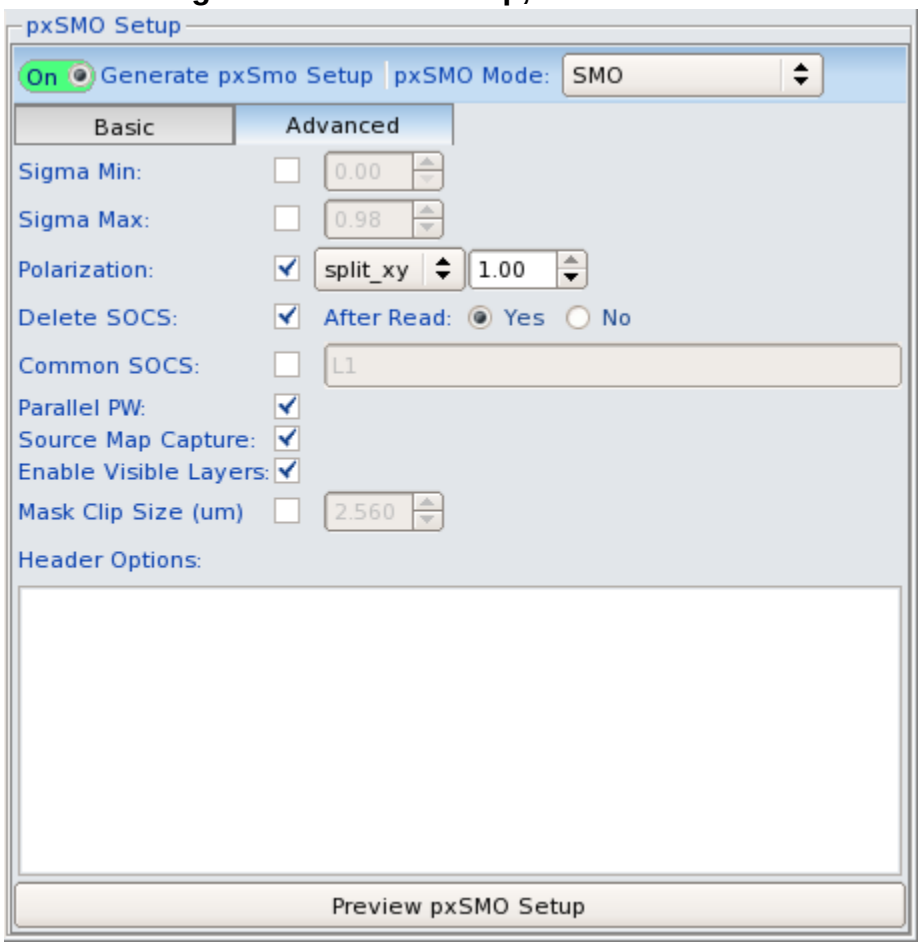
The pxSMO Setup pane creates a file called *pxsmo.setup* by default. The more commonly changed settings are available in the **Basic** tab.

Figure 5-10. SMO Setup, Basic Tab



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 5-11. SMO Setup, Advanced Tab



Objects

Object	Description
On/Off Generate PxSMO Setup	Set to Off to use a prepared pxSMO setup file instead of the GUI for configuring pxSMO runs.
pxSMO Mode	Specifies the optimization type: • SMO — Source-mask optimization. • MO (Mask Only) — Mask-only optimization. • SO (Source Only) — Source-only optimization. Changing the pxSMO Mode changes the job types in the pxSMO setup file. MO mode uses job types ending with _mo; SO mode uses job types ending with _so.
Preview PxSMO Setup	Shows the equivalent SMO setup file for the settings currently selected.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Basic Tab	
PW Table	Shows the process window conditions that will be used for each pxSMO job. The nominal condition should always be used. Only conditions with the pxSMO column selected in the session PW Table PW Table Pane are shown in the pxSMO Setup PW Table. To add a condition, use the session PW Table and click **Update**.
Scanner	ASML, Nikon, EUV3300, and EUV3400 are particular sets of defaults. They are described in detail in "scanner" on page 148. Use Custom to specify the pixel width.
Image Model	Aerial (the default) is recommended when the litho model uses a CTR resist model or aerial images. Setting CM1 adds a Polish-2 job and can provide a better match with the OPC and Verify results, but requires that the litho model include a CM1 resist model. **Restriction:** The CM1 option is not available in the current release.
Source Symmetry	The symmetry to use for the optimized source. The types are described in "source_symmetry" on page 161.
Pupil Fill (%)	The minimum percentage of pixels to illuminate in the source. The scanner provider usually specifies this value.
Anchor/Thres/Dose	Opens the Anchor/Threshold/Dose Settings Dialog Box to set up anchoring gauge and threshold.
Debug Level	Sets the level of messages to be echoed to the transcript. Setting this value as low as possible improves run time and file size.
2nd Stage Run	Applies mask-only optimization (MO) to SMO-disabled clips. After enabling, click the gear icon to set up the MO recipe.
Constant Flare (%)	Appears only if an EUV litho model with a flare model is loaded. Sets the flare level applied across all process window conditions.
Weight Layer Weight	Appears only if at least one of the SMO Layer Type cells is set to Weight when creating the layout/gauge pair. Weight layers are unavailable for CDOF or EL/ILS optimization.
Advanced Tab	
Sigma Min/Sigma Max	Specifies the inner (Min) and outer (Max) limits of the source that should be bright in normalized units.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Polarization	Specifies the polarization type used by the scanner and the weighting given to the polarization type. This allows you to compare results from different polarization types. The default behavior is to use the source polarization type from the first element defined in the “illumtype COMPOSITE” section of the optical model file. Use the pulldown menu to select a different polarization type. The default polarization type is **split_xy** for DUV scanners and **none** for EUV scanners. The weighting range is 0.00 to 1.00.
Delete SOCS	Clear the checkbox if you do not want the SOCS directory removed from the session directory at the end of the run. By default Calibre pxSMO deletes the directory after reading it to preserve space.
Common SOCS	Creates a directory to cache the optical model kernels for reuse within the sessions of a single layout/gauge pair. This is *not recommended* with distributed processing.
Parallel PW	Increases the possible parallelization with distributed processing. If this is set, each combination of gauge and process window condition is sent to a remote CPU. If this is not set, each gauge with all associated process window conditions is sent.
Source Map Capture	Clear the checkbox if space is a concern. By default, Calibre pxSMO saves source map images to update the **Result** tab before optimization is complete.
Header Options	Type in Calibre pxSMO commands to use in the header level. (For per-job commands, select the Job: node in the tree to the right.) Manual customization is not recommended for the inexperienced.

Usage Notes

To override default job values such as iterations, select the pxSMO Job listing in the navigation tree on the right.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Anchor/Threshold/Dose Settings Dialog Box

To access: In the Session Browser, activate a session and select pxSMO in the Setup Items tree. In the **Basic** tab of the pxSMO Setup pane, click **Set** next to Anchor/Thres/Dose.

The anchoring setup dialog box enables adjusting the threshold used by a litho model to print a specified anchor gauge on target using a specified mask bias.

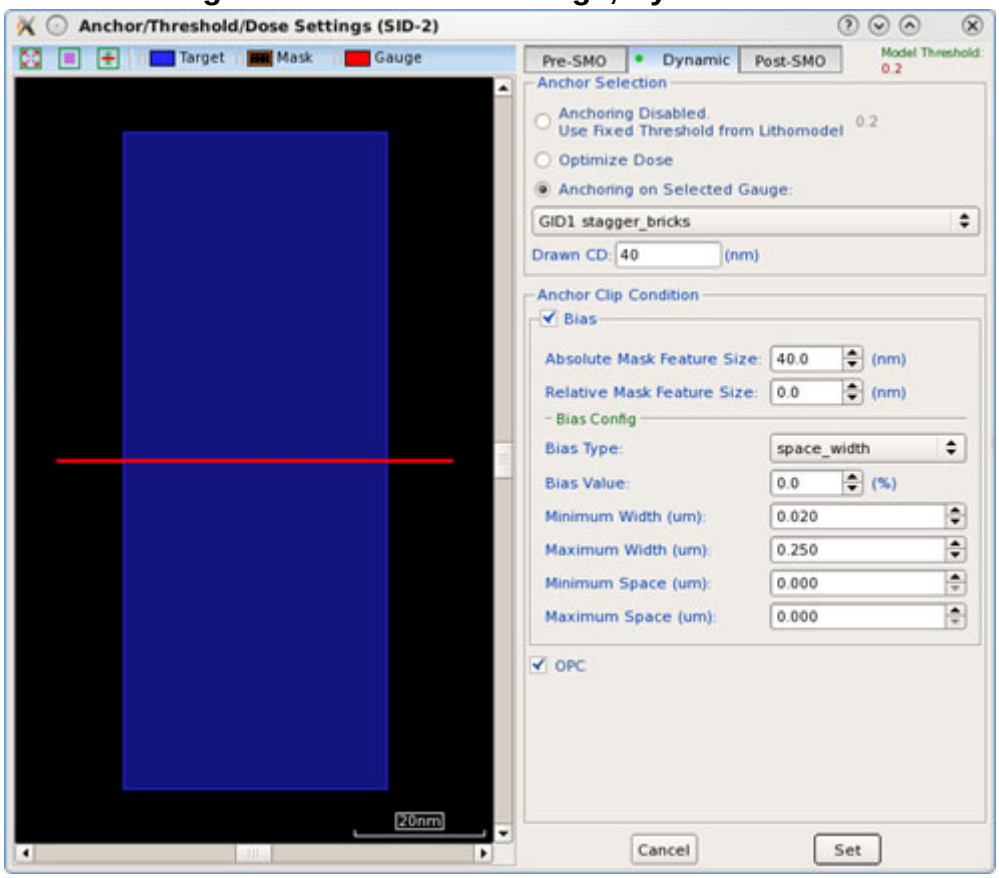
Description

You can apply anchoring to three stages:

- Pre-SMO
- pxSMO (Dynamic) — this is the default tab
- Post-SMO

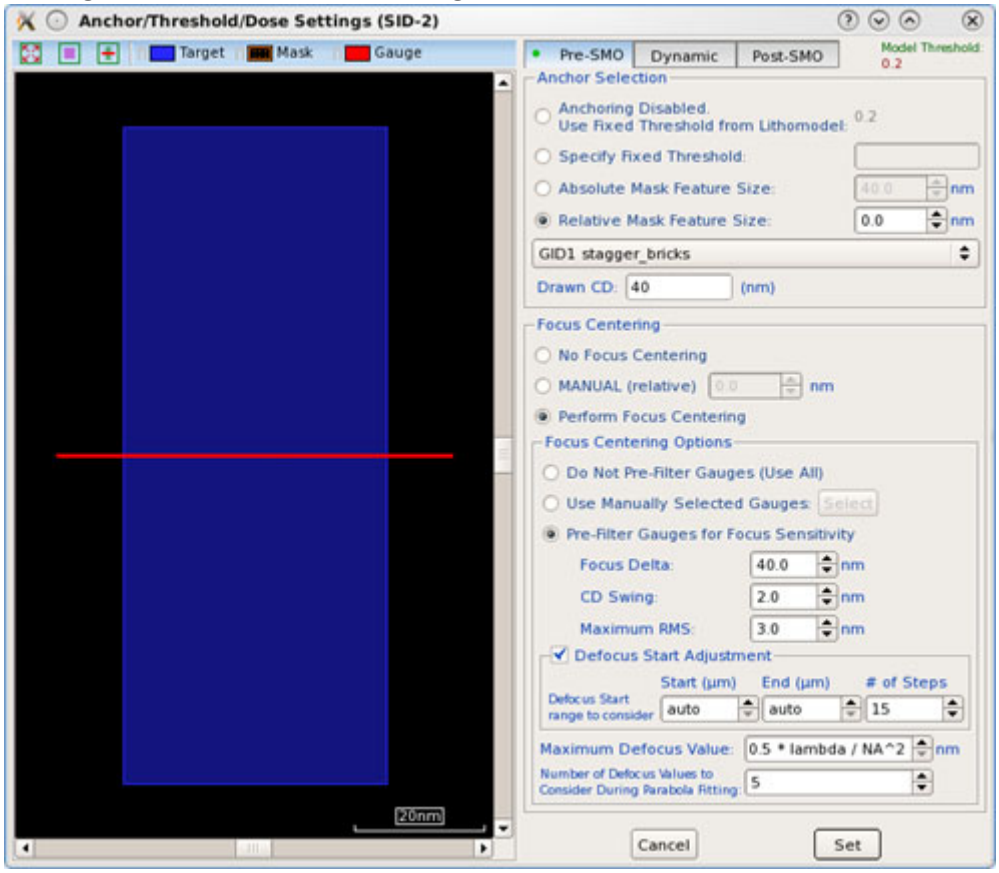
Each stage has a separate settings tab. The **Pre-SMO** and **Post-SMO** tabs display the same setting choices.

Figure 5-12. Anchor Settings, Dynamic Tab



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 5-13. Anchor Settings, Pre-SMO and Post-SMO Tabs



Objects

Object	Description
Fit to clip Fit to SMO clip Fit to gauge	Resizes the viewer to show the clip zoomed-out or zoomed-in. Click the icon to activate the state.
Target Target	Toggles viewer between hiding and displaying the target layer.
Mask Mask	Toggles viewer between hiding and displaying the mask layer.
Gauge Gauge	Toggles viewer between hiding and displaying the gauge.
Dynamic Tab	
Anchoring Selection Settings Settings to control the anchor selection method.	

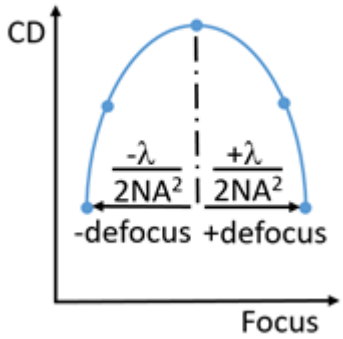
Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Anchoring Disabled. Use Fixed Threshold from Lithomodel	Deactivates anchoring and uses the displayed threshold from the litho model. This is the default.
Optimize Dose	Optimizes the dose value instead of anchoring to a gauge.
Anchoring on Selected Gauge	Activates anchoring to a specified gauge.
Anchor Gauge selector	Specifies the gauge to use to print on target. The default is the first gauge.
Drawn CD	Reports the drawn CD for the selected gauge. This value is read-only.
Anchor Clip Condition Settings Bias Settings Settings activate anchoring and set the mask feature size.	
Absolute Mask Feature Size	Specifies the feature mask size in nanometers.
Relative Mask Feature Size	Specifies the feature mask bias in nanometers relative to the target size.
Bias Config Settings Settings control application of bias to target features.	
Bias Type	Specifies the type of CD measurements that the bias is applied to: • **space** — Applies the bias to the external CD measurement. • **width** — Applies the bias to the internal CD measurement. • **space_width** — Applies the bias to the minimum of the internal and external CD measurements. This is the default. • **fix** — Applies a constant CD tolerance in nanometers. This is the default for EL jobs.
Bias Value	Specifies the bias applied to the target. By default, the bias value is 0 percent. When bias type **fix** is used, the units change to nanometers.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Minimum Width (um) Maximum Width (um) Minimum Space (um) Maximum Space (um)	Applies the bias value to lines and spaces within the minimum and maximum values. • If the target CD is between the minimum and maximum, then the bias is applied to the target CD. • If the target CD is below the minimum, the bias is applied to the minimum value. • If the target CD is above the maximum, the bias is applied to the maximum value. When **Minimum Space** and **Maximum Space** are set to zero, they use the **Minimum Width** and **Maximum Width** values. All values are in microns.
Copy Target Clip	Copies the anchor clip from the target layer to the correction layer. This option appears only if a correction layer is mapped.
OPC	Uses the anchor clip in OPC and Verify jobs. Default is enabled.
Pre-SMO and Post-SMO Tabs	
Anchoring Selection Settings Settings to control the anchor selection method.	
Anchoring Disabled. Use Fixed Threshold from Lithomodel	Deactivates anchoring and uses the displayed threshold from the litho model. This is the default.
Specify Fixed Threshold	Sets a different threshold than the lithomodel value.
Absolute Mask Feature Size	Specifies the feature mask size in nanometers.
Relative Mask Feature Size	Specifies the feature mask bias in nanometers relative to the target size.
Anchor Gauge selector	Specifies the gauge to use to print on target. The default is the first gauge.
Drawn CD	Reports the drawn CD for the selected gauge. This value is read-only.
Focus Centering Settings Settings activate focus centering and specify the centering method.	
No Focus Centering	Deactivates focus centering. This is the default.
MANUAL (relative)	Specifies a focus offset in nanometers relative to the nominal condition. When activated, the default offset is 0 nm.
Perform Focus Centering	Specifies an automated search for focus center using the Focus Centering Options.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Focus Centering Options Settings Activated when Perform Focus Centering is selected. Settings specify gauge filtering and selection.	
Do Not Pre-Filter Gauges (Use All) Use Manually Selected Gauges Pre-Filter Gauges for Focus Sensitivity	Specifies which gauges are used to determine focus center. • Do Not Pre-Filter Gauges (Use All) uses the average focus center of all gauges. This is the default. • Use Manually Selected Gauges uses the average focus center for specified gauges. Specify the gauges to use by clicking **Select**. • Pre-Filter Gauges for Focus Sensitivity selects gauges that meet a minimum CD swing requirement (that is, CD change from the focus center to the focus delta value) and have a fitting RMS below the specified maximum.
Defocus Start Adjustment	Simultaneously optimizes both the beam focus and defocus start values using the target CD. Requires at least 2 gauges to be selected for focus centering. The defocus start range values are in microns.
Maximum Defocus Value	Specifies the maximum defocus to use in the focus sensitivity calculation. Default value is 0.5 * lambda / NA^2. Hovering the cursor over the default formula displays the value. 
Number of Defocus Values to Consider During Parabola Fitting	Specifies the number of focus values used in the focus sensitivity calculation. Default is 5.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Objective Region Tab

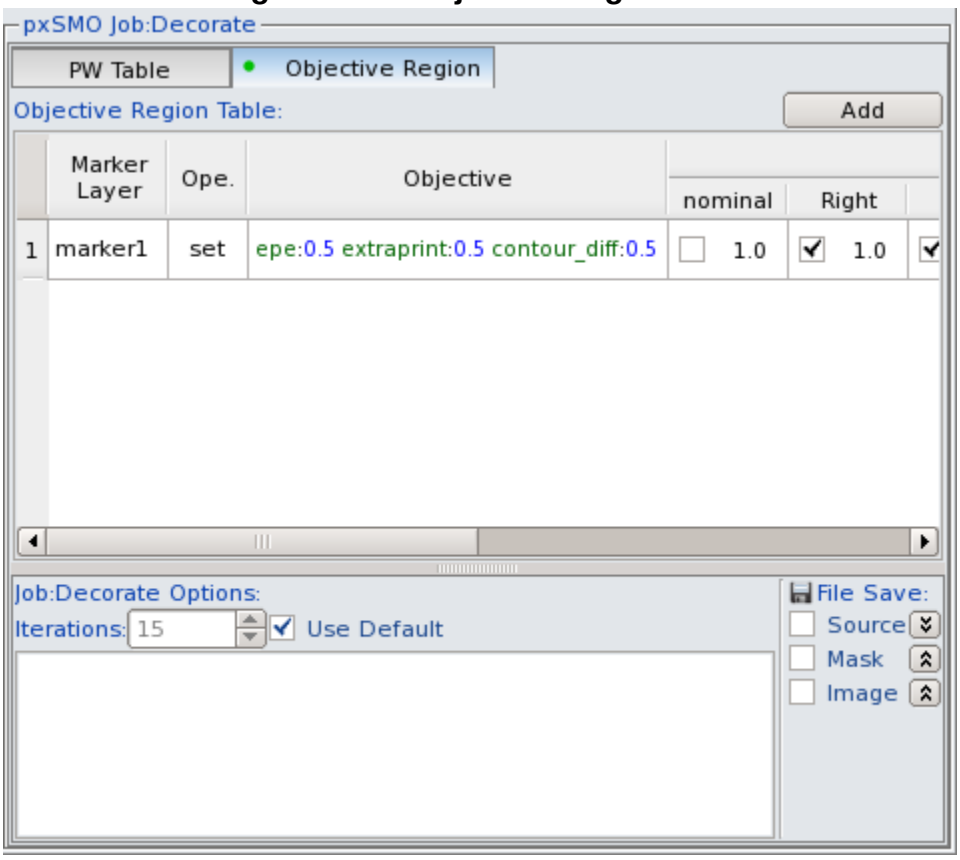
To access: In the Session Browser, activate a session and select any Job under pxSMO or pxOPC. In the Job setup pane, click the **Objective Region** tab.

The **Objective Region** tab assigns process window conditions to objective regions.

Description

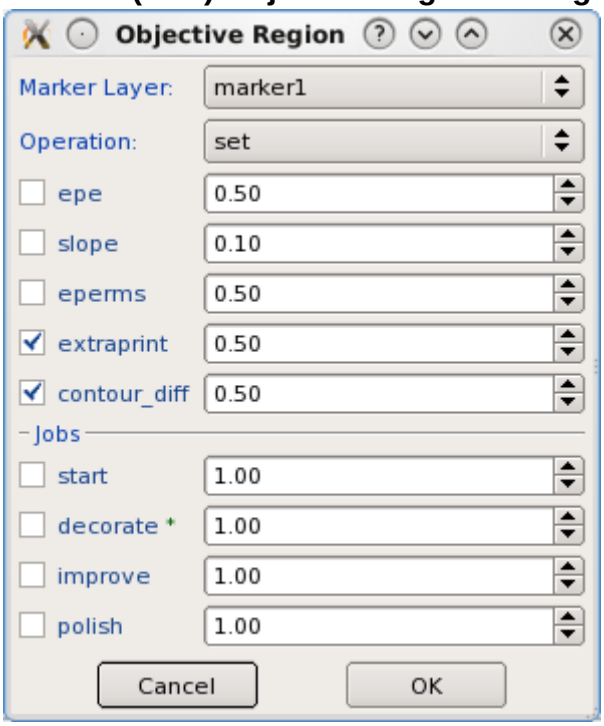
The **Objective Region** tab manages custom objectives assigned to marker layers at specified process window conditions. Adding a marker layer with objectives opens the Objective Region dialog box.

Figure 5-14. Objective Region Tab



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 5-15. (Add) Objective Region Dialog Box



Objects

Table 5-14. Objective Region Tab Objects

Object	Description
Objective Region Table	Displays marker layers and objectives. Use the table to assign process window conditions to marker layers. Right-clicking a marker layer row opens a menu with the options **Delete selected** and **Edit**.
Add	Adds a marker layer with objectives.

Table 5-15. Objective Region Dialog Box

Object	Description
Marker Layer	Specifies the input layer to which the objectives are applied. If **backdrop (all)** is selected, then the specified objectives are applied outside of all marker layers.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-15. Objective Region Dialog Box (cont.)

Object	Description
Operation	Optimizes the marker layer using either only the specified objectives or by combining the specified objectives with existing objectives. **set** optimizes the marker layer using only the selected objectives. **add** optimizes the marker layer by combining the selected objectives with existing objectives.
epe slope eperms extraprint contour_diff job names	Objectives and objective weights for optimizing the marker layer. • epe — Optimizes the mask to minimize the sum of edge placement error (EPE). • slope — Optimizes the mask to maximize the image slope. • eperms — Optimizes the mask to minimize the total area of edge placement error (EPE). Useful for layers with line end features. • extraprint — Optimizes the mask to minimize extra printing. • contour_diff — Optimizes the mask to minimize contour differences between the specified process window conditions. At least two process window conditions must be specified in the Objective Region table. • The individual job names apply the default objectives for the specified job. The listed job names differ for pxSMO and pxOPC.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

pxSMO Job:cDOF Pane

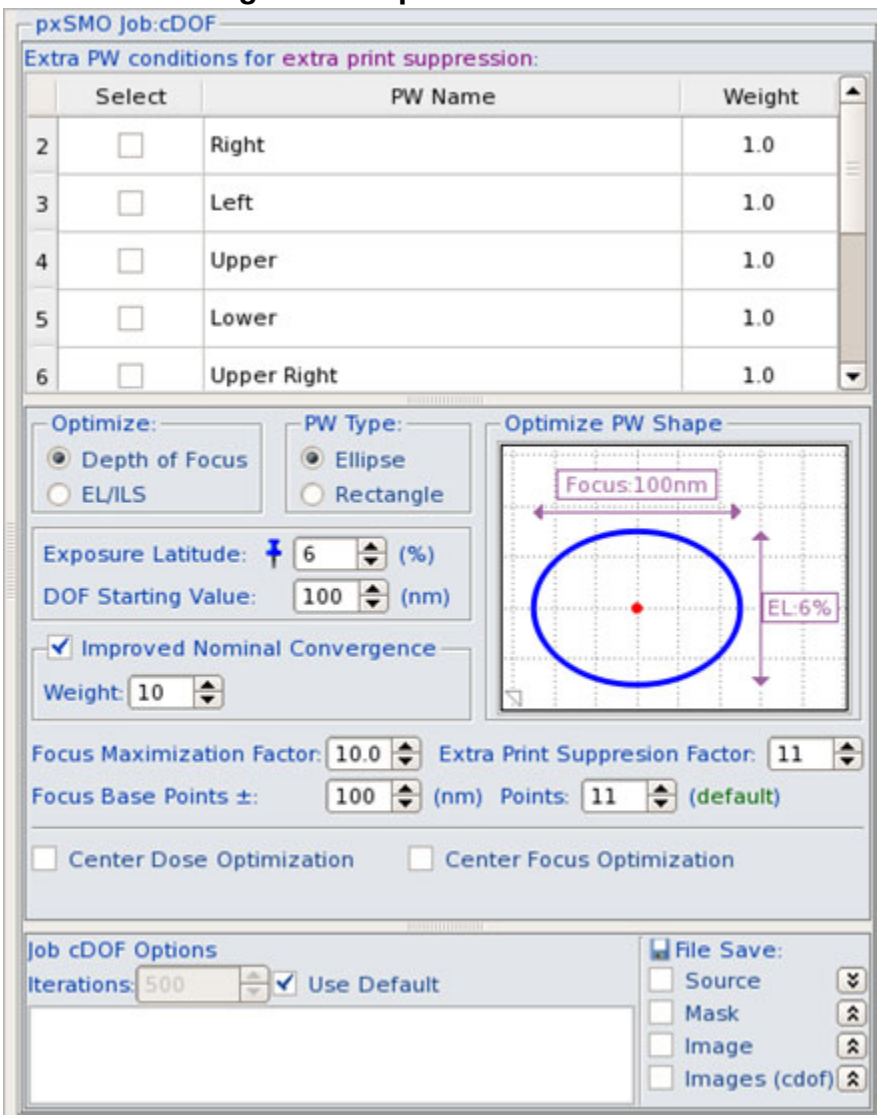
To access: In the Session Browser, activate a session and click **Job:cDOF** in the Setup Items tree.

The pxSMO Job:cDOF pane enables setup of the SMO run to maximize common depth of focus before execution, or viewing of settings when the run is complete. If EL/ILS optimization is selected, the labels change to **Job:EL** and the SMO run will maximize exposure latitude.

Description

The pxSMO Job:cDOF pane manages the settings that maximize common depth of focus for a specified exposure latitude. If EL/ILS optimization is selected, then the labels change to **Job:EL** and job maximizes exposure latitude for a specified depth of focus. Most settings are used by both job types.

Figure 5-16. pxSMO Job:cDOF



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Objects

Object	Description
Extra PW conditions for extra print suppression table	Turns on SRAF print suppression for specified process window conditions. Nominal condition does not appear in the table.
Optimize	Specifies the process window value to optimize. Selecting **Depth of Focus** freezes the exposure latitude value during optimization. Selecting **EL/ILS** freezes the depth of focus value during optimization.
PW Type	Specifies the shape to inscribe in the process window for calculating depth of focus. Default is Ellipse.
Exposure Latitude	Specifies the exposure latitude percentage when common depth of focus is optimized. Default is 6 percent.
DOF Starting Value	Specifies the initial depth of focus in nanometers when common depth of focus is optimized. Default is 100 nm.
EL Starting Value	Specifies the initial exposure latitude when EL/ILS is optimized. Default is 6 percent.
Depth of Focus	Specifies the depth of focus in nanometers when exposure latitude is optimized. Default is 100 nm.
Improved Nominal Convergence	Improves EPE for the nominal process window condition. Default is on. **Weight** — Specify higher values to improve EPE. Default is 10.
Focus Maximization Factor	Controls the relative emphasis given to common depth of focus during process window optimization. Used only with CDOF jobs.
Focus Base Points	Specifies the range of defocus conditions for through-focus aerial image calculation. Used only with CDOF jobs.
Points	Specifies the number of focus base points to use for through-focus aerial image calculation. Used only with CDOF jobs.
Extra Print Suppression Factor	Controls the relative emphasis given to SRAF print suppression. Default is 10.
Dose Maximization Factor	Controls the relative emphasis given to exposure latitude during process window optimization. Used only with EL jobs. Default is 100.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Center Dose Optimization Center Focus Optimization	Enables optimization of the dose center and focus center during process window optimization. Default is optimization disabled.
Job:cDOF Options **Job:EL Options**	
File Save	Saves files for debugging. File names can be specified. • **Source** — Saves source map file. • **Mask** — Saves OASIS file of all clips. • **Image** — Saves contours of all clips. • **Images (cdof)** — Saves input layers and process window contours.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Custom OPC Flow Editor

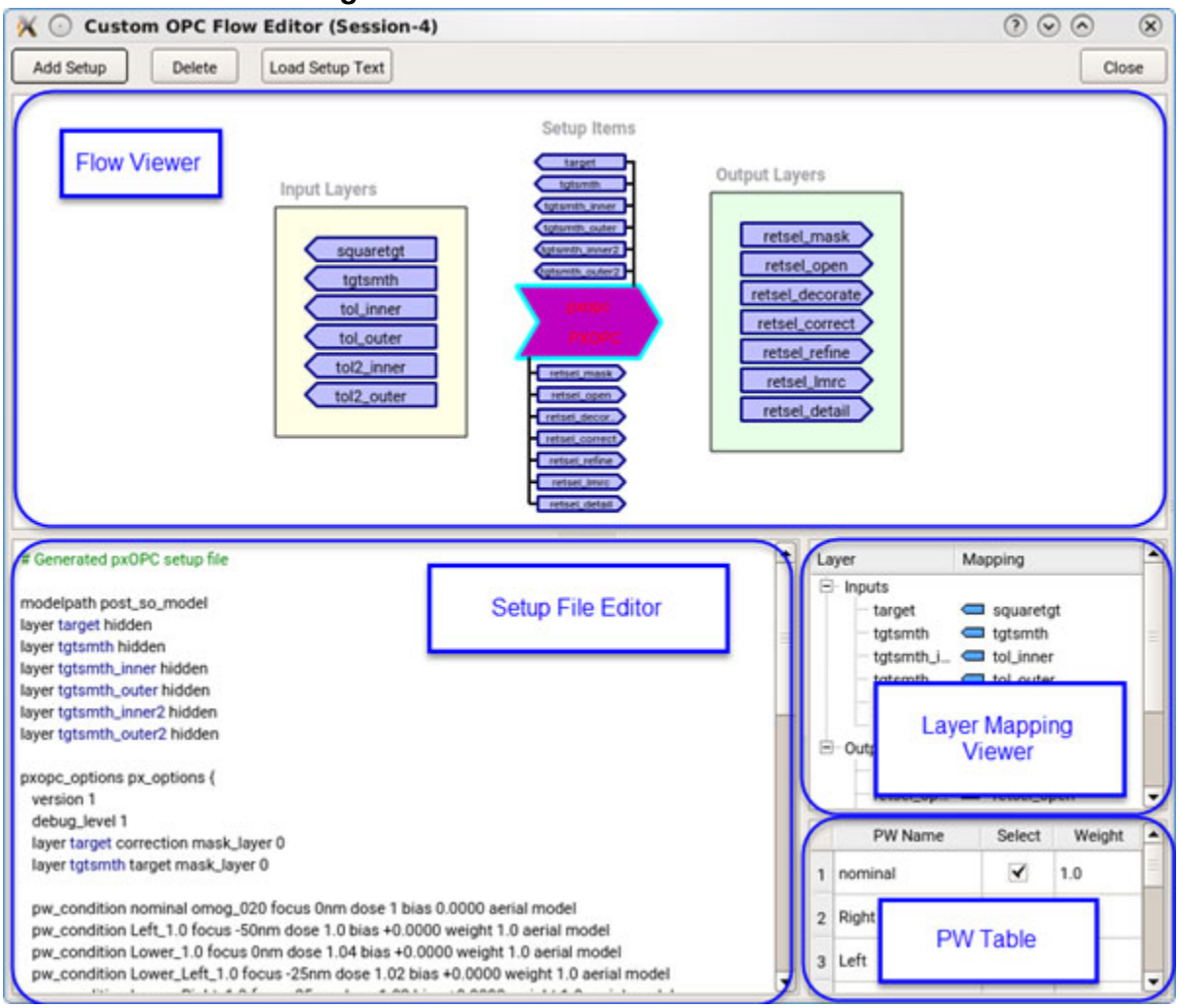
To access: In the Session Browser, activate a session and click the OPC item in the Setup Items tree. Select **Custom OPC** as the OPC engine. Click **Edit Custom OPC Flow**.

The Custom OPC Flow Editor enables an advanced user to build custom OPC flows with different OPC, mask bias, and SRAF setups.

Description

The Custom OPC Flow Editor creates setup files for each setup used in a custom OPC flow.

Figure 5-17. Custom OPC Flow Editor



Objects

The following table describes the action buttons at the top of the window.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Add Setup	Adds a setup to the flow. Opens the Custom OPC Setup Configuration window to set the setup options.
Delete	Deletes the selected setup from the flow.
Load Setup Text	Loads a setup file and places the file contents in the Setup File Editor.

Related Topics

Setting Up a Custom OPC Flow

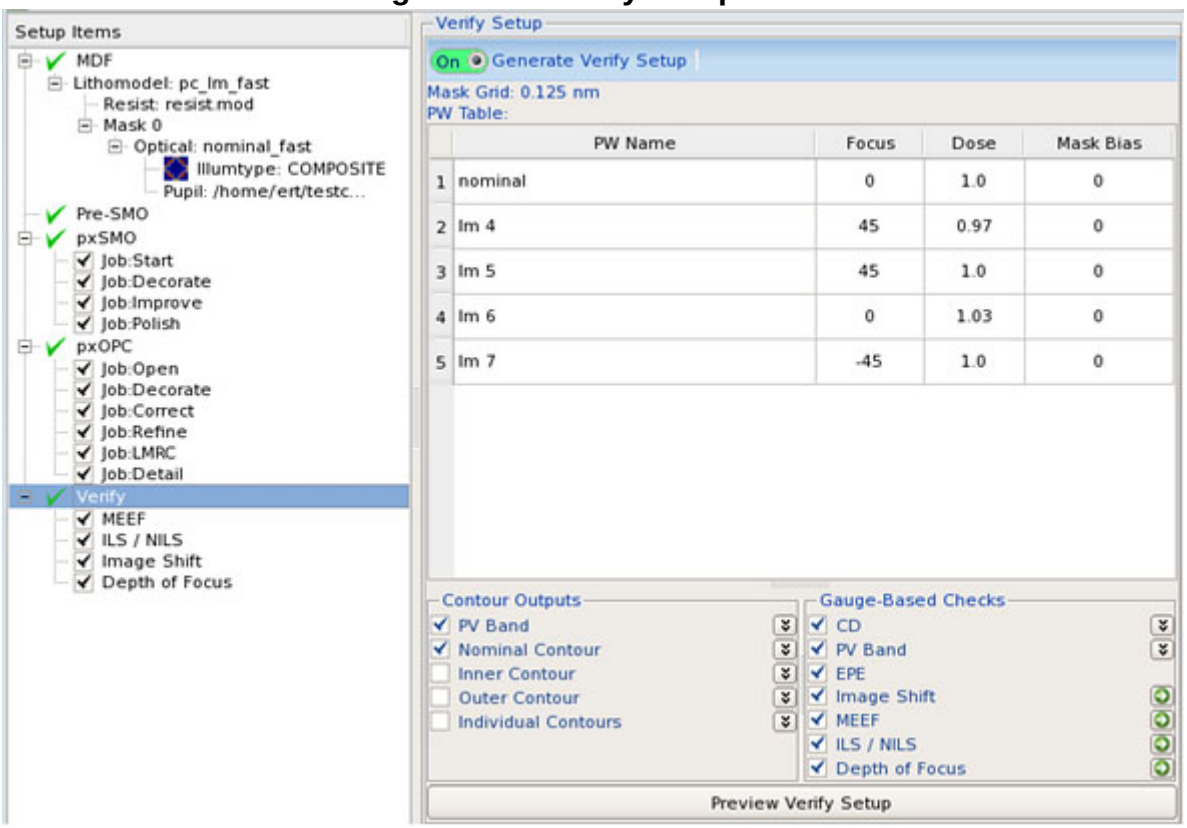
Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Verify Setup Pane

To access: In the Session Browser, activate a session and click Verify in the Setup Items tree

Enables quick setup of the Calibre OPCverify run before execution and configuration of the Process Window Analysis plot.

Figure 5-18. Verify Setup Pane



Description

The Verify Setup pane creates a file called *verify.setup* by default. The pane allows you to select different measurements to make, such as PV band and CD. It also lists the process window conditions in the PW Table. To change the conditions, use the Verify column in the PW Table Pane.

Note

The PW Table conditions are shared across all sessions in a layout/gauge pair. Do not change the table if sessions are executing.

Some options appear duplicated between the Contour Outputs and Gauge-Based Checks, but are actually using different commands. You can see the commands being used by selecting the checks and clicking **Preview Verify Setup**. All commands in the Verify setup file are documented in the *Calibre OPCverify User's and Reference Manual*.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

The gauge-based Image Shift, MEEF, ILS/NILS, and Depth of Focus checks have additional settings that are accessed either through the Setup Items tree or the right-arrow icons after the check name. The Depth of Focus pane configures the Common Process Window plot.

Figure 5-19. Verify > Depth of Focus PW Settings Tab

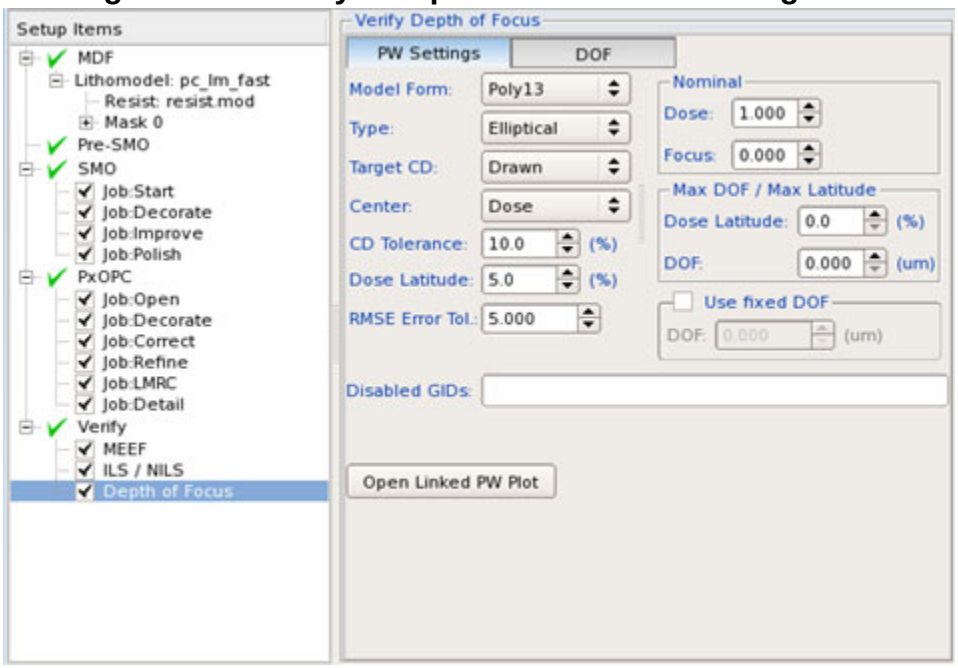
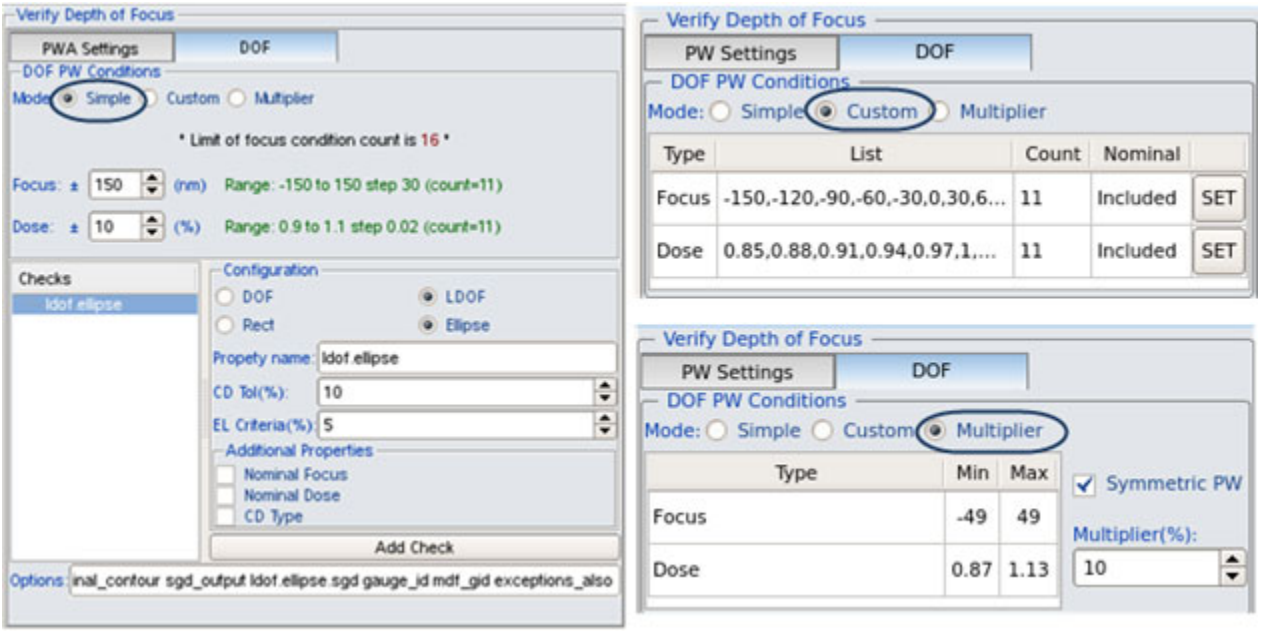


Figure 5-20. Verify > Depth of Focus DOF Tab



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Objects

Table 5-16. Verify Setup

Object	Description
On/Off Generate Verify Setup	Set to Off to use a prepared Calibre OPCverify setup file instead of the RET Selection GUI for specifying checks.
Mask Grid	Reports the grid size (precision) of the layout file. This value is read-only.
PW Table	Reports the process window conditions used for the Verify run. This table is read-only.
Contour Outputs	Includes copies of the specified contours in the mask output. Click the button to set the output layer name and add any additional arguments.
Gauge-Based Checks	Measures the selected properties using the gauges. The setup file adds a property for each measurement to the setlayer gauges check. The arrows for Image Shift, MEEF, ILS/NILS, and Depth of Focus open the same pane as the entries in the Setup Items tree.

Table 5-17. Verify > Depth of Focus

Object	Description
PW Settings Tab Settings affect the Common Process Window (cPW) calculations.	
Model Form	The type of polynomial to use when modeling the common process window. • **Poly13** — Default. Provides better fit for the DOF measurement. • **Poly8** — A smaller polynomial provided for backwards compatibility. Poly8 is not recommended.
Type	The shape to fit inside the common area when measuring depth of focus (DOF). Select **Elliptical** (default) or **Rectangular**.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-17. Verify > Depth of Focus (cont.)

Object	Description
Target CD	Whether the DOF calculations should use the nominal print image CD or the drawn CD from the super gauge data (if available). **Drawn** is the default and recommended. If you do not have a super gauge data file or if it does not include drawn CD measurements, the DOF calculation uses the nominal print image CD from simulation instead. Only set **Nominal** if you want to ignore the drawn CD. If the super gauge data file contains target CD data in the "other" column, select **Other**. Choose this option when performing process window analyses where the mask CD is in the "drawn" column and the nominal CD is in the "simulated_CD" column.
Center	Forces the inscribed ellipse or rectangle in the common process window to be centered. • **Dose** — Default. This forces the dose variation to be symmetric around the dose value set in the Nominal field. It does not constrain the focus. • **Focus** — Similar to Dose, but forces the inscribed shape to be centered on the nominal focus. • **None** — Use for maximum common DOF. May be overly optimistic. • **Both** — Use to explore the common process window around nominal conditions.
CD tolerance	The allowable deviation between target and simulated CD on gauges. Gauges that cannot be resolved to within the tolerance are not included in the common process window plot. The CD tolerance upper and lower bounds are calculated using the Target CD selection (either Drawn or Nominal). The default is 10%.
Dose latitude	The extent of the common process window around the dose axis. The default is 5%.
RMSE Error Tol	Defines the threshold for outliers. The RET Selection common process window is calculated with a two-step fitting. Gauges whose CD at a given dose and focus vary greater than the RMSE value are not included in the second part of the calculation. The default is 5.
Nominal	Specify a focus or dose to use in conjunction with Center. Dose is in percentage. (100% is 1.) Focus is in microns. Changing the nominal focus and dose affects the inscribed shape.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-17. Verify > Depth of Focus (cont.)

Object	Description
Max DOF/Max Latitude	Specify a tolerance for depth of focus and exposure latitude. Both default to 0, allowing the full range of latitude and focus to be explored.
Use fixed DOF	When set, DOF is held steady at the specified value.
Disabled GIDs	Gauges to be omitted when calculating common process window. Set the values by clicking **Open Linked PW Plot** and setting the gauges to **Off** in the cPW Analyze column.
DOF Tab Settings affect the gauge-based DOF calculations.	
DOF PW Conditions	Select the Simple, Custom, or Multiplier mode to adjust focus and dose latitude for the depth of focus process window. • Simple mode permits setting only the maximum and minimum exploration distance. • Custom shows the exact values to be used. Click **SET** to edit them. • Multiplier displays the minimum and maximum values, which you adjust indirectly via a multiplier. **Note:** The Dose and Focus values set in the tab are not related to the Dose and Focus values set in the **PW Settings** tab. The initial values are drawn from the PW Table. Fewer than 16 defocus conditions should be specified.
Checks	Use the Configuration controls to the left to add checks to the Checks list. Initially the list is populated with only ldof.ellipse, the default Depth of Focus check. To remove checks. right-click the check name and select **Delete**.
DOF LDOF	Specifies the dose latitude of the otherwise-identical check. • **DOF** — Uses a minimum dose latitude; use for focus sensitivity or for comparing to older Calibre OPCverify DOF checks. • **LDOF** — Varies the dose latitude according to EL Criteria. Produces standard DOF data.
Rect Ellipse	Specifies the shape to be inscribed in the process window for calculating DOF.
Property name	Specify a unique name for the check. Duplicate names cause the session to fail with an error.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-17. Verify > Depth of Focus (cont.)

Object	Description
CD Tol(%) EL Criteria(%)	Specifies the CD tolerance and EL criteria (dose latitude). Larger values give larger DOF and focus ranges. Varying these may cause the best focus and best dose to shift. EL Criteria is only available with LDOF.
Additional properties	Select properties to add to the gauge output.

Usage Notes

The PV Band contour is constructed from only the outer and inner contour, and if you have a complicated set of process window conditions may not represent the complete PV band. You can add more contours using the Options field in the selection's pop-up menu, accessed from the button to the right of the label.

Plot Types

There are four plot access points. Two of them open windows with multiple plots.

Inter-Session Plots (Layout/Gauge Pair ID Inter-Plots Window)

The inter-session plots accessed by the **Inter-plots** button graph the data for each session together in single-view plots. The individual plots have complex controls, described in detail in "Inter-Plots Window" on page 218.

The plots are grouped by the type of data:

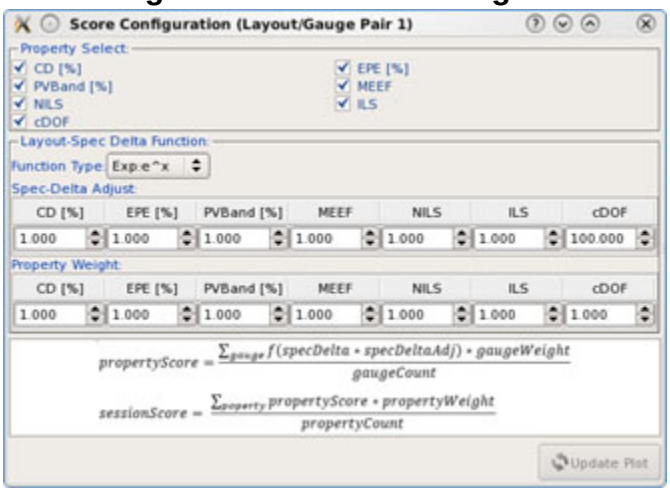
- **Score Plots**

  The Session Score Components and Session Score plots use only the factors defined in the Gauge Property Spec Editor. To access the editor, click the **Edit Layout Spec** icon and assign values in the Spec columns. When you are done, click the **Update All Plots** icon in the dialog box toolbar.

  The contribution of the components is weighted in the Score Configuration. To access the settings, click the **Config Score** icon. The Spec-Delta Adjust and Property Weight fields control the relative weighting used in the property score and session score, whose equations are shown below. (See Figure 5-21.)

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 5-21. Config Score — Score Configuration Dialog Box



- **Session Plots**

  The session plots show the exposure latitude (EL) and depth of focus (DOF) results for all sessions. To remove gauges with bad data from consideration, set their cPW value to Off in the **Gauges** tab. The settings in the PW Plot are not saved and do not affect the Inter-Plots calculations.

- **Gauge Plots and Gauge Box Plots**

  The gauge-based plots show the same data as the session gauge plots, but with all displayed sessions' gauges shown in a common data area.

Gauge Plots (Session ID Plots Window)

The session plots accessed by the **Session Plot** button let you examine per-gauge metrics for a particular source solution. The number of plots may seem overwhelming but you can reduce the number shown by either of these methods:

- Use the Plots pane to turn off the plots you do not care about.
- Change your default view by selecting **Config Plot** (above the gauge table) and toggling the plots On or Off.

The plots available in the Session Plot Table are as follows, available as both lines and histograms:

Table 5-18. Session Plots

CD	CD Target
CD DIFF, Absolute CD DIFF	iDOF, Max iDOF
Max iEL	Focus at iDOF, Focus at Max iDOF, Focus at Max iEL

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-18. Session Plots (cont.)

ILS, ILS-Left/Bottom (Edge), ILS-Right/Top (Edge)	Image Shift
Nominal EPE, EPE-Left, EPE-Right	Relative nominal EPE
MEEF	NILS
PV band	Relative PV band (by percentage)

Property PW Plots display specified metrics across focus and dose.

EL vs DOF Plot (Across a Database)

The EL vs DOF plot shows how depth of focus (DOF) changes with exposure latitude (EL).

The plot by default displays a thumbnail of the source and the session name. You cannot make changes in the plot once drawn, but you can have any number of plots open at the same time.

See "Comparing Process Window Performance" on page 68 for instructions on using it.

Process Window Plot

The Process Window plot is a type of gauge plot, in that it only includes data from gauges of a single session. It is not displayed in the Session Plots window, however.

To create a Process Window plot, the Verify stage must include a DOF check. The results of this are written to *output/<check>.sgd*, by default *output/ldof.ellipse.sgd*. (You can also access this from the main window's **Tools > PW Plot** window, but you will need to navigate to an *.sgd* file.)

There are two forms of the Process Window plot. Both can be accessed from the RET Selection GUI by clicking on the filename link in the **Result** tab.

- If Use CWB PW Plot is not selected, the RET Selection Process Window plot is displayed. This plot is described in "Process Window Plot" on page 224. This window also provides access to Bossung plots and an EL vs DOF plot.
- If Use CWB PW Plot is selected, the Calibre WORKbench Process Window plot is displayed. This plot is described in "Viewing the Process Window Tolerance" in the *Calibre WORKbench User's and Reference Manual*.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

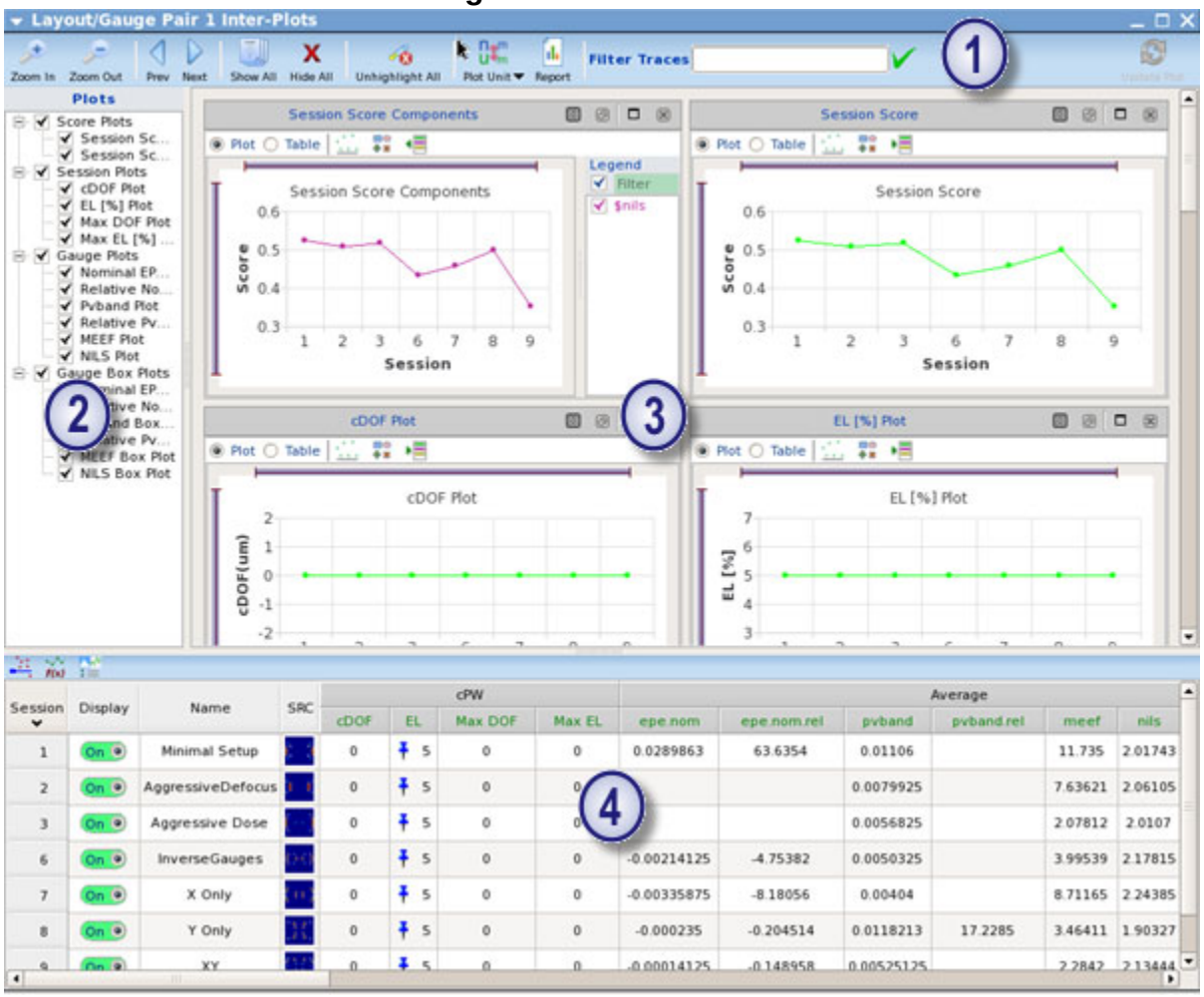
Inter-Plots Window

To access:

- In the Session Browser **Result** tab, click **Inter-Plots** and select **Sessions In this Layout**.
- In the Session Browser **Result** tab, click **Inter-Plots** and select **Selected Sessions...**.
- In the Run Control/Layout Session View, right-click in a session row and select **Session Compare Plots ...**. In Session Compare Plots dialog box, choose the sessions to compare and the Spec. Layout. Click **Open Plots**.
- In the Run Control/Layout Session View, right-click in a session row and select **Layout ID > Inter-Plot**.

The Inter-Plots window shows selected plots for groups of sessions within a layout/gauge pair.

Figure 5-22. Plots Tab



Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Note

For a list of all plot types available in the window, see "Plot Types" on page 215. The Inter-Plots Window focuses on the controls common to all the plots.

Objects

Table 5-19. Plot Viewer Controls

Field	Description
1	Plot menu bar controls. Controls in this bar apply to all active plot views. • **Zoom In**, **Zoom Out** — Zooms all plots. • **Prev**, **Next** — Cycles through the list of plots. • **Show All**, **Hide All** — Displays or hides all plot views. • **Unhighlight All** — Removes all selection highlights. • **Show Points Label**, **Hide Points Label** — Displays or hides all plot views. • **Plot Unit** — Set plot units to nanometers (nm) or microns (um). • **Report** — Generates an HTML report. You will be prompted for a directory for the report; create a new directory for each one. (Directory contents are overwritten.) • **Filter Traces** — Similar to the legend filter, this text field filters all plot views for legends that contain a string. Remove the filter by deleting any text in the field and clicking the check button. • **Update Plot** — Click after changing session data in bottom of window.
2	Plot selector. Only plots that are checked in this list are shown in the Plot viewing area.
3	Plot viewing area. Plot views appear in the main area of the window unless deselected in field 2. Each plot has its own set of filtering and viewing controls that appear when you hover over the central area. (See next table.)

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-19. Plot Viewer Controls (cont.)

Field	Description
4	Session summary table. Displays the session results and aggregate "goodness" score (Layout-Spec Delta Components columns at far right of table). Above the session rows are these buttons: • **Edit Layout Spec** — Opens the Gauge Property Spec Editor, in which you can define per-gauge per-parameter target values. These are used to calculate each session's goodness score. See "Scoring" on page 66. • **Config Score** — Opens the Score Configuration Editor, in which you can weight the six different properties that contribute to the goodness score and set whether the delta function is measured as a linear, polynomial, or exponential function. • **Config Plot** — Opens the Plot Configuration Editor, in which you can create custom plots and define the look of automatic plots. • **Save Table to CSV** — Writes all contents of the session summary table to a CSV file.

Usage Notes

You can toggle which sessions are plotted as a set, rather than using the individual On/Off control.

1. In the session summary table, use Shift-click and Ctrl-click to select the session rows.
2. Right-click and select **Set 'Display' for selected rows**.
3. Toggle the On/Off control to the desired setting and click **Set**.
4. Click **Update Plot** in the upper right of the Inter-Plot window.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Individual Plot Window

To access: From the Inter-Plots window, undock a plot.

An individual plot window charts a single property across a group of sessions. Undocking the window allows easier access to controls and resizing for legibility.

Note

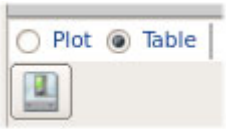
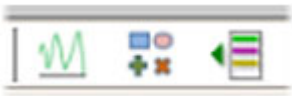
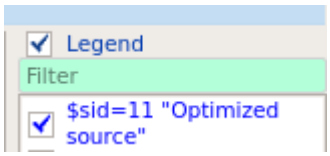
For a list of all plot types, see "Plot Types" on page 215.

Figure 5-23. Individual Plot Window, Undocked

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Objects

Table 5-20. Individual Plot Controls

Field	Description
1 	Plot and Table options. Figure 5-23 shows the Plot view. The Table view offers the following controls: • **Save Plot Data** button — Saves the plot's data in CSV format. (Shown in the image to left.) • Advanced filtering — Enter text in the column headings for trace name, X coordinate, Y coordinate, gauge ID (GID), tags, session ID (SID), or property to show only those points that have the specified text in the table view. You can also use the column headings to sort the data. • Highlighting — Select a row and right-click **Highlight**. Highlighted points show in the plot with a red circle.
2 	View controls. From left to right, the icons are • **Remove Connecting Lines** or **Show Connecting Lines** — Toggles plot between points and lines. • **Change Markers Style** — Opens a palette with controls for color, line style, marker size, and marker type. (Only visible traces can be changed.) • **Hide Legends** or **Show Legends** — Hides or shows area 3, the Legend/session trace pane.
3 	Legend pane. Use this pane to filter sessions (green field) or toggle session plot visibility (the checkboxes). Entering a string in the filter field retains only plot traces that contain the string in their legend name. Clearing the field restores the list of traces to the view.
4	Scroll bars. Move the shaded area along the red line to scroll the zoomed-in plot. (The green line, visible in some plots, indicates where the layout specification for that property is relative to the measurements. If there is no green line in the plot, it means that the property is not set in the Gauge Property Spec Editor window. Click **Edit Layout Spec** in the session summary table to open the spec editor.)

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-20. Individual Plot Controls (cont.)

Field	Description
5	Plot area. Some of the things you can do in this area include: • Zoom in or out by holding down the right mouse button and dragging diagonally up or down. • Selecting multiple points by holding down the left mouse button and dragging over them. These points are also highlighted on the other plots and the **Gauges** tab in the RET Selection window. Note that all points of a gauge are selected even if you only included a subset. To deactivate, click **Unhighlight** (in the **Gauges** tab) or **Unhighlight All** from any plot window. • Get exact values by hovering over a data point. • Switch to the session plot window by right-clicking a session trace and selecting **Locate to session <sid> plot.** The gauge on which you clicked is indicated with a rotating red square in all the plots for that session.

Usage Notes

When an HTML report is generated from the Inter-Plots window, the individual plots are included as displayed at the time the report is created. They are arranged on the HTML page in a grid, but other details reflect the current plot window settings, such as which sessions are visible.

Changes to settings in the Inter-Plots window affect all individual plot windows, even undocked ones.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Process Window Plot

To access: Use one of the methods below, then in the Process Window dialog box, adjust settings and click **Re-Plot**.

- From Calibre WORKbench, **Litho** > **PW Plot**.
- From RET Selection, **Tools** > **PW Plot**.
- From RET Selection Session Browser window, **Result** tab, click the thumbnail of the process window plot in the Verify Summary.
- From RET Selection Session Browser window, **Result** tab, click an *.sgd* file link.
- From RET Selection Verify Depth of Focus pane, click the **Open Linked PW Plot** button (unlocked sessions only).

The Process Window plot shows the common process window, best focus, and best dose across the gauges of the session. It displays two types of plots in separate tabs - a Common Process Window (CPW) and exposure latitude (EL) versus depth of focus (DOF) plot. It provides controls to toggle individual gauges or adjust model settings to quickly see how they affect the CPW or EL vs DOF values.

Description

The Process Window plot requires that the Verify Setup checks include the gauge-based DOF check. It uses many of the same settings that appear in the **DOF** tab of the Verify Setup pane. These appear under the **Model Setting** tab. In the Process Window plot, you can change those settings and click **Re-Plot** to see how the different polynomial types, shapes, and centering affect the common process window and the best dose and focus. Changes in the **Model Setting** tab are also reflected in the Verify Setup screen's Depth of Focus pane.

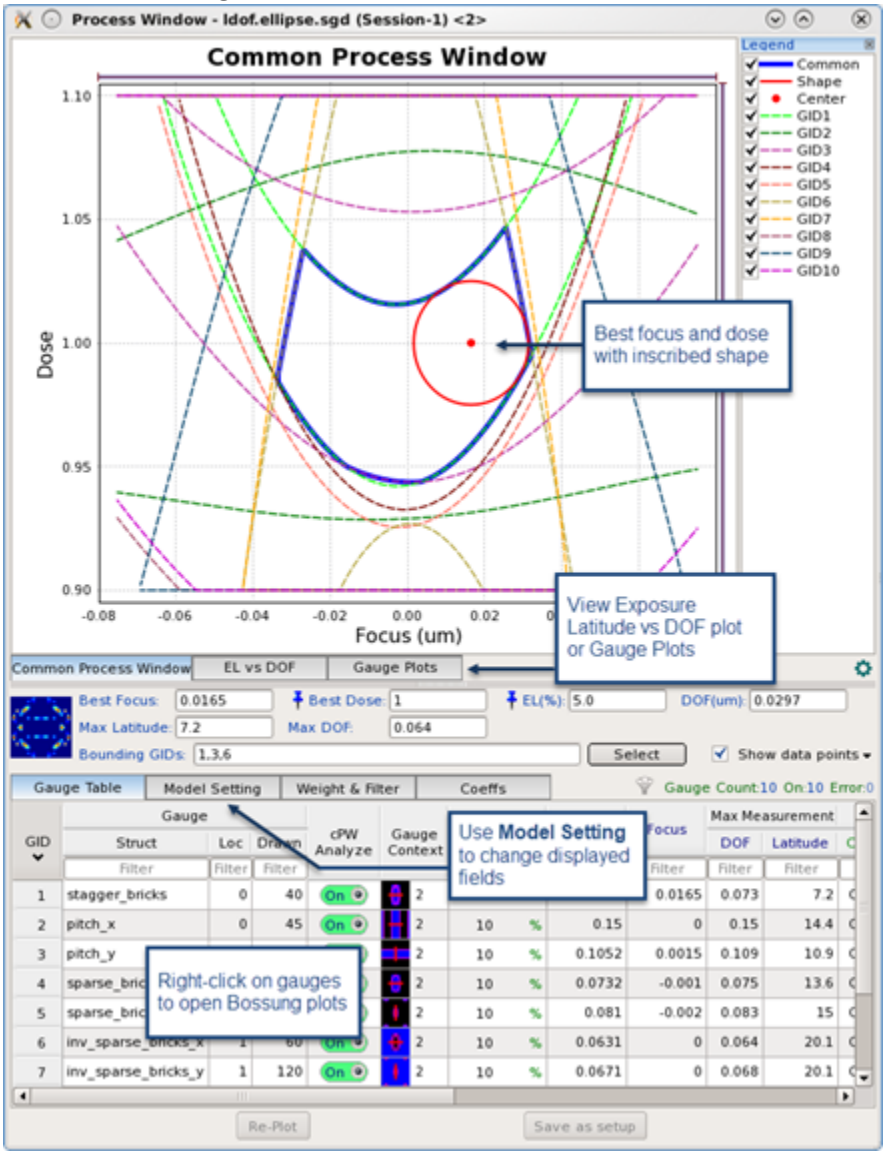
The Process Window tool also provides access to the Exposure Latitude vs DOF plot (**EL vs DOF** tab) and eight Bossung plots.

The area between the two sets of tabs is not editable, aside from the Show data points option and menu. Use the **Model Setting** tab to change EL% and DOF and the process window object settings. When you click **Re-Plot**, the Best Focus, Best Dose, and Bounding GIDs fields are re-calculated. The pushpin icons indicate which values are fixed (not varying) based on the model setting fields.

To see the points used in calculating the common process window, be sure Show data points is selected, then click a curve. By default, the points used show as solid markers. Use the dropdown list to additionally show points filtered out by the first pass (X markers) or the second pass (bowtie-shaped markers). To dismiss the points, click in the graph area or unselect Show data points. (See "Usage Notes" at the end of this topic for information on first and second pass filtering.)

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Figure 5-24. Process Window Plot



Objects

Object	Description
Plot area	Click a curve to highlight the gauge in the gauge table and display data points. Select data points by dragging over a group or clicking. The points are also highlighted in the Bossung plots.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
	Click to open a settings menu for the process window analysis. • **Reset PW plot window size** restores the default size. • **Save PWA settings to file** saves analysis settings to an XML file. • **Load PWA settings from file** loads analysis settings from an XML file.
Common Process Window EL vs DOF Gauge Plots	Moves between different views of the SGD data. The **EL vs DOF** tab shows plots for both elliptical and rectangular DOF. The red marker on the EL vs DOF plot indicates the best focus and dose. The **Gauge Plots** tab shows plots of metrics by gauge ID. Plot types include iDOF, iEL, uDOF, uEL, Focus, and Dose plots.
Read-Only Area	Reports values for best focus, best dose, EL, DOF, maximum latitude at DOF 0, and the IDs of the gauges that touch the common process window. If a pushpin icon is next to best focus, best dose, EL, or DOF, then the value is set in the Use fixed DOF option or the **Model Settings** tab Center control. The thumbnail of the source map opens the Source View tool. The **Select** button highlights the bounding gauges. The Gauges entry reports values for Count, On and Error. The Error entry reports the total number of gauges whose calculated model root mean square error (RMSE) is greater than the RMSE tolerance.
Gauge Table tab An analysis area with interactive controls.	
Filter cells	Type a value and press Enter to display only the gauges that match the filter. You can use simple constraints such as “>100” or “.*x” to match gauges that end in x. Two-part constraints are not supported. To clear a filter, delete it and press Enter. Clicking on a column heading sorts the table by that column.
Table area	Right-click on a gauge to access the Bossung plots for that gauge, or enable or disable all gauges. If Show data points is set, clicking the row of any gauge whose cPW Analyze setting is **On** displays the data points.
Gauge columns	Loc 0 crosses a drawn shape. Loc 1 crosses a space. Drawn is the distance between the two edges that the gauge crosses.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
cPW Analyze On/Off	Includes or removes the selected gauge from the Common Process Window. Toggle On/Off and click **Re-Plot**.
CD Tolerance	Reports the gauge's CD tolerance. CD tolerance can be in percentage, absolute value in nanometers, or a range. Blue values indicate a non-default value.
DOF	Depth of focus in microns, calculated using CDOF settings.
Focus Dose	Best focus in microns and dose for individual gauges. If fixed by the model, the column does not display.
Max Measurement	Latitude is a percentage. DOF is in microns.
Model Stat columns	Report model statistics per gauge, given in detail at the end of "Usage Notes" at the end of this topic.
Model Setting tab Repeats the pane from the PW Settings tab in the DOF setup for the Verify job. See the second table in "Verify Setup Pane" on page 210. Click **Re-Plot** to update the read-only area and the plot if you change settings.	
Save as setup	Only active with unlocked sessions. Not shown when the window is opened from Calibre WORKbench.
Weight & Filter tab Settings used to remove outliers from the CD model.	
Weight subtab	When enabled, a Gaussian weighting function is applied to the CD model data points centered on best dose and focus values by default. • **Width Factor** — Width of weighting function. Smaller values decrease the influence of data points that are furthest from the focus and dose centers. Default is 1.0. • **Focus Center** — Specify a focus center to use when applying weighting. The default behavior is to not center the focus. • **Dose Center** — Specify a dose center to use when applying weighting. The default behavior is to not center the dose.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
Prefilter subtab	CD model data points are filtered before fitting the CD model polynomial. Default is enabled. • **Percent CD** — Prefilter type that filters data points less than and greater than the specified percentage. • **Min/Max CD** — Prefilter type that filters data points less than and greater than the specified Min CD and Max CD values. • **Min Dose** and **Max Dose** — Filter data points below a minimum dose and above a maximum dose. Default is off. • **Min Focus** and **Max Focus** — Filter data points below a minimum focus and above a maximum focus. Default is off. • **Prefilter data points** — Specify data points to filter from CD model. Given in detail at the end of "Usage Notes."
Filter subtab	CD model data points are filtered after fitting the CD model polynomial. Default is enabled. • **RMSE Multiplier** — Filter data points from the CD model that are greater than a multiple of the RMSE. Default filter type is RMSE Multiplier with a value of 2.0. • **Max Residual CD** — Specify a residual CD value for removing data points from the CD model. Default is 1000.0 nm when on.
Coeffs tab Displays coefficient values for the polynomial used for the CD model.	

Usage Notes

Table 5-21. Hidden Tools in the Process Window

Goal	Notes
Select multiple gauges	1. Go to the **Gauge Table** tab. 2. (Optional) Use a filter cell to display only the gauges of interest. 3. Click to select the first row, then use Shift-click or Ctrl-click to select additional rows. Most actions can be applied to multiple gauges at a time.
Change a gauge's CD tolerance	1. In the **Gauge Table** tab, select the gauge. 2. Right-click in the CD Tolerance column and choose **Set CD Tolerance**. 3. After dismissing the dialog box, click **Re-Plot** to update the table and plot.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-21. Hidden Tools in the Process Window (cont.)

Goal	Notes
Identify gauges with poor-quality data	• In the **Gauge Table**, right-click and choose **Select Error Gauges**. • In the **Gauge Table**, scroll to the Converged column and filter on the state (Converged, Not Converged, Bad Fit, No Window). • In the **Gauge Table**, scroll through the list. Gauges with poor data are highlighted.
Change columns displayed in Gauge Table	1. In the Gauge Table, right-click a table header and choose **Show Column Manager**. 2. In the PW Plot Column Manager, select the headers to display or hide. 3. Click **OK** to apply changes.
Plot measurements	Hover over a cell or read-only field and an arrow appears in the plot showing the corresponding area.
View gauge data	Click in the row of a gauge or a GID in the Legend. If the points do not appear, verify Show data points is selected.
Crossprobe data	With all plots of interest open and gauge data showing, select points of interest by clicking or dragging over a group.
Crossprobe gauges in the WORKbench viewer	1. In the Gauge Table, right-click a gauge and choose **Gauge Highlight ... > Highlight Gauge**. 2. Go to the WORKbench layout viewer and examine the highlighted gauge.
Find maximum latitude (EL) for a particular DOF	1. In the **Model Setting** tab, select Use fixed DOF. 2. Specify DOF in um.
Remove data points from CD model at specific dose and focus conditions	1. In the **Weight & Filter** tab, select the **Prefilter** subtab. 2. In the Prefilter data points table, click **Edit**. 3. Select a single dose and focus by right-clicking the cell and choosing **Add Selected**. Use Ctrl-click to select additional cells or Shift-click to select multiple cells. 4. Click **OK** to close the window, then click **Re-Plot**.

The RET Selection Process Window plot differs in its fitting method and interface from the Calibre WORKbench process window plot, available in the CM1 Center. Do not expect the two plots to give the same results.

By default, the RET Selection Process Window uses two-pass data filtering to improve model robustness. The first pass removes data based on a percentage of target CD. The second pass fits the 13-term or 8-term polynomial model and then removes points whose residuals exceed 2x RMSE or an absolute CD value. The model is then re-fit.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Of particular note, the window is truncated at the dose and focus limits and does not extrapolate past the available data.

The Model Stat columns include the following data:

- **Converged** — Whether the gauge is included in the plot. Possible values are:
  - **Converged** — The model converged, and for some range of defocus the upper dose curve is greater than the lower dose curve.
  - **Not Converged** — Too few data points remain after filtering to fit a model. For a poly13 model, a curve requires 4 dose conditions, 5 focus conditions, and at least 14 clean points after filtering. For a poly8 model, a curve requires 3 dose conditions, 3 focus conditions, and at least 9 clean points after filtering.
  - **Bad Fit** — The fit is non-physical; for example, the slope of the dose is inconsistent.
  - **No Window** — There is no open window in the focus range.
  - **Blank** — Gauge is disabled.
- **Points** — How many sampling points contributed to the curve.
- **Chi2** and **Reduced Chi2** — Refer to X^2. Can be used to identify a gauge with outlier data even when RMSE is small.
- **Rmse** — Root mean square error. This value is higher for poor-quality data.
- **Stdev** — Standard deviation.
- **R2** — Coefficient of determination.
- **Mean error** and **Mean abs error** — Mean error and mean absolute error.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

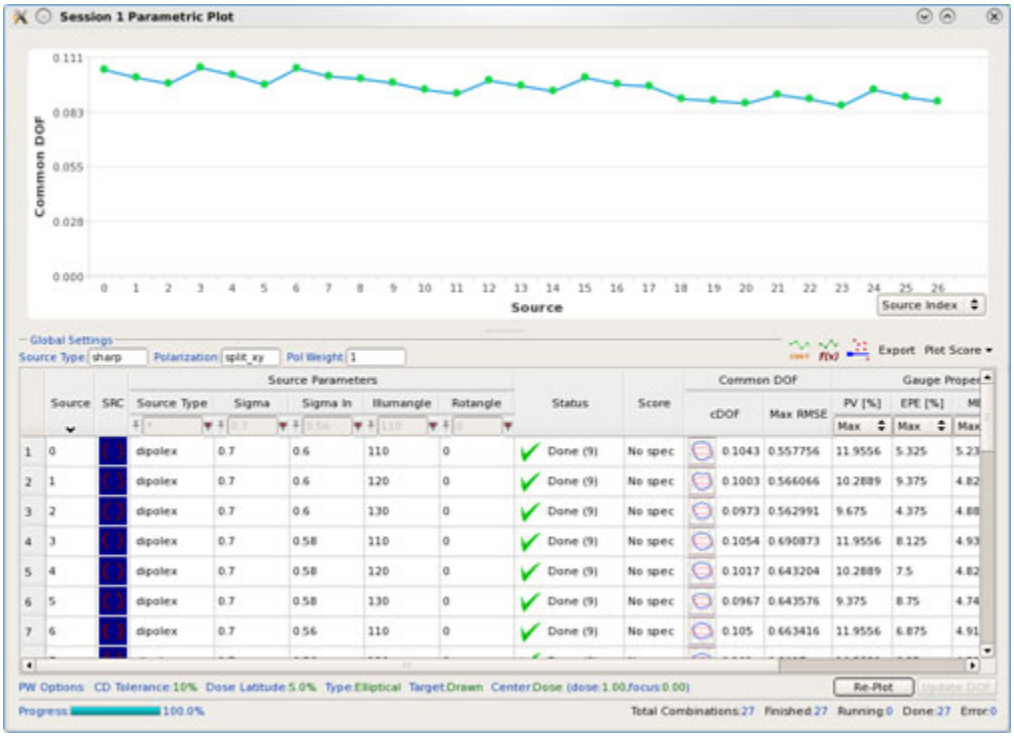
Parametric Plot

To access: Click **Parametric Plot** or the process window plot thumbnail in the **Result** tab.

The Parametric Plot shows the results of source explorations when the Parametric Explorer session mode is used.

Description

The Parametric Plot displays results in a graph and table. The graph displays common depth of focus for the source explorations. The table displays the settings and results for each source exploration. The results can be filtered in the table and displayed in the graph.



Objects

Using the data filtering controls, the Parametric Explorer results can be filtered and displayed in the graph.

Table 5-22. Data Filtering Controls

Object	Description
Source Index Table Index	Sets the results displayed in the graph. **Source Index** displays all sources and **Table Index** displays only sources filtered by the table controls. Default is **Source Index** display.
	Fixes the sorting order for a column. When enabled for one column, a second column can be filtered and retains the order of the fixed column.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Table 5-22. Data Filtering Controls (cont.)

Object	Description
	Toggles the data filter mode. The available data filter modes are no filter, =, >, >=, <, and <=. Clicking the icon toggles the filter mode. Default mode is no filter.
Re-Plot	Updates the graph using updated settings in the table. For example, if the sorting order is changed, **Re-Plot** updates the graph with the new order.

Using the parametric plot tools, the Parametric Explorer results can be analyzed, scored, and saved.

Table 5-23. Parametric Plot Tools

Object	Description
CUST	Opens the Custom Parametric Plot tool.
f(x)	Opens the Score Editor. Results are displayed in the Score column of the table.

Usage Notes

When custom sources are explored, the table reports each custom source with the Source Type value reported as “custom”. When numerical apertures are explored, the table displays an additional column to report the NA value.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Custom Parametric Plot

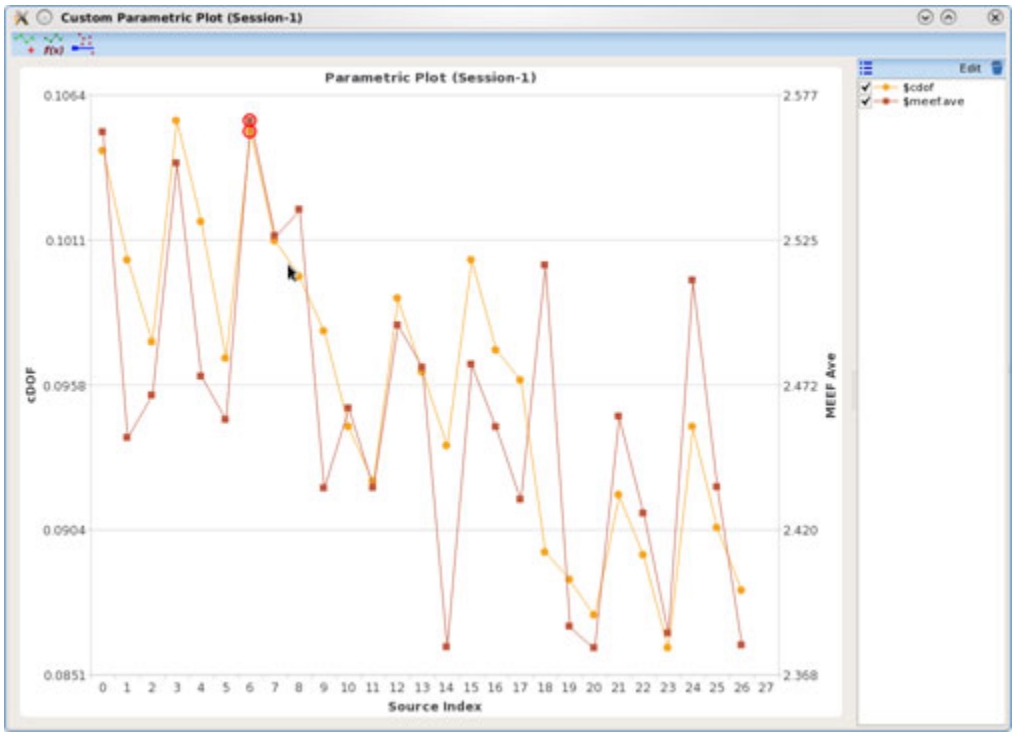
To access: Click the **Open Custom Parametric Plot** button in the Parametric Plot window.

The Parametric Plot creates custom graphs of the Parametric Explorer results.

Description

The Custom Parametric Plot creates customized graphs using results from the Parametric Plot. The customization features include the following:

- Selecting the dataset for the x-axis.
- Plotting multiple data series on the y-axis.



Objects

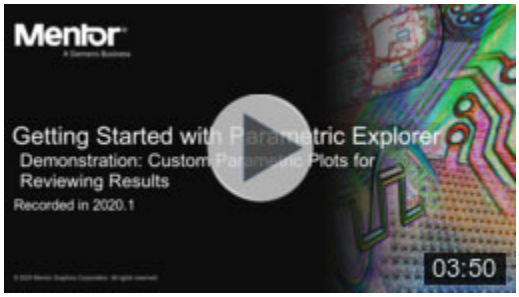
Object	Description
	Add Plot Adds a new graph to the window to display multiple graphs in the same window.
	Open Score Editor. Creates a custom score for results.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Object	Description
	Open Layout Spec Editor Creates custom specs for gauges.
	Options Sets graph display options, including Show Lines, Show Specs, and Show Markers.
Edit	Edit Plot Sets plot title, x-axis, and plot data. Plot data allows selection of multiple metrics.
	Delete Plot

Usage Notes

The “Demonstration: Custom Parametric Plots for Reviewing Results” video in the “Getting Started with Parametric Explorer” video series demonstrates results review using Custom Parametric Plots.



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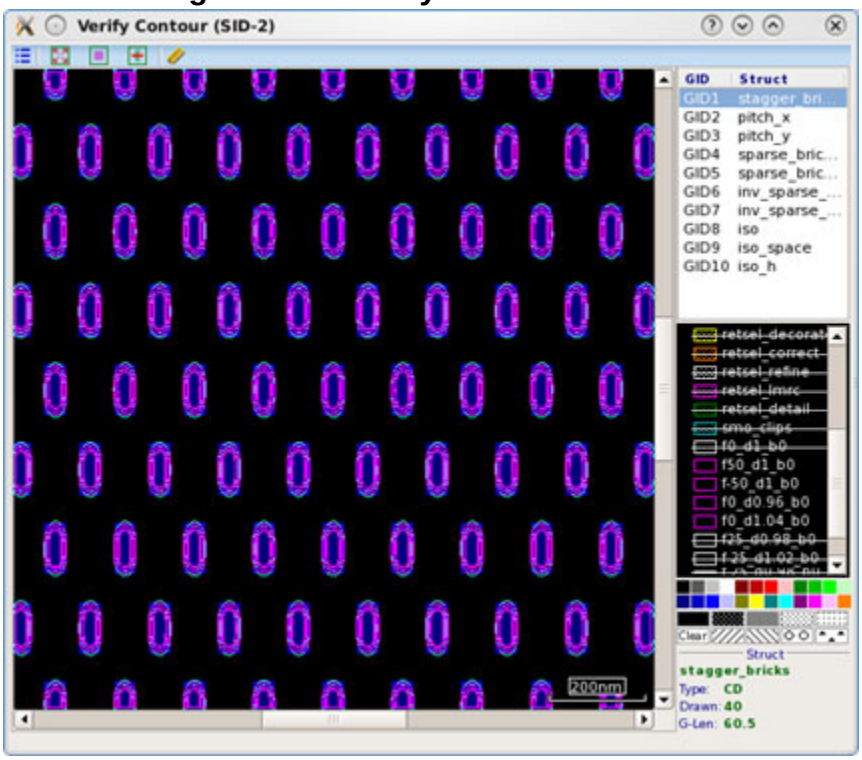
Verify Contour Window

To access: In the Session Browser **Result** tab, click **View Contour** and select **Open Verify Layout Viewer**.

The Verify Contour window enables inspection of the post-run layout.

Figure 5-25. Verify Contour Window



Description

The Verify Contour window displays the post-run layout. The user can use the tool to inspect individual gauges at initial setup, intermediate stages, and final results.

Objects

Object	Description
GID Struct	Select the gauge for inspection in the viewer using the gauge id or structure description.

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Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Chapter 6
RET Selection MDF Commands

When you interact with the RET Selection window, commands are echoed to the Command Window and Log Window as well as the terminal from which Calibre WORKbench was invoked. You can use the commands to create Tcl scripts to run Calibre pxSMO without a GUI.

This chapter summarizes the RET Selection commands. Other commands that begin "mdf" are part of the Calibre nmModelflow interface and are covered there.

All commands that begin "mdf" follow Tcl syntax rules.

mdf gauges commands 237
mdf litho commands 238
mdf smo commands 243
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Move a Session Into Another Layout/Gauge Pair 255

mdf gauges commands

Commands that begin "mdf gauges" control operations on the gauge file.

computeils

Calculates image log slope (ILS) at polygon edges in a layer for all gauges.

computeils -layer *layer_num* [-simtype aerial | full | both]

- **-layer *layer_num***
  A required argument set specifying the layer containing the polygon edges.
- -simtype aerial | full | both
  An optional argument set specifying the image type for simulation.
  - aerial simulates the aerial image. This is the default image for ILS calculation.
  - full simulates the full resist image.
  - both simulates both aerial and full resist images.

After simulation, the tool adds following columns to the gauge table:

- XL and YL — Left-side coordinates in dbu where the gauge crosses the polygon edge.

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- IlsLCtr — Left-side ILS calculation for the full resist image.
- IlsL — Left-side ILS calculation for the aerial image.
- XR and YR — Right-side coordinates where the gauge crosses the polygon edge.
- IlsRCtr — Right-side ILS calculation for the full resist image.
- IlsR — Right-side ILS calculation for the aerial image.

pw

Creates process window conditions for gauges. Subcommands “dose” and “focus” accept a list of values or a range using a start:step:end format. The following example adds three defocus conditions to the litho model file and builds optical models from the nominal:

```
mdf gauges pw focus "0 -0.050 0.050"
```

The next example simplifies a focus list by using a range format:

```
mdf gauges pw focus "-0.15:0.03: 0.15"
```

mdf litho commands

The commands that begin “mdf litho” configure sessions.

Typical commands interact with layout files, load setup files, and start runs.

add

Adds a litho operation to the current list of litho operations.

add *op_name1* [-at-end | -at-beginning | {-before | -after *op_name2*}] [-setup *setup_filename*] [-inputs ‘{’*input*...‘}’] [-outputs ‘{’*output_layer*...‘}’] [-gauge_prop *prop_name*] [-command {opcverify | denseopc | load | mbsraf | multiload | nmbias | opcbias | pxopc | retsbar }]

Adds a litho operation named ***op_name1*** to the current list of litho operations. The new litho operation is added to the end of the list of litho operations unless another location is specified. If *setup_filename* is specified, the list of input layers must match the input layer definitions in the setup file.

The -command argument runs the specified tool on *setup_filename*. If the load command is specified, then no setup file is required; the input must be a single *.oas* file, and the output must be a single layer name. Similarly, if the multiload command is specified, the number of input files must equal the number of output layer names. The layout must correspond to the loaded gauge file. If *prop_name* is specified with the load command, then a property named *prop_name* is created and set to the gauge id for each gauge.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Common litho operation names and examples include:

- **loadclips** — Transfers layout files into memory. The following example loads clips and assigns the "mdf_gid" property to the gauge id of each gauge:

```
mdf litho add loadclips1 -inputs {retsel_gaugelayer.oas} \
   -outputs {retsel_gauges} -gauge_prop mdf_gid -command load
```

- **nmopc** — Performs the nmOPC step. Usage requires a presraf litho operation and either a pos_sraf or neg_sraf litho operation.

```
mdf litho add nmopc -setup nmopc.setup \
   -inputs {squaretgt retsel_pos_sraf tgtsmth retsel_no_mbfrags} \
   -outputs {retsel_opc_output} -command denseopc
```

- **pos_mbsraf** and **neg_mbsraf** — Performs the Pos-SRAF or Neg-Sraf step for the nmOPC engine. Usage requires presraf and nmopc litho operations.

```
mdf litho add pos_mbsraf -setup nm_pos_sraf.setup \
   -inputs {squaretgt tgtsmth} -outputs {retsel_pos_sraf} \
   -command mbsraf
```

- **presraf** — Performs the Pre-Sraf step for the nmOPC engine. Usage requires an nmopc litho operation and either a pos_sraf or neg_sraf litho operation.

```
mdf litho add presraf -setup nmopc_pre_sraf.setup \
   -inputs {squaretgt tgtsmth} \
   -outputs {retsel_presraf retsel_no_mbfrags} -command denseopc
```

- **pxopc** — Performs the pxOPC step.

```
mdf litho add pxopc -setup pxopc.setup -inputs {squaretgt tgtsmth} \
   -outputs {retsel_mask} -command pxopc
```

- **verify** — Performs the OPCverify step.

```
mdf litho add verify -setup verify.setup -inputs \
   {squaretgt retsel_mask retsel_gauges smo_clips smooth_target} \
   -outputs {pv nominal f0_d1_b0 gauge_layer}
```

  The following example implies usage of the default opcverify command that smooths the target:

```
mdf litho add smooth -setup smooth.setup -inputs {6} \
   -outputs {targetSmooth}
```

check

Examines all litho operations to verify that they use the same litho model. The check is on by default and performed at the beginning of an "mdf litho run" command. The following example disables the check:

```
mdf litho check off
```


Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

clip_bias

clip_bias -input *input_layer* -output *output_layer* -clips *gid_list* [-biaspct *bias_percent*] [-biastype width|space|space_width|{fix *fixed_bias*}] [-minwidth *min_width*] [-maxwidth *max_width*] [-minspace *min_space*] [-maxspace *max_space*] [-tablestep *table_step*]

Applies a bias to clips specified by ***gid_list***.

Commonly used in the presmo block with “mdf smo copyclip” and “mdf litho inter_copy” to create an anchor gauge clip with CD bias on a separate layer.

The following options control edge biasing:

- -biaspct *bias_percent* — Specifies a fixed percentage CD bias for moving target edges.
- -biastype — Specifies the default edge bias type for moving target edges. Edge bias types include:
  - space — Moves edges based on space dimensions.
  - width — Moves edges based on width dimensions.
  - space_width — Moves edges based on the smaller value of the space or width dimensions. For this option, a table-based bias rule is used, and the -tablestep option specifies the bias table step size. The default step size is 0.005.
- The following options control the biasing of lines and spaces:
  - -minwidth *min_width* -maxwidth *max_width* -minspace *min_space* -maxspace *max_space*
  - If the target CD is between the minimum and the maximum, then the CD bias is applied to the target CD.
  - If the target CD is below the minimum, the CD bias is applied to the minimum value.
  - If the target CD is above the maximum, then the CD bias is applied to the maximum value.
  - When *min_space* and *max_space* are set to zero, then they use the *min_width* and *max_width* values. All values are in microns.
  - -tablestep *table_step* — Specifies the granularity of the bias table in microns. The default value is 0.005 um steps.

gencliparray

Generates a version of the layout that has adequate spacing between clips to prevent any interaction between optimized masks. For global litho models (used for EUV sources), clips and gauges are written at each slit location. The new layout is written to *retsel_cliparray.oas*. The adjusted gauges are *retsel_cliparray.gg*.

Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

The RET Selection GUI automatically includes this command in the pre-SMO stage and loads the new layout to Calibre WORKbench.

genggl

Creates the gauges as polygons. Each gauge goes on a separate layer.

```
mdf litho genggl layout_filename
```

inter_copy

inter_copy -input *input_layer* -copy *copy_layer* -output *output_layer* -clips *gid_list*

Copies clips specified by ***gid_list*** from ***copy_layer*** to ***output_layer***. All clips from ***input_layer*** are also copied to ***output_layer***.

This command is used in the presmo block with “mdf smo copyclip” and “mdf litho clip_bias” to create an anchor gauge clip with CD bias on a separate layer. The anchor gauge is copied from the target layer to the correction layer to ensure the correction layer has the target layer anchor clip.

list

Displays the current list or queue of litho operations.

measure

Measures properties based on gauges. For example,

```
mdf litho measure -input layout_filename -gauges gauges.gg \
   -output mdf_litho.dat -model lithomodel -props {nils meef ils eils epe}
   [-compute_pw {0|1} -pw_focus '{'focus_list'}'
```

computes NILS, MEEF, ILS, EILS, and EPE for the gauges in *gauges.gg* with the post-OPC mask in *layout_filename*. (Each gauge should have a separate layer.) The file specified by -output contains the measured property values for each gauge.

Use the -target *target_layer* option if gauges do not span post-OPC mask shapes. This can occur when the mask requires significant OPC adjustments, typically around line ends. The -target option can be used with -scale *factor*. This adjusts the scaling of the gauge length against the drawn CD. When used with -target, the default is 5. When -scale is used without -target, the default is 2.

Use the -compute_pw 1 option to compute NILS, MEEF, ILS, EILS, or EPE at custom process window conditions. Specify the process window conditions using the following additional syntax:

```
-compute_pw 1 -pw_focus '{'focus_list'}' -pw_dose '{'dose_list'}'
```


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where *focus_list* and *dose_list* specify defocus and dose conditions for simulation. Each list must be enclosed with braces. By default, *focus_list* uses all defocus conditions specified by mdf smo preverify. The default *dose_list* is 0.90 to 1.10 step 0.02. By default, -compute_pw is set to 0 (disabled).

All clips are merged into one layout. By default, this is *tmpworkdir/smo/retsel_maskmerge.oas* but you can specify a different name with -merge_out *filename*.

merge_layouts_gauges

merge_layouts_gauges -layouts_in '{' '{' ***input_layout_filename input_layer_list*** '}'... '}' **-gauges_in** '{' ***input_gauge_filename*** ...'}' **-layers_out** ***output_layer_list*** **-merged_layout** ***merged_layout_filename*** **-merged_gauges** ***merged_gauges_filename***

Combines multiple layout and gauge pairs into a single pair of files.

The number of input layout files must match the number of input gauge files. The ***input_layout_filename*** and ***input_layer_list*** must be enclosed with braces. Additionally, the number of layers in ***input_layer_list*** must match the number of layers in ***output_layer_list***. If ***input_layer_list*** or ***output_layer_list*** has more than one layer in the list, the layers must be space separated and enclosed in braces.

run

Executes the current list or queue of litho operations built using "mdf litho add". Use additional arguments to configure the distributed run. For example, the following command sets the execution to a mode like Calibre® MT™ parallel processing:

```
mdf litho run -parallel
```

saveclip and savelayout

Writes a file containing the clips or the entire layout to the specified directory. For example, the following command writes clips to an OASIS layout on the clipLayer layer:

```
mdf litho saveclip db_home/retsel_clip.oas clipLayer
```

tol_bands

Generates inner and outer tolerance bands around a target layer.

mdf litho tol_bands -input ***target_layer*** **-outputs** '{'***inner_tol_band outer_tol_band***'}' [-gauges *filename*] [-cdtolmap {*layernum*:*cdtol*}...] [-tolpct *pct_cd_tol*] [-minwidth *minwidth*] [-maxwidth *maxwidth*] [-maxspace *maxspace*] [-minspace *minspace*] [-biastype {width | space | space_width | {fix *fix_value*}}] [-tablestep *tablestep*] [-gauge_type_bias {0 | 1}] —

Generates Manhattan inner and outer tolerance bands around the target layer. In a later step, a user-specified pre-SMO curve_target recipe smooths the tolerance bands.

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To control the tolerance band width at specific locations, use the -cdtolmap option to specify an input layout containing gauge markers. In the specified layout, the gauge markers must be placed on separate layers with one layer per tolerance value.

Tolerance band generation uses the NMBIAS operation to generate tolerance band edges by biasing target edges. For more information, see the *Calibre Rule-Based OPC User's and Reference Manual*, especially the section "LITHO NMBIAS Command". The following options control edge biasing:

- **-biastype** — Specifies the default edge bias type for moving target edges. Edge bias types include:
  - space — Moves edges based on space dimensions.
  - width — Moves edges based on width dimensions.
  - space_width — Moves edges based on the smaller value of the space or width dimensions. For this option, a table-based bias rule is used, and the -tablestep option specifies the bias table step size. The default step size is 0.005.
- **-cdtolmap** — Moves the gauge edges using the custom CD tolerance band value.
- **-gauge_type_bias** — Applies edge bias based on the gauge type when set to 1 and ignores -biastype setting. A CD gauge receives a width-based bias and a space gauge receives a space-based bias. Default behavior ignores the gauge type during edge biasing. If a custom CD tolerance is specified for a gauge layer, the gauge-type bias is ignored.

The following example creates inner and outer tolerance bands using the smaller value of the space or width dimensions:

```
mdf litho tol_bands -input {6} -outputs {target_inner target_outer} \
   -tolpct 10 -minwidth 0.02 -maxwidth 0.25 -minspace 0 -maxspace 0 \
   -biastype space_width
```

mdf smo commands

Commands that begin "mdf smo" control the runs (for example, pre-SMO or Verify).

archive

Imports or exports a self-contained, runnable archive. Archives contain a session and its associated layout.

- **export *session_id archive_file*** — Creates *archive_file*, which contains the layout, session, setup files, results, and a Tcl script to run the archive as a testcase.
- **import** [-layout_only] ***archive_file layout_directory*** — Imports the contents of ***archive_file*** into the RET Selection database as a new layout.

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clips

Generates clips. There are several subcommands:

- **list** — Also the default, if you see “mdf smo clips” with no other arguments. Lists information about the current clips.
- **draw** — Draws clips in Calibre WORKbench. For example, the following command draws clip 3:

  ```
  mdf smo clips draw 3
  ```

- **gen or generate** — Generates clips for SMO and OPC steps. It also generates the masking layer for the Verify step.
- **load** — Loads previously generated clips.
- **select** — Selects optically significant clips from a set based on threshold.
- **upd or update** — Updates the gauge weight and anchor gauge for clips.

configopt

Configures the in-session optical models (that is, pre_so_model and post_so_model) before loading the model.

configopt [-imageplane_mode {auto | only}] [-planes {*imageplane*}...] [-no_extra_planes] [-specs {*spec_name*}...] [-spec_config *spec_config_file*] [-no_extra_specs]

- -imageplane_mode auto | only — Specifies the mode of the imageplanes command. If -imageplane_mode is not specified, then the -planes and -no_extra_planes arguments are ignored.
  - auto — Instructs the tool to select image planes.
  - only — Turns interpolation off.
- -planes *imageplane* — Specifies a list of additional image plane values in microns that are stored in the target optical models.
- -no_extra_planes — Removes image plane values not specified in the -planes argument from the target optical models.
- -specs *spec_name* — Specifies an active spec list. The list of spec names is used to select specs from the *spec_config_file*. The selected specs are either added to the target optical model or replace existing specs in the target optical model. If -specs is not specified, then all of the specs in *spec_config_file* are used in the target optical model.

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- -spec_config *spec_config_file* — An optional argument specifying a spec configuration file containing information in the following format:

  ```
  spec spec_name
  {
  optical_model_text_line
   ...
  }
  ...
  ```

  Use the command in presmo, preopc, and preverify command blocks to configure the optical model for the corresponding stage (SMO, OPC, or Verify).

  A spec file can define one or more optical model specifications (specs); each spec block specifies one or more optical model text lines. For more information on specific optical model commands, refer to "Optical File Parameters" in the *Calibre WORKbench User's and Reference Manual*.

  The following spec file example specifies a spec for a Z5 Zernike coefficient (vertical astigmatism) and another spec with multiple Zernike coefficients:

  ```
  spec Z5
  {
  zernike 0 0 0 0 0.02
  zernike_multiplier_flag 0
  zernike_rms_flag 1
  }
  spec multi_z
  {
  zernike 0 0 0 0 0.02 0 0 0.64 0 0.05
  zernike_multiplier_flag 0
  zernike_rms_flag 1
  }
  ```

- -no_extra_specs — Removes specs not specified in the -specs argument from the target optical models.

copyclip

copyclip *source_gid copied_gid* { **anchor** | **anchor_noopc** }

Copies the specified gauge ***source_gid*** to the specified gauge id ***copied_gid*** in the *retsel_cliparray.oas* layout file and *retsel_cliparray.gg* gauge file.

This command is issued in the presmo block before "mdf litho inter_copy" and "mdf litho clip_bias" to create an anchor gauge clip with CD bias on a separate layer.

You can use this command to copy the specified gauge from the target layer to the correction layer in the preSMO step, which increases the number of gauges. The keyword **anchor** indicates that the gauge is an anchor gauge; the keyword **anchor_noopc** causes the tool to skip OPC on that anchor gauge.

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end

A required command when running in batch mode. It ends the RET Selection operations and removes the objects from memory.

flarelongrange

Configures flare_longrange statements in the pre_so_model and post_so_model *setup.in* files.

flarelongrange {*default_flare* | none | *flare_value*':'*name*}

- *default_flare* — Adds a "flare_longrange *lithomodel* constant *default_value*" statement. *lithomodel* specifies the name of the lithomodel. *default_value* specifies a flare value between 0 and 1.
- none — Removes all "flare_longrange *lithomodel* constant *default_value*" statements.
- *flare_value*':'*name* — Adds "flare_longrange *lithomodel* constant *flare_value* name *name*" statement. The *name* argument specifies the name of a constant flare value in the lithomodel file.

genggl

Creates SMO-style gauges and writes the layout. Each gauge is on a separate layer. For example, the following command writes the gauges to a layout file named *geng.oas*:

```
mdf smo genggl geng.oas
```

layout

Operates on the layout/gauge pair. There are several subcommands:

- **No subcommand** — That is, just "mdf smo layout". Shows information about the current layout/gauge pair and session.
- **A number** — For example, "mdf smo layout 1". Sets the layout/gauge pair associated with that number to the active layout/gauge. This also has the subcommands loadspec, savespec, and delspec.
- **new** — Creates a new layout/gauge pair in the current directory. You must specify the layout and gauge names, for example:

  ```
  mdf smo layout new {mdf gauges gauges.gg layout.oas 6 6}
  ```

- **clone** — Clones a layout/gauge pair. The full syntax is "mdf smo layout clone id new_dir", where id is the layout/gauge pair number and new_dir is the new directory to keep files associated with that layout/gauge pair.

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- **name** — Sets the name of a layout/gauge pair. The full syntax is “mdf smo layout id name {pair_name}” where id is the layout/gauge pair number and pair_name is a name or description for the layout/gauge pair.

list

Lists all existing layout/gauge pairs and their sessions.

mask

Performs operations on the mask. For example, the following command imports an external mask:

```
mdf smo mask import {maskfile}
```

This command runs Calibre pxOPC to generate optimized mask clips.

```
mdf smo mask {
   mdf litho add loadclips \
   -inputs {./tmpworkdir/smo/retsel_smoothtarget.oas \
      ./tmpworkdir/smo/retsel_squaretarget.oas \
      ./tmpworkdir/smo/retsel_tolband_inner.oas \
      ./tmpworkdir/smo/retsel_tolband_outer.oas} \
   -outputs {tgtsmth squaretgt tol_inner tol_outer} \
   -command multiload; \
   mdf litho add pxopc \
      -setup pxopc.setup
      -inputs {squaretgt tgtsmth tol_inner tol_outer} \
      -outputs {retsel_mask} \
      -command pxopc; \
   mdf litho check off; \
   mdf litho run -distributed; \
   }
```

maxclipsize

Controls the maximum layout size used to generate a clip layout from a gauge.

mdf smo maxclipsize *size_val*

Limits the clip layouts created in presmo to be no larger than *size_val* in microns. The default *size_val* is 5.0 microns.

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parametric

Operates on Parametric Explorer sessions to perform mask-only optimization. There are several subcommands:

- **new** — Sets up a parametric source exploration run. The following example sets up the run using settings from a file named *doeParam.setup*:

  ```
  mdf smo parametric new doeParam.setup
  ```

- **run** — Starts a parametric source exploration run. The following example runs using settings from a file named *doescript.tcl* and specified process window analysis settings:

  ```
  mdf smo parametric run 1 doescript.tcl max_parallel 2 pwoptions \
     {-cdtol 10 -doselat 5 -type elliptical}
  ```

polarization

Sets the source polarization.

polarization { **split_xy** | **te** | **tm** | **linearx** | **lineary** | **none** } [*weight*]

- **split_xy** | **te** | **tm** | **linearx** | **lineary** | **none**
  - **split_xy** — Splits any illumination source along four quadrant lines (y=x and y=-x). Anything in the east or west quadrants (abs(x) > abs(y)) is treated as **lineary**; anything in the north or south quadrants (abs(y) > abs(x)) is treated as **linearx**.
  - **te** — Transverse electric or S (S-polarized).
  - **tm** — Transverse magnetic or P (P-polarized).
  - **linearx** — X-axis polarization.
  - **lineary** — Y-axis polarization.
  - **none** — Unpolarized.

  For detailed information on individual polarization types, refer to "Source Polarization" in the *Calibre WORKbench User's and Reference Manual*.

- *weight* — An optional parameter specifying a weight value for the specified polarization type. The default value is 1.

postsmo

A required command when running in batch mode. This command should be used to run any remaining commands after the Verify stage.

```
mdf smo postsmo {}
```


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preopc

This command should be used to run any mdf commands needed before “mdf smo mask”, such as selecting process window conditions.

presmo

A required command when running in batch mode. This command should be used to run any mdf commands needed before “mdf smo setup”, such as selecting process window conditions. The following command runs the target smoothing and saves it in *targetSmooth.oas*.

```
mdf smo presmo {mdf litho add smoo -setup smoo.setup -inputs {6} \
   -outputs {tgtsmth};mdf litho run;mdf litho savelayout \
   ./tmpworkdir/smo/targetSmooth.oas {tgtsmth:7 *};mdf gauges layout \
   ./tmpworkdir/smo/targetSmooth.oas 7 6 ;}
```

preverify

This command should be used to run any mdf commands needed before “mdf smo verify”, such as selecting process window conditions.

pwa

Creates or deletes process window objects.

- **mdf smo pwa new *sgd*** [-gid_from_struct] [[-disable] ‘{’*gauge_list*‘}’]

  Creates a new process window object from the data in ***sgd***, a super gauge data file. You can select which gauges to use with the *gauge_list*. The new process window object has default settings of 13-term polynomial with third order dose and fourth order focus; target CD based on drawn CD values; 5% dose latitude; and the inscribed ellipse should center on nominal dose of 1.0.

  If -gid_from_struct is specified, gauge IDs are based on the structure column of the file; for example, G015 becomes gauge ID 15.

- **mdf smo pwa delete *$PWO***

  Deletes the process window object, ***$PWO***. There are no optional keywords.

For additional operations that can be performed on a process window object, see “Process Window Object Commands” on page 253.

pwanalyze

Computes the common depth of focus (DOF) for a super gauge data file. By default, it uses a CD tolerance of 10% and dose latitude of 5% on drawn CDs on the nominal process window. These can be overridden by additional arguments.

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The optional subcommand set -load *pwa_file* loads process window analysis settings from an XML file.

pwoutput

Generates plots of exposure latitude (EL) versus DOF. This can be useful for determining the process window.

session

Operates on sessions. There are several subcommands:

- **A number** — Activates the specified session id number. The following example changes the active session to session 2:

```
mdf smo session 2
```

- **new** — Creates a new session and adds it to the database with the next sequential session id number. The new session becomes the current active session. The following example creates a new session from the mdf_setup.in setup file:

```
mdf smo session new {mdf_setup.in}
```

- **name** — Sets the session name. Full syntax is "mdf smo session id name {session_name}" where id is the session id number and session_name is a name or description for the session.
- **files** — Loads files into a session. The following example loads a gauge file and setup files into the active session:

```
mdf smo session files {session_1_test_pattern.gg; \
   smoo.setup;pxsmo.setup;pxopc.setup;verify.setup}
```

- **pxsmo** — Enables pxSMO. An "mdf smo session pxsmo yes" statement is required before "mdf smo source" in a Free-Form pxSMO session; the statement is not used in a Parametric Explorer session.
- **close** — Makes the session inactive.
- **state** — Reports properties of the active session. The property smoState can have the following values:

smoState Number	smoState Description	Associated mdf Command
0	(blank)	mdf smo start
1	MDFLITHOMODEL (1)	mdf smo new {setup.in}
2	PRESMO (2)	mdf smo presmo {}
3	Setup Done (3)	mdf smo setup

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smoState Number	smoState Description	Associated mdf Command
4	Clips Done (4)	mdf smo clips gen
5	SOCS Done (5)	mdf smo source
6	SO Done (6)	mdf smo source (covers both smoState 5 and 6 and does not stop at smoState 5)
7	MO Done (7)	mdf smo mask {}
8	Verify Done (8)	mdf smo verify {}
9	Complete (9)	mdf smo postsmo {}

In the GUI, the smoState descriptions appear in the upper-right corner of the Session Browser.

setclips

Copies a custom clip file to the session directory and database. The custom clip file information is later used by the pre-SMO step and gencliparray command. For example,

```
mdf smo setclips customClips.dat
```

setgauges

Copies a custom gauge file to the session directory and database. The custom gauge file information is later used by the pre-SMO step and gencliparray command. For example,

```
mdf smo setgauges customGauges.gg
```

setup

Loads a setup file. For example,

```
mdf smo setup smo_setup_file.in
```

source

Without any other options, runs Calibre pxSMO to generate an optimized source.

Some options work on components unique to Calibre pxSMO, such as this command to import an existing optical source:

```
mdf smo source import /user/opt_engr1/session_2/output/source_sopxopc.src
```


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To execute pxSMO in the mask (that is, OPC) command block, add the command with the maskgen argument using the following syntax:

```
mdf smo source maskgen -opc_setup pxsmo_setup_file [-opc_clip clip_file]
[-opc_control {[set_focus_range:0|1] [use_raw_src:0|1] } ]
```

For example, the following executes pxSMO in the OPC block using settings specified in *pxsmo_mask.setup*:

```
mdf smo mask {mdf smo source maskgen -opc_setup pxsmo_mask.setup}
```

- -opc_setup *pxsmo_setup_file* — A required argument specifying a pxSMO setup file.
- -opc_clip *clip_file* — An optional argument specifying a clip file to use for custom gauge weights.
- -opc_control [set_focus_range:0|1] [use_raw_src:0|1] — An optional argument specifying inputs inherited by second-stage pxSMO.
  - set_focus_range — Replaces the second-stage pw_condition_group focus_range value with the output value from the first-pass pxSMO stage.
    - When set to 1, second-stage SMO uses the output first-pass focus_range value.
    - When set to 0, second-stage SMO uses the initial focus_range value from the first-pass stage.

    For example, if the initial first-pass focus_range value is 100 nm and the output focus_range value is 75 nm, setting set_focus_range to 1 uses 75 nm as the initial second-stage focus_range value whereas setting_focus_range to 0 uses 100 nm as the initial second-stage value. The default value is 1.
  - use_raw_src — Specifies the type of source file to use for the initial source in second-stage pxSMO.
    - When set to 1, second-stage pxSMO uses the raw pxSMO output source file from the first-pass pxSMO stage as the initial source for optimization.
    - When set to 0, second-stage pxSMO uses the standard Calibre output source file as the initial source.

    Using the standard Calibre output source file can introduce some changes from the raw pxSMO source file. The default value is 1.

start

This command is required in batch runs before any other MDF commands are issued. It initializes the process.

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tgtextent

Sets the extents of the clips for the OPC and OPCverify stages. The following example sets the clip extents to the product of the optical diameter of the model (that is, the hoodpix value) and the multiplier 1.1:

```
mdf smo tgtextent 1.1
```

verify

Runs Calibre OPCverify with any specified commands. Output is stored in the *./output* directory by default. For example, the following command runs the Verify stage on a clip named "squaretgt":

```
mdf smo verify {mdf litho add loadclips1 \
   -inputs {./tmpworkdir/smo/retsel_squaretgt.oas} \
   -outputs {squaretgt} \
   -command load
```

Process Window Object Commands

The process window object commands act on a process window object created by mdf smo pwa new. Use them to customize common process window calculations.

mdf smo pwa new | **delete** — Creates or deletes process window objects ($PWO). The process window objects can be manipulated with the following commands:

- **$PWO cdtol set** [-gid *gauge* | '{'*gauge_list*'}'] ***pctcd*** | {***mincd maxcd***} — Sets per-gauge CD tolerance by either percent (***pctcd***) or absolute minimum and maximum. For minimum and maximum, you must specify -gid. The default CD tolerance for all gauges is 10%.
- **$PWO compute** [-gid *gauge*] [-doselat *pctdose*] [-type {rectangular | <u>elliptical</u>}] [-center {none | <u>dose</u> | focus | both}] [-nomdose *dose*] [-nomfocus *focus*] — Computes the common process window or (if *gauge* is specified) the depth of focus for an individual gauge.

  The result is returned as type (ellipse or rectangle), center focus, center dose, maximum latitude, and depth of focus.
- **$PWO filter disable** [-gid *gauge_list*] — Disables two-pass filtering for the specified gauge list, or all gauges if -gid is not specified.
- **$PWO filter enable** [-gid *gauge_list*] [{-rmse *mult*} | {-maxcd *cd*}] — Enables two-pass filtering based on first-pass RMSE or maximum residual CD value. Only one of -rmse or -maxcd can be specified at a time; the default is an RMSE multiplier of 2.0.
- **$PWO gauge get -gid *gauge*** {**stats** | **model**} — Returns a Tcl list with the requested statistics or model coefficients.

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- **$PWO maxlatitude** [-gid *gauge* | all] [-dof *value*] [-type {rectangular | elliptical}] [-center {none | dose | focus | both}] [-nomdose *dose*] [-nomfocus *focus*] — Computes the maximum exposure latitude (EL) as a percentage of the nominal dose for an individual gauge or over all gauges (the common process window). Use -dof to specify a fixed-width ellipse or rectangle. If -dof is not specified it defaults to 0.

  The result is returned as type (ellipse or rectangle), center focus, center dose, maximum latitude, and depth of focus.

- **$PWO model set** {**poly13** | **poly8** | {***dose_order focus_order***}} — Sets the modelform to be used for process window analysis. The default is a 13-term polynomial. Both ***dose_order*** and ***focus_order*** cannot exceed 4.

  You can use **$PWO model** {**enableterm** | **disableterm**} ***dose_order focus_order*** to access specific terms.

- **$PWO prefilter disable** [-gid *gauge_list*] — Disables checking the gauges before fitting the model. The pre-fitting filter removes gauges with CD outliers and is recommended.

- **$PWO prefilter enable** [-gid *gauge_list*] [{-maxcd *cd* -mincd *cd*} | -pctcd *pctcd*] — Enables checking the gauges before fitting the model. You can further limit the affected gauges with either -pctcd *pctcd* (percentage of the target CD) or -maxcd *cd* -mincd *cd* (explicit range). The default is -pctcd 50.

- **$PWO target set** [-gid '{'*gauge_list*'}'] {**nominal** | **drawn** | ***cd***} — Sets the target CD to the nominal or drawn value. To use a custom value (***cd***), you must specify a list of gauges.

By default, process windows models use two-pass filtering with a threshold of RMSE 2.0. Two pass filtering is a method of fitting the input data and computing the residual values, then removing data points that fail the filter criteria. The remaining data points are then re-fit. This process is done to remove outliers.

Examples

To create a process window object (PW) from the super gauge data file *ldof.ellipse.sgd*:

```
set PW [mdf smo pwa new ldof.ellipse.sgd]
```

Change the prefiltering value:

```
$PW prefilter enable -pctcd 75
```

Calculate the DOF on gauge 8 and save the value in a variable, dof:

```
set dof [$PW compute -gid 8]
```

Delete the process window object when done to release memory:

```
mdf smo pwa delete $PW
```


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Move a Session Into Another Layout/Gauge Pair

Sessions in different layout/gauge pairs cannot be compared in the plots even if the layout and gauges are identical. You can use a short command-line script to move the session to another layout/gauge pair.

Solution

This procedure will change the layout id of a session.

Restrictions and Limitations

- No sessions must be active.
- You must know the layout ID and session ID of the session to move. You can get this information from the Session Browser.

Procedure

1. If you have the RET Selection window open, close it. This will deactivate any sessions.
2. In Calibre WORKbench, select **LITHO > RET Selection**. The RET Selection window opens with your last database open, but does not activate any sessions.
3. In the Command Window pane of the RET Selection window, enter

   mdf smo start

   mdf smo session *id* layout *id*

   where ***id*** is the session ID and layout ID of the session you want to move.
4. (Optional) Move the session directory to be part of the layout/gauge pair.

   cp -r *session_dir new_dir*

   where ***session_dir*** is the existing directory the session is stored in, and ***new_dir*** is where you would like it to be.
5. (Optional) After moving all sessions out of the duplicate layout/gauge pair directory, delete it.

   rm -r *old_dir*
6. If you moved the session, reset the session path.

   cd *new_dir*

   mdf smo session *id* workdir pwd

   Instead of “pwd”, you can enter the directory path.

Related Topics

mdf smo commands

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Chapter 7
Calibre SMO Best Practices

This chapter summarizes the best practices for running Calibre pxSMO and the Calibre RET Selection interface.

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Process Window Best Practices 258

Recommendations for Tuning Results

There are several things that can improve your optimized source or mask, but are too case-specific for inclusion in the procedures.

The following list is organized from most commonly applicable to highly-specific situations.

- Tuning the smoothed curve to more closely match the achievable nominal contour usually improves results. The defaults are rarely adequate. Check the curve on a variety of feature types. A good initial approximation can often be had with the following:
  - Use curve_target instead of curve.
  - Set lineEndRatio between 1.2 and 1.5.
  - Set criticalDistance to approximately the minimum dimension. The default for curve_target is based on the opticalsystem setting in the nominal optical model.
- Investigate how well the process window conditions cover PV band maxima and minima using Bossung plots and contours of verification conditions. Increasing the number of conditions can sometimes improve common DOF compared to the standard three process window conditions.
- When tuning process window conditions, focus is typically the most sensitive parameter.
- Ready-type DDM libraries are not adequate for SMO because they have already determined which sectors are bright. During SMO, any pixel in the illuminator can turn on. There needs to be sufficient DDM signals across the pupil to support accurate imaging calculations. Universal-type DDM libraries use a high-frequency sampling that makes this possible.

  A ready-type DDM library can be converted into a universal-type DDM library by adding the line “modeltype universal” and replacing illumination lines with “illumination universal na obj_na”to the masksim input file and re-running Calibre MaskSim.

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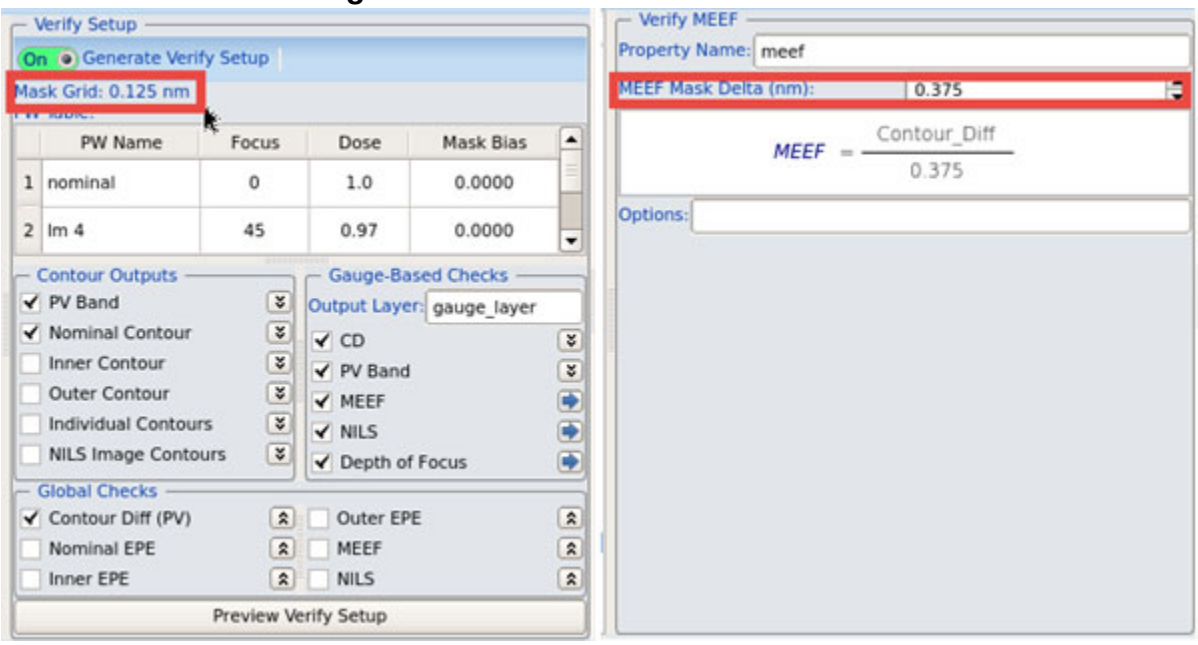
- If the NILS values are not good, check the litho model's aerial image threshold. In the litho model, this is the image_threshold parameter. For runs using CTR modelforms or only aerial image, use the Calibre WORKbench RET Flow Tool image map.
- For MEEF, check that the mask delta value is optimal for the MEEF calculation. By default, the mask delta is equal to the mask grid. Use the arrows for MEEF Mask Delta to increment the value. A small mask delta value from 0.25 to 1 nm is typically recommended. The Setup window shows the mask grid on the main Verify Setup pane and the mask delta when you select **Verify** > **MEEF**. See Figure 7-1.

Figure 7-1. Mask Grid and Mask Delta



- For compound optical sources, simulations use the linear polarization of the first element. If this is not what you want, modify the optical file to put the desired polarization first. Frequently this is SPLIT_XY.

Process Window Best Practices

These process window recommendations have been developed from extensive testing. Settings are relative to those used in the Calibre OPCverify setup file unless otherwise noted.

Note

More information is available on Support Center in KB article MG598348 "pxSMO Best Practice: PW Condition Selection."

Siemens EDA strongly recommends the following practices:

- Use more aggressive definitions for SMO and OPC stages than for the Verify stage.

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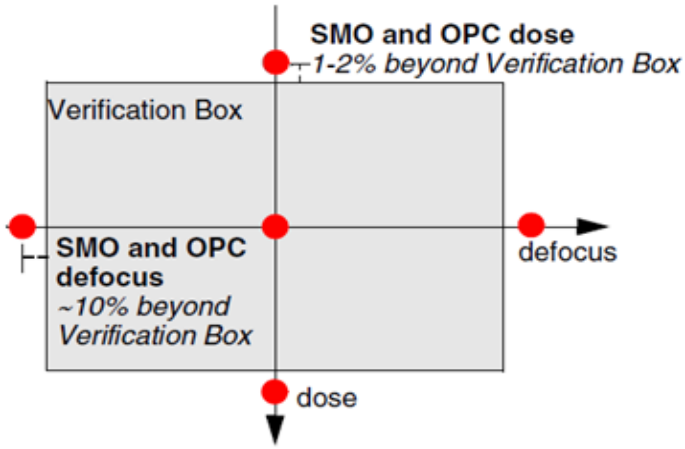
The standard recommendation is to make the process window conditions about 1- 10% worse (relative to nominal) for SMO and OPC. This is illustrated in Figure 7-2 and tabulated in Table 7-1 and Table 7-2.

Figure 7-2. Inner and Outer Process Window Conditions



Consult the *Calibre pxOPC User's and Reference Manual* when tuning the pxOPC settings.

Table 7-1. Typical Settings for Verification Box Conditions

Parameter	Nominal Setting	Lower Value	Upper Value
Defocus	0 nm	-50 nm	50 nm
Dose	0	0.96	1.04

Table 7-2. Typical Settings for SMO and OPC Process Window Conditions

Parameter	Nominal Setting	Lower Value	Upper Value
Defocus	0 nm	110% of Verification Box Lower Defocus	110% of Verification Box Upper Defocus
Dose	0	101-102% of Verification Box Lower Dose	101-102% of Verification Box Upper Dose

- Use at least five process window conditions: nominal, two defocus (for example, ±50 nm), and two off-nominal dose (for example, ±4 percent). If the initial process window conditions do not produce a sufficient common process window value, then the conditions can be adjusted. Adjustments depend on the requirements for the layer and the solutions from the initial SMO runs.
- Investigate how well the SMO process window conditions cover PV band maxima and minima using Bossung plots and contours of verification conditions. The chosen process window conditions must represent the maxima and minima of PV band variation across

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all feature types. The SMO and OPC stage process window conditions should be slightly larger than the settings used by the Verify stage. Reasonable starting values are 10% defocus and 1-2% dose.

- In the beginning, use zero for the mask size setting. The weights should be set to one in the PW table and can be adjusted in each point tool's setup pane.
- Values for focus-dose pairs within the dose and defocus ranges. The number of pairs must meet the polynomial convergence criteria.

Related Topics

Defining Process Window Conditions

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Chapter 8
File Format Reference

This chapter describes file formats used in Calibre RET Selection:

Clip File Format 262
Setup File Format for RET Selection 264

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Clip File Format

Input for: RET SMO commands

The clip file contains information about clipping rectangles and their properties, relevant for setting boundary conditions, and taking advantage of possible periodicities.

Format

A clip file must conform to the following restrictions:

- Use one line per clipping rectangle.
- Use "#" or "//" to indicate a comment.
- At least one clipping rectangle must be described.

```
rect x1 y1 x2 y2 option [option]... gid gid [gid...] cid cid \
 [smo 1|0] [opc 1|0] [cname "clipname"] [weight weight_val]
rect x1 y1 x2 y2 option [option]... gid gid [gid...] cid cid\
 [smo 1|0] [opc 1|0] [cname "clipname"] [weight weight_val]
```

Parameters

- **rect** ***x1 y1 x2 y2***

  The required keyword **rect** indicates the line describes a clipping rectangle. The values ***x1***, ***x2***, ***y1***, and ***y2*** are coordinates in microns. (***x1***, ***y1***) is the lower left and (***x2***, ***y2***) is the upper right.

  The coordinates are followed by one or more options.

- *option*

  An optional keyword and value applied to the clipping rectangle. Valid options are:

  - periodicity {XY | X | Y | N} — Defines if the clip is periodic in X, Y, or both, or not periodic (N). See "Periodicity Types" on page 183. The default is not periodic (N).

    For the "half-periodic" clips (periodicity X or Y), the non-periodic direction is treated as aperiodic and the simulation region extends one optical radius beyond the clip.

  - symmetry {F | '|' | - | + | ST | SL } — Defines the clip to have one of the symmetries described in "Symmetry Types" on page 183.

    The symmetries can be thought of as being in two groups: reflection (|, -, and +) and flip with reflection (ST and SL).

- **gid** ***gid*** [*gid...*]

  A required parameter set specifying the gauge id. The ***gid*** value must be an integer.

  If multiple gauges are in the same clipping rectangle, specify the additional gauge ids in the same line. Place a comma between each gauge id without spaces.

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- smo 1 | 0

  An optional parameter enabling the clip for the SMO stage. The default value is 1 (clip enabled).

- opc 1 | 0

  An optional parameter enabling the clip for the OPC and Verify stages. The default value is 1 (clip enabled).

- **cid *cid***

  A required parameter set specifying the clip id. The ***cid*** value must be an integer.

- cname "*clipname*"

  An optional parameter set specifying the clip name. The *clipname* value must be enclosed with quotation marks.

- weight *weight_val*

  An optional parameter set specifying a weight applied to a clip and its gauges. Clip weight values specified in the clips file overwrite gauge weight values. The default behavior applies gauge weights.

Examples

Example 1

The following clip file contains information for two clips with no periodicity or symmetry:

```
# common clip file name is clips.dat

rect -0.640000 9.360000 0.640000 10.640000 periodicity N symmetry F gid 2
cid 1
rect -0.640000 -0.640000 0.640000 0.640000 periodicity N symmetry F gid 1
cid 2
```

Example 2

The following clip file contains information for one clip with 3 gauges (comma-separated gids) with no periodicity or symmetry:

```
rect -0.640000 9.360000 0.640000 10.640000 periodicity N symmetry F gid
1,2,3 cid 1
```

Example 3

The following clip file contains information for two named clips with the pitch_y clip disabled during the SMO stage:

```
rect 12.162500 2.197250 13.442500 3.477250 periodicity N symmetry F gid 2\
 cid 2 cname "pitch_x"
rect 22.174625 2.232500 23.454625 3.512500 periodicity N symmetry F gid 3\
 cid 3 cname "pitch_y" smo 0
```


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Setup File Format for RET Selection

Input for: Layout and Gauge Pair Loader (Setup File selection)

Generated by: Layout and Gauge Pair Loader (Lithomodel selection)

The RET Selection setup file can be used instead of a litho model when creating a new layout/gauge pair in the RET Selection GUI. If you use the other choice in the wizard, Lithomodel, at the end of the setup the wizard exports a RET Selection setup file.

When creating a new layout/gauge pair, the Lithomodel option is recommended.

Format

For your convenience, a template is provided in Figure 8-1. Replace the italic words with appropriate values for your model and layout. The *models* directory should be the parent of the *litho_model_directory_name* directory.

The setup file must have at least two layers defined outside the image_options block. The smoothed_target_layer can be created by SMO and does not need to exist in the clip layout file. The order of the layers does not matter, and the names do not need to match the layout because they are mapped when creating the layout/gauge pair.

Figure 8-1. Setup File for Layout and Gauge Pair Loader

```
modelpath models
layer        smoothed_target_layer
layer        drawn_target
tilemicrons  100
image_options MDF {
   layer drawn_target visible mask_layer 0
   litho_model litho_model_directory_name
}
setlayer im0 = image MDF
```

Parameters

- **modelpath *models***

  A required parameter indicating the full path to the litho model directory. The path can be absolute or relative.

- **layer *layer_name***

  A required parameter that specifies a target layer, which will be read from the layout, and a smoothed layer created by setlayer curve or setlayer curve_target. The RET Selection session can be set up to create the curve for the smoothed layer.

  This parameter must occur at least two times. The ***layer_names*** must be unique.

- **tilemicrons 100**

  A required parameter for parsing. The value is not used, as each point tool has its own setup file.

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- **image_options *MDF*** ‘**{**‘

  layer *layer_name* visible mask_layer 0

  litho_model *litho_model_directory_name*

  ‘**}**’

  A required image options block that identifies the litho model and the target layer. Although this is based on the Calibre OPCverify image_options, the RET Selection GUI accepts only the two specifications shown. The braces ({ }) are required and must be in the positions shown.

- **setlayer im0 = image *MDF***

  A required parameter that causes the image_options block to be read. The ***MDF*** value must match the ***MDF*** value of the image_options block.

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Note - Viewing PDF files within a web browser causes some links not to function. Use HTML for full navigation.

Appendix A
System Flow And Runscript Information

It is useful to understand the system flow and runscripts used by the RET Selection GUI.

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Custom Runscripts 268
Using the Platform LSF Runscript. 270

RET Selection System Flow

The system flow in the RET Selection interface and Calibre pxSMO involves the use of specialized runscripts that are executed by optimization jobs.

The runscript is a required element of an optimization job. Multiple runscripts are available to you. When a runscript is executed, the following steps are performed by the RET Selection tool.

1. Calibre WORKbench prepares a job directory, generating the following read-only files:
   - *job.sh* – Sources environment settings coming from the session, and calls the runscript with the user-specified arguments for that specific job along with all of the required options.
   - *job.tcl* – Contains the stage commands to execute in the job on a remote host chosen exclusively by the runscript.
   - *env.sh* – Contains script environment settings (including licensing). The settings can be changed by the code in the runscript. The *env.sh* file is required because some mechanisms such as rsh and ssh do not automatically preserve required environment settings (for example, license file variable settings, beta variable settings, etc.).
2. Calibre WORKbench starts a background dispatcher process, and the job is queued to the dispatcher. The dispatcher handles the execution of the runscript on the same host in parallel with and separately from the user session, so as to allow the user session to continue execution. This is to allow the user to monitor the job from that user session.

   Note

   The name “dispatcher” is a historical artifact; it is not doing any dispatching to distribution systems, but only executes the runscript, which then is in full control of dispatching to remote hosts through a dispatching system.

   You can exit Calibre WORKbench at this point; the RET Selection job continues execution, even if it is running on a separate host.

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3. The runscript is executed with the job directory as the current working directory. The runscript may execute the *job.tcl* script on the primary host or a remote host, depending on how it was written.

   You can check on the status of the job using one of the following methods:

   - Examining the Status field in the Run Control pane in the RET Selection GUI.
   - Examining the *status* file in the job directory. This file is updated by the dispatcher process when the job completes (successfully or otherwise).
   - By using the mdf smo job wait command in batch mode or in the Command window to wait for the job to complete.

4. After the job finishes, the dispatcher process detects an exit code from the runscript and updates the *status* file in the job directory. This action is performed independently of the active Calibre WORKbench session, if any.
5. If the job has any successors that are queued for execution, and the current job completed successfully, the successor jobs are executed next.
6. After about 10 seconds of inactivity (no jobs are running or queued), the dispatcher ends the process. The dispatcher process creates a separate log that can be examined for debugging purposes.

Custom Runscripts

The runscript file can be customized, usually by a system administrator. All runscripts have specific requirements for use, but can be written in any scripting language.

Runscript examples are located in the product tree in the location:

$CALIBRE_HOME/pkgs/icmdf/pvt/runscripts

Runscripts are plain text files. The example code is implemented as Tcl, /bin/sh, or /bin/bash. Both the user and system administrator have full control over the runscript content.

All runscripts should perform the following operations, in order.

1. Accept the standardized minimal arguments.
2. List usage information if the -h option was used, and exit.
3. Emit option metadata if the -optionmetadata option is used. This option should list the same information as would be emitted by the -h option, but in XML form.
4. Acquire or identify a host to execute the calibrewb job session. This can use either MT or Calibre MTflex (for example, by requiring the user to specify the -remotefile option). This host will be used as the Calibre MTflex primary host. The hostname can be

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hardcoded in the runscript, but the intention is for the host to be acquired by a distributed processing system.

5. If the runscript is designed to run Calibre MTflex, it should also perform the following steps:
   - Acquire or identify one or more hosts for Calibre MTflex remotes. These hosts can also be hardcoded, but the intention is for the remotes to be retrieved from the distribution system, similar to the Calibre MTflex primary host.
   - Construct a remote configuration file to pass to the calibrewb job. This can be a static file, but it is more effective when the remote configuration file is generated by the script.

     Alternatively, since calibrewb uses standard MTflex, a REMOTE COMMAND can be specified in the remote configuration file instead of hosts; this command would use a distribution system to launch the remote computing server processes (note that you would use "calibrewb -mtflex *H*:*P*" instead of "calibre -mtflex")
6. The runscript should next execute calibrewb and pass it the *job.tcl* script, along with the -remote configuration file option if Calibre MTflex execution has been chosen. The calibrewb execution command should:
   - Redirect all standard output and standard error messages from the execution of calibrewb into the *job.transcript* file.
   - Pass all other output from the script without redirecting them to a file; the dispatcher process will redirect all other standard output and standard error into the *runscript.transcript* file.

     The *runscript.transcript* file output represents failures in execution to distribution systems (such as failure to rsh into systems, failures in requesting job execution to the distributed system, and so on), which is separate from the calibrewb execution output sent to the *job.transcript* file.

     This is so the user can view the *runscript.transcript* file separately from the *job.transcript* file.
7. The runscript must wait for the calibrewb job to finish, even if it is running on a remote host indirectly through a distribution system.

   The exit code from the calibrewb process must be returned from the runscript as its exit code, regardless of whether the runscript ran the job on the primary host or dispatched it to a remote host. This is so the dispatcher process can update the status file and also execute dependent jobs upon successful completion.

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Using the Platform LSF Runscript

The *run_lsf.sh* runscript executes sessions within the RET Selection environment using the Platform LSF distribution system.

Prerequisites

- $PATH environment variable must have the LSF bsub command included

Procedure

1. Create a script to set up your environment for RET Selection, similar to the following.

```
#!/bin/bash
export CALIBRE_MDF_WORKDIR_DEFAULT="./tmpworkdir"
export CALIBRE_MDF_DISPATCHER_DIR="./mdfdispatcher"
export CALIBRE_MDF_DB_HOME="./mdfdatabase"
$MGC_HOME/bin/calibrewb
```

2. Run the script to invoke Calibre WORKbench in SMO mode, then select **Litho** > **RET Selection** to open the RET Selection GUI.

3. Edit an existing session by clicking on the following items in succession:

   a. Run Control pane

   b. The session to edit

   c. The **Run Config** button

4. Change the Dispatcher Configuration option to Run Script. In the Run Script field, specify the *run_lsf.sh* script and provide the arguments as follows:

```
run_lsf.sh -nummastercpus NUM_PRIMARY_CPUS -numremotecpus
NUM_REMOTE_CPUS -masterbsuboptions MASTER_BSUB_OPTIONS
-remotebsuboptions REMOTE_BSUB_OPTIONS
```

   where:

   - NUM_PRIMARY_CPUS is the number of CPUs the primary should contain. LSF is instructed to allocate a single machine with that number of cores to be the primary.
   - NUM_REMOTE_CPUS is the number of remote cores to allocate to the job. LSF is instructed to launch Calibre MTflex remotes on that many cores on LSF-allocated machines.

   An example Run Script might look like the following:

```
run_lsf.sh -nummastercpus 8 -numremotecpus 8 -masterbsuboptions
'type=Linux -q calcmq' -remotebsuboptions 'type=Linux -q calcmq'
```

   Save the command.

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Note

The example script is generic; you might need to add additional options for your configuration. Contact Siemens EDA for support.

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Glossary

active session
The session that will receive any changes you make in the setup panes. There can be only one active session at a time.

clip
A rectangular area of the layout used for simulation. Each clip should be distinct and separate from other clips in the layout.

global litho model
A litho model for extreme ultraviolet (EUV) processes. Global litho models support variant optical models for different x-coordinates (slits) in the EUV field. See "EUV Through-Slit Litho Model Extension" in the *Calibre OPCverify User's and Reference Manual* for details.

job
A phase in the optimization. It solves for a particular combination of objective functions.

pane
A defined area within a larger window. The main RET Selection panes are able to be pulled out of the RET Selection window, so are sometimes also referred to as windows. These child windows also contain panes.

source mask optimization (SMO)
The process of optimizing an optical source and a mask layer in tandem in order to most accurately manufacture a desired layout.

tolerance bands (tolbands)
A pair of boundaries around a target indicating acceptable edge placement for a resist contour. Tolerance bands comprise the inner and outer boundaries for resist contour edges across a range of dose and focus conditions.

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Third-Party Information

Details on open source and third-party software that may be included with this product are available in the *<your_software_installation_location>/legal* directory.

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